A QUANTITATIVE ECOLOGICAL STUDY OF SELECTED NEARSHORE MARINE PLANTS AND ANIMALS AT THE DIABLO CANYON POWER PLANT SITE: A PRE-OPERATIONAL BASELINE

RESOURCES AGENCY
CALIFORNIA
DEPARTMENT
FISH&GAME

1973 - 1978

by

Daniel W. Gotshall Laurence L. Laurent
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MARINE RESOURCES
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STATE OF CALIFORNIA
THE RESOURCES AGENCY
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PACIFIC GAS AND ELECTRIC COMPANY

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ABSTRACTS

Biologists of the California Department of Fish and Game, under contract with the Pacific Gas and Electric Company, conducted surveys of intertidal and subtidal plants and animals in the vicinity of the Diablo Canyon Nuclear Power Plant for the summer of 1973 through 1978. Abundances of the dominant plants and animals were obtained at random as well as permanent stations in Diablo Cove as well as nearby control areas. A total of 643 permanent and random stations were surveyed, 262 in the intertidal and 381 in the subtidal.

Natural as well as man-caused occurrences have resulted in several significant changes in plant and animal abundance in the study areas; these include the arrival of the southern front of the sea otter population in Diablo Cove in 1974; a strong red tide bloom in the fall of 1974; and the release of copper ions from the power plant condenser tubes into Diablo Cove during the summer of 1974.

Our intertidal and subtidal random station data have shown a strong decline in giant red sea urchin, Strongylocentrotus franciscanus, densities and the surface canopy kelp, Nereocystis/leutkeana, and a corresponding increase in the subcanopy kelps, Pterygophora and Laminaria. Seasonal patterns of abundance of foliose red algae at random intertidal stations occurred at all study areas. Several species intertidal and subtidal invertebrates showed increasing or decreasing trends in levels of abundance during the five year study period covered by the report. Some of these changes in abundance may be related to the natural man-caused impacts mentioned above.

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ACKNOWLEDGEMENTS

Much of the success of any large ecological study rests with people other than those whose names appear on the cover of the final report. This study is no exception and without the aid and assistance of many people this project would have been diminished considerably. Seasonal employees helped to collect field data and conduct laboratory and office work. Department statisticians and computer specialists lent their expertise to data processing and analysis. Biologists not directly associated with our study often gave time and talent to field work and/or taxonomic questions that plague any ecological study. Each of these people has our gratitude and deserves mention.

Over the years there have been many short-term employees with our project, working either as seasonal aids, student assistants or graduate student assistants. Each of these folks brought with them particular sets of skills and abilities that proved valuable to the project. (In return, we like to think we provided valuable opportunities for experience in field biology.) Most of them assisted in intertidal surveys, served as boat tenders during subtidal surveys, sorted and identified algae and invertebrate samples in the lab, transcribed data onto computer forms, worked on graphics for reports, and provided necessary maintenance on project equipment. Alphabetically these people are: Laurel Ayres, Suzanne Benech, Rosemary Bowker, Kathleen Casson, Kathleen Cheap, Jane Dykzeul, Monica Farris, Sally Krenn, Franklin Oaks, Phillip Taylor, Terrie Tiffany, Steven Wiley, and Katharine Wright. Other seasonal employees, besides participating in the previously mentioned activities, also served as project divers, helping to collect subtidal data:

Robert Chamberlain, Gary Farrens, Barbara Freeman, James Kelly, and Heidi Togstad.

In the Herculean effort to make sense of the reams of data collected, we owe a special debt to gratitude to the biostatistics branch of the Department of Fish and Game: to Bernice Hammer, computer programmer par excellence; John Geibel, biologist/statistician nonpareil; and to Leo Pinkas and his Long Beach biostatistics staff for punching tens of thousands of data cards.

We have also been assisted from time to time by other Department biologists. Members of the Sea Otter Project, Bob Hardy, Jack Ames, and Fred Wendell, helped perform diving surveys (Fred was also a valued member of our project from 1973-77). Dick Burge, Unit Manager from Morro Bay, helped us to re-locate existing permanent intertidal and subtidal stations during the beginning phase of this project. Earl Ebert and Marine Culture Lab crew conducted temperature-tolerance tests on red abalone.

On many occasions we have turned to several sources with taxonomic questions: Dr. Shirley Sparling, Cal Poly; Faylla Chapman, Hopkins Marine Station; Dr. Wheeler North, Cal Tech; Dr. Robert Givens, USC; David Behrens and James Kelly, PG&E; Dr. Robert Lavenberg, L.A. County Museum; John Fitch and Bob Lea, California Department of Fish and Game; and the "Lockheed Boys"--Jim Blecha, Jay Carroll, Chris Ehrler, and Scott Kimura. Together, we often confirmed that many specimens don't always fit into presently available taxonomic keys, with the result that some of the taxonomic "splitters" among us have been transmogrified into humble "lumpers".

In giving this report form, several people have played key roles. We have been blessed with three excellent secretaries: Lois Sloan (1974-77) Sally Barker (1977-80), and Sandra Dostalek (1980-82). We have also been graciously assisted, in times of need, by Lydia Machado and Kathy Rhodes, secretaries in Marine Resources Branch, Sacramento. Much of the chore of fact-checking and error-finding for this report was performed by a new biologist on our staff, Sandra Owen, who did a good job on a difficult task.

Finally, special thanks are due the funding body for this study--Pacific Gas and Electric Company. Besides insuring absolute autonomy to our study, the amount of cooperation offered by PG&E was high throughout the course of the pre-operational phase. Supervising biologists James R. Adams and John W. Warrick were unflaggingly helpful in supporting the goals of our project.

SUMMARY

1. Diablo Canyon Power Plant, located between Morro Bay and Avila Beach, California, will use ocean water in its "once-through" condenser cooling system. This water, heated an average of 10°C (20°F) above ambient water temperature, will be discharged at about 2,000 cfs per nuclear unit into the shoreline receiving waters of Diablo Cove.

2. In order to assess the effects of the heated effluent on nearshore marine life and the effects of the arrival of the sea otter, this ecological study was begun in 1973 to establish a baseline data-set on selected species of plants, invertebrates, and fish.

3. A randomized sampling approach within designated study areas was chosen because of its usefulness in generating quantifiable data with estimates of error on the populations of the selected species.

4. Species to be studied were selected primarily for their importance to sport or commercial fisheries. Additional species were selected on the basis of predator/prey relationships with the former group or as representatives of various habitats or trophic levels.

5. During the construction and testing phases of the power plant, two man-caused occurrences affected the marine communities in or near Diablo Cove. The first was deposition of large amounts of silt and other sediments within the 10 acre basin of Intake Cove. The second was a discharge of copper ions from the condenser tubes of the power plant cooling system which resulted in the loss of numerous abalone from Diablo Cove in July 1974.

6. Natural phenomena have also caused changes in the local marine communities during the course of this study. Some have been short-term, "dynamic" changes, such as the consequences of a "red-tide" bloom in 1974, or the heavy rains and storm seas of that same winter. One phenomenon has had long-lasting, change-of-community-structure impact: the arrival of the sea otter, Enhydra lutris, in Diablo Cove in 1974.

7. A series of four null hypotheses were proposed to test on data collected to fulfill our objective of determining the statistical significance of any apparent changes in measured abundances of selected species.

8. Four fixed intertidal study areas were established for random surveys: North Diablo Cove, South Diablo Cove, Diablo Point, and North Control. In addition to the random surveys, permanent intertidal transects, established in Diablo Cove and control areas during an earlier study, were monitored for abalone abundances.

9. Two fixed subtidal study areas were established for random surveys: Diablo Cove and North Control. Diablo Cove was further divided into north and south components which were studied separately. In addition permanent subtidal stations, established in Diablo Cove and control areas during an earlier study, were monitored for abundance of various species.

10. Random intertidal stations were sampled twice yearly: once during the minus tides of the fall and winter months and once during the minus tides of the spring and summer months.

11. At each random intertidal station, four 0.25-m^2 quadrats were sampled along a 30-m transect line placed parallel to shoreline in the low intertidal. Sampling locations along the 30-m line were determined by selection from a random number table. Each quadrat was sampled for numbers of selected invertebrate species (occurring only on exposed rocky surfaces) and the percentage cover by articulate coralline algae and surfgrasses. All "soft" red and green algae were collected from quadrats for biomass determination in the laboratory. In addition to the quadrats, surveys for abalone were performed in a two meter wide band along the entire 30-m line. An additional abalone random survey was performed perpendicularly-to-shoreline to monitor abalone over their entire intertidal range.

12. Permanent intertidal stations were also monitored for abalone a minimum of twice yearly. Three additional permanent intertidal stations, located in "thermal transition" areas, were established during the course of study.

13. Surveys at random subtidal stations, were conducted once yearly--usually from June through October.

14. Two survey methods were used at each random subtidal station: a circular, 30-m2 "arc transect" to provide counts and estimates for larger animals and kelp; and 0.25-m^2 quadrats, randomly sampled along a linear 30-m transect, to provide numerical estimates of the smaller animals and biomass estimates of the "soft" red algae. Numbers of bull kelp, <u>Nereocystis leutkeana</u>, were counted along one meter to either side of the 30-m transect line.

15. Fish species were also recorded at the random "arc" stations to provide estimates of percent frequency of occurrence. In addition, another method of quantifying fish species dominance was attempted late in the study.

16. Permanent subtidal stations, part of an earlier Fish and Game study, were monitored for abundance or presence/absence of macro-invertebrates, brown algae, foliose red algae and fish. Relocating and maintaining these stations proved to be a chronic problem.

17. Several auxilliary studies concerning fish were also conducted: tidepool fish were collected to determine species composition; stomach contents were analyzed for three species of intertidal fish and three subtidal species; a catch-per-unit-of-effort study using standard fishing gear also was attempted in the subtidal study areas.

18. Field observations on sea otters were made whenever possible to document their presence and activity within our study areas.

19. When commercial abalone and sea urchin fisheries were active in the area, we monitored their activities and catch efforts in an attempt to assess any potential influence on these fisheries by the power plant.

20. An annual shoreline census of bull kelp was performed in Diablo Cove in early October to provide another method of estimating the population of this important marine plant.

21. When it became evident that power plant cooling system operation would result in the production of large amounts of foam on the surface of Diablo Cove, we began frequent observations to document the extent of foam under a variety of conditions.

22. The soft red and green algae collected from intertidal and subtidal 0.25-m^2 quadrats were sorted to species in the laboratory and dried to waterfree weights to provide estimates of their biomass by species and in the aggregate.

23. Statistical analysis, in testing the various null hypotheses, was primarily accomplished with non-parametric procedures. These procedures resolve the problems presented by non-normality and heteroscedacticity of data for even the most common species. Standard ANOVA was used on some of the intertidal data sets.

24. The combined biomass of all algae species at Diablo Point was the highest among the four intertidal study areas: The grand mean of the six sampling periods were 124 g/0.25-m^2. The biomass also was clearly greater in summer than in winter. The dominant algae species or species groups at Diablo Point, in descending order, were: *Iridaea* complex, *Prionitis lanceolata*, *Gigartina* complex, *Erythophyllum delesserioides*, *Microcladia coulteri*, *Hymenena* spp., *Microcladia borealis*, *Iridaea lineare*, *Cryptopleura* spp., *Gigartina papillata*, and *Hymenena flabelligera*. These eleven taxa formed over 95% of the total biomass at Diablo Point.

25. Articulated coralline algae cover was two to three times more abundant at Diablo Point than at the other intertidal study areas. They did not exhibit a seasonality of cover, nor did they appear to inhibit soft algal biomass.

26. The surfgrasses, Phyllospadix spp., did not appear at any of the Diablo Point stations during the course of study.

27. In terms of soft algal biomass, South Diablo Cove was the least productive of the four study areas: The grand mean for all sampling periods was 53 g/0.25-m^2. The twelve dominant species or species groups at South Diablo Cove, in descending order, were: Gastroclonium coulteri, Iridaea complex, Prionitis lanceolata, Rhodomela larix, Gigartina canaliculata, Gigartina papillata, Microcladia coulteri, Ulva spp., Rhodoglossum roseum, Neoagardhiella baileyi, Prionitis lyallii, and Iridaea heterocarpa. These taxa formed over 90% of the total biomass at South Diablo Cove.

28. Articulated coralline algae cover at South Diablo Cove was also lowest among the four study areas. Although coralline cover appeared to vary during the study, there was no obvious seasonality to its variation. There was also no evident relationship between coralline cover and soft algal biomass.

29. Surfgrass is an important component of the flora at South Diablo Cove where it was second in percentage cover among the study areas. There was a

significant, negative relationship between surfgrass cover and soft biomass at this study area, perhaps indicating an inhibition of algae by the surfgrass.

30. In terms of algae biomass, North Diablo Cove was second most productive among the intertidal study areas: The grand mean of all six sampling periods was 74 g/0.25-m^2. The summer periods showed significantly greater amounts of algae than the winter periods. As in South Diablo Cove, twelve species or species groups formed over 90% of the total biomass. In descending order these were: *Iridaea* complex, *Gastroclonium coulteri*, *Gigartina canaliculata*, *Prionitis lanceolata*, *Gigartina* complex, *Cryptopleura* spp., *Microcladia coulteri*, *Hymenena* spp., *Botryoglossum farlowianum*, *Rhodoglossum roseum*, *Gigartina papillata*, and *Neoagardhiella baileyi*.

31. As it did for algal biomnass, North Diablo Cove showed the second highest average amount of articulated coralline algae cover among the four intertidal study areas. Although varying significantly through the six sampling periods, the articulated corallines did not demonstrate a distinct seasonality. There was no significant relationship between coralline cover and soft algal biomass at North Diablo Cove.

32. Although surfgrass, *Phyllospadix* spp., is an important part of the North Diablo Cove Intertidal, its average cover was the lowest of the three study areas where it was found. It did not appear to vary seasonally. As in South Diablo Cove, surfgrass appeared to inhibit soft algal biomass.

33. The average soft algal biomass at North Control Intertidal was just slightly less than that at North Diablo Cove--about 72 g/0.25-m^2. Biomass seasonality was quite clearcut--the summers were obviously the periods of greater productivity. Algal species diversity at North Control was lower; only nine species or species groups formed 95% of the total biomass. In descending order these were: Iridaea complex, Gastroclonium coulteri, Prionitis lanceolata, Gigartina canaliculata, Gigartina complex, Gigartina papillata, Cryptopleura spp., Hymenena spp., and Botryoglossum farlowianum.

34. Articulated coralline algae cover at North Control Intertidal was the third lowest of the four study areas. As in the other study areas, there was no seasonal trend in the coralline algae cover at North Control. However, unlike the other areas, there appeared to be a positive relationship between coralline algae cover and soft algae biomass at this area.

35. Surfgrass cover at North Control Intertidal showed the highest average among all the study areas. The cover was also the most stable over the six sampling periods of all the study areas. The relationship between surfgrass cover and soft algae biomass was strongly negative, suggesting, as in Diablo Cove, an inhibitory effect on soft algae biomass.

36. A comparison of the soft algal biomass of the intertidal study areas shows that each area appears different, although statistically North Diablo Cove is similar to North Control and South Diablo Cove is also similar to North Control (North and South Diablo Coves are dissimilar). Diablo Point is the most different area in terms of biomass. Although there is great

variability between areas, each area seems to produce a characteristic amount of soft algal biomass that might be considered "predictable."

37. Relative algal species composition is also different among the intertidal study areas, although many species are shared in common. With the exception of Diablo Point, the same four taxa represent at least 70% of the total biomass at the study areas: _Iridaea_ complex, _Prionitis lanceolata_, _Gastroclonium coulteri_, and _Gigartina canaliculata_. Of these, the _Iridaea_ complex, is by far the greatest component of the total of biomass and alone accounts for most of the increased summer productivity.

38. Articulated coralline algal cover also varied significantly among the intertidal study areas. As it was with soft algal biomass, South Diablo Cove showed the least coralline cover and Diablo Point the most, by far. Variability of coralline cover within each study area during the sampling periods was generally low, indicating that this group of red algae is fairly stable.

39. Surfgrass is an important intertidal floral component at three of the study areas; it did not appear in samples taken at Diablo Point. As with the articulated coralline algae cover, each study area possessed an average surfgrass cover that tested as significantly different from the other study areas. Within-area variability of surfgrass cover appeared quite low.

40. Although the intertidal study areas appear to sustain many species of small invertebrates, especially among the "shrubby" algae, there were relatively few of the common species of macro-invertebrate taxa recorded here; these

taxa include: Pugettia producta, Pugettia richii/gracilis complex, Fissurella volcano, Acmaea spp., Tegula brunnea, Tegula funebralis, Tonicella lineata, Serpulorbis squamigerus, Henricia leviuscula, Leptasterias spp., Pisaster ochraceous, and Strongylocentrotus purpuratus. Nine of these taxa occur commonly enough in all study areas to be statistically compared. In addition, size information for six of the taxa is presented.

41. Statistical analysis of the data for the common intertidal macro-invertebrates indicates that each study area, except North Diablo Cove, possesses at least six taxa that demonstrate within-area stability over the sampling periods. North Diablo Cove had only two such taxa.

42. A statistical comparison of the common intertidal macro-invertebrates showed that none of the taxa were comparable between all four study areas or were completely "stable" through the six sampling periods.

43. The size frequency structure of each of the six intertidal macro-invertebrates measured during the study appear to be generally similar from area to area. That is, while each area appears to support different population levels of the selected taxa, the physical sizes for most of the taxa seem to be comparable between study areas.

44. Populations of intertidal black and red abalone from the random stations varied from study area to study area. Black abalone were more abundant than red abalone along both parallel-to-shoreline and perpendicular-to-shoreline transects. There appeared to be a decline in some of the abalone populations at the parallel stations after the first sampling period of

1973-74, but thereafter both species seemed to remain fairly stable. Black abalone at the random perpendicular stations remained fairly stable in each of the study areas and the population levels at these areas were significantly different from each other (North Diablo Cove showed the most black abalone, South Diablo Cove the least). Red abalone also remained stable at the perpendicular stations of each study area, after the first sampling period, but at very low levels.

45. Black and red abalone counts at permanent intertidal stations varied considerably from year to year. At the end of this study period (summer 1978) most stations showed mean densities of black and red abalone quite near the initial mean densities.

46. The biomass of Diablo Cove subtidal soft red algae, sampled at 0.25-m^2 random stations during 1977 and 1978, appeared to be quite stable for both years. However, stations in North Diablo Cove were substantially more productive than stations in South Diablo Cove. Species diversity also appeared higher in the northern portion of the cove.

47. The biomass of subtidal soft red algae from North Control random 0.25-m^2 stations was significantly higher than Diablo Cove subtidal stations during both years. Species diveristy was somewhat lower.

48. Eight species or species groups of soft red algae comprised the greatest proportion of the biomass in both Diablo Cove and North Control random subtidal stations. These taxa are: Botryoglossum/Hymenena complex, Gigartina corymbifera/exasperata complex, Iridaea cordata var. splendens,

Neotilota densa, *Opuntiella californica*, *Prionitis lanceolata*, *Microcladia coulteri*, and *Callophyllis pinnata*. These same taxa were analyzed for depth distribution.

49. Three species of brown algae have been closely monitored at 30-m^2 arcs and 0.25-m^2 quadrats surveyed at random subtidal stations during the course of the study--*Laminaria dentigera*, *Pterypophora californica*, and *Nereocystis luetkeana*. Since 1974, numbers of both *Laminaria* and *Pterypophora* have increase dramatically and significantly at the 30-m^2 stations in Diablo Cove; *Laminaria* has had a similar significant increase in North Control while the apparent increase of *Pterypophora* was not statistically significant. As these two species of kelp have increased, the third species, *Nereocystis*, has declined significantly since 1975 in Diablo Cove 30-m^2 stations and had an apparent decline in North Control during the same period. Depth relationships of the three species have also been analyzed and seem to vary according to the species, the area, and study method.

50. Of the hundreds of species of invertebrates identified from the random subtidal surveys, relatively few were common enough to merit quantification and analysis. The results for 19 invertebrates species which appear at either the quadrat stations, the arc stations, or at both, are presented in this report. Mean numbers per station, frequencies of occurrence, and statistical analyses are presented for each of these species in North Diablo Cove, South Diablo Cove, and North Control study areas. Data for the remaining, less common species are summarized in the appendices. The

19 species include the following: *Tethya aurantia*, *Anthopleura xanthogrammica*, *Balanophyllia elegans*, *Epiactis prolifera*, *Cancer antennarius*, *Acmaea mitra*, *Astraega gibberosa*, *Doriopsilla albopunctata*, *Haliotis rufescens*, *Homalopoma luridum*, *Serpulorbis squamigerus*, *Tegula brunnea*, *Tonicella lineata*, *Henricia leviuscula*, *Patiria miniata*, *Pisaster giganteus*, *Pycnopodia helianthoides*, *Strongylocentrotus franciscanus*, and *Styela montereyensis*.

51. The 19 invertebrate species at the random subtidal stations varied in different ways depending on the study area and study method--some species increased in abundances while others decreased. The most dramatic decrease of an invertebrate species during this study, and the one with the most far-reaching ecological consequences, is the near-disappearance of the red sea urchin, *Strongylocentrotus franciscanus*. Before the arrival of the sea otter, the red sea urchin was probably the most abundant macro-invertebrate species in Diablo Cove. Red abalone, *Haliotis rufescens*, another prey species for the sea otter, was at very low levels of abundance at the beginning of the study and has not changed significantly since then in either subtidal study area.

52. Fish species observed at the subtidal 30-m^2 random arc stations were also recorded. Thirty-seven species, representing 13 families, were observed in the North Control subtidal area. On the basis of percent frequency of occurrence, the two areas share in common, although in slightly different order, the same 14 species in the upper ranks of occurrence (with the exception of one species in North Control). In general order of descending frequency of occurrence the fish are: blue

rockfish, painted greenling, striped surfperch, black and yellow rockfish, senorita, kelpfish, cabezon, snubnose sculpin, kelp greenling, gopher rockfish, olive rockfish, pile surfperch, black-eye goby, and lingcod. These 14 species were generally observed with the same frequencies of occurrence in the two study areas. Nine of these species are important to sport and/or commercial fisheries.

53. Observations of fish from the 0.25-m^2 quadrat stations appear to be less adequate than the 30-m^2 arc stations in reflecting the "true" occurrence of larger species of fish. The strengths of the quadrat observations seem to lay in the ability to denote the presence of smaller species such as the sculpins and kelpfish.

54. A total of nine permanent subtidal stations, established in an earlier Fish and Game study, was monitored during the period of this study: five in Diablo Cove and four in control areas. Later, one additional Diablo Cove station was established. Organisms monitored at these stations included brown algae, macro-invertebrates and fish. Owing to problems of re-locating and maintaining the exact positions of the permanent markers of all the stations, there is probably variability in the data that cannot be accounted for. However, the population trends of major plants and animals at the permanent stations usually paralleled the results at random subtidal stations.

55. Two kelp species, <u>Laminaria dentigera</u> and <u>Pterypophora californica</u>, increased dramatically at the shallower permanent stations in Diablo Cove after initial surveys in 1974. Their increase at Control stations was

apparent but less obvious. The third species counted, Nereocystis luetkeana, followed the trend noted at Diablo Cove random stations where its numbers steeply declined after 1975.

56. Mean densities of the 11 species of macro-invertebrates counted at the Diablo Cove and Control permanent subtidal stations are presented in this report: Tethya aurantia, Anthopleura xanthogrammica, Cancer antennarius, Astraea gibberosa, Dendrodoris albopunctata, Haliotis rufescens, Patiria miniata, Pisaster giganteus, Pycnopodia helianthoides, Strongylocentrotus franciscanus, and Styela montereyensis. In general, most of the species' counts at the various stations fluctuated without obvious trend over the period of study. However, the red sea urchin, S. franciscanus, declined severely at most stations after surveys in 1973. Red abalone, H. rufescens, were common in 1973 only at one station, in Diablo Cove, when their numbers also began to diminish rapidly and have remained very low since.

57. A total of 31 species of fish were observed at the six Diablo Cove permanent stations, while 28 species were noted at the four permanent control stations. Blue rockfish and painted greenling were the most frequently observed species in either area.

58. Results of the random and permanent subtidal studies are discussed in further detail. Trends noted in various populations of organisms, and their possible or probable causes, are also commented on. Four null hypotheses were constructed to test the data of the pre-operational phase of this study, and these are also discussed in relation to the subtidal invertebrates.

59. A separate study of fish populations, in Diablo Cove, using intervals of observation, was not performed with a sufficient sample size to provide the hoped-for statistical analysis. However, on the basis of percentage of timed intervals during which the fish were observed, the method ranked 10 of the 14 species noted at the 30-m^2 arc stations at the top of the occurrence structure.

60. Two collections of intertidal fish were made in the North Control area and one was made in South Diablo Cove. Due to the small areas sampled, and the use of different collection methods, the results are difficult to compare. Generally, the most common species from these collections were kelpfish, black prickleback, rock prickleback, fluffy sculpin, wooly sculpin, and high cockscomb.

61. The catch-per-unit-of-effort study, terminated in 1976, showed that blue rockfish was the most frequently caught species in either Diablo Cove or North Control study area. Other species commonly caught were gopher rockfish, black rockfish and lingcod. Although North Control showed a higher catch/effort than Diablo Cove, this difference may be attributable to the dense bull kelp forest that existed in Diablo Cove during 1974-76, which physically hindered rod and reel jig line fishing.

62. Stomach contents of six fish species were collected and examined to determine relative composition and importance of food items. A total of 205 stomachs was collected from striped kelpfish, gopher rockfish, black and yellow rockfish, grass rockfish, black prickleback, and rock prickleback. Crustaceans were the most frequently observed prey group in five of the six fish species studied. The exception was the rock prickleback which appears to feed largely on foliose red algae.

63. The main southern migratory front of sea otters reached Diablo Cove in 1974 when a raft of 30-40 animals moved into the area. Observations of this southern front indicated a cyclical nature to the otter's movements with a southward expansion occurring in the spring months followed by a return to the north in the fall and winter. By 1975, the sea otter front had reached Pecho Rock, approximately 3 km south of Diablo Cove. Although the main front is now well past Diablo Canyon, individual otters are still often observed foraging in Diablo Cove and divers frequently see freshly empty abalone shells, with characteristic signs of sea otter predation, in both subtidal study areas. Observations made in 1973-74 indicate that abalone and sea urchins made up over 70% of the otter's diets.

64. The commercial fisheries for abalone and sea urchin no longer exist in the Pt. Buchon to Pt. San Luis area. The abalone fishery was well-established for many years and its demise seems firmly correlated, chronologically and geographically, to the southward expansion of the sea otter. The sea urchin fishery was a short-lived one, existing in this area for less than four years. Its failure was due initially to economics and, finally, removal of sea urchins by sea otters. With the continued presence of sea otters in the area, it is unlikely that any sport or commercial invertebrate fishery will again be successful here.

65. Annual censuses of bull kelp, <u>Nereocystis luetkeana</u>, in Diablo Cove indicated that its population reached peak numbers in 1975 and since then has declined steadily. In 1977 giant kelp, <u>Macrocystis pyrifera</u>, was first observed in Diablo Cove and seems to be increasing as bull kelp decreases.

66. Observations on foam conditions were made in 1976 in Diablo Cove during and without cooling system pump operation. Foam was generally more prevalent and thicker during pump operation than under natural conditions. Amounts of foam generated either naturally or by the discharge varied according to wind speed and sea state as well as tidal stage.

67. Conclusions and recommendations concerning the various components of this study are made at report end.

INTRODUCTION

An ecological study of selected nearshore marine plants and animals in the vicinity of Diablo Canyon (Figure 1) was conducted from 1973 through 1978 to develop additional baseline data prior to operation of Pacific Gas and Electric Company's Diablo Canyon Power Plant (DCPP).

The power plant will discharge heated ocean water from its cooling system. This water, heated approximately 10°C (20°F) above the ambient ocean temperature, will be discharged directly into Diablo Cove (Figure 2). Because of the projected temperature elevation due to the discharge, it is anticipated that many of the cold-water adapted plants and animals may not tolerate this change. This discharge may influence species in both subtidal and intertidal communities and, therefore, the study was designed to emphasize these two communities. The study was limited to measuring density, biomass, or presence/absence of the larger, more common invertebrates, fishes and the more abundant algae.

This study was conducted because an earlier baseline study by California Department of Fish and Game in 1970-71 (Burge and Schultz 1973) to document seasonal, annual, and spatial variations of the Diablo Canyon marine community, would probably be invalidated by the movement of the sea otter, Enhydra lutris, into the area. The sea otter "frontier" reached Diablo Canyon in 1974.

Prior to the beginning of this study, human activity was relatively low in the area. There were sport and commercial fisheries, operating mostly from boats, for species such as red abalone, Haliotis rufescens; crab, Cancer spp.; and several species of fish.

The rationale of the study design was to develop data on selected species to serve as baseline information which will be used to detect changes in species densities or in species composition of the existing communities once the power plant is operating. These changes might include the decrease, increase, or disappearance of certain species, and perhaps recruitment of species new to the area. At this point, it is difficult to predict the nature or magnitude of possible changes. Any change could be either beneficial or detrimental to the existing community of the area. This, in turn, could have an economic impact on the sport and commercial fisheries.

Prior to this study in 1973, most ecological studies used permanent stations to attempt to describe biological change in an area. Permanent stations, chosen to be representative of a study area, have fixed perimeters and are sampled repeatedly throughout the course of study. An alternative to this method is to use a random sampling plan in which an entire study area can be sampled and which allows generation of statistical estimates of abundance of target species in that area. Because we felt permanent stations were more susceptible to catastrophic change due to natural causes (such as landslides, erosion, scouring, and local invasion of predators) and limited our ability to interpret population trends in the study area, we decided that a random study design should be our major approach. Random stations also offered the opportunity to estimate with identifiable levels of precision, seasonal and yearly fluctuations in abundance, and abundance by depths of the common macrospecies (approximately $\geq$ 10 mm) throughout Diablo Cove and control areas before the power plant began operating.

History

Involvement of Department of Fish and Game

Biologists of the California Department of Fish and Game have been conducting studies of the marine life in the vicinity of Diablo Canyon since 1966.

Prior to 1966, the only data available for the Diablo Canyon area were Department records of commercial and sport fisheries. These records include statistics describing commercial abalone and finfish catches and sport catches from partyboats in the Diablo Canyon area (Fish and Game Catch Blocks 614 and 615). Some of these were summarized by Clark (1966), who estimated that the average annual commercial harvest of red abalone between Pt. Buchon and Pt. San Luis was 621,000 lbs. Of this harvest, an average of 6,200 pounds was estimated to come annually from Diablo Cove. The annual finfish catch from Diablo Cove by commercial and sport fisherman was estimated to be approximately 2,300 lbs annually (Clark 1966).

The first Department surveys related to the power plant were conducted in May 1966 (Ebert 1966). Ebert's diving surveys indicated that the largest concentration of abalones was located south (near Pecho Rock) and north (near Pt. Buchon) of Diablo Cove. Ebert estimated the population of red abalone, Haliotis rufescens, between Lion Rock and the cove south of what is now Intake Cove to be approximately 6,000 animals. He also indicated an interrelationship between abalones, sea urchins and brown algae.

In December 1966, the Resources Agency of the State of California and Pacific Gas and Electric Company (PG&E) entered into an agreement for PG&E to fund an ecological study to be conducted by the California Department of Fish and Game at the site of the proposed Diablo Canyon Power Plant. This study, to be conducted between Pt. Buchon and Pecho Rock (Figure 1), was designed specifically to document the occurrence of important sport and commercial species in the Diablo Canyon area. The California Supreme Court in 1972 voided the agreement between the Resources Agency and PG&E; however, the Department of Fish and Game continued to be involved in ecological studies at Diablo Canyon at the request of PG&E.

In 1969, Department biologists established five permanent intertidal and eleven permanent subtidal stations in Diablo Cove and Control areas north and south of Diablo Cove (Figure 3). The objectives of these studies were to establish abundance levels for abalones, abalone predators and competitors, fish, and brown algae at each of these stations. In addition, the species composition of fishes in Diablo Cove and the cove just north of Diablo Cove (Field's Cove) was determined by extensive fish collections. The surveys of the permanent stations were conducted during 1970 and 1971 (Burge and Schultz 1973).

In 1973, the southern front of the sea otter in California moved into the area just south of Pt. Buchon. Because of the known impact on abalone and sea urchin populations by sea otters, PG&E and the Department of Fish and Game felt that additional baseline studies were needed in Diablo Cove to document the arrival of the sea otters and their effect on the biota of Diablo Cove.

In July 1973, the present study was begun with a new contractual agreement between PG&E and the Department of Fish and Game for the Department to conduct intensive quantitative studies of the intertidal and subtidal communities in Diablo Cove and a control area north of Diablo Cove (Figure 3).

Man's Impacts 1969-1978

Several phases of the construction activities and testing of the power plant have affected the marine communities in and around Diablo Cove. The construction of two breakwaters to form the Intake Cove was one of the first major construction impacts on the marine communities. In order to minimize the impact, several thousand abalones were removed between 1969 and 1972 by PG&E and Department divers from the reefs that would be covered by the breakwaters. The abalone were replanted in suitable rocky habitat away from the site. Following breakwater installation, two cofferdams were built to permit the construction of the seawater intake and discharge structures. Cofferdam construction resulted in losses of habitat and marine life. In this case, too, divers removed and replanted hundreds of abalones prior to placement of the Diablo Cove and Intake Cove cofferdams (Burge and Schultz 1973).

The most significant impact (through 1972) occurred with the construction and removal of the cofferdam in Intake Cove. There, large amounts of silt within the cofferdam itself were deposited over the sea floor (Burge and Schultz 1973). This silt smothered most bottom organisms behind the cofferdam as well as throughout the Intake Cove. Because of the siltation, Intake Cove was no longer considered suitable habitat for abalones and, in May 1972, PG&E, Department of Fish and Game employees, and students from California Polytechnic

State University, San Luis Obispo, removed 741 abalones from Intake Cove. These abalones were replaced in suitable habitat away from site (Warrick 1974). Silt depths in Intake Cove at the conclusion of construction ranged from a few inches to several feet. Attempts by PG&E in 1974 and 1975 to remove silt from Intake Cove by dredging, were only partially successful (Gotshall, Laurent, Ebert, Wendell, and Farrens 1974; Gotshall, Laurent, and Wendell 1976). Natural silt deposition due to the quiet water created by the jetties also contributed to the problem.

Removal of the Diablo Cove discharge structure cofferdam in 1974 did not appear to cause any long-lasting impacts of siltation because proper fill material had been used in this case. In fact, the intertidal area where the cofferdam was located appeared to recover within a year after cofferdam removal.

In June of 1974, testing of the Unit 1 cooling water system was begun. The testing of the pumps continued through the spring of 1977 with several periods of pump shutdown (Figure 4). Three potential problem areas directly related to pump operation that would affect the plant and animal communities in Diablo Cove became evident during and after pump testing: turbulence; surface foam (Gotshall, Laurent, and Wendell 1977); and discharge of high levels of copper corrosion products from copper-nickel condenser tubes (Gotshall et al. 1976), of the three, the release of copper presented the most serious and immediate problem.

On July 21, 1974, Department of Fish and Game personnel discovered a number of dead red abalone, _H. rufescens_, and black abalone, _H. cracherodii_, in the south part of Diablo Cove (Gotshall et al. 1976). Subsequent subtidal and intertidal investigations found dead or stressed abalone in Diablo Cove but not at a control area 1 mile north of the cove. Gill and digestive gland tissue were taken from abalone in Diablo Cove and North Control and analyzed for heavy metals. Abalones from Diablo Cove had concentrations of copper four to twelve times higher than abalones from North Control (unpublished memorandum to the Nuclear Regulatory Commission by Michael Martin, California Department of Fish and Game, Monterey, California). The investigation also indicated that several species of plants in the Cove had accumulated above-normal levels of copper in their tissues. The copper ion problem was resolved when PG&E replaced the copper-nickel condenser tubes in the cooling system with titanium alloy tubes in 1975. We have not observed any further direct mortalities since the copper-nickel components were replaced.

During the pump testing, we also observed large amounts of foam in certain portions of Diablo Cove. The continuous presence of foam may decrease light penetration significantly enough to hinder algal growth and reproduction. PG&E personnel are continuing to study factors creating the foam and are investigating the effects of the foam on photosynthetically active wavelengths of light.

Diving surveys after periods of pump testing indicated that the souring by the discharged water removed most plants and animals from the area where the discharge contacted the bottom.

Natural Impacts

Several natural phenomena that have affected our studies have taken place in the Diablo Canyon area since 1973: the arrival of the sea otters in May 1974; a bloom of a "red tide" dinoflagellate in the fall of 1974; heavy rains and storm seas during the winter of 1974-75; and the drought of 1975-76 and 1976-77.

The arrival of approximately 40 sea otters in Diablo Cove during the spring of 1974, triggered a series of changes in the plant and animal communities in Diablo Cove that we have been able to document; in fact, we consider the effect of the sea otter foraging to be the most dynamic and long-lasting of all impacts, natural or man-caused, that we have observed.

The "red tide" that occurred during October and November 1974 appeared particularly intense in the South Diabo Cove. Previous occurrences of red tide have been associated with large-scale mortalities of invertebrates and fish.

Finally, the effects due to heavy seas caused by intense winter storms and side effects of the drought years (for example, observed dessication and die-off of some intertidal algae species) have undoubtedly contributed to some of the variability of data that we have observed in our study.

OBJECTIVES

The objectives of our studies at Diablo Canyon since 1973 have been to establish a new baseline and document any changes in populations of the common macro-animals and plants (approximately ≥ 10 mm) in Diablo Cove, and to determine if the changes are statistically significant. We also hoped to learn if the specific cause or causes for the changes were attributable to man's impact or natural influences.

Specifically, our stratified random sampling plan was designed to measure densities of the common plants and animals in the intertidal and subtidal environment of Diablo Cove and our Control area. The stratified random sampling would permit us eventually to expand mean counts/area into population estimates for the Cove in order to estimate population increases or decreases that might occur in Diablo Cove due to construction and operation of the power plant or to natural causes. In this report, we have not made any population estimates.

The following null hypotheses were to be tested at the end of our pre-operational study:

Null Hypothesis 1: Comparability of Study Areas.

There is no significant difference in sample mean densities of specific invertebrates or algae biomass between South and North Diablo Cove or between Diablo Cove and the control areas.

Null Hypothesis 2: Temporal Stability of Study Areas.

There has been no significant change in sample mean densities of specific invertebrates or algae biomass over the time span of the study.

Null Hypothesis 3: Comparability of Depth Distribution.

There is no significant difference in sample mean densities of specific invertebrates or algae biomass between shallow and deep subtidal stations in Diablo Cove and the control areas.

Null Hypothesis 4: Temporal Variability Within a Sampling Period.

There was no significant difference over time in sample mean densities during a particular sampling period of 3 to 4 months.

Statistical Analysis

Data analysis for ecological surveys with diversity of species with spatial and temporal variations in no simple task. The scarsity of many species and the contagious spatial distributions of most species make it difficult to directly use models amenable to well-established statistical procedures; e.g., t-test, F-test, etc. However, we wanted to do more than use mere basic descriptive statistics on our survey data. Besides establishing certain baseline values on various subsets of the ecological survey data, it was desirable to do some hypotheses testing to establish effects of space-time variations among subsets of data. Except for a few occasions when we take advantage of the robustness of the analysis of variance procedure with respect to its tolerance to non-normality, most of our analyses were carried out with non-parametric procedures, namely the Mann-Whitney test and the Kruskal-Wallis test. These procedures offer the advantage of uniformity of statistical procedures for the multitude of subsets of data comparisons. Otherwise, we would have to determine the best model to approximate each subset distribution or to carry out different transformations for most analyses. The task would be immensely more complicated in view of the future necessity of comparing pre-operational and operational survey data. Non-parametric statistics furnish such a desired flexibility since they can be thought of as distribution-free procedures, freeing the investigators from constantly worrying about the soundness of most underlying assumptions for parametric tests (Gertz, 1978). In essence, we have chosen approximate methods for exact problems, over exact methods for approximate problems. The asymptotic relative efficiency of the Mann-Whitney test is 0.955 as compared to the t-test if the underlying distribution is normal. The Kruskal-Wallis test has a similar efficiency of 0.955 as compared to the usual parametric F-test for the analysis of variance. These efficiencies could be higher if the assumptions for the parametric tests were not met (Conover, 1972). Most of the analyses reported are straightforward comparisons between data subsets. It is hoped that such simple approaches will provide general assessments to the pre-operational ecology of Diablo Cove. These ranking tests are used to analyze differences between median values rather than between mean values and it is assumed, for this report, that if the medians are significantly different, so are the means (Elliot, 1977).

OPERATIONS

From July 1973 through December 1978, our field and laboratory studies consumed 6,189 man-days of which 4,060 were at the site (Appendix 1a). During this period, we completed 643 surveys of permanent and random stations; 262 in the intertidal (Appendices 1b and 1c) and 381 in the subtidal (Appendices 1d and 1e). We also made three tidepool fish collections. Shore surveys of the bull kelp, Nereocystis luetkeana, in Diablo Cove were conducted once each year in the fall from 1973 to 1978. Shell lengths of intertidal red and black abalone were measured as time permitted. In addition, we completed 268 sea otter observations, 170 fish catch-per-unit-of-effort-stations, 113 commercial abalone and urchin fishermen interviews, and 98 foam observations in Diablo Cove.

In 1978, most of our time was involved with data analysis and preparing this report. Field sampling was curtailed to the extent that we did not survey random 30-m^2 arcs, nor did we conduct surveys at the random intertidal stations.

Our laboratory time was spent in processing 1,049 algae samples for taxonomic identification and biomass measurement (dry weight), and 205 fish stomachs for content analysis.

INTERTIDAL STUDIES

Study Areas and their Physical Descriptions

Diablo Point

Diablo Point is a narrow peninsula located at the southern entrance to Diablo Cove (Figure 5). The intertidal stations are located on the exposed seaward portion of this prominence. Although this study area receives some protection from waves due to the presence of offshore rocks, it is still subjected to much greater wave energy than any of the other study areas. This is due to the greater depths of the water surrounding Diablo Point: wave energy dissipates in shallow waters. As a consequence, zonation of plants and animals on this point has been affected. Organisms normally found in the lower intertidal regions in more protected areas occur in the mid- and even upper-intertidal levels on Diablo Point because of surge and wave splash.

The substrate at the Diablo Point stations is composed of a hard metamorphic rock. Erosion from both biological and geological processes has created numerous small depressions, ledges, and fissures which provide protection for many plant and animal species. The slope of the intertidal region, especially in the +1.0 m (+3') to -0.6 m (-2') range, is quite steep, often exceeding 45 degrees. Above the + 1.0 m height, the intertidal flattens and is nearly table-like for an average width of about 7 m (20'), beyond which the slope again steepens. There is no sand, gravel, or cobble in the transect areas.

South Diablo Cove

South Diablo Cove intertidal (Figure 5) is composed of a variety of habitats. The substrate is predominantly flat bedrock but there are also large patches of sand, raised rocky seams, large and small boulders, and pools with gravel and cobble. There is little permanent cryptic habitat (e.g. cracks, crevices, or other areas not easily accessible). The slope of this area is gentle, and the intertidal region averages about 30-m to 35-m wide. The intertidal is bordered on land by a steep sedimentary bluff approximately 24-m (80') high. This bluff is probably the most rapidly eroding locale of any of the study areas and has suffered at least two large landslides since our study began. This bluff contributes significant amounts of sediment, from the size of boulders to silt, to the intertidal and subtidal regions. Another origin of sediment in Diablo Cove is Diablo Creek; a source that may have been reduced by streambed alteration and damming by PG&E.

Because of topographic configuration and current patterns in the Cove, the South Diablo Cove area seems to receive most of the material entrained by water transport, be it flotsam or sediment. Protection from storm waves from the north by Diablo Rock, and winter storm waves from the south by Diablo Point, creates a comparatively quiet-water area in which transported sediments settle out and tend to remain until winter storms remove it.

North Diablo Cove

Substrate composition of the intertidal area in the north part of Diablo Cove (Figure 5) is much more homogeneous than that of South Diablo Cove. For the most part, the substrate is comprised of large, fairly permanent boulders overlaying bedrock. In the higher region, above the +1.2 m (+4') level, the substrate is composed of smaller rocks and gravel. In a 30-m to 50-m long section of the northermost corner of this area, sand invades the low and mid-intertidal. At the mouth of Diablo creek, the substrate is mostly gravel. The width of the intertidal region averages about 25-m to 30-m.

Because of the large boulders, there is a great deal of substrate relief in this area which provides cryptic habitat important to a number of animals such as abalone, crabs, and fish. The average slope of the intertidal zone is slightly greater than that of South Diablo Cove. Water circulation is stronger in the North Cove than in the south, and there is also more exposure to storm seas, especially during the winter when storm waves often come from the south.

North Control

The substrate of the North Control intertidal (Figure 6), and the habitat that it forms, can be best described as a combination of the three study areas in Diablo Cove. There is a small, semi-exposed point resembling Diablo Point, exposed bedrock as in South Diablo Cove, and large boulders similar in size and exposure to those found in North Diablo Cove. The average width of the intertidal is about 20-m.

Although this area directly faces the sea, it receives some protection from wave energy by scattered offshore rocks and by a fairly extensive shallow subtidal that also dampens waves. Because of shoreline configuration and the combination of exposure and protection, this area is a "catchment basin" for drift algae torn loose by storm seas. At times these algal drifts can be two to three feet deep in some portions of the intertidal.

Random Station Studies

Macroflora

Methods

A. Field

Of the four locales established as intertidal study areas (Figures 5 and 6), three of them are expected to be affected by the discharge of heated water; two (North Diablo Cove and South Diablo Cove) are within Diablo Cove, situated to either side of the discharge, and another (Diablo Point) is on an exposed point at the opening of the Cove. The fourth (North Control) is well removed (to the north) from possible influence by the heated discharge and serves as a control area. The stations were named for their locations and will be referred to in this report by their initials: North Diablo Cove Intertidal (NDCI), South Diablo Cove Intertidal (SDCI), Diablo Point Intertidal (DPI), and North Control Intertidal (NCI).

The study areas were divided into stations each about 30-m long. At NDCI and SDCI, nine stations were established; at DPI, three; at NCI, ten.

Random sampling was performed at each station twice yearly to determine seasonal differences in biomass: once during the minus tides of fall and winter; and once during the minus tides of spring and summer. A consistent sampling procedure was established at the beginning of the study in order to minimize sampling error.

Because there is an approximate 3 meter (9') range from the highest tide to the lowest tide (Figure 7) which covers a large area of the intertidal, we decided to limit the portion of the intertidal that we sampled to minimize sample variability. For the most part, this decision was made because of manpower limitations. In determining which section of the intertidal to exclude from sampling, we reasoned that the higher portions of the intertidal, that is, the areas above mean sea level (≥+0.9 m), would be more likely to contain plants and animals better adapted to higher temperature regimes since they experience greater exposure than organisms of the lower intertidal (Ricketts, Calvin, and Hedgpeth 1968; Moore 1966). Because our study was designed to identify temperature-related effects, we decided to sample the intertidal in regions lower than +0.9 m. Preferably, the samples were to be taken in habitat ± 0.5 m relative to the 0.0-m tide level MLLW (Mean Lower Low Water) to include the more temperature sensitive organisms. Intertidal sampling dates and tide levels are listed in Appendix 2.

To minimize sampling error due to habitat differences and sampling difficulties, the surface enclosed by a randomly placed quadrat had to be at least 75% rock, with no more than 25% of the area covered by water.

Based on work done earlier in the project, a sampling program was designed based on manpower availability and calculated sample size necessary to detect a 40% change in total algal biomass means at the 95% confidence level within a study area.

The calculated sample size formula (Elliott 1971) is:

n = sample size

t = critical value of Student's t-distribution at $a = 0.05$

s = sample standard deviation

D = relative percentage error of the mean

$\bar{x}$ = sample mean

The sample size for total algal biomass per study area was determined to be approximately 30 quadrats.

Sampling for algae at the intertidal stations consisted of quadrat sampling at four selected points along a 30-m long linear transect for all soft, non-calcareous algae. The transect line was laid from an arbitrary starting point parallel to shoreline and as nearly level as possible. The quadrat device selected for sampling was a square frame, 0.25-m^2 in area, measuring 0.5 m on a side. Four quadrats were sampled at each station. Their locations were determined by pre-selection of numbers from a random number table, corresponding to the marked increments on the transect line (from one to thirty). In addition four alternate numbers were selected in case any of the four primary locations were rejected for smapling. The square quadrat was positioned with its center over the selected incremental mark on the transect line.

At each quadrat, the following information was recorded: time of sampling, estimated height of quadrat center above water level at time of sampling, quadrat slope, estimated percentage cover of articulated coralline algae, and estimated percentage cover of Phyllospadix spp. (surfgrass). Any "soft", non-calcareous red and all green algae species occurring within each quadrat were removed by picking and scraping and placed with seawater into an appropriately marked plastic bag for later treatment in the laboratory. Counts of individuals of brown algae were also made.

B. Laboratory

The algae collected from the random intertidal quadrats were brought to the lab and preserved in a buffered 10 percent formalin mixture. This preservation was necessary since time usually was not available during the sampling period to work up the fresh samples. Processing of a preserved sample began by running freshwater over it to remove the formalin. The sample was washed over a 0.5-mm mesh screen in order to prevent plants and animals larger than this from washing out of the sample. After washing and draining, the sample was then sorted by species and all invertebrates were removed, preserved, and stored in appropriately marked vials. A drained wet weight was recorded for each algal species. Each species from a sample was then put in an appropriately marked aluminum container, placed in a drying oven, and dried for a time adequate to remove all water from its tissues. This time varied from species to species depending upon thallus thickness. Thus, plants were left in the oven for a time adequate to dry the slowest drying species--a period of 24 to 48 hours. Drying temperature was 15°C to prevent ashing.

Once dried, the species were weighed, wrapped in aluminum foil, and placed in appropriately marked paper bags with labels containing the study area, station number, sampling date, species present, and their dry weights. This was done to provide for accounting and easy retrieval if a sample was ever in question for any reason. Weighing for both wet and dry weights was done on a triple beam balance to 0.1-g accuracy.

Dry weights were used to provide a standard of uniformity since intercellular water and water on the surface of an alga could vary widely, introducing a source of sampling error. Wet weights were taken to determine average water content for each species. These wet weight data were not used in analysis because of their variability but often provided a valuable double check to verify correct labeling of a dried sample.

C. Statistical

The collected data were analyzed in one of two ways: using standard analysis of variance (ANOVA) tests if the assumptions for analysis of variance appeared to be met by the data, or by a non-parametric test for differences (Kruskal-Wallis test) if the tests for homogenity of variances were highly significantly among the groups with ANOVA. Data treated by ANOVA were the total biomass (dry weights) of algae from the random intertidal quadrats and the percentage cover estimates of articulated coralline algae and *Phyllospadix* spp. The biomass data were not transformed, but the percentage cover values were subjected to an arc-sine transformation before analysis. Analysis of individual species (or species categories) of algae was performed by the

Kruskal-Wallis (K-W) test. The purpose of the statistical tests was to test the null hypotheses 1 and 2 listed in the Objectives section.

In the data analysis, species categories of algae were created to combine two or more species into generic "groups" (Table 1) when: 1) one or more species within a selected genus did not occur commonly enough to merit analysis, or 2) there was reason to suspect taxonomic confusion. For example, two species of *Iridaea*, *I. cordata* v. *splendens* and *I. flaccida*, are distinguished fairly easily in the field by color, but this characteristic can be altered when preserved in formalin or frozen. Thus, the two species were combined in the "*Iridaea* complex" group. The "*Gigartina* spp." group contains five species--*G. agardii*, *G. harveyana*, *G. volans*, *G. leptorhychos*, and *G. spinosa* -- which were combined because of their relatively rare occurrences. The percent frequency of occurrence for each of these species is listed in Appendix 3).

Results

A. Diablo Point Intertidal

1. Biomass of Soft Red Algae

The biomass of soft algae at DPI showed a distinct seasonality during all sampling periods, with the possible exception of the winter of 1975-76 (Figure 17). The biomass means of the three summer periods ranged from 173.1 g to 196.4 g per 0.25-m^2, whereas the winter biomass ranged from 37.4 g to 110.2 g per 0.25-m^2. The greatest summer productivity is also reflected in the ranges of sample dry weights.

TABLE 1. Artificial Species Groupings of Soft Green and Red Algae, Articulated Coralline Algae, and Phyllospadix spp. Found at Random Intertidal 0.25-m^2 Quadrats. DCPP, 1973-1977

Species Group	Species*
CHLOROPHYTA	
Ulva spp.	*U. lobata*
	U. expansa
	U. taeniata
	U. lactuca
Cladophora spp.	*C. columbiana*
	C. graminea
RHODOPHYTA	
Gelidium spp.	*G. pusillum*
	G. robustum
	G. arborescens
	G. purpurascens
Callophyllis spp.	*C. crenulata*
	C. heanophylla
	C. pinnata
	C. obtusifolia
Farlowia spp.	*F. compressa*
	F. conferta
	F. mollis
Halymenia spp.	*H. californica*
	H. schizymenioides
Pikea spp.	*P. robusta*
	P. pinnata
	P. californica
Prionitis spp.	*P. linearis*
	P. lyallii
	P. andersonii
	P. australis
Rhodymenia spp.	*R. californica*
	R. pacifica
	R. lobulifera
RHODOPHYTA (continued)	
Gigartina spp.	*G. agardhii*
	G. harveyana
	G. volans
	G. leptorhynchos
	G. spinosa
Gigartina Complex	G. corymbifera
	G. exasperata
Iridaea complex	*I. cordata* v. *splendens*
	I. flaccida
Callithamnion spp.	*C. pikeanum*
	C. rupicolum
Ceramium spp.	*C. eatonianum*
	C. gardneri
	C. pacificum
Cryptopleura spp.	*C. lobulifera*
	C. corallinara
Hymenena spp.	*H. multiloba*
	H. cuneifolia
	H. smithii
	H. setchellii
	H. kylinii
Articulated corallines	*Calliarthron* spp.
	Bossiella spp.
	Corallina spp.
SPERMATOPHYTA	
Phyllospadix spp.	*P. scouleri*
	P. torreyi

*Inclusion of a species in a group does not necessarily imply occurrance of that species at all study areas.

The greatest summer sample weights were over two to three times greater than the largest winter sample weight. The grand mean of the biomass of the DPI stations for all six sampling periods is 124.09 g per 0.25-m^2, the highest of any study area.

Analysis of variance of the DPI algal biomass by sampling periods showed that the difference between periods was highly significantly (F prob.= 0.0000). A subsequent multiple range test (Student-Newman-Keuls procedure) confirmed that the biomass of the summer periods sorted out cleanly from biomass of the winter periods (Table 2).

TABLE 2. Student-Newman-Keuls Multiple Range Test of Seasonal Soft Algae Biomass Values, Diablo Point Intertidal Study Area. DCPP, 1973-1977.

Subset Number	Sampling Periods(s) Mean Gram Dry Weight per 0.25 m		
1	Winter 1974-73 (37.42)	Winter 1973-74 (44.34)	
2	Winter 1975-76 (110.24)		
3	Summer 1976 (173.12)	Summer 1975 (183.02)	Summer 1977 (196.42)

2. Species Composition of Soft Red Algae

Of the 59 species of foliose and filamentous algae identified from the samples taken at DPI, eleven species and/or species groups comprise over 95% of the biomass of the six sampling periods (Figure 9). Seasonal data will be presented for only these eleven taxa since the remaining species found at DPI are relatively rare and quite variable in occurrence. The seasonal frequencies of occurrence of all sampled algae including these rarer species have been summarized elsewhere in this report (Appendix 3). The dominant species are discussed in descending order of their abundance relative to the biomass grand mean for DPI.

Iridaea complex. Although two species of *Iridaea* have been combined into this complex for the sake of standardization of the study area results, most, if not all, of this complex at DPI was represented by *I. cordata* v. *splendens*. The seasonal variation of *Iridaea* is quite distinct (Figure 10), with summer periods being the apparent time of greatest standing crop. A Kruskal-Wallis one-way test for differences showed this variation to be significant (Table 3). This complex formed 38.3% of the biomass grand mean for all sampling periods (Figure 9).

Prionitis lanceolata. The variation through time of *P. lanceolata* is equally as significant as *Iridaea* complex (Table 3) but the variation is most likely due to very low value of the first winter's sampling (Figure 10). Otherwise, this species seemed fairly stable from winter to summer. Overall, this alga comprised 15.3% of the biomass (Figure 9).

TABLE 3. Results of Kruskal-Wallis Analysis on Seasonal Abundances of Domimant Macraflora at Diablo Point random Intertidal 0.25-m^2 Quadrats. DCPP, 1973-1977.

Species	Winter 73-74	Winter 74-75	Summer 75	Winter 75-76	Summer 76	Summer 77	Kruskall-Wallis Significance*
Iridaea complex	26.54 19.23 36.92	5.34 7.31 16.25	69.21 94.66 38.25	22.66 26.45 29.38	68.33 50.49 49.00	93.57 83.38 48.75	0.001*
Prionitis lanceolata	1.49 3.21 13.42	15.14 15.94 35.58	34.92 20.30 53.50	20.13 14.04 40.38	21.44 22.67 37.17	20.81 10.81 40.17	0.000*
Gigartina complex	3.66 6.36 23.17	5.35 7.76 30.80	31.43 43.12 40.25	20.26 13.01 50.13	11.39 16.66 34.33	18.68 27.99 41.04	0.029*
Erythrophyllum delesserioides	0.04 0.14 15.96	0.50 0.99 22.71	18.33 18.83 46.71	23.00 24.04 48.33	21.93 33.27 44.92	5.23 7.44 40.38	0.000*
Microcladia coulteri	0.00 0.00 9.50	0.78 1.74 25.71	7.82 7.28 50.63	2.98 3.40 41.13	13.88 19.35 43.79	7.03 8.09 48.25	0.000*
Hymenena spp.	0.00 0.00 24.50	0.00 0.00 24.50	2.34 4.17 37.46	5.17 9.30 39.67	13.12 19.49 47.63	11.32 24.85 45.25	0.002*
Microcladia borealis	3.20 7.32 32.92	0.19 0.40 22.92	1.76 3.04 40.92	0.10 0.29 17.04	15.14 31.68 50.46	10.85 21.94 54.75	0.000*
Iridaea lineare	0.27 0.92 34.29	6.87 14.27 46.13	10.96 24.07 41.04	2.51 8.69 35.54	0.00 0.00 31.50	0.00 0.00 31.50	0.023*
Cryptopleura spp.	4.08 5.85 37.54	0.29 0.47 28.96	0.54 1.04 32.00	1.92 2.84 39.88	3.45 6.11 37.38	8.26 15.92 43.25	0.542
Gigartina papillata	0.49 1.37 36.50	0.58 1.84 36.38	1.82 5.65 39.54	3.41 10.89 39.58	0.00 0.00 30.50	6.05 20.98 36.50	0.614
Hymenena flabelligera	0.00 0.00 34.00	0.00 0.00 34.00	0.00 0.00 34.00	4.08 8.20 42.83	0.00 0.00 34.00	4.44 10.85 40.17	0.050*

+Seasonal values for species represent: $\bar{x}$ (grams dry wt./0.25 m^2) Standard Deviation
Kruskal Wallis Mean Rank

*Significance level ($p \leq 0.05$)

Gigartina complex. This alga was also unstable through time (Table 3). With the exception of the last winter period sampled, the Gigartina complex showed a tendency toward greater biomass during the summer periods (Figure 10).

Erythrophyllum delesserioides. This alga, found in quantity only at DPI, also showed a significant variation in abundance through time (Table 3). Rather than demonstrating a winter/summer dichotomy, however, it apparently reached its peak abundance in the middle of the pre-operational survey period (Figure 10). Largely due to its abundance during three seasons, E. delesserioides formed 9.3% of the grand mean of DPI biomass (Figure 9)].

Microcladia coulteri. This alga is an epiphyte and in none of the study areas was it as abundant as it was in DPI where it represented 4.3% of the biomass (Figure 9). Its species grand mean at DPI was nearly three times higher than the next greatest grand mean for this species (at NDCI). The probable reason for this is that its preferred "host" plants: Iridaea cordata v. splendens, Prionitis lanceolata, Gigartina exasperata, and G. corymbifera, were the dominant algae at DPI. The seasonal variation of M. coulteri was significant (Table 3), occurring with greater abundance during the summer periods (Figure 10).

Hymenena spp. This species group contains members that are often associated with articulated coralline algae. The amount of articulated coralline algae at DPI, about twice that of the next most coralline-dominant area (NDCI), possibly accounts for the greater abundance of this species group in much the same way Microcladia coulteri owes its existence to its host. Like

Microcladia borealis. Unlike its generic relative, *M. coulteri*, this alga is not an epiphyte but occurs on rocky points and headlands where wave exposure is high. It occurred in only minute amounts in the other study areas, but at DPI, it formed 4.2% of the biomass grand mean (Figure 9). It, too, appears to be a summer "bloomer" (Figure 11), and this variation through time is significant (Table 3).

Iridaea lineare. This alga is another species associated with exposure to waves. At DPI, it occurred during the first four sampling periods but did not appear in the samples of the last two summer periods (Figure 11). Its variation through time is significant, possibly due to this "disappearance", (Table 3), but nothing may be guessed about its seasonality; it may very well be cyclical. *I. lineare* formed 4.2% of the biomass grand mean (Figure 9).

Cryptopleura spp. This species group is largely epiphytic, often occurring on articulated coralline algae. While it composed 2.5% of the biomass grand mean (Figure 9), its occurrence was quite variable (Figure 11) and "unpredictable." Its variation through time was not significant (Table 3).

Gigartina papillata. This species, which represented 1.7% of the DPI biomass (Figure 9), occurred in five of the six sampling periods. However, there was not a clear-cut winter/summer trend (Figure 11) and a Kruskal-Wallis test for differences yielded a non-significant result (Table 3).

Hymenena flabelligera. This least abundant species of the dominant algae biomass at DPI represented 1.1% of the grand mean (Figure 9). It occurred in only two of the six sampling periods; once in the winter and once in the summer, and its significant variation through time (Table 3) is probably due to its sporadic occurrence (Figure 11).

3. Articulated Coralline Algae

The seasonal means for percentage cover of articulated corallines ranged from a low of about 41.4 degrees (arc-sine value) in the first winter sampled to a high of about 61.7 degrees in the summer of 1975 (Figure 12). The grand mean of coralline cover was 51.5 degrees. With the exception of the first winter, there were no quadrat sampled at DPI without articulated coralline algae present in them.

On the basis of percentage cover, articulated corallines "prefer" the exposure of DPI as they were nearly two to three times more abundant here than at the other three study areas. They were slightly more abundant at DPI during the summer periods, but this does not appear to be significant. This was verified by an S-N-K multiple range test which sorted the seasons into two mixed subsets (Table 4).

TABLE 4. Student-Newman-Keuls Multiple Range Test of Seasonal Articulated Coralline Algal Cover (Arc-Sine Values), Diablo Point Intertidal Study Area. DCPP, 1973-1977.

Subset Number	Sampling Period(s) Mean Arc-Sine Value				
1	Winter 73-74 (41.42)	Winter 75-76 (45.82)	Winter 74-75 (48.61)	Summer 76 (54.44)	Summer 77 (56.74)
2	Winter 75-76 (45.82)	Winter 74-75 (48.61)	Summer 76 (54.44)	Summer 77 (56.74)	Summer 75 (61.72)

Since articulated coralline algae occupy space that might otherwise be used by other algal species, it seems important to know whether their presence affects the presence of other algae. To test the influence of articulated corallines of soft algae biomass, a linear regression was performed for soft algal biomass on articulated coralline cover (arc-sine values). The result for DPI was non-significant (F= 2.093, Significance level = 0.152), indicating that the corallines do not inhibit algae productivity expressed in terms of biomass. We did not test each soft algal species or species group against coralline cover. Undoubtedly, some species, such as those epiphytic on corallines, will be enhanced by coralline presence, while others which require "open space" to grow lushly, such as Gastroclonium coulteri and Gigartina canaliculata, may be inhibited.

4. Phyllospadix spp.

There was no Phyllospadix spp. at the DPI stations. These flowering plants evidently require a different set of environmental factors than those at our DPI stations.

B. South Diablo Cove Intertidal

1. Biomass of Soft Red Algae

On the basis of biomass, the soft algae at SDCI were the least productive of the four study areas; the grand mean for all six sampling periods was 52.6 g per 0.25-m^2, fully 26% lower than the next most productive area (NCI). There appears to be a winter/summer difference in productivity (Figure 13) as all three summer period biomass means are above the grand mean line and all three winter periods fall below it. This was confirmed by an S-N-K procedure in that all three winter periods were grouped into the first (lowest) homogeneous subset (Table 5).

TABLE 5. Student-Newman-Keuls Multiple Range Test of Seasonal Soft Algae Biomass Values, South Diablo Cove Intertidal Study Area. DCPP, 1974-1977.

Subset Number	Sampling Period(s) Mean Gram Dry Weights		
1	Winter 1975-76 (17.70)	Winter 1974-75 (27.07)	Winter 1976-77 (39.74)
2	Winter 1976-77 (39.74)	Summer 1977 (57.84)	Summer 1975 (65.90)
3	Summer 1976 (102.15)		

2. Species Composition of Soft Red Algae

A total of 16 species or species groups of algae composed 95% of the biomass at SDCI (Figure 14). Several of these algae are rather rare, each representing less than one percent of the biomass grand mean. Accordingly, only the data for the 12 most abundant species (those with an abundance equal to or greater than 1% of the biomass grand mean) will be reported in detail.

Gastroclonium coulteri. Only at SDCI did this alga, an important invertebrate habitat former, occur as the most abundant species. Overall, it represented 23% of the biomass (Figure 14). Although a Kruskal-Wallis test for differences showed it to vary significantly through time (Table 6), a distinct seasonality is not evident, probably due to the large mean of the last winter's sampling period (Figure 15).

TABLE 6. Results of Kruskal-Wallis Analysis of Seasonal Abundances of Dominant Macraflora at South Diablo Cove Random Intertidal 0.25-m^2 Quadrats DCPP, 1974-1977.

Species	Winter 74-75	Summer 75	Winter 75-76	Summer 76	Winter 76-77	Summer 77	Kruskall-Wallis Significance*
Gastroclonium coulteri	9.53 15.69 104.08	22.05 29.67 125.19	6.00 10.07 87.27	14.44 22.06 112.39	17.06 22.22 119.17	6.00 13.07 85.29	0.021*
Iridaea complex	1.75 3.45 99.22	2.44 4.40 89.50	0.14 0.39 59.58	30.86 43.53 139.57	4.09 7.21 100.85	17.09 24.80 140.83	0.000*
Prionitis lanceolata	10.96 15.16 118.57	12.17 14.78 115.39	10.20 14.81 116.68	6.70 8.63 94.43	6.09 8.10 95.40	7.21 12.68 97.51	0.276
Rhodomela larix	0.29 1.59 98.14	9.34 24.76 119.21	0.00 0.00 92.50	17.77 53.30 124.90	1.57 5.61 104.03	0.10 0.58 95.35	0.000*
Gigartina canaliculata	1.52 2.56 95.72	4.49 8.81 97.42	0.86 2.45 69.52	13.87 22.92 138.57	4.59 6.92 130.56	2.59 6.92 99.10	0.000*
Gigartina papillata	0.44 1.06 101.81	5.00 12.18 119.96	0.04 0.15 73.66	5.49 9.77 127.74	1.29 2.81 124.49	0.49 2.12 83.86	0.000*
Microcladia coulteri	0.22 0.65 70.75	3.61 6.43 119.00	0.31 1.16 69.21	1.13 2.03 111.81	0.74 1.28 98.18	3.55 4.63 162.44	0.000*
Ulva spp.	0.03 0.07 70.36	0.59 1.19 107.01	0.05 0.27 63.35	1.85 3.12 127.15	1.08 2.25 127.94	5.44 11.34 134.25	0.000*
Rhodoglossum roseum	0.09 0.52 62.36	1.31 5.67 81.53	0.10 0.20 93.48	1.68 3.57 138.15	0.66 1.28 128.82	1.30 1.83 129.74	0.000*
Neoagardhiella baileyi	0.07 0.15 70.36	0.16 0.64 107.01	0.04 0.12 63.35	0.18 0.51 127.15	0.06 0.25 127.94	4.40 11.80 134.25	0.000*
Prionitis lyallii	1.23 2.79 116.78	0.23 0.68 100.17	0.22 1.20 90.26	0.54 2.64 100.46	0.22 0.89 95.29	1.70 2.91 130.86	0.000*
Iridaea heterocarpa	0.09 0.40 84.94	0.49 1.23 111.31	0.01 0.03 81.45	2.31 4.92 146.25	0.06 0.26 89.36	1.01 2.46 119.28	0.000*

†Seasonal values for species represent: $\bar{x}$ (grams dry wt./0.25 m^2) Standard Deviation
Kruskal Wallis Mean Rank

*Significance level ($p \leq 0.05$)

Iridaea complex. This species group composed 18.9% of the biomass grand mean (Figure 14). Despite a low value in the first summer's period Figure 15), it tested as significantly different through time (Table 6). Its period of greatest productivity was during the summers.

Prionitis lanceolata. This species showed no significant variation through time (Table 6). It was most abundant during the first three sampling periods after which it appeared to decline slightly (Figure 15). It formed 17.3% of the biomass (Figure 14).

Rhodomela larix. This species appeared only in the samples from SDCI where it formed 9.9% of the biomass (Figure 14). Its variation through the sampling periods was significant (Table 6), probably due largely to the relatively high values of the first two summer periods. However, it was patchy in occurrence, and not encountered at all during one period (Figure 15).

Gigartina canaliculata. This species formed 8.7% of the biomass grand mean at SDCI (Figure 14). Although its variation through time was significant (Table 6), it was not consistently more abundant during the summers than during the winters (Figure 15).

Gigartina papillata. This species' variation in abundance was also significant (Table 6), and, with the exception of the final sampling period, was most abundant during the summer months (Figure 15). It represented 3.9% of the biomass (Figure 14).

Microcladia coulteri. This epiphytic species formed 2.9% of the grand mean (Figure 14). Its seasonal variability was significant (Table 6) probably due to its clear-cut relative abundance during two of the three summer sampling periods (Figure 16).

Ulva spp. The one green alga to occur as a "dominant" form, this species group was found only in abundance at SDCI where it formed 2.7% of the biomass grand mean (Figure 14). It also appeared to be on the increase; each winter's period mean was higher than the previous winter period, as was each summer's period mean higher than the preceding summer (Figure 16). This variation through time was significant (Table 6).

Rhodoglossum roseum. This species accounted for only 1.5% of the total biomass (Figure 14) and was apparently a summer bloomer (Figure 16). The Kruskal-Wallis test for differences yielded a significant value for its biomass through time (Table 5).

Neoagardhiella baileyi. Present in small amounts throughout most of the study period, this species increased in abundance during the last summer sampling period (Figure 16). Probably due to this increase, its variation through time tested to be significant (Table 6). Also due to this summer periods's abundance, this species composed 1.5% of the total biomass (Figure 14).

Prionitis lyallii. This species occurred in any abundance only at SDCI and even here it occurred sporadically, without an obvious seasonal trend (Figure 16) though its variation through time was significant (Table 6). It comprised 1.2% of the biomass grand mean (Figure 14).

Iridaea heterocarpa. Although this species occurred in only small amounts (1.1% of the biomass) (Figure 14), it demonstrated a significant difference between the winter and summer sampling periods (Table 6 and Figure 16).

3. Articulated Coralline Algae

The grand mean cover of articulated coralline algae at SDCI was the lowest of the four study areas: 15.4 degrees. The seasonal values of articulated corallines were significantly different (ANOVA, F = 0.0004) but they did not demonstrate a distinct seasonality of abundance (Figure 17). This apparent lack of seasonality was substantiated by an S-N-K test which sorted the cover values for the different periods into three mixed subsets (Table 7).

TABLE 7. Student-Newman-Keuls Multiple Range Test of Seasonal Articulated Coralline Algal Cover (Arc-Sine Values), South Diablo Cove Intertidal Study Area. DCPP, 1974-1977.

Subset Number	Sampling Period(s) Mean Arc-Sine Value			
1	Summer 76 (11.65)	Summer 75 (12.41)	Winter 75-76 (14.02)	Winter 74-75 (14.44)
2	Summer 75 (12.41)	Winter 75-76 (14.02)	Winter 74-75 (14.44)	Winter 76-77 (18.61)
3	Winter 76-77 (18.61)	Summer 77 (21.57)		

A linear regression of soft red algal biomass on articulated coralline cover percentages (arc-sine values) showed that the slope (b = +0.397) was not significantly different from zero (F = 1.162, significance level = 0.282), indicating no effect on soft algae biomass abundance by articulated corallines.

4. Phyllospadix spp.

Surfgrass, which appeared stable during the first four sampling periods at SDCI, seemed to decline somewhat during the final two periods (Figure 18). This decline was not measurable by an S-N-K test as all periods sorted into one subset (Table 8). However, ANOVA showed the variation between periods to be significant (F = 0.023). The grand mean of *Phyllospadix* cover, over the six sampling periods, was 25.03 degrees.

TABLE 8. Student-Newman-Keuls Multiple Range Test of Seasonal *Phyllospadix* spp. Cover (Arc-Sine Values), South Diablo Cove Intertidal Study Area. DCPP, 1974-1977.

Subset Number	Sampling Period(s) Mean Arc-Sine Value					
1	Winter 76-77 (17.39)	Summer 77 (20.06)	Summer 76 (25.87)	Winter 75-76 (26.85)	Winter 74-75 (29.71)	Summer 75 (29.79)

A linear regression of soft red algal biomass on Phyllospadix cover (arc-sine values) demonstrated a significant relationship (F = 40.221, significance level = 0.0000). The slope of this regression was negative (b = -1.233) which indicated an inverse relationship between *Phyllospadix* and soft algae biomass (Figure 19). The substantiates our general field observations: that is, the more Phyllospadix in a quadrat, the less abundant were the soft algae.

C. North Diablo Cove Intertidal

1. Biomass of Soft Red Algae

North Diablo Cove was the second most productive study area, in terms of algal biomass, with a dry-weight grand mean of 74.28 g per 0.25-m^2. Seasonal biomass means ranged from a low of 35 g per 0.25-m^2 in the first winter to a high of 112 g per 0.25-m^2 in the last summer's sampling period (Figure 20). The means of the winter period appeared to increase through time, but these periods were marked by sample ranges that never exceeded 116 g per 0.25-m^2. The summer periods, whose biomass means also appeared to increase with time, were contrasted by very high quadrat ranges--as high as 380.0 g per 0.25-m^2. The seasonality of algal productivity is distinctly different (ANOVA, F = 0.0000). The S-N-K procedure sorted the periods into three subsets, with a clear distinction between winter and summer periods (Table 9).

TABLE 9. Student-Newman-Keuls Multiple Range Test of Seasonal Soft Algae Biomass Values, South Diablo Cove Intertidal Study Area. DCPP, 1974-1977.

Subset Number	Sampling Period(s) Mean Grams Dry Weight		
1	Winter 74-75 (34.19)	Winter 75-76 (40.93)	Winter 76- 77 (60.31)
2	Winter 76-77 (60.31)	Summer 75 (85.07)	
3	Summer 75 (85.07)	Summer 76 (105.77)	Summer 77 (112.00)

2. Species Composition of Soft Red Algae

Of the 102 species of algae identified from the samples taken at NDCI, 10 species and six species groups (composed of 12 species) represented 95% of the biomass grand mean (Figure 21). Again, only the results for those algal species with a grand mean of $\geq$ 1% of the biomass grand mean will be presented.

Iridaea complex. As it was in two of the other three study areas, Iridaea complex (I. cordata v. splendens and I. flaccida) was the dominant alga in NDCI. Here, it represented 34.6% of the biomass grand mean (Figure 21.). Its seasonality, with summer peaks of abundance, is quite evident (Figure 22), and its variation through time tested as significant (Table 10).

Gastroclonium coulteri. This important habitat former (for small worms, molluscs, and arthropods) was second in abundance at NDCI, forming 14.3% of the biomass (Figure 21). Although its variability through time tested as significant (Table 10), it did not show a definite winter/summer trend (Figure 22).

Gigartina canaliculata. This alga, which can form a dense turf much like Gastroclonium, is also an important habitat for small invertebrates. At NDCI, it composed 11.3% of the biomass (Figure 21). Except for a lower mean during the first winter sampled, G. canaliculata appeared to be stable through time at NDCI (Figure 22), and a Kruskal-Wallis test for differences showed variation to be non-significant (Table 10).

Prionitis lanceolata. This alga, seeming to do well in all four study areas, formed 10.4% of the biomass at NDCI (Figure 21). Although a Kruskal-Wallis test showed it to vary significantly through time (Table 10), it did not demonstrate a definite seasonality (Figure 22).

Gigartina complex. This species complex formed 7.1% of the biomass grand mean (Figure 21). Its variation through time was statistically significant (Table 10), probably attributable to increased productivity during the last two summer periods (Figure 23).

Table 10. Results + of Kruskel-Wallis Analysis on Seasonal Abundance of Dominan Macroflora at North Diablo Cove Random Intertidal 0.25-m^2 Quadrats. DCPP, 1974-1977.

Species	Winter 74-75	Summer 75	Winter 75-76	Summer 76	Winter 76-77	Summer 77	Kruskall-Wallis Significance*
Iridaea complex	10.07 18.03 82.09	44.38 71.53 109.69	11.94 18.53 96.99	47.29 70.14 120.12	11.22 16.92 94.86	34.90 38.61 126.08	0.024*
Gastroclonium coulteri	6.97 0.36 98.27	12.21 20.33 105.64	6.32 8.26 108.93	7.40 17.17 79.94	18.67 24.33 127.97	12.69 22.18 111.64	0.022*
Gigartina canaliculata	5.21 7.00 98.08	10.56 15.14 105.64	9.33 10.34 119.25	9.23 18.42 90.69	11.41 13.31 123.26	8.24 17.44 96.01	0.134
Prionitis lanceolata	7.07 16.46 94.09	4.41 10.22 80.72	3.67 6.64 88.01	6.11 7.06 116.18	7.21 10.32 112.22	13.31 14.87 139.53	0.000*
Gigartina complex	0.16 0.54 81.22	0.52 1.55 84.38	2.88 8.20 104.24	9.11 22.53 117.97	2.54 6.01 116.72	10.73 20.33 125.71	0.001*
Cryptopleura	0.89 2.09 81.75	3.13 4.82 120.75	2.31 3.74 111.96	2.65 4.70 85.33	3.29 5.83 122.86	3.34 5.98 108.07	0.011*
Microcladia coulteri	0.26 0.67 64.77	1.04 2.27 93.03	0.24 0.52 69.32	3.57 4.94 141.65	0.91 2.14 106.93	4.75 10.09 150.70	0.000*
Hymenena spp.	0.19 0.43 95.02	0.57 2.19 94.44	0.19 0.55 88.46	5.95 10.73 142.54	0.54 1.40 110.99	3.20 10.80 99.44	0.000*
Botryoglossum farlowianum	0.02 0.10 100.03	1.14 4.92 103.31	0.11 0.65 97.15	0.40 1.41 103.00	0.08 0.24 107.57	4.25 13.25 120.87	0.044*
Rhodoglossum roseum	0.08 0.25 62.54	0.03 0.11 81.53	0.60 1.04 93.48	2.77 3.69 138.15	0.86 1.78 128.82	1.07 1.84 129.74	0.000*
Gigartina papillata	1.50 3.80 113.16	1.53 4.67 106.28	1.32 5.00 111.15	0.08 0.29 92.58	0.37 1.78 103.94	0.65 2.57 107.06	0.575
Neoagardhiella baileyi	0.08 0.25 107.53	0.30 1.08 95.31	0.14 0.38 87.52	1.99 7.05 105.74	0.50 1.50 93.26	1.68 5.01 144.08	0.024*
Hymenena flabelligera	0.00 0.00 95.50	0.07 0.42 101.14	0.65 1.23 101.18	0.00 0.00 95.50	0.56 0.29 101.13	4.63 14.89 137.21	0.000*

†Seasonal values for species represent: $\frac{\bar{x}\ (\text{grams dry wt.}/0.25\ m^2)\quad \text{Standard Deviation}}{\text{Kruskal Wallis Mean Rank}}$

*Significance level ($p \leq 0.05$)

Cryptopleura spp. This species group represented 3.4% of the biomass grand mean (Figure 21). Although its biomass variability tested as significant (Table 10) through time, it actually appears stable in all periods except the first winter (Figure 23).

Microcladia coulteri. This epiphyte, seventh in abundance at NDCI (Figure 21), occupies the same relative position as it did in SDCI. At NDCI, it represented 2.3% of the biomass and, as it did in both DPI and SDCI, it occurred with a significant seasonality (Table 10). Its period of peak abundance was during the summer months (Figure 23).

Hymenena spp. This species group, which occurs largely in the lower intertidal, also represented 2.3% of the biomass grand mean (Figure 21). It, too, showed a fairly clear peak in abundance during the summer periods (Figure 23), which was significant (Table 10).

Botryoglossum farlowianum. This alga, growing in the same intertidal region as *Hymenena flabelligera* and often difficult to distinguish from it, formed 1.5% of the biomass (Figure 21). It was significantly a summer bloomer at NDCI (Figure 24, Table 10).

Rhodoglossum roseum. Although not very abundant (1.1% of the biomass) (Figure 21), this alga appeared to reach its peak abundance during summer 1975 (Figure 24). Its variation through time was significant (Table 10).

Gigartina papillata. This alga also formed 1.1% of the biomass (Figure 21), but its variation during the study period was not significant (Table 10).

Neoagardhiella baileyi. This species formed just 1.0% of the biomass (Figure 21), and, as in SDCI, seemed to increase in abundance with time (Figure 24). It variation through time was significant (Table 10).

Hymenena flabelligera. Also representing 1% of the biomass grand mean (Figure 21), this alga was missing from the samples during two periods (Figure 24). Because of the these "zeroes" and because of a much higher mean value during the final summer period, the variation through time of *H. flabelligera* was significant (Table 10).

3. Articulated Coralline Algae

The grand mean of the estimate of cover of articulated corallines (arc-sine values) in NDCI was 29.7 degrees, the second highest value among the four study areas. Its seasonal mean values ranged from a low of 19.28 degrees during summer 2975, to a high of 37.04 degrees during winter 1976-77 (Figure 25). An ANOVA showed the difference through time to be highly significant (F = 0.0000). However, as in SDCI, the corallines did not appear to be predictably seasonal in abundance, and an S-N-K procedure sorted out the various sampling periods into three mixed subsets (Table 11).

A regression of soft algae biomass on articulated coralline cover showed, as it did at study areas DPI and SDCI, there was no significant relationship between the two (F = 0.069, significance level = 0.79). The slope of the line was close to zero (b = +0.070).

TABLE 11. Student-Newman-Keuls Multiple Range Test of Seasonal Articulated Coralline Algae Cover (Arc-Sine Values), North Diablo Cove Intertidal Study Area. DCPP, 1974-1977.

Subset Number	Sampling Period(s) Mean Arc-Sine Value		
1	Summer 75 (19.29)	Winter 74-75 (26.27)	Winter 75-76 (27.22)
2	Winter 74-75 (26.27)	Winter 75-76 (27.22)	Summer 76 (28.76)
3	Summer 76 (28.76)	Summer 77 (36.50)	Winter 76-77 (37.04)

4. *Phyllospadix* spp.

Of the three study areas where *Phyllospadix* spp. occurred (there was none at DPI), NDCI had the lowest grand mean: 20.2 degrees. The lowest mean was 12.63 degrees, during the second winter period, and the highest was 25.71 degrees, during the first summer period (Figure 26). That it did not appear to possess an obvious seasonality was reflected by an S-N-K test which sorted out the periods into two subsets containing both winter and summer periods (Table 12).

TABLE 12. Student-Newman-Keuls Multiple Range Test of Seasonal *Phyllospadix* spp. Cover (Arc-Sine Values), North Diablo Cove Intertidal Study Area. DCPP, 1974-1977.

Subset Number	Sampling Period(s) Mean Arc-Sine Value				
1	Winter 75-76 (12.63)	Winter 76-77 (13.45)	Summer 76 (22.63)	Summer 77 (22.96)	Winter 74-75 (23.37)
2	Summer 76 (22.63)	Summer 77 (22.96)	Winter 74-75 (23.37)	Summer 75 (25.71)	

As demonstrated by regression analysis in SDCI, *Phyllospadix* spp. in NDCI also had an inverse relationship to algal biomass (b = -1.092). This relationship was significant (F = 20.180, significance level = 0.000; Figure 27).

D. North Control Intertidal

1. Biomass of Soft Red Algae

The grand mean of soft algae biomass at NCI was the third highest of the four study areas--71.65 g per 0.25 m^2; just 2.63 g less than the grand mean for NDCI. The seasonality of algal productivity was quite clear-cut and regular (Figure 28); the means for the winter periods ranged from 23.07 g to 32.97 g per 0.25 m^2, while the summer means ranged from 107.79 to 118.37 g. The winter and summer periods sorted quite distinctly into two homogeneous subsets (Table 13).

TABLE 13. Student-Newman-Keuls Multiple Range Test of Seasonal Soft Algae Biomass Values, North Control Intertidal Study Area. DCPP, 1974-1977.

Subset Number	Sampling Period(s) Mean Grams Dry Weight		
1	Winter 75-76 (23.07)	Winter 74-75 (31.80)	Winter 76-77 (32.97)
2	Summer 75 (107.79)	Summer 76 (111.65)	Summer 77 (118.37)

2. Species Composition of Soft Red Algae

While the grand mean of the algal biomass was quite near that of NDCI, there were substantially fewer species or species groups making 95% of that biomass at NCI. A total of five species and four species groups comprised that 95% (Figure 29).

Iridaea complex. As it was in DPI and NDCI, Iridaea was the most abundant alga at NCI. Nowhere, however, did it form as much of the total biomass than at NCI (Figure 29); here it represented 71.2%. Its summer peaks in productivity were also quite evident (Figure 30). The difference in abundance between the winter and summer sampling periods was significant (Table 14). Iridaea accounted for nearly all of the increase in soft algae biomass from winter to summer.

Gastroclonium coulteri. This species represented 5.9% of the biomass grand mean at NCI (Figure 29). Although it was always more abundant during summers than during winters (Figure 30), the difference between the seasonal means did not test as significant (Table 14).

Prionitis lanceolata. This species, among the four most abundant species at all four study areas, formed 5.0% of the biomass at NCI (Figure 29). Its seasonal presence at this study area was fairly regular (Figure 30) and did not test to be significantly different through time (Table 14).

Gigartina canaliculata. This alga comprised approximately 4% of the NCI biomass grand mean (Figure 29). Its seasonal variation was significant (Table 14) probably due to peaks of abundance in the summer of 1975 and 1976 (Figure 30).

Gigartina complex. This species complex accounted for 3.0% of the NCI biomass grand mean (Figure 29). Although its temporal variability tested as significant (Table 14), it did not show a definite seasonality (Figure 30).

Gigartina papillata. This alga represented 1.6% of the total biomass, ranking sixth in abundance at the NCI stations (Figure 29). Generally, it appeared to be slightly more abundant in summers than in winters (Figure 30), and its seasonal variation was significant (Table 14).

Cryptopleura spp. This species group formed just 1.5% of the biomass grand mean at NCI (Figure 29). Despite its relative paucity in the samples, it demonstrated a definite summer peak in abundance (Figure 31) that was significant (Table 14).

TABLE 14. Results + Kruskal-Wallis Analysis on Seasonal Abundances of Dominant Macraflora at North Control Random Intertidal 0.25-m^2 Quadrats. DCPP, 1974-1977.

Species	Winter 74-75	Summer 75	Winter 75-76	Summer 76	Winter 76-77	Summer 77	Kruskal-Wallis Significance*
Iridaea complex	19.64 20.80 102.01	85.58 87.61 137.71	8.37 10.85 72.06	87.41 85.90 145.82	19.61 29.86 92.32	82.86 98.79 135.92	0.000*
Gastroclonium coulteri	3.01 6.44 113.15	5.06 10.18 128.22	0.42 1.63 94.14	8.08 16.06 122.82	3.73 9.00 124.01	4.91 15.00 106.84	0.061
Prionitis lanceolata	4.31 6.28 136.08	3.13 7.96 102.00	4.06 9.26 112.07	2.17 5.67 101.55	2.79 7.58 107.06	4.91 8.82 128.40	0.089
Gigartina canaliculata	1.36 2.40 109.47	4.30 7.48 124.56	2.01 5.00 89.96	5.85 15.53 131.05	2.17 5.80 128.10	2.20 7.03 105.72	0.026*
Gigartina complex	0.45 1.26 112.15	2.14 9.34 98.39	3.72 11.75 106.94	1.10 2.92 115.66	0.98 2.90 111.65	4.25 13.11 140.07	0.012*
Gigartina papillata	1.08 4.20 110.07	2.26 4.81 130.18	0.72 2.30 87.01	0.97 1.95 121.84	0.71 1.14 127.32	1.25 2.67 112.99	0.026*
Cryptopleura spp.	0.46 0.86 125.49	1.67 4.38 125.85	0.48 0.14 74.71	1.09 2.15 127.22	0.79 1.68 120.28	2.43 5.00 116.26	0.001*
Hymenena spp.	0.20 0.70 107.00	0.07 0.21 97.18	0.27 0.91 96.84	0.38 1.66 115.59	0.14 0.36 111.03	4.27 9.33 156.54	0.000*
Botryoglossum farlowianum	0.10 0.42 112.25	0.66 3.58 104.38	1.23 3.44 134.60	0.16 0.79 103.00	0.22 0.73 113.22	2.54 9.03 118.19	0.019*

†Seasonal values for species represent: x̄ (grams dry wt./0.25 m^2) Standard Deviation
Kruskal-Wallis Mean Rank

***Significance level ($p \leq 0.05$)**

Hymenena spp. occupying approximately the same intertidal position as Cryptopleura spp., this species group represented 1.3% of the biomass grand mean (Figure 29). Its abundance, quite small and regular during the first five seasons, peaked during summer, 1977 (Figure 31). Probably due to this peak, its seasonality tested as significant.

Botryoglossum farlowianum. The final species among the dominant algal species composing 95% of the biomass, Botryoglossum formed 1.2% of the NCI grand mean (Figure 29). Its variation through time was significant (Table 14), but its seasonal abundance was irregular (Figure 31).

3. Articulated Coralline Algae

The grand mean for percentage cover by articulated corallines in the 0.25-m^2 quadrats was 19.7 degrees the third lowest value among the four study areas. Its seasonal mean values ranged from 14.1 degrees during the first summer period, to 24.5 degrees during the second summer period (Figure 32). Articulated corallines did not demonstrate any particular seasonality in their percentage cover estimates, making NCI similar to the other study areas where there was no identifiable seasonal trends. An S-N-K multiple range test sorted the various sampling periods into two subsets containing both winter and summer values (Table 15).

TABLE 15. Student-Newman-Keuls, Multiple Range Test of Seasonal Articulated Coralline Algal Cover (Arc-Sine Values), North Control Intertidal Study Area. DCPP, 1974-1977.

Subset Number	Sampling Periods Mean Arc-Sine Value				
1	Summer 75 (14.13)	Winter 75-76 (15.85)	Summer 77 (20.81)	Winter 76-77 (21.23)	Winter 74-75 (21.24)
2	Winter 75-76 (15.85)	Summer 77 (20.81)	Winter 76-77 (21.23)	Winter 74-75 (21.24)	Summer 76 (24.48)

Unlike the other study areas, however, there was a possible relationship between soft algal biomass and coralline cover at NCI (Figure 33). A linear regression of biomass (grams dry weight) on articulated coralline cover (arc-sine values) indicated a significant and positive (b = +1.212) influence by the calcareous algae (F = 10.383, sig. level = 0.001). This seems to imply that the greater the cover of articulated corallines is, the greater the amount of soft algal biomass will be.

4. Phyllospadix spp.

The grand mean of the estimated cover of Phyllospadix, 28.7 degrees, was the highest of the three study areas where these surfgrass species occurred. The seasonal means ranged from 26.2 degrees to 33.3 degrees (Figure 34). As in the other two study area, there was no obvious seasonal trend of Phyllospadix cover at NCI. All sampling periods sorted into one subset by the S-N-K procedure (Table 16).

TABLE 16. Student-Newman-Keuls Multiple Range Test of Seasonal Phyllospadix spp. Cover (Arc-Sine Values), North Control Intertidal Study Area. DCPP, 1974-1977.

Subset Number	Sampling Period(s) Mean Arc-Sine Value					
1	Winter 76-77 (26.17)	Summer 75 (26.24)	Summer 77 (26.58)	Winter 74-75 (28.25)	Winter 75-76 (30.86)	Summer 76 (33.34)

Similar to SDCI and NDCI where Phyllospadix also occurred, there was a significant relationship between surfgrass abundance and biomass (Figure 35). A linear regression of biomass on Phyllospadix yielded a negative slope (b = -2.048) that was statistically significant (F = 90.72, significance level = 0.000). This may indicate that surfgrass has an inhibitory influence on soft algal biomass.

Discussion

A. Biomass of Soft Red Algae

Our studies have illustrated at least two features of the soft algae biomass in intertidal communities in the Diablo Canyon area. For one, they are more productive in summers than in winters. For another, different areas are differentially productive. An analysis of variance of biomass by study areas and by sampling periods has shown these biomass differences to be significant (F = 0.001).

To determine how the study areas contribute to this difference, a step-wise one-way ANOVA of total biomass was performed for the various combinations of study areas. This analysis showed that DPI was significantly different (greater biomass) than the other three study areas, and that NDCI was significantly different (greater biomass) than SDCI. But SDCI was not significantly different from NCI (T prob. = 0.058), neither was NDCI significantly different from NCI (T prob. 0.209). A multiple range test using the Student-Newman-Keuls procedure resulted in the same finding (Table 17).

TABLE 17. Student-Newman-Keuls Multiple Range Test Comparing Algal Biomass Values From the Four Intertidal Study Areas for all Sampling Periods.
DCPP, 1974-1977.

Subset Number	Study Area(s) Gram Dry Weight Grand Mean	
1	South Diablo Cove Intertidal (52.38)	North Control Intertidal (71.66)
2	North Control Intertidal (71.65)	North Diablo Cove Intertidal (73.93)
3	Diablo Point Intertidal (124.10)	

In view of the variability of the biomass data between study areas, then, it is necessary to ask whether these data will be useful in a future comparison to algal biomass after the power plant begins operation. That is, can *each* of the study areas be characterized significantly to be considered "predicable" in their various levels of algal biomass? The answer seems to be "yes"; each area's biomass seems to vary seasonally in a predictable manner around its grand mean in that the summer periods sort out from the winter periods in homogeneous subsets (Tables 2, 5, 9 and 13). Therefore, if the null hypothesis is to be upheld, we would expect that each of the study areas ("impact" as well as "control") will continue to support an algal standing crop at its own variable yet predictable, level after the discharge of heated water begins.

B. Species Composition of Soft Red Algae

Our studies have shown that relatively few species compose the major portion of algal biomass in each of the four study areas (Figure 36). With the exception of DPI, the same four species represent at least 70% of the total biomass at the study areas: *Iridaea* complex, *Prionitis lanceolata*, *Gastroclonium coulteri*, and *Gigartina canaliculata*. Of these, the *Iridaea* complex, is the greatest contributor to biomass; alone, it accounts for most of the increased summer productivity.

The dominant species, as we have termed those which when lumped together to comprise 95% of the biomass, also occur with differing relative abundances at each of the study areas. Kruskal-Wallis tests of these species, comparing their means between the study areas during each sampling period, have shown significant differences in nearly all cases. Therefore, making a species-by-species comparison of the study areas would be a tedious and confusing exercise. With the statistical methods we have used thus far, there is no clear and easy-to-understand way of analyzing and comparing species composition within and between study areas. However, a relatively new application to ecological data of a multivariate method known as "Canonical Analysis of Discriminance" seems to hold promise for easier understanding and depiction of community structure (Pimental 1978). Using either presence-absence or abundance data of the most common species, a community (or study area) may be represented by a "group centroid"--a location in two- or three-dimensional space. Change through time in group centroids--either alone or in relation to one another--can be investigated to determine between- and within-group differences.

C. Articulated Coralline Algae

This group of calcareous algae, composed of three genera, occurred at all four study areas. As with the soft algae, different study areas support differing amounts of coralline algae. An analysis of variance of the percentage cover estimates (in arc-sine form) by study areas and sampling periods combined, has shown these differences to be significant ($p \leq 0.000$). To determine how the study areas compare, both a step-wise one-way analysis of variance of study area pairs and a Student-Newman-Keuls (S-N-K) test confirmed this difference, placing each study area in its own homogeneous subset (Table 18).

Perhaps the factor most greatly affecting the abundance of articulated coralline algae is wave exposure. The study area which probably experiences the greatest average wave energy, Diablo Point, supports the greatest cover of the corallines. Conversely, the area which seems to receive the least amount of wave energy throughout the year, South Diablo Cove, supports the smallest amount of the calcareous algae. North Control, described as being physically intermediate between South and North Coves, supports an intermediate cover of coralline algae.

TABLE 18. Student-Newman-Keuls Multiple Range Test Comparing Articulated Coralline Algal Cover (Arc-Sine Values) From the Four Intertidal Study Areas for All Sampling Periods. DCPP, 1974-1977.

Subset Number	Study Area Grand Mean Arc-Sine Degrees of Cover
1	South Diablo Cove (15.48)
2	North Control (19.67)
3	North Diablo Cove (29.74)
4	Diablo Point (51.47)

The levels of articulated coralline cover in each of the study areas seem to be quite stable (Tables 4, 7, 11, and 15), and should serve as good indicators should any significant change occur after power plant operation begins.

D. *Phyllospadix* spp.

The two species of surfgrass, *P. scouleri* and *P. torreyi*, are the only flowering marine plants to grow on the open coast in California. Both species occur here, but *P. scouleri* is the dominant form in the three study areas where surfgrass is found. It was not encountered at any of the three Diablo Point stations during this pre-operational study.

Where it occurs, North Diablo Cove, South Diablo Cove, and North Control, it covers an average of 26.6% to 32.4% (20.2 degrees to 28.7 degrees, arc-sine values) of the sampled substrate in the study areas. A one-way analysis of variance shows that the abundance of surfgrass from area to area is significantly different ($p \leq 0.000$). To determine where these differences exist, a step-wise ANOVA of the various pairs of study areas and a Student-Newman-Keuls multiple range test were performed. The ANOVA revealed that there are significant differences at the 95% level between all populations of Phyllospadix from the four study areas. The S-N-K test confirmed this, placing each study area in its own subset (Table 19).

TABLE 19. Student-Newman-Keuls Multiple Range Test Comparing Phyllospadix spp. Cover (Arc-Sine Values) From the Four Intertidal Study Areas for All Sampling Periods. DCPP, 1974-1977.

Subset Number	Study Area Grand Mean Arc-Sine Degrees of Cover
1	Diablo Point (0.0)
2	North Diablo Cove (20.20)
3	South Diablo Cove (25.03)
4	North Control (28.66)

In both SDCI and NCI, the populations of surfgrass appear very stable as S-N-K tests for each study area by sampling period placed all periods within one subset (Tables 8 and 16). At NDCI, Phyllospadix was slightly less stable.

Invertebrates

Quadrat Surveys

A. Methods

1. Field

The study areas and stations are the same as for the algal study. See the Macroflora Methods section for a review of the procedure for laying out the stations and locating quadrat positions.

With the time available during a minus tide to sample four quadrats at each station, we limited sampling to only exposed surfaces. Therefore, cryptic organisms i.e., under-rock dwelling forms, were eliminated from our study design.

Within each quadrat, counts of all macro-invertebrates (generally $\geq$ 10 mm) were made and estimates of abundance (scarce, common, or abundant) were made for colonial organisms such as sponges or tunicates.

Carapace widths for the crabs *Pugettia producta* and *Pugettia richii/gracilis*, shell length for the volcano limpet, *Fissurella volcano*, arm-tip to arm-tip widths for the sea stars *Henricia leviuscula* and *Leptasterias* spp., and test widths for the purple sea urchin, *Strongylocentrotus purpuratus*, were measured in situ.

Animals difficult to identify in the field were brought back to the laboratory.

2. Laboratory

Any animal brought back to the laboratory was identified to the lowest taxen possible. Any macro-invertebrates found in the collected algae biomass samples were counted and added to the invertebrate counts, while smaller animals were preserved in alcohol and labeled with the date, station, study, and quadrat number. This collection of smaller invertebrates has been given to Dustin Chivers at California Academy of Sciences in San Francisco.

3. Statistical

The collected data were analyzed with the non-parametric Kruskal-Wallis (K-W) test for differences because prior testing using Analysis of Variance (ANOVA) for the homogeneity of variances showed that the data did not meet the assumptions for parametric testing. The Kruskal-Wallis test was used to analyze individual species (or species categories) of invertebrates. The purpose of the statistical analyses was to test the null hypotheses 1 and 2 listed in the Objectives section.

Histograms are used to depict size frequencies for those animals measured in the field.

In the data analysis, species categories were created when there might be taxonomic confusion. The decorator crabs, _Pugettia richii_ and _Pugettia gracilis_, are difficult to distinguish in the field so the species complex

"*Pugettia richii/gracilis*" was created. The genus *Acmaea* is composed of many species, most of which are difficult to field identify. Removal of individuals to the lab for identification would kill most of the collected animals so it was decided to lump all of them under the "*Acmaea* spp." grouping. There are two species of *Leptasterias*, and it difficult to separate them. Therefore, we have included both species under the "*Leptasterias* spp." group.

The percent frequency of occurrence information for all invertebrate species identified from the stations is summarized in Appendix 4.

The term "significance" used here is based upon the 95% level of probability ($p \leq 0.05$).

B. Results

In the competition for exposed space in the Diablo Canyon area mid- and low-intertidal, macro-invertebrates (approximately 10 mm or greater) appear less successful than algae. A random inspection of this area reveals an abundance of very small invertebrate organisms (notably gastropods, polychaetes, ophiuroids, decapods, and amphipods), living among the "shrubby" algae, but relatively few invertebrate species above a size of 10 mm are found. Density data for the most common of these macro-invertebrate species encountered at our stations will be reported here.

Generally, the non-colonial macro-invertebrates characterizing the mid-and low-intertidal fall into three phyla: Arthropoda, Mollusca, and Echinodermata. For this report statistical analyses were performed on data collected for the following 12 taxon from the three phyla:

ARTHROPODA

- **Pugettia producta*
- **Pugettia richii/gracilis*

MOLLUSCA

- **Fissurella volcano*
- *Acmaea* spp.
- *Tonicella lineata*
- *Tegula brunnea*
- *Tegula funebralis*
- *Serpulorbis squamigerus*

ECHINODERMATA

- **Henricia leviuscula*
- **Leptasterias* spp.
- *Pisaster orchraceous*
- **Strongylocentrotus purpuratus*

*Invertebrates for which size information is also presented.

1. Diablo Point Intertidal

ARTHROPODA

Pugettia producta

The kelp crab occurred at an average of $0.81/0.25\text{-m}^2$. Although never highly abundant in any season, it generally increased during the summers

(Figure 37). This apparent seasonality, however, was not significant (Table 20). Carapace width of the 57 kelp crabs sampled here averaged 16.9 mm, while the mode was 12 to 14 mm (Figure 57).

Pugettia richii/gracilis complex

The decorator crabs were substantially less abundant than the kelp crab, and were not found during the first winter sampling period (Figure 37). Even so, a K-W test showed no significant difference through time (Table 20) probably due to the low seasonal numbers. Overall, the mean density was 0.15/0.25 m^2. The carapace width average was 13.4 mm while the mode was 12 to 14 mm for the 11 animals measured (Figure 58).

MOLLUSCA

Fissurella volcano

The volcano limpet occurred at an average of 0.36/25-m^2 (Figure 38). A K-W test showed this population to be relatively stable during the sampling periods (Table 20). The mean shell length of the 23 animals was 21.3 mm and the mode was 24 to 25 mm (Figure 59).

Acmaea spp.

The limpet group was found at an average of 0.97/0.25-m^2. It seemed to decline sharply after the first winter period and to increase gradually thereafter (Figure 38). A K-W showed this change through time to be significant at the 95% confidence level (Table 20).

TABLE 20. Results of Kruskal-Wallis Analysis on Seasonal Abundance of Dominant Macro-Invertebrates at Diablo Point Intertidal. DCPP, 1973-1977.

Species	Winter 73-74	Winter 74-75	Summer 75	Winter 75-76	Summer 76	Summer 77	Kruskal-Wallis Significance*
ARTHROPODA							
Pugettia producta	0.33 0.65 28.00	0.42 0.67 30.42	1.00 1.48 38.38	0.58 0.67 35.25	1.17 1.99 38.46	1.33 1.07 48.50	0.120
Pugettia richii/ gracilis complex	0.00 0.00 32.50	0.08 0.289 35.38	0.17 0.58 35.71	0.08 0.29 35.38	0.17 0.58 35.71	0.42 0.67 44.33	0.187
MOLLUSCA							
Fissurella volcano	0.17 0.39 35.08	1.83 0.29 32.29	0.17 0.39 35.08	0.17 0.39 35.08	0.25 0.62 35.58	1.33 2.35 45.88	0.260
Acmaea spp.	2.50 5.18 44.75	0.08 0.29 28.96	0.42 1.44 29.96	0.58 1.16 37.17	5.83 1.50 32.92	1.67 2.31 45.25	0.045*
Tonicella lineata	0.42 0.79 36.17	0.17 0.39 31.83	0.25 0.45 34.50	0.42 0.67 38.00	0.50 0.90 37.00	0.58 0.79 41.50	0.800
Tegula brunnea	2.25 2.26 31.54	6.67 8.13 44.96	2.92 2.91 35.13	5.67 5.42 42.25	2.17 3.51 27.54	4.16 5.27 37.58	0.307
Tegula funebralis	NOT OBSERVED						
Serpulorbis squamigerus	0.33 0.65 22.54	1.58 2.13 37.58	1.92 2.02 40.58	3.58 3.03 40.58	1.25 1.91 30.33	1.83 1.75 39.67	0.034*
ECHINODERMATA							
Henricia leviuscula	0.08 0.29 25.54	0.58 0.67 39.33	0.67 0.98 38.33	0.75 0.87 41.50	0.50 0.80 35.33	0.67 0.89 38.96	0.300
Leptasterias spp.	0.58 0.67 27.75	1.25 0.96 40.75	1.00 1.76 29.71	1.92 2.35 39.58	1.67 3.08 34.75	1.67 1.15 46.46	0.178
Pisaster ochraceous	0.17 0.39 36.75	0.19 0.49 37.21	0.25 0.62 37.21	0.25 0.45 39.63	0.00 0.00 31.00	0.25 0.62 37.21	0.713
Strongylocentrotus purpuratus	4.42 8.39 33.21	1.58 4.25 25.96	0.25 0.62 18.08	3.92 3.62 41.38	16.42 28.91 53.38	9.75 17.64 48.00	0.000*

†Seasonal values for species represent: $\frac{\bar{x}\ (\text{count}/0.25\text{-m}^2)\quad \text{Standard Deviation}}{\text{Kruskal-Wallis Mean Rank}}$

*Significance level ($p \leq 0.05$)

Tonicella lineata

The lined-chiton, which occurs on encrusting coralline substrate, was found at an average of 0.39/0.25-m^2. Despite its rather low numbers during each period (Figure 38), it was quite stable (Table 20).

Tegula brunnea

The brown turban snail was quite common at DPI, occurring with a mean of 3.97/0.25-m^2. Highest numbers found were during two winter periods (Figure 39), but it did not demonstrate a distinct seasonality (Table 20).

Tegula funebralis

No black turban snails were encountered at the DPI stations.

Serpulorbis squamigerus

The scaly tube snail was common only at DPI. Here it occurred with a mean of 1.75/0.25-m^2. Probably due to a low count during the first winter (Figure 39), its variation through time was significant (Table 20).

ECHINODERMATA

Henricia leviuscula

The blood star population was stable at DPI (Table 20). However, its average of 0.54/0.25-$m2$ (Figure 40) was the lowest for this species among the study areas. Its mean size (greatest diameter, armtip-to-armtip) for a total of 38 animals was 18.6 mm, but showed a tri-modal size structure (9 to 11 mm, 18 to 20 mm, and 24 to 26 mm) for the combined sampling periods (Figure 60).

Leptasterias spp.

The six-rayed star was found at an average of $1.35/0.25\text{-m}^2$ at DPI (Figure 40). Like Henricia, this star was also quite stable through time (Table 20). The mean size of the 88 animals measured during the sampling periods was 18.5 mm, while the modal increment was 12 to 14 mm (Figure 61).

Pisaster ochraceous

The ocher star occurred with significance only at DPI and even there it was not very abundant (Figure 41). It was found at a mean of $0.19/0.25\text{-m}^2$, but at this low level it was quite stable through time (Table 20).

Strongylocentrotus purpuratus

Only at DPI did we see mature populations of the purple urchin. While our data indicate a wide seasonal fluctuation (Figure 41), this may be more the result of a few samples taken at higher elevations of the intertidal where there is a denser population. The higher elevations were sampled when storm seas made the lower intertidal inaccessible. The variation through time was significant (Table 20), a probable effect of sampling. Measurements of test diameters, taken sporadically due to the urchin's crevice-dwelling nature,

2. South Diablo Cove Intertidal

ARTHROPODA

Pugettia producta

The kelp crab occurred at an average of $0.75/0.25\text{-m}^2$. It did not appear to be seasonal in occurrence (Figure 42) and this was verified by a Kruskal-Wallis test of its abundance by sampling period (Table 21~~0~~.) The mean carapace width of the 179 animals measured was 14.4 mm, with a mode of 12 to 14 mm (Figure 57).

Pugettia richii/gracilis complex

With a mean of $0.54/0.25\text{-m}^2$, this crab group was more abundant at SDCI than at the other study areas. It was, however, unstable through time (Table 21), probably due to its extremely low occurrence of the first winter (Figure 42). Its mean carapace width, based on 114 animals, was 11.8 mm, with a mode at 12 to 14 mm (Figure 58).

MOLLUSCA

Fissurella volcano

The volcano limpet was not abundant at SDCI ($0.16/0.25\text{-m}^2$) (Figure 43), but occurred with sufficient regularity to be considered stable (Table 21). Its mean shell length for 37 animals was 20.8 mm and there were two modes: 18 to 20 mm and 24 to 26 mm (Figure 59).

Acmaea spp.

Limpets were found on the average of 0.39/0.25-m^2. There was no evident seasonal or temporal variation (Figure 43) which was confirmed by a K-W test (Table 21).

Tonicella lineata

The lined chiton was consistently rare at SDCI (Figure 43). At this low level, no significant seasonal differences could be detected (Table 21).

Tegula brunnea

The brown turban snail was found at an average of 0.73/0.25-m^2, the lowest figure of any study area. A highly mobile herbivore, it was irregular in occurrence (Figure 44). This irregularity was reflected by a K-W test which showed a significant difference between the various sampling periods (Table 21).

Tegula funebralis

Black turban snails, though abundant in the upper intertidal at South Diablo Cove, were only found during two winter sampling periods. Even then, they were quite rare (Figure 44). The K-W test showed the two occurrences to be barely different from zero (Table 21).

ECHINODERMATA

Table 21. Results of Kruskal-Wallis Analysis on Seasonal Abundance of Dominant Macro-Invertebrates at South Diablo Cove Intertidal. DCPP, 1974-1977.

Species	Winter 74-75	Summer 75	Winter 75-76	Summer 76	Winter 76-77	Summer 77	Kruskal-Wallis Significance*
ARTHROPODA							
Pugettia producta	0.58 1.08 99.47	0.50 0.77 99.50	0.47 0.72 99.03	0.81 1.33 108.63	0.89 1.37 110.44	0.94 1.19 121.10	0.460
Pugettia richii/ gracilis complex	0.06 0.23 79.11	0.56 1.11 104.39	0.31 0.59 98.63	0.47 0.91 103.36	0.89 1.19 125.81	0.94 1.39 126.83	0.000*
MOLLUSCA							
Fissurella volcano	0.22 0.64 109.90	0.22 0.87 106.83	0.03 0.18 98.22	0.08 0.28 103.58	0.25 0.50 118.15	0.17 0.70 101.39	0.170
Acmaea spp.	0.31 0.58 109.94	0.44 1.11 104.22	0.19 0.40 103.00	0.64 1.68 110.00	0.25 0.91 96.97	0.47 0.88 114.47	0.581
Tonicella lineata	0.08 0.28 109.29	0.14 0.42 112.39	0.06 0.25 107.09	0.03 0.17 103.43	0.03 0.17 103.43	0.03 0.17 103.43	0.520
Tegula brunnea	0.97 1.54 126.79	1.25 2.92 114.39	0.50 1.44 94.69	0.36 0.68 104.42	0.78 1.65 109.96	0.11 0.32 87.44	0.010*
Tegula funebralis	0.11 0.66 107.49	0.00 0.00 104.50	0.00 0.00 104.50	0.00 0.00 104.50	0.08 0.28 113.29	0.00 0.00 104.50	0.060
Serpulorbis squamigerus	**NOT OBSERVED**						
ECHINODERMATA							
Henricia leviuscula	0.33 0.63 74.25	0.92 1.27 100.18	1.00 1.34 105.84	1.86 2.03 127.49	1.31 1.80 108.86	1.61 1.81 122.75	0.001*
Leptasterias spp.	0.39 0.96 63.68	2.19 4.58 100.13	1.44 3.89 89.06	2.14 2.10 102.86	5.00 7.29 134.60	2.72 3.09 128.74	0.000*
Pisaster ochraceous				NOT OBSERVED			
Strongylocentrotus purpuratus	0.14 0.35 104.17	0.22 0.92 104.69	0.31 0.96 107.03	0.25 0.60 110.33	0.28 0.62 111.08	0.14 0.42 101.75	0.899

† Seasonal values for species represent: $\frac{\bar{x}\text{ (count/0.25 m}^2\text{)} \quad \text{Standard Deviation}}{\text{Kruskal-Wallis Mean Rank}}$

* Significance level ($p \leq 0.05$)

Henricia leviuscula

With an average of $1.13/0.25\text{-m}^2$ over the six sampling periods, the blood star seemed to increase in numbers through time (Figure 45). A K-W test showed this temporal difference to be significant (Table 21). Measurements of 266 animals showed an average diameter (armtip-to-armtip) of 16.5 mm with a modal class of 12 to 14 mm (Figure 60).

Leptasterias spp.

The six-rayed star occurred at its highest average level and was the most abundant at SDCI: $2.19/0.25\text{-m}^2$. Although it was stable in the summers, it was quite variable in the winters (Figure 45). This variability caused a significant seasonal difference (Table 21). The average size of the 508 animals measured was 19.3 mm with a mode of 18 to 20 mm (Figure 61).

Strongylocentrotus purpuratus

The purple urchin occurred at its lowest level at SDCI: $0.22/0.25\text{-m}^2$. The majority of urchins there are small juveniles; for the 41 animals measured, the average test diameter was 12.0 mm, and the mode was 6 to 8 mm (Figure 62), indicating a population that never reaches maturity. This juvenile population appears, however, quite stable (Figure 46), which is supported by a K-W test (Table 21).

3. North Diablo Cove Intertidal

ATHROPODA

Pugettia producta

The kelp crab occurred at an average of 0.88/0.25-m^2 at NDCI (Figure 47). It showed a significant difference in its periodic occurrence (Table 22) but did not evidence a true seasonality (Figure 47). A mean carapace width of 15.2 mm was derived from measurements of 202 animals, with a modal class of 9 to 11 mm (Figure 57).

Pugettia richii/*gracilis* complex

This crab group was found at an average of 0.36/0.25-m^2, and it seemed to be more common in summers (Figure 47). This possible seasonality was supported by a K-W test (Table 22). Its average carapace width for 75 animals was 12.5 mm with a mode of 12 to 14 mm (Figure 58).

MOLLUSCA

Fissurella volcano

This volcano limpet was most abundant at NDCI: 1.00/0.25-m^2. Unlike the other study areas, however, these animals at NDCI appeared to vary through time (Figure 48). A K-W test showed this variation to be significant (Table 22). Measurements of 216 animals yielded a mean shell length of 17.0 mm, with a mode of 12 to 14 mm (Figure 59).

TABLE 22. Results of Kruskal-Wallis Analysis on Seasonal Abundances of Dominant Macro-Invertebrates at Nort- Diablo Cove Intertidal. DCPP, 1974-1977.

Species	Winter 74-75	Summer 75	Winter 75-76	Summer 76	Winter 76-77	Summer 77	Kruskal-Wallis Significance
ARTHROPODA							
Pugettia producta	0.56 0.98 86.94	1.33 1.22 131.21	0.71 0.93 99.30	0.92 1.38 102.11	1.06 1.31 114.61	0.67 0.79 99.53	0.026*
Pugettia richii / gracilis complex	0.13 0.49 89.28	0.61 0.93 121.04	0.11 0.40 90.79	0.56 1.00 118.87	0.22 0.59 97.01	0.52 0.941 116.72	0.002*
MOLLUSCA *Fissurella volcano*	0.94. 1.52 104.19	0.94 1.72 101.94	1.94 2.38 128.24	0.47 1.03 84.82	1.58 2.62 124.76	0.42 0.60 92.47	0.003*
Acmaea spp.	0.19 0.40 103.97	0.139 0.424 97.00	0.60 0.98 123.47	0.28 0.57, 108.50	0.22 0.54 103.03	0.194 0.525 100.29	0.045
Tonicella lineata	0.06 0.25 106.06	0.03 0.17 102.42	0.06 0.24 105.50	0.00 0.00 99.50	0.14 0.42 111.35	0.11 0.32 111.17	0.291
Tegula brunnea	2.44 3.26 89.14	4.89 7.87 105.60	2.89 4.27 97.77	2.64 4.42 93.50	6.58 6.12 148.99	2.31 1.88 101.57	0.000*
Tegula funebralis	2.81 5.56 130.00	0.03 0.17 101.25	0.26 1.20 104.79	0.00 0.00 96.00	2.33 2.97 124.61	0.00 0.00 96.00	0.000*
Serpulorbis squamigerus	NOT OBSERVED						
ECHINODERMATA *Henricia leviuscula*	0.13 0.42 54.06	1.08 1.34 98.76	1.11 1.23 103.86	1.58 1.87 111.00	2.33 2.97 124.61	2.19 1.77 137.94	0.000*
Lepatasterias spp.	0.13 0.34 60.75	0.83 0.91 105.00	0.94 1.41 100.14	0.92 1.25 103.86	1.41 1.56 125.39	1.56 1.34 135.67	0.000*
Pisaster ochraceous	NOT OBSERVED						
Strongylocentrotus purpuratus	0.09 0.390 90.50	0.36 1.22 101.25	1.03 1.60 132.73	1.14 2.706 117.50	0.14 0.35 97.33	0.19 0.62 95.71	0.000*

† Seasonal values for species represent: $\frac{\bar{x}\ (\text{count}/0.25\ m^2)\quad \text{Standard Deviation}}{\text{Kruskal-Wallis Mean Rank}}$

* Significance level ($p \leq 0.05$)

Acmaea spp.

Limpets (>10 mm shell length) were neither very common here (Figure 48) nor consistent in occurrence from period to period. They also did not appear to be seasonally distributed (Table 22).

Tonicella lineata

The lined chiton, as in SDCI, was extremely rare in this area. It occurred with an average of 0.07/0.25-m^2 (Figure 48). Though it was not encountered during one summer period, a K-W test did not show significant variation through time (Table 22), due to its low numbers.

Tegula brunnea

The brown turban snail was the most abundant animal at NDCI ((0.54/0.25-m^2) Its occurrence was irregular (Figure 49) which led to a significant difference in abundance by sampling period (Table 22).

Tegula funebralis

The black turban snail, abundant in the upper intertidal at NDCI, was not very common at our stations in the lower intertidal (0.52/0.25-m^2). It did not occur during two of the summer sampling periods (Figure 49). The high value of the first winter probably caused a significant difference in abundance by sampling period (Table 22).

ECHINODERMATA

Henricia leviuscula

The blood star reached its highest abundance at NDCI: $1.36/0.25\text{-m}^2$. Generally, its numbers seemed to increase throughout the sampling period (Figure 50). As a result, a K-W test of its abundance through the sampling periods proved highly significant (Table 22). The mean size of the 319 animals measured was 14.7 mm with a mode of 12 to 14 mm (Figure 60).

Leptasterias spp.

The six-rayed star occurred at an average of $0.92/0.25\text{-m}^2$. It appeared to increase through time (Figure 50) and this increase was shown to be statistically significant by the K-W test (Table 22). Its mean size, from 213 animals measured, was 18.2 mm, with a mode of 12 to 14 mm (Figure 61).

Strongylocentrotus purpuratus

The purple urchin occurred at an average of $0.50/0.25\text{-m}^2$. Because of an apparent increase in numbers during the two middle sampling periods (Figure 51), its variation through time was significant (Table 22). As in SDCI, the urchin population here is largely juvenile and hence very small (Figure 62). Of the 56 urchins measured, the average test diameter was 16.7 mm with a mode of 6 to 8 mm.

3. North Diablo Cove Intertidal

4. North Control Intertidal

ARTHROPODA

Pugettia producta

The average abundance of the kelp crab at NCI, $0.58/0.25\text{-m}^2$, was the lowest of all the study areas. There seemed to be a tendency toward increased abundance in the summer (Figure 52), but this did not test as significant (Table 23). Corresponding to the other study areas, the intertidal kelp crab population consists mostly of juveniles (Figure 57). Average carapace width of the 138 individuals measured was 16.6 mm with a modal class of 12 to 14 mm.

Pugettia richii/gracilis complex

This crab group was never very abundant at NCI and was not encountered during the first winter period (Figure 52). Its overall mean was $0.20/0.25\text{-m}^2$, and was unstable through time (Table 23). Mean carapace width of the 46 animals measured was 13.6 mm with a class mode of 12 to 14 mm (Figure 58).

MOLLUSCA

Fissurella volcano

With a mean of $0.91/0.25\text{-m}^2$, the volcano limpet was nearly as abundant as NCI, as it was at NDCI. In contrast to the NDCI population, however, it was remarkably stable through time (Figure 53). This stability was confirmed by a

K-W test (Table 23). With the exception of a few larger animals at NDCI, the population size structure over the sampling periods at this study area seems to closely resemble that of the SDCI population (Figure 59). Mean shell length was 20.8 mm with a class mode of 24 to 26 mm for 197 measured limpets.

Acmaea spp.

The average level of abundance of limpets at NCI was quite low and similar to SDCI and NDCI: 0.37/0.25-m^2 (Figure 53). It did not vary significantly through time (Table 23).

Tonicella lineata

As at NDCI and SDCI, the lined chiton was quite scarce at the NCI stations (Figure 53). It occurred with a mean of 0.09/0.25-m^2. The K-W test for differences between seasons indicated that the population was "stable" (Table 23). However, because of the low numbers counted, this result might also be interpreted as being not significantly different from zero.

Tegula brunnea

Brown turban snails were the most abundant animal sampled at NCI. They occurred at an average of 6.74/0.25-m^2. They were also quite stable through the sampling periods (Figure 54) as reflected by a K-W test of their abundance by period (Table 23).

TABLE 23. Results of Kruskal-Wallis Analysis on Seasonal Abundances of Dominant Macro-Invertebrates at North Control Intertidal. DCPP. 1974-1977.

Species	Winter 74-75	Summer 75	Winter 75-76	Summer 76	Winter 76-77	Summer 77	Kruskal-Wallis Significance*
ARTHROPODA							
Pugettia producta	0.36 0.54 105.53	0.69 0.92 126.14	0.40 0.67 105.79	1.00 1.38 131.89	0.44 0.91 100.11	0.58 0.84 116.37	0.090
Pugettia richii/ gracilis complex	0.00 0.00 98.50	0.17 0.51 111.39	0.07 0.27 106.64	0.42 0.78 130.34	0.19 0.47 117.00	0.32 0.77 121.47	0.009*
MOLLUSCA							
Fissurella volcano	0.78 1.29 114.37	0.94 1.60 118.37	0.78 1.91 107.35	1.00 1.66 117.99	1.22 2.10 121.64	0.80 1.67 108.42	0.850
Acmaea spp.	0.19 0.47 106.07	0.53 0.91 126.15	0.22 0.53 107.46	0.28 0.60 110.66	0.44 1.11 113.82	0.48 0.82 123.09	0.360
Tonicella lineata	0.17 0.38 123.92	0.08 0.28 114.46	0.05 0.22 110.67	0.08 0.27 113.51	0.11 0.52 111.57	0.08 0.27 113.51	0.520
Tegula brunnea	5.08 9.08 98.78	8.36 17.41 117.04	6.65 14.04 104.77	5.35 7.35 108.21	7.42 9.98 129.86	9.15 15.26 125.55	0.206
Tegula funebralis	0.44 0.94 125.79	1.61 4.25 121.97	0.05 0.22 103.27	0.05 0.22 103.27	1.44 4.07 136.08	0.25 0.17 100.64	0.000*
Serpulorbis squambigerus	NOT OBSERVED						
ECHINODERMATA							
Henricia leviuscula	0.28 0.51 85.46	0.75 0.97 115.03	0.80 0.99 117.44	0.58 0.87 102.34	0.86 1.25 116.10	1.75 2.01 147.95	0.000*

TABLE 23. (Continued)

Species	Winter 74-75	Summer 75	Winter 75-76	Summer 76	Winter 76-77	Summer 77	Kruskal-Wallis Significance*
Leptasterias spp.	0.05 0.81 91.54	0.67 0.93 102.54	1.28 1.40 134.81	0.82 0.87 115.82	1.11 1.64 115.64	1.10 1.34 123.26	0.040*
Pisaster ochraceus	NOT OBSERVED						
Strongylocentrotus purpuratus	0.36 1.24 197.39	0.36 0.72 118.85	0.30 0.69 113.45	1.12 2.49 129.62	0.14 0.42 103.13	0.30 0.72 113.15	0.181

+ Seasonal Values for Species Represent: $\bar{x}$ (Count/0.25-m2) Standard Deviation / Kruskal-Wallis Mean Rank

* Significance level: ($p \leq 0.05$)

Tegula funebralis

Black turban nails, because of their "preference" for the upper intertidal areas, were encountered irregularly at the NCI stations (Figure 54). Over all the sampling periods, they occurred with a mean of $0.72/0.25\text{-m}^2$. Their variation in abundance through time was significant (Table 23).

ECHINODERMATA

Henricia leviuscula

The blood star occurred with a mean of $0.80/0.25\text{-m}^2$. Probably due to a low mean during the first winter period and a high mean during the last summer period (Figure 55), its variation through time was significant (Table 23). Average size of the 194 animals measured throughout this preoperational period, as determined by greatest armtip-to-armtip distance, was 17.2 mm with neighboring bimodal classes of 12 to 14 mm and 15 to 17 mm (Figure 60).

Leptasterias spp.

The six-rayed star occurred at an average very close to that of the NDCI population: $0.90/0.25\text{-m}^2$. Probably due to the very low mean during the first winter period (Figure 55), its variation through time was significant (Table 23). Its average size was 20.4 mm with a modal class of 18 to 20 mm for 218 measured animals (Figure 61).

Strongylocentrotus purpuratus

The purple urchin was found at an average of $0.44/0.25\text{-m}^2$. Its period-to-period levels of abundance appeared fairly static (Figure 56) and a K-W test confirmed this (Table 23). The 80 animals measured showed an average test diameter of 17.4 mm, with modes at 12 to 14 mm and 18 to 20 mm (Figure 62).

5. Comparison of Study Areas

To determine how the selected invertebrate species compare in mean abundance through time and among the study areas, the Kruskal-Wallis test was utilized to test two null hypotheses: 1) there has been no change in sample mean densities for specific invertebrates at each study area over the time span of the study (temporal stability of study areas); 2) there is no difference in sample mean densities of specific invertebrates among the study areas (comparability of study areas). Necessary assumptions to make in interpreting the test results is that non-significance among the mean counts of invertebrates during sampling periods can be equated with stability in terms of time and that non-significance among the mean counts of invertebrates at study areas can be equated with comparability of the study areas.

ARTHROPODA

Pugettia producta

The kelp crab appears to be one of the more stable and more evenly distributed invertebrates studied. It showed no significant difference in numbers over time in three of the study areas (Table 24). The only area to

TABLE 24. Results of Kruskal-Wallis Analysis for Temporal Stability of the Four Intertidal Study Areas by Dominant Macro-Invertebrate Abundances. + DCPP, 1974-1977.

Species	Diablo Point Level of Significance*	South Diablo Cove Level of Significance*	North Diablo Cove Level of Significance*	North Control Level of Significance*
ARTHROPODA				
Pugettia producta	0.123	0.456	0.026*	0.094
P. richii/gracilis	0.187	0.000*	0.002*	0.009*
MOLLUSCA				
Acmaea spp.	0.045*	0.581	0.045*	0.360
Fissurella volcano	0.262	0.157	0.003*	0.846
Tegula brunnea	0.307	0.010*	0.000*	0.206
T. funebralis	-	0.056	0.000*	0.000*
Tonicella lineata	0.796	0.515	0.291	0.524
Serpulorbis squamigerus	0.034*	-	-	-
ECHINODERMATA				
Henricia leviuscula	0.302	0.001*	0.000*	0.000*
Leptasterias spp.	0.178	0.000*	0.000*	0.040*
Pisaster ochraceous	0.713	-	-	-
Strongylocentrotus purpuratus	0.000*	0.899	0.000*	0.181

* significance level ($p \leq 0.05$)

\- absent or too rare for meaningful treatment

* All sampling periods were used in analysis for each study area

show a difference among sampling periods was NDCI where it also showed a slightly higher grand mean. It also showed an between-area stability for four of the six periods sampled (Table 25). One feature of the kelp crab population that appears to be nearly constant from one study area to the next is the size of animal. The modal size of the crab is 12 to 14 mm in all areas except NDCI where it is smaller--9 to 11 mm (Figure 57).

Pugettia richii/gracilis complex.

This species group appeared to be stable over the entire study period only in DPI (Table 24). However, it was comparable in numbers at four of the six sampling periods when the data from the four study areas were compared seasonally (Table 25). Perhaps of interest is that these periods of stability coincided with those for the kelp crab, P. producta. Again, the sizes of the animals appear to be consistent among the study areas (Figure 58) with a common modal class of 12 to 14 mm.

MOLLUSCA

Acmaea spp.

The limpet group was found to be stable over the six sampling periods in two study areas: SDCI and NCI (Table 24). The grand means for these two study areas were also very close ($0.39/0.25\text{-m}^2$ and $0.37/0.25\text{-m}^2$, respectively). It was comparable in numbers at the four study areas in the first four sampling periods (Table 25).

Fissurella volcano

The volcano limpet showed no significant difference in mean counts through time at DPI, SDCI, and NCI (Table 24). However, its numbers at SDCI were very low and a non-significant difference in abundance here may not have as much meaning as in an area with a larger population. This range in population size between the study areas may be responsible for the lack of any seasonal similarity between the study areas (Table 25). The size data taken over the pre-operational study period showed similar average shell lengths (near 21 mm) of animals at DPI, SDCI, and NCI: near 21mm. There was a higher percentage of small animals at NDCI where the mean shell length was 17.0 mm (Figure 59).

Tegula brunnea

The brown turban snail was stable through the sampling periods in two areas, DPI and NCI (Table 24), which were locations of their greatest abundance, as well. The differences of their overall abundance among the study areas were all significant (Table 25) perhaps due mostly to the lower numbers found in SDCI.

Tegula funebralis

The black turban snail was not seen at DPI. At the other three study areas the snail was stable in numbers over time only at South Diablo Cove (Table 24). Comparability of numbers of black turban snail among the other three study areas was found only during two of the six sampling seasons (Table 25).

TABLE 25. Results of Kruskal-Wallis Analysis for Between Area Comparability for each Sampling Period in all Study AReas) Macra-Invertebrate Abundances. DCPP, 1974-1977.

Species[†]	Winter 74-75 Level of Significance	Summer 75 Level of Significance	Winter 75-76 Level of Significance	Summer 76 Level of Significance	Winter 76-77++ Level of Significance	Summer 77 Level of Significance
ARTHROPODA						
Pugettia producta	0.973	0.007*	0.430	0.894	0.020*	0.084
P. richii/gracilis	0.476	0.046*	0.101	0.419	0.000*	0.052
MOLLUSCA						
Acmaea spp.	0.575	0.096	0.169	0.967	0.019*	0.037*
Fissurella volcano	0.016*	0.013*	0.000*	0.013*	0.001*	0.014*
Tegula brunnea	0.001*	0.000*	0.000*	0.000*	0.000*	0.000*
T. funebralis[+]	0.003*	0.003*	0.302	0.000*	0.009*	0.552
Tonicella lineata	0.474	0.140	0.011*	0.007*	0.083	0.001*
ECHINODERMATA						
Henricia leviuscula	0.048*	0.804	0.695	0.005*	0.001*	0.041*
Leptasterias spp.	0.000*	0.541	0.212	0.026*	0.004*	0.035*
Strongylocentrotus purpuratus	0.036*	0.654	0.000*	0.000*	0.005*	0.000*

* significance level ($p \leq 0.05$)

+ only three study areas compared

++ data from winter, 73-74 at DPI, included for winter, 1976-77, which was not sampled

† Pisaster ochraceous was not included in statistical analysis because it was observed at only one study area

Tonicella lineata

The lined chiton was stable over time within each of the study areas (Table 24). However, with the exception of DPI, the numbers of animals were quite low and none of the grand means for the remaining three study areas exceeded 0.10/0.25-m^2. The differences in numbers between the study areas were not significant during three of the sampling periods (Table 25).

Serpulorbis squamigerus

The scaled tube worm occurred in sufficient numbers for statistical treatment only at DPI and did not appear to be stable over time (Table 24).

ECHINODERMATA

Henricia leviuscula

Only at DPI were numbers of the blood star not significantly different through time (Table 24). There were two periods, however, when the means among the study areas did not differ significantly and two other periods which were close to non-significance (Table 25). The size data (Figure 60) indicated a juvenile population in all study areas (adult size can exceed 100 mm). Average sizes ranged from 14.7 to 18.6 mm.

Leptasterias spp.

The six-rayed star was stable over time only within the DPI study area (Table 24). Between the study areas, no significant difference of numbers occurred only during two periods (Table 25). Length measurements showed that DPI and NDCI shared a class mode of 12 to 14 mm while SDCI and NCI shared a mode of 18 to 20 mm (Figure 61).

Pisaster ochraceous

The ochre star occurred commonly only in DPI. Over the time of the study at DPI, it was stable in numbers from period to period (Table 24).

Strongylocentrotus purpuratus

The purple urchin was most stable over time in SDCI and NCI (Table 24) where they also showed their lowest grand means. Only during one study period was there no significant difference between study areas. There was little comparability among the study areas (Table 25). The measurements of urchins at DPI are somewhat misleading in that relatively few of the larger animals were measured when found. If they had been measured, a much higher test diameter would have been derived. Measurements at other study areas better reflect size composition of their urchin populations (Figure 62), that is, the populations are composed mostly of small juveniles that probably do not survive to adulthood, most likely due to a lack of adequate habitat in the lower intertidal.

C. Discussion

The Kruskal-Wallis tests for within-area stability over time (Table 24) indicate that at three of the four study areas several species may occur regularly enough to be called "stable." At DPI there are eight such species, and at SDCI and NCI there are six each. The exception is NDCI at which data for only one species (<u>Tonicella lineata</u>) yielded a non-significant Kruskal-Wallis value which can be interpreted to mean that the numbers over time were stable. These "stable" species may be particularly useful to determine if a change has occurred after power plant operation begins.

In interpreting the invertebrate results, it is necessary to remember that sample size at intertidal stations was based on the calculated adequacy of determining algal biomass in an area. Manpower was not available to take enough samples to achieve the same desired precision (± 40% of the mean at the 95% confidence interval) at the species level. Therefore, the within-area and, in particular, the between-area variability is quite high for most species. This is not to imply that the species data may not be useful in making post start-up comparisons. It may very well be that abundance levels of the quantified species at the impact stations may change enough, either by increasing or decreasing, to enable us in making statistically demonstrable comparisons. By the same token, if the range of variation does not change in the study areas, we may be able to infer that no change has taken place.

It may be, too, rather than making a species-by-species comparison called for in our original null hypothesis, that we may be able to measure "community" change by utilizing an analytical method, newly available on computer, known as "Canonical Analysis of Discriminants" which was mentioned in the Algae Results section.

Abalone Transect Surveys

A. Methods

1. Field

The objectives of this study were to establish a numerical baseline on black abalone, Haliotis cracherodii, and red abalone, H. rufescens, and their shell lengths at random intertidal stations.

Abalone counts were done parallel to the shoreline along each 30-m long random intertidal station transect line. The abalone were counted within one meter to either side of the line, for a total area covered of 60 m^2 at each station. These "parallel transect" counts began in 1973.

Counts and identifications were made both visually and by feeling as far under rocks as possible. Tactile identification could be made to separate black abalone from red abalone due to the difference of shells' anterior lips and tentacle pores. The red abalone has a rugose lip and raised pores, whereas the black abalone is smooth in both instances.

To supplement the data from the parallel transects, which we came to realize did not generally include the densest black abalone habitat, we began a "perpendicular transect" survey in January 1975 at South Diablo Cove, North Diablo Cove, and North Control. The starting point of this transect was determined randomly from the parallel transect. It began at the water's edge, ran perpendicular to the shoreline, and was limited in length by the extent of abalone habitat. As for the parallel transects, the abalone were counted within a 2 m band of the perpendicular transect. Abalone habitat is defined as rocky substrate of bedrock or large boulders that provide crevices or holes for the abalone. The upper extent of the habitat is usually the upper littoral where the black turban snail, Tegula funebralis, or the brown rock-week, Fucus sp. is found. The area of each perpendicular transect, therefore, was variable, depending on extent of habitat.

As time and sea conditions allowed, a sample of abalone was measured for shell length at random parallel transects at all intertidal study areas. We measured only those red or black abalone that were readily accessible and could be removed from the substrate without harm to the animals. Vernier calipers were used to measure the abalone to the nearest 1.0 mm after which the abalone were replaced in the same location from which they were removed. The shell length study was discontinued in 1977 because the 316(a) field team were conducting a similar but more intensive length and tagging study.

2. Statistical

Counts of abalones along the parallel and perpendicular transects were converted to mean number per m^2 for comparison among study areas. The Kruskal-Wallis test was used to determine if significant ($p \leq 0.05$) changes over time in mean counts per m^2 had occurred at the parallel and perpendicular stations at each study area. The Mann-Whitney "U" Test was used to analyze for differences between study areas by sampling periods for counts at the parallel and the perpendicular transects.

No statistical analysis was done on abalone lengths.

B. Results

1. Diablo Point Intertidal

Black abalone, Haliotis cracherodii, densities at Diablo Point parallel stations remained stable throughout the study (Table 26, Figure 63). There was no significant decrease in mean densities between the first two study periods such as occurred in North Control and South Diablo Cove.

Red abalone, H. rufescens, were found at Diablo Point parallel stations during only two of the seven sampling periods.

Perpendicular staions were not established at Diablo Point.

Black abalone measured at Diablo Point ranged in size from 28 mm to 177 mm. There was little change in mean shell lengths during the study period (Figure 65). Red abalone were too scarce and inaccessible to expend effort measuring at Diablo Point.

2. South Diablo Cove Intertidal

Black abalone densities at parallel and perpendicular random intertidal stations in South Diablo Cove were consistently lower than those at North Diablo Cove and North Control stations (Figures 63 and 64). Comparison of mean densities between South Diablo Cove and those areas yielded highly significant differences ($p \leq 0.05$) when all study years were combined at both parallel and perpendicular stations (Tables 26 and 27).

TABLE 26. Mean Number per m^2 of Black Abalone (*Haliotis cracherodii*) and Red Abalone (*Haliotis rufescens*) at Diablo Point (DPI), South Diablo Cove (SDCI), North Diablo Cove (NDCI), and North Control (NCI) *Parallel* Intertidal Stations; and Results of Kruskal-Wallis Analysis to Compare Abundances Between First Sampling Period and Subsequent Sampling Periods. DCPP, 1973-1977.

	Winter 73-74		Winter 74-75		Summer 75		Winter 75-76		Summer 76		Winter 76-77		Summer 77		Kruskal-Wallis Significance Level	
Area	Black	Red	Black	Red	Black	Red	Black	Red	Black	Red	Black	Red	Black	Red	Black	Red
DPI	1.03	0.00	0.98	0.00	1.89	0.00	0.95	0.02	1.48	0.00	-	-	1.56	0.02	0.610	0.466
SDCI	0.09	0.13	0.02	0.10	0.01	0.03	0.02	0.06	0.01	0.09	0.04	0.06	0.03	0.05	0.024*	0.358
NDCI	2.87	0.34	1.85	0.10	1.40	0.09	1.28	0.16	1.14	0.13	1.35	0.15	0.94	0.10	0.323*	0.019*
NCI	2.04	0.03	0.55	0.02	0.65	0.01	0.30	0.05	0.61	0.01	0.42	0.03	0.72	0.01	0.015*	0.714

- Not sampled

* Significance level ($P \leq 0.05$)

The highest densities of black abalone found in South Diablo Cove parallel stations were tabulated during the 1973-74 winter period when a mean of 0.09 per m^2 was recorded (Table 26, Figure 63). There was a substantial decrease in mean densities at these stations during the following survey period (winter 1975-76) when only 0.02 black abalone per m^2 were found. Throughout the study periods, there was a generally decreasing trend in black abalone densities at parallel random intertidal stations. A significant decrease was observed between densities of black abalone tabulated during the 1973-74 winter and densities found during the remaining periods (Table 26).

Red abalone mean densities at parallel random intertidal stations in South Diablo Cove were also significantly different than densities at other study areas (Table 26). However, a decrease in South Diablo Cove red abalone densities over the years was not demonstrably significant (Table 27).

Perpendicular random stations were first surveyed during the 1974-75 winter period. Therefore, the data from those stations do not reflect any immediate decrease in abalone densities such as occurred at parallel stations after the 1973-74 survey. Generally, densities of both red and black abalones at perpendicular stations showed no changes throughout the years of the study (Figures 66 and 67). There was no significant different between densities of red abalones at perpendicular intertidal stations in South Diablo Cove and densities in North Diablo Cove or North Control during any, or all, study periods. However, black abalone densities were significantly lower in South Diablo Cove perpendicular stations than in the other areas (Table 27).

Black abalone measured at South Diablo Cove ranged in size from 116 mm to 182 mm. The mean length varied little during the study (Figure 65). Red

TABLE 27. Mean Number Per m^2 of Black Abalone (*Haliotis cracherodii*) and Red Abalone (*H. rufescens*) at South Diablo Cove (SDCI), North Diablo Cove (NDCI), and North Control (NCI) *Perpendicular* Intertidal Stations. DCPP, 1974-1977.

	MEAN NUMBER PER m^2												Kruskal-Wallis Significance Level	
	Winter 74-75		Summer 75		Winter 75-76		Summer 76		Winter 76-77		Summer 77			
Area	Black	Red	Black	Red	Black	Red	Black	Red	Black	Red	Black	Red	Black	Red
SDCI	0.05	0.12	0.18	0.01	0.30	0.05	0.11	0.02	0.08	0.05	0.14	0.01	0.585	0.905
NDCI	2.77	0.03	1.90	0.02	2.39	0.05	2.78	0.04	3.60	0.04	1.94	0.03	0.671	0.346
NCI	1.24	0.00	0.42	0.01	0.37	0.00	0.72	0.00	1.29	0.01	0.91	0.01	0.277	0.346

abalone ranged in size from 62 mm to 237 mm; however, the mean lengths between seasons varied by ony 16 mm (Figure 65).

3. North Diablo Cove Intertidal

As in South Diablo Cove, there was a substantial decrease in the mean densities of both black and red abalones at North Diablo Cove parallel stations between the first (Winter 1973-74) and the second (Winter 1974-75) survey periods (Figure 72 and Table 27). The highest mean densities of black abalone (2.87 per m^2) a red abalones (0.34 per m^2) that were found in our intertidal study areas were recorded during the first survey period in North Diablo Cove. These densities dropped to 1.85 per m^2, respectively, during the following survey period. The decrease in densities that occurred at North Diablo parallel stations between the first study period and those following was statistically significant ($p \leq 0.05$) for red, but not for black, abalone. However, there was a generally decresing trend in the mean densities of black abalones surveyed at North Diablo Cove stations during the term of the study (Table 27).

North Diablo Cove parallel had the highest densities of both black and red abalones of any of our study areas. Mean densities of both species were significantly different ($p \leq 0.05$) than at North Control or South Diablo Cove when all years' data were combined (Table 28). Each year, the densities in North Diablo Cove were higher than in North Control or South Diablo Cove stations (Table 27). However, during several survey periods, these density differences were not statistically significant.

Table 28. Significance Levels of Mann-Whitney "U" Tests for Seasonal Differences in Black Abalone (*Haliotis cracheroidii*) and Red Ablone (Haliotis rufescens) Densities Between Diablo Point (DPI), South Diablo Cove (SDCI), North Diablo Cove (NDCI), and North Control (NCI) Parallel Intertidal Abalone Transects. DCPP, 1973-1977.

Area		Winter 1973-1974	Winter 1974-1975	Summer 1975	Winter 1975-1976	Summer 1976	Winter 1976-1977	Summer 1977	All Seasons Combined
SDCI vs NDCI	Black	0.1011	1.0000	0.0017*	0.0019*	1.0000	0.0006*	0.0051*	0.0000*
	Red	0.2274	0.4604	0.0094*	0.0272*	0.5217	0.0828	0.1759	0.0001*
SDCI vs NCI	Black	1.0000	1.0000	0.0017*	0.0008*	1.0000	0.0046*	0.0003*	0.0000*
	Red	0.3758	0.3906	0.0968	0.9263	0.0646	0.4429	0.3598	0.0259*
NDCI vs NCI	Black	0.3815	0.0093*	0.1999	0.0313*	0.5962	0.0272*	0.7750	0.0001*
	Red	1.0000	0.0277*	0.0006*	0.0043*	0.0126*	0.0138*	0.0184*	0.0001*
DPI vs NCI	Black	0.2482	0.9262	0.0990	0.0650	0.0662	No Data	0.4462	0.0012*
	Red	0.1967	0.0398*	0.4844	0.1671	0.2410	No Data	1.0000	0.0054*
NCI vs NDCI + SDCI	Black	0.4142	0.4641	0.2973	0.4017	0.1670	0.7367	0.0517	0.0087*
	Red	0.0509	0.2486	0.0039*	0.0943	0.0117*	0.0615	0.0559	0.0000*

* Significance level ($p \leq 0.05$)

At perpendicular stations in North Diablo Cove, black and red abalone densities remained relatively stable during the study (Figure 73 and Table 30). Densities of black abalones were significantly higher than those in both North Control and South Diablo Cove (Table 29). There were no significant differences in red abalone densities between North and South Diablo Cove stations.

Black abalone measured at North Diablo Cove ranged from 27 mm to 182 mm, the mean lengths were similar for all the sampling periods (Figure 65). Red abalone ranged in size from 37 mm to 182 mm (Figure 65).

4. North Control Intertidal

Mean densities of black abalone at North Control parallel intertidal stations declined significantly from a high of 2.04 per m^2 during the 1973-74 winter to 0.55 per m^2 during the next winter period (Figure 72 and Table 27). These densities remained depressed throughout the remaining survey periods.

There was no significant difference in black abalone mean densities between North Control parallel stations and the combined North Diablo Cove, South Diablo Cove, and Diablo Point stations if all years were considered together (Table 28). However, there is a significant difference between North Control and Diablo Cove black abalone densities for these years if Diablo Point stations are not included (Table 28).

Red abalone at parallel stations were apparently at low levels of abundance throughout the study period and this was verified by the K-W comparison

TABLE 29. Mean Number Per m^2 of Black Abalone (<u>Haliotis cracherodii</u>) and Red Abalone (<u>H. rufescens</u>) at Field's Cove, North Diablo Cove, South Diablo Cove, and Seal Haul-Out. DCPP, 1970-1978.

		Mean Number/m^2 of Abalone at Permanent Stations																			
		Summer 1970*		Summer 1971*		Summer 1974		Summer 1975		Winter 1975-1976		Summer 1976		Winter 1976-1977		Summer 1977		Winter 1977-1978		Summer 1978	
Area	Station	Black	Red	Black	Red	Black	Red	Black	Red	Black	Red	Black	Red	Black	Red	Black	Red	Black	Red	Black	Red
Field's Cove	1A	7.90	0.00	10.70	0.00	---	---	---	---	10.00	0.00	---	---	---	---	10.74	0.00	---	---	8.95	0.00
	1B	5.73	0.00	6.75	0.00	---	---	---	---	8.59	0.00	8.76	0.00	10.65	0.00	10.26	0.00	11.93	0.00	9.00	0.00
North Diablo Cove	2A	3.02	0.04	4.45	0.04	6.72	0.03	7.06	0.06	5.42	0.10	3.00	0.03	5.40	0.27	2.82	0.02	4.85	0.13	5.53	0.02
	2B	1.15	0.03	1.71	0.05	3.21	0.07	2.97	0.10	1.76	0.14	2.58	0.18	3.17	0.12	2.57	0.18	1.86	0.05	1.25	0.03
South Diablo Cove	3A	0.32	0.01	0.37	0.04	0.35	0.00	0.12	0.00	0.53	0.00	0.58	0.02	0.30	0.12	0.40	0.00	0.30	0.00	0.73	0.00
	3B	0.50	0.03	0.61	0.10	---	---	0.83	0.08	0.67	0.03	1.17	0.07	0.95	0.00	0.94	0.02	1.47	0.00	0.84	0.03
Field's Cove	P1	---	---	---	---	---	---	---	---	4.14	0.05	3.75	0.02	3.35	0.00	3.63	0.03	3.82	0.00	3.38	0.00
South Diablo Cove	P2	---	---	---	---	---	---	---	---	5.97	0.00	6.50	0.03	6.50	0.03	6.31	0.00	---	---	9.16	0.00
Seal Haul-Out	P3	---	---	---	---	---	---	---	---	1.34	0.00	1.04	0.00	1.04	0.00	1.38	0.00	1.06	0.00	1.45	0.03

--- Not sampled.

* Burge and Schultz 1973.

(Tables 27 and 28). Red abalone mean density was significantly higher at combined Diablo Cove Stations than at North Control (Figure 28).

Densities of black abalones at perpendicular stations dropped from 1.24 per m^2 during the Davidson 1974-75 survey period to less than 0.50 per m^2 and remained low until the 1976-77 Davidson surveys (Table 29). Red abalone densities at these stations were low throughout the years of the study with no significant changes observed. Perpendicular station black abalone densities show no significant difference between North Control and Diablo Cove. Diablo Point is not included in this since perpendicular stations were not surveyed in that area. Red abalone also show a significant difference between NCI and Diablo Cove when all seasons are combined (Table 30).

Black abalone at North Control varied in size from 28 mm to 176 mm. There was a slight decrease in mean shell length from 1973-1974 to 1975-1976, but an increase in mean lengths in 1976-1977 (Figure 65). Red abalone measured in North Control ranged in size from 90 mm to 204 mm. The mean length decreased from 1975-1976 (Figure 65).

5. Comparison of Study Areas

Black abalone counted along the parallel transects were most abundant at North Diablo Cove and least abundant at South Diablo Cove (Figure 63). The Mann-Whitney "U" Test analysis shows that there was a significant difference between densities at those sites when all seasons were combined (Table 28). There were significant differences also between SDCI and NCI, NDCI and NCI, DPI NCI, and between NCI and Diablo Cove (NDCI and SDCI combined) (Table 28). At

TABLE 30. Significance Levels of Mann-Whitney "U" Test for Seasonal Differences in Black Abalone (<u>Haliotis cracherodii</u>) and Red Abalone (<u>Haliotis rufescens</u>) Densities Between South Diablo Cove (SDCI), North Diablo Cove (NDCI), and North Control (NCI), <u>Perpendicular</u> Stations. DCPP, 1974-1977.

Area		Winter 1973-1974	1974-1975	1975	1975-1976	1976	1976-1977	1977	All Seasons Combined
SDCI vs	Black	0.1011	1.0000	0.0017*	0.0019*	1.0000	0.0006*	0.0051*	0.0000*
	Red	0.2274	0.4604	0.0094*	0.0272*	0.5217	0.0828	0.1759	0.0001*
SDCI vs NCI	Black	1.0000	1.0000	0.0017*	0.0008*	1.0000	0.0046*	0.0003*	0.0000*
	Red	0.3758	0.8906	0.0968	0.9263	0.0646	0.4429	0.3598	0.0269*
NDCI vs NCI	Black	0.8815	0.0093*	0.1999	0.0313*	0.5962	0.0272*	0.7750	0.0001*
	Red	1.0000	0.0277*	0.0006*	0.0043*	0.0126*	0.0138*	0.0184*	0.0001*
DPI vs NCI	Black	0.2482	0.9262	0.0990	0.0650	0.0662	No Data	0.4462	0.0012*
	Red	0.1967	0.0398*	0.4844	0.1671	0.2410	No Data	1.0000	0.0054*
NCI vs NDCI + SDCI	Black	0.4142	0.4641	0.2973	0.4017	0.1670	0.7367	0.0517	0.0087*
	Red	0.0509	0.2486	0.00039*	0.0943	0.0117	0.0615	0.0559	0.0000*

* Significance level ($p \leq 0.05$)

both NDCI and NCI the number per m^2 decreased between the witner of 1973-1974 and the winter of 1974-1975.

Red abalone found along the parallel intertidal transects were most common at North Diablo Cove and least common at Diablo Point. The Mann-Whitney "U" Test was used to test for differences in density between study areas. Every study site was found to be significantly different from the other sites when all the seasons were combined (Table 28).

Black abalone at perpendicular transects were most abundant at NDCI and least abundant at SDCI (Figure 66), a result also reflected in parallel transects. The Mann-Whitney "U" Test shows this difference to be significant when all the seasons are combined (Table 29). There are also significant differences in densities between SDCI and NCI, NDCI and NCI (Table 29). Red abalone were about as common at the perpendicular transects as they were along the parallel transects (Figures 67 and 64). The most red abalone seen at a perpendicular transect were in SDCI during the first winter survey (1974-1975). After that survey the densities were similar for NDCI and SDCI. A Mann-Whitney "U" Test found no significant difference in densities between NDCI and SDCI (Table 29). The lowest density of red abalone was at NCI (Figure 64).

The total range of black abalone shell lengths at the four study areas was from 28 mm to 182 mm. Three study areas: Diablo Point, South Diablo Cove, and North Control generally had abalone in a wide range of sizes while at South Diablo Cove black abalone had a much narrower size range: from 116 mm to 182 mm. The black abalone at Diablo Point had the smallest mean shell lengths (Figure 65), probably as a result of space limitation of the holes and crevices they occupied.

Red abalone shell lengths ranged from 62 mm to 237 mm at all four study areas combined. South Diablo Cove red abalone varied the most in size. South Diablo Cove red abalone generally had mean shell lengths greater than red abalone at the other study areas (Figure 65).

C. Discussion

Variability in abalone counts along parallel transects may be attributed, in part, to sampling conditions. Sampling at North Diablo Cove and North Control stations in 1973 and 1974 was done at the +2 to +4 ft. (NDCI) and 0.0 to 3.5 ft. (NCI) tide levels relative to MLLW. In late 1974 and for the remainder of the study period, random stations were conducted at or very near MLLW (Appendix 2). Another source of error may be the "tactile" portion of our survey; both arm length and willingness to reach under boulders vary between samplers. Although each sampling period was during low water tidal cycles, ocean conditions varied greatly. It is probable that some part of the variability is also due to the samplers' reaction to large waves breaking in the areas they worked.

The abalone population differences between North Diablo Cove and South Diablo Cove can be attributed mostly to habitat. North Diablo Cove, intertidally, has a large area of excellent abalone habitat and the larger numbers of black abalone counted there may reflect the overall robustness of that population.

The decline in black abalone numbers in North Diablo Cove and North Control undoubtedly reflects effects of sea otter foraging since 1973 (NCI) and 1974 (NDCI). The decline in numbers of black abalone in South Diablo Cove even though slight, probably is due to both the copper released in July 1974, and sea otter foraging.

The same reasons also apply to declines of red abalone in NDCI (sea otters) and SDCI (copper ion discharge, sea otters, and red tide). The [actual] declines of both species probably are underestimated from our sampling due to the fact that we are not able to observe and to count smaller abalone under rocks or in deep crevices. Thus as the exposed abalone have been removed by natural and man-caused mortality, the "countable" population is replaced by this hidden population. If this speculated is correct, then at some point in time the populations of both red and black abalone should show further declines if stress on them continues.

The fact that black abalone densities have remained fairly stable at Diablo Point suggests that sea otters have not foraged here, and/or the area was not affected by the release of copper and the red tide in 1974. Diablo Point is a very exposed area, and subject to the cleansing effect of almost continuous wave force.

Despite the fact that populations of red and black abalone declined at most Diablo Cove stations after the arrival of sea otters in 1974, there was little change in the mean sizes of either species of abalone. Apparently, the foraging activities of the sea otter were random enough so that no particular size group of either red or black abalone was affected.

PERMANENT STATION STUDY

Abalone Transects

Methods

A. Field

The objective of this study was to establish a baseline on abalone numbers per m^2 at specific areas of intertidal abalone habitat.

Permanent intertidal stations were established in Diablo Cove and Control areas in 1970 (Burge and Schultz 1973). Some of these stations were discontinued because they proved to have poor accessibility or were in areas surveyed by other methods.

The stations established by Burge and Schultz and continued through this study are 1A and 1B in Field's Cove, 2A and 2B in North Diablo Cove, and 3A and 3B in South Diablo Cove. New stations were established inside and outside Diablo Cove in 1975 to allow us to investigate effects of a possible thermal gradient on abalone. The new stations established are P1 in Field's Cove, P2 in South Diablo Cove, and P3 outside of Intake Cove (Figure 68).

The stations vary in lengths and in orientation to the shoreline. Markers were located at each end of a station line. Additional markers were placed along the line on some stations. These markers: concrete blocks, galvanized pins, or eyebolts, proved to be less than permanent and required replacement at irregular intervals. Stainless steel "L" bolts, more recently installed, have proven more durable.

Surveys of permanent intertidal stations were conducted a minimum of twice annually, once during each of the spring and fall periods of low tides. A transect line was attached to the station markers and abalone within one meter of each side of the line were counted.

B. Statistical

Field counts were converted to mean counts of abalone per m^2 to facilitate comparisons among study areas. No statistical analyses were done on the data.

Results

Results of abalone counts at many of our permanent intertidal stations show considerable variability from year to year and from one season to the next (Table 29).

1. Diablo Cove

Black abalone populations at permanent stations 2A and 2B in North Diablo Cove declined slightly over the years of the study (Table 29). During the 1974 summer period, $6.72/m^2$ black abalones were counted at station 2A. This number increased to $7.07/m^2$ during the 1975 summer period and began a gradual decline that resulted in a count of $3.53/m^2$ during the 1978 summer period. Similar results but lower numbers per m^2 were seen at station 2B. Initial counts at this station during the 1974 summer survey resulted in a calculated mean of $1.15/m^2$ black abalone, in 1974 there were 3.21 black abalone per m^2 and in 1975 there were $2.97/m^2$. As in station 2A, counts over the following surveys showed a gradual decline in numbers of abalone until 1978 when 1.25 black abalone per m^2 were found. Red abalone numbers at these stations were so low historically as to prohibit any trends being observed.

The black abalone populations at two South Diablo Cove stations (3A and 3B) are lower in density than at either North Diablo Cove station. The lower numbers found at these stations make it difficult to detect any trends; however, it appears that this population is quite stable (Table 29).

Red abalone were seen at very low densities at station 3A by Burge and Schultz in 1970 and 1971. After 1971 red abalone were seen at 3A only in 1976. Very low numbers of red abalone were seen at 3B throughout the study.

At P2 the red abalone were observed only once, in 1976 (Table 29). Black abalone densities at P2 remained high throughout the study.

2. Control Areas

Permanent intertidal stations were not established in the North Control area. Instead, there are three in Field's Cove (1A, 1B and P1) and one close to South Cove (P3). At 1A and P1 numbers of black abalone were stable and no trends were apparent in their densities (Table 29). The black abalone density at 1B, however, has steadily increased from $5.7/m^2$ in 1970 to a high of

$11.9/m^2$ in 1977-78. Many of those counted in the latter years were small abalone. Red abalone were encountered regularly at station P1 in Field's Cove and once at Station P3 (Table 29).

Discussion

The variability in counts of abalone at our permanent intertidal stations stems from two factors: sampling error, and increased mortality since 1973. Sampling error is the result of the biologists' inability to observe and count many abalone that are periodically hidden beneath rocks and crevices. The increased mortality since 1973 is due to the movement of sea otters into the Control areas and Diablo Cove; the release of copper into Diablo Cove in 1974; and the red tide conditions in Diablo Cove in the fall of 1974. We believe that the declines of black abalone observed in 1978 at stations 1A and 1B are due to sea otter foraging. The declining trend in both red and black abalone at stations 2A and 2B are also due to the sea otter foraging. The fact that similar declines for black abalone are not as evident at stations 3A and 3B in South Diablo Cove may be due to the very low population of intertidal black abalone that have been recorded here since surveys of these stations began in 1970. Red abalone showed a stronger decline at station 3B and this parallels the slight declines at random intertidal stations in South Diablo Cove, which were most likely due to sea otter foraging, the copper release, and red tide.

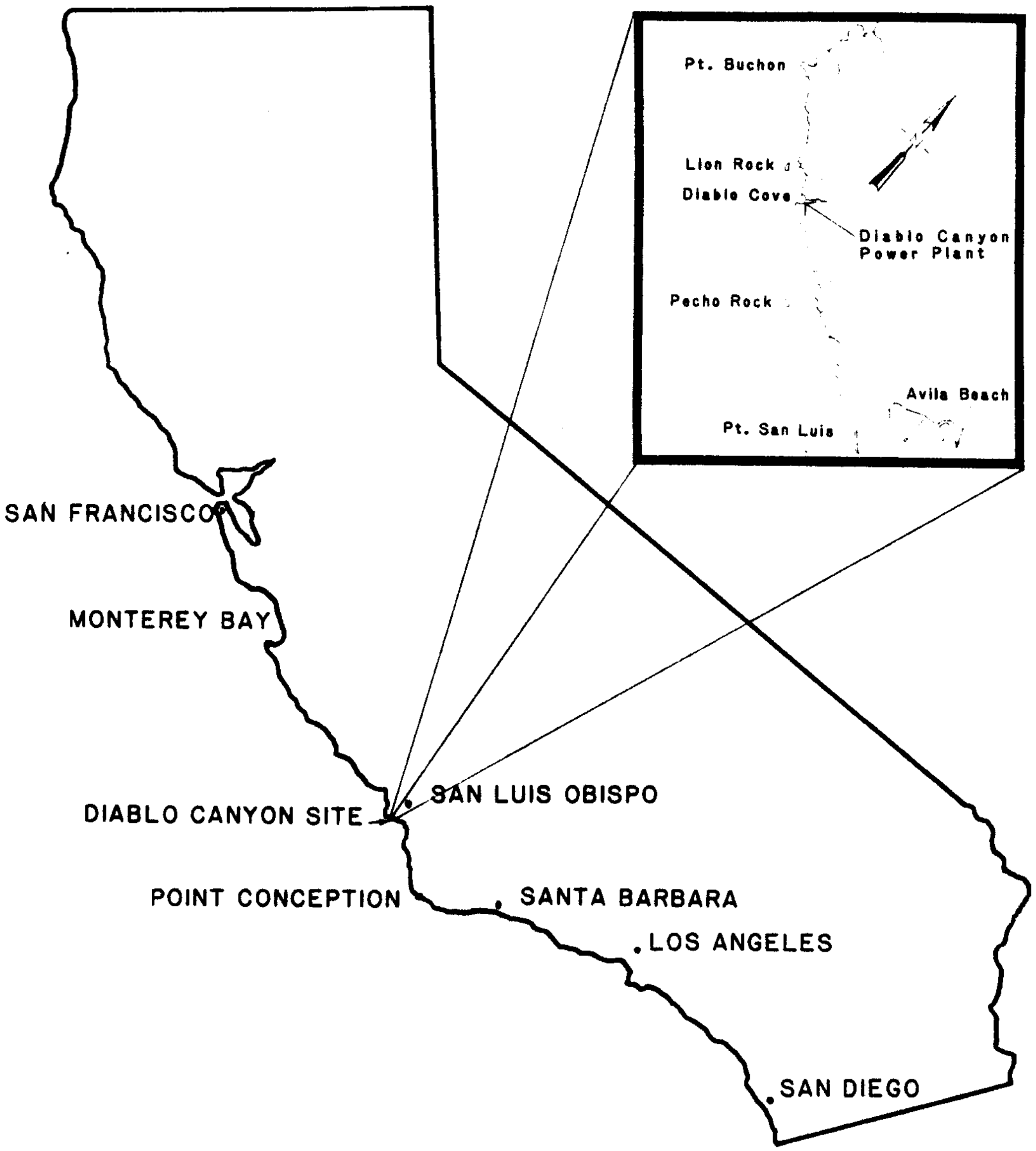


Figure 1. Location of Diablo Canyon Power Plant, San Luis Obispo County, California.

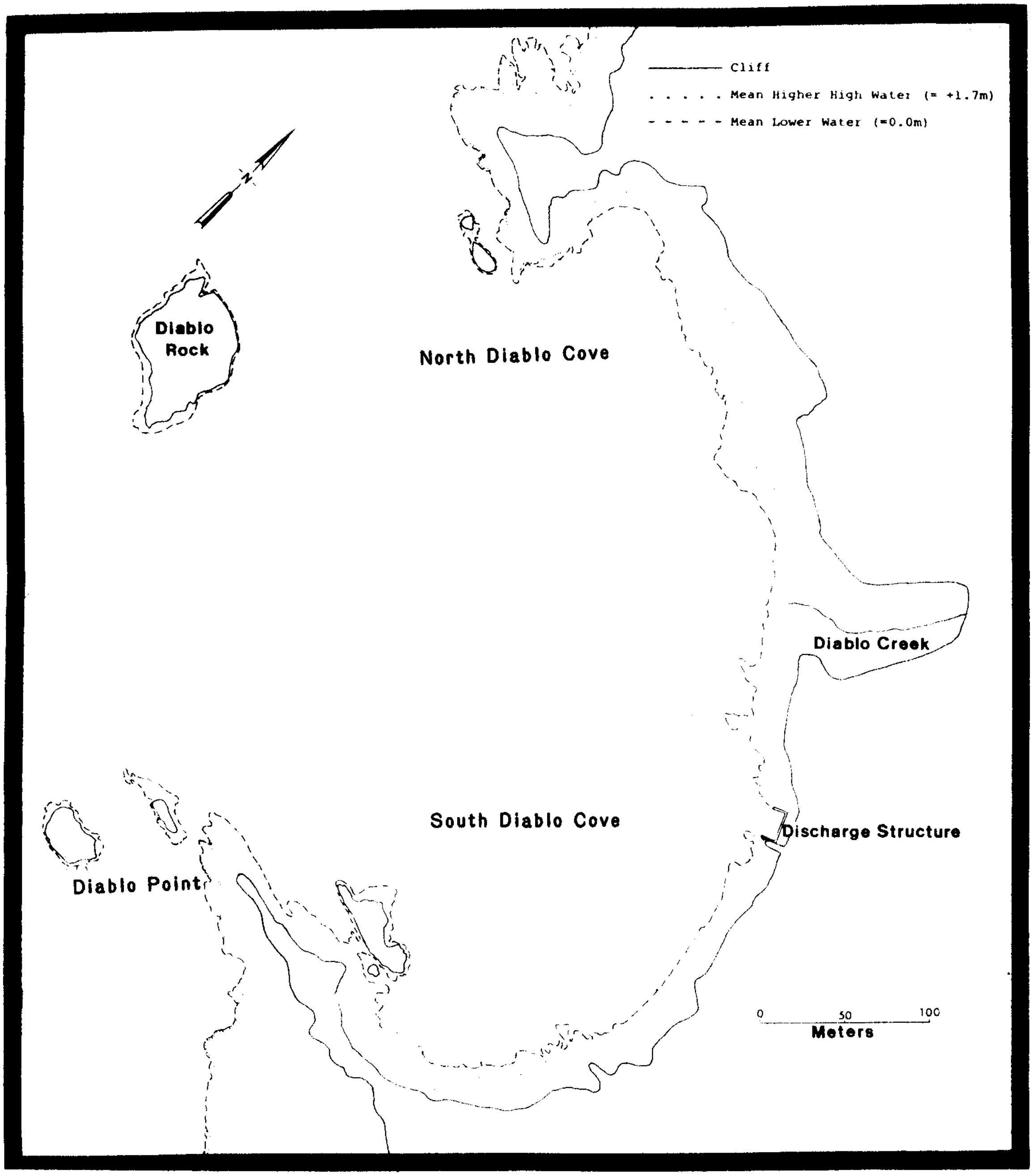


Figure 2. Location of the Diablo Canyon Power Plant Discharge Structure in Diablo Cove.

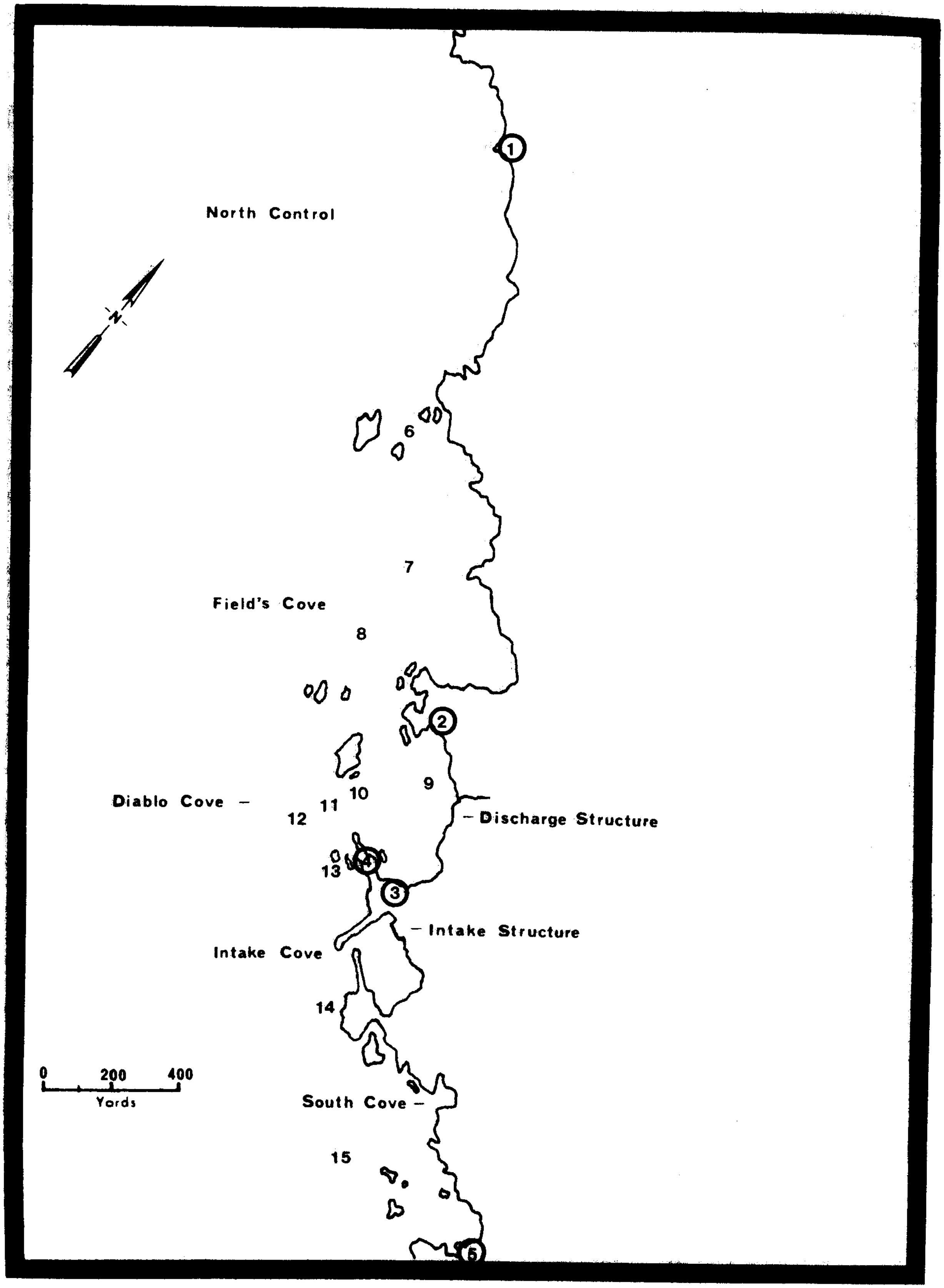


Figure 3. Locations of Intertidal Stations (1-5) and Subtidal Stations (6-15) Established in 1969 by California Department of Fish and Game at Diablo Canyon (Burge and Schultz 1973). DCPP, 1969-1979.

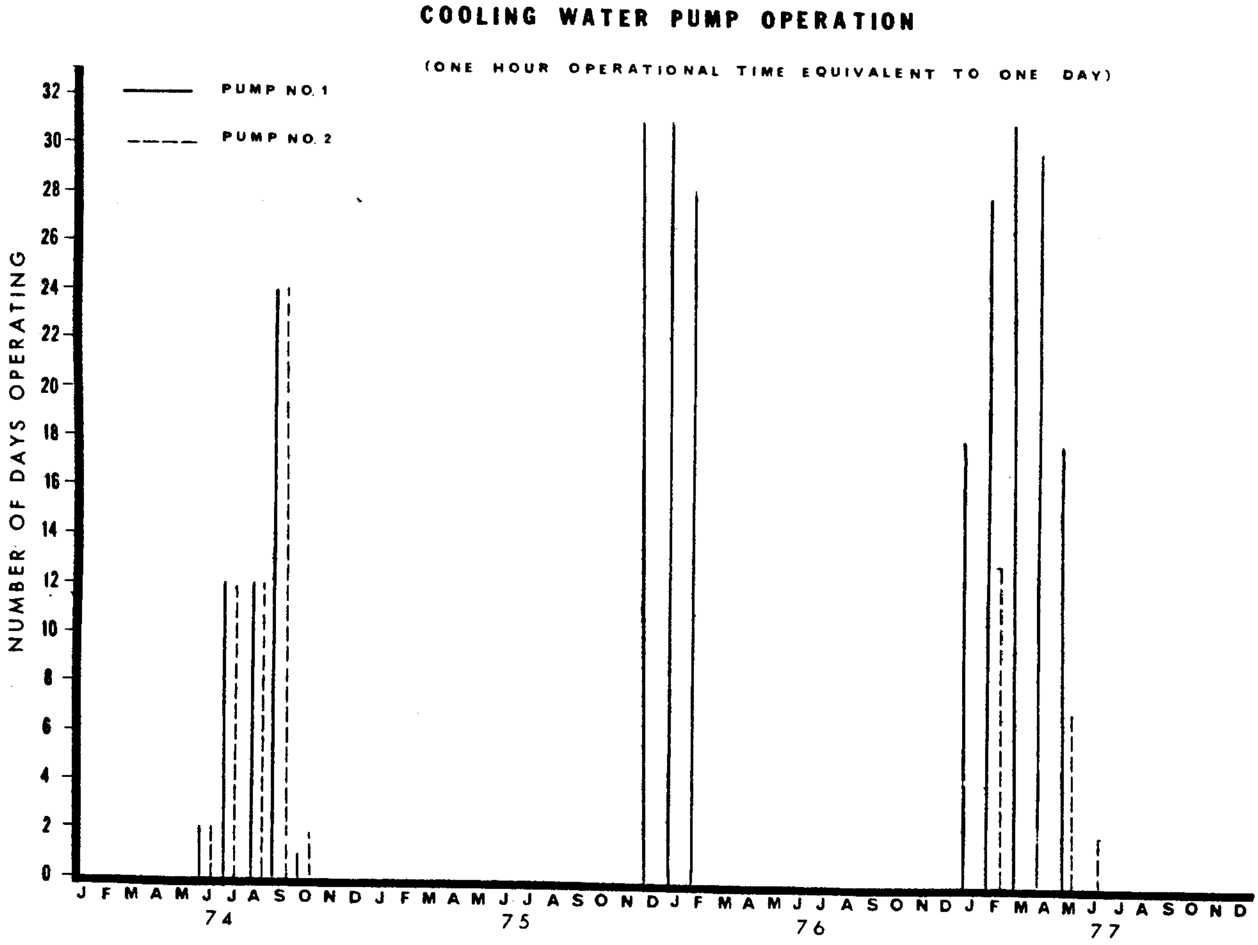


Figure 4. Cooling Water Pump Operation and Discharge into Diablo Cove. DCPP, 1974-1977.

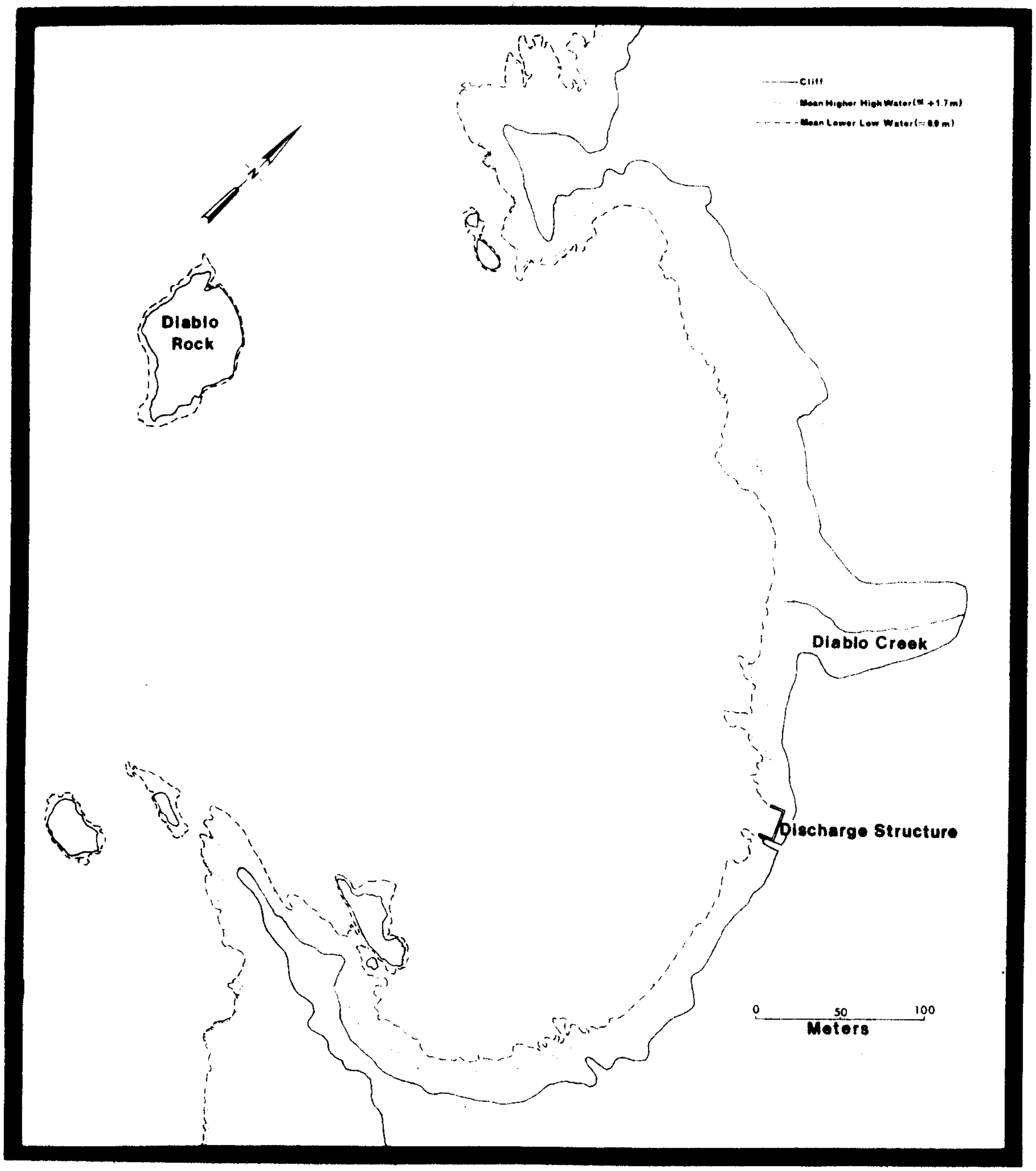


Figure 5. Locations of Diabloc Cove Random Intertidal Stations; North Diablo Cove Intertidal (NDCI), South Diablo Cove Intertidal (SDCI), and Diablo Point Intertidal (DPI). DCPP, 1973-1977.

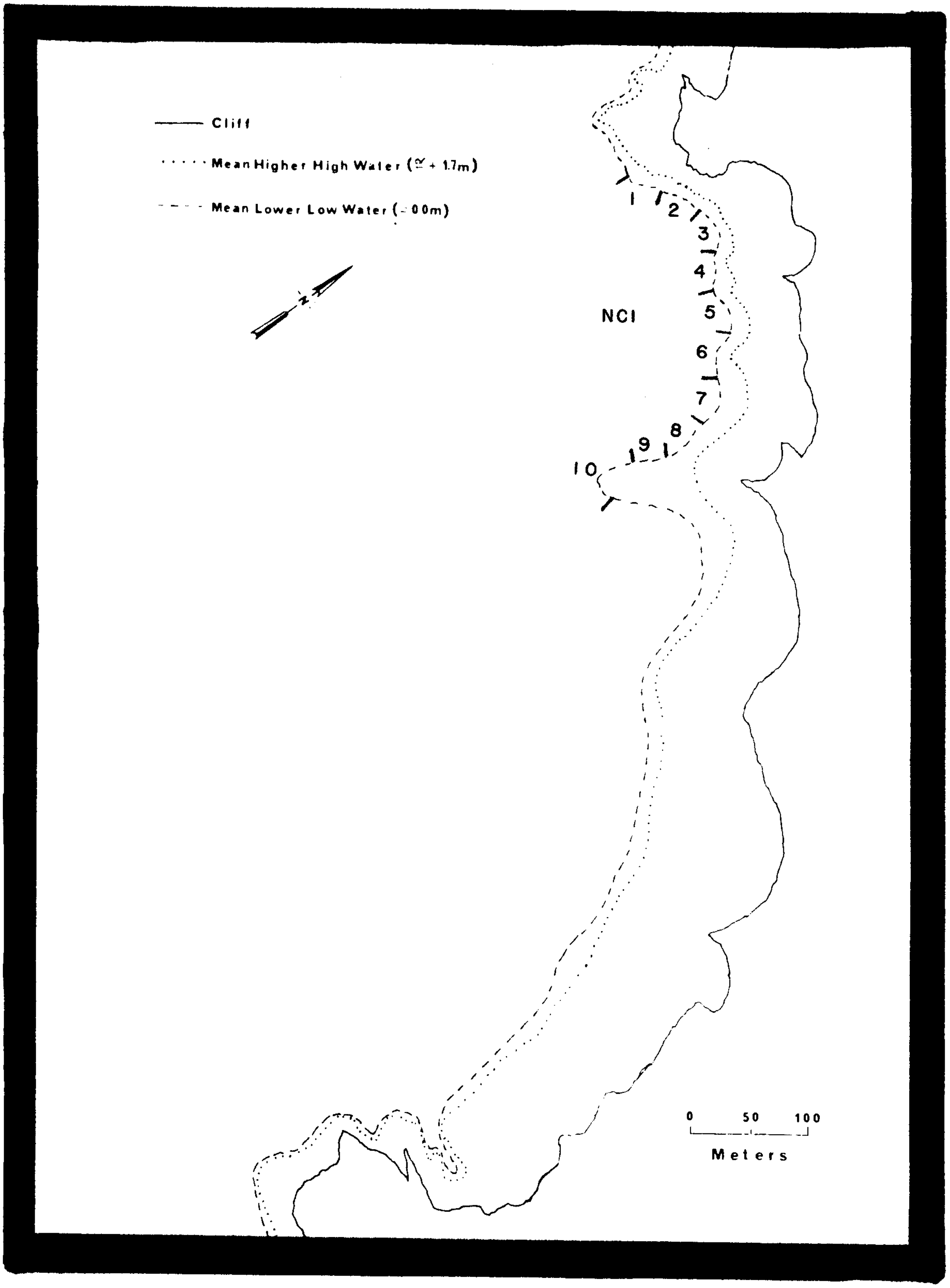


Figure 6. Locations of North Control Intertidal (NCI) Random Intertidal Stations. DCPP, 1973-1977.

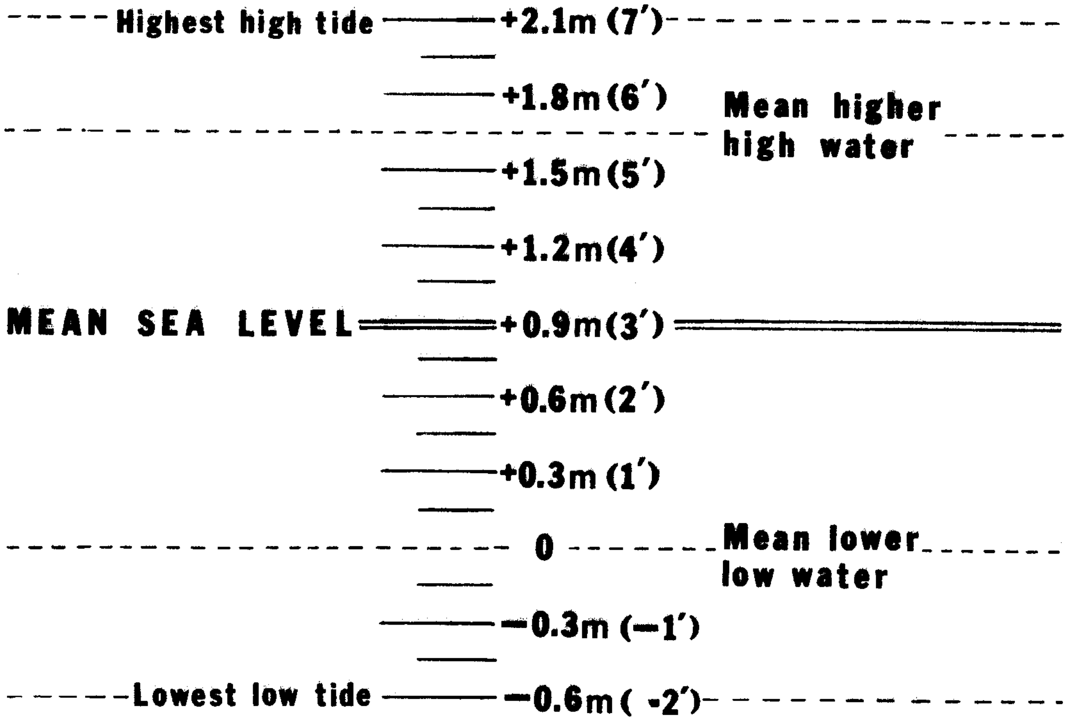


Figure 7. Range of Semi-diurnal Tides in Central California. DCPP, 1973-1977.

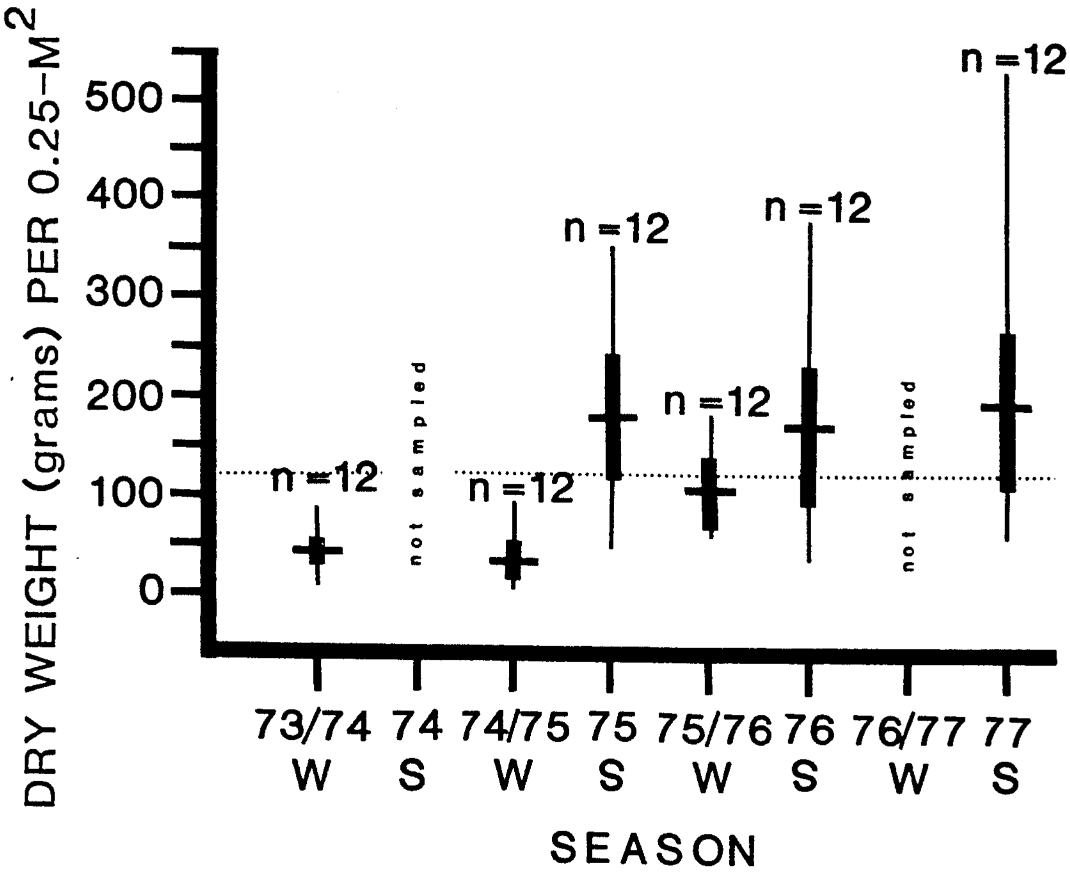


Figure 8. Means, 95% confidence intervals, and ranges of seasonal biomass of soft red algae from Diablo Point Intertidal. DCPP, 1973-1977. (Dotted horizontal line is cumulative mean for all six sampling periods).

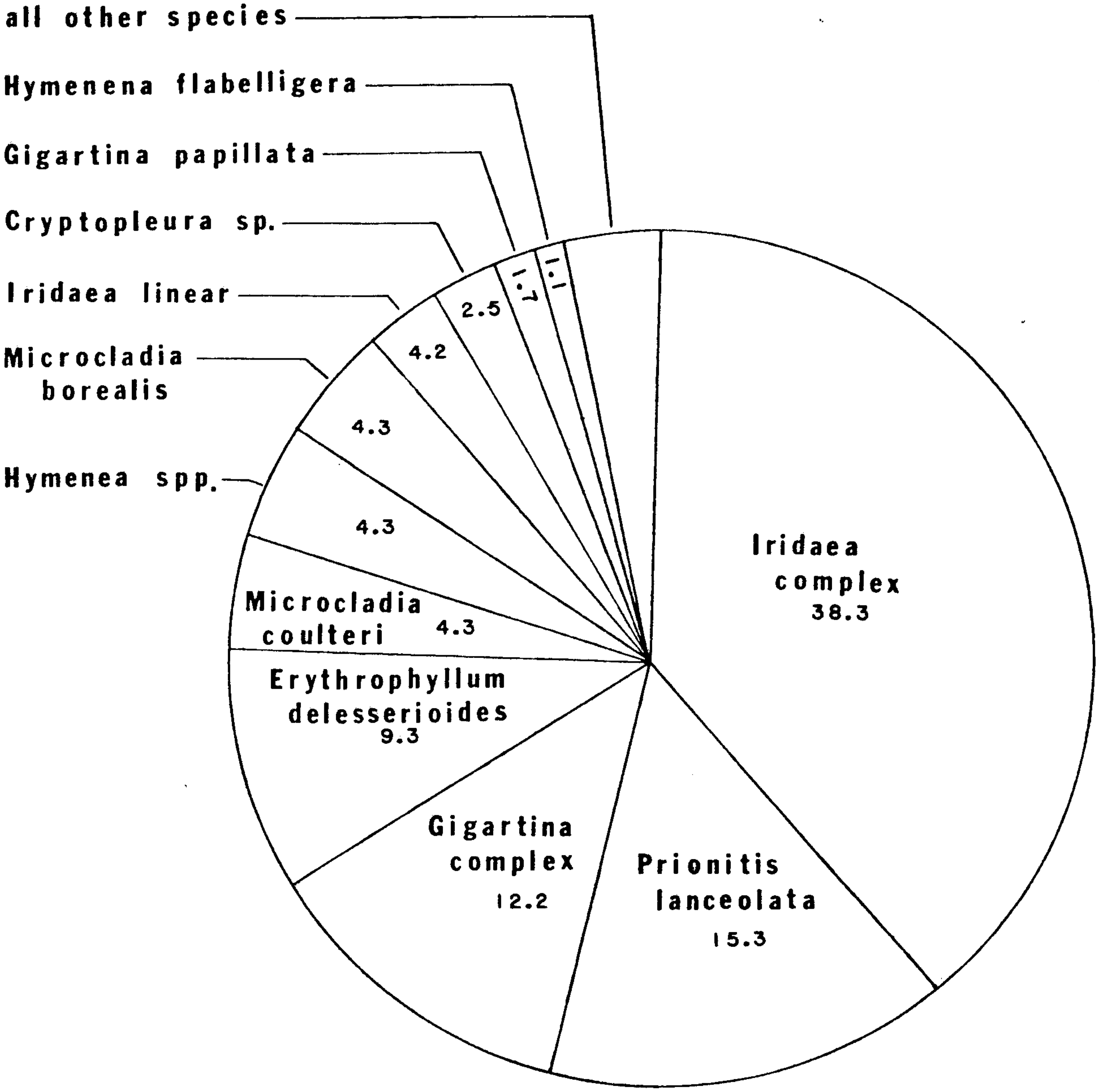


Figure 9. Relative Composition of Soft Algal Species of Diablo Point Intertidal Random 0.25-m^2 quadrats. DCPP, 1973-1977.

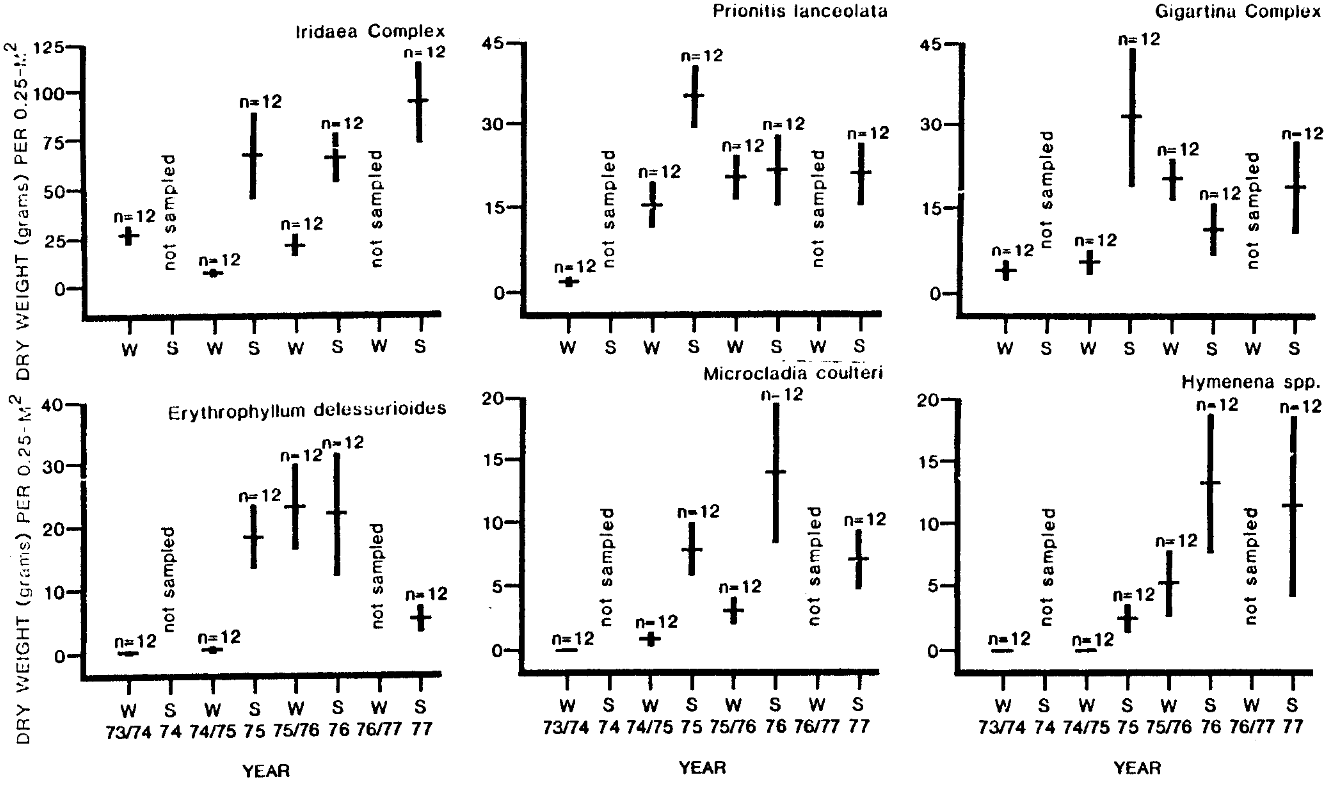


Figure 10. Seasonal biomass means and standard errors of Iridaea complex, Prionitis lanceolata, Gigartina complex, Enthrophyllum delesserioides, Microcladia coulteri, and hymenena spp. from Diablo Point Intertidal. DCPP, 1973-1977.

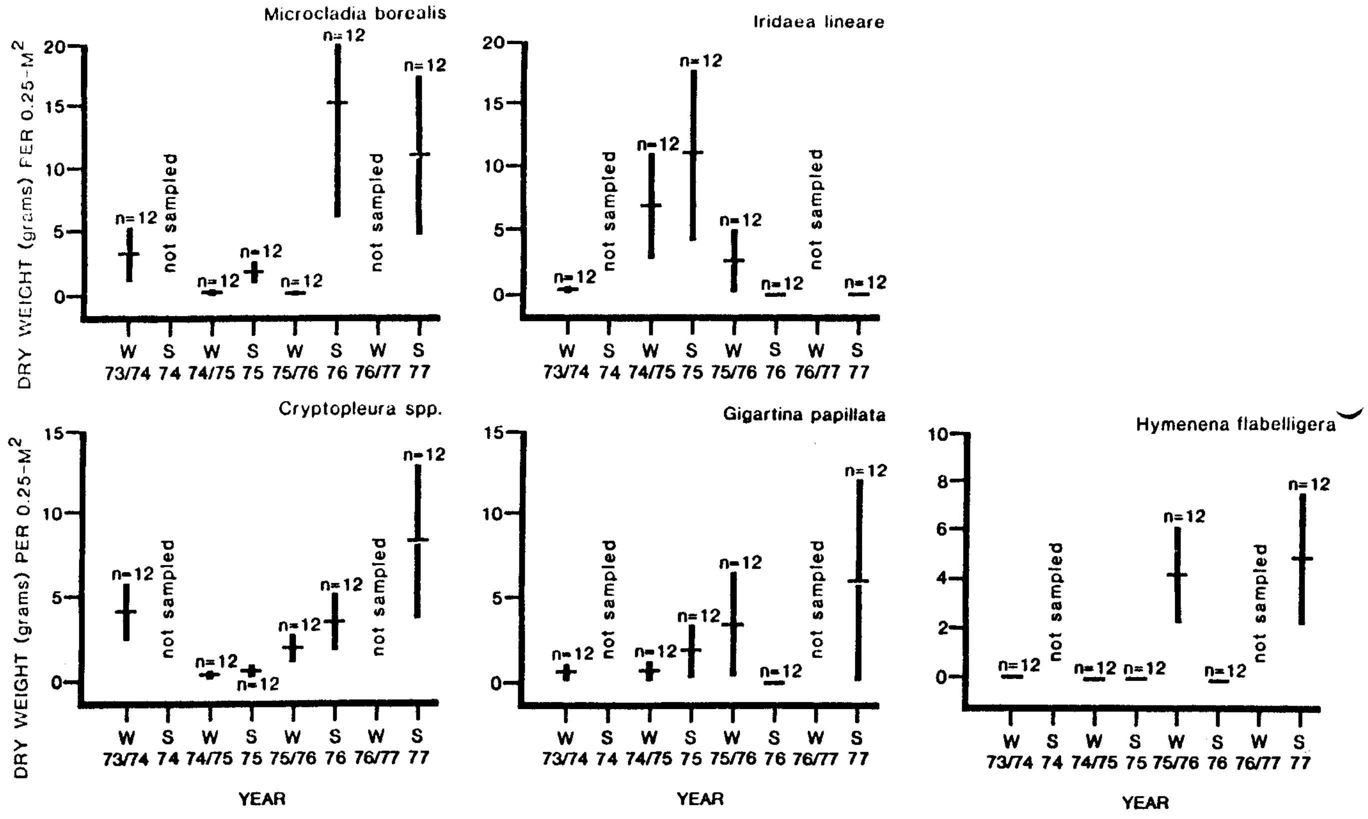


Figure 11. Seasonal biomass means and standard errors of *Microcladia borealis*, *Iridaea lineare*, *Cryptopleura* spp., *Gigartina papillata*, and *Hymenena flabeligera* from Diablo Point Intertidal. DCPP, 1973-1977.

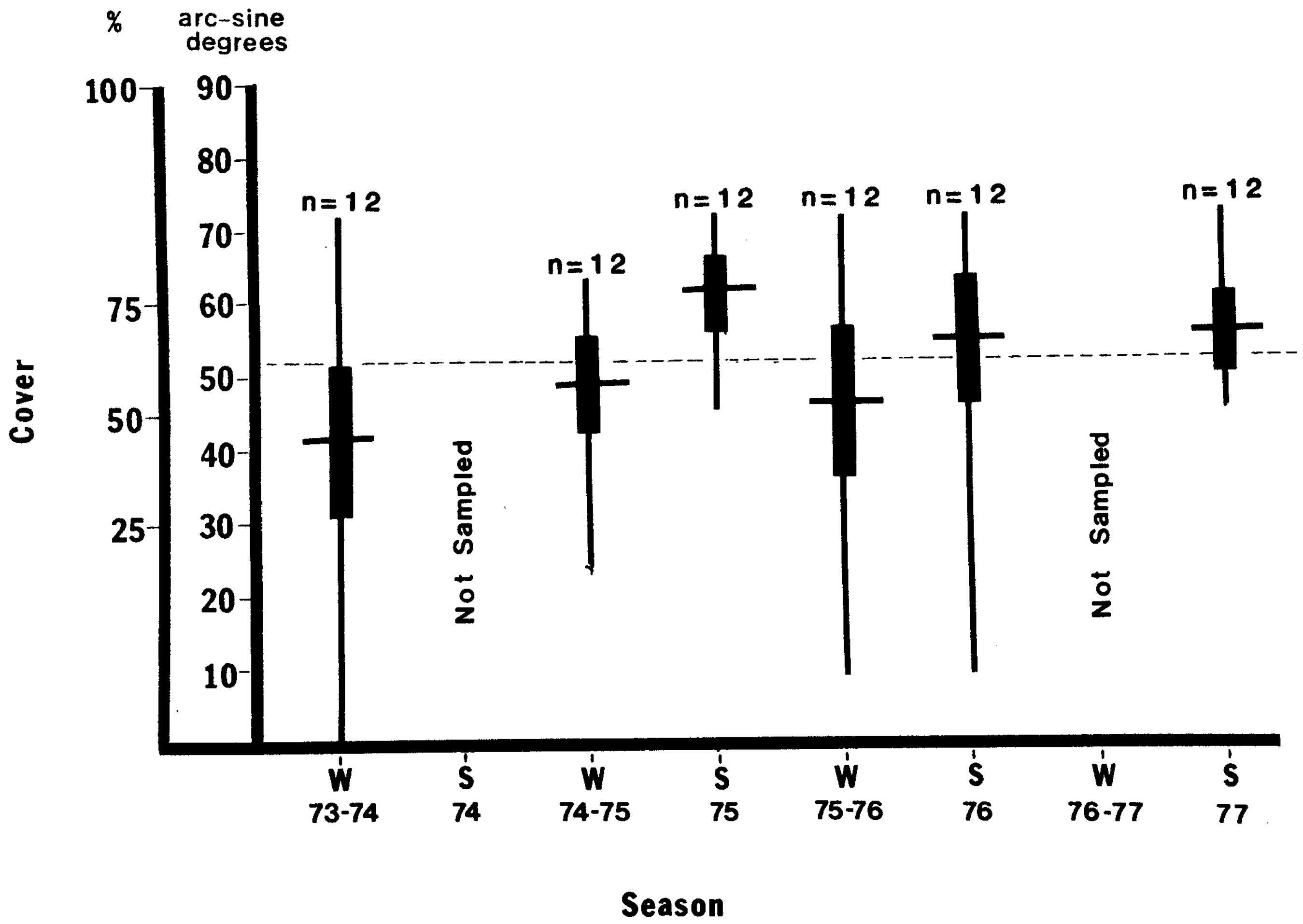


Figure 12. Seasonal means, 95% confidence intervals, and ranges of arc-sine values of articulated coralline algae cover at Diablo Point Intertidal. DCPP, 1973-1977. (Horizontal dotted line represents the cumulative mean for all seasons. A percentage axis is provided for reader convenience).

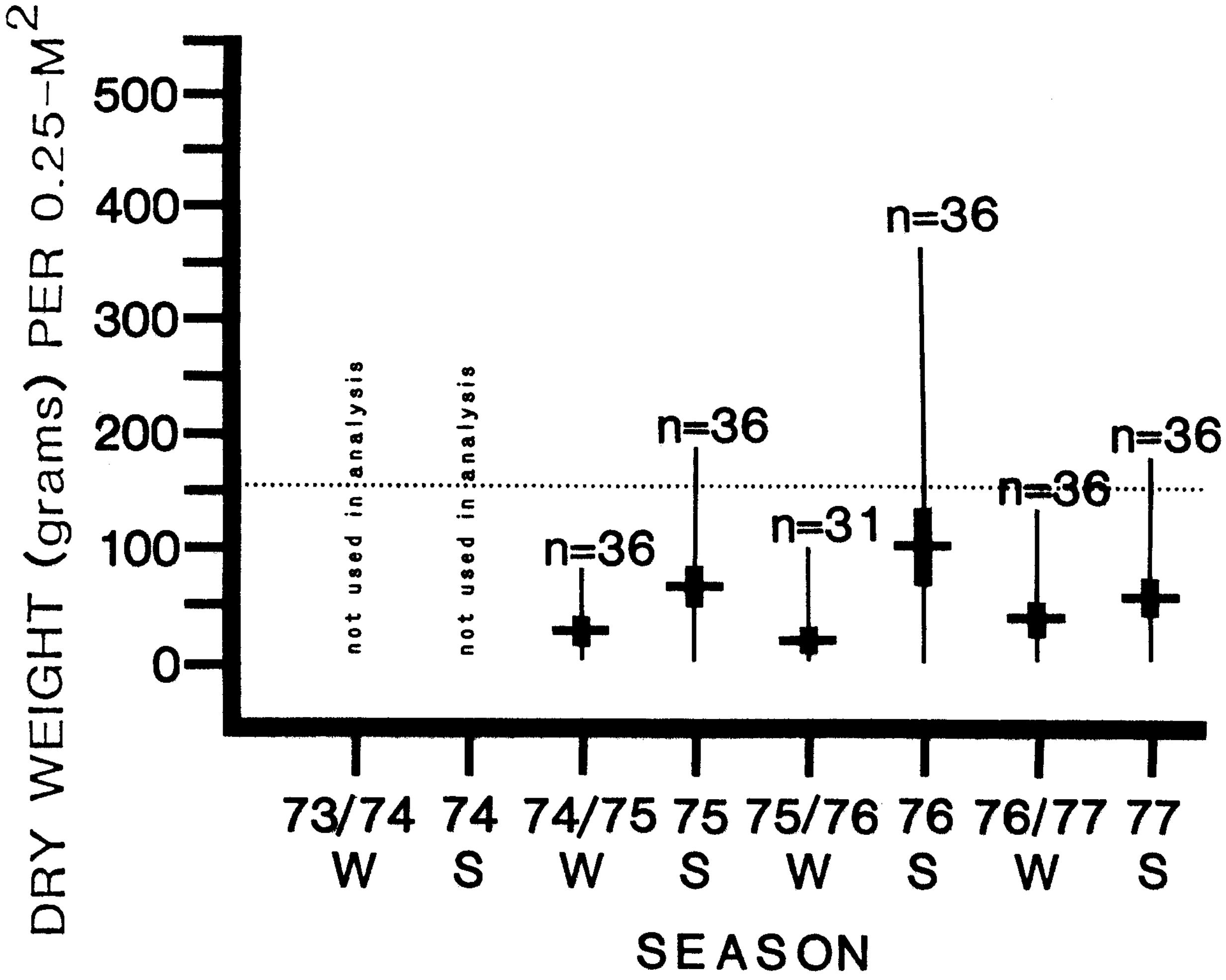


Figure 13. Means, 95% confidence intervals, and ranges of seasonal biomass of soft red algae from South Diablo Cove Intertidal. DCPP, 1974-1977. (Dotted horizontal line is cumulative mean for all six sampling periods).

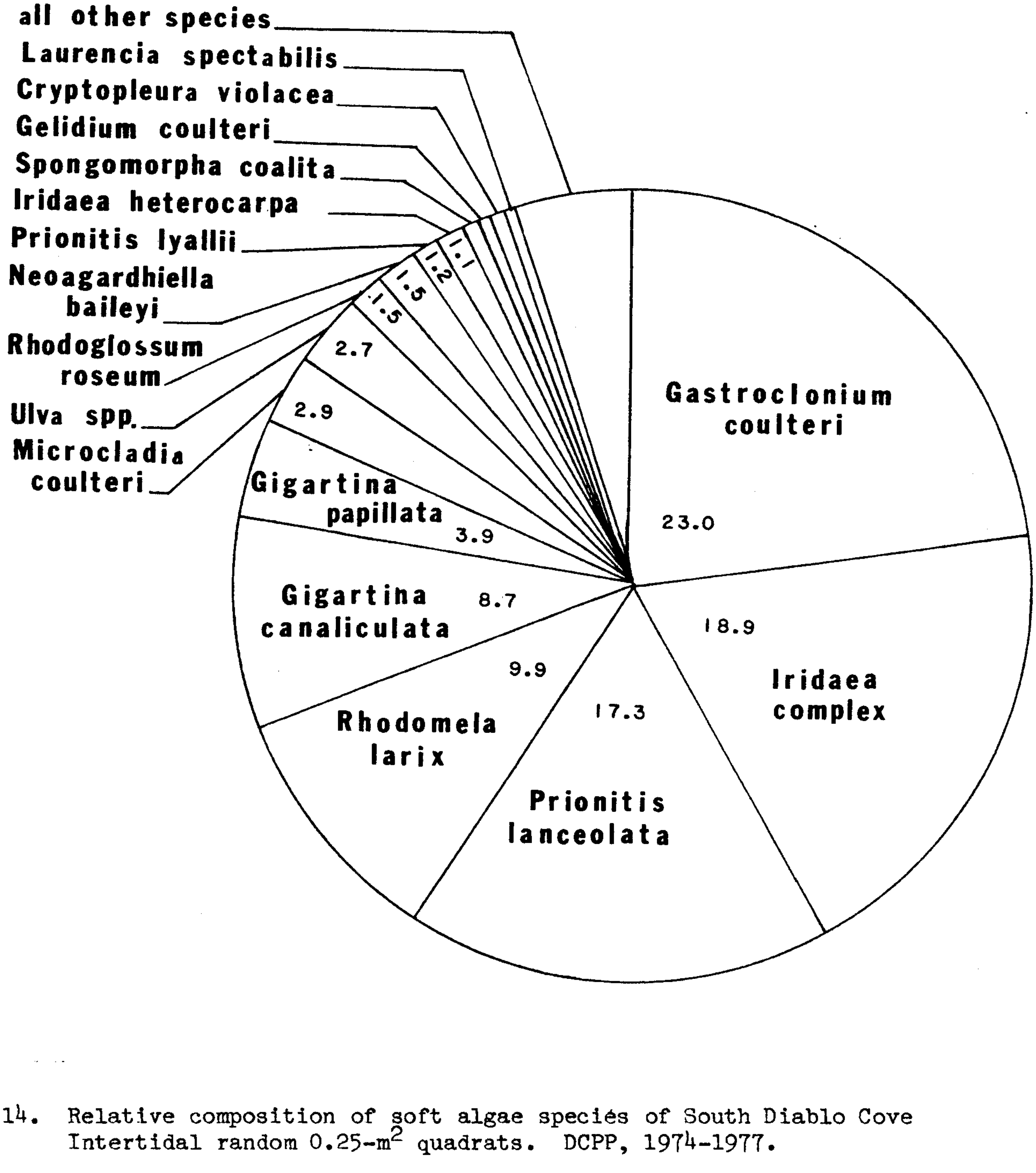


Figure 14. Relative composition of soft algae species of South Diablo Cove Intertidal random 0.25-m^2 quadrats. DCPP, 1974-1977.

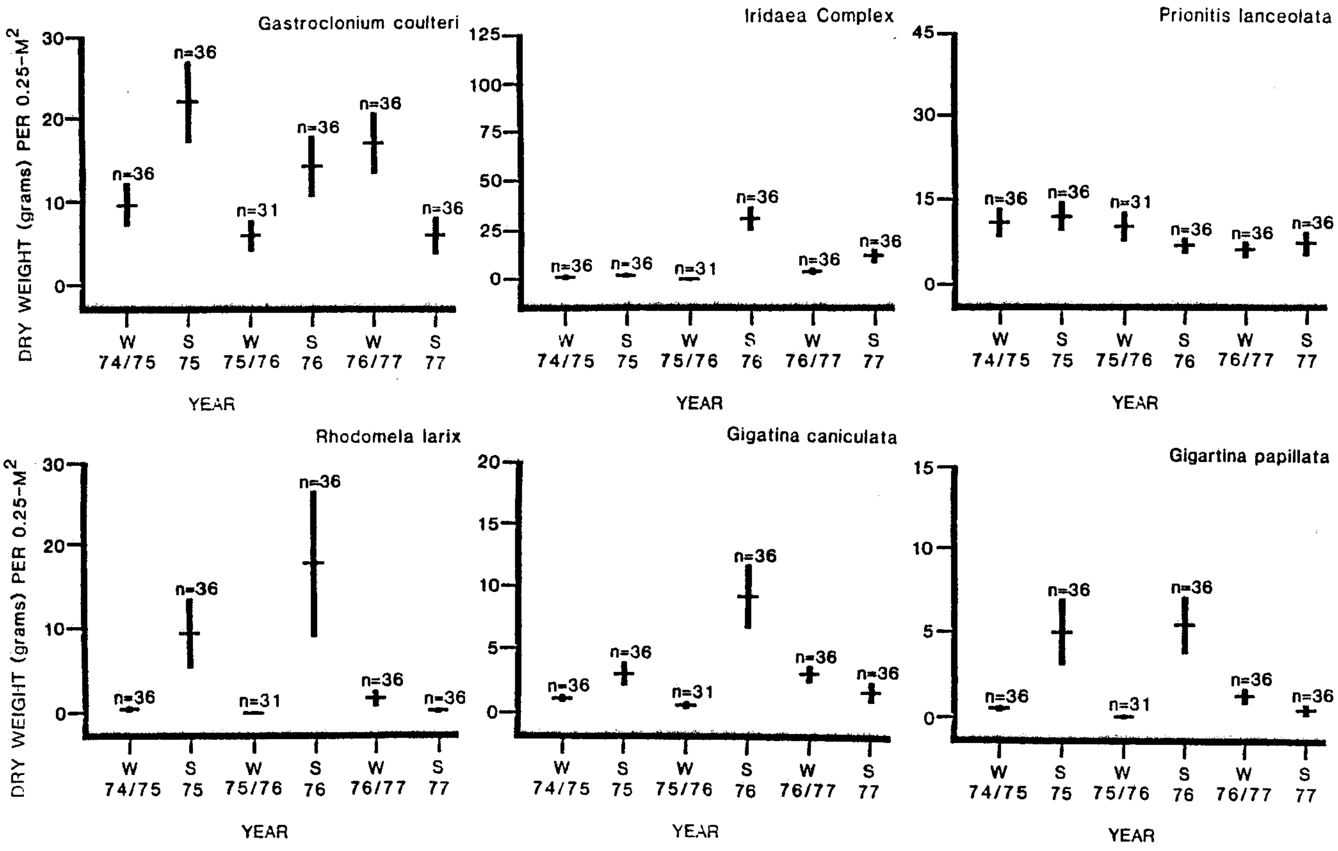


Figure 15. Seasonal biomass means and standard errors of Gastroclonium coulteri, Iridaea complex, Prionitis lanceolata, Rhodomela larix, Gigartina caniculata, and Gigartina papillata from South Diablo Point Intertidal DCPP, 1974-1977.

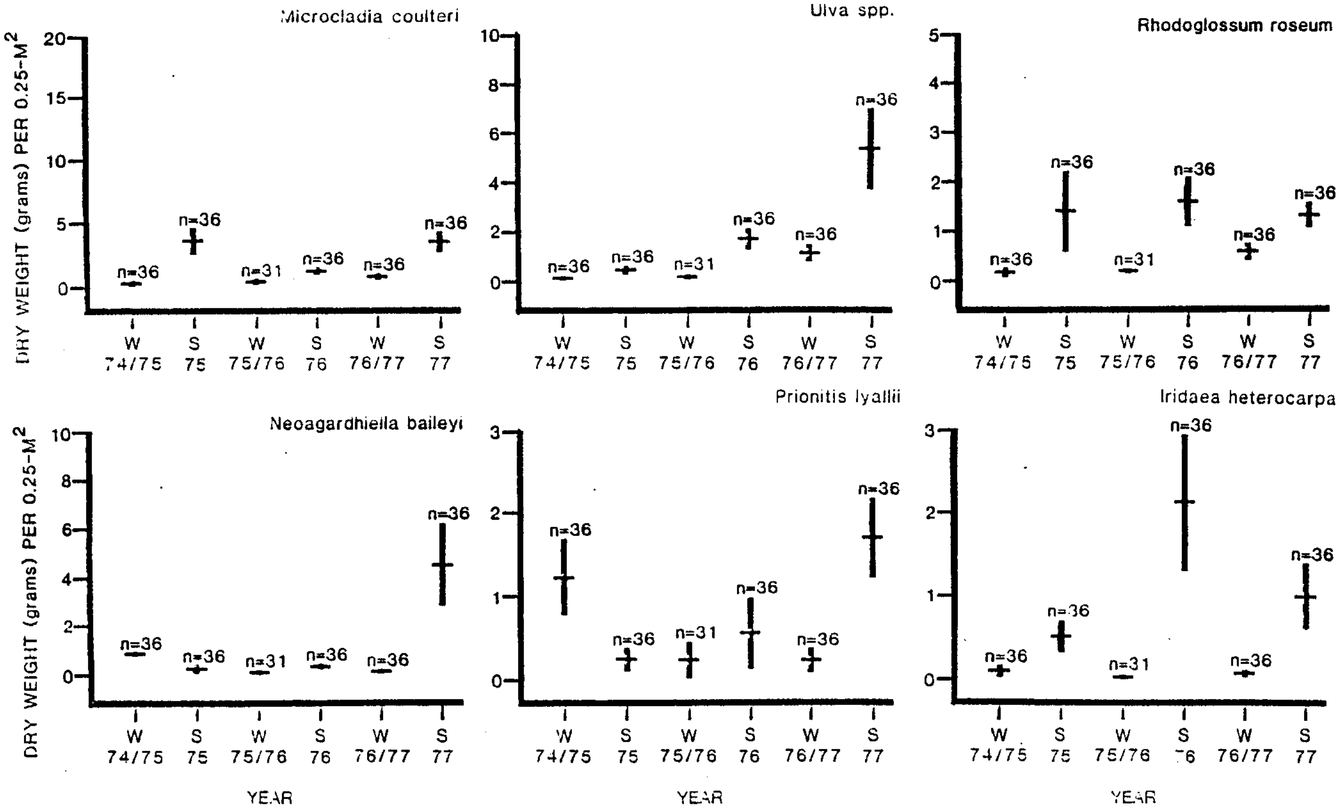


Figure 16. Seasonal biomass means and standard errors of *Microcladia coulteri*, *Ulva* spp., *Rhodoglossum roseum*, *Neoagardhiella baileyi*, *Prionitis lyalli*, and *Iridaea heterocarpa* from South Diablo Cove intertidal.

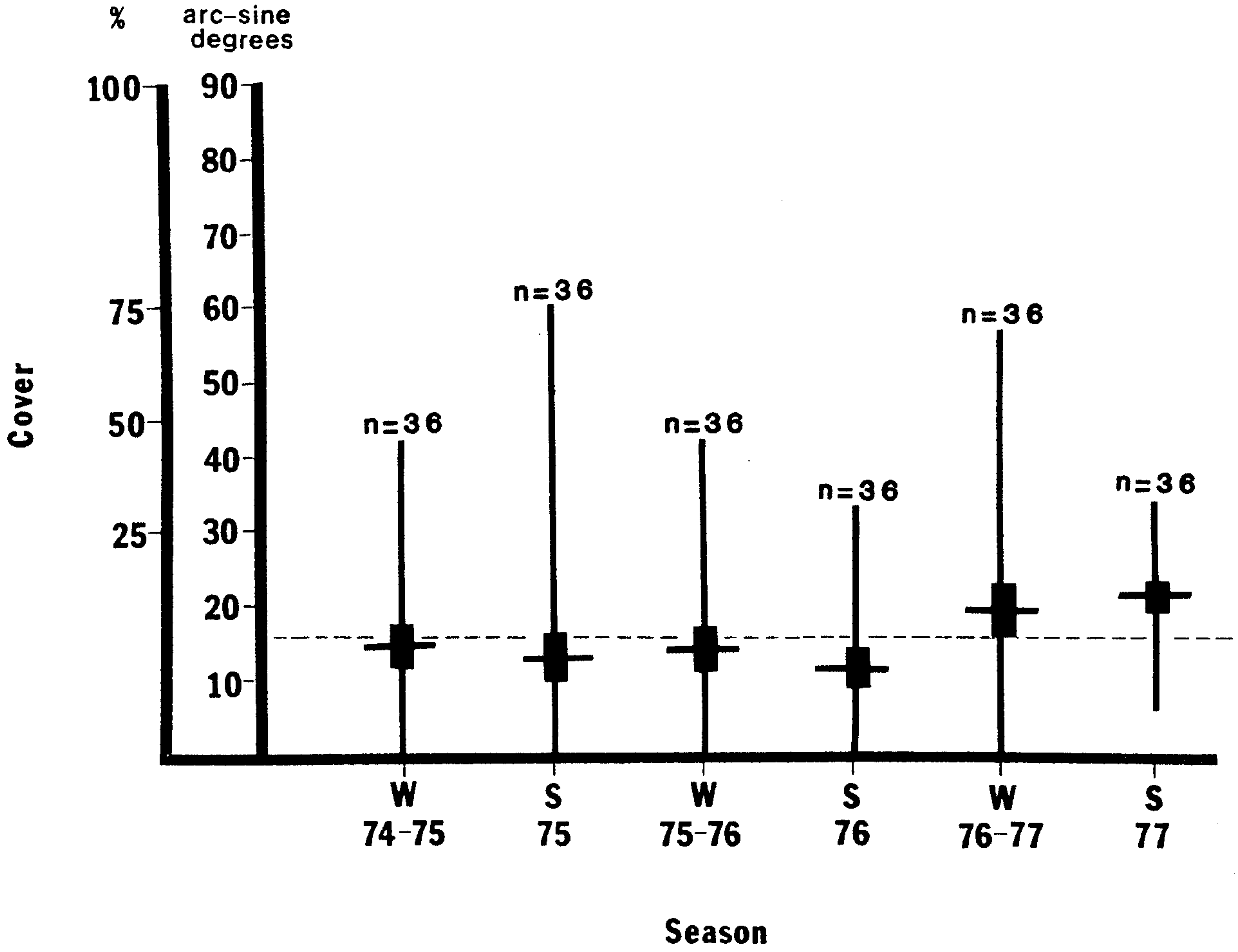


Figure 17. Seasonal means, 95% confidence intervals, and ranges of arc-sine values of articulated coralline algae cover at South Diablo Cove Intertidal. DCPP, 1974-1977. (Horizontal dotted line represents the cumulative mean for all seasons. A percentage axis is provided for reader convenience).

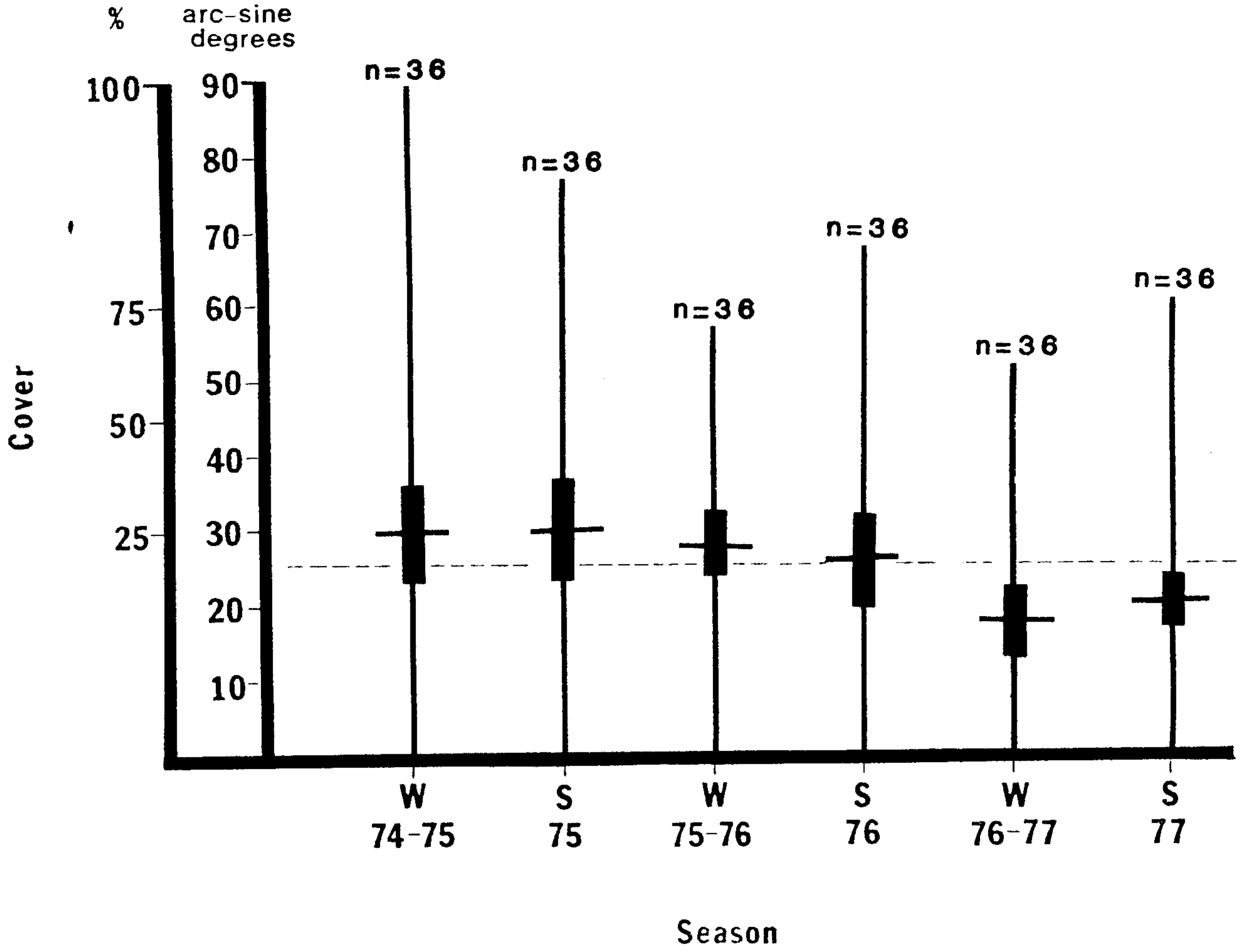


Figure 18. Seasonal means, 95% confidence intervals, and ranges of arc-sine values of Phyllospadix spp. cover at South Diablo Cove Intertidal. DCPP, 1974-1977. (Horizontal dotted line represents the cumulative mean for all seasons. A percentage axis is provided for reader convenience).

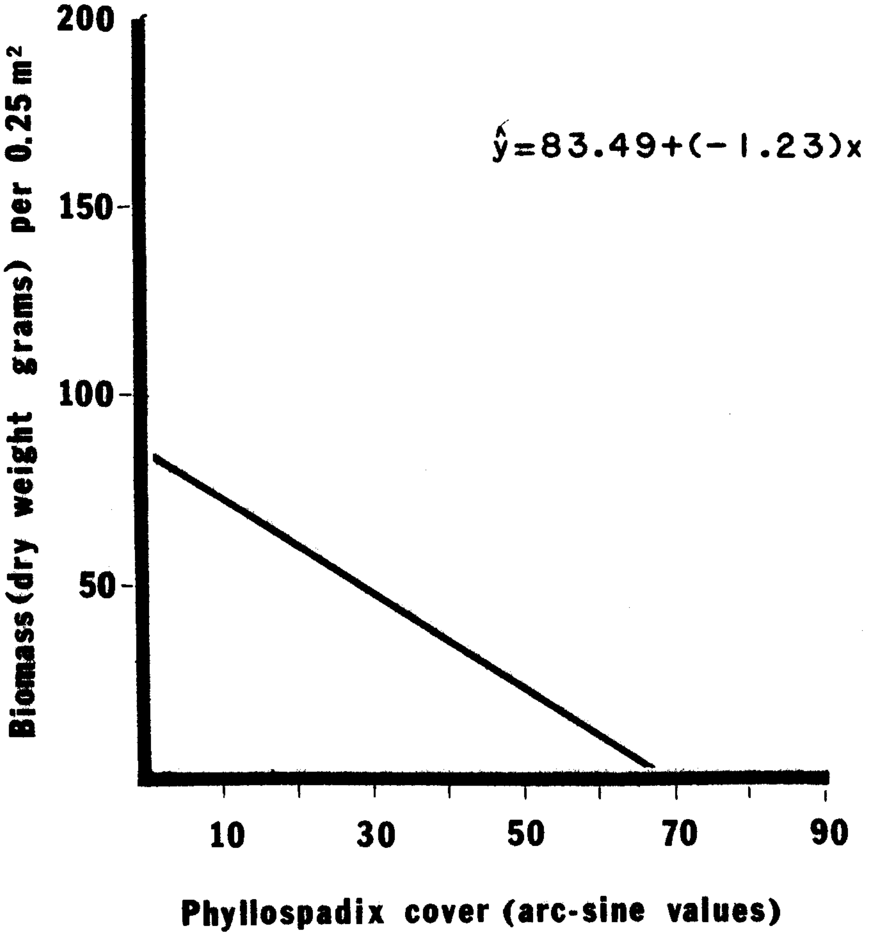


Figure 19. Regression analysis of relationship between Phyllospadix cover and soft red algal biomass at South Diablo Cove Intertidal. DCPP, 1974-1977. (All sampling periods combined).

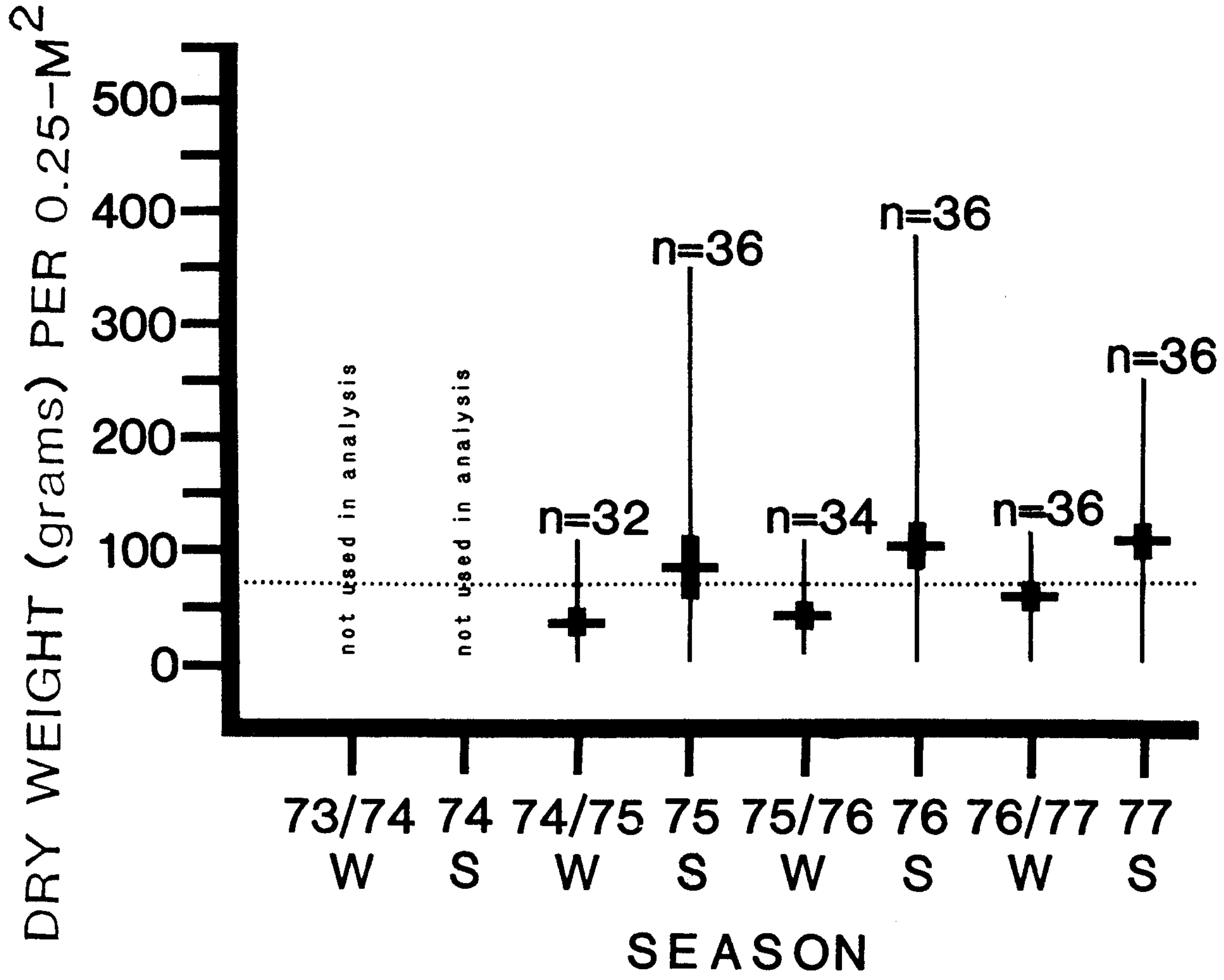


Figure 20. Means, 95% confidence intervals, and ranges of seasonal biomass of soft algae from North Diablo Cove Intertidal. (Horizontal dotted line is cumulative biomass mean for all six sampling periods).

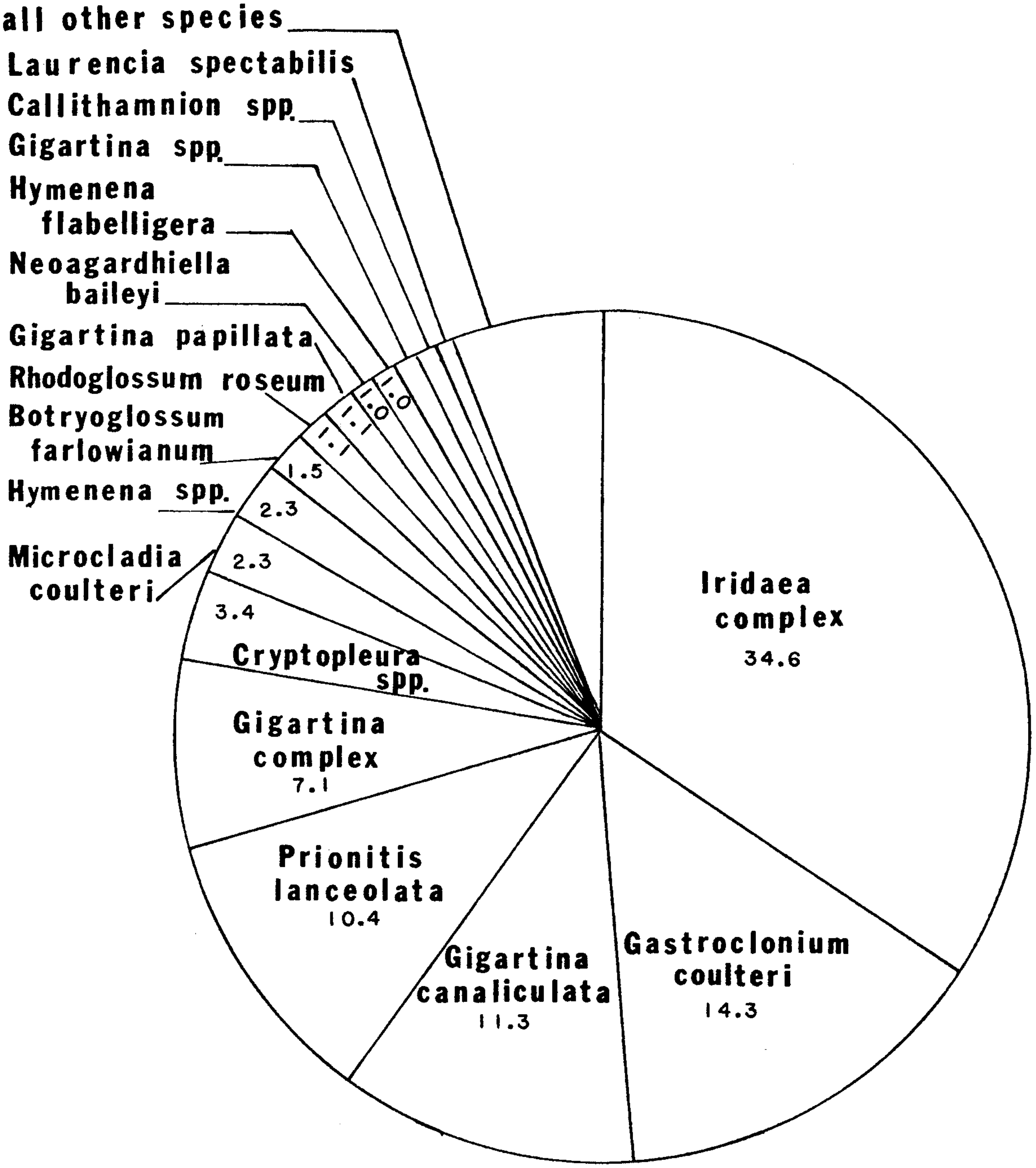


Figure 21. Relative composition of soft algal species at North Diablo Cove Intertidal random 0.25-m^2 quadrats. DCPP, 1974-1977.

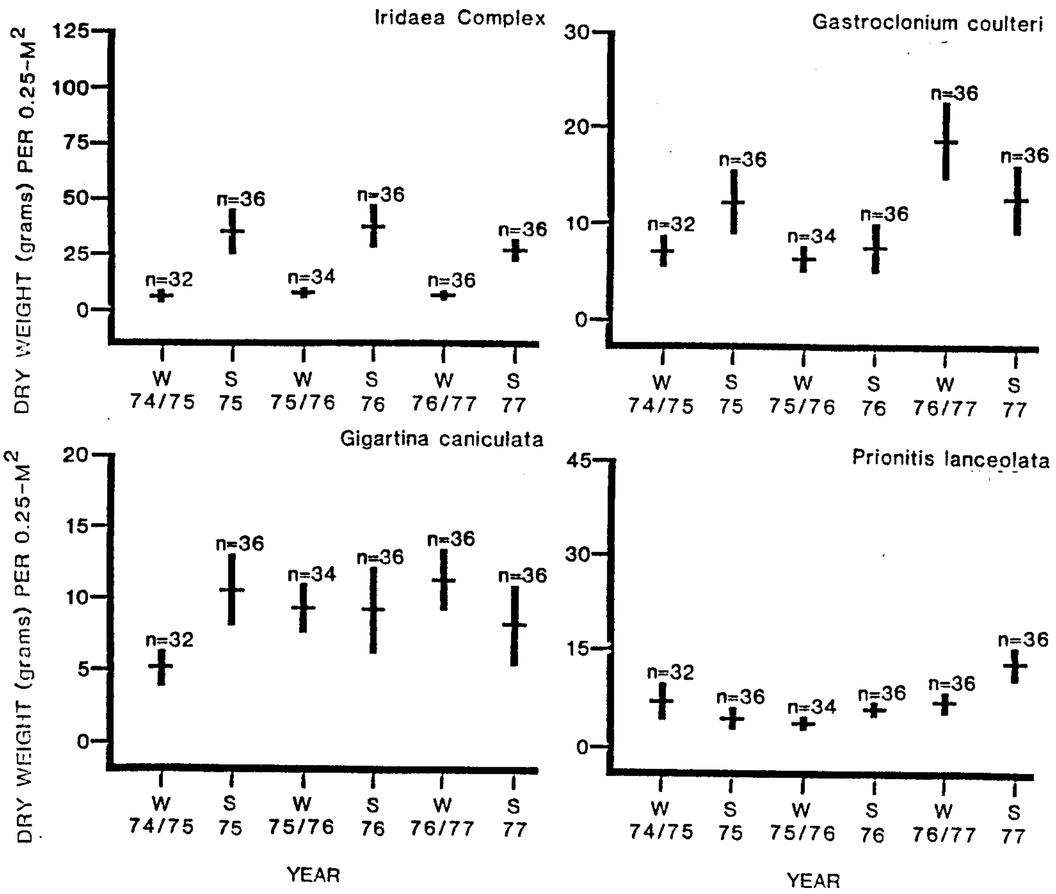


Figure 22. Seasonal biomass means and standard errors of Iridaea complex, Gastroclonium coulteri, Gigartina caniculata, and Prionitis lanceolata from North Diablo Cove Intertidal. DCPP, 1974-1977.

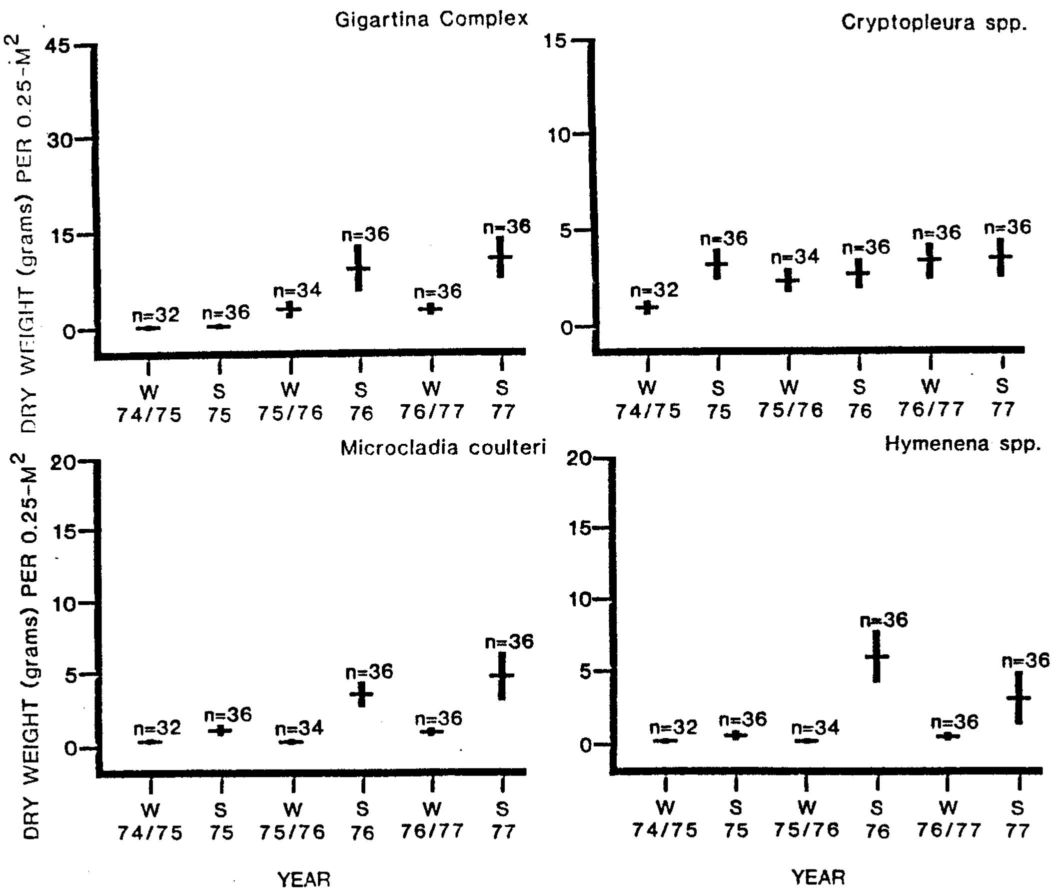


Figure 23. Seasonal biomass means and standard errors of Gigartina complex, Cryptopleura spp., Microcladia coulteri, Hymenena spp. from North Diablo Cove Intertidal. DCPP, 1974-1977.

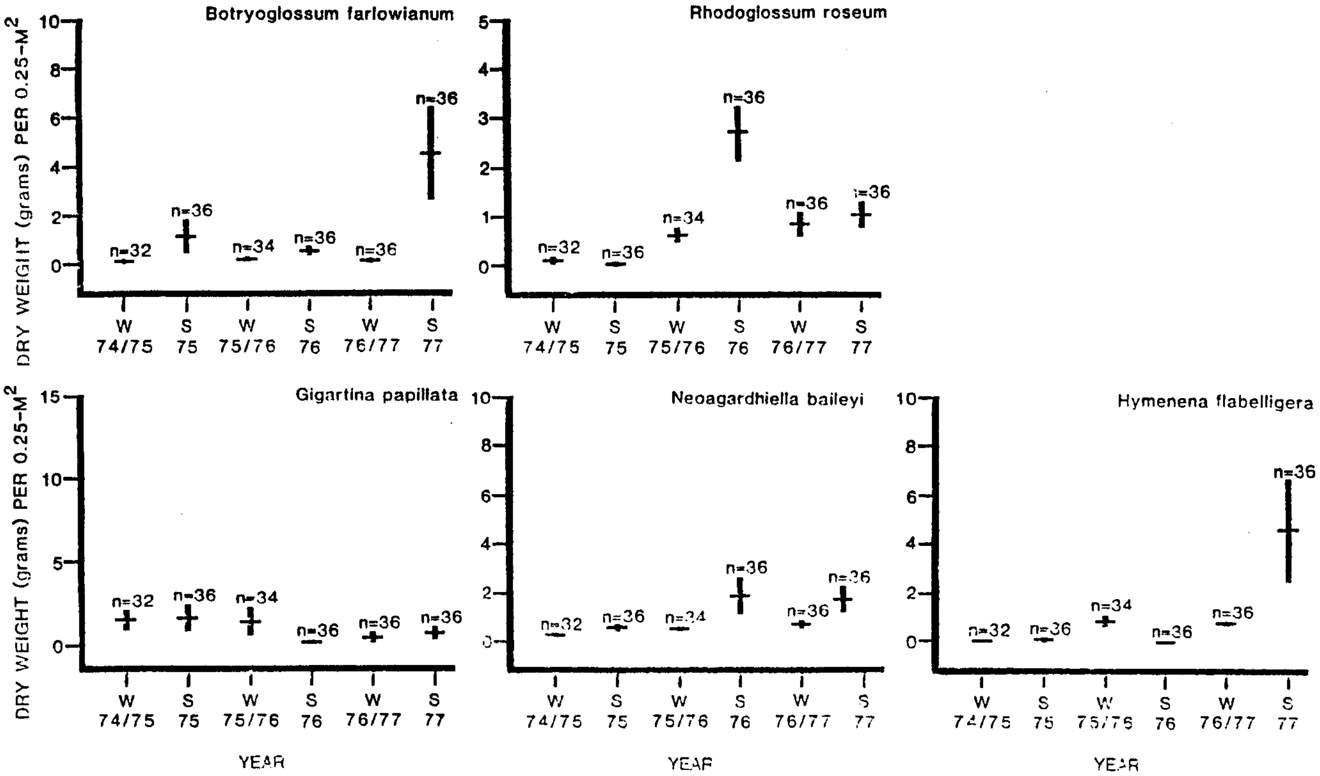


Figure 24. Seasonal biomass means and standard errors of Botryoglossum farlowianum, Rhodoglossum roseum, Gigartina papillata, Neoagardiella baileyi, and Hymenena flabelligera from North Diablo Cove Intertidal.

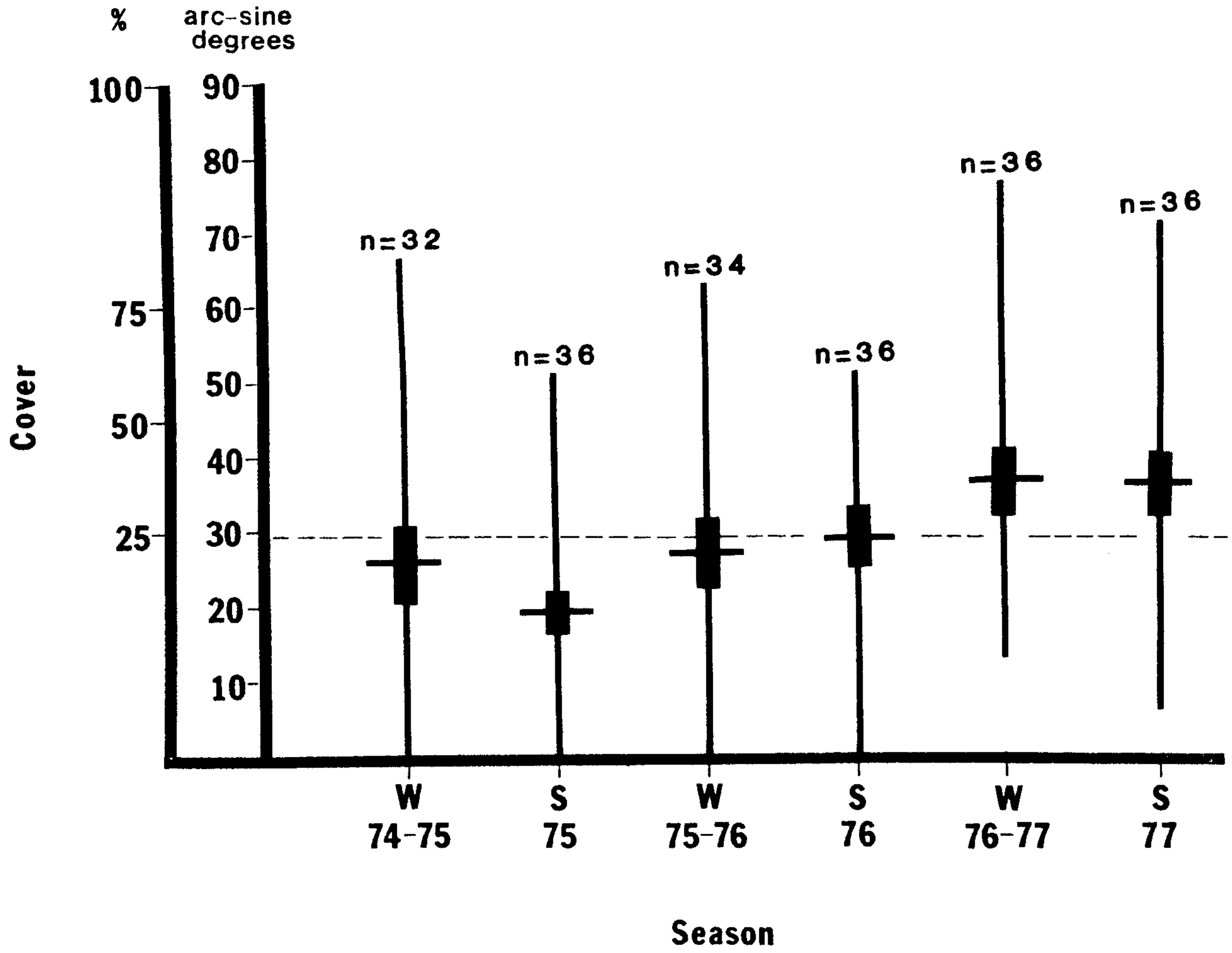


Figure 25. Seasonal means, 95% confidence intervals, and ranges of arc-sine values of articulated coralline algae at North Diablo Cove Intertidal. DCPP, 1974-1977. (Horizontal dotted line represents the cumulative mean for all seasons. A percentage axis is provided for reader convenience).

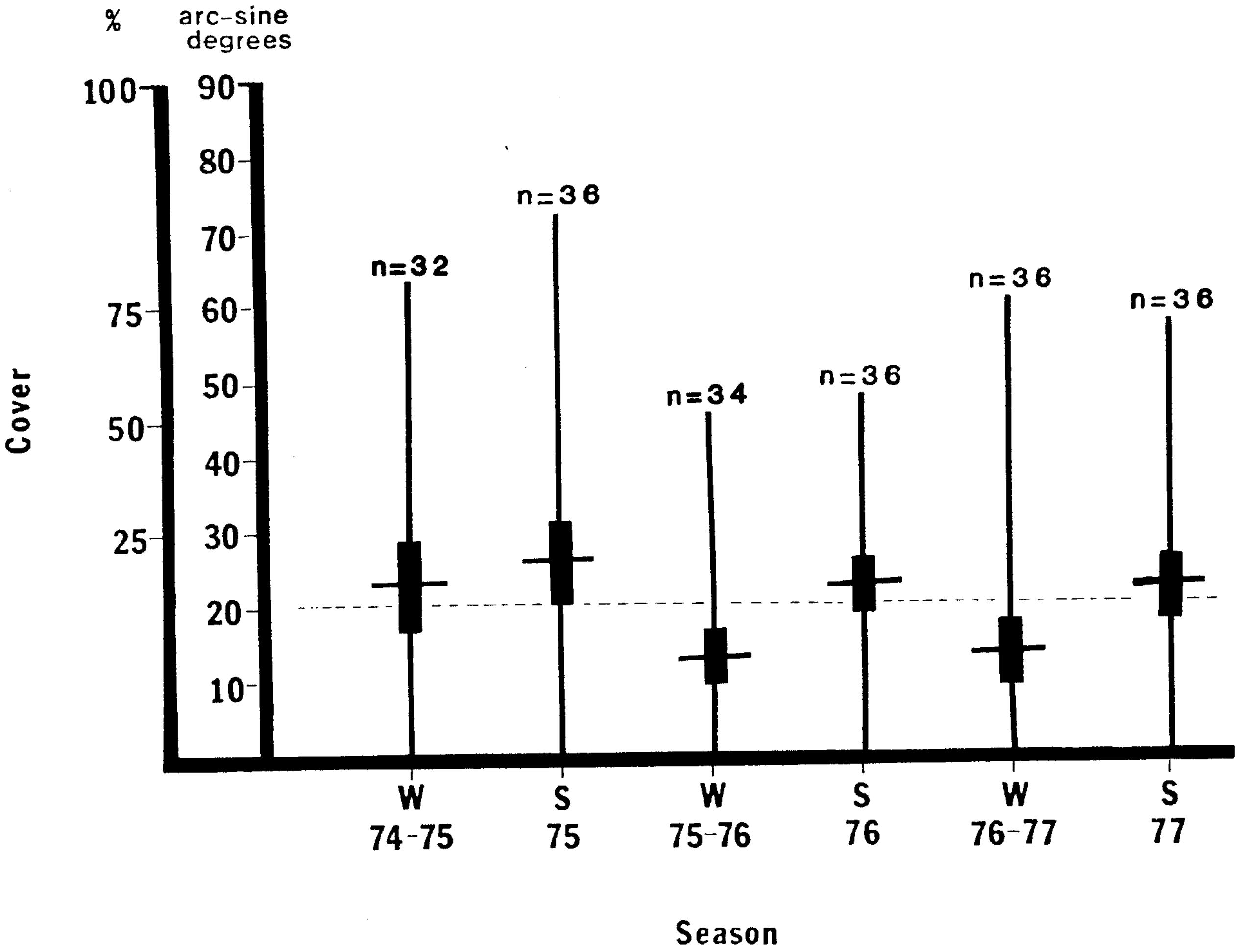


Figure 26. Seasonal means, 95% confidence intervals, and ranges of Phyllospadix spp. cover at North Diablo Cove Intertidal. DCPP, 1974-1977. (Horizontal dotted line represents the cumulative mean for all seasons. A percentage axis is provided for reader convenience).

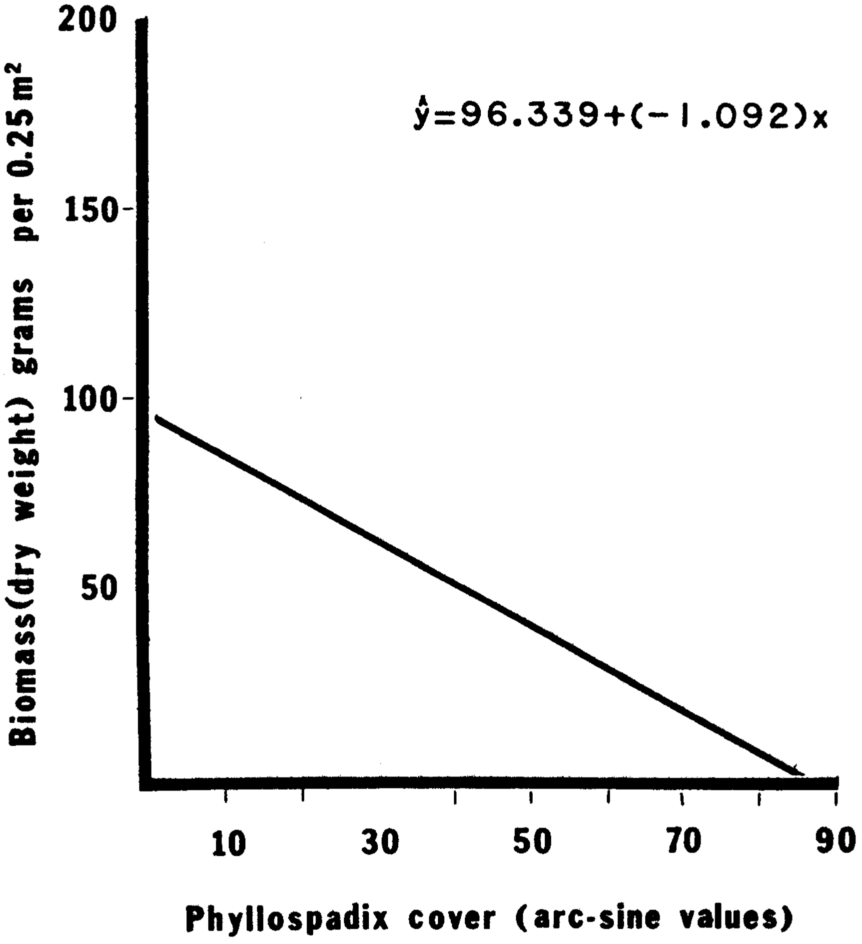


Figure 27. Regression analysis of relationship between Phyllospadix cover and soft algal biomass at North Diablo Cove Random Intertidal. 0.25-m^2 quadrats. DCPP, 1974-1977.

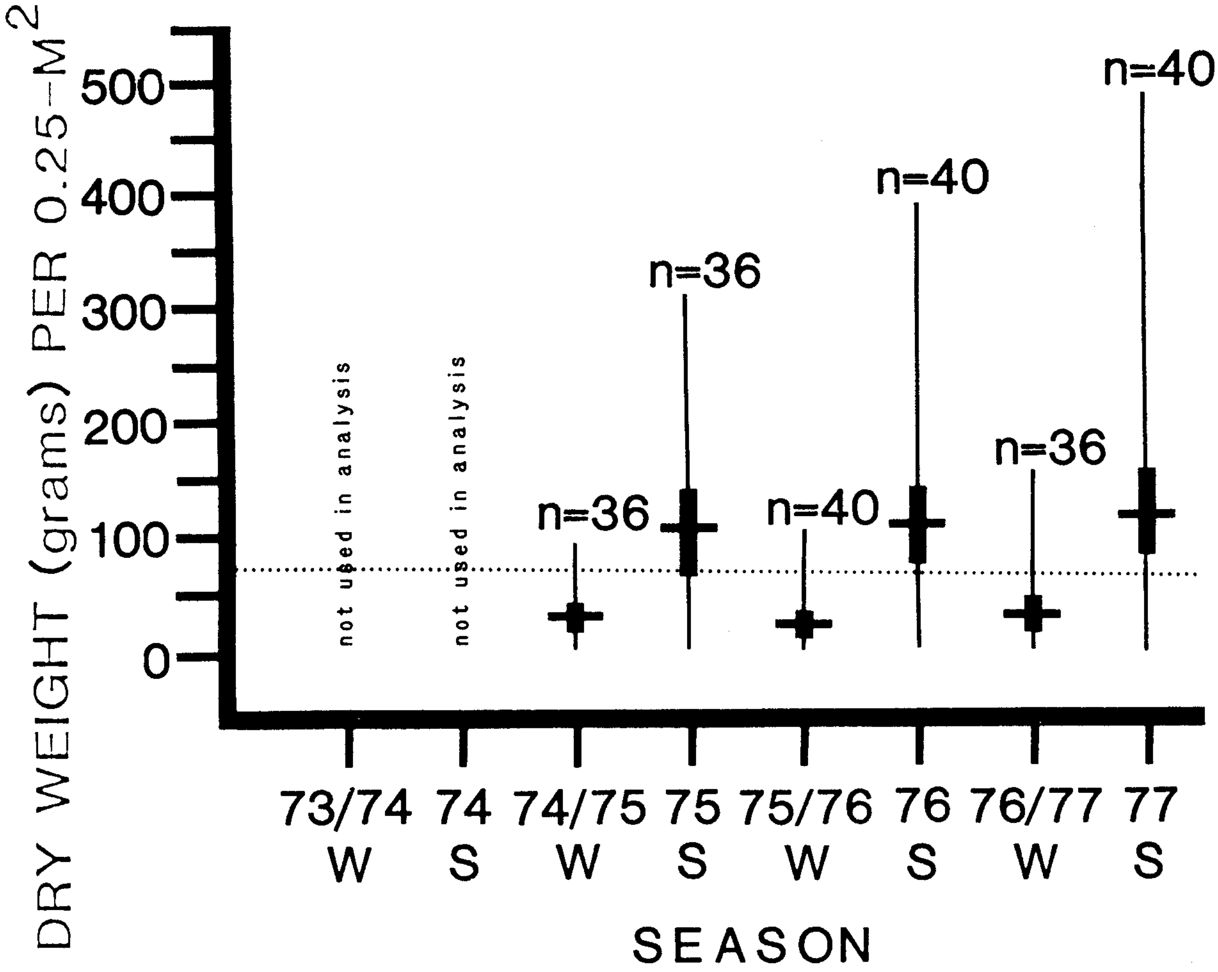


Figure 28. Means, 95% confidence intervals, and ranges of seasonal biomass of soft red algae from North Control Intertidal. DCPP, 1974-1977. (Dotted horizontal line is cumulative mean for all six sampling periods).

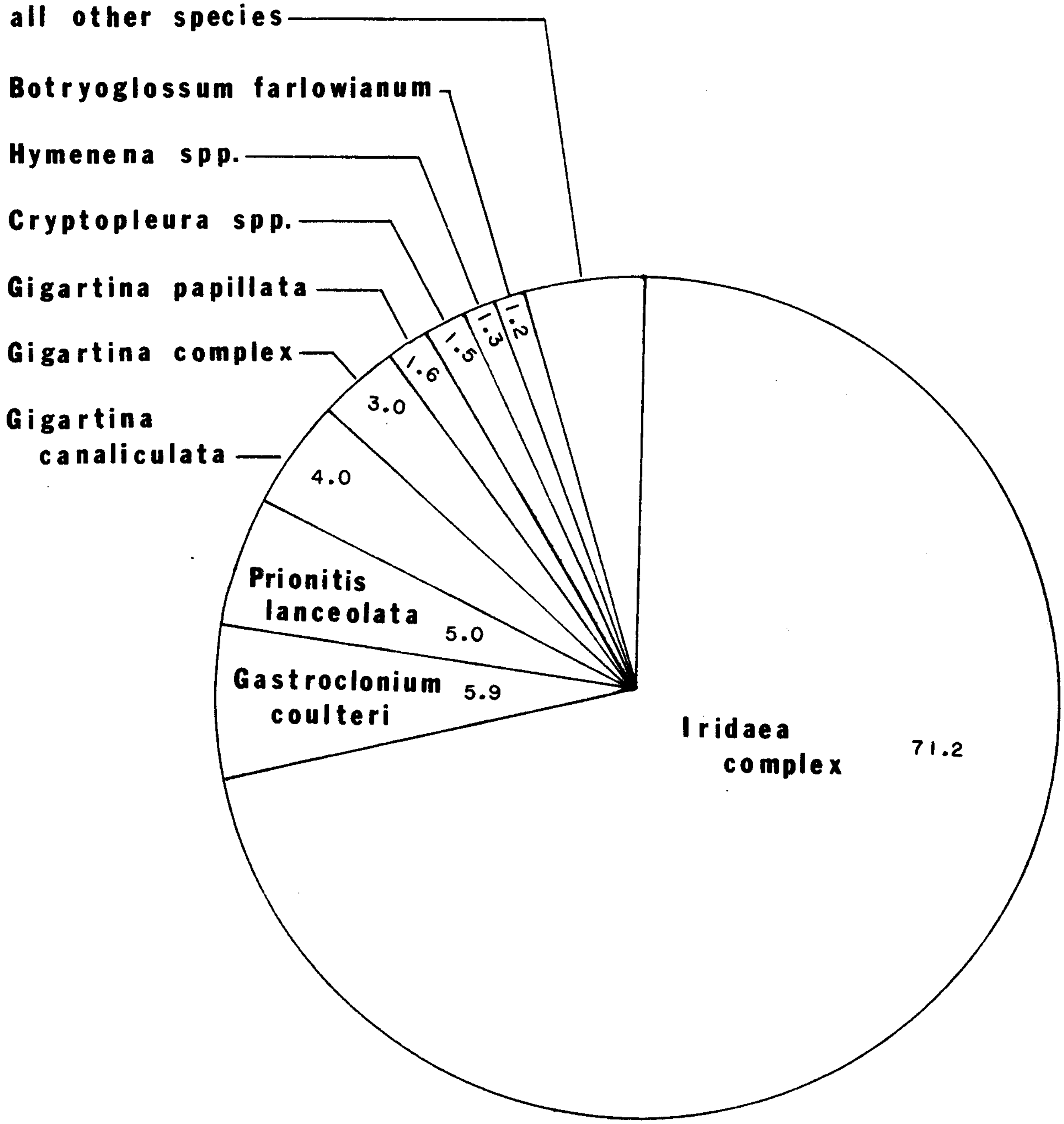


Figure 29. Relative composition of soft algal species at North Control Intertidal random 0.25-m^2 quadrats. DCPP, 1974-1977.

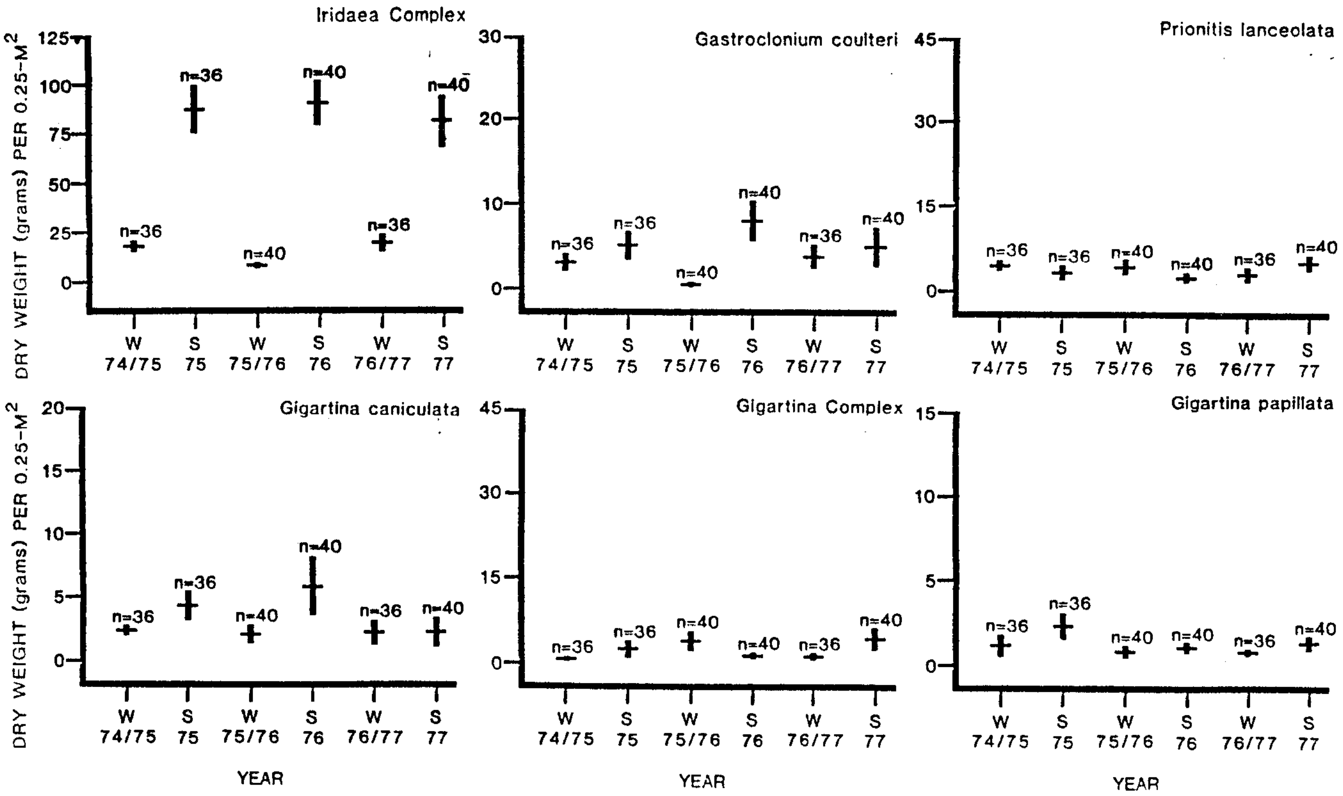


Figure 30. Seasonal biomass means and standard errors of Iridaea complex, Gastroclonium coulteri, Prionitis lanceolata, Gigartina caniculata, Gigartina complex, and Gigartina papillata from North Control Intertidal. DCPP, 1974-1977.

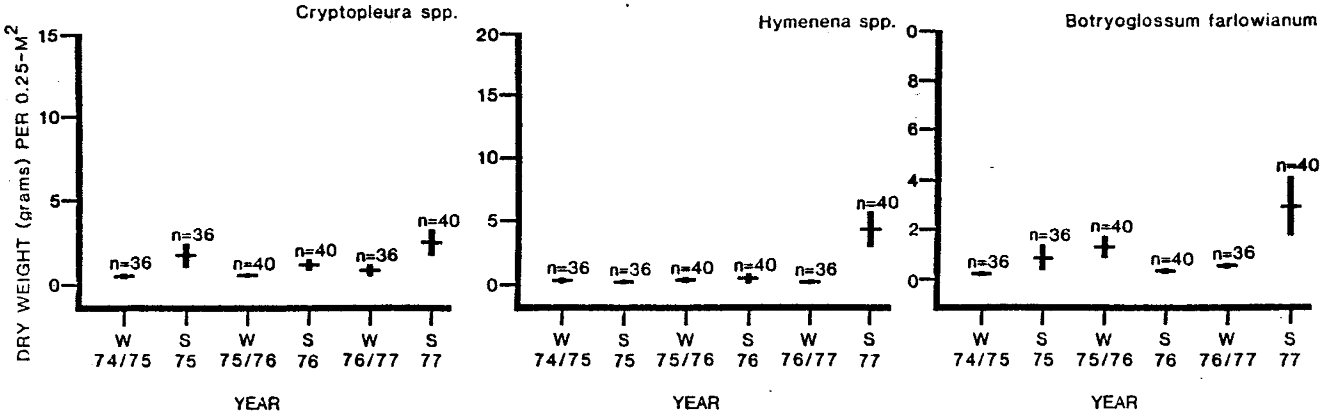


Figure 31. Seasonal biomass means and standard errors of <u>Cryptopleura</u> spp., <u>Hymenena</u> spp., and <u>Botryoglossum</u> <u>farlowianum</u> from North Control Intertidal. DCPP, 1974-1977.

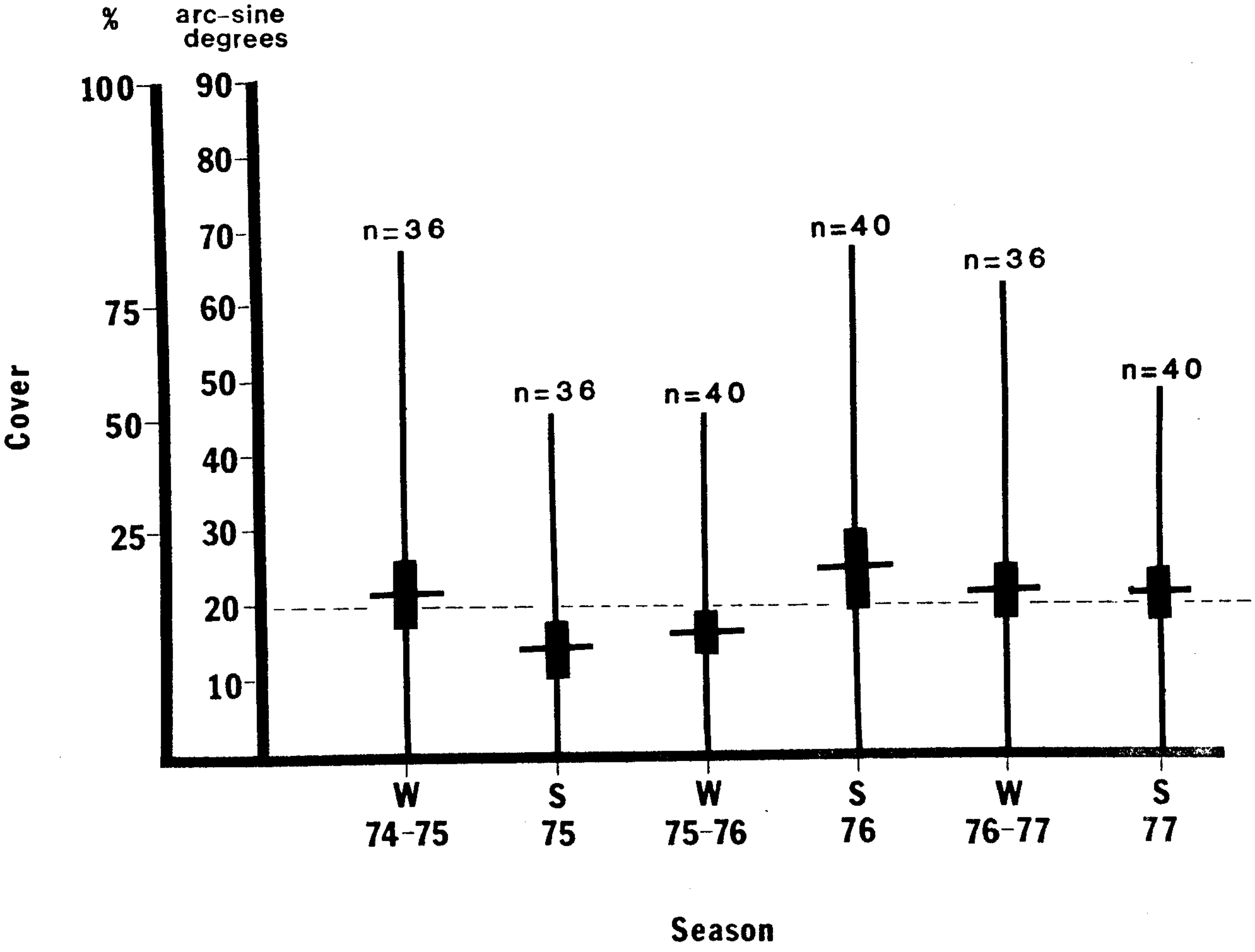


Figure 32. Seasonal means, 95% confidence intervals, and ranges of arc-sine values of articulated coralline algae cover at North Control Intertidal. DCPP, 1974-1977. (Horizontal dotted line represents the cumulative mean for all seasons. A percentage axis is provided for reader convenience).

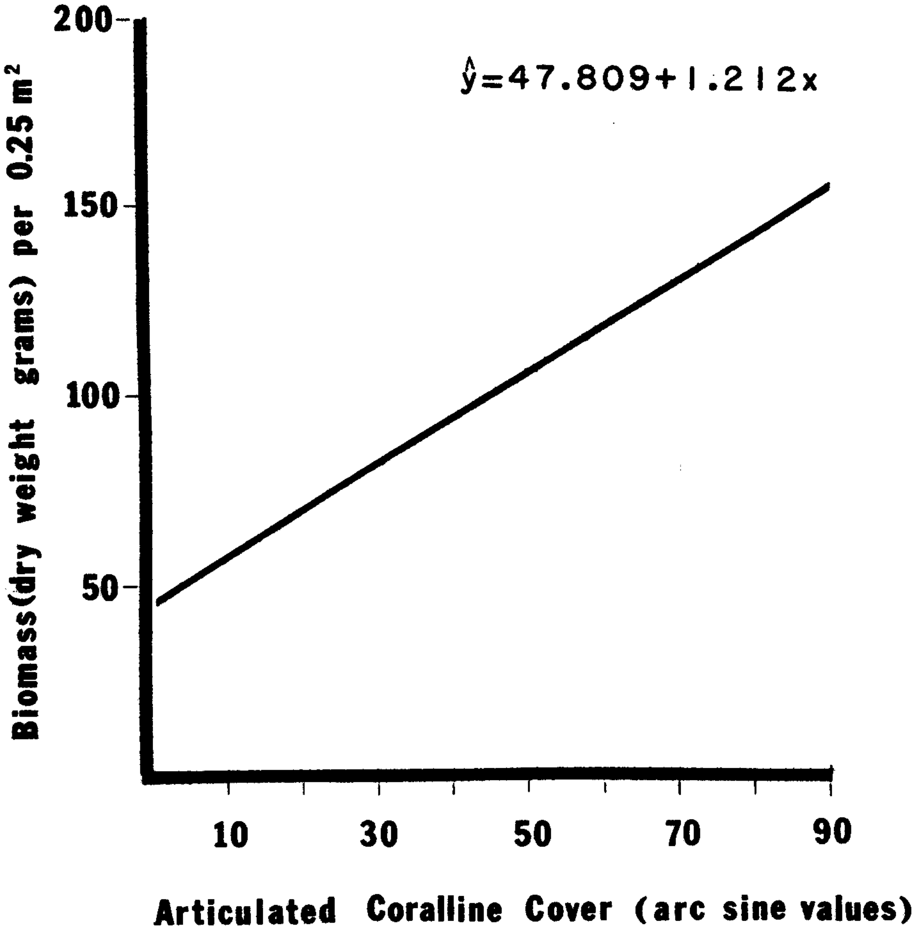


Figure 33. Regression analysis of relationship between articulated coralline algae cover and soft algal biomass at North Control Random Intertidal. 0.25-m^2 quadrats. DCPP, 1974-1977.

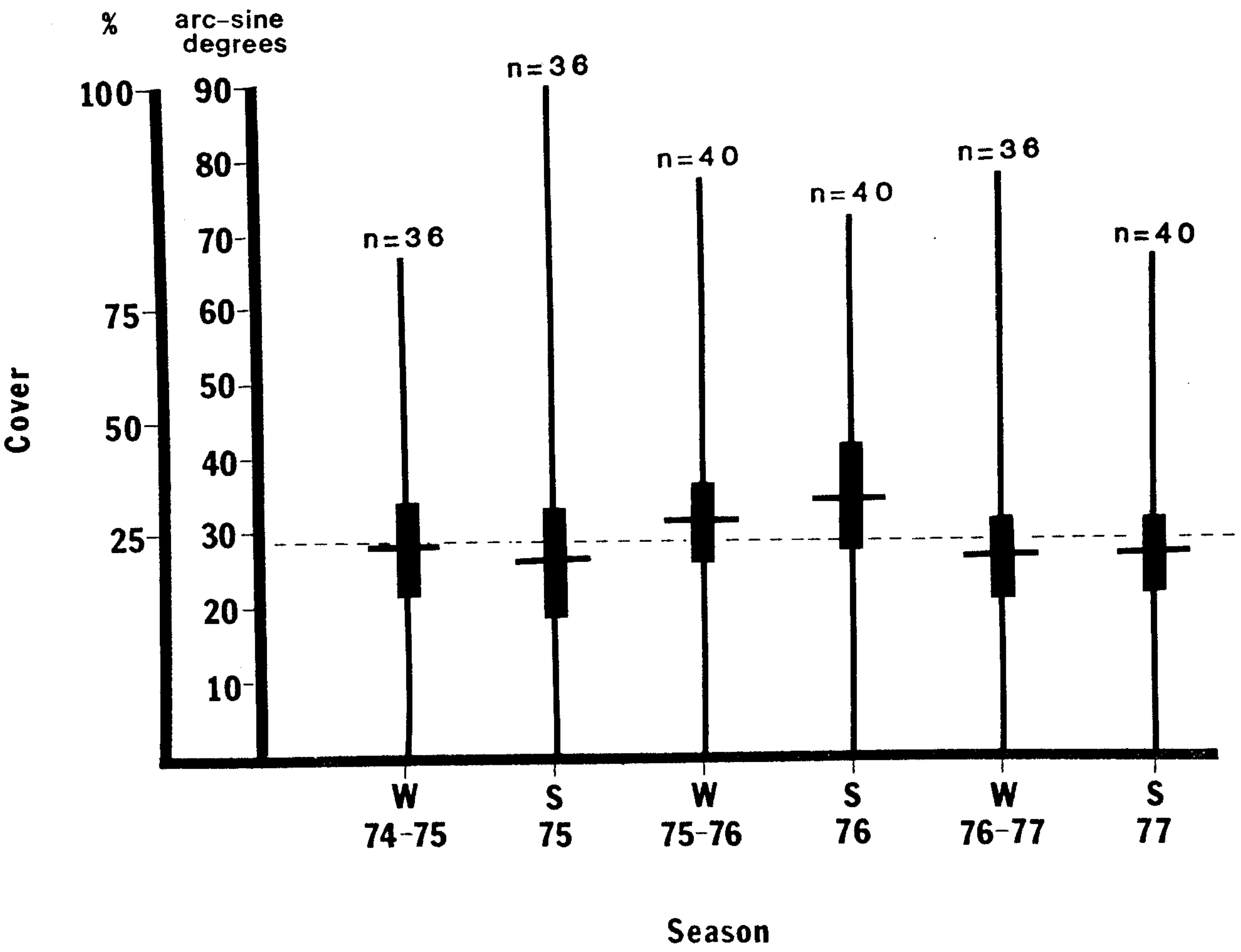


Figure 34. Seasonal means, 95% confidence intervals, and ranges of arc-sine values of *Phyllospadix* spp. cover at North Control Intertidal. DCPP, 1974-1977. (Horizontal dotted line represents the cumulative mean for all seasons. A percentage axis is provided for reader convenience).

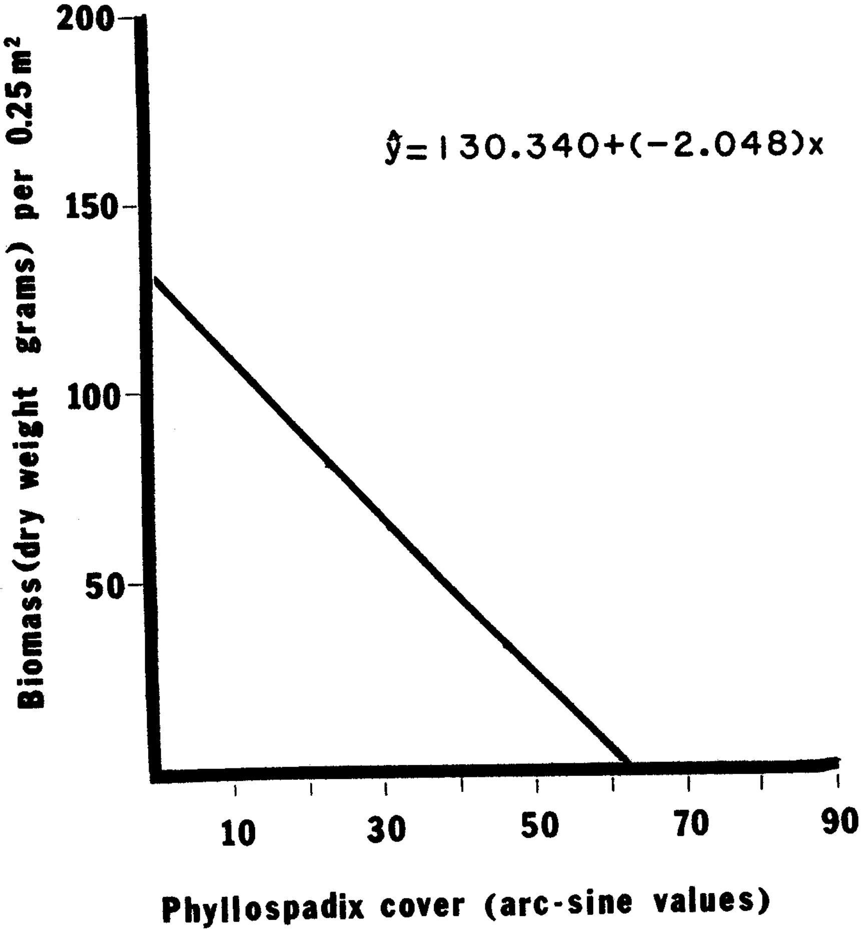
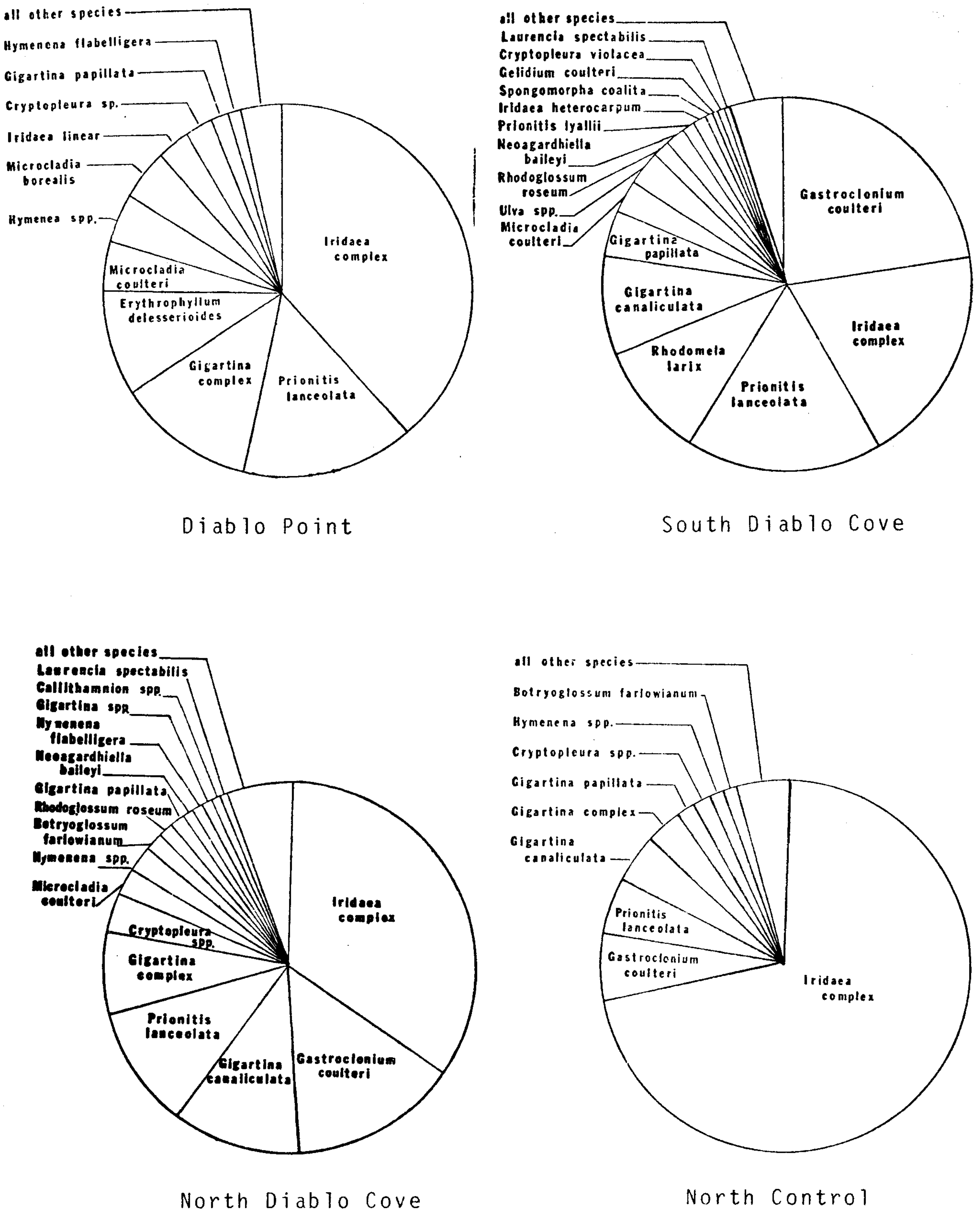


Figure 35. Regression analysis of relationship between *Phyllospadix* cover and soft algal biomass at North Control Random Intertidal. 0.25-m^2 quadrats. DCPP, 1974-1977.



Diablo Point

South Diablo Cove

North Diablo Cove

North Control

Figure 36. Relative composition of dominant soft algae species at the four intertidal study areas. DCPP, 1973-1977.
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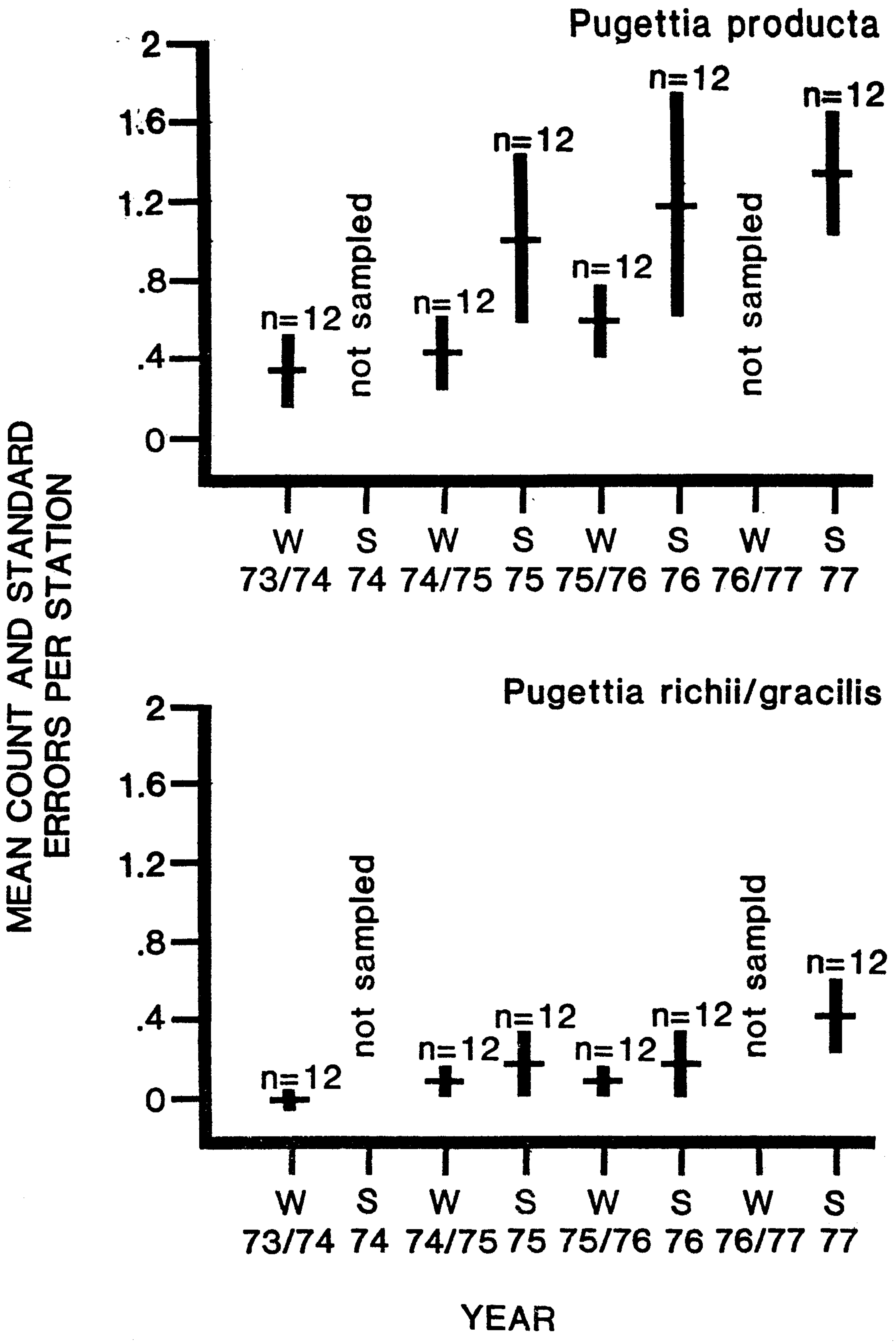


Figure 37. Seasonal abundance (means and standard errors) of Pugettia producta and Pugettia richii/gracilis at Diablo Point Intertidal. DCPP, 1973-1977.

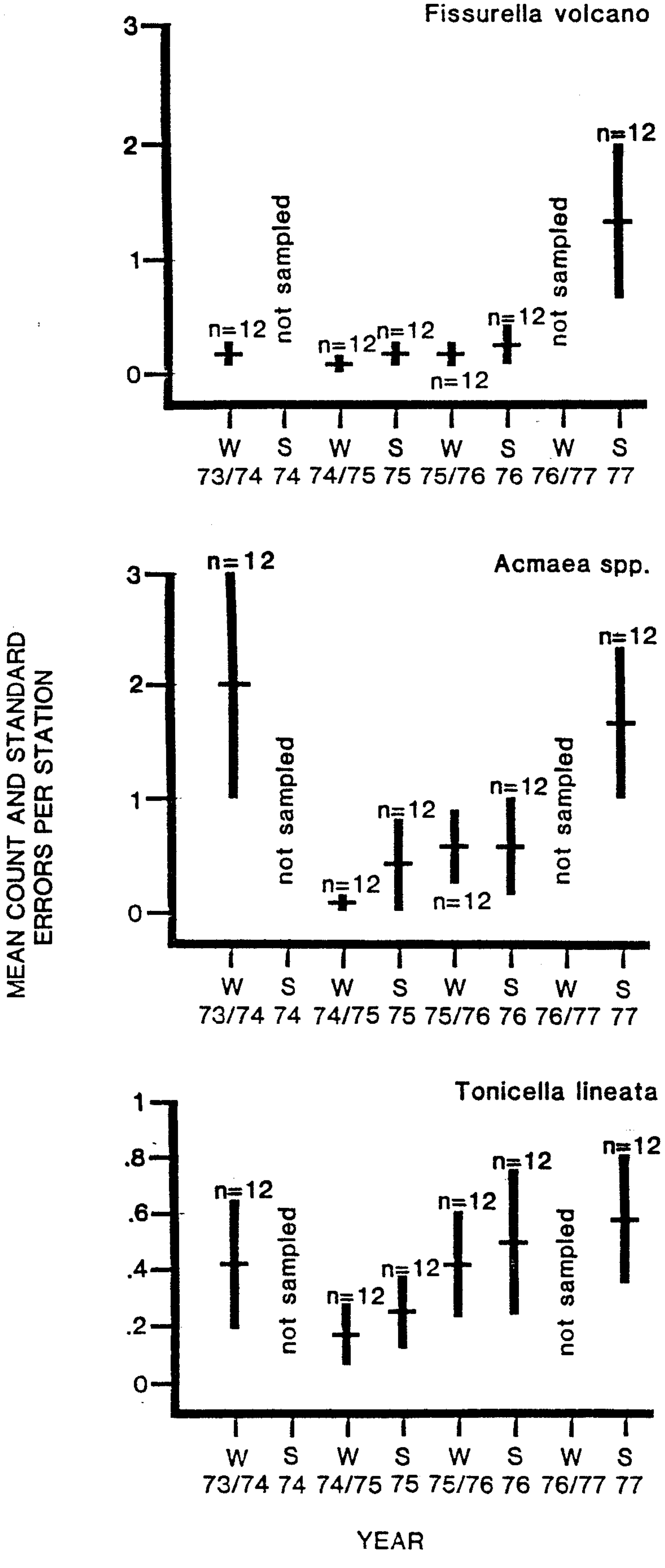


Figure 38. Seasonal abundance (means and standard errors) of Fissurella volcano, Acmaea spp., and Tonicella lineata at Diablo Point Intertidal. DCPP, 1973-1977.

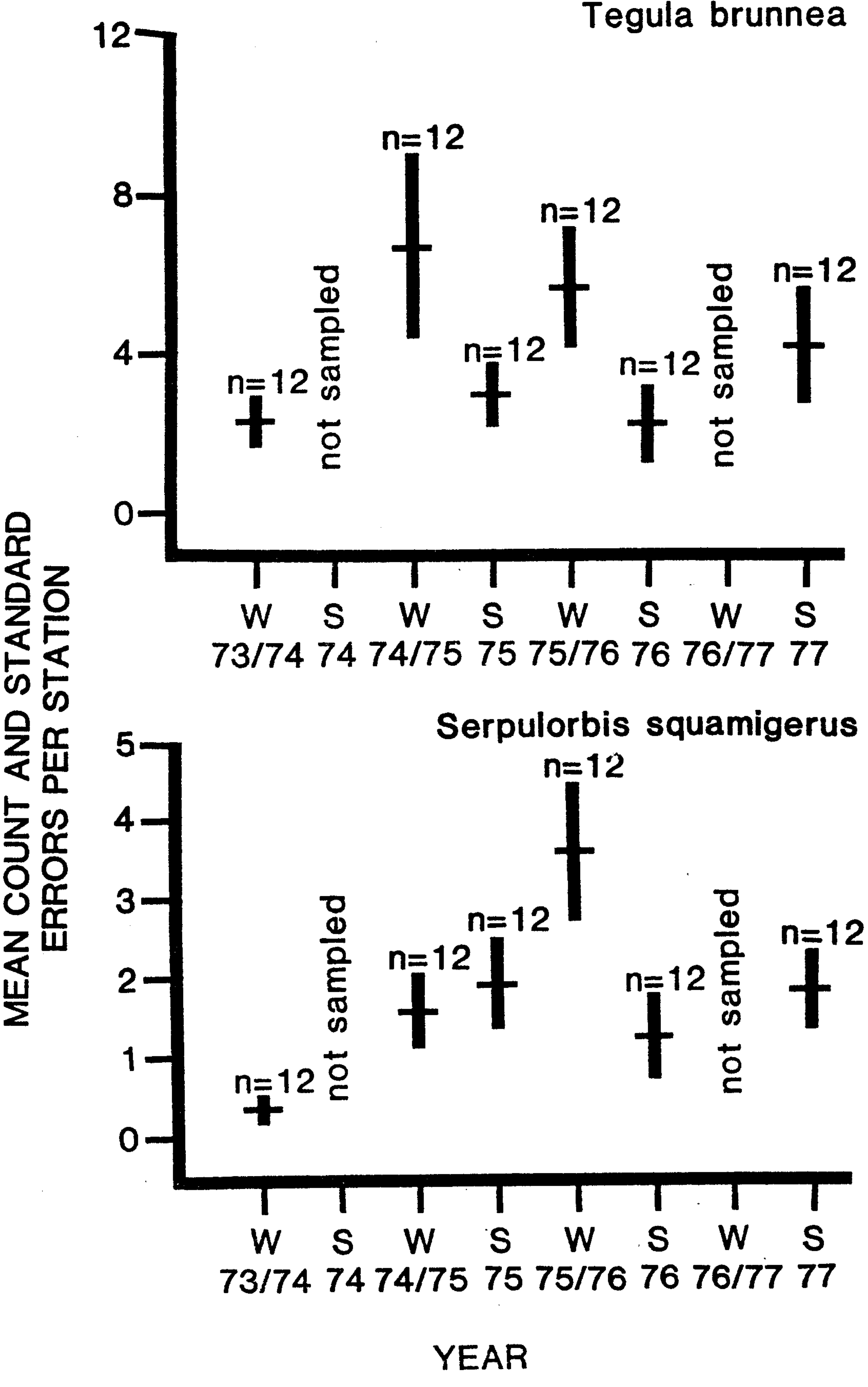


Figure 39. Seasonal abundance (means and standard errors) of Tegula brunnea and Serpulorbis squamigerus at Diablo Point Intertidal. DCPP. 1973-1977.

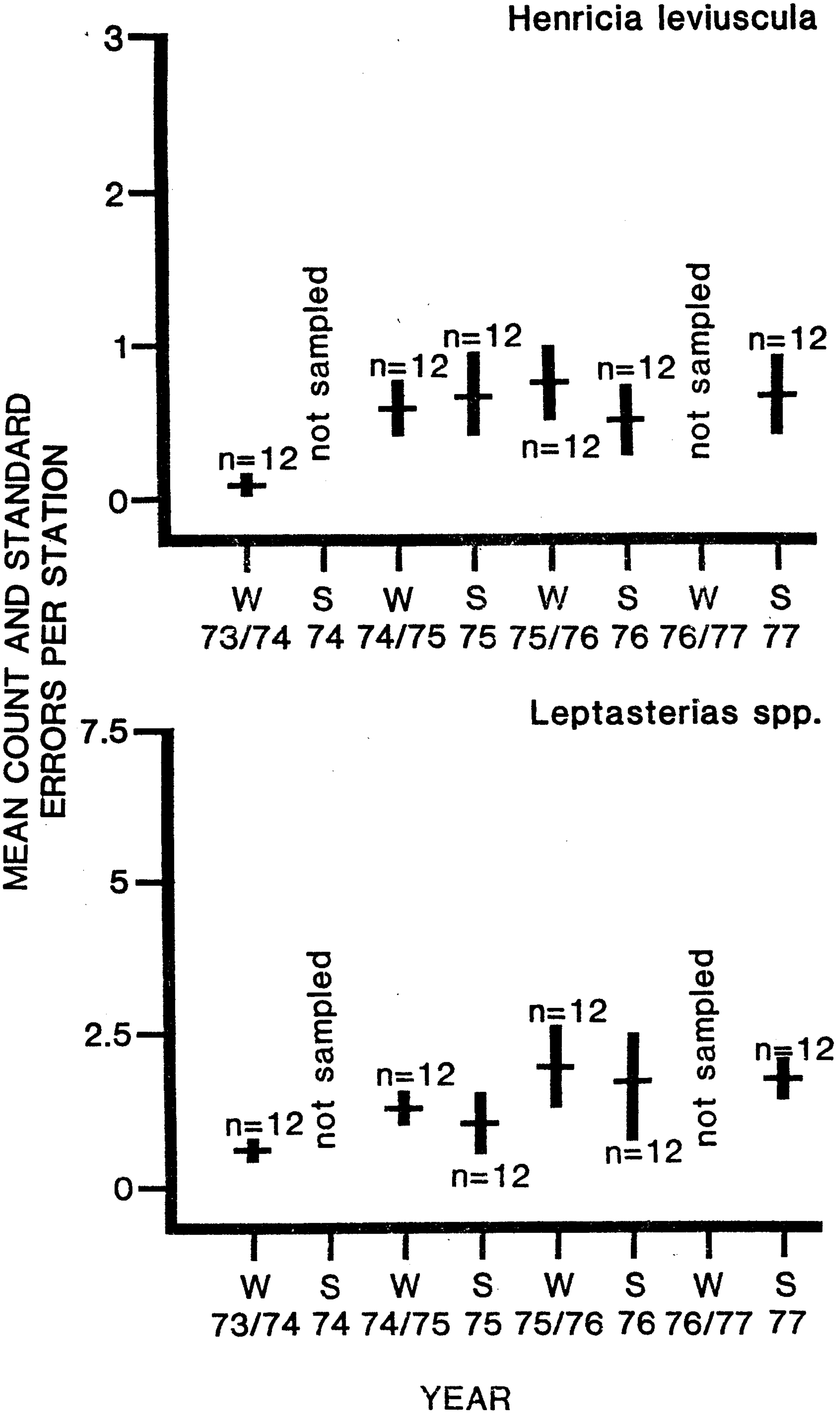


Figure 40. Seasonal abundance (means and standard errors) of Henricia leviuscula and Leptasterias spp. at Diablo Point Intertidal. DCPP. 1974-1977.

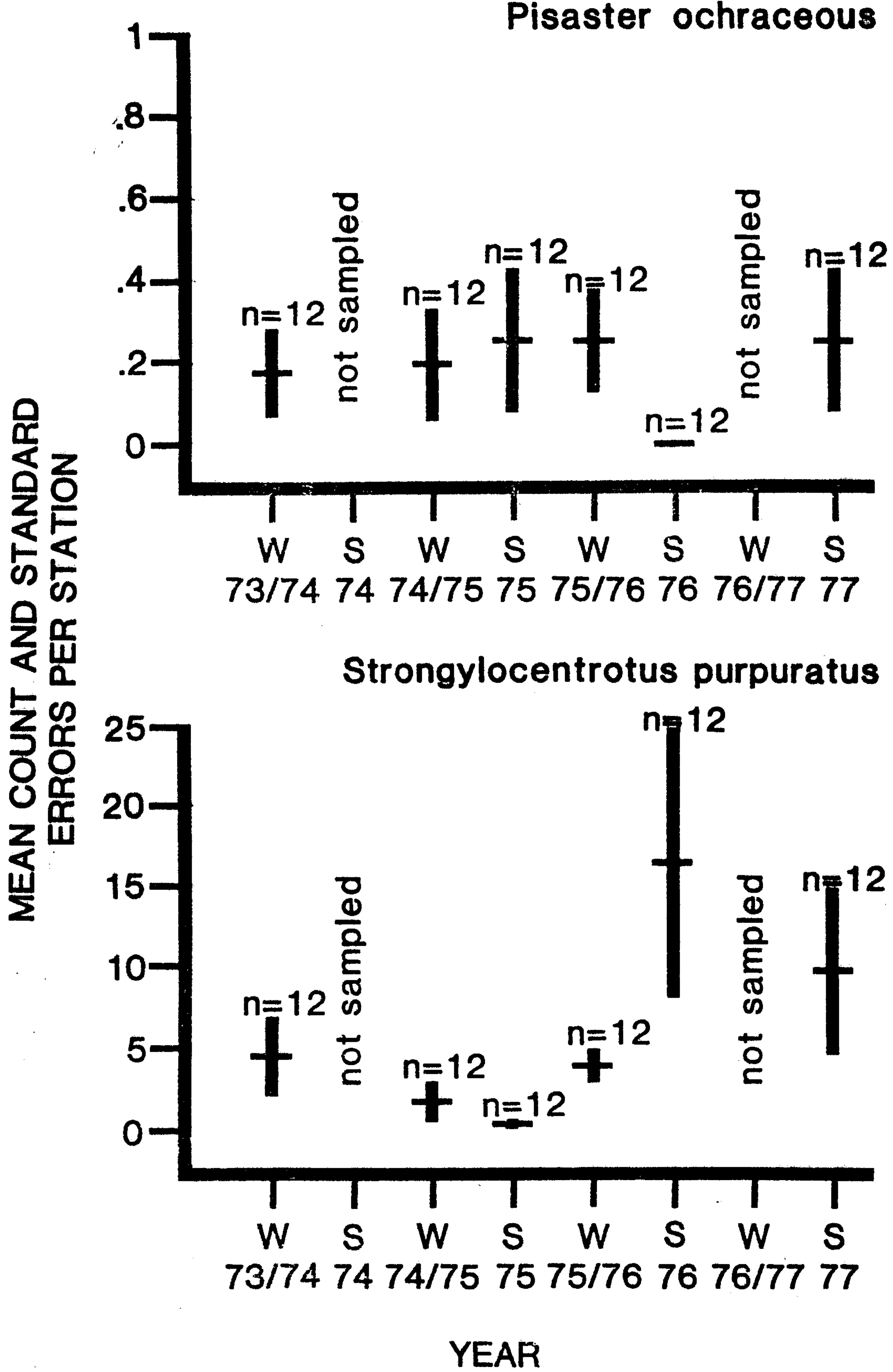


Figure 41. Seasonal abundance (means and standard errors) of *Pisaster ochraceous* and *Strongylocentrotus purpuratus* at Diablo Point Intertidal. DCPP, 1973-1977.

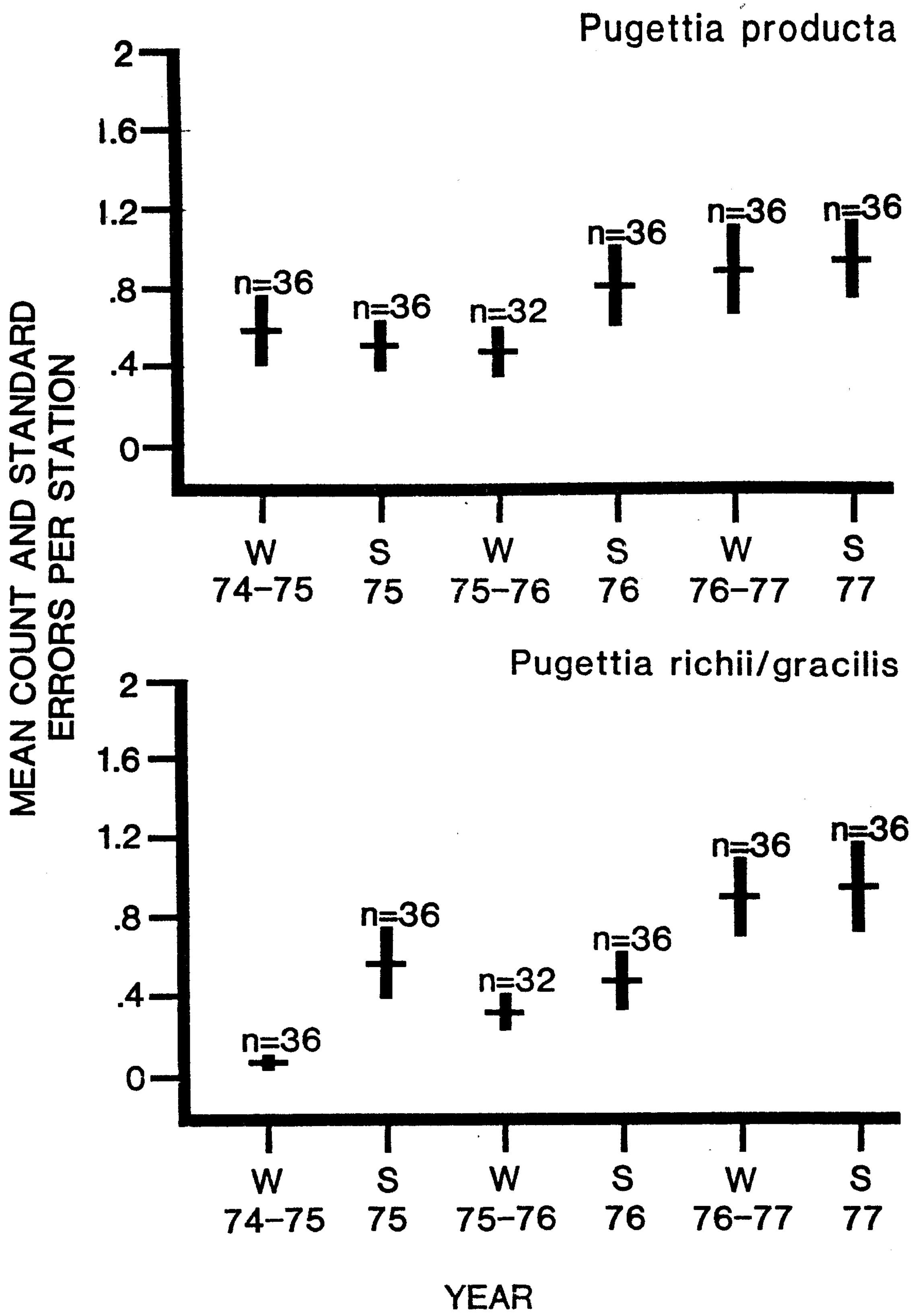


Figure 42. Seasonal abundance (means and standard errors) of Pugettia producta and Pugettia richii/gracilis at Diablo Point Intertidal. DCPP. 1974-1977.

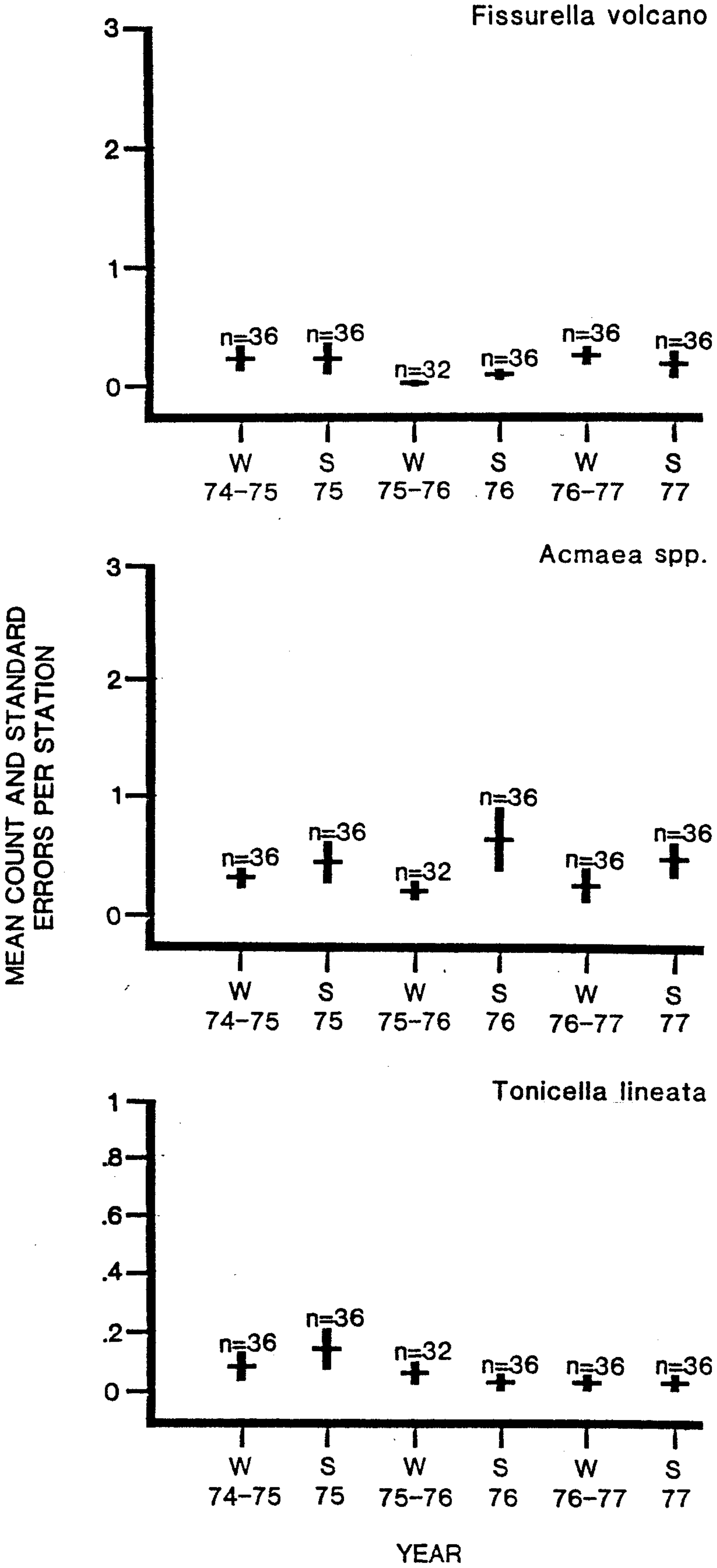


Figure 43. Seasonal abundance (means and standard errors) of Fissurella volcano, Acmaea spp., and Tonicella lineata at South Diablo Cove Intertidal. DCPP, 1974-1977.

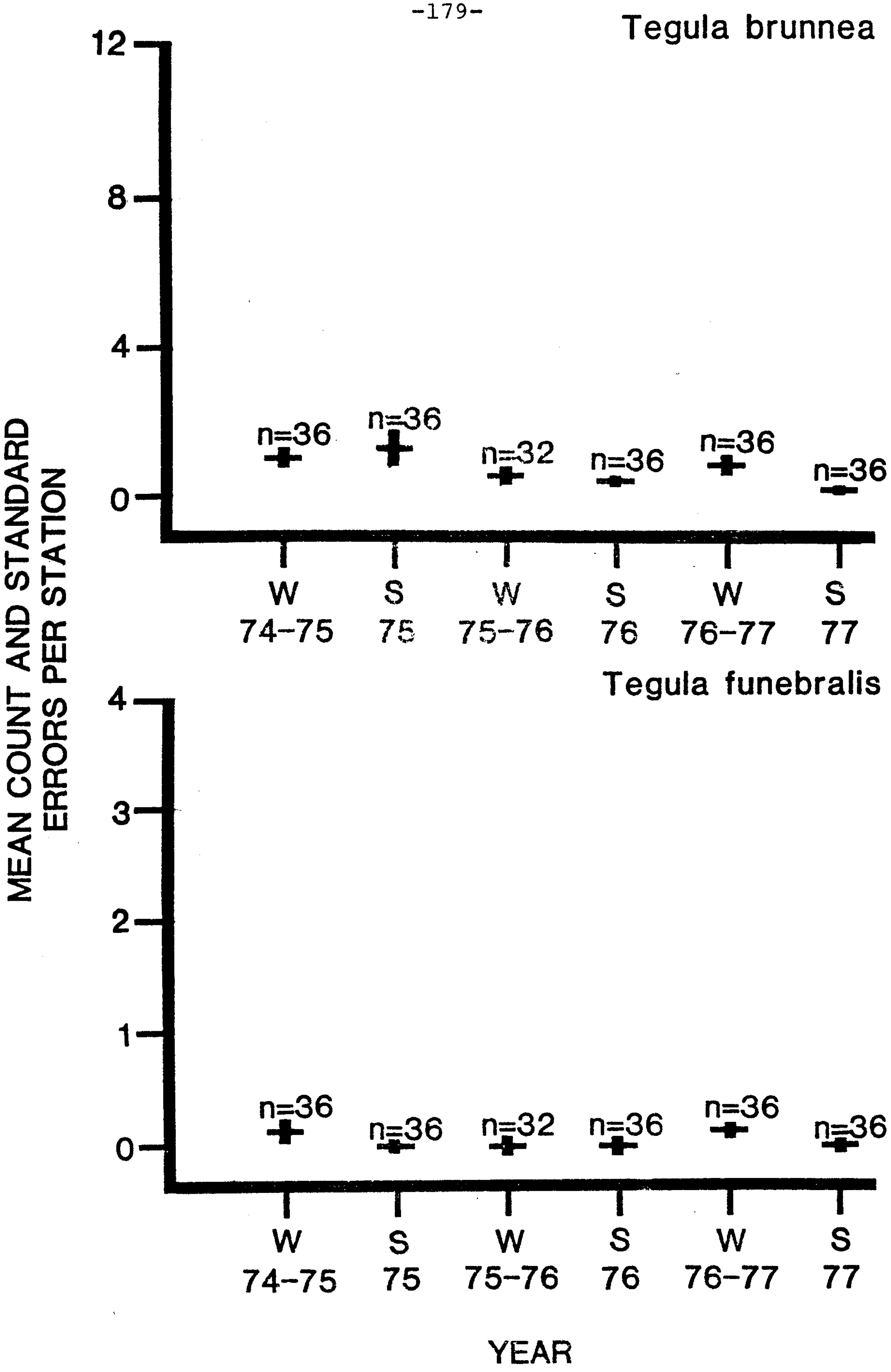


Figure 44. Seasonal abundance (means and standard errors) of Tegula brunnea and Tegula funebralis at South Diablo Cove Intertidal. DCPP, 1974-1977.

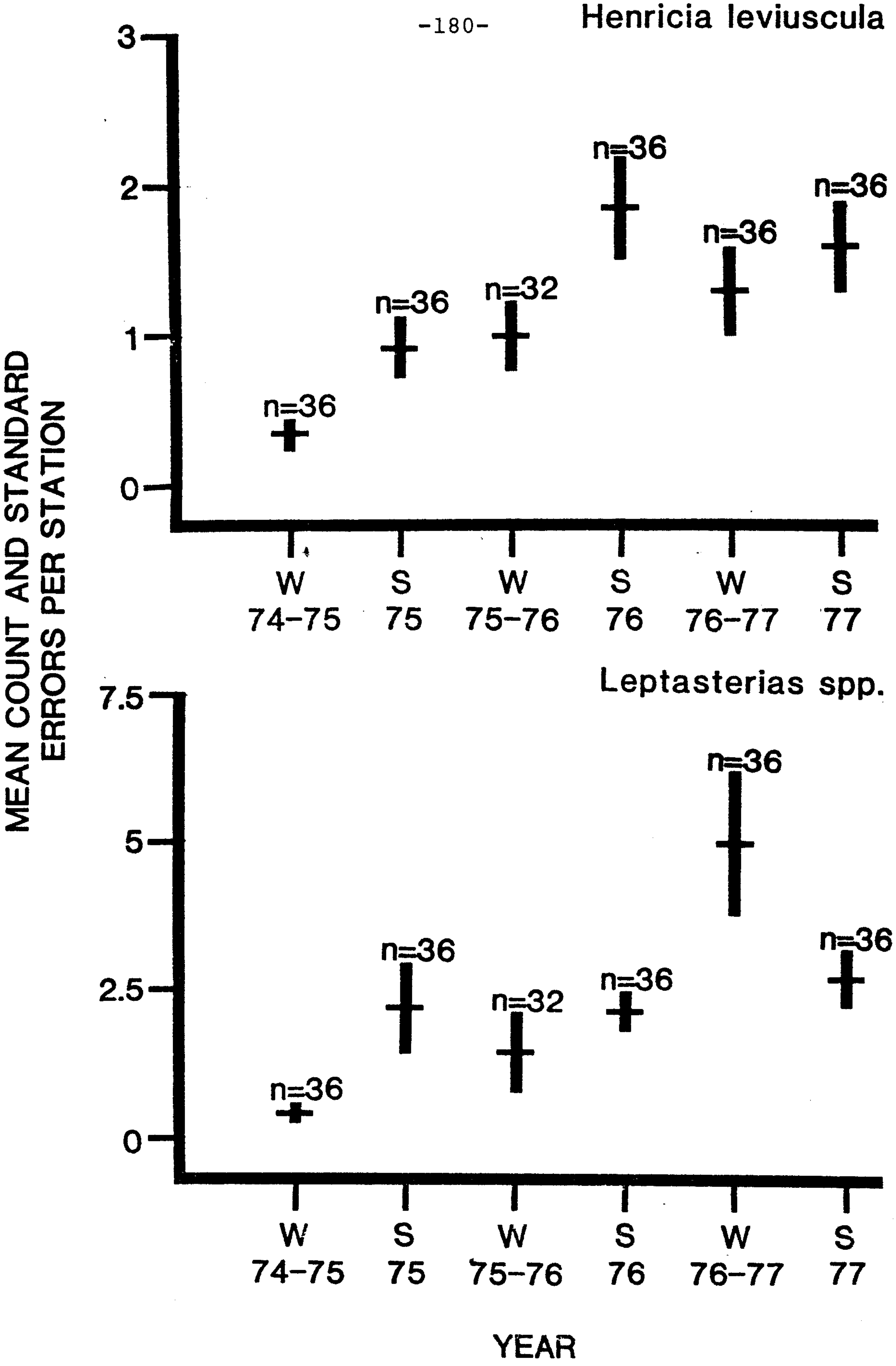


Figure 45. Seasonal abundance (means and standard errors) of <u>Henricia leviuscula</u> and <u>Leptasterias</u> spp. at South Diablo Cove Intertidal. DCPP, 1974-1977.

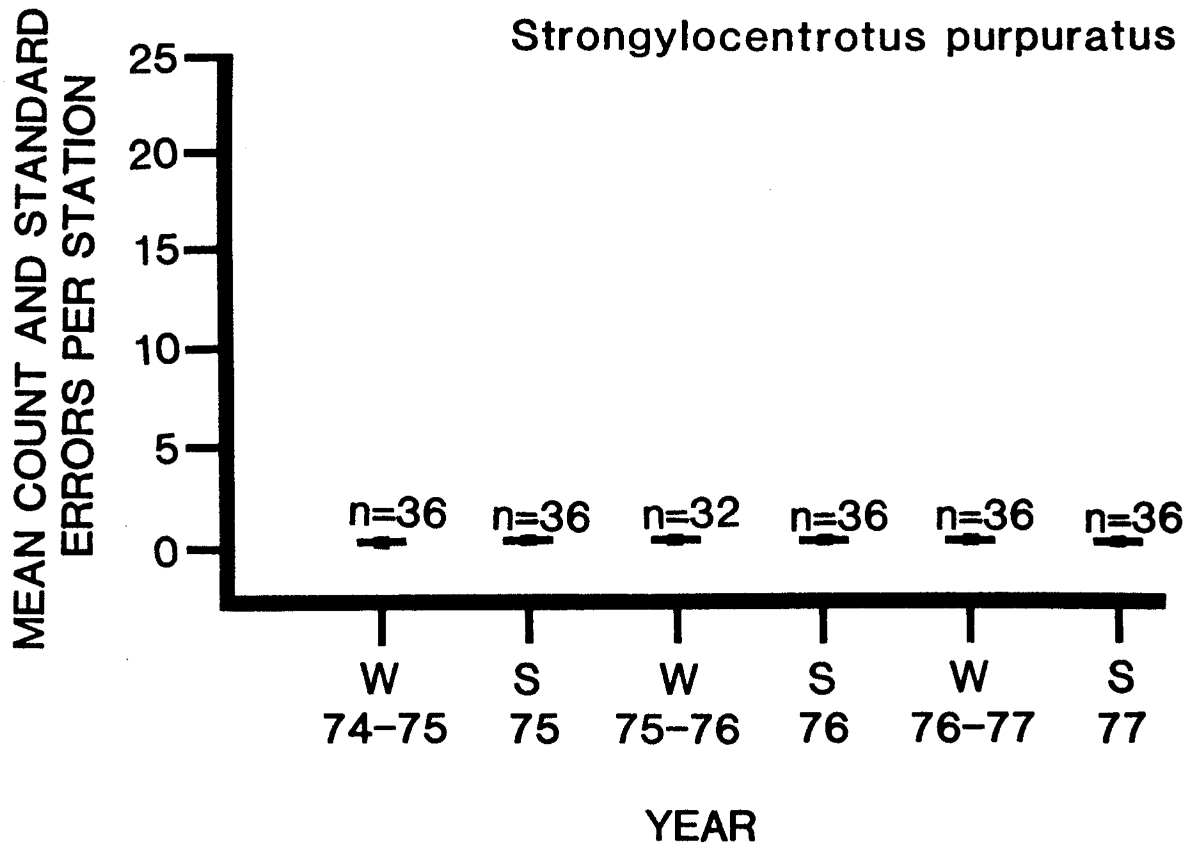


Figure 46. Seasonal abundance (means and standard errors) of Strongylocentrotus purpuratus at South Diablo Cove Intertidal. DCPP, 1974-1977.

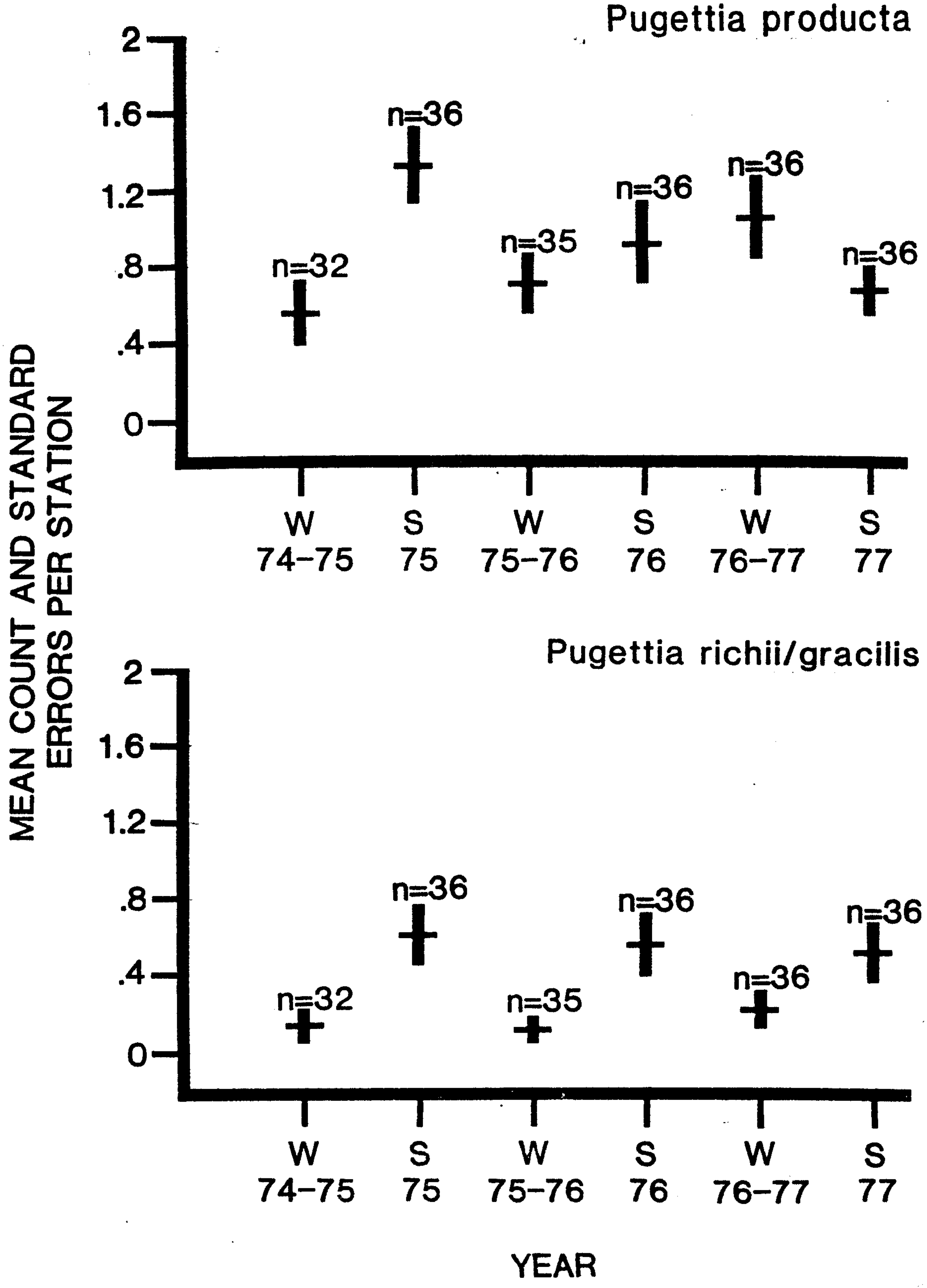


Figure 47. Seasonal abundance (means and standard errors) of Pugettia producta and Pugettia richii/gracilis at North Diablo Cove Intertidal. DCPP. 1974-1977.

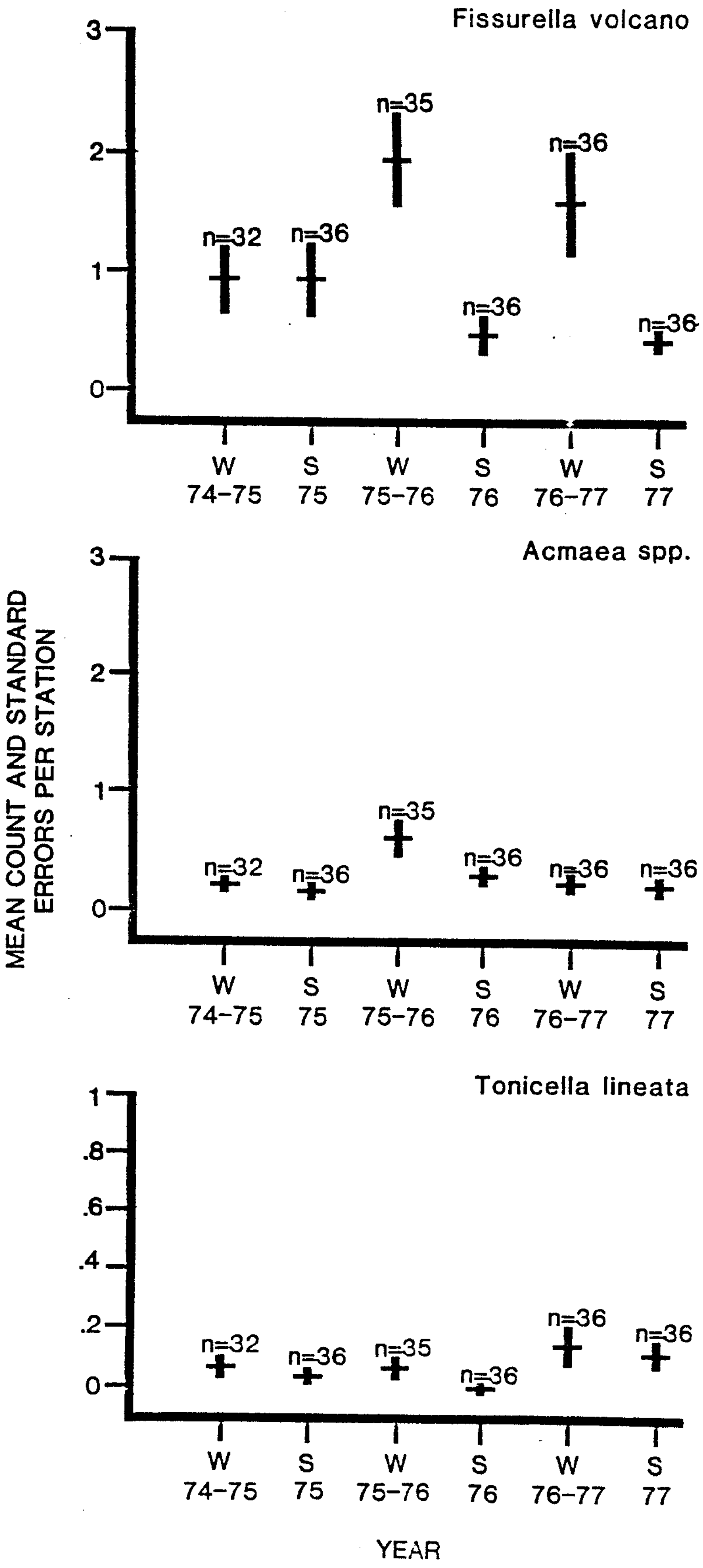


Figure 48. Seasonal abundance (means and standard errors) of _Fissurella volcano_, _Acmaea_ spp., and _Tonicella lineata_ at North Diablo Cove Intertidal. DCPP, 1974-1977.

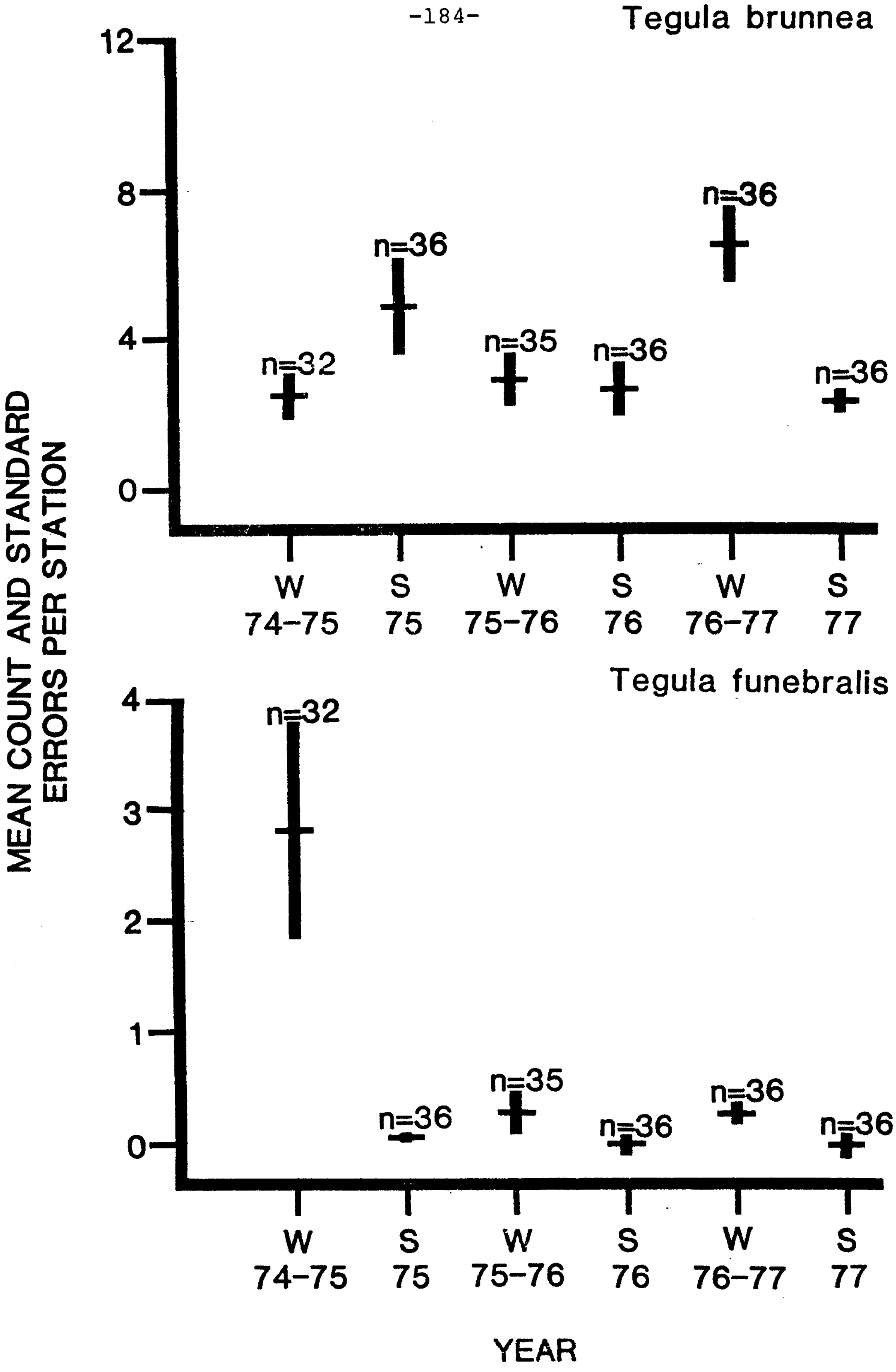


Figure 49. Seasonal abundance (means and standard errors) of Tegula brunnea and Tegula funebralis at North Diablo Cove Intertidal. DCPP, 1974-1977.

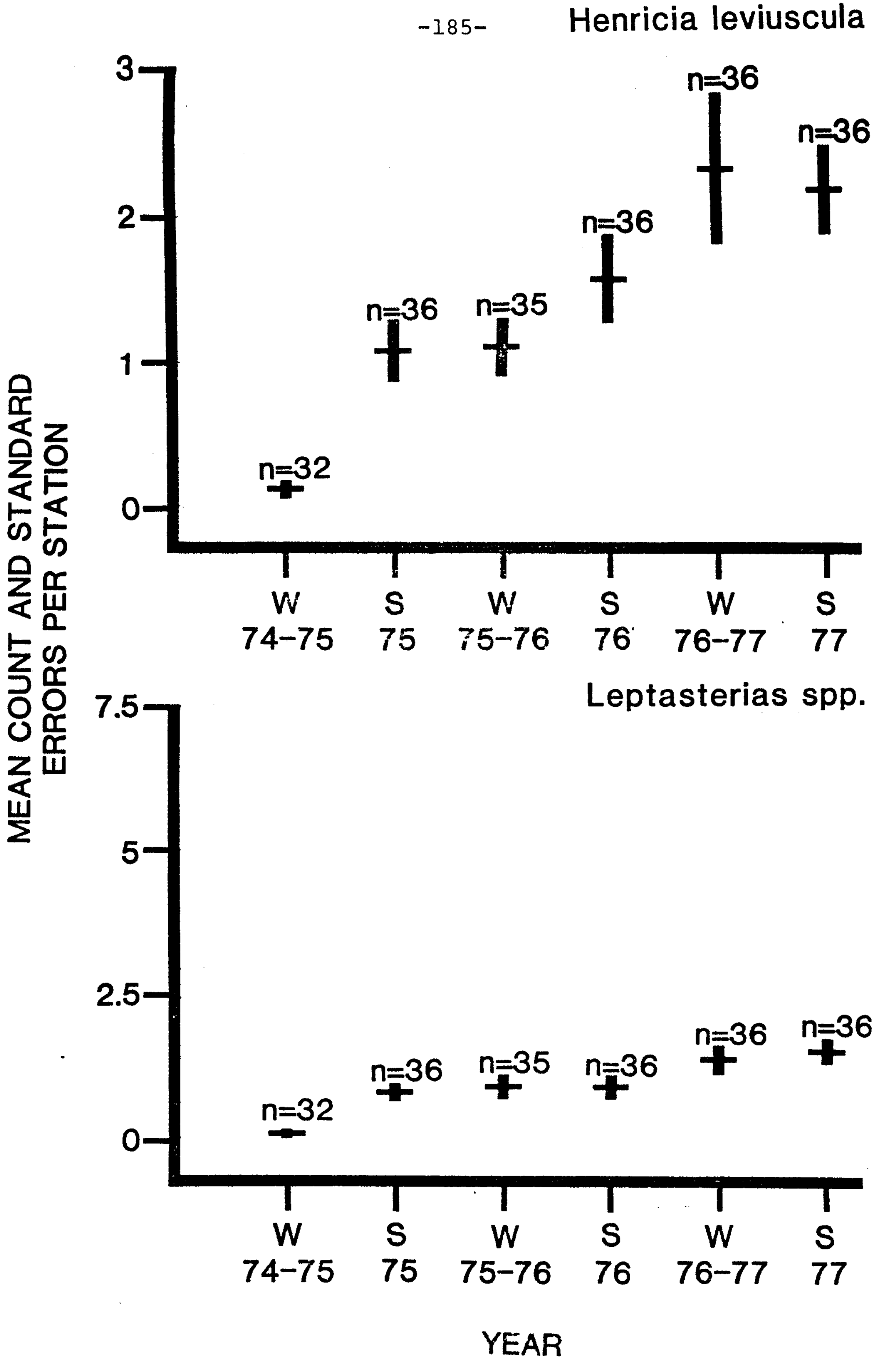


Figure 50. Seasonal abundance (means and standard errors) of Henricia leviuscula and Leptasterias spp. at North Diablo Cove Intertidal. DCPP. 1974-1977.

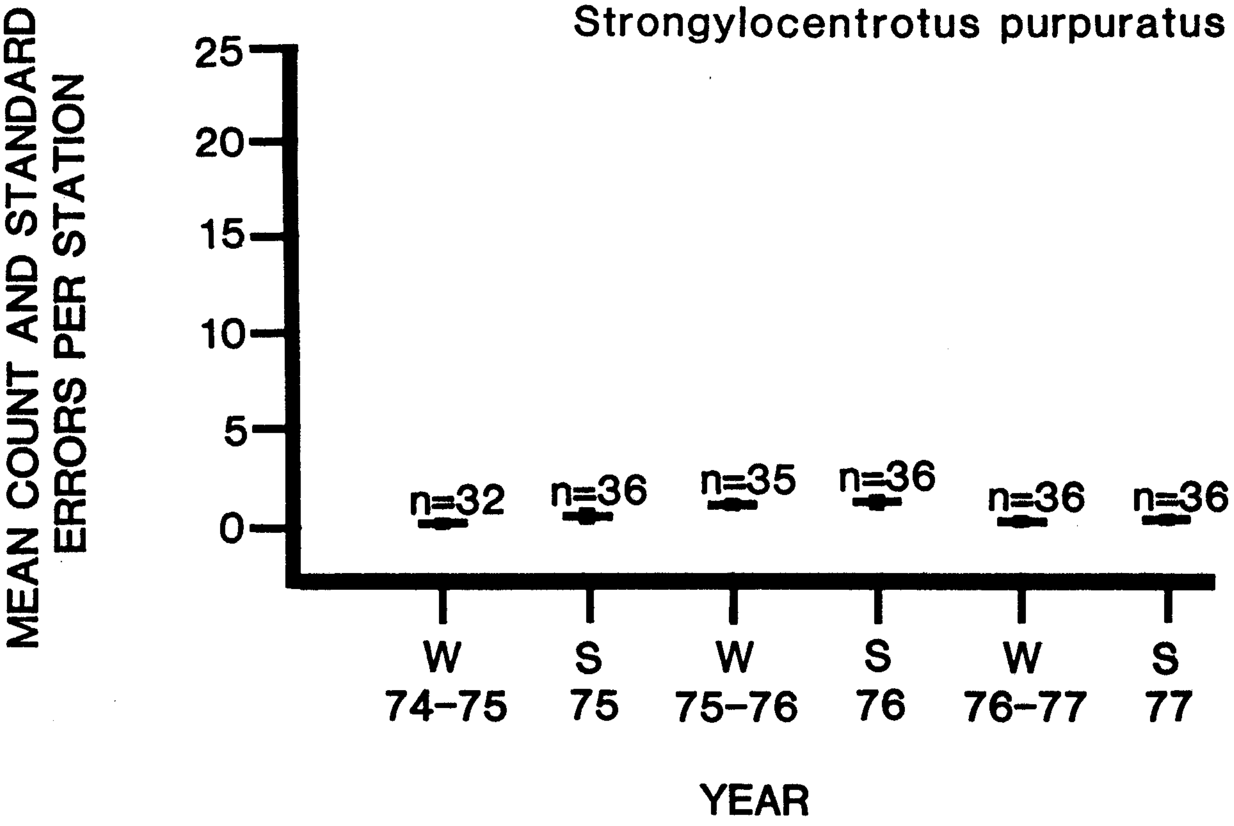


Figure 51. Seasonal abundance (means and standard errors) of Strongylocentrotus purpuratus at North Diablo Cove Intertidal. DCPP, 1974-1977.

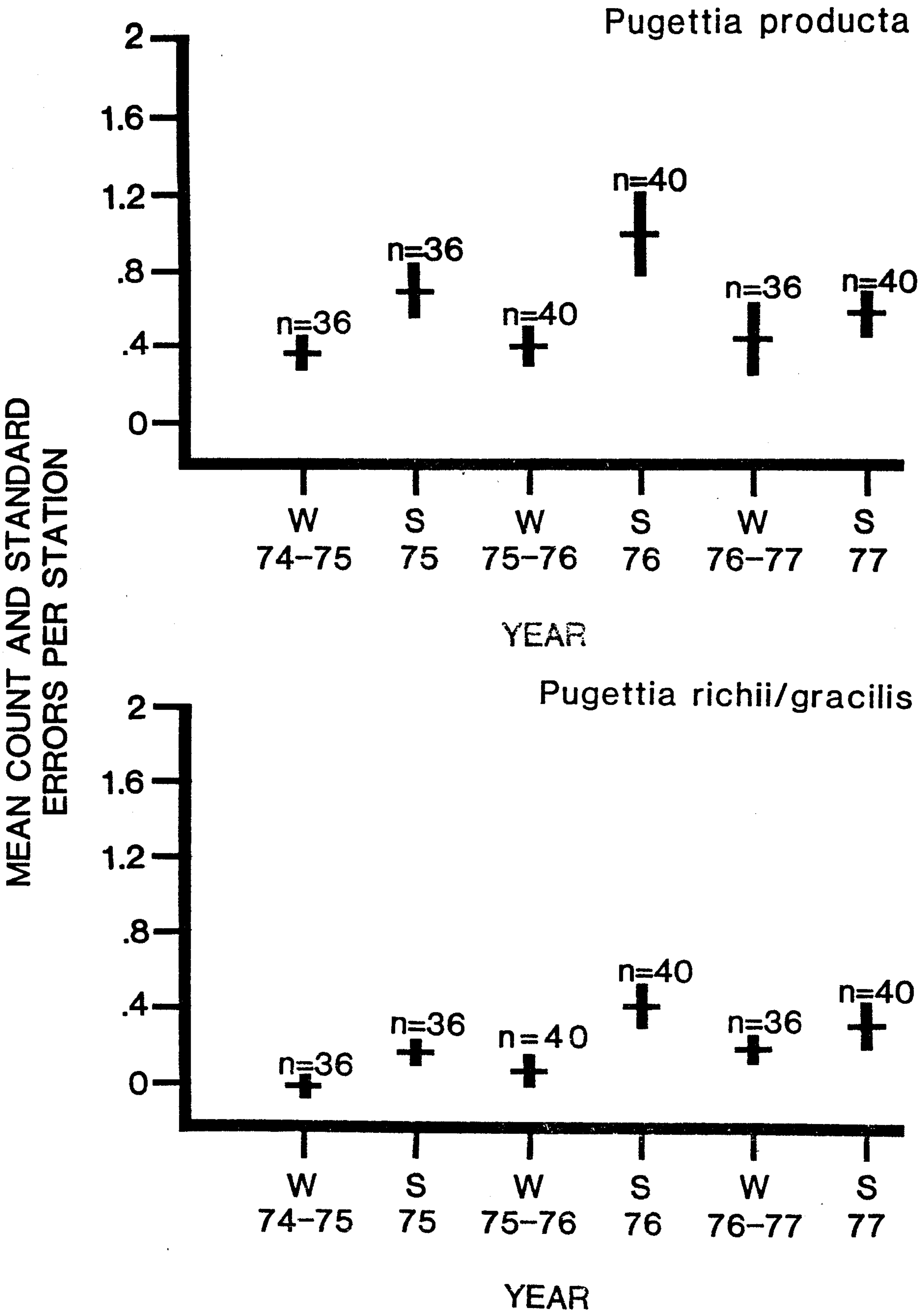


Figure 52. Seasonal abundance (means and standard errors) of Pugettia producta and Pugettia richii/gracilis at North Control Intertidal. DCPP. 1974-1977.

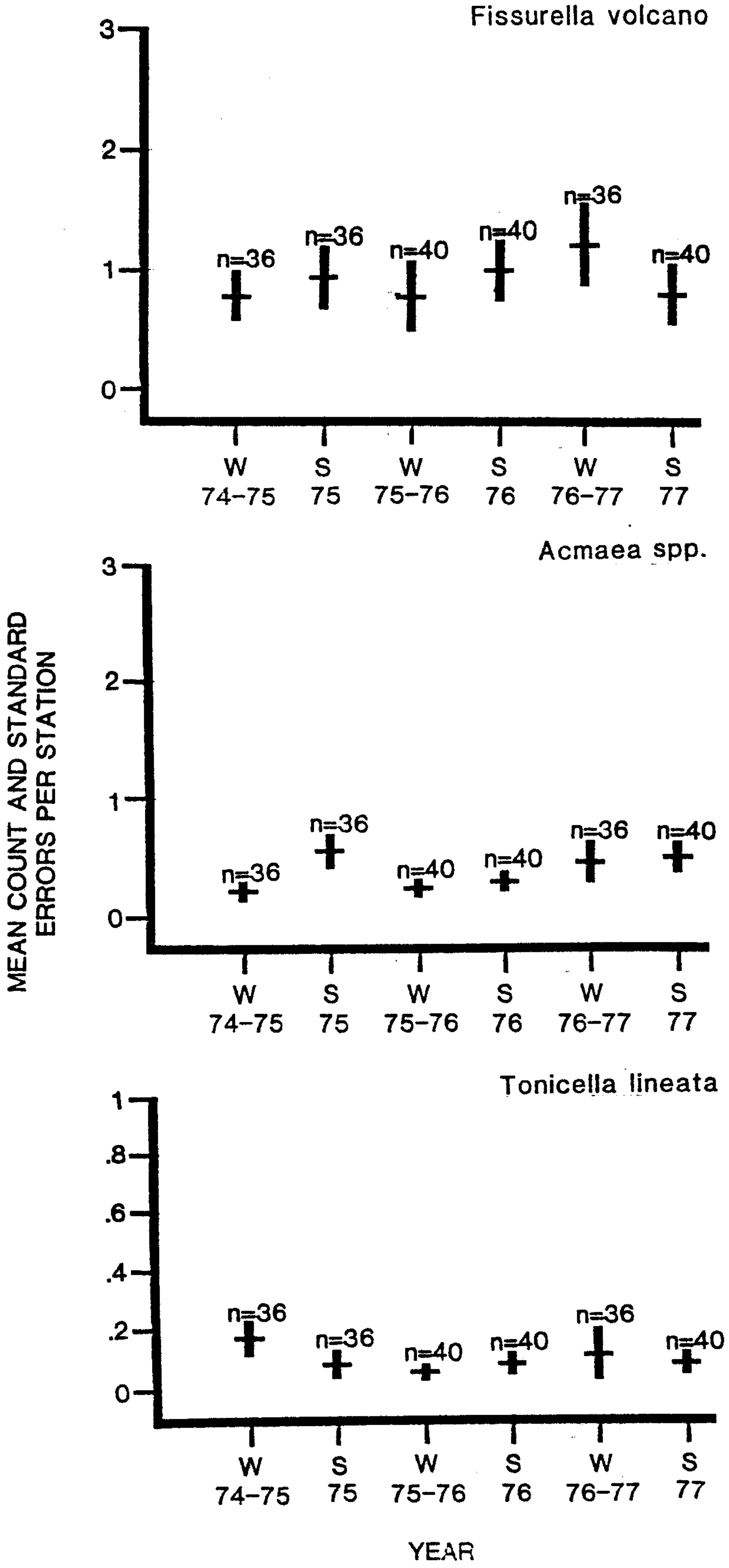
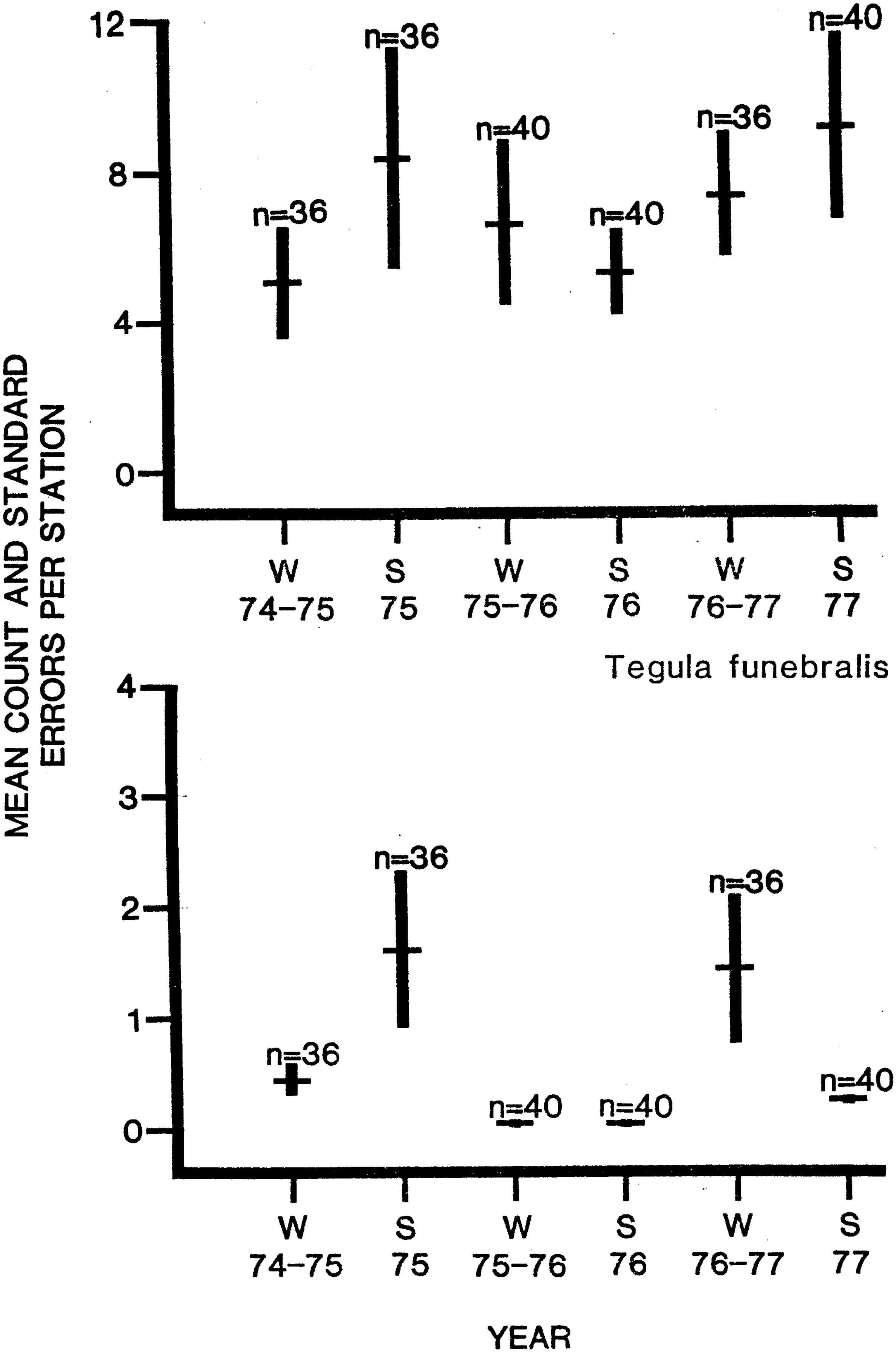


Figure 53. Seasonal abundance (means and standard errors) of Fissurella volcano, Acmaea spp., and Tonicella lineata at North Control Intertidal. DCPP, 1974-1977.

Tegula brunnea



Tegula funebralis

Figure 54. Seasonal abundance (means and standard errors) of Tegula brunnea and Tegula funebralis at North Control Intertidal. DCPP, 1974-1977.

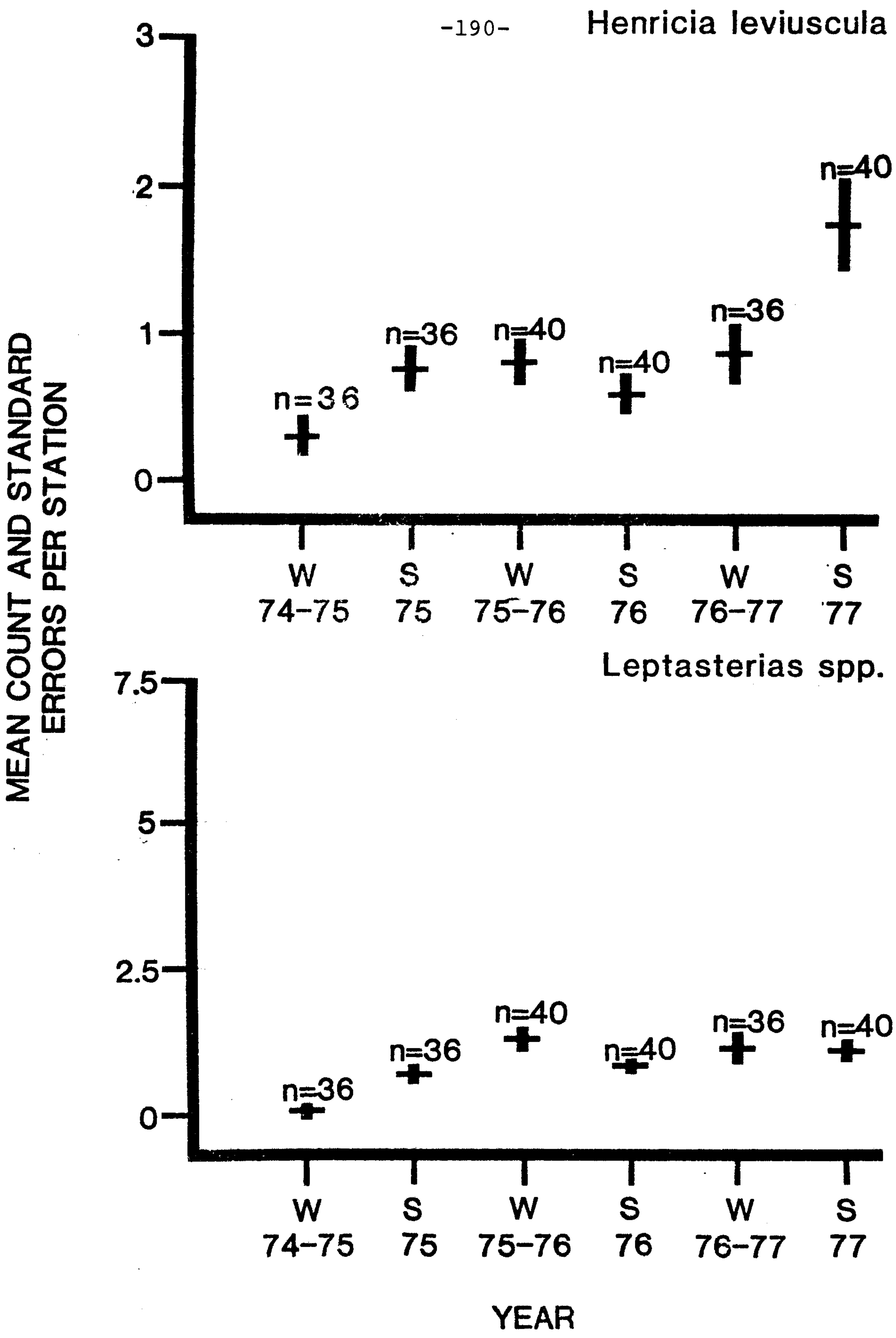


Figure 55. Seasonal abundance (means and standard errors) of Henricia leviuscula and Leptasterias spp. at North Control Intertidal. DCPP, 1974-1977.

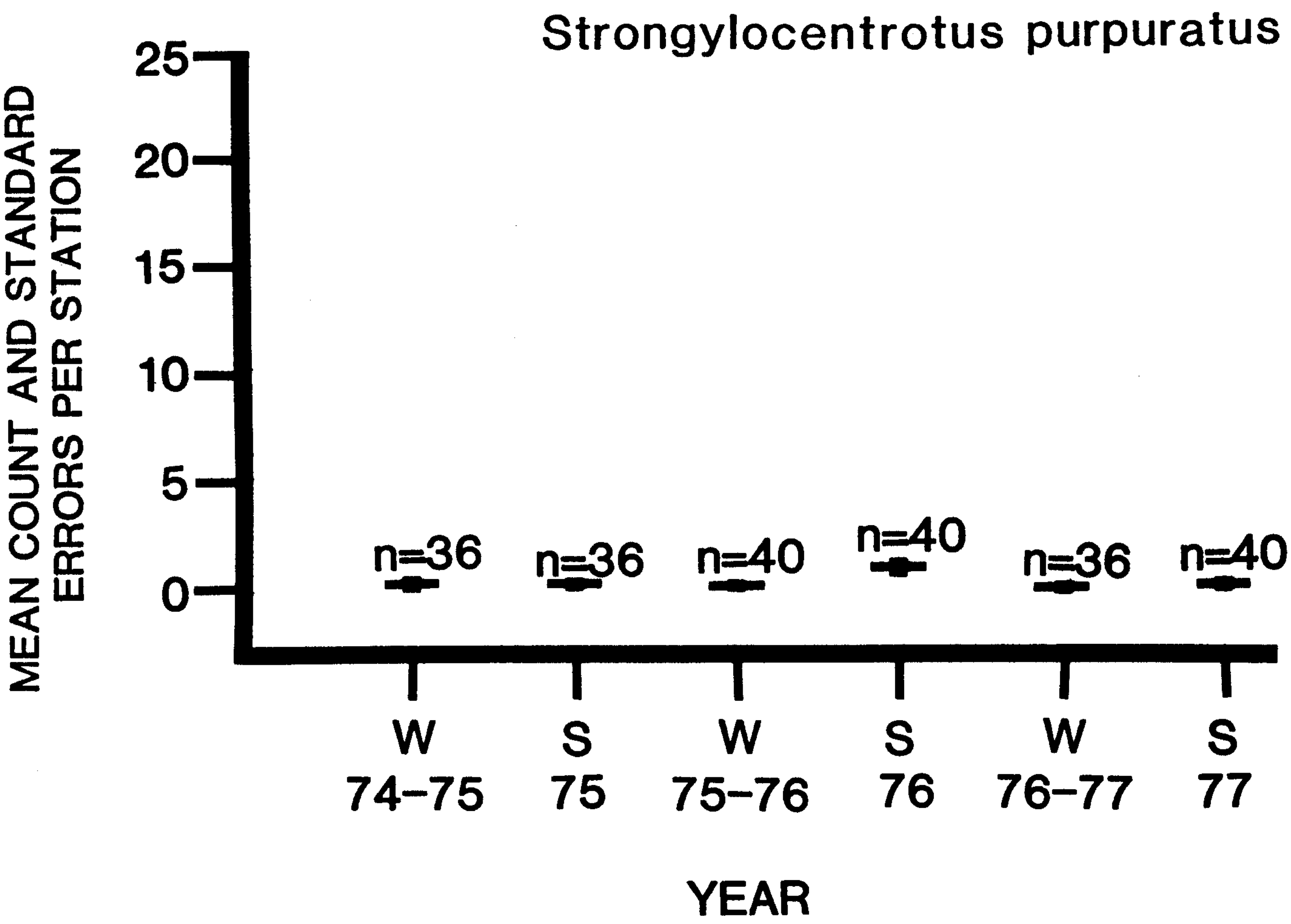


Figure 56. Seasonal abundance (means and standard errors) of Strongylocentrotus purpuratus at North Control Intertidal.

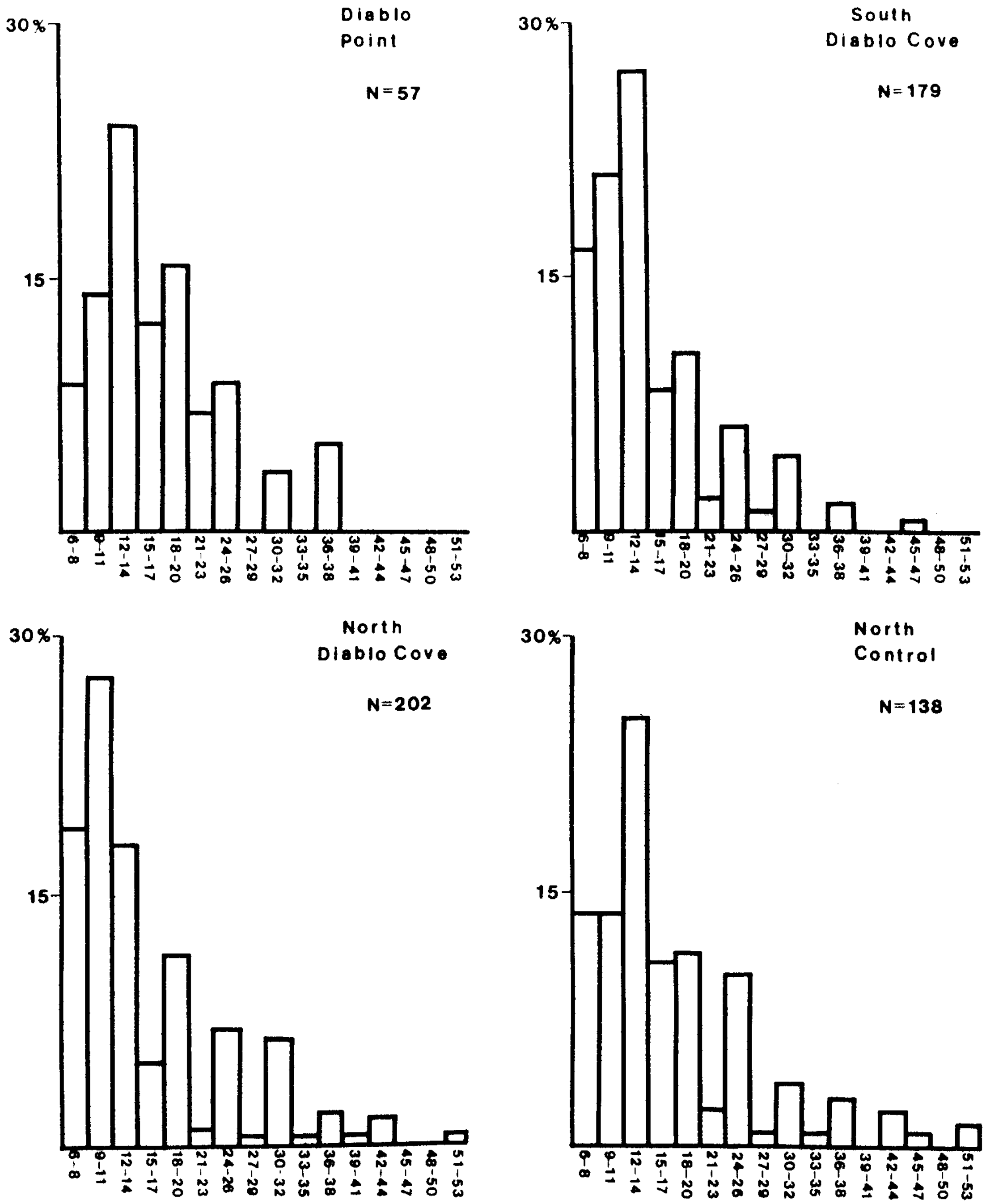


Figure 57. Size frequencies (greatest carapace width in mm) of *Pugettia producta* from the four intertidal study areas for all years combined. DCPP, 1974-1977.

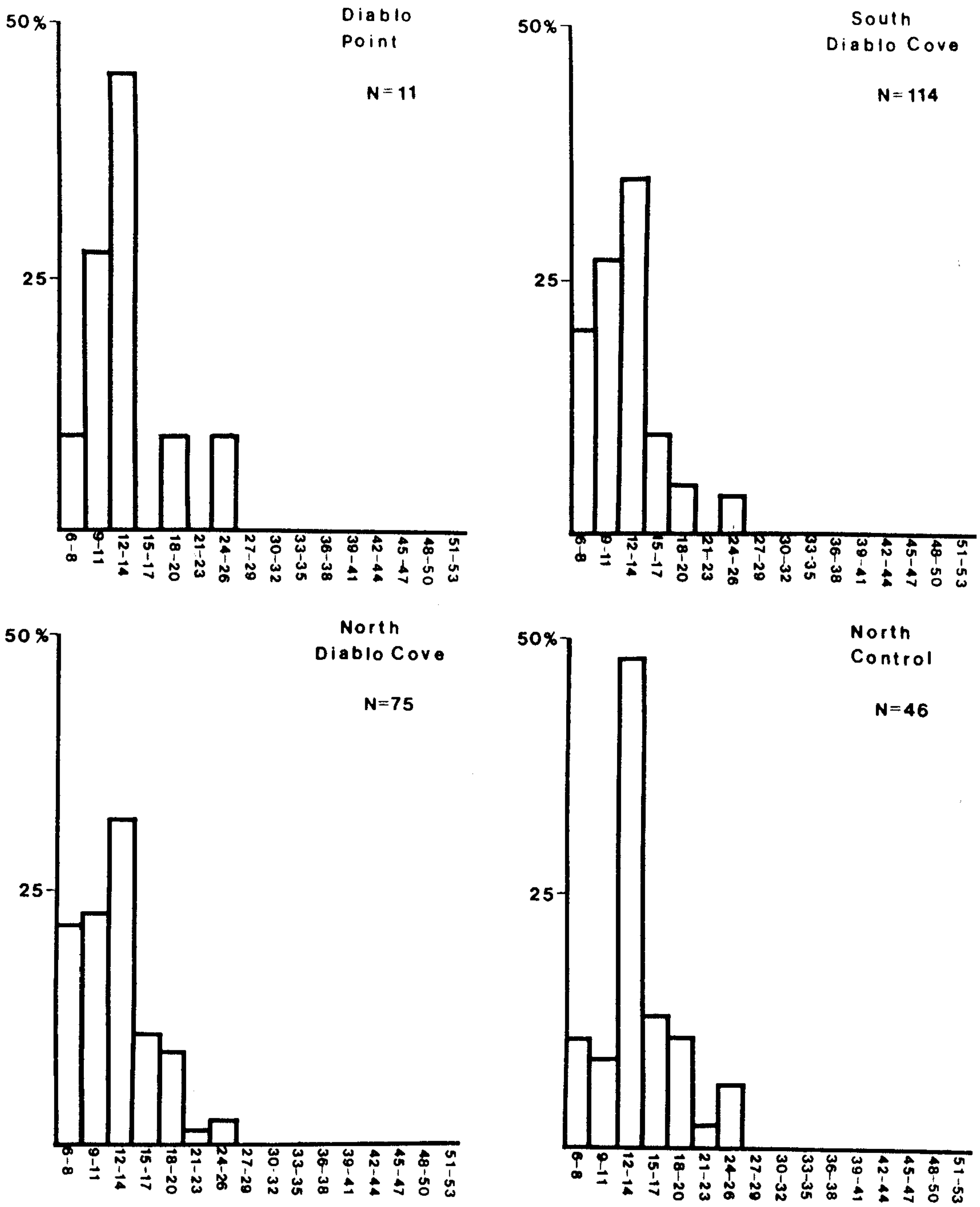


Figure 58. Size frequencies (greatest carapace width in mm) of Pugettia richii/-gracilis complex from the four intertidal study areas for all years combined. DCPP, 1974-1977.

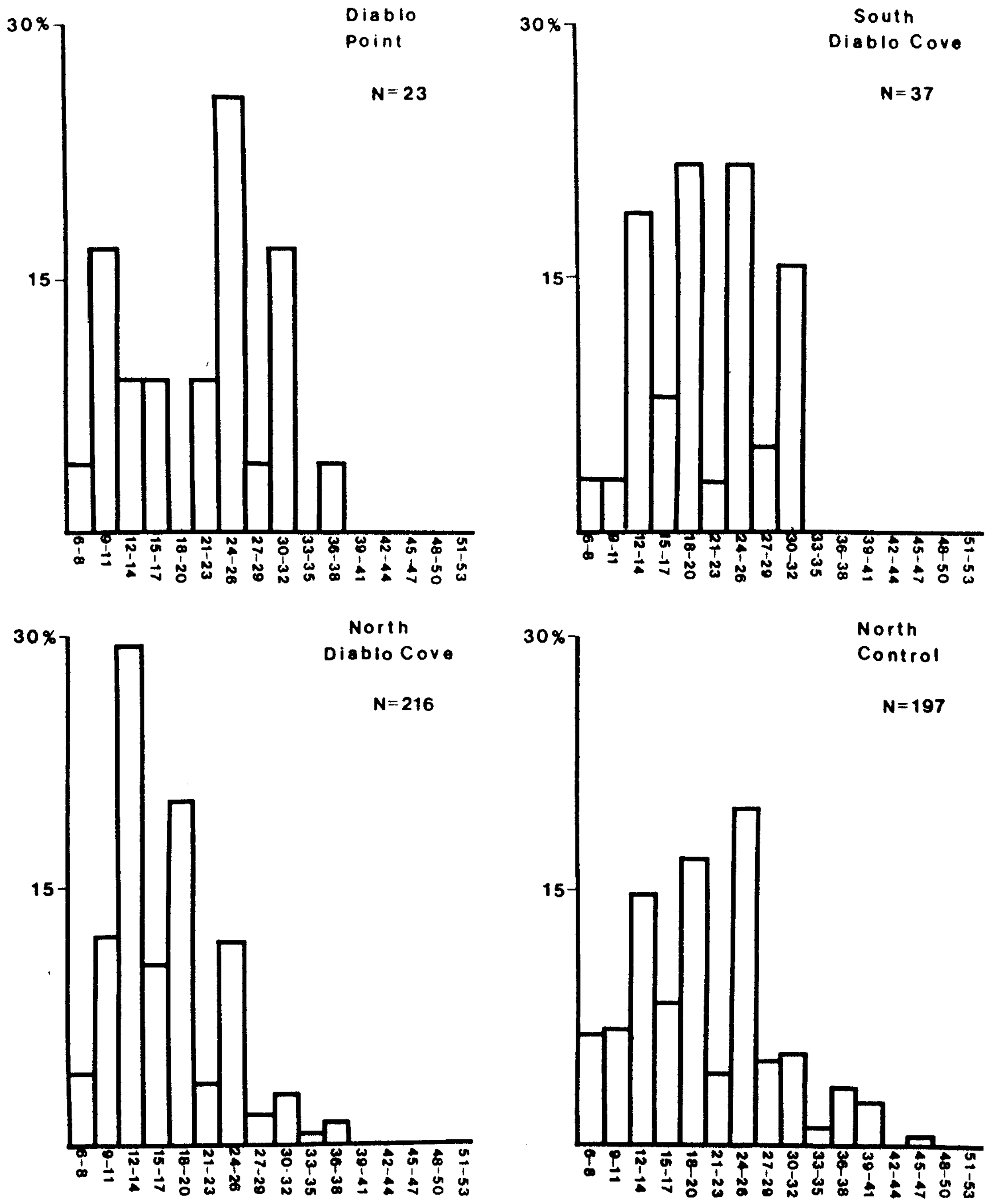


Figure 59. Size frequencies (shell length in mm) of *Fissurella volcano* from the four intertidal study areas for all four years combined. DCPP, 1974-1977.

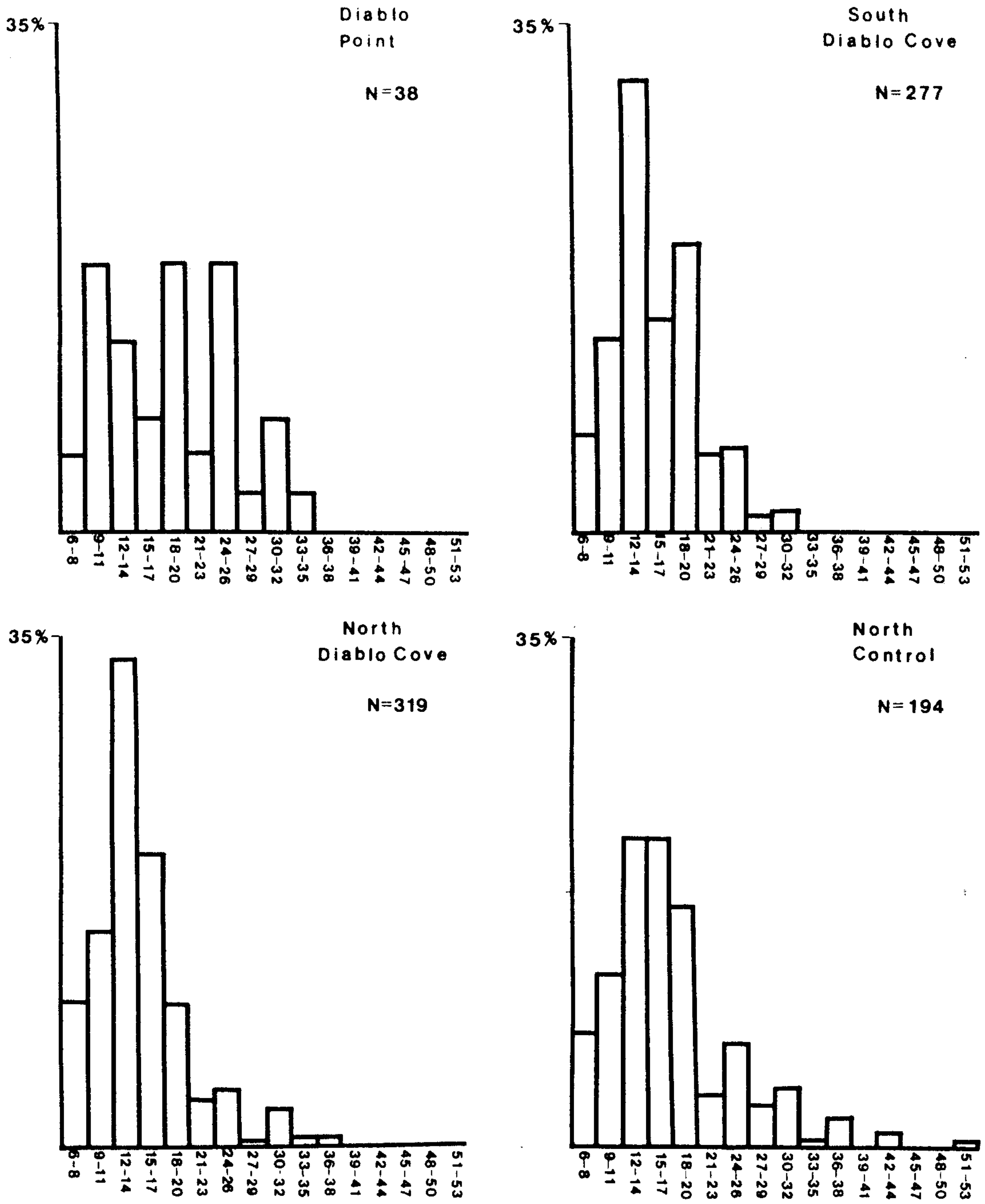


Figure 60. Size frequencies (greatest armtip-to-armtip distance in mm) of <u>Henricia leviuscula</u> from all four intertidal study areas for all years combined. DCPP, 1974-1977.

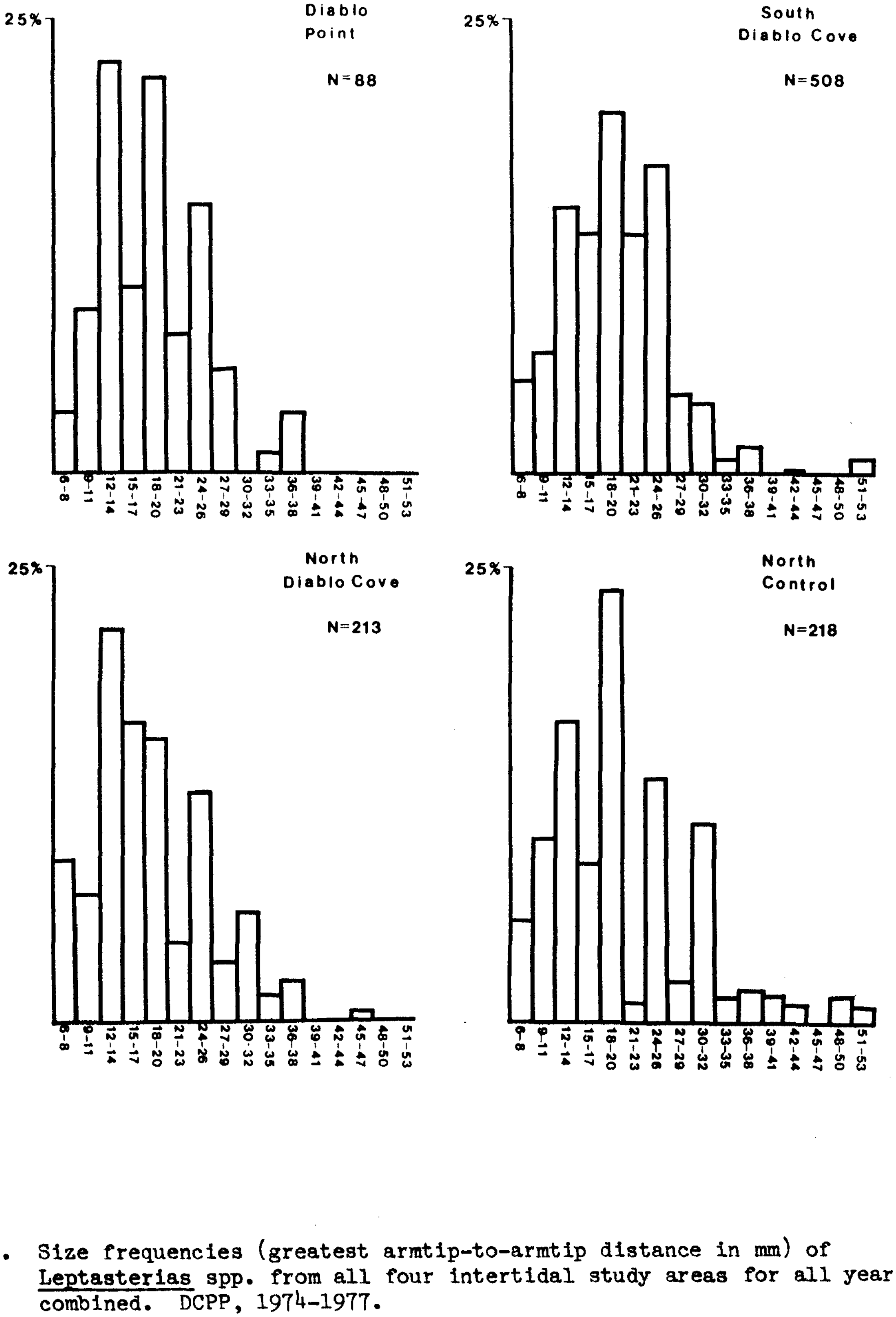


Figure 61. Size frequencies (greatest armtip-to-armtip distance in mm) of Leptasterias spp. from all four intertidal study areas for all years combined. DCPP, 1974-1977.

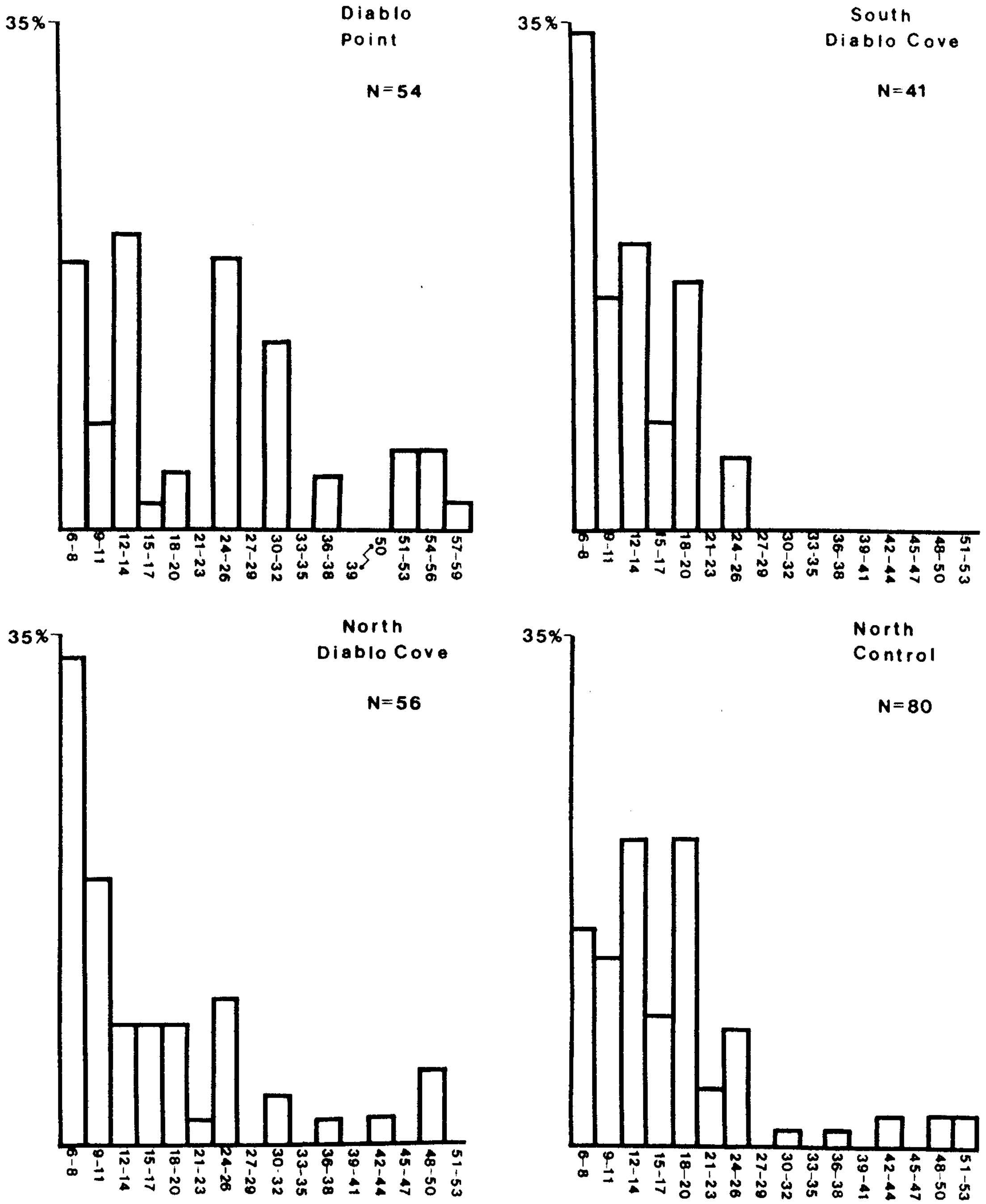


Figure 62. Size frequencies (test diameter in mm) of Strongylocentrotus purpuratus from all four intertidal study areas for all years combined. DCPP, 1974-1977.

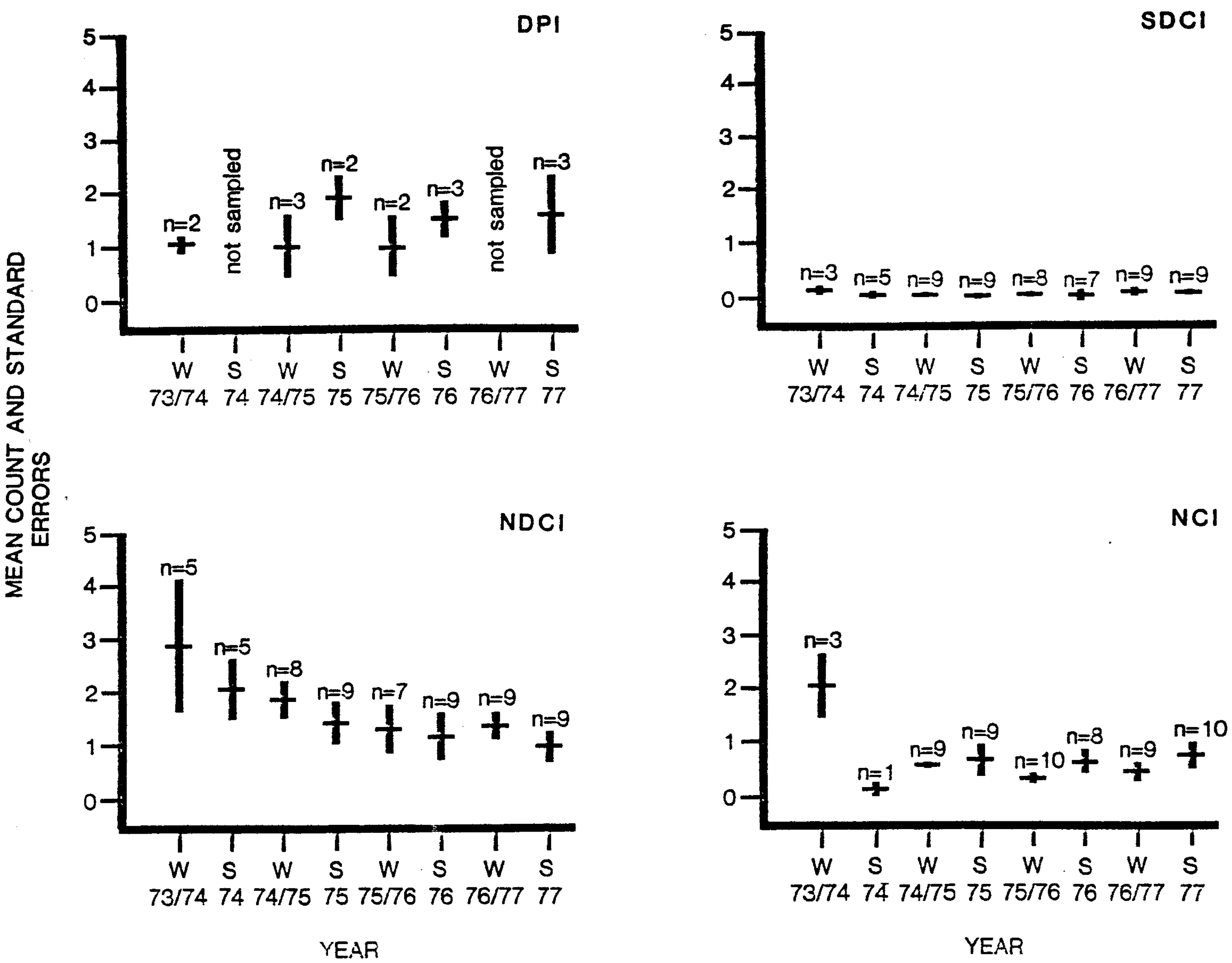


Figure 63. Levels of abundance (mean number/m^2 and standard errors) of black abalone (<u>Haliotis cracherodi</u>) at random intertidal <u>parallel</u> transects at Diablo Point, South Diablo Cove, North Diablo Cove, and North Control. DCPP, 1973-1977.

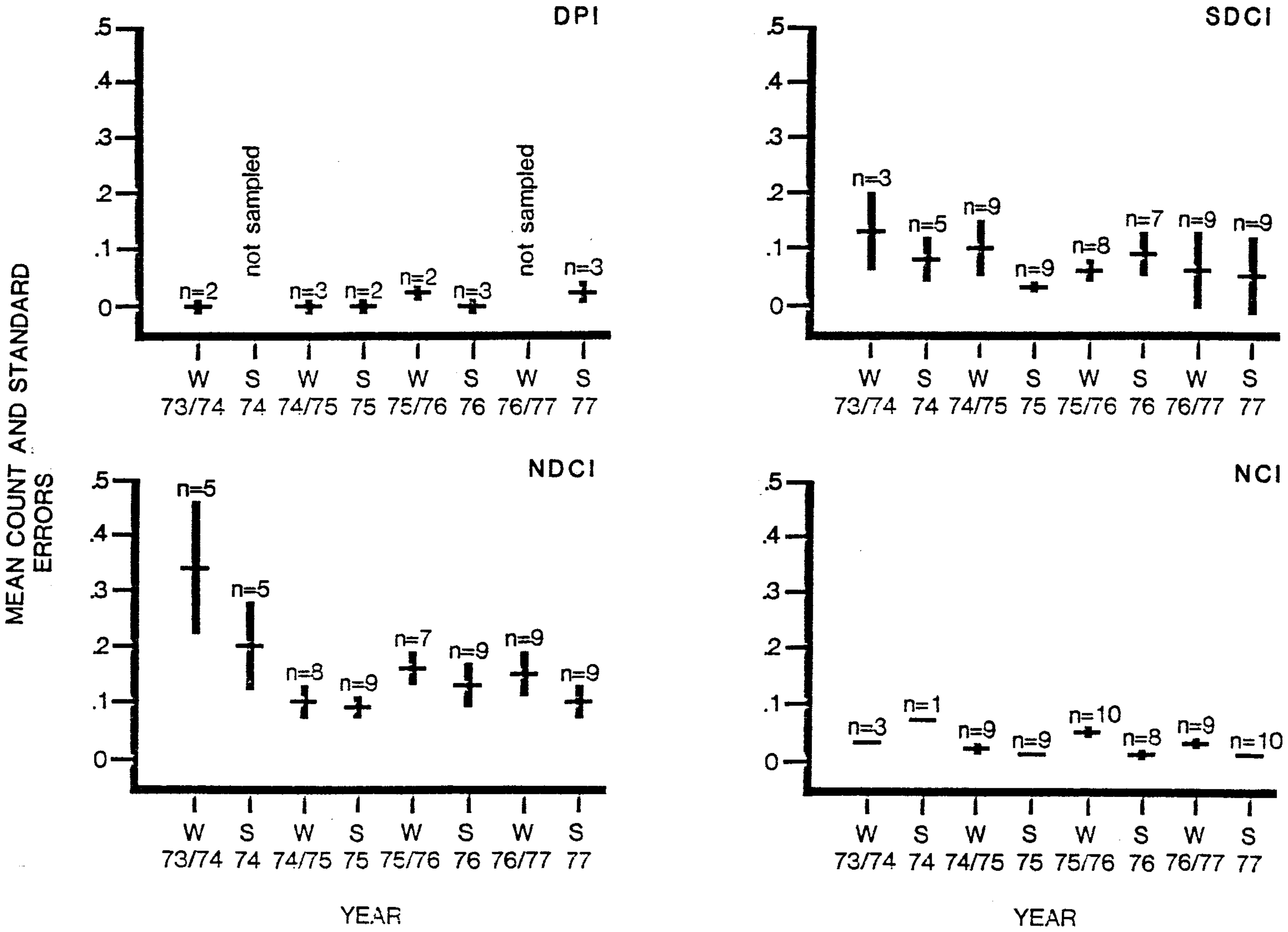


Figure 64. Levels of abundance (mean number/m^2 and standard errors) of red abalone (Haliotis rufescens) at random intertidal parallel transects at Diablo Point, South Diablo Cove, North Diablo Cove, and North Control. DCPP, 1973-1977.

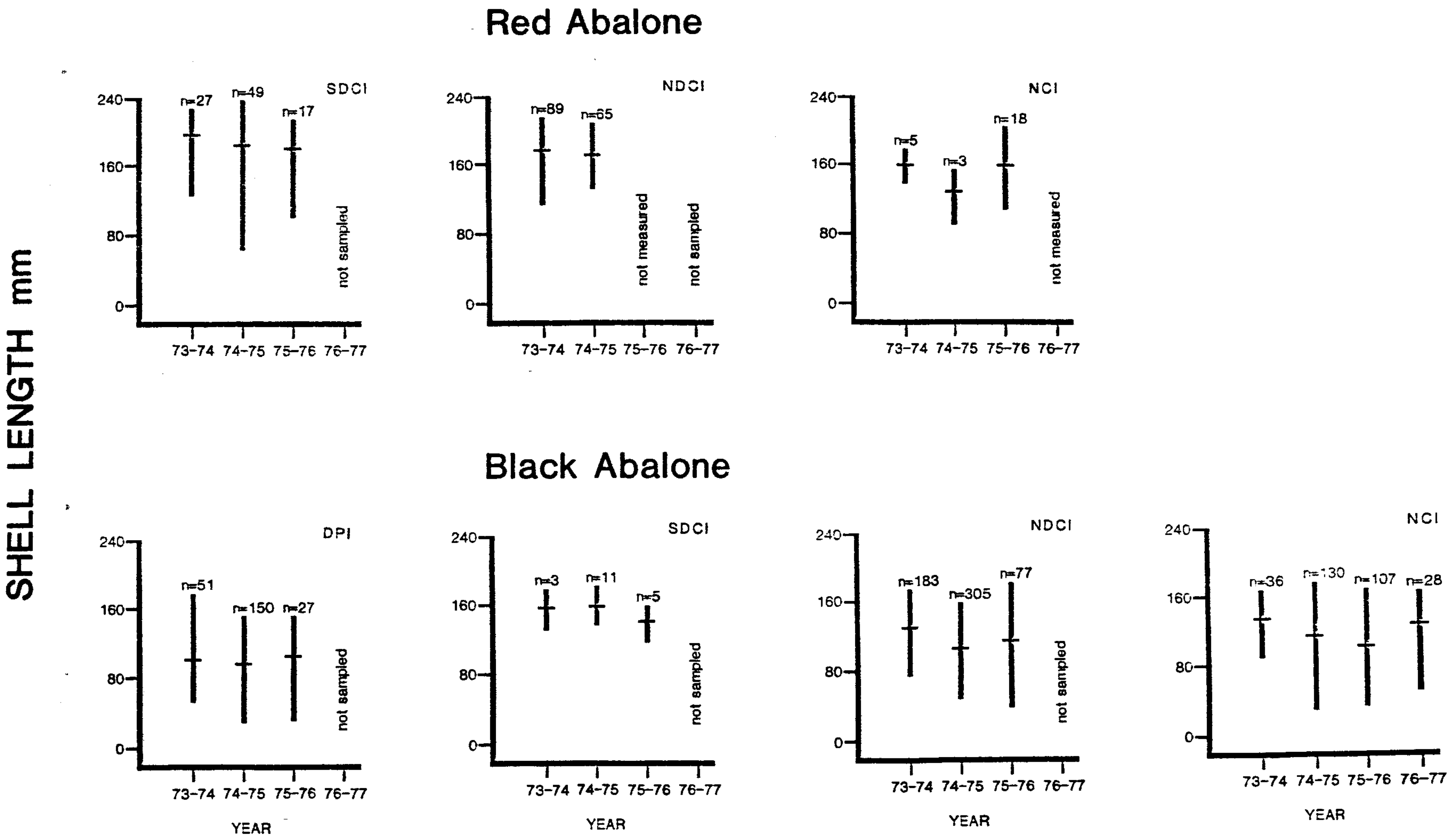


Figure 65. Shell lengths (mean and ranges) of black abalone (<u>Haliotis cracheroidii</u>) and red abalone (<u>Haliotis rufescens</u>) measured at random intertidal transects at Diablo Point, South Diablo Cove, North Diablo Cove, and North Control. DCPP, 1973-1977.

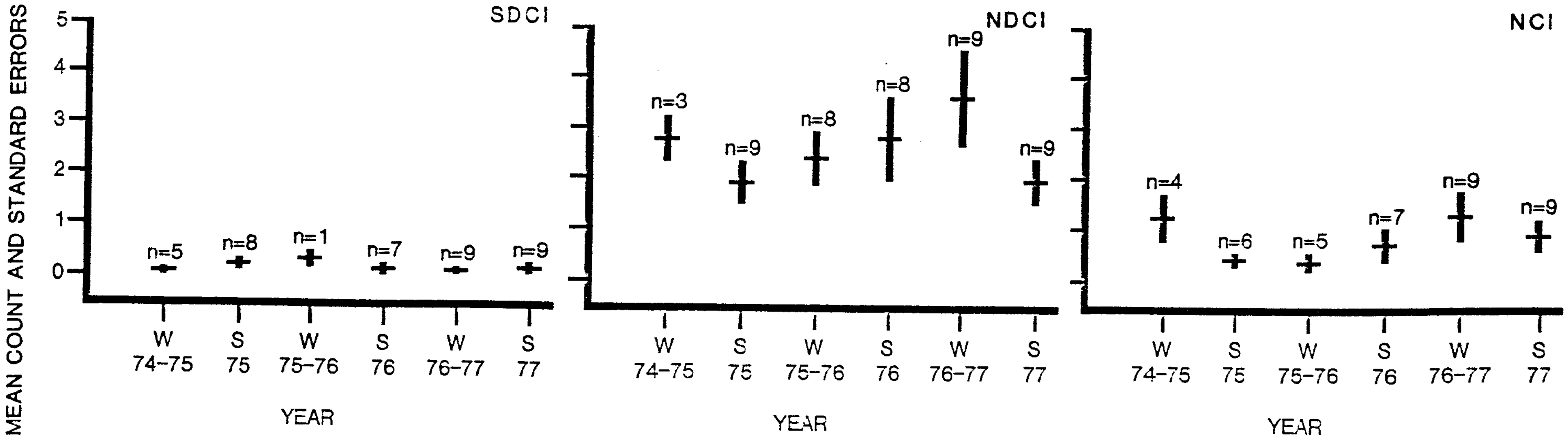


Figure 66. Levels of abundance (mean number/m^2 and standard errors) of black abalone (Haliotis cracheroidii) at random intertidal perpindicular transects at South Diablo Cove, North Diablo Cove, and North Control. DCPP, 1973-1977.

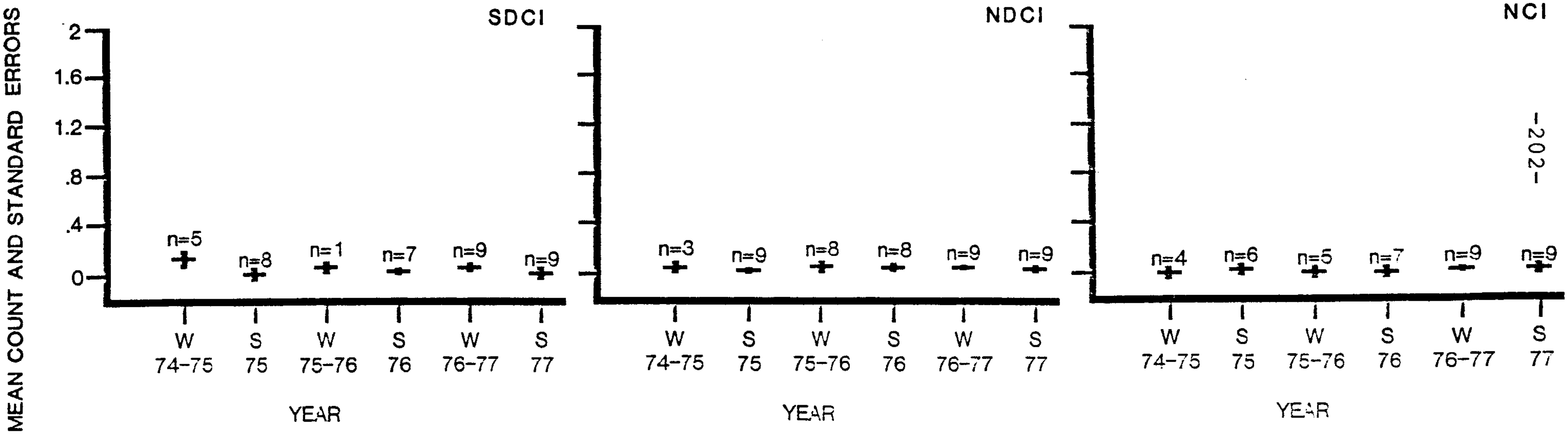


Figure 67. Levels of abundance (mean number/m^2 and standard errors) of red abalone (Haliotis rufescens) at random intertidal perpindicular transects at South Diablo Cove, North Diablo Cove, and North Control. DCPP, 1973-1977.

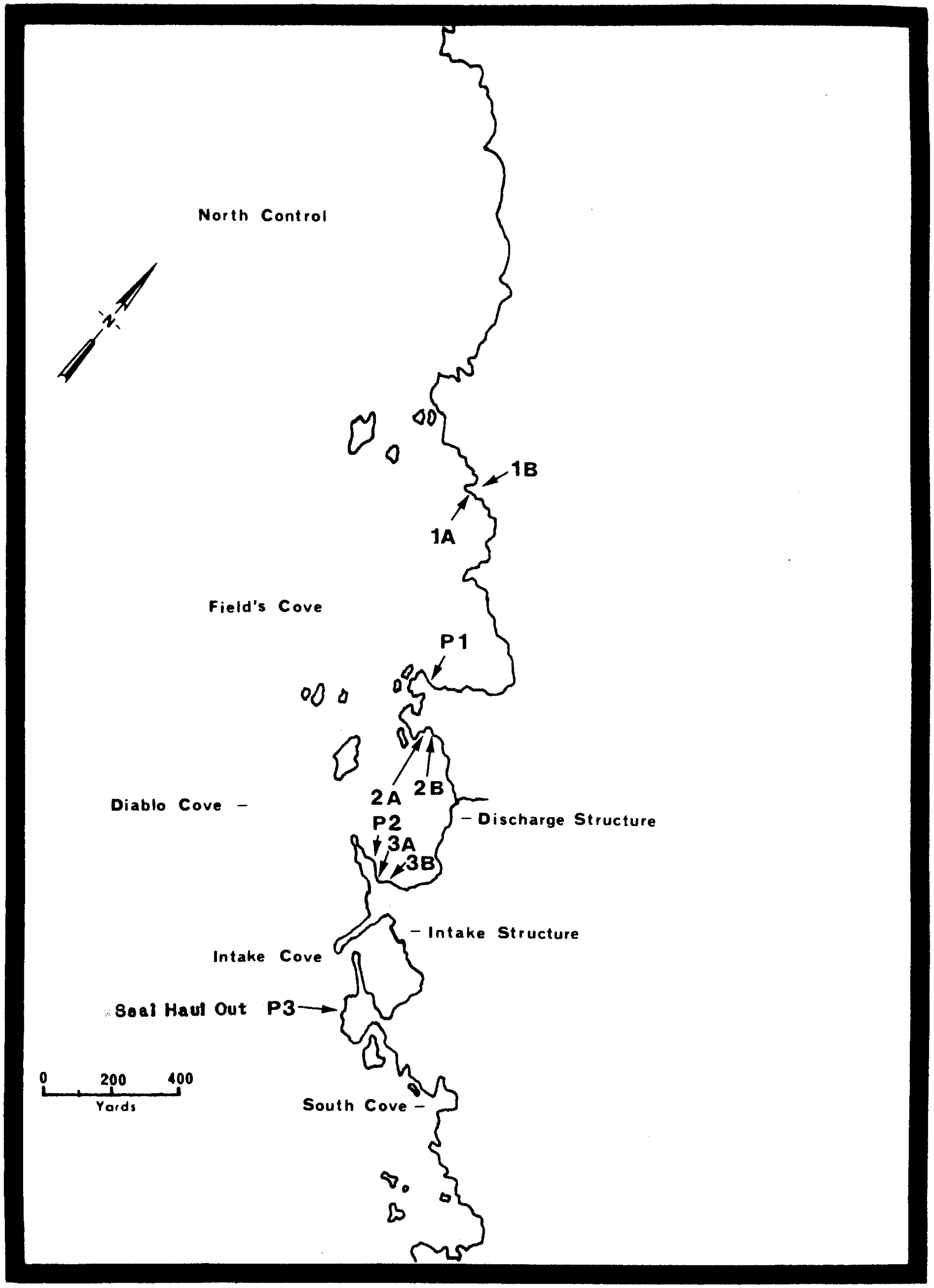


Figure 68. Locations of Permanent Intertidal Stations for Abalone Transects in Diablo Cove and Control Areas. DCPP, 1970-1978.

SUBTIDAL STUDIES

Study Areas and Their Physical Description

Random Stations

During sampling at random 0.25-m^2 quadrats, the substrate type was noted and recorded. On a few occasions, divers encountered large areas of sand. When this occurred, the quadrat was moved to encompass rocky substrate. This was done to decrease variability caused by differing substrate. Divers then estimated the percentages of sand ($\leq$ 1/8"), gravel (> 1/8" $\leq$ 1/2"), cobble (>1/2" $\leq$ 6"), boulder (> 6" and movable), and bedrock (any size and immovable) within the quadrat.

These estimates were totaled and averages were taken for each study area: North Control (NCI); North Diablo Cove (NDC); and South Diablo Cove (SDC).

South Diablo Cove

This area (Figure 69) contains the greatest amount of sand. There was approximately 13% sand in quadrats in the 0- 7.6 m (0-25 feet) areas and 12% in quadrats in the areas 7.7 - 15.2 m (25-50 feet deep) (Figures 70 and 71). Both shallow and deep areas have trace amounts of gravel. Boulders comprised approximately 3% of the substrate in shallow areas and 1% in the deeper areas. Rock was abundant in both shallow areas (77%) and deep areas (85%). South Diablo Cove has, for the most part, little relief except in shallow areas where low profile reefs extend from the intertidal to approximately 6.1 m (20 feet). A smattering of boulders, notably in the southwest corner, provides undercuts which appear to be potential prime abalone habitat. Much of the remaining area is covered by broad expanses of sand.

North Diablo Cove

In NDC (Figure 69) rock comprises the major portion of the substrate in both shallow (85%) and deep (75%) areas (Figures 70 and 71). Shallow stations had approximately similar amounts of sand (4%), gravel (2%), and cobble (3%) with boulders comprising 6% of the substrate. Deeper stations had 8% sand, 4% gravel, 4% cobble, and 9% boulder. Subtidally, NDCI varies between protected rocky coast, in the area to the lee of Diablo Rock, and exposed rocky coast. North Diablo Cove contains a series of east-west reefs with large boulders and patches of sandy gravel.

North Control

North Control (Figure 69) subtidal substrate is quite homogeneous (Figures 70 and 71). At quadrats between 0 and 7.6 m (0 and 25 feet), the substrate is comprised of 76% rock, 8% boulder, 7% cobble, and approximately 4% gravel, and 4% sand (Figure 70). Deeper areas from 7.7 m to 15.2 m (26 to 50 feet) contain more rock (89%), less boulder (4%), less cobble (less than 1%), less gravel (less than 1%), and more sand (7%) (Figure 71).

North Control subtidal can be characterized as exposed rocky coast with low relief in shallow 0 to 7.6 m (0 to 25 feet) areas and higher relief in deeper areas.

Permanent Stations

Diablo Cove

There are six permanent subtidal stations in Diablo Cove (Figure 72). Five of these (9, 10, 11, 12, 16) were established by Burge and Schultz in 1970 (Burge and Schultz 1973). The sixth station, No. 1, was established in 1977.

Station 1 is located on a pinnacle to the south of Diablo Rock. It is typified by high relief, ranging in depth from 7.7 to 14.6 m (25 to 48 feet). Primarily solid rock (about 95%), it contains 5% gravel in pockets.

Of the three stations located in what could be termed mid-Diablo Cove, Station 9 is the shallowest, 4.6 m to 7.9 m (15 to 25 feet), and closest to shore. It is composed of 85% rock, 5% boulder, and 10% sand. Station 10, slightly southeast of Diablo Rock, ranges in depth from 12.2 m to 13.7 m (40 to 45 feet). This station was re-established in 1978 after a two-year hiatus during which it was not found due to loss of station markers. Comprised mostly of rock (80%), there is also some sand (10%) and boulder (10%).

Station 11 is our closet permanent station to Diablo Rock, located immediately to its south in depths between 12.2 m and 13.7 m (40 and 50 feet). Of our permanent Diablo Cove stations, this has the most sand and gravel (15% each). Rock (60%) and boulder comprise the remaining susbtrate.

Station 16 located at 3.1 m to 3.4 m (10 to 11 feet) depths in southeast Diablo Cove. Its substrate is composed of 60% rock, 10% boulder, 20% sand, and 10% gravel.

Station 12 is located just outside Diablo Cove to the southwest of Diablo Rock at the base of a pinnacle. It is our deepest station, ranging between 19.8 m and 21.3 m (65 and 70 feet). Boulder and rock, approximately 45% each, comprise most of the substrate, with sand (10%) present in crevices.

Control Areas

There are three permanent subtidal control stations each in a different area in the vicinity of Diablo Canyon (Figure 72). Station 6 is located in the northwest corner of Field's Cove in the lee of Lion and Pup Rocks. It is in water ranging from 4.3 m to 8.5 m (14 to 28 feet) deep and is comprised of 70% rock and 30% sand. Station 7 is located at 9.1 m to 10.7 m (30 to 35 feet) depths in the center of Field's Cove. It is comprised of 100% rock. Station 15, in South Cove, is located on a pinnacle and ranges in depth from 4.6 m to 13.7 m (15 to 45 feet). Its substrate is comprised of 85% rock, with 15% sand in the deeper cracks and crevices.

One more station in Field's Cove (8) and two more stations in South Cove (13, 14) were established in 1970 but were lost in storms and not sampled during this study.

Other than substrate type, the only other physical parameter we measured was temperature. In general, our temperature data reflects the results of extensive work done by PG&E research teams (Warrick in PG&E 1979). The data indicate seasonal temperature cycles with cooler periods beginning around March, and warmer periods beginning around June that reach a peak in the fall. A particularly warm period was noted from June 1976 through February 1977.

Random Stations Studies

Red Algae

Methods

A. Field

Surveys of random subtidal stations were conducted once each year from June through November (Appendix Id).

1. Locating Stations

a. Diablo Cove

Using a bathymetric map of Diablo Cove (PG&E unpublished data), we created stations by dividing the Cove into blocks measuring 30.5 m (100') on a side (Figure 73). In order to determine if organism densities were related to depth, this block grid was then stratified into two depth areas based on the bathymetric map: shallow--2.1 to 7.6 m, (7 to 25 ft.) and deep--7.7 to 18.3 m (25 to 60 ft.).

Compass bearings to three known fixed objects on land and locatable on the map were determined for each station. Each year, station numbers to be sampled were randomly selected by computer. Alternate stations were chosen if the location of a station was unsuitable or unsafe for diving. At the time of sampling the station was located from the boat by triangulation on the compass bearings with a hand-held compass. A recording fathometer was used to verify depth of water. When the station was located, and the boat securely anchored, bottom and surface temperatures were recorded by a person on the boat, using a hydrographic thermometer.

Sampling of the random stations was performed by an "arc transect" method (Figure 14). The procedure for this circular transect was as follows:

(a) two divers swam down the anchor line to the anchor, each carrying a set of two lines, 3.1 in length, with a snap-swivel at the lines' origin and lead weights attached to the terminal ends to hold the lines in place;

(b) the divers attached the lines to the anchor with the snap-swivel and then each diver placed one of their lines side by side to mark their starting point;

(c) each of the second lines were moved to form an "arc" or wedge, the area encompassed depended on conditions such as density of algae cover and visibility;

(d) divers then counted or recorded presence/absence of the macro-invertebrates (10 mm and larger), brown algae, and fish in each wedge;

(e) when each diver completed counts in the first wedge, the starting point line was moved to mark the next wedge. This procedure was repeated until the divers met.

The total area covered by the arcs was a circle of 30-m^2. The counts were recorded on waterproof paper containing printed lists of plants and animals. In addition to the counts and abundance estimates, the divers recorded minimum and maximum depths of the station, estimated type and percentages of substrate (i.e., sand, gravel, cobble, boulder, or rock) percentage of cryptic habitat, and estimated water visibility. After the arc transect was completed, algal abundance was sampled by placing a 0.25-m^2 quadrat on an area of maximum red algae density. All foliose red algae were removed from within the quadrat and placed in a mesh bag.

b. Random Quadrat Station

In 1975, we initiated another random subtidal study to quantify the common but smaller invertebrates in Diablo Cove and North Control that were not being adequately quantified in the 30-m^2 arcs. This study was conducted with a linear 30-m transect along which four 0.25-m^2 areas were sampled. In 1977, we began collecting all the foliose red algae within the quadrat.

At each random station location (coinciding with the "arc" transects) a weighted 30-m long transect line was placed in either a northerly direction or parallel to shore, depending on which heading most closely followed a depth contour. The transect line was marked in one-meter increments. Four random numbers between one and thirty were pre-selected for each station and these random numbers were used to locate a metal 0.25-m^2 quadrat at a corresponding increment. Each diver sampled two quadrat locations, for a total of 4 quadrats along the transect, removing all foliose red algae within the quadrat and counting all identifiable invertebrates. The algae were placed in mesh bags containing labels identifying the station and quadrat. Counts were made of all invertebrates ($\leq$ 10 mm), brown algae stipes, and fish that occurred in the quadrat.

B. Laboratory

The foliose red algae collected at the subtidal random 30-m^2 arcs and 0.25-m^2 quadrats were treated the same as the algae discussed earlier in the Intertidal Macroflora section.

C. Statistical

For the red algae collected at areas of maximal biomass within a 30-m^2 arc the data were treated simply by calculating the mean dry weight grams of total biomass per quadrat. Data for the red algae species collected at the 0.25-m^2 quadrats along the 30-m transect were analyzed using the non-parametric Kruskal-Wallis and Mann-Whitney "U" procedures to test the null hypotheses 1, 2, and 3 listed in the Objectives section. The Kruskal-Wallis (K-W) test was used to test for differences in biomass distribution by water depth and to test for differences in biomass abundance between study areas and between years. The Mann-Whitney "U" test was used to test for differences in mean grams of biomass per quadrat between the study areas.

For this section of the report, significance is defined at the 5% levels of significance ($p \leq 0.05$).

Results

A. Diablo Cove

1. Random Arc Station

Prior to 1977, when the 0.25-m^2 quadrat stations were begun, red algae were sampled at 30-m^2 arc stations by removing all foliose red algae from an 0.25-m^2 area subjectively chosen as having the densest cover. This initial study was meant to depict maximal algal abundance and diversity and cannot be compared to the results from the randomly selected 0.25-m^2 quadrats.

The total dry weight from each year was converted to mean grams per quadrat to make comparisons among years (Table 31). The mean weight per quadrat in Diablo Cove increased from 53.2 g/0.25-m^2 in 1974 to a high of 125.0 g/0.25-m^2 in 1976 then decreased to 87.9 g per quadrat in 1977.

The species of red algae found in Diablo Cove during this study are documented in previous reports (Gotshall, et al. 1974; Gotshall et al. 1976; and Gotshall et al. 1977).

2. Random Quadrat Station

In 1977, the subtidal random quadrat study was started. In that year 50 species of red algae were identified from North Diablo Cove quadrats and 39 species were found in South Diablo Cove (Appendix 5). Fifty-one species were collected in South Diablo Cove and 33 species were identified from North Diablo

TABLE 31. Mean Grams of Red Algal Biomass Taken from 0.25-m^2 Quadrats Placed Within Areas of Densest Algal Growth Inside 30-m^2 Arcs in Diablo Cove and North Control. DCPP, 1974-1977.

Year	Number of Quadrats	$\bar{X}$ Grams Biomass (Dry Weight) 0.25-m^2 Quadrat
	Diablo Cove	
1974	6	53.2
1975	7	44.8
1976	12	125.0
1977	19	87.9
	North Control	
1974	6	148.0
1975	21	110.6
1976	23	164.9
1977	17	132.7

Cove quadrats in 1978 (Appendix 5). Of the species identified in all the study areas, only eight species or species groups individually comprised more than 1% of the total red algal biomass (Table 32): Botryoglossum farlowianum/Hymenena flabelligera complex, Gigartina corymbifera/G. exasperata complex, Iridaea cordata v. splendens, Neoptilota densa, Opuntiella californica, Prionitis lanceolata, Mircocladia coulteri, and Callophyllis pinnata.

Botroyoglossum farlowianum and Hymenena flabelligera were combined into a complex, for the purpose of our analysis, since the taxonomic characteristics of these algae intergrade, often making identification at species level difficult. Abbott and Hollenberg (1976) state that H. flabelligera "a very common species; when very mature and eroded, is difficult to distinguish from Botryoglossum farlowianum." Both species are found in low intertidal to subtidal locations (approximately 35 feet) from Vancouver Island, British Columbia, to San Luis Obispo County, California, with B. farlowianum extending down to Baja California. This algal complex was the most abundant of all red algae in Diablo Cove in terms of frequency of occurrence and biomass (Tables 32 and 33). In Diablo Cove, we found significant difference ($p \leq 0.01$) in distribution of the complex by depth, with the greatest density occurring between 11 and 20 feet (Table 34).

At North Diablo Cove stations, this complex averaged 20.8 g (dry weight) per quadrat (35.2% of the red algal biomass) in 1977 and 28.6 g per quadrat (49.4% of the red algal biomass) in 1978 (Table 33). The abundance (mean dry weight) of this complex in NDC was significantly different than in SDC (Table 35). South Diablo Cove stations averaged 6.5 g in 1977 and 7.7 g in 1978 (Table 33). This represents 66.4% and 39.9% of the SDC red algal biomass, respectively.

TABLE 32. Percent Frequency of Occurrence of the Eight Most Common Algal Species at Random 0.25-m^2 Quadrats in North Diablo Cove, South Diablo Cove, and North Control. DCPP, 1977-1978.

	% Frequency of Occurrence								
	North Diablo Cove			South Diablo Cove			North Control		
Species	1977	1978	Both Years	1977	1978	Both Years	1977	1978	Both Years
Botryoglossum farlowianum/ Hymenena flabelligera	85	79	81	62	62	62	92	82	87
Gigartina corymbifera/ exasperata complex	56	53	55	6	11	9	33	33	33
Iridaea cordata v. splendens	44	43	43	6	8	7	11	23	18
Neoptilota densa	23	2	12	16	30	23	20	45	34
Opuntiella californica	44	15	28	12	16	14	34	23	28
Prionitis lanceolata	31	28	29	6	14	10	16	13	14
Microcladia coulteri	54	74	65	16	27	22	32	54	48
Callophyllis pinnata	26	15	20	3	8	6	15	22	19
Total Number of Quadrats Sampled	39	47	71	32	37	84	79	94	173

TABLE 33. Mean Grams of Algal Biomass (Dry Weight) per Random 0.25-m^2 Quadrats and Percentage Composition of Biomass by Study Area for Eight Species of Algae at North Diablo Cove, South Diablo Cove, and NOrth Control Random 0.25-m^2 Quadrats. DCPP, 1977-1978.

Species	North Diablo Cove				South Diablo Cove				North Control			
	1977		1978		1977		1978		1977		1978	
	$\frac{\bar{x}\text{ grams}}{\text{quadrat}}$	% of NDC biomass	$\frac{\bar{x}\text{ grams}}{\text{quadrat}}$	% of NDC biomass	$\frac{\bar{x}\text{ grams}}{\text{quadrat}}$	% of SDC biomass	$\frac{\bar{x}\text{ grams}}{\text{quadrat}}$	% of SDC biomass	$\frac{\bar{x}\text{ grams}}{\text{quadrat}}$	% of NC biomass	$\frac{\bar{x}\text{ grams}}{\text{quadrat}}$	% of NC biomass
Botryoglossum/Hymenena complex	20.8	35.2	28.6	49.4	6.5	66.4	7.7	39.9	44.2	65.5	39.8	64.3
Gigartina corymbifera/ exasperata	20.7	34.9	17.8	30.6	0.1	<1.0	5.5	28.8	14.0	20.7	9.3	15.0
Iridaea cordata v. *splendens*	5.5	9.2	1.0	1.6	0.1	1.5	0.2	1.2	1.4	2.1	2.2	3.5
Neoptilota densa	0.7	1.2	<0.1	<1.0	0.5	4.8	1.2	6.2	1.2	1.7	2.0	3.2
Opuntiella californica	1.0	1.7	0.2	<1.0	0.7	7.1	0.3	1.4	1.5	2.3	0.9	1.5
Prionitis lanceolata	1.7	2.9	1.5	2.6	<0.1	<1.0	0.5	2.7	0.7	1.1	0.2	<1.0
Microcladia coulteri	0.6	1.0	2.2	3.7	<0.1	<1.0	0.6	3.7	0.4	<1.0	0.4	<1.0
Callophyllis pinnata	0.9	0.6	0.7	1.2	<0.1	<1.0	<0.1	<1.0	0.8	1.2	0.6	1.0
Total Biomass (Dry Weight) per Quadrat (Includes all species)	59.3		58.3		9.8		19.2		67.5		62.0	
Number of Quadrats Sampled	39		47		32		32		79		94	

TABLE 34. Distribution by Depth of Mean Grams of Algal Biomass (Dry Weight) and Results of Kruskal-Wallis Tests for Significant Differences in Depth Distribution for Eight Species of Algae at Random 0.25-m^2 Quadrats in Diablo Cove and North Control. DCPP, 1977-1978.

		Depths Sampled							
Species and Location		0-10 ft.	11-20 ft.	21-30 ft.	31-40 ft.	41-50 ft.	51-60 ft.	61+ ft.	
Diablo Cove Sample Size		(N=15)	(N=73)	(N=34)	(N=13)	(N=17)	(N=10)	(N=0)	K-W Test Sig. Level
North Control Sample Size	Area	(N=18)	(N=58)	(N=48)	(N=16)	(N=10)	(N=3)	(N=3)	Both Years Combined
Botryoglossum/Hymenena	Diablo Cove	21.3	24.1	16.6	0.6	0.3	0.0	---	0.000**
	North Control	66.7	63.8	39.3	15.5	4.6	0.1	0.1	0.000**
Gigartina corymbifera/ exasperata complex	Diablo Cove	10.6	18.0	10.2	2.3	0.3	0.0	---	0.467
	North Control	24.7	22.7	3.3	1.7	1.0	0.0	0.0	0.000**
Iridaea cordata v. *splendens*	Diablo Cove	2.1	2.5	1.5	0.0	0.2	0.0	---	0.091
	North Control	6.5	3.0	0.4	0.2	0.0	0.0	0.0	0.053
Neoptilota densa	Diablo Cove	2.2	0.8	0.0	0.0	0.0	0.0	---	0.061
	North Control	2.4	2.4	1.8	0.2	0.1	0.4	0.0	0.351
Opuntiella californica	Diablo Cove	0.0	0.2	0.7	1.0	1.3	2.2	---	0.027*
	North Control	0.0	0.4	0.9	2.7	6.3	0.7	0.0	0.000**
Prionitis lanceolata	Diablo Cove	1.2	1.3	1.4	0.0	0.0	0.0	---	0.138
	North Control	0.4	1.0	0.2	0.1	0.0	0.0	0.0	0.182

TABLE 35. Results of Kruskal-Wallis Tests for Significant Differences in Algal Biomass (Dry Weight) Abundance Between Study Areas for Eight Species of Algae at Random 0.25-m^2 Quadrats. DCPP, 1977-1978.

Species	North Diablo Cove vs. South Diablo Cove	North Control vs. Diablo Cove	North Control vs. North Diablo Cove
Botryoglossum/ Hymenena complex	0.000** (NDC)	0.000** (NC)	0.000** (NC)
Gigartina corymbifera/ exasperata complex	0.000** (NDC)	0.999	0.003** (NDC
Iridaea cordata V. splendens	0.000** (NDC)	0.063	0.000** (NDC)
Neoptilota densa	0.063	0.000** (NC)	0.000** (NC)
Opuntiella californica	0.077	0.080	0.535
Prionitis lanceolata	0.002** (NDC)	0.081	0.002** (NDC)
Microcladia coulteri	0.000** (NDC)	0.677	0.001** (NDC)
Callophyllis pinnata	0.009** (NDC)	0.186	0.170

+ = Significance level ($p \leq 0.05$)

** = Significance level ($p \leq 0.01$)

(NDC) = Indicates greater abundance in North Diablo Cove

(SDC) = Indicates greater abundance in South Diablo Cove

(NC) = Indicates greater abundance in North Control

Gigartina corymbifera and G. exasperata were also combined into a complex for our analysis due to the difficulty in identifying juveniles and more mature, eroded specimens. The two species co-occur over most of their ranges: G. corymbifera ranges from Washington to Cabo San Quintin, Baja California, down to 30 m and G. exasperata, which is found to 20 m, ranges from Vancouver Island, British Columbia, to Punta Maria, Baja California (Abbott and Hollenberg 1976). In Diablo Cove Kruskal-Wallis tests indicated no significant differences in depth distribution (Table 34).

At North Diablo Cove stations, this complex averaged 20.7 g (dry weight) per quadrat in 1977, which represented 34.9% of that area's red algal biomass. In 1978, a mean of 17.8 g per quadrat was found, representing 30.6% of the biomas (Table 33). South Diablo Cove stations were significantly difference ($p \leq 0.01$) in Gigartina complex abundance (Table 35). In 1977, this complex comprised less than 1% of South Diablo Cove's red algal biomass. However, in 1978 this figure reached 28.8%, or 5.5 g per quadrat (Table 33).

Iridaea cordata v. splendens, a low intertidal to subtidal (7 m) species, ranges from Queen Charlotte Island, British Columbia to northern Baja Californa (Abbott and Hollenberg 1976). Although it was most common in shallow depths, it demonstrated no significant differences in density by depth at Diablo Cove stations (Table 34). North Diablo Cove averaged 5.5 g (dry weight) in 1977 and 1.0 g per quadrat in 1978. This represents 9.2% and 1.6%, respectively, of the red algal biomass (Table 33). South Diablo Cove stations had significantly lower mean abundances of Iridaea cordata v. splendens than NDC stations (Table 35). The mean dry weight at SDC quadrats was 0.1 g (1.5% of the biomass) in 1977 and 0.2 g (1.2% of the biomass) in 1978 (Table 33).

Neoptilota densa is a low intertidal to subtidal species (to 15 m), found from Tomales Bay, California, to Bahia Rosario, Baja California (Abbott and Hollenerg 1976). Probably due to low amounts found at either Stratum there were no significant depth distribution differences in Diablo Cove; however, it was only found at 20 feet and shallower (Table 34). N. densa averaged 0.7 g (1.2% of the red algal biomass) per quadrat at NDC stations in 1977, but dropped to less than 0.1 g (less than one percent of the biomass) in 1978. At SDC stations, N. densa averaged 0.5 g (4.8% of biomass) per quadrat in 1977 and 1.2 g (6.2% of the biomass) in 1978 (Table 33).

N. densa was one of only three species to demonstrate a significant difference ($p \leq 0.05$) in abundance between years; more was found in 1978 than in 1977 (Table 36). This may be a statistical artifact due to the relatively low abundance and not reflective of the real conditions.

Opuntiella californica is a mostly subtidal (to 30 m) red alga found from Alaska to Punta Santo Tomas, Baja California (Abbott and Hollenberg 1976). In the Diablo Canyon study areas, it appears to be strictly subtidal. It was found to be significantly ($p \leq 0.05$) distributed by depth. The greatest amount was found between 51 and 60 feet (Table 34). In both North Diablo Cove stations and South Diablo Cove stations there was a decrease in abundance from 1977 to 1978 (Table 33). At NDC quadrats, O. californica decreased from 1.0 g per quadrat (1.7% of the biomass) in 1977, to 0.2 g per quadrat (less than 1.0% of the biomass) in 1978. In SDC the situation was similar, with O. californica declining from 0.7 g per quadrat (7.1% of the biomass) in 1977 to 0.3 g (1.4% of the biomass) in 1978. There was no statistically significant difference in abundance between NDC and SDC quadrats (Table 35). There is, however, a significant ($p \leq 0.05$) difference in abundance between years (Table 36).

Prionitis lanceolata occurs on rocks from the mid-intertidal to subtidal (30 m) and ranges from Vancouver Island, British Columbia to Punta Santa Rosalia, Baja California (Abbott and Hollenberg 1976). No significant difference in distribution by depth was found in Diablo Cove, although it was found only at 30 feet and shallower (Table 34). There was, however, a significant difference in abundance between NDC and SDC stations (Table 35).

North Diablo Cove stations averaged 1.7 g (dry weight) per quadrat in 1977 and 1.5 g per quadrat in 1978, comprising 2.9% and 2.6%, respectively, of the red algal biomass. P. lanceolata was relatively scarce at SDC quadrats in 1977, averaging less than 0.1 g and 1% of the biomass per quadrat. In 1978, SDC quadrats averaged 0.5 g dry weight, which made up 2.7% of the biomass (Table 33).

Microcladia coulteri is epiphytic on several species of large red algae and occasionally on large brown algae. It is found from the mid-intertidal to subtidal (10 m) and ranges from Vancouver Island, British Columbia, to Baja California (Abbott and Hollenberg 1976). In Diablo Cove, no significant difference in abundance by depth was found, although it was not found deeper than 40 feet (Table 34). There was, however, a significant difference in abundance betwen NDC and SDC stations (Table 35). North Diablo Cove quadrats averaged 0.6 g in 1977 and 2.2 g in 1978. This represents 1.0% and 3.7%, respectively, of the red algal biomass in NDC. South Diablo Cove quadrats averaged less than 0.1 g (less than 1.0% of biomass) per quadrat in 1977, and 0.6 g (3.7% of biomass) per quadrat in 1978 (Table 33). At Diablo Cove stations more M. coulteri was found in 1978 than in 1977, and this difference between years was significant (Table 36).

Callophyllis pinnata is found from the low intertidal to upper subtidal and ranges from Washington to Baja California (Abbott and Hollenberg 1976). In Diablo Cove we found no significant differences in abundance by depth, although none was found deeper than 40 feet (Table 34). In South Diablo Cove quadrats, the mean dry weights were less than 0.1 g in both 1977 and 1978 (Table 33). There was a significant ($p \leq 0.01$) difference in abundance betwen North Diablo Cove and South Diablo Cove (Table 35). The mean grams per quadrat were greater in North Diablo Cove with 0.9 g per quadrat in 1977 and 0.7 g per quadrat in 1978. This comprised 1.6% (1977) and 1.2% (1978) of the NDC red algal biomass. The SDC figures for both years represented less than 1% of that area's biomass (Table 33).

B. North Control

1. Random Arc Station

The total dry weight of red algal biomass collected from within 0.25-m quadrats placed in areas of maximum algal biomass and diversity at North Control ranged from a low of 110.6 g per quadrat in 1975 to a high of 164.9 g per quadrat in 1976 (Table 31). These results are not comparable to the weights obtained from the random quadrat studies since the sampling methods differ.

2. Random Quadrat Station

TABLE 36. Results of Kruskal-Wallis Tests for Significant Differences in Algal Biomass Abundance Between Years 1977 and 1978 for All Study Areas Combined for Eight Species of Algae at Random 0.25-m^2 Quadrats. DCPP, 1977-1978.

Species	1977 vs. 1978
Botryoglossum Hymenena	0.158
Gigartina/corymbifera exasperata complex	0.906
Iridaea cordata V. splendens	0.190
Neoptilota densa	0.050*(1978)
Opuntiella californica	0.014*(1977)
Prionitis lanceolata	0.810
Microcladia coulteri	0.001** (1978)
Callophyllis pinnata	0.427

( ) = Indicates the year with the greatest abundance

* = Significance level ($p \leq 0.05$)

** = Significance level ($p \leq 0.01$)

North Control stations yielded 34 species of red algae in 1977 and 46 species in 1978 (Appendix 5).

Botryoglossum farlowianum and Hymenena flabelligera complex, as in Diablo Cove, comprised the most frequently observed algae in our samples (Table 32). The dry weight of this species group formed the greatest portion of the total biomass of all the species (Table 33). In 1977, the B. farlowianum and H. flabelligera complex averaged 44.2 g dry weight per quadrat. This was 65.5% of the red algal biomass of North Control. The average dry weight in 1978 was 39.8 g which represented 64.3% of the biomass. These figures were significantly ($p \leq 0.01$) different (higher) from the means of the same species in North Diablo Cove and Diablo Cove (Table 35).

The depth/density differences noted in Diablo Cove were also seen in North Control stations. We found significant difference ($p \leq 0.01$) in abundance by depth at NC stations (Table 34). Greater amounts were found at quadrats between 1 and 20 feet in depth.

Gigartina corymbifera and G. exasperata averaged 14.0 g dry weight per quadrat in 1977 and 9.3 g per quadrat in 1978 (Table 33). This represented 20.7% and 15.0% respectively, of the North Control red algal biomass. This complex of algae was second in abundance only to the Botryoglossum farlowianum/Hymenena flabelligera complex.

At North Control stations in contrast to Diablo Cove, there was a significant difference ($p \leq 0.01$) in abundance by depth (Table 34). Shallower quadrats contained greater amounts of Gigartina corymbifera/G. exasperata biomass than deeper stations.

Iridaea cordata v. splendens comprised 2.1% of the red algal biomass (1.4 g dry weight per quadrat) in 1977 and 3.5% (2.28 per quadrat) in 1978 (Table 33). There was no significant difference in distribution by depth at NC stations although most of the algae was found in the first 20 feet (Table 34).

Neoptilota densa increased from 1.2 g per quadrat (1.7% of the red algal biomass) in 1977 to 2.0 g per quadrat (3.2% of the biomass) in 1978 (Table 34).

Opuntiella californica, which comprised 2.3% of the red algal biomass in North Control in 1977 and 1.5% in 1978 (Table 33), demonstrated statistically significant differences ($p \leq 0.01$) in distribution by depth (Tabler 34). At North Control stations, O. californica was most abundant between 31 and 50 feet. The mean dry weight per quadrat decreased from 1.5 g in 1977 to 0.9 g in 1978.

Prionitis lanceolata comprised 1.1% of the red algal biomass at North Control stations in 1977 and less than 1% in 1978. The mean dry weight per quadrat was 0.7 g in 1977 and 0.2 g in 1978 (Table 33).

Microcladia coulteri comprised less than 1% of the red algal biomass at North Control stations (Table 33). It was found to have significant differences in abundance by depth at North Control (Table 34).

Callophyllis pinnata had a mean dry weight per quadrat at North Control stations of 0.8 g in 1977 and 0.6 g in 1978. This represented 1.2% and 1.0% of the red algal biomass, respectively (Table 33). This species was found to be significantly distributed by depth in North Control (Table 34).

C. Comparison of Study Areas

1. Random Arc Station

The mean biomass (grams dry weight) for quadrats placed in areas of maximal abundance and diversity was higher in North Control than in Diablo Cove for all years (Table 31)

2. Random Quadrat Station

Botryoglossum farlowianum/Hymenena flabelligera. This species group was the commonest in terms of percent frequency of occurrence in both Diablo Cove and North Control (Table 320. There were significant ($p \leq 0.01$) differences in overall abundance between North Control and Diablo Cove (Table 35). There were also significant differences in abundance by depth at both study areas.

Gigartina corymbifera/G. exasperata. There was no significant difference in abundance between North Control and Diablo Cove (South Diablo Cove and North Diablo Cove combined), though there was a significant ($p \leq 0.01$) difference in abundance between North Conrol and North Diablo Cove (Table 35). This complex had a significant ($p \leq 0.01$) difference in abundance by depth at North Control but not at Diablo Cove (Table 34).

Iridaea cordata v. *splendens*. North Diablo Cove had significantly ($p \leq 0.01$) different amounts (greater) of biomass of this species than North Control, however, when South Diablo Cove and North Diablo Cove were combined, then compared to North Control, there were no significant differences between Diablo Cove and North Control (Table 35).

Neoptilota densa. Significantly different amounts of this species were found when North Control and Diablo Cove were compared (Table 35). North Control yielded higher means of dry weight per quadrat (Table 33).

Opuntiella californica. There was no significant difference in abundance between North Control and Diablo Cove (Table 35).

Prionitis lanceolata. While there was no significant difference in abundance of P. lanceolata between North Control and the combined Diablo Cove stations, there was a significant ($p \leq 0.01$) difference in abundance between North Control and North Diablo Cove (Table 35).

Microcladia coulteri. There was no significant difference in abundance of M. coulteri between North Control and Diablo Cove; however, there was a significant ($p \leq 0.01$) difference between North Control and North Diablo Cove (Table 35). This alga was found to have a significant ($p \leq 0.01$) difference of amounts of biomass by depth in North Control but not in Diablo Cove (Table 34).

Callophyllis pinnata. Abundance in grams dry weight per quadrat was similar at both North Control and Diablo Cove stations. There was no statistically significant difference in abundance between North Control and Diablo Cove (Table 35). There was no difference statistically in abundance by depth in Diablo Cove but there was this difference by depth in North Control (Table 34).

TABLE 37. Summary of Statistical Tests for Significant Differences in Abundances for Eight Species of Red Algae at Subtidal Random Quadrat Stations by Comparison of Study Areas, Over Time, and By Depth. DCPP, 1977-1978.

	NULL HYPOTHESES				
	1		2	3	
	Comparability of Study Areas		Temporal Stability of Study Areas	Comparability of Depth Distribution	
SPECIES	SDC vs. NDC	DC vs. NC	1977 vs. 1978	DC	NC
Botryoglossum/ Hymenena flabelligera	R	R		R	R
Gigartina corymbifera/ exasperata complex	R				R
Iridaea cordata v. *splendens*	R				
Neoptilota densa		R	R		
Opuntiella californica			R	R	R
Prionitis lanceolata	R				
Microcladia coulteri	R		R		R
Callophyllis pinnata	R				R

R = rejection of null hypothesis

Discussion

Results of our sampling indicate that North Control has a greater abundance of red algae than Diablo Cove. It is also clear that North Diablo Cove is significantly richer, in both red algae biomass and species diversity, than South Diablo Cove. These differences possibly result from the differences in habitat between the areas. North Control has a higher percentage of rock than Diablo Cove, thus providing more substrate for red algal growth. South Diablo Cove, particularly, has a higher percentage of sand and gravel which reduces, proportionately, the amount of favorable substrate for saxicolous algae. The higher amount of sand in South Diable Cove also contributes to increased turbidity and scouring, especially during periods of rough seas, further contributing to lower algal diversity and abundance.

The differences in red algal biomass between North Control and Diablo Cove and between North and South Diablo Cove violate the null hypothesis for comparability of study areas (Table 37). However, this should not diminish algae's usefulness in assessing possible effects of power plant operations. Despite differences in speciation, the stability of each area, reflected by the similarity of the biomass between years, (Table 36) establishes them as points for future comparison.

Differences in species diversity between the areas are more difficult to assess. It is a generally recognized ecological principle that in most communities a small percentage of species are usually very abundant, either in terms of numbers or of biomass, and a large percentage are rare. It is these numerous, rarer species that contribute to high species diversity in a community. Both Diablo Cove and North Control fit well into this pattern. In both of these areas, a few species, or complexes of species, comprise a very large percentage of the biomass. However, these two study areas are different with respect to speciation. The differences between the areas are, perhaps, functions of several factors. Odum (1971) states "species diversity tends to be low in physically controlled ecosystems and high in biologically controlled ecosystems" and that physically controlled ecosystems are "subject to strong physiochemical limiting factors." Several such factors may be extant in our study areas, particularly in South Diablo Cove. Diablo Cove, protected as it is in the lee of Diablo Rock, is observably less subject to the vagaries of current and wave shock than North Control which is a more exposed outer coast. South Diablo Cove, more exposed than North Diablo Cove during parts of our sampling periods, is also more subject to the problems of sediment, mentioned above, that are less obvious in North Diablo Cove or North Control. Also, due to the gyre conditions that are sometimes present in South Diablo Cove, warmer water may "stack up" in the area. South Diablo Cove, from our earliest observations, has been an area of lower species diversity than NDC or NC, most likely because it is, in large part, a physically controlled ecosystem.

The most diverse area we sampled, in terms of red algal speciation, was North Diablo Cove. North Control, to a lesser degree, also shows greater red algal species diversity than South Diablo Cove. Ecologically, diversity is usually higher in most "established" communities and lower in most younger communites. However, the relatively recent removal of major herbivores, sea urchin and abalone, by sea otters, and the subsequent increase in canopy-forming brown algae, such as Laminaria and Pterygophora in Diablo Cove, indicate that this area is in flux (Table 37). Whether the red algae community living under the canopy will change, is a matter of conjecture. Such changes may have occurred previous to our intentive red algae sampling program.

The significant difference in amounts of biomass by depth apparently violates another null hypothesis, that of no difference in sample mean densities between depths (Table 37). However, it is to be expected that each species has its optimum range from for growth and the distributional patterns established for red algal species in our pre-operational studies would provide adequate basis for comparison with operational results.

Brown Algae

Methods

A. Field

Surveys of subtidal brown algal numbers were conducted each year from June through November at both the 30-m^2 arc and 0.25-m^2 quadrat stations. The methods of locating and sampling at the arc and quadrat stations has been detailed in the Field Method for subtidal red algae.

Stipes (thick, stem-like structures that bear blades) of *Pterygophora californica*, *Laminaria dentigera*, and *Nereocystis luetkeana* were counted if they occurred within the area covered by the 30-m^2 arc or the 0.25-m^2 quadrat.

A third method of quantifying *Nereocystis luetkeana* plants was begun in 1975. As the 30-m long transect line was laid out for the random 0.25-m^2 quadrats, all *Nereocystis* stipes observed within 1 meter to either side of the of the line were counted along the entire lenght of the line. The total area covered was 60 m^2.

B. Statistical

The objectives of the brown algae study were to test the null hypotheses 1, 2, and 3 listed in the Objectives section.

For the 30-m^2 arc stations the non-parametric Kruskal-Wallis test was used to determine if there were significant differences in the mean counts over time at each study area and to test for significant differences in depth distribution. To detect significant differences in mean counts per station between the study areas a Mann-Whitney test was used.

Data from the 0.25-m^2 quadrats were treated in a manner similar to the arc station data. Mean counts of the brown algae were subjected to a Kruskal-Wallis analysis to determine if there were significant differences between years. The Mann-Whitney test was used to detect significant differences between study areas.

The counts along the 30-m transect line (60 m^2 area) were converted to mean numbers per station and a Mann-Whitney "U" test was used to determine if there were significant differences in abundance between Diablo Cove and North Control.

For the subtidal brown algae section, significance is defined at the 1-5% levels of significance ($p \leq 0.05$). Sampling effort (number of stations or quadrats surveyed) is presented in Appendix 1d.

Results

A. Diablo Cove

1. Random Arc Station

Laminaria dentigera ranges from the Bering Strait to Ensenada, Baja, California and is found from the lower intertidal to the shallow subtidal in moderately exposed areas (Abbott and Hollenberg 1976). At Diablo Cove 30-m^2 stations there was a significant ($p \leq 0.01$) change in density from 1974-1977. There were 15.6 stipes per station in 1974 and 142.8 in 1977 (Figure 76, Table 38). Within Diablo Cove, both North Diablo Cove and South Diablo Cove 30-m^2 stations showed significant changes in density from 1974 to 1977 (Table 38). Both areas had increases in Laminaria plant numbers. By depth, there was no significant difference in L. dentigera distribution in either NDC or SDC 30-m^2 arc stations (Table 39). Within Diablo Cove, North Diablo Cove 30-m^2 stations were significantly ($p \leq 0.05$) different in density than South Diablo Cove (Table 40); North Diablo Cove arc stations had more stipes per station than South Diablo Cove.

Pterygophora california occurs from Vancouver Island, British Columbia to Bahia del Rosario, Baja, California. P. californica is found in water 7 to 20 m deep (Abbott and Hollenberg 1976). Densities at Diablo Cove 30-m^2 stations changed significantly ($p \leq 0.01$) over time from a mean of 23.4 per (Table 38). An apparent increase in mean number noted at NDC stations was not found to be statistically significant. P. californica at 30-m^2 stations in South Diablo Cove demonstrated a significant ($p \leq 0.05$) difference in distribution by depth which was not noted in North Diablo Cove (Table 39).

TABLE 38. Mean Numbers of Three Species of Brown Algae and Results of Kruskal-Wallis Tests for Significant Differences in Abundance Years at Diablo Cove and North Control Random 30-m^2 Arc Stations. DCPP, 1974-1977.

Species	Area	1974-1977 Mean	1974	1975	1976	1977	Kruskal-Wallis Significance Among Years 1974-1974
Laminaria dentigera	Diablo Cove+	90.8	15.6	90.5	80.0	142.8	.0000**
	North Control	17.2	6.0	9.4	21.3	27.8	.0216*
	North Diablo Cove	114.0	32.3	100.7	109.9	172.3	.0111**
	South Diablo Cove	68.0	1.3	80.4	50.1	113.2	.0003**
Pterygophora californica	Diablo Cove+	129.4	23.4	131.0	168.8	145.9	.0001**
	North Control	23.1	10.0	15.6	13.6	48.9	.3289
	North Diablo Cove	63.3	21.0	52.2	96.3	62.6	.2832
	South Diablo Cove	194.0	25.4	209.8	241.2	229.3	.0037**
Nereocystis luetkeana	Diablo Cove+	37.6	34.2	86.9	21.4	6.5	.0001**
	North Control	4.5	9.4	3.8	5.3	1.3	.9511
	North Diablo Cove	53.4	73.5	107.2	34.5	8.5	.0083**
	South Diablo Cove	22.2	0.4	66.7	8.3	4.5	.0000**

* Significance level ($p \leq 0.05$).

** Significance level ($p \leq 0.01$).

\+ Diablo Cove numbers are composed of counts from South Diablo Cove and North Diablo Cove.

TABLE 39. Results of Kruskal-Wallis Tests for Significant Differences in Abundance by Depth for Three Species of Brown Algae from Random 30-m^2 Arc Stations in Diablo Cove and North Control. DCPP, 1974-1977.

Species	Area	Kruskal-Wallis Significance Level (1974-1977 lumped)	Depth of Greatest Density
Laminaria dentigera	North Control	.0170*	41-50 ft.
	North Diablo Cove	.0889	+
	South Diablo Cove	.5021	+
Pterygophora californica	North Control	.0000**	31-40 ft.
	North Diablo Cove	.6008	+
	South Diablo Cove	.0422*	21-30 ft.
Nereocystis luetkeana	North Control	.0000**	41-50 ft.
	North Diablo Cove	.2467	+
	South Diablo Cove	.0316*	21-30 ft.

* Significance level ($p \leq 0.05$).

** Significance level ($p \leq 0.01$).

\+ No significant difference in density by depth was detected, therefore there was no one depth with significantly greater amounts than any other depth.

TABLE 40. Results of Mann-Whitney Tests for Significant Differences in Abundance of Three Species of Brown Algae Between Study Areas at Random 30-m^2 Arc Stations. DCPP, 1974-1977.

Species	Mann-Whitney Significance level North Diablo Cove vs. South Diablo Cove All Years (1974-77) Combined	Mann-Whitney Significance level Diablo Cove vs. North Control All years (1974-77) Combined
Laminaria dentigera	.000** (DC)	.019* (NDC)
Pterygophora californica	.000** (DC)	.000** (SDC)
Nereocystis luetkeana	.000** (DC)	.012* (NDC)

* = Significance level ($p \leq 0.05$)

** = Significance level ($p \leq 0.01$)

(DC) indicates that higher numbers occurred in Diablo Cove

(NDC) indicates that higher numbers occurred in North Diablo Cove

(SDC) indicates that higher numbers occurred in South Diablo Cove

(Table 38). An apparent increase in mean number noted at NDC stations was not found to be statistically significant. P. californica at 30-m^2 stations in South Diablo Cove demonstrated a significant ($p \leq 0.05$) difference in distribution by depth which was not noted in North Diablo Cove (Table 39).

South Diablo Cove 30-m^2 stations for all years combined had significantly different ($p \leq 0.01$) densities (194.0 plants per station) than North Diablo Cove stations (63.3 plants per station) (Tables 38 and 40).

Nereocystis luetkeana is present from Shumagin Island in Alaska to San Luis Obispo County, California and is most common north of Carmel, California in water from 10 to 17 m deep (Abbott and Hollenberg 1976). At Diablo Cove 30-m^2 stations there was a significant ($p \leq .01$) change in abundance between 1974, when 34.2 plants per station were counted, and 1977 when there were 6.5 per station (Table 38). A peak of 86.9 per station surveyed was observed in 1975. Within Diablo Cove, both North Diablo Cove and South Diablo Cove 30-m^2 stations had significant ($p \leq 0.01$) changes in density from 1974 to 1977 (Table 38). There was a significant difference in distribution by depth noted at SDC 30-m^2 stations, but not at NDC stations (Table 34). N. luetkeana densities at 30-m^2 stations were significantly different between NDC and SDC (Table 40).

2. Random Quadrat Station

Laminaria dentigera data collected at 0.25-m^2 stations in Diablo Cove were not separated into North Diablo Cove and South Diablo Cove components for the purposes of this analysis. No significant change in density through the station in 1974 to 145.9 per station in 1977 (Figure 76, Table 38). These increases occurred principally at South Diablo Cove stations, where densities increased from 25.4 per station in 1974 to 229.3 per station in 1977 years was noted at 0.25-m^2 stations in Diablo Cove (Fiugre 77a, Table 41). However, a significant difference in depth distribution was noted at these stations where the greatest concentrations were found between 41 and 50 feet (Table 42).

Pterygophora californica densities at Diablo Cove 0.25-m^2 stations remained comparatively stable from 1975 to 1978 (Figure 77a, Table 41). There were also no significant difference in distribution by depth at 0.25-m^2 stations (Table 42).

Nereocystis luetkeana densities decreased was noted at 0.25-m^2 stations from 0.25 per quadrat in 1975 to 0.06 in 1978 but the change over time was not statistically significant (Figure 77a, Table 41). There was no significant difference in depth distribution of N. luetkeana at 0.25-m^2 Diablo Cove stations (Table 42).

3. 60-m^2 Transect

The third method of quantifying Nereocystis luetkeana was along a 30-m transect line from which the 0.25-m^2 quadrats were sampled. Counts were made of all N. luetkeana within one meter of each side of the line, for a total area covered of 60 m^2. Densities along these lines dropped from a mean of 114.11 in 1975 to 10.45 in 1978 (Table 43).

TABLE 41. Mean Numbers per Quadrat of Three Species of Brown Algal and Results of Kruskal-Wallis Tests for Differences in Abundance Between Years at Random 0.25-m^2 Quadrats. DCPP, 1975-1978

Species	Area	1975	1976	1977	1978	Kruskal-Wallis Significance Level
Laminaria dentigera	Diablo Cove	0.91	1.21	1.44	1.95	1.107
	North Control	---	0.27	0.91	0.77	0.127
Pterygophora californica	Diablo Cove	0.43	1.19	1.49	1.20	0.367
	North Control	---	1.04	0.77	0.77	0.056
Nereocystis luetkeana	Diablo Cove	0.25	0.35	0.05	0.06	0.227
	North Control	---	0.00	0.07	0.07	0.055

-- = not sampled

TABLE 42. Results of Kruskal-Wallis Tests for Significant Differences in Abundance by Depth for Three Species of Brown Algae from Random 0.25-m^2 Quadrat Stations in Diablo Cove and North Control. DCPP, 1975-1978.

Species	Area	Kruskal-Wallis Significance Level (1975-1978 Combined for DC) (1976-1978 Combined For NC)	Depth Of Greatest Density
Laminaria dentigera	Diablo Cove	.002**	41 - 50 ft.
	North Control	.871	†
Pterygophora Californica	Diablo Cove	.235	†
	North Control	.000**	50 - 60 ft.
Nereoaptis Luetkeana	Diablo Cove	.175	†
	North Control	.006**	41 - 50 ft.

* = Significance level ($p \leq 0.05$)

**= Significance level ($p \leq 0.01$)

† = No significant difference in density by depth was detected, therefore there was no one depth with significantly greater amounts than any other depth.

TABLE 43. Mean Numbers Per Station and Results of Mann-Whitney Tests for Significant Differences in Abundance in Nereosystis luetkeana Between Study Areas Along 60-m^2 Transects. DCPP, 1976-1978.

Year	Diablo Cove	North Control	Mann-Whitney Significance Level Diablo vs. North Control
1975	114.11	---	---
Number of Stations	8		
1976	30.50	5.17	.001**
Number of Stations	12	12	
1977	14.08	1.71	.002**
Number of Stations	24	21	
1978	10.46	13.87	.393
Number of Stations	24	24	

--- = not sampled

** = Significance level ($p \leq 0.01$)

B. North Control

1. Random Arc Station

Laminaria dentigera densities increased at 30-m^2 stations from 6.0 per station in 1974 to 27.3 in 1977 (Figure 76, Table 38). The change in density over time was significant ($p \leq 0.05$). There was also a significant difference in depth distribution; the greatest concentration was found between 41-50 feet (Table 39).

Pterygophora californica mean densities increased at North Control 30-m^2 stations also, but the apparent increase was not statistically significant ($p \leq 0.05$). At 30-m^2 arc stations there was a significant ($p \leq 0.0.5$) depth/density distribution observed with the greatest numbers of individuals found between 31 and 40 feet (Table 39).

Nereocystis luetkeana declined from 9.4 per 30-m^2 station in 1974 to 1.3 per station in 1977 (Figure 76, Table 38). This change, interestingly, was not statistically significant. At 30-m^2 stations N. luetkeana was found to have a statistically significant depth/density relationship. The greatest concentration was found between 41-50 feet (Table 39).

2. Random Quadrat Station

Laminaria dentigera at the 0.25-m^2 stations in North Control showed no significant differences in either the density or depth relationships (Figure 77, Tables 41 and 42).

Pterygophora californica decreased in abundance at the North Control 0.25-m^2 quadrats, however, this change in density was not statistically significant (Figure 77, Table 41). There was, however, a significant difference found in depth distribution with the greatest concentration found between 51 and 60 feet (Table 42).

Nereocystis luetkeana at North Control 0.25-m-^{2} quadrats did not change significantly in abundance over the years (Table 11). There was a statistically significant difference in distribution by depth. The greatest concentration was found between 41-50 feet (Table 11). These results are similar to data from the 30-m^2 stations.

3. 60-m^2 Transect

Along the 60-m^2 linear areas surveyed in North Control, Nereosystis luetkeana decreased in abundance from 1976 to 1977 but increased in 1978 (Table 43).

B. Comparison of Study Areas

1. Random Arc Station

Laminaria dentigera densities were significantly ($p \leq 0.01$) different between Diablo Cove 30-m^2 stations and North Control stations when all the years were combined (Table 40); Diablo Cove stations had more L. dentigera plants than North Control.

Pterygophora californica was found to occur in significantly ($p \leq 0.01$) different densities at the 30-m^2 in Diablo Cove than in North Control (Table 40). The grand mean of P. californica per 30-m^2 station in Diablo Cove was 129.4 while the grand mean in North Control was 23.1 (Table 38).

Nereocystis luetkeana densities at 30-m^2 stations were significantly different between Diablo Cove and North Control (Table 40). Diablo Cove had greater mean densities of N. luetkeana during all years (Table 38).

2. Random Quadrat Station

Laminaria dentigera at the 0.25m-^{2} quadrat stations also, there were significant differences in mean densities of L. dentigera between Diablo Cove and North Control for three study years (Table 44); Diablo Cove stations had higher densities of L. dentigera than North Control.

Pterygophora californica at the 0.25-m^2 quadrat stations there were significant ($p \leq 0.05$) differences in P. californica densities between Diablo

TABLE 44. Results of Mann-Whitney Tests for Differences in Mean Density of Three Species of Brown Algal Between Diablo Cove and North Control at Random 0.25-m2 Quadrats. DCPP, 1976-1978.

	Diablo Cove vs. North Control		
Species	1976	1977	1978
Laminaria dentigera	.005** (DC)	.000** (DC)	.000** (DC)
Pterygophora californica	.045* (DC)	.000** (DC)	.071
Nereocystis luetkeana	.022* (DC)	.059	.969

* = Significance level ($p \leq 0.05$)

** = Singificance level ($p \leq 0.01$)

(DC) Indicates that higher numbers occurred in Diablo Cove

Cove and North Control. During 1976 and 1977, there were higher densitites of P. californica in Diablo Cove than in North Control (Table 44).

Nereocystis luetkeana at the 0.25-m^2 quadrat stations Diablo Cove had a slightly higher mean number per quadrat in 1976 and 1977 than North Control (Table 41), but the difference in mean density was only significant in 1976 (Table 44).

3. 60-m^2 Transect

Along the 60-m^2 linear transects, Nereocystis luetkeana was more abundant in Diablo Cove than in North Control during 1976 and 1977. The differences in mean counts per station between Diablo Cove and North Control were significant for both years (Table 43).

Discussion

The changes in brown algae density noted in Diablo Cove, particularly at 30-m^2 arc stations, were reflected, to a lesser degree, in North Control. In general, Laminaria dentigera and Pterygophora californica increased in abundance. Nereocystis luetkeana, after a substantial increase in 1975, decreased dramatically. Diablo Cove had significantly greater numbers of the three brown algae species than North Control.

The trends exhibited are similar to those noted by Dayton (1975) in his work on algal canopy interactions in a sea otter dominated kelp community in Alaska. He found that a large surface canopy-forming alga, Alaria fistulosa, behaves as a fugitive species with respect to Laminaria and Agarum, which are lower canopy-forming species. Fugitive species, as stated by Hutchinson in Colinvaux (1973), are opportunists, having diverted relatively large amounts of energy into an apparatus for dispersion, foregoing specializations that would enable them to make the best use of stable environments. Nereosystis luetkeana, in the present context, may be considered such a species. Their diphasic annual reproductive cycle may make them less competitive than lower-story perennials such as L. dentigera and P. californica in sea otter-dominated areas. Dayton (1975) noted that Macrocystis pyrifera in southern California forms a heavy surface canopy which may inhibit the growth of understory species. M. pyrifera, L. dentigera, and P. californica, being perennials, may enjoy competitive advantages when large numbers of major herbivores are removed.

As mentioned above, North Control had significantly less brown algae than Diablo Cove. The reduction in foragers of brown algae that occurred in Diablo Cove also took place in North Control, and this was reflected in a substantial increase in numbers of P. californica and L. dentigera. However, there was a very abundant red algal substrate cover (particularly articulated corallines) already extant in North Control which may have reduced the available substrate for brown alga settling and germination.

Adults of L. dentigera and P. californica may scour nearby substrate as they respond to water movement and, in dense stands block light from reaching the bottom. It is possibe that the abundance of those plants now present could inhibit foliose red algae colonization. It is also possible that Macrocystis pyrifera may eventually become the dominant brown algae in the study area since it is a canopy-forming perennial that seems to be highly competitive when free from urching foraging.

Statistical analyses were used on subtidal brown algae numbers to test three null hypotheses: comparability of study areas; temporal stability of study areas; and comparability of depth distribution. A summary of the results of these tests is presented (Tables 45 and 46).

Invertebrates

Methods

1. Field

At the 30-m^2 arc stations in Diablo Cove and the North Control, located and worked as described in the red algae methods section, the divers either made counts or recorded presence of all visible, macro-invertebrates (10 mm and larger).

At the 0.25-m^2 random quadrats, also described in the red algae section, all identifiable, visible invertebrates ($\geq$ 10 mm) were counted and recorded.

2. Laboratory

Invertebrates that could not be identified in the field were returned to the laboratory for identification and either added to our reference collection or released. Laboratory time was used to transfer field data to computer forms for key punching.

3. Statistical

TABLE 45. Summary of Statistical Tests for Significant Differences in Abundance for Three Species of Algae at Subtidal Random Arc Stations by Comparison of Study Areas, Overtime, and by Depth. DCPP. 1974-1977.

	Null Hypotheses				
	1		2	3	
Species	Comparability of Study Areas*		Temporal Stability of Study Areas* 1977 vs. 1978	Comparability of Depth Distribution*	
	SDC vs. NDC	DC vs NC		DC	NC
Botryoglossum/ Hymenena	R	R		R	R
Gigartina corymbifera/ exasperata complex	R				R
Iridaea cordata v. *Splendens*	R				
Neoptilota densa		R	R		
Opuntiella californica			R	R	R
Prionitis lanceolata	R				
Microcladia coulteri	R		R		R
Callophyllis pinnata	R				R

R = rejection of the null hypothesis
* = All years (1974-1977) Combined
SDC = South Diablo Cove
NDC = North Diablo Cove
DC = Diablo Cove (North Diablo Cove - South Diablo Cove)
NC = North Control
( ) = Indicates area of most abundance

TABLE 46. Summary of Statistical Tests for Significant Differences in Abundance for Three Species of Algae at Subtidal Random Quadrat Stations by Comparison of Study Areas, Overtime, and by Depth. DCPP, 1974-1977.

	Null Hypotheses						
Species	1			2		3	
	Comparability of Study Areas DC vs. NC			Temporal Stability of Study Area		Comparability of Depth Distribution 1976-1978 Combined	
	1976	1977	1978	DC 1975-1978	NC 1976-1978	DC	NC
Laminaria dentigera	R	R	R			R	
Pterygophora californica	R	R					R
Nereocystis luetkeana	R						R

R = Rejection of the null hypothesis
DC = Diablo Cove
NC = North Control
( ) = Indicates area of most abundance

In order to test the four hypotheses listed in the Objectives section, we first selected those invertebrate species that occurred most frequently at the arc and quadrat stations - in general, species that occurred at 25% or more of the stations in at least one of our study areas were the species selected.

At the 30-m^2 arc stations we selected for analysis 11 species; and 13 species from the 0.25-m^2 quadrats (Table 47). We tested the data with standard tests to determine normality of data and to determine whether parametric or non-parametric tests should be used.

Based on the rationale discussed in the Statistical Analysis section, we decided that the Kruskal-Wallis test, a non-parametric test, would be the most suitable test to analyze the data. All of the analyses were performed on count-per-station data rather than count-per-area data.

For this section of the report the word "significant" is defined at the 5% level of probability ($P \leq 0.05$).

Results

A. Diablo Cove

We began random sampling of the subtidal invertebrate communities in May 1974 utilizing the 30-m^2 arc method. These surveys were continued each summer through 1977. In 1978, we did not survey the random arcs because most of our time was used to analyze data for this report. In 1975, we started sampling 0.25-m^2 quadrats in Diablo Cove. Eight random quadrat stations (32 quadrats) were surveyed that year. Sampling at these quadrat

TABLE 47. List of Species Surveyed at Subtidal Random 30-m^2 Arc and 0.25-m^2 Quadrat Stations at Diablo Cove and North Control. DCPP, 1974-1977.

Species	30-m^2 Arcs	0.25-m^2 Quadrats
PHYLUM PORIFERA		
Tethya aurantia	X	
PHYLUM CNIDARIA		
Anthopleura xanthogrammica	X	
Balanophyllia elagans		X
Epiactis prolifera		X
PHYLUM ARTHROPODA		
Cancer antennarius	X	
PHYLUM MOLLUSCA		
Acmaea mitra		X
Astraea gibberosa	X	X
*Doriopsilla albopunctata**	X	X
Haliotis rufescens	X	X
Homalopoma luridum		X
Serpulorbis squamigerus		X
Tegula brunnea		X
Tonicella lineata		X
PHYLUM ECHINODERMATA		
Henricia leviuscula		X
Patiria miniata	X	X
Pisaster giganteus	X	
Pycnopodia helianthoides	X	
Strongylocentrotus franciscanus	X	X
PHYLUM CHORDATA		
Styela montereyensis	X	

* Considered a complex of *Doriopsilla albopuncata*, *Dendrodoris fulva*, and an undescribed Porostome.

stations was continued through the summer of 1978. A total of 86 random arc stations and 272 random quadrats has been surveyed during our pre-operational studies in Diablo Cove (Appendix 1d).

During our random surveys, we have observed and identified several hundred species of invertebrates, but only a fraction of this complex community occurred frequently enough for statistical analysis. Therefore, our intensive analysis is limited to eleven species at the arc stations and 13 species at the quadrats. The 13 quadrat species include five of the eleven species analyzed for the arc stations. Statistical tables for each of these species are in the Appendix and include the number of animals counted, the mean per station, the standard deviation, and the number of stations sampled, by year. The remaining species are also listed in two types of tables in the Appendix; the first set of tables (Appendix 6) lists identified species or species groups. For each species, we list the number of animals counted, mean per stations, and % frequency of occurrence. There are separate tables for the arc and quadrat stations, and for each study area, i.e., Diablo Cove, and North Control. The second set of tables (Appendix 7) contains those animals that we did not count at each station, but only noted presence or absence; for each of the species we have calculated the percent frequency of occurrence by year for each study area.

Our analysis and discussion in this report are limited to species quantified at the arc and quadrat stations whose frequency of occurrence was large enough for statistical analysis. The one exception to this is the red abalone, historically important, but whose densities or frequency of occurrence are now at such a low level that they can no longer be considered as an important segment of the animal community in Diablo Cove and the North Control. The other animals discussed generally represent all of the major phyla and all phases of the food web.

The results of analysis for each species are presented in alphabetical order within each phylum.

PORIFERA

Tethya aurantia

The orange puffball sponge (Figure 77b), occurs from southeastern Alaska to central Baja California from the intertidal to depths of 53 m (Gotshall and Laurent 1979). It is the most common large sponge in Diablo Cove. Data analysis was limited to counts at 30-m^2 arcs. At 30-m arc stations, the numbers per station have ranged from a low of 1.92 to a high of 6.92 in South Diablo Cove and 1.92 to 3.00 in North Diablo Cove (Figure 78).

When we compared densities, using the Kruskal-Wallis test, at arc stations between years, there was no significant difference for South Diablo Cove or North Diablo Cove stations (Tables 48 and 49).

The comparison of densities between depths (3 m depth intervals) for all years was significant for South Diablo Cove quadrats, but not for North Diablo Cove quadrats (Tables 48 and 49); Tethya were more abundant at deeper South Diablo Cove stations (Table 50). However, when the depth was analyzed by year, both areas of the Cove yielded significant differences in 1976 (Tables 48 and 49).

CNIDARIA

TABLE 48. Summary of Levels of Significance of Kruskal-Wallis* Tests on Invertebrates Quantified at Subtidal Random 30-m^2 Arc Stations, South Diablo Cove. DCPP, 1974-77.

Species	Between Years** All Depths Combined	Between Depths** All Years Combined	Between Depths			
			1974	1975	1976	1977
PORIFERA						
Tethya aurantia	0.2955	0.0011*	0.1116	0.0539	0.0299*	0.2490
CNIDARIA						
Anthopleura xanthogrammica	0.0925	0.0019*	0.1577	0.2201	0.6758	0.1616
ARTHROPODA						
Cancer antennarius	0.6193	0.4877	0.8147	0.8104	0.0369*	0.7842
MOLLUSCA						
Astraea gibberosa	0.5831	0.1893	0.1798	0.5010	0.2314	0.4535
Doriopsilla albopunctata	0.8253	0.0542	0.5629	0.4017	0.1772	0.4897
Haliotis rufescens	0.6642	0.5685	0.7212	0.8442	0.7788	0.8139
ECHINODERMATA						
Patiria miniata	0.3800	0.0009*	0.1616	0.1194	0.0415*	0.1606
Pisaster giganteus	0.2312	0.0261*	0.2123	0.0859	0.1536	0.2688
Pycnopodia helianthoides	0.6339	0.0216*	0.4979	0.2051	0.7534	0.2251
Strongylocentrotus franciscanus	0.0003*	0.0303*	0.5084	0.0272*	0.1486	0.3108
CHORDATA						
Styela montereyensis	0.0001*	0.0142*	0.1116	0.3613	0.3892	0.4881

* Significance level ($p < 0.05$)
** 1974-1977.

TABLE 49. Summary of Levels of Significance of Kruskal-Wallis* Tests on Invertebrates Quantified at Subtidal Random 30-m^2 Arc Stations, North Diablo Cove. DCPP, 1974-1977.

Species	Between Years** All Depths Combined	Between Depths** All Years Combined	Between Depths			
			1974	1975	1976	1977
PORIFERA						
Tethya aurantia	0.9618	0.2976	0.9291	0.3635	0.0163*	0.2483
CNIDARIA						
Anthopleura xanthogrammica	0.1496	0.5908	0.3061	0.5781	0.3350	0.6266
ARTHROPODA						
Cancer antennarius	0.0975	0.7543	1.0000	0.2486	0.6539	0.4898
MOLLUSCA						
Astraea gibberosa	0.5135	0.4308	0.1591	0.2748	0.5025	0.3178
Doriopsilla albopunctata	0.2909	0.3012	1.0000	0.4953	0.0365*	0.2988
Haliotis rufescens	0.2105	0.7261	1.0000	1.0000	0.0585	0.9476
ECHINODERMATA						
Patiria miniata	0.2657	0.1106	0.3425	0.3604	0.0061*	0.7209
Pisaster giganteus	0.4974	0.4395	0.4578	0.8731	0.2521	0.4711
Pycnopodia helianthoides	0.2859	0.9325	0.8861	0.9068	0.9333	0.2581
Strongylocentrotus franciscanus	0.0022*	0.7533	0.5258	0.5127	0.1697	0.3536
CHORDATA						
Styela montereyensis	0.0012*	0.0042*	1.0000	0.2669	0.0037*	0.0764

---

* Significance level ($p \leq 0.05$).

** 1974-1977.

TABLE 50. Summary of Statistics for *Tethya aurantia* at Subtidal Random 30-m^2 Arc Stations, Diablo Cove. DCPP, 1974-1977.

		1974				1975				1976				1977			
	Depth Range	Sum	$\bar{x}$	Sd	N	Sum	$\bar{x}$	Sd	N	Sum	$\bar{x}$	Sd	N	Sum	$\bar{x}$	Sd	N
SOUTH DIABLO COVE	0 - 3.0 m	0			3	1	0.20	0.45	5	0			0	0			2
	3.1 - 6.1 m	8	4.00	0.00	2	17	5.67	0.08	3	0			8	16	2.29	2.87	7
	6.2 - 9.2 m	0			0	4	4.00	0.00	1	16	5.33	8.39	3	3	3.00	0.00	1
	9.3 - 12.3 m	9	9.00	0.00	1	6	6.00	0.00	1	7	7.00	0.00	1	0			1
	12.4 - 15.4 m	5	5.00	0.00	1	55	27.50	6.36	2	0			0	7	7.00	0.00	1
	15.5 - 18.5 m	0			1	0			0	0			0	0			0
	COMBINED DEPTHS	22	2.75	3.33	8	83	6.92	10.70	12	23	1.92	4.58	12	26	2.17	2.82	12
NORTH DIABLO COVE	0 - 3.0 m	0			0	0			0	0			0	16	16.00	0.00	1
	3.1 - 6.1 m	12	3.00	3.83	4	15	2.14	3.24	7	4	0.67	1.21	6	13	2.60	2.51	5
	6.2 - 9.2 m	1	1.00	0.00	1	4	1.00	1.41	4	26	4.33	3.01	6	7	1.75	2.06	4
	9.3 - 12.3 m	2	2.00	0.00	1	4	4.00	0.00	1	0			0	0			1
	12.4 - 15.4 m	0			0	0			0	0			0	0			0
	15.5 - 18.5 m	0			0	0			0	0			0	0			1
	Combined Depths	15	2.50	3.08	6	23	1.92	2.64	12	30	2.50	2.91	12	36	3.00	4.59	12

Giant green anemones (Figure 77b) are known to range from Alaska to Panama from the intertidal to depths of 30 m (Gotshall and Laurent 1979). In Diablo Cove, they are most apt to be found in rocky areas containing sand pockets. Only the data from 30-m^2 arcs were analyzed. Densities varied considerably at 30-m^2 arc stations; they were more abundant at North Diablo Cove arc stations than at South Diablo Cove arc stations (Figure 79). The Kruskal-Wallis tests for the 30-m^2 stations data indicated there was no significant difference in densities of giant green anemones between years in either North or South Diablo Cove (Tables 48 and 49). A comparison of densities of giant green anemones by 3 m depth intervals indicated a difference in South Diablo Cove for the combined data; they were more abundant at shallow stations (Table 51).

Balanophyllia elegans

The orange cup coral (Figure 77b) is the most common of four species of true stony corals that occur in the Diablo Cove area. The other species we have observed are Paracyathus stearnsi, Astrangia lajollanensis, Coenocyathus bowersi. Orange cup corals have been recorded from British Columbia to central Baja California; from the low intertidal to about 25 m (Gotshall and Laurent 1979). They are most frequently observed in Diablo Cove where there is enough water circulation to provide plankton for food and prevent siltation. We did not attempt to count orange cup corals at random 30-m^2 stations, but we did note their presence/or absence (Appendix 7). The highest mean densities at 0.25-m^2 quadrats were recorded in 1975 at both South and North Diablo Cove stations, 13.8 and 17.3, respectively, while the lowest densities overall were observed in 1976 at SDC quadrats (Figure 80). The Kruskal-Wallis tests comparing densities between years in South Diablo Cove were not significant;

TABLE 51. Summary of Statistics for *Anthopleura xanthogrammica* at Subtidal Random 30-m^2 Arc Stations, Diablo Cove. DCPP, 1974-1977.

	Depth Range	1974				1975				1976				1977			
		Sum	x	Sd	N	Sum	x	Sd	N	Sum	x	Sd	N	Sum	x	Sd	N
SOUTH DIABLO COVE	0 - 3.0 m	6	2.00	2.00	3	9	1.80	2.04	5	0			0	6	3.00	1.41	2
	3.1 - 6.1 m	11	5.50	0.71	2	15	5.00	2.64	3	58	7.25	5.55	8	54	7.71	5.41	7
	6.2 - 9.2 m	0			0	1	1.00	0.00	1	21	7.00	5.57	3	3	3.00	0.00	1
	9.3 - 12.3 m	8	8.00	0.00	1	3	3.00	0.00	1	2	2.00	0.00	1	1	1.00	0.00	1
	12.4 - 15.4 m	0			1	1	0.05	0.71	2	0			0	1	1.00	0.00	1
	15.5 - 18.5 m	3	3.00	0.00	1	0			0	0			0	0			0
	COMBINED DEPTHS	28	3.50	2.83	8	29	2.42	2.39	12	81	6.75	5.24	12	65	5.42	4.96	12
NORTH DIABLO COVE	0 - 3.0 m	0			0	0			0	0			0	6	6.00	0.00	1
	3.1 - 6.1 m	80	20.00	37.34	4	136	19.43	23.25	7	37	6.17	9.41	6	77	15.40	17.41	5
	6.2 - 9.2 m	2	2.00	0.00	1	62	15.50	19.12	4	75	12.50	10.78	6	76	19.00	21.56	4
	9.3 - 12.3 m	0			1	4	4.00	0.00	1	0			0	7	7.00	0.00	1
	12.4 - 15.4 m	0			0	0			0	0			0	0			0
	15.5 - 18.5 m	0			0	0			0	0			0	2	2.00	0.00	1
	COMBINED DEPTHS	82	13.67	30.55	6	202	16.83	20.36	12	112	9.33	10.20	12	168	14.00	16.44	12

however, this test did yield a significant difference of densities through time for North Diablo Cove stations (Tables 52 and 53). There was also a difference in densities when we compared 3-m depth intertidals for all years; Balanophyllia was more abundant at the mid-depth stations (Table 54).

Epiactis prolifera

Proliferating anemones (Figure 77b) have been reported from Puget Sound, Washington, to La Jolla, California, in depths from the intertidal to 20 m (Gotshall and Laurent 1979). In Diablo Cove they are common to abundant on tops of rocks and on various species of algae. We did not count proliferating anemones at arc stations because of their small size and large numbers in some areas. Therefore, the data analysis is limited to the 0.25-m^2 quadrats. The mean density at quadrats in South Diablo Cove increased between 1975 and 1978, but the increase was not significant when tested with the Kruskal-Wallis test (Figure 81, Table 52). Densities also increased at North Diablo Cove quadrats from 1975 through 1977, then decreased; these changes in density over the years were significant (Figure 81, Table 53). Epiactis were significantly more abundant at shallower quadrats in South and North Diablo Coves when all years' data were combined (Tables 52, 53, and 55).

ARTHROPODA

Cancer antennarius

Rock crabs (Figure 82) were the only crustaceans that were consistently observable by divers and appeared frequently enough to be counted during our

TABLE 52. Summary of Levels of Significance of Kruskal-Wallis* Tests on Invertebrates Quantified at Subtidal Random 0.25-m^2 Quadrat Stations, South Diablo Cove. DCPP, 1975-1978.

Species	Between Years** All Depths Combined	Between Depths** All Years Combined	Between Depths 1975	1976	1977	1978
CNIDARIA						
Balanophyllia elegans	0.0675	0.0000*	0.8017	0.1487	0.0004*	0.0000
Epiactis prolifera	0.0757	0.0000*	1.0000	0.9911	0.0177*	0.0036*
MOLLUSCA						
Acmaea mitra	0.0165*	0.7078	0.2049	0.1164	0.8930	0.5243
Astraea gibberosa	0.0014*	0.0988	0.2886	0.1653	0.2030	0.0937
Doriopsilla albopunctata	0.0006*	0.1124	1.0000	1.0000	0.0104*	0.0896
Haliotis rufescens	0.3227	0.7937	1.0000	1.0000	0.7894	1.0000
Homalopoma luridum	0.0482*	0.0280*	0.4492	0.3922	0.2804	0.1923
Serpulorbis squamigerus	0.3318	0.0001*	0.1233	0.0095*	0.0676	0.0009*
Tegula brunnea	0.0029*	0.0717	1.0000	0.5173	0.4772	0.1309
Tonicella lineata	0.1446	0.0203*	0.7567	0.0598	0.0794	0.7525
ECHINODERMATA						
Henricia leviuscula	0.3684	0.8894	0.0639	0.3958	0.4388	0.7571
Patiria miniata	0.0431*	0.0020*	0.5685	0.4857	0.0071*	0.5451
Strongylocentrotus franciscan	0.0813	0.6560	0.3679	0.3842	0.2722	0.9322

* Significance level ($p \leq 0.05$).
** 1975-1978.

TABLE 53. Summary of Levels of Significance of Kruskal-Wallis* Tests on Invertebrates Quantified at Subtidal Random 0.25-m^2 Quadrat Stations. North Diablo Cove. DCPP, 1975-1978.

Species	Between Years** All Depths Combined	Between Depths** All Years Combined	Between Depths 1975	1976	1977	1978
CNIDARIA						
Balanophyllia elegans	0.0205*	0.0003*	0.3476	0.0079*	0.4418	0.0250*
Epiactis prolifera	0.0292*	0.0007*	0.1251	0.0234*	0.1327	0.1054
MOLLUSCA						
Acmaea mitra	0.2389	0.0026*	0.0398*	0.0303*	0.0375*	0.1402
Astraea gibberosa	0.6611	0.4605	0.0377*	0.3496	0.4785	0.7113
Doriopsilla albopunctata	0.2578	0.3972	0.6026	0.5724	0.0381*	0.3922
Haliotis rufescens	0.3519	0.4538	0.6026	1.0000	0.4278	1.0000
Homalopoma luridum	0.2569	0.0859	0.4039	0.6802	0.0542	0.1407
Serpulorbis squamigerus	0.0803	0.2206	0.9377	0.1192	0.4942	0.2558
Tegula brunnea	0.0004*	0.0045*	0.0624	0.4475	0.0993	0.0456*
Tonicella lineata	0.0224*	0.0033*	0.0510	0.4323	0.1221	0.2880
ECHINODERMATA						
Henricia leviuscula	0.2525	0.0937	0.4085	0.2908	0.4774	0.1738
Patiria miniata	0.1019	0.0024*	0.1420	0.0408*	0.0242	0.7116
Stronglyocentrotus franciscan	0.2586	0.5588	0.1027	0.7484	0.4909	0.6923

* Significance level ($p \leq 0.05$).
** 1975-1978.

TABLE 54. Summary of Statistics for *Balanophyllia elegans* at Subtidal Random 0.25-m^2 Quadrat Stations, Diablo Cove. DCPP, 1975-1978.

	Depth Range	1975				1976				1977				1978			
		Sum	$\bar{x}$	Sd	N	Sum	$\bar{x}$	Sd	N	Sum	$\bar{x}$	Sd	N	Sum	$\bar{x}$	Sd	N
SOUTH DIABLO COVE	0 - 3.0 m	0			0	13	2.60	4.21	5	18	1.80	4.40	10	0			2
	3.1 - 6.1 m	0			0	8	0.66	0.98	12	49	2.22	6.29	22	44	1.69	3.70	26
	6.2 - 9.2 m	89	14.80	19.90	6	54	9.00	11.90	6	163	20.30	19.80	8	27	3.38	2.77	8
	9.3 - 12.3 m	27	13.50	9.20	2	0			0	46	15.30	22.40	3	169	28.20	26.50	6
	12.4 - 15.4 m	0			0	0			0	24	12.00	7.00	2	240	40.00	38.10	6
	15.5 - 18.5 m	49	12.30	12.80	4	0			0	42	14.00	14.20	3	0			0
	COMBINED DEPTHS	165	13.80	15.30	12	75	3.30	6.99	23	342	7.13	12.90	48	480	10.00	21.10	48
NORTH DIABLO COVE	0 - 3.0 m	0			1	0			7	3	0.60	0.89	5	0			1
	3.1 - 6.1 m	137	19.60	27.00	7	15	2.11	4.18	7	128	5.12	7.56	25	69	3.83	7.38	18
	6.2 - 9.2 m	153	19.10	12.90	8	90	11.25	11.90	8	79	7.90	12.00	10	208	9.90	19.40	21
	9.3 - 12.3 m	57	14.30	16.20	4	90	45.00	56.60	2	48	12.00	15.80	4	0			0
	12.4 - 15.4 m	0			0	0			0	16	4.00	8.00	4	252	31.50	26.30	8
	15.5 - 18.5 m	0			0	0			0	0			0	0			0
	COMBINED DEPTHS	347	17.3	18.90	20	195	8.12	18.40	24	274	5.70	9.20	48	529	11.00	19.40	48

TABLE 55. Summary of Statistics for *Epiactis prolifera* at Random 0.25-m^2 Quadrat Stations, Diablo Cove, Diablo Canyon Power Plant Site.

		1975				1976				1977				1978			
	Depth Range	Sum	$\overline{x}$	Sd	N	Sum	$\overline{x}$	Sd	N	Sum	$\overline{x}$	Sd	N	Sum	$\overline{x}$	Sd	N
SOUTH DIABLO COVE	0 - 3.0 m	0			0	13	2.60	3.97	5	102	10.20	14.10	10	0			2
	3.1 - 6.1 m	0			0	24	2.00	3.90	12	60	2.72	4.38	22	1233	47.42	195.30	26
	6.2 - 9.2 m	0			6	18	3.00	4.80	6	1	0.13	0.35	8	31	3.88	10.50	8
	9.3 - 12.3 m	0			2	0			0	0			3	0			6
	12.4 - 15.4 m	0			0	0			0	0			2	0			6
	15.5 - 18.5 m	0			4	0			0	0			3	0			0
	COMBINED DEPTHS	0			12	55	2.39	4.00	23	163	3.40	7.79	48	1264	26.33	144.39	48
NORTH DIABLO COVE	0 - 3.0 m	8	8.00	0.00	1	12	1.71	1.11	7	165	33.00	44.60	5	2	2.00	0.00	1
	3.1 - 6.1 m	5	0.71	1.25	7	34	4.86	3.63	7	97	3.88	7.87	25	51	2.83	7.63	18
	6.2 - 9.2 m	4	0.50	1.06	8	10	1.25	2.76	8	32	3.20	6.30	10	38	1.90	3.18	21
	9.3 - 12.3 m	0			4	1	0.50	0.70	2	9	2.25	3.20	4	0			0
	12.4 - 15.4 m	0			0	0			0	0			4	0			8
	15.5 - 18.5 m	0			0	0			0	0			0	0			0
	COMBINED DEPTHS	17	0.85	1.95	20	57	2.38	2.98	24	303	6.31	17.18	48	91	1.94	5.16	47

surveys of 30-m^2 arcs. They are known to range from British Columbia to Magdalena Bay, Baja, California, in depths from the low intertidal to at least 130-m (Gotshall and Laurent 1979). They were observed throughout Diablo Cove in areas of rocky substrate, particularly where holes or crevices were large enough for them to hide in. Only the density data from 30-m^2 arcs were analyzed. The fluctuations between years in mean densities of rock crabs at South or North Diablo Cove 30-m^2 arc stations were not significant (Tables 48, 49, and 56, and Figure 83).

In South Diablo Cove, there was a significant difference in density of rock crabs between different depths only during 1976 surveys (Tables 48 and 49). There was not a significant difference in density for rock crabs between depths in North Diablo Cove (Table 48).

MOLLUSCA

Acmaea mitra

The white cap limpet (Figure 82) has been reported from the Aleutian Island to northern Baja, California, from the low intertidal to depths of 30-m (Gotshall and Laurent 1979). In Diablo Cove, they are commonly observed on rocks with large areas of encrusting coralline algae. Data analysis was limited to the 0.25-m^2 quadrat stations as Acmaea were not counted at the 30-m^2 arcs.

Densities of Acmaea decreased at quadrats in South as well as North Diablo Cove (Figure 84). This decrease was significant at the 95% level for South Diablo Cove quadrats, but not for North Diablo Cove quadrats (Tables 52 and

TABLE 56. Summary of Statistics for Cancer antennarius at Subtidal Random 30-m^2 Arc Stations, Diablo Cove. DCPP, 1974-1977.

			1974				1975				1976				1977		
	Depth Range	Sum	x	Sd	N	Sum	x	Sd	N	Sum	x	Sd	N	Sum	x	Sd	N
SOUTH DIABLO COVE	0 - 3.0 m	3	1.00	1.73	3	3	0.60	0.55	5	0			0	2	1.00	1.41	2
	3.1 - 6.1 m	1	0.50	0.71	2	2	0.67	1.15	3	0			8	3	0.43	0.79	7
	6.2 - 9.2 m	0			0	0			1	1	0.33	0.58	3	0			1
	9.3 - 12.3 m	0			1	0			1	1	1.00	0.00	1	0			1
	12.4 - 15.4 m	0			1	1	0.50	0.71	2	0			0	0			1
	15.5 - 18.5 m	0			1	0			0	0			0	0			0
	COMBINED DEPTHS	4	0.50	1.07	8	6	0.50	0.67	12	2	0.17	0.39	12	5	0.42	0.79	12
NORTH DIABLO COVE	0 - 3.0 m	0			0	0			0	0			0	1	1.00	0.00	1
	3.1 - 6.1 m	0			4	5	0.71	0.49	7	4	0.67	1.21	6	1	0.20	0.45	5
	6.2 - 9.2 m	0			1	1	0.25	0.50	4	5	0.83	0.98	6	1	0.25	0.50	4
	9.3 - 12.3 m	0			1	1	1.00	0.00	1	0			0	0			1
	12.4 - 15.4 m	0			0	0			0	0			0	0			0
	15.5 - 18.5 m	0			0	0			0	0			0	0			1
	COMBINED DEPTHS	0	0.00	0.00	6	7	0.58	0.51	12	9	0.75	1.06	12	3	0.25	0.45	12

53). The comparison of densities of Acmaea between depths yielded a significant difference for North Diablo Cove quadrats (Tables 52, 53, and 57).

Astraea gibberosa

Red turban snails (Figure 82) are known to range from British Columbia to southern Baja California from low intertidal to 30 m (Gotshall and Laurent 1979). Astraea was most common in Diablo Cove on rocky substrate where articulated coralline algae were abundant. We counted Astraea at both 30-m^2 arcs and 0.25-m^2 quadrats, and data from both these studies were analyzed.

The mean density at arc stations declined in North and South Diablo Coves (Figures 85). Neither of these changes in density was significant when tested with the Kruskal-Wallis test (Tables 48 and 49), nor was there a difference in densities at arc stations at the various depths sampled within the Cove (Table 53).

Astraea declined in density at the 0.25-m^2 quadrats in South Diablo Cove; the decline was significant (Figure 86, Table 52). There was a nonsignificant increase in Astraea density at North Diablo Cove quadrats (Figure 86, Table 53). The Kruskal-Wallis test for differences in densities by depths of Astraea indicated no significant differences at arc or quadrat stations, with one exception; there was a significant difference between densities by depths at 0.25-m^2 quadrats sampled in 1975 in the North Diablo Cove (Tables 53 and 59).

TABLE 57. Summary of Statistics for *Acamaea mitra* at Subtidal Random 0.25-m^2 Quadrat Stations, Diablo Cove. DCPP, 1975-1978.

	Depth Range	1 9 7 5				1 9 7 6				1 9 7 7				1 9 7 8			
		Sum	x	Sd	N	Sum	x	Sd	N	Sum	x	Sd	N	Sum	x	Sd	N
SOUTH DIABLO COVE	0 - 3.0 m	0			0	4	0.80	0.45	5	2	0.20	0.42	10	0			2
	3.1 - 6.1 m	0			0	21	1.75	1.71	12	7	0.32	0.57	22	17	0.65	0.98	26
	6.2 - 9.2 m	17	2.83	4.07	6	2	0.33	0.81	6	6	0.75	1.16	8	6	0.75	0.89	8
	9.3 - 12.3 m	1	0.50	0.71	2	0			0	2	0.67	1.15	3	1	0.17	0.41	6
	12.4 - 15.4 m	0			0	0			0	1	0.50	0.70	2	2	0.33	0.52	6
	15.5 - 18.5 m	2	0.50	0.58	4	0			0	1	0.33	0.58	3	0			0
	COMBINED DEPTHS	20	1.67	3.02	12	27	1.17	1.44	23	19	0.40	0.71	48	26	0.54	0.85	48
NORTH DIABLO COVE	0 - 3.0 m	0			1	0			7	7	1.40	1.52	5	0			1
	3.1 - 6.1 m	7	1.00	1.15	7	5	0.71	0.49	7	31	1.24	1.61	25	9	0.50	0.86	18
	6.2 - 9.2 m	17	2.12	1.64	8	8	1.00	0.76	8	4	0.40	0.70	10	18	0.86	1.20	21
	9.3 - 12.3 m	0			4	3	1.50	2.12	2	0			4	0			0
	12.4 - 15.4 m	0			0	0			0	0			4	0			8
	15.5 - 18.5 m	0			0	0			0	0			0	0			0
	COMBINED DEPTHS	24	1.20	1.47	20	16	0.67	0.82	24	42	0.88	1.38	48	27	0.56	0.99	48

TABLE 58. Summary of Statistics for *Astraea gibberosa* at Subtidal Random 30-m^2 Arc Stations, Diablo Cove. DCPP, 1974-1977.

		1974				1975				1976				1977			
	Depth Range	Sum	$\bar{x}$	Sd	N	Sum	$\bar{x}$	Sd	N	Sum	$\bar{x}$	Sd	N	Sum	$\bar{x}$	Sd	N
SOUTH DIABLO COVE	0 - 3.0 m	11	3.67	4.72	3	17	3.40	2.30	5	0			0	5	2.50	0.71	2
	3.1 - 6.1 m	34	17.00	2.82	2	20	6.67	6.43	3	47	5.88	3.27	8	30	4.29	3.45	7
	6.2 - 9.2 m	0			0	18	18.00	0.00	1	22	7.33	3.79	3	7	7.00	0.00	1
	9.3 - 12.3 m	41	41.00	0.00	1	4	4.00	0.00	1	0			1	11	11.00	0.00	1
	12.4 - 15.4 m	7	7.00	0.00	1	19	9.40	10.60	2	0			0	4	4.00	0.00	1
	15.5 - 18.5 m	4	4.00	0.00	1	0			0	0			0	0			0
	COMBINED DEPTHS	97	12.12	13.31	8	78	6.50	6.19	12	69	5.75	3.62	12	57	4.75	3.41	12
NORTH DIABLO COVE	0 - 3.0 m	0			0	0			0	0			0	7	7.00	0.00	1
	3.1 - 6.1 m	35	8.75	4.79	4	24	3.43	2.30	7	26	4.33	3.39	6	17	3.40	5.40	5
	6.2 - 9.2 m	1	1.00	0.00	1	19	4.75	5.74	4	37	6.17	10.50	6	5	1.25	1.89	4
	9.3 - 12.3 m	0			1	18	18.00	0.00	1	0			0	0			1
	12.4 - 15.4 m	0			0	0			0	0			0	0			0
	15.5 - 18.5 m	0			0	0			0	0			0	5	5.00	0.00	1
	COMBINED DEPTHS	36	6.00	5.66	6	61	5.08	5.37	12	63	5.25	7.51	12	34	2.83	3.93	12

TABLE 59. Summary of Statistics for *Astraea gibberosa* at Subtidal Random 0.25-m^2 Quadrat Stations, Diablo Cove. DCPP, 1975-1978.

		1975				1976				1977				1978			
	Depth Range	Sum	x	Sd	N	Sum	x	Sd	N	Sum	x	Sd	N	Sum	x	Sd	N
SOUTH DIABLO COVE	0 - 3.0 m	0			0	1	0.20	0.45	5	0			10	0			2
	3.1 - 6.1 m	0			0	0			12	1	0.05	0.21	22	3	0.12	0.43	26
	6.2 - 9.2 m	6	1.00	0.89	6	0			6	0			8	1	0.12	0.35	8
	9.3 - 12.3 m	0			2	0			0	0			3	6	1.00	1.26	6
	12.4 - 15.4 m	0			0	0			0	0			2	1	0.17	0.41	6
	15.5 - 18.5 m	2	0.50	1.00	4	0			0	1	0.33	0.58	3	0			0
	COMBINED DEPTHS	8	0.67	0.89	12	1	0.04	0.21	23	2	0.04	0.20	48	11	0.23	0.63	48
NORTH DIABLO COVE	0 - 3.0 m	0			1	1	0.14	0.38	7	1	0.20	0.45	5	0			1
	3.1 - 6.1 m	0			7	0			7	5	0.20	0.41	25	5	0.28	0.46	18
	6.2 - 9.2 m	0			8	2	0.25	0.46	8	0			10	4	0.19	0.51	21
	9.3 - 12.3 m	2	0.50	0.58	4	1	0.50	0.71	2	0			4	0			0
	12.4 - 15.4 m	0			0	0			0	2	0.50	1.00	4	6	0.75	1.49	8
	15.5 - 18.5 m	0			0	0			0	0			0	0			0
	COMBINED DEPTHS	2	0.10	0.31	20	4	0.17	0.38	24	8	0.17	0.43	48	15	0.31	0.75	48

Doriopsilla albopunctata

White-spotted sea goddess nudibranchs (Figure 82) occur from Mendocino County, California, to Baja, California, and the northern Gulf of California, from the intertidal to depths of about 40 m (Gotshall and Laurent 1979). In Diablo Cove Doriopsilla were commonly observed on rocky substrate where little or no foliose or coralline algae was present. These nudibranchs were counted at both arc and quadrat stations.

The small change in mean density observed at 30-m^2 stations in Diablo Cove over the years was not significant (Figure 87, Tables 48 and 49).

The densities of Doriopsilla in South Diablo Cove 0.25-m^2 quadrats increased significantly through time (Figure 88, Table 52). The apparent increase in numbers of Doriopsilla at North Diablo Cove 0.25-m^2 quadrats was not significant (Figure 88).

There was a significant difference in densities between depths in North Diablo Cove 30-m^2 arc stations during only one year, 1976 (Tables 49 and 60). There was no significant differences in density at depths in South Diablo Cove arc stations (Table 49).

Analysis of 0.25-m^2 quadrat data for Doriopsilla yield differences in density between depths for 1977 only (Tables 52, 53, and 61).

TABLE 60. Summary of Statistics for *Doriopsilla albopunctata* at Subtidal Random 30-m^2 Arc Stations, Diablo Cove. DCPP, 1974-1977.

		1974				1975				1976				1977			
	Depth Range	Sum	$\bar{x}$	Sd	N	Sum	$\bar{x}$	Sd	N	Sum	$\bar{x}$	Sd	N	Sum	$\bar{x}$	Sd	N
SOUTH DIABLO COVE	0 - 3.0 m	2	0.67	0.56	3	10	2.00	2.50	5	0			0	0			2
	3.1 - 6.1 m	5	2.50	3.54	2	5	1.67	2.89	3	8	1.00	1.77	8	23	3.29	4.42	7
	6.2 - 9.2 m	0			0	1	1.00	0.00	1	8	2.67	1.53	3	3	3.00	0.00	1
	9.3 - 12.3 m	4	4.00	0.00	1	8	8.00	0.00	1	3	3.00	0.00	1	2	2.00	0.00	1
	12.4 - 15.4 m	3	3.00	0.00	1	8	4.00	1.41	2	0			0	5	5.00	0.00	1
	15.5 - 18.5 m	0			1	0			0	0			0	0			0
	COMBINED DEPTHS	14	1.75	1.98	8	32	2.67	2.77	12	19	1.58	1.78	12	33	2.75	3.57	12
NORTH DIABLO COVE	0 - 3.0 m	0			0	0			0	0			0	2	2.00	0.00	1
	3.1 - 6.1 m	12	3.00	0.00	4	47	6.71	6.68	7	6	1.00	1.55	6	21	4.20	3.42	5
	6.2 - 9.2 m	3	3.00	0.00	1	25	6.25	5.85	4	22	3.67	2.53	6	16	4.00	2.83	4
	9.3 - 12.3 m	3	3.00	0.00	1	2	2.00	0.00	1	0			0	0			1
	12.4 - 15.4 m	0			0	0			0	0			0	0			0
	15.5 - 18.5 m	0			0	0			0	0			0	1	1.00	0.00	1
	COMBINED DEPTHS	18	3.00	0.00	6	74	6.17	5.95	12	28	2.33	2.46	12	40	3.33	2.93	12

TABLE 61. Summary of Statistics for <u>Doriopsilla albopunctata</u> at Subtidal Random 0.25-m^2 Quadrat Stations, Diablo Cove. DCPP, 1975-1978.

		1975				1976				1977				1978			
	Depth Range	Sum	x	Sd	N	Sum	x	Sd	N	Sum	x	Sd	N	Sum	x	Sd	N
SOUTH DIABLO COVE	0 - 3.0 m	0			0	0			5	0			10	0			2
	3.1 - 6.1 m	0			0	0			12	0			22	11	0.42	0.58	26
	6.2 - 9.2 m	0			6	0			0	0			8	1	0.12	0.35	8
	9.3 - 12.3 m	0			2	0			0	0			3	0			6
	12.4 - 15.4 m	0			0	0			0	0			2	0			6
	15.5 - 18.5 m	0			4	0			0	1	0.33	0.58	3	0			0
	COMBINED DEPTHS	0			12	0			23	1	0.02	0.14	48	12	0.25	0.48	48
NORTH DIABLO COVE	0 - 3.0 m	0			1	0			7	0			5	0			1
	3.1 - 6.1 m	1	0.14	0.38	7	0			7	3	0.12	0.44	25	1	0.06	0.24	18
	6.2 - 9.2 m	0			8	1	0.12	0.35	8	0			10	7	0.33	0.66	21
	9.3 - 12.3 m	0			4	0			2	2	0.50	0.58	4	0			0
	12.4 - 15.4 m	0			0	0			0	0			4	2	0.25	0.46	8
	15.5 - 18.5 m	0			0	0			0	0			0	0			0
	COMBINED DEPTHS	1	0.05	0.22	20	1	0.04	0.20	24	5	0.10	0.37	48	10	0.21	0.50	48

TABLE 62. Summary of Statistics for *Haliotis rufescens* at Subtidal Random 30-m^2 Arc Stations, Diablo Cove. DCPP, 1974-1977.

		1974				1975				1976				1977			
	Depth Range	Sum	$\bar{x}$	Sd	N	Sum	$\bar{x}$	Sd	N	Sum	$\bar{x}$	Sd	N	Sum	$\bar{x}$	Sd	N
SOUTH DIABLO COVE	0 - 3.0 m	1	0.33	0.58	3	2	0.40	0.89	5	0			0	0			2
	3.1 - 6.1 m	6	3.00	4.25	2	0			3	1	0.13	0.35	8	2	0.29	0.49	7
	6.2 - 9.2 m	0			0	0			1	0			3	0			1
	9.3 - 12.3 m	0			1	0			1	0			1	0			1
	12.4 - 15.4 m	0			1	0			2	0			0	0			1
	15.5 - 18.5 m	0			1	0			0	0			0	0			0
	COMBINED DEPTHS	7	0.88	2.10	8	2	0.17	0.58	12	1	0.08	0.29	12	2	0.17	0.39	12
NORTH DIABLO COVE	0 - 3.0 m	0			0	0			0	0			0	0			1
	3.1 - 6.1 m	0			4	0			7	12	2.00	2.28	6	6	1.20	2.68	5
	6.2 - 9.2 m	0			1	0			4	0			6	1	0.25	0.50	4
	9.3 - 12.3 m	0			1	0			1	0			0	0			1
	12.4 - 15.4 m	0			0	0			0	0			0	0			0
	15.5 - 18.5 m	0			0	0			0	0			0	0			1
	COMBINED DEPTHS	0	0.00	0.00	6	0	0.00	0.00	12	12	1.00	1.86	12	7	0.58	1.73	12

TABLE 63 a. Summary of Statistics for Haliotis rufescens at Subtidal Random 0.25-m^2 Quadrat Stations, Diablo Cove. DCPP, 1975-1978.

	Depth Range	1975				1976				1977				1978			
		Sum	x	Sd	N	Sum	x	Sd	N	Sum	x	Sd	N	Sum	x	Sd	N
SOUTH DIABLO COVE	0 - 3.0 m	0			0	0			5	0			10	0			2
	3.1 - 6.1 m	0			0	0			12	3	0.14	0.47	22	0			26
	6.2 - 9.2 m	0			6	0			6	0			8	0			8
	9.3 - 12.3 m	0			2	0			0	0			3	0			6
	12.4 - 15.4 m	0			0	0			0	0			2	0			6
	15.5 - 18.5 m	0			4	0			0	0			3	0			0
	COMBINED DEPTHS	0			12	0			23	3	0.06	0.32	48	0			48
NORTH DIABLO COVE	0 - 3.0 m	0			1	0			7	1	0.20	0.45	5	0			1
	3.1 - 6.1 m	1	0.14	0.38	7	0			7	1	0.04	0.20	25	0			18
	6.2 - 9.2 m	0			8	0			8	0			10	0			21
	9.3 - 12.3 m	0			4	0			2	0			4	0			0
	12.4 - 15.4 m	0			0	0			0	0			4	0			8
	15.5 - 18.5 m	0			0	0			0	0			0	0			0
	COMBINED DEPTHS	1	0.05	0.22	20	0			24	2	0.04	0.20	48	0			48

Haliotis rufescens

Red abalone (Figure 89) have been recorded from Coos Bay, Oregon, to Baja, California, in depths from the intertidal to about 25 m. In Diablo Cove red abalone are sparse but appear to be most common in the shallow subtidal and low intertidal areas which contain large boulders with many undercuts and crevices. Red abalone frequency of occurrence was fairly static at arcs as well as quadrats (Figures 90 and 91).

The decline in density observed at South Diablo Cove arc stations was not significant (Figure 90, Table 48), nor was the apparent increase in density at North Diablo Cove arc stations significant (Figure 90).

Their occurrence at quadrats was very low (Figure 91). Even though our observations suggest that red abalones are more common at shallow stations, these differences in density at depth were not statistically significant (Tables 62 and 63a).

Homalopoma luridum

Dwarf turban snails have been recorded from Sitka, Alaska to San Geronimo Island, Baja, California (McLean 1978), from the low intertidal at about 30 m. Dwarf turban snails were most commonly found in Diablo Cove on rocky substrate where foliose and coralline algae abundance was minimal. Because of their small size, dwarf turbans were not quantified at arc stations. Their abundance in South Diablo Cove quadrats increased from 1975 through 1978; this increase was significant ($p \leq 0.05$) (Figure 92, Table 52). The apparent increasing trend in North Diablo Cove quadrats was not significant (Figure 92); Homalopoma was most abundant at mid-depth quadrats, (6.2 to 12.3 m) in Diablo Cove (Table 63b). This difference in densities between depths was significant in South Diablo Cove but not in North Diablo Cove (Tables 52 and 53).

Serpulorbis squamigerus

Scaled worm shells (Figure 89) have a recorded range from Point Sur, California, to central Baja California, in depths from the low intertidal to 30 m (Gotshall and Laurent 1979). Serpulorbis was most commonly observed in Diablo Cove attached to the sides of rocks. We did not quantify scaled worm shells at arc stations. The fluctuations in density at quadrats in North and South Diablo Cove were not significant at the 95% level (Figure 93, Tables 52 and 53). Scaled worm shells were more abundant at mid-depth stations (Table 64). This difference in densities by depth was significant ($p \leq 0.05$) for South Diablo Cove quadrats, but not for North Diablo Cove quadrats (Tables 52 and 53).

Tegula brunnea

Brown turban snails (Figure 89) range from Oregon to southern California in depths from the mid-intertidal to about 12 m (Gotshall and Laurent 1979). In Diablo Cove they are commonly found on various species of brown algae. Brown turban snails were not quantified at random 30-m^2 arcs. At quadrat stations the mean densities increased over the years for both South and North Diablo Cove (Figure 94). This increase was statistically significant for both South Diablo Cove and North Diablo Cove quadrats (Tables 52 and 53).

TABLE 63 b. Summary of Statistics for *Homalopoma luridum* at Subtidal Random 0.25-m^2 Quadrat Stations, Diablo Cove. DCPP, 1975-1978.

		1975				1976				1977				1978			
	Depth Range	Sum	$\bar{x}$	Sd	N	Sum	$\bar{x}$	Sd	N	Sum	x	Sd	N	Sum	$\bar{x}$	Sd	N
SOUTH DIABLO COVE	0 - 3.0 m	0			0	5	1.00	1.41	5	30	3.00	4.35	10	0			2
	3.1 - 6.1 m	0			0	19	1.58	1.50	12	40	2.00	2.83	20	93	3.56	3.69	26
	6.2 - 9.2 m	13	2.17	3.71	6	16	2.67	2.42	6	38	4.75	3.84	8	38	4.75	2.81	8
	9.3 - 12.3 m	6	6.00	3.00	2	0			0	13	4.33	3.21	3	27	4.50	2.51	6
	12.4 - 15.4 m	0			0	0			0	5	2.50	2.12	2	21	3.50	2.07	6
	15.5 - 18.5 m	3	0.75	0.96	4	0			0	3	1.00	0.00	3	0			0
	COMBINED DEPTHS	22	1.83	2.82	12	40	1.74	1.79	23	129	2.80	3.37	46	179	3.73	3.23	48
NORTH DIABLO COVE	0 - 3.0 m	0			1	3	0.43	0.53	7	17	3.40	6.50	5	5	5.00	0.00	1
	3.1 - 6.1 m	2	0.29	0.76	7	6	0.86	0.90	7	94	3.76	4.24	25	43	2.39	3.33	18
	6.2 - 9.2 m	9	1.12	1.36	8	9	1.12	1.55	8	9	0.90	2.02	10	25	1.19	2.11	21
	9.3 - 12.3 m	4	1.00	1.15	4	2	1.00	0.00	2	3	0.75	0.96	4	0			0
	12.4 - 15.4 m	0			0	0			0	2	0.50	0.58	4	4	0.50	0.53	8
	15.5 - 18.5 m	0			0	0			0	0			0	0			0
	COMBINED DEPTHS	15	0.75	1.12	20	20	0.83	1.05	24	125	2.60	3.97	48	77	1.60	2.59	48

TABLE 64. Summary of Statistics for Serpulorbis squamigerus at Subtidal Random 0.25-m^2 Quadrat Stations, Diablo Cove. DCPP, 1975-1978.

	Depth Range	1975				1976				1977				1978			
		Sum	x	Sd	N	Sum	x	Sd	N	Sum	x	Sd	N	Sum	x	Sd	N
SOUTH DIABLO COVE	0 - 3.0 m	0			0	0			5	2	0.20	0.63	10	0			2
	3.1 - 6.1 m	0			0	0			12	17	0.77	1.50	22	6	0.23	0.81	26
	6.2 - 9.2 m	14	2.33	5.71	6	5	0.83	0.98	6	2	0.25	0.46	8	10	1.25	1.75	8
	9.3 - 12.3 m	8	4.00	2.82	2	0			0	12	4.00	4.58	3	14	2.33	3.88	6
	12.4 - 15.4 m	0			0	0			0	0			2	39	6.50	4.76	6
	15.5 - 18.5 m	1	0.25	0.50	4	0			0	3	1.00	0.00	3	0			0
	COMBINED DEPTHS	23	1.92	4.19	12	5	0.22	0.60	23	36	0.75	1.68	48	69	1.44	3.02	48
NORTH DIABLO COVE	0 - 3.0 m	0			1	0			7	5	1.00	1.41	5	0			1
	3.1 - 6.1 m	7	1.00	1.73	7	0			7	26	1.04	1.39	25	22	1.22	2.07	18
	6.2 - 9.2 m	5	0.62	0.91	8	6	0.75	1.75	8	11	1.10	1.29	10	29	1.38	2.31	21
	9.3 - 12.3 m	11	2.75	5.50	4	14	7.00	9.90	2	0			4	0			0
	12.4 - 15.4 m	0			0	0			0	2	0.50	1.00	4	41	5.12	8.75	8
	15.5 - 18.5 m	0			0	0			0	0			0	0			0
	COMBINED DEPTHS	23	1.15	2.60	20	20	0.83	2.99	24	44	0.92	1.28	48	92	1.92	4.17	48

Tegula were apparently more abundant at shallow quadrats in North Diablo Cove and South Diablo Cove (Table 65). This difference in densities was significant for North Diablo Cove quadrats (Table 53).

Tonicella lineata

Lined chitons (Figure 89) have been reported from northern Japan, and the Aleutian Islands to San Diego, from intertidal depths to about 30 m (Gotshall and Laurent 1979). In Diablo Cove lined chitons were most common on rocks with large areas of encrusting coralline algae. Because of their cryptic coloration, which makes them difficult to observe, we did not quantify *Tonicella* at arc stations. Differences in mean densities at North Diablo Cove quadrat stations over the years were significant, but the differences in density observed in South Diablo Cove quadrats were not significant (Tables 52 and 53, Figure 95).

Lined chitons were significantly more abundant at mid-depth quadrats in both North and South Diablo Coves when data from all years were compared (Table 52, 53, and 66).

ECHINODERMATA

Henricia leviuscula

Blood stars (Figure 96) have a known range from the Aleutian Islands to central Baja California from the intertidal to depths of 670 m (Gotshall and Laurent 1979). In Diablo Cove our observations indicated that juvenile blood

TABLE 65. Summary of Statistics for *Tegula brunnea* at Subtidal Random 0.25-m^2 Quadrat Stations, Diablo Cove. DCPP, 1975-1978.

		1975				1976				1977				1978			
	Depth Range	Sum	x	Sd	N	Sum	x	Sd	N	Sum	x	Sd	N	Sum	x	Sd	N
SOUTH DIABLO COVE	0 - 3.0 m	0			0	1	0.20	0.44	5	7	0.70	1.06	10	0			2
	3.1 - 6.1 m	0			0	1	0.08	0.29	12	15	0.68	1.04	22	30	1.15	1.59	26
	6.2 - 9.2 m	0			6	0			6	13	1.62	3.80	8	7	0.88	1.12	8
	9.3 - 12.3 m	0			2	0			0	0			3	3	0.50	0.83	6
	12.4 - 15.4 m	0			0	0			0	0			2	0			6
	15.5 - 18.5 m	0			4	0			0	0			3	0			0
	COMBINED DEPTHS	0			12	2	0.09	0.29	23	35	0.73	1.76	48	40	0.83	1.34	48
NORTH DIABLO COVE	0 - 3.0 m	1	1.00	0.00	1	1	0.14	0.37	7	4	0.80	0.83	5	2	2.00	0.00	1
	3.1 - 6.1 m	6	0.86	1.57	7	4	0.57	0.79	7	34	1.36	1.29	25	71	3.94	5.30	18
	6.2 - 9.2 m	0			8	3	0.38	1.06	8	6	0.60	0.80	10	32	1.52	2.30	21
	9.3 - 12.3 m	0			4	0			2	5	1.25	1.30	4	0			0
	12.4 - 15.4 m	0			0	0			0	0			4	2	0.25	0.46	8
	15.5 - 18.5 m	0			0	0			0	0			0	0			0
	COMBINED DEPTHS	7	0.35	0.99	20	8	0.33	0.76	24	49	1.02	1.16	48	107	2.23	3.81	48

TABLE 66. Summary of Statistics for <u>Tonicella lineata</u> at Subtidal Random 0.25-m^2 Quadrat Stations, Diablo Cove. DCPP, 1975-1978.

		1975				1976				1977				1978			
	Depth Range	Sum	x	Sd	N	Sum	x	Sd	N	Sum	x	Sd	N	Sum	x	Sd	N
SOUTH DIABLO COVE	0 - 3.0 m	0			0	0			5	1	0.10	0.32	10	0			2
	3.1 - 6.1 m	0			0	10	0.83	0.83	12	6	0.27	0.88	22	11	0.42	0.76	26
	6.2 - 9.2 m	4	0.67	0.52	6	9	1.50	1.51	6	6	0.75	0.89	8	5	0.62	0.74	8
	9.3 - 12.3 m	1	0.50	0.70	2	0			0	1	0.33	0.57	3	5	0.83	1.33	6
	12.4 - 15.4 m	0			0	0			0	1	0.50	0.70	2	3	0.50	0.84	6
	15.5 - 18.5 m	3	0.75	1.50	4	0			0	4	1.33	1.53	3	0			0
	COMBINED DEPTHS	8	0.67	0.89	12	19	0.83	1.07	23	19	0.40	0.84	48	24	0.50	0.82	48
NORTH DIABLO COVE	0 - 3.0 m	0			1	1	0.14	0.38	7	1	0.20	0.45	5	0			1
	3.1 - 6.1 m	22	1.34	2.85	7	11	1.57	2.30	7	31	1.24	1.76	25	12	0.67	1.19	18
	6.2 - 9.2 m	29	3.62	1.92	8	6	0.75	1.03	8	19	1.90	1.91	10	29	1.38	1.63	21
	9.3 - 12.3 m	1	0.25	0.50	4	5	2.50	3.53	2	4	1.00	2.00	4	0			0
	12.4 - 15.4 m	0			0	0			0	0			4	7	0.88	1.81	8
	15.5 - 18.5 m	0			0	0			0	0			0	0			0
	COMBINED DEPTHS	52	2.60	2.46	20	23	0.96	1.68	24	55	1.15	1.70	48	48	1.00	1.50	48

stars were more common at shallow rocky substrate stations, while the adults frequented deeper rocky areas. We have analyzed only the 0.25-m^2 quadrat counts because of the questionable accuracy of our counts at the 30-m^2 arc stations. There was not a significant difference in fluctuations in mean densities at South or North Diablo Cove quadrats during the study (Figure 97, Tables 52 and 53). Neither were there significant differences in densities between depths (Tables 52, 53, and 67).

Patiria miniata

Sea bats (Figure 96) have been recorded from Sitka, Alaska, to San Benitos Islands, Baja California, from the intertidal to 300 m (Gotshall and Laurent 1979). Counts from both 30-m^2 arcs and 0.25-m^2 quadrats were analyzed.

Fluctuations in mean densities of sea bats at 30-m^2 arc stations were not significant for South or North Diablo Cove (Figure 98, Table 48 and 49).

The decline in densities in South Diablo Cove 0.25-m^2 quadrats was significant (Figure 99, Table 52). There was no significant change in sea bat densities at North Diablo Cove quadrats over time (Figure 99, Table 53).

Mean densities of sea bats between depths were significantly different at South and North Diablo Cove 30-m^2 arc stations when we compared the data from all years (Tables 48 and 49). They were more abundant at the deeper South Diablo Cove stations and mid-depth (6.2 to 9.2 m) North Diablo Cove arcs (Table 68). At North Diablo Cove arcs, there was also a significant difference between depths for sea bats for 1976 data (Table 49).

TABLE 67. Summary of Statistics for *Henricia leviuscula* at Subtidal Random 0.25-m^2 Quadrat Stations, Diablo Cove. DCPP, 1975-1978.

		1975				1976				1977				1978			
	Depth Range	Sum	x	Sd	N	Sum	x	Sd	N	Sum	x	Sd	N	Sum	x	Sd	N
SOUTH DIABLO COVE	0 - 3.0 m	0			0	0			5	3	0.30	0.48	10	0			2
	3.1 - 6.1 m	0			0	3	0.25	0.45	12	6	0.27	0.88	22	9	0.35	0.89	26
	6.2 - 9.2 m	2	0.33	0.51	6	2	0.33	0.51	6	0			8	1	0.12	0.35	8
	9.3 - 12.3 m	2	1.00	0.00	2	0			0	0			3	0			6
	12.4 - 15.4 m	0			0	0			0	0			2	1	0.17	0.41	6
	15.5 - 18.5 m	0			4	0			0	0			3	0			0
	COMBINED DEPTHS	4	0.33	0.49	12	5	0.22	0.42	23	9	0.19	0.64	48	11	0.23	0.69	48
NORTH DIABLO COVE	0 - 3.0 m	0			1	5	0.71	0.75	7	3	0.60	0.55	5	0			1
	3.1 - 6.1 m	1	0.14	0.39	7	3	0.43	0.53	7	18	0.72	0.94	25	12	0.66	1.10	18
	6.2 - 9.2 m	5	0.62	1.00	8	2	0.25	0.71	8	6	0.60	0.84	10	8	0.38	0.49	21
	9.3 - 12.3 m	0			4	0			2	6	1.50	1.90	4	0			0
	12.4 - 15.4 m	0			0	0			0	0			4	0			8
	15.5 - 18.5 m	0			0	0			0	0			0	0			0
	COMBINED DEPTHS	6	0.30	0.73	20	10	0.42	0.65	24	33	0.69	0.97	48	20	0.42	0.77	48

TABLE 68. Summary of Statistics for *Patiria miniata* at Random 30-m^2 Arc Stations, Diablo Cove. DCPP, 1974-1977.

		1974				1975				1976				1977			
	Depth Range	Sum	$\bar{x}$	Sd	N	Sum	$\bar{x}$	Sd	N	Sum	$\bar{x}$	Sd	N	Sum	$\bar{x}$	Sd	N
SOUTH DIABLO COVE	0 - 3.0 m	27	9.00	7.55	3	98	19.60	12.99	5	0			0	11	5.50	2.12	2
	3.1 - 6.1 m	141	70.50	20.51	2	200	66.67	46.82	3	270	33.75	30.25	8	622	88.86	51.89	7
	6.2 - 9.2 m	0			0	66	66.60	0.00	1	266	88.67	9.82	3	96	96.00	0.00	1
	9.3 - 12.3 m	69	69.00	0.00	1	185	185.00	0.00	1	14	14.00	0.00	1	107	107.00	0.00	1
	12.4 - 15.4 m	120	120.00	0.00	1	156	78.00	19.80	2	0			0	185	185.00	0.00	1
	15.5 - 18.5 m	20	20.00	0.00	1	0			0	0			0	0			0
	COMBINED DEPTHS	377	47.12	42.28	8	705	58.75	52.25	12	550	45.83	36.03	12	1021	85.08	59.93	12
NORTH DIABLO COVE	0 - 3.0 m	0			0	0			0	0			0	77	77.00	0.00	1
	3.1 - 6.1 m	403	100.75	79.32	4	817	116.71	72.88	7	117	19.50	12.85	6	538	107.60	72.14	5
	6.2 - 9.2 m	173	173.00	0.00	1	589	147.25	51.41	4	850	141.67	74.28	6	646	161.50	54.71	4
	9.3 - 12.3 m	115	115.00	0.00	1	56	56.00	0.00	1	0			0	140	140.00	0.00	0
	12.4 - 15.4 m	0			0	0			0	0			0	0			0
	15.5 - 18.5 m	0			0	0			0	0			0	129	129.00	0.00	1
	COMBINED DEPTHS	691	115.17	67.90	6	1462	121.83	65.29	12	967	80.58	81.57	12	1530	127.50	59.63	12

Quadrat stations in both North and South Diablo Cove yielded significant differences in densities for sea bats between depths when data from all years were compared (Tables 52, 53, and 69).

Pisaster giganteus

Giant-spined sea stars (Figure 96) range from Vancouver Island to Cedros Island and Pablo Bay, Baja California, from the low intertidal to depths of 30 m (Gotshall and Laurent 1979). In Diablo Cove they were common on most rocky reefs. Giant-spined sea stars did not occur frequently enough at 0.25-m^2 quadrats to merit analysis. The fluctuations in mean density of P. giganteus at North and South Diablo Cove arc stations were not statistically significant (Figure 100, Tables 48 and 49). In South Diablo Cove they were more abundant at mid-depth (9.3 to 15.4 m) arc stations (Table 70). The differences in abundance by depth was significant (Table 48).

Pycnopodia helianthoides

Sunflower stars (Figure 101), have been reported from Alaska to San Diego, from intertidal depths to depths of 30 m or more (Gotshall and Laurent 1979). We have observed these large shellfish predators throughout Diablo Cove on all types of substrate, including sand. Only the density data from the 30-m^2 arcs have been analyzed.

The changes in mean density at arc stations over the years were not significant (Figure 102, Tables 48, and 49). In South Diablo Cove Pycnopodia was more abundant at deeper 30-m^2 arc stations (Table 71). The differences

TABLE 69. Summary of Statistics for <u>Patiria miniata</u> at Subtidal Random 0.25-m^2 Quadrat Stations, Diablo Cove. DCPP, 1975-1978.

			1975				1976				1977				1978		
	Depth Range	Sum	x	Sd	N	Sum	x	Sd	N	Sum	x	Sd	N	Sum	x	Sd	N
SOUTH DIABLO COVE	0 - 3.0 m	0			0	5	1.00	1.70	5	0			10	0			2
	3.1 - 6.1 m	0			0	2	0.17	0.39	12	12	0.55	1.18	22	17	0.65	0.89	26
	6.2 - 9.2 m	5	0.83	0.75	6	2	0.33	0.52	6	9	1.12	1.12	8	7	0.88	1.13	8
	9.3 - 12.3 m	4	2.00	1.41	2	0			0	6	2.00	1.00	3	5	0.83	0.40	6
	12.4 - 15.4 m	0			0	0			0	0			2	6	1.00	2.00	6
	15.5 - 18.5 m	8	2.00	2.44	4	0			0	1	0.33	0.58	3	0			0
	COMBINED DEPTHS	17	1.42	1.56	12	9	0.39	0.89	23	28	0.58	1.07	48	35	0.73	1.05	48
NORTH DIABLO COVE	0 - 3.0 m	0			1	0			7	3	0.60	1.30	5	0			1
	3.1 - 6.1 m	10	1.43	2.90	7	2	0.29	0.76	7	29	1.16	1.37	25	20	1.11	1.90	18
	6.2 - 9.2 m	16	2.00	1.50	8	18	2.25	2.55	8	11	1.10	0.99	10	29	1.38	1.80	21
	9.3 - 12.3 m	3	0.75	0.50	4	1	0.50	0.70	2	12	3.00	1.41	4	0			0
	12.4 - 15.4 m	0			0	0			0	17	4.25	3.20	4	8	1.00	1.41	8
	15.5 - 18.5 m	0			0	0			0	0			0	0			0
	COMBINED DEPTHS	29	1.45	1.99	20	21	0.88	1.78	24	72	1.50	1.76	48	57	1.19	1.78	48

TABLE 70. Summary of Statistics for <u>Pisaster giganteus</u> at Subtidal Random 30-m^2 Arc Stations, Diablo Cove. DCPP, 1974-1977.

		1974				1975				1976				1977			
	Depth Range	Sum	$\bar{x}$	Sd	N	Sum	$\bar{x}$	Sd	N	Sum	$\bar{x}$	Sd	N	Sum	$\bar{x}$	Sd	N
SOUTH DIABLO COVE	0 - 3.0 m	0			3	0			5	0			0	0			2
	3.1 - 6.1 m	1	0.50	0.71	2	1	0.33	0.58	3	6	0.75	0.89	8	5	0.71	0.76	7
	6.2 - 9.2 m	0			0	0			1	7	2.33	2.52	3	2	2.00	0.00	1
	9.3 - 12.3 m	0			1	0			1	9	9.00	0.00	1	1	1.00	0.00	1
	12.4 - 15.4 m	6	6.00	0.00	1	4	2.00	1.41	2	0			0	0			1
	15.5 - 18.5 m	0			1	0			0	0			0	0			0
	COMBINED DEPTHS	7	0.88	2.10	8	5	0.42	0.90	12	22	1.83	2.69	12	8	0.67	0.78	12
NORTH DIABLO COVE	0 - 3.0 m	0			0	0			0	0			0	0			1
	3.1 - 6.1 m	3	0.75	0.96	4	18	2.57	2.76	7	9	1.50	2.07	6	9	1.80	2.17	5
	6.2 - 9.2 m	2	2.00	0.00	1	20	5.00	5.68	4	18	3.00	2.83	6	6	1.50	1.00	4
	9.3 - 12.3 m	1	1.00	0.00	1	3	3.00	0.00	1	0			0	0			1
	12.4 - 15.4 m	0			0	0			0	0			0	0			0
	15.5 - 18.5 m	0			0	0			0	0			0	2	2.00	0.00	1
	COMBINED DEPTHS	6	1.00	0.89	6	41	3.42	4.30	12	27	2.25	2.49	12	17	1.42	1.56	12

TABLE 71. Summary of Statistics for Pycnopodia helianthoides at Subtidal Random 30-m^2 Arc Stations, Diablo Cove. DCPP, 1974-1977.

		1974				1975				1976				1977			
	Depth Range	Sum	$\bar{x}$	Sd	N	Sum	$\bar{x}$	Sd	N	Sum	$\bar{x}$	Sd	N	Sum	$\bar{x}$	Sd	N
SOUTH DIABLO COVE	0 - 3.0 m	3	1.00	1.00	3	3	0.60	0.89	5	0			0	0			2
	3.1 - 6.1 m	2	1.00	1.41	2	3	1.00	1.00	3	6	0.75	1.17	8	9	1.29	1.38	7
	6.2 - 9.2 m	0			0	2	2.00	0.00	1	3	1.00	1.00	3	0			1
	9.3 - 12.3 m	1	1.00	0.00	1	2	2.00	0.00	1	1	1.00	0.00	1	2	2.00	0.00	1
	12.4 - 15.4 m	3	3.00	0.00	1	8	4.00	2.82	2	0			0	3	0.00	0.00	1
	15.5 - 18.5 m	2	2.00	0.00	1	0			0	0			0	0			0
	COMBINED DEPTHS	11	1.38	1.06	8	18	1.50	1.68	12	10	0.83	1.03	12	14	1.17	1.34	12
NORTH DIABLO COVE	0 - 3.0 m	0			0	0			0	0			0	1	1.00	0.00	1
	3.1 - 6.1 m	17	4.25	4.03	4	15	2.14	1.68	7	7	1.17	0.75	6	6	1.20	1.64	5
	6.2 - 9.2 m	2	2.00	0.00	1	11	2.75	3.20	4	8	1.33	1.63	6	12	3.00	1.15	4
	9.3 - 12.3 m	2	2.00	0.00	1	1	1.00	0.00	0	0			0	2	2.00	0.00	1
	12.4 - 15.4 m	0			0	0			0	0			0	0			0
	15.5 - 18.5 m	0			0	0			0	0			0	1	1.00	0.00	1
	COMBINED DEPTHS	21	3.50	3.33	6	27	2.25	2.14	12	15	1.25	1.22	12	22	1.83	1.47	12

in density by depth were significant for South Diablo Cove but not at North Diablo Cove.

Strongylocentrotus franciscanus

Red sea urchins (Figure 101) are known to occur from the Gulf of Alaska to Cedros Island, Baja California, from the low intertidal down to about 30 m (Gotshall and Laurent 1979). In Diablo Cove, before the arrival of the California sea otter, they were one of the most abundant macro-invertebrates, and were present on all types of substrate.

The substantial changes in mean density at South and North Diablo arc stations were statistically significant (Figure 102, Tables 48 and 49).

The fluctuations in density at North and South Diablo Cove quadrats were not significant (Figure 103, Tables 52, and 53).

Densities of giant red sea urchins were significantly different between depths in South Diablo Cove (Table 48). The urchins were more abundant at deeper South Diablo Cove arc stations (Tables 48, 49 and 72).

Differences in densities between depths at 0.25-m^2 quadrats were not significant (Tables 52, 53 and 73).

TABLE 72. Summary of Statistics for <u>Strongylocentrotus</u> <u>franciscanus</u> at Subtidal Random 30-m^2 Arc Stations, Diablo Cove. DCPP, 1974-1977.

		1974				1975				1976				1977			
	Depth Range	Sum	x	Sd	N	Sum	x	Sd	N	Sum	x	Sd	N	Sum	x	Sd	N
SOUTH DIABLO COVE	0 - 3.0 m	172	57.33	62.74	3	0			5	0			0	2	1.00	1.41	2
	3.1 - 6.1 m	201	100.50	77.07	2	0			3	2	0.25	0.46	8	2	0.29	0.49	7
	6.2 - 9.2 m	0			0	3	3.00	0.00	1	68	68.00	0.00	1	0			1
	9.3 - 12.3 m	60	60.00	0.00	1	13	13.00	0.00	1	0			0	0	0.00	0.00	1
	12.4 - 15.4 m	7	7.00	0.00	1	53	26.50	0.71	2	0			0	4	4.00	0.00	1
	15.5 - 18.5 m	153	153.00	0.00	1	0			0	0			0	0			0
	COMBINED DEPTHS	593	74.12	62.08	8	69	5.75	10.38	12	74	6.17	19.51	12	8	0.67	1.23	12
NORTH DIABLO COVE	0 - 3.0 m	0			0	0			0	0			0	7	7.00	0.00	1
	3.1 - 6.1 m	518	129.50	72.08	4	218	31.12	35.46	7	46	7.67	15.88	6	31	6.20	13.31	5
	6.2 - 9.2 m	182	182.00	0.00	1	110	27.50	51.69	4	183	30.50	43.70	6	23	5.75	3.69	4
	9.3 - 12.3 m	52	52.00	0.00	1	4	4.00	0.00	1	0			0	1	1.00	0.00	1
	12.4 - 15.4 m	0			0	0			0	0			0	0			0
	15.5 - 18.5 m	0			0	0			0	0			0	0			1
	COMBINED DEPTHS	752	125.33	69.64	6	332	27.67	38.38	12	229	19.08	33.54	12	62	5.17	8.55	12

TABLE 73. Summary of Statistics for <u>Strongylocentrotus</u> <u>franciscanus</u> at Subtidal Random 0.25-m^2 Quadrat Stations, Diablo Cove. DCPP, 1975-1978.

		1975				1976				1977				1978			
	Depth Range	Sum	x	Sd	N	Sum	x	Sd	N	Sum	x	Sd	N	Sum	x	Sd	N
SOUTH DIABLO COVE	0 - 3.0 m	0			0	0			5	1	0.10	0.32	10	0			2
	3.1 - 6.1 m	0			0	6	0.50	1.44	12	6	0.27	0.46	22	1	0.04	0.20	26
	6.2 - 9.2 m	0			6	4	0.67	1.21	6	0			8	0			8
	9.3 - 12.3 m	0			2	0			0	0			3	0			6
	12.4 - 15.4 m	0			0	0			0	1	0.50	0.70	2	0			6
	15.5 - 18.5 m	1	0.25	0.50	4	0			0	0			3	0			0
	COMBINED DEPTHS	1	0.08	0.29	12	10	0.43	1.20	23	8	1.67	0.38	48	1	0.02	0.14	48
NORTH DIABLO COVE	0 - 3.0 m	0			1	5	0.71	1.10	7	0			5	0			1
	3.1 - 6.1 m	5	0.71	1.11	7	7	1.00	2.20	7	7	0.28	0.84	25	2	0.11	0.32	18
	6.2 - 9.2 m	0			8	5	0.62	1.40	8	3	0.30	0.48	10	2	0.10	0.30	21
	9.3 - 12.3 m	0			4	0			2	0			4	0			0
	12.4 - 15.4 m	0			0	0			0	2	0.50	1.00	4	2	0.25	0.46	8
	15.5 - 18.5 m	0			0	0			0	0			0	0			0
	COMBINED DEPTHS	5	0.25	0.72	20	17	0.71	1.52	24	12	0.25	0.70	48	6	0.12	0.33	48

CHORDATA

Styela montereyensis

Stalked tunicates (Figure 101) have been recorded from Alaska to San Diego from the intertidal to depths of about 30 m (Gotshall and Laurent 1979). Styela were most often observed in Diablo Cove attached near to or on the top of rocks. We have only analyzed the data from the 30-m^2 arcs. There was a significant change in mean densities at both South and North Diablo Cove 30-m^2 arc stations (Figure 104, Tables 48 and 49). Styela were more abundant at mid-depth (9.13 to 12.3 m) stations (Table 74). This difference in density between depths was significant at both South Diablo Cove and North Diablo Cove (Tables 48 and 49).

B. North Control

As in Diablo Cove, we began surveys of North Control 30-m^2 arc stations in the summer of 1974 and continued them through the fall of 1977. In 1976, we began summer surveys of quadrat stations in North Control. These surveys were continued through the fall of 1978. A total of 85, 30-m^2 stations was surveyed. The species encountered at the arc and quadrat stations, other than those subjected to analysis and discussed below are listed in Appendices 6 and 7.

PORIFERA

TABLE 74. Summary of Statistics for *Styela montereyensis* at Subtidal Random 30-m^2 Arc Stations, Diablo Cove. DCPP, 1974-1977.

		1974				1975				1976				1977			
	Depth Range	Sum	$\bar{x}$	Sd	N	Sum	$\bar{x}$	Sd	N	Sum	$\bar{x}$	Sd	N	Sum	$\bar{x}$	Sd	N
SOUTH DIABLO COVE	0 - 3.0 m	0			3	2	0.40	0.89	5	0			0	0			2
	3.1 - 6.1 m	0			2	2	0.67	0.58	3	76	9.50	8.80	8	57	8.14	8.55	7
	6.2 - 9.2 m	0			0	0			1	55	18.33	25.74	3	8	8.00	0.00	1
	9.3 - 12.3 m	0			1	4	4.00	0.00	1	36	36.00	0.00	1	2	2.00	0.00	1
	12.4 - 15.4 m	1	1.00	0.00	1	1	0.50	0.71	2	0			0	5	5.00	0.00	1
	15.5 - 18.5 m	0			1	0			0	0			0	0			0
	COMBINED DEPTHS	1	0.12	0.35	8	9	0.75	1.22	12	167	13.92	15.28	12	72	6.00	7.16	12
NORTH DIABLO COVE	0 - 3.0 m	0			0	0			0	0			0	0			1
	3.1 - 6.1 m	0			4	5	0.71	0.76	7	10	1.67	2.25	6	22	4.40	2.61	5
	6.2 - 9.2 m	0			1	13	3.25	3.40	4	109	18.17	9.62	6	29	7.25	1.50	4
	9.3 - 12.3 m	0			1	1	1.00	0.00	1	0			0	12	12.00	0.00	1
	12.4 - 15.4 m	0			0	0			0	0			0	0			0
	15.5 - 18.5 m	0			0	0			0	0			0	8	8.00	0.00	1
	COMBINED DEPTHS	0	0.00	0.00	6	19	1.58	2.23	12	119	9.92	10.89	12	71	5.92	3.42	12

Tethya aurantia

The change in mean densities of orange puffball sponges recorded at North Control 30-m^2 arc stations was statistically significant (Figure 105, Table 75). Orange puffball sponges were generally more abundant at deeper stations (Table 76). The differences in densities between depths were significant (Table 75).

CNIDARIA

Anthopleura xanthogrammica

The mean densities of giant green anemones increased over the years at 30-m^2 arc stations; the change in density was statistically significant (Figure 107, Table 75). Significant differences in densities between depths were obtained when tested with the K-W test (Table 75). *Anthopleura* were more abundant at shallow (3.1 to 9.2) arc stations (Table 77).

Balanophyllia elegans

There was little change in *Balanophyllia* density in 0.25-m^2 quadrats over the years (Figure 108), but the differences in densities between depths were significant (Table 78). Orange cup corals were more abundant at deeper quadrat stations (15.5 to 18.5 m) (Table 79).

TABLE 75. Summary of Levels of Significance of Kruskal-Wallis* Tests on Invertebrates Quantified at Random 30-m^2 Arc Subtidal Stations, North Control, Diablo Canyon Power Plant Site.

Species	Between Years** (All Depths)	Between Depths** (All Years)	Between Depths			
			1974	1975	1976	1977
Tethya aurantia	0.0244*	0.0000*	0.0761	0.0254*	0.0057*	0.0052
Anthopleura xanthogrammica	0.0041*	0.0000*	0.0598	0.0071*	0.0806	0.0036*
Cancer antennarius	0.4838	0.1374	0.4091	0.1307	0.2679	0.5531
Astraea gibberosa	0.0001*	0.0872	0.5818	0.5146	0.0546	0.1496
Doriopsilla albopunctata	0.0218*	0.0978	0.3050	0.3076	0.2060	0.8828
Haliotis rufescens	0.1098	0.5712	0.7457	0.5946	0.2405	0.4563
Patiria miniata	0.1575	0.0000*	0.1314	0.0029*	0.0082*	0.2929
Pisaster giganteus	0.7299	0.0013*	0.1791	0.1784	0.0210*	0.4921
Pycnopodia helianthoides	0.4136	0.0093*	0.1449	0.4898	0.2914	0.1985
Strongylocentrotus franciscanus	0.0049*	0.0986	0.1977	0.3389	0.0854	0.7575
Styela montereyensis	0.0000*	0.0053*	0.0484*	0.2559	0.1627	0.2113

* Significance level ($p \leq 0.05$)

** 1974-1977

TABLE 76. Summary of Statistics for <u>Tethya aurantia</u> at Subtidal Random 30-m^2 Arc Stations, North Control. DCPP, 1974-1977.

		1974				1975				1976				1977			
	Depth Range	Sum	$\bar{x}$	Sd	N	Sum	$\bar{x}$	Sd	N	Sum	$\bar{x}$	Sd	N	Sum	$\bar{x}$	Sd	N
NORTH CONTROL	0 - 3.0 m	0			0	0			0	0			0	0			0
	3.1 - 6.1 m	9	1.50	1.97	6	17	1.89	2.26	9	15	1.50	1.90	10	22	2.00	2.53	11
	6.2 - 9.2 m	0			4	32	4.57	4.43	7	38	5.43	3.65	7	69	13.80	6.61	5
	9.3 - 12.3 m	2	1.00	1.41	2	31	7.75	4.65	4	15	5.00	2.00	3	37	9.25	4.86	4
	12.4 - 15.4 m	0			0	24	12.00	4.25	2	77	25.67	7.09	3	21	10.50	4.95	2
	15.5 - 18.5 m	12	6.00	4.24	2	23	11.50	7.78	2	34	34.00	0.00	1	20	20.00	0.00	1
	COMBINED DEPTHS	23	1.64	2.62	14	127	5.29	5.11	24	179	7.46	10.05	24	169	7.35	6.91	23

TABLE 77. Summary of Statistics for _Anthopleura xanthogrammica_ at Subtidal Random 30-m^2 Arc Stations, North Control. DCPP, 1974-1977.

NORTH CONTROL

Depth Range	1974 Sum	1974 x	1974 Sd	1974 N	1975 Sum	1975 x	1975 Sd	1975 N	1976 Sum	1976 x	1976 Sd	1976 N	1977 Sum	1977 x	1977 Sd	1977 N
0 - 3.0 m	0			0	0			0	0			0	0			0
3.1 - 6.1 m	37	6.17	6.11	6	101	11.22	5.02	9	254	25.40	26.34	10	353	32.09	24.87	11
6.2 - 9.2 m	13	3.25	2.75	4	106	15.14	18.36	7	197	28.14	27.46	7	47	9.40	7.30	5
9.3 - 12.3 m	0			2	1	0.25	0.50	4	38	12.67	6.50	3	17	4.25	2.22	4
12.4 - 15.4 m	0			0	1	0.50	0.71	2	2	0.67	0.58	3	2	1.00	1.41	2
15.5 - 18.5 m	0			2	5	2.50	3.53	2	0			1	4	4.00	0.00	1
COMBINED DEPTHS	50	3.57	4.82	14	214	8.92	11.58	24	491	20.46	24.03	24	423	18.39	21.84	23

TABLE 78. Summary of Levels of Significance of Kruskal-Wallis* Tests on Invertebrates Quantified at Random 0.25-m^2 Subtidal Stations, North Control. DCPP, 1976-1978.

Species	Between Years** (All Depths Combined)	Between Depths** (All Years Combined)	Between Depths		
			1976	1977	1978
CNIDARIA					
Balanophyllia elegans	0.4209	0.0000*	0.0000*	0.0000*	0.0000*
Epiactis prolifera	0.0854	0.0000*	0.0101	0.0004*	0.0025*
MOLLUSCA					
Acmaea mitra	0.1433	0.1282	0.0259*	0.3541	0.1074
Astraea gibberosa	0.0219*	0.4959	0.5433	0.5478	0.6307
Doriopsilla albopunctata	0.0044*	0.9233	0.9547	0.3593	0.8756
Haliotis rufescens	0.0747	0.7393	1.0000	0.7419	1.0000
Homalopoma luridum	0.0000*	0.0008*	0.0014*	0.1110	0.1007
Serpuloribis squamigerus	0.3438	0.0001*	0.0107*	0.3966	0.0002*
Tegula brunnea	0.2894	0.0000*	0.0029*	0.0050*	0.0000*
Tonicella lineata	0.0337*	0.2501	0.0237*	0.4734	0.1869
ECHINODERMATA					
Henricia leviuscula	0.0001*	0.0020*	0.0204*	0.0204*	0.2324
Patiria miniata	0.6068	0.0002*	0.0398	0.0782	0.0611
Strongylocentrotus franciscanus	0.0013*	0.3450	0.2608	0.2930	0.9211

* Significance level (≤ 0.05)

** 1976-1978

TABLE 79. Summary of Statistics for *Balanophyllia elegans* at Subtidal Random 0.25-m^2 Quadrat Stations, North Control. DCPP, 1976-1978

	1976				1977				1978			
Depth Range	Sum	$\bar{x}$	Sd	N	Sum	$\bar{x}$	Sd	N	Sum	$\bar{x}$	Sd	N
0 - 3.0 m	1	0.25	0.50	4	0			8	0			10
3.1 - 6.1 m	12	0.86	2.21	14	47	1.81	4.80	26	43	1.34	3.88	32
6.2 - 9.2 m	109	7.79	16.30	14	364	12.55	24.60	29	110	5.00	7.93	22
9.3 - 12.3 m	192	24.00	25.50	8	116	10.54	11.40	11	485	30.31	32.80	16
12.4 - 15.4 m	201	28.71	19.50	7	125	20.83	11.30	6	55	13.75	4.30	4
15.5 - 18.5 m	91	91.00	0.00	1	164	41.00	29.80	4	547	45.58	42.30	12
COMBINED DEPTHS	606	12.62	21.73	48	816	9.71	18.84	84	1240	12.92	25.70	96

Epiactis prolifera

The changes in mean density at 0.25-m^2 quadrats were not significant over the years (Figure 109, Table 78). *Epiactis* were more abundant at shallow (0 to 6.1 m) quadrat stations (Table 80). These density differences between depths were significant (Table 78).

ARTHROPODA

Cancer anntennarius

The change in the density of rock crabs at 30-m^2 arcs was not significant (Figure 110), nor was there a significant difference in density between depths (Table 81).

MOLLUSCA

Acmaea mitra

The change in mean densities of *Acmaea* observed in 1978 at 0.25-m^2 quadrat stations was not statistically significant (Figure 111, Table 78). *Acmaea* were slightly more abundant at mid-depth 0.25-m^2 stations, (9.3 to 12.3 m) but not significantly so (Tables 78 and 82).

Astraea gibberosa

TABLE 80. Summary of Statistics for *Epiatis prolifera* at Subtidal Random 0.25 Quadrat Stations, North Control. DCPP, 1976-1978.

	1976				1977				1978			
Depth Range	Sum	$\bar{x}$	Sd	N	Sum	$\bar{x}$	Sd	N	Sum	$\bar{x}$	Sd	N
0 - 3.0 m	4	1.00	1.41	4	10	1.25	1.39	8	39	3.90	4.70	10
3.1 - 6.1 m	26	1.86	2.03	14	189	7.27	10.86	26	41	1.28	1.73	32
6.2 - 9.2 m	8	0.57	1.16	14	71	2.45	4.51	29	81	3.68	8.54	22
9.3 - 12.3 m	0			8	0			11	7	0.44	0.81	16
12.4 - 15.4 m	0			7	1	0.17	0.40	6	0			4
15.5 - 18.5 m	0			1	0			4	0			12
COMBINED DEPTHS	38	0.79	1.49	48	271	3.23	7.12	84	168	1.75	4.64	96

TABLE 81. Summary of Statistics for *Cancer antennarius* at Subtidal Random 30-m^2 Arc Stations, North Control. DCPP, 1974-1977.

Depth Range	1974				1975				1976				1977			
	Sum	$\bar{x}$	Sd	N	Sum	$\bar{x}$	Sd	N	Sum	$\bar{x}$	Sd	N	Sum	$\bar{x}$	Sd	N
0 - 3.0 m	0			0	0			0	0			0	0			0
3.1 - 6.1 m	1	0.16	0.41	6	5	0.56	0.73	9	8	0.80	0.92	10	4	0.36	0.67	11
6.2 - 9.2 m	0			4	0			7	1	0.14	0.38	7	3	0.60	0.89	5
9.3 - 12.3 m	0			2	0			4	0			3	1	0.25	0.50	4
12.4 - 15.4 m	0			0	1	0.50	0.71	2	2	0.67	1.15	3	0			2
15.5 - 18.5 m	1	0.50	0.71	2	0			2	0			1	1	1.00	0.00	1
COMBINED DEPTHS	1	0.07	0.36	14	6	0.25	0.53	24	11	0.46	0.78	24	9	0.39	0.66	23

TABLE 82. Summary of Statistics for *Acmaea mitra* at Subtidal Random 0.25-m^2 Quadrat Stations, North Control. DCPP, 1975-1978.

Depth Range	1975				1976				1977				1978			
	Sum	x	Sd	N	Sum	x	Sd	N	Sum	x	Sd	N	Sum	x	Sd	N
0 - 3.0 m	0			0	1	0.25	0.50	4	3	0.38	0.52	8	0			10
3.1 - 6.1 m	0			0	0			14	26	1.00	1.67	26	12	0.38	0.66	32
6.2 - 9.2 m	0			0	9	0.64	0.84	14	12	0.41	0.91	29	4	0.18	0.39	22
9.3 - 12.3 m	0			0	10	1.25	1.67	8	7	0.64	2.11	11	5	0.31	0.48	16
12.4 - 15.4 m	0			0	9	1.28	1.60	7	2	0.33	0.82	6	1	0.25	0.50	4
15.5 - 18.5 m	0			0	0			1	0			4	0			12
COMBINED DEPTHS	0			0	29	0.60	1.10	48	50	0.60	1.34	84	22	0.23	0.49	96

There was a significant change in mean densities of red turban snails at 30-m^2 arc stations from 1974 through 1977 (Figure 112, Table 75).

The mean densities at quadrats were identical in 1976 and 1977, but declined in 1978 (Figure 113). This change over time was significant (Table 78).

This snail seemed to be more abundant at mid-depth stations (6.2 to 9.2 m) (Tables 83 and 84) at both arc and quadrat stations.

Doriopsilla albopunctata

The change in Doriopsilla mean densities at 30-m^2 arc and 0.25-m^2 quadrat stations was significant (Figures 114 and 115, Tables 75 and 78). There was little difference in densities between sampled depths (Tables 85 and 86).

Haliotis rufescens

The mean density of red abalones seemed to decline at 30-m^2 arc stations between 1974 and 1975, then increased (Figure 116), but these changes were not statistically significant. Red abalones were not common at arcs or quadrats at any depth (Figures 116 and 117, and Tables 87 and 88).

Homalopoma luridum

The changes in mean densities of Homalopoma at quadrats were statistically significant (Figure 118, Table 78). Homalopoma were more common at deeper

TABLE 83. Summary of Statistics for <u>Astraea</u> <u>gibberosa</u> at Subtidal Random 30-m^2 Arc Stations, North Control. DCPP, 1974-1977.

	1974				1975				1976				1977			
Depth Range	Sum	$\bar{x}$	Sd	N	Sum	$\bar{x}$	Sd	N	Sum	$\bar{x}$	Sd	N	Sum	$\bar{x}$	Sd	N
0 - 3.0 m	0			0	0			0	0			0	0			0
3.1 - 6.1 m	16	2.67	2.50	6	42	4.67	3.67	9	124	12.40	12.00	10	123	11.18	11.50	11
6.2 - 9.2 m	5	1.25	2.50	4	113	16.14	17.00	7	153	21.86	9.88	7	112	22.40	9.34	5
9.3 - 12.3 m	1	0.50	0.71	2	51	12.75	15.20	4	37	12.33	7.50	3	52	13.00	9.09	4
12.4 - 15.4 m	0			0	25	12.50	17.60	2	3	1.00	1.00	3	31	15.50	0.71	2
15.5 - 18.5 m	2	1.00	1.41	2	14	7.00	0.00	2	1	1.00	0.00	1	4	4,00	0.00	1
COMBINED DEPTHS	24	1.71	2.20	14	245	10.21	12.20	24	318	13.25	11.66	24	331	14.39	10.48	23

TABLE 84. Summary of Statistics for *Astraea gibberosa* at Subtidal Random 0.25 Quadrat Stations, North Control. DCPP, 1976-1978.

Depth Range	1976				1977				1978			
	Sum	$\bar{x}$	Sd	N	Sum	$\bar{x}$	Sd	N	Sum	$\bar{x}$	Sd	N
0 - 3.0 m	0			4	4	0.50	0.76	8	1	0.10	0.32	10
3.1 - 6.1 m	11	0.78	1.05	14	13	0.50	1.07	26	5	0.16	1.37	32
6.2 - 9.2 m	15	1.07	1.73	14	22	0.76	1.21	29	5	0.23	0.53	22
9.3 - 12.3 m	2	0.25	0.46	8	7	0.64	1.03	11	6	0.38	0.62	16
12.4- 15.4 m	2	0.28	0.49	7	6	1.00	1.26	6	0			4
15.5- 18.5 m	0			1	0			4	3	0.25	0.62	12
COMBINED DEPTHS	30	0.62	1.16	48	52	0.62	1.07	84	20	0.21	0.48	96

TABLE 85. Summary of for *Doriopsilla albopunctata* at Subtidal Random 30-m^2 Arc Stations, North Control. DCPP, 1974-1977.

	1974				1975				1976				1977			
Depth Range	Sum	$\bar{x}$	Sd	N	Sum	$\bar{x}$	Sd	N	Sum	$\bar{x}$	Sd	N	Sum	$\bar{x}$	Sd	N
0 - 3.0 m	0			0	0			0	0			0	0			0
3.1 - 6.1 m	7	1.17	1.16	6	26	2.89	2.89	9	25	2.50	3.50	10	75	6.82	4.81	11
6.2 - 9.2 m	25	6.25	5.67	4	49	7.00	5.83	7	36	5.14	3.62	7	51	10.20	7.19	5
9.3 - 12.3 m	4	2.00	2.83	2	9	2.25	3.86	4	11	3.67	2.10	3	32	8.00	8.49	4
12.4 - 15.4 m	0	4.00	1.41	2	20	10.00	8.49	2	8	2.67	3.06	3	16	8.00	8.49	2
15.5 - 18.5 m	8	4.00	1.41	2	12	6.00	7.00	2	14	14.00	0.00	1	12	12.00	0.00	1
COMBINED DEPTHS	44	3.14	3.78	14	116	4.83	5.05	24	94	3.92	3.79	24	186	8.09	5.96	23

TABLE 86. Summary of Statistics for *Doriopsilla albopunctata* at Subtidal Random 0.25 Quadrat Stations, North Control. DCPP, 1976-1978.

Depth Range	1976				1977				1978			
	Sum	$\overline{X}$	Sd	N	Sum	$\overline{X}$	Sd	N	Sum	$\overline{X}$	Sd	N
0 - 3.0 m	0			4	3	0.38	1.06	8	1	0.10	0.32	10
3.1 - 6.1 m	1	0.07	0.27	14	2	0.08	0.27	26	11	0.34	0.60	32
6.2 - 9.2 m	2	0.14	0.36	14	4	0.14	0.44	29	8	0.36	0.66	22
9.3 - 12.3 m	1	0.12	0.35	8	0			11	7	0.44	0.73	16
12.4 - 15.4 m	1	0.14	0.38	7	2	0.33	0.52	6	3	0.75	1.50	4
15.5 - 18.5 m	0			1	0			4	4	0.33	0.65	12
COMBINED DEPTHS	5	0.10	0.31	48	11	0.13	0.46	84	34	0.35	0.66	96

TABLE 87. Summary of Statistics for <u>Haliotis rufescens</u> at Subtidal Random 30-m^2 Arc Stations, North Control. DCPP, 1974-1977.

		1974				1975				1976				1977		
Depth Range	Sum	x	Sd	N	Sum	x	Sd	N	Sum	x	Sd	N	Sum	x	Sd	N
0 - 3.0 m	0			0	0			0	0			0	0			0
3.1 - 6.1 m	11	1.83	3.60	6	4	0.44	0.01	9	6	0.60	1.26	10	24	2.18	2.52	11
6.2 - 9.2 m	3	0.75	0.96	4	1	0.14	0.38	7	2	0.29	0.49	7	7	1.40	3.13	5
9.3 - 12.3 m	2	1.00	1.41	2	0			4	2	0.70	0.60	3	1	0.25	0.50	4
12.4 - 15.4 m	0			0	0			2	0			3	3	1.40	2.12	2
15.5 - 18.5 m	0			2	1	0.50	0.70	2	0			1	0			1
COMBINED DEPTHS	16	1.14	2.41	14	6	0.25	0.68	24	10	0.42	0.88	24	35	1.48	2.35	23

TABLE 88. Summary of Statistics for *Haliotis rufescens* at Subtidal Random 0.25 Quadrat Stations, North Control. DCPP, 1976-1978.

	1976				1977				1978			
Depth Range	Sum	$\bar{x}$	Sd	N	Sum	$\bar{x}$	Sd	N	Sum	$\bar{x}$	Sd	N
0 - 3.0 m	0			4	2	0.25	0.71	8	0			10
3.1 - 6.1 m	0			14	1	0.04	0.20	26	0			32
6.2 - 9.2 m	0			14	1	0.03	0.18	29	0			22
9.3 - 12.3 m	0			8	0			11	0			16
12.4- 15.4 m	0			7	0			6	0			4
15.5- 18.5 m	0			1	0			4	0			12
COMBINED DEPTHS	0			48	4	0.05	0.26	84	0			96

TABLE 89. Summary of Statistics for *Homalopoma luridum* at Subtidal Random 0.25-m^2 Quadrat Stations, North Control. DCPP, 1975-1978.

Depth Range	1975 Sum	1975 $\overline{X}$	1975 Sd	1975 N	1976 Sum	1976 $\overline{X}$	1976 Sd	1976 N	1977 Sum	1977 $\overline{X}$	1977 Sd	1977 N	1978 Sum	1978 $\overline{X}$	1978 Sd	1978 N
0 - 3.0 m	0			0	0			4	16	2.00	2.20	8	15	1.50	1.65	10
3.1 - 6.1 m	0			0	0			14	55	2.11	2.25	26	30	0.94	1.56	32
6.2 - 9.2 m	0			0	10	0.71	1.20	14	105	3.62	3.70	29	26	1.18	2.15	22
9.3 - 12.3 m	0			0	16	2.00	1.31	8	44	4.00	4.90	11	32	2.00	2.78	16
12.4 - 15.4 m	0			0	9	1.28	1.70	7	37	6.17	6.97	6	6	1.50	2.38	4
15.5 - 18.5 m	0			0	0			1	0			4	1	0.08	0.29	12
COMBINED DEPTHS	0			0	35	0.73	1.25	48	257	3.06	3.97	84	110	1.14	1.95	96

stations than at shallow stations (Table 89). The difference in densities between depths was significant (Table 78).

Serpulorbis squamigerus

The increase in mean density of *Serpulorbis* in 0.25-m^2 quadrats in 1978 was not significant (Figure 119, Table 78). *Serpulorbis* were more abundant at the deeper 0.25-m^2 quadrat stations (12.4 to 15.4 m) (Table 90). The K-W test indicated that the differences in densities between depths were significant (Table 78).

Tegula brunnea

Mean densities of *Tegula* seemed to increase at 0.25-m^2 quadrats but the change over time was not significant (Figure 120, Table 78). Brown turban snails were more abundant in shallow quadrats (2 to 6.1 m) (Table 91). The K-W test showed the differences in densities between depths to be significant (Table 78).

Tonicella lineata

The mean density of lined chitons decreased in 0.25-m^2 quadrats in 1978 (Figure 121). The change in mean density over time was significant (Table 78). There were no significant differences in depth distribution (Table 92).

ECHINODERMATA

Henricia leviuscula

TABLE 90. Summary of Statistics for *Serpulorbis squamigerus* at Subtidal Random 0.25-m^2 Quadrat Stations, North Control. DCPP, 1975-1978.

Depth Range		1975				1976				1977				1978		
	Sum	$\bar{x}$	Sd	N	Sum	$\bar{x}$	Sd	N	Sum	$\bar{x}$	Sd	N	Sum	$\bar{x}$	Sd	N
0 - 3.0 m	0			0	0			4	1	0.12	0.35	8	0			10
3.1 - 6.1 m	0			0	7	0.50	1.60	14	11	0.42	0.98	26	23	0.71	1.20	32
6.2 - 9.2 m	0			0	14	1.00	1.80	14	30	1.03	1.90	29	8	0.36	0.65	22
9.3 - 12.3 m	0			0	1	0.12	0.35	8	4	0.36	0.81	11	69	4.30	5.60	16
12.4 - 15.4 m	0			0	15	2.14	2.67	7	12	2.00	3.95	6	17	4.25	2.75	4
15.5 - 18.5 m	0			0	0			1	2	0.50	1.00	4	5	0.41	0.79	12
COMBINED DEPTHS	0			0	37	0.77	1.74	48	60	0.71	1.67	84	122	1.27	2.91	96

TABLE 91. Summary of Statistics for *Tegula brunnea* at Subtidal Random 0.25-m^2 Quadrat Stations, North Control. DCPP, 1975-1978.

Depth Range	1975 Sum	1975 $\bar{x}$	1975 Sd	1975 N	1976 Sum	1976 $\bar{x}$	1976 Sd	1976 N	1977 Sum	1977 $\bar{x}$	1977 Sd	1977 N	1978 Sum	1978 $\bar{x}$	1978 Sd	1978 N
0 - 3.0 m	0			0	12	3.00	3.16	4	20	2.50	2.39	8	33	3.30	2.50	10
3.1 - 6.1 m	0			0	25	1.79	1.31	14	71	2.73	4.00	26	75	2.34	2.20	32
6.2 - 9.2 m	0			0	13	0.93	1.80	14	62	2.10	3.10	29	26	1.20	1.50	22
9.3 - 12.3 m	0			0	1	0.13	0.35	8	4	0.36	0.50	11	7	0.44	0.63	16
12.4 - 15.4 m	0			0	0			7	0			6	0			4
15.5 - 18.5 m	0			0	0			1	0			4	0			12
COMBINED DEPTHS	0			0	51	1.06	1.68	48	157	1.87	3.10	84	141	1.47	1.99	96

TABLE 92. Summary of Statistics for *Tonicella lineata* at Subtidal Random 0.25-m^2 Quadrat Stations, North Control. DCPP, 1975-1978.

Depth Range	1975				1976				1977				1978			
	Sum	$\bar{x}$	Sd	N	Sum	$\bar{x}$	Sd	N	Sum	$\bar{x}$	Sd	N	Sum	$\bar{x}$	Sd	N
0 - 3.0 m	0			0	1	0.25	0.50	4	4	0.50	1.06	8	7	0.70	1.34	10
3.1 - 6.1 m	0			0	4	0.29	0.83	14	29	1.11	1.45	26	26	0.81	1.23	32
6.2 - 9.2 m	0			0	14	1.00	2.11	14	40	1.38	1.66	29	3	0.13	0.35	22
9.3 - 12.3 m	0			0	18	2.30	2.50	8	10	0.90	1.30	11	9	0.56	0.89	16
12.4 - 15.4 m	0			0	13	1.85	1.46	7	5	0.83	0.75	6	3	0.75	0.95	4
15.5 - 18.5 m	0			0	0			1	2	0.50	1.00	4	12	1.00	1.76	12
COMBINED DEPTHS	0			0	50	1.04	1.80	48	90	1.07	1.42	84	60	0.63	1.14	96

The mean densities of Henricia increased in 1977 and then decreased in 1978 at 0.25-m^2 quadrats; the changes over time were significant (Figure 122, Table 78). Henricia were more abundant at shallow quadrat stations (0 to 6.1 m), (Table 93). The differences in densities between depths were significant (Table 78).

Patiria miniata

The changes in mean density of Patiria at 30-m^2 arc and 0.25-m^2 quadrat stations were not significant (Figures 123 and 124, Tables 75 and 78). Patiria were more abundant at the deeper arc and quadrat stations (12.4 to 15.4 m) (Tables 94 and 95). The K-W test indicated that the differences in densities between depths were significant (Tables 75 and 78).

Pisaster giganteus

Giant-spined sea stars' mean density appeared to decline at arc stations during the study (Figure 125),but the change over time was not significant (Table 75). Giant-spined sea stars were more abundant at deeper arc stations (Table 96).

Pycnopodia helianthoides

Sunflower stars' mean density at 30-m^2 arc stations varied little over the study period (Figure 126). In the density/depth comparison, the differences in densities were significant (Table 75). Sunflower stars were more abundant at deeper stations (12.4 to 18.5 m) (Table 97).

TABLE 93. Summary of Statistics for *Henricia leviuscula* at Subtidal Random 0.25-m^2 Quadrat Stations, North Control. DCPP, 1975–1978.

	1975				1976				1977				1978			
Depth Range	Sum	$\bar{x}$	Sd	N	Sum	$\bar{x}$	Sd	N	Sum	$\bar{x}$	Sd	N	Sum	$\bar{x}$	Sd	N
0 - 3.0 m	0			0	2	0.50	0.57	4	16	2.00	1.50	8	8	0.80	0.79	10
3.1 - 6.1 m	0			0	16	1.10	1.00	14	35	1.34	1.29	26	19	0.59	0.87	32
6.2 - 9.2 m	0			0	4	0.29	0.47	14	41	1.40	1.60	29	9	0.41	0.80	22
9.3 - 12.3 m	0			0	0			8	7	0.64	1.00	11	3	0.19	0.54	16
12.4 - 15.4 m	0			0	2	0.29	0.76	7	4	0.67	0.52	6	3	0.75	0.96	4
15.5 - 18.5 m	0			0	0			1	1	0.25	0.50	4	5	0.41	0.67	12
COMBINED DEPTHS	0			0	24	0.50	0.80	48	104	1.20	1.40	84	47	0.49	0.78	96

TABLE 94. Summary of Statistics for <u>Patiria</u> <u>miniata</u> at Subtidal Random 30-m^2 Arc Stations, North Control. DCPP, 1974-1977.

	1974				1975				1976				1977			
Depth Range	Sum	$\bar{x}$	Sd	N	Sum	$\bar{x}$	Sd	N	Sum	$\bar{x}$	Sd	N	Sum	$\bar{x}$	Sd	N
0 - 3.0 m	0			0	0			0	0			0	0			0
3.1 - 6.1 m	141	23.50	19.54	6	177	19.67	13.27	9	448	44.80	32.54	10	570	51.82	43.62	11
6.2 - 9.2 m	235	58.75	91.11	4	437	62.43	25.34	7	484	69.14	29.80	7	387	77.40	28.13	5
9.3 - 12.3 m	131	65.50	0.71	2	445	111.25	73.36	4	359	119.70	31.00	3	362	90.50	64.85	4
12.4 - 15.4 m	0			0	241	120.50	26.16	2	420	140.00	28.35	3	252	126.00	70.71	2
15.5 - 18.5 m	218	109.00	21.21	2	109	54.50	4.95	2	127	127.00	0.00	1	99	99.00	0.00	1
COMBINED DEPTHS	725	51.79	54.90	14	1409	58.71	48.74	24	1838	76.58	46.18	24	1670	72.61	48.78	23

TABLE 95. Summary of Statistics for *Patiria miniata* at Subtidal Random 0.25-m^2 Quadrat Stations, North Control. DCPP, 1975-1978.

		1975				1976				1977				1978		
Depth Range	Sum	$\bar{x}$	Sd	N	Sum	$\bar{x}$	Sd	N	Sum	$\bar{x}$	Sd	N	Sum	$\bar{x}$	Sd	N
0 - 3.0 m	0			0	4	1.00	1.40	4	4	0.50	0.53	8	1	0.10	0.32	10
3.1 - 6.1 m	0			0	7	0.50	1.30	14	14	0.54	0.86	26	19	0.59	0.95	32
6.2 - 9.2 m	0			0	12	0.86	1.03	14	34	1.17	1.23	29	17	0.77	0.81	22
9.3 - 12.3 m	0			0	11	1.38	2.00	8	9	0.82	1.40	11	17	1.06	2.00	16
12.4 - 15.4 m	0			0	8	1.14	0.38	7	10	1.67	1.03	6	5	1.25	0.96	4
15.5 - 18.5 m	0			0	3	3.00	0.00	1	8	1.00	0.81	4	12	1.00	1.34	12
COMBINED DEPTHS	0			0	45	0.94	1.31	48	75	0.89	1.09	84	71	0.74	0.97	96

TABLE 96. Summary of Statistics for <u>Pisaster giganteus</u> at Subtidal Random 30-m^2 Arc Stations, North Control. DCPP, 1974-1977.

	1974				1975				1976				1977			
Depth Range	Sum	$\bar{x}$	Sd	N	Sum	$\bar{x}$	Sd	N	Sum	$\bar{x}$	Sd	N	Sum	$\bar{x}$	Sd	N
0 - 3.0 m	0			0	0			0	0			0	0			0
3.1 - 6.1 m	5	0.83	2.04	6	5	0.56	0.73	9	10	1.00	1.63	10	16	1.45	1.69	11
6.2 - 9.2 m	24	6.00	4.55	4	13	1.86	1.35	7	7	1.86	1.35	7	3	0.60	0.55	5
9.3 - 12.3 m	13	6.50	9.19	2	22	5.50	7.19	4	7	2.30	1.50	3	8	2.00	3.37	4
12.4 - 15.4 m	0			0	4	2.00	2.83	2	23	7.67	3.21	3	7	3.50	3.53	2
15.5 - 18.5 m	17	8.50	6.36	2	5	2.50	2.12	2	5	5.00	0.00	1	3	3.00	0.00	1
COMBINED DEPTHS	59	4.21	5.09	14	49	2.04	3.30	24	52	2.17	2.73	24	37	1.61	2.04	23

TABLE 97. Summary of Statistics for _Pycnopodia helianthoides_ at Subtidal Random 30-m^2 Arc Stations, North Control. DCPP, 1974-1977.

	1974				1975				1976				1977			
Depth Range	Sum	$\bar{x}$	Sd	N	Sum	$\bar{x}$	Sd	N	Sum	$\bar{x}$	Sd	N	Sum	$\bar{x}$	Sd	N
0 - 3.0 m	0			0	0			0	0			0	0			0
3.1 - 6.1 m	6	1.00	1.26	6	8	0.89	0.60	9	12	1.20	1.23	10	7	0.64	0.67	11
6.2 - 9.2 m	13	3.25	1.71	4	11	1.57	1.99	7	5	0.71	0.76	7	10	2.00	2.12	5
9.3 - 12.3 m	6	3.00	1.41	2	6	1.50	1.29	4	6	2.00	1.00	3	6	1.50	1.00	4
12.4 - 15.4 m	0			0	11	5.50	6.36	2	8	2.67	2.52	3	4	2.00	1.41	2
15.5 - 18.5 m	4	2.00	0.00	2	4	2.00	1.41	2	2	2.00	0.00	1	3	3.00	0.00	1
COMBINED DEPTHS	29	2.07	1.59	14	40	1.67	2.18	24	32	1.33	1.34	24	31	1.35	1.33	23

Strongylocentrotus franciscanus

The differences in mean densities of red sea urchins at arc and quadrats were significant (Figures 127 and 128, Tables 75 and 78). There were significant differences in densities between depths (Tables 98 and 99).

CHORDATA

Styela montereyensis

The mean density of *Styela* at arc stations increased until 1976, then declined slightly (Figure 129). Results of the Kruskal-Wallis test of the change in densities was significant (Table 75). Highest mean densities were observed at arc stations in depths of 9.3 to 12.3 m (Table 100). The differences in density at depths were significant (Table 75).

C. Comparison of Study Areas

PORIFERA

Tethya aurantia

The comparison of densities at 30-m^2 arcs with the Kruskal-Wallis test yielded no significant difference over time between North Diablo Cove and South Diablo Cove (Table 101). However, the densities of *Tethya aurantia* were significant different when North Control and Diablo Cove 30-m^2 arc stations were compared; *Tethya* was more abundant at North Control arc stations.

TABLE 98. Summary of Statistics for *Strongylocentrotus franciscanus* at Subtidal Random 30-m^2 Arc Stations, North Control. DCPP, 1974-1977.

	1974				1975				1976				1977			
Depth Range	Sum	$\bar{x}$	Sd	N	Sum	$\bar{x}$	Sd	N	Sum	$\bar{x}$	Sd	N	Sum	$\bar{x}$	Sd	N
0 - 3.0 m	0			0	0			0	0			0	0			0
3.1 - 6.1 m	46	7.67	10.11	6	14	1.56	1.67	9	33	3.30	3.56	10	19	1.72	2.93	11
6.2 - 9.2 m	496	124.00	116.08	4	60	8.57	10.58	7	18	2.57	2.82	7	13	2.60	3.97	5
9.3 - 12.3 m	18	9.00	11.31	2	10	2.50	3.32	4	0			3	12	3.00	3.56	4
12.4 - 15.4 m	0			0	9	4.50	2.12	2	23	7.67	6.43	3	0			2
15.5 - 18.5 m	148	74.00	43.84	2	13	6.50	6.36	2	22	22.00	0.00	1	1	1.00	0.00	1
COMBINED DEPTHS	708	50.57	78.52	14	106	4.42	6.56	24	96	4.00	5.42	24	45	1.96	3.04	23

TABLE 99. Summary of Statistics for *Strongylocentrotus franciscanus* at Subtidal Random 0.25-m^2 Quadrat Stations, North Control. DCPP, 1975-1978.

Depth Range	1975				1976				1977				1978			
	Sum	$\bar{x}$	Sd	N	Sum	$\bar{x}$	Sd	N	Sum	$\bar{x}$	Sd	N	Sum	$\bar{x}$	Sd	N
0 - 3.0 m	0			0	0			4	9	1.12	1.36	8	3	0.3	0.67	10
3.1 - 6.1 m	0			0	3	0.21	0.43	14	13	0.50	1.24	26	5	0.16	0.37	32
6.2 - 9.2 m	0			0	27	1.92	5.17	14	12	0.41	0.63	29	4	0.18	0.50	22
9.3 - 12.3 m	0			0	0			8	6	0.55	0.93	11	3	0.18	0.53	16
12.4 - 15.4 m	0			0	0			7	4	0.67	0.82	6	0			4
15.5 - 18.5 m	0			0	0	0		1	0			4	1	0.08	0.29	12
COMBINED DEPTHS	0			0	30	0.62	2.86	48	44	0.52	0.98	84	16	0.16	0.45	96

TABLE 100. Summary of Statistics for Styela montereyensis at Subtidal Random 30-m^2 Arc Stations, North Control. DCPP, 1974-1977.

		1974				1975				1976				1977			
	Depth Range	Sum	$\bar{x}$	Sd	N	Sum	$\bar{x}$	Sd	N	Sum	$\bar{x}$	Sd	N	Sum	$\bar{x}$	Sd	N
NORTH CONTROL	0 - 3.0 m	0			0	0			0	0			0	0			0
	3.1 - 6.1 m	0			6	12	1.33	2.40	9	61	6.10	10.01	10	47	4.27	4.90	11
	6.2 - 9.2 m	7	1.75	2.87	4	13	1.86	2.34	7	34	4.86	2.67	7	38	7.60	4.39	5
	9.3 - 12.3 m	6	3.00	2.83	2	22	5.50	4.80	4	71	23.67	10.00	3	60	15.00	14.88	4
	12.4 - 15.4 m	0			0	1	0.50	0.71	2	23	7.67	5.50	3	7	3.50	2.12	2
	15.5 - 18.5 m	0			2	1	0.50	0.71	2	2	2.00	0.00	1	4	4.00	0.00	1
	COMBINED DEPTHS	13	0.93	1.98	14	49	2.04	3.03	24	191	7.96	9.52	24	156	6.78	7.86	23

CNIDARIA

Anthopleura xanthogrammica

The difference in densities of *Anthopleura* at the 30-m^2 arcs between North and South Diablo Cove was significant ($p \leq 0.05$) in 1975 and for all years combined (Table 101). There was no significant difference in densities when we compared Diablo Cove arc stations with North Control arc stations (Table 101).

Balanophyllia elegans

There was not a significant difference in 0.25-m^2 quadrat densities between North and South Diablo Cove (Table 102). There was also no significant difference over time between Diablo Cove quadrat densities and North Control quadrat densities when all years (1976-1978) combined were tested.

Epiactis prolifera

When we tested the quadrat densities of *Epiactis* between North and South Diablo Cove, for all years combined, there was not a significant difference (Table 102). There was a significant difference ($p \leq 0.05$) in densities between the North Control and Diablo Cove quadrats but only in 1976.

ARTHROPODA

TABLE 101. Summary of Levels of Significance of Kruskal-Wallis, and Mann-Whitney (M-W) Tests Comparing Study Areas for Invertebrates at Random 30-m^2 Subtidal Stations. Diablo Cove and North Control. DCPP, 1974-1977.

	North Control and Diablo Cove					North Diablo Cove and South Diablo Cove				
Species	1974 (K-W)	1975 (K-W)	1976 (K-W)	1977 (K-W)	All Years Combined (K-W)	1974 (M-W)	1975 (M-W)	1976 (M-W)	1977 (M-W)	All Years Combined (M-W)
PORIFERA										
Tethya aurantia	0.3264	0.0960	0.0098*	0.0135*	0.0011*	1.0000	0.4210	0.0999	0.7433	0.5480
CNIDARIA										
Anthopleura xanthogrammica	0.8151	0.4747	0.1070	0.1074	0.0718	0.4340	0.0025*	0.9768	0.0874	0.0158*
ARTHROPODA										
Cancer antennarius	0.9397	0.0473*	0.8497	0.7038	0.4069	0.2037	0.5784	0.1298	0.8192	0.4809
MOLLUSCA										
Astraea gibberosa	0.0062*	0.1658	0.0115*	0.0000*	0.0051*	0.4371	0.5034	0.1967	0.0749	0.0297*
Doriopsilla albopunctata	0.9246	0.8434	0.0468*	0.0024*	0.0079*	0.2118	0.1296	0.4212	0.3955	0.0230*
Haliotis rufescens	0.1935	0.4509	0.6210	0.0307*	0.0180*	0.2037	0.3173	0.2301	0.9290	0.6514
ECHINODERMATA										
Patiria miniata	0.3825	0.0664	0.0948	0.0554	0.1805	0.0707	0.0141*	0.3550	0.1190	0.0011*
Pisaster giganteus	0.2114	0.4519	0.5452	0.4806	0.0869	0.1952	0.0036*	0.5704	0.2448	0.0031*
Pycnopodia helianthoides	0.8129	0.5764	0.4015	0.6272	0.9099	0.1201	0.4414	0.3770	0.2217	0.0453*
Strongylocentrotus franciscanus	0.0190*	0.5474	0.4969	0.7724	0.4154	0.1213	0.0265*	0.0334*	0.0545	0.0033*
CHORDATA										
Styela montereyensis	0.1297	0.5627	0.3629	0.9234	0.6572	0.3865	0.2179	0.5436	0.4843	0.5222

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* Significance level ($p \leq 0.05$).

TABLE 102. Summary of Levels of Significance of Kruskal-Wallis* Tests Comparing Study Areas for Invertebrates at Random 0.25-m^2 Subtidal Stations. Diablo Cove and North Control. DCPP, 1976-1978.

	North Control and Diablo Cove				North Diablo Cove and South Diablo Cove				
Species	1976	1977	1978	All Years Combined	1975	1976	1977	1978	All Years Combined
CNIDARIA									
Balanophyllia elegans	0.0466*	0.9378	0.9595	0.9442	0.7399	0.9264	0.6967	0.6486	0.3365
Epiactis prolifera	0.0096*	0.8807	0.9073	0.6885	0.0646	0.2018	0.4642	0.5412	0.3712
MOLLUSCA									
Acmaea mitra	0.0708	0.2207	0.0185*	0.0002*	0.9023	0.3137	0.0830	0.7991	0.5385
Astraea gibberosa	0.0082*	0.0001*	0.9112	0.0004*	0.0270*	0.1755	0.0792	0.4532	0.2810
Doriopsilla albopunctata	0.0986	0.2620	0.2449	0.0160*	0.4386	0.3276	0.1676	0.4915	0.7892
Haliotis rufescens	1.0000	0.8406	1.0000	0.6416	0.4386	1.0000	0.9831	1.0000	0.7144
Homalopoma luridum	0.0240*	0.6093	0.0001*	0.0077*	0.3342	0.1050	0.4612	0.0002*	0.0001*
Serpulorbis squamigerus	0.0628	0.2344	0.6272	0.7277	0.7943	0.9854	0.2530	0.2372	0.1706
Tegula brunnea	0.0030*	0.0558	0.4706	0.0003*	0.1660	0.2219	0.0228*	0.0403*	0.0029*
Tonicella lineata	0.9133	0.0179*	0.5741	0.6902	0.0339*	0.6384	0.0170*	0.1895	0.0045*
ECHINODERMATA									
Henricia leviuscula	0.3847	0.0000*	0.0791	0.0000*	0.4697	0.3129	0.0010*	0.0614	0.0009*
Patiria miniata	0.0294*	0.7960	0.6489	0.8154	0.8389	0.5976	0.0015*	0.3689	0.0042*
Stronglyocentrotus franciscan	0.2684	0.0030*	0.1431	0.0214*	0.5444	0.3579	0.8891	0.0509	0.1519

* Significance level ($p \leq 0.05$).

Cancer antennarius

The densities of rock crabs at 30-m^2 arc stations in Diablo Cove and the North Control were not significant different except in 1975. When densities at 30-m^2 arcs in North and South Diablo Cove were compared for individual years and all years combined, no significant differences were found (Table 101).

MOLLUSCA

Acmaea mitra

When we tested for differences in densities of Acmaea between North Control and Diablo Cove 0.25-m^2 quadrats, the Kruskal-Wallis test results indicated a significant difference (Table 102); Acmaea were more abundant in Diablo Cove (Figures 84 and 111). This test did not yield a significant difference between South and North Diablo Cove.

Astraea gibberosa

The Kruskal-Wallis test result for differences in densities of Astraea between North and South Diablo Cove 30-m^2 arc stations was significant for all years combined (Table 101). They were more abundant in South Diablo Cove (Figure 85). This same test for the 0.25-m^2 quadrat data yielded a significant difference only for the first year of sampling in 1975 (Table 102); again Astraea were more abundant in South Diablo Cove (Figure 86). When we tested Astraea density differences between North Control and Diablo Cove, the

Kruskal-Wallis test indicated significant ($p \leq 0.05$) differences for 30-m^2 arc and 0.25-m^2 quadrat data (Tables 101 and 102); except for the 1978 quadrat stations, *Astraea* were more abundant at North Control arc and quadrat stations (Figures 85, 86, 112, and 113).

Doriopsilla albopunctata

Doriopsilla densities at 30-m^2 arcs and 0.25-m^2 quadrats were significantly different when we compared North Control with Diablo Cove for all years combined (Tables 101 and 102); they were more abundant in the North Control (Figures 87, 88, 114,and 115). The nudibranchs were significantly ($p \leq 0.05$) more abundant at North Diablo Cove 30-m^2 arc station than at the South Diablo Cove arcs for all years combined (Table 101).

Haliotis rufescens

The Kruskal-Wallis test for significant differences in densities of red abalone between study areas did not produce significant results when North and South Diablo Cove arc and quadrat stations were tested(Tables 101 and 102). The Kruskal-Wallis test did not indicate a significant difference in red abalone densities at 30-m^2 arcs when North Control and Diablo Cove stations were compared (Table 101), although red abalone appeared to be more abundant in the North Control (Figures 90 and 116).

Homalopoma luridum

Densities of dwarf turban snails were higher in Diablo Cove quadrats than in North Control quadrats; this difference in densities was significant

(Table 102). Dwarf turban snails were also more abundant in South Diablo Cove quadrats than in North Diablo Cove quadrats (Figure 92). The difference in density was significant (Table 102).

Serpulorbis squamigerus

There were no significant differences in densities between Diablo Cove and North Control quadrats or between Diablo Cove and North Control arc stations (Table 102).

Tegula brunnea

Brown turban snails were more abundant at North Control quadrats than at Diablo Cove quadrats (Figures 94 and 120). This difference in densities was significant (Table 102). *Tegula* were consistantly more abundant over the years in North Diablo Cove quadrats than in South Diablo Cove quadrats (Figure 94); this difference was also significant (Table 102).

Tonicella lineata

In comparing study area densities of lined chitons at 0.25-m^2 quadrats, we found that the differences between North and South Diablo Coves and between North Control and Diablo Cove were significant (Table 102). Lined chitons were more abundant in Diablo Cove (Figures 95 and 121).

ECHINODERMATA

Henricia leviuscula

The comparison of densities of *Henricia* for all years combined between South and North Diablo Cove quadrats and Diablo Cove and North Control quadrats yielded a significant difference (Table 102); they were more abundant at North Diablo Cove and North Control quadrats, respectively (Figure 97).

Patiria miniata

When we compared densities of sea bats between North Control and Diablo Cove 30-m^2 arcs for all years combined, the difference was not significant. There was, however, a significant difference in densities at 30-m^2 arcs between South and North Diablo Cove (Table 101). There was also a significant difference in sea bat densities between South and North Diablo Cove 0.25-m^2 quadrats (Table 102). Sea bats were more abundant in North Diablo Cove (Figure 99).

Pisaster giganteus

Giant-spined sea stars were significantly more abundant at North Diablo Cove 30-m^2 arcs than in South Diablo Cove arcs (Table 101). However, the densities in Diablo Cove arcs were not significantly different from the North Control arcs.

Pycnopodia helianthoides

Sunflower stars were significantly more abundant at North Diablo Cove 30-m^2 arcs than at South Diablo Cove arcs (Figure 102, Table 101).

Strongylocentrotus franciscanus

Comparing the densities at 30-m^2 arc stations of red sea urchins between study areas using the Kruskal-Wallis test we found significant differences between South and North Diablo Cove (Table 101); they were more abundant in North Diablo Cove. The 0.25-m^2 quadrat counts yielded a significant difference between North Control and Diablo Cove (Table 102); they were more abundant in Diablo Cove (Figures 104 and 128).

CHORDATA

Styela montereyensis

Stalked tunicate densities at 30-m^2 arcs in North and South Diablo Coves were not significantly different, nor were the densities between Diablo Cove and North Control (Table 101).

Discussion

The impacts of man's activities, i.e., testing of cooling water pumps, and natural causes, i.e., siltation, sea otter foraging, and red tides, have contributed to many of the changes that we have observed in Diablo Cove and our control areas since 1973. Some of these changes have, in turn, forced us to reject our null hypotheses for several species. It seems best then, in our discussion of the results of the subtidal invertebrates studies, to do so in terms of each of the original hypotheses and to attempt to relate the reflection of a particular hypothesis for a species to the impacts and changes that we have observed.

Null Hypothesis 1-- Comparability of Study Areas

We assumed that the mean densities of the selected species at random stations in North and South Diablo Cove would not be significantly different, nor would the combined densities differ significantly from North Control mean densities. The Kruskal-Wallis test comparing Diablo Cove with North Control for all study years yielded significant differences ($p \leq 0.05$) in mean densities for *Tethya aurantia* and *Haliotis rufescens* at arc stations; and *Astraea gibberosa* and *Dendrodoris albopunctata* at arc as well as quadrats stations (Tables 103 and 104). There was also significant differences in mean densities at quadrat stations for *Acmaea mitra*, *Homalopoma luridum*, *Tegula brunnea*, *Henricia leviuscula* and *Strongylocentrotus franciscanus* (Table 104) when Diablo Cove was compared to North Control. We feel that most of these differences in abundance between the two study areas were due to difference in habitat. For example, *Tethya* was more abundant at North Control arc stations which are more exposed. The open coast of the North Control probably provides more drifting food to this suspension filter feeder because of greater water movement.

From our observations, red abalone are more abundant in the North Control because there appears to be more suitable substrate in the form of low-profile rocky reefs with many undercuts and crevices. This bedrock habitat also appears to be more stable and less subject to movement during storm seas than much of the substrate in Diablo Cove. In the North Control, the average percentage of solid rock, boulders and cobble recorded at random arc stations in depths less than 7.6 m was 76, 8 and 7 percent, respectively. In North Diablo Cove, the percentages were 85, 6 and 3 percent; and in South Cove, the percentages were 77, 3, and 6 percent (Figure 70).

TABLE 103. Summary of Null Hypotheses Tests for Invertebrates Counted at Subtidal Random 30-m^2 Arc Stations, Diablo Cove and North Control. DCPP, 1974-1977. (R= Rejection of Null Hypothesis).

	Null Hypotheses									
	1		2			3			4	
	Comparability of Study Areas		Temporal Stability of Study Areas			Comparability of Depth Distribution			Temporal Stability Within a Sampling Period	
Species	SDC vs. NDC	DC vs. NC	SDC	NDC	NC	SDC	NDC	NC	DC	NC
PORIFERA										
Tethya aurantia		R			R	R		R		
CNIDARIA										
Anthopleura xanthogrammica	R				R	R		R		
ARTHROPODA										
Cancer antennarius										
MOLLUSCA										
Astraea gibberosa	R	R			R				R (1)	R (2)
Doriopsilla albopunctata	R	R			R					
Haliotis rufescens		R								R (1)
ECHINODERMATA										
Patiria miniata	R					R		R		
Pisaster giganteus	R					R		R		
Pycnopodia helianthoides	R					R		R		
Strongylocentrotus franciscanus	R		R	R	R	R				
CHORDATA										
Styela montereyensis			R	R	R	R	R	R		

( ) Indicates the number of seasons that were significantly different.

TABLE 104. Summary of Null Hypotheses Tests for Invertebrates Counted at Subtidal Random 0.25-m^2 Quadrat Stations. Diablo Cove and North Control. DCPP, 1976-1978. (R= Rejection of Null Hypothesis).

	Null Hypotheses									
	1		2			3			4	
	Comparability of Study Areas		Temporal Stability of Study Areas			Comparability of Depth Distribution			Temporal Stability Within a Sampling Period	
Species	SDC vs. NDC	DC vs. NC	SDC	NDC	NC	SDC	NDC	NC	DC	NC
CNIDARIA										
<u>Balanophyllia elegans</u>				R		R	R	R	R (2)	R (2)
<u>Epiactis prolifera</u>				R		R	R	R	R (1)	R (1)
MOLLUSCA										
<u>Acmaea mitra</u>		R	R				R			R (1)
<u>Astraea gibberosa</u>		R	R		R					
<u>Doriopsilla albopunctata</u>		R	R		R				R (1)	
<u>Haliotis rufescens</u>										
<u>Homalopoma luridum</u>	R	R	R		R	R		R	R (1)	R (2)
<u>Serpulorbis squamigerus</u>						R		R	R (1)	
<u>Tegula brunnea</u>	R	R	R	R			R	R	R (1)	R (2)
<u>Tonicella lineata</u>	R				R	R	R			R (1)
ECHINODERMATA										
<u>Henricia leviuscula</u>	R	R			R			R		R (2)
<u>Patiria miniata</u>	R		R			R	R	R		
<u>Stronglyocentrotus franciscanus</u>		R			R					

( ) indicates the number of seasons that were significantly different.

The fact that red abalone were apparently more abundant at North Control subtidal random stations than in Diablo Cove after more than a year of foraging by sea otters whose monthly mean numbers ran as high as 40 animals in 1974 (Gotshall et al. 1974) suggests that abalone were possibly more abundant in North Control than in Diablo Cove before the sea otters arrived. The group of sea otters that foraged in Diablo Cove in 1974 was similar (highest monthly average count was 13 in June 1974) and their prolonged foraging in the Cove lasted only six months. Unfortunately, our random subtidal surveys did not begin until June 1974, so we can only speculate on abalone abundances before 1974. To add to the problem, three potentially major impacts on the Diablo Cove subtidal plant and animal communities occurred during the time we were completing our initial random surveys: sea otter foraging, the discharge of copper corrosion products during the cooling water pump tests, and a red tide. We also suspect that at least some of the differences in mean densities of other invertebrates, such as Astraea and Strongylocenttrotus, between Diablo Cove and North Control were due to the sea otters and possibly the discharge of copper corrosion products and the red tide.

In 1974, after completing our summer surveys of random subtidal stations, we determined there were differences between North and South Diablo Cove, both in habitat and in densities of some of the species we were quantifying. In 1975, we divided the Cove into north and south sections, and the random stations were divided equally between the two sections. When the mean densities in the two areas of the Diablo Cove were compared using the Kruskal-Wallis test, significant differences ($p \leq 0.05$) for several of the animals and plants were confirmed. At random arc stations, Anthopleura xanthogrammica, Doriopsilla albopunctata, Patiria miniata, Pisaster giganteus, Pycnopodia helianthoides, and Strongylocentrotus franciscanus were more abundant at North

Diablo Cove stations than that at South Diablo Cove stations, while Astraea gibberosa was more abundant in South Diablo Cove. The differences in mean densities of these seven animals, in South Diablo Cove and North Diablo Cove, was significant (Table 103). Assuming sea otter foraging in 1974 was equally divided between the two sections of the Cove, the reasons for these differences can be attributed to natural causes, such as differences in substrate (Figures 70 and 71), the occurrence of red tide conditions observed in the fall of 1974, and possibly the discharge of copper corrosion products during the 1974 cooling-pump tests. South Diablo Cove differs physically from North Diablo Cove in several important ways: the water circulation in the Cove has been shown to favor a north-to-south flow and the configuration in the southeast corner supports a circular movement (or gyre) of the water during cooling water pump operation; otherwise, water movement is often sluggish, allowing sediments and drift objects to accumulate (Warrick 1974). The random subtidal arc stations in South Diablo Cove were composed of an average of 17 percent sand, while in the north portion of the Cove, the average was 6 percent (Figures 70 and 71). Because of the configuration of the Cove, the north portion usually receives more wave energy. In South Diablo Cove, Diablo Rock and Diablo Point provide more protection from most storm waves, thus the quieter waters create a sediment trap. These conditions also tended to concentrate the copper corrosion products and the bloom of red tide in South Diablo Cove in the summer and fall of 1974. All of the above factors influence the species and density of invertebrates in South Diablo Cove.

In summary, although there were significant differences in mean densities of some species between study areas this should not prevent us from using these animals or plants to detect changes during the operational phase of the power plant. As long as the selected populations of animals and plants are "stable" within study areas, area comparisons can be made legitimately.

Null Hypothesis 2--Temporal Stability of Study Areas

This hypothesis focuses on the stability of the populations during the study period and assumes no significant changes in abundance neither decreases nor increases. The Kruskal-Wallis tests for densities at the arc stations indicated that more animals had significant changes in abundance at North Control stations over the years, than at either North or South Diablo Cove stations (Table 103). Six of the selected species in North Control showed significant changes in mean densities, of these, Tethya, Anthopleura, Astraea, Doriopsilla, and Styela increased in abundance at North Control random arc stations between 1974 and 1977 (Table 103).

We suspect that for many species in Diablo Cove these changes in density were the direct or indirect result of sea otter foraging. The sharp decline in red sea urchins, a major forager on brown algae in our study areas, has resulted in a corresponding increase in abundance of at least three species of brown algae, Laminaria, Pterygophora, and Nereocystis (bull kelp). Some of the increases in densities may be due to increased diver recognition of a particular species with increasing experience.

The quadrat station results in the North Control supported the increases noted at arc stations for Astraea and Dendrodoris numbers, and the decrease noted in giant red sea urchin numbers. Fluctuations in density were also significant for Homalopoma, Tonicella, and Henricia at quadrats (Table 104).

Only two species showed significant changes in density over time at North and South Diablo Cove arc stations: red sea urchins, and *Styela montereyensis* (Table 103). Sea otter foraging was most likely responsible for the sharp decline in red sea urchin numbers, while the increase in *Styela* was probably due to an increase in available habitat or some other factor that provided for higher survival. We have speculated in past reports that the disappearance of red sea urchins in the southeast corner of Diablo Cove might also have been caused by the 1974 red tide conditions, or the release of copper corrosion products during the cooling pump testing or even possibly because of a synergistic effect of both phenomena (Gotshall et al. 1976). The fact that red urchins were completely absent from 8 of 12 North Diablo Cove arcs after the 1974 surveys, and also at permanent stations 10 and 16 located in the south corner of South Diablo Cove (see Subtidal Permanent Station Studies sections) in 1975, lends support to another cause of mortality in South Diablo Cove in addition to sea otter foraging.

There is little doubt that the increase in *Laminaria* and *Pterygophora* at random arc stations in Diablo Cove were the direct result of the severe decline in red sea urchin numbers.

The data for red urchins from the random 0.25-m^2 quadrats in North and South Diablo Cove did not follow the pattern observed at arc stations (Figures 103 and 104). This might be due to the fact that most of the decline in density at arc stations occurred in 1974, and that counts at arc stations of red sea urchins were limited to mature adults and large sub-adults while at quadrats, most of the red sea urchins we encountered were small juveniles. In other words, the population of zero-, one- and two-year-old red sea urchins may urchins may not be preyed on by sea otters. Another interesting, but a puzzling fact emerged from analysis of the quadrat samples. That is, these juvenile red sea urchins were slightly more abundant at South Diablo Cove quadrats than at North Diablo Cove quadrats (Figure 104). Possibly the changes in algae abundance favored the survival of larval red sea urchins in 1975, 1976 and 1977. It is also quite possible that the apparent differences are due entirely to the sampling error biases and random variation.

The decline of Astraea at South Diablo Cove random quadrats followed an apparent decline at random arcs (Figures 85 and 86). The change in abundance in the quadrats was significant while the change in the arcs was not (Tables 48 and 52). We suspect that this decline may in part be due to the release of copper and also the "red tide", as well as sea otter foraging. The Kruskal-Wallis test results indicated significant changes in abundance for five invertebrates in South Diablo Cove and for four invertebrates in North Diablo Cove. Acmaea mitra and Patiria miniata decreased in mean densities in South Diablo Cove quadrats while Doriopsilla, Homalopoma, and Tegula increased in abundance. In North Diablo Cove, Tegula abundance increased, Balanophyllia densities decreased, and densities of Epiactis increased then decreased at North Diablo Cove quadrats. Also in North Diablo Cove Tonicella declined in abundance from 1975 and 1976, then increased in 1977 again, but to less than 50% of the 1975 level. We believe that the increase in observed Tegula abundance is due almost entirely to an increase in understory kelp abundance (Laminaria and Pterygophora). From our observations Tegula feed on these kelps, and their increase provided a great increase in available living and feeding space for the brown turban snail. The sharp decline in Tonicella abundance between 1975 and 1976 may be related to an increase in brown and foliose red algae abundance and a reduction of exposed encrusting coralline algae upon which they feed (Barnes and Gonor 1973). We have no idea what caused the fluctuation in Balanophyllia abundance. The fluctuations in Epiactis density may be due at least in part of the increase in suitable substrate provided by the increase in alga abundance as we have observed large numbers of Epiactis attached to various species of red and brown algae.

Finally, natural random variability and observer error should not be ignored when evaluating many of the observed changes in density.

Null Hypothesis 3-- Compariability of Depth Distribution

In order to assess changes in selected organisms after the power plant goes into operation, we had to determine the natural depth distribution of each species. Significant changes in depth distribution for species in Diablo Cove after the plant goes into operation, especially for predominantly shallow-occurring species, would indicate which organisms were being stressed or displaced by the thermal plume.

Data subjected to statistical analyses for the eleven species quantified at North Control random arc stations showed significant differences in mean densities for six of the species between shallower-water (3 to 7.6 m) and deep-water (7.9 to 18.3 m) stations (Tables 75 and 103). Tethya, Patiria, Pisaster, and Pycnopodia were most abundant at the deeper stations; Anthopleura was most abundant at shallow stations and Styela was most abundant at mid-depth stations (9.3 to 12.3 m). North Diablo Cove data yielded only one species with a significant difference in density at depth - Styela. In South Diablo Cove significant differences were obtained for the same species as in the North

Control, plus on additional species--giant red sea urchins, which were more abundant at deeper stations. In North Diablo Cove only *Styela* showed a significant difference in density at depth (Table 104).

The fact that North Diablo Cove arc depth/density data did not follow the pattern observed in the North Control and South Diablo Cove areas is probably due to the almost complete lack of stations deeper than 12.3 m in North Diablo Cove, while 5 of the 44 arc stations surveyed in South Diablo Cove were deeper than 12.3 m and 15 of 85 arc stations in North Control were deeper than 12.3 m.

The significant differences of abundance of giant red sea urchins by depth at South Diablo Cove arcs are possibly related to the urchin mortality that occurred during the summer and fall in the shallow southeast corner of the Cove.

The combined random quadrat station data by depths from all study areas indicate significant density/depth differences for eight of the smaller invertebrates (Table 104), and support the significant differences obtained for *Patiria* at arc stations.

Homalopoma was most abundant at mid-depths at North Control and South Diablo Cove quadrats. *Serpulorbis* and *Balanophyllia* were most abundant at deep stations in all study areas; however, this difference in abundance by depth was not significant for *Serpulorbis* in North Diablo Cove.

Tegula and *Epiactis* were most abundant at shallow quadrats in all study areas, with the exception that density/depth difference was not significant for

Tegula in South Diablo Cove. Acmaea mitra appeared to be more abundant at shallow stations, but this distribution was only significant in North Diablo Cove. Homalopoma were more abundant at mid-depth (6.2 to 12.3 m) quadrat stations in South Diablo Cove and at deep stations (7.6 to 18.3 m) in North Control quadrats. Tonicella were more abundant at mid-depth quadrats in North and South Diablo Coves (Table 66).

All of the density/depth distributions at random arcs and quadrats appear to be part of the normal pattern for this section of coast with one exception--the depth distribution of red sea urchins in South Diablo Cove. These urchins have almost disappeared from the shallow portion of South Diablo Cove.

Null Hypothesis 4 -- Temporal Stability Within A Sampling Period

From 1974 through 1977, one-half of the random arc stations were sampled in Diablo Cove, then we moved to the North Control and surveyed one-half of the stations there. The remaining halves were then surveyed in the same order. This resulted in a 2- to 4-week interval between survey periods in the two study areas. We assumed at that time that no significant mortality or recruitment was occurring for any quantified species during the 3 to 4 months required to complete the subtidal stations which might bias our tests of the other hypotheses. At arc stations, the Kruskal-Wallis test yielded a significant difference ($p \leq 0.05$) for only one species in Diablo Cove (Astraea gibberosa in 1976) and two species in the North Control (Astraea and Haliotis rufescens in 1977) (Tables 105 and 106).

At the random quadrats, six species in Diablo Cove showed significant difference in means between survey periods; Doriopsilla albopunctata in 1977;

TABLE 105. Summary of Levels of Significance of Kruskal-Wallis, and Mann-Whitney Tests on Mean Densities from Early and Late Summer Subtidal Surveys of Intervertebrates at Random 30-m^2 Arcs, Diablo Cove. DCPP, 1974-1977.

	Survey Dates			
	May 7-June 22 vs. Aug. 17-Sept. 20	July 8-July 17 vs. Aug. 14-Sept. 5	July 1-Aug. 10 vs. Aug. 24-Sept. 21	July 5-20 vs. Aug. 26-Sept. 22
PORIFERA				
<u>Tethya aurantia</u>	0.2220	0.9048	0.4461	0.9278
CNIDARIA				
<u>Anthopleura xanthogrammica</u>	0.93.73	0.7268	0.1552	0.8600
ARTHROPODA				
<u>Cancer antennarius</u>	0.4434	0.1895	0.2938	0.2162
MOLLUSCA				
<u>Astraea gibberosa</u>	0.1010	0.5791	0.0455*	0.3906
<u>Doriopsilla albopunctata</u>	0.6757	0.2664	1.0000	0.4054
<u>Haliotis rufescens</u>	0.4434	0.3576	0.9289	0.1360
ECHINODERMATA				
<u>Patiria miniata</u>	0.8153	0.2585	0.6847	0.4822
<u>Pisaster giganteus</u>	0.5434	0.8297	0.1975	0.4563
<u>Pycnopodia helianthoides</u>	0.8068	0.6558	0.5821	0.6287
<u>Strongylocentrotus franciscanus</u>	0.0516	0.8804	0.2591	0.8257
CHORDATA				
<u>Styela montereyensis</u>	0.6015	0.2527	0.4332	0.2038

* Significance level ($p \leq 0.05$).

TABLE 106. Summary of Levels of Significance of Kruskal-Wallis, and Mann-Whitney Tests on Means from Early and Late Summer Surveys of Invertebrates at Random 30-m^2 Arcs, Diablo Cove. DCPP, 1974-1977.

	Survey Dates			
Species	June 3-21 vs. Aug. 14-Sept. 19 1974	July 22-Aug. 5 vs. Sept. 4-Sept. 24 1975	Aug. 4-Sept. 9 vs. Sept. 27-Oct. 18 1976	July 25-Sept. 2 vs. Sept. 26-Nov. 21 1977
PORIFERA				
<u>Tethya aurantia</u>	0.7737	0.7045	0.5218	0.8772
CNIDARIA				
<u>Anthopleura xanthogrammica</u>	0.3256	0.6619	0.4350	0.3883
ARTHROPODA				
<u>Cancer antennarius</u>	0.2024	0.4363	0.7809	0.1828
MOLLUSCA				
<u>Astraea gibberosa</u>	0.6784	0.8615	0.0685	0.0067*
<u>Doriopsilla albopunctata</u>	0.5966	0.8607	0.5599	0.1952
<u>Haliotis rufescens</u>	0.2259	0.3479	1.0000	0.0157*
ECHINODERMATA				
<u>Patiria miniata</u>	0.6985	0.1728	0.6235	0.7349
<u>Pisaster giganteus</u>	0.6286	0.1275	0.9293	0.3037
<u>Pycnopodia helianthoides</u>	0.7924	0.4555	0.5911	0.5394
<u>Strongylocentrotus franciscanus</u>	0.6048	1.0000	0.8146	0.1345
CHORDATA				
<u>Styela montereyensis</u>	0.4660	0.7606	0.2967	0.6432

* Significance level ($p \leq 0.05$).

Homalopoma luridum and Serpulorbis squamigerus in 1976; Tegula brunnea in 1978; Balanophyllia elegans in 1976 and 1977; and Epiactis prolifera in 1976 (Table 107).

Several species at North Control quadrats also showed significant differences in means between the two sampling periods; Acmaea mitra in 1976; Homalopoma luridum in 1976 and 1977; Tegula brunnea in 1976 and 1978; Tonicella lineata in 1976; Balanophyllia elegans in 1976 and 1978; Epiactis prolifera in 1977; and Henricia leviuscula in 1976, 1977 and 1978 (Table 108). These differences may be due solely to random variation; or either high natural mortality or high recruitment during the summer. These species whose mean densities increased possibly due to recruitment (through immigration or reproduction) include: Tegula brunnea and Epiactis prolifera. It is important to note that the lowest number of significant differences for both study areas combined occurred in 1978 when we attempted to survey all 96 quadrat stations, in each study area, during one period.

These significant differences in abundance may have affected the results of the tests of the other hypothesis. However, since there were no significant differences for most of the other animals tested, including red sea urchins, the results of the tests were most likely not affected. Since 1978, we have made all efforts to complete surveys in each study area in the shortest time possible.

Fish Species Occurrence Studies

Methods

TABLE 107. Summary of Levels of Significant of Kruskal-Wallis, and Mann-Whitney Tests on Means from Early and Late Summer Subtidal Surveys of Invertebrates at Random 0.25-m^2 Quadrats, Diablo Cove. DCPP. 1976-1978.

		Survey Dates	
Species	July 1-14 vs. July 27-Aug. 10 1976	May 27-July 21 vs. Aug. 26-Sept. 23 1977	June 26-July 20 vs. July 24-Aug. 23 19-78
CNIDARIA			
Balanophyllia elegans	0.0015*	0.0146*	0.8391
Epiactis prolifera	0.0011*	0.2968	0.1183
MOLLUSCA			
Acmaea mitra	0.3615	0.0892	0.5047
Astraea gibberosa	0.1607	0.7060	0.1874
Doriopsilla albopunctata	0.3173	0.0224*	0.4915
*Haliotis rufescens***	--	--	--
Homalopoma luridum	0.0332*	0.8202	0.7335
Serpulorbis squamigerus	0.0098*	0.5417	0.7020
Tegula brunnea	0.2528	0.7124	0.0301*
Tonicella lineata	0.2854	0.1933	0.1374
ECHINODERMATA			
Henricia leviuscula	0.3586	0.5382	0.1569
Patiria miniata	0.1191	0.7159	0.8920
Strongylocentrotus franciscanus	0.8115	0.3865	0.2414

* Significance level ($p \leq 0.05$).

** Analysis not possible because of the large number of zeros.

TABLE 108. Summary of Levels of Significant of Kruskal-Wallis, and Mann-Whitney Tests on Means from Early and Late Summer Subtidal Surveys of Invertebrates at Random 0.25-m^2 Quadrats, North Control. DCPP, 1976-1978.

	Survey Dates		
Species	June 12-24 vs. Aug. 5-Sept. 9 1976	July 26-Sept. 2 vs. Sept. 27-Oct. 13 1977	Sept. 5-Sept. 22 vs. Oct. 2-Nov. 15 19-78
CNIDARIA			
<u>Balanophyllia elegans</u>	0.0011*	0.9686	0.0014*
<u>Epiactis prolifera</u>	0.0997	0.0217*	0.3480
MOLLUSCA			
<u>Acmaea mitra</u>	0.0106*	0.3829	0.6385
<u>Astraea gibberosa</u>	0.2964	0.5998	0.5907
<u>Doriopsilla albopunctata</u>	0.6401	0.7224	0.5786
<u>Haliotis rufescens</u>**	--	--	--
<u>Homalopoma luridum</u>	0.0008*	0.0112*	0.4767
<u>Serpulorbis squamigerus</u>	0.1320	0.2028	0.8075
<u>Tegula brunnea</u>	0.0011*	0.5612	0.0004*
<u>Tonicella lineata</u>	0.0283*	0.1834	0.7848
ECHINODERMATA			
<u>Henricia leviuscula</u>	0.0113*	0.0176*	0.0156*
<u>Patiria miniata</u>	0.0583	0.7155	0.9644
<u>Strongylocentrotus franciscanus</u>	0.6865	0.9742	0.2520

* Significance level ($p \leq 0.05$).

** Analysis not possible because of the large number of zeros.

A. Field

At the random 30-m^2 arc stations, located and worked as described in the Subtidal Random Stations Red Algae Field Methods Section, divers recorded the presences of all fishes observed within the arc, as well as any fish observed near or above the arc. Because of the near impossibility of counting fishes, due to their great mobility, observations at arc stations were limited to presence/absence and estimated abundance. This method will be called the "arc station fish survey" in this report.

At the random 0.25-m^2 quadrats, divers counted all fishes observed within the confines of the quadrats. For this report the method is termed the "quadrat station fish survey."

In 1978, we attempted to test a new method of quantifying fish. The method, reported by Jones and Thompson (1978), consists of counts of all observed species of fishes during five minute time intervals while divers swam around a specific reef or some other type of habitat. Our divers made the surveys in the same general vicinity as the random stations. The habitat included rocky reefs and sand and gravel patches. We chose to do six time intervals for our experiment which is called the "timed fish species count" in this report. Unfortunately, we were not able to complete a full set of stations in Diablo Cove due to time limitations; however, based on the stations we did complete, we felt the method was unsuitable for the Diablo Cove and North Control. This decision was based on several factors:

1. The highly variable underwater visibility could lead to highly variable counts.

2. The large area covered by swimming, even for only 5 minutes, would not allow for enough replicates, without the divers overlapping stations.

3. The large variety of habitats in Diablo Cove would add another variation factor which could further add to difficulties in interpreting the results of the surveys and the data analysis.

B. Laboratory

Whenever possible fishes that we could not identify in the field were captured with hand-dip nets and brought into the laboratory for identification. Once identified, the fish were then either returned alive to the water or preserved and put into our reference collection.

C. Statistical

None of the fish data were subjected to statistical analysis because the observations at the arc station fish survey consisted solely of presence/-absence information; the quadrat station fish survey yielded numbers of fish too low to produce meaningful comparisons; and there were only a small number of observations done at the timed fish species count stations.

For the arc stations fish survey, the data are presented as the frequency of occurrence for each species or species group by year and by study area. For species which occurred at ≥ 25% of the stations in at least one year, the frequency of occurrence is presented as a bar graph to show trends. The mean number of fish species for all years combined for each of the study areas is presented by division into either shallow (0-7.6 m) or deep-water (7.7-15.2 m) stations. The frequency of occurrence is determined with all years combined to show the relative ranks of the dominant fishes for each study area. The frequency of occurrence is shown as a bar graph for all years and study areas combined with the information divided into appearance of the fish at the shallow and/or deep-water stations.

For the quadrat station fish survey information on the following is presented. The mean number of fish per quadrat and the frequency of occurrence of that species is given by year and by study area.

For the timed fish species count observations, the percent frequency of occurrence per total timed intervals is presented in graph form for Diablo Cove.

Results

A. Diablo Cove

The wide diversity of habitats found in Diablo Cove provide ideal conditions for a large number of California's inshore fishes. We have recorded a total of 44 species or species groups from 13 families at the Diablo Cove random subtidal arcs and quadrats (Table 109).

TABLE 109. Summary of Fish Species Observed at Subtidal Random 30-m^2 Arc and 0.25m-^2 Quadrat Stations in Diablo Cove and North Control. DCPP, 1974-1978.

Scientific Name	Common Name	Diablo Cove	North Control
ANARHICHADIDAE			
Anarrhichthys ocellatus	Wolf-eel	X	
BATHYMASTERIDAE			
Rathbunella hypoplecta	Smooth ronquil	X	X
BOTHIDAE			
Citharichthys sordidus	Pacific sanddab		X
CEBIDICHTHYIDAE			
Cebidichthys violaceus	Monkeyface-eel	X	
CLINIDAE			
Gibbonsia spp.	Kelpfish	X	X
Neoclinus blanchardi	Sarcastic fringehead	X	
Neoclinus uninotatus	Onespot fringehead	X	
Neoclinus sp.	Fringehead		X
Neoclinus stephensae	Yellowfin fringehead	X	
COTTIDAE			
Artedius corallinus	Coralline sculpin	X	X
Artedius lateralis	Smoothhead sculpin		X
Hemilepidotus spinosus	Brown Irish lord		X
Jordania zonope	Longfin sculpin	X	X
Orthonopias triacis	Snubnose sculpin	X	X
Scorpaenichthys marmoratus	Cabezon	X	X
EMBIOTOCIDAE			
Brachyistius frenatus	Kelp surfperch	X	
Cymatogaster aggregata	Shiner surfperch	X	
Damalichthys vacca	Pile surfperch	X	X
Embiotoca jacksoni	Black surfperch	X	X
Embiotoca lateralis	Striped surfperch	X	X

TABLE 109. (cont'd)

Hypsurus caryi	Rainbow surfperch	X	X
Phanerodon atripes	Sharpnose surfperch		X
Phanerodon furcatus	White surfperch	X	
Rhacochilus toxotes	Rubberlip surfperch	X	
GASTEROSTEIDAE			
Aulorhynchus flavidus	Tubesnout	X	X
GOBIESOCIDAE			
Gobiesox maeandricus	Northern clingfish	X	X
Rimicola muscarum	Kelp clingfish	X	X
GOBIIDAE			
Coryphopterus nicholsii	Blackeye goby	X	X
HEXAGRAMMIDAE			
Hexagrammos decagrammus	Kelp greenling	X	X
Ophiodon elongatus	Lingcod	X	X
Oxylebius pictus	Painted greenling	X	X
LABRIDAE			
Oxyjulis californica	Senorita	X	X
Pimelometopon pulchrum	California sheephead		X
SCORPAENIDAE			
Sebastes atrovirens	Kelp rockfish	X	X
Sebastes carnatus	Gopher rockfish	X	X
Sebastes chrysomelas	Black-and-Yellow Rockfish	X	X
Sebastes caurinus	Copper rockfish	X	
Sebastes melanops	Black rockfish	X	X
Sebastes miniatus	Vermilion rockfish	X	X
Sebastes mystinus	Blue rockfish	X	X
Sebastes paucispinis	Bocassio	X	
Sebastes rastrelliger	Grass rockfish	X	X
Sebastes serranoides	Olive rockfish	X	X
STICHAEIDAE			
Chirolophis nugator	Mosshead warbonnet	X	X

A summary of the percent frequency of occurrence of fishes at the arc stations in Diablo Cove is presented (Table 110).

For the quadrat stations the mean number of fish per quadrat and the percent frequency of occurrence of each fish species in Diablo Cove are listed (Table 111).

We are also presenting results of the species counts using the method developed by Jones and Thompson (1978); unfortunately, we did not complete enough stations for statistical analysis. The results are presented by species as the percentage frequency of occurrence; the unit of measurement is occurrence within the time intervals.

The results of all of these observations are presented by family. Frequencies of occurrence are presented in graphic form only for those species which occurred in at least 25% of the arc station during one year. Generally, we encountered more fish species at the stations deeper than 7.6 m in Diablo Cove, although in the north portion of Diablo Cove, the depth-species distribution was not as predictable (Figure 130). South Diablo Cove shallow stations yielded the lowest average number of species over the years.

ANARHICADIDAE

This family is represented by only one species in California (Miller and Lea 1976)--the wolf-eel, Anarrhichthys ocellatus. During the day wolf-eels are found in crevices holes, and caves. One wolf-eel was observed in Diablo Cove during our studies. This fish was encountered at an arc station in 1977 (Table 110).

Wolf-eels ranked sixteenth in frequency of occurrence at arc stations (Figure 131).

BATHYMASTERIDAE

Ronquil taxonomy, particularly that of the genus Rathbunella, is still in flux. Miller and Lea (1976), listed two species under the genus Rathbunella; however, recent studies suggest there may be others (Robert Lavenberg, pers. commun.). We observed only one species, the smooth ronquil, Rathbunella hypoplecta, at two arc stations in 1975 and one arc station in 1977 (Table 110). Smooth ronquils also occurred in one quadrat each in 1975 and 1977 (Table 111).

CEBIDICHTHYIDAE

This is another family containing only one species, the monkeyface-eel, Cebidichthys violaceus. In fact, many taxonomists place the monkeyface-eel in the family Stichaeidae (Robert Lea, CDFG pers. commun.). Monkeyface-eels are crevice dwellers and are often difficult to observe. They ranked sixteenth at arcs (Figure 131).

CLINIDAE

Twelve species of clinids are known from California (Miller and Lea 1976). We recorded three species plus the Gibbonsia spp. complex at arc and quadrat stations in Diablo Cove (Tables 110 and 111). Three species of kelpfish, Gibbonsia spp., have been reported from Diablo Cove (Burge and Schultz 1973). Unfortunately, divers are not able to distinguish between the three species

TABLE 110. Summary of Percent Frequency of Occurrence of Fish Species Observed at Random 30-m^2 Arc Stations in Diablo Cove, DCPP, 1974-1977.

	Percent Frequency of Occurrence			
	1974	1975	1976	1977
ANARHICHADIDAE				
Anarrhichthys ocellatus				4.2
BATHYMASTERIDAE				
Rathbunella hypoplecta		8.3		4.2
CEBIDICHTHYIDAE				
Cebidichthys violaceus			4.2	
CLINIDAE				
Gibbonsia spp.	28.6	37.5	41.7	45.8
Neoclinus blanchardi				4.2
Neoclinus uninotatus				4.2
COTTIDAE				
Artedius corallinus	7.1	4.2		12.5
Jordania zonope				4.2
Orthonopias triacis	7.1	16.7	33.3	45.8
Scorpaenichthys marmoratus	28.6	25.0	25.0	41.7
EMBIOTOCIDAE				
Brachyistus frenatus		4.2		
Cymatogaster aggregata				8.3
Damalichthys vacca	14.3	16.7	16.7	8.3
Embiotoca jacksoni	28.6	8.3	4.2	
Embiotoca lateralis	28.6	87.5	41.7	41.7
Hypsurus caryi		8.3	4.2	4.2
Phanerodon furcatus				4.2
Rhacochilus toxotes				4.2
GASTEROSTEIDAE				
Aulorhynchus flavida			8.3	4.2
GOBIESOCIDAE				
Gobiesox maeandricus	7.1			
GOBIIDAE				
Coryphopterus nicholsii	14.3	16.7		8.3
HEXAGRAMMIDAE				
Hexagrammos decagrammus	50.0	37.5	20.8	16.7
Ophiodon elongatus	21.4	12.5	8.3	
Oxylebius pictus	50.0	54.2	45.8	54.2

TABLE 110. (Continued)

	Percent Frequency of Occurrence			
	1974	1975	1976	1977
LABRIDAE				
Oxyjulis californica	21.4	25.0	8.3	54.2
SCORPAENIDAE				
Sebastes atrovirens				8.3
Sebastes carnatus	28.6	16.7	20.8	33.3
Sebastes chrysomelas	14.3	41.7	25.0	25.0
Sebastes caurinus				4.2
Sebastes melanops	14.3	8.3	4.2	4.2
Sebastes miniatus	7.1	4.2		
Sebastes mystinus (adult)	42.8	50.0	25.0	45.8
Sebastes mystinus (juv.)	71.4	87.5	33.3	79.2
Sebastes paucispinis		12.5		8.3
Sebastes rastrelliger	7.1			
Sebastes serranoides	7.1	29.2	12.5	25.0
Sebastes spp. (juv.)				29.2
STICHAEIDAE				
Chirolophis nugator		4.2		
TOTAL STATIONS	14	24	24	24

TABLE 111. Summary of Mean Number Per Quadrat and Percent Frequency of Occurrence of Fish Species Observed at Subtidal Random 0.25-m^2 Quadrats in Diablo Cove. DCPP, 1975-1978.

Species	1975		1976		1977		1978	
	Mean Number Per Quadrat	Percent Freq. of Occurrence	Mean Number Per Quadrat	Percent Freq. of Occurrence	Mean Number Per Quadrat	Percent Freq. of Occurrence	Mean Number Per Quadrat	Percent Freq. of Occurrence
BATHYMASTERIDAE								
Rathbunnella hypoplecta	0.03	3.1		0.0	0.01	1.0		0.0
CLINIDAE								
Gibbonsia spp.		0.0	0.08	6.4	0.23	18.0	0.02	2.1
Neoclinus stephansae		0.0		0.0	0.02	2.1		0.0
COTTIDAE								
Artedius corallinus	0.03	3.1		0.0	0.02	2.1		0.0
Orthonopias triacis	0.16	15.6	0.04	4.2	0.07	7.3	0.02	2.1
Scorpaenichthys marmoratus		0.0		0.0	0.02	2.1		0.0
GOBIIDAE								
Coryphopterus nicholsii		0.0		0.0	0.01	1.0		0.0
GOBIESOCIDAE								
Gobiesox maeandricus	0.03	3.1		0.0		0.0		0.0
HEXAGRAMMIDAE								
Oxylebius pictus	0.12	9.4	0.02	2.1	0.01	1.0		0.0
SCORPAENIDAE								
Sebastes carnatus		0.0		0.0	0.02	2.1		0.0
Sebastes caurinus		0.0		0.0	0.09	9.4		0.0
Sebastes chrysomelas	0.06	6.2		0.0	0.01	1.0	0.01	1.0
STICHAEIDAE								
Chirolophis nugator	0.03	3.1		0.0	0.01	1.0		0.0
Total Number of Quadrats Surveyed in Diablo Cove	32		47		96		96	

under water. Identification requires a dissecting microscope to examine the characters that separate the three species. Observed Gibbonsia spp. frequency of occurrence at arc stations increased during our studies (Figure 132, Table 110), where they ranked third (Figure 131). At quadrat stations Gibbonsia spp. were the most common species encountered particularly in 1977 (Table 111). The two species of fringeheads, Neoclinus, were rarely observed at arc or quadrat stations (Tables 110 and 111). At arc stations the fringeheads ranked sixteenth (Figure 131). At the timed fish species count stations kelpfishes, Gibbonsia spp., ranked thirteenth (Figure 133).

COTTIDAE

Forty-two species of sculpins have been reported from California (Miller and Lea 1976). Twenty of these were collected or observed during the Department's 1970-71 surveys (Burge and Schultz 1973). Because sculpins require examinations by a microscope to distinguish most species, we were only able to identify four species under water. Only two of these were observed at 25% or more of the arc stations (Table 110).

Orthonopias triacis

Snubnose sculpins have been reported from Monterey to San Geronimo Island, Baja California, from the intertidal to depths of 30 m (Miller and Lea 1976). Their observed frequency of occurrence increased over the years at arc stations where they rank fifth for all years combined (Figures 134 and 131). At quadrats their frequency of occurrence appeared to decline (Table 111). Snubnose sculpins ranked twelfth out of 22 species (15 rankings) recorded at fish species count stations (Figure 133).

Scorpaenichthys marmoratus

Cabezon (Figure 135) have a known range from Sitka, Alaska, to Point Abreojos, Baja California, from the intertidals to 7.6 m (Miller and Lea 1976). In Diablo Cove they were observed on all types of rocky substrate, but usually resting on ledges or near the tops of rocks. They are the largest member of the family, reaching 99 cm in length and are highly sought after and prized by sportfishermen. Their observed frequency of occurrence at arcs, when all years were combined, remained fairly constant until 1977 when it increased (Figures 136 and 131). They were rarely encountered in quadrats (Table 111). Cabezon ranked ninth in frequency at the timed fish species count stations (Figure 133).

EMBIOTOCIDAE

The surfperch are represented by 19 species in California many of which are important sportfish (Miller and Lea 1979; Miller and Gotshall 1965). Eight species were found at arc stations in Diablo Cove (Table 109). Two species were observed at 25% of the arc stations during at least one year.

Embiotoca jacksoni

Black surfperch (Figure 135) are known to range from Fort Bragg to Point Abreojos, Baja California, to depth of 40 m (Miller and Lea 1976). Adults and juveniles were commonly observed throughout the Cove and around reefs and with low-growing brown algae. There was a decrease in their observed frequency of occurrence at arc stations (Figure 137) where they ranked tenth (Figure 110).

At the timed fish species count stations, black surfperches ranked thirteent in frequency of occurrence (Figure 133).

Embiotoca lateralis

Striped surfperches (Figure 135) have been recorded from Port Wrangell, Alaska, to Point Cabras, Baja California, to depths of 17 m (Miller and Lea 1976). Striped surfperches were the most commonly observed surfperches in Diablo Cove. Their frequency of occurrence at arcs where they ranked second increased substantially in 1975, then decreased and remained stable (Figure 138). They ranked third in the timed fish species count survey (Figure 133).

GASTEROSTEIDAE

The California fish fauna is represented by two members of this family; only one has been recorded from Diablo Cove (Miller and Lea 1976), *Aulorhynchus flavidus*. Tubeshouts ranged from Prince William Sound, Alaska, to Point Rampiente, Baja California (Miller and Lea 1976). They spend most of their time near the surface in and around the bull kelp canopy; thus they were infrequently encountered by our divers working on the bottom. They were observed at two arc stations in 1976 and one in 1977, and ranked fifteenth when all years were combined (Table 110, and Figure 131).

GOBIESOCIDAE

Miller and Lea (1976), reported seven species of clingfishes from California. Only one of these, the northern clingfish, *Gobiesox maeandricus*, was observed by our divers at Diablo Cove subtidal arc stations. Northern clingfishes range from Guadalupe Island, Baja California, to Revillagigedos Island, Alaska (Miller and Lea 1976). They ranked sixteenth in frequency of occurrence at arc stations for all years combined (Figure 131), (Miller and Lea 1976).

GOBIIDAE

Of the 14 species of gobies reported from California by Miller and Lea (1976), only three have been observed in Diablo Cove (Burge and Schultz 1973). The blackeye goby, *Coryphopterus nicholsii*, (Figure 139) is the only species commonly encountered by divers in the Cove. Their known range is from Point Rampiente, Baja California, to Queen Charlotte Island, British Columbia. Their observed frequency of occurrence declined over the years at arc stations where they ranked ninth (Figures 140 and 141). Blackeye gobies were rarely observed in quadrats (Table 111). They ranked tenth at the timed fish species counts stations (Figure 133). We did not observe the other two species: *Lythrypnus dalli* and *L. zebra*.

HEXAGRAMMIDAE

The greenling family is well represented in Diablo Cove. Of the five species recorded from California (Miller and Lea 1976), three occur commonly in the Cove.

Hexagrammos decagrammus

Kelp greenlings (Figure 139) ranges from the Aleutian Islands, Alaska, to La Jolla, California, from the intertidal to 46 m (Miller and Lea 1976). In Diablo Cove they are present around all types of rocky habitat. Kelp greenlings declined substantially in their observed frequency of occurrence at arc stations, where they ranked fourth during our studies (Figures 141 and 131). They ranked eighth at our 1978 timed fish species count stations (Figure 133).

Ophiodon elongatus

Lingcod (Figure 139) have been reported from Kodiak Island, Alaska, to Point San Carlos, Baja California, to depths of 427 m (Miller and Lea 1976). They are a very important sportfish and a major predator on nearshore fish including juvenile rockfishes, Sebastes spp. (Miller and Geibel 1973). In Diablo Cove they were observed around all types of rocky habitat. The lingcod observed frequency of occurrence declined appreciably at arc stations (Figure 142). This apparent decline was also reflected in the catches of local partyboat fishermen (Partyboat logbook data provided by Leo Pinkas (CDF&G) (Figure 143). They ranked eleventh in the 1978 timed fish species counts (Figure 133).

Oxylebius pictus

Painted greenlings (Figure 139) have been recorded from the Queen Charlotte Islands, British Columbia, to Point San Carlos, Baja California, from the intertidal to 49 m (Miller and Lea 1976). They are common around most habitats in Diablo Cove except sand. Their observed frequency of occurrence at arc stations, where they ranked second when all years were combined, remained about the same throughout the study (Figures 144 and 131). Painted greenlings occurred infrequently in quadrats (Figure 144). They ranked fifth at the timed fish species count stations (Figure 133).

LABRIDAE

Three members of the wrasse family occur off California (Miller and Lea 1976), two of them in the Diablo Canyon area: California sheephead, Pimelometopon pulchrum and senoritas, Oxyjulis californica. California sheepheads were infrequently encountered by our divers and none were observed in Diablo Cove.

Oxyjulis californica

Senoritas have been reported from San Francisco Bay to Cedros Island, Baja California, to a depth of 55 m (Miller and Lea 1976). Their observed frequency of occurrence at arc stations, where they ranked fourth, fluctuated widely (Figures 145 and 131). Senoritas ranked second in the 1978 timed fish species counts (Figure 133).

SCORPAENIDAE

The scorpionfish family has more representative in California waters than any other fish family. Sixty-two species were reported by Miller and Lea (1976). In Diablo Cove, we have observed ten species (Table 109). One additional species has been observed by PG&E biologists, the treefish, Sebastes serriceps (Tom Wilson, PG&E pers. commun.). Five species occurred frequently enough to merit discussion.

Sebastes carnatus

Gopher rockfishes (Figure 146) have a recorded range from Humboldt Bay, California, to San Roque, Baja California, to depths of 55 m (Miller and Lea 1976). These demersal, cryptic rockfishes occurred at mid- to deep stations (7.6 to 18.3 m) in areas of rocky substrate in Diablo Cove. Their observed frequency of occurrence fluctuated little at arc stations, where they ranked sixth (Figures 147 and 131). Gopher rockfishes were observed at quadrats in 1977 only (Table 111). In the timed fish species count stations, they ranked seventh (Figure 133).

Sebastes chrysomelas

Black-and-yellow rockfishes (Figure 146) have been reported from Humboldt Bay to Natividad Island, Baja California, from the intertidal to 37 m (Miller and Lea 1976). In Diablo Cove, we have observed these cryptic rockfishes in and around rocky habitat, particularly in the shallower portions of the Cove (3 to 12 m). The observed frequency of occurrence of black-and-yellow rockfishes at arc stations, where they ranked fourth, increased in 1975 then decreased in 1976 and again in 1977 (Figures 148 and 131). Juveniles occurred in a small number of the quadrats every year. Black-and-yellow rockfish ranked seventh in the 1978 timed fish species count stations (Figure 133).

Sebastes mystinus

Blue rockfishes (Figure 146) have a recorded range from the Bering Sea to Point Santo Tomas, Baja California, to a depth of 92 m (Miller and Lea 1976). They are one of the most important sportfishes in central California and were the most common and abundant rockfishes in Diablo Cove during our surveys, appearing in schools of 100 to 500 or more fish. With the exception of 1976, adults' and juveniles' frequency of occurrence remained static through most of the study at arc stations, where they ranked first (Figures 149 and 131). In 1976, there was a temporary decline in the observed frequencies for both adults and juveniles. Blue rockfishes were the most frequently counted species at our 1978 time fish species count stations (Figure 133).

Sebastes serranoides

Olive rockfishes (Figure 146) range from Redding Rock, California, to the San Benito Island, Baja California, to depths of 146 m (Miller and Lea 1976). In Diablo Cove individual adults and schools of juveniles were usually observed around high profile reefs in the outer portions of the Cove. Their observed frequency of occurrence at arc stations, where they ranked seventh, fluctuated from year to year (Figures 131 and 150). Olive rockfishes ranked fourteenth at the 1978 timed fish species count stations (Figure 133).

STICHAEIDAE

The prickleback family is represented in California by 12 species (Miller and Lea 1976; Behrstock 1976). Seven species have been recorded from the Diablo Canyon area (Burge and Schultz 1973). We observed only the mosshead warbonnet, Chirolophis nugator, at one arc station in 1975 (Table 110). Mosshead warbonnets were also observed in our quadrats (Table 111).

B. North Control

At North Control subtidal stations, we have recorded 33 species from 12 families of fish, 32 at arc stations and 14 in quadrats (Tables 112 and 113). This number includes one family not represented at Diablo Cove stations; Bothidae, the left-eye flounders. In the North Control, Pacific sanddabs, Citharichthys sordidus, were observed only at stations where there was a large percentage of sand. Pacific sanddabs were not observed at Diablo Cove random stations.

The average number of species observed at North Control arc stations ranged from 3.7 to 5.7 at shallow stations, and 5.2 to 6.7 at deep stations (Figure 130). We did not conduct the timed fish species counts in the North Control. The following results are limited to those fish that occurred at 25% or more of the stations, by one or more of the survey methods during at least one year's surveys.

CLINIDAE

Gibbonsia spp.

The kelpfishes appeared to increase in their frequency of occurrence at arc stations over time where they ranked seventh when all years were combined (Figures 151 and 152).

TABLE 112. Summary of Percent Frequency of Occurrence of Fish Species Observed at Subtidal Random 30-m^2 Arc Stations in North Control. DCPP. 1974-1977.

Species	Percent Frequency of Occurrence 1974	1975	1976	1977
BATHYMASTERIDAE				
Rathbunella hypoplecta			4.2	4.5
BOTHIDAE				
Citharichthys sordidus		4.2		
CLINIDAE				
Gibbonsia spp.	28.6	20.8	70.8	59.1
Neoclinus spp.				4.5
COTTIDAE				
Artedius corallinus	7.1	33.3	16.7	27.3
Hemilepidotus spinosus			4.2	
Jordania zonope		4.2		
Orthonopias triacis	21.4	20.8	50.0	40.9
Scorpaenichthys marmoratus	35.7	25.0	29.2	45.4
EMBIOTOCIDAE				
Damalichthys vacca	14.3	25.0	12.5	9.1
Embiotoca jacksoni		4.2		4.5
Embiotoca lateralis	42.8	54.2	62.5	45.4
Hypsurus caryi		4.2		
Phanerodon atripes			4.2	
GASTEROSTEIDAE				
Aulorhynchus flavidus		4.2		
GOBIESOCIDAE				
Gobiesox maeandricus				4.5
Rimicola muscarum			4.2	
GOBIIDAE				
Coryphopterus nicholsii	14.3	29.2	25.0	31.8
HEXAGRAMMIDAE				
Hexagrammos decagrammus	37.7	16.7	29.2	13.6
Ophiodon elongatus	21.4	8.3		4.5
Oxylebius pictus	50.0	58.3	62.5	63.6

TABLE 112. (cont'd)

LABRIDAE				
Oxyjulis californica	14.3	29.2	37.5	54.5
Pimelometopon pulchrum				4.5
SCORPAENIDAE				
Sebastes atrovirens			4.2	
Sebastes carnatus	7.1	25.0	25.0	27.3
Sebastes chrysomelas	7.1	41.7	37.5	50.0
Sebastes melanops		4.2	4.2	9.1
Sebastes miniatus	7.1	8.3	8.3	4.5
Sebastes mystinus (adult)	50.0	54.2	58.3	59.1
Sebastes mystinus (juv.)	64.3	66.7	79.2	100.0
Sebastes rastrelliger	14.3		4.2	4.5
Sebastes serranoides	14.3	41.7	20.8	4.5
Sebastes spp. (juv.)				4.5
STICHAEIDAE				
Chirolophis nugator			4.2	
Total Number of Arc Stations surveyed in North Control	14	24	24	22

TABLE 113. Summary of Mean Number Per Quadrat and Percent Frequency of Occurrence of Fish Species Observed at Subtidal Random 0.25-m^2 Quadrats in North Control. DCPP, 1976-1978.

Species	1976		1977		1978	
	Mean Number Per Quadrat	Percent Frequency of Occurrence	Mean Number Per Quadrat	Percent Frequency of Occurrence	Mean Number Per Quadrat	Percent Frequency of Occurrence
BATHYMASTERIDAE						
Rathbunella hypoplecta		0.0		0.0	0.05	4.2
CLINIDAE						
Gibbonsia spp.	0.14	14.6	0.15	14.3	0.03	3.1
COTTIDAE						
Artedius corallinus		0.0	0.07	6.0	0.05	5.2
Artedius lateralis	0.04	2.1		0.0		0.0
Orthonopias triacis	0.04	4.1	0.04	3.6	0.01	1.0
Scorpaenichthys marmoratus	0.02	2.1	0.01	1.2		0.0
GOBIESOCIDAE						
Gobiesox maeandricus	0.02	2.1	0.02	1.2		0.0
GOBIIDAE						
Coryphopterus nicholsii	0.04	4.1	0.01	1.2		0.0
HEXAGRAMMIDAE						
Oxylebius pictus		0.0	0.02	2.4		0.0
Hexagrammos decagrammus		0.0	4.1		0.01	1.0
SCORPAENIDAE						
Sebastes carnatus	0.04	4.1		0.0	0.03	2.1
Sebastes chrysomelas		0.0		0.0	0.02	2.1
Sebastes mystinus (juv.)		0.0	0.04	2.4	0.02	0.0
Chirolophis nugator		0.0		0.0	0.01	1.0
Total Number of Quadrats Surveyed in North Control	48		84		96	

COTTIDAE

Artedius corallinus

Coralline sculpins fluctuated in frequency of occurrence at arc stations where they ranked ninth (Figures 153 and 151). They were not observed at quadrats in 1976 but appeared at about five percent of the quadrats in 1977 and 1978.

Orthonopias triacis

Snubnose sculpins' frequency of occurrence increased at arc stations in 1976, then declined slightly (Figure 154). Their rank at the arc stations was sixth when all years were combined (Figure 152). Their frequency of occurrence at quadrats declined from 1976 through 1978 (Table 113).

Scorpaenichthys marmoratus

Cabezon declined, then increased in frequency of occurrence at arc stations, where they ranked eighth (Figures 155 and 152); they were rarely observed in quadrats.

Damalichthys vacca

Pile surfperches have been recorded from Port Wrangell, Alaska, to Guadalupe Island to a depth of 46 m (Miller and Lea 1976). In the North Control they were observed in 25% of the samples during survey year 1975 (Figure 156). They ranked twelfth in frequency of occurrence (Figure 152).

Embiotoca jacksoni

Black surfperches were only observed at one North Control arc station in 1975 and one arc station in 1977 (Table 112, Figure 157). They ranked fifteenth in frequency of occurrence (Figure 152).

Embiotoca lateralis

Striped surfperches observed frequency of occurrence at arc station, where they ranked third, showed little fluctuation during our studies (Figures 152 and 158).

GOBIIDAE

Coryphopterus nicholsii

Blackeye gobies increased in their observed frequency of occurrences at arc station, where they ranked eleventh (Figures 159 and 152). They appeared to decline at quadrats (Table 113).

HEXAGRAMMIDAE

Hexagrammos decagrammus

The observed frequency of occurrence of kelp greenlings at arcs, where they ranked tenth (Figure 152), showed a declining trend (Figure 160). They were observed only once at a quadrat station (Table 113).

Ophiodon elongatus

As in Diablo Cove lingcod declined in observed frequency of occurrence at arc stations, where they ranked thirteenth (Figures 161 and 152).

Oxylebius pictus

The observed frequency of occurrences of painted greenlings increased slightly at arc stations, where they ranked second during our studies (Figures 162 and 152). They were rarely observed in quadrats (Table 113).

LABRIDAE

Oxyjulis californica

Senoritas showed a definite increase in their frequency of occurrence at arc stations (Figure 163), where they ranked fifth (Figure 152) during the study period.

SCORPAENIDE

Sebastes carnatus

The observed frequency of occurrence of the gopher rockfishes remained fairly stable, particularly after 1974 (Figure 164). They ranked ninth in frequency of occurrence at arc stations (Figure 152).

Sebastes chrysomelas

There was an increasing trend in black-and-yellow rockfishes frequency of occurrence at arc stations, where they ranked fourth when all years were combined (Figures 165 and 152).

Sebastes mystinus

As in Diablo Cove blue rockfish were the most abundant and the most frequently encountered fish at arc stations (Figure 152). Adult frequency of occurrence remained about the same during the study but increased for junveniles (Figure 166).

Sebastes serranoides

Olive rockfishes were more common at North Control arcs where they ranked tenth (Figure 152), than in Diablo Cove. There was a declining trend in their frequency of occurrence (Figure 167).

Discussion

Burge and Schultz (1973) recorded 77 species of fish from the Diablo Cove subtidal. Most of these records were obtained from ichthyocide stations conducted in the Cove. Twenty-four species were observed during their diving operations. During our diving surveys of random stations, we have observed 44 species from Diablo Cove and North Control (Table 109). The most likely reason for the larger number of fish species observed during our diving operations is that we sampled more stations over a longer period of time. Both our studies and those of Burge and Schultz (1973) indicate that blue rockfishes are the most abundant, non-cryptic fish found in Diablo Cove. Blue rockfishes rank first at random stations and in the random timed species counts. In Diablo Cove striped surfperches ranked second in frequency of occurrence at random arc stations along with the painted greenlings (Figure 131). Senoritas and striped surfperches were second and third, respectively, at the timed species count stations (Figure 133). Burge and Schultz's (1973) observations at their permanent stations indicated that olive rockfishes and painted greenlings ranked second and third in 1970 and that painted greenlings and blackeye gobies ranked second and third in 1971. Burge and Schultz (1973) also considered black-and-yellow rockfishes, pile surfperches, kelp greenlings, black rockfishes, lingcod and cabezon as common species. All of these except black rockfishes were among the top ten ranked species at our random arcs and fish species count stations in Diablo Cove. Assuming the difference between the 1970-71 studies and our present studies are real, then some changes have taken place in these fish populations in the Cove since the 1970-71 studies. This appears to be true in the case of the lingcod. During the 1970-71 studies, lingcod were observed at 43% and 28% of the Diablo Cove permanent stations. From 1973 through 1978, lingcod were observed at only 10% of permanent Diablo Cove stations. The observations at random stations and partyboat catch-per-unit-of effort data (Leo Pinkas, pers. commun.) tends to support this apparent decline in abundance (Figure 143).

Observations at North Diablo Control random arc stations indicate the three most frequently observed fishes were blue rockfishes, painted greenlings, and striped surfperches (Figure 152), which agrees closely with Diablo Cove random arc station observations. In fact, eleven of the 15 species that ranked in the first ten in Diablo Cove also were in the first ten ranks in the North Control

(Figures 131 and 152). There were patterns in observed frequency of occurrence at random arc stations in relation to depth: blue rockfishes, painted greenlings, senoritas, kelp greenlings, snubnose sculpins, gopher rockfishes, blackeye gobies, lingcod, and black rockfishes appeared more frequently at deep stations (Figure 168). Striped surfperches, kelpfishes, black-and-yellow rockfishes, cabezon, pile surfperches, and black surfperches were more commonly observed at stations shallower than 7.7 m.

To sum up, there appears to have been little change in fish species composition form 1973 through 1977. Blue rockfishes continue to be the most abundant non-cryptic fishes in the Diablo Canyon area. There has been an apparent decline in lingcod abundance in this area, but we have no reason to believe that this decline is due to any activities at the power plant site.

Most of the fish species we have observed are cold-temperate or boreal species. However, several warm-temperate fishes (Briggs 1974) have been observed in the Diablo Canyon area (Point San Luis to Point Buchon California) sheepheads, Semicossyphus pulcher; senoritas, Oxyjulis californica; opaleyes, Girella nigricans; treefishes, Sebastes serriceps; calico rockfishes, Sebastes dalli (Tom Wilson, pers. commun.); swell sharks, Cephaloscyllium ventriosum; bluebanded gobies, Lythrypnus dalli; and zebra gobies, Lythryphus zebra (Burge and Schultz 1973). Several other warm-temperature fishes have been reported but not confirmed: kelp basses, Paralabrax clathratus; blacksmiths, Chromis punctipinnis; Pacific bonitos, Sarda chiliensis; and Californica morays, Gymnothorax mordax.

We predict, based on observations at other power plants including Morro Bay and Redondo Beach which discharge warm waters, that as the waters of Diablo

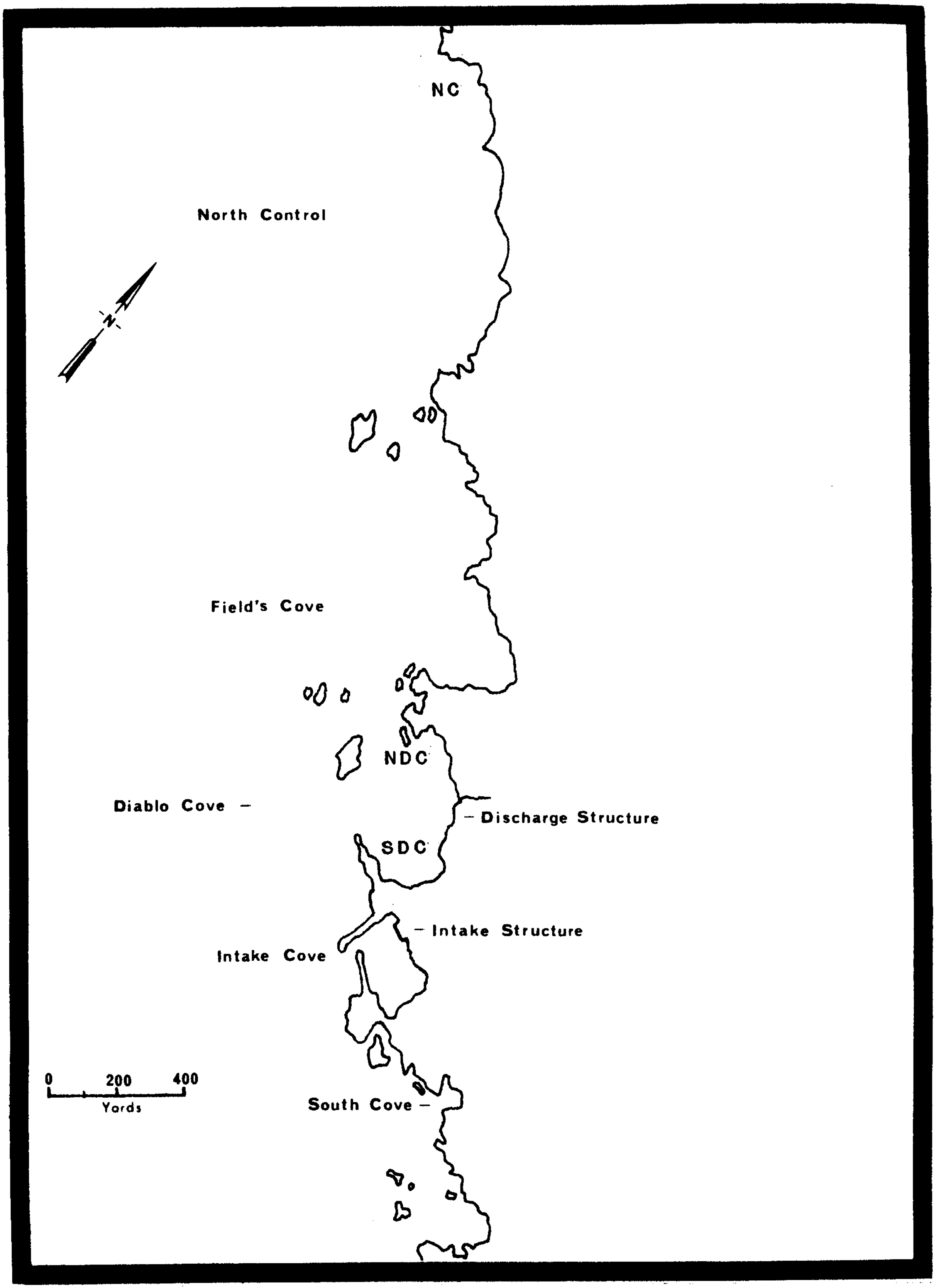


Figure 69. Locations of Subtidal Study Areas: South Diablo Cove (SDC), North Diablo Cove (NDC) and North Control (NC). DCPP, 1973-1977.

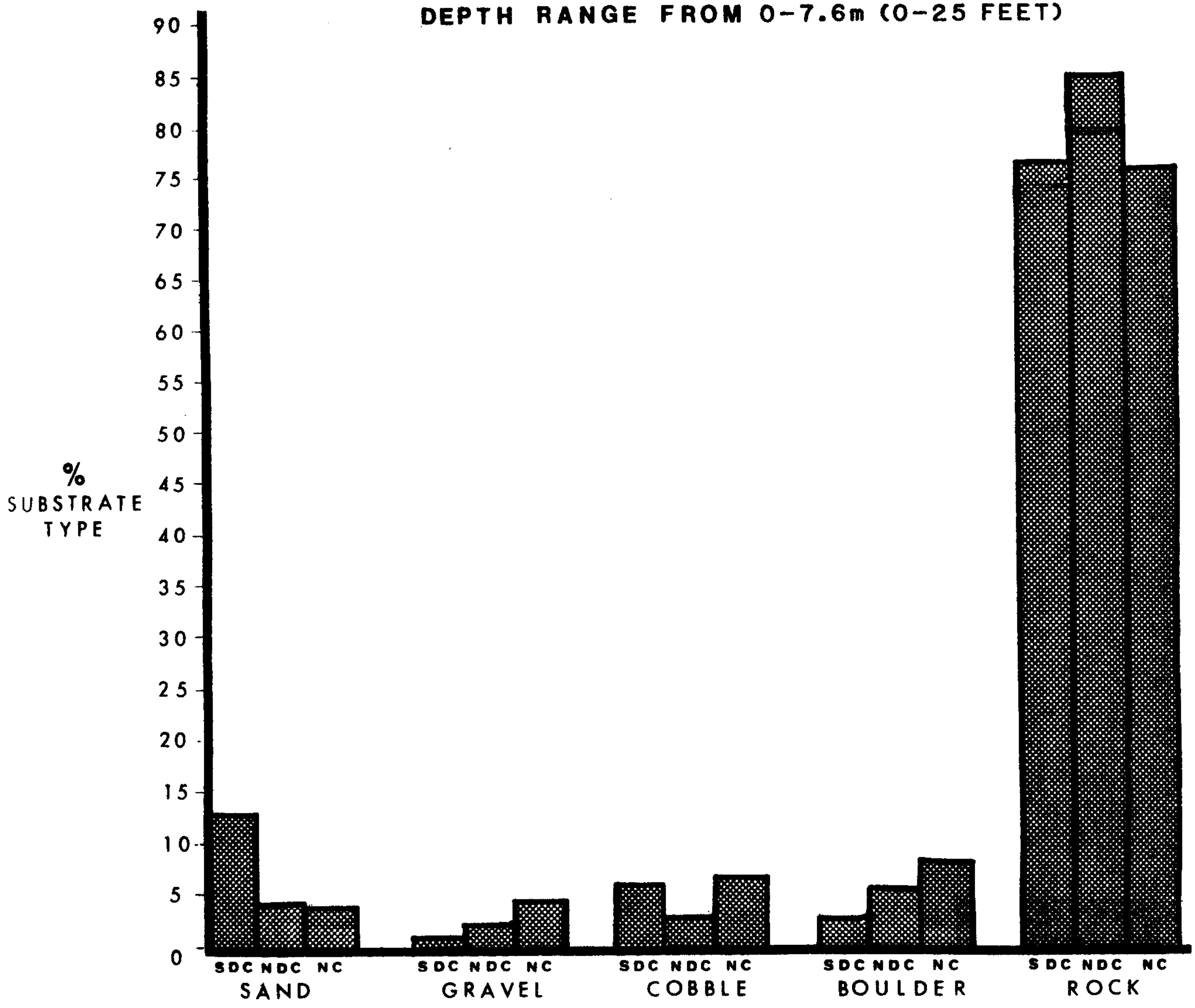


Figure 70. Substrate Composition at Shallow, 0-7.6m (0.25 feet), Subtidal Stations in South Diablo Cove (SDC), North Diablo Cove, (NDC), and North Control (NC). DCPP, 1973-1977.

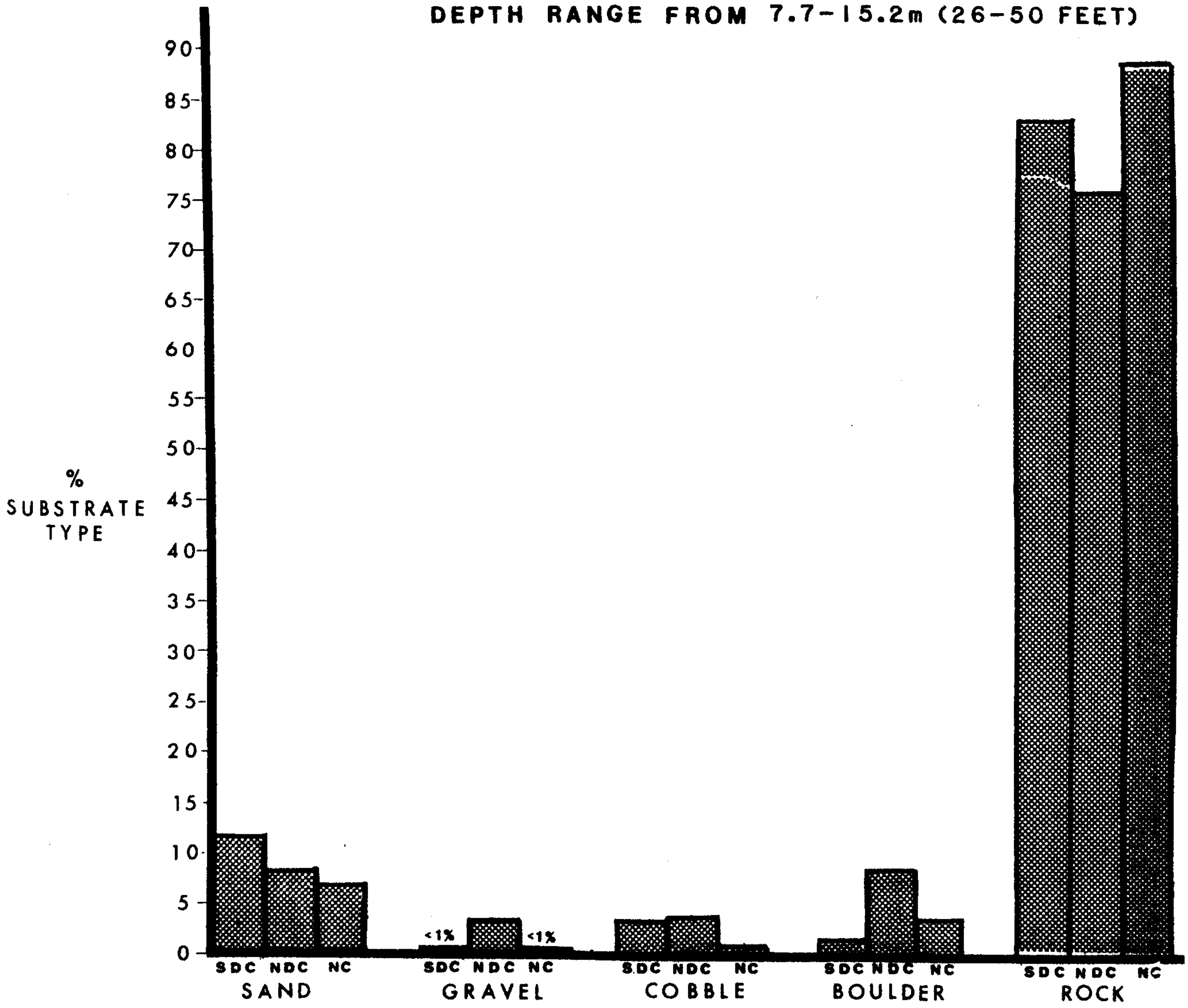


Figure 71. Substrate Composition at Deep, 7.7-15.2m (26-50 feet), Stations in South Diablo Cove (SDC), North Diablo Cove, (NDC), and North Control (NC). DCPP, 1973-1977.

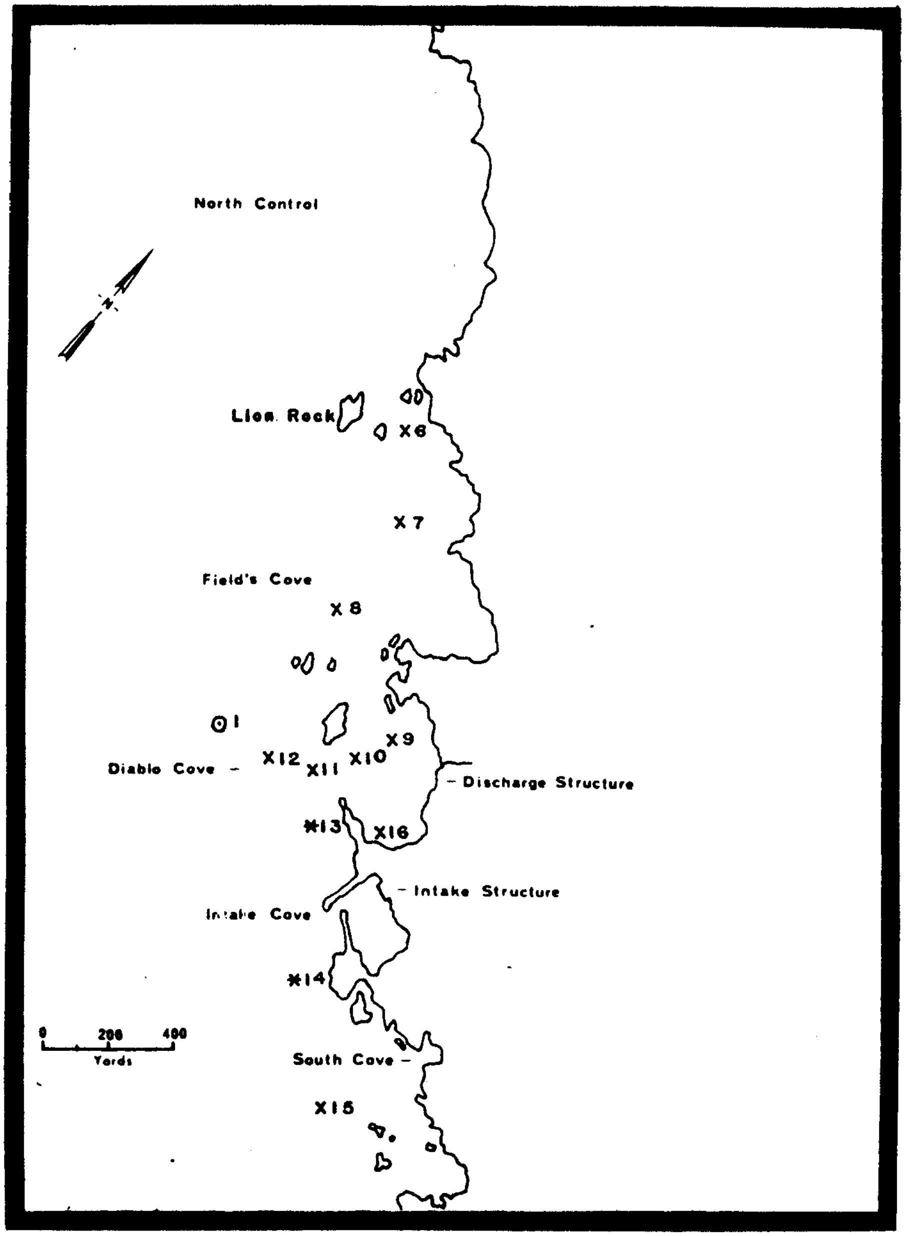


Figure 72. Locations of Subtidal Permanent Stations.

X = Stations established by Burge and Schultz in 1970. Surveyed in 1970, 1971, 1973-1978.

* = Stations established by Burge and Schultz in 1970. Surveyed in 1970 and 1971.

O = Stations established in 1977. Surveyed in 1977 and 1978.

DCPP, 1970-1978.

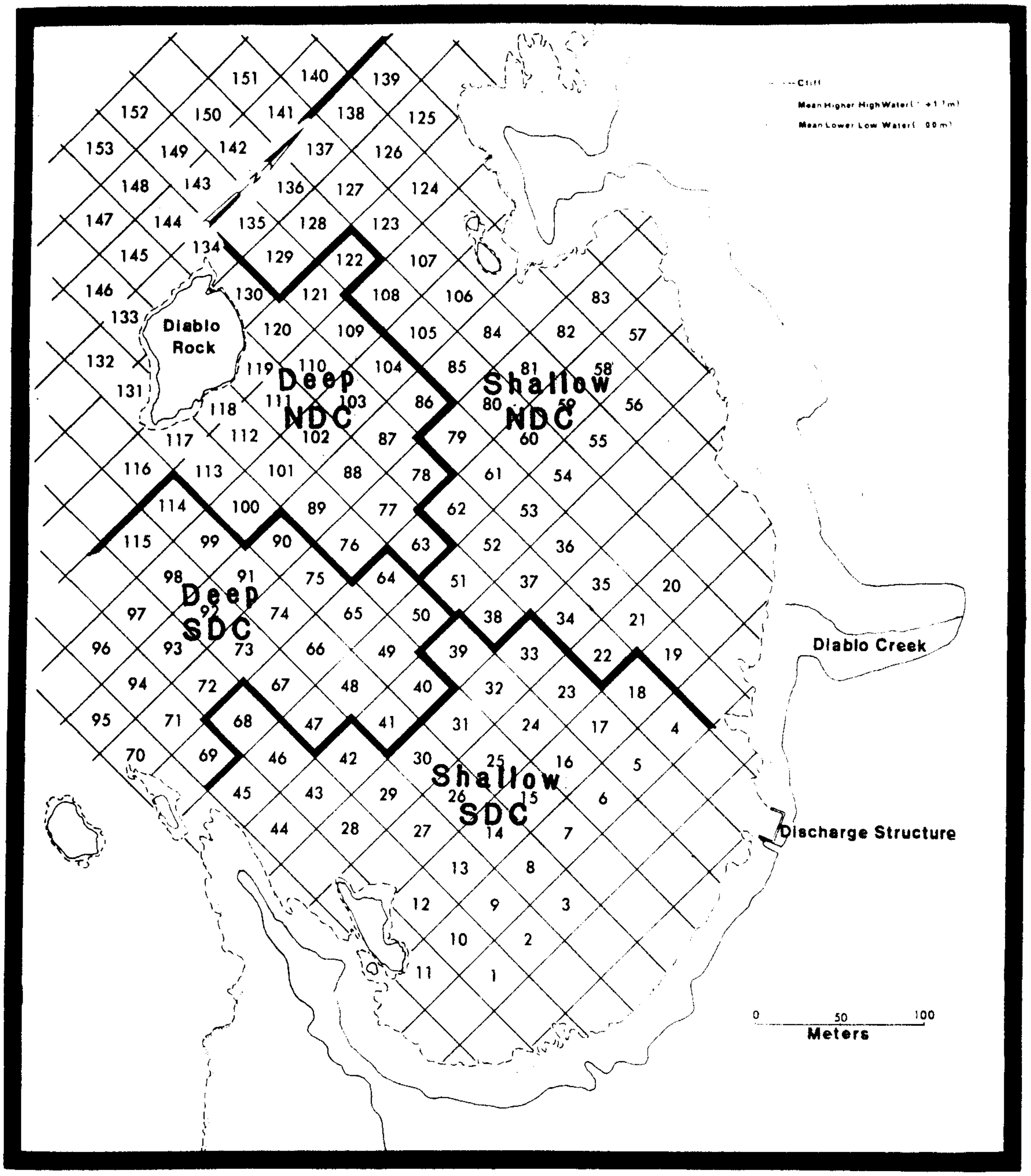


Figure 73. Locations of Diablo Cove Random Subtidal Stations: North Diablo Cove (NDC), South Diablo Cove (SDC). DCPP, 1974-1978.

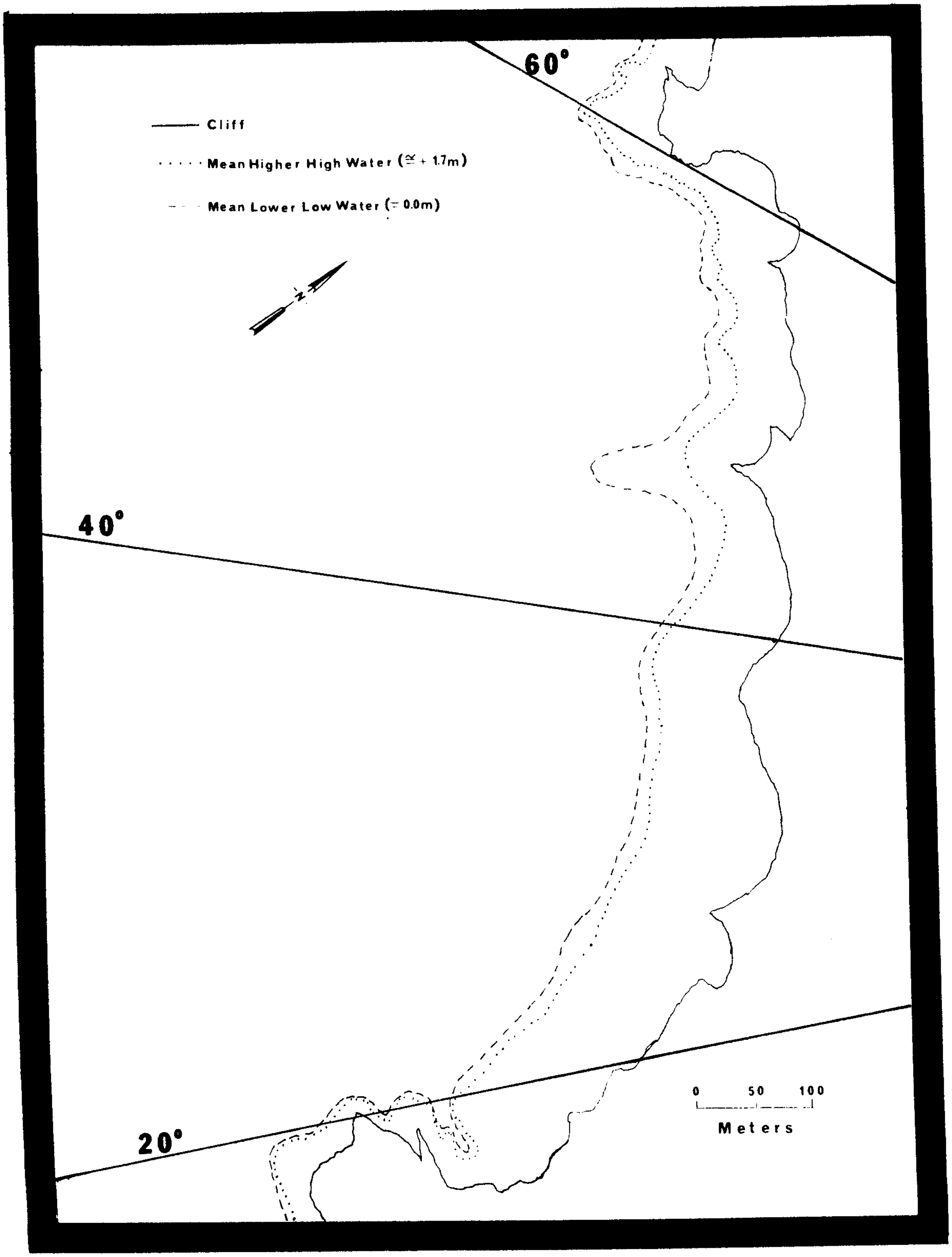


Figure 74. Random North Control Subtidal Study Area Showing Magnetic Compass Bearings to a Fixed Landmark. (a metal barn). DCPP, 1974-1978.

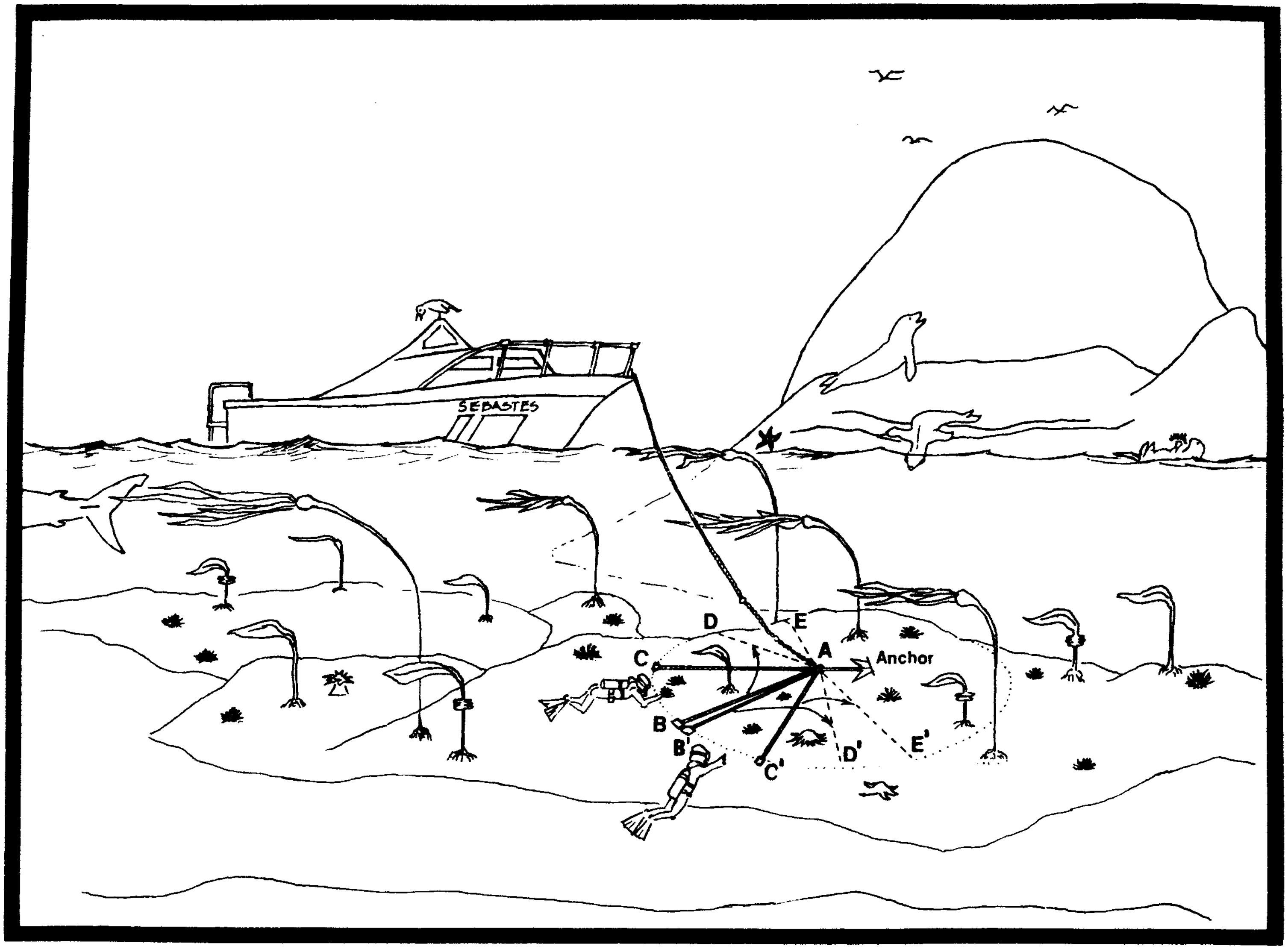


Figure 75. Subtidal random survey method - the 30 m^2 arc. Divers attach paired 3.1 m lines to anchor shackle (point A) and create neighboring wedges B-C and B'-C'. When counts of selected plants and animals are completed, line B is moved to point D, and B' is moved to D' to create the next wedges C-D and C'-D'. The process is repeated until an entire 30 m^2 circular area is surveyed. DCPP, 1974-1978.

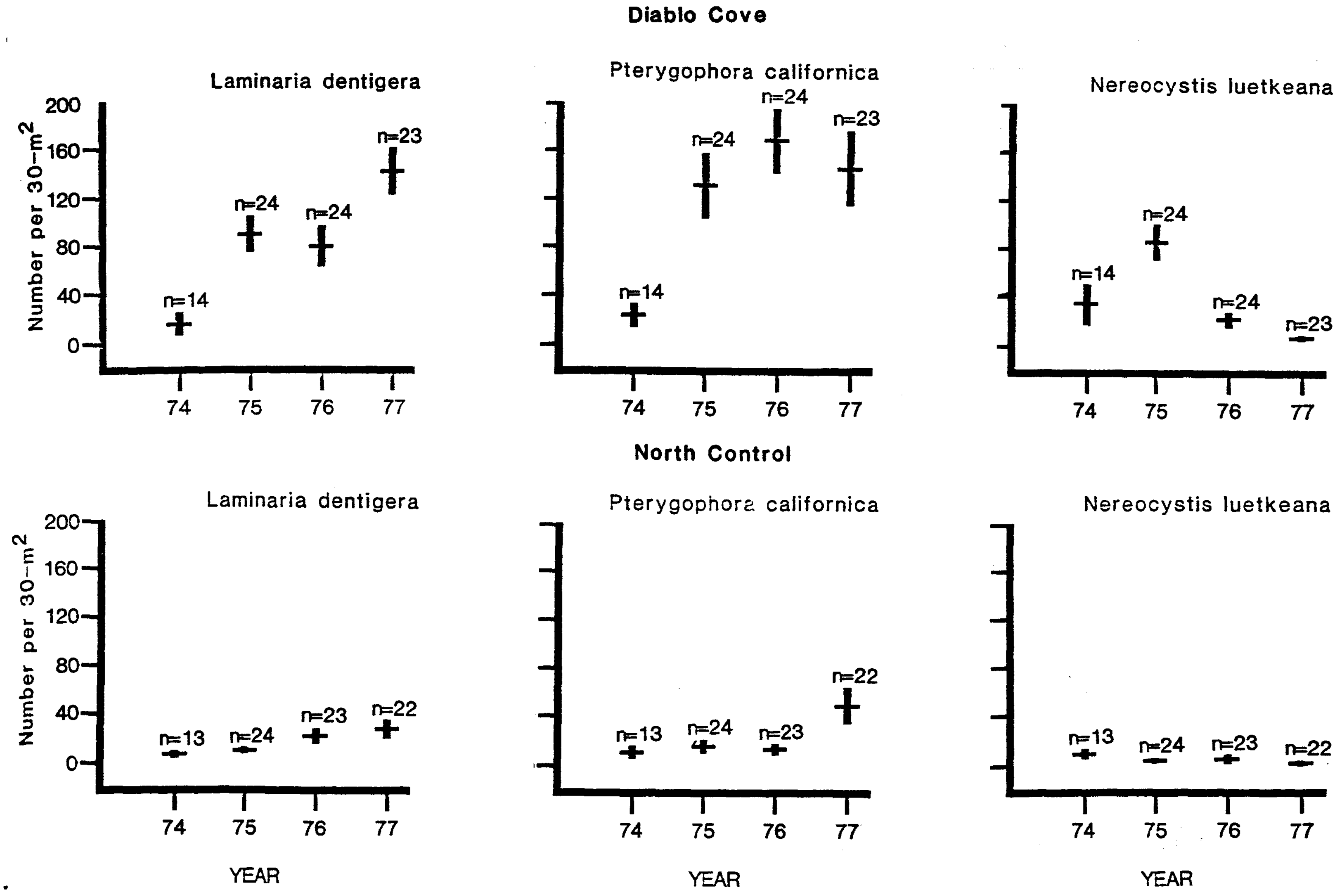


Figure 76. Mean numbers and standard errors for *Laminaria dentigera*, *Pterygophora californica*, and *Nereocystis luetkeana* at Diablo Cove and North Control subtidal random arc stations. DCPP, 1974-1977.

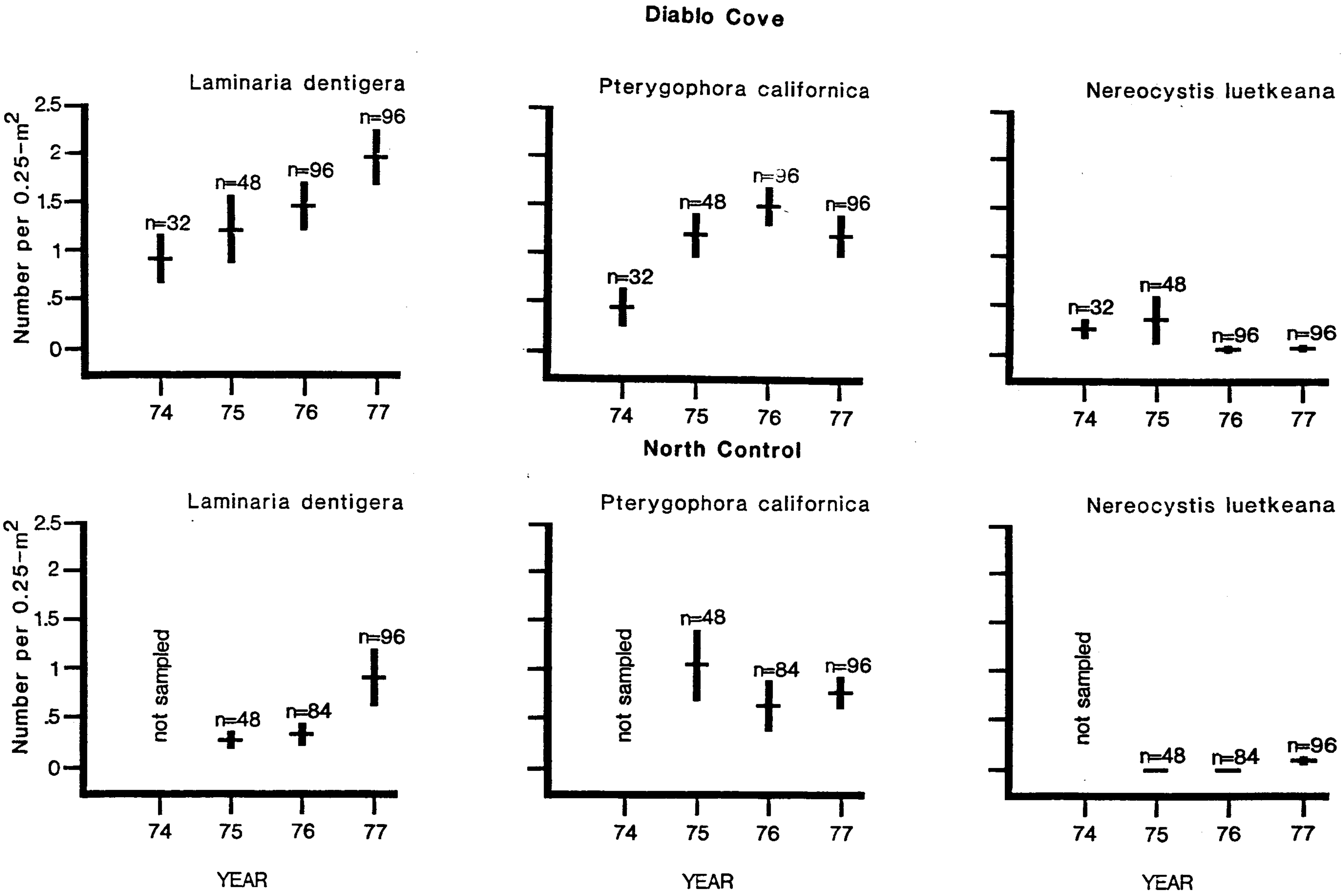


Figure 77. Mean numbers and standard errors for Laminaria dentigera, Pterygophora californica, and Nereocystis luetkeana at Diablo Cove and North Control Subtidal Random Quadrat Stations. DCPP, 1974-1977.

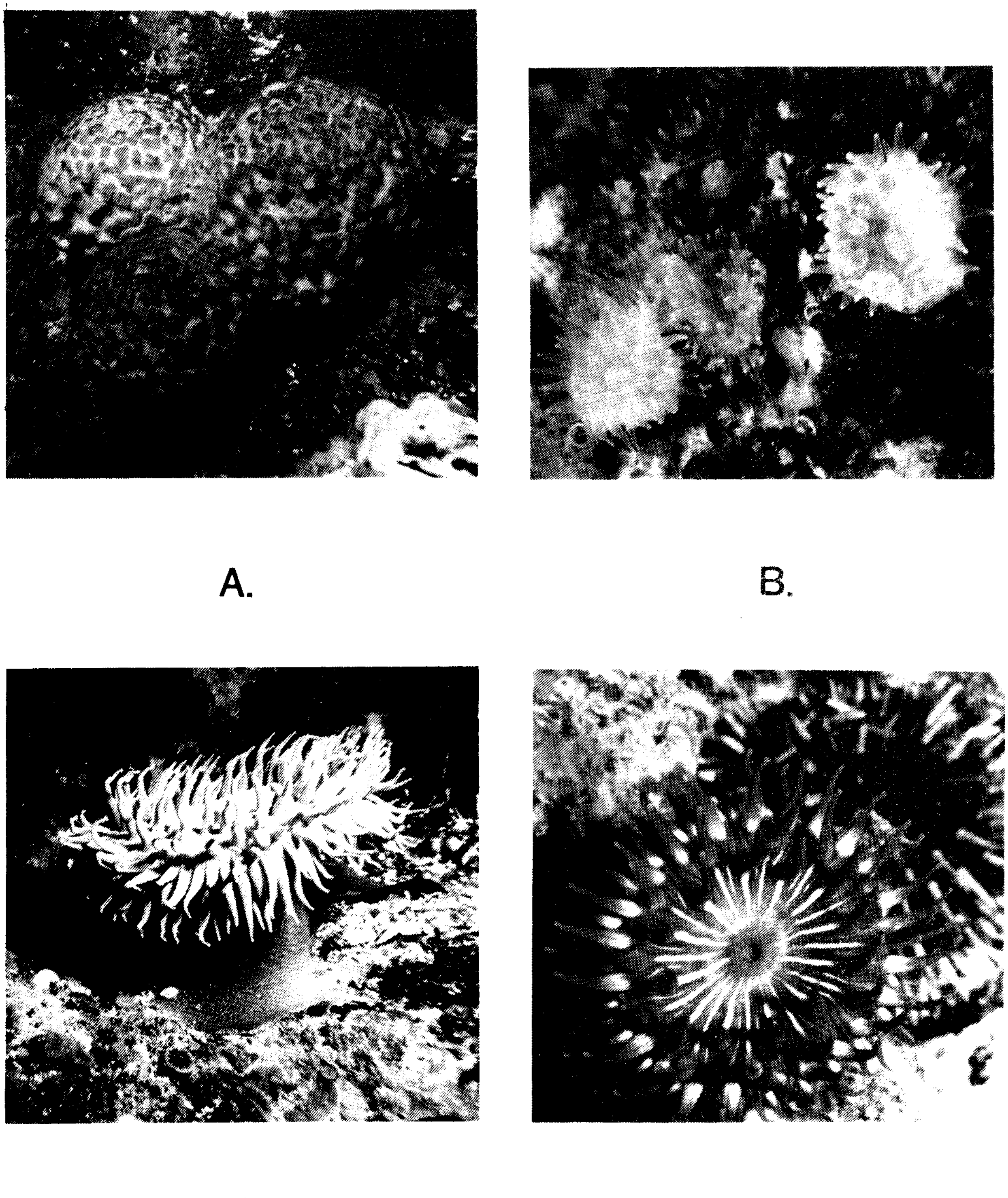


Figure 77b. A. *Tethya aurantia*, B. *Anthopleura xanthogrammica*, C. *Balanophyllia elegans*, D. *Epiactis prolifera*. (Photos by Daniel W. Gotshall).

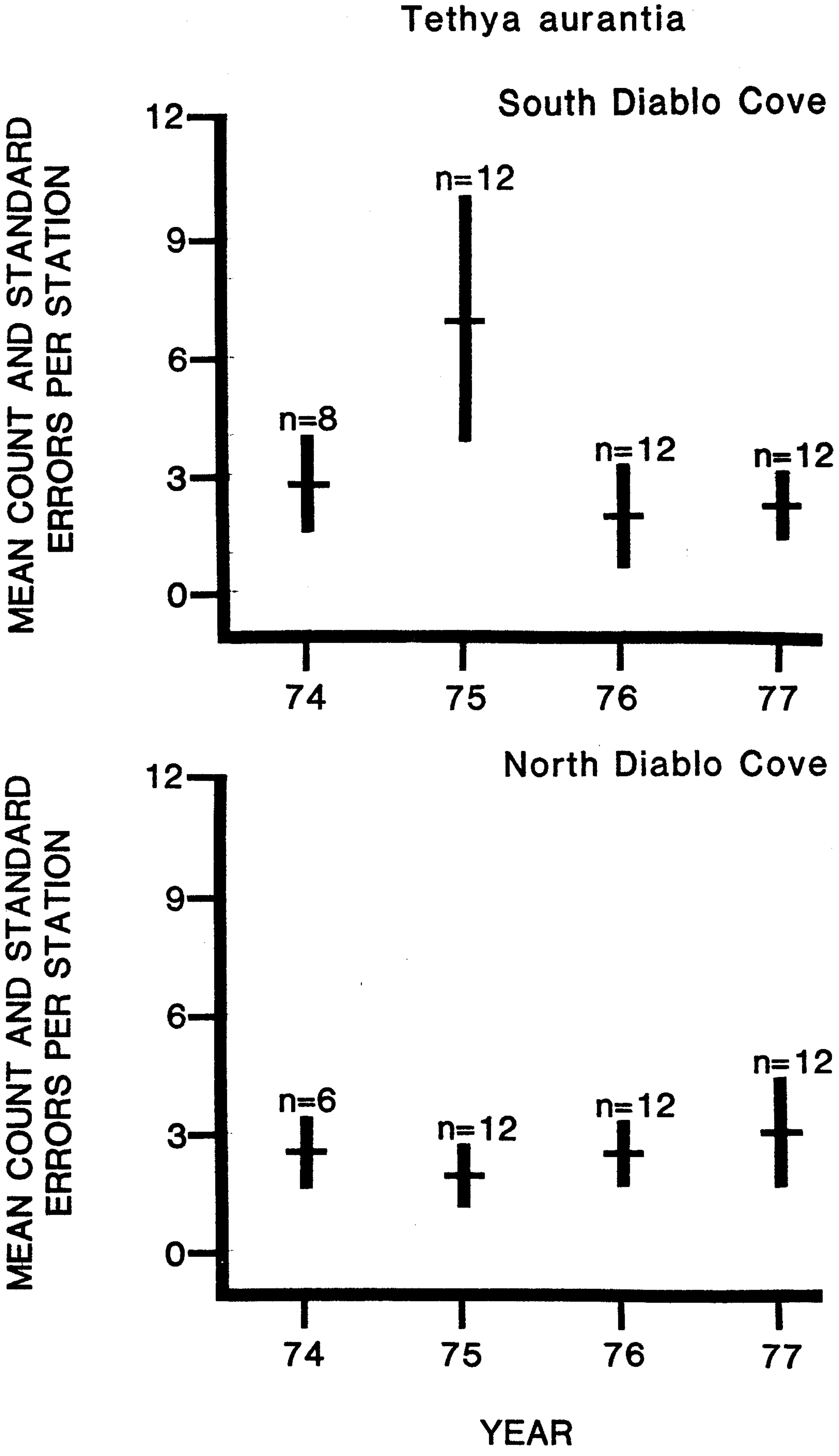


Figure 78. Mean counts and standard errors per station for Tethya aurantia at subtidal random arc stations in South Diablo Cove and North Diablo Cove. DCPP, 1974-1977.

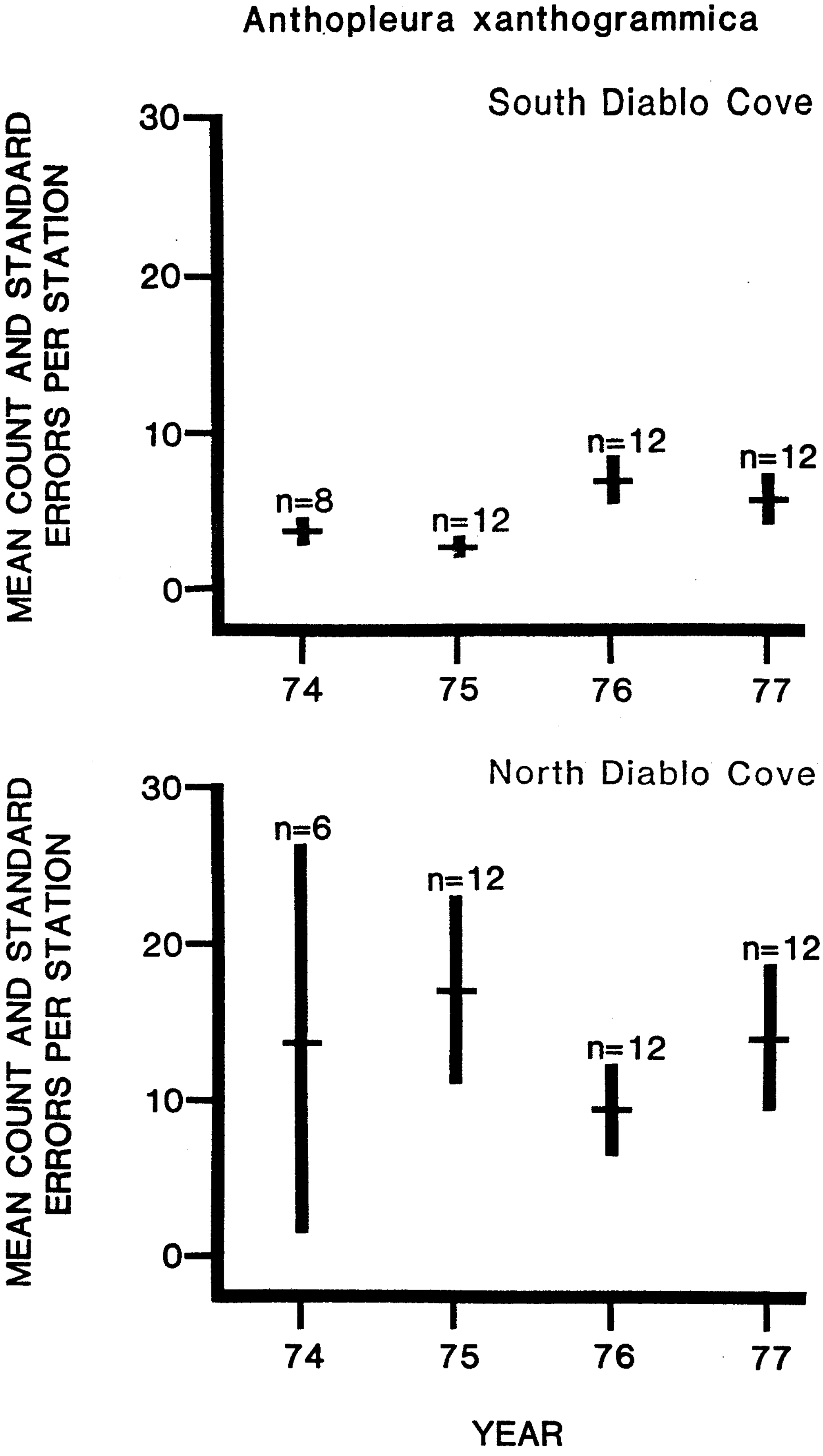


Figure 79. Mean counts and standard errors per station for Anthopleura xanthogrammica at subtidal random arc stations in South Diablo Cove and North Diablo Cove. DCPP, 1974-1977.

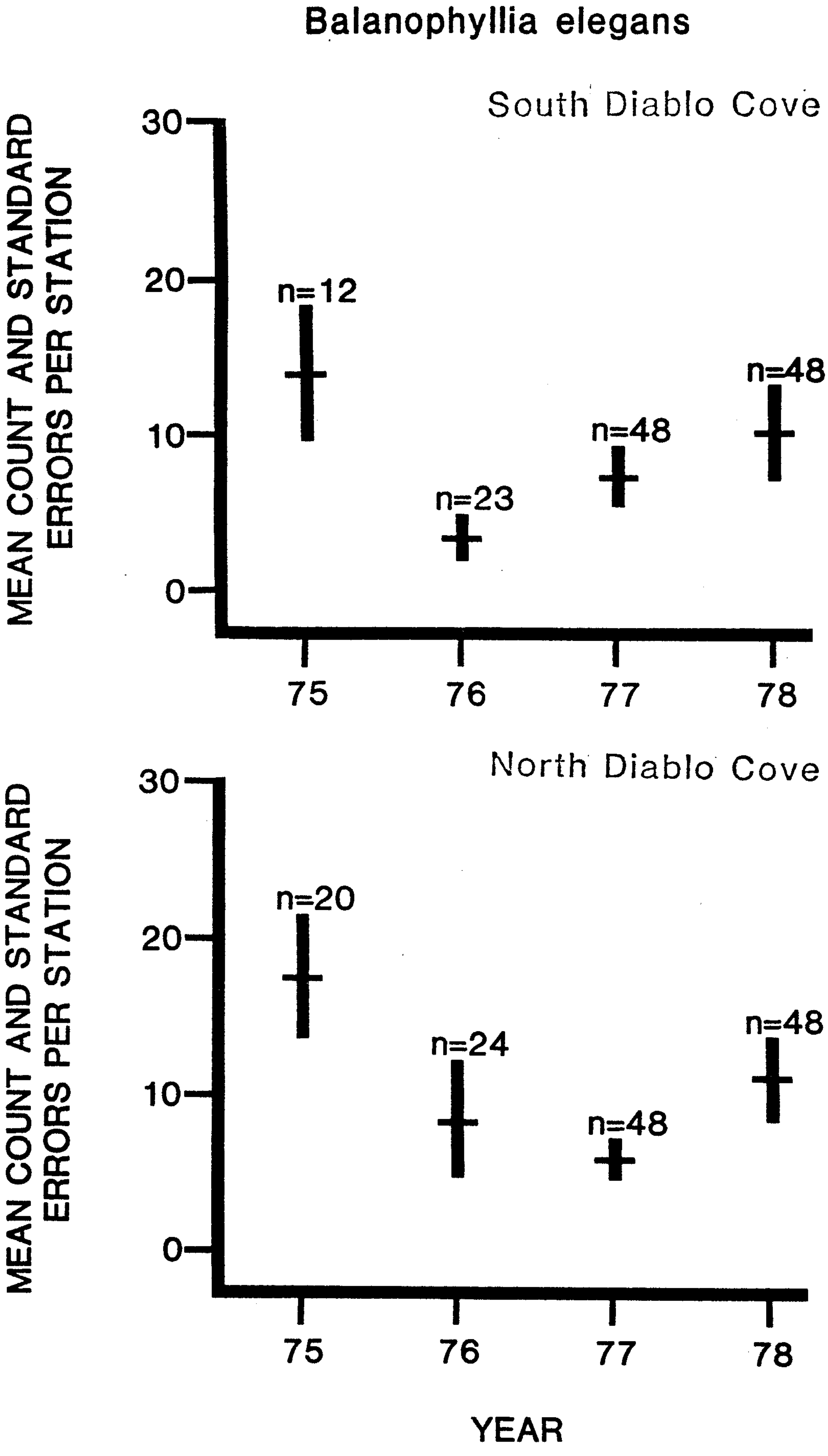


Figure 80. Mean counts and standard errors per station for Balanophyllia elegans at subtidal random quadrat stations in South Diablo Cove and North Diablo Cove. DCPP, 1975-1978.

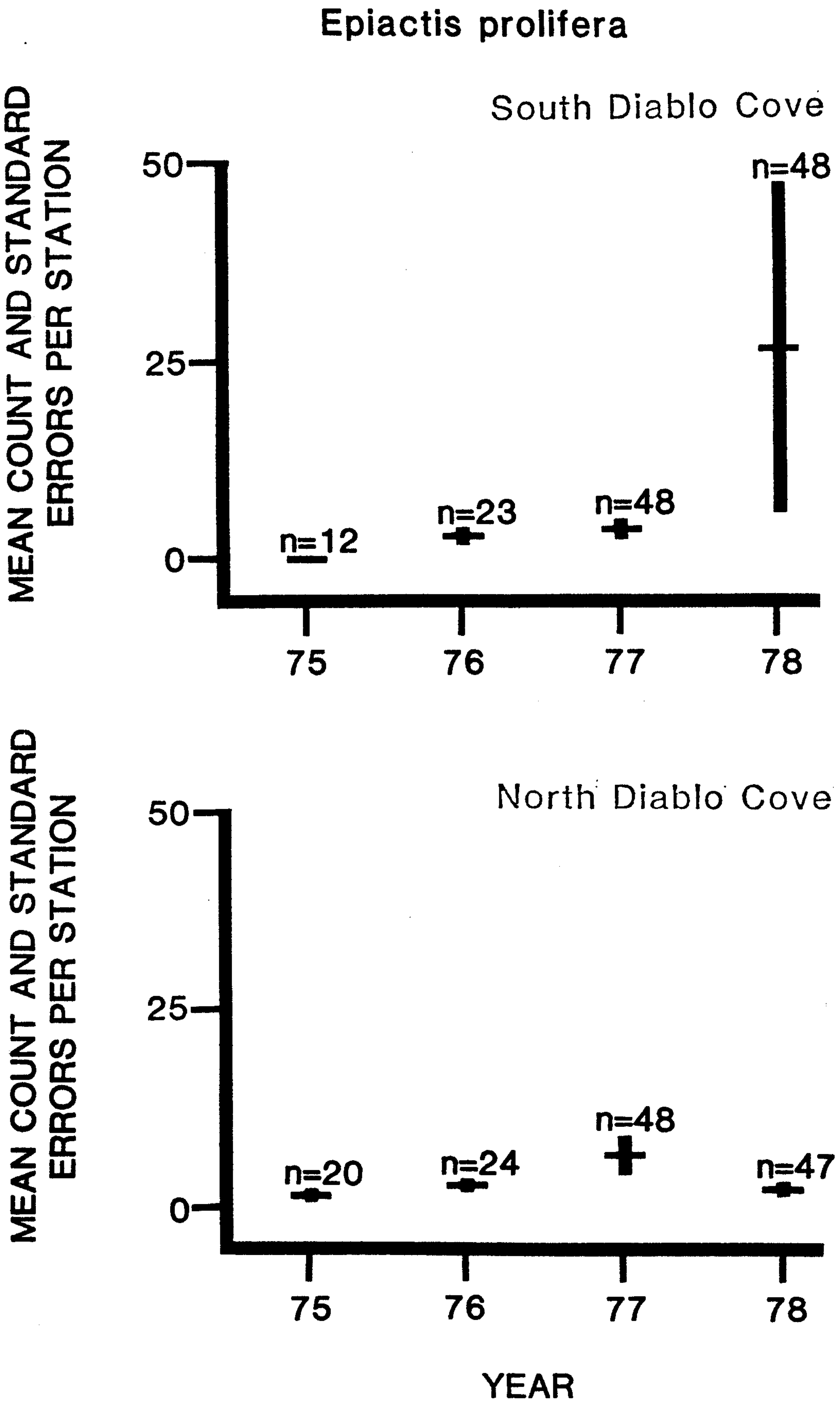


Figure 81. Mean counts and standard errors per station for Epiactis prolifera at subtidal random quadrat stations in South Diablo Cove and North Diablo Cove. DCPP, 1975-1978.

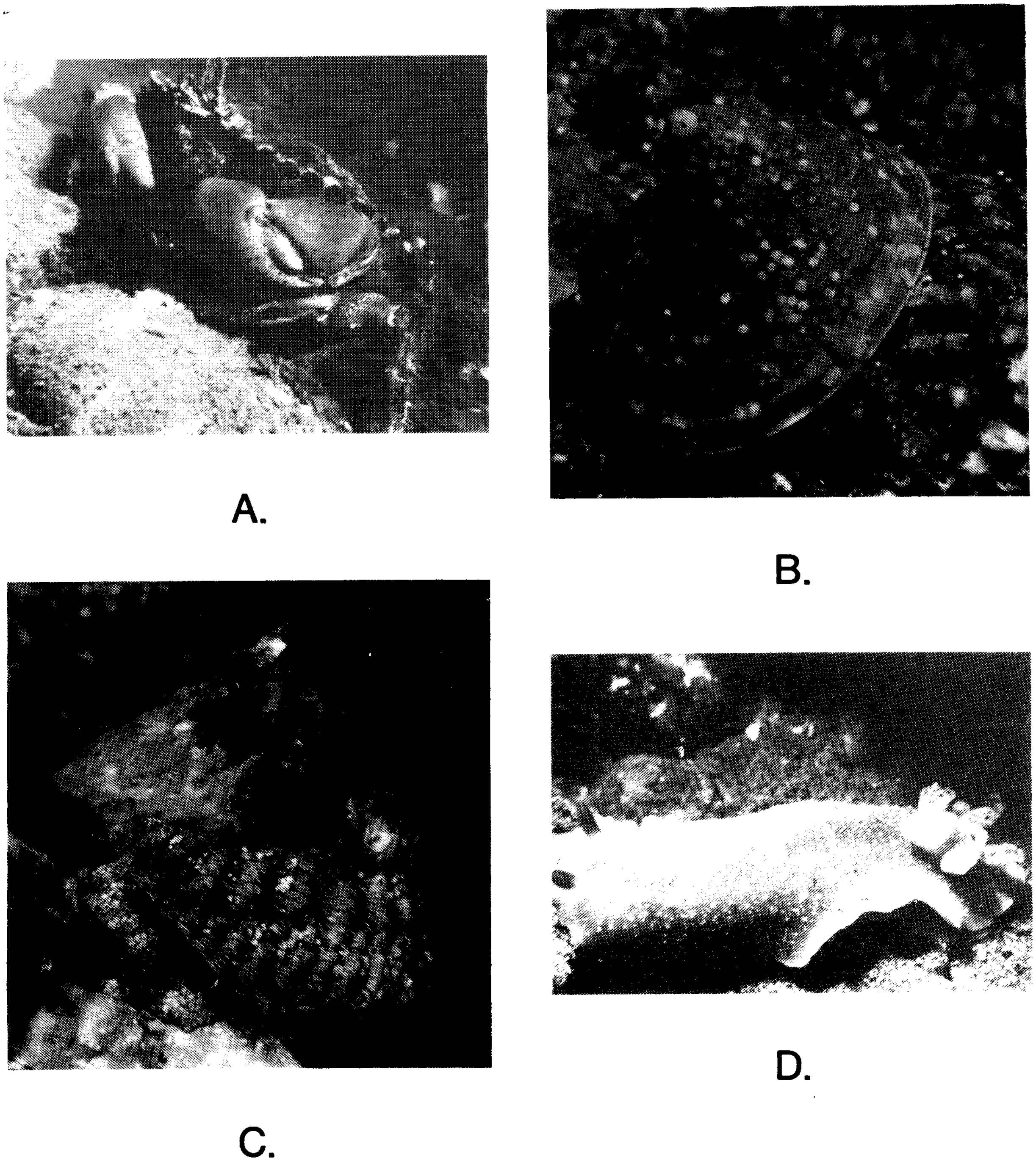


Figure 82. A. *Cancer antennarius*, B. *Acmaea mitra*, C. *Astraea gibberosa*, D. *Doriopsilla albopunctata*. (Photos by Daniel W. Gotshall).

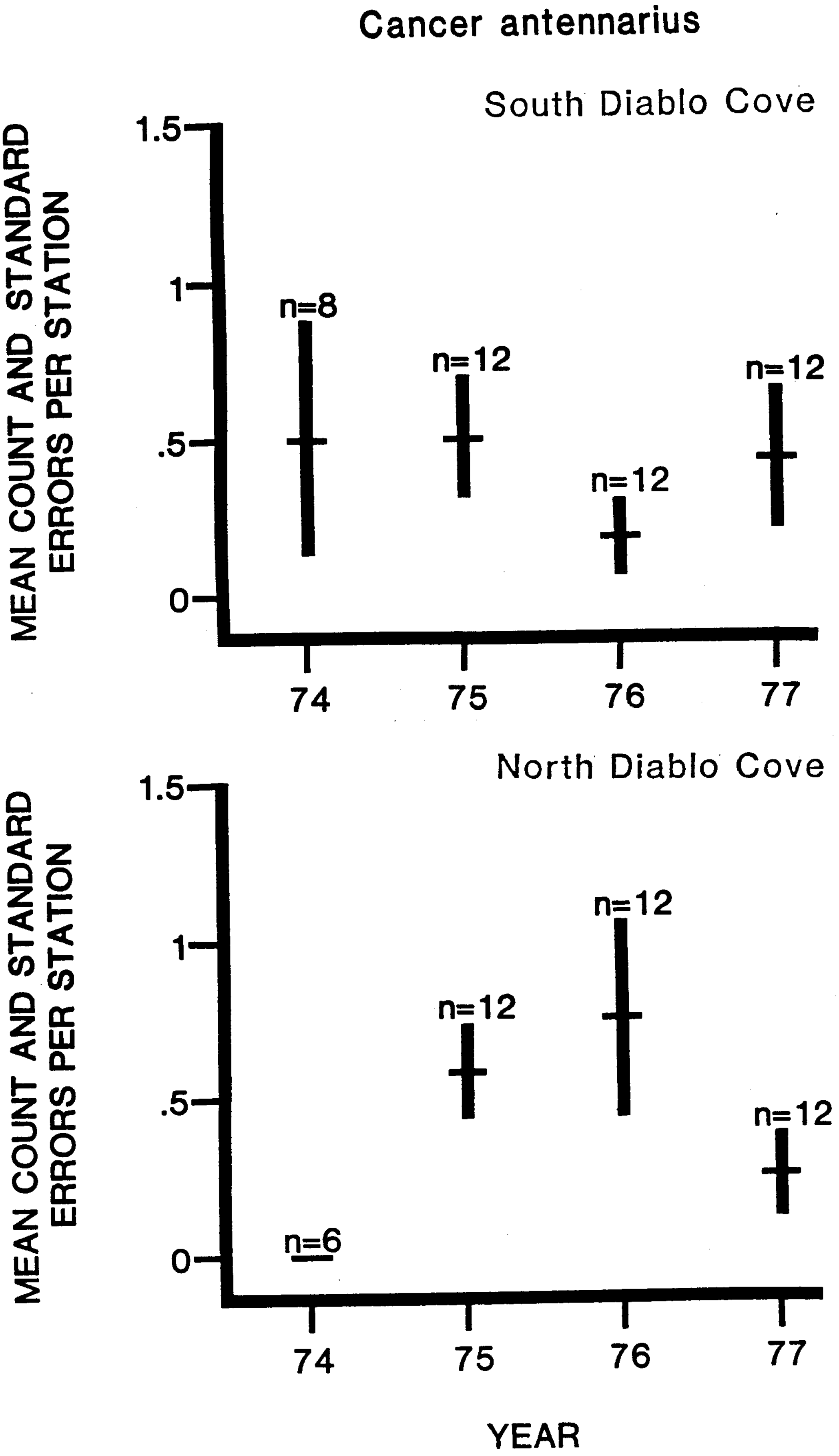


Figure 83. Mean counts and standard errors per station for <u>Cancer antennarius</u> at subtidal random arc stations in South Diablo Cove and North Diablo Cove. DCPP, 1974-1977.

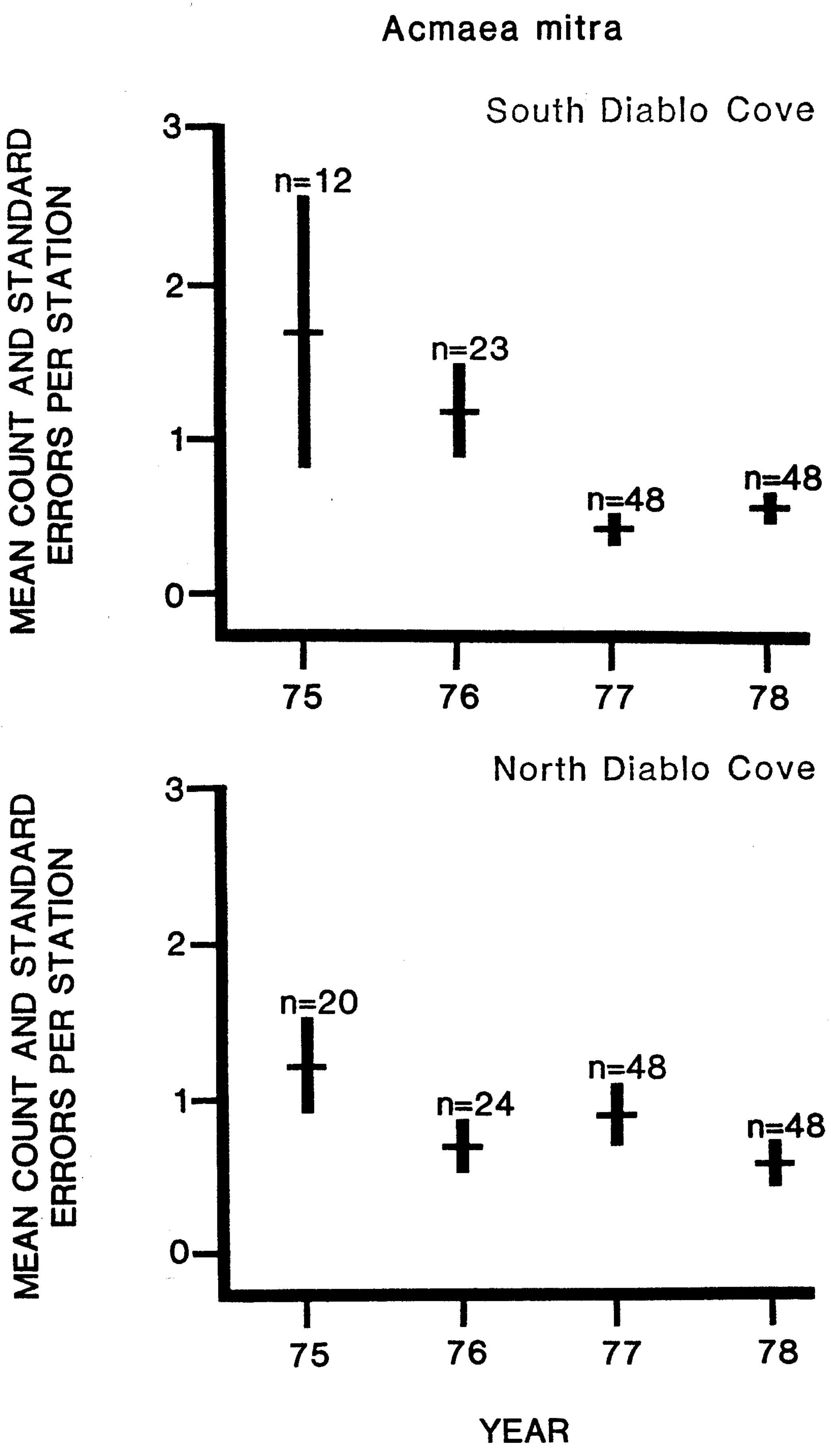


Figure 84. Mean counts and standard errors per station for <u>Acmaea mitra</u> at subtidal random quadrat stations in South Diablo Cove and North Diablo Cove. DCPP, 1975-1978.

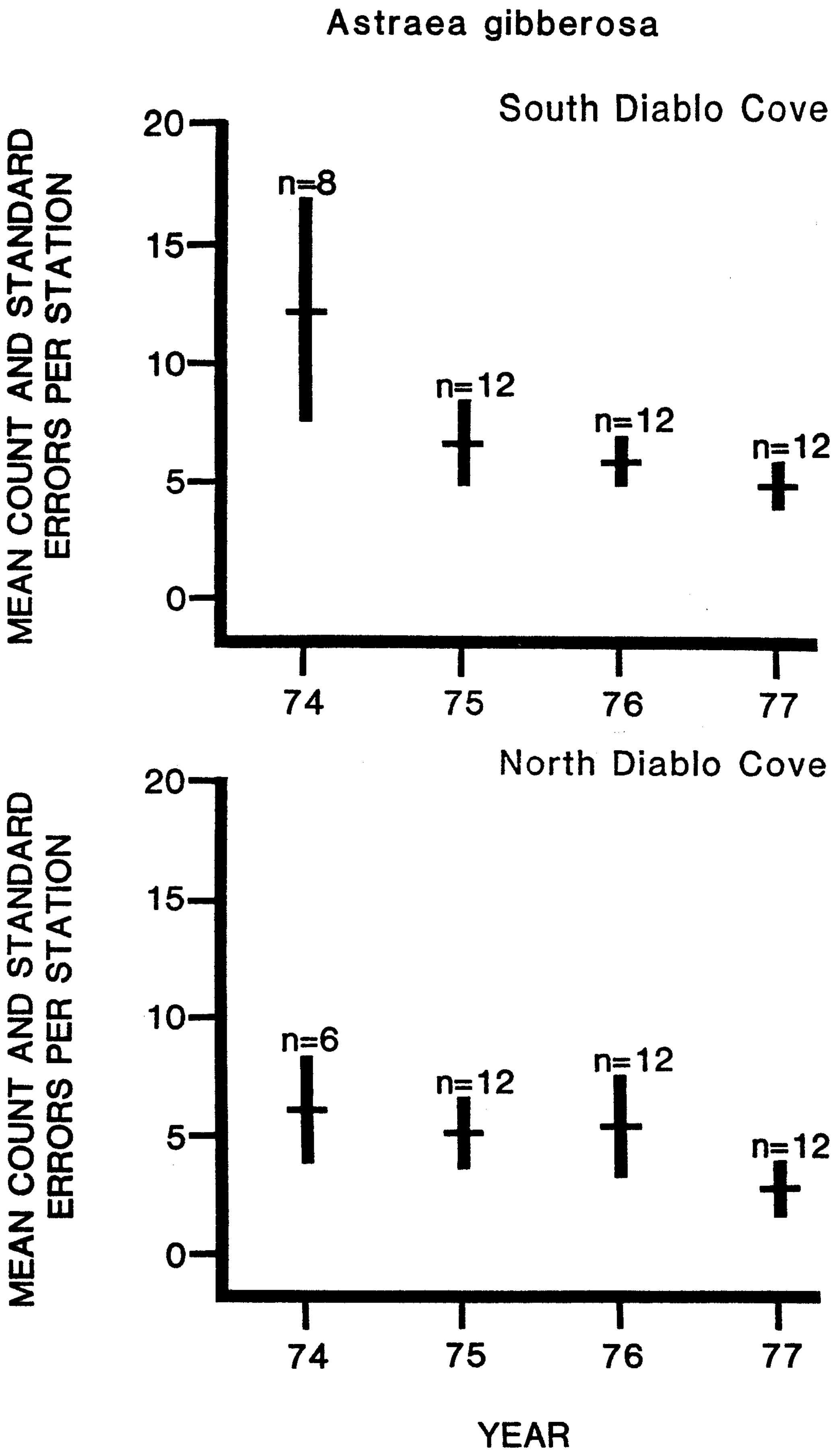


Figure 85. Mean counts and standard errors per station for Astraea gibberosa at subtidal random arc stations in South Diablo Cove and North Diablo Cove. DCPP, 1974-1977.

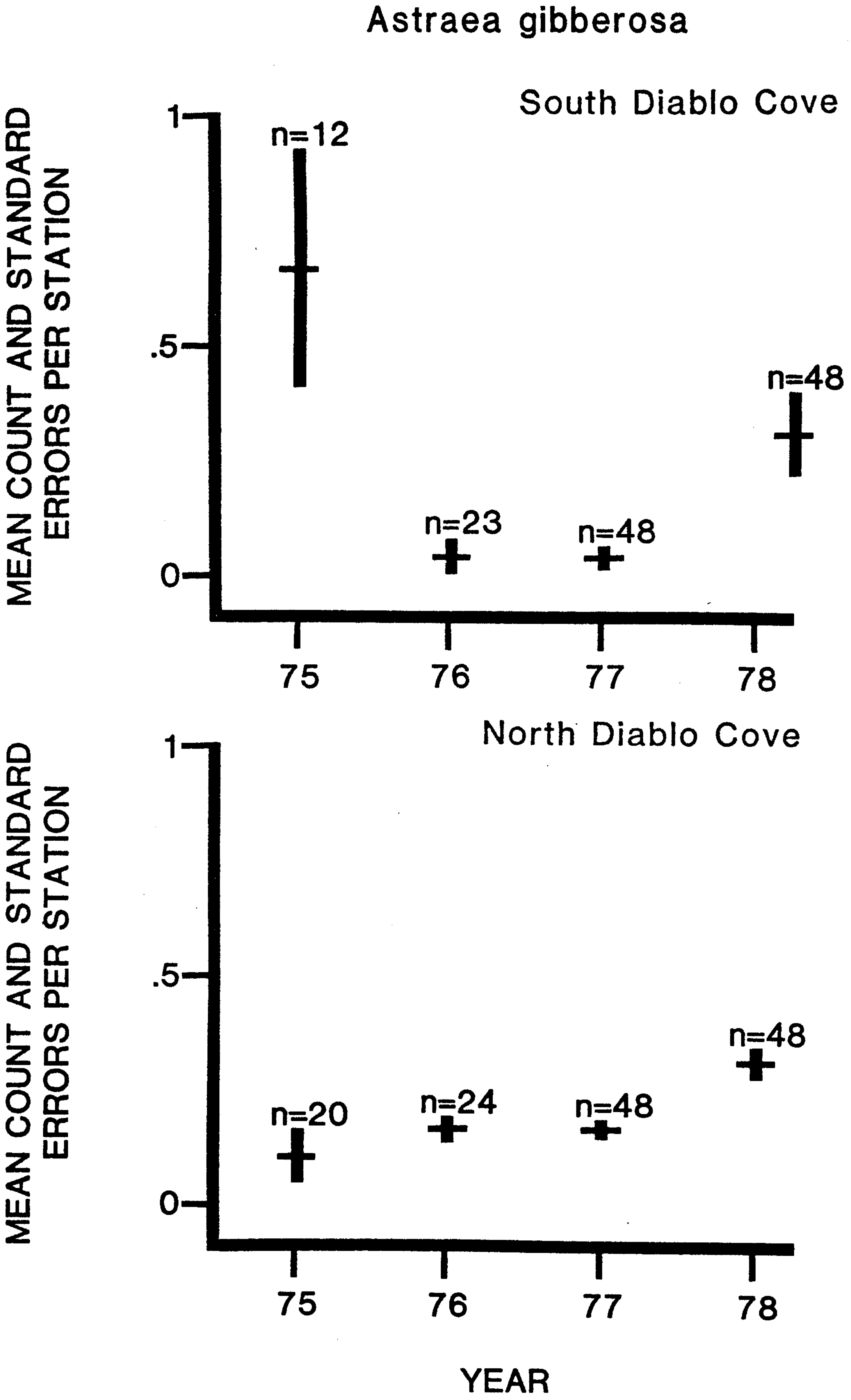


Figure 86. Mean counts and standard errors per station for Astraea gibberosa at subtidal random quadrat stations in South Diablo Cove and North Diablo Cove. DCPP, 1975-1978.

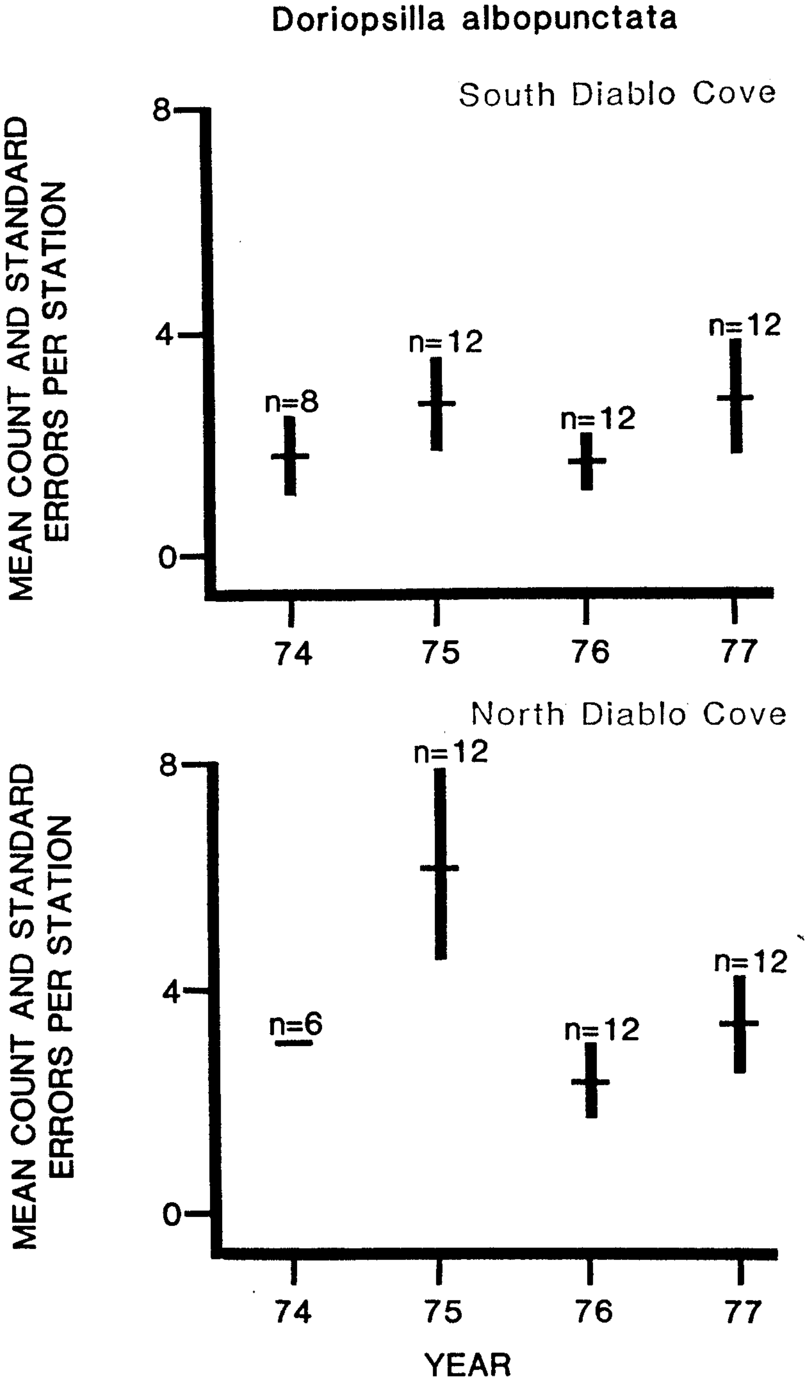


Figure 87. Mean counts and standard errors per station for *Doriopsilla albopunctata* at subtidal random arc stations in South Diablo Cove and North Diablo Cove. DCPP, 1974-1977.

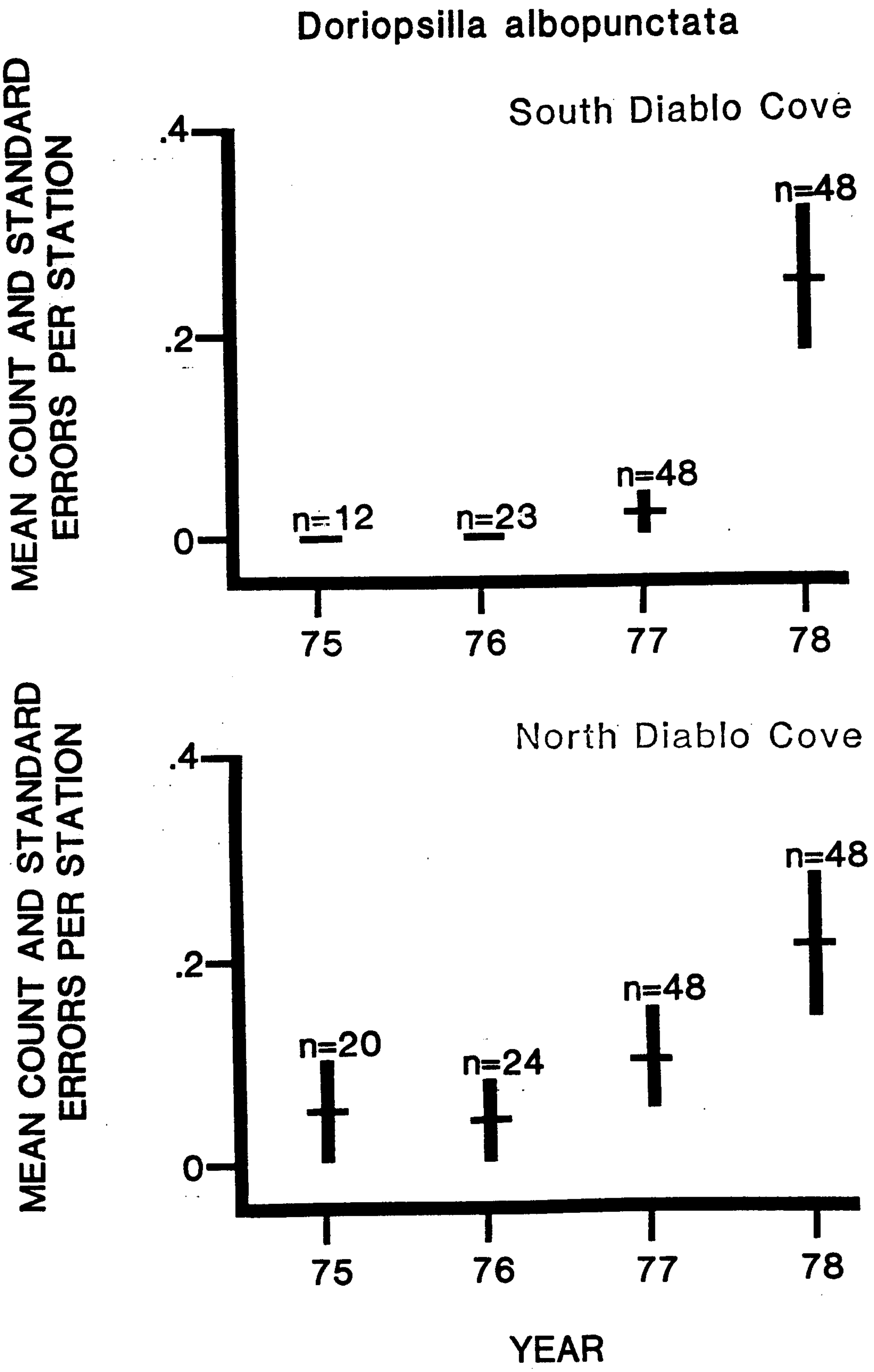


Figure 88. Mean counts and standard errors per station for Doriopsilla Albopunctata at subtidal random quadrat stations in South Diablo Cove and North Diablo Cove. DCPP, 1975-1978.

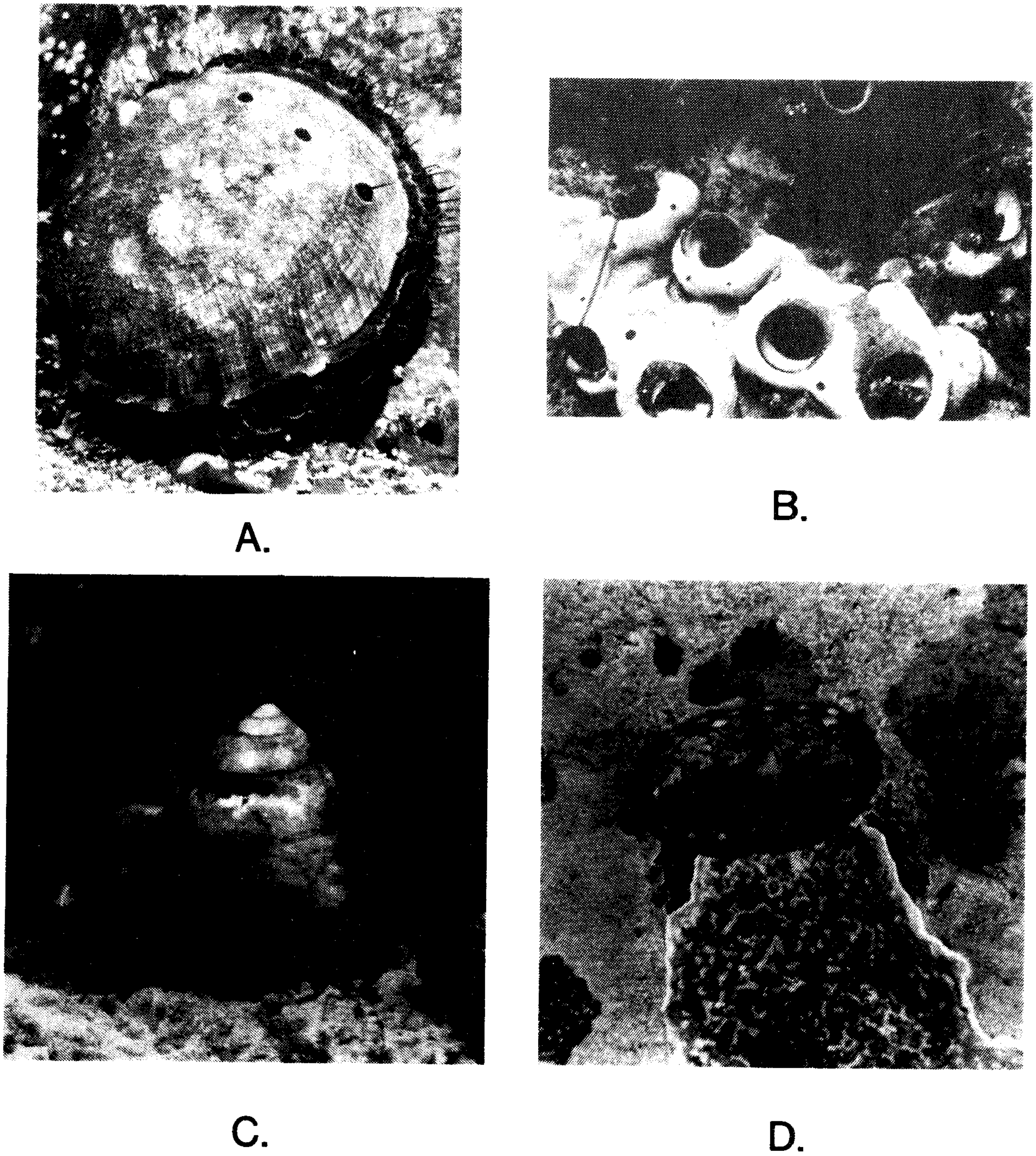


Figure 89. A. *Haliotis rufescens*, B. *Serpulorbis squamigerus*, C. *Tegula brunnea*, D. *Tonicella lineata*. (Photos by Daniel W. Gotshall).

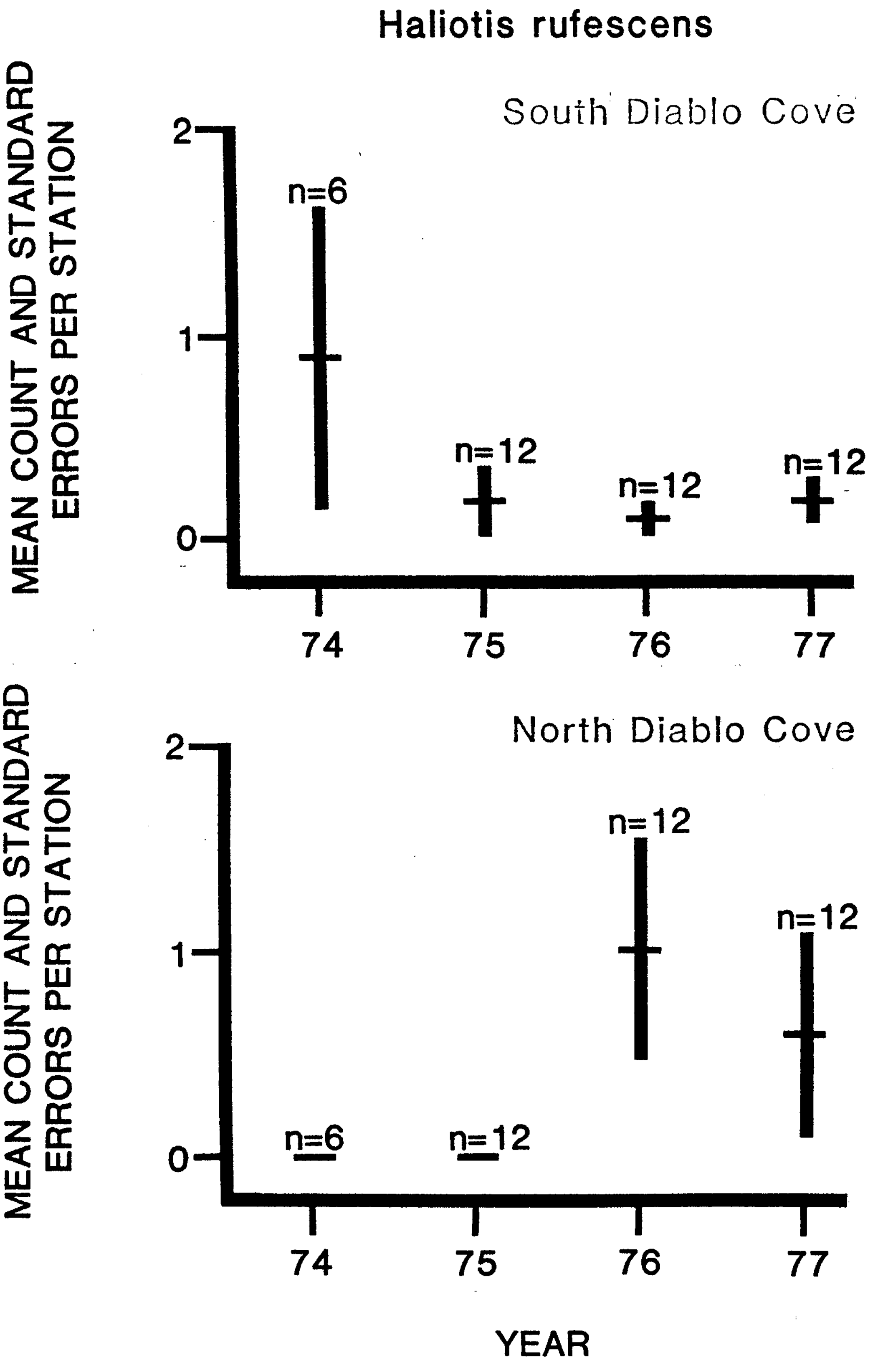


Figure 90. Mean counts and standard errors per station for Haliotis rufescens at subtidal random arc stations in South Diablo Cove and North Diablo Cove. DCPP, 1974-1977.

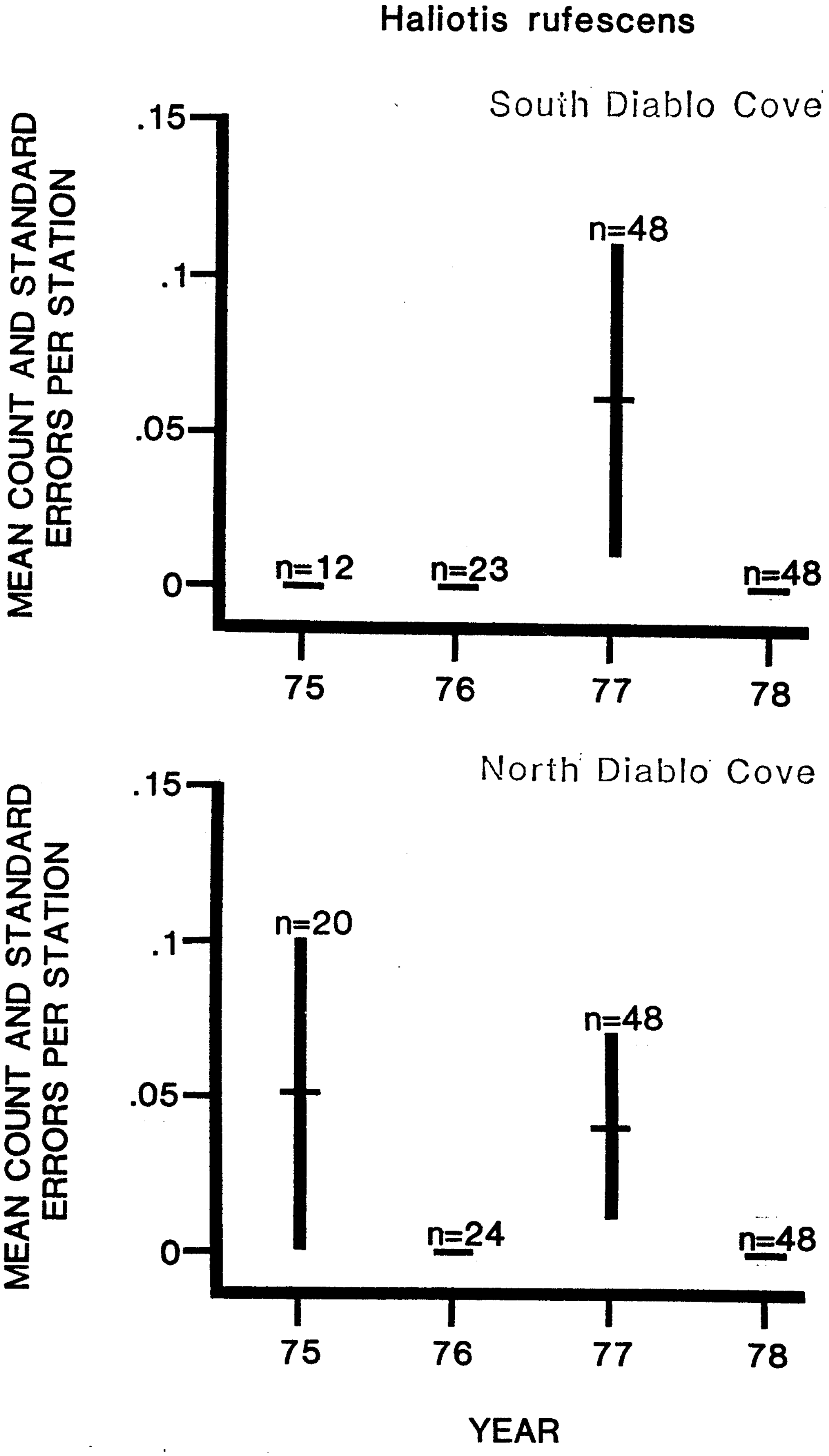


Figure 91. Mean counts and standard errors per station for <u>Haliotis rufescens</u> at subtidal random quadrat stations in South Diablo Cove and North Diablo Cove. DCPP, 1975-1978.

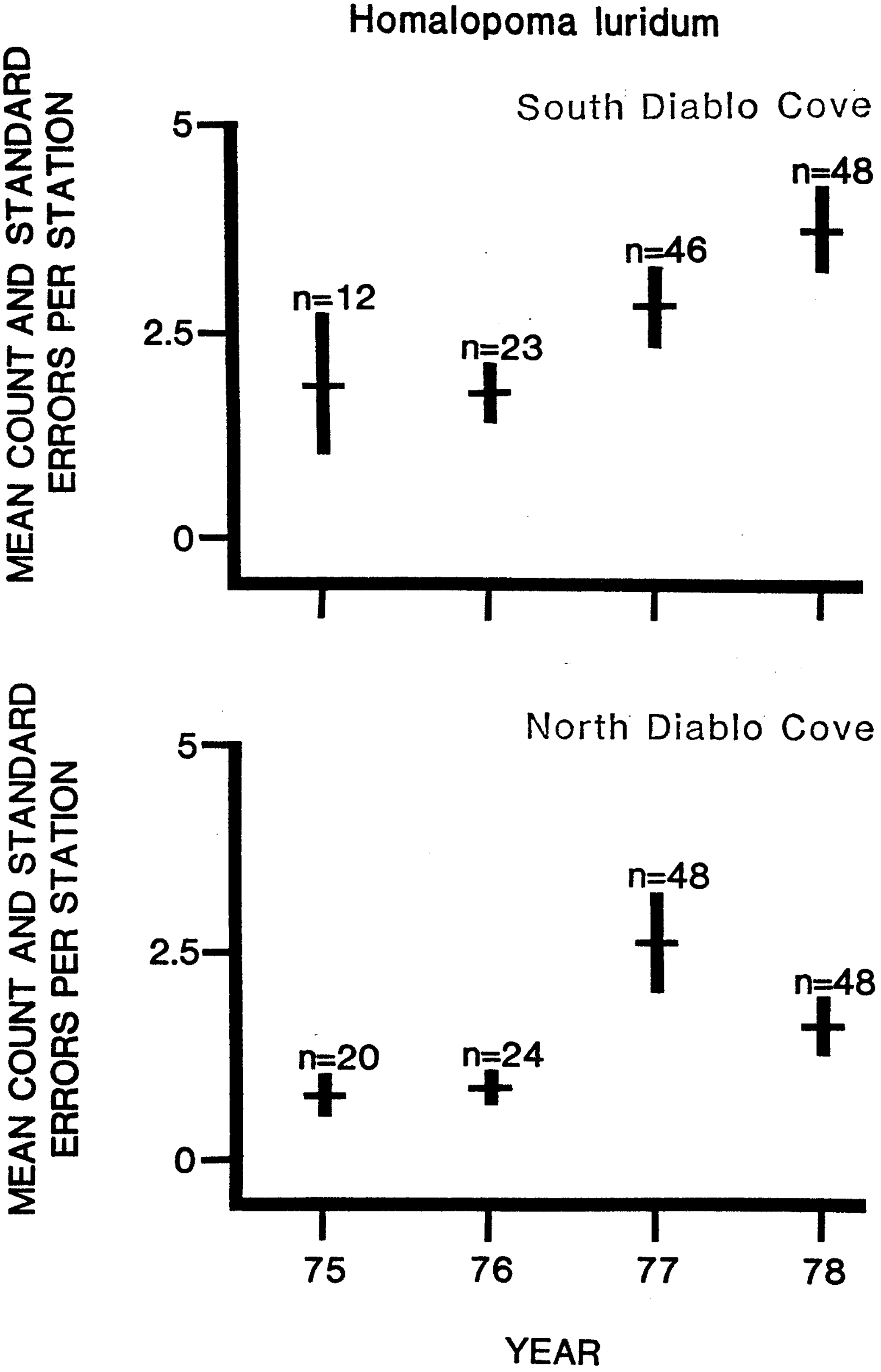


Figure 92. Mean counts and standard errors per station for *Homalopoma luridum* at subtidal random quadrat stations in South Diablo Cove and North Diablo Cove. DCPP, 1975-1978.

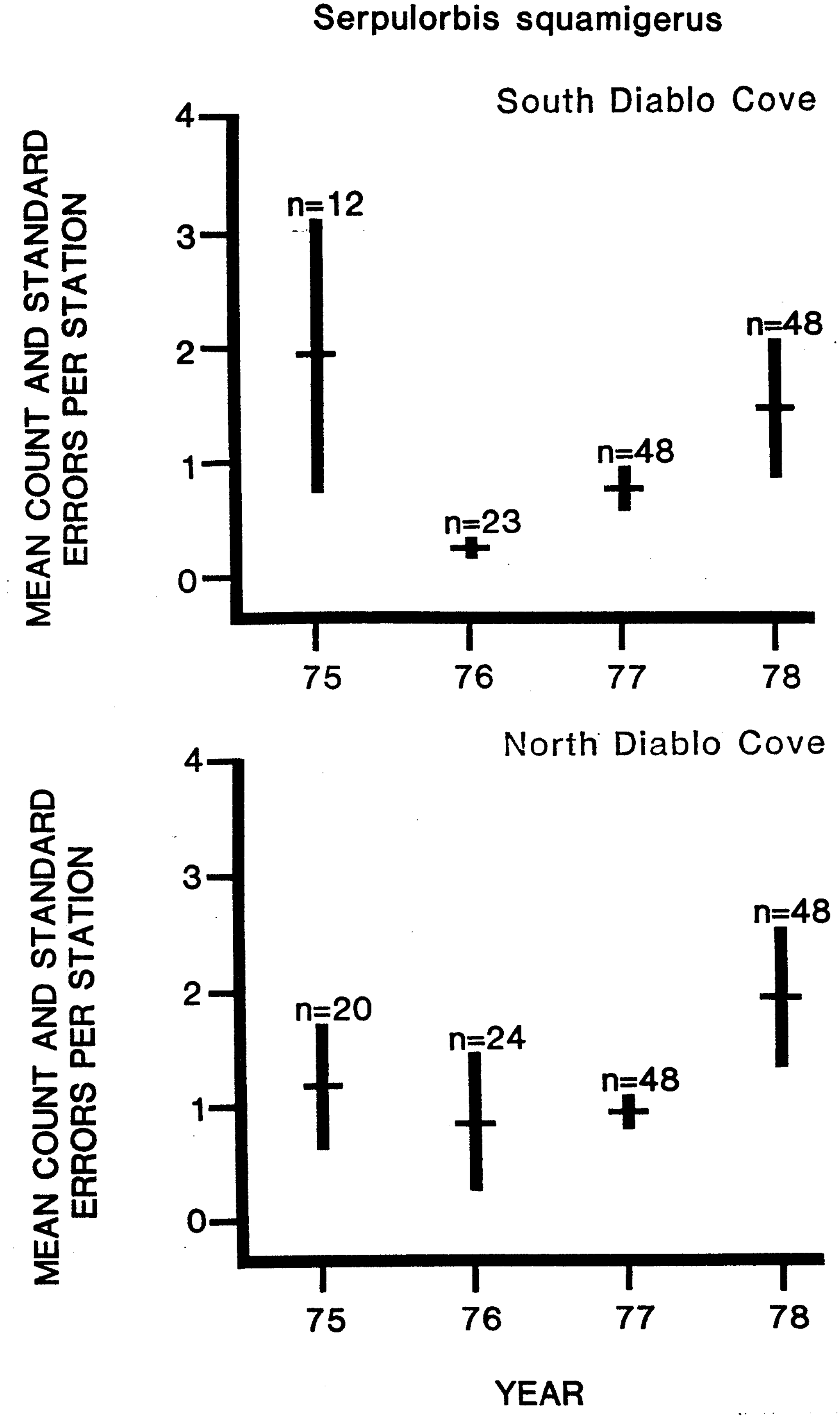


Figure 93. Mean counts and standard errors per station for Serpulorbis squamigerus at subtidal random quadrat stations in South Diablo Cove and North Diablo Cove. DCPP, 1975-1978.

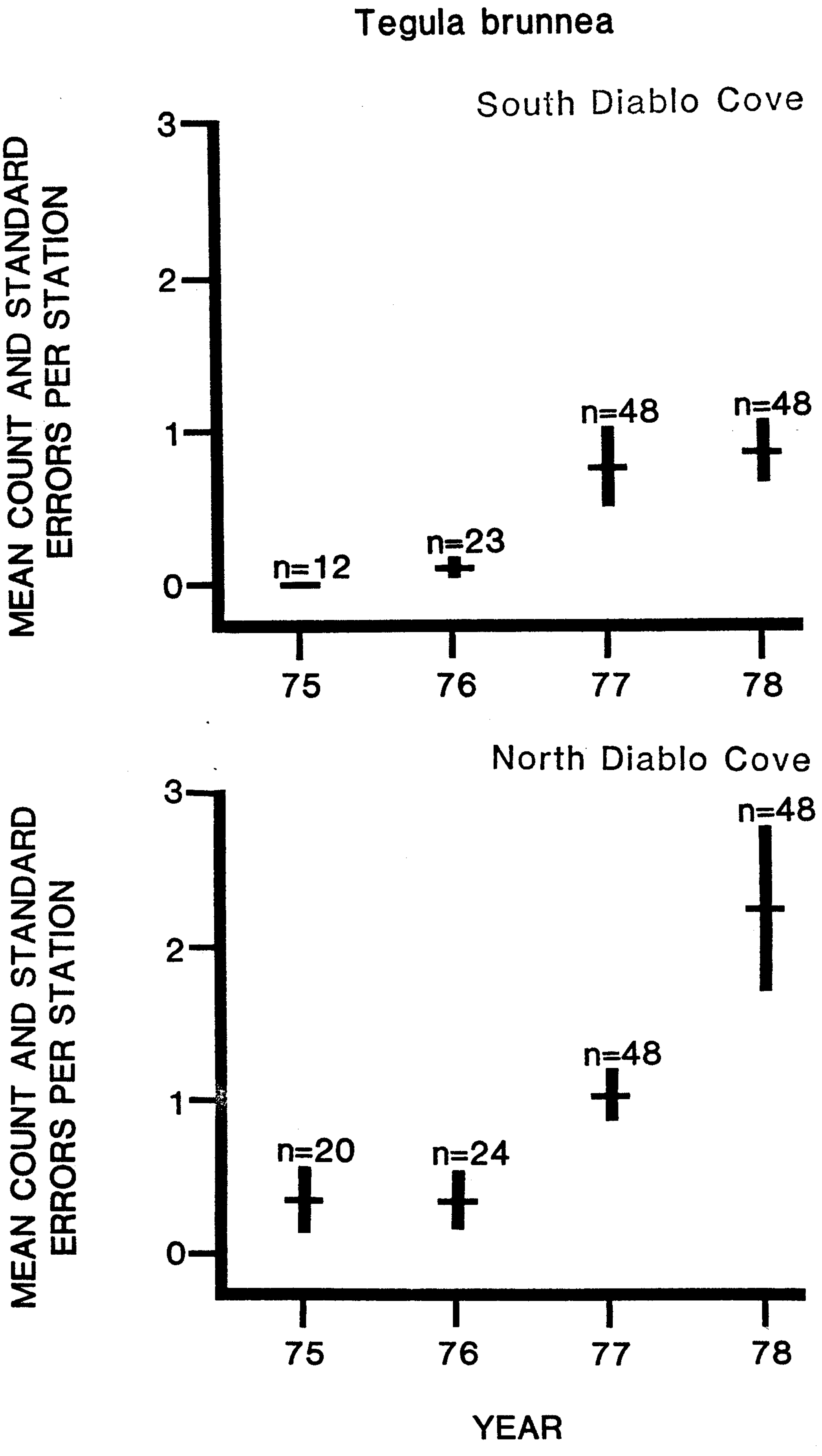


Figure 94. Mean counts and standard errors per station for Tegula brunnea at subtidal random quadrat stations in South Diablo Cove and North Diablo Cove. DCPP, 1975-1978.

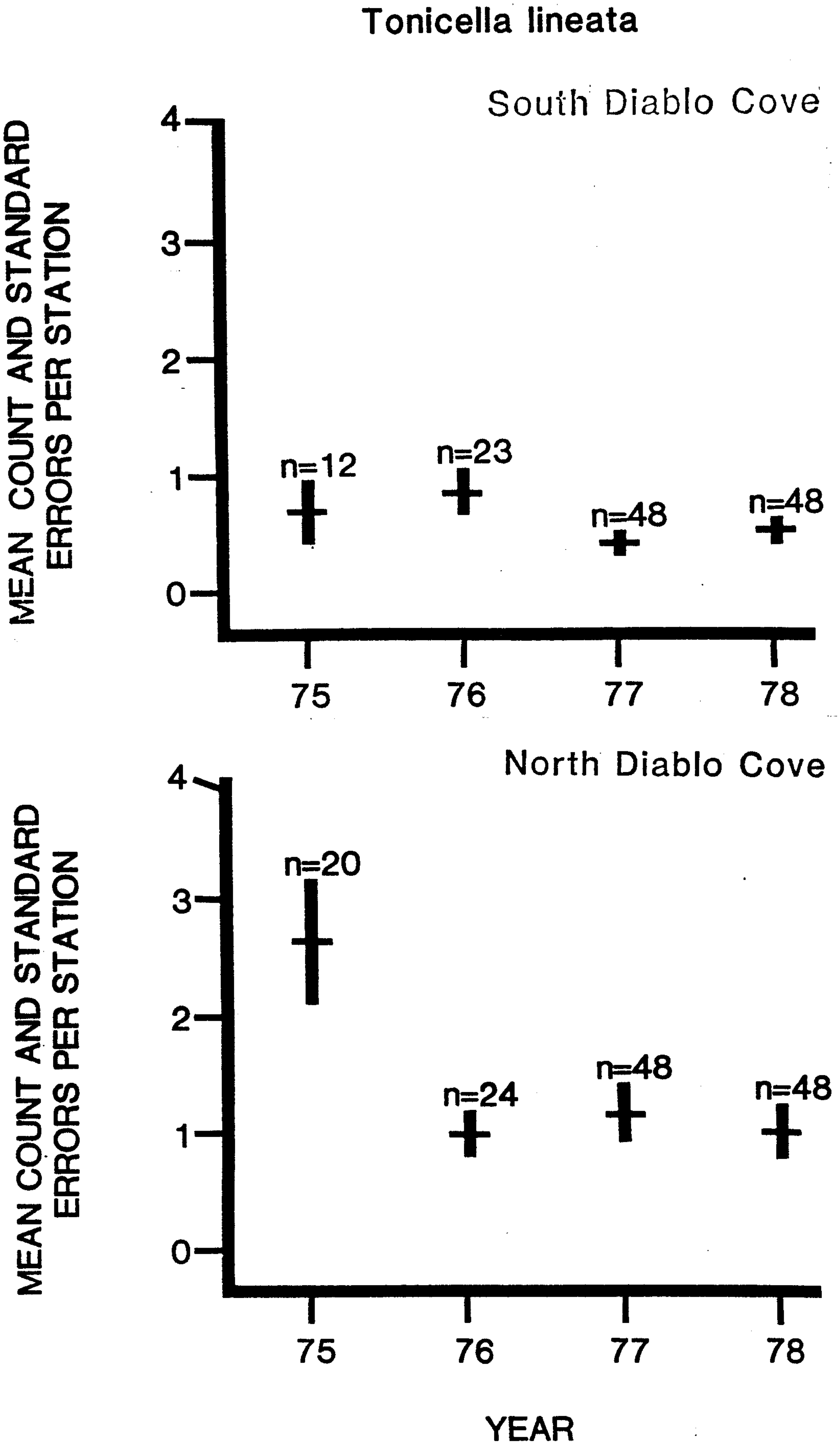


Figure 95. Mean counts and standard errors per station for Tonicella lineata at subtidal random arc stations in South Diablo Cove and North Diablo Cove. DCPP, 1974-1977.

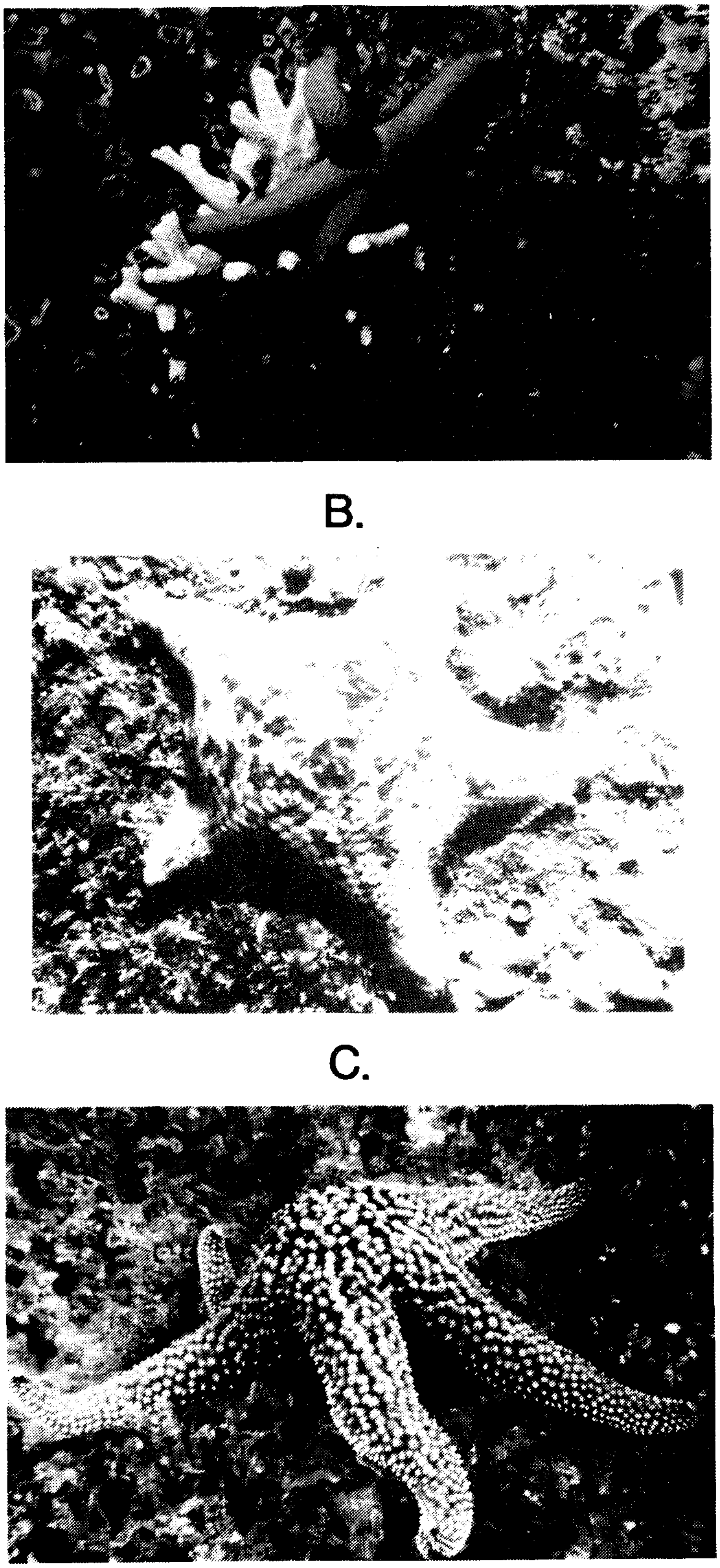


Figure 96. A. Henricia leviuscula, B. Pateria miniata, C. Pisaster giganteus. (Photos by Daniel W. Gotshall).

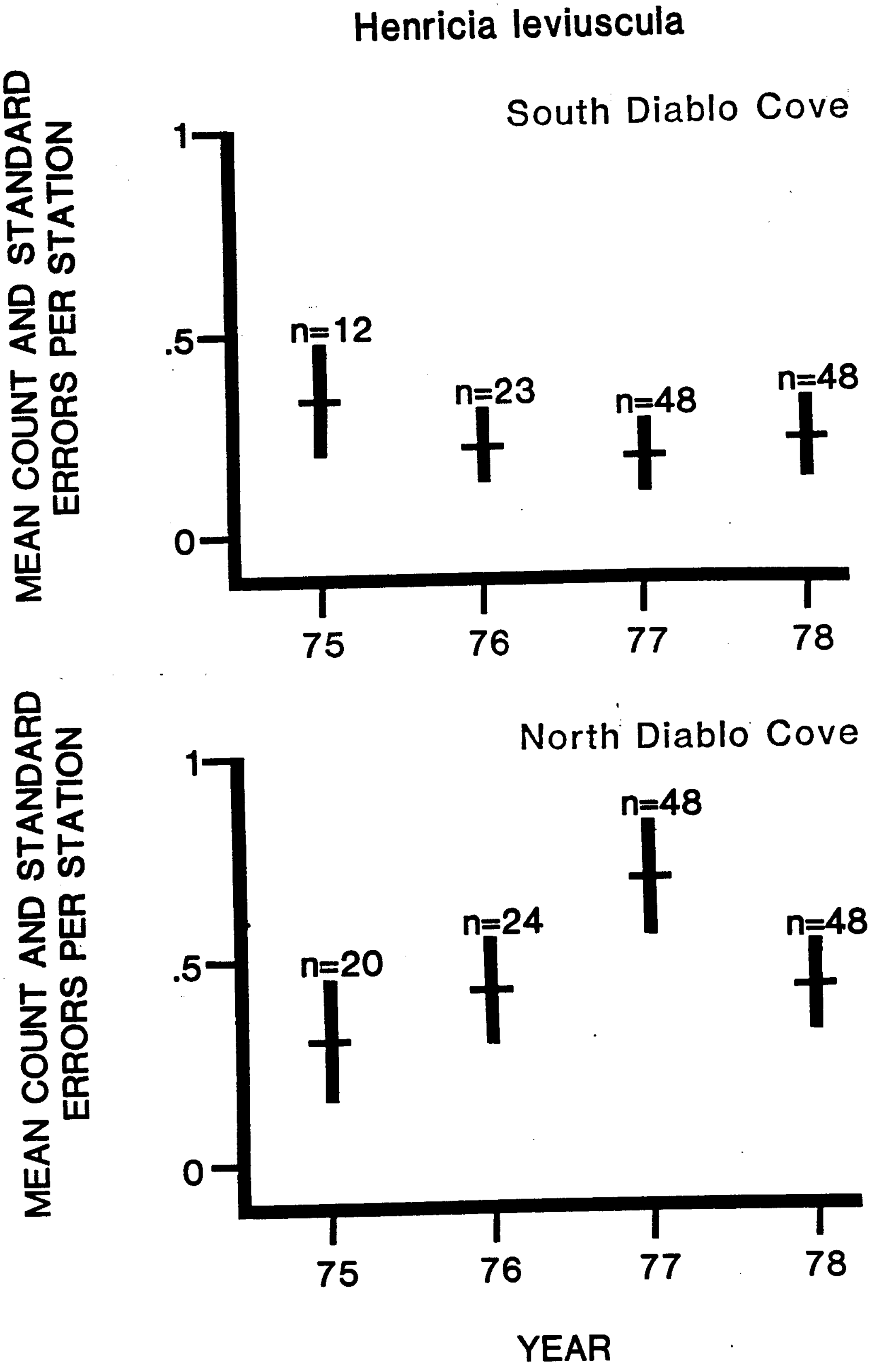


Figure 97. Mean counts and standard errors per station for <u>Henricia leviuscula</u> at subtidal random quadrat stations in South Diablo Cove and North Diablo Cove. DCPP, 1975-1978.

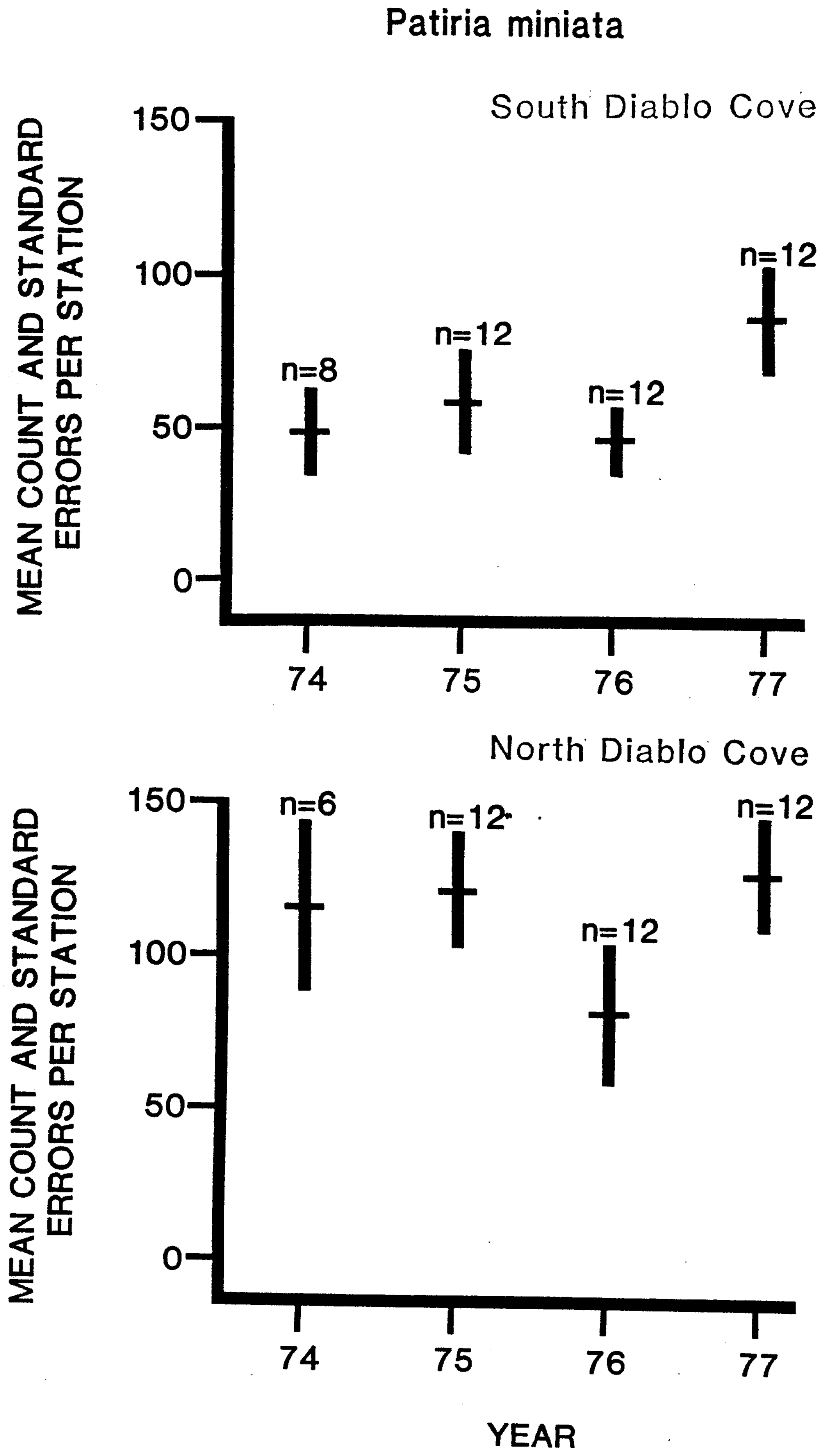


Figure 98. Mean counts and standard errors per station for Patiria miniata at subtidal random arc stations in South Diablo Cove and North Diablo Cove. DCPP, 1974-1977.

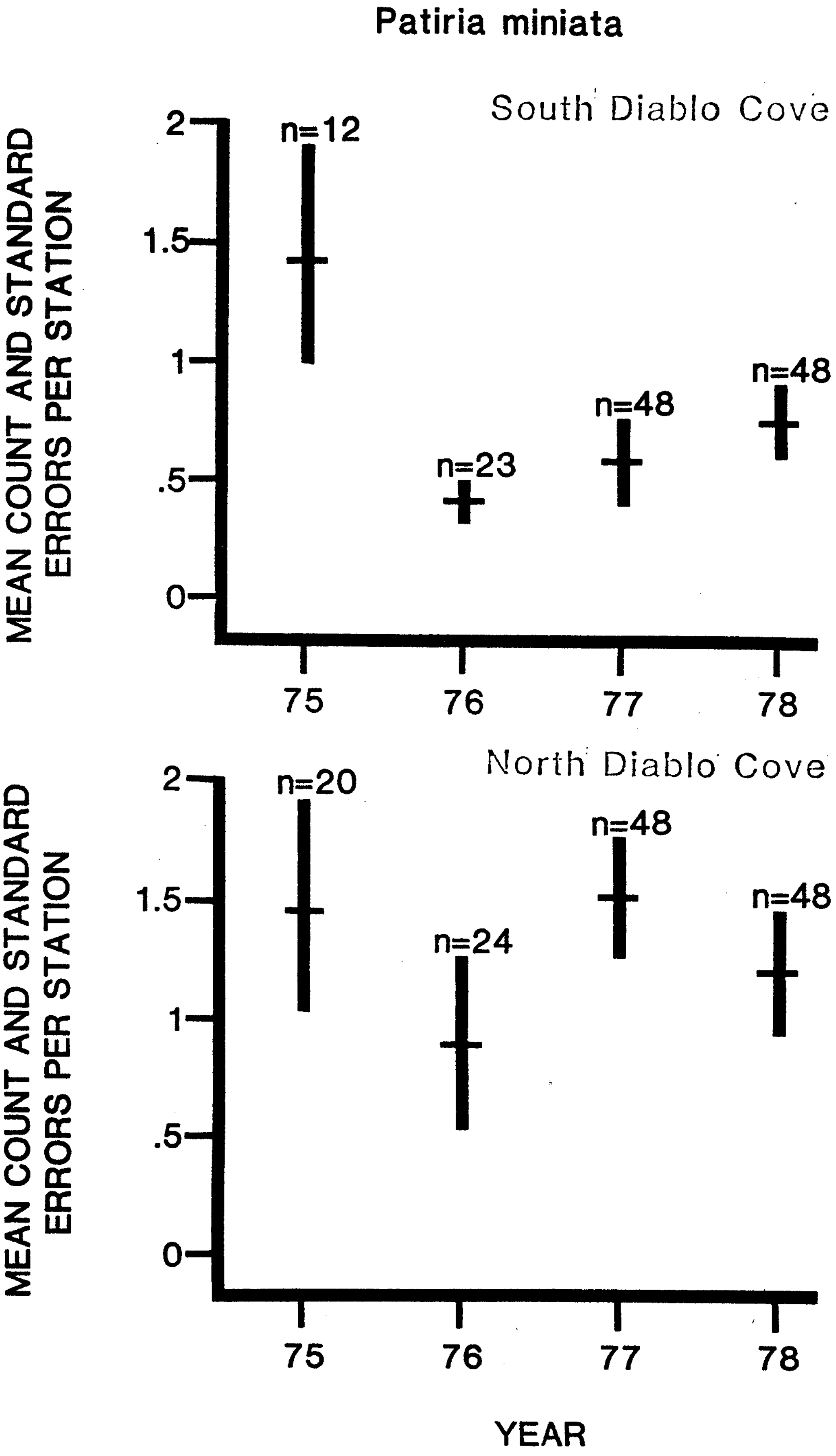


Figure 99. Mean counts and standard errors per station for Patiria miniata at subtidal random quadrat stations in South Diablo Cove and North Diablo Cove. DCPP, 1975-1978.

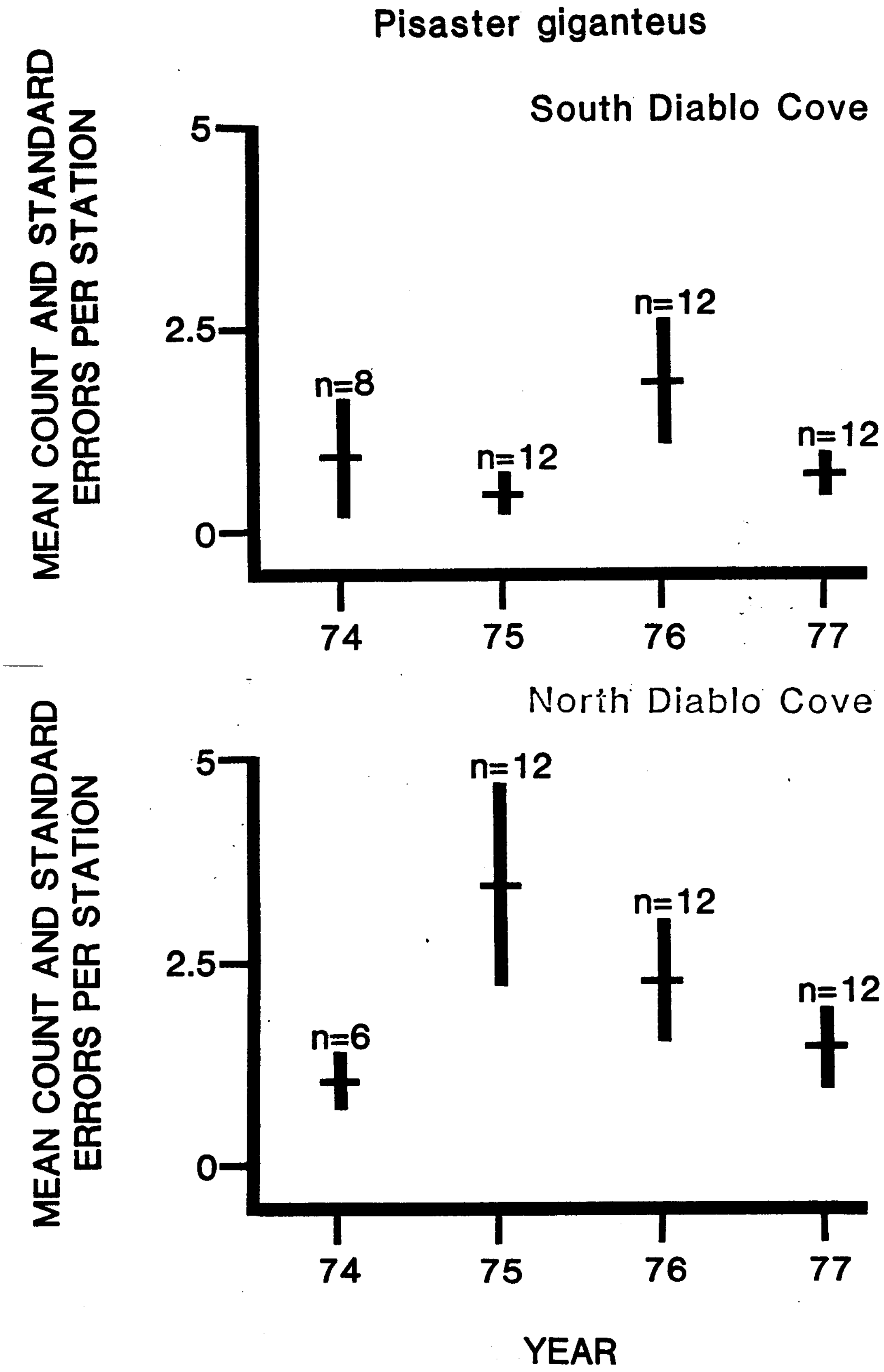


Figure 100. Mean counts and standard errors per station for Pisaster giganteus at subtidal random arc stations in South Diablo Cove and North Diablo Cove. DCPP, 1974-1977.

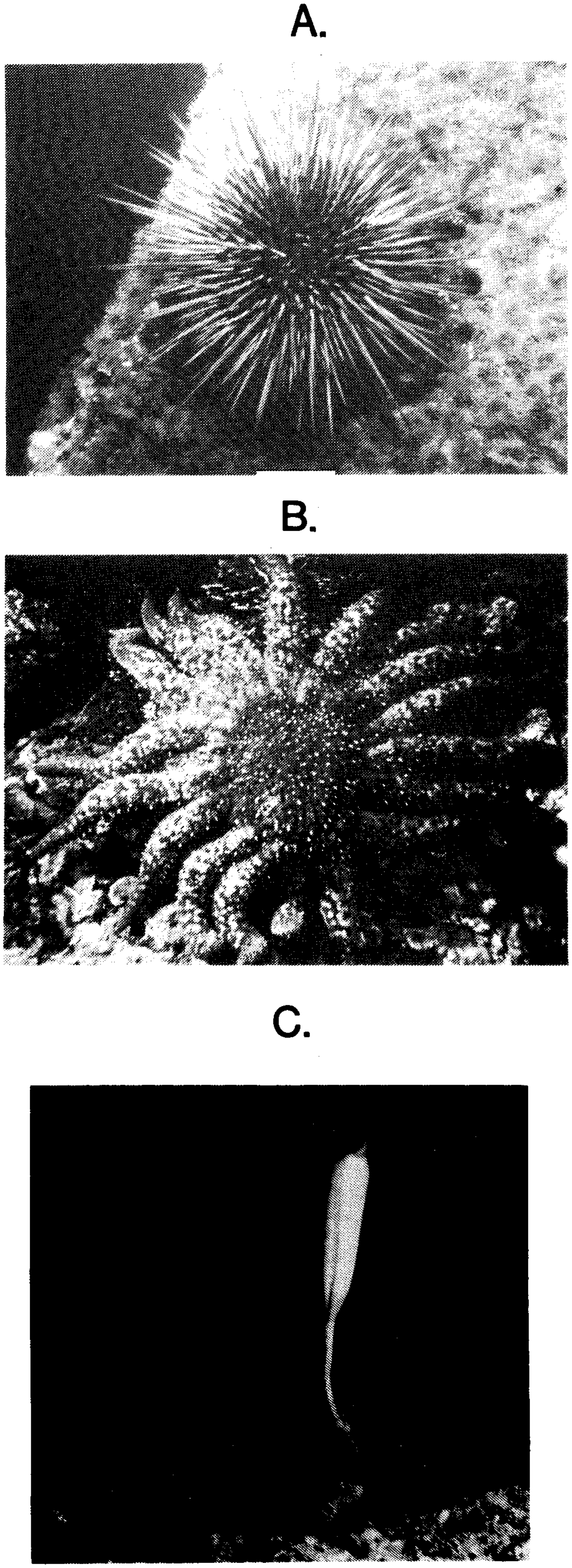


Figure 101. A. Strongylocentrotus franciscanus, B. Pycnopodia helianthoides, C. Styela montereyensis. (Photos by Daniel W. Gotshall).

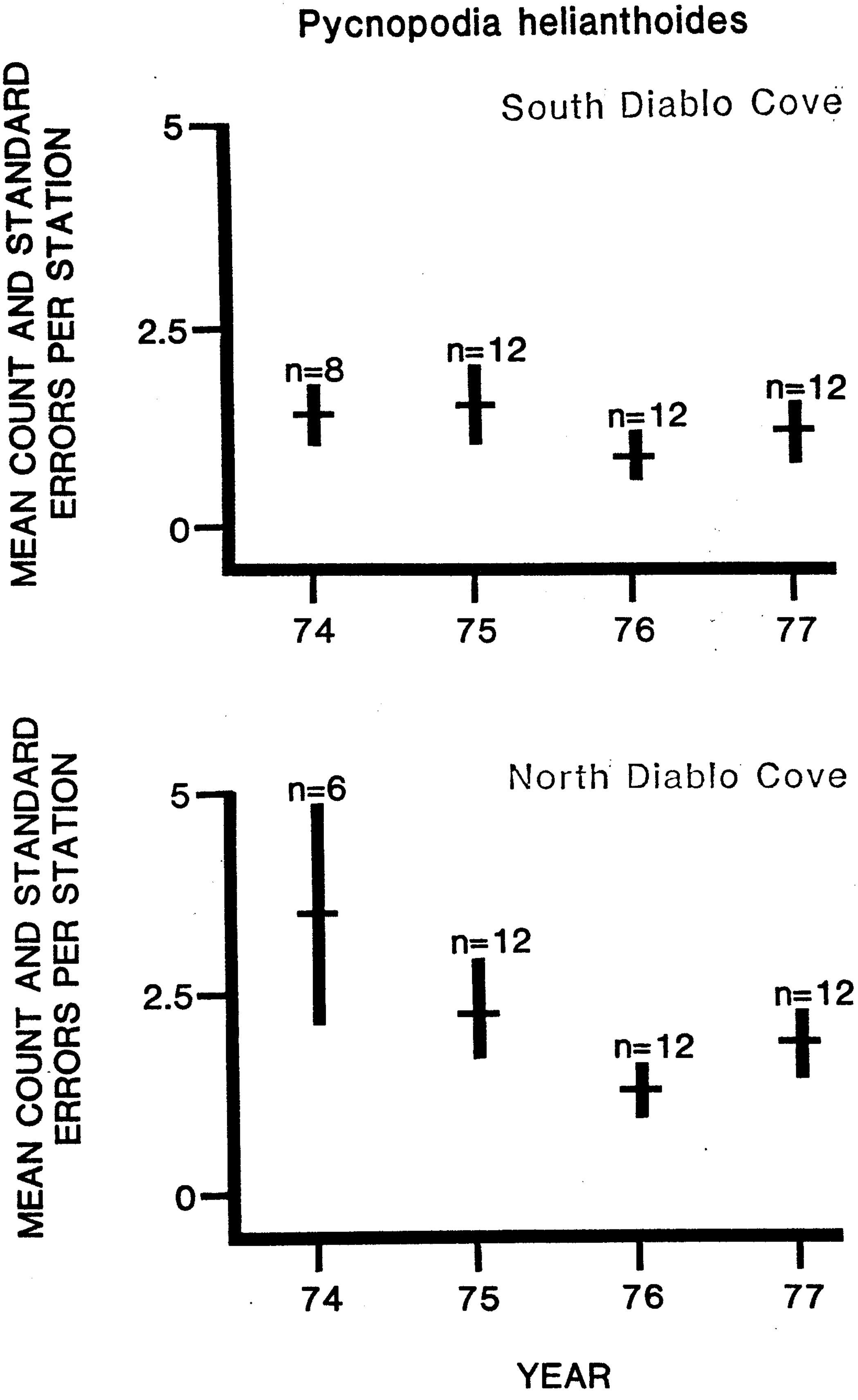


Figure 102. Mean counts and standard errors per station for <u>Pycnopodia helianthoides</u> at subtidal random arc stations in South Diablo Cove and North Diablo Cove. DCPP, 1974-1977.

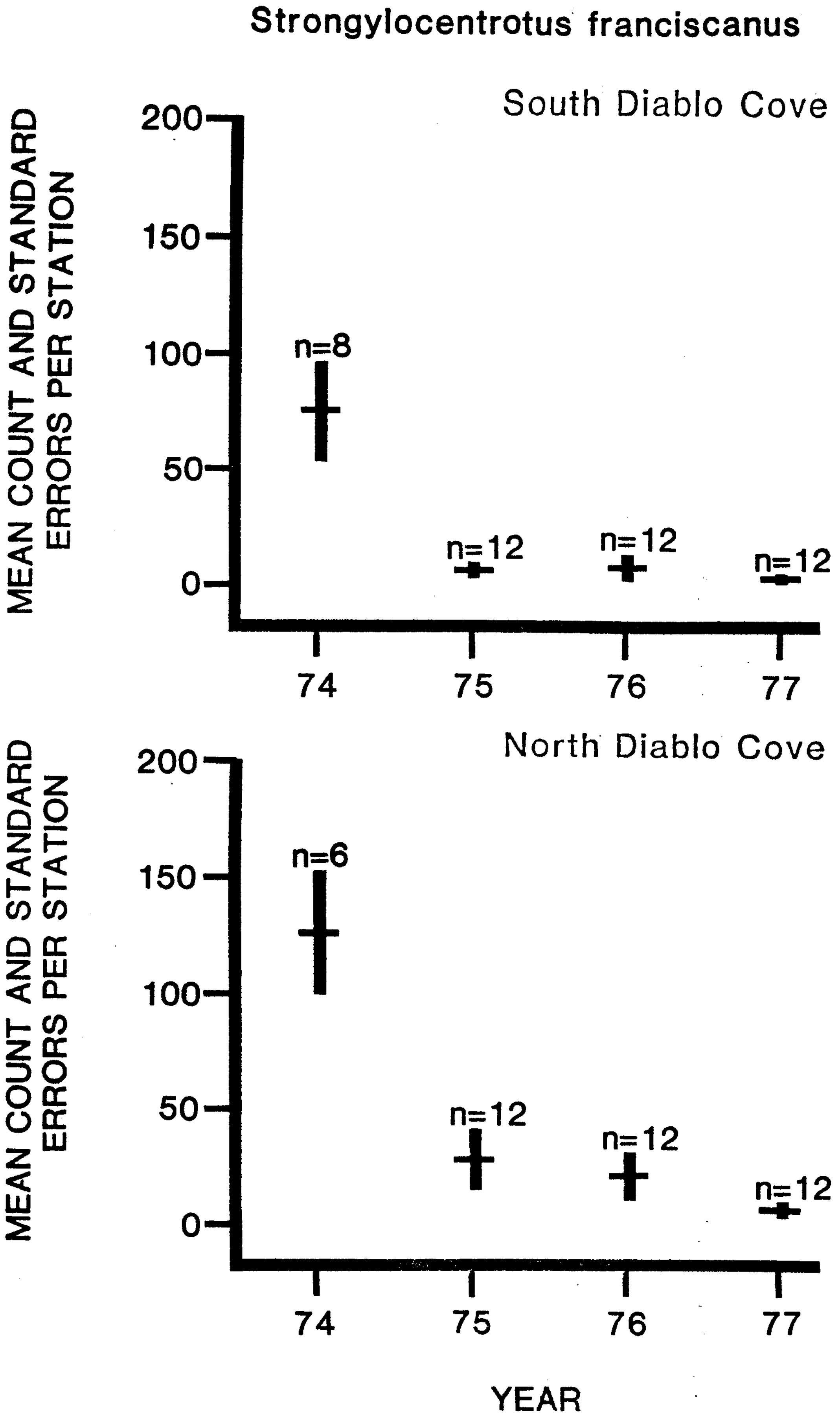


Figure 103. Mean counts and standard errors per station for Strongylocentrotus franciscanus at subtidal random arc stations in South Diablo Cove and North Diablo Cove. DCPP, 1974-1977.

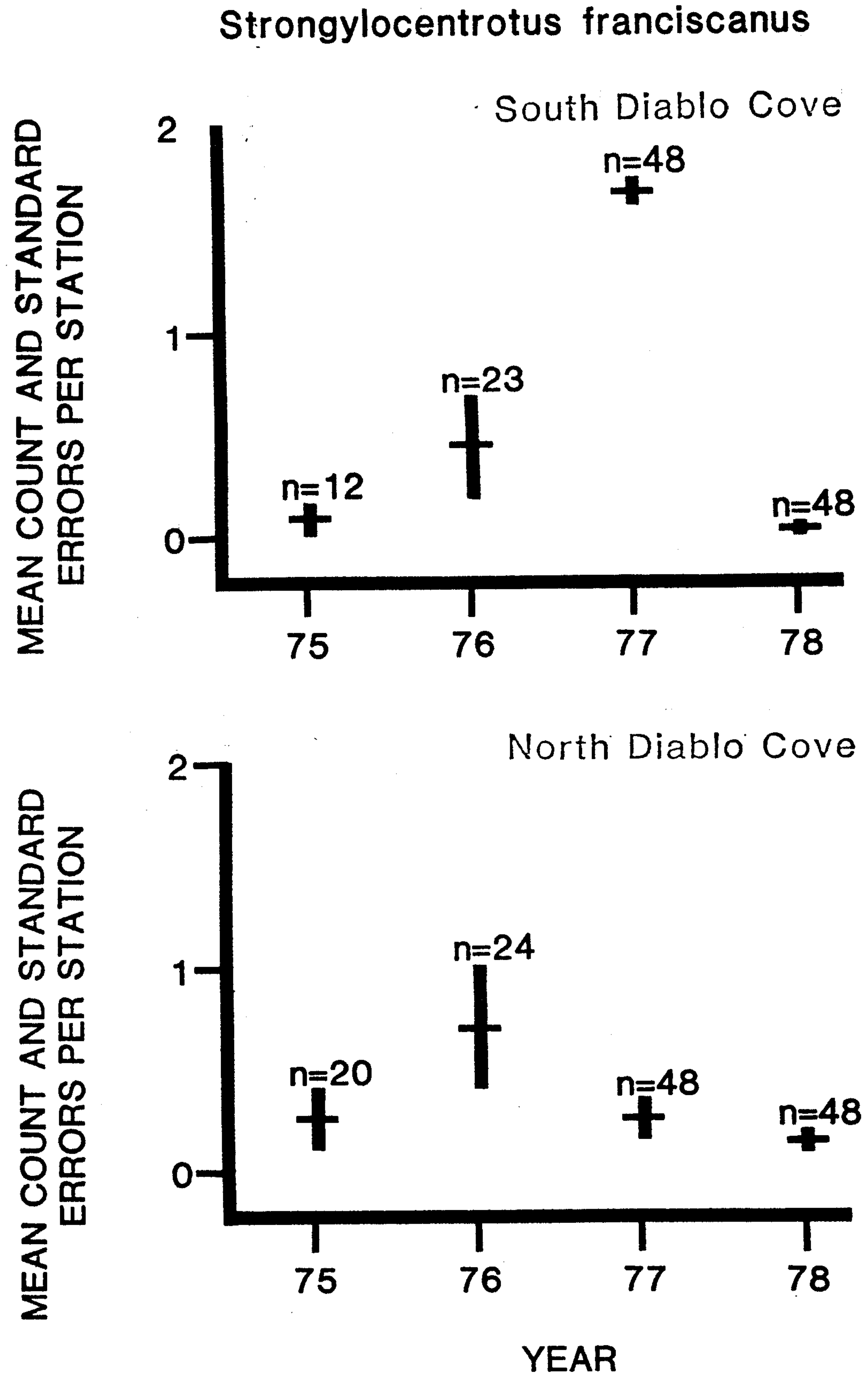


Figure 104. Mean counts and standard errors per station for Strongylocentrotus franciscanus at subtidal random quadrat stations in South Diablo Cove and North Diablo Cove. DCPP, 1975-1978.

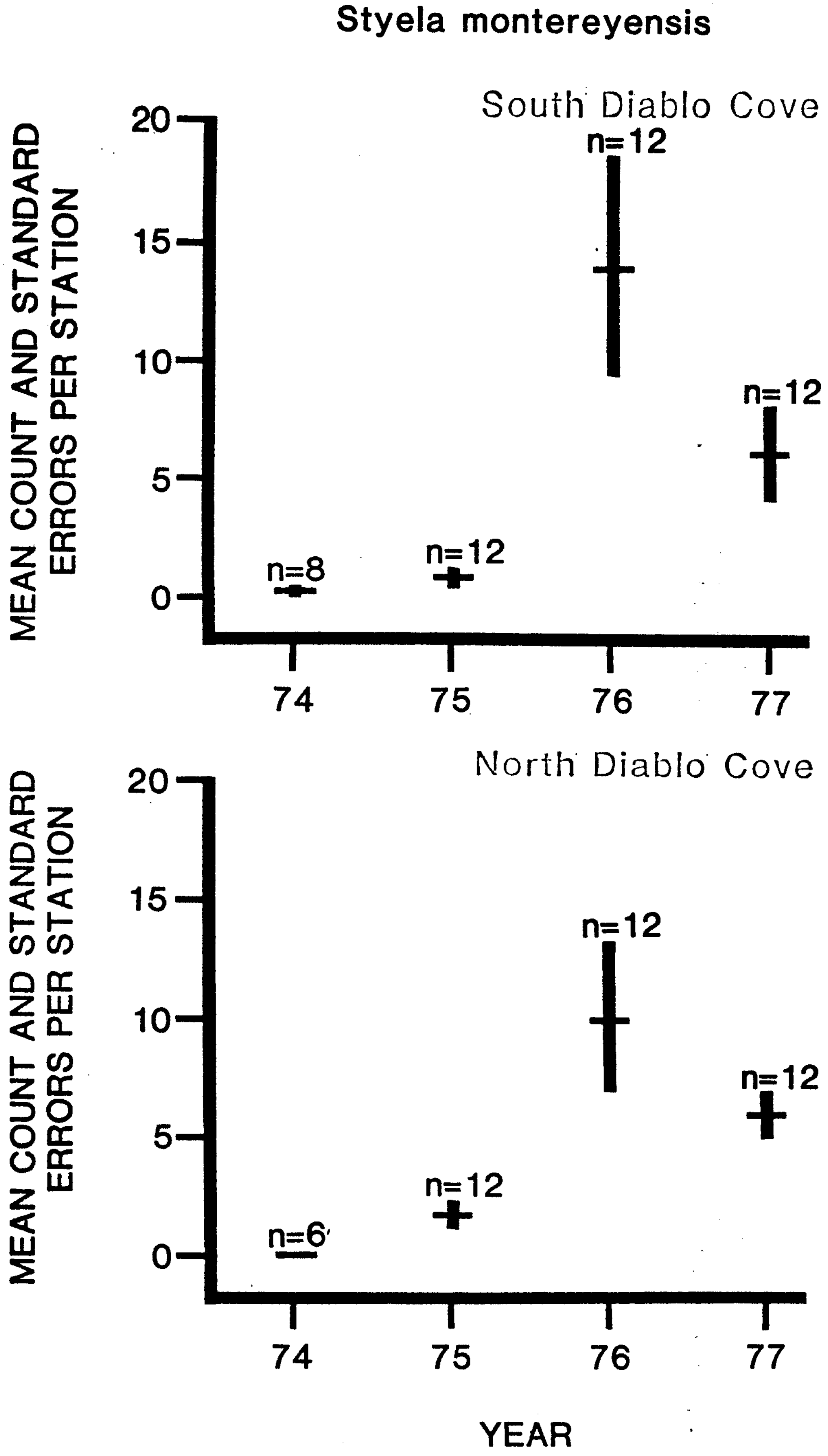


Figure 105. Mean counts and standard errors per station for Styela montereyensis at subtidal random arc stations in South Diablo Cove and North Diablo Cove. DCPP, 1974-1977.

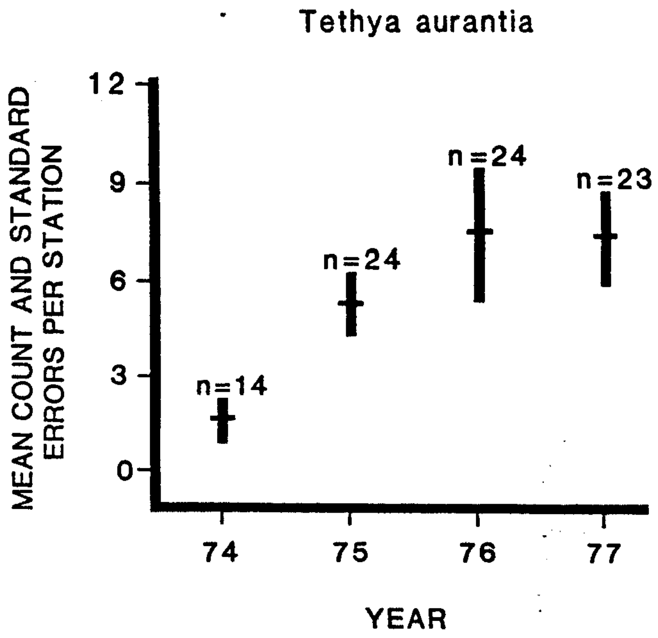


Figure 106. Mean counts and standard errors for Tethya aurantia at subtidal random arc stations in North Control. DCPP, 1974-1977.

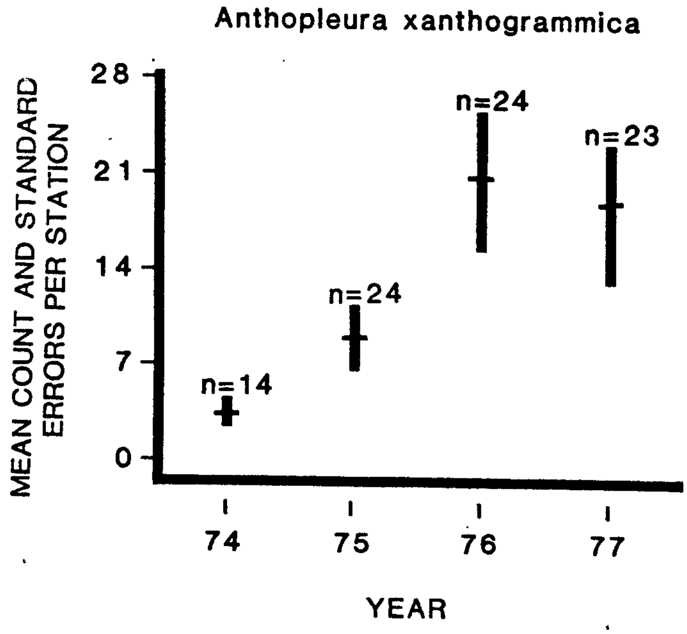


Figure 107. Mean counts and standard errors for Anthopleura xanthogrammica at subtidal random arc stations in North Control. DCPP, 1974-1977.

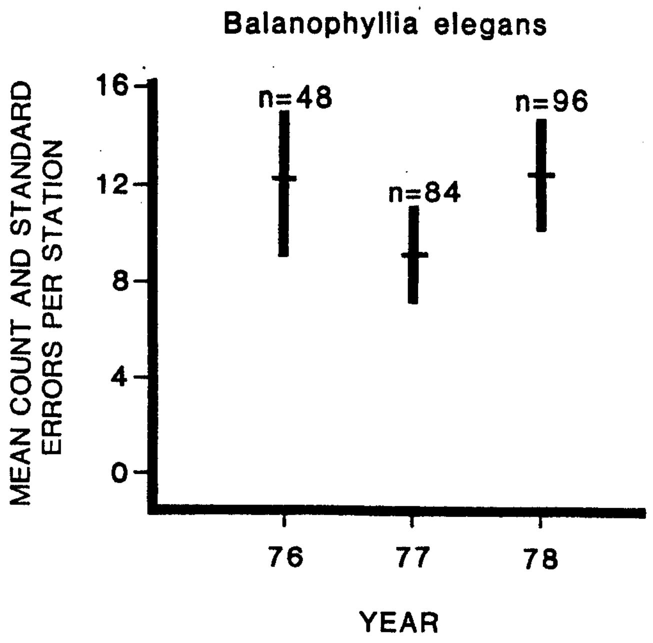


Figure 108. Mean counts and standard errors for Balanophyllia elegans at subtidal random quadrat stations in North Control. DCPP, 1976-1978.

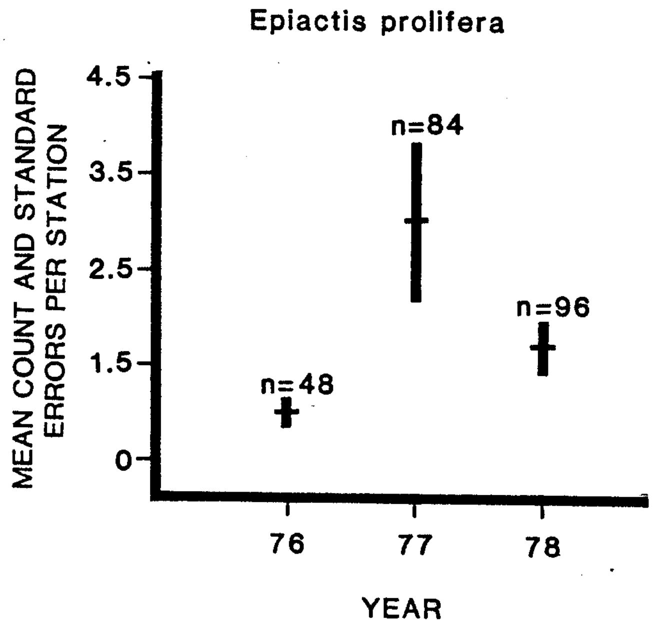


Figure 109. Mean counts and standard errors for Epiactis prolifera at subtidal random quadrat stations in North Control. DCPP, 1976-1978.

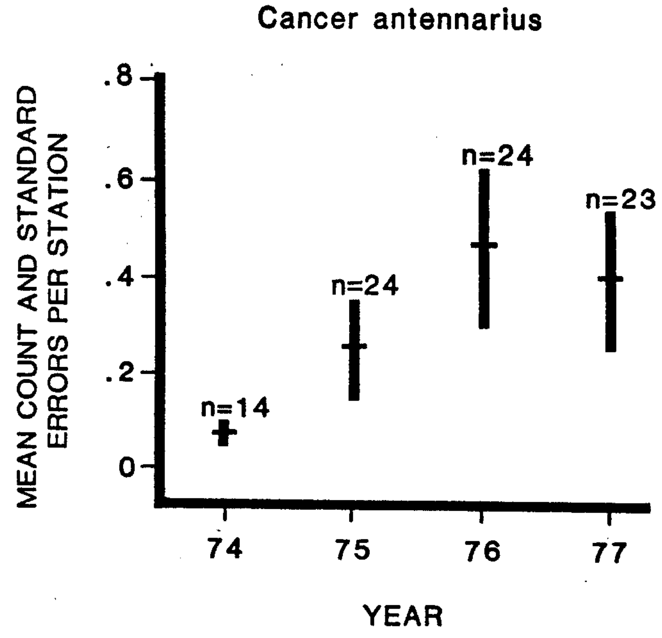


Figure 110. Mean counts and standard errors for Cancer antennarius at subtidal random arc stations in North Control. DCPP, 1974-1977.

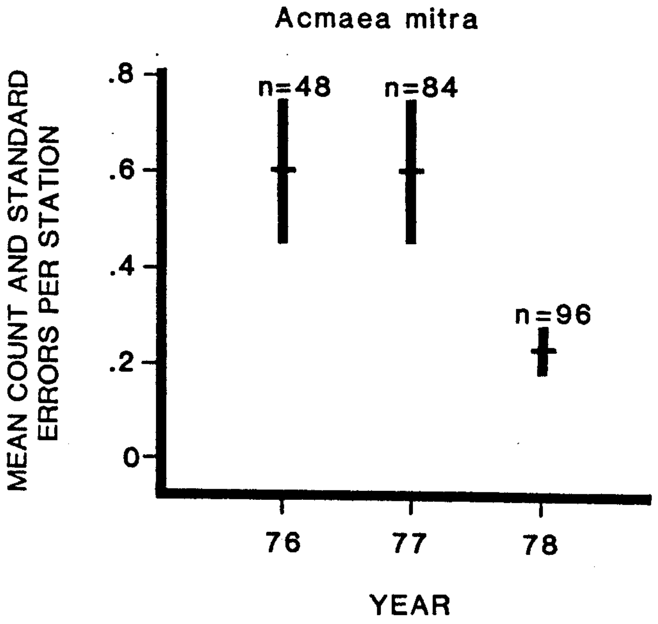


Figure 111. Mean counts and standard errors for Acmaea mitra at subtidal random quadrat stations in North Control. DCPP, 1976-1978.

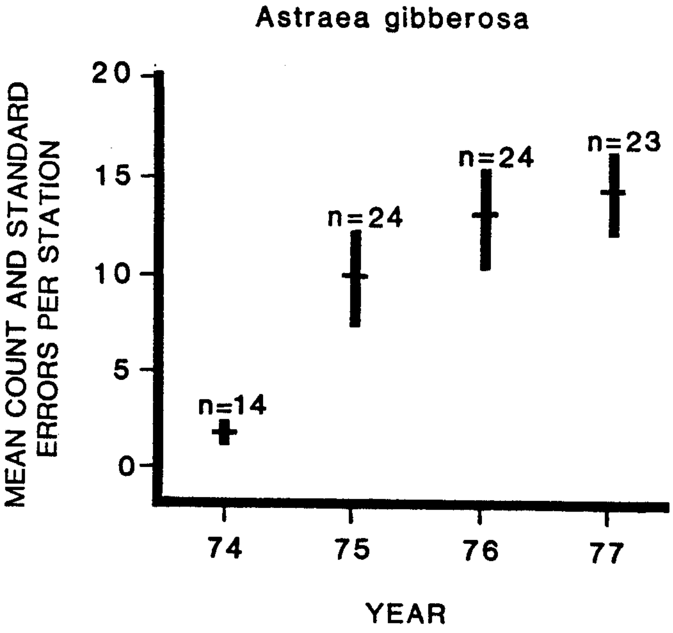


Figure 112. Mean counts and standard errors for Astraea gibberosa at subtidal random arc stations in North Control. DCPP, 1974-1977.

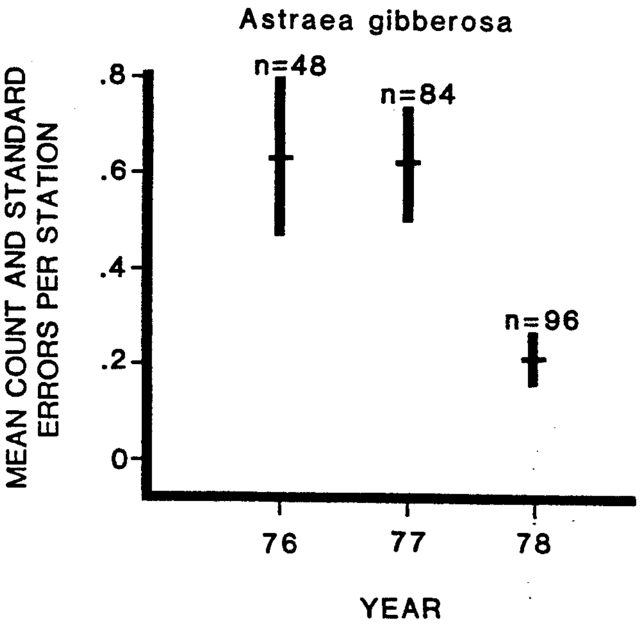


Figure 113. Mean counts and standard errors for Astraea gibberosa at subtidal random quadrat stations in North Control. DCPP, 1976-1978.

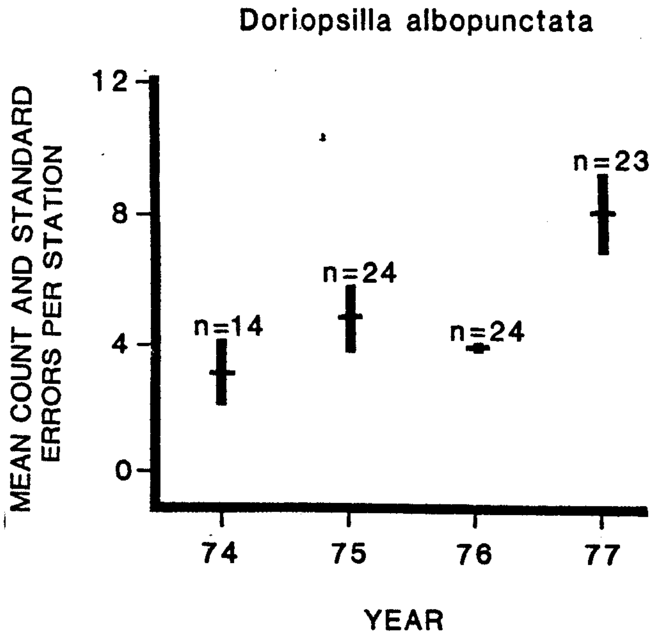


Figure 114. Mean counts and standard errors for Doriopsilla albopunctata at subtidal random arc stations in North Control. DCPP, 1974-1977.

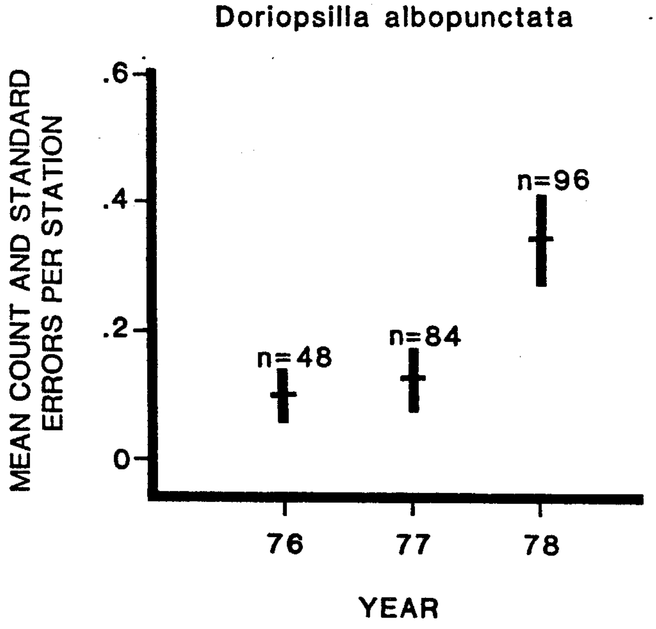


Figure 115. Mean counts and standard errors for Doriopsilla albopunctata at subtidal random quadrat stations in North Control. DCPP, 1976-1978.

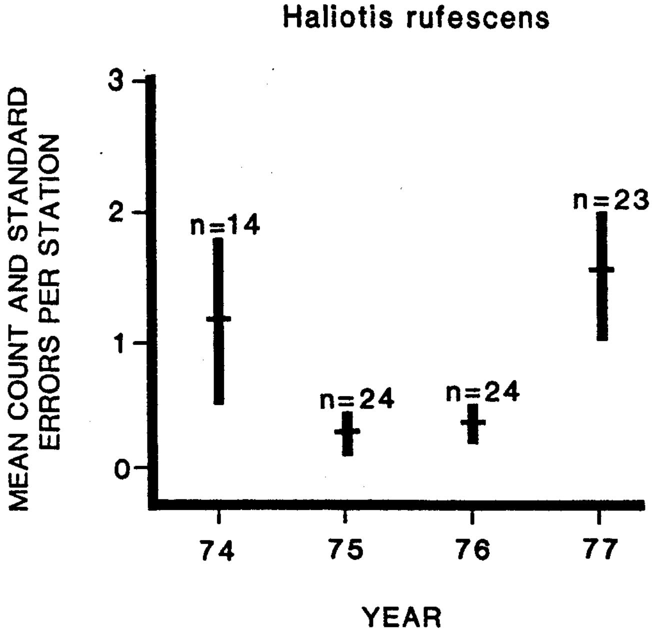


Figure 116. Mean counts and standard errors for Haliotis rufescens at subtidal random arc stations in North Control. DCPP, 1974-1977.

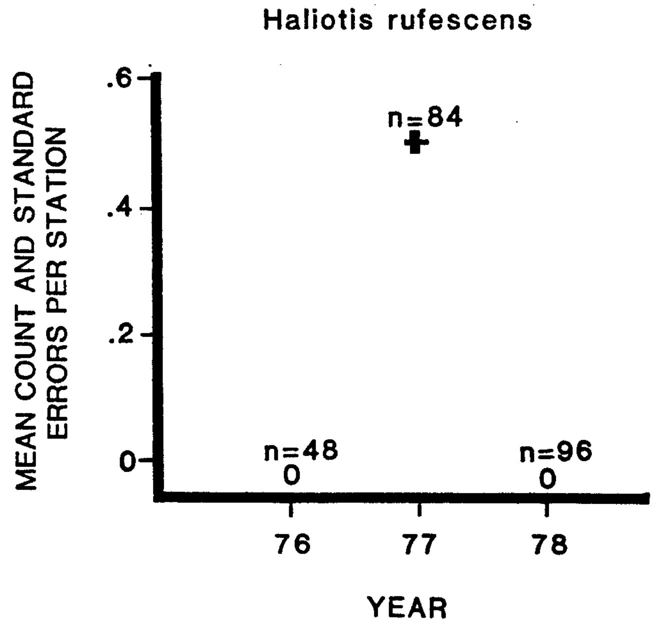


Figure 117. Mean counts and standard errors for Haliotis rufescens at subtidal random quadrat stations in North Control. DCPP, 1976-1978.

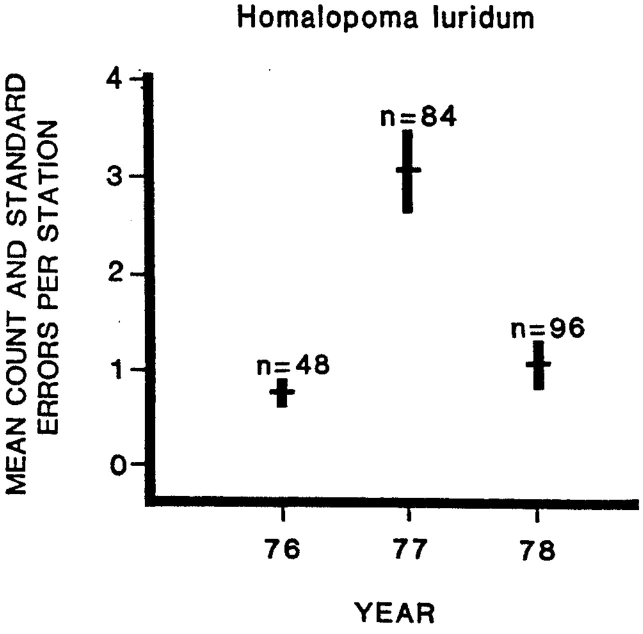


Figure 118. Mean counts and standard errors for Homalopoma luridum at subtidal random quadrat stations in North Control. DCPP, 1976-1978.

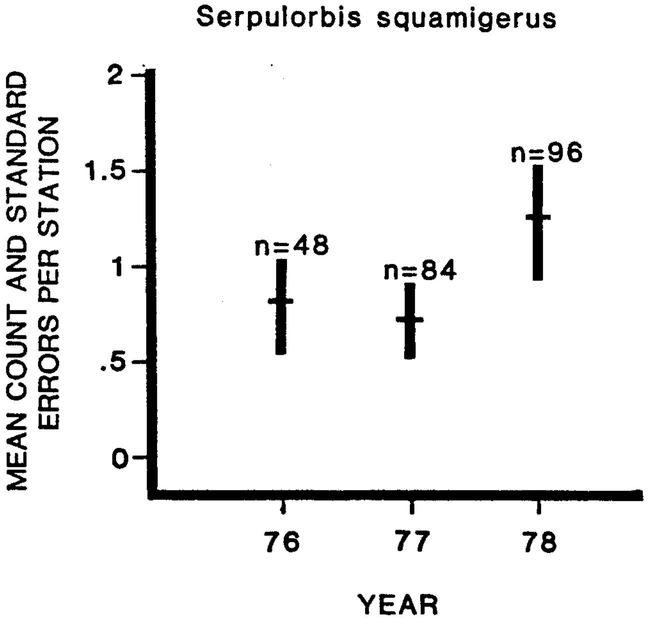


Figure 119. Mean counts and standard errors for Serpulorbis squamigerus at subtidal random quadrat stations in North Control. DCPP, 1976-1978.

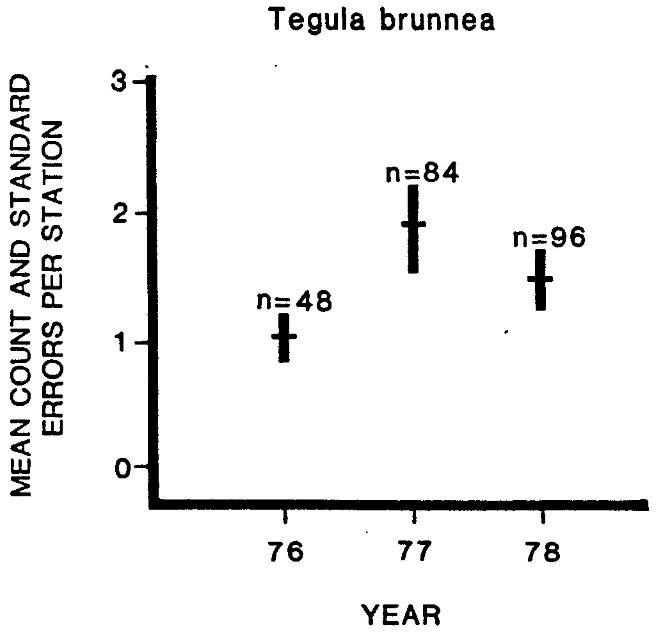


Figure 120. Mean counts and standard errors for Tegula brunnea at subtidal random quadrat stations in North Control. DCPP, 1976-1978.

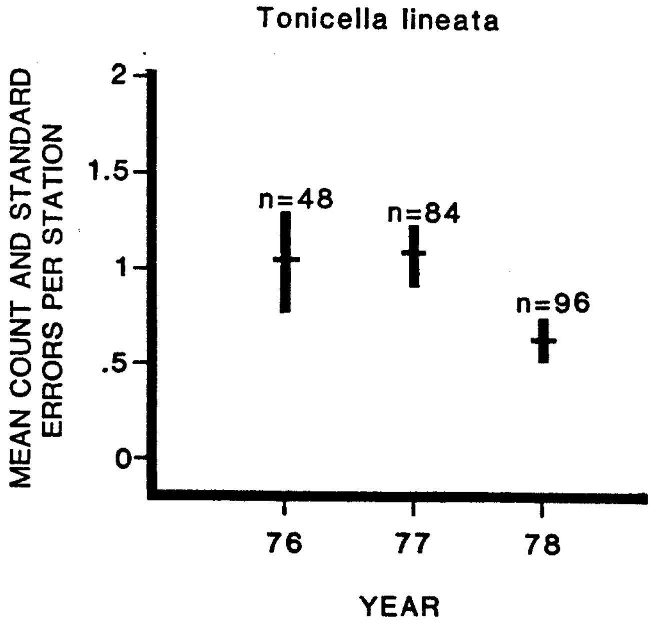


Figure 121. Mean counts and standard errors for Tonicella lineata at subtidal random quadrat stations in North Control. DCPP, 1976-1978.

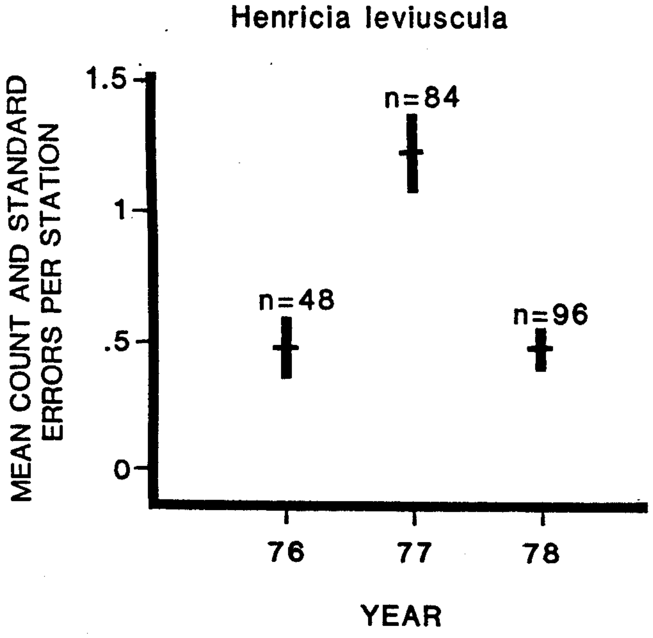


Figure 122. Mean counts and standard errors for Henricia leviuscula at subtidal random quadrat stations in North Control. DCPP, 1976-1978.

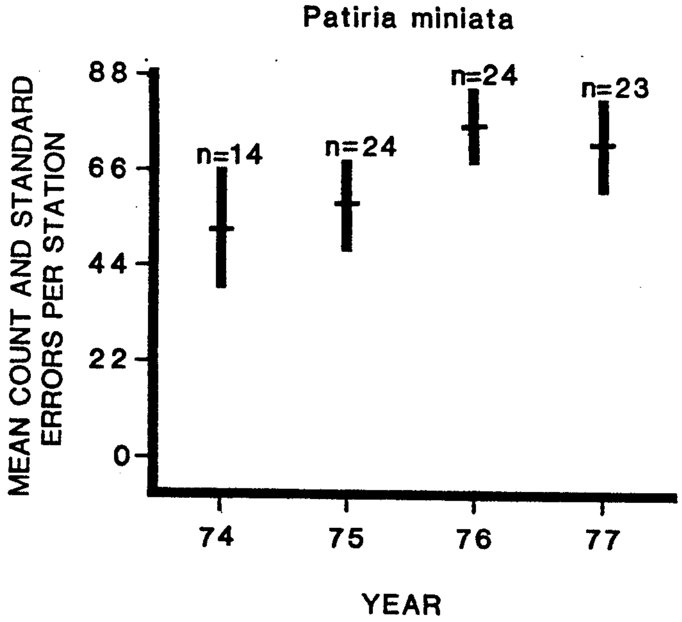


Figure 123. Mean counts and standard errors for Patiria miniata at subtidal random arc stations in North Control. DCPP, 1974-1977.

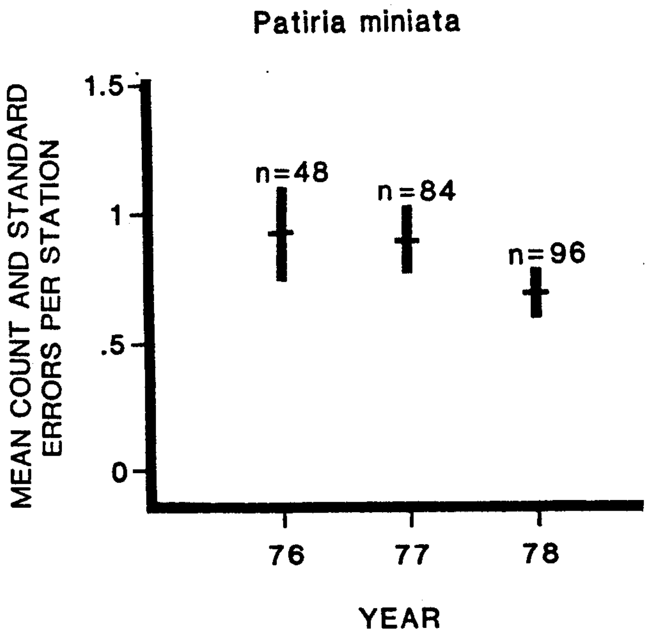


Figure 124. Mean counts and standard errors for Patiria miniata at subtidal random quadrat stations in North Control. DCPP, 1976-1978.

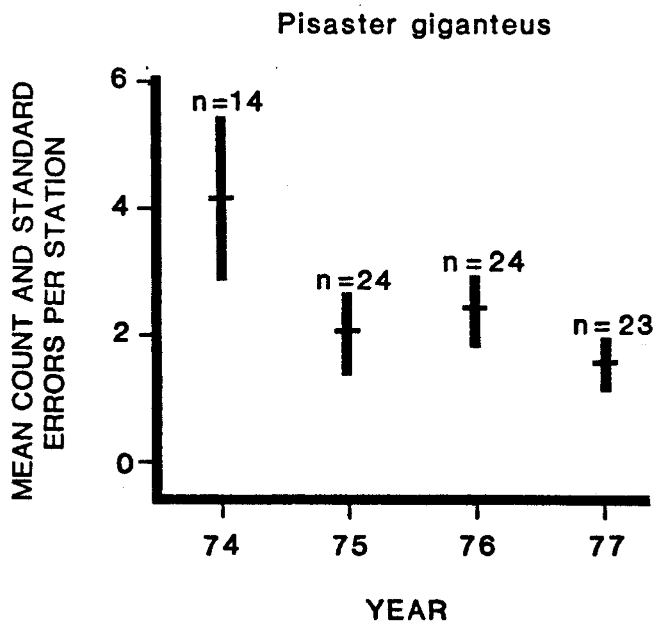


Figure 125. Mean counts and standard errors for Pisaster giganteus at subtidal random arc stations in North Control. DCPP, 1974-1977.

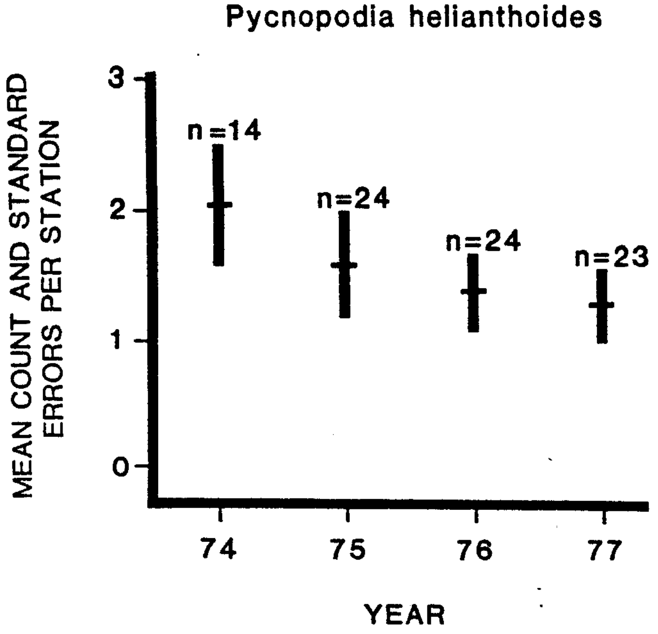


Figure 126. Mean counts and standard errors for Pycnopodia helianthoides at subtidal random arc stations in North Control. DCPP, 1974-1977.

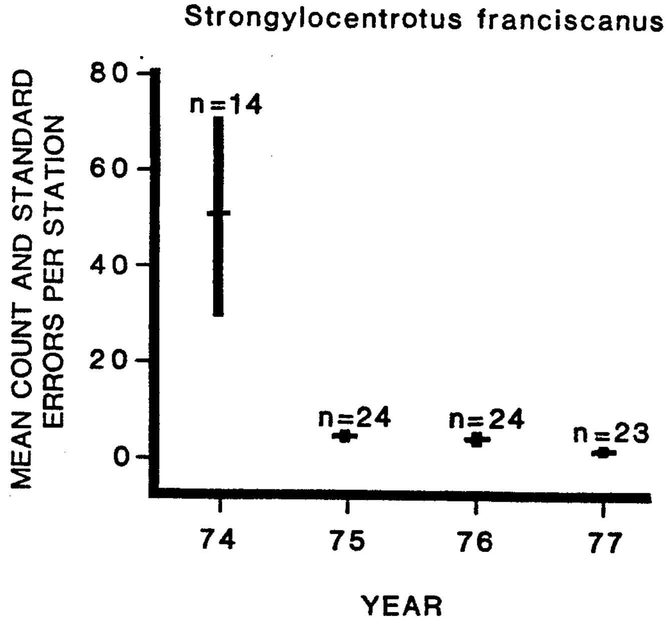


Figure 127. Mean counts and standard errors for Strongylocentrotus franciscanus at subtidal random arc stations in North Control. DCPP, 1974-1977.

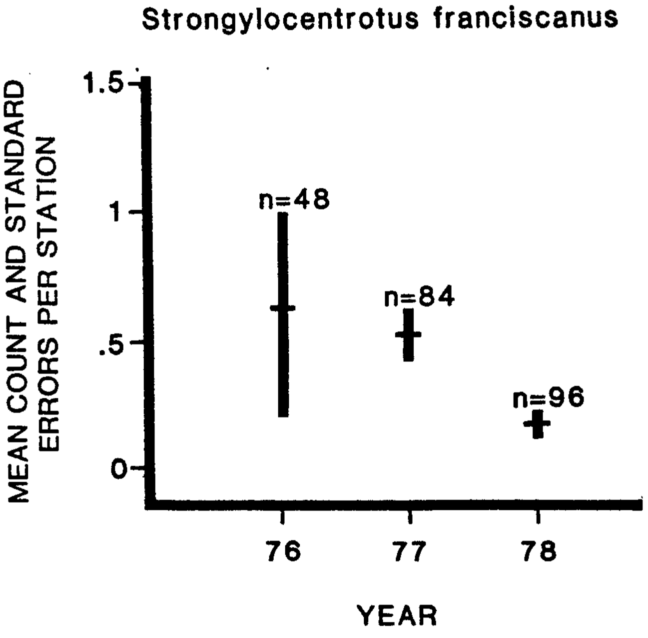


Figure 128. Mean counts and standard errors for Strongylocentrotus franciscanus at subtidal random quadrat stations in North Control. DCPP, 1976-1978.

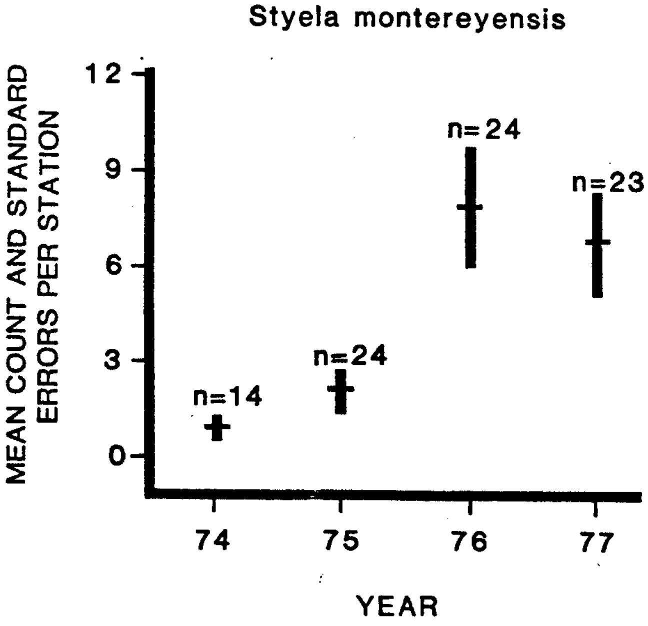


Figure 129. Mean counts and standard errors for Styela montereyensis at subtidal random arc stations in North Control. DCPP, 1974-1977.

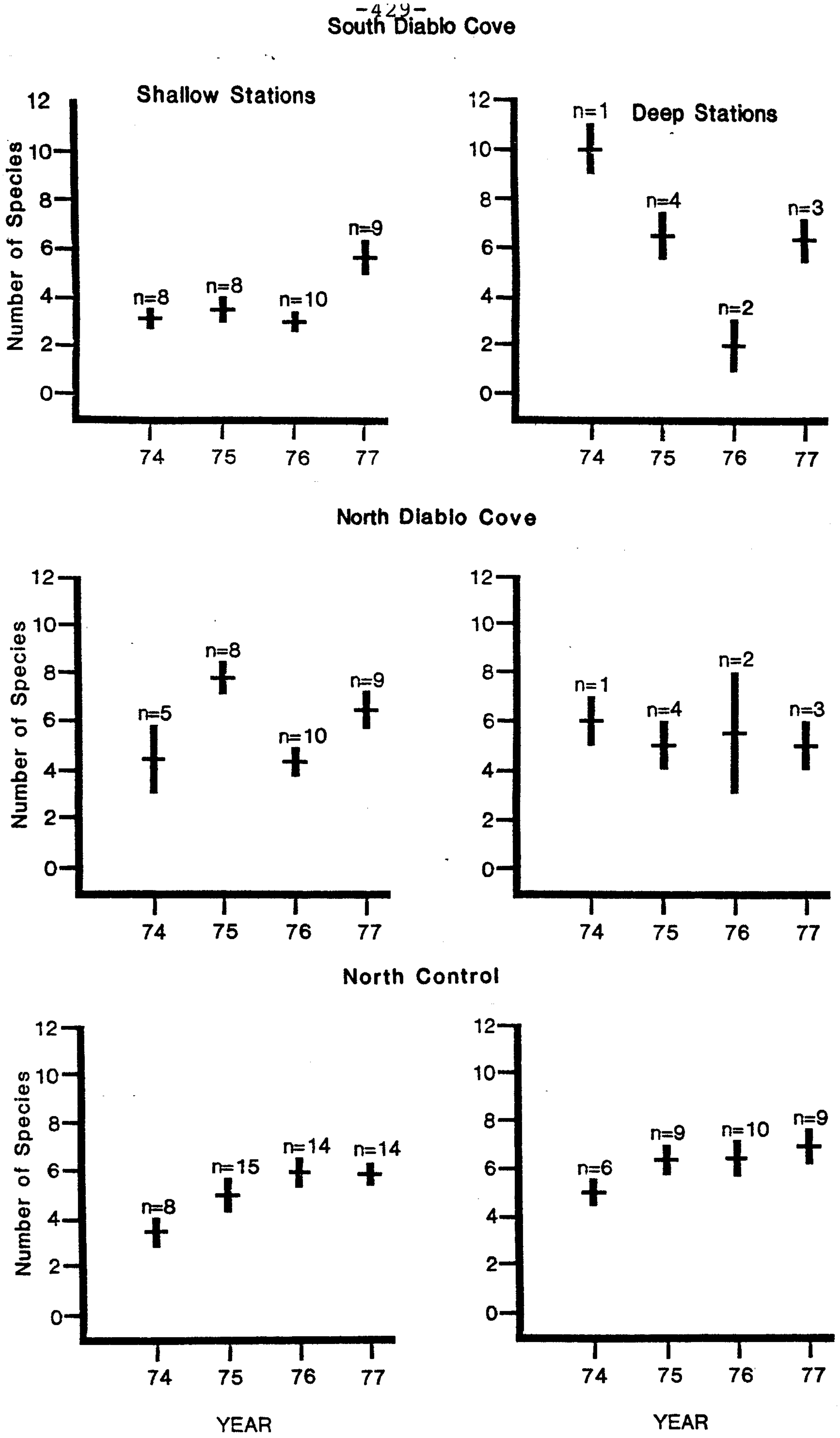


Figure 130. Mean number and standard errors of fish species per shallow (-07.6m) and deep (7.7-15.2m) subtidal random 30-m^2 arc stations in South Diablo Cove, North Diablo Cove, and North Control. DCPP, 1974-1977.

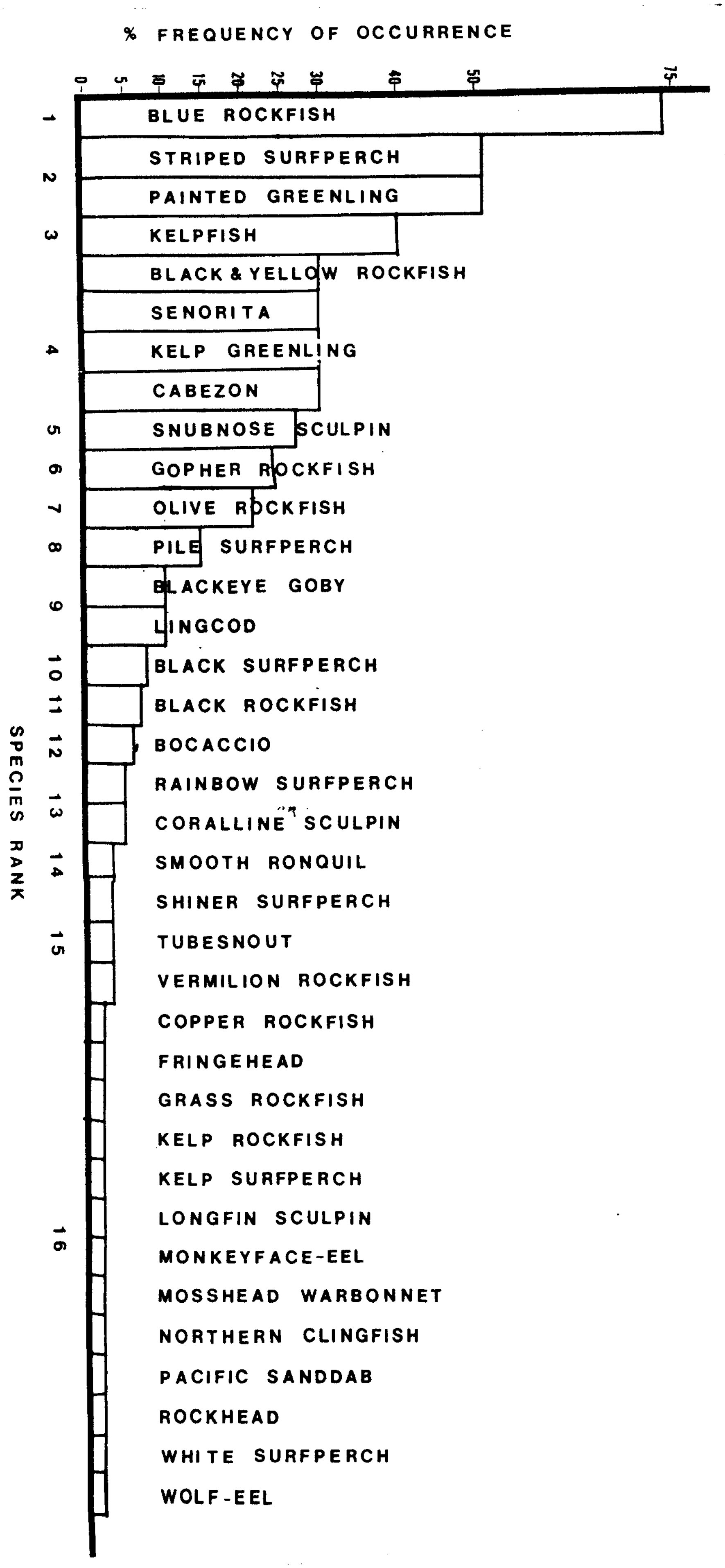


Figure 131. Percent frequency of occurrence and numerical ranks of fishes observed at subtidal random 30-m^2 arc stations in Diablo Cove. DCPP, 1974-1977.

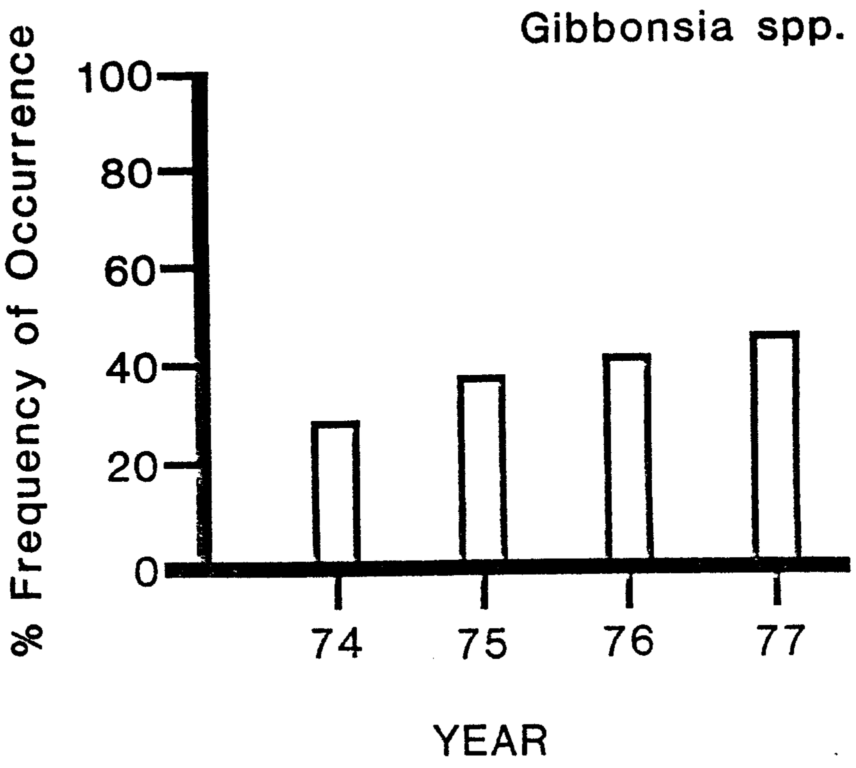


Figure 132. Percent frequency of occurrence of Gibbonsia spp. at subtidal random arc stations in Diablo Cove. DCPP, 1974-1977.

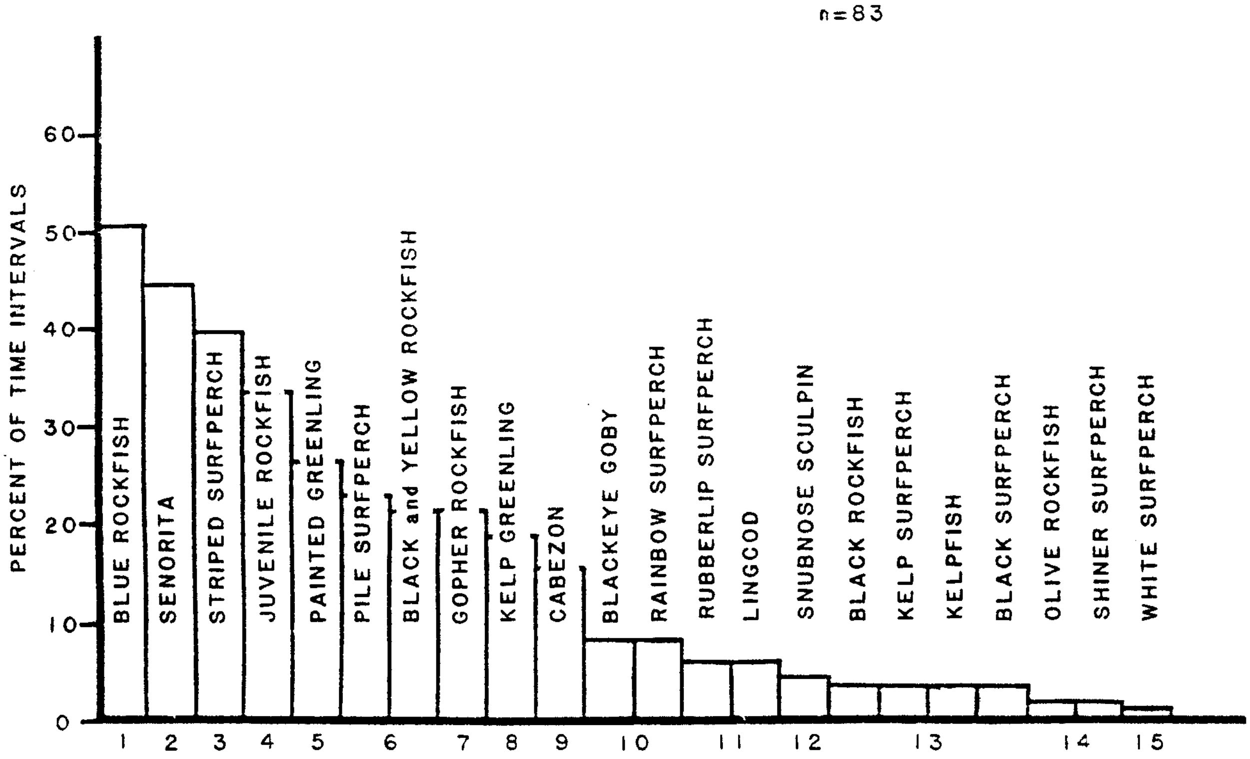


Figure 133. Percent frequency of occurrence (by time intervals) and numerical ranks fishes observed at the timed fish species count stations in Diablo Cove. DCPP, 1978.

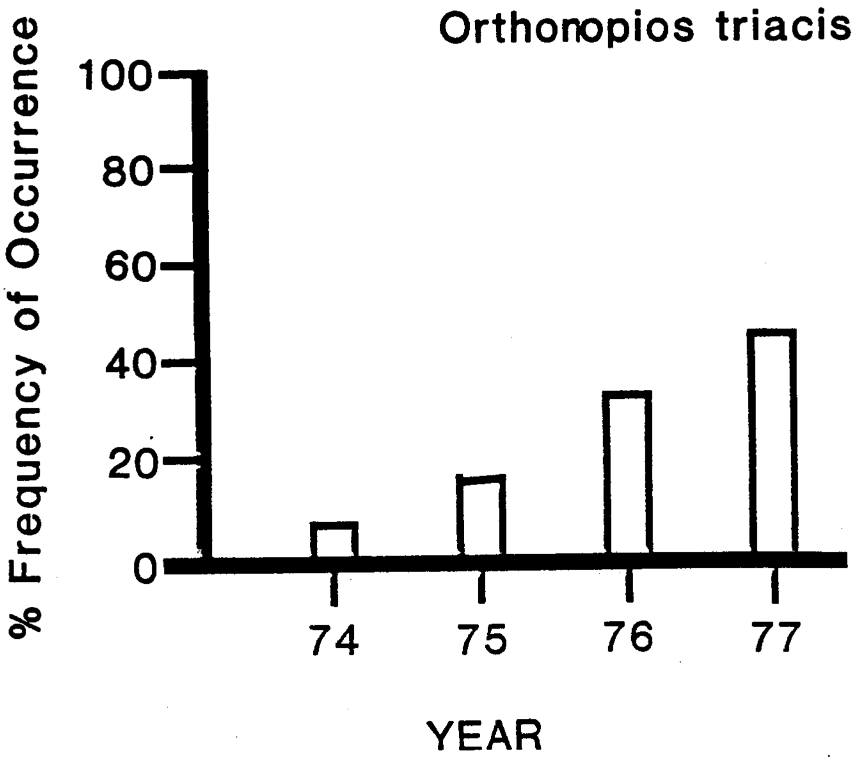


Figure 134. Percent frequency of occurrence of Orthonopias triacis at subtidal random arc stations in Diablo Cove. DCPP, 1974-1977.

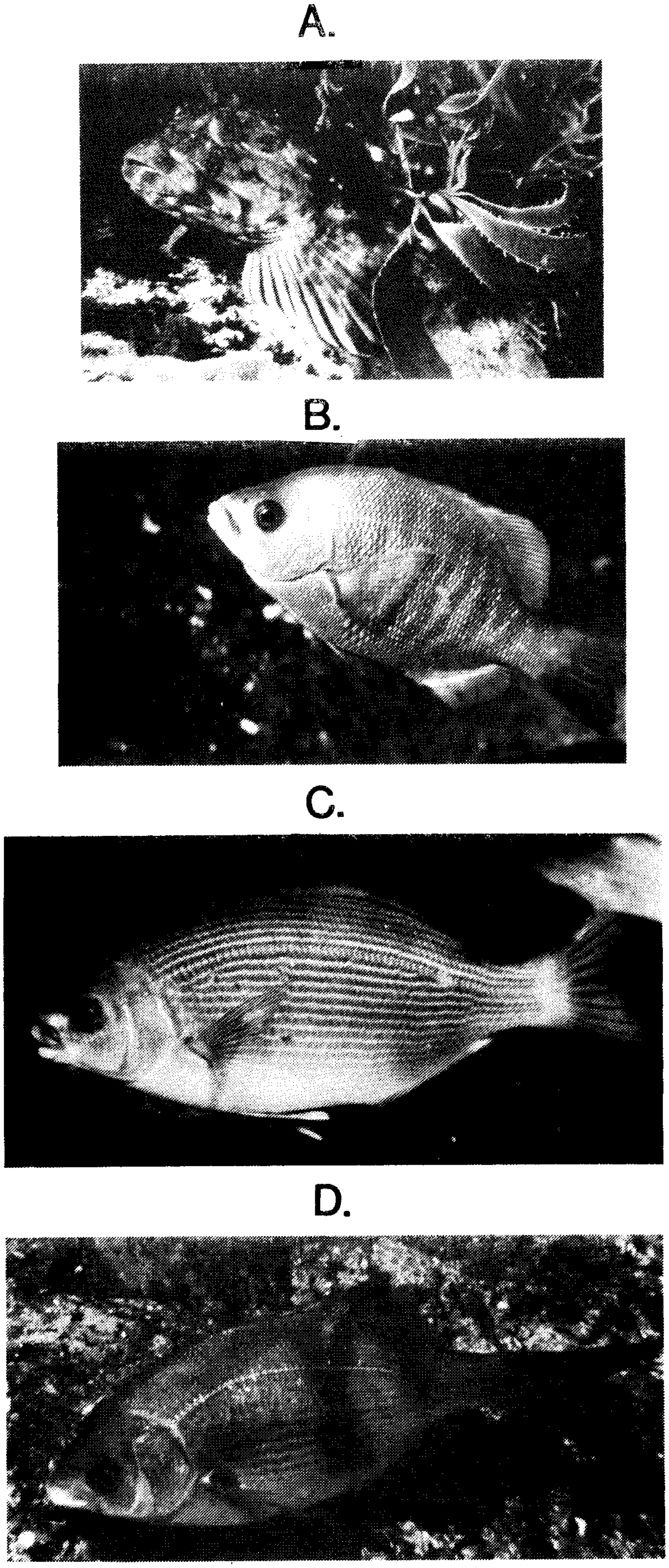


Figure 135. A. Scorpaenichthys marmoratus, B. Embiotoca jacksoni, C. Embiotoca lateralis, D. Damalichthys vacca. (Photos by Daniel W. Gotshall).

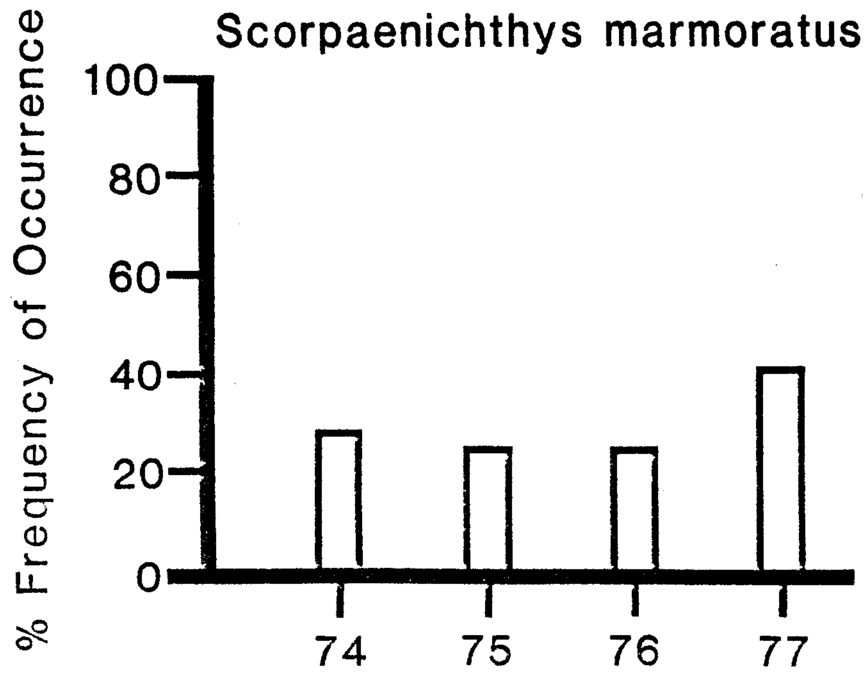


Figure 136. Percent frequency of occurrence of Scorpaenichthys marmoratus at subtidal random arc stations in Diablo Cove. DCPP, 1974-1977.

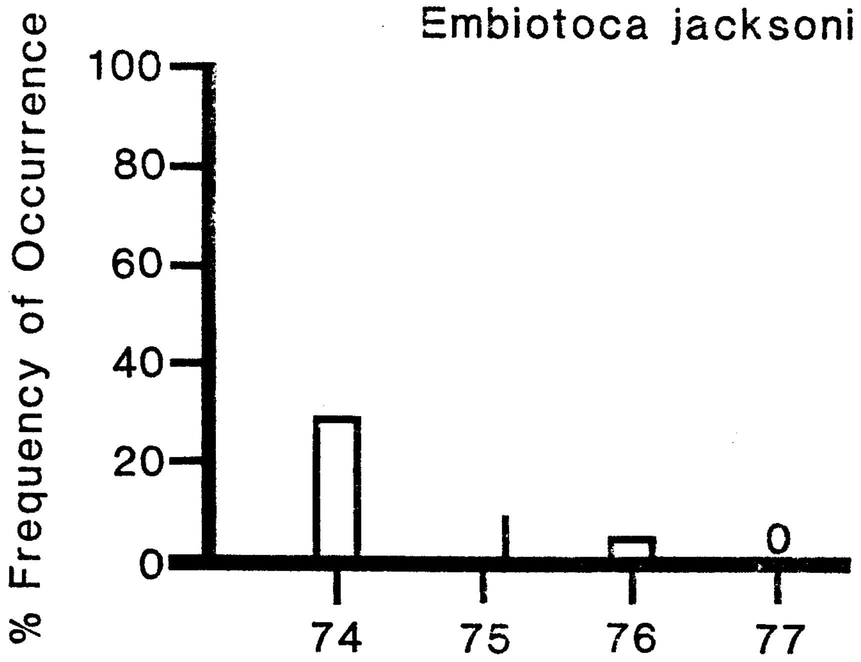


Figure 137. Percent frequency of occurrence of Embiotoca jacksoni at subtidal random arc stations in Diablo Cove. DCPP, 1974-1977.

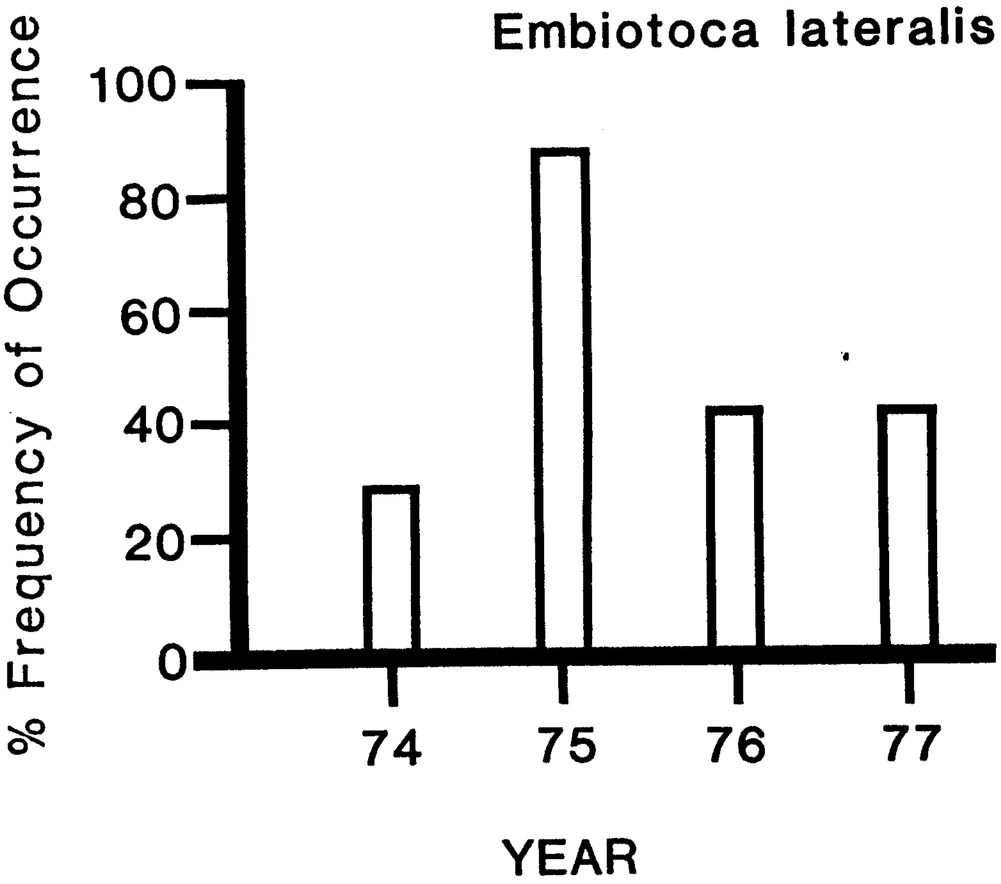


Figure 138. Percent frequency of occurrence of Embiotoca lateralis at subtidal random arc stations in Diablo Cove. DCPP, 1974-1977.

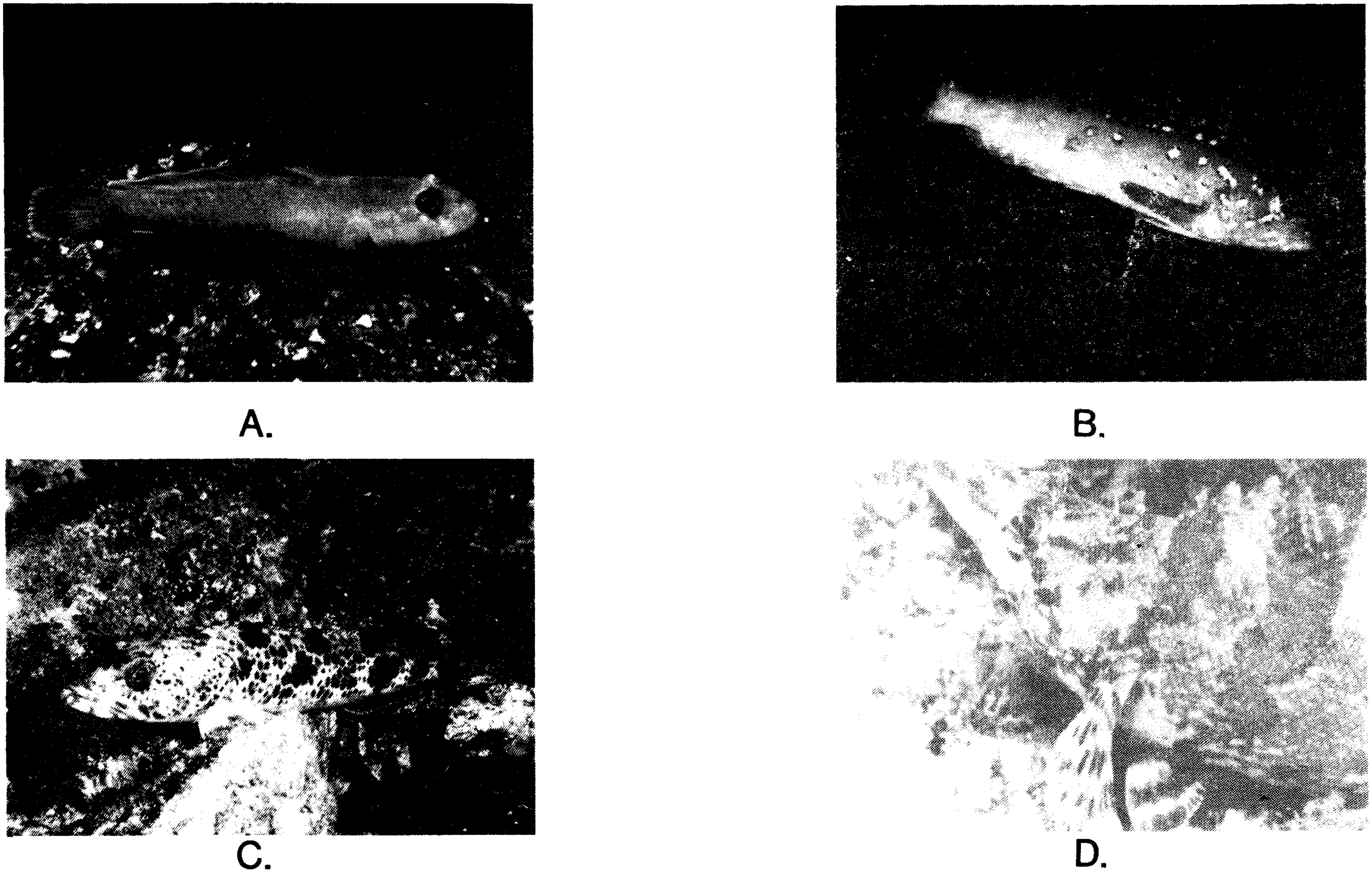


Figure 139. A. *Coryphopterus nicholsii*, B. *Hexagrammos decagrammus*, C. *Ophiodon elongatus*, D. *Oxylebius pictus* (Photos by Daniel W. Gotshall).

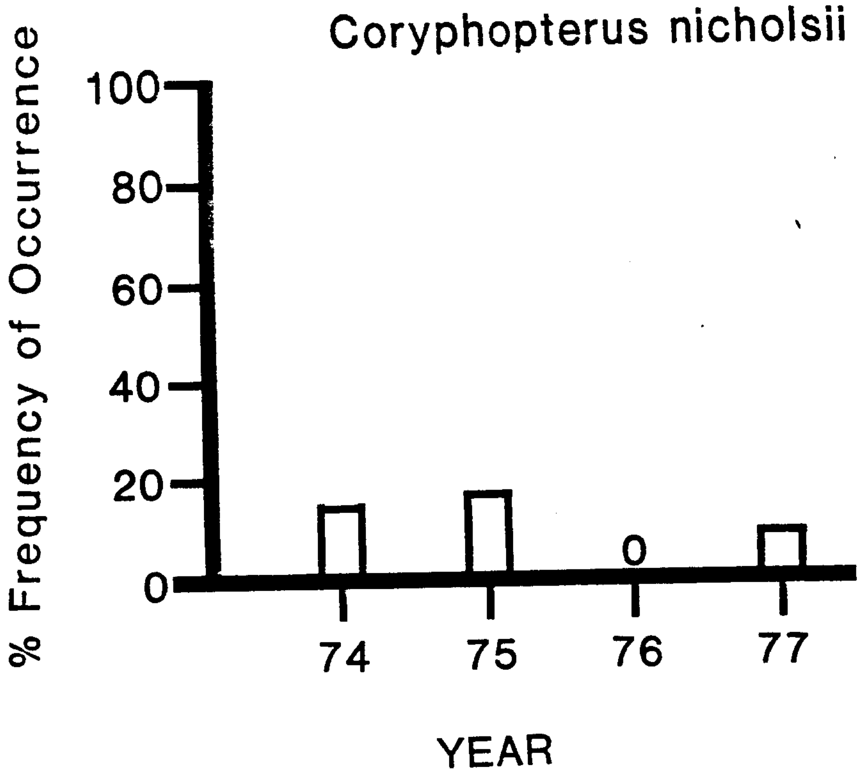


Figure 140. Percent frequency of occurrence of Coryphopterus nicholsii at subtidal random arc stations in Diablo Cove. DCPP, 1974-1977.

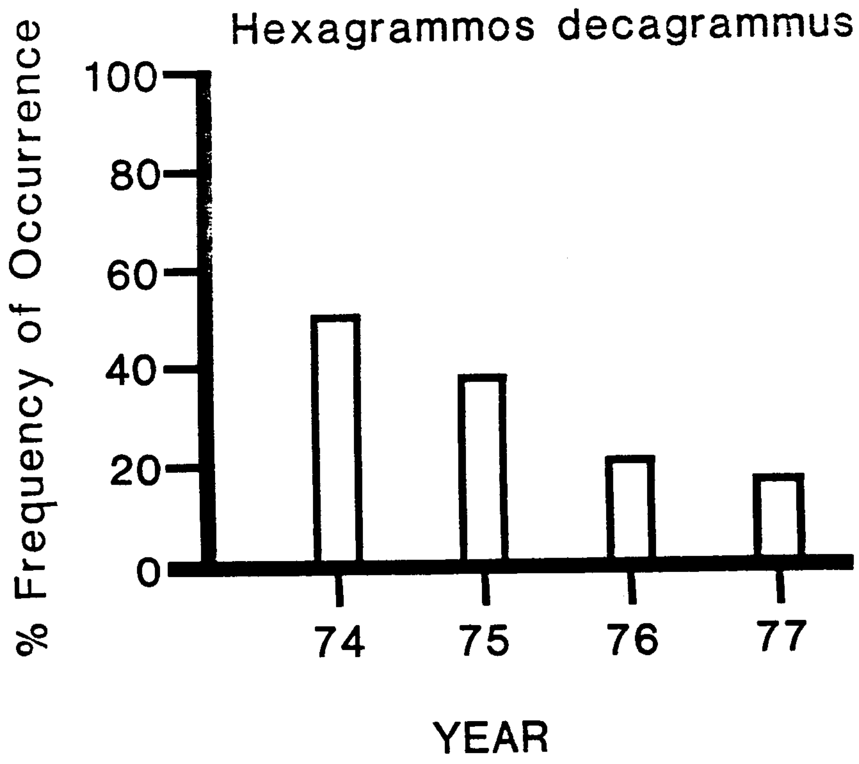


Figure 141. Percent frequency of occurrence of Hexagrammos decagrammus at subtidal random arc stations in Diablo Cove. DCPP, 1974-1977.

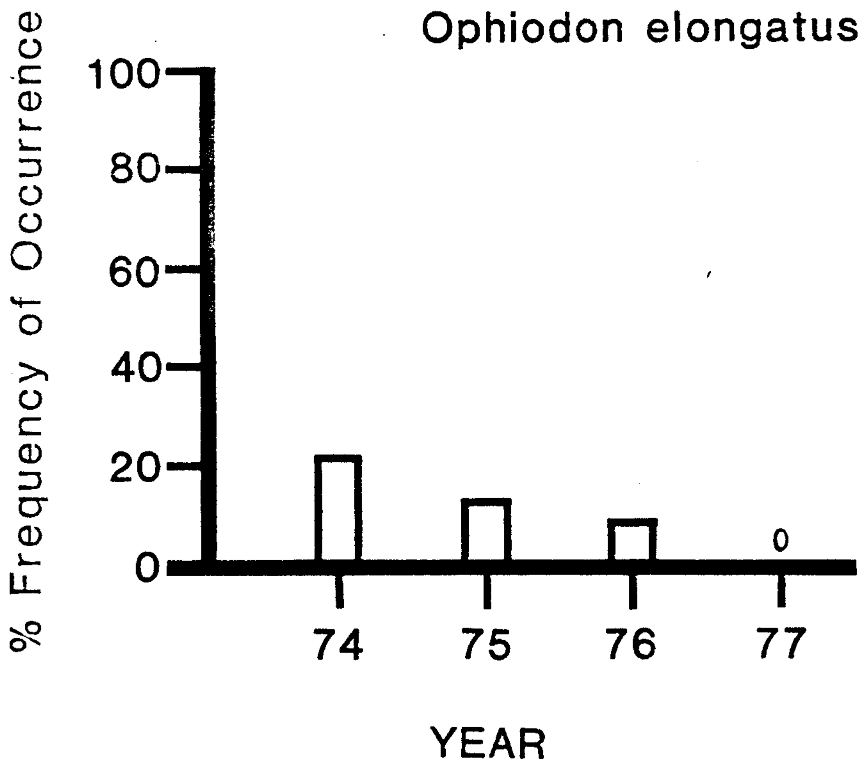


Figure 142. Percent frequency of occurrence of Ophiodon elongatus at subtidal random arc stations in Diablo Cove. DCPP, 1974-1977.

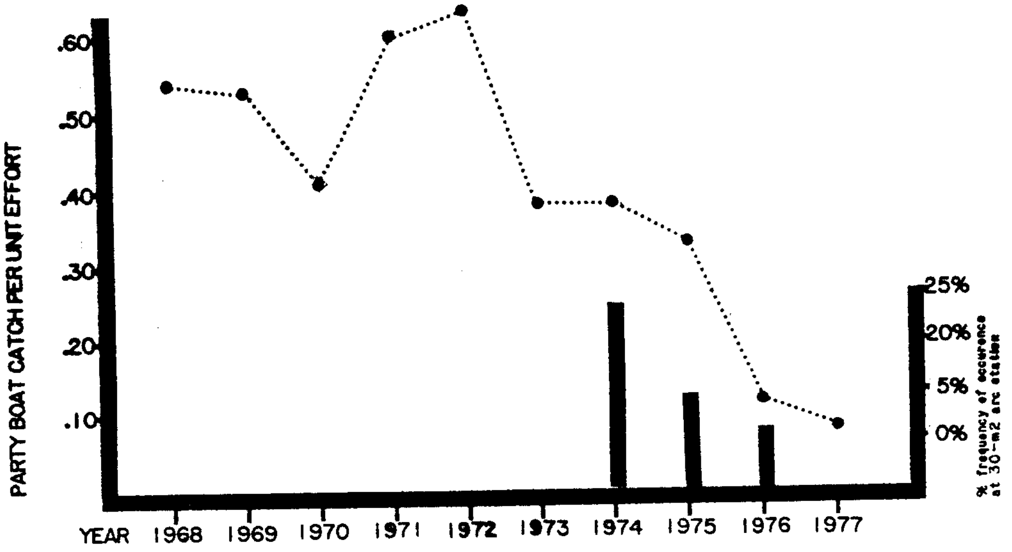


Figure 143. Party boat catch-per-unit-of-effort (.......) and percent frequency of occurrence (▌) of Lingcod, Ophiodon elongatus, at subtidal random arc stations. DCPP, 1968-1977.

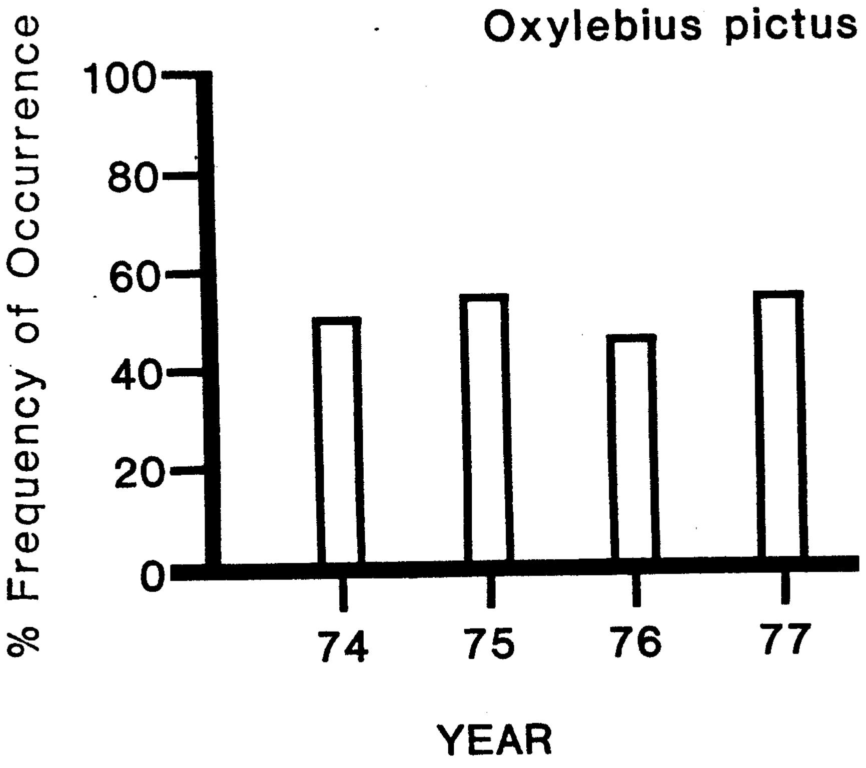


Figure 144. Percent frequency of occurrence of Oxylebius pictus at subtidal random arc stations in Diablo Cove. DCPP, 1974-1977.

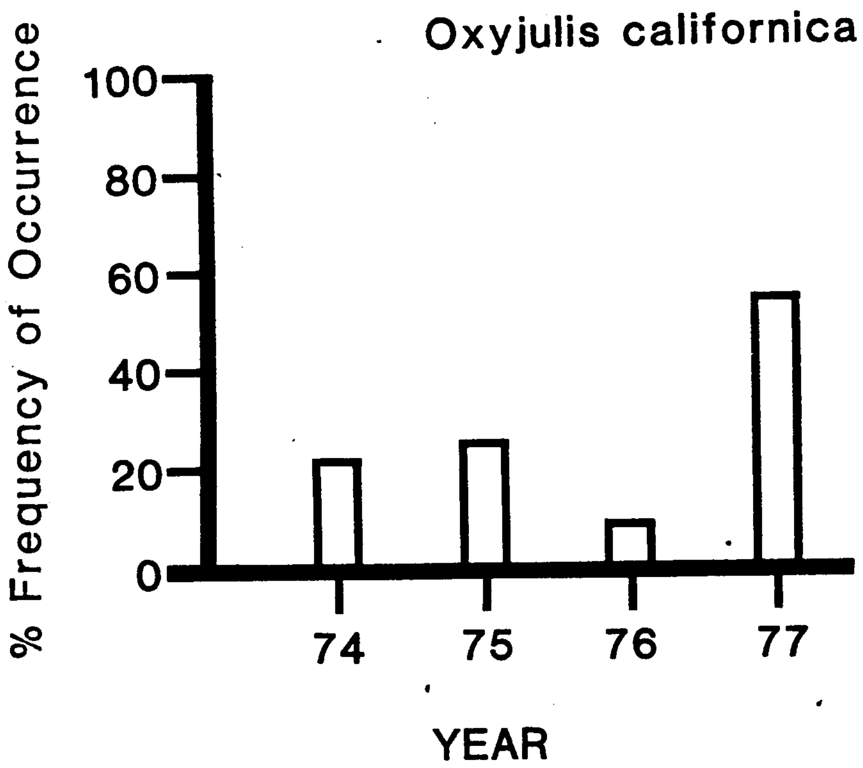


Figure 145. Percent frequency of occurrence of Oxyjulis californica at subtidal random arc stations in Diablo Cove. DCPP, 1974-1977.

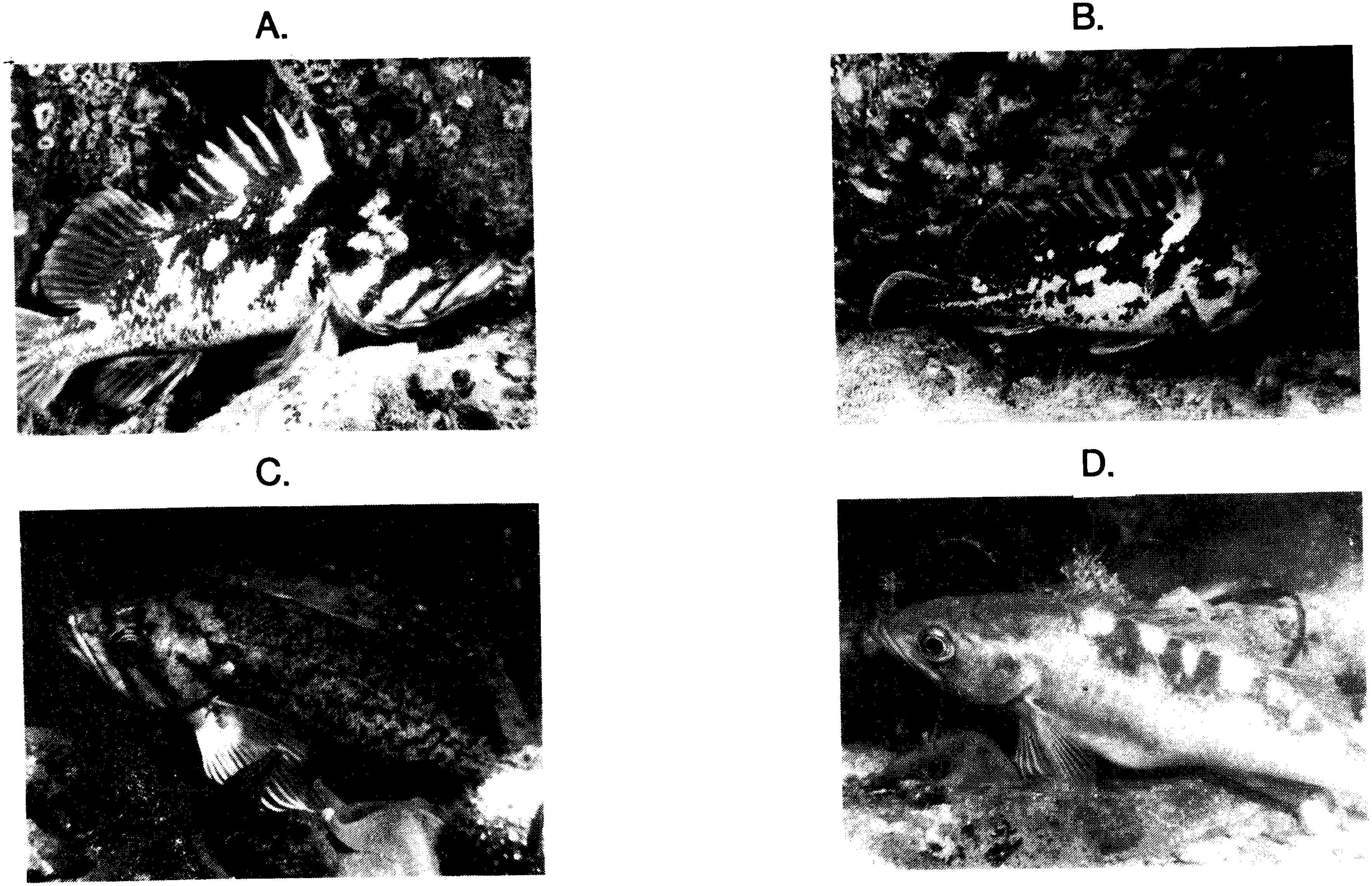


Figure 146. A. Sebastes carnatus, B. Sebastes chrysomelas, C. Sebastes mystinus, D. Sebastes serronoides. (Photos by Daniel W. Gotshall).

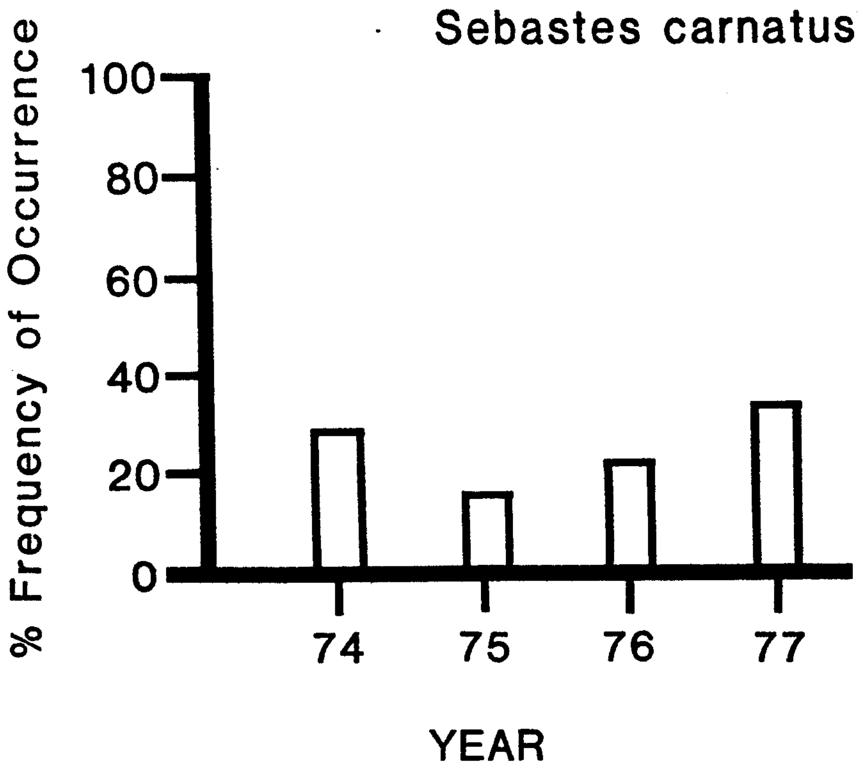


Figure 147. Percent frequency of occurrence of Sebastes carnatus at subtidal random arc stations in Diablo Cove. DCPP, 1974-1977.

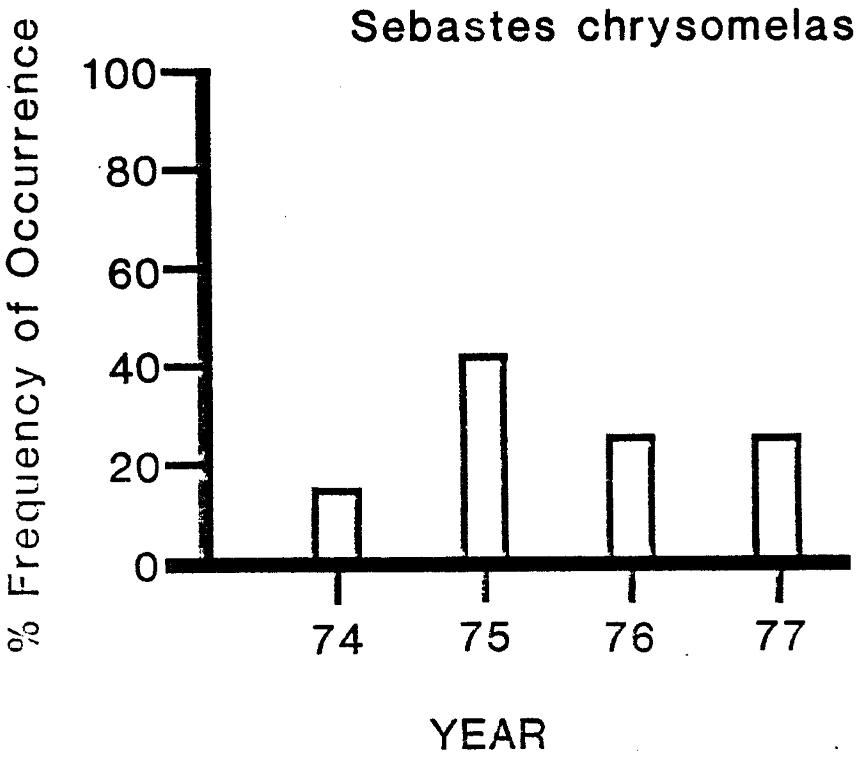


Figure 148. Percent frequency of occurrence of Sebastes chrysomelas at subtidal random arc stations in Diablo Cove. DCPP, 1974-1977.

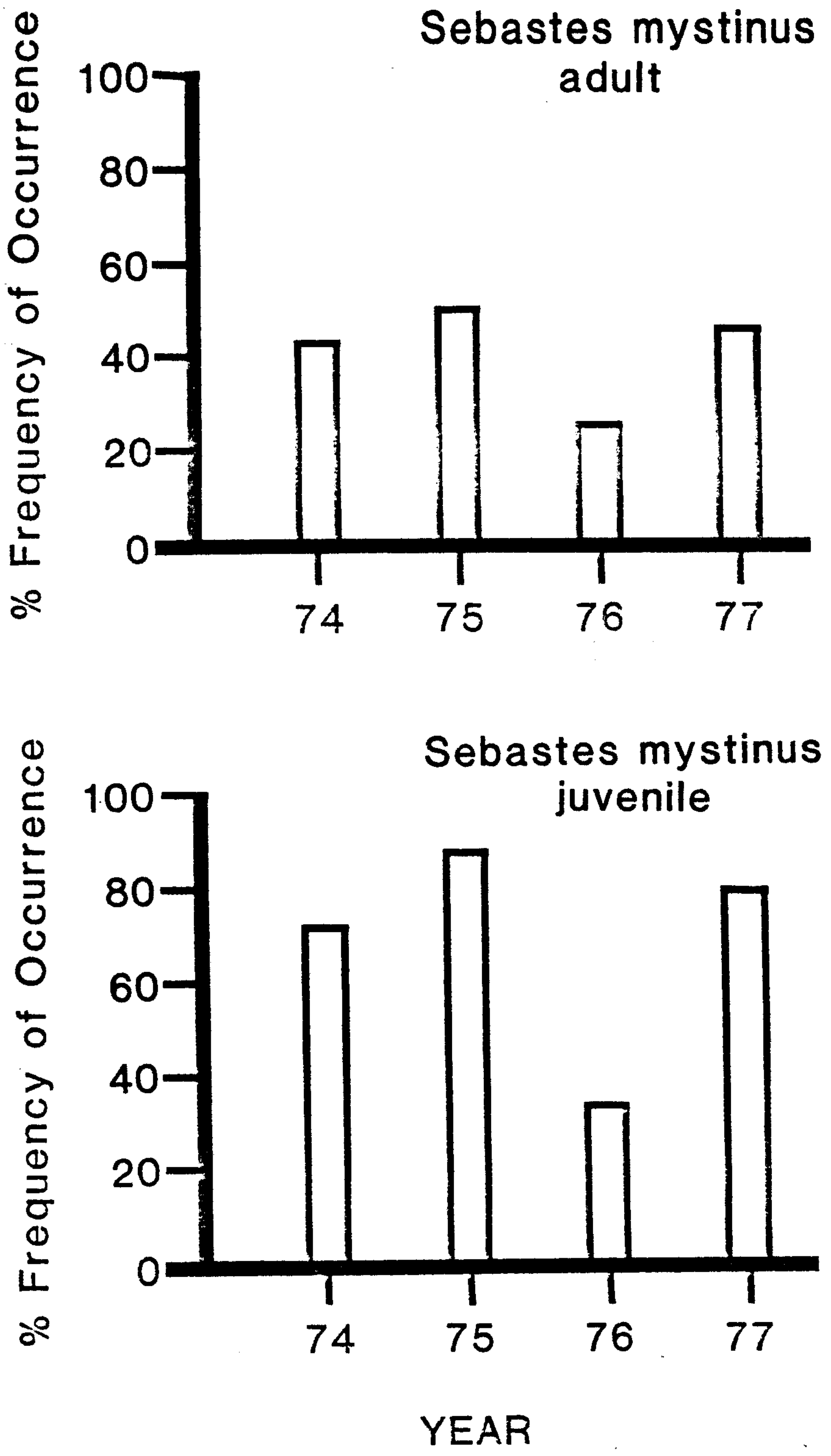


Figure 149. Percent frequency of occurrence of Sebastes mystinus (adult and juvenile) at subtidal random arc stations in Diablo Cove. DCPP, 1974-1977.

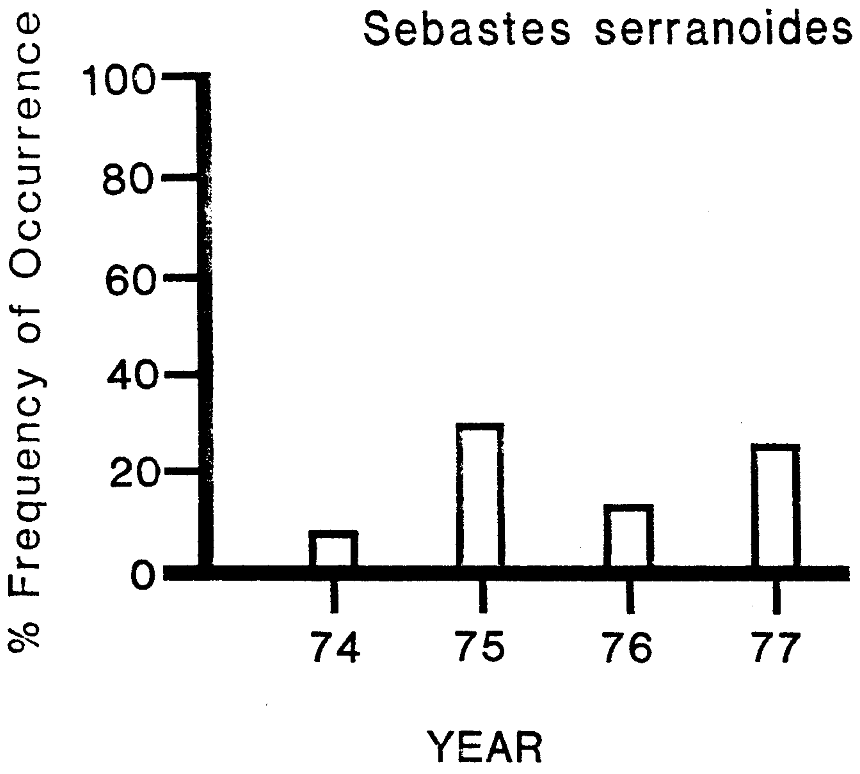


Figure 150. Percent frequency of occurrence of Sebastes serranoides at subtidal random arc stations in Diablo Cove. DCPP, 1974-1977.

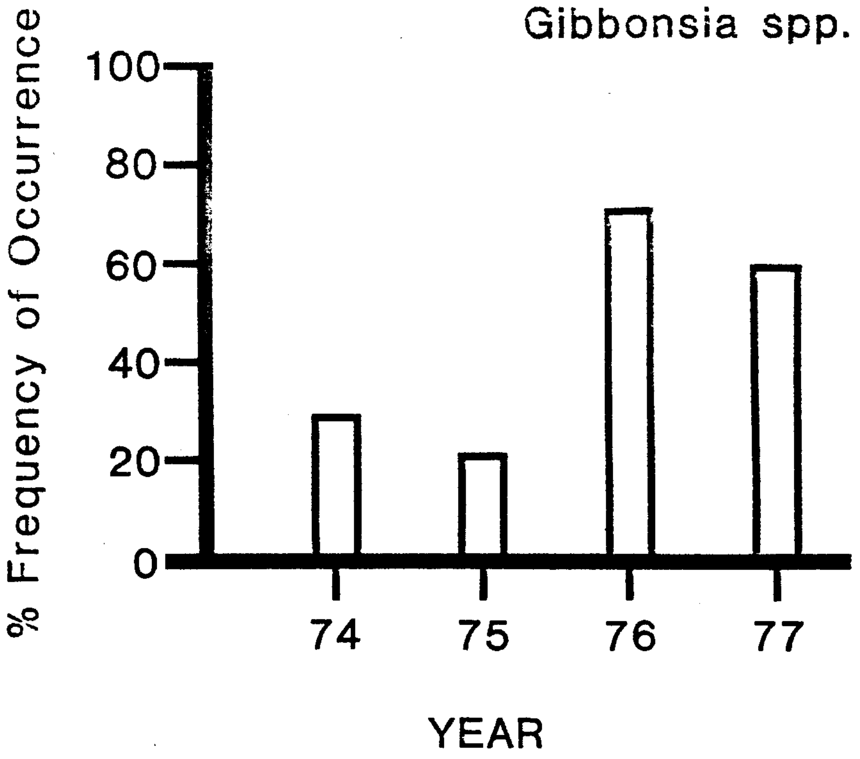


Figure 151. Percent frequency of occurrence of Gibbonsia spp. at subtidal random arc stations in North Control. DCPP, 1974-1977.

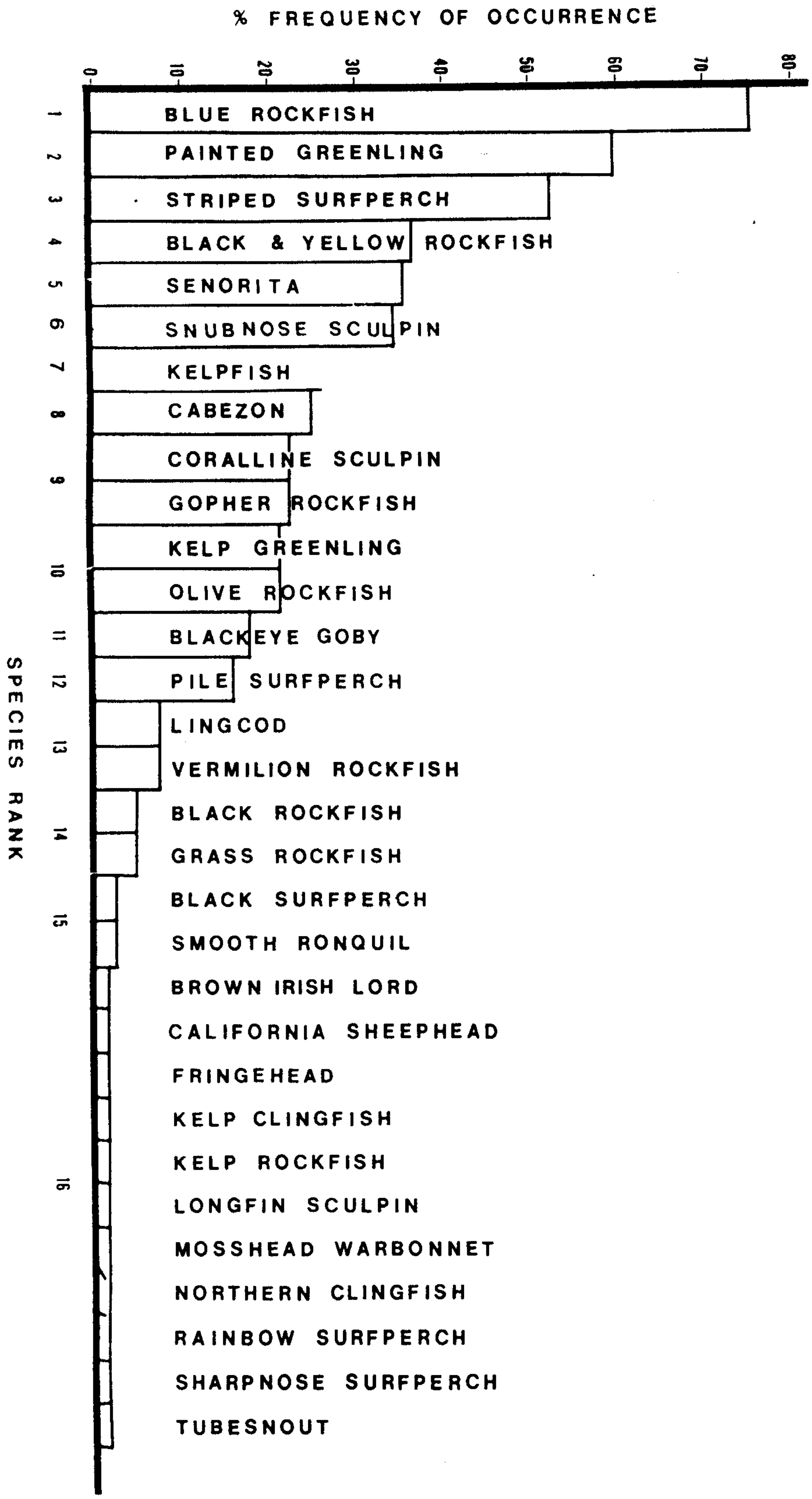


Figure 152. Percent frequency of occurrence and numerical ranks of fishes observed at subtidal random 30-m^2 arc stations in North Control. DCPP, 1974-1977.

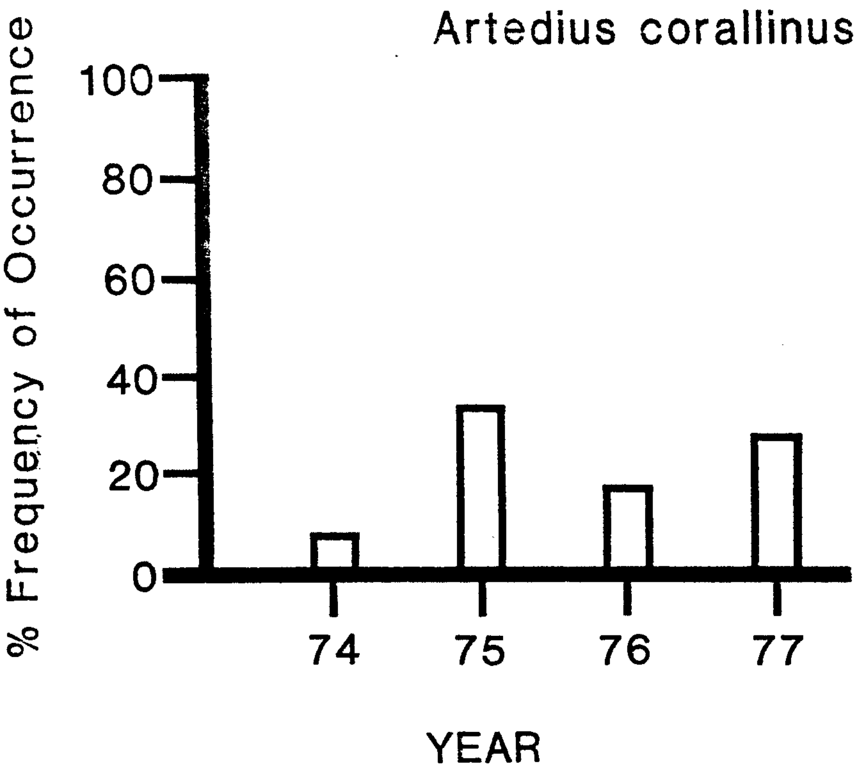


Figure 153. Percent frequency of occurrence of Artedius corallinus at subtidal random arc stations in North Control. DCPP, 1974-1977.

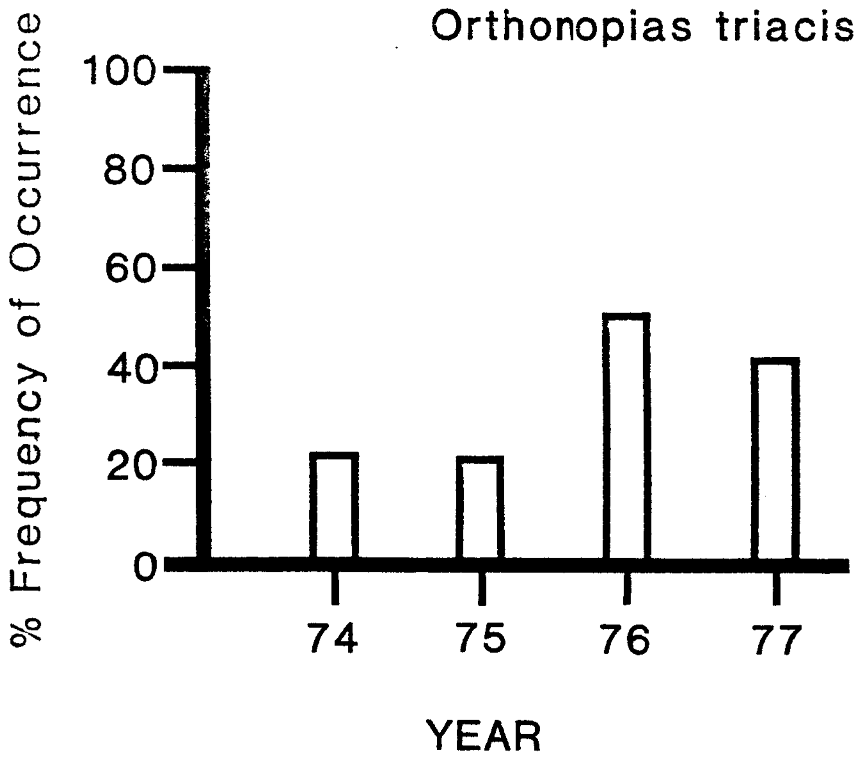


Figure 154. Percent frequency of occurrence of Orthonopias triacis at subtidal random arc stations in North Control. DCPP, 1974-1977.

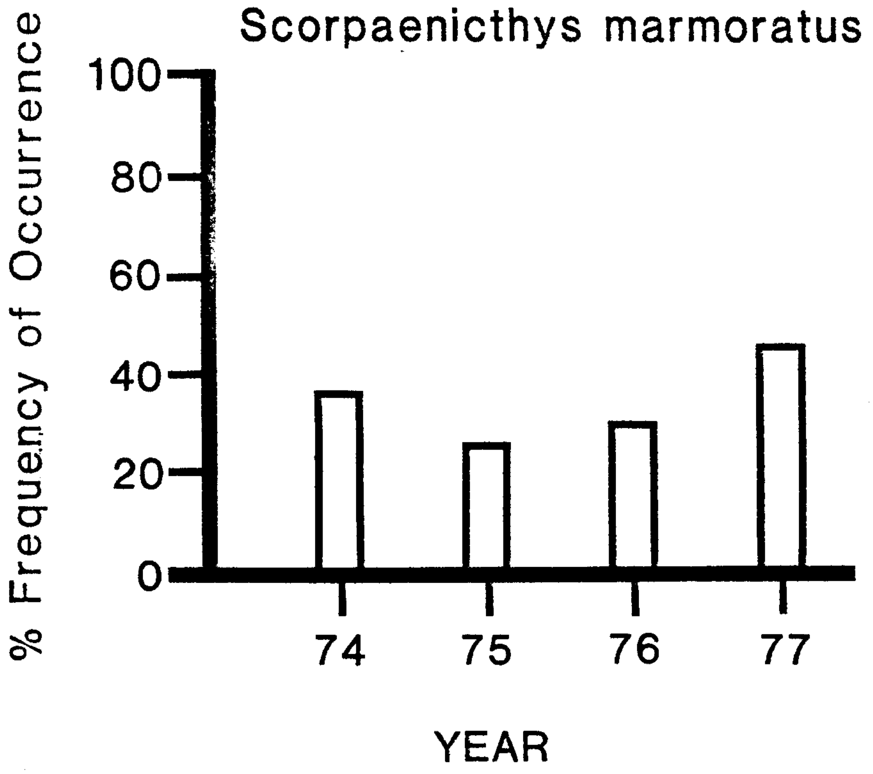


Figure 155. Percent frequency of occurrence of Scorpaenichthys marmoratus at subtidal random arc stations in North Control. DCPP, 1974-1977.

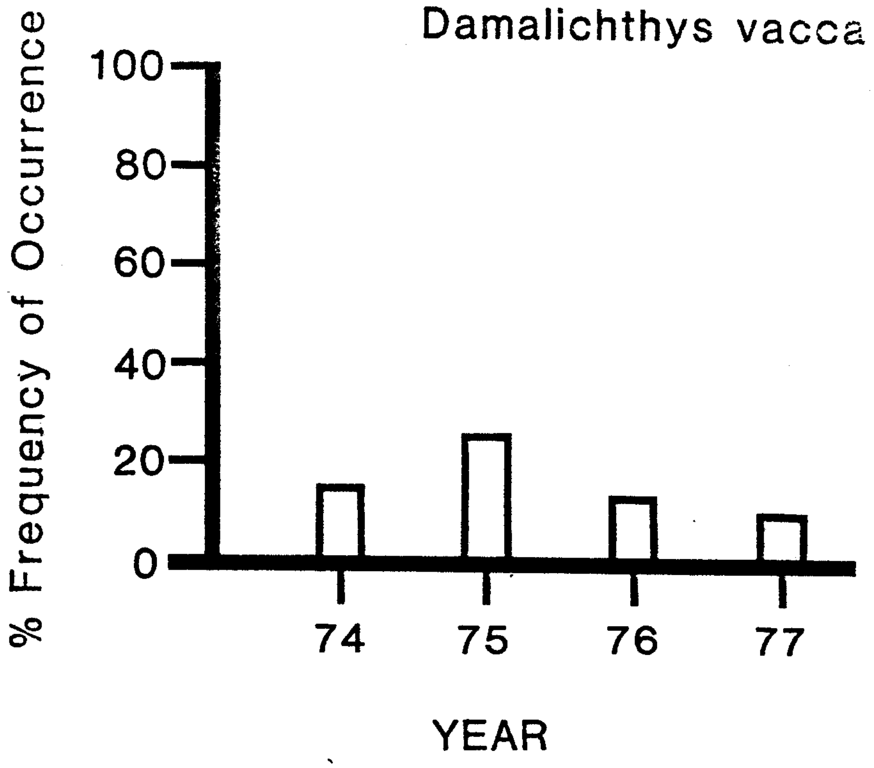


Figure 156. Percent frequency of occurrence of Damalichthys vacca at subtidal random arc stations in North Control. DCPP, 1974-1977.

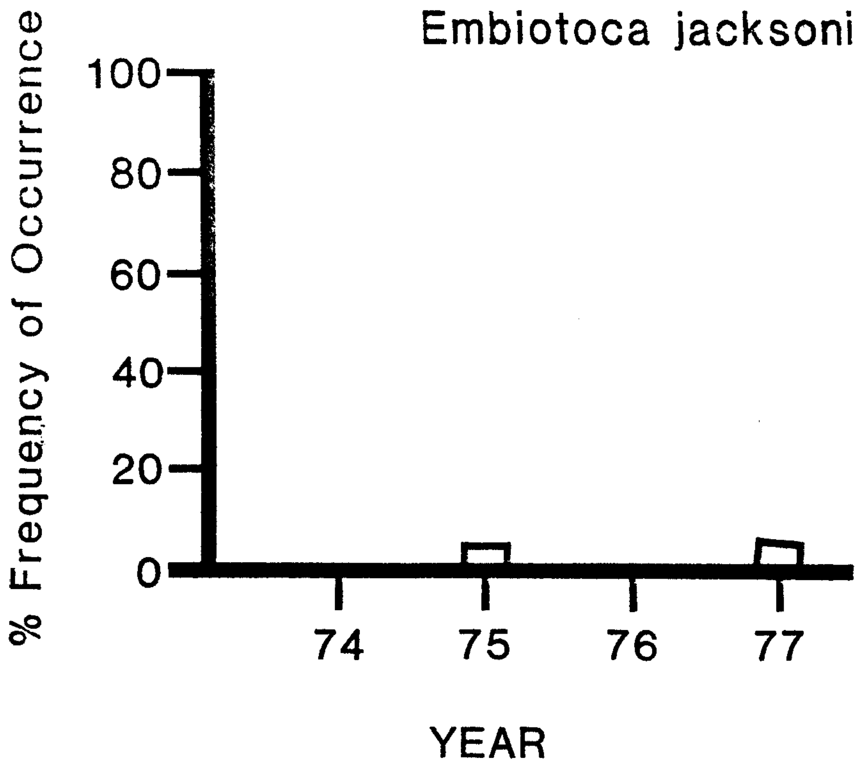


Figure 157. Percent frequency of occurrence of Embiotoca jacksoni at subtidal random arc stations in North Control. DCPP, 1974-1977.

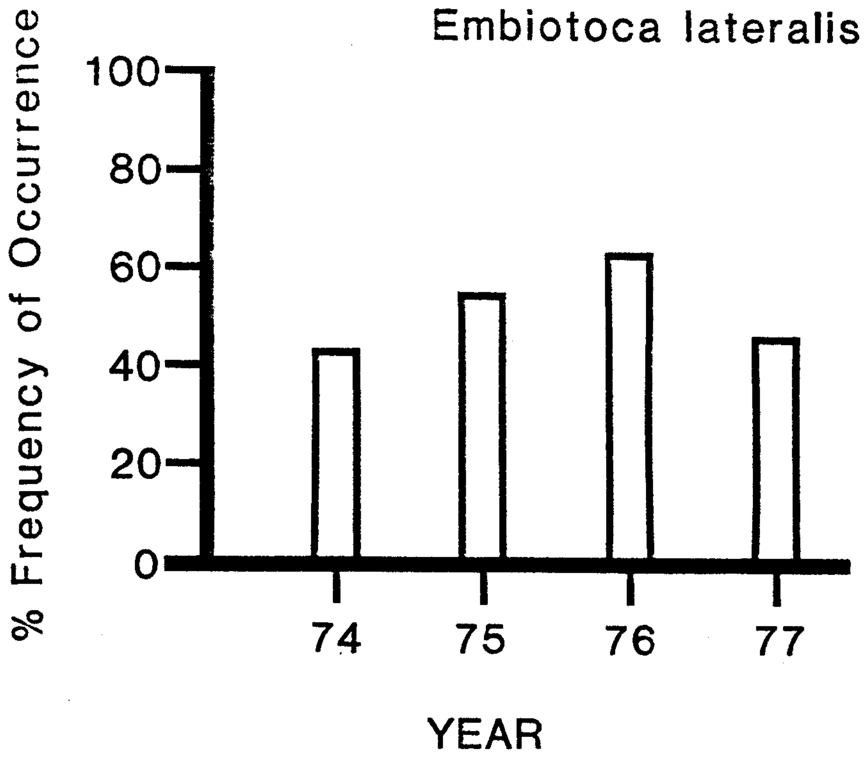


Figure 158. Percent frequency of occurrence of Embiotoca lateralis at subtidal random arc stations in North Control. DCPP, 1974-1977.

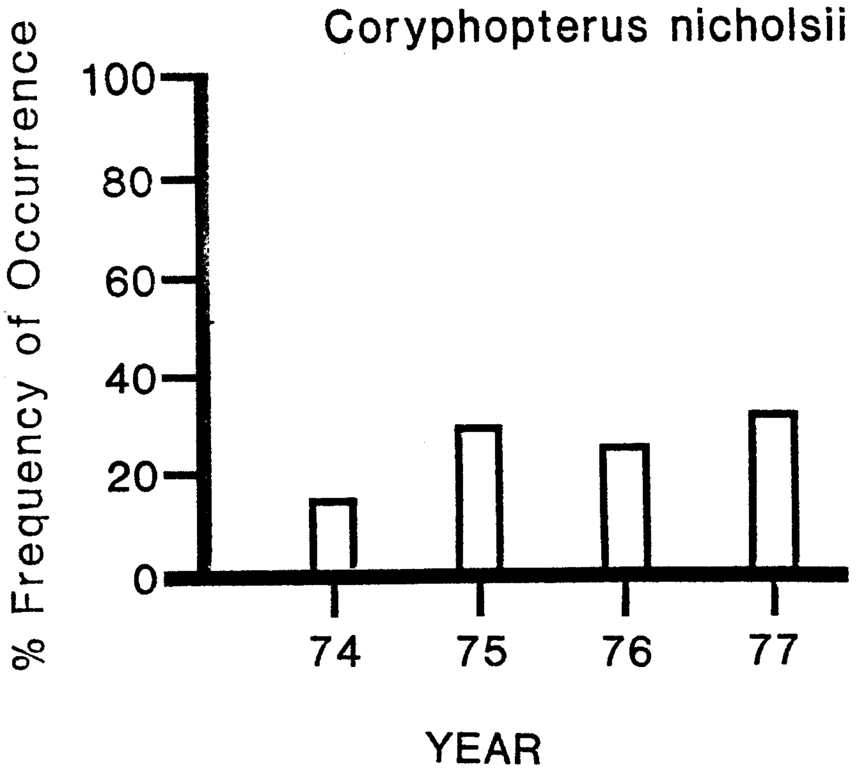


Figure 159. Percent frequency of occurrence of Coryphopterus nicholsii at subtidal arc stations in North Control. DCPP, 1974-1977.

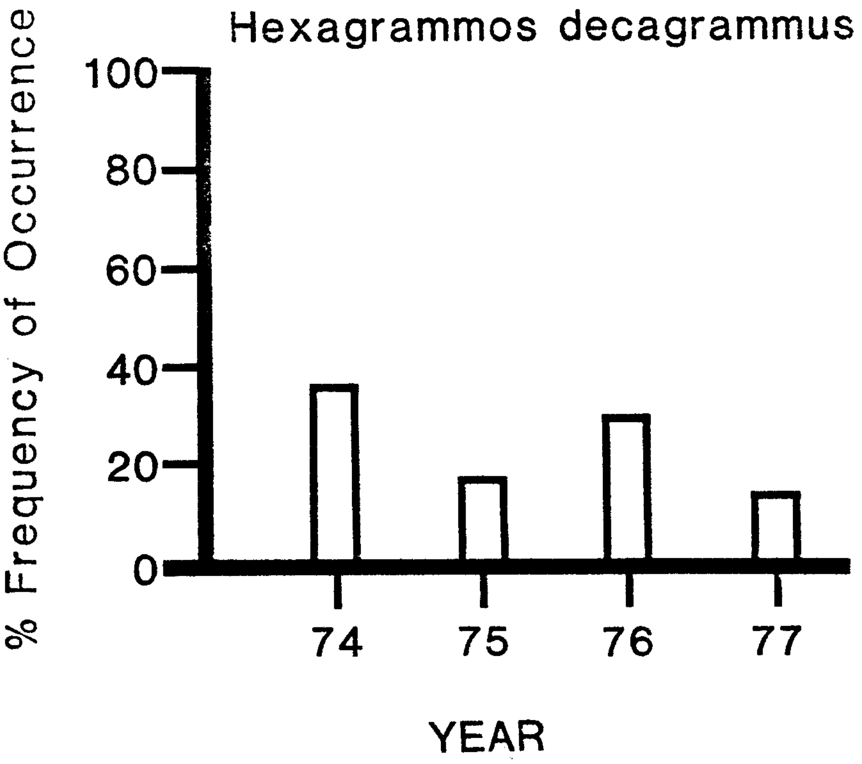


Figure 160. Percent frequency of occurrence of Hexagrammos decagrammus at subtidal random arc stations in North Control. DCPP, 1974-1977.

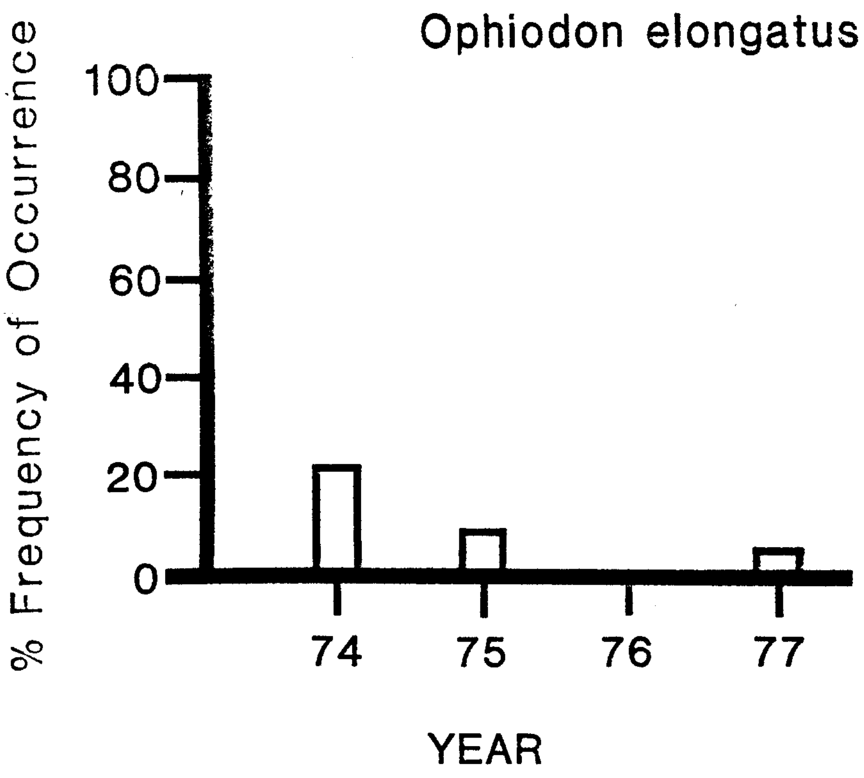


Figure 161. Percent frequency of occurrence of Ophiodon elongatus at subtidal random arc stations in North Control. DCPP, 1974-1977.

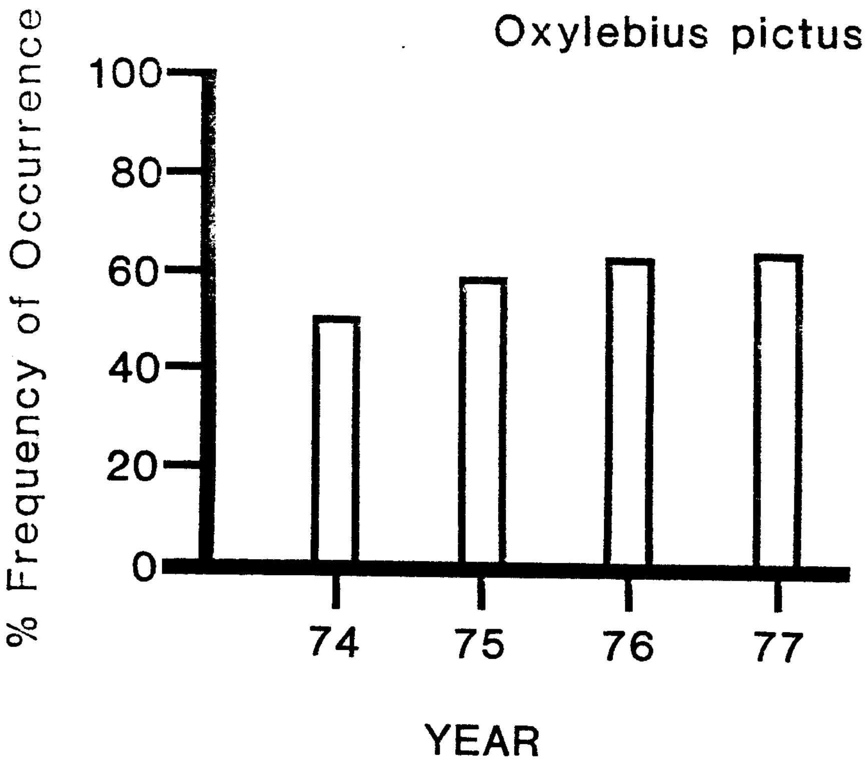


Figure 162. Percent frequency of occurrence of Oxylebius pictus at subtidal random arc stations in North Control. DCPP, 1974-1977.

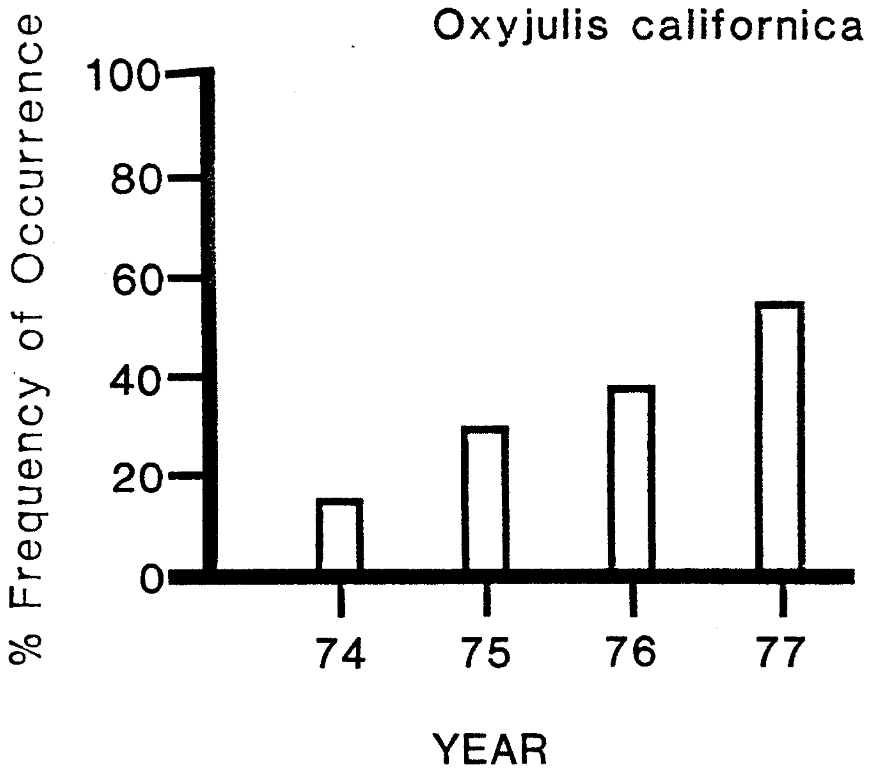


Figure 163. Percent frequency of occurrence of Oxyjulis californica at subtidal random arc stations in North Control. DCPP, 1974-1977.

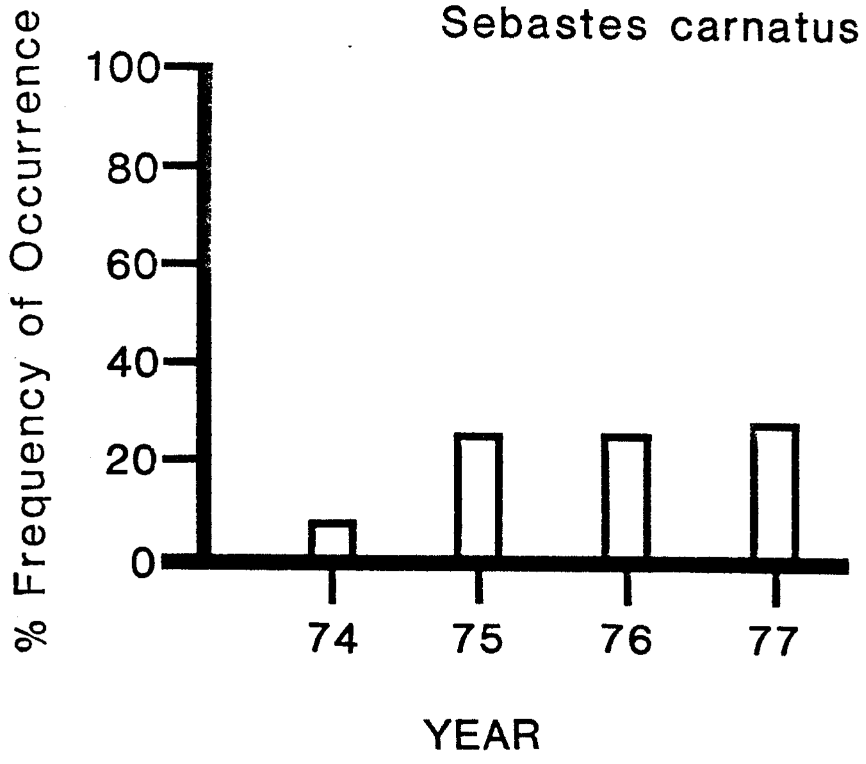


Figure 164. Percent frequency of occurrence of Sebastes carnatus at subtidal random arc stations in North Control. DCPP, 1974-1977.

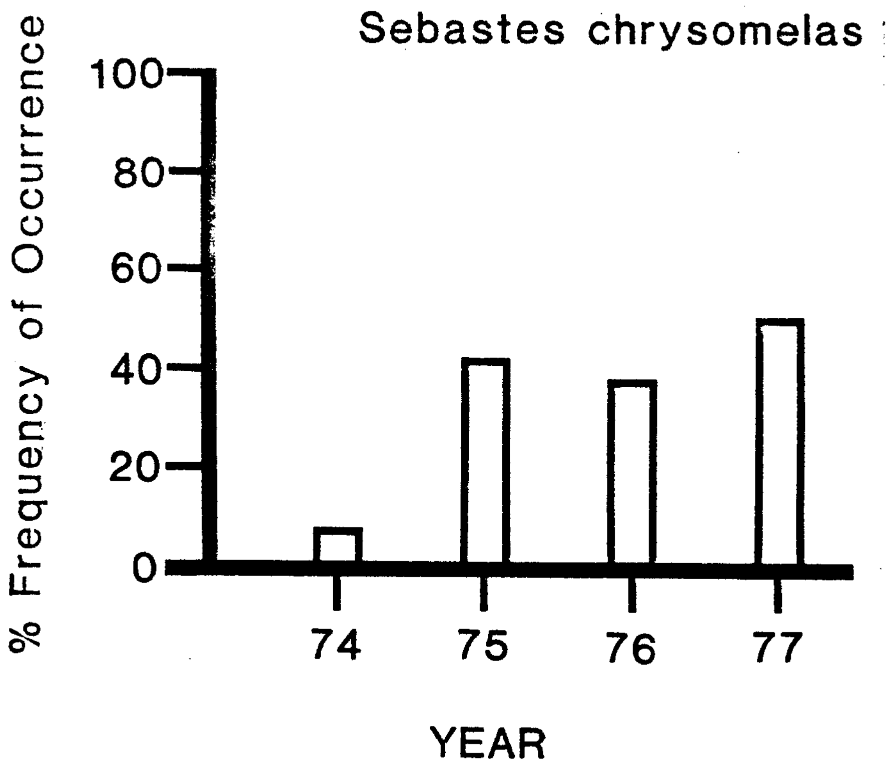


Figure 165. Percent frequency of occurrence of Sebastes chrysomelas at subtidal random arc stations in North Control. DCPP, 1974-1977.

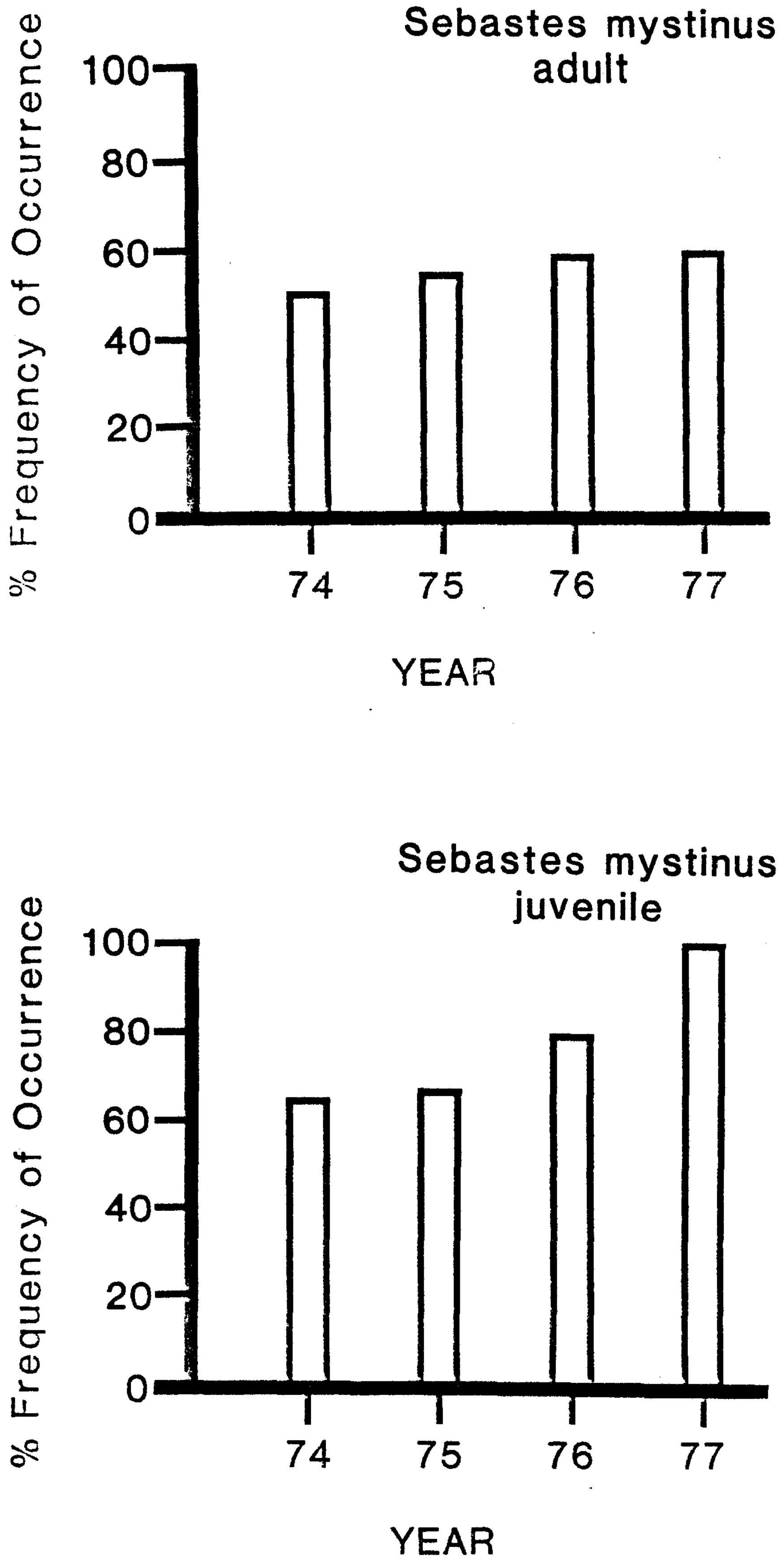


Figure 166. Percent frequency of occurrence of Sebastes mystinus (adult and juvenile) at subtidal random arc stations in North Control. DCPP, 1974-1977.

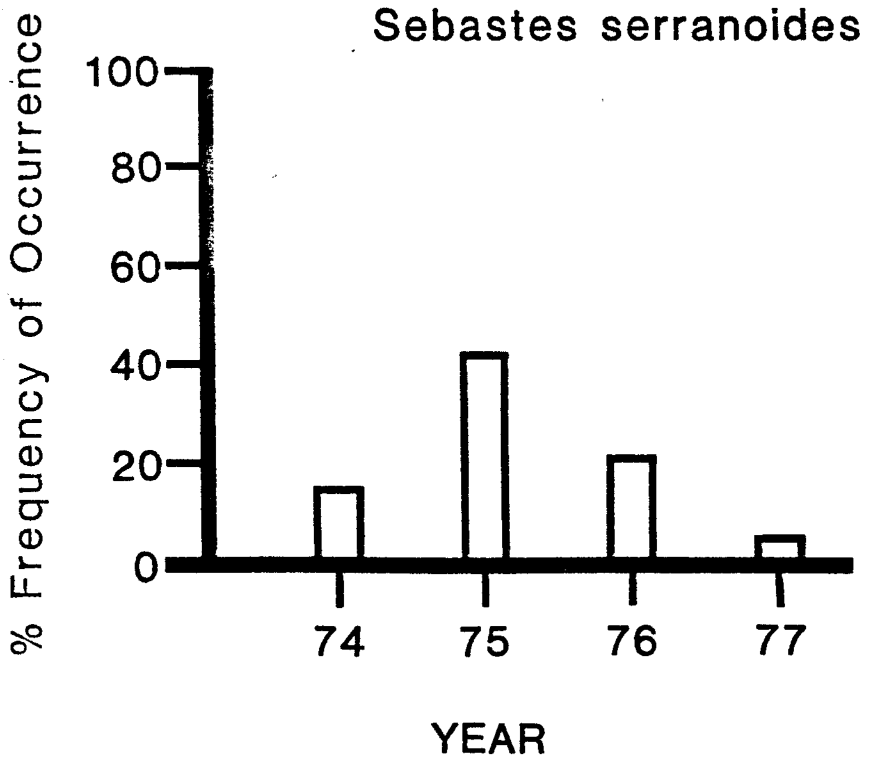


Figure 167. Percent frequency of occurrence of Sebastes serranoides at subtidal random arc stations in North Control. DCPP, 1974-1977.

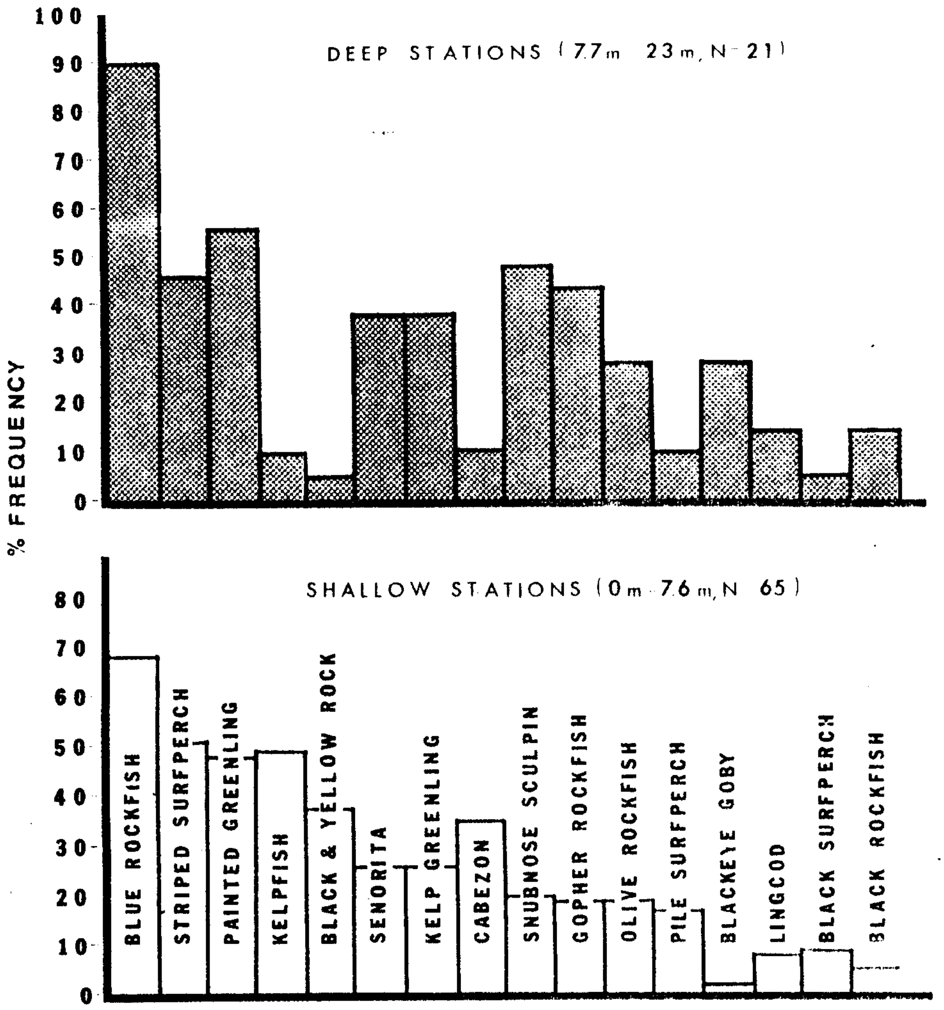


Figure 168. Percent frequency of occurrence of fishes observed at shallow and deep arc stations in Diablo Cove and North Control. DCPP, 1974-1977.

Cove increase in temperature, from the input of the warm cooling water discharged into the Cove, new species will take up residence in the Cove.

Permanent Station Studies

Brown Algae

Methods

A. Field

In 1970, Department of Fish and Game biologists established five permanent stations in Diablo Cove (9, 10, 11, 12, and 16) and six control stations outside Diablo Cove; three in Field's Cove (6, 7, and 8) and three in the two coves south of Diablo Cove (13, 14, and 15) (Figure 72) (Burge and Schultz 1973). These stations were marked with polypropylene ropes cemented into the substrate. Each station was 30 m long by 2 m wide. Surface buoys attached by lines to the anchored ropes were used to relocate stations. The stations were maintained during the 1970-81 surveys, but were abandoned thereafter until we began our studies in 1973.

When our study team began subtidal surveys in the summer of 1973, we had to find and re-mark the permanent stations. We were assisted in the operation by Richard Burge. We were able to locate all of the stations in Diablo Cove and Field's Cove, but only one of the stations (15) in the coves south of Diablo Cove. The two unlocated control stations in South Cove (13 and 14) were never re-established. Station 8 was lost and re-established three times between 1973 and 1975, and then lost to storm seas in 1978 and was not re-established. A sixth station in Diablo Cove (1) was established in 1977.

During our studies, we have had to relocate all of these stations at least once. Stations 9, 11, 12, and 16 have always been relocated in approximately the same area as the original stations. The original station 10 markers, however, were lost in 1976 and the situation was re-established in approximately the same depth, but slightly to the south of the original area. Our attempts to establish permanent markers at each station, to prevent straying of the 30 m transect line, have consistently met with failure. Thus, the results of our surveys of the permanent stations must be tempered by the fact that the counts are not surveys made in the same 30 x 2 m area each time the station was surveyed. However, the population trends of the major plants and animals at the permanent stations usually paralleled the results at the random stations.

Surveys of each permanent station were attempted during the winter, spring, and fall seasons. The surveys were conducted by two divers who swam along either side of a 30 m transect line between the permanent end markers. Each diver counted or noted presence/absence of brown algae, observed within 1 m to either side of the transect line. The total area covered was 60-m^2.

Numbers or estimate of abundance of brown algal are listed in Appendix 8.

B. Laboratory

There was no laboratory activity involved with the brown algal studies at subtidal permanent station.

C. Statistical

Statistical analysis was not performed on the permanent station brown algae data because the total population in the station area was counted rather than a portion sampled.

Results

A. Diablo Cove

Laminaria dentigera

At all three permanent stations in mid-Diablo Cove (9, 10, and 11), *L. dentigera* increased dramatically in number during the study periods (Table 114). At two of these stations (9 and 11), the increase was tenfold or better. At the remaining station the number more than doubled. Station 16, in southeast Diablo Cove, also demonstrated a substantial increase in *L. dentigera* numbers. Station 1, recently established just outside Diablo Cove, was relatively stable during the two periods in which it was sampled. Station 12 was located in water apparently too deep (19.8-21.4 m) for rich *L. dentigera* growth since we found only two individuals during only one sampling period (Table 114).

Pterygophora californica

Results of our studies indicate that *P. californica* exhibited trends similar to *L. dentigera*. At Stations 9 and 11 there was an approximately

TABLE 114. Numbers of Laminaria dentigera, Pterygophora californica, and Nereosystis luetkeana at Permanent Subtidal Stations in Diablo Cove. DCPP, 1974-1978.

Station	Spring 1974	Winter 1974-75	Spring 1975	Winter 1975-76	Spring 1976	Winter 1976-77	Spring 1977	Winter 1977-78	Spring 1978	Station Depth (m)
STATION 9										
Laminaria	22	27	71	50	110	150	NOT SURVEYED	NOT SURVEYED	218	4.6 - 7.6
Pterygophora	40	78	244	245	210	241			317	
Nereocystis	64	76	191	55	35	17			0	
STATION 10										
Laminaria	132	NOT SURVEYED	107	NOT SURVEYED	192	124	216	NOT SURVEYED	279	12.2 - 13.7
Pterygophora	120		172		232	212	241		226	
Nereocystis	99		2		2	35	0		0	
STATION 11										
Laminaria	31	79	107	NOT SURVEYED	108	292	297	301	406	12.2 - 15.2
Pterygophora	0	15	44		103	123	123	115	138	
Nereocystis	60	2	61		0	0	0	0	0	
STATION 12										
Laminaria	2	0	0	0	0	0	0	0	0	19.8 - 21.4
Pterygophora	0	0	0	0	0	0	0	0	0	
Nereocystis	0	0	0	0	0	0	0	0	0	
STATION 16										
Laminaria	0	0	5	1	43	65	NOT SURVEYED	NOT SURVEYED	213	3.0 - 3.4
Pterygophora	209	0	220	240	205	210			246	
Nereocystis	0	0	2	0	3	0			0	
STATION 1 (Established in 1977)										
Laminaria								176	197	7.6 - 14.6
Pterygophora								6	111	
Nereocystis								19	21	

tenfold increase while at Station 10 numbers almost doubled. Station 16 numbers remained very stable through the study with between 200 and 250 plants found each sampling period. P. californica increased over the two periods sampled at Station 1 but was never noted at Station 12 (Table 114).

Nereocystis luetkeana

Stations 1, 10, and 11 all exhibited the decline in N. luetkeana numbers that were noted at random 30-m^2 and 0.25-m^2 stations (Figures 75 and 76). The increase in numbers seen at random stations in 1975 was evident at the permanent Diablo Cove stations only at Station 9. N. luetkeana were recorded at Station 16 during only two of the sampling periods and none were sampled at Station 12. N. luetkeana was present at Station 1 in moderate numbers during both periods that we sampled at that station (Table 114).

B. Control Areas

Laminaria dentigera

In contract to results from Diablo Cove, L. dentigera numbers remained relatively stable during the study years at the control stations. There were some increases, but the changes were not as dramatic as in Diablo Cove (Table 115).

TABLE 115. Numbers of *Laminaria dentigera*, *Pterygophora californica*, and *Nereocystis luetkeana* at Permanent Subtidal Stations in Control Areas. DCPP, 1974-1978.

Station	Spring 1974	Winter 1974-75	Spring 1975	Winter 1975-76	Spring 1976	Winter 1976-77	Spring 1977	Winter 1977-78	Spring 1978	Station Depth(m)
STATION 6										
Laminaria	13	NOT SURVEYED	27	20	29	NOT SURVEYED	24	NOT SURVEYED	39	4.3 - 8.5
Pterygophora	37		114	134	79		97		133	
Nereocystis	58		7	2	0		0		7	
STATION 7										
Laminaria	9	NOT SURVEYED	47	25	22	37	41	NOT SURVEYED	NOT SURVEYED	9.2 - 10.7
Pterygophora	172		373	283	296	379	336			
Nereocystis	38		47		7	0	0			
STATION 15										
Laminaria	97	NOT SURVEYED	47	64	92	106	114	145	0	4.6 - 13.7
Pterygophora	0		0	0	2	0	0	12	0	
Nereocystis	31		0	0	0	0	123	41	0	

Invertebrates

Methods

A. Field

The surveys of invertebrates at permanent stations were conducted by two divers who swam along either side of the 30 m transect line stretched between the markers described in Field Method section for the brown algae. Each diver counted or noted presence/absence of macro-invertebrates (10 mm or larger) observed within 1 m either side of the transect line. The divers recorded the data on waterproof slates. In addition the divers recorded the horizontal underwater visibility.

B. Laboratory

Data from each station was transferred to permanent record sheets; collected animals that could not be identified in the field were identified and either released alive or put into our reference collection.

C. Statistical

The mean densities per station per year for the more common invertebrates were analyzed by the Kruskal-Wallis test to determine if significant changes in abundances has occurred over time. Probably because of the small sample size, none of the animals showed significant changes ($p \leq 0.05$) in abundance (Table 116). The counts from the (1970-71) surveys by Burge and Schultz were not included in the tests.

Results

A. Diablo Cove

To provide comparability, only those species covered in the results of the random arc stations will be presented in this Permanent Station Results section. Counts of the other plants and animals observed at the permanent stations are listed in Appendix 8. Arbitrarily in the discussion below, we have considered stations that depths were 7.6 m or less as shallow stations, and the stations 7.7 m or more as deep stations.

PORIFERA

Tethya aurantia

The mean density of orange puffball sponges changed little at the shallow Diablo Cove permanent stations (9 and 16) during the study (Figure 169). At the stations deeper than 7.6 m (10, 11, and 12), orange puffball sponges appeared to increase slightly over the years (Figure 170). *Tethya* were also more abundant at the deep stations than at the shallow stations.

TABLE 116. Results of Kruskal-Wallis Analysis on Invertebrate Abundances Over Time at Diablo Cove and Control Areas Permanent Subtidal Statiosn. DCPP, 1973-1978.

Species	Diablo Cove Stations					Control Stations		
	9	10	11	12	16	6	7	15
Tethya aurantia	0.4799	0.2353	0.0826	0.3452	0.3237	0.6186	0.2527	0.1498
Anthopleura xanthogrammica	0.3756	0.2535	0.2733	0.1473	0.5884	0.1579	0.1823	0.2678
Cancer antennarius	0.2666	0.5341	0.4934	0.7512	0.3400	0.2900	0.7358	0.1978
Astraea gibberosa	0.3539	0.5607	0.1891	0.3228	0.2242	0.6747	0.7139	0.2125
Doripsilla albopunctata	0.1409	0.2359	0.1280	0.4201	0.4327	0.1812	0.3427	0.1520
Haliotis rufescens	0.1641	0.2206	0.0514	0.4799	0.2667	0.3232	0.4060	0.1272
Patiria miniata	0.1962	0.3144	0.4951	0.1272	0.3967	0.7664	0.1983	0.4319
Piaster giganteus	0.3211	0.3940	0.7360	0.3515	0.6865	0.3008	0.3343	0.6716
Pycnopodia helianthoides	0.3238	0.4808	05242	0.2466	0.1656	0.7102	0.0942	0.1752
Strongylocentrotus franciscanus	0.2399	0.2629	0.1086	0.2173	0.1562	0.2032	0.1520	0.1308
Styela montereyensis	0.3324	0.2484	0.1648	1.0000	0.3269	0.2233	0.1215	0.2137
Station Depths (m)	4.6-7.6	12.2-13.7	12.2-15.2	19.8-21.4	3.0-3.4	4.3-8.5	9.2-10.7	4.6-13.7

CNIDARIA

Anthopleura xanthogrammica

Giant green anemones increased in abundance at stations shallower than 7.6 m (Figure 171). However, in 1978 there was a sharp decline in observed giant green anemones. At Station 10, where the depth ranges from about 10.7 to 12 m, the abundance also showed an apparent increasing trend, but without the decline in 1978. At the two deepest stations (11 and 12), giant green anemone density appeared to change a little (Figure 172). Giant green anemones were less numerous at the deepest stations than at the shallower stations.

ARTHROPODA

Cancer antennarius

Rock crabs showed little change in density at Diablo Cove permanent stations (Figure 173), with the exception of Station 9 where there was an increase in density from 1973 through 1977, then an apparent sharp decline. They appeared to be slightly more abundant at shallow stations than at the deep stations (Figures 173 and 174).

MOLLUSCA

Astraea gibberosa

Red turban snails appeared to decline in abundance at Station 9, but no such trend was evident at the other stations where densities fluctuated from year to year (Figure 175). They appeared to be more abundant at the mid-depth Stations 9, 10, and 11 than at the deepest stations, 12, or the shallowest station 16 (Figure 176).

Doriopsilla albopunctata

Observed densities of white-speckled nudibranchs fluctuated from year to year at most Diablo Cove permanent stations, with no apparent trend except for Station 12, where they appeared to increase in density (Figures 177 and 178) the lowest observed densities at all stations were noted at Station 16.

Haliotis rufescens

Red abalone were abundant only at Station 16 during the 1970-71 surveys (Burge and Schultz 1973) and 1973 when we first began the present studies. In 1974 and 1975, the observed numbers of red abalone declined sharply at Station 16 and have remained at low levels ever since (Figures 179 and 180).

ECHINODERMATA

Patiria miniata

Sea bats were more abundant at the shallow stations in 1974, then declined at Stations 9 and at Station 16 (Figure 181). At the three deeper Diablo Cove permanent stations, there was an increasing trend in observed abundance over the years (Figure 182).

Pisaster giganteus

Giant-spined sea stars' observed density fluctuated from year to year at shallow stations with no evident trend (Figure 183). At deep Station 12, there was an increasing trend, while at Stations 10 and 11, there was slight decreased in observed abundance (Figure 184). Giant-spined sea stars appeared to be more abundant at the deeper stations.

Pycnopodia helianthoides

The year-to-year observed changes in density of sunflower stars followed no apparent pattern at any of the stations (Figures 185 and 186).

Strongylocentrotus franciscanus

The observed density of giant red sea urchins declined substantially at all Diablo Cove permanent stations except 12 (Figures 187 and 188). The sharpest decline occurred between 1973 and 1974. Prior to the observed declines, giant red sea urchins were most abundant at mid-depth stations.

CHORDATA

Styela montereyensis

The observed density of stalked tunicates reached a peak in 1976, then apparently declined at all Diablo Cove permanent stations, except 12 where they have not been observed (Figures 189 and 190). They were more abundant at the mid-depth stations (9, 10, and 11).

B. Control Areas

PORIFERA

Tethya aurantia

Orange puffball sponge densities increased at Station 7 (Figure 191).

CNIDARIA

Anthopleuraxanthogrammica

Very little change in observed density of giant green anemones' were noted at control stations (Figure 192).

ARTHROPODA

Cancer antennarius

Rock crabs were not abundant at any of the control stations. Their observed mean density fluctuated over the years at all stations (Figure 193).

MOLLUSCA

Astraea gibberosa

Observed mean densities of red turban snails changed little over the years at control stations (Figure 194). They were most abundant at Station 7 in Field's Cove.

Dendrodoris albopunctata

White-speckled nudibranch observed densities increased at Stations 6, 7 and 15 (Figure 195).

Haliotis rufenscens

Mean densities of red abalone declined at Stations 15 and 17 (Figure 196).

ECHINODERMATA

Patiria miniata

Observed abundance of sea bats changed little at Station 6; at Station 7, there was a decline in abundance from 1973 through 1976 and subsequent increase from 1976 through 1977 (Figure 197). There appeared to be an increase in their density at Station 15.

Pisaster giganteus

Observed densities of giant-spined sea stars increased over the years at Stations 6 and 7 (Figure 198).

Pycnopodia helianthoides

Sunflower stars were not abundant in any of our study areas; on the average, we usually observed one or two at each permanent control station during a survey (Figure 199).

Strongylocentrotus franciscanus

Giant red sea urchins declined in abundance at Stations 6, 7, and 15 (Figure 200). It should be pointed out that the sharp declines in densities at Station 15 occurred in 1977 and 1978, while the decline at Station 6 and 7 started in 1974.

CHORDATA

Styela montereyensis

As in Diablo Cove, 1976 was a peak year for densities of stalked tunicates (Figure 201). The increase was followed by a decrease in abundance at all three stations.

Discussion

As indicated in the Results section of the subtidal permanent station surveys, the Kruskal-Wallis tests to detect significant changes in densities over the years were not significant at the ($p \leq 0.05$) 95% level for any of the eleven invertebrate species tested. However, some of the trends observed at the Diablo Cove random stations were reflected in the Diablo Cove permanent station data. This was particularly true for giant red sea urchins which decreased from a mean density of 74.12 per station at Diablo Cove random arc station in 1974, to a density of 0.67 per station in 1977 (Figure 102). In the North Control they declined from 125.33 per station in 1974 to 5.70 per station in 1977 (Figure 127).

Fish Species Occurrence Study

Methods

A. Field

At the permanent stations described in the Permanent Station Brown Algae Methods section, as visibility allowed, the two divers recorded all fish species observed on and in the vicinity of the 30 m transect.

B. Laboratory

We attempted to collect any unidentified fish observed at the permanent stations. These were returned to the laboratory for identification released in Intake Cove or preserved for our reference collection.

C. Statistical

The fish data from the permanent stations was not subjected to statistical analysis.

The frequency of occurrence of each fish species is given by station and by area for Diablo Cove and Control Areas. The mean number of species seen at each station is given by year for the study areas.

Results

A. Diablo Cove

A total of 31 species of fishes were recorded at the six Diablo Cove permanent stations during our studies (Table 117). All of the species observed at permanent stations were also observed at random station except canary rockfishes, Sebastes pinniger, and Pacific sanddabs, Citharichtys sordidus.

Observations at Station 9 yielded the largest number of species (23), followed by Stations 12 and 16, respectively (Table 118). Station 12 produced the highest average number of species per survey during a single year: 12.5 survey in 1974 (Figure 202).

Station 10 in 1975 and 1976, and Station 16 in 1977, yielded the lowest average species counts per survey (Figure 202).

When all years' observations were combined, blue rockfishes ranked first in frequency of occurrence followed by painted greenlings and blackeye gobies (Figure 203). Fish that were observed at every station were: coralline sculpins, cabezon, kelp greenlings, painted greenlings, gopher rockfishes, and blue rockfishes.

TABLE 117. Summary of Fish Species Observed at Subtidal Permanent Stations in Diablo Cove and the Control Areas. DCPP, 1973-1978.

Scientific Name	Common Name	Diablo Cove	Control Areas
ANARHICHADIDAE			
Anarrhichthys ocellatus	Wolf-eel		X
BATHYMASTERIDAE			
Rathbunella hypoplecta	Smooth Ronquil	X	X
BOTHIDAE			
Citharichthys sordidus	Pacific sanddab	X	
CEBIDICHTHYIDAE			
Cebidichthys violaceous	Monkeyface-eel	X	
CLINIDAE			
Gibbonsia spp.	Kelpfish	X	X
COTTIDAE			
Artedius corallinus	Coralline sculpin	X	X
Jordania zonope	Longfin sculpin	X	
Orthonopias triacis	Snubnose sculpin	X	X
Scorpaenichthys marmoratus	Cabezon	X	X
EMBIOTOCIDAE			
Brachyistius frenatus	Kelp surfperch	X	
Cymatogaster aggregata	Shiner surfperch	X	
Damalichthys vacca	Pile surfperch	X	X
Embiotaca jacksoni	Black surfperch	X	X
Embiotoca lateralis	Striped surfperch	X	X
Hypsurus caryi	Rainbow surfperch	X	X
Phanerodon atripes	Sharpnose surfperch		X
Rhacochilus toxotes	Rubberlip surfperch	X	X

GASTEROSTEIDAE			
Aulorhynchus flavidus	Tubesnout	X	X
GOBIIDAE			
Coryphopterus nicholsii	Blackeye goby	X	X
HEXAGRAMMIDAE			
Hexagrammos decagrammus	Kelp greenling	X	X
Ophiodon elongatus	Lincod	X	X
Oxylebius pictus	Painted greenling	X	X
LABRIDAE			
Oxyjulis californica	Senorita	X	X
Pimelometopon pulchrum	California Sheephead		X
SCORPAENIDAE			
Sebastes atrovirens	Kelp rockfish	X	X
Sebastes carnatus	Gopher rockfish	X	X
Sebastes chrysomelas	Black and Yellow rockfish	X	X
Sebastes melanops	Black rockfish	X	X
Sebastes miniatus	Vermilion rockfish	X	X
Sebastes mystinus	Blue rockfish	X	X
Sebastes pinniger	Canary rockfish	X	X
Sebastes rastrelliger	Grass rockfish	X	X
Sebastes serranoides	Olive rockfish	X	X
SCYIORHINIDAE			
Cephaloscyllium ventriosum	Swell shark		X
STICHAEIDAE			
Chirolophis nugator	Mosshead warbonnet	X	

TABLE 118. Frequency of Occurrence of Fishes Observed at Permanent Subtidal Stations, Diablo Cove, DCPP, 1973 - 1978.

Species	Station						Totals	Rank
	1	9	10	11	12	16		
BATHYMASTERIDAE								
Rathbunella hypoplecta	0	0	0	5	8	0	13	8
BOTHIDAE								
Citharichthys sordidus	0	1	0	0	0	1	2	18
CEBIDICHTHYIDAE								
Cebidichthys violaceus	0	2	0	0	0	1	3	17
CLINIDAE								
Gibbonsia spp.	0	6	0	1	0	5	12	9
COTTIDAE								
Artedius corallinus	1	1	3	1	3	2	11	10
Orthonoplas triacis	0	3	4	7	4	2	20	6
Jordania zonope	0	1	0	2	2	0	5	15
Scolpaenichthys marmoratus	1	6	4	4	5	6	26	5
EMBIOTOCIDAE								
Brachyistus frenatus	0	0	0	0	0	1	1	19
Cymatogaster aggregata	0	0	0	0	0	1	1	19
Damalichthys vacca	0	1	0	2	4	4	11	10
Embiotoca jacksoni	0	1	1	0	6	0	8	12
Embiotoca lateralis	2	6	0	3	6	9	26	5
Hypsurus caryi	0	2	0	0	1	1	4	16
Rhacochiles toxotes	0	0	0	0	2	2	4	16
GASTEROSTEIDAE								
Aulorhynchus flavidus	0	2	1	0	0	0	3	17
GOBIIDAE								
Coryphopterus nicholsii	0	5	7	9	10	0	31	3
HEXAGRAMMIDAE								
Hexagrammos decagrammus	2	3	3	4	5	3	20	6
Ophiodon elongatus	0	2	1	4	4	0	11	10
Oxylebius pictus	2	9	6	11	11	2	41	2
LABRIDAE								
Oxyjulius californica	0	1	0	1	0	4	6	14

TABLE 118. (Continued)

Species	Station 1	9	10	11	12	16	Totals	Rank
SCORPAENIDAE								
Sebastes atrovirens	0	6	0	0	0	3	9	11
Sebastes carnatus	2	1	4	11	11	1	30	4
Sebastes chrysomelas	1	10	1	0	1	5	18	7
Sebastes melanops	0	0	0	4	3	0	7	13
Sebastes miniatus	0	0	0	2	4	0	6	14
Sebastes mystinus	1	10	6	12	8	5	42	1
Sebastes pinniger	0	0	1	0	4	0	5	15
Sebastes rastrelliger	0	1	0	0	0	5	6	14
Sebastes serranoides	1	1	0	3	3	0	8	12
STICHAEIDAE								
Chirolophis nugator	0	0	0	1	1	0	2	18
TOTAL SURVEYS	2	10	8	12	11	9	52	
TOTAL SPECIES	9	23	13	19	21	20		

B. Control Areas

Observations at the four permanent control station yielded 29 species of fish (Table 118). We observed the highest number of species at Station 6 in Field's Cove (Table 119); although Station 8 yielded the highest mean number during any one year, 13 in 1975 (Figure 204). Station 8 also produced the lowest mean count, 3 in 1973. There was an apparent declining trend in the number of species at Station 15. Blue rockfishes, painted greenlings, and black-and-yellow rockfishes ranked first, second, and third in occurrence, respectively at the Control Stations (Figure 205).

Discussion

As mentioned in the discussion of the fish at random stations, Burge and Schultz (1973), recorded 24 species of fish at the permanent subtidal stations. During our surveys of these stations from 1973 through mid 1978, we have observed a total of 35 species (Table 117). The fact that more surveys were involved with the present studies probably accounts for the large discrepancy in totals.

As at the random stations, blue rockfishes were at the most frequently observed species followed by painted greenlings which agrees with the finding of Burge and Schultz (1973).

Two warm temperate fish, California sheephead, Pimelometopon pulchrum, and swell sharks, Cephaloscyllium ventriosum, were observed at control stations but not in Diablo Cove. Both of these species may become part of the Diablo Cove fish fauna after the power plant begins operating. The fact that more species

TABLE 119. Frequency of Occurrence of Fishes Observed at Permanent Subtidal Station, Control Areas. DCPP, 1973 - 1978.

	Station					
Species	6	7	8	15	Totals	Rank
ANARICHADIDAE						
Anarrichthys ocellatus	3	0	0	0	3	14
BATHYMASTERIDAE						
Rathbunella hypoplecta	1	0	0	0	1	16
CLINIDAE						
Gibbonsia spp.	0	2	2	1	5	12
COTTIDAE						
Artedius corallinus	1	2	2	2	7	10
Orthonoplas triacis	2	5	3	5	15	6
Scorpaehichthys marmoratus	3	3	2	6	14	7
EMBIOTOCIDAE						
Damalichthys vacca	1	2	1	0	4	13
Embiotoca jacksoni	2	2	1	1	6	11
Embiotoca lateralis	3	4	3	7	17	5
Phanerodon atripes	0	0	0	3	3	14
Rhacochiles toxotes	1	1	0	0	2	15
GASTEROSTEIDAE						
Aulorhynchus flavidus	1	0	0	0	1	16
GOBIIDAE						
Coryphopterus nicholsii	8	3	0	6	17	5
HEXAGRAMMIDAE						
Hexagrammos decagrammus	4	6	2	6	18	4
Ophiodon elongatus	3	4	2	3	12	8
Oxylebius pictus	7	5	4	9	25	2
LABRIDAE						
Oxyjulius californica	1	2	1	1	5	12
Pimelometopon pulchrum	0	0	1	2	2	15
SCORPAENIDAE						
Sebastes atrovirens	6	3	0	3	12	8
Sebastes carnatus	6	5	0	4	15	6
Sebastes chrysomelas	8	2	2	9	21	3
Sebastes melanops	4	0	0	0	4	13
Sebastes miniatus	1	0	0	1	2	15
Sebastes mystinus	8	8	4	10	30	1
Sebastes pinniger	0	0	0	1	1	16
Sebastes rastrelliger	1	1	0	0	2	15
Sebastes serranoides	1	2	0	7	10	9

TABLE 119. (Continued)

Species	Station 6	7	8	15	Totals	Rank
SCYLLORHINIDAE						
Cephaloscyllium ventriosum	1	0	0	0	1	16
TOTAL SURVEYS	6	9	4	11		
TOTAL SPECIES	24	19	13	20		

of fish were observed at random 30-m^2 arc stations in Diablo Cove (37 species) than at the permanent stations (31 species) is probably due to the fact that there were more random stations and the random stations tend to sample all the different types of habitat in Diablo Cove, while the permanent stations do not.

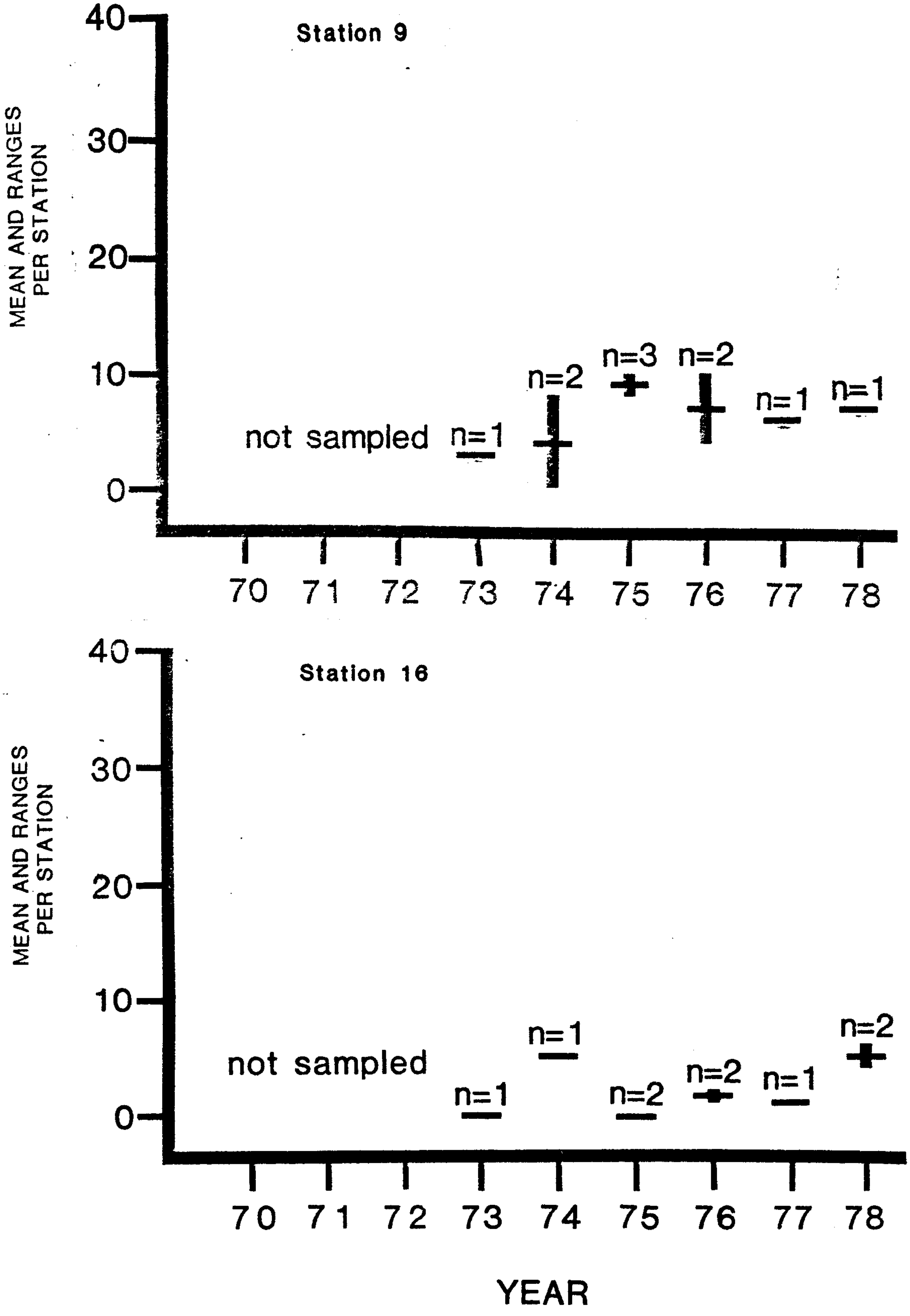


Figure 169. Means and ranges per station for <u>Tethya</u> <u>auranta</u> at subtidal permanent stations 9 and 16 in Diablo Cove. DCPP, 1970-1978.

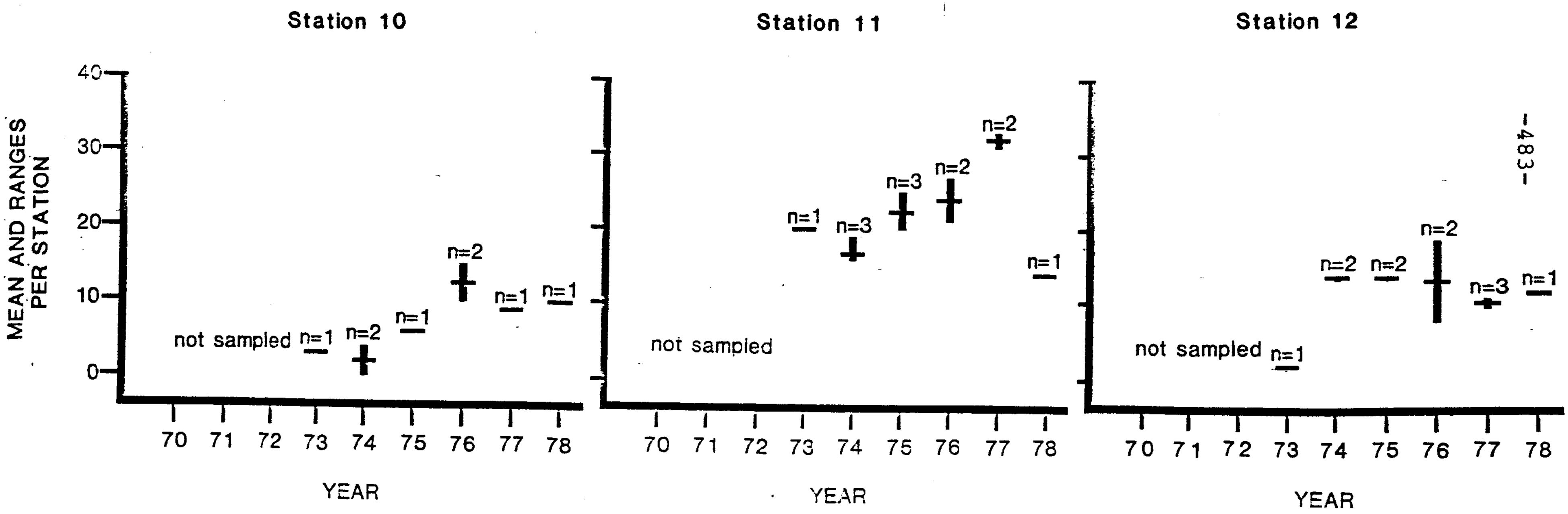


Figure 170. Means and ranges per station for Tethya aurantia at subtidal permanent stations 10, 11 & 12 in Diablo Cove. DCPP, 1970-1978.

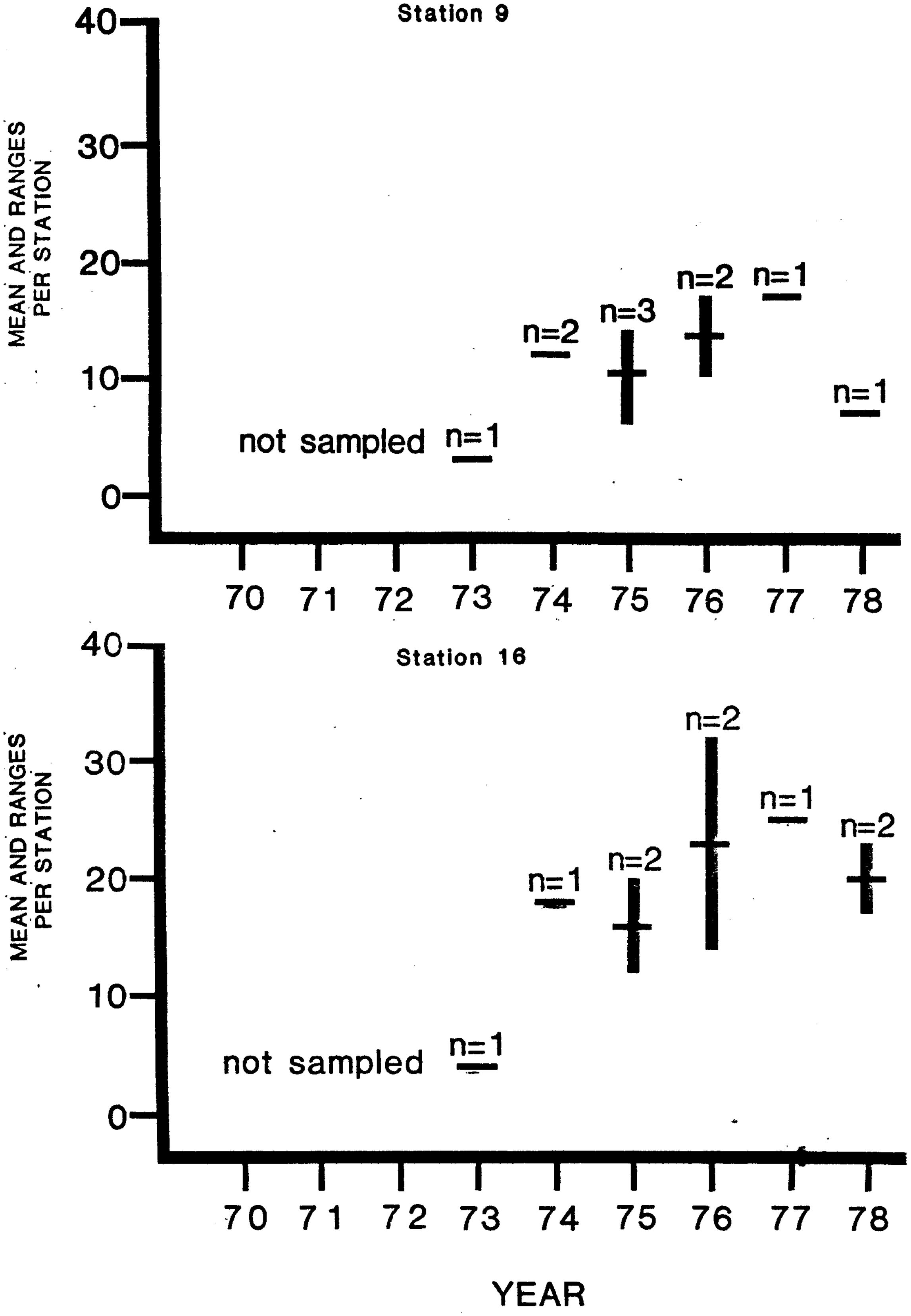


Figure 171. Means and ranges per station for Anthopleura xanthogrammica at subtidal permanent stations 9 and 16 in Diablo Cove. DCPP, 1970-1978.

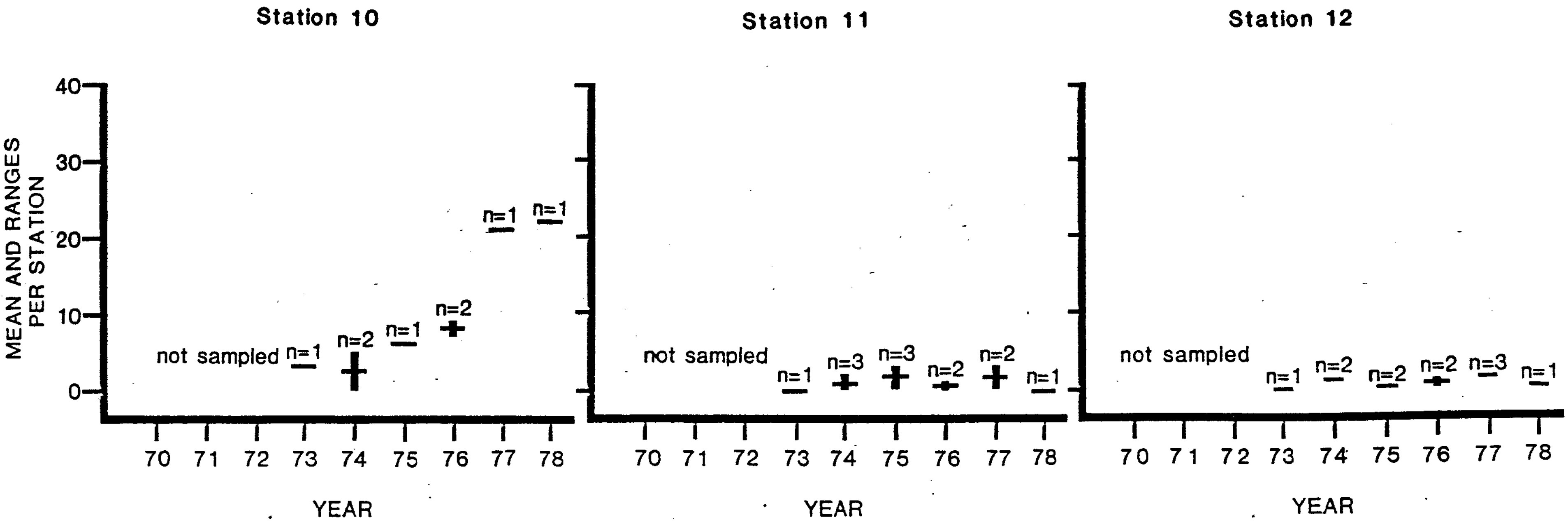


Figure 172. Means and ranges per station for Anthopleura xanthogrammica at subtidal permanent stations 10, 11 & 12 in Diablo Cove. DCPP, 1970-1978.

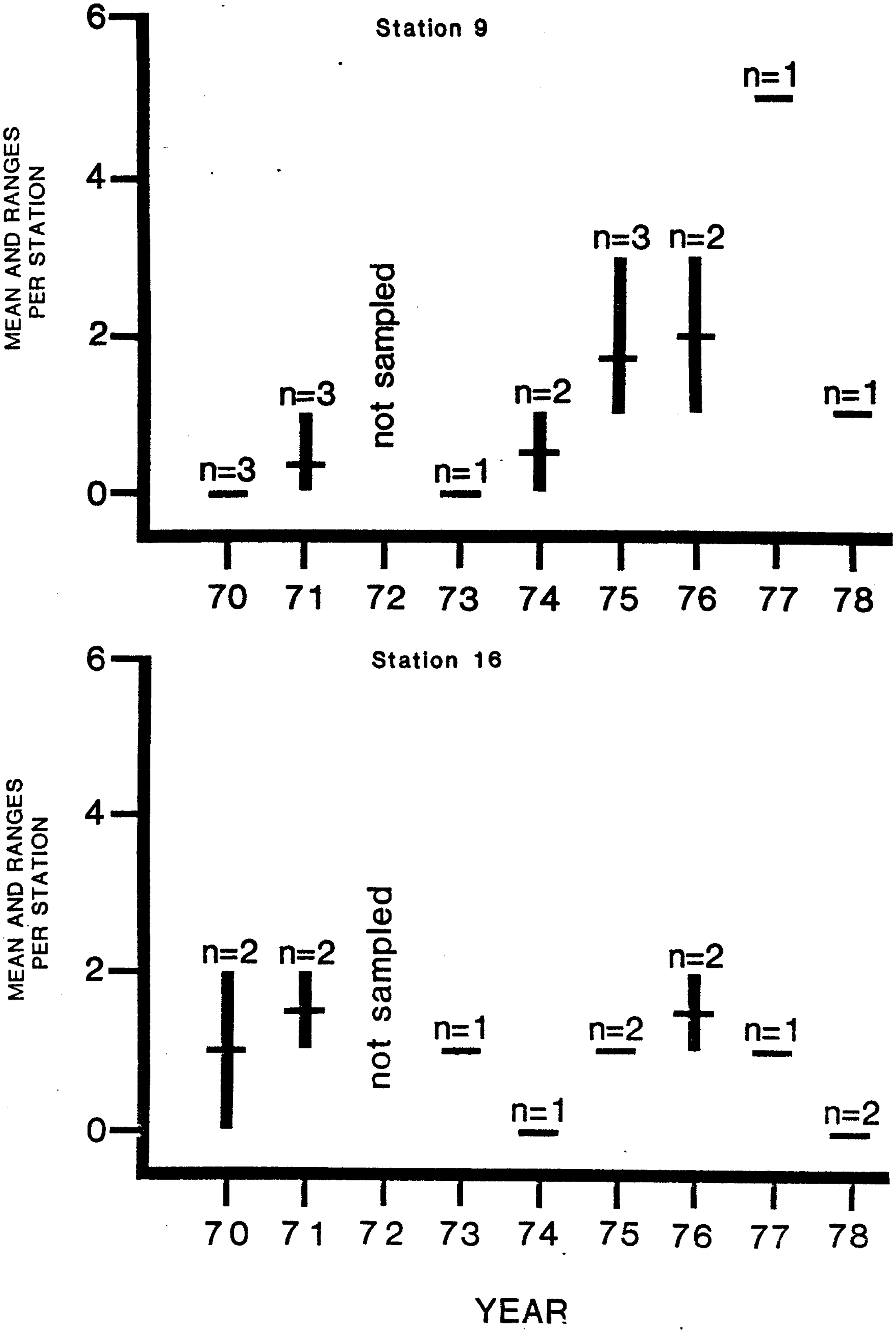


Figure 173. Means and ranges per station for Cancer antennarius at subtidal permanent stations 9 and 16 in Diablo Cove. DCPP, 1970-1978.

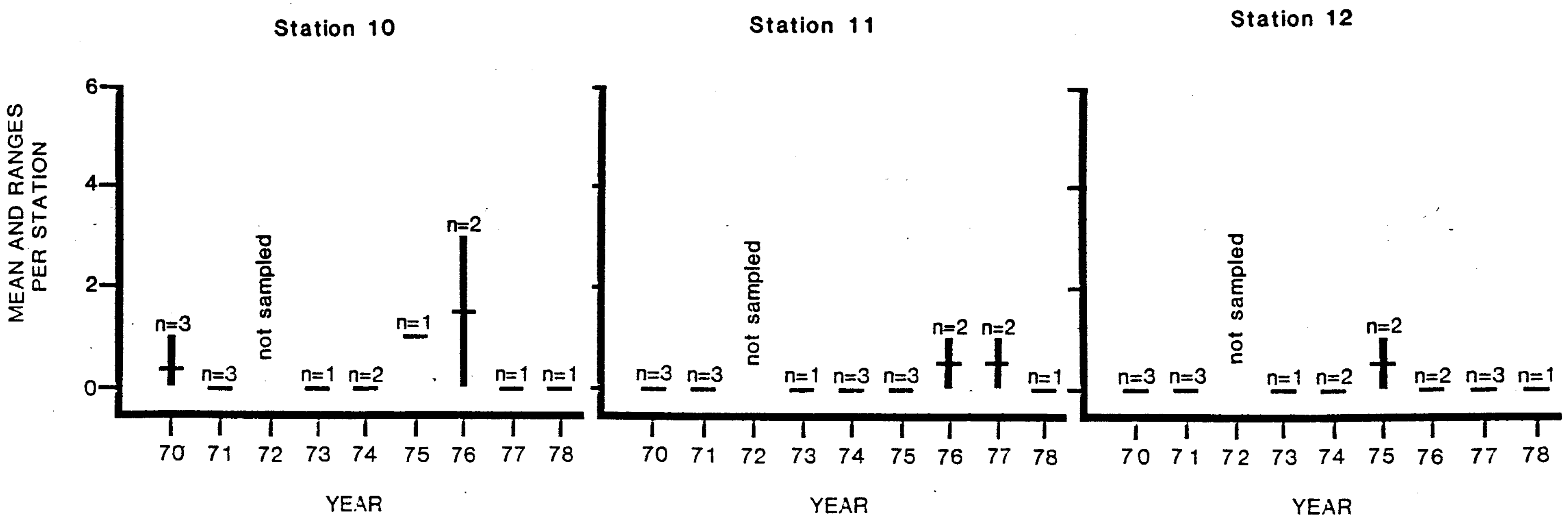


Figure 174. Means and ranges per station for Cancer antennarius at subtidal permanent stations 10, 11 & 12 in Diablo Cove. DCPP, 1970-1978.

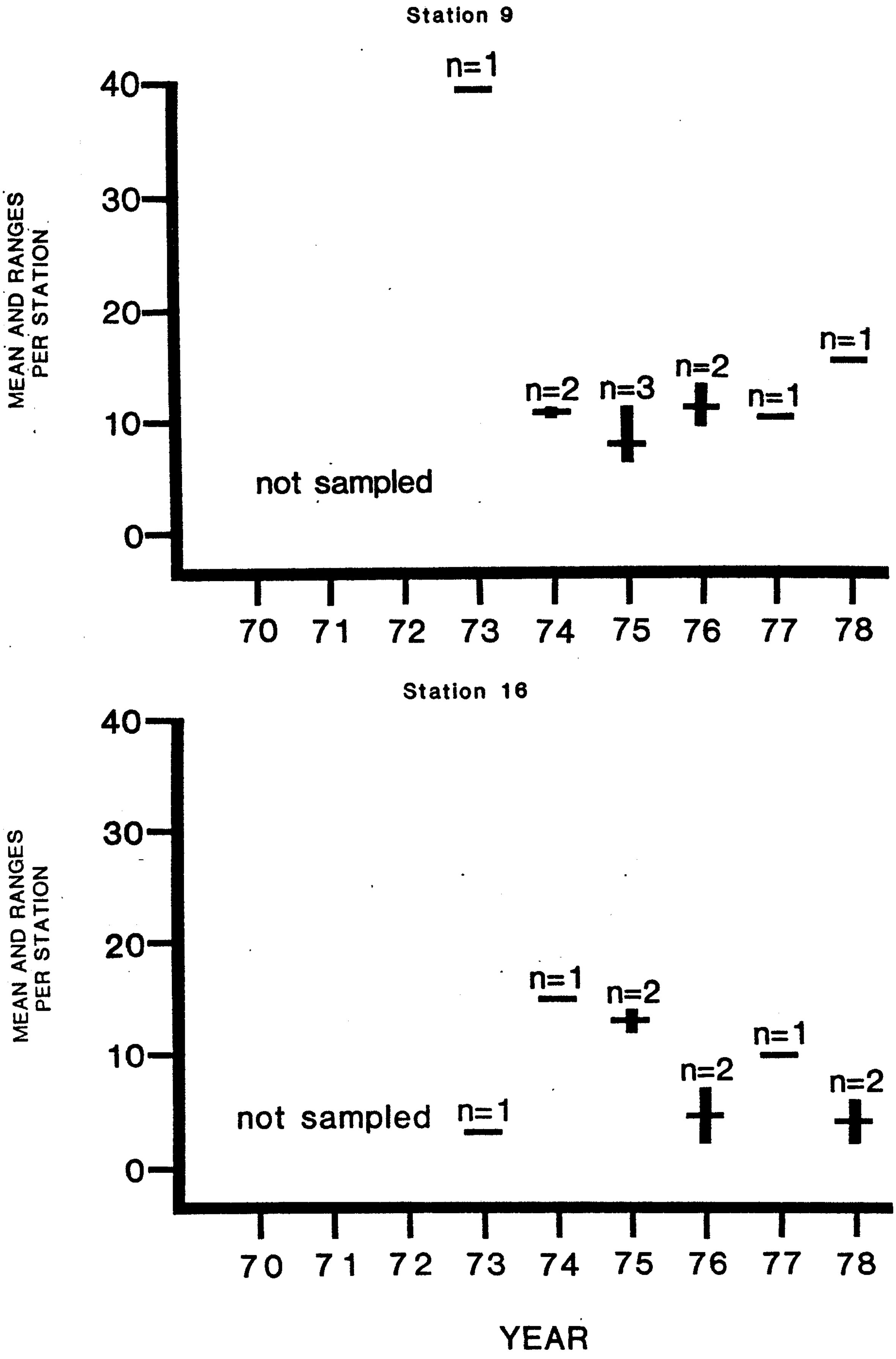


Figure 175. Means and ranges per station for Astraea gibberosa at subtidal permanent stations 9 and 16 in Diablo Cove. DCPP, 1970-1978.

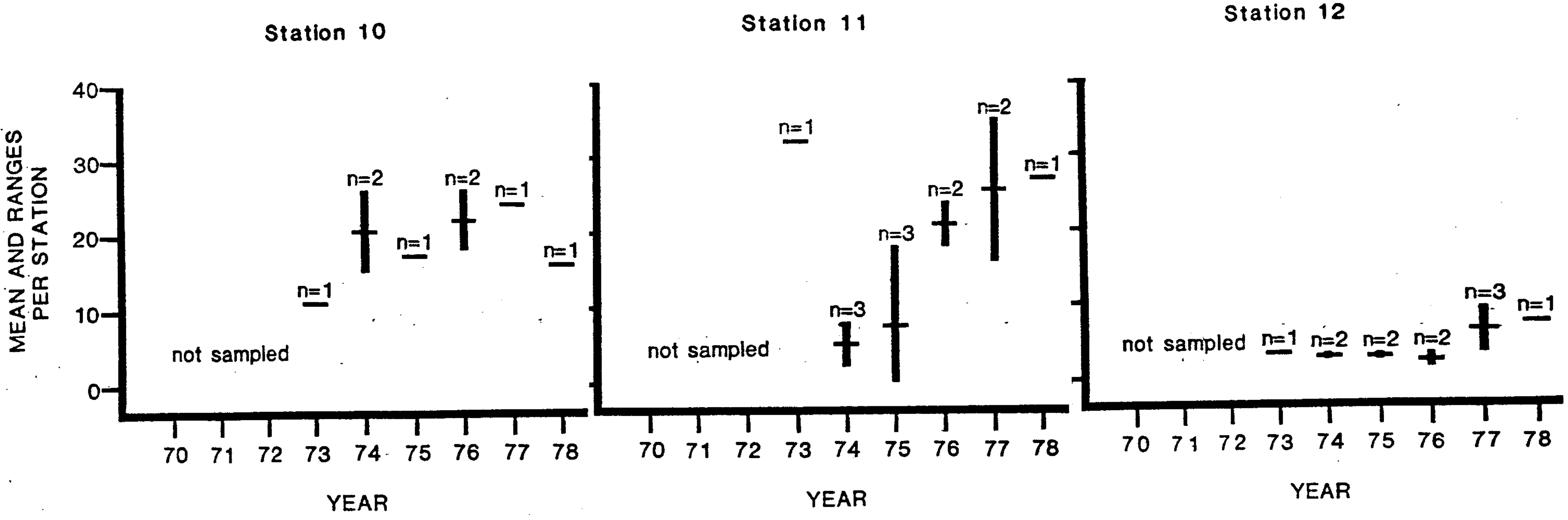


Figure 176. Means and ranges per station for Astraea gibberosa at subtidal permanent stations 10, 11 & 12 in Diablo Cove. DCPP, 1970-1978.

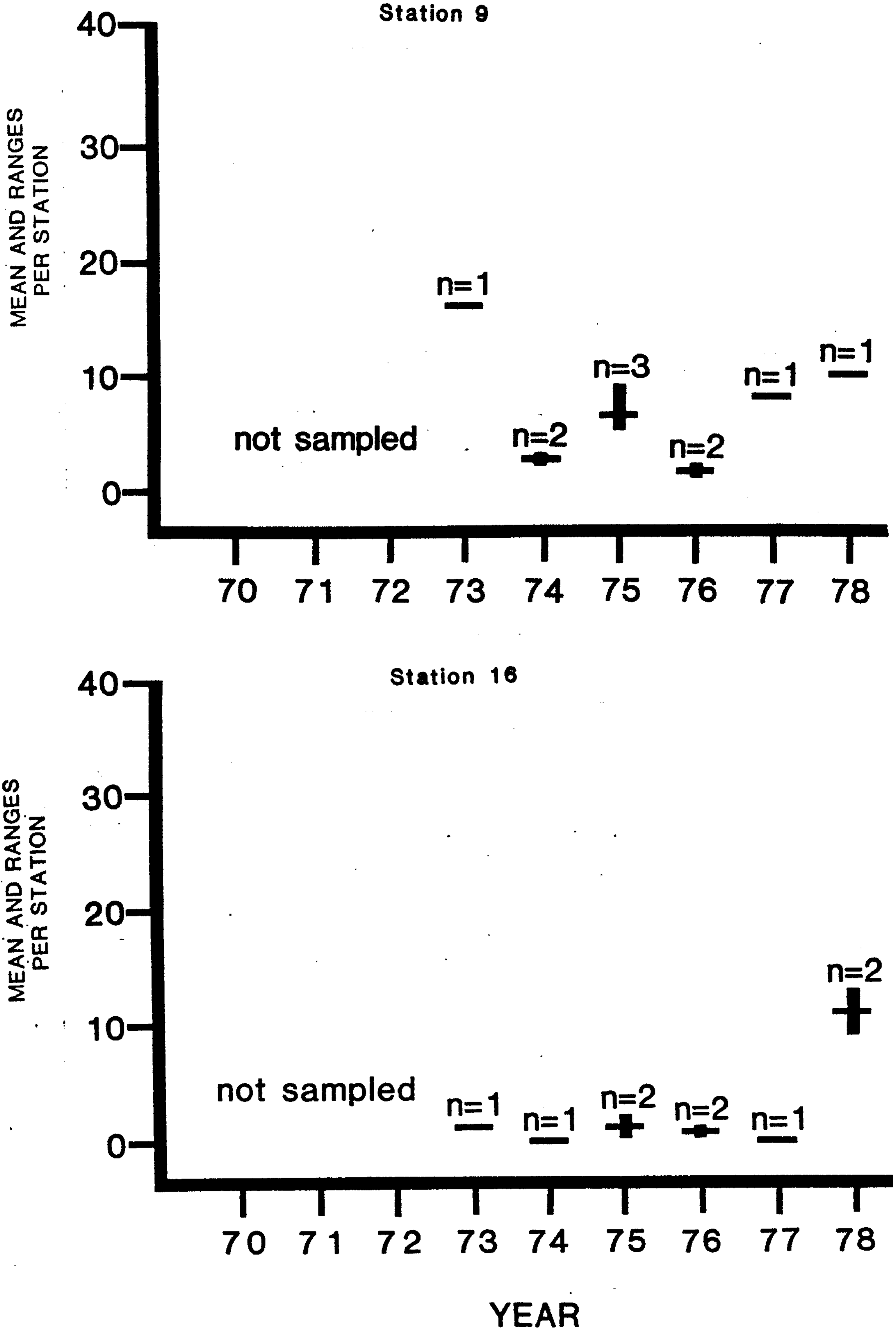


Figure 177. Means and ranges per station for Doriopsilla albopunctata at subtidal permanent stations 9 and 16 in Diablo Cove. DCPP, 1970-1978.

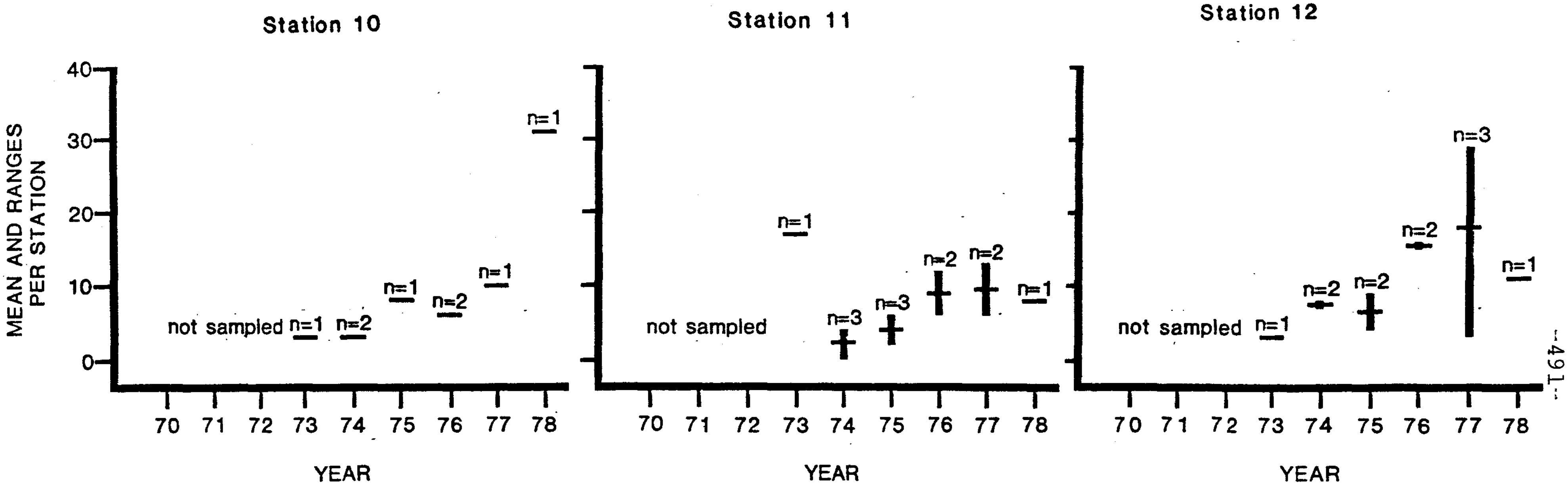


Figure 178. Means and ranges per station for Doriopsilla albopunctata at subtidal permanent stations 10, 11 & 12 in Diablo Cove. DCPP, 1970-1978.

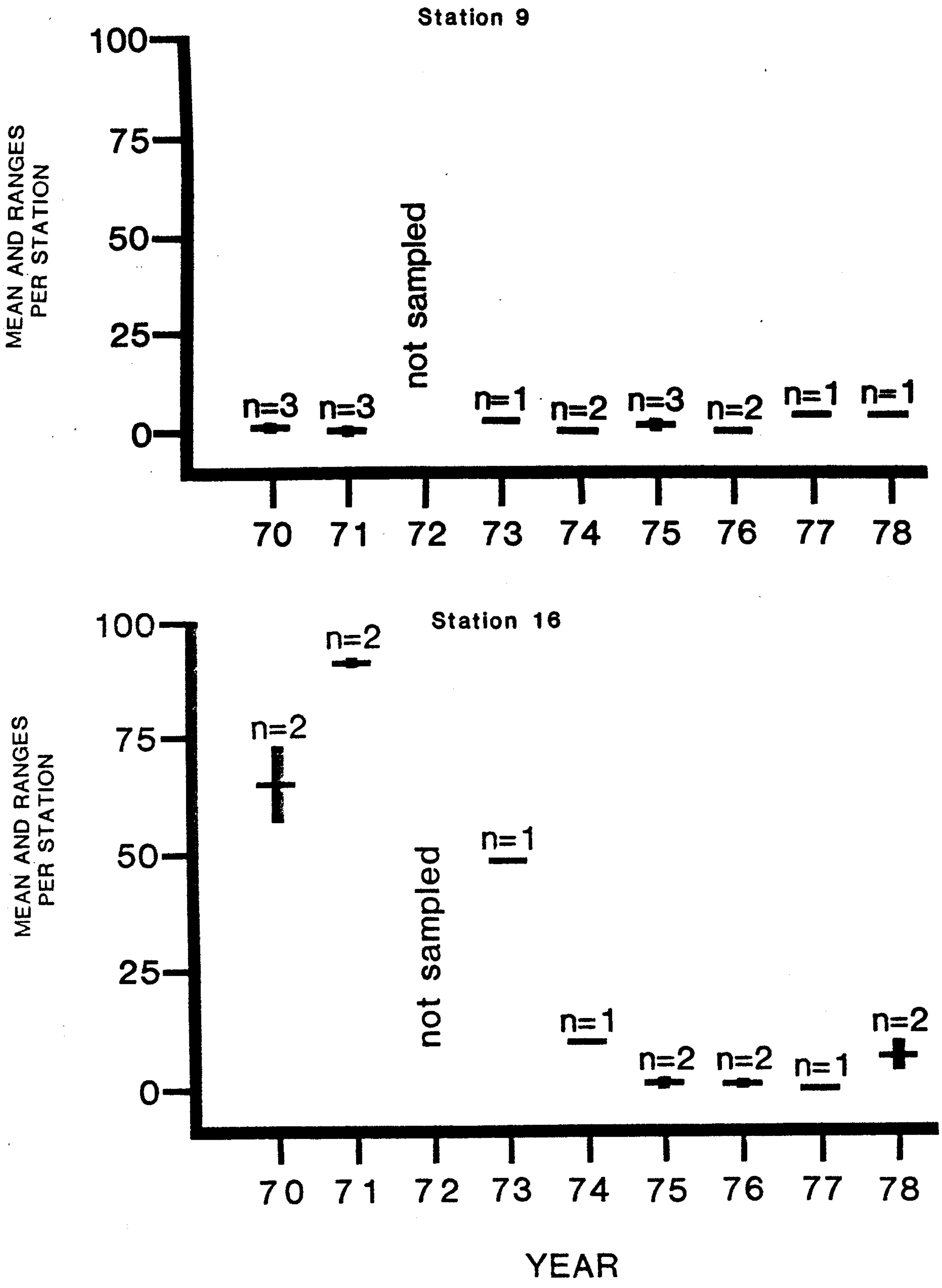


Figure 179. Means and ranges per station for Haliotis rufescens at subtidal permanent stations 9 and 16 in Diablo Cove. DCPP, 1970-1978.

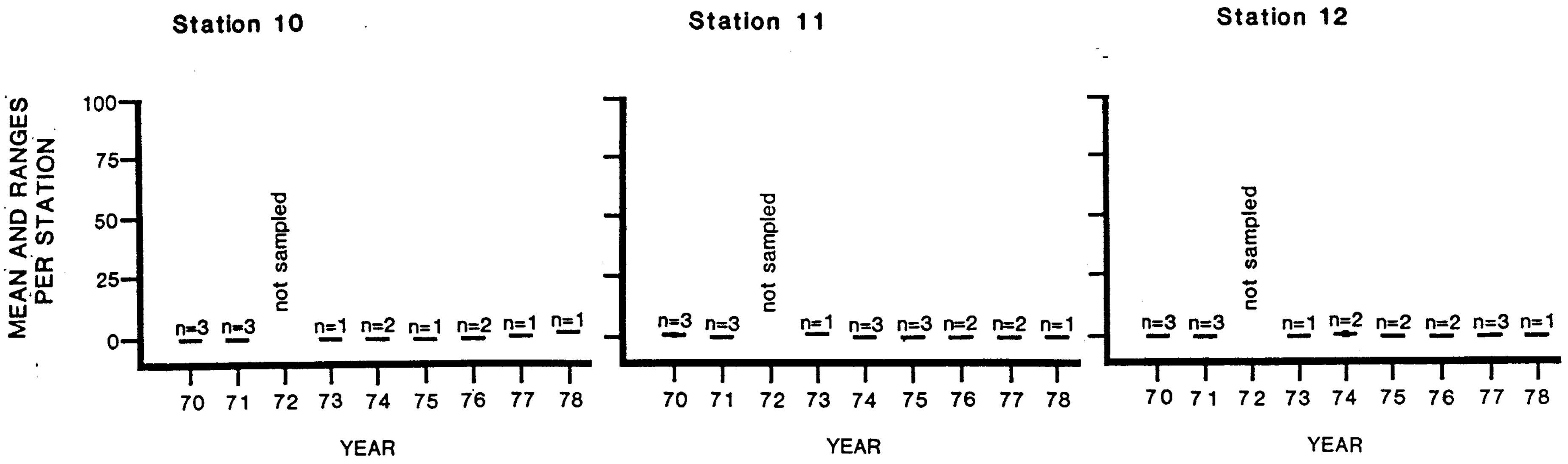


Figure 180. Means and ranges per station for Haliotis rufescens at subtidal permanent stations 10, 11 & 12 in Diablo Cove. DCPP, 1970-1978.

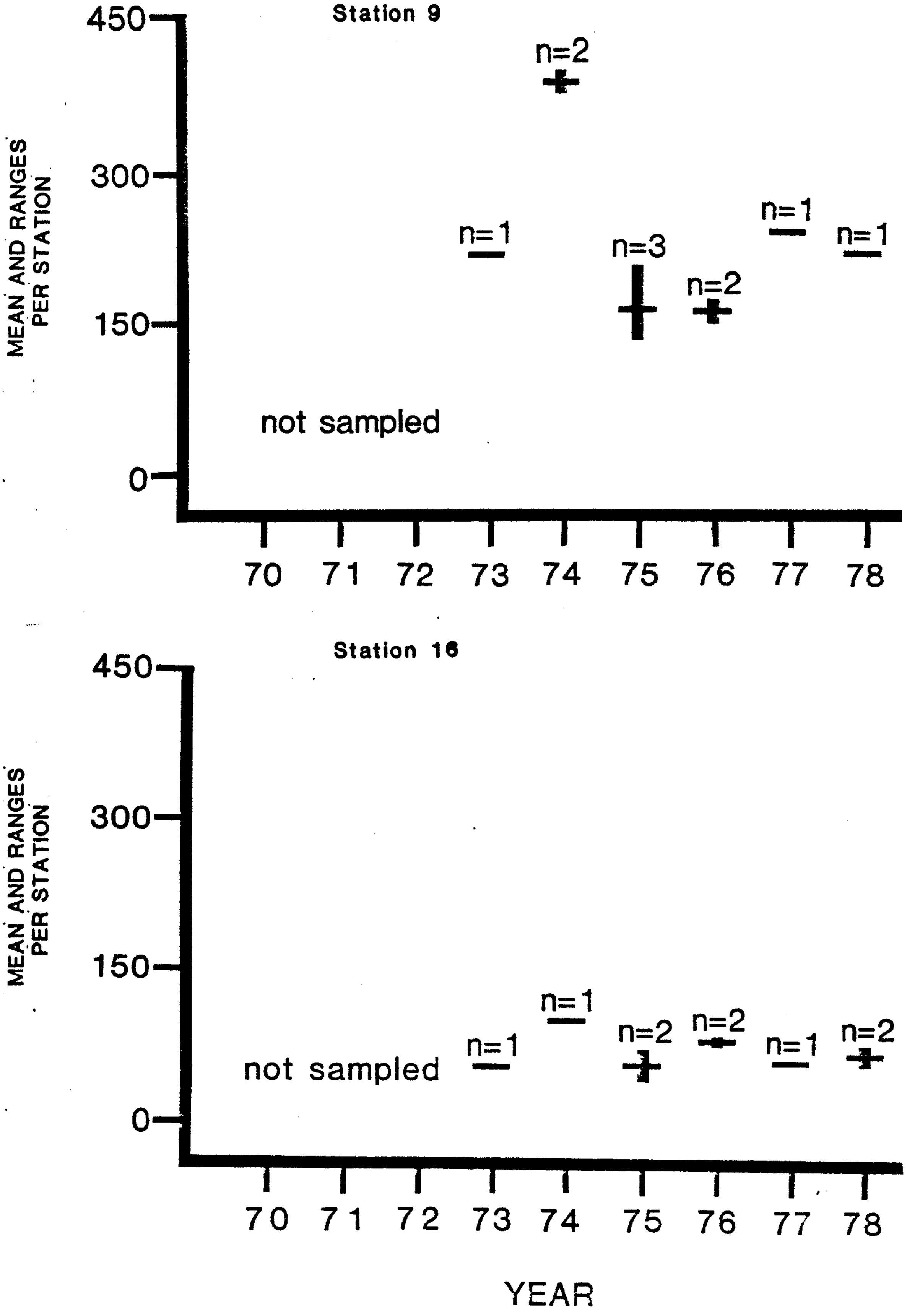


Figure 181. Means and ranges per station for Patiria miniata at subtidal permanent stations 9 and 16 in Diablo Cove. DCPP, 1970-1978.

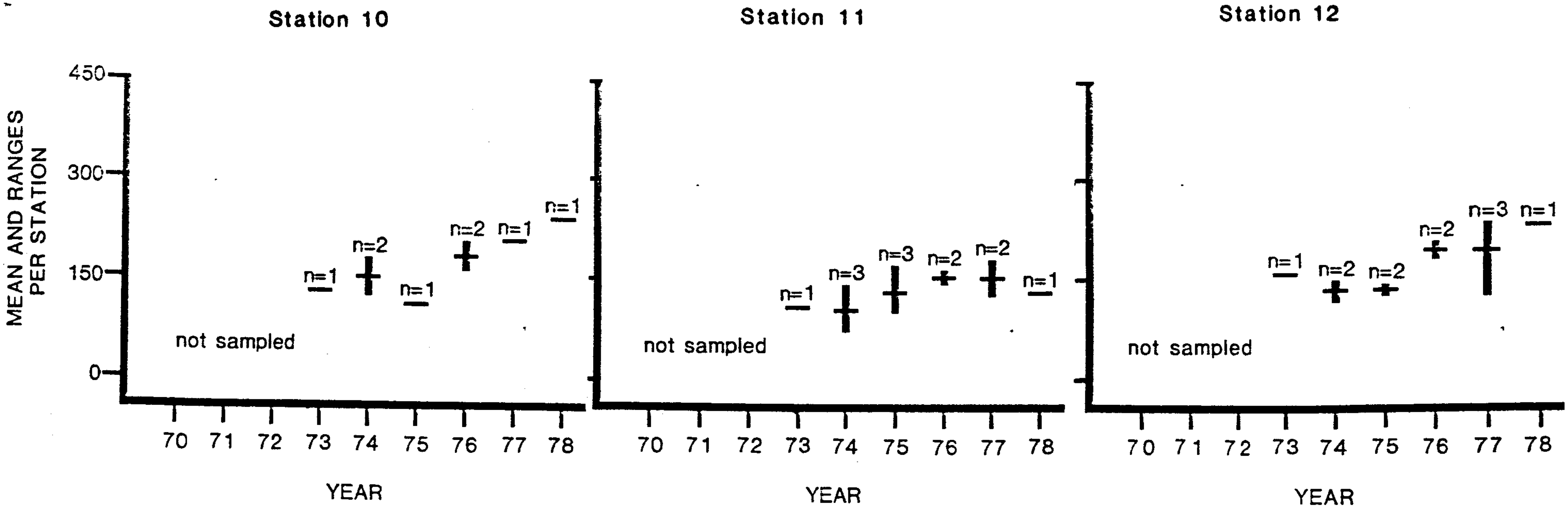


Figure 182. Means and ranges per station for <u>Patiria miniata</u> at subtidal permanent stations 10, 11 & 12 in Diablo Cove. DCPP, 1970-1978.

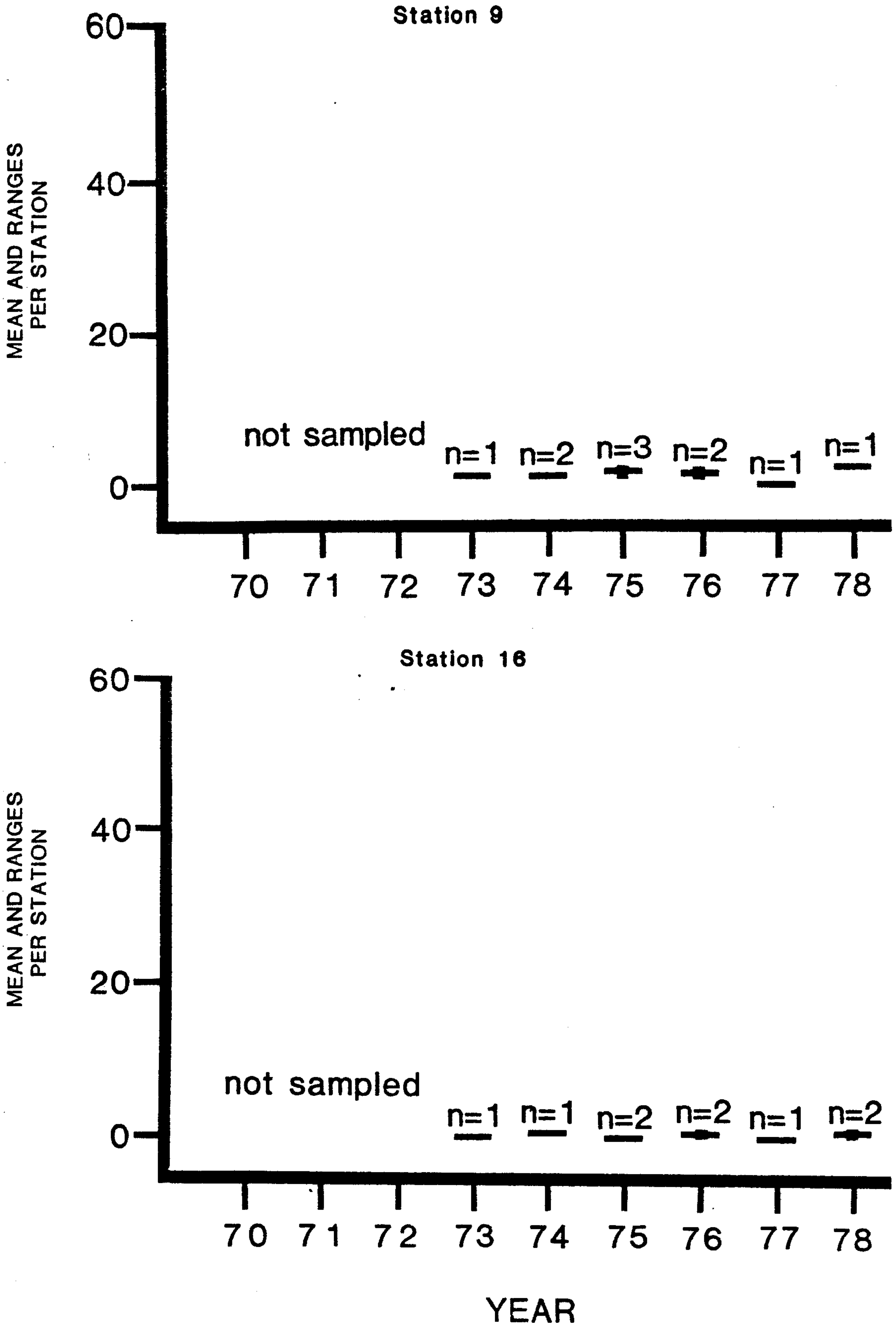


Figure 183. Means and ranges per station for Pisaster giganteus at subtidal permanent stations 9 and 16 in Diablo Cove. DCPP, 1970-1978.

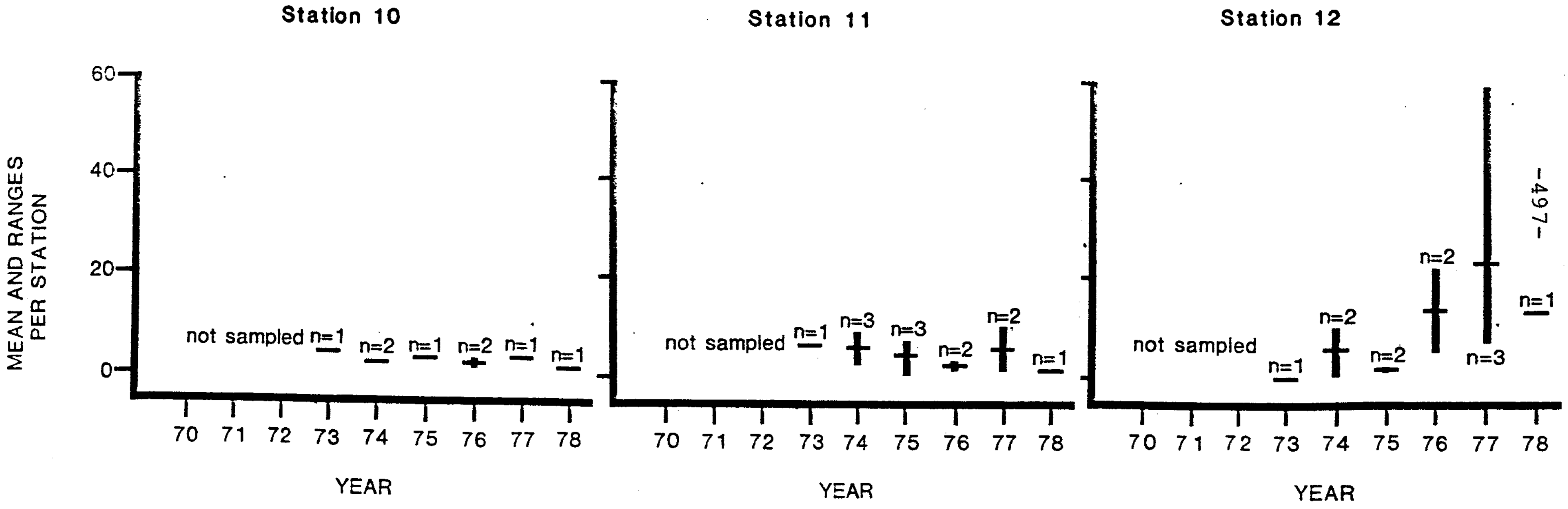


Figure 184. Means and ranges per station for Pisaster giganteus at subtidal permanent stations 10, 11 & 12 in Diablo Cove. DCPP, 1970-1978.

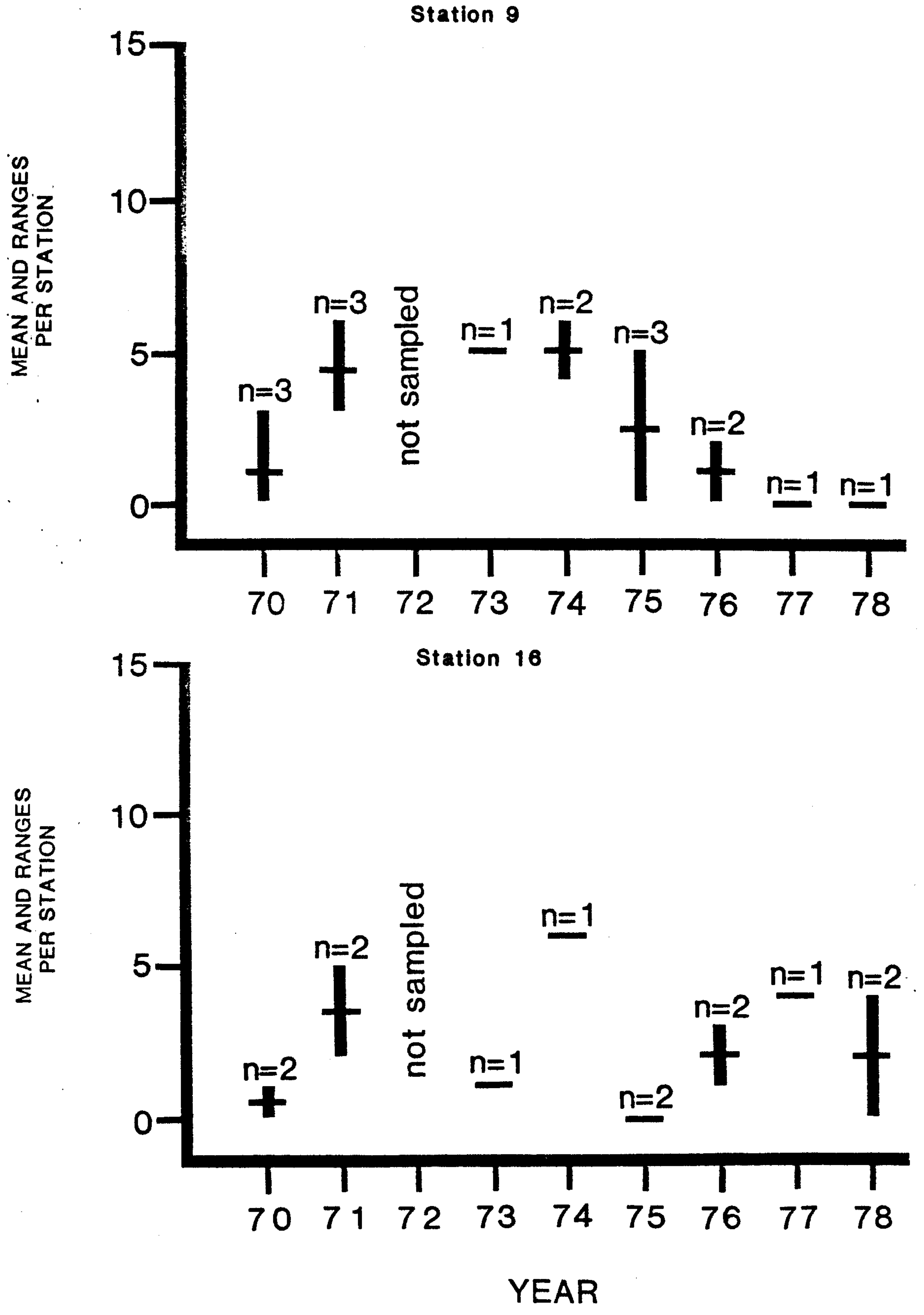


Figure 185. Means and ranges per station for Pycnopodia helianthoides at subtidal permanent stations 9 and 16 in Diablo Cove. DCPP, 1970-1978.

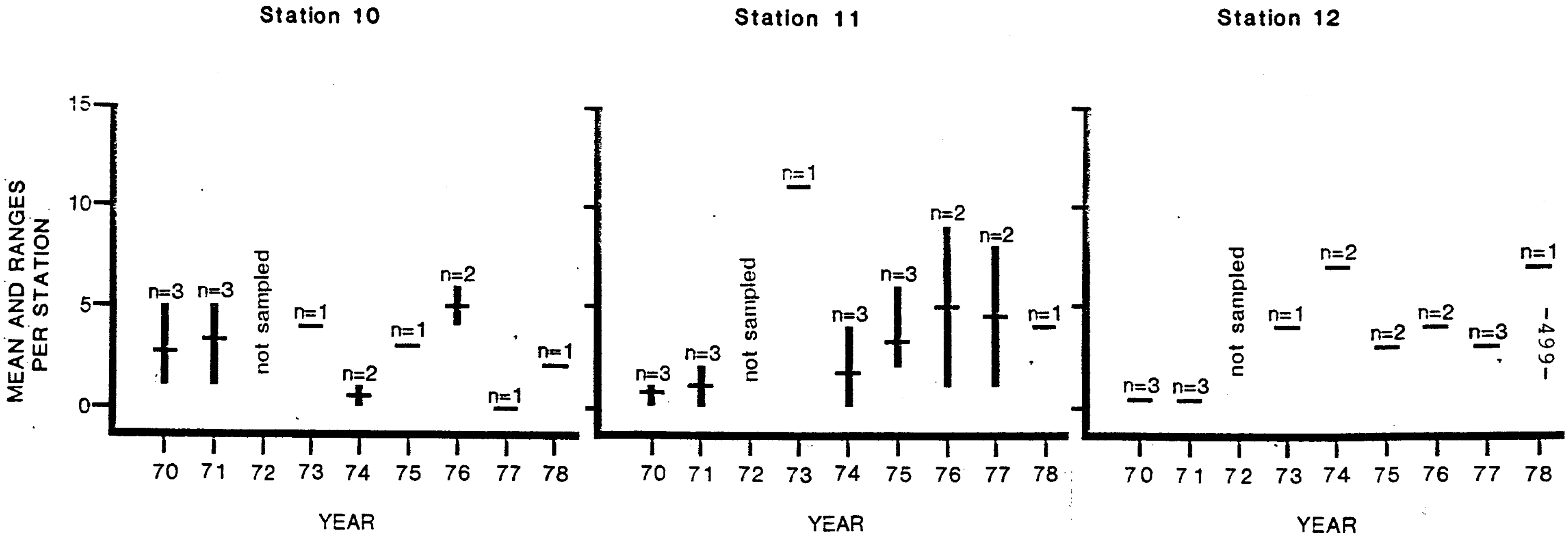


Figure 186. Means and ranges per station for <u>Pycnopodia helianthoides</u> at subtidal permanent stations 10, 11 & 12 in Diablo Cove. DCPP, 1970-1978.

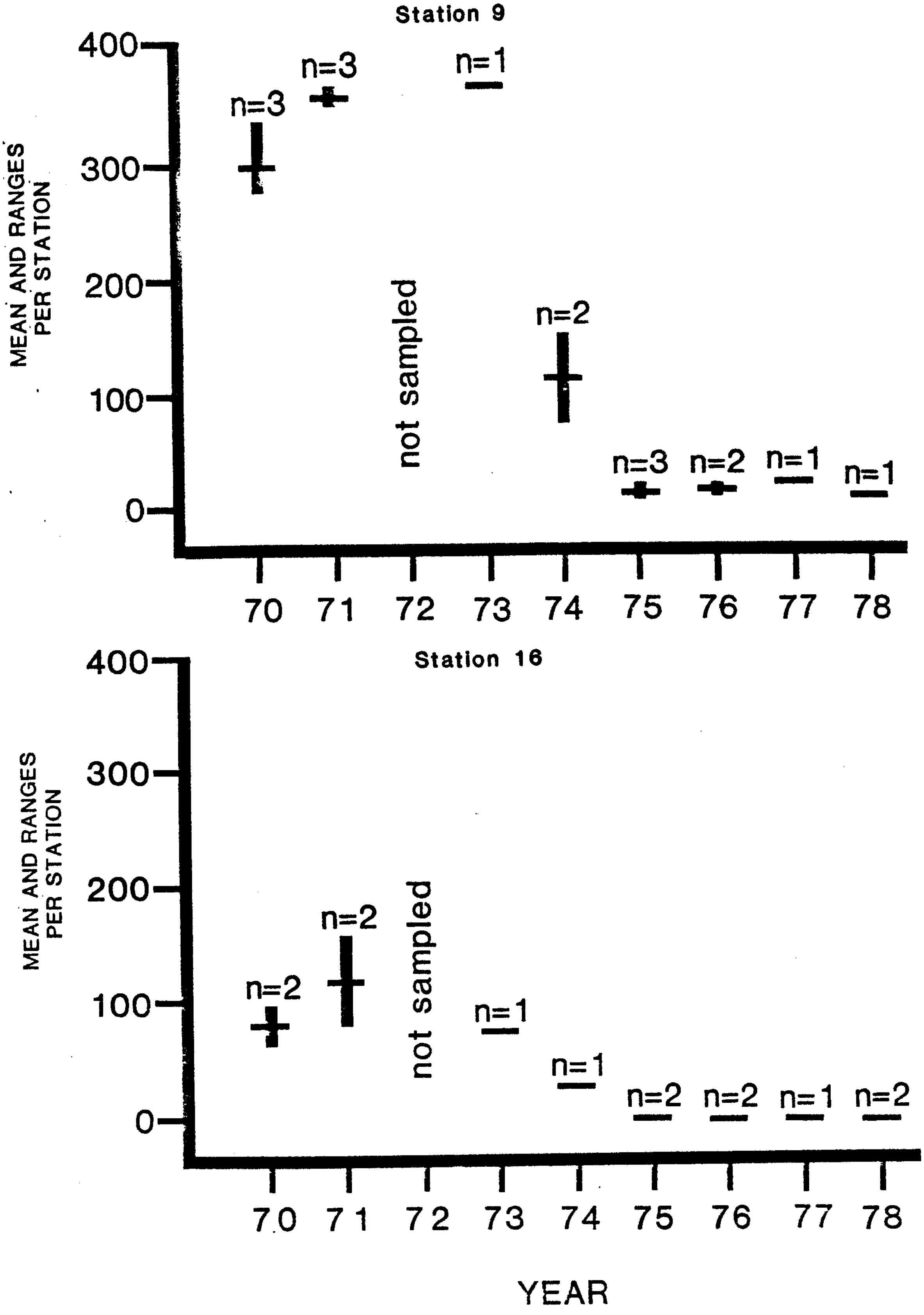


Figure 187. Means and ranges per station for Strongylocentrotus franciscanus at subtidal permanent stations 9 and 16 in Diablo Cove. DCPP, 1970-1978.

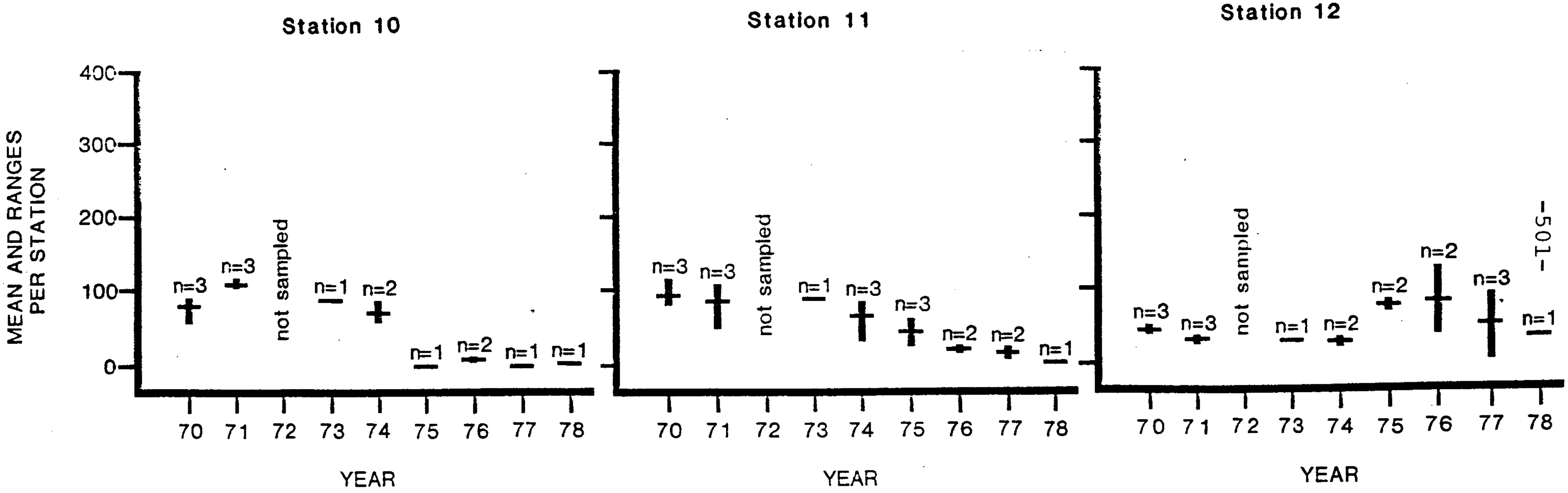


Figure 188. Means and ranges per station for <u>Strongylocentrotus</u> <u>franciscanus</u> at subtidal permanent stations 10, 11 & 12 in Diablo Cove. DCPP, 1970-1978.

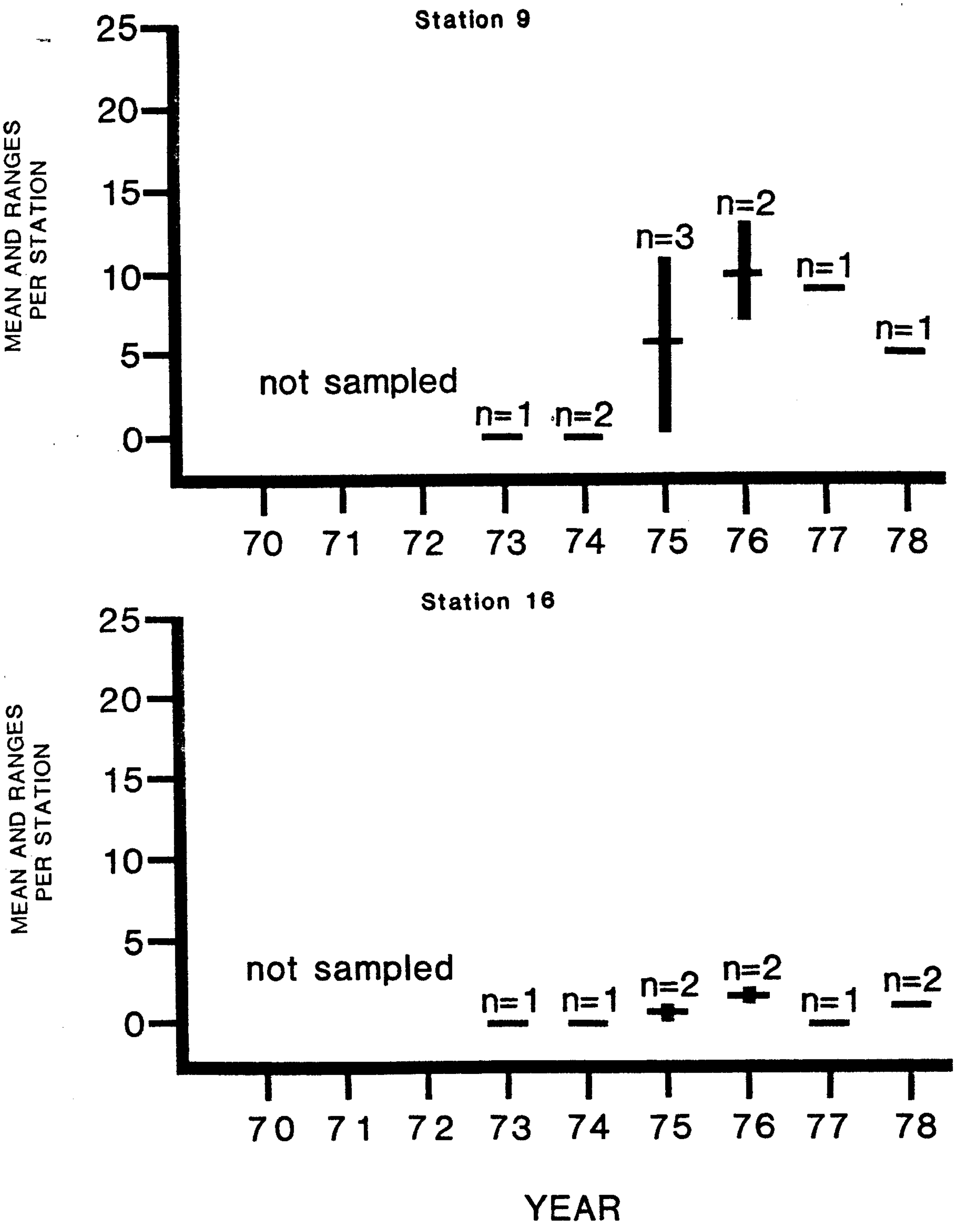


Figure 189. Means and ranges per station for Styela montereyensis at subtidal permanent stations 9 and 16 in Diablo Cove. DCPP, 1970-1978.

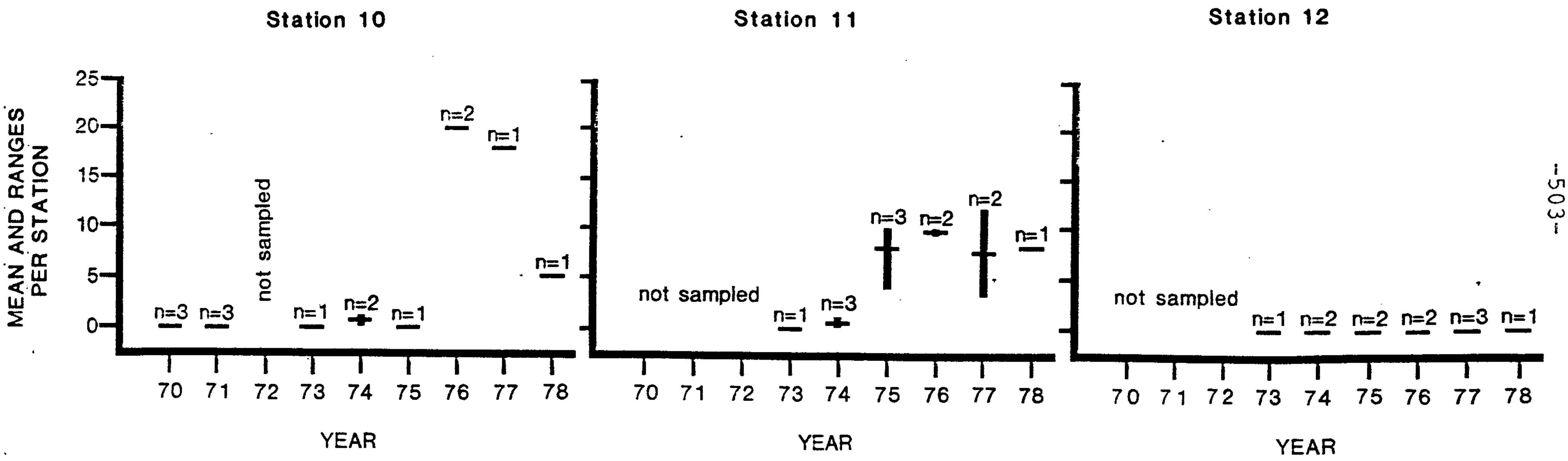


Figure 190. Means and ranges per station for Styela montereyensis at subtidal permanent stations 10, 11 & 12 in Diablo Cove. DCPP, 1970-1978.

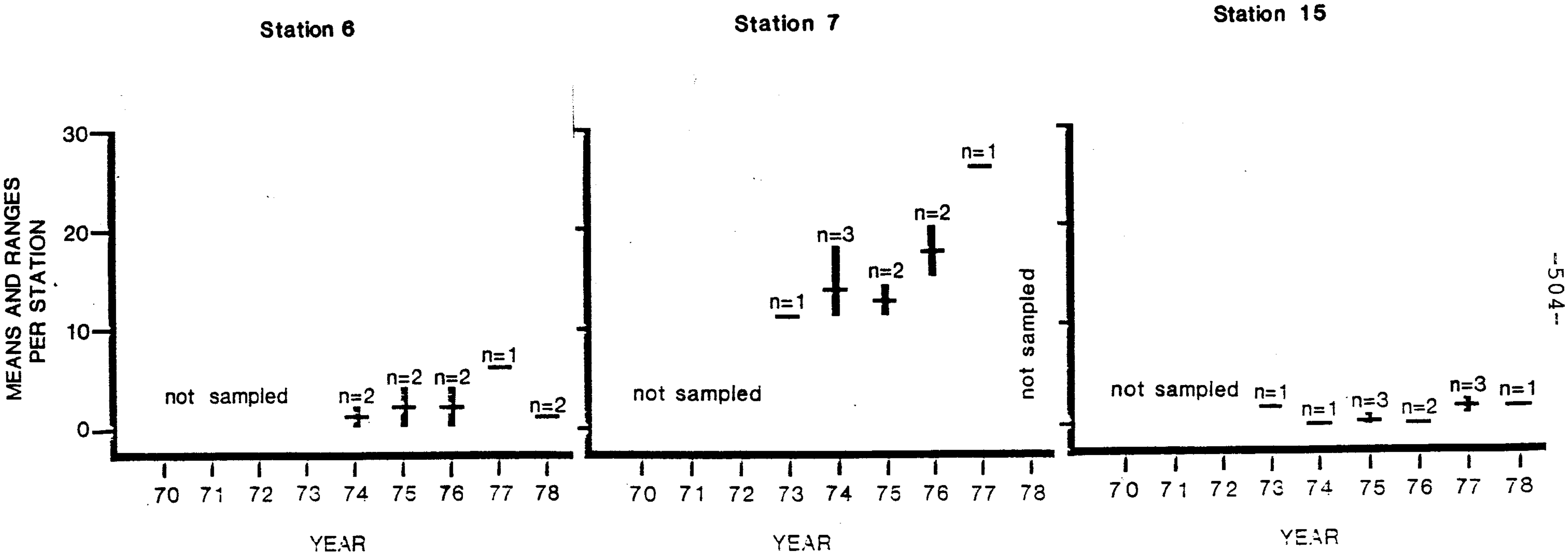
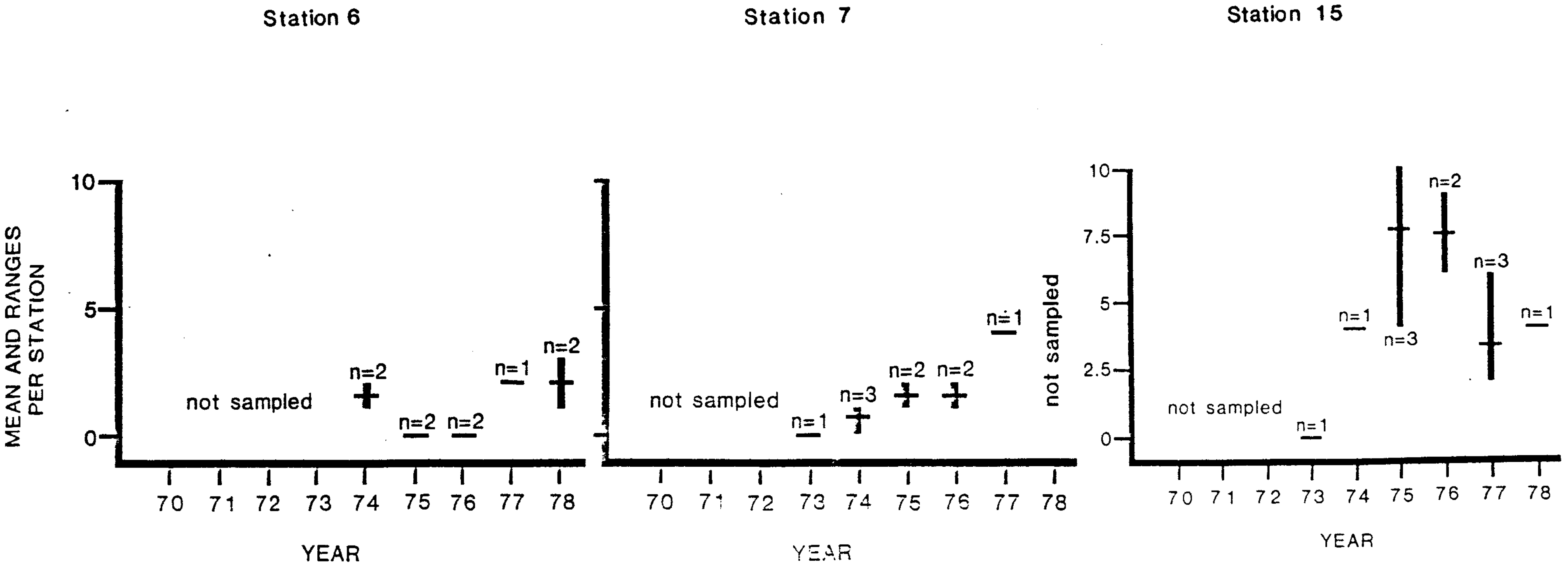


Figure 191. Means and ranges per station for <u>Tethya aurantia</u> at subtidal permanent stations 6, 7 & 15 in Control Areas. DCPP, 1970-1978.


Station 6
Station 7
Station 15
MEAN AND RANGES PER STATION
10
5
0
not sampled
n=2
n=2
n=2
n=1
n=2
70 71 72 73 74 75 76 77 78
YEAR
not sampled
n=1
n=3
n=2
n=2
n=1
70 71 72 73 74 75 76 77 78
YEAR
not sampled
10
7.5
5
2.5
0
not sampled
n=1
n=1
n=3
n=2
n=3
n=1
70 71 72 73 74 75 76 77 78
YEAR

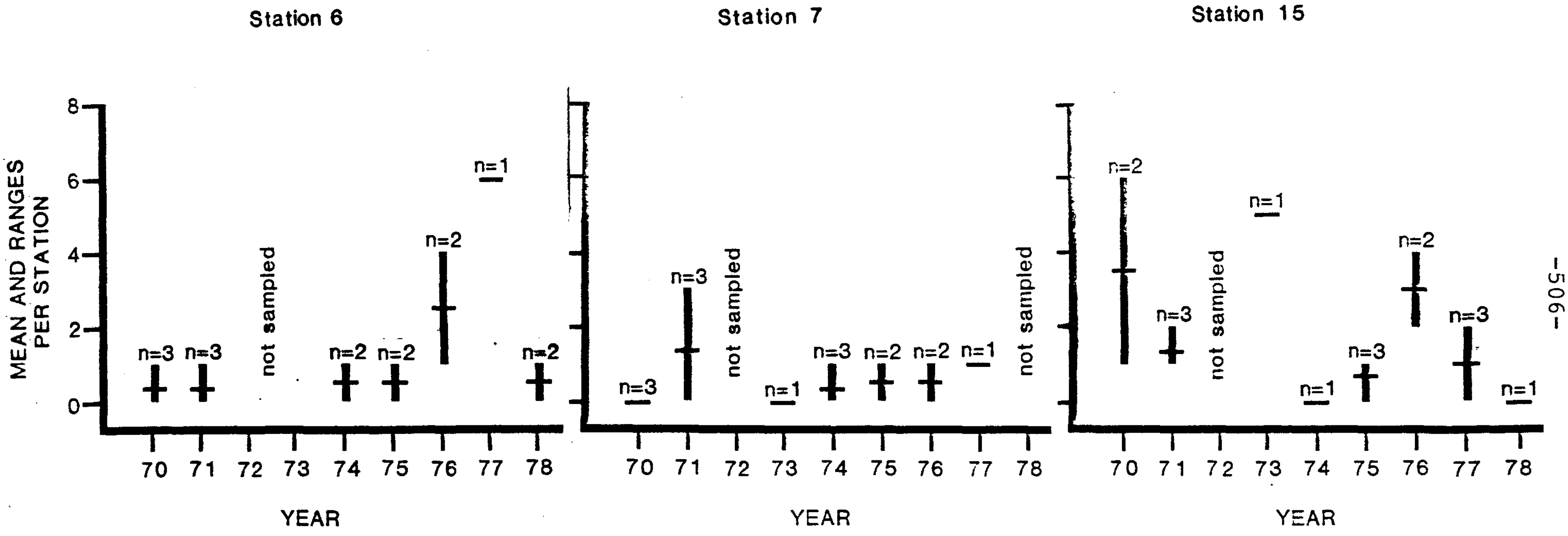


Figure 193. Means and ranges per station for Cancer antennarius at subtidal permanent stations 6, 7 & 15 in the Control Areas. DCPP, 1970-1978.

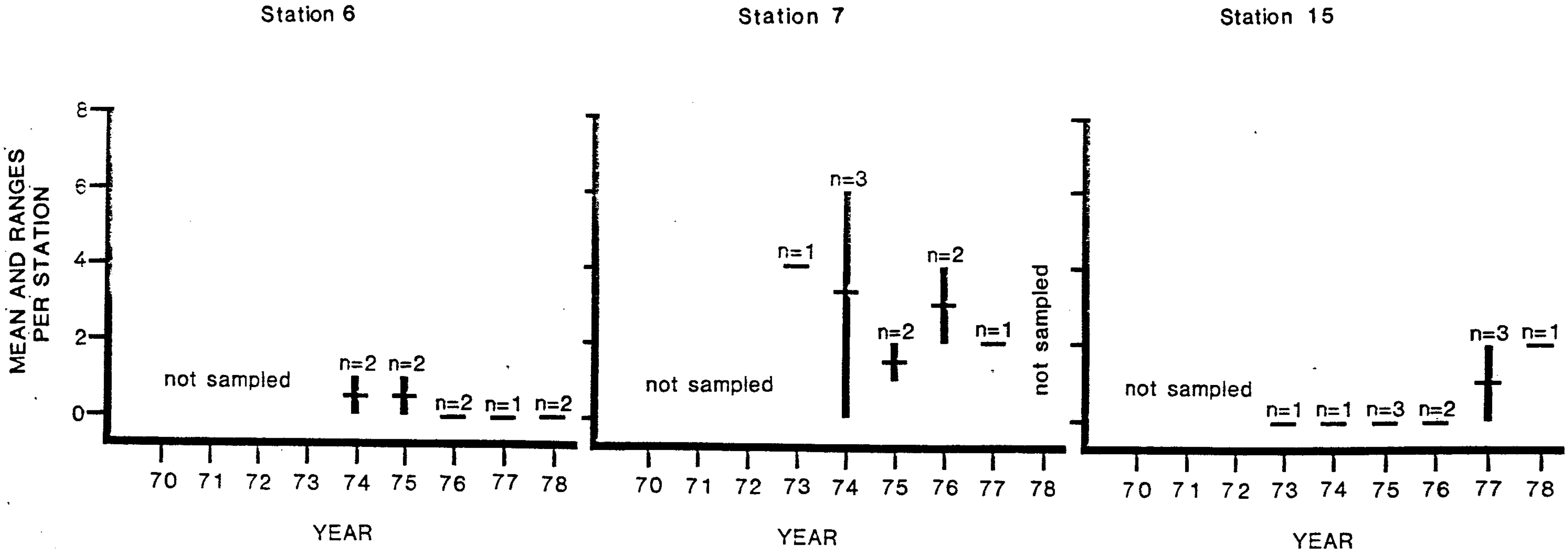


Figure 194. Means and ranges per station for Astraea gibberosa at subtidal permanent stations 6, 7, & 15 in the Control Areas. DCPP, 1970-1978.

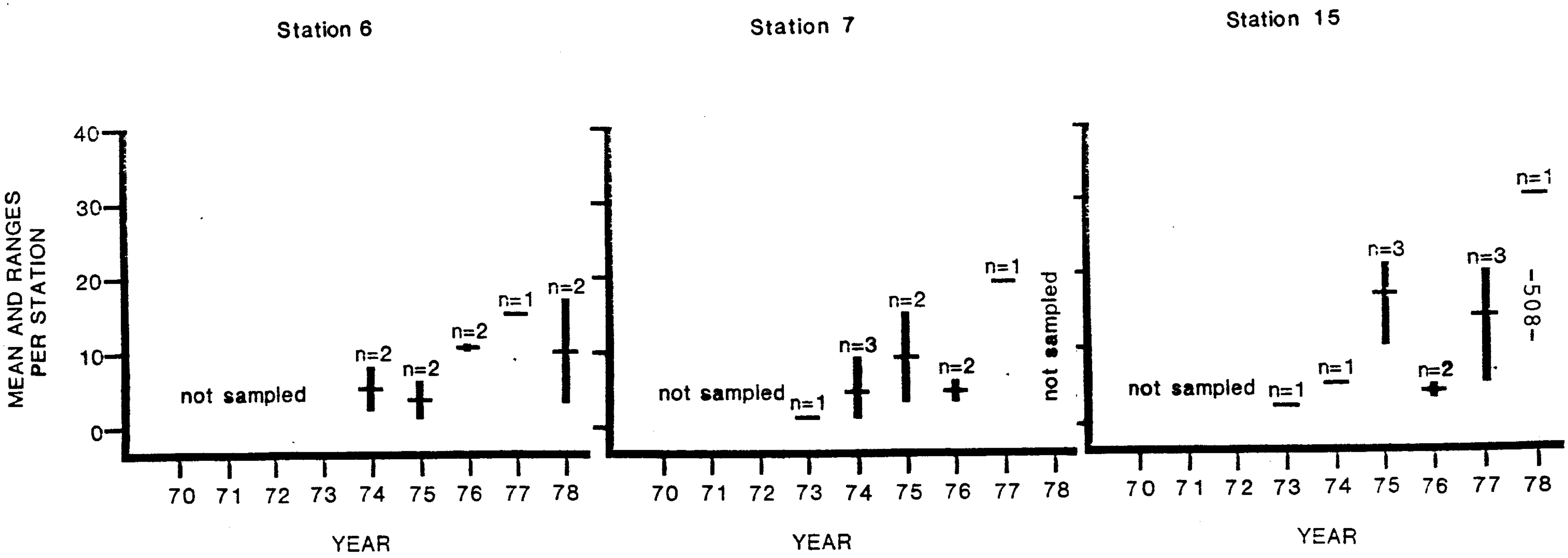


Figure 195. Means and ranges per station for <u>Doriopsilla albopunctata</u> at subtidal permanent stations 6, 7 & 15 in the Control Areas. DCPP, 1970-1978.

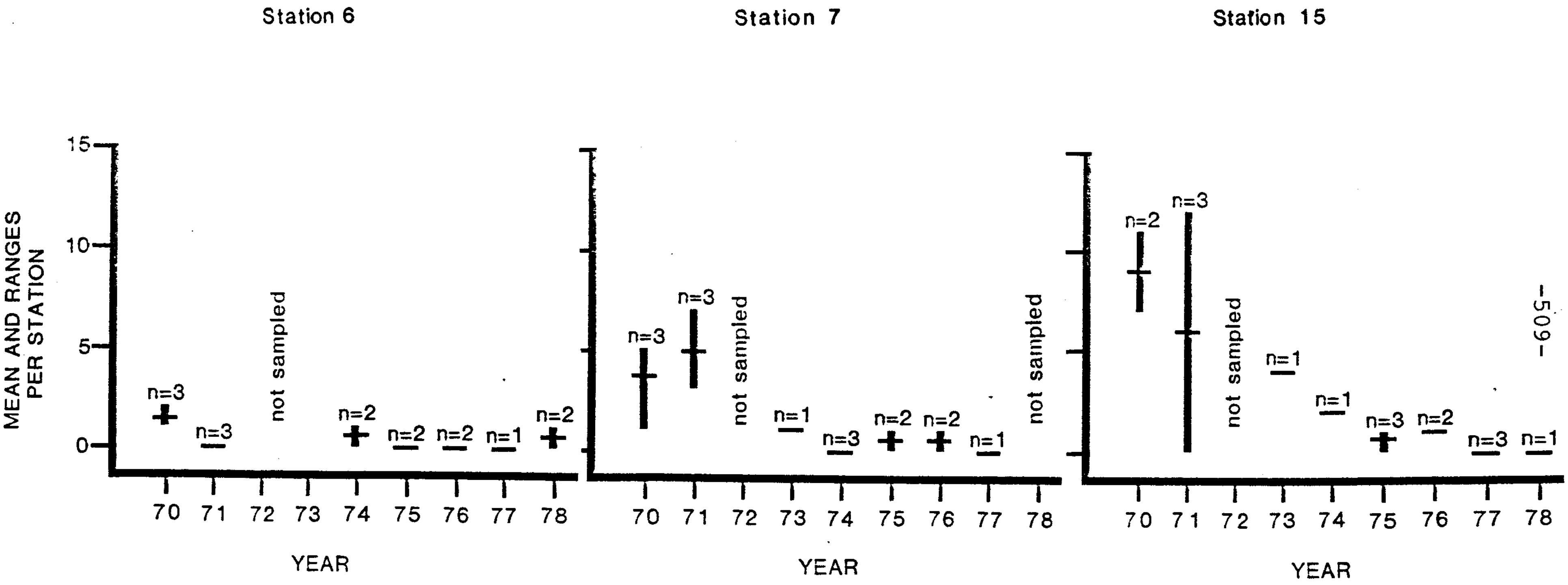


Figure 196. Means and ranges per station for *Haliotis rufescens* at subtidal permanent stations 6, 7, & 15 in the Control Areas. DCPP, 1970-1978.

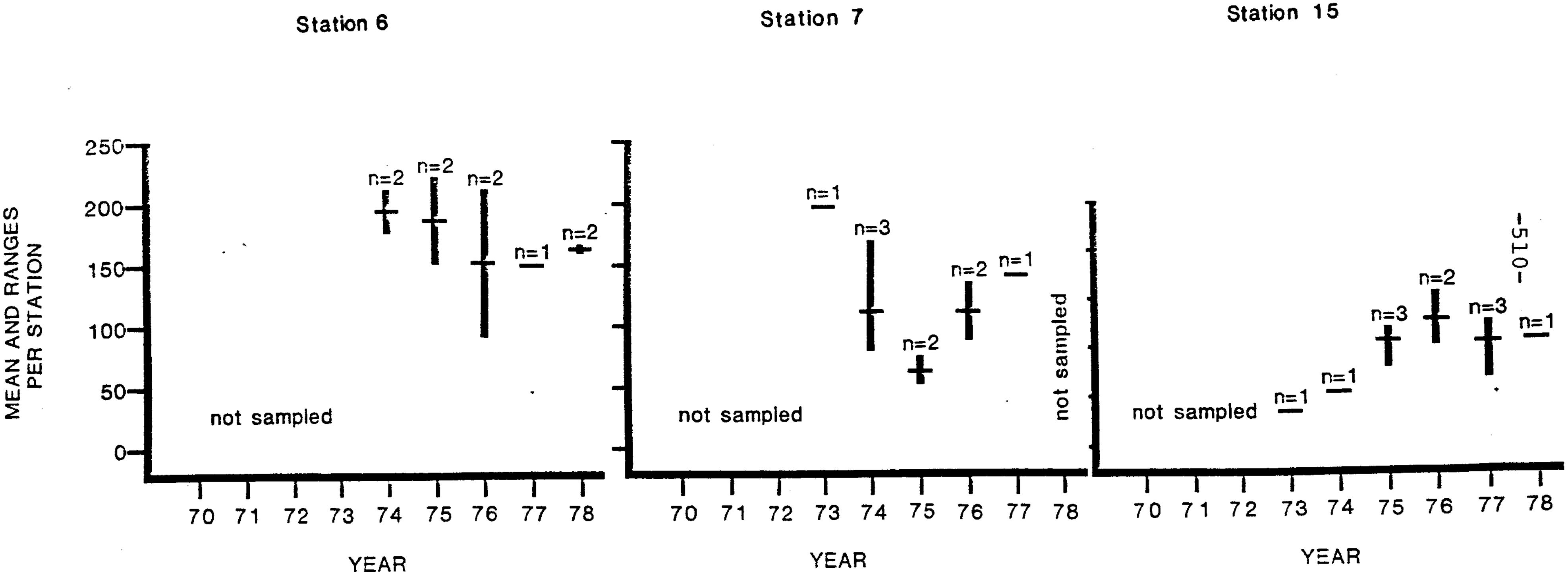


Figure 197. Means and ranges per station for Patiria miniata at subtidal permanent stations 6, 7, & 15 in the Control Areas. DCPP, 1970-1978.

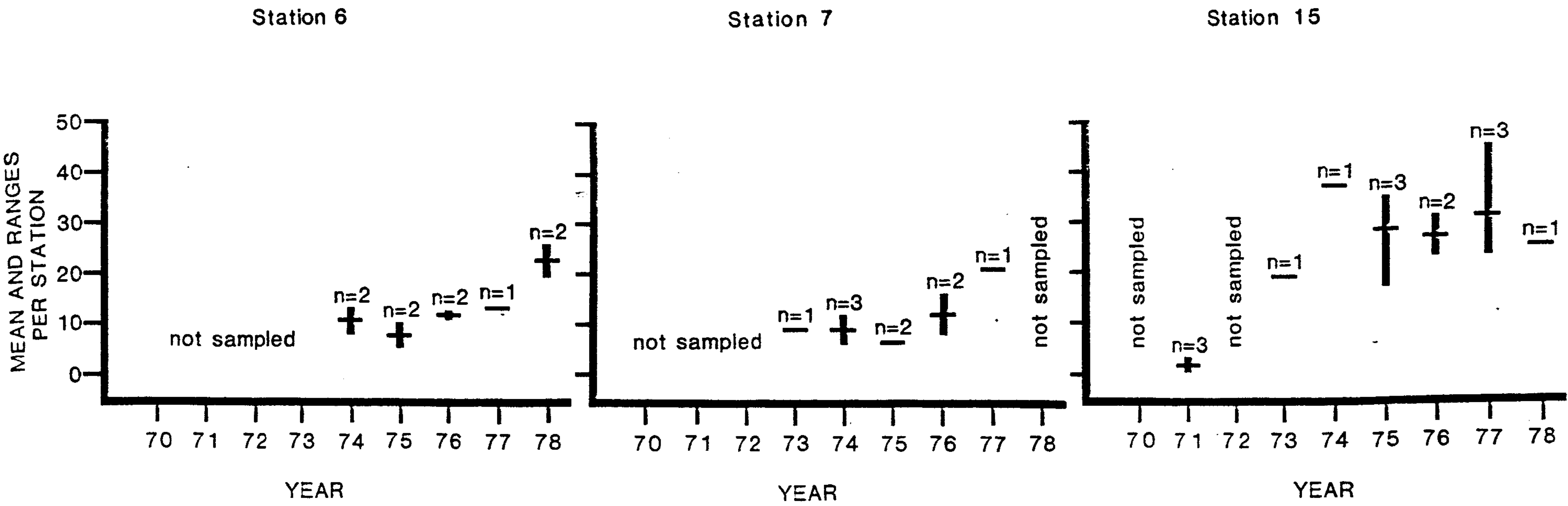


Figure 198. Means and ranges per station for Pisaster giganteus at subtidal permanent stations 6, 7, & 15 in the Control Areas. DCPP, 1970-1978.

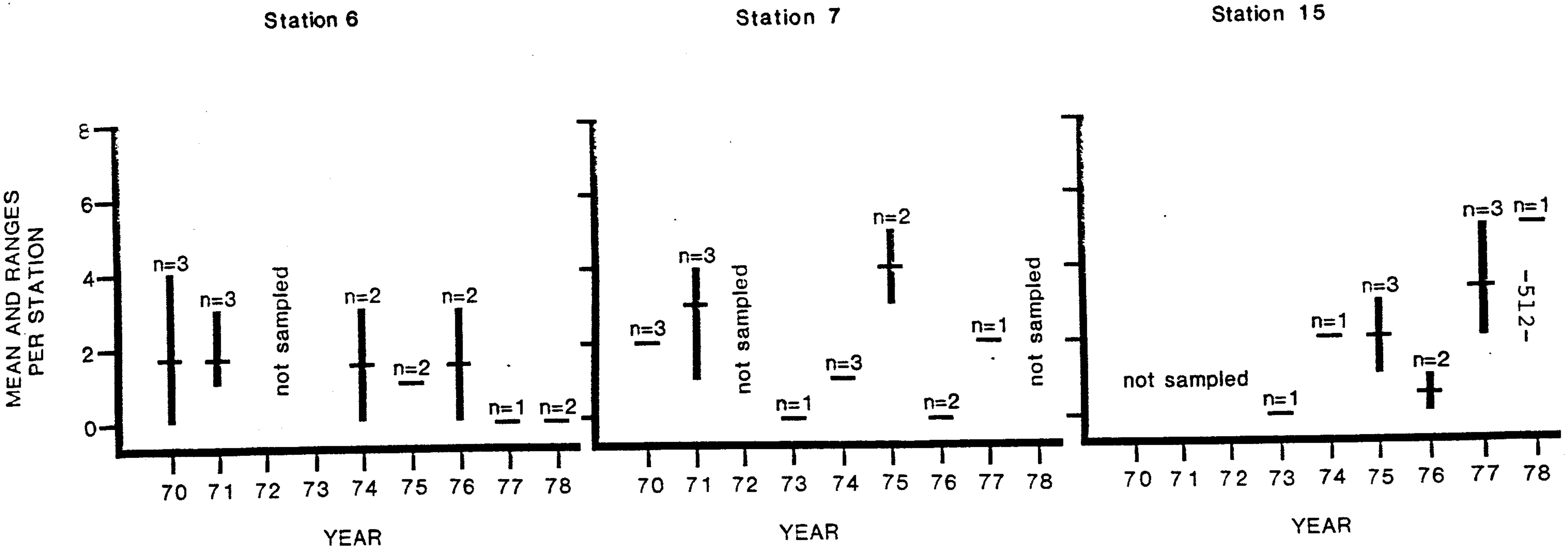


Figure 199. Means and ranges per station for *Pycnopodia helianthoides* at subtidal permanent stations 6, 7, & 15 in the Control Areas.

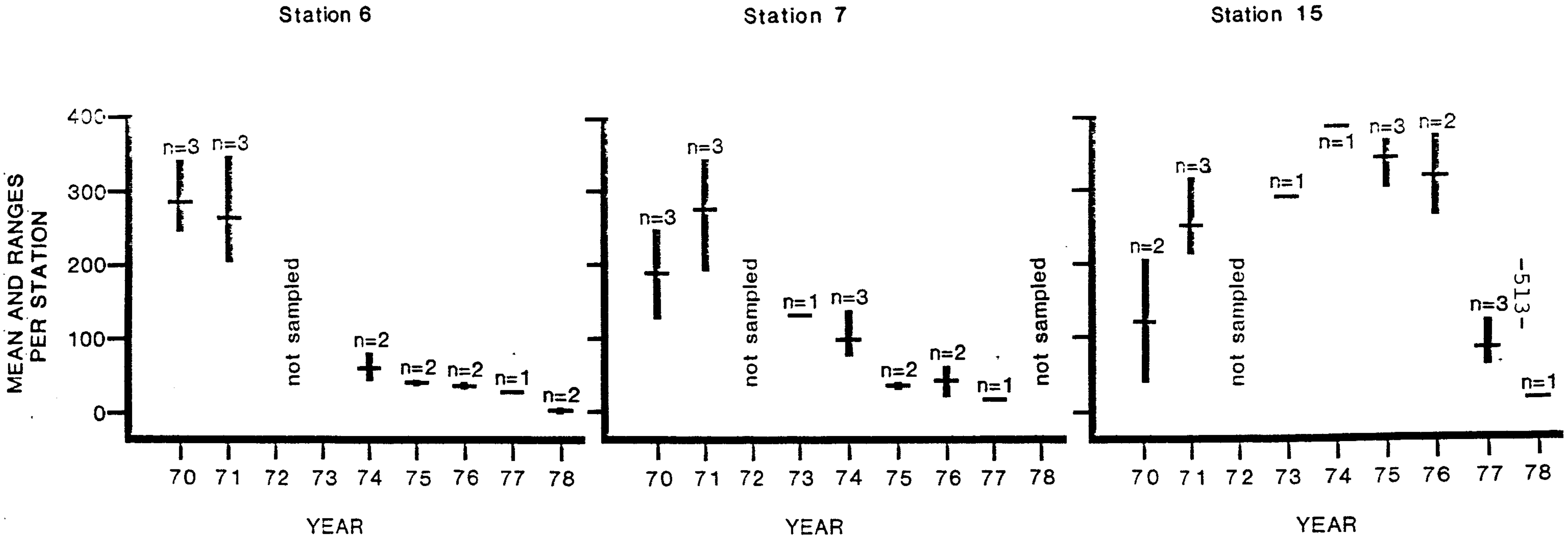


Figure 200. Means and ranges per station for Strongylocentrotus franciscanus at subtidal permanent stations 6, 7, & 15 in the Control Areas. DCPP, 1970-1978.

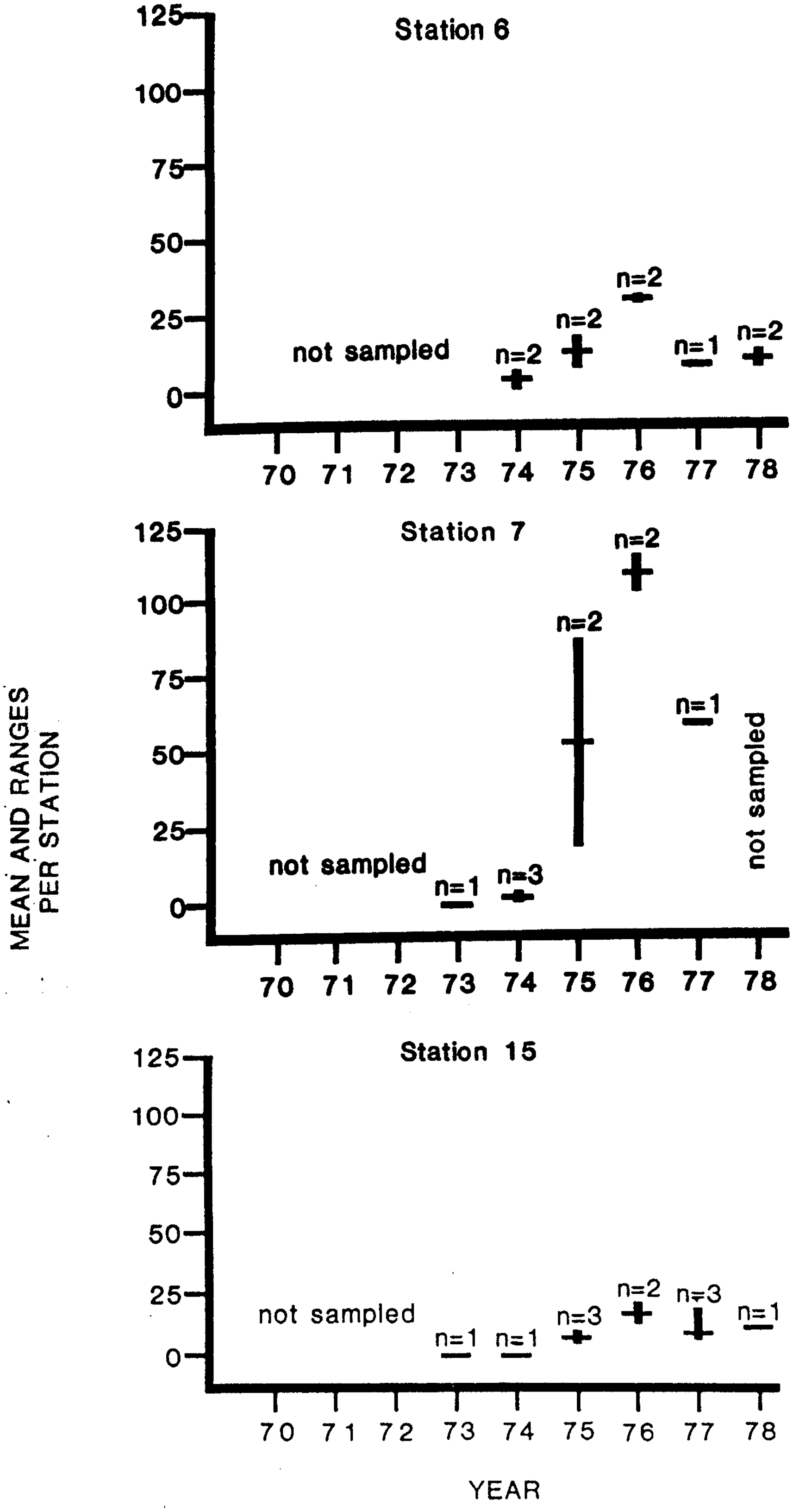


Figure 201. Means and ranges per station for Styela montereyensis at subtidal permanent stations 6, 7, & 15 in the Control Areas. DCPP, 1970-1978.

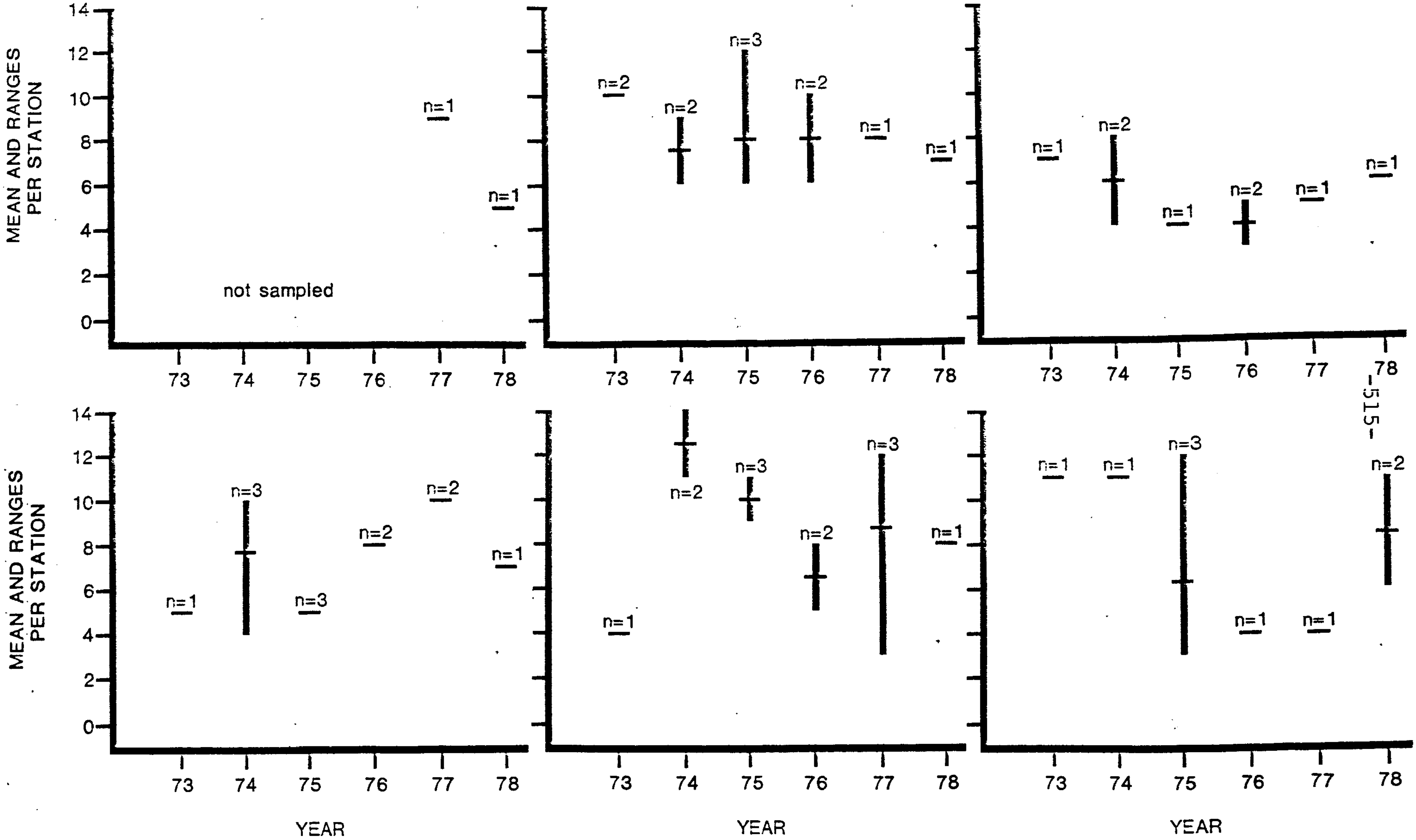


Figure 202. Mean number and range of fish species observed at subtidal permanent stations 1, 9, 10 (top row) and, 11, 12, 16 (bottom row). DCPP, 1973-1978.

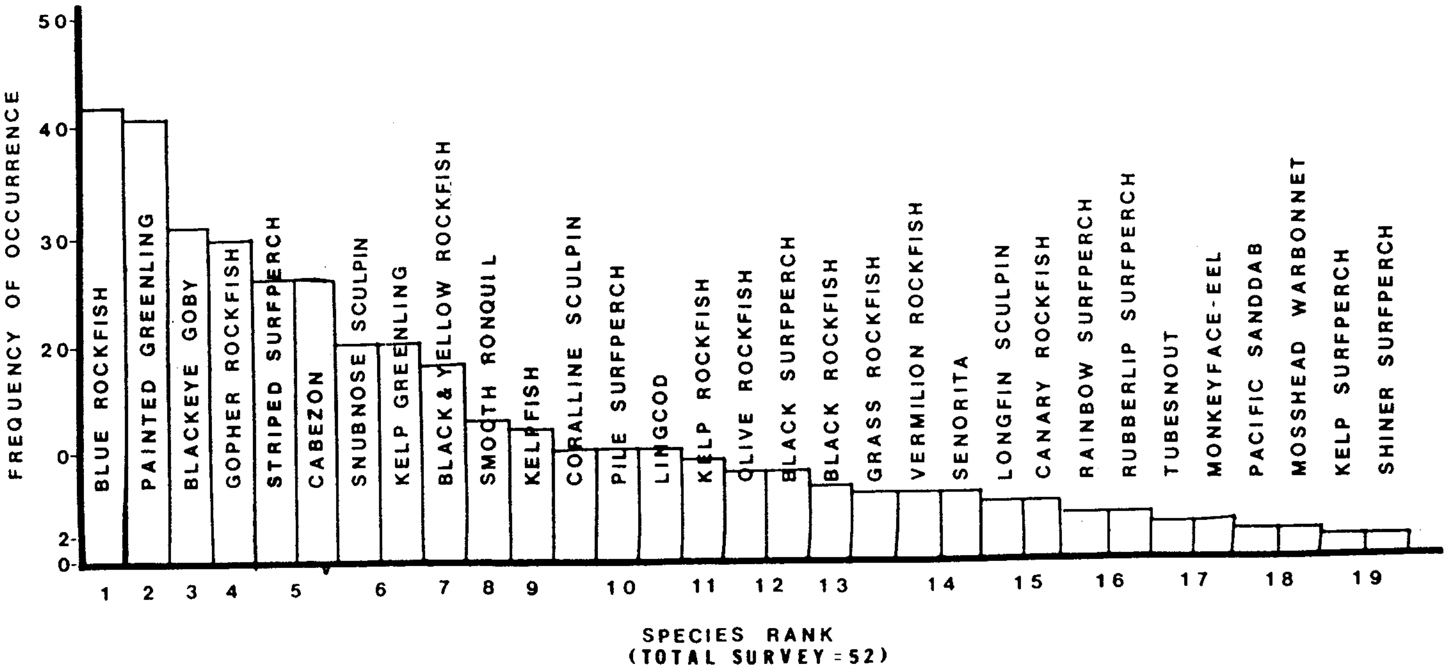


Figure 203. Percent frequency of occurrence and ranks of fishes observed at subtidal permanent stations in Diablo Cove. DCPP, 1973-1978.

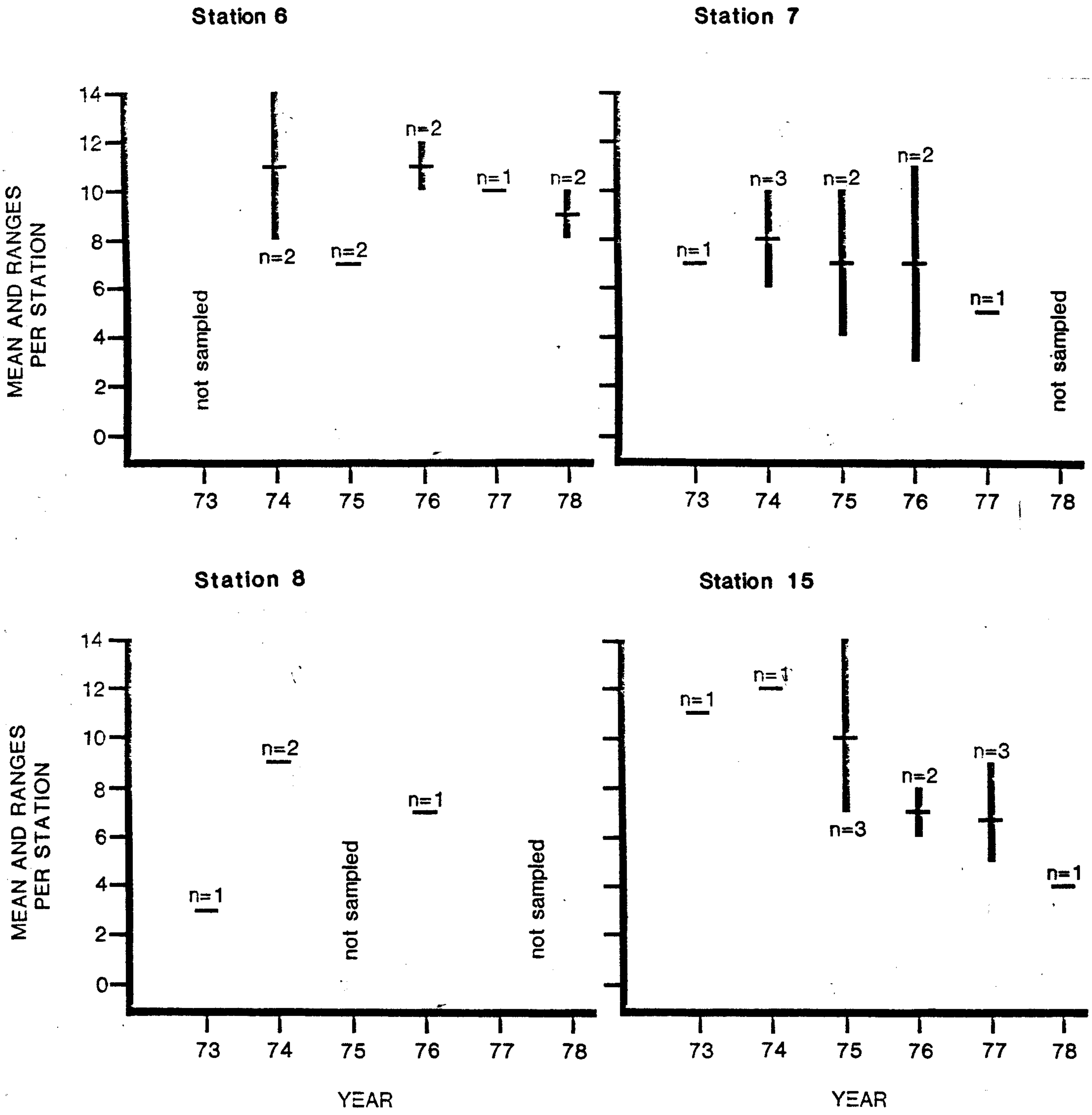


Figure 204. Mean number and range of fish species observed at subtidal permanent stations 6, 7, 8 and 15. DCPP, 1973-1978.

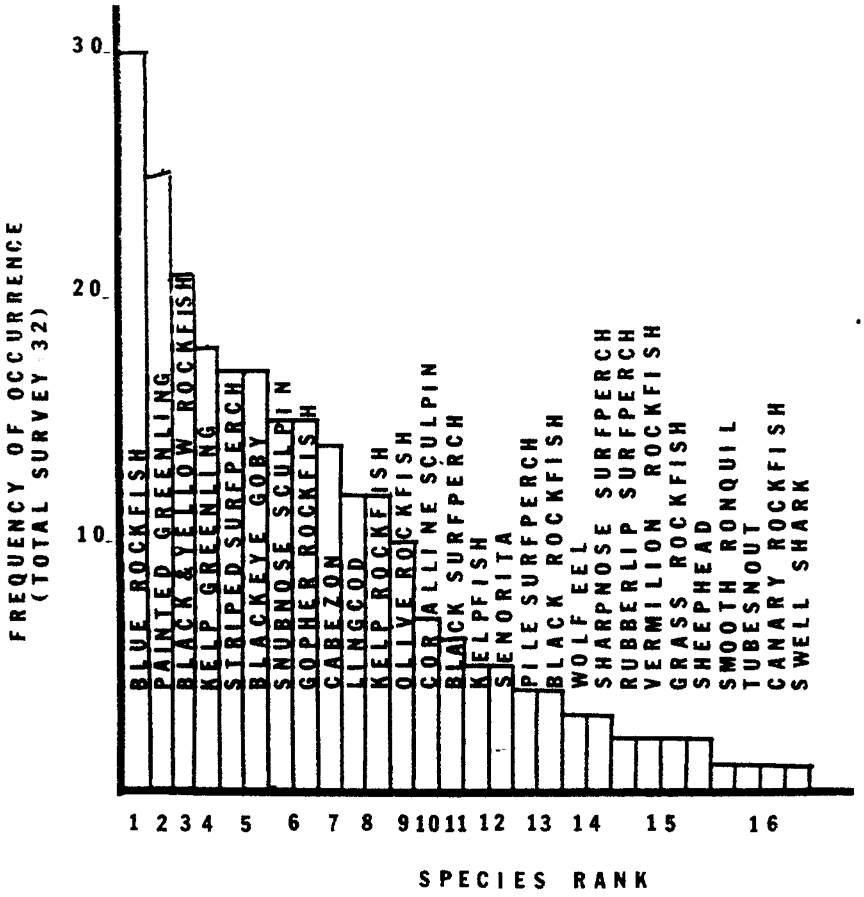


Figure 205. Percent frequency of occurrence and rank of fishes observed at subtidal permanent stations in the Control Areas. DCPP, 1973-1978.

MISCELLANEOUS STUDIES

Tidepool Fish Study

This study was conducted in order to determine intertidal fish species composition.

Methods

A. Field

Intertidal fish collections were conducted either by using an ichthyocide or by draining a selected tidepool using a small bilge pump connected to a 12 volt battery. We were able to pump out a pool averaging 7.5 m^3 in about 30 minutes. Fish were captured by hand and by dip nets, identified, and measured for total length (TL) or standard length (SL). Live fish were then released in adjacent tidepools.

B. Laboratory

Unidentifiable fish were taken to the laboratory for final identification. Selected species were saved for stomach content analysis (See Fish Stomach Content Study).

Results

During the 1970-71 Department of Fish and Game studies, three collections of intertidal fishes were made in South Diablo Cove and one collection in Field's Cove (Burge and Schultz 1973).

To determine species composition of intertidal fish at our North Control area, two fish collections were made (Table 120), the first using rotenone (a chemical ichthyocide), and the second by draining a tidepool. A tidepool in South Diablo Cove was also drained to compare the species composition with that of North Control. The two North Control collections yielded a total of 13 species including the Gibbonsia spp. complex, which may contain three species (*G. elegans*, *G. metzi*, and *G. montereyensis*). Members of the genus Gibbonsia are very difficult to differentiate in the field requiring microscope evaluation of the spacing of dorsal fin rays, and presence/absence of scales on the caudal peduncle and caudal fin.

The first collection at North Control (using rotenone) yielded 170 fish from a tidepool about 0.7 m above mean level low water (estimated elevation), approximately 7.6 m long x 3.1 m wide, with an average depth of 0.8 m. Black prickleback, *Xiphister atropurpureus*, were the most abundant fish recovered from this tidepool, followed by rock pricklebacks, *Xiphister mucosus*; and fluffy sculpin, *Oligocottus snyderi* (Table 120). All of these fish were killed by the ichthyocide.

The second North Control fish collection was made by draining a tidepool approximately 3.7 m wide and 3.7 m long, with a maximum depth of 0.4 m. This pool was located about 25 m from the first pool about 0.6 m above MLLW. This

TABLE 120. Number of Fish Captured and the Range of Lengths Measured by Species at North Control and Diablo Cove Tidepools. DCPP, 1974-1976.

Species	North Control February 1974 (Rotenone) Number	 Standard Length (mm) RANGE	 January 1975 (Draining) Number	 Standard Length (mm) RANGE	Diablo Cove December 1976 (Draining) Number	 Total Length (mm) RANGE
Anoplarchus purpurescens	15	38-40	10	49-92	8	44-98
Artedius lateralis	4	58-115	7	43-92	1	---
chilara taylori	0		0		1	81
Clinicottus analis	2	74-84	9	20-98	13	26-72
<u>cottidae</u> (unidentified)	2	11-12	1	29	0	
Gibbonsia spp.*	15	25-185	7	69-167	33	54-93
Girella nigricans	0		0		2	37-47
Gobiesox maeandricus	6	35-76	2	40-56	1	32
Oligocottus rimensis	3	14-29	0		0	
Oligocottus snyderi	18	13-62	11	21-71**	12	39-69
Scorpaenichthys marmoratus	0		4	109-124**	0	
Sebastes melanops	0		1	97*	0	
Xererpes fucorum	11	63-101	6	67-90	0	
Xiphister atropurpureus	61	34-178	4	134-184**	0	47-140
Xiphister mucosus	33	53-367	1	55**	0	
TOTALS	170		63		77	

* Group includes G. elegans, metzi, and montereyensis
** Total Length

tidepool collection yielded 63 fish. The three most numerous species were fluffy sculpins, high cockscombs, Anoplarchus purpurescens; and wooly sculpins, Clinocottus analis, respectively (Table 120). The species composition of the second collection was similar to that of the first tidepool; the exception was the three Oligocottus rimensis collected at the rotenone station but not at the drained tidepool.

In December 1976, we drained a tidepool in South Diablo Cove. The pool was about 0.5 m above the mean lower-low water and measured approximately 5 m long x 3 m wide, with a maximum depth of 0.8 m. Seventy-seven fish represented by nine species were collected from this pool. The most abundant fish were kelpfish, Gibbonsia spp., followed by wooly and fluffy sculpins, respectively. Five species collected at North Control tidepools were not observed: Saddleback sculpins, Oligocottus rimensis; cabezon, Scorpaenichthys marmoratus; black rockfish, Sebastes melanops; rockweek gunnels, Xererpes fucorum; and rock pricklebacks, Xiphister mucosus. Two species were colected in South Diablo Cove, but not at North Control tidepools; spotted cusk-eels, Chilara taylori; and two juvenile opaleyes, Girella nigricans.

Discussion

The three shore ichthyocide stations sampled in 1970 and 1971 in South Diablo Cove in a massive effort using a large amount of rotenone and numerous collectors, yielded 2,431 fish composed of 49 species; of these 25 can be considered intertidal fishes, while the rest are considered nearshore fishes (Burge and Schultz 1973). The three most abundant intertidal fish in these collections were rockweed gunnels (24.8%) black pricklebacks (11.1%), and rock pricklebacks (15.3%); these three species made up 56% of the collected fish. The Gibbonsia spp. complex was next in importance (8.7%). The shore ichthyocide station sampled in Field's Cove in 1971 produced 897 fishes, composed of 29 species, 20 of these are considered intertidal fish. Again, rockweed gunnels and black pricklebacks made up the bulk of the collection (72.6%). The Gibbonsia complex was also fourth in numerical importance here.

Most of the Diablo Cove intertidal is composed of boulders, with some bedrock areas. All of these materials form tidepools of varying sizes during low tides, which provide protection for the intertidal fishes. Unfortunately, there are only a few pools that are self-contained so that they can be drained. However, we feel that the tidepool collection can be used to represent the species composition of intertidal fishes.

Based on the 1970-71 collections and our own studies, there can be little doubt that the rockweed gunnels and black and rock pricklebacks are important components of the intertidal fish communities of the Diablo Canyon area. The Gibbonsia spp. complex, as well as Oligocottus snyderi, also must be considered as important segments of this specialized fish group.

It is also quite evident that the use of an ichthyocide yields more fish and more species than non-destructive sampling techniques such as draining tidepools. The question of whether to use destructive sampling methods in future fish studies in the Diablo Cove will have to be given very careful evaluation based on our requirements of data after the power plant goes into operation.

Fish Catch-per-Unit-of-Effort Study

Catch-per-unit-of-effort (CPUE) studies were begun in July 1974 to attempt to obtain quantitative data on some of the common fishes.

Methods

A. Field

The method consisted of fishing with rod and reel using standard terminal tackle at random and permanent subtidal stations throughout the year, time and weather conditions permitting. We used rockfish lures ("Wonder Jigs") with and without strips of cut squid. Wonder Jigs are commercially produced lures with four hooks, covered with yellow and red yarn, attached to 30-lb test leaders. Fishing was conducted for 30 minutes at each station, with one or two rods. We attempted to catch as many fish as possible during the time interval, regardless of size or species. Records were kept of the station location, depth, bottom and surface temperatures, secchi disc reading, and number, size and sex (if identifiable) of each species caught. Most fishes were returned to the water. We retained all gopher and black-and-yellow rockfishes, _Sebastes carnatus_ and _S. chrysomelas_, respectively, for stomach contents analysis (see Fish Stomach Content Study).

Results

A total of 170 CPUE stations were sampled between July 1974 and December 1976; 88 in Diablo Cove and 82 at random and permanent control stations in the North Control, Field's Cove and South Cove (Table 121). The control areas

TABLE 121. Summary of Sportfish Catch-Per-Unit-of-Effort Data From Diablo Cove and Control Areas. DCPP, 1974-1976.

	1974 July-Dec.	1975 Jan.-June	1975 July-Dec.	1976 Jan.-June	1976 July-Dec.	Totals
DIABLO COVE						
Total Stations	10	10	7	20	34	81
Depth Range of Stations (m)	7.6-21.3	6.2-24.8	6.2-21.3	4.6-21.3	3.1-20.7	
Total Effort (Pole Hours)	9.0	8.0	4.1	14.7	19.8	55.6
Total Catch (No. of Fish)	6	5	11	13	19	54
Mean* Number of Fish Per Hour	0.60	0.90	2.00	0.75	0.91	0.94
Standard Deviation	0.84	1.66	3.06	1.02	2.25	1.89
Number of Zero Stations	6	7	4	12	24	53
CONTROL AREAS						
Total Stations	10	9	25	8	30	82
Depth Range of Station (m)	3.1-18.6	6.2-18.6	3.7-16.8	6.2-16.8	3.1-16.8	
Total Effort (Pole Hours)	7.2	15.0	13.5	6.0	18.0	59.7
Total Catch (No. of Fish)	45	52	36	20	21	174
Mean* Number of Fish Per Hour	5.10	6.18	2.67	3.38	1.19	2.74
Standard Deviation	8.61	7.26	3.53	2.26	1.96	4.69
Number of Zero Stations	4	1	15	1	19	40

*A weighted mean calculated by averaging the calculated number of fish per pole hour from each station.

yielded the highest catch-per-hour, almost three times as high as Diablo Cove when all years' data were combined. Blue rockfish produced the highest mean catch/hour rate in Diablo Cove and control areas (Table 122). Gopher rockfish in Diablo Cove and black rockfish in control areas produced the second highest mean catch/hour rate. The third highest catch rates were produced by cabezon in Diablo Cove and lingcod in the control areas.

Diablo Cove yielded nine species and the control areas yielded 12 species. However, species other than the top three were relatively unimportant.

Discussion

As with other studies, our objective was to be able to compare catch rates between years, between study areas, and between pre-operational and operational phases of the plant. This study was terminated in December 1976 because we felt that large variances, due primarily to a large number of zero stations, would prevent detection of changes within acceptable limits of precision. During one survey period, the standard deviation was more than twice the mean (Table 121).

The CPUE study might have yielded more precise results if we had been able to increase substantially the number of stations sampled. In addition, we feel that the large number of stations where no fish were caught, particularly in Diablo Cove was due in part to the large amount of kelp and the fact that stations shallower than 7.6 m rarely produced any fish. Thus, in order to decrease the large variance, it would probably be best to limit fishing to areas on the edge of or away from the kelp, in depths greater than 7.6 m.

TABLE 122. Number and Mean Catch-Per-Unit-of Effort for Fish Caught by Hook and Line at Subtidal Random and Permanent Station in Diablo Cove and the Control Areas. DCPP, 1974-1976.

	Diablo Cove					Control Areas				
Species	1974	1975	1976	Total	$\bar{x}$ Catch/ Hour	1974	1975	1976	Total	$\bar{x}$ Catch/ Hour
Striped surfperch			1	1	0.02				0	
Kelp greenling			1	1	0.02				1	0.02
Lingcod				0			4	1	4	0.08
Senorita				0		1			1	0.02
Cabezon			6	6	0.11			2	2	0.03
Kelp rockfish				0		1			1	0.02
Gopher rockfish	1	2	8	11	0.20	2	3	16	21	0.35
Copper rockfish				0				1	1	0.02
Black-and-yellow rockfish	1		1	2	0.04	1	1	1	3	0.05
Black rockfish		6	6	12	0.22		3		3	0.05
Vermilion rockfish				0			1		1	0.02
Blue rockfish	1	8	7	19	0.34	40	75	19	134	2.24
Grass rockfish			1	1	0.02				0	
Olive rockfish			1	1	0.02		1	1	2	0.03
Total Number of Stations	10	17	54	81		10	34	38	82	

We believe that the most important result of this CPUE study was the fact that the catches were dominated by blue rockfish, thus bolstering our subtidal observation that this species is the most abundant non-cryptic sportfish in the Diablo Canyon area.

Fish Stomach Content Study

The analysis of stomach contents was conducted on three species of intertidal fish collected in our tidepool studies: *Gibbonsia metzi*, *Xiphister atropurpureus*, and *X. mucosus*; and three subtidal species collected by spear and during catch-per-unit-of-effort study: *Sebastes chrysomelas*, *S.carnatus*, and *S. rastrelliger*.

Methods

A. Field

The fish were caught by the methods described in the Tidepool Fish Study and the Fish Catch-per-unit-of-Effort Study sections.

B. Laboratory

Stomachs were removed from the fish in the laboratory and preserved in 70% isopropyl alcohol. Food items were sorted and examined under a dissecting microscope. Data recorded for each fish stomach included: total or standard length of fish, sex, and stomach content identified to the lowest possible taxon.

Results

A total of 205 stomachs from the six species of fish were examined during our pre-operational studies to determine the species composition of intertidal and subtidal prey. The fish were selected specifically because of a lack of published data on their food.

Gibbonsia metzi: Striped kelpfish were obtained from our tidepool collections in the North Control and South Diablo Cove. A total of 41 stomachs were examined, 11 from the North Control and 30 from Diablo Cove (Table 123). Crustaceans as a group were observed in 96.7% of the stomachs. Hermit crabs (Paguridae) and gammarid amphipods were the most frequently observed crustacean taxa. The smaller striped kelpfish collected in South Cove, appeared to feed more heavily on amphipods, while larger fish, collected in the North Control, fed more often on crabs of the genus Cancer (Table 123).

Sebastes chrysomelas: We examined stomachs from only eight black-and-yellow rockfish collected in Diablo Cove and Control Area. However, it appears again crustaceans are a very important food source; they appeared in 75% of the stomachs. Here, too, crabs were dominant; 15 of the 36 items were identified as crabs represented by the genera, Cancer, Hapalogaster, Lophopanopeus, Pachycheles, Petrolisthes, and Pugettia (Table 124).

Sebastes carnatus: Gopher rockfish were collected by hook and line and spear in Diablo Cove and Control areas. Crustaceans as a group were also very important food items for gopher rockfish also (Table 124). Of the 44 items found in the 24 stomach, 18 were crabs. Identified genera included: Cancer, Loxorhynchus, Mimulus, Pachycheles, and Pugettia.

TABLE 123. Stomach Contents of Striped Kelpfish, *Gibbonsia metzi*, Collected at Tidepools in North Control and South Diablo Cove. DCPP, 1974-1976.

Food Item	North Control No. of Items	North Control Percent Freq. of Occurrence	South Diablo Cove No. of Items	South Diablo Cove Percent Freq. of Occurrence	Combined No. of Items	Combined Percent Freq. of Occurrence
CRUSTACEA*	46	100.0	100	96.7	146	97.6
Cancer antennarius	1	9.1	0		1	2.4
Cancer jordani	1	9.1	0		1	2.4
Cancer sp.	3	27.3	0		3	7.3
Caridae	3	18.2	7	13.3	10	14.6
Decapoda	2	9.1	0		2	2.4
Gamarid amphiphod	4	18.2	33	50.0	37	41.5
Graspsid crabs	0		5	10.0	5	7.3
Hemigrapsus sp.	1	9.1	3	10.0	4	9.8
Idotea sp.	0		1	3.3	1	2.4
Isopoda	2	9.1	10	33.3	12	24.4
Megalops	0		1	3.3	1	2.4
Pachygrapsus sp.	0		1	3.3	1	2.4
Paguridae	25	54.5	15	36.7	40	41.5
Pugettia gracilis	0		4	10.0	4	7.3
Pugettia producta	3	27.3	0		3	7.3
Pugettia sp.	1	9.1	0		1	2.4
Unidentified crustaceans	0		20	76.7	20	56.1
MOLLUSCA	6	45.4	23	30.0	39	34.1
Barleela sp.	0		12	10.0	12	7.3
Crepidula adunca	1	9.1	0		1	2.4
Crepidula sp.	0	18.2	2	6.7	2	4.9
GASTROPODA	3	27.3	6	20.0	9	14.6
Granulina sp.	1	9.1	0		1	2.4
Pelecypoda	0		3	10.0	3	7.3
Tegula sp.	1	9.1	0		1	2.4

TABLE 123. (Cont'd)

Food Item	North Control No. of Items	North Control Percent Freq. of Occurrence	South Diablo Cove No. of Items	South Diablo Cove Percent Freq. of Occurrence	Combined No. of Items	Combined Percent Freq. of Occurrence
MISCELLANEOUS*	9	36.4	15	40.0	24	39.0
Bryozoa	0		2	6.7	2	4.9
Polychaeta	7	63.6	9	30.0	16	39.0
Pycnogonida	1	9.1	0		1	2.4
Strongylocentrotus sp.	0		4	13.3	4	9.8
Turritopsis sp. (Hydrozoa)	1	9.1	0		1	2.4
Total Stomachs Examined	11		30		41	
Total Empty	0		1		1	
Size Range of Fish (Total Length)	124-210 mm		59-94 mm			

* Includes all material identified to species or some higher taxonomic group in the Class Crustacea, Phylum Mollusca, or miscellaneous group.

TABLE 124. Stomach Contents of Black and Yellow Rockfish, Sebastes, chrysomelas, and Gopher Rockfish, S. carnatus. Collected in Diablo Cove and the Control Area. DCPP.

	Sebastes chrysomelas		Sebastes carnatus	
Food Item	No. of Items	Percent Freq. of Occurrence	No. of Items	Percent Freq. of Occurrence
CRUSTACEA*	24	75.0	31	75.0
Amphipoda	1	12.5	0	
Balanus sp.	3	12.5	0	
Brachyura	1	12.5	3	12.5
Cancer antennarius	1	12.5	0	
Cancer jordani	1	12.5	4	12.5
Cancer productus	3	25.0	0	
Cancer sp.	1	12.5	1	4.2
Caridae	0		3	12.5
Crangon sp.	0		1	4.2
Crustacea	3	25.0	7	25.0
Hapalogaster cavicauda	1	12.5	0	
Hippolytidae	0		1	4.2
Lophopanopeus heathii	1	12.5	0	
Loxorhynchus crispatus	2	25.0	4	16.7
Mimulus foliatus	0		4	12.5
Pandalus sp.	0		1	4.2
Pachycheles sp.	2	12.5	1	4.2
Petrolisthes cinctipes	1	12.5	0	
Pugettia gracilis	2	12.5	1	4.2
Pugettia producta	1	12.5	0	
MISCELLANEOUS*	12	50.0	13	41.7
Nematoda	5	12.5	1	4.2
Octopus sp.	1	12.5	0	
Ophiothrix spiculata	0		4	12.5
Polychaeta	3	12.5	2	8.3
Salpa sp.	0		1	4.2
Unidentified fish	2	25.0	3	12.5
Unidentified algae	1	12.5	2	8.3
Total Stomachs Examined	8		24	
Total Empty	1		4	
Size Range of Fish (Total Length)	271-330 mm		229-325 mm	

*Sum of Group

Sebastes rastrelliger: Grass rockfish are one of the largest predators residing in the shallow (less than 10 m) waters of the Diablo Canyon area. Because of its important in the region adjacent to the intertidal zone, the grass rockfish could produce valuable data on relative abundance of some of the invertebrates and fishes that serve as prey. Unfortunately, grass rockfish are not an abundant fish, at least in the areas we have surveyed; thus, we have attempted to collect these fish from areas adjacent to Diablo Cove, North and South of Diablo Cove, Morro Bay, and the San Simeon area rather than deplete the population within the Cove.

The eleven stomachs examined from the Diablo Canyon area contained a variety of Crustaceans and few fish (Table 125). In 34 stomachs from grass rockfish collected in Morro Bay and 17 from fish collected in the San Simeon/-Piedras Blancas area, fish were more important; in fact, fish were the most frequently observed food items in the stomachs from the San Simeon area (Table 125). When all the stomach contents are combined, crustaceans as a group appeared in 51.6% of the stomachs, and fish appeared in 40.3% of the stomachs. The analysis of stomachs from different sizes of grass rockfish from the various areas suggest that the smaller grass rockfish feed more on crustaceans, while larger fish prey more on fish (Table 125).

Xiphister atropurpureus

A total of 38 black prickleback stomachs were examined, but only four contained food (Table 126). Gammarid amphipods were the most frequently observed organism, while unidentified foliose red algae (Rhodophyta) was second.

TABLE 125. Stomach Contents of Grass Rockfish, *Sebastes rastrelliger*, Collected at Diablo Cove, Morro Bay, and San Simeon. DCPP, 1974-1977.

Food Item	Diablo Canyon +		Morro Bay**		San Simeon/Piedras		Blancas	Combined
	No. of Items	Percent Freq. of Occurrence	No. of Items	Percent Freq. of Occurrence	No. of Items	Percent Freq. of Occurrence	No. of Items	Percent Freq. of Occurrence
CRUSTACEA*	20	45.4	63	58.8	8	41.2	91	51.6
Brachyura	5	36.4	1	2.9	4	23.5	9	12.9
Cancer antennarius	0		5	11.8	2	11.8	7	9.7
Cancer gracilis	0		4	8.8	0		4	4.8
Cancer productus	0		2	5.9	0		2	3.2
Cancer sp.	0		11	23.5	0		11	12.9
Caprellids	0		10	17.6	0		10	9.7
Crangon franciscorum	5	9.1	1	2.9	1	5.9	7	4.8
Caridea	1	9.1	7	20.6	0		8	12.9
Gammarid amphiphod	0		11	17.6	0		11	9.7
Idotea	0		2	5.9	0		2	3.2
Isopoda	7	18.2	1	2.9	1	5.9	9	6.4
Pagurus sp.	1	9.1	0		0		1	1.6
Pugettia richii	1	9.1	0		0		1	1.6
Upogebia pugettensis	0		1	2.9	0		1	1.6
MISCELLANEOUS*	5	36.4	16	35.3	17	58.8	38	41.9
Porichthys notatus	0		0		4	11.8	4	3.2
Unidentified algae	1	9.1	2	5.9	3	17.6	6	9.7
Unidentified fish	4	36.4	14	35.3	10	52.9	28	40.3
Total Stomachs Examined	7		34		17		58	
Total Empty	2		8		4		14	
Size Range of Fish (Total length)	87-514 mm		54-255 mm		319-516 mm			

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* Sum of Group

\+ Four Stomachs from November ichthyocide station

** Collection made by David W. Behrens, PG&E

TABLE 126. Stomach Contents of Two Stichaeid Fishes Collected From North Control Tidepools. DCPP, 1974-1975.

Food Item	*Xiphister atropurpureus* % Freq. of Occurrence	*Xiphister mucosus* % Freq. of Occurrence
CRUSTACEA*	7.9	9.4
Caridae	2.6	0.0
Gammarid amphipod	7.9	3.1
Heptacarpus pictus	0.0	9.4
RHODOPHYTA*	5.3	87.5
Endocladia muricata	0.0	3.1
Gigartina canaliculata	0.0	15.6
Gigartina papillata/agardhii	0.0	6.2
Iridaea cordata v. *splendens*	0.0	37.5
Iridaea heterocarpa	0.0	6.2
Iridaea sp.	0.0	25.0
Laurencia sp.	0.0	3.1
Laurencia splendens	0.0	3.1
Microcladia coulteri	0.0	18.8
Plocamium pacificum	0.0	3.1
Prionitis lanceolata	0.0	6.2
Unidentified Rhodophyta	5.3	25.0
MISCELLANEOUS*	5.3	12.5
Phyllospadix sp.	0.0	6.2
Polychaeta	2.6	0.0
Lacuna sp.	2.6	0.0
Unidentified mollusc	0.0	6.2
Total Stomachs Examined	38	32
Total Empty	34	5
Size Range of Fish (Total Length)	86-184 mm	115-383 mm

*Sum of Group

Xiphister mucosus

Approximately 88% of the 32 rock prickleback stomachs that we examined contained foliose red algae (Table 126), while only 9.4% contained crustaceans. The algal genus of Iridaea appeared in the most number of stomachs.

Discussion

Probably the most important result of our examinations of the fish stomach contents is the fact that crustaceans were the most frequently observed food group in five of the six species of fish that we studies. Two genera, Cancer and Pugettia, appeared in all of the fish diets except the pricklebacks' which are too small to eat these larger crustaceans. Also, of interest was the similarity of stomach contents of the grass rockfish collected from two different areas i.e., crustaceans, particularly crabs, and fish were the dominant groups. These results were also similar to those observed in eleven grass rockfish stomachs from the Point Area area (Gotshall et al. 1974).

Although the small numbers of stomachs examined preclude drawing conclusions, it appears that we might be able to use stomach content analysis to detect extreme changes of some common prey species in Diablo Cove or the control areas. For example, striped kelpfish fed frequently on Cancer crabs and kelp crabs, Pugettia. If, for some reason, populations of one or both of these generic groups should decrease drastically or even disappear, this could by partially confirmed by examining stomach contents, assuming, of course, that the population of striped kelpfish was not adversely affected at the same time. The use of the predators to detect relative abundance of a particular prey species has been successful in predicting ocean shrimp, Pandalus jordani, abundance in northern California by examining Pacific hake stomachs, Merluccius productus (Gotshall 1959).

From our limited data on the two pricklebacks, it appears that the rock prickleback feeds primarily on foliose red algae while the black pricklebacks feed more on small crustaceans. This is supported by Barton's (1973) study of X. mucosus and X. atropurpureus at Piedras Blancos, San Simeon California. Thus both species can co-exist in the same habitat in relatively large numbers because of their diverse feeding strategies. Barton's (1973) studies support this hypothesis. He found only one out of 25 stomachs of rock pricklebacks that contained animals matter, while only six of the 25 black prickleback stomachs contained algae.

SEA OTTER STUDY

Methods

Sea otter (Enhydra lutris) between Point Buchon and Pecho Rock were counted weekly from July 1973 to the present. The first Fish and Game project observer was Suzanne Benech, who continued this function when she became an employer of PG&E and then Ecomar, a consulting company. The area was covered by walking and driving along the coast from Point Buchon to Pecho Rock. A 30-60x spotting scope was used to make counts and observe behavior.

In late 1976, project personnel resumed otter counts within the study area. These counts, made as often as possible, were an attempt to establish day-to-day usage of the areas by otters. Observations were made from vantage points above Lion Rock, North Cove, Diablo Cove, Intake Cove, and South Cove areas. Field binoculars and a 30-60x spotting scope were used. If otters were observed feeding, an attempt was made to identify the food item.

Results

Results of studies by Department of Fish and Game personnel and by a consultant to PG&E, Suzanne V. Benech (1979 pers. commun.), show both the seasonal movement of sea otters and their generally southern migration through the Diablo Canyon area during the period from 1973 through 1978 (Tables 127 and 128). In presenting Ms. Benech's data, the number of otters she observed during a given month was divided by the number of observations days that month to derive mean daily numbers of otters for each area. This allowed the presentation of her data in a format consistent with that developed by

Department personnel in compiling daily count data from our smaller observation area restricted to our study area locales.

Observations by DF&G Diablo Canyon personnel during 1977 and 1978 indicate a gradual increase in numbers of sea otters during the spring and early summer followed by a decrease in fall and winter (Table 127). This trend is also reflected in Benech's data (Table 128). Of significant interest has been the movement of the main group of otters into, and subsequently through, the study areas. In May and June 1974, the main raft of sea otters moved into Diablo Cove. This raft numbered between 30 and 40 animals (Gotshall et al. 1976). By May of 1975, the main southern raft was located near Pecho Rock and has remained south of our study area during the springs and summers since then. Our recent observations indicate a reduced but consistent presence in the study areas' herd and/or a small female raft that has been located inshore of Lion Rock each spring since 1977.

Since the main raft moved south of Diablo Cove in 1975, most otters observed within our study areas have been in the vicinity of Lion Rock (the small female raft) and off the south breakwater of Intake Cove. After this time, relatively few otters have been observed in Diablo Cove. Still, indications of sea otters foraging in Diablo Cove and North Control, such as abalone and other shells and sea urchin tests freshly broken in a characteristic manner, have been observed on numerous of our survey dives through the study period. This foraging has probably been done by otters moving up and down the coast between rafting areas.

TABLE 127. Summary of Suzanne Benech's Sea Otter Observations in the Vicinity of Diablo Canyon Power Plant Site. DCPP, 1974-1978.

Location	January			February			March			April			May			June			July			August			September			October			November			December		
	Otters	Days	Mean	Otters	Days	Mean	Otters	Days	Mean	Otters	Days	Mean	Otters	Days	Mean	Otters	Days	Mean	Otters	Days	Mean	Otters	Days	Mean	Otters	Days	Mean	Otters	Days	Mean	Otters	Days	Mean	Otters	Days	Mean
																1974																				
North Control	24	3	8	11	4	2.7	0	2	0	3	1	3.0	227	5	45.0	142	4	35.0	114	4	8.0	32	4	8.0	2	5	<1	2	4	<1	14	4	3.5	5	4	1.2
Lion Rock	0	3	0	0	4	0	0	4	0	0	4	0	7	5	1.4	0	4	0	1	4	<1	10	4	2.5	1	5	<1	1	4	<1	2	4	<1	0	4	0
North Cove	0	3	0	0	4	0	0	4	0	0	4	0	1	5	<1	13	4	3.2	86	4	21.0	0	4	0	178	5	36	85	4	21.3	0	4	0	0	4	0
Diablo Cove	0	3	0	0	4	0	0	4	0	0	4	0	0	5	0	55	4	13.7	22	4	5.5	39	4	9.7	4	5	<1	3	4	<1	0	4	0	0	4	0
South Cove	0	3	0	0	4	0	0	4	0	0	4	0	0	5	0	0	4	0	0	4	0	0	4	0	0	4	0	0	4	0	0	4	0	0	4	0
																1975																				
North Control	57	5	11.4	8	4	2.0	0	5	0	24	4	6.0	0	5	0	0	5	0	0	4	0	1	4	<1	0	4	0	0	5	0	1	4	<1	1	4	<1
Lion Rock	0	5	0	1	4	<1	1	5	<1	0	4	0	3	5	<1	1	5	<1	1	4	<1	0	4	0	0	4	0	0	5	0	0	4	0	1	4	<1
North Cove	0	5	0	4	4	1.0	0	5	0	0	4	0	0	5	0	0	5	0	0	4	0	0	4	0	0	4	0	0	5	0	0	4	0	0	4	0
Diablo Cove	0	5	0	0	4	0	0	5	0	1	4	<1	0	5	0	3	5	<1	0	4	0	0	4	0	0	4	0	0	5	0	0	4	0	0	4	0
South Cove	0	5	0	0	4	0	0	5	0	0	4	0	0	5	0	0	5	0	0	4	0	0	4	0	0	4	0	0	5	0	0	4	0	0	4	0

TABLE 127. (Continued)

Location	January			February			March			April			May			June			July			August			September			October			November			December		
	Otters	Days	Mean	Otters	Days	Mean	Otters	Days	Mean	Otters	Days	Mean	Otters	Days	Mean	Otters	Days	Mean	Otters	Days	Mean	Otters	Days	Mean	Otters	Days	Mean	Otters	Days	Mean	Otters	Days	Mean	Otters	Days	Mean
																1976																				
North Control	1	5	<1	4	4	1.0	0	4	0	15	4	3.8	1	3	<1	3	5	<1	0	4	0	0	3	0	1	4	<1	0	3	0	0	3	0	0	3	0
Lion Rock	0	5	0	0	4	0	0	4	0	3	4	<1	0	3	0	8	5	1.6	5	4	1.2	15	3	5.0	0	4	0	0	3	0	1	3	0	0	3	0
North Cove	0	5	0	3	4	<1	0	4	0	0	4	0	0	3	0	0	5	0	0	4	0	0	3	0	0	4	0	0	3	0	0	3	0	0	3	0
Diablo Cove	0	5	0	0	4	0	0	4	0	2	4	<1	0	3	0	0	5	0	0	4	0	0	3	0	0	4	0	0	3	0	0	3	0	2	3	<1
South Cove	0	5	0	0	4	0	0	4	0	0	4	0	0	3	0	1	5	<1	0	4	0	0	3	0	0	4	0	0	3	0	0	3	0	1	3	<1
																1977																				
North Control	0	2	0	5	3	1.7	0	2	0	0	3	0	4	5	<1	0	3	0	2	5	<1	0	3	0	0	4	0	0	3	0	0	3	0	0	3	0
Lion Rock	0	2	0	1	3	<1	4	2	2	71	3	9.0	37	5	7.4	20	3	6.7	10	5	2.0	10	3	3.3	0	4	0	0	3	0	3	3	1.0	0	3	0
North Cove	0	2	0	0	3	0	0	2	0	1	3	<1	2	5	<1	0	3	0	9	5	1.8	0	3	0	0	4	0	0	3	0	0	3	0	0	3	0
Diablo Cove	0	2	0	0	3	0	0	2	0	0	3	0	0	5	0	0	3	0	0	5	0	0	3	0	0	4	0	0	3	0	0	3	0	0	3	0
South Cove	2	2	1.0	6	3	2.0	0	2	0	0	3	0	2	5	<1	1	3	<1	2	5	<1	0	3	0	0	4	0	0	3	0	0	3	0	0	3	0

TABLE 127. (Continued)

Location	January			February			March			April			May			June			July			August			September			October			November			December		
	Otters	Days	Mean	Otters	Days	Mean	Otters	Days	Mean	Otters	Days	Mean	Otters	Days	Mean	Otters	Days	Mean	Otters	Days	Mean	Otters	Days	Mean	Otters	Days	Mean	Otters	Days	Mean	Otters	Days	Mean	Otters	Days	Mean
																1978																				
North Control	0	3	0	1	4	<1	0	2	0	0	3	0	0	4	0	0	3	0	0	0	0	0	5	0	0	6	0	0	3	0	0	2	0	0	3	0
Lion Rock	0	3	0	1	4	<1	4	2	2	32	3	10.7	100	4	9.2	21	3	7.0	0	0	0	3	5	<1	2	6	<1	0	3	0	1	2	<1	0	3	0
North Cove	0	3	0	0	4	0	0	2	0	3	3	1.0	1	4	<1	0	3	0	0	0	0	0	5	0	0	6	0	0	3	0	0	2	0	0	3	0
Diablo Cove	0	3	0	0	4	0	0	2	0	1	3	<1	3	4	<1	2	6	<1	0	0	0	0	5	0	0	6	0	0	3	0	0	2	0	0	3	0
South Cove	0	3	0	5	4	1.2	2	2	1	1	3	<1	0	4	0	0	6	0	0	0	0	0	5	0	1	6	<1	0	3	0	0	2	0	0	3	0

TABLE 128. Summary of Department of Fish and Game Sea Otter Observations in the Vicinity of Diablo Canyon Power Plant Site. DCPP, 1977-1979.

Location	January			February			March			April			May			June			July			August			September			October			November			December		
	Otters	Days	Mean	Otters	Days	Mean	Otters	Days	Mean	Otters	Days	Mean	Otters	Days	Mean	Otters	Days	Mean	Otters	Days	Mean	Otters	Days	Mean	Otters	Days	Mean	Otters	Days	Mean	Otters	Days	Mean	Otters	Days	Mean
																1977																				
Lion Rock	0	0	0	0	0	0	37	14	2.6	71	13	5.5	35	6	5.8	77	14	5.5	13	5	2.6	10	6	1.7	2	4	<1	0	3	0	1	8	<1	3	6	<1
North Cove	0	0	0	0	0	0	5	14	<1	3	13	<1	6	6	1.0	2	14	<1	4	5	<1	0	6	0	0	4	0	0	3	0	0	8	0	0	6	0
Diablo Cove	0	0	0	0	0	0	2	13	<1	1	12	<1	0	6	0	1	14	<1	0	5	0	0	6	0	0	4	0	0	3	0	0	8	0	0	6	0
South Cove	0	0	0	22	2	11	1	13	<1	2	13	<1	2	6	<1	4	14	<1	1	5	<1	0	5	0	0	4	0	0	3	0	0	8	0	0	6	0
																1978																				
Lion Rock	1	5	<1	1	4	<1	13	8	1.6	82	12	6.8	100	15	6.2	30	10	3.0	5	7	<1	4	2	2.0	10	8	1.2	7	4	1.8	1	4	<1	0	3	0
North Cove	0	5	0	0	6	0	2	8	<1	16	12	1.3	3	16	<1	6	10	<1	0	7	0	0	2	0	0	8	0	0	4	0	0	4	0	0	3	0
Diablo Cove	0	5	0	1	4	<1	4	10	<1	8	13	<1	3	16	<1	4	10	<1	0	7	0	0	2	0	0	8	0	0	4	0	0	4	0	0	3	0
South Cove	0	5	0	5	6	<1	36	10	4.6	34	13	2.8	35	15	2.2	20	9	2.0	5	7	<1	0	2	0	0	8	0	1	4	<1	0	4	0	0	3	0
																1979																				
Lion Rock	0	15	0	0	3	0	0	7	0	27	14	1.9																								
North Cove	0	15	0	1	3	<1	0	7	0	0	14	0																								
Diablo Cove	1	15	<1	0	5	0	0	7	0	3	14	<1																								
South Cove	4	15	0	0	5	0	2	7	<1	3	14	<1																								

Discussion

The movement of sea otters into the vicinity of Diablo Canyon power plant had profound effects upon the populations of larger invertebrates. The preferential feeding on larger invertebrates (specifically abalone, sea urchin, and rock crab) by otters in newly colonized areas discussed was by Wild and Ames (1974). They hypothesized that 100 sea otters could consume from 230,000 kg to 460,000 kg of abalone in a year's time. Since the main raft of sea otters that inhabited Diablo Cove in 1974 numbered approximately 40 animals and their presence there was not for a full year, we cannot presume the levels mentioned above.

Observations by Benech from October 1973 to December 1974 indicate that the diet of sea otters in the vicinity of Diablo Canyon was comprised of 40% abalone and 33% red sea urchins (Benech 1978). Using these figures, and a conservative estimate of 18 kg as the average weight of the 40 otters in the Cove, we can estimate that approximately 60 kg of abalone and 50 kg of red sea urchin soft tissues were consumed daily since each otter requires about 20% of its body weight in food each day. Using approximations of 1.0 kg per adult abalone and 0.3 kg per adult red sea urchin (Ebert 1968), we can estimate that these 40 otters consumed 50 to 70 abalone and about 150 red sea urchins a day. These are rough estimates; the relative abundance and size of the various food items available to foraging otters preclude more accurate estimates at this time. It is obvious, however, that decreases occurred in population levels of both abalone and giant red sea urchin (Tables 129, 130, 131, and 132).

The decrease in giant red sea urchin numbers that occurred between 1974 and 1975 in both Diablo Cove and North Control areas continued, to a reduced

TABLE 129. Summary of Commercial Abalone Dive Interviews from Port San Luis and Morro Bay, October 1973 through July 1975. DCPP, 1973-1975.

Date	Number of Boats Sampled	Number of Diving Hours	Number of Red Abalone	Abalone Per Hour	Average Weight (kg)	Size Range (mm)
October	11*	61.0	590	9.7	1.8	196 - 228
November 1973	2	11.0	95	8.6	1.7	195 - 225
December 1973	1	5.5	193	35.1	---	195 - 227
September 1974	8	58.0	443	7.6	1.7	
October 1974	3	13.5	157	11.63	1.8	199 - 217
November 1974	9	63.5	685	10.9	1.6	
January 1975	2	12.0	118	9.8	1.7	
April 1975	2	16.5	113	6.8	1.5	196 - 211
May 1975	1	7.0	33	4.7	1.7	191 - 216
June 1975	1	8.5	48	5.6	---	
July 1975	1	6.0	48	8.0	1.4	184 - 216
Totals	41	262.5	2523	9.61	1.7	184 - 228

* Three other boats brought in a total of eighty-eight abalone, however, diving hours were not available so these boats and the abalone catch are not included in this table.

--Not weighed

TABLE 130. Annual Commercial Landings of Red Abalone (Haliotis rufescens) from Morro Bay to Port San Luis (Department of Fish and Game Blocks 615 and 614) from 1964 through 1977. DCPP, 1964-1977.

Year	(kg)
1964	331,550
1965	274,925
1966	176,863
1967	134,632
1968	165,908
1969	129,009
1970	86,411
1971	123,499
1972	117,249
1973	46,932
1974	61,120
1975	37,415
1976	15,146
1977	2,625

TABLE 131. Summary of Commercial Sea Urchin Diver Interviews, Point Buchon to Point San Luis, July 1973 through October 1974. DCPP, 1973-1974.

	Number of Boats Sampled	Number of Diving Hours	Weight of Sea Urchins Landed (kg)	kg of Urchins Per Hour	Mean Weight (kg)
July 1973	2	-	1,759	-	0.56
February 1974	2	-	2,237	-	-
April 1974	13	51.0	10,328	202.5	0.64
June 1974	15	54.5	14,349	263.3	-
July 1974	16	48.5	18,396	379.3	0.59
August 1974	1	3.0	1,197	399.0	0.57
September 1974	11	31.0	10,460	337.4	0.60
October 1974	4	11.0	2,377	216.1	0.66
Totals	64	199.0	61,103	287.0	0.60

TABLE 132. Annual Commercial Landings (Kg) of Giant Red Sea Urchins, *Strongylocentrotus franciscanus*, from the Area Between Morro Bay and Shell Beach. DCPP, 1972-1975.

YEAR	Red Urchins (lbs)	kg
1972	69,861	31,689
1973	264,968	120,188
1974	441,831	200,411
1975	100,725	45,688

degree, throughout the years of our study. The effects of sea otters are not as apparent in intertidal abalone densities. Generally, at parallel intertidal stations, mean densities of both red abalone and black abalones dropped substantially between 1974 and 1975 and, in some areas, showed a slight increase during 1976 and 1977 (Figures 63 and 64).

The fluctuation in abalone density data is compatible with the sea otters' pattern of usage within the study areas. The main body of otters in the southern migrant front moved into Diablo Cove in early summer of 1974, foraged there during spring, and gradually retreated as summer progressed. In 1975, the main raft was located south of Diablo Cove in the vicinity of Pecho Rock with reduced numbers of otters observed foraging the Cove. The apparent subsequent increase in abalone densities recorded during 1976 and 1977 may be the result of the decrease in foraging pressure. Abalone are only vulnerable to sea otter predation when they are exposed. Those buried deep in crevices are relatively protected from sea otter foraging methods. It is possible that the abalone we tabulated during 1976 and 1977, leading to an apparent increase in density, are those individuals that were able, due to a smaller size, to escape otter foraging. Subsequent growth could have forced them out to a more vulnerable, and more easily counted, position.

Our observations indicate that giant red sea urchin are generally more vulnerable to sea otter predation than abalone. Sea urchins can be pulled out of cracks by sea otters without the use of tools that abalone predation usually requires. The giant red sea urchin densities show no signs of reversing the downward population trends begun when the otters first arrived.

Our observations indicate that sea otter predation was perhaps the most significant factor in the changing community structures in the Diablo Cove and North Control subtidal areas. Abalone and sea urchin are primary predators on large brown algae. One secondary effect of sea otter foraging in the study areas has been a significant increase in the two dominant species of brown algae (Table 128 and 131) due primarily to the decrease in abalones and giant red sea urchins, the once dominant herbivores of this subtidal area.

In view of the migratory habits of sea otters, it is highly probable that they will continue to move into and through the Diablo Canyon area. The continuing expansion of the sea otter's range along its southern front and the gradual establishment of resident populations along this section of the coast indicate that the effects of their predation will continue. Any subsequent change in the subtidal and intertidal communities must be considered in view of this.

Commercial Giant Red Sea Urchin Fishery Survey

The objective of this study was to establish a baseline of information on the local commercial fishery for giant red sea urchins, _Strongylocentrotus franciscanus_. The data was to be used to assess the impact, if any, upon the fishery by the operating power plant.

Methods

Commercial sea urchin divers were interviewed at the dock whenever possible. Most interviews were conducted at Port San Luis in Avila Beach.

Data recorded included total pounds landed, number of diving hours, and location and depth of catch. When time permitted, we also weighed a sample of 50 urchins in order to determine the average weight (Table 131). Total landings for the area between Morro Bay and Shell Beach were obtained from the Department's biostatistical section in Long Beach (L. Pinkas, DFG, pers. commun.) (Table 132).

Results

We conducted interviews with divers from 64 boats from July 1973 through October 1974 (Table 131). These divers averaged 287 kg of giant red sea urchins per hour (478 urchins) during this period. The catch varied from 202.5 kg to 399.0 kg per hour (39 to 700 urchins).

This fishery began in this area in 1972 and the last landing were made in 1975 (Table 132). The largest landings were made in 1974.

Discussion

The fishery for giant red sea urchins, Strongylocentrotus franciscanus, began relatively recently with the recognition of a demand by foreign markets for sea urchin roe. The fishery originated in southern California but spread to central California when commercial abalone divers, faced with dwindling red abalone populations, attempted to make livings by harvesting sea urchins. Although limited in geographic extent, the area between Point San Luis and Diablo Canyon was prime for a sea urchin fishery; the red sea urchin was the dominant benthic macro-invertebrate, often approaching average mean density of

10-m^2 (Figure 102). Beginning tentatively in 1972, the fishery was, however, short-lived.

The termination of the sea urchin fishery in 1975 was due to two factors; the southerly movement of foraging sea otters into the prime sea urchin beds around Pecho Rock and conflicts between the urchin processors and the divers. All of the local catch of sea urchins were processed in Santa Barbara. This resulted in price disputes between the divers and processors.

Commercial Red Abalone Fishery Survey

The objective of this study was to establish a baseline of data on the local commercial red abalone, Haliotis rufescens, fishery. The baseline was to be used to later assess any influence of the operating power plant on the fishery.

Methods

Commercial abalone divers were interviewed at the dock whenever possible; most interviews were conducted in Morro Bay. Data recorded included numbers and total pounds landed, number of diving hours, location and depth of catch, and when time permitted, the abalone were weighed and measured to determine average weight and shell length. Total landings for the area between Morro Bay and Shell Beach were obtained from the Department's biostatistical section in Long Beach (L. Pinkas, DFG, pers. commun.).

Results

From October 1975 through July 1975, we interviewed commercial abalone divers from a total of 41 boats. The average number of red abalone collected by these diver per hour was 9.6 (Table 129). Commercial landings for the area between Morro Bay and Avila ranged from a high of 331,550 kg (730,947 lbs.) in 1964 to a low of 2,625 kg (5,787 lbs) in 1977 (Table 130). The landings declined sharply after the arrival of the otter in the Point Buchon area in 1973. Most of the commercial diving effort was conducted south of Diablo Cove in the Pecho Rock area between 1973 and 1977; however, we did observe an occasional abalone diving boat in Diablo Cove in 1973 and 1974.

We have not observed commercial abalone divers in the area between Point Buchon and Avila Beach since 1977.

Discussion

There is little doubt that the movement of foraging sea otters into the sea south of Point Buchon in 1973 and the further movement of these animals south to Avila in 1974, 1975, 1977, and 1978 was the cause of the decline and eventual elimination of the commerical abalone fishery.

Historically, Morro Bay served as the locus for the central California abalone industry with the primary abalone beds located between Cape San Martin and Point Estero. These beds had been harvested continuously since 1929 on an approximate sustained yield basis and produced an average of well over one million pounds per year until 1968. (Cox 1962, L. Pinkas, DFG, Biostatistical Section, Long Beach, pers. commun.). Beginning in 1968, abalone landings at Morro Bay began a severe decline that was associated with the expansion, in the mid-60's, of the sea otter into these long productive abalone beds. With the abandonment of abalone areas north of Morro Bay, commercial divers began to turn their attention to the Point Buchon-Point San Luis area to the south. This area was previously considered inferior, in terms of abalone production, but served as a damper in what proved to be the terminal years of the central California abalone industry.

Bull Kelp Survey

The shoreline census of bull kelp, *Nereocystis luetkeana*, was started by Burge and Schultz (1973) to document numbers and locations of this upper canopy-forming kelp in Diablo Cove. This kelp, an annual plant, has been noted in other areas to fluctuate in abundance annually. The objective of this study was to continue the documentation of the distribution and abundance of this kelp in Diablo Cove.

Methods

This census of bull kelp has been performed on the Diablo Cove population annually since 1970. No censuses were conducted during two of the years, in 1972, when no Diablo Canyon project existed, and 1975, when the surface canopy was so dense as to prohibit a shore census. This census takes place in early October at the time of greatest kelp canopy and just prior to the onset of winter storms. Two biologists stationed on the bluff overlooking the cove, working independently with binoculars and/or a spotting scope, count the plants in the surface canopy. The biologists mark the locations of major aggregations ("beds") of kelp on a chart of Diablo Cove. Although not a precise method, due to difficulty in counting individual plants at a distance, it provides us with an annual corallary estimate of bull kelp numbers to compare with estimates from the subtidal surveys.

The subtidal survey method for bull kelp is described in the Subtidal Studies Brown Algae section. The mean number of bull kelp per 30-m^2 arc station was used to estimate the total population of this alga for the total 36 acres of Diablo Cove. The shore census number in 1975 is estimated from the subtidal survey.

Results

The annual censuses (Table 133) show an increasing population to bull kelp from 1970 to 1974. Although no shoreline census was performed in 1975, the subtidal survey data reflected an increasing number of Nereocystis through 1975 (Figure 206) corresponding to our visual impressions that the bed was at its greatest recorded density. After 1975, the numbers of Nereocystis declined during the succeeding censuses.

Discussion

The shoreline census in Diablo Cove does not provide an accurate estimate of total population of bull kelp, it does, however, provide a relative estimate. The reason for this is that many plants, probably the majority, do not reach the surface. Also, when plants are densely clumped, overlaying occurs which obscures from view many plants. The comparison between the

TABLE 133. Numbers of Bull Kelp, Nereocystis luetkeana, in Diablo Cove from Shore Census and Subtidal Surveys. DCPP, 1970-1978.*

Year	Numbers of Nereocystis in Surface Canopy (Shore Census)	Estimated Total Population of Bull Kelp from Substidal Surveys
1970	4,686	No Subtidal Survey
1971	5,445	No Subtidal Survey
1973	10,263	No Subtidal Survey
1974	18,663	166,000
1975	No Census (estimate = 46,000)	421,000
1976	11,323	103,000
1977	10,563	31,000
1978	5,295	No Subtidal Survey

* Neither census nor survey were performed in 1972.

shoreline census and subtidal surveys is made by expanding the mean number of plants derived from annual subtidal surveys to a population estimate for the 36-acre Cove. This estimate is rough at best since an even distribution of plants within the Cove must be assumed for all years.

This comparison (Figure 206) shows that in 1974 and 1976, when both methods were performed, an estimated eleven times more plants were accounted for in the subtidal surveys than in the shore census. This 11:1 ratio was used to generate the shoreline census estimate for 1975 since counting was not possible. In 1977, the ratio of total estimated plants to surface canopy plants fell to about 3:5:1, perhaps due to the "patchier" nature of plant distribution during that year.

In addition to providing a relative estimate of bull kelp within Diablo Cove, the annual censuses also provide charts showing the distribution of this alga in the study area (Figure 207-213). Two features of the <u>Nereocystis</u> population in Diablo Cove can be seen by examining these distributions. The first feature is that the population is largely peripheral in nature. During most of the census years, there were many fewer plants in the center of the Cove (Figures 207, 209 and 213). This may be related to a depth-dependent success of the maturing sporophytes. However, the central portion of the Cove was densely populated during the successful years in 1974 through 1976 when the bull kelp appeared to be more evenly distributed than in preceding and succeeding years. This smoother distribution limited our ability to determine individual "beds" and necessitated the counts to be made in wedges or blocks during 1974 and 1976 (Figures 210 and 211). The second feature of bull kelp distribution is that the majority of the population, from year to year, occurs in the northern portion of Diablo Cove. This is most probably due to better (i.e., more solid) substrate in the northern part of the Cove and conversely, a greater amount of sand bottom in the southern part. However, underwater clarity and water movement are also generally greater in northern Diablo Cove and these conditions may favorably affect *Nereocystis* success as well.

In 1977 about 22% of the counted kelp occurred in shallow water just seaward of the discharge structure (Figure 212). In the winter and spring of 1977, the Unit I discharge pumps were tested on a nearly continuous schedule, and this probably resulted in scouring of the shallow (0 to 3.0 m) subtidal fronting the discharge structure. When pump testing was halted in May 1977, this newly available habitat was densely colonized by late-in-the-year *Nereocystis* sporelings.

Also, in 1977, *Macrocystis pyrifera*, giant kelp, appeared in Diablo Cove for the first time since this study began. One plant was observed in the lee of Diablo Rock (Figure 212). In 1978 four plants were evident on the surface in the same area (Figure 213). The reasons for the appearance of *Macrocystis* in Diablo Cove are unclear.

Foam Study

When we observed the testing of the sea water cooling system in 1974-75, we noted large amounts of foam, (or froth) were produced in Diablo Cove, apparently by the turbulence of discharged water. The extent and thickness of the foam during some of those tests caused a concern, if the foam proved to be chronic, that the benthic plant community could be affected by light attenuation. In order to monitor foam conditions, we began making frequent observations of Diablo Cove during periods of pump testing and also when the pumps were off.

Methods

During each observation period, conducted from the Diablo Cove bluff near the meteorological tower, we made estimates of the cover and thickness of the foam; wind speed and direction; and swell direction and energy. Time, tidal stage and whether pumps were operating were also noted. Documentary photographs usually accompany the observations. Observations were usually made during mid-day.

Results

Observations made during 1976 allowed us to make generalization about factors influencing foam generation in Diablo Cove, the amount of foam varied, depending on pump operation and sea and wind conditions. With cooling pumps on, we observed foam 95% of the time. When pumps were off, foam was present 75% of the time.

During pump operation the greatest amounts of foam appeared correlated with calm to moderate sea, low wind, and flood or slack tides. Foam did not appear to accumulate as readily under harsher weather conditions. At times, the foam came on shore; with moderate wind blowing (5 to 15 knots), billows of foam have piled up in the southern portion of the Diablo Cove intertidal. The foam covered several hundred square meters of intertidal area apparently for several hours at a time, and was up to 0.2 m thick. Significant percentages of the Diablo Cove surface water, several thousand square meters, were often covered by a slowly moving foam mat during pump operations.

When pumps were off, the observed foam was never thick and rarely as extensive as we observed during the pump testing period. Here again, we observed more foam at flood and slack tides and during periods of low wind speeds. Heavy seas produced greater amounts of foam, especially in the area of offshore rocks and headlands that high winds seemed to inhibit accumulation.

Discussion

In 1977, PG&E installed an automated, timed camera on the meteorological tower on the south bluff above Diablo Cove to record the presence of foam. Since the method was superior to our observations and photos were taken quarter-hourly, Fish and Game observations were halted. Approximately 28 months of data were collected with this camera and the resultant photos have been analyzed by PG&E (Wyman 1979). Their study will provide a baseline against which to compare natural versus discharged-created foam.

CONCLUSIONS AND RECOMMENDATIONS

Intertidal Studies

When we designed this study, our goal was to be able to detect biological change brought about by the discharge of heated seawater from the cooling system of the power plant. At that time, mid-1973, operation of the plant was expected to begin about 1976 or 1977. Because we were concerned about the future health of the Diablo Cove ecosystem, rather than just isolated sport or commercially important species in it, our study was designed to include as many species as possible. With the limitations inherent in a finite funding base, we designed a randomized study meant to cover as many species and as much of the Cove and Control area as we thought practicable. Permanent stations, as primary sources of information, were rejected for several reasons.

Ideally, the ability to detect change would be enhanced if the selected study areas were directly comparable in species composition and abundance. However, analysis of our intertidal data has shown that, on a species-by-species basis, between-area variability is quite high. Nearly all species when tested individually showed significant differences in abundance between study areas. This indicates that species exist at different levels of abundance in the various study areas. As a result, the study areas in most cases cannot be compared directly to each other, except for year-to-year trends in abundance.

Instead, within-area variability, in many instances, is acceptably low enough so that each area will be able to serve as its own "control" in a pre- and post- start-up comparison. For example, in terms of general algal standing-crop, each study area seems to support a characteristic level of winter and summer biomass that is statistically definable. Articulated coralline and Phyllospadix cover estimates also seem to be fairly constant within the study areas where they occur. There are also several invertebrates species within each study area whose numbers remained statistically stable during the pre-operational period. All of these together should enable us to statistically prove the case for biological change, should it occur.

One reason that more species do not fall within the category of "predictable stability" in our sample design is related to their spatial distributions. Contagion is the rule in distribution of marine organisms, (Elliott 1971, Sokal and Rolf 1969), with the great majority of species adapted to specific sets of physical and biological variables and limited to rather "narrow" habitat. The amount of statistical variability due to spatial considerations possibly could have been reduced by changing our sample design. One change would be to significantly increase the number of samples taken, and another would be to further limit the sorts of habitat and substrate sampled. Neither option was pursued for two difference reasons. To significantly increase sample size would have required manpower far in excess of our budgetary ability. To limit substrate and habitat would have called for a change in the assumption of the study plan, effectively negating comparability of data collected previous to the decision to change.

Consequently, for many of the less common species anything less than outright disappearances may be difficult to document by standard ANOVA techniques utilized to date. However, we hope in the future, to improve our ability of detecting more subtle changes by using community analyses. At the least, these methods should provide another approach, based on a different view of the data, to aid us in making comparative interpretations.

Subtidal Studies

In the Introduction, we listed the various man-made and natural impacts that have been observed in the Diablo Canyon area since the Department of Fish and Game began their studies in 1970. Most of the significant changes that we have documented in the plant and animal communities in Diablo Cove and the Control areas are directly or indirectly related to those impacts. Thus, we feel that the most efficient way of listing the conclusions from our studies is to relate them to the various impacts in a chronological order.

A. Intake Cove - jetty and cofferdam construction and silting of intake cove.

1. The construction of the jetties enclosing Intake Cove resulted initially in the formation of a protected inner-coast environment subject to increased deposition of silt and debris because of the lack of current and wave action.

2. This new environment probably would have supported similar type populations of plant and animals, present before the jetties were constructed, including abalone and urchins. However, there is reason to believe that the quiet waters would have fostered the development of a *Macrocystis* canopy instead of the existing *Nereocystis* (bull kelp) canopy.

3. The release of silt, from the cofferdam construction, into the Cove almost completely destroyed the benthic community.

4. A new, soft-bottom benthic community is developing in Intake Cove, and a fairly rich rocky reef community has developed on the breakwaters. This community includes substantial numbers of red abalone and giant red sea urchins.

5. Intake Cove has also attracted large numbers of fish, especially several species of juvenile rockfish during certain parts of the year.

6. A red algae community has been established on the breakwaters in depths of 15 to 20 feet and shallower.

7. The dominant brown algae in Intake Cove is not Macrocystis.

8. Even if the silt had not been released into the Cove, we believe that the benthic community eventually would have become dominated by soft-bottom animals and plants, due to natural deposition of silt from run-off and erosion.

B. North Control - arrival of Sea Otters.

1. Early in 1973, the southern front of the sea otters moved south of Point Buchon and took up residence in the kelp bed just north of Lion Rock.

2. In May 1974, we began our random subtidal studies, and we selected this area for our Control area.

3. During our initial random surveys in 1974, it was quite evident that sea otters were foraging on red abalone and giant red sea urchins.

4. The otters continued to forage in this area even after the front moved south to Diablo Cove, and eventually, Pecho Rock.

5. The random stations in the North Control reflected the foraging activities by yielding a highly significant decline in giant red sea urchin density from 1974 through 1977.

6. Red abalone density seemed to decline from 1974 to 1975, then apparently increased after this. However, these changes were not statistically significant.

7. The density of the two most common species of brown algae, <u>Laminaria</u> and <u>Pterygophora</u>, increased at random arc stations between 1974 and 1977. However, the increase in <u>Pterygophora</u> density was not statistically significant.

8. Bull kelp densities declined during our studies at the arc stations between 1974 and 1977, but increased significantly at quadrats between 1976 and 1978. Apparently, other factors were acting on the bull kelp abundance other than the decline in numbers of giant red sea urchins.

9. All of these observed changes in the biota, we feel, are due directly to sea otter foraging.

C. Diablo Cove - arrival of sea otter, release of copper corrosive products, red tide, removal of cofferdam.

1. In May 1974, sea otters moved into Diablo Cove. In July 1974, during cooling water pump testing and release of copper into the Cove, dead and dying abalone were observed in South Diablo Cove. From September through November 1974, a bloom of red tide organisms occurred in the Diablo Canyon area.

2. From 1974 through 1977, we observed significant declines in giant red sea urchin densities in both North and South Diablo Cove, in fact, they have not been recorded from most South Diablo Cove random stations since 1974.

3. Bull kelp (*Nereocystis*) increased substantially in density from 1974 to 1975 but declined thereafter.

4. *Pterygophora* and *Laminaria* both showed highly significant increases in density between 1974 and 1977.

5. From our observations, the drastic decline in sea urchins in Diablo Cove resulted from sea otter foraging, as well as red tide, and probably the release of copper. The decline in sea urchins allowed for a high production of bull kelp, *Nereocystis*, in 1975 and the two understory kelps, *Pterygophora* and *Laminaria*, also increased in density. The decline after 1975 was probably due to the fact that this alga, an annual, was unable to compete with the perennial understory kelps *Pterygophora* and *Laminaria*.

6. Sea otter foraging and the copper release presumably caused a reduction in abalone population. Unfortunately, the subtidal red abalone population was set at such a low level when we began our studies in 1973 that the permanent and random station data do not indicate a significant decline.

7. We suspect that other significant changes or differences shown by analysis of the subtidal data could have been due to the three factors mentioned above or fluctuations in the environment.

8. Changes in fish populations, particularly the decline in observations of lingcod and kelp greenlings, are probably due to natural causes. However, the local sport and commercial fisheries may be involved with the population fluctuations.

9. There appeared to be little or no relationship between bull kelp abundance and fish species diversity.

10. The removal of the cofferdam in front of the outfall structure, in contrast to that in the Intake Cove, resulted in only small amounts of silt and sand to be deposited in Diablo Cove with little or no observed impact to the subtidal communities.

We feel that the significant differences between our study areas for many of the plants and animals reflect the differences in habitats of these areas. For example, South Diablo Cove supports a community that is adjusted to semi-protected waters subject to occasional high rates of sediment movement. North Diablo Cove, on the other hand, supports a more diverse community that is adjusted to a semi-protected cove largely protected from sediment scouring or burial and is also more greatly supplied by currents. The subtidal communities in the North Control, an exposed coast type of habitat, most closely resemble those of North Diablo Cove, although they do differ in their own regard.

Most of the significant differences in densities at depths are probably due to natural distribution patterns of the particular plant or animal. However, the difference in giant red sea urchin densities at depth may be related to sea otter foraging patterns and/or mortalities due to the red tide and release of copper into Diablo Cove. From our observations the sea otters tend to feed on animals in the shallower waters when they first arrive in an area. It also appears that there has been little or no juvenile giant red sea urchin recruitment since the arrival of the otters. This may be due to the lack of adults as well as lack of suitable protective habitat in which the juvenile giant red sea urchins develop.

Based on these conclusions and the analysis of the data, we make the following recommendations:

1. Surveys of random arcs and quadrats should be continued once a year in the interim period before the plant begins operating, at least in the shallow waters (less than 25 feet deep) of Diablo Cove and the North Control.

2. Surveys of permanent subtidal stations be discontinued as the analysis of the random data has yielded more significant results for the changes that we have observed. The stations monitored by the 316A biologists appear to be sufficient.

3. Once the plant becomes operational, we recommend that the random subtidal studies be intensified to a level of effort at least equal to our pre-operational studies. This effort would include surveys of 24 30-m^2 arcs in each Diablo Cove and the North Control and 96 0.25-m^2 quadrats in each Diablo Cove and the North Control.

4. We recommend that additional fish studies be initiated by our project as well as PG&E or one of their contractors to obtain more quantified data in Diablo Cove and our North Control.
   Specifically:

   a. During the interim non-operational period, baseline studies should be initiated utilizing rapid visual species counts and/or modifications of this method now being tested by Department biologists.

   b. Rapid visual species counts should be conducted at all our future random benthic stations.

   c. An attempt should be made to conduct rapid visual counts at night to obtain data on nocturnal species.

Miscellaneous Studies

Tidepool Fish Study

The tidepool fish collections were similar for Diablo Cove and North Control. Any changes in these intertidal communities should be reflected by changes in the fish populations, both in numbers and species changes. Continued monitoring of these populations through rotenone or tidepool draining should be continued as a check in intertidal changes. A decision as to the method (rotenone or draining) has to be made. More fish are collected with rotenone, but the fish are killed. Draining collects fewer fish but has less of a detrimental effect on the fish.

Catch-Per-Unit-Of-Effort Study

The standard deviations were often greater than the mean numbers of fish caught in this study. The unreliability of the data does not warrant further study unless our methods are modified to maximize fishing effort. The results of the concluded study, however, have been valuable in confirming our visual observations as to the most abundant non-cryptic species.

Fish Stomach Content-Content Study

Stomach contents of fish from the tidepool collections provide a check on the populations of the invertebrates and vertebrates prey species. Fish can serve as "collectors" of organisms difficult for biologists to sample. Changes in fish diet, whether in numbers of prey caught or in prey species, could be used as an indicator of community change. Emphasis should be placed on fish that consume animal food rather than on herbivorous fish.

Sea Otter Study

The movement of sea otters into the Diablo Canyon area resulted in significant changes in the plant and animal communities. It is our belief that most of the significant changes we have observed in invertebrate and plant populations were the direct or indirect results of foraging sea otters. We recommend that our observations of sea otter activity within the Diablo Canyon area be continued.

Commercial Abalone and Urchin Fishery Surveys

Our interviews with the commercial fisherman harvesting abalone and urchins showed the decline and eventual end of both fisheries as the sea otters moved through the area. The landing showed the demise of these fisheries.

As these fisheries no longer exist, we have no recommendations regarding further studies.

Bull Kelp Survey

Our annual fall census of the surface canopy of bull kelp in Diablo Cove reflected the significant changes documented at random subtidal stations. The changes reflected include the large increase in the population from 1974 to 1975, and the ensuing decline from 1976 through 1978. We feel these changes were due to the removal of sea urchins by sea otters and the resulting "bloom" of the subsurface canopy of Laminaria and Pterygophora.

We recommend that this annual census be continued.

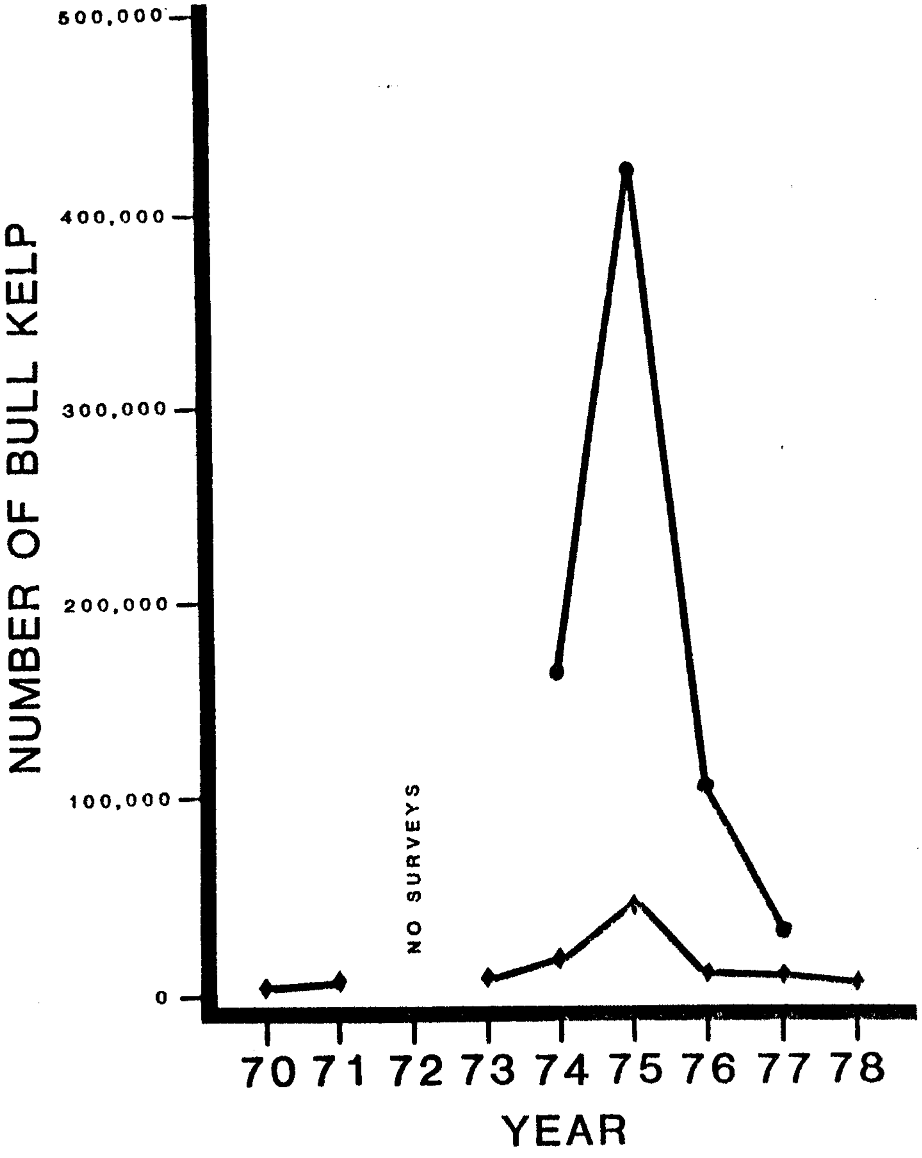

Figure 206. Numbers of bull kelp, Nereocystis luetkeana, from shore census (●) and subtidal survey population estimates (♦) in Diablo Cove. DCPP, 1973-1978.

*From Burge and Schultz 1973
**The shore survey in 1975 is estimated from subtidal survey counts

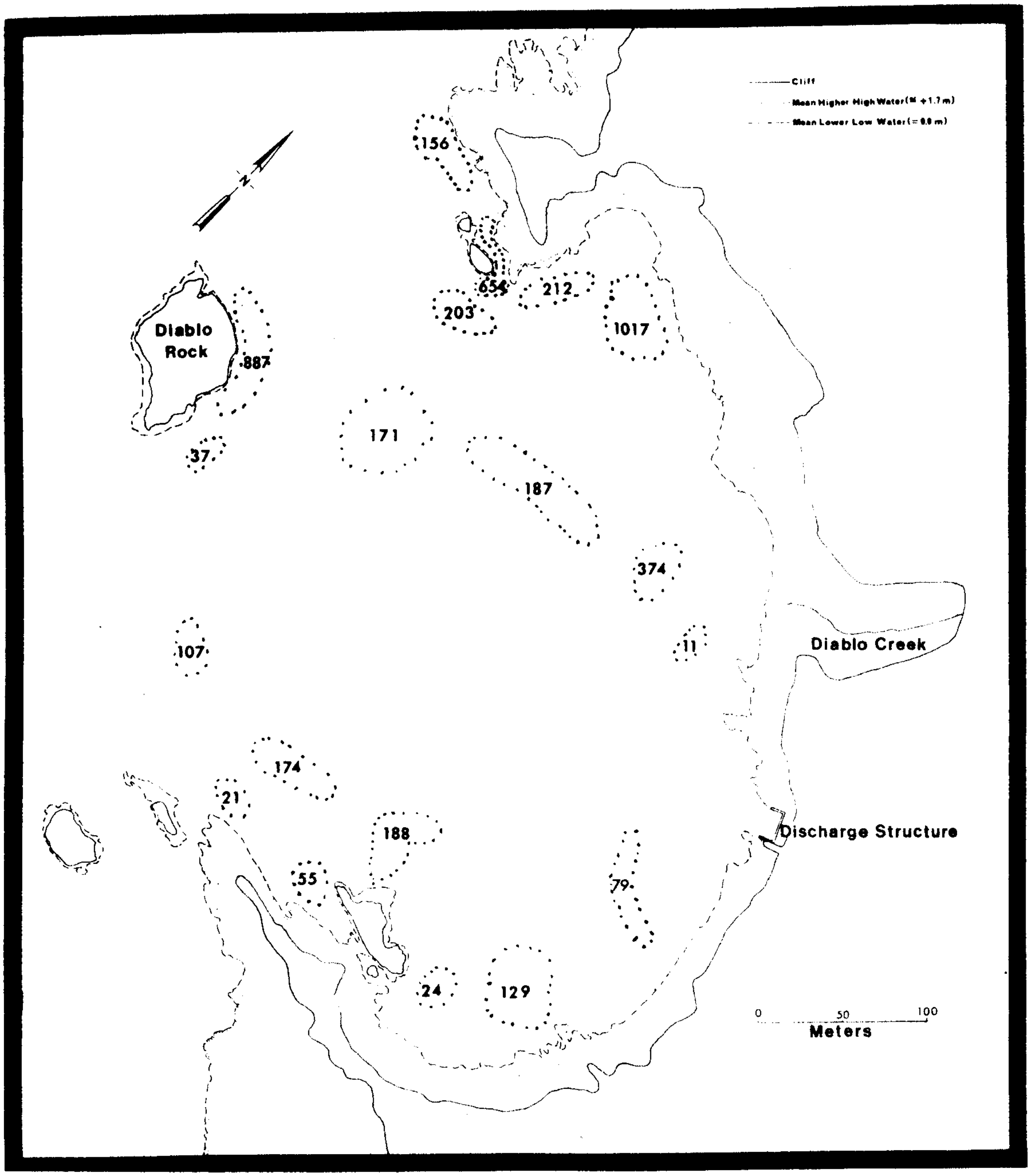

Figure 207. Distribution and numbers of bull kelp, <u>Nereocystis luetkeana</u>, within Diablo Cove assessed during the October, 1970 shore census (Modified from Burge and Schultz, 1973).

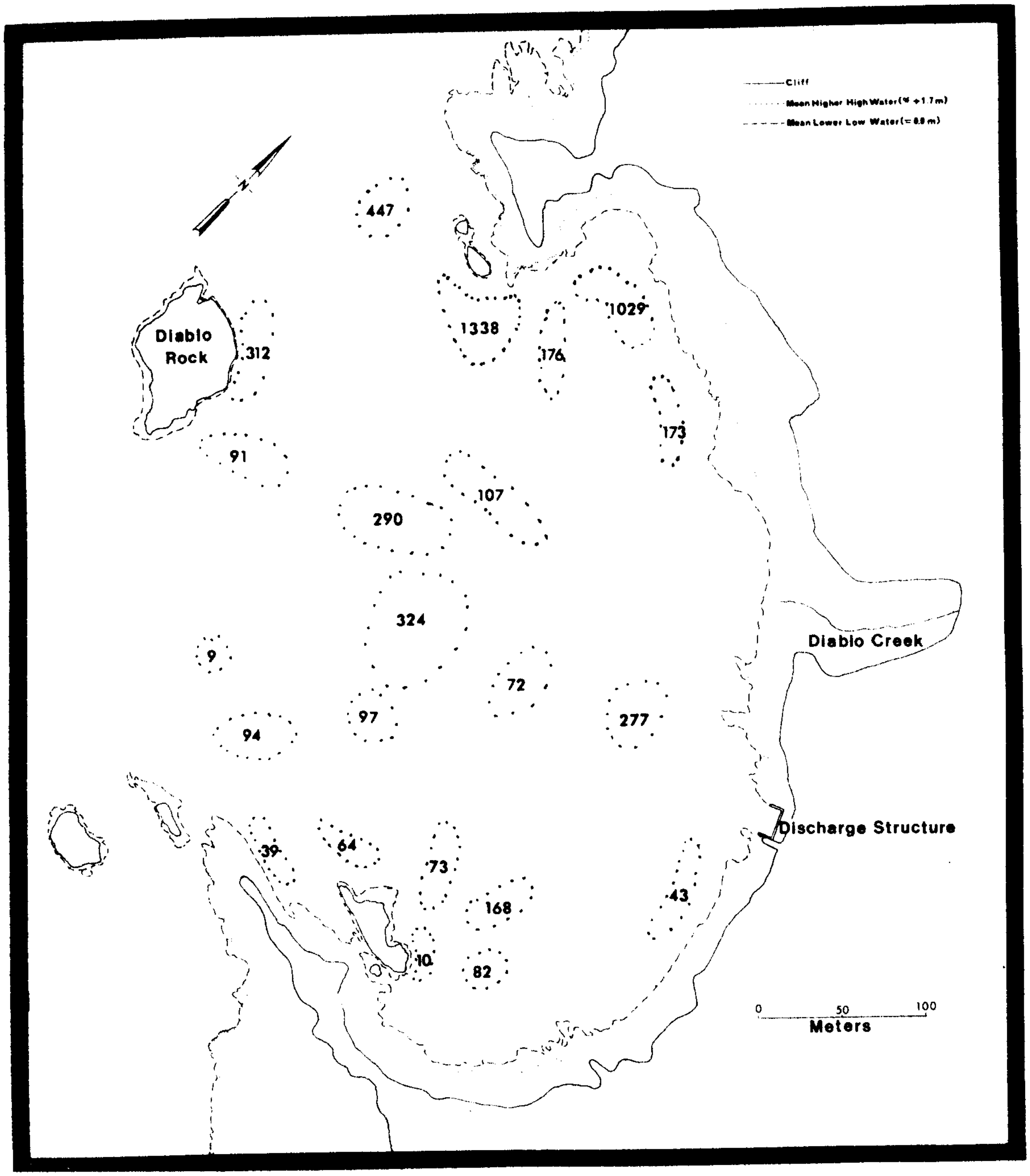

Figure 208. Distribution and numbers of bull kelp, <u>Nereocystis luetkeana</u>, within Diablo Cove assessed during the October, 1971 shore census (Modified from Burge and Schultz, 1973).

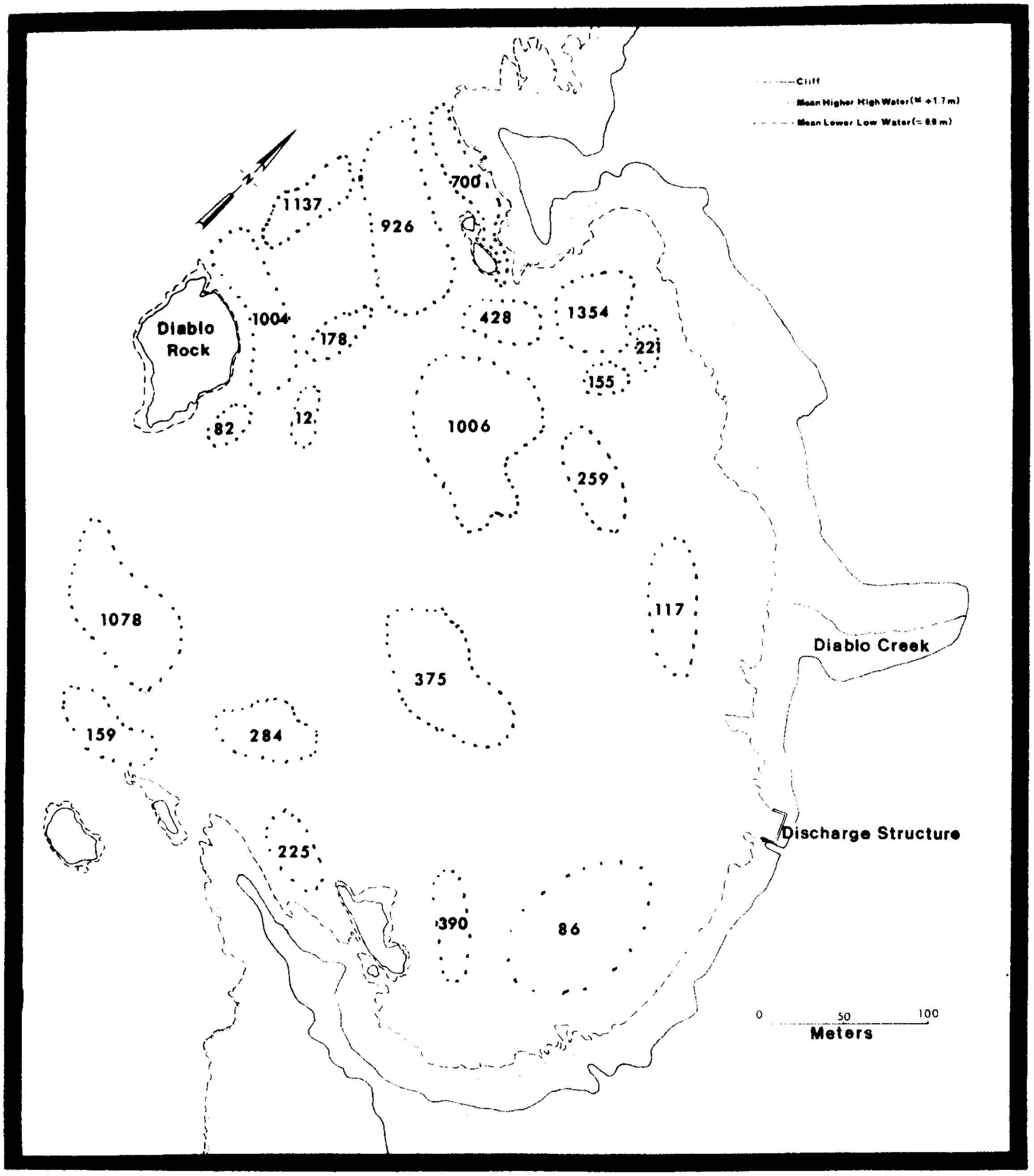

Figure 209. Distribution and numbers of bull kelp, Nereocystis luetkeana, within Diablo Cove assessed during the October, 1973 shore census.

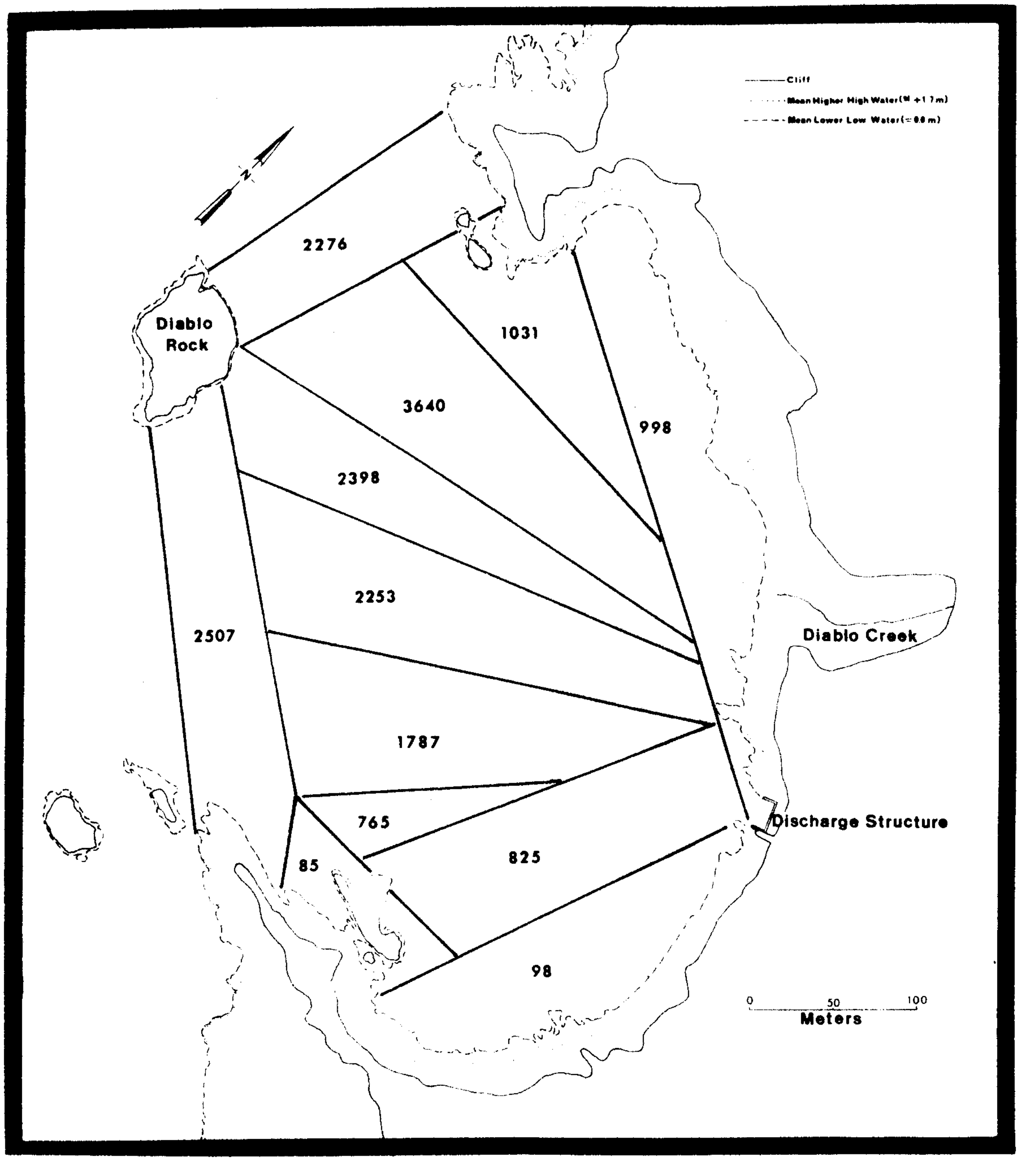

Figure 210. Distribution and numbers of bull kelp, Nereocystis luetkeana, within Diablo Cove assessed during the October, 1974 shore census.

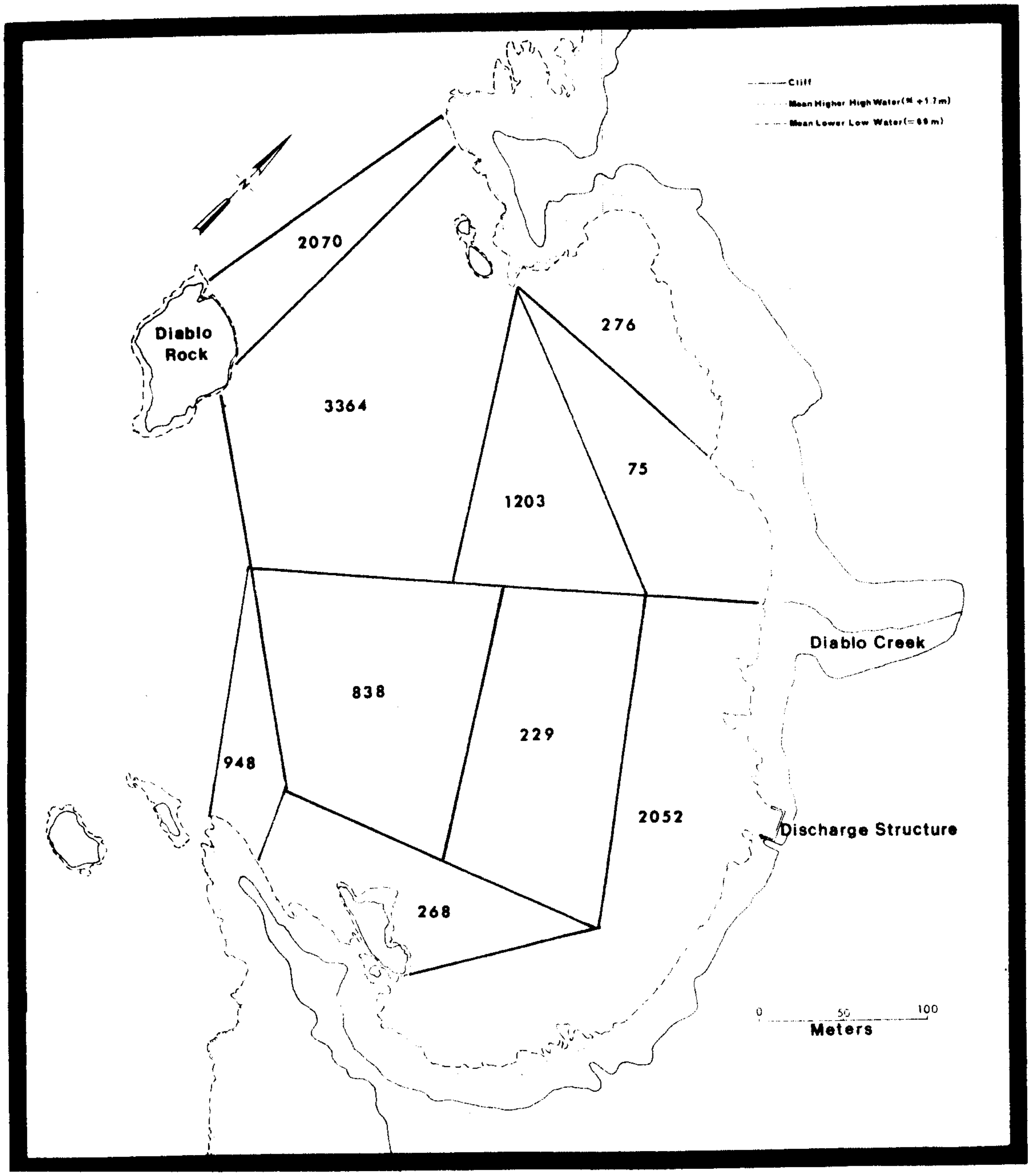

Figure 211. Distribution and numbers of bull kelp, *Nereocystis luetkeana*, within Diablo Cove assessed during the October, 1976 shore census.

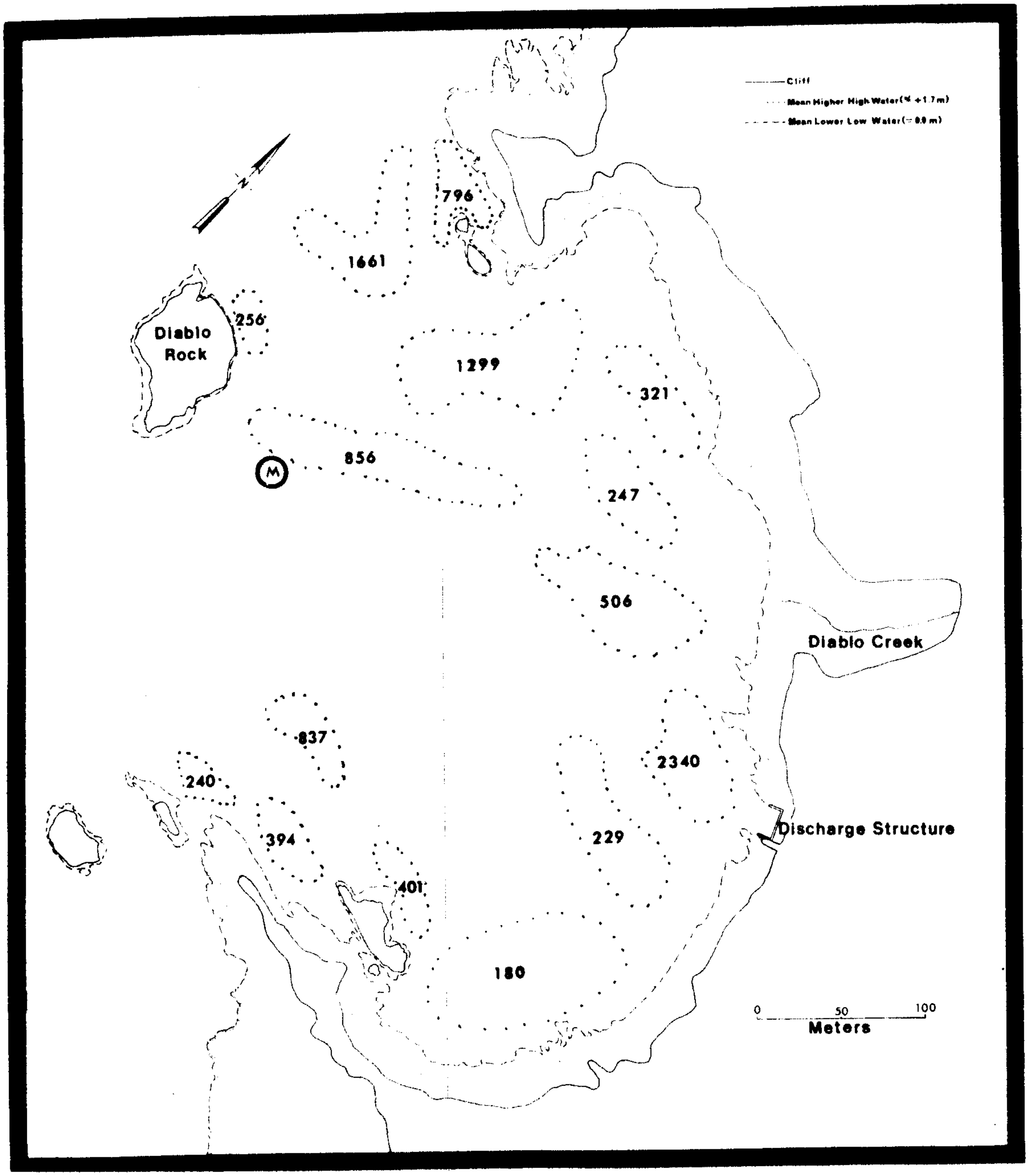

Figure 212. Distribution and numbers of bull kelp, Nereocystis luetkeana, within Diablo Cove assessed during the October, 1977 shore census.

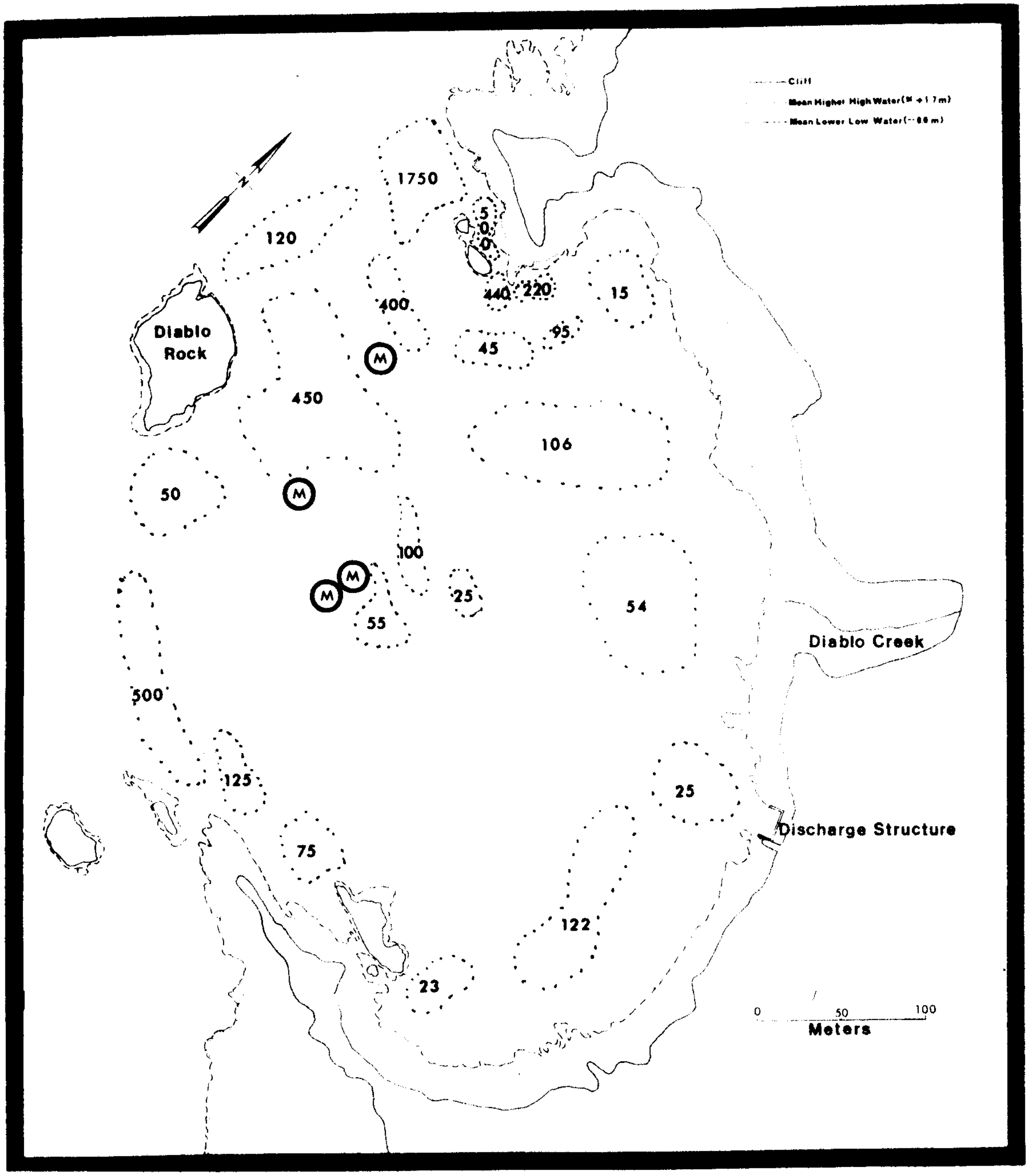

Figure 213. Distribution and numbers of bull kelp, *Nereocystis luetkeana*, within Diablo Cove assessed during the October, 1978 shore census.

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APPENDIX 1a. Summary of Personnel Man-Days, Boat Time, and Laboratory Time. DCPP, 1973-1979.

July 1, 1973 -- December 31, 1978

	July 1973 through June 1974	July 1974 through June 1974	July 1975 through June 1976	July 1976 through June 1977	July 1977** through June 1978	July 1978 through June 1979	Totals
Total Man-Days	902	947	1048	1062	1172	1058	6189
Man-Days at Site*	238	263	765	818	1012	964	4060
Boat Time (Hours)	36	42	89	72	65	58	362
Laboratory Time Man-Days†	618	642	268	224	24	-	1776

*Total time spent at Diablo Canyon by all project personnel; includes both field and laboratory time.

**Total time spent at Diablo Canyon by all project personnel; includes both field as well as laboratory time. Beginning with this report, all time off for vacation, sick leave, etc., will be excluded.

†Time spent at Monterey office.

APPENDIX 1b. Summary of Intertidal Sampling Effort: Number of Stations; Random 0.25-m^2 Quadrats; Parallel Abalone Transects and Perpendicular Abalone Transects. DCPP, 1973-1977. (- Indicates not sampled)

Diablo Point Intertidal

	Stations	0.25-m2 Quadrats	Parallel Abalone Transects	Perpendicular Abalone Transects
Winter 1973-74	3	12	2	Not Done at DPI
Summer 1974	-	-	-	
Winter 1974-75	3	12	3	
Summer 1975	3	12	2	
Winter 1975-76	3	12	2	
Summer 1976	3	12	3	
Winter 1976-77	-	-	-	
Summer 1977	3	12	3	
Totals	18	72	15	

South Diablo Cove Intertidal

	Stations	0.25-m2 Quadrats	Parallel Abalone Transects	Perpendicular Abalone Transects
Winter 1973-74	5	20	3	-
Summer 1974	5	20	5	-
Winter 1974-75	9	36	9	5
Summer 1975	9	36	9	8
Winter 1975-76	8	32	8	1
Summer 1976	9	36	7	7
Winter 1976-77	9	36	9	9
Summer 1977	9	36	9	9
Totals	63	252	59	39

APPENDIX 1b. (continued)

North Diablo Cove Intertidal

	Stations	0.25-m2 Quadrats	Parallel Abalone Transects	Perpendicular Abalone Transects
Winter 1973-74	5	18	5	-
Summer 1974	5	20	5	-
Winter 1974-75	8	32	8	3
Summer 1975	9	36	9	9
Winter 1975-76	9	35	7	8
Summer 1976	9	36	9	8
Winter 1976-77	9	36	9	9
Summer 1977	9	36	9	9
Totals	63	249	61	46

North Control Intertidal

	Stations	0.25-m2 Quadrats	Parallel Abalone Transects	Perpendicular Abalone Transects
Winter 1973-74	5	18	3	-
Summer 1974	1	4	1	-
Winter 1974-75	9	36	9	4
Summer 1975	9	36	9	6
Winter 1975-76	10	40	10	5
Summer 1976	10	40	8	7
Winter 1976-77	9	36	9	9
Summer 1977	10	40	10	9
Totals	64	250	59	40

APPENDIX 1c. Summary of Intertidal Sampling Effort, Permanent Abalone transects. DCPP, 1969-1978. (- indicates not sampled)

	Seal Haul-Out	South Diablo Cove	North Diablo Cove	Field's Cove
Winter 1969-70*	-	2	2	2
Summer 1970*	-	2	2	2
Winter 1970-71*	-	2	2	2
Summer 1974	-	1	2	-
Summer 1975	-	2	2	-
Winter 1975-76	1	3	2	3
Summer 1976	1	3	2	2
Winter 1976-77	1	3	2	2
Summer 1977	1	3	2	3
Winter 1977-78	1	2	2	1
Summer 1978	1	1	2	3
Totals	6	24	22	20

* From Burge and Schultz 1973

APPENDIX 1d. Summary of Subtidal Sampling Effort, Random Stations. DCPP, 1974-1978. (- indicates not sampled)

	30-m^2 Arc Stations				0.25-m^2 Quadrat Stations*			
	Depth Range (m)				Depth Range (m)			
Year	0-7.6	7.7-15.2	15.3-22.9	Total	0-7.6	7.7-15.2	15.3-22.9	Total
				South Diablo Cove				
1974	6	2	-	8	-	-	-	0
1975	8	4	-	12	-	12	-	12
1976	8	4	-	12	20**	4	-	24
1977	9	3	-	12	36	9	3	48
1978	-	-	-	0	35	13	-	48
				North Diablo Cove				
1974	5	1	-	6	-	-	-	0
1975	8	4	-	12	12	8	-	20
1976	8	4	-	12	20	4	-	24
1977	9	2	1	12	37	11	-	48
1978	-	-	-	0	33	15	-	48
				North Control				
1974	8	5	1	14	-	-	-	0
1975	15	9	-	24	-	-	-	0
1976	14	9	1	24	28	20	-	48
1977	15	7	2	24	49	31	4	84
1978	-	-	-	0	48	36	12	96

* Four quadrats per station

** One quadrat was not included on the invertebrate data analysis because it was on 100 percent sand.

APPENDIX 1e. Summary of Subtidal Sampling Effort, Permanent Stations. DCPP, 1970-1978. (- indicates not sampled)

Permanent Stations (60-m2)	1970*	1971*	1973	1974	1975	1976	1977	1978	Totals
				Diablo Cove					
1	-	-	-	-	-	-	1	1	2
9	3	3	1	2	3	2	1	1	16
10	3	3	1	2	1	2	1	1	14
11	3	3	1	3	3	2	2	1	18
12	3	3	1	2	3	2	2	1	17
16	2	2	1	1	3	2	1	1	13
				Field's Cove					
6	3	3	-	2	2	2	1	1	14
7	3	3	1	3	2	2	1	-	15
8	2	3	1	2	-	-	1	-	9
				South Cove					
15	2	3	1	1	3	2	3	1	16
Totals	24	26	8	18	20	16	14	8	134

* From Burge and Schultz 1973

Appendix 2. Intertidal Sampling Dates and Tide Levels (in feet) for Diablo Point, South Diablo Cove, North Diablo Cove, and North Control. DCPP, 1973-1977.

North Control Intertidal

Station Number	Winter 1973-74	Summer 1974	Winter 1974-75	Summer 1975	Winter 1975-76	Summer 1976	Winter 1976-77	Summer 1977
1	05Jan74(-0.9)	N/S	14Dec74(-0.9)	25May75(-1.4)	30Nov75(-0.8)	14May76(-1.6)	N/S	05Jun77(-0.9)
2	21Dec73( )	N/S	N/S	29May75(-0.3)	30Nov75(-0.8)	14May76(-1.6)	19Dec76(-1.4)	01Jun77(-1.5)
3	N/S	N/S	13Dec74(-1.0)	25May75(-1.4)	01Dec75(-1.2)	15May76(-1.5)	19Dec76(-1.4)	01Jun77(-1.5)
4	N/S	N/S	25Jan75(-1.2)	22Jun75(-1.1)	01Dec75(-1.2)	15May76(-1.5)	18Jan77(-1.4)	02Jun77(-1.7)
5	21Jan74(-0.6)	N/S	12Dec74(-1.0)	26May75(-1.3)	02Dec75(-1.4)	16May76(-1.2)	18Jan77(-1.4)	02Jun77(-1.7)
6	06Jan74(-1.4)	N/S	25Jan75(-1.2)	24Jun75(-1.0)	02Dec75(-1.4)	16May76(-1.2)	18Jan77(-1.4)	03Jun77(-1.6)
7	N/S	N/S	11Dec74(-0.9)	27May75(-1.0)	03Dec75(-1.4)	17May76(-0.8)	19Jan77(-1.4)	03Jun77(-1.6)
8	N/S	N/S	24Jan75(-0.8)	24Jun75(-1.0)	03Dec75(-1.4)	17May76(-0.8)	19Jan77(-1.4)	04Jun77(-1.4)
9	10Dec74(-0.6)	N/S	10Dec74(-0.6)	28May75(-0.7)	14Jan76(-0.6)	13Jun76(-1.4)	19Jan77(-1.4)	04Jun77(-1.4)
10	N/S	N/S	24Jan75(-0.8)	N/S	14Jan76(-0.6)	13Jun76(-1.4)	03Mar77(-0.5)	06Jun77(-0.5)

( ) = Tide Level

Appendix 2. (continued)

North Diablo Cove Intertidal

Station Number	Winter 1973-74	Summer 1974	Winter 1974-75	Summer 1975	Winter 1975-76	Summer 1976	Winter 1976-77	Summer 1977
1	09Nov73	18Aug74(-0.8)	11Nov74(-0.4)	14May75(-0.7)	17Jan76(-1.1)	17Apr76(-1.0)	19Nov76(-0.7)	04May77(-1.4)
2	N/S	N/S	13Jan75(-0.6)	11Jun75(-1.1)	17Jan76(-1.1)	17Apr76(-1.0)	19Nov76(-0.7)	03May77(-1.2)
3	04Feb74(-1.4)	24May74(-1.3)	25Feb75(-1.1)	14May75(-0.7)	27Jan76(-0.7)	30Jun76(-0.5)	20Nov76(-1.2)	04May77(-1.4)
4	09Dec73	18Jul74(-1.3)	09Jan75(-0.8)	11Jun75(-1.1)	27Jan76(-0.7)	29Jun76(-0.7)	05Dec76(-0.4)	04Jul77(-0.7)
5	N/S	25May74(-1.0)	12Nov74(-0.8)	15May75(-0.5)	28Jan76(-0.9)	29Jun76(-0.7)	02Feb77(-0.7)	04Jul77(-0.7)
6	N/S	N/S	08Jan75(-0.5)	10Jun75(-1.1)	28Jan76(-0.9)	14Jun76(-1.1)	03Feb77(-0.7)	30Jul77(-1.2)
7	N/S	21Jun74(-1.6)	26Jan75(-1.5)	15May75(-0.5)	30Jan76(-0.9)	14Jun76(-1.1)	13Feb77(-0.5)	30Jul77(-1.2)
8	20Jan74(-0.6)	N/S	N/S	10Jun75(-1.1)	04Nov75(-1.2)	12Jun76(-1.5)	13Feb77(-0.5)	29Jul77(-1.2)
9	10Nov73	N/S	26Feb75(-0.8)	25Jun75(-0.8)	04Nov75(-1.2)	12Jun76(-1.5)	14Feb77(-0.8)	29Jul77(-1.2)

( ) = Tide Level

Appendix 2. (continued)

South Diablo Cove Intertidal

Station Number	Winter 1973-74	Summer 1974	Winter 1974-75	Summer 1975	Winter 1975-76	Summer 1976	Winter 1976-77	Summer 1977
1	07Feb74(-1.3)	N/S	13Nov74(-0.9)	12May75(-0.8)	29Jan76(-1.0)	16Apr76(-1.2)	22Oct76(-0.7)	05May77(-1.4)
2	08Dec73( )	N/S	12Jan75(-0.7)	13Jun75(-0.7)	16Jan76(-1.1)	18Apr76(-0.6)	22Oct76(-0.7)	05May77(-1.4)
3	N/S	23May74(-1.4)	29Jan75(-0.9)	13May75(-0.8)	16Jan76(-1.1)	18Apr76(-0.6)	23Oct76(-1.0)	06May77(-1.2)
4	11Nov73( )	17Aug74(-1.0)	10Jan75(-0.9)	13Jun75(-0.7)	15Jan76(-0.9)	15Jun76(-0.7)	23Oct76(-1.0)	06May77(-1.2)
5	12Nov73( )	22Jun74(-1.4)	29Jan75(-0.9)	13May75(-0.8)	15Jan76(-0.9)	15Jun76(-0.7)	24Oct76(-1.0)	03Jul77(-1.1)
6	19Jan74(-0.4)	22May74(-1.4)	11Jan75(-0.8)	14Jun75(-0.3)	N/S	11Jul76(-1.2)	17Feb77(-0.9)	01Jul77(-1.6)
7	N/S	N/S	28Jan75(-1.3)	16May75(-0.2)	30Dec75(-1.2)	11Jul76(-1.2)	17Jan77(-0.9)	01Jul77(-1.6)
8	N/S	24Jun74(-0.5)	08Feb75(-0.6)	23Jun75(-1.1)	03Nov75(-1.2)	12Jul76(-1.0)	17Jan77(-0.9)	30Jun77(-1.5)
9	N/S	N/S	28Jan75(-1.3)	23Jun75(-1.1)	03Nov75(-1.2)	12Jul76(-1.0)	18Dec76(-1.0)	29Jun77(-1.1)

( ) = Tide Level

Appendix 2. (continued)

Diablo Point Intertidal

Station Number	Winter 1973-74	Summer 1974	Winter 1974-75	Summer 1975	Winter 1975-76	Summer 1976	Winter 1976-77	Summer 1977
1		N/S						
2		N/S						
3		N/S						
4		N/S						
5	07Dec73	N/S	06Feb75(-0.4)	12Jun75(-1.0)	02Nov75(-0.7)	16Jun76(-0.3)	N/S	07May77(-0.8)
6	18Jan74(-0.1)	N/S	14Nov74(-0.9)	26Jun75(-0.5)	02Nov75(-0.7)	28Jun76(-0.7)	N/S	07May77(-0.8)
7	07Dec73	N/S	23Feb75(-1.1)	12Jun75(-1.0)	13Feb76(-0.9)	28Jun76(-0.7)	N/S	01Aug77(-0.6)
8		Sampled twice not included in analysis.						
9		Sampled once not included in analysis.						
10		N/S						

( ) = Tide Level

Appendix 3. Percent Frequency of Occurrence of Algal Species Observed at Random Intertidal 0.25-m^2 Quadrats for Diablo Point, South Diablo Cove, North Diablo Cove, and North Control. DCPP, 1973-1977.

	Survey Period							
Species	Winter 73-74	Summer 1974	Winter 74-75	Summer 1975	Winter 75-76	Summer 1976	Winter 76-77	Summer 1977
<u>GREEN ALGAE</u>								
Cladophora sp.	8.3		0	0	0	0		0
Derbesia marina	0		0	0	0	8.3		0
<u>BROWN ALGAE</u>								
Alaria marginata	8.3		16.7	25.0	0	0		16.7
Analipus japonicus	33.3		0	0	8.3	0		8.3
Egregia menziesii	16.7		33.3	16.7	8.3	8.3		8.3
Egregia sp.	0		0	0	0	0		16.7
Laminaria dentigera	0		0	25.0	0	25.0		25.0
<u>RED ALGAE</u>								
Botryoglossum farlowianum	16.7		0	8.3	0	0		8.3
Callithamnion pikeanum	0		8.3	25.0	8.3	41.7		33.3
Callithamnion rupicolum	0		16.7	0	8.3	8.3		25.0
Callophyllis crenulata	0		0	0	16.7	0		0
Callophyllis firma	0		0	8.3	0	8.3		0
Callophyllis flabellulata	0		0	0	16.7	8.3		0
Callophyllis heanophylla	0		0	0	8.3	0		0
Callophyllis sp.	0		0	25.0	33.3	58.3		8.3
Callophyllis violacea	0		0	8.3	8.3	8.3		50.0
Cryptopleura lobulifera	41.7		0	25.0	41.7	0		33.3
Cryptopleura sp.	25.0		50.0	41.7	41.7	0		33.3

Endocladia muricata	16.7	0	0	8.3	0	16.7
Erythrophyllum delesserioides	8.3	33.3	75.0	33.3	0	91.7
Farlowia mollis	0	8.3	0	0	0	0
Fauchea media	0	0	8.3	0	0	0
Gastroclonium coulteri	8.3	16.7	8.3	16.7	0	16.7
Gelidium coulteri	0	8.3	0	0	0	8.3
Gelidium robustum	8.3	8.3	0	8.3	8.3	0
Gigartina agardhii	16.7	0	0	0	8.3	0
Gigartina canaliculata	16.7	16.7	8.3	0	8.3	8.3
Gigartina corymbifera	0	0	0	0	0	25.0
Gigartina exasperata	41.7	75.0	66.7	91.7	66.7	58.3
Gigartina papillata	16.7	16.7	25.0	25.0	0	16.7
Gigartina sp.	8.3	0	0	0	0	0
Gigartina spinosa	0	0	8.3	0	0	0
Hymenena flabelligera	0	0	0	25.0	0	16.7
Hymenena multiloba	0	0	0	8.3	16.7	8.3
Hymenena sp.	0	0	41.7	41.7	58.3	50.0
Iridaea cordata v. *splendens*	91.7	91.7	91.7	66.7	100.0	100.0
Iridaea lineare	8.3	41.7	25.0	8.3	0	0
Iridaea heterocarpa	0	25.0	16.7	0	8.3	16.7
Iridaea sp.	0	0	0	33.3	0	0
Laurencia gardneri	0	0	0	0	8.3	0
Laurencia spectabilis	41.7	16.7	8.3	8.3	25.0	16.7
Microcladia borealis	58.3	50.0	83.3	25.0	100.0	100.0
Microcladia californica	33.3	0	0	0	0	0
Microcladia coulteri	0	25.0	100.0	91.7	91.7	91.7
Neoptilota densa	8.3	8.3	8.3	0	0	33.3

Neoptilota hypnoides	0		16.7	50.0	8.3	33.3		25.0
Pikea californica	0		0	8.3	0	0		16.7
Plocamium violaceum	33.3		0	0	16.7	8.3		8.3
Polysiphonia hendryi	0		0	0	0	8.3		0
Polysiphonia sp.	0		0	0	0	8.3		0
Porphyra perforata	0		0	8.3	0	0		0
Porphyra sp.	0		8.3	8.3	8.3	41.7		25.0
Prionitis australis	0		8.3	0	0	0		0
Prionitis lanceolata	50.0		91.7	100.0	91.7	83.3		91.7
Prionitis lyallii	0		0	8.3	0	0		0
Pterosiphonia dendroidea	0		0	0	0	8.3		0
Rhodoglossum parvum	8.3		16.7	0	8.3	0		50.0
Rhodomela larix	0		0	8.3	0	0		0
Rhodymenia callophyllidoides	0		0	8.3	0	0		0
Rhodymenia californica	0		0	0	8.3	0		8.3
Rhodymenia pacifica	16.7		0	0	0	0		25.0
Rhodymenia sp.	0		8.3	0	0	0		0
Schizymenia pacifica	0		0	0	0	8.3		8.3
Unidentified red algae	0		25.0	25.0	8.3	0		0
NUMBER OF QUADRATS SAMPLED	12	N/S	12	12	12	12	N/S	12

Appendix 3. (continued)

South Diablo Cove Intertidal

Species	Survey Period Winter 73-74	Summer 1974	Winter 74-75	Summer 1975	Winter 75-76	Summer 1976	Winter 76-77	Summer 1977
GREEN ALGAE								
Bryopsis hypnoides	0	0	5.6	2.8	0	0	0	0
Cladophora graminea	0	0	0	0	0	2.8	2.8	0
Cladophora sp.	0	5.0	0	2.8	0	0	0	0
Derbesia marina	0	0	0	25.0	9.7	19.4	16.7	2.8
Spongomorpha coalita	0	5.0	0	13.9	0	25.0	11.1	30.6
Spongomorpha sp.	0	0	0	27.8	0	0	0	0
Ulva sp.	25.0	20.0	19.4	52.8	9.7	63.9	72.2	66.7
Unidentified green algae	0	0	0	0	0	0	2.8	0
BROWN ALGAE								
Analipus japonicus	0	0	5.6	0	0	5.6	0	0
Colpomenia sp.	0	0	0	2.8	0	0	0	0
Cystoseira osmundacea	0	0	5.6	0	3.1	0	0	5.6
Cystoseira sp.	0	5.0	0	0	0	0	0	0
Egregia menziesii	5.0	0	2.8	0	9.4	2.8	2.8	0
Laminaria dentigera	5.0	0	5.6	2.8	0	0	0	11.1
Pterogophora sp.	0	5.0	0	0	0	0	0	0
Ralfsia sp.	0	0	2.8	0	0	0	0	0
RED ALGAE								
Amplisiphonia pacifica	0	0	0	0	3.2	0	0	0
Antithamnion uncinatum	0	0	0	0	0	8.3	0	0

Gelidium robustum	10.0	5.0	11.1	0	0	0	0	0
Gelidium sp.	5.0	15.0	2.8	0	0	0	0	0
Gigartina agardhii	0	10.0	0	0	0	2.8	0	0
Gigartina canaliculata	60.0	65.0	66.7	55.6	48.4	80.6	86.1	80.6
Gigartina corymbifera	0	0	0	0	0	0	0	5.6
Gigartina exasperata	20.0	35.0	22.2	11.1	9.7	8.3	11.1	19.4
Gigartina leptorhynchus	0	10.0	2.8	5.6	0	13.9	11.1	5.6
Gigartina papillata	55.0	55.0	44.4	52.9	19.4	58.3	63.9	27.8
Gigartina spinosa	0	0	2.8	2.8	0	8.3	2.8	5.6
Gigartina volans	0	0	0	0	0	0	8.3	0
Gigartina sp.	10.0	0	2.8	2.8	3.2	0	0	0
Gloisiphonia capillaris	5.0	0	0	0	0	8.3	0	0
Grateloupia doryphora	5.0	0	2.8	2.8	0	2.8	0	19.4
Grateloupia setchellii	10.0	0	0	0	0	0	0	0
Griffithsia pacifica	0	0	0	0	0	0	0	2.8
Gymnogongrus lingaris	0	0	0	0	0	0	0	5.6
Halosaccion glandiforme	0	0	0	0	0	30.6	0	2.8
Halymenia schizymenoides	0	0	0	0	0	0	2.8	0
Halymenia sp.	0	0	0	0	0	0	0	2.8
Herposiphonia verticiliata	0	0	0	0	0	0	2.8	0
Hollenbergia subulata	0	0	2.8	0	0	0	0	0
Hymenena flabelligera	5.0	15.0	0	0	0	2.8	0	19.4
Hymenena sp.	0	5.0	2.8	2.8	6.5	19.4	19.4	22.2
Iridaea cordata v. *splendens*	70.0	60.0	77.8	30.6	38.7	77.8	66.7	83.3
Iridaea flaccida	0	5.0	0	2.8	3.2	0	0	0
Iridaea heterocarpa	30.0	20.0	8.3	33.3	6.5	66.7	13.9	38.9
Iridaea sp.	0	0	0	22.2	3.2	0	0	0

Antithamnion sp.	0	0	0	5.6	0	0	0	0
Botryoglossum farlowianum	50.0	45.0	2.8	0	0	0	2.8	0
Callithamnion pikeanum	0	5.0	5.6	11.1	0	22.2	5.6	2.8
Callithamnion rupicolum	0	5.0	2.8	0	0	0	2.8	2.8
Callophyllis flabellulata	0	0	0	0	0	0	0	5.6
Callophyllis violacea	10.0	0	0	0	0	0	0	5.6
Callophyllis sp.	5.0	10.0	0	0	9.7	8.3	8.3	0
Ceramium eatonianum	0	0	0	2.8	3.2	13.9	2.8	11.1
Ceramium gardneri	0	5.0	0	2.8	0	0	0	0
Ceramium pacificum	0	0	0	0	0	5.6	0	0
Ceramium sp.	0	0	0	0	0	2.8	0	0
Chondria deciprens	0	0	0	0	0	2.8	16.7	0
Cryptopleura corallinaria	0	0	0	0	0	0	13.9	0
Cryptopleura lobulifera	15.0	5.0	0	0	0	0	5.6	11.1
Cryptopleura violacea	5.0	35.0	2.8	2.8	0	0	5.6	38.9
Cryptopleura sp.	15.0	25.0	50.0	22.2	38.7	41.7	27.8	13.9
Cryptosiphonia woodii	0	0	0	2.8	0	0	0	0
Endocladia muricata	5.0	10.0	2.8	16.7	0	11.1	27.8	5.6
Farlowia compressa	5.0	0	0	2.8	0	2.8	2.8	8.3
Farlowia mollis	5.0	5.0	2.8	8.3	3.2	33.3	5.6	0
Farlowia sp.	0	5.0	0	0	0	0	0	0
Fauchea media	15.0	0	2.8	0	0	0	5.6	0
Gastroclonium coulteri	70.0	55.0	66.7	75.0	51.6	75.0	66.7	52.8
Gelidium arborescens	0	0	0	0	0	0	2.8	0
Gelidium coulteri	10.0	10.0	27.8	27.8	12.9	63.9	50.0	16.7
Gelidium purpurascens	0	10.0	0	0	0	5.6	13.9	16.7
Gelidium pusillum	0	0	2.8	2.8	2.8	0	5.6	0

Laurencia blinksii	0	0	0	0	0	2.8	0	0
Laurencia spectabilis	70.0	45.0	13.9	25.0	22.6	11.1	22.2	27.8
Laurencia sp.	0	0	0	0	0	2.8	0	0
Microcladia borealis	0	0	0	8.3	0	11.1	0	0
Microcladia coulteri	65.0	60.0	58.3	80.6	58.1	83.3	72.2	100.0
Neoagardhiella baileyi	20.0	50.0	30.6	16.7	9.7	27.8	16.7	58.3
Neoptilota densa	0	0	2.8	5.6	2.8	0	5.6	8.3
Neoptilota hypnoides	0	0	0	8.3	0	0	0	2.8
Odanthalia floccosa	0	5.0	0	0	0	0	0	0
Pikea californica	0	0	0	0	0	0	0	8.3
Pikea pinnata	0	0	0	0	0	0	2.8	0
Plocamium cartilagineum	0	10.0	0	0	6.5	0	0	0
Polyneura latissima	0	0	0	2.8	0	8.3	2.8	5.6
Polysiphonia collinsii	0	0	0	0	0	2.8	0	0
Polysiphonia hendryi	5.0	0	0	5.6	0	8.3	8.3	0
Polysiphonia pacifica	0	0	0	0	0	0	0	2.8
Polysiphonia sp.	0	0	0	0	0	2.8	0	0
Porphyra sp.	0	5.0	0	0	0	11.1	0	2.8
Prionitis andersonii	5.0	0	27.8	11.1	3.2	2.8	0	0
Prionitis lanceolata	85.0	65.0	91.6	77.8	90.3	69.4	80.6	75.0
Prionitis lyallii	0	0	2.8	2.8	0	11.1	8.3	38.9
Prionitis sp.	0	0	0	0	0	0	0	2.8
Pseudogloiophloea confusa	0	0	0	2.8	0	0	0	0
Pterocladia cologlossoides	0	0	0	0	3.2	0	0	0
Pterosiphonia dendroidea	0	0	0	0	0	5.6	0	13.9
Ptilota sp.	0	0	0	2.8	0	0	0	0
Rhodoglossum affine	0	5.0	30.6	2.8	0	0	19.4	8.3

Rhodoglossum parvum	0	0	8.3	25.0	48.4	69.4	72.2	63.9
Rhodoglossum sp.	0	0	0	0	0	8.3	0	0
Rhodomela larix	25.0	20.0	5.6	25.0	0	30.6	11.1	2.8
Rhodymenia pacifica	0	0	0	2.8	0	0	0	5.6
Rhodymenia rhizoides	0	0	0	0	0	0	2.8	0
Rhodymenia sp.	0	0	0	2.8	3.2	8.3	0	0
Schizymenia pacifica	0	5.0	13.9	19.4	0	16.7	11.1	30.6
Schizymenia sp.	5.0	0	0	0	6.5	0	0	0
Smithora naiadum	0	30.0	0	0	0	0	0	0
Unidentified red algae	45.0	10.0	16.7	13.9	6.5	2.8	5.6	2.8

Appendix 3. (continued)

North Diablo Cove Intertidal

Species	Survey Period							
	Winter 73-74	Summer 1974	Winter 74-75	Summer 1975	Winter 75-76	Summer 1976	Winter 76-77	Summer 1977
GREEN ALGAE								
Bryopsis hypnoides	0	0	3.1	2.8	0	0	0	0
Cladophora graminea	0	0	0	0	0	2.8	0	0
Cladophora sp.	5.6	5.0	0	0	0	0	2.8	0
Codium setchellii	0	0	3.1	0	0	0	0	0
Derbesia marina	0	0	0	22.2	26.5	16.7	8.3	5.6
Spongomorpha coalita	0	5.0	0	0	8.8	22.2	0	2.8
Spongomorpha sp.	0	0	0	8.3	0	0	0	0
Ulva sp.	11.1	15.0	12.5	22.2	38.2	52.8	16.7	16.7
BROWN ALGAE								
Egregia menziesii	0	0	3.1	5.6	5.7	25.0	11.1	11.1
Dictyoneurum sp.	0	0	0	0	0	2.8	0	0
Laminaria dentigera	0	0	0	0	0	11.1	2.8	5.6
Ralfsia sp.	0	0	0	0	2.9	0	0	0
RED ALGAE								
Antithamnion sp.	0	10.0	3.1	0	0	0	0	0
Botryoglossum farlowianum	55.6	25.0	6.2	8.3	2.9	8.3	11.1	25.0
Botryoglossum sp.	0	0	0	0	0	0	2.8	0
Callithamnion biseriatum	0	0	0	0	8.8	0	0	0
Callithamnion pikeanum	11.1	50.0	15.6	50.0	35.3	50.0	16.7	13.9
Callithamnion rupicolum	0	0	18.8	27.8	17.7	22.2	22.2	11.1
Callithamnion sp.	0	10.0	0	0	0	0	0	2.8

Callophyllis firma	0	0	0	0	0	5.6	0	0
Callophyllis flabellulata	0	0	0	0	0	0	2.8	5.6
Callophyllis heanophylla	0	0	0	0	0	0	5.6	0
Callophyllis obtusifolia	0	0	0	2.8	0	2.8	0	0
Callophyllis pinnata	0	0	0	0	2.9	0	0	2.8
Callophyllis violacea	0	0	0	36.1	14.7	25.0	13.9	58.3
Callophyllis sp.	11.1	15.0	6.2	8.3	20.6	16.7	19.4	5.6
Centrocerus clavulatum	0	0	0	0	0	2.8	0	0
Ceramium eatonianum	0	30.0	3.1	19.4	5.8	19.4	11.1	8.3
Ceramium gardneri	0	15.0	3.1	8.3	17.7	0	0	0
Ceramium sp.	0	0	0	5.6	0	0	0	0
Cryptonemia obovata	0	0	0	2.8	0	0	0	0
Cryptopleura corallinaria	0	0	0	0	0	0	38.9	13.9
Cryptopleura lobulifera	22.2	35.0	0	47.2	32.4	8.3	30.6	58.3
Cryptopleura violacea	0	5.0	0	0	2.9	2.8	8.3	38.9
Cryptopleura sp.	27.8	6.0	75.0	58.3	67.7	50.0	66.7	11.1
Endocladia muricata	11.1	10.0	0	8.3	2.9	19.4	13.9	8.3
Erythroglossum californicum	0	0	0	2.8	0	0	0	0
Erythrophyllum delesserioides	5.6	0	6.2	11.1	0	13.9	2.8	5.6
Farlowia compressa	0	0	0	0	2.9	5.6	0	5.6
Farlowia mollis	5.6	0	6.2	2.8	0	0	0	0
Farlowia sp.	0	0	0	0	0	0	0	0
Fauchea media	5.6	0	0	0	0	0	0	0
Gastroclonium coulteri	50.0	65.0	53.1	55.6	73.5	33.3	72.2	66.7
Gelidium coulteri	0	5.0	15.6	30.6	11.8	27.8	38.9	19.4
Gelidium purpurascens	0	0	0	0	8.8	2.8	2.8	5.6
Gelidium pusillum	0	0	0	2.8	0	0	5.6	2.8

Gelidium robustum	0	20.0	28.1	0	2.9	0	5.6	0
Gigartina agardhii	0	0	0	0	2.9	0	5.6	0
Gigartina boryi	0	0	0	0	0	0	2.8	0
Gigartina canaliculata	44.4	75.0	75.0	66.7	85.3	66.7	83.3	77.8
Gigartina corymbifera	0	0	0	0	0	2.8	0	16.7
Gigartina exasperata	38.9	20.0	15.6	16.7	38.2	47.2	47.2	33.3
Gigartina harveyana	0	0	0	5.6	0	0	2.8	0
Gigartina leptorhynchus	0	0	6.2	0	0	0	5.6	0
Gigartina papillata	11.1	30.0	34.3	27.8	35.3	19.4	30.6	30.6
Gigartina spinosa	5.6	0	0	2.8	0	0	5.6	5.6
Gigartina volans	0	0	0	0	0	0	2.8	0
Gloiosiphonia capillaris	0	0	0	0	2.9	0	0	0
Gonimophyllum skottsbergii	5.6	0	0	0	0	0	0	0
Grateloupia doryphora	0	0	0	0	0	22.2	0	11.1
Grateloupia setchellii	5.6	0	0	0	0	0	5.6	0
Gymnogongrus leptophyllus	0	0	0	0	0	0	2.8	0
Halosaccion glandiforme	5.6	25.0	12.5	13.9	14.7	16.7	19.4	2.8
Halymenia californica	0	0	0	2.8	2.9	8.3	0	0
Herposiphonia verticiliata	0	5.0	0	2.8	0	0	5.6	0
Hymenena cuneifolia	0	0	0	0	0	0	0	2.8
Hymenena flabelligera	0	0	0	5.6	5.8	0	5.6	38.9
Hymenena kylinii	0	0	0	0	0	0	2.8	0
Hymenena multiloba	0	0	0	0	0	2.8	0	0
Hymenena sp.	0	0	31.2	27.8	23.5	66.7	44.4	27.8
Iridaea cordata v. *splendens*	77.8	45.0	71.9	41.7	88.2	91.6	91.6	86.1
Iridaea flaccida	0	20.0	0	8.3	0	0	0	0
Iridaea heterocarpa	22.2	5.0	25.0	50.0	61.8	75.0	30.6	19.4

Iridaea sp.	0	0	6.2	27.8	8.8	2.8	0	0
Laurencia blinksii	0	0	0	0	8.8	0	0	0
Laurencia spectabilis	38.9	10.0	43.8	30.6	47.1	30.6	75.0	61.1
Laurencia sp.	0	0	0	2.8	0	0	0	0
Microcladia borealis	5.6	55.0	3.1	30.6	5.8	25.0	2.8	13.9
Microcladia coulteri	55.6	85.0	56.2	75.0	67.7	94.4	88.9	100.0
Neoagardhiella baileyi	27.8	15.0	18.8	16.7	17.7	41.7	30.6	41.7
Neoptilota densa	0	0	3.1	0	0	0	0	0
Neoptilota hypnoides	0	0	0	2.8	0	2.8	0	0
Plenosporium squarrulosum	0	0	0	5.6	0	0	0	0
Plocamium cartilagineum	0	5.0	0	0	0	0	0	0
Plocamium violaceum	0	0	0	0	0	8.3	0	0
Plocamium sp.	0	5.0	0	0	0	0	0	0
Polyneura latissima	0	0	0	5.6	0	0	0	2.8
Polysiphonia hendryi	0	0	3.1	2.8	8.8	0	0	2.8
Polysiphonia pacifica	0	0	0	2.8	0	0	2.8	2.8
Polysiphonia paniculata	0	5.0	0	5.6	2.9	0	0	0
Porphyra sp.	0	5.0	0	2.8	0	2.8	2.8	8.3
Prioritis andersonii	0	0	0	2.8	0	0	2.8	0
Prionitis lanceolata	88.9	45.0	71.9	69.4	73.5	91.7	86.1	91.6
Prionitis lyallii	0	0	0	0	0	0	8.3	2.8
Prionitis sp.	0	0	0	0	0	0	0	2.8
Pterosiphonia dendroidea	0	0	0	0	0	0	0	5.6
Rhodoglossum affine	0	0	31.2	0	5.8	0	2.8	5.6
Rhodoglossum parvum	5.6	0	15.6	13.9	76.5	0	83.3	55.6
Rhodoglossum sp.	0	0	3.1	0	2.9	0	0	5.6

Rhodymenia californica	0	0	0	2.8	0	2.8	0	0
Rhodymenia lobulifera	0	0	0	2.8	0	0	0	0
Rhodymenia pacifica	0	0	0	2.8	0	2.8	0	5.6
Rhodymenia sp.	0	0	0	2.8	2.9	0	8.3	0
Schizymenia epiphytica	0	0	0	2.8	0	0	0	0
Schizymenia pacifica	5.6	0	0	2.8	29.4	27.8	13.9	11.1
Schizymenia sp.	0	0	0	5.6	0	0	0	0
Unidentified red algae	11.1	5.0	12.5	11.1	2.9	11.1	2.8	0
UNIDENTIFIED ALGAE	0	5.0	0	0	0	0	0	0

Appendix 3. (continued)

North Control Intertidal

Species	Winter 73-74	Summer 1974	Winter 74-75	Summer 1975	Winter 75-76	Summer 1976	Winter 76-77	Summer 1977
GREEN ALGAE								
Cladophora graminea			0	0	0	0	2.8	0
Codium sp.	0		2.8	0	0	0	5.6	0
Derbesia marina			3.1	0	0	17.5	0	5.0
Spongomorpha coalita			0	0	0	5.0	0	0
Ulva sp.			0	2.8	5.0	10.0	2.8	2.5
BROWN ALGAE								
Dictyoneurum californianum	0		0	0	2.5	0	0	2.5
Egregia menziesii	5.6		0	0	0	5.0	2.8	7.5
Laminaria dentigera	0		0	0	0	2.5	2.8	5.0
Laminaria sp.	0		0	0	2.5	0	0	0
RED ALGAE								
Arcrochaetium spp.			0	0	2.5	0	0	0
Baylesia plumosa			0	0	0	0	5.6	0
Botryoglossum farlowianum			18.8	8.3	35.0	7.5	16.7	20.0
Callithamnion pikeanum			18.8	44.4	10.0	45.0	13.1	17.5
Callithamnion rupicolum			6.2	5.6	0	12.5	2.8	10.0
Callithamnion sp.			0	2.8	0	0	0	0
Callophyllis firma			3.1	0	0	2.5	8.3	7.5
Callophyllis flabellulata			0	0	0	0	5.6	2.5
Callophyllis heanophylla			0	0	2.5	0	2.8	0

Callophyllis obtusifolia	3.1	0	0	0	0	0
Callophyllis pinnata	0	0	2.5	0	0	2.5
Callophyllis violacea	6.2	8.3	0	7.5	5.6	32.5
Callophyllis sp.	0	8.3	12.5	22.5	22.2	7.5
Ceramium eatonianum	3.1	5.6	0	5.0	0	40.0
Cryptopleura corallinaria	0	0	0	0	5.6	0
Cryptopleura lobulifera	9.4	13.9	7.5	5.0	16.7	10.0
Cryptopleura violacea	0	2.8	0	2.5	0	7.5
Cryptopleura sp.	21.9	52.7	17.5	60.0	41.7	0
Endocladia muricata	0	11.1	0	10.0	5.6	25.0
Erythrophyllum delesserioides	0	2.8	2.5	5.0	0	7.5
Farlowia compressa	0	0	2.5	0	0	7.5
Farlowia mollis	0	0	0	5.0	0	0
Gastroclonium coulteri	34.3	44.4	17.5	37.5	41.7	25.0
Gelidium coulteri	9.4	22.2	7.5	22.5	16.7	12.5
Gelidium purpurascens	0	0	5.0	2.5	2.8	2.5
Gelidium pusillum	0	0	2.5	2.5	0	2.5
Gelidium robustum	15.6	0	7.5	0	0	5.0
Gigartina agardhii	0	0	10.0	2.5	5.6	5.0
Gigartina boryi	0	0	0	0	2.8	0
Gigartina canaliculata	53.1	55.6	27.5	65.0	66.7	52.5
Gigartina corymbifera	0	0	0	0	0	10.0
Gigartina exasperata	28.1	11.1	17.5	27.5	25.0	40.0
Gigartina leptorhynchus	0	0	2.5	0	2.8	0
Gigartina papillata	53.1	57.8	25.0	57.5	5.6	45.0
Gigartina spinosa	0	0	0	5.0	0	0
Gigartina volans	0	0	2.5	0	0	2.5

Gigartina sp.	0	2.8	0	0	0	2.5
Grateloupia doryphora	0	0	0	0	5.6	0
Grateloupia setchellii	0	0	0	0	0	2.5
Gymnogongrus leptophyllis	0	0	0	0	0	2.5
Gymnogongrus lingaris	0	0	0	0	0	5.0
Halosaccion glandiforme	3.1	5.6	0	10.0	0	0
Halymenia californica	0	0	0	2.5	0	0
Hymenena cuneifolia	0	0	0	0	0	2.5
Hymenena flabelligera	0	8.3	10.0	2.5	0	2.5
Hymenena sp.	34.3	22.2	20.0	40.0	36.1	62.5
Iridaea cordata v. *splendens*	96.8	88.9	50.0	95.0	86.1	92.5
Iridaea flaccida	0	2.8	0	0	0	0
Iridaea heterocarpa	6.2	41.6	7.5	62.5	38.9	17.5
Iridaea lineare	0	0	0	2.5	0	2.5
Iridaea sp.	0	0	22.5	0	0	0
Laurencia spectabilis	31.2	25.0	27.5	27.5	25.0	37.5
Microcladia borealis	3.1	11.1	2.5	10.0	0	2.5
Microcladia coulteri	56.2	44.4	32.5	60.0	44.4	70.0
Microcladia sp.	0	0	2.5	0	0	0
Neoagardhiella baileyi	21.9	13.9	2.5	20.0	16.7	30.0
Neoptilota densa	0	8.3	2.5	5.0	0	10.0
Neoptilota hypnoides	0	2.8	0	2.5	0	5.0
Odonthalia floccosa	0	0	0	2.5	0	2.5
Pikea californica	0	0	0	0	2.8	20.0
Plenosporium squarrulosum	0	2.8	0	0	0	0
Plocamium cartilagineum	0	2.8	0	7.5	0	2.5
Plocamium violaceum	3.1	2.8	0	5.0	0	7.5

Plocamium sp.	0	2.8	0	0	0	0
Polyneura latissima	0	0	0	0	2.8	10.0
Polysiphonia brodiaei	0	0	0	2.5	0	0
Polysiphonia hendryi	0	0	0	0	0	2.5
Polysiphonia sp.	0	0	0	0	0	2.5
Porphyra sp.	3.1	8.3	0	17.5	2.8	15.0
Prionitis australis	0	0	2.5	0	0	0
Prionitis andersonii	6.2	0	0	2.5	0	0
Prionitis lanceolata	84.4	50.0	55.0	55.0	61.1	72.5
Prionitis linearis	0	2.8	0	0	0	0
Prionitis lyallii	0	0	0	0	0	2.5
Prionitis sp.	0	0	10.0	0	0	2.5
Pterochondria woodii	3.1	0	0	0	2.8	0
Rhodoglossum affine	40.6	2.8	0	0	2.8	5.0
Rhodoglossum parvum	12.5	19.4	27.5	70.0	50.0	52.5
Rhodoglossum sp.	0	0	0	0	25.0	5.0
Rhodymenia californica	0	8.3	5.0	0	8.3	2.5
Rhodymenia lobulifera	0	0	0	2.5	0	0
Rhodymenia pacifica	3.1	0	0	0	2.8	15.0
Rhodymenia sp.	0	0	0	2.5	2.8	2.5
Schizymenia epiphytica	0	2.8	0	0	0	0
Schizymenia pacifica	6.2	0	2.5	20.0	2.8	10.0
Undientified red algae	18.8	8.3	5.0	17.5	0	0

Appendix 4. Percent Frequency of Occurrence of Fish and Invertebrate Species Observed at Random Intertidal 0.25-m^2 Quadrats for Diablo Point, South Diablo Cove, North Diablo Cove, and North Control. DCPP, 1973-1977.

Diablo Point Intertidal

Species	Survey Period Winter 73-74	Summer 1974	Winter 74-75	Summer 1975	Winter 75-76	Summer 1976	Winter 76-77	Summer 1977
FISH								
Oligocottus snyderi	0		0	0	0	8.3		0
INVERTEBRATES								
Acmaea sp.	50.0		8.3	8.3	33.3	16.7		50.0
Aglaophenia sp.	8.3		0	0	8.3	0		0
Aldisa sanguinea	8.3		0	0	0	0		0
Allopora porphyra	0		0	16.7	25.0	0		0
Allopora sp.	0		0	8.3	0	0		0
Amphissa sp.	0		0	0	16.7	0		0
Anthopleura elegantissima	8.3		16.7	25.0	8.3	25.0		33.3
Anthopleura xanthogrammica	58.3		16.7	25.0	16.7	16.7		16.7
Aplidium sp.	0		0	0	25.0	0		0
Balanophyllia elegans	0		0	0	0	0		8.3
Balanus tintinnabulum	0		50.0	16.7	8.3	16.7		0
Balanus sp.	66.7		33.3	16.7	16.7	16.7		91.7
Bittium sp.	0		0	0	0	0		8.3
Cadlina luteomarginata	8.3		0	0	0	0		0
Calliostoma ligatum	0		33.3	0	41.7	25.0		50.0
Calliostoma sp.	0		0	0	0	0		8.3
Cancer antennarius	0		0	41.7	41.7	33.0		58.3
Cancer sp.	0		0	0	8.3	0		0
Clavelina huntsmani	0		0	8.3	8.3	0		0
Corynactis californica	16.7		25.0	50.0	41.7	33.3		33.3
Coryphella fisheri	0		8.3	0	0	0		0
Crisia sp.	0		0	0	0	16.7		25.0
Cyanoplax dentiens	0		0	0	0	8.3		0
Diaulula sandiegensis	0		0	0	0	0		8.3
Doriopsilla albopunctata	8.3		0	0	0	0		0

Epiactis prolifera	25.0	25.0	41.7	50.0	50.0	58.3
Eurystomella bilabiata	0	0	0	66.7	16.7	16.7
Fissurella volcano	16.7	8.3	16.7	16.7	16.7	41.7
Flustrella corniculata	0	0	0	8.3	0	0
Haliotis cracherodii	58.3	50.0	16.7	41.7	50.0	50.0
Haliotis kamtschatkana	0	0	0	0	8.3	0
Haliotis rufescens	0	0	0	16.7	0	8.3
Henricia leviuscula	8.3	50.0	41.7	50.0	33.3	41.7
Hippodiplosia insculpta	0	0	0	8.3	0	0
Homalopoma luridum	0	16.7	0	0	0	0
Idotea sp.	8.3	0	8.3	0	0	8.3
Katharina tunicata	16.7	0	0	0	0	0
Leptasterias spp.	50.0	75.0	41.7	66.7	58.3	91.7
Leucilla nuttingi	8.3	8.3	8.3	0	0	0
Mopalia spp.	33.3	16.7	0	33.3	25.0	8.3
Mytilus californianus	50.0	8.3	33.3	33.3	33.3	16.7
Nereis sp.	8.3	0	0	0	0	0
Nucella emarginata	8.3	8.3	16.7	0	0	0
Nuttallina californica	16.7	0	0	8.3	8.3	8.3
Pachycheles sp.	0	0	0	25.0	0	0
Pagurus granosimanus	0	0	0	0	8.3	0
Pagurus sp.	0	0	16.7	33.3	16.7	25.0
Petrolisthes cinctipes	0	0	0	0	8.3	0
Pisaster ochraceus	16.7	16.7	16.7	25.0	0	16.7
Pista sp.	0	0	0	0	0	8.3
Pododesmus cepio	0	16.7	0	16.7	8.3	0
Pollicipes polymerus	8.3	16.7	8.3	0	8.3	16.7
Pugettia gracilis	0	8.3	8.3	0	8.3	0
Pugettia producta	25.0	33.3	50.0	50.0	50.0	75.0
Pugettia richii	0	0	0	8.3	0	33.3
Pyrura haustor	0	0	0	8.3	0	0
Rostanga pulchra	0	0	0	0	0	8.3
Serpulidae	0	0	8.3	33.3	16.7	25.0
Serpulorbis squamigerus	25.0	66.7	75.0	66.7	33.3	66.7
Sertutarella sp.	0	0	0	0	16.7	0
Stronglocentrotus purpuratus	50.0	41.7	16.7	75.0	91.7	91.7

Styela montereyensis	0	0	16.7	0	8.3	0
Tegula brunnea	66.7	83.3	75.0	75.0	58.3	75.0
Tetraclita squamosa rubescens	0	0	0	8.3	8.3	8.3
Tetraclita sp.	25.0	0	0	0	0	0
Tonicella lineata	25.0	16.7	25.0	33.3	25.0	41.7
Triopha catlinae	0	0	0	8.3	0	0
Triopha maculata	0	0	0	0	0	8.3
Tubularia sp.	0	0	0	8.3	16.7	0
Unidentified anemone	0	0	0	8.3	0	0
Unidentified barnacle	0	0	0	0	8.3	0
Unidentified chiton	0	0	0	0	0	8.3
Unidentified ectoprocta	8.3	0	0	0	0	0
Unidentified hydroids	0	8.3	0	0	0	0
Unidentified pholads	0	0	0	8.3	0	8.3
Unidentified sponge	25.0	0	8.3	16.7	16.7	41.7
Unidentified tunicate	0	8.3	41.7	41.7	58.3	66.7

Appendix 4. (continued)

South Diablo Intertidal

	Sampling Period							
Species	Summer 73-74	Winter 1974	Summer 74-75	Winter 1975	Summer 75-76	Winter 1976	Summer 76-77	Winter 1977
INVERTEBRATES								
Acmaea sp.	3.0	20.0	25.0	16.7	18.8	22.2	2.8	27.8
Aeolidia papillosa	0	0	0	0	0	0	0	2.8
Amphissa sp.	0		0	0	2.8	0	2.8	16.7
Anisidoris nobilis	0	0	0	0	2.8	0	0	0
Anthopleura elegantissima	0	0	0	8.3	9.4	11.1	5.6	2.8
Anthopleura xanthogrammica	15.0	10.0	11.1	0	6.2	2.8	16.7	2.8
Astraea gibberosa	10.0	10.0	2.8	8.3	6.2	0	5.6	5.6
Balanus sp.	0	0	2.8	0	3.1	5.6	0	0
Bittium sp.	0	0	0	0	0	2.8	25.0	61.1
Cactosoma arenaria	0	0	0	0	0	0	5.6	22.2
Calliostoma ligatum	0	0	0	0	0	2.8	0	2.8
Cancer antennarius	5.0	10.0	5.6	8.3	18.8	22.2	22.2	36.1
Cancer jordani	0	0	0	2.8	6.2	0	5.6	25.0
Cancer productus	0	0	0	0	0	5.6	5.6	2.8
Cancer sp.	0	5.0	0	5.6	6.2	0	2.8	2.8
Clavelina huntsmani	5.0	0	2.8	2.8	0	19.4	2.8	36.1
Conus californicus	0	10.0	2.8	5.6	9.4	5.6	0	2.8
Crangon dentipes	0	0	0	0	0	2.8	0	0
Cryptolithodes sitchensis	0	0	0	2.8	0	0	0	0
Cyanoplax dentiens	0	0	0	0	0	0	2.8	2.8
Diopatra sp.	0	0	0	0	6.2	0	0	2.8
Epiactis prolifera	40.0	35.0	33.3	38.9	43.8	38.9	86.1	77.8
Epitonium tinctum	0	0	2.8	0	0	2.8	5.6	5.6
Eupentacta quinquesemita	0	0	0	0	0	2.8	0	0
Eurystomela bilabiata	10.0	0	0	0	9.4	5.6	8.3	2.8
Fissurella volcano	10.0	0	13.9	11.1	3.1	8.3	22.2	5.6
Halcampa decemtentaculata	0	0	0	0	0	2.8	5.6	0
Haliotis cracherodii	15.0	5.0	13.9	75.0	18.8	11.1	19.4	27.8
Haliotis rufescens	10.0	20.0	19.4	75.0	28.1	22.2	27.9	25.0
Haplogaster sp.	0	0	0	0	0	0	2.8	0
Henricia leviuscula	30.0	50.0	25.0	47.2	56.2	63.9	52.8	63.9
Hermissenda crassicornis	0	0	5.6	0	0	0	2.8	0

Homalopoma luridum	0	0	0	0	0	0	2.8	2.8
Idotea sp.	0	5.0	0	0	0	0	0	0
Ischnochiton sp.	0	0	0	0	0	0	0	2.8
Lepidozona mertensii	0	0	0	0	0	2.8	5.6	2.8
Leptasterias spp.	40.0	30.0	22.2	52.8	50.0	69.4	75.0	77.8
Leucosolenia sp.	0	0	0	0	3.1	0	0	0
Lissothuria nutriens	0	0	2.8	0	12.5	0	13.9	5.6
Lophopanopeus bellus	0	0	0	0	0	2.4	2.8	0
Lophopanopeus spp.	0	0	0	0	0	0	2.8	0
Loxorhynchus crispatus	0	0	0	0	6.2	0	2.8	0
Megatebennus bimaculatus	0	0	0	0	3.1	0	0	0
Mimulus foliatus	0	0	0	2.8	0	0	5.6	2.8
Mitra idae	0	0	0	0	0	8.3	0	2.8
Mitrella spp.	0	0	8.3	0	18.8	11.1	33.3	63.9
Mopalia spp.	10.0	5.0	16.7	19.4	3.1	2.8	13.9	5.6
Mytilus californianus	0	5.0	2.8	0	3.1	2.8	2.8	0
Nereis sp.	0	5.0	0	0	0	0	2.8	0
Nucella emarginata	0	5.0	5.6	0	0	2.8	0	0
Nucella spp.	0	0	0	0	0	0	2.8	0
Nuttallina californica	0	0	0	0	0	5.6	0	0
Ocenebra sp.	0	0	0	0	3.1	5.6	22.2	22.2
Pachycheles sp.	0	0	0	0	0	0	2.8	0
Pagurus sp.	0	10.0	11.1	25.0	53.1	33.3	16.7	44.4
Paraxanthias taylori	0	0	0	2.8	0	0	0	0
Patiria miniata	5.0	0	5.6	0	0	0	5.6	5.6
Phidiana nigra	0	5.0	0	0	0	0	2.8	13.9
Pisaster sp.	0	0	2.8	0	0	0	0	0
Pista sp.	20.0	5.0	33.3	47.2	56.2	47.2	50.0	75.0
Pseudomelatoma torosa	0	0	0	0	0	2.8	2.8	11.1
Pugettia gracilis	0	5.0	0	25.0	15.6	27.8	38.9	5.6
Pugettia producta	55.0	40.0	36.1	36.1	37.5	41.7	41.7	52.8
Pugettia richii	5.0	5.0	10.0	2.8	9.4	0	11.1	47.2
Pycnogonida	0	0	0	5.6	0	0	0	0
Pycnogonida helianthoides	0	0	2.8	0	0	0	0	0
Pyura haustor	0	0	0	0	9.4	0	0	0
Rostanga pulchra	0	0	0	0	0	2.8	0	0
Searlesia dira	0	0	0	0	0	0	2.8	0
Serpulidae	0	0	0	0	0	0	0	2.8
Serpulorbis squamigerus	5.0	5.0	0	0	3.1	0	13.9	0
Strongylocentrotus franciscanus	0	0	2.8	0	15.6	2.8	11.1	2.8
Strongylocentrotus purpuratus	5.0	10.0	13.9	13.9	0	16.7	19.4	11.1
Tegula brunnea	40.0	20.0	47.2	33.3	15.6	27.8	30.6	11.1
Tegula funnebralis	5.0	15.0	2.8	0	0	0	8.3	0

Tetraclita squamosa elegans	0	0	0	0	0	0	2.8	0
Tonicella lineata	15.0	0	8.3	11.1	6.2	2.8	2.8	2.8
Triopha catalinae	0	0	0	0	0	0	2.8	0
Triopha maculata	0	0	0	0	0	5.6	0	0
Unidentified anemone	0	0	0	0	0	0	0	2.8
Unidentified chiton	0	10.0	13.9	16.7	3.1	13.9	8.3	5.6
Unidentified crab	0	0	0	3.1	0	0	0	0
Unidentified gastropods	0	0	2.8	2.8	3.1	5.6	2.8	0
Unidentified nudibranch	0	0	0	0	0	2.8	0	0
Unidentified pholads	0	0	0	0	0	2.8	0	0
Unidentified sponge	0	0	0	0	0	0	11.1	5.6
Unidentified tunicate	5.0	0	16.7	75.0	53.1	22.2	44.4	41.7

Appendix 4. (continued)

North Diablo Cove Intertidal

	Survey Period							
Species	Winter 73-74	Summer 1974	Winter 74-75	Summer 1975	Winter 75-76	Summer 1976	Winter 76-77	Summer 1977
FISH								
Anoplarchus purpurescens	0	0	0	0	0	2.8	0	0
Apodichthys flavidus	5.6	0	0	0	0	0	0	0
Sebastes chrysomelas	5.6	0	0	0	0	0	0	0
Xiphister mucosus	0	0	0	0	0	0	5.6	0
INVERTEBRATES								
Acmaea sp.	16.7	20.0	18.8	11.1	34.3	22.2	16.7	13.9
Amphissa sp.	0	0	0	0	2.9	0	16.7	8.3
Anthopleura elegantissima	0	0	6.2	0	0	0	0	2.8
Anthopleura xanthogrammica	0	0	9.4	0	5.7	2.8	0	0
Aplidium sp.	0	0	0	0	0	2.8	0	0
Archidistoma spp.	0	0	0	0	0	0	2.8	0
Astraea gibberosa	11.1	5.0	0	0	2.9	0	0	2.8
Balanus sp.	11.1	0	6.2	8.3	22.9	0	8.3	8.3
Bittium sp.	0	5.0	0	0	0	5.6	41.7	19.4
Cactosoma arenaria	0	0	0	0	0	0	30.6	25.0
Cadlina flavomaculata	0	0	0	0	2.9	0	2.8	0
Cadlina luteomarginata	0	0	0	0	0	0	0	2.8
Calliostoma ligatum	0	0	0	8.3	2.9	0	2.8	2.8
Cancer antennarius	0	5.0	6.2	0	17.1	5.6	36.1	27.8
Cancer jordani	0	5.0	0	2.8	0	0	5.6	11.1
Cancer productus	0	0	0	0	0	0	2.8	0
Cancer sp.	0	0	6.2	0	8.6	5.6	0	0
Chama pellucida	0	0	0	0	0	0	2.8	0
Clavelina huntsmani	11.1	0	0	13.9	5.7	13.9	5.6	44.4
Cryptolithodes sitchensis	0	0	0	2.8	0	0	0	0
Diaulula sandiegensis	0	0	0	0	0	0	2.8	0
Epiactis prolifera	50.0	10.0	25.0	58.3	57.1	52.8	63.9	66.1
Epitonium tinctum	0	0	0	0	0	0	2.8	0
Eurystomella bilabiata	0	0	3.1	0	5.7	19.4	27.8	16.7
Fissurella volcano	22.2	25.0	40.6	38.9	57.1	22.2	61.1	36.1
Haliotis cracherodii	38.9	30.0	53.1	58.3	48.6	52.8	58.3	50.0
Haliotis rufescens	33.3	30.0	25.0	38.9	34.3	30.6	41.7	38.9
Henricia leviuscula	27.8	20.0	9.4	52.8	62.9	55.6	69.4	83.3

Hermissenda crassicornis	0	0	0	0	0	0	2.8	0
Homalopoma luridum	0	0	9.4	2.8	0	2.8	2.8	16.7
Hopkinsia rosacea	0	0	0	0	0	0	0	2.8
Idotea sp.	5.6	0	0	0	0	0	2.8	0
Ischnochiton regularis	0	0	0	0	0	0	0	2.8
Ischnochiton sp.	0	0	0	0	2.9	0	0	0
Lamellaria sp.	0	0	0	0	0	2.8	0	0
Lepidozona mertensii	0	0	0	0	0	0	0	2.8
Leptasterias spp.	22.2	30.0	12.5	52.8	45.7	50.0	69.4	77.8
Leucandra heathi	0	0	0	0	0	0	5.6	0
Leucilla nuttingi	0	0	0	0	0	0	0	2.8
Leucosolenia sp.	0	0	0	0	0	2.8	0	0
Lissothuria nutriens	0	0	0	0	5.7	5.6	30.6	19.4
Lophopanopeus bellus	0	0	0	0	0	0	5.6	8.3
Lophopanopeus leucomanus heathii	0	0	0	0	0	2.8	0	0
Lophopanopeus spp.	0	0	0	0	0	0	2.8	0
Megatebennus bimaculatus	0	0	0	2.8	0	0	5.6	0
Mimulus foliatus	0	0	0	0	0	0	5.6	5.6
Mitrella sp.	0	0	3.1	0	5.7	25.0	44.4	44.4
Mopalia spp.	0	5.0	6.2	5.6	20.0	5.6	11.1	2.8
Mytilus californianus	0	5.0	15.6	5.6	5.7	2.8	2.8	0
Nucella emarginata	5.6	0	0	5.6	0	0	0	0
Nucella spp.	0	0	0	0	0	0	2.8	0
Nuttallina californica	5.6	10.0	0	2.8	0	0	2.8	0
Ocenebra sp.	0	0	0	0	0	0	16.7	16.7
Pachycheles rudis	0	0	0	0	2.9	0	0	0
Pachycheles sp.	0	0	0	0	0	0	2.8	2.8
Pagurus spp.	0	5.0	12.5	13.9	48.6	33.3	36.1	41.7
Patiria miniata	5.6	5.0	9.4	0	2.9	5.6	2.8	2.8
Phidiana nigra	0	0	0	0	0	0	0	2.8
Pisaster ochraceus	0	0	0	0	2.9	0	0	0
Pista sp.	0	0	0	25.0	8.6	22.2	41.7	30.6
Pseudomelatoma torosa	0	0	0	0	0	0	0	2.8
Pugettia gracilis	0	0	3.1	36.1	2.9	36.1	13.9	11.1
Pugettia producta	44.4	45.0	34.3	72.2	45.7	44.4	61.1	50.0
Pugettia richii	5.6	0	3.1	2.8	5.7	0	0	25.0
Pycnopodia helianthoides	5.6	0	0	0	0	0	2.8	0
Pyura haustor	0	0	0	0	5.7	8.3	0	0
Rostanga pulchra	0	0	0	0	0	0	2.8	0
Sabellid polychaetes	0	0	3.1	0	0	0	0	0
Serpula vermicularis	0	0	0	0	0	0	0	2.8
Serpulorbis squamigerus	0	0	0	8.3	8.6	2.8	5.6	2.8
Strongylocentrotus franciscanus	0	0	0	0	5.7	0	13.9	8.3

Strongylocentrotus purpuratus	11.1	10.0	6.2	16.7	45.7	30.6	13.9	11.1
Syoclum parfustis	0	0	0	0	0	8.3	0	0
Tegula brunnea	44.4	40.0	56.2	69.4	68.6	72.2	97.2	80.6
Tegula funebralis	11.1	15.0	31.2	2.8	8.6	0	16.7	0
Tetraclita squamosa elegans	0	0	0	0	0	0	0	2.8
Tetraclita squamosa rubescens	0	0	6.2	0	0	0	0	0
Tonicella lineata	16.7	10.0	6.2	0	5.7	0	11.1	11.1
Unidentified amphipoda	0	0	0	0	0	2.8	0	0
Unidentified anemone	5.6	0	0	0	0	0	0	0
Unidentified chiton	0	0	0	5.6	2.9	0	5.6	8.3
Unidentified gastropods	0	0	3.1	2.8	2.9	0	2.8	0
Unidentified Glyceridae	0	0	0	0	0	2.8	0	0
Unidentified sponge	0	0	12.5	19.4	2.9	5.6	13.9	16.7
Unidentified tunicate	0	0	3.1	19.4	45.7	41.7	41.7	63.9

Appendix 4. (continued)

North Control Intertidal

Species	Survey Period Winter 73-74	Summer 1974	Winter 74-75	Summer 1975	Winter 75-76	Summer 1976	Winter 76-77	Summer 1977
FISH								
Anoplarchus purpurescens	0		0	0	0	0	2.8	0
Gibbonsia montereyensis	0		0	0	0	0	2.8	0
Oligocottus snyderi	0		0	0	0	0	2.8	0
Xiphister mucosus	0		0	0	0	0	2.8	0
INVERTEBRATES								
Acmaea mitra	0		0	0	10.0	2.5	2.8	0
Acmaea sp.	22.2		16.7	33.3	7.5	17.5	19.4	30.0
Amphissa sp.	0		0	0	7.5	0	5.6	15.0
Anthopleura elegantissima	0		2.8	11.1	0	5.0	5.6	2.5
Anthopleura xanthogrammica	0		11.1	2.8	2.5	2.5	8.3	2.5
Aplidium sp.	0		0	0	0	7.5	0	0
Astraea gibberosa	5.6		0	0	0	0	0	0
Balanophyllia elegans	0		0	0	2.5	0	0	0
Balanus sp.	0		2.8	5.6	20.0	7.5	8.3	7.5
Bittium sp.	0		0	0	0	0	27.8	22.5
Cactosoma arenaria	0		0	0	0	0	27.8	17.5
Cadlina flavomaculata	0		2.8	0	0	0	0	0
Calliostoma annulatum	0		2.8	0	0	0	0	0
Calliostoma canaliculatum	0		0	0	5.0	0	0	0
Calliostoma ligatum	0		0	8.3	10.0	5.0	5.6	5.0
Cancer antennarius	5.6		5.6	8.3	0	15.0	8.3	17.5
Cancer jordani	0		0	2.8	5.0	5.0	0	10.0
Cancer productus	5.6		0	0	0	0	2.8	0
Clavelina huntsmani	0		0	0	2.5	0	0	5.0
Conus californicus	0		0	0	0	0	2.8	5.0
Corynactis californica	5.6		0	0	0	2.5	0	0
Crangon dentipes	0		0	2.8	0	0	2.8	5.0
Cyanoplax sp.	0		2.8	0	0	0	0	0
Diaulula sandiegensis	0		0	0	5.0	2.5	0	2.5
Diopatra sp.	0		0	0	2.5	0	0	0
Doriopsilla albopunctata	0		0	0	0	2.5	0	0

Epiactis prolifera	0	47.2	52.8	85.0	40.0	72.2	80.0
Epitonium tinctum	0	0	0	0	0	2.8	2.5
Eupentacta quinquesemita	0	0	0	0	0	2.8	5.0
Eurystomella bilabiata	0	0	0	7.5	2.5	5.6	5.0
Fissurella volcano	33.3	36.1	38.9	30.0	37.5	38.9	30.0
Fusinus sp.	0	0	0	0	0	0	2.5
Glans subquadrata	0	0	0	0	0	2.8	0
Haliotis cracherodii	44.4	44.4	44.4	40.0	45.0	58.3	50.0
Haliotis rufescens	16.7	19.4	8.3	27.5	7.5	27.8	17.5
Henricia leviuscula	5.6	25.0	50.0	50.0	35.0	50.0	65.0
Homalopoma luridum	0	0	0	0	0	0	2.5
Idotea sp.	5.6	2.8	8.3	0	0	0	0
Katharina tunicata	0	0	0	0	2.5	0	0
Lacuna sp.	0	0	0	0	0	5.6	2.5
Lepidozona mertensii	0	0	0	0	0	2.8	2.5
Leptasterias spp.	27.8	33.3	44.4	70.0	55.0	50.0	57.5
Leucandra heathi	0	0	0	0	0	5.6	2.5
Leucosolenia sp.	0	0	2.8	2.5	0	0	0
Lissothuria nutriens	0	2.8	0	0	0	16.7	7.5
Lophopanopeus leucomanus heathii	0	0	0	0	2.5	0	2.5
Mimulus foliatus	0	0	0	2.5	2.5	0	7.5
Mitrella sp.	0	0	0	5.0	10.0	44.4	50.0
Mopalia spp.	16.5	13.9	11.1	7.5	15.0	8.3	7.5
Mytilus californianus	0	11.1	5.6	5.0	5.0	2.8	5.0
Nucella emarginata	5.6	2.8	0	0	0	0	5.0
Nucella lamellosa	0	0	0	2.5	0	0	0
Nuttallina californica	11.1	0	0	2.5	0	2.8	0
Ocenebra sp.	0	0	0	0	5.0	16.7	2.5
Onchidella borealis	0	0	0	0	2.5	0	0
Pagurus granosimanus	0	0	0	2.5	0	0	0
Pagurus samuelis	0	0	0	0	0	2.8	0
Pagurus sp.	0	0	30.6	57.5	45.0	50.0	67.5
Paraxanthias taylori	0	0	0	0	0	2.8	0
Patiria miniata	5.6	0	0	0	2.5	0	2.5
Pisaster ochraceous	0	5.6	0	0	0	0	2.5
Pista sp.	0	25.0	30.6	37.5	32.5	50.0	52.5
Placiphorella velata	0	0	0	2.5	0	0	0
Pododesmus cepio	0	0	0	0	2.5	0	0
Pollicipes polymerus	0	0	0	2.5	0	0	0
Pseudomelatoma torosa	0	0	0	0	0	0	2.5
Pugettia gracilis	0	0	8.3	2.5	27.5	13.9	12.5
Pugettia producta	27.8	33.3	50.0	32.5	50.0	22.2	40.0
Pugettia richii	0	0	5.6	5.0	0	5.6	10.0
Pycnogonida	0	0	0	2.5	0	0	0

Pyura haustor	0	0	0	0	2.5	0	0
Rostanga pulchra	5.6	0	2.8	0	0	0	0
Sabellid polychaetes	0	0	0	0	0	0	2.5
Serpula vermicularis	0	0	0	0	2.5	0	0
Serpulidae	0	0	0	2.5	0	0	0
Serpulorbis squamigerus	0	11.1	0	7.5	0	0	10.0
Spurilla oliviae	0	0	0	0	0	2.8	2.5
Strongylocentrotus franciscanus	0	0	2.8	7.5	0	5.6	2.5
Strongylocentrotus purpuratus	5.6	13.9	25.0	20.0	32.5	11.1	20.0
Styela montereyensis	0	0	0	2.8	0	0	0
Synoicum parfustis	0	0	0	0	5.0	0	0
Tegula brunnea	50.0	72.2	77.8	80.0	80.0	88.9	92.5
Tegula funnebralis	50.0	25.0	19.4	5.0	5.0	33.3	2.5
Tegula montereyi	0	0	0	0	0	2.8	0
Tetraclita squamosa rubescens	0	0	0	5.0	0	0	0
Tonicella lineata	5.6	16.7	8.3	5.0	7.5	5.6	7.5
Unidentified chiton	0	5.6	2.8	7.5	7.5	0	15.0
Unidentified gastropod	0	0	0	10.0	0	0	2.5
Unidentified Holothuroidea	0	0	2.8	5.0	0	0	0
Unidentified pholads	0	0	2.8	0	0	0	0
Unidentified sponge	0	11.1	2.8	30.0	10.0	47.2	12.5
Unidentified tunicate	0	11.1	36.1	30.0	20.0	36.1	60.0

Appendix 5. Total Dry Weight (g) of Algae Species Collected in Subtidal 0.25m^2 Quadrats, DCPP, 1977-1978.

	Diablo Cove		North Control	
	1977	1978	1977	1978
GREEN ALGAE				
Cladophora graminea	0.1			
Ulva sp.	4.3			
RED ALGAE				
Antithamnion defectum		0.1		
Antithamnionella sp.		0.1		
Botryoglossum farlowianum	576.6	1279.2	2025.9	2954.7
Botryoglossum sp.		5.6		
Callithamnion acutum				0.4
Callophyllis crenulata	3.8	13.2	11.8	14.5
Callophyllis firma	0.1	0.3		0.1
Callophyllis flabelluita	13.2	13.7	11.5	27.9
Callophyllis pinnata	38.3	34.0	62.3	58.8
Callophyllis sp.	15.7	7.1	1.2	
Callophyllis violacea	86.2	77.3	56.4	32.7
Cryptopleura lobulifera			1.4	
Cryptopleura sp.	0.1			
Cryptopleura violacea	4.4	8.1	6.3	13.9
Erythrophyllum delesserioides	8.6	10.3	0.1	
Farlowia conferta		0.1		
Farlowia compressa	4.2		15.7	88.3
Farlowia mollis		1.2		
Fauchea laciniata	0.4	0.3	0.2	0.8
Fryeella gardneri	0.1	4.4	4.5	8.1
Gelidium arborescens	0.1			
Gelidium coulteri				0.4
Gelidium purpurascens	2.2		10.2	2.7
Gelidium robustum	0.4	0.5		15.4
Gelidium sp.				0.2
Gigartina canaliculata	0.1			
Gigartina corymbifera	448.8	734.5	860.7	556.7
Gigartina exasperata	358.7	315.0	241.4	317.2
Gigartina harveyana				1.1

Appendix 5. (continued)

	Diablo Cove		North Control	
	1977	1978	1977	1978
Gigartina sp.	0.2	2.3		1.9
Gigartina volans	3.3			
Gonimophyllum skottsbergii				0.1
Grateloupia doryphora	1.7	5.2	6.8	1.7
Griffthsia pacifica		0.1		0.1
Gymnogongrus leptophyllus		0.2		
Gymnogongrus linearis	0.3			
Gymnogongrus platyphyllus		0.7		
Gymnogongrus sp.	0.2			1.5
Halymenia californica		0.2		
Halymenia coccinea				0.2
Halymenia schizymenioides		0.3		
Halymenia sp.		0.2		
Hymenena cuneifolia	8.1			
Hymenena flabelligera	445.8	351.1	1466.6	791.6
Hymenena multiloba	3.4			
Hymenena sp.	39.1	0.1	0.6	
Iridaea cordata var. splendens	218.0	53.5	113.6	203.5
Iridaea heterocarpa	0.2		2.9	
Iridaea sp.		4.5		0.2
Laurencia blinksii			0.2	
Laurencia spectabilis	1.8	0.9	18.8	5.9
Membranoptera sp.	0.1			
Membranoptera weeksiae	0.1			
Microcladia borealis	0.3	0.4		
Microcladia coulteri	24.1	122.4	35.8	41.0
Neoagardhiella baileyi	1.1	1.1	3.7	8.7
Neoptilota densa	44.0	44.6	91.9	186.2
Neoptilota hypnoides		0.6		0.8
Odanthalia floccosa				0.1
Opuntiella californica	61.1	20.2	120.1	87.6
Phycodrys setchelli		0.4		

Appendix 5. (continued)

	Diablo Cove		North Control	
	1977	1978	1977	1978
Pikea californica	16.9	4.2	3.0	0.8
Pikea robusta	0.1	0.3		
Platythamnion sp.		0.1		0.1
Platythamnion villosum	0.1	0.6		
Plecnosporium squarrulosum		0.2		0.4
Plocamium cartilagineum	4.7	0.2		18.8
Plocamium violaceum	0.1		9.9	
Polysiphonia brodiael				0.1
Polysiphonia hendryi		0.5		
Polysiphonia pacifica	3.4	11.3	10.3	1.5
Polysiphonia sp.	0.1			
Polyneura latissima	64.1	119.3	43.7	293.6
Prionitis australis	0.7			
Prionitis lanceolata	69.9	90.0	57.2	18.9
Prionitis linearis			0.5	
Prionitis lyallii	3.8			0.1
Prionitis sp.		0.1		
Pseudogloiophloea confusa	0.1	0.7		0.7
Pterosiphonia dendroidea		0.1		
Pugetia fragilissima	0.1	1.1		1.2
Rhodoglossum parvum	0.1	1.2		7.9
Rhodoptilum plumosum	0.1	12.2		
Rhodymenia californica	12.3	41.3	5.8	32.0
Rhodymenia callophyllidoides	0.1			
Rhodymenia lobulifera		3.3		
Rhodymenia pacifica	17.2	41.0	19.0	21.7
Rhodymenia rhizoides	10.5			
Rhodymenia sp.	0.2			
Rhodymenia sympodiophyllum			.01	
Schizymenia pacifica	2.5	8.8	1.9	
Schizymenia sp.	0.1			
Stenogramme interrupta				0.6
Tiffaniella snyderiae	0.2	0.1		
Weeksia reticulata	0.3	0.3	1.4	0.2
Unid. red algae		0.1		
Total Quadrats	96	96	84	96

Appendix 6a. Summary of Data Collected for Quantified Invertebrates at Random 0.25-m^2 Subtidal Stations, Diablo Cove. DCPP, 1975-1978.

	1975			1976			1977			1978		
	Sum	$\bar{x}$	%	Sum	$\bar{x}$	%	Sum	$\bar{x}$	%	Sum	$\bar{x}$	%
ANNELIDA												
Aphrodite sp.	0			0			1		1.0	0		
Diopatra sp.	168	5.25	40.6	273	5.69	18.8	546(2)	5.80	26.0	162(1)	1.70	22.9
Eudistylia polymorpha	14	0.44	21.9	13	0.27	14.6	29	0.30	12.5	4	0.04	3.1
Myxicola sp.	0		0.0	0			7	0.07	6.2	0		
Pista sp.	1	0.03	3.1	3	0.06	6.2	20	0.21	15.6	13	0.14	10.4
Serpula vermicularis	0		0.0	0			9	0.09	2.1	1	0.01	1.0
ARTHROPODA												
Balanus glandula	8	0.25	6.2	0			0			0		
Balanus nubilus	1	0.03	3.1	0			0			2	0.02	1.0
Cancer antennarius	1	0.03	3.1	0			0			0		
Cancer jordani	0			0			3	0.03	2.1	0		
Cancer productus	0			0			4			0		
Cancer sp.	0			0			1	0.01	1.0	1	0.01	1.0
Cryptolithoides sitchensis	1	0.03	3.1	3	0.06	2.1	2	0.02	2.1	0		

Lophopanopeus spp.	0			5	0.10	10.4	11	0.11	9.4	1	0.01	1.0
Loxorhynchus crispatus	5	0.16	15.6	5	0.10	10.4	3	0.03	3.1	0		
Mimulus foliatus	0			14	0.29	16.7	14	0.14	11.4	4	0.04	4.2
Mytlimeria nuttingi	0			0			1	0.01	1.0	0		
Pachycheles spp.	1	0.03	3.1	1	0.02	2.1	1	0.01	1.0	0		
Pandalus gurneyi	1	0.03	3.1	0			0			0		
Petrolisthes cinctipes	0			2	0.04	2.1	1	0.01	1.0	0		
Pugettia gracilus	0			17	0.35	12.5	7	0.07	5.2	0		
Pugettia producta	0			0			8	0.08	8.3	2	0.02	2.1
Pugettia richii	1	0.03	3.1	7	0.14	12.5	46	0.48	27.1	15	15.6	11.4
Scyra acutifrons	0			1	0.02	2.1	1	0.01	1.0	1	0.01	1.0
CHORDATA												
Boltenia villosa	7	0.22	18.8	4	0.08	4.2	19	0.20	10.4	12	0.12	11.4
Clavelina huntsmani	1	0.03	3.1	4	0.08	4.2	21	0.22	6.2	12(2)	0.13	4.2
Cnemidocarpa finmarkiensis	0			3	0.06	6.2	4	0.04	4.2	13	0.14	6.2
Pyura haustor	0			4	0.08	4.2	13	0.14	9.4	4	0.04	4.2
Styela gibbsi	0			0			1	0.01	1.0	1	0.01	1.0
Styela montereyensis	6	0.19	12.5	0			0			4	0.04	3.1
CNIDARIA												
Anthopleura artemesia	4	0.12	9.3	6	0.12	8.3	10	0.10	8.3	13	0.14	11.4

Anthopleura xanthogrammica	5	0.16	15.6	11	0.23	18.8	20	0.20	15.6	12	0.12	11.4
Cactosoma arenaria	0			0			29	0.30	13.5	20(1)	0.21	11.4
Corynactis californica	58	1.81	12.5	322	6.71	12.5	112	1.17	12.5	31(2)	0.33	6.2
Diadumene luciae	0			0			5	0.05	2.1	0		
Halcampa decemtentaculata	0			15	0.31	18.8	8	0.08	7.3	5	0.05	4.2
Paracyathus stearnsii	10	0.31	12.5	2	0.04	2.1	57	0.59	6.2	43	0.45	11.4
Tealia lofotensis	3	0.09	6.2	2	0.04	2.1	1	0.01	1.0	2	0.02	2.1
Tealia pisciuora	0			0			0			1	0.01	1.0
ECHINODERMATA												
Cucumaria miniata	1	0.03	3.1	1	0.02	2.1	3	0.03	1.0	4	0.04	1.0
Cucumaria sp.	0			0			52	0.54	14.6	31(1)	0.33	12.5
Eupentacta quinquesmita	6	0.19	12.5	21	0.44	20.8	17	0.18	11.4	12	0.12	7.3
Leptasterias aequalis	3	9.4	3.1	19	0.39	0.25	53	0.55	0.30	39	0.41	18.8
Lissothuria nutriens	0			1	0.02	2.1	2	0.02	2.1	17	0.18	2.1
Ophioplocus esmarki	1	0.03	3.1	0			4	0.04	2.1	2	0.02	2.1
Ophiothrix spiculata	0			0			1	0.01	1.0	4	0.04	4.2
Pisaster brevispinus	0			0			0			1	0.01	1.0
Pisaster giganteus	1	0.03	3.1	0			0			2	0.02	2.1
Pisaster ochraceus	0			0			0			2	0.02	2.1
Pisaster sp. (juv.)	0			0			0			2	0.02	1.0

Pycnopodia helianthoides	1	0.03	3.1	2	0.04	4.2	0			8	0.08	7.3
Strongylocentrotus purpuratus	0			4	0.08	4.2	9	0.09	9.4	1	0,01	1,0
Strongylocentrotus sp.	0			0			0			6	0.06	6.2
Stylasterias forreri	0			0			0			1	0.01	1.0
MOLLUSCA												
Aeolidia papillata	0			0			4	0.04	2.1	0		
Amphissa columbiana	0			0			6	0.06	3.1	0		
Anisodoris nobilis	0			0			1	0.01	1.0	1	0.01	1.0
Cadlina flavomaculata	0			0			1	0.01	1.0	0		
Cadlina sparsa	0			0			3	0.03	2.1	0		
Calliostoma annulatum	0			7	0.14	0.08	1	0.01	1.0	7	0.07	6.2
Calliostoma canaliculatum	0			0			3	0.03	3.1	1	0.01	1.0
Calliostoma ligatum	1	0.03	3.1	15	0.31	14.6	56	0.58	21.9	56	0.58	31,2
Calliostoma sp.	0			3	0.06	2.1	0			2	0.02	1.0
Calliostoma supragranasum	2	0.06	6.2	0			0			0		
Ceratostoma foliatum	3	0.09	6.2	0			0			2	0.02	2.1
Chama pellucida	0			0			1	0.01	1.0	0		
Collisella sp.	2	0.06	3.1	0			0			0		
Conus californicus	0			2	0.04	2.1	5	0.05	4.2	0		
Coryphella fisheri	0			0			2	0.02	1.0	4	0.04	4.2

Cryptochiton stelleri	0			0			1	0.01	1.0	4	0.04	4.2
Diaulula sandiegensis	1	0.03	3.1	0			2	0.02	2.1	1	0.01	1.0
Diodora aspera	0			1	0.02	2.1	1	0.01	1.0	2	0.02	2.1
Dirona picta	0			0			2	0.02	2.1	0		
Discodoris heathi	0			0			0			3	0.03	3.1
Epitonium tinctum	2	0.06	3.1	1	0.02	2.1	5	0.05	4.2	2	0.02	2.1
Fissurella volcano	0			2	0.04	2.1	3	0.03	2.1	1	0.01	1.0
Halliotis kamtschatkana	2	0.06	3.1	0			1	0.01	1.0	0		
Haliotis rufescens	1	0.03	3.1	0			5	0.05	4.2	0		
Haliotis walallensis	0			0			1	0.01	1.0	1		
Hermissenda crassicornis	0			4	0.08	6.2	4	0.04	4.2	4	0.04	3.1
Hiatella arctica	0			0			1	0.01	1.0	0		
Hinnites giganteus	0			0			0			1	0.01	1.0
Hopkinsia rosacea	0			0			1	0.01	1.0	3	0.03	2.1
Ischnochiton radians	0			0			1	0.01	1.0	2	0.02	2.1
Ischnochiton sp.	0			0			2	0.02	1.0	0		
Lacuna sp.	0			0			1	0.01	1.0	0		
Laila cockerelli	0			1	0.02	2.1	1	0.01	1.0	2	0.02	2.1
Lepidozona mertensii	0			1	0.02	2.1	0			0		
Lithophaga plumula kelseyi	32	1.00	12.5	0			0			0		

Maxwellia santarosana	2	0.06	3.1	0			0			0		
Mitra ida	4	0.12	12.5	3	0.06	6.2	22	0.23	16.7	12	0.12	9.4
Mopalia sp.	2	0.06	6.2	3	0.06	6.2	3	0.03	3.1	4	0.04	4.2
Mytilus sp.	1	0.03	3.1	0			0			0		
Nucella emarginata	2	0.06	6.2	0			0			0		
Ocenebra beta	0			0			0			5	0.05	3.1
Ocenebra interfossa	2	0.06	3.1	0			0					
Ocenebra lurida	0			0			0			6	0.06	4.2
Ocenebra sp.	0			5	0.10	8.3	10	0.10	7.3	30	0.31	20.8
Phidiana nigra	2	0.06	6.2	1	0.02	2.1	2	0.02	2.1	1	0.01	1.0
Placophorella velata	0			0			1	0.01	1.0	0		
Pododesmus cepio	1	0.03	3.1	0			4	0.04	3.1	0		
Pseudomelatoma torosa	0			6	0.12	6.2	11	0.11	9.4	11	0.11	8.3
Rostanga pulchra	0			1	0.02	2.1	2	0.02	2.1	0		
Searlesia dira	0			0			1	0.01	1.0	0		
Spurilla oliviea	0			0			3	0.03	2.1	0		
Tegula montereyi	3	0.09	9.4	2	0.04	4.2	10	0.10	7.3	6	0.06	6.2
Tegula pulligo	3	0.09	6.2	4	0.08	8.3	9	0.09	8.3	19	0.20	16.7
Tegula sp.	1	0.03	3.1	29	0.60	18.8	0			0		
Triopha catalinae	3	0.09	9.4	1	0.02	2.1	0			1	0.01	1.0

Triopha maculata	0			0			0			5	0.05	5.2
Tritonia festiva	0			0			0			1	0.01	1.0
Trivia californiana	0			0			1	0.01	1.0	0		
PORIFERA												
Leucandra heathi	0			0			16	0.17	7.3	6(1)	0.06	6.2
Leucilla nuttingi	9	0.28	6.2	2	0.04	2.1	56	0.58	15.6	49(1)	0.52	18.8
Tethya aurantia	2	0.06	6.2	1	0.02	2.1	6	0.06	4.2	2	0.02	2.1
SIPUNCULA												
Phascolosoma agassizii	0			3	0.06	2.1	9	0.09	4.2	0		
Unid. Sipunculid	0			0			0			10	0.10	3.1
TOTAL QUADRATS	32			48			96			96		

Appendix 6b. Summary of Data Collected for Quantified Invertebrates at 30-m^2 Random Subtidal Stations, Diablo Cove. DCPP, 1974-1977.

	1974			1975			1976			1977		
	Total Observed	Mean Per Station	% Freq. of Occurrence	Sum	$\bar{x}$	%	Sum	$\bar{x}$	%	Sum	$\bar{x}$	%
ARTHROPODA												
Cancer productus				1	0.04	4.2	1	0.04	4.2			
Cryptolithoides sitchensis				2	0.08	8.3	4	0.17	12.5	5	0.21	12.5
Loxorhynchus crispatus	1	0.07	7.1	2	0.08	4.2	7	0.29	20.8	2	0.08	8.3
Pugettia gracilis				3	0.12	12.5	5	0.21	12.5			
Pugettia producta				3	0.12	8.3	7	0.29	29.2	17	0.71	45.8
Pugettia richii				2	0.08	4.2	4(1)	0.17	16.7	24	1.00	37.5
Scyra acutifrons										1	0.04	4.2
CHORDATA												
Boltenia villosa				18	0.75	33.3	33(2)	1.50	41.7	98	4.08	50.0
CNIDARIA												
Anthopleura artemesia	22	1.57	14.3	51	2.12	37.5	24	1.00	33.3	59	2.46	54.2
Halcampa decemtentaculata				40	1.67	12.5	69(3)	3.28	58.3	23(2)	1.04	37.5

Tealia coriacea							1	0.04	4.2	5	0.21	12.5
Tealia crassicornis	3	0.21	14.3	5	0.21	20.8	3	0.12	12.5	6	0.25	16.7
Tealia lofotensis	11	0.78	35.7	75	3.12	33.3	42	1.75	20.8	73	3.04	29.2
ECHINODERMATA												
Ophioplocus esmarki				2	0.08	8.3				4	0.17	16.7
Orthasterias koehleri	12	0.86	50.0	25	1.04	41.7	9	0.38	25.0	13	0.54	33.3
Parastichopus californicus				3	0.12	12.5	2	0.08	8.3	4	0.17	12.5
Parastichopus parvimensis				1	0.04	4.2	3	0.12	8.3	3	0.12	12.5
Parastichopus spp.	2	0.14	7.1									
Pisaster brevispinus				4	0.17	16.7	3	0.12	12.5	3	0.12	12.5
Pisaster ochraceus	4	0.28	28.6	11	0.46	12.5	13	0.54	25.0	22	0.92	50.0
Strongylocentrotus purpuratus	1	0.07	7.1	2	0.08	8.3	35(1)	1.52	37.5	16	0.67	8.3
Stylasterias forreri	1	0.07	7.1	2	0.08	8.3	3	0.12	8.3	4	0.17	16.7
MOLLUSCA												
Aegires albopunctatus										1	0.04	4.2
Anisodoris nobilis				13	0.54	16.7	15	0.62	29.2	1	0.04	4.2
Archidoris montereyensis	2	0.14	14.3	10	0.42	16.7	9	0.38	25.0			
Cadlina luteomarginata	4	0.28	21.4	3	0.12	12.5	7	0.29	20.8	5	0.21	16.7
Ceratostoma spp.	1	0.07	7.1	2	0.08	8.3	4	0.17	12.5	7	0.29	16.7
Coryphella fisheri										4	0.17	8.3

Cryptochiton stelleri				3	12.5	8.3				1	0.04	4.2
Diaulula sandiegensis	1	0.07	7.1	8	0.33	25.0	5	0.21	16.7	19	0.79	33.3
Diodora aspera							1	0.04	4.2			
Haliotis kamtschatkana	2	0.14	7.1				1	0.04	4.2			
Haliotis walallensis												
Hermissenda crassicornis	5	0.35	14.3	9	0.38	12.5	5	0.21	8.3	4	0.17	16.7
Hinnites multirugosus				1	0.04	4.2	7	0.29	16.7	2	0.08	8.3
Hopkinsia rosacea				4	0.17	16.7	3	0.13	8.3	12	0.50	25.0
Laila cockerelli				1	0.04	4.2				1	0.04	4.2
Megathura crenulata										1	0.04	4.2
Mitra ida				13	0.54	25.0	33	1.38	50.0	53	2.21	54.2
Phidiana nigra	3	0.21	14.3	5	0.21	8.3	8	0.33	29.2	5	0.21	16.7
Triopha catalinae	1	0.07	7.1	12	0.50	20.8	10	0.42	16.7	2	0.08	8.3
Triopha maculata							1	0.04	4.2			
TOTAL STATIONS		14			24			24			24	

( ) = Number of Stations Where Counts Were Not Made.

Appendix 6c. Summary of Data Collected for Quantified Invertebrates at Random 0.25-m^2 Subtidal Stations, North Control. DCPP, 1976-1978.

	1976			1977			1978		
	Sum	$\bar{x}$	%	Sum	$\bar{x}$	%	Sum	$\bar{x}$	%
ANNELIDIA									
Aphrodite sp.	0		0.0	0		0.0	1	0.01	1.0
Chaetopterus varopedatus	0		0.0	1	0.01	1.2	0		0.0
Diopatra sp.	61	1.27	16.7	174	1.89	17.8	100	1.04	11.4
Eudistylia polymorpha	6	0.12	8.3	12	0.13	10.7	10	0.10	6.2
Myxicola sp.	0		0.0	6	0.06	6.0	1	0.01	1.0
Pista sp.	8	0.17	12.5	14	0.15	13.1	8	0.08	4.2
Serpula vermicularis	0		0.0	3	0.03	1.2	4	0.04	3.1
Thelepus crispus	0		0.0	0		0.0	1	0.01	1.0
ARTHROPODA									
Balanus nubilus	1	0.02	2.1	4	0.04	2.4	NC	--	9.4
Cancer antennarius	1	0.02	2.1	3	0.03	3.6	2	0.02	2.1
Cancer jordani	0		0.0	2	0.02	2.4	1	0.01	1.0
Cancer sp.	0		0.0	0		0.0	6	0.06	6.2
Cryptolithoides sitchensis	1	0.02	2.1	11	0.12	9.5	8	0.08	7.3
Heptacarpus brevirostinis	0		0.0	2	0.02	2.4	0		0.0
Hippolyte californiensis	0		0.0	0		0.0	1	0.01	1.0
Lebbeus lagunae	0		0.0	5	0.05	4.8	0		0.0
Lophopanopeus bellus	1	0.02	2.1	11	0.12	9.5	0		0.0
Lophopanopeus leucomanus heathii	0		0.0	3	0.03	2.4	0		0.0
Lophopanopeus spp.	0		0.0	1	0.01	1.2	8	0.08	3.1

Loxorhynchus crispatus	3	0.06	6.2	7	0.08	7.1	1	0.01	1.0
Mimulus foliatus	5	0.10	10.4	29	0.32	25.0	1	0.01	1.0
Pachycheles rudis	0		0.0	1	0.01	1.2	0		0.0
Petrolisthes cinctipes	0		0.0	6	0.06	3.6	0		0.0
Pugettia gracilis	9	0.19	16.7	6	0.06	6.0	0		0.0
Pugettia producta	0		0.0	7	0.08	7.1	1	0.01	1.0
Pugettia richii	3	0.06	4.2	81	0.88	42.8	24	0.25	16.7
Pugettia sp. (juv.)	0		0.0	0		0.0	1	0.01	1.0
Scyra acutifrons	0		0.0	4	0.04	3.6	5	0.05	5.2
Spirontocaris prionota	0		0.0	5	0.05	4.8	0		0.0
CHORDATA									
Boltenia villosa	9	0.09	12.5	11	0.12	7.1	21	0.22	14.6
Clavelina huntsmani	0		0.0	4	0.04	1.2	18	0.19	2.1
Cnemidocarpa finmarkiensis	3	0.06	4.2	2	0.02	2.4	15	0.16	8.3
Mogula sp.	0		0.0	1	0.01	1.2	0		0.0
Pyura haustor	2	0.04	4.2	5	0.05	4.8	5	0.05	4.2
Styela montereyensis	4	0.08	8.3	14	0.15	13.1	6	0.06	6.2
Styela gibbsi	0		0.0	0		0.0	1	0.01	1.0
CNIDARIA									
Anthopleura artemisia	19	0.40	18.8	17	0.18	13.1	22	0.23	11.4
Anthopleura elegantissima	0		0.0	2	0.02	2.4	6	0.06	3.1
Anthopleura xanthogrammica	16	0.33	20.8	23	0.25	16.7	23	0.24	19.8
Cactosoma arenaria	0			46	0.50	8.3	25	0.26	8.3
Corynactis californica	2	0.04	4.2	500	5.43	7.1	NC	—	14.6
Halcampa decemtentaculata	3	0.06	4.2	4	0.04	4.8	0		0.0
Paracyathus stearnsii	56	1.17	20.8	16	0.17	6.0	139	1.45	13.5

Tealia crassicornis	1	0.02	2.1	0					
Tealia lofotensis	2	0.04	2.1	2	0.02	2.4	0		0.0
ECHINODERMATA									
Cucumaria miniata	0		0.0	0		0.0	7	0.07	2.1
Cucumaria piperata	0		0.0	0		0.0	1	0.01	1.0
Cucumaria sp.	0		0.0	78	0.85	32.1	5	0.05	3.1
Eupentacta quinquesemita	12	0.25	14.6	13	0.14	13.1	4	0.04	4.2
Leptasterias spp.	26	0.54	29.2	78	0.85	53.6	44	0.46	30.2
Lissothuria nutriens	0		0.0	12	0.13	6.0	18	0.19	5.2
Ophioplocus esmarki	1	0.02	2.1	18	0.20	9.5	7	0.07	5.2
Ophiothrix spiculata	1	0.02	2.1	42	0.46	17.8	2	0.02	2.1
Orthasterias koehleri	0		0.0	0		0.0	1	0.01	1.0
Parastichopus parvimensis	0		0.0	2	0.02	2.4	0		0.0
Pisaster brevispinus	0		0.0	0		0.0	2	0.02	2.1
Pisaster giganteus	0		0.0	1	0.01	1.2	6	0.06	6.2
Pisaster ochraceus	0		0.0	1	0.01	1.2	0		0.0
Pisaster sp. (juv.)	0		0.0	0		0.0	10	0.10	9.4
Pycnopodia helianthoides	0		0.0	1	0.01	1.2	1	0.01	1.0
Strongylocentrotus purpuratus	12	0.25	18.8	6	0.06	4.8	0		0.0
Strongylocentrotus sp.	0		0.0	0		0.0	5	0.05	4.2
Stylasterias forreri	0		0.0	0		0.0	1	0.01	1.0
MOLLUSCA									
Aegires albopunctatus	0		0.0	1	0.01	1.2	0		0.0
Aeolidia papillata	0		0.0	4	0.04	3.6	0		0.0
Aldisa sanguinea	0		0.0	1	0.01	1.2	0		0.0
Ancula pacifica	0		0.0	2	0.02	1.2	0		0.0

Anisodoris nobilis	1	0.02	2.1	1	0.01	1.2	1	0.01	1.0
Bittium sp.	0		0.0	5	0.05	2.4	0		0.0
Cadlina flavomaculata	0		0.0	2	0.02	2.4	1	0.01	1.0
Cadlina luteomarginata	0		0.0	2	0.12	2.4	0		0.0
Cadlina sparsa	0			3	0.03	2.4			
Calliostoma annulatum	1	0.02	2.1	2	0.02	1.2	6	0.06	6.2
Calliostoma canaliculatum	1	0.02	2.1	0			1	0.01	1.0
Calliostoma ligatum	3	0.06	6.2	52	0.56	26.2	40	0.42	20.8
Calliostoma sp.							1	0.01	1.0
Chlamys spp.	0			1	0.01	1.2			
Ceratostoma nuttallii	2	0.04	4.2	4	0.04	4.8	2	0.02	2.1
Conus californicus	2	0.04	4.2	2	0.02	2.4	3	0.03	3.1
Coryphella fisheri	0		0.0	3	0.03	3.6	2	0.02	2.1
Cryptochiton stelleri	1	0.02	2.1	1	0.01	1.2	6	0.06	5.2
Diaulula sandiegensis	3	0.06	6.2	1	0.01	1.2	2	0.02	2.1
Diodora aspera	0		0.0	2	0.02	2.4	2	0.02	2.1
Discodoris heathi	0		0.0	1	0.01	1.2	0		0.0
Epitonium tinctum	1	0.02	2.1	2	0.02	2.4	0		0.0
Erato vitellina	0		0.0	2	0.02	2.4	1	0.01	1.0
Flabellinopsis iodinea	0		0.0	1	0.01	1.2	0		0.0
Fissurella volcano	2	0.04	4.2	4	0.04	4.8	8	0.08	6.2
Fusinus sp.	1	0.02	2.1	3	0.03	3.6	2	0.02	2.1
Haliotis kamtchatkana	1	0.02	2.1	2	0.02	2.4	1	0.01	1.0
Haliotis rufescens	0		0.0	4	0.04	3.6	0		0.0
Hermissenda crassicornis	1	0.02	2.1	4	0.04	4.8	1	0.01	1.0
Hinites multirugosus	1	0.02	2.1	3	0.03	3.6	3	0.03	3.1
Hopkinsia rosacea	0		0.0	7	0.08	7.1	2	0.02	2,1

Ischnochiton radians	1	0.02	2.1	0		0.0	0		0.0
Ischnochiton regularis	4	0.08	4.2	0		0.0	0		0.0
Ischnochiton sp.	0		0.0	15	0.16	4.8	1	0.01	1.0
Lepidozona mertensii	1	0.02	2.1	7	0.08	6.0	0		0.0
Lepidozona sinudentata	0		0.0	1	0.01	1.2	1	0.01	1.0
Megatebennus bimaculatus	0		0.0	1	0.01	1.2	0		0.0
Mitra ida	5	0.10	8.3	19	0.21	19.0	18	0.19	15.6
Mopalia spp.	2	0.04	4.2	3	0.03	3.6	2	0.02	2.1
Nucella emarginata	3	0.06	2.1	0		0.0	0		0.0
Ocenebra beta	0		0.0	0		0.0	1	0.01	1.0
Ocenebra luridum	0		0.0	1	0.01	1.2	9	0.09	5.2
Ocenebra spp.	5	0.10	10.4	43	0.47	28.6	19	0.20	13.5
Placophorella velata	0		0.0	1	0.01	1.2	0		0.0
Pododesmus cepio	0		0.0	2	0.01	2.4	6	0.06	4.2
Pseudomelatoma torosa	3	0.06	6.2	20	0.22	19.0	11(1)	0.12	11.4
Rostanga pulchra	0		0.0	3	0.03	3.6	0		0.0
Searlesia dira	0		0.0	2	0.02	2.4	0		0.0
Tegula montereyi	12	0.25	16.7	9	0.10	7.1	13	0.14	12.5
Tegula pulligo	9	0.19	16.7	40	0.43	26.2	5	0.05	4.2
Tritonia festiva	0		0.0	1	0.01	1.2	1	0.01	1.0
Triopha catalinae	1	0.02	2.1	0			1	0.01	1.0
Triopha maculata	0		0.0	3	0.03	2.4	0		0.0
PORIFERA									
Leucandra heathi	1	0.02	2.1	15	0.16	11.9	9(1)	9.50	7.3
Leucilla nuttingi	9	0.19	6.2	58(2)	0.64	10.7	21	0.22	9.4
Tethya aurantia	3	0.06	6.2	6	0.06	6.0	4	0.04	4.2
SIPUNCULA									
Phascolosoma agassizii	0			3	0.03	2.4	3	0.03	2.1
TOTAL QUADRATS	48			84			96		

Appendix 6d. Summary of Data Collected for Quantified Invertebrates at 30-m^2 Random Subtidal Stations, North Control. DCPP, 1974-1977.

	1974			1975			1976			1977		
	Total Observed	Mean Per Station	% Freq. of Occurrence	Sum	$\bar{x}$	%	Sum	$\bar{x}$	%	Sum	$\bar{x}$	%
ARTHROPODA												
Cancer productus	1	0.07	7.1				1	0.04	4.2	4	0.17	13.0
Cryptolithoides sitchensis				1	0.04	4.2	9	0.38	25.0	21	0.88	43.5
Loxorhynchus crispatus				6	0.25	16.7	12	0.50	25.0	9	0.38	21.7
Pugettia gracilis				2	0.08	8.3	20	0.83	33.3			
Pugettia producta	2	0.14	14.3	10	0.42	20.8	13(1)	0.56	37.5	4	0.17	13.0
Pugettia richii	1	0.07	7.1	8	0.33	20.8	25	1.04	50.0	94	3.92	69.6
Scyra acutifrons							2	0.08	4.2	7	0.29	21.7
CHORDATA												
Boltenia villosa	1	0.07	7.1	40(2)	1.82	54.2	58	2.42	45.8	182	7.91	65.2
CNIDARIA												
Anthopleura artemesia	6	0.43	7.1	13	0.54	25.0	45	1.88	37.5	123	5.35	52.2
Halcampa decemtentaculata				4	0.17	12.5				(1)		

Tealia coriacea							3	0.12	12.5	4	0.17	8.7
Tealia crassicornis	3	0.21	14.3	12	0.50	25.0	8	0.33	25.0	12	0.52	26.1
Tealia lofotensis	23	1.64	28.6	15	0.62	20.8	10	0.42	33.3	13	0.56	34.8
ECHINODERMATA												
Orthasterias koehleri	25	1.78	42.8	13	0.54	29.2	27	1.12	37.5	10	0.43	21.7
Parastichopus californicus				14	0.58	20.8	24	1.00	33.3	5	0.22	8.7
Parastichopus parvimensis				9	0.38	20.8	3	0.12	12.5	10	0.43	26.1
Parastichopus spp.	16	1.14	35.7									
Pisaster brevispinus	3	0.21	14.3	4	0.17	8.3						
Pisaster ochraceus	17	1.21	42.8	10	0.42	16.7	11	0.45	37.5	18	0.78	39.1
Strongylocentrotus purpuratus	4	0.28	7.1	10	0.42	20.8	22	0.92	20.8	9	0.39	26.1
Stylasterias forreri	2	0.14	14.3	3	0.12	8.3	3	0.12	12.5	4	0.17	8.7
MOLLUSCA												
Acanthodoris brunnea										4	0.17	4.3
Aegires albopunctatus										3	0.13	8.7
Aeolidia papillata										1	0.04	4.3
Anisodoris nobilis	6	0.43	14.3	17	0.71	50.0	33	1.38	62.5	33	1.43	52.2
Archidoris montereyensis	2	0.14	14.3	8	0.33	20.8	11	0.46	33.3	3	0.13	8.7
Archidoris odhneri							4	0.17	1.3			
Cadlina flavomaculata							2	0.08	8.3	8	0.35	17.4

Cadlina luteomarginata				9	0.38	16.7	15	0.62	29.2	6	0.26	17.4
Cadlina sparsa							2	0.08	4.2	1	0.04	4.3
Ceratostoma spp.				5	0.21	16.7	21	0.88	29.2	20	0.87	34.8
Coryphella fisheri							1	0.04	4.2	21	0.91	26.1
Cryptochiton stelleri	3	0.21	21.4	9	0.38	37.5	3	0.12	12.5	3	0.13	13.0
Dendronotus albus										3	0.13	13.0
Diaulula sandiegensis	1	0.07	7.1	3	0.12	12.5	24	1.00	45.8	15	0.65	43.4
Diodora aspera				4	0.17	12.5	1	0.04	4.2	3	0.13	13.0
Discodoris heathi										1	0.04	4.3
Flabellinopsis iodinea										1	0.04	4.3
Haliotis kamtchatkana	1	0.07	7.1	5	0.21	8.3	1	0.04	4.2	1	0.04	4.3
Haliotis walallensis							1	0.04	4.2			
Hermissenda crassicornis				1	0.04	4.2	8	0.33	12.5	15	0.65	39.1
Hinnites multirugosus	4	0.28	14.3	1	0.04	4.2	14	0.58	33.3	25	1.09	43.4
Hopkinsia rosacea	2	0.14	14.3	6	0.25	16.7	2	0.08	8.3	79(1)	3.43	63.6
Laila cockerelli							5	0.21	12.5	2	0.09	8.7
Megathura crenulata												
Mitra ida	1	0.07	7.1	28	1.17	41.7	52	2.17	58.3	69	3.00	82.6
Phidiana nigra				2	0.08	8.3	4	0.17	8.3	13	0.56	21.7
Triopha catalinae	7	0.50	14.3	11	0.46	29.2	5	0.21	16.7	4	0.17	17.4
Triopha maculata							1	0.04	4.2			
PORIFERA												
Tetilla arb							1	0.04	4.2	10	0.43	17.4
TOTAL STATIONS		14			24			24			23	

( ) = Number of Stations Where Counts Were Not Made.

Appendix 7a. Frequency of Occurrence of Non-quantified Invertebrates Observed at 30-m^2 Random Subtidal Stations, Diablo Cove. DCPP, 1974-1977.

Species	1974	1975	1976	1977
ANNELIDIA				
Diopatra sp.	7.1	16.7	54.2	58.3
Eudistylia polymorpha	42.8	58.3	58.3	66.7
Myxicola sp.				25.0
Pista sp.	21.4		8.3	66.7
Salmacina tribranchiata				12.5
Serpula vermicularis				4.2
Serpulidae	14.2	45.8	54.2	70.8
Terebellidae	7.1	12.5	4.2	25.0
ARTHROPODA				
Balanus spp.		4.2	8.3	37.5
Balanus glandula		8.3		4.2
Balanus nubilus		12.5		
Lebbeus lagunae				4.2
Lophopanopeus bellus				8.3
Mimulus foliatus			8.3	4.2
Pagurus spp.	50.0	16.7	54.2	66.7
Pandalus gurneyi	7.1		4.2	8.3
Petrolisthes cinctipes				
Tetraclita sp.			4.2	
CHORDATA				
Aplidium sp.			4.2	4.2

Archididistoma sp.			4.2	
Clavelina huntsmani		8.2	16.7	37.5
Cnemidocarpa finmarkiensis	21.4	41.7	25.0	33.3
Pyura haustor		4.2	12.5	50.0
Styela gibbsi			8.3	8.3
Trididemnum opacum			12.5	
CNIDARIA				
Aglaophenia sp.		12.5	12.5	25.0
Allopora californica		4.2		
Allopora porphyra		4.2	12.5	
Balanophyllia elegans	78.6	66.7	75.0	91.7
Cactosoma arenaria			8.3	20.8
Corynactis californica	14.3	12.5	25.0	29.2
Epiactis prolifera	50.0	33.3	66.7	62.5
Pachycerianthus fimbriatus				4.2
Paracyathus stearnsii	14.3	25.0	8.3	12.5
Tubularia sp.	7.1			
ECHINODERMATA				
Cucumaria miniata	7.1	20.8	16.7	29.2
Cucumaria sp.				29.2
Eupentacta quinquesemita	7.1	33.3	25.0	25.0
Leptasterias aequalis	14.2	37.5	62.5	58.3
Ophioplocus esmarki		41.7		16.7
ECTOPROCTA				
Barentsia sp.				12.5
Crisia sp.				20.8

Diaperoecia californica	7.1	16.7	8.3	8.3
Eurystomella bilabiata				4.2
Flustrella corniculata		4.2		
Heteropora magna			8.3	
Hippodiplosia insculpta	7.1		4.2	4.2
Phidolopora pacifica	14.2		4.2	16.7
MOLLUSCA				
Acmaea mitra		33.3	66.7	70.8
Amphissa sp.		8.3		12.5
Ancula pacifica				4.2
Bittium sp.			4.2	4.2
Calliostoma annualtum	7.1	4.2	8.3	4.2
Calliostoma canaliculatum	14.3		4.2	8.3
Calliostoma ligatum		12.5	41.7	75.0
Calliostoma sp.	7.1	20.8		
Conus californicus			4.2	4.2
Epitonium tinctum		4.2		8.3
Fissurella volcano				8.3
Homalopoma luridum		4.2	33.3	66.7
Lacuna sp.				4.2
Mopalia sp.			12.5	
Ocenebra sp.			4.2	25.0
Olivella biplicata				
Petaloconchus montereyensis				12.5
Pholads			25.0	
Pododesmus cepio		4.2		4.2
Pseudomelatoma torosa				16.7
Rostanga pulchra				4.2

Serpulorbis squamigerus		45.8	58.3	83.3
Tegula brunnea	35.7	33.3	83.3	83.3
Tegula montereyi		16.7	26.8	33.3
Tegula pulligo			29.2	62.5
Tetraclita	7.1			
Tonicella lineata	42.8	83.3	79.2	66.7
Zirfaea pilsbryi	7.1			
PORIFERA				
Acarnus erithacus			4.2	
Hymenanphiastra cyanocrypta				4.2
Leucandra heathi			50.0	50.0
Leucilla nuttingi	21.4	20.8	58.3	70.8
Leucosolenia sp.				8.3
TOTAL STATIONS	14	24	24	24

Appendix 7b. Frequency of Occurrence of Non-quantified Invertebrates Observed at 30-m^2 Random Subtidal Stations, North Control. DCPP, 1974-1977.

Species	1974	1975	1976	1977
ANNELIDIA				
Aphrodite sp.			4.2	
Chaetopterus raropedatus				8.7
Diopatra sp.		4.2	41.7	52.2
Eudistylia polymorpha	21.4	33.3	79.2	69.6
Myxicola sp.			4.2	34.8
Phragmatopoma californica				26.1
Pista sp.		8.3	37.5	87.0
Salmacina tribranchiata			8.3	21.7
Serpula vermicularis				
Serpulidae		37.5	54.2	78.3
Terebellidae			20.8	30.4
ARTHROPODA				
Balanus spp.	7.1	8.3	16.7	52.2
Balanus nubilus				8.7
Balanus tintinnabulum			4.2	
Heptacarpus brevirostris				4.3
Lebbeus lagunae				4.3
Lophopanopeus bellus				13.0
Mimulus foliatus			8.3	13.0
Pagurus spp.	50.0	20.8	70.8	87.0
Pandalus gurneyi	7.1			8.7

Petrolisthes cinctipes				13.0
Phyllolithodes papillosus			4.2	
Spirontocaris prionota				4.3
Xanthias taylori				4.3
CHORDATA				
Aplidium sp.			12.5	
Archidistoma spp.			4.2	
Ciona intestinalis			4.2	
Clavelina huntsmani		4.2	4.2	4.3
Cnemidocarpa finmarkiensis		12.5	16.7	30.4
Mogula sp.				4.3
Pynnoklavella stanleyi			4.2	
Pyura haustor		4.2	8.3	69.6
Styela gibbsi				4.3
Trididemnum opacum			20.8	
CNIDARIA				
Abeitinaria sp.				4.3
Aglaophenia sp.	7.1	12.5	33.3	39.1
Allopora sp.			12.5	
Allopora californica	7.1	4.2		
Allopora porphyra	7.1	8.3	4.2	
Balanophyllia elegans	78.5	87.5	87.5	91.3
Cactosoma arenaria			8.3	17.4
Corynactis californica	35.7	12.5	20.8	21.7
Epiactis prolifera	21.4	50.0	75.0	87.0
Pachycerianthus fimbriatus				

Paracyathus stearnsii	14.3	29.2	29.2	17.4
Tubularia sp.				4.3
ECHINODERMATA				
Cucumaria sp.				60.7
Cucumaria miniata	21.4	20.8	29.2	17.4
Eupentacta quinquesemita	7.1	33.3	41.7	60.9
Leptasterias aequalis	28.6	75.0	75.0	78.3
Lissothuria nutriens			4.2	8.7
Ophioplocus esmarki		4.2	41.7	52.2
Ophiothrix spiculata			4.2	26.1
Psolus chitonoides			4.2	
ECTOPROCTA				
Barentsia sp.				4.3
Celleporaria brunnea			4.2	
Crisia sp.			8.3	21.7
Diaperoecia californica	7.1	8.3	12.5	17.4
Eurystomella bilabiata			12.5	
Flustrella corniculata	7.1	4.2		
Heteropora magna				
Hippodiplosia insculpta		8.3	25.0	
Phidolopora pacifica	28.6	16.7	12.5	13.0
MOLLUSCA				
Acmaea mitra	7.1	50.0	62.5	82.6
Aldisa sanquinea			4.2	
Amphissa sp.		8.3	4.2	47.8
Calliostoma sp.	14.3	8.3		

Calliostoma annulatum	14.3	8.3	16.7	34.8
Calliostoma canaliculatum			8.3	21.7
Calliostoma ligatum		66.7	83.3	87.0
Calliostoma gloriosum			8.7	
Chama pellucida				4.3
Conus californicus			8.3	21.7
Epitonium tinctum			4.2	4.3
Fissurella volcano			8.3	8.7
Fusinus sp.			4.2	13.0
Homalopoma luridum			45.8	78.3
Ischnochiton regularis				4.3
Lepidozona mertensii				4.3
Megatebennus bimaculatus				8.7
Mitrella sp.				17.4
Mopalia spp.			8.3	21.7
Ocenebra spp.			16.7	78.2
Petaloconchus montereyensis				13.0
Pholads			8.3	13.0
Placophorella velata				4.3
Pododesmus cepio	7.1	4.2	8.3	26.1
Pseudomelatoma torosa			25.0	43.5
Rostanga pulchra				4.3
Searlsia dira				4.3
Serpulorbis squamigerus		50.0	75.0	82.6
Tegula brunnea	57.1	58.3	75.0	91.3
Tegula montereyi		29.1	25.0	21.7
Tegula pulligo			20.8	78.3
Tonicella lineata	64.3	83.3	83.3	100.0

PLATYHELMINTHES				
Hoplopana californica			4.2	
PORIFERA				
Acarnus erithacus		4.2	8.3	
Hymenanphiastra cyanocrypta				13.0
Leucandra heathi			70.8	65.2
Leucilla nuttingi		16.7	41.7	52.2
Leucosolenia sp.			4.2	21.7
Polymastia pachymastia		4.2	4.2	
Spheciospongia confoederata			4.2	
Toxadocia sp.			4.2	
TOTAL STATIONS	14	24	24	23

Appendix 7c. Frequency of Occurrence of Non-quantified Invertebrates at Random 0.25-m^2 Subtidal Stations, Diablo Cove and North Control. DCPP, 1975-1978.

	Diablo Cove				North Control		
	1975	1976	1977	1978	1976	1977	1978
ANNELIDA							
Phragmatopoma californica	0.0	0.0	5.2	5.2	2.1	10.7	5.2
Sabellidae	0.0	0.0	0.0	0.0	8.3	2.4	0.0
Salmacina tribranchiata	0.0	2.1	2.1	0.0	0.0	1.2	0.0
Serpulidae	40.6	20.8	25.0	8.3	12.5	16.7	8.3
Terebellidae	12.5	10.4	3.1	0.0	2.1	8.3	0.0
ARTHROPODA							
Balanus spp.	25.0	10.4	28.1	9.4	10.4	27.4	9.4
Pagurus spp.	21.9	35.4	37.5	36.4	25.0	59.5	3.1
CHORDATA							
Aplidium sp.	0.0	0.0	2.1	2.1	2.1	0.0	2.1
Didemnum sp.	0.0	0.0	1.0	0.0	0.0	0.0	0.0
Trididemnum opacum	0.0	2.1	0.0	1.0	0.0	0.0	1.0
CNIDARIA							
Aglaophenia sp.	3.1	2.1	10.4	15.6	4.2	10.1	15.6
Allopora porphyra	3.1	0.0	0.0	0.0	0.0	0.0	0.0
ECTOPROCTA							
Eurystomella bilabiata	0.0	0.0	5.2	1.0	14.6	3.6	0.0
Crisia sp.	0.0	0.0	14.6	0.0	0.0	9.5	25.0
MOLLUSCA							
Amphissa sp.	0.0	18.8	38.5	30.2	12.5	46.4	30.2
Bittium sp.	0.0	0.0	3.1	0.0	0.0	2.4	0.0
Mitrella sp.	0.0	8.3	11.4	14.6	2.1	11.9	14.6
Petalochonchus montereyensis	0.0	0.0	14.6	27.1	0.0	28.8	27.1
Pholididae	43.8	50.0	52.1	0.0	18.8	38.1	10.4
PORIFERA							
Leucosolenia sp.	0.0	0.0	1.0	0.0	0.0	3.6	0.0
TOTAL QUADRATS	32	48	96	96	48	84	96

APPENDIX 8b. Numbers or Estimates of Abundance of Brown Algae and Invertebrates Observed at Permanent Subtidal Station 6, Field's Cove. DCPP, 1974-1978.

Species	YEAR	1974	1974	1975	1975	1976	1976	1977	1978	1978
	MONTH	JULY	OCT	JULY	NOV	MAR	OCT	APR	JUN	DEC
PHAEOPHYTA										
Cystoseira osmundacea		2	Sc	19	24	22	21	Sc	Sc	C
Desmarestia sp.		P	Sc	C	C	0	Sc	0	Sc	C
Dictyoneurum californicum		P	0	C	C	C	C	Sc	Sc	C
Laminaria dentigera		20	6	27	17	22	29	24	39	43
Macrocystis pyrifera		0	0	0	0	0	0	0	1	3
Nereocystis luetkeana		72	44	7	3	1	0	0	7	3
Pterygophora californica		31	43	114	104	163	79	97	133	161
ANNELIDA										
Diopatra sp.		0	0	0	C	A	0	Sc	C	0
Dodecaceria fewkesi		0	0	0	0	0	0	0	Sc	0
Eudistylia polymorpha		0	0	0	Sc	C	C	C	Sc	3
Pista sp.		0	0	0	0	0	0	C	Sc	Sc
Serpulidae		0	C	0	0	0	0	Sc	C	Sc
Terebellidae		0	0	0	0	0	Sc	0	0	0
ARTHROPODA										
Cancer antennarius		1	0	1	0	4	1	6	0	1
Loxorhynchus crispatus		0	2	0	0	0	2	1	0	0
Pandalus gurneyi		0	2	0	0	0	0	1	0	0
Pugettia producta		1	0	0	0	1	0	0	0	0

COELENTERATA									
Aglaophenia sp.	0	0	0	0	0	Sc	Sc	0	0
Allopora porhyra	0	0	0	P	0	Sc	0	0	0
Anthopleura artemisia	0	Sc	0	1	0	0	0	2	1
Anthopleura xanthogrammica	1	2	0	0	0	0	2	1	3
Astrangia lajollanensis	0	0	0	0	0	0	0	Sc	Sc
Balanophyllia elegans	C	Sc	0	A	A	C	C	C	A
Coenocyathus sp.	0	0	0	0	0	0	0	0	Sc
Corynactis californica	C	Sc	C	C	C	C	C	A	A
Epiactis prolifera	0	0	0	0	0	0	0	Sc	0
Paracyathus stearnsii	C	Sc	Sc	A	C	C	C	Sc	0
Tealia crassicornis	1	2	3	1	1	1	0	2	2
Tealia lofotensis	0	0	4	1	3	4	4	5	3
Unidentified solitary coral	0	0	0	0	0	S	0	0	0
ECHINODERMATA									
Cucumaria miniata	0	0	6	0	4	0	4	C	2
Cucumaria sp.	0	0	0	0	0	0	0	Sc	0
Eupentacta quinquesemita	0	0	0	0	0	0	0	Sc	1
Henricia levivscula	0	0	1	0	0	0	1	1	0
Leptasterias hexactis	0	0	0	0	0	3	0	C	0
Ophioplocus esmarki	0	0	0	0	0	1	0	0	0
Orthasterias koehleri	5	8	2	6	6	1	5	3	7
Parastichopus californicus	0	0	8	1	10	1	19	17	0
Parastichopus parvimensis	0	0	5	0	9	0	1	4	4
Parastichopus spp.	4	3	0	0	0	0	0	0	0
Patiria miniata	211	176	151	221	212	90	149	166	158
Pisaster brevispinus	5	4	3	5	6	10	1	0	0
Pisaster giganteus	13	8	10	5	11	12	13	19	26
Pisaster ochraceous	2	3	4	2	3	3	3	1	7
Pycnopodia helianthoides	0	3	1	1	3	0	0	0	0
Strongylocentrotus franciscanus	78	40	40	36	37	32	27	1	6
Strongylocentrotus purpuratus	2	4	4	4	3	1	6	0	0
Strongylocentrotus sp.	0	0	0	0	0	0	0	8	0
Stylasterias forreri	0	2	0	0	2	1	5	4	0

ECTOPROCTA									
Celleporaria brunnea	0	0	0	0	0	Sc	0	0	0
Crisia sp.	0	0	0	0	0	0	0	C	0
Diaperoecia californica	Sc	0	0	Sc	0	Sc	0	0	0
Heteropora magna	0	0	0	0	0	Sc	0	Sc	0
Phidolopora pacifica	C	Sc	0	Sc	Sc	Sc	C	Sc	0
MOLLUSCA									
Acmaea mitra	0	0	0	0	0	C	0	0	0
Aegires albopunctatus	0	0	0	0	0	0	1	0	0
Anisodoris nobilis	0	0	1	0	4	2	0	1	1
Archidoris montereyensis	0	2	0	1	0	3	0	1	0
Astraea gibberosa	0	1	0	1	0	0	0	0	0
Cadlina flavomaculata	0	0	0	0	0	0	0	1	0
Cadlina luteomarginata	0	0	1	0	0	0	0	0	0
Calliostoma annulatum	0	Sc	5	0	Sc	C	5	Sc	1
Calliostoma ligatum	0	0	0	0	Sc	C	C	Sc	0
Calliostoma sp.	1	0	0	0	0	0	0	0	0
Ceratostoma foliatum	0	1	0	0	0	0	0	0	0
Coryphella fisheri	0	0	0	0	0	0	1	0	0
Cryptochiton stelleri	0	1	0	0	0	0	0	0	0
Discodoris sandiegensis	1	2	1	2	2	6	3	0	2
Doriopsilla albopunctata	2	8	6	1	10	11	15	17	3
Flabellinopsis iodinea	0	0	0	0	0	0	3	0	2
Haliotis kamtschatkana	0	0	1	0	0	0	0	0	0
Haliotis rufescens	0	1	0	0	0	0	0	1	0
Hermissenda crassicornis	0	1	0	0	0	0	0	1	0
Hinnites multirugosus	0	1	0	0	4	3	8	1	3
Hopkinsia rosacea	0	0	0	0	0	0	2	0	0
Mitra idae	5	1	3	3	10	8	11	5	7
Ocenebra sp.	0	0	0	0	0	0	7	1	1
Phidiana nigra	3	0	6	0	0	0	0	0	0
Serpulorbis squamigerus	0	Sc	C	C	C	C	C	C	C
Tegula brunnea	0	0	0	0	Sc	0	0	Sc	C
Tegula montereyi	0	2	0	0	0	0	0	Sc	0
Tegula sp.	1	0	0	0	0	0	0	0	0

Tonicella lineata	P	Sc	31	0	3	C	0	Sc	C
Triopha catalinae	0	0	3	1	0	2	0	0	0
Unidentified nudibranch	0	P	0	0	0	0	0	0	0
Unidentified pholad	0	0	0	0	0	0	0	0	Sc
PORIFERA									
Hymenamphiastra cyanocrypta	0	0	0	0	0	0	0	0	Sc
Leucandra heathi	0	0	0	0	0	Sc	0	Sc	Sc
Leucilla nuttingi	0	Sc	0	0	0	Sc	C	Sc	C
Speciospongia confoederata	0	0	0	P	0	0	0	0	0
Tethya aurantia	3	2	0	4	4	0	6	1	1
Unidentified sponge	1	P	0	0	0	0	0	0	0
UROCHORDATA									
Boltenia villosa	0	0	1	2	4	Sc	1	Sc	0
Cnemidocarpa finmarkiensis	0	1	0	0	0	0	0	0	0
Pyura haustor	0	0	0	0	0	Sc	8	Sc	0
Styela montereyensis	4	7	7	18	32	29	8	13	7
Unidentified tunicate	0	0	0	0	Sc	0	0	0	0

A = Abundant C = Common P = Present Sc = Scarce

Appendix 8a. Numbers or Estimates of Abundance of Brown Algae and Invertebrates Observed at Permanent Subtidal Station 1, Diablo Cove. DCPP, 1977-1978.

SPECIES	YEAR MONTH	1977 DEC	1978 JUNE
PHAEOPHYTA			
Cystoseira osmundacea		2	0
Desmarestia ap.		0	C
Dictyoneurom californicum		Sc	C
Laminaria dentigera		176	197
Nereocystis leutkeana		6	111
Pterogyphora californica		19	21
ANNELIDA			
Eudistylia polymorpha		C	Sc
Serpulidae		Sc	0
ARTHROPODA			
Balanus nubilus		C	0
Balanus sp.		A	Sc
Cancer antennarius		2	0
Scyra acutifrons		2	0

Appendix 8a. (continued)

SPECIES	YEAR MONTH	1977 DEC	1978 JUNE
ARTHROPODA (continued)			
Unidentified shrimp		1	0
COLENTERATA			
Aglaophenia sp.		0	Sc
Allopora californica		6	0
Allopora sp.		0	9
Anthopleura artemisia		5	0
Balanophyllia elegans		C	Sc
Corynactis californica		A	A
Epiactis prolifera		Sc	Sc
Paracyathus stearnsii		Sc	0
Tealia crassicornis		0	1
Tealia lofotensis		25	17
ECHINODERMATA			
Cucumaria miniata		1	Sc

Appendix 8a. (continued)

SPECIES	YEAR MONTH	1977 DEC	1978 JUNE
ECHINODERMATA (continued)			
Henricia leviuscula		16	3
Leptasterias spp.		C	0
Ophiothrox spiculata		Sc	0
Orthasterias koehleri		4	5
Patiria miniata		108	77
Pisaster giganteus		55	90
Pisaster ochraceous		18	50
Pisaster sp.		13	0
Pycnopodia helianthoides		4	4
Strongylocentrotus franciscanus		142	36
Strongylocentrotus purpuratus		11	4
Stylasterias forreri		1	0
ECTOPROCTA			
Crisia sp.		C	0
Diaperoecia californica		C	0

Appendix 8a. (continued)

SPECIES	YEAR MONTH	1977 DEC	1978 JUNE
ECTOPROCTA (continued)			
Flustrella corniculata		Sc	0
Hippodiplosia insculpta		Sc	0
MOLLUSCA			
Anisodoris nobilis		7	0
Cadlina sparsa		3	0
Cadlina luteomarginata		1	0
Calliostoma annulatom		Sc	Sc
Calliostoma ligatum		C	Sc
Calliostoma canaliculatum		Sc	0
Doriopsilla albupunctata		34	3
Dendronotus spp.		1	0
Discodoris heathi		2	0
Hinnites multirugosus		27	Sc
Pododesmus cepio		0	Sc
Tonicella lineata		Sc	C

Appendix 8a. (continued)

	YEAR	1977	1978
SPECIES	MONTH	DEC	JUNE
MOLLUSCA (continued)			
Triopha catalinae		4	0
PORIFERA			
Leucandra heathi		C	0
Leucilla nuttingi		C	Sc
Tethya aurantia californica		1	3
UROCHORDATA			
Aplidium sp.		0	A
Boltenia villosa		Sc	0
Pyura haustor		3	0
Styela montereyensis		7	4

A = Abundance C = Common P = Present Sc = Scarce

APPENDIX 8a. Numbers or Estimates of Abundance of Brown Alage and Invertebrates Observed at Permanent Subtidal Station 1, Diablo Cove. DCPP, 1977-1978.

SPECIES	YEAR MONTH	1977 DEC	1978 JUNE
PHAEOPHYTA			
Cystoseira osmundacea		2	0
Desmarestia sp.		0	C
Dictyoneurum californicum		Sc	C
Laminaria dentigera		176	197
Nereocystis luetkeana		6	111
Pterygophora californica		19	21
ANNELIDA			
Eudistylia polymorpha		C	Sc
Serpulidae		Sc	0
ARTHROPODA			
Balanus nubilus		C	0
Balanus sp.		A	Sc
Cancer antennarius		2	0
Scyra acutifrons		2	0
Unidentified shrimp		1	0
COELENTERATA			
Aglaophenia sp.		0	Sc
Allopora californica		6	0
Allopora sp.		0	9
Anthopleura artemisia		5	0
Balanophyllia elegans		C	Sc
Corynactis californica		A	A
Epiactis prolifera		Sc	Sc
Paracyathus stearnsii		Sc	0
Tealia crassicornis		0	1
Tealia lofotensis		25	17
ECHINODERMATA			
Cucumaria miniata		1	Sc
Henricia levivscula		16	3
Leptasterias spp.		C	0
Ophithrix spiculata		Sc	0
Orthasterias koehleri		4	5
Patiria miniata		108	77
Pisaster giganteus		55	90
Pisaster ochraceous		18	50
Pisaster sp.		13	0

Pycnopodia helianthoides	4	4
Strongylocentrotus franciscanus	142	36
Strongylocentrotus purpuratus	11	4
Stylasterias forreri	1	0
ECTOPROCTA		
Crisia sp.	C	0
Diaperoecia californica	C	0
Flustrella corniculata	Sc	0
Hippodiplosia insculpta	Sc	0
MOLLUSCA		
Anisodoris nobilis	7	0
Cadlina sparsa	3	0
Cadlina luteomarginata	1	0
Calliostoma annulatum	Sc	Sc
Calliostoma ligatum	C	Sc
Calliostoma canaliculatum	Sc	0
Doriopsilla albopunctata	34	3
Dendronotus spp.	1	0
Discodoris heathi	2	0
Hinnites multirugosus	27	Sc
Pododesmus cepio	0	Sc
Tonicella lineata	Sc	C
Triopha catlinae	4	0
PORIFERA		
Leucandra heathi	C	0
Leucilla nuttingi	C	Sc
Tethya aurantia	1	3
UROCHORDATA		
Aplidium sp.	0	A
Boltenia villosa	Sc	0
Pyura haustor	3	0
Styela montereyensis	7	4

A = Abundant C = Common P = Present Sc = Scarce

Appendix 8b. Numbers or Estimates of Abundance of Brown Algae and Invertebrates Observed at Permanent Subtidal Station 6, Diablo Cove. DCPP, 1977-1978.

SPECIES	YEAR MONTH	1974 JULY	1974 OCT	1975 JULY	1975 NOV	1976 MAR	1976 OCT	1977 APR	1978 JUN	1978 DEC
PHAEOPHYTA										
Cystoseira osmundacea		2	Sc	19	24	22	21	Sc	Sc	C
Desmarestia ligulata		P	Sc	C	C	0	Sc	0	Sc	C
Dictyoneurum californicum		P	0	C	C	C	C	Sc	Sc	C
Laminaria dentigera		20	6	27	17	22	29	24	39	43
Macrocystis pyrifera		0	0	0	0	0	0	0	1	3
Nereocystis luetkeana		72	44	7	3	1	0	0	7	3
Pterygophora californica		31	43	114	104	163	79	97	133	161
ANNELIDA										
Diopatra sp.		0	0	0	C	A	0	Sc	C	0
Dodecaceria fewkesi		0	0	0	0	0	0	0	Sc	0
Eudistylia polymorpha		0	0	0	Sc	C	C	C	Sc	3
Pista sp.		0	0	0	0	0	0	C	Sc	Sc
Serpulidae		0	C	0	0	0	0	Sc	C	Sc
Terebellidae		0	0	0	0	0	Sc	0	0	0

Appendix 8b. (continued)

SPECIES	YEAR MONTH	1974 JULY	1974 OCT	1975 JULY	1975 NOV	1976 MAR	1976 OCT	1977 APR	1978 JUN	1978 DEC
ARTHROPODA										
Cancer antennarius		1	0	1	0	4	1	6	0	1
Loxorhynchus crispatus		0	2	0	0	0	2	1	0	0
Pandalus gurneyi		0	2	0	0	0	0	1	0	0
Pugettia producta		1	0	0	0	1	0	0	0	0
COELENTERATA										
Aglaophenia sp.		0	0	0	0	0	Sc	Sc	0	0
Allopora porphyra		0	0	0	P	0	Sc	0	0	0
Anthopleura artemisia		0	Sc	0	1	0	0	0	2	1
Anthopleura xanthogrammica		1	2	0	0	0	0	2	1	3
Astrangia lajollanensis		0	0	0	0	0	0	0	Sc	Sc
Balanophyllia elegans		C	Sc	0	A	A	C	C	C	A
Coenocyathus sp.		0	0	0	0	0	0	0	0	Sc
Corynactis californica		C	Sc	C	C	C	C	C	A	A
Epiactis prolifera		0	0	0	0	0	0	0	Sc	0
Paracyathus stearnsii		C	Sc	Sc	A	C	C	C	Sc	0

Appendix 8b. (continued)

SPECIES	YEAR MONTH	1974 JULY	1974 OCT	1975 JULY	1975 NOV	1976 MAR	1976 OCT	1977 APR	1978 JUN	1978 DEC
COELENTERATA (continued)										
Tealia crassicornis		1	2	3	1	1	1	0	2	2
Tealia lofotensis		0	0	4	1	3	4	4	5	3
unidentified solitary coral		0	0	0	0	0	S	0	0	0
ECHINODERMATA										
Cucumaria miniata		0	0	6	0	4	0	4	C	2
Cucumaria sp.		0	0	0	0	0	0	0	Sc	0
Eupentacta quinquisemita		0	0	0	0	0	0	0	Sc	1
Henricia levivscula		0	0	1	0	0	0	1	1	0
Leptasterias hexactis		0	0	0	0	0	3	0	C	0
Ophioplocus esmarki		0	0	0	0	0	1	0	0	0
Orthasterias koehleri		5	8	2	6	6	1	5	3	7
Parastichopus californicus		0	0	8	1	10	1	19	17	0
Parastichopus parvimensis		0	0	5	0	9	0	1	4	4
Parastichopus spp.		4	3	0	0	0	0	0	0	0
Patria miniata		211	176	151	221	212	90	149	166	158

Appendix 8b. (continued)

	YEAR	1974	1974	1975	1975	1976	1976	1977	1978	1978
SPECIES	MONTH	JULY	OCT	JULY	NOV	MAR	OCT	APR	JUN	DEC
ECHINODERMATA (continued)										
Pisaster brevispirus		5	4	3	5	6	10	1	0	0
Pisaster giganteus		13	8	10	5	11	12	13	19	26
Pisaster ochraceous		2	3	4	2	3	3	3	1	7
Pycnopodia helianthoides		0	3	1	1	3	0	0	0	0
Strongylocentrotus franciscanus		78	40	40	36	37	32	27	1	6
Strongylocentrotus purpuratus		2	4	4	4	3	1	6	0	0
Strongylocentrotus sp.		0	0	0	0	0	0	0	8	0
Stylasterias forreri		0	2	0	0	2	1	5	4	0
ECTOPROCTA										
Celleporaria brunnea		0	0	0	0	0	Sc	0	0	0
Crisia sp.		0	0	0	0	0	0	0	C	0
Diaperoecia californica		Sc	0	0	Sc	0	Sc	0	0	0
Heteropora magna		0	0	0	0	0	Sc	0	Sc	0
Phidolopora pacifica		C	Sc	0	Sc	Sc	Sc	C	Sc	0
MOLLUSCA										
Acmaea mitra		0	0	0	0	0	C	0	0	0

Appendix 8b. (continued)

SPECIES	YEAR MONTH	1974 JULY	1974 OCT	1975 JULY	1975 NOV	1976 MAR	1976 OCT	1977 APR	1978 JUN	1978 DEC
MOLLUSCA (continued)										
Aegires albopunctatus		0	0	0	0	0	0	1	0	0
Anisodoris nobilis		0	0	1	0	4	2	0	1	1
Archidoris montereyensis		0	2	0	1	0	3	0	1	0
Astraea gibberosa		0	1	0	1	0	0	0	0	0
Cadlina flavomaculata		0	0	0	0	0	0	0	1	0
Cadlina luteomarginata		0	0	1	0	0	0	0	0	0
Calliostoma annutatum		0	Sc	5	0	Sc	C	5	Sc	1
Calliostoma ligatum		0	0	0	0	Sc	C	C	Sc	0
Calliostoma sp.		1	0	0	0	0	0	0	0	0
Ceratostoma foliatum		0	1	0	0	0	0	0	0	0
Coryphella fisheri		0	0	0	0	0	0	1	0	0
Cryptochiton stelleri		0	1	0	0	0	0	0	0	0
Discodoris sandiegensis		1	2	1	2	2	6	3	0	2
Doriopsilla albopunctata		2	8	6	1	10	11	15	17	3
Flabellinopsis iodinea		0	0	0	0	0	0	3	0	2
Haliotis kamtschatkana		0	0	1	0	0	0	0	0	0

Appendix 8b. (continued)

SPECIES	YEAR MONTH	1974 JULY	1974 OCT	1975 JULY	1975 NOV	1976 MAR	1976 OCT	1977 APR	1978 JUN	1978 DEC
MOLLUSACA (continued)										
Haliotis rufescens		0	1	0	0	0	0	0	1	0
Hermissenda crassicornis		0	1	0	0	0	0	0	1	0
Hinnites multirugosus		0	1	0	0	4	3	8	1	3
Hopkinsia rosacea		0	0	0	0	0	0	2	0	0
Mitra ida		5	1	3	3	10	8	11	5	7
Ocenebra sp.			0	0	0	0	0	7	1	1
Phidiana nigra		3	0	6	0	0	0	0	0	0
Serpulorbis squamigerus		0	Sc	C	C	C	C	C	C	C
Tegula brunnea		0	0	0	0	Sc	0	0	Sc	C
Tegula montereyi		0	2	0	0	0	0	0	Sc	0
Tegula sp.		1	0	0	0	0	0	0	0	0
Tonicella lineata		P	Sc	31	0	3	C	0	Sc	C
Triopha catalinae		0	0	3	1	0	2	0	0	0
Unidentified nudibranch		0	P	0	0	0	0	0	0	0
Unidentified pholad		0	0	0	0	0	0	0	0	Sc

Appendix 8b. (continued)

SPECIES	YEAR MONTH	1974 JULY	1974 OCT	1975 JULY	1975 NOV	1976 MAR	1976 OCT	1977 APR	1978 JUN	1978 DEC
PORIFERA										
Hymenamphiastra		0	0	0	0	0	0	0	0	Sc
Leucandra heathi		0	0	0	0	0	Sc	0	Sc	Sc
Leucilla nuttingi		0	Sc	0	0	0	Sc	C	Sc	C
Speciospongia confoederata		0	0	0	P	0	0	0	0	0
Tethya aurantia californiana		3	2	0	4	4	0	6	1	1
Unidentified sponge		1	P	0	0	0	0	0	0	0
UROCHORDATA										
Boltenia villosa		0	0	1	2	4	Sc	1	Sc	0
Cnemidocarpa finmarkiensis		0	1	0	0	0	0	0	0	0
Pyura haustor		0	0	0	0	0	Sc	8	Sc	0
Styela montereyensis		4	7	7	18	32	29	8	13	7
Unidentified tunicate		0	0	0	0	Sc	0	0	0	0

A = Abundant C = Common P = Present Sc = Scarce

Appendix 8c. Numbers or Estimates of Abundance of Brown Algae and Invertebrates Observed at Permanent Subtidal Station 7, Fields's Cove. DCPP, 1973-1977.

SPECIES	YEAR MONTH	1973 SEP	1974 MAR	1974 AUG	1974 OCT	1975 AUG	1975 NOV	1976 APR	1976 NOV	1977 APR
PHAEOPHYTA										
Cystoseira osmundacea		0	0	0	2	20	0	P	Sc	C
Desmarestia ligulata		0	0	24	Sc	C	Sc	0	0	0
Dictyoneurum californicum		0	0	A	Sc	Sc	Sc	Sc	0	0
Dictyota sp.		0	0	0	0	C	0	0	Sc	0
Laminaria dentigera		0	0	6	12	47	25	22	37	41
Nereocystis luetkeana		0	0	43	34	47	6	7	0	0
Pterygophora californica		0	0	111	232	373	283	296	379	336
ANNELIDA										
Diopatra sp.		0	0	0	0	Sc	Sc	P	P	C
Eudistylia polymorpha		0	Sc	0	P	Sc	Sc	P	0	Sc
Myxicola sp.		0	0	0	0	0	0	0	3	4
Pista sp.		0	0	0	0	Sc	0	0	Sc	C
Serpulidae		0	0	0	0	0	0	0	C	Sc
Terebellid polychaetes		C	0	0	0	C	0	0	0	0

Appendix 8c. (continued)

SPECIES	YEAR MONTH	1973 SEP	1974 MAR	1974 AUG	1974 OCT	1975 AUG	1975 NOV	1976 APR	1976 NOV	1977 APR
ARTHROPOD										
Cancer antennarius		0	1	0	0	0	1	1	0	1
Loxorhynchus crispatus		0	0	0	1	0	1	0	2	0
Pagurus sp.		C	0	0	P	0	0	0	3	2
Pugettia producta		0	0	0	0	0	0	0	1	1
Pugettia richii		0	0	0	0	0	0	0	1	0
COELENTERATA										
Aglaophenia sp.		0	0	0	0	0	0	0	Sc	Sc
Allopora porphyra		0	0	0	0	Sc	0	0	0	0
Anthopleura artemesia		C	2	0	1	1	10	7	2	33
Anthopleura xanthogrammica		0	0	1	0	2	1	2	1	4
Balanophyllia elegans		C	Sc	C	0	C	C	C	C	C
Corynactis californica		0	0	0	0	0	0	0	Sc	Sc
Epiactis prolifera		0	0	0	0	0	0	0	Sc	0
Paracyathis stearnsii		Sc	Sc	C	0	Sc	Sc	0	Sc	0
Telia crassicornis		1	1	1	1	1	1	1	1	0
Telia lofotensis		3	3	1	3	1	1	0	2	4

Appendix 8c. (continued)

YEAR	1973	1974	1974	1974	1975	1975	1976	1976	1977
SPECIES MONTH	SEP	MAR	AUG	OCT	AUG	NOV	APR	NOV	APR
ECHINODERMATA									
Cucumaria miniata	Sc	0	0	0	7	0	11	A	0
Eupentacta quinquisemita	0	2	0	0	11	0	1	C	0
Henricia leviuscula	2	1	0	1	2	3	1	2	3
Ophioplocus esmarki	0	0	0	0	Sc	0	0	12	0
Ophiothrix spiculata	0	0	0	0	C	0	0	0	0
Orthasterias koehleri	4	4	3	3	0	2	2	10	9
Parastichopus californicus	0	0	0	0	0	0	0	0	3
Parastichopus spp.	1	1	0	0	0	0	0	0	0
Patiria miniata	195	167	78	86	50	73	86	134	141
Pisaster brevispinus	10	5	6	17	6	10	10	3	13
Pisaster giganteus	9	9	6	12	6	7	16	8	21
Pisaster ochraceous	0	0	4	1	0	0	1	2	1
Pycnopodia helianthoides	0	1	1	1	5	3	0	0	2
Strongylocentrotus franciscanus	131	137	75	84	41	30	22	59	16
Strongylocentrotus purpuratus	0	0	0	0	0	0	0	2	1
Stylasterias forreri	0	0	0	0	0	0	1	0	0

Appendix 8c. (continued)

SPECIES	YEAR	1973	1974	1974	1974	1975	1975	1976	1976	1977
	MONTH	SEP	MAR	AUG	OCT	AUG	NOV	APR	NOV	APR
ECTOPROCTA										
Diaperoecia californica		0	0	0	0	P	0	0	Sc	0
Phidolopora pacifica		0	0	0	0	Sc	0	0	Sc	0
MOLLUSCA										
Acmaea mitra		0	0	0	0	Sc	0	0	0	P
Acmaea sp.		Sc	0	0	0	0	0	0	0	0
Anisodoris nobilis		0	0	1	0	2	1	3	0	3
Archidoris montereyensis		0	0	1	0	1	0	1	1	0
Archidoris odhneri		0	0	0	0	0	0	1	1	0
Astraea gibberosa		4	4	0	6	1	2	4	2	2
Cadlina flavomaculata		0	0	0	0	0	0	0	2	0
Cadlina luteomarginata		0	0	1	0	0	0	0	3	1
Calliostoma annulatum		0	0	0	0	1	0	0	0	0
Calliostoma canaliculatum		0	0	0	0	0	0	0	Sc	2
Calliostoma gloriosum		0	0	0	2	0	0	0	0	0
Calliostoma ligatum		0	0	0	0	Sc	0	0	C	7

Appendix 8c. (continued)

SPECIES	YEAR MONTH	1973 SEP	1974 MAR	1974 AUG	1974 NOV	1975 AUG	1975 NOV	1976 APR	1976 NOV	1977 APR
MOLLUSCA (continued)										
Calliostoma sp.		Sc	0	2	0	0	0	0	0	0
Ceratostoma foliatum		0	0	0	1	0	0	0	2	0
Cryptochiton stelleri		0	3	1	0	1	0	1	2	0
Discodoris sandiegensis		1	0	2	2	2	0	1	1	0
Doriopsilla albopunctata		1	9	1	3	15	3	3	6	19
Haliotis kamtschatkana		0	1	0	0	0	0	0	0	0
Haliotis rufescens		1	0	0	0	1	0	0	1	0
Hermissenda crassicornis		5	0	0	0	0	0	0	0	0
Hinnites multirugosus		0	0	0	0	1	0	0	7	0
Mitra idae		Sc	Sc	3	9	9	2	0	12	39
Olivella biplicata		0	0	0	0	0	0	0	0	P
Phidiana hiltoni		0	0	0	0	1	0	0	0	0
Pseudomelatoma torosa		0	0	0	0	0	0	0	0	1
Serpulorbis squamigerus		0	0	0	0	Sc	0	0	C	Sc
Tegula brunnea		0	0	0	0	Sc	Sc	Sc	Sc	0

Appendix 8c. (continued)

SPECIES	YEAR MONTH	1973 SEP	1974 MAR	1974 AUG	1974 MAR	1975 AUG	1975 NOV	1976 APR	1976 NOV	1977 APR
MOLLUSCA (continued)										
Tegula montereyi		0	0	0	0	Sc	C	Sc	Sc	0
Tegula pulligo		Sc	0	0	0	0	0	0	0	0
Tonicella lineata		Sc	Sc	4	C	C	0	0	C	P
Triopha catalinae		0	0	0	0	5	3	1	2	2
Triopha maculata		0	0	0	0	0	0	0	1	0
unidentified pholads		0	0	0	0	0	0	0	C	0
PORIFERA										
Leucandra heathi		0	0	0	0	0	0	0	4	0
Leucilla nuttingi		0	0	0	0	0	0	0	0	P
Tethya aurantia californica		11	11	12	18	14	11	15	20	26
unidentified sponge		0	0	0	0	Sc	0	0	0	0
UROCHORDATA										
Boltenia villosa		Sc	0	0	1	C	17	0	32	9
Clavelina huntsmani		0	0	0	0	0	0	P	0	C
Cnemidocarpa finmarkiensis		Sc	0	0	4	C	0	0	7	0
Pyura haustor		0	0	0	0	0	2	0	1	0

Appendix 8c. (continued)

SPECIES	YEAR MONTH	1973 SEP	1974 MAR	1974 AUG	1974 OCT	1975 AUG	1975 NOV	1976 APR	1976 NOV	1977 APR
UROCHORDATA (continued)										
Styela montereyensis		0	0	0	4	18	87	103	115	59
Trididemnum opacum		0	0	0	0	0	0	0	0	C

A = Abundant C = Common P = Present Sc = Scarce

Appendix 8d. Numbers or Estimates of Abundance of Brown Algae and Invertebrates Observed at Permanent Subtidal Station 8, Fields's Cove. DCPP, 1973-1977.

SPECIES	YEAR MONTH	1973 SEP	1974 AUG	1974 OCT	1977 APR
PHAEOPHYTA					
Cystoseria osmundacea		0	2	P	8
Desmarestia ligulata		A	C	P	0
Dictyoneurum californicum		A	C	P	C
Laminaria dentigera		C	17	20	76
Nereocystis luetkeana		11	53	47	0
Pterygophora californica		0	48	47	77
Unidentified algae		0	P	0	0
ANNELIDA					
Eudistylia polymorpha		C	C	Sc	C
Myxicola sp.		0	0	0	2
Pista sp.		0	0	0	Sc
Serpulidae		0	0	0	Sc
ARTHROPODA					
Cancer antennarius		1	0	0	0

Appendix 8d. (continued)

SPECIES	YEAR MONTH	1973 SEP	1974 AUG	1974 OCT	1977 APR
ARTHROPODA (continued)					
Loxorhynchus crispatus		0	0	0	1
Pagurus sp.		0	0	0	Sc
Pugettia producta		1	0	0	0
COELENTERATA					
Aglaophenia sp.		0	0	0	Sc
Allopora porphyra		C	0	0	0
Anthopleura artemesia		0	0	0	2
Anthopleura xanthogrammica		2	58	87	91
Balanphyllia elegans		C	A	C	C
Corynactis californica		A	0	0	0
Epiactis prolifera		0	C	0	Sc
Paracyathus stearnsii		Sc	0	0	Sc
Tealia crassicornis		0	3	3	0
Tealia lofotensis		8	0	3	8

Appendix 8d. (continued)

SPECIES	YEAR	1973	1974	1974	1977
	MONTH	SEP	AUG	OCT	APR
MOLLUSCA					
Acmaea mitra		0	0	0	Sc
Acmaea sp.		Sc	0	0	0
Aldisa sanguinea		0	0	0	1
Anisodoris nobilis		0	0	0	1
Astraea gibberosa		1	18	13	22
Calliostoma annulatum		0	0	Sc	1
Calliostoma ligatum		0	0	0	2
Calliostoma sp.		Sc	0	0	0
Chryptochiton stelleri		3	0	1	1
Discodoris heathi		0	0	0	1
Doriopsilla albopunctata		1	9	4	18
Haliotis rufescens		7	0	0	3
Haliotis walallensis		0	0	0	1
Hermissenda crassicornis		0	1	0	0
Homalopoma luridum		0	0	0	C
Hopkinsae rosacea		0	0	0	1

Appendix 8d. (continued)

SPECIES	YEAR MONTH	1973 SEP	1974 AUG	1974 OCT	1977 APR
ECTOPROCTA					
Flustrella corniculata		A	0	0	0
Phidolopora pacifica		Sc	0	0	0
ECHINODERMATA					
Cucumaria miniata		0	0	1	0
Eupentacta quinquesemita		0	1	0	0
Henricia levisucula		5	2	2	11
Leptasterias hexactis		1	0	0	1
Orthasterias koehleri		4	3	0	1
Parastichopus spp.		0	2	0	0
Patiria miniata		214	287	272	213
Pisaster giganteus		14	2	1	4
Pisaster ochraceous		6	0	0	1
Pycnopodia helianthoides		1	4	4	4
Strongylocentrotus franciscanus		222	187	41	53
Strongylocentrotus purpuratus		0	0	0	1

Appendix 8d. (continued)

SPECIES	YEAR MONTH	1973 SEP	1974 AUG	1974 OCT	1977 APR
MOLLUSCA (continued)					
Mitra idae		0	2	1	9
Phidiana hiltori		0	0	0	2
Pseudomelatoma torosa		0	0	0	1
Serpulorbis squamigerus		0	0	0	Sc
Tegula brunnea		0	0	0	A
Tegula sp.		Sc	0	0	0
Tonicella lineata		C	0	Sc	0
PORIFERA					
Leucilla nuttingi		0	0	0	Sc
Tethya aurantia californiana		6	0	2	3
UROCHORDATA					
Boltenia villosa		Sc	0	0	0
Clavelina huntsmani		Sc	0	0	0
Cnemidocarpa finmarkiensis		Sc	0	0	1
Styela montereyensis		Sc	4	0	34

Appendix 8e. Numbers or Estimates of Abundance of Brown Algae and Invertebrates Observed at Permanent Subtidal Station 9, Diablo Cove. DCPP, 1973-1978.

SPECIES	YEAR MONTH	1973 SEP	1974 AUG	1974 NOV	1975 APR	1975 AUG	1975 DEC	1976 APR	1976 NOV	1977 MAR	1978 MAY
PHAEOPHYTA											
Cystoseira osmundacea		0	0	0	0	1	67	A	A	100	A
Desmarestia ligulata		Sc	C	P	C	C	0	Sc	P	0	0
Dictyoneurum californicum		C	0	0	Sc	Sc	Sc	C	0	C	Sc
Dictyota binghamiae		0	0	0	0	0	0	0	0	0	Sc
Dictyota sp.		0	0	0	C	C	0	C	Sc	0	0
Laminaria dentigera		0	22	27	73	69	50	110	133	166	218
Nereocystis lutkeana		0	64	76	77	304	55	35	34	0	0
Pterygophora californica		0	40	78	293	195	245	210	236	246	317
ANNELIDA											
Diopatra sp.		0	0	Sc	0	0	Sc	P	Sc	Sc	Sc
Eudistylia polymorpha		A	0	0	A	C	C	A	C	A	Sc
Pista sp.		0	0	0	C	Sc	0	0	Sc	Sc	Sc
Serpulidae		0	0	0	C	Sc	Sc	C	C	C	Sc
Terebellidae		Sc	0	0	0	0	0	0	Sc	0	0

Appendix 8e. (continued)

SPECIES	YEAR MONTH	1973 SEP	1974 AUG	1974 NOV	1975 APR	1975 AUG	1975 DEC	1976 APR	1976 NOV	1977 MAR	1978 MAY
ARTHROPODA											
Cancer antennarius		0	0	1	1	3	1	1	3	5	1
Cryptolithoides sitchensis		0	0	0	0	0	0	0	1	0	1
Loxorhynchus crispatus		0	1	0	0	0	1	1	3	0	1
Pagurus sp.		0	C	C	C	0	C	P	C	Sc	0
Pagurus spp.		0	0	0	0	0	0	0	0	0	C
Pugettia gracilis		0	0	0	0	0	0	0	1	0	0
Pugettia producta		0	0	0	0	0	0	3	0	4	0
Scyra acutifrons		0	0	0	0	0	0	0	0	0	1
COELENTERATA											
Anthopleura artemisia		0	0	1	0	0	0	0	0	0	2
Anthopleura xanthogrammica		3	12	12	11	6	14	10	17	17	7
Unidentified anemone		0	0	0	1	0	0	0	0	0	0
Balanophyllia elegans		C	C	C	C	Sc	Sc	C	Sc	C	0
Epiactis prolifera		Sc	0	0	C	C	Sc	C	Sc	Sc	0
Halcampa decemtentaculata		0	0	0	0	3	11	18	5	2	0

Appendix 8e. (continued)

SPECIES	YEAR MONTH	1973 SEP	1974 AUG	1974 NOV	1975 APR	1975 AUG	1975 DEC	1976 APR	1976 NOV	1977 MAR	1978 MAY
COELENTERATA (continued)											
Paracyathus stearnsii		0	C	0	0	0	P	0	0	0	Sc
Tealia cariacea		0	0	0	0	0	0	0	1	0	1
Tealia crassicornis		0	2	4	0	1	0	0	0	0	0
Tealia lofotensis		0	0	2	1	2	3	1	0	3	2
ECHINODERMATA											
Cucumaria miniata		0	0	0	0	1	0	0	1	0	0
Cucumaria sp.		0	0	0	0	0	0	0	0	0	C
Eupentacta quinquesemita		0	0	0	0	0	0	1	0	4	Sc
Henricia leviuscula		4	1	0	2	0	9	5	6	1	9
Leptasterias hexactis		0	0	0	0	1	0	0	Sc	0	0
Leptasterias spp.		0	0	0	0	0	0	0	0	0	Sc
Orthasterias koehleri		2	3	1	2	3	1	0	1	0	1
Patiria miniata		218	375	406	215	131	157	150	181	241	211
Pisaster giganteus		1	1	1	1	2	2	1	2	0	2
Pisaster ochraceous		0	0	0	0	0	1	0	0	0	1

Appendix 8e. (continued)

SPECIES YEAR	1973	1974	1974	1975	1975	1975	1976	1976	1977	1978
MONTH	SEP	AUG	NOV	APR	AUG	DEC	APR	NOV	MAR	MAY
ECHINODERMATA (continued)										
Pycnopodia helianthoides	5	4	6	5	0	2	2	0	0	0
Parastichopus californicus	0	0	0	0	0	1	0	0	0	0
Parastichopus spp.	0	1	2	0	0	0	0	0	0	0
Strongylocentrotus franciscanus	363	151	72	20	4	6	11	16	19	6
Strongylocentrotus purpuratus	0	0	0	0	0	0	0	2	0	2
Stylasterias forreri	1	0	2	0	0	0	0	0	0	0
ECTOPROCTA										
Hippodiplosia insculpta	0	0	0	0	0	C	0	0	0	0
MOLLUSCA										
Acanthodoris brunnea	0	0	0	0	0	0	0	0	1	0
Acmaea mitra	0	0	0	0	C	C	C	C	Sc	C
Acmaea sp.	0	C	0	0	0	0	0	0	0	0
Anisodoris nobilis	3	0	1	0	0	1	0	0	0	0
Archidoris montereyensis	0	0	0	0	0	0	0	1	0	0
Astraea gibberosa	39	10	11	11	6	6	9	13	10	15

Appendix 8e. (continued)

SPECIES	YEAR MONTH	1973 SEP	1974 AUG	1974 NOV	1975 APR	1975 AUG	1975 DEC	1976 APR	1976 NOV	1977 MAR	1978 MAY
MOLLUSCA (continued)											
Cadlina flavomaculata		0	0	0	0	0	0	0	2	0	0
Cadlina luteomargainata		0	0	0	1	0	0	0	1	1	0
Calliostoma annulatum		0	0	0	0	0	0	0	0	0	Sc
Calliostoma ligatum		0	0	0	0	0	0	0	0	C	Sc
Calliostoma sp.		Sc	0	0	Sc	0	0	0	0	0	0
Ceratostoma foliatum		0	0	0	0	0	6	4	0	1	1
Chromodoris macfarlandi		1	0	0	0	0	0	0	0	0	0
Cryptochiton stelleri		0	0	0	0	0	0	0	1	0	0
Diaulula sandiegensis		0	0	0	0	0	1	0	3	0	0
Discodoris heathi		0	0	0	0	0	0	0	1	0	1
Doriopsilla albopunctata		16	3	2	9	5	5	1	2	8	10
Haliotis rufescens		2	0	0	1	0	0	0	0	3	3
Hexmissenda crassicornis		2	0	0	0	0	0	0	0	0	0
Hinnites multirugosus		0	1	0	1	1	1	0	3	1	1
Homalopoma luridum		0	0	0	0	0	0	0	Sc	C	C

Appendix 8e. (continued)

	YEAR	1973	1974	1974	1975	1975	1975	1976	1976	1977	1978
SPECIES	MONTH	SEP	AUG	NOV	APR	AUG	DEC	APR	NOV	MAR	MAY
MOLLUSCA (continued)											
Hopkinsia rosacea		0	0	0	1	0	0	0	0	4	3
Megathura crenulata		0	0	0	0	1	0	0	0	1	0
Mitra idae		Sc	0	0	3	2	5	2	2	8	6
Mopalia spp.		Sc	0	0	0	0	0	0	0	1	0
Phidiana hiltoni		1	0	0	2	0	0	1	1	0	0
Pododesmus cepio		0	0	0	0	1	0	0	0	0	0
Pseudomelatoma torosa		0	0	0	0	0	0	0	0	C	1
Serpulorbis squamigerus		0	0	P	C	Sc	C	C	C	C	Sc
Tegula brunnea		0	0	0	0	0	0	0	0	0	C
Tegula montereyi		0	0	0	0	0	Sc	0	P	Sc	0
Tegula pulligo		0	0	0	0	0	0	0	P	Sc	C
Tegula sp.		0	0	0	C	0	0	0	0	0	0
Tonicella lineata		Sc	C	12	16	C	C	C	C	P	C
Triopha catalinae		0	0	0	0	0	1	0	2	1	0
Triopha maculata		0	0	0	0	0	1	0	0	0	2
Tritonia festiva		1	0	0	0	0	0	0	0	0	0

Appendix 8e. (continued)

SPECIES YEAR MONTH	1973 SEP	1974 AUG	1974 NOV	1975 APR	1975 AUG	1975 DEC	1976 APR	1976 NOV	1977 MAR	1978 MAY
PORIFERA										
Leucandra heathi	0	0	0	0	0	0	0	11	0	0
Leucilla nuttingi	0	0	0	Sc	0	0	0	Sc	Sc	Sc
Polymastia pachymastia	0	0	0	Sc	0	0	0	0	0	0
Tethya aurantia	3	0	8	8	9	10	10	4	6	7
Unidentified sponge	0	0	0	0	0	3	0	0	0	0
UROCHORDATA										
Boltenia villosa	0	0	0	0	1	4	1	1	1	2
Clavelina huntsmani	0	0	0	0	0	0	0	Sc	0	0
Cnemidocarpa finmarkiensis	0	3	0	0	0	0	0	1	0	2
Pyura havstor	0	0	0	0	0	0	0	6	Sc	0
Styela montereyensis	1	0	0	0	6	11	7	23	9	5
Unidentified tunicate	0	0	0	0	0	0	0	Sc	0	0

A = Abundant C = Common P = Present Sc = Scarce

Appendix 8f. Numbers or Estimates of Abundance of Brown Algae and Invertebrates Observed at Permanent Subtidal Station 10, Diablo Cove. DCPP, 1973-1978.

SPECIES	YEAR	1973	1974	1974	1975	1976	1976	1977	1978
	MONTH	SEPT	MAR	AUG	APR	APR	NOV	APR	MAY
PHAEOPHYTA									
Cystoseira osmundacea		0	0	0	0	5	Sc	P	0
Desmarestia ligulata		0	0	C	0	0	Sc	0	0
Dictyoneurum californicum		0	0	0	0	Sc	Sc	0	Sc
Dictyota sp.		0	0	0	0	0	Sc	0	0
Laminaria dentigera		0	0	132	107	192	124	216	279
Nereocystis luetkeana		0	0	99	2	2	35	0	0
Pterygophora californica		0	0	120	172	232	212	241	226
ANNELIDA									
Diopatra sp.		C	Sc	0	C	C	Sc	C	Sc
Eudistylia polymorpha		C	Sc	C	A	0	Sc	P	Sc
Myxicola sp.		0	0	0	0	0	Sc	Sc	0
Pista sp.		0	Sc	0	C	Sc	2	Sc	1
Terebellidae		C	0	0	Sc	0	0	0	0
Serpulidae		0	0	0	0	0	Sc	0	C

Appendix 8f. (continued)

	YEAR	1973	1974	1974	1975	1976	1976	1977	1978
SPECIES	MONTH	SEPT	MAR	AUG	APR	APR	NOV	APR	MAY
ARTHROPODA									
Balanus sp.		0	0	0	0	0	P	0	0
Cancer antennarius		0	0	0	1	0	3	0	0
Loxorhynchus crispatus		0	0	0	0	0	1	0	0
Mimulus foliatus		0	1	0	1	0	0	0	0
Pagurus sp.		0	0	Sc	0	Sc	Sc	3	0
Pandalus gurneyi		4	0	0	0	0	0	0	0
Pugettia producta		0	0	0	0	0	0	0	1
Scyra acutifrons		0	0	0	1	0	0	0	0
COELENTERATA									
Anthopleura artemisia		0	4	0	10	5	0	20	6
Anthopleura xanthogrammica		3	0	5	6	7	9	21	22
Astrangia lajollaensis		0	0	0	0	0	0	Sc	0
Balanophyllia elegans		C	A	A	C	C	C	C	C
Corynactis californica		0	0	0	0	0	0	0	Sc
Epiactis prolifera		0	0	0	0	0	0	P	Sc

Appendix 8f.   (continued)

SPECIES	YEAR	1973	1974	1974	1975	1976	1976	1977	1978
	MONTH	SEPT	MAR	AUG	APR	APR	NOV	APR	MAY
COELENTERATA									
Halcampa decemtentaculata		0	0	0	0	0	0	1	0
Paracyathus stearnsii		0	4	C	C	C	Sc	0	Sc
Tealia crassicornis		0	0	1	1	0	0	0	1
Tealia lofotensis		0	0	0	0	2	1	2	1
Unidentified anemone		0	0	0	2	0	2	0	6
ECHINODERMATA									
Cucumaria miniata		1	0	0	0	0	Sc	4	0
Cucumaria sp.		0	0	0	0	0	0	0	C
Eupentacta quinquesemita		1	0	0	1	1	Sc	5	4
Henricia leviuscula		0	2	4	3	3	2	2	5
Leptasterias haxactis		0	0	0	0	0	0	0	Sc
Orthasterias koehleri		0	3	5	5	4	4	0	8
Parastichopus parvimensis		0	0	0	1	0	0	0	0
Parastichopus sp.		0	0	2	0	0	0	0	0
Patiria miniata		129	119	179	110	165	199	205	241

Appendix 8f. (continued)

	YEAR	1973	1974	1974	1975	1976	1976	1977	1978
SPECIES	MONTH	SEPT	MAR	AUG	APR	APR	NOV	APR	MAY
ECHINODERMATA									
Pisaster brevispinus		0	1	0	1	0	2	1	0
Pisaster giganteus		4	2	2	3	3	1	3	1
Pisaster ochraceous		0	0	1	0	0	0	0	1
Pycnopodia helianthoides		4	4	1	3	4	6	4	2
Strongylocentrotus franciscanus		86	56	86	0	4	7	6	1
Stronlylocentrotus purpuratus		0	0	0	1	0	0	0	0
Stylasterias forreri		1	2	0	0	0	0	0	0
ECTOPROCTA									
Crisia sp.		0	0	0	0	0	Sc	0	0
Phidolopora pacifica		0	0	0	0	0	Sc	0	0
MOLLUSCA									
Acmaea mitra		0	0	0	0	C	C	C	0
Acmaea sp.		0	Sc	Sc	Sc	0	0	0	0
Aegires albopunctatus		0	0	0	0	0	1	0	0
Anisodoris nobilis		0	0	0	1	1	1	0	0

Appendix 8f. (continued)

SPECIES	YEAR MONTH	1973 SEPT	1974 MAR	1974 AUG	1975 APR	1976 APR	1976 NOV	1977 APR	1978 MAY
MOLLUSCA (continued)									
Archidoris montereyensis		0	0	0	0	0	2	0	1
Astraea gibberosa		11	26	15	17	26	18	24	16
Cadlina luteomarginata		0	0	0	0	1	2	3	0
Calliostoma annulatum		0	0	0	2	0	0	0	14
Calliostoma canaliculatum		1	0	0	0	0	1	1	0
Calliostoma ligatum		0	0	0	2	2	3	1	Sc
Ceratostoma foliatum		0	0	0	2	3	14	0	0
Ceratostoma nuttalli		0	0	0	0	0	0	2	0
Cryptochiton stelleri		0	0	0	0	0	1	0	0
Discodoris sandiegensis		0	0	0	1	0	1	3	0
Doriopsilla albopunctata		3	3	3	8	4	8	10	31
Fusinus sp.		0	0	0	1	0	0	1	0
Haliotis kamtschatkana		0	2	0	0	0	0	0	0
Haliotis refescens		0	0	0	0	0	0	1	2
Hinnites multirugosus		0	0	0	0	0	0	1	0
Homalopoma luridum		0	0	0	Sc	0	Sc	C	C

Appendix 8f. (continued)

SPECIES	YEAR	1973	1974	1974	1975	1976	1976	1977	1978
	MONTH	SEPT	MAR	AUG	APR	APR	NOV	APR	MAY
MOLLUSCA (continued)									
Homalopoma luridum		0	0	0	Sc	0	Sc	C	C
Laila cockerelli		0	0	0	0	0	1	0	0
Mitra idae		0	Sc	11	6	0	19	15	21
Ocenebra lurida		0	0	0	0	0	0	0	1
Ocenebra sp.		0	0	0	0	0	0	3	1
Phidiana hiltoni		0	0	1	0	0	1	0	0
Pododesmus cepio		0	0	0	1	0	0	Sc	0
Pseudomelatoma torosa		0	0	0	0	0	2	1	0
Serpulorbis squamigerus		0	0	0	Sc	Sc	C	C	C
Tegula brunnea		Sc	0	0	0	0	0	C	C
Tegula montereyi		Sc	0	0	9	0	0	0	Sc
Tegula pulligo		0	0	0	0	0	Sc	C	0
Tegula sp.		0	0	0	0	C	0	0	0
Tonicella lineata		Sc	Sc	Sc	27	Sc	C	C	Sc
Triopha catalinae		0	0	0	1	0	0	0	2
Triopha maculata		0	0	0	0	0	0	0	1

Appendix 8f. (continued)

SPECIES	1973 SEPT	1974 MAR	1974 AUG	1975 APR	1976 APR	1976 NOV	1977 APR	1978 MAY
MOLLUSCA (continued)								
Tritonia festiva	0	0	0	0	0	0	1	0
Unidentified pholads	0	0	0	Sc	0	C	0	0
Unidentified nudibranch	0	0	0	1	0	0	0	1
PORIFERA								
Leucandra heathi	0	0	0	0	0	2	0	Sc
Leucilla nuttingi	0	0	0	Sc	0	Sc	P	Sc
Tethya aurantia californiana	3	4	4	6	15	10	9	10
Tetilla arb	0	0	0	0	0	0	1	0
UROCHORDATA								
Clavelina huntsmani	0	0	0	0	Sc	0	0	0
Boltenia villosa	0	0	0	6	11	14	15	Sc
Cnemidocarpa finmarkiensis	Sc	0	0	2	5	2	3	Sc
Pyura haustor	0	0	0	0	0	6	10	0
Styela montereyensis	0	1	0	0	20	20	18	5

Appendix 8f. (continued)

SPECIES	YEAR MONTH	1973 SEPT	1974 MAR	1974 AUG	1975 APR	1976 APR	1976 NOV	1977 APR	1978 MAY
UROCHORDATA (continued)									
Trididemnum opacum		0	0	0	0	0	0	C	0
Unidentified tunicate		0	0	0	0	0	P	0	0

A = Abundant C = Common P = Present Sc = Scarce

Appendix 8g. Numbers or Estimates of Abundance of Brown Algae and Invertebrates Observed at Permanent Subtidal Station 11, Diablo Cove. DCPP, 1973-1978.

SPECIES	YEAR MONTH	1973 SEPT	1974 MAR	1974 AUG	1974 NOV	1975 APR	1975 AUG	1975 NOV	1976 MAR	1976 OCT	1977 APR	1977 NOV	1978 JUNE
PHAEOPHYTA													
Cystoseria osmundacea		0	0	0	0	0	0	0	1	0	Sc	Sc	0
Desmarestia lingulata		0	0	Sc	0	0	C	Sc	Sc	Sc	0	0	0
Dictyoneurum californicum		0	0	0	0	0	Sc	0	0	Sc	Sc	Sc	0
Dictyota binghamiae		0	0	0	0	0	0	0	0	0	0	Sc	0
Dictyota sp.		0	0	0	0	0	C	Sc	Sc	0	0	0	Sc
Laminaria dentigera		0	0	31	79	37	177	C	108	292	297	301	406
Nereocystis luetkeana		0	0	60	2	0	121	0	0	0	0	0	0
Pterygophora californica		0	0	0	15	32	56	C	103	123	123	115	138
ANNELIDA													
Diopatra sp.		C	0	0	0	0	0	Sc	C	C	C	C	0
Eudistylia polymorpha		0	0	0	0	Sc	0	0	Sc	0	0	0	Sc
Myxicola sp.		0	0	0	0	0	0	0	0	Sc	0	0	0
Pista sp.		0	0	0	0	0	0	0	0	2	Sc	4	Sc
Terebellidae		Sc	0	0	0	0	0	0	0	0	0	0	0
Serpulidae		0	0	0	0	0	0	0	Sc	0	0	C	Sc

Appendix 8g. (continued)

	YEAR	1973	1974	1974	1974	1975	1975	1975	1976	1976	1977	1977	1978
SPECIES	MONTH	SEPT	MAR	AUG	NOV	APR	AUG	NOV	MAR	OCT	APR	NOV	JUNE
ARTHROPODA													
Balanus sp.		0	0	0	0	0	0	1	A	0	0	A	0
Cancer antennarius		0	0	0	0	0	0	0	0	1	1	0	0
Loxorhynchus crispatus		0	0	0	0	0	3	0	0	0	0	0	0
Pagurus sp.		0	0	0	0	0	0	0	0	0	2	0	0
Pandalus gurneyi		2	0	0	0	0	0	2	0	0	0	0	0
Scyra acutifrons		0	0	0	0	0	0	0	0	0	0	1	0
COELENTERATA													
Anthopleura artemisia		C	1	0	0	2	1	2	3	1	8	4	6
Anthopleura xanthogrammica		0	2	0	0	2	3	0	0	1	3	3	0
Astrangia lajollaensis		Sc	0	0	0	0	0	0	Sc	0	0	0	0
Balanophyllia elegans		A	A	C	C	C	Sc	C	C	C	C	A	C
Corynactis californica		Sc	0	C	0	C	Sc	Sc	Sc	Sc	Sc	Sc	C
Epiactis prolifera		0	0	0	0	0	0	0	Sc	0	0	0	0
Halcampa decemtentaculata		0	0	0	0	0	0	3	0	0	1	0	0
Paracyathus stearnsii		C	Sc	Sc	Sc	C	Sc	0	Sc	C	C	Sc	Sc

Appendix 8g. (continued)

YEAR	1973	1974	1974	1974	1975	1975	1975	1976	1976	1977	1977	1978
SPECIES MONTH	SEPT	MAR	AUG	NOV	APR	AUG	NOV	MAR	OCT	APR	NOV	JUNE
COELENTERATA												
Tealia crassicornis	0	0	1	0	2	2	1	1	1	1	3	1
Tealia lofotensis	0	0	3	0	2	0	0	2	2	1	3	2
Tubularia sp.	0	0	0	0	0	0	0	Sc	0	0	0	0
ECHINODERMATA												
Cucumaria miniata	6	0	0	0	12	0	1	14	0	0	0	0
Cucumaria sp.	0	0	0	0	0	0	0	0	0	0	48	21
Eupentacta quinquesemita	0	0	0	0	0	1	0	2	0	2	1	4
Henricia leviscula	4	4	2	1	2	2	4	3	2	3	1	0
Leptasterias hexactis	0	0	0	0	0	0	0	0	0	0	0	2
Leptasterias spp.	0	0	0	0	0	0	0	0	0	0	4	0
Ophioplocus esmarki	0	0	0	0	0	0	0	1	0	0	4	0
Ophiothrix spiculata	0	0	0	0	0	0	0	0	0	0	12	0
Orthasterias koehleri	5	1	2	2	3	5	14	6	7	8	4	2
Parastichopus californicus	0	0	0	0	0	0	0	0	2	1	0	0
Parastichopus spp.	1	2	1	1	0	0	0	0	0	0	0	1

Appendix 8g. (continued)

SPECIES	YEAR MONTH	1973 SEPT	1974 MAR	1974 AUG	1974 NOV	1975 APR	1975 AUG	1975 NOV	1976 MAR	1976 OCT	1977 APR	1977 NOV	1978 JUNE
ECHINODERMATA (continued)													
Patiria miniata		110	110	139	72	98	171	124	144	164	125	183	128
Pisaster brevispinus		5	7	0	1	1	1	2	1	2	4	1	5
Pisaster giganteus		6	9	2	6	7	0	5	3	1	10	1	1
Pisaster ochraceous		3	1	0	1	4	1	3	0	1	4	5	0
Pisaster sp.		0	0	0	0	0	0	0	0	0	0	0	27
Psolus chitonoides		0	0	0	0	0	0	0	0	1	0	0	0
Pycnopodia helianthoides		11	1	4	0	6	2	2	1	9	1	8	4
Strongylocentrotus franciscanus		89	81	84	31	47	61	23	22	18	5	24	1
Strongylocentrotus purpuratus		0	0	0	0	0	0	0	0	8	1	4	0
Stylasterias forreri		0	2	0	0	1	1	0	2	0	2	2	2
ECTOPROCTA													
Celleporaria brunnea		0	0	0	0	0	0	0	0	Sc	0	0	0
Crisia sp.		0	0	0	0	0	0	0	0	Sc	0	C	0
Diaperoecia californica		0	0	0	0	0	0	0	Sc	C	Sc	C	0
Phidolopora pacifica		0	0	0	0	2	0	0	0	Sc	0	0	4

Appendix 8g. (continued)

SPECIES	YEAR MONTH	1973 SEPT	1974 MAR	1974 AUG	1974 NOV	1975 APR	1975 AUG	1975 NOV	1976 MAR	1976 OCT	1977 APR	1977 NOV	1978 JUNE
ECTOPROCTA (continued)													
Unidentified ectoprocta		0	0	0	0	P	0	0	0	0	0	0	0
MOLLUSCA													
Acanthodoris brunnea		0	0	0	0	1	0	0	0	0	0	0	0
Acmaea mitra		Sc	0	0	0	0	0	0	0	Sc	Sc	C	C
Acmaea sp.		0	Sc	0	0	0	0	0	0	0	0	0	0
Aegires albopunctatus		0	0	0	0	0	0	0	0	1	0	0	0
Aldisa sanguinea		0	0	0	0	0	0	0	0	1	0	0	0
Anisodoris nobilis		0	0	0	0	1	0	0	0	2	1	0	0
Archidoris montereyensis		0	0	0	0	0	0	0	0	2	0	0	0
Archidoris odhneri		0	0	0	0	0	1	1	0	0	1	0	0
Astraea gibberosa		32	8	5	2	4	0	18	18	24	16	35	27
Cadlina lutcomarginata		1	1	0	0	0	1	0	1	2	0	2	0
Calliostoma annulatum		3	0	0	0	Sc	1	0	4	Sc	2	2	8
Calliostoma canaliculatum		0	0	0	0	0	0	0	0	1	3	0	0
Calliostoma ligatum		0	0	0	0	0	Sc	0	0	Sc	2	0	Sc

Appendix 8g. (continued)

SPECIES	YEAR MONTH	1973 SEPT	1974 MAR	1974 AUG	1974 NOV	1975 APR	1975 AUG	1975 NOV	1976 MAR	1976 OCT	1977 APR	1977 NOV	1978 JUNE
MOLLUSCA (continued)													
Calliostoma sp.		0	Sc	0	0	0	0	0	0	0	0	0	0
Ceratostoma foliatum		4	0	1	0	1	1	0	5	7	4	1	0
Ceratostoma nuttalli		0	0	0	0	0	0	0	0	0	0	0	3
Chromadoris macfarlandi		0	0	0	0	0	0	0	0	2	0	0	1
Coryphella fisheri		0	0	0	0	0	0	0	0	0	1	1	1
Chryptochiton stelleri		0	0	0	0	0	0	0	0	0	0	1	1
Discodoris sandiegensis		0	0	0	0	6	0	3	5	2	3	3	4
Discodoris heathi		0	0	0	0	0	0	0	0	1	0	0	0
Doropsilla albopunctata		17	3	4	0	6	4	2	6	12	13	6	8
Haliotis kamtschatkana		0	1	1	0	1	0	0	1	2	0	0	0
Haliotis refescens		1	0	0	0	0	0	0	0	0	0	0	0
Hermissenda crassicornis		1	0	18	0	0	2	0	0	0	0	0	0
Hinnites multirugosus		0	1	0	0	1	0	0	1	2	2	1	Sc
Homalopoma luridum		0	0	0	0	0	0	0	Sc	0	C	C	0
Irus lamellifer		0	0	0	0	0	0	0	0	1	0	0	0
Mitra idae		2	Sc	5	0	0	5	0	7	11	13	12	9

Appendix 8g. (continued)

	YEAR	1973	1974	1974	1974	1975	1975	1975	1976	1976	1977	1977	1978
SPECIES	MONTH	SEPT	MAR	AUG	NOV	APR	AUG	NOV	MAR	OCT	APR	NOV	JUNE
MOLLUSCA (continued)													
Ocenebra lurida		0	0	0	0	0	0	0	0	0	0	0	2
Octopus		0	0	0	0	0	0	0	0	1	0	0	0
Pentaloconchus montereyensis		0	0	0	0	0	0	0	0	0	0	C	0
Phidiana hiltoni		2	0	0	0	2	1	0	0	0	4	0	0
Serpulorbis squamigerus		0	0	0	0	0	Sc	Sc	C	C	C	C	0
Tegula brunnea		0	0	0	0	0	0	0	0	0	0	C	Sc
Tegula montereyi		0	0	0	0	0	0	Sc	C	Sc	0	0	
Tegula pulligo		0	0	0	0	0	0	0	0	Sc	A	C	0
Tonicella lineata		Sc	Sc	1	0	0	0	0	C	0	Sc	0	4
Tritonia festiva		1	0	0	0	0	0	0	1	0	1	1	0
PORIFERA													
Leucandra heathi		0	0	0	0	0	0	0	0	5	0	Sc	0
Leucilla nuttingi		0	0	0	0	0	Sc	0	0	Sc	0	0	Sc
Tethya auantia californiana		20	12	19	16	25	20	22	21	27	33	31	14
Tetilla arb		0	0	0	0	1	0	0	0	1	1	0	1

Appendix 8g. (continued)

SPECIES	YEAR MONTH	1973 SEPT	1974 MAR	1974 AUG	1974 NOV	1975 APR	1975 AUG	1975 NOV	1976 MAR	1976 OCT	1977 APR	1977 NOV	1978 JUNE
UROCHORDATA													
Boltenia villosa		Sc	Sc	0	0	P	C	22	31	16	5	41	9
Clavelina huntsmani		0	0	0	0	0	0	0	0	0	0	0	Sc
Cnemidocarpa finmarkiensis		Sc	0	0	0	0	0	0	0	0	0	1	0
Pyura haustor		0	0	0	0	0	0	0	Sc	2	5	4	0
Styela montereyensis		0	0	0	1	4	10	10	9	10	3	12	8
Synoicum parfustis		0	0	0	0	3	0	0	0	0	0	0	0
Trididemnum opacum		0	0	0	0	0	0	0	0	0	C	0	0
Unidentified tunicate		0	0	0	0	0	1	0	2	0	0	0	C

A = Abundance C = Common P = Present Sc = Scarce

Appendix 8h. Numbers or Estimates of Abundance of Brown Algae and Invertebrates Observed at Permanent Subtidal Station 12, Diablo Cove. DCPP, 1973-1978.

SPECIES YEAR MONTH	1973 SEP	1974 AUG	1974 DEC	1975 APR	1975 AUG	1975 NOV	1976 MAY	1976 NOV	1977 APR	1977 NOV	1978 JUNE
PHAEOPHYTA											
Desmarestia ligulata	0	5	0	0	0	0	0	0	0	0	0
Laminaria dentigera	0	2	0	0	0	0	0	0	0	0	0
ANNELIDA											
Diopatra sp.	0	0	P	0	0	0	C	Sc	A	C	0
Eudistylia polymorpha	0	Sc	0	0	0	0	0	0	0	0	0
Myxicola sp.	0	0	0	0	0	0	0	0	1	1	0
Pista sp.	Sc	0	0	0	0	0	Sc	Sc	C	C	0
Serpulidae	0	0	0	0	0	0	0	0	0	C	Sc
ARTHROPODA											
Balanus sp.	0	0	P	0	0	0	A	1	0	A	0
Cancer antennarius	0	0	0	0	1	0	0	0	0	0	0
Cryptolithoides sitchensis	1	0	0	0	0	0	0	0	0	0	0
Lopholithoides foraminatus	0	1	0	0	0	0	0	0	0	0	0
Loxorhynchus crispatus	0	1	0	0	2	0	0	0	0	0	0

Appendix 8h. (continued)

SPECIES	YEAR MONTH	1973 SEP	1974 AUG	1974 DEC	1975 APR	1975 AUG	1975 NOV	1976 MAY	1976 NOV	1977 APR	1977 NOV	1978 JUNE
ARTHROPODA (continued)												
Pachycheles sp.		0	1	0	0	0	0	0	0	0	0	0
Pagurus sp.		0	0	0	0	0	0	0	Sc	1	0	Sc
Pandalus gurneyi		1	0	0	0	0	0	0	1	0	3	0
Pugettia producta		0	0	0	0	0	0	0	0	0	1	0
Scyra acutifrons		0	0	0	0	0	0	0	0	0	1	0
COELENTERATA												
Allopora californica		0	0	0	0	0	0	0	1	1	0	0
Allopora sp.		0	0	0	0	0	0	0	0	0	0	2
Anthopleura artemesia		0	0	0	2	0	0	0	0	5	0	2
Anthopleura xanthogrammica		0	1	1	0	0	0	0	1	1	1	0
Astrangia lajollanensis		0	0	0	0	Sc	0	0	0	0	0	0
Balanophyllia elegans		A	Sc	C	A	C	A	A	C	C	A	A
Corynactis californica		0	0	0	0	0	0	0	0	0	0	C
Paracyathus stearnsii		Sc	Sc	0	C	C	A	Sc	C	C	C	Sc
Telia columbiana		0	0	0	0	0	0	0	1	1	1	0

Appendix 8h. (continued)

	YEAR	1973	1974	1974	1975	1975	1975	1976	1976	1977	1977	1978
SPECIES	MONTH	SEP	AUG	DEC	APR	AUG	NOV	MAY	NOV	APR	NOV	JUNE
COELENTERATA (continued)												
Telia crassicornis		0	6	3	12	14	23	12	18	21	22	9
Telis lofotensis		0	2	2	1	1	0	0	0	0	0	0
ECHINODERMATA												
Cucumaria miniata		7	0	0	1	0	0	6	0	0	0	0
Cucumaria sp.		0	0	0	0	0	0	0	0	0	1	8
Eupentacta quinquesemia		1	0	0	0	0	0	1	0	1	1	4
Henricia leviuscula		2	3	6	6	1	1	6	10	13	9	16
Mediaster aequalis		0	0	1	0	0	0	0	0	1	1	0
Ophiothrix spiculata		0	0	0	0	0	0	0	C	0	Sc	0
Orthasterias koehleri		8	0	3	2	8	10	13	12	7	27	22
Parastichopus californicus		0	0	0	5	0	1	3	0	2	0	0
Parastichopus parvimensis		0	0	0	0	0	0	0	0	3	1	0
Parastichopus sp.		6	5	0	0	0	0	0	0	0	0	8
Patiria miniata		163	148	111	140	126	171	216	175	221	239	234
Pisaster brevispinus		0	2	3	1	2	0	8	5	3	2	7
Pisaster giganteus		0	1	10	2	1	6	22	5	7	3	13

Appendix 8h. (continued)

SPECIES	YEAR MONTH	1973 SEP	1974 AUG	1974 DEC	1975 APR	1975 AUG	1975 NOV	1976 MAY	1976 NOV	1977 APR	1977 NOV	1978 JUNE
ECHINODERMATA (continued)												
Pisaster ochranceous		0	0	0	0	0	0	0	0	0	2	4
Pisaster sp.		0	0	0	0	0	0	0	0	0	0	28
Psolus chitonoides		0	0	0	0	0	0	0	0	1	0	0
Pycnopodia helianthoides		4	8	6	4	2	3	5	3	5	2	7
Strongylocentrotus franciscanus		29	21	33	67	84	65	36	128	91	56	32
Strongylocentrotus purpuratus		0	0	0	0	0	0	0	2	0	4	4
Stylasterias forreri		0	2	1	0	2	0	1	0	0	1	1
Unidentified holothuroidea		0	0	0	7	0	0	0	0	0	0	0
Unidentified ophuiroidea		0	C	0	0	0	0	0	0	0	0	0
ECTOPROCTA												
Heteropora magna		0	0	0	0	0	0	0	0	0	0	Sc
Phidolopora pacifica		0	Sc	0	0	0	0	0	0	0	0	Sc
MOLLUSCA												
Acmaea mitra		0	0	P	0	0	0	0	0	P	0	0

Appendix 8h. (continued)

SPECIES	YEAR	1973	1974	1974	1975	1975	1975	1976	1976	1977	1977	1978
	MONTH	SEP	AUG	DEC	APR	AUG	NOV	MAY	NOV	APR	NOV	JUNE
MOLLUSCA (continued)												
Acmaea sp.		0	0	0	0	0	1	0	0	0	0	0
Amisodoris nobilis		0	1	0	1	4	0	4	1	4	1	0
Archidoris montereyensis		1	0	0	0	0	0	0	2	1	0	0
Archidous odhneri		0	0	0	0	0	0	0	3	0	0	0
Astraea gibberosa		3	3	2	2	3	1	3	1	3	6	7
Cadlina luteomarginata		2	1	0	1	0	1	0	2	5	0	0
Calliostoma annulatum		0	0	Sc	5	0	0	5	Sc	7	Sc	4
Calliostoma canaliculatum		0	0	0	0	0	0	0	2	0	1	0
Calliostoma ligatum		0	0	0	7	0	0	0	Sc	0	Sc	0
Calliostoma sp.		0	C	Sc	0	0	0	0	0	0	0	0
Ceratostoma foliatum		6	5	4	33	1	2	0	10	18	13	0
Coryphella fisheri		0	0	0	0	0	0	0	0	0	0	1
Diaulula sandiedensis		0	0	0	2	0	0	0	2	0	3	0
Diodora aspera		0	0	0	0	1	0	0	0	0	0	0
Discodoris heathi		0	0	0	0	0	0	0	0	0	0	1
Doriopsilla albopunctata		3	7	8	9	4	0	16	15	29	3	11

Appendix 8h. (continued)

SPECIES	YEAR MONTH	1973 SEP	1974 AUG	1974 DEC	1975 APR	1975 AUG	1975 NOV	1976 MAY	1976 NOV	1977 APR	1977 NOV	1978 JUNE
MOLLUSCA (continued)												
Flabellinopsis iodinea		0	0	0	1	0	0	0	0	1	0	1
Haliotos Kamtschatkana		0	0	0	0	2	1	2	3	1	2	0
Haliotis refescens		0	0	1	0	0	0	0	0	0	0	0
Hinnites multirugosus		0	0	0	0	0	0	1	0	0	0	0
Laila cockerelli		0	0	0	0	0	0	0	1	0	0	0
Maxwellia santarosana		0	0	0	0	0	0	2	0	0	0	0
Mitra idae		0	3	0	6	0	0	5	4	27	2	3
Serpulorbis squamigerus		0	0	0	0	0	0	0	Sc	Sc	C	2
Tegula pulligo		0	0	0	0	0	0	0	Sc	Sc	0	0
Tonicella lineata		0	5	0	0	0	0	0	Sc	P	Sc	1
Triopha catalinae		3	2	0	1	0	0	0	0	0	1	1
Triotonia festiva		0	0	0	0	0	0	0	0	1	0	0
PORIFERA												
Leucandra heathi		0	0	0	0	0	0	0	0	1	0	0
Leucilli nuttingi		0	0	0	0	0	0	0	0	Sc	0	1

Appendix 8h. (continued)

SPECIES	YEAR MONTH	1973 SEP	1974 AUG	1974 DEC	1975 APR	1975 AUG	1975 NOV	1976 MAY	1976 NOV	1977 APR	1977 NOV	1978 JUNE
PORIFERA (continued)												
Tethya aurantia californiana		2	14	14	14	14	13	19	8	12	10	12
Tetilla arb		0	0	0	3	1	0	0	1	2	1	0
Unidentified sponge		0	0	0	0	0	C	0	0	0	0	0
UROCHORDATA												
Soltenia villosa		Sc	0	9	C	C	0	19	5	10	A	17
Ciona intestinalis		0	0	0	0	0	0	0	0	0	1	0
Pyura haustor		0	0	0	0	0	0	0	2	2	1	0
Trididemnum opacum		0	0	0	0	0	0	0	0	C	0	0
Unidentified tunicate		0	C	0	0	0	0	0	0	0	0	C

A = Abundant C = Common P = Present Sc = Scarce

Appendix 81. Numbers or Estimates of Abundance of Brown Algae and Invertebrates Observed at Permanent Subtidal Station 15, South Cove. DCPP, 1973-1978.

SPECIES YEAR MONTH	1973 OCT	1974 AUG	1975 APR	1975 AUG	1975 DEC	1976 APR	1976 OCT	1977 MAR	1977 MAY	1977 NOV	1978 JUNE
PHAEOPHYTA											
Cystoseira osmundaceae	0	1	0	0	0	0	0	0	0	0	0
Desmarestia ligulata	C	0	0	0	0	0	0	0	C	0	0
Desmarestia sp.	0	0	0	0	0	0	0	0	0	0	A
Dictyoneurum californicum	C	A	C	Sc	C	C	Sc	0	C	0	0
Laminaria dentigera	C	97	68	80	64	78	106	106	114	145	0
Nereocystis luetkeana	2	31	0	0	0	0	0	0	123	41	0
Pterogophora californica	0	0	0	0	0	4	0	0	0	12	0
ANNELIDA											
Diopatra sp.	A	A	C	A	C	A	C	A	C	C	C
Dodecaceria fewkesi	0	0	0	0	0	0	0	0	0	0	C
Eudistylia polymorpha	C	0	A	A	C	A	C	A	A	C	11
Myxicola sp.	0	0	0	0	0	0	0	0	1	0	0
Pista sp.	0	0	0	0	0	0	0	Sc	Sc	Sc	0
Serpulidae	0	0	0	0	C	Sc	0	0	0	0	0

Appendix 8i. (continued)

	YEAR	1973	1974	1975	1975	1975	1976	1976	1977	1977	1977	1978
SPECIES	MONTH	OCT	AUG	APR	AUG	DEC	APR	OCT	MAR	MAY	NOV	JUNE
ARTHROPODA												
Balanus glandula		0	0	0	0	0	0	0	0	0	Sc	0
Balanus nubilus		0	0	0	Sc	0	0	0	0	0	0	0
Balanus sp.		Sc	0	0	0	0	0	0	0	0	A	1
Cancer antennarius		5	0	1	1	0	2	4	0	1	2	0
Lebbeus lagunae		0	0	0	0	0	0	0	0	0	Sc	0
Loxorhynchus crispatus		0	0	2	Sc	0	1	0	0	0	0	0
Mimulus foliatus		0	0	0	Sc	0	1	0	0	0	0	0
Pugettia producta		1	0	0	0	0	0	3	1	0	0	0
Pugettia richii		0	0	0	0	1	0	1	0	0	0	0
Scyra acutifrons		0	2	0	0	0	0	0	0	0	2	0
COELENTERATA												
Aglaephenia sp.		C	0	A	C	A	A	C	A	A	C	C
Allopora porphyra		0	0	Sc	A	C	A	C	0	0	0	0
Anthopleura artemesia		0	0	0	1	1	3	0	0	0	5	0
Anthopleura xanthogrammica		0	4	4	9	10	9	6	2	6	2	4
Astrangia lajollanensis		0	0	0	0	0	0	0	Sc	0	0	Sc

Appendix 8i. (continued)

SPECIES	YEAR	1973	1974	1975	1975	1975	1976	1976	1977	1977	1977	1978
	MONTH	OCT	AUG	APR	AUG	DEC	APR	OCT	MAR	MAY	NOV	JUNE
COELENTERATA (continued)												
Balanophyllia elegans		A	C	A	0	A	C	C	A	A	A	A
Corynactis californica		A	A	A	A	A	A	A	C	A	A	A
Epiactis prolifera		Sc	C	C	A	C	A	C	Sc	C	Sc	C
Haliplannella luciae		0	0	0	0	Sc	0	0	0	0	0	0
Metridium senile		Sc	C	A	C	C	C	C	0	Sc	C	0
Pachycerianthus fimbriatus		Sc	0	0	0	0	0	0	0	0	Sc	0
Paracyathus stearnsii		Sc	C	C	0	C	Sc	C	C	C	C	C
Telia crassicornis		1	0	0	0	0	0	0	0	0	0	0
Telia Lofotensis		2	9	11	12	17	11	19	14	17	22	25
Unidentified anenome		0	0	0	0	0	0	0	0	Sc	0	0
ECHINODERMATA												
Cucumaria miniata		0	0	6	16	0	0	0	6	0	0	0
Cucumaria sp.		0	0	0	0	0	0	0	0	2	0	2
Eupentacta quinquesiemita		0	1	0	2	0	0	0	0	0	Sc	1
Henricia leviuscula		3	5	7	8	13	7	3	3	2	9	10

Appendix 8i. (continued)

SPECIES YEAR MONTH	1973 OCT	1974 AUG	1975 APR	1975 AUG	1975 DEC	1976 APR	1976 OCT	1977 MAR	1977 MAY	1977 NOV	1978 JUNE
ECHINODERMATA (continued)											
Leptasterias hexactis	0	2	9	9	6	15	8	3	0	0	0
Leptasterias spp.	0	0	0	0	0	0	0	0	9	7	4
Orthasterias koehleri	0	2	2	4	3	2	1	2	1	0	7
Parastichopus californicus	0	0	1	2	0	0	0	0	0	0	0
Parastichopus parvmensis	0	0	0	0	0	1	0	0	0	0	0
Parastichopus spp.	0	6	0	0	0	0	0	0	0	0	0
Patiria miniata	34	52	118	118	77	99	154	117	65	124	104
Pisaster giganteus	19	37	35	17	33	23	31	25	23	45	25
Pisaster ochraceous	26	25	19	25	16	17	19	12	15	24	27
Pisaster sp.	0	0	0	0	0	0	0	0	0	0	20
Pycnopodia helianthoides	0	2	3	1	2	1	0	5	2	3	5
Strongylocentrotus franciscanus	289	384	359	366	301	263	373	160	122	69	14
Strongylocentrotus purpuratus	1	0	5	3	5	4	23	8	3	7	2
Stylasterias forreri	0	0	0	0	1	0	0	2	1	1	0
ECTOPROCTA											
Crisia sp.	0	0	0	0	0	0	0	C	0	A	0

Appendix 8i. (continued)

SPECIES	YEAR MONTH	1973 OCT	1974 AUG	1975 APR	1975 AUG	1975 DEC	1976 APR	1976 OCT	1977 MAR	1977 MAY	1977 NOV	1978 JUNE
ECTOPROCTA (continued)												
Diaperoecia californica		0	0	Sc	0	0	0	Sc	0	0	C	0
Flustrella corniculata		A	0	A	0	0	A	A	0	0	0	0
Heteropora magna		0	0	0	0	0	0	0	0	0	0	Sc
Hippodiplosia insculpta		0	0	0	0	0	0	Sc	0	0	C	0
Phidolopora pacifica		0	0	0	0	0	0	Sc	Sc	C	C	C
MOLLUSCA												
Acanthodoris brunnea		0	0	0	0	1	0	0	0	0	0	0
Acmaea mitra		0	0	0	C	0	C	C	Sc	0	0	Sc
Acmaea sp.		0	0	0	0	0	0	0	0	0	0	C
Anisodoris nobilis		3	0	6	0	5	5	8	3	3	4	0
Archidoris montereyensis		1	0	0	7	0	2	4	2	1	0	1
Astraea gibberosa		0	0	0	0	0	0	0	1	2	0	2
Berthella californica		0	0	0	0	0	0	0	0	1	0	0
Cadlina luteomarginata		1	0	0	0	0	0	0	0	0	0	0
Cadlina sparsa		0	0	0	0	0	0	0	0	1	0	0

Appendix 8i. (continued)

SPECIES YEAR MONTH	1973 OCT	1974 AUG	1975 APR	1975 AUG	1975 DEC	1976 APR	1976 OCT	1977 MAR	1977 MAY	1977 NOV	1978 JUNE
MOLLUSCA (continued)											
Calliostoma annulatum	0	0	Sc	0	0	2	0	Sc	Sc	0	C
Calliostoma canaliculatum	0	0	0	0	0	0	0	0	0	Sc	C
Calliostoma ligatum	0	0	C	C	C	19	A	Sc	C	C	C
Coryphella fisheri	0	0	0	0	0	0	0	1	2	0	2
Discodoris sandiegensis	0	0	0	0	2	2	3	2	0	0	0
Doriopsilla albopunctata	2	5	21	20	10	3	5	20	17	5	30
Haliotis rufescens	4	2	1	1	0	1	1	0	0	0	0
Hermissenda crassicornis	0	0	0	1	0	0	1	0	2	0	0
Hinnites multirugosus	6	6	3	3	3	3	8	4	1	14	5
Mitra idae	0	0	1	0	0	0	0	3	8	0	6
Phidiana hiltoni	1	0	0	0	0	0	1	12	20	0	2
Pododesmus cepio	0	0	C	1	C	0	C	Sc	0	A	0
Rostangia pulchra	0	0	0	0	0	0	0	0	0	0	1
Serpulorbis squamigerus	0	0	C	0	0	0	0	C	A	C	C
Tonicella lineata	C	C	C	C	C	C	C	Sc	C	0	C
Triopha catalinae	0	5	3	7	3	0	2	0	0	2	14

Appendix 8i. (continued)

YEAR	1973	1974	1975	1975	1975	1976	1976	1977	1977	1977	1978
SPECIES MONTH	OCT	AUG	APR	AUG	DEC	APR	OCT	MAR	MAY	NOV	JUNE
MOLLUSCA (continued)											
Triopha maculata	0	0	1	0	0	0	0	0	0	0	0
Unidentified nudibranch	0	0	0	0	1	0	0	0	0	0	0
PORIFERA											
Leucandra heathi	0	0	0	0	0	0	5	0	1	C	3
Leucilla nuttingi	0	0	C	A	Sc	0	C	Sc	C	Sc	C
Tethya aurantia californiana	2	0	1	0	0	0	0	3	2	1	2
Unidentified sponge	0	0	0	0	0	0	0	Sc	0	0	0
UROCHORDATA											
Boltenia villosa	0	0	0	0	0	0	0	0	0	C	2
Chelysoma productum	0	0	0	0	0	0	0	0	0	Sc	0
Cnemidocarpa finmarkiensis	0	0	0	0	0	0	0	0	0	0	1
Pyura haustor	0	0	0	0	0	0	0	0	0	0	1
Styela montereyensis	0	0	9	5	4	21	12	2	5	19	10
Unidentified tunicate	0	0	C	C	C	C	0	0	0	0	A

A = Abundant C = Common P = Present Sc = Scarce

Appendix 8j. Numbers or Estimates of Abundance of Brown Algae and Invertebrates Observed at Permanent Subtidal Station 16, Diablo Cove. DCPP, 1973-1978.

SPECIES	YEAR MONTH	1973 SEP	1974 AUG	1975 APR	1975 AUG	1975 NOV	1976 MAR	1976 OCT	1977 MAR	1978 MAY
PHAEOPHYTA										
Cystoseira osmundacea		A	40	72	81	85	68	77	A	A
Desmarestia ligulata		A	0	0	0	P	Sc	0	0	0
Desmarestia sp.		0	0	0	0	0	0	0	0	Sc
Dictyoneurum californicum		A	0	0	0	Sc	Sc	Sc	0	Sc
Egregia menziesii		0	0	0	0	0	0	4	0	0
Laminaria dentigera		0	0	0	10	5	18	43	65	213
Nereocystis luetkeana		11	0	0	4	0	3	0	0	0
Pterygophora californica		C	209	221	220	149	332	205	210	246
ANNELIDA										
Eudistylia polymorpha		0	0	0	0	0	0	Sc	1	0
Serpulidae		0	0	Sc	0	0	0	0	1	Sc
ARTHROPODA										
Cancer antennarius		1	0	1	1	2	1	2	1	0
Loxorhynchus crispatus		0	1	0	0	0	0	0	0	0

Appendix 8j. (continued)

SPECIES	YEAR MONTH	1973 SEP	1974 AUG	1975 APR	1975 AUG	1975 NOV	1976 MAR	1976 OCT	1977 MAR	1978 MAY
ARTHROPODA (continued)										
Pagurus sp.		0	0	P	C	C	C	C	C	0
Pagurus spp.		0	0	0	0	0	0	0	0	C
Paraxanthias taylori		0	0	0	0	0	0	0	0	1
Pugettia producta		0	0	0	2	0	0	0	1	1
Pugettia richii		0	0	0	0	0	0	0	1	1
COELENTERATA										
Anthopleura artemisia		Sc	0	0	0	0	7	0	5	2
Anthopleura xanthogrammica		4	18	20	12	24	32	14	25	17
Balanophyllia elegans		Sc	C	C	Sc	C	Sc	Sc	C	Sc
Cactosoma arenaria		0	0	0	0	0	0	0	P	0
Epiactis prolifera		Sc	0	Sc	0	0	Sc	0	P	Sc
Halcampa decemtentacula		0	0	0	0	0	1	2	1	0
Tealia coriacea		0	0	1	0	0	1	3	3	0
Tealia crassicornis		0	0	0	1	0	0	0	0	0
Tealia lofotensis		0	0	0	0	0	0	0	1	0

Appendix 8j. (continued)

SPECIES	YEAR MONTH	1973 SEP	1974 AUG	1975 APR	1975 AUG	1975 NOV	1976 MAR	1976 OCT	1977 MAR	1978 MAY
ECHINODERMATA										
Eupentacta quinquesemita		0	1	0	1	0	0	0	0	0
Henricia leviuscula		1	1	0	1	3	0	0	3	3
Leptasterias hexactis		2	0	0	1	0	0	2	0	Sc
Patiria miniata		53	101	39	72	81	84	76	57	76
Pisaster giganteus		0	1	0	0	1	2	0	0	0
Pycnopodia helianthoides		1	6	0	0	0	1	3	4	0
Strongylocentrotus franciscanus		73	26	0	0	0	0	0	0	0
Strongylocentrotus purpuratus		0	1	0	0	0	0	0	0	0
MOLLUSCA										
Acanthadoris brunnea		0	0	0	0	0	0	0	0	1
Acmaea mitra		0	0	0	0	0	0	Sc	Sc	C
Acmaea sp.		0	0	P	0	0	C	0	0	0
Astraea gibberosa		3	15	14	12	19	2	7	10	2
Cadlina luteomarginata		0	0	0	0	0	0	0	1	0
Calliostoma annulatum		0	0	0	0	0	0	1	0	0

Appendix 8j. (continued)

SPECIES	YEAR MONTH	1973 SEP	1974 AUG	1975 APR	1975 AUG	1975 NOV	1976 MAR	1976 OCT	1977 MAR	1978 MAY
MOLLUSCA (continued)										
Calliostoma ligatum		0	0	0	0	0	0	1	0	Sc
Discodoris sandiegensis		0	0	0	0	0	0	0	0	2
Doriopsilla albopunctata		1	0	0	2	2	0	1	0	9
Haliotis rufescens		48	11	3	0	2	0	2	0	4
Hopkinsia rosacea		0	0	0	3	0	0	1	2	2
Mitra idae		0	2	0	0	0	0	0	0	3
Mopalia spp.		0	0	0	0	0	0	1	1	Sc
Pododesmus cepio		1	0	0	0	0	0	0	0	0
Serpulorbis squamigerus		0	0	C	Sc	C	Sc	Sc	C	Sc
Tegula brunnea		C	0	C	C	G	0	Sc	A	C
Tegula sp.		0	5	0	0	0	0	0	0	0
Tonicella lineata		0	4	0	0	2	0	Sc	0	Sc
Triopha maculata		0	0	0	0	0	0	0	0	2
PORIFERA										
Leucilla nuttingi		0	0	0	0	0	0	0	Sc	0

Appendix 8j. (continued)

SPECIES	YEAR MONTH	1973 SEP	1974 AUG	1975 APR	1975 AUG	1975 NOV	1976 MAR	1976 OCT	1977 MAR	1978 MAY
PORIFERA (continued)										
Tethya aurantia californica		0	5	0	0	2	1	2	1	4
Tetilla arb		0	0	0	0	0	0	0	1	0
URCHORDATA										
Boltenia villosa		0	0	Sc	0	0	0	0	0	0
Clavelina huntsmani		0	0	Sc	Sc	0	0	Sc	0	Sc
Styela montereyensis		0	0	1	0	1	1	2	0	1
Unidentified tunicate		0	0	0	0	0	0	0	0	Sc

A = Abundant C = Common P = Present Sc = Scarce