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MEC BIOLOGICAL PROJECT
SAN ONOFRE NUCLEAR GENERATING STATION
MONITORING STUDIES ON
MYSIDS AND SOFT BOTTOM BENTHOS
FINAL REPORT

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provide information that would enable the California Coastal Commission to evaluate the impacts of SONGS operations. The goals of the MRC studies were to detect significant changes in the marine biota, to determine the magnitude and extent of those changes, and to determine whether the operation of Units 2 and 3 caused those changes. The MRC defined a significant change as a 50 percent reduction in abundance below what would be expected to occur in the absence of SONGS. The sampling program was designed to detect such a change if it occurred over an area of several square kilometers.

Two of the communities near SONGS that the MRC decided to monitor were the mysids and soft-bottom benthos. The mysids were chosen because they are an important trophic link between the benthos and the pelagic zone (which includes fish) and they are abundant near SONGS year-round. The benthos was chosen because benthic organisms are a major food source for demersal fish, the benthos is for the most part stationary, and it is amenable to quantitative sampling. Section 1.4 of this report provides an overview of the mysid and benthic communities of the study area.

MEC's monitoring studies sought to determine whether the operation of SONGS had caused marked changes in: (1) the abundance of mysids and benthic organisms; (2) their distribution in space; (3) the structure of the mysid and benthic communities; and (4) the relationships between the organisms and their environment.

Section 2 of this report explains the rationale behind the selection of species and groups to be studied and the details of the sampling and analysis plans. Mysids were sampled at two locations: an impact location three km south of SONGS (to permit the detection of large-scale changes) and a control area 18 km south (to correspond with fish studies). Samples were collected along onshore/offshore transects analyses of benthic community structure and pattern were applied to 48 taxonomic subsets of 19 trophic-motility (TM) groups and to approximately 250 individual taxa. BACI analyses were applied to 18 TM groups, 2 to 4 taxonomic subsets of 7 of those TM groups, and 28 individual taxa.

MEC's results are presented in Section 3. The analysis of physical and chemical data (Section 3.1) showed that there was a marked difference between 8 and 18 m in the temporal and spatial distributions of most of the variables that were studied. Sediments were coarser at 8 m than at 18 m. A large input of silt and clay which appeared in 1981 dominated the 18 m sediments within 2 km of SONGS until early 1985. Sediment chlorophyll concentrations were very low during 1982 and 1983, presumably reflecting the effects of the 1982-1984 California El Nino, but increased substantially in 1986. Values of percent silt and clay and sediment chlorophyll at 18 m, macrodetritus at 8 m, and organic carbon at both depths appeared to be higher within 2 km of SONGS during part or all of the operational period, but these gradients did not extend as far downcoast as the mysid transects or the benthic Intermediate and Control stations. There were very few correlations among the physical and chemical variables.

MEC detected few changes in the mysid community that could be attributed to the operation of SONGS (Section 3.2). The power of the BACI test was high enough to detect 50 percent changes with more than a 50 percent probability in five of the nine species and two of the three summary groups, and in nineteen of the thirty-six life stages. Two of the five species showed significant BACI changes in abundance; both were relative increases at SONGS. The analyses of the individual life stages generally supported the results from the total abundance of each species. BACI tests showed that the proportion of brooding females of

The community analyses identified the area within about 3 km downcoast from SONGS as different in the After period from the Control stations 6.7-9.4 km downcoast, primarily at 18 m. The upcoast stations were dominated in the After period by subsurface motile polychaetes, the downcoast ones by colonizing crustacea. The pattern analysis of individual TM groups and taxa tended to concur that an area extending about 1-3 km downcoast from SONGS was different from the rest of the study area in the After period.

Small changes in the trophic structure of the benthic community occurred from the Before to the After period, at both depths. At 8 m, motile subsurface deposit-feeding and surface suspension/deposit-feeding polychaetes, as well as carnivore/omnivores, declined in abundance. These declines caused motile surface deposit-feeding crustaceans to increase in relative importance, and the community to become indicative of an earlier successional stage. At 18 m, there was increased dominance near SONGS of subsurface deposit-feeding motile organisms, particularly polychaetes, and an increased importance and abundance of discretely motile crustaceans away from SONGS. The abundance of carnivore/omnivores also changed between the Before and After periods. These changes resulted in species assemblages characteristic of an earlier successional stage, and a marked longshore difference in the species composition of those assemblages.

A total of 10 of the 114 categories tested yielded BACI and pattern analysis results clearly interpretable as SONGS effects. At 8 m, combinations of primary BACI, secondary BACI, and pattern analysis results for 10 of the 53 categories tested showed possible effects. Two of them were clearly associated with SONGS (these were relative decreases for the motile surface omnivore/deposit-feeders and for Typosyllis hyalina). At 18 m, 31 of the 61 categories tested indicated community from the El Nino event. At 8 m the recovery appeared to be similar among all sampling stations downcoast of SONGS. At 18 m, the recovery began to diverge longshore in early 1986. By the end of the study, the species assemblage at the downcoast stations was different than that at the upcoast stations. This implies that SONGS may have influenced the composition of the community. The ecological importance of the difference at 18 m cannot be fully judged with the information at hand because none of the sampling locations had fully recovered from the El Nino-related disruption by the end of the study. To make this final judgement an assessment would have to be made as to whether full recovery to a late successional stage has presently occurred further downcoast than 9400 m and/or whether the difference in species composition between the upcoast and downcoast stations will continue.

species in the cooling water results in the death of a large proportion of those animals (Barnett et al., 1982, for Unit 2 and 3 losses and review of Unit 1), thus removing them from the system and potentially reducing their populations. Their carcasses, and the carcasses of invertebrates that live in the intake conduits and feed upon the material in the withdrawn water, are discharged into the environment, and may serve as an additional food source for the surrounding animals. Discharged material and animals entrained from the nearshore zone may be transported to the faster longshore currents farther offshore, and thus be lost to the inner nearshore zone. Sediments may be altered as a result of the transport of water high in suspended matter from inshore to farther offshore by the discharge currents. Predator/prey interactions may be altered as a result of changes in the abundances of predators or their prey. Discharges of biocides, metals, or radionuclides may contribute to any net reductions in abundance; however, evaluations of such potential contributions are outside the scope of these studies.

One of the original concerns raised when Units 2 and 3 were being planned was that the use of so much cooling water, and the entrainment of water representing about eight times that volume in the discharge, could have cumulative effects that would lead to large-scale reductions in the aquatic biota, possibly extending several kilometers from SONGS. An alternative view was that the longshore currents, eddy diffusivity, and cross-shelf circulation would be sufficiently strong to dilute the effects of SONGS rapidly to below detectable levels.

In 1974, as part of the permitting process for the San Onofre Nuclear Generating Station Units 2 and 3, the California Coastal Zone Commission (now the California Coastal Commission) issued Permit No.

depending upon how important the effect is judged to be, appropriate isolating studies can be conducted to determine the specific source(s) of the observed change and the mechanism(s) by which the change is effected. Note that it is possible that the sum of the positive effects and the negative effects can result in a zero net sum. Thus, a drawback to this approach is that there could be effects, but they could not be identified or measured.

The second approach is to design each of the monitoring elements, possibly in conjunction with controlled laboratory and field experiments, in such a way as to make that element relate specifically to a particular source of, and/or mechanism for, potential effects. Negative results allow one to remove that source or mechanism from continued scrutiny. Positive results permit a more rapid determination of effects and potential mitigations. This approach is costly at a facility such as SONGS, at which a variety of mechanisms can cause changes in many different marine populations. Furthermore, it may or may not be possible to integrate the results of the various elements arithmetically, since some effects may interact synergistically to cause an impact far different from their arithmetic sum. These could include opposing effects that cancel each other. For these reasons, isolating specific hypothesized mechanisms, even with the support of laboratory experiments, is difficult, and in some cases may be impossible.

In general, the MRC has taken the first approach in designing and implementing its studies. The resultant monitoring program, called BACI (an acronym for Before/After, Control/Impact), has been the MRC's primary tool for investigating SONGS net effects. The second approach, i.e., the study of mechanisms, was the primary approach to the study of

The soft-bottom benthos consists of organisms that live on or in the substratum, and includes representatives from every major animal phylum. The benthos is of interest in part because benthic organisms are a major source of food for demersal fish. In addition, the benthos is suitable for studies of SONGS impacts because it is stationary, widely distributed in the study area, and relatively amenable to quantitative sampling. SONGS could affect the benthos by changing the nature of the sediment near SONGS, which would cause some species to decline and others to increase; by providing additional food, which would cause increases in abundance; by changing the number and type of predators; and by reducing or preventing recruitment in the vicinity of the intakes and diffusers through the removal of larvae from the water column.

1.2 The Issues Addressed by Marine Ecological Consultants Studies

Marine Ecological Consultants (MEC) has studied mysids and soft-bottom benthos in the vicinity of SONGS since 1976. Monitoring studies began in 1979. The fundamental questions that MEC's monitoring study design asked were whether power plant operations had caused marked changes in:

1) the abundance of mysids and benthic fauna;
2) their distribution in space;
3) the structure of the mysid and benthic communities in the study area;
4) the relationships between physical/chemical variables and the patterns of abundance and community structure that we detected in the study area.

We studied individual species for three reasons. First, direct effects of the plant, namely removal of individuals, can be detected as

1.3 Approach

The MRC established a monitoring plan to measure net changes in the abundance of animals that could be attributed to SONGS operations. MEC's sample collection and data analysis were designed primarily to permit the detection of such changes.

1.3.1 Synopsis of Sampling Design

The details of the station locations, sampling schemes, and sample analysis procedures are presented in Section 2 and Appendix B. This section presents an outline of the sampling schemes used in the mysid and benthos studies.

1.3.1.1 Mysid Sampling

The mysid sampling scheme was designed to assess possible effects of SONGS on the nearshore (< 37 m) species assemblage defined by Clutter (1967) and Bernstein and Gleye (1981). Preliminary analyses (e.g., Clutter, 1977; Bernstein, 1980) suggested that entrainment and mortality in the intake could result in the daily loss of as many as 10% of the mysids in the vicinity of the intake, and changes in the abundance of mysids within 6 km of the plant.

To investigate those possibilities, mysids were collected at three transects, representing the Impact area in the BACI model, located 2.5 to 3.5 km downcoast (southeast) of the discharges, and at three transects, representing the Control area of the BACI model, located 17.5 to 18.5 km downcoast. The location of the Impact sampling area was chosen for two reasons. First, we reasoned that very large-scale changes, such as had been predicted, would be detectable at a station somewhat removed from SONGS, whereas any effects in the immediate

Mysids were sampled on a total of 43 occasions: 19 times during the preoperational period (October 1979 to December 1981; 7 times during the interim period (March 1982 to October 1983), and 17 times during the operational phase (October 1983 to December 1986). Surveys were conducted at approximately two-week intervals during 1979 and 1980, and quarterly during 1981 to 1983. Note that frequent sampling during the preoperational period only took place over approximately one year (November 1979 to November 1980).

During the operational period, surveys were conducted at approximately five-week intervals. The five-week interval was chosen for two reasons. First, that interval would spread the sampling over the course of two years (August 1984 to December 1986). Second, because the generation time of the most abundant mysid is approximately five weeks, using that interval would reduce the degree of serial correlation in the data set. Close-interval sampling (approximately monthly) occupied two full years (December 1984 to December 1986).

1.3.1.2 Benthos Sampling

The benthic sampling plan was designed to assess possible effects of SONGS on the soft-bottom benthic community near SONGS. Preliminary studies of Unit 1 (e.g., Diener and Parr, 1977; Parr and Diener, 1978) showed that the benthic community within 0.2 to 0.4 km of the intake and discharge contained fewer species and fewer individuals than did the community at the Control site, possibly because of the plant-induced coarsening of the sediments near the discharge and reduced settlement of larvae due to intake losses. Outside of the zone of coarsened sediments, and extending to 0.8 to 1.6 km from the plant, there was an increase in both abundance and diversity. This was attributed to to four weeks between November 1979 and November 1980 (preoperational) and between December 1984 and December 1986 (operational), and approximately quarterly during 1981 through 1984.

1.3.2 Analytical Design

1.3.2.1 Changes in Abundance

The difficulties inherent in attempting to determine the differences between potential SONGS effects and natural variation in an open marine system were appreciated at an early stage by the MRC, their consultants, their contractors, and others. Accordingly, in 1979 the BACI analysis scheme was developed by the MRC and its consultants. The BACI analytical procedure is described in detail in Section 2. Briefly, however, samples are collected from Control sites and from potential Impact sites near SONGS many times during both the preoperational (Before) and operational (After) periods. On each occasion the results of the Control are subtracted from the results of the Impact, yielding a set of Before differences and a set of After differences, or "Deltas." The mean of the differences between the Impact and Control samples in the Before period--the Before Deltas--is then tested against the mean of the After Deltas by a two-sample t-test to determine whether a significant change occurred. A significant change would imply an effect due to SONGS.

As a technique for analyzing monitoring measurements of marine organisms, BACI has some definite advantages. Marine populations integrate effects over time as well as effects arising from different stresses or enhancements. Using the differences between Impact and Control should eliminate, or at least minimize, the effects of natural changes in time. Therefore, BACI analyses should detect net changes in marine populations occurring over large scales.

As an aid to interpreting the results of the BACI analyses of mysid abundance, MEC calculated the intake losses of mysids. Mysids are, to some degree, planktonic at night, which makes them vulnerable to intake losses through withdrawal and entrainment. Because mysids vary in their inshore/offshore distribution, some species and life stages are more vulnerable to intake losses than others. Therefore, we estimated the losses of the various life stages of each species separately. This gave us insight into which species were more at risk to the direct effects of intake losses.

Mysid reproductive potential was also considered in these studies. The proportion of adult females in brooding condition was analyzed by an adaptation of the BACI procedure. A period-by-location analysis of covariance (ANCOVA), with the number of total females as the covariate, was used to obtain a relationship between the number of brooding females and the number of adult females at SONGS Before, SONGS After, Control before, and Control After. The slopes of these relationships represented the average proportion of brooding females within each BACI cell. We contrasted the slopes for each combination of paired cells to determine which pairs were different. A significant difference in the slope of SONGS After that did not occur at Control suggested a SONGS effect.

1.3.2.2 Changes in Distribution

MEC structured the sampling scheme to permit the examination of changes in the spatial (inshore/offshore) distribution of mysid species over time and changes in longshore patterns of abundance of benthic groups between the Before and After periods. We thought that plant-induced changes in the physical environment might cause a differences that occurred at all the others in order to determine where, within the study area, those changes occurred. A pattern shift would be demonstrated if some stations showed different degrees of changes in abundance.

1.3.2.3 Changes in Community Structure

The structure of the mysid species assemblage was examined using analysis of the rank order of abundance of the component species. Small but persistent changes in abundance could show up as changes in the rank order of a species group, thereby suggesting a fundamental change in the dominance structure of the community. The MANOVA procedure was used to detect changes in the rank order of species between the Before and After periods at the Control and SONGS locations separately. Observed changes at each location were then tested by t-tests on each species, with the significance level adjusted to reflect multiple testing.

The structure of the benthic community was investigated by a comparison of the average percentages of each TM group at each station in the Before and After periods. We were interested to know whether the percentage of certain indicator groups changed only near SONGS. The number of species (i.e., diversity), the abundance, and the evenness of each group were also considered in the same fashion. The structures of both mysid and benthic communities were also examined by cluster analysis to describe associations of species. Cluster analysis groups entities, such as samples or species, on the basis of the similarity of some attribute. MEC used an agglomerative hierarchical clustering technique to examine the structures of both the mysid and benthic communities. For mysids, the stages of the species were first grouped on the basis of their similarity with regard to their abundances at

1.4 Mysids and Benthos of the Study Area

The mysids and benthos near San Onofre are part of a faunal assemblage characteristic of the shallow shelf zone of the Southern California Bight (Jones, 1969). The mysids of the bight have been studied in some detail (e.g., Clarke, 1971; Clutter, 1967, 1969; Bernstein and Gleye, 1981; Barnett et al., 1983b, 1984b, 1985). The taxonomy of the group has recently undergone revisions; Table 1-1 presents the old and new names of the common species of the San Onofre area. Previous reports to the MRC used the old names. In this, the final report, the current taxonomic nomenclature is used. The studies cited above have identified a nearshore species group whose distribution extends to a depth of 37 m off San Onofre. The most abundant species in that group is <u>Metamysidopsis</u> <u>elongata</u>. Within the nearshore zone, these species exhibit a distinct horizontal zonation (Table 1-1). Inshore species tend to occur in water less than 15 m deep, and offshore species tend not to be found at depths of less than 15 m. The cross-shelf species are widely distributed throughout most of the depth range studied.

Mysids are omnivores (Mauchline, 1980), feeding on small live animals, dead animals, plants, and detritus. Mysids feed by selecting larger particles and filtering suspended material. Certain species migrate up into the water column at night, where they probably feed largely by filtering. In the San Onofre area, Barnett et al. (1983b) showed that a decrease in the abundance of three mysid species in the period 1979 to 1983 reflected decreases in macrodetritus, sediment phaeopigment, and water column chlorophyll-<u>a</u> concentrations and an increase in temperature. The same study detected a reduction in mysid reproduction, which suggested that the increase in reproduction

Numerous studies have documented the overriding importance of grain size in determining the species composition of the benthic infauna (see the review by Gray, 1974). Grain-size determines optimal feeding modes (for example, deposit feeders tend to be favored in unstable silts and muds, whereas suspension-feeding tends to prevail in more stable, coarser-grained sediments; Flint, 1981), and influences such factors as the retention of organic matter and the concentration of oxygen.

Benthic communities are known to vary along physical gradients such as depth (Johnson, 1970),, wave disturbance (Oliver et al., 1980; McLachlan et al., 1984), organic pollution (Pearson and Rosenberg, 1978) and substrate type (Johnson, 1970; Nichols, 1970; Flint and Rabalais, 1980; Jaramillo et al., 1984). On a smaller scale, infaunal assemblages have been shown to be sensitive to local patterns of food concentration (e.g., Whitlach, 1980), predation intensity (Thistle, 1980; Van Blaricom, 1982; Ambrose, 1984), and the silt and clay content of the sediment (Nichols, 1970).

In the vicinity of SONGS, Parr and Diener (1978) attributed the observed changes in the abundance and diversity of benthic species to the changes in sediment, hydrographic, and detritus conditions caused by the intake and discharge of Unit 1. Mobile species, such as amphipods and cumaceans, were apparently attracted to the discharge by the increased supply of detritus; some species near the intake declined, possibly as a result of decreased recruitment caused by the entrainment of larvae; and changes in the grain size of sediments in the intake/outfall area apparently caused changes in the abundance of several infauna species. Barnett et al. (1983a) demonstrated a progression of species assemblages with depth in the San Onofre area during the preoperational period, and showed that differences in grain study area comprise three more or less distinct assemblages: a nearshore (less than 10 m depth) assemblage, an offshore (10 to 35 m) assemblage, and a shelf assemblage seaward of the other two. The nearshore assemblage is dominated by the polychaetes Amastigos acutus, Owenia collaris, and Prionospio pygmaea, the bivalve Tellina modesta, and the cumacean crustacean Diastylopsis tenuis. The offshore assemblage is dominated by the polychaetes Mediomastus californiensis, Nephtys sp., Acesta catherinae, Tauberia gracilis, and Aricidea wassi, the bivalves Tellina modesta and Macoma sp., and the tanaid crustacean Leptochelia dubia. The shelf assemblage is dominated by brittle stars (Ophiuroidea) and small polychaetes. Subsequent studies (Barnett et al., 1982; 1983a,b, 1984a, 1985, 1986) have described as many as nine more or less distinct groups (Table 1-2). In the table, groups A through E are subgroups of the 15-30 m fauna, the subgroups being defined along narrower depth zones or on the basis of seasonal occurrence. Group F is associated with the kelp beds, group G is ubiquitous across the shelf, and groups H and I are characteristic of the 8-15 m fauna. The recent studies have elaborated upon the early groupings, but have not revealed material changes in species distributions and associations.

1.5 Scope of the Report

This introductory section has presented the framework within which the mysid and benthos studies were conducted, and a general overview of MEC's approach to the study design, sampling, and data analysis problems involved in attaining the goals set by the MRC. Subsequent sections will describe the sampling and analytical methods in detail, and will present the results of the analyses.

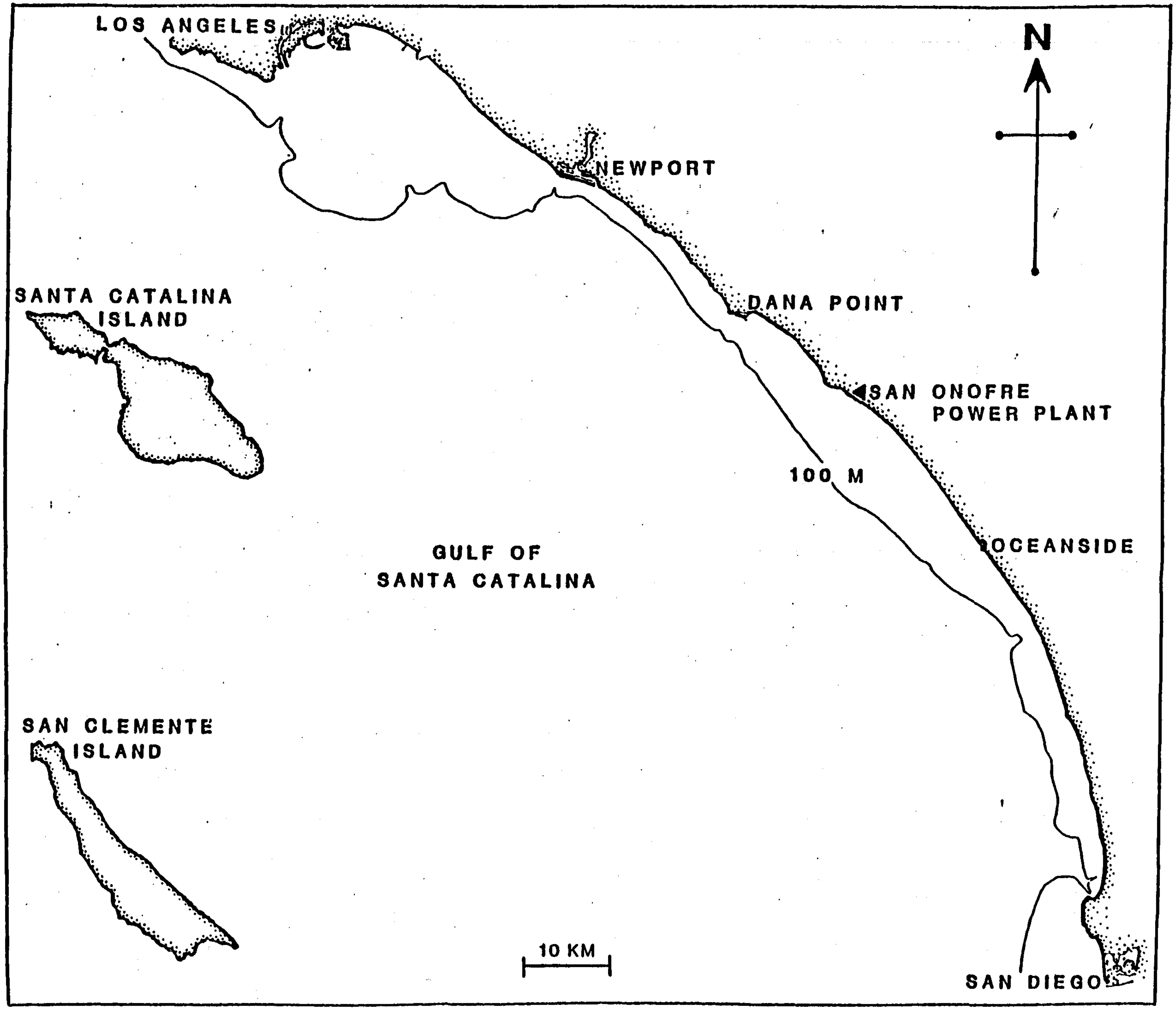


Figure 1-1. Regional setting of the SONGS site.

As part of the MEC quality assurance program, the precision associated with subsampling mysid samples was investigated for 27 samples (Barnett et al., 1982). The 95% confidence bounds associated with obtaining subsampling counts of 50 Metamysidopsis elongata or 100 total mysids were ± 28% and 20% of the mean, respectively. This translates to a coefficient of variation of about 5%.

Representative specimens of each mysid taxon have been separately curated in a documented reference collection (Barnett et al., 1982). The taxonomic accuracy of the reference collection has been assured through verification of voucher specimens by recognized mysid taxonomists (M. Bacescu, Romania; C. Holmquist, Sweden; L. Gleye, MEC). In some cases, original type specimens were obtained on loan from museums and compared with MEC collected specimens.

2.2 Benthos Monitoring

2.2.1 Field Sampling

Benthic samples were collected at depths of 8 m and 18 m at six locations: two in the immediate Impact area, 700 m and 1100 m downcoast of SONGS Unit 1, two at intermediate sites, 1900 m, and 3200 m (18 m depth) or 3350 m (8 m depth) downcoast of SONGS, and two in the Control area, 6700 m and 9400 m downcoast of SONGS (Figures 1-4 and 2-3). The 8 m stations generally corresponded to the depth of water in which the SONGS intakes are located and the 18 m stations to the depth of the diffusers. During the preoperational phase of monitoring, samples were also collected from 24 m and 30 m at the 700 m Impact and 9400 m Control locations. In addition, 15 m stations were sampled at San Onofre kelp bed approximately 700 m south of SONGS, and at Barn Kelp, approximately 10.6 km south of SONGS. The 15 m, 24 m, and 30 m stations were categories: crustaceans, molluscs, polychaetes, and "others" (other phyla). Nematodes were counted but not removed from the sorted samples. Animals within each taxonomic category were identified to the lowest practicable taxon.

After the animals were identified, the wet weight biomass of the sorted organisms from each station was determined. Animals from each of the replicate cores were combined according to taxonomic category, excess alcohol was removed by vacuum pump for 10 seconds, and wet weights of each of the four groups to the nearest 0.01 gm were measured on an electronic balance.

After June 1979 the sorted samples from each of the three replicates from a station were combined, and the average macrodetritus content of the samples was determined. The composite sample was swirled and the macrodetritus was poured off onto a preweighed filter. Macrodetritus was identified to categories of old (anoxic) and new terrestrial particles, marine macrophytic particles, animal tubes, organic particles, and inorganic particles. The percent (± 5%) composition of each category was visually estimated. The filter was then dried at 80°C for 10-12 hours and weighed (to nearest 0.01 gm). The dry weight of the composite macrodetritus samples was divided by three to yield an estimated macrodetritus dry weight per core. During the preoperational and interim period, the types of macrodetritus were not identified.

Sediment cores for grain size analyses were held at 0°C. For the analysis, a 20-50 ml subsample was transferred to a 240 ml bottle, mixed with 150 ml of deflocculent (sodium hexametaphosphate), and allowed to stand overnight. The sand fraction was shaken through and collected on eleven U.S.A. Standard Testing Sieves, which ranged in 0.5 phi base. Identified core samples and reserve cores were stored by survey in alcohol-filled jars with their lids secured with tape. Alcohol levels were checked each year to control evaporation. As part of the MEC quality assurance program, representative specimens of each taxon were separately curated in a documented reference collection (Barnett et al., 1982). The taxonomic quality of the reference collection has been assured by MEC's active participation in the Southern California Association of Marine Invertebrate Taxonomists (SCAMIT).

2.3 Benthic Gradient Survey

At the request of the MRC, MEC conducted one benthic gradient survey in December 1986 designed to determine if the operation of SONGS Units 2 and 3 had altered the benthic environment and biological community near the intakes.

2.3.1 Field Sampling

Sampling was conducted along three 750 m transect lines, one downcoast, one offshore, and the third onshore, all originating at the SONGS Units 3 intake structure and running normal to the coast. The first samples were taken 50 m from the intake. Additional samples were taken every 50 m out to 750 m from the intake for a total of 15 sampling locations per line, 45 locations total.

Three random replicate cores for grain size analysis were collected at each location on all three transect lines, yielding a total of 135 cores. Four random replicate cores for benthic organisms were collected at each location on the downcoast transect line, yielding a total of 60 cores. The collection and processing techniques described in Section 2.2.2 were employed for this survey as well.

(4) Analyses of longshore abundance patterns of the soft-bottom benthos to investigate the extent of any observed effect after SONGS Units 2 and 3 began operating;

(5) Community structure analysis to determine if the patterns of species dominance at SONGS during the operational period were different from those seen at Control during this period; this analysis was based on a t-test for mysids and a qualitative evaluation of table listings of abundance and percent composition for benthic taxa;

(6) Cluster analyses to identify changes in the mysid or benthos communities at SONGS during the operational period;

(7) Multiple regression analyses to determine whether observed changes in physical and chemical variables could be linked to observed changes in the biota.

Both individual mysid and benthic taxa and pooled groups of taxa were analyzed for this report. Analyses for changes in abundance were performed on individual taxa that were among the most abundant at each depth in the preoperational period as well as on additional taxa for which a high power of detecting changes was projected on the basis of the tests of preoperational data. Mysids were summed by their onshore-offshore distribution into three summary categories: the Inshore Mysid Group, the Offshore Mysid Group, and the Cross-Shelf Mysid Group. These summary categories were also analyzed. Benthic taxa were grouped according to trophic and motility characteristics. Mysid and benthic taxa were also evaluated according to their multivariate cluster groupings. The procedures for grouping the mysid and benthic taxa are described in Section 2.4.1.

Table 1-1). Since mysids are considered to feed similarly as scavengers and planktivores (Bernstein and Gleye, 1981), these summary groups are analogous to the benthic trophic motility groups discussed later in this section.

The developmental stages (adults, immatures, and juveniles) of each mysid species and summary group were analyzed separately to aid in understanding the results obtained for each species or group as a whole ("All" in Tables 3-3 and 3-4). Significant results for stages were not taken to indicate a significant change for a species or group unless the change was also seen in the "All stages combined" category.

Benthic taxa were analyzed using both the multivariate cluster approach and the community organization approach whereby taxa were grouped a priori according to trophic and motility characteristics. By utilizing both approaches to provide an integrated interpretation, we attempt to improve our understanding of the changes to the benthic community despite the limitations or lack of precision associated with either approach.

Feeding type has been used widely for classifying benthic taxa (e.g., Sanders, 1958 and 1960; Young and Rhoads, 1971; Bloom et al., 1972). More recently, feeding type has been supplemented with interactive criteria such as species motility and preferred feeding site (Woodin, 1976; Fauchald and Jumars, 1979; Whitlatch, 1980; Brenchley, 1981; Van Blaricom, 1982; Dorsey et al., 1983). For this report we have defined functional groups in the benthos as collections of taxa sharing common trophic and motility characters. The macrofauna at 8 m and 18 m BACI stations were assigned to trophic/motility (TM) groups (Table 2-2) based on literature reports of their site and mode of feeding, and of the motility associated with feeding. Species belonging

Mode of motility refers to whether an organism burrows, crawls, swims, nestles, or is tube-dwelling. Non-tubiculous sedentary organisms were also classified according to whether they occur on top of the sediment as epifauna or in the sediment as infauna.

Some animals respond to disturbance by immigrating to (colonizing) a disturbed area or by rapidly increasing their local abundance through rapid population growth (opportunism) (MacArthur, 1960; Grassle and Grassle, 1974; Oliver et al., 1977; Pearson and Rosenberg, 1978; Van Blaricom, 1978; Grizzle, 1984). These species are scarce, less abundant, or absent from undisturbed communities presumably because of limited food resources or their poor competitive abilities. Therefore, the abundance of species with known colonizing or opportunistic capabilities can be used as evidence of environmental perturbation. For example, more species and higher abundance of mobile colonizing or opportunistic species suggests organic enrichment. Conversely, fewer species, coupled with an increase only in the abundance of opportunistic species suggests degradation.

Species were classified as opportunists/colonizers (Table 2-2) if they had been reported in the literature as such. Because these terms are not consistently distinguished in the literature, we do not attempt to separate them here. Some species, not confirmed as colonizers or opportunists, but from the same genus as reported colonizers or opportunists, are denoted with a (?) in Table 2-2. Colonizing or opportunistic behaviors are not specified if reports were not found in the literature. Defining functional groups according to colonization or opportunistic tendency might be directly relevant to recognizing SONGS effects; however, because reports of colonization or opportunistic tendencies are limited and not always distinguishable, we have not attempted to define groups using these characteristics.

2.4.2 The Study Periods

The data were divided into preoperational (Before) and operational (After) sets for the analyses. The time between the preoperational and operational periods is referred to as the interim period.

The mysid preoperational data base consists of 19 surveys, 16 taken from October 1979 to July 1980 and 3 taken in June, September, and December 1981 when Units 2 and 3 were not operating (Table 2-1). The operational data base consists of 17 surveys, which were taken from October 1983 to December 1986. The operational monitoring period was initiated in July 1983 but sampling for mysids was delayed three months in order to allow time for SONGS operations to affect the physical environment of the near-bottom zone where these organisms concentrate during the day. Three months represents from 1 to 3 generation times for most of the mysid species in the nearshore area.

The benthic preoperational data base consists of 23-26 surveys, depending upon the depth (Table 2-1). Five surveys were conducted at quarterly intervals between June 1976 and July 1977 at the 8 m stations and eight surveys were conducted between June 1976 and July 1979 at the 18 m stations. Fifteen surveys of the 8 m and 18 m depths were conducted on a triweekly basis from November 1979 to November 1980, and three surveys were conducted in June, September, and December 1981 when Units 2 and 3 were not operating. The operational data base consists of 32 surveys at both the 8 m and 18 m depths from March 1984 to December 1986.

The six-month lag between the start of Units 2 and 3 pumping operations in July 1983 and the onset of the benthic operational monitoring period was intended to allow any SONGS-induced changes in the benthic environment to be reflected in the benthic community.

were first calculated on a seasonal basis and then averaged over seasons and years. This procedure matched more closely the operational levels with mysid abundances. The warm season was defined as April - September, the cool season October - March (Barnett et al., 1986).

The data used in the loss calculations were based on samples taken at the Control location. We assume that data from the Control area better reflect source water conditions, whereas stations on the SONGS transect during the operational period reflect biotic conditions after being subjected to SONGS cooling operations. All surveys taken in the operational monitoring period were included. Note that this approach was developed in the preoperational period, when abundances were similar at SONGS and Control. Abundances in the operational period, however, were generally marked higher at SONGS, so that the losses presented here may actually be underestimates.

The model of estimated losses was based on the following assumptions:

(1) Water is withdrawn in equal proportion from the whole water column (Reitzel et al., in press).

(2) Mysids can, to a great extent, avoid entrainment during the day when they are restricted to the bottom 1 meter of the water column. They do this by swimming against the current and using visual topological cues to maintain position. Orientation to visual cues by mysids in a current has been demonstrated by Clutter (1969).

(3) This behavior disappears at night, when visual orientation becomes impossible, so that mysids are entrained during the night with the water they inhabit. Reduced ability to maintain position in the dark has been demonstrated by Clutter (1969).

cubic meters per day was calculated using the volumes in the DBSONGS data base (MRC, in prep.) for the October 1983 through December 1986 operational period. The cross-shelf area affected by the intakes of Units 2 and 3 was calculated by dividing the average intake volume by the average longshore movement of water.

The mean number per cubic meter (density) in each inshore-offshore stratum was used in the calculation of intake withdrawal losses and potential diffuser losses of mysids. The equation used to produce these mean numbers per cubic meter was:

$$\text{mean}_j/\text{m}^3 = \frac{1}{3} \sum_{i=1}^{3} (\text{number}_j/\text{m}^3)$$

where i refers to a transect and j refers to an inshore-offshore stratum (tow). For each sampling date the number of mysids withdrawn was calculated as follows:

$$\text{Number Withdrawn} = (V/L) \times (1/H) \times D \times P$$

where V = average intake volume in cubic meters per day
L = average longshore flow in meters per day
H = average height of the water column at the intake (9 m)
D = abundance in number under a square meter in 8-12 m tow
P = percent of mysids that are affected
$= (100\%_{\text{night}} + 25\%_{\text{day}})/2 = 62.5\%$

Each of these estimates of withdrawal by sampling date was assigned to a season category, the seasonal mean loss was calculated from the number withdrawn, and then the mean over seasons was calculated. This mean loss over seasons represented the mean annual loss during the operational period.

P = percent of mysids that are affected

$$(100\%_{\text{night}} + 25\%_{\text{day}})/2 = 62.5\%$$

Three estimates of potential diffuser losses were made: 10%, 25%, and 50% of those entrained. Each of these loss estimates was added to the intake losses, and both the number of mysids lost and the percentage of the cross-shelf numbers that was lost was calculated as above.

2.4.4 BACI

To determine whether observed changes in field abundances could be associated with SONGS operations, abundances of individual taxa and pooled groups of taxa were analyzed by the BACI procedure Before-After/Control-Impact. The framework of the BACI procedure is presented in the next sections.

The test variables for the BACI analyses of mysids were the weighted mean numbers per cubic meter in the cross-shelf by location (Impact, Control) and date. The equation used to produce these variables was:

$$\text{Weighted mean/m}^3 = \frac{1}{3} \sum_{i=1}^{3} \left(\sum_{j=1}^{6} \frac{(\text{number}_j/\text{m}^3)(\text{volume}_j)}{\text{volume}_i} \right)$$

where i refers to a transect and j refers to an inshore/offshore stratum (tow). As mentioned in Section 2.1 three transects were collected at each location (Impact, Control) and six tows were collected along each transect.

The test variables for benthic taxa and TM groups were based on the total number in all cores analyzed at the two stations at each location at a given depth. Two stations at Impact and two stations at Control were used for the BACI tests. For each location (Impact, Control) and depth (8, 18 m) and date (from November 1979 onward) the equation used to calculate the test variables was:

Before period. That is, measurements cannot be made too close together, because they are then essentially duplicate observations. At the end of the Before period the number of surveys that must be taken in the After period in order to yield the desired power of the statistical test is calculated (and hence "fixed"). This period is discussed further below. Control locations are chosen with care to mimic, as nearly as possible, natural changes occurring in populations of species at the Impact site in the Before period. Thus, any differences in the Control/Impact relationship in the After period compared to the Before period can be attributed to SONGS. Impact minus Control differences, called Deltas, estimate the differences between the sizes of the populations at the two sites at the times observed. The average Delta in the Before or After period estimates the mean difference in population size for that period. A significant difference between the average Delta in the Before time period and the average Delta in the After time period would indicate that the power plant is having an effect on the population at the Impact site.

For many species in our studies the average Delta in the Before time period was zero, indicating that the populations at the two sites were the same size. If the populations were not the same size in the Before period, we looked for a continuation of the same relative difference between the populations in the After period. A more negative average Delta in the After period than in the Before Delta would indicate that the population near the power plant had decreased in size relative to the Control site population.

Note that since BACI analysis is performed on the Deltas, which are a measure of the relationship between population sizes at the Impact and Control locations, variations in population sizes in response to

+ L + T + S, where S is the additive difference due to the SONGS. Notice that L appears in both Impact means because it represents the Impact-Control difference; T appears in both operational means because it represents the After-Before difference. The SONGS effect, S, only appears in the operational, Impact model mean.

For the additive model, the parameters of the model represent changes in abundances, that is, numbers of organisms. For example, L = 125 indicates there are 125 more organisms, on average, at the Impact site than at the Control location. S, the SONGS effect parameter, represents the change in abundance at the Impact site relative to the population that would have been there if the power plant were not there. Thus, S = -60 indicates that 60 fewer organisms were found at the Impact than would have been found if the power plant were not present.

Maintaining the model's format, the averages of the observations can be displayed as:

	Impact	Control
Before	Y_{IB}	Y_{CB}
After	Y_{IA}	Y_{CA}

Y_{IB} is the average of all the Impact observations in the preoperational period, and Y_{CB} is the average of all the Control observations in the preoperational period. In the operational period, Y_{IA} is the average of all Impact observations and Y_{CA} is the average of all Control observations. Therefore,

$$\mu = Y_{CB}$$

$$L = Y_{IB} - Y_{CB}$$

$$T = Y_{CA} - Y_{CB}$$

$L = \text{antilog } (Y_{IB} - Y_{CB})$

$T = \text{antilog } (Y_{CA} - Y_{CB})$

$S = \text{antilog } ((Y_{IA} - Y_{CA}) - (Y_{IB} - Y_{CB}))$

$S = \text{antilog } (\text{DELTA}_A - \text{DELTA}_B)$

where the Ys are now averages of log-transformed data and the Deltas are differences of averages of log-transformed data. S, the SONGS effect parameter, represents a proportion applied to the mean abundance that would have been found at the Impact location if the power plant were not there. For example, if S = 0.6, it means that the abundance of organisms at the Impact location with SONGS present was 60% of the abundance that would have been measured if the power plant were not present. Or, stated differently, the power plant has caused a (1 - S) = 40% reduction in the abundance of organisms.

We wish to emphasize that when a multiplicative model is invoked, all analyses are performed on log-transformed data. Results from log-transformed data analyses can sometimes be different from what one would expect from looking at the untransformed data. We discuss below both how we decided whether to use an additive or a multiplicative model, and how we attempted to reconcile the differences between these two ways of looking at the data.

The BACI test reduces to a t-test of the null hypothesis,

$H_o\text{: } \text{DELTA}_A - \text{DELTA}_B = 0.$

The alternative hypothesis for both the mysids and soft-bottom benthos is $H_a\text{: } \text{DELTA}_A \neq \text{DELTA}_B$, which is a two-tailed test. A t-statistic is calculated, equal to the difference between the two Deltas divided by an estimate of the pooled standard error of that difference. Degrees of freedom for this t-test are 2 less than the total number of surveys taken.

observed difference between the mean of the Before Deltas and the mean of the After Deltas and on the amount of variability in the Before and After periods. The power of each BACI test was calculated and reported.

In order for the stated Type I error and power to be close to the true error and power, certain assumptions must be met. The next section briefly discusses these assumptions, how they are tested, and how their absence would affect the test results and can be corrected for. For a more complete exposition of the BACI model and assumptions see Stewart-Oaten (1986).

2.4.4.2 BACI Assumptions Description

In order that the BACI hypothesis of $\text{DELTA}_A = \text{DELTA}_B$ is meaningful and that the Type I error and power are valid, the following assumptions on the Deltas must be met:

- additivity in the Before time period,
- lack of trends with time in the Before time period,
- lack of serial correlation in both time periods, and
- normally distributed errors in both time periods. Each of these assumptions will be discussed below. Appendix C presents the protocol developed to examine the assumptions tests in order to minimize subjective interpretation.

The Additivity Assumption

A fundamental assumption in framing the BACI hypothesis is that the Deltas within each time period are observations from the same distribution; in particular, the mean Delta must be constant over all surveys within a period. This is a restatement of the assumption for a t-test that the observations, in this case Deltas, must be independent and identically distributed.

location, then the slope of the Delta (SONGS minus Control) versus sum (SONGS plus Control) line is approximately equal to 45 degrees. In this case, the result is an artifact of the additivity test structure, and the test is not appropriate.

The other solution is to invoke the multiplicative model and to apply a log-transformation of the abundance data. If abundances are multiplicative (e.g., 2x), taking the log linearizes them (e.g., log(2x) = log(2) + log(x)). The Deltas are then the differences between the log-transformed abundances. Note that we refer later in the text to log-transformed Deltas, by which we mean Deltas of the log-transformed abundances.

Using a log transformation introduces a new problem: the log of zero is undefined, and the abundance data may contain many zeroes. Two solutions to this new problem are (1) to eliminate the surveys containing abundances equal to zero and perform the BACI analyses on log-transformations of a smaller data set; or (2) to add a small constant amount to all observations before log-transforming. Since, however, the size of the most appropriate constant is not known, we had to try a number of different constants and test each constant for all BACI assumptions.

In the situation where one cell of observations (e.g., Before SONGS) contains a preponderance of zero abundance values, the size of the constant added to all observations before log-transforming can control the results of the BACI test. We use a Chi^2 test to identify these cases. If such circumstances exist, the BACI analyses are not used as the primary tests and may only be used as corroborative tests if more than one log(x + constant) are available (i.e., passes all assumption tests).

occurred only infrequently (when numbers per 4" core were standardized to numbers per 3" core where more than six cores had been analyzed). Note that adding a constant before taking a log shifts the abundances right or left on the horizontal axis and can thus change this effect, but it can never get rid of it because of the shape of the logarithm curve. We found situations in which the untransformed data appeared to indicate a change in one direction, but BACI results on log-transformed data showed a change in the opposite direction. In such situations the direction of the change indicated by the BACI test was the direction we discussed in our results.

Because of these difficulties in interpreting and understanding log-transformed results, we preferred to perform all BACI testing on untransformed data, and to use log-transformations as little as possible. We also discussed untransformed species abundance whether or not BACI testing was performed on log-transformations. The percent relative change in abundance values in our discussions are, however, based on transformed data when the testing was performed on transformed data.

Trends in the Before Time Period Assumption

For a testable hypothesis the Deltas cannot exhibit a trend with time in the Before period. If the Deltas did show a trend with time, for example if they were increasing, then the Control site population was not mimicking the Impact site population changes. In other words, the Control site was not a good match for the Impact site in the Before period. Since the two sites did not match in the Before period, any change in the After period could not be attributed to SONGS.

$$\text{Delta}_{jk} = \mu + D_k S + \varepsilon_{jk}$$

where k = 1 for observations in the Before period

2 for observations in the After period

j = survey number within a period

μ = Before time period mean Delta

D_k = 0 for k = 1, Before period observations

1 for k = 2, After period observations

S = SONGS effect

ε_{jk} = independent, normal $(0,\sigma^2)$ random errors

In the case of serially correlated data, only the error term in the above model changes, incorporating autoregressive terms:

$$\varepsilon_{jk} = A_1 \varepsilon_{j-1,k} + A_2 \varepsilon_{j-2,k} + \nu_{jk}$$

where A_1 = coefficient of the first order autoregressive term

A_2 = coefficient of the second order autoregressive term

ν_{jk} = independent, normal $(0, \sigma^2)$ random errors

Maximum likelihood techniques are used to estimate all the coefficients in the autoregressive errors model. With two extra terms in the model, A_1 and A_2, the degrees of freedom now decrease by two. However, the trade-off is that we have ν, an estimate of error free of autoregressive correlation, to be used as the error term (MSE) in the BACI t-test. The p-value from the autoregressive t-test for the BACI effects is asymptotically correct, yielding valid results for sample sizes greater than 30 when correlations are small (Fuller, 1976).

Fitting observations unequally spaced in time to a correlated errors model as if they were equally spaced can generate correlations in the residuals. For example, consider observations closely spaced at the beginning of a series, and widely spaced at the end of the series, with correlations at the beginning and independence at the end. Fitting

2.4.4.3 Other Procedures

In place of, or as a confirmation of, the BACI t-tests, several other analyses were performed. These procedures, all of which are discussed below, were: Wilcoxon rank sum tests; a SONGS versus Control regression procedure; and a binomial SONGS effect test.

Wilcoxon Rank Sum Test

We used the results of the BACI Wilcoxon rank sum test, a non-parametric test, as a substitute for the BACI t-test when influence points (violating the additivity assumption) were found. Because averages are sensitive to outliers, their presence could strongly affect the BACI t-test results. The test also was used for corroboration of BACI t-test results when no outliers were present.

We applied the Wilcoxon rank sum test to the Deltas. Assuming the distributions of the Deltas in the two time periods were identical except for a possible shift in their median positioning, L, the null hypothesis is that $L_A - L_B = 0$, with a two-tailed alternative hypothesis, $L_A - L_B \neq 0$. All the Deltas were ordered and ranked. Under the null hypothesis, the ranks should be randomly distributed between the two periods. We computed the sum of the ranks of the Deltas within the time period that included the smallest number of surveys. We then calculated the p-level, which indicated the probability, under the null hypothesis, of obtaining the sum of ranks observed or a sum reflecting a less random distribution of ranks.

Occasionally the Wilcoxon rank sum test and the BACI t-test gave different results. These divergences can be explained in terms of the size of the numbers and their variabilities. For example, suppose that the Before Deltas were mostly positive and included a few large positive

SONGS versus Control Regressions

Plots of SONGS versus Control values provide a useful visual understanding of possible SONGS effects. The analysis was used to interpret conflicting additivity results, to look for non-linear SONGS effects, and as corroboration of the binomial test. SONGS effects can also be tested by fitting various functions to the SONGS/Control relationship and testing for non-zero coefficients.

If the SONGS-Control Deltas are additive, then $S - C = d$ or $S = d + (1 \times C)$. In other words, the SONGS versus Control graph will be a 45 degree line (slope = 1) with an intercept at d. The SONGS/Control relationship in the After period in the case of a SONGS effect would also be a 45 degree line with a different intercept, d_1, which would be less than d. This graph would consist of two parallel 45 degree lines separated by a constant amount, equal to $d - d_1$, which is the SONGS effect.

We fit a straight line regression model to the SONGS/Control data for each period separately. We then looked for equality of slopes and intercepts. If the slopes were equal but the intercepts were not, that was taken as evidence of a SONGS effect equal to the change in intercepts. If the slopes of the Before and After regressions were not equal, then SONGS may have had a more complicated effect. Note that slopes not equal to 1 imply a multiplicative model in the Deltas.

We also fit curved lines to the SONGS versus Control data. Data which fit the curved lines will exhibit a more complicated form of multiplicativity. If the regression fit two parallel curved lines, then the interpretation was that the relationship between SONGS and Control abundances was the same in both time periods, but that the abundance changed in the After time period. If two different curved

Whenever possible we preferred to use the untransformed data. The low absolute values of most of our data suggest that additive models are appropriate; in fact, extensive trials with other transformations (e.g., log(x), log(x + c), inverse, and square root) did not substantially improve either the degree to which the data were amenable to statistical analysis or our ability to interpret the data. Finally, in most cases in which there were zero observations, the data transformed by log(x + c), initially thought to be most desirable, were too sensitive to the value of the constant, c. Thus, we did all that we reasonably could in our analytical protocol to accept untransformed data before resorting to the imposition of a transformation.

Description of Change

The number of surveys to be taken in the After time period was calculated on the basis of the requirement that the power (probability) to detect a 50% change be at least 80%. The 50% change was estimated by assuming that abundance levels at the Control site would remain constant and that abundance levels at the SONGS site would double or decrease by half. For this report we wished to retain this perspective, and we therefore calculated a relative percent change which could be compared to that used in estimating sample size.

As we mentioned in Section 2.4.4.1, within an additive model, $Delta_A$ estimates the location effect and $Delta_B$ estimates the location effect and the SONGS effect. $Delta_A$ - $Delta_B$, therefore, estimates only the SONGS effect, S, or the number of organisms gained or lost due to the presence of the plant. We have taken this number and expressed it as a percent relative to the average number of organisms found at SONGS in the Before time period. It is reported as the percent relative change in abundance of the organism.

$Y_{CB} \times T \times L \times (S - 1)$ = abundance lost at the Impact Site in the After period due to SONGS

% Relative Change = $100 (Y_{CB} \times T \times L \times (S - 1)) / Y_{IB}$.

Once T, L, and S have been estimated, S - 1 represents the estimated proportion of organisms at SONGS lost due to the presence of the power plant. This proportion is relative to the number of organisms that would have been found at the Impact site if the power plant were not present. Thus, to estimate the number of organisms lost as a result of the power plant, we need to estimate the number of organisms that would have been observed in the absence of the power plant. This number is estimated as the average abundance at the Control site in the Before period, times the proportional increase (or decrease) due to location, times the proportional change due to time, or $Y_{CB} \times L \times T$. Multiplying $Y_{CB} \times L \times T$ by (S - 1) yields the number of organisms lost as a result of the power plant. Dividing this number by the average abundance at the Impact site in the Before time period yields a percent change that is comparable to that calculated with an additive model.

Because this estimate of percent change is based on arithmetic means applied to a multiplicative model, the percentage found may differ in sign from that found using geometric means (i.e., means of log-transformed data), which is what the fully multiplicative model uses.

BACI Testing

The level of significance (α-level) for the BACI test was selected to be either 0.05 or 0.10; the power of the BACI t-test was used as the selection criterion (recall that the power of the BACI test is the probability of detecting a 50% decrease or increase when such a change

2.4.4.4 Adaptation of BACI Approach to Analyze Mysid Reproductive Potential

This analysis was developed to test whether the proportion of adult females carrying young (brooding female/total adult female) was the same in the four BACI cells for each mysid species. The proportion of brooding females was estimated as the slope of the line between brooding females versus all females, forced through the origin. To make comparisons between the brooding female proportions among the four BACI cells, an analysis of covariance (ANCOVA) was established as follows:

$$BR = a * ABI + b * ABC + c * AAI + d * AAC + e$$

where BR = number of brooding females for this observation.
ABI = number of adult females in the Before period at the Impact station, or
= 0 if not a Before, Impact observation.
ABC = number of adult females in the Before period at the Control station, or
= 0 if was not a Before, Control observation.
AAI = number of adult females in the After period at the Impact station, or
= 0 if not an After, Impact observation.
AAC = number of adult females in the After period at the Control station, or
= 0 if not an After, Control observation.
a = proportion of brooding females at Before, Impact.
b = change in proportion of brooding females at Before, Control relative to Before, Impact.
c = change in proportion of brooding females at After, Impact relative to Before, Impact.
d = change in proportion of brooding females at After, Control relative to Before, Impact.
e = independent, identically Normally distributed errors.

For the pattern analysis, all Before observations (both SONGS and Control) and the After-Control observations were combined into one group (hereafter called "Before-or-Control") to be compared with the After-SONGS group. Combining Before-SONGS with Before-Control and After-Control groups simplifies the analysis while putting any differences between those three categories into the error variance. This in turn causes the analysis to be more conservative (i.e., makes it harder to find differences). It has the virtue, however, of building a standard based on all of the conditions that can be regarded as unaffected by SONGS Units 2 and 3 operations.

If the MANOVA was performed on untransformed abundance data, the technique might be sensitive to an overall change in abundance. That is, significant differences might be found in all tows due to a change in abundance everywhere in the After-SONGS group. Therefore, the pattern analysis was performed using ranks of abundances. Each tow of each survey was a vector variable. In this analysis only the relative changes between the tows were important.

The mean abundances (number per cubic meter) for each of the inshore-offshore strata by location (Impact, Control) and date observations were used to rank the observations. The equation used to produce these mean abundances was:

$$\text{mean/m}^3 = \frac{1}{3} \sum_{i=1}^{3} (\text{number}_j/\text{m}^3)$$

where i refers to a transect and j refers to an inshore-offshore stratum. The rank was then used in the pattern analyses (MANOVA, ANOVA, Bonferroni t-test) of mysid onshore-offshore distributions. The mean numbers per cubic meter were ranked from lowest to highest by location and date. A "phantom" stratum was always assigned the lowest value (1) in order to avoid singularity in the test results.

A multivariate repeated measures analysis (SAS, 1985, GLM procedure) was used to test for a period-by-location interaction; e.g., period and distance from SONGS. A repeated measures analysis of variance is used when there are within-subject correlations. In the analysis of longshore patterns of abundance we suspected spatial correlations in the data. Since each sampling survey represents a subject, these correlations could be explicitly incorporated into the statistical model with the repeated measures procedure. The distance from SONGS was the repeated measure; a multivariate procedure was used in order to incorporate a vector, the elements of which were the values of abundance at the longshore locations.

If the multivariate analysis showed significant period-by-location interactions, then Bonferroni multiple comparisons on the univariate period-by-location differences were used to determine where in the longshore those differences occurred. In this technique, a one-way univariate ANOVA was used to identify which locations changed from the Before to the After period. A second factor, survey-nested-within-period, which is a measure of the survey-to-survey differences, was included in the ANOVA analyses in order to keep that variation out of the error term. The results of the second factor were not pertinent to the question being asked. _A priori_ contrasts between locations were then tested for locational differences between periods. For example, the difference between the mean abundances in the Before and After periods of a given taxon at 700 m downcoast from SONGS at the 18 m depth was tested against the same difference at 1100 m downcoast from SONGS. The significance level for each of the 15 _a priori_ locational contrasts was adjusted, using Bonferroni's inequality to .05/15 = .0033. Using these locational contrasts, a multiple comparison presentation was using a Bonferroni level of .05/9 = .005 to guarantee at least a .05 level for the nine species collection. The mean rank orders of abundance at each location were compared for each time period and the two locations were also compared to determine if the same species showed similar significant changes between the study periods at both locations.

2.4.7.2 Benthos

The community summary variables for the benthos were not utilized in a separate analysis as was done for the mysids, but instead were used together with the cluster analysis to describe community level changes.

2.4.8 Community Patterns -- Cluster Analyses

2.4.8.1 Mysids

In their final report for the preoperational period Bernstein and Gleye (1981) reported on the consistent associations of mysid species that characterized the nearshore in the San Onofre region. These associations of various developmental stages of different mysid species were based on both depths of occurrence and on seasons. Cluster analysis was used to identify patterns of relationships.

We repeated the cluster analysis with some alterations to assess whether SONGS stations in the After period formed a unique group which would suggest a change in community in the SONGS area. A second purpose was to determine if relationships had changed since the onset of operation at Units 2 and 3.

In order to reduce the data to a level that could be analyzed by available computer software we condensed our abundance-by-depth data to the weighted mean abundance in the nearshore Tows 1, 2, and 3 (6-15 m) basis of a cluster intensity coefficient (β) set at -.25. Using $\beta = -.25$ with flexible sorting tended to produce distinct groups and is a conventional approach (Boesch, 1977). The normal and inverse classifications were used to produce a two-way coincidence table (Figure 3-19) of species and depth by time and location (=strata) groups.

The level of resemblance deemed sufficient to identify a group was subjectively set at a Bray-Curtis distance of $\geq .50$ for the strata (the normal classification), while for species (the inverse classification) it was set at $\geq .80$. In the species dendrogram the level of resemblance considered sufficient to identify groups varied; that is, a flexible "stopping rule" was used. Boesch (1977) pointed out that this is a reasonable procedure with the type of classification analysis used here. The strata dendrogram is included in Appendix C.1 (Figure C.1-1) and may be used to examine the depth by time and location groupings indicated on the two-way table presented in Section 3.

2.4.8.2 Benthos

Resemblances among benthic taxa in terms of their relative abundances at the various sampling times and places, which define species clusters, and among the various stations and times in terms of the relative abundances of the various taxa, which describe station groups, can be demonstrated by the use of cluster analysis. As for the mysids, the principal use of cluster analysis in the benthos study was to reveal whether a particular suite of stations--SONGS-area stations in the Operational period--could readily be distinguished from the rest of the data. A secondary use of cluster analysis was to describe aspects of the biology of the benthic community, such as seasonality and

Station groups identified in the cluster analysis were described in terms of their species composition by a standardized abundance technique (Smith, 1976). For each group, the abundances of each species in the group were square-root transformed, then standardized by the square root of that species' maximum observed abundance. For each species, the standardized values of the abundances of that species within group were summed and divided by the number of occurrences. Thus, a value of 1.0 means that within that group the species always occurred at its maximum abundance, whereas a low value means that the species was rarely, if ever, close to its maximum abundance. This approach weights the species more equitably, preventing the less abundant, but consistently present, species from being overwhelmed by the very abundant species. The result is essentially the rank order of relative abundance of species within each group. The species characteristic of a station group were taken to be the ten to fifteen highest-ranking on the basis of the relative abundance: for the 8 m data all species and TM groups present at greater than 0.25 were included, and at 18 m, because overall abundance was greater than at 8 m, 0.35 was used. Note that as a consequence of this method of standardizing abundance, identification of a species as a characteristic member of a station group implies that in that station group it was at or near its maximum abundance, but not necessarily that it had to be one of the most abundant species in that station group.

In view of the enormous number of points comprising the benthic data base, multidimensional scaling was also used to describe the biological variation in the data. In this method, described by Smith, Bernstein, and Cimberg (in press), the distance between any two samples in a multidimensional environmental space should be proportional to variables were independent of each other and of SONGS operations. Throughout our analyses we used cooling water volume as a surrogate for the operations and effects of SONGS. The P/C variables represented food and habitat characteristics. As Section 3.1 shows, there were no spatial patterns of P/C variables at the 3 km line that could be attributed to the operation of SONGS at that distance and farther downcoast -- none of the variables showed a change with the onset of SONGS operations, and none was strongly correlated with cooling water volume. Because SONGS effects on P/C variables were thus eliminated, changes in these constituents represented natural variability in the system. We were able, therefore, to proceed to test for SONGS effects.

Our second step was to perform stepwise multiple regressions of the abundances of each mysid life stage on the P/C variables. The results showed which variables were significantly correlated with the mysid abundances. More importantly, they accounted for effects of natural variability on natural abundances.

In the third step, we compared the changes in abundance of each mysid stage at SONGS and Control. If SONGS changes in the After period were matched by parallel changes at Control, we could not investigate the relationships between mysid abundances, predators, and SONGS operations. This was because if changes in abundance were the same at both locations, then we could not distinguish effects of predators and SONGS operations from effects of large-scale natural changes. In those cases, we could only examine the relationships between P/C variables and mysid abundance. If the changes were different however, then we proceeded with the analysis.

In the fourth step, we repeated the regression, but added the abundance of the fish that were presumed to eat mysids. These indicating a cause-and-effect relationship. If, however, the addition of pumping volume improved the correlation, then we evaluated the sign of the relationship as well as changes in mysid abundance at Control to see if, all considered, a SONGS relationship could reasonably be inferred. Note that the relationship between mysids and SONGS could be positive or negative, depending on whether the SONGS effect was an improvement of the habitat, such as an increase in food, or a detrimental effect, such as intake mortality. We accepted a positive or negative relationship for stages of mysids that inhabited the cross-shelf or offshore zone. This is because we could envision the possibilities of either improved conditions (e.g., food or habitat changes at 12-20 m due to diffuser fallout) or degraded conditions (e.g., discharged and entrained waters emptied of viable mysids). However, for mysids with inner nearshore distributions we accepted only negative relationships between mysids and SONGS activity. We could not envision improved habitat or food changes occurring in the inner nearshore zone that would be reflected 3 km downcoast.

Finally, if both SONGS and fish were significantly correlated with mysids, then we had to examine the data on a case by case basis to see if we could determine if each was acting independently or if fish were responding to SONGS.

Note that this analysis was not of a BACI type. No habitat or food variables were available from the mysid Control stations. Therefore, we could only address variables through time at the Impact area. Food and habitat observations were restricted to those measured within the sampling zone of the mysid Impact area (3350 m downcoast) from both 6-12 m and 15-23 m zones. Mysid abundances averaged over the 6-12 m depth transects or the 15-23 m transects on each survey were the dependent adjusted r^2 depended on the number of independent variables as well as the correlations. The maximum value of the adjusted r^2 was used to define the "optimum" regression result.

The "optimum" result was further evaluated to assess the fit of the model. Values of Cook's D statistic, which is a measure of influence (Cook, 1977, 1979; SAS, 1985), were examined for each survey and depth to determine whether there were observations having undue influence on the regression result. A high Cook's D for a particular survey and depth indicated either that the relationship between the environmental and biological variables was different for this observation, or that the environmental variables were outliers, or both.

If there was an observation with a significant (as compared to F-values; Draper and Smith, 1981, p. 170) Cook's D, then the observations for that survey and depth were deleted, the regression was re-run, and the results with and without the influential observations were compared. Upon evaluation, if the single observation determined the outcome of the model (e.g., doubled the correlation), then the model without the observation was used for interpretation.

Some of the data used in the multiple regression analyses were transformed. The abundance of mysids (the dependent variable) was transformed by log(x) if logs were used for the earlier BACI analyses. Otherwise they were not transformed. By using phi units, grain size variables were already transformed. Fish abundance was log(x + 1) transformed.

2.4.9.2 Benthos

The multiple regression analysis of the benthos with physical/chemical environmental variables was essentially the same as

Table 2-1. List of survey dates and descriptions applied to them in this report.

MYSIDS	BENTHOS	DESCRIPTIONS
	04 Jun 1976	Additional surveys that were used in some analyses as Preoperational surveys
	29 Sep 1976	
	14 Jan 1977	
	21 Apr 1977	
	08 Jul 1977	
	02 Feb 1978	
	28 Apr 1978	
	10 Oct 1978	
	08 Feb 1979	
	03 Jun 1979	
09 Oct 1979	13 Nov 1979	Preoperational Surveys
23 Oct 1979	04 Dec 1979	
06 Nov 1979	27 Dec 1979	
20 Nov 1979	04 Feb 1980	
03 Dec 1979	20 Mar 1980	
17 Dec 1979	07 Apr 1980	
17 Jan 1980	25 Apr 1980	
27 Feb 1980	20 May 1980	
13 Mar 1980	09 Jun 1980	
12 Apr 1980	30 Jun 1980	
25 Apr 1980	16 Jul 1980	
08 May 1980	04 Aug 1980	
22 May 1980	26 Aug 1980	
19 Jun 1980	15 Sep 1980	
03 Jul 1980	17 Nov 1980	
07 Aug 1980	26 Jun 1981	
11 Jun 1981	15 Sep 1981*	
22 Sep 1981	01 Dec 1981*	
07 Dec 1981		
20 Mar 1982		Interim Surveys
14 Jun 1982		
14 Sep 1982	02 Mar 1982	
14 Dec 1982	01 Jun 1982	
31 Mar 1983	22 Sep 1982	
23 Jun 1983	14 Jan 1983	
21 Sep 1983	11 Mar 1983	
	23 Jun 1983	
	29 Sep 1983	
	22 Dec 1983	

* - different preservation technique these surveys

Table 2-2. Summary of foraging depth, feeding type, motility associated with feeding, colonization, wide-ranging (≥10m**2) mobility, and sensitivity to environmental disturbance. See Section 2.4.1 for a discussion of terms. Information was compiled from the following literature sources: Ansell and Trevallion 1969, Baker 1975, Barnard 1963, Barnes 1968, Biernbaum 1979, Bloom et al. 1972, Brenchley 1981, Coe 1943, Enquist 1949, Fauchald 1983, Fauchald and Jumars 1979, Given 1970, Jones 1963, Mauer 1976, McCall 1977, Oakden 1984, Oakden et al. 1984, Ocklemann 1958, Oliver 1980, Oliver et al. 1980, Pearson and Rosenberg 1978, Rhoads 1974, Stanley 1970, Thompson 1982, Young and Rhoads 1971, Van Blaricom 1982, and Whitlatch 1980. The following abbreviations for the trophic column are defined as follows: F= suspension feeders that filter food from the water column; D= deposit or detritus feeders that ingest sediment and/or detritus; C= carnivores that feed on live animal tissue; O= omnivores that scavenge dead animal tissue or feed on a wide variety of animal, plant, and detritus particles; and H= herbivores that selectively graze on plants or sedentary diatoms.

---------------------------- DEPTH =8 Trophic-Motility Group =Subsurface deposit feeder: Discrete ----------------------------

SPECIES	PHYLUM	TROPHIC	MOTILITY	COLONIZATION	MOBILITY	SENSITIVITY
Cadulus cf. fusiformis	Molluscs	D	Burrows		No	
Dentalium neonexagonum	Molluscs	D	Burrows		No	
Hemichordate unidentified	Others	D	Burrows		No	

---------------------------- DEPTH =9 Trophic-Motility Group =Subsurface deposit feeder: Motile ----------------------------

SPECIES	PHYLUM	TROPHIC	MOTILITY	COLONIZATION	MOBILITY	SENSITIVITY
Caudina arenicola	Echinoderms	D	Burrows		?	
Leptosynapta sp	Echinoderms	D	Burrows		?	
Amastigos acutus	Polychaetes	D	Burrows		No	
Mediomastus californiensis/ambiseta	Polychaetes	D	Burrows	Yes	No	Tol. pollution
Mediomastus acutus	Polychaetes	D	Burrows		No	
Notomastus (C.) tenuis	Polychaetes	D	Burrows		No	
Notomastus sp.	Polychaetes	D	Burrows		No	
Anotomastus gordiodes	Polychaetes	D	Burrows		No	
Decamastus gracilus	Polychaetes	D	Burrows		No	
Capitella capitata	Polychaetes	D	Tubiculous	Yes	No	Tol. pollution
Capitellidae unidentified	Polychaetes	D	Burrows		No	
Cossura cf. candida	Polychaetes	D	Burrows		No	
Armandia bioculata	Polychaetes	D	Burrows	Yes	No	Tol. pollution
Travisia gigas	Polychaetes	D	Burrows		No	
Travisia sp.	Polychaetes	D	Burrows		No	
Leitoscoloplos elongatus	Polychaetes	D	Burrows	Yes	No	Tol. pollution
Leitoscoloplos sp.	Polychaetes	D	Burrows		No	
Naineris uncinata	Polychaetes	D	Burrows		No	
Scoloplos acmeceps	Polychaetes	D	Burrows		No	
Scoloplos armiger	Polychaetes	D	Burrows	Yes	No	Tol. pollution
Scoloplos sp.	Polychaetes	D	Burrows		No	
Orbiniidae unidentified	Polychaetes	D	Burrows		No	
Acesta catherinae	Polychaetes	D,H	Burrows		No	
Acesta horikoshii	Polychaetes	D,H	Burrows		No	
Acesta sp. B	Polychaetes	D,H	Burrows		No	
Aedicira pacifica	Polychaetes	D,H	Burrows		No	
Aedicira sp.	Polychaetes	D,H	Burrows		No	
Aricidea sp. A	Polychaetes	D,H	Burrows		No	?Res. organics
Aricidea wassi	Polychaetes	D,H	Burrows		No	?Res. organics
Aricidea sp. B	Polychaetes	D,H	Burrows		No	?Res. organics
Cirrophorus furcatus	Polychaetes	D,H	Burrows		No	
Paraonella platybranchiata	Polychaetes	D,H	Burrows		No	
Paraonella sp.	Polychaetes	D,H	Burrows		No	
Tauberia gracilis	Polychaetes	D,H	Burrows		No	
Paraonidae unidentified	Polychaetes	D,H	Burrows		No	
Pectinaria californiensis	Polychaetes	D	Burrows, tubes		No	

Table 2-2. (cont.)

------------------------------ DEPTH =8 Trophic-Motility Group =Surface deposit-detrital: Motile ------------------------------

SPECIES	PHYLUM	TROPHIC	MOTILITY	COLONIZATION	MOBILITY	SENSITIVITY
Argissa hamatipes	Crustaceans	D	Burrows, swims			
Megaluropus longimerus	Crustaceans	D	Burrows, swims	Yes	Yes	Res. organics
Meliphisana bola	Crustaceans	D			?	
Monoculodes hartmanae	Crustaceans	D	Burrows, swims	Yes	Yes	Res. organics
Tiron tropakis	Crustaceans	D	Burrows, swims		?	
Tiron biocellata	Crustaceans	D	Burrows, swims		?	
Anchicolurus occidentalis	Crustaceans	D	Burrows, swims		Yes	
Campylaspis rubromaculata	Crustaceans	D	Burrows, swims		Yes	
Campylaspis sp. C SCAMIT	Crustaceans	D	Burrows, swims		Yes	
Cumella sp. A SCAMIT	Crustaceans	D	Burrows, swims		Yes	
Cyclaspis nubila	Crustaceans	D	Burrows, swims		Yes	
Cyclaspis sp.C SCAMIT	Crustaceans	D	Burrows, swims		Yes	
Cyclaspis sp.B SCAMIT	Crustaceans	D	Burrows, swims		Yes	
Diastylopsis tenuis	Crustaceans	D	Burrows, swims	Yes	Yes	Res. organics
Hemilamprops californica	Crustaceans	D	Burrows, swims		Yes	
Lamprops carinata	Crustaceans	D	Burrows, swims		Yes	
Lamprops quadriplicata	Crustaceans	D	Burrows, swims		Yes	
Lampropidae juvenile	Crustaceans	D	Burrows, swims		Yes	
Leptocuma forsmani	Crustaceans	D	Burrows, swims		Yes	
Oxyurostylis pacifica	Crustaceans	D	Burrows, swims		Yes	
Lovenia cordiformis	Echinoderms	D	Burrows		?	
Echinoid juvenile	Echinoderms	D	Burrows		?	
Haminoea virescens	Molluscs	D	Crawls		Yes	
Calliostoma sp.	..Molluscs	D	Crawls		No	
Caulleriella sp.	Polychaetes	D	Burrows		No	
Chaetozone corona	Polychaetes	D	Burrows		No	
Chaetozone setosa	Polychaetes	D	Burrows		No	
Cirriformia spirabrancha	Polychaetes	D	Burrows		No	Semi-tolerant
Cirratulidae unidentified	Polychaetes	D	Burrows		No	

------------------------------ DEPTH =8 Trophic-Motility Group =Surface deposit-detrital: Sessile ------------------------------

SPECIES	PHYLUM	TROPHIC	MOTILITY	COLONIZATION	MOBILITY	SENSITIVITY
Golfingia catharinae	Others	D	Infauna		No	
Golfingia misakiana	Others	D	Infauna		No	
Siphonosoma ingens	Others	D	Infauna		No	
Sipunculida unidentified	Others	D	Infauna		No	
Ampharete labrops	Polychaetes	D	Tubiculous		No	
Amphicteis scaphobranchiata	Polychaetes	D	Tubiculous		No	
Ampharetidae juvenile	Polychaetes	D	Tubiculous		No	
Ampharetidae unidentified	Polychaetes	D	Tubiculous		No	
Pista disjuncta	Polychaetes	D	Tubiculous		No	
Pista sp.	Polychaetes	D	Tubiculous		No	
Terebellidae juvenile	Polychaetes	D	Tubiculous		No	

Table 2-2. (cont.)

---------------------------- DEPTH =8 Trophic-Motility Group =Surface, suspension-deposit: Discrete ----------------------------

SPECIES	PHYLUM	TROPHIC	MOTILITY	COLONIZATION	MOBILITY	SENSITIVITY
Acuminodeutopus heteruropus	Crustaceans	D,F	Tubiculous	Yes	No	Res. organics
Amphideutopus oculatus	Crustaceans	D,F	Tubiculous		No	
Aoroides columbiae	Crustaceans	D,F	Tubiculous		No	
Corophium californianum	Crustaceans	D,F	Tubiculous		No	? Tol. Poll
Cerapus tubularis	Crustaceans	D,F	Tubiculous		No	
Listriella sp. juvenile	Crustaceans	D,F,O			Yes	
Listriella diffusa	Crustaceans	D,F,O			Yes	
Listriella melanica	Crustaceans	D,F,O			Yes	
Photis brevipes	Crustaceans	D,F	Tubiculous		?	
Photis californica	Crustaceans	D,F	Tubiculous		?	
Photis macrotica	Crustaceans	D,F	Tubiculous		?	
Photis bifurcata	Crustaceans	D,F	Tubiculous		?	
Photis lacia	Crustaceans	D,F	Tubiculous		?	
Corophium baconi	Crustaceans	D,F	Tubiculous		No	? Tol. Poll
Aoroides intermedius	Crustaceans					
Callianassa californiensis	Crustaceans					
Callianassa sp. juvenile	Crustaceans	D,F	Burrows		No	
Macoma sp.	Molluscs	D,F	Burrows		No	
Macoma yoldiformis	Molluscs	D,F	Burrows		No	
Macoma nr. secta	Molluscs	D,F	Burrows		No	
Tellina modesta	Molluscs	D,F	Burrows	Yes	No	
Macoma indentata	Molluscs	D,F	Burrows		No	
Tellina carpenteri	Molluscs	D,F	Burrows		No	
Macoma cf. balthica	Molluscs	D,F	Burrows	Yes	No	Tol. pollution
Macoma acolasta	Molluscs	D,F	Burrows		No	
Tellina bodegensis	Molluscs	D,F	Burrows		No	
Renilla kolleri	Others	F,O	Crawls		No	
Owenia collaris	Polychaetes	D,F	Tubiculous	Yes	No	
Laonice cirrata	Polychaetes	D,F	Tubiculous		No	
Paraprionospio pinnata	Polychaetes	D,F	Tubiculous	Yes	No	Tol. pollution
Polydora bioccipitalis	Polychaetes	D,F	Tubiculous	Yes	No	
Polydora nuchalis	Polychaetes	D,F	Tubiculous		No	Tol. pollution
Polydora sp.	Polychaetes	D,F	Tubiculous		No	
Prionospio cirrifera	Polychaetes	D,F	Tubiculous	Yes	No	Tol. pollution
Prionospio pygmaea	Polychaetes	D,F	Tubiculous		No	
Prionospio sp.	Polychaetes	D,F	Tubiculous		No	
Scolelepis squamata	Polychaetes	D,F	Tubiculous	Yes	No	Tol. pollution
Scolelepis sp.	Polychaetes	D,F	Tubiculous	Yes	No	Tol. pollution
Spiophanes bombyx	Polychaetes	D,F	Tubiculous		No	
Spiophanes missionensis	Polychaetes	D,F	Tubiculous		No	
Spiophanes sp.	Polychaetes	D,F	Tubiculous		No	
Spionidae unidentified	Polychaetes	D,F	Tubiculous		No	
Diospio uncinata	Polychaetes	D,F	Tubiculous		No	

Table 2-2. (cont.)

---------------------------------- DEPTH =8 Trophic-Motility Group =Suspension feeder: Motile ----------------------------------

SPECIES	PHYLUM	TROPHIC	MOTILITY	COLONIZATION	MOBILITY	SENSITIVITY
Emerita analoga	Crustaceans	F	Burrows, swims		Yes	

---------------------------------- DEPTH =8 Trophic-Motility Group =Suspension feeder: Sessile ----------------------------------

SPECIES	PHYLUM	TROPHIC	MOTILITY	COLONIZATION	MOBILITY	SENSITIVITY
Balanus sp. juvenile	Crustaceans	F	Epifauna		No	
Crepidula coei	Molluscs	F	Epifauna		No	
Crepidula spp.	Molluscs	F	Epifauna		No	
Amiantis callosa	Molluscs	F	Infauna		No	
Asthenothaerus villosior	Molluscs	F	Infauna		No	
Kellia sp.	Molluscs	F	Infauna		No	
Lepton sp.	Molluscs	F	Epifauna		No	
Compsomyax subdiaphana	Molluscs	F	Infauna		No	
Cooperella subdiaphana	Molluscs	F	Infauna		No	
Modiolus sp. A	Molluscs	F	Epifauna		No	
Modiolus neglectus	Molluscs	F	Epifauna		No	
Parvilucina tenuisculpta	Molluscs	F	Infauna		No	Tol. pollution
Veneridae unidentified	Molluscs	F	Infauna		No	
Nemocardium centrifilosum	Molluscs	F	Infauna		No	
Modiolus rectus	Molluscs	F	Epifauna		No	
Felaniella cornea	Molluscs	F	Infauna		No	
Thecondonta oblongus	Molluscs	F	Infauna		No	
Modiolus spp.	Molluscs	F	Epifauna		No	
Kellia laperousii	Molluscs	F	Infauna		No	
Mya cf. arenaria	Molluscs	F	Infauna	Yes	No	Tol. pollution
Entodesma saxicolum	Molluscs	F	Infauna		No	
Mytilus edulis	Molluscs	F	Epifauna		No	
Glottidia albida	Others	F	Epifauna		No	
Zaolutus actius	Others	F	Infauna		No	
Phoronis spp.	Others	F	Tubiculous		No	
Chone veleronis	Polychaetes	F	Tubiculous		No	
Chone albocincta	Polychaetes	F	Tubiculous		No	
Chone sp.	Polychaetes	F	Tubiculous		No	
Euchone hancocki	Polychaetes	F	Tubiculous		No	
Sabellidae unidentified	Polychaetes	F	Tubiculous		No	
Sabellaria sp.	Polychaetes	F	Tubiculous		No	
Sabellaria nanella	Polychaetes	F	Tubiculous		No	
Sabellaria cementarium	Polychaetes	F	Tubiculous		No	

---------------------------- DEPTH =8 Trophic-Motility Group =Surface carnivore-omnivore: Discrete ----------------------------

SPECIES	PHYLUM	TROPHIC	MOTILITY	COLONIZATION	MOBILITY	SENSITIVITY
Crangon alaskensis elongata	Crustaceans	C	Tubiculous		Yes	
Ancinus granulatus	Crustaceans	O	Crawls		?	
Edotea sublittoralis	Crustaceans	C,O	Crawls		No	
Exosphaeroma inornata	Crustaceans	O	Crawls		No	
Idotea fewkesi	Crustaceans	C,O	Crawls		No	
cf. laniropsis sp.	Crustaceans	O	Crawls		No	
Idoteid	Crustaceans	O	Crawls		No	
Jaeropsis dubia	Crustaceans	O	Crawls		No	

Table 2-2. (cont.)

---------------------------- DEPTH =3 Trophic-Motility Group =Surface carnivore-omnivore: Motile -------------------------------

SPECIES	PHYLUM	TROPHIC	MOTILITY	COLONIZATION	MOBILITY	SENSITIVITY
Crab zoea	Crustaceans	C,O	Swims		Yes	
Cancer gracilis	Crustaceans	C,O	Crawls		Yes	
Cancer spp. juvenile	Crustaceans	C,O	Crawls		Yes	
Isocheles pilosus	Crustaceans	C,O	Crawls		Yes	
Lepidopa californica	Crustaceans	C,O	Burrows		Yes	
Majidae sp. A	Crustaceans	C	Burrows		Yes	
Megalops juvenile	Crustaceans	C	Swims		Yes	
Pinnixa hiatus	Crustaceans	C,O	Crawls		?	
Pagurus turgidus	Crustaceans	O	Crawls		Yes	
Pinnixa sp. juvenile	Crustaceans	C,O	Burrows, crawls		?	
Pinnixa tubicola/tomentosa	Crustaceans	C,O	Burrows, crawls		?	
Randallia ornata	Crustaceans	C	Swims		?	
Pinnixa longipes	Crustaceans	C,O	Burrows, crawls		?	
Pagurus sp.	Crustaceans	O	Crawls		Yes	
Pyromaia tuberculata	Crustaceans	C	Crawls		?	
Loxorhynchus crispatus	Crustaceans	C	Crawls		Yes	
Munnogonium tillerae	Crustaceans	C,O	Crawls		No	
Munna ubiquita	Crustaceans	C,O	Crawls		No	
Astropecten spp. juvenile	Echinoderms	C	Crawls		Yes	
Acteocina harpa	Molluscs	C	Crawls		No	
Kurtziella beta	Molluscs	C	Crawls		Yes	
Kurtziella plumbea	Molluscs	C	Crawls		Yes	
Nassarius perpinquis	Molluscs	O	Crawls		Yes	
Nassarius sp.	Molluscs	O	Crawls		Yes	
Neverita sp.	Molluscs	C	Crawls		Yes	
Neverita reclusiana	Molluscs	C	Crawls		Yes	
Olivella baetica	Molluscs	C	Burrows, crawls		Yes	
Ophiodermella halcyonis	Molluscs	C	Crawls		Yes	
Opistobranchia unidentified	Molluscs	C,O	Crawls		?	
Opistobranch sp. X	Molluscs	C,O	Crawls		?	
Rictaxis punctocoelatus	Molluscs	C	Crawls		No	
Sulcoretusa xystrum	Molluscs	C	Crawls		No	
Tricolia pulloides	Molluscs	C	Crawls		No	
Volvuella cylindrica	Molluscs	C	Crawls		No	
Woodbridgea polystrigma	Molluscs	C	Crawls		No	
Philine sp.	Molluscs	C	Crawls		No	
Acteocina inculta	Molluscs	C	Crawls		No	
Woodbridgea sp.	Molluscs	C	Crawls		No	
Acteocina sp.	Molluscs	C	Crawls		No	
Cyclostremella californica	Molluscs	C	Crawls		No	
Cingula sp.	Molluscs	D,H	Crawls		No	
Conualevia alba	Molluscs	C	Crawls		?	
Doto sp.	Molluscs	C	Crawls		?	
Acteocina cf. smirna	Molluscs	C	Crawls		No	
Tricolia sp.	Molluscs	C	Crawls		No	
Philine sp. A	Molluscs	C	Crawls		No	
Tricolia rubrilineata	Molluscs	C	Crawls		No	
Rissoina sp.	Molluscs	D,H	Crawls		No	
Ophiodermella ophioderma	Molluscs	C	Crawls		Yes	
Acanthodoris rhodoceras	Molluscs	C	Crawls		Yes	
Zygeupolia sp.	Others	C	Burrows		?	
Paranemertes sp. A	Others	C			No	
Paranemertes sp. B	Others	C			No	
Cerebratulus or Micrura spp.	Others	C	Burrows		?	

Table 2-2. (cont.)

---------------------------- DEPTH =8 Trophic-Motility Group =Surface carnivore-omnivore: Motile -----------------------------

SPECIES	PHYLUM	TROPHIC	MOTILITY	COLONIZATION	MOBILITY	SENSITIVITY
Tetrastemma spp.	Others	C	Crawls		No	
Amphiporus spp.	Others	C	Crawls		No	
Carinoma mutabilis	Others	C	Burrows		?	
Nemertina unidentified	Others	C			No	
Flatworm 1	Others	C,O	Crawls		No	
Flatworm 3	Others	C,O	Crawls		No	
Flatworm 4	Others	C,O	Crawls		No	
Flatworm "white"	Others	C,O	Crawls		No	
Flatworm 6	Others	C,O	Crawls		No	
Flatworm 8	Others	C,O	Crawls		No	
Pareurythoe californica	Polychaetes	C	Crawls		No	
Paleanotus bellis	Polychaetes	C	Crawls		No	
Protodorvillea gracilus	Polychaetes	C,O	Crawls	?Yes	No	?Tol. pollution
Pareulepis fimbriata	Polychaetes	C	Crawls		No	
Podakeopsis brevipalpa	Polychaetes	C	Crawls		No	
Hesionidae,genus a	Polychaetes	C	Crawls		No	
Syllidia sp. A	Polychaetes	C	Crawls		No	
Syllidia sp. B	Polychaetes	C	Crawls		No	
Syllidia sp. C	Polychaetes	C	Crawls		No	
Hesionidae unidentified	Polychaetes	C	Crawls		No	
Hirudinea leech	Polychaetes	C	Crawls		No	
Eteone dilatae	Polychaetes	D,C	Crawls		?	Tol. pollution
Eteone sp.	Polychaetes	D,C	Crawls		?	
Hesionura coineaui difficilis	Polychaetes	C	Crawls		?	
Phyllodoce (Aponaitides) hartmanae	Polychaetes	D,C	Crawls		?	
Phyllodoce (Anaitides) papillosa	Polychaetes	D,C	Crawls		?	
Phyllodoce sp.	Polychaetes	C	Crawls		?	
Eumida sanguinea	Polychaetes	C	Crawls		?	Tol. pollution
Phyllodocidae unidentified	Polychaetes	C	Crawls		?	
Ancistrosyllis hamata	Polychaetes	C	Crawls		No	
Sigambra tentaculata	Polychaetes	C,O	Crawls		No	
Parandalia fauveli	Polychaetes	C,O	Crawls		No	
Harmothoe cf. lunulata	Polychaetes	C	Crawls		No	
Harmothoe priops	Polychaetes	C	Crawls		No	
Polynoidae unidentified	Polychaetes	C	Crawls		No	
Sthenelais verruculosa	Polychaetes	C	Crawls		No	
Sthenelais tertiaglabra	Polychaetes	C	Crawls		No	
Sthenelais sp.	Polychaetes	C	Crawls		No	
Sthenelanella uniformis	Polychaetes	C	Crawls		No	
Thalenessa spinosa	Polychaetes	C	Crawls		No	
Sigalionidae unidentified	Polychaetes	C	Crawls		No	
Streptosyllis sp. A	Polychaetes	C	Crawls		No	
Streptosyllis latipalpa	Polychaetes	C	Crawls		No	
Typosyllis hyalina	Polychaetes	C	Crawls		No	
Odontosyllis phosphorea	Polychaetes	C	Crawls		No	
Odontosyllis sp.	Polychaetes	C	Crawls		No	
Autolytus sp.	Polychaetes	C	Crawls		No	

Table 2-2. (cont.)

---------------------------- DEPTH =18 Trophic-Motility Group =Subsurface deposit feeder: Discrete ----------------------------

SPECIES	PHYLUM	TROPHIC	MOTILITY	COLONIZATION	MOBILITY	SENSITIVITY
Cadulus cf. fusiformis	Molluscs	D	Burrows		No	
Cadulus sp.	Molluscs	D	Burrows		No	
Dentalium sp.	Molluscs	D	Burrows		No	
Hemichordate unidentified	Others	D	Burrows		No	

---------------------------- DEPTH =18 Trophic-Motility Group =Subsurface deposit feeder: Motile ----------------------------

SPECIES	PHYLUM	TROPHIC	MOTILITY	COLONIZATION	MOBILITY	SENSITIVITY
Caudina arenicola	Echinoderms	D	Burrows		?	
Leptosynapta sp	Echinoderms	D	Burrows		?	
Amastigos acutus	Polychaetes	D	Burrows		No	
Mediomastus californiensis/ambiseta	Polychaetes	D	Burrows	Yes	No	Tol. pollution
Mediomastus acutus	Polychaetes	D	Burrows		No	
Notomastus (C.) tenuis	Polychaetes	D	Burrows		No	
Notomastus sp.	Polychaetes	D	Burrows		No	
Anotomastus gordiodes	Polychaetes	D	Burrows		No	
Anotomastus sp.	Polychaetes	D	Burrows		No	
Capitella capitata	Polychaetes	D	Tubiculous	Yes	No	Tol. pollution
Capitellidae unidentified	Polychaetes	D	Burrows		No	
Cossura cf. candida	Polychaetes	D	Burrows		No	
Cossura sp.	Polychaetes	D	Burrows		No	
Armandia bioculata	Polychaetes	D	Burrows	Yes	No	Tol. pollution
Travisia gigas	Polychaetes	D	Burrows		No	
Travisia sp.	Polychaetes	D	Burrows		No	
Leitoscoloplos elongatus	Polychaetes	D	Burrows	Yes	No	Tol. pollution
Naineris sp.	Polychaetes	D	Burrows		No	
Scoloplos armiger	Polychaetes	D	Burrows	Yes	No	Tol. pollution
Scoloplos sp.	Polychaetes	D	Burrows		No	
Phylo felix	Polychaetes	D	Burrows		No	
Orbiniidae unidentified	Polychaetes	D	Burrows		No	
Acesta catherinae	Polychaetes	D,H	Burrows		No	
Acesta horikoshii	Polychaetes	D,H	Burrows		No	
Acesta sp. B	Polychaetes	D,H	Burrows		No	
Aedicira pacifica	Polychaetes	D,H	Burrows		No	
Aedicira sp.	Polychaetes	D,H	Burrows		No	
Aricidea sp. A	Polychaetes	D,H	Burrows		No	?Res. organics
Aricidea wassi	Polychaetes	D,H	Burrows		No	?Res. organics
Aricidea sp. B	Polychaetes	D,H	Burrows		No	?Res. organics
Cirrophorus furcatus	Polychaetes	D,H	Burrows		No	
Cirrophorus lyra	Polychaetes	D,H	Burrows		No	
Cirrophorus sp.	Polychaetes	D,H	Burrows		No	
Tauberia gracilis	Polychaetes	D,H	Burrows		No	
Allia antennata	Polychaetes	D,H	Burrows		No	
Paraonidae unidentified	Polychaetes	D,H	Burrows		No	
Pectinaria californiensis	Polychaetes	D	Burrows, tubes		No	
Sphaerodoropsis minuta	Polychaetes	D	Burrows		No	
Sphaerodoropsis biserialis	Polychaetes	D	Burrows		No	
Sternaspis fossor	Polychaetes	D	Burrows		No	

Table 2-2. (cont.)

DEPTH =18 Trophic-Motility Group =Surface deposit-detrital: Discrete

SPECIES	PHYLUM	TROPHIC	MOTILITY	COLONIZATION	MOBILITY	SENSITIVITY
Polycirrus californiensis	Polychaetes	D	Tubiculous		No	
Polycirrus sp.	Polychaetes	D	Tubiculous		No	

DEPTH =18 Trophic-Motility Group =Surface deposit-detrital: Motile

SPECIES	PHYLUM	TROPHIC	MOTILITY	COLONIZATION	MOBILITY	SENSITIVITY
Argissa hamatipes	Crustaceans	D	Burrows, swims			
Megaluropus longimerus	Crustaceans	D	Burrows, swims	Yes	Yes	Res. organics
Meliphisana bola	Crustaceans	D			?	
Monoculodes hartmanae	Crustaceans	D	Burrows, swims	Yes	Yes	Res. organics
Tiron tropakis	Crustaceans	D	Burrows, swims		?	
Tiron biocellata	Crustaceans	D	Burrows, swims		?	
Westwoodilla caecula	Crustaceans	D	Burrows, swims		Yes	
Anchicolurus occidentalis	Crustaceans	D	Burrows, swims		Yes	
Campylaspis canaliculata	Crustaceans	D	Burrows, swims		Yes	
Campylaspis rubromaculata	Crustaceans	D	Burrows, swims		Yes	
Campylaspis sp. C SCAMIT	Crustaceans	D	Burrows, swims		Yes	
Cumella sp. A SCAMIT	Crustaceans	D	Burrows, swims		Yes	
Cumella sp. D	Crustaceans	D	Burrows, swims		Yes	
Cyclaspis nubila	Crustaceans	D	Burrows, swims		Yes	
Cyclaspis sp.C SCAMIT	Crustaceans	D	Burrows, swims		Yes	
Leptostylis B SCAMIT	Crustaceans	D	Burrows, swims		Yes	
Diastylopsis tenuis	Crustaceans	D	Burrows, swims	Yes	Yes	Res. organics
Eudorella pacifica	Crustaceans	D	Burrows, swims		Yes	
Hemilamprops californica	Crustaceans	D	Burrows, swims		Yes	
Lamprops carinata	Crustaceans	D	Burrows, swims		Yes	
Lampropidae juvenile	Crustaceans	D	Burrows, swims		Yes	
Cumacea unidentified	Crustaceans	D	Burrows, swims		Yes	
Leptocuma forsmani	Crustaceans	D	Burrows, swims		Yes	
Oxyurostylis pacifica	Crustaceans	D	Burrows, swims		Yes	
Lovenia cordiformis	Echinoderms	D	Burrows		?	
Falcidens sp. E	Molluscs	D	Crawls		No	
Haminoea sp.	Molluscs	D	Crawls		Yes	
Haminoea virescens	Molluscs	D	Crawls		Yes	
Calliostoma sp.	Molluscs	D	Crawls		No	
Chaetozone corona	Polychaetes	D	Burrows		No	
Chaetozone setosa	Polychaetes	D	Burrows		No	
Chaetozone sp.	Polychaetes	D	Burrows		No	
Cirriformia luxuriosa	Polychaetes	D	Burrows		No	
Cirratulidae unidentified	Polychaetes	D	Burrows		No	

Table 2-2. (cont.)

------------------------------ DEPTH =18 Trophic-Motility Group =Surface omnivore-deposit: Motile ------------------------------

SPECIES	PHYLUM	TROPHIC	MOTILITY	COLONIZATION	MOBILITY	SENSITIVITY
Pachynus barnardi	Crustaceans	D,O	Burrows, swims		Yes	
Orchomene anaquela	Crustaceans	D,O	Burrows, swims		Yes	
Orchomene pinguis	Crustaceans	D,O	Burrows, swims		Yes	
Pleustes platypa	Crustaceans	D,H	Crawls		Yes	
Parapleustes pugettensis	Crustaceans	D,H	Burrows, swims		Yes	
Lepidepecreum sp. A SCAMIT	Crustaceans					
Synchelidium shoemakeri	Crustaceans	D,H	Burrows, swims	Yes	Yes	Res. organics
Pleusymtes subglaber	Crustaceans	D,O	Nestler			
Pontogeneia intermedia	Crustaceans	D,O			?	
Lysianassa oculata	Crustaceans	D,O	Burrows, swims		Yes	
Lysianassidae juvenile	Crustaceans	D,O	Burrows, swims		Yes	
Hippomedom zetesimus	Crustaceans	D,O	Burrows, swims		Yes	
Orchomene obtusa	Crustaceans	D,O	Burrows, swims		Yes	
Orchomene spp. juvenile	Crustaceans	D,O	Burrows, swims		Yes	
Synchelidium rectipalmum	Crustaceans	D,H	Burrows, swims		Yes	
Nebalia pugettensis	Crustaceans	D,O	Burrows, swims		Yes	
Euphilomedes carcharodonta	Crustaceans	D,O	Swims		Yes	Semi-tolerant
Rutiderma rostrata	Crustaceans	D,C,O	Swims	Yes	Yes	
Sarsiella sp. B	Crustaceans	D,C,O	Swims		Yes	
Rutiderma sp. A	Crustaceans	D,C,O	Swims		Yes	
Sarsiella sp. A SCAMIT	Crustaceans	D,C,O	Swims		Yes	
Harbansus bradmyersi	Crustaceans	D,O	Swims		Yes	
Lytechinus anamesus	Echinoderms	D,O	Crawls		?	
Fartulum occidentale	Molluscs	D,O	Crawls		No	
Lacuna unifasciata	Molluscs	D,H	Crawls		No	

-------------------------- DEPTH = 8 Trophic-Motility Group =Surface, suspension-deposit: Discrete ----------------------------

SPECIES	PHYLUM	TROPHIC	MOTILITY	COLONIZATION	MOBILITY	SENSITIVITY
Acuminodeutopus heteruropus	Crustaceans	D,F	Tubiculous	Yes	No	Res. organics
Amphideutopus oculatus	Crustaceans	D,F	Tubiculous		No	
Aoroides columbiae	Crustaceans	D,F	Tubiculous		No	
Corophium californianum	Crustaceans	D,F	Tubiculous		No	? Tol. Poll
Cerapus tubularis	Crustaceans	D,F	Tubiculous		No	
Listriella sp. juvenile	Crustaceans	D,F,O			Yes	
Listriella diffusa	Crustaceans	D,F,O			Yes	
Listriella goleta	Crustaceans	D,F,O			Yes	
Listriella melanica	Crustaceans	D,F,O			Yes	
Photis brevipes	Crustaceans	D,F	Tubiculous		?	
Photis californica	Crustaceans	D,F	Tubiculous		?	
Photis macrotica	Crustaceans	D,F	Tubiculous		?	
Photis bifurcata	Crustaceans	D,F	Tubiculous		?	
Photis lacia	Crustaceans	D,F	Tubiculous		?	
Aoroides intermedius	Crustaceans					
Callianassa sp. juvenile	Crustaceans	D,F	Burrows		No	
Macoma sp.	Molluscs	D,F	Burrows		No	
Macoma yoldiformis	Molluscs	D,F	Burrows		No	
Tellina modesta	Molluscs	D,F	Burrows	Yes	No	
Tellina idae	Molluscs	D,F	Burrows		No	
Macoma carlottensis	Molluscs	D,F	Burrows		No	Tol. pollution
Macoma acolasta	Molluscs	D,F	Burrows		No	
Tellina bodegensis	Molluscs	D,F	Burrows		No	

Table 2-2. (cont.)

---------------------------- DEPTH =18 Trophic-Motility Group =Surface, suspension-deposit: Sessile ----------------------------

SPECIES	PHYLUM	TROPHIC	MOTILITY	COLONIZATION	MOBILITY	SENSITIVITY
Ampelisca cristata microdentata	Crustaceans	D,F	Tubiculous		Yes	Sen. sewage
Ampelisca pugetica	Crustaceans	D,F	Tubiculous		Yes	
Ampelisca juvenile	Crustaceans	D,F	Tubiculous		Yes	
Ampelisca brevisimulata	Crustaceans	D,F	Tubiculous		Yes	Sen. sewage
Ampelisca agassizi	Crustaceans	D,F	Tubiculous		Yes	
Ampelisca cristata	Crustaceans	D,F	Tubiculous		Yes	Sen. sewage
Ampelisca careyi	Crustaceans	D,F	Tubiculous		Yes	
Spiochaetopterus costarum	Polychaetes	D,F	Tubiculous		No	Tol. pollution
Chaetopteridae unidentified	Polychaetes	D,F	Tubiculous		No	

------------------------------- DEPTH =18 Trophic-Motility Group =Suspension feeder: Discrete -------------------------------

SPECIES	PHYLUM	TROPHIC	MOTILITY	COLONIZATION	MOBILITY	SENSITIVITY
Erichthonius brasiliensis	Crustaceans	F	Tubiculous		No	
Chione californiensis	Molluscs	F	Burrows		No	
Ensis myrae	Molluscs	F	Burrows		No	
Leptopecten latiauratus	Molluscs	F	Swims		No	
Mysella tumida	Molluscs	F	Burrows		No	Semi-tolerant
Siliqua lucida	Molluscs	F	Burrows		No	
Solen rosaceus	Molluscs	F	Burrows		No	
Solen sicarius	Molluscs	F	Burrows		No	
Mysella grippi	Molluscs	F	Burrows		No	
Chione sp.	Molluscs	F	Burrows		No	
Trachycardium quadragenarium	Molluscs	F	Burrows		No	
Mysella sp. A	Molluscs	F	Burrows		No	
Mysella compressa	Molluscs	F	Burrows		No	
Solen sp.	Molluscs	F	Burrows		No	
Mysella sp.	Molluscs	F	Burrows		No	
Solen sp.	Molluscs	F	Burrows		No	
Mysella golischi	Molluscs	F	Burrows		No	
Mysella cf. aleutica	Molluscs	F	Burrows		No	
Mysella sp. C	Molluscs	F	Burrows		No	
Heterospio catalinensis	Polychaetes	F	Tubiculous		No	

------------------------------- DEPTH =18 Trophic-Motility Group =Suspension feeder: Motile -------------------------------

SPECIES	PHYLUM	TROPHIC	MOTILITY	COLONIZATION	MOBILITY	SENSITIVITY
Bathyleberis garthi	Crustaceans	F	Swims		Yes	

Table 2-2. (cont.)

---------------------------- DEPTH =3 Trophic-Motility Group =Surface carnivore-omnivore: Discrete ----------------------------

SPECIES	PHYLUM	TROPHIC	MOTILITY	COLONIZATION	MOBILITY	SENSITIVITY
Alpheus clamator	Crustaceans	C,O			Yes	
Crangon alaskensis elongata	Crustaceans	C	Tubiculous		Yes	
Crangon sp. juvenile	Crustaceans	C	Tubiculous		Yes	
Ancinus granulatus	Crustaceans	O	Crawls		?	
Edotea sublittoralis	Crustaceans	C,O	Crawls		No	
Gnathia crenulatifrons	Crustaceans	O	Crawls		No	
Caecianiropsis psammophila	Crustaceans	O	Crawls		No	
Silophasma geminatum	Crustaceans	O	Crawls		No	
Idotea rufescens	Crustaceans	O	Crawls		No	
Neastacilla californica	Crustaceans	O	Crawls		No	
Synidotea hartfordi	Crustaceans	O	Crawls		Yes	
Balcis micans	Molluscs	C	Crawls		No	
Epitonium sp.	Molluscs	C	Crawls		No	
Odostomia (Evalea) sp. B	Molluscs	C	Crawls		No	
Odostomia spp.	Molluscs	C	Crawls		No	
Odostomia (Evalea) sp. D	Molluscs	C	Crawls		No	
Turbonilla (Chemnitzia) sp. B	Molluscs	C	Crawls		No	
Turbonilla (Pyrgiscus) sp.	Molluscs	C	Crawls		No	
Epitonium bellastriatum	Molluscs	C	Crawls		No	
Turbonilla (Chemnitzia) sp. A	Molluscs	C	Crawls		No	
Turbonilla (Chemnitzia) sp.	Molluscs	C	Crawls		No	
Odostomia (Evalea) sp.	Molluscs	C	Crawls		No	
Odostomia (Evalea) sp. A	Molluscs	C	Crawls		No	
Balcis rutila	Molluscs	C	Crawls		No	
Eulima almo	Molluscs	C	Crawls		No	
Odostomia (Evalea) sp.C	Molluscs	C	Crawls		No	
Turbonilla (Pyrgiscus) sp. F	Molluscs	C	Crawls		No	
Balcis spp.	Molluscs	C	Crawls		No	
Odostomia (Evalea) sp. F	Molluscs	C	Crawls		No	
Turbonilla (Chemnitzia) sp. C	Molluscs	C	Crawls		No	
Odostomia (Evalea) sp. E	Molluscs	C	Crawls		No	
Odostomia (Evalea) sp. H	Molluscs	C	Crawls		No	
Turbonilla (Chemnitzia) sp. D	Molluscs	C	Crawls		No	
Odostomia (Evalea) sp. B	Molluscs	C	Crawls		No	
Turbonilla (Pyrgiscus) sp. G	Molluscs	C	Crawls		No	
Turbonilla (Pyrgolampos) sp. E	Molluscs	C	Crawls		No	
Turbonilla (Chemnitzia) sp. F	Molluscs	C	Crawls		No	
Turbonilla (Pyrgolampros) sp. F	Molluscs	C	Crawls		No	
Edwardsia sp. A (orange w/ white base)	Others	D,C,H	Burrows		No	
Metedwardsia sp. A	Others	D,C,H	Burrows		No	
Edwardsia sp. B (white w/white base)	Others	D,C,H	Burrows		No	
Scolanthus sp. A SCAMIT	Others	D,C,H	Burrows		No	
Tubulanus pellucidus (red)	Others	C	Tubiculous		No	
Tubulanidae sp. B	Others	C	Tubiculous		No	
Tubulanus nothus (black)	Others	C	Tubiculous		No	
Tubulanus sp. P	Others	C	Tubiculous		No	
Glycera convoluta	Polychaetes	C	Burrows		No	
Glycera americana	Polychaetes	C	Burrows		No	
Glycera siphonostoma	Polychaetes	C,O	Burrows		No	
Glycera capitata	Polychaetes	C,O	Burrows		No	
Glycera sp.	Polychaetes	C,O	Burrows		No	
Glyceridae unidentified	Polychaetes	C,O	Burrows		No	
Glycinde armigera	Polychaetes	C	Burrows		No	?Tol. pollution
Glycinde sp. juvenile	Polychaetes	C	Burrows		No	

Table 2-2. (cont.)

----------------------------- DEPTH =18 Trophic-Motility Group =Surface carnivore-omnivore: Motile -----------------------------

SPECIES	PHYLUM	TROPHIC	MOTILITY	COLONIZATION	MOBILITY	SENSITIVITY
Nassarius perpinquis	Molluscs	O	Crawls		Yes	
Nassarius sp.	Molluscs	O	Crawls		Yes	
Neverita reclusiana	Molluscs	C	Crawls		Yes	
Olivella baetica	Molluscs	C	Burrows, crawls		Yes	
Ophiodermella halcyonis	Molluscs	C	Crawls		Yes	
Opistobranchia unidentified	Molluscs	C,O	Crawls		?	
Rictaxis punctocoelatus	Molluscs	C	Crawls		No	
Sinum scopulosum	Molluscs	C	Crawls		Yes	
Sulcoretusa xystrum	Molluscs	C	Crawls		No	
Terebra sp.	Molluscs	C	Crawls		Yes	
Volvuella cylindrica	Molluscs	C	Crawls		No	
Woodbridgea polystrigma	Molluscs	C	Crawls		No	
Volvuella sp.	Molluscs	C	Crawls		No	
Philine sp.	Molluscs	C	Crawls		No	
Cylichna diegensis	Molluscs	C	Crawls		No	
Kurtzia arteaga	Molluscs	C	Crawls		Yes	
Volvulella panamica	Molluscs	C	Crawls		No	
Acteocina inculta	Molluscs	C	Crawls		No	
Cylichna sp.	Molluscs	C	Crawls		No	
Woodbridgea sp.	Molluscs	C	Crawls		No	
Acteocina sp.	Molluscs	C	Crawls		No	
Cyclostremella californica	Molluscs	C	Crawls		No	
Cingula sp.	Molluscs	D,H	Crawls		No	
Bulla sp.	Molluscs	C	Crawls		No	
Corambe pacifica	Molluscs	C	Crawls		?	
Bulla gouldiana	Molluscs	C	Crawls		No	
Aglaja ocelligera	Molluscs	C	Crawls		No	
Conualevia alba	Molluscs	C	Crawls		?	
Doto sp.	Molluscs	C	Crawls		?	
Carinaria japonica	Molluscs	C	Swims		Yes	
Terebra danai	Molluscs	C	Crawls		Yes	
Cephalaspidea sp. A	Molluscs	C	Crawls		No	
Philine sp. A	Molluscs	C	Crawls		No	
MGAS0401	Molluscs					
Procephalothrix	Others	C	Crawls		?	
Zygeupolia sp.	Others	C	Burrows		?	
Lineus bilineatus	Others	C	Burrows		No	
Paranemertes sp. A	Others	C			No	
Paranemertes sp. B	Others	C			No	
Cerebratulus or Micrura spp.	Others	C	Burrows		?	
Tetrastemma spp.	Others	C	Crawls		No	
Amphiporus spp.	Others	C	Crawls		No	
Carinoma mutabilis	Others	C	Burrows		?	
Nemertine N	Others	C			No	
Nemertina unidentified	Others	C			No	
Flatworm 1	Others	C,O	Crawls		No	
Flatworm 3	Others	C,O	Crawls		No	
Flatworm 4	Others	C,O	Crawls		No	
Flatworm "white"	Others	C,O	Crawls		No	
Flatworm 6	Others	C,O	Crawls		No	
Flatworm 7	Others	C,O	Crawls		No	
Flatworm 8	Others	C,O	Crawls		No	
Flatworm juvenile	Others	C,O	Crawls		No	
Aphrodita sp.	Polychaetes	C	Crawls		?	

Table 2-2. (cont.)

---------------------------- DEPTH =18 Trophic-Motility Group =Surface carnivore-omnivore: Sessile ------------------------------

SPECIES	PHYLUM	TROPHIC	MOTILITY	COLONIZATION	MOBILITY	SENSITIVITY
Stalked anemone	Others	C	Infauna		No	
Cerianthidae sp. B	Others	C	Infauna		No	?Tol. pollution
Epiactis prolifera	Others	C	Epifauna		No	
Cerianthidae sp. A	Others	C	Infauna		No	?Tol. pollution
Hydroid unidentified	Others	C	Epifauna		No	

------------------------------ DEPTH =18 Trophic-Motility Group =Multi-feeding strategy: Discrete ------------------------------

SPECIES	PHYLUM	TROPHIC	MOTILITY	COLONIZATION	MOBILITY	SENSITIVITY
Ophiuroconis bispinosa	Echinoderms	D,F,O	Burrows, crawls			
Amphiodia urtica	Echinoderms	D,F,O	Burrows, crawls		?	
Amphiodia spp. juvenile	Echinoderms	D,F,O	Burrows, crawls		?	
Amphiodia occidentalis	Echinoderms	D,F,O	Burrows, crawls		?	
Amphioplus hexacanthus	Echinoderms	D,F,O	Burrows, crawls		?	
Ophiuroidea juvenile	Echinoderms	D,F,O	Burrows, crawls		?	

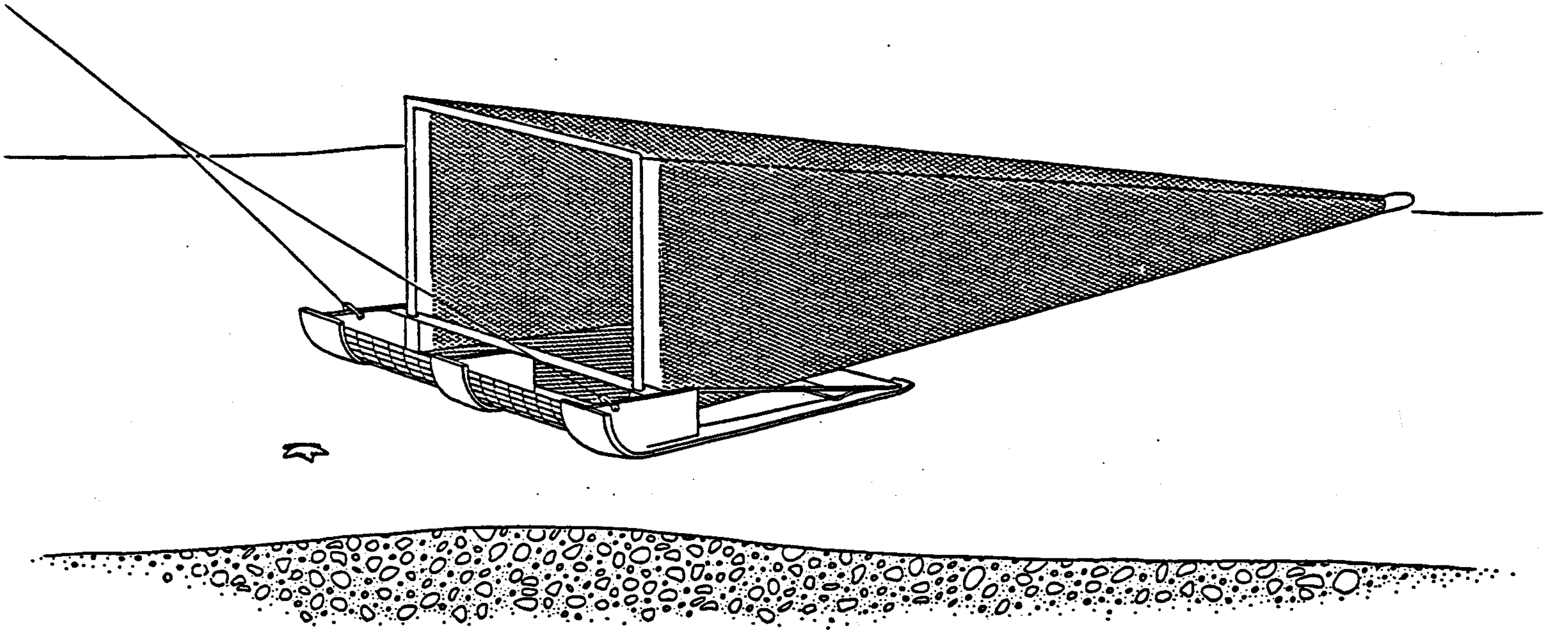


Figure 2-2. Configuration of the gear used to sample mysids.

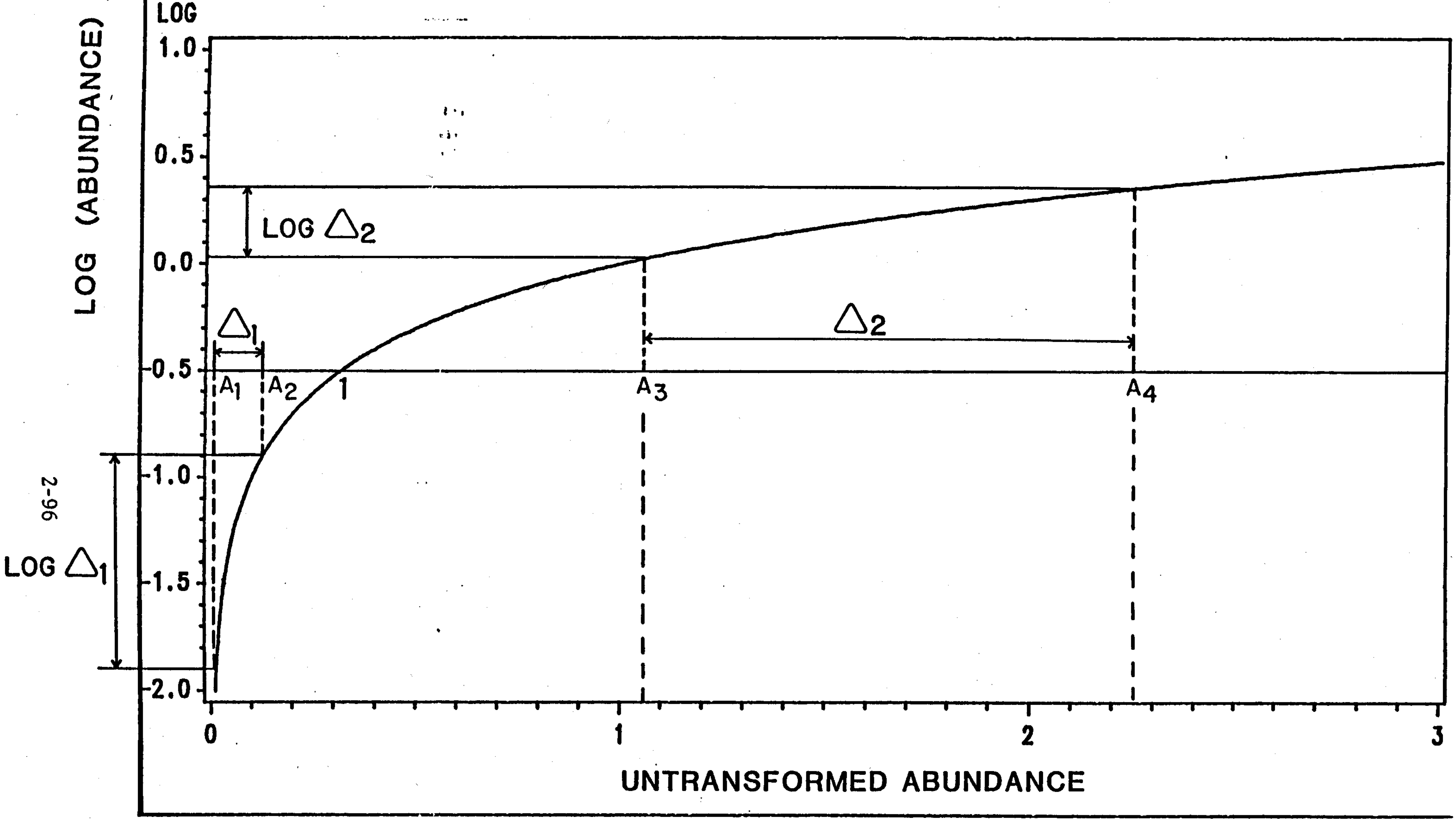


Figure 2-4. Influence of log-transforming abundances on the calculated deltas (Δ). The A's are untransformed abundance values; the Δ's are for untransformed values; logΔ's are for log-tansformed values.

SONGS (Figure 2-3). Some variables were measured on mysid surveys. Water column chlorophyll was measured on MEC plankton surveys, and the two-month mean of temperature came from EcoSystems Management current meters.

The data were analyzed in two ways. Data collected along the benthic lines were displayed on the appropriate time and space axes, which provided clear pictures of the longshore distribution of each variable at each depth over the course of the entire study. Data collected on a more restricted spatial scale, such as temperature and water column chlorophyll, were simply plotted against time.

The results showed that:

- there was a marked difference between 8 and 18 m in the distributions of most of the variables examined;
- bottom water temperatures varied between 11.5 and 19.5°C at the 18 m station and between 14 and 22°C at the 8 m station;
- sediments at 8 m were coarser (3 to 4 phi) and less well-sorted than those at 18 m (4 to 5 phi); a large input of silt and clay which appeared in early 1981 dominated the sediments at 18 m within 2 km of SONGS until early 1985;
- starting in early 1982, concentrations of organic carbon in the sediments were higher at 18 m than at 8 m, and were higher within 2 km of SONGS than farther downcoast at both depths; this may reflect the influence of either the kelp bed or SONGS;
- a period of very low sediment chlorophyll concentrations (< 1 ug/g dry sediment) at both depths coincided with the 1982-1984 California El Nino (see Reitzel et al., 1987a for a description of El Nino); chlorophyll concentrations rose

depth of water at the station, not the actual depth at which the measurement was made. The 8 m station was less than 1 km from shore, the 18 m station approximately 3 km. Because there was no longshore component to the sampling scheme for these variables, there is no way to detect any effects of SONGS on those variables.

There was a 2°C difference in extremes of temperature between the 8 and 18 m stations (Figures 3-1 and 3-2). Temperatures at 8 m ranged from 14 to 22°C, those at 18 m from 11.5 to 19.5°C. The temperature range in any given year was generally greater at 8 m than at 18 m. In 1979, 1980, and, apparently, 1981 a combination of storms and strong upwelling prevented temperatures at 18 m from exceeding 15°C, but at 8 m this effect was only pronounced in 1979.

Water column chlorophyll concentrations (Figures 3-3 and 3-4) generally varied between 0.5 and 4 ug/L during the preoperational and interim periods. Gaps in the data record, the coarseness of the record, and the effects of El Nino in California from 1982 to 1984 prevent us from describing the seasonal cycle of chlorophyll in detail; data from the preoperational period and from 1986 suggest that the standing crop is highest in spring and early summer. Very dense (> 30 ug/L) blooms occasionally distort the record, which is based upon two-month means, and obscure the seasonal pattern.

Secchi depths (Figures 3-5 and 3-6) varied between 2 m and the bottom at the 8 m station, and between 2 and 13.5 m at the offshore station. The seasonal pattern of changes in water transparency was very similar at the two stations. In general, water transparency appeared to be highest during summer and autumn and lowest during the winter. This apparent pattern may be in part an artifact of the fact that the data points in the figures represent two-month means; one would not expect sediments from a combination of SONGS construction effects and storm-related land runoff during 1979-1980 and 1982-1983 (Barnett et al., 1982; Reitzel et al., 1987b). Note that since Unit 2 began pumping in 1982 and Unit 3 in 1983 (except for some pump testing in 1980-1981), the temporal pattern of change in the silt/clay content cannot be attributed to SONGS Unit 2 and 3 operations. There is a suggestion in these data that a pattern of increased silt/clay content near SONGS has been maintained throughout 1985 and 1986; this could be an effect of the operation of SONGS, but there is no obvious relationship between the changes in the silt/clay fraction during mid-1983 to late 1986 and the pumping volume, which was fairly constant. Note that neither the phi values nor the percent silt/clay patterns that show high values near SONGS extend downcoast as far as the mysid sampling area (2500 to 3500 m, corresponding to the benthos 3350 m line at 8 m and the 3200 m line at 18 m).

The final measure of the character of the sediment that we examined directly was sorting, which is a measure of the dispersion of observed grain sizes about the mean value, i.e., how uniform in size the sediment is. Lower values of dispersion mean increasingly well-sorted sediment. At 8 m (Figure 3-11) the sediment was generally well-sorted until late 1982, then became markedly less well-sorted, particularly at the 6700 m line, until late 1984, when it became increasingly well-sorted. This pattern suggests an influx of material of a different grain size, such as a veneer of coarse material being deposited on finer material. The data on mean grain size (Figure 3-7) support this hypothesis, since there was a corresponding decrease in mean phi-size at the 6700 line. In the 18 m data (Figure 3-12), the areas of well-sorted sediment (i.e., low dispersion) correspond to extremes of grain size. Thus, the coarser study. The pattern at 18 m was similar, but the values were generally somewhat lower, and the increase in 1984 was much less marked than at 8 m. There was no longshore gradient in chlorophyll concentrations at the 8 m stations, but at the 18 m stations concentrations were generally higher near SONGS during the operational period.

Organic carbon concentrations were lower at 8 m than at 18 m (Figures 3-15 and 3-16). In the preoperational period, organic carbon at 8 m was evenly distributed longshore, but in the operational period concentrations were highest along the 1900 m line. At 18 m the pattern of organic carbon concentrations generally mirrored that of sediment chlorophyll concentrations (Figure 3-14). In both the preoperational and operational periods the concentrations of organic carbon were usually higher nearer SONGS. The higher concentrations near SONGS at 8 and 18 m may reflect the presence of the kelp bed (Figure 1-4), or they may be due to an input of organic detritus from the diffusers.

Macrodetritus can be considered to be a measure of food available to mysids and certain other benthic organisms. Detritus in the benthic samples was routinely measured in order to determine whether SONGS was affecting the food regime of the organisms. The results (Figures 3-17 and 3-18) show that macrodetritus varied somewhat at both depths over time, but that there was very little longshore variability at either depth. There is a suggestion, in the 8 m data, of higher concentrations near SONGS in 1985 and 1986, but the effect is not pronounced. Although macrodetritus concentrations were generally higher during the operational period, the increase did not correspond closely to the start of Units 2 and 3 operations. Note that at both the 8 and 18 m depths there was very little variation through time in the mysid sampling area (3200 and 3350 m lines) and in the benthos control area (6700 and 9400 m lines).

1985 and 1986, when the cooling water flow was high, than earlier in the study. There are two reasons for this conclusion. First, macrodetritus exhibited no longshore changes that would reflect a SONGS source. Second, cooling water flow was also high during part of 1983 and all of 1984, but macrodetritus concentrations were very low, so that there is no justification for attributing a cause-and-effect relationship to this correlation. Cooling water flow was also correlated with grain size dispersion at the 3200 m line. As pointed out above, the higher values of dispersion noted in the operational period did not appear to be the result of plant operations, so that in this case, too, the correlation reflects a relationship with time, rather than a cause-and-effect relationship with cooling water flow. The fourth correlation was between the number of fish and the concentration of sediment chlorophyll. Both increased sharply in 1986 (Figures 3-13 and 3-14; Barnett et al., 1987), and in the absence of a plausible cause-and-effect mechanism without invoking a long lag time, we conclude that this correlation is a coincidence that may reflect a relaxation from El Nino conditions for both constituents.

In summary, only four of the correlations between the physical/chemical variables had correlation coefficients greater than 0.4. Three of those four appeared to be coincidences, unrelated by a causal mechanism. Therefore, we conclude that there was no evidence for cause-and-effect relationships between the physical and chemical factors that were examined over the course of the study.

(5) to determine if the mysid community as a whole changed at SONGS in the After period in a way that was not reflected at Control in the After period; this evaluation was based on cluster analysis; and

(6) to determine if changes noted in the abundance of a species at SONGS could be related to changes in the environment, predator abundances, or SONGS operations. Because physical and chemical data were only available for the SONGS area, relationships could be noted but not used as evidence for a SONGS effect; these relationships were examined using multiple regressions.

The nine mysid species that were tested fell into three groups, as defined by the onshore-offshore distribution of the species: inshore, cross-shelf, and offshore. The risk of withdrawal/entrainment losses was expected to be highest for the inshore species (Table 3-2). The cross-shelf species were expected to be susceptible both to intake losses and to diffuser-induced habitat alterations. The offshore species were expected either to be susceptible to alterations of habitat and predation pressure, or to occur outside the area influenced by SONGS.

The results were:

- One cross-shelf species (*Mysidopsis intii*) and one offshore species (*Neomysis kadiakensis*) as well as the offshore summary group increased at SONGS relative to Control during the operational period. No other species as a whole showed a significant BACI change, and only one stage of one species not mentioned above changed (this change was not detected by the corroborative BACI test). Power was too low to detect differences of 50% or less in four of the nine species and one of the three summary groups. There were 36 categories of life an inshore assemblage abundant during the preoperational study period; (2) an inshore assemblage abundant during the operational period; (3) a cross-shelf assemblage; and (4) a deeper water assemblage. Groups that were similar on the basis of seasonal occurrence formed within these assemblages. SONGS and Control locations intermingled within each of the four assemblages.

- Regression analysis revealed very few strong correlations between mysid species and the physical and chemical variables; four species showed relationships (three positive and one negative) with SONGS operations as defined by volume of cooling water pumped. The positive relationships were consistent with the increases in abundance at SONGS noted for those species, but the negative relationship was obtained for a life stage that also increased during the operational period.

3.2.2 Abundances of Species and Groups

We used the BACI approach to investigate changes in abundance of individual mysid species and summary groups. The results of the BACI tests are given in Table 3-3 along with a listing of the tests and transformations used. Also given are the results of the MANOVA/ANOVA/Bonferroni pattern analyses of the distribution based on ranks of abundance, by life stage, through the cross-shelf. Table 3-4 gives the number of observations (surveys) included in the tests, the percent change in abundance at SONGS and Control separately and at SONGS relative to Control, and the mean densities in the two locations during each period.

3.2.2.1 Power of the Tests

Five of the 9 species and 19 of the 36 developmental stages tested had a greater than 50% power to detect a BACI change. In other words, they had more than a fifty-fifty chance of detecting a 50% change in the abundance relationship (Delta) between SONGS and Control. Some of the life stages of the species with low power, most notably the juveniles and immatures of Acanthomysis macropsis, Metamysidopsis elongata, and Mysidopsis cathengelae, showed very large (>90%) percent changes in relative abundance (see Table 3-4). Since low power is a reflection of large variability in the data, the BACI test would require additional observations in order to detect significant differences. Below, results of changes in relative abundance (i.e., BACI changes) are reported for only those species or stages with power greater than 50% or when significance occurred. In general, power was higher for the more abundant species (Tables 3-3 and 3-4). As a result the BACI tests were more sensitive to changes in the abundance of the more abundant species than to changes in the rarer species.

3.2.2.2 Inshore Group

There was no evidence that changes in abundance noted for the inshore species were related to operation of SONGS Units 2 and 3. Where the power of the test was relatively high (≥ .70), the changes in relative abundance tended to be low (e.g., immature and adult, all of Acanthomysis davisii, and adults and immatures of the inshore group; Tables 3-3 and 3-4). The "all" category of Mysidopsis cathengelae was the exception to this rule. Despite relatively high power (72.6 percent), the change in relative abundance was high because of a single data point (28 August 1984; Appendix D, Figure D-16). This point comparisons. In the case of Holmesimysis costata, high variability in the data prevented the increase at Control-After from being significant.

The reproductive indices for Mysidopsis cathengelae, which ranged from 0.18 - 0.28, were relatively high throughout the study, but not significantly different. A single operational date, 28 August 1984, was an extreme outlier and highly influential. It was deleted from the data set prior to the analyses of this species and of the inshore summary group.

3.2.2.3 Cross-Shelf Group

The cross-shelf species, as a group, increased in abundance from the preoperational to the operational period, more so at SONGS (146%) than at Control (20%) (Table 3-4). The BACI t-test (Table 3-3) and the corroborative Wilcoxon rank sums test (Figure D-66) detected significant differences between SONGS and Control changes. Large absolute and relative increases in the developmental stages of this summary group also occurred at SONGS (Table 3-4). Unusually high abundances of immatures and juveniles at SONGS and of adults at Control occurred on one operational date, 28 August 1984; however, elimination of this date in the testing procedure was inappropriate because the high abundances that occurred on 28 August 1984 were not unique for any of the three species comprising the group. Similar high abundances were reported at other times during the study for each of those species.

The juveniles of the cross-shelf species Metamysidopsis elongata and Acanthomysis macropsis were largely restricted to shallow water (Section 3.2.3.3), and comprised most of the juveniles of the cross-shelf summary group. Thus the summary group juveniles are not really

The results for the cross-shelf indicate that mysids found in the cross-shelf SONGS area during the operational period were generally more abundant than would have been predicted from the Control area population. The strongest statistical support for this conclusion is supplied by those tests on *M. intii*, by tests for the summary group, and by the reproductive index of *A. macropsis*.

3.2.2.4 Offshore Group

The offshore species group and the offshore species *Neomysis kadiakensis* showed significant relative increases in abundance at SONGS between the two test periods. The patterns for the summary group and *N. kadiakensis* were similar, largely because *N. kadiakensis* constituted over 80% of the offshore group.

All of the life stages of *N. kadiakensis* and of the summary group decreased at the Control area between the preoperational and operational periods. Juveniles of the species and of the summary group also decreased, although to a lesser extent, at SONGS. The immatures and adults, however, increased in abundance at SONGS between the two periods. Of the relative increases of *N. kadiakensis* at SONGS, only the adults were significant, but when all the stages combined were tested, the increase was significantly different.

It would appear, then, that factors near SONGS caused a smaller decrease in the abundances of juveniles of *N. kadiakensis* and the summary group at SONGS than at Control, and an increase in the abundance of the immatures and adults in the populations at SONGS as opposed to the decrease observed at Control.

Changes in the abundances of *N. kadiakensis* juveniles were different at SONGS from those at Control, although not significantly

15 m depth interval, although less so than in the 6 to 12 m interval. Individual species within the inshore group did show significant differences when the "SONGS After" distributions based on ranks were compared with the "Before and Control" distributions. Ranks in the 6-8 m zone were significantly higher for adults of *Mysidopsis cathengelae* and *Holmesimysis costata* at SONGS during the operational period than they were preoperationally or at Control. At SONGS in the After (operational) period the ranks of the immature and juvenile stages of *M. cathengelae* increased in the 8-12 m zone while the highest rank abundance remained in the 6-8 m zone.

These differences between patterns at SONGS in the operational period and the preoperational and Control patterns are an indication that the 6-8 m and 8-12 m depth zones at SONGS in the operational period were different from those depths at the preoperational and Control. The pattern shifts occurred between these two depth zones, so that the inshore (6-15 m), unit did not appear to be different at SONGS in the operational period.

Juveniles of the cross-shelf group exhibited a very strong onshore-offshore gradient of distribution at SONGS and Control throughout the study. The highest ranks consistently occurred in the 6 to 8 m interval. Adults and immatures of the cross-shelf group showed significant differences in their distributions between the SONGS operational and the Control and SONGS Before location-period combination. The rank abundance of immatures in the 6-8 m zone decreased at SONGS during the operational period. The adults broadened the range in which their abundance was highest, from the 12-23 m interval in the "Before and Control" observations to the 8-23 m interval in the "SONGS After" observations. No individual species exhibited these significant shifts in distribution.

3.2.3.3 Cluster Analyses

Studies in the SONGS area have identified distinctive communities delimited by the 15 m depth for ichthyoplankton (Barnett et al., 1984), zooplankton (Barnett and Jahn, 1987), and benthos (Barnett et al., 1983) communities. Bernstein and Gleye (1981), using cluster analyses, reported that the nearshore preoperational mysid community at San Onofre was divided into an inshore group (occurring in water < 15 m deep), an offshore group (> 15 m), and a cross-shelf group (spanning the 15 m depth). In neither the benthic nor mysid study did cluster analysis distinguish between SONGS and Control.

Since communities of species are often more sensitive than individual species to environmental changes (Boesch 1977), we subjected the mysid community abundance data to hierarchical cluster analysis. This was done to determine if the mysid community at SONGS in the operational period was separated from the Control community and from the preoperational community.

Using the operational data combined with the preoperational data, the cluster analysis detected no assemblage distinctive of SONGS in the After period. However, the analysis did form four onshore-offshore mysid assemblages (Figure 3-19). There were two inshore assemblages, one characteristic of the preoperational period and one characteristic of the operational period. The preoperational and operational inshore assemblages were different because Neomysis rayii and Acanthomysis davisii virtually disappeared during the interim period, and Holmesimysis costata decreased markedly in abundance (Table 3-4). These species were replaced in the operational period by Mysidopsis cathengelae, which increased fourfold from its preoperational abundance, and by juveniles of two cross-shelf species, Metamysidopsis

3.2.4 Relationships Between Mysids and Their Food, Habitat, Potential Predators, and SONGS

Multiple regression was used to examine the relationship between the abundance of mysid life stages and a suite of physical and chemical (P/C) variables, predation by fish, and SONGS operations. Table 3-7 summarizes the results of the multiple regressions; it may be helpful to review Section 2.4.9, which describes the rationale for interpreting the regressions. It is important to note that the regression analyses are not BACI-type analyses, because there were no P/C data from the Control location -- the regressions themselves refer only to the SONGS location, although interpretations may extend to the Control area.

All 24 of the stages (3 stages for each of 8 species) were examined for their relationships with the P/C variables. Seventeen categories, including all life stages of 5 species (Acanthomysis davisii, Holmesimysis costata, Mysidopsis cathengelae, Mysidopsis intii, and Neomysis rayii), as well as adult Acanthomysis macropsis and juvenile Neomysis kadiakensis, showed very similar patterns of large scale changes in abundance at SONGS and Control (Table 3-4). These were therefore not examined for predator-related and SONGS-related changes, since there was no way to detect such effects, unconfounded by Control changes. The remaining seven categories Metamysidopsis elongata, immature and juvenile A. macropsis, and adult and immature N. kadiakensis showed different patterns of change at SONGS and Control, and were examined for possible effects of SONGS or fish.

Nine of the 24 categories showed no significant relation to any of the variables that we examined. The other 15 categories were significantly related to various P/C variables, but those relationships were generally not strong. Of those that were significant, only 5 had

Adult Mysidopsis cathengelae were weakly (r^2=.23) correlated with grain size, but the other life stages were unrelated to any P/C variable. There is no indication in these data of the reason for the large increase in abundance at both locations.

3.2.4.2 Cross-Shelf Species

Acanthomysis macropsis immatures and juveniles increased substantially in absolute and relative abundance at SONGS and Control between the Before and After periods, whereas adults increased only in absolute abundance. Adult A. macropsis were correlated with organic carbon concentrations, but the relationship was too weak (r^2=.23) to be considered important. The addition of pumping volume did not improve the correlation, so we conclude that adult A. macropsis were unaffected by SONGS operation. The immatures and juveniles were unrelated to any P/C variable or to fish. When pumping volume was added, however, significant correlations of .36 and .38 were obtained. These substantial improvements in the relationship indicate a clear effect of SONGS on the immatures and juveniles. The relationships with pumping volume were positive, suggesting that A. macropsis, which is distributed throughout the cross-shelf (Section 3.2.3), benefited from the operation of SONGS, possibly as a result of increased food.

Mysidopsis elongata increased as much as six-fold at SONGS between the two monitoring periods. Adults and juveniles increased at Control, but immatures decreased. Both adults and immatures were found throughout the cross-shelf, but juveniles were only found shoreward of the 23 m isobath. Adults and immatures showed very weak ($r^2 \leq .27$) relationships with P/C variables, and we concluded that they responded to factors other than those we measured. The addition of fish improved were negatively correlated with temperature, indicating an association with colder water, and less strongly with several other factors. Neither fish abundance nor pumping volume were significantly correlated with the abundance of adults, indicating that those factors had no influence on adults. In the case of immatures, however, the regressions showed that the addition of pumping volume improved the correlation markedly, yielding a negative relation between pumping volume and abundance. This suggests a negative effect of SONGS. Since the species was concentrated well offshore of the intake, a negative influence of SONGS might be due to entrainment effects.

3.2.4.4 Summary

The regressions revealed strong correlations ($r^2 > .5$) with P/C variables only for all life stages of Acanthomysis davisii, for juveniles of Metamysidopsis elongata, and juveniles of Neomysis rayii. Neither P/C variables nor fish appeared to be related to the abundances of any other species or life stage. The analyses also suggested that SONGS-related activity exerted negative effects on immature Neomysis kadiakensis and positive effects on immature and juvenile Acanthomysis macropsis and juvenile Mysidopsis elongata. The positive effects were consistent with the patterns of changes in abundance (Section 3.2.2), but the negative relationship was contrary to the observed change in abundance of immature Neomysis kadiakensis.

3.2.5 Summary of the Mysid Results

We conclude that no major changes in abundance attributable to SONGS operations occurred in any species restricted to depths shallower than 15 m. Therefore, the effects, if any, of intake withdrawal and abundance of these organisms. In those cases in which we were able to detect changes, changes either occurred at both Control and SONGS (onshore-offshore distributions, community structure, cluster) or the changes suggested enhanced conditions for mysids (BACI, regressions) in the vicinity of SONGS during the operational period.

3.3 Soft Bottom Benthos

3.3.1 Synopsis

MEC's primary goals in this final analysis of the soft-bottom benthos were:

1) to determine whether the operation of SONGS had altered the structure of the benthic community--this was the cluster analysis, which was supported by multidimensional scaling analysis and spatial/temporal plotting of the cluster results;

2) to examine in detail any changes in the structure of the community that were revealed by the cluster analysis, on the scales that the cluster analysis identified as being important, and to help us to interpret those changes--this was the assessment of trophic structure;

3) to determine whether there were significant changes in numbers of benthic organisms near SONGS relative to numbers at a Control location between the Before and After periods--this was the BACI analysis. The variables chosen for testing were summary measures of the community (number of species, total abundance, biomass), and the abundances of species and taxonomic and trophic-motility (TM) groups (groups of species that resemble one another in mode and site of feeding and locomotion).

broadly similar way and in the same place were expected to respond to perturbations in a generally similar fashion. Selected taxonomic subsets (e.g., crustaceans, polychaetes; see Section 2.4.1) of some of the broader-based TM groups were also analyzed because the responses to perturbations were expected to be more similar within a subset than between subsets of a TM group. At the finest level of taxonomic resolution, several of the most abundant individual taxa (usually species) at each depth, as well as others that had high BACI power (see Section 2.4.1 for selection criteria), were analyzed with BACI tests to determine whether the results for these individual TM group components would provide insight into the results for the overall group.

MEC anticipated that an effect of SONGS on the structure of the benthic community would be revealed in any or all of the following ways:

- a longshore difference, concentrated near SONGS, in cluster groups of stations in the operational period that was not present in the preoperational period;
- a consistent difference between the multidimensional scaling scores of the SONGS stations and those of the Control stations in the operational period, which would be apparent as different patterns on the ordination axes;
- a difference in the relative abundance and degree of dominance among the TM groups at the stations nearer SONGS as opposed to the stations farther downcoast that was not present in the preoperational period.

MEC anticipated that the results of BACI and pattern analyses of abundance would fall into one of three categories:

- Category 1--those results that failed to show an effect, i.e., there was no statistically significant change in sediment grain-size as a result of increased runoff, decreased phytoplankton and benthic algal productivity as a result of altered circulation and reduced water transparency, and migrations of predators into or out of the area in response to natural changes. The changes in abundance associated with these mechanisms would have occurred during the Before and interim periods, when the severe storms, El Nino, and SONGS Units 2 and 3 construction took place.

All of the changes that were detected, and which are presented in the following sections, were evaluated in terms of the natural and SONGS-induced mechanisms that could have produced them.

The results of MEC's analyses were:

- Cluster analysis and multidimensional scaling analysis of species abundance and trophic-motility groups showed that the primary trend in the data was a coastwide difference between the preoperational and operational periods, probably resulting from the perturbing effects of the severe climatic conditions of 1979 to 1983. The species groups at both depths changed over the course of the study from assemblages characteristic of relatively late successional stages to assemblages indicative of earlier successional stages. The cluster analysis of the 18 m data did identify minor subgroups of SONGS-area After stations as distinct from Before stations and Control stations. Multidimensional scaling analysis showed the maximum dissimilarity between samples to occur along an axis corresponding to time, clearly separating the Before and After periods, and did not reveal a difference based upon location.

SONGS area, both relative decreases; the remaining changes may have been associated with SONGS, but were not conclusive.

- At 18 m, 31 of the 61 categories tested showed significant BACI and/or pattern analysis results that could be interpreted as SONGS effects. Twenty-eight of those changes were relative increases, eight of which were clearly associated with the SONGS area. Of those eight, five involved the motile subsurface deposit-feeding TM group and its component polychaetes. In addition, nematodes and surface-dwelling carnivore/omnivore crustaceans decreased downcoast but not at SONGS, and the total number of species increased near SONGS.
- Inspection of the P/C data indicated that there were large-scale temporal changes, and somewhat less pronounced spatial changes, in certain measures of organic enrichment, sediment type, and the physical regime. These patterns suggested that the changes in the biota were linked to changes in the P/C variables. Furthermore, some of the variables, particularly sediment chlorophyll and percent silt and clay at 18 m, macrodetritus at 8 m, and sediment organic carbon at both depths, tended to change at stations nearer SONGS in the operational period, and could, therefore, act as mechanisms by which SONGS was affecting the biota. However, multiple regression analyses of the abundance of the taxa and groups that showed BACI changes, of other abundant taxa, and of the variations along ordination axes of the multidimensional scaling analysis of species and TM groups, did not reveal any strong relationships ($r^2>0.5$) with the measures of the

The cluster analysis was supported by multidimensional scaling (Section 3.3.2.2) and by plots of longshore and temporal trends of cluster groups (Section 3.3.2.3).

The results of the cluster analysis are summarized in Figures 3-20 through 3-23. The lists of the species and TM groups characteristic of the station groups identified by the cluster analysis are presented in Tables 3-8 through 3-11. The complete two-way tables and listings of the species and TM groups in each station group are presented in Appendix C.2. The taxonomic and trophic-motility affiliations of the species discussed in this section are presented in Table 2-2 and Section 2.4.1. Tables 3-8 and 3-10 also include the classification of the species as rapid, early, delayed, or late colonizers. The classifications are based on whether a species has been reported to occupy an area within 10 days, 30 days, 30-90 days, or more than 90 days (usually a year or more) after a disturbance, respectively. In cases where reports of colonization were lacking for a species found at San Onofre, but were available for a congeneric species, the colonization information was noted in Tables 3-8 and 3-10 with a "?". Colonization information for nemerteans, which often are not identified to species in the literature, was also noted in the tables with a "?".

The species assemblages characterizing the station groups are discussed in terms of their successional stages on the basis of information on colonization gathered from the literature. Succession refers to the sequential changes in species composition following a perturbation (Connell and Slatyer, 1977; Glasser, 1982). Faunal recovery information was derived from sources that dealt with succession following a variety of disturbances, including anoxic conditions, dredging, and pollution abatement (Dauer and Simon, 1976;

predominantly nearfield (700 and 1100 m) or downcoast (3350-9400 m), stations. However, the fact that the cluster distance between those subgroups and adjacent subgroups containing all stations was minor relative to the temporal changes indicates that the disturbance between the Before and After periods was coastwide.

Cluster analysis of the TM groups at 8 m (Figure 3-21, Table 3-9) distinguished 3 major station groups and three major clusters of TM groups. Station Group 1 consisted largely of the Before and Interim stations, although a subgroup contained 23 After stations drawn evenly from all six sampling locations. Station Groups 2 and 3 consisted largely of operational stations. In general, the longshore locations were not clearly discriminated. There were only subtle changes in the high-ranking TM groups characteristic of Station Groups 1 and 2. Therefore, the cluster analysis of the TM groups was not effective in distinguishing shifts in the trophic-motility structure of the 8 m community. This was because of the great variability within the station groups (see the two-way table in Appendix C.2). (However, in the analysis of trophic structure presented in Section 3.3.3, which used only the mean abundances of the preoperational and operational periods, we were able to detect shifts in dominance among the TM groups).

In summary, the cluster analysis of the 8 m data distinguished a coastwide difference indicative of disturbance between the Before and After periods. It did not distinguish the stations near SONGS in the operational period as being markedly distinct from the other locations on the basis of species composition or composition by TM groups. Thus, the cluster analysis provided no clear evidence of an effect of SONGS on the composition of the benthic community at 8 m.

22; Appendix C.2-3) suggests that the three station groups were not markedly different in terms of their patterns of species composition and abundance. The After station groups, particularly Station Groups 1 and 2, shared many of the characteristics of Before Station Groups 4 and 5. The high-ranking species characteristic of the After period, as well as their trophic-motility affiliations, were similar to those of the Before period (Table 3-10). However, the Before station groups were considered representative of later successional stages than the After station groups even though in some cases the distinction was fairly small. The colonizing information in Table 3-10 describes this difference. Most of the slower colonizing (late, delayed-late, delayed) species were considered late colonizers in the Before period, whereas delayed/late colonizers were at least as numerous as late colonizers in the After period.

Subgroups within Station Group 1 seemed to be distinguished on the basis of both seasonal occurrence and location. One of the three subgroups contained winter-spring samples from 1985 and 1986, and another contained primarily summer samples. The third contained two smaller subgroups, one predominantly from the 700 and 1100 m stations, the other from the downcoast stations; however, the cluster distance separating these smaller subgroups was much smaller than the distance separating station groups (Figure 3-22). Station Group 1 differed from the Before station groups, and from Station Groups 2 and 3, in having a similar number of late and delayed/late colonizers as rapid and/or early colonizers. Thus, Station Group 1 may be considered representative of an earlier successional stage.

Station Group 2 also included primarily After stations; one of its two major subgroups consisted mostly of upcoast stations, with 21 of 29 relative to After Group 2 and the Before station groups. With the exception of the fact that Station Group 3 contained fewer high-ranking species, the basis of the separation between Station Groups 1 and 3 was not clear.

Results of the cluster analysis of species at 18 m suggest some disturbance of the benthic community between the Before and After periods. This was most evident when one compared the Before Station Groups 4 and 5 with the relatively earlier successional stages of After Station Groups 1 and 3. Because many of the species, trophic-motility affiliations, and number of relatively late and relatively early colonizers were not markedly different between the After (particularly Station Group 2) and Before station groups, the disturbance appeared to have resulted in only a relatively small effect on the benthic community.

The upcoast-downcoast distinction among the two subgroups of Station Group 2, along with the small upcoast subgroup of Station Group 1, constitute the clearest evidence of a SONGS effect that the cluster analysis produced. As noted above, however, the distinctions between groups in the After period, and between subgroups within groups, were not strong, so that the SONGS effect was not marked.

Cluster analysis of the TM groups at 18 m (Figure 3-23, Table 3-11) did not distinguish the preoperational and operational periods as clearly as did the species cluster analysis. A total of six station groups emerged from the analysis. The preoperational samples were clustered into Station Groups 3 and 6. Most of the interim and operational samples were assigned to Station Groups 4 and 5; Station Groups 1 and 2 were both relatively small groups of operational-period samples. SONGS-area samples formed subgroups of Station Groups 4 and 5.

determine the source of the biological variability (e.g., time, location, sediment type). We applied multidimensional scaling analysis to the species and TM group data at 8 m and 18 m, separately, and then regressed the axis scores on the P/C data to investigate sources of biological variability.

In this study, it took ten axes to account for 80% of the biological variability. The first two axes of the 8 m and 18 m species and TM group data accounted for 25 to 30 percent of the variability in the biological data. Thus, in the discussion that follows, use of more than the first two axes did not increase our understanding. It is necessary to keep in mind that the patterns expressed in ordination space represent only a fraction of the variation that actually occurred in the benthic community.

On the plots of the ordination spaces defined by Axes 1 and 2 (Figures 3-24 to 3-27) the preoperational, interim, and operational samples are described by different symbols, and the stations in each monitoring period are encircled by a line. The figures show that the preoperational and operational groups of stations defined by species occurrences and relative abundances (Figures 3-24 and 3-25) are clearly separated in ordination space at both 8 m and 18 m. In every case the operational period stations lie to the left of the preoperational period stations, and the interim period stations lie between. This means that the principal separation is along Axis 1. The two groups overlap only once (8 m depth, 1900 m station).

In the case of the stations defined by TM groups (Figures 3-26 and 3-27), the pattern is different, and less distinct. Although most of the groups overlap to some extent, the operational period stations clearly lie below and, in the case of 8 m, to the right, of the preoperational regressions failed to reveal strong correlations ($r^2 \geq 0.50$) with any combination of P/C variables. This indicates that changes in P/C variables could not account for the separation of the data along the coordinate axes.

The clear separation of the preoperational and operational station groups in all of the ordination plots, and the weak correlations with P/C variables, make it apparent that the major influence was time. The species composition and TM group composition of the benthic community changed over time, and it changed in a similar way at all stations. In the case of species composition, the gradient of time is clearly represented by Axis 1, which accounts for more of the variation in the data (15% at 8 m, 18% at 18 m) than do any of the other axes. In the case of the TM groups at 18 m the gradient of time is expressed along Axis 2 (11%), but at 8 m time is expressed along both axes. The strong separation between the preoperational and operational periods corresponds closely to the timing of the 1982-1984 California El Nino. This correspondence suggests that the community structure was fundamentally altered, coastwide, by the hydrographic and climatic changes associated with the El Nino event.

3.3.2.3 Longshore and Temporal Patterns

Longshore differences in the species composition of the benthic community was examined by plotting the cluster group to which each station was assigned, survey by survey. This technique provides a readily interpretable guide to how the community varied longshore during the course of this study. Substantial differences should manifest themselves as longshore differences in the station groups. Tables 3-12 and 3-13 show that during the preoperational period there three (juvenile Rhepoxynius, Diastylopsis tenuis, Synchelidium shoemakeri) were still highly ranked at the end of the study (Station Groups 2 and 3, Tables 3-8 and 3-12). This shift began in early 1983, before SONGS Units 2 and 3 became fully operational. It was in all likelihood the result of the stormy conditions associated with the 1982-1984 California El Nino. Some recovery of the benthic community from the El Nino disturbance was apparent by mid-1985, with the appearance of Station Group 4. The recovery process was interrupted, however, during the fall-winter period later that year, and by the end of the study the community had not recovered to as mature a successional state as in the Before period. SONGS operation, which began in 1984, did not appear to influence these patterns of disturbance and recovery.

All of the samples collected at 18 m through 1982 were assigned to Station Groups 4 and 5 (Table 3-13); which contained species assemblages characteristic of relatively late successional stages (Table 3-10; Section 3.3.2.1). There were no longshore differences in the station groups during this period. In early 1983 there was a coastwide shift from Station Group 4 to Station Group 3. Station Group 3 persisted until mid-1984, when Station Group 1 appeared. This pattern indicated a trend toward less stable conditions, since Station Groups 1 and 3 represent earlier successional stages than do Station Groups 4 and 5 (Table 3-10; Section 3.3.2.1).

Station Group 1 persisted until early 1986, when it was replaced coastwide by Station Group 2. Station Group 2 represents a later successional stage than do Station Groups 1 and 3 (Table 3-10; Section 3.3.2.1), suggesting that a process of recovery from the 1983 disturbance was occurring. As noted in Section 3.3.2.1, there was a longshore difference in species composition within Station Group 2, than between locations. Therefore, MEC examined changes in the trophic structure of the benthic community by comparing mean abundances between the two periods. Our objective was to study the changes in detail so as to gain some interpretive insight into their ecological significance. Mean abundances were used to calculate the percent composition, which is a measure of dominance, of each station by trophic-motility categories. Supporting tables containing complete listings of the abundance, number of species, and percent contribution of the trophic-motility groups are presented in Appendix Tables C.2-9 to C.2-12.

Initially, the infaunal community off San Onofre was numerically dominated by subsurface deposit-feeding polychaetes and by suspension/deposit-feeders (polychaetes, amphipods, and tellinid bivalves). Subdominants included omnivore/deposit-feeding and deposit-feeding peracarid and ostracod crustaceans (Tables 2-2, 3-14, and 3-15). The abundant taxa were typical of nearshore sand bottom assemblages off Southern California (Barnard 1963; Van Blaricom, 1982). Although the dominant TM groups persisted throughout the study period, the percent contribution of most shifted between preoperational and operational periods.

The trophic structure of the benthic community at 8 m, as indicated by the abundance and percent contribution of the trophic-motility groups (Table 3-14), showed that during the Before period the three stations nearest SONGS were more similar to each other than to any of the downcoast stations, and the three downcoast stations were more similar to each other than to any of the upcoast stations. Sites within 3350 m of SONGS were dominated (46-52%) by suspension/deposit-feeding discretely motile organisms (mostly polychaetes), but at the Control sites this TM group was less important (21-36%) and the surface deposit-

(Control) sites were similar to each other. At the sites within 3200 m, motile subsurface deposit-feeders (capitellid and paraonid polychaetes) accounted for 29-37% of the individuals, and discretely motile suspension/deposit-feeders represented 14-19% of the individuals. At the Control sites, however, the two TM groups were co-dominant, each accounting for about 22% of the individuals.

Shifts in the abundance and percent contributions of the component TM groups occurred unequally along the distance gradient between the Before and After periods (Table 3-15). The abundance of the subsurface deposit-feeding motile group (mostly polychaetes) increased at the 700 and 1100 m stations but decreased at all other sites. The increase was very large at the 700 m site, which raised the percent contribution from 30% in the Before period to 39% in the After period, but at 1100 m the percent contribution decreased somewhat because of increases in the abundance of other TM groups. The absolute and relative abundance of discretely motile omnivore/deposit-feeders (mostly crustaceans) remained nearly constant at 700 and 1100 m, but increased at all other sites. On the other hand, the discretely motile carnivore/omnivore group remained nearly constant at the 700 and 1100 m sites but decreased at all other sites. In general, abundance became more evenly distributed among the TM groups at 18 m with increasing distance from SONGS during the After period. The fact that the trophic structure changed from one of clear dominance by one or two TM groups in the Before period to one of a more even distribution of abundance among two or more TM groups in the After period at all sites except 700 m, where one TM group became dominant, suggests effects localized near SONGS. These changes were not evident in the cluster analysis of TM groups.

feeders), of which Tauberia is a principal component, yielded a correlation of 0.19. Analyzing Tauberia alone yielded a correlation of 0.22, indicating that some of the other members of the subset detracted from the relationship. The analyses of community patterns and structure revealed considerable changes in the abundance of species and TM groups between the Before and After periods as well as longshore variations in changes in the composition of species groups. Similarly, the P/C data revealed changes between the monitoring periods and in the longshore (Section 3.1). Therefore, the poor correlations between biological and P/C variables were unexpected.

In general, these poor correlations clearly show that changes in the P/C regime could account for only a small portion of the biological changes that occurred during the study. The result of low correlations is identical to the regressions of P/C variables against the ordination axes (Section 3.3.2.2).

There are several possible reasons for this observation. The first is that the biota did not respond to the P/C regime on the time and space scales that were analyzed, i.e., that over short time scales, P/C changes and biological changes were decoupled. P/C changes that are large in magnitude but of short duration may be integrated by an organism over a longer time period, rather than being translated into an immediate change in abundance. However, lack of detailed knowledge of the relationships between the various species in the SONGS area and their environment prohibits the incorporation of such relationships into the multiple regression.

Another reason is that the very large spatial scale of this study makes short-term immigration responses by organisms unlikely. Instead, species may respond on the population level, i.e., by increasing or benthic communities (Woodin, 1974; Virnstein, 1977; Evans, 1983). These possibilities could not be addressed in the present study, and are simply pointed out as possible mechanisms for the observed changes.

3.3.5 Abundances of Species and TM Groups

As pointed out in Section 3.3.1, two of MEC's major goals in the final analyses of the abundances of soft bottom benthic taxa and TM groups were: (1) to determine via BACI testing whether there were significant changes in abundance near SONGS relative to abundance at a Control location in the After period, and (2) to determine via the longshore abundance pattern analyses whether any such significant changes were unique to the nearfield.

Summaries of the BACI tests, pattern analyses, and changes in abundance are presented in Tables 3-18 through 3-33. These results were interpreted in terms of three possible categories. Category 1 includes results that indicate no SONGS effect. Category 2 includes results that showed a change in the abundance relationship between SONGS and Control that occurred only in the Before period (note that such a pattern indicates a violation of the BACI constant mean assumption). Results in this category were attributed to storms, including the 1982-1984 California El Nino, and construction, which was largely confined to the Before period. The third category included results indicating effects that either occurred in the After period or changed between the Before and After periods. Some of these results were clearly attributable to SONGS, others may or may not have been SONGS effects. Tables 3-19, 3-21, 3-27, and 3-29 portray these categories graphically.

Of the taxa and TM groups at 8 m for which power was greater than 0.5, only one taxon and one TM group exhibited relative decreases. No

3.3.5.1 BACI and ANOVA Results at 8 m

3.3.5.1.1 Summary of Results

Three summary variables of the 8 m community --the number of species, total abundance, and total biomass --were analyzed, and showed no relative changes in the After monitoring period that could be unequivocally attributed to SONGS. Of these three community measures, only total abundance yielded statistically significant results; these largely reflected changes that began and ended before Units 2 and 3 began operations (e.g., Figure D-163).

Among the sixteen TM groups tested at 8 m (Table 3-18), seven had power greater than 0.5, and could therefore have been expected to show effects had they occurred. Of these seven, only one, the surface omnivore/deposit-feeding: motile group, showed a change in relative abundance that was clearly associated with the SONGS area (Table 3-19; Figures D-213, D-216). One other TM group, the discretely motile surface suspension/deposit-feeders, showed a change that could be attributed to changes in abundance that began and ended before the start of Units 2 and 3 operation (Table 3-19; Figure D-223).

Of the 19 taxonomic subsets (Table 3-18) of TM groups that were tested, eight had power greater than 0.5. Of those eight, none showed a clear effect localized near SONGS; however, the test results for three subsets, the mollusc and "other" subsets of the surface carnivore/omnivore: motile TM group and the crustaceans of the discretely motile surface carnivore/omnivore group, suggested possible effects (Table 3-19).

Eight of the fifteen individual taxa examined had power greater than 0.5 (Table 3-20). Only the polychaete Typosyllis hyalina (a member of the surface carnivore/omnivore: motile TM group noted above) yielded

The results of the individual tests of TM groups and subgroups and of species at 8 m were consistent with the results of the analyses of community patterns and structure. Few SONGS effects were noted in both cases. Most of those that were identified by the individual tests (e.g., motile surface omnivore/deposit-feeders) were also seen by the community analyses.

The following subsections present more detailed discussions of statistically significant results at 8 m. For the convenience of the reader, these are organized into results that clearly display an effect (Section 3.3.5.1.2) and those that may show an effect (Section 3.3.5.1.3). Readers interested only in a general summary of results may wish to skip these subsections and continue reading at Section 3.3.5.2: Results at 18 m.

3.3.5.1.2 Effects at 8 m

Of the sixteen TM groups that were tested at 8 m, only one, the motile surface omnivore/deposit-feeders, showed clear evidence of an effect that actually began as a rapid increase in abundance at the Impact site and a smaller increase at Control in the Before period (Figure D-215). Following this initial increase, abundance remained elevated at both SONGS and Control into the After period. During the After period abundance continued to increase slowly at Control while simultaneously declining at the Impact site (Figure D-215), yielding a decrease in relative abundance and the significant BACI result. The longshore pattern analysis (Figure D-216) showed that this BACI result was an Impact site phenomenon, since longshore abundance patterns were nearly parallel in the two monitoring periods, except at the Impact stations. The spatial extent of the BACI effect -- less than 2000 m -- reinforces the selection of the Control station locations.

connection between the declining nearfield abundance and an increasing contribution of silt and clay-size particles to the nearfield sediments (remember that during the period of increasing abundance in 1979-1980, the percent silt and clay changed little in the nearfield). However, as noted above the multiple regression analysis showed only a very weak relationship between abundance of the TM group and the physical/chemical parameters measured. Thus some factor(s) other than natural variations in sediment parameters must have been involved in the observed abundance changes.

Phoxocephalids have been shown to actively avoid sediments containing low concentrations of cadmium (ca. 6 µg/g) or zinc (ca. 50 µg/g) (Oakden et al., 1984). Both metals are discharged by the SONGS Units. However, a hypothetical link between trace metal discharges and declining abundance of this TM group cannot be evaluated because time series of sediment metal concentrations are not available. Other direct mechanisms such as intake withdrawal and secondary entrainment of swimming adults or planktonic larvae are unlikely to have contributed in any important way to the observed nearfield decline since most organisms belonging to this TM group do not have planktonic larvae and most have not been shown to spend a large proportion of their lives in the water column.

Test results and abundance patterns for the TM group were not entirely consistent with those of its component taxa that were also tested. The codominant taxa, the ostracod Euphilomedes longiseta and the amphipod Synchelidium shoemakeri, yielded neither statistically significant test results nor abundance patterns particularly suggestive of an Impact site effect, except that both displayed brief (2-4 months), but large increases in abundance at the Impact site in individual taxa reflected parts of the pattern. The TM group experienced a regional increase in abundance sometime during the period that included the stormy winters of 1977-1978 and 1979-1980, and which also coincided with the Units 2 and 3 offshore construction activity. The subsequent abundance decline was localized near SONGS in the After period. The mechanism(s) leading to this could not be identified, but since the decline was localized in the nearfield it must be considered an important result.

No other TM group showed convincing evidence of an effect localized near SONGS although one species, the syllid polychaete _Typosyllis hyalina_, a member of the motile surface carnivore/omnivore TM group (which showed no evidence of an effect), clearly showed an effect (Figures D-363, D-364). This species displayed some indication of a regional increase in abundance sometime between late 1977 and late 1979 and a regional decline in the After period, but the most striking change in abundance was its virtual disappearance from the SONGS area in the After period (Figures D-363, D-364). The multiple regression analyses indicated little relationship between these abundance patterns and the physical/chemical parameters measured, except sediment total organic carbon, although even there the relationship was weak (Table 3-16) and apparently had nothing to do with the nearfield disappearance. Thus the observed abundance changes must have reflected influences in the nearfield other than those measured in the physical/chemical data.

Intake withdrawal and/or secondary entrainment of planktonic larvae might represent a mechanism unique to the nearfield that might have contributed to the observed disappearance. Many syllids do reproduce via planktonic larvae, but some others brood their young nearfield, during and immediately following the stormy winter of 1979-1980. By late 1981 abundance was already returning to lower levels which were subsequently maintained through the After period. The BACI and ANOVA results for this TM group thus reflect abundance changes that began and essentially ended prior to Units 2 and 3 operations, and they probably do not reflect SONGS effects.

In addition to the TM group described above, taxonomic subsets of two other TM groups--the motile surface carnivore/omnivore molluscs and "others", and the discretely motile surface carnivore/omnivore crustaceans--had power greater than 0.5 and also yielded significant BACI results (Table 3-18). The two codominant subsets of the motile surface carnivore/omnivore TM group showed opposite relative changes in abundance: the molluscs decreased, while the others increased (Table 3-24). Inspection of the longshore patterns of abundance for the molluscs (Figure D-272) showed that their BACI result probably came about largely because abundance did not decline in the After period at the Control station 6.7 km downcoast, unlike at all other locations. This would appear to indicate that the effect in this case was only natural variability downcoast; however, SONGS effects such as intake withdrawal of planktonic larvae during the After period could have contributed to the slightly larger decline at SONGS. Unfortunately, this possibility cannot be evaluated because we have no estimates of the number of larvae of this TM group available for withdrawal/entrainment. A lack of information about feeding habits precludes an evaluation of potential changes in prey availability to the observed results for the motile surface carnivore/omnivore molluscs. It does seem plausible to suggest that the regional increase in abundance which was underway by the winter of 1979-1980 (and could have started as early as late 1977) represented likely that the test results really reflected changes that occurred prior to SONGS operations, and that they therefore do not indicate SONGS effects. This may support the interpretation of no effect for the taxonomic subset.

Among the individual taxa tested at 8 m, only those already discussed above (i.e., Rhepoxynius menziese and Rhepoxynius spp. juveniles, Typosyllis hyalina, and Zygeupolia sp.) yielded significant BACI results. These discussions are not repeated here.

3.3.5.2 Results at 18 m

3.3.5.2.1 Summary of Results

All three summary variables of the soft-bottom benthic community at 18 m--the number of species, total abundance, and total biomass--increased coastwide beginning in the Before period (Figures D-371, D-375, D-379). The increase in the number of species and total abundance was significantly larger near SONGS during the After period. An increase in the number of benthic species often is indicative of mild organic enrichment (e.g., Pearson and Rosenberg, 1978), such as was expected to occur near the diffusers (e.g., MRC, 1980). However, although the sediment organic carbon data showed some evidence of a nearfield enrichment (Figure 3-16), the multiple regression analyses (Section 3.3.4) incorporating measures of the sedimentary, physical, and chemical environment and of organic enrichment, provided little insight into the changes in the benthic biota. This result was surprising because at 18 m there was a pronounced shift of the sediments toward silt and clay size particles, especially within about 2 km from SONGS, that broadly coincided with the changes (toward increased dominance by subsurface deposit-feeders) in the soft bottom benthos at near SONGS while declining in abundance at the downcoast stations. This pattern is in general agreement with the results of the trophic structure analysis of the TM group as a whole (Section 3.3.3), which showed that abundance remained constant between periods near SONGS but decreased markedly at the downcoast stations in the After period. A third subset, the paraonid polychaetes of the motile subsurface deposit-feeding TM group, did not actually have a significant primary BACI test result (Table 3-26), but the ancillary tests (Figure D-389) did indicate a change between periods and the longshore pattern analysis (Figure D-392) clearly showed that this was a relative increase largely attributable to the nearfield. Furthermore, the analyses of community pattern and structure (Sections 3.3.2 and 3.3.3) showed that these changes in the abundance of paraonid polychaetes were influential in altering the composition of the benthic community near SONGS in the After period.

Of the 20 taxa tested individually, 15 had power greater than 50%, or had to be tested by the binomial test (Table 3-28). Nine of those 15 yielded significant BACI results, three of which (unidentified nematodes and the polychaetes Tauberia gracilis and Mediomastus californiensis/ambiseta) were clearly associated with the SONGS area (Table 3-29). A third polychaete, Acesta catherinae, yielded non-significant BACI results, but was considered to show a clear SONGS effect because its abundance increased greatly near SONGS in the After period, the binomial and regression were significant, and the ANOVA identified the 700 m station as different from the others (Figures D-533 through D-536). These polychaetes are members of the two polychaete subsets of the motile subsurface deposit-feeding TM group, which as noted above also showed a significant BACI effect. The analyses of effects. In those cases, the "possible effects" originated as regional increases in abundance beginning in the winter of 1979-1980, when a major shift in the nature of the sediment toward a higher proportion of silt and clay occurred (all of these are marked in the "Possible Storm/Construction Effect" column of Tables 3-27 and 3-29). An additional 21 groups and taxa that did not yield significant BACI test results were assigned to the storm/construction effects category on the basis of their temporal patterns of abundance. For these 39 groups and taxa, the effects may have been direct or indirect responses to the sediments becoming finer. Despite the considerable number of results that fell into the storm/construction category, the multiple regressions of P/C variables with the abundances of species and TM groups revealed no clear relationships. However, the analyses of community structure and pattern did identify the difference between the preoperational and operational periods, which involved many taxa and which took place across the entire study area over long periods of time, as being the major change in the biota.

A small number of groups and taxa (10) at 18 m either had power less than 50% or yielded nonsignificant test results and displayed abundance patterns suggestive of neither SONGS nor storm/construction effects. These are listed in the "No Effect" column of Tables 3-27 and 3-29 and their test results are given on the summary tables (Tables 3-26, 3-28, 3-30, 3-31) and in Appendix D, but they are not discussed.

The following subsections present discussions of statistically significant results at 18 m. For the convenience of the reader these are organized into results that clearly display an effect localized in the SONGS area (Section 3.3.5.2.2) and those that show possible effects (Section 3.3.5.2.3).

The motile subsurface deposit-feeding group as a whole displayed a significant relative increase (Table 3-32) which began as a regional abundance increase in late 1979 (Figure D-383). Following this initial increase, abundance was much more variable than it had been earlier. Beginning in late 1980 SONGS abundance became higher than Control abundance, although the SONGS and Control abundance trends remained roughly parallel with little net change until 1986 when a further large increase in the nearfield was not matched by an increase at the Control stations (Figure D-383). The patterns of abundance downcoast (from the 1900 m intermediate station to the 9400 m Control station) were more or less parallel in the Before and After periods. Nearer SONGS, however, the patterns diverged, particularly at the 700 m Impact station (Figure D-384), yielding the significant BACI and ANOVA results.

The motile subsurface deposit-feeder TM group comprises a wide variety of polychaete families and holothurian echinoderms (Table 2-2). In the San Onofre region it is dominated by capitellid and paraonid polychaetes, whose abundance patterns resembled those of the group as a whole. However, as a result of their higher variability in the After period the principal BACI test results were nonsignificant for both subsets (but all secondary test results were significant: Figures D-385, D-389). The temporal patterns of abundance for these taxonomic subsets differed somewhat from one another, but the combination of the two patterns closely matched the temporal pattern of the TM group as a whole. Thus, these subsets in combination appear to have driven the result for the whole group. Inspection of the abundance plots for these taxonomic subsets (Figures D-387 and D-391) suggested that the early regional abundance increase noted above for the TM group was largely attributable to the marked increase, beginning in winter 1979, of the

D-543). Capitellid abundance remained roughly level at both sites until late 1986 when dramatic increases (largely *M. californiensis/ambiseta*) occurred at both sites. The After period temporal patterns for these paraonid and capitellid species, particularly the very abundant *T. gracilis* and *M. californiensis/ambiseta*, both with significant relative increases, produced the divergence in SONGS-Control abundance trends that led to the significant relative increase for the TM group as a whole.

Plots of longshore abundance patterns indicated that the longshore pattern for the motile subsurface deposit-feeder group resembled the pattern of the paraonid polychaetes, but also included features of the capitellid pattern (c.f. Figures D-384, D-388, D-392). The nearfield abundance increase noted for the TM group largely reflected higher nearfield paraonid abundance (Figure D-392A), while the lower After abundance at intermediate stations reflected the capitellid pattern (Figure D-388A). The capitellid pattern was nearly identical with that of *Mediomastus californiensis/ambiseta* (c.f. Figures D-388A and D-564A), and the paraonid pattern was mainly that of *Tauberia gracilis*, with a smaller contribution from *Acesta catherinae* (c.f. Figures D-392A, D-604A, D-539A). Thus the longshore pattern for the TM group appears to have been produced principally by these three taxa.

The mechanism(s) underlying the changes in temporal and spatial abundance patterns described above are unclear, largely because the biology of the taxa and groups involved are not sufficiently well known. Clearly, the different patterns shown by the capitellid and paraonid polychaetes suggest different responses or different levels of response to environmental variation. Within the paraonid taxonomic subset, the different patterns shown for the three most abundant species (*Tauberia* wastewater input was predicted for an area within about 1 km of the diffusers (MRC, 1980). However, the sediment organic carbon data (Section 3.1 and Figure 3-16) show little evidence for an increase in the nearfield. The multiple regression analysis did indicate that among the physical/chemical parameters measured, various measures of food availability--especially sediment organic carbon--were best correlated with the abundance of M. californiensis/ambiseta (Table 3-16), but the overall correlation was very small (r^2=0.08). Thus, nearfield enrichment apparently cannot account for the observed temporal pattern of M. californiensis/ambiseta in the After period.

The results for the motile subsurface deposit-feeder TM group, therefore, are significant relative increases near SONGS for the group, and for two of the numerically dominant taxa--Tauberia gracilis and Mediomastus californiensis/ambiseta-- in that group. Abundance changes for the dominant taxonomic subsets that those two taxa belong to were similar as well, although owing to high variability in the After period the principal BACI test failed to recognize their relative increases as significant. We cannot account for the mechanism(s) responsible for the significant BACI results and the longshore and temporal abundance patterns, but the longshore pattern analyses clearly identified both the TM group result and the T. gracilis result with the near Impact (700 m) site. The longshore analysis result for M. californiensis/ambiseta, although less clear, also suggested that the BACI result was localized in the very nearfield. The motile subsurface deposit-feeders were the dominant TM group at most longshore study sites in both the Before and After periods, and the dominant taxa, T. gracilis and M. californiensis/ambiseta were numerically important taxa at the 18 m depth in the San Onofre region. Thus, these are important, even though unexplainable, results.

nearfield (Figure D-568). This suggests that the nearfield remained relatively more hospitable to nematodes in the After period; however, because the nematode category contains a number of species whose natural histories are poorly known, there is no basis for postulating the mechanism(s) that might have maintained this condition. Studies in other areas have indicated that the free-living marine nematodes have widely varied and complex life cycles and microhabitat requirements (e.g., Alongi and Tietjen, 1980), and this is undoubtedly true in the San Onofre region as well. Thus, even though the mechanism(s) responsible for the apparent effect cannot be postulated, the results do clearly suggest that the nearfield has remained relatively favorable for nematodes.

3.3.5.2.3 Possible Effects at 18 m

In addition to the eight categories discussed above, significant BACI and/or ANOVA results were obtained for 23 of the 61 tested categories at 18 m, but for these the principal BACI test result was not supported by secondary test results (Tables 3-26, 3-28; Appendix D) and/or the longshore pattern analysis indicated that the nearfield was not unique (Tables 3-30, 3-31). In either case, the test results were rarely considered to be strongly suggestive of a SONGS effect. Only results for four of the categories were considered to be reasonably likely indicators of effects. These categories were: the discretely motile subsurface deposit-feeders and one component of that TM group--unidentified hemichordates--both with relative decreases; the capitellid polychaetes of the motile subsurface deposit-feeder TM group, and the polychaetes of the discretely motile surface carnivore/omnivore TM group, both with relative increases. In all four more or less constant during the After period (e.g., the discretely motile surface deposit/detrital-feeding polychaetes: Figure D-427). Evidence of a relaxation from the storm/construction period changes in abundance was largely limited to the groups and taxa interpreted as showing strictly storm/construction effects (e.g., the discretely motile surface suspension/deposit-feeding molluscs: Figure D-455), although a few of the groups and taxa having significant relative changes in addition to the storm/construction effects may also have begun to show a similar relaxation in the late operational monitoring period (e.g., the motile surface omnivore/deposit-feeding TM group: Figure D-435). In general, for the class of results indicating both BACI and storm/construction types of effects, the longshore pattern analyses showed that changes in abundance in the nearfield were not much different from changes at most or all other longshore study sites (e.g., Tables 3-30, 3-31); these temporal patterns of abundance could thus be interpreted as being more-or-less regional in nature (e.g., Figures D-428A and D-436A for the discretely motile surface deposit/detrital-feeding polychaetes and the motile surface omnivore/deposit-feeders, respectively). On the other hand, many of these groups and taxa did increase in abundance at the 700 m near Impact site relative to the far Impact and/or near intermediate sites 1100 m and 1900 m downcoast, respectively, in both the Before and After periods. If these localized increases in the Before period actually did represent responses to storm/construction activities in the Before period, then the maintenance of such nearfield increases in the After period might have represented continued, but very localized, disturbance or mild enrichment. However, there is little evidence of this in the physical/chemical data.

The polychaete subset of the discretely motile surface carnivore/omnivore TM group is dominated by goniadids and nereids. One species belonging to this group--*Goniada maculata* (not a dominant)--was tested individually. *G. maculata* showed no evidence of an effect. Goniadids are thought to be carnivores (Fauchald and Jumars, 1979) that prefer fine sediments (Hartman, 1969), whereas nereids are largely omnivores and occur in a variety of habitats (Taylor, 1984). The abundance patterns of these polychaetes can be thought to reflect their food resources; however, their diets are not sufficiently well known to allow useful discussion. Furthermore, there is no pattern of change in the physical/chemical data set that can account for the failure of the nearfield abundance of these polychaetes to decrease in the After period as it did elsewhere, given the attributes described above. Nevertheless, the very nearfield does appear to have been somewhat unique in the After period for the subset as a whole, and may suggest the existence of an effect.

The discretely motile subsurface deposit-feeder TM group and its dominant taxon, unidentified hemichordates, were both rarer in the After period than they had been in the Before period, and both declined significantly in relative abundance (Tables 3-26, 3-28, 3-32, 3-33) because the Before and After longshore abundance patterns diverged in the nearfield but converged at the 9400 m Control site (Tables 3-30, 3-31; Figures D-396, D-556). Both the longshore and temporal patterns of abundance were nearly identical for the TM group and the taxon (c.f. Figures D-395, D-555 for temporal patterns, Figures D-396, D-556 for longshore patterns), indicating that the results for the group were driven by its dominant taxon. The natural histories of the hemichordates in the region are not sufficiently well known to allow the

Table 3-1. Pearson correlation coefficients (r) of physical and chemical variables measured near the mysid SONGS location sampling area. Values of p are given below the correlation coefficients; $p < 0.05$ indicates a significant correlation.

	CHLORO	MACROD	ORGCRB	WATCHLOR	TMYSID	SECCHI	GSMEAN	GSDISP	PUMPVOL
MACROD	0.26416 0.0761								
ORGCRB	0.09623 0.5247	-0.30896 0.0367							
WATCHLOR	0.29161 0.0493	0.18040 0.2302	0.05145 0.7342						
TMYSID	-0.12138 0.4216	0.27089 0.0686	-0.24461 0.1013	-0.19211 0.2009					
SECCHI	-0.26300 0.0774	-0.27311 0.0663	0.26935 0.0703	-0.10726 0.4780	-0.01888 0.9009				
GSMEAN	-0.335932 0.0142	-0.29015 0.0505	0.21943 0.1429	-0.07001 0.6438	-0.16594 0.2704	0.35302 0.0161			
GSDISP	-0.14090 0.3503	-0.03108 0.8375	-0.00551 0.9710	0.06334 0.6758	-0.09916 0.5121	0.08941 0.5546	0.66804 0.0001		
PUMPVOL	-0.03638 0.8103	0.45855 0.0014	-0.31457 0.0332	0.09042 0.5501	0.33813 0.0215	-0.17551 0.2433	0.37864 0.0095	0.42877 0.0029	
LFISH	0.41042 0.0046	0.02653 0.8610	0.21439 0.1525	0.22598 0.1310	0.00186 0.9902	0.04310 0.7761	-0.05842 0.6998	0.00425 0.9776	-0.04646 0.7592

CHLORO - chlorophyll in the sediment
MACROD - macrodetritus in core samples
ORGCRB - total organic carbon in core samples
WATCHLOR - chlorophyll in the water column
TMYSID - water temperature near the bottom
SECCHI - secchi depth
GSMEAN - mean grain size (phi)
GSDISP - dispersion of grain size (phi)
PUMPVOL - cooling water flow of SONGS Units 2 and 3
LFISH - log of abundance of demersal fish

Table 3-3. Summary of results of BACI and pattern analyses on mysids. BACI analyses were run on abundances of mysids, pattern analyses were run on ranks of areas within the cross-shelf by taxa (All) and by developmental stages within each taxon (Adult, Immature, and Juvenile). NS = test result not significant; SIG = test result significant; X = not tested. Lower case letters (ns and sig) indicate results in which we had less confidence, most often due to lack of confirmation by secondary test results. The Power is the power to detect a 50% change in relative abundance. Values of p are given for all BACI test results and for significant or borderline pattern results.

TAXON	DEVELOPMENTAL STAGE	FORM OF TEST	TRANSFORMATION	α	POWER	BACI TEST RESULT (p)	PATTERN RESULTS
Inshore Mysid Group	All	t-test	None	.10	61.8	NS (0.87)	NS
	Adult	Autoregressive Errors t-test	log(x)	.10	77.8	NS (0.70)	NS
	Immature	Autoregressive Errors t-test	log(x)	.05	82.3	NS (0.87)	NS
	Juvenile	t-test	None	.10	39.6	NS (0.80)	NS
<u>Acanthomysis</u> <u>davisii</u>	All	Autoregressive Errors t-test	None	.10	81.8	sig (0.02)	SIG (0.01)
	Adult	t-test	None	.10	62.9	NS (0.26)	SIG (0.006)
	Immature	t-test	None	.10	70.4	NS (0.36)	NS (0.104)
	Juvenile	Autoregressive Errors t-test	None	.10	46.6	NS (0.14)	SIG (0.03)
<u>Neomysis</u> <u>rayii</u>	All	t-test	None	.10	43.3	NS (0.28)	NS
	Adult	t-test	None	.10	28.9	NS (0.85)	NS
	Immature	t-test	None	.10	26.8	NS (0.44)	NS
	Juvenile	t-test	None	.10	28.4	NS (0.20)	NS
<u>Holmesimysis</u> <u>costata</u>	All	Autoregressive Errors t-test	log(x)	.10	45.5	NS (0.74)	NS
	Adult	Binomial	None	.05		NS (0.96)	SIG (0.03)
	Immature	Binomial	None	.05		NS (0.95)	NS
	Juvenile	Binomial	None	.05		NS (0.76)	NS
<u>Mysidopsis</u> <u>cathengelae</u>	All	t-test	log(x)	.10	72.6	NS (0.86)	NS
	Adult	t-test	None	.10	18.9	sig (0.04)	SIG (0.014)
	Immature	t-test	log(x+.1)	.10	51.0	NS (0.91)	SIG (0.02)
	Juvenile	Binomial	None	.05		NS (0.91)	SIG (0.049)
Cross-Shelf Mysid Group	All	t-test	None	.10	23.0	SIG (0.06)	NS
	Adult	t-test	None	.10	42.0	sig (0.06)	SIG (0.015)
	Immature	t-test	None	.10	33.2	SIG (0.030)	SIG (0.02)
	Juvenile	Binomial	None	.05	<10	sig (0.005)	NS
<u>Acanthomysis</u> <u>macropsis</u>	All	t-test	None	.10	13.1	NS (0.106)	NS
	Adult	t-test	log(x)	.10	84.7	NS (0.89)	NS
	Immature	Autoregressive Errors t-test	None	.10	20.0	NS (0.50)	NS
	Juvenile	t-test	None	.10	<10.0	NS (0.101)	NS
<u>Metamysidopsis</u> <u>elongata</u>	All	t-test	log(x)	.10	70.0	NS (0.37)	NS
	Adult	t-test	log(x)	.10	65.7	NS (0.31)	NS
	Immature	t-test	log(x)	.10	53.6	NS (0.21)	NS
	Juvenile	t-test	log(x+.1)	.10	20.7	NS (0.62)	NS

Table 3-4. Percent change in mean abundance at SONGS and at Control, and percent change in relative abundance (SONGS-Control), from the preoperational (Before) to the operational (After) period for mysid. Percent change is given for mysids by taxa (All) and by developmental stages within each taxon (Adult, Immature, and Juvenile). N = number of surveys in each period (which may vary as a result of deletions of zero abundance data points); relative abundance change marked with an asterisk (*) are statistically significant (see Table 3-3).

				PERCENT CHANGE			MEAN CONCENTRATION (#/m^3)			
TAXON	DEVELOPMENTAL STAGE	N		MEAN ABUNDANCE		RELATIVE ABUNDANCE	SONGS		CONTROL	
		BEFORE	AFTER	SONGS	CONTROL		BEFORE	AFTER	BEFORE	AFTER
Inshore Mysid Group	All	19	17	-32	-44	-4	7.87	5.37	4.86	2.70
	Adult	19	17	-11	-9	-7	0.99	0.87	0.45	0.41
	Immature	19	17	-38	-30	-24	2.64	1.63	1.21	0.84
	Juvenile	19	17	-32	-55	+9	4.24	2.86	3.21	1.45
<u>Acanthomysis davisii</u>	All	19	15	-96	-96	+5	2.61	0.09	2.74	0.10
	Adult	19	12	-94	-81	-24	0.29	0.02	0.25	0.05
	Immature	19	12	-95	-97	-17	1.01	0.05	0.81	0.02
	Juvenile	19	11	-96	-96	+28	1.31	0.05	1.68	0.07
<u>Neomysis rayii</u>	All	19	13	-92	-97	+31	0.71	0.06	0.91	0.03
	Adult	17	8	-46	-88	-8	0.05	0.02	0.02	0.00
	Immature	18	3	-69	-72	-47	0.05	0.02	0.02	0.00
	Juvenile	19	9	-91	-95	+43	0.63	0.06	0.88	0.04
<u>Holmesimysis costata</u>	All	19	16	-69	-70	+1	3.66	1.13	0.76	0.23
	Adult	19	17	-24	-10	-22	0.58	0.44	0.11	0.10
	Immature	19	16	-63	-61	-51	1.31	0.48	0.26	0.10
	Juvenile	19	15	-85	-90	-66	1.77	0.26	0.39	0.04
<u>Mysidopsis cathengelae</u>	All	16	17	+363	+420	-56.9	0.89	4.11	0.45	2.36
	Adult	17	17	+376	+249	+145	0.09	0.41	0.08	0.28
	Immature	17	17	+268	+450	-182	0.31	1.14	0.13	0.73
	Juvenile	19	17	+380	+412	+176	0.54	2.57	0.26	1.35
Cross-Shelf Mysid Group	All	19	17	+146	+20	+119*	20.65	50.71	27.33	32.91
	Adult	19	17	+67	+20	+38	7.71	12.87	10.98	13.20
	Immature	19	17	+82	-10	+96*	7.71	14.06	10.29	9.21
	Juvenile	19	17	+355	+73	+270*	5.22	23.78	6.06	10.50
<u>Acanthomysis macropsis</u>	All	19	17	+375	+188	+212	3.70	17.56	3.19	9.20
	Adult	19	17	+128	+163	-36	1.13	2.58	0.78	2.06
	Immature	19	17	+252	+177	+94	1.06	3.74	0.95	2.63
	Juvenile	19	17	+647	+209	+444	1.51	11.24	1.46	4.51
<u>Metamysidopsis elongata</u>	All	19	17	+159	+21	+127	11.51	29.89	17.87	21.65
	Adult	19	17	+82	+23	+44	5.14	9.35	8.50	10.46
	Immature	19	17	+105	-16	+129	4.41	9.04	6.93	5.85
	Juvenile	19	17	+488	+118	+369	1.96	11.51	2.44	5.34

Table 3-5. The reproductive index (number of females carrrying young/total number of females) of mysids at SONGS and Control during the preoperational (Before) and operational (After) monitoring periods. The reproductive index was calculated as the mean slope. The results cited under each taxon and the reproductive indices were based on ANCOVA analyses. * Indicates that an influence date (28 August 1984) was deleted from the data prior to testing.

	SONGS-Before	Control-Before	SONGS-After	Control-After
Inshore Summary Group No significant differences	.08	.16	.15	.14*
Acanthomysis davisii No significant differences	.09	.10	.04	.00
Neomysis rayii Control-Before different from all other cells, no other sig. differences	.01	.25	.00	.00
Holmesimysis costata No significant differences	.06	.09	.08	.16
Mysidopsis cathengelae No significant differences	.20	.28	.27	.18*
Cross-Shelf Summary Group No significant differences	.19	.12	.17	.15
Acanthomysis macropsis SONGS-After different from Control-After, no other significant differences	.25	.22	.29	.21
Metamysidopsis elongata No significant differences	.20	.13	.15	.15
Mysidopsis intii No significant differences	.09	.06	.05	.12
Offshore Summary Group SONGS-After different from all other cells, no other significant differences	.20	.18	.49	.29
Neomysis kadiakensis SONGS-After different from all other cells, no other significant differences	.23	.19	.44	.24
Acanthomysis nephrophthalma SONGS-After not different from Control-Before, all other comparisons significantly different	.07	.02	<.01	.20

Table 3-7. Results of multiple regressions of physical and chemical variables, cooling water flow, and fish abundance against the abundances of life stages of eight mysid species. Underlined variables in upper case letters were those that yielded the significant correlation with mysid abundance. Values of r-squared are given for significant correlation. (L) indicates that mysid data were log-transformed. See Table 3-1 for definitions of variables; TMEAN=mean water temperature at current meter station.

		r2	p	n											
Acanthomysis davisii	Adult	.75	<.0005	25	macrod	chloro	WATCHLOR	TMEAN	TMYSID	secchi	GSMEAN	GSDISP	ORGCRB		
	Immature	.52	<.001	26	MACROD	chloro	WATCHLOR	tmean	tmysid	secchi	gsmean	gsdisp	orgcrb		
	Juvenile	.55	<.001	30	MACROD	chloro	WATCHLOR	TMEAN	TMYSID	secchi	GSMEAN	gsdisp	orgcrb		
Holmesimysis costata	(L)Adult		NS	24	macrod	chloro	watchlor	tmean	tmysid	secchi	gsmean	gsdisp	orgcrb		
	(L)Immature		NS	24	macrod	chloro	watchlor	tmean	tmysid	secchi	gsmean	gsdisp	orgcrb		
	(L)Juvenile	.17	05	23	MACROD	chloro	watchlor	tmean	tmysid	secchi	gsmean	gsdisp	orgcrb		
Neomysis rayii	Adult		NS	16	macrod	chloro	watchlor	tmean	tmysid	secchi	gsmean	gsdisp	orgcrb		
	Immature		NS	15	macrod	chloro	watchlor	tmean	tmysid	secchi	gsmean	gsdisp	orgcrb		
	Juvenile	.68	<.0001	26	MACROD	chloro	watchlor	tmean	tmysid	SECCHI	GSMEAN	GSDISP	orgcrb		
Mysidopsis cathengelae	Adult	.23	<.05	30	macrod	chloro	watchlor	tmean	TMYSID	secchi	GSMEAN	gsdisp	orgcrb		
	(L)Immature		NS	24	macrod	chloro	watchlor	tmean	tmysid	secchi	gsmean	gsdisp	orgcrb		
	(L)Juvenile		NS	22	macrod	chloro	watchlor	tmean	tmysid	secchi	gsmean	gsdisp	orgcrb		
Acanthomysis macropsis	(L)Adult	.23	<.05	42	MACROD	chloro	watchlor	tmean	tmysid	SECCHI	gsmean	GSDISP	ORGCRB		
	Immature		NS	44	macrod	chloro	watchlor	tmean	tmysid	secchi	gsmean	gsdisp	orgcrb		
	Juvenile		NS	46	macrod	chloro	watchlor	tmean	tmysid	secchi	gsmean	gsdisp	orgcrb		
Acanthomysis macropsis	Immature		NS	44	macrod	chloro	watchlor	tmean	tmysid	secchi	gsmean	gsdisp	orgcrb	fish	
	Juvenile	.14	<.05	46	MACROD	chloro	watchlor	tmean	tmysid	secchi	gsmean	gsdisp	ORGCRB	fish	
Acanthomysis macropsis	Immature	.38	<.005	44	MACROD	chloro	watchlor	TMEAN	tmysid	SECCHI	GSMEAN	gsdisp	ORGCRB	fish	PUMPVOL
	Juvenile	.36	<.005	46	macrod	CHLORO	watchlor	tmean	TMYSID	secchi	GSMEAN	gsdisp	orgcrb	fish	PUMPVOL
Metamysidopsis elongata	(L)Adult	.09	<.05	46	macrod	chloro	watchlor	tmean	TMYSID	secchi	gsmean	gsdisp	orgcrb		
	(L)Immature	.27	<.05	44	macrod	chloro	watchlor	TMEAN	TMYSID	SECCHI	GSMEAN	gsdisp	orgcrb		
	(L)Juvenile	.65	<.0001	27	MACROD	chloro	watchlor	tmean	TMYSID	secchi	GSMEAN	gsdisp	ORGCRB		
Metamysidopsis elongata	(L)Adult	.20	<.05	46	macrod	CHLORO	watchlor	tmean	TMYSID	secchi	GSMEAN	gsdisp	orgcrb	FISH	
	(L)Immature	.24	<.05	44	macrod	chloro	watchlor	TMEAN	TMYSID	SECCHI	GSMEAN	gsdisp	orgcrb	FISH	
	(L)Juvenile	.65	<.0001	27	MACROD	chloro	watchlor	tmean	TMYSID	secchi	GSMEAN	gsdisp	ORGCRB	fish	
Metamysidopsis elongata	(L)Adult	.20	<.05	46	macrod	CHLORO	watchlor	tmean	TMYSID	secchi	GSMEAN	gsdisp	orgcrb	FISH	pumpvol
	(L)Immature	.28	<.01	44	macrod	chloro	watchlor	tmean	TMYSID	SECCHI	GSMEAN	gsdisp	orgcrb	FISH	pumpvol
	(L)Juvenile	.73	<.0001	27	macrod	chloro	watchlor	tmean	TMYSID	SECCHI	GSMEAN	gsdisp	orgcrb	fish	PUMPVOL

Table 3-8. Most important taxa in the 8 m station groups. Abundance for each taxon was standardized to its maximum abundance (see Section 2.4.8.2) and a maximum standardized abundance ≥ 0.25 was used as the cut-off level for considering a taxon important, except in the case of Groups 2 and 3, for which taxa are presented. Taxonomic affiliations are: C-crustacean, M=mollusc, O=other minor phylum (e.g., nemerteans, hemichordates), P=polychaete. Trophic-motility affiliations are indicated by letter codes; the letter(s) in the first position indicate feeding mode and the letter after the hyphen indicates motility type: in the first position D=deposit or detrital feeders, SUBD=subsurface deposit feeders, OD=omnivore-detrital feeders, SD=suspension-deposit feeders, S=suspension feeders, SUBCD=carnivore-subsurface deposit feeders, and CO=carnivore-omnivores; in the second position D=discretely motile, M=motile, and S=sessile. Taxa are classified as rapid (R), early (E), delayed (D), or late (L) colonizers or some combination of these categories based on whether they have been reported to recolonize a disturbed area within 10 days, 30 days, 30-90 days, or >90 days (usually a year or more), respectively. A "?" indicates some uncertainty regarding the designation. Literature sources that provided trophic-motility information can be found in Table 2-2. Literature sources that provided colonization information include: Buchanan et al., 1974; Dauer and Simon, 1976; McCall, 1977; Oliver and Slattery, 1973; Oliver et al., 1977; Pearson and Rosenberg, 1978; Rosenberg, 1976; Sanders et al., 1980; Stull et al., 1986; Van Blaricom, 1978, 1982.

TAXON	RELATIVE ABUNDANCE	TAXONOMIC AFFILIATION	TROPHIC/MOTILITY AFFILIATION	COLONIZATION
Group 1				
Tiron biocellata	0.37	C	D-M	
Photis californica	0.35	C	SD-M	
Group 2				
Thalenessa spinosa	0.29	P	CO-M	L
Rhepoxynius sp. A	0.27	C	OD-M	D/L
Leptocuma forsmani	0.27	C	D-M	
Scoloplos armiger	0.25	P	SUBD-M	E/D
Group 3				
Rhepoxynius sp. A	0.42	C	OD-M	?D/L
Leptocuma forsmani	0.39	C	D-M	
Paraonella platybranchiata	0.35	P	SUBD-M	
Rhepoxynius sp. juvenile	0.32	C	OD-M	?D/L
Spiophanes bombyx	0.30	P	SD-D	?D/L
Synchelidium shoemakeri	0.29	C	OD-M	R/E
Rhepoxynius abronius	0.27	C	OD-M	D/L
Diastylopsis tenuis	0.26	C	D-M	R
Magelona sacculata	0.25	P	D-M	R/E
Group 4				
Acesta catherinae	0.49	P	SUBD-M	
Rhepoxynius sp. A	0.38	C	OD-M	?D/L
Spiophanes bombyx	0.37	P	SD-D	?D/L
Rhepoxynius abronius	0.37	C	OD-M	D/L
Synchelidium shoemakeri	0.33	C	OD-M	R/E
Pectinaria californiensis	0.33	P	SUBD-M	?E
Rhepoxynius sp. juvenile	0.33	C	OD-M	?D/L
Scoloplos armiger	0.29	P	SUBD-M	E/D
Pista disjuncta	0.28	P	D-S	
Nephtys sp.	0.27	P	SUBCD-M	L

Table 3-9. Most important trophic-motility (TM) groups in the 8 m station groups. Abundance for each TM group was standardized to its maximum abundance (see Section 2.4.8.2) and a maximum abundance > 0.25 was used as the cut-off level for considering a TM group important. See Section 2.4.1 and Table 2-2 for descriptions of the TM groups. Taxonomic subsets of TM groups are indicated by a letter to the left of each TM group name: C=crustacean, M=mollusc, O=other minor phylum, P=polychaete, PCAP=capitellid polychaete, PPAR=paraonid polychaete.

Group 1

O-Surface carnivore-omnivore: Motile
C-Surface omnivore-deposit: Motile
P-Surface carnivore-omnivore: Discrete
P-Subsurface carnivore-deposit: Motile
M-Surface carnivore-omnivore: Motile
C-Surface deposit-detrital: Discrete
M-Surface suspension-deposit: Discrete
PPAP-Subsurface deposit feeder: Motile
C-Surface carnivore-omnivore: Discrete
P-Surface suspension-deposit: Discrete
P-Surface carnivore-omnivore: Motile

Group 2

C-Surface omnivore-deposit: Motile
O-Surface carnivore-omnivore: Motile
C-Surface deposit-detrital: Motile
P-Surface carnivore-omnivore: Discrete
P-Subsurface carnivore-deposit: Motile
M-Surface carnivore-omnivore: Motile
PPAR-Subsurface deposit feeder: Motile
C-Surface suspension-deposit: Discrete

Group 3

C-Surface omnivore-deposit: Motile
O-Surface carnivore-omnivore: Motile
P-Surface carnivore-omnivore: Discrete
P-Subsurface carnivore-deposit: Motile
M-Surface carnivore-omnivore: Motile
PPAR-Subsurface deposit feeder: Motile
C-Surface suspension-deposit: Discrete

Table 3-10. (Cont.)

TAXON	RELATIVE ABUNDANCE	TAXONOMIC AFFILIATION	TROPHIC/MOTILITY AFFILIATION	COLONIZATION
<u>Group 3</u>				
Tellina modesta	0.46	M	SD-D	D
Paraprionospio pinnata	0.42	P	SD-D	R
Synchelidium shoemakeri	0.40	C	OD-M	R/E
Oxyurostylis pacifica	0.35	C	D-M	
Acesta catherinae	0.35	P	SUBD-M	
Euphilomedes carcharodonta	0.35	C	OD-M	L
Rutiderma rostrata	0.34	C	OD-M	L
Sulcoretusa xystrum	0.32	M	CO-M	
Rhepoxyniuus menziese	0.31	C	OD-M	D/L
Mediomastus californiensis/ambiseta	0.29	P	SUBD-M	D/L
Tauberia gracilis	0.29	P	SUBD-M	R
Jassa falcata	0.29	C	OD-D	
Leitoscoloplos elongatus	0.26	P	SUBD-M	?E
Rhepoxynius stenodes	0.26	C	OD-M	D/L
Tharyx sp.	0.26	P	D-D	
<u>Group 4</u>				
Nephtys sp.	0.57	P	SUBCD-M	L
Ampelisca cristata	0.51	C	SD-S	?E/D
Mediomastus californiensis/ambiseta	0.51	P	SUBD-M	D/L
Acuminodeutopus heteruropus	0.47	C	SD-D	R
Aricidea wassi	0.46	P	SUBD-M	
Rutiderma rostrata	0.45	C	OD-M	L
Tharyx sp.	0.44	P	D-D	
Hemichordate unidentified	0.44	O	SUBD-D	?L
Tellina modesta	0.44	M	SD-D	D
Tubulanidae sp. B	0.40	O	CO-M	?L
Prionospio pygmaea	0.39	P	SD-D	R/E
Paraprionospio pinnata	0.39	P	SD-D	R
Rhepoxynius menziese	0.39	C	OD-M	D/L
Euphilomedes carcharodonta	0.39	C	OD-M	L
Tauberia gracilis	0.38	P	SUBD-M	R
Typosyllis hyalina	0.38	P	CO-M	
Synchelidium shoemakeri	0.37	C	OD-M	R/E
Anotomastus gordiodes	0.35	P	SUBD-M	
<u>Group 5</u>				
Hemichordate unidentified	0.46	O	SUBD-D	?L
Typosyllis hyalina	0.44	P	CO-M	
Prionospio pygmaea	0.43	P	SD-D	R/E
Nephtys sp.	0.42	P	SUBCD-M	L
Rutiderma rostrata	0.41	C	OD-M	L
Hemilamprops californica	0.41	C	D-M	
Rhepoxynius menziese	0.37	C	OD-M	?D/L
Aricidea wassi	0.35	P	SUBD-M	
Mediomastus californiensis/ambiseta	0.35	P	SUBD-M	D/L
Goniada littorea	0.34	P	CO-D	D/L
Tubulanus nothus (black)	0.32	O	CO-M	?L
Paraprionospio pinnata	0.32	P	SD-D	R
Lumbrineris sp.	0.31	P	SUBCD-M	L
Tauberia gracilis	0.31	P	SUBD-M	R
Edwardsia sp. A(orange w/white base)	0.30	O	CO-D	L

Table 3-11. (Cont.)

GROUP 3

C-Surface omnivore-deposit: Motile
PPAR-Subsurface deposit feeder: Motile
P-Surface carnivore-omnivore: Motile
P-Surface deposit-detrital: Discrete
P-Subsurface carnivore-deposit: Motile
O-Surface carnivore-omnivore: Motile
P-Surface, suspension-deposit: Discrete
PCAP-Subsurface deposit feeder: Motile
O-Surface carnivore-omnivore: Discrete
C-Surface deposit-detrital: Motile
P-Surface carnivore-omnivore: Discrete
M-Surface carnivore-omnivore: Motile
P-Subsurface deposit feeder: Sessile
C-Surface, suspension-deposit: Sessile
P-Suspension feeder: Motile
M-Surface, suspension-deposit: Discrete

GROUP 4

C-Surface omnivore-deposit: Motile
C-Surface deposit-detrital: Motile
M-Surface, suspension-deposit: Discrete
O-Surface carnivore-omnivore: Motile
M-Surface carnivore-omnivore: Motile
P-Surface carnivore-omnivore: Motile
O-Surface carnivore-omnivore: Discrete
PPAR-Subsurface deposit feeder: Motile

GROUP 5

C-Surface omnivore-deposit: Motile
P-Surface carnivore-omnivore: Motile
P-Subsurface carnivore-deposit: Motile
O-Subsurface deposit feeder: Discrete
O-Surface carnivore-omnivore: Discrete
PPAR-Subsurface deposit feeder: Motile
M-Surface, suspension-deposit: Discrete
PCAP-Subsurface deposit feeder: Motile

GROUP 6

C-Surface omnivore-deposit: Motile
C-Surface deposit-detrital: Motile
P-Surface deposit-detrital: Discrete

Table 3-13. 18 m station groups to which the samples from each survey were assigned. See Table 3-10 for dominant species in each group.

SURVEY	DATE	BENTHIC SAMPLING STATION 700	1100	1900	3200	6700	9400
15	13NOV79	4	5	4	4	4	4
16	04DEC79	4	5	4	4	4	4
17	27DEC79	4	4	4	4	4	4
18	04FEB80	5	4	5	5	5	5
19	20MAR80	5	5	5	5	5	5
20	07APR80	5	5	5	5	5	5
21	25APR80	5	5	5	5	5	5
22	20MAY80	5	5	5	5	5	5
23	09JUN80	5	5	4	5	5	5
24	30JUN80	5	5	5	5	5	5
25	16JUL80	5	5	5	5	5	5
26	04AUG80	5	5	5	5	5	5
27	26AUG80	5	5	5	5	5	5
28	15SEP80	5	5	5	5	5	5
29	17NOV80	5	5	5	5	5	5
30	26JUN81	5	5	5	5	5	5
31	15SEP81	4	4	4	4	4	4
32	01DEC81	4	4	4	4	4	4
33	02MAR82	4	4	4	4	4	4
34	01JUN82	4	4	4	4	4	4
35	22SEP82	4	4	4	4	4	4
36	14JAN83	4	4	4	4	4	4
37	11MAR83	3	4	3	3	3	3
38	23JUN83	3	3	3	3	3	3
39	29SEP83	3	3	4	3	3	3
40	22DEC83	3	3	4	3	3	3
41	09MAR84	3	3	3	3	3	3
42	20JUN84	3	3	3	3	3	3
43	19SEP84	3	3	3	3	3	3
44	04DEC84	1	3	1	3	1	3
45	24JAN85	3	1	1	1	1	1
46	25FEB85	1	1	1	1	1	1
47	21MAR85	1	1	1	1	1	1
48	19APR85	1	1	1	1	1	1
49	20MAY85	1	1	1	1	1	1
50	17JUN85	1	1	1	1	1	1
51	09JUL85	1	1	1	1	1	1
52	02AUG85	1	1	1	1	1	1
53	26AUG85	1	1	1	1	1	1
54	19SEP85	1	1	1	1	1	1
55	14OCT85	1	1	1	1	1	1
56	07NOV85	1	1	1	1	1	1
57	05DEC85	1	1	1	1	1	3
58	30DEC85	1	1	1	1	1	1
59	23JAN86	1	1	1	1	1	1
60	20FEB86	1	1	1	1	3	3
61	21MAR86	2	2	1	3	3	3
62	15APR86	2	2	1	1	1	2
63	08MAY86	1	1	1	1	2	2
64	02JUN86	2	2	1	2	2	2
65	30JUN86	2	2	2	2	2	2
66	22JUL86	2	2	2	2	2	2
67	14AUG86	2	2	2	2	2	2
68	08SEP86	2	2	2	2	2	2
69	03OCT86	2	2	2	2	2	2
70	05NOV86	2	2	2	2	2	2
71	25NOV86	2	2	2	2	2	2
72	17DEC86	2	2	2	2	2	2

Table 3-15. Mean abundance and percent composition of selected trophic-motility groups at 18 meters at the six sampling stations. Listings of all trophic-motility group abundance data are included as Appendix Tables C.2-12.

DEPTH=18 PERIOD=BEFORE

TMGROUP	PHYLUM	700		1100		1900		3200		6700		9400	
		%	mean	%	mean	%	mean	%	mean	%	mean	%	mean
Subsurface deposit feeder: Motile	All	30	68	37	78	34	87	29	60	23	55	21	47
	capitellid polychaetes	22	49	22	45	23	59	19	39	16	38	16	37
	paraonid polychaetes	8	18	15	31	10	26	10	21	6	15	4	9
Surface suspension-deposit: Discrete	All	19	42	16	34	14	36	17	35	23	54	22	49
	Crustaceans	7	16	5	11	6	15	7	15	11	27	10	23
	Molluscs	4	9	3	6	4	10	5	10	5	12	6	14
	Polychaetes	8	17	8	18	4	11	5	10	6	15	5	12
Surface carnivore-omnivore: Motile	All	7	15	7	14	7	18	7	15	7	17	7	17
	Crustaceans	1	2	1	2	1	2	0	1	1	2	1	1
	Molluscs	2	4	2	3	1	3	2	4	2	4	2	4
	Others	2	3	2	3	2	4	2	3	1	3	1	3
	Polychaetes	3	6	2	5	4	10	3	6	3	7	4	8
Surface omnivore-deposit: Motile	All	7	17	6	12	8	20	6	13	9	22	11	25
	Crustaceans	7	17	6	12	8	20	6	13	9	22	11	25
Surface omnivore-deposit: Discrete	All	4	10	3	7	3	9	6	12	8	18	9	20
	Crustaceans	4	10	3	7	3	9	6	12	8	18	9	20
Subsurface carnivore-deposit: Motile	All	10	22	8	17	8	22	9	19	7	18	7	15
	Polychaetes	10	22	8	17	8	22	9	19	7	18	7	15
Surface deposit feeder: Motile	All	4	8	3	7	4	9	4	8	4	8	5	11
	Crustaceans	3	6	2	5	2	6	3	5	2	6	3	7
	Molluscs	0	0	0	0	0	3	0	1	0	1	0	0
	Polychaetes	1	2	1	2	1	3	1	2	1	3	2	4
Surface carnivore-omnivore: Discrete	All	5	12	7	14	6	17	6	13	5	11	4	10
	Molluscs	1	1	1	1	1	1	0	1	0	1	0	1
	Others	3	6	3	6	2	5	2	5	2	4	2	4
	Polychaetes	2	5	3	6	4	10	4	7	2	6	2	4
Suspension feeder: Sessile	All	2	4	2	3	2	6	3	7	3	7	3	6
	Molluscs	1	2	1	1	1	3	2	4	2	4	1	3
	Others	0	0	0	1	0	1	0	1	0	1	0	1
	Polychaetes	1	1	1	1	1	3	1	3	1	2	1	3
Surface suspension-deposit: Sessile	All	3	7	3	5	2	5	3	6	3	6	3	7
	Crustaceans	3	6	2	5	2	5	3	5	2	6	3	6

Table 3-16. Results of multiple regressions of physical and chemical variables against the abundances of individual benthic taxa in the 8 m and 18 m samples. Underlined values are those that yielded the significant correlation. See Table 3-17 for definition of variable labels.

	r2	p	n	Variables									
8 m													
Total abundance	0.10	<0.0001	343	*siltclay*	gsmean	*gsdisp*	*gsskew*	*macrod*	orgcrb	chloro	*phaeop*	t7	*orbvels*
Acesta catherinae	0.02	n.s.	263	siltclay	gsmean	gsdisp	gsskew	*macrod*	orgcrb	chloro	phaeop	t7	*orbvels*
Amastigos acutus	0.14	<0.0001	269	siltclay	gsmean	gsdisp	gsskew	*macrod*	orgcrb	*chloro*	*phaeop*	*t7*	orbvels
Goniada littorea	0.14	<0.0001	198	siltclay	*gsmean*	gsdisp	*gsskew*	*macrod*	*orgcrb*	chloro	phaeop	*t7*	orbvels
Hemichordate unidentified	0.22	n.s.	25	siltclay	gsmean	gsdisp	gsskew	macrod	orgcrb	chloro	phaeop	t7	orbvels
Mediomastus californiensis/ambiseta	0.18	<0.0001	126	*siltclay*	gsmean	gsdisp	gsskew	*macrod*	orgcrb	*chloro*	phaeop	*t7*	orbvels
Nematodes unidentified	0.09	<0.0002	243	*siltclay*	gsmean	gsdisp	gsskew	*macrod*	orgcrb	*chloro*	phaeop	*t7*	orbvels
Rhepoxynius menziese	0.02	<0.05	236	siltclay	gsmean	gsdisp	gsskew	macrod	orgcrb	chloro	phaeop	t7	*orbvels*
Tellina modesta	0.12	<0.0001	231	siltclay	*gsmean*	gsdisp	gsskew	*macrod*	*orgcrb*	chloro	phaeop	t7	orbvels
Typosyllis hyalina	0.26	<0.0001	114	siltclay	gsmean	gsdisp	gsskew	macrod	*orgcrb*	chloro	phaeop	t7	orbvels
Rhepoxynius juvenile	0.05	<0.001	192	siltclay	gsmean	gsdisp	gsskew	macrod	orgcrb	chloro	phaeop	*t7*	orbvels
Zygeupolia sp.	0.15	<0.001	126	siltclay	*gsmean*	*gsdisp*	gsskew	*macrod*	orgcrb	chloro	phaeop	*t7*	orbvels
18 m													
Acesta catherinae	0.12	<0.0001	333	*siltclay*	coarse	gsdisp	*gsskew*	macrod	orgcrb	chloro	*phaeop*	t7	orbvels
Cossura cf. *candida*	0.09	<0.01	181	*siltclay*	*coarse*	*gsdisp*	*gsskew*	macrod	orgcrb	chloro	*phaeop*	t7	*orbvels*
Goniada littorea	0.08	<0.01	149	siltclay	coarse	gsdisp	gsskew	macrod	*orgcrb*	chloro	*phaeop*	t7	orbvels
Hemichordate unidentified	0.12	<0.0001	180	*siltclay*	*coarse*	gsdisp	gsskew	macrod	*orgcrb*	chloro	phaeop	t7	orbvels
Mediomastus californiensis/ambiseta	0.08	<0.0001	343	siltclay	coarse	gsdisp	gsskew	macrod	*orgcrb*	*chloro*	*phaeop*	t7	*orbvels*
Nematodes unidentified	0.09	<0.0001	319	siltclay	coarse	gsdisp	gsskew	*macrod*	*orgcrb*	*chloro*	phaeop	*t7*	orbvels
Rhepoxynius menziese	0.03	n.s.	263	siltclay	coarse	gsdisp	gsskew	macrod	orgcrb	chloro	phaeop	t7	orbvels
Tauberia gracilis	0.22	<0.0001	310	siltclay	coarse	gsdisp	gsskew	macrod	*orgcrb*	chloro	*phaeop*	t7	orbvels
Tellina modesta	0.10	<0.0001	342	*siltclay*	*coarse*	gsdisp	gsskew	macrod	*orgcrb*	chloro	*phaeop*	*t7*	orbvels
Typosyllis hyalina	0.14	<0.0001	347	*siltclay*	*coarse*	*gsdisp*	*gsskew*	*macrod*	*orgcrb*	chloro	phaeop	t7	orbvels
Acuminodeutopus heteruropus	0.05	<0.0001	292	siltclay	coarse	gsdisp	gsskew	macrod	orgcrb	chloro	phaeop	*t7*	orbvels
Rutiderma rostrata	0.10	<0.001	299	*siltclay*	*coarse*	gsdisp	*gsskew*	macrod	orgcrb	chloro	phaeop	*t7*	orbvels

Table 3-18. Summary of results of the BACI analyses on benthic trophic-motility groups and selected taxonomic subsets at the 8 m depth. The "Principal Test Result" column gives the probability of obtaining a test statistic as large, or larger, than the one obtained. In the same column, NS = test result not significant; SIG = test result significant. Lower case letters indicate statistical results in which we had less confidence, usually owing to lack of confirmation by secondary test results.

TROPHIC-MOTILITY GROUP	FORM OF TEST	TRANSFORMATION	α	POWER	PRINCIPAL TEST RESULT
Subsurface deposit feeder: Motile	t-test	log(x)	0.05	0.91	0.88 NS
Capitellid Polychaetes	t-test	log(x)	0.10	0.73	0.35 ns
Paraonid Polychaetes	Autoregressive Errors t-test	None	0.10	0.26	0.44 NS
Subsurface deposit feeder: Discrete	t-test	None	0.10	0.12	0.53 NS
Surface deposit-detrital feeder: Motile	Autoregressive Errors t-test	None	0.10	0.67	0.29 ns
Crustaceans	Autoregressive Errors t-test	None	0.10	0.69	0.26 ns
Polychaetes	t-test	log(x+0.1)	0.10	0.11	<0.01 SIG
Surface deposit-detrital feeder: Discrete	t-test	None	0.10	0.18	0.81 NS
Molluscs	t-test	None	0.10	0.22	0.12 ns
Polychaetes	t-test	None	0.10	0.12	0.02 sig
Surface deposit-detrital feeder: Sessile	Autoregressive Errors t-test	None	0.10	<0.10	0.75 ns
Surface omnivore-deposit: Motile	Autoregressive Errors t-test	log(x)	0.05	0.90	<0.01 SIG
Surface omnivore-deposit: Discrete	Wilcoxon Rank Sum Test	None	0.10	0.18	0.75 ns
Surface suspension-deposit: Motile	Wilcoxon Rank Sum Test	None	0.10	0.28	0.10+ ns
Surface suspension-deposit: Discrete	t-test	log(x)	0.05	0.99	0.01 sig
Crustaceans	Autoregressive Errors t-test	None	0.10	0.25	0.84 NS
Molluscs	Binomial	None	0.05		0.35 NS
Polychaetes	t-test	log(x)	0.05	0.91	0.08 ns
Surface suspension-deposit: Sessile	t-test	None	0.10	0.15	0.44 ns
Suspension feeder: Discrete	t-test	None	0.10	<0.10	0.07 sig
Suspension feeder: Sessile	t-test	None	0.10	0.18	0.65 NS
Molluscs	t-test	None	0.10	0.16	0.56 ns
Polychaetes	t-test	None	0.10	0.11	0.37 NS

Table 3-18. (Cont.)

TROPHIC-MOTILITY GROUP	FORM OF TEST	TRANSFORMATION	α	POWER	PRINCIPAL TEST RESULT
Surface carnivore-omnivore: Motile	t-test	None	0.10	0.69	0.38 NS
Crustaceans	t-test	None	0.10	<0.10	0.37 ns
Molluscs	t-test	None	0.10	0.69	0.04 sig
Others	t-test	None	0.10	0.68	0.01 sig
Polychaetes	t-test	None	0.10	0.79	0.21 NS
Surface carnivore-omnivore: Discrete	t-test	None	0.05	0.90	0.67 ns
Crustaceans	Wilcoxon Rank Sum Test	None	0.05	0.86	0.04 sig
Molluscs	t-test	None	0.10	0.14	0.84 NS
Others	Wilcoxon Rank Sum Test	None	0.10	0.23	0.35 NS
Polychaetes	t-test	None	0.10	0.73	0.65 NS
Subsurface carnivore-deposit: Motile	t-test	log(x+1)	0.10	0.81	0.71 NS
Multi-feeding strategy: Discrete	Binomial	None	0.05		0.51 ns

Table 3-19. (Cont.)

GROUP/TAXON	CLEAR EFFECT	POSSIBLE EFFECT	POSSIBLE STORM/ CONSTRUCTION EFFECTS	NO EFFECT
	INTERPRETATION OF FULL SUITE OF TEST RESULTS			
Suspension feeder: Sessile				X
Molluscs				X
Polychaetes				X
Surface carnivore-omnivore: Motile			X	
Crustaceans				X
Molluscs		X		
Others		X	X	
Polychaetes			X	
Surface carnivore-omnivore: Discrete			X	
Crustaceans		X	X	
Molluscs				X
Others				X
Polychaetes			X	
Subsurface carnivore-deposit: Motile			X	
Multifeeding strategy: Discrete				X

Table 3-22. Summary of results of the ANOVA on untransformed data for shifts in longshore patterns of benthic trophic-motility groups and selected taxonomic subsets from the preoperation (Before) to the operational (After) period along the 8 m isobath. Longshore locations (given as meters downcoast from SONGS) are ordered from highest After-Before difference in abundance to lowest difference; difference values are not significantly different between underlined locations ($p > 0.05$).

TROPHIC-MOTILITY GROUP	INTERACTION: MONITORING PERIOD X LONGSHORE LOCATION	LONGSHORE LOCATION ORDERED BY DIFFERENCE (AFTER-BEFORE) VALUE HIGHEST DIFFERENCE					LOWEST DIFFERENCE
Subsurface deposit feeder: Motile	0.27	1900	6700	9400	1100	3350	700
Capitellid Polychaetes	0.28	1900	6700	9400	1100	700	3350
Paraonid Polychaetes	0.05	3350	1900	9400	6700	700	1100
Subsurface deposit feeder: Discrete	0.72	1900	700	6700	1100	9400	3350
Surface deposit-detrital feeder: Motile	0.44	1900	3350	700	1100	6700	9400
Crustaceans	0.39	1900	3350	700	1100	6700	9400
Polychaetes	0.29	700	1900	3350	1100	6700	9400
Surface deposit-detrital feeder: Discrete	0.67	6700	700	9400	1100	1900	3350
Molluscs	<0.01	1900	700	1100	9400	6700	3350
Polychaetes	0.06	6700	9400	3350	700	1900	1100
Surface deposit-detrital feeder: Sessile	0.36	6700	9400	3350	1100	1900	700
Surface omnivore-deposit: Motile	0.04	3350	9400	1900	6700	700	1100
Surface omnivore-deposit: Discrete	0.61	3350	700	9400	6700	1100	1900
Surface suspension-deposit: Motile	<0.01	3350	1100	700	6700	1900	9400

Table 3-21. Interpretation of test results for individual benthic taxa at the 8 m depth. Possible storm/construction effects refer to abundance shifts during, or immediately following, the stormy winter of 1979-1980; since this stormy period approximately coincided with the completion of Units 2 and 3 offshore construction activity, construction effects cannot always be distinguished from storm effects. The schematic representations of abundance patterns through time are examples of patterns that would be interpreted as shown in the column headings; these diagrams are not an exhaustive catalogue of the patterns actually obtained. Note that the Before period for BACI purposes extended from 1976 through 1981 and is shown in the diagrams below; the Before period available for longshore pattern analysis extended from 1979 through 1981.

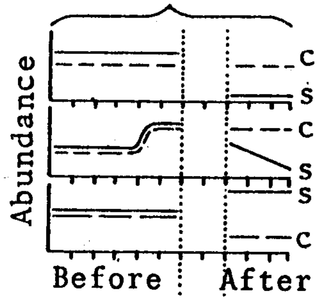
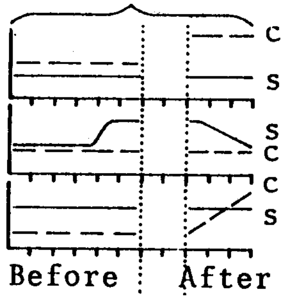
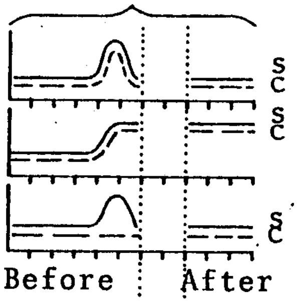
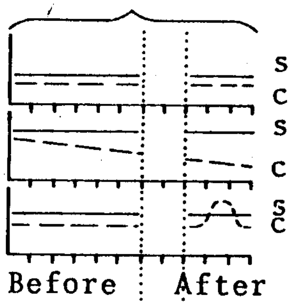
	INTERPRETATION OF FULL SUITE OF TEST RESULTS			
GROUP/TAXON	CLEAR EFFECT	POSSIBLE EFFECT	POSSIBLE STORM/ CONSTRUCTION EFFECTS	NO EFFECT
				
Acesta catherinae				X
Amastigos acutus			X	
Diastylopsis tenuis				X
Edotea sublittoralis			X	
Euphilomedes longiseta			X	
Goniada littorea				X
Nematodes, unidentified				X
Owenia collaris			X	
Prionospio pygmaea			X	
Rhepoxynius menziese		X		
Rhepoxynius spp. juveniles		X		
Synchelidium shoemakeri				X
Tellina modesta				X
Typosyllis hyalina	X		X	
Zygeupolia sp.			X	

Table 3-22. (Cont.)

TROPHIC-MOTILITY GROUP	INTERACTION: MONITORING PERIOD X LONGSHORE LOCATION	LONGSHORE LOCATION ORDERED BY DIFFERENCE (AFTER-BEFORE) VALUE HIGHEST DIFFERENCE					LOWEST DIFFERENCE
Surface carnivore-omnivore: Discrete	0.02	1900	6700	1100	3350	9400	700
Crustaceans	0.23	6700	1100	1900	3350	9400	700
Molluscs	0.27	9400	1900	3350	700	1100	6700
Others	0.70	700	1100	1900	6700	3350	9400
Polychaetes	<0.01	1900	6700	1100	3350	700	9400
Subsurface carnivore-deposit: Motile	0.35	700	6700	1100	3350	9400	1900
Multi-Feeding strategy: Discrete	0.56	1100	3350	1900	700	9400	6700

Table 3-24. Percent change in mean abundance at SONGS and at Control, and percent change in relative abundance (SONGS-Control), from the preoperational (Before) to the operational (After) period for benthic trophic-motility groups and selected taxonomic subsets at the 8 m depth. N = number of surveys in each period; relative abundance changes marked with an asterisk (*) are statistically significant (see Table 3-18).

TROPHIC-MOTILITY GROUP	N		PERCENT CHANGE		
			Mean Abundance		
	BEFORE	AFTER	SONGS	CONTROL	RELATIVE ABUNDANCE
Subsurface deposit feeder: Motile	23	32	-59	-51	-8
Capitellid Polychaetes	23	32	-85	-89	+4
Paraonid Polychaetes	23	32	+52	+94	-71
Subsurface deposit feeder: Discrete	5	11	+122	+20	+97
Surface deposit-detrital feeder: Motile	23	32	+6	-16	+21
Crustaceans	23	32	+4	-18	+21
Polychaetes	9	13	+234	-64	+297*
Surface deposit feeder: Discrete	23	32	+170	+173	-16
Molluscs	19	14	+54	-34	+95
Polychaetes	21	30	+142	+275	-277*
Surface deposit feeder: Sessile	12	22	+55	+4461	-2831
Surface omnivore-deposit: Motile	23	32	+5	+96	-92*
Surface omnivore-deposit: Discrete	16	30	+206	+310	-2
Surface suspension-deposit: Motile	23	31	+25	-43	+84*
Surface suspension-deposit: Discrete	23	32	-69	-54	-16*
Crustaceans	22	30	+87	+80	+5
Molluscs	23	30	-64	-69	-5
Polychaetes	23	32	-73	-59	-14
Surface suspension-deposit: Sessile	15	29	+136	+1511	+73
Suspension feeder: Discrete	19	30	+887	+724	-1972*
Suspension feeder: Sessile	23	32	+20	-11	+38
Molluscs	23	30	0	-31	+56
Polychaetes	23	32	-73	-59	-14
Surface suspension-deposit: Sessile	15	29	+136	+1511	+73
Suspension feeder: Discrete	19	30	+887	+724	-1972*
Suspension feeder: Sessile	23	32	+20	-11	+38
Molluscs	23	30	0	-31	+56
Polychaetes	9	11	+48	+103	-177

Table 3-25. Percent change in mean abundance at SONGS and at Control, and percent change in relative abundance (SONGS-Control), from the preoperational (Before) to the operational (After) period for benthic taxa at the 8 m depth. N = number of surveys in each period; relative abundance changes marked with an asterisk (*) are statistically significant (see Table 3-20).

TAXON	N		PERCENT CHANGE		
			Mean Abundance		
	BEFORE	AFTER	SONGS	CONTROL	RELATIVE ABUNDANCE
Acesta catherinae	23	31	-9	+88	-162
Amastigos acutus	17	28	-87	-86	-2
Diastylopsis tenuis	23	32	-20	-43	+21
Edotea sublittoralis	22	26	-76	-64	-25
Euphilomedes longiseta	21	30	-51	-58	-34
Goniada littorea	23	31	-79	-76	+64
Nematodes, unidentified	19	31	-84	-78	-6
Owenia collaris	19	16	-99	-99	-57
Prionospio pygmaea	23	32	-54	-6	-48
Rhepoxynius menziese	23	31	-25	+121	-146*
Rhepoxynius spp. juveniles	23	30	-44	+23	-59*
Synchelidium shoemakeri	23	30	-4	-20	+12
Tellina modesta	23	28	-69	-72	+38
Typosyllis hyalina	23	17	-94	-45	-57*
Zygeupolia sp.	21	15	-72	-88	+123*
Number of Species	18	32	+10	+13	-4
Total Abundance	23	32	-50	-32	-26*
Total Biomass	18	32	+52	+163	-112

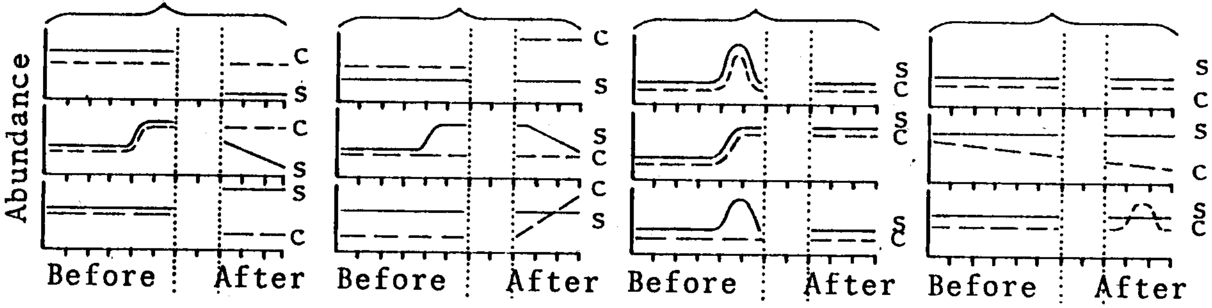
Table 3-26. (Cont.)

TROPHIC-MOTILITY GROUP	FORM OF TEST	TRANSFORMATION	α	POWER	PRINCIPAL TEST RESULT
Surface carnivore-omnivore: Motile	t-test	None	0.10	0.19	0.71 ns
Crustaceans	t-test	None	0.10	<0.10	0.41 ns
Molluscs	t-test	None	0.10	0.35	0.31 ns
Others	t-test	None	0.10	0.46	0.71 ns
Polychaetes	Autoregressive Errors t-test	None	0.10	0.82	0.12 ns
Surface carnivore-omnivore: discrete	Autoregressive Errors t-test	None	0.05	0.95	0.08 ns
Crustaceans	Wilcoxon Rank Sum Test	None	0.10	0.20	<0.01 SIG
Molluscs	Binomial	None	0.05		0.71 NS
Others	Autoregressive Errors t-test	None	0.10	0.74	0.83 NS
Polychaetes	t-test	None	0.10	0.84	<0.01 SIG
Surface carnivore-omnivore: Sessile	t-test	None	0.10	0.17	0.70 NS
Subsurface carnivore-deposit: Motile	t-test	None	0.05	0.93	0.07 ns
Multi-feeding strategy: Discrete	Binomial	None	0.05		<0.01 SIG

Table 3-27. (Cont.)

GROUP/TAXON	INTERPRETATION OF FULL SUITE OF TEST RESULTS CLEAR EFFECT	POSSIBLE EFFECT	POSSIBLE STORM/ CONSTRUCTION EFFECTS	NO/EFFECT
Surface suspension-deposit: Sessile		X	X	
Suspension feeder: Discrete			X	
Suspension feeder: Sessile		X		
Molluscs			X	
Polychaetes		X		
Surface carnivore-omnivore: Motile				X
Crustaceans			X	
Molluscs			X	
Others			X	
Polychaetes			X	
Surface carnivore-omnivore: Discrete			X	
Crustaceans	X			
Molluscs			X	
Others			X	
Polychaetes		X	X	
Surface carnivore-omnivore: Sessile				X
Subsurface carnivore-deposit: Motile		X	X	
Multifeeding strategy: Discrete		X	X	

Table 3-29. Interpretation of test results for individual benthic taxa at the 18 m depth. Possible storm/construction effects refer to abundance shifts during, or immediately following, the stormy winter of 1979-1980; since this stormy period approximately coincided with the completion of Units 2 and 3 offshore construction activity, construction effects cannot always be distinguished from storm effects. The schematic representations of abundance patterns through time are examples of patterns that would be interpreted as shown in the columnn headings; these diagrams are not an exhaustive catalogue of the patterns actually obtained. Note that the Before period for BACI purposes extended from 1976 through 1981 and is shown in the diagrams below; the Before period available for longshore pattern analysis extended from 1979 through 1981.



GROUP/TAXON	INTERPRETATION OF FULL SUITE OF TEST RESULTS CLEAR EFFECT	POSSIBLE EFFECT	POSSIBLE STORM/ CONSTRUCTION EFFECTS	NO EFFECT
Acesta catherinae	X			
Acuminodeutopus heteruropus		X	X	
Aricidea wassi				X
Euphilomedes carcharodonta				X
Goniada maculata				X
Hemichordates, unidentified		X		
Hemilamprops californica		X	X	
Mediomastus californiensis	X			
Nematodes, unidentified	X			
Paranemertes sp. A		X	X	
Paraprionospio pinnata			X	
Pinnixa hiatus			X	
Prionospio pygmaea			X	
Rhepoxynius menziese			X	
Rhepoxynius spp. juveniles			X	

Table 3-30. Summary of results of the ANOVA on untransformed data for shifts in longshore patterns of benthic trophic-motility groups and selected taxonomic subsets from the preoperational (Before) to the operational (After) period along the 18 m isobath. Longshore locations (given as meters downcoast from SONGS) are ordered from highest After-Before difference in abundance to lowest difference; difference values are not significantly different between underlined locations ($p > 0.05$).

TROPHIC-MOTILITY GROUP	INTERACTION: MONITORING PERIOD X LONGSHORE LOCATION	LONGSHORE LOCATION ORDERED BY DIFFERENCE (AFTER-BEFORE) VALUE HIGHEST DIFFERENCE					LOWEST DIFFERENCE
Subsurface deposit feeder: Motile	<0.01	700	1100	9400	3200	6700	1900
Capitellid Polychaetes	0.01	700	1100	9400	3200	6700	1900
Paraonid Polychaetes	<0.01	700	1100	9400	6700	1900	3200
Subsurface deposit feeder: Discrete	0.03	9400	3200	6700	1100	1900	700
Subsurface deposit feeder: Sessile	0.08	700	1900	1100	6700	9400	3200
Surface deposit-detrital feeder: Motile	0.59	700	1100	6700	1900	3200	9400
Crustaceans	0.91	700	6700	1900	3200	9400	1100
Polychaetes	<0.01	700	1100	1900	3200	6700	9400
Surface deposit-detrital feeder: Discrete	0.59	700	1100	3200	9400	6700	1900
Crustaceans	0.04	9400	1100	1900	3200	700	6700
Molluscs	0.11	700	1900	1100	3200	6700	9400
Polychaetes	<0.01	700	1100	3200	6700	9400	1900
Surface deposit-detrital feeder: Sessile	0.12	6700	1900	700	9400	1100	3200
Surface omnivore-deposit: Motile	0.05	3200	1100	1900	700	6700	9400
Surface omnivore-deposit: Discrete	0.31	9400	3200	1900	6700	700	1100

Table 3-30. (Cont.)

TROPHIC-MOTILITY GROUP	INTERACTION: MONITORING PERIOD X LONGSHORE LOCATION	LONGSHORE LOCATION ORDERED BY DIFFERENCE (AFTER-BEFORE) VALUE HIGHEST DIFFERENCE					LOWEST DIFFERENCE
Surface carnivore-omnivore: Discrete	<0.01	700	9400	1100	6700	3200	1900
Crustaceans	0.04	700	3200	1100	1900	6700	9400
Molluscs	0.38	700	1100	6700	9400	3200	1900
Others	0.82	6700	9400	700	3200	1900	1100
Polychaetes	<0.01	700	1100	9400	6700	3200	1900
Subsurface carnivore-deposit: Motile	0.04	1100	700	9400	6700	3200	1900
Multi-Feeding strategy: Discrete	0.07	700	1100	9400	3200	6700	1900

Table 3-31. (Cont.)

TAXON	INTERACTION: MONITORING PERIOD X LONGSHORE LOCATION	LONGSHORE LOCATION ORDERED BY DIFFERENCE (AFTER-BEFORE) VALUE					
		HIGHEST DIFFERENCE					LOWEST DIFFERENCE
Tauberia gracilis	<0.01	700	1100	9400	3200	6700	1900
Tellina modesta	0.03	1100	3200	6700	700	1900	9400
Typosyllis hyalina	0.04	1100	700	3200	9400	6700	1900
Number of Species	<0.01	700	1100	3200	9400	1900	6700
Total Abundance	0.16	700	3200	1100	9400	1900	6700
Total Biomass	0.24	1100	1900	6700	9400	3200	700

Table 3-32. (Cont.)

TROPHIC-MOTILITY GROUP	N		PERCENT CHANGE		
			Mean Abundance		
	BEFORE	AFTER	SONGS	CONTROL	RELATIVE ABUNDANCE
Surface carnivore-omnivore: Discrete	26	32	+16	-15	+28*
Crustaceans	17	11	+141	-69	+236*
Molluscs	23	31	+61	+45	+16
Others	26	32	-21	-13	-11
Polychaetes	26	32	+33	-32	+63*
Surface carnivore-omnivore: Sessile	6	3	-12	+50	-42
Subsurface carnivore-deposit: Motile	26	32	-22	-56	+26
Multi-feeding strategy: Discrete	23	29	-12	-76	+64*

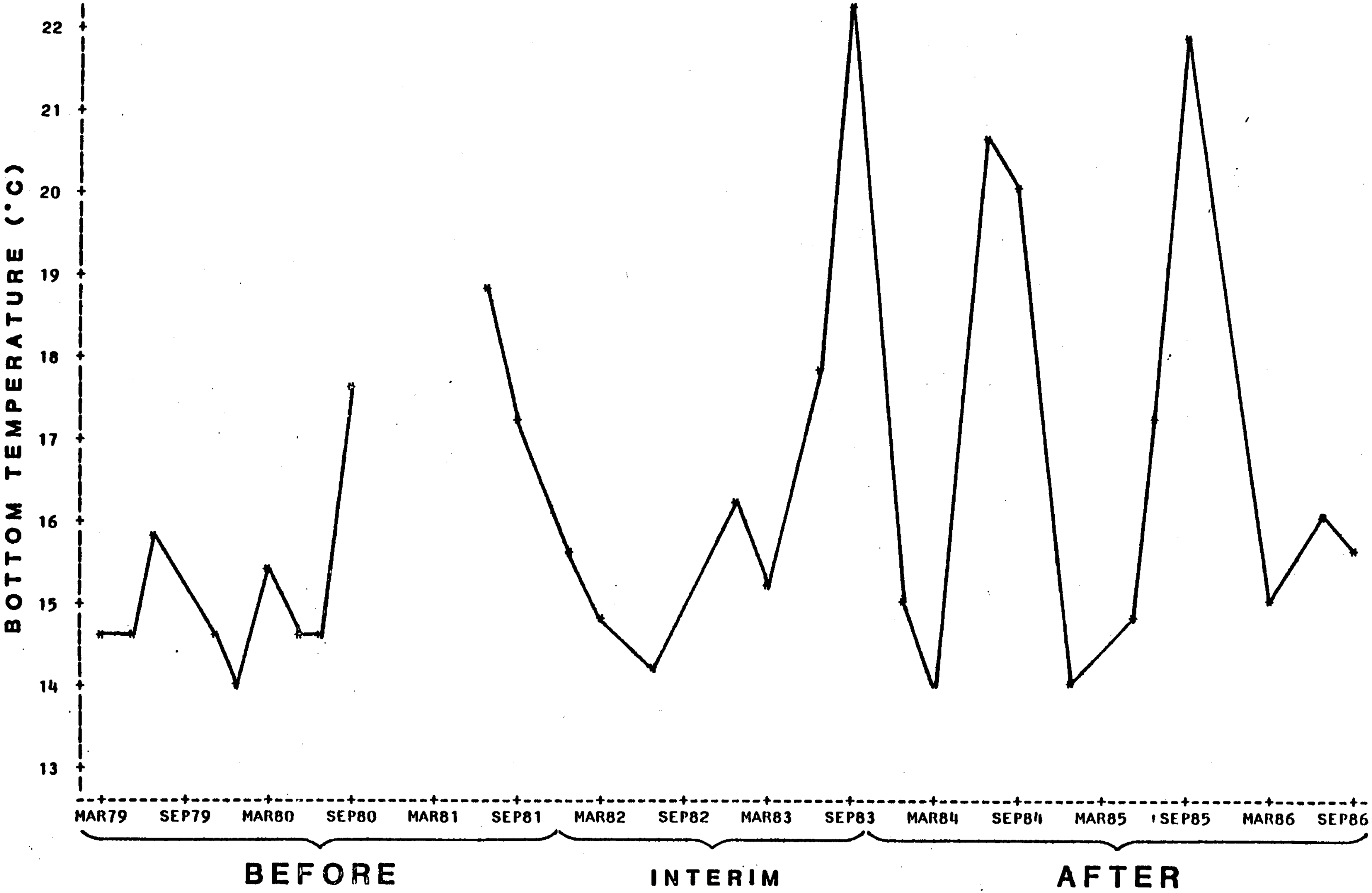


Figure 3-1. Water temperature at the bottom, measured between the 6 and 12 m isobaths near SONGS during the monitoring periods.

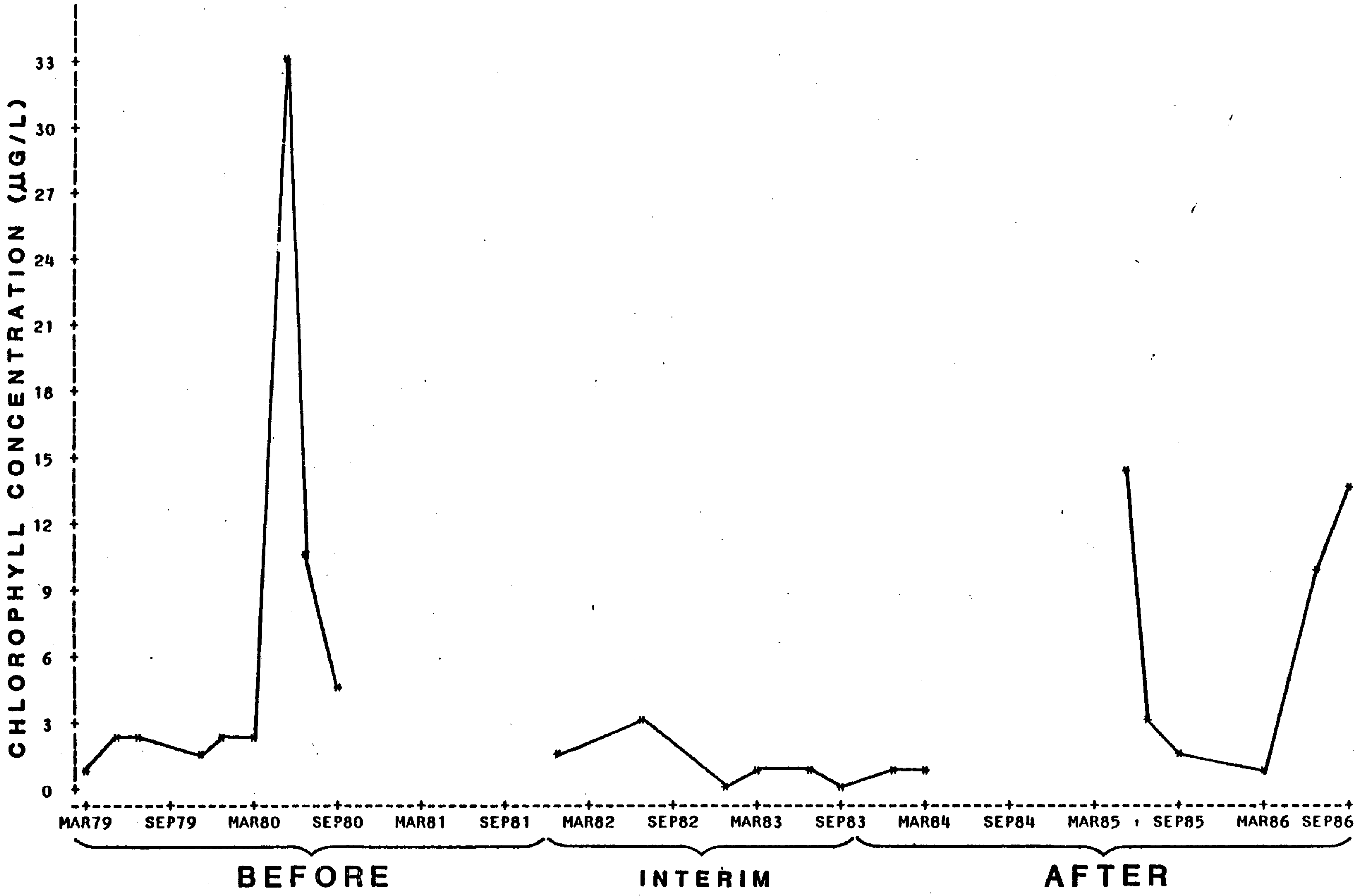


Figure 3-3. Water column chlorophyll concentrations at the 8 m isobath off SONGS during the monitoring periods.

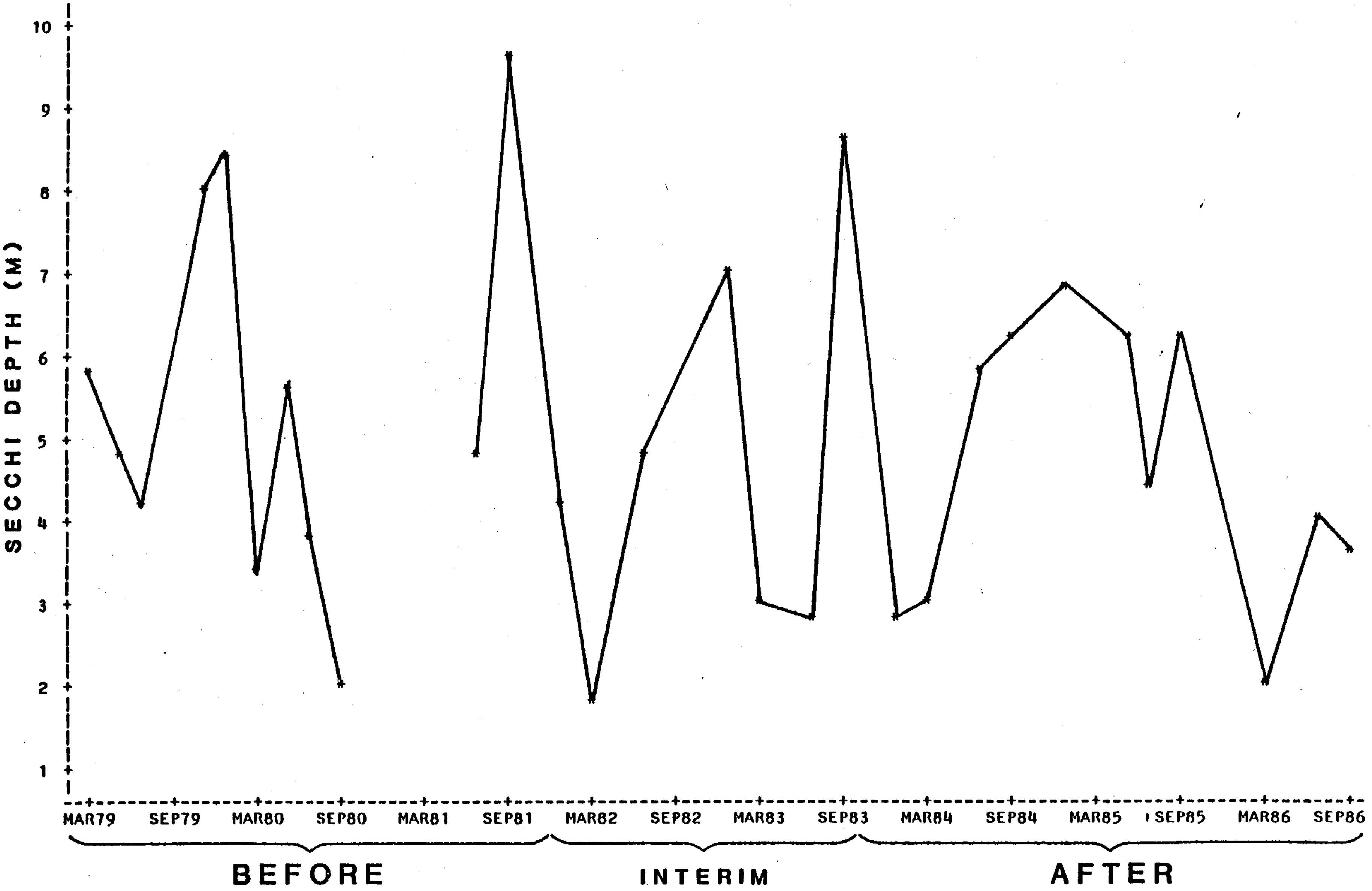


Figure 3-5. Secchi measurements made between the 6 and 12 m isobaths near SONGS during the mysid monitoring period.

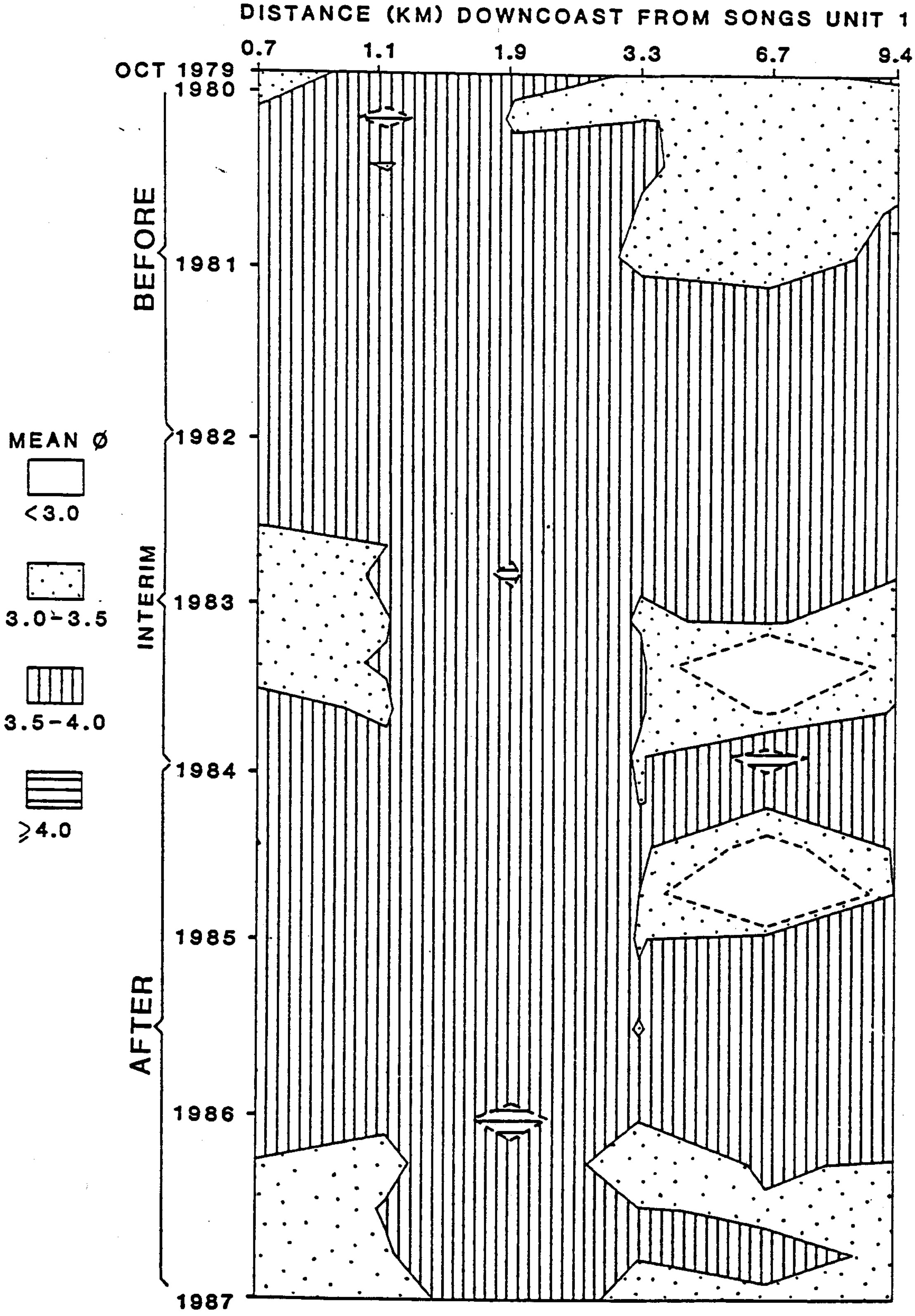


Figure 3-7. Mean grain size (ϕ) along the 8m isobath downcoast from SONGS Unit 1 during the monitoring periods. AFTER refers to benthos monitoring; the AFTER period for mysids commenced in October, 1983.

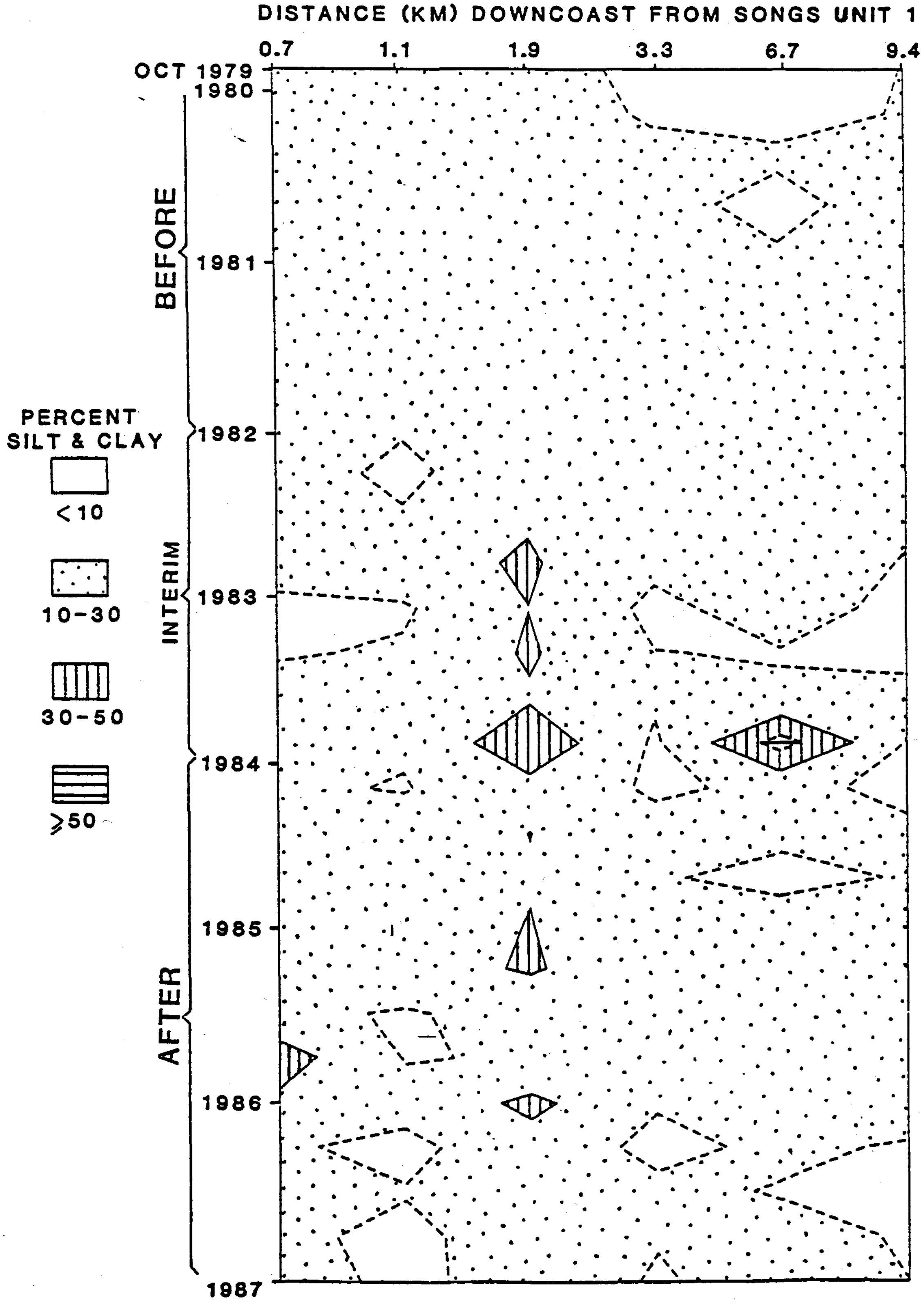


Figure 3-9. Percent silt and clay in the sediments along the 8m isobath downcoast from SONGS Unit 1 during the monitoring periods. AFTER refers to benthos monitoring; the AFTER period for mysids commenced in October, 1983.

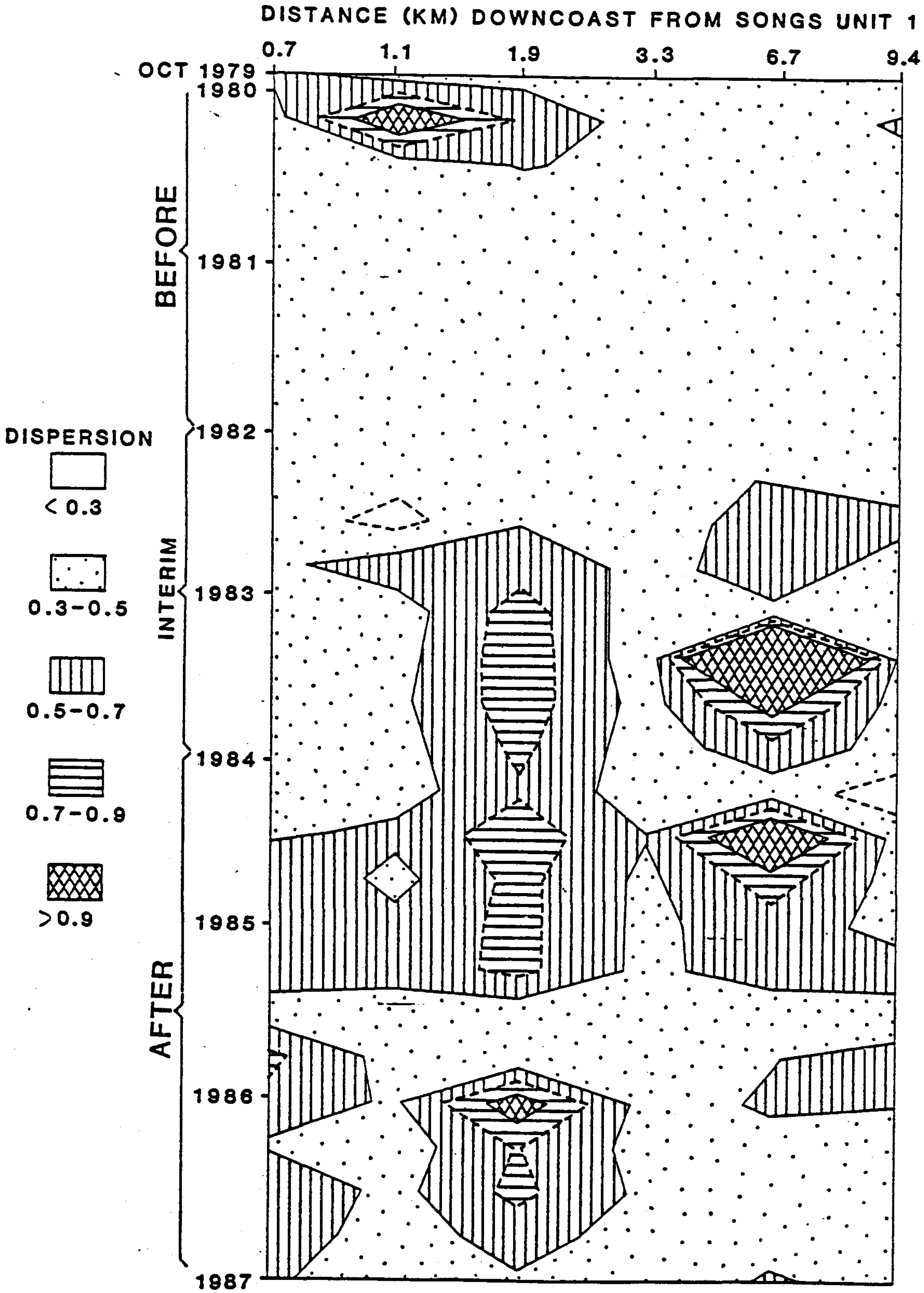


Figure 3-11. Grain size dispersion along the 8m isobath downcoast from SONGS Unit 1 during the monitoring periods. AFTER refers to benthos monitoring; the AFTER period for mysids commenced in October, 1983.

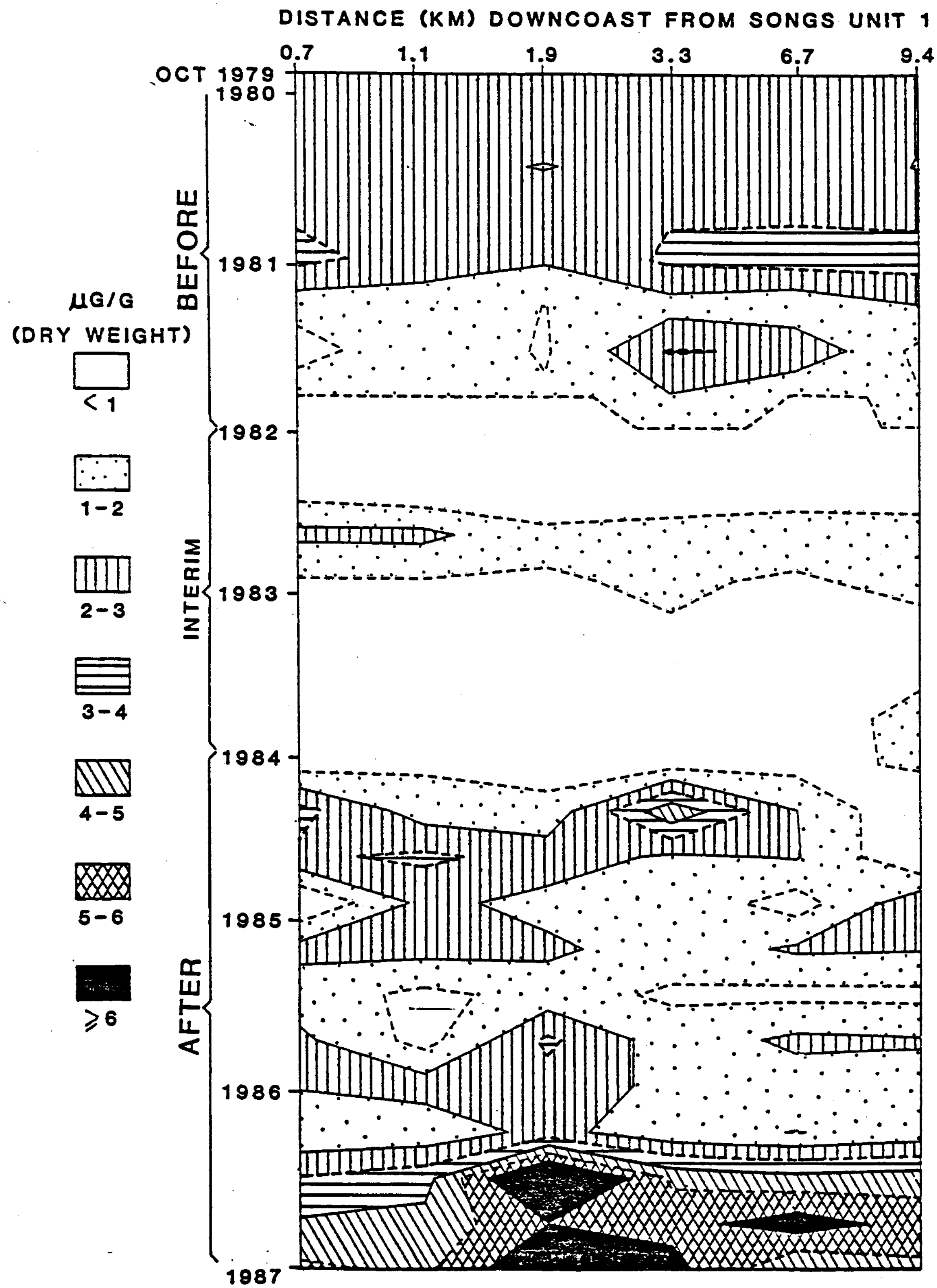


Figure 3-13. Sediment chlorophyll along the 8m isobath downcoast from SONGS Unit 1 during the monitoring periods. AFTER refers to benthos monitoring; the AFTER period for mysids commenced in October, 1983.

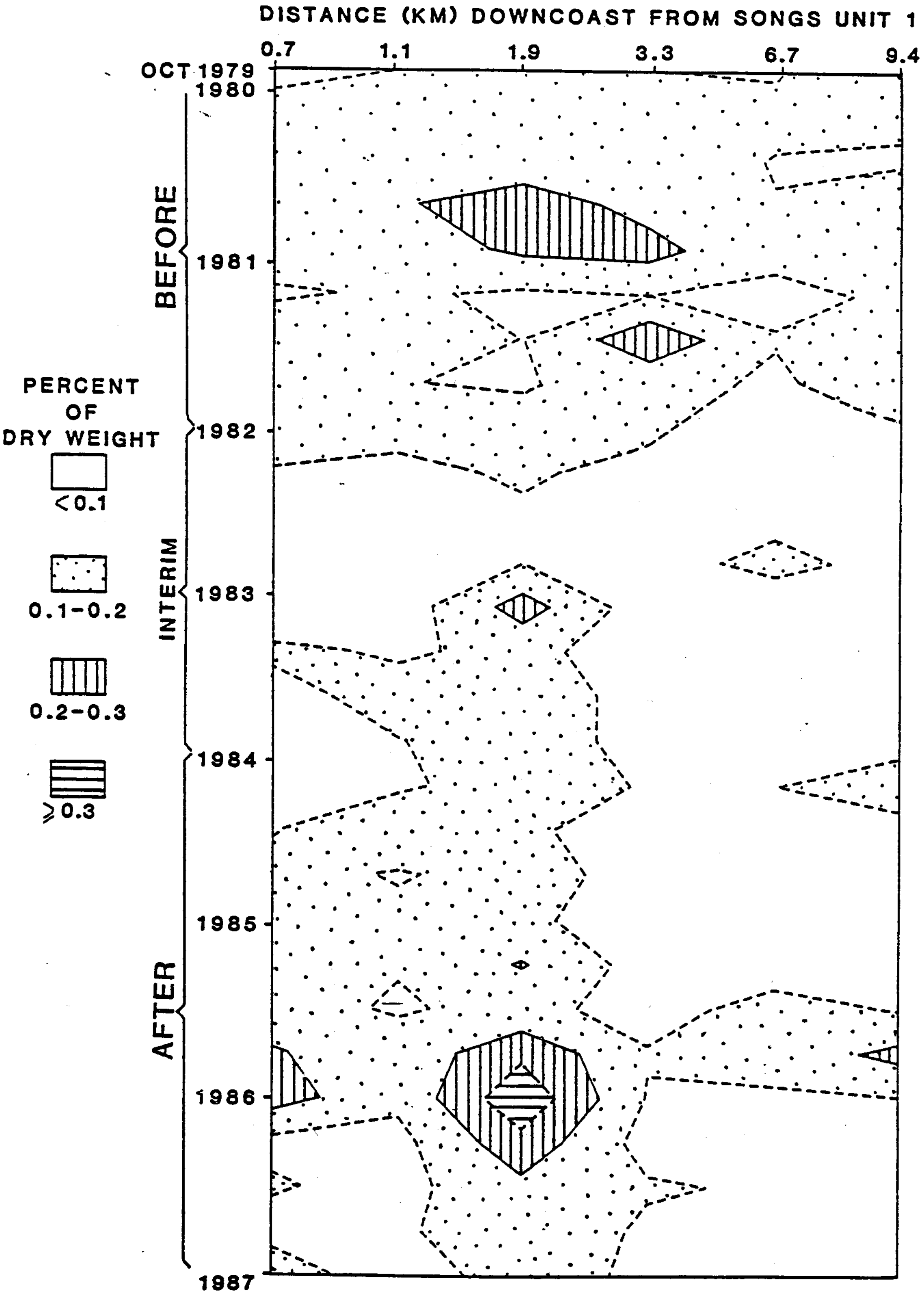


Figure 3-15. Total organic carbon in the sediments along the 8m isobath downcoast from SONGS Unit 1 during the monitoring periods. AFTER refers to benthos monitoring; the AFTER period for mysids commenced in October, 1983.

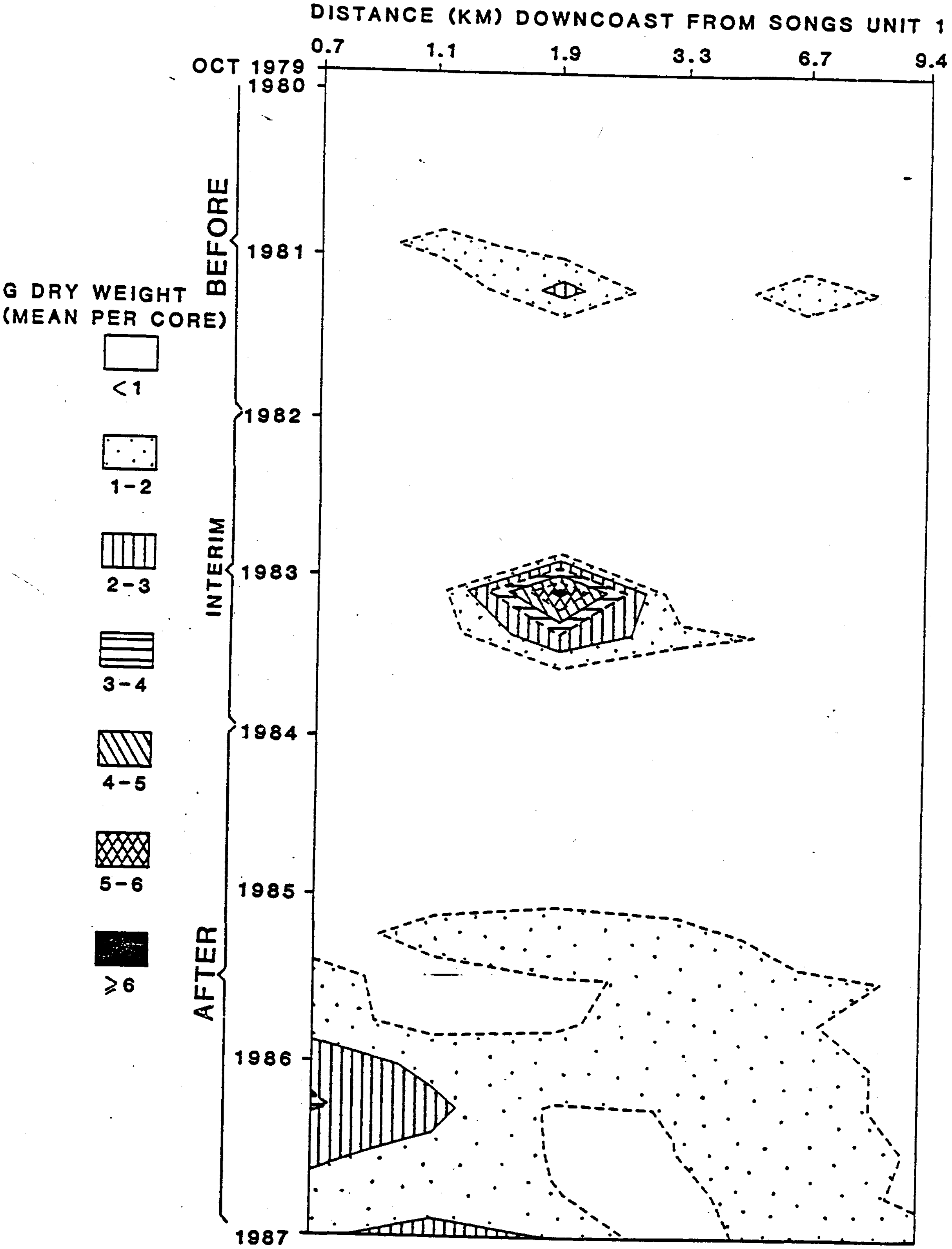


Figure 3-17. Macrodetritus along the 8m isobath downcoast from SONGS Unit 1 during the monitoring periods. AFTER refers to benthos monitoring; the AFTER period for mysids commenced in October, 1983.

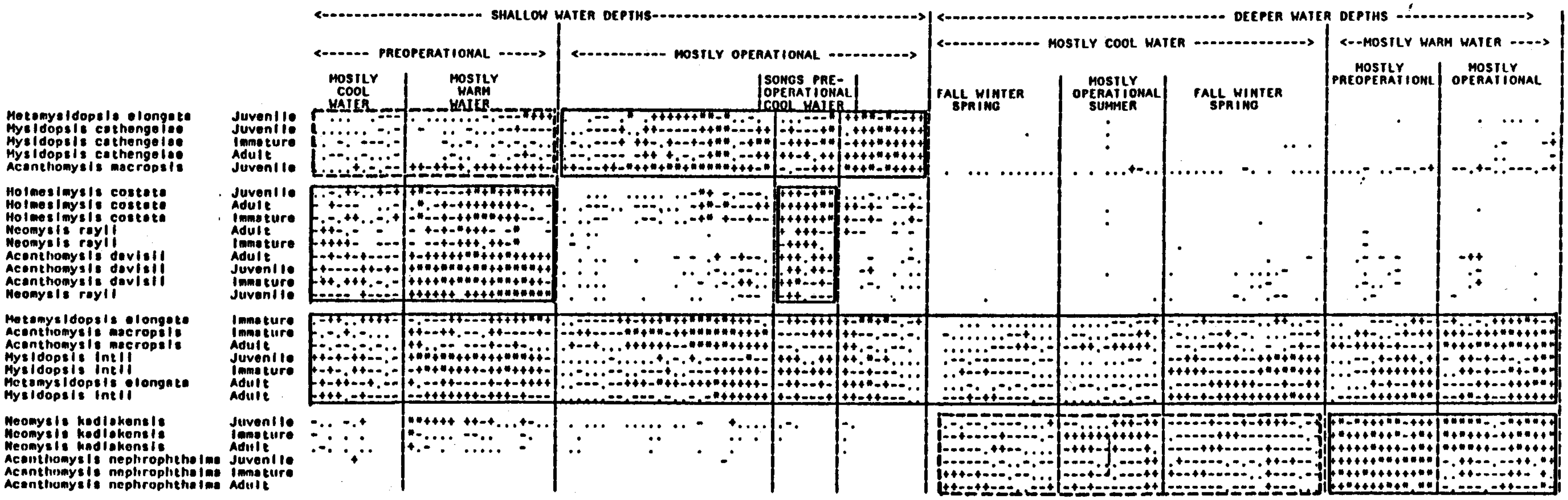


Figure 3-19. Two-way coincidence table of mysid species by developmental stage and sampling by dates/locations. Dashed lines separate species and space/time assemblages identified from the species and space/time dendrograms resulting from the cluster analysis. Within a species assemblage, a solid line borders a period of relatively high abundance and a dark dashed line borders a period of relatively moderate abundance. The mean abundance for each developmental stage in each space/time observation was square-root transformed and standardized by the mean of the developmental stage for each species over all observations to give relative abundances. Relative abundances are given by symbols: blank = 0, . =>0 to .5, - = >.5 to 1.0, + = >1.0 to 2.0, * = >2.0.

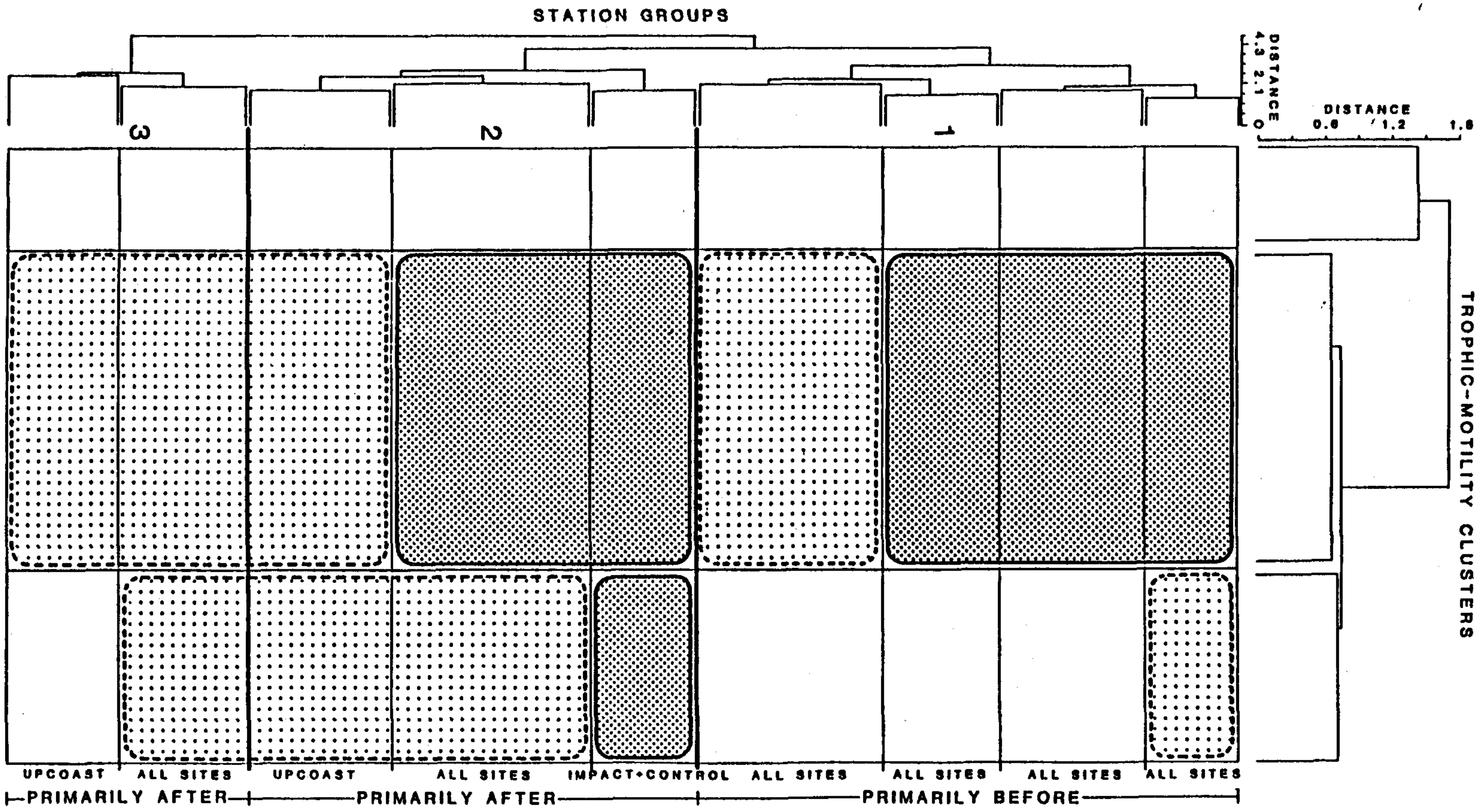


Figure 3-21. Trophic-motility and station dendrograms and resulting two-way table based on the cluster analysis of trophic-motility groups along the 8 m isobath. Major station groups are denoted by numerals; subgroups of stations are shown with fine lines on the two-way table. Shading denoted relative abundance: darker shading indicates generally higher relative abundance, light shading indicates moderate relative abundance, and no shading indicates generally low relative abundance. The complete two-way table giving relative abundance for each trophic-motility group at each station is presented in Appendix C, Table C-2. The most highly ranked trophic-motility groups in each major station group are listed on Table 3-9. Upcoast stations generally are those within 700-1900 m downcoast from SONGS; downcoast stations are those 3350-9400 m downcoast. Actual station locations are shown on Table C-2.

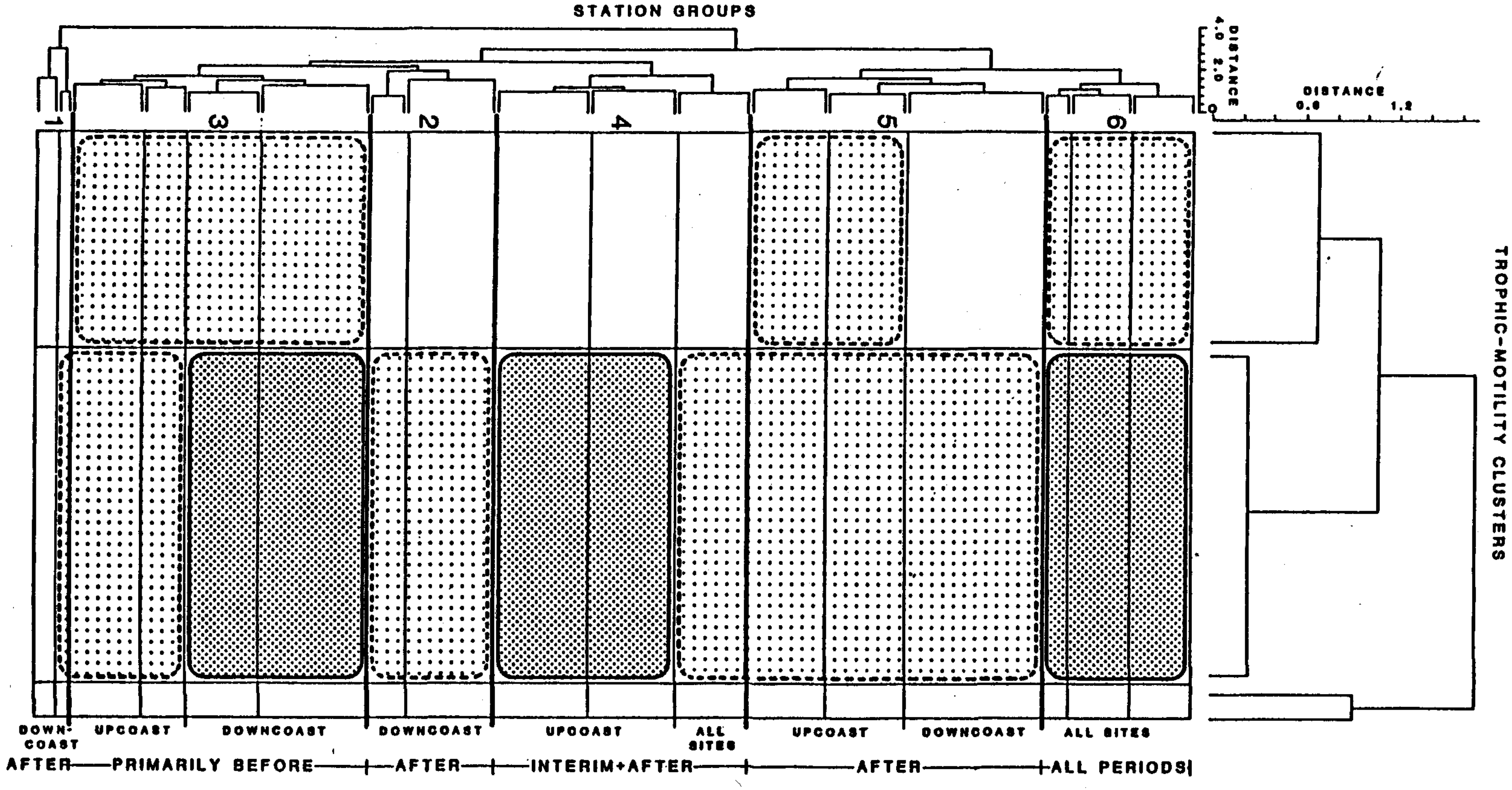


Figure 3-23. Trophic-motility and station dendrograms and resulting two-way table based on the cluster analysis of trophic-motility groups along the 18 m isobath. Major station groups are denoted by numorals; subgroups of stations are shown with fine lines on the two-way table. Shading denoted relative abundance: darker shading indicates generally higher relative abundance, light shading indicates moderate relative abundance, and no shading indicates generally low relative abundance. The complete two-way table giving relative abundance for each trophic-motility group at each station is presented in Appendix C, Table C-4. The most highly ranked trophic-motility groups in each major station group are listed on Table 3-11. Upcoast stations generally are those within 700-1900 m downcoast from SONGS; downcoast stations are those 3200-9400 m downcoast. Actual station locations are shown on Table C-4.

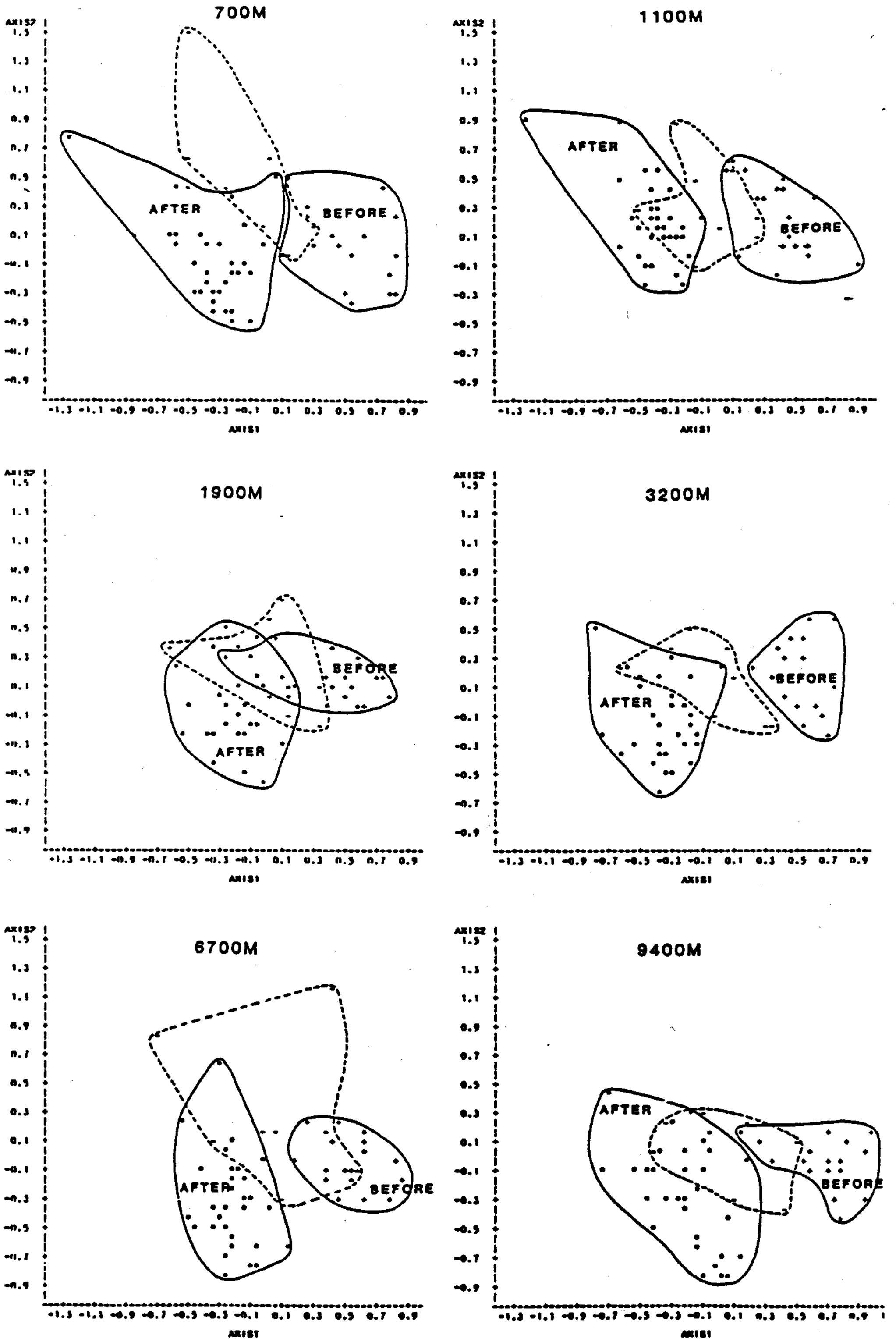


Figure 3-25. Before, interim and After surveys at each longshore station (700 m is nearest SONGS, 9400 m is farthest away) plotted on principal coordinate axes 1 and 2 from the analysis on individual benthic taxa along the 18 m isobath. Before and After surveys are enclosed with solid lines, and interim surveys with a dashed line. +=Before, -=interim, *=After.

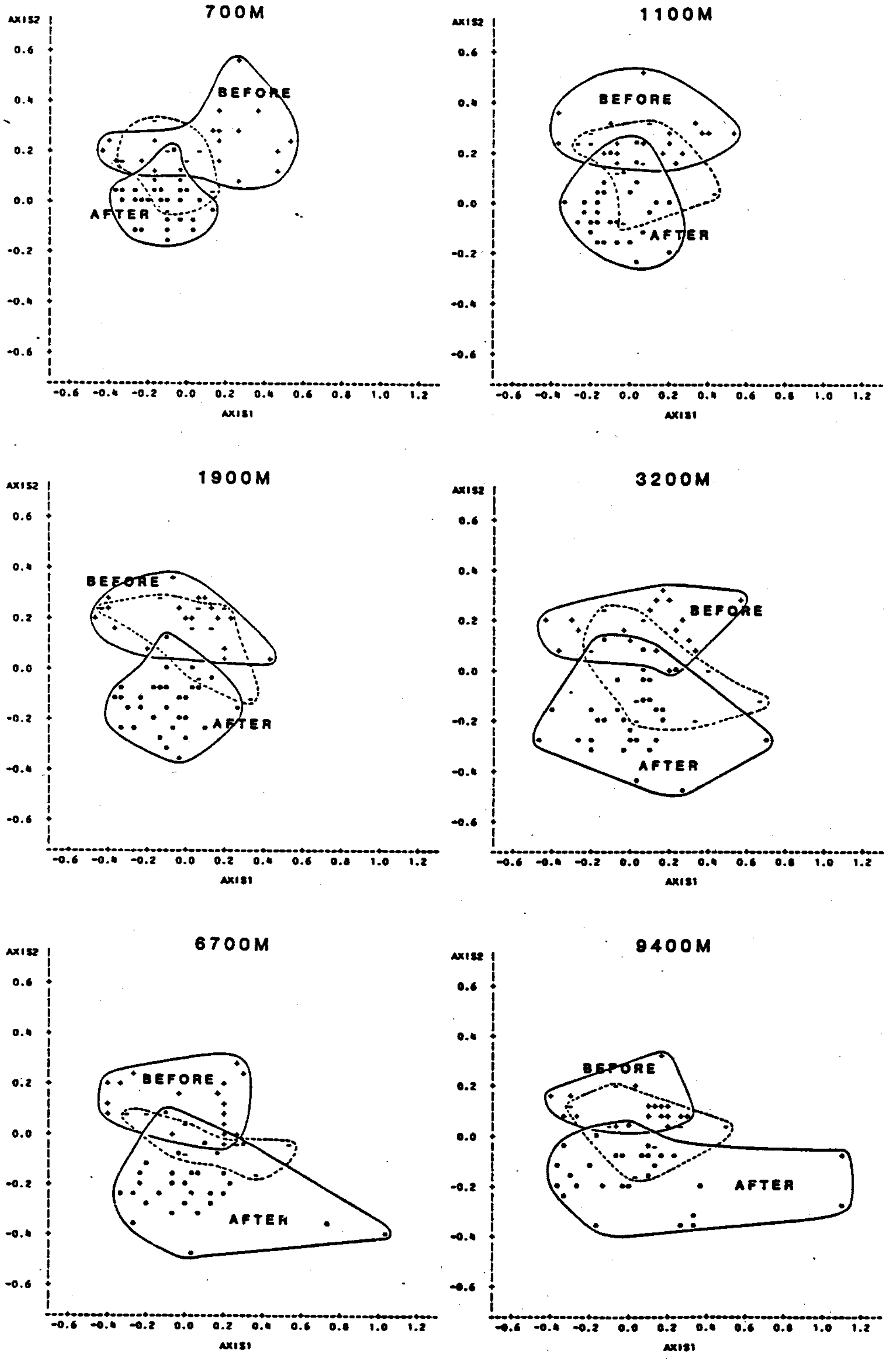


Figure 3-27, Before, interim and After surveys at each longshore station (700 m is nearest SONGS, 9400 m is farthest away) plotted on principal coordinate axes 1 and 2 from the analysis on trophic-motility groups along the 18 m isobath. Before and After surveys are enclosed with solid lines, and interim surveys with a dashed line. +=Before, -=interim, *=After.

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