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REVISIONS AND ADDENDA

Prepared by Arthur M. Barnett, Principal Investigator

Contributing Staff:

William Watson  
Linda G. Gleye  
Susan D. Watts  
Karen D. Green  
Thomas D. Johnson  
Douglas N. Beanan

Consultant:

Janice D. Callahan

MARINE ECOLOGICAL CONSULTANTS OF SOUTHERN CALIFORNIA  
531 Encinitas Boulevard Suite 110  
Encinitas, California 92024

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This volume contains addenda and revisions to the first volume of Appendices of the MEC Biological Project San Onofre Nuclear Generating Station Monitoring Studies on Ichthyoplankton and Zooplankton Final Report, and is intended to be used in conjunction with that appendix volume. The contents of Volume 2 are: Appendix A.1 Nature of the Plankton Near SONGS; Appendix A.2 Glossary of Special Use Terminology; Appendix C.2 Application of Statistical Analyses to Clevelandia ios; Appendix C.3 Application of Statistical Analyses to Gobiosox rhesodon; Appendix D Patterns of Ichthyoplankton and Macrozooplankton Distribution in the Cross-shelf Strata; and Appendix E Documentation of Computer Programs.

Appendix A.1 is a new appendix giving background information on the plankton community in the SONGS vicinity, and on the individual taxa selected for BACI analysis. Appendices A.2, C.2, C.3, and E revise and replace Appendices A, C.2, C.3, and E, respectively, of the first Appendix volume. The figures of distribution patterns given in Appendix D of Volume 2 replace the corresponding figures in Appendix D of Volume 1. To facilitate this, the figure number, figure caption, and page number for each figure in Appendix D of Volume 2 matches those of the corresponding figure in Appendix D of Volume 1.

A second set of Appendix D figures is attached to this volume, these may be removed and pasted over the corresponding figures in Volume 1. In addition, a new Appendix Volume 1 cover page, and a page explaining which Volume 1 appendices are superceded by the appendices given in Volume 2, are also attached and may be removed and inserted in Volume one.

## APPENDIX A.1

### Nature of the Plankton Near SONGS

Most plankton studies in the Southern California Bight deal principally or exclusively with only a single component of the plankton (e.g., bacterioplankton, phytoplankton, ichthyoplankton, other zooplankton); this is particularly true of studies dealing with macroplankton. Because each plankton study tends to deal with a single taxonomic category, the following synopsis of the planktonic biota of the Bight will be organized, for ease of description, into three broad taxonomic categories: phytoplankton, zooplankton (excluding fish eggs and larvae), and ichthyoplankton. Since the MRC studies at San Onofre have not dealt with bacteria, the bacterioplankton will not be included in this synopsis. Azam (1986) reviewed the bacterioplankton studies in the Southern California Bight and discussed the significance of bacteria in the food web.

#### Phytoplankton

The most important components of the phytoplankton in the Bight are the diatoms, dinoflagellates, coccolithophorids, silicoflagellates, monads, and flagellates (Raymont, 1980). Among these, the diatoms and dinoflagellates are best known. The diatom-dinoflagellate assemblage is dominated by temperate water forms, but also includes forms with warm water/tropical and cold water/boreal affinities (Kimor et al., 1978; Beers, 1986). Balech (1960) demonstrated that the composition of this assemblage was temporarily altered during the 1957-1958 El Nino, when the warm water/tropical species were abundant and the appearance of cold water forms was delayed and restricted. Reid et al.

(1985) noted that some small diatom and dinoflagellate species that are usually associated with warm oceanic water occurred inshore at Scripps Pier in 1983, during the 1982-1984 El Nino. Aside from these taxa, the microplankton species composition was not unusual during 1983, although overall microplankton abundance tended to be lower than the abundances reported from other, non-El Nino, years (Reid et al., 1985). Fiedler (1984) used satellite data and vertical chlorophyll profiles to demonstrate that phytoplankton production was reduced in the California Current region during the recent El Nino.

The phytoplankton composition in the SONGS area varies through the year (Barnett et al., 1981). Winter well-mixed water column conditions foster a variety of phytoplankton taxa, dominated by diatoms. In the spring the water column warms and begins to become stratified; this stratification favors large dinoflagellates, which thus tend to dominate in these conditions. During spring and early summer (April through July) the developing stratification is frequently interrupted, and the nearshore nutrient supply increased, by coastal upwelling. This stimulates nearshore phytoplankton production, particularly of diatoms and smaller dinoflagellates. After the cessation of upwelling and with the re-establishment of stratification in late summer, the diatoms and small dinoflagellates become rare, and the remaining dinoflagellate flora becomes dominated by Gonyaulax. This pattern of changing dominance through the year has been observed with temporal and spatial variability throughout the Bight (e.g., the review by Mullin, 1986). The timing and intensity of local coastal upwelling, interannual changes in the flow of the major currents, and phenomena such as El Nino are among the factors which contribute to this variability. Satellite imagery of surface chlorophyll distributions in the Bight (e.g., Smith

and Baker, 1982; Fiedler, 1986) has illustrated some of this temporal and geographic variability.

### Zooplankton

Zooplankton abundance is seasonal. Large seasonal fluctuations in zooplankton biomass have been documented for both offshore (e.g., Loeb et al., 1983a) and nearshore (e.g., Petersen et al., 1986) waters of the Bight. Offshore, zooplankton biomass peaks were noted in May and July off central California, in May off southern California, and in March off northern Baja California (Loeb et al., 1983a). In the nearshore region off southern California, between Ormond Beach and San Onofre, Petersen et al. (1986) reported zooplankton biomass maxima during April-June, with minima from December to February, in general accord with the offshore pattern for the same region.

A cluster analysis based on values of abundance between the 8 m and 100 m depth contours classified the zooplankton at San Onofre into three seasonal assemblages (Barnett et al., 1981). Cladoceran crustaceans were most abundant in the fall-winter assemblage, anchovy eggs and larvae in the winter-spring assemblage, and all other taxa in the spring-summer assemblage.

In addition to the seasonal abundance cycles of the zooplankton, there is also a seasonal cycle in the cross-shelf location of individual taxa and of zooplankton biomass. Barnett et al. (1981) identified five spatial/temporal zooplankton groups. These groups were: (1) fall-winter, outer nearshore, (2) fall-winter, inner nearshore/transition, (3) late winter-summer, inner nearshore/ transition, (4) late winter-late summer, inner nearshore/transition, and (5) spring-summer, outer nearshore. The switch from fall-winter to spring-summer assemblages

occurred about two months earlier in the inner nearshore zone than it did in the outer nearshore zone. The groups appear to be related to the cross-shelf gradients in density stratification, turbidity, and food supply (measured as phytoplankton and chlorophyll concentrations), and to seasonal cycles of upwelling and phytoplankton composition and abundance (Barnett et al., 1981).

The major El Nino of 1982-1984, by virtue of its magnitude, might have been expected to produce marked shifts in zooplankton abundance and/or community structure. In the Southern California Bight, however, the El Nino apparently had only moderate effects. McGowan (1984) suggested that zooplankton volume decreased in the California Current during El Nino; Chelton et al. (1982) showed a similar reduction in zooplankton displacement volume during the 1957-1959 El Nino. Nearer shore, Petersen et al. (1986) reported that in 1983-1984, zooplankton biomass tended to be low shoreward of the 75 m isobath between Ormond Beach and San Onofre. They attributed this to a combination of factors, including offshore transport and reduced food availability (i.e., reduced phytoplankton production) along the southern California coast during El Nino. Petersen et al. (1986), and Reitzel and Zabloudil (1983), reported the occurrence of various oceanic water masses inshore during this time. Barnett et al. (1983a) stated that during periods of shoreward transport of this oceanic water, the abundance of the nearshore copepod Acartia tonsa (most abundant, on average, 2-4 km from shore) was reduced, but that more typical levels of abundance were restored during an intervening upwelling period. Early in the El Nino (December 1982 - February 1983), also during a period of shoreward transport of oceanic water, nearshore standing stocks of macrozooplankters were generally low at San Onofre. At the same time, the

macrozooplankton category "unidentified holoplankton" more than doubled its contribution to the total nearshore macrozooplankton. Barnett et al. (1983a) attributed these occurrences to a combination of normal seasonal abundance patterns and an inshore incursion of offshore water, together with its organisms (i.e., "unidentified holoplankton").

The observations that an event of the magnitude of the 1982-1984 El Nino did not substantially affect the standing stock or the cross-shelf distribution of the nearshore zooplankton community, and that local upwelling and downwelling events also tend not to disrupt these patterns, except to shift assemblages somewhat seaward or shoreward (Barnett and Jahn, 1987), indicate that the nearshore community is stable, at least in the cross-shelf dimension. The MRC (1977) attributed this cross-shelf stability to the fact that nearshore currents typically are mainly alongshore, tend to reverse with an approximately tidal frequency, and have only weak cross-shelf components that at San Onofre produce an apparent net onshore movement. The zooplankters located closest to shore tend to be most abundant near the bottom (e.g., Barnett and Jahn, 1987; Jahn and Lavenberg, 1986), where current velocities are even lower and the likelihood of being advected away from the nearshore zone is even less. In addition to the relatively non-dispersive current regime of the nearshore zone, a favorable feeding environment is provided by the nutrient recycling and tidal mixing over the shallow shelf (Barnett and Jahn, 1987; Petersen et al., 1986), which allows higher rates of phytoplankton production near shore. Because the nearshore zooplankton tends to be dominated by smaller organisms (Barnett and Jahn, 1987), which are likely to have higher turnover rates (Sheldon et al., 1977) than the larger organisms

farther from shore, the nearshore populations are likely to be able to recover more rapidly from environmental perturbations.

The following sections present synopses of the biology of the zooplankton species chosen for BACI testing.

### Acartia clausi

The shallow water/estuarine copepod Acartia clausi is found in coastal areas of both the Atlantic and Pacific Oceans. This small (0.85-1.22 mm) calanoid is a cold-water species with an upper critical thermal level of approximately 20-22°C (Uye and Fleminger, 1976). MEC found low abundances of A. clausi near shore off San Onofre in the cold water months, but did get consistent peaks of abundance in summer. Studies by Landry (1978) in the Pacific northwest and by Uye (1982) in a bay in Japan also described a winter minimum/summer maximum in patterns of abundance.

Vertical migrators, A. clausi copepodids (juveniles) and adults are more abundant at the surface at night than during the day, whereas the nauplii appear in the water column both day and night (Landry, 1978). Barnett and Jahn (1987), using data from day samples, have noted the very strong affinity of A. clausi for the bottom.

The adult females release eggs that may fall to the bottom, where they can remain dormant until they are washed free and returned to the plankton by wave action, tidal currents, or upwelling. Once free of the bottom, the eggs hatch into nauplii (Uye, 1982). Generation time is about 14 days at 20°C (Landry, 1978). Mortality is very high in the young stages (egg - N II), generally low and constant from the N III stage to adult, then high again for adults (Uye, 1982). The major



source of adult mortality is predation, rather than physiological deterioration (Landry, 1978). Generation time is negatively correlated with water temperature (Uye, 1982).

#### Oithona oculata

Oithona oculata is a cyclopoid copepod which can tolerate oceanic conditions but generally prospers best in littoral habitats (Yeatsman, 1976; Sander and Moore, 1979).

At San Onofre, Oithona oculata occurs predominantly in the 8 m epibenthos, and secondarily in the rest of the 8 m water column and in the epibenthos at 13 m; occurrences offshore of the 13 m isobath are rare (Figure D-376).

The natural history of this genus has not been studied.

#### Acartia tonsa

Acartia tonsa is a small (1.0-1.5 mm) calanoid copepod found in coastal areas of the Atlantic, Indian, and Pacific Oceans. In the eastern Pacific, it ranges north to southern California (Brodskii, 1950). It is one of the two dominant zooplankters in the Southern California Bight (Barnett et al., 1983). It is a warm season species most abundant in the spring/summer (Esterley, 1928; Uye and Fleminger, 1976; Barnett and Jahn, 1987). In the San Onofre area it is evenly distributed in abundance between the 8 m and 30 m isobath during the fall and winter, while in the spring and summer it is more abundant between the 13 m and 30 m isobaths than near the 8 m isobath (Barnett and Jahn, 1987). Throughout the year the younger stages are more nearshore than the older ones. A vertical migrator, it is more abundant at the surface at night than during the day (Esterley, 1917).

Acartia tonsa feeds omnivorously by actively seining the water with its maxillae (Gauld, 1966). Its generation time is about two weeks at 12 °C (Heinle, 1966). Females can produce overwintering dormant eggs (Uye and Fleminger, 1976).

#### Cirriped Larvae

Barnacles have six naupliar and one cypris larval stages (see Schram, 1986). The naupliar stages last three to four weeks, and are followed by metamorphosis into the nonfeeding cypris larva. The cypris larva is the strongly geotactic settlement phase, and spends its time near the bottom searching for a suitable habitat. Once that habitat is found, the cypris larva attaches itself to the substratum and metamorphoses into the adult form. In general, substratum selection is also influenced by local currents, with different species selecting different optimal current velocities.

Barnett and Jahn (1987) found that both the nauplii and cypris stages were most abundant year round in the nearshore/transitional areas (shoreward of the 30 m isobath), the nauplii occurring nearer shore than the cypris. The cypris larvae were most abundant in the epibenthic layer of the water column. The nearshore abundance of barnacle larvae corresponds to the shallow habitat of most adult barnacles, and the epibenthic distribution of the cypris results from pre-settlement behavior.

Barnacles often are early colonizers of new substrate. The most common barnacles in the San Onofre area, Megabalanus tintinabulum, Balanus pacifica, and B. tiganus, were among the first to settle on new anthropogenic structures such as the Pendleton Artificial Reef (Schroeter, pers. comm.), although they were later overgrown and

replaced by other fouling organisms. These taxa have also been consistently found on frequently disrupted habitats, such as buoy lines and inside the SONGS intake conduits (as evidenced by the discharge of barnacle shell fragments during heat treatments).

Osman et al. (1981) found some indication that the recruitment of Balanus may have been greater near SONGS and in the nearby San Onofre Kelp bed than at his reference stations. He found no general difference between inshore and offshore recruitment.

#### Cladocerans

Cladocerans are small brachiopod crustaceans, commonly referred to as "water fleas". Five marine cladocerans occurred in the San Onofre studies: Evadne nordmanni, E. spinifera, E. tergestina, Penilia avirostris, and Podon polyphemoides. Owing to the difficulty of distinguishing the species, E. spinifera and E. tergestina were both included in the E. spinifera counts (most were E. spinifera). Of the four cladoceran taxa counted, only Podon was abundant year round, Penilia and E. nordmanni were spring/summer species, and E. spinifera was classified as a fall/winter species (Barnett and Jahn, 1987). All four species were temporally patchy, with very high abundances interspersed with low ones. All four species occurred shoreward of the 30 m isobath. Only E. spinifera has been shown to have oceanic affinities (Frey, 1982). In studies conducted during May and October, Fiedler (1982) found that Penilia avirostris was most abundant at 10-20 m depth in the daytime in the Southern California Bight while Evadne was more abundant in the upper 20 meters.

Cladocerans alternate between sexual and asexual (parthenogenic) phases. The asexual phase predominates in spring and summer; the sexual

phase in the fall produces resting eggs which can overwinter. Except for the resting eggs, which are released into the environment, cladocerans brood their young. Development is direct and the young are released from the brood chamber as miniature adults. Cladocerans are herbivorous filter feeders.

### Corycaeus anglicus

Corycaeus anglicus is a small (0.8-1.15 mm) cyclopoid copepod that occurs in coastal regions (shallower than approximately 100 m), principally in the upper 35 m of the water column (Johnson, 1969; Fiedler, 1982). It is more abundant at night than during the day in the surface plankton off Scripps Pier (Esterley, 1928).

Off San Onofre, this species is most abundant shoreward of the 30 m isobath in the fall and winter and farther offshore in the spring and summer (Barnett and Jahn, 1987).

Reproduction occurs year round. The females are iteroparous (multiple brooders), carrying the egg sacs until the young are released as nauplii. The number of eggs in a sac (clutch size) is correlated with the size of the female and the time of year (Johnson, 1969). The average monthly reproductive rate is high enough (14.7 eggs per female per day) to suggest that C. anglicus nauplii contribute importantly to the microzooplankton in the Southern California coastal waters (Johnson, 1969).

This copepod is a raptorial carnivore both as a juvenile and as an adult, and probably does not directly consume plant material.

## Cyphonautes Larvae

Cyphonautes larvae are the planktonic larval form of some bryozoans. One of the most common bryozoans in the San Onofre area, Membranipora, an encrusting epizoont on the giant kelp Macrocystis, produces cyphonautes larvae.

However, because the cyphonautes of different species are very similar, making identification to genus difficult (all cyphonautes larvae are triangular in shape, laterally compressed, and enclosed in chitinous, bivalve shells). Consequently, we made no attempt in the SONGS studies to determine whether all specimens were Membranipora.

The cyphonautes of Membranipora has been studied extensively, particularly by Yoshioka (1973). These larvae can be found far from shore, but are most concentrated along the coast in the winter (Yoshioka, 1973). Mullin (1986) reported that Membranipora larvae were most abundant in the winter in the Southern California Bight. They are negatively bouyant but actively photopositive, and passively sink in warm (18-20°C) sea water. During the winter and spring, when the surface waters are cool and well mixed, the larvae concentrate in the upper 5 to 10 m. They are absent from this layer in the summer and early fall, when the water is warm and thermally stratified (Yoshioka, 1973).

The larvae spend two to four weeks in the near-surface plankton before they settle. In the Point Loma kelp bed they preferred younger Macrocystis blades in the canopy to older ones, and blades on the outer edge to those farther into the bed (Bernstein and Jung, 1979). This edge effect was not apparent in smaller kelp beds.

Bernstein and Jung (1979) reported that the cyphonautes of Membranipora demonstrated a strong preference for the lower water column/benthic kelp Pterygophora over Macrocystis, suggesting that

Pterygophora may serve as a refuge in the warm water months when Membranipora are excluded from the kelp canopy.

Labidocera trispinosa

Labidocera trispinosa is a large calanoid copepod found principally in inshore waters of southern California and northern Mexico. At San Onofre it ranges seaward to 100 m depth (Barnett and Jahn, 1987). Esterley (1928) found it to be most abundant in the summer and autumn off Scripps Pier.

Although Esterley (1912) reported higher abundances near the surface at night than in the day in a deep water study (bottom depth = 100 fathoms), Barnett (1974) showed that vertical distribution is ontogenetic rather than diel in shallower water (< 80 m). In these studies only the late nauplii and early copepodid stages were neustonic, while adults and early nauplii occurred in deeper water. The late nauplii and early copepodids occupied depths in which their prey were most often found in high abundances.

Labidocera feeds over a 24 hour period, although feeding is depressed in late afternoon and early evening (Barnett, 1974). Barnett divided this copepod into trophic groups by developmental stage. Nauplii (N) I and II do not feed; N III to copepodid (C) II are primarily herbivores, C III to C V are omnivores, and adults are primarily carnivores. The adults can feed raptorially or by filtering. They apparently can switch their feeding preference in the presence of large concentrations of alternate food (Barnett, 1974). L. trispinosa is an effective predator on larval fish (Lillelund and Lasker, 1971). The development time of L. trispinosa is inversely related to temperature. The average generation time is about 40 days at 15°C. Barnett (1974) estimated the fecundity rate to be about 15 eggs per female per day.

### Oithona plumifera

Oithona plumifera is a widely distributed epipelagic cyclopoid copepod, chiefly found in warm tropical to subtropical waters. In the Southern California Bight, Olson (1949) found it at 40% of his deeper coastal stations (depths greater than 200 m) sampled between May and July 1939, as well as in samples collected in La Jolla Bay and off Scripps Pier.

At San Onofre, O. plumifera ranges seaward to at least 100 m depth year-round; it is less strongly associated with the inner nearshore zone (8 m) in the spring and summer than it is in the fall and winter (Barnett and Jahn, 1987).

The natural history of this genus has not been studied.

### Paracalanus parvus

Paracalanus parvus is a small (0.74-1.40 mm) calanoid copepod which inhabits warm surface waters both in the open ocean and near the shore. It occurs globally except in the arctic and antarctic regions (Brodskii, 1950).

Near San Onofre P. parvus was abundant year-round shoreward of the 100 m isobath, but was more abundant nearshore (at 8 m) during the fall and winter than during the spring and summer. The younger stages were closer to shore than the older stages (Barnett and Jahn, 1987). Fiedler (1982) described a monotonic decrease in P. parvus abundances from the surface to 40 m depth.

The nauplii are herbivorous, whereas the copepodids and adults are omnivorous (Bartram, 1980). Checkley (1980a, 1980b) postulated that nitrogen could be the limiting factor to egg production.

### Sagitta euneritica

Sagitta euneritica is a medium-sized (ca. 1-16 mm long) zooplankter belonging to the phylum Chaetognatha (arrow worms). It resides in the neritic zone of the eastern north Pacific Ocean (Alvarino, 1965). In the Southern California Bight it tends to be most abundant within about 12 km of shore (O'Connell, 1971). At San Onofre S. euneritica tends to increase in abundance within about 4.4 km of shore (shoreward of the 30 m isobath) during fall and winter, and shifts seaward beyond 4.4 km from shore during spring and summer (Barnett and Jahn, 1987). S. euneritica may undertake a limited daily vertical migration (O'Connell, 1971); this migration is upward in the water column at night (Brewer et al., 1984; Mullin, 1986) and may be more extensive during the summer than during the winter (e.g., Mullin, 1986).

S. euneritica, like all Sagitta species, is a protandric hermaphrodite that sheds very small planktonic eggs. Reproduction occurs throughout the year. The planktonic eggs hatch within several days; newly-hatched individuals look much like miniature adults and develop directly to the adult form.

S. euneritica is a carnivore; owing to its small size, it is largely limited to feeding on microzooplankton and small macrozooplankton. Bigger items such as fish larvae probably do not constitute an important part of its diet (e.g., Alvarino, 1980).

### Calanus pacificus

Calanus pacificus, a calanoid copepod, is a member of the northern Pacific surface fauna. It occurs predominantly in warm oceanic surface waters (to a depth of 200-400 m) and avoids areas of cold currents



(Brodskii, 1950). It is a regular member of the spring and summer plankton community in the southern California Bight, but its abundance in the San Onofre area is greatly reduced during winter (Barnett and Jahn, 1987). Brodskii (1950) identified its southern-most summer range limit in the eastern Pacific as being around northern Baja California, and the northern-most winter range limit as being around Vancouver, British Columbia.

The following synopsis of the biology of C. pacificus is taken from Beers (1986) and from Mullin (1986).

Calanus reproduces throughout the year. Four to five weeks elapse between the egg stage and the reproductive adult stage. The nauplii are resistant to starvation, having up to five days after hatching in which to find concentrations of phytoplankton sufficient to support growth and development. Feeding begins at the N III stage. Natural mortality rates of nauplii, ranging from 18% to 48% per day, are higher than those of the copepodid stages.

Growth is dependent on available food; Calanus compensates for low food concentrations by increasing its grazing rate. Feeding rates also increase with age. Although Calanus begins life as an herbivore, the copepodids and adults are omnivores. The adults will prey on Calanus nauplii but not on the copepodids; adults may, therefore, when they are abundant, be a source of significant naupliar mortality.

Vertical migration begins at the time of first feeding and increases in magnitude with growth. Conversely, growth rates, which are highest in the first two naupliar stages, begin to decrease with the onset of the diel vertical migrations and continue to decrease with age.

## Ichthyoplankton

There are longshore patterns in ichthyoplankton abundance in both the offshore and nearshore waters of the Bight (e.g., Loeb et al., 1983a; Lavenberg et al., 1986), although Lavenberg et al. (1986) pointed out that the patterns are not as strongly developed in the nearshore zone. The abundances of two taxa have been shown to be reduced, on average, at San Onofre. White croaker (Love et al., 1984) and northern anchovy eggs and yolk sac larvae (Lavenberg et al., 1986) are less abundant at San Onofre than in nearshore areas farther north in the Bight.

Ontogenetic shoreward movements have been demonstrated for a few species at San Onofre. For example, Barnett et al. (1984) showed that the zone of highest abundance was closer to shore for the older larvae of queenfish, white croaker, and northern anchovy than it was for the younger larvae. The oldest California halibut larvae tended to be most abundant shoreward of the 12 m isobath, while older larvae of kelp and sand bass typically were most abundant shoreward of the 22 m isobath (usually 12-22 m; Barnett et al., 1981). Lavenberg et al. (1986) showed that both eggs and larvae of Pacific sardine were most abundant shoreward of the 75 m isobath between Ormond Beach and San Onofre, and Watson (1985) showed that larval abundance was highest on average between the 22 m and 45 m isobaths off San Onofre.

Several studies have been conducted in the San Onofre vicinity to evaluate the importance to fish larvae of special habitats not normally sampled during conventional ichthyoplankton surveys. These habitats included kelp beds, cobble reefs, and the very nearshore zone along the open coast. Barnett and Sertic (1978) concluded that the waters over cobble reefs are an important habitat for larvae of demersally-spawning

adults (principally clinids, gobies, and gobioides), since larvae of these species were about 150 times more abundant over the reefs than in open water, and that atherinid, queenfish, and blind goby larvae are more abundant very near shore, at the wave base, than farther from shore. They also found that no species are more abundant in the open water between giant kelp plants than in the open water away from kelp beds. Additional sampling in and near kelp beds with a diver-operated plankton sampler (Barnett and Sertic, 1979b) confirmed those results. Barnett and Sertic (1980a) showed an approximately 10-fold increase in the abundance of kelp clingfish larvae around the kelp plants, but did not show differences between the water near kelp plants and open water away from the kelp bed for any other species. Based on these studies, Barnett and Sertic (1979b, 1980a) concluded that kelp beds are unimportant as habitat for nearshore fish larvae, although kelp beds are known to provide important habitat for the juveniles and adults of many fish species (e.g., Ebeling and Bray, 1976; Feder et al., 1974).

Daily vertical migration has been documented for many larval fish species world-wide, although it is not as common among the ichthyoplankton as among the other zooplankton (e.g., Woodhead, 1966). In the Southern California Bight, daily vertical migration occurs among several larval fish species, although it appears to have a relatively unimportant effect on distribution (e.g., Ahlstrom, 1959; Barnett et al., 1984; Brewer and Kleppel, 1986; Jahn and Lavenberg, 1986).

Seasonal patterns of ichthyoplankton abundance, reflecting seasonal reproduction, are well documented in the Southern California Bight (e.g., Brewer et al., 1980; Gruber et al., 1982; Lavenberg et al., 1986; Loeb et al., 1983b; Parrish et al., 1981; Schlotterbeck and Connally, 1982; Walker et al., 1987). At San Onofre, Walker et al.

(1987) used cluster analysis to classify 63 taxa into two principal seasonal assemblages, one containing the larvae of winter-spring (December-May), the other those of summer-fall (June-November) spawners. Demersal spawners tended to have longer reproductive seasons than pelagic spawners, and the winter-spring spawners tended to have longer spawning seasons than the summer-fall spawners. Northern anchovy larvae dominated both the winter-spring and the summer-fall assemblages; white croaker, rockfish, and California halibut larvae were important contributors to the winter-spring assemblage; queenfish, blenny, and kelp and sand bass larvae were important members of the summer-fall assemblage (Walker et al., 1987). Lavenberg et al. (1986) presented very similar results.

The 1982-1984 El Nino, one of the strongest events of the century, appears to have had little effect on the seasonal cycles of abundance of the resident nearshore fish larvae, although Barnett et al. (1983b) did note that the occurrence of young larvae of a few summer-fall spawners as late as December in 1982 suggested a slight extension of the summer-fall spawning season that year. More pronounced effects were detected offshore. For example, in 1983 the spawning range of northern anchovy extended much farther north than usual, eggs matured more rapidly than usual, and the resulting year class consisted of unusually small individuals, probably as a result of reduced food availability (Fiedler, 1984).

An apparent manifestation of El Nino at San Onofre was the influx into the nearshore zone of fish larvae with offshore or southern affinities. Barnett et al. (1983a) noted that the larvae of mesopelagic and warm-water epipelagic fish species taken inshore at San Onofre during the El Nino event were similar to the assemblages characteristic

of the offshore Southern California and Baja California CalCOFI regions (Ahlstrom, 1965; Loeb et al., 1983b). Lavenberg et al. (1986) reported the sudden appearance of larval round herring, a southern species, in Santa Monica Bay during the 1982-1984 El Nino. Larvae of this species appeared at San Onofre a short time later, and eggs and larvae have been collected every summer since then.

The minimal effects of El Nino on standing stocks and cross-shelf distributions of the common nearshore fish larvae suggest that this community, like the nearshore zooplankton community, is stable, at least in the cross-shelf dimension. This may be in part because the generally low velocities of the nearshore currents and their tendency for tidal reversal serve to minimize the likelihood of offshore dispersal of the nearshore taxa (e.g., Barnett et al., 1984; Jahn and Lavenberg, 1986). In addition to minimizing the likelihood of seaward transport, the very nearshore environment should provide the advantage of a reasonably good feeding environment for fish larvae. Lasker (1978), working along three offshore transects between Santa Monica Bay and Del Mar, showed that the food items suitable for first feeding anchovy larvae (e.g., dinoflagellates), were available in adequate concentrations mainly in the chlorophyll maximum layer within about 10 km from shore, and the microneuplii suitable for older larvae were available in adequate concentrations within 2 km from shore. Upwelling and storms periodically disrupted these aggregations, temporarily reducing concentrations to below threshold levels for successful anchovy feeding. O'Connell (1980) described patches of starving and of healthy anchovy larvae off Newport Beach which he ascribed to patchiness of their food organisms since the starving larvae were generally found in water having low concentrations of plankton. The

epibenthic habitat favored by most of the very nearshore fish larvae may confer a feeding advantage since nearshore zooplankters tend to be more abundant near the bottom (e.g., Barnett and Jahn, 1987; Brewer and Kleppel, 1986; Jahn and Lavenberg, 1986), although Jahn et al. (1985) argued that this cannot be the case, at least for flexion-stage white croaker larvae, since they are largely epibenthic even though their principal food organisms are more widely distributed through the water column. Barnett and Sertic (1980b) and Davis (1979) suggested that, for the sciaenids at least, the initial movement toward the nearshore epibenthos during the flexion-stage is largely to avoid seaward transport. For the larger larvae, which are more capable of maintaining position and may be able to avoid seaward transport through their own efforts, the principal advantage of the nearshore epibenthic habitat is the availability of appropriate food items.

The following synopses summarize the biology of the fish species that were chosen for BACI testing.

#### Clevelandia ios

The following information on the arrow goby is taken largely from Brothers (1975) and Prasad (1959). C. ios is a small, benthic goby whose principal habitat is intertidal and shallow subtidal mud and muddy-sand bottoms, where it usually is associated with invertebrate burrows (Callianassa burrows are especially favored). The distributions of burrowing invertebrates, especially Callianassa, Upogebia, and Urechis, are important determinants of C. ios' distribution. Clevelandia ios tends to co-occur with Ilypnus gilberti and Quietula y-cauda, but has somewhat different microhabitat preferences and, being nonterritorial and unaggressive, in contrast to

the other two species, generally occurs in microhabitats not strongly preferred by the other species. C. ios exhibits greater plasticity in resource selection and utilization than the other two species.

Clevelandia lives one to three years. Females may spawn clutches of 150-1,000 eggs (usually about 150-350) two or three times per season during a reproductive life span of up to two years (the majority in southern California probably die after their first season). Although spawning can occur throughout the year, the major reproductive period is about September through June. The eggs, which are attached to the walls of a burrow constructed for this purpose by the reproductive male and guarded by him, hatch about 10 days after spawning. Larvae enter the plankton upon hatching at about 3 mm, and recruit to the benthic mud-bottom habitat roughly 4-6 weeks later at about 15 mm. During the planktonic period, C. ios larvae are most abundant near the bottom in shallow water. The larvae swim weakly during the first week or ten days of life, but thereafter are thought to be capable of oriented behavior that serves to minimize tidally-induced transport (Brothers, 1975). Owing to its potentially rapid population growth rate, C. ios is considered an opportunistic species capable of rapidly colonizing new areas.

#### Quietula y-cauda

This synopsis of the shadow goby is taken from Brothers (1975). Q. y-cauda is a small benthic goby whose preferred summer habitat is shallow subtidal mud or sand bottom densely covered with algae or Zostera. During winter, it moves to deeper water Zostera beds and rocky areas. Quietula tends to co-occur in the same general areas with Clevelandia ios and Ilypnus gilberti, but its preference for algae

cover and the aggressive, territorial behavior of breeding males reduce its degree of microhabitat overlap with the other species. Burrowing is done predominantly by males during breeding season. Burrows function largely as brood chambers; shelter is provided by the Zostera and algae beds.

Quietula lives four or five years, with females usually maturing and spawning in their second or third year. Spawning occurs throughout the year with a broad peak in summer. Females may spawn only once in their first season, but subsequently may spawn two or three times per season. As in the case of the other gobies, a clutch of eggs representing a single spawning event (on the order of one- to a few hundred eggs) is attached to the inner walls of the burrow and guarded by the male. The incubation period is unknown, but is assumed to be comparable to that of C. ios and I. gilberti, i.e., about 10 days. Larvae hatch at a length of about 3 mm and spend perhaps about 6-10 weeks in the plankton. During this planktonic period, Q. y-cauda larvae are most abundant in the midwater and epibenthos in water shallower than about 13 m. Settlement to the Zostera - algae adult habitat occurs at a length of about 10 mm; the peak settlement period is late summer through early fall, although some settlement occurs throughout the year. Survival rates may be higher for fish settling in summer than for those settling in spring.

#### Ilypnus gilberti

This brief synopsis of the cheekspot goby is taken largely from Brothers (1975). I. gilberti is a small benthic goby residing principally on intertidal and shallow subtidal open sandy bottoms in bays, estuaries, and lagoons. Populations also occur in deeper waters



off the coast. I. gilberti tends to co-occur with the gobies Clevelandia ios and Quietula y-cauda, but its different microhabitat preferences and strongly aggressively territorial behavior tends to exclude all but the large male Quietula from its preferred areas. All adult I. gilberti construct burrows which serve both as the principal source of shelter and as the brood chamber during the spawning season. Burrow construction allows I. gilberti to occupy the open sand-bottom habitat that is effectively unavailable to the other two goby species.

Ilypnus lives four or five years, with females usually maturing and spawning in their second or third year. Newly maturing females may spawn only once in their first season, but older females may spawn two or three times per season. Spawning occurs throughout the year, perhaps with peaks in spring and fall. The eggs are attached to the inner walls of the burrow and guarded by the male. Each clutch of eggs represents a single spawning event; clutch size is similar to that of C. ios (i.e., one-to a few hundred eggs). The incubation period is approximately ten days; newly-hatched larvae (about 3 mm) enter the plankton where they remain for roughly 6 weeks before settling to the benthic sand bottom habitat at about 13 mm length. Settlement occurs throughout the year with a peak from summer through early fall. During the planktonic period, I. gilberti larvae are most abundant in the midwater and epibenthos in water shallower than about 22 m.

#### Gobiesox rhessodon

The California clingfish is a small benthic clingfish closely associated with intertidal and shallow subtidal (to about 11 m depth) rocky reefs (Allen, 1979; Eschmeyer et al., 1983). Spawning probably occurs principally in spring and early summer (Allen, 1979), although

planktonic larvae may be collected throughout the year (Walker et al., 1987). Eggs are attached under rocks and cobble and guarded by the adult (Allen, 1979). Relatively well-developed larvae hatch at about 4 mm length, spend perhaps 2-5 weeks in the plankton (duration based on an assumed daily growth rate of 0.25 mm: Parker and DeMartini, 1987), and then settle to the benthic habitat at about 8-12 mm (Allen, 1979). While in the plankton, larvae occur mainly shoreward of about 22 m depth, where they are most abundant in the epibenthic and midwater strata. G. rhessodon larvae may tend to migrate or settle from midwater to the epibenthos at night (Barnett et al., 1984).

#### Paraclinus integripinnis

The reef finspot is a small (to about 6 cm long) cryptic inhabitant of tidepools and shallow subtidal rocky reefs (Eschmeyer et al., 1983). It ranges to as deep as 15 m, although most individuals remain in water shallower than about 3 m (Rosenblatt and Parr, 1969). Despite its easy accessibility, little has been published on the natural history of the reef finspot. For example, nothing has been published on its early life history.

An Atlantic congener, Paraclinus marmoratus, spawns masses of adhesive eggs in algal or sponge nests guarded by the male. Several females may spawn in succession in the same nest, with the result that the nest typically contains eggs in several stages of development (Breder, 1939, 1941). Planktonic larvae hatch from the eggs following an incubation period of about 10 days (Breder, 1939). It is reasonable to suppose that reproduction is much the same for P. integripinnis.

Reef finspot reproduction is seasonal. Although larvae may occur from spring through fall, abundance is much higher in summer (Walker et

al., 1987). Larvae hatch at about 4 mm length and enter the plankton where they remain for perhaps 7 weeks (assuming settlement at about 17 mm length and an average growth rate of 0.25 mm per day; Parker and DeMartini, 1987). During their planktonic existence, larvae are located predominantly in the nearshore (shallower than about 22 m) epibenthos and midwater zones (Barnett et al., 1985). They may tend to settle from the midwater into the epibenthos at night (Barnett et al., 1984).

#### Gibbonsia sp. A

Four Gibbonsia species occur along the southern California coast and any or all could be included in the taxon Gibbonsia sp. A. However, since Gibbonsia sp. A larvae are morphologically homogeneous, and large postflexion-stage larvae closely resemble newly-settled specimens of Gibbonsia elegans, it seems likely that Gibbonsia sp. A is attributable predominantly or entirely to G. elegans, the spotted kelpfish.

The spotted kelpfish is a small (to about 16 cm long) inhabitant of low intertidal and subtidal (to about 56 m depth) rocky areas (Eschmeyer et al., 1983), especially those areas with dense algal or eelgrass cover (Williams, 1954). Areas with mat-forming algal cover are especially favored (Coyer, 1982). During the spawning season, nests consisting of small clumps of eggs attached to the algae or eelgrass are guarded by the male (Eschmeyer et al., 1983). Spawning can occur throughout the year with a peak in winter (Williams, 1954) or from winter through spring (Feder et al., 1974).

Gibbonsia larvae occur throughout the year off San Onofre but tend to be most abundant in late winter and spring (Walker et al., 1987). Following an incubation period of unknown duration (probably on the

order of 1-2 weeks), relatively well-developed Gibbonsia larvae hatch at a length of about 4 mm and enter the plankton where they remain for perhaps six weeks before settling to the benthic juvenile and adult habitat (Parker and DeMartini, 1987). During the planktonic period larvae are most abundant in the epibenthic and midwater strata near shore, in water shallower than about 12 m (Barnett et al., 1984, 1985).

### Heterostichus rostratus

The giant kelpfish is a moderately large (to about 60 cm long) inhabitant of kelp forests and subtidal algae-covered rocky reefs. It occurs to depths of about 40 m (Eschmeyer et al., 1983). H. rostratus lives approximately five years. It matures at the end of its first year or in its second year, and may spawn several times each year thereafter (Coyer, 1982; Stepien, 1986). Spawning in algal nests occurs throughout the year, with a peak from midwinter through early summer (Feder et al., 1974; Walker et al., 1987). Short, bushy, or branched algae are preferred nesting sites; the male guards the eggs, which are attached to the algal substrate (Coyer, 1982). Each nest contains about 400-1200 eggs, all in the same stage of development, representing a single spawning event (Stepien, 1986).

Relatively well-developed larvae about 6 mm long hatch and enter the plankton following an incubation period of about 2 weeks (Stepien, 1986). The planktonic stage lasts about another two weeks, after which larvae are nektonic, schooling around giant kelp canopies (Feder et al., 1974; Stepien, 1986). H. rostratus settles to the macroalgal juvenile/adult habitat at about 30-50 mm length, corresponding to an age of about 8-12 weeks. During the planktonic period, larvae are most abundant in the midwater and epibenthic strata at depths shallower than about 12 m (Barnett et al., 1985).

## Seriphus politus

The queenfish is a small (to about 30 cm long) abundant croaker that schools over soft bottoms in bays, estuaries and along the shallow open coast at depths less than about 21 m (Eschmeyer et al., 1983; Feder et al., 1974). Queenfish school principally at depths shallower than about 11 m during the day, but disperse offshore at night to feed (Hobson and Chess, 1976; Allen and DeMartini, 1983) and spawn (DeMartini and Fountain, 1981). During the winter they may remain farther from shore in deeper water (Allen and DeMartini, 1983).

Some queenfish mature at the end of their first year, and all are mature by age two. Young females spawn over a period of about 3 months in the middle of the spawning season (about March through September), whereas older females may spawn for up to six months. Batch fecundity ranges from about 5,000-90,000 eggs, depending on the size of the female; the average-size female (14 cm) in the San Onofre vicinity in 1979 had a potential batch size of 12,000-13,000 eggs (DeMartini and Fountain, 1981).

Small (about 1.5 mm long) poorly-developed planktonic yolksac-stage larvae hatch from the planktonic eggs about two days after spawning. The yolksac stage lasts approximately another two days. During these two days, queenfish develop from the essentially embryonic newly-hatched form to fully functional larval fish. The larval growth rate varies seasonally, from an average 0.22 mm per day early in the spawning season (May) to an average 0.27 mm per day late in the season (August), when average water temperature is highest (Barnett and Sertic, 1980c). Transformation to the juvenile stage occurs at about 20 mm, about 10-12 weeks after hatching.

During the larval stage, queenfish are most abundant in midwater and epibenthic strata at depths shallower than about 45 m. The larvae move shoreward and toward the bottom with age. While preflexion-stage larvae commonly occur in midwater and epibenthic strata out to about 45 m depth, flexion and postflexion-stage larvae occur mainly in midwater and epibenthic strata shallower than about 12 m depth, and are most abundant in the epibenthos shoreward of 9 m depth (Barnett et al., 1984).

Jahn and Lavenberg (1986) speculated that the tendency of queenfish larvae to concentrate near the bottom is largely to avoid dispersal, although they did not discount the possibility that the near-bottom distribution could have some trophic significance. Barnett and Sertic (1980b) reported that the harpacticoid copepod, Euterpina acutifrons, with a predominantly nearshore epibenthic distribution, constituted an important component of the diet of all larval stages of queenfish near San Onofre. Other important items for the younger larvae included tintinnids, gastropod veligers, polychaete larvae, cyphonautes larvae, and various copepod nauplii. Most of these zooplankters have midwater distributions, where young queenfish larvae are also abundant. Older queenfish larvae, on the other hand, are largely epibenthic, and feed on epibenthic organisms such as mysids and amphipods in addition to E. acutifrons.

#### Genyonemus lineatus

The following synopsis is taken largely from the review of white croaker by Love et al. (1984). The white croaker is a small to medium-size sciaenid (to about 41 cm long) of moderate sport and commercial value that schools, mainly over soft bottoms, across the shelf from the

surf zone to as deep as 183 m. It tends to be most abundant shoreward of 30 m depth (Eschmeyer et al., 1983); juveniles are largely restricted to this nearshore zone whereas larger specimens may inhabit deeper waters as well. White croakers nearshore tend to disperse seaward at night, and during early winter all tend to remain farther from shore (Allen and DeMartini, 1983; Love et al., 1986).

White croakers mature at an age of about 1-3 years (over 50% are mature at age 1) and live up to 12 years. During the reproductive season (principally November through April, although some spawning can continue throughout the year) females may spawn as often as every five days. Young females have a relatively short spawning period of about 3 months centered around the peak of the spawning season, during which they may spawn as many as 18 batches of about 1,000-4,000 small planktonic eggs. Older females have a longer season (about 4 months) that can start earlier and end later, during which they spawn up to 24 batches of about 4,000-40,000 eggs each.

Small (about 1.6 mm long) yolksac stage larvae that are little more than planktonic embryos hatch from these planktonic eggs about 2.5 days after spawning (Watson, 1982). The yolksac stage, during which larvae have only very feeble swimming ability, lasts five to seven days (Barnett and Sertic, 1980c; Watson, 1982). The subsequent larval growth rate varies only slightly over the reproductive season, ranging, for example, from 0.19-0.20 mm per day between March and May (Barnett and Sertic, 1980c). White croakers become increasingly competent fish during larval development, which ends at a length of about 19 mm and an approximate age of 14 weeks (Barnett and Sertic, 1980c) with transformation to the juvenile stage.

During early larval development white croaker are most abundant in the midwater and epibenthic strata shoreward of about 45 m depth, but this distribution contracts toward shore and toward the bottom with increasing larval age so that postflexion-stage larvae are most abundant in the epibenthic stratum shoreward of about 21 m depth (Barnett et al., 1984). Brewer and Kleppel (1986) suggested that small larval white croaker disperse upward into the water column at night, although Barnett et al. (1984) detected no evidence of daily vertical migration near shore at San Onofre.

Jahn et al. (1985) compared the vertical distribution of larval white croaker off Seal Beach with those of their major prey organisms and concluded that feeding cannot be the principal reason for these fish larvae to live in the epibenthic stratum, since some of the principal food organisms for the older, most epibenthic larvae were most abundant above the epibenthic stratum. Barnett and Sertic (1980b) reported that at San Onofre young white croaker larvae prey on a variety of items having both upper water column and epibenthic affinities (the epibenthic copepod Euterpina acutifrons and the predominantly midwater, bivalve veligers were especially favored), while the older, largely epibenthic larvae feed predominantly on epibenthic organisms such as mysids, gammaridean amphipods, and Euterpina acutifrons. Thus it appears that although feeding is probably not the only reason for moving into the epibenthos (avoidance of seaward dispersal is undoubtedly important too) it certainly must be an important contributor.

Larval white croaker are less abundant from San Onofre south to the Mexican border than they are farther north between Laguna Beach and Point Conception. In the San Onofre vicinity, long-term declining



trends have been noted the abundances of in both larvae and adults (e.g., DeMartini et al., 1985; Barnett et al., 1986). These declines may have been regional; for example, Love et al. (1986) showed some evidence for a regional decline nearshore in adult white croaker abundance from 1982-1984, possibly related to El Nino. They also noted a strong recruitment at San Onofre in 1984. DeMartini et al. (1985) suggested that the declining abundance of adults near San Onofre reflected poor recruitment during the early 1980s, and during El Nino probably included an emigration from the nearshore zone to cooler offshore waters. Love et al. (1986) likewise noted an emigration from the nearshore zone of several fish species during El Nino.

#### Cheilotrema saturnum

The black croaker is a small (to about 38 cm long) sciaenid that resides over the open sandy bottom and rocky areas of bays and near shore along the open coast; it often may be found in caves and large crevices in rocky reefs (Limbaugh, 1961; Feder et al., 1974; Eschmeyer et al., 1983). Juveniles typically school with juvenile sargo and salema in very shallow coastal water (1-5 m bottom depth); adults are more solitary and range farther from shore, to about 46 m depth although most occur shoreward of 15 m depth (Limbaugh, 1961; Feder et al., 1974).

Spawning is in spring and summer (Limbaugh, 1961); the small planktonic eggs hatch about 1-2 days after being spawned (Feder et al., 1974). The newly-hatched yolksac-stage larvae (about 1.7 mm long), like the newly hatched larvae of most species with small planktonic eggs, are little more than planktonic embryos with very limited swimming ability. Larvae metamorphose at about 15 mm, perhaps 8 weeks after hatching (assuming an average growth rate of 0.25 mm per day;

Parker and DeMartini, 1987). During the planktonic stage, larvae are located predominantly in midwater across the shelf to about the 45 m isobath (Barnett et al., 1985). The pattern analysis done in conjunction with the final BACI analysis, although based on few surveys for the older larvae, suggests that the larvae move shoreward as they develop (Figure D-195).

#### Menticirrhus undulatus

The California corbina is a large (to about 71 cm long) sciaenid of considerable sport fishery value. It occurs principally along the sandy shores of the open coast and in bays, from the surf zone to about 14 m depth, but most often at about 1-5 m depth (Feder et al., 1974; Eschmeyer et al., 1983).

California corbina matures at an age of about 2-3 years and may live at least eight years (Frey, 1971). Spawning is in summer (Frey, 1971; Feder et al., 1974) with highest larval abundance in the San Onofre region in August and September (Walker et al., 1987). The eggs are small and planktonic, like those of the other sciaenids, and probably have a similar incubation period (1-2.5 days). Newly hatched larvae are essentially planktonic embryos. Subsequent larval development may require about 7 weeks (assuming an average growth rate of 0.25 mm per day; Parker and DeMartini, 1987), with transformation to the juvenile by about 14 mm length.

During their planktonic existence, larvae tend to be most abundant in midwater shoreward of about 45 m depth (about 5.4 km from shore at SONGS) and in the neuston and epibenthos shoreward of the 1.2 m isobath (Barnett et al., 1985). The pattern analysis done in conjunction with the final BACI testing, although based on few observations for the older

larvae, suggests that the larvae move shoreward as they develop (Figure D-206). Small juveniles have been reported from nearshore waters about 1-3 m deep (Frey, 1971).

#### Paralabrax Species

The kelp and sand basses are large (to 56-72 cm long, depending on species) and highly valued nearshore sport fish (Eschmeyer et al. 1983). Four species occur along the southern California coast although only the kelp bass and the barred and spotted sandbasses are common. Since the larvae of these three species co-occur and closely resemble one another, they cannot be routinely separated with any certainty. Larvae that could be identified with some confidence from the San Onofre ichthyoplankton samples have predominantly been barred sandbass (P. nebulifer) and kelp bass (P. clathratus), with only a small proportion contributed by spotted sandbass (P. maculatofasciatus). Likewise, juveniles and adults in the San Onofre vicinity are predominantly barred sandbass and kelp bass (e.g., DeMartini et al., 1985).

Both kelp bass and barred sandbass are most abundant near shore at depths shallower than about 26 m, although they may range seaward to about 45 m (kelp bass) or 60 m (barred sandbass) depth. Barred sandbass live on or near rocky reefs; larger adults may prefer open sandy bottoms near reefs (Feder et al., 1974). Kelp bass, on the other hand, live in and around kelp beds although larger adults may occur in deeper rocky areas lacking algae cover (Feder et al., 1974).

All three Paralabrax species spawn small planktonic eggs from late spring through early fall (Smith and Young, 1966; Butler et al., 1982). At San Onofre, larvae are abundant only during the three month period from July through September (Walker et al., 1987).

The incubation period is about 1.5 days for kelp bass; the sand basses presumably require about the same amount of time. The planktonic yolksac-stage larvae of kelp bass are small (about 2.2 mm long) and poorly developed at hatching; the sand basses are similarly poorly developed and about the same size. Yolk absorption requires about four days in spotted sandbass and about five days in kelp bass. Subsequent larval development is rapid, requiring about another 3.5 weeks before transformation to the juvenile at about 11 mm length (Butler et al., 1982).

During the planktonic period, Paralabrax spp. larvae near San Onofre are most abundant in midwater and the neuston between the 12 and 45 m isobaths, but occur in all strata between the 6 and 75 m isobaths (Barnett et al., 1985). Lavenberg et al. (1986) noted that between Ormond Beach and San Onofre, larvae are most abundant shoreward of the 36 m isobath.

#### Hypsopsetta guttulata

The diamond turbot is a small to moderate size (to 46 cm long) flatfish that lives on muddy and sandy bottoms in bays and estuaries and along the open coast to as deep as 46 m (Eschmeyer et al., 1983). Although its feeding habits have not been described, they probably resemble those of other turbot (e.g., Allen, 1982), which are benthic searchers or stalkers feeding predominantly on infauna such as polychaetes and bivalves. The diamond turbot could, therefore, benefit from any increases of the infaunal populations near the SONGS diffusers. The diamond turbot is taken incidentally in sport and commercial fishery catches (Frey, 1971).

The diamond turbot spawns small planktonic eggs (Eldridge, 1975; Sumida et al., 1979) from spring through fall (Eldridge, 1975; Wang, 1981). Near San Onofre, larvae may occur in any month, but tend to be most abundant during spring (Walker et al., 1987). Newly hatched planktonic yolksac-stage larvae are small (1.6-2.0 mm long) and poorly developed, like the newly hatched larvae of most other species with small planktonic eggs. Subsequent growth and development to the benthic juvenile stage (about 11 mm length) may require about five weeks, assuming an average growth rate of 0.25 mm per day (Parker and DeMartini, 1987).

During their planktonic existence, diamond turbot larvae are most abundant in the neuston and midwater near shore (Barnett et al., 1984), over depths shallower than 22 m (within about 3.8 km from shore at San Onofre). Larvae occur only infrequently and in low numbers in the epibenthos or farther seaward (e.g., Barnett et al., 1985).

#### Paralichthys californicus

The California halibut is a large (to about 150 cm long; Miller and Lea, 1972) flatfish that is highly valued in both recreational and commercial fisheries, and has recently become the subject of considerable scientific interest, as well.

California halibut may be found in harbors, bays and estuaries, and along the open coast from just outside the surf zone offshore to depths of 183 m, although they tend to be most abundant shoreward of about 30 m (Eschmeyer et al., 1983; Frey, 1971). Smaller halibut tend to be more abundant at shallower depths, while larger ones tend to reside in deeper water. Halibut most often occur on sand bottoms (Eschmeyer et al., 1983), where they lie partly buried in order to ambush nektonic prey (Allen, 1982).

California halibut may live as long as 30 years. Females may mature and spawn as early as age 1 or 2, and all are mature by age 5 or 6 (Frey 1971). Halibut apparently spawn throughout the year, but with a peak in spawning activity during late winter and spring (Lavenberg et al., 1986; Walker et al., 1987). The small planktonic eggs hatch about 2.5 days after spawning; the newly-hatched larvae are small (about 2 mm long) and poorly developed, like the newly-hatched larvae of most species with small planktonic eggs. The yolk sac stage lasts about two days and the subsequent larval stage about another four weeks, until metamorphosis at a length of about 9-10 mm (Parker and DeMartini, 1987).

During their planktonic existence California halibut larvae occur almost exclusively in the coastal zone (Gruber et al., 1982); at San Onofre they are most abundant on average in midwater between the 9 m and 45 m isobaths (Barnett et al., 1984). The older larvae move inshore during metamorphosis (i.e., about 7-9 mm when one eye migrates from the future blind side to the future eyed side); highest concentrations of the oldest larvae occur shoreward of 9 m depth (Barnett et al., 1983a). Late larvae or early juveniles are thought to settle in bays, estuaries and coastal lagoons (Plummer et al., 1983).

#### Atherinopsis californiensis

The jacksmelt is a large (to at least 45 cm long) planktivorous member of the silversides (Atherinidae) family (Miller and Lea, 1972). Jacksmelt school, mainly near the surface, throughout the nearshore southern California Bight (Frey, 1971; Feder et al., 1974).

Jacksmelt live eight to eleven years, maturing and first spawning in their second or third winter, at a length of about 15-18 cm (Clark, 1929; Feder et al., 1974). Females spawn more than once during the

October through March or April spawning season (Clark, 1929). The large eggs are attached to one another by long intertwined filaments arising from the chorions, forming large masses which themselves are attached to an eelgrass or algal substrate. The incubation period is quite long: 17-19 days (at 12-14°C). Larvae are large (8-9 mm long) and well developed at hatching. The yolksac stage lasts about four days and the subsequent larval stage another 5-6 weeks (assuming an average daily growth rate of 0.25 mm/day; Parker and DeMartini, 1987) until transformation to the juvenile at a length of 18-19 mm.

Newly-hatched yolksac-stage jacksmelt larvae are capable of vigorous swimming, and move almost immediately into the neuston where they principally remain throughout the larval stage (e.g., Barnett et al., 1985). Feeding begins before yolk absorption is completed, and the distinction between yolksac and older preflexion-stage larvae is often unclear. Juveniles and adults are distributed much like the larvae in that they are typically most abundant near the surface, although they may range more deeply in the water column as well.

### Leuresthes tenuis

The California grunion is a small (to 19 cm long) member of the silversides family (Atherinidae) well known for its spawning behavior. This habit of spawning on sandy beaches is also largely responsible for the considerable sport fishery value of the grunion. Grunion typically remain nearshore (shoreward of about 18 m depth) where they school near the surface during the day. At night, they may disperse offshore to some extent (Allen and DeMartini, 1983).

California grunion mature at the end of their first year and may live as long as four years. The oldest fish are the earliest to spawn in

the March through August spawning season; younger fish begin to spawn in the middle of the season (Clark, 1925). Spawning is at approximately fortnightly intervals, beginning shortly after high tide between the second and sixth nights following the new and full moon (Thompson, 1919; Clark, 1925; Frey, 1971). Individual females may spawn up to about six successive times in a season (Frey, 1971), producing about 1,600-3,600 eggs each time (Clark, 1925). Larger females produce more eggs in each batch than the smaller females do. Eggs are deposited in the sand on the receding high spring tide and are covered more deeply by the successive high tides. The incubation period may be as short as 10 days (Clark, 1925), although hatching does not occur until the eggs are agitated, as they are at the next spring tide. Because of this tidal control, hatching normally is about 15 days after spawning, but it can be delayed as long as 30 days (Walker, 1952).

The newly-hatched larvae are relatively large (about 6.5-8.5 mm long) and well developed (Erlich and Farris, 1971; David, 1939). Yolk absorption requires about 3-5 days and subsequent larval development to the juvenile stage (about 16 mm length) is completed within about another 4-5 weeks (assuming an average growth rate of 0.27-0.30 mm per day: Erlich and Farris, 1971; Parker and DeMartini, 1987). Larvae move immediately to the neuston upon hatching, dispersing seaward throughout the neritic zone (shoreward of about the 75 m isobath), but tending to remain more abundant near shore. Older larvae remain almost exclusively neustonic but tend to become more concentrated near shore (shoreward of the 12 m isobath) by the postflexion stage.



Engraulis mordax

The northern anchovy is a small (less than 23 cm long) schooling fish that occurs throughout the Southern California Bight (it ranges from British Columbia to the tip of Baja California: Eschmeyer et al., 1983). The northern anchovy forms the basis of a reduction fishery and is highly valued as a bait fish in recreational fisheries (e.g., Frey, 1971; Sunada and Silva, 1980). Northern anchovy has been subjected to intense scientific scrutiny for a number of years as well (e.g., Kramer and Ahlstrom, 1968; Smith, 1972; MacCall, 1974; Lasker, 1978; Methot and Kramer, 1979; Hunter and Goldberg, 1980; Koslow, 1981; Fiedler, 1984; Schmitt, 1986).

Northern anchovies occur in dense schools during the day, usually near the surface during spring and deeper in the water in summer and fall (Frey, 1971). The schools disperse at night (Frey, 1971; Allen and DeMartini, 1983). Northern anchovies tend to be most abundant within about 30 km of shore, especially during spring and early summer months, but may range far out to sea, as well.

The northern anchovy feeds either by filtering zooplankton and phytoplankton when the potential food density is above a threshold level, or by biting large individual items such as fish larvae (Leong and O'Connell, 1969). When filtering, it takes larger items preferentially (Hunter and Dorr, 1982). Hunter and Kimbrell (1980) suggested that adult anchovies might inflict substantial predation mortality on their own eggs and larvae.

E. mordax lives approximately four years, maturing during its first or second year at a length of about 9-13 cm. Spawning occurs throughout the year, but with a broad peak from January through June (Kramer and Ahlstrom, 1968). Roughly 10-16% of the mature females spawn

each night during the peak spawning season (Hunter and Goldberg, 1980; Hunter and Macewicz, 1980); thus each female spawns on average somewhat less often than once per week, or up to twenty times per season. The batch fecundity ranges from 389-444 eggs per gram of female, or about 7,000 eggs per spawning, on average (Hunter and Macewicz, 1980). Eggs are larger in winter and smaller in summer (Hunter, 1976).

The small planktonic eggs hatch after an incubation period of 2.5-3.5 days (Hunter, 1976). The newly-hatched planktonic yolk sac stage larvae are small (2.5-3.5 mm long), poorly developed, and largely inactive (Hunter, 1976; Kramer and Zweifel, 1970). During the yolk sac stage, northern anchovy larvae may be highly susceptible to invertebrate predators (e.g., Lillelund and Lasker, 1971). The yolk sac stage lasts about two to four days, during which functional visual, respiratory, and feeding systems develop and swimming ability greatly improves (Hunter, 1972, 1976). Larvae must begin feeding within about 2.5 days after yolk absorption, although winter larvae have a little more time than summer larvae owing to their larger yolk reserve. Lasker (1975) showed that sufficient concentrations of suitable food items for first-feeding anchovies (e.g., dinoflagellates such as Gymnodinium) may occur relatively infrequently, but that such patches of food may be relatively more common near shore. Upwelling or local storms may disperse these food aggregations, increasing the likelihood of starvation (Lasker, 1978). O'Connell (1980) showed some evidence that anchovy larvae do starve in the sea, in localized areas interspersed with areas where the larvae are healthy. Hunter (1977) pointed out that larval size, water temperature, food distribution, and recent larval feeding history all interact to influence larval cruising speed, which itself interacts with a complex of variables to determine

the volume of water that can be searched and the response of a larva to any potential prey encountered, and thus determines whether the larvae feed or starve. Larval behavior is such that when a concentration of suitable food is encountered, the larvae tend to remain in it by frequently reversing direction rather than swimming straight ahead (Hunter and Thomas, 1974). Methot and Kramer (1979) concluded, on the basis of larval growth rates in the sea, that if anchovy larvae can find enough food to survive, they also have enough to grow rapidly.

Northern anchovy larvae off southern California grow at average rates ranging from 0.34-0.55 mm per day, with an overall average close to 0.37 mm per day (Methot and Kramer, 1979). Growth as measured by larval length is essentially linear during the preschooling larval period.

Northern anchovy larvae begin schooling well before transformation to the juvenile (about 35 mm). Schooling begins about three weeks after hatching, at a larval length of 11-12 mm, and is well established by about four weeks, at 13-15 mm (Hunter and Coyne, 1982). The beginning of schooling is concurrent with a number of structural and behavioral changes which together allow the anchovy larvae to function as micronekton rather than ichthyoplankton. The early onset of schooling is thought to reduce the susceptibility of individual northern anchovy larvae to predation, and to facilitate their search for food (Hunter and Coyne, 1982). Transformation to the juvenile stage is at about 35 mm, and is marked by events such as the initiation of filter-feeding and the beginning of the satiation response (Hunter and Coyne, 1982).

During their planktonic existence northern anchovy larvae off southern California tend to be most abundant in the coastal zone, but

may occur in high abundance anywhere in the Bight (e.g., Kramer and Ahlstrom, 1968; Hewitt, 1980). They usually dominate in both nearshore and offshore ichthyoplankton collections (e.g., Gruber et al., 1982; Loeb et al., 1983b; Lavenberg et al., 1986; Walker et al., 1987). Larvae are largely limited to the upper 45 m of the water column (Ahlstrom, 1959); in shallower coastal waters they occur predominantly in midwater except very near shore, where abundance is highest in the epibenthos (Barnett et al., 1984; Brewer et al., 1981; Schlotterbeck and Connally, 1982). Although northern anchovy larvae larger than 10 mm typically migrate to the surface at night to fill their swimbladders (Hunter and Sanchez, 1976), Barnett et al. (1984) detected no evidence of daily vertical migration near shore at San Onofre, possibly because their catches were dominated by the smaller non-migrating size classes. Brewer and Kleppel (1986) suggested that larger northern anchovy larvae may migrate upward at night near shore in Santa Monica Bay.

At San Onofre the older larvae tend to be more concentrated nearer shore (shoreward of the 45 m isobath) than the younger larvae, which remain abundant to 75 m depth or beyond (Barnett et al., 1984). Lavenberg et al. (1986) noted that the mean annual abundance of northern anchovy eggs in the nearshore zone is lower at San Onofre than it is farther to the north, although no such trend is apparent for the larvae. Barnett et al. (1984) likewise remarked that there were far too few northern anchovy eggs near shore at San Onofre to account for the numbers of larvae. Both Barnett et al. (1984) and Lavenberg et al. (1986) concluded that because of the discrepancy between numbers of anchovy eggs and larvae near shore at San Onofre, most of the larvae must have come from outside the area.

Citharichthys spp.

Four species of sanddabs occur off the southern California coast. Three of these, the speckled sanddab (Citharichthys stigmaeus), longfin sanddab (C. xanthostigma), and Pacific sanddab (C. sordidus) are common in the San Onofre area. The larvae of all three closely resemble one another in their early stages and were not routinely separated in the MRC ichthyoplankton studies. Identifiable early larvae most often were speckled sanddabs, although late larvae and newly-settled juveniles of all three species were also occasionally identified.

The adults of all three sanddab species occupy a broad depth range: speckled and longfin sanddabs may occur very near shore at depths as shallow as 2 m, but also range seaward to 200-400 m depth, while Pacific sanddabs range from 9-549 m depth (Eschmeyer et al., 1983). Speckled sanddabs typically are found nearer shore and Pacific sanddabs farther from shore among these three species.

All three of these flatfish species reside principally on soft bottom (Allen, 1982). All three sanddabs are generalist feeders, taking a variety of benthic infauna, epifauna, and plankton (Allen 1982). Pacific sanddab has some commercial fishery value in central and northern California, but all three have little commercial or sport value in southern California (Feder et al., 1974).

Sanddabs may live three (speckled sanddab: Feder et al., 1974) to eight (Pacific sanddab: Arora 1951) years, maturing in their second (speckled sanddab) or third (Pacific sanddab) year. Speckled and Pacific sanddabs spawn in summer (e.g., Arora, 1951; Feder et al., 1974), while longfin sanddabs spawn in winter (Goldberg, 1982). Females probably spawn more than once per season, but the number of times is unknown (Arora, 1951; Goldberg, 1982).

The planktonic eggs are very small and the newly-hatched yolksac stage larvae are small and poorly developed, like the newly hatched larvae of most species with small planktonic eggs. The incubation period, duration of the yolksac stage, and duration of the subsequent planktonic larval stage are all unknown. Sanddab larvae are large at metamorphosis (>30 mm) and thus may have an extended pelagic larval stage. Sanddab larvae occur in all months, but usually are most abundant in late winter-spring and again in late summer-fall, presumably reflecting the different peak spawning seasons (Walker et al., 1987; Ahlstrom and Moser, 1975).

Larvae occur in nearshore waters and far to sea (Ahlstrom and Moser, 1975; Barnett et al., 1984; Gruber et al., 1982). In the San Onofre vicinity, they are most abundant in midwater, from the 6 m isobath seaward to 75 m depth or beyond (Barnett et al., 1985). Gruber et al. (1982) and Barnett et al. (1984) noted that sanddab larvae tend to be more abundant seaward at depths greater than 22 m than they are closer to shore.

#### Hypsoblennius spp.

The three California blenny species, Hypsoblennius gentilis, H. gilberti, and H. jenkinsi, are all included in the taxon Hypsoblennius spp.. Larvae of these species cannot be adequately separated at lengths smaller than about 10 mm, well into the postflexion stage. Identifiable postflexion stage larvae taken off San Onofre during the MRC study were predominantly mussel blennies, H. jenkinsi. Rockpool blennies (H. gilberti) also occurred in modest numbers but bay blenny larvae (H. gentilis) were rare.

Adults of all three species are small, demersal epifaunal pickers. All shelter within crevices in rocky areas, in empty mussel and clam shells, etc. Rockpool blennies range from tidepools to 18 m depth while mussel blennies are subtidal to 21 m depth (Eschmeyer et al., 1983).

All three Hypsoblennius species spawn adhesive eggs in a nests guarded by the male parent. H. jenkinsi nests may contain well over 10,000 eggs, representing multiple spawnings of about 300-650 eggs each by several different females (Stevens and Moser, 1982; Losey, 1968). The incubation period is quite long: up to 22 days (at a temperature of 15-18°C). Larvae are small at hatching (about 2.5 mm long) but relatively well developed, as is typical of larvae hatching from demersal eggs. Subsequent larval development requires about 6-9 weeks until settlement from the water column and transformation to the juvenile at about 15 mm (H. jenkinsi) to about 22 mm (H. gilberti), assuming an average larval growth rate of 0.29 mm per day (Parker and DeMartini, 1987; Stevens and Moser, 1982). Throughout larval life Hypsoblennius spp. are located predominantly in the neuston and midwater from very near shore to beyond the 75 m isobath (Barnett et al., 1984; Stevens and Moser, 1982). Larvae are most abundant from spring through fall (Walker et al., 1987).





## APPENDIX A.2

### Glossary of Special Use Terminology

The following list of terms and definitions is intended to cover special or particular uses of terms which are either peculiar to the MRC contractor language, have meanings in the SONGS context differing from normal use or have evolved specific or restricted meanings over the course of this project. It is not intended to cover all technical terms used in this report. Some of these terms are further defined in context within this report and its appendices, or in prior MEC reports. For terms whose definitions have changed over time, the meaning presented here refers to this report.

**After:** the time period of monitoring sample collection following initial full power operation of Unit 3 (Unit 2 had already been brought up to full power) and with or without operation of Unit 1; the actual dates vary by organism assemblage because they are based on a presumption of whether the organisms might respond immediately (instantaneous) or in integrated fashion (cumulative) to SONGS conditions. For ichthyoplankton and macrozooplankton the After period begins 1 July 1983 (see Figure 1-3). The After period, often referred to as the "Operational Period" is a continuous time span from its initiation noted above through the present and into the future.

**Before:** the time period of monitoring sample collection before December 1981, with or without operation of Unit 1. After that time, Unit 2 cooling operations comprised both circulation through

the cooling system and a heated discharge; the length of the Before period varies by monitoring group (see Section 2); for some groups it includes both preconstruction and construction period sampling, with construction referring to that of the ocean portion of the cooling systems of Units 2 and 3.

Control Area: the most proximate and similar habitat for monitoring sampling to the Impact Area which is sufficiently remote from the intake/discharge structures of Units 2 and 3 to be (hypothetically) beyond their withdrawal, entrainment or discharge influences; the locations vary by monitoring group; Control areas for MEC ichthyoplankton and plankton projects are given in Section 2.

Cooling System: the complete once-through circulating seawater system at SONGS including the intake structures, conduits, screenwells, pumps, condensers, discharge structures and all the additions to and removals from that system including the additions of waste heat, chemicals and radionuclides.

Delta: the difference between the Control and Impact values of each of a set of cells during each survey; this is the basic variate of the BACI analysis; the means of the Before and After Deltas are the values compared in the BACI t-test. The cells are abundance values of individual taxa, functional subsets of taxa or pools of taxa; the composition of cells vary with each monitoring group.

Entrainment: the process of capturing and relocating parcels of water (the "entrained water") and portions of those parcels' biota by the flow of discharged water through the receiving water in the immediate vicinity of the discharge ports. Entrainment results from the friction between the relatively high speed of the

discharged water and the relatively low speed and differing direction of the receiving water; see "Withdrawal" for comparison; at SONGS Units 2 and 3 Entrainment results in the upward and offshore translocation of near-bottom water and midwater and some of its biota.

Impact: a regionally significant result of a SONGS effect (equals significant effect).

Impact Area: Potential Impact Area the area for monitoring sampling within the definable withdrawal, entrainment or discharge influence of the SONGS Units 2 and 3 intake and discharge structures; the locations of Impact Area stations vary with monitoring group; Impact Areas for MEC ichthyoplankton and plankton projects are given in Section 2.

Interim: referring to the period between commencement of the sample collections following the first persistent heat generating operations of Unit 2 in January 1982 and the first qualifying Instantaneous Effects sample period following startup of Unit 3 or the first qualifying Cumulative Effects sample period, depending upon the monitoring group; Interim dates are between 1 December 1981 and 1 July 1983 for ichthyoplankton and macrozooplankton.

Mechanism: the physical, chemical and/or biological changes in the entrained or receiving water body produced by the plant source, including the biological process by which the changes act to create the potential effects.

Monitoring Group: the taxonomic or functional group comprising one of the four MEC subprojects, i.e., zooplankton, ichthyoplankton, mysids and soft-bottom benthos.

Net Relative Effect: a measurable change in one or more Impact Area populations as determined by the BACI analysis resulting from one or any combination of SONGS operations related mechanisms. Net relative change can result from a change in the mean abundance at Control in the operational period unaccompanied by a change in SONGS abundances, as well as changes in After SONGS abundances.

Operational: referring to the specific periods after 1 July 1983 or surveys during the After Period. Unit 1 may or may not have been operating in the period leading up to any given Operational sample collection.

Plant: the physical power plant facility including the reactor, turbines and cooling system.

Plant Source: the design or operational feature which produces the potential effect.

Potential Effect: the translation of the mechanism on the biota to a gain or loss in population of affected species; by MRC definition, the result would be a BACI effect if the change were statistically significant on a local scale; it would be an impact if it were also significant on a regional scale.

Preoperational Monitoring: referring to the period before the first persistent heat generating operations of Unit 2; the duration backward in time varies with monitoring group; specific dates of the Preoperational samples are given for each group in Section 2.

Preoperational: refers to Preoperational Monitoring samples and to baseline and Unit 1 effects studies samples which were not taken in the SONGS/Control configuration and are therefore not appropriate or needed for the BACI analysis; the number and dates vary with monitoring group.

Significant BACI Effect: a significant t-test result of the difference of means of the Before and After pools of Deltas. Type one (= alpha) errors are set at 0.05 or 0.10 depending on the predetermined power of the test. The t-test is one-tailed for ichthyoplankton (i.e., we were considering only cross-shelf decreases) and two-tailed for macrozooplankton.

SONGS Effect: a detectable change in the Impact Area populations which can be ascribed to a Plant source and/or mechanism.

SONGS Operations: partial or complete, normal or non-normal working of the cooling system including such aperiodic operations as heat treatment and chlorination.

Taxa: taxonomic groupings and/or pools of taxa used in the BACI analysis.

Withdrawal: the capture of parcels of water (the "withdrawn water") and portions of their included biota at the intake structures as a result of the operation of the circulating seawater pumps of the cooling system.



## APPENDIX C.2

### Application of Statistical Analyses to Clevelandia ios

A step-by-step description of the application of the BACI, binomial, and pattern analyses to the abundance data for Clevelandia ios is given below as an example of the procedure used to arrive at the results and conclusions reached for each ichthyoplankton and macrozooplankton taxon analyzed. The protocol detailed in Appendix C.1 was followed in the BACI testing; the rationale for these procedures is given in the main body of the text in Section 3.

1. The untransformed preoperational data and a suite of log-transformations of that data were tested to see whether they met the BACI assumptions for additivity, lack of serial correlation, and lack of time trends in the preoperational period Delta values. Because the outcome of the BACI analysis is often determined by the nature of the transformation applied, the results based on untransformed data were always preferred over all others whenever the requisite assumptions were met for the nontransformed data. For C. ios larvae, the untransformed data met all requisite assumptions except additivity. This did not immediately disqualify use of the untransformed data; instead two additional procedures were applied to further examine the failure to meet the additive model.
2. The first additional procedure applied to the untransformed data was removal from the data set of all sampling dates with a zero occurrence at either SONGS or Control (simultaneous zero

occurrences at both locations were deleted prior to the initial assumption testing and were not used in the BACI analysis). The assumption of additivity was then retested. The untransformed C. ios data again failed the test and the second procedure was applied (if deletion of zeros had yielded additivity, the use of untransformed data would have been accepted and the second procedure would not have been applied).

3. The second procedure used to examine the failure of untransformed data to fit the additive model involved examination of regressions of Delta vs. the sum (SONGS and Control) to identify influence points that could be forcing nonadditivity (for example see Figure C.1-3). One such point was present in the C. ios preoperational set: 10 March 1980 (Figure C.2-1). This datum was deleted and the assumption of additivity was retested (zeros at one location were not deleted). The assumption was now met and the untransformed data were thus accepted for BACI analysis.
4. The  $\alpha$ -level for the BACI test on untransformed data was set at 0.10. This level was selected over the more traditional 0.05-level because power at  $\alpha = 0.05$  was 0.14, far less than the desired 0.80. Power was 0.24 at  $\alpha = 0.10$ . At this power we had a poor chance of detecting a change in relative abundance of half the magnitude of the average Before Delta if there was one. Thus, we were restricted to detecting only large (e.g., larger than the absolute values of the average Before Delta) changes for this species.
5. After going through this series of assumption testing and rejection level setting procedures, the nonparametric Wilcoxon BACI test on untransformed data was done. The zero occurrence (at



one location) data were included, as was the influence datum, 10 March 1980. Inclusion of these serves to increase variability, in effect giving a more conservative test. The BACI result indicated a significant ( $p = 0.05$ ) negative change in relative abundance. Even though there was little power to recognize such a change, it was sufficiently large to be detected.

Examination of mean untransformed abundance values showed a small decrease in abundance at SONGS coupled with a large increase at Control:

	Preoperational Period	Operational Period	Percent Change in Abundance
SONGS	0.79/400 m <sup>3</sup>	0.49/400 m <sup>3</sup>	- 38
Control	0.90/400 m <sup>3</sup>	3.04/400 m <sup>3</sup>	+238

6. Results of BACI tests on other data treatments that met the requisite assumptions of the BACI model were examined to determine whether they conformed with the result for the principal BACI test. For C. ios, the  $\log(x)$ ,  $\log(x + 0.1)$  and  $\log(x + 1)$  transformations met all assumptions except that of no serial correlation of Deltas. The  $\log(x)$  transformation was unacceptable, however, because too many surveys were deleted with this transformation (8 preoperational and 4 operational surveys). The  $\log(x + 0.1)$  transformation yielded higher power than  $\log(x + 1)$ : 0.34 vs. 0.28 for  $\alpha = 0.10$ . The autoregressive errors procedure (AUTOREG) designed to deal with serial correlation indicated significant ( $p < 0.02$ ) first and third order autocorrelations; the third order model was selected as the best one on the basis of minimizing the root MSE (mean square error),

AIC (Akaike Information Criterion) and SBC (Schwartz Information Criterion) terms of the model. When the third-order autocorrelation was modeled, the procedure indicated a significant ( $p = 0.07$ ) decline in relative abundance, in accord with the principal BACI result.

7. To help interpret the BACI result, abundance at SONGS was plotted against abundance at Control for each monitoring period. If there was no effect, the two regression lines should have indistinguishable slopes and intercepts. For C. ios the slopes and intercepts were indistinguishable (Figure C.2-2). This implies that Deltas were not different between the two monitoring periods. However, examination of the SONGS vs. Control plot shows that high abundances at Control in the operational period were not matched by high abundances at SONGS, and that most Before values at both locations were grouped near the origin. This suggests that the monitoring periods were different, and that the nonsignificant test results were statistical artifacts.
8. Two additional BACI tests were applied to help determine whether any significant primary BACI results could be attributed to SONGS, or in the case of a nonsignificant primary result to help determine whether this was attributable to a relatively weak effect that may have only been detectable during periods when Units 2 and 3 were pumping at high volume and the discharge plume crossed the Impact site sampling transect. The operational period data set was thus subdivided into plume (discharge plume crossing the Impact transect) and non-plume (Units 2 and 3 not operating or discharge plume not crossing the Impact transect) subsets and reanalyzed. Since the data treatment of choice was based on preoperational

data, the same treatment used for the full operational data set was applied to these analyses. For the plume data set, a significant ( $p < 0.01$ ) result was obtained even though power was quite low (0.20 at  $\alpha = 0.10$ ). Mean abundances showed a small decrease at SONGS and a very large increase at Control:

	Preoperational Period	Operational Period Plume Dates Only	Percent Change in Abundance
SONGS	0.79/400 m <sup>3</sup>	0.66/400 m <sup>3</sup>	- 16
Control	0.90/400 m <sup>3</sup>	4.46/400 m <sup>3</sup>	+396

The non-plume data set yielded a nonsignificant result ( $p = 0.53$ ) associated with a decrease in abundance at SONGS and an increase at SONGS:

	Preoperational Period	Operational Period Plume Dates Only	Percent Change in Abundance
SONGS	0.79/400 m <sup>3</sup>	0.26/400 m <sup>3</sup>	- 67
Control	0.90/400 m <sup>3</sup>	1.49/400 m <sup>3</sup>	+ 65

9. As a further aid in evaluating the BACI result, the binomial test procedure was applied to determine whether the proportion of the total operational period SONGS + Control larval abundance that was contributed by SONGS was significantly less than the proportion contributed by SONGS to the preoperational period total. It was ( $p < 0.001$ ), thus supporting the BACI result.
10. In order to determine whether the observed change could be localized in any particular cross-shelf strata, a pattern analysis was done to compare the ranked abundance in each stratum containing larvae between SONGS in the operational period and the combination of preoperational SONGS plus all Control data. The

form of the test was thus "After SONGS" vs. "Before SONGS plus Control", and we looked for pattern shifts between these two sets. The analysis clearly distinguished abundance in Blocks A and B epibenthos (higher) from all other strata (lower), but did not distinguish between monitoring locations except to give a (nonsignificant) hint of a slightly more seaward distribution at SONGS in the operational period (Figure C.2-3). The center of abundance did not shift, however, and there appears to have been a general reduction in abundance at SONGS in the operational period relative to the "control" data set.

11. To determine whether the results for total C. ios were similar over all larval stages, or perhaps dominated by only a single stage, the entire suite of analyses was rerun, this time on abundances partitioned into preflexion, flexion and postflexion stage values.
12. The untransformed data for preflexion stage larvae again met all requisite assumptions except additivity.
13. When dates with a zero occurrence at either SONGS or Control were deleted and the additivity assumption retested, the untransformed data for preflexion stage larvae again failed the test.
14. Examination of the Delta vs. SONGS + Control regression for preoperational period data (Figure C.2-4) revealed that 7 July 1981 was an influence point. When this datum was deleted and the additivity assumption retested, the untransformed data again failed to meet the assumption. Thus use of the untransformed data was rejected.
15. The preferred data transformation is  $\log(x)$  since this transformation of the data is the most easily visualized and

understood in addition to fulfilling the primary goal of transforming the multiplicative model to an additive one. For C. ios preflexion stage larvae, the log (x) transformed data met all requisite assumptions of the BACI model. However, because there were many zero occurrences of preflexion stage larvae at one location or the other, the data sets using the log (x) transformation were very small: preoperational n = 8, operational n = 4. This is equivalent to discarding more than two-thirds of the data and was deemed unacceptable. Among the remaining transformations, the log (x + 0.1) and log (x + 1) transformations also met all requisite assumptions of the BACI model; power was slightly higher for log (x + 1) - transformed data than for the log (x + 0.1) transformation (0.14 vs. 0.12 at  $\alpha = 0.05$ ) and log (x + 1) was therefore selected as the most appropriate data treatment.

16. The  $\alpha$  level was set at 0.10 for the BACI t-test on log (x + 1) transformed data in order to maximize power (power = 0.14 at  $\alpha = 0.05$ ; power = 0.24 at  $\alpha = 0.10$ ).
17. The BACI t-test on the log (x + 1) transformed data set indicated an insignificant increase ( $p = 0.82$ ) in relative abundance of preflexion stage C. ios larvae.

Mean abundance decreased slightly at both SONGS and Control, from similar preoperational values to identical operational period values:

	Preoperational Period	Operational Period	Percent Change in Abundance
SONGS	0.32/400 m <sup>3</sup>	0.20/400 m <sup>3</sup>	- 36
Control	0.40/400 m <sup>3</sup>	0.20/400 m <sup>3</sup>	- 51

18. The log (x + 0.1)-transformed data likewise yielded a nonsignificant BACI result (p = 0.84).
19. The regressions of SONGS abundance on Control abundance for each monitoring period did not differ from one another (Figure C.2-5). Thus the conclusion that there was no effect for preflexion stage C. ios is supported.
20. The BACI analysis on the operational period plume data set yielded a nonsignificant result (p = 0.77) associated with small decreases in mean abundance at both SONGS and Control:

	Preoperational Period	Operational Period Plume Dates	Percent Change in Abundance
SONGS	0.32/400 m <sup>3</sup>	0.32/400 m <sup>3</sup>	- 2
Control	0.40/400 m <sup>3</sup>	0.25/400 m <sup>3</sup>	-37

Similarly, the BACI analysis on the non-plume data set yielded a nonsignificant result (p = 0.80) associated with larger decreases in mean abundance at both SONGS and Control:

	Preoperational Period	Operational Period Non-plume Dates	Percent Change in Abundance
SONGS	0.32/400 m <sup>3</sup>	0.11/400 m <sup>3</sup>	-66
Control	0.40/400 m <sup>3</sup>	0.15/400 m <sup>3</sup>	-64

21. The binomial test indicated that the proportion of the total preflexion stage C. ios larvae at SONGS in the operational period did not differ from the proportion in the preoperational period (p = 0.61).
22. The pattern analysis confirmed the conclusion of "no effect" for preflexion stage C. ios: no group of strata was clearly distinguishable from all others and the pattern in the operational

period at SONGS was essentially the same as that for the "control" data set, except that mean abundance was generally lower in all strata in the operational SONGS data set.

23. The untransformed data for flexion stage C. ios met all requisite BACI assumptions except that of additivity.
24. When dates with a zero occurrence at SONGS or Control were deleted and additivity retested, the untransformed data again failed the test.
25. The Delta vs. SONGS+Control abundance regression (Figure C.2-6) showed that the 10 March 1980 datum was an influence point. With this survey deleted the untransformed data fit the additive model.
26. The  $\alpha$ -level was set at 0.10 to maximize power (power < 10% for both  $\alpha = 0.05$  and  $\alpha = 0.10$ ).
27. The BACI nonparametric test indicated a significant ( $p < 0.01$ ) reduction in relative abundance from the preoperational to the operational period even though the power to detect such a change was very low.

This result was associated with a decline in mean abundance at SONGS and an increase at Control:

	Preoperational Period	Operational Period	Percent Change
SONGS	0.15/400 m <sup>3</sup>	0.06/400 m <sup>3</sup>	- 61
Control	0.17/400 m <sup>3</sup>	0.88/400 m <sup>3</sup>	+432

28. The log (x + 0.1)-transformed data also met all requisite BACI assumptions, as did the log (x + 1)-transformed data when the 10 March 1980 influence point was deleted. Power at  $\alpha = 0.10$  was 0.22 for the log (x + 0.1) transformation and 0.18 for the log (x + 1)

transformation. Examination of the results from the BACI t-test on log (x + 0.1)-transformed data and the Wilcoxon rank sums test on log (x + 1)-transformed data revealed a significant (both p < 0.01) decrease in relative abundance, in accord with the primary BACI result.

29. Surprisingly, even though the BACI test identified the change in relative abundance as significant the regressions of SONGS abundance on Control abundance did not differ in slope or intercept between monitoring periods. The usual interpretation for this result is "no effect". The plot (Figure C.2-7) showed that nearly all high abundance values occurred during the operational period at Control, and that most preoperational period values were grouped near the origin. We interpret this as showing that the periods were different and the nonsignificant result is a statistical artifact.

30. The BACI analysis on the plume data set indicated a significant (p < 0.01) decrease in relative abundance even though the power to detect such a change was less than 0.10. Mean abundance declined at SONGS while substantially increasing at Control:

	Preoperational Period	Operational Period	Percent Change
SONGS	0.15/400 m <sup>3</sup>	0.06/400 m <sup>3</sup>	- 60
Control	0.17/400 m <sup>3</sup>	1.29/400 m <sup>3</sup>	+681

The BACI analysis on non-plume dates, in contrast, did not yield a significant effect (p = 0.51) although again mean abundance decreased at SONGS while increasing at Control:



	Preoperational Period	Operational Period	Percent Change
SONGS	0.15/400 m <sup>3</sup>	0.07/400 m <sup>3</sup>	- 57
Control	0.17/400 m <sup>3</sup>	0.38/400 m <sup>3</sup>	+127

31. In accord with the BACI results, the binomial test indicated that the proportion of flexion stage larvae at SONGS in the operational period was significantly lower ( $p = 0.01$ ) than the expectation based on preoperational period data.
32. The pattern analysis did not indicate a shift at SONGS in the operational period (Figure C.2-3), but instead a generally lower mean abundance in all strata relative to the "control" data set. Thus the BACI effect is a general one rather than being localized in a particular stratum.
33. The untransformed data for postflexion stage C. ios larvae met all requisite assumptions except additivity.
34. When surveys with a zero occurrence at either SONGS or Control were deleted and the additivity assumption retested, the untransformed data again failed.
35. The regression of Delta on the sum of SONGS+Control abundance (Figure C.2-8) showed that the 10 March 1980 survey was an influence point. When this datum was deleted and the additivity assumption retested, the untransformed data once again failed and thus could not be used for BACI analysis.
36. The preferred data transformation,  $\log(x)$ , passed all assumption tests except that for serial correlation of Deltas. However, use of the  $\log(x)$  transformation required dropping of ten preoperational and five operational surveys and was considered unacceptable. Both the  $\log(x + 0.1)$  and  $\log(x + 1)$

transformations met all assumptions except that of no serial correlation in the operational period. The transformation with highest power was selected and retained for use with the autoregressive errors procedure rather than with the standard BACI t-test. Power was a little higher for the log (x + 0.1) transformed data than for the log (x + 1) transformation (0.18 vs. 0.13 at  $\alpha = 0.05$ ) and log (x + 0.1) was thus selected.

37. The  $\alpha$ -level was set at 0.10 to maximize power (power = 0.18 at  $\alpha = 0.05$ , power = 0.29 at  $\alpha = 0.10$ ).
38. The autoregressive errors procedure indicated that there was a significant first order autocorrelation; with this correlation modeled the decrease in relative abundance was significant ( $p = 0.07$ ).

This change was associated with a small decrease in mean abundance at SONGS and a larger increase at Control:

	Preoperational Period	Operational Period	Percent Change
SONGS	0.48/400 m <sup>3</sup>	0.32/400 m <sup>3</sup>	- 34
Control	0.56/400 m <sup>3</sup>	2.13/400 m <sup>3</sup>	+281

39. Application of the first order autoregressive errors model to the log (x + 1)-transformed data also revealed a significant decrease in relative abundance ( $p = 0.03$ ), in accord with the principal BACI result.
40. The regressions of SONGS abundance on Control abundance for each monitoring period did not differ from one another. However, examination of the raw data tended to concur with BACI result, for example, the SONGS vs. Control abundance plots (Figure C.2-9)

showed that high abundances (except 10 March 1980) occurred only at Control in the operational period, and that most preoperational period observations were clustered near the origin. Thus the two monitoring periods look different even though we were unable to statistically demonstrate this difference by the regression procedure.

41. When the operational period data were partitioned into plume and non-plume subsets, the serial correlation present in the full operational period data set was no longer present and the  $\log(x + 0.1)$ - and  $\log(x + 1)$ -transformed data met all requisite BACI assumptions for both subsets. The  $\log(x + 0.1)$  transformation yielded higher power (.25 at  $\alpha = 0.10$ , vs. 0.20 for  $\log(x + 1)$ ). The BACI t-test on the plume subset revealed a significant ( $p < 0.01$ ) reduction in relative abundance associated with a small decline at SONGS and a large increase at Control in mean abundance:

	Preoperational Period	Operational Period	Percent Change
SONGS	0.48/400 m <sup>3</sup>	0.41/400 m <sup>3</sup>	- 15
Control	0.56/400 m <sup>3</sup>	3.08/400 m <sup>3</sup>	+452

In contrast, the BACI t-test on the non-plume subset yielded a nonsignificant ( $p = 0.36$ ) result, although mean abundance again declined at SONGS while increasing at Control:

	Preoperational Period	Operational Period	Percent Change
SONGS	0.48/400 m <sup>3</sup>	0.16/400 m <sup>3</sup>	- 67
Control	0.56/400 m <sup>3</sup>	1.13/400 m <sup>3</sup>	+103

42. The binomial procedure indicated that the proportion of total postflexion stage larvae at SONGS in the operational period was significantly lower ( $p < 0.01$ ) than would have been expected based on preoperational period surveys. This is in accord with the primary BACI result.
43. The pattern analysis showed that abundance was consistently highest in Blocks A and B epibenthos in both monitoring periods at both monitored locations, but did not show a pattern shift at SONGS in the operational period (Figure C.2-3). Instead, mean abundance was generally lower across all strata at SONGS in the operational period.

### APPENDIX C.3

#### Application of Statistical Analyses to Gobiesox rhesodon

A step-by-step description of the application of the BACI, binomial, and pattern analyses as applied to Gobiesox rhesodon abundance data is given here as an example of the complete analytical procedure used to arrive at a conclusion of "no effect". These steps were followed for each ichthyoplankton and macrozooplankton taxon included in Section 4 of the Final Report. The reader is referred to Appendix C.1 for an outline of steps taken in the complete BACI analysis and to the main body of the report (Section 3) for descriptions of the analytic procedures and a discussion of their rationale.

1. The untransformed preoperational data and a suite of log-transformations of that data were tested to see whether they met the requisite BACI assumptions for additivity, symmetry, no serial correlation, and no temporal trends in the preoperational period Delta values. Only the non-transformed data and transformations meeting all the requisite assumptions could be considered in subsequent steps of the analysis. Non-transformed data were always preferred; among the transformations, the log (x) transformation was preferred over all others. For G. rhesodon, the untransformed data met the requisite preoperational assumptions.
2. Operational period untransformed data were tested to see whether they met the BACI assumptions of no serial correlation of Delta values. The data passed this test and therefore were used in the primary BACI analysis.

3. Other transformations were inspected for compliance with the BACI assumptions; those meeting all conditions were used in checks on the primary BACI test result. The  $\log(x)$  and all  $\log(x + C)$  transformations met all requisite assumptions; however, owing to the large number of zero occurrences at SONGS or at Control (mostly at Control), the data sets available for analysis with  $\log(x)$  were substantially reduced (from 34 preoperational and 22 operational surveys to 13 and 14 surveys, respectively). Loss of this much information was considered unacceptable and the  $\log(x)$  transformation was rejected.
4. The Type 1 error level ( $\alpha$ ) was set to maximize power for the selected primary data treatment. Since power was ca. 0.16 at the traditional  $\alpha = 0.05$  level for the untransformed data, the  $\alpha$  level was set at 0.10 (power increased to 0.27).
5. The BACI test indicated a non-significant ( $p = 0.76$ ) increase in relative abundance.

Examination of mean untransformed abundance values showed that abundance increased at both SONGS and Control, with the increase at SONGS larger:

	Preoperational Period	Operational Period	Percent Change
SONGS	0.65/400 m <sup>3</sup>	1.01/400 m <sup>3</sup>	+ 56
Control	0.36/400 m <sup>3</sup>	0.39/400 m <sup>3</sup>	+ 6

6. Results for the  $\log(x + C)$  transformations were also non-significant: all t-tests yielded  $p \gg 0.10$ . Thus the principal BACI result was confirmed.

7. To confirm the non-significant BACI result, abundance at SONGS was regressed against abundance at Control for each monitoring period. If there was no effect, the two regression lines should have statistically indistinguishable slopes and intercepts. They did. In fact, most points for both periods were near the vertical (SONGS) axis, indicating that larvae occurred mainly at SONGS in both monitoring periods (Figure C.3-1).
8. When the operational period data set was separated into plume (the discharge plume crossing the Impact transect) and non-plume (Units 2 and 3 not operating or discharge plume not crossing the Impact transect) subsets and analyzed using the same data treatment used for the full operational period data set, a non-significant ( $p = 0.41$ ) result was obtained for the plume subset. This was associated with increases in mean abundance at both SONGS and Control:

	Preoperational Period	Operational Period	Percent Change
SONGS	0.65/400 m <sup>3</sup>	0.71/400 m <sup>3</sup>	+ 10
Control	0.36/400 m <sup>3</sup>	0.55/400 m <sup>3</sup>	+ 51

A non-significant result was also obtained for the small ( $n = 5$ ) non-plume subset ( $p = 0.82$ ); this time associated with an increase at SONGS and decrease at Control:

	Preoperational Period	Operational Period	Percent Change
SONGS	0.65/400 m <sup>3</sup>	0.80/400 m <sup>3</sup>	+ 23
Control	0.36/400 m <sup>3</sup>	0.12/400 m <sup>3</sup>	- 66

9. The binomial test indicated that the proportion of total G. rhessodon larvae at SONGS in the operational period was not different from the expectation based on preoperational period values ( $p = 0.77$ ).
10. In order to determine whether an effect independent of abundance changes detectable by the BACI analysis might have occurred, a pattern analysis was performed to compare abundance in each cross-shelf stratum containing larvae between After-SONGS and Before-Control data sets. The analysis did not identify a significant pattern shift, but indicated that abundance tended to be highest in the nearshore epibenthos at both monitored locations in both monitoring periods (Figure C.3-2).
11. In order to determine whether the results for total G. rhessodon were similar over all larval stages, or perhaps were dominated by only a single stage, the entire suite of analyses was rerun again, this time on abundances partitioned into preflexion, flexion and postflexion stage values.
12. The untransformed data and all log transformations for preflexion stage larvae passed all the assumption tests for additivity, symmetry, no serial correlation and no trends in preoperational period Deltas. All except the  $\log(x)$  and  $\log(x + 0.1)$  transformed data failed the assumptions of no serial correlation in operational period Delta values. However, since the autoregressive errors procedure (AUTOREG) deals with serial correlation, the non-transformed data were considered acceptable. The large number of zero occurrences of preflexion stage larvae substantially reduced the data sets available for analysis using the  $\log(x)$  transformation (from 30 preoperational and 21



operational surveys to 10 and 12 surveys, respectively); therefore, the transformation used to confirm the primary result based on untransformed data was  $\log(x + 0.1)$ .

13. The  $\alpha$ -level was set at 0.10 in order to maximize power (power = 0.18 at  $\alpha = 0.05$ ; power = 0.29 at  $\alpha = 0.10$ ).
14. The autoregressive errors procedure identified no significant first, second, or third order autocorrelations and therefore was not used. The t-test with independent errors yielded a nonsignificant result ( $p = 0.52$ ).

This insignificant change was associated with small increases in mean abundance at both SONGS and Control:

	Preoperational Period	Operational Period	Percent Change
SONGS	0.57/400 m <sup>3</sup>	0.65/400 m <sup>3</sup>	+ 14
Control	0.25/400 m <sup>3</sup>	0.31/400 m <sup>3</sup>	+ 24

15. The t-test on  $\log(x + 0.1)$  transformed data gave a non-significant result ( $p = 0.40$ ), confirming the principal result.
16. The regressions of SONGS abundance on Control abundance for the two monitoring periods did not differ significantly in slope or intercept, again confirming the non-significant BACI result. Most values fell near the vertical (SONGS) axis of the plot, indicating that preflexion stage larvae usually occurred mainly at SONGS (Figure C.3-3).
17. When the operational period was partitioned into plume and non-plume subsets, the serial correlation present for non-transformed data in the full operational data set no longer existed. Thus non-transformed data were now amenable to the BACI t-test. The t-test

result for the plume subset revealed a significant reduction in relative abundance ( $p = 0.10$ ) which was confirmed by results for all  $\log(x + C)$ -transformed data (all  $p \leq 0.10$ ). This was associated with reduced mean abundance at SONGS and increased mean abundance at Control:

	Preoperational Period	Operational Period	Percent Change
SONGS	0.57/400 m <sup>3</sup>	0.24/400 m <sup>3</sup>	- 58
Control	0.25/400 m <sup>3</sup>	0.43/400 m <sup>3</sup>	+ 68

Inspection of the time plot of Deltas (Figure C.3-4) revealed considerable overlapping of preoperational and operational period Delta values, but also showed that the largest operational period values were never as high as the largest preoperational period values.

The t-test on non-plume dates yielded a nonsignificant result ( $p = 0.68$ ) which was confirmed by the t-test on  $\log(x + C)$  transformed data (all  $p \gg 0.10$ ). Owing to the small size of the non-plume data set ( $N = 5$ ), the statistical tests were probably meaningless. Mean abundance increased at SONGS while decreasing at Control:

	Preoperational Period	Operational Period	Percent Change
SONGS	0.57/400 m <sup>3</sup>	0.66/400 m <sup>3</sup>	+ 17
Control	0.25/400 m <sup>3</sup>	0.08/400 m <sup>3</sup>	+ 68

The time plot of Delta values (Figure C.3-5), except for the dearth of operational period values, looked very much like the plume plot; again, the highest non-plume operational period Delta values were never as high as the largest preoperational period values.

18. The binomial test on preflexion stage larvae indicated that the proportion of total preflexion stage larvae at SONGS in the operational period was not different from the proportion at SONGS in the preoperational period ( $p = 0.45$ ).
19. The pattern analysis did not indicate a shift in cross-shelf distribution in the operational period at SONGS relative to the Before-Control set. Preflexion stage larvae were most abundant in the nearshore epibenthos at both SONGS and Control in both monitoring periods.
20. The untransformed data for flexion stage larvae met the requisite assumptions of no serial correlation and no trends in preoperational period Delta values, but failed the assumption of additivity. When dates with a zero occurrence at either SONGS or Control were deleted and the additivity assumption retested, the untransformed data met this assumption. Non-transformed data also passed the assumption test for no serial correlation of Deltas in the operational period. All  $\log(x + C)$  met the requisite BACI assumptions and were suitable for t-testing as a confirmation of the primary result based on the non-transformed data.
21. Because power was only 0.15 at  $\alpha = 0.05$ , the BACI  $\alpha$ -level was set at 0.10 in order to increase power (to 0.24).
22. The BACI t-test results (with the surveys having a zero occurrence at either SONGS or Control reinstated) showed a non-significant change ( $p = 0.65$ ) in relative abundance.

Mean abundance increased at both SONGS and Control:

	Preoperational Period	Operational Period	Percent Change
SONGS	0.17/400 m <sup>3</sup>	0.31/400 m <sup>3</sup>	+ 76
Control	0.03/400 m <sup>3</sup>	0.10/400 m <sup>3</sup>	+230

23. The t-tests on  $\log(x + C)$  transformed data confirmed the non-significant principal result (all  $p \gg 0.10$ ).
24. The regression lines of SONGS abundance on Control abundance did not differ in either slope or intercept between monitoring periods, confirming the BACI test result of no change between monitoring periods. Again, the data points nearly all fell along the vertical (SONGS) axis (Figure C.3-6).
25. The BACI t-test on non-transformed data for plume dates yielded a non-significant ( $p = 0.52$ ) result (confirmed by tests on all  $\log(x + C)$  transformations), associated with an increase in mean abundance at SONGS and a larger increase at Control:

	Preoperational Period	Operational Period	Percent Change
SONGS	0.17/400 m <sup>3</sup>	0.31/400 m <sup>3</sup>	+ 76
Control	0.03/400 m <sup>3</sup>	0.15/400 m <sup>3</sup>	+399

Inspection of the time plot of Delta values revealed no reason to doubt this result: there was no indication whatsoever of a difference between monitoring periods (Figure C.3-7).

The BACI t-test on untransformed data for the non-plume subset also yielded a nonsignificant ( $p = 0.42$ ), and owing to the small non-plume data set ( $N = 4$ ), probably meaningless result. Mean abundance decreased a little at SONGS and increased a little at Control:

	Preoperational Period	Operational Period	Percent Change
SONGS	0.17/400 m <sup>3</sup>	0.15/400 m <sup>3</sup>	- 16
Control	0.03/400 m <sup>3</sup>	0.03/400 m <sup>3</sup>	+ 15

26. The binomial test indicated that the proportion of flexion stage larvae at SONGS in the operational period was not different from the expected proportion based on preoperational surveys ( $p = 0.34$ ).
27. The pattern analysis for flexion stage larvae indicated a significant ( $p < 0.01$ ) shift in pattern during the operational period at SONGS; however, inspection of the patterns (Figure C.3-2) did not reveal a striking difference in pattern between the operational SONGS and Before-Control data sets. A slight seaward shift in the area of highest abundance was apparent at SONGS in the operational period.
28. For postflexion stage larvae the untransformed data passed the assumption tests for additivity, no serial correlation and no trends in preoperational period Delta values. The untransformed data also met the assumption of no serial correlation in the operational period. The  $\log(x + C)$  transformations were suitable for confirmatory tests.
29. Because the power at the traditional  $\alpha = 0.05$  level was very low ( $< 0.10$ ), the  $\alpha$ -level for the BACI test was set at  $\alpha = 0.10$ .
30. The BACI t-test result on the untransformed data indicated a non-significant ( $p = 0.85$ ) change in relative abundance. The t-test on  $\log(x + C)$ -transformed data likewise yielded non-significant results (all  $p \gg 0.10$ ), confirming the primary result.

Mean abundance changed little between monitoring periods at Control, but increased substantially at SONGS if the 23 August 1984 datum was included, or increased much less if that datum was excluded:

	Preoperational Period	Operational Period	Percent Change
SONGS	0.04/400 m <sup>3</sup>	0.34/400 m <sup>3</sup>	+820
SONGS (excluding 23Aug84)		0.06/400 m <sup>3</sup>	+ 66
Control	0.04/400 m <sup>3</sup>	0.04/400 m <sup>3</sup>	- 6

31. The regressions of SONGS abundance on Control abundance for the two monitoring periods yielded statistically indistinguishable lines (Figure C.3-8), supporting the interpretation of no change between monitoring periods.
32. The BACI t-test on non-transformed plume data yielded a nonsignificant result ( $p = 0.84$ ) which was confirmed by the t-test on  $\log(x + C)$  transformed data (all  $p \gg 0.10$ ). Mean abundance increased greatly at SONGS owing to the 23 August 1984 datum, and was virtually unchanged at Control:

	Preoperational Period	Operational Period	Percent Change
SONGS	0.04/400 m <sup>3</sup>	0.44/400 m <sup>3</sup>	+1054
Control	0.04/400 m <sup>3</sup>	0.04/400 m <sup>3</sup>	+ 1

We consider this difference in mean abundance changes to be meaningless.

A statistical test was not performed on the non-plume subset of the operational data for postflexion stage larvae because the non-plume data set contained only two observations. Mean abundance increased 11% at SONGS and decreased 2% at Control, but owing to the very low abundance values and small sample size we consider this difference meaningless.

33. The binomial test result was non-significant ( $p = 0.73$ ), indicating that the proportion of the total postflexion stage

larvae at SONGS in the operational period did not differ from the proportion at SONGS in the preoperational period.

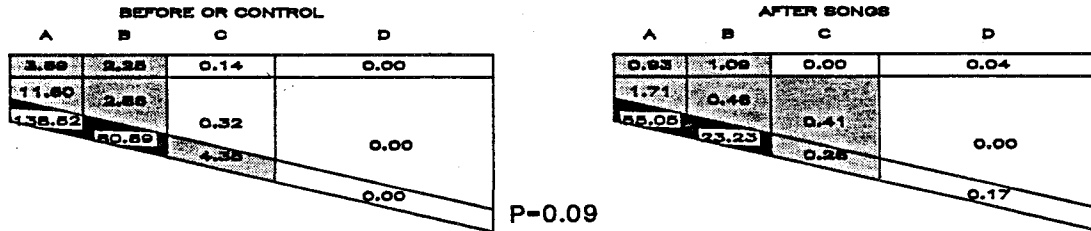
34. In order to determine whether an effect independent of abundance changes detectable by the BACI analysis might have occurred, a pattern analysis was performed. This analysis showed a significantly higher abundance of postflexion larvae in the nearshore epibenthos but it did not distinguish between monitored locations or monitoring periods. There was a suggestion of a slight seaward shift or excess of larvae in the more seaward epibenthos at SONGS during the operational period, but this shift was small enough to remain undetectable by the BACI analysis.





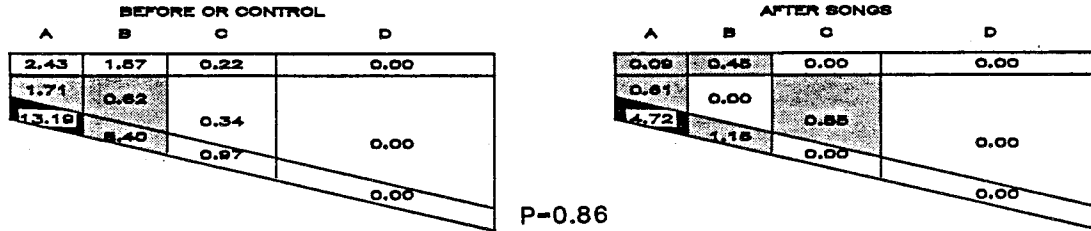
# Clevelandia ios

## larvae



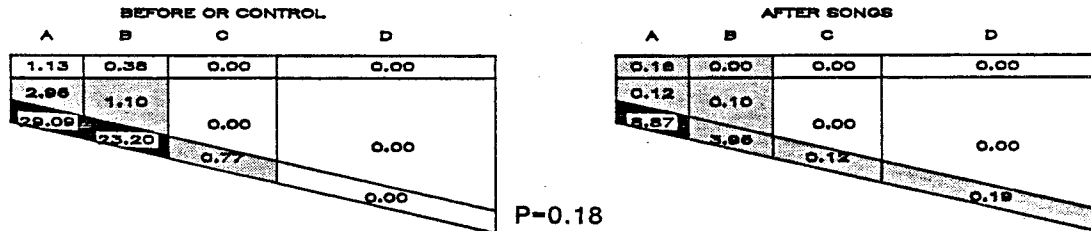
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## preflexion



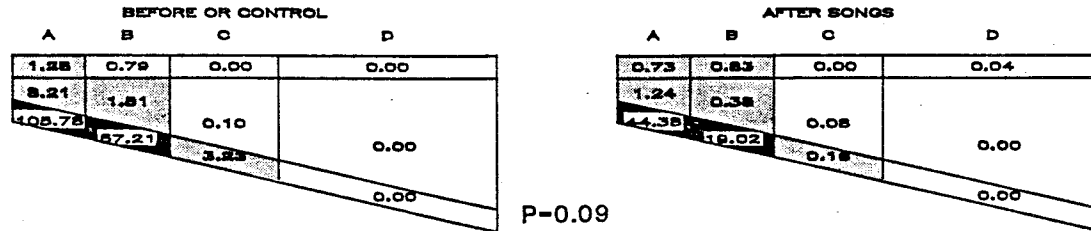
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## flexion



ae AE be BE am AM BM DE AN OE bm BN oe an bn de

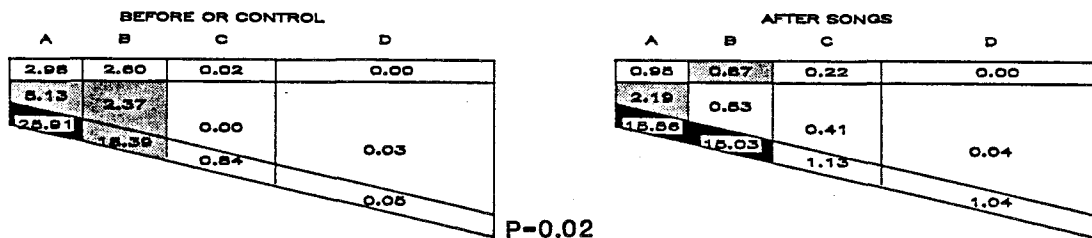
## post-flexion



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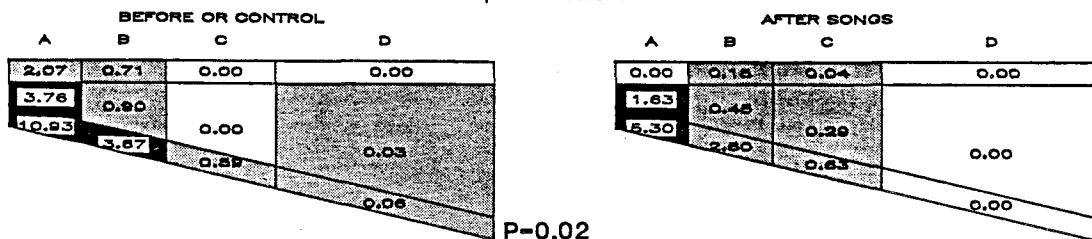
Figure D-6 . Cross-shelf distributional patterns for *Clevelandia ios*. Shading denotes strata groupings based on the results of the Bonferroni t-test. Strata designations are ordered from highest to lowest mean rank abundance. Strata not significantly separable are underlined. Upper case strata designations (e.g., AM=Block A midwater) are for SONGS in the After data set, lower case are strata in the Before-Control data set (SONGS in the Before period and Control in both periods). Only strata in which larvae occurred were tested. The results of the MANOVA are also shown.

Quietula y-cauda  
larvae



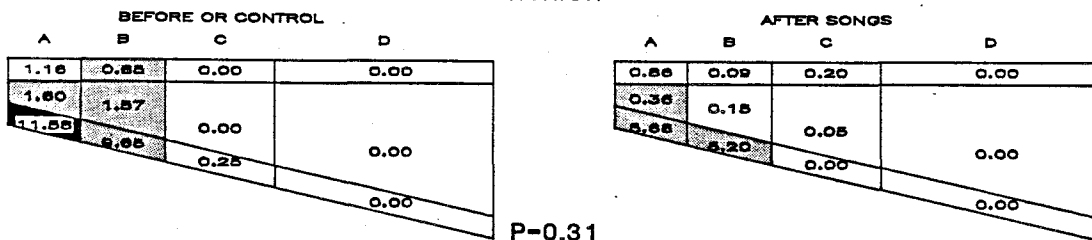
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preflexion



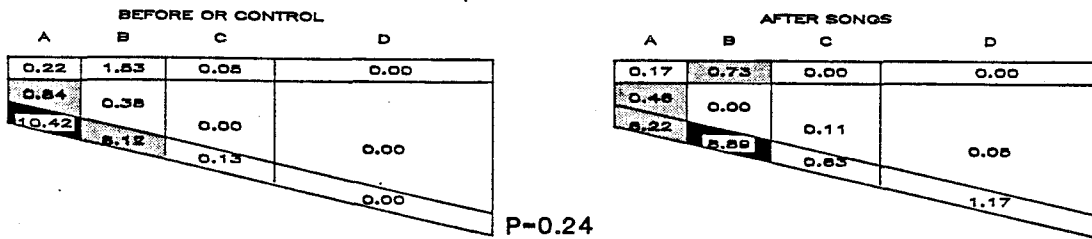
AE ae am be AM BM BE bm CE CM BN an bn ee dm CN de em en AN DE DM

flexion



ae AE be BE am AM bm bn CN AN BM BN an CM ee CE em en

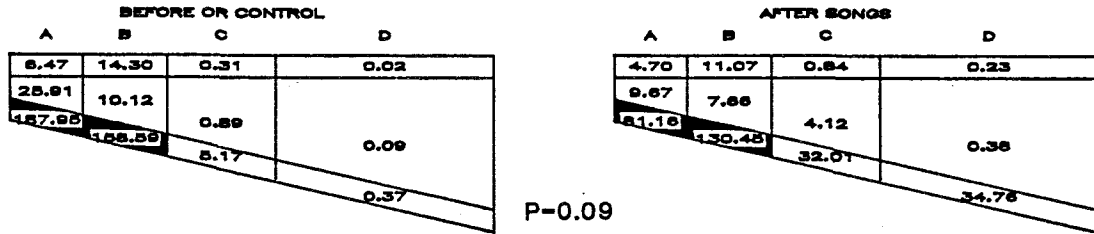
post-flexion



BE ae be AE BN am AM an bn bm ee DE CE CM AN DM en em de dm BM CN

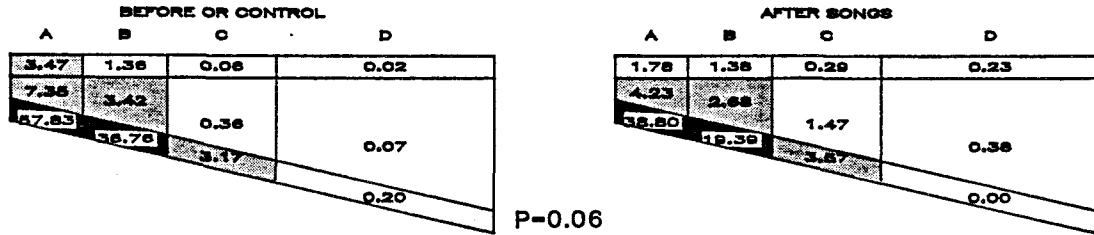
Figure D-27. Cross-shelf distributional patterns for Quietula y-cauda. Shading denotes strata groupings based on the results of the Bonferroni t-test. Strata designations are ordered from highest to lowest mean rank abundance. Strata not significantly separable are underlined. Upper case strata designations (e.g., AM=Block A midwater) are for SONGS in the After data set, lower case are strata in the Before-Control data set (SONGS in the Before period and Control in both periods). Only strata in which larvae occurred were tested. The results of the MANOVA are also shown.

*Ilypnus gilberti*  
larvae



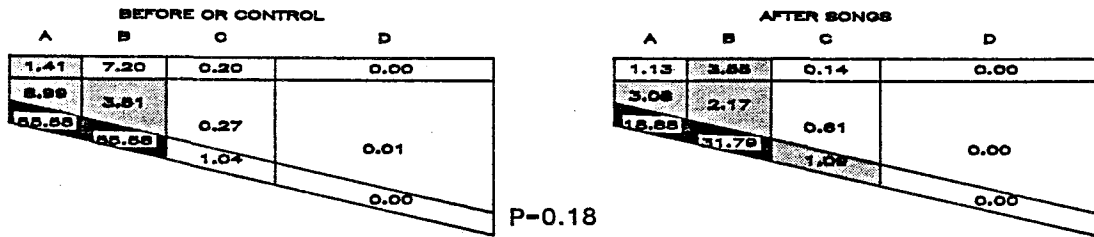
BE ae AE be AM CE am BM bm BN ce an bn AN em CM en de dm dn ON DM DE DN

preflexion



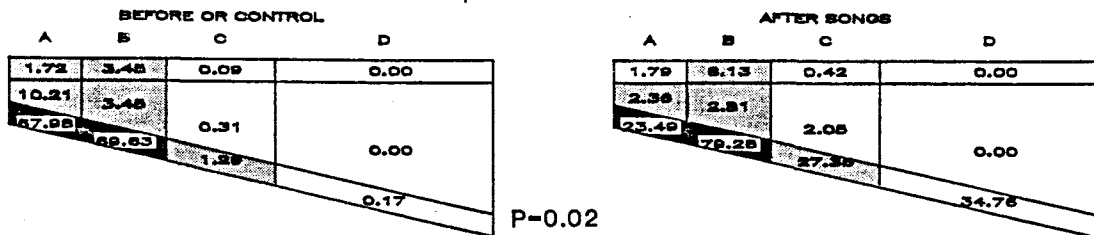
AE BE ae be AM am BM bm CE ce an bn BN AN CM em CN de en dm dn DM DN DE

flexion



ae BE AE be AM am BN BM bm an CE bn ce AN CM em en dm CN DM

post-flexion



BE ae AE be CE am BM bm AM BN an ce bn AN em de en CM DE CN

Figure D-48 . Cross-shelf distributional patterns for *Ilypnus gilberti*. Shading denotes strata groupings based on the results of the Bonferroni t-test. Strata designations are ordered from highest to lowest mean rank abundance. Strata not significantly separable are underlined. Upper case strata designations (e.g., AM=Block A midwater) are for SONGS in the After data set, lower case are strata in the Before-Control data set (SONGS in the Before period and Control in both periods). Only strata in which larvae occurred were tested. The results of the MANOVA are also shown.

Gobiesox rhesodon  
larvae

BEFORE OR CONTROL

A	B	C	D
0.04	0.08	0.18	0.00
1.38	0.90		
41.84	18.84	0.32	0.18
		2.07	
			1.00

AFTER SONGS

A	B	C	D
0.00	0.00	0.00	0.00
3.12	3.60		
13.42	28.27	0.14	0.20
		29.81	
			0.00

P=0.11

BE CE be AE ae oe BM am AM bm em de dm bn en an CM DM AN BN CN DE

preflexion

BEFORE OR CONTROL

A	B	C	D
0.05	0.03	0.18	0.00
0.99	0.74		
10.95	12.84	0.34	0.12
		1.82	
			0.41

AFTER SONGS

A	B	C	D
0.00	0.00	0.00	0.00
2.97	2.47		
12.78	21.52	0.15	0.00
		18.07	
			0.00

P=0.55

BE AE be ae CE oe BM am AM bm em de dm en an bn CM AN BN ON DE DM

flexion

BEFORE OR CONTROL

A	B	C	D
0.00	0.00	0.00	0.00
0.56	0.26		
1.89	8.22	0.85	0.00
			0.68

AFTER SONGS

A	B	C	D
0.00	0.00	0.00	0.00
0.12	1.62		
1.82	7.92	0.00	0.00
		11.65	
			0.00

P=.005

CE be BE ae oe AE BM am bm de AM DE

post-flexion

BEFORE OR CONTROL

A	B	C	D
0.00	0.00	0.00	0.00
0.06	0.00		
2.36	5.13	0.33	0.00
			0.50

AFTER SONGS

A	B	C	D
0.00	0.00	0.00	0.00
0.36	0.00		
0.00	3.75	0.00	0.37
		12.01	
			0.00

P=0.14

CE be BE ae oe de am AM DM dm AE DE

Figure D-69 . Cross-shelf distributional patterns for Gobiesox rhesodon. Shading denotes strata groupings based on the results of the Bonferroni t-test. Strata designations are ordered from highest to lowest mean rank abundance. Strata not significantly separable are underlined. Upper case strata designations (e.g., AM=Block A midwater) are for SONGS in the After data set, lower case are strata in the Before-Control data set (SONGS in the Before period and Control in both periods). Only strata in which larvae occurred were tested. The results of the MANOVA are also shown.

Paraclinus integripinnis

larvae

BEFORE OR CONTROL

A	B	C	D
0.11	0.43	0.38	0.00
2.52	3.08	0.92	
2.62	3.18	0.88	0.00
			0.00

AFTER SONGS

A	B	C	D
0.57	0.88	0.00	0.00
9.14	8.28	0.87	
33.16	8.78	1.85	0.00
			0.16

P=0.02

am AM bm AE BE be em CE EN BM ce CM bn ee en an AN de DE ON

preflexion

BEFORE OR CONTROL

A	B	C	D
0.00	0.18	0.13	0.00
1.50	1.86	0.47	
1.68	2.04	0.38	0.00
			0.00

AFTER SONGS

A	B	C	D
0.57	0.17	0.00	0.00
6.03	4.87	0.52	
16.25	6.40	0.58	0.00
			0.16

P=0.05

AM AE am bm BE be BM ce em CE CM EN bn en ee AN en de DE ON

flexion

BEFORE OR CONTROL

A	B	C	D
0.00	0.50	0.00	0.00
0.97	0.55	0.24	
1.18	0.24	0.51	0.00
			0.00

AFTER SONGS

A	B	C	D
0.00	0.88	0.00	0.00
3.24	1.20	0.17	
16.53	1.30	0.57	0.00
			0.00

P=0.63

bm AE AM am CE BE ce EN ee em bn be BM CM

post-flexion

BEFORE OR CONTROL

A	B	C	D
0.43	0.00	1.02	0.00
1.41	1.11	0.50	
0.10	0.08	0.00	0.00
			0.00

AFTER SONGS

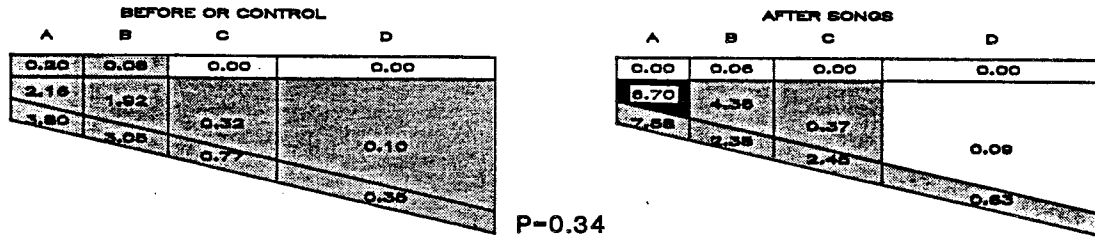
A	B	C	D
0.00	0.00	0.00	0.00
1.13	0.71	0.54	
7.82	0.88	1.12	0.00
			0.00

P=0.40

AE am AM CE CM be bm em BE en an BM ee ee AN ON

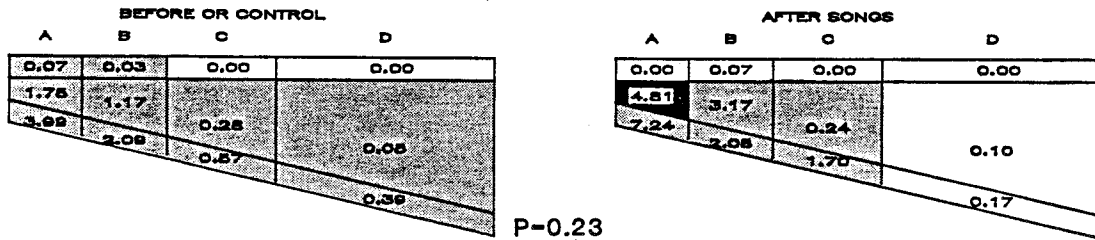
Figure D-90 . Cross-shelf distributional patterns for Paraclinus integripinnis. Shading denotes strata groupings based on the results of the Bonferroni t-test. Strata designations are ordered from highest to lowest mean rank abundance. Strata not significantly separable are underlined. Upper case strata designations (e.g., AM=Block A midwater) are for SONGS in the After data set, lower case are strata in the Before-Control data set (SONGS in the Before period and Control in both periods). Only strata in which larvae occurred were tested. The results of the MANOVA are also shown.

Gibbonsia type a  
larvae



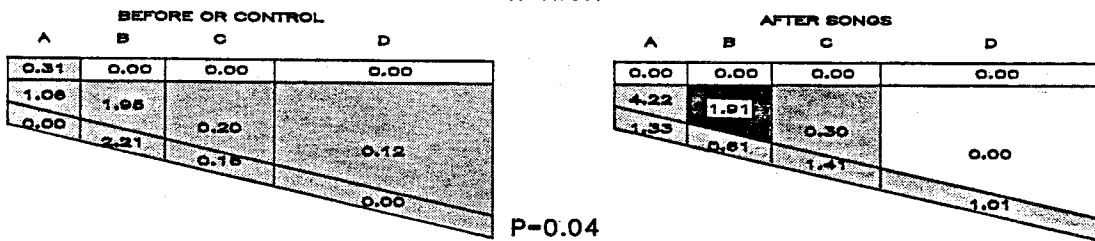
AM BM am AE be bm BE ce ce CE em CM an de dm bn DE DM BN AN

preflexion



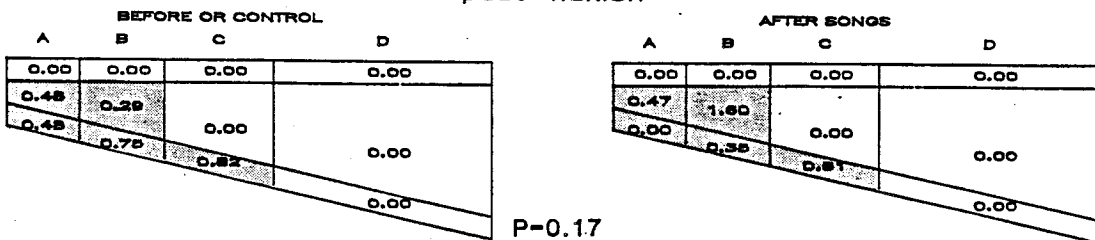
AM BM am AE ce be bm BE ce CE em an de dm bn CM BN DE DM AN

flexion



BM AM am be bm AE BE CM ce an em dm CE DE ce de AN DM

post-flexion



AM BM am ce BE CE ce be bm AE

Figure D-111. Cross-shelf distributional patterns for Gibbonsia type a. Shading denotes strata groupings based on the results of the Bonferroni t-test. Strata designations are ordered from highest to lowest mean rank abundance. Strata not significantly separable are underlined. Upper case strata designations (e.g., AM=Block A midwater) are for SONGS in the After data set, lower case are strata in the Before-Control data set (SONGS in the Before period and Control in both periods). Only strata in which larvae occurred were tested. The results of the MANOVA are also shown.

# Heterostichus rostratus

larvae

BEFORE OR CONTROL

A	B	C	D
0.00	0.09	0.00	0.00
0.83	0.46		
4.22	4.16	0.15	0.00
		0.43	
			0.00

AFTER SONGS

A	B	C	D
0.00	0.11	0.00	0.00
3.37	0.77		
2.57	11.23	0.09	0.00
		8.57	
			0.00

P=0.30

BE be ae AM BM am CE bm AE ee em bn CM BN

preflexion

BEFORE OR CONTROL

A	B	C	D
0.00	0.00	0.00	0.00
0.71	0.46		
2.42	3.18	0.09	0.00
		0.22	
			0.00

AFTER SONGS

A	B	C	D
0.00	0.15	0.00	0.00
2.22	0.98		
3.04	2.57	0.13	0.00
		3.91	
			0.00

P=0.14

AM BE be ae BM am bm AE CE ee em bn CM BN

flexion

BEFORE OR CONTROL

A	B	C	D
0.00	0.00	0.00	0.00
0.37	0.18		
3.37	1.46	0.18	0.00
		0.37	
			0.00

AFTER SONGS

A	B	C	D
0.00	0.00	0.00	0.00
1.34	0.12		
0.00	3.27	0.00	0.00
		4.88	
			0.00

P=0.004

BE ae AM CE be am bm ee em BM AE CM

post-flexion

BEFORE OR CONTROL

A	B	C	D
0.00	0.00	0.00	0.00
0.21	0.00		
0.68	6.22	0.00	0.00
		0.00	
			0.00

AFTER SONGS

A	B	C	D
0.00	0.00	0.00	0.00
3.12	0.00		
1.37	7.01	0.00	0.00
		1.89	
			0.00

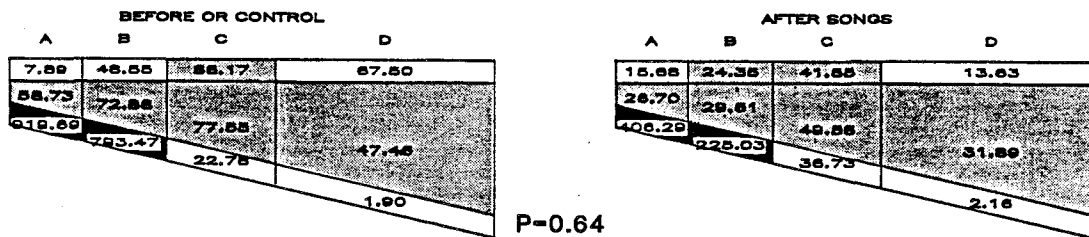
P=0.41

BE be ae AM CE am AE ee

Figure D-132. Cross-shelf distributional patterns for *Heterostichus rostratus*. Shading denotes strata groupings based on the results of the Bonferroni t-test. Strata designations are ordered from highest to lowest mean rank abundance. Strata not significantly separable are underlined. Upper case strata designations (e.g., AM=Block A midwater) are for SONGS in the After data set, lower case are strata in the Before-Control data set (SONGS in the Before period and Control in both periods). Only strata in which larvae occurred were tested. The results of the MANOVA are also shown.

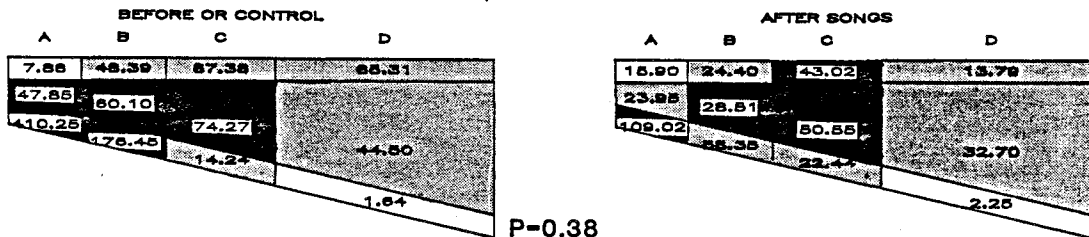
Seriphus politus

larvae



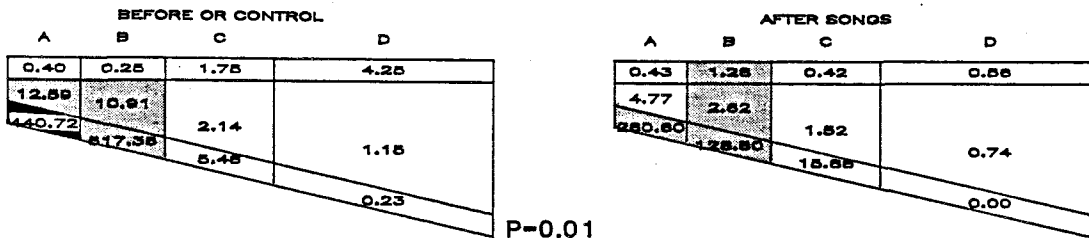
ae AE be BE am am CM bm BM AM CN dm DM en BN dn CE ee bn DN AN an DE de

preflexion



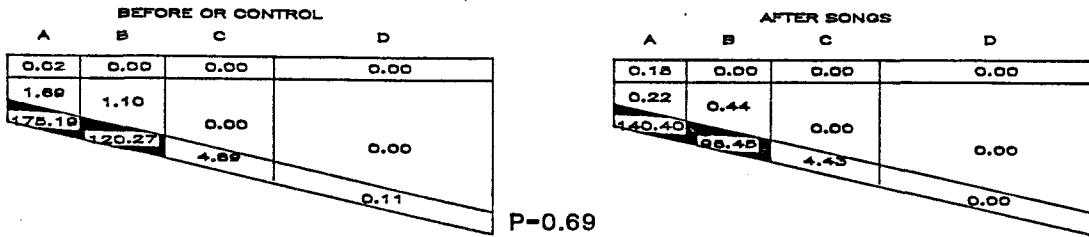
ae am CM AE be BM am bm CN AM BE DM dm en dn CE BN bn DN ee AN an DE de

flexion



ae AE be BE am BM bm BN CE AM ee AN CM em DM DN CN dm DE an dn en bn de

post-flexion



AE ae BE be ae am BM AM bm CE AN de en DE

Figure D-153. Cross-shelf distributional patterns for Seriphus politus. Shading denotes strata groupings based on the results of the Bonferroni t-test. Strata denotes strata groupings based on the results of the Bonferroni t-test. Strata designations are ordered from highest to lowest mean rank abundance. Strata not significantly separable are underlined. Upper case strata designations (e.g., AM=Block A midwater) are for SONGS in the After data set, lower case are strata in the Before-Control data set (SONGS in the Before period and Control in both periods). Only strata in which larvae occurred were tested. The results of the MANOVA are also shown.



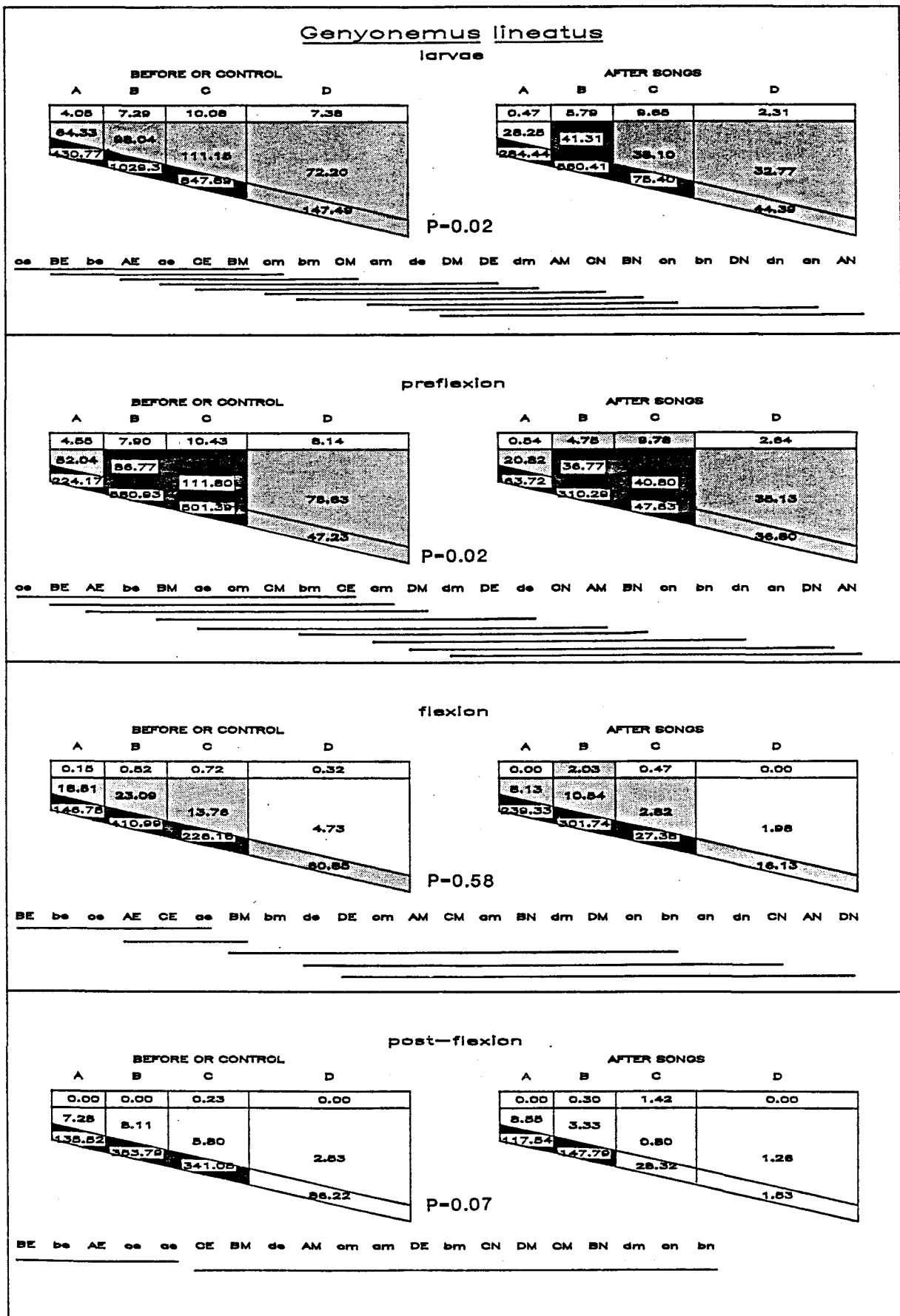
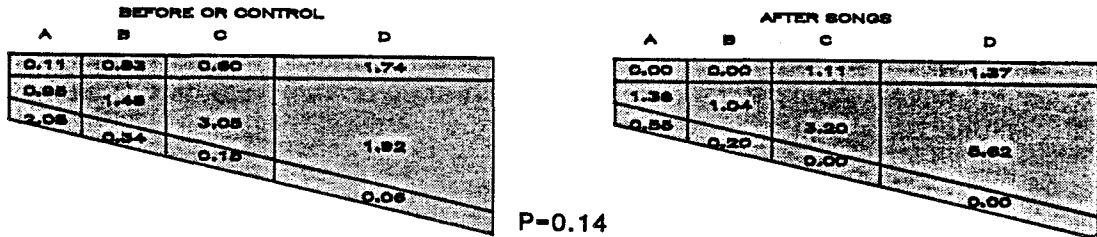


Figure D-174. Cross-shelf distributional patterns for *Genyonemus lineatus*. Shading denotes strata groupings based on the results of the Bonferroni t-test. Strata designations are ordered from highest to lowest mean rank abundance. Strata not significantly separable are underlined. Upper case strata designations (e.g., AM=Block A midwater) are for SONGS in the After data set, lower case are strata in the Before-Control data set (SONGS in the Before period and Control in both periods). Only strata in which larvae occurred were tested. The results of the MANOVA are also shown.

D-175

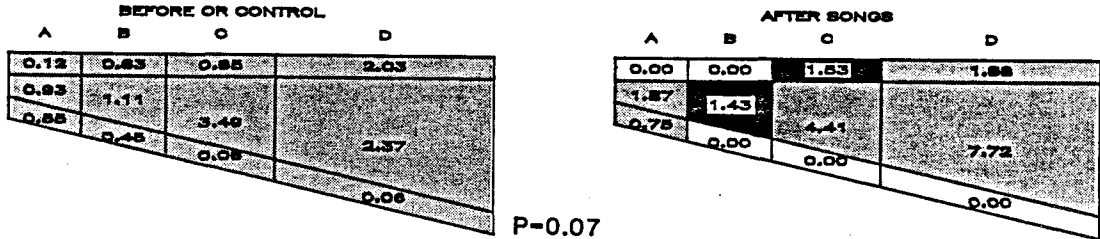
# Cheilotrema saturnum

larvae



ON BM CM bm am em DM DN dm bn ce dn AM en AE BE en be ce de AN BN CE DE

preflexion



ON BM CM am em DM bm DN dm dn bn en AM AE en be ce de ce AN BE BN CE DE

Figure D-195. Cross-shelf distributional patterns for Cheilotrema saturnum. Shading denotes strata groupings based on the results of the Bonferroni t-test. Strata designations are ordered from highest to lowest mean rank abundance. Strata not significantly separable are underlined. Upper case strata designations (e.g., AM=Block A midwater) are for SONGS in the After data set, lower case are strata in the Before-Control data set (SONGS in the Before period and Control in both periods. Only strata in which larvae occurred were tested. The results of the MANOVA are also s

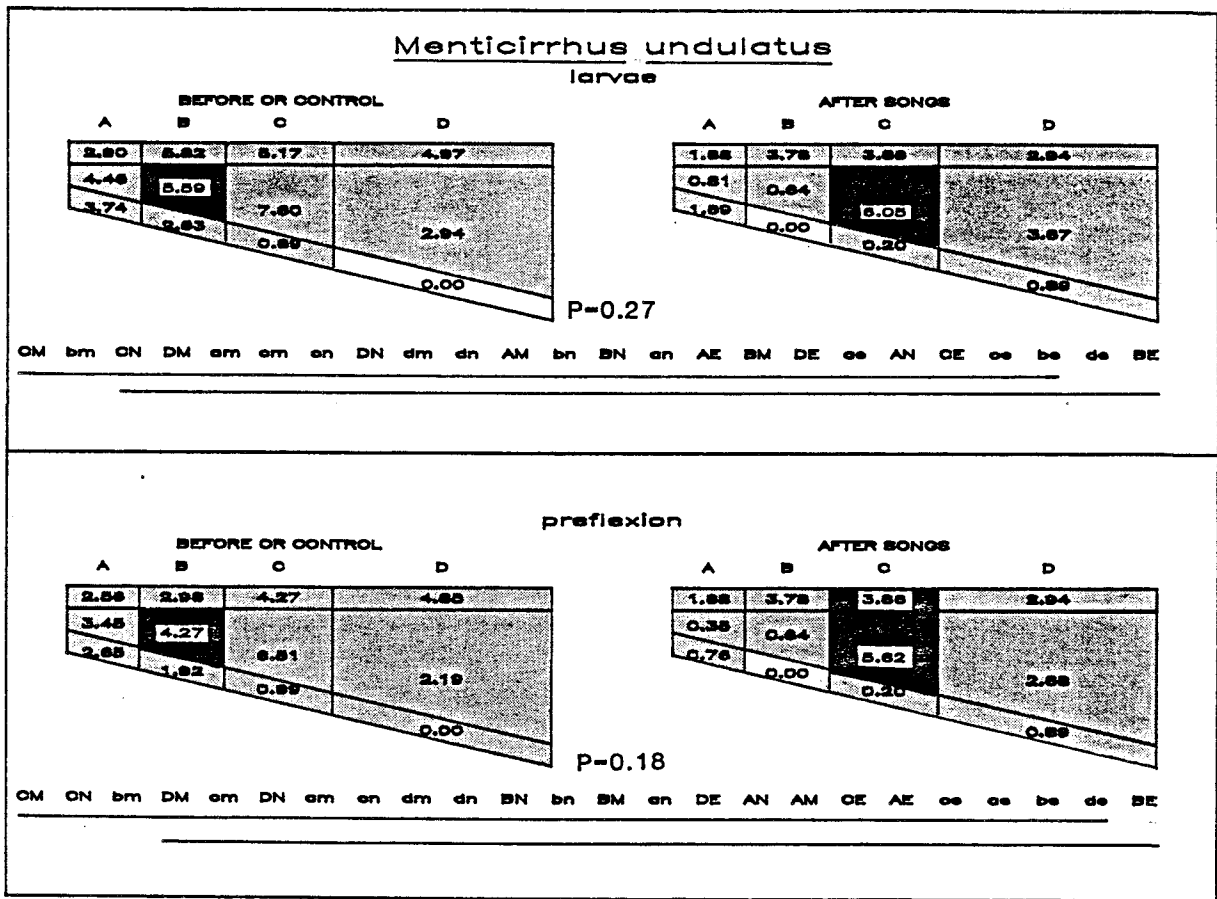
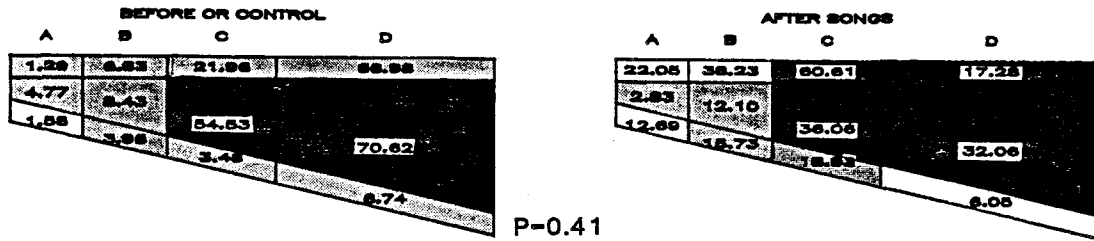


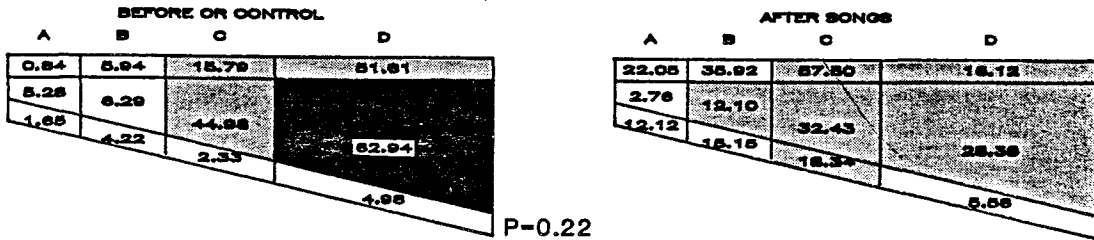
Figure D-206. Cross-shelf distributional patterns for *Menticirrhus undulatus*. Shading denotes strata groupings based on the results of the Bonferroni t-test. Strata designations are ordered from highest to lowest mean rank abundance. Strata not significantly separable are underlined. Upper case strata designations (e.g., AM=Block A midwater) are for SONGS in the After data set, lower case are strata in the Before-Control data set (SONGS in the Before period and Control in both periods). Only strata in which larvae occurred were tested. The results of the MANOVA are also shown.

Paralabrax spp.  
larvae



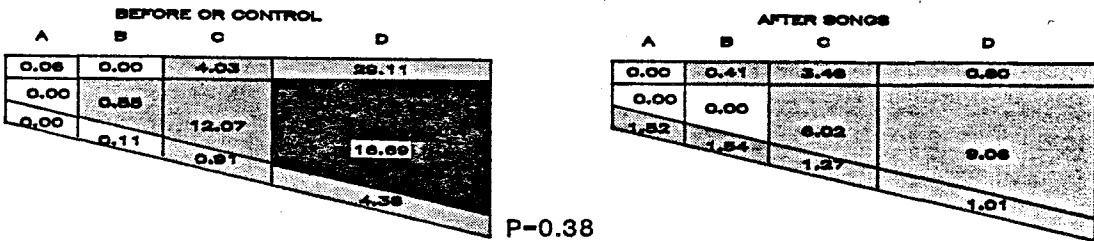
dm DM em CM ON DN dn BM CE en bm ee BE am bn de be en AM DE BN AE ee AN

preflexion



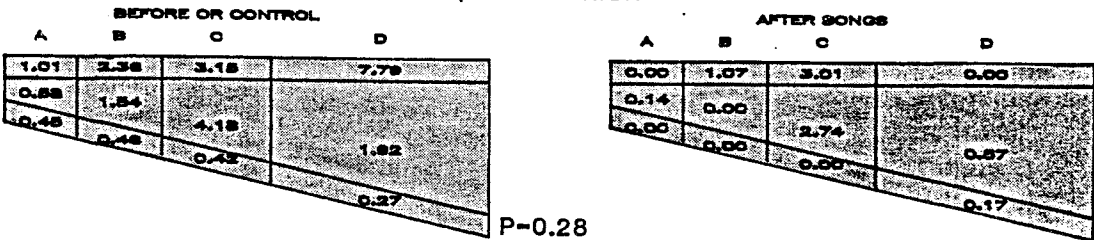
dm DM em CM ON DN dn BM CE en bm BE de ee am be bn an DE AM BN ee AE AN

flexion



dm CN em DE ee DM dn BE CM de AE CE DN BN en bm be en ee bn AN BM

post-flexion

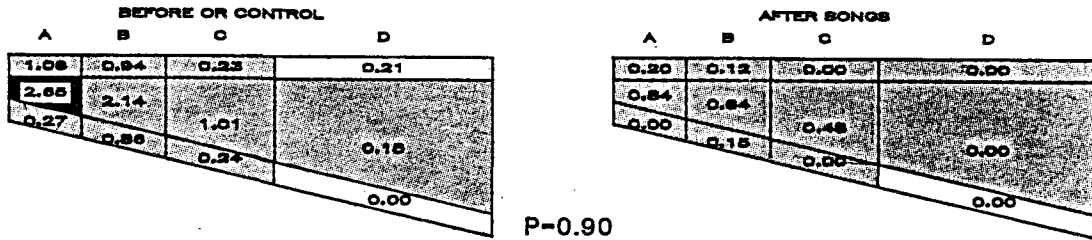


CN em BN en bn em dm CM DM AM DE dn bm en be ee ee AE AN BE BM CE DN de

Figure D-217. Cross-shelf distributional patterns for *Paralabrax* spp. Shading denotes strata groupings based on the results of the Bonferroni t-test. Strata designations are ordered from highest to lowest mean rank abundance. Strata not significantly separable are underlined. Upper case strata designations (e.g., AM=Block A midwater) are for SONGS in the After data set, lower case are strata in the Before-Control data set (SONGS in the Before period and Control in both periods). Only strata in which larvae occurred were tested. The results of the MANOVA are also shown.

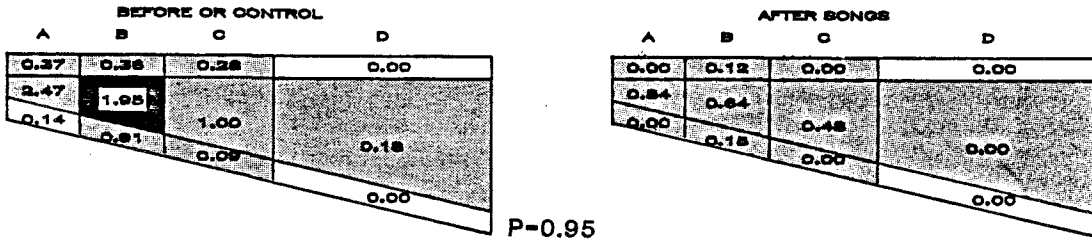
# Hypsopsetta guttulata

larvae



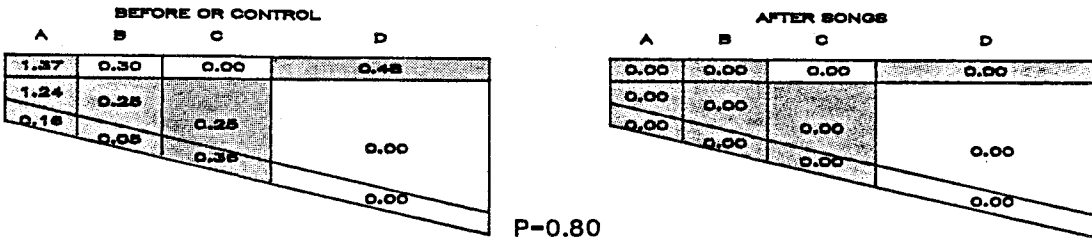
am bm AM CM an BM om bn BE AN BN be AE CE CN DM DN dm ee en ee dn

preflexion



bm am AM CM om BM be BE BN an bn dm AE AN CE CN DM en ee ee

flexion



en am bn AE AM AN BE BM BN CE CM DN bm om dn ee ee be

Figure D-238. Cross-shelf distributional patterns for *Hypsopsetta guttulata*. Shading denotes strata groupings based on the results of the Bonferroni t-test. Strata designations are ordered from highest to lowest mean rank abundance. Strata not significantly separable are underlined. Upper case strata designations (e.g., AM=Block A midwater) are for SONGS in the After data set, lower case are strata in the Before-Control data set (SONGS in the Before period and Control in both periods. Only strata in which larvae occurred were tested. The results of the MANOVA are also shown

*Paralichthys californicus*

larvae

BEFORE OR CONTROL

A	B	C	D
3.18	4.78	4.04	2.98
4.78	11.53		
1.37	6.68	20.94	
		6.11	20.76
			1.06

AFTER SONGS

A	B	C	D
2.32	6.29	9.35	4.32
2.61	11.40		
2.47	1.63	17.01	
		8.09	9.62
			0.69

P=0.75

om CM dm DM BM bm CN CE AM ce en bn AN en BN am DN dn be de AE DE BE ce

preflexion

BEFORE OR CONTROL

A	B	C	D
1.27	3.58	3.33	1.73
4.62	8.59		
1.11	6.58	23.88	
		8.69	18.50
			0.79

AFTER SONGS

A	B	C	D
2.18	4.55	9.38	4.13
2.20	10.88		
2.47	1.28	18.82	
		3.63	8.63
			0.69

P=0.45

om CM dm DM bm BM CN ce en CE AM bn BN AN am DN dn be en AE DE de BE ce

flexion

BEFORE OR CONTROL

A	B	C	D
0.00	0.09	0.07	0.09
0.00	0.37		
0.18	0.34	2.88	
		1.04	3.78
			0.56

AFTER SONGS

A	B	C	D
0.00	0.41	0.00	0.37
0.00	0.29		
0.00	0.77	2.49	
		2.58	1.91
			0.00

P=0.44

CE dm em CM DM ce BE bm de DN BM BN be dn ce en bn AE CN DE

post-flexion

BEFORE OR CONTROL

A	B	C	D
2.89	1.69	0.64	1.74
0.54	0.18		
0.22	0.22	1.21	
		0.38	1.40
			0.02

AFTER SONGS

A	B	C	D
0.28	0.83	0.00	0.08
0.70	0.69		
0.00	0.00	0.28	
		0.31	0.08
			0.00

P=0.62

en AM em AN dm CM BM BN em bn CE DM ce en dn bm be ce AE BE CN DE DN de

Figure D-254. Cross-shelf distributional patterns for *Paralichthys californicus*. Shading denotes strata groupings based on the results of the Bonferroni t-test. Strata designations are ordered from highest to lowest mean rank abundance. Strata not significantly separable are underlined. Upper case strata designations (e.g., AM=Block A midwater) are for SONGS in the After data set, lower case are strata in the Before-Control data set (SONGS in the Before period and Control in both periods). Only strata in which larvae occurred were tested. The results of the MANOVA are also shown.

*Atherinopsis californiensis*

larvae

BEFORE OR CONTROL				AFTER SONGS			
A	B	C	D	A	B	C	D
358.77	434.89	497.98	88.88	145.76	181.47	53.04	50.34
18.40	6.60			11.20	2.86		
2.63	2.25	2.71		3.80	2.74	1.82	
		0.80	0.86			0.43	0.00
			0.27				0.00

P=0.17

AN an bn BN en CN DN dn AM am bm BM AE BE em CM ae be dm ee de CE DE DM

preflexion

BEFORE OR CONTROL				AFTER SONGS			
A	B	C	D	A	B	C	D
308.18	419.86	534.89	82.32	110.44	159.91	51.44	42.88
19.70	6.88			11.83	2.82		
2.88	2.02	2.96		3.52	1.74	1.94	
		0.89	0.79			0.48	0.00
			0.23				0.00

P=0.43

AN an bn BN en DN CN dn AM am bm BM em CM AE BE ae be dm ee CE de DE DM

flexion

BEFORE OR CONTROL				AFTER SONGS			
A	B	C	D	A	B	C	D
91.08	89.80	18.71	2.54	39.79	14.00	8.08	13.45
0.89	0.52			0.09	0.13		
0.16	0.19	0.15		0.63	0.00	0.00	
		0.00	0.00			0.00	0.00
			0.10				0.00

P=0.94

AN an bn BN DN CN en dn am bm AM AE BM ae de em be BE CM DE

post-flexion

BEFORE OR CONTROL				AFTER SONGS			
A	B	C	D	A	B	C	D
33.33	28.14	7.77	1.80	20.93	0.49	0.00	0.00
0.36	0.00			0.00	0.00		
0.00	0.11	0.00		0.00	0.00	0.00	
		0.00	0.10			0.00	0.00
			0.00				0.00

P=0.77

AN an bn BN en dn am AM BE CN DM DN be dm

Figure D-275. Cross-shelf distributional patterns for *Atherinopsis californiensis*. Shading denotes strata groupings based on the results of the Bonferroni t-test. Strata designations are ordered from highest to lowest mean rank abundance. Strata not significantly separable are underlined. Upper case strata designations (e.g., AM=Block A midwater) are for SONGS in the After data set, lower case are strata in the Before-Control data set (SONGS in the Before period and Control in both periods. Only strata in which larvae occurred were tested. The results of the MANOVA are also shown

Leuresthes tenuis

larvae

BEFORE OR CONTROL

A	B	C	D
188.87	137.19	82.88	81.83
1.22	0.36		
0.38	0.25	0.16	
		0.18	0.16
			0.29

AFTER SONGS

A	B	C	D
300.83	183.44	182.70	282.41
2.98	2.28		
1.56	0.96	0.24	
		0.00	0.04
			0.00

P=0.08

en AN bn cn BN CN dn DN AM AE em BM BE CM ee em be bm de ee DM dm OE DE

preflexion

BEFORE OR CONTROL

A	B	C	D
148.78	112.37	84.88	81.23
1.32	0.17		
0.38	0.19	0.19	
		0.21	0.19
			0.22

AFTER SONGS

A	B	C	D
210.42	138.05	187.13	248.83
3.19	2.82		
1.41	0.83	0.10	
		0.00	0.05
			0.00

P=0.35

AN en bn CN BN cn DN dn AM AE em BM ee em ee BE be dm bm de CM DM OE DE

flexion

BEFORE OR CONTROL

A	B	C	D
82.82	31.84	38.88	30.88
0.09	0.15		
0.07	0.05	0.00	
		0.00	0.00
			0.00

AFTER SONGS

A	B	C	D
78.07	31.43	38.38	42.00
0.13	0.00		
0.00	0.00	0.21	
		0.00	0.00
			0.00

P=0.64

AN en BN bn DN cn CN dn ee CM em be bm AM em AE BE BM

post-flexion

BEFORE OR CONTROL

A	B	C	D
21.00	17.12	5.34	6.88
0.00	0.14		
0.00	0.06	0.00	
		0.00	0.00
			0.12

AFTER SONGS

A	B	C	D
71.51	49.73	4.41	9.88
0.00	0.00		
0.38	0.27	0.00	
		0.00	0.00
			0.00

P=0.51

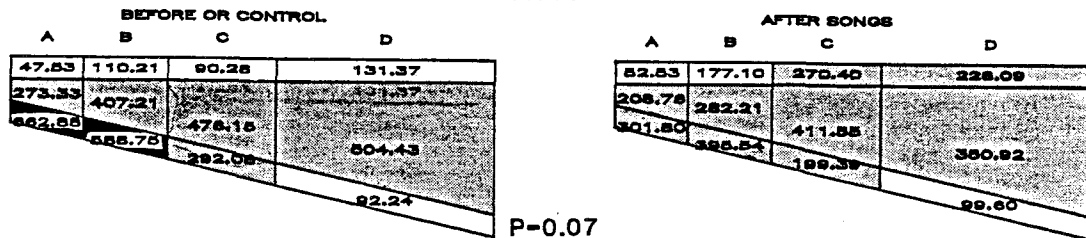
en AN bn BN DN cn dn CN AE BE be de bm BM DE ee

Figure D-296. Cross-shelf distributional patterns for Leuresthes tenuis. Shading denotes strata groupings based on the results of the Bonferroni t-test. Strata designations are ordered from highest to lowest mean rank abundance. Strata not significantly separable are underlined. Upper case strata designations (e.g., AM=Block A midwater) are for SONGS in the After data set, lower case are strata in the Before-Control data set (SONGS in the Before period and Control in both periods. Only strata in which larvae occurred were tested. The results of the MANOVA are also shown.



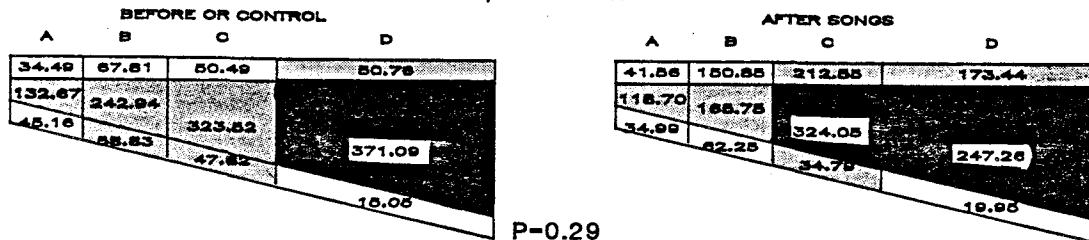
# Engraulis mordax

## larvae



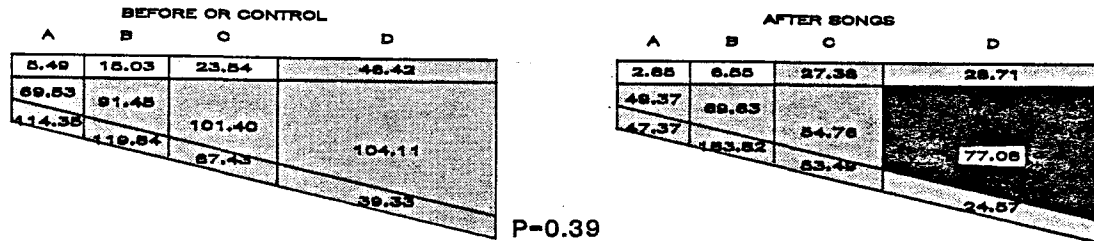
be ae DM dm em BE CM AE ee bm BM CE em AM ON DN DE dn en BN de bn AN an

## preflexion



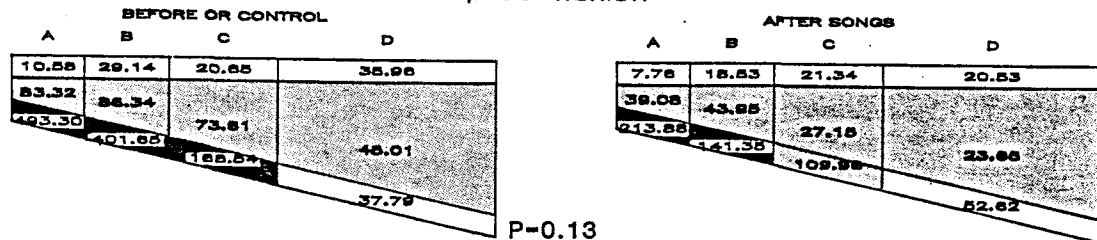
DM dm CM em BM bm ON DN dn be em AM ae CE en BE bn ee BN DE de AE en AN

## flexion



DM dm em CM BM bm em be ee BE AE CE ee AM DN DE CN dn de en BN bn an AN

## post-flexion

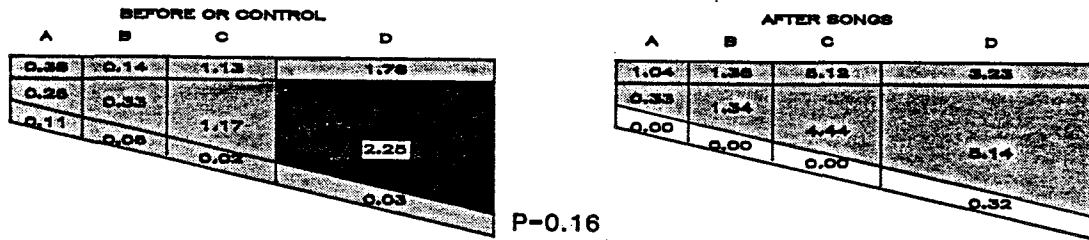


ae be AE BE ee bm BM em em CE DM AM dm CM DE CN BN DN de dn en bn AN an

Figure D-317. Cross-shelf distributional patterns for *Engraulis mordax*. Shading denotes strata groupings based on the results of the Bonferroni t-test. Strata designations are ordered from highest to lowest mean rank abundance. Strata not significantly separable are underlined. Upper case strata designations (e.g., AM=Block A midwater) are for SONGS in the After data set, lower case are strata in the Before-Control data set (SONGS in the Before period and Control in both periods). Only strata in which larvae occurred were tested. The results of the MANOVA are also shown.

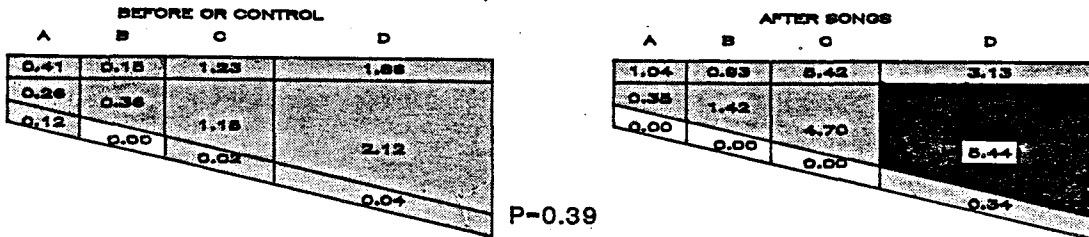
Citharichthys spp.

larvae



dm DM DN DN OM dn on BN em BM em bm bn AN AM en ee be de oe DE AE BE OE

preflexion



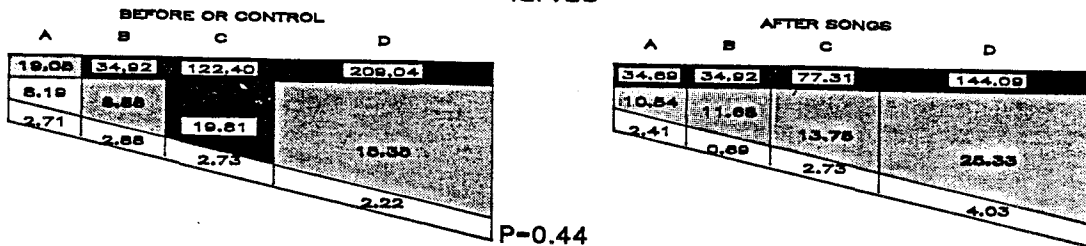
DM dm DN OM DN dn on em BM BN bm em bn AM en ee oe de DE AN AE OE

Figure D-338. Cross-shelf distributional patterns for Citharichthys spp. Shading denotes strata groupings based on the results of the Bonferroni t-test. Strata designations are ordered from highest to lowest mean rank abundance. Strata not significantly separable are underlined. Upper case strata designations (e.g., AM=Block A midwater) are for SONGS in the After data set, lower case are strata in the Before-Control data set (SONGS in the Before period and Control in both periods. Only strata in which larvae occurred were tested. The results of the MANOVA are also shown.

D-339

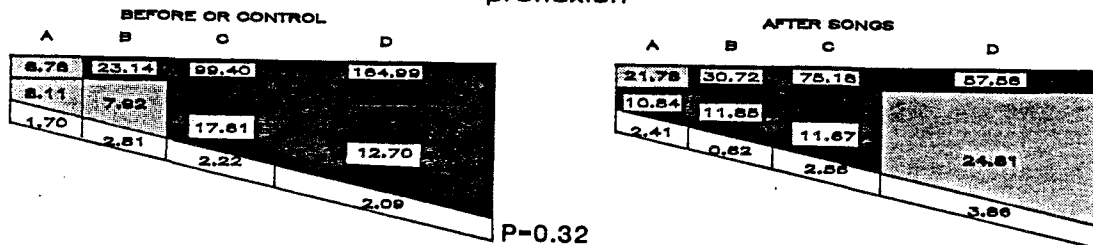
Hypsoblennius spp.

larvae



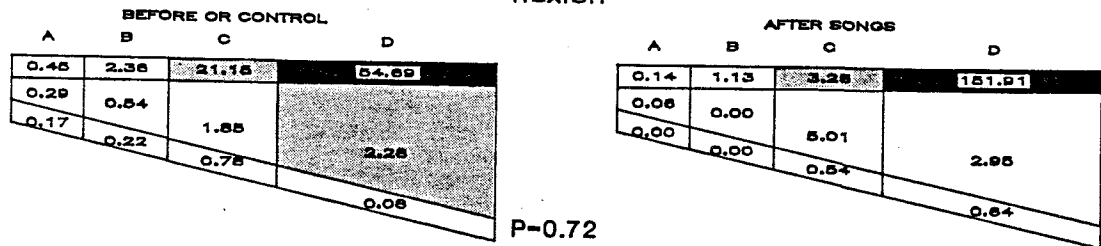
dn CN en BN DN AN em bn an dm BM AM OM DM bm em ee CE de DE AE ae BE be

preflexion



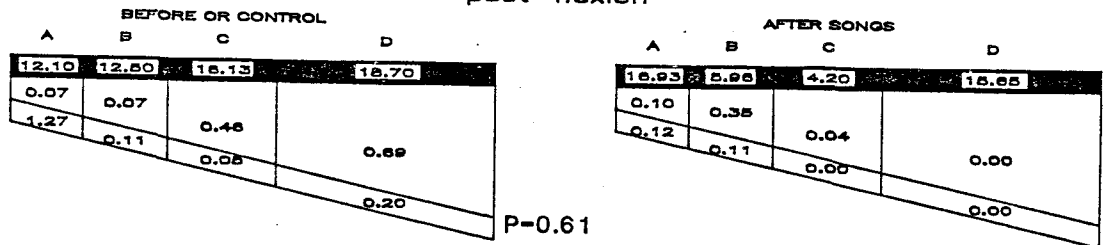
dn CN BN en em DN dm BM AM bn OM bm DM AN an am ee de CE DE ae AE be BE

flexion



DN dn dm en CN BN DM em bn CE CM ee DE bm AN AM an am ae be de AE BE BM

post-flexion

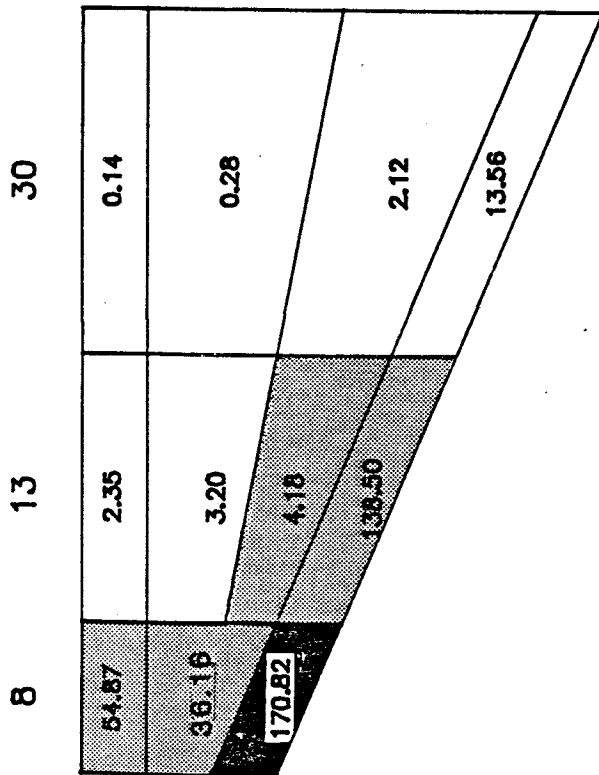


on AN dn en bn BN DN CN AM BM BE AE CM dm em ee CE DE DM bm em de be ee

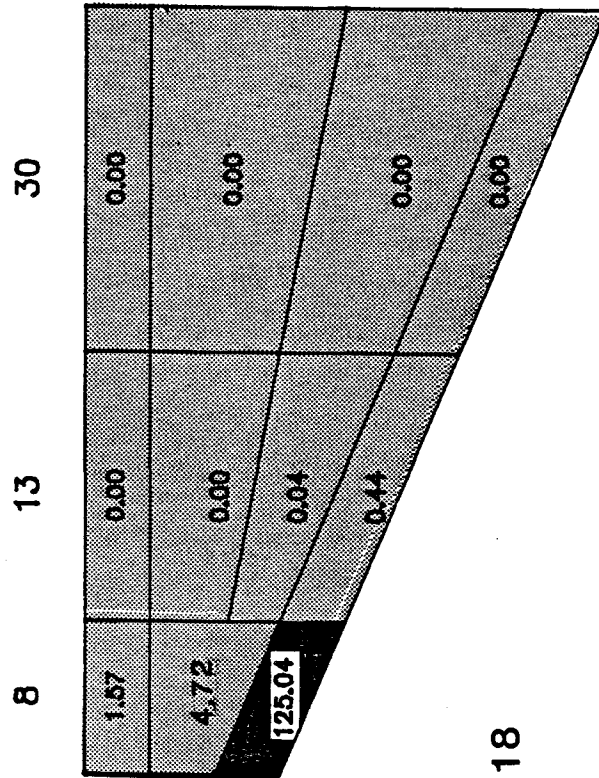
Figure D-349. Cross-shelf distributional patterns for Hypsoblennius spp. Shading denotes strata groupings based on the results of the Bonferroni t-test. Strata designations are ordered from highest to lowest mean rank abundance. Strata not significantly separable are underlined. Upper case strata designations (e.g., AM=Block A midwater) are for SONGS in the After data set, lower case are strata in the Before-Control data set (SONGS in the Before period and Control in both periods). Only strata in which larvae occurred were tested. The results of the MANOVA are also shown.

# Acartia clausi

BEFORE OR CONTROL



AFTER SONGS



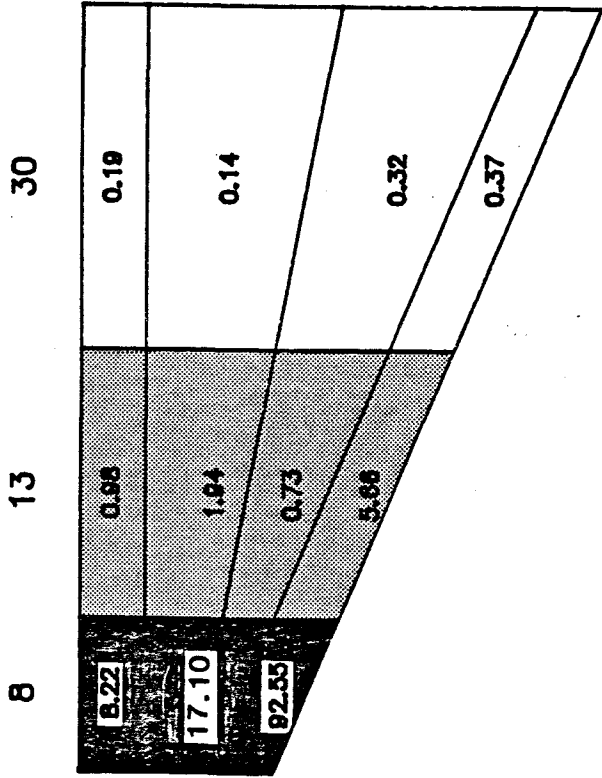
P=0.18

8e 8E 8s 13e 8H 13E 8S 13L 13H 13S 30E 30H 30L 30S 13I 30e 13s 13h 30I 30h 30s

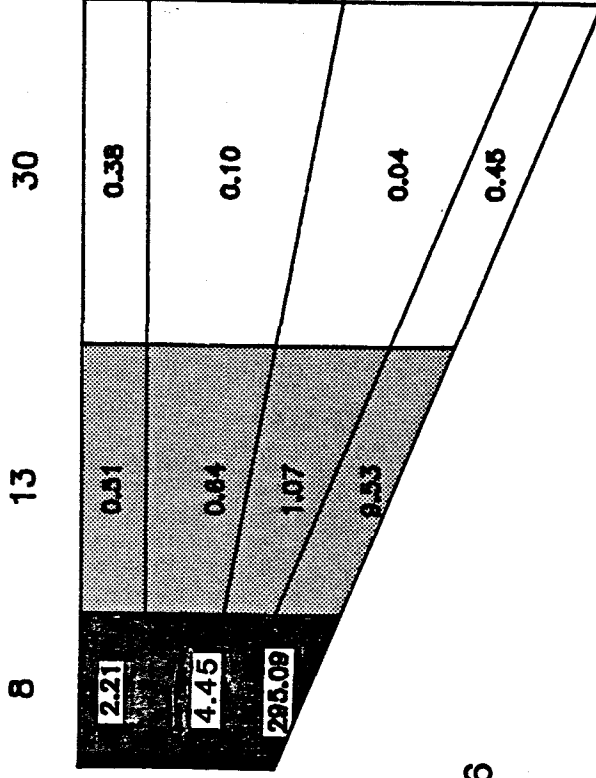
Figure D-370. Cross-shelf distributional patterns for *Acartia clausi*. Shading denotes strata groupings based on the results of the Bonferroni t-test. Strata designations are ordered from highest to lowest mean rank abundance. Strata not significantly separable are underlined. Upper case strata designations (e.g., 8E = 8 m epibenthos) are for SONGS in the After data set, lower case are strata in the Before-Control data set (SONGS in the Before period and Control in both periods). Only strata in which larvae occurred were tested. The results of the MANOVA are also shown.

# Oithona oculata

BEFORE OR CONTROL



AFTER SONGS



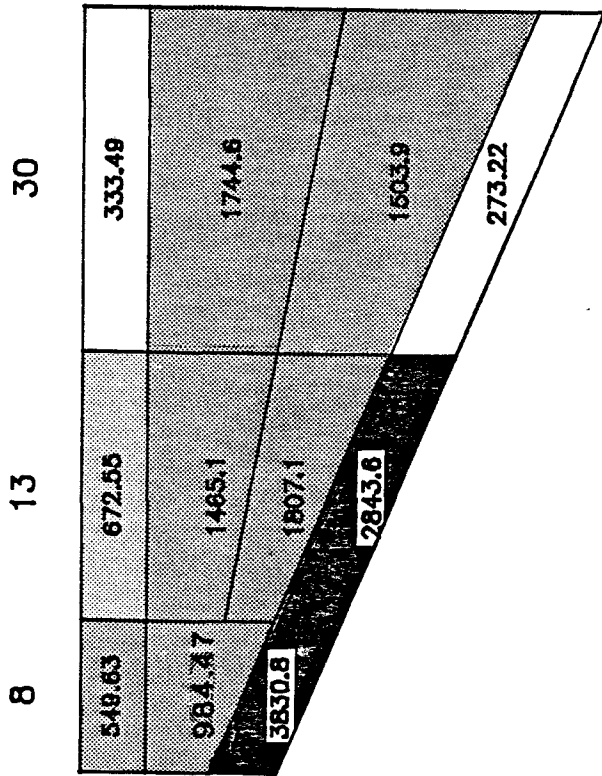
P=0.56

8e 8E 8s 8H 8S 8S 8S 13e 13E 13H 13L 13S 13S 13S 13h 13I 13I 30E 30E 30E 30e 30S 30H 30I 30L 30s 30h

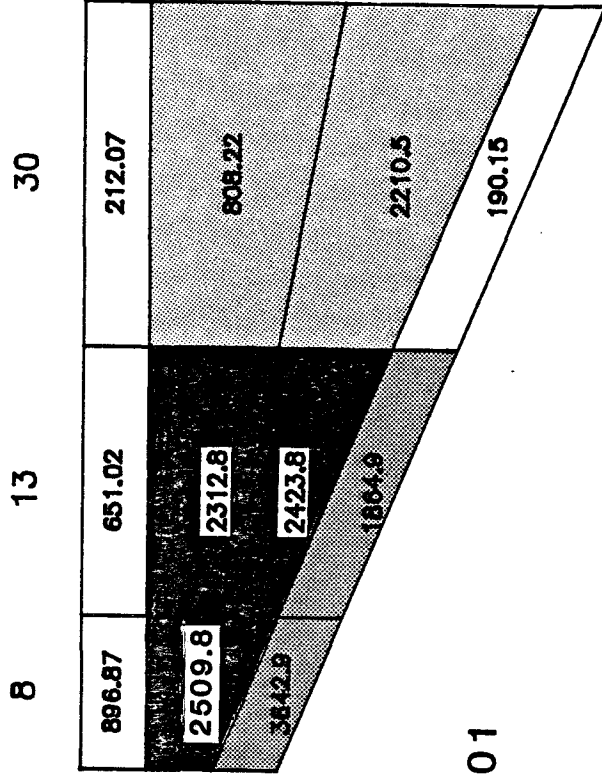
Figure D-376. Cross-shelf distributional patterns for *Oithona oculata*. Shading denotes strata groupings based on the results of the Bonferroni t-test. Strata designations are ordered from highest to lowest mean rank abundance. Strata not significantly separable are underlined. Upper case strata designations (e.g., 8E = 8 m epibenthos) are for SONGS in the After data set, lower case are strata in the Before-Control data set (SONGS in the Before period and Control in both periods). Only strata in which larvae occurred were tested. The results of the MANOVA are also shown. D-377

# Acartia tonsa

BEFORE OR CONTROL



AFTER SONGS



P=0.01

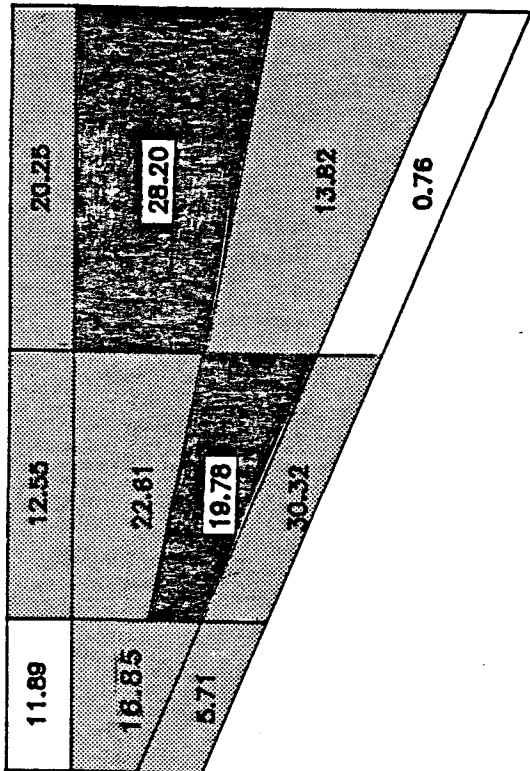
13L 8e 13H 8H 13e 13I 13E 8E 13h 8h 30I 30L 30h 30H 8s 13s 8S 13S 30s 30S 30e 30E

Figure D-382. Cross-shelf distributional patterns for *Acartia tonsa*. Shading denotes strata groupings based on the results of the Bonferroni t-test. Strata designations are ordered from highest to lowest mean rank abundance. Strata not significantly separable are underlined. Upper case strata designations (e.g., 8E = 8 in epibenthos) are for SONGS in the After data set, lower case are strata in the Before-Control data set (SONGS in the Before period and Control in both periods. Only strata in which larvae occurred were tested. The results of the MANOVA are also shown.

# Cirriped nauplii

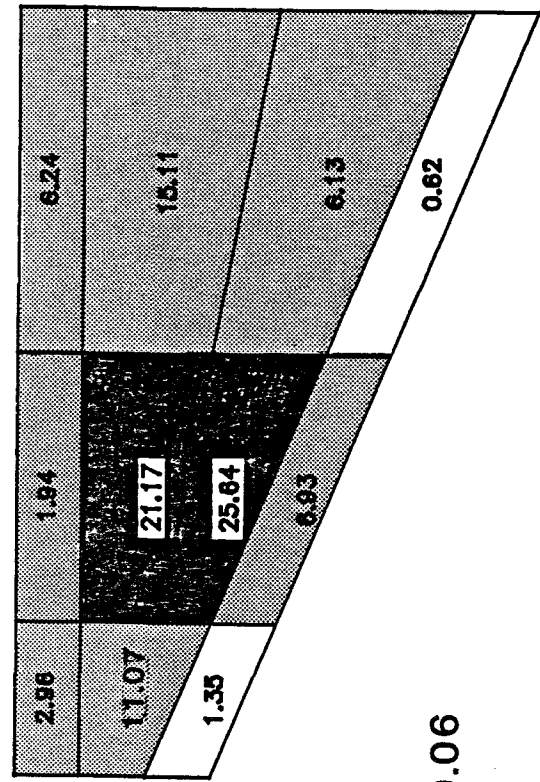
BEFORE OR CONTROL

8 13 30



AFTER SONGS

8 13 30

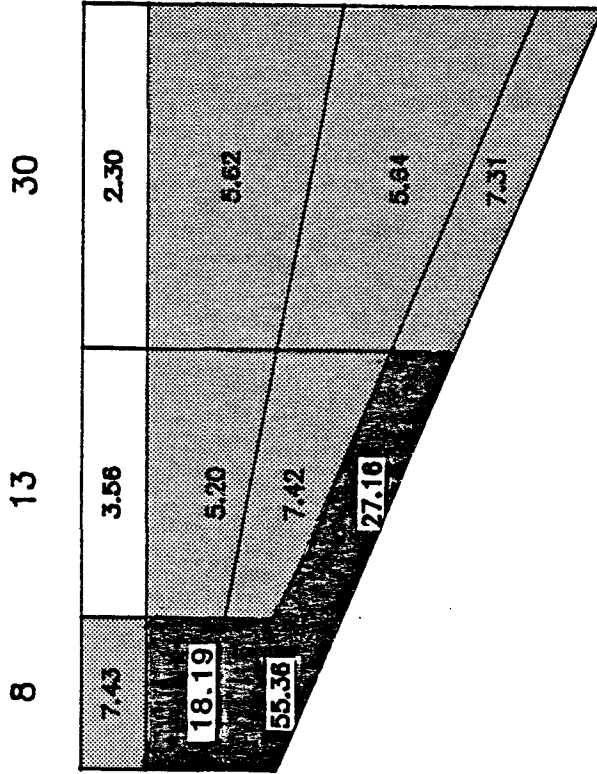


13H 13L 13I 30h 13h 13e 30I 30H 8H 30L 8h 13E 30S 30s 8S 13S 13s 8e 8s 8E 30E 30e

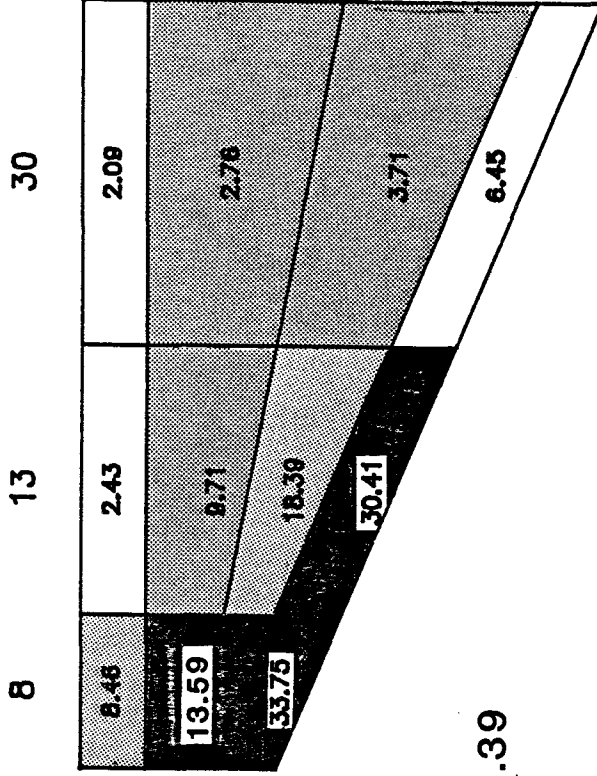
Figure D-388. Cross-shelf distributional patterns for cirriped nauplius. Shading denotes strata groupings based on the results of the Bonferroni t-test. Strata designations are ordered from highest to lowest mean rank abundance. Strata not significantly separable are underlined. Upper case strata designations (e.g., 8E = 8 m epibenthos) are for SONGS in the After data set, lower case are strata in the Before-Control data set (SONGS in the Before period and Control in both periods. Only strata in which larvae occurred were tested. The results of the MANOVA are also shown. D-389

# Cypris larvae

BEFORE OR CONTROL



AFTER SONGS



P=0.39

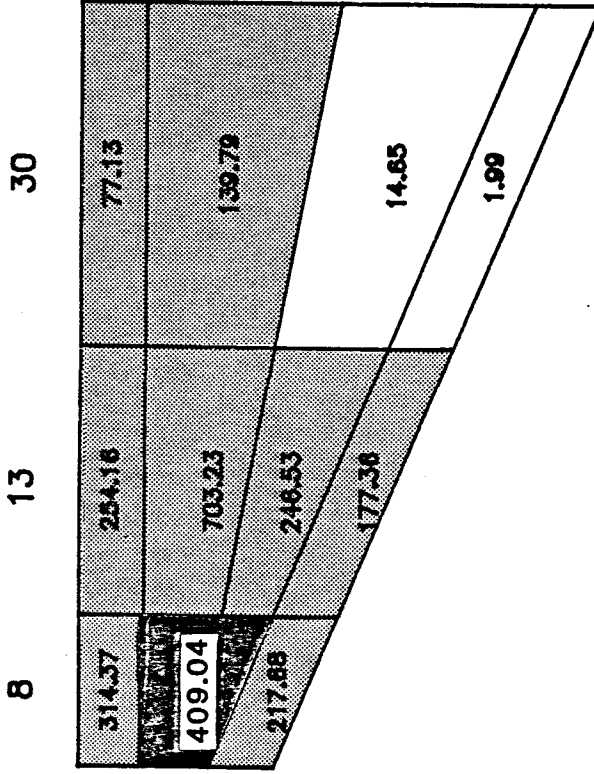
8e 8E 13E 13e 8H 8h 13L 13l 13I 13i 8s 8S 13H 13h 13S 13s 30E 30e 30S 30s

Figure D-394. Cross-shelf distributional patterns for Cypris larvae. Shading denotes strata groupings based on the results of the Bonferroni t-test. Strata designations are ordered from highest to lowest mean rank abundance. Strata not significantly separable are underlined. Upper case strata designations (e.g., 8E = 8 m epibenthos) are for SONGS in the After data set, lower case are strata in the Before-Control data set (SONGS in the Before period and Control in both periods. Only strata in which larvae occurred were tested. The results of the MANOVA are also shown.

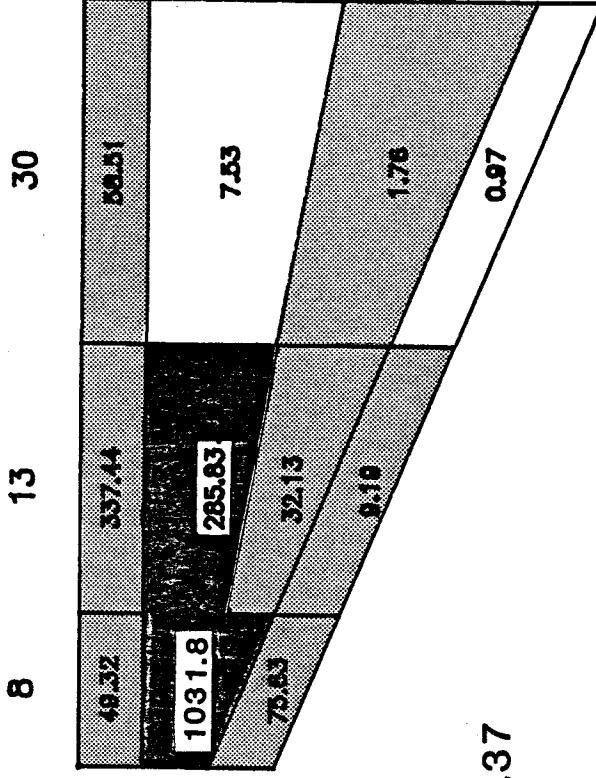


# Podon polyphemoides

BEFORE OR CONTROL



AFTER SONGS



P=0.37

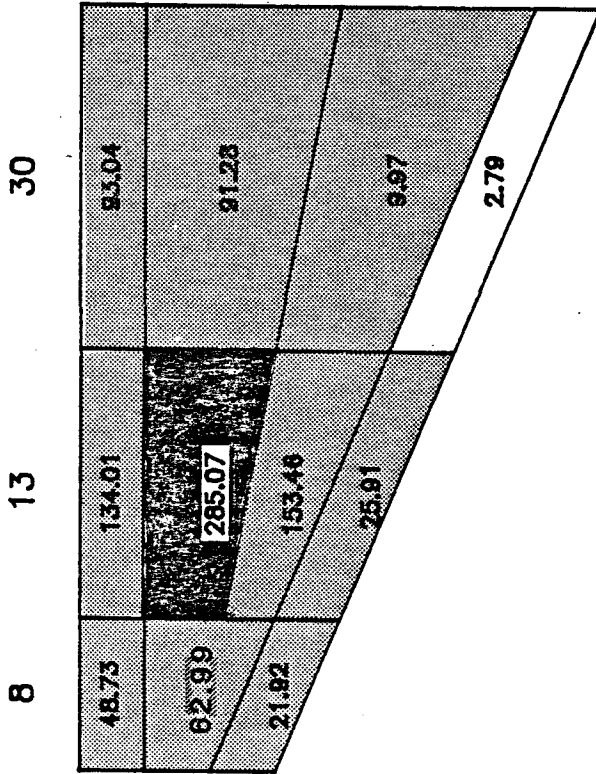
8H 8h 13H 8s 13S 13s 13h 13l 13L 8e 8E 30s 13e 30L 13E 30h 30S 30I 30H 30e 30E

Figure D-400. Cross-shelf distributional patterns for Podon polyphemoides. Shading denotes strata groupings based on the results of the Bonferroni t-test. Strata designations are ordered from highest to lowest mean rank abundance. Strata not significantly separable are underlined. Upper case strata designations (e.g., 8E = 8 m epibenthos) are for SONGS in the After data set, lower case are strata in the Before-Control data set (SONGS in the Before period and Control in both periods. Only strata in which larvae occurred were tested. The results of the MANOVA are also shown.

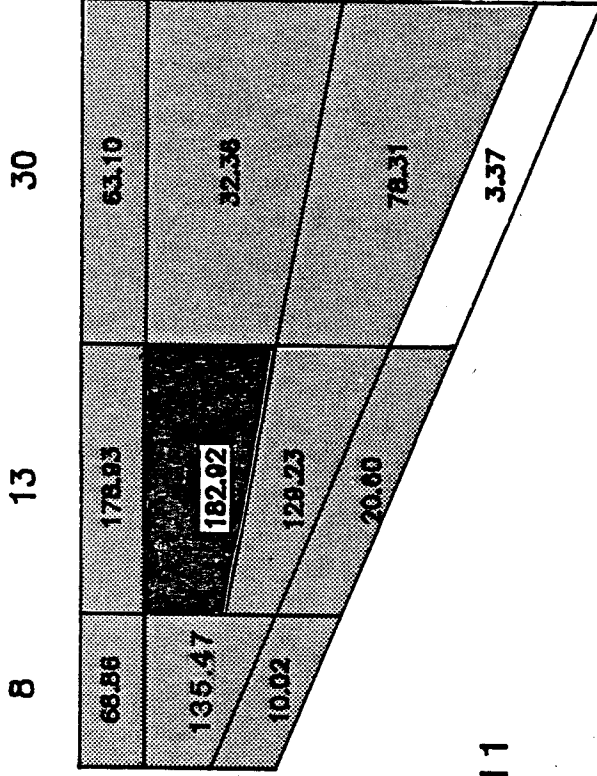
D-401

# Evadne nordmanni

BEFORE OR CONTROL



AFTER SONGS



P=0.11

13H 13h 30s 13L 13S 13s 30h 8H 13I 30S 8H 8S 8s 30H 13E 8e 13e 30L 30I 8E 30e 30E

Figure D-406. Cross-shelf distributional patterns for *Evadne nordmanni*. Shading denotes strata groupings based on the results of the Bonferroni t-test. Strata designations are ordered from highest to lowest mean rank abundance. Strata not significantly separable are underlined. Upper case strata designations (e.g., 8E = 8 m epibenthos) are for SONGS in the After data set, lower case are strata in the Before-Control data set (SONGS in the Before period and Control in both periods). Only strata in which larvae occurred were tested. The results of the MANOVA are also shown.

# Evadne spinifera

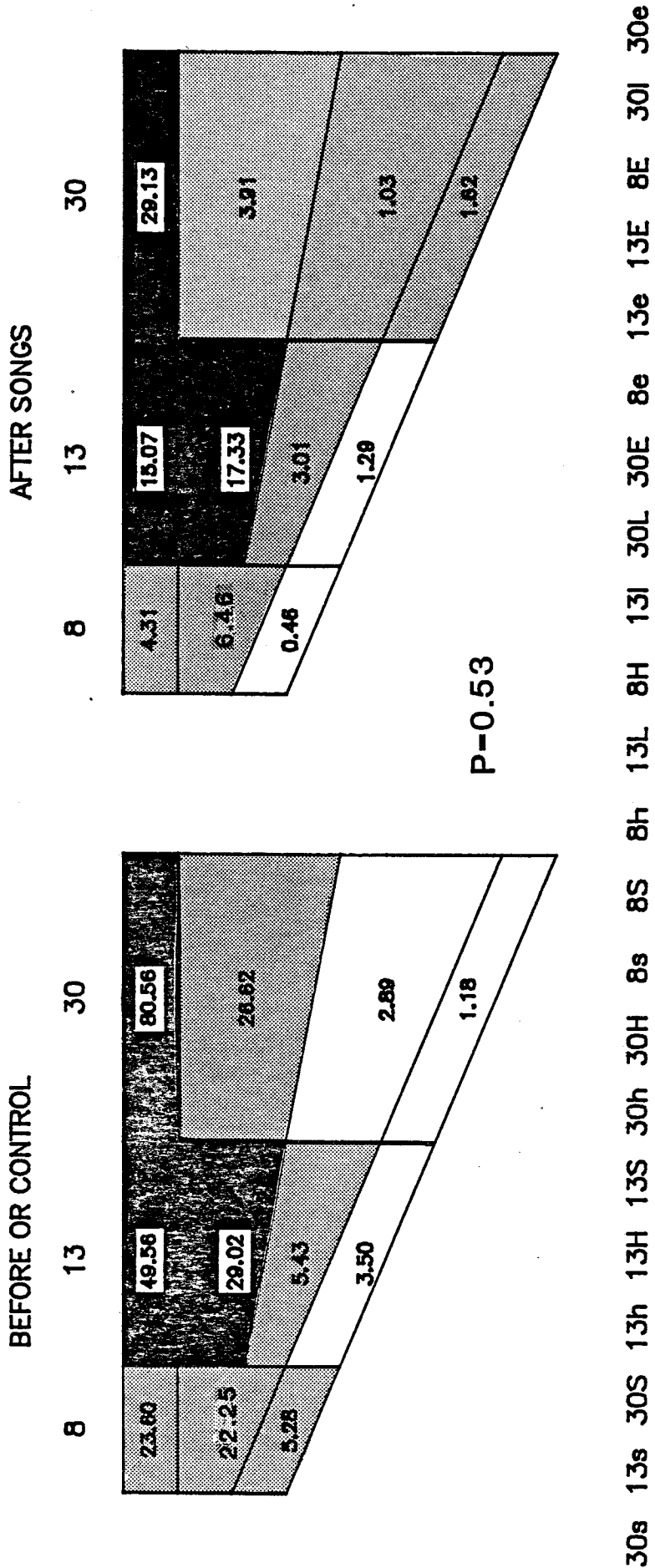
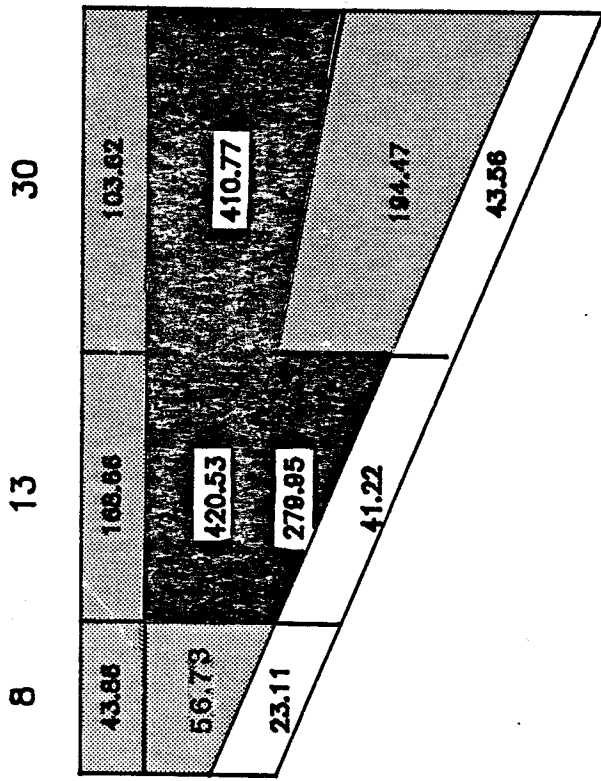


Figure D-412. Cross-shelf distributional patterns for *Evadne spinifera*. Shading denotes strata groupings based on the results of the Bonferroni t-test. Strata designations are ordered from highest to lowest mean rank abundance. Strata not significantly separable are underlined. Upper case strata designations (e.g., 8E = 8 m epibenthos) are for SONGS in the After data set, lower case are strata in the Before-Control data set (SONGS in the Before period and Control in both periods. Only strata in which larvae occurred were tested. The results of the MANOVA are also shown.

D-413

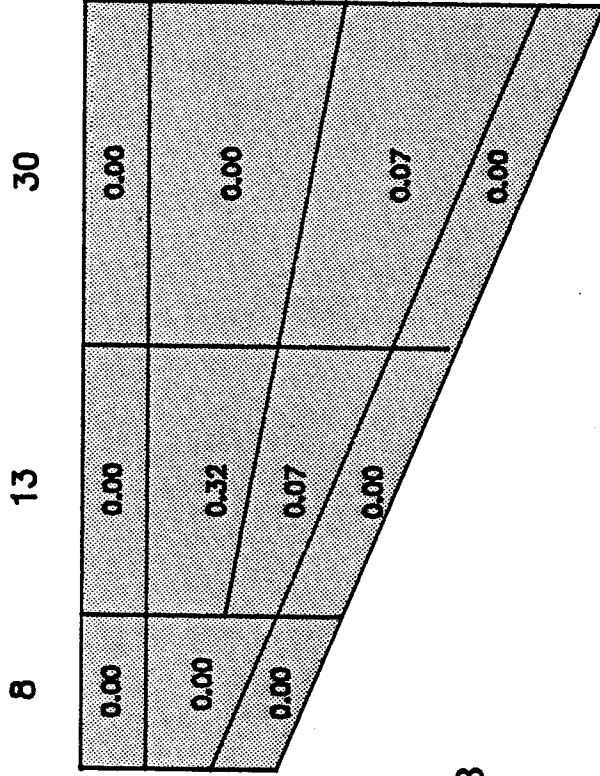
# Penilia avirostris

BEFORE OR CONTROL



P=0.03

AFTER SONGS

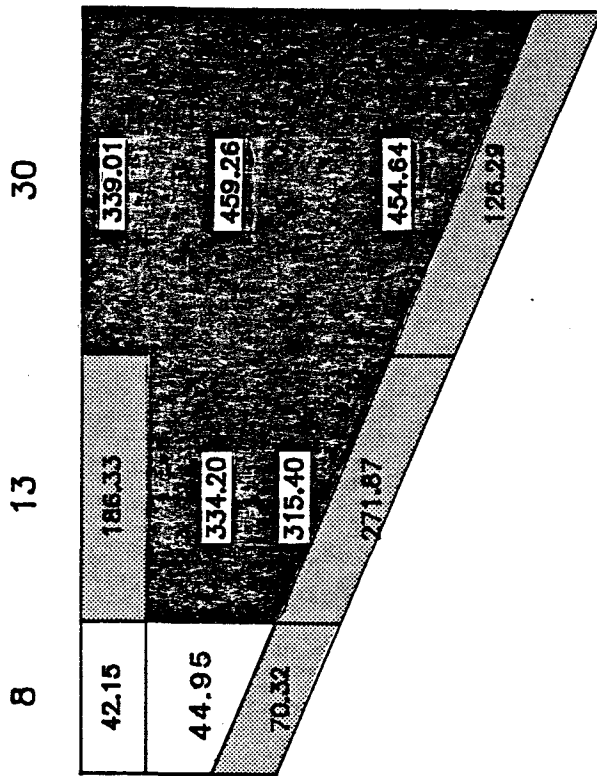


30h 13h 13s 13H 30s 30I 13L 30L 13E 13S 30E 30H 30S 8E 8H 8S 8h 8s 13e 8e 30e

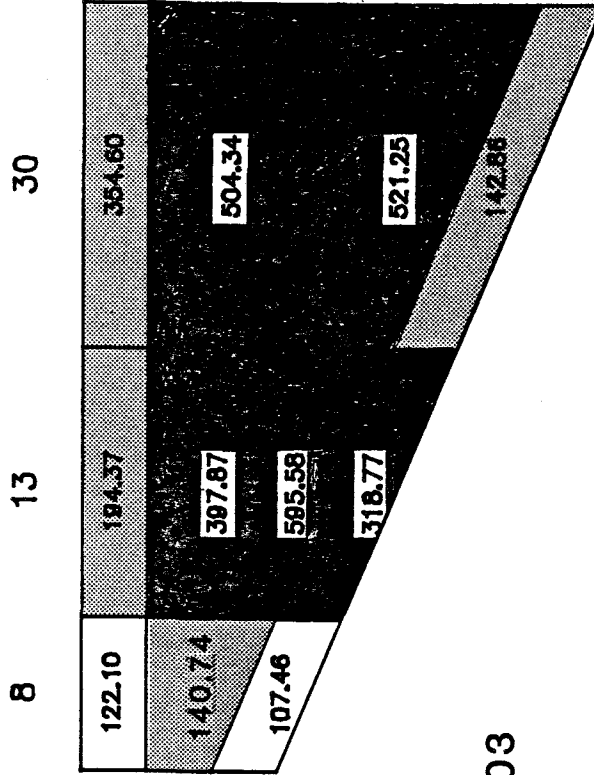
Figure D-418. Cross-shelf distributional patterns for *Penilia avirostris*. Shading denotes strata groupings based on the results of the Bonferroni t-test. Strata designations are ordered from highest to lowest mean rank abundance. Strata not significantly separable are underlined. Upper case strata designations (e.g., 8E = 8 m epibenthos) are for SONGS in the After data set, lower case are strata in the Before-Control data set (SONGS in the Before period and Control in both periods. Only strata in which larvae occurred were tested. The results of the MANOVA are also shown.

# Corycaeus anglicus

BEFORE OR CONTROL



AFTER SONGS



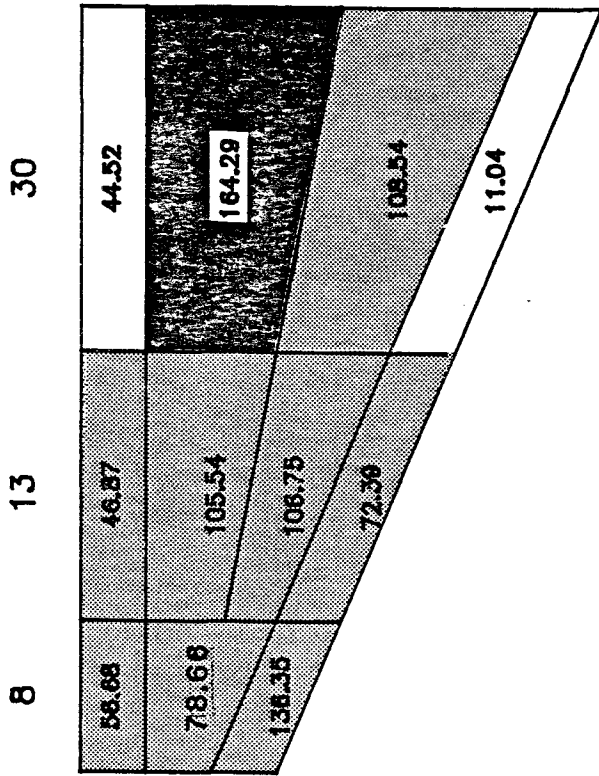
P=0.03

13L 30H 30L 30I 30h 13h 13H 13I 30s 13E 13s 13e 13S 30S 30e 8H 8h 8S 8s 8E

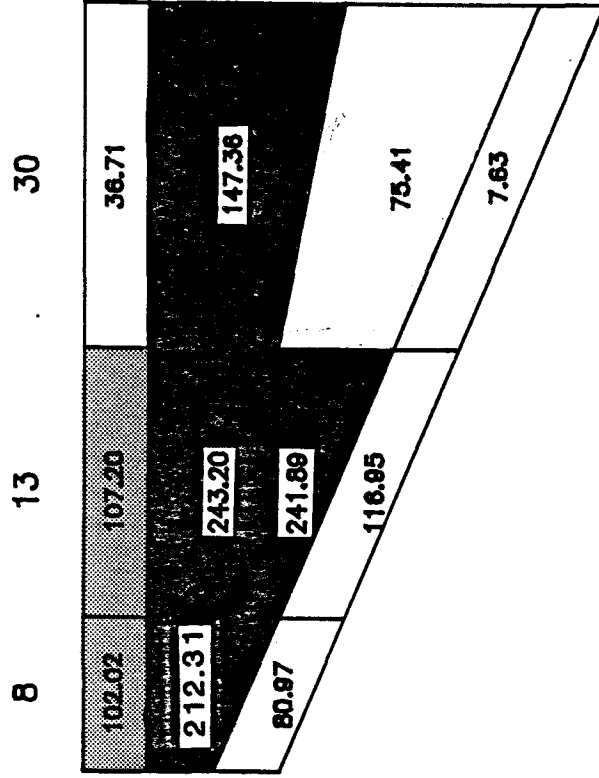
Figure D-424. Cross-shelf distributional patterns for *Corycaeus anglicus*. Shading denotes strata groupings based on the results of the Bonferroni t-test. Strata designations are ordered from highest to lowest mean rank abundance. Strata not significantly separable are underlined. Upper case strata designations (e.g., 8E = 8 m epibenthos) are for SONGS in the After data set, lower case are strata in the Before-Control data set (SONGS in the Before period and Control in both periods. Only strata in which larvae occurred were tested. The results of the MANOVA are also shown. D-425

# Cyphonautes larvae

BEFORE OR CONTROL



AFTER SONGS



P=0.03

13H 8H 13L 30H 13h 13l 30l 8h 8e 8s 13s 13e 13s 30L 8E 30s 13E 30S 30e 30E

Figure D-430. Cross-shelf distributional patterns for Cyphonautes larvae. Shading denotes strata groupings based on the results of the Bonferroni t-test. Strata designations are ordered from highest to lowest mean rank abundance. Strata not significantly separable are underlined. Upper case strata designations (e.g., 8E = 8 m epibenthos) are for SONGS in the After data set, lower case are strata in the Before-Control data set (SONGS in the Before period and Control in both periods. Only strata in which larvae occurred were tested. The results of the MANOVA are also shown.

# Labidocera trispinosa

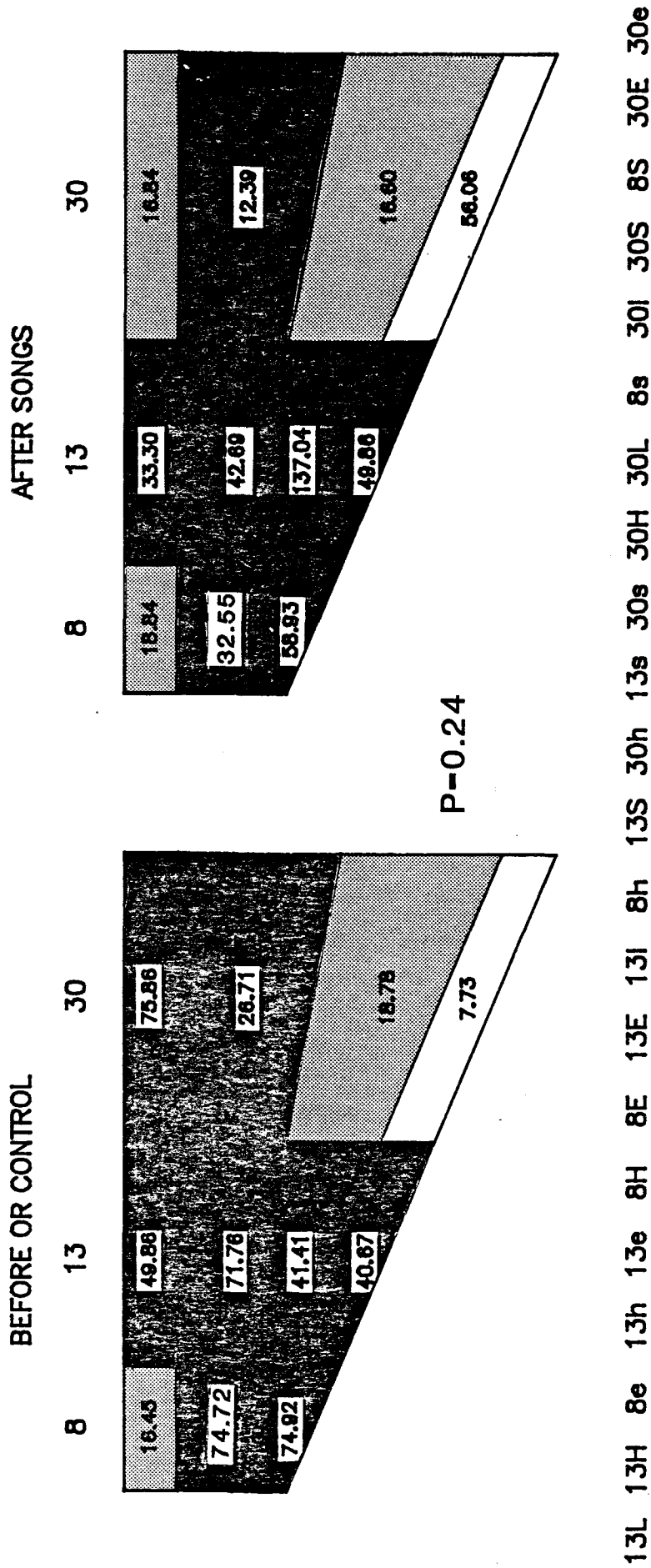
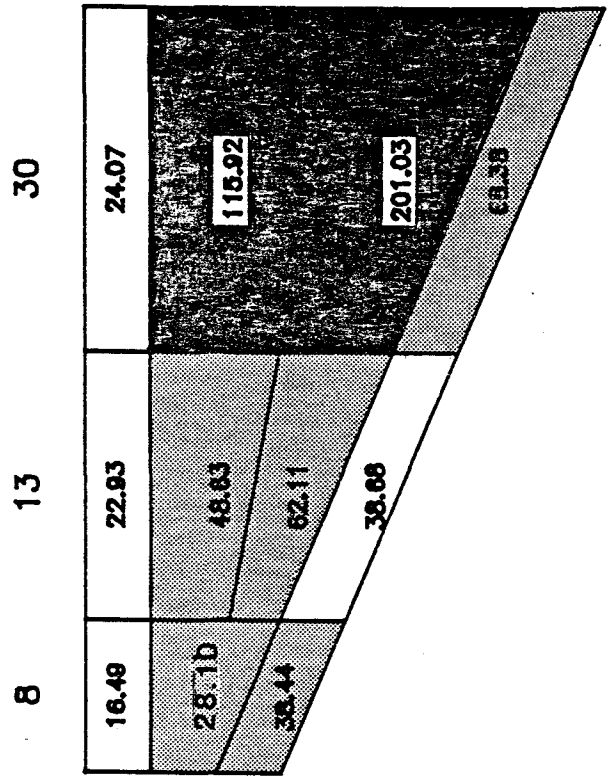


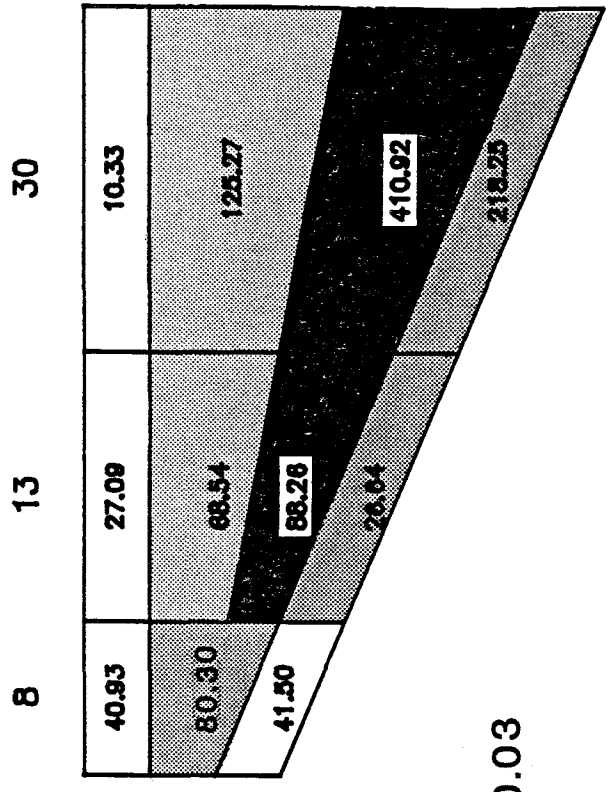
Figure D-436. Cross-shelf distributional patterns for *Labidocera trispinosa*. Shading denotes strata groupings based on the results of the Bonferroni t-test. Strata designations are ordered from highest to lowest mean rank abundance. Strata not significantly separable are underlined. Upper case strata designations (e.g., 8E = ♀ m epibenthos) are for SONGS in the After data set, lower case are strata in the Before-Control data set (SONGS in the Before period and Control in both periods. Only strata in which larvae occurred were tested. The results of the MANOVA are also shown. D-437

# Oithona plumifera

BEFORE OR CONTROL



AFTER SONGS



P=0.03

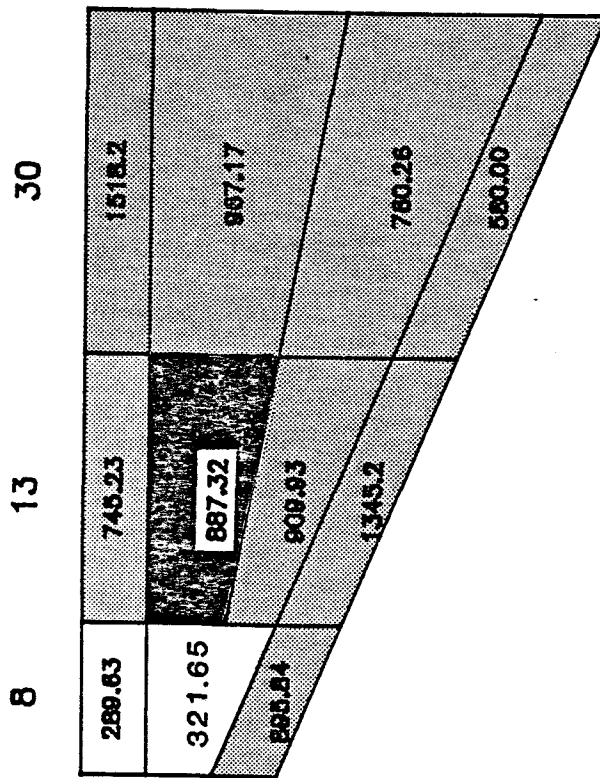
30L 30I 30h 13L 13H 30E 30H 13I 30e 8H 8e 13h 8h 13E 8h 8s 13s 8s 13s 30s

Figure D-442. Cross-shelf distributional patterns for *Oithona plumifera*. Shading denotes strata groupings based on the results of the Bonferroni t-test. Strata designations are ordered from highest to lowest mean rank abundance. Strata not significantly separable are underlined. Upper case strata designations (e.g., 8E = 8 m epibenthos) are for SONGS in the After data set, lower case are strata in the Before-Control data set (SONGS in the Before period and Control in both periods). Only strata in which larvae occurred were tested. The results of the MANOVA are also shown.



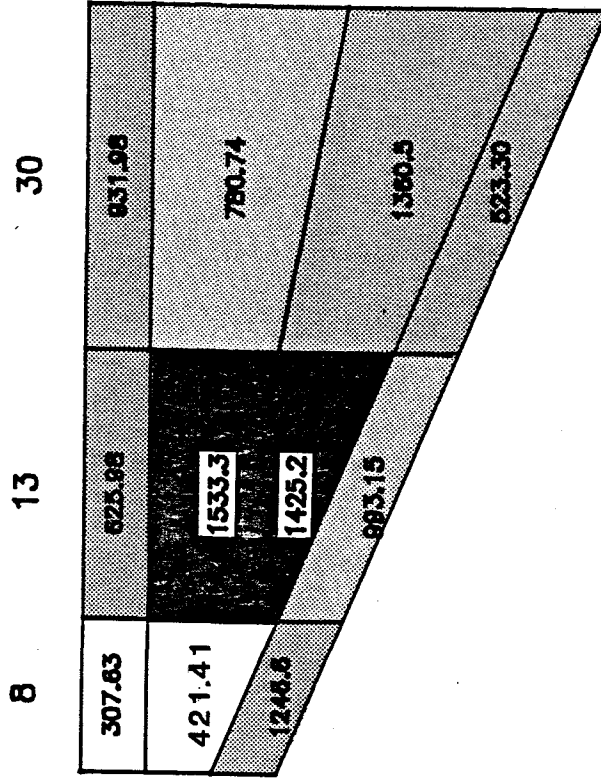
# Paracalanus parvus

BEFORE OR CONTROL



P=0.89

AFTER SONGS

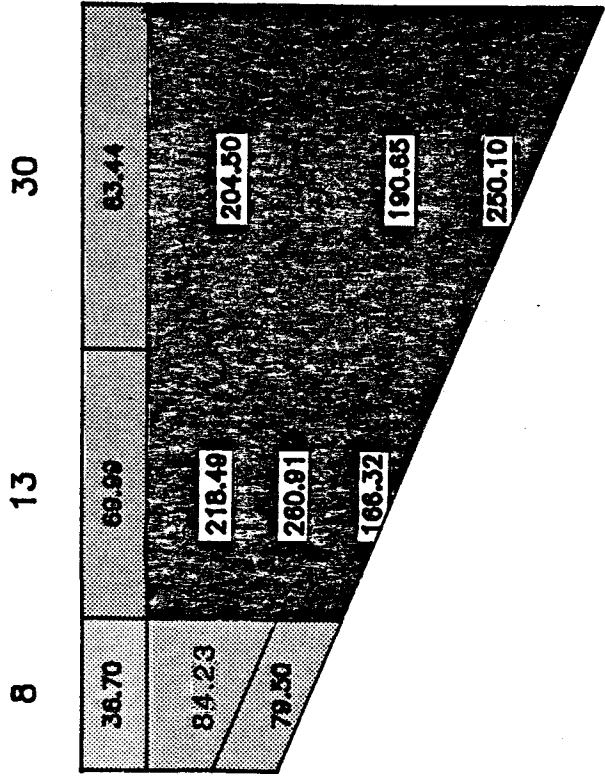


13L 13H 13h 30s 13E 13e 30L 13I 8e 8E 30H 30I 30h 13s 30S 13S 30E 8H 8h 8s 8S

Figure D-448. Cross-shelf distributional patterns for *Paracalanus parvus*. Shading denotes strata groupings based on the results of the Bonferroni t-test. Strata designations are ordered from highest to lowest mean rank abundance. Strata not significantly separable are underlined. Upper case strata designations (e.g., 8E = 8 m epibenthos) are for SONGS in the After data set, lower case are strata in the Before-Control data set (SONGS in the Before period and Control in both periods. Only strata in which larvae occurred were tested. The results of the MANOVA are also shown. D-449

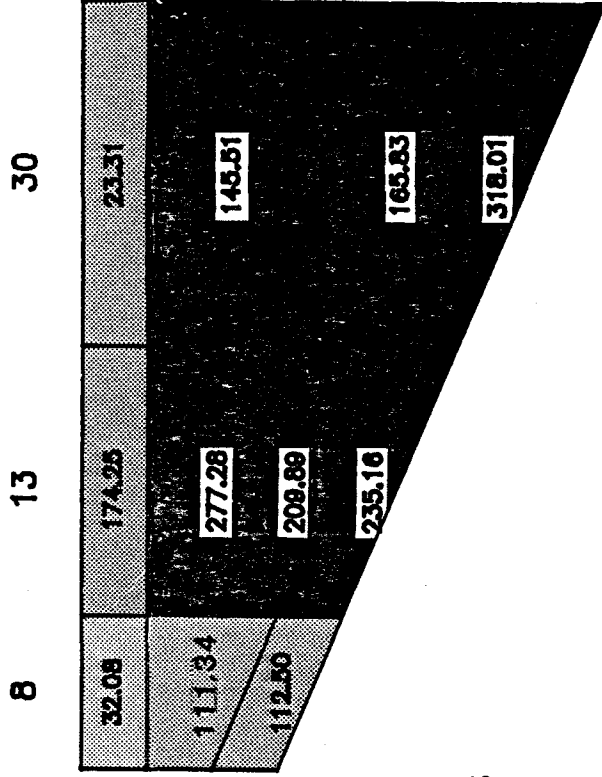
# Sagitta euneritica

BEFORE OR CONTROL



P=0.13

AFTER SONGS

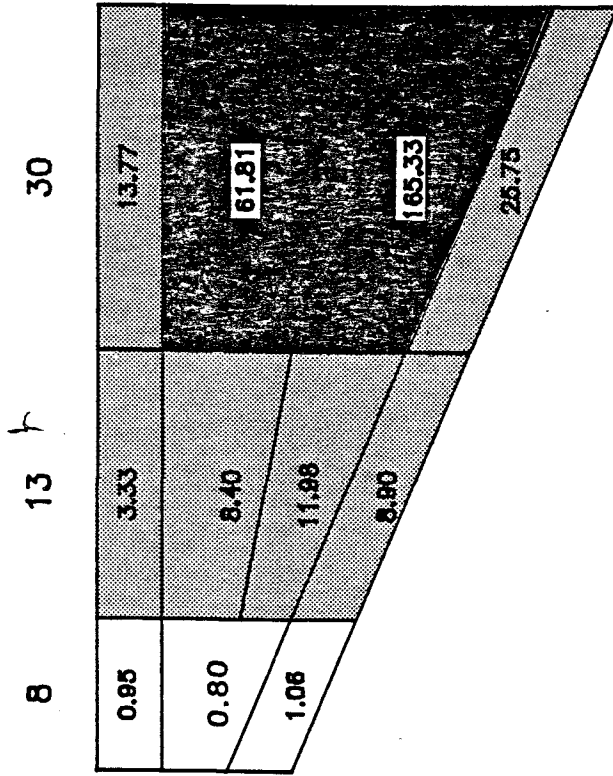


30E 30e 30L 13E 13I 30H 13e 30I 30h 13L 13h 8e 30s 13s 8E 8H 13S 8H 30S 8S 8s

Figure D-454. Cross-shelf distributional patterns for *Sagitta euneritica*. Shading denotes strata groupings based on the results of the Bonferroni t-test. Strata designations are ordered from highest to lowest mean rank abundance. Strata not significantly separable are underlined. Upper case strata designations (e.g., 8E = 8 m epibenthos) are for SONGS in the After data set, lower case are strata in the Before-Control data set (SONGS in the Before period and Control in both periods. Only strata in which larvae occurred were tested. The results of the MANOVA are also shown.

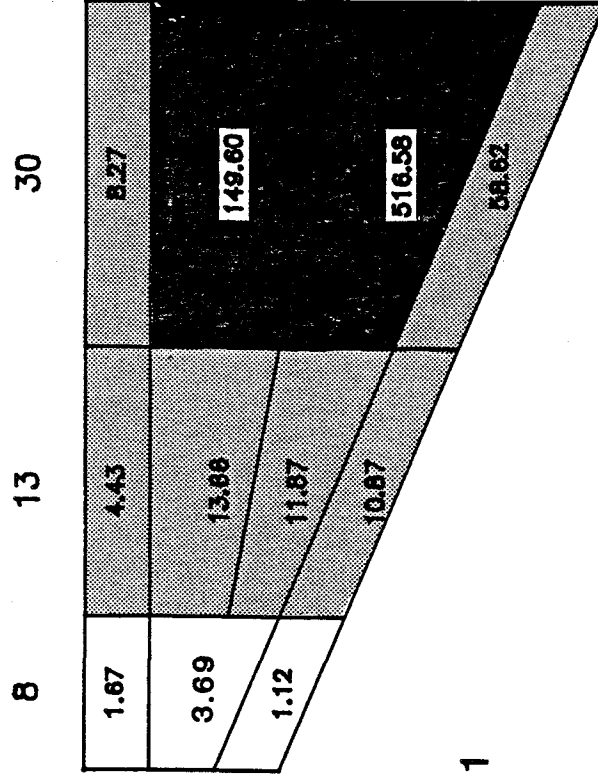
# Calanus pacificus

BEFORE OR CONTROL



P=0.11

AFTER SONGS

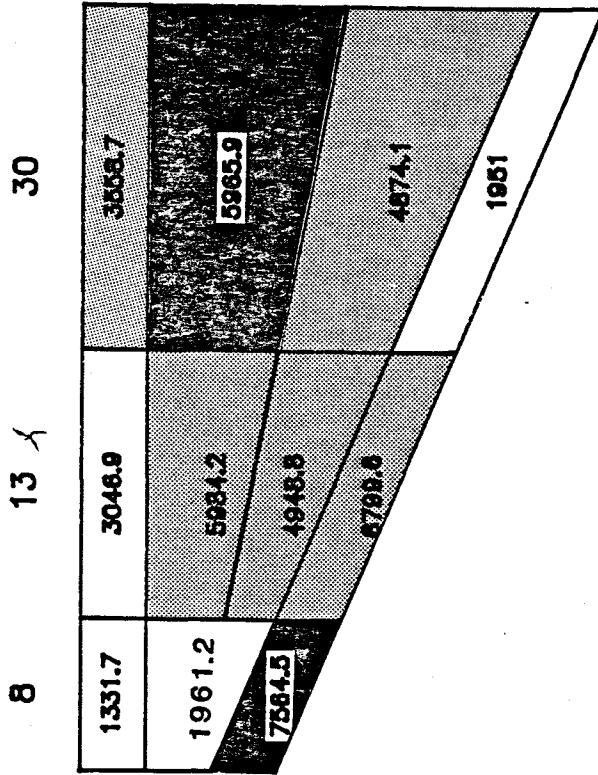


30L 30I 30H 30h 30e 13H 13I 13h 30s 13L 13E 13e 13S 13s 8E 8e 8S 8h

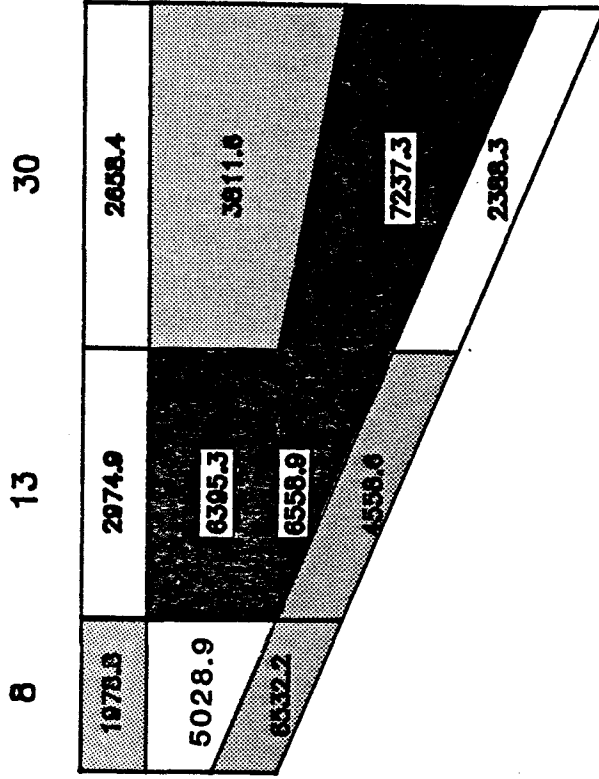
Figure D-460. Cross-shelf distributional patterns for *Calanus pacificus*. Shading denotes strata groupings based on the results of the Bonferroni t-test. Strata designations are ordered from highest to lowest mean rank abundance. Strata not significantly separable are underlined. Upper case strata designations (e.g., 8E = ♂ m epibenthos) are for SONGS in the After data set, lower case are strata in the Before-Control data set (SONGS in the Before period and Control in both periods. Only strata in which larvae occurred were tested. The results of the MANOVA are also shown. D-461

# Total zooplankton

BEFORE OR CONTROL



AFTER SONGS



P=0.01

13L 13H 30L 8e 13h 30I 13I 13e 30H 13E 8E 30s 8H 13S 13s 30S 30E 8h 30e 8S 8s

Figure D-466.

Cross-shelf distributional patterns for Total zooplankton. Shading denotes strata groupings based on the results of the Bonferroni t-test. Strata designations are ordered from highest to lowest mean rank abundance. Strata not significantly separable are underlined. Upper case strata designations (e.g., 8E = 8 m epibenthos) are for SONGS in the After data set, lower case are strata in the Before-Control data set (SONGS in the Before period and Control in both periods). Only strata in which larvae occurred were tested. The results of the MANOVA are also shown.

APPENDIX E

Documentation of Computer Programs

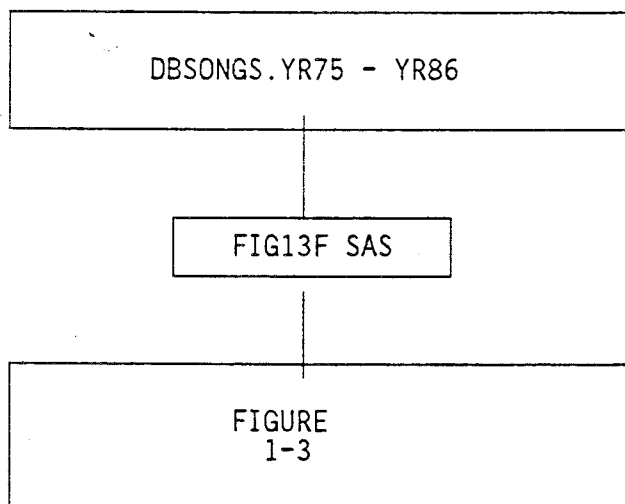
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## APPENDIX E

### Documentation of Computer Programs

This Appendix contains flow charts to document all SAS software used to derive data presented in tables or figures contained within this report. Each figure shows the flow from the MRC data base(s) through SAS software to the final table or figure presentation. All SAS programs listed herein have been documented in the MRC computer system by the software in the Disk Inventory Control System. The location of the documented SAS software (either the ichthyoplankton or zooplankton report disk) is shown on each figure.

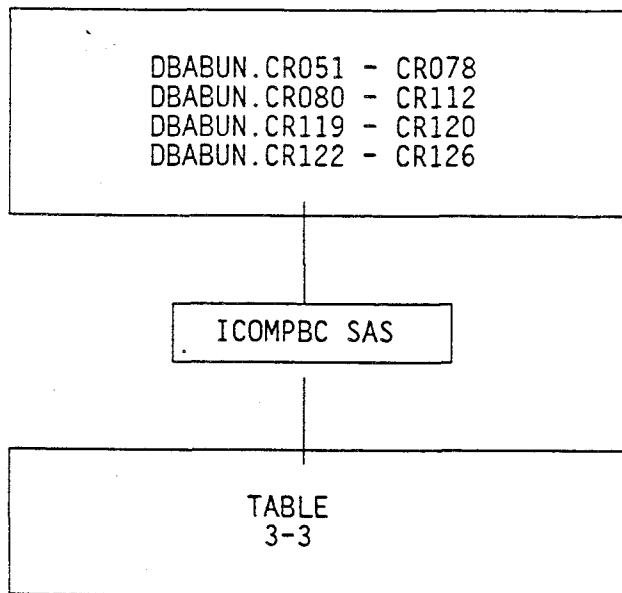


---

FIG13F SAS computes and plots the weekly average number of pumps for SONGS Units 1, 2, and 3

---

Figure E-1. Documentation of program used to generate Figure 1-3. The SAS program has been placed on the ichthyoplankton report disk.



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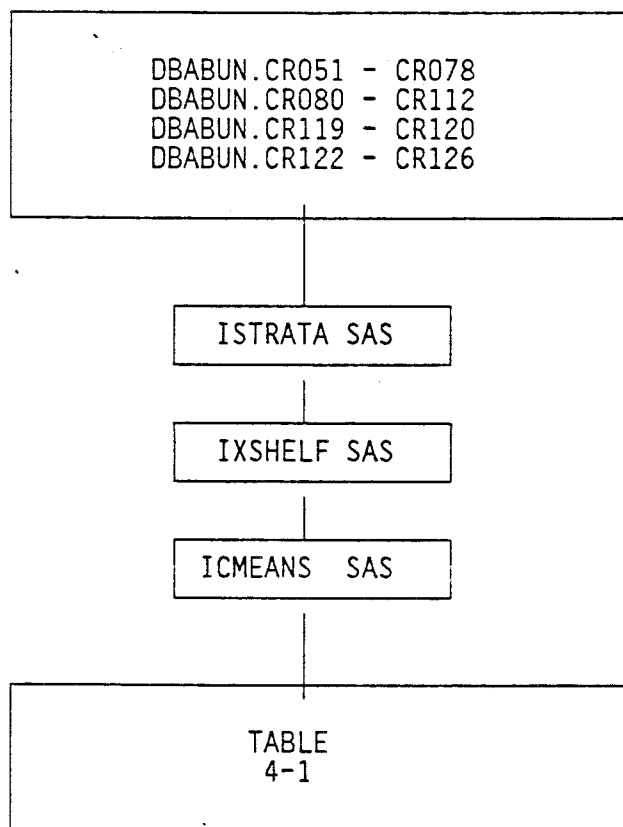
ICOMPBC SAS selects species from DBABUN data base,  
compares the Block B and Block C stations taken near SONGS  
to those taken downcoast of the San Onofre kelp bed

---

e

Figure E-2. Documentation of programs used to generate tables and figures presented in Section 3 for ichthyoplankton. The SAS programs have been placed on the ichthyoplankton report disk.






---

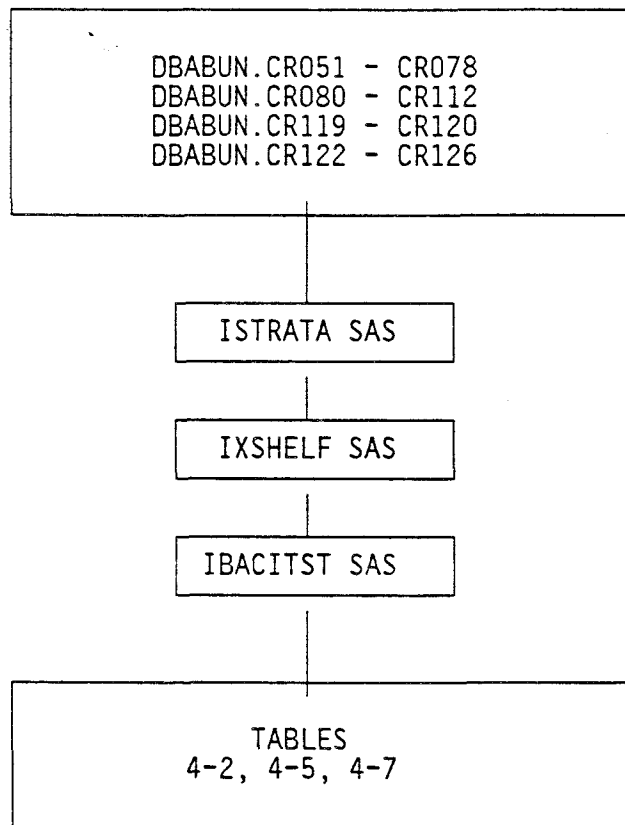
ISTRATA SAS selects selected species from DBABUN data base,  
 computes number per 400 cubic meters,  
 outputs number per stratum for each larval stage and for all larvae

IXSHELF SAS computes the weighted mean number per 400 cubic meters in the  
 cross-shelf transect

ICMEANS SAS computes means and standard deviations on abundance  
 data for SONGS and Control, Before and After data

---

Figure E-3. Documentation of programs used to generate tables and figures presented in Section 4 for ichthyoplankton. The SAS programs have been placed on the ichthyoplankton report disk.




---

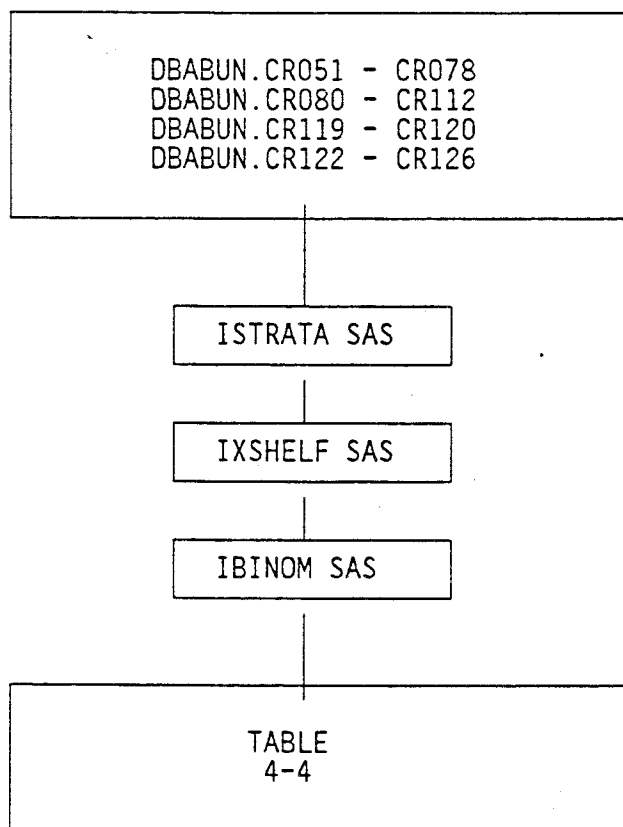
ISTRATA SAS selects selected species from DBABUN data base,  
 computes number per 400 cubic meters,  
 outputs number per stratum for each larval stage and for all larvae

IXSHELF SAS computes the weighted mean number per 400 cubic meters in the  
 cross-shelf transect

IBACITST SAS runs assumption tests on Before data  
 runs BACI t-test on Before and After data  
 computes percent change in abundance at SONGS

---

Figure E-3. (cont.)




---

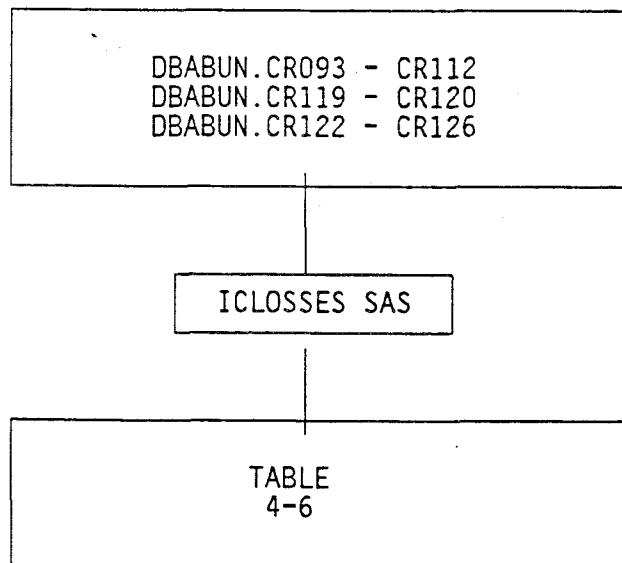
ISTRATA SAS selects selected species from DBABUN data base,  
 computes number per 400 cubic meters,  
 outputs number per stratum for each larval stage and for all larvae

IXSHELF SAS computes the weighted mean number per 400 cubic meters in the  
 cross-shelf transect

IBINOM SAS runs binomial test on BACI data

---

Figure E-3. (cont.)

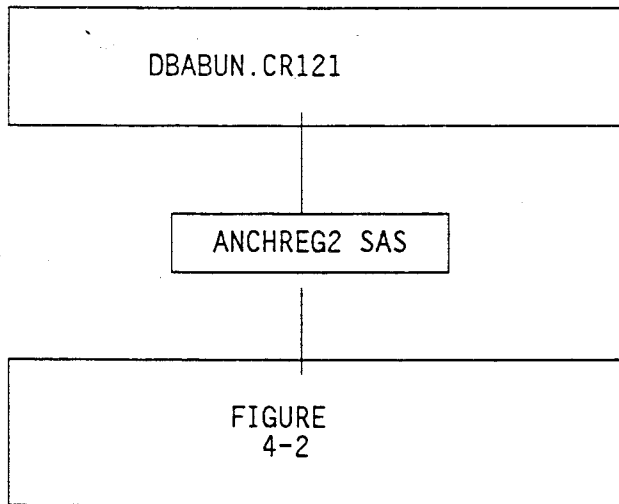


---

ICLOSSES SAS selects selected species from DBABUN data base,  
computes average daily intake loss percentage, and  
also estimates of possible diffuser entrainment losses

---

Figure E-3. (cont.)

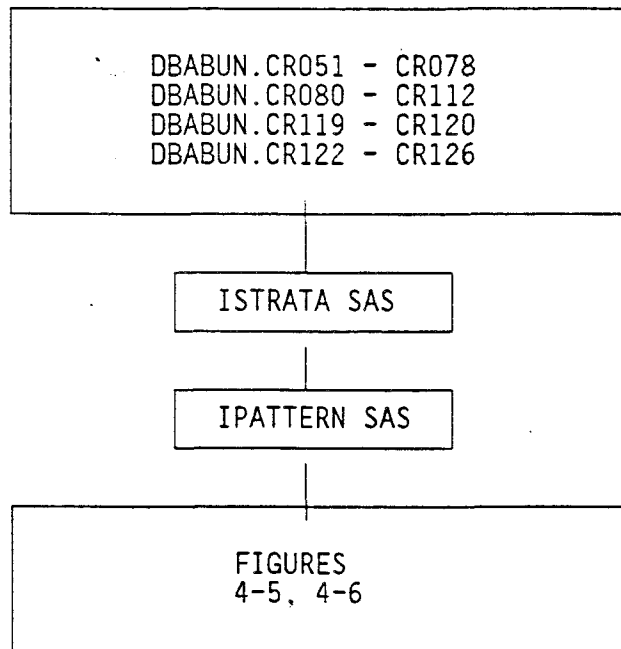


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ANCHREG2 SAS plots the number of anchovy larvae found with distance  
downcoast from SONGS

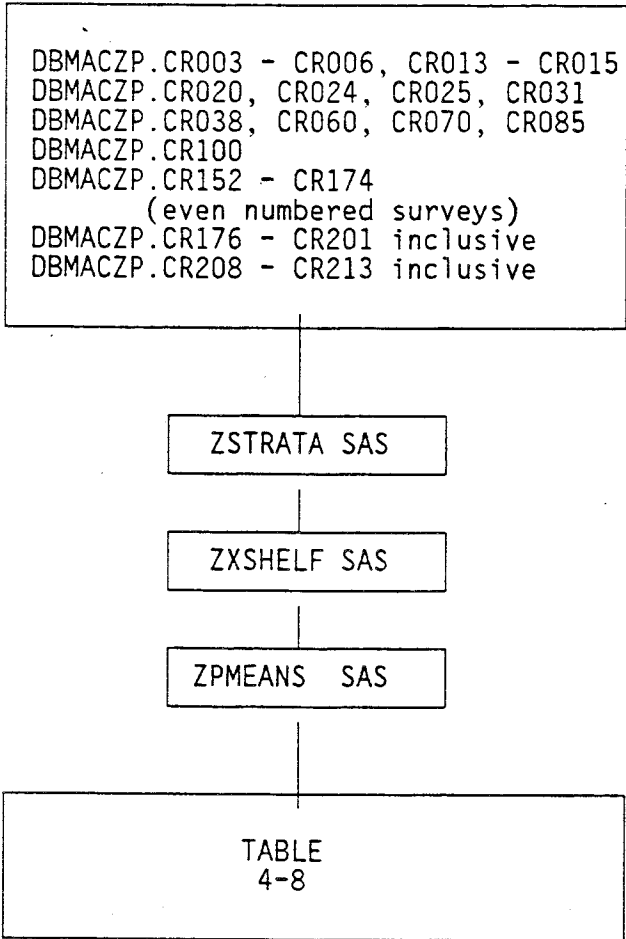
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Figure E-3. (cont.)



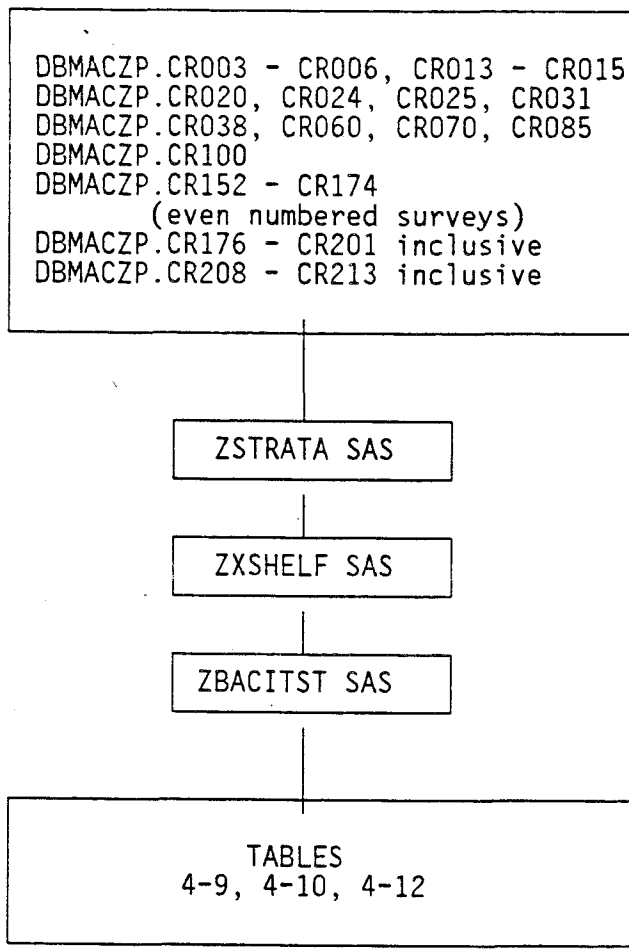
---

Figure E-3. (cont.)



- 
- ZSTRATA SAS selects selected species from DBMACZP data base, outputs number per stratum for each taxon
- ZXSHELF SAS computes the weighted mean number per cubic meter in the cross-shelf transect
- ZPMEANS SAS computes means and standard deviations on abundance data for SONGS and Control, Before and After data
- 

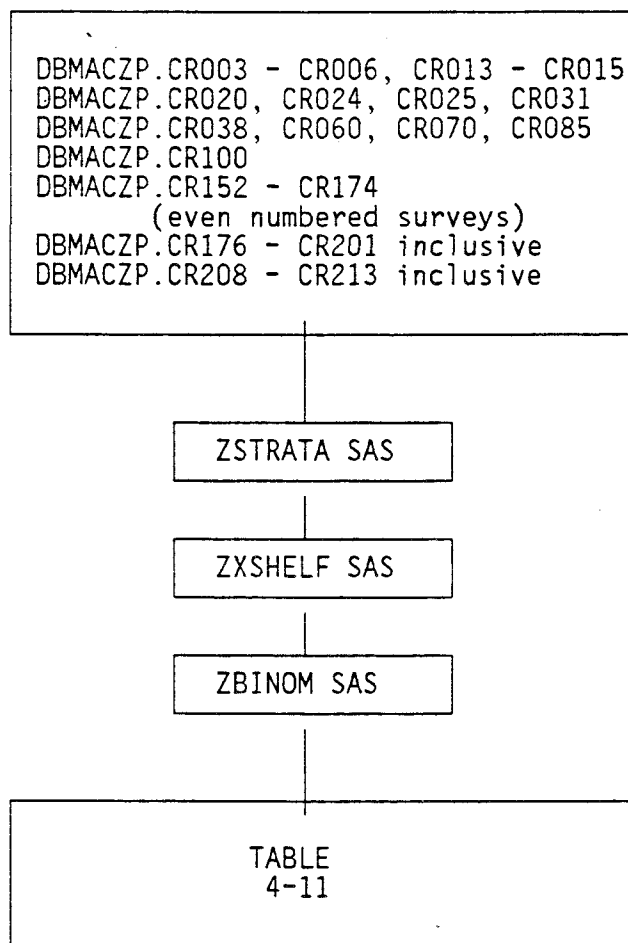
Figure E-4. Documentation of programs used to generate tables and figures presented in Section 4 for zooplankton. The SAS programs listed have been placed on the zooplankton report disk.



- 
- ZSTRATA SAS    selects selected species from DBMACZP data base,  
                  outputs number per stratum for each taxon
  - ZXSHELF SAS    computes the weighted mean number per cubic meter in the  
                  cross-shelf transect
  - ZBACITST SAS    runs assumption tests on Before data  
                  runs BACI t-test on Before and After data  
                  computes percent change in abundance at SONGS
- 

Figure E-4. (cont.)






---

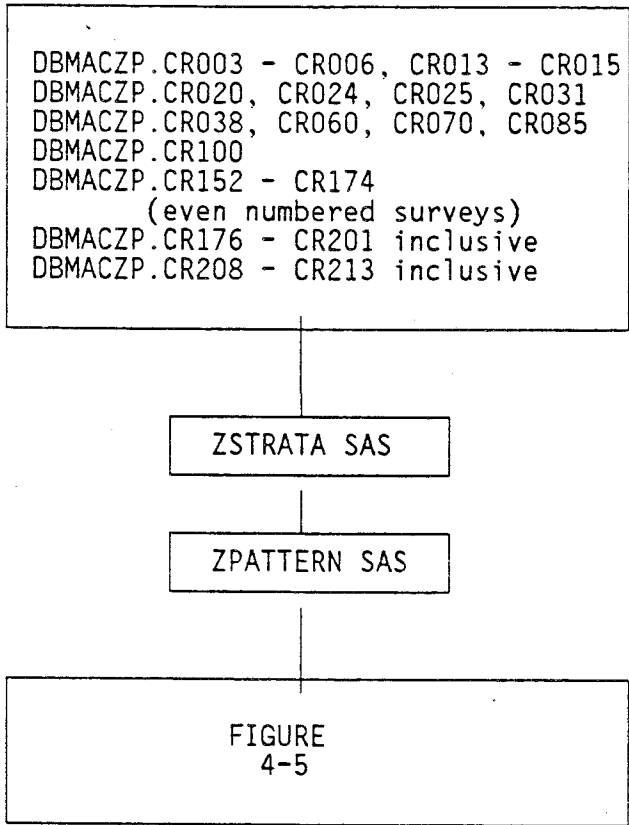
ZSTRATA SAS selects selected species from DBMACZP data base,  
outputs number per stratum for each taxon

ZXSHLF SAS computes the weighted mean number per cubic meter in the  
cross-shelf transect

ZBINOM SAS runs binomial test on BACI data

---

Figure E-4. (cont.)



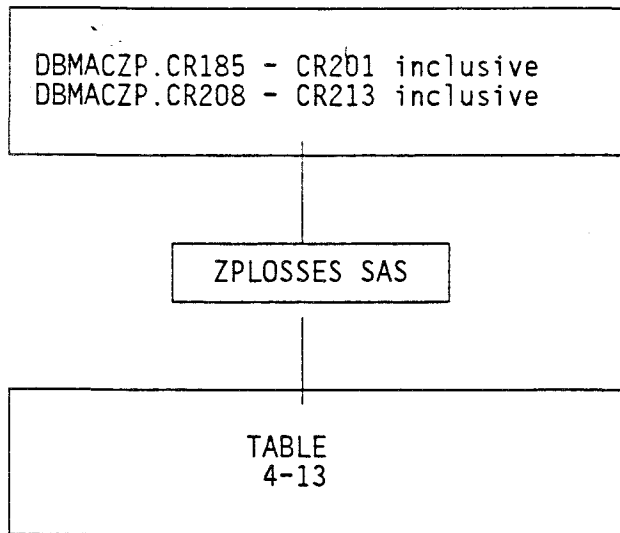
---

ZSTRATA SAS selects selected species from DBMACZP data base,  
outputs number per stratum for each taxon

ZPATTERN SAS ranks the abundances per transect and performs MANOVA and  
ANOVA analysis on the ranks

---

Figure E-4. (cont.)



---

ZPLOSSES SAS selects selected species from DBMACZP data base,  
computes average daily intake loss percentage, and  
also estimates of possible diffuser entrainment losses

---

Figure E-4. (cont.)

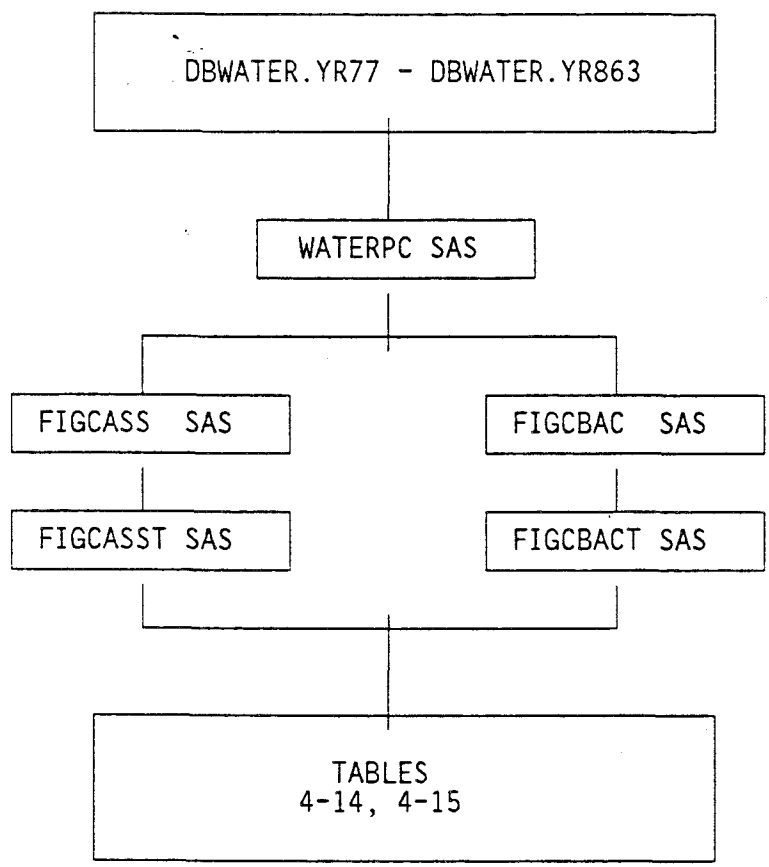
DBMACZP.CR003 - CR006, CR013 - CR015  
DBMACZP.CR020, CR024, CR025, CR031  
DBMACZP.CR038, CR060, CR070, CR085  
DBMACZP.CR100  
DBMACZP.CR152 - CR174  
(even numbered surveys)  
DBMACZP.CR176 - CR201 inclusive  
DBMACZP.CR208 - CR213 inclusive

ZSTRATA SAS

ZPATTERN SAS

FIGURE  
4-6

Figure E-4. (cont.)




---

WATERPC SAS selects strata from DBWATER for BACI analyses

FIGCASST SAS runs assumption tests on Before data  
 runs BACI t-test on Before and After data  
 computes percent change in concentration at SONGS

---

Figure E-5. Documentation of programs used to generate tables and figures presented in Section 4 for chlorophyll. The SAS programs listed have been placed on the zooplankton report disk.

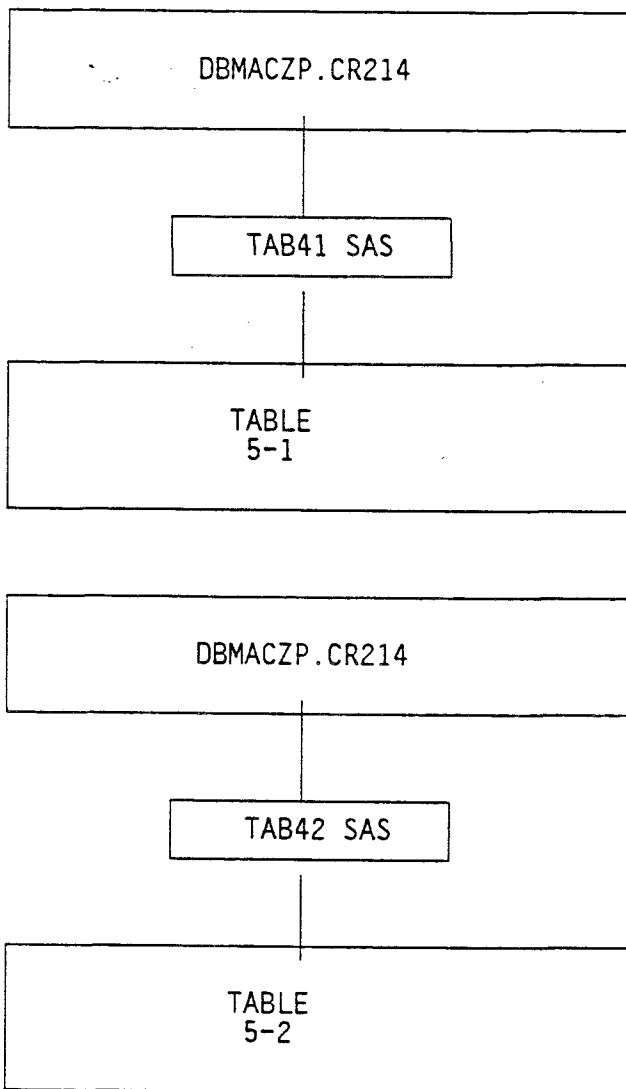


Figure E-6. Documentation of programs used to generate tables presented in Section 5. The SAS programs listed have been placed on the ichthyoplankton or zooplankton report disk.

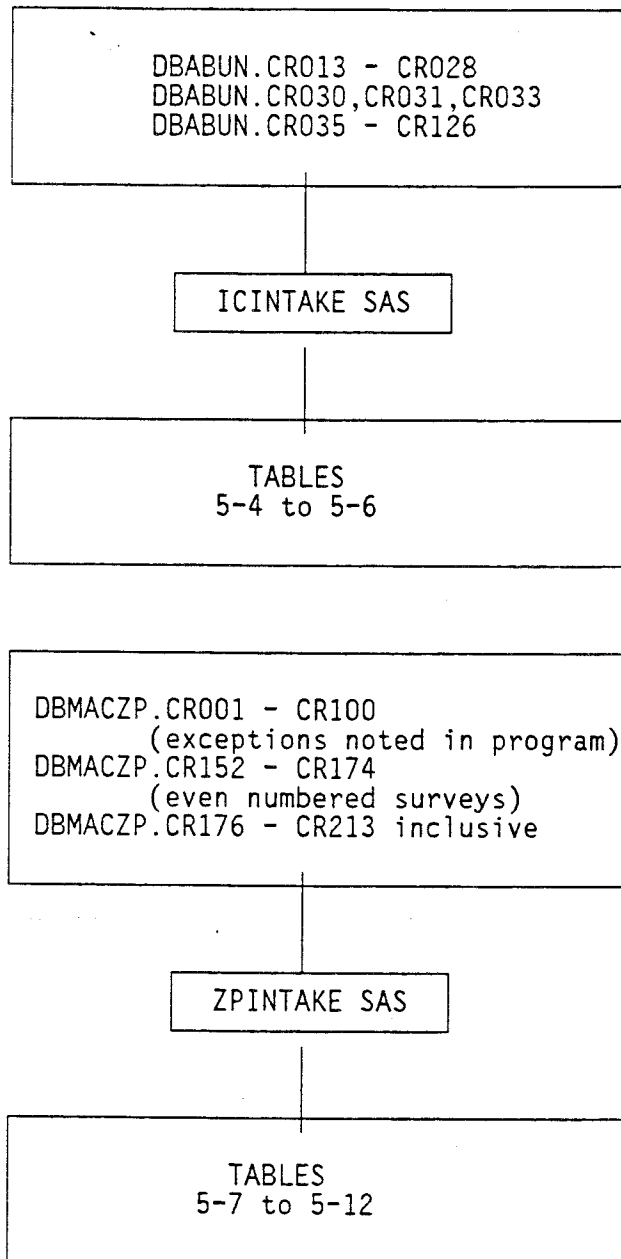
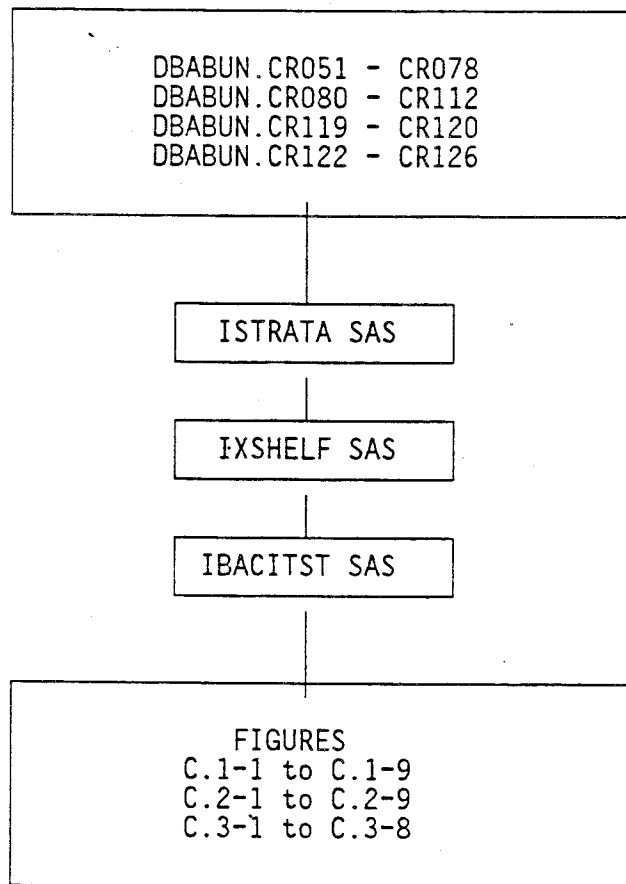


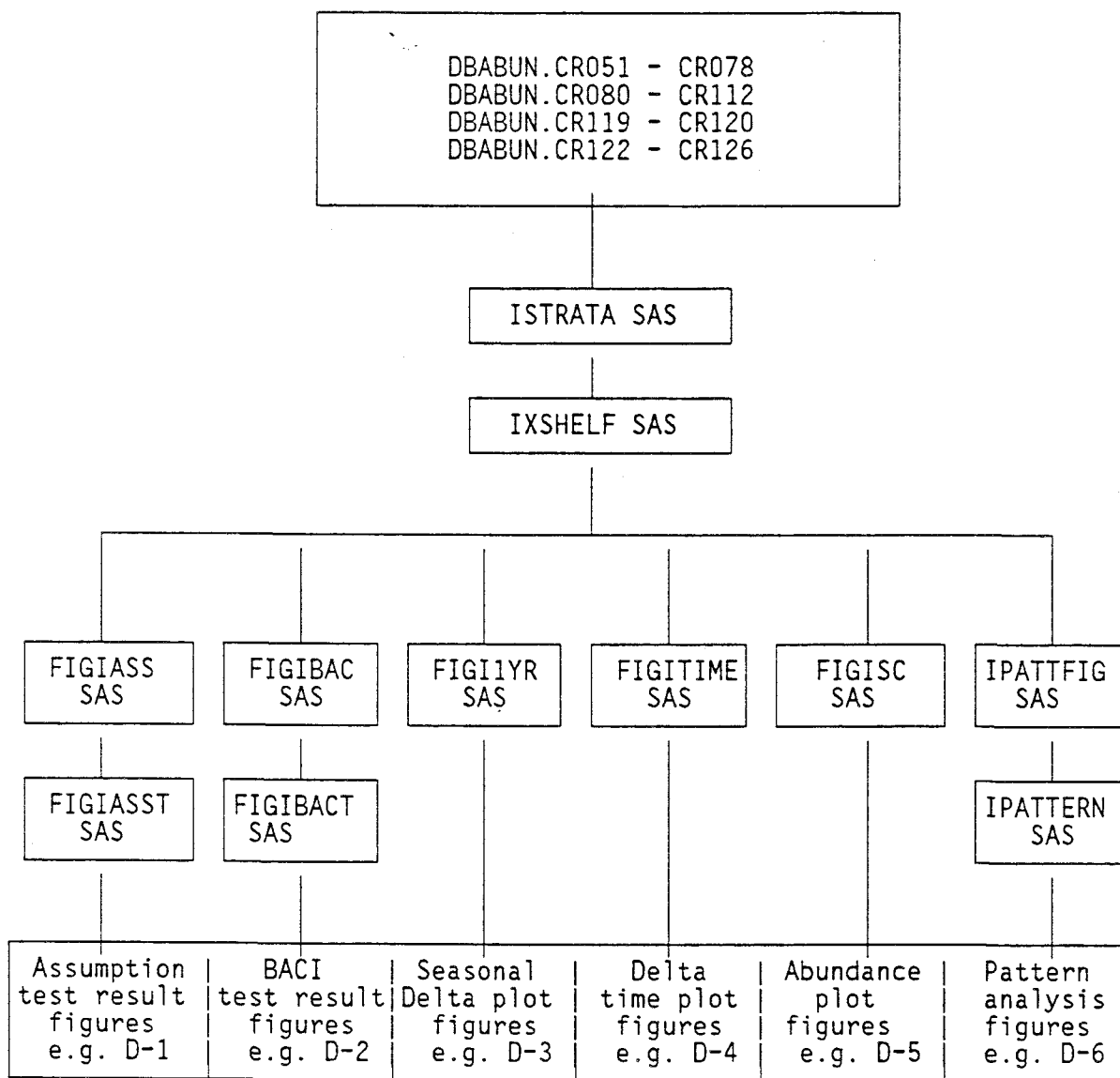
Figure E-6. (cont.)



- 
- ISTRATA SAS selects selected species from DBABUN data base,  
computes number per 400 cubic meters,  
outputs number per stratum for each larval stage and for all larvae
- IXSHELF SAS computes the weighted mean number per 400 cubic meters in the  
cross-shelf transect
- IBACITST SAS runs assumption tests on Before data  
runs BACI t-test on Before and After data  
computes percent change in abundance at SONGS
- 

Figure E-7. Documentation of programs used to generate figures presented in Appendix C.1, C.2, and C.3. The SAS programs listed have been placed on the ichthyoplankton report disk.





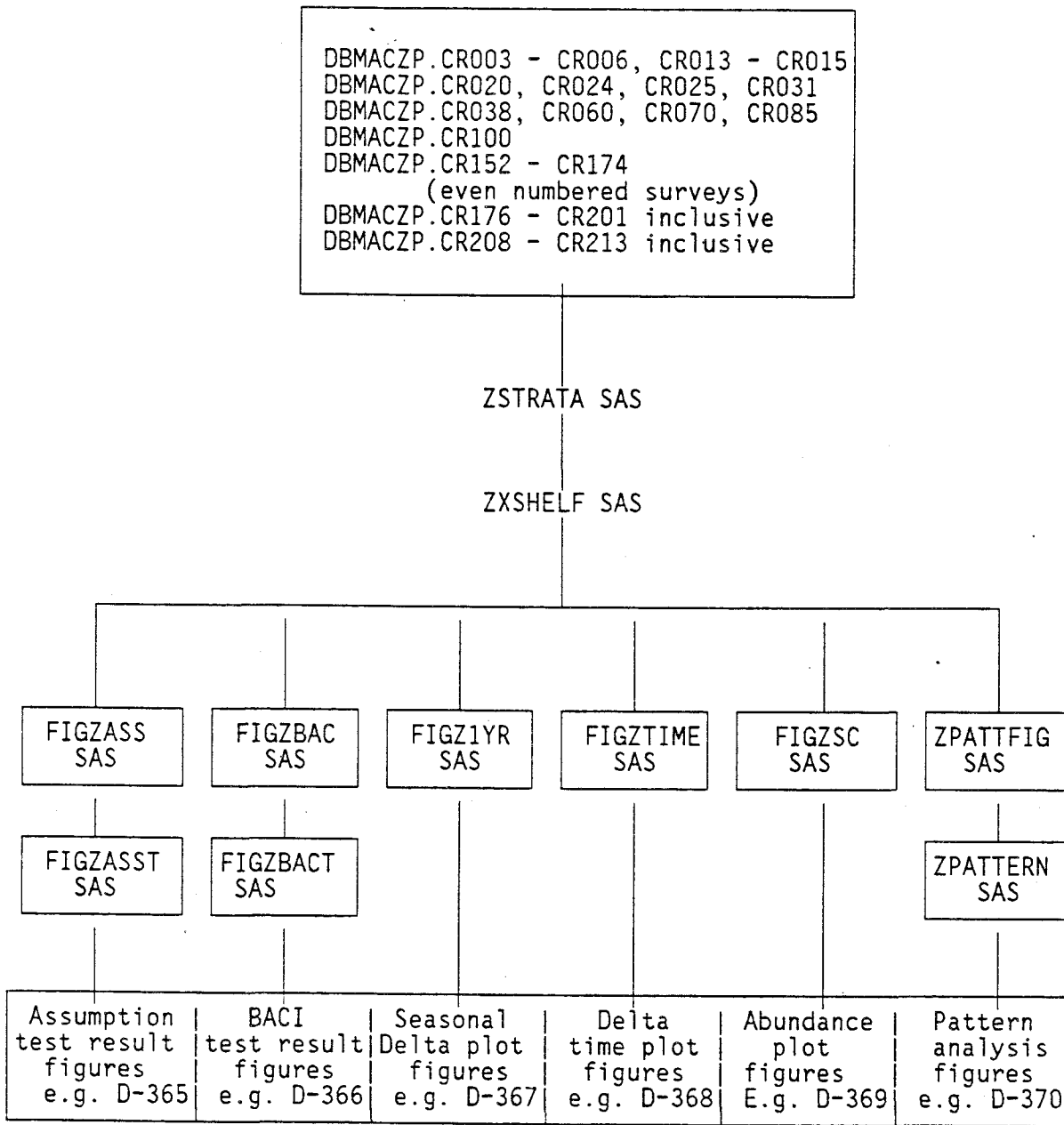

---

ISTRATA SAS selects selected species from DBABUN data base, computes number per 400 cubic meters, outputs number per stratum for each larval stage and for all larvae

IXSHELF SAS computes the weighted mean number per 400 cubic meters in the cross-shelf transect.

---

Figure E-8. Documentation of programs used to generate figures presented for ichthyoplankton in Appendix D. The SAS programs listed have been placed on the ichthyoplankton report disk.



ZSTRATA SAS selects selected species from DBMACZP data base, outputs number per stratum for each taxon

ZXSHELF SAS computes the weighted mean number per cubic meter in the cross-shelf transect

Figure E-9. Documentation of programs used to generate figures presented for zooplankton in Appendix D. The SAS programs listed have been placed on the zooplankton report disk.