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REVISIONS AND ADDENDA

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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 In addition, a new Appendix Volume 1 cover page, and a page explaining which Volume 1 appendices are superceded by the appendices given in Volume 2, are also attached and may be removed and inserted in Volume one.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 macrozooplankers 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 gobiesocids), 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