3.5.3 Invertebrate/Vertebrate Assemblages Associated with Kelp Forests

The kelp forests of the MBNMS provide habitat for a large variety of invertebrates, fishes, birds and mammals which are distributed among three different regions of the forests; the surface canopies, the midwater and the substrate (Foster and Schiel, 1985; Figure 5).

The holdfasts of giant kelp and mats of geniculate coralline algae provide microhabitats for an abundant and species rich association of invertebrates (Andrews, 1945; Foster and Schiel, 1985; Dearn, 1987). Andrews (1945) found approximately 23,000 individuals from nine invertebrate phyla residing in five giant kelp holdfasts collected from the Monterey and Carmel Bays, the most common of which were polychaetes, amphipods, decapods, gastropods and ophiuroids.

Outside the holdfasts, sponges, tunicates, anemones, cup corals and bryozoans are probably the most commonly occurring sessile animals within kelp forests (Foster and Schiel, 1985; Table 1). McLean (1962) observed 204 species of invertebrates living in a bull kelp forest along an exposed coast south of Carmel during 30 SCUBA dives. In addition to these bottom dwelling species, a large number of invertebrates, such as the isopod *Idotea resecata* and the bryozoan *Membranipora tuberculata* occur within the canopies, while diverse assemblage of planktonic species such as jellyfish, crustaceans and fish larvae live in the water column of the kelp forests (Figure 5).

A wide variety of motile grazers, the majority of which do not remove entire kelp plants but graze upon their tissue and other associated algae (Foster and Schiel, 1985), also occur in the forests. Some species, such as sea urchins (*Strongylocentrotus franciscanus* and *S. purpuratus*), may completely remove entire kelp plants by grazing through their holdfasts (Pearse and Hines, 1979; Foster and Schiel, 1985; Kenner, 1992). Where urchin predators are present, sea urchins typically remain stationary in cryptic habitats and feed on detritus and macroalgal drift. (Ebeling et al., 1985; Foster and Schiel, 1985; Watanabe and Harrold, 1991). Other species, like the gastropods *Tegula spp*., graze along the entire thallus of the kelp plants from the substrate to the surface (Watanabe, 1984). In addition to herbivores, several species of predatory sea stars, snails and crabs inhabit the kelp forests, but comparatively little is known about the dynamics of these organisms (Foster and Schiel, 1985).

Although they are not limited to kelp forests, a variety of fish occur within them, including many of economic importance. The commercial fisheries associated with kelp forest fishes are reviewed in Leet, Dewees and Haugen (1992). In addition to the commercial fisheries, a large sport fishery is associated with kelp forests, particularly with rockfish, *Sebastes spp.* (Karpov et al., 1995).

The heterogeneous environment of the forest provides an important source of food and shelter for many fish species (Foster and Schiel, 1985; Bodkin, 1988; Table 1). These can be categorized according to where they reside in the forest (Foster and Schiel, 1985). Midwater species of the kelp canopy, such as the senorita (*Oxyjulius californica*) and the surfperch (*Brachyistius frenatus*) browse on the small crustaceans associated with both the kelp fronds and canopies. Other midwater predatory fishes including the common plankton-feeding blue rockfish (*S. mystinus*), the blacksmith (*Chromus punctipinnus*) and juveniles of the predatory kelp rockfish (*S. atrovirens*), olive *rockfish (S. serranoides*) and black rockfish (*S. melanops*). Compared to southern California kelp forests, MBNMS kelp forests have relatively few tropically-derived fish species and even fewer families, but generally host more species per family (see Foster and Schiel (1985) for a review of kelp forest fishes).

Along the central California coast, fish diversity and abundance decrease in areas where the kelp canopies have been removed (Bodkin, 1988). In addition, mass mortality of kelp forest fishes, particularly *Sebastes spp.* have been observed as a result of large waves at the southern end of the MBNMS at San Simeon (Bodkin et al., 1987). Variations in fish abundance may have significant impacts on other communities. For example, juvenile rockfishes associated with kelp forests in Monterey Bay can reduce the amount of barnacle larvae reaching the intertidal to 2% of the level found in the absence of fish (Gaines and Roughgarden, 1988).

Harbor seals (*Phoca vitulina*) and California sea lions (*Zalophus californianus*) are common in and around MBNMS kelp forests. Harbor seals feed on shallow-dwelling kelp forest fishes, while California sea lions, which feed mainly on pelagic fishes, probably limit their use of the forests to transitory feeding (Foster and Schiel, 1985). Gray whales (*Eschrichtius robustus*) have been observed entering kelp forests to escape predation from killer whales (*Orcinus orca*, Baldridge, 1972) and also to feed on invertebrates such as midwater crustacean swarms (Nerini, 1984).

Sea otters (*Enhydra lutris*) are one of the most recognizable marine mammals associated with the kelp forests in the MBNMS. The current California sea otter population occupies a linear coastal range of about 280 km in central California. Most of the population occurs within the boundaries of the MBNMS. Sea otters feed on invertebrates, many of which are associated with kelp forests (Foster and Schiel, 1985 and 1988; Estes et al., 1986), and must consume 25% of their body weight per day to meet their energy needs (Costa, 1978). Otters also use kelp forests as a refuge from predation by white sharks and winter storms, and as nursery areas for females with pups (Foster and Schiel, 1985).

Sea otters can have significant impacts on sea urchin populations, which in turn may affect the kelp forests themselves (Foster and Schiel, 1988). In this respect otters have been called a "keystone species," since they occur high in the food web and by controlling their prey species (sea urchins), they greatly alter the community as a whole (Estes and Palmisano, 1974; Estes and Duggins, 1995). As background, Keystone species concept (Paine, 1969) are defined as have cascading effects disproportionate to their abundance (Chris Harrold, pers. comm.). While the "keystone species" concept is academically debatable for sea otters (Foster et al., 1988; Foster 1990; Riedman and Estes, 1990), the effect of sea otters on a kelp forest is probably significant

A wide variety of birds use MBNMS kelp forests although their relationship with the forests is poorly known (Table 1). Foster and Schiel (1985) report that kelp provides three distinct habitats used by birds: the kelp forest made up of living attached plants associated with rocky substrata, drift kelp floating in the open sea, and the kelp wrack, i.e. detached kelp deposited on the beach by water motion. Kelp forests provide a large potential source of invertebrate and fish prey as well as a refuge from storms. Birds commonly observed in this habitat are gulls, terns, snowy egrets, great blue herons and cormorants (Foster and Schiel, 1985). Birds associated with drift kelp, like phalaropes, feed on the associated plankton and larvae. The kelp wrack provides an important food source and habitat for kelp flies, maggots and small crustaceans on which several species of shore birds, starlings, common crows, black phoebes and warblers feed (Davis and Baldridge, 1980).

### 3.5.4 Seasonal Patterns and Kelp Life Histories

The seasonal patterns in the kelp forests of central California are very different from those observed in southern California. In central California, giant kelp and bull kelp exhibit their greatest recruitment in the spring and maximum canopies in early fall (Foster, 1982a) while kelp canopies in southern California reach their maximum in the winter. Recruitment of giant kelp sporophytes in southern California is greatest during periods of low temperatures and high nutrients, called "recruitment windows" (Deysher and Dean, 1986). These conditions are nearly continuous in central California but are particularly evident during spring upwelling (McLean, 1962; Breaker and Broenkow, 1994) when light is also high because of canopy thinning by winter storms. These new kelp sporophytes grow from the substrate to the surface where they are supported by gas-filled bladders called pneumatocysts, and may form very dense surface canopies.

Although individual giant kelp plants can live up to seven years (Rosenthal et al., 1974), plants in central California may be shorter lived because they are removed during periods of high water motion associated with winter storms (McLean, 1962;

Foster, 1982a; Reed and Foster, 1984; Harrold et al., 1988). During these periods, giant kelp survivorship is positively correlated with the hardness of the substrate to which the plants are attached (Foster and Schiel, 1985). Another major source of kelp mortality along central California has been grazing by sea urchins (*Strongylocentrotus spp.*) (Pearse and Hines 1979, Watanabe and Harrold, 1991). The effect of urchins however, has decreased due to predation by the sea otter *Enhydra lutris* (McLean, 1962; Kenner, 1992; Watanabe and Harrold, 1991).

Although much is known about growth and survivorship of adult kelp sporophytes, relatively little is known about the ecology of their microscopic stages. These stages are probably highly vulnerable to grazing (Leonard, 1994) and sedimentation (Devinny and Volse, 1978; Deysher and Dean, 1986) such as that from sewage discharges, which may thus be important in determining the distribution of kelp forests within the Sanctuary (see also Meistrell and Montagne 1992). Studies on microscopic stages of giant kelp suggest they are also sensitive to the toxins associated with municipal and industrial waste discharges. For example, growth and fertility are reduced when gametophytes are exposed to elevated copper concentrations in discharge effluent (Anderson et al., 1990; see also Foster et al., 1983 for a review).

### 3.5.5 Marine Ecological Changes Near the Monterey Peninsula (prepared entirely by MBNMS Staff)

Ecologically, the area of the Monterey Peninsula has undergone numerous changes since recorded history. The sea otter, which once populated the area, was eliminated from the habitat by man before the beginning of the Twentieth Century. Sea otters did not arrive back again on the Monterey Peninsula until the late 1950's (Riedman and Estes, 1990). Assuming sea otters do have a significant effect on the nearshore environment (Estes and Palmisano, 1974; Estes and Duggins, 1995), it is nearly impossible to predict what the Monterey Peninsula's nearshore "pristine" condition may have been like.

Historically large nearshore abalone and kelp harvesting industries have been supported off the Monterey Peninsula (Scofield, 1959; Cox, 1962; Donnellan and Foster, 1999). The nearshore area along Cannery Row was once predominantly a *Nereocystis* community until the 1960's (Donnellan and Foster, 1999). Also, the intertidal "torching" of the Peninsula's intertidal areas (Bonnot, 1931: See Below) for the red algae industry may have had significant effects, at least in the short term, on the intertidal ecosystem.

Nearshore development is assumed to pose the threat of significant impacts to the nearshore environment (Foster and Shiel, 1985; also, See Below Under Section 4.2.2). As one of the most heavily populated and developed areas of the California Central Coast, the onshore origins of issues (e.g., runoff, sewage, development) most certainly have an impact on the nearshore kelp forests.

For a more in-depth discussion of the ecology of kelp forests, see, "The Ecology of Giant Kelp Forests in California: A Community Profile" (Foster and Schiel, 1985), or the DFG Kelp Management Plan for the State of California (DFG, November 1995).