Appendix 2 — Biological Resources

This appendix presents additional detailed environmental information on plankton (Section Ap.2.1), fish (Section Ap.2.2), marine mammals (Section Ap.2.3), sea turtles (Section Ap.2.4), seabirds (Section Ap.2-5), and benthos (Section Ap.2.6).

Ap.2.1 Plankton

Plankton refers to organisms that have limited or no swimming ability and drift or float along with ocean currents. The two broad categories of plankton are phytoplankton and zooplankton. Phytoplankton, or plant plankton, form the base of the food web by photosynthesizing organic matter from water, carbon dioxide, and light. They are usually unicellular or colonial algae and support zooplankton, fish, and through their decay, large quantities of marine bacteria. Fish production is highly dependent on the growth and productivity of phytoplankton and zooplankton (Ryther, 1969) and fishery yields increase exponentially with increasing primary production in marine environments (Hanson and Leggett, 1982; Nixon, 1988).

Zooplankton are the animal plankton. Holoplankton spend their entire life as plankton while meroplankton spend a portion of their life cycle as plankton and are larval stages of benthic invertebrates. Ichthyoplankton are larval stages of fish. Zooplankton are a primary link between phytoplankton and larger marine organisms in marine food webs.

Plankton distribution, abundance, and productivity are dependent on several environmental factors. Factors include light, nutrients, water quality, terrestrial runoff, and upwelling. Their distribution tends to be very patchy with high seasonal and inter-annual variability along the California coastline. Because phytoplankton are photosynthetic, they are generally limited to the photic zone while zooplankton can occur throughout the water column from surface to bottom.

A description of plankton communities along the central California coast is provided in the following sections.

Phytoplankton

The phytoplankton community off the California coast primarily consists of diatoms, dinoflagellates, silicoflagellates, and coccolithophores (USDOI, BLM 1979). Standard measures for describing phytoplankton communities are productivity, standing crop, and species composition.

Productivity, which is a measure of growth or new plant material per unit time, is highly variable off the California coast (Owen, 1980). Generally, the highest productivity levels occur within about 50 km of the coastline, and tend to be the highest or about six times higher in upwelling areas than the open ocean Riznyk (Owen, 1974). Oguri and Kanter (1971) reported that spring primary productivity levels were approximately five times higher than summer and ten times higher than winter.

Standing crop, or the amount of phytoplankton cells present in the water, is also highly variable and heterogeneous off the California coast. Owen (1974) reported highest standing crop values during the summer (range of 2.50 to 3.00 mg/m^3) and lowest values during the winter months (range of 0.30 to 0.40 mg/m^3). Palaez and McGowan (1986) reported high densities of phytoplankton in spring and summer that lessen in the fall, and become the lowest in the late fall and early winter. They attributed the seasonal differences to ocean circulation patterns and the nutrient content of waters off the California coast. Nutrient-poor waters associated with winter currents and oceanic periods result in reduced phytoplankton biomass (Bolin and Abbott 1963; Garrison 1976).

Phytoplankton biomass have been reported to be higher near Point Conception than in southern or central California regions possibly due to greater upwelling off the Point (Owen 1974). Biomass reached peak levels during summer (July to September) and decreased from October to December and with distance from shore. Highest biomass values were reported during August and in the upper 20 m of the water column (Owen and Sanchez 1974).

Data from several studies (e.g., Bolin and Abbott 1963; Allen 1945) indicated that the phytoplankton community is similar in species composition along the entire coast of California. The diatom *Chaetoceros* was the most abundant species found along the coast (Bolin and Abbott 1963; Cupp 1943). Other dominant species included the diatoms *Skeletonema*, *Nitzschia*, *Eucampia*, T*halassionema*, *Rhizosolenia* and *Asterionella*, and the dinoflagellates *Ceratium*, *Peridinium*, *Noctiluca*, and *Gonyaulax* (Bolin and Abbott, 1963).

In nearby Diablo Canyon, Icanberry and Warrick (1978) reported similar species in their studies. Dominant phytoplankton species were the diatoms *Chaetoceros*, *Nitzschia*, *Navicula*, *Rhizosolenia*, and *Thalassiosira* and the dinoflagellate *Gonyaulax*.

Nearshore plankton tows were conducted about 15 miles down the coast from the Project area, in the vicinity of the Unocal Santa Maria refinery by Clogston (1970). He reported seasonal variation in the relative abundance of phytoplankton and species similar to those reported by Icanberry and Warrick (1978) for Diablo Canyon. A summary of results is presented in Table Ap.2-1.

Zooplankton

Zooplankton are those animals that spend part (meroplankton) or all (holoplankton) of their life cycle as plankton. Their temporal and spatial distributions are dependent on a number of factors including currents, water temperature, and phytoplankton abundance (Loeb et al. 1983). Spring blooms occur for both meroplankton and holoplankton while fall blooms tend to be restricted to the holoplankton. The meroplankton include the larvae of many commercial species of fish, lobster, and crabs. Like phytoplankton, spatial distribution of zooplankton is extremely patchy.

Based on data collected by the California Cooperative Oceanic Fisheries Investigations (CalCOFI), McGowan and Miller (1980) reported a high degree of variability in species composition in offshore waters and that dominant species vary widely even from sample to sample. Fleminger (1964) reported 190 species and 65 genera of calanoid copepods. Kramer and Smith (1972) estimated that 546 invertebrate and 1,000 species of fish larvae occur in the California Current System. Major zooplankton groups off the California coast include copepods, euphausiids, chaetognaths, mollusks, thaliaceans, and fish larvae.

In studies conducted at nearby Diablo Canyon, Icanberry and Warrick (1978) identified 94 taxonomic zooplankton categories. Dominant categories included calanoid copepod nauplii and copepodites, thalicians, *Oikopleura*, *Euphausia*, calyptopis, cyclopoid and harpacticoid copepodites, and the copepod *Acartia tonsa*. Seasonal studies at Diablo Canyon indicate that zooplankton production is highest during June and July, and in January and February. These periods coincide with upwelling periods with corresponding increases in phytoplankton (Icanberry and Warrick, 1978; Smith 1974).

Table Ap.2-1. Relative Abundance of Phytoplankton Species in the Project Area (Clogston, 1970)

	SAMPLING PERIOD					
	September Relative Abundance			November Relative Abundance		
Species	Many	Some	Few	Many	Some	Few
Astrionella japonica		x				
Biddulphia alternans		x			x	
B. aurita		x				
Chaetoceros curvisetus	x					
C. debilis	x				x	
C. radicans	x					
Coscinodiscus discolor	x				x	
C. excentricus	x					
Ditylum brightwelli		x				
Gyrosigma spencerii		x				
Isthmia nervosa			x			
Nitzschia pacifica		x				
Pleurosigma normanii			x			
Rhizosolenia alata			x			
R. hebetata	x					
R. setigera	x				x	
Thalassionema nitzshioides	x				x	
T. rotula						x

From CalCOFI investigations conducted offshore of the Morro Bay region, Fleminger (1964, 1967) reported 176 species of zooplankton. Dominant species included *Calanus tenuicornis*, *Ctenocalanus vanus*, *Acartia danae*, and *Clausocalanus furcatus*. According to Olsen (1949), cyclopoid copepods comprise over half of zooplankton species offshore central California with *Oithona similis* being the most abundant species.

Nearshore zooplankton tows were conducted about 15 miles down the coast at Unocal Santa Maria Refinery during September and November of 1969 by Clogston (1970). Zooplankton species sampled during these surveys and their relative abundance is presented in Table Ap.2-2. Densities of zooplankton species were higher in September than November; consistent with the seasonal variations found with other surveys conducted in the study region. Copepods were the dominant group of organisms found in the zooplankton. Finfish eggs or larvae were not found; however, clam and crab larvae were reported.

Ichthyoplankton

Ichthyoplankton, or fish eggs and larvae, are a component of the zooplankton community. With the exception of a few fish species (e.g., the embiotocidae or surfperches that bear live young), most fish that occur in central California are present as larvae or eggs in the plankton community. The spatial and temporal distribution and composition of the ichthyoplankton are generally due to the spawning habits and the requirements of the adults. Seasonal patterns of ichthyoplankton in nearshore waters are influenced by the spawning cycles of demersal fish species and the northern anchovy, *Engraulis* *mordax*, while further offshore, composition is influenced by pelagic and migratory species and rockfish (*Sebastes* spp). Like phytoplankton and zooplankton, the spatial distribution of ichthyoplankton is patchy and influenced by several environmental factors.

Table Ap.2-2. Relative Abundance of Zooplankton Species Reported in the Project Area (Clogston, 1970)

	SAMPLING PERIOD					
	September Relative Abundance			November Relative Abundance		
Species	Many	Some	Few	Many	Some	Few
Copepoda						
Corycaeus affinis		x				x
Eucalanus elongata	x				x	
Microcalanus pusillus	x				x	
Microsetella norvegica			x			
Pseudocalanus minutus	x				x	
Unidentified nauplii	x				x	
Unidentified copepods	x				x	
Barnacle nauplii	x				x	
Crab zoeae		x				
Clam veliger larvae					x	
Snail veliger larvae						x
Protozoa						
Micro-flagellates				x		
Ceratium sp.						x
Gyrodinium glaucans						x
Noctoluca scintilla						x
Globigerina sp.						x
Tintinnids					x	
Radiolaria						x

In CalCOFI samples collected offshore California, ichthyoplankton densities were found to be at the highest during January to March (Loeb et al., 1983). This was due to the peak spawning season for the northern anchovy, Pacific hake, Pacific mackerel, and the Pacific sardine. During this period, larvae of these species comprised up to 84 percent of the samples. Generally, they found that ichthyoplankton densities decreased from north to south and onshore to offshore between San Francisco and Baja California.

In a year-round study off of Pt. Arguello, the white croaker, *Genyonemus lineatus*, and the northern anchovy, *Engraulis mordax* were the most abundant fish larvae collected (Chambers Consultants, 1980).

In surveys conducted at Diablo Canyon by Icanberry and Warrick (1978), 55 taxa of larval fish were identified. The most abundant larvae were the rockfish, *Sebastes* spp.; white croaker, *Genyonemus lineatus*; blennies, Blennioidae; northern anchovy, *Engraulis mordax*; sculpins, *Artedius* spp.; and the northern lampfish, *Stenobrachius leucopsarus*. These species comprised over 92 percent of the larvae collected. Rockfish and anchovy larvae were most abundant in January and February; and white croaker larvae were found from September through March. Their abundance was highest in February. Generally, eggs were most abundant from August to December while fish larvae were most abundant during the spring months.

In a summary of CalCOFI fish larvae data, Ahlstrom (1965a) found that twelve taxa made up over 90 percent of the larvae collected. The most abundant was the northern anchovy, Engraulis mordax. Other common larval species were the Pacific hake, Merluccius productus; rockfish, Sebastes spp.; flatfish, Citharichthys spp.; and the California smoothtongue, Leuroglossas stilbius. Anchovy and rockfish larvae were abundant from the winter to spring seasons. Spawning varied by season with no discernible pattern within the California Current system (Kramer and Ahlstrom 1968; Ahlstrom et al. 1978).

Ap.2.2 Fish

The fish resources in the Project area off the coast of central California are comprised of both year-round residents and seasonal migrants. Fish resources in the area are dynamic and rich and are comprised of over 500 species of fish (USDOI 1996a). Large numbers of shellfish and other invertebrate species also occur in the area with the most important being crab, shrimp, bivalves, and squid. The high level of diversity is reflective of the complex hydrographic, physical, and geologic conditions of the region that provide a wide variety of habitats for fish resources. The distribution of fishes in the area fluctuates on a daily, seasonal, and annual basis for many reasons including food availability, environmental conditions, and migration (USDOI 1996a).

The offshore environment can generally be divided into several zones. For fishes in the area, these zones include the benthic or shelf and pelagic zones. Demersal species are those that live on or near the sea floor while pelagic fish species occur in the water column. Information on species composition, abundance, and distribution of demersal and pelagic fish communities in the Project area are described below.

Demersal Fish

The offshore benthic environment generally consists of sandy, muddy, or rocky substrates. Fish species common to the area in deeper water beyond the tidal and wave zone that are important commercially or recreationally include flatfishes, rockfishes, lingcods, and cods. In shallower waters that are affected by waves and tides, common fish species are the perches, smelts, skates, rays, and flatfishes. Several researchers have reported that demersal fish species distributions are based on depth or depth-related factors (e.g., Bence et al. 1992; Wakefield 1990; Caillet et al. 1992). Depth distributions for fish common to central California are summarized in Table Ap.2-3.

Fish densities on the shelf between 50 and 200 m water depth are generally high, with flatfish densities being highest for species such as Pacific sanddabs and English and Dover sole. Rockfish, as a group, are also extremely abundant on the shelf and at depths to 270 m (Bence et al. 1992). Fish densities and biomass on the upper and middle slope are relatively high with rockfish, sablefish, and flatfish such as Dover sole dominating (SAIC 1992). At deeper depths (greater than 1,500 m), the numbers of fish species, densities, and biomass are typically low. Rattails and slickheads are the most common species at this depth (SAIC 1992). Recent studies, however, have reported significant declines with certain rockfish species (Love et al. 1998; Ralston 1998). While specific species, areas, and reasons for the decline have been debated, there is little doubt that rockfish biomass and commercial harvests have decreased since the 1960s (Bloeser 1999).

Pelagic Fish

Pelagic fish are those species associated with the ocean surface or the water column. Distribution of pelagic fish is generally governed by water depth, distance from shore, and other environmental factors. Oceanic waters up to depths of approximately 200 m are referred to as the epipelagic zone. Epipelagic zone waters are typically well lighted, well mixed, and support photosynthetic algal communities. Water depth from 200 to approximately 1,000 m is referred to as the mesopelagic zone, while depths greater than 1,000 m is called the bathypelagic zone. With increasing depths, light, temperature, and dissolved oxygen concentrations decrease as pressure increases. Hence, the bathypelagic zone is characterized by complete darkness, low temperature, low oxygen concentrations, and high pressure. Each zone is distinguished by characteristic fish assemblages (Moyle and Cech 1988). Generally, epipelagic fishes are relatively large, active, fast growing, long-lived fishes that reproduce early and repeatedly. Mesopelagic fishes are relatively small, slow growing, long-lived fishes that reproduce early and frequently. Bathypelagic fishes are relatively large, sluggish, rapid-growing, slightly shorter-lived fishes that reproduce late and maybe only once (Childress et al., 1980).

Table Ap.2-3. Depth Distribution of Demersal Fish Common to Central California

Water Depth			
50 - 200 m	200 - 500 m	500 - 1200 m	1200 - 3200 m
Sand dabs *Citharichthys sordidus*	Sablefish *Anoplopoma fimbria*	Thornyheads *Sebastolobus* spp.	Rattails *Coryphaenoides filifer*
English sole *Pleuronectes vetulus*	Pacific hake *Merluccius productus*	Pacific hake *Merluccius productus*	Thornyheads *Sebastolobus* spp.
Rex sole *Errex zachirus*	Slickhead *Alepocephalus tenebrosus*	Slickhead *Alepocephalus tenebrosus*	Finescale codling *Antimora microlepis*
Rockfish *Sebastes* spp.	Eelpouts *Lycenchelys jordani*	Rattails *Coryphaenoides filifer*	Eelpouts *Lycenchelys jordani*
Pink surfperch *Zalembius rosaceus*	Rockfish *Sebastes* spp.		
Plainfin midshipman *Porichthys notatus*	Thornyheads *Sebastolobus* spp.		
White croakers *Genyonemus lineatus*			

Pelagic fishes in the Project area are a mix of year-round residents and migrants from several different habitats. Species include large predators (e.g., tunas, sharks, swordfish) and forage fish (e.g., northern anchovy, Pacific sardine, Pacific saury, Pacific whiting). The distributional ranges for pelagic fishes are generally quite extensive and cover much of the coastal California region. Many fish in the pelagic zone such as albacore tuna and Pacific salmons migrate over vast areas in the Pacific.

Common epipelagic fish in the region include the mackerel, *Scomber japonicus*; salmon, *Onchorhyncus* spp.; schooling fish such as Pacific herring, *Clupea pallasii*; northern anchovy, *Engraulis mordax*; and rockfish, *Sebastes* spp. Bence et al. (1992) reported approximately 140 epipelagic species from midwater trawls off central California. In those trawls, juvenile rockfish, Pacific herring, and northern anchovy were the dominant species. Other epipelagic species common to the area included medusafish, *Icichthys lockingtoni*; Pacific sardine, *Sardinops sagax*; Pacific saury, *Cololabis saira*; Pacific argentines, *Argentina sialis*; and tunas (ARPA 1995). Certain epipelagic species such as albacore tuna (*Thunnus alalunga*) and salmon that occur in the region are important commercial and recreational fish species.

Sharks and rays, which are also epipelagic fish, occur in the general Project area. Twenty shark species were reported in the Monterey Bay area by Ferguson and Cailliet (1990). The same study found that the blue shark (*Prionace glauca),* the sevengill shark (*Notorhynchus cepedianus)*, and the sixgill shark (*Hexanchus griseus)* were common species in central California in areas that are characterized by a nearshore continental shelf, which extends offshore to the upper and middle continental slope. The blue shark, which is probably the most common shark species off the coast of California, also commonly utilizes these habitats. Prey species of the blue shark, which is found worldwide in temperate and subtropical seas include various fish species such as the slender sole (*Lyopsetta exilis)*, cuskeels, sanddabs, and squid (Love 1991).

Less is known on the pelagic fish in the mesopelagic and bathypelagic zones. Typical species in the area include the blacksmelt (*Bathylagus milleri)*, and northern lampfish, viperfish, and the lanternfish (Cross and Allen 1993). Example bathypelagic fish include dragonfish, hatchetfish, and bristlemouth (Cross and Allen 1993).

Bottom trawls were conducted about 15 miles south of the Project area by Rechnitzer and Limbaugh (1956, 1959) at water depths ranging from 5 to 26 m. The fish that were captured by these trawls are listed in Table Ap.2-4 in decreasing order of abundance.

Speckled sanddab, barred surfperch, spotfin surfperch, and the pricklebreast poacher were the most common species 5- to 14-m water depths. Several species of demersal fish (e.g., sole, sanddab, lingcod) were also reported (Rechnitzer and Limbaugh 1956, 1959).

Diver surveys were also conducted in rocky bottom habitats at nearby Mussel Point (Tenera (1995a 1995b). Fish species observed included the pile perch, striped surfperch, the kelp greenling (*Hexagrammos decagrammus)*, the sculpin (*Oligocottus spp*.), the snubnose sculpin (*Orthonopias triacis)*, the convict fish (*Oxylebius pictus)*, the cabezon (*Scorpaenichthys marmoratus)*, the brown rockfish (*Sebastes auriculatus)*, the gopher rockfish (*S. carnatus)*, the black and yellow rockfish (*S. chrysomelas)*, and the blue rockfish (*S. mystinus)*.

Recreational fishery statistics for the period between 1981 and 1986 show that in San Luis Obispo County, the Pacific staghorn sculpin, shiner perch, white croakers, and surfperches were the most commonly caught species from shoreline locations such as piers, docks, jetties and breakwaters (Albin et al. 1993).

Table Ap.2-4. Relative Abundance of Fish Caught in Bottom Trawls in the Project Area (Rechnitzer and Limbaugh, 1956, 1959)

	Sampling Period		
Species	April	December	March
Citharichthys stigmaeus Speckled sanddab	Abundant*	Abundant	Common
Stellerina xyosterna Pricklebreast poacher	Abundant	Few	None
Hyperprosopon anale Spotfin surfperch	Common	Common	Few
Amphistichus argenteus Barred surfperch	Common	Common	Abundant
Psettichthys melanostictus Sand sole	Few	Few	Common

Table Ap.2-4. Relative Abundance of Fish Caught in Bottom Trawls in the Project Area (Rechnitzer and Limbaugh, 1956, 1959)

	Sampling Period		
Species	April	December	March
Allosmerus elongatus Whitebait smelt	Few	Few	None
Genyonemus lineatus White croaker	Few	Few	None
Leptocottus armatus Staghorn sculpin	Few	Few	None
Ophiodon elongatus Lingcod	Few	None	None
Parophrys vetulus English sole	Few	None	None
Pleuronichthys coenosus C-O turbot	Few	None	None
Sebastes spp. Rockfish	Few	None	None
Syngnathus spp. Pipefish	Few	None	None
Artedius notospilotus Padded sculpin	Few	Few	None
Citharichthys sordidus Pacific sanddab	None	Few	None
Seriphus politus Queenfish	None	Few	None
Cymatogaster aggregata Shiner surfperch	None	Few	None

*Abundant = >30 percent of catch; Common = >5 percent of catch; Few = <5 percent of catch

Ap.2.3 Marine Mammals

In a comprehensive marine mammal census program, Dohl et al. (1983a) reported 27 marine mammal species in central California. The three categories of marine mammals species he reported in central California were: (1) migrants that pass through the area on their way to calving or feeding grounds, (2) seasonal visitors that remain for a few weeks to feed on a particular food source, or (3) residents of the area. Of the 27 species, 21 were cetaceans (i.e., whales, dolphins, and porpoises), seven were pinnipeds (i.e., seals and sea lions), and one was a fissiped (the sea otter). Generally, marine mammals are characterized by extensive distributional ranges (Gaskin 1982). The central California area represents a region of overlap. It is an area where populations of marine mammals having different biogeographic affinities intermingle (Dohl et al., 1983a). Several marine mammal species reach the southern limit of their ranges in central California while other species are at their northern range limits (Hubbs, 1960; Bonnell and Daily, 1993).

Boreal species, which are marine mammals found in the cooler waters of the North Pacific occur in central California during winter through early summer. They are found in areas of coastal upwelling and in the coolest waters of the California current. Example boreal species include Dall's porpoises, harbor porpoises, and the northern fur seals.

In late summer and autumn, marine mammals found in warmer waters to the south are found in central California. Examples include the California sea lions and northern elephant seals, bottlenose dolphins and pilot whales.

Some species, for example the southern sea otter, is endemic to coastal central California and occurs year-round. Several species are largely restricted to the waters of the California Current and occur in high numbers off of central California. These species include the California sea lion, northern elephant seal, and during its migration, the California gray whale (Dohl et al. 1983a).

Bonnell and Dailey (1993) list 39 species of marine mammals in the eastern North Pacific. Of the 39 species, 32 of them are cetaceans followed by six species of pinnipeds and one species of fissiped, the sea otter. A listing of these species and their abundance and status is provided in Table Ap.2-5.

Cetaceans

Cetaceans (whales, dolphins, and porpoises) occur in the waters off of central California year-round. The numbers and species vary from season to season and from year to year, but there are cetaceans always utilizing the waters offshore central California. Cetacean population levels are at their lowest in spring and are at their highest level during the autumn (Dohl et al. 1983a). Five species of porpoises represent the major cetacean fauna found off of central California. They are the Pacific white-sided dolphin *Lagenorhynchus obliquidens*, the northern right whale dolphin *Lissodelphis borealis*, Risso's dolphin *Grampus griseus*, Dall's porpoises *Phocoenoides dalli*, and the harbor porpoise *Phocoena phocoena*. Collectively, these five species accounted for more than 95 percent of cetaceans observed off the central California coast. These species vary in their patterns of usage of the area and periods of peak abundances (Dohl et al. 1983a).

Numerically, baleen whales are not a major component of the area's cetacean fauna. Four species have been reported, the California gray whale (*Eschrichtius robustus)*, the humpback whale (*Megaptera novaeangliae)*, the blue whale (*Balaeoptera musculus)*, and the fin whale (*B. physalus)* (Dohl et al. 1983a). The majority of these whales use the coastal waters as migratory routes twice a year. The whales often pause to feed along the coast during their migration. The California gray whale is the most common baleen whale that passes through the area twice each year on its annual migration. Most of the world population of this species make the biannual trip along the California coastline and the majority are found close to shore over continental shelf waters (Herzing and Mate 1984; Reilly 1984; Rice et al. 1984; Rugh 1984; Dohl et al. 1983a; Sund and O'Connor 1974). The southerly migration of the gray whale has been monitored from the shore at the Diablo Canyon Power Plant since 1981 (Behrens et al. 1985; Behrens and Shaffer 1985). Over the years, the whales were found to be within 0.9 to 1.8 kilometers (0.5 to 1 nautical mile) from shore. During the migrations from 1983 through 1985, the majority of the animals were 1.5 to 1.8 kilometers offshore (0.8 to 1 nautical miles) and less than 20 percent were as close as 0.9 kilometer (0.5 nautical mile).

Peak periods of abundance of baleen whales occur during the winter and spring migration seasons. However, as overall populations of certain species increase (e.g., gray whales and humpback), larger numbers are becoming resident to areas offshore California (Dohl et al. 1983a). Both species have historically appeared off central California as they primarily migrate through the area to winter off of Baja California. Blue and fin whales have also been observed offshore central California. Although only a few were observed, their numbers appear to be increasing outside of the normal peak abundance periods of summer through autumn (Dohl et al. 1983a).

Table Ap.2-5. Cetaceans of the Eastern North Pacific and their Status off Central California (adapted from Bonnell and Dailey, 1993)

Common Name	Scientific Name	Abundance	Status
Cetaceans Baleen Whales (Suborder Mysticeti)			
Blue whale	*Balaeoptera musculus*	Rare. Population highest in summer due to northward migration from subtropics	E*
Fin whale	*B. physalus*	Rare. Population highest in summer due to northward migration from subtropics	E
Sei whale	*B. borealis*	Rare. Seen only during summer months during migration	E
Bryde's whale	*B. edeni*	Rare. Single sighting occurred near San Diego	NA
Minke whale	*B. acutorostrata*	Migratory population; common, peak abundance during spring and summer	NA
Humpback whale	*Megaptera novaeangliae*	Migratory population; not common with peak abundance during summer and autumn	E
Gray whale	*Eschrichtius robustus*	Common during migration in winter and spring	NA
Northern right whale	*Balaena glacialis (also referred to as Eubalaena glacialis)*	Rare. Only two sightings in southern California	E
Order Cetacea Tooth Whales (Suborder Odontoceti)			
Sperm whale	*Physeter macrocephalus*	Rare on continental shelf but abundant in deeper waters. Occasional visitor.	E
Common dolphin	*Delphinus delphis*	Common. Year-round resident	NA
Northern right-whale dolphin	*Lissodelphis borealis*	Common in the winter and spring	NA
Pacific white-sided dolphin	*Lagenorhynchus obliquidens*	Common. Year-round resident	NA
Risso's dolphin	*Grampus griseus*	Common. Year-round resident with peak population in summer and autumn	NA
Dall's porpoise	*Phocoenoides dalli*	Common. Year-round resident with peak population in autumn and winter	NA
Bottlenose dolphin	*Tursiops truncatus (also referred to as T. gilli)*	Common. Year-round resident	NA
Harbor porpoise	*Phocoena phocoena*	Rare. Occasional visitor to area from northern latitudes	NA
Short-finned pilot whale	*Globicephala macrorhynchus (also referred to as G. scammonii)*	Small year-round population with increases during winter	NA
Killer whale	*Orcinus orca*	Occasional visitor to area from northern latitudes. Not common	NA
False killer whale	*Pseudorca crassidens*	Occurs primarily in tropical to warm temperate waters. Occasional visitor to area	NA
Cuvier's beaked whale	*Ziphius cavirostris*	Occurs in tropical and warm temperate waters. Have been recorded in area	NA
Baird' beaked whale	*Berardius bairdii*	Rare. Endemic to Arctic and cool temperate waters	NA
Hubb's beaked whale	*Mesoplodon carhubbsi*	Rare. Known primarily from stranding records	NA
Ginkgo-toothed beaked whale	*M. ginkgodens*	Rare. Known primarily from stranding records	NA
Hector's beaked whale	*M. hectori*	Rare. Known primarily from stranding records	NA

Table Ap.2-5. Cetaceans of the Eastern North Pacific and their Status off Central California (adapted from Bonnell and Dailey, 1993)

Common Name	Scientific Name	Abundance	Status
Blainville's beaked whale	*M. densirostris*	Rare. Possible visitor to area	NA
Bering Sea beaked whale	*M. stejnegeri*	Rare. Possible visitor to area	NA
Dwarf sperm whale	*Kogia simus*	Occurs in tropical and warm temperate waters. Sightings and strandings have occurred in California	NA
Pygmy sperm whale	*K. breviceps*	Occurs in tropical and warm temperate waters. Sightings and strandings have occurred in California	NA
Striped dolphin	*Stenella coeruleoalba*	Occasional visitor to area. Known from sightings and strandings	NA
Spinner dolphin	*S. longirostris*	Occurs in tropical waters; possible visitor to area	NA
Spotted dolphin	*S. attenuate*	Occurs in tropical waters; possible visitor to area	NA
Rough-toothed dolphin	*Steno bredanensis*	Occurs in tropical waters; possible visitor to area	NA

NA = Not Applicable; E = Endangered; T = Threatened

The most abundant cetacean species that occur within the three-mile boundary of the Proposed Project are provided in Table Ap.2-6. The number of species and individuals on the shelf within three miles from shore are substantially lower than those found in deeper waters on the shelf and slope (Dohl et al. 1983a). Within three miles, the highest number of cetaceans was observed during the winter and spring seasons. This was largely due to southward migrating gray whales in the winter and the northward migration during the spring. The lowest number of cetaceans within three miles from shore occur during the summer months. Dall’s and harbor porpoises, although present, were scattered and usually solitary individuals. The total number of cetaceans increased during the autumn. Although species diversity was low, numbers of Pacific white-sided dolphins and harbor porpoises increased substantially during the autumn.

Table Ap.2-6. Seasonal Distribution of Cetaceans Within 3 Miles of Shore on the Continental Shelf (Dohl et al., 1983a)

Winter	Spring	Summer	Autumn
Gray whale	Gray whale	Dall’s porpoise	Pacific white-sided dolphin
Dall’s porpoise	Risso’s dolphin	Harbor porpoise	Harbor porpoise
Harbor porpoise	Harbor porpoise	Humpback whale	

Pinnipeds

Five pinniped species occur off central California (Table Ap.2-7). The pinnipeds are the California sea lion (*Zalophus californianus)*, the Northern (Steller) sea lion (*Eumetopias jubatus)*, the northern fur seal (*Callorhinus ursinus)*, the northern elephant seal (*Mirounga angustirostris)*, and the harbor seal (*Phoca vitulina),* as listed in Table Ap.2-7 below (Bonnell et al. 1983).

Table Ap.2-7. Pinnipeds of the Eastern North Pacific and Their Status Off California (Adapted from Bonnel and Dailey 1993)

Carnivora Pinnipeds (Suborder Pinnipedia)			
California sea lion	Zalophus californianus	Abundant, year-round resident	NA
Northern (Steller) sea lion	Eumetopias jubatus	Occasional visitor to area from northern latitudes. Not common	NA
Northern fur seal	Callorhinus ursinus	Common, year-round resident	NA
Guadalupe fur seal	Arctocephalus townsendi	Occasional visitor to area from southern breeding grounds. Not common	T
Northern elephant seal	Mirounga angustirostris	Year-round resident. Common	NA
Pacific harbor seal	Phoca vitulina	Year-round resident. Common	NA

T = Threatened Species; NA = Not Applicable

The total population size of pinnipeds for the continental shelf is estimated to exceed 50,000 animals in the fall and nearly 50,000 animals during the spring (Figure Ap.2-1). At least 30,000 pinnipeds are estimated to occur in the area all year-round. The pinniped population at sea is predominately composed of northern fur seals or California sea lions. When one population is at its peak, the other is at its low for the area (Bonnell et al. 1983). Northern fur seals reach their peak in winter and spring, as migrants from the Bering Sea arrive to overwinter in California waters. California sea lions reach their peak in fall (Figure Ap.2-2) as the breeding population disperses northward from rookery islands in the Southern California Bight.

Pinnipeds occur year-round within the three-mile boundary of the Project area (Table Ap.2-8). The California sea lion is the most abundant and common pinniped in the Project area. Their numbers are highest in the autumn and lowest in the winter. Although fewer in numbers, harbor seals also occur throughout the year in the Project area. Their numbers are highest during the spring and lowest in the summer. Although their numbers are not as high as the California sea lion or harbor seals, the northern elephant seal occurs in the Project area for most of the year. All three species haul-out at various locations on the central California coast.

Table Ap.2-8. Seasonal Distribution of Pinnipeds in the Project Area within 3 Miles of the Shoreline (Dohl et al., 1983a)

Winter	Spring	Summer	Autumn
California sea lion	California sea lion	California sea lion	California sea lion
Harbor seal	Harbor seal	Northern elephant seal	Northern elephant seal
Northern elephant seal	Northern elephant seal	Steller sea lion	Harbor seal
Steller sea lion		Harbor seal	
		Northern fur seal	

Note: Three pinniped species maintain breeding populations off central California. They are the Steller sea lion, the northern elephant seal, and the harbor seal. A rookery for the elephant seal is located in nearby Piedras Blancas but rookies for the Steller sea lion and the harbor seal have not been reported in the area although pups of these species are often observed in the general area (Bonnell et al., 1983).

Figure Ap.2-1.
Annual Cycle of Pinniped Abundance in Central and Northern California

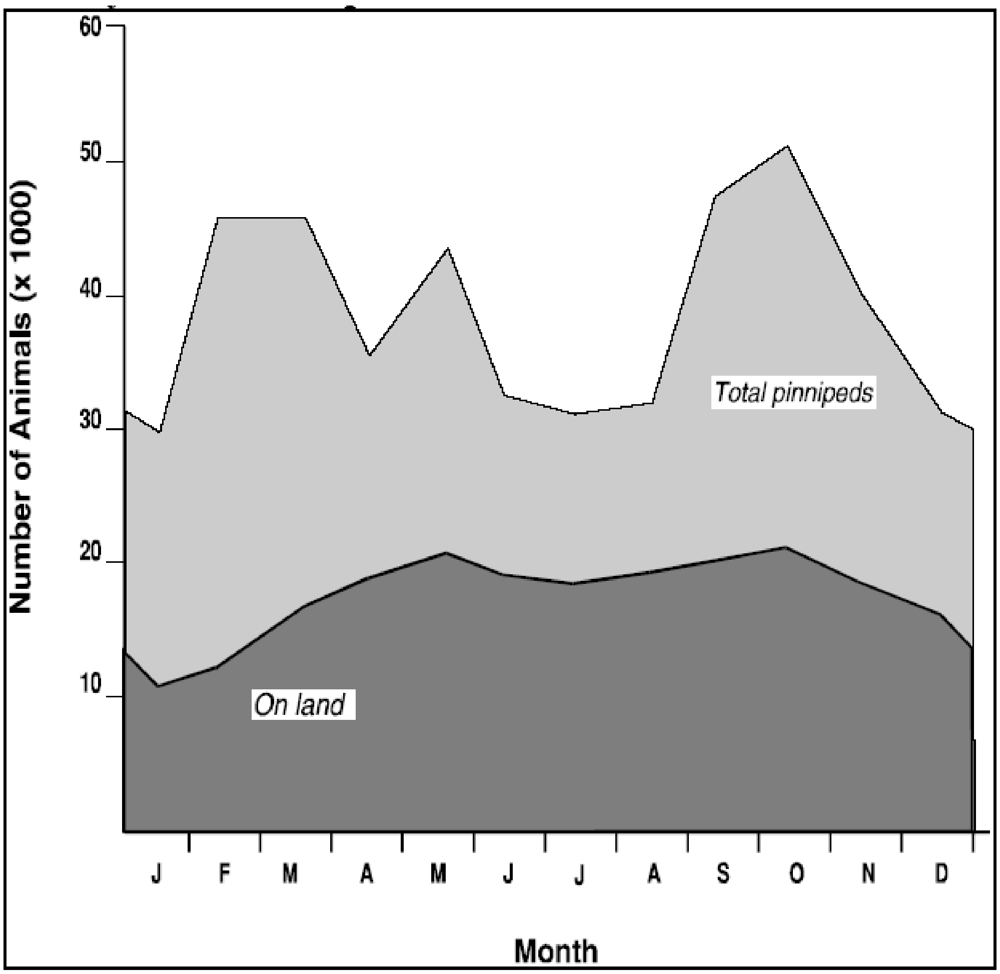
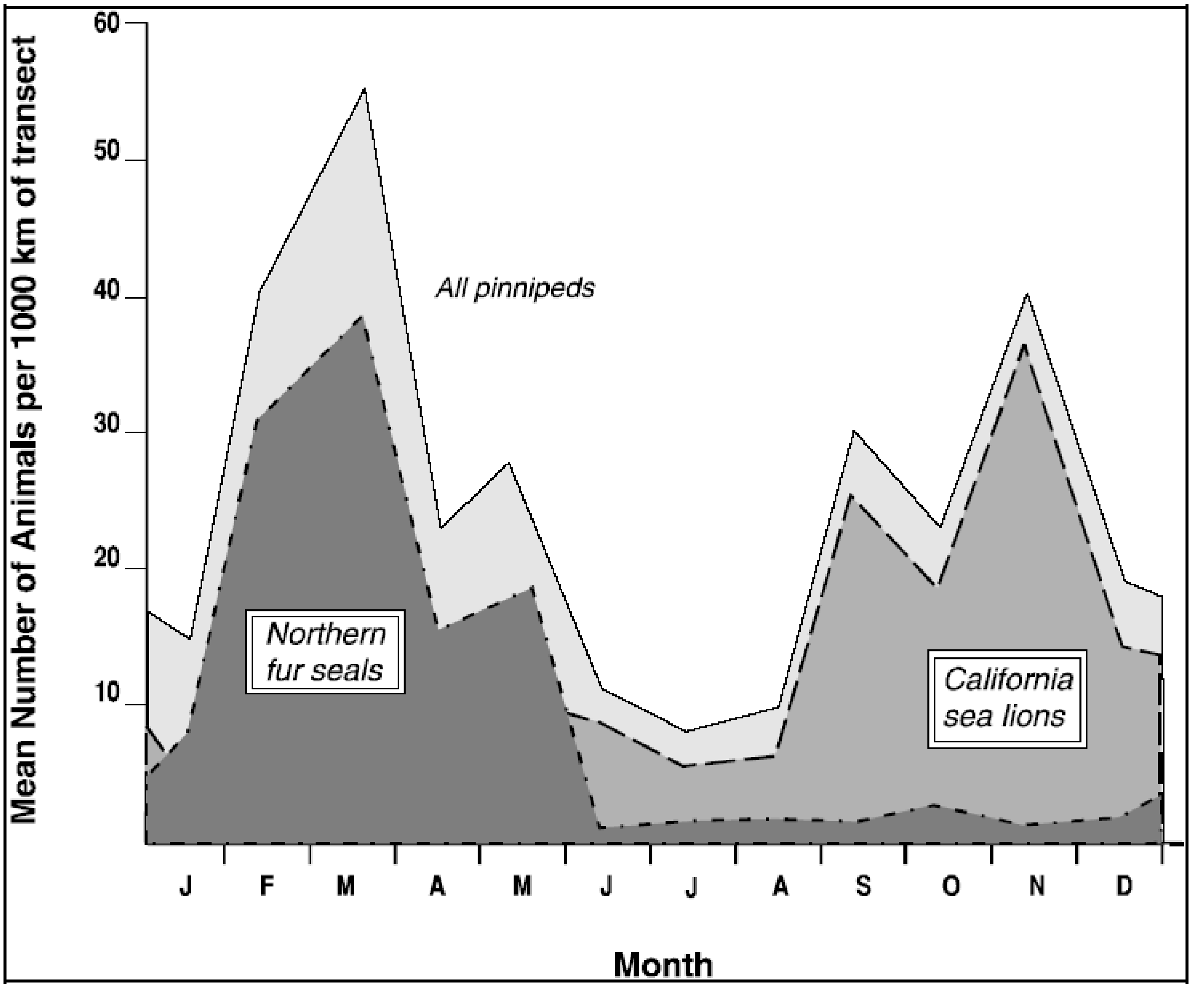


Figure Ap.2-2.
Seasonal Abundance of Pinnipeds in the Waters of Central and Northern California



Fissipeds

During the past 15 years, sea otters (*Enhydra lutris*), have generally ranged from approximately Point Año Nuevo in the north to about Pt. Conception in the south (Bonnell et al. 1983). It is a remnant population, which during pre-exploitation, numbered about 150,000 animals ranging from about Prince William Sound in Alaska to Morro Hermoso in Mexico (Kenyon 1969). The present population of sea otters off the central California coast is descendent from a small remnant group estimated at 100 to 150 animals initially sighted at Bixby Creek. The recovering population was not known to the general public until the opening of the Pacific Coast Highway (Bryant 1915; Bolin 1938). Substantial changes have occurred in the distribution and density of sea otters within the California range in the last 20 years. The changes have generally been unidirectional shifts in population distribution and indicate increases in the use of some areas and the decline in the use of others (Bonnell et al. 1983). The changes are expected for a resource-dependent species. Sea otters, a federally and state-protected species, have recently been observed in the Project area (USGS 1999).

The sea otter population undergoes seasonal migration twice a year. The migrations are attributed to the breeding season (June to November) and the non-breeding season (November to May). During the breeding season, the size of the southernmost group declines dramatically, presumably because of a northward movement of animals towards the center of the range (Bonnell et al. 1983; Estes and Jameson 1983). This movement of males from the population fronts into the more established areas occupied by females during the summer and fall breeding season is a feature of the sea otter's annual cycle (Bonnell et al. 1983). While the southern concentration of sea otter is comprised mainly of males, pups have been observed as far south as the Purisima Point area.

In the Project area, a raft of 30 to 40 sea otters was first observed just north of Port San Luis in 1974 (Gotshall et al. 1984). Between 1979 and 1982, a baseline study at the Diablo Canyon Power Plant Site reported an increasing trend in sea otters in the Project area (Gotshall et al. 1986). The number of pups seen each year had increased, indicating that the area had become a more established portion of the sea otter range. The southward expansion of the sea otter seemed chronologically and geographically correlated to the decline of the abalone fishery. Aerial surveys conducted for the U.S. Minerals Management Service in 1980, 1981, and 1983, found otters numbering 69, 59, and 59 individuals, respectively, in the Point Buchon to Cayucos Point area (Bonnell et al. 1983).

In California, sea otters feed almost entirely on macroinvertebrates (Ebert 1968; Estes et al. 1981; Riedman and Estes 1990). In rocky areas along the central California coast, major prey items include abalones, crabs, and sea urchins. In sandy areas, prey items include clams, snails, octopus, scallops, sea stars, and echiuroid worms (Boolootian 1961; Ebert 1968; Estes 1980; Estes et al. 1981; Wendell et al. 1986; Riedman and Estes 1990). In the Project area, sea otters were observed feeding on invertebrates residing on the hard-bottom structures out to water depths of 30-35 m. Crabs appeared to be the principal prey item (SLO 1999).

In recent otter surveys coordinated by the U.S. Department of Interior (USGS 1997, 1998, 1999) off the coast of California, the total number of sea otters have decreased in the past several years. Sea otter counts offshore California in the past two years have ranged between 1,937 in the fall of 1998 to 2,114 in the spring of 1998. Generally, the total number of sea otters in the Project area has remained fairly constant over the past several years. In the spring and fall surveys during the past two years, about 50 to 70 (spring) and 60 to 100 (fall) otters were counted in 1998 and 1999 in the entire survey block encompassing the Project area (USGS 1997, 1998, 1999).

Ap.2.4 Sea Turtles

Although infrequent, sea turtles have occasionally been reported in coastal California. Over the years, four species have been reported in the Project area. The four species are the green turtle (*Chelonia mydas)*, the Pacific ridley turtle (*Lepidochelys olivacea)*, the leatherback turtle (*Dermochelys coriacea)*, and the loggerhead turtle (*Caretta caretta)* (Hubbs 1977).

Of the four species, three of them (Pacific ridley, leatherback, and green) are listed as endangered species under the U.S. Endangered Species Act. The loggerhead is listed as a threatened species under the same act.

Populations of marine turtles have been greatly reduced due to overharvesting and loss of nesting sites in coastal areas (Ross 1982). In the eastern Pacific, most of the turtles nest along the coasts of Mexico and Central America. The nesting season varies with species, but is generally from May to September (Mager 1984). Sea turtles breed at sea; and the females return to their natal beaches to lay their eggs (Mager 1984). Female turtles can nest several times in a season but at two to three-year intervals. The eggs, after being laid in the sand, hatch in about two months; and the young instinctively head for the sea.

Although marine turtles are not common to the Project area, they have occasionally been reported. According to the California Marine Mammal Stranding Network Database, 12 marine turtles were reported between Morro Bay and Pismo Beach during the 1982-1995 period. Of the 12 sightings, 10 were leatherbacks, and 1 each was a loggerhead, and green (NOAA 1997). At the nearby Diablo Canyon Power Plant, 1 green turtle was reported in 1994 and 1997 (NOAA 1997; Port San Luis Harbor District 1997). General distribution information for marine turtles is provided below.

Green Sea Turtles

Generally, green sea turtles (*Chelonia mydas*) occur worldwide in waters above 20°C. Central California represents the northern end of their range so they are infrequent visitors to the area. However, green turtles have been reported as far north as Redwood Creek in Humboldt County and off the coast of Washington and Oregon (Green et al. 1991; Smith and Houck 1983). Green turtles, at one time, were fairly common in San Diego Bay (Hubbs 1977). The green sea turtle is thought to nest on the Pacific coasts of Mexico, Central America, South America, and the Galapagos Islands (Mager 1984). The only known nesting location in the continental U.S. is on the east coast of Florida. The green sea turtles are herbivores, feeding on algae and sea grasses. In the Project area, green turtles were reported at the Diablo Canyon Power Plant in 1994 and as recently as 1997 (NOAA 1997; Port San Luis Harbor District 1997).

Pacific Ridley Sea Turtle

The Pacific ridley or olive sea turtle (*Lepidochelys olivacea*) is an infrequent visitor to the California coast. In the past, they have been reported as far north as Washington, Oregon, and California (Green et al. 1991; Houck and Joseph 1958; Smith and Houck 1983; Hubbs 1977). In the eastern North Pacific, the primary range of the Pacific ridley extends from Columbia to Mexico (USDOI 1996a). Major nesting beaches are located on the Pacific coasts of Mexico and Costa Rica. The population on Pacific beaches in Mexico has declined from an estimated 10 million adults in 1950 to less than 80,000 in 1983 (Mager 1984). The Pacific ridley sea turtle is omnivorous, feeding on fish, crabs, shellfish, jellyfish, sea grasses and algae (Ernst and Barbour 1972). There have not been sightings of Pacific ridley turtles in the Project area in recent years (NOAA 1997).

Leatherback Sea Turtle

Leatherback sea turtles (*Dermochelys coriacea*) range farther north than any of the other sea turtles. This is due to their ability to maintain warmer body temperatures in colder waters (Frair et al. 1972). These turtles have been sighted as far north as Alaska and British Columbia (Mager 1984; Smith and Houck 1983).

Leatherback sea turtles are the most common sea turtle off the west coast of the U.S. (Dohl et al. 1983a; Green et al. 1989). From aerial surveys off the coast of Washington and Oregon, 16 sightings of leatherbacks have been reported between June and September when sea surface temperatures were the warmest (Green et al. 1991). During a three-year survey, leatherback sea turtles were reported off the coast of central California (Dohl et al. 1983a). The majority of their sightings occurred during the summer and fall seasons. Their sightings were distributed from 10 to 185 km offshore, but occurred primarily in waters over the continental slope. Ten strandings of leatherback sea turtles were reported between Morro Bay and Pismo Beach between 1982 and 1995 (NOAA 1997).

Leatherback sea turtles are omnivores but feed principally on soft prey items such as jellyfish and tunicates (Mager 1984). The population of leatherback sea turtles in the eastern Pacific is estimated at 8,000 nesting females and is concentrated in western Mexico, Central America, and northern Peru (Pritchard 1971; Mager 1984).

Loggerhead Sea Turtles

Loggerhead turtles (*Caretta caretta*) primarily occur in subtropical to temperate waters and are generally found over the continental shelf (Mager 1984). The eastern Pacific population breed on beaches in Central and South America (Mager 1984). Southern California is considered to be the northern limit of loggerhead sea turtle distribution (Stebbins, 1966). However, loggerheads have stranded on beaches as far north as Washington and Oregon (Green et al. 1991). In 1978, a loggerhead sea turtle was captured near Santa Cruz Island in southern California (Guess 1982). Loggerhead sea turtles are omnivorous and feed on a wide variety marine life including shellfish, jellyfish, squid, sea urchins, fish, and algae (Carr 1952; Mager, 1984). One loggerhead stranding was reported in the Morro Bay area (NOAA 1997)

Ap.2.5 Seabirds

The seabird fauna of central California is large, diverse, and conspicuous from the coastline to hundreds of kilometers offshore. Because Project activities are proposed only for offshore waters exceeding 15 m in water depth, and not in shoreline or intertidal areas, this discussion is limited to seabirds or those species that obtain most of their food from the ocean or are predominantly found over water.

Regional Perspective

Seabirds found in central California are far ranging and come from all corners of the Pacific Ocean, Bering Sea, Arctic Ocean, inland North America, and the North Atlantic. Jones et al. (1981) reported

102 species of seabirds in central and northern California. In a three-year survey for seabirds off of central and northern California, Dohl et al. (1983b) reported up to thirty-five common species and thirty-four rare species. Dohl et al. (1983b) also found that the seabird fauna of central California is dominated by cool-water species (e.g., boreal North Pacific) but also includes subtropical species during the late summer and autumn. The numbers of seabirds present in central California is similar to Oregon, the Gulf of Alaska, and Bering Sea, but is higher than those published for southern California (Dohl et al. 1983b; Weins and Scott 1975; Briggs et al. 1981; Schneider and Hunt 1981).

According to Souls et al. (1980), 17 seabird species nest on the central and northern California coastline. The most numerous of the nesting residents are the murre, Cassin's Auklet, Brandt's Cormorant, and the Western Gull. The largest nesting sites are located in northern California with perhaps the Farallon Islands being the most important of them all. In central California, Souls et al. (1980) estimated that about 7 percent of the seabird population breeds between Ventura and Monterey Counties; but that the majority of this occurs on the Channel Islands. In the area from Morro Bay south to Point Conception, Chambers Consultants and Planners (1980) reported that very few seabirds breed in coastal mainland habitats due to human disturbances.

Project Area

Seabirds occur year-round in the Project area and the species present vary according to the season (Briggs et al. 1981). Dohl et al. (1983b) reported the highest density of seabirds during the summer and autumn due to the presence of migrants, winter visitors, and nesting residents at the same time. The lowest density of seabirds occurred during the winter. The dominant species in the area, by season, are provided in Table Ap.2-9 (Dohl et al. 1983b).

Table Ap.2-9. Seasonal Distribution of Coastal Seabirds in the Project Area (Dohl et al., 1983b)

Winter	Spring	Summer	Autumn
Arctic Loon	Arctic Loon	Sooty Shearwater	Arctic Loon
Cassins's Auklet	Sooty Shearwater	Phalaropes	Sooty Shearwater
Common Murre	Phalaropes	Brown Pelican	Phalaropes
Western Gull	Bonaparte's Gull	Brandt's Cormorant	Cassin's Auklet
Western Grebe	Western Grebe	Western Gull	Common Murre
Brandt's Cormorant	Brandt's Cormorant	Heerman's Gull	California Gull
Pelagic Cormorant	Surf Scoter		Western Gull
Surf Scoter	Western Gull		Western Grebe
California Gull	Common Murre		Brown Pelican
			Brandt's Cormorant
			Heerman's Gull
			Bonaparte's Gull

Briggs et al. (1981) reported over 93 seabird species off the coast of California. One of the areas having a high concentration of seabirds included the Project area between Point Piedras Blancas and Point Conception. Common nearshore species were the California gull, herring gull, western gull, Bonaparte's gull, Brandt's cormorant, surf scoter, western grebe, and northern phalarope. Common nearshore seabirds reported by Briggs et al. (1981) and Lehman (1982) during late winter and early spring in the Project area are provided in Table Ap.2-10.

Table Ap.2-10. Nearshore Seabirds in the Project Area (Briggs et al.,1981; Lehman, 1982)

	Nearshore (<5 km)			
Species	Jan/Feb	Mar	Apr	May
Grebes Western grebe		x		
Cormorants Brandt's cormorant		x	x	
Waterfowl Surf scoter		x		
Shorebirds Northern phalarope			x	
Gulls				
Herring gull	x			
Bonaparte's gull			x	x
California gull	x			
Western gull		x	x	x

Nesting sites in the Project area include Morro Rock, Pillar Rock, Spooner's Cove, Point Buchon, Lion Rock, and several unnamed rocks. Nesting species include the pelagic cormorant, Brandt's cormorant, western gull, and the pigeon guillemot.

Ap.2.6 Benthos

The benthos consists of organisms that live in or on the ocean floor. Benthic habitats are often classified according to substrate type, either unconsolidated sediments (e.g., gravel, sand, or mud) or rock. The former category is often referred to as soft bottom and the latter is often referred to as hard bottom or rocky substrate. Each supports its own characteristic biological community. In addition to substrate type, water depth and water temperature play important roles in the distribution of benthic organisms. Distance from shore, food availability, and water quality are also important factors that influence the distribution of benthic organisms. Benthic organisms can be epifaunal (attached or motile species that inhabit rock or sediment surfaces) or infaunal (live in soft sediments) (Thompson et al. 1993). Generally, more is known about intertidal and shallow subtidal benthic species than those of deeper areas. In this section, benthic invertebrates residing in soft sediments are described separately from those occurring on hard substrates.

Rock Substrates (Hard-Bottom)

Rocky subtidal habitats within the study area are of interest because: a) deepwater reefs are relatively rare along the central and southern California coast; b) they support a diverse assemblage of epifaunal invertebrates; c) they attract fish as a nursery ground, food source, and as shelter; and d) epibiota are sensitive to mechanical disturbance (USDOI 1995a) and increased sediment loads (Hardin et al. 1994). In addition to habitat disturbance, potential impacts to epibiota from the Proposed Project can arise from their sensitivity to increased suspended sediment loads. Many epifaunal taxa inhabiting high-relief rock outcrops are suspension feeders. They are not prevalent on low-relief (< 1-m) rock substrates because of intolerance to near-bottom turbidity caused by resuspension of surficial sediments. In the Santa Maria Basin, immediately south of the study area, significant reductions in some epifaunal taxa were observed in response to exposure to drilling-mud discharge (Hyland et al. 1994). These biological changes were not associated with chemical contaminants, which were below toxic levels, but were related to the physical effects of particle loading.

Stable rocky areas consisting of large boulders, plateau-like mesas, and siltstone reefs are typically inhabited by a diverse flora and fauna, which attach to the substrate and are collectively referred to as epifauna and epiflora. Although rocky intertidal and subtidal habitats are not present in the immediate vicinity of the Project RSG unloading area, they occur at the western and eastern boundaries of Port San Luis. The eastern end is marked by Fossil Point, a wave cut rocky point with an extensive subtidal reef complex (Everts Coastal 1996). To the west, near the mouth of San Luis Obispo Creek and adjacent to the Unocal Pier, is an intertidal boulder field and a submerged wedge-shaped reef extending offshore. The western coast of San Luis Obispo Bay consists of rocky shores with a series of narrow sandy beaches out to Point San Luis and the breakwater. Outside of the bay and to the northwest is exposed rocky coastline. The vicinity of the Diablo Canyon Power Plant has been studied extensively by the California Department of Fish and Game (CDFG) and PG&E since 1973 for its intertidal and subtidal ecology (Gotshall et al. 1984).

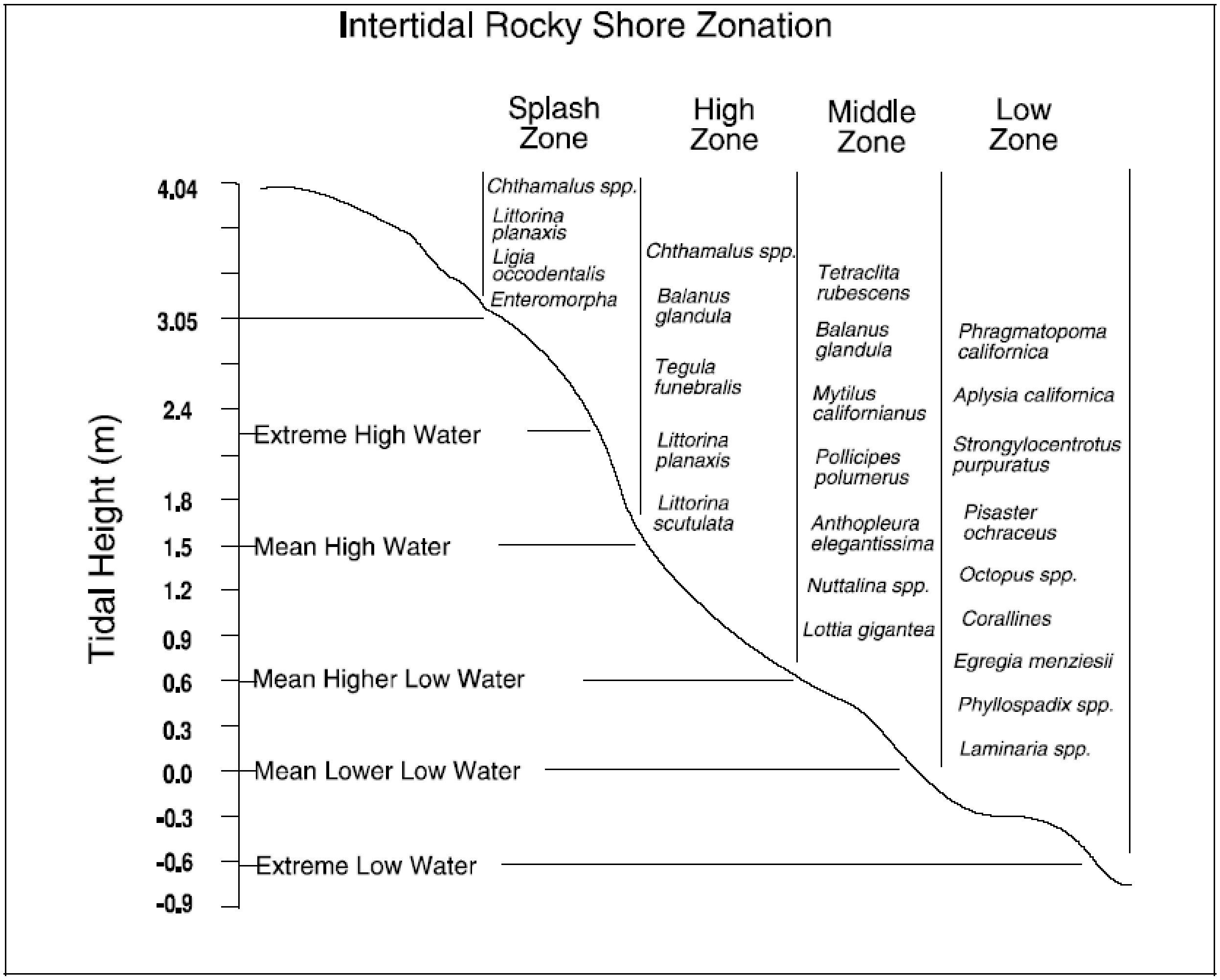
Intertidal

The tidal cycle of coastal California is semidiurnal with two unequal high tides alternating each day with two unequal low tides. As a result, four bands or zones are delineated based on the physical habitats. The vertical zonation of typical rocky intertidal organisms along the California coast is shown in Figure Ap.2-3. The upper most zone, above the high-tide line, is referred to as the "splash zone" and is usually not covered by the tides. Some of the more common inhabitants of this zone are the rock lice (*Ligia occidentalis),* periwinkles (*Littorina* spp.), and white acorn barnacles (*Chthamalus* spp). along with the green algaes. Downward in progression are the upper and mid- intertidal zones. California mussels (*Mytilus californianus*) form beds in these zones, which are the basis of a diverse array fauna. The seastar, mostly Pisaster ochraceus is the hardiest predator in the middle intertidal. Other animals include the gooseneck barnacles (*Pollicipes* spp.), acorn barnacles (*Balanus* spp.), abalone (*Haliotis* spp.), limpets (*Lottia* spp.), chitons, and the anemones (*Anthopleura* spp.). Interspersed within the mussel beds are numerous species of polychaetes and amphipods. A variety of algae provide shelter and protection from desiccation for many animals that otherwise could not exist so high up on shore (Ricketts et al. 1985). Common invertebrate species within the low rocky intertidal zone are the sea urchin (*Strongylocentrotus* spp.) and the limpet (*Acmaea* spp.). Examples of intertidal species reported by CDFG (Gotshall et al. 1986) at the Diablo Canyon Power Plant Site is provided in Table Ap.2-11.

Table Ap.2-11. Common Rocky Intertidal Invertebrates from the Diablo Canyon Power Plant Site

Species
ARTHROPODA
Cancer antennarius, rock crab
Pagurus sp,
Pugettia producta, kelp crab
Pugettia richii/gracilis (complex), decorator crab
MOLLUSCA
Acmaea spp., limpets
Fissurella volcano, volcano limpet
Mytilus californianus, California mussel
Haliotis cracherodii, black abalone
Haliotis rufescens, red abalone
Serpulorbis squamigerus, scaled-worm shells
Tegula brunnea, brown turban snail
Tegula funebralis, black turban snail
Tonicella lineata, lined chiton
ECHINODERMATA
Henricia leviuscula, blood star
Leptasterias spp., six rayed-star
Pisaster orchraceous, ocher star
Strongylocentrotus purpuratus, purple urchin
CNIDARIA (Anemones)
Anthopleura xanthogrammica, giant green anemone
Anthopleura elegantissima, aggregating anemone
Epiactis prolifera, proliferating anemone

Figure Ap.2-3.
Intertidal Zonation of a Rocky Shore in Southern California (modified from Dailey et al., 1994)



Subtidal

The species diversity of hard-bottom communities is influenced in part by the availability of light and nutrients, degree of exposure to waves, and substrate characteristics (i.e., relief and texture). Underwater investigations performed for Everts Coastal in 1996 examined the littoral barrier extents of Fossil Point, Unocal Pier Point, and Point San Luis. Fossil Point was found to be a two-pronged feature with a western and eastern headland. The vertical relief of the eastern reef complex is much greater than that of the western reef. The western part of Fossil Point reef extends out to Avila Rock at a depth of about 45 ft and was found to have variable relief ranging between 0.3 and 3 m. Although the biology of the reefs was not inventoried, it was noted that a lush algal community was present off of Fossil Point, indicating that the reef had not been covered with sand for some time. Likely inhabitants of such a community would include scour tolerant organisms such as anemones (*Anthopleura spp*.), sea stars (*Pisaster* spp.), limpets (*Acmaea* spp.), chitons (*Tonicella* spp.), and turban snails (*Tegula* spp.). The Unocal Pier Point reef extends about 500 feet offhshore to a water depth of 15 feet mean lowerlow water (mllw). Relief heights of this wedge-shaped reef ranged between 0.3-m nearshore to 3 m at the offshore tip. Epifaunal communities would be expected to be similar at Fossil Point reef, Unocal Pier Point reef and on the hard-bottom areas on the bay side of the Point San Luis breakwater.

The Diablo Canyon Power Plant nearshore marine biota monitoring program represents the closest hard-bottom subitidal assemblage studied in the vicinity of the Project site. This area is exposed rocky coast. Selected areas were characterized by divers using a random 0.25-m^2 quadrat method to depths of 15.2 m (50 feet). An example intertidal species reported by CDFG (Gotshall et al. 1984) at the Diablo Canyon Power Plant Site is provided in Table Ap.2-12

Table Ap.2-12. Common Rocky Intertidal Invertebrates from the Diablo Canyon Power Plant Site

Species
PORIFERA
Tethya aurantia, orange puffball sponge
CNIDARIA
Anthopleura xanthogrammica, giant green anemone
Balanophyllia elagans, orange cup coral
Epiactis prolifera, proliferating anemones
ARTHROPODA
Cancer antennarius, rock crab
MOLLUSCA
Acmaea mitra, white cap limpet
Astraea gibberosa, red turban snails
Halitotis rufescens, red abalone
Homalopoma luridum, dwarf turban snails
*Serpulorbis squamigerus,*scaled-worm shells
Tegula brunnea, brown turban snail
Tonicella lineata, lined chiton
ECHINODERMATA
Henricia leviuscula, blood star
Leptasterias spp., six rayed-star
Patiria miniata, sea bats
Pisaster giganteus, giant-spined sea stars
Pycnopodia helianthoides, sunflower star
Strongylocentrotus franciscanus, red sea urchin
CHORDATA (Tunicates)
Styela montereyensis, stalked tunicates

Soft Substrates

This section describes the benthic infauna found within seafloor sediments in the Project area. Sandy beaches are the predominant intertidal habitat in the area. Because of the inherent difficulties in conducting ecological studies in sand, far less is known about invertebrate communities that live there than those found on rocky substrates. Sand dwelling organisms are very motile, difficult to mark, and cannot be easily monitored over time. Immigration and emigration rates are high and often contribute to the high level of temporal and spatial patchiness in density that is often reported (Thompson et al. 1993). Also, studies are difficult to conduct in unstable sediments in a high-energy environment.

Although not obvious, vertical zonation of invertebrates occurs on sandy beaches. The invertebrates that live in sand (infauna) are quite motile and change position with respect to tidal level. Also, predictably, certain species will be found higher or lower than others. Common invertebrates in the upper intertidal are several species of amphipods in the genus *Orchestoidea*; the predatory isopod (*Excirolana chiltoni),* and several species of polychaetes (e.g., *Excirolana chiltoni*, *Euzonus mucronata*, and *Hemipodus borealis*). The middle intertidal is characterized by species such as the sand crab (*Emerita analoga)* and the polychaete *Nephtys californiensis*. Emerita is generally the most abundant of the common middle intertidal organisms often comprising over 99 percent of the individuals on a given beach (Straughan, 1983).

In the low intertidal, polychaetes and nemerteans dominate (Straughan 1982). Also, the large sand crab, (*Blepharipoda occidentalis)* and the Pismo clam (*Tivela stultorum)* can be found locally. Tivela was once more abundant in the intertidal. Its present reduction in population is probably the result of overharvesting (Ricketts et al., 1985).

In shallow water < 10 m, epifaunal (organisms which live on the sediment or rock surfaces) communities are generally well developed (Thompson 1993). With increasing depth, the density of epifaunal species decline while that of infauna increases probably because of the greater stability of sediments (Barnard 1963). Also, with depth, polychaetes become more dominant over crustaceans (Oliver et al. 1980). Physical changes to nearshore subtidal habitats are associated with increasing depth. One of the most important is a decrease in wave surge and as a result, finer sediments, which influences the distribution of epifaunal species in nearshore environments (Thompson 1993). Merrill and Hobson (1970) have shown that shoreward limit of the sand dollars (*Dendraster excentricus*) occurs near the break line with the inner most population consisting of small juveniles. Seaward, they found that sand dollars become progressively larger and more abundant.

The effects of wave action on benthic infauna are not well known. However, several studies indicate the declines in the abundance of tube-building polychaetes in shallow water (< 10 m) to increasing substrate disturbance (Oliver et al. 1980; Davis and VanBlaricom 1978).

Horizontal and Temporal Distribution

Many organisms are characterized by patchy distribution in the intertidal zone. Sand crabs show horizontal patchiness on scales from meters to kilometers due to alterations in longshore current patterns caused by natural topographic features or man-made structures such as jetties and pier pilings (Cubit 1968). Natural and man-made features which create convergence areas where the water pools tend to be areas where sand crabs can concentrate (Thompson et al. 1993).

The local abundance of invertebrate species on sandy beaches can change significantly over short time periods. Sand crabs move up and down the beach with the tides and maintain their position in the swash zone (Thompson 1993). Hence, an abundance of sand crabs in the intertidal roughly corresponds to a curve that is similar to that of the tides (Efford 1965; Cubit 1968; Perry 1980). Beach hoppers *(Orchestoidea spp.)* also migrate vertically in the intertidal in approximate synchrony with the tides (Thompson 1993). At low tides, they emerge from burrows in the high intertidal and move vertically down the intertidal to feed on stranded algal material. They then retreat before the incoming tide and return to their burrows in the high intertidal (Fawcett 1969).

Seasonal variability in the population density of sand crabs is high. Normally, they tend to be more abundant in the summer and fall. Their numbers are reduced during the winter months and can be absent on beaches (Barnes and Wenner 1968; Perry 1980).

Mechanisms Responsible for Distribution Patterns

The composition of invertebrate assemblages on a sandy beach is correlated to slope and sand texture. Within a beach, crustaceans and molluscs tend to be more common on steeper, coarser, and dryer upper intertidal zone. Polychaetes and nemerteans are the dominant invertebrates in the lower intertidal where the slope is not as steep and the sand is usually finer and wetter (Wenner 1988; McLachlan and Hesp 1984; Straughan 1982). Studies conducted on invertebrates (e.g., Emerita), demonstrate how physical forces such as wave action can influence the distribution and abundance of sand-dwelling invertebrates. Emerita aggregate in the middle intertidal and move vertically with the tides (Efford 1965; Cubit 1968; Barnes and Wenner 1968). Small male crabs tend to occur highest on the shore, and the females predominate lower on the shore (MacGinitie, 1938; Efford, 1965; Cubit, 1968). Studies indicate that sand crab aggregations are formed by the response of crabs to waves and currents interacting with features on the beach (Cubit 1968; Barnes and Wenner 1968; Dillery and Knapp 1969; Perry 1980). Cubit (1968) performed a classic experiment that demonstrated how sand crabs react to physical forces that could account for distribution patterns. Breaking waves suspend sand. Sand crabs react by burrowing out of the sand and are carried up the beach. As the upwash loses momentum, the sand crabs burrow into the sand and begin to feed. Uprushing water reaching the top of the wash zone soaks through it causing it to become fluid or thixotropic. Sand crabs then respond to this change by burrowing out and are carried down the beach until the momentum of the backwash lessens. At this point, they then burrow into the sand. The behavior of burrowing out when the beach sand becomes fluid, combined with physical properties of waves, explain how aggregations of sand crabs are maintained in a swash zone that shifts among tidal levels (Thompson et al. 1993).

This mechanism also seems to account for lower density of sand crabs on shallow-sloped, fine-grained beaches were waves are small, and the dominance of small sand crabs near the top of the swash zone and large ones near the bottom. The change from thixotropic to nonthixotropic sand is less marked on shallow-sloping beaches because waves are smaller and sand is finer. Small waves suspend less sand at the bottom of the swash zone and fine sand tends to be saturated with water, which does not undergo the shift from a nonfluid to a fluid state (Thompson et al. 1993). Other physical mechanisms also account for horizontal distribution of *E. analoga*. When cusps are formed on beaches, sand crabs tend to aggregate in their bays or furrows and in convergence areas (Cubit 1968; Dillery and Knapp 1969; Perry 1980).

Biological Interactions

Sand crabs are heavily preyed upon by shallow subtidal fishes, in particular, the barred surfperch (*Amphistichus argenteus)*. Studies have shown that the sand crab constitutes as much as 90 percent of the surfperch diet (Carlisle et al. 1960; Fitch and Lavenberg 1971). Staphlinid beetles have been reported to prey on beach hoppers in the upper intertidal (Craig 1968). Beach hopper densities, however, were not significantly affected by beetle predation.

Influences to Invertebrates from Human Activities

Human activities that have been reported to change invertebrate distributions include the construction of jetties, groins, sea walls, buildings, highways, channeling and damming of streams and rivers, beach maintenance, and oil spills (Thompson et al. 1993). However, the evidence that these changes cause long-term changes to population levels of sandy beach invertebrates is scant and indirect. Damming of streams reduces sediment input to beaches and, in some cases, has caused erosion that could affect invertebrate communities (Thompson et al. 1993). Straughan (1982) found that construction of a sea wall reduced the slope, intertidal range of a section of a sandy beach, and sediment grain size. She found that these changes appeared to select for polychaetes and nemerteans and against crustaceans. In her study of sandy beach invertebrates, Straughan found that heavily used and populated beaches in southern California were regularly cleaned of kelp and other debris. Sand was also added to these beaches periodically. These beaches were consistently depauperate and lacked beach hoppers over a ten-year period.

General Project Area

Straughan (1982) conducted comprehensive intertidal surveys in central and southern California over a 12-year period. Her northern-most group of stations extended from Estero Bay and Morro Bay to Guadalupe Beach in southern San Luis Obispo County. At sampling sites located along a transect extending from the supratidal to intertidal areas, annelids and crustaceans dominated. Species which were common to this general area are listed in Table Ap.2-13.

At offshore monitoring stations located at 18 m water depth off Oceano, California, approximately 97 benthic infaunal species were found (ABC 1995). Rank order and the relative abundance of the 20 most dominant species are listed in Table Ap.2-14. Annelid worms were the most abundant group of found at the stations. Epifaunal species collected at these stations include the echinoderms, *Amphiodia occidentalis* and *Dendraster excentricus*; the arthropod, *Heterocrypta occidentalis*; and the molluscs, *Nassarius fossata*, *N. perpinguis*, *Olivella baetica*, and *Polinices lewisii* (ABC 1995).

In another monitoring program conducted at the Unocal Santa Maria Refinery outfall south of Oceano, California, five stations at approximately 10-m water depth were sampled for benthic infauna (KLI 1996). Annelids were the most abundant group at 45.9 percent. In abundance, annelids were followed by crustaceans (25.1 percent), molluscs (14.1 percent), and echinoderms (13.3 percent). Miscellaneous phyla such as nematodes and nemerteans comprised 1.5 percent of the total abundance. The rank order of benthic infauna species from the KLI survey is provided in Table Ap.2-15.

Table Ap.2-13. List of Intertidal Species Collected at Guadalupe Beach (Straughan, 1982)

Vermes	Crustacea
Cerebratulus californiensis	Archaeomysis grebnitzki
Dispio uncinata	A. maculata
Eteone dilatae	Emerita analoga
Euzonus dillonensis	Eohaustorius sawyeri
E. mucronata	E. washingtonianus
Hemipodus californiensis	Excirolana chiltoni
Lumbrineris zonata	Lepidopa californica
Lumbrineridae	Orchestoidea benedicti
Nemertea sp.	O. columbiana
Nephtys californiensis	O. corniculata
Nephtys sp.	Synchelidium sp.
Opheliidae	Insecta/Arachnida
Orbinia johnsoni	Anthomyiidae
Orbiniidae	Calliphoridae larvae
Paranemertes californica	Cyclorrhapha larvae
Pygospio californica	Ephydridae larvae
Scoloplos armiger	Sarcophagidae pupae
S. acmeceps	Mollusca
Zygeupolia rubens	Collisella strigatella
	Siliqua patula

Table Ap.2-14. Dominant Infauna Species Reported from Monitoring Stations Located Offshore Oceano, CA (ABC, 1995)

Species	Total	Percent of Total
Carinoma mutabilis (N)	407	13.9
Lumbrineris tetraura (A)	377	12.9
Tellina modesta (M)	372	12.7
Magelona sacculata (A)	292	10.0
Prionospio pygmaea (A)	281	9.6
Glycera capitata (A)	144	4.9
Glycinde picta (A)	109	3.7
Nephtys caecoides (A)	74	2.5
Odostomia sp. (M)	74	2.5
Leitoscoloplos pugettensis (A)	57	1.9
Chaetozone setosa (A)	55	1.8
Chione undatella (M)	51	1.7
Typosyllis fastigiata (A)	46	1.5
Nemertea sp. (N)	32	1.0
Macoma secta (M)	30	1.0
Mediomastus californiensis (A)	30	1.0
Spiophanes bombyx (A)	30	1.0
Chone magna (A)	27	1.0
Onuphis vexillaria (A)	22	1.0
Photis macinerreyi (Ar)	21	1.0
Thalenessa spinosa (A)	21	1.0

N = Nemertea, A = Annelida, M = Mollusca, Ar = Arthropoda

Epifaunal organisms were collected in the same general vicinity as part of earlier outfall monitoring surveys by Pimentel (1959) and Clogston (1970). Species they reported are provided in Table Ap.2-16.

Grain Size and Infauna

Because of the dependence of infauna on ambient sediment properties, data for grain-size distribution is also provided. Accurate determination of sediment grain size is important for assessing potential impacts from the Proposed Project. Because infauna reside within sediment interstices, their spatial distribution is directly related to local sediment properties. Specifically, a different suite of infaunal taxa reside within coarse-grained sediments as compared to finer grained sands, silts, and clays. This relationship has been described in numerous infaunal studies although the precise mechanism describing the interaction between infauna and sediments has not been determined in most cases (Snelgrove and Butman 1994).

Two soft substrate sampling programs have been conducted in the vicinity of the Project at Avila Beach/Port San Luis and Montaña de Oro/Estero Bay. The study locations buffer the southern and northern boundaries of the Project study area. The Avila beach study area is immediately adjacent to the Port San Luis RSG barge landing site. The Montaña de Oro/Estero Bay site would be characteristic of soft substrate areas north of Point San Luis and immediately offshore of the DCPP.

Avila Beach/Port San Luis

In Avila Beach/Port San Luis marine invertebrate samples were collected and analyzed at a total of 72 sites within

Table Ap.2-15. Rank Order of Benthic Infauna Species from the Unocal Santa Maria Refinery Receiving Water Monitoring Program (KLI, 1996)

Species	Total	Percent of Total	Cumulative Percent
Notomastus latericeus (A)	433	37.4	37.4
Dendraster excentricus (E)	154	13.0	50.7
Olivella pycna (G)	136	11.75	62.4
Synchelidium shoemakeri (C)	107	9.25	71.7
Mandibulophoxus gilesi (A)	101	8.72	80.4
Chaetozone sp. (A)	49	4.23	84.6
Eohaustorius sencillus (C)	42	3.63	88.3
Rhepoxynius menziesi (C)	21	1.81	90.1
Nassarius perpinguis (M)	17	1.46	91.5
Nephtys cf. *caecoides* (A)	16	1.38	92.9
Scoloplos armiger (A)	15	1.29	94.2
Nemertea, unident.	11	0.95	95.2
Rhepoxynius sp. (C)	10	0.86	96.0
Euclymeninae sp.(A)	6	0.52	96.5
Nassarius fossatus (M)	5	0.43	97.0
Lineus sp. (N)	5	0.43	97.4
Dispio uncinata (A)	4	0.34	97.8
Listriella sp. (C)	4	0.34	98.1
Magelona sacculata (A)	3	0.26	98.4
Tellina bodegensis (M)	3	0.26	98.6
Nematodes, unident.	2	0.17	98.8
Glycera convoluta (A)	2	0.17	99.0
Polydora bioccipitalis (A)	2	0.17	99.1
Monoculodes spinipes (C)	2	0.17	99.3
Tellina modesta (M)	2	0.17	99.5
Euzonus mucronata (A)	1	0.09	99.6
Heteromastus sp. (A)	1	0.09	99.7
Corophium baconi (C)	1	0.09	99.7
Alpheus sp. (C)	1	0.09	99.8
Lepidopa californica (C)	1	0.09	99.9
Lissocrangon stylirostris (C)	1	0.09	100.0

A = Annelida, E = Echinodermata, C = Crustacea, M = Mollusca, N = Nemertea

Table Ap.2-16. Epifaunal Species Reported in the Vicinity of the Project Area by Pimentel (1959) and Clogston (1970)

Species
Cancer gracilis, slender cancer crab
Dendraster excentricus, sand dollar
Holopaguris pilosus, hermit crabs
Nassarius fossatus, channeled basket shell
Olivella biplicata, purple olive snail
Pisaster brevispinus, sea star

three zones along 24 cross-shore transects. The three zones were delimited by their elevation and proximity to the nearshore wave environment. Samples in the lower intertidal zone were collected at elevations between 0.5 feet and 2 feet) mllw, whereas middle intertidal samples were collected farther up the beach face (2 feet to 5 feet mllw) but still seaward of the crest of the beach berm. Samples in the supratidal zone were collected on the landward side of the berm crest at an elevation of about 9 feet mllw. At 13 of the 24 lower intertidal sites, an additional sample was collected for sediment chemistry analysis.

The inter-related aspects of beach topography and grain size determine the type of invertebrate community that resides on the beach. On short, steeply sloping beaches, crustaceans are generally the only organisms found within the coarse sand grains (Straughan 1982). On wide, gently sloping beaches, there are more organisms and more species, with polychaetes worms and molluscs becoming more prevalent. Avila Beach is a sandy-beach habitat that is comparatively protected from intense littoral processes that dominate along the exposed beaches to the south. As such, it is a more gently sloping beach composed of fine-grained sands.

The topographic character of Avila Beach is reflected in the three cross-shore elevation profiles collected during the field survey of October 1996 (Figure Ap.2-4). These profiles are consistent with the beach profiles acquired by Cannon Associates since January 1995 and summarized by Everts Coastal (1996). The beach width, as measured between the sea wall and mllw, decreases from west to east (Figure Ap.2-4). Near San Luis Obispo Creek, the width is about 400 feet. The beach width declines to around 250 feet at a distance of about 300 feet east of the pier. This width is comparable to the 190 feet mean width, referenced to mean sea level (msl), reported by Everts Coastal (1996) based on profiles measured by Canon Associates. The 60 feet width discrepancy represents the approximate width of the beach contained within the 2.6 feet elevation gain between mllw and msl.

The beach slope within the intertidal zone ranges between 0.03 and 0.06 as determined from the three profiles collected during the October 1996 survey. This compares well with the Cannon Associate's beach profiles collected at Avila Beach and is 4 to 5 times lower than that of the steep slopes associated with beaches to the south. Similarly, Avila Beach berm elevations near 8 feet mllw (Figure Ap.2-4) are comparable to mean 5.5 feet msl elevations determined from the Cannon Associate's surveys conducted through July 1996. They are about 3 feet lower than the berm heights on the exposed beaches to the south, near the Guadalupe Dunes (ADL 1997).

To assess its potential influence in this study, the degree of gross spatial variation in sediment grain size was determined from sediment samples collected at 12 sites that span the sampling region. Although some minor differences between grain-size distributions exist, especially at three outlier sites, the overall variability is small. The sediment samples consist largely of moderately well sorted fine sand with nearly symmetrical distributions (Table Ap.2-17). The cumulative weight distribution (Figure Ap.2-5) indicates that the two outliers (Stations 8 and 24) in the lower intertidal zone have their largest departures at grain sizes coarser than 125μm. In contrast, supratidal Station 24 differs throughout the distribution except in its content of very coarse sands ($\phi=0$). All three of these samples were unusual in that they were coarse-skewed (Skewness < -0.1 in Table Ap.2-17) indicating an excess of coarse material in the tail of their distributions. The two lower intertidal outliers (Stations 8 and 24) were also significantly less sorted [$\sigma(\phi)>0.7$] and were indicative of a bimodal distribution. These features are consistent with the presence of an abnormal amount of gravel-sized material observed at the wave-break site in other surveys at Avila Beach (Everts Coastal 1996).

Figure Ap.2-4.
Beach Profiles Measured during the October 1996 Field Survey

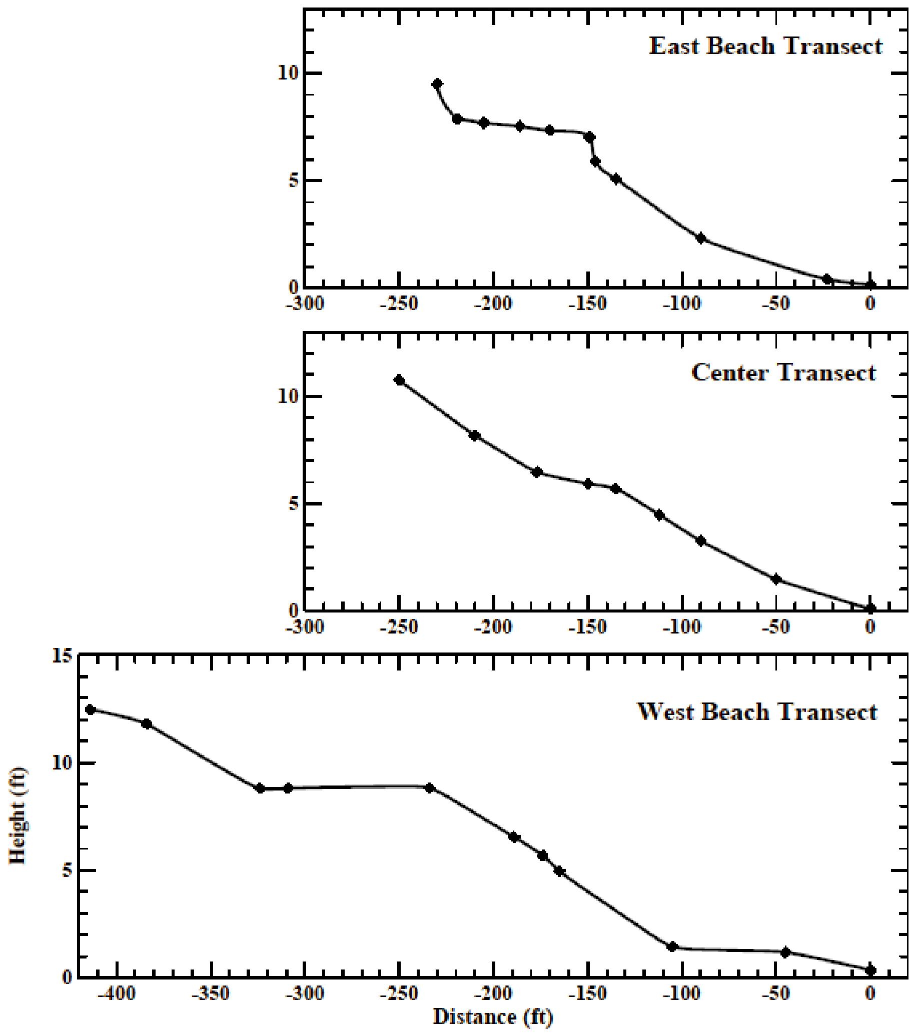


Figure Ap.2-5.
Grain-Size Distribution for Nine Similar Sites and Three Outliers

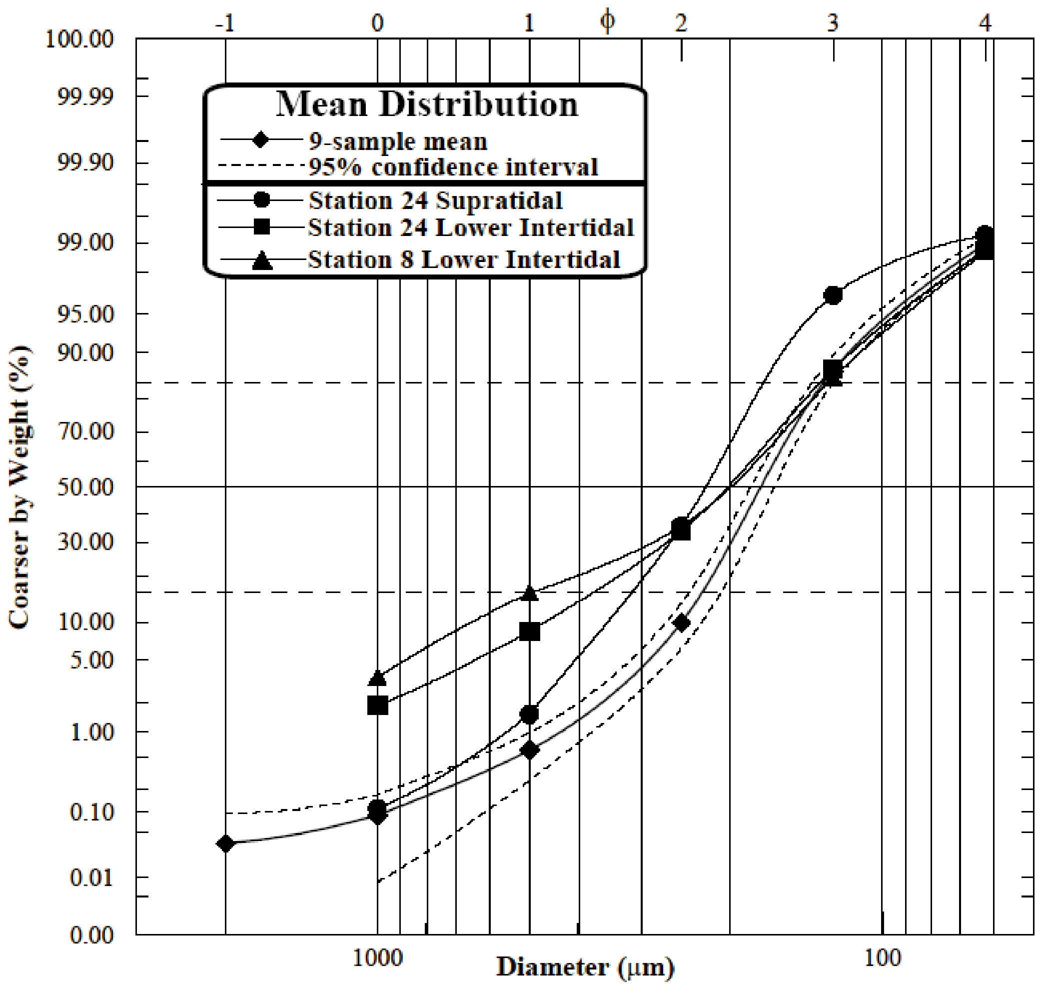


Table Ap.2-17. Grain-Size Distribution along Four Cross-Shore Transects

Zone	Station	Mean (ϕ)	σ (ϕ)	Skewness (ϕ)	Mean (µm)
Supratidal	1	2.65	0.312	0.12	159
	8	2.44	0.389	-0.06	184
	16	2.53	0.342	0.05	173
	24	2.13	0.463	-0.11	228
Middle Intertidal	1	2.50	0.504	0.02	177
	8	2.53	0.570	-0.03	173
	16	2.60	0.406	0.09	165
	24	2.52	0.483	0.04	174
Lower Intertidal	1	2.49	0.497	0.05	178
	8	2.10	0.986	-0.29	233
	16	2.64	0.420	0.12	160
	24	2.21	0.796	-0.17	216

Zone	Station	Percent Coarser than Listed Diameter (µm)				
		5%	16%	50%	84%	95%
Supratidal	1	222	192	160	131	100
	8	314	233	183	147	114
	16	262	213	174	141	109
	24	409	316	224	170	138
Middle Intertidal	1	323	243	177	129	92
	8	366	248	173	122	88
	16	261	210	166	129	92
	24	308	235	174	129	92
Lower Intertidal	1	314	245	179	129	93
	8	871	493	203	128	89
	16	253	207	163	122	88
	24	646	371	204	133	92

There is little evidence of a strong longshore trend in grain size from the limited number of samples collected in the October 1996 survey. Any longshore trend is masked by the variability in samples from the different beach elevations at a given station. This contrasts with the findings of Everts Coastal (1996), which noted that samples collected in September 1996 from east of the pier were finer than those to the west. However, the September samples covered more of the littoral zone (to depths of 26 feet mllw) and the composite mean distribution was weighted by the thickness of the littoral sediment lens. Also, the difference between the grain size distribution on the two sides of the pier was small, on the order of the variability in samples shown in Figure Ap.2-5.

The only clear spatial trend evident in the sediment samples collected in the October 1996 infaunal survey was in the cross-shore direction. The fine fraction (clay, silt and find sands) was consistently smaller in the supratidal zone. This is evident from the larger fine-sand diameters where 84 percent of the material is coarser (Table Ap.2-17). This trend is also evident for very fine sand diameters (100µm) where 95 percent of the material is coarser. The fine fraction is lower in the supratidal zone along all four transects. Although this spatial trend is small, it is indicative of the large difference in habitats between the supratidal zone and the relatively similar middle and lower intertidal environments.

Table Ap.2-18. Invertebrate Organisms Identified in Samples Collected During the October 1996 Beach Survey

Phylum **Class** **Order** **Family** ***Genus Species***	**Sampling Station**																							
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**13**	**14**	**15**	**16**	**17**	**18**	**19**	**20**	**21**	**22**	**23**	**24**
	Supratidal Zone																							
Arthropoda																								
Crustacea																								
Thoracica																								
Balanidae																								
Balanus spp.						1																		
Amphipoda (Gammaridea)																								
Talitridae																								
Megalorchestia columbiana	1	4	1	8	2	3	4			1						1		1				1		
Insecta		5	3	10		16				4						4								
Total Number of Supratidal Organisms	**1**	**9**	**4**	**18**	**2**	**20**	**4**	**0**	**0**	**5**	**0**	**0**	**0**	**0**	**0**	**5**	**0**	**1**	**0**	**0**	**0**	**1**	**0**	**0**
	Middle Intertidal Zone																							
Nemertea																								
Enopla																								
Hoplonemertea																								
Emplectonematidae																								
Paranemertes californica						1	1																	
Annelida																								
Polychaeta																								
Phyllodocidae																								
Eteone spp.																			1				1	
Nephtyidae																								
Nephtys californiensis						1	1				1			1	1									
Spionidae																								
Pygospio californica	1		4		1									1		1		2	2	1	5	1	2	
Scolelepis bullibranchia																	3	1	9		1	3		1
Opheliidae																								
Euzonus dillonensis	4																							
Euzonus mucronata	38	3	17	51													26	36	103		139	13	118	77
Arthropoda																								
Crustacea																								
Isopoda (Flabellifera)																								
Cirolanidae																								
Excirolana linguifrons	1																							
Excirolana kincaidi													1											
Amphipoda (Gammaridea)																								
Oedicerotidae																								
Americhelidium micropleon																				1				
Decapoda																								
Hippidae																								
Emerita analoga	1																							
Total Middle Intertidal Organisms	**45**	**3**	**21**	**51**	**1**	**2**	**2**	**0**	**0**	**0**	**1**	**0**	**1**	**2**	**1**	**1**	**29**	**39**	**115**	**2**	**145**	**17**	**121**	**78**

Table Ap.2-18. Invertebrate Organisms Identified in Samples Collected During the October 1996 Beach Survey

Phylum **Class** **Order** **Family**	**Sampling Station**																							
Genus Species	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**13**	**14**	**15**	**16**	**17**	**18**	**19**	**20**	**21**	**22**	**23**	**24**
	Lower Intertidal Zone																							
Nemertea		1																						
Enopla																								
Hoplonemertea																								
Emplectonematidae																								
Paranemertes californica											1								1					
Nematoda														4										
Annelida																								
Polychaeta																								
Phyllodocidae																								
Eteone spp.		1																						
Hesionura spp.																						1		
Nephtyidae																								
Nephtys californiensis	1	2	2		1										1				1					
Paraonidae																								
Paraonella platybranchia		1	1		1		2		1	1			1				2	1					1	2
Spionidae																								
Pygospio californica			2	1																				
Mollusca																								
Bivalvia																								
Paxillosida																								
Veneridae																								
Tivela stultorum			1											1										
Arthropoda																								
Crustacea																								
Amphipoda (Gammaridea)																								
Haustoriidae																								
Eohaustorius spp.		2																						
Eohaustorius sawyeri		1																						
Oedicerotidae																								
Americhelidium micropleon	1			2			2				1		2	9	2		17	2	1	11		1	2	2
Decapoda																								
Hippidae																								
Emerita analoga								1										1				3	1	
Total Number of Lower Intertidal Organisms	**2**	**8**	**6**	**3**	**2**	**0**	**4**	**1**	**1**	**1**	**2**	**0**	**3**	**14**	**3**	**0**	**19**	**4**	**3**	**11**	**0**	**5**	**4**	**4**

A total of 847 organisms representing 21 invertebrate taxa were collected and enumerated at 72 sites (Table Ap.2-18). Thirteen of the 21 taxa were identified to species level and five were identified to genus level. Total abundance varied widely among the samples. Twenty-one samples were devoid of invertebrate organisms. Most of these uninhabited samples were collected in the supratidal zone, although the middle and lower intertidal zones each had four samples without organisms. The eight depauperate samples from the intertidal zones were largely collected near the center of the longshore sampling grid. One station had no organisms in any samples from all three zones.

Despite wide variation in abundance among samples, distinct differences between the three tidal zones were evident. Because there were only slight differences in the bulk sediment properties between the zones, the observed taxonomic differences were probably more related to shoreline proximity rather than any direct causal relationship with grain size. Some of the observed taxonomic differences in the lower intertidal zone could be ascribed to the smaller sieve size (0.5 mm) used to collect specimens there. However, a smaller sieve size should yield a higher total abundance, but the total invertebrate density in the middle intertidal zone (1546 m^2) was about seven times larger than that of the lower intertidal zone (228 m^2). Moreover, the same sieve size (1.0 mm) was used in the upper two zones (middle intertidal and supratidal) where some of the largest taxonomic differences were evident. In fact, there were no taxa common to both the supratidal and intertidal zones and different taxa dominated the middle and lower intertidal zones (Figure Ap.2-6).

Montaña de Oro/Estero Bay

For the Montaña de Oro/Estero Bay sampling program, samples were collected at the 27 stations. Within the area surveyed, there were three distinct deep sediment subregions. The nearshore subregion, around water depths of 10 to 30 m, was intensively sampled. The mid-depth subregion included an area of deep sediments at water depths ranging from 50 to 60 m. Finally, offshore sediments were characterized with sediment samples collected at three benthic stations beyond the 65-m isobath. In contrast to the appearance of nearshore sediments, the mid-depth sediments exhibited distinct layers. Visual inspection of the undisturbed grab samples revealed a distinct vertical structure with mud overlain by gravel, pebbles, and small stones embedded in a surficial layer of coarse sand. The coarse material on the surface of the grab was reddish-brown in color and appeared to have a different mineralogy than the dark olive-green subsurface silts. This type of layering is typical of the armoring that occurs in benthic sediments subjected to high-speed flows that winnow the fines from surficial sediments. It is a phenomenon that was observed at a similar location to the south of the study area (see CaMP R8 in Figure V-4; Drake, et al. 1992). The visual character of the offshore area samples was distinct from the other subregions. The samples consisted of well-mixed very fine sands and silts with a dark olive-green hue.

The distinct visual differences in sediment grab samples among subregions were quantified in the grain-size analysis. These results are summarized in Table Ap.2-19 and Figure Ap.2-7. The nearshore sediment samples were all nearly identical as indicated by the very narrow width of the confidence limits in Figure Ap.2-7. Nearshore sediments consisted of very well sorted fine sands that are typical of an energetic wave environment. This means that nearly all of the sediment particles were the same size (157 μm) within each sample (i.e., well-sorted), and among all of the 26 samples collected at nearshore sites (i.e., narrow confidence limits). Also, the variation among replicate samples collected at Stations 5 and 16 was comparable to the differences between stations; so any perceived spatial trends within the nearshore subregion were not statistically significant ($p>0.05$) except in the very fine sand and silt fractions. In fact, the grain-size distribution in the nearshore subregion was nearly identical to the distribution determined at nearshore sites 9 km to the north that were analyzed as part of an outfall monitoring program (MRS 1999).

Figure Ap.2-6.
Dominant Invertebrate Taxa Characteristic of the Three Beach zones
Note: Percent composition is shown in parentheses

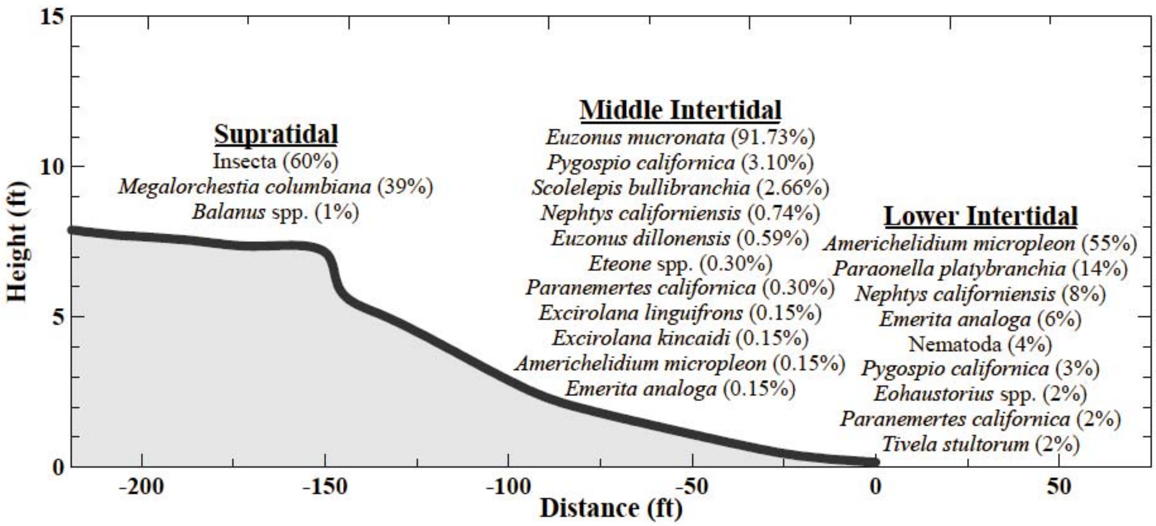


Figure Ap.2-7.
Mean Grain-Size Distributions and 95% Confidence Limits for the Three Sediment Subregions

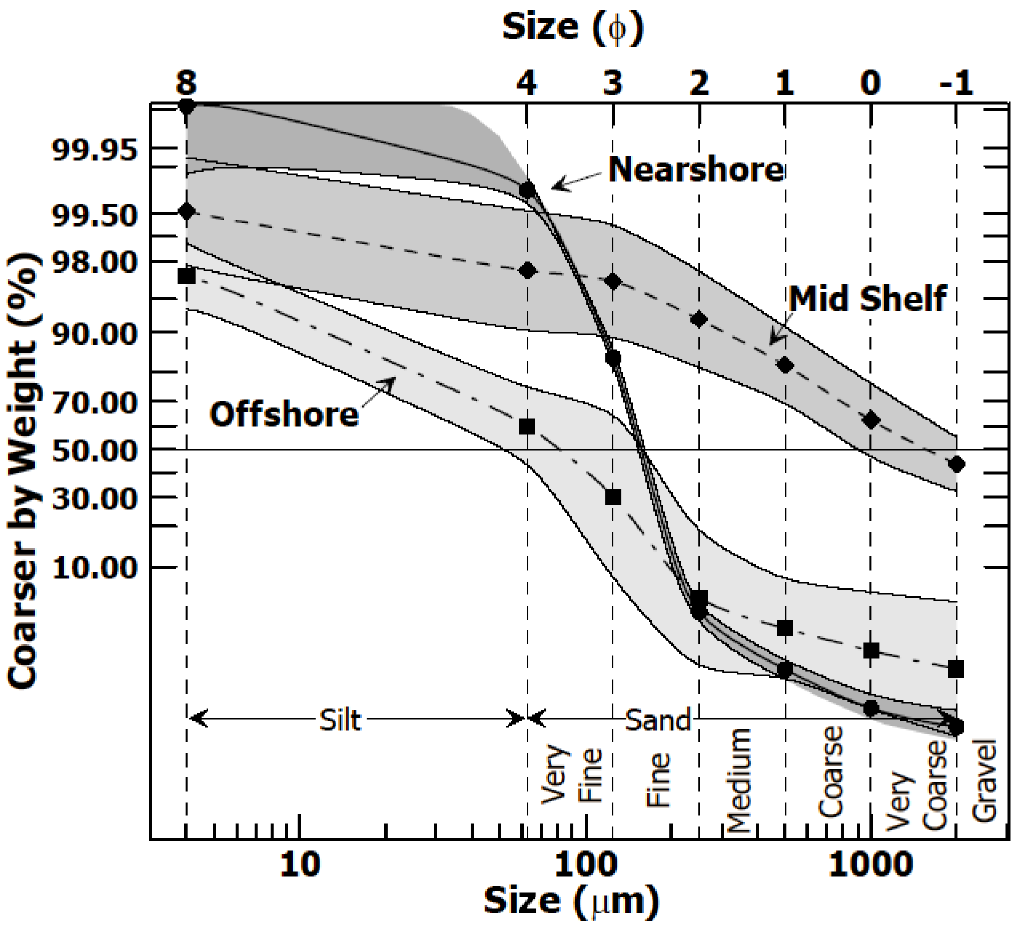


Table Ap.2-19. Description of Average Grain-Size Properties of Benthic Samples

Location	Distribution	Average Size	Spread	Skewness
Near shore	Unimodal	Fine sand (ϕ=2.7)	Very well sorted (σ=0.35)	Symmetrical (α=0.04)
Mid-depth	Bimodal	Pebbles and Silt		
Offshore	Unimodal	Very fine sand/silt (ϕ=4)	Poorly sorted (σ=1.57)	Very skewed toward excess fines (α=0.35)

The grain-size distribution in the mid-depth subregion was significantly different from the other two subregions. It exhibited a distinctive bimodal distribution with one mode in pebble-sized and another in the silt fraction. Bimodality resulted from the layering that was visually observed during grab sample collection. Consequently, the computed median grain size lies between these modes. Because of this bimodality, other computed properties of the distribution, such as spread and skewness, are irrelevant. Bimodal distributions are often indicative of two transport mechanisms, but in the case of the mid-shelf sediment samples, the bimodal distribution probably resulted from armoring of surficial sediments as previously described. In addition, there was wide variability in grain-size among the five stations within the mid-depth subregion. This is reflected in the broad span of the confidence limits shown in Figure Ap.2-7. Despite this large with-region variability, the mean grain-size distribution among mid-depth samples was significantly different ($p < 0.05$) from the mean distribution in the other two sub-regions. This is evident from the fact that the 95 percent confidence limits surrounding the mean distribution within any given subregion, do not encompass the means from the other subregions. The only exception to this was for particles coarser than fine sands in the nearshore and offshore subregions. Within that size range, the difference in mean distributions in offshore and nearshore samples could not be reliably distinguished. However, the mean coarse fraction in mid-depth samples was significantly different.

The particle-size distribution in sediment samples collected at the offshore subregion consisted mostly of very fine sands and silts although the material was poorly sorted. These sediment samples punctuate the strong trend toward increasing fine-sediment fractions with increasing distance from shore. A similar cross-shelf trend was observed 23 km to the south at Stations R1, R2, and R3 during the California Monitoring Program (Steinhauer and Imamura 1990). Again, the confidence limits surrounding the mean grain-size distribution in offshore samples are broad, but this is probably an artifact of the few (3) stations used to compute the mean.

During the benthic field survey, 2,821 sediment-dwelling organisms were collected. These infaunal organisms represented 303 separate taxa. Each organism was identified to the lowest practical taxonomic level and each taxon was enumerated within all of the 39 samples.

The spatial distribution of taxa was far from uniform as exemplified by the apportioning of the most abundant taxon, the Olive Snail (*Olivella pedroana*), among samples. Nearly all of these specimens were found in a single sample; namely, 150 specimens were collected at a nearfield station, while only four were found elsewhere. Nevertheless, it represented more than 5 percent of the total number of specimens collected in the entire survey. Other dominant taxa, including the gammarid amphipods *Desdimelita desdichada*, and *Atylus tridens*, also had a patchy spatial distribution with a single sample containing most of the specimens. Species with erratic spatial distributions were evident throughout the database and patchiness was also reflected in the large number singleton taxa (only a single specimen was collected during the survey). More than one third, or 106, of the 303 identified taxa were singletons. The erratic spatial distribution suggests that many organisms occupy a relatively narrow ecological niche and that the location of habitat disturbance caused by the Proposed Project can strongly influence which organisms will be impacted.

Despite the patchy distribution of individual taxa, distinct large-scale spatial trends were evident. Specifically, infaunal community composition was significantly different among the three subregions, similar to the differences observed in grain size and in epifauna. Because of this, evaluation of potential impacts to infauna from the Proposed Project was performed within subregions rather than on the database as a whole. These spatial differences were evident in the marked increase in diversity with increasing distance from shore as shown in Figure Ap.2-8. Average species richness as measured by the number of species increased by a factor of about two between the nearshore and mid-depth subregions, and about 2.5 between the mid-depth and offshore subregions. On average, there were 25 taxa present in offshore samples as compared with only five taxa in the nearshore region.

A more robust measure of the differences in community composition is provided by multivariate analyses. One such technique, known as canonical correspondence analysis (ter Braak and Verdonschot 1995), revealed highly significant ($p < 0.001$) trends in community composition related to subregion. Because grain size and water depth also varied with subregion, the causative mechanism for the differences in community structure could not be unequivocally determined. However, grain size has historically been considered a dominant factor controlling infaunal distributions (Snelgrove and Butman 1994). Because of this, its influence was examined in detail through the application of correspondence analysis to this survey's database (Figure Ap.2-8).

Figure Ap.2-9 shows the strong correspondence between the grain size of seafloor sediments and the infaunal community that resides within them. The arrows point in the direction of increasing prevalence of a particular size fraction within each sample. Samples shown by the ■ symbols and the closer their proximity to one another, the more similar are their infaunal communities. Thus, the taxa found within samples from the offshore Stations 33, 34, and 35, were similar to one another but very different from the infauna found within other subregions. Because these samples also contained a significantly increased fraction of silts and clays (Figure Ap.2-7), their unique infaunal community correlated strongly with a high amount of fine-grained sediment. The infaunal species whose abundance was significantly elevated in these fine-grained samples are shown by the ✶ symbols.

These influential taxa included the annelid worms *Paraprionospio pinnata* and *Poecilochaetus* Sp.A, and the Red Brittlestar *Amphiodia urtica*. *P. pinnata* is a cosmopolitan polychaete common to silty sediments and is prevalent throughout the offshore portion of the Santa Maria Basin (USDOI 1996b). It rapidly recolonizes disturbed habitats so seafloor impacts from mechanical disturbance caused by the Proposed Project would have minimal effect on this species (Dauer and Simon 1976). The *Poecilochaetus* Sp. A specimens enumerated in the benthic survey probably represent juvenile forms of the burrowing polychaete Poecilochaetus johnsoni. It is also common to silty sediments throughout the Santa Maria Basin (USDOI 1996b). The Red Brittlestar (*A. urtica*) is prevalent within Estero Bay although its presence is not restricted to silty sediment (MRS 1999). It is one of the most common benthic invertebrates along the southern California Shelf.

The other influential taxa within this more-quiescent offshore environment consisted mostly of delicate annelid worms although the rich infaunal community spanned a wide range of major taxonomic groups as summarized in Table Ap.2-20. Offshore samples had singularly high densities of bivalves, cnidarians (anemones), echinoderms (sea stars, brittle stars, urchins and sea cucumbers), hemichordates, nemerteans (ribbon worms), and phronids. Hemichordates consisted of acorn worms, which are fragile burrowing organisms. The wormlike phoronids were only found within samples collected from the offshore subregion.

Figure Ap.2-8.
Infaunal Species Richness

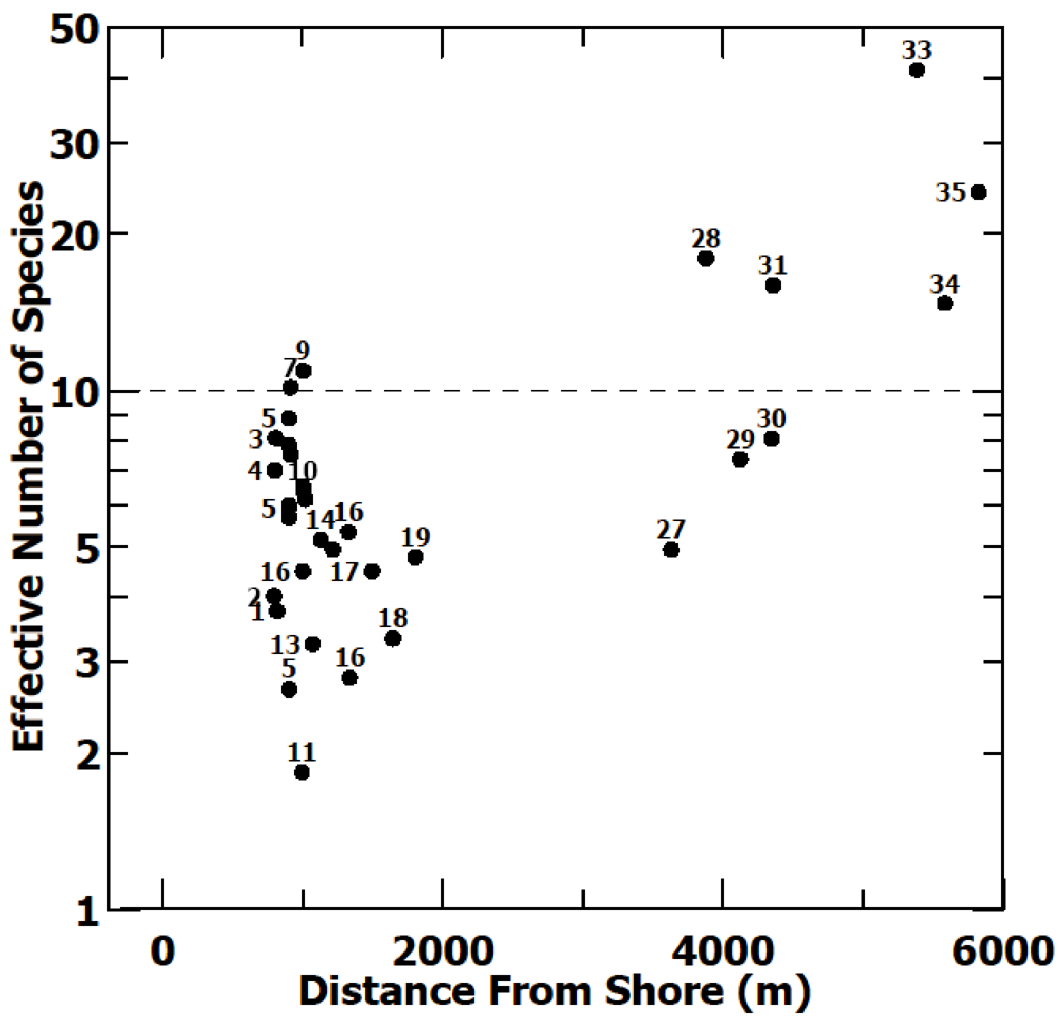


Figure Ap.2-9.
Correspondence between Grain-Size and Infaunal Community Structure.

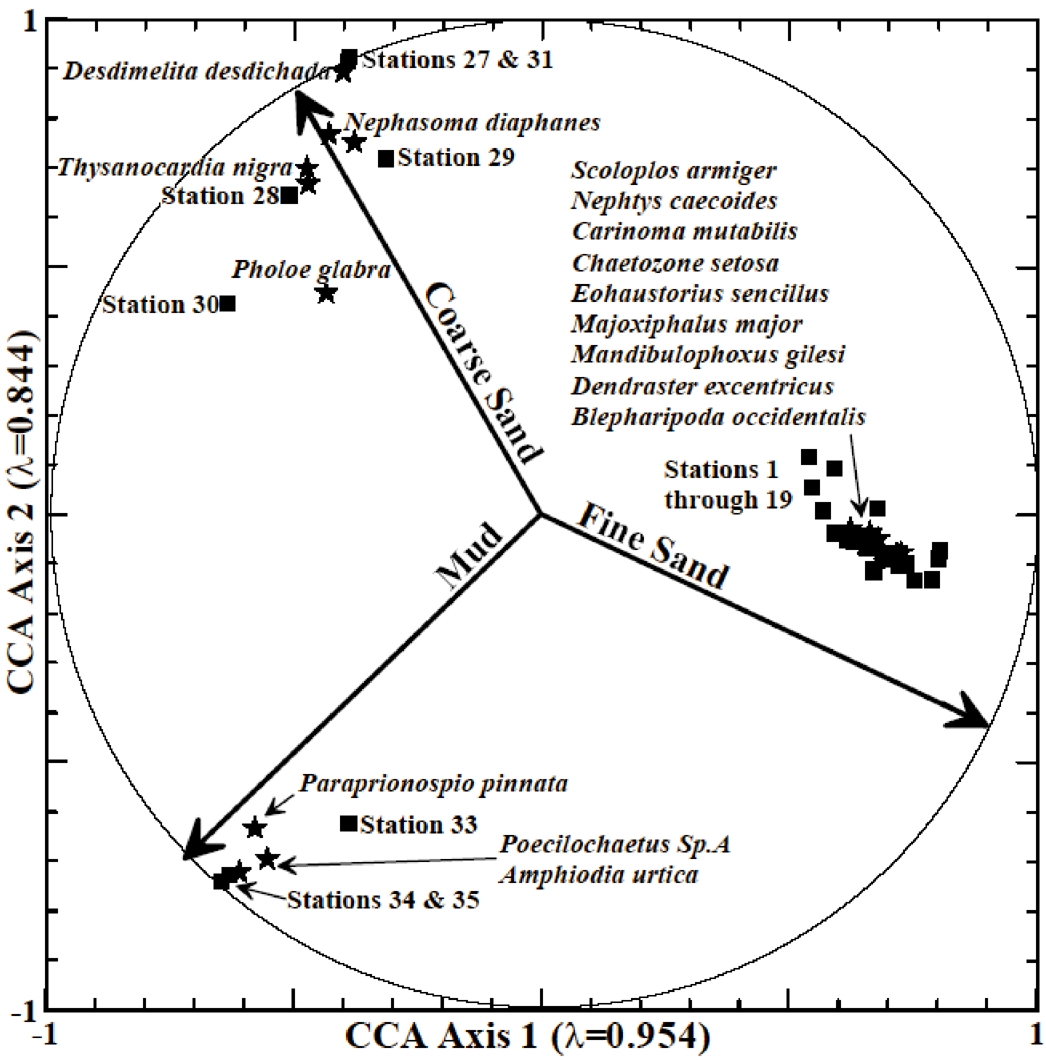


Table Ap.2 20. Infaunal Community Properties by Subregion

Parameter	Nearshore	Mid-Depth	Offshore
Distance from Shore (km)	<2	4	6
Grain Size	Fine Sand	Coarse Sand	Silt
Average Number of Taxa	5.7	10.9	26.7
Density of Major Groups (m^{-2})			
Total Infauna	5	970	1670
Annelida	98	426	977
Bivalvia	7	0	43
Cnidaria	1	14	30
Crustacea	208	246	210
Echinodermata	53	72	260
Gastropoda	61	2	23
Hemichordata	0	2	23
Nemertea	28	14	47
Phoronida	0	0	37
Platyhelminthes	0	26	0
Sipuncula	0	168	3

Dominant Taxa, Their Density (m^{-2}), and Percent of Total		
Olivella pedroana ($59m^{-2}$, 13%)	Desdimelita desdichada ($212m^{-2}$, 22%)	Amphiodia urtica ($207m^{-2}$, 12%)
Dendraster excentricus ($52m^{-2}$, 11%)	Nephasoma diaphanes ($106m^{-2}$, 11%)	Poecilochaetus Sp.A ($100m^{-2}$, 6%)
Eohaustorius sencillus ($44m^{-2}$, 10%)	Pholoe glabra ($68m^{-2}$, 7%)	Paraprionospio pinnata ($67m^{-2}$, 4%)
Chaetozone setosa ($25m^{-2}$, 5%)	Leptosynapta ($68m^{-2}$, 7%)	Spiophanes missionensis ($57m^{-2}$, 3%)
Carinoma mutabilis ($25m^{-2}$, 5%)	Thysanocardia nigra ($62m^{-2}$, 6%)	Euclymene Sp.A ($53m^{-2}$, 3%)
Cheirimedia zotea ($24m^{-2}$, 5%)	Chaetozone Sp.1 ($44m^{-2}$, 5%)	Cossura candida ($47m^{-2}$, 3%)

In the mid-depth subregion, where coarse sands dominated the sediment distribution, Figure Ap.2-9 shows that six taxa had significantly elevated abundance compared to other samples. They included: the gammarid amphipod (*Desdimelita desdichada)*, although its distribution was patchy; the sipunculoid peanut worms (*Nephasoma diaphanes* and *Thysanocardia nigra)*; the burrowing worm-like sea cucumber (*Leptosynapta)*; and the annelids *Chaetozone* Sp.1, and *Pholoe glabra*. Cirratulids (*Chaetozone* Sp.1) are burrowing organisms while *P. glabra* is a small crawling scale worm often found crawling over the surface over muddy sediments littered with shell hash or rocks. The carnivorous polychaete *P. glabra* is abundant throughout the Santa Maria Basin where it spawns in early summer (Kropp and Carroll 1990). As described above, this subregion was probably subjected to high near-bottom current velocities that winnowed the fine sands from the surficial sediments. Under these adverse conditions, platyhelminthes and sipunculoids had singularly high densities compared to other subregions (Table Ap.2-11). Bivalves and phoronids were virtually absent. Because peanut worms (Sipuncula) tend to hide under rocks, their almost-exclusive presence in this gravely subregion is not surprising. Similarly, free-living flatworms or platyhelmminthes are typically found under small stones, which explains why they were only observed in the mid-depth subregion where the armored seafloor was strewn with pebble-sized rocks.

In the subregion closest to shore, where fine sand was prevalent, a different set of species were predominant (Figure Ap.2-9). In this harsh wave-dominated environment, influential species included the annelid worms, *Scoloplos armiger*, *Nephtys caecoides*, and *Chaetozone setosa* as well as the nemertean *Carinoma mutabilis*. Several hearty crustacean species were also prevalent including *Eohaustorius sencillus*, *Majoxiphalus major*, *Mandibulophoxus gilesi*, and *Blepharipoda occidentalis*. Finally, the sand dollar, *Dendraster excentricus*, was found only in the nearshore samples. All of these species were also common to other nearshore sites within northern Estero Bay (MRS 1999). Major taxonomic categories, with comparatively high densities within this subregion, included gastropods and nemerteans (Table Ap.2-20). Cnidarians, phoronids, platyhelminthes, and sipunculoids were essentially absent in this nearshore region.