CHAPTER 4 ENVIRONMENTAL IMPACTS

Monitoring studies of relatively long-lived organisms (including many fish and invertebrate species) will often have low statistical power to detect ecologically significant changes in density. Changes in natural populations on the order of 50% will often go undetected (Schroeter et al. 1993). With this caveat in mind, the following sections discuss the effects of the proposed project on the existing environment described in Chapter 3. An analysis of the cumulative impacts will be presented at the end of the chapter.

4.1 Effect of Kelp Harvest on Finfish Populations

Giant Kelp

The relationship between fish populations and *Macrocystis* harvesting in southern California was reported in the State of California Fish Bulletin 139 (North and Hubbs, 1968). There were three approaches used to study this relationship: a qualitative study by Limbaugh (1955), a quantitative study by Quast (1968d), and a statistical analysis of sportfishing in kelp beds and kelp harvesting by Davies (1968). All three investigators arrived at the same conclusion, namely that "no evidence has been obtained that kelp harvesting has a measurable effect on the fish populations." However, researchers in central California found that kelp harvesting affected the distribution of fishes associated with kelp forests, especially juvenile rockfishes, in that they tended to move either vertically or horizontally away from the impacted area. The removal of canopy cover may also contribute to greater predator success in harvested versus control areas (Miller and Geibel 1973, Houk and McCleneghan 1993).

Limbaugh's (1955) qualitative study was conducted throughout kelp beds from Monterey, California to Baja California, Mexico from 1948 to 1954. Limbaugh dived and observed kelp harvesting operations as related to fishes and ecology of the kelp forests. He also tagged kelp bass and followed their movement relative to harvested and unharvested areas of the kelp forest. Limbaugh (1955) concluded that harvesting did not impact populations of fishes in kelp forests and nearby coastal areas.

Quast (1968a, b, c, d) conducted his quantitative analysis of the standing crop and food of kelp bed fishes, and the effects of kelp harvesting on these fishes in the kelp forests of southern California. Quast (1968d) also considered the question of whether kelp harvesting destroyed significant amounts of eggs and larval fish species of sport value. He noted that tiny kelp clingfish and larger kelpfish attached their eggs to giant kelp and other objects, but found no eggs of sportfish attached to the kelp. Larvae of fishes may occasionally reach high concentrations in the kelp canopy. Quast (1968d) reported that a minimal fraction of the larval fish population was taken aboard the harvester because the forward motion of the vessel creates currents and eddies, sweeping most of the larvae away from the kelp as it is brought aboard. Quast (1968d) concluded that kelp harvesting had minimal effect on fish populations living in forests of giant kelp.

Davies (1968) used a statistical analysis to evaluate the relation between kelp harvesting and sportfishing in southern California kelp beds during a ten year period (1947-1956). He found no correlation between kelp harvesting and sport fishing success and noted that the catch per unit effort increased from 4.51 to 7.00 during the 10 years, while harvesting was 1.5 times greater in 1956 than at the beginning of the study in 1947. Sportfishing success, expressed as catch per unit effort, increased while kelp harvesting increased. These data also indicate that kelp harvesting had no measurable effect on sportfish populations.

Recreational anglers in private vessels as well as commercial passenger fishing vessels (CPFV) will follow behind the harvesters during cutting. Large numbers of fish move up from the bottom enticed by the presence of small fish, invertebrates, and bits of algae shaken loose from the kelp as it is moved onto the harvester. Recreational fishermen utilize their knowledge of this fish attraction to their advantage by moving into these just harvested areas. In addition, kelp harvesters open up lanes in the canopy that allows CPFV's access to areas that were previously closed due to the density of the kelp (CDFG 1995). Thus, by creating easier access to interior portions of a bed, kelp harvesting can indirectly increase fishing related mortality.

Miller and Geibel (1973) conducted experimental harvesting of *Macrocystis* canopies in central California to determine if there were any measurable impacts of harvesting on fishes. They recognized that studies had been done in southern California by Quast (1968a, b, c, d) but felt that the central California kelp habitat and suite of fishes were very different. Miller and Geibel (1973) noted that southern California kelp beds are less turbid, less turbulent, and tend to maintain some kelp canopy throughout the year compared to central California. There is a wider range of canopies in central California from almost none in winter to dense in summer. Kelp beds in southern California are typified by kelp bass, blacksmith, California sheephead, rock wrasse, señorita, black surfperch, topsmelt, and kelp surfperch. Kelp beds in central California are dominated by blue rockfish, striped surfperch, olive rockfish, and kelp surfperch in the canopy and midlevel area. There are also dense concentrations of juvenile rockfish in the kelp beds in central California from April through November each year. The juveniles were observed throughout the kelp forest; at times associated with shallow rockweed growth, rocks, the holdfast area, and at other times they were densely aggregated in the canopy and midwater zones (Miller and Geibel, 1973). Similar "swarms" of juvenile rockfishes are not encountered in southern California (Quast, 1968b).

Miller and Geibel (1973) evaluated underwater transects in an unharvested control area and a harvested experimental area to determine if harvesting impacted fish populations in the *Macrocystis* forest off Point Cabrillo, in Monterey Bay. They cut the canopy five times during the study that lasted a little longer than a year. They compared fish counts from along the transects following four of the five experimental cuttings.

Miller and Geibel (1973) found that analysis of transect data, to disclose effects of canopy removal on fish populations, was difficult because of the high variability between seasons and particular niche preference for each species. If only minimal effects occurred, they may have been masked by multiple natural changes affecting each species. Best results were obtained studying striped perch and juvenile rockfishes. Miller and Geibel (1973) found that striped perch were not affected by experimental cutting. Counts of juvenile rockfishes were quite similar in canopy and at the bottom in the control area where the canopy was not harvested experimentally. The data in the harvested area suggested that juvenile rockfishes went down to the bottom after the harvest rather than move horizontally to the nearby uncut surface fronds. As canopies reformed in the harvested area, juvenile rockfishes would reappear.

Miller and Geibel (1973) also conducted small-scale harvest experiments to evaluate the macro-organisms that exist in the canopy and might be taken aboard a kelp harvester. Several species of fishes were collected in the canopy, including: kelpfishes (genus *Gibbonsia*), penpoint gunnel, kelp gunnel, rockweed gunnel, kelp clingfish, and saddleback sculpin. The same species were taken in samples from the commercial harvest of kelp off Granite Canyon and Carmel Bay. The northern clingfish, tidepool snailfish, and manacled sculpin were taken aboard the harvester but not taken during the experimental harvest. Miller and Geibel (1973) noted that the more mobile schooling rockfish and surfperch did not show up in experimental harvests. These fishes were abundant near the canopy but were apparently frightened by the divers during the experimental hand-harvesting. Some juvenile rockfishes and surfperches are taken aboard the kelp harvester during routine commercial operations in central California (McPeak, pers. obs.).

Miller and Geibel (1973) concluded that adult fishes are probably not affected by the canopy removal. A similar conclusion was reached by Quast (1968d) for southern California kelp beds. Miller and Geibel (1973) did suggest that there is some concern about the environmental changes of a large commercial operation possibly adversely affecting summertime juvenile fish concentrations in central California.

Houk and McCleneghan (1993) continued the California Department of Fish and Game research in central California and reported the results of a 1977 study on the effects of canopy removal on young-of-the-year (YOY) blue rockfishes and bocaccio. They used two methods to census YOY rockfishes in experimentally harvested, unharvested, and control *Macrocystis* beds; fish transects by divers and capture/recapture techniques. They evaluated the fish population along transects within 2 m of the bottom and 2 m of the surface (i.e.. canopy). Young-of-the-year blue rockfish were by far the most numerous, followed by bocaccio. Houk and McCleneghan (1993) found a significant reduction in fish populations in the harvested area following the harvest, as well as a significant reduction in the fish population in the unharvested area. The reductions were not significantly different between the areas. The large reduction in the fish population in the harvested area occurred when fish moved into the unharvested area. The large, unexpected reduction in fish numbers in the unharvested area occurred when larger predatory YOY bocaccio moved into the control area as the experimental area was being harvested. The bocaccio removed in excess of 20% of the biomass of YOY blue rockfish, which was composed of resident fish and recently migrated fish from the harvested kelp bed. Predation on YOY blue rockfish was also noted in the harvested area.

Houk and McCleneghan (1993) noted that any substantial change in fish populations that might have occurred between the harvested and unharvested areas was masked by the immigration of significant numbers of larger predatory YOY bocaccio which reduced the number of YOY blue rockfish in all three areas. Research by Houk and McCleneghan (1993) indicates that YOY rockfishes associated with the canopy are able to move to nearby unharvested areas rather than down to the bottom as suggested by Miller and Geibel (1973).

In conclusion, it appears that populations of fishes in southern and central California may be displaced for a time following harvesting. Harvesting of canopies may open some areas to predation by fishes that otherwise would not feed in the area, and potentially increases the fishing mortality for some fish species due to easier access to those species.

Bull Kelp

The effect of *Nereocystis* harvest on finfish populations has had limited study. Leaman (1980) conducted a harvest experiment in British Columbia using a patch harvest method. He removed 100 m^2 patches from three different parts of a bull kelp bed: exposed outer edge, middle of the bed, inshore edge of the bed. Gillnet operations and diving surveys were conducted to identify fish prior to and following canopy removal. It is important to remember when evaluating impacts, that commercial harvest of *Macrocystis* involves removal of the upper 4 feet or so of canopy, leaving the rest of the plant essentially intact. On the other hand, *Nereocystis* harvest results in the loss of the entire canopy as the single surface float is removed causing the entire plant to eventually sink to the bottom

Leaman (1980) found differing effects, depending on the area of harvest. Thus, when harvesting occurred at the outer edge of the bed, there was no appreciable effect on benthic species diversity and abundance but a negative effect on neritic fishes. By contrast, when canopy removal occurred in the middle or inner areas, there was a significant reduction in the species diversity and abundance of benthic fish but a positive effect on the neritic species. The clearing of the canopy in the inner portion of the bed allowed plankton to aggregate, thus creating a feeding environment for inner neritic residents. The opening allowed these fish to feed without the associated predation pressure that exists in the outer areas of the bed. The effect of canopy removal on resident fish populations lasted about 25 days in this experiment (Leaman, 1980). Therefore, this experiment showed harvesting had both positive and negative short term effects.

Leaman (1980) was not able to identify any effects of canopy removal on associated and transient species. However, he felt that disturbances to the kelp bed ecosystem could extend beyond the boundaries of the kelp bed through possible effects on these species.

Effects of harvest may be highly site–specific. Leaman (1980) recommended that limited harvesting be allowed in conjunction with experiments designed to evaluate the effects of canopy removal on kelp bed fish species. He also stated that determining the optimal time of harvest would minimize any possible impacts of canopy removal on fish reproduction and recruitment.

At this time, too little research has been done on the effect of bull kelp harvest on fish and until more information is gathered, it is impossible to tell whether the impacts are significant or not. Therefore, a precautionary approach, adopting a risk-averse strategy, is included in existing regulations which close beds 303-307 to harvest and set a maximum harvest rate of 15% on the remaining 300 series beds (CCR 165(c)5(A) and 165.5(b)5).

The proposed project and suggested alternatives would shift the existing management strategy in a conservative direction. While there is some uncertainty over potential impacts from the harvest of bull kelp on finfish populations, the precautionary approach taken with existing regulation has been enhanced, particularly with regard to the harvest of bull kelp. Given the enhanced safeguards and a lack of apparent impact under the existing regulatory strategy, any impacts from the proposed project on finfish populations is considered to be short-term and less than significant.

4.2 Effect of Kelp Harvest on Invertebrate Populations

Giant Kelp

Macrocystis canopies are rich in motile and sessile invertebrates (see section 3.2.9.1). Bryozoans and hydroids are the most abundant sessile animals (Bernstein and Jung, 1979), while crustaceans and molluscs are the most abundant motile animals in the canopy (Coyer, 1984, 1986). At times, the tiny motile animals associated with encrusted fronds of giant kelp number more than 100,000 per m^2 of plant tissue (Wing and Clendenning, 1971). These, mostly small creatures, are consumed by various species of fishes and invertebrates in the kelp community.

Kelp harvesting obviously removes the sessile animals that are attached to the fronds. These animals, however, have evolved to reproduce rapidly in the ephemeral kelp canopy environment. Many of the sessile animals in the canopy produce offspring within days or weeks of settling. Since mature fronds are preferred for harvesting, sessile animals have usually reproduced before the fronds are removed by harvesting.

Quast (1968d) noted that the forward motion of the harvesting vessel creates strong currents and eddies around the kelp being harvested, and these forces sweep a major portion of the motile invertebrates from the blades and stipes. Also the kelp drains as it is being loaded, giving the animals a second chance to escape. Quast (1968d) also noted that some canopy is usually missed by the harvesters, and some new canopy appears in the wake of the harvester because freshly cut fronds are less bent by the pull of the surface currents. Both the kelp that remains or appears on the surface and the fronds that are just beneath the surface are available as refuge for the displaced motile animals.

Wing and Clendenning (1971) estimated that about 1/3 of the motile invertebrates in the kelp canopy are taken aboard the kelp harvester during harvesting, while Quast (1968d) suggested that the figure was closer to 1/4 or less when all forage animals were considered. Quast (1968d) considered the reconstitution of the canopy population and calculated the annual loss of motile invertebrates through harvesting at about 11%.

Limbaugh (1955) and Quast (1968d) considered the question of whether the amount of invertebrates removed during kelp harvesting was a significant amount of food for fishes. They concluded that fishes were not being impacted by the small amount of invertebrates being taken during harvesting.

There are several species of benthic invertebrates that inhabit forests of giant kelp and are being harvested commercially and by sportsmen: sea urchins, *Strongylocentrotus franciscanus*, and to a less extent, *S. purpuratus*; California spiny lobster, *Panulirus interruptus*; abalone, *Haliotis* spp.; and sea cucumbers, *Parastichopus parvimensus*. All of these species produce planktonic larvae that drift in the water for anywhere from a week (abalone) to a year (lobster). The larvae are not associated with the canopy of *Macrocystis* and therefore should not be affected by kelp harvesting.

Miller and Geibel (1973) conducted an experiment in central California to determine or estimate the amount of macro-organisms (larger than about 10 mm in length) per acre of kelp canopy. They considered the canopy to extend to a depth of 10 ft. (six feet deeper than is allowed by commercial kelp harvesting). They cut similar-sized areas of canopy by hand at a depth of 10 ft. in experimental and control areas three times (February 4-9, April 30, and August 5, 1970) and compared the number of macro-organisms. The animals were sampled by taking the mass of cut kelp and floating it over a 20 x 30 ft. (6 x 9 m) burlap blanket. One side of the blanket was attached to the boat, while the other three sides were held out of the water by poles. The fronds were selected one by one and the animals enumerated.

The isopod, *Idotea resecata*, far outnumbered all other macroorganisms, but molluscs as a group made up the largest bulk of the invertebrates. *Tegula* and *Calliostoma* (6 species) were the most abundant molluscs encountered in the canopy.

Miller and Geibel (1973) noted that there were significant differences in the estimates or organisms in the cut and uncut areas. For instance, they estimated more than 13,000 *Idotea resecata* per acre in the cut area following the second harvest (April 30) compared to only 420 per acre in the uncut area. They believed the differences were due to methodology and natural fluctuations of the density of invertebrates rather than to the effects of cutting. All of the cut samples were taken from the same part of the bed during early morning calm conditions, while the uncut samples were taken from different areas of the kelp bed and during windy conditions.

Miller and Geibel (1973) recognized that there were some problems with the methodology of the study but concluded that canopy removal did not permanently reduce the kinds and numbers of invertebrate species. They did suggest that a commercial operation would remove a larger segment of canopy and were concerned about certain invertebrate species moving into the cut area from the adjoining uncut canopy as the new canopy reformed.

While the harvest of kelp does incidentally remove some sessile and motile invertebrates, the overall effect on invertebrate populations does not appear to be significant.

Bull Kelp

Andrew (1925) found 40 species of invertebrates colonizing the holdfasts of bull kelp, consisting in some cases of up to 2600 individuals. Harvesting of bull kelp results in eventual loss of the entire plant, including the holdfast, with impacts to the holdfast-dwelling organisms.

Fewer invertebrates colonize bull kelp blades than those of *Macrocystis* because of natural fluctuations in abundance of bull kelp and the usually limited availability of the canopy (3 to 4 months). The sessile animals that do inhabit the canopy have evolved lifespans that are short in duration and produce large numbers of offspring (Andrew, 1925; 1945). Motile invertebrates (amphipods, shrimp, trochid snails) opportunistically move into and out of the canopy depending on availability. During an eight–year span of harvesting *Nereocystis* in Port Orford, Oregon, the only macro-invertebrate commonly encountered in the canopy was the kelp crab (*Pugettia producta*). This species appeared for a two-month period and was easily removed and returned to the water during hand–harvesting operations (Fanning, pers. comm.).

When the blades and pnuematocyst are removed during harvest, the stipe may sink to the seafloor or become tangled with the stipes of other plants. The decaying stipe provides a food source for diatoms, bacteria and fungi as well as benthic invertebrates such as sea urchins, abalone, chitons and crabs (Burge and Schultz, 1973; Albright et. al., 1982). Under normal circumstances, this tissue is not available until late in the season or after storms. Therefore, there does not appear to be a significant effect on invertebrate populations as a result of the harvest of bull kelp.

The proposed project and suggested alternatives would shift the existing management strategy in a conservative direction. Given the characterization of general harvest impacts provided above and recognizing the conservative orientation of the proposed changes, any impacts from the proposed project on invertebrate populations is considered to be short-term and less than significant.

4.3 Effect of Kelp Harvest on Bird Populations

Giant Kelp

Marine birds frequently forage adjacent to and within *Macrocystis* beds or rest on these beds in southern and central California (Conner and McPeak, 1982). These birds use the food web in the upper layer of the ocean and are not specifically tied to forests of giant kelp (Anderson et al., 1992). Though there has not been a study to specifically look at the effect of kelp harvesting on bird populations, it does not appear that birds are adversely affected by the periodic removal of canopy.

One of the richest areas for marine birds in California is the Channel Islands of southern California. These islands support breeding colonies of 11 species of marine birds (Hunt et al., 1980). Kelp has been harvested from around the islands since the early 1940's. At times, the marine birds around the Channel Islands even use the harvester to their advantage in feeding. Terns and gulls frequently follow the harvester and dive into the wake after the canopy has been cut (McPeak, pers. obs.). These birds feed on crustaceans and small fishes that are exposed by the kelp harvester.

Stalking birds, such as great blue herons and common egrets, occasionally perch on canopies of giant kelp while searching for prey. These birds fly to nearby areas to forage as the kelp harvester approaches. Diving birds, such as cormorants, also fly to nearby open water to forage if approached by a kelp harvester.

While it is recognized that numerous species of birds utilize the kelp forests, the effect of canopy removal and kelp harvesting operations on bird populations is not significant.

Bull Kelp

Seabird feeding ecology studies indicate that the major components of a number of their diets are fish and invertebrates associated with kelp beds (Ch.3). As stated previously, the harvest of bull kelp kills the entire plant, thus creating a complete absence of canopy, the size of which would be dependent on the amount and location of the harvest. Existing regulations limit series 300 beds to a maximum of 15% harvest, which should help to mitigate any adverse impacts to bird populations. However, should 15% of a bed be taken from one localized area, e.g. near a breeding colony of pigeon guillemots, adverse impacts might be sustained. Bull kelp beds in central California are not protected in the same manner as the 300 series and their susceptibility to overharvest could impact bird populations in that area. Several of the measure suggested in the proposed project are intended to reduce the potential for overharvest of bull kelp in central California. With these measures in place, the effect of canopy removal and kelp harvesting operations on bird populations is not significant.

The proposed project and suggested alternatives would shift the existing management strategy in a conservative direction. Given the characterization of general harvest impacts provided above and recognizing the conservative orientation of the proposed changes, any impacts from the proposed project on bird populations is considered to be short-term and less than significant.

4.4 Effect of Kelp Harvest on Marine Mammal Populations

Giant Kelp

Sea otters, pinnipeds (seals and sea lions), and occasionally gray whales are observed in beds of *Macrocystis* in California.

The sea otter, *Enhydra lutris*, is a threatened species that is protected by Federal and State laws and regulations. Sea otters have the closest association of all marine mammals with canopies of giant kelp. They can be seen rafting, resting, or foraging in forests of giant kelp and are easily observed while at the surface from kelp harvesting vessels.

Macrocystis has regularly been harvested within the sea otter range since 1970. The larger vessels, associated with the algin industry, generally work within the sea otter range from Cayucos to the Monterey Peninsula from June through October or November, depending upon the growth and condition of kelp canopies in both southern and central California (See section 3.4.1 for more information on harvesting vessels). Very little *Macrocystis* is harvested in central California for algin production if ample canopies exist in southern California to satisfy production needs. On rare occasions, canopies develop early in central California and may be harvested for algin beginning in late April or early May.

Smaller harvesters, used by the aquaculture industry, have worked within the range of sea otters since the 1970s. These harvesters have concentrated their effort from Pismo Beach to Santa Cruz. Despite the sea otter's mobility, the scoping sessions identified a concern with regard to harvesting impacts on this species. Larger harvesters, used by the algin industry, have worked in kelp beds within the sea otter's range over 600 times since 1970 (Glantz, pers. comm.). The kelp harvesting operation has never injured an otter during the 30 years of operation within the sea otter's range. The kelp harvesters only move at about 1.5 knots through the kelp bed during harvesting. Sea otters seem to react to these harvesters much like they would any other vessel. They hear and see the harvester well before it approaches and move to nearby canopy as the kelp harvester passes (Glantz, pers. comm.).

While the quantity or availability of kelp canopy has not been identified as a population limiting factor, the removal of canopy could impact individual sea otters by requiring them to shift rafting or foraging locations. The individuals most likely to be impacted would be those that have developed foraging tactics that focus on prey found with the canopy. Included within this group would be some female otters that are caring for dependent pups. Under most conditions, those individuals would likely respond to the removal of canopy by shifting foraging locations. However, under adverse weather conditions, anything that affects food availability could impact an otter that is food stressed.

Two factors tend to minimize the potential impacts to levels that are less than significant. First, the quantity of invertebrates prey that are removed is likely small (Limbaugh 1955 and Quast 1968b). Second, most harvesting occurs during good weather windows when food availability is not an issue.

Some harvesting does occur during poor weather to meet aquaculture needs and it can be concentrated within localized areas that are protected. The Department has proposed a closure within specific portions of bed 220 near Monterey to address resource use conflicts. That closure will also tend to minimize any potential for adverse impacts to individual otters by providing protected canopy for foraging.

Pinnipeds (seals and sea lions) are frequently seen in forests of giant kelp. Harbor seals are frequently seen resting in canopies of giant kelp. Both harbor seals and sea lions forage within kelp forests and in deeper water for a variety of prey items. Elephant seals usually forage in very deep water at night, offshore of kelp beds. They may be seen passing through forests of giant kelp on their way to the offshore feeding grounds.

Despite ongoing harvesting of kelp, these seal and sea lion populations continue to expand at 6 to 12% per year. Consequently, impacts from harvesting are considered to be less than significant.

Gray whales, which occasionally come into forests of giant kelp, also appear not to be bothered or harmed by kelp harvesters. Gray whales occasionally feed on small crustaceans that live in forests of giant kelp (Wellington and Anderson, 1978). Harvest captains have reported gray whales spending the entire day in a kelp bed being harvested. On one occasion, a gray whale followed a harvesting vessel as it cut canopies near Point Conception (Scott, pers. comm.).

Based on a review of available information, kelp harvesting activities have little to no effect on marine mammals utilizing the kelp forests.

Bull Kelp

There have been no studies on the effect of *Nereocystis* harvest on marine mammals. However, the harvest of bull kelp has been underway for 5 years in the Crescent City area and there have been no reports of negative interactions between the harvester and pinnipeds (Van Hook, Hook, pers. comm.). With one exception, it is probable that the harvest of bull kelp does not significantly affect the marine mammal populations in California.

In central California within mixed beds, sea otters will preferentially raft and forage in *Macrocystis* canopy (Wendell pers comm). Consequently, the harvest of *Nereocystis* within those beds will tend to have limited impact on resident or transient otters. If the harvest occurs within pure *Nereocystis* beds, otters will lose the benefit of the canopy as a resting and foraging area. Since the status of California's sea otter population is uncertain, the impacts to sea otters that are resident in those beds could be significant if the availability of resting or foraging habitat is a limiting factor. While most research is focused on other potential limiting factors, it would be prudent to limit harvesting of *Nereocystis*.

Several measures in the proposed project are intended to limit the harvest impacts associated with harvesting bull kelp. With these measures in place, the effect of kelp harvesting on marine mammals is considered to be short-term and less than significant.

4.5 Effect of Kelp Harvest on Biological Communities That Use Drift Kelp

Drift kelp, plants that are not attached, contribute their energy to a number of communities. Two such communities, kelp wrack (Section 3.2.9.5) and deep water communities, rely heavily on drift kelp as an energy source. The kelp wrack community is almost entirely dependent on the shoreline deposition of drift kelp. While not as apparent, deep water communities may also rely heavily on drift kelp or on breakdown products as an energy source. The potential impact of human harvest on these communities will focus of the beach wrack community since it shows the greatest reliance on drift kelp, and consequently is likely to have the greatest potential for showing impacts indirectly resulting from human harvest of kelp.

4.5.1 Effect of Kelp Harvest on Beach Wrack Communities

Kelp wrack provides a distinctive habitat for many invertebrates including small crustaceans such as shore crabs, beach hoppers (talitrid amphipods) and sand flies. These in turn provide forage for many shore birds. Eventually kelp wrack is broken down by detritivores and recycled into the food web with nutrients recycled on shore or returned to the marine environment.

Commercial kelp harvesting techniques prior to 1920 increased the amount of kelp deposited on beaches, whereas present harvest techniques may lead to a reduction of kelp available to beach wrack communities (ZoBell, 1971). However, Zobell (1971) found no positive correlation between the quantity of kelp on beaches and the operation of kelp harvesters in nearby kelp beds. Since only a small portion of the total coast-wide canopy area is harvested during any given period, indirect impacts from harvesting on beach wrack communities tend to be localized. Recreational harvesters and some abalone culturing businesses also impact kelp wrack communities by directly removing drift kelp from the shoreline. The low recreational daily bag limit (10 pounds wet weight) and limited commercial interest in drift kelp combined suggest that the impact on beach wrack communities associated with these uses are less than significant. Further, the harvest of beach wrack by abalone culture businesses spreads potential harvest impacts across communities that rely on attached kelp or on drift kelp.

Because of safety concerns, large mechanical harvesters do not operate in waters less than 30 feet. This practice leaves a large proportion (from 25-90%) of most beds unharvested and potentially available to kelp wrack communities (Wright, pers. comm.). In addition, the ability of kelp to replace harvested fronds with new growth helps to ensure that harvest related losses to the system are temporary. Further, other non-harvested algal species are also important contributors to kelp wrack communities. ZoBell (1971) found that non-harvested algal species comprise 40% of the total drift algae along San Diego Counties beaches.

The kelp wrack community naturally experience wide variations in the amount of available kelp. For example, urchin grazing or unusual oceanographic conditions such as El Niño have lead to the loss of entire kelp beds and a corresponding reduction in the amount of kelp potentially available to these communities. Adaptations to handle these variations would tend to buffer potential impacts from human harvest.

Bull Kelp

Bull kelp is an important component of kelp wrack in northern California and parts of central California. There have been no studies on the effect of bull kelp harvest on kelp wrack communities. Harvesting bull kelp can impact wrack communities by reducing the amount of kelp biomass that can potentially reach the shoreline. The loss of further production from individual bull kelp plants resulting from harvest can exacerbate those potential impacts. However, the potential effects are offset to some extent by the lack of focused harvest pressure. That is, the proportion of total bull kelp biomass available to the wrack community after harvesting is proportionally larger than that available after harvesting of giant kelp.

The potential impacts from the harvest of kelp on kelp wrack communities is considered to be short-term and less than significant for the following reasons: 1) the kelp wrack community had adapted to large fluctuations in availability of kelp; 2) human uses tend to leave large proportions of kelp beds available as potential contributors to this community; and 3) non-harvested kelp provide a significant component of the kelp wrack.

4.6 Land Use

The harvest of kelp, whether for commercial or recreational use, does not have a significant negative impact on land use. Commercial harvest operations are conducted far enough from shore that they do not interfere with various land–based activities such as beachcombing or surf–fishing. Recreational harvesters generally collect fresh drift kelp off beaches or from the shallow subtidal beds that are reachable during low tides. These activities are hardly noticed by other beachgoers as the quantities taken are small. In some cases, removal of drift kelp by the public is welcomed by nearby residents who object to naturally occurring beach litter for aesthetic reasons.

If kelp harvesting activities influence whether entire plants remain attached to the substrate within the bed, harvesting could indirectly affect the amount of drift kelp that reaches land. Drift kelp can accumulate to the point where it can influence land uses and some municipalities actually incur the costs of removal. Unfortunately, research does not offer clarity as to the influence that harvesting can have on accumulation. That ambiguity suggests that harvesting can cause kelp plants to break free of the substrate in some circumstances and the opposite in other circumstances.

Consequently, the impacts on land use from harvesting of giant and bull kelp appears to be less than significant.

4.7 Scenic, Recreation and Noise Impacts

The removal of portions of the kelp beds by commercial harvesters can temporarily affect the scenic quality of an area depending on the size of the harvesting operation and the harvesting vessel. Aquaculturists who hand harvest generally collect small amounts of *Macrocystis* and have had no appreciable visual effect on the canopy. Mechanized harvesters, such as those used by ISP Alginates, have a large load capacity and can cause the disappearance of the surface canopy from a significant portion of some kelp beds . However, the harvesters try to remove only canopy that has reached maturity, is near its natural sloughing point, and has the highest algin content. This kelp is generally ragged–looking, and if left alone (not harvested), large portions of the beds would disappear naturally. Cut canopy will be restored from young fronds beneath the surface. The restoration will be quick (a few weeks) during good growing conditions and slow (several months) during poor growing conditions. The rates of recovery also appear to be slower in central California compared to southern California. Recognizing these differences, commercial harvest of kelp does not significantly effect the scenic value of the coastline in most locations.

Generally, kelp harvesting operations have no significant effect on the recreational use of the nearshore environment. However, in localized areas, such as near the city of Monterey, kelp harvest has been in conflict with some recreational users. The preferred alternative seeks to reduce that conflict by closing a portion of bed 220 to commercial harvest.

While some recreational users are temporarily displaced by harvesting operations, they also receive some benefits as well. Recreational anglers in private vessels as well as commercial passenger fishing vessels (CPFV) will follow behind the harvesters during cutting. Large numbers of fish move up from the bottom enticed by the presence of small fish, invertebrates, and bits of algae shaken loose from the kelp as it is moved onto the harvester. The recreation anglers use their knowledge of this fish attraction to their advantage by moving into these just harvested areas. In addition, kelp harvesters open up lanes in the canopy that allows CPFV's access to areas that were previously closed due to the density of the kelp. Even non–consumptive users such as kayakers, and underwater photographers may benefit from harvesting operations. The harvesters open lanes in the canopy that allows passage through dense beds and more light to penetrate and lighten the subsurface areas.

Whether kelp harvesting occurs from a small boat or one of the large harvesters, a certain amount of noise will be produced. The extent of this noise will be dependent on the activity of the harvester (i.e. traveling to a site vs harvesting), distance, and background noise (i.e. surf, traffic). Surf noise was measured on a moderately windy day (10 kts) and the levels recorded at 3 ft and 650 ft were 88dB and 67dB, respectively (Johnson et. al., 1989).

When kelp harvesting vessels are in transit, the amount of engine noise generated is higher than during harvesting. This is due to the vessels traveling at a faster speed. However, during transit, the distance from shore is greater, which allows vessels to take the most direct route to a harvest site. Thus, the amount of noise perceived by a person onshore would not be audible, or at most, be barely audible.

During harvesting, the distance from shore is reduced (about one–half mile to a mile and a half) but the engines are either off, set in idle, or traveling at a speed of less than 2 knots depending on the harvesting operator (ISP Alginates, Abalone Farms, or Abalone International). Thus the engine noise is reduced and would not be noticeable from land (Johnson et. al., 1989; Drown, pers. comm.). Table 4–1 contains a list of the noise levels of various ocean going vessels and detection levels at various distances.

Table 4-1. Representative uncontrolled operation noise.					
Noise source	Engine type[a]	Power rating (hp)	dBA at 50 feet	Distance to sensitive location[b]	dBA at sensitive location
Generator	P	200	78	500	36
Tanker	T	10,800	80	3,500	44
Launch	D	400	76	3,000	41
Boom boat	D	235	76	3,000	41
Kelco Harvester-Kelstar	D	500/375[c]	76	>2,640	pending
Abalone Farms, Inc	D	671	76	2,640	pending
Abalone Inter.	G	40	N/D	2,640	N/D

[a]D=Diesel, G=Gasoline, T=Turbine, P=Propane
[b]Sensitive locations, points where noise levels can have significant impacts, the adjacent coastline for offshore sources.
[c]Engine used during harvesting.
N/D – noise levels not detectable over ambient noise.
Source: SBCRMD, 1992; Drown, pers. comm.; Van Hook, pers. comm.

From the table, it is apparent that the noise generated by kelp harvesting vessels is comparable to other types of marine vessel traffic and with distance, noise attenuates. Based on the 65dBA significance threshold, the noise impact of kelp operations is not significant. Example: A vessel 1.75 mi from shore with a noise level of 37 dBA, under certain atmospheric conditions and during times of minimal background noise, would be comparable to a soft whisper heard from a distance of three feet (SBCRMD, 1992).

The proposed project and suggested alternatives would shift the existing management strategy in a conservative direction. Given the characterization of general harvest impacts provided above and recognizing the conservative orientation of the proposed changes, any impacts from the proposed project from noise levels, recreational uses, or scenic quality are considered to be short-term and less than significant.

4.8 Air Quality and Fuel Use

The state has adopted air quality standards that are as stringent as federal standards (Aspen Environmental Group, 1992). While kelp harvesting operations occur along the entire coast and the offshore islands, the impacts to air quality are of greater concern in highly urbanized areas due to the existence of long-term land–based impacts.

Air quality is affected by local climatic and meteorological conditions. Therefore in an area like the Los Angeles basin, where there are persistent temperature inversions, predominant onshore winds, long periods of sunlight, and topography that traps wind currents, the effects of pollutants would be more severe than along the central California coast where one or more of these components is missing.

Air quality is determined by measuring ambient concentrations of pollutants that are known to have deleterious effects. The degree of air quality degradation is then compared to health–based standards such as the California ambient air quality standards (CAAQS) and the National ambient air quality standards (NAAQS). A summary of the emissions generated by three representative harvesters using gas or diesel engines in commercial kelp harvesting vessels is provided in Table 4–2, 4–3, and 4–4.

The calculation of emissions from kelp harvester was based on the following emission factors for diesel fuel and gasoline:

<u>Diesel</u>

Carbon Monoxide (CO) = 110 lb/1000 gal fuel
Hydrocarbons (HC) = 50 lb/1000 gal fuel
Nitrogen Oxides (NO_x) = 270 lb/1000 gal fuel
Sulfur Oxides (SO_x) = 27 lb/1000 gal fuel

<u>Gasoline</u>

Carbon Monoxide (CO) = 1,822 lb/1000 gal fuel
Hydrocarbons (HC) = 11 lb/1000 gal fuel

Nitrogen Oxides (NO_x) = 96 lb/1000 gal fuel
Sulfur Oxides (SO_x) = 6 lb/1000 gal fuel

Table 4–2. Daily emission rates from Kelco harvesting vessels (Tons/Day) in comparison with statewide fishing vessel emission rates and statewide emission rates from all sources.

Pollutant	Emission Rate	Daily Emission Rates for Fishing Vessels	% of F.V. Rate	Daily Emission Rates - All Sources
CO	0.005	20.54	0.02	19,000
HC	0.004	7.91	0.05	7,300
NO_x	0.021	100.19	0.02	3,500

SO_x	0.002	37.33	0.01	400

Table 4–3. Daily emission rates from Abalone Farms, Inc. harvesting vessel (Tons/Day) in comparison with statewide fishing vessel emission rates and statewide emission rates from all sources.

Pollutant	Emission Rate	Daily Emission Rates for Fishing Vessels	% of F.V. Rate	Daily Emission Rates - All Sources
CO	0.002	20.54	0.01	19,000
HC	0.001	7.91	0.01	7,300
NO_x	0.005	100.19	0.004	3,500
SO_x	0.001	37.33	0.003	400

Table 4–4. Daily emission rates from Abalone International, Inc. harvesting vessel (Tons/Day) in comparison with statewide fishing vessel emission rates and statewide emission rates from all sources.

Pollutant	Emission Rate	Daily Emission Rates for Fishing Vessels	% of F.V. Rate	Daily Emission Rates - All Sources
CO	0.01	20.54	0.05	19,000
HC	0.0001	7.91	0.001	7,300
NO_x	0.001	100.19	0.001	3,500
SO_x	0.0001	37.33	<0.001	400

The daily pollutant output from kelp harvesting vessels is relatively low, representing less than 1% of the total fishing vessel daily emission rates for the state. Additionally, overall fishing operations are responsible for less than 1% of the daily emissions from all sources (mobile and nonmobile) in California (CARB, 1989; CARB, 1991; CARB, 1994). The emission levels from harvesting vessels are low due primarily to operating method and location. Kelp vessels, unlike other commercial operations, do not operate in the same locations at the same time but rather harvest kelp from distant locations on different timelines. Thus, several harvesting vessels are not working close together at one time, which would lead to higher emission levels. Also, there are only a handful of harvesters, who operate between 130 to 150 days per year depending on weather and the condition of the kelp beds. For comparison, the daily emission rate for the commercial herring fishery in San Francisco Bay produces 100 times the emission levels of the kelp harvesting vessels. The herring fishery was determined to have a less than significant impact on air quality (CDFG, 1993).

The pollution emissions released when vessels are underway are influenced by a variety of factors including power source, engine size, fuel use, operating speed, and load. The emission factors can only provide a rough approximation of daily emission rates.

The proposed project and suggested alternatives would shift the existing management strategy in a conservative direction. Given the characterization of general harvest impacts provided above and recognizing the conservative orientation of the proposed changes, the operation of kelp harvester vessels in state waters under the proposed project would only have a localized, short-term effect and no significant long term effect on air quality.

4.9 Cumulative Effects

The current status of kelp resources in California was discussed in detail in Chapter 3. A variety of factors have the capacity to influence the future abundances of giant and bull kelp in addition to the proposed project or the alternatives. The factors with the greatest potential include continued commercial harvest of kelp, commercial and recreational fishing, waste disposal, water quality and unusual weather events. For example, California has experienced 3 major El Nino events since 1982, and some of the impacted kelp beds have not yet recovered, especially in localized areas of the mainland southern California coast, and along the San Mateo county coast. As beds which are commercially harvested become impacted by multiple factors, harvest pressure can increase either on these 'stressed' beds and/or shift to other healthier beds as demand for product remains static or increases relative to the available kelp, resulting in a condition of overharvest.

4.9.1 Effects of Kelp Harvest on Giant and Bull Kelp

Giant Kelp

The effects of harvesting on giant kelp have been studied since harvesting began in the early 1900s. Researchers have studied the effects of harvesting on frond growth and regeneration, holdfast development, survivorship of plants, and survivorship of populations of plants (Cameron, 1915; Crandall, 1915; Brandt, 1923; Limbaugh, 1955; Clendenning, 1968a; North, 1968b; Barilotti, et. al., 1985; Miller and Geibel, 1973; McCleneghan and Houk, 1985; Barilotti and Zertuche, 1990).

While kelp utilization was being developed in California (1912-1915) almost every possible method of harvesting was tried (Scofield, 1959). Some of the early methods were either destructive or caused excessive beach litter. One method involved cutting the kelp from a skiff and letting the kelp drift ashore where it was collected. Another method entailed encircling a portion of the bed with a cable and power pulling the plants into a bundle where they were cut. Many of the plants were uprooted by this process.

A mechanical method of harvesting, very much like that being used today, was developed in the early 1900s. Information presented in the remainder of this section relates to mechanical harvesting where canopies are cut no deeper than 4 feet or the evaluation of mechanical harvesting through experimental hand harvesting at various depths.

Crandall (1915) and Brandt (1923), who conducted their research in southern California, recognized that cut fronds grew very little after harvesting and regeneration of the beds following harvesting was mainly from growth of new fronds from below. Brandt (1923) recommended that three to four months be used between harvesting to allow regrowth of the canopies.

The effect of harvesting surface canopy on the *Macrocystis* plant depends on a variety of factors, including, the length and maturity of surface fronds, turbidity of the water, length of submerged fronds, etc. Kelp canopies, under certain conditions, nourish underlying tissues more than they starve them by self-shading; under other conditions the shading factor predominates.

The *Macrocystis* harvest consists mainly of mature fronds that have completed their growth (Clendenning, 1968a). With increasing time at the surface, sloughing and encrustation increases on these mature fronds, and photosynthesis gradually declines. The harvest of these mature and senescent fronds takes up to 2/3 of the blade supply, photosynthetic capacity, and organic matter content of the frond (Clendenning, 1968a). Photosynthesis suffices for maintenance of the cut frond at best. Harvesting canopy affects submerged fronds by allowing more light to reach these fronds and decreasing translocation (Clendenning, 1968a). Removal of the canopy eliminates the harvested canopy as a source of food, but this may be balanced by the increased light. The effect of cutting the canopy depends on the length of the submerged fronds and the turbidity of the water. Canopy rapidly regenerates if growing fronds are near the surface (Clendenning, 1968a). Harvesting may also be beneficial to juvenile sporophytes by allowing more light to penetrate the water.

North (1968b) developed a mathematical model that formulated the photosynthetic capability of a kelp plant in terms of seven variables. The model was tested using several canopy cutting experiments off La Jolla, California. In the first two experiments, there was no significant difference between the means of the standard growth rate of young fronds of cut plants and uncut controls. The amount of material removed in these experiments was small. In two subsequent experiments, up to 55% of the plant's biomass was removed in the harvest and the mean growth rates were significantly retarded up to one month after the harvest.

The results of harvesting experiments using a commercial harvester (F/V Elwood) agreed with North's previous experimental work (North, 1968b). There was an initial retardation in the mean growth rate, but within a month, the cut plants did not differ significantly from the controls. North (1968b) concluded that "the model predicts, and experiments amply confirm, that canopy cutting can stimulate kelp growth or retard it, depending on circumstances during and after cutting." Harvesters try to take mature canopies. That is, they harvest under conditions where canopy removal favors kelp growth or at least does not have seriously adverse effects. In natural situations, where heavy canopies are shading plants, harvesting probably temporarily reduces growth of the large plants and stimulates the growth of smaller plants. This could lead to an increase in survival rates by lowering interspecific competition (North, 1968b).

Rosenthal et.al. (1974) reported a single incidence of plants being uprooted during kelp harvesting in southern California. Other researchers suggested that kelp harvesting may reduce the number of plants being uprooted by storms because harvesting removes the canopy and associated drag (Brandt, 1923; Guzman del Proo et al., 1971).

Research has also been conducted in southern California to determine if there is a relationship between kelp harvesting and the amount of beach litter. ZoBell (1971) made nearly 10,000 observations on 49 beaches in San Diego and Orange Counties, during a twelve-year period, to determine whether kelp harvesting contributed significantly to beach litter. ZoBell (1971) identified more than 100 species of seaweed in the drift on beaches and noted that little more than half of the biomass of beached seaweeds was contributed by giant kelp. He determined that the major causes of seaweeds being set adrift were storms, boring and chewing animals, microbial parasites, and other natural causes. ZoBell (1971) concluded that there was no evidence that kelp harvesting, as currently practiced, significantly contributed to beach litter. He suggested that harvesting may actually reduce beach litter because mature canopies, that would otherwise slough and breakaway, are collected by the harvester.

The above reported studies were all done in southern California. Miller and Geibel (1973) recognized that forests of *Macrocystis* in central California were different than forests in southern California since canopies virtually disappeared during late fall and winter each year in central California, but not in southern California. They conducted frond growth studies in central California during 1969-1970 in an experimentally harvested area and an unharvested control area. Plants were cut five times in a 408-day period at or below four feet (the depth permitted by California law). Growth rates in the cut area followed the same general pattern as those in the control area. Growth rates varied considerably during the study, but, in general, fronds grew fastest in the spring, summer, and early fall months and slowest in late fall and winter. Fastest growth rates were obtained in April. Miller and Geibel (1973) concluded that "overall, there appeared to be little difference in the growth rate of *Macrocystis* in the cut or uncut areas."

In March 1971, following the growth studies, Miller and Geibel returned to the study site in central California to discover that plants had been lost during the winter in the experimentally harvested area but not in the unharvested control. They theorized that continuous harvesting (five times in a 408-day period) removed fronds of older plants, resulted in reduced translocation to the holdfast, reduced hapteral growth, and weakening of holdfast attachment to the substrate. Miller and Geibel (1973) suggested that holdfasts of older, cut *Macrocystis* plants became relatively less efficient than those of mature plants in the uncut area, and during winter storms these weakened holdfasts were more readily torn from the substrate.

A short-term study was initiated in 1971 to test whether hapteral growth was impacted by harvesting (Miller and Geibel, 1973). Growth of haptera and the addition of new fronds was studied on five harvested and five unharvested control plants. Miller and Geibel (1973) reported a significant retardation of hapteral growth in the cut plants but not in the uncut controls. The number of fronds per cut plant also remained significantly lower each month after harvesting than in the uncut series. In October, however, cut plants had as many new fronds 1-5 feet long as did uncut plants. Miller and Geibel (1973) concluded that harvesting of kelp canopy as done in their experiments could result in: l) lower yield because less biomass is produced, and 2) premature loss of plants because of decreased holdfast efficiency. The studies by Miller and Geibel (1973) raised concerns that harvesting could adversely affect the survival of *Macrocystis* in central California. As a result, a series of studies were initiated to determine the effects of harvesting on survivorship of plants in central California kelp beds (Barilotti et. al. 1985, and Zertuche, 1990). McCleneghan and Houk (1985), on the basis of a one year study, concluded that haptera branching was significantly lower in plants that were experimentally harvested compared to unharvested controls. In contrast, during a three-year study of hapteral elongation and branching, there was no conclusion regarding the impact of commercial harvesting on hapteral elongation and branching (Barilotti, et al., 1985). Hapteral branching was extremely variable, significantly lower in harvested areas relative to controls one year, significantly higher in the harvested area in another year, and not significantly different the third year (Barilotti et al., 1985).

A survivorship study in a commercially harvested kelp bed, in central California, was done in Carmel Bay from 1978 through 1982 (Barilotti and Zertuche-Gonzalez, 1990). The Carmel Bay kelp bed was harvested commercially each year to obtain kelp for algin extraction. The study was designed to determine if there was an immediate loss of plants by uprooting, or a longer-term loss of plants during the winter months. Barilotti and Zertuche-Gonzalez (1990) tagged a total of nearly 400 plants in harvested and control areas and found that plants were not pulled free by the harvester as reported by Rosenthal el al. (1974) on one occasion in southern California. There were also no longer-term effects where more plants were lost in the harvested area during winter months than in the unharvested area. They concluded that there was no significant statistical difference in survivorship between harvested and unharvested areas during routine commercial harvesting in Carmel Bay.

Miller and Geibel (1973) also reported that a dense growth of red algae inhibited recruitment of *Macrocystis* in the area where kelp was lost due to overharvesting. However, neither the persistence nor the long-term ecological effects of the dense red algae were followed by these authors. Studies in Carmel Bay in commercially harvested areas revealed no increase in the abundance of red algae as a result of harvesting (Kimura and Foster, 1984).

North (1968c) stated that "in summary, predictions from the model, the cutting experiments, and physiological and ecological evidence combine to indicate that kelp harvesting as currently practiced causes very little damage to kelp beds and under certain circumstances may be beneficial. Such a conclusion is further supported by Clendenning's findings that the beds harvested most heavily showed no tendency to decrease their yields."

North (1968c) also indicates that his results do not mean that harvesting cannot harm plants. He notes that there have been instances where cutting has been excessive and damaging. A strip of kelp, for example, continuously cut by small boat traffic at Paradise Cove displayed a smaller standing crop of tissue than the surrounding bed (North, 1957). Beds harvested four times per year showed a decreasing yield in contrast to beds harvested less frequently (Brandt, 1923).

In conclusion, research in both southern and central California suggests that kelp harvesting can, in some instances, impact populations of *Macrocystis* resulting in loss of plants and reduced production of biomass. Most of the research, though limited, seems to indicate that there are not problems associated with harvesting of the type practiced by ISP Alginates, whereby plants are harvested a maximum of three times per year. However, there are presently no specific regulations limiting the number of times a bed can be harvested in a year, nor the areal extent of the harvest on a particular bed. Fish and Game Code section 6654 does give the Fish and Game Commission authority to close a bed for up to one year if they determine that harvesting is having a detrimental impact .

Bull Kelp

Studies of the effects of harvesting on *Nereocystis* have been conducted in California and in British Columbia (Nicholson, 1970; Leaman, 1980; Foreman, 1984; Roland, 1984). However, the most intensive studies on the effects of harvesting on *Nereocystis* were done in Barkley Sound, British Columbia. In these studies, a variety of harvest methods were evaluated including hand–harvesting, strip harvesting, patch harvesting (Foreman, 1984) and lamina harvesting (Roland, 1984). It is important to remember that bull kelp, unlike giant kelp, has only one pnuematocyst per plant and that reproductive sori are produced on the blades. Therefore, any activity that removes the pnuematocyst and blades results in the death of that plant as well as loss of regenerative and reproductive material.

In the study conducted by Foreman (1984), 100 M^2 plots were harvested over a three-year period (1978 to 1980). The canopy within the harvested plots was removed using a mechanical harvester, which cut to a depth of 1 m below the surface. All harvesting occurred in late August or early September (Foreman, 1984). The results of this investigation revealed that there were no detectable harvesting impacts on plant density between the control and harvest plots. In addition, comparison of mean plant biomass for harvested and control plots also failed to show significant differences. The main conclusion from this study was that natural year–to–year variability in high density *Nereocystis* beds is greater than harvesting–induced variability, conditioned on controlling the areal extent and timing of the harvest (Foreman, 1984).

Foreman noted that if sustained harvesting were to be achieved, consideration must be given to harvesting after spore production has occurred or in a manner that leaves sufficient plants to insure adequate recruitment in the following year. One way to harvest bull kelp throughout the year and still sustain recruitment potential in the next would be to hand–harvest or to use the strip method. Harvesting *Nereocystis* by hand allows for selective removal of post–sori released plants. Additionally, the quantities removed by this method are small and have no visible impact on bull kelp beds (Foreman, pers. comm.). The second method recommended by Foreman was strip harvesting. This method involves removing the entire canopy in a given width, perpendicular to the prevalent water current and down current from a strip of equal or greater width. He also suggested that harvest be limited to 20% of the bed or that about 4 times the harvest width be left undisturbed. By using this harvest technique, large quantities could by harvested at one time while upcurrent plants would be available to release sori into the cleared area. However, the second method should only be used on high to moderately dense beds (Foreman, pers. comm.).

Roland (1984) examined the effect of partial blade removal as a harvest method of bull kelp. In this study, all but 30 cm of the blades were removed to allow continued blade and plant growth. Plants were either treated to single or multiple harvests. Overall survival of plants was not affected by the two treatments when compared to control plants. However, the lamina growth rates and production of sori for the single and multiple cut plants were significantly reduced. Total plant biomass (wet kg per plant) of the single and multiple cuts was 50% lower than the control. Work conducted by Nicholson (1970) in California supports these findings.

Roland (1984) concluded that use of this method would not affect the overall recruitment and sustained yield of *Nereocystis* beds, particularly if the harvest method was staggered between different plants. However, the multiple harvest of lamina was inefficient in view of the low yield relative to initial crops.

Currently, targeted bull kelp harvesting takes place in Crescent City for use in an abalone mariculture operation (Sec. 3.4.1.). To date there has been no evidence that harvesting causes significant effects on the *Nereocystis* population in this state. However, as mentioned in section 4.3, bull kelp beds in central California are not protected in the same manner as the 300 series in northern California and their susceptibility to overharvest is a concern.

Bull kelp is also harvested in British Columbia on a limited basis (Hodgson, pers. comm.). In the waters off British Columbia, the kelp forests are composed of 80% *Nereocystis luetkeana* and 20% *Macrocystis integrifolia*. The Ministry of Agriculture, Fisheries and Food for British Columbia allows harvest of only 20% of the standing stock of bull kelp per year with the following constraints: 1) only the frond may be cut and the cut must be at least 4 inches from the bulb, allowing the blade to continue to grow; 2) harvest time is limited by the time of herring spawn within an area; in most cases the harvest season is between June and October; 3) all licenses are issued annually (Hodgson, pers. comm.).

The restrictions placed on bull kelp harvest are not based on concern that harvesting will adversely impact the kelp forests of the Province, but based on the concerns of commercial herring fishermen that harvesting will affect their fishery because the herring lay their eggs on the blades of bull and giant kelp. The Ministry considers the Pacific herring fishery, which exists in provincial waters, to be more economically valuable than any potential kelp harvesting industry could be (Hodgson, pers. comm).

The proposed project and suggested alternatives would shift the existing management strategy in a conservative direction. Given the characterization of general harvest impacts provided above and recognizing the conservative orientation of the proposed changes, any impacts from the proposed project on kelp is considered to be short-term and less than significant.

4.9.2 Effect of Commercial Fishing on Kelp Resources

Commercial fishing activities can affect giant and bull kelp in a similar manner. Commercial fishermen, who transit into the kelp to check their gear, cause some damage to the kelp canopy. As they pass through the kelp, the propeller cuts the blades and stipes. The use of certain fishing gear, such as crab pots, lobster traps, live fish traps, and gillnets, occasionally cause breakage of stipes and fronds as well as periodically pull up holdfasts when the gear is being set and retrieved. Repeated travel into the kelp and usage of the same area can result in cleared passageways and spots devoid of surface canopy. None of these activities make appreciable additions to the mass of kelp being continuously sloughed off through natural causes (Feder et. al., 1974).

The most damage occurs through the removal of the top kelp forest predators such as sheephead and lobster. The removal of sheephead has resulted in the expansion of purple sea urchins (*Strongylocentrotus purpuratus*) populations in southern California. Sheephead and lobster are such important predators of sea urchins that they help to regulate urchin densities (Tegner and Dayton, 1981). The large–scale removal of sheephead may allow the aggregation of sea urchins which would be detrimental to the kelp beds.

The removal of red sea urchins and abalone has caused reductions in the bull kelp beds in California. These species graze on the gametophytes and young sporophytes of competitive algal species (Dayton et. al., 1984). By harvesting these algivores, turf community species such as coralline algae, foliose reds (*Botryoglossum farlowianum*, *Polyneura latissima*), and midwater canopy species (*Laminaria* spp., *Pterygophora californica*, *Eisenia arborea*) can develop under *Nereocystis* canopies. Once in place, these species can prevent the recruitment of bull kelp (Paine and Vadas, 1969; Duggins, 1980; Dayton et. al., 1984).

This phenomenon has been observed in Carmel following the mass mortality of sea urchins, in Torch Bay and Surge Bay, Alaska following the introduction of sea otters, in Diablo Cove after sea otters moved into the area in the mid-1970s and removed the large macro–herbivores, and in Fort Bragg where the commercial fishery for red sea urchins has been occurring since 1985 (Pearse and Hines, 1979; Duggins, 1980; Gotshall et. al., 1984; Estes and Duggins 1995; Karpov et. al. In Press).

The removal of top grazer species is beneficial for bull kelp in areas of heavy scour and unstable substrates. Periodic scouring of the substrate removes competitive algal species. The resulting open spaces can be rapidly colonized by bull kelp. Duggins (1980) reported that *Nereocystis* was unable to compete with perennial brown algae, *Laminaria* spp. following urchin removal except in areas of deep water or unstable substrate.

Thus commercial fishing can significantly effect the kelp forests through the removal of predator species that are known to influence kelp communities.

4.9.3 Effect of Sportfishing on Kelp Resources

All motorized boat activities in the kelp beds, whether fishing, pleasure or other purposes, will result in a certain amount of kelp damage due to cutting by propellers. Frequently, vessels will "back down" while traveling through the kelp canopy. This practice involves putting the engine in reverse when the propeller becomes fouled with kelp. This not only frees the entangled kelp but also cuts more of the canopy. Kelp plants can also be uprooted when commercial passenger fishing vessels and private boats anchor in kelp beds. Plants are frequently pulled up when the anchor is retrieved. However, these losses of kelp canopy and plants appear to have no lasting effect on the kelp beds as a whole (Feder et. al., 1974).

Recreational fishing can also affect the kelp forests. Species such as sheephead, cabezon, lingcod, and lobster are popular with recreational harvesters. The indirect effect on kelp abundance by removing kelp forest associated predators was discussed in section 4.6. However, recreational fishing also removes "nibblers". These are species that pick off invertebrates on the kelp or graze on the fronds and stipes such as surfperch, señorita, and blacksmith and which can cause substantial damage to the kelp forests (McPeak et. al., 1988).

In general, the removal of fish and invertebrates from kelp forests can cause significant changes but the extent of these changes has not been quantified.

4.9.4 Effect of Waste Disposal on Kelp Resources

As California's population and industry base grew during the early part of last century, our capacity to deal with human and industrial waste was stretched beyond the breaking point. Thus ocean disposal was felt to be the answer to our waste problems until the effects of this type of disposal were exhibited by changes in the nearshore ecosystems (Foster, 1986). The discharge of human and industrial wastes containing bacteria, phosphates, heavy metals went unchecked for 25 years. Associated with this discharge was an increase in water turbidity, sedimentation and an overall reduction in light penetration (Meistrell and Montagne, 1983). These factors, in conjunction with natural environmental changes (warm water events), lead to the disappearance of kelp. The most notable loss was that of the giant kelp beds off of Palos Verdes and Point Loma in the 40's and 50's. Changes in Federal and State water quality laws and improvements in waste treatment methodology have resulted in improved water quality and the return of kelp growth near these outfalls, but there remain problem areas near

California's coastal metropolitan areas. Because, while human and industrial waste treatment systems have improved in some areas, untreated storm drain discharges and their associated turbidity have increased with burgeoning human populations in southern and central California.

A second type of ocean waste that adversely effects kelp communities is warm water discharge, usually associated with nuclear power plants like Diablo Canyon and San Onofre. As discussed in Sections 3.2.10 and 3.2.12, the increase of ambient water temperature can cause serious damage to giant and bull kelp forests through loss of adult tissue and early death as well as retardation of gametophytic and sporophytic development.

4.9.5 Effect of Coastal Development on Kelp Resources

The tremendous population growth that southern California has experienced during the past 50 years has greatly changed the coastal landscape. Runoff from coastal development activities has introduced sediment into nearshore waters. As discussed in Section 3.2.10.1, introduced sediment can negatively effect kelp growth by decreasing water clarity. Introduced sediment can also reduce kelp recruitment by covering reef habitat. Construction of harbors and marinas have also effect kelp by physically disturbing plants and reef habitat, increasing water turbidity levels, increasing sedimentation, and changing current patterns (Foster and Schiel, 1985).

Modern conservation techniques have reduced the effects of coastal development on nearshore reef habitat when applied. For example, barriers have been used to catch sediment before it enters culverts. Planting or covering exposed hillsides has also been used to prevent soil erosion.

The impacts from coastal development on kelp tend to be localized in nature and to some extent mimic natural sedimentation processes. The same processes that move naturally occurring sediment will, in many instances, also move development induced sedimentation.

4.9.6 Water Quality

The physical act of harvesting giant and bull kelp does have a small localized effect on water quality. The extent of the effect is dependent on the size of the operation. For instance, hand–harvesting of *Nereocystis* results in a less than noticeable change in the local water quality due to the small amount of kelp harvested at any one time (4 tons maximum). During large–scale harvesting operations, invertebrates, fish, and bits of kelp are shaken loose as the kelp is moved up the conveyor belt and into the ship. Typically, the loosened material falls through the conveyor and into the water. Department biologists reported that 2 hours after a harvesting operation occurred offshore of Big Creek, Monterey County, the water quality was back to normal (Van Tresca, pers. comm.). They also reported that kelp litter covered the bottom. However, the biologists did not feel this presented a ecological problem as most of the pieces would probably be consumed by benthic herbivores.

Recognizing that kelp harvesting does change local water quality conditions, the effect is short–term and does not present a significant environmental problem.

4.9.7 Unusual Weather Events

The occurrence of unusual weather events such as the El Niños of 1982-83, 1992-93, 1997-98, severe winter storms, and the 200–year storm have had significant influence on the relative abundance of kelp resources in California as outlined in Sections 3.2.7.1 and 3.2.12. Whether these events happen separately or in concert, as was the case in 1982–83, the stress resulting from these disturbances causes the loss of whole beds as well as canopy reduction in other areas. This in turn affects the nearshore fish and invertebrate communities that depend on the kelp forests for food and shelter. Commercial kelp harvesting and aquaculture operations also suffer from unusual meteorological events. Reduced and patchy kelp canopies mean that it is not economically feasible to harvest and kelp must be purchased from other sources to keep their businesses in operation (Glantz,, pers. comm.; Van Hook, pers. comm.). This condition also puts stress on remaining kelp beds to make up the shortfall. The depletion of kelp resources is also felt by the commercial fishing industry and recreational user groups who discover that finfish and shellfish abundances are greatly reduced following unusual weather events.

The kelp bed community has shown considerable resilience in recovering from impacts associated with unusual weather events in the past. At present the cumulative effect of these events is considered to be short-term and less than significant. However, global warming could change those patterns to the extent that past recovery patterns do not reasonably predict future responses. Under those conditions, this factor alone could have a significant and long-term effect on kelp bed communities. Ongoing monitoring of physical oceanographic conditions and periodic review of kelp management regulations provide a reasonable opportunity to adjust should unusual weather patterns occur more frequently.

Cumulative effects, under existing impact levels, suggest that a prudent, conservative approach to consumptive use of kelp is warranted. However, those impact levels are not sufficient to warrant a prohibition on consumptive uses. At present, the cumulative impacts combined are considered to be localized, short-term, and less than significant.