SEA OTTER (ENHYDRA LUTRIS) ACTIVITIES WITHIN THE VICINITY OF THE DIABLO CANYON NUCLEAR POWER PLANT, 1973-1978

Suzanne V. Benech
ECOMAR, INC.
158 Santa Felicia Drive
Goleta, CA 93017

ABSTRACT.

Sea otter (*Enhydra lutris*) herd size, distribution and foraging behavior have been monitored on a weekly basis within the vicinity of the Diablo Canyon Nuclear Power Plant since 1973. The 15-km study area includes the recognized southern front of the sea otter's range. The sex composition of the population at the front is predominantly male. Periodically moving southward, the herd has made 18 major rafting-site relocations over six years within the study area.

The southern front herd exhibits a seasonal fluctuation in size, with the largest numbers of animals present in the winter and the lowest in the fall. This phenomenon may be related to breeding behavior.

Abalones, sea urchins and crabs are the predominant food items consumed by otters within the study area. Feeding observations and supportive subtidal foraging evidence suggest sea otters have significantly contributed to the decline of large herbivorous invertebrates within the vicinity of the Diablo Canyon Nuclear Power Plant. Sea urchin densities have dropped to less than 1% of their original levels at subtidal study sites within the range of sea otter foraging activity.

INTRODUCTION

Among the Mustelidae, the sea otter (*Enhydra lutris*) is the only truly marine form. It is one of the largest Mustelidae, being rivaled only by the giant Amazon river otter, *Pteronura brasiliensis* (Morrison, et. al. 1975).

Male sea otters are generally 135 cm long and weigh approximately 32 kilograms. Females are slightly smaller. The animal's rounded forepaws are used to hold food and other objects. The large webbed hind feed, together with a 25 cm vertically flattened tail, are used in swimming. The most common position for resting or swimming is on its back. All appendages are used to preen the otter's dense pelage in which trapped air provides the necessary insulation critical to an otter's survival in cold ocean waters. Unlike most other marine mammals, the otter has no protective blubber layer and must rely on its pelage and high metabolic rate for thermal regulation. To satisfy the otter's high caloric needs (approximately 5,000 calories per day), the adult otter may consume as much as 7 kg or 25% of its total body weight per day (Miller 1974). Sea otters are opportunistic feeders but generally prefer abalone, urchins and crabs.

Historical: The aboriginal range of the sea otter extended from Japan, along the Pacific Ridge and southward as far as Baja California (Lensink 1962). Because of its luxurious fur, the otter was hunted for 170 years, beginning in 1741, by fur traders from four countries (Barabash-Nickforov, et. al. 1947).

Over 200,000 animals were harvested in California waters, and by 1911, the California population was thought to be extinct (Ogden 1941). At that time, an international fur treaty was signed by the United States, Russia, Japan and Great Britain granting the otter complete protection throughout its range. Since that time, additional laws have been enacted including that of the 1972 Marine Mammal Protection Act to assure the otter's survival.

A remnant herd of otter discovered off Bixby Creek in Monterey, California in 1938 marked the beginning of the observed re-establishment of the California otter population (Fisher 1939).

Since these original sightings of approximately 100 animals, the California otter population has made a remarkable recovery, expanding in both numbers (approaching nearly 2,000) and range: Point Santa Cruz to the north and Point San Luis to the south (Fred Wendel, Cal. Dept. Fish and Game, personal communication).

The continuing expansion and re-establishment of sea otters along the California coast have led to an ever-increasing number of investigations into what effects these tool-using preditors have on near shore biotic communities (Ebert 1967, Estes and Palmisano 1974; Dayton 1975).

In 1970 the California Department of Fish and Game (CDF&G) began environmental surveys to determine the effects of the Diablo Canyon Nuclear Power Plant's thermal effluent on the near shore biotic community (Burge and Shultz 1973).

Three years into the surveys, the southern migratory frontier population of sea otter established a rafting site and began foraging just north of the power plant. In order to establish what interrelationships and subsequent changes were being created by the sea otter within the associated sublittoral community adjacent to the power plant, this investigation was designed in conjunction with other supporttive and interactive environmental investigations in the same area conducted by CDF&G, U.S. Fish and Wildlife Service, Pacific Gas and Electric Company PG&E), and their associated consultants (PG&E 1975).

When I began the sea otter study in 1973, it was initially funded by CDF&G. Since 1974, the study has been continued to the present through funding from PG&E.

This presentation represents a summary of six years of observations begun when the southern sea otter front expanded their range to the Buchon headland within the vicinity of the Diablo Canyon Nuclear Power Plant (Benech and Colson 1976, Benech 1977).

In order to address the effects the otters may have on the local near shore community, the following specific objectives were addressed:

1. Determine the population size within the vicinity of the power plant site.
2. Monitor the population's movements within an established study area.
3. Record the food items consumed by these otters.
4. Monitor sea urchin densities (a preferred food item) within an area before and after otter habitation.

Study Area:

The study area is located along the coastal portion of Buchon headland in San Luis Obispo County, California. The survey area encompasses adjacent coastal waters from Coon Creek to Rattlesnake Creek and out 2 km (Figure 1). This area is subdivided into five zones based on major raft locations, visual landmarks and observation continuity (Figure 2). These major zones are furhter subdivided into 32 standardized subunits (Figure 3). Sea otter activities can be easily and accurately traced and mapped within these standardized zones.

Procedures:

Sea otter numbers, locations, distribution, movements and feeding behavior were recorded throughout the study area on a weekly basis. Feeding observations and herd counts were usually conducted on separate days. This improved count continuity by allowing the rapid coverage of each successive zone thereby decreasing the chances of counting moving animals

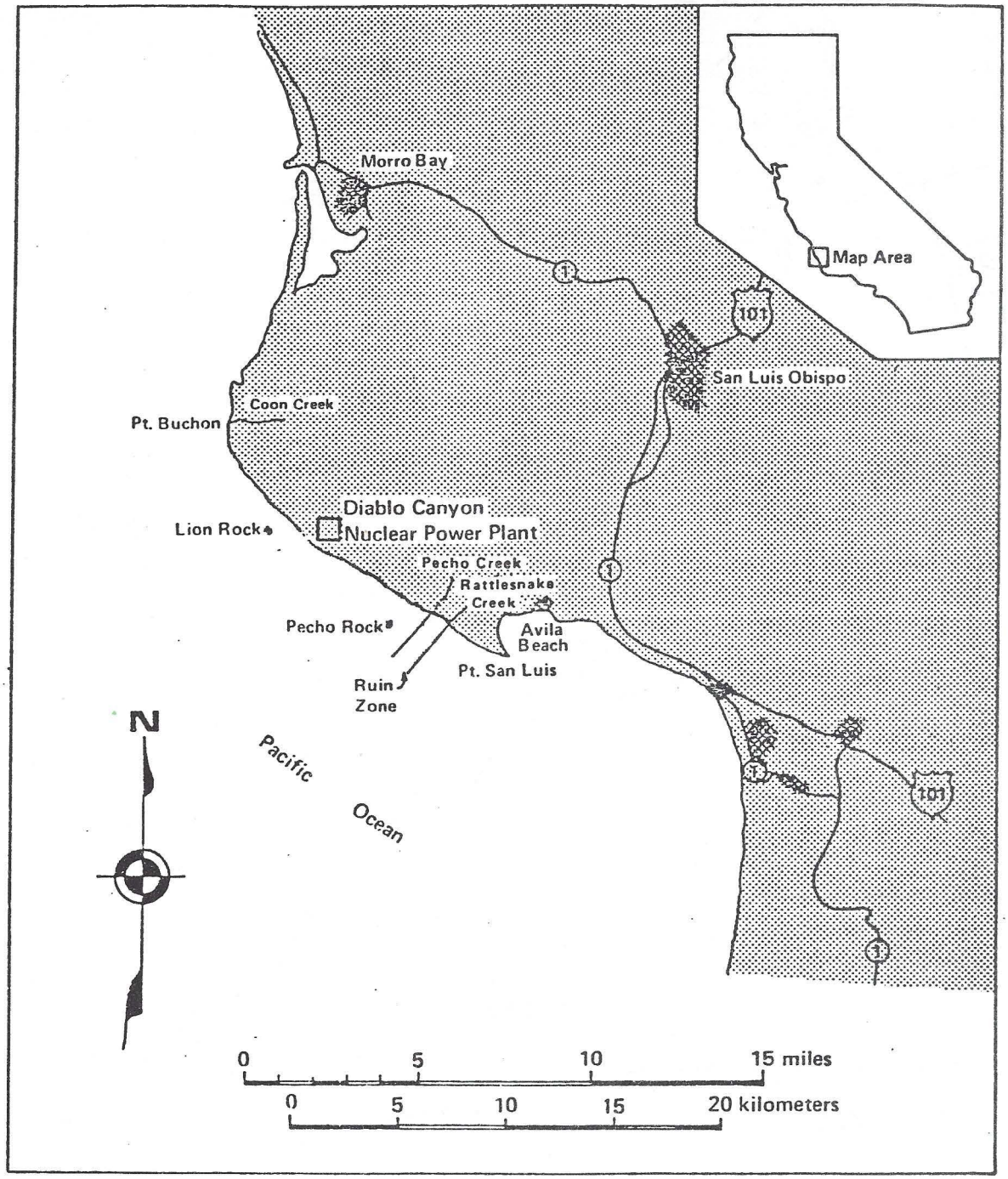

FIGURE 1. STUDY AREA

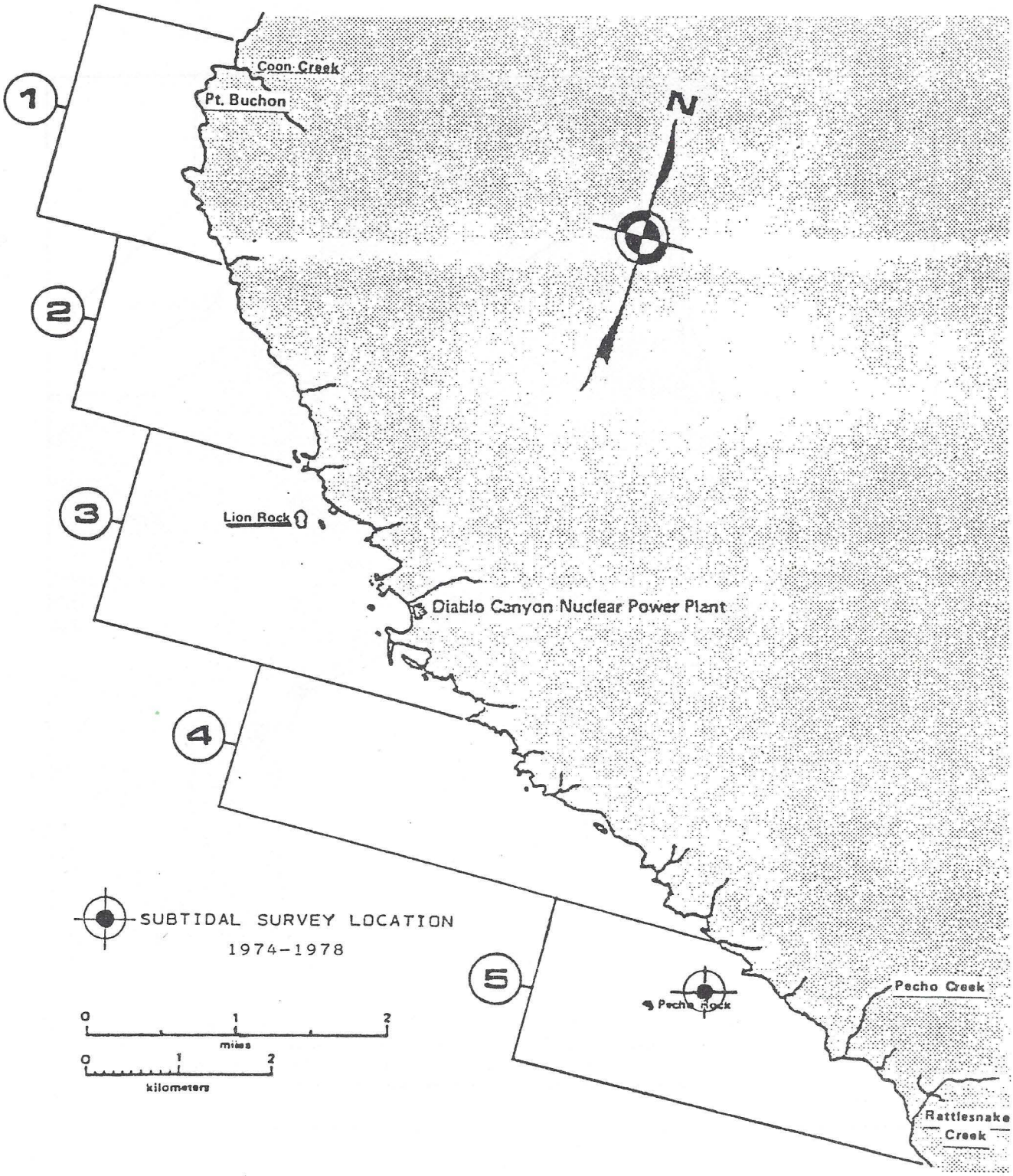

FIGURE 2. Study area divided into five zones based on major raft locations.

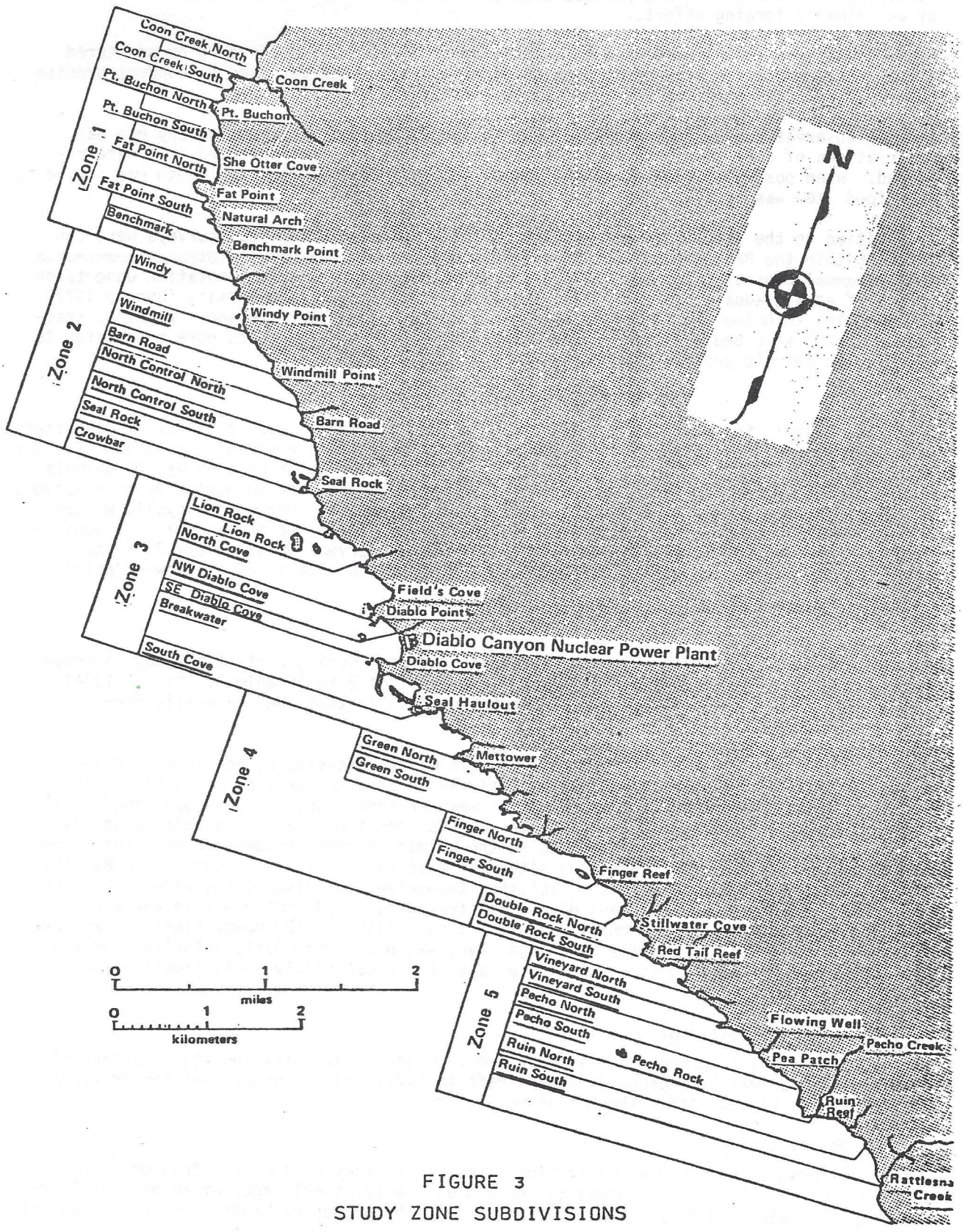

FIGURE 3
STUDY ZONE SUBDIVISIONS

more than once. This task separation also improved the quality of feeding observations. Remaining stationary for long periods enabled the observer to follow the entire course of an animal's forging effort.

Field binoculars (7X35) were used to quickly locate large rafts of otters or scattered animals near shore. A high-resolution (80X) field telescope was used to conduct precise counts after otter location was accomplished with field binoculars.

Feeding observations were generally conducted within a single zone during any one day. Observations of dive times, surface interval and number of dives per food item were recorded. When possible, the sex of the animal and its relative foraging depth was recorded. Each food item was usually identified to species.

In addition to the land-based observations of otter behavior, subtidal surveys were conducted within the Pecho Rock area (Figure 2). A survey of sea urchin (*Strongylocentrotus franciscanus*) densities and age classes was made to continue the documentation undertaken by myself as a graduate student at California Polytechnic State University (Benech 1977). The sampling technique consisted of 10 randomly placed 30-m^2 arc transects within a specified 0.5-km^2 kelp bed area near Pecho Rock (Figure 2). Urchin counts were restricted to macroscopic animals greater than 2 cm.

RESULTS/DISCUSSION

Population Size: Six years of otter ocunts indicate a seasonal cyclic influx of sea otters within the study area (Figure 4). There appears to be a basic resident population of otter equaling approximately 50 in number, with an additional influx of as many as 100 animals during the winter and spring. This observation recently has been supported by observations of otters tagged by CDF&G and U.S. Fish and Wildlife Service. During the cyclic winter influx, otters tagged as far north as 145 km were observed in the study area. In addition, otters tagged in the vicinity of the plant site were observed approximately 35 km north of the plant site during summer months when the population size is at its lowest point within the study area.

Population Distribution:

Otters throughout their range usually aggregate and rest during part of the day in groups known as rafts. In California, rafts usually consist of 2 to 16 animals (Miller 1974). The animals within the study area are somewhat unusual in that they generally form aggregates of 40 to 166 animals.

Over the past six years, the otters have made 18 major raft-site relocations. These relocations have been generally but not exclusively in the southerly progression. Relocation of raft sites appears to be a result of weather conditions, kelp canopy, food availability and social behavior. In the winter months when the *Nereocystis* kelp canopy is breaking up, weather conditions seem to be the primary factor influencing movement. When rafting otter relocated their resting site, the move was generally en masse. In May 1974 a raft of approximately 50 otters established themselves for five months within the Diablo Cove area, site of the power plant discharge structure, and directly within the study area of other ongoing environmental investigations. Although the power plant intake cove, located just down coast from the discharge cove, was not continuously inhabited, it also provides a regular rafting site for single males and occasionally small (four) groups of females.

Population Sex Composition:

The southern front is predominantly comprised of males, and, until the establishment of a small (5-10 animals), segregated female raft in 1976, only an occasional female was positively identified within the Buchon population.

Fedding Observations:

Just as otters maintain preferred rafting sites, so do they predictably frequent specific feeding grounds. It is not unusual to see a small (6-12 otter) group of animals splinter off from the main herd in unison and disperse once the preferred feeding ground is reached.

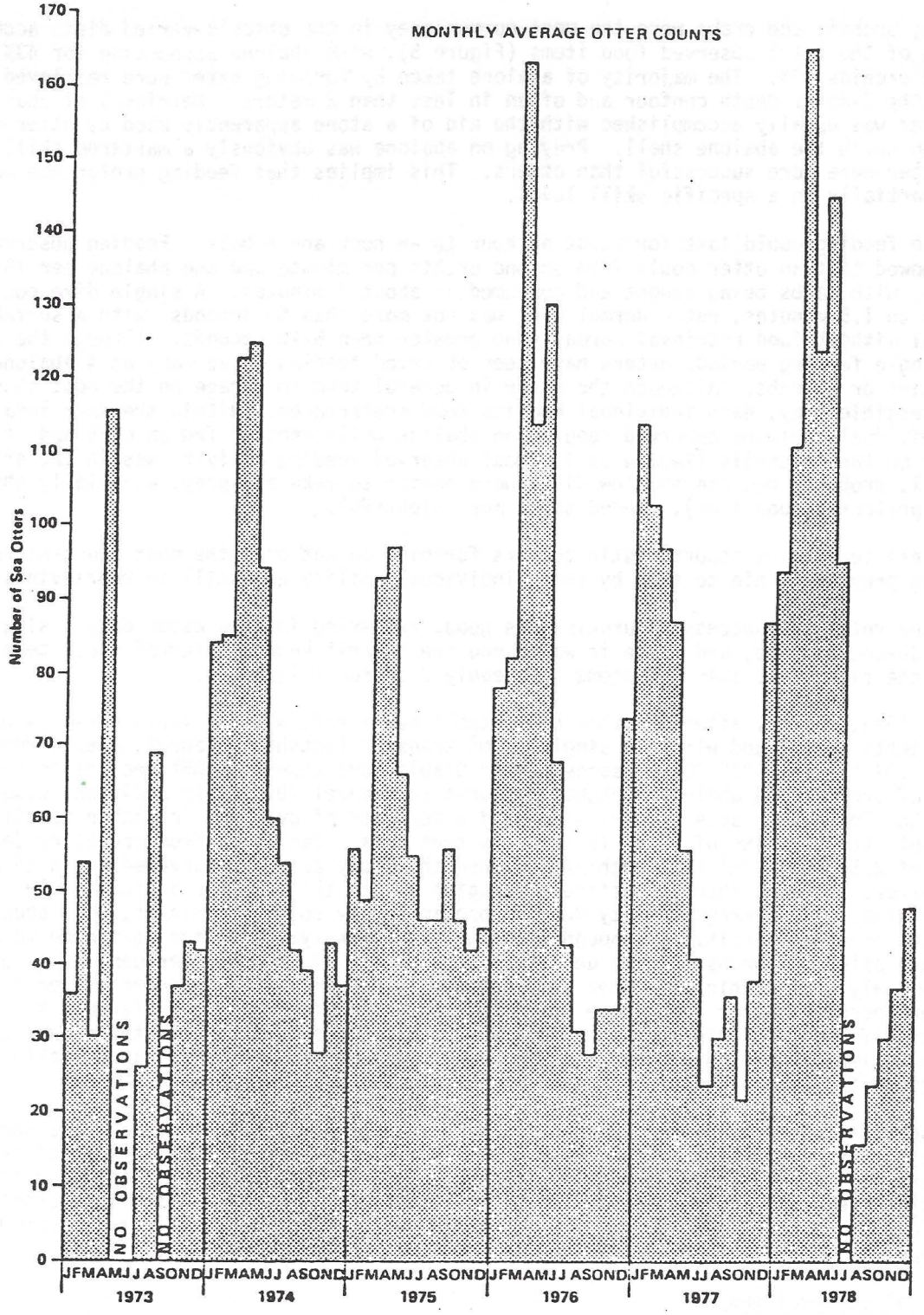

FIGURE 4. Monthly Averages of Sea Otter Counts in the Study Area.

Although the otters in this study generally rafted in large groups, when they fed, they would separate and forage as individuals. Otter foraging activity reached a peak in mid-morning and again in the late afternoon.

Abalone, urchins and crabs were the most common prey in the otter's varied diet, accounting for 78% of the total observed food items (Figure 5), with abalone accounting for 43%, crabs 16% and urchins 13%. The majority of abalone taken by foraging otter were retrieved well within the 3-meter depth contour and often in less than 2 meters. Retrieval of abalone by sea otter was usually accomplished with the aid of a stone apparently used by otter underwater to crush the abalone shell. Preying on abalone was obviously a mastered skill, as some otter were more successful than others. This implies that feeding preference may be based partially on a specific skill level.

A single feeding could last for about an hour to an hour and a half. Feeding observations also showed that an otter could feed on one urchin per minute and one abalone per 15 minutes, with carbs being caught and consumed in about 7 minutes. A single dive could last up to 1.5 minutes, but a normal dive was not more than 55 seconds, with a surface interval without food retrieval normally no greater than 5-10 seconds. Through the course ov a single feeding period, otters have been observed feeding on as many as 4 abalone, 21 urchins or 8 crabs. Although the otter in general tend to forage on the most abundant and accessible prey, each individual had its food preferences. Within the same locale, one individual could be observed feeding on abalone while another fed on crab and still another on turbin snails (*Tegula* sp.). Most observed feeding activity was in the shallow subtidal, probably because shallow dives were easier to make and prey, especially abalone (their preferred food item), tended to be more plentiful.

Sea otters tend to be opportunistic feeders foraging on not only the most abundant prey but also prey available to them by their individual ability and skill in retrieving.

Since the retrieval success of urchins was good, requiring in some cases only a single 20- to 30-second dive, and since it was among the otters' known preferred food items, it was the first food item to become noticeably depleted (Figure 5).

By June 1974, shortly after 40 otter had established a raft within Diablo Cove, 24 broken urchin tests were found within a single 30-m^2 transect (Gotshall, Lauret, Ebert, Wendel & Farrens 1974). The 1975 CDF&G assessment of Diablo Cove showed an 85% decline in the number of urchins and abalone (Gotshall, Lauret and Wendel 1976). In addition, studies within the Pecho Rock area (Figure 6) showed a decrease of over 50% in urchin densities after only three months of otter foraging in that area. Declining from pre-otter densities of 2.5 urchins/m^2 to 1 urchin/m^2. When the study area was surveyed again in June 1977, otters had been observed actively foraging within the area for approximately eight months. The average density dropped precipitously to 0.1 urchin/m^2, only about 5% of the original density. Although I thought it unlikely, densities continued to drop such that after 27 months, urchin densities are down to 1% of pre-otter densities, or approximately 0.03 urchin/m^2. When this density is compared with those estimated prior to otter encroachment or even those of initial otter habitation, the difference is strikingly significant. Within the Pecho Rock and Diablo Canyon areas, sea otters have had a definite impact on urchin survival. Apparently only those urchins located within the protection of deep, inaccessible crevices remain.

These subtidal observations in conjunction with feeding observations support the theory that sea otter have played a significant role in the decline of these large herbivores. Other ongoing studies being conducted within the vicinity of the power plant have indicated the removal of these herbivores by sea otters has created a detectible change in both algal composition and abundance which could eventually change the overall community structure.

Incidental Observations:

In addition to otter counts and feeding observations, a variety of incidental behavior was observed through the course of the study, providing insight into otter behavior. For example:

1. By far the most varied display of otter activity has been observed within the female

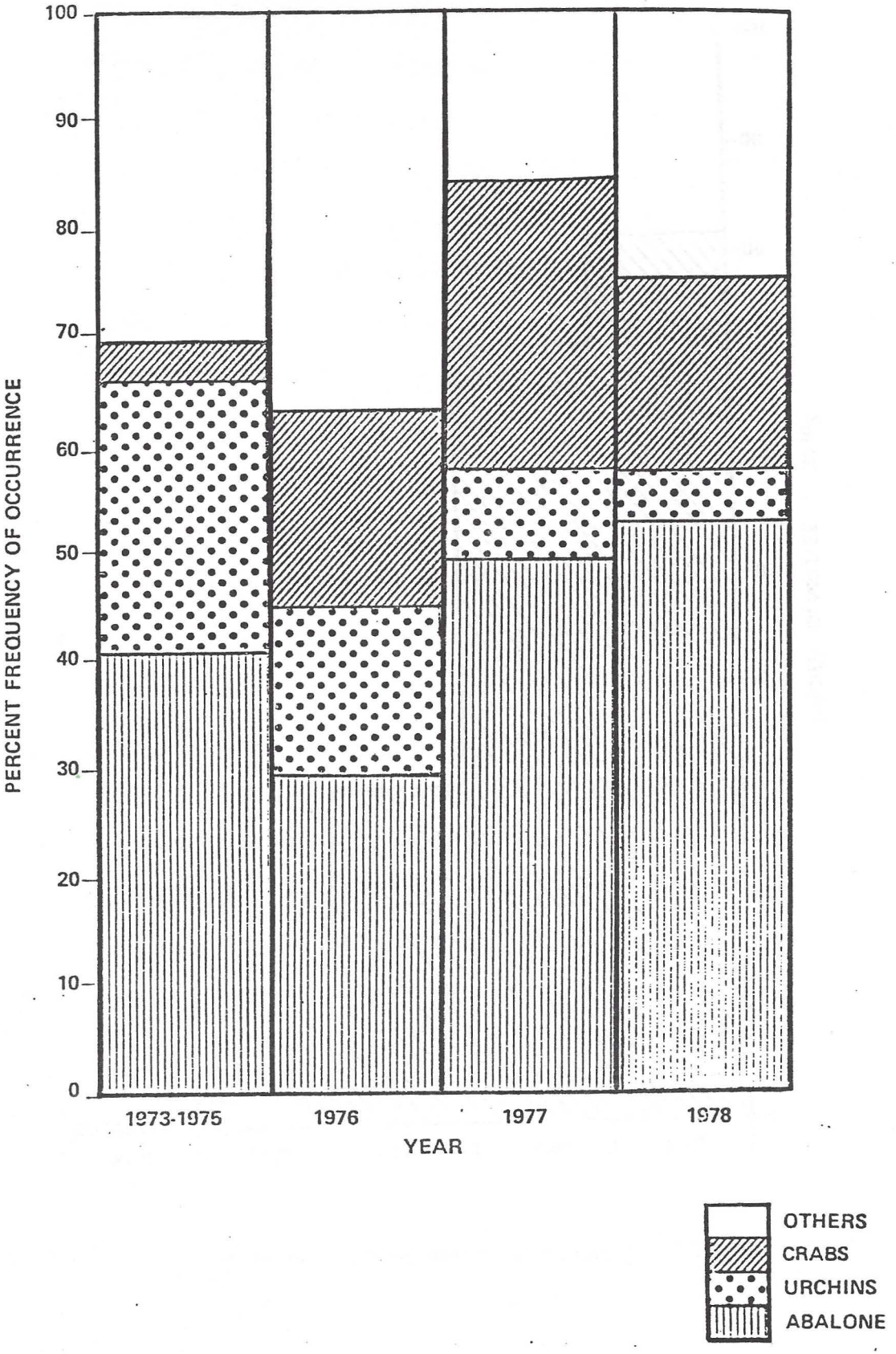

FIGURE 5. Food Item Summary Frequency of Occurrence.

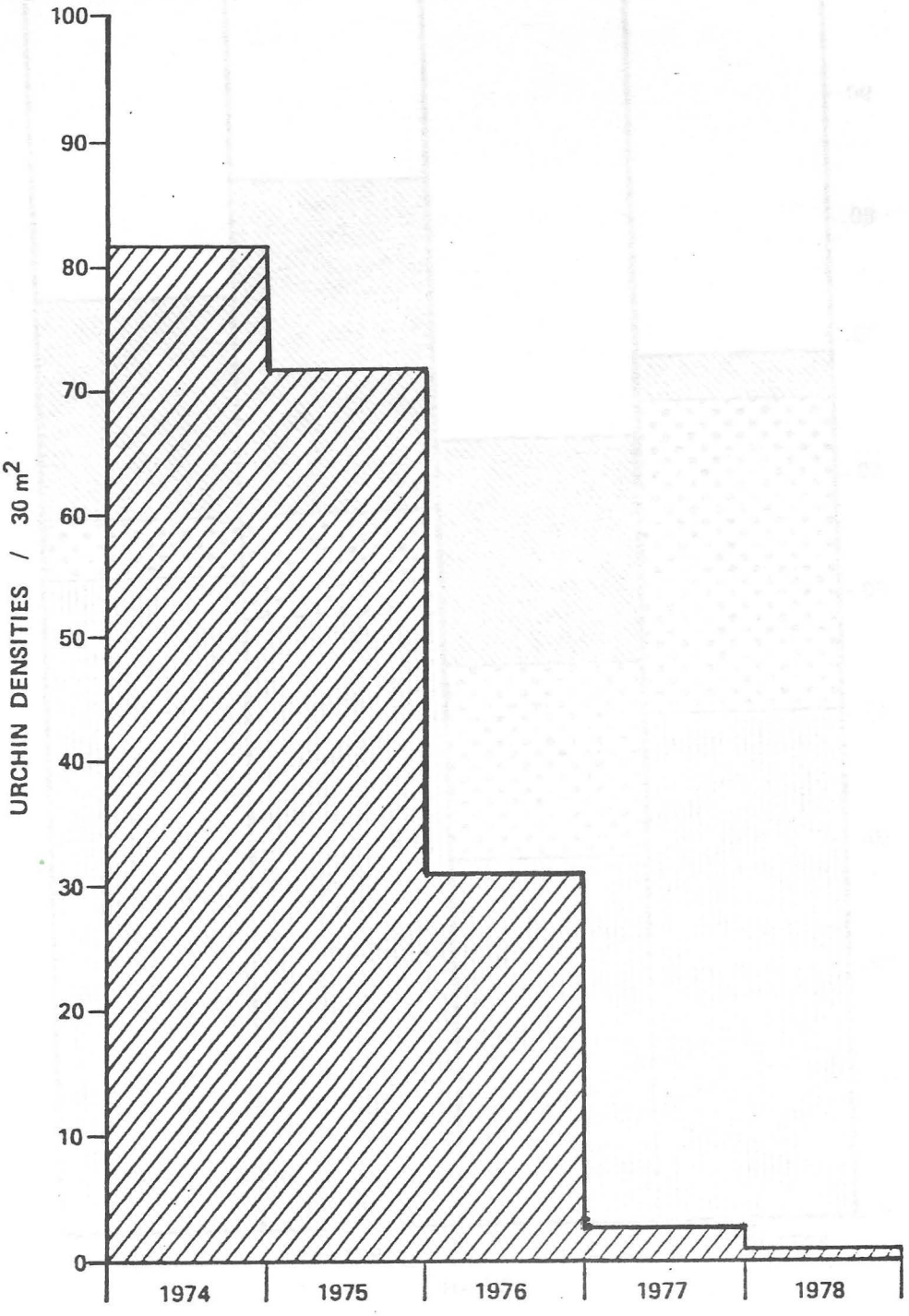

FIGURE 6. A Summary of Urchin Densities at Pecho.

raft. An adult male made repeated visits to the female raft approaching each of the nine females in an attempt to mate, but was rebuffed. He remained persistent, however, and went to the point of pulling a dozing pup off one mother's belly and moving into its place. The pup began crying (loud shriek) whereupon the mother rolled, dumping the male, and replaced her pup. This action was repeated several times before the male left the raft. When a breeding partner is finally chosen, it seems as though the pair leave the raft and mate in relative solitude, as was observed in April 1976. After mating has occurred, the female returns to her raft and does not remain with the male.

2. Communal pup care also may be a feature of the female raft. Not only have mothers been observed leaving young pups in the attendance of other rafting females while they forage, but a pup has been observed attempting to suckle each of the resting females, finally being accepted by a female which may or may not have been his mother.

3. Sea otter-harbor seal (*Phoca vitulina*) interactions are not unusual. Sightings of seals amid otter rafts were not uncommon. I was, however, rather surprised to see two otters hauled-out on a rock with several harbor seals. I was even more surprised later to find 16 otter hauled-out within the same area, reportedly a habit uncommon among California otters.

4. Through the course of my studies, I have observed otters not only foraging in very shallow water but also taking advantage of the +2 MLLW intertidal.

5. Within a large raft of otters, there appears to be a hierarchical stratification. The raft is not just simply a convenient resting unit but forms the basic unit for relocation travel. Within this larger unit, smaller groups exist which sometimes forage together or segregate themselves on occasion to rest apart from the central unit. Associated with the large rafting core are isolated otters scattered along the edges of the main herd. Perhaps these isolates serve as guards and warn the raft in the event of danger.

In summary, otter investigations within the vicinity of the Diablo Canyon Nuclear Plant have shown:

1. The total numbers of otters within the study area follow a cyclic influx during the winter and spring when the population reaches nearly 200 animals then drops to levels of approximately 50 animals during the summer and fall.

2. Although the population sex ocmposition is presently predominantly male, the overall trend indicates further establishment and expansion of segregated female rafts within the area.

3. A continued otter range expansion southward seems inevitable.

4. The otters have a significant effect on the near shore community by effectively removing large herbivores such as abalone and sea urchins, their preferred food items.

CONCLUSIONS

Since the Diablo Canyon Nuclear Power Plant is still in its pre-operative phase, we cannot say what effect it may have on the otter or its associated biotic community. These pre-operative studies, however, show the otter, as a top carnivore, has a profound effect on the near shore environment within the vicinity of the Diablo Canyon power plant and will have such effects whenever the population extends its influence into previously unestablished areas.

LITERATURE CITED

Morrison, P. , M. Rosenmann, and J. Estes. 1975. Metabolism and thermoregulation in the sea otter. Physiol. Zool. (PH2OA) 47 (4).

Miller, D.J. 1974. The sea otter (*Enhydra lutris*); its life history, taxonomic status, and some ecological relationships. Calif. Dept. Fish and Game, Mar. Resour. Leaflet 7:13.

Lensink, C.J. 1962. The history and status of sea otter in Alaska. Purdue Univ. 188 pp. Ph.D. thesis. Univ. Microfilms, Ann Arbor, MI.

Barabash-Nickforov, I.I., V.V. Reshetkin, and N.K. Shidlovskaya. 1947. The sea otter. Transl. from Russian by A. Birron and Z.S. Cole, 1962. Nat. Sci. Foun. and U.S. Dept. Int., Wash., DC (Isreal Program for Sci. Transl.) 277 pp.

Ogden, A. 1941. (Report Ed. 1974). The California sea otter trade 1784-1848. Univ. Calif. Press, Berkeley. 251 pp.

Fisher, E.M. 1939. Habits of the southern sea otter. J. Mamm., 20(1):21-36.

Ebert, E.E. 1967. Food habits of the southern sea otter, *Enhydra lutris nereis*, and ecological aspects of their population and distributional expansion. Cal. Dept. Fish and Game, MRO Ref. 67-18.

Burge, R.T. and S.A. Schultz. 1973. The marine environment in the vicinity of Diablo Cove with special references to abalones and bony fishes. Res. Agency, Cal. Dept. Fish and Game. Mar. Resour. Tech. Rept. 19:433.

PGandE. 1975. Environmental investigations at Diablo Canyon. 1974. PGandE Dept. Engr. Res. San Ramon, CA.

Benech, S.V. and E. Colson. 1976. Size and distribution of the California sea otter population in the vicinity of Diablo Canyon Nuclear Power Plant October 1973 to December 1975. PGandE Dept. Engr. Res. Rept. 7846.11-76.

_____. 1977. Size, distribution and behavior of the California sea otter population in the vicinity of Diablo Canyon Nuclear Power Plant January to December 1976. Ecomar, Inc. report #VII-1-76.

_____. 1977. Preliminary investigation of the giant red sea urchin resource of San Luis Obispo County, California. M.S. thesis. Sch. of Sci. and Math. Biol. Sci. Dept. Cal. State Polytech. Unvi., San Luis Obispo.

Gotshall, D.W., L.L. Laurent, E.E. Ebert, F.E. Wendel, and G.D. Farrens. 1974. Diablo Canyon Power Plant site ecological study annual report, July 1973 to June 1974. Cal. Dept. Fish and Game, Mar. Resour. Admin. Rept. No. 74-10:107.

Gotshall, D.W., L.L. Laurent and F.E. Wendel. 1976. Diablo Canyon Power Plant site ecological study annual report, July 1974 to June 1975. Cal. Dept. Fish and Game, Mar. Resour. Admin. Rept. No. 76-8:112.

Estes, J.A. and J.F. Palminsano. 1974. Sea otters: their role in structuring near shore communities. Sci., Wash., DC. 185:1058-1060.

Dayton, P.K. 1975. Experimental studies of algal canopy interactions in a sea otter-dominated kelp community at Amchitka Island, Alaska. Fish Bull. 73(2):230-237.