STATUS OF THE SEA OTTER POPULATION IN CALIFORNIA AND POTENTIAL MANAGEMENT OF OTTER AND SHELLFISH RESOURCES

Daniel J. Miller
California Department of Fish and Game
Monterey, California

Abstract. A safe population of sea otters now occupies the California coastline from Santa Cruz south to almost Avila. The "sea otter-abalone" conflict has evolved into a sea otter-shellfish resource controversy. When the otter moved into Pismo clam beaches and around piers where red and rock crabs were taken, it soon became evident that the efficiency of sea otter foraging would preclude several fisheries. The fisheries that will be precluded statewide if sea otters are not eventually contained are: Pismo clam, abalone, sea urchin, and ocean mariculture. Severely reduced fisheries will be red and rock crabs, sea mussel, rock scallop, and razor clam. Fisheries potentially in jeopardy may be the Dungeness crab, spiny lobster, and oyster rack fisheries.

This growing controversy is being evaluated in a society in which non-consumptive values of wildlife species are gaining recognition. Society will have to make a decision to either have sea otters occupy the entire coastline or to contain the sea otter within certain boundaries, outside of which shellfish fisheries can be maintained.

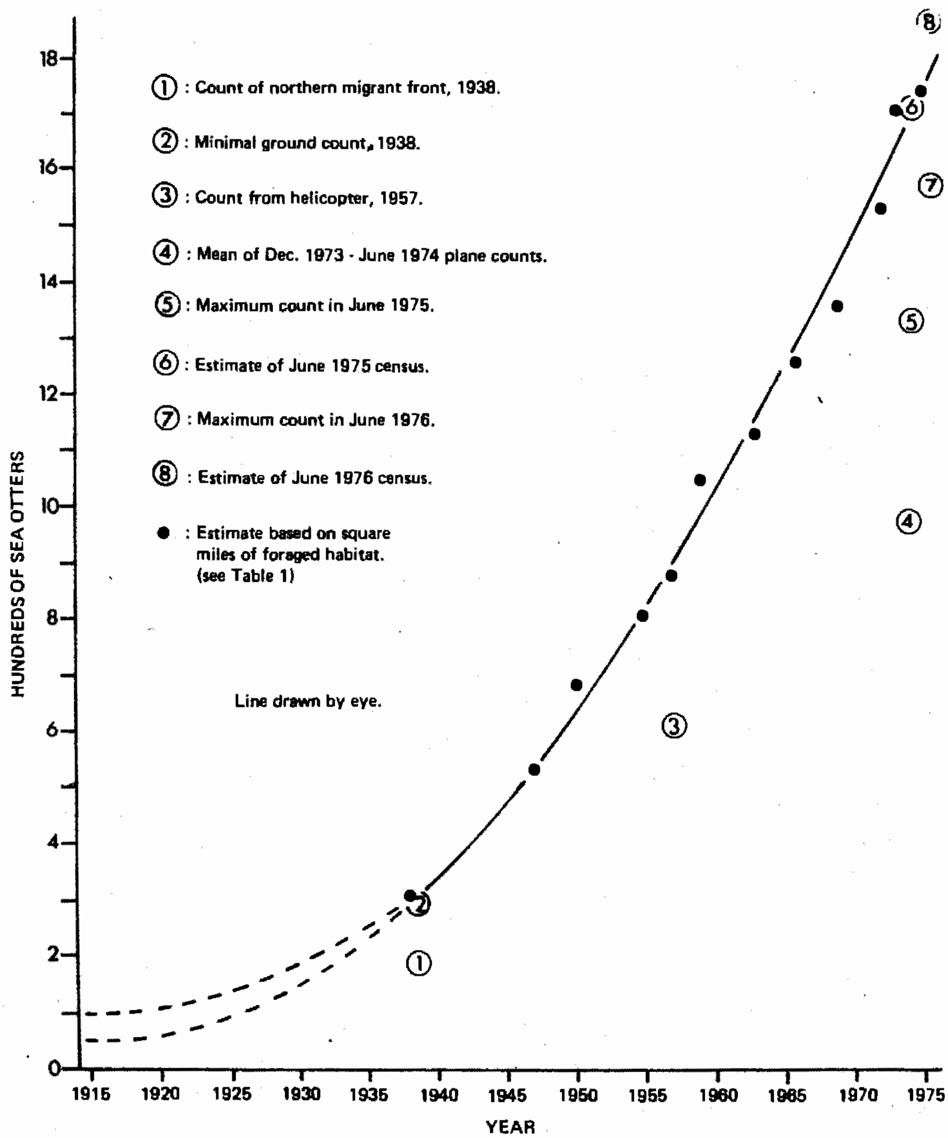
Containment management is not being recommended by the State of California at this time. Research must first be conducted on the effects of removal of the large concentration of animals at the range peripheries, the migrant front animals. These animals are mostly young males that theoretically are surplus to the population.

The sea otter's limiting factor appears to be starvation. The carrying capacity is thus determined by food items available, and the rate of emigration into new areas is determined by the number of animals in the migrant fronts and the amount of food available in each new foraging area.

INTRODUCTION

The "sea otter-abalone" resource conflict has been with us since the early 1950's. That conflict has more recently evolved into a "sea otter-shell-

Fig. 1. Estimates of sea otter numbers based on square miles of habitat to 20 fm (36.6 m) occupied between migrant fronts, 1914 to 1975 compared with certain ground and aerial counts and estimates.



fish" resource controversy now that the impact of otter foraging on other shellfish fisheries has been documented (Wild and Ames 1973; Miller 1974; Miller et al. 1975). At the same time, there has been a shift of cultural values due to the recent growing public environmental awareness. This awareness includes a strong desire to return to a "natural" state and to emphasize aesthetic values of wildlife as opposed to consumptive values. There is also a deepening cultural rejection of violence as a way of solving social and political problems. This non-violent morality is being projected more and more into human interactions with wildlife species. The synthesis of these protective and aesthetic values has resulted in a cultural shift from conservative use of living fugitive resources to one of full protection.

Are we thus caught up in an irreversible cultural trend from the full unlimited consumption of our pioneer days to non-consumption of wildlife species? Conservationists are working more and more with an active, concerned, but generally ecologically unsophisticated public which is for the most part motivated from emotional and philosophical levels. These motivations may be derived from the above altruistic values, or their actions may be an atonement arising from our cultural guilt of misuse of our wild land, as was pointed out by Rene DuBois (1968). Within this cultural milieu, it is becoming increasingly difficult to present a rational argument to manage and to conduct proper research on controversial species. Irrational emotionalism is difficult to overcome even with good environmental and biological data; without data it cannot be overcome except through counter political strength which may not necessarily impose the best solution for the species.

The above cultural trends seem to apply especially to marine mammals. The ocean "mystic" has been with humans for a long time. America's basic legacy of wildlife values has been to hunt and exploit terrestrial fauna. This was especially so during the frontier days of food gathering and hunting, when guns were considered as a necessary artifact for survival, and when there were seemingly unlimited resources.

Those who strive to return to a "natural" state will rarely, if ever, fully attain their goal. Human activity affects every habitat and every animal in ways not present before the arrival of technological society. Furthermore, no uncompromising person advocating full protection should desire to manage some of our wildlife species as they were exploited during aboriginal times. The sea otter (Enhydra lutris) and pinnipeds were vulnerable to primitive clubbing and spearing (Kroeber and Barrett 1960). With more sophisticated use of bows and arrows and nets and snares set from boats, sea otters in some areas were depleted by aboriginal hunters. In the Aleutian Islands (Kenyon 1969; Turner et al. 1974) shellfish was the principal source of energy to the Aleuts in areas where sea otters could be reduced to rare levels by hunting.

Protective Legislation

With the arrival of fur hunters equipped with guns along California in the mid-1800's some inshore mammal populations suffered severe depredation. Breeding populations of Guadalupe fur seal (Arctocephalus townsendi) northern elephant seal (Mirounga angustirostris) and northern fur seal (Callorhinus alascanus) were eliminated in California. The sea otter was almost exterminated. By 1921, the only remnant population of sea otters south of Prince William Sound, Alaska, was at Pt. Sur, California.

Marine mammals are a group of animals with which nearly everyone can identify, and there is a strong movement throughout the world to fully protect them. This desire to protect marine mammals is not a recent phenomenon. In 1913, the State of California enacted legislation to fully protect the mammals that were depredated. As the result of this protection, the northern elephant seal has returned to nearly pristine numbers and distribution, and the Guadalupe fur seal has increased in Mexican waters and is slowly returning to its former breeding grounds on offshore California islands. The northern fur seal has returned to several offshore islands to breed, and the sea otter has expanded steadily in numbers and range along the mainland and is no longer considered endangered or threatened by the State of California.

The Marine Mammal Protection Act of 1972 preempted State jurisdiction of all marine mammals, and to take species covered under the Act for research or management requires a permit from the U.S. Department of the Interior. Presently, the State of California is requesting a special research permit to tag sea otters throughout the present California range and to translocate otters that migrate south of Avila to the northern range limit near Santa Cruz. This experimental removal of the southern migrant front is designed to determine the effects of the removal of the front on the established population adjacent to the range periphery. This research must be completed before containment management strategies can be suggested.

The Department of Fish and Game has not considered the sea otter population in California to be threatened since the early 1960's, and this species was not listed in the Federal Endangered Species Act of 1973 when enacted. Subsequently, in 1974, a State Department sponsored international treaty, the Convention of International Trade in Endangered Species of Wild Fauna and Flora, was enacted. The Convention included the "southern" sea otter (*Enhydra lutris nereis*) as an endangered species. Roest (1973) conducted a thorough study of differences between Alaskan and California sea otters and found no significant subspecific differences in any structural and behavioral attribute and concluded that *nereis* is not valid and that there is but one subsspecies in the eastern Pacific. Davis and Lidicker (1975) believe *nereis* to be valid but offer no new information to substantiate their conclusion. In fact, several behavioral attributes chosen by Davis and Lidicker to indicate significant variability are not in fact valid differences. For this and other reasons the Department follows Roest's synonymy. However, the Department does not base its decision on whether the California population is threatened because of its taxonomic status.

The Fund for Animals Inc. requested the endangered status listed in Appendix I of the Convention to be included in the 1973 Endangered Species Act. After a year's accumulation of comments by individuals, organizations, and agencies including an intensive public letter writing and petition campaign conducted by protectionists organizations, the U.S. Fish and Wildlife Service announced (Federal Register, January 14, 1977) that the sea otter in California is threatened.

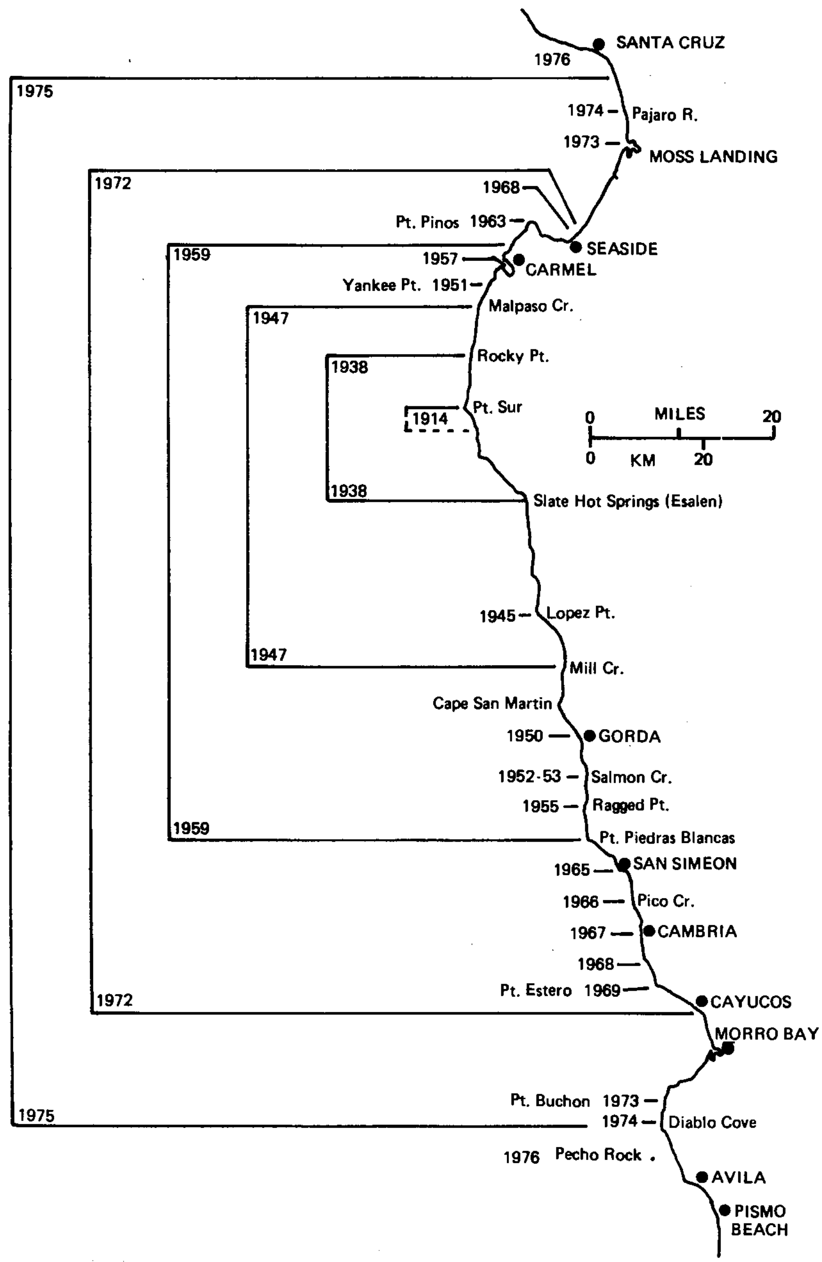
The State still does not consider the sea otter population as threatened.

Biological Status of the Sea Otter in California

The sea otter has increased steadily in numbers (Figure 1) and range (Figure 2; Table 1) since about 1911. The remnant population at that time near Pt. Sur was around 50 to 100 animals. Over a period of 60 years this population has increased to at least 1,800 and possibly to 2,000 sea otters now established throughout the area between Santa Cruz to near Avila, a distance of 170 miles (274 km). This expansion represents an average increase in numbers of around 5% per year and an increase in range of around 2.5 miles (4.0 km) per year.

Social behavior, distribution, physiology, and mortality studies of the sea otter all support statements of previous workers that starvation is the limiting factor. The behavior of remaining in water for most of their life, or possibly entire life for some individuals, and lack of an insulating layer of blubber necessitate several adaptations to retain their high body temperature of 38°C. Some adaptations are a thick fur with a trapped air

Fig. 2. Established sea otter range between migrant fronts, 1938 through 1976.



layer next to the skin, a high metabolic rate of 2.5 met (Morrison, Rosenmann, and Estes 1974) which requires a high daily intake of food averaging around 25% of the body weight per day (Stullken and Kirkpatrick 1955), and the behavior of holding their paws and flippers out of the water as much as possible. Morrison *et al*. (1974) report that 60 percent of the body heat is lost through these appendages. Another way to conserve energy is to haul out on land. Estes and Smith (1973) indicate that 20% less oxygen is consumed by otters on land than when in water.

The daily intake of food amounts to an annual consumption of around 2.5 tons (2,268 kg) of shellfish meats per year for an average sized otter. The scattered, non-migratory distribution appears to ensure that all the forageable habitat within the sea otter's range, at least to 60 ft (18.9 m) depth, is foraged almost constantly and uniformly. There is a strong negatively contiguous distribution during peak feeding periods, and when resting during midday, the overall distribution is of scattered single animals or small aggregates, except for the two large migrant front concentrations at the range peripheries. Ebert (1968) found no exposed large red sea urchins (*Strongylocentrotus franciscanus*) or red abalone (*Haliotis rufescens*) on any of the transects surveyed at one-mile intervals throughout the sea otter's range. Long-term underwater transect data in Carmel Bay also demonstrate efficient sea otter foraging, with only an occasional exposed edible macroinvertebrate present.

In our annual census we have noted most of the animals remain either singly or in scattered small aggregates of up to 8-10 animals during the midday rest period. Large groups of animals in excess of 50 are rare in California except at the peripheries where the migrant front animals are concentrated. Up to 150 animals have been observed in these front aggregates. Migrant front animals have a strong tendency to remain where they are and will not move on to areas of more abundant forage items until the area they have newly occupied becomes depleted of food. These front animals are almost entirely young males with a few old males and an occasional young female present. Theoretically, these animals may be surplus to the population and probably would have died had they not been able to find the range periphery where food is abundant.

Health of the Sea Otter Population

As in Alaska (Lensink 1962) and Russia (Barabash-Nikiforov *et al*. 1947), deaths in California attributable to mal- or under-nutrition appear to be more acute than chronic (Morejohn, Ames, and Lewis 1975). More emaciated animals appear in the natural mortality records during the late winter period when motile food items are less available during storms, when the small amount of body fat that is accumulated may be used up, and when the otter cannot readily forage in the intertidal zone during periods of high swells. Kelp canopies that contain forage items are also greatly reduced by mid-winter. Starvation may happen rapidly, in that if an otter does not eat, it can lose up to 10% of its body weight per day (Kenyon 1969).

The sea otter has no limiting natural predator; the only predator in California being the white shark (*Carcharodon carcharias*). In pristine times, bald eagles (*Haliaeetus leucocephalus*) probably preyed upon pups as they now do in Alaska (Estes and Smith 1973), and land carnivores may have preyed upon hauled-out otters.

There are no enzootic pathogenic diseases present in the sea otter, and there are no ectoparasites in the fur (Kenyon 1969). Heavy parasite loads have been noted in the gut (Wild and Ames 1974; Morejohn, Ames, and Lewis 1975), and possibly these infections could have caused death to animals weakened from starvation or from wound infections.

Thorough testing has been made for concentrations of heavy metals (Martin 1974) and chlorinated hydrocarbons (Wild and Ames 1974; Rote 1975). Concentrations of toxic metals and pesticides are not at injurious levels. The Department's pesticide laboratory in Sacramento report that pesticide concentrations in the sea otter are not higher than those found in other healthy marine and terrestrial mammals. Current monitoring of the population would reveal a decline of reproductive success if it had or was occurring. Shooting by humans has also not been limiting, and now that the sea otter population has expanded into areas adjacent to shoreline development, patrolling is facilitated from shore and boats and shooting will be readily observed and reported by the public.

Oil pollution is the only impact that could adversely affect the sea otter population in California. If the integrity of the fur is lost, water can reach the skin and lowering of the body temperature may kill the animal. There is no threat to the entire population, even though a major oil spill may kill sea otters. Reproducing animals are spread throughout the range, and pupping occurs throughout the year but with pronounced peaks in the late winter and spring. We have computer analyzed wind stress patterns and conclude that no one massive oil spill could impact the entire range of the sea otter.

Management of Sea Otter and Shellfish Stocks

Everyone would be heralding the return of the sea otter with joy if the otter ate food items not important as recreational or commercial species. Unfortunately, the otter favors shellfish that humans have become accustomed to take for recreational and commercial purposes. The otter is a much more efficient food gatherer than are humans. Within 1 to 3 years after otters move into a new foraging area at the range periphery, at least 90% of the Pismo clams (Tivela stultorum), abalones, and urchins are removed. The only remaining breeding stock and viable population of red sea urchins and red abalones are deep within crevices into which the otter cannot reach. There are always some of these crevice animals leaving their protection, but eventually the otter will find them. Red crabs (Cancer productus) and rock crabs (Cancer antennarius) and other motile foraging items are not as easily preyed upon, and larger populations of these species can exist with the otter; however, predation by the otter is still sufficient to reduce large crabs to virtually non-consumptive levels within the otter's range. It is for this reason that we are concerned about the Dungeness crab (Cancer magister) and spiny lobster (Panulirus interruptus) fisheries if the otter is allowed to emigrate into these fishing grounds.

There are many possible management strategies we may consider now, and there may be additional possibilities as more information is accumulated. A few basic strategies will be offered here to reveal the nature of this resource conflict and the value judgments that will have to be made.

1. Non-containment Management

In this case the sea otter would be allowed to continue its expansion both to the north and south and eventually re-occupy the entire California coastline. The projected maximum population that the California habitat could support would be around 16,000 animals. This figure is a projection of population densities within the present range applied to the coastline outside the range. Otter densities average about 12.5 per mile of coastline within the established range.

The rate of emigration will be determined by the numbers of animals in the migrant fronts and the food supply in each new foraging area. The rate of expansion in Monterey Bay where there were no rocky reefs was about 7 miles (11.2 km) per year. The otter did not spread over the entire sandy beach area from Monterey to Santa Cruz; rather, the front animals remained in a

Table 1. Range and population expansion of the sea otter along the California coast, 1914 to 1975.

Year	Location of Migrant Front		Increase in Range in Statute Miles			Average Increase in Miles Per Year			Linear Miles of Range	Total Miles² of Habitat to 20 fm	Total*** Estimated Population	Years Between Estimates
	Northern	Southern	to North	to South	Total	to North	to South	Total				
1914	Pt. Sur	(Pfeiffer* Pt.)	-	-	-	-	-	-	(7)*	(9.0)*	(50)*	-
1938	Rocky Pt.	Slate Hot Springs	7	(13)	(20)	0.29	(0.63)	(0.92)	27	18.4	310	24
1947	Malpaso Cr.	Mill Cr.	5	14	19	0.56	1.02	1.58	46	36.5	530	9
1950	Yankee Pt. (1951)	Gorda	1	8	9	0.33	2.67	3.00	55	46.2	660	3
1955	Pt. Lobos South Shore	Ragged Pt.	2	10	12	0.40	2.00	2.40	67	59.2	800	5
1957	Pescadero Pt.	Pt. Sierra Nevada	7	4	11	3.50	2.00	5.50	78	66.0	880	2
1959	Pt. Joe	Pt. Piedras Blancas	4	4	8	2.00	2.00	4.00	86	74.2	1,050	2
1963	Otter Pt.	San Simeon	3	6	9	0.75	1.50	2.25	95	84.7	1,190	4
1966	Lover's Pt.	Pico Cr.	0	4	4	0.00	1.33	1.33	99	92.0	1,260	3
1969	Seaside	Pt. Estero	4	8	12	1.33	2.67	4.00	111	105.2	1,390	3
1972	Seaside	Cayucos Pt.	0	9	9	0.00	3.00	3.00	120	125.2	1,530	3
1973	Moss Landing	Pt. Buchon	14	18	32	14.00	18.00	32.00	152	142.0**	1,720	1
1974	Pajaro River	Pt. Buchon	4	0	4	4.00	0.00	4.00	156	144.2**	1,730	1
1975	Sunset State Beach	Pt. Buchon	5	0	5	5.00	0.00	5.00	161	146.7**	1,760	1
TOTALS			56	98	154	0.92	1.61	2.52	161	146.7	1,760	61

* No records, rough assumptions made.

**Square miles of foraging habitat along Pismo clam beaches are considered 0.50 miles² per linear mile of sandy beach.

***Population estimates are computed by multiplying the square miles of habitat occupied by 13 and adjusting for migrant front concentrations.

Pismo clam concentration until the clams were foraged to low levels then moved into the next adjacent clam bed. If large amounts of clams are not available along sandy beaches, the emigration rate will be much higher per year.

Under this management regime otters will move into all heavily congested harbor areas and likelihood of boat damage, adverse effects from small oil spills, and local accidental concentrations of pollutants will cause increased danger to some animals. More stranded pups will appear on the beaches resulting in emotional concern and costly handling for animals that may have been abandoned because of lack of food in a population which is periodically exceeding its maximum population level.

The shellfish fisheries that would be lost if the otter is allowed to occupy the entire coast of California are the Pismo clam recreational fishery, the abalone commercial and recreational fisheries except for a very few abalones that could be taken by shore pickers from deep protective crevices, and the red sea urchin fishery. Fisheries possibly to be precluded are the Dungeness crab and spiny lobster fisheries. Fisheries that will be reduced to low levels are the red and rock crab shallow water fishery, the razor clam and possibly other clam resources not in muddy substrate, and the sea mussel taken in the intertidal zone. Today the annual value of these shellfish fisheries that will and may be precluded by the otter is around $40 million.

Biological enhancement to the inshore ecosystems occupied by the otter is relatively unknown except for greater growth of understory algae. Presently, we are investigating the change in community structure and trophic levels as sea otters move into a new area. The results of these contract studies being conducted by the University of California, Santa Barbara, will have an impact on future decisions. The Department has surveyed fishing success by shore and skiff fishermen and skindivers in areas before otters moved in and three years after sea otter foraging. Catch-per-hour values did not increase for the total catch, and, in fact, there was a slight decline in take of invertebrate feeding fishes. These data do not prove that the sea otter was responsible for the decline, but they do show that the changes in the ecosystem other than a dramatic decline in macro-invertebrates and an increase in understory algae may be quite subtle.

There are several parameters of sea otter biology and habitat changes due to sea otter foraging that need more study before any management regime can be suggested; however, direct effects of foraging on our shellfish fisheries is well documented. Society can have both sea otters and shellfish fisheries, but not in the same geographic location.

2. Containment Management

Containment management assumes that society has decided to have both otters and shellfish fisheries. Two basic problems have to be solved here, i.e., what shellfish fisheries should be retained, and what is to be done with sea otters that emigrate beyond the established range limits.

The first requirement is to satisfy both state and federal protection laws in assuring that the geographically contained sea otter population is not threatened in any way. We feel this requirement has already been met with even the present population distribution.

The principal problem with containment management is the disposal of extralimital animals. Very likely, the large numbers of immature males now aggregating at the range peripheries are an accumulation of animals over the years. Once these front animals are removed, only a few animals annually may move beyond the limit of range. If these are constantly removed, the annual "escapement" may be placed in live containment in oceanariums and zoos or be transshipped to a new population in some other state or country.

If there are more animals leaving the range than can be placed in live containment, then either the reproductive rate must be lowered near the peripheries of the range or excess animals would have to be culled.

Methodology for reproductive rate decrease has not been studied; possibly some form of sterilization or sex ratio manipulation would be possible. One of the parameters of our migrant front study is to determine, through tagging of young animals throughout the range, where the animals are being born that form the migrant front. If these animals are originating from throughout the range, attempts to lower the reproductive rate in some way may not be feasible. If these front animals originate from near the limits of the range, then possibly some form of lowered reproduction could be feasible to keep the population below carrying capacity and inhibit the drive to find new food sources.

The shellfish stocks are now under strict management, and monitoring procedures keep us informed of the status of our resources. There has been repeated implication by some who prefer full protection and favor non-containment sea otter management that shellfish resources are presently drastically depleted by human exploitation and that increased use will ultimately result in termination of these fisheries without sea otter depredation. The State has been managing the State's natural resources for over 50 years, and most of the shellfish fisheries have now leveled off at a sustainable, but often fluctuating, level. The Dungeness crab fishery north of San Francisco has returned as predicted last year, with a yield of about 18 million pounds (18 times that of the previous year). The San Francisco stocks have not returned significantly, but this local problem is not because of over exploitation by fishermen. Pismo clam stocks are in good shape at all beaches outside the sea otter's range from Newport Beach north to Pismo Beach. Because of good year class strength in the 1960's, the catches are increasing at many beaches, not declining. Had the sea otter not precluded the Monterey Bay Pismo clam fishery, the best take of clams for over 30-40 years would have taken place in the last 2 years.

Red and rock crab catches are not declining at piers where otters have not foraged, and the red sea urchin fishery is still in its developmental stage. The recreational abalone fishery is in good shape along the north coast; new laws are expected to head off a potential problem there. New proposed laws changing the commercial fishery to a limited entry status will solve the over-exploitation problem in southern California.

Management will perpetuate fugitive shellfish fisheries as well as potential mariculture practices indefinitely, unless the sea otter occupies the entire coastline. Society must choose what they want from their natural resources; it's up to the management agencies to inform the public of the impact of their decision and to supply the best means to the chosen ends.

LITERATURE CITED

Barabash-Nikiforov, I.I., V.V. Reshetkin and N.K. Shidlovskaya. 1947. The sea otter (Kalan). [Transl. from Russian by A. Birron and Z.S. Cole, for Nat. Sci. Found. and U.S. Dept. Inter., 1962.] U.S. Dept. Comm. Off. Tech. Serv., Wash. D.C. 227 p.

Davis, J., and W.Z. Lidicker, Jr. 1975. The taxonomic status of the southern sea otter. Proc. Calif. Acad. Sci. 4th ser. 60(14):429-437.

Dubois, R. 1968. So human an animal. Charles Scribner's Sons, N. Y. 300 p.

Ebert, E.E. 1968. California sea otter census and habitat survey. Underwater Nat., 5(3):20-23.

Estes, J.A., and N.S. Smith. 1973. Research on the sea otter, Amchitka Island, Alaska: final report. (Amchitka Bioenvironmental Program) Ariz. Coop. Wildl. Res. Unit, Univ. Ariz., Tucson. 68 p. [AEC contract AT(26-1-520)].

Kenyon, K.W. 1969. The sea otter in the Eastern Pacific Ocean. U.S. Bur. Sport Fish. Wildl., Wash. D.C., No. Amer. Fauna, (68):1-352.

Kroeber, A.L., and S.A. Barrett. 1960. Fishing among the Indians of northwestern California. Univ. Calif., Anthropol. Rec., 21(1):1-210.

Lensink, C.J. 1962. The history and status of sea otters in Alaska. Ph.D. Thesis, Purdue Univ., Lafayette, Ind. 188 p.

Martin, J.H. 1974. Bioaccumulation of heavy metals by littoral and pelagic marine organisms. Calif. State Univ., Moss Landing Mar. Lab., EPA Grant R802 350, 2nd Yr. Prog. Rept. 96 p.

Miller, D.J. 1974. The sea otter (Enhydra lutris) its life history, taxonomic status, and some ecological relationships. Calif. Dept. Fish Game, Info. Leaflet No. 7. 13 p.

______________, J. Hardwick and W. Dahlstrom. 1975. Pismo clams and sea otters. Calif. Dept. Fish Game, Mar. Tech. Rept., (31):1-49.

Morejohn, G.V., J.A. Ames and D.B. Lewis. 1975. Post mortem studies of sea otters (Enhydra lutris L.) in California. Calif. Dept. Fish Game, Mar. Tech. Rept., (30):1-81.

Morrison, P., M. Rosemann and J.A. Estes. 1974. Metabolism and thermoregulation in the sea otter. Physiol. Zool. 47(4):218-229.

Reost, A.I. 1973. Subspecies of the sea otter (Enhydra lutris). Los Angeles County, Nat. Hist. Mus., Contrib. Sci., (252):1-17.

Rote, J.W. 1975. Analysis of chlorinated hydrocarbon pollutants in the marine ecosystem. Ph.D. thesis. Hopkins Marine Station, Stanford Univ.

Stullken, D.E., and C.M. Kirkpatrick. 1955. Physiological investigation of captivity mortality in the sea otter (Enhydra lutris). No. Amer. Wildl. Conf., Trans., (20):476-494.

Turner, Richards, and Turner. 1974. Arizona State University. (Paper presented at 41st Inter. Cong. of Americanists, Mexico City, Sept. 2-7, 1974.)

Wild, P.W., and J.A. Ames. 1974. A report on the sea otter (Enhydra lutris L.) in California. Calif. Dept. Fish Game, Mar. Res. Tech. Rept., (20): 1-93.