Sea Otter, *Enhydra lutris*, Mortalities in California, 1968 through 1993

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Sea Otter, *Enhydra lutris*, Mortalities in California, 1968 through 1993

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Abstract

Sea otter, *Enhydra lutris*, mortality in California and the relative contribution from specific causes was assessed for the 26 years from 1968 through 1993. There were 2,082 dead sea otters recorded from Tomales Bay (Marin County) south to Bluff Cove (Los Angeles County) during that period. The average number of carcasses recorded was 80 per year and seven per month. Sex was identified in 87% (n=1,819) of the cases and was composed of 47% female and 53% male. A relative age was assigned to 97% (n=2,017) of the cases and was composed of 28% pup, 18% subadult and 54% adult.

Specific causes of death were determined for 26% (n=551) of the cases. The majority of these (n=381) were considered to be due to natural causes and included the following specific causes: shark bitten (n=78), probably shark bitten (n=106), other natural causes (n=140), and mating wounds (n=57). The remaining (n=170) were considered to be due to human-related causes and includedthe following specific causes: shot (n=72), probably shot (n=8), net drowned (n=76), and other human causes (n=14).

The large proportion of carcasses without an identified specific cause of death prompted a more detailed necropsy effort in 1992 and 1993. During that period, 78 of the 232 recovered carcasses were examined by veterinary pathologists and a specific cause of death was determined in 76% (n=59) of the cases. This effort identified a wide range of specific causes of death that otherwise may have been categorized as "unknown without trauma". Considering the variety of diseases diagnosed in this expanded necropsy program, it would be prudent to continue this level of examination to refine our knowledge of sea otter pathology.

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Introduction

The California Department of Fish and Game (Department) initiated sea otter, *Enhydra lutris*, population studies in 1968 (Wild and Ames 1974) in response to State Senate Concurrent Resolution 74 (Bissel and Hubbard 1968). Although the main objective of these studies was to provide a foundation for resolving conflicts involving sea otters and the commercial abalone industry, acquiring a better understanding of the sea otter's population dynamics was considered an important element in the safe management of the species in California.

Management responsibility for sea otters was assumed by the Federal government in 1972 with the passage of the Marine Mammal Protection Act. This Act and the listing of the population as threatened under terms of the Endangered Species Act in 1977 have guided all subsequent management decisions. The Department's sea otter research was supported in part by Federal funds for a period of time after they assumed management authority for the species.

Developing a knowledge of the otter's population dynamics has remained an important element in the formation of sea otter recovery plans and has been the focus of ongoing research. Mortality studies are an essential component of that research. A key objective in these studies has been the diagnosis of mortality causes and an assessment of the relative contribution of each cause to the total mortality.

Prior analyses of sea otter mortality data collected in California have identified a variety of mortality causes and in some instances have assessed their relative magnitude. A considerable amount of this information is available in the published literature. Mattison and Hubbard (1969) reported on the causes of death of 13 sea otters recovered in 1968 and 1969. Wild and Ames (1974) reported on the causes of death of 222 sea otters recovered through 1973. Morejohn et al. (1975) reported on the causes of death of 286 sea otters recovered through 1974. Ames et al. (unpublished report) reported on the causes of death of 1,057 sea otters recovered through 1982.

A variety of specific causes of death are reported in these analyses. White shark, *Carcharodon carcharias*, attacks on sea otters were frequently reported (Orr 1959, Ames and Morejohn 1980, Ames et al. in press). Mattison and Hubbard (1969), Wild and Ames (1974), Morejohn et al. (1975) and Ames et al. (unpublished report) reported on the occurrence of shot sea otters. Cornell et al. (1979) described the first known case of Coccidioidomycosis (Valley Fever) in a sea otter. Williams et al. (1980) reported on a female that died due to complications from giving birth to twins. Rennie and Woodhouse (1988) reported on a case of scoliosis and uterine torsion in a pregnant otter.

Although not diagnosed as causes of death, other health-related factors have been reported. Mattison and Hubbard (1969), Hennessey (1972), Morejohn et al. (1975) and Hennessey and Morejohn (1977) reported on the occurrence of parasites and food items found in the gastrointestinal tracts of sea otters. Shaw (1971), Rote (1976), and Risebrough (1989) reported on the presence of chlorinated hydrocarbons in sea otters. Martin (1974) and Risebrough (1989) reported on the presence of heavy metals in sea otters.

Riedman and Estes (1990) and Riedman et al. (1993) evaluated sea otter population data collected through 1989 and assessed the influence of mortality on population growth trends. They suggest that the California sea otter population's apparent slow growth rate was attributable to a high mortality rate rather than to a low rate of reproduction. This evaluation increased concerns for the health of the population.

The large proportion of sea otter carcasses without specific diagnosed causes of death generated support for more detailed mortality studies, and thus, the necropsy effort was expanded in 1992. Since then, the detailed examination of fresh carcasses by veterinary pathologists has greatly increased the proportion of carcasses with specific causes of death. Consequently, the baseline information on sea otter pathology has been greatly expanded.

In this report, we assess the relative significance of identified causes of mortality for the 26-year period from 1968 through 1993. We evaluate the influences of sex, age, temporal, and geographic factors on the relative significance of the more common causes of mortality. We also compare results from detailed necropsies on fresh dead otters with those obtained during field examinations.

Methods

Study Area

The study area included the California mainland coast and the Channel Islands where carcasses were found (Figure 1). Since the study began in 1968, the sea otter's mainland range has expanded from approximately 188 kilometers (km) to over 388 km in 1993 (Figure 2). The locations of recovered carcasses were identified to the nearest 0.5-km unit along a smoothed coastal contour line (ATOS line = As The Otter Swims/Strands line). Here we combined these units into 20-km segments identified as ATOS Recovery Areas (Figure 3). Although equal in length along the smoothed contour line, these 20-km segments do not have equal areas of habitat.

Recovery of Carcasses

Attempts were made to recover all reported dead sea otters. A majority of the dead otters recorded were reported by the public. Only verified carcasses were recorded. Some structured recovery efforts have occurred in which segments of beaches were regularly searched for carcasses.

Reports of dead sea otters were directed to cooperating agencies or organizations in the area of the stranding. In 1968, primarily Department personnel were involved in the recovery of dead otters. By the early 1970's, there was a network of agencies and organizations cooperating in the recovery efforts. By the 1990's, the network had expanded substantially. The Department's Sea Otter Research Project maintained responsibility for coordination of carcass recovery efforts and data management throughout the study period.

Carcass Examinations and Necropsies

Carcass examinations varied considerably from cursory external examinations to necropsies performed by biologists, medical doctors or veterinary pathologists. Carcasses were either examined at the recovery site or collected for later examination. When an examination was performed at the recovery site, the skull and baculum (if the otter was a male) were usually collected for cleaning and ageing and

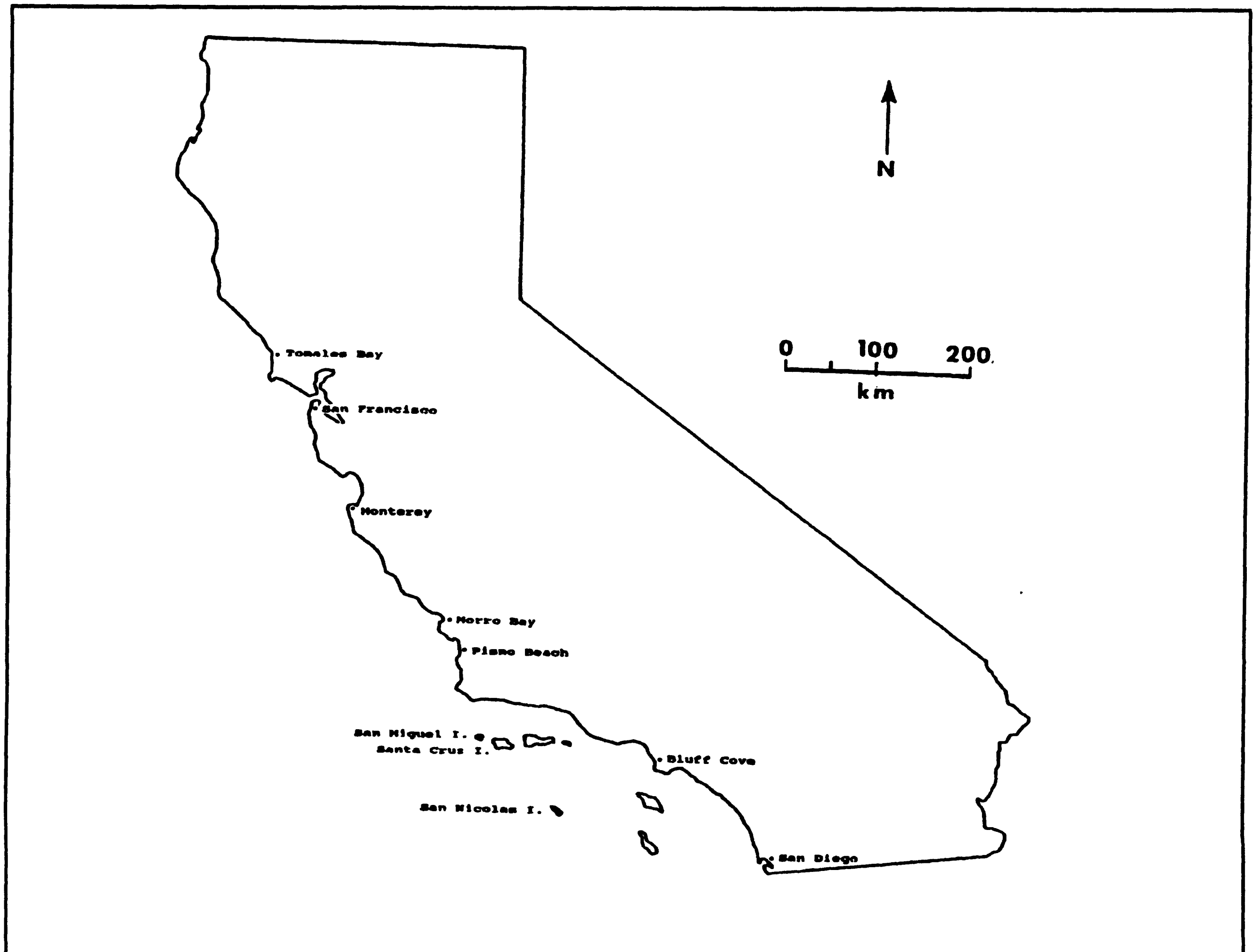

FIGURE 1. California and Channel Islands.

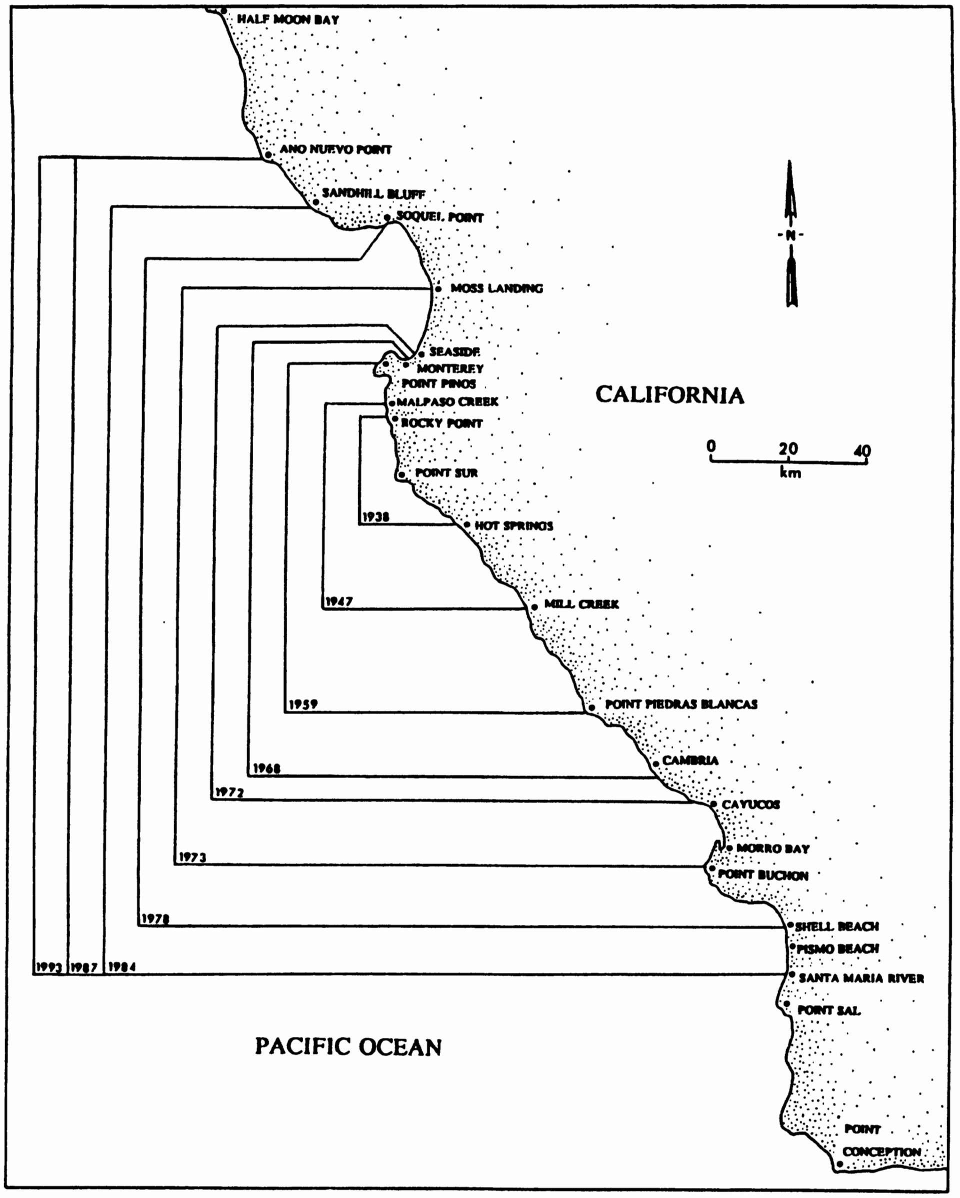

FIGURE 2. Sea otter range expansion in California, 1938-1993.

the remainder of the carcass was buried. A typical examination began with an external inspection to determine carcass condition, sex, total length, teeth condition, tags or tag wounds, and for indications of trauma or abnormalities. When feasible, an internal examination was also conducted to assess whether acute or chronic factors were implicated in the cause of death. Internal examinations usually included an assessment of the presence of parasites, enteritis, food in the gut, infections and physical trauma. A detailed protocol for conducting necropsies is described in Appendix 1. Beginning in 1992, fresh carcasses were handled following a specific protocol discussed under Special Studies.

Recorded Information

Data were recorded on a Dead Sea Otter Fact Sheet following the Protocol for Stranded and Dead Sea Otters (Appendix 1). Recovery location was recorded in three different ways: 1) A written description of the recovery location; 2) The Recovery Area Code; and 3) The ATOS# (Appendix 1). If the ATOS# was not identified on the initial report, it was subsequently assigned based on the written description of the recovery location.

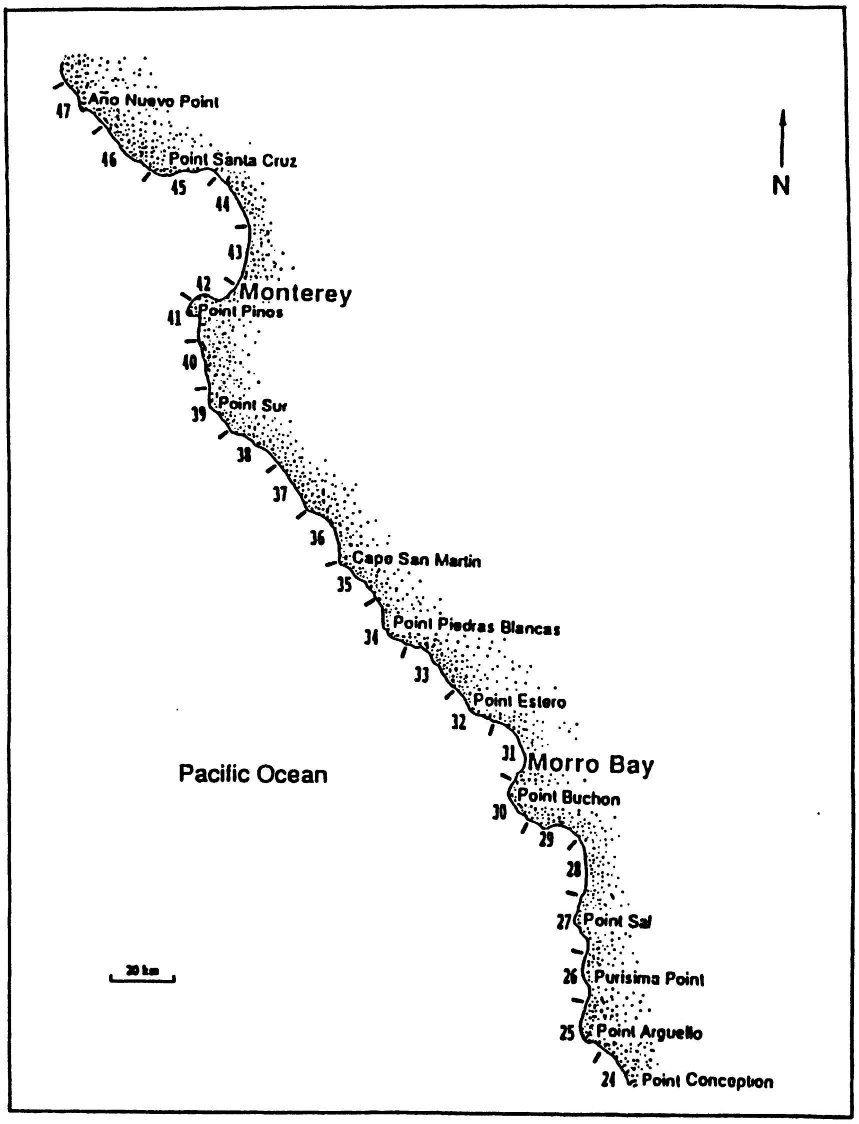

FIGURE 3. Sea otter carcass ATOS recovery areas (20-Km sections) along the central California coastline.

Condition of animals at the time of recovery varied from moribund to mummified and fragmented. Eight categories were developed to describe condition. Two of these categories, Captive and Rehabilitated, were not used for this report (Appendix 1).

The relative age of an animal was determined based on the animal's total length, teeth condition, and pelage type. Skull characteristics, such as tooth eruption and the degree of fusion of various sutures of the skull (Morejohn et al. 1975), were subsequently used to reassess the initial age assessment in many cases. However, body length was often the only parameter used to assign an age category. We summarized age data using three general age groups: Pup (pup, immature and young); Subadult; and Adult (adult and aged adult) (Appendix 1).

Total length and weight were recorded to the nearest centimeter and kilogram, respectively. If either measurement was considered to be questionable it was recorded with a qualifying symbol (Appendix 1).

Teeth condition was evaluated by a subjective assessment of wear patterns (Appendix 1). Beginning in 1990, vestigial premolars were regularly removed from subadult and adult carcasses for ageing studies. These were sent to Matson's Laboratory, Milltown, MT where the teeth roots were cleaned, sectioned, and an age assigned based on a count of cementum layers. This information was not assessed for this report.

Sex identification was usually based on the presence or absence of the male baculum. The shape of the pelvic girdle was occasionally used when the carcass was fragmented (Morejohn et al. 1975). Some carcasses were so decomposed or scavenged that sex was not determined.

When tags were noted, information on tag type, color, number, right or left flipper, and position on the flipper were recorded; position and description of tag wounds were noted for missing tags. Initiated in 1968, an electronic reader was used to determine whether a subcutaneous Passive Integrated Transponder (PIT) was present to identify tagged individuals with missing tags, (Thomas et al. 1987) (Appendix 1).

Since the early 1970's, most of the carcasses with small penetrating wounds were x-rayed to evaluate whether a gunshot could have caused the mortalities. Cases where a bullet passed completely through a carcass were often detected by the observation of broken or fractured bones on x-rays or from noting a path of damage through tissues during a necropsy. Often when carcasses exhibited indications of human-caused injuries (e.g., shot, net entanglement, or propeller wounds) a Department warden (prior to 1972) or a United States Fish and Wildlife (USFWS) Special Agent was contacted and, where appropriate, a Chain of Custody Record was completed (Appendix 1).

Mortality categories used to summarize causes of death ranged from unknown to precisely known causes of death. These include: Unknown; Uncertain with Trauma; Uncertain with No Trauma; Shark Bitten; Probably Shark Bitten; Lacerated; Shot; Probably Shot; Research Otters; Other Human Causes; Other Natural Causes; Obviously Dependent Otter with No Trauma; Obviously Dependent Otter with Trauma; Mating Wounds; Dead Pups Observed with Mother; Net Drowned; and Live Captive Otters (Appendix 1). Research Otters and Live Captive Otters categories were not used in this analysis.

We reviewed the records to verify continuity in application of assigned mortality categories. In some cases, we changed the assigned mortality category upon review. For example, otters originally classified into the "uncertain with no trauma" category but had obvious signs of enteritis, no fat, and a heavy acanthocephalan parasite infection were reclassified into the "other natural causes" mortality category.

Special Studies

Fresh Carcass Necropsy Study

A study was initiated in January 1992 in which all fresh sea otter carcasses were necropsied by veterinary pathologists. This was a cooperative effort involving the USFWS, the National Biological Service (NBS), the National Wildlife Health Center (NWHC), and the Department. The goal of the study was to develop baseline data on sea otter pathology and examine in greater detail the large proportion of recoveries that were typically diagnosed with no apparent cause of death by field biologists. In April of 1992, the NWHC laboratory was selected to conduct the necropsies. A single laboratory was used to insure consistency in procedures and results. Before the laboratory was selected, all fresh carcasses and carcasses of special interest (shot, tagged, and known-age otters), except pups were recovered and frozen. Initially pups were not included because limited resources were focused towards cases in which it was thought the most information could be gained. However, in December 1992, the study was expanded to include all fresh pup carcasses.

Valley Fever Study on Decomposed Sea Otters

A cooperative study designed to determine the presence of the fungus *Coccidioides immitis* in decomposed sea otter carcasses was initiated in 1993. This study was initiated after the fungus had been identified in sea otters by the fresh carcass necropsy studies. Tissue samples of lung, liver and kidney were collected from a number of field necropsied carcasses. These were processed by Central Coast Pathology Consultants Inc., San Luis Obispo, CA.

Results and Discussion

Annual Mortality

A total of 2,082 sea otter carcasses was collected during the 26-year period. Annual recoveries ranged from 16 in 1968 to 153 in 1981 (Figure 4a), and averaged 80 per year. Several peaks in annual mortality occurred. Wild and Ames (1974) reported a peak in mortality in 1970 when 51 carcasses were recorded. Six of these were determined to have been shot. Ames et al. (unpublished report) identified a peak in mortality in the late 1970's. There was also an apparent peak in annual mortality in the early 1980's when an annual average of 129 mortalities was recorded each year during a 5-year period. Since 1985, annual mortality has increased gradually as has population size. An average of 89 carcasses per year was recorded during this 9-year period.

Seasonal Mortality

Monthly mortality ranged from 0 to 23 and averaged seven otters. Frequency distribution by month suggests that mortality peaked from March through August (Figure 5a).

The assessment of seasonal trends is based on recovery date. The date a carcass was found was usually not the date of death. No adjustment was made for date of death based on carcass condition. We think that most of the animals identified as decomposed probably died within 1 month of the date found. Further, the assessment of seasonal influences on mortality patterns may be limited by seasonal changes in temperature affecting the rate of decomposition.

Also influencing the seasonal recovery of carcasses is the amount of human activity along the coast. June through August is a period of high human activity along California beaches. With more people on the beaches, the probability of a carcass being found and reported increases. However, the number of fresh carcasses found during the summer did not increase appreciably, possibly because warm summer weather increases the rate of decomposition.

Wild and Ames (1974) reported a significant increase in mortality during early 1973; 55 carcasses were recorded from January through April. They suggest that severe winter storm conditions contributed to most of the deaths. A majority of the recoveries were young (pup and immature) animals and several were aged adults. Conditions commonly observed in those that were necropsied were emaciation, hemorrhagic enteritis, and pneumonia. Morejohn et al. (1975) also commented on the significant increase of mortalities from January through April in 1973. They developed a weather-roughness index which correlated well with this peak in seasonal mortality. They also reported an increase in otter mortality during the later half of 1972, despite mild weather. This increase in mortality was attributed to population pressures (Morejohn et al. 1975).

Mortalities By Sex Composition

Sex was identified in 87% (n=1,819) of the documented mortalities. There was an average of 32 female and 37 male otters per year (1:1.16). Male mortalities were numerically dominant in 20 of the 26 years (Figure 4b). For all years combined, males were also dominant in all months except March, November, and December (Figure 5b).

Although sex composition varied through time, the percentage of females increased during the study period. Wild and Ames (1974) reported the sex composition for 203 otters to be 38% female and 62% male. Morejohn et al. (1975) reported 39% female and 61% male for 264 carcasses. Ames et al. (unpublished report) reported 42% female and 58% male based on 911 cases where sex was identified. In our study, the composition was 47% female and 53% male, based on 1,819 sexed recoveries. We believe this increase in the proportion of recovered female carcasses is due to range expansion. Well-established female rafting sites now occupy areas that were once the range periphery, male-dominated, and easily accessible for recovery of carcasses.

Relative Age Composition

Relative age was assigned in 97% (n=2,017) of the total recorded mortalities, and sex was determined for 90% of those (n=1,815). Adults exceeded pups and subadults combined for 23 of the 26 years (all but 1968, 1971 and 1973) (Figure 4e) and in all months except April, based on cumulative data (Figure 5e). In April, pup recoveries almost exceeded adults (41% pups compared to 44% adults).

Based on the cumulative data of aged recoveries (n=2,017), the age composition was 28% pups, 18% subadults, and 54% adults. The percentage of females assigned a relative age (n=848) included: 26% pups, 16% subadults, and 58% adults. The percentage of males assigned a relative age (n=967) included: 25% pups, 20% subadults, and 55% adults.

There were no obvious trends in the occurrence of subadults and adults in the total annual mortality (Figure 4c, 4d, and 4e). However, the relative abundance of pups appeared to cycle around a 28% average (Figure 4c).

Seasonal mortality trends differed among age groups (Figure 5c, 5d, and 5e). All age groups were recovered in every month of the year. Pup mortality was highest from January through May (Figure 5c). The peak coincides with the primary seasonal peak in pupping (Wendell et al. 1984). Kenyon (1969)

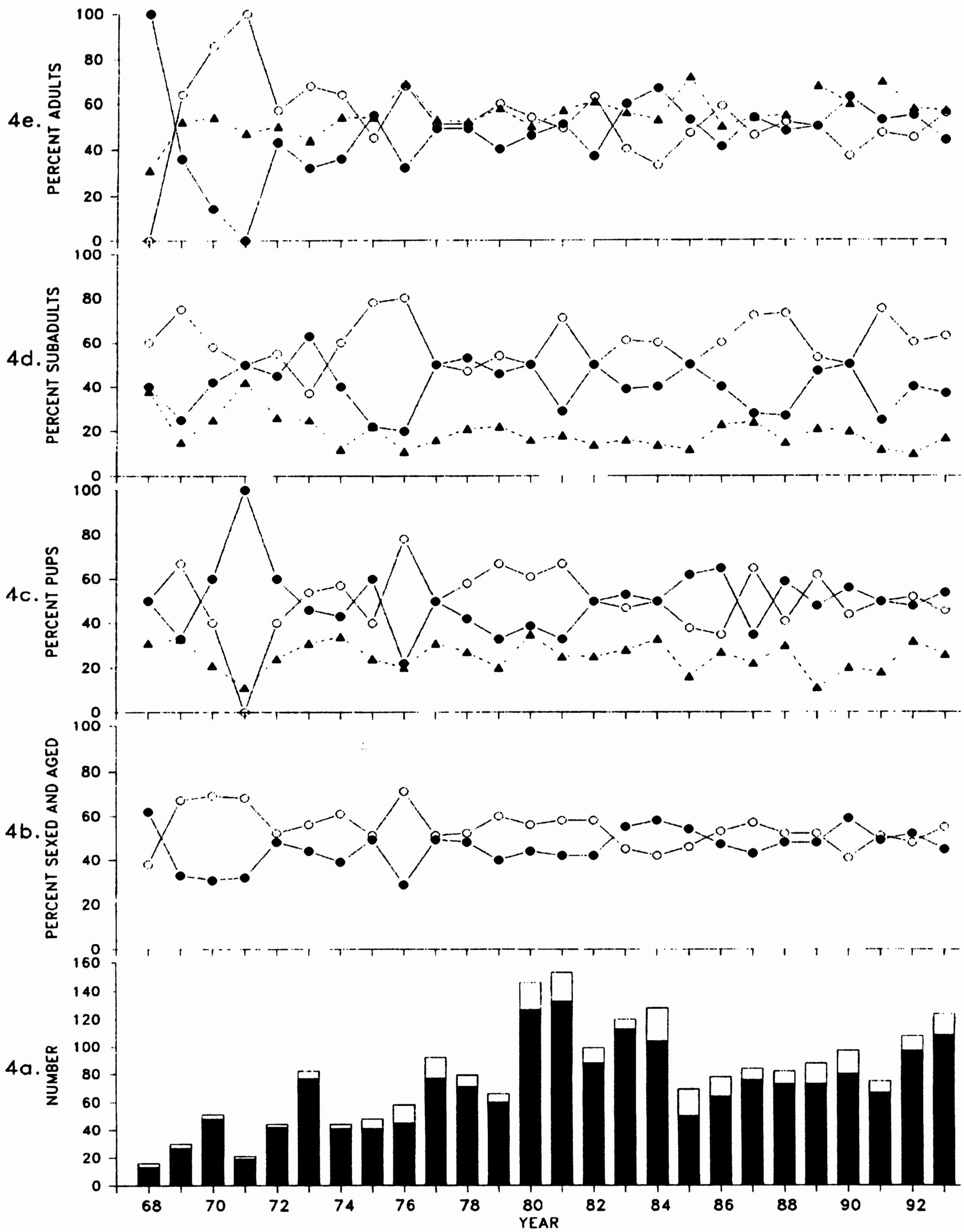

FIGURE 4. Recovered dead sea otters by year, 1968-1993.

□ = Total Number Recorded
■ = Number Sexed and Aged
● = Female
○ = Male
▲ = Percent of Number Sexed and Aged

a. Total Number Recorded	n = 2082	
Number Sexed and Aged	n = 1815	

	Female	Male
b. Percent Sexed and Aged	n = 848	n = 967
c. Percent Pups	n = 224	n = 247
d. Percent Subadults	n = 135	n = 190
e. Percent Adults	n = 489	n = 530

commented that pups may be abandoned if the mother is unable to acquire an adequate amount of food to sustain both mother and pup. Subadult mortality was highest from June through January, with a peak in August (Figure 5d). Adult mortality was highest from June through December, with a peak in October (Figure 5e).

Recovery By Area

Sea otter carcasses were recovered beyond their established range, as far north as Tomales Bay, Marin County, and south to Bluff Cove, Los Angeles County and from San Miguel and Santa Cruz Islands (Figure 1). Research-related mortalities occurred at San Nicolas Island and as far south as San Diego but are not included in this analysis.

The number of mortalities varied within the ATOS Recovery Areas (20-km segments), and were concentrated at both ends of the range. We believe this is primarily a reflection of limited coastal access and a sparse human population in the middle of the range rather than a reflection of actual mortality rates. However, we also see that it may be partially reflective of spacial distribution (concentration at the range peripheries) or a geographically disparate cause of mortality (Acanthocephalan enteritis/ peritonitis associated with sandy habitat near the range peripheries).

The proportion of females recovered in the middle of the range (Point Pinos to Cambria) was higher than at the range peripheries (Figure 6b). That portion of the range was well established and occupied predominantly by females and pups through the study period; 65% (n=644) of the total carcasses recorded where sex was identified were female. Males showed the opposite pattern with higher proportions recovered at the range peripheries (Figure 6b). Also, the proportion of pups tended to be higher in the middle of the range. Consequently, the proportion of adults and subadults was greater near the range peripheries (Figure 6e, 6d).

In most cases, the carcass recovery area probably reflects the general area occupied while the otter was alive because the typical wind and wave patterns tend to push carcasses onto adjacent beaches. However, the recovery site was not always in the area where the otter lived or died. Morejohn et al. (1975) reported on carcasses recovered from the Morro Bay area before there were otters living within 8 km of the area. Consequently, the carcass-recovery location data do not accurately reflect geographic population configurations.

Mortality Causes

General

A carcass condition was recorded for 94% (n=1,964) of the total mortalities and ranged from fragments to whole carcasses in widely varying stages of decomposition. Of the 1,964 cases, 31% (n=608) were fresh. The remainder (69%, n=1,356)

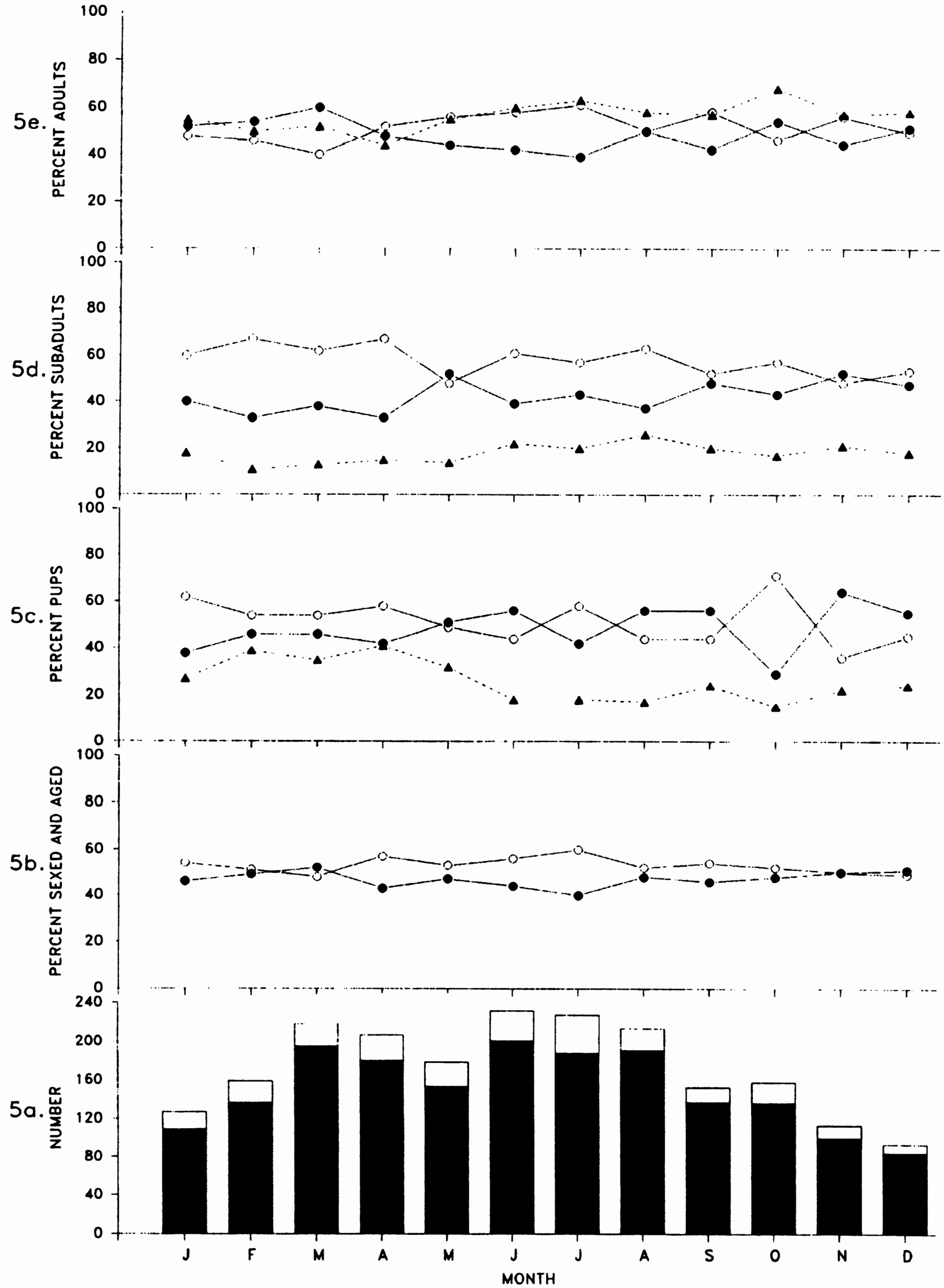

FIGURE 5. Recovered dead sea otters cumulative by month, 1968-1993.

□ = Total Number Recorded
■ = Number Sexed and Aged
● = Female
○ = Male
▲ = Percent of Number Sexed and Aged

a. Total Number Recorded	n = 2082	
Number Sexed and Aged	n = 1815	
	Female	**Male**
b. Percent Sexed and Aged	n = 848	n = 967
c. Percent Pups	n = 224	n = 247
d. Percent Subadults	n = 135	n = 190
e. Percent Adults	n = 489	n = 530

were in more advanced states of decomposition.

The condition of a carcass can affect the ability to determine the cause of death. Any mortality source that leads to faster decomposition would be underestimated if the diagnostic characteristics disappear with decomposition. For example, small carcasses (pups) and carcasses in which the body cavity has been opened (due to trauma and/or scavengers) generally decompose at a faster rate than large (adult) or whole carcasses.

A specific cause of death was identified in 26% (n=551) of the cases. Natural causes was the most commonly identified cause of death (18%, n=381). Natural causes included: shark bitten (n=78); probably shark bitten (n=106); other natural causes (n=140); and mating wounds (n=57). The remaining cases with an identified specific cause of death fall under the general category of human-related mortalities (8%, n=170) and included: shot (n=72); probably shot (n=8); net drowned (n=76); and other human causes (n=14) (Figure 7a).

The cause of death was uncertain in 74% (n=1,531) of the cases and included: unknown (n=519); uncertain with trauma (n=127); uncertain with no trauma (n=398); lacerated (n=54); obviously dependent otter with no trauma (n=351); obviously dependent otter with trauma (n=52); and dead pups observed with mother (n=30).

Natural

Predation. The ability to discern a shark-attack mortality has improved through time. Ames and Morejohn (1980) reexamined wound descriptions and reassigned cause of death from boat propeller wounds to probable shark-bite wounds in 22 cases reported by Wild and Ames (1974). Evidence indicating an attack by white sharks includes shark tooth fragments, scratch patterns matching the white shark tooth serration on otter bone, and wound (puncture and laceration) patterns. Using these criteria, 11% (n=238) of the recorded mortalities were caused by a shark bite. However, only 78 were certain or nearly certain to have been bitten by a white shark. An additional 106 were probably shark bitten and 54 were lacerated (Figure 7a). Lacerated carcasses were included because we believe that these carcasses were most likely shark bitten.

There was an average of nine shark-bitten carcasses (including the lacerated category) per year with a range from four to 16 (Figure 8). The number of shark-bitten carcasses recovered annually varied without an apparent trend. Shark-bitten carcasses have been recovered in all months, but most frequently from March through August (Figure 9).

Shark mortality was dominated by males (male n=170, female n=64, unknown sex n=4). Adults were recovered more often than other age groups

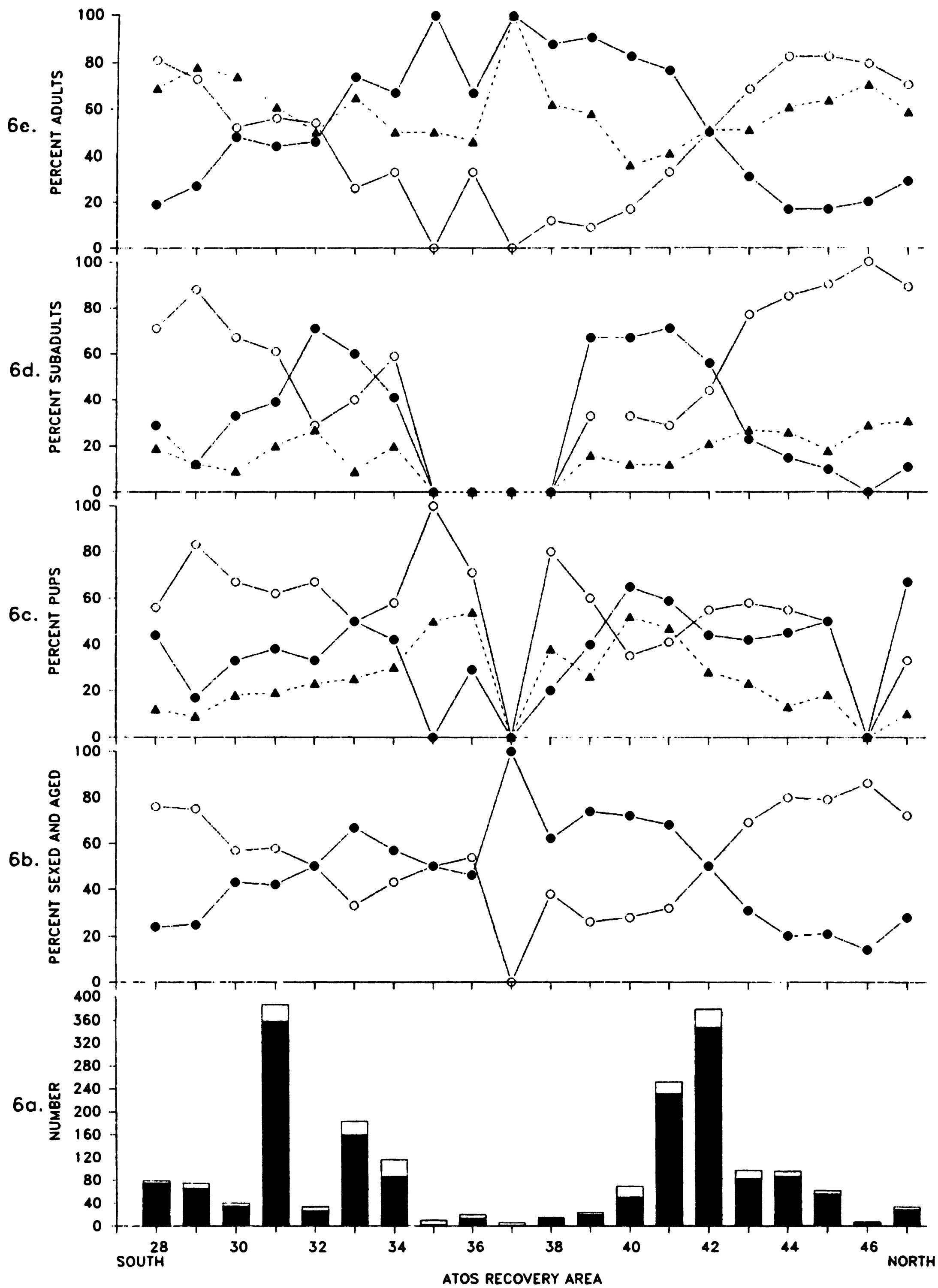

FIGURE 6. Recovered dead sea otters by ATOS recovery areas, 1968-1993.

□ = Total Number Recorded
■ = Number Sexed and Aged
● = Female
○ = Male
▲ = Percent of Number Sexed and Aged

a. Total Number Recorded	n = 2082
Number Sexed and Aged	n = 1815

	Female	Male
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(adult n=155, subadult n=68, and pup n=11), but shark-bitten subadults were recovered in proportionally greater numbers. Males dominated both the subadult and adult age categories (Figure 10). The low proportion of pups (5%) may be attributable to their rapid decomposition, reduced likelihood of recovery, or being consumed whole.

Shark-bitten otters were recovered most commonly in the Monterey Peninsula and Morro Bay areas (Figure 11). Forty-three percent (n=102) of all shark-bitten carcasses were recovered in the Monterey area, from Indian Head Beach to Point Lobos (ATOS Recovery Areas 41 and 42). Sixteen percent of the recoveries from that area (102 of 631) were shark bitten. Fourteen percent (n=34) of all shark-bitten carcasses were recovered in the Morro Bay area from Cayucos Point to the south end of the Morro Bay Sandspit (ATOS Recovery Area 31). Nine percent of the recoveries from that area (34 of 386) were shark bitten. Shark attack is a significant source of mortality within these areas and could be a significant factor in limiting population growth rangewide particularly since it often involves otherwise healthy prime-age adults.

Other potential predators include the killer whale, *Orcinus orca*, and the Steller sea lion, *Eumetopias jubatus*. There is very little evidence that killer whales or Steller sea lions prey on sea otters. Thus, predation by animals other than white shark does not seem to be a significant source of mortality. Kenyon (1969) reported that killer whales and sea otters in close proximity seemed unaware of one another. Steller sea lions have been reported to feed on sea otters (Steller 1742). Tikhomirov (1964) states that Kamchatkan aborigines reported sea lions feeding not only on fish but also on seals and sea otters. A deep penetrating wound to the chest with fracture of the scapulohumeral joint in a California sea otter was diagnosed as a bite injury compatible with a sea lion attack.

Mating Wounds. Male otters often inflict nose and other facial injuries to females during mating. Live females are often observed with nose wounds of varying severity, ranging from small scars to significant portions of the nose pad missing. The contributing effect of a mating wound to a mortality is difficult to determine. Seven percent (n=57) of the total female otter carcasses (n=849) recovered had mating wounds severe enough that we considered them to be a significant factor in the cause of death. An average of two females with a range from 0 to 10 per year were documented as mating mortalities. Mating mortalities have been recovered in all months, but most frequently during the winter-spring period. Mortalities from mating wounds occurred in both subadult and adult females, but the majority were adults (Figure 7).

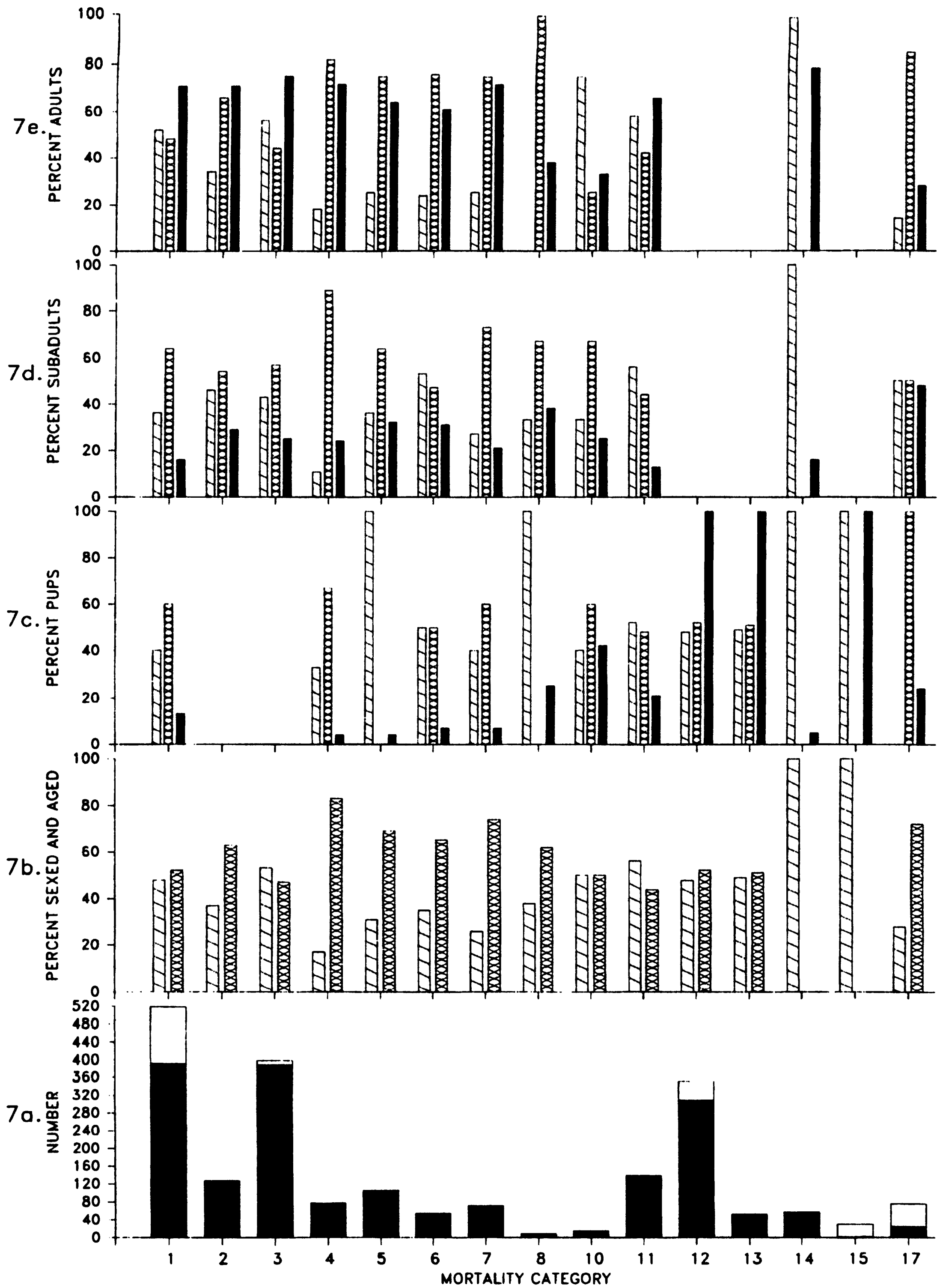

FIGURE 7. Recovered dead sea otters by mortality categories, 1968-1993.

= Total Number Recorded
= Number Sexed and Aged
= Female
= Male
= Percent of Sexed and Aged

a. Total Number Recorded	n = 2082	
Number Sexed and Aged	n = 1815	
	Female	**Male**
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Mortality Categories

1 Unknown
2 Uncertain; with trauma
3 Uncertain; with no trauma
4 Shark bitten
5 Probably shark bitten
6 Lacerated
7 Shot
8 Probably shot
9 Research - not included
10 Other human causes
11 Other natural causes
12 Obviously dependent otter with no trauma
13 Obviously dependent otter with trauma
14 Mating wounds
15 Dead pups observed with mother
16 Discontinued
17 Net drowned
18 Live captive otter - not included

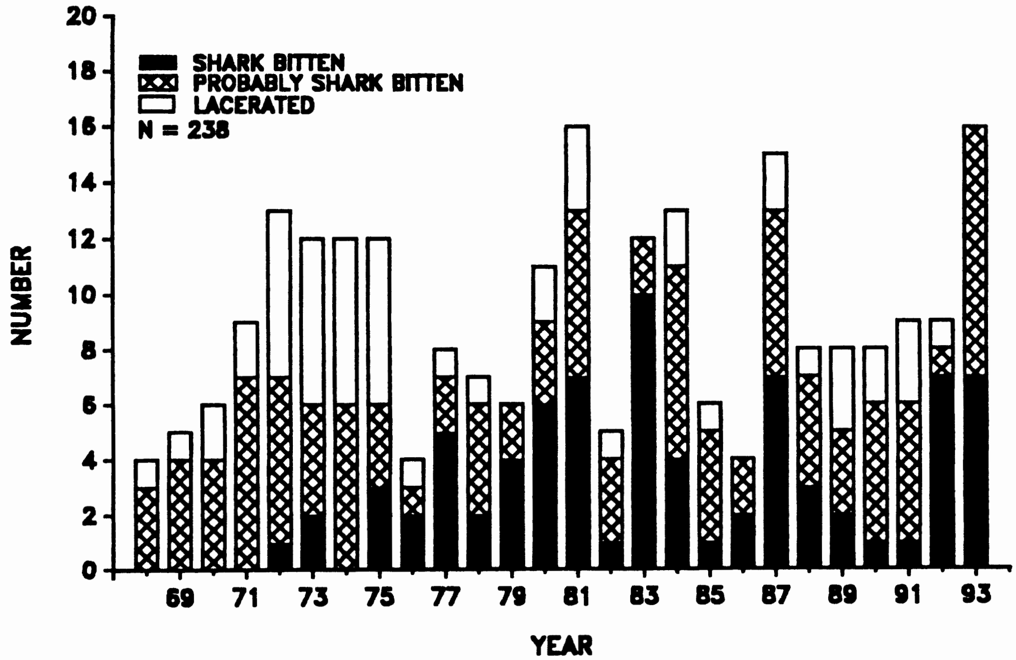

FIGURE 8. Recovered shark-bitten sea otters by year, 1968-1993.

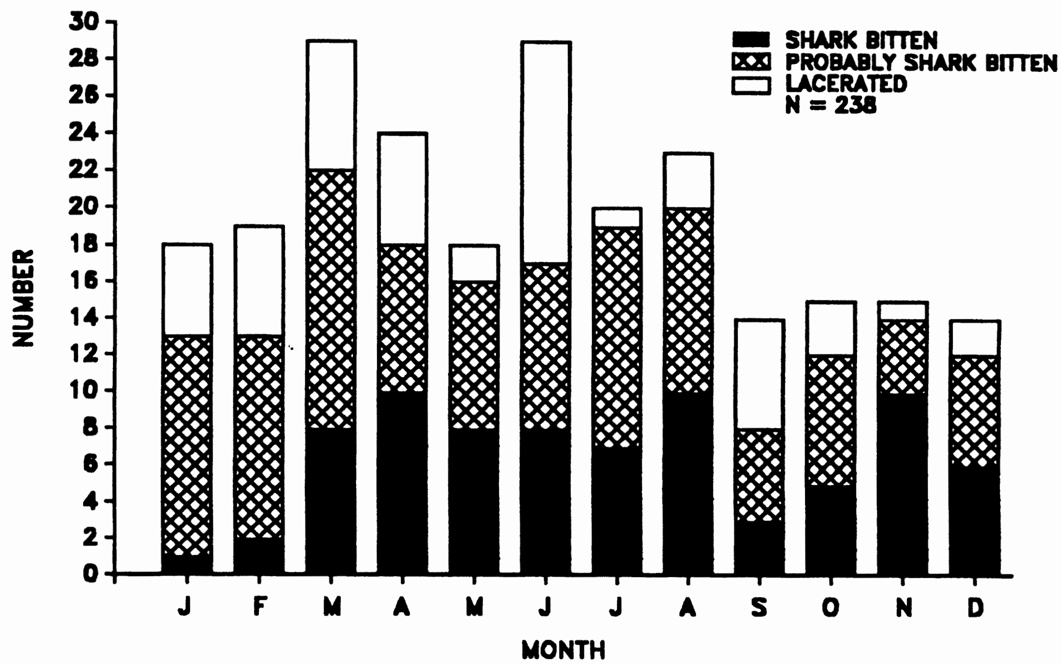

FIGURE 9. Recovered shark-bitten sea otters cumulative by month, 1968-1993.

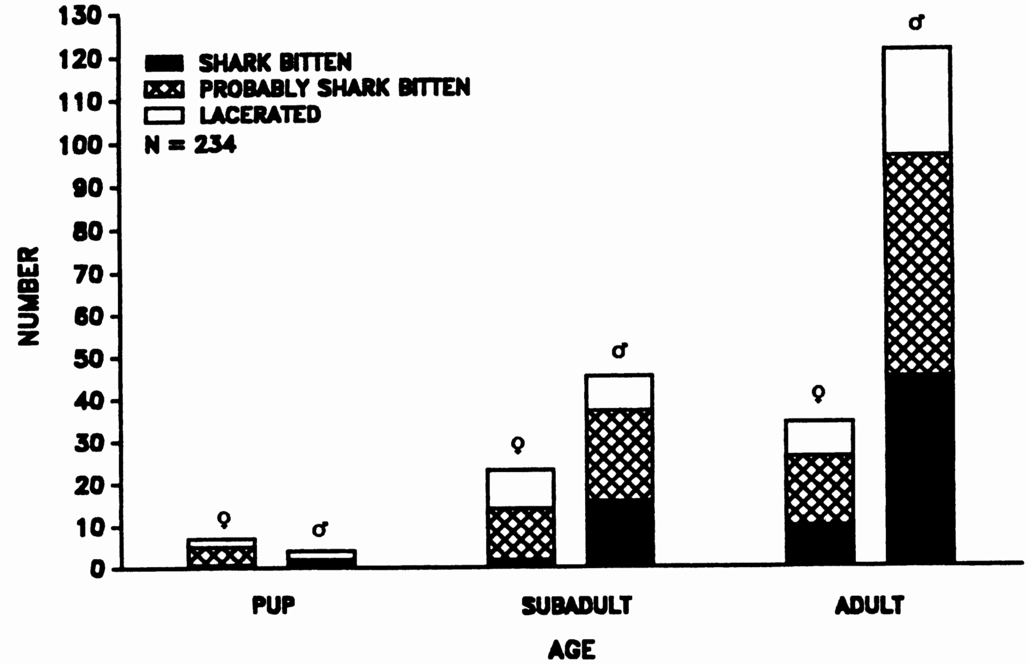

FIGURE 10. Recovered shark-bitten sea otters by sex and age, 1968-1993.

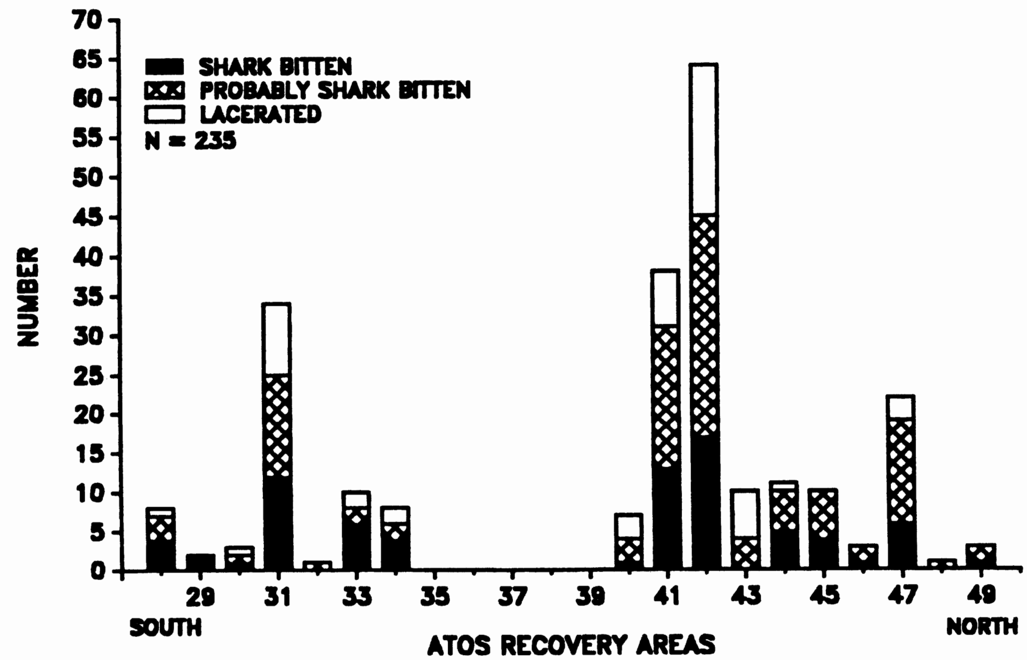

FIGURE 11. Recovered shark-bitten sea otters by ATOS areas, 1968-1993.

Detailed necropsies performed by NWHC pathologists identified mating wounds as the cause of death in only one case. However, in four other cases where the pathologist listed emaciation as the primary cause of death, we had judged the mating wounds as severe enough to be listed as the primary cause of death.

Other Natural Causes. Other natural causes included identified diseases, conditions and ailments not associated with predation or mating trauma. During the study, a wide variety of causes were diagnosed. Following is a list of some reported conditions, not including diagnoses from the study on fresh carcasses during 1992-1993: acute hepatitis, aspergillosis of the liver, coccidioidomycosis (Valley Fever), diaphragmatic hernia, intestinal infection, intussusception, perforated intestine, peritonitis, prolapsed rectum, prolapsed uterus, prolapsed vagina, stomach ulcers, twisted intestine, twin fetuses lodged in the birth canal, and uterine leiomyomas (Morejohn et al. 1975; Williams et al. 1980; Ames et al. unpublished report).

Weight loss prior to death is common in otters suffering from a prolonged debilitating condition. A number of mortalities where a debilitating condition was identified and many where the cause of death was unknown appeared emaciated. Emaciation with indications of stress (hemorrhagic enteritis, acanthocephalan enteritis, and acanthocephalan peritonitis) were commonly observed in carcasses, but comments regarding emaciation were not consistently kept. Regardless, it is difficult to determine if a disease compromised an animal's ability to forage, or if the lack of forage exacerbated the severity of the condition (Ames, et al. unpublished report).

Wendell et al. (unpublished report), using a subset of these mortality data, assessed geographical differences in poor body condition (emaciated). The appraisal of poor body condition was based on a double-split length-weight regression approach using all accurate length-weight data. All cases, sorted by sex, with a weight that fell below the initial length-weight regression line were used to develop a second length-weight data set. Cases where weight fell below the regression line of this second set were considered to be in poor body condition.

Based on this criterion, otters within the well-established portion of the range were in generally poorer body condition than those at the range peripheries. Also, significantly more emaciated animals were within certain age groups in the well-established range, compared with those age groups in newly occupied areas. The analysis suggests that the well-established range was at or near carrying capacity and those otters that died without trauma in the well-established range were more likely to have died from natural, density-dependent causes. Food resource availability is suggested as a limiting factor within the well-established portion of the range for some age groups (Wendell et al. unpublished report).

Human-Related Causes

Shot. Four percent (n=80) of all recorded carcasses were shot, including 72 carcasses where the diagnosis was certain or nearly certain and eight that were probably shot (Figure 12). An average of three carcasses was recorded as shot per year with a range from 0 to nine. The percentage shot by year varied from 0 to 11 and showed no apparent trend (Figure 12). Shot carcasses have been recovered in all months, but most frequently from May through August (Figure 13). More males than females were shot (58 and 22 respectively), and more adults than other age groups were shot (adult=55, subadult=18, pup=7) (Figure 14). Males dominated the shot mortalities in subadult and adult age groups.

Shot otters have been recovered along both the southern and northern sea otter range peripheries, but the highest frequencies of occurrence were in the Monterey and Morro Bay to Pismo Beach areas (Figure 15). The number of shot otters within ATOS Recovery Areas ranged from zero to 26 (Figure 15). Thirty-one percent (n=25) of all shot otters were recovered in the Monterey area from Aptos Creek to Point Joe (ATOS Recovery Areas 42-44). This is 4% of that area's total carcass recoveries (n=572). Sixty-one percent (n=49) of all shot otters were recovered from Cayucos Point to the Santa Maria River near the southern range periphery (ATOS Recovery Areas 28-33). This is six percent of that area's total carcass recoveries (n=795).

Accidental Drowning in Gill Nets. In 1973, the sea otter population expanded its range into areas where the gill and trammel net fishery for California halibut, *Paralichthys californicus*, was concentrated (Wendell et al. 1986). From 1980 through 1984, there was a significant increase in documented sea otter mortality (Figure 4a). An annual average of 129 mortalities was recorded during that period. Wendell et al. (1986) identified accidental drowning in nets as a major contributor to this elevated mortality. The annual number of otters actually observed in nets

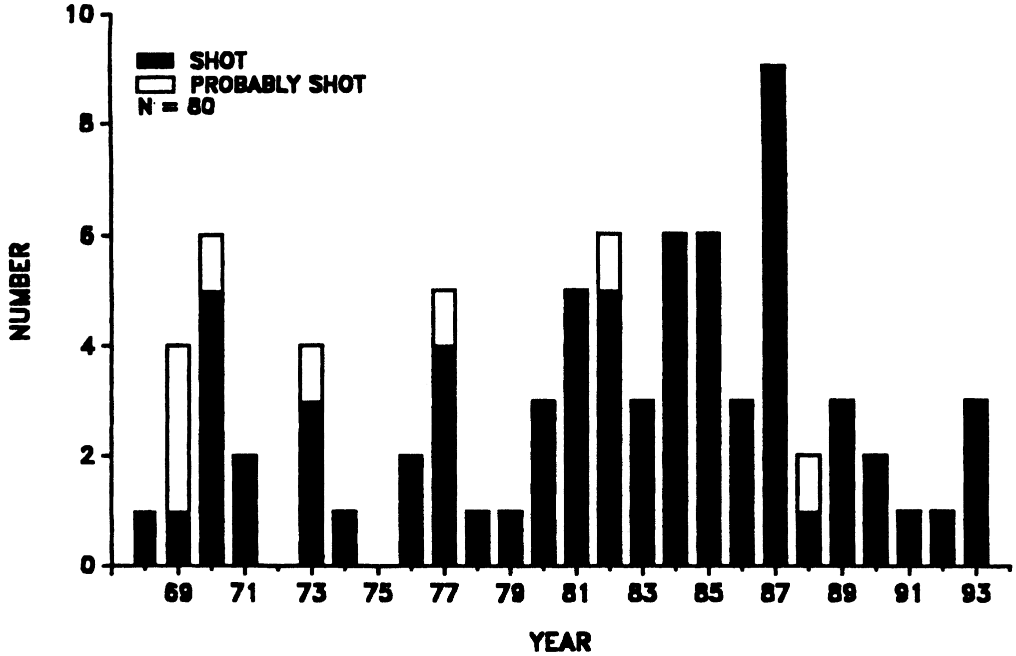

FIGURE 12. Recovered shot sea otters by year, 1968-1993.

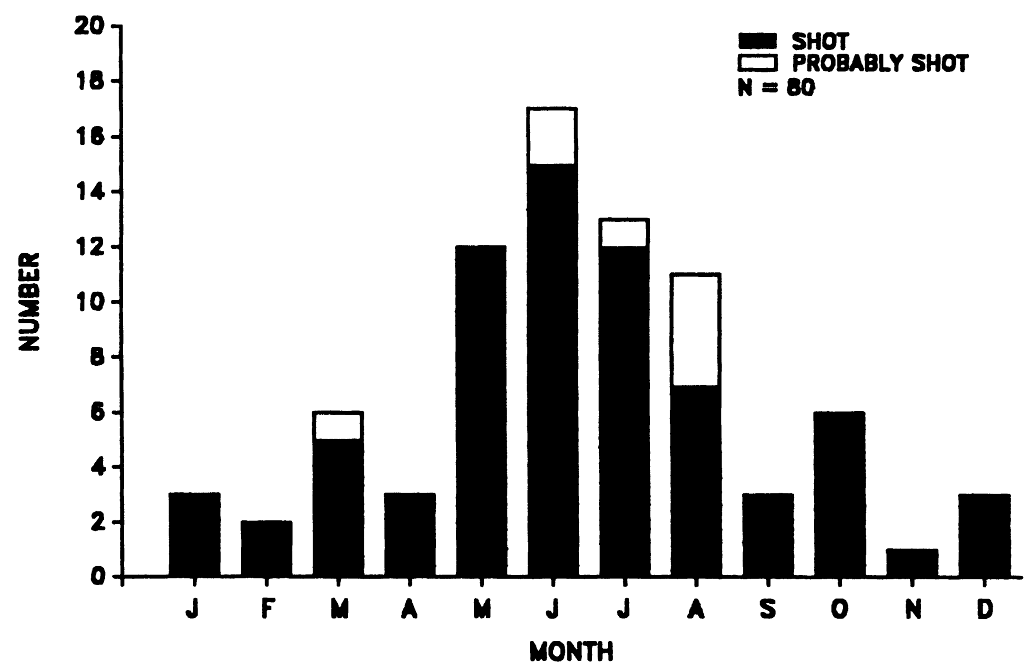

FIGURE 13. Recovered shot sea otters cumulative by month, 1968-1993.

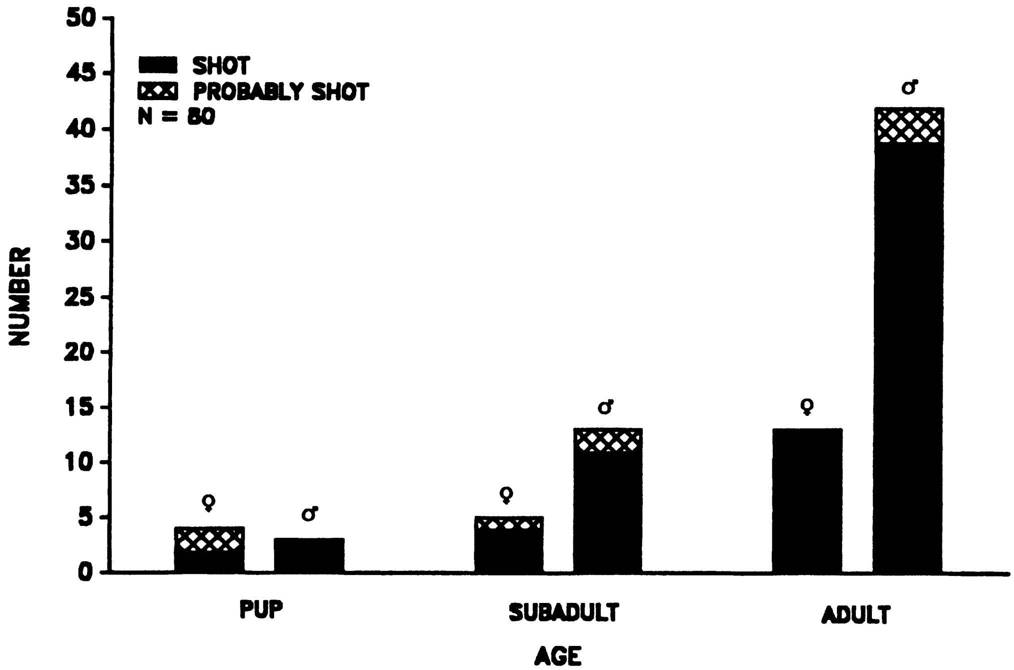

FIGURE 14. Recovered shot sea otters by sex and age, 1968-1993.

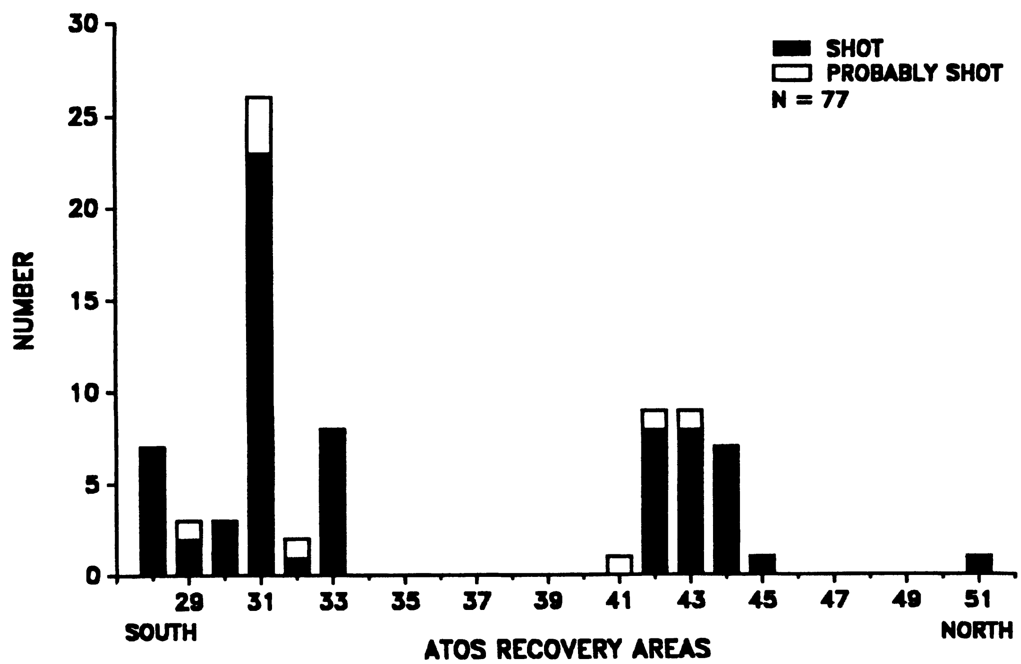

FIGURE 15. Recovered shot sea otter by ATOS areas, 1968-1993.

during that period ranged from 0 to 16 (Figure 16). Wendell et al. (1986) estimate that 80 otters were drowned annually.

These data suggest that the level of accidental take of sea otters could have been a significant factor in the apparent lack of sea otter population growth in the late 1970's and early 1980's (Wendell et al. 1986). Since 1982, a series of laws restricting the use of entangling nets within the sea otter's range has gradually lowered the accidental take of otters to near zero (Wild 1990).

Other Human Causes. Documented mortality attributable to human-related causes, other than shooting and drowning in nets, was uncommon. These include drowning in lobster traps (1), crab traps (1), and fish traps (2); cuts associated with net or fishing line entanglement (3); collision with boats (3); entanglement with fish hooks (1); and exposure to oil (1) (Figure 16).

Mortality from environmental contaminants has not been documented. However, studies have focused on assessing the levels of contaminants in sea otter tissues and in their habitat (Shaw 1971, Rote 1976, Martin 1974, and Risebrough 1989).

Special Studies

Fresh-Carcass Necropsy Study

Since work began on this report, many of the 1992 and 1993 NWHC preliminary reports have been amended. Therefore, to provide the most useful data and best comparison, the information in this section has been updated and may not reflect the data provided in other sections of this report. All of the updated information reflects changes to the diagnosed causes of death.

During 1992 and 1993, 232 carcasses were recorded. Thirty-two percent (n=75) of these carcasses were examined by the NWHC veterinarian pathologists. Twenty-eight percent (n=64) of the carcasses were considered fresh and are used in a comparison with results obtained from examinations by field biologists. Of 11 decomposed carcasses examined by the NWHC, causes of death were diagnosed for only four and include: acanthocephalan peritonitis, emaciation, probable shark bite, and shot.

A wide variety of diseases, conditions, and ailments were diagnosed by the pathologists. Often,

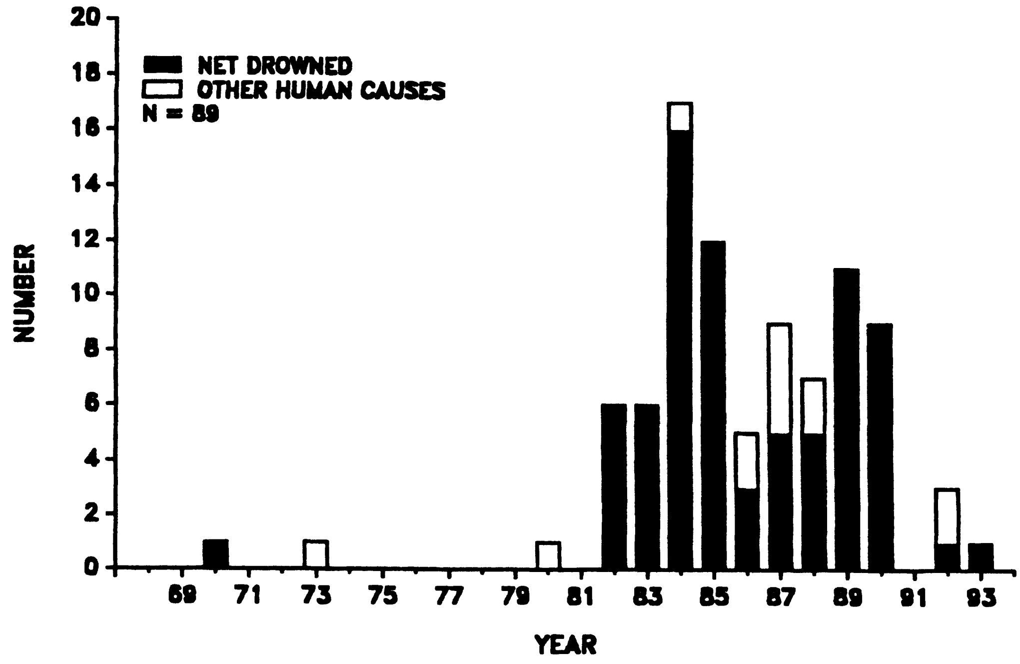

FIGURE 16. Recovered human-related mortalities, other than shot, by year, 1968-1993.

an animal suffered from multiple ailments. Some interesting diagnoses not discussed in more detail included: blindness; carcinoma; endocarditis; myocarditis; neoplasia; septicemia; and splenic infarctions (NWHC, unpublished reports).

Parasites were often observed in otter carcasses. Parasites were identified as the cause of death in 30% (n=19) of the fresh carcasses examined by NWHC pathologists. Seventeen percent (n=11) were diagnosed with parasitic peritonitis and enteritis. Peritonitis (inflammation of the lining of the abdominal cavity associated with a bacterial infection) is caused by the acanthocephalan, *Polymorphous sp.*, migrating through the intestinal wall and into the body cavity. Enteritis (inflammation of the intestinal tract) is caused by stress and/or the acanthocephalan, *Corynosoma enhydra*, which was found only in the intestine (NWHC, unpublished reports). A majority of the cases diagnosed with parasitic peritonitis and enteritis occurred from March through September (n=8) and were female (n=7). The young were most frequently affected (pup n=6, subadult n=2, and aged adult n=3). Carcasses with peritonitis and enteritis were recovered throughout the range.

Twelve percent (n=8) of the fresh carcasses examined by NWHC pathologists were diagnosed with encephalitis (inflammation of the brain). Five of these were determined to be caused by protozoa and three were suspect (NWHC, unpublished reports). Six of the animals came ashore moribund and were either seizuring or comatose. All of the cases occurred from March through June and the majority were male (n=5). All age categories were affected (pup=2, subadult=3, adult=3), and these otters were recovered throughout the range.

Coccidioidomycosis (Valley Fever) was determined to be the cause of death in four cases in 1992 and 1993; a veterinarian pathologist at University of California at Davis also diagnosed one additional case. This disease is of special interest because humans are also susceptible. In all four cases, the animals were found in a moribund condition and died soon after being recovered. All were recovered within a 48-km area from Morro Bay to Pismo Beach. These cases were recovered throughout the year. All four were males and included one subadult and three adults. We believe that fungal spores carried offshore by winds and inhaled by otters may be the source of the infection.

In 1993, two otters died from esophageal blockage. The pathologists were unable to determine the causes of the blockages. Pathologists expected heavy metal toxicosis, particularly mercury for the blockage, and tested liver and kidney tissues, but tests indicated normal levels of mercury. During the same period in 1993, sea birds dying from a similar condition were diagnosed to have died from domoic acid poisoning (S. M. Loscutoff, Calif. Dept. of Health Services, pers. comm.). Both otters were tested for domoic acid, but the results were negative.

Valley Fever Study on Decomposed Sea Otters

Nine field-necropsied, decomposed carcasses were sampled for the presence of the fungus, *Coccidioides immitis* during 1993. Eight of the carcasses were recovered between Morro Bay and Pismo Beach and one was recovered at Asilomar Beach near Monterey. None of the tissue samples were determined to contain the fungus.

NWHC Representativeness

Historically, causes of death for a large proportion of the carcasses were listed as "unknown" or "unknown without trauma". This is of concern, particularly because the population's growth rate has been considered unusually slow and an elevated mortality rate has been suggested as the most likely cause (Estes 1981). The NWHC's efforts were designed to characterize sea otter mortality patterns, provide baseline data on sea otter pathology, and provide a specific cause of death for specimens that would most likely have been diagnosed by field biologists as "unknown" or "unknown with no trauma".

Our ability to generalize beyond the specific results obtained through detailed examinations of fresh carcasses depends on whether that sample can be considered to be representative of population-wide mortality patterns. We assessed the representativeness by comparing NWHC's fresh-carcass necropsy/demographic patterns with all field necropsy/demographic patterns during 1992-1993.

We used a test for independence (G-statistic) to assess whether the distribution of carcasses with regard to age, sex, or recovery location was independent of the method of examination (Sokal and Rohlf 1969). We suggest that consistency in the distribution of these factors, if it exists, implies that the results from the examination of NWHC fresh carcasses did not introduce a new bias.

The number of fresh carcasses examined by the NWHC during 1992 was relatively small (n = 21). We compared field necropsy data, with much larger sample sizes, for the 2 years to determine whether combining years was warranted to increase the NWHC's fresh sample size. The frequency of occurrence within age groups (G = 1.95, $x^2_{.05[2]}$ = 5.99), sex (G = 3.70, $x^2_{.05[1]}$ = 3.84), and geographic areas (G = 5.44, $x^2_{.05[5]}$ = 11.07) was independent of year. There were also no statistically significant differences in any pairwise comparison within age, sex, or geographical groups. The frequency of occurrence within mortality groups was also independent of year (G = 12.23, $x^2_{.05[6]}$ = 12.59). Seven groups were used: unknown; unknown with trauma; unknown without trauma; shark bitten; shot; other human caused; and other natural causes. Pairwise comparisons using only field necropsy data were almost all statistically indistinguishable. Only the proportion of carcasses within the "unknown with trauma" group was statistically different (t_s = 2.14, P = 0.032) and the total number of recoveries within this group for the 2-year period was very small (n=8). Based on these results, combining data for 1992 and 1993 was warranted.

In order to assess the representativeness of the combined 1992-93 NWHC fresh carcass necropsy results, we again evaluated consistency in the distribution of carcasses with regard to age, sex, and geographic area. The frequency of occurrence within age groups (G = 0.39, $x^2_{.05[2]}$ = 5.99) and sex (G = 0.26, $x^2_{.05[1]}$ = 3.84) was independent of examination type (NWHC fresh vs. field) for the 1992-93 grouped data. All pairwise comparisons within these groups suggest that individual categories were also not statistically different. However, the distribution of carcasses within geographical areas was not independent of examination type (G = 11.90, $x^2_{.05[5]}$ = 11.07). Pairwise comparisons suggest that two of the six areas considered had disproportionate sampling based on examination type.

A significantly higher proportion of the carcasses recovered from rocky habitat north of Monterey Bay received field necropsies (t_s = 2.52, P = 0.011). And, a significantly higher proportion of the carcasses recovered from sandy habitat at the south end of the range were fresh and received the detailed examination provided by the NWHC. These differences may influence our ability to generalize from results based on the examination of NWHC fresh carcasses, particularly if there were localized differences in causes of mortality.

Several causes of mortality appear to have been localized in their expression. However, their potential to bias generalizations based on results from detailed examinations of fresh carcasses is limited. In one instance, the source of mortality was localized on a larger geographical scale than the area that had statistically significant differences in the pairwise comparisons. Valley fever has only been identified in fresh carcasses recovered between Morro Bay and Pismo Beach, but only one of the four cases occurred within the area that had statistically significant differences in the pairwise comparisons (sandy habitat at the south end of the range).

The second area where there was a significant difference in pairwise comparisons, the rocky habitat on the northern end of the range, also had a cause of mortality that could be considered to be localized. Sampling suggests that recovery of shark-bitten otters occurred with greater frequency in that area. If shark attacks lead to rapid decomposition, generalizations based on results from the examination of fresh carcasses could be biased. However, the proportion of recorded shark attacks within NWHC and field categories for the area in question were similar (NWHC = 33% vs. field = 38%). Consequently, the potential for a strong bias is limited and we consider generalizations based on the examination of fresh carcasses to be appropriate.

The frequency of occurrence of mortality causes when grouped into the seven general mortality categories was not independent of the examination type (G = 91.55, $x^2_{.05[6]}$ = 12.59). Pairwise comparisons indicated that the NWHC had a significantly lower proportion of carcasses within the "unknown" category (0.016 vs. 0.273)(t_s = 5.69, P < 0.0002) and the "unknown without trauma" category (0.094 vs. 0.377)(t_s = 4.70, P = 0.002). The NWHC also had a significantly higher proportion of carcasses within the "natural" cause-of-death category (0.750 vs. 0.156) (t_s = 8.62, P < 0.0002). There were no other statistically significant differences in proportions within the remaining mortality categories when compared by type of examination.

The proportion of carcasses within "unknown" and "unknown without trauma" categories based on field examination (0.65) closely agrees with the proportion of carcasses within the "natural" category based on the examination of NWHC fresh carcasses (0.75). Since the NWHC results are considered to be generally representative, the similarity in these proportions suggest that the majority of carcasses within unknown categories, based on field examinations, probably died from natural causes during the 2-year period.

To assess whether these generalizations might apply in preceding years, we again evaluated consistency in the distribution of carcasses with regard to age, sex, and recovery location. Our evaluation was limited to years later than 1986 in order to minimize biases associated with the influence of gill net mortality.

The frequency of occurrence within age groups (G = 16.896, $x^2_{.05[12]}$ = 21.026) and habitat types (newly-reoccupied rocky habitat, newly-reoccupied sandy habitat, well-established rocky habitat, and well-established sandy habitat) (G = 26.638, $x^2_{.05[18]}$ = 28.869) was independent of year.

The distribution of carcasses by sex was not independent of year (G = 195.396, $x^2_{.05[6]}$ = 12.592). Pairwise comparisons suggest a significant difference only between the years 1991 and 1992. However, pairwise comparisons using 2-year groupings yielded no significant differences. Therefore we believe the fluctuation in sex ratio through the period considered added no significant bias to the comparison.

The frequency of occurrence of mortality causes when grouped into the seven general mortality categories was not independent of the year (G = 118.868, $x^2_{.05[36]}$ = 50.998). We also tested whether the frequency of occurrence of five more generally grouped mortality causes (unknown, unknown without trauma, and other natural causes; unknown with trauma; shark; shot; and other human caused) was independent of year. Again, we found the frequency of occurrence of the mortality groups not independent of year. We then tested the independence of each group against all other mortality groups combined. Here we found the frequency of occurrence for the "unknown with trauma" (G = 11.198, $x^2_{.05[6]}$ = 12.592) and the "shark" mortality (G = 6.298, $x^2_{.05[6]}$ = 12.592) to be independent of year. As anticipated, the frequency of occurrence of the other three groups was not independent of year. The two groups, "shot" and "other human causes", had obvious peaks during the period under consideration. Shooting mortality had a peak in 1987 that was more than double for any subsequent year, and the "other human causes" mortality was influenced by gill net deaths. The frequency of occurrence of the group that included "unknown", "unknown without trauma", and "other natural causes" was not independent of year and showed a gradual increase through time.

We consider the NWHC results to be generally representative for age, sex, and recovery location for the period of 1987 through1993. However, temporal fluctuations in mortality causes, such as shootings or gill net mortality, do not allow us to confidently apply the NWHC's results to preceding years other than to suggest that the mortalities identified as "unknown without trauma" were more likely to have been due to natural causes.

Conclusions

The mortality studies undertaken during the 26-year study period (1968-1993) provide useful information on sea otter population dynamics in California. The data have been applied to questions regarding the perceived slow growth of the California population and have been an important element in the formation of the sea otter recovery plans by the USFWS.

The intensive necropsy effort since 1992 provides excellent baseline data on sea otter pathology. These data have applications for Natural Resource Damage Assessment, such as in oil spills and other unusual mortality events, and could prove valuable in assessing impacts from environmental contaminants. Considering the variety of mortality causes diagnosed in the intensive necropsy program and apparent differences between years, it would be prudent to continue this level of examination. We also feel that archived tissue samples from the NWHC necropsy effort should be analyzed for a variety of environmental contaminants. This analysis, coupled with the intensive necropsy effort, could help elucidate whether contaminants have played any role in influencing sea otter health profiles.

Acknowledgments

A great number of individuals have participated in many ways in the last 26 years. We offer our sincere appreciation to all past and present participants of the sea otter network. We would like to acknowledge and offer our special thanks to Jack Ames and Bob Hardy for a good deal of work through the years. Their continuing support and suggestions are truly appreciated.

We would like to acknowledge the following organizations and institutions for their efforts in the recovery and examination of sea otter carcasses:

Monterey Bay Aquarium, National Wildlife Health Center, Santa Barbara Museum of Natural History, Friends of the Sea Otter, University of California at Berkeley, University of California at Santa Cruz, California Academy of Science, California Department of Parks and Recreation, California Polytechnic State University at San Luis Obispo, Marine Mammal Center, National Biological Service at Piedras Blancas and Santa Cruz, National Oceanographic and Atmospheric Administration's Gulf of the Farallones National Marine Sanctuary, National Marine Fisheries Service, Moss Landing Marine Labs, Long Marine Lab, Hopkins Marine Station, Biological Sonar Laboratory, and United States Fish and Wildlife Service at Ventura.

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APPENDIX 1

Protocol for Stranded and Dead Sea Otters

Stranded Sea Otters

Reports of stranded adults and abandoned pups should be referred to one of the following: Marine Mammal Center (MMC) 415/289-7325; Monterey Bay Aquarium (MBA) 408/648-4829 or 408/648-4840; or Sea World of California 619/226-3830 or 619/222-6362.

Dead Sea Otters

Reports of dead sea otters must be verified by authorized persons. Necropsies should be performed by pathologists or experienced biologists.

Complete Form FG 970

CDFG and USFWS DEAD SEA OTTER FACT SHEET

The following instructions and explanations apply to the numbered items on the enclosed CDFG (California Department of Fish and Game) and USFWS (United States Fish and Wildlife Service) Dead Sea Otter Fact Sheet (FACT SHEET). **PLEASE USE PENCIL (DARK)**

1) **SO #**: Obtained AFTER collecting information on items 4 - 18.
Sea otter numbers (SO#) for all verified dead sea otters are issued by CDFG Monterey (408/649-2870) and are subsequently used to identify reports, pelts, skeletal parts and tissue samples. Last two digits indicate the year. The CDFG Monterey office will maintain a list of persons authorized to request a SO#. Persons may be added to and removed from current list below through Morro Bay CDFG office.

Ano Nuevo Area:		
Ray Bandar - Cal Academy (>8:30 AM)		415/334-6341
Karen Cebra - Cal Academy		415/750-7177
Burney Le Boeuf - UCSC		408/459-2845
Santa Cruz Area:		
Jim Estes - NBS		408/459-2820
Mike Kenner - NBS		408/459-3244
NBS - Messages		408/459-2357
Monterey Area:		
Michelle Staedler - MBA Research		408/648-4976
Alisa Giles - MBA Research		408/648-4973
Jack Ames - CDFG		408/649-2893
CDFG - Messages		408/649-2870
Cambria and San Simeon Area:		
Brian Hatfield - NBS		805/927-3893
Morro Bay Area and south:		
Fred Wendell - CDFG	Office	805/772-1714
	Home	805/489-1697

Christine Pattison - CDFG	Office	805/772-1135
	Home	805/541-0397
CDFG - Messages		805/772-3011
Santa Barbara and Ventura Area:		
Kate Symonds - USFWS		805/644-1766

2) **NWHC #**: Number assigned by National Wildlife Health Center (NWHC) when otter is received and logged into NWHC system.

3) **OTHER #**: Number issued by another agency performing examinations (Cal Acad #, OSPR #, UCD #, etc). Not the tag reference number.

4) **DATE FOUND**: Date otter was found or, if alive, date otter was removed from the wild. Moribund otters taken in for rehabilitation often eventually die. In these cases, date listed is date otter was removed from wild and not date of death. Otters captured for research or public display (some of which are still in captivity) are listed by date of removal from wild.

5) **PERSON THAT FOUND OTTER**: Name of person that found otter.

6) **PHONE #**: Phone number of person that found otter.

7) **PERSON REPORTING TO MONTEREY**: Person reporting otter to CDFG Monterey office at (408/649-2870) and issued SO#. This person is responsible for completing and sending FACT SHEET to the Morro Bay CDFG office.

8) **RECOVERY AREA CODE**: See Recovery Area Codes.

9) **RECOVERY LOCATION**: Describe location where otter was recovered by indicating distance from the nearest named geographic or structural feature (river, creek, point of land, pier, street). Include both city and county. Be as specific as possible.

10) **AS-THE-OTTER-SWIMS-#**: ATOS#'s are consecutive numbers established every .5 kilometers along a smoothed 5 fathom line along the coast of California. The assigned as-the-otter-swims-number corresponds to recovery location of that particular otter on shore or in the water. Otters recovered inside an embayment or harbor are assigned the ATOS# corresponding to the entrance of the embayment or harbor. The ATOS# is preceded by B (e.g. B364) to indicate recovery in an embayment or harbor. Maps will be provided.

11) **CARCASS CONDITION**: Condition of otter when found. See Sea Otter Carcass Condition Codes.

Otter carcasses that meet the following criteria should be handled according to the Protocol for Shipping Dead Sea

Otters to the National Wildlife Health Center (NWHC).

A. Fresh

B. Otters with an indication of human caused injuries (e.g., chains, netting, gun shot wounds, or parallel lacerations). USFWS Special Agent Bill Talkin should be contacted immediately at 805/528-7980. Talkin will indicate if it is necessary to complete a CHAIN OF CUSTODY RECORD (included).

C. Known otters (tagged or previously tagged). Agency which tagged the otter should be contacted and decide whether the otter should be sent.

OTTERS MEETING CRITERIA A, B OR C SHOULD NOT BE ALTERED IN ANYWAY

Before shipping an otter to NWHC an initial examination should be performed and a number of sections on the FACT SHEET completed. On occasion an otter cannot be returned (e.g. potential health concerns or evidence in court) and pathology reports do not always include information required on FACT SHEET. These include total length; weight; teeth condition; grizzle rating; field remarks; and cause of death. Please make an educated judgement regarding cause of death. We would like to compare our initial impressions with final results from NWHC. This may be helpful in comparing our past mortality assignments and may help to guide us in assigning cause of death in the future when we no longer have the services of trained pathologists. It would be expedient to remove a premolar during the initial examination rather than waiting for otter to be returned from NWHC or the skull cleaned at NBS, Piedras Blancas.

12) **AGE**: Approximate age of otter is determined at field exam using teeth, total length (TL), and pelage. Characteristics of cleaned skull will be used to confirm ageing from initial exam. Otters with age codes 3, 4, 5, or 6 should have the head removed after completing the necropsy (see section 31 - TOOTH EXTRACTED). See Sea Otter Age Codes.

13) **SEX**: Determine by presence or absence of a baculum.

14) **TOTAL LENGTH:** Place otter on its back on a flat surface and measure in a straight line from tip of nose to tip of tail (see Fig. 5 on back side of the FACT SHEET). Do not follow body contour. Please report in centimeters. Otter should not be frozen or in rigor. Questionable lengths (estimates or when major portions of otter are missing) are preceded by a negative sign. Example: -127 cm. Do not leave blank. Estimates are preferable to blanks.

15) **WEIGHT**: Remove any extraneous material before weighing (i.e. sand,

water, kelp). Please report in kilograms. Questionable weights (estimates or when major portions of otter are missing) are preceded by a negative sign. Example: -20 kg. Do not leave blank. Estimates are preferable to blanks.

16) **TEETH CONDITION**: Determine general teeth condition. See Sea Otter Teeth Condition Codes.

17) **GRIZZLE RATING**: Determine grizzle rating. See Sea Otter Grizzle Rating Codes.

18) **TAGGED**: Yes, No, or ?. Look for evidence of tagging on both hind flippers (tag or hole) and both ears (monel tag or hole). Record position of tags, tag holes, or tears (e.g., Right 1/2 is positioned between the first and second digit of the right flipper, see Fig. 1 on back of FACT SHEET). If tag(s) are present record color, position and number (e.g. RED, 1/2, 234). If there is evidence of tagging, a PIT (Passive Integrated Transponder) reader should be used to determine if the otter has a PIT. Lay otter on back and scan for the PIT in the inguinal area and dorsal side of neck. Record number if present. If otter has a PIT tag, notify NWHC in letter that accompanies otter, and request return of PIT.

19) **KNOWN AGE**: Yes or No. All otters of known age (or of any significance) are to be archived at the Santa Barbara Museum of Natural History or another appropriate institution. It is important to note if an otter is of known age, especially if it is to be sent to NWHC. If an otter's age is known, notify NWHC in letter that accompanies otter that carcass is not to be destroyed before contacting us and that we want otter returned to us if at all possible. These are very important specimens!

20) **ORIGINALLY TAGGED**: Date of first tagging.

21) **AGE AT TAGGING**: Known age or estimated age at time of first tagging based on teeth, total length, pelage, and weight, etc. This information should be on the tag data sheet. Please attach copies of all tagging data sheets to the FACT SHEET.

22) **WEIGHT AT TAGGING**: Weight at time of first tagging.

23) **NECROPSY PERFORMED**: Yes or No. If yes, record the level of examination (e.g., field, NWHC or other laboratory).

24) **BY WHOM**: Person(s) performing necropsy.

25) **DATE OF NECROPSY**: Date necropsy performed.

26) **SUBCUTANEOUS FAT**: Check mid-dorsal at the level of kidneys and circle appropriate amount on the FACT SHEET.

27) **TARRY FECES**: Examine the anus and distal intestine for black, tarry material and circle appropriate amount on FACT SHEET.

28) **FOOD IN GUT**: Examine gut and intestine for presence or absence of food items and circle appropriate amount on FACT SHEET. If present, identify and record contents.

29) **PARASITES**: Examine stomach, alimentary canal and abdominal cavity for presence or absence of parasites. If present, indicate type, circle appropriate location, and estimate number.

30) **FIELD & NECROPSY REMARKS**: Describe any wounds, missing

parts, anomalous or noteworthy findings (e.g., presence of oil, matted fur, or old and new nose scars, etc.). Describe any necropsy findings that may be diagnostic to the cause of death. Figures are provided on back side of FACT SHEET for illustrating size and position of wounds, etc.

31) **TOOTH EXTRACTED**: Yes or No. An upper first premolar may be extracted using special tooth elevators. Clean tooth and place in coin envelope labeled with SO#. Send to: Brian Hatfield, NBS, Piedras Blancas Research Station, P.O. Box 70, San Simeon, CA 93452-0070. Removing a first premolar without damaging the root requires some practice. Examiner may choose to remove skull, place in plastic bag, label with SO# and freeze. Skulls will be cleaned and first premolar removed by NBS, Piedras Blancas Research Station personnel.

32) **X-RAY**: Circle appropriate answer. If yes, record number of x-rays taken, and by whom. X-rays should be sent to C. Pattison at CDFG in Morro Bay. All X-rays indicating presence of bullet fragments will be kept by USFWS Special Agent Bill Talkin.

33) **PHOTOS**: Yes or No. If yes, record subject matter, number taken, and storage location.

34) **TISSUES COLLECTED**: Yes or No. If yes, record tissue types, storage medium, and storage location.

35) **CAUSE OF DEATH (MORTALITY CODE)**: Be as specific as observations will allow and code appropriately. See Sea Otter Mortality Codes.

36) **DISPOSITION CODES**: Location of carcass, pelt, skeleton, skull, postcranium, baculum, and teeth at time of the report. If carcass is sent to NWHC (or any other laboratory) the date shipped and whether carcass was frozen, or not frozen should be recorded. CDFG in Morro Bay will update

codes as carcasses and/or parts are distributed.
See Sea Otter Disposition Codes.

37) **SIGNATURE**: Signature of person completing Fact Sheet.

After completing the field examination, and if carcass is not being saved, mark carcass and bury it, or dispose of it in a garbage dumpster. The removal of the head is one method of marking the otter, others include biodegradable twine around the torso and under the forelegs. Marking will help to avoid counting the otter again if it is uncovered in the future.

FINAL STEP: Once FACT SHEET is completed, a copy should be kept by person completing FACT SHEET and original sent to:

Christine Pattison
California Department of Fish and Game
213 Beach Street
Morro Bay, CA 93442

All dead sea otter parts are controlled and distributed by permits which are issued by the CDFG Wildlife Protection Branch (WPB) in Sacramento. Requests for sea otter material are coordinated between the WPB and the Sea Otter Project in Morro Bay. Requests for sea otter parts should be directed to the CDFG office in Morro Bay (Attn: Christine Pattison).

SEA OTTER NECROPSY KIT:

1. Clipboard
2. Dead Sea Otter Fact Sheet
3. Pencils
4. Gloves (disposable)
5. Tape measure
6. Knife
7. Knife sharpener
8. Scalpels & blades
9. Tooth extraction tools
10. Plastic bags - head & body
11. Tags & line
12. Shovel
13. PIT reader
14. Scale & rope

S.O. #: ____________________
NWHC #: ____________________
OTHER #: ____________________

CDFG AND USFWS
DEAD SEA OTTER FACT SHEET

DATE FOUND: ________________ MM - DD - YY
PERSON THAT FOUND OTTER: ____
PHONE #: __________________________
PERSON REPORTING TO MONTEREY: ____
RECOVERY AREA CODE: ______________
RECOVERY LOCATION: ____
AS-THE-OTTER-SWIMS #: ____________

******* SEE KEYS FOR DETAILED DESCRIPTIONS OF CODES *******
CARCASS CONDITION: 1=ALIVE 2=FRESH 3=MOD DECOMP 4=ADVAN DECOMP 5=MUMMIFIED/FRAG 6=UNKNOWN 7=CAPTIVE 8=REHABILITATED

AGE: 1=FETUS 2=PUP 3=IMMATURE 4=SUBADULT 5=ADULT 6=AGED ADULT 7=YOUNG 9=UNKNOWN

SEX: F / M / ? **TOTAL LENGTH**: __________ CM / IN **WEIGHT**: __________ KG / LB

TEETH CONDITION: 1=EXCELLENT 2=GOOD 3=FAIR 4=POOR 5=UNKNOWN ____

GRIZZLE RATING: 1=NONE TO SLIGHT 2=TO EYES 3=TO LAMBDOIDAL CREST 4=TO CHEST 5=TO TAIL 6=NATAL 7=UNKNOWN

TAGGED: Y / N / ? R:______/______/______ L:______/______/______ EAR: _______ PIT: ______________________ TAG REF #: __________
COLOR POS NUM COLOR POS NUM

KNOWN AGE: Y / N **ORIGINALLY TAGGED**: ________________ MM - DD - YY
AGE AT TAGGING: _____________ **WEIGHT AT TAGGING**: ________ KG / LB
NECROPSY PERFORMED: Y / N **BY WHOM**: ______________________________________
DATE OF NECROPSY: __________________ MM - DD - YY
SUBCUTANEOUS FAT: - = UNKNOWN 0=NONE 1=SCANT 2=FAIR 3=MOD 4=ABUND
TARRY FECES: - = UNKNOWN 0=NOT OBVIOUS 1=SLIGHT 2=OBVIOUS
FOOD IN GUT: - = UNKNOWN 0=EMPTY 1=LITTLE 2=MEDIUM 3=FULL
____

PARASITES: ACANTHOCEPHALAN/OTHER_______________ INTESTINAL: Y/N EST # ____ OR >500 ABDOMINAL CAVITY: Y/N EST # ____ OR >500

FIELD & NECROPSY REMARKS (WOUNDS, MISSING PARTS, ETC--USE SKETCHES ON BACK):

____
____
____
____
____
____

TOOTH EXTRACTED: Y / N ____________ **XRAY**: 0=NO 1=YES 2=NOT SHOT 3= SHOT ________________ **PHOTO(S) TAKEN**: Y / N ______________

TISSUES COLLECTED: Y / N

____

CAUSE OF DEATH (MORTALITY CODE): __________________________________

DISPOSITION CODES CARCASS:_______ PELT:______ POSTCRANIUM:______ SKELETON:______ SKULL:_______ BACULUM:______ TEETH:_______

____

FG 970

SIGNATURE

SEA OTTER RECOVERY AREA CODES

Recoveries from a boundary line are included with the area to the north (upcoast).

CODE	DESCRIPTION
4	North of Pillar Point
5	Pillar Point to Martin's Beach (Lobitos Creek)
6	Martin's Beach (Lobitos Creek) to Pescadero Creek
7	Pescadero Creek to Ano Nuevo Point
8	Ano Nuevo Point to Sand Hill Bluff
9	Sand Hill Bluff to Point Santa Cruz
10	Point Santa Cruz to Capitola Pier
11	Capitola Pier to Moss Landing Jetty
12	Moss Landing Jetty to Seaside (northern end)
13	Seaside (northern end) to Monterey Wharf #2
14	Wharf #2 to Lover's Point
15	Lover's Point to Point Pinos
16	Point Pinos to Point Joe
17	Point Joe to Cypress Point
18	Cypress Point to Carmel River
19	Carmel River to Yankee Point
20	Yankee Point to Rocky Point
21	Rocky Point to Point Sur
22	Point Sur to Pfeiffer Point
23	Pfeiffer Point to Partington Point
24	Partington Point to Lopez Point
25	Lopez Point to Cape San Martin
26	Cape San Martin to Salmon Creek
27	Salmon Creek to Point Sierra Nevada
28	Point Sierra Nevada to San Simeon Point
29	San Simeon Point to Santa Rosa Creek
30	Santa Rosa Creek to Point Estero
31	Point Estero to Cayucos Pier
32	Cayucos Pier to Morro Rock
33	Morro Rock to Hazard Canyon
34	Hazard Canyon to Point Buchon
35	Point Buchon to Point San Luis
36	Point San Luis to Pismo Pier
37	Pismo Pier to Oso Flaco Creek
38	Oso Flaco Creek to Point Sal
39	Point Sal to Purisima Point
40	South of Purisima Point
99	Unknown

SEA OTTER AGE CODES

Approximate age is determined at the initial field exam using 1) teeth, 2) total length, and 3) pelage. In younger animals, primary consideration should be given to presence or absence of deciduous teeth. Skull characteristics are generally discernable only with a cleaned skull and will be used to confirm ageing. If age is based on the skull, a 1 is placed in front of age code.

CODE	AGE	DESCRIPTION
1	FETUS	TEETH: Deciduous teeth may be present. In womb. Not included in any summaries.
2 OR 12	PUP	TEETH: Most deciduous teeth erupted. TOTAL LENGTH: 40 - 90 cm. SKULL: Small with no crest; all sutures loose (open); exoccipital-basioccipital suture open to closing. Dependent animal.
3 OR 13	IMMATURE	TEETH: Deciduous teeth fully erupted or replaced in some alveoli with permanent teeth; in most specimens permanent teeth evident beneath deciduous teeth. TOTAL LENGTH: 80 - 105 cm. SKULL: Exoccipital-basioccipital suture closed; other sutures may be open or beginning to close. Small animal probably dependent. Large animal may be independent.
4 OR 14	SUBADULT	TEETH: All deciduous teeth shed. No tooth wear evident. TOTAL LENGTH: female 95-115 cm. male 100-125 cm. SKULL: Basioccipital-basisphenoid suture open, but most other sutures closed; suture between palatine bones becoming greatly interdigitated. Independent animal.

CODE	AGE	DESCRIPTION
5 OR 15	ADULT	TEETH: Slight to obvious tooth wear evident. TOTAL LENGTH: female > 105 cm. male > 115 cm. SKULL: Lambdoidal and sagittal crests beginning to develop; palatine sutures mostly obliterated; growth of ventral lips of glenoid fossae largely locking mandibular condyles to skull when mandibles held together at mandibular symphysis.
6 OR 16	AGED	TEETH: Severe tooth wear, some teeth may be chipped or cracked; some molars may be worn to gum line; there may be tooth loss (mostly premolars) and/or necrosis of alveoli. SKULL: Lambdoidal and sagittal crests well developed; no evidence of palatine sutures; mandibular condyles locked to skull such that jaws cannot be removed unless separated at the mandibular symphysis.
7	YOUNG	Probably pup (2) or immature (3).
9	UNKNOWN	Did not or could not determine age.

SEA OTTER CARCASS CONDITION CODES

CODE	DESCRIPTION
1 = ALIVE	Moribund, injured or abandoned.
2 = FRESH	Freshly dead (edible).
3 = MOD DECOMP	Moderately decomposed (organs still intact, days old).
4 = ADVAN DECOMP	Advanced decomposition (organs beyond recognition, carcass still intact, weeks old).
5 = MUMMIFIED/FRAGMENTED	Old carcass (skeleton remains or mummy, age indeterminate).
6 = NA	Did not or could not determine carcass condition.
7 = CAPTIVE	Permanently in captivity.
8 = REHABILITATED	Released after rehabilitation (not used in any summaries).

SEA OTTER TEETH CONDITION CODES

CODE	DESCRIPTION
1 = EXCELLENT	Teeth show no signs of wear. All canines entire and pointed. Usually a bright white.
2 = GOOD	Light wear. Canines may be slightly rounded. Molars show little wear.
3 = FAIR	Moderate wear. Canines rounded, one or more may be broken. Cusps on molars flattened. Some teeth may show signs of old breaks. One or more incisors may be missing.
4 = POOR	Heavy wear. Teeth worn nearly to gums, caries present, cracked and broken teeth obvious.
5 = UNKNOWN	Did not or could not determine teeth condition.

SEA OTTER GRIZZLE RATING CODES

Late juvenile pelage is similar to an adult, typically dark bodied and buffy to light gray headed. The head tends to become whiter with age (grizzled). At birth the "natal" pelage is brownish with long yellowish-tipped guard hair and the head is a light buff color. Over a period of several weeks the guard hair grows out, often giving the pup a distinctly yellowish appearance.

CODE	DESCRIPTION
1 = NONE TO SLIGHT GRIZZLE	Head and facial area similar in color or slightly lighter (dark tan) than rest of pelage.
2 = GRIZZLED TO EYES	Facial area clearly lighter in color to, or just beyond eyes; but not to the area of the lambdoidal crest (posterior top of skull).
3 = GRIZZLED TO LAMBDOIDAL CREST	Facial area and head clearly lighter in color to lambdoidal
4 = GRIZZLED TO CHEST	As in 3, but light color extends onto neck, upper chest and forelegs.
5 = GRIZZLED TO TAIL	As in 4, but light color extends onto entire chest, belly, rear legs, inguinal area and penial ridge (in males).
6 = NATAL	Natal pelage. Brownish with long yellowish-tipped guard hair and the head is a light buff color.
7 = UNKNOWN	Did not or could not determine grizzle rating.

SEA OTTER MORTALITY CODES

Assign a specific mortality code (4, 5, 6, 7, 8, 9, 10, 11, 14, 17) whenever possible. A specific code takes precedence over a more general code (1, 2, 3, 12, 13).

CODE	DESCRIPTION

1 **UNKNOWN.** Includes otters for which there is little or no information. Usually otter very decomposed. In some cases, otters with possible trauma but because of advanced decomposition makes it difficult to confirm trauma, are included here.
Obviously dependent otters are placed in code 12.

2 **UNCERTAIN; WITH TRAUMA certain or probable.** Includes otters for which the cause of the trauma is unclear. Includes some possible lacerations or possible penetrating wounds (all otters with penetrating wounds should be x-rayed to determine if shot) if the distinction is obscure due to decomposition.
Obviously dependent otters are placed in code 13.

3 **UNCERTAIN; WITH NO TRAUMA apparent.** Includes otters that received brief to detailed post mortem examinations where no injuries are noted and no cause of death is determined. Otters receiving only brief exams require a statement such as "no obvious injuries" to be assigned to code 3, otherwise they are assigned to code 1. Otters receiving detailed exams require only the omission of injury statement to be assigned to code 3. Otters with minor mating or fighting wounds are placed here.
Obviously dependent otters are placed in code 12.

4 **SHARK BITTEN certain or near certain.** Includes otters where white shark tooth fragments are found or where "diagnostic" white shark tooth scratch patterns are found on bones.
Takes precedence over codes 2 and 13.

5 **PROBABLY SHARK BITTEN.** Includes otters with comments like: multiple small cuts, multiple stab-like wounds sometimes with broken bones, or deep stab-like penetrations.
Takes precedence over codes 2 and 13.

6 **LACERATED.** Includes otters with comments like: large superficial gash; multiple small cuts with no underlying tissue damage; cuts where deep stab-like wounds are not noted.
Takes precedence over codes 2 and 13.

CODE DESCRIPTION

7 **SHOT certain or near certain.** Includes otters where 1) bullets, fragments, or pellets are recovered; 2)where the above are identified in x-rays; or 3) where an examination reveals an entry hole and sometimes an exit hole with an obvious path ofdamage (i.e. small isolated spot of blood on pelt; broken bones; and linearly torn tissue). Takes precedence over codes 2 and 13.

8 **PROBABLY SHOT.** Includes otters with a probable bullet entry and sometimes an exit hole, but without an obvious path of damage. Takes precedence over codes 2 and 13.

9 **RESEARCH otters.** Includes all otters killed as a result of sea otter capture operations. Otters drowned in research nets that were set to sample fishes are included in code 17.
Not included in most summaries.

10 **OTHER HUMAN CAUSES.** Includes otters entangled in fishing line with or without fish hooks, otters in crab traps, and otters with evidence of oil as cause of death.

11 **OTHER NATURAL CAUSES.** Includes otters where the cause of mortality does not fall into another more specific code (4, 5, 6, 7, 8, 9, 10, 14, 17). In this category are otters where the pathologist's final diagnoses have included: acanthocephalan peritonitis, acute hepatitis, aspergillosis, bacterial myocarditis, bacterial septicemia, bronchitis, coccidioidomycosis (valley fever), diaphragmatic hernia, drowning, duodenal impaction, emaciation, esophageal impaction, hemorrhagic gastritis, intestinal perforation, intestinal volvulus, intussusception, neoplasia, nonsuppurative encephalitis, nonsuppurative myocarditis, osteosarcoma, penile hematoma, pneumonia, prolapsed penis, prolapsed uterus, prolapsed vagina, severe fight trauma in males (fight trauma is defined as bite like wounds primarily on the head and flippers), twin fetuses lodged in birth canal, and twisted intestine. Mature and immature with mating trauma (bite trauma) are placed in code 14. Very young females are placed in code 13. Otters with minor mating or bite trauma are usually included in code 3.

12 **OBVIOUSLY DEPENDENT OTTER WITH NO TRAUMA apparent.** Includes pup and sometimes immature otters for which there is little or no information and no obvious trauma is noted. In some cases, obviously dependent otters with "trauma" (i.e. crushed skulls are common in decomposed pups and may be due to disarticulating bones; missing parts and tissue; and holes in otter that may be due to scavengers) but because of advanced decomposition are included here.

Larger, possibly independent, otters with similar findings are included in codes 1 or 3.

13 **OBVIOUSLY DEPENDENT OTTER WITH TRAUMA certain or probable.** Includes otters where trauma is noted. In the past obviously dependent otters with crushed skulls were included here.
Larger, possibly independent, otters with trauma are placed in codes 2 or 11. Adult and young females with severe bite or mating wounds are placed in code 14.

14 **MATING WOUNDS.** Includes mature and immature female otters with severe nose and face wounds, sometimes with infection and pneumonia.
Minor mating type wounds are included in code 3.

15 **DEAD PUPS observed with the mother.** Historically, this code has included at least one very large pup.

16 Discontinued (included with code 14).

17 **NET DROWNED.** Includes otters drowned in entangling nets set for the purpose of catching fish.
Otters drowned in nets set to catch otters are included in code 9.

18 **LIVE CAPTIVE OTTER.** Otters alive and in permanent captivity.
Should also have a carcass condition code of 7. When a captive otter dies the mortality code changes to reflect cause of death. Carcass condition code remains 7.

DISPOSITION CODES

CODE	DESCRIPTION
00	Buried or disposed
01	Armed Forces Institute of Pathology
02	Cabrillo College
03	California Polytechnic State University, San Luis Obispo
04	California Department of Parks and Recreation
05	California Department of Fish and Game (CDFG)
06	CDFG, Long Beach
07	CDFG, Monterey
08	CDFG, Morro Bay
09	CDFG, Menlo Park
10	CDFG, Sacramento & Rancho Cordova
11	Hull, Knovick, & Borucki, Inc.
12	Hopkins Marine Station of Stanford University
13	Humbolt State College
14	Los Angeles County Museum of Natural History
15	Moss Landing Marine Laboratories
16	Monterey Peninsula College
17	Naval Post Graduate School, Monterey
18	Pennsylvania State University
19	Sacramento
20	Santa Barbara City College
21	Santa Cruz City Museum
22	San Francisco Medical Center
23	San Jose State University
24	San Jose Zoo
25	San Luis Obispo County
26	Society for the Prevention of Cruelty to Animals
27	Sea World, San Diego
28	University of California, Berkeley
29	University of California, Davis
30	University of California, Los Angeles
31	University of California, Santa Cruz
32	University of Iowa
33	University of Puget Sound
34	U.S. Department of Agriculture
35	University of Vermont
36	University of Washington
37	West Valley College
38	San Diego Zoo
39	Stanford Research Institute

This is a partial list. There are over 150 disposition locations.