

Human-related injuries observed in live stranded pinnipeds along the central California coast 1986-1998

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Abstract

From January 1986 to September 1998, of a total of 6196 live stranded pinnipeds including California sea lions (*Zalophus californianus*), Pacific harbor seals (*Phoca vitulina*), northern elephant seals (*Mirovunga angustirostris*), northern fur seals (*Callorhinus ursinus*), Guadalupe fur seals (*Arctocephalus townsendi*) and Steller sea lions (*Eumetopias jubatus*) admitted to a rehabilitation center on the central California coast, 464 (7.5%) had human-related injuries. Three hundred and six (5%) had lesions caused by gunshots, 107 (1.7%) had lesions caused by entanglement with manmade marine debris (includes active or discarded fishing nets and monofilament line, packing straps, plastic bags, rope and rubber o-rings), 46 (0.7%) had injuries caused by fishing tackle and 5 (0.1%) had boat propeller damage. The majority of human-interaction injuries seen in these pinnipeds involved yearling California sea lions that stranded in Monterey Bay. June was the peak month for admission of animals with these injuries. Wounds caused by gunshots most commonly occurred in California sea lions. The most effective way of diagnosing gunshot cases was by radiography.

Key words: pinnipeds, gunshot, entanglement, human interactions, strandings, California sea lion, Guadalupe fur seal.

Introduction

Interactions between pinnipeds and humans in California are of interest due to the steady increase in both populations (Stewart, 1997). Many studies have been conducted in other geographic areas to determine the importance of entanglement with fishing gear in mortality of pinnipeds and cetaceans (Shaughnessy, 1980; Bonner & McCann, 1982; Stewart & Yochem, 1986; Fowler, 1987; Croxall *et al.*, 1990; Woodley & Lavigne, 1993; Harcourt,

1994; Barlow *et al.*, 1994; Julian, 1995; Stewart, 1997). Other studies have evaluated the conflicts between marine mammals and fisheries to determine the monetary losses incurred through damage to equipment due to interaction with pinnipeds (Briggs & Davis, 1972; Demaster *et al.*, 1985; Miller, 1981; Ainley *et al.*, 1982; O'Hara *et al.*, 1986; Pemberton & Shaughnessy, 1993; Barlow *et al.*, 1994). Little is known about the number of pinnipeds killed or injured due to firearm use, although in many marine mammal mortality surveys, injuries due to gunshots have been noted (Schroeder *et al.*, 1973; Sweeney & Gilmartin, 1974; Stroud, 1979; Dierauf, 1983; Hansen, 1981; Gerber *et al.*, 1993). Shooting of marine mammals interacting with deployed fishing gear was permitted in California by the National Marine Fisheries Service between 1988 and 1994, but is currently banned under the Marine Mammal Protection Act. There are many anecdotal accounts of intentional shootings of marine mammals in California (Miller, 1981), but very few have been witnessed. This paper reports the numbers of human related injuries recorded in pinnipeds that stranded alive along the central California coast between January 1986 and September 1998, the species and age classes involved, and the types of injuries observed.

Materials and methods

Pinnipeds that stranded alive along the central California coast between 37°42'N, 123°05'W and 35°59'N, 121°30'W, were transported to The Marine Mammal Center (TMMC), Sausalito, CA, a rehabilitation facility. Animals were considered stranded according to the criteria of Gerber *et al.* (1993). On admission, animals were aged on the basis of length, pelage, sagittal crest size (male California sea lions (*Zalophus californianus*) only) and tooth development (Riedman, 1990). The sex was recorded on the basis of external genital

morphology. Clinical examinations on each animal included auscultation of lungs, blood sampling for hematology and serum biochemistry profiles and thorough examination of any wounds and discharges. For animals in which man-made marine debris, fish hooks or types of shot were causing clinical disease, the objects were removed when possible and the wounds cleaned and debrided. Man-made marine debris included all types of active and discarded fishing netting, fishing line, plastic strapping, plastic bags, ropes and rubber o-rings. In cases where gunshots were suspected, the animals were radiographed. All radiographs were reviewed to determine location, type and size of the ammunition. Post mortem examinations were performed on all animals that died during rehabilitation. Presence of wounds, marine debris or lead fragments were recorded and recovered ammunition was typed and measured. Standard sizes for shot in increasing gauge are: shot pellets from 9-2 ga., BB, and buckshot from 4-000 ga. Lead pieces were classified as fragments if size could not be determined due to distortion on impact.

For this retrospective study, data were obtained from TMMC's medical records dated from January 1986 through September 1998. In all years, recorded information included species, stranding date and location, sex, age, weight, standard length, type of interaction and final disposition of the animal (released, euthanized, died, placed in captivity). For the years 1992 through 1998 the following additional information was recorded: evidence of interaction, location of injury, shot type, size and amount, and presence of clinical abnormalities such as blindness.

Statistical analyses were performed using MS-Excel 97. G-tests were used for goodness of fit (G_G) and heterogeneity (G_H), which are preferable to chi-square tests when expected frequencies are low (Sokal & Rohlf, 1981). Tests for independence of the number of human interaction cases observed and the species, age, sex, year, month and county of stranding were performed. Counties with less than five affected animals stranded (Mendocino, Humboldt, Alameda and Contra Costa) were pooled. Linear regression (Prevalence of human interaction or gunshot cases against year) were performed to examine trends over time. For gunshot cases, statistical tests were performed on data for California sea lions only.

Results

A total of 6196 live-stranded pinnipeds were admitted between January 1986 and September 1998 of which 463 (7.5%) had evidence of human-related injuries (Table 1). The prevalence of human interactions observed increased significantly from 1986-

1998 ($R^2=0.43$, $F=8.22$, $df=1,12$, $P=0.015$) and was not independent of year ($G_H=77.23$, $df=12$, $P<0.001$). The years 1992 (13.4% prevalence) and 1996 (10.7% prevalence) contributed most to the variation among years. California sea lions were the most commonly affected species (431 individuals) and a much larger number were inflicted with gunshot wounds (296) as compared with man-made marine debris (96), hooks (36) and boat propeller damage (3). The other species examined were more affected by interaction with marine debris than with firearms (Table 1).

A total of 158 cases involved man-made marine debris, fishing hooks or trauma caused by boat propellers. Typical lesions caused by entanglements were seen around the neck and head. The material was usually embedded in granulation tissue and muscle, caused swelling and deep suppurative wounds and left behind an obvious scar once removed. Fish hooks were most often found embedded in the mouths, esophagus, stomachs and flippers of animals. Ingested hooks were most commonly diagnosed with radiographs. In the cases where trauma was suspected due to boat propellers, diagnosis was made based on the presence of multiple parallel, deep, smooth edged lacerations.

Of these 158 man-made marine debris, fish hook and boat-related cases, 135 involved California sea lions, 15 were Pacific harbor seals (*Phoca vitulina*), 6 northern elephant seals (*Mirounga angustirostris*) and 2 Guadalupe fur seals (*Arctocephalus townsendi*) (Table 1). Although the highest numbers of California sea lions were observed with debris, fish hooks or boat propeller damage the prevalence was only 3.8% as compared to 15.4% in Guadalupe fur seals despite the low numbers stranded of the latter species. The prevalence of these cases was significantly lower for harbor seals (1.2%) and northern elephant seals (0.4%) ($G_H=74.82$, $df=3$, $P<0.001$). Cases were observed throughout the year, with the most seen during the summer months of June (44), followed by both July and May with 23 and August with 21 (Fig. 1A). Significantly more of this group of injured pinnipeds were males (61%) than females (61%) than females (39%) ($G_H=7.17$, $df=1$, $P<0.001$). All of the northern elephant seals and Guadalupe fur seals affected were pups, as were 10 of the 15 Pacific harbor seals. In contrast, most of the affected California sea lions were yearlings or subadults; ten were adults and only one pup was affected (Fig. 2). The prevalence of these interactions was not independent of the county in which animals stranded ($G_H=43.08$, $df=7$, $P<0.001$) and was highest in Monterey county (4.0%) and Santa Cruz (3.0%) counties (Table 2). Of these injured animals, 66% were released, 27% died naturally and 7% were euthanized.

Table 1. Interactions between pinnipeds and humans recorded by The Marine Mammal Center from 1986-1998

Year	California Sea Lions				Harbor Seals				Northern Elephant Seals				Guadalupe Fur Seals				Steller Sea Lions											
	Total admitted	Total H.I.	Gun shot	Debris	Propeller damage	Hooks	Gun shot	Debris	Total admitted	H.I.	Gun shot	Debris	Propeller damage	Hooks	Gun shot	Debris	Total admitted	H.I.	Gun shot	Debris	Total admitted	H.I.	Gun shot	Debris	Total admitted	H.I.	Gun shot	Debris
1986	48	3	2	1	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
1987	36	3	1	2	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
1988	209	8	6	1	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
1989	89	10	3	7	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
1990	111	16	9	6	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
1991	247	14	9	4	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
1992	457	98	74	17	6	1	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
1993	364	44	34	6	2	2	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
1994	299	43	33	9	1	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
1995	345	38	28	8	2	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
1996	247	46	30	13	3	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
1997	394	38	27	11	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
1998	728	69	40	11	18	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
Totals	3574	431	296	96	36	3	1072	18	3	3	10	2	1484	12	6	6	13	2	2	2	12	1	1	1	1	1	1	1

Total H.I.—total number of animals for that species with human interaction injuries seen that year; debris—includes active or discarded fishing gear and monofilament line, packing straps, plastic bags, rope and rubber o-rings.

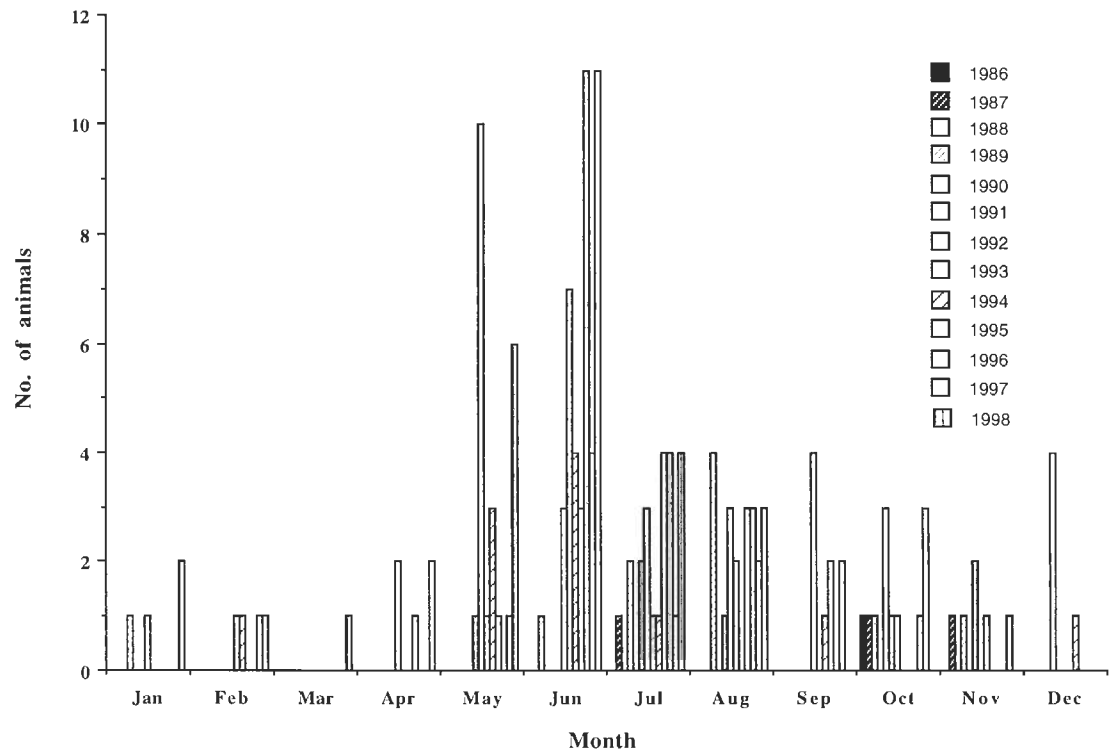


Figure 1A. Month of stranding of man-made debris, fish hook and boat propeller damage cases observed at TMMC from Jan. 1986–Sept. 1998.

A total of 306 gunshot cases were recorded from 1986–1998. The majority of cases were in California sea lions, three were Pacific harbor seals pups, six were northern elephant seal pups and one Steller sea lion subadult. The most gunshot cases were recorded in 1992 (16%). The prevalence of gunshot cases was not independent of year ($G_H=70.06$, $df=12$, $P<0.001$), although there was not a significant increase over time ($R^2=0.22$, $F=3.04$, $df=6$, $P=0.109$). There was no significant difference in prevalence of gunshot cases between the years when shooting marine mammals was legal (1988–1994, mean=6.8%) and subsequent years (1995–1998, mean=8.0%) (Mann–Whitney U-test, $U=23$, n.s.) (Fig. 3). Most of these gunshot animals stranded in Monterey (129) and Santa Cruz (56) Counties, although prevalence was significantly higher in San Francisco (9.3%) county ($G_H=36.05$, $df=7$, $P<0.001$) (Table 2). Although gunshot cases were seen throughout the year, there were significantly more during the summer months, particularly in June (24.4%) ($G_H=203.7$, $df=11$, $P<0.001$) (Fig. 1B). Of these 295 gunshot sea lions significantly more were males (68%) than were females (32%) ($G_G=40.72$, $df=1$, $P<0.001$). There were significantly more yearlings shot (154) than subadults (99)

and adults (43) ($G_G=236.67$, $df=2$, $P<0.001$). The most common type of ammunition recorded was shotgun pellets (32%), followed by bullets (23%)—primarily 0.22 in caliber, buck shot (11%), combination of shotgun pellets and bullets (6%) and BB's (3%).

Clinical presentation of animals suspected of gunshot included paralysis or paresis, signs of central nervous system damage such as blindness or seizures, lesions typical of bullet entry or exit wounds, deep draining abscesses from puncture wounds or multiple small dermal wounds from shotgun pellets. Radiography was the most useful diagnostic tool and provided evidence for 201 of the 274 gunshot cases from 1992–1998. (Fig. 4). Ammunition was recovered on necropsy from 114 of the cases. In 35 additional cases, no lead was detected, although the lesions were considered indicative of gunshot injury. The majority of wounds caused by gunshot were found in the head (61%) and less frequently in the spine (17%), in the thorax (8%), shoulders (7%) and abdomen (2%). Many animals had multiple lesions, most commonly a combination of being shot in the head and thorax or spine. One hundred and five of the animals shot in the head area had ocular

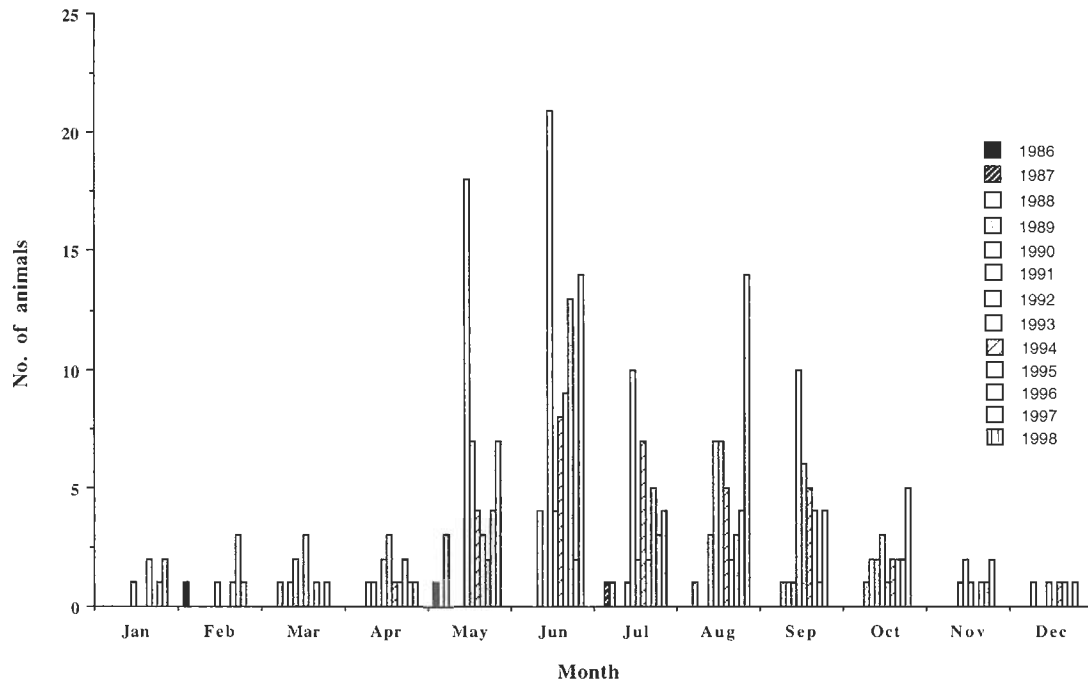


Figure 1B. Month of stranding of gunshot California Sea Lions observed at TMMC from Jan. 1986–Sept. 1998.

involvement resulting in compromised vision. Of the gunshot animals, 45% were euthanized, 38% died naturally and 17% were released. One was deemed unreleasable and was placed in a captive facility.

Discussion

The data compiled in this study, indicate that in central California the predominant human-interaction injury to stranded pinnipeds is the shooting of California sea lions. The number of live stranded animals with gunshot wounds is considerably higher than that previously documented along the west coast of the United States (Stroud, 1979; Dierauf, 1983; Hansen, 1981; Gerber *et al.*, 1993). In these studies, the numbers of gunshot pinnipeds ranged from four in a five year period to 33 in the same time frame. However, the degree of interaction with man-made marine debris is similar to that reported in other species in other areas including Northern fur seals (*Callorhinus ursinus*) on the Pribilof Islands (Fowler, 1987), Antarctic fur seals (*Arctocephalus gazella*) at South Georgia (Bonner & McCann, 1982; Croxall *et al.*, 1990) and off the South Africa coast (Shaughnessy, 1980), Hooker's sea lions (*Phocarcctos hookeri*) in New Zealand (Woodley & Lavigne, 1993) and California sea

lions in Mexico (Harcourt, 1994) and on San Nicolas Island of California (Stewart & Yochem, 1986). From our data, the prevalence was highest for Guadalupe fur seals. This is an important finding, even though the numbers involved are so low, as the shooting of Guadalupe fur seals has not been previously reported and the species has been listed as threatened since 1985. The population was last estimated to be around 6500 individuals (Stewart, 1997).

The higher number of cases recorded in the latter period of the study (1992–1998) may partially be a consequence of improved diagnostic techniques and record keeping since 1991, as well as an increase of the California sea lion population. Population estimates for California sea lions off the California coast suggest it is now over 188 000 animals and has been growing at 8.3% per year since 1993 (Barlow *et al.*, 1997; Stewart, 1997). The highest number of human interaction cases were recorded in 1992. This could be attributed to a record number of animals stranded along the California coast in this year, which was an El Niño year (Cordero, 1997). It may be that sea lions were feeding closer to shore or had a poorer nutritional status with a potential for more interaction with humans (Trillmich & Ono, 1991). As the majority of these animals stranded in Monterey and Santa Cruz counties in the summer, this may be due to the

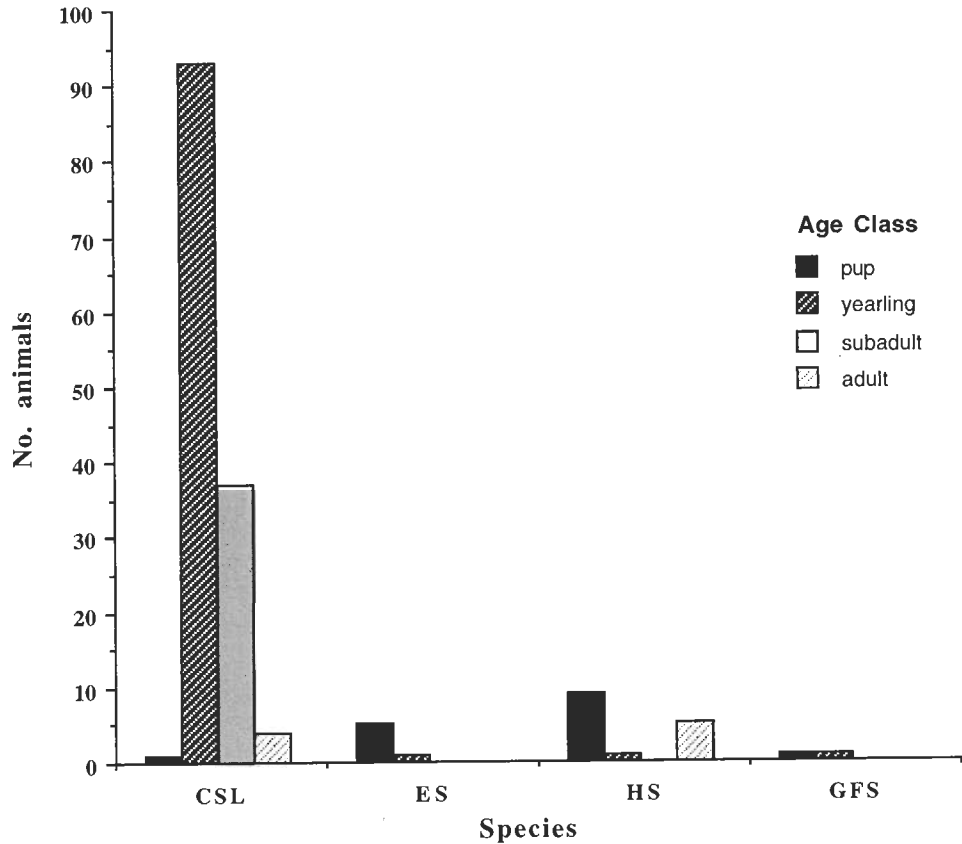


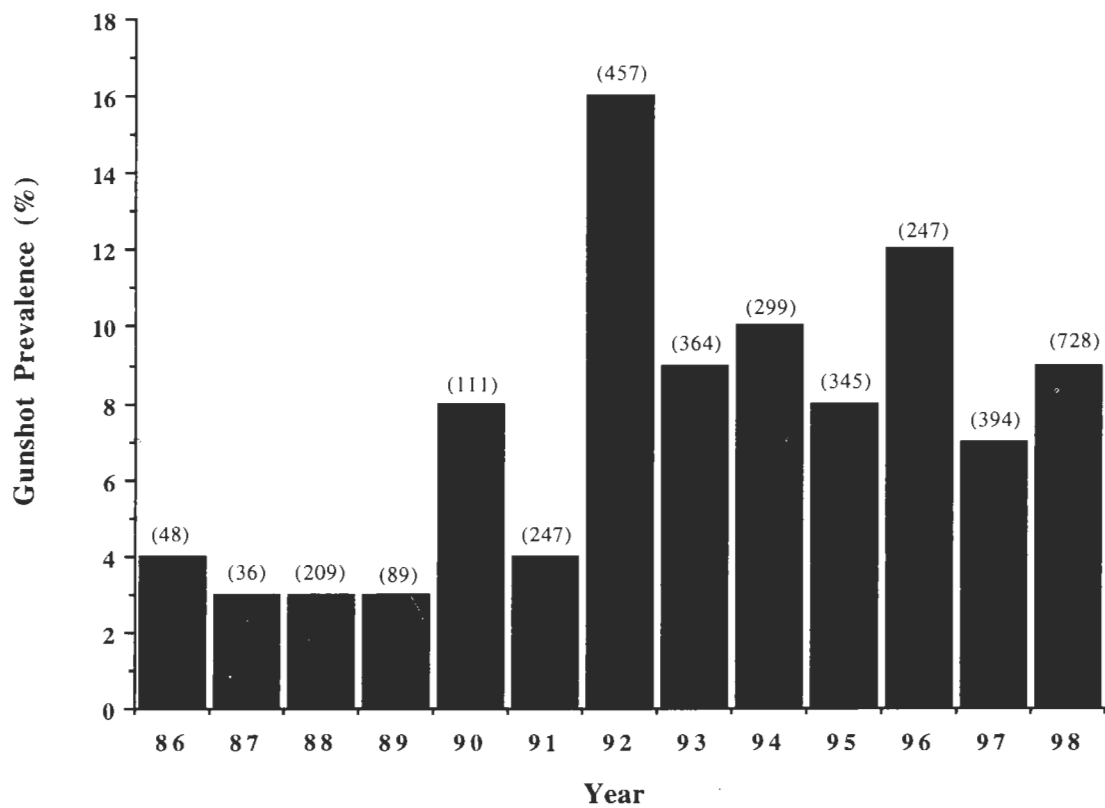
Figure 2. Age structure of stranded pinnipeds with evidence of interaction with man-made debris, fish hooks and boat propellers.

high concentration of California sea lions in areas that are also highly populated by humans and thus heavily used by commercial and sport fishermen. It is important to note that there is no way to determine exactly where, geographically, these animals are shot as an injured animal may be able to travel considerable distances prior to stranding. The majority of these animals were shot in the head and spine, presumably because these were the areas that were exposed frequently when the animals were in the water. The seasonal peak of observed cases in May through September around Monterey Bay correlates with the annual movements of the California sea lions as well as the active seasons for many of the commercial and sport fisheries off the California coast. California sea lions have become abundant in recent years in Monterey Bay and as far north as the Farallon islands between June and September (Ainley *et al.*, 1982) and females have been recorded foraging as far as 460 km north of the Channel islands along the mainland coast (Melin *et al.*, 1993). Many

fisheries off central California have been identified as having consistent interactions with marine mammals: these include the commercial salmon trolling fishery (open season is generally from July through September but is subject to area closures and changes seasonally), the California halibut gill-net fishery (open season is June through March), the Pacific Herring purse sein fishery (open season is April through October), the partyboat and skiff salmon fishery (open season is generally from March to November but is subject to area closures and changes seasonally), the purse seine fisheries for anchovy, mackerel and tuna (open season for Anchovy is May through December, mackerel and Tuna may be taken at any time), the California driftnet fishery for sharks and swordfish (open season 50 miles offshore from May to August and near the coast from August through January) and the California squid purse seine fishery (season opens April 1 until November) (Demaster *et al.*, 1985; Barlow *et al.*, 1994; Barlow *et al.*, 1997; Melchiorre, 1998). According to these sources,

Table 2. Interactions between human and pinnipeds observed at The Marine Mammal Center from 1986–1998 by county of stranding

County	Total admit	No. with debris	Prevalence (%)	No. gunshot	Prevalence (%)
Monterey	1967	79	4	129	6.5
Santa Cruz	1112	34	3	56	5
San Luis Obispo	966	22	2.3	36	3.7
San Mateo	715	10	1.4	32	4.5
Marin	516	6	1.2	10	1.9
Sonoma	366	2	0.5	17	4.6
Mendocino	147	0	0	4	2.7
San Francisco	150	3	2	14	9.3
Del Norte	40	0	0	0	0
Alameda	31	2	6.5	2	6.5
Humboldt	113	0	0	3	2.7
Contra Costa	28	0	0	1	3.5
Oregon	3	0	0	0	0
Unknown	7	0	0	0	0

**Figure 3.** Prevalence of gunshot California Sea Lions at TMMC from 1986–1998. Numbers over bars equal that total number of Sea Lions admitted that year.

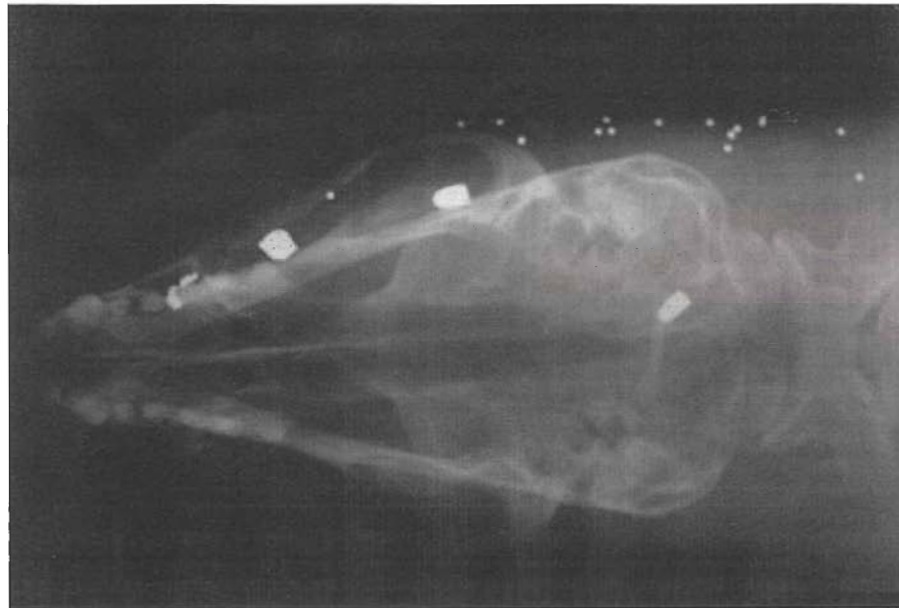


Figure 4. Radiograph of a California Sea Lion skull with multiple shot pellets and three bullets.

California sea lions are the primary species involved in the fishery interactions, which is consistent with the data presented here.

The most effective method of diagnosing gunshot animals was by radiography. However, this was not performed unless gunshot injuries were suspected. It is therefore likely that a higher number of animals admitted to TMMC were shot than were diagnosed. Occasionally when animals die from naturally occurring illnesses, bullets and/or pellets are inadvertently found during necropsy or when skulls are being prepared for display. The number of live-stranded animals reported as shot for this time period is thus a conservative estimate. In addition, this study only involved live stranded pinnipeds with no data from dead stranded animals. The total number of pinnipeds shot per year in California is therefore probably considerably higher. Stranded pinnipeds are a valuable source of data, but it is important to remember that they are not a random sample of the overall population, and the number of animals examined is a very small percentage of the entire population. These data can thus not be used to determine the total number of pinnipeds inflicted with human-interaction injuries in the populations off the California coast due to the number of biases involved. However, they do suggest that extensive pinniped-human interactions do occur along the central California coast, and that the predominant interaction is shooting of California sea lions. It is not possible to determine from the information presented here whether these

types of human-related injuries significantly impact the pinniped populations. From current population estimates and rates of increase, it is however, unlikely that the number of cases documented in this paper significantly impact pinniped populations off central California.

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