CALIFORNIA SEA LION INTERACTION AND DEPREDATION RATES WITH THE COMMERCIAL PASSENGER FISHING VESSEL FLEET NEAR SAN DIEGO

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ABSTRACT

California sea lions depredate sport fish caught by anglers aboard commercial passenger fishing vessels. During a statewide survey in 1978, San Diego County was identified as the area with the highest rates of interaction and depredation by sea lions. Subsequently, the California Department of Fish and Game began monitoring the rates and conducting research on reducing them. The sea lion interaction and depredation rates for San Diego County declined from 1984 to 1988.

RESUMEN

Los leones marinos en California depredan peces colectados por pescadores a bordo de embarcaciones pesqueras deportivas. La investigación llevada a cabo en el estado de California en el año 1978, identificó al condado de San Diego como el área con la tasa de interacción y depredación más alta. En consecuencia, el departamento "California Department of Fish and Game" inició un programa de monitoreo de las tasas y condujo una investigación con el objeto de reducirlas. Los valores de las tasas de interacción y depredación del león marino en el condado de San Diego declinaron desde 1984 a 1988.

INTRODUCTION

California's largest commercial passenger fishing vessel (CPFV) fleet operates from San Diego County with boats ranging in size to about 100 feet. The boats make scheduled trips for various lengths of time: half-day, three-quarter-day, full-day, multi-day, and twilight or evening. Passengers pay a fee to ride these boats and catch, with rod and reel, a variety of fish species, depending on the trip length, season, and fish availability.

California sea lions, *Zalophus californianus*, and occasionally Pacific harbor seals, *Phoca vitulina richardsi*, swim near or follow these boats and may take (depredate) the fish that have been caught and are being reeled in. In addition to taking the angler's catch, these marine mammals eat the fish used for chum. Chumming is done mainly with northern anchovies, *Engraulis mordax*, which are thrown from the fishing boat to lure surface and mid-depth fish within casting range. Although depredation behavior has not been observed along the California coast among other marine mammals, it has become a serious problem with sea lions, and is less serious with harbor seals. The behavior is generally not appreciated by the boat operators or the anglers, even though some crew and anglers encourage it by hand-feeding the sea lions.

During depredation, sea lions usually surface some distance from the boat, dive to swim under the boat, take a fish, and then reappear a safe distance away to eat the fish, tear it apart, or just throw it around on the surface of the water. The angler or observer may never see the sea lion take a fish off the hook. What the angler experiences after hooking a fish and starting to reel it in is a tremendous tug and rush of line as the sea lion takes the fish. Occasionally, the sea lion itself may get hooked and get away by breaking the line, but it then carries the fishing hook until the hook rusts away.

In 1978, the California Department of Fish and Game (CDFG) began studying sea lion-fisheries interactions, and determined that the fishery off San Diego County was one of the most adversely affected in the state (Miller et al. 1983). The adverse effects included interactions (presence near a fishing vessel) and depredations. Since that time, CDFG biologists have investigated methods of reducing the interaction and depredations. Additionally, they have continued to monitor the rates while aboard the vessels to identify and measure the fish caught.

Some methods that have been tried for reducing or eliminating the interactions are small explosives, rockets, noise emitted through underwater transducers, slingshots, guns, and chemical deterrents. An additional method of stopping troublesome sea lions from bothering a particular fishing vessel was to move the boat to a new area and, while moving, pass close enough to another fishing boat so the sea lion becomes interested in the second vessel's operation and "drops or passes off" on it. Each method has limitations, and none works in every case or

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against individual sea lions that repeatedly depredate catch (Scholl 1987; Scholl and Hanan 1987a, 1987b).

In 1986, despite negative findings about the effectiveness of nonlethal deterrents, the Sportfishing Association of California (an organization of CPFV operators) applied for and received a general permit from the National Marine Fisheries Service allowing CPFV operators to obtain certificates of inclusion. The certificates gave the operators permission to use nonlethal methods of harassment to keep sea lions away from their fishing activities. Recently a number of CPFV operators have stated that they have stopped using the deterrents.

Sea lion interaction and depredation rates are summarized and analyzed for the San Diego County CPFV fleet during the 1984–88 period to determine trends in those rates.

MATERIALS AND METHODS

Field data were gathered by CDFG observers aboard CPFVs to investigate deterrents or to identify and measure the fish catch. For this study, we used only information from half-day, three-quarter-day, and twilight trips, which limits this study to fishing areas near the mainland and does not include any trips to the offshore islands, where sea lion interactions and depredations are reported to occur more frequently. Because harbor seals were rarely involved, they are not included in the summaries or analyses. The specific boats and the types of trips observed were chosen randomly, but space availability and crew cooperation played a part in the selection.

Observers completed specially developed data forms when they saw a marine mammal interaction or depredation. The forms included port of landing, fishing area by complex (figure 1), Fish and Game boat identification number, boat name, date, name of stop (fishing spot), number of marine mammals involved, number of marine mammals taking fish, kind of fish taken, the length of time spent at the stop, total time for the trip, and whether the same mammals followed the boat and appeared at each fishing stop.

We defined an interaction as a sea lion swimming within 100 yards of the boat, because some boat operators claim that the mere presence of a sea lion will "shut down the bite" (discourage fish from feeding and often scare them away from the boat). A depredation was defined as a sea lion taking one or more hooked fish (including part of a fish, since sea lions will often take the body and leave just the fish head on the hook) or a sea lion itself becoming

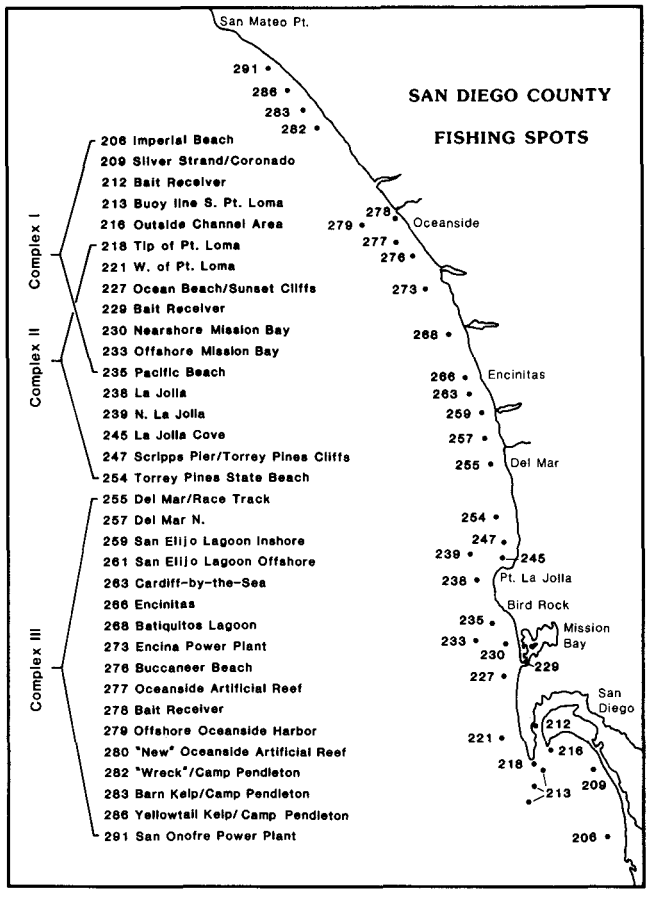

Figure 1. San Diego fishing spots used by commercial passenger fishing vessels (partyboats) are divided into three complexes depending on home port of the vessels using the fishing spots.

hooked (this implies that it ate a fish). The observer counted one sea lion taking multiple fish as a single depredation. Eating the chum or being hand-fed was not considered depredation.

CPFVs often made several fishing stops during a trip; when sea lions appeared at more than one stop, the observer was asked to determine whether they were the same animals at each stop. Skippers often attempted to "pass off" sea lions that were following them. If the technique was unsuccessful, a single sea lion could have several interactions or depredations involving a particular fishing vessel during one fishing trip. Each interaction or depredation was recorded as a separate incident for the summary and analysis.

Field data were entered into a microcomputer data base for summary and analysis. The data were grouped by area into three overlapping regions (referred to as complexes by the CDFG project that samples these fishing vessels) based on home port of the CPFV: San Diego Bay (Pacific Beach, Point Loma, and Imperial Beach); Mission Bay (La Jolla,

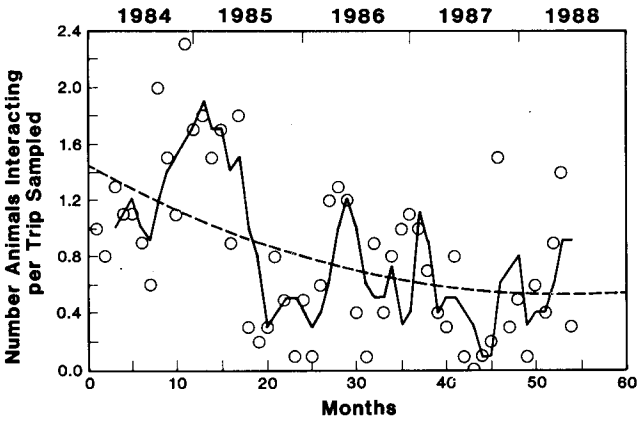

Figure 2. Average number of sea lions interacting (within 100 yards of the boat) per trip sampled with commercial passenger fishing vessels plotted by month, 1984 through 1988 (*open circles*), fit with a three-month running mean (*solid line*) and polynomial regression (*broken line*).

Pacific Beach, and Point Loma); and Oceanside (north San Diego County) (figure 1). There is overlap because boats from one complex occasionally fished in another, but the data were still grouped with the home port. Interaction and depredation rates are presented on a per trip basis.

Two models, polynomial and exponential, were used to describe the interaction and depredation data. The first model used a least squares fit of the polynomial regression:

$$y = a_0 + a_1x + a_2x^2$$

where a_0, a_1, and a_2 are the regression coefficients (figures 2–4). A polynomial regression was chosen for the interaction and depredation rates because we assumed that these rates would only approach zero if the sea lion population was reduced toward zero. In the second or exponential model, the data were

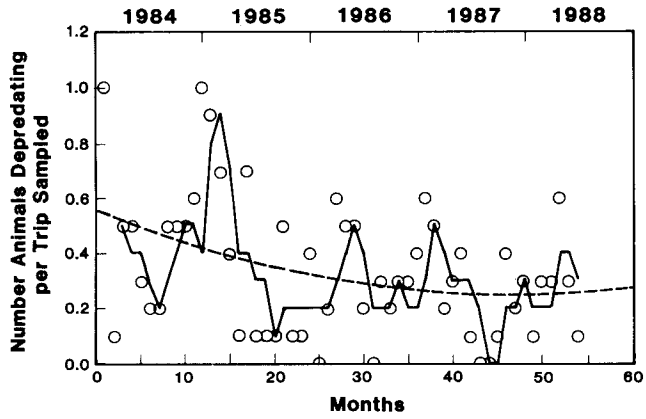

Figure 3. Average number of sea lion depredations (taking hooked fish) from commercial passenger fishing vessels plotted by month, 1984 through 1988 (*open circles*), fit with a three-month running mean (*solid line*) and polynomial regression (*broken line*).

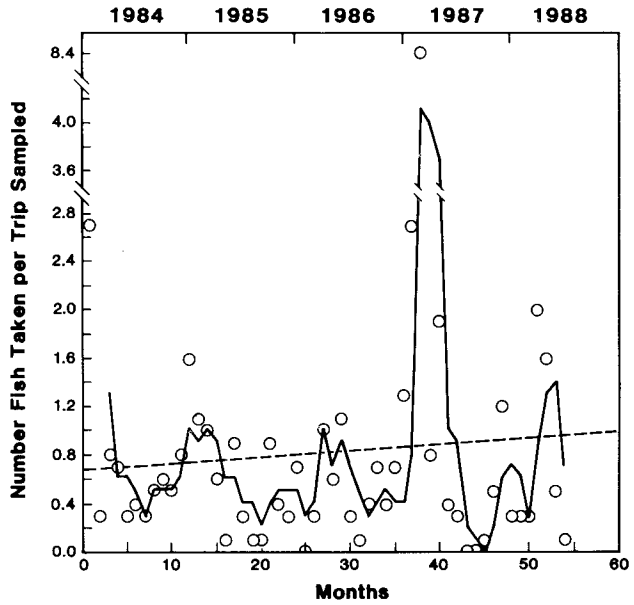

Figure 4. Average number of fish depredated by sea lions per trip plotted by month, 1984 through 1988 (*open circles*), fit with a three-month running mean (*solid line*) and least squares regression (*broken line*).

log-transformed, and a least squares linear regression was fit using

$$y = a_0 \exp(a_1x).$$

RESULTS AND DISCUSSION

The data indicate seasonal trends in the interaction and depredation rates (figures 2–4). The rates decreased in the spring and early summer, possibly because sea lions congregate at the southern California Channel Islands for pupping and breeding during this period. Rates increased each year in midsummer along coastal San Diego County, coinciding with the end of the breeding season.

The data also show that the number of interactions and depredations per trip were decreased during the five-year period (table 1, figures 2 and 3). The mean number of fish depredated by sea lions per sampled trip appears to increase slightly (figure 3), but an ANOVA test of the slope indicates that it was not significantly different from zero ($f = 0.25$; DF = 1, 52; $p > .05$). Therefore we assume that the average number of fish taken per depredation remained constant, while the numbers of interactions and depredations declined.

Potential explanations for these trends are (1) sea lions are more likely to depredate surface and midwater fish, which may have been more available during and immediately following the 1983–84 El Niño event than during recent years; (2) the nonlethal deterrents used by the CPFV operators are

TABLE 1
Summary Output from Regression Analyses for 1984–88 Mean Sea Lion Interactions, Depredations, and Fish Taken per CPFV Trip Sampled

	Sample size	Regression coefficient			f	$P > f$
		a_0	a_1	a_2		
Polynomial						
Interactions	54	1.45	−0.034	0.0003	7.5	0.0014
SE		0.22	0.018	0.0003		
t		11.36	−1.9	1.01		
Depredations	54	0.56	−0.013	0.0001	3.93	0.0259
SE		0.099	0.008	0.0002		
t		15.76	−1.56	0.94		
Number of fish depredated	54	0.673	0.005	—	0.25	0.6184
SE		0.338	0.011	—		
t		1.99	0.50	—		
Exponential						
Interactions	54	0.803	−0.009	—	13.94	0.0005
SE		0.077	0.002	—		
t		10.47	−3.73	—		
Depredations	54	0.379	−0.004	—	6.22	0.0159
SE		0.047	0.002	—		
t		8.13	−2.49	—		
Number of fish depredated	54	0.484	0.0004	—	0.01	0.91
SE		0.111	0.0035	—		
t		4.37	0.12	—		

working on all but a few of the more aggressive and successful sea lions; or (3) the total number of sea lions is decreasing, and the numbers of interactions and depredations are approximately proportional to sea lion numbers.

Based on CDFG studies of nonlethal deterrents (Scholl 1987; Scholl and Hanan 1987a, 1987b), we do not expect that those deterrents are affecting interaction or depredation rates. Because the number of sea lions does not appear to be declining (Demaster et al. 1982), we conclude that declining interaction and depredation rates are a function of fish availability and the desirability of the fish targeted by the CPFV fishery. This inference is consistent with anecdotal information gathered from CPFV skippers and anglers. Their impression is that sea lions prefer to depredate more desirable sport fish such as yellowtail, barracuda, or bonita. Sea lions rarely interact or depredate when CPFVs are fishing for rockfish or other bottomfish. This inference is further supported by findings that anchovies are the major diet component of free-ranging sea lions in the Southern California Bight, while bottomfish are a minor component (Lowry and Oliver 1986; Lowry et al. 1986; Lowry and Folk 1987; Lowry et al.[1]).

The "rogue animal" concept suggests that most CPFV/sea lion interactions and depredations are caused by relatively few sea lions that have learned to follow the fishing boats and take the hooked fish. Since the studies of sea lions' food habits mentioned above show that the natural diet rarely includes fish caught in CPFV fisheries, we postulate that a few rogue sea lions have learned that it is easier or more satisfying to follow fishing boats and take a few good-sized sport fish than to catch a large number of free-swimming anchovies.

[1]Lowry, M. S., C. W. Oliver, C. Macky, and J. B. Wexler. MS. The feeding habits of the California sea lion, *Zalophus californianus californianus*, at San Clemente Island, California, from September 1981 through September 1986.

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