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Surveys of Sea Otters in The Gulf of Alaska In Response To Effects of The *Exxon Valdez* Oil Spill

Marine Mammal Study 6

Final Report

June 1993

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TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

EXECUTIVE SUMMARY

Sea otter (*Enhydra lutris*) abundance and distribution in the Gulf of Alaska west of Prince William Sound were surveyed by helicopter in the spring of 1989 at the time of the *Exxon Valdez* oil spill and the following fall. Estimated size of populations did not significantly decline between spring and fall. No significant ($p > 0.05$) shifts of sea otter distributions in heavily, lightly and unoiled areas were detected between spring and fall surveys.

Key words: abundance, distribution, helicopter, line transect, sea otter, strip count, survey

INTRODUCTION

As oil from the T/V *Exxon Valdez* exited Prince William Sound in March 1989 and became constrained in the Alaska Coastal Current, it was apparent that hundreds of miles of coastline were at risk of contamination by spilled oil (Galt and Payton 1990). Sea otters (*Enhydra lutris*) inhabit much of the coastline that was in the path of oil from the *Exxon Valdez*, and are very susceptible to contamination from spilled oil (Geraci and Williams 1990, Ralls and Siniff 1990, Siniff et al. 1982). As oil spread outside Prince William Sound, there was concern that large numbers of sea otters, far removed from the spill site, would be adversely affected. Other than early survey work reported in Kenyon (1969) and fixed-wing surveys conducted in the Kodiak Archipelago in 1984 and 1985, recent data on sea otter abundance from the area were lacking. The U.S. Fish and Wildlife Service (USFWS) initiated helicopter surveys along the Kenai and Alaska Peninsulas and in the Kodiak Archipelago in April and May 1989, to guide sea otter response activities. Portions of those surveys were repeated in September and October 1989, to examine the effects of the oil spill on the distribution and abundance of sea otters.

OBJECTIVES

1. Gather information that could be used to guide oil spill response activities, such as capture and treatment of sea otters.

2. Measure the effects of the *Exxon Valdez* oil spill by comparing pre-spill and post-spill estimates of sea otter abundance.

3. Measure the effects of the *Exxon Valdez* oil spill by comparing pre-spill and post-spill patterns in sea otter distribution.

METHODS

Survey Methodology

Surveys from a Bell 206 or Hughes 500 helicopter were initiated on the Kenai Peninsula in April 1989, immediately following the first contact of oil from the T/V *Exxon Valdez* on the coastline. Surveys were flown at an altitude of about 92 m and a speed of 130 km per hour. The surveys progressed westward to the Kodiak Archipelago and the Alaska Peninsula in advance of the spreading oil. Specific areas surveyed included: 2423 km of coastline on the Kenai Peninsula, from Cape Puget to Anchor Point in Cook Inlet; 2960 km of coastline in the Kodiak Archipelago north of Rocky Point and the Buskin River on Kodiak Island; and 2138 km of coastline on the Alaska Peninsula, from Cape Douglas to Castle Cape (Fig. 1).

Strip and line transect techniques (Burnham et al. 1980) were employed to estimate nearshore (coastal) and offshore populations, respectively. Nearshore populations were determined by counting all sea otters within a 400-m coastal strip. Two observers, front and rear, watched out opposite sides of the helicopter as it flew approximately 200 m offshore. The front observer was always on the coastal side of the aircraft. The outer or offshore edge of the 400-m strip was established by a mark on the helicopter window that was corrected for the viewing angle of each rear-seat observer.

We used line transect methods to estimate offshore sea otter abundance beyond 400 m from shore. Transect locations were established systematically prior to the survey and ran perpendicular from the shoreline to the 50 fathom isobath. Paired transects (2 nautical miles apart) were flown every 10 nautical miles along the coast. This pattern allowed flying one transect offshore and another on the return, minimizing dead-head time on transects. For each side of the aircraft, we assigned observations of otters to one of 14 perpendicular distance intervals from the transect line, again using marks on the helicopter window that were placed specific to the viewing angles for each observer. We also mapped each observation on NOAA nautical charts and assigned them to nearshore (within the 400 m coastal strip) and offshore (outside the 400 m coastal strip) categories.

During the spring survey, offshore transects were frequently omitted to allow survey crews to keep pace with advancing oil, particularly at Kodiak and the Alaska Peninsula. During the fall survey, all offshore transects within the spill area were completed.

We conducted hover counts on every 20th observation of sea otter groups to obtain a "sightability" ratio to adjust the observed sea otter counts for animals unobserved because they were diving. During hover counts, the helicopter circled (usually ≈ 1 minute) around the animal or group to obtain the highest total count for that sighting. The highest total count included the initial count plus any additional otters that surfaced while hovering. We increased helicopter altitude during these hover counts to minimize disturbance.

Large groups of sea otters (>20) could not be counted accurately on the initial observation. Therefore, we circled large groups until a confident count was obtained. Consequently, adjustments due to diving were not made on groups of more than 20 individuals.

Data Analysis

Prior to calculating final population estimates, we adjusted our observations for two factors known to affect detectability of otters: 1) group size bias--increased probability of detecting large groups vs. individuals with increasing perpendicular distance from the survey platform, and 2) "sightability"--a ratio estimate (Cochran 1977) defined in these surveys as "hover-count" to "initial-count" that compensated for animals unobserved because they were diving surveys to accommodate potential seasonal variation in feeding behavior. Both adjustments were made for the offshore line transect estimates, while the coastal strip counts were adjusted only for sightability.

We estimated the sizes of sea otter populations in each area as follows. The density of offshore sea otter groups was estimated using the offshore line transect data and methods described by Burnham et al. (1980). For purposes of analysis, the offshore data included observations made on transects between 400 m offshore and the 50 fathom isobath or those crossing bays or fiords with mouths less than 6.4 km across, regardless of their depth. Group size bias, as described above, was tested statistically, and adjusted for if necessary, using the computer programs "Sizetran I" and "Sizetran II" (Drummer and McDonald 1987, Drummer et al. 1990). An offshore density of individual otters was then calculated by multiplying the group density by mean group size. The variance of this offshore density was calculated as the variance of the product of two random variables as defined by Goodman (1960). An offshore population estimate was calculated by multiplying the individual offshore density by the total offshore area.

To derive the total adjusted population estimate, the offshore population estimate was added to the total coastal-strip count and the sum was multiplied by the respective spring or fall "sightability" ratio. The variance was again calculated as the variance of the product of two random variables (Goodman 1960). The number of coastal-strip otters observed in groups larger than 20 individuals were subtracted before the adjustment ratio was applied, and subsequently added back to provide the total.

The number of otter groups observed on the fall Kenai Peninsula offshore population survey (n=16) was insufficient to develop an independent line transect estimate of offshore group density. Consequently, fall transect data were pooled for all areas and the resulting probability density function (detection curve) was used for the fall Kenai Peninsula offshore transect analysis.

To determine whether we could detect a change in the abundance of sea otters, we compared population estimates at the time of the spill with those from the fall surveys. Survey data for the spring and fall sampling effort were comparable for the Kenai Peninsula, and two subregions in the Kodiak Archipelago. Data for these areas were used to statistically compare sea otter abundance between the spring and fall periods using a z-test. One Kodiak subregion included northeastern Afognak Island and eastern Shuyak Island (NE Afognak subregion), and the second subregion (Viekoda subregion) encompassed Afognak Bay, Kupreanof Strait, Viekoda Bay, and Uganik Bay (Figure 1). Within the two Kodiak subregions, spring and fall population estimates were calculated using the entire nearshore and offshore line transect data. We did not use coastal strip surveys in the analysis of Kodiak data because the outer edge of the nearshore coastal strip was not consistently demarcated by all observers during spring coastal surveys.

The Alaska Peninsula survey area was subdivided into three zones for comparative purposes: a northern zone (Cape Douglas to Cape Aklek), a central zone (Cape Aklek to Cape Kuyuyukak), and a southern zone (Cape Kuyuyukak to Castle Cape). However, because of time constraints during the spring surveys, sampling effort and allocation was inadequate to derive unbiased offshore population estimates, thus precluding comparisons with the fall survey.

To determine whether the spill affected the distribution of sea otters, we compared the proportion of sea otters in spring and fall surveys adjacent to shorelines characterized as to degree of oiling. Otter locations observed during the spring and fall coastal surveys were overlaid on the Alaska Department of Environmental Conservation (ADEC) oil-impact map dated 22 November 1989. The level of oiling on surveyed coastline was classified as moderate to heavy, very light to light, or none observed. All sea otters observed in the adjacent coastal strip were assigned to the respective oil class. Otters adjacent to unclassified shorelines were excluded. The difference in the proportions of sea otters adjacent to shorelines of each oil class between spring and fall was tested using a Chi-square statistic.

RESULTS

Results of the spring surveys were used immediately by oil spill response teams to identify critical areas for protection and rehabilitation.

We estimate that about 24,300 sea otters resided in the study area at the time of the fall survey, including 2300 along the Kenai Peninsula, 13,500 sea otters in the Kodiak Archipelago, and 8500 sea otters along the Alaska Peninsula as far south as Castle Cape (Table 1). Point estimates of the total adjusted population size of sea otters declined from spring to fall for all areas that were investigated (Table 1). However, these differences between spring and fall total adjusted population estimates for the Kenai Peninsula and two subregions in the Kodiak Archipelago (NE Afognak and Viekoda) were not significantly different (z-test, p=0.59, 0.29, and 0.72, respectively). The combination of shoreline strip and offshore transect methods revealed that the overall increase in sea otters in the coastal strata of the Kenai Peninsula was accompanied by a more than off-setting decrease in offshore areas.

There were no significant differences in hover count ratios between spring and fall surveys (1.26 vs. 1.37, z-test, p=0.17); however, fall ratios were consistently larger than spring ratios for all surveyed areas, suggesting that sea otters may have spent a greater amount of time foraging during the fall.

The distribution of sea otters in the coastal strata during spring and fall surveys was not affected by the degree of shoreline oiling (Table 2). For unoiled, lightly oiled and heavy to moderately oiled shorelines, the proportion of sea otters distributed along those shorelines did not change significantly between spring and fall surveys for the Kenai Peninsula, Kodiak Archipelego, and Alaska Peninsula (Chi-square; p=0.24, 0.49, and 0.32, repsectively).

DISCUSSION

Sea otters dive to feed and also dive when disturbed by aircraft and boats. This behavior complicates the analysis of survey data. We attempted to adjust for this by conducting hover counts of small (≤20) groups of sea otters. However, hover counts did not allow us to correct for single otters that may have been underwater as we flew over, potentially resulting in underestimates of population size. Determining the degree of bias that was introduced to these population estimates by not correcting for single otters that were underwater when the helicopter passed over would require rigorous testing of sightability, which was beyond the scope of this study. However, this bias does not likely affect the results of this study because it was consistent across surveys.

The mean estimates of sea otter populations decreased after the spill in all regions where both coastal and offshore surveys were completed; however, variance of estimates was high and no statistical differences (≤P0.05) were detected. The differences in our spring and fall estimates of sea otter populations for the Kenai Peninsula and the Kodiak Archipelago appear reasonable in light of other analyses of sea otter mortality data from this area (Bodkin and Udevitz 1993). Impacts to sea otter populations were most likely to be observed on the Kenai Peninsula where nearly as many carcasses were recovered (n=167) as in the Kodiak Archipelago and the Alaska Peninsula combined (n=190; Doroff et al. 1993). In addition, more than six times the number of sea otters initially believed to require some kind of treatment for oil exposure were captured on the Kenai Peninsula than in the Kodiak area and Alaska Peninsula (Bayha and Kormendy 1990). Although mortality of sea otters was documented along the Kenai Peninsula following the spill, the survey technique described in this report was not sensitive enough to detect a change in population size at standard levels of statistical confidence. Also, we did not begin the spring survey on the Kenai Peninsula until shortly after the leading oil front had passed beyond the western edge of the Kenai Peninsula. Thus, any early sea otter mortality caused by initial oiling on the Kenai Peninsula would not have been detected by the helicopter surveys.

Along the Alaska Peninsula, comparisons between spring and fall total population estimates were not possible due to sampling constraints. Although the coastal strip surveys showed a decrease in sea otter numbers between spring and fall, changes in offshore numbers remain unknown (note the reversed offset for Kenai spring and fall surveys, Table 1). The Kenai survey data showed that otter abundances in nearshore and offshore zones can differ substantially through time, and demonstrated that comparisons of only coastal-strip survey data could lead to misinterpretation. Burn (1993) also found shifts in the proportion of sea otters using nearshore and offshore areas in surveys of sea otters in Prince William Sound.

There is little evidence from other studies that indicate that sea otters along the Alaska Peninsula, especially the southern survey zone, were affected by the spill. Less than 5% of 878 carcasses recovered after the oil spill were recovered there (DeGange and Lensink 1990) and no sea otters requiring treatment from oil exposure were captured in this area, although much less effort was expended in this area during the response and almost no effort during the damage assessment.

This study was unable to detect any differences in the proportion of sea otters using unoiled, lightly oiled, and moderately and heavily oiled coastline between spring and fall surveys. The analysis was weakened because of the relatively small amount of coastline in the study area that was evaluated as to degree of oiling on the 22 November 1989 ADEC maps. These maps were never validated. In addition, shoreline oiling is not necessarily indicative of damage to subtidal prey communities which might result in displacement of sea otters from specific areas. Undoubtedly, some displacement did occur from the spill, through mortality, or through aversion to oil or response activities, especially in Prince William Sound. However, outside of Prince William Sound, displacement was not observed.

CONCLUSION

Helicopter survey estimates of sea otter population size did not show a significant change between pre- and post-oil spill conditions for the Kenai Peninsula and two subregions of the Kodiak Archipelago. Although recovered carcasses and captured animals demonstrated that damage did occur to the sea otter populations, a more sensitive survey technique would be required to measure the magnitude of change that resulted from the oil spill. The proportions of sea otters observed near unoiled, lightly oiled, and moderate to heavily oiled coastlines, as determined from the 22 November 1989 ADEC oil-impact map, did not differ significantly between the spring and fall surveys.

ACKNOWLEDGEMENTS

The following individuals assisted with the surveys: Steve Amstrup, Vic Barnes, Donna Dewhurst, Jeff Somebody, Craig Gardner, Gerald Garner, and Steve Knick. The comments of Brenda Ballachey, Leslie Holland-Bartels, Larry F. Pank, Karen Oakley, and improved the report.

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Table 1. Estimated sea otter abundance in coastal Southcentral Alaska before and after the *Exxon Valdez* oil spill.

Location	Study area (km²)		Survey period	Nearshore strip surveys			Offshore line transect surveys			Total adjusted number of otters[4]	
	Coastal[1]	Offshore[2]		No. obs.	Adjusted[3] N	Adjusted[3] SE	Total transect length (km)	Estimated # of otters N	Estimated # of otters SE	N	SE
Kenai Peninsula	778	3353	April	1083	1275	26	285	836	215	2330	279
			Sept.	1346	1672	58	454	354	113	2146	194
Kodiak	916	3685	Oct.	3380	4226	150	409	6778	712	13526	1199
NE Afognak Subregion	1226[5]		April				278	1145[5]	251	1444	319
			Oct.				151	795[5]	66	1091	106
Viekoda Subregion	454[5]		April				122	3021[5]	663	3810	842
			Oct.				105	2527[5]	299	3467	445
Alaska Peninsula	755	5182	May	1766	1952	25					
			Oct.	421	562	26	464	5745	906	8445	1311
South			May	1019	1116	36					
			Oct.	174	239	12					
Central			May	177	215	6					
			Oct.	93	119	6					
North			May	570	620	20					
			Oct.	154	203	11					

1 Coastal strip 400 m wide.
2 Area from 400 m coastal strip to 50 fathom line, including all bays with mouths less than 6.4 km across.
3 Nearshore counts adjusted for sightability ratio (applied to groups of 20 or fewer otters).
4 Adjusted for grup size (offshore observations) and sightability.
5 Kodiak sub-regions estimated with line transect data that sampled both near and offshore.

Table 2. Pre- and post-spill (relative) distribution of sea otters observed along oil-impacted shorelines.

Oil Impact Assessment[1]	Kenai Peninsula			Kodiak Island			Alaska Peninsula		
	Length (km)	Spring (n)	Fall (n)	Length (km)	Spring (n)	Fall (n)	Length (km)	Spring (n)	Fall (n)
Heavy-moderate	6.4 (96km)	<0.1 (3)	<0.1 (4)	2.6 (65km)	<0.1 (14)	<0.1 (13)	5.0 (52km)	<0.1 (5)	<0.1 (3)
Light-very light	19.6 (295km)	7.2 (48)	9.6 (78)	21.1 (517km)	14.5 (306)	14.9 (451)	33.7 (348km)	58.0 (202)	50.7 (71)
None observed	74.0 (1115km)	92.4 (618)	89.9 (729)	76.3 (1875km)	84.8 (1792)	84.7 (2577)	61.0 (631km)	40.5 (141)	47.1 (66)

[1] As mapped by Alaska Dept. of Environmental Conservation, 22 November, 1989.

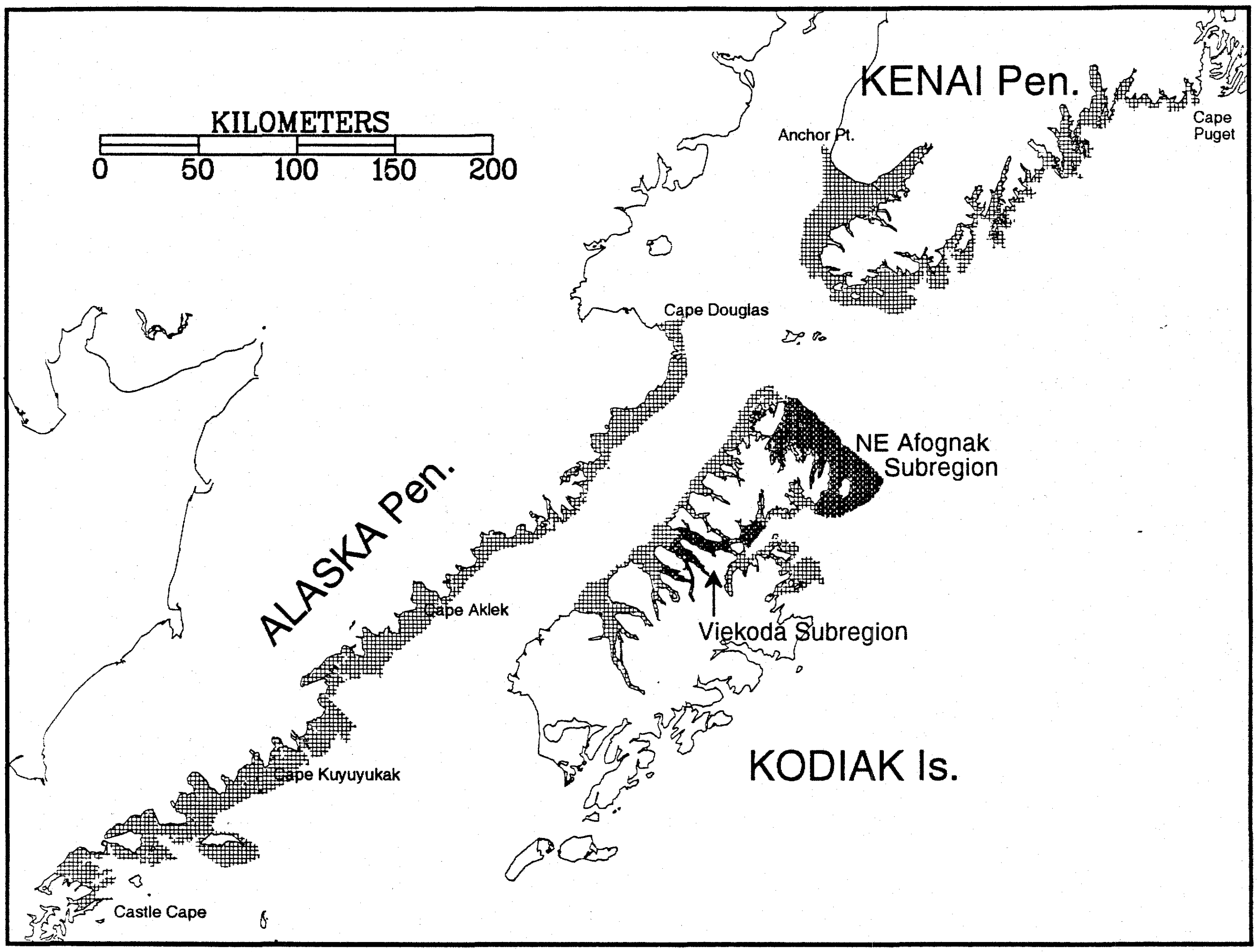

Figure 1. Areas surveyed by helicopter for documenting sea otter distribution and abundance following the *Exxon Valdez* oil spill.