Exxon Valdez Oil Spill
Restoration Project Final Report

Population Survey of Bald Eagles in Prince William Sound

Restoration Project 95029
Final Report

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Study History: Restoration Project 95029 was initiated to determine bald eagle population size in Prince William Sound and compare 1995 populations with 1982 data and 1989-91 data. This survey was designed to confirm the predicted recovery of bald eagles after the *Exxon Valdez* oil spill. Results of previous surveys were reported in the final report for Bird Study 4, Effects of the *Exxon Valdez* Oil Spill on Bald Eagles, March 1993. A journal article related to the project was published in 1995 (Bowman, T. D., P. F. Schempf, and J. A. Bernatowicz. 1995. Bald eagle survival and population dynamics in Alaska after the *Exxon Valdez* oil spill. J. Wildl. Manage. 59: 317-324.).

Abstract: We initiated studies to determine whether the *Exxon Valdez* oil spill influenced bald eagle (Haliaeetus leucocephalus) demographics in Prince William Sound (PWS), Alaska, because bald eagle population size and trend after the spill were uncertain. Using fixed-wing aircraft, we surveyed bald eagle populations within random plots once each year and censused nearly all islands in PWS in 1989-91 and 1995 to estimate population size. We calculated population indices (uncorrected for birds not seen) of 2199, 1935, 2116, and 2641 adult eagles for the 4 years studied. The eagle population returned to its estimated pre-spill size before 1995. The PWS bald eagle population has increased at an average annual rate of 3.7% from 1982 to 1995. The estimated proportion of immatures in the population did not vary significantly among years and averaged 29%.

Key Words: Alaska, bald eagle, *Exxon Valdez* oil spill, Haliaeetus leucocephalus, populations, Prince William Sound, surveys.

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Table of Contents

List of Tables

List of Figures

EXECUTIVE SUMMARY

We initiated studies to determine whether the *Exxon Valdez* oil spill influenced bald eagle (Haliaeetus leucocephalus) demographics in Prince William Sound (PWS), Alaska, because bald eagle population size and trend after the spill were uncertain. Using fixed-wing aircraft, we surveyed bald eagle populations within random plots once each year and censused nearly all islands in PWS in 1989-91 and 1995 to estimate population size. We calculated population indices (uncorrected for birds not seen) of 2199, 1935, 2116, and 2641 adult eagles for the 4 years studied. The eagle population returned to its estimated pre-spill size before 1995. The PWS bald eagle population increased at an average annual rate of 3.7% from 1982 to 1995. The proportion of immatures in the population did not vary significantly among years and averaged 29%.

An estimated 45,000 bald eagles live in Alaska, about three times the number of bald eagles living in the rest of the United States (Stalmaster 1987). Eagles in Alaska were widely persecuted and bounties were paid on about 129,000 of them from 1917 through 1953 (Robards and King 1966, King et al. 1972). However, their populations have since increased and are believed to be approaching carrying capacity (Bowman et al. 1995, Hansen and Hodges 1985).

INTRODUCTION

Bald eagles typically are surveyed with aerial surveys (Fuller and Mosher 1987). Bald eagles older than 4 years have predominantly white heads and tails and are highly visible. The plumage of immature eagles is more cryptic and therefore these eagles are difficult to see and accurately count during aerial surveys. Consequently, population surveys usually determine an index of the number of adult eagles, uncorrected for birds not seen.

On 24 March 1989, the oil tanker *Exxon Valdez* ran aground and spilled more than 42 million liters of crude oil into the waters of PWS, Alaska. The oil contaminated extensive shoreline areas used by bald eagles as far west as the Alaska Peninsula. An estimated 247 bald eagles died as a direct result of the oil spill in PWS (Bowman et al. 1993). In 1989, reproductive success was significantly reduced in oiled areas within PWS (Bowman et al. 1993).

This study was conducted in 1989-91 and 1995 to determine bald eagle numbers in PWS following the spill. We documented a significant increase in eagle numbers from 1989 to 1995 and conclude that the PWS bald eagle population has recovered from the adverse effects of the *Exxon Valdez* oil spill.

Our research was supported by the *Exxon Valdez* Oil Spill Trustee Council. However, the findings and conclusions presented by the authors are their own and do not necessarily reflect the views or position of the Trustee Council. B. Conant and J. I. Hodges were pilots during surveys. J. A. Bernatowicz, M. J. Jacobson, T. V. Schumacher, and D. Williamson served as observers on surveys. We thank J. D. Fraser, M. Samuels, R. A. Stehn, and 2 anonymous reviewers for reviews of the manuscript.

OBJECTIVES

1. Estimate the size of the bald eagle population in Prince William Sound in 1995.

2. Compare 1995 population size with 1982 data and 1989-91 data to assess changes after the oil spill.

METHODS

Survey Methods

We conducted population surveys with techniques used by Hodges et al. (1984) in British Columbia. The survey area was subdivided into approximately square 16,828-ha plots. Plot boundaries were parallel to lines of latitude and longitude with 12.96 km between plot centers. Plots that consisted entirely of water or entirely of uplands were excluded. Of the remaining 110 plots that contained coastline, 22 were selected randomly and surveyed in 1989-95 (Fig. 1). In addition, we counted bald eagles along the shorelines of all islands in PWS (except Esther Island, which we treated as mainland because it is separated from mainland only by a narrow channel).

We conducted surveys in late April and early May once each year with a turbine DeHavilland Beaver aircraft on amphibious floats. At that time of year, adult eagles were nesting (U.S. Fish and Wildl. Serv., unpubl. data) and surveys provide an index to the size of the resident population. Furthermore, experience indicates that the adult component of bald eagle populations is relatively stable in Alaska (Hodges et al. 1987). We searched shorelines from an altitude of 50-100 m at an airspeed of ~160 km/hour. The pilot and another observer counted all eagles with predominantly white heads and tails and marked their locations on U.S..Geological Survey 1:63,360 scale topographic maps. We digitized locations of eagles into a geographic information system (GIS) and determined eagle numbers within plots and on islands.

We examined how numbers of eagles changed in oiled versus unoiled regions of PWS. Using a GIS, we delineated an approximate boundary for the oiled area in PWS (Fig. 2) and summed all observations of adult eagles within the oiled and within unoiled areas.

Estimation of the Immature Proportion of the Population

To estimate the proportion of immatures in the population, we also recorded the number, locations, and ages of all eagles seen flying within surveyed areas. The age ratio of flying eagles can be used to represent the age ratio of eagles in the study area, assuming that adults and immatures have the same probability of flushing or flying and have similar detection rates (Hancock 1964, Hodges et al. 1984). The proportion of immatures in the population could serve as a rough measure of productivity for the 3-4 years before the survey, given equal emigration among years. We tested for differences in age ratios for the 3 years after the oil spill (pooled, 1989-91) and 1995 using a Fisher's Exact Test (Zar 1984). Confidence limits on estimates of the percentage of all flying eagles that were immatures were calculated assuming independence and a binomial distribution (Fowler and Cohen 1986).

Data Analysis

To obtain population indices, we divided the total number of adult eagles for sampled plots on mainland by the proportion of mainland plots sampled in PWS. The total for mainland areas was added to the total number of adult eagles observed on islands to yield the adult population index (uncorrected for adults not seen). We calculated variance for mainland areas based on a simple random sample including a finite population correction (Cochran 1977). Counts of eagles on islands (1989-95 only) were a census and had no variance.

The only pre-spill data on eagle population size was a 1982 survey, which was conducted with identical methods but unlike later years, included only 18 plots with incomplete coverage of islands. Calculation of a population index and variance with these data was the same as other years, but without addition of island census counts (i.e., 1982 plot counts included both mainland and island shorelines).

The actual pre-spill population index was unknown because some oil-caused mortality had occurred before the 1989 population survey was conducted. To evaluate whether the bald eagle population had returned to its 1989 pre-spill level by 1995, we made some assumptions regarding the 1989 survey. We estimated what the pre-spill population index might have been by assuming that all of the eagles killed by the spill died before the survey was conducted. Of course, not all those eagles killed were adults or would have been seen during surveys. We estimated that 71% (age ratio during 1989 population survey) of the eagles killed were adults, and that detection rates of adult eagles are about 70% (U.S. Fish and Wildl. Serv, unpubl. data). Accordingly, of an estimated 247 eagles killed (Bowman et al. 1993), 175 were adults (247*0.71), of which we would have seen 123 (175*0.70). Therefore, the pre-spill population index could be estimated at 2,199 + 123 = 2,322 adult eagles. This was a conservative approach (in the context of testing for oil spill effects) because some eagles probably died after the surveys were conducted (carcasses were collected from beaches through Aug 1989).

RESULTS

The population index varied little in the 3 years following the oil spill, ranging from 1,935 to 2,199 adult eagles (Table 1), but the 1995 index (2,641 eagles) is no different from the 1989 index adjusted for suspected mortality (2,322 adults) as described above ($t = 2.018$, 22 df, $P = 0.167$, one-tailed test).

A simple linear regression on the data indicated a significant population increase from 1982 to 1995 ($r = 0.24$, $P = 0.02$[Fig. 3]). From 1982 to 1995, the number of bald eagles observed in PWS increased at a calculated average annual rate of 3.7%.

Of 510 eagles seen flying during population surveys in PWS during the 5 years of surveys, a pooled average of 29.2% were immatures (Table 2). There was no significant difference in age ratio between the pooled average for the 3 years after the oil spill (30.6%) and 1995 (26.5%)(Fisher's Exact Test, $Z = 0.939$, $P = 0.65$ [two-tailed]).

Numbers of adult eagles counted increased by 22% (494 to 603), and by 35% (994 to 1,341) in oiled and unoiled areas, respectively, from 1989 to 1995.

DISCUSSION

The 1995 index is equal to or greater than the 1989 index adjusted for suspected mortality, leaving little doubt that the PWS bald eagle population has recovered from the adverse effects of the *Exxon Valdez* oil spill. This observation is consistent with the prediction by Bowman et al. (1995) that the population would return to its pre-spill size relatively quickly.

Given the observed increase in population size between 1982 and later years, we are fairly certain that the population has increased since 1982, and again since 1991. However, we cannot determine with certainty, the magnitude of population change before and after the oil spill without data on population size immediately before the spill and definite knowledge about the magnitude of oil-related mortality.

An accurate comparison of population changes between oiled and unoiled areas from 1989 to 1995 was difficult to make. We had difficulty assigning eagles to oiled and unoiled groups because of their mobility, a lack of knowledge of how individual eagles use available habitats, and, possibly, the inaccuracy of oiling maps. Further, in 1995, one herring spawning area in the unoiled area (northern Montague Island, Fig. 3) attracted an aggregation of about 300 eagles of unknown origin. This single factor could have influenced the distribution of eagles enough to change the trends in population size, depending on the actual origin of eagles (e.g., if only 40 of the 300 eagles had come from oiled areas, trends between oiled and unoiled areas would be equal). Consequently, we feel that the apparent disproportional increase in numbers of eagles between oiled and unoiled areas from 1989 to 1995 does not provide convincing evidence of an oiling effect, but rather reflects local shifts in distribution related to temporally abundant food (i.e., herring).

Eagle productivity was impaired due to the spill in 1989, but not in 1990 or 1991 (Bowman et al. 1993, White et al. 1995), and no surveys were conducted in 1992-94. However, we believe it was unlikely that eagle productivity in PWS was impaired from 1992 to 1994 because (1) reproduction in PWS was good in the 2 years following the spill (1990-91), (2) the proportion of immatures in the population did not decrease significantly from 1989 to 1995, even in oiled areas, and (3) the population has increased significantly since 1991.

CONCLUSIONS

Results of the 1995 population survey suggests that the bald eagle population has returned to its pre-spill level. We recommend that the population be monitored at 4-5-year intervals.

ACKNOWLEDGMENTS

The research described in this paper was supported by the *Exxon Valdez* Oil Spill Trustee Council. However, the findings and conclusions presented by the authors are their own and do not necessarily reflect the views or position of the Trustee Council. J. I. Hodges and B. Conant were pilots during surveys. J. A. Bernatowicz, M. J. Jacobson, T. V. Schumacher, and D. Williamson served as observers on various surveys. We thank J. D. Fraser, R. A. Stehn, M. Samuels, and 2 anonymous reviewers for helpful reviews on earlier drafts of the manuscript.

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Table 1. Estimates of bald eagles in randomly selected survey plots and on islands, and population indices in Prince William Sound, Alaska, during spring of 1982, 1989-91, and 1995.

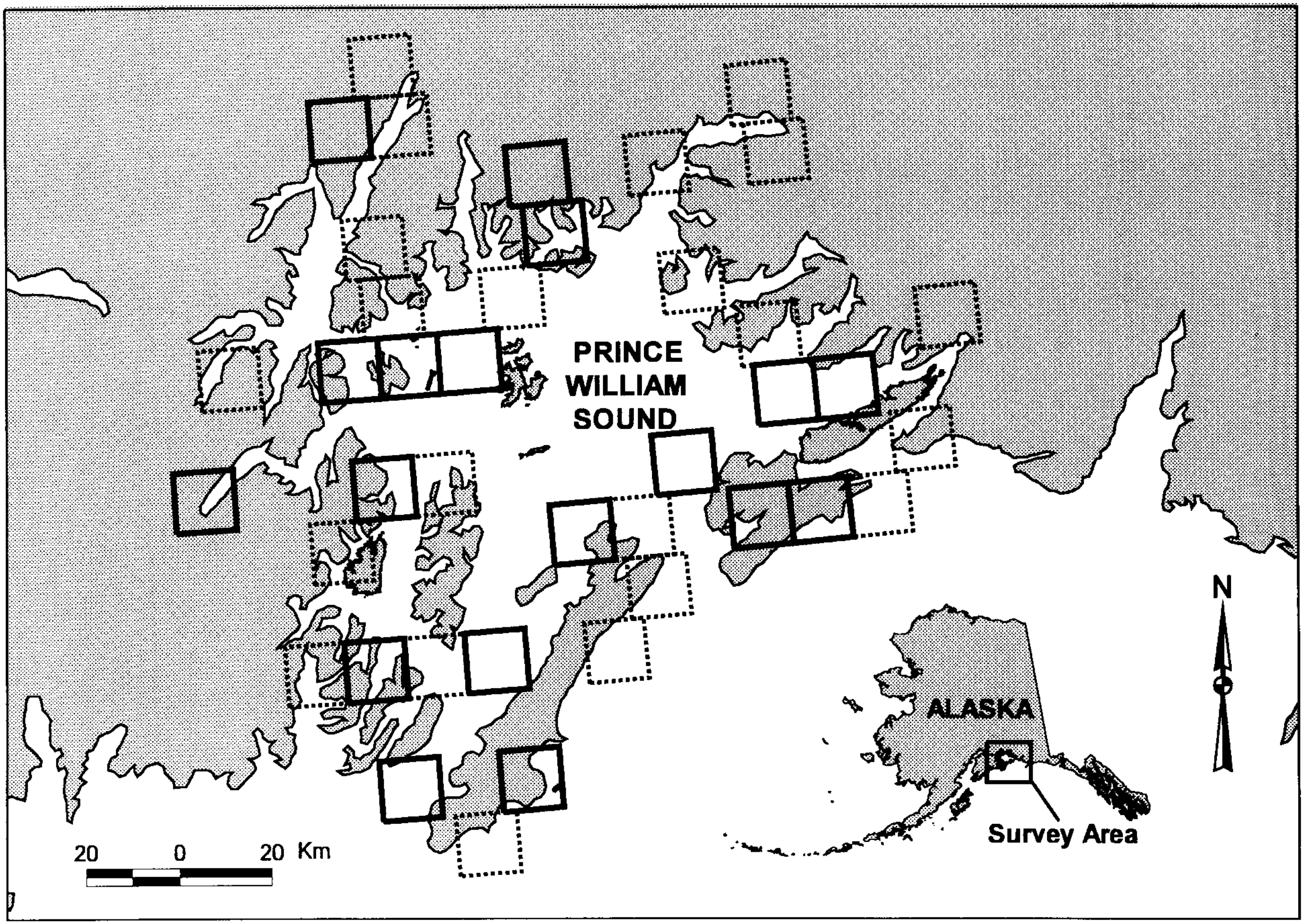
	No. Eagles		Adult Index
Year	No. On Plots[a]	Island Census[a]	(±90% CI)
1982	1,662[b]	NA[c]	1,662 (543)
1989	1,131	1,068	2,199 (405)
1990	756	1,179	1,935 (209)
1991	868	1,248	2,116 (243)
1995	1,134	1,507	2,641 (376)

[a] Adults only.
[b] Expanded totals for 18 plots that encompassed both mainland and island areas.
[c] Islands not censused in 1982.

Table 2. Age ratios of bald eagles seen flying during population surveys in Prince William Sound, Alaska, 1982, 1989, 1990, 1991, and 1995.

Year	No. Immatures	No. adults	% immatures (±90% CI)
1982	3	8	27.3 (27.6)
1989	26	64	28.9 (9.4)
1990	44	102	30.1 (7.5)
1991	32	65	33.0 (9.4)
1995	44	122	26.5 (6.7)
All years	149	361	29.2 (4.0)

Fig. 1. Location of randomly selected plots surveyed for bald eagles within Prince William Sound, Alaska, 1982 (n = 18) and 1989-95 (n = 40). Plots with dashed borders were surveyed only in 1989-95. In addition to these plots, all islands were censused in 1989-95.



PRINCE
WILLIAM
SOUND
ALASKA
Survey Area
N
20
0
20
Km

Fig. 2. Approximate boundary of the area oiled after the Exxon Valdez oil spill in Prince William Sound, Alaska.

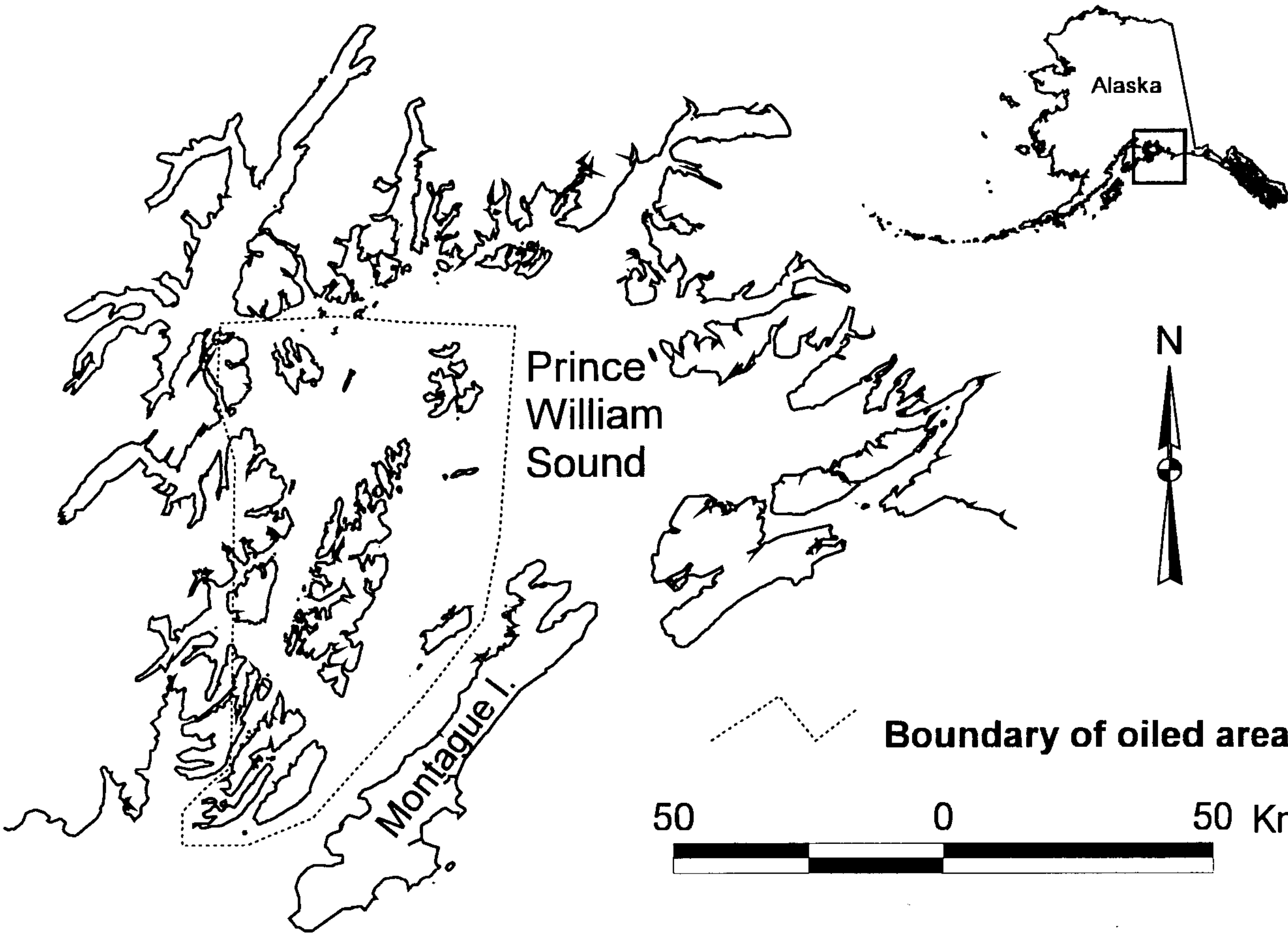
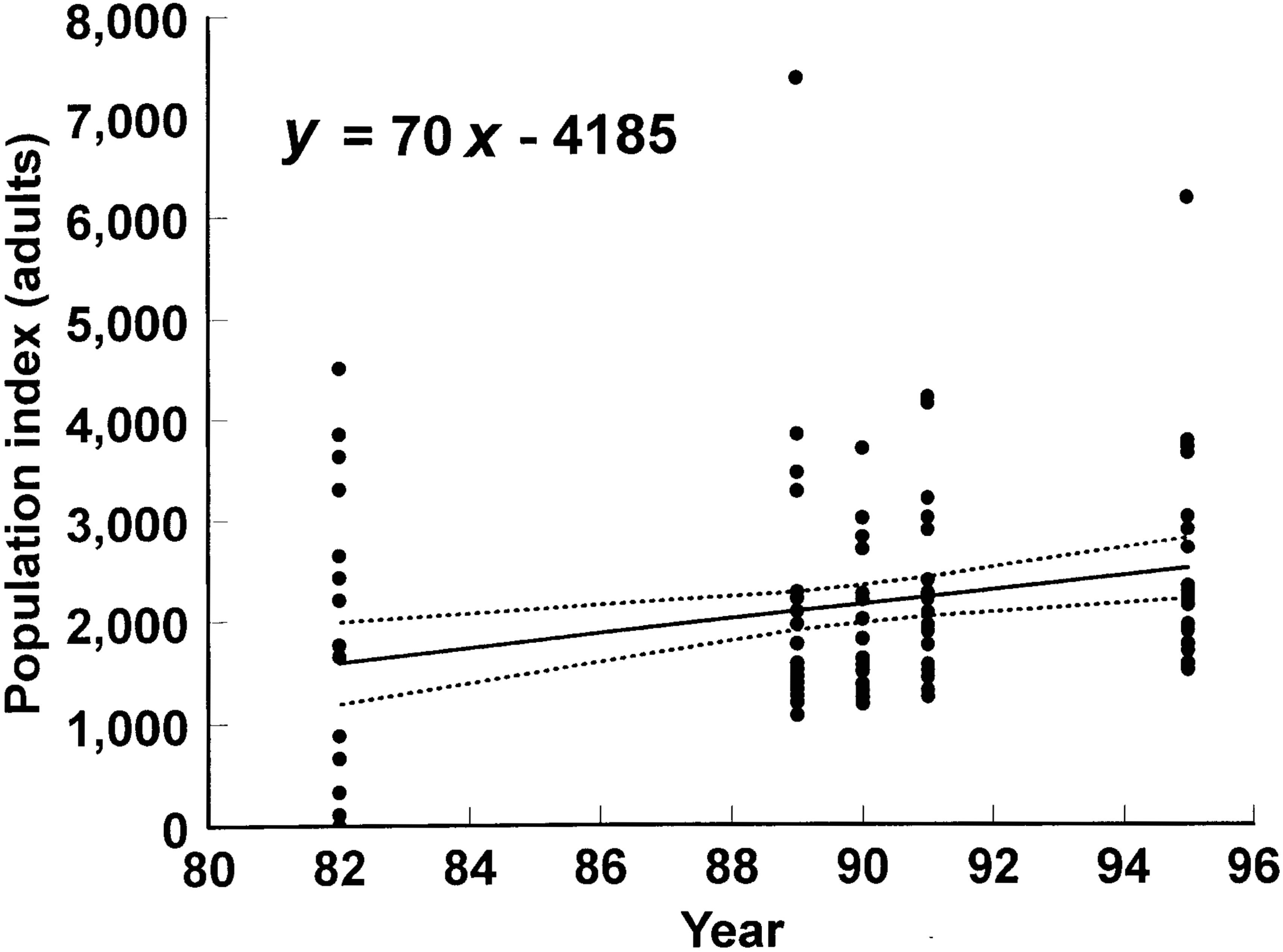

Alaska
N
Prince William Sound
Montague I.
Boundary of oiled area
50 0 50 Km

Fig. 3. Trend in indices of bald eagle population size in Prince William Sound, Alaska, 1982-95. Indices include adult eagles only and are not corrected for adults not seen. Points represent individual plot totals expanded to all plots in the survey area in 1982 (N = 110 plots) or, in 1989-95, to mainland plots only (N = 63) added to the total number of adults observed during a complete census of islands. Dashed lines indicate the 90% confidence limits on the regression line.


y = 70 x - 4185
Population index (adults)
8,000
7,000
6,000
5,000
4,000
3,000
2,000
1,000
0
80
82
84
86
88
90
92
94
96
Year