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Study Title: Assessment of Injury to Waterbirds from the Exxon Valdez Oil Spill: Boat Surveys to Determine Distribution and Abundance of Migratory Birds in Prince William Sound

Study ID Number: Bird Study Number 2

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EXECUTIVE SUMMARY

This is a preliminary draft. A final report by this investigator is expected early in 1992.

The focus of this study, now in its third year, is to estimate abundance of waterbirds in Prince William Sound (and other areas of the spill zone in 1989 and 1990), examine changes in populations between pre-spill and post-spill surveys, and to compare changes in oiled zones to changes in areas not affected by the spill. This survey cannot pinpoint causes of any declines, but serves as a support to more detailed studies of individual bird species, and documents continuing declines or recovery of populations after the spill. Distribution, age class and habitat data from this study also serve investigations of individual speces.

Pre-oil spill boat-based surveys for birds in Prince William Sound (PWS) include surveys of both pelagic and shoreline areas in March and July 1972 and March and August 1973, and a shoreline survey conducted over the summers of 1984 and 1985. Data from these surveys are compared to shoreline and pelagic surveys conducted for this study in June, July and August 1989; in March, June, July and August 1990; and in March and July 1991. Over 120 species of birds and 20 species of mammals have been counted on surveys.

Overall declines (some of them dramatic) in Prince William Sound populations occurred between 1972/1973 and the years after the oil spill for the following 16 out of 39 species or species groups examined: **grebes, cormorants, Northern Pintail, Harlequin Duck, Oldsquaw, scoters, goldeneyes, Bufflehead, Black Oystercatcher, Bonaparte's Gull, Black-legged Kittiwake, Arctic Tern, Pigeon Guillemot, Branchyramphus (Marbled and Kittlitz') murrelets, and Northwestern Crow**. Even if these species were declining prior to the spill, they should be considered at risk from the additional damage the spill may have caused. In addition, it is possible that the spill caused wider damage than we assume from our oiling definitions, and that damage to a population could be Sound-wide. T-tests indicated that five of the above species or groups: **cormorants, Harlequin Duck, Black Oystercatcher, Pigeon Guillemot and Northwestern Crow** declined more in the oiled area than in the non-oiled area since the early 1970s. In addition, **murres** declined in the oiled area but not in the non-oiled area.

Nineteen species or groups occurring in shoreline habitats were examined for declines since D. Irons 1984 shoreline survey. Using one procedure, **Harlequin Duck, Black Oystercatcher, murres, Pigeon Guillemot and Tufted Puffin** populations declined more in the oiled area compared to the non-oiled area. "Paired" t-tests comparing numbers in the same transects pre- and post-spill found greater declines in the oiled area for **cormorants, Black Oystercatcher, Arctic Tern, murres, and Pigeon Guillemot.** Irons' survey did not count Northwestern Crows.

The large amount of time between the 1972/1973 pre-spill surveys and the spill makes it difficult to relate changes in population to the oil spill, and other ecological events may well

have contributed to declines. However, many of the same species show declines since the 1984 shoreline survey, indicating that declines occurred after 1984.

Ongoing analyses include relating shoreline type and bathymetry data to distribution of birds; analysis of post-spill population trends; transfering the distribution information from this survey into a format from which any investigators can easily access data in graphical form (in cooperation with the USFWS Oil Spill GIS team); redesigning the pelagic stratum to lower variances; planning (in cooperation with Oil Spill Sea Otter studies) to collect pup ratio information on surveys. Linear and area densities of "shoreline species" (such as Black Oystercatcher, Bald Eagle) are now available to investigators of these species. Additional data collected in 1989 and 1990 are available in previous reports (Klosiewski and Hotchkiss 1990, Laing 1990). Information on Sea Otters is available in reports from NRDA Marine Mammal Study 6 (DeGange and Burn 1989, Ballachey, Bodkin and Burn 1990, 1991).

OBJECTIVES

A. To determine distribution and estimate abundance (with 95% confidence limits) of waterbirds in Prince William Sound (PWS) (1989, 1990 and 1991) and the northern Gulf of Alaska (GOA) (1989, 1990).

B. To test the null hypothesis that estimates of waterbird relative abundances, using new and comparable historical data, are not significantly lower (@=0.05) in oiled than non-oiled areas in PWS (1989, 1990 and 1991) and the northern GOA (1989, 1990).

C. To estimate the long- and short-term trends in populations that were determined in previous objectives to be reduced by the oil spill.

D. (1990 only) To test the null hypothesis that the total number of Pigeon Guillemots attending colonies at Naked Island, PWS, following the oil spill is not significantly lower than the total number attending in prior years.

E. (1990 only) To test the null hypothesis that the abundance index of Marbled Murrelets on five transects on the western side of Naked Island, PWS, following the oil spill is not significantly lower than the abundance index on each transect in prior years.

METHODS

Sampling Methods

Prince William Sound

Damage Assessment Surveys.--Surveys were conducted jointly with Marine Mammal Study No. 6 using 3 25-foot boats each manned with an operator and two observers. Observers recorded all birds and mammals within 100 m on each side of the boat within survey transects, and whether the animal was in the water, on land or in the air. The survey window extended approximately 40-50 m ahead of and 100 m above the moving boat, but was extended for animals that exhibited strong avoidance behavior when the boat was more than 50 m away (e.g. scoters, murrelets, Harlequin Ducks, Harbor Seals). Surveys were conducted only when seas were less than 2 feet. Date and time of survey, and environmental variables including wind velocity and direction, air and water temperature, weather, observation conditions, sea state, tide, presence of oil, and presence of human activity were also recorded for each transect.

A stratified random sampling design using shoreline, coastal/pelagic and pelagic strata was used to meet Objectives A-C. Surveys were conducted in July and August 1989, in March,

June, July and August 1990, and in March and July 1991. A survey of the shoreline stratum alone was conducted in June 1989.

The shoreline stratum was divided into 742 transects used in surveys by Irons, Nyeswander and Trapp (1988, ND) (see Pre-Oil Spill Surveys below). For summer 1989 surveys, 187 transects covering approximately 25% of the shoreline were randomly selected to be surveyed. For March surveys, concern about weather delays forced a reduction in the number of transects to be surveyed, so the first half of the 187 randomly chosen transects were surveyed. The number of transects surveyed during summer 1990 included all 187 transects sampled in 1989, plus 25 additional transects randomly selected from the population of transects surveyed by Irons et al. (1988, ND) in 1984. These transects were added because statistical reviewers advised that the oiled area was under-represented in our sampled transects.

The shoreline stratum included all water within 200 m of shoreline. Transects were surveyed by travelling 100 m offshore, parallel to the coast, at 5-10 knots. One observer recorded all animals seen between the coast and the boat while the other recorded all animals between 100-200 m offshore.

Pelagic and coastal/pelagic strata consisted of plots of water delineated by 5-minute intervals (latitude and longitude) on NOAA charts. Forty-six of 206 coastal/pelagic plots and 25 of 86 pelagic plots were randomly selected to be surveyed in 1989. The same plots were surveyed in all summer surveys in 1990 and 1991. Twenty-nine coastal/pelagic plots were surveyed in March surveys. Plots excluded any water within 200 m of the coast. The two strata differed in that coastal/pelagic plots intersected more than approximately 1 nm (nautical mile) of shoreline, whereas pelagic plots intersected less than 1 nm of shoreline. For plots that were 5 minutes wide (east to west), two north-south transect lines located 1 minute inside the east and west boundaries of the plot were surveyed. For plots that were less than 5 minutes wide due to intersection with land, either one or two transect lines were surveyed, depending on plot size. In cases where a plot would be very small, it was combined with an adjacent plot, so that some plots contained three transect lines.

Transects in pelagic and coastal/pelagic plots were steered by a combination of compass heading and LORAN-C coordinates. Boat velocity was higher than for shoreline surveys, ranging from 15-20 knots, depending on observation conditions.

Pre-Oil Spill Surveys.--Two major survey efforts by the USFWS were made prior to 1989. Original data from both these efforts were located for this study and put into the same computer format as data from Damage Assessment Surveys.

The first effort was a series of 4 boat surveys conducted in March/April 1972, July 1972, March 1973 and August 1973 (Dwyer et al. nd). These surveys systematically selected approximately 13% of transects in pelagic and shoreline strata in 1972, and systematically selected transects within subgroups of these strata in 1973 ("open water" and "coastal" subgroups within the pelagic stratum and "outer exposed beaches", "inner exposed beaches"

and "inner bays and fjords" within the shoreline stratum)[1]. Observation methods were comparable to those used in Damage Assessment Surveys, with transect width 100 m on either side of the boat, except that small bays were included in the shoreline stratum, and were surveyed in their entirety as part of shoreline transects. Although individual transects used in these surveys were different from those used in Damage Assessment Surveys, population estimates from both surveys are statistically valid and can be compared.

During July and August of 1984 and 1985, a complete survey of the Prince William Sound shoreline was conducted, using observation methods similar to those used for Damage Assessment Surveys (Irons, Nyeswander and Trapp ND). The shoreline was divided into 742 transects, which were subsequently sampled for the shoreline portion of Damage Assessment Surveys. The western half of the Sound was surveyed in 1984, and the eastern half was surveyed in 1985. No surveys of pelagic strata were attempted.

Naked Island Studies of Pigeon Guillemots and Marbled Murrelets.--These studies were not included in this project in 1991. A separate report by K. Kuletz meeting Objectives D and E and including additional information collected on these species at Naked Island was attached to the 1990 report for this study (Laing 1990: Appendix A)). The final report on 1989 and 1990 NRDA Naked Island studies will be completed by K. Kuletz in 1992. M. Cody collected information on Black Oystercatchers coincidentally to Naked Island studies in 1990, when no NRDA study on Oystercatchers was funded. This information will be incorporated into the Restoration Study on Black Oystercatchers (Andres 1991).

Southern Kenai Peninsula

This area was not surveyed for this study in 1991.

Kodiak Island

This area was not surveyed for this study in 1991.

Data Analysis

Prince William Sound

Poststratification by oiling.--Consistent definitions of oiled areas have not yet been standardized for Damage Assessment studies. Until this process is complete, final assessment

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[1]Laing (1990) reported that these transects were randomly selected, based on Dwyer et al. nd). Close examination of notes found with the original data confirm that that transects were systematically selected within each stratum.

of injury to birds from this study is not possible. For this report, poststratification of each stratum into oiled and non-oiled areas was defined by the author as follows. All available datasets (see below) were examined and a line drawn around the area of the Sound that was considered to be oiled by any dataset. There were undoubtably "islands" of non-oiled habitat within this area; it was assumed that animals on a "non-oiled" transect surrounded by oil were likely to be affected by oil. This "zone" definition was used because it appeared to combine the most accurate data from all sources, and because it could be used for both shoreline and pelagic strata. Because this definition includes some "non-oiled" areas, it is conservative: non-affected areas may be included as "oiled", making it less likely for an oiling effect to be detected.

Previous reports of this study (Klosiewski and Hotchkiss 1990, Laing 1990) used shoreline oiling datasets to define oiling for each shoreline transect. Results of t-tests in this report are therefore different from results in the earlier reports.

The "zone" oiling stratification definition used in this report was derived from the following datasets. Shoreline oiling information was collected by the Alaska Department of Environmental Conservation (ADEC) in early summer 1989 (ADEC Summer 1989 Shoreline Assessment Data), fall 1989 (ADEC Fall 1989 Shoreline Assessment Data ("Fall Walk-a-thon")) and spring 1990 (Multi-agency Spring 1990 Survey ("SSAT Survey")). The area of water covered by oil was estimated from maps based on ADEC aerial observations in March and April 1989 and from a NOAA HAZMAT hindcast model of the movement of spilled oil (J.A. Galt and D.L. Payton, National Oceanic and Atmospheric Administration, Hazardous Materials Response Branch, Seattle, WA). These datasets were all described in GIS Technical Group (1990).

The areas of oiled and non-oiled zones were automated onto USFWS Geographic Information System (GIS) using ArcInfo and overlain on the transect schemes for each of the two survey designs (i.e. 1972/1973 design, and the 1984/1985/1989 design) Datasets describing the area (km^2) of oiling on each transect for pre- and post-spill surveys were then generated and used for analysis described below.

Population estimates and variances (Objective A).--Estimates for oiled and non-oiled zones of PWS were produced by adding estimates generated for each stratum (shoreline, coastal/pelagic and pelagic) for each zone within a survey. These were computed using a ratio estimator as follows (Sheaffer, Mendenhall and Ott 1986: 131):

Population estimate:

$$\hat{T}_y = \frac{\sum_{i=1}^{n} y_i}{\sum_{i=1}^{n} x_i} T_x = r T_x$$

Variance:

$$\hat{V}(\hat{T}_y) = T_x^2 \hat{V}r = T_x^2 \frac{N-n}{nN} \frac{1}{\bar{x}^2} \frac{\sum_{i=1}^{n} (y_i - r x_i)^2}{n-1}$$

Bound on the error of estimation (EE):

$$2\sqrt{\hat{V}\hat{T}_y}$$

where $\hat{T}_y$ = *population estimate for a stratum*
y_i = *number of birds counted on a transect*
x_i = *area of a transect sampled*
T_x = *total area of all transects*
$V(T_y)$ = *estimated variance of* T *y*
N = *total number of transects*
n = *number of sampled transects*
$\bar{x}$ = *mean area of all transects*

The formulas differed for pelagic strata in that y_i was estimated as the density of animals counted in transects multiplied by the area of the block sampled, and the finite population correction (fpc=(N-n)/N) was not included.

Using ratio estimators is appropriate if the number of birds counted is positively correlated with transect length. When all strata of data are available, and the appropriateness of

stratifying by habitat is evaluated for each species, the extent of such a correlation will be determined.

Population estimates for 1972 were post-stratified using the stratification scheme used in 1973, and then post-stratified by oiling zone as for all other surveys.

Statistical tests (Objective B).--To examine whether oiled and non-oiled populations changed in the same way between the Irons 1984 shoreline survey and surveys conducted after the spill, the change in population size in oiled shoreline areas compared to non-oiled shoreline areas was computed as follows for transects surveyed within July:

Change in popn. = $[(R_1 - R_2)_{oiled} - (R_1 - R_2)_{non\text{-}oiled}] X_{oiled}$
in oiled compared
to non-oiled area

Variance of change = $\{ \frac{var(t_{1oiled} - t_{2oiled})}{X^2_{oiled}} + \frac{var(t_{1non} - t_{2non})}{X^2_{non\text{-}oiled}} \} X_{oiled}$

where y_1 = July 1984 counts from transects surveyed in both 1984 and 1989 (or 1990)

y_2 = July 1989 (or 1990) counts from transects surveyed in both 1984 and 1989 (or 1990)

w = July counts from transects surveyed in 1984 only

z = July counts from transects surveyed in 1989 (or 1990) only

x = transect area for y (x), w (x') and z (x*)

$R_1 = \frac{y_1 + w}{x + x'}$

$R_2 = \frac{y_2 + z}{x + x^*}$

$var(t_1 - t_2) =$

$$X^2 \{1/(n_1+n_2)-1/N\}\{s^2_{1counts}+R^2_1 s^2_{1area}-2R_1 s_{1counts,area}\}/((x+x')/(n_1+n_2))^2$$

$$+\{1/(n_1+n_2)-1/N\}\{s^2_{2counts}+R^2_2 s^2_{2area}-2R_2 s_{2counts,area}\}/((x+x^*)/(n_1+n_3))^2$$

$$-2(n_1/(n_1+n_2)(n_1+n_3)-1/N)s_{((\quad))}/(x+x')/(n_1+n_2) * (x+x^*)/(n_1+n_3)\}$$

The western half of PWS was surveyed in 1984, and the eastern half in 1985. Transects surveyed in 1985 were not combined with those sampled in 1984, because variation due to year surveyed could not be isolated. A separate test using 1985 data could not be conducted because few transects affected by oil were sampled in 1985.

The above formulas allow us to use transects which were sampled in either pre- or post-spill surveys, as well as transects which were sampled in both survey periods.

Prior to development of the "all-transects" set of formulas, t-tests were performed on the set of transects sampled both in 1984 and 1989, and on the set of transects sampled in 1984 and 1990 ("paired-transects" t-tests). The difference of the logs of counts between 1984 and 1989 (or between 1984 and 1990) on each transect surveyed during a given month was first computed. The differences for all "oiled" shoreline transects (using shoreline oiling data) were then compared by t-test to the differences for all "non-oiled" transects. These t-tests were reported in the 1990 draft report. These tests were repeated using the "zone" definition of oiled area described in the previous section, and this new version is reported here.

Two-sample t-tests were performed on datasets consisting of population estimates from each survey in a given month prior to and after the spill. For example, population estimates for all strata combined for the month of March 1972, 1973 and 1990 and 1991 were compared.

Poststratification of PWS into habitats for various species has not been completed. Habitat analysis will use previously collected data on shoreline types, bathymetry data and examination of each species' distribution. Such stratification may make statistical tests more sensitive to spill-related population changes. All statistical treatments may be revised after such stratification.

Southern Kenai Peninsula

The Kenai Peninsula was not included in this project in 1991.

Kodiak Island

Kodiak Island was not included in this project in 1991.

RESULTS

Surveys conducted before (1972 and 1973) and after (1989, 1990, 1991) indicate that Prince William Sound populations declined for 16 out of 39 species or species groups (Tables 1-12). These species or groups included loons, grebes, cormorants, Northern Pintail, Harlequin Duck, Oldsquaw, scoters, goldeneyes, Bufflehead, Black Oystercatcher, Bonaparte's Gull, Black-legged Kittiwake, Arctic Tern, Pigeon Guillemot, Branchyramphus murrelets, and Northwestern Crow.

T-tests comparing the change in population of oiled areas between the early 1970s and the post-spill years with the change in population of non-oiled areas indicate either greater declines ($P<0.1$) in the non-oiled area than in the oiled area, or declines in the oiled area compared to no-change or increases in the non-oiled area. Such declines were found for cormorants (July), Harlequin Ducks, (March, July and August), Black Oystercatchers (March, August), murres (March), Pigeon Guillemots (March), and Northwestern Crow (July). Tables giving T- and P- values for all 30 species or groups tested will be given in the next draft of this report.

The procedure performed on shoreline data for 19 species using D. Irons July 1984 shoreline survey to detect declines in the oiled area compared to the non-oiled area indicate that five species or groups: Harlequin Duck, Black Oystercatcher, murres, Pigeon Guillemot and Tufted Puffin declined in the oiled area of the Sound compared to the non-oiled area since 1984 (Tables 13-15). T-tests performed on the same data demonstrated oiled-area effects ($P<0.05$) for cormorants (1984/1989, 1984/1990, 1984/1991 tests), Black Oystercatchers (1984/1989, 1984/1989 tests), Arctic Terns (1984/1989 test), murres (1984/1989, 1984/1990, 1984/1991 tests), and Pigeon Guillemots (1984/1989, 1984/1990, 1984/1991 tests). Tables detailing these results will be given in the next draft of this report.

More than 120 species of birds and 20 species of mammals were counted on surveys (Table 16), and data on all these species are available upon request. Mammals are outside the range of this report; many bird species occur in Prince William Sound sporadically or in small numbers, or are terrestrial and therefore not adequately sampled by this survey method. For these reasons, population estimates were generated for a smaller number of species (Tables 1-12).

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Table 12. July 1991 population estimates ± 95% bound on the error of estimation for birds on water in Prince William Sound. Animals on land within 100 m of water were also counted.

COMMON NAME	Non-oiled area	Non-oiled error	Oiled area	Oiled error	Total	Total error
All Brachyramphus Murrelets	52,611	15,456	28,787	8,746	81,398	17,759
Parakeet Auklet	281	270	561	455	842	529
Tufted Puffin	1,909	1,249	1,910	980	3,819	1,588
Horned Puffin	693	637	559	458	1,252	784
Northwestern Crow	1,267	511	379	132	1,646	528

Table 13. Number of birds by which shoreline populations declined in oiled areas more than expected. The difference in population (non-oiled minus oiled area populations) in July 1984 and the difference in population (non-oiled minus oiled area populations) in July 1989 in Prince William Sound were compared. Bold type indicates that significant declines in oiled areas compared to non-oiled areas were detected. Values in parentheses indicate increased populations in oiled compared to non-oiled populations. Values for which the 95% error estimate is greater than the change in population indicate that no change was detected.

COMMON NAME	Population change	Estimated Error
All Cormorants	(321)	485
Harlequin Duck	(233)	491
All Scoters	(108)	124
All Mergansers	(737)	297
Bald Eagle	(73)	77
Black Oystercatcher	**87**	**82**
Surfbird	(1,628)	344
All Shorebirds	3,619	12,006
Bonaparte's Gull	(196)	49
Mew Gull	(255)	220
Glaucous-winged Gull	563	1,521
Black-legged Kittiwake	(4,500)	2,524
All Gulls	(6,512)	4,651
Arctic Tern	61	1,108
All Murres	**317**	**253**
Pigeon Guillemot	**588**	**383**
All Brachyramphus Murrelets	486	1,430
Tufted Puffin	**556**	**309**
Horned Puffin	(104)	160

Table 14. Number of birds by which shoreline populations declined in oiled areas more than expected: comparison of differences in oiled vs. non-oiled area populations between 1984 and 1990. See Table 13 for further explanation.

COMMON NAME	Population change	Estimated Error
All Cormorants	23	89
Harlequin Duck	1,282	1,368
All Scoters	26	256
All Mergansers	(359)	284
Bald Eagle	41	80
Black Oystercatcher	**163**	**107**
Surfbird	(1,906)	517
All Shorebirds	(3,257)	910
Bonaparte's Gull	(201)	39
Mew Gull	298	630
Glaucous-winged Gull	(687)	1,938
Black-legged Kittiwake	(4,782)	3,629
All Gulls	(5,509)	5,202
Arctic Tern	(254)	705
All Murres	**455**	**57**
Pigeon Guillemot	**457**	**419**
All Brachyramphus Murrelets	(1,413)	944
Tufted Puffin	**626**	**210**
Horned Puffin	(50)	36

Table 15. Number of birds by which shoreline populations declined in oiled area more than expected: comparison of differences in oiled and non-oiled area shoreline populations between 1984 and 1991 in Prince William Sound. See Table 13 for further explanation.

COMMON NAME	Population change	Estimated Error
All Cormorants	(199)	419
Harlequin Duck	**1,407**	**1,247**
All Scoters	540	668
All Mergansers	103	759
Bald Eagle	(111)	104
Black Oystercatcher	33	70
Surfbird	(2,180)	847
All Shorebirds	(3,975)	1,053
Bonaparte's Gull	(194)	42
Mew Gull	125	279
Glaucous-winged Gull	(804)	2,474
Black-legged Kittiwake	(3,207)	3,179
All Gulls	(4,533)	3,995
Arctic Tern	256	313
All Murres	315	338
Pigeon Guillemot	297	361
All Brachyramphus Murrelets	(646)	1,620
Tufted Puffin	352	484
Horned Puffin	(73)	55

Table 16. All bird and mammal species counted on boat surveys in Prince William Sound in 1972, 1973, 1984, 1985, 1989, 1990 or 1991.

COMMON NAME
Birds
Gaviiformes
Gaviidae: Loons
Red-throated Loon
Pacific Loon
Common Loon
Yellow-billed Loon

Podicipediformes
Podicipedidae: Grebes
Horned Grebe
Red-necked Grebe

Procellariiformes
Procellariidae: Shearwaters and Petrels
Northern Fulmar
Sooty Shearwater
Short-tailed Shearwater

Hydrobatidae: Storm-petrels
Fork-tailed Storm-petrel
Leach's Storm-petrel

Pelecaniformes
Phalacrocoracidae: Cormorants
Double-crested Cormorant
Pelagic Cormorant
Red-faced Cormorant

Ciconiiformes
Ardeidae: Bitterns and Herons
Great Blue Heron

Anseriformes
Anatidae: Swans, Geese, and Ducks

Cygnini: Swans
Tundra Swan
Trumpeter Swan

Anserini: Geese
Greater White-fronted Goose

Table 16. All bird and mammal species counted on boat surveys in Prince William Sound in 1972, 1973, 1984, 1985, 1989, 1990 or 1991.

Emperor Goose
Pacific Black Brant
Canada Goose

Anatini: Dabbling Ducks
Green-winged Teal
Blue-winged Teal
Mallard
Northern Pintail
Northern Shoveler
Gadwall
American Wigeon

Aythyini: Diving Ducks
Ring-necked Duck
Greater Scaup
Lesser Scaup

Mergini: Sea Ducks
Common Eider
King Eider
Steller's Eider
Harlequin Duck
Oldsquaw
Black Scoter
Surf Scoter
White-winged Scoter
Common Goldeneye
Barrow's Goldeneye
Bufflehead
Common Merganser
Red-breasted Merganser

Falconiformes
Accipitridae:Eagles, Hawks, and Allies
Bald Eagle
Northern Harrier
Sharp-shinned Hawk
Northern Goshawk
Red-tailed Hawk
Rough-legged Hawk
Golden Eagle

Table 16. All bird and mammal species counted on boat surveys in Prince William Sound in 1972, 1973, 1984, 1985, 1989, 1990 or 1991.

Falconidae: Falcons
Peregrine Falcon
Gyrfalcon

Galliformes
Phaseianoidea: Grouse and Ptarmigan
Unidentified Ptarmigan

Gruiformes
Rallidae: Rails, Gallinules, and Coots
Sandhill Crane

Charadriiformes
Charadriidae: Plovers
Semipalmated Plover

Haematopodidae: Oystercatchers
Black Oystercatcher

Scolopacidae: Sandpipers, Phalaropes, and Allies
Greater Yellowlegs
Lesser Yellowlegs
Solitary Sandpiper
Wandering Tattler
Spotted Sandpiper
Whimbrel
Black Turnstone
Ruddy Turnstone
Surfbird
Sanderling
Semipalmated Sandpiper
Western Sandpiper
Least Sandpiper
Pectoral Sandpiper
Rock Sandpiper
Dunlin
Short-billed Dowitcher
Long-billed Dowitcher
Unidentified Dowitcher
Red-necked Phalarope
Red Phalarope
Unidentified Phalarope

Table 16. All bird and mammal species counted on boat surveys in Prince William Sound in 1972, 1973, 1984, 1985, 1989, 1990 or 1991.

Laridae: Gulls and Terns
Pomarine Jaeger
Parasitic Jaeger
Long-tailed Jaeger
Unidentified Jaeger
Bonaparte's Gull
Mew Gull
Herring Gull
Thayer's Gull
Glaucous-winged Gull
Glaucous Gull
Black-legged Kittiwake
Sabine's Gull
Caspian Tern
Arctic Tern
Aleutian Tern

Alcidae: Auks, Murres, and Puffins
Common Murre
Thick-billed Murre
Pigeon Guillemot
Marbled Murrelet
Kittlitz's Murrelet
Unidentified Brachyramphus
Ancient Murrelet
Cassin's Auklet
Parakeet Auklet
Crested Auklet
Rhinoceros Auklet
Tufted Puffin
Horned Puffin

Strigiformes
Strigidae: Owls
Snowy Owl
Northern Hawk Owl

Apodiformes
Trochilidae: Hummingbirds
Rufous Hummingbird

Coraciiformes
Alcedinidae: Kingfishers

Table 16. All bird and mammal species counted on boat surveys in Prince William Sound in 1972, 1973, 1984, 1985, 1989, 1990 or 1991.

Belted Kingfisher

Passeriformes
Hirundinidae: Swallows
Tree Swallow
Bank Swallow

Corvidae: Jays, Magpies, and Crows
Steller's Jay
Black-billed Magpie
Northwestern Crow
Common Raven

Muscicapidae: Thrushes
Unidentified Thrush

Bombycillidae: Waxwings
Bohemian Waxwing

Emberizidae: Emberizids
Unidentified Warbler
Snow Bunting

Fringillidae: Finches and Allies
Pine Grosbeak
Pine Siskin
Unidentified Passerine
Unidentified Bird

Mammals
Rodentia
Erethizontidae: New World Porcupines
Porcupine

Cetacea
Delphinidae: Dolphins,Porpoises and Killer Whales
Harbor Porpoise
Dall Porpoise
Killer Whale
Pilot Whale

Eschrichtidae: Gray Whales

Table 16. All bird and mammal species counted on boat surveys in Prince William Sound in 1972, 1973, 1984, 1985, 1989, 1990 or 1991.

Gray Whale

Balaenopteridae: Rorquals and Humpback Whales
Minke Whale
Humpback Whale

Carnivora
Ursidae: Bears
Brown Bear
Black Bear

Mustelidae: Minks, Martens and Otters
Mink
Marten
Wolverine
Sea Otter
River Otter
Unidentified Otter

Pinnipedia
Otariidae: Sea Lions, Fur Seals
Steller's Sea Lion

Phocidae: Seals
Harbor Seal

Artiodactyla: Even-toed Ungulates
Cervidae: Deer
Sitka Black-tailed Deer

Bovidae: Goats and Sheep
Mountain Goat
Unidentified Mammal

. 1972 population estimates ± 95% bound on the error of estimation for birds on water in Prince William Sound. .and within 100 m of water were also counted.

COMMON NAME	Non-oiled area	Non-oiled error	Oiled area	Oiled error	Total	Total error
All Loons	3,041	1,777	294	322	3,335	1,806
All Grebes	6,678	2,720	2,628	1,303	9,306	3,016
Fork-tailed Storm-petrel	0	0	0	0	0	0
All Cormorants	6,644	2,302	4,148	1,544	10,792	2,772
Canada Goose	48	88	0	0	48	88
Green-winged Teal	148	254	0	0	148	254
Mallard	7,139	8,543	46	68	7,185	8,543
Northern Pintail	348	592	0	0	348	592
All Scaup	1,626	919	0	0	1,626	919
Harlequin Duck	6,395	2,235	6,084	2,414	12,480	3,290
Oldsquaw	15,741	15,919	3,446	3,118	19,187	16,221
All Scoters	43,098	17,878	9,837	6,848	52,935	19,144
All Goldeneyes	13,861	4,773	941	393	14,802	4,789
Bufflehead	7,676	4,872	521	748	8,198	4,929
All Mergansers	4,721	3,025	1,076	572	5,797	3,079
Bald Eagle	987	338	385	186	1,372	386
Black Oystercatcher	0	0	181	309	181	309

Table 1. March 1972 population estimates ± 95% bound on the error of estimation for birds on water in Prince William Sound. Animals on land within 100 m of water were also counted.

COMMON NAME	Non-oiled area	Non-oiled error	Oiled area	Oiled error	Total	Total error
Surfbird	0	0	8	14	8	14
Rock Sandpiper	775	801	0	0	775	801
Red-necked Phalarope	0	0	0	0	0	0
All Shorebirds	775	801	881	840	1,656	1,161
Pomarine Jaeger	0	0	0	0	0	0
Parasitic Jaeger	0	0	0	0	0	0
Long-tailed Jaeger	0	0	0	0	0	0
Bonaparte's Gull	112	193	0	0	112	193
Mew Gull	8,576	9,928	374	490	8,949	9,940
Herring Gull	198	172	0	0	198	172
Glaucous-winged Gull	25,731	12,010	2,199	1,170	27,930	12,067
Black-legged Kittiwake	7,279	10,664	2,165	1,619	9,444	10,786
Sabine's Gull	0	0	0	0	0	0
All Gulls	43,098	23,054	7,148	2,193	50,247	23,158
Arctic Tern	0	0	0	0	0	0
All Murres	4,015	1,825	4,180	3,225	8,195	3,705
Pigeon Guillemot	2,331	958	1,363	849	3,695	1,280

Table 1. March 1972 population estimates ± 95% bound on the error of estimation for birds on water in Prince William Sound. Animals on land within 100 m of water were also counted.

COMMON NAME	Non-oiled area	Non-oiled error	Oiled area	Oiled error	Total	Total error
All Brachyramphus Murrelets	6,520	1,704	5,392	1,730	11,913	2,428
Parakeet Auklet	0	0	0	0	0	0
Tufted Puffin	0	0	0	0	0	0
Horned Puffin	0	0	0	0	0	0
Northwestern Crow	3,549	1,455	3,734	2,950	7,283	3,289

Table 2. July 1973 population estimates ± 95% bound on the error of estimation for birds on water in Prince William Sound. Animals on land within 100 m of water were also counted.

COMMON NAME	Non-oiled area	Non-oiled error	Oiled area	Oiled error	Total	Total error
All Loons	2,388	1,443	179	182	2,567	1,454
All Grebes	199	242	7	12	206	242
Fork-tailed Storm-petrel	7,364	7,296	10,174	6,066	17,539	9,488
All Cormorants	6,105	5,838	13,939	18,291	20,045	19,200
Canada Goose	0	0	0	0	0	0
Green-winged Teal	106	197	0	0	106	197
Mallard	291	261	0	0	291	261
Northern Pintail	177	328	0	0	177	328
All Scaup	29	45	0	0	29	45
Harlequin Duck	1,676	1,044	1,931	1,726	3,607	2,017
Oldsquaw	90	144	0	0	90	144
All Scoters	12,225	7,088	749	863	12,975	7,141
All Goldeneyes	420	377	7	12	427	377
Bufflehead	0	0	0	0	0	0
All Mergansers	6,480	4,742	190	230	6,670	4,748
Bald Eagle	1,005	417	167	75	1,172	423
Black Oystercatcher	442	395	102	124	544	414

Table 2. July 1973 population estimates ± 95% bound on the error of estimation for birds on water in Prince William Sound. Animals on land within 100 m of water were also counted.

COMMON NAME	Non-oiled area	Non-oiled error	Oiled area	Oiled error	Total	Total error
Surfbird	1,238	2,234	344	561	1,582	2,304
Rock Sandpiper	0	0	0	0	0	0
Red-necked Phalarope	2,162	3,488	16	31	2,178	3,488
All Shorebirds	2,109	2,283	1,916	2,291	4,025	3,234
Pomarine Jaeger	762	616	249	223	1,011	655
Parasitic Jaeger	203	310	0	0	203	310
Long-tailed Jaeger	0	0	0	0	0	0
Bonaparte's Gull	9,746	9,699	102	182	9,848	9,701
Mew Gull	7,238	2,794	1,350	1,016	8,588	2,973
Herring Gull	0	0	0	0	0	0
Glaucous-winged Gull	45,203	32,640	6,647	4,007	51,850	32,885
Black-legged Kittiwake	71,790	32,972	34,974	19,511	106,764	38,312
Sabine's Gull	0	0	0	0	0	0
All Gulls	133,982	54,714	43,213	21,470	177,196	58,775
Arctic Tern	21,076	7,316	12,101	5,911	33,177	9,405
All Murres	3,604	2,846	2,310	1,804	5,915	3,370
Pigeon Guillemot	10,257	4,399	5,310	2,543	15,567	5,081

Table 2. July 1973 population estimates ± 95% bound on the error of estimation for birds on water in Prince William Sound. Animals on land within 100 m of water were also counted.

COMMON NAME	Non-oiled area	Non-oiled error	Oiled area	Oiled error	Total	Total error
All Brachyramphus Murrelets	206,685	95,107	97,747	21,041	304,432	97,407
Parakeet Auklet	401	232	1,492	1,266	1,893	1,287
Tufted Puffin	2,737	1,898	6,859	4,352	9,596	4,748
Horned Puffin	2,593	2,894	986	874	3,580	3,023
Northwestern Crow	1,243	904	831	468	2,074	1,018

Table 3. March 1973 population estimates ± 95% bound on the error of estimation for birds on water in Prince William Sound. Animals on land within 100 m of water were also counted.

COMMON NAME	Non-oiled area	Non-oiled error	Oiled area	Oiled error	Total	Total error
All Loons	3,245	2,336	24	24	3,268	2,336
All Grebes	6,308	2,222	6,437	5,233	12,744	5,685
Fork-tailed Storm-petrel	0	0	0	0	0	0
All Cormorants	15,864	4,608	12,643	6,685	28,507	8,119
Canada Goose	138	246	0	0	138	246
Green-winged Teal	59	78	0	0	59	78
Mallard	1,602	1,123	15	23	1,617	1,123
Northern Pintail	276	480	0	0	276	480
All Scaup	2,583	2,506	0	0	2,583	2,506
Harlequin Duck	10,180	4,114	5,652	3,606	15,831	5,470
Oldsquaw	10,192	8,068	1,524	1,147	11,716	8,150
All Scoters	52,429	21,602	8,166	4,940	60,595	22,159
All Goldeneyes	23,726	12,360	1,504	691	25,230	12,379
Bufflehead	5,363	2,385	250	235	5,612	2,397
All Mergansers	3,654	1,566	819	523	4,473	1,651
Bald Eagle	1,207	348	708	386	1,916	520
Black Oystercatcher	20	25	187	345	207	346

Table 3. March 1973 population estimates ± 95% bound on the error of estimation for birds on water in Prince William Sound. Animals on land within 100 m of water were also counted.

COMMON NAME	Non-oiled area	Non-oiled error	Oiled area	Oiled error	Total	Total error
Surfbird	0	0	0	0	0	0
Rock Sandpiper	6,415	7,420	773	985	7,188	7,485
Red-necked Phalarope	0	0	0	0	0	0
All Shorebirds	6,700	7,426	960	1,013	7,660	7,495
Pomarine Jaeger	0	0	0	0	0	0
Parasitic Jaeger	0	0	0	0	0	0
Long-tailed Jaeger	0	0	0	0	0	0
Bonaparte's Gull	0	0	336	464	336	464
Mew Gull	2,546	1,583	856	901	3,401	1,822
Herring Gull	228	550	168	381	396	669
Glaucous-winged Gull	18,598	8,247	14,025	14,378	32,623	16,575
Black-legged Kittiwake	4,617	2,897	1,485	1,233	6,102	3,148
Sabine's Gull	0	0	0	0	0	0
All Gulls	25,988	10,645	16,870	14,414	42,858	17,919
Arctic Tern	0	0	0	0	0	0
All Murres	4,318	2,479	7,051	8,348	11,369	8,708
Pigeon Guillemot	5,812	3,682	3,783	3,975	9,595	5,419

Table 3. March 1973 population estimates ± 95% bound on the error of estimation for birds on water in Prince William Sound. Animals on land within 100 m of water were also counted.

COMMON NAME	Non-oiled area	Non-oiled error	Oiled area	Oiled error	Total	Total error
All Brachyramphus Murrelets	33,965	15,625	42,743	12,652	76,708	20,105
Parakeet Auklet	3	5	3	6	5	8
Tufted Puffin	0	0	0	0	0	0
Horned Puffin	0	0	0	0	0	0
Northwestern Crow	7,038	5,162	1,849	1,712	8,887	5,438

Table 4. August 1973 population estimates ± 95% bound on the error of estimation for birds on water in Prince William Sound. Animals on land within 100 m of water were also counted.

COMMON NAME	Non-oiled area	Non-oiled error	Oiled area	Oiled error	Total	Total error
All Loons	1,722	1,147	545	264	2,267	1,177
All Grebes	650	474	80	67	730	479
Fork-tailed Storm-petrel	7,107	9,767	1,723	2,375	8,829	10,052
All Cormorants	5,997	7,190	965	468	6,962	7,205
Canada Goose	195	209	0	0	195	209
Green-winged Teal	206	268	0	0	206	268
Mallard	2,473	1,930	50	84	2,523	1,931
Northern Pintail	3,103	3,824	0	0	3,103	3,824
All Scaup	3,211	5,178	98	177	3,309	5,181
Harlequin Duck	3,390	2,322	14,828	26,540	18,218	26,641
Oldsquaw	0	0	87	148	87	148
All Scoters	17,013	10,614	1,465	1,138	18,477	10,674
All Goldeneyes	2,955	2,952	0	0	2,955	2,952
Bufflehead	0	0	0	0	0	0
All Mergansers	4,192	2,161	402	300	4,594	2,182
Bald Eagle	1,562	865	479	242	2,041	899

Table 4. August 1973 population estimates ± 95% bound on the error of estimation for birds on water in Prince William Sound. Animals on land within 100 m of water were also counted.

COMMON NAME	Non-oiled area	Non-oiled error	Oiled area	Oiled error	Total	Total error
Black Oystercatcher	699	556	549	706	1,248	89
Surfbird	1,686	2,820	157	215	1,843	2,828
Rock Sandpiper	0	0	0	0	0	0
Red-necked Phalarope	8,835	6,214	7,709	3,309	16,544	7,040
All Shorebirds	5,739	6,015	2,583	2,943	8,323	6,696
Pomarine Jaeger	0	0	0	0	0	0
Parasitic Jaeger	0	0	0	0	0	0
Long-tailed Jaeger	0	0	0	0	0	0
Bonaparte's Gull	5,535	5,659	0	0	5,535	5,659
Mew Gull	23,370	15,394	2,124	780	25,494	15,414
Herring Gull	59	80	3	6	62	80
Glaucous-winged Gull	39,477	18,468	10,621	8,067	50,098	20,153
Black-legged Kittiwake	126,850	102,354	14,592	7,478	141,442	102,627
Sabine's Gull	0	0	0	0	0	0
All Gulls	200,335	123,953	27,340	12,278	227,675	124,560
Arctic Tern	10,841	6,131	4,974	3,548	15,815	7,084
All Murres	2,288	1,784	1,205	539	3,493	1,863

Table 4. August 1973 population estimates ± 95% bound on the error of estimation for birds on water in Prince William Sound. Animals on land within 100 m of water were also counted.

COMMON NAME	Non-oiled area	Non-oiled error	Oiled area	Oiled error	Total	Total error
Pigeon Guillemot	12,343	8,470	3,577	2,481	15,919	8,826
All Brachyramphus Murrelets	87,670	24,149	22,739	12,550	110,409	27,215
Parakeet Auklet	55	94	146	187	201	210
Tufted Puffin	2,029	1,631	3,020	4,175	5,049	4,482
Horned Puffin	227	219	508	417	735	471
Northwestern Crow	1,710	1,133	323	304	2,033	1,173

Table 5. July 1989 population estimates ± 95% bound on the error of estimation for birds on water in Prince William Sound. Animals on land within 100 m of water were also counted.

COMMON NAME	Non-oiled area	Non-oiled error	Oiled area	Oiled error	Total	Total error
All Loons	587	312	178	226	765	385
All Grebes	0	0	0	0	0	0
Fork-tailed Storm-petrel	26,010	37,709	9,412	5,930	35,422	38,172
All Cormorants	366	280	439	511	805	583
Canada Goose	159	277	3	5	162	277
Green-winged Teal	0	0	0	0	0	0
Mallard	275	380	0	0	275	380
Northern Pintail	0	0	0	0	0	0
All Scaup	437	516	0	0	437	516
Harlequin Duck	3,042	1,252	845	377	3,887	1,307
Oldsquaw	0	0	0	0	0	0
All Scoters	2,317	1,461	3,393	3,307	5,710	3,616
All Goldeneyes	374	252	13	16	387	252
Bufflehead	0	0	0	0	0	0
All Mergansers	2,005	1,302	640	304	2,646	1,337
Bald Eagle	923	227	189	58	1,112	234
Black Oystercatcher	737	764	113	55	850	766

Table 5. July 1989 population estimates ± 95% bound on the error of estimation for birds on water in Prince William Sound. Animals on land within 100 m of water were also counted.

COMMON NAME	Non-oiled area	Non-oiled error	Oiled area	Oiled error	Total	Total error
Surfbird	121	211	549	757	670	786
Rock Sandpiper	0	0	0	0	0	0
Red-necked Phalarope	8,057	8,977	1,639	1,862	9,696	9,168
All Shorebirds	6,890	9,858	1,048	879	7,939	9,897
Pomarine Jaeger	1,125	696	382	338	1,508	774
Parasitic Jaeger	277	208	228	229	505	309
Long-tailed Jaeger	0	0	0	0	0	0
Bonaparte's Gull	2,234	1,822	221	175	2,454	1,830
Mew Gull	4,999	1,889	621	217	5,620	1,902
Herring Gull	4	8	3	5	7	9
Glaucous-winged Gull	15,742	4,452	4,985	1,862	20,727	4,826
Black-legged Kittiwake	33,563	7,767	24,814	5,518	58,377	9,528
Sabine's Gull	0	0	0	0	0	0
All Gulls	67,647	14,094	32,504	7,149	100,151	15,804
Arctic Tern	4,732	1,873	2,512	1,571	7,245	2,445
All Murres	1,448	1,385	732	581	2,180	1,502
Pigeon Guillemot	2,511	1,193	1,536	882	4,047	1,484

Table 5. July 1989 population estimates ± 95% bound on the error of estimation for birds on water in Prince William Sound. Animals on land within 100 m of water were also counted.

COMMON NAME	Non-oiled area	Non-oiled error	Oiled area	Oiled error	Total	Total error
All Brachyramphus Murrelets	64,858	13,798	42,374	10,733	107,232	17,481
Parakeet Auklet	349	612	150	249	499	661
Tufted Puffin	714	597	1,561	953	2,275	1,124
Horned Puffin	1,471	1,848	383	264	1,854	1,866
Northwestern Crow	1,138	564	330	218	1,468	604

Table 6. August 1989 population estimates ± 95% bound on the error of estimation for birds on water in Prince William Sound. Animals on land within 100 m of water were also counted.

COMMON NAME	Non-oiled area	Non-oiled error	Oiled area	Oiled error	Total	Total error
All Loons	755	781	242	239	997	817
All Grebes	1,313	1,087	44	33	1,357	1,088
Fork-tailed Storm-petrel	8,979	8,896	5,358	2,310	14,338	9,191
All Cormorants	342	159	510	484	852	510
Canada Goose	683	510	21	35	704	511
Green-winged Teal	383	471	0	0	383	471
Mallard	720	478	0	0	720	478
Northern Pintail	94	115	0	0	94	115
All Scaup	17	24	0	0	17	24
Harlequin Duck	5,298	1,725	1,491	1,056	6,789	2,022
Oldsquaw	0	0	0	0	0	0
All Scoters	2,868	1,730	98	98	2,966	1,733
All Goldeneyes	643	460	22	31	665	461
Bufflehead	0	0	0	0	0	0
All Mergansers	3,767	1,219	538	285	4,305	1,251
Bald Eagle	1,128	228	271	115	1,399	256
Black Oystercatcher	720	458	275	150	995	482

Table 6. August 1989 population estimates ± 95% bound on the error of estimation for birds on water in Prince William Sound. Animals on land within 100 m of water were also counted.

COMMON NAME	Non-oiled area	Non-oiled error	Oiled area	Oiled error	Total	Total error
Surfbird	0	0	128	171	128	171
Rock Sandpiper	0	0	0	0	0	0
Red-necked Phalarope	17,748	10,167	2,240	2,230	19,989	10,408
All Shorebirds	1,577	1,000	676	343	2,253	1,057
Pomarine Jaeger	1,862	780	1,785	1,501	3,647	1,692
Parasitic Jaeger	135	110	118	141	253	179
Long-tailed Jaeger	0	0	0	0	0	0
Bonaparte's Gull	903	718	152	248	1,055	760
Mew Gull	7,960	2,440	1,462	615	9,422	2,516
Herring Gull	912	500	44	31	956	501
Glaucous-winged Gull	37,942	14,511	10,633	4,190	48,574	15,104
Black-legged Kittiwake	35,500	8,410	27,090	6,737	62,591	10,776
Sabine's Gull	0	0	0	0	0	0
All Gulls	99,651	22,070	40,461	9,864	140,111	24,174
Arctic Tern	583	417	750	494	1,333	646
All Murres	1,868	907	761	529	2,629	1,049
Pigeon Guillemot	2,448	1,288	1,837	1,435	4,284	1,928

Table 6. August 1989 population estimates ± 95% bound on the error of estimation for birds on water in Prince William Sound. Animals on land within 100 m of water were also counted.

COMMON NAME	Non-oiled area	Non-oiled error	Oiled area	Oiled error	Total	Total error
All Brachyramphus Murrelets	26,444	9,222	20,787	8,470	47,231	12,522
Parakeet Auklet	4	7	0	0	4	7
Tufted Puffin	613	582	1,382	878	1,995	1,053
Horned Puffin	649	604	402	304	1,051	676
Northwestern Crow	1,689	975	316	203	2,005	996

Table 7. March 1990 population estimates ± 95% bound on the error of estimation for birds on water in Prince William Sound. Animals on land within 100 m of water were also counted.

COMMON NAME	Non-oiled area	Non-oiled error	Oiled area	Oiled error	Total	Total error
All Loons	696	411	168	173	864	446
All Grebes	5,496	2,204	1,506	607	7,002	2,286
Fork-tailed Storm-petrel	431	685	164	167	595	705
All Cormorants	4,426	1,263	4,687	2,251	9,113	2,581
Canada Goose	37	70	0	0	37	70
Green-winged Teal	0	0	0	0	0	0
Mallard	1,911	1,364	17	24	1,928	1,364
Northern Pintail	0	0	0	0	0	0
All Scaup	1,762	1,595	1	1	1,763	1,595
Harlequin Duck	7,785	2,314	2,738	974	10,523	2,511
Oldsquaw	7,667	10,103	856	1,086	8,522	10,162
All Scoters	9,377	2,617	3,269	2,367	12,646	3,529
All Goldeneyes	15,879	4,204	3,451	1,069	19,331	4,338
Bufflehead	3,860	1,634	210	174	4,070	1,643
All Mergansers	1,929	726	1,562	501	3,491	882
Bald Eagle	1,073	330	533	148	1,606	362
Black Oystercatcher	15	19	0	0	15	19

Table 7. March 1990 population estimates ± 95% bound on the error of estimation for birds on water in Prince William Sound. Animals on land within 100 m of water were also counted.

COMMON NAME	Non-oiled area	Non-oiled error	Oiled area	Oiled error	Total	Total error
Surfbird	276	517	626	1,152	902	1,263
Rock Sandpiper	0	0	0	0	0	0
Red-necked Phalarope	0	0	0	0	0	0
All Shorebirds	2,802	3,145	665	1,166	3,467	3,354
Pomarine Jaeger	0	0	0	0	0	0
Parasitic Jaeger	0	0	0	0	0	0
Long-tailed Jaeger	0	0	0	0	0	0
Bonaparte's Gull	0	0	0	0	0	0
Mew Gull	2,118	1,254	406	253	2,524	1,279
Herring Gull	55	71	98	157	154	172
Glaucous-winged Gull	4,092	1,063	4,322	1,565	8,414	1,892
Black-legged Kittiwake	101	97	56	68	157	118
Sabine's Gull	0	0	0	0	0	0
All Gulls	9,798	5,097	5,635	2,066	15,433	5,499
Arctic Tern	0	0	0	0	0	0
All Murres	4,872	2,502	2,566	1,547	7,439	2,942
Pigeon Guillemot	554	277	253	205	807	345

Table 7. March 1990 population estimates ± 95% bound on the error of estimation for birds on water in Prince William Sound. Animals on land within 100 m of water were also counted.

COMMON NAME	Non-oiled area	Non-oiled error	Oiled area	Oiled error	Total	Total error
All Brachyramphus Murrelets	19,036	8,868	6,846	3,498	25,882	9,533
Parakeet Auklet	0	0	0	0	0	0
Tufted Puffin	0	0	0	0	0	0
Horned Puffin	0	0	0	0	0	0
Northwestern Crow	2,144	1,733	868	671	3,013	1,859

Table 8. June 1990 population estimates ± 95% bound on the error of estimation for birds on water in Prince William Sound. Animals on land within 100 m of water also counted.

COMMON NAME	Non-oiled area	Non-oiled error	Oiled area	Oiled error	Total	Total error
All Loons	1,019	561	89	130	1,109	576
All Grebes	11	13	0	0	11	13
Fork-tailed Storm-petrel	4,719	3,171	8,486	11,828	13,205	12,245
All Cormorants	112	83	284	271	396	283
Canada Goose	1,790	1,910	167	169	1,957	1,917
Green-winged Teal	27	28	0	0	27	28
Mallard	943	861	0	0	943	861
Northern Pintail	81	141	0	0	81	141
All Scaup	205	190	0	0	205	190
Harlequin Duck	4,526	1,733	739	936	5,266	1,970
Oldsquaw	111	124	0	0	111	124
All Scoters	736	635	621	917	1,357	1,116
All Goldeneyes	228	157	32	51	260	165
Bufflehead	0	0	0	0	0	0
All Mergansers	2,819	1,136	182	97	3,001	1,141
Bald Eagle	1,429	328	551	115	1,981	347
Black Oystercatcher	426	116	133	56	559	129

Table 8. June 1990 population estimates ± 95% bound on the error of estimation for birds on water in Prince William Sound. Animals on land within 100 m of water also counted.

COMMON NAME	Non-oiled area	Non-oiled error	Oiled area	Oiled error	Total	Total error
Surfbird	0	0	85	141	85	141
Rock Sandpiper	0	0	0	0	0	0
Red-necked Phalarope	165	293	242	424	408	515
All Shorebirds	535	128	369	237	904	269
Pomarine Jaeger	17	29	400	409	416	410
Parasitic Jaeger	149	195	204	154	353	248
Long-tailed Jaeger	92	113	63	108	155	156
Bonaparte's Gull	31	54	0	0	31	54
Mew Gull	1,442	874	359	165	1,801	890
Herring Gull	4	8	0	0	4	8
Glaucous-winged Gull	7,614	3,140	5,750	3,341	13,363	4,585
Black-legged Kittiwake	28,958	9,621	15,324	7,641	44,282	12,286
Sabine's Gull	0	0	0	0	0	0
All Gulls	41,827	12,035	22,049	9,617	63,876	15,406
Arctic Tern	6,530	3,940	1,434	1,236	7,964	4,130
All Murres	1,645	743	660	429	2,305	858
Pigeon Guillemot	1,294	384	874	456	2,168	596

Table 8. June 1990 population estimates ± 95% bound on the error of estimation for birds on water in Prince William Sound. Animals on land within 100 m of water also counted.

COMMON NAME	Non-oiled area	Non-oiled error	Oiled area	Oiled error	Total	Total error
All Brachyramphus Murrelets	27,449	8,726	21,911	6,298	49,360	10,761
Parakeet Auklet	380	443	123	216	504	492
Tufted Puffin	1,213	776	2,409	1,424	3,622	1,622
Horned Puffin	53	88	361	252	414	267
Northwestern Crow	1,514	395	598	179	2,112	434

Table 9. July 1990 population estimates ± 95% bound on the error of estimation for birds on water in Prince William Sound. Animals on land within 100 m of water were also counted.

COMMON NAME	Non-oiled area	Non-oiled error	Oiled area	Oiled error	Total	Total error
All Loons	348	245	23	15	372	245
All Grebes	29	38	0	0	29	38
Fork-tailed Storm-petrel	7,191	2,723	11,235	4,569	18,426	5,319
All Cormorants	103	70	123	81	227	107
Canada Goose	1,933	3,380	0	0	1,933	3,380
Green-winged Teal	61	86	3	5	64	87
Mallard	208	249	0	0	208	249
Northern Pintail	44	73	0	0	44	73
All Scaup	0	0	0	0	0	0
Harlequin Duck	7,598	3,168	1,784	1,518	9,382	3,513
Oldsquaw	93	111	0	0	93	111
All Scoters	2,383	1,861	2,176	3,832	4,559	4,260
All Goldeneyes	213	148	25	23	238	149
Bufflehead	0	0	0	0	0	0
All Mergansers	3,374	2,049	583	249	3,956	2,064
Bald Eagle	1,173	270	311	55	1,484	275
Black Oystercatcher	609	188	162	77	771	203

Table 9. July 1990 population estimates ± 95% bound on the error of estimation for birds on water in Prince William Sound. Animals on land within 100 m of water were also counted.

COMMON NAME	Non-oiled area	Non-oiled error	Oiled area	Oiled error	Total	Total error
Surfbird	95	104	592	681	687	688
Rock Sandpiper	0	0	0	0	0	0
Red-necked Phalarope	1,693	1,153	721	649	2,415	1,323
All Shorebirds	2,095	949	1,186	935	3,280	1,332
Pomarine Jaeger	419	331	279	217	699	396
Parasitic Jaeger	56	94	0	0	56	94
Long-tailed Jaeger	5	8	0	0	5	8
Bonaparte's Gull	1,395	1,169	45	73	1,440	1,171
Mew Gull	7,200	2,736	1,112	654	8,312	2,813
Herring Gull	117	128	8	8	125	129
Glaucous-winged Gull	21,610	7,140	10,506	3,306	32,116	7,868
Black-legged Kittiwake	21,670	5,536	20,603	6,798	42,272	8,767
Sabine's Gull	0	0	0	0	0	0
All Gulls	56,442	12,705	32,826	9,314	89,268	15,753
Arctic Tern	3,893	1,532	2,370	921	6,263	1,787
All Murres	1,261	776	252	179	1,512	796
Pigeon Guillemot	1,738	597	1,226	474	2,965	762

Table 9. July 1990 population estimates ± 95% bound on the error of estimation for birds on water in Prince William Sound. Animals on land within 100 m of water were also counted.

COMMON NAME	Non-oiled area	Non-oiled error	Oiled area	Oiled error	Total	Total error
All Brachyramphus Murrelets	52,611	15,456	28,787	8,746	81,398	17,759
Parakeet Auklet	281	270	561	455	842	529
Tufted Puffin	1,909	1,249	1,910	980	3,819	1,588
Horned Puffin	693	637	559	458	1,252	784
Northwestern Crow	1,267	511	379	132	1,646	528

Table 10. August 1990 population estimates ± 95% bound on the error of estimation for birds on water in Prince William Sound. Animals on land within 100 m of water were also counted.

COMMON NAME	Non-oiled area	Non-oiled error	Oiled area	Oiled error	Total	Total error
All Loons	199	145	353	394	552	420
All Grebes	531	495	148	135	679	513
Fork-tailed Storm-petrel	3,498	1,662	6,918	7,432	10,417	7,615
All Cormorants	798	299	136	182	934	350
Canada Goose	1,219	1,652	359	346	1,579	1,687
Green-winged Teal	491	654	0	0	491	654
Mallard	227	344	59	78	286	352
Northern Pintail	14	18	0	0	14	18
All Scaup	18	32	0	0	18	32
Harlequin Duck	4,629	1,716	3,224	1,336	7,854	2,175
Oldsquaw	0	0	0	0	0	0
All Scoters	3,807	4,630	5,699	7,000	9,506	8,392
All Goldeneyes	287	276	745	736	1,032	786
Bufflehead	0	0	3	5	3	5
All Mergansers	1,873	713	2,236	1,467	4,109	1,631
Bald Eagle	2,137	681	379	135	2,516	694
Black Oystercatcher	541	206	161	85	702	223

Table 10. August 1990 population estimates ± 95% bound on the error of estimation for birds on water in Prince William Sound. Animals on land within 100 m of water were also counted.

COMMON NAME	Non-oiled area	Non-oiled error	Oiled area	Oiled error	Total	Total error
Surfbird	227	245	49	39	276	248
Rock Sandpiper	0	0	0	0	0	0
Red-necked Phalarope	16,035	5,379	25,426	9,625	41,461	11,026
All Shorebirds	1,321	396	736	433	2,057	587
Pomarine Jaeger	1,407	875	1,013	829	2,420	1,205
Parasitic Jaeger	73	106	140	139	213	175
Long-tailed Jaeger	2	3	1	2	3	4
Bonaparte's Gull	3,361	3,263	157	231	3,518	3,271
Mew Gull	10,507	3,918	3,656	1,381	14,163	4,154
Herring Gull	36	34	20	19	55	39
Glaucous-winged Gull	38,552	10,699	12,330	4,107	50,882	11,460
Black-legged Kittiwake	32,518	10,301	26,334	8,423	58,852	13,306
Sabine's Gull	55	93	60	95	114	133
All Gulls	91,097	19,793	46,346	11,221	137,443	22,752
Arctic Tern	1,679	1,219	1,582	1,449	3,260	1,894
All Murres	1,877	1,112	1,303	754	3,180	1,343
Pigeon Guillemot	1,515	477	2,305	1,017	3,820	1,123

Table 10. August 1990 population estimates ± 95% bound on the error of estimation for birds on water in Prince William Sound. Animals on land within 100 m of water were also counted.

COMMON NAME	Non-oiled area	Non-oiled error	Oiled area	Oiled error	Total	Total error
All Brachyramphus Murrelets	19,773	5,355	31,665	11,970	51,437	13,114
Parakeet Auklet	41	69	0	0	41	69
Tufted Puffin	972	549	1,826	1,311	2,798	1,422
Horned Puffin	105	96	315	434	420	445
Northwestern Crow	1,119	744	169	199	1,288	770

Table 11. March 1991 population estimates ± 95% bound on the error of estimation for birds on water in Prince William Sound. Animals on land within 100 m of water were also counted.

COMMON NAME	Non-oiled area	Non-oiled error	Oiled area	Oiled error	Total	Total error
All Loons	1,507	1,185	126	128	1,634	1,192
All Grebes	4,136	1,923	1,459	1,150	5,595	2,240
Fork-tailed Storm-petrel	0	0	0	0	0	0
All Cormorants	5,559	2,177	3,481	1,518	9,040	2,654
Canada Goose	0	0	0	0	0	0
Green-winged Teal	0	0	0	0	0	0
Mallard	8,249	11,958	0	0	8,249	11,958
Northern Pintail	0	0	0	0	0	0
All Scaup	431	775	0	0	431	775
Harlequin Duck	8,327	2,696	2,832	989	11,158	2,872
Oldsquaw	2,486	1,325	683	508	3,169	1,419
All Scoters	13,605	6,797	3,281	1,933	16,886	7,067
All Goldeneyes	19,603	6,219	4,036	1,340	23,639	6,361
Bufflehead	2,003	654	125	92	2,129	660
All Mergansers	3,697	3,153	2,226	1,091	5,923	3,336
Bald Eagle	1,262	441	549	212	1,811	489
Black Oystercatcher	8	14	0	0	8	14

Table 11. March 1991 population estimates ± 95% bound on the error of estimation for birds on water in Prince William Sound. Animals on land within 100 m of water were also counted.

COMMON NAME	Non-oiled area	Non-oiled error	Oiled area	Oiled error	Total	Total error
Surfbird	0	0	0	0	0	0
Rock Sandpiper	38	69	160	210	197	221
Red-necked Phalarope	0	0	0	0	0	0
All Shorebirds	348	623	190	217	538	660
Pomarine Jaeger	0	0	0	0	0	0
Parasitic Jaeger	0	0	0	0	0	0
Long-tailed Jaeger	0	0	0	0	0	0
Bonaparte's Gull	0	0	94	178	94	178
Mew Gull	5,960	2,691	3,825	1,977	9,785	3,339
Herring Gull	56	108	39	77	96	133
Glaucous-winged Gull	6,567	3,089	3,659	2,023	10,226	3,693
Black-legged Kittiwake	442	380	401	250	843	455
Sabine's Gull	0	0	0	0	0	0
All Gulls	14,105	4,539	8,378	2,922	22,483	5,398
Arctic Tern	0	0	0	0	0	0
All Murres	13,915	7,882	10,188	9,149	24,103	12,076
Pigeon Guillemot	2,064	2,144	777	383	2,842	2,178

Table 11. March 1991 population estimates ± 95% bound on the error of estimation for birds on water in Prince William Sound. Animals on land within 100 m of water were also counted.

COMMON NAME	Non-oiled area	Non-oiled error	Oiled area	Oiled error	Total	Total error
All Brachyramphus Murrelets	13,873	9,383	9,637	6,061	23,510	11,171
Parakeet Auklet	0	0	0	0	0	0
Tufted Puffin	23	43	0	0	23	43
Horned Puffin	81	137	0	0	81	137
Northwestern Crow	3,139	1,599	186	160	3,325	1,607

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Table 12. July 1991 population estimates ± 95% bound on the error of estimation for birds on water in Prince William Sound. Animals on land within 100 m of water were also counted.

COMMON NAME	Non-oiled area	Non-oiled error	Oiled area	Oiled error	Total	Total error
All Loons	1,502	1,122	146	130	1,649	1,129
All Grebes	88	68	0	0	88	68
Fork-tailed Storm-petrel	6,320	2,046	13,118	10,947	19,438	11,137
All Cormorants	366	210	614	526	980	567
Canada Goose	3,098	5,284	3	5	3,101	5,284
Green-winged Teal	78	130	0	0	78	130
Mallard	457	293	0	0	457	293
Northern Pintail	0	0	0	0	0	0
All Scaup	342	375	0	0	342	375
Harlequin Duck	7,597	3,094	667	368	8,264	3,116
Oldsquaw	47	69	0	0	47	69
All Scoters	3,350	1,683	2,601	3,431	5,950	3,821
All Goldeneyes	359	236	497	878	856	909
Bufflehead	20	27	0	0	20	27
All Mergansers	2,218	885	470	294	2,688	932
Bald Eagle	1,571	315	754	166	2,325	356
Black Oystercatcher	627	307	146	74	773	316

Table 12. July 1991 population estimates ± 95% bound on the error of estimation for birds on water in Prince William Sound. Animals on land within 100 m of water were also counted.

COMMON NAME	Non-oiled area	Non-oiled error	Oiled area	Oiled error	Total	Total error
Surfbird	1,519	2,408	2,361	2,378	3,880	3,385
Rock Sandpiper	0	0	0	0	0	0
Red-necked Phalarope	15,769	27,397	3,045	2,604	18,814	27,521
All Shorebirds	2,325	2,426	2,593	2,432	4,918	3,435
Pomarine Jaeger	0	0	0	0	0	0
Parasitic Jaeger	270	212	100	125	371	247
Long-tailed Jaeger	63	95	0	0	63	95
Bonaparte's Gull	809	688	14	11	823	689
Mew Gull	2,990	1,091	288	100	3,278	1,096
Herring Gull	91	105	124	147	214	180
Glaucous-winged Gull	18,433	4,642	6,634	2,973	25,067	5,512
Black-legged Kittiwake	33,581	7,204	28,015	6,272	61,596	9,552
Sabine's Gull	0	0	0	0	0	0
All Gulls	59,872	10,230	35,229	7,895	95,102	12,922
Arctic Tern	4,920	1,240	1,263	633	6,183	1,392
All Murres	4,915	1,932	2,042	769	6,957	2,079
Pigeon Guillemot	5,600	4,928	984	351	6,585	4,940

Table 12. July 1991 population estimates ± 95% bound on the error of estimation for birds on water in Prince William Sound. Animals on land within 100 m of water were also counted.

COMMON NAME	Non-oiled area	Non-oiled error	Oiled area	Oiled error	Total	Total error
All Brachyramphus Murrelets	61,940	14,189	44,013	14,040	105,952	19,961
Parakeet Auklet	7	11	0	0	7	11
Tufted Puffin	2,463	1,563	2,418	1,204	4,882	1,973
Horned Puffin	821	756	476	313	1,297	818
Northwestern Crow	1,677	597	384	110	2,061	607