Exxon Valdez Oil Spill
Restoration Project Final Report

Marine Bird and Sea Otter Population Abundance of Prince William Sound, Alaska: Trends following the *T/V Exxon Valdez* Oil Spill, 1989-93

Restoration Project 93045
Final Report

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STUDY HISTORY: The U. S. Fish and Wildlife Service, Migratory Bird Management conducted boat surveys in Prince William Sound prior to the *Exxon Valdez* oil spill in 1972-73 (Dwyer et al. 1976) and 1984-85 (Irons et al. 1988a,b). After the oil spill, Natural Resource Damage Assessment Bird Study Number 2 (Burn 1994, Klosiewski and Laing 1994) was initiated to document damage from the oil spill on the marine bird and sea otter populations of Prince William Sound. Data from these surveys indicated that populations of sea otters (Burn 1994) and several marine bird species (Klosiewski and Laing 1994) declined in the oil spill area. Thus, restoration project 93045 (Agler et al. 1994) was initiated to continue monitoring marine birds and sea otter population abundance to assess recovery of injured species. This study continues the original *Exxon Valdez* oil spill damage assessment study (Bird Study Number 2) conducted by S. Klosiewski and K. Laing, Migratory Bird Management, U. S. Fish and Wildlife Service in 1989-91 (Klosiewski and Laing 1994). We used Klosiewski and Laing's (1994) sampling design and data, and we are grateful for the statistical advice and insight they provided.

ABSTRACT: We conducted small boat surveys to estimate marine bird and sea otter (*Enhydra lutris*) populations in Prince William Sound, Alaska during March and July 1993, using methods developed for the 1989-91 surveys (Klosiewski and Laing 1994). During 1993, we recorded 65 bird and 13 mammal species. We estimated that 402,760 $\pm$ 167,697 marine birds were in the Sound during March 1993, an increase of >200,000 birds over 1990 and 1991. This increase was largely due to an unexplained influx of murres (*Uria* spp.) followed by a die-off (Kendall et al. 1993, Piatt and van Pelt 1993). We estimated that 83,172 $\pm$ 34,794 birds were in the oiled zone, and 319,589 $\pm$ 164,048 birds were in the unoiled zone during March. During July 1993, an estimated 371,327 $\pm$ 58,189 marine birds were in Prince William Sound. We estimated that 116,219 $\pm$ 26,896 birds were in the oiled zone, and 255,108 $\pm$ 51,600 birds were in the unoiled zone. The July 1993 estimate was 8-56% higher than the 1989-91 estimates (Klosiewski and Laing 1994) but was 41% lower than the July 1972 estimate (Haddock et al., unpubl. data).

To examine trends in our marine bird population estimates from 1989-93, we assumed that in the absence of oil spill effects, population estimates in the oiled zone would change at the same rate as those in the unoiled zone. The goldeneye (*Bucephala* spp.) and black oystercatcher (*Haematopus bachmani*) populations showed significantly different trends between the oiled and unoiled zones during March, and the surfbird (*Aphriza virgata*) population showed significantly different trends between the oiled and unoiled zones in July. The goldeneye and surfbird populations increased at a slower rate in the oiled zone than in the unoiled zone, indicating that continued effects from the oil spill. The black oystercatcher population increased more in the oiled zone than in the unoiled zone. However, the data used to indicate this trend may not be biologically meaningful (March population estimates for black oystercatchers were $\leq$15) and must be interpreted with caution.

For Prince William Sound as a whole, we examined population trends from 1989-93, using regression analyses. We found significant positive trends for the goldeneye, gull (*Larus* and *Rissa* spp.), murre (*Uria* spp.), and waterfowl during March. No significant trend during July in overall abundance of any species or species group was found.

We also examined the relative abundance of the species groups seen in Prince William Sound from 1972 to 1993. The most common species group observed during March was waterfowl ($\bar{x}$ = 47.7% of the total marine bird population), except in 1993, when murres comprised 54.9% of the total. The most common species groups recorded during July were *Brachyramphus* murrelets ($\bar{x}$ = 38.3%) and gulls ($\bar{x}$ = 31.6%).

Sea otter populations in 1993 were estimated at 6,813 $\pm$ 1,861 for March and 8,216 $\pm$ 2,435 for July. We found no difference in the rate of change between the oiled and unoiled zones from 1989-93 for either the March or July population estimates. There was no significant trend in the total number of sea otters in Prince William Sound from 1989-93.

KEY WORDS: population estimates, marine birds, sea otters, trends, Prince William Sound.

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EXECUTIVE SUMMARY

We conducted small boat surveys to estimate marine bird and sea otter (*Enhydra lutris*) populations in Prince William Sound, Alaska during March and July 1993, using the methods developed for surveys conducted from 1989-91 after the *T/V Exxon Valdez* oil spill (Klosiewski and Laing 1994). During the 1993 surveys, we recorded 65 bird and 13 mammal species in Prince William Sound. We estimated that 402,760 ± 167,697 marine birds were present in the Sound during March 1993, an increase of >200,000 birds over the 1990 and 1991 estimates. This increase was largely due to an unexplained influx of murres (*Uria* spp.) into Prince William Sound, subsequently followed by a die-off (Kendall et al. 1993, Piatt and van Pelt 1993). We estimated that 83,172 ± 34,794 birds were in the oiled zone, and 319,589 ± 164,048 birds were in the unoiled zone during March. During July 1993, an estimated 371,327 ± 58,189 marine birds were in Prince William Sound. An estimated 116,219 ± 26,896 birds were in the oiled zone, and 255,108 ± 51,600 birds were in the unoiled zone. The July 1993 population estimate for all of Prince William Sound was 8-56% higher than the 1989-91 estimates (Klosiewski and Laing 1994) but was 41% lower than the July 1972 estimate (Haddock et al., unpubl. data).

To determine whether there were any trends in our marine bird population estimates from 1989-93, we assumed that in the absence of oil spill effects population estimates in the oiled zone would change at the same rate as those in the unoiled zone. The goldeneye (*Bucephala* spp.) and black oystercatcher (*Haematopus bachmani*) populations showed significantly different trends between the oiled and unoiled zones during March, and the surfbird (*Aphriza virgata*) population showed significantly different trends between the oiled and unoiled zones in July. We found that the goldeneye and surfbird populations increased at a slower rate in the oiled zone than in the unoiled zone, indicating that there may be continued effects due to the oil spill. The black oystercatcher population increased more in the oiled zone than in the unoiled zone. However, the data used to indicate this trend may not be biologically meaningful (March population estimates for black oystercatchers were ≤15) and must be interpreted with caution.

For Prince William Sound as a whole, we also examined the population trends from 1989-93 using regression analyses. We found significant positive trends for the goldeneye, gull (*Larus* and *Rissa* spp.), murre (*Uria* spp.), and waterfowl populations during March. No significant trend in overall abundance of any species or species group was found for Prince William Sound during July.

We also examined the relative abundance of the species groups seen in Prince William Sound from 1972 to 1993. The most common species group observed during March was waterfowl ($\dot{x}$ = 47.7% of the total marine bird population), except in 1993, when murres comprised 54.9% of the total. The most common species groups recorded during July were *Brachyramphus* murrelets ($\dot{x}$ = 38.3%) and gulls ($\dot{x}$ = 31.6%).

Sea otter populations in 1993 were estimated at 6,813 $\pm$ 1,861 for March and 8,216 $\pm$ 2,435 for July. We found no difference in the rate of change between the oiled and unoiled zones from 1989-93 for either the March or July population estimates. There was no significant trend in the total number of sea otters in Prince William Sound from 1989-93.

INTRODUCTION

The waters and shorelines of Prince William Sound provide important feeding, resting, and breeding sites for many marine birds and sea otters (Isleib and Kessel 1973, Hogan and Murk 1982, Irons et al. 1988a,b). In 1989, the *T/V Exxon Valdez* grounded on Bligh Reef in the northeastern corner of the Sound and spilled 11 million gallons of crude oil into the surrounding waters. Over 30,000 marine bird (Piatt et al. 1990) and 900 sea otter (DeGange and Lensink 1990) carcasses were recovered following the spill. Of these, 3,400 birds (Piatt et al. 1990) and approximately 500 sea otters (DeGange and Lensink 1990) were recovered in Prince William Sound. Direct mortality of marine birds in Prince William Sound and the Gulf of Alaska was estimated as 100,000-300,000 birds by Piatt et al. (1990) and 375,000-435,000 birds by Ecological Consulting, Inc. (1991). Mortality of sea otters was estimated as 350-4,950 otters (Garrott et al. 1993).

The U. S. Fish and Wildlife Service conducted boat surveys in Prince William Sound during 1972-73 (Dwyer et al. 1976), 1984-85 (Irons et al. 1988a,b), and 1989-91 (Burn 1994, Klosiewski and Laing 1994) to determine the population abundance of marine birds and sea otters. Data from the 1989-91 surveys indicated that populations of sea otters (Burn 1994) and several marine bird species (Klosiewski and Laing 1994) declined in the oil spill area. Burn (1994) demonstrated a 35% decline in sea otter density along the shoreline of the oiled zone. Klosiewski and Laing (1994) documented overall declines of some Prince William Sound marine bird populations between the early 1970's (Dwyer et al. 1976) and the years after the oil spill. Populations that declined more in the oiled zone than in the unoiled zone were cormorants (*Phalacrocorax* spp.), harlequin duck (*Histrionicus histrionicus*), black oystercatchers, pigeon guillemot (*Cepphus columba*), and northwestern crow (*Corvus caurinus*). Differences in abundance also were detected between the oiled and unoiled zones of Prince William Sound since Irons et al. (1988a,b) conducted a shoreline survey in 1984-85. Populations that declined included loons (*Gavia* spp.), scoters (*Melanitta* spp.), harlequin duck, black oystercatcher, mew gull (*Larus canus*), and Arctic tern (*Sterna paradisaea*; Klosiewski and Lang 1994). More detailed studies of black oystercatcher (Andres 1994), and pigeon guillemot (Oakley and Kuletz 1993) populations in Prince William Sound corroborated the changes in abundance determined by the boat surveys (Klosiewski and Laing 1994).

The overall purpose of this study was to continue monitoring the marine bird and sea otter populations of Prince William Sound following the *T/V Exxon Valdez* oil spill to determine whether species affected by the oil spill were recovering. Our primary objectives included estimating abundances of marine bird and sea otter populations in Prince William Sound during March and July 1993 and comparing these estimates with the 1989-91 estimates to ascertain trends in marine bird and sea otter population abundance in Prince William Sound.

OBJECTIVES

The purpose of this study was to obtain annual estimates of the summer and winter populations of marine birds and sea otters in Prince William Sound in order to determine whether species whose populations may have declined due to the *T/V Exxon Valdez* oil spill have recovered. Our specific objectives were:

a. To determine distribution and estimate abundance, with 95% confidence limits, of marine bird and sea otter populations in Prince William Sound during summer and winter, 1993;

b. To determine if marine bird species, whose populations declined more in the oiled zone than in the unoiled zone of Prince William Sound, have recovered;

c. To examine the relative abundance of the common species groups from 1972-93; and

d. To support restoration studies on harlequin duck, black oystercatcher, pigeon guillemot, marbled murrelet (*Brachyramphus marmoratus*), and other marine birds and sea otters by providing data on population changes, distribution, and habitat use of Prince William Sound populations.

METHODS

Study Area

Prince William Sound is a large embayment north of the Gulf of Alaska, located approximately 100 km southeast of Anchorage, Alaska (Fig. 1). Our study area included all waters within Prince William Sound and all land within 100 m of the shore. We excluded Orca Inlet, near Cordova, Alaska and the southern sides of Montague, Hinchinbrook, and Hawkins Islands (Klosiewski and Laing 1994).

Survey Methods

We conducted 2 surveys in 1993; 1 in March and another in July. Transects were surveyed in 14 working days during a 3-week period. Survey methodology was similar to that of surveys conducted by the U. S. Fish and Wildlife Service during 1972-73 by Haddock et al. (unpubl. data) and during 1989-91 by Klosiewski and Laing (1994). To enable us to detect population trends, the same transects were surveyed each year. Surveys were conducted at the same time by three 7.7 m fiberglass boats traveling at speeds of 10-20 km/hr. Two observers counted all birds and mammals detected in a sampling window 100 m on either side, 100 m ahead, and 100 m overhead of the vessel (Klosiewski and Laing 1994). When surveying shoreline transects, observers also recorded birds and mammals sighted on land within 100 m of shore. Observers sampled continuously and used binoculars to aid in species identification. Most transects were surveyed when wave height was <30 cm. No surveys were conducted when wave height was >60 cm.

Although the survey design was changed in 1989 (Klosiewski and Laing 1994), surveys are still comparable with the 1972-73 surveys (Haddock et al., unpubl. data, Klosiewski and Laing 1994). Prince William Sound was divided into 3 strata: shoreline, coastal-pelagic, and pelagic. Irons et al. (1988b) divided the shoreline stratum, all waters within 200 m of land, into 742 transects with a total area of 820.74 km^2 (Table 1). Shoreline transects were of varied size, ranging from small islands with <1 km of coastline to sections of the mainland with over 30 km of coastline. Mean transect length was 5.55 km. Shoreline transects were located by geographic features, such as points of land, to facilitate orientation in the field and to separate the shoreline by habitats.

In 1989, 25% (187) of the total 742 shoreline transects were randomly selected for the surveys. An additional 25 shoreline transects from western Prince William Sound were randomly selected and added in July 1990 to increase the precision of estimates from the oiled zone. The number of shoreline transects was reduced to 99 (13% of the total 742 transects) during March surveys to accommodate potential weather delays. Sample sizes in individual surveys varied

because some transects could not always be surveyed due to blockage by ice or other weather conditions (Table 2).

To sample the coastal-pelagic (nearshore) and pelagic (offshore) waters of Prince William Sound, the study area was divided into 5-minute latitude-longitude blocks. If blocks included >1.8 km of shoreline, they were classified in the coastal-pelagic stratum. Blocks that included ≤1.8 km of shoreline were classified in the pelagic stratum. If coastal-pelagic or pelagic blocks intersected the 200 m shoreline buffer, they were truncated to avoid overlap with the shoreline stratum. Two transects were then placed in each block. If a block was too small to contain both transects, it was combined with an adjacent block (Klosiewski and Laing 1994). Blocks were randomly chosen, and during the July surveys, 22% of the coastal-pelagic blocks (n = 207) and 29% of those within the pelagic stratum (n = 86) were sampled (Table 2). We surveyed 2 north-south transect lines, each 200 m wide, located 1 minute inside the east and west boundaries of each coastal-pelagic and pelagic block. We used Global Positioning Systems and nautical compasses to navigate transect lines.

Poststratification by Oiling

To examine population trends over time and to determine if populations injured by the spill were recovering, we poststratified the Sound into oiled and unoiled zones (Fig. 1; Klosiewski and Laing 1994).

Burn (1994), in his study of sea otter populations after the oil spill, chose a slightly different area as his oiled zone than Klosiewski and Laing (1994). Due to the inherent uncertainty of the exact geographical extent of the surface oiling and the fact that sea otters are mobile, Burn (1994) placed a 5 km buffer around the oiled zone to represent the area within which otters might have been affected by oil. For the purposes of this report, we chose to treat the data for all species and all years the same and used the zones delineated by Klosiewski and Laing (1994).

Statistical Analysis

Grouping of Data.--Species that were difficult to identify correctly in the field were analyzed by species group (Table 3). For example, data for marbled, Kittlitz's (*Brachyramphus brevirostris*), and unidentified *Brachyramphus* murrelets were analyzed as murrelets. Gulls, shorebirds, and waterfowl were analyzed both by individual species and by group. We recorded several species, such as northern harrier (*Circus cyaneus*) and bank swallow (*Riparia riparia*), that are not ordinarily classified as marine birds. Of these, we analyzed the data for bald eagles (*Haliaeetus leucocephalus*) and northwestern crows, species common on the Prince William Sound shoreline.

Population Estimates.--We used two-stage cluster sampling and a ratio estimator (Cochran 1977) to estimate population sizes and variances (Klosiewski

and Laing 1994). The population of each species and species group was calculated for each stratum using the formula:

$$\hat{Y} = X \frac{\sum_{i=1}^{n} y_i}{\sum_{i=1}^{n} x_i} \qquad (1)$$

where:

$\hat{Y}$ = *population estimate for a stratum.*
X = *total area of the stratum.*
y_i = *number of birds on the ith sampling unit.*
x_i = *area of ith sampling unit.*

The areas for each stratum are listed in Table 1. The variance for the population estimate was calculated as follows:

$$\hat{v}(\hat{Y}) = X^2 \frac{N - n}{nN} \frac{1}{\bar{x}^2} \frac{\sum_{i=1}^{n} (y_i - \hat{R}x_i)^2}{n - 1} \qquad (2)$$

where:

$\hat{v}(\hat{Y})$ = *estimated variance of* $\hat{Y}$.
N = *total number of sampling units in the stratum.*
n = *number of sampling units in the stratum.*
$\bar{x}$ = *mean area of all sampling units in the stratum.*

$$\hat{R} = \frac{\sum_{i=1}^{n} y_i}{\sum_{i=1}^{n} x_i}$$

Shoreline transects were treated as a simple random sample, whereas the coastal-pelagic and pelagic transects were analyzed as two-stage cluster samples of unequal size. We estimated y_i as the density of birds counted on the combined transects for a block and multiplied by the area of the sampled block to obtain a population estimate for each block. We added the estimates from all blocks surveyed and divided by the sum of the areas of all blocks surveyed. We calculated the population estimate for a strata by multiplying this estimate by the area of all blocks in the strata. We estimated the variance for the primary unit (the blocks) and ignored the variance contributed by the secondary units (the transects).

We calculated total population estimates for Prince William Sound by adding the population estimates by stratum for each species. The 95% confidence intervals were calculated from the sum of the variances by stratum for each species (Klosiewski and Laing 1994).

Population Trends.--We compared population trends between the oiled and unoiled zones of Prince William Sound to examine whether species injured by the oil spill recovered or whether species with population estimates of >500 individuals changed over time. Only 3 years of data (1990, 1991, and 1993) were available from March, and 4 years of data (1989, 1990, 1991, and 1993) were available from July (Klosiewski and Laing 1994). Analyses were done on the $\log_{10}$ of each population estimate after adding 0.5 to the estimate to account for the effects of log 0.

We assumed that marine bird and sea otter populations changed at the same rate in the oiled and unoiled zones. Thus, we tested whether the populations in the oiled and unoiled zones were changing at different rates by examining the homogeneity of the slopes between the annual population estimates of the oiled and the unoiled zones (Freud and Littell 1981). Significantly different slopes indicated that population abundance of a species or species group in a zone was changing at a different rate than in the other zone. For species or species groups showing a significant difference in slopes, we determined the rate of change in each zone by linear regression analyses.

To examine population trends from 1989-93 for the entire Sound, we calculated linear regressions of the total population estimates of each species during March and July.

Relative Abundance of Marine Birds.--To compare the composition of species within Prince William Sound by year, we estimated the total population abundance of marine birds in the Sound for each year and calculated the percentage of birds found in each major species group. We then compared these percentages or relative abundances among years.

RESULTS

During the 1993 surveys, 65 bird and 13 mammal species were observed in Prince William Sound. Of these, 40 bird species were sighted during March, and 60 bird species were observed during July. One species, the short-billed dowitcher (*Limnodromus griseus*), was new to the survey.

Marine Birds

Population Estimates.--During March 1993, we estimated that 402,760 ± 167,697 marine birds were in Prince William Sound, an increase of >200,000 birds over the number of birds estimated during March 1990 and 1991 (Table 4). We estimated that during March 1993, 83,172 ± 34,794 birds were in the oiled zone, and 319,589 ± 164,048 birds were in the unoiled zone (Table 5). The March 1993 estimate was 71% and 23% larger than the March 1972 and 1973 estimates, respectively (Haddock et al., unpubl. data).

During July 1993, we estimated that 371,327 ± 58,189 marine birds were in Prince William Sound (Table 4). Of these, 116,219 ± 26,896 birds were estimated in the oiled zone, and 255,108 ± 51,600 birds were estimated in the unoiled zone (Table 5). The July 1993 population estimate for Prince William Sound was slightly higher (30,000-130,000 birds) than the estimate from the July 1989-91 surveys (Klosiewski and Laing 1994, Table 4). The July 1993 population estimate was 8% higher than the 1991 population estimate, 56% higher than the 1990 estimate, and 23% higher than the 1989 estimate. The July 1993 estimate was 41% lower than the July 1972 estimate (Haddock et al., unpubl. data), a difference of approximately 250,000 birds.

Population Trends.--When we compared the total population estimates of birds from 1989-93 in the oiled zone with those estimated in the unoiled zone, we found no difference in the rate of change between these zones for March (Table 6) or July (Table 7). We also found no trend in the total population abundance of marine birds in Prince William Sound for March (Table 8) or July (Table 9).

The goldeneye population, estimated as 34,070 ± 9,093 birds in March 1993, and the black oystercatcher population, estimated as 12 ± 16 birds in March 1993, were the only species or species groups with populations that had significantly different rates of change between the oiled and unoiled zones during March ($P = 0.03$ and $P = 0.05$, respectively; Table 6). Regression analyses indicated that the goldeneye population increased faster in the unoiled zone ($F = 434{,}813.40$, $R^2 = 1.00$, $P = 0.002$, Slope = 0.09) than in the oiled zone ($F = 62.66$, $R^2 = 0.98$, P = 0.08, Slope = 0.05). The black oystercatcher population increased faster in the oiled zone ($F = 5.08$, $R^2 = 0.84$, $P = 0.27$, Slope = 0.47) than in the unoiled zone ($F = 40.93$, $R^2 = 0.98$, $P = 0.10$, Slope = -0.51). Surfbird, estimated as 4,285 ± 4,599 birds in July 1993, was the only population that had a significantly different rate of change between the oiled and unoiled zones during July ($P = 0.05$, Table 7).

Regression analysis indicated that the surfbird population increased slower in the oiled zone ($F = 3.35$, $R^2 = 0.63$, $P = 0.21$, Slope = -0.77) than in the unoiled zone ($F = 10.53$, $R^2 = 0.84$, $P = 0.08$, Slope = 0.44).

Regression analyses of the overall abundance estimates of Prince William Sound from 1989-93 showed significant trends for 4 species or species groups. During the March surveys, the populations of goldeneyes, gulls, murres, and waterfowl showed positive trends (Table 8). No significant changes in overall abundance for any species or species group were found for July (Table 9). When the estimates were graphed (Figs. 2 and 3), it appeared that several other species and species groups had increasing or decreasing trends during either March or July (Figs. 2 and 3), but none of these were significant (Tables 8 and 9).

Relative Abundance of Marine Birds.--We examined the relative abundance of each major species group found in Prince William Sound from 1972 to 1993 (Table 10). The most common species group seen in March was waterfowl ($\dot{x} = 47.7\%$), except for March 1993, when the most common species group was murres (54.9%). The second most common species groups observed in March were gulls ($\dot{x} = 16.2\%$) and *Brachyramphus* murrelets ($\dot{x} = 13.6\%$). The most common species groups observed during July were *Brachyramphus* murrelets ($\dot{x} = 38.3\%$) and gulls ($\dot{x} = 31.6\%$).

We found that the relative abundance of some species groups (e.g., scoters, gulls, and waterfowl) decreased over time during March, while the relative abundance of murres increased. The murre population estimate for March 1993 was unusually high, and when we removed this species group from our calculations, the relative abundance of most species groups fluctuated within a narrow range over the study (Table 10). This would indicate our sampling protocol is similar across species among years. Data from the July surveys suggested that the relative abundance of cormorants and terns decreased from 1972 to 1993, while scoters, murres, and waterfowl increased (Table 10).

Sea Otters

Population Estimates.--In 1993, we estimated that 6,813 $\pm$ 1,861 sea otters were in Prince William Sound during March, and 8,216 $\pm$ 2,435 otters were in Prince William Sound during July. In the oiled zone, the population estimate was 1,687 $\pm$ 1,015 otters during March and 1,525 $\pm$ 1560 otters during July. In the unoiled zone, the population was estimated as 5,123 $\pm$ 1,610 otters during March and 6,688 $\pm$ 2344 otters during July.

Population Trends.--For either March or July 1989-93, we found no differences in the rate of change in the abundance of otters between the oiled and unoiled zones (Table 11). There was also no significant trend in the total Prince William Sound sea otter population from 1989-93 for either March (Table 8) or July (Table 9).

DISCUSSION

Marine Birds

When we compared the total population estimates of marine birds in Prince William Sound among years, there were no significant changes in abundance since the 1989 *T/V Exxon Valdez* oil spill. Although the population estimates for July have increased slightly since 1990, this was not a significant trend. The July population abundance of Prince William Sound remained low when compared with the 1972-73 estimates (Haddock et al., unpubl. data).

The March 1993 estimate of marine birds in Prince William Sound was much higher than all previous estimates, including those from 1972-73 (Table 4; Haddock et al., unpubl. data). Although the increase in the March 1993 estimate suggests that the winter marine bird population of Prince William Sound may be increasing, there was no significant trend. We hypothesize that this change in population abundance was largely due to an unexplained increase in the number of murres (mostly common murres, *Uria aalge*) into the Sound during winter 1993.

We estimated that approximately 225,000 murres were present during the March 1993 survey, an increase of 1,298% over the mean of previous estimates. This changed the relative abundance of murres from a mean of 6.6% from 1972-91 to 54.9% in 1993. The March 1993 survey of Prince William Sound was followed by a die-off of an estimated 10,000-100,000 birds (Kendall et al. 1993, Piatt and van Pelt 1993). Die-offs of seabirds have occurred previously in Alaskan waters (Bailey and Davenport 1972, Nysewander and Trapp 1984). The cause of these occurrences remains unexplained, but in all instances birds appeared to die of malnutrition. If murres were excluded from the Sound-wide population estimate, the March estimate was similar (177,760 birds) to that of 1990 and 1991.

Although the relative abundance of murres during both March and July 1993 was much higher than previously recorded, the relative abundance during July 1993 of storm-petrels (*Oceanodroma* spp.) and shearwaters and fulmars (*Puffinus* spp. and *Fulmarus glacialis*) was much lower than previous years. The relative abundance of these species within the Sound varied greatly from year to year. Waterfowl were the most common species group recorded during the March surveys, whereas *Brachyramphus* murrelets and gulls were the most common species sighted during July.

The overall purpose of this study was to monitor the recovery of marine bird populations that declined due to the *T/V Exxon Valdez* oil spill. We assumed that populations should be either increasing or decreasing at the same rate in the oiled and unoiled zones of Prince William Sound. We were especially interested in the recovery of species whose populations were shown to be injured by the oil spill (Klosiewski and Laing 1994). Of the 3 species or species groups (goldeneye, surfbird, and black oystercatcher) whose populations showed significant differences in these rates of population increase or decrease between the oiled and unoiled zones (Tables 6 and 7), only black oystercatcher was previously considered

to be injured by the oil spill (Klosiewski and Laing 1994). The wintering black oystercatcher population showed an increase in the oiled zone. Although the goldeneye (March) and surfbird (July) populations were not previously shown to be affected by the spill (Klosiewski and Laing 1994), we found that both increased faster in the unoiled zone than the oiled zone, indicating that the *T/V Exxon Valdez* oil spill might have continuing effects that have yet to be detected.

Because we examined the population trends of 32 species or species groups in July and 28 species or species groups in March, we had a high probability of finding at least one significant trend. With a 95% confidence level, we would expect to find a significant trend due to chance 5% of the time, or for 1-2 species. In addition, data from a multi-species survey are more meaningful for some species than for others. During March, goldeneyes are distributed throughout Prince William Sound, and their population is fairly large. Random samples of goldeneyes are fairly representative of the population, thus these samples are biologically meaningful. Non-breeding black oystercatchers congregate in large groups (B. Andres, pers. commun.), and surfbirds migrate through Prince William Sound in July and also cluster in large groups. During March 1990-93, we recorded sightings of only 1-2 individual black oystercatchers, which yielded estimates of $\leq$15 birds (Appendix A). Surveys using random transects will not always present a representative picture of the population trends for clustered species. Thus, trends from the data on black oystercatchers and surfbirds should be interpreted cautiously. The low population estimates for black oystercatchers do not indicate a population that is recovering from an environmental perturbation.

The survey design also had an effect on the variance of the population estimate for each species. Although we stratified the study area into 3 strata on the basis of habitat, other habitat variables also influenced bird distribution. These variables differed for each species and were influenced by tidal and other environmental conditions. The variance was affected by the fact that the sampling unit did not always fit the natural parameters for each species, but it would be difficult to design a survey that could account for each parameter by species.

Graphical depiction of the data suggested that the population estimates of several other species and species groups either increased or decreased over time (Figs. 2 and 3). For example, ancient murrelets (*Synthliboramphus antiquus*; Fig. 3s) and murres (Fig. 3p) appeared to increase throughout the Sound during July, while jaegers (*Stercorarius* spp.) decreased (Fig. 3l). No significant trends were found for these populations (P = 0.06, P = 0.09, P = 0.24, respectively; Table 9).

We are limited in our ability to determine trends in population abundance using these data (Taylor and Gerrodette 1993). We only had 3 years of data from March and 4 years of data from July. With so few data points, statistical tests lack the power to detect a trend in population size. The year to year variability between estimates also makes it difficult to detect trends (Taylor and Gerrodette 1993, Klosiewski and Laing 1994). Klosiewski and Laing (1994) performed Monte-Carlo simulations to examine the probability of detecting declines or recovery of

bird populations using regression analyses. They found that population trends can be detected with the implementation of routine monitoring. The probability of detecting changes in populations increases with the number of years of data, though for slowly changing populations, such as seabirds, sampling frequency can be reduced with little loss of statistical power (Klosiewski and Laing 1994). Until we have more years of data, we will be limited in our ability to determine recovery or continued injury of populations affected by the *T/V Exxon Valdez* oil spill.

A method to be explored for detecting trends is "route regression analysis," which requires at least 5 years of data (Geissler and Sauer 1990). This technique has been used by the Breeding Bird Survey (Sauer and Geissler 1990) and measures change on individual transects by log-linear regression techniques. We will consider using this technique after our next sampling period in 1996, when we will have the minimum sample size (n = 5) for both the summer and winter data.

This study was unique for several reasons. There are few other studies of marine birds that have persisted for such a long period of time (4 years) after a large environmental perturbation, such as the *T/V Exxon Valdez* oil spill. Thus, we had the rare opportunity to examine the effect of an oil spill on an area over time. Also, most data on the population trends of marine and coastal birds have been collected on a relatively short-term basis, usually only 1-2 years (Wooller et al. 1992, Vermeer and Rankin 1984), or opportunistically over a large area (Gould et al. 1982, Powers 1983). Long-term studies traditionally have been on a single species, usually at a breeding location (Wooller et al. 1992), but this survey covered a large, yet discrete area and collected data on several species. We know of only one similar study, also from Alaska, a 5-year study of wintering marine birds near Kodiak Island (Zwiefelhofer and Forsell 1989).

As with all sampling methods, we have some biases that might affect our population estimates. We assumed that we counted all birds and mammals on the transects; however, it was likely that some unknown percentage of birds and mammals was missed, causing us to underestimate population abundance. For instance, we might not see birds or otters leave the transect due to the noise of the boat. Udevitz et al. (1995) conducted a pilot study of the sightability of sea otters from boat surveys. In their study, observers on the boat surveys only saw 70% of the otters seen by observers on land. Due to their small sample size, the authors advised against wide application of their results (Udevitz et al. 1995), so we have taken the conservative approach and not corrected our estimates for sea otters upward. For most marine bird species, studies of this type have not been conducted, so there are no correction factors available to use to increase our estimates appropriately.

Sea Otters

We detected no significant trends in abundance for sea otters between either the oiled and unoiled zones or throughout the whole of Prince William Sound. This demonstrated that there has been no significant recovery of sea

otters in the oiled zone, and no population change for the entire Sound since 1989. Due to the few years of data available, we had little power to detect trends at this time (Taylor and Gerrodette 1993). We defined the oiled and unoiled zones somewhat differently than Burn (1994), but when we compared the population trends using both approaches, we found that the results were similar to those presented in this paper (D. Burn, pers. commun.).

Irons et al. (1988a) found that between 1972 and 1984, sea otter populations within Prince William Sound expanded both in numbers and distribution. Estes (1990) examined 5 northern populations of sea otters and a population from California. All but the Amchitka Island, Alaska, population, were increasing at an annual rate of >5% (Estes 1990). Our surveys from 1989-93 showed no trend in the population abundance of sea otters in Prince William Sound. From Irons' et al. (1988a) and Estes' (1990) results, we might expect that the Prince William Sound otter population should be increasing. There are two possible reasons why we did not detect a positive trend: (1) there has been no increase since 1989, because either the population is still suffering from damage inflicted by the oil spill or the population has expanded to fill its range within Prince William Sound; or (2) lack of statistical power.

CONCLUSIONS

Only 3 species or species groups of marine birds showed a significant difference in population abundance between the oiled and unoiled zones of Prince William Sound from 1989-93 (March, goldeneye and black oystercatcher; July, surfbird). The goldeneye and surfbird populations increased more slowly in the oiled zone, indicating that there may be long-term continued effects from the oil spill. Black oystercatcher populations increased at a greater rate in the oiled zone, but the overall low population estimates throughout the study period (<15 birds) are not indicative of a population that is recovering from the effects of an environmental perturbation. Populations of other species and species groups did not show any trend, but with only 3-4 years of data, we lack the power to detect trends in the population abundance of most species.

Within Prince William Sound as a whole, we also examined population trends from 1989-93. We found that the goldeneye, gull, murre, and waterfowl populations showed significant upward trends during March, while no species or species group showed a significant trend in overall abundance during July.

For the sea otter population, we found no difference in the rate of change between the oiled and unoiled zones from 1989-93 for either the March or July population estimates. There was also no significant trend in the total number of sea otters in Prince William Sound from 1989-93, indicating that the sea otter population has not recovered from the oil spill.

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Table 1. Area (km^2) of each stratum in the oiled and unoiled zones of Prince William Sound from small boat surveys during 1989-91 (Klosiewski and Laing 1994) and 1993.

	Stratum		
Zones	Shoreline	Coastal-pelagic	Pelagic
Oiled	247.72	1,645.80	1,684.00
Unoiled	572.75	2,878.39	1,952.92
Total	820.47	4,524.19	3,636.92

Table 2. Number of transects and blocks surveyed in each of the 3 strata used during small boat surveys of Prince William Sound from 1989-91 (Klosiewski and Laing 1994) and 1993.

Year	March					July				
	Shoreline	Coastal-pelagic		Pelagic		Shoreline	Coastal-pelagic		Pelagic	
	Transect	Transect	Block	Transect	Block	Transect	Transect	Block	Transect	Block
1989[a]						187	88	46	50	25
1990	99	57	29	50	25	212[b]	89	46	50	25
1991	99	57	29	50	25	212	87	45	50	25
1993	98	42[c]	21	50	25	212	88	45	50	25
Total[d]	742		207		86	742		207		86

[a] No survey was conducted in March 1989.

[b] In 1990, 25 transects were added to the shoreline stratum in western Prince William Sound to increase the precision of estimates in the oiled zone.

[c] Data were not used from 13 transects due to recording errors. Two transects were covered by ice.

[d] Total number of transects possible for shoreline stratum and/or total number of blocks for the coastal-pelagic and pelagic strata.

Table 3. Species groups used in data analyses of marine bird populations estimated by small boat surveys in Prince William Sound during March 1990-91 (Klosiewski and Laing 1994) and 1993 and July 1989-91 (Klosiewski and Laing 1994) and 1993.

Group /Common Name	Species Name
Loons	
Red-throated loon	*Gavia stellata*
Pacific loon	*G. pacifica*
Common loon	*G. immer*
Yellow-billed loon	*G. adamsii*
Unidentified loon	*G.* sp.
Grebes	
Horned grebe	*Podiceps auritus*
Red-necked grebe	*P. grisegena*
Unidentified grebe	*P.* sp.
Fulmars and Shearwaters[a]	
Northern fulmar	*Fulmarus glacialis*
Sooty shearwater	*Puffinus griseus*
Unidentified shearwater	*P.* sp.
Unidentified procellariid	*P.* sp. or *F.* sp.
Shearwaters[a]	
Sooty shearwater	*P. griseus*
Unidentified shearwater	*P.* sp.
Storm-petrels[a]	
Fork-tailed storm-petrel	*Oceanodroma furcata*
Unidentified storm-petrel	*O.* sp.
Cormorants	
Double-crested cormorant	*Phalacrocorax auritus*
Pelagic cormorant	*P. pelagicus*
Red-faced cormorant	*P. urile*
Unidentified cormorant	*P.* sp.
Waterfowl[a]	
Trumpeter swan	*Cygnus buccinator*
Tundra swan	*C. columbianus*
Emperor goose	*Chen canagica*

Table 3 (continued).

Group /Common Name	Species Name
Waterfowl (continued)	
Brant	*Branta bernicla*
Canada goose	*B. canadensis*
Green-winged teal	*Anas crecca*
Mallard	*A. platyrhynchos*
Northern pintail	*A. acuta*
Northern shoveler	*A. clypeata*
Gadwall	*A. strepera*
American wigeon	*A. americana*
Unidentified dabbling duck	*A.* sp.
Greater scaup	*Aythya marila*
Unidentified scaup	*A. marila* or *A. affinis*
Steller's eider	*Polysticta stelleri*
Unidentified eider	*Somateria* or *Polysticta* sp.
Harlequin duck	*Histrionicus histrionicus*
Oldsquaw	*Clangula hyemalis*
Black scoter	*Melanitta nigra*
Surf scoter	*M. perspicillata*
White-winged scoter	*M. fusca*
Unidentified scoter	*M.* sp.
Common goldeneye	*Bucephala clangula*
Barrow's goldeneye	*B.islandica*
Unidentified goldeneye	*B. islandica* or *B. clangula*
Bufflehead	*B. albeola*
Common merganser	*Mergus merganser*
Red-breasted merganser	*M. serrator*
Unidentified merganser	*Mergus* sp.
Unidentified diving/sea duck	
Unidentified duck	
Scaup	
Greater scaup	*Aythya marila*
Unidentified scaup	*A. marila* or *A. affinis*
Scoters	
Black scoter	*Melanitta nigra*
Surf scoter	*M. perspicillata*
White-winged scoter	*M. fusca*
Unidentified scoter	*M.* sp.

Table 3 (continued).

Group /Common Name	Species Name
Goldeneyes	
Barrow's goldeneye	*Bucephala islandica*
Common goldeneye	*B. clangula*
Unidentified goldeneye	*B. islandica* or *B. clangula*
Mergansers	
Common merganser	*Mergus merganser*
Red-breasted merganser	*M. serrator*
Unidentified merganser	*M.* sp.
Shorebirds	
Black oystercatcher	*Haematopus bachmani*
Lesser yellowlegs	*Tringa flavipes*
Unidentified yellowlegs	*T. flavipes* or *T. melanoleuca*
Solitary sandpiper	*T. solitaria*
Wandering tattler	*Heteroscelus incanus*
Spotted sandpiper	*Actitis macularia*
Whimbrel	*Numenius phaeopus*
Black turnstone	*Arenaria melanocephala*
Ruddy turnstone	*A. interpres*
Unidentified turnstone	*A.* sp.
Surfbird	*Aphriza virgata*
Sanderling	*Calidris alba*
Semipalmated sandpiper	*C. pusilla*
Western sandpiper	*C. mauri*
Rock sandpiper	*C. ptilocnemis*
Unidentified small sandpiper	*C.* sp.
Short-billed dowitcher	*Limnodromus griseus*
Long-billed dowitcher	*L. scolopaceus*
Unidentified dowitcher	*L. sp.*
Unidentified shorebird	
Jaegers	
Pomarine jaeger	*Stercorarius pomarinus*
Parasitic jaeger	*S. parasiticus*
Long-tailed jaeger	*S. longicaudus*
Unidentified jaeger	*S.* sp.

Table 3 (continued).

Group /Common Name	Species Name
Gulls	
Bonaparte's gull	*Larus philadelphia*
Mew gull	*L. canus*
Herring gull	*L. argentatus*
Glaucous-winged gull	*L. glaucescens*
Glaucous gull	*L. hyperboreus*
Black-legged kittiwake	*Rissa tridactyla*
Unidentified gull	*L.* or *R.* sp.
Terns[a]	
Caspian tern	*Sterna caspia*
Arctic tern	*S. paradisaea*
Aleutian tern	*S. aleutica*
Unidentified tern	*S.* sp.
Murres	
Common murre	*Uria aalge*
Thick-billed murre	*U. lomvia*
Unidentified murre	*U.* sp.
Murrelets	
Marbled murrelet	*Brachyramphus marmoratus*
Kittlitz's murrelet	*B. brevirostris*
Unidentified *Brachyramphus* murrelet	*B.* sp.
Puffins[a]	
Tufted puffin	*Fratercula cirrhata*
Horned puffin	*F. corniculata*
Unidentified puffin	*F.* sp.

[a] Species groups added in 1993.

Table 4. Estimated number of marine birds, with 95% CI, from small boat surveys of Prince William Sound during winter and summer of 1972-73 (Haddock et al., unpubl. data), 1989-91 (Klosiewski and Laing 1994), and 1993.

	Winter[a]		Summer[b]	
Year	Estimate	CI	Estimate	CI
1972	235,579	63,480	628,696	141,858
1973	328,091	59,955	475,618	144,213
1989			302,538	54,444
1990	141,911	22,902	237,900	32,570
1991	171,433	30,868	343,357	98,670
1993	402,760	167,697	371,327	58,189

[a] All winter surveys were conducted in March, except for March 1989, when no survey was conducted.

[b] Surveys were conducted during July, except for 1973, when the Sound was surveyed in August.

Table 5. Estimated number of marine birds, with 95% CI, from small boat surveys of Prince William Sound during March 1990-91 (Klosiewski and Laing 1994) and 1993 and July 1989-91 (Klosiewski and Laing 1994) and 1993 listed by zone oiled by the *T/V Exxon Valdez* oil spill.

	Oiled Zone		Unoiled Zone	
Year	Estimate	CI	Estimate	CI
March				
1990	36,343	7,760	105,568	21,547
1991	49,649	13,422	121,784	27,797
1993	83,171	34,794	319,589	164,048
July				
1989	102,402	20,032	200,136	50,625
1990	88,191	20,140	149,709	25,597
1991	116,115	24,129	227,242	95,674
1993	116,219	26,896	255,108	51,600

Table 6. Results of homogeneity of slopes test comparing estimates of marine bird populations in the oiled zone with estimates of bird populations in the unoiled zone of Prince William Sound after the *T/V Exxon Valdez* oil spill. Data were collected by small boat surveys during March 1990-91 (Klosiewski and Laing 1994) and 1993. Only species groups and individual species with population estimates of >500 birds were used. All categories have 1 degree of freedom, except for ERROR, which has 2 degrees of freedom.

Species	SS	*F*	*P*
Loons			
OILING	0.08	2.90	0.23
YEAR	0.00	0.02	0.89
YEAR*OILING	0.01	0.23	0.68
ERROR	0.06		
Grebes			
OILING	0.03	16.48	0.06
YEAR	0.01	8.26	0.10
YEAR*OILING	0.00	2.35	0.27
ERROR	0.00		
Storm-petrels			
OILING	0.05	0.02	0.89
YEAR	5.67	2.65	0.25
YEAR*OILING	0.03	0.02	0.91
ERROR	4.27		
Cormorants			
OILING	0.00	0.18	0.71
YEAR	0.01	2.51	0.25
YEAR*OILING	0.01	1.35	0.36
ERROR	0.01		
Mallard			
OILING	0.56	1.27	0.38
YEAR	0.37	0.85	0.45
YEAR*OILING	0.55	1.25	0.38
ERROR	0.88		

Table 6 (continued).

Species	SS	*F*	*P*
Scaup			
OILING	5.76	16.62	0.06
YEAR	0.51	1.46	0.35
YEAR*OILING	2.48	7.15	0.12
ERROR	0.69		
Harlequin duck			
OILING	0.02	8.82	0.10
YEAR	0.04	22.47	0.04
YEAR*OILING	0.01	7.02	0.12
ERROR	0.00		
Oldsquaw			
OILING	0.05	0.75	0.48
YEAR	0.02	0.25	0.67
YEAR*OILING	0.03	0.38	0.60
ERROR	0.14		
Scoters			
OILING	0.03	11.59	0.08
YEAR	0.01	4.49	0.17
YEAR*OILING	0.01	2.53	0.25
ERROR	0.01		
Goldeneyes			
OILING	0.06	466.01	0.00
YEAR	0.04	690.10	0.00
YEAR*OILING	0.00	33.17	0.03
ERROR	0.00		
Bufflehead			
OILING	0.31	6.67	0.12
YEAR	0.01	0.21	0.69
YEAR*OILING	0.00	0.03	0.87
ERROR	0.09		

Table 6 (continued).

Species	SS	*F*	*P*
Mergansers			
OILING	0.02	2.11	0.28
YEAR	0.09	10.11	0.09
YEAR*OILING	0.09	9.21	0.09
ERROR	0.02		
Waterfowl			
OILING	0.05	131.02	0.01
YEAR	0.02	45.10	0.02
YEAR*OILING	0.00	8.82	0.10
ERROR	0.00		
Bald eagle			
OILING	0.01	21.38	0.04
YEAR	0.04	72.99	0.01
YEAR*OILING	0.00	2.59	0.25
ERROR	0.00		
Black oystercatcher[a]			
OILING	2.44	21.36	0.04
YEAR	0.01	0.04	0.85
YEAR*OILING	2.23	19.46	0.05
ERROR	0.23		
Surfbird			
OILING	0.04	0.02	0.91
YEAR	6.51	2.66	0.24
YEAR*OILING	0.02	0.01	0.93
ERROR	4.90		
Shorebirds			
OILING	0.00	0.00	0.98
YEAR	0.66	4.07	0.18
YEAR*OILING	0.09	0.52	0.54
ERROR	0.33		

Table 6 (continued).

Species	SS	*F*	*P*
Mew gull			
OILING	0.00	0.00	0.96
YEAR	0.08	0.30	0.64
YEAR*OILING	0.08	0.27	0.65
ERROR	0.57		
Herring gull			
OILING	0.03	0.24	0.67
YEAR	0.73	5.38	0.15
YEAR*OILING	0.05	0.34	0.62
ERROR	0.27		
Glaucous-winged gull			
OILING	0.00	0.00	0.96
YEAR	0.01	0.49	0.56
YEAR*OILING	0.00	0.32	0.63
ERROR	0.02		
Black-legged kittiwake			
OILING	0.13	1.90	0.30
YEAR	1.43	20.21	0.05
YEAR*OILING	0.19	2.67	0.24
ERROR	0.14		
Gulls			
OILING	0.00	6.60	0.12
YEAR	0.18	267.55	0.00
YEAR*OILING	0.00	3.28	0.21
ERROR	0.00		
Murres			
OILING	0.00	0.15	0.74
YEAR	1.95	138.74	0.01
YEAR*OILING	0.04	3.17	0.22
ERROR	0.03		

Table 6 (continued).

Species	SS	*F*	*P*
Pigeon guillemot			
OILING	0.02	0.14	0.75
YEAR	0.04	0.31	0.64
YEAR*OILING	0.00	0.02	0.90
ERROR	0.24		
Brachyramphus murrelets			
OILING	0.05	4.74	0.16
YEAR	0.06	5.82	0.14
YEAR*OILING	0.01	1.31	0.37
ERROR	0.02		
Northwestern crow			
OILING	0.07	0.61	0.52
YEAR	0.00	0.03	0.89
YEAR*OILING	0.00	0.04	0.86
ERROR	0.23		
Total marine birds			
OILING	0.02	5.81	0.14
YEAR	0.19	59.98	0.02
YEAR*OILING	0.01	1.73	0.32
ERROR	0.01		

[a] Populations were <500. This species was included because it was shown to be injured by the oil spill (Klosiewski and Laing 1994).

Table 7. Results of homogeneity of slopes tests comparing the population estimates of marine birds in the oiled zone with the estimates of the bird populations from the unoiled zone of Prince William Sound after the *T/V Exxon Valdez* oil spill. Data were collected by small boat surveys during July 1989-91 (Klosiewski and Laing 1994) and 1993. Only species groups and individual species with population estimates of >500 birds were used. All categories have 1 degree of freedom, except for ERROR, which has 4 degrees of freedom.

Species	SS	*F*	*P*
Loons			
OILING	0.40	2.20	0.21
YEAR	0.02	0.10	0.76
YEAR*OILING	0.01	0.07	0.81
ERROR	0.72		
Shearwaters			
OILING	0.40	0.12	0.74
YEAR	0.00	0.00	0.99
YEAR*OILING	0.14	0.04	0.86
ERROR	14.98		
Storm-petrels			
OILING	0.01	0.08	0.79
YEAR	0.23	2.64	0.18
YEAR*OILING	0.05	0.57	0.49
ERROR	0.35		
Cormorants			
OILING	0.10	0.70	0.45
YEAR	0.22	1.49	0.29
YEAR*OILING	0.18	1.24	0.33
ERROR	0.60		
Canada goose			
OILING	3.32	10.23	0.03
YEAR	1.69	5.22	0.08
YEAR*OILING	0.02	0.08	0.80
ERROR	1.30		

Table 7 (continued). 31

Species	SS	*F*	*P*
Harlequin duck			
OILING	0.24	0.41	0.10
YEAR	0.07	1.38	0.31
YEAR*OILING	0.00	0.03	0.87
ERROR	0.21		
Scoters			
OILING	0.02	0.73	0.44
YEAR	0.04	1.22	0.33
YEAR*OILING	0.09	3.00	0.16
ERROR	0.13		
Goldeneyes			
OILING	0.71	2.95	0.16
YEAR	0.42	1.76	0.25
YEAR*OILING	0.16	0.66	0.46
ERROR	0.96		
Mergansers			
OILING	0.29	10.88	0.03
YEAR	0.05	1.80	0.25
YEAR*OILING	0.05	1.72	0.26
ERROR	0.11		
Waterfowl			
OILING	0.14	5.67	0.08
YEAR	0.10	4.04	0.11
YEAR*OILING	0.02	0.74	0.44
ERROR	0.10		
Bald eagle			
OILING	0.12	3.30	0.14
YEAR	0.10	2.61	0.18
YEAR*OILING	0.00	0.06	0.81
ERROR	0.15		

Table 7 (continued). 32

Species	SS	*F*	*P*
Black oystercatcher			
OILING	0.07	7.21	0.05
YEAR	0.02	2.88	0.17
YEAR*OILING	0.03	2.92	0.16
ERROR	0.03		
Black turnstone			
OILING	0.31	0.15	0.72
YEAR	4.39	2.12	0.22
YEAR*OILING	0.00	0.00	0.99
ERROR	8.31		
Surfbird			
OILING	3.38	3.97	0.12
YEAR	0.48	0.56	0.50
YEAR*OILING	6.37	7.48	0.05
ERROR	3.41		
Red-necked phalarope			
OILING	0.10	0.37	0.58
YEAR	0.36	1.36	0.31
YEAR*OILING	0.02	0.09	0.78
ERROR	1.05		
Shorebirds			
OILING	0.00	0.01	0.93
YEAR	0.19	1.16	0.34
YEAR*OILING	0.20	1.24	0.33
ERROR	0.64		
Jaegers			
OILING	0.00	0.02	0.89
YEAR	0.49	5.99	0.07
YEAR*OILING	0.02	0.23	0.65
ERROR	0.33		

Table 7 (continued). 33

Species	SS	*F*	*P*
Bonaparte's gull			
OILING	0.31	3.22	0.15
YEAR	0.37	3.84	0.12
YEAR*OILING	0.35	3.72	0.13
ERROR	0.38		
Mew gull			
OILING	0.57	6.96	0.06
YEAR	0.00	0.03	0.88
YEAR*OILING	0.07	0.88	0.40
ERROR	0.33		
Glaucous-winged gull			
OILING	0.04	2.24	0.21
YEAR	0.00	0.27	0.63
YEAR*OILING	0.02	1.42	0.30
ERROR	0.07		
Black-legged kittiwake			
OILING	0.00	0.13	0.74
YEAR	0.01	1.04	0.37
YEAR*OILING	0.03	2.28	0.21
ERROR	0.05		
Gulls			
OILING	0.01	3.40	0.14
YEAR	0.00	0.31	0.61
YEAR*OILING	0.01	3.20	0.15
ERROR	0.02		
Terns			
OILING	0.01	0.82	0.42
YEAR	0.00	0.01	0.93
YEAR*OILING	0.06	6.61	0.06
ERROR	0.04		

Table 7 (continued). 34

Species	SS	*F*	*P*
Murres			
OILING	0.29	2.51	0.19
YEAR	1.17	10.00	0.03
YEAR*OILING	0.18	1.52	0.29
ERROR	0.47		
Pigeon guillemot			
OILING	0.05	1.10	0.35
YEAR	0.00	0.06	0.81
YEAR*OILING	0.00	0.02	0.90
ERROR	0.19		
Brachyramphus murrelets			
OILING	0.01	1.08	0.35
YEAR	0.04	4.37	0.10
YEAR*OILING	0.00	0.28	0.62
ERROR	0.04		
Ancient murrelet			
OILING	0.71	1.19	0.34
YEAR	4.78	8.00	0.05
YEAR*OILING	0.54	0.90	0.40
ERROR	2.30		
Parakeet auklet			
OILING	0.05	0.03	0.88
YEAR	0.01	0.01	0.94
YEAR*OILING	0.00	0.00	0.99
ERROR	8.12		
Puffins			
OILING	0.01	1.43	0.30
YEAR	0.02	3.18	0.15
YEAR*OILING	0.01	2.46	0.19
ERROR	0.02		

Table 7 (continued). 35

Species	SS	*F*	*P*
Northwestern crow			
OILING	0.12	61.5	0.00
YEAR	0.01	6.03	0.07
YEAR*OILING	0.00	0.52	0.51
ERROR	0.01		
Total marine birds			
OILING	0.03	4.66	0.10
YEAR	0.02	2.95	0.16
YEAR*OILING	0.00	0.27	0.63
ERROR	0.02		

Table 8. Regression analyses of individual species' and species groups' population estimates to determine population trends for Prince William Sound as a whole from March 1990-93. Only species and species groups with population estimates of >500 birds were used.

Species	R^2	F	P	Slope
Marine birds				
Loons	0.01	0.01	0.94	0.01
Grebes	0.81	4.35	0.28	-0.03
Cormorants	0.89	7.82	0.22	0.04
Mallard	0.04	0.04	0.87	0.04
Scaup	0.72	2.52	0.36	-0.22
Harlequin duck	0.94	14.70	0.16	0.09
Oldsquaw	0.00	0.00	1.00	<-0.01
Scoters	0.80	3.99	0.30	0.05
Goldeneyes	1.00	9,905.12	0.01	0.08
Bufflehead	0.04	0.04	0.88	0.02
Mergansers	0.94	15.26	0.16	0.14
Waterfowl	1.00	2,866.89	0.01	0.06
Bald eagle	0.99	68.19	0.08	0.02
Black oystercatcher [a]	0.01	0.01	0.93	-0.01
Shorebirds	0.46	0.87	0.52	-0.20
Mew gull	0.52	1.10	0.49	0.16
Glaucous-winged gull	0.50	1.00	0.50	0.02
Black-legged kittiwake	0.94	15.31	0.16	0.42
Gulls	1.00	305.58	0.04	0.14
Murres	1.00	5,634.22	0.01	0.49
Pigeon guillemot	0.15	0.18	0.74	0.07
Brachyramphus murrelets	0.97	31.46	0.10	-0.09
Northwestern crow	0.26	0.34	0.66	-0.01
Total marine birds	0.97	37.15	0.10	0.16
Marine mammals				
Sea otter	0.22	0.29	0.69	0.03

[a] Although the population estimate was <500 birds, this species was included because it was shown to be injured by the oil spill (Klosiewski and Laing 1994).

Table 9. Regression analyses of individual species' and species groups' population estimates to determine population trends for Prince William Sound as a whole from July 1989-93. Only species and species groups with population estimates of >500 birds were used.

Species	R^2	F	P	Slope
Marine birds				
Loons	0.01	0.02	0.91	0.11
Shearwaters	0.00	0.01	0.93	-0.06
Storm-petrels	0.76	6.37	0.13	-0.09
Cormorants	0.42	1.44	0.35	0.15
Canada goose	0.58	2.80	0.24	0.27
Harlequin duck	0.36	1.14	0.40	0.06
Scoters	0.72	5.25	0.15	0.08
Goldeneyes	0.34	1.04	0.42	0.08
Mergansers	0.30	0.84	0.46	0.03
Waterfowl	0.85	11.73	0.08	0.07
Bald eagle	0.79	7.73	0.11	0.08
Black oystercatcher	0.05	0.11	0.77	<0.01
Black turnstone	0.60	2.97	0.23	-0.48
Surfbird	0.75	5.90	0.14	0.23
Red-necked phalarope	0.18	0.44	0.57	-0.12
Shorebirds	0.02	0.04	0.86	-0.01
Jaegers	0.58	2.76	0.24	-0.16
Bonaparte's gull	0.01	0.02	0.91	-0.01
Mew gull	0.08	0.17	0.72	-0.03
Glaucous-winged gull	0.50	1.96	0.30	0.04
Black-legged kittiwake	0.41	1.40	0.36	0.04
Gulls	0.48	1.87	0.31	0.02
Terns	0.54	2.33	0.27	0.03
Murres	0.83	9.83	0.09	0.25
Pigeon guillemot	0.00	0.06	0.83	0.01
Brachyramphus murrelets	0.60	2.95	0.23	0.05
Ancient murrelet	0.89	15.62	0.06	0.42
Parakeet auklet	0.00	0.01	0.95	-0.03
Puffins	0.62	3.22	0.21	0.04
Northwestern crow	0.63	3.39	0.21	0.03
Total marine birds	0.46	1.67	0.33	0.03
Marine mammals				
Sea otter	0.03	0.05	0.84	<0.01

Table 10. Relative abundance (%) of species groups estimated by year from small boat surveys of marine birds in Prince William Sound from 1972-73 (Haddock et al., unpubl. data), 1989-91 (Klosiewski and Laing 1994) and 1993.

Species	March						July				
	1972	1973	1990	1991	1993[a]		1972	1989	1990	1991	1993
					w/	w/o					
Loons	1.4	0.9	0.6	1.0	0.3	0.6	0.4	0.3	0.2	0.5	0.2
Grebes	4.0	3.9	4.6	3.3	1.3	2.9	0.0	0.0	0.0	0.0	0.0
Shearwaters and fulmars	0.0	0.0	0.0	0.0	0.0	0.2	0.1	0.0	11.2	0.0	
Storm-petrels	0.0	0.0	0.4	0.0	0.0	0.0	2.8	12.0	0.0	5.7	3.7
Cormorants	4.6	8.4	6.4	5.3	3.0	6.5	3.2	0.3	0.1	0.3	0.5
Waterfowl	54.2	39.0	47.0	44.1	24.6	54.2	3.9	4.6	8.7	6.8	7.4
Scoters	22.5	18.3	9.0	9.9	4.6	10.2	2.1	1.9	1.9	1.7	2.9
Goldeneyes	6.3	7.7	13.8	13.8	8.5	18.6	0.1	0.1	0.1	0.3	0.2
Mergansers	2.5	1.4	2.4	3.5	2.3	5.1	1.1	0.9	1.7	0.8	1.1
Shorebirds	0.7	2.3	2.5	0.3	0.2	0.0	0.6	2.6	1.4	1.4	1.5
Gulls	21.3	12.9	10.8	13.1	10.4	22.9	28.2	33.3	37.4	27.7	31.4
Terns	0.0	0.0	0.0	0.0	0.0	0.0	5.2	2.4	2.6	2.0	2.5
Murres	3.5	3.3	5.3	14.1	54.9	-	0.9	0.7	0.6	2.1	4.4
Murrelets	5.1	23.1	18.4	13.7	3.5	7.7	47.7	35.5	34.2	31.0	42.9
Puffins	0.0	0.0	0.0	0.1	0.0	0.0	2.1	1.4	2.1	1.9	1.6

[a] Because murre numbers were unusually high in Prince William Sound during March 1993, we examined the relative abundance of species with murres (w/) and without (w/o).

Table 11. Results of a homogeneity of slopes test for sea otters comparing the population estimates in the oiled zone with the estimates from the unoiled zone of Prince William Sound after the *T/V Exxon Valdez* oil spill. Data were collected by small boat surveys during March 1990-91 and July 1989-91 (Klosiewski and Laing 1994) and 1993. All categories have 1 degree of freedom, except for ERROR, which has 2 degrees of freedom for March and 4 for July.

Month/Source	SS	*F*	*P*
March			
OILING	0.01	0.46	0.57
YEAR	0.00	0.13	0.76
YEAR*OILING	0.01	0.22	0.68
ERROR	0.05		
July			
OILING	0.13	30.91	0.01
YEAR	0.00	0.01	0.93
YEAR*OILING	0.00	0.48	0.53
ERROR	0.02		

Figure 1. Map of the study area. The area oiled by the *T/V Exxon Valdez* oil spill in March 1989 is designated by the dark stippling (oiled zone). The remaining area is considered the unoiled zone. The dashed line denotes the southern boundary of the study area.

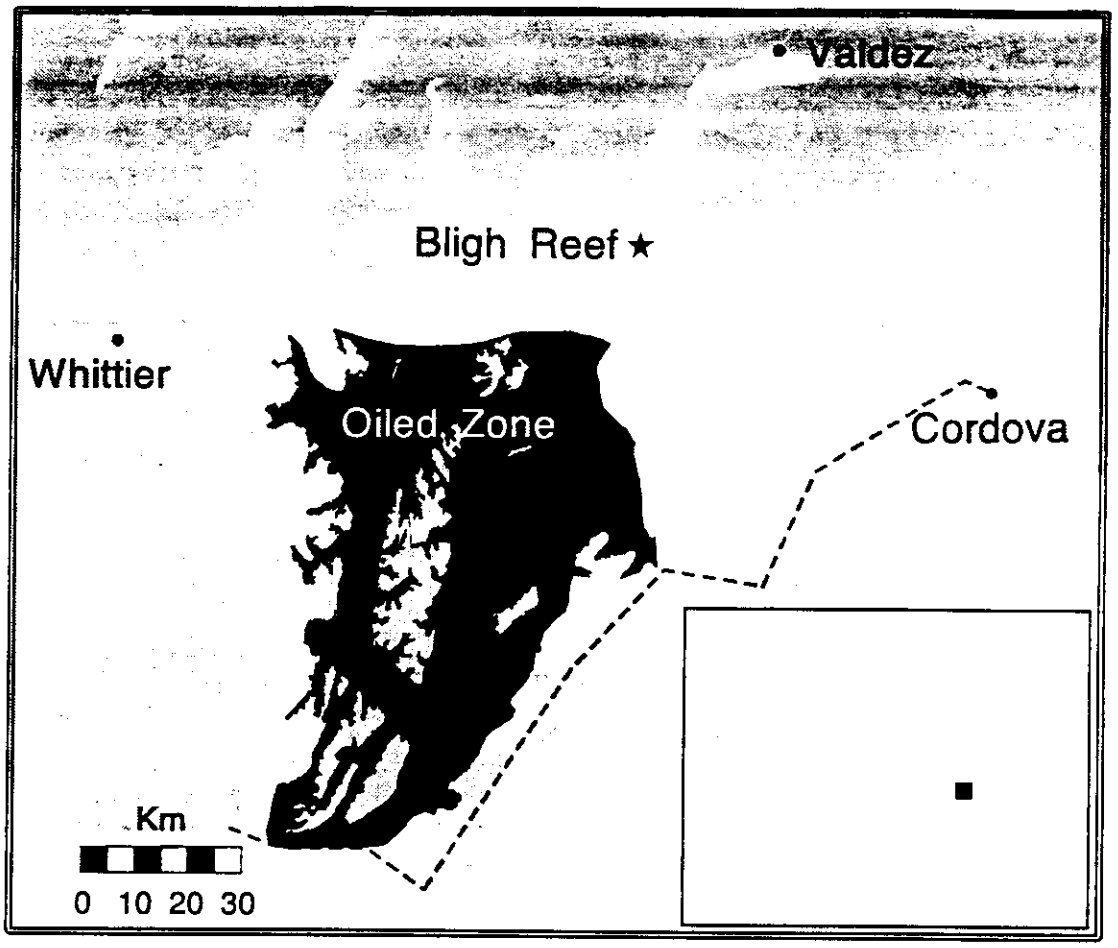
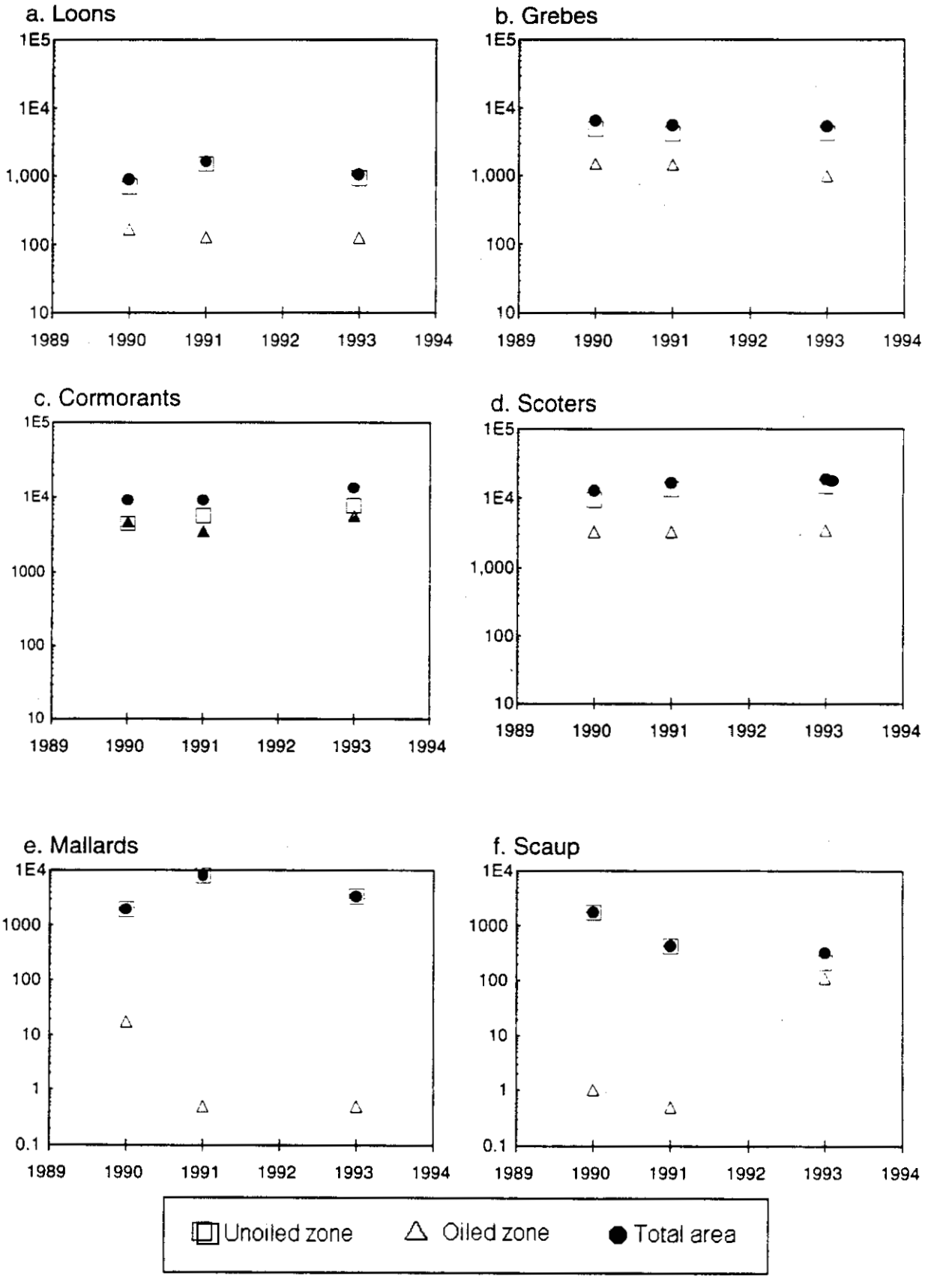
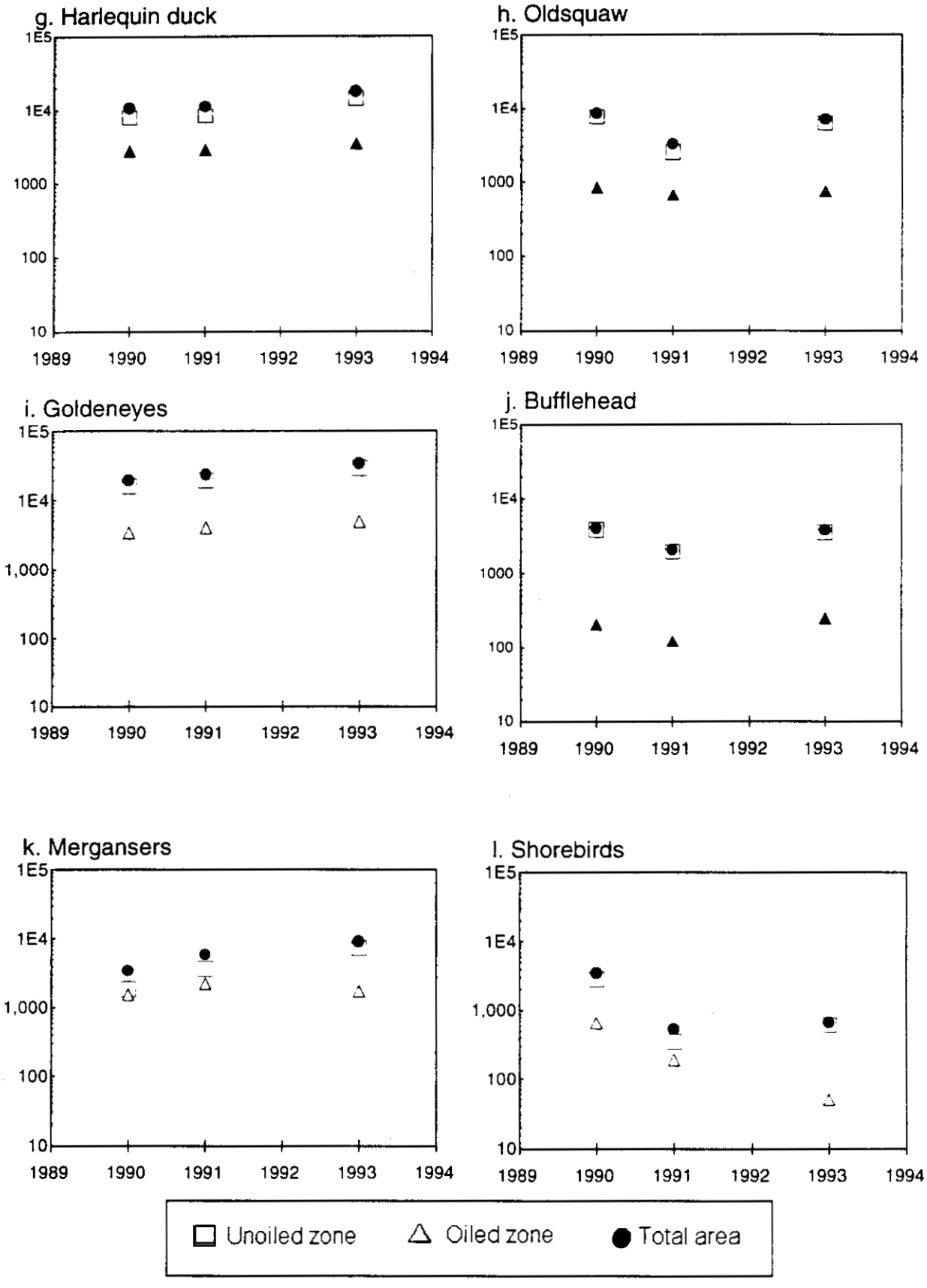
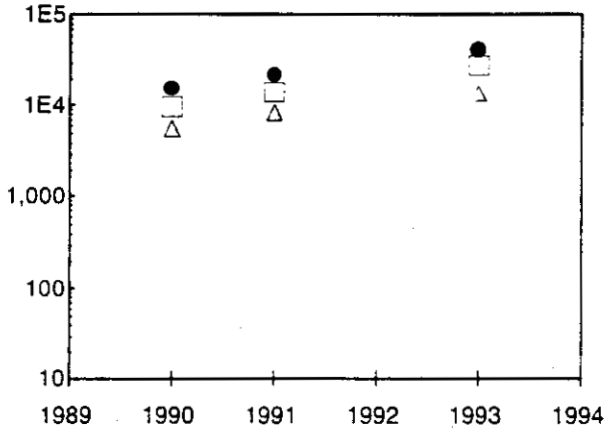

Valdez
Bligh Reef
Whittier
Oiled Zone
Cordova
Km
0 10 20 30

Figure 2. Population estimates (log 10) of individual species and species groups with population estimates of >500 birds and species of special concern for the unoiled (squares) and oiled zones (triangles) and the entire area of Prince William Sound (circles) from March 1990-91 (Klosiewski and Laing 1994) and 1993.

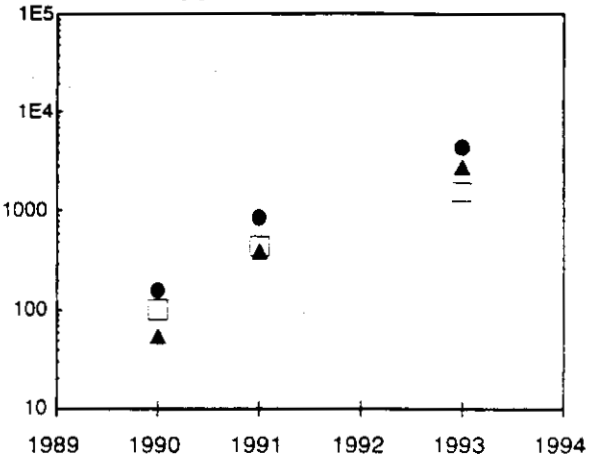

a. Loons
b. Grebes
c. Cormorants
d. Scoters
e. Mallards
f. Scaup
1E5
1E4
1,000
1000
100
10
1
0.1
1989
1990
1991
1992
1993
1994
Unoiled zone
Oiled zone
Total area


g. Harlequin duck
h. Oldsquaw
i. Goldeneyes
j. Bufflehead
k. Mergansers
l. Shorebirds
1E5
1E4
1000
1,000
100
10
1989
1990
1991
1992
1993
1994
Unoiled zone
Oiled zone
Total area

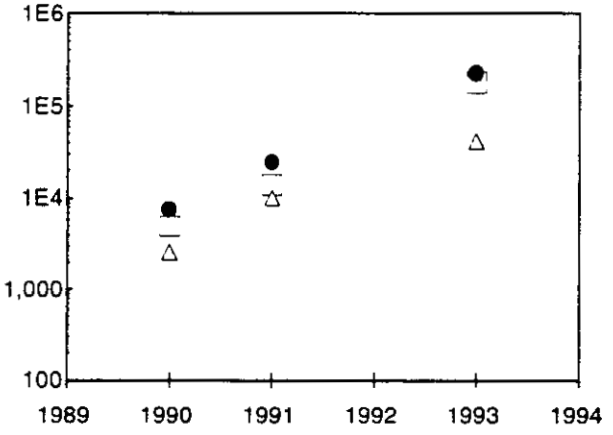
m. Gulls



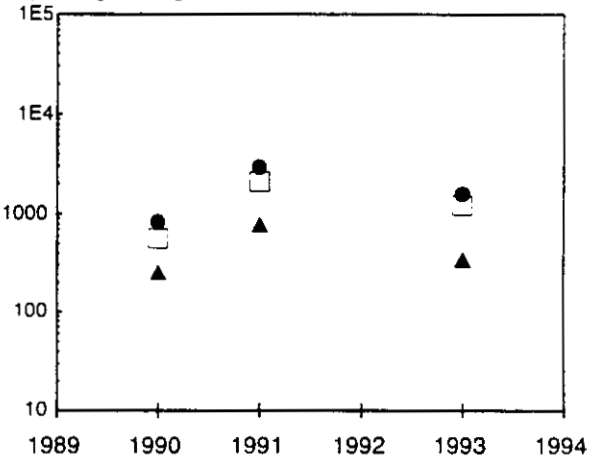
n. Black-legged kittiwake



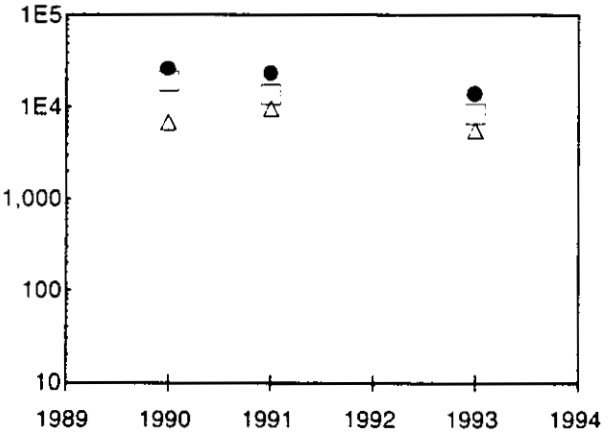
o. Murres



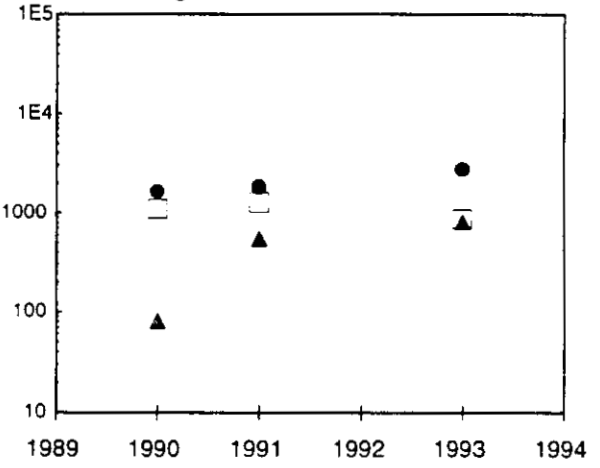
p. Pigeon guillemot

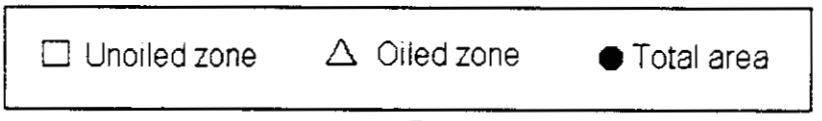


q. Murrelets

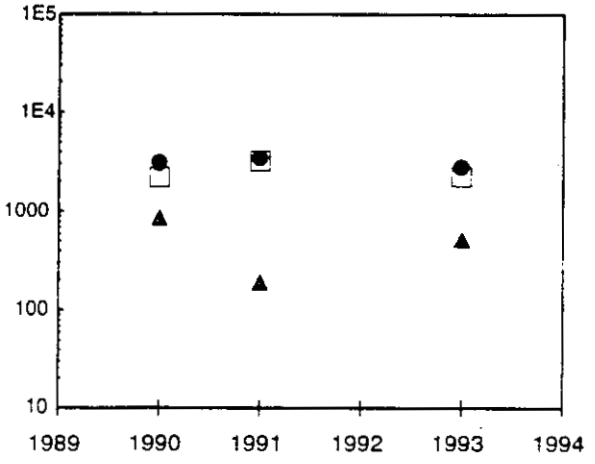


r. Bald eagle

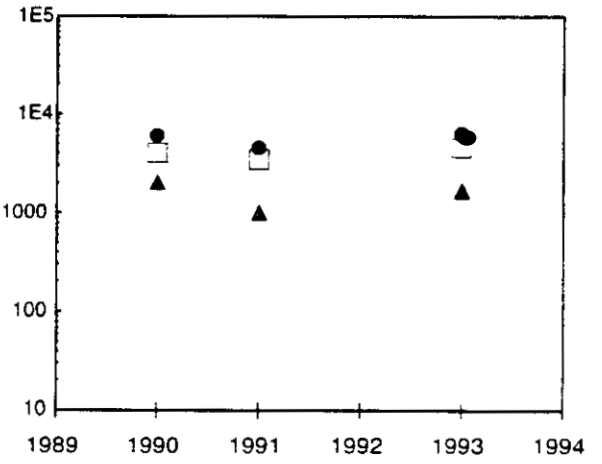




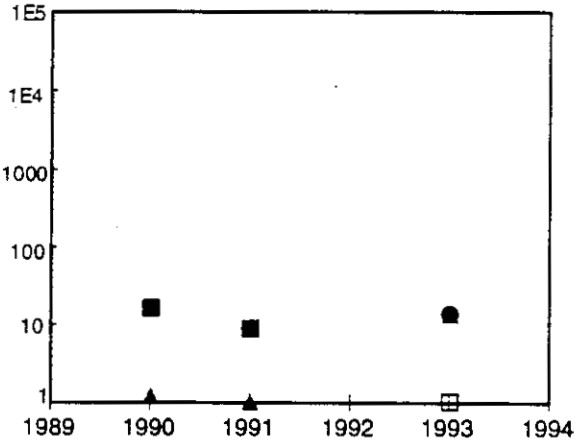
s. Northwestern crow



t. Sea otter

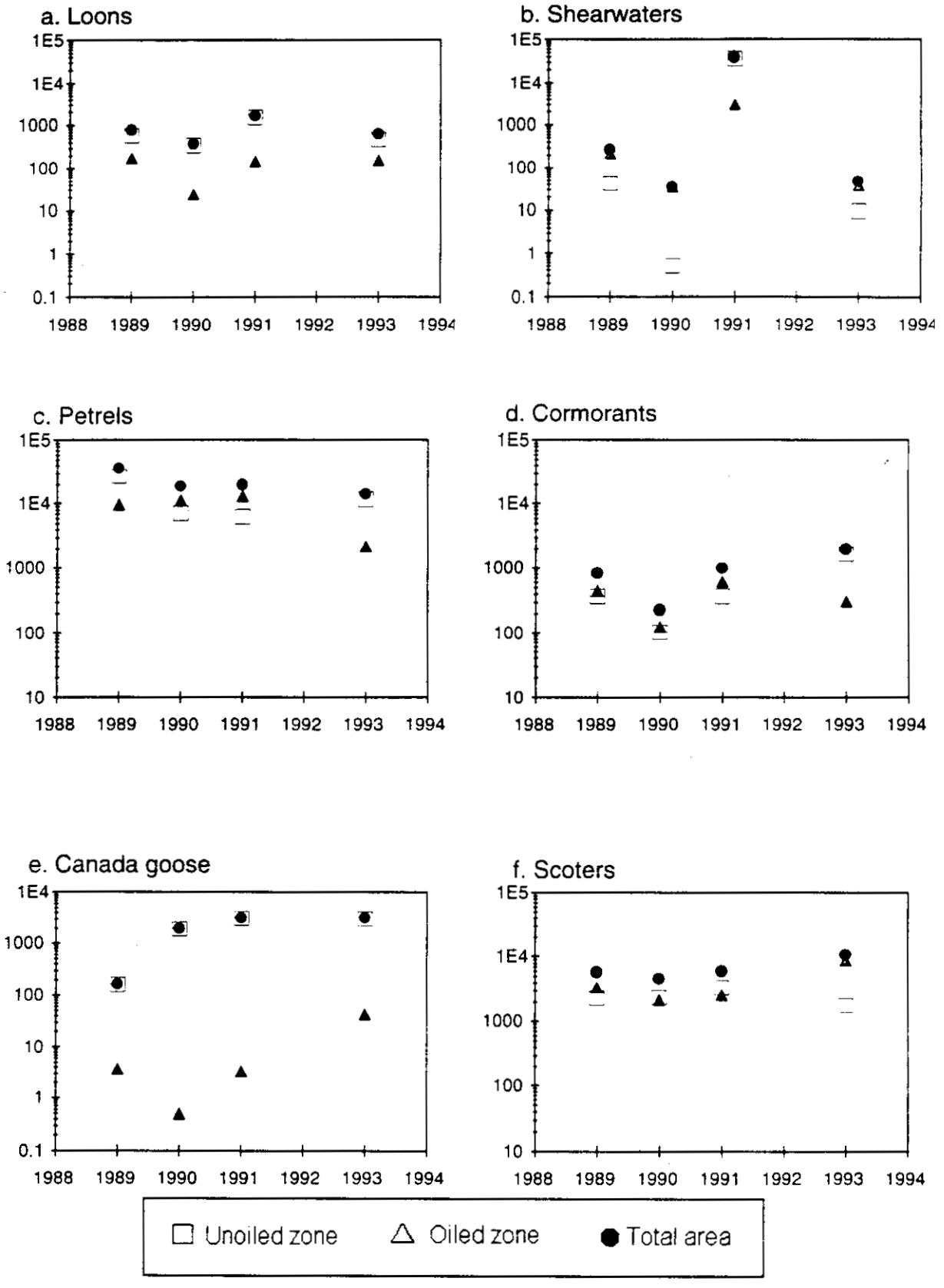


u. Black oystercatcher[a]

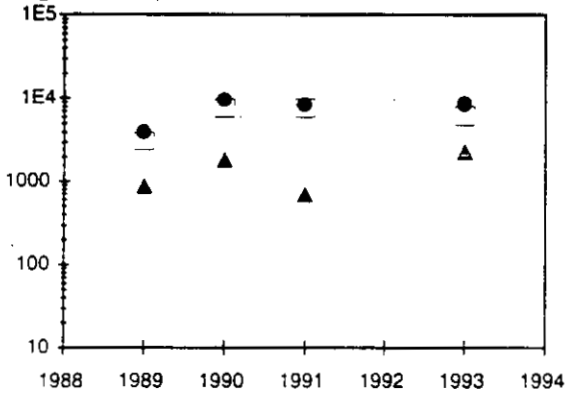


[a] Although the population estimate was <500 birds, this species was included because it was shown to be injured by the oil spill (Klosiewski and Laing 1994).

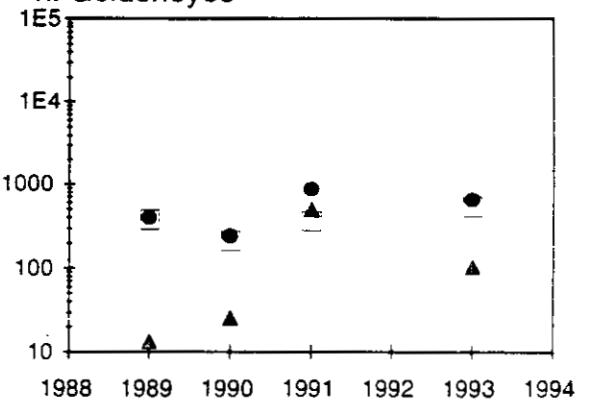
Figure 3. Population estimates (log 10) of individual species and species groups with population estimates of >500 birds for the unoiled (squares) and oiled (triangles) zones and the entire area of Prince William Sound (circles) from July 1989-91 (Klosiewski and Laing 1994) and 1993.


a. Loons
1E5
1E4
1000
100
10
1
0.1
1988 1989 1990 1991 1992 1993 1994
b. Shearwaters
1E5
1E4
1000
100
10
1
0.1
1988 1989 1990 1991 1992 1993 1994
c. Petrels
1E5
1E4
1000
100
10
1988 1989 1990 1991 1992 1993 1994
d. Cormorants
1E5
1E4
1000
100
10
1988 1989 1990 1991 1992 1993 1994
e. Canada goose
1E4
1000
100
10
1
0.1
1988 1989 1990 1991 1992 1993 1994
f. Scoters
1E5
1E4
1000
100
10
1988 1989 1990 1991 1992 1993 1994
Unoiled zone
Oiled zone
Total area

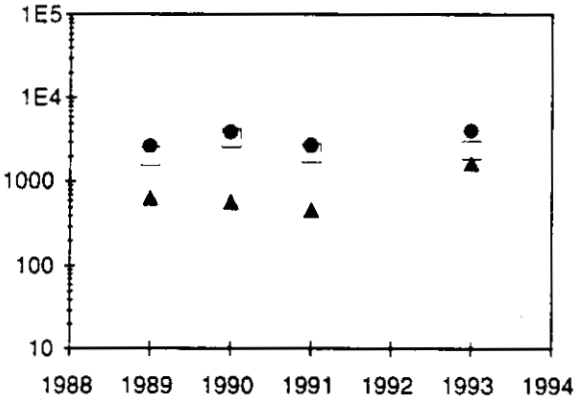
g. Harlequin duck



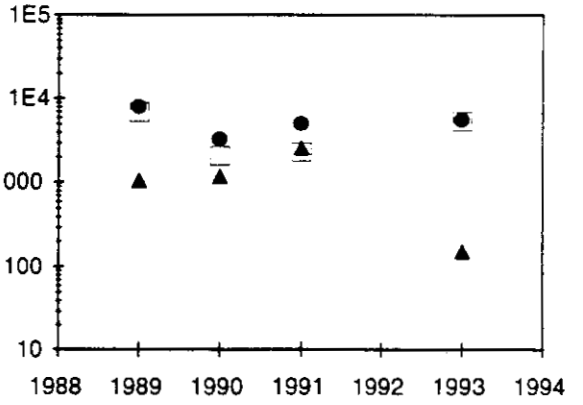
h. Goldeneyes



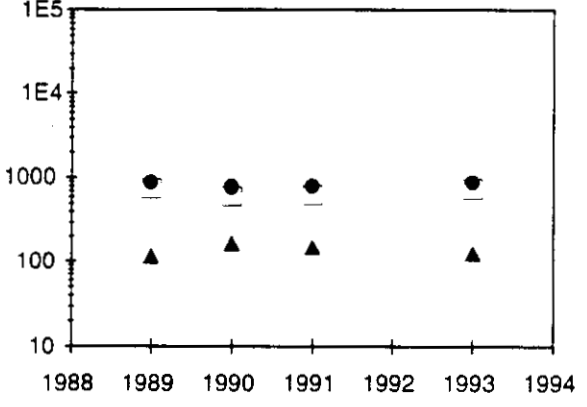
i. Mergansers



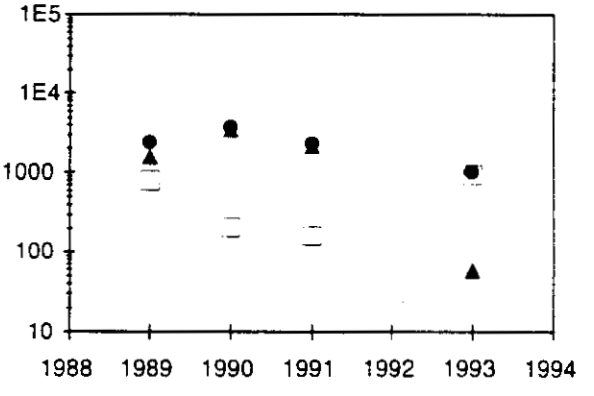
j. Shorebirds

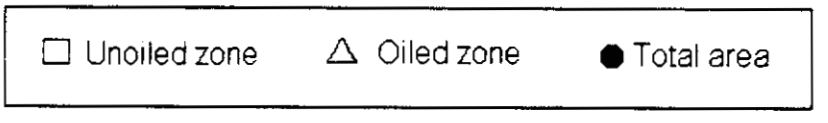


k. Black oystercatcher

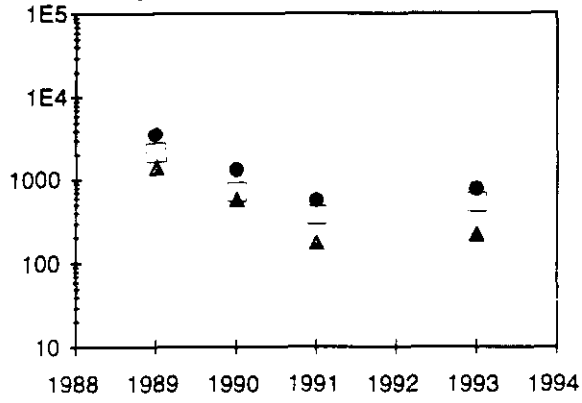


l. Surfbird

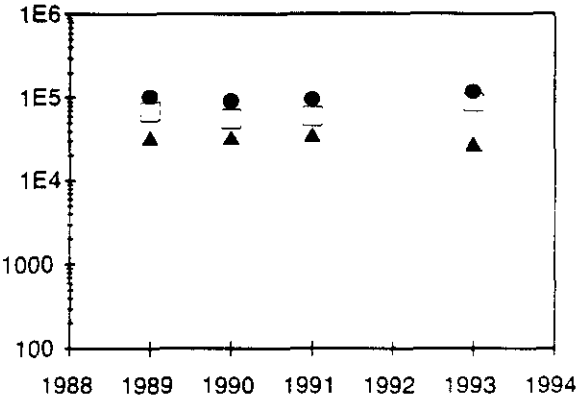




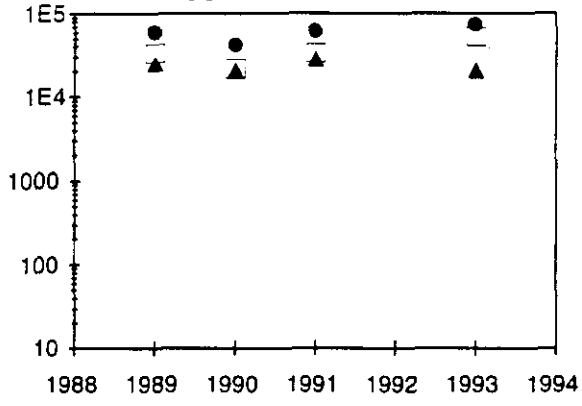
m. Jaegers



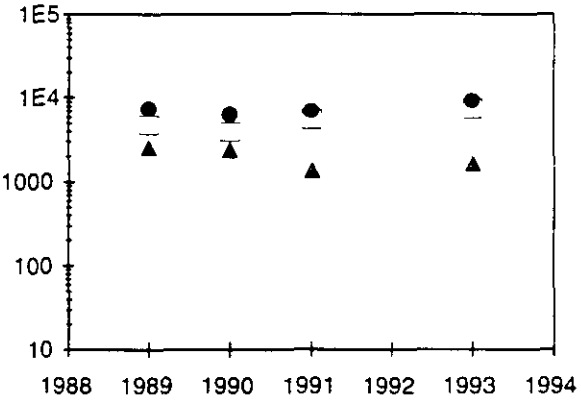
n. Gulls



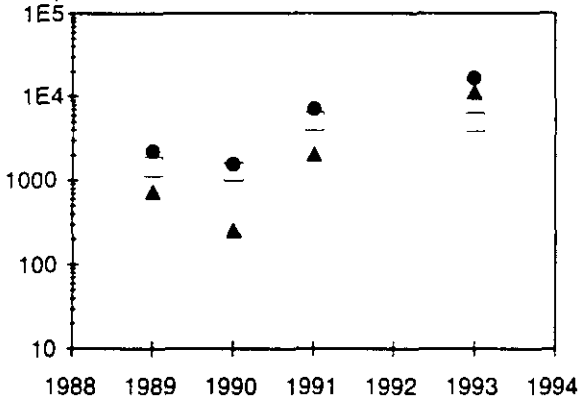
o. Black-legged kittiwake



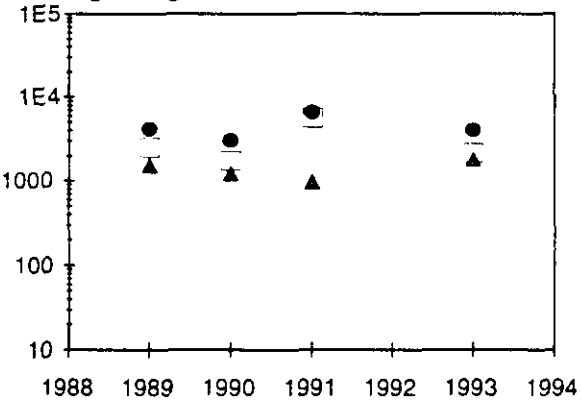
p. Terns

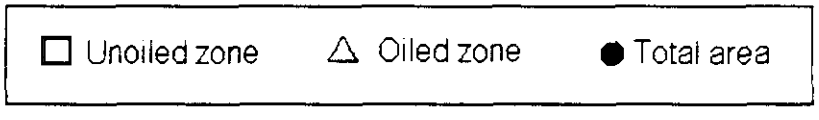


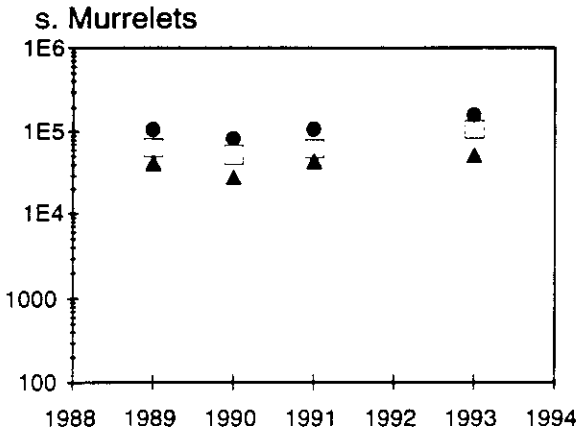
q. Murres

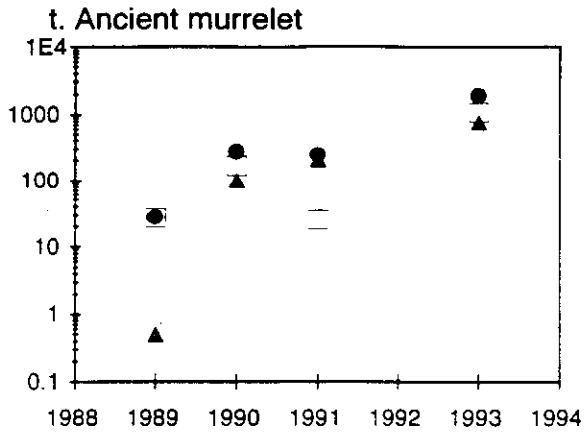


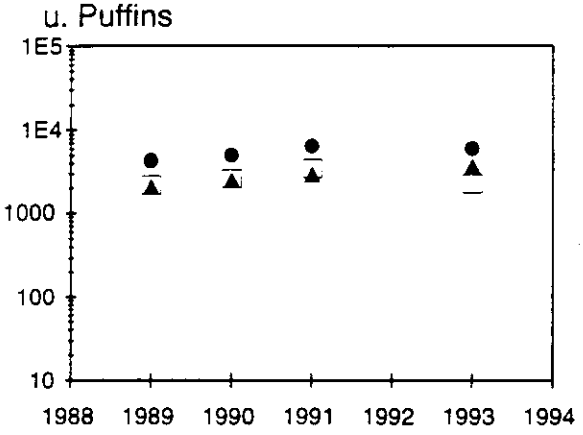
r. Pigeon guillemot

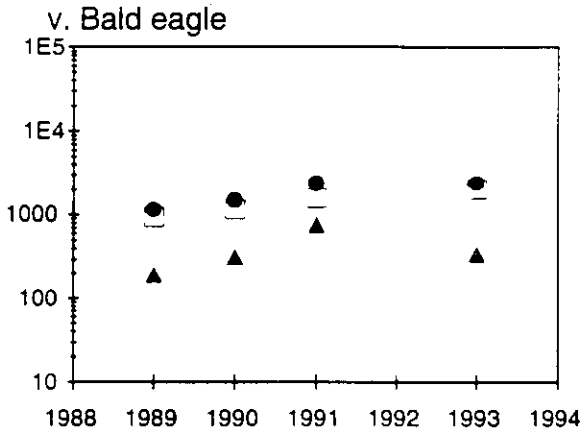


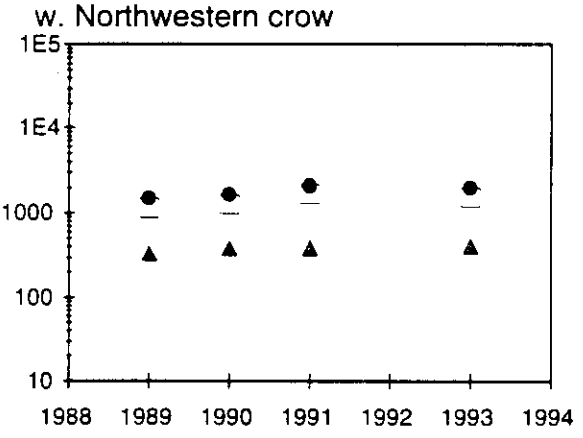


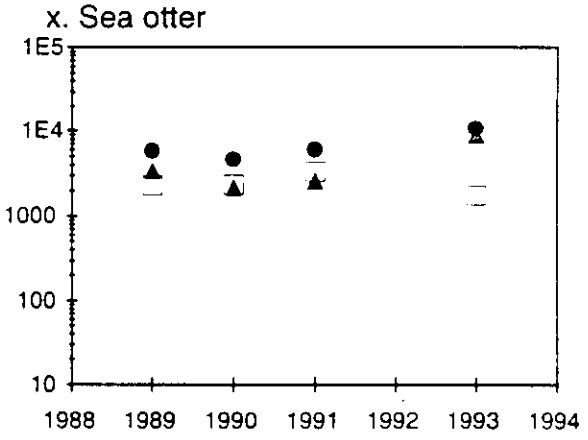

s. Murrelets
1E6
1E5
1E4
1000
100
1988 1989 1990 1991 1992 1993 1994


t. Ancient murrelet
1E4
1000
100
10
1
0.1
1988 1989 1990 1991 1992 1993 1994


u. Puffins
1E5
1E4
1000
100
10
1988 1989 1990 1991 1992 1993 1994


v. Bald eagle
1E5
1E4
1000
100
10
1988 1989 1990 1991 1992 1993 1994


w. Northwestern crow
1E5
1E4
1000
100
10
1988 1989 1990 1991 1992 1993 1994


x. Sea otter
1E5
1E4
1000
100
10
1988 1989 1990 1991 1992 1993 1994


Unoiled zone
Oiled zone
Total area

Appendix A. Estimated numbers of birds (*N*), with 95% CI, for species and species groups observed in Prince William Sound during March and July 1972-73 (Haddock et al., unpubl. data), 1989-91 (Klosiewski and Laing 1994), and 1993. No surveys were done in July 1973 or March 1989. Species listed in phylogenetic order following American Ornithologists' Union (1983).

Species/Year	March		July	
	N	CI	*N*	CI
Loons				
Red-throated loon (*Gavia stellata*)				
1972	179	161	1,255	1,125
1973	29	33		
1989			128	132
1990	8	14	3	4
1991	90	166	110	198
1993	89	126	13	17
Pacific loon (*Gavia pacifica*)				
1972	2,470	1,702	1,027	682
1973	1,112	1,479		
1989			0	0
1990	66	121	80	101
1991	0	0	86	75
1993	0	0	90	93
Common loon (*Gavia immer*)				
1972	97	102	133	169
1973	7	12		
1989			420	271
1990	230	249	82	47
1991	386	397	596	448
1993	67	48	244	166
Yellow-billed loon (*Gavia adamsii*)				
1972	426	444	12	15
1973	143	246		
1989			4	8
1990	23	32	0	0
1991	47	69	6	6
1993	23	25	51	78

Appendix A (continued).

Species/Year	March N	March CI	July N	July CI
Unidentified loon (*Gavia* sp.)				
1972	163	139	140	222
1973	1,762	1,619		
1989			216	242
1990	549	323	204	214
1991	1,111	1,133	851	859
1993	871	644	229	165
Total loons (*Gavia* spp.)				
1972	3,335	1,788	2,567	1,469
1973	3,051	2,322		
1989			768	386
1990	874	453	370	245
1991	1,634	1,192	1,649	1,129
1993	1,051	659	627	255
Grebes				
Horned grebe (*Podiceps auritus*)				
1972	4,847	2,247	60	113
1973	5,370	1,634		
1989			0	0
1990	3,780	1,545	0	0
1991	2,255	1,609	31	48
1993	400	326	0	0
Red-necked grebe (*Podiceps grisegena*)				
1972	4,459	1,695	146	223
1973	7,369	11,316		
1989			0	0
1990	2,108	1,397	20	27
1991	1,565	509	50	41
1993	681	324	31	30

Appendix A (continued).

Species/Year	March		July	
	N	CI	*N*	CI
Unidentified grebe (*Podiceps* sp.)				
1972	0	0	0	0
1973	5	9		
1989			0	0
1990	611	302	10	12
1991	1,775	1,375	7	11
1993	4,210	2,132	0	0
Total grebes (*Podiceps* spp.)				
1972	9,306	3,048	206	245
1973	12,744	9,046		
1989			0	0
1990	6,499	2,053	29	38
1991	5,595	2,240	88	68
1993	5,291	2,298	31	30
Procellariiformes				
Northern fulmar (*Fulmarus glacialis*)				
1972	0	0	999	760
1973	0	0		
1989			0	0
1990	0	0	39	48
1991	0	0	0	0
1993	0	0	41	69
Sooty shearwater (*Puffinus griseus*)				
1972	0	0	0	0
1973	0	0		
1989			78	69
1990	0	0	0	0
1991	0	0	0	0
1993	0	0	0	0

Appendix A (continued).

Species/Year	March		July	
	N	CI	*N*	CI
Unidentified shearwater (*Puffinus* sp.)				
1972	0	0	0	0
1973	0	0		
1989			187	310
1990	0	0	34	55
1991	0	0	38,428	62,788
1993	0	0	46	64
Total shearwaters (*Puffinus* spp.)				
1972	0	0	0	0
1973	0	0		
1989			265	314
1990	0	0	34	55
1991	0	0	38,428	62,788
1993	0	0	46	64
Total fulmars and shearwaters (*Fulmarus* and *Puffinus* spp.)				
1972	0	0	999	760
1973	0	0		
1989			265	314
1990	0	0	72	73
1991	0	0	38,428	62,788
1993	0	0	87	94
Unidentified petrel (*Pterodroma* or *Oceandroma* sp.)				
1972	0	0	0	0
1973	0	0		
1989			828	1,321
1990	0	0	0	0
1991	0	0	0	0
1993	0	0	0	0

Appendix A (continued).

Species/Year	March		July	
	N	CI	*N*	CI
Fork-tailed storm-petrel (*Oceanodroma furcata*)				
1972	0	0	17,539	10,570
1973	0	0		
1989			35,424	38,172
1990	595	705	18,426	5,319
1991	0	0	19,519	11,141
1993	0	0	13,811	8,139
Unidentified storm-petrel (*Oceanodroma* sp.)				
1972	0	0	0	0
1973	0	0		
1989			155	257
1990	0	0	0	0
1991	0	0	0	0
1993	0	0	40	50
Total petrels (*Oceanodroma* and *Pterodroma* spp.)				
1972	0	0	17,539	10,570
1973	0	0		
1989			36,406	38,138
1990	595	705	18,426	5,319
1991	0	0	19,519	11,141
1993	0	0	13,851	8,144
Cormorants				
Double-crested cormorant (*Phalacrocorax auritus*)				
1972	0	0	0	0
1973	0	0		
1989			89	108
1990	269	233	54	51
1991	124	109	49	48
1993	1,041	1,059	254	310

Appendix A (continued).

Species/Year	March		July	
	N	CI	*N*	CI
Pelagic cormorant (*Phalacrocorax pelagicus*)				
1972	0	0	0	0
1973	0	0		
1989			394	289
1990	8,448	2,552	138	84
1991	5,431	2,266	512	341
1993	8,050	3,179	1,351	681
Red-faced cormorant (*Phalacrocorax urile*)				
1972	0	0	0	0
1973	0	0		
1989			22	25
1990	0	0	0	0
1991	8	14	0	0
1993	6	10	15	18
Unidentified cormorant (*Phalacrocorax* sp.)				
1972	10,792	2,744	20,045	19,401
1973	27,679	8,203		
1989			307	363
1990	352	358	34	28
1991	3,477	1,303	419	402
1993	2,775	1,611	340	228
Total cormorants (*Phalacrocorax* spp.)				
1972	10,792	2,744	20,045	19,401
1973	27,679	8,203		
1989			812	590
1990	9,068	2,583	225	106
1991	9,040	2,654	980	567
1993	11,872	4,079	1,959	871

Appendix A (continued).

Species/Year	March		July	
	N	CI	*N*	CI
Herons				
Great blue heron (*Ardea herodias*)				
1972	113	85	47	50
1973	50	41		
1989			18	16
1990	49	37	54	33
1991	30	33	36	33
1993	106	118	93	54
Waterfowl				
Tundra swan (*Cygnus columbianus*)				
1972	0	0	0	0
1973	0	0		
1989			0	0
1990	0	0	0	0
1991	8	14	0	0
1993	0	0	0	0
Trumpeter swan (*Cygnus buccinator*)				
1972	0	0	146	260
1973	0	0		
1989			0	0
1990	0	0	3	5
1991	0	0	0	0
1993	0	0	0	0
Emperor goose (*Chen canagica*)				
1972	0	0	0	0
1973	0	0		
1989			0	0
1990	6	11	0	0
1991	0	0	0	0
1993	0	0	0	0

Appendix A (continued).

Species/Year	March		July	
	N	CI	*N*	CI
Brant (*Branta bernicla*)				
1972	0	0	0	0
1973	0	0		
1989			0	0
1990	0	0	0	0
1991	0	0	3	4
1993	0	0	0	0
Canada goose (*Branta canadensis*)				
1972	48	90	0	0
1973	138	252		
1989			164	279
1990	38	71	1,907	3,326
1991	0	0	3,101	5,284
1993	37	67	3,099	5,323
Green-winged teal (*Anas crecca*)				
1972	148	259	106	201
1973	59	80		
1989			0	0
1990	0	0	64	86
1991	0	0	78	130
1993	0	0	0	0
Mallard (*Anas platyrhynchos*)				
1972	7,185	8,722	291	266
1973	1,617	1,150		
1989			278	383
1990	1,954	1,382	207	246
1991	8,249	11,958	457	293
1993	3,401	2,532	30	47

Appendix A (continued).

Species/Year	March		July	
	N	CI	*N*	CI
Northern pintail (*Anas acuta*)				
1972	348	605	177	336
1973	276	492		
1989			0	0
1990	0	0	44	72
1991	0	0	0	0
1993	8	14	0	0
Northern shoveler (*Anas clypeata*)				
1972	0	0	0	0
1973	0	0		
1989			0	0
1990	0	0	0	0
1991	0	0	23	37
1993	0	0	0	0
Gadwall (*Anas strepera*)				
1972	4,407	8,025	6	11
1973	487	625		
1989			17	30
1990	174	327	27	32
1991	151	257	22	40
1993	155	292	0	0
American wigeon (*Anas americana*)				
1972	474	863	0	0
1973	0	0		
1989			0	0
1990	0	0	68	98
1991	8	14	310	341
1993	0	0	4	8

Appendix A (continued).

Species/Year	March		July	
	N	CI	*N*	CI
Unidentified dabbling duck (*Anas* sp.)				
1972	0	0	0	0
1973	0	0		
1989			0	0
1990	1,043	1,510	47	51
1991	621	720	9	16
1993	1,607	2,893	0	0
Greater scaup (*Aythya marila*)				
1972	0	0	0	0
1973	0	0		
1989			439	518
1990	1,187	1,478	0	0
1991	0	0	147	214
1993	0	0	82	128
Unidentified scaup (*Aythya marila* or *affinis*)				
1972	1,626	943	29	46
1973	2,583	2,566		
1989			0	0
1990	600	753	0	0
1991	431	775	195	311
1993	328	421	0	0
Total scaup (*Aythya marila* and *affinis*)				
1972	1,626	943	29	46
1973	2,583	2,566		
1989			439	518
1990	1,787	1,616	0	0
1991	431	775	342	375
1993	328	421	82	128

Appendix A (continued).

Species/Year	March		July	
	N	CI	*N*	CI
Steller's eider (*Polysticta stelleri*)				
1972	0	0	0	0
1973	13	25		
1989			0	0
1990	0	0	0	0
1991	0	0	0	0
1993	0	0	0	0
Unidentified eider (*Somateria* or *Polysticta* sp.)				
1972	40	44	0	0
1973	0	0		
1989			0	0
1990	0	0	0	0
1991	0	0	0	0
1993	0	0	0	0
Harlequin duck (*Histrionicus histrionicus*)				
1972	12,480	3,325	3,607	2,038
1973	15,831	5,528		
1989			3,923	1,318
1990	10,629	2,544	9,341	3,507
1991	11,158	2,872	8,264	3,116
1993	18,619	7,389	8,322	2,658
Oldsquaw (*Clangula hyemalis*)				
1972	19,187	16,562	90	147
1973	11,377	8,314		
1989			0	0
1990	8,635	10,373	92	109
1991	3,169	1,419	47	69
1993	7,035	3,241	17	16

Appendix A (continued).

Species/Year	March		July	
	N	CI	*N*	CI
Black scoter (*Melanitta nigra*)				
1972	4,119	2,575	35	36
1973	8,671	8,197		
1989			1,235	1,765
1990	2,765	1,510	42	51
1991	1,387	825	431	457
1993	1,956	1,048	276	244
Surf scoter (*Melanitta perspicillata*)				
1972	16,400	6,162	8,177	6.280
1973	27,089	17,248		
1989			528	381
1990	4,554	1,355	1,955	2.373
1991	9,313	4,709	1,069	710
1993	5,921	1,941	1,980	1,031
White-winged scoter (*Melanitta fusca*)				
1972	23,910	12,909	4,763	3,023
1973	16,782	6,523		
1989			3,024	3,003
1990	3,316	1,349	1,089	1.350
1991	5,296	2,747	3,564	3,131
1993	6,959	4,341	7,593	8,132
Unidentified scoter (*Melanitta* sp.)				
1972	8,505	7,327	0	0
1973	7,647	7,493		
1989			937	1.165
1990	2,136	2,402	1,464	1,658
1991	890	998	887	662
1993	3,761	2,028	808	968

Appendix A (continued).

Species/Year	March N	March CI	July N	July CI
Total scoters (*Melanitta* spp.)				
1972	52,935	19,345	12,975	7,069
1973	60,187	22,389		
1989			5,724	3,619
1990	12,770	3,557	4,551	4,258
1991	16,886	7,067	5,950	3,821
1993	18,597	5,736	10,657	8,295
Common goldeneye (*Bucephala clangula*)				
1972	0	0	0	0
1973	0	0		
1989			204	194
1990	896	721	28	28
1991	148	121	135	139
1993	102	112	123	112
Barrow's goldeneye (*Bucephala islandica*)				
1972	0	0	0	0
1973	0	0		
1989			99	105
1990	14,970	3,601	6	9
1991	20,311	6,070	50	69
1993	13,694	3,628	73	75
Unidentified goldeneye (*Bucephala clangula* or *islandica*)				
1972	14,802	4,741	427	381
1973	25,230	12,509		
1989			87	92
1990	3,678	1,678	203	146
1991	3,181	2,306	671	895
1993	20,274	7,866	446	475

Appendix A (continued).

Species/Year	March		July	
	N	CI	*N*	CI
Total goldeneyes (*Bucephala clangula* and *islandica*)				
1972	14,802	4,741	427	381
1973	25,230	12,509		
1989			390	254
1990	19,544	4,397	237	148
1991	23,639	6,361	856	909
1993	34,070	9,093	642	558
Bufflehead (*Bucephala albeola*)				
1972	8,198	4,981	0	0
1973	5,612	2,422		
1989			0	0
1990	4,122	1,666	0	0
1991	2,129	660	20	27
1993	4,125	1,856	22	28
Common merganser (*Mergus merganser*)				
1972	0	0	0	0
1973	0	0		
1989			2,670	1,347
1990	1,076	386	3,425	2,046
1991	4,466	2,322	2,389	894
1993	5,954	3,114	3,227	986
Red-breasted merganser (*Mergus serrator*)				
1972	0	0	0	0
1973	0	0		
1989			0	0
1990	1,477	476	106	82
1991	231	160	0	0
1993	465	408	352	237

Appendix A (continued).

Species/Year	March		July	
	N	CI	*N*	CI
Unidentified merganser (*Mergus* sp.)				
1972	5,797	3,111	6,670	4,798
1973	4,473	1,634		
1989			0	0
1990	867	552	409	223
1991	1,226	1,641	299	209
1993	2,825	3,110	459	241
Total mergansers (*Mergus* spp.)				
1972	5,797	3,111	6,670	4,798
1973	4,473	1,634		
1989			2,670	1,347
1990	3,420	875	3,941	2,062
1991	5,924	3,336	2,688	932
1993	9,244	4,749	4,038	1,015
Unidentified diving/sea duck				
1972	0	0	0	0
1973	0	0		
1989			376	310
1990	2,202	2,754	98	99
1991	3,227	1,505	1,008	492
1993	1,675	895	655	432
Unidentified duck				
1972	0	0	0	0
1973	0	0		
1989			65	83
1990	404	401	0	0
1991	76	82	20	27
1993	408	502	4	8

Appendix A (continued).

Species/Year	March		July	
	N	CI	*N*	CI
Total waterfowl (Family Anatidae)				
1972	127,673	42,739	24,524	10,279
1973	127,885	37,920		
1989			14,046	4,615
1990	66,728	14,400	20,625	7,453
1991	75,676	21,503	23,198	8,958
1993	99,309	21,977	27,572	11,158
Hawks and Eagles				
Bald eagle (*Haliaeetus leucocephalus*)				
1972	1,372	382	1,172	419
1973	1,916	525		
1989			1,120	235
1990	1,620	366	1,473	273
1991	1,811	489	2,325	356
1993	2,678	911	2,387	686
Unidentified eagle (*Haliaeetus* or *Aquila* sp.)				
1972	0	0	0	0
1973	0	0		
1989			0	0
1990	8	14	0	0
1991	0	0	0	0
1993	0	0	0	0
Shorebirds				
Black oystercatcher (*Haematopus bachmani*)				
1972	181	337	544	410
1973	207	355		
1989			432	126
1990	15	19	766	202
1991	8	14	773	316
1993	12	16	864	224

Appendix A (continued).

Species/Year	March		July	
	N	CI	*N*	CI
Lesser yellowlegs (*Tringa flavipes*)				
1972	0	0	0	0
1973	0	0		
1989			0	0
1990	0	0	0	0
1991	0	0	0	0
1993	0	0	11	13
Unidentified yellowlegs (*Tringa flavipes* or *melanoleuca*)				
1972	0	0	6	11
1973	0	0		
1989			0	0
1990	0	0	84	91
1991	0	0	0	0
1993	0	0	4	8
Solitary sandpiper (*Tringa solitaria*)				
1972	0	0	0	0
1973	0	0		
1989			0	0
1990	0	0	0	0
1991	0	0	0	0
1993	0	0	3	5
Wandering tattler (*Heteroscelus incanus*)				
1972	0	0	408	353
1973	0	0		
1989			3	5
1990	0	0	84	73
1991	0	0	8	9
1993	0	0	0	0

Appendix A (continued).

Species/Year	March		July	
	N	CI	*N*	CI
Spotted sandpiper (*Actitus macularia*)				
1972	0	0	55	56
1973	0	0		
1989			13	13
1990	0	0	48	26
1991	0	0	21	16
1993	0	0	8	10
Whimbrel (*Numenius phaeopus*)				
1972	0	0	27	54
1973	0	0		
1989			108	133
1990	0	0	39	40
1991	0	0	30	35
1993	0	0	64	76
Black turnstone (*Arenaria melanocephala*)				
1972	0	0	0	0
1973	0	0		
1989			5,169	8,994
1990	37	59	802	763
1991	303	554	22	26
1993	0	0	69	66
Ruddy turnstone (*Arenaria interpres*)				
1972	0	0	0	0
1973	0	0		
1989			0	0
1990	0	0	0	0
1991	0	0	0	0
1993	31	56	0	0

Appendix A (*continued*).

Species/Year	March		July	
	N	CI	*N*	CI
Unidentified turnstone (*Arenaria* sp.)				
1972	57	76	0	0
1973	66	126		
1989			0	0
1990	0	0	0	0
1991	0	0	0	0
1993	0	0	0	0
Surfbird (*Aphriza virgata*)				
1972	8	15	1,582	2,352
1973	0	0		
1989			679	798
1990	906	1,266	686	688
1991	0	0	3,880	3,385
1993	0	0	4,285	4,599
Sanderling (*Calidris alba*)				
1972	0	0	0	0
1973	157	322		
1989			0	0
1990	0	0	0	0
1991	0	0	0	0
1993	0	0	0	0
Semipalmated sandpiper (*Calidris pusilla*)				
1972	0	0	0	0
1973	0	0		
1989			9	15
1990	0	0	0	0
1991	0	0	0	0
1993	0	0	0	0

Appendix A (continued).

Species/Year	March		July	
	N	CI	*N*	CI
Western sandpiper (*Calidris mauri*)				
1972	0	0	95	163
1973	0	0		
1989			0	0
1990	0	0	0	0
1991	0	0	0	0
1993	0	0	0	0
Rock sandpiper (*Calidris ptilocnemis*)				
1972	775	822	0	0
1973	7,188	7,976		
1989			0	0
1990	0	0	0	0
1991	197	221	0	0
1993	435	733	109	133
Dunlin (*Calidris alpina*)				
1972	0	0	0	0
1973	42	65		
1989			0	0
1990	0	0	0	0
1991	0	0	0	0
1993	0	0	0	0
Short-billed dowitcher (*Limnodromus griseus*)				
1972	0	0	0	0
1973	0	0		
1989			0	0
1990	0	0	0	0
1991	0	0	0	0
1993	0	0	16	27

Appendix A (continued).

Species/Year	March		July	
	N	CI	*N*	CI
Long-billed dowitcher (*Limnodromus scolopaceus*)				
1972	0	0	0	0
1973	0	0		
1989			6	10
1990	0	0	0	0
1991	0	0	0	0
1993	0	0	0	0
Unidentified dowitcher (*Limnodromus* sp.)				
1972	0	0	12	22
1973	0	0		
1989			0	0
1990	0	0	0	0
1991	0	0	0	0
1993	0	0	0	0
Red-necked phalarope (*Phalaropus lobatus*)				
1972	0	0	2,178	3,561
1973	0	0		
1989			9,701	9,169
1990	0	0	2,414	1,323
1991	0	0	19,218	27,529
1993	0	0	1,938	1,739
Unidentified phalarope (*Phalaropus* sp.)				
1972	0	0	0	0
1973	0	0		
1989			0	0
1990	0	0	163	262
1991	0	0	0	0
1993	0	0	121	205

Appendix A (continued).

Species/Year	March		July	
	N	CI	*N*	CI
Unidentified *Calidris* sp.				
1972	329	316	0	0
1973	0	0		
1989			612	862
1990	0	0	3	5
1991	0	0	41	37
1993	0	0	18	31
Unidentified shorebird				
1972	306	595	1,296	2,141
1973	0	0		
1989			545	453
1990	2,547	3,152	754	529
1991	31	57	143	90
1993	192	299	118	77
Total shorebirds (Families Haematopodidae and Scolopacidae, except *Phalaropus* sp.)				
1972	1,656	1,185	4,025	3,202
1973	7,660	7,986		
1989			7,576	9,942
1990	3,504	3,394	3,268	1,330
1991	538	660	4,919	3,435
1993	670	790	5,570	4,618
Jaegers				
Pomarine jaeger (*Stercorarius pomarinus*)				
1972	0	0	1,011	662
1973	0	0		
1989			1,508	774
1990	0	0	699	396
1991	0	0	0	0
1993	0	0	369	263

Appendix A (continued).

Species/Year	March		July	
	N	CI	*N*	CI
Parasitic jaeger (*Stercorarius parasiticus*)				
1972	0	0	203	316
1973	0	0		
1989			505	309
1990	0	0	56	94
1991	0	0	371	247
1993	0	0	127	113
Long-tailed jaeger (*Stercorarius longicaudus*)				
1972	0	0	0	0
1973	0	0		
1989			0	0
1990	0	0	4	8
1991	0	0	63	95
1993	0	0	75	124
Unidentified jaeger (*Stercorarius* sp.)				
1972	0	0	29	57
1973	0	0		
1989			1,543	954
1990	0	0	538	343
1991	0	0	115	108
1993	0	0	186	159
Total jaegers (*Stercorarius* spp.)				
1972	0	0	1,243	841
1973	0	0		
1989			3,556	1,305
1990	0	0	1,296	628
1991	0	0	549	276
1993	0	0	757	394

Appendix A (continued).

Species/Year	March		July	
	N	CI	*N*	CI
Gulls				
Bonaparte's gull (*Larus philadelphia*)				
1972	112	248	9,848	9,803
1973	336	997		
1989			2,469	1,843
1990	0	0	1,423	1,153
1991	94	178	823	689
1993	0	0	2,108	1,646
Mew gull (*Larus canus*)				
1972	8,949	10,045	8,588	3,004
1973	3,401	1,860		
1989			5,645	1,909
1990	2,457	1,286	8,254	2,793
1991	9,785	3,339	3,278	1,096
1993	9,069	10,036	5,353	1,353
Herring gull (*Larus argentatus*)				
1972	198	176	0	0
1973	396	1,439		
1989			7	9
1990	154	172	125	129
1991	96	133	214	180
1993	858	548	48	38
Glaucous-winged gull (*Larus glaucescens*)				
1972	27,930	12,405	51,850	33,230
1973	32,215	17,002		
1989			21,255	4,876
1990	8,269	1,866	31,979	7,789
1991	10,226	3,693	25,107	5,504
1993	10,053	4,653	33,616	10,554

Appendix A (continued).

Species/Year	March		July	
	N	CI	*N*	CI
Glaucous gull (*Larus hyperboreus*)				
1972	5	10	0	0
1973	0	0		
1989			0	0
1990	0	0	0	0
1991	0	0	0	0
1993	0	0	3	5
Black-legged kittiwake (*Rissa tridactyla*)				
1972	9,444	11,013	106,764	39,116
1973	6,102	3,214		
1989			58,642	9,569
1990	157	118	42,191	8,757
1991	843	455	61,596	9,552
1993	3,292	2,919	73,093	25,012
Unidentified gull (*Larus* or *Rissa* sp.)				
1972	3,607	3,226	146	244
1973	0	0		
1989			13,063	8,204
1990	4,230	4,750	4,975	2,141
1991	1,440	973	4,124	1,817
1993	18,547	11,969	2,510	2,175
Total gulls (*Larus* and *Rissa* spp.)				
1972	50,247	23,401	177,196	59,393
1973	42,451	18,416		
1989			101,082	15,939
1990	15,267	5,541	88,947	15,680
1991	22,483	5,398	95,143	12,917
1993	41,818	17,235	116,730	27,834

Appendix A (continued).

Species/Year	March		July	
	N	CI	*N*	CI
Terns				
Caspian tern (*Sterna caspia*)				
1972	0	0	0	0
1973	0	0		
1989			0	0
1990	0	0	0	0
1991	0	0	40	68
1993	0	0	0	0
Arctic tern (*Sterna paradisaea*)				
1972	0	0	33,177	9,504
1973	0	0		
1989			7,279	2,455
1990	0	0	6,240	1,782
1991	0	0	6,224	1,384
1993	0	0	8,558	4,893
Aleutian tern (*Sterna aleutica*)				
1972	0	0	6	11
1973	0	0		
1989			0	0
1990	0	0	0	0
1991	0	0	323	483
1993	0	0	114	133
Unidentified tern (*Sterna* sp.)				
1972	0	0	0	0
1973	0	0		
1989			52	76
1990	0	0	49	81
1991	0	0	318	323
1993	0	0	481	409

Appendix A (continued).

Species/Year	March		July	
	N	CI	*N*	CI
Total terns (*Sterna* spp.)				
1972	0	0	33,183	9,504
1973	0	0		
1989			7,331	2,456
1990	0	0	6,289	1,783
1991	0	0	6,905	1,548
1993	0	0	9,153	4,901
Alcidae				
Common murre (*Uria aalge*)				
1972	0	0	0	0
1973	0	0		
1989			268	209
1990	4,895	2,107	875	530
1991	11,735	6,637	4,533	1,494
1993	157,177	142,396	16,005	6,433
Thick-billed murre (*Uria lomvia*)				
1972	0	0	0	0
1973	0	0		
1989			0	0
1990	0	0	60	110
1991	0	0	0	0
1993	264	505	0	0
Unidentified murre (*Uria* sp.)				
1972	8,195	4,037	5,915	3,405
1973	10,681	9,144		
1989			1,914	1,436
1990	2,597	1,960	576	561
1991	12,368	6,898	2,505	1,287
1993	63,528	38,015	364	350

Appendix A (continued).

Species/Year	March		July	
	N	CI	*N*	CI
Total murres (*Uria* spp.)				
1972	8,195	4,037	5,915	3,405
1973	10,681	9,144		
1989			2,183	1,503
1990	7,492	2,978	1,512	796
1991	24,103	12,076	7,038	2,061
1993	220,969	162,517	16,368	6,439
Pigeon guillemot (*Cepphus columba*)				
1972	3,695	1,294	15,567	5,134
1973	9,188	6,231		
1989			4,070	1,488
1990	812	348	2,961	762
1991	2,842	2,178	6,625	4,941
1993	1,640	916	3,947	953
Marbled murrelet (*Brachyramphus marmoratus*)				
1972	11,567	2,413	236,633	51,727
1973	72,675	25,410		
1989			59,284	11,825
1990	13,764	5,939	39,486	9,986
1991	7,717	4,595	42,477	9,151
1993	7,360	4,090	14,177	4,499
Kittlitz's murrelet (*Brachyramphus brevirostris*)				
1972	346	657	63,229	80,122
1973	3,219	3,827		
1989			6,436	3,151
1990	958	1,599	5,231	8,457
1991	466	398	1,184	1,121
1993	448	326	2,710	1,343

Appendix A (continued).

Species/Year	March		July	
	N	CI	*N*	CI
Unidentified *Brachyramphus* murrelet sp.				
1972	0	0	4,570	7,875
1973	0	0		
1989			41,634	8,221
1990	11,379	7,026	36,624	7,910
1991	15,328	7,288	62,816	14,012
1993	6,176	3,267	142,546	41,876
Total *Brachyramphus* murrelet spp.				
1972	11,913	2,454	304,432	98,430
1973	75,893	31,963		
1989			107,354	17,483
1990	26,102	9,663	81,341	17,758
1991	23,510	11,171	106,478	20,095
1993	13,983	6,286	159,433	42,059
Ancient murrelet (*Synthliboramphus antiquus*)				
1972	0	0	446	347
1973	0	0		
1989			26	26
1990	0	0	265	260
1991	81	145	231	223
1993	0	0	1,874	1,281
Cassin's auklet (*Ptychoramphus aleuticus*)				
1972	0	0	0	0
1973	0	0		
1989			0	0
1990	0	0	0	0
1991	39	48	0	0
1993	0	0	0	0

Appendix A (continued).

Species/Year	March		July	
	N	CI	*N*	CI
Parakeet auklet (*Cyclorrhynchus psittacula*)				
1972	0	0	1,893	1,455
1973	5	8		
1989			501	665
1990	0	0	842	529
1991	0	0	7	11
1993	0	0	725	648
Rhinoceros auklet (*Cerorhina monocerata*)				
1972	0	0	269	283
1973	0	0		
1989			0	0
1990	0	0	0	0
1991	0	0	0	0
1993	0	0	0	0
Tufted puffin (*Fratercula cirrhata*)				
1972	0	0	9,596	4,798
1973	0	0		
1989			2,282	1,128
1990	0	0	3,819	1,588
1991	23	43	5,043	2,011
1993	0	0	4,092	1,356
Horned puffin (*Fratercula corniculata*)				
1972	0	0	3,580	3,055
1973	0	0		
1989			1,856	1,867
1990	0	0	1,252	784
1991	81	137	1,297	818
1993	0	0	1,520	1,209

Appendix A (continued).

Species/Year	March		July	
	N	CI	*N*	CI
Unidentified puffin (*Fratercula* sp.)				
1972	0	0	0	0
1973	0	0		
1989			106	134
1990	0	0	0	0
1991	0	0	38	63
1993	0	0	342	386
Total puffins (*Fratercula* spp.)				
1972	0	0	13,176	5,799
1973	0	0		
1989			4,244	2,217
1990	0	0	5,071	1,960
1991	104	144	6,378	2,219
1993	0	0	5,954	2,360
Unidentified alcid				
1972	0	0	0	0
1973	0	0		
1989			0	0
1990	251	412	619	324
1991	621	438	1,584	1,050
1993	468	382	205	160
Kingfishers				
Belted kingfisher (*Ceryle alcyon*)				
1972	0	0	0	0
1973	9	17		
1989			21	16
1990	12	15	10	10
1991	0	0	12	12
1993	32	26	64	41

Appendix A (continued).

Species/Year	March		July	
	N	CI	*N*	CI
Passerines				
Black-billed magpie (*Pica pica*)				
1972	141	151	12	22
1973	123	92		
1989			0	0
1990	88	80	50	33
1991	52	51	43	29
1993	101	54	29	22
Northwestern crow (*Corvus caurinus*)				
1972	7,283	3,470	2,074	1,029
1973	8,887	5,553		
1989			1,479	609
1990	3,041	1,881	1,638	523
1991	3,325	1,607	2,061	607
1993	2,905	1,223	1,944	603
Common raven (*Corvus corax*)				
1972	98	100	79	87
1973	52	40		
1989			121	190
1990	178	179	157	148
1991	302	278	62	80
1993	451	322	79	41
Unidentified bird				
1972	1,025	767	0	0
1973	0	0		
1989			2,056	977
1990	1,293	1,206	871	476
1991	2,288	2,360	281	224
1993	1,182	770	204	193

Appendix A (continued).

Species/Year	March		July	
	N	CI	*N*	CI
Total marine birds				
1972	235,579	63,480	628,696	141,858
1973	328,091	56,955		
1989			302,538	54,444
1990	141,911	22,902	237,900	32,570
1991	171,433	30,868	343,357	98,670
1993	402,760	167,697	371,327	58,189

Appendix B. Estimated numbers of marine mammals (*N*), with 95% CI, of species observed in Prince William Sound during March and July 1972-73 (Haddock et al., unpubl. data), 1989-91 (Klosiewski and Laing 1994), and 1993. Surveys were not conducted in July 1973 or March 1989.

Species/Year	March		July	
	N	CI	*N*	CI
Cetaceans				
Harbor porpoise (*Phocoena phocoena*)				
1972	395	454	939	693
1973	818	2,074		
1989			0	0
1990	197	364	0	0
1991	155	257	112	191
1993	372	312	789	609
Dall's porpoise (*Phocoenoides dalli*)				
1972	2,356	3,054	5,782	2,567
1973	9,467	6,110		
1989			153	154
1990	1,330	1,286	1,012	1,009
1991	0	0	482	299
1993	1,394	1,680	435	503
Killer whale (*Orcinus orca*)				
1972	243	352	101	187
1973	0	0		
1989			0	0
1990	0	0	0	0
1991	0	0	36	45
1993	16	29	37	62
Unidentified porpoise				
1972	1,052	867	1,207	963
1973	1,522	6,214		
1989			0	0
1990	41	69	39	48
1991	0	0	40	62
1993	0	0	224	249

Appendix B (continued).

Species/Year	March		July	
	N	CI	*N*	CI
Minke whale (*Balaenoptera acutorostrata*)				
1972	0	0	7	16
1973	0	0		
1989			0	0
1990	0	0	0	0
1991	0	0	39	48
1993	0	0	0	0
Humpback whale (*Megaptera novaeangliae*)				
1972	0	0	188	281
1973	0	0		
1989			0	0
1990	0	0	0	0
1991	0	0	0	0
1993	0	0	225	170
Unidentified whale				
1972	0	0	125	245
1973	106	132		
1989			62	106
1990	0	0	78	96
1991	0	0	0	0
1993	0	0	0	0
Otters				
Sea otter (*Enhydra lutris*)				
1972	2,561	1,158	8,868	8,268
1973	2,979	1,997		
1989			8,238	2,056
1990	5,968	1,682	6,648	3,159
1991	4,413	989	6,634	1,878
1993	6,813	1,861	8,216	2,435

Appendix B (continued).

Species/Year	March		July	
	N	CI	*N*	CI
River otter (*Lutra canadensis*)				
1972	0	0	0	0
1973	0	0		
1989			9	16
1990	75	53	15	15
1991	0	0	23	24
1993	0	0	77	47
Unidentified otter				
1972	41	45	0	0
1973	0	0		
1989			0	0
1990	6	12	3	5
1991	0	0	0	0
1993	0	0	4	8
Sea Lions				
Steller sea lion (*Eumetopias jubatus*)				
1972	2,518	1,599	80	96
1973	6,733	7,419		
1989			2,358	2,366
1990	6,261	10,051	3,702	3,066
1991	3,795	4,600	2,312	2,364
1993	3,260	3,694	1,000	796
Unidentified pinniped				
1972	0	0	0	0
1973	0	0		
1989			0	0
1990	0	0	0	0
1991	12	23	0	0
1993	0	0	0	0

Appendix B (continued).

Species/Year	March		July	
	N	CI	*N*	CI
Seals				
Harbor seal (*Phoca vitulina*)				
1972	5,585	2,820	16,204	12,449
1973	4,239	2,016		
1989			2,428	870
1990	1,832	779	2,666	2,807
1991	911	452	1,583	491
1993	1,513	1,313	16,920	26,784