Exxon Valdez Oil Spill State/Federal Natural Resource Damage Assessment
Annual Report

Assessment of Injury to Glaucous-Winged Gulls Using Prince William Sound

Bird Study Number 10
Annual Report

This annual report has been prepared for peer review as part of the *Exxon Valdez* Oil Spill Trustee Council restoration program for the purpose of assessing project progress. Peer review comments have not been addressed in this annual report.

Samuel M. Patten

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Study History: Bird Study Study Number 10 was initiated as part of a detailed study plan in 1989. The study was designed to assist in assessment of injury to waterbirds under the Comprehensive Environmental Response, Compensation and Liability Act (CERCLA) (42 USC 9601 et seq.). The study was consistent with Type B assessment regulations concerning the physiological malfunction category of reduced avian reproduction as defined in 43 CFR 11.62 (f)(3)(r)(B).

Abstract: Glaucous-winged gulls (*Larus glaucescens*) are among the most numerous birds in Prince William Sound (PWS). During early phases of the *Exxon Valdez* oil spill (EVOS), a high percentage of glaucous-winged gulls observed in PWS were oiled. Existing literature indicates that small amounts of ingested crude oil inhibit gull chick growth and affect osmoregulation, hepatic, and adrenal gland activity. Oil transfer from adult breast feathers to eggs may cause embryo mortality and a significant decline in population productivity. Previous research has verified that most of the glaucous-winged gulls frequenting PWS originate from Egg Island, the world's largest colony. Our initial objectives were to replicate prior studies on the glaucous-winged gull on Egg Island to determine if EVOS injured the population or its long-term reproductive viability. Data was collected on numbers of breeding pairs, nest density, clutch size, and hatching and fledging success on Egg Island in 1989. No significant evidence of a decline in glaucous-winged gull reproductive success on Egg Island was found as a result of EVOS. Winds and current patterns deflected the spill away from the immediate vicinity of Egg Island; at the time most gulls breeding on Egg Island were defending territories on site, escaping immediate impact.

Key Words: Crude oil, damage assessment, Egg Island, *Exxon Valdez* oil spill, glaucous-winged gulls, *Larus glaucescens*, oiled birds, Prince William Sound, reproduction.

Project Data: there are no available data beyond that summarized in the report.

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TABLE OF CONTENTS

LIST OF TABLES

Page

LIST OF FIGURES

II. EXECUTIVE SUMMARY

Glaucous-winged Gulls (Larus glaucescens) are among the most numerous birds in Prince William Sound. Approximately 50,000 Glaucous-winged Gulls use Prince William Sound in the summer, and lesser numbers are present the year round (Isleib and Kessel, 1973; Sowls, Hatch and Lensink, 1978). They survive primarily by scavenging and foraging in littoral and intertidal areas (Patten and Patten, 1976). During early phases of the Exxon Valdez Oil Spill (EVOS), a high percentage of Glaucous-winged Gulls observed in Prince William Sound (PWS) were oiled. Existing literature indicates that small amounts of ingested crude oil inhibit gull chick growth and affect osmoregulation (salt gland), hepatic, and adrenal gland activity (Butler and Lukasiewicz, 1979; Peakall et al, 1982). Existing literature also demonstrates that minute quantities of (LD50=50 microns) of North Slope crude oil are toxic to gull egg embryos (Patten and Patten, 1977, 1979). Transfer of oil from adult gull breast feathers to eggs may cause embryo mortality (King and Lefever, 1979) and a significant decline in population productivity (Samuels and Ladino, 1984).

Previous research has verified that most of the Glaucous-winged Gulls frequenting PWS originate from Egg Island 20 km south of Cordova, and smaller colonies such as Perry Island within PWS (Patten and Patten, 1976, 1979; Sowls, Hatch and Lensink, 1978). Egg Island, located about 25 km southeast from the nearest part of Prince William Sound, forms a sandbar barrier island off the Copper River Delta. Egg Island is the largest Glaucous-winged Gull colony in the world, with 10,000 breeding pairs (Patten and Patten, 1975, 1976, 1977, 1979) (Patten 1980).

Initial objectives of this project were to replicate prior studies on the Glaucous-winged Gulls on Egg Island to determine if the EVOS injured the population or its long-term reproductive viability (Samuels and Ladino, 1984). The study was designed to assist in assessment of injury to waterbirds under the Comprehensive Environmental Response, Compensation and Liability Act (42 USC 9601 et seq.). The study was consistent with Type B assessment regulations concerning the physiological malfunction category of reduced avian reproduction as defined in 43 CFR 11.62(f)(3)(r)(B).

The Principal Investigator collected data on numbers of breeding pairs, nest density, clutch size, hatching success, and fledging success on Egg Island in 1989, using identical methods as in prior studies on Egg Island and other sites in southern Alaska (Patten, 1974; Patten and Patten, 1975, 1976, 1979; Patten, 1980).

There was no significant evidence of a decline in Glaucous-winged Gull reproductive success on Egg Island in 1989 as a result of the EVOS. Winds and current patterns deflected the oil spill away from the immediate vicinity of Egg Island. At the time of the oil spill we now believe most gulls breeding on Egg Island were defending

territories on site, and therefore escaped immediate impact.

III. OBJECTIVES

A. To test the hypothesis that the total number of breeding Glaucous-winged Gulls pairs and nests in the Egg Island colony following the Exxon Valdez oil spill is not significantly different from historical data.

B. To test the hypothesis that reproductive success for Glaucous-winged Gulls at Egg Island is not significantly different from prior years.

C. To test the hypothesis that the mean distance to nearest neighboring nest (a density measurement) in the Egg Island colony following the Exxon Valdez oil spill is not significantly different from previous such measurements.

D. To determine causes of egg hatching failure by direct observation and contaminant analysis and compare to previous data from Egg Island and other gull colonies in southern Alaska.

E. To determine chick mortality rates and those portions attributable to oil contamination by comparison with prior results from Egg Island and other colonies.

F. To determine losses in productivity attributable to oil by comparing pre- and post-spill productivity indices as measured in chicks fledged per nest.

G. To determine locations and causes of mortality of banded recently fledged juveniles and compare to prior returns.

H. Identify potential alternative methods and strategies for restoration of lost use, populations, or habitat where injury is identified.

IV. STUDY METHODOLOGY

A. Sampling Methods

The 1989 study replicated prior studies (1975-76) of Glaucous-winged Gulls at Egg Island. Identical methods were used to the extent possible. The methods used in gathering data on breeding biology in the 1989 season, following the EVOS, are described below. Results have been compared to earlier studies on Egg Island and other sites in southern Alaska 1972-1977 (Patten, 1974; Patten and Patten 1975, 1976, 1977, 1979; (Patten,1980). Reproductive data on Egg Island gulls in 1975-76 was collected in a study area at the east end of the island. The study area was located on grassy dunes southwest of Egg Island Light. The 1989 study resumed in the identical area.

Parameters measured in 1989 included: breeding chronology, distance to nearest neighboring nest, clutch size, hatching success (percent of eggs laid that hatch); fledging success (percent of hatched chicks that fledge); and breeding success (percent of eggs laid that fledge).

All nests under study were marked with survey stakes at the beginning of the investigation in early June 1989. Each heavy wire survey stake had a numbered bright vinyl flag attached. A fiberglass meter tape was used to find the direct distance from every study nest to the center of the nearest neighboring nest. As part of each sequential visit through the gull colony, numbers of eggs and chicks from each nest site inspected were recorded in weatherproof field notebooks. Visits at Egg Island averaged once every three days during incubation, and once every three days during the chick stage. Young chicks were counted in the nest upon hatching. Older chicks were banded with USFWS 7A aluminum bands and an additional 2.5 cm lynply band with engraved codes in black alphanumeric characters on the opposite leg. Chicks were not banded until nearly fledged in order to reduce disturbance in the study area. At the end of the survey period, counts were made of fledged, banded chicks for the entire study area. As many chicks as possible were banded outside the main study area. Factors influencing hatching and fledging success on Egg Island and other sites in southern Alaskan Larus colonies have been analyzed in detail in a previous series of publications (Patten, 1974; Patten and Patten, 1975, 1976, 1977, 1979; Patten, 1980).

V. STUDY RESULTS

A. Study Area and Population Studied: distribution and abundance of Glaucous-winged Gulls in Prince William Sound before the Exxon Valdez Oil Spill of March 24, 1989.

An estimated 50,000 Glaucous-winged Gulls use Prince William Sound, including breeding adults from Egg Island, first, second and third year immatures, and non-breeding adults (Isleib and Kessel, 1973, Sowls, Hatch and Lensink, 1978). Much lower numbers of the closely related Herring Gull (Larus argentatus), which breed on interior Alaskan lakes and rivers, also use Prince William Sound in fall, winter, and spring. Glaucous-winged and Herring Gulls first breed at age four. The 50,000+ gulls were potentially exposed to crude oil at time of the Exxon Valdez Spill. Three age classes of immature gulls join non-breeding adults, and breeding adult gulls from Egg Island foraging in Prince William Sound. These gulls, in conjunction with low numbers of individuals from scattered smaller colonies in Prince William Sound, form the Glaucous-winged Gull population utilizing Prince William Sound. Ratios of the various gull age classes change, however, with the seasons. Band returns indicate a large number of recently fledged juveniles enter Prince William Sound from Egg Island in August. These birds feed on spawning salmon before a substantial portion of the population migrates south to the Puget Sound area in October, returning again in March. Tons of spawning herring roe in intertidal zones of Prince William Sound annually attract thousands of foraging gulls in April and May (Norton et al., 1990). By late March, however, most adult gulls breeding on Egg Island are defending territories on site, south of Cordova, outside Prince William Sound. Thus we believe most of the breeding adult gulls on Egg Island escaped contact with the oil spill. This is a function of the territorial behavior of the breeding adult gulls on Egg Island, and the trajactory of the oil spill, which flowed west and then southwest across Prince William Sound, along the Kenai Peninsula, inside Kodiak Island, and out the Alaska Peninsula.

Glaucous-winged Gulls are opportunistic scavengers and predators, taking a wide variety of invertebrates and fishes. They feed in the intertidal and by plunge-diving near the water surface. At the time of the oil spill (March, April and May 1989) a large proportion of the Glaucous-winged Gulls observed in Prince William Sound were oiled, principally on upper breast feathers (Lowry, pers. comm.). Complete immersion in oil would probably lead to rapid mortality from hypothermia, but oil on upper breast feathers of the gulls is probably the result of exposure in the intertidal zones. Observers reported thousands of many species of birds dead on the rocky beaches of Prince William Sound. The dead birds were rapidly scavenged, with typically only sternum, clavicle, and humeri remaining. This pattern of skeletal remains is characteristic of gull scavenging, and the Glaucous-winged Gull is an important scavenger in PWS.

It is highly likely that a proportion of the gulls in Prince William Sound was exposed by direct external contact with intertidal oil, and internally by consumption of oiled vertebrate and invertebrate prey. The study reported here was designed in April 1989 as an analysis of oil effects on gull reproductive parameters on Egg Island because of the availability of baseline information from the site during 1975-76 NOAA-OCS baseline studies.

Although the trajectory the oil would follow was unknown at the time the study was planned, wind and current patterns deflected the Exxon Valdez Oil Spill from Bligh Reef to western and southwestern Prince William Sound, away from Egg Island and the Copper River Delta. The oil spill flowed along the Kenai Peninsula, impacting Kodiak Island and the Alaska Peninsula as well.

Egg Island lies of the south coast of Alaska 20 km S of Cordova and 25 km SE of Prince William Sound (Figure 1). Prior to the 1964 earthquake, Egg Island was a series of sand dunes and bars, but since the earthquake the sandbars and dunes have coalesced and built up one basic island, with a large increase in surface area undergoing colonization by the beach rye grass Elymus (Figure 2). Egg Island currently extends for 10 km along a series of dunes arranged on an east-west axis. Egg Island supports the largest known Glaucous-winged Gull colony, an estimated 10,000 nesting pairs. These birds forage in inlets and shoals of the Copper River Delta, around Cordova, and in Prince William Sound.

This study began in early June 1989. The Egg Island study site, located in section number 27 on the seaward slope of grassy dunes SW of Egg Island Light, contained 134 nests in 1989 (Figure 2). The study site was shaped as rough parallelogram two hundred meters on a side. The eastern border of the study site was determined by Egg Island Channel, the western border was determined by a large alder bush, the north side by the crest of the main dunes, and the south side by the cessation of Elymus cover on the sandy substrate. The northern border of the study site, on the crest of the main dunes, was characterized by the USGS VABM "Nest" survey marker. The study site was in the same location as in the previous ('75-'76) investigations. The eastern side of the island is, however, being eroded by Egg Island Channel, which is cutting into the study area.

Comparative study areas for other Larus colonies investigated by the PI in southern Alaska are included in Table 1.

B. Evidence of Injury Found. Results presented in this report focus on the main features of gull reproductive success on Egg Island in 1989, including clutch size, hatching failure, chick mortality, and fledging success.

1. Clutch size. Clutch size is one of the important parameters determining the reproductive success of gulls. The seriousness of hatching failure, or chick loss, is partially determined by the clutch size. Reproduction can be maintained if the mean clutch size is sufficiently high before predation or other egg loss. A gull population with a higher mean clutch size can support a greater rate of hatching failure or chick loss than a population with a lower mean clutch size.

Clutch size, number of nests examined, and number of fledglings per nest in Larus colonies in southern Alaska are presented in Table 2. The Egg Island study site in 1989 contained 134 nests, with a mean 2.54 eggs per nest. This is essentially identical to the clutch size of 2.56 recorded on Egg Island in 1976. This figure falls well within the normal range of clutch sizes reported in other studies of Larus gulls. Clutch size in other Larus colonies in southern Alaska ranged from a high of 3.0 eggs per nest in a small colony on an island in Glacier Bay in 1973 to 2.05 eggs per nest recorded in the Egg Island study area in 1975 (Table 2).

2. Hatching Failure. Hatching failure in southern Alaskan gull colonies can be attributed to three general factors, using Paynter's (1949) formulation: (1) eggs disappearing (lost) from the nest during incubation; (2) eggs remaining in nests but not hatching (dying); and (3) eggs which pip but the chick dies before emerging. Lost eggs are considered hatching failures because almost all egg loss was due to predation in which the eggs were destroyed. Petroleum related effects to eggs are most expected in classification (2).

"Lost," Inviable, and Pipped Eggs failing to hatch in Larus colonies in southern Alaska (1972 - 1977 and 1989) are presented in Table 3. Note that inviable eggs in the Egg Island study site in 1989 amounted to 2.6%. Eggs which pipped but failed to hatch amounted to less than 1%. Both of these 1989 percentages are within the historical normal range for Alaskan gulls. The percentage of "lost" (predated) eggs is however relatively high (48.7%), but this factor is not believed related to petroleum exposure (Table 3).

Previous experiments conducted by the PI on Egg Island and on Middleton Island in the Gulf of Alaska indicated an LD50 (50% mortality) with 50 microns of unweathered North Slope Crude Oil applied to gull egg surfaces at early stages of incubation (Patten and Patten, 1979). Eggs failing to hatch because of experimental petroleum exposure were continuously brooded by adults which did not renest during the season.

3. Chick Mortality. Chick mortality in southern Alaskan gull colonies was divided into two classifications: chicks which were observed dead, and chicks which disappeared, were not counted as fledged, and which were presumed dead.

Hatching success, chick mortality, and fledging success in Larus colonies in southern Alaska (1972 - 1977 and 1989) are presented in Table 4. Hatching success ranged from 67% to 93% in previous Alaskan gull studies conducted by the PI. Hatching success in the Egg Island study area in 1989 was a relatively low 54% (Table 4). This figure is inversely related to the high rate of egg loss through predation recorded on Egg Island in 1989 and is not a petroleum-related effect. Observed chick mortality in other gull studies conducted by the PI in southern Alaska was low, ranging from 3% to 12% (Table 4). Observed chick mortality in the Egg Island study site in 1989 was 6%, within the normal historical range (3% to 12%). Chicks which disappeared, were not recorded as fledged, and which were presumed mortalities ranged from 2% to 49% in the PI's previous studies. The moderate level of 25% chick disappearance recorded on Egg Island in 1989 resembles the 26% recorded on Egg Island in 1975 and the 31% recorded in 1976 (Table 4).

4. Fledging Success. Fledging success in this and other gull studies is computed by dividing the number of fledged, banded chicks in the study area by the number of nests examined. The fledging success, as measured in chicks produced per nest, depends upon the clutch size and hatching success as well as chick mortality. A comparison of mean clutch size and fledging success in Larus colonies in southern Alaska is presented in Table 5. The summary comparison of the mean clutch size and number of fledglings produced per nest provides the clearest picture of reproductive success in Larus colonies in southern Alaska. Both the mean clutch size (2.54 eggs per nest) and the mean number of fledglings per nest (1.03 chicks fledged per nest) recorded on Egg Island in 1989 fall within the normal range of the PI's previous studies and essentially replicate prior results from Egg Island 1975-76. The 1989 Egg Island fledging success is compared to other studies in the literature (Table 6). This comparison also indicates that the productivity index for Egg Island in 1989, as well as in 1975-76, is at the low end of the normal range for other studies in the literature.

B. Evidence that the injury found was caused by the Exxon Valdez Oil Spill.

Year	no. fledglings	no. nests	fledglings/nests
1975	157	153	1.0261
1976	208	186	1.1183
1989	138	134	1.0299

Treating the 1975 and 1976 data as coming from the same population we can construct a 95% lower confidence limit and determine if the 1989 data is within the limit or below it. If the 1989 data is below the 95% lower confidence limit, we can conclude that a significant reduction in Glaucous-winged Gull productivity on Egg Island has occurred, at alpha=0.05. The mean and standard error of the 1975 and 1976 data are 1.0722 and 0.0461, respectively. Assuming a normal distribution, the 95% lower limit is 1.0722 - 1.645x0.0461 = 0.9964. Since the observed 1989 datum (1.0299) is greater that the 95% lower confidence limit, we conclude that there is no significant evidence of a decline in Glaucous-winged Gull reproductive success on Egg Island in 1989 as a result of the EVOS.

C. Type of potential injury remaining uninvestigated.

Locations and causes of mortality of Egg Island gulls can be determined from previous band returns (11,212 gulls banded 1975-1978). Although band returns from Egg Island gulls have continued to accumulate for a decade, data since 1979 remains unanalyzed. Earlier results can be compared to returns of gulls banded in 1989. Approximately 850 nearly fledged chicks were banded on Egg Island in late July and 150 chicks were banded on Perry Island in early August 1989 (Objective G). Analysis of banding data is incomplete because of termination of the project as of February 1990 and banding results will not be presented in this report. Previous band returns from Egg Island indicated that post-fledging juveniles rapidly disperse to Prince William Sound in August. If substantial mortality occurred to recently-fledged juveniles, second or third-year immatures, or non-breeding adults in Prince William Sound, the possibility exists for cohort or age-class weaknesses in the population structure of Glaucous-winged Gulls using Prince William Sound. These features of the population structure will not become apparent for another three to four years, since gulls first breed at age four.

VI. Status of Injury Assessment

This study was conducted using procedures employed by the PI to measure gull productivity in Alaska since 1972. The results of the 1989 study of the reproductive productivity of Glaucous-winged Gulls on Egg Island, from the aspect of experimental design, indicated the colony exhibited parameters of an unexposed control site (Objectives B,F) as far as oil spill damage assessment was concerned. This was not known at the time the study was planned in April 1989. Winds and current patterns deflected the oil spill southwest from Bligh Reef, through western Prince William Sound, and away from the immediate vicinity of Egg Island. Although many other gulls in Prince William Sound were impacted by the oil spill, at the time of the oil spill we now believe most gulls breeding on Egg Island were defending territories on site, and therefore escaped immediate impact. Because no immediate oil injury to gull reproduction on Egg Island in 1989 was apparent, this study was terminanted in February 1990.

The assessment of injury to Glaucous-winged Gulls using Prince William Sound was therefore incomplete. Assessment in a complete experimental design should have included a study of reproductive productivity in the exposed colony on Perry Island, located in the oil-impacted area of northwestern Prince William Sound. Approximately 150 gull chicks were banded on Perry Island in 1989, but other aspects of gull reproductive productivity were not addessed because the study design focused on Egg Island. Observers reported the Glaucous-winged Gull colony on Perry Island declined by approximately 50% in 1990 (Weaverling, pers. comm.).

It was also recommended that an additional colony site inhabited by Herring Gulls wintering in and migrating through Prince William Sound be investigated. Band returns from the PI's previous research indicate these gulls concentrate in northern Prince William Sound in spring and fall and may have been substantially impacted by the EVOS. The USFWS confirmed these observations and seconded the concerns (Nysewander, pers. comm.). The readily accessed gull colony at Lake Louise, located immediately north of Prince William Sound, was investigated by the PI as part of dissertation and NOAA-OCS sponsored research in the 1970's. Comparative baseline data from thje 1970's and early 1980's was available, although the work was not carried out after the oil spill because funding was directed elsewhere.

A photocensus of the Egg Island colony was not completed (Objective A). Density measurements from the Egg Island study site remained unanalyzed (Objective C). Contaminant analysis of eggs, chicks, and adults was not completed (Objectives D,E). Objective G was not addressed, nor was Objective H.

Recommended study plans for the 1990 field season were to include:

1) analysis of the reproductive productivity in the colony at Perry Island, in the heavily exposed area of northwestern Prince William Sound;
2) comparison to the 1990 productivity at Egg Island, serving as the unexposed control;
3) investigation of the colony at Lake Louise, north of Prince William Sound, inhabited by gulls migrating through and wintering in Prince William Sound.

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