BLM - WASH D.C.

Research Unit # 96 - 76

EVOLUTION, PATHOBIOLOGY AND BREEDING ECOLOGY OF THE GULF OF ALASKA HERRING GULL GROUP

(*Larus argentatus* x *Larus glaucescens*)

FINAL REPORT

by

Samuel M. Patten, Jr., M. Sc.
Associate Investigator
Department of Pathobiology

The Johns Hopkins University

Linda Renee Patten
Research Technician
Department of Pathobiology

The Johns Hopkins University

An analysis of the 1975 & 1976 and previous field seasons presented as a final report to the

U.S. Department of Commerce
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and

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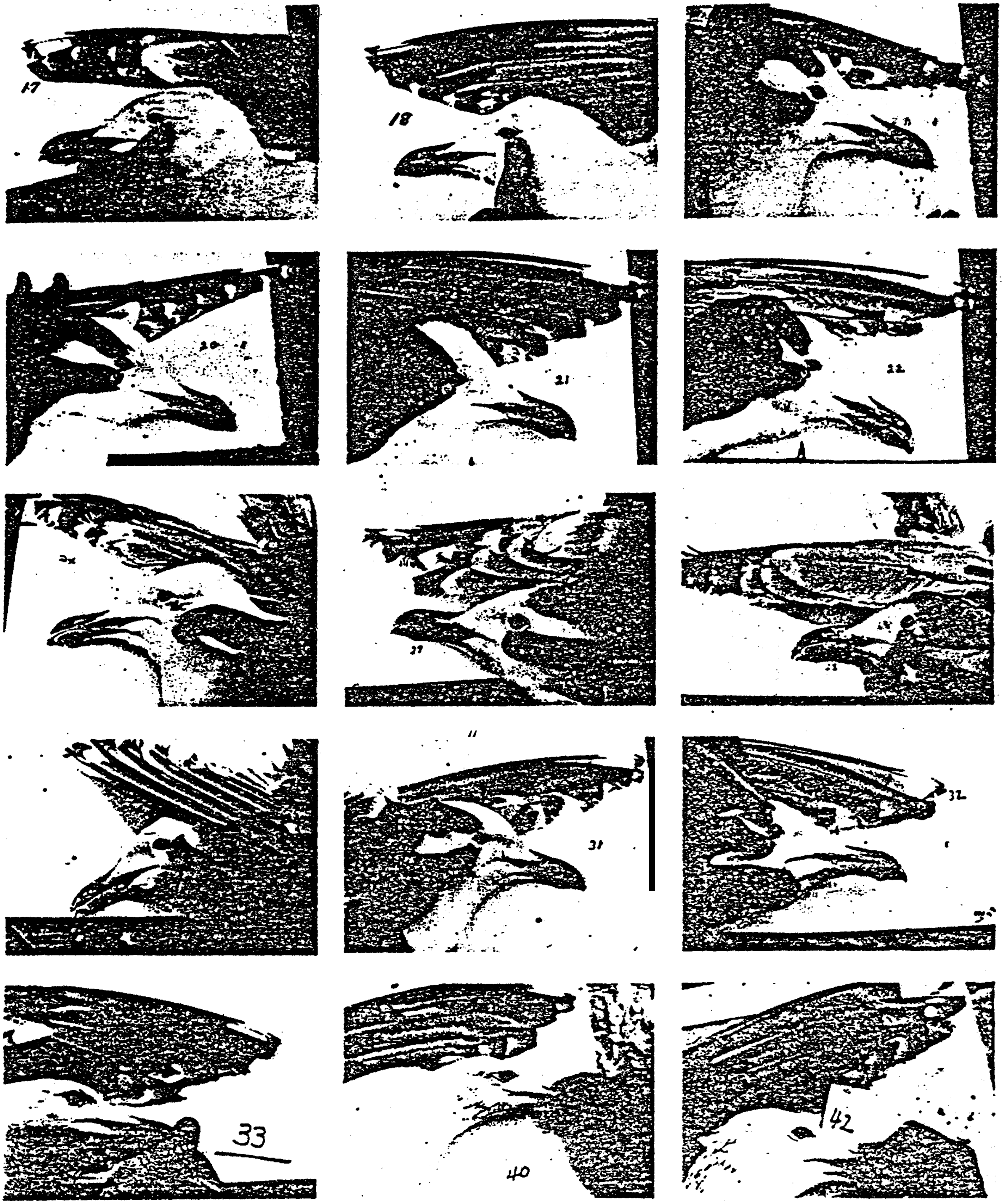
U.S. Department of Interior
Bureau of Land Management

as part of the

Environmental Assessment of the Alaskan Continental Shelf



Frontispiece

Sympatric Gulls from Dry Bay, mouth of the Alsek River

17, 18, 23: yellow-eyed black- primaries Herring Gulls
20, 21, 22: dark-eyed gulls with varying amounts of melanin in primaries
24, 27, 28: dark-eyed gulls with black primaries
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SUMMARY OF OBJECTIVES, CONCLUSIONS AND IMPLICATIONS WITH RESPECT TO OCS OIL AND GAS DEVELOPMENT IN THE NORTHERN GULF OF ALASKA:

This final report of Research Unit # 96 - 76 is addressed to the following tasks:

TASKA-4 -- Summarize and evaluate existing literature and unpublished data on the distributions abundance, behavior, and food dependencies of marine birds.

TASKA-5 -- Determine the seasonal density, distribution, critical habitats, migratory routes, and breeding locales for the principal marine bird species in the study area. Identify critical species particularly in regard to possible effects of oil and gas development.

TASK A-6 — Describe dynamics and trophic relationships of selected species at offshore and coastal study sites.

TASK A-28 — Determine by field and laboratory studies the incidence of diseases presently existing in fish, shellfish, birds, and mammals for use in evaluating future impacts of petroleum-related activity.

This report provides information on the evolution, breeding ecology and disease aspects of the Gulf of Alaska Herring Gull group (*Larus argentatus* x *Larus glaucescens*).

D. There are six known large gull colonies along the northeast Gulf of Alaska between Cordova and Juneau, in an area soon to be impacted by the development of oil resources. These colonies are located at Egg Island, Copper Sands, Strawberry Reef, Haenke Island, Dry Bay and North Marble Island. There is little information known about these colonies prior to this investigation. The goal of this study has been to assess the reproductive health of these gull populations. Reproductive indices are now available for two of these colonies, Egg Island and North Marble Island. (Egg Island: 1.08 chicks produced per nest per year; North Marble Island: 1.77 chicks produced per nest per year.)

This information indicates these populations have the potential for rapid increase with access to human garbage, sewage and refuse associated with increased oil operations, but their colonies are sensitive to disturbance during the breeding season. Gulls are associated with canneries, fish-packing houses, garbage dumps, sewer outfalls and municipal water supplies along the coast of Alaska, and are clearly implicated with human bacterial and parasitic diseases in Alaska.

As the availability of human generated refuse increases with the development of oil resources in the Gulf of Alaska, populations of gulls previously more isolated may come into closer contact with one another. The gene flow between gull populations in the Gulf of Alaska may be further increased in coming years as a secondary influence of human activities which may lead to a new adaptive peak in this commensal bird species, with consequences for municipal health and sanitation.

INTRODUCTION

The Larinae (gulls) have a world-wide distribution with 42 species. Gulls as a group may have evolved in the North Pacific and North Atlantic (Fisher & Lockley, 1954). Sixteen species of gulls are found in the North Pacific (Vermeer, 1970). Birds of this family have been considered chiefly inshore feeders, and most coasts support a smaller scavenging species and a larger more piratical type (Cody, 1973). Recent evidence indicates that large white-headed gulls can behave as essentially marine species, feeding far out at sea and coming to land only occasionally or to breed (Sanger, Isleib & Kessel, 1973; Barrington, 1975; Lensink, pers. comm.). Most gulls live in flocks; they forage together in characteristic patterns the year around and nest in colonies during the breeding season (Tinbergen, 1960). These gregarious birds nest in a wide variety of habitats ranging from vertical cliffs to open marshes (Smith, 1966a). Gulls lend themselves to population analysis, especially productivity, because of their colonial breeding tendency (Kadlec & Drury, 1968).

An important reason for studying gulls is their use as indicators of the health of the environment (Vermeer, 1970). Chemical pollution of the environment poses an increasing and immediate threat to all organisms including man. A recent survey conducted by the U.S. Fish & Wildlife Service of chemical residues in marine avifauna showed gulls to be among the most contaminated birds examined, probably due to their feeding habits (Ohlendorf, pers. comm.). Since gulls nest in colonies, changes in breeding populations can be monitored and related to environmental conditions, among which are industrial development and the concurrent changes in food supply.

An additional reason for studying gulls is that the age structure, mortality rate, life expectancy and survival rates of gull populations aid in the general understanding of population mechanisms. The mere knowledge of the size of a population from year to year indicates little about population. problems without such data (Paynter, 1949).

The size, age structure, growth or decline of a population are a result of fluctuations in time and space of natality and mortality, in addition to movement into or out of a population of a species. Breeding adults form the base of the population structure ~~structure,~~ because only by successful production of young can a population grow or maintain itself (Kadlec & Drury, 1968).

Reproductive rate has an important effect on age structure and growth of the population. The average number of young which a breeding pair can raise to fledging is a good measure of gull reproductive success, Meadow-nesting gulls are excellent subjects for a study of reproductive success because eggs and young are readily accessible. Information is available on breeding biology and dynamics of gulls near large urban centers or in recent post-glacial environments, but comparative base-line data on gulls along the southern coastline of Alaska prior to the development of oil resources is completely lacking.

This report presents results of a study of meadow-nesting gulls in widely-spaced colonies in the northeast Gulf of Alaska. These sites have been selected for research because of the incipient development of oil resources in the vicinity and the necessity to provide base-line information on marine birds along this relatively wild stretch of Alaskan coastline.

The overall objective of this study has been an investigation of the reproductive biology of the "brown rat with wings" to answer the key question of reproductive rate and the factors which influence it prior to the development of oil resources, Reproductive rate in gulls can be measured in chicks produced per nest per year. We have studied colony sites, behavior of adults and young, and feeding areas. We gathered supporting information on distribution and pathologies which will become increasingly important and compared the data to our knowledge of other Alaskan gull populations. We banded a large number of gulls, and color-marked, collected and removed blood samples from others. We carried out a concentrated investigation of the breeding biology of *Larus glaucescens* on Egg Island near the mouth of the Copper River, in Chugach National Forest, near Cordova, Alaska, and surveyed other gull colonies on barrier islands off the Copper River Delta. We examined a mixed colony of *Larus argentatus* and *Larus glaucescens* at Dry Bay, mouth of the Alsek River, in Tongass National Forest near Yakutat, Alaska. Included in this report is information previously gathered on a *L. glaucescens* colony on Haenke Island at Disenchantment Bay (near Yakutat) and data from North Marble Island in Glacier Bay National Monument. (Fig. 1),

The Glaucous-winged Gull (*L. glaucescens*), which breeds along the coast from Washington State to the Aleutians, is quite closely related to the Herring Gull (*L. argentatus*), a common and widely distributed species. Herring Gulls make up a low proportion of the breeding gulls in the northeast Gulf of Alaska, but occur more commonly in winter and offshore. The Herring Gull replaces the Glaucous-winged Gull in interior Alaska, British Columbia, and the Yukon. The Glaucous-winged Gull is morphologically similar to the Herring Gull except that the black pigment on the tips of the primaries is replaced by a light grey usually matching the rest of the mantle. Conversely, the eye of the Glaucous-winged Gull is darker than that of the Herring Gull. These two gulls are considered separate species in the A.O.U. *Checklist of North American Birds* (1957), but the taxonomic and ecological relationships between the two have not been clearly defined. In some areas hybrids are common (Fig. 2a,b).

We gathered information on other species of plants and animals inhabiting coastal areas of the northeast Gulf of Alaska to support the main objectives of our study. This final report presents the results and analysis of data collected in 1975 and 1976 in addition to material from previous years of research.

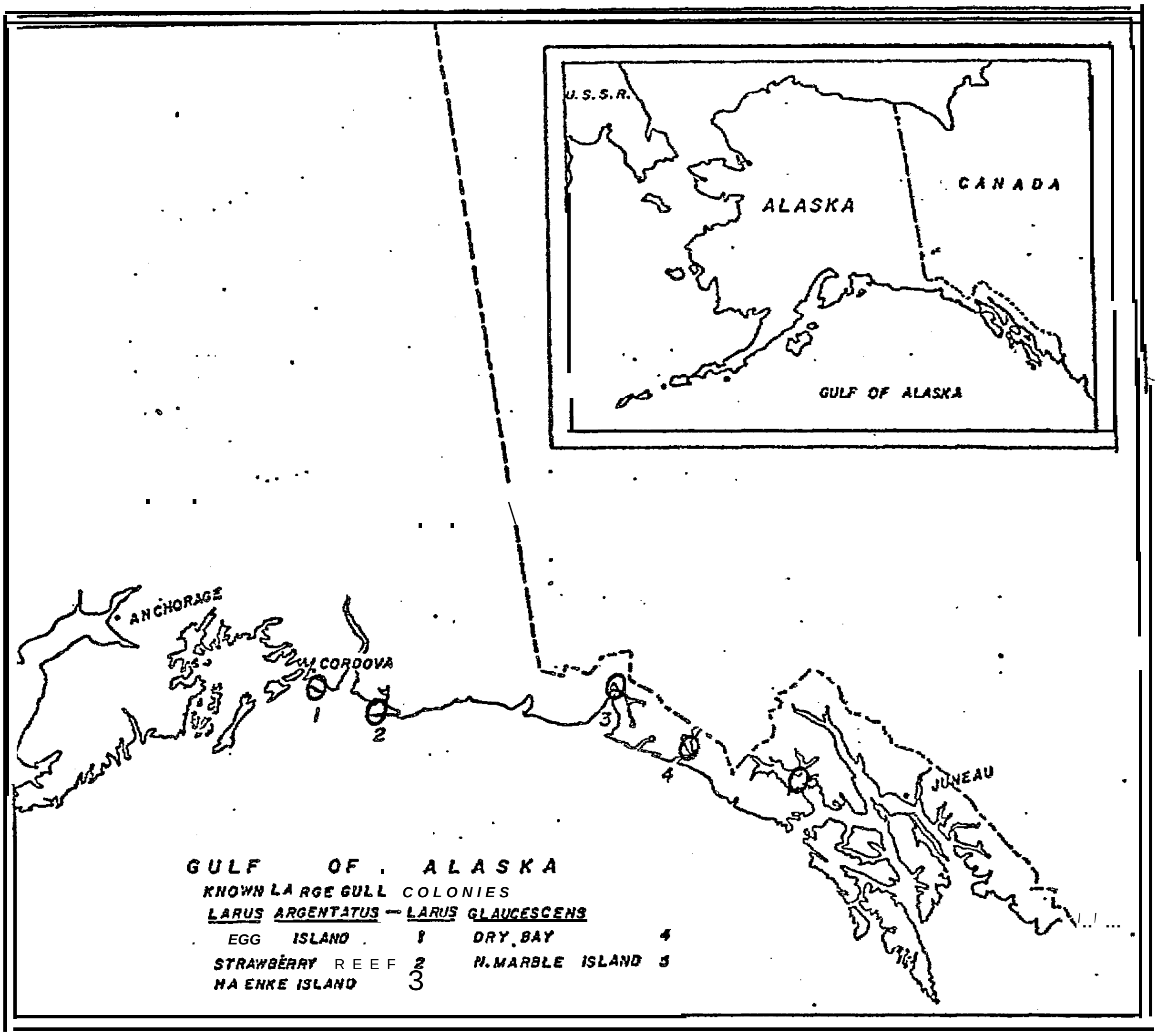


Figure **1.** **Map** of the northeast **Gulf** of Alaska, showing known **large gull** colonies of the <u>**Larus argentatus**</u> - <u>**Larus glaucescens**</u> **species group.** (Inset: map **of** Alaska and northwest Canada showing **Gulf** of Alaska.)

Oil lease areas are located offshore from colony (19 **and** between colonies **(2) and** (3). Tanker traffic **will** pass **all gull** colonies,

(a) (b)

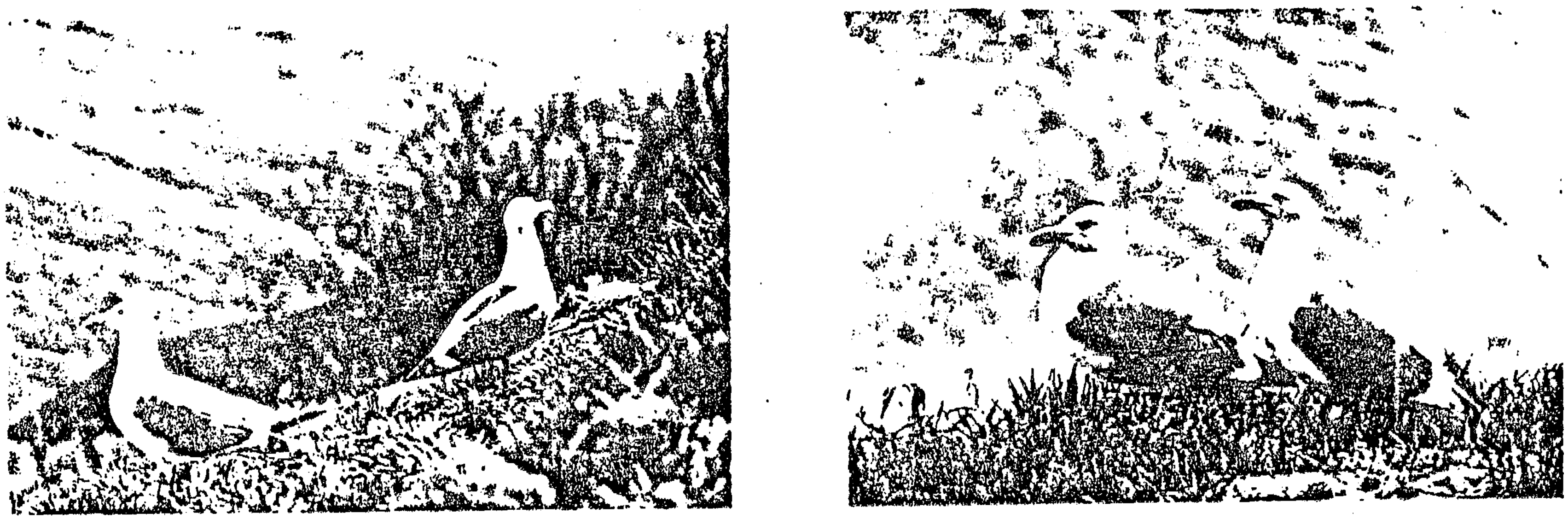


Figure 2. The overall objective of this study has been an investigation of gull breeding biology to answer the key question of reproductive rate prior to the development of oil resources in the northeast Gulf of Alaska. Study animals have been Herring and Glaucous-winged Gulls. Among the factors which influences reproductive rate is genetic composition of parents.
(a). Herring Gull paired with Glaucous-winged Gull, Southeast Colony, North Marble Island, 1973.
(b). Herring Gull paired with Glaucous-winged Gull, West Colony, North Marble Island, 1972.

SCOPE AND SIGNIFICANCE OF THE STUDY

The nature of this study has been to examine reproductive biology in colonies of Herring and Glaucous-winged Gulls in the northeast Gulf of Alaska. This report covers information from 1976 and earlier field seasons. We have studied several aspects of gull breeding biology for comparative purposes. Such information is available in the literature for gull population outside of Alaska and from Glacier Bay to the southeast of the current study area (see Lit. Cited section). The comparison serves as a basis from which to draw conclusions.

An important aspect of this report is the data on fledging success. " As can be seen from the literature review, fledging success can serve as an index to the dynamics of an avian population. If fledging success is poor over a number of seasons, a population will decline through adult mortality and low recruitment of breeding adults. If fledging success is high, one can expect a stable or expanding population. We -present here 1975 and 1976 fledging success from the largest gull colony in the northeast Gulf of Alaska. We offer supporting data from other colonies in the NEGOA.

Results from this study provide the National Oceanic and Atmospheric Administration and the Bureau of Land Management with specific information concerning the status of a marine-oriented animal population during two successive breeding seasons prior to the development of oil resources. More broadly, this report indicates additional areas to be investigated for a better understanding of an Alaskan marine bird species under environmental conditions certain to change with increasing human activity.

CURRENT STATE OF KNOWLEDGE

The breeding biology of gulls, especially the Herring Gull, has been studied in detail by Goethe (1937), Paludan (1951), Tinbergen (1960), Harris (1964) and Ludwig (1966). Their results consistently indicate that Herring Gulls raise an average of one young per pair per year to fledging. Extremes of variation are shown to be 0.5 by Paludan (1951) and 1.5 by . . Ludwig (1966) (in Kadlec and Drury, 1968). The population dynamics of the Herring Gull in eastern United States and Canada have been reasonably well investigated by Kadlec and Drury (1968). Kadlec and Drury (lot. cit.) found the usual productivity is apparently 0.8 to 1.4 young per nest in the New England Herring Gull, averaging about 50 percent fledging success. They showed this to be a major factor in the structure of the New England Herring Gull population, which has been rapidly increasing since the turn of the. century. In a later paper (Kadlec et al., 1969) they examined the critical period between hatching and fledging for mortality factors.

Their results indicate the average clutch size in the Herring Gull is nearly always three, and variations are small (Keith, 1966; Brown, 1967b; Paynter, 1949; Kadlec and Drury, 1968). Hatching success is usually 60 to 80 percent. Keith (1966) has discussed in detail the problems of accurately measuring success, which are due to predation or Cannibalism of eggs and chicks before they can be counted. Critical factors affecting hatching and fledging rate are chick and egg loss through cannibalism, chick mortality due to aggressive behavior of adults, and weather conditions during the breeding season (Paynter, 1949; Paludan, 1951; Tinbergen, 1960; Brown, 1967b).

In contrast to the intensive investigations of Herring Gulls in Europe and eastern North America, few workers have studied gulls along the Pacific Coast of North America. Breeding biology of the Western Gull (*Larus occidentalis*) has been studied by Coulter (1969), Schreiber (1970), Harpur (1971) and Coulter, et. al. (1971). Aspects of the ti.ceding biology are similar to those of the closely related Herring Gull, but nesting habitat selection and nest materials differ because of the drier conditions on California islands. Recently Hunt and Hunt (1973) and Hunt and McLoon (1975) have investigated supernormal clutches, aberrant pairing, and chick mortality in Western Gulls.

Vermeer (1963) published a major work on the breeding biology of the Glaucous-winged Gull, although Schultz (19.51) reported on growth in this species. In most aspects the Glaucous-winged Gull is similar to the Herring Gull, including plumage sequences (Schultz, ins).

Other important papers on gulls are those of Coulson and White (1956, 1958, 1959, 1960) on the Kittiwake (Rissa tridactyla), in which they attempt to refute Darling's (1938) contention that egg-laying synchrony in the Herring Gull and the Lesser Black-backed Gull was related to social facilitation. Darling's (1938) hypothesis of social stimulation suggests that stimulation received from other birds in a colony produced greater synchrony of egg-laying within the colony. This in turn resulted in earlier egg-dates and a shorter spread of egg-laying in large colonies. Coulson and White (1956), however, showed that the difference in breeding times between colonies of the Kittiwake was not significant and that the spread of egg-dates increased with the size of the colony. Coulson and White (1960) observed that the greater part of the differences in time of breeding were correlated with density. They found that the spread of breeding was greatest in dense colonies of Kittiwakes, which does not support Darlingts contention. Moreover, breeding occurred earlier in the more dense colonies. Hunt and Hunt (1975) have found in the Western Gull, which tends to nest on level ground, that territory size expands and agonistic interactions increase with the hatching of chicks.

Cúllen (1957) reported on adaptations of the Kittiwake to cliff-nesting, which was followed by N.G. Smith's (1966a) work on adaptation to cliff-nesting in arctic gulls (Larus), and his more extensive study (1966b) on evolution in arctic gulls. Smith found four sympatric species on Baffin Island to be reproductively isolated due to such mechanisms as species recognition and nesting habitat selection. Ingolfsson (1970) noted rapid evolution in Icelandic gulls (Larus argentatus and Larus hyperboreus) since 1925, probably due to a secondary contact between these species associated with the development of large-scale Atlantic fisheries and the concurrent spread of the Herring Gull to Iceland.

In summary, one finds that the Herring Gull and relatives in North America lay a clutch of three from which they normally fledge one young per nest per year. Predation and attacks by members of the same species are the primary factors responsible for egg and chick loss. Gulls have increased rapidly in Europe and eastern North America within the last seventy years. The increase in gull population is associated with environmental deterioration, due to increases in refuse, fish scraps, and similar garbage (Fig. 6).

THE STUDY AREA

The largest and probably most important gull colonies in the northeast Gulf of Alaska are located on sandbar islands off the Copper River Delta. For millenia the Copper River has flowed from interior Alaska through the Chugach Mountains (2000-3000 m) to the Pacific Ocean. The river carries a naturally heavy load of silt, sand and gravel from montaine erosion and the severe and current glaciation of the higher peaks. This massive river system flows into the Gulf of Alaska south of Cordova, Alaska, and carries mud, clay and Gletschermilch of the Scott, Sheridan and Sherman glaciers as well as other ice complexes (USFS, 1975) (Figure 3).

The Copper River and the confluent Martin River have deposited their sands and mud where they meet the sea. The suspended inorganic matter precipitates out with the increasing salinity gradient, forming a 50 km wide delta. The rivers move across the delta, crossing tidal mudflats and passing through brackish sloughs and creating shallow ponds in sedgy or grassy marshes. Summers in the Copper Delta region tend to be cool and rainy, while winters bring extremely strong storms, intense cold and interior winds which blow with incredible velocity.

The Copper River Delta has been one of the most productive and important breeding and migration grounds for waterfowl on the North American continent (USFS, 1975). Millions of birds pass through the area in spring and fall, and tens of thousands of ducks, geese and swans remain to breed (Isleib & Kessel, 1973). Brown bear and moose roam the delta, while black bear, lynx, wolf, coyote, black-tailed deer and wolverine are found in forested areas of the delta nearer the mountains. Another indicator of the importance and productivity of the Copper River Delta is the sizable fishery on the "Copper Flats" for king, sockeye and silver salmon. The king and sockeye salmon migrate up

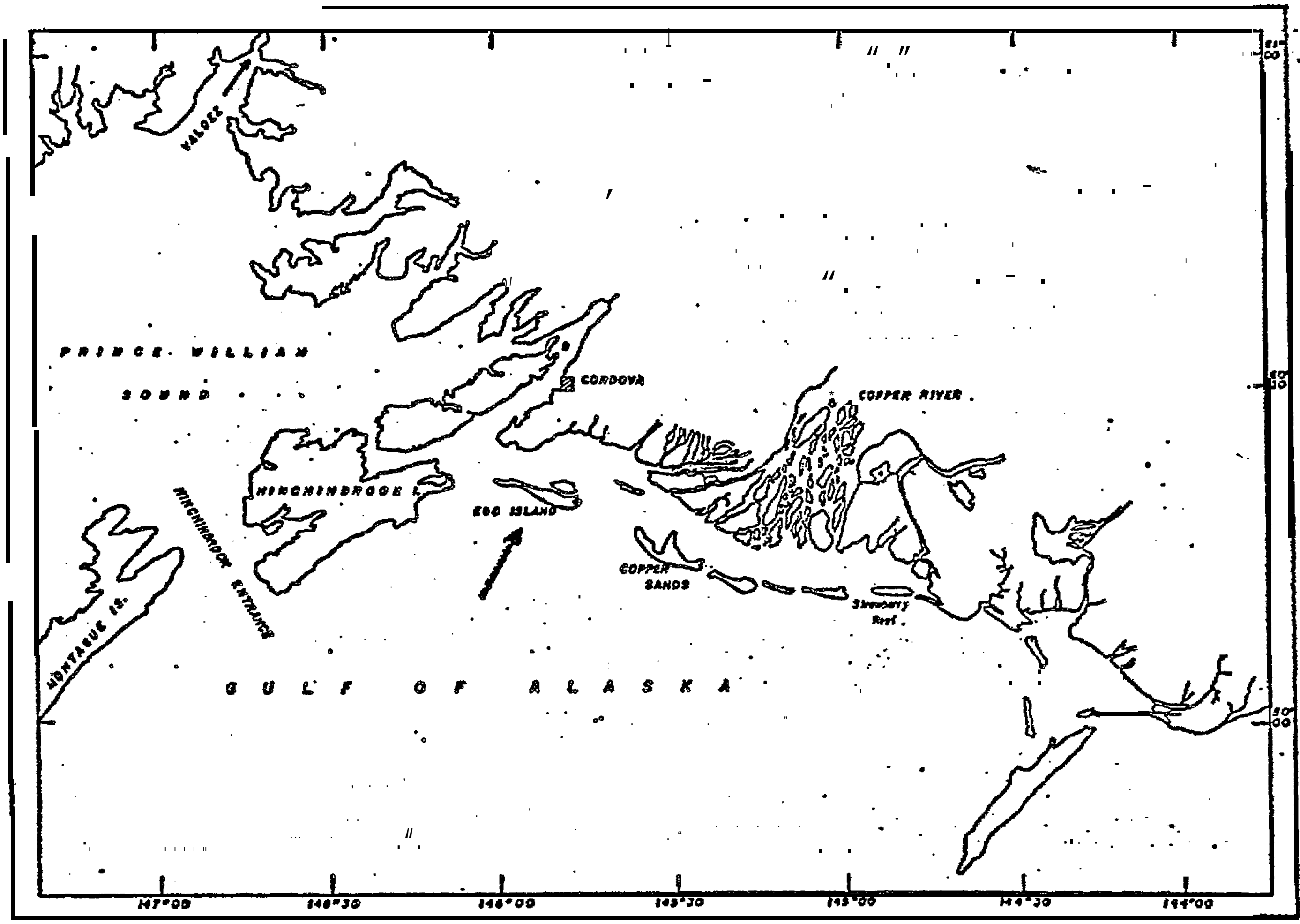


Figure 3. Map of the Copper River Delta region and, Prince William Sound, showing location of Cordova, the Copper River, Egg Island (arrow), Copper Sands, and Strawberry Reef.

the Copper River into the interior to spawn, while the silver salmon breed in the tributaries of the delta. A herring fishery is important and increasing in nearby Prince William Sound. Eulachon run up small streams of the delta. It is in evitable that this concentration of food resources should attract fish-eating birds.

A few kilometers offshore from the mouth of the Copper River a series of low sandbar-dune islands forms a partial barrier to ocean storms. These islands have been formed by the deposition of sand and mud from the Copper River, and have been shaped by the counter-clockwise onshore currents of the Pacific Ocean.

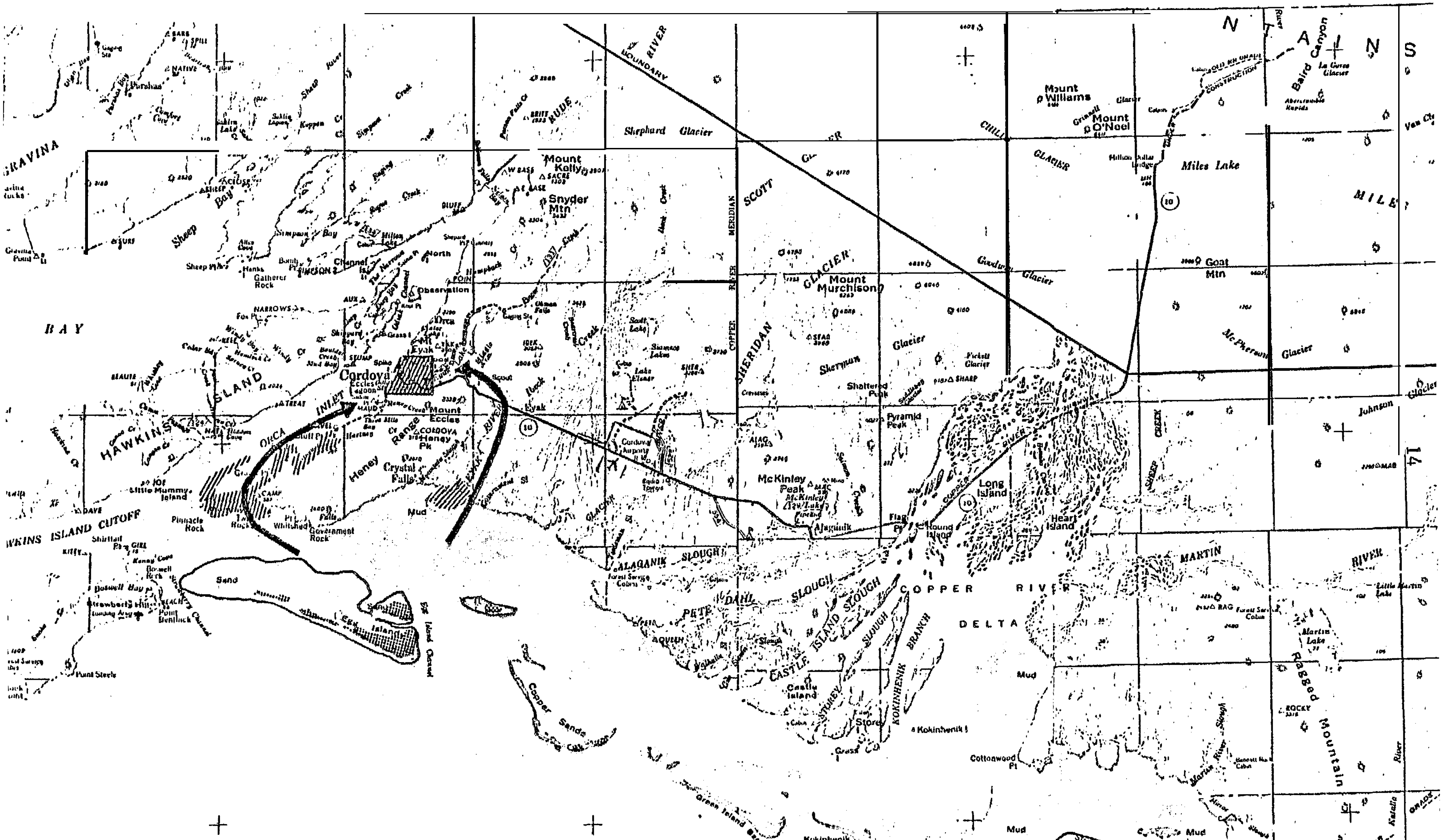
Constant change is a characteristic of the interface between land and sea, especially where rivers enter the ocean. Sandy islands are built up and eroded away in a relatively uninterrupted process. However, the Copper River Delta and surrounding area has been marked by sudden geological changes that have been extremely important in affecting. local biota. Janson (1975) wrote of major earthquakes in the Copper Delta occurring at the end of the last century. The most severe earthquake recorded on the North American continent during modern times occurred in this area of Alaska in March 1964. The whole Copper River Delta including offshore islands was uplifted an average of two meters in a series of severe shockwaves (USFS, 1975). The abrupt uplift disrupted the complex delta ecosystem and altered the balance between fresh and salt water. Nutrient input from salt water to the delta appreciably diminished; several species of intertidal invertebrates declined in numbers, and nesting populations of ducks changed much for the worse. Willows and alders began to replace grassy and sedgy marshes in areas of the delta. Certain tidal sloughs dried out (Scheierl & Meyer, 1976).

The sandbar barrier islands at the mouth of the Copper River underwent the same sharp geological forces as the delta itself, but due to the nature of the islands and the marine bird species using them, the resulting changes were quite different. Shallow salt-water channels between islets were eliminated, and new ridges of sand dunes formed, joining islets together. The actual land area of the barrier islands increased due to the uplift. The small breeding populations of waterfowl on the sandbar islands were not affected to the degree as those nesting on the delta itself because fresh water was limited on the islands even before the earthquake.

The gulls, which compose the largest breeding bird population on the outer islands, were influenced in the following manner. The long lines of dunes increased in height and area due to earthquake uplift and wind action. Plant succession began on newly formed dunes, with Elymus, the beach rye, forming scattered tufts on the sandy surface. The beach rye spread from the older high dunes covered with grassy meadows, in which Elymus was the dominant plant species, More and more dunes become covered with meadows as succession continues.

Large colonies of gulls nest on these meadow-covered dunes. The actual area upon which gulls can nest is increasing. However, a few young alder, willows and cottonwood are growing on the higher dunes on Egg Island; Strawberry Reef has scattered clumps of spruces. If this trend towards woody vegetation continues, with time the result could be displacement of nesting gull populations. However, at the moment there are large areas of unoccupied meadows capable of supporting nesting gulls.

Five important seafood packing canneries and fish-processing houses (Fig. 4) in Cordova provide a major food source to gulls in the form of discarded salmon and crab gurry in addition to the open municipal dump at the edge of the harbor. The potential for discarded human food and industrial waste



LEGEND

NESTING COLONIES OF *Larus glaucescens* OFF COPPER RIVER DELTA

MAJOR FEEDING AREAS

TRANSIT ROUTES INTO CORDOVA

Figure 4.

0 5 km

increases daily. Isleib (pers. comm.)" sees an increasing gull population in the Cordova area to date. Additional factors of unknown consequence enter the picture, The trans-Alaska pipeline is nearing completion from Prudhoe Bay on the North Slope to Valdez on Prince William Sound on the south. Valdez is less than 150 km northwest of the Copper River. Tanker traffic will pass just offshore from the barrier islands through the entrance to Prince William Sound. The Copper River Delta itself is rich in both mineral and fossil resources and has seen previous spurts of industrial activity (Janson, 1975). The first oil well in Alaska was developed just south of the delta at Katalla in 1901 (USFS, 1975). A consortium of oil companies is presently involved in exploratory research offshore. The first offshore oil leasing took place on 13 April 1976 and included an area near Middleton Island, 'and a large group of tracts offshore between Kayak Island and Icy Bay (Figure 1). These lease sale areas are bracketed by large gull colonies at Egg Island, Strawberry Reef, Haenke Island and Dry Bay. Banding returns and sightings of color-marked gulls from this study indicate the lease sale area is repeatedly traversed by gulls under current investigation (see below), With the development of offshore oil resources; gull-associated problems of human waste and garbage disposal are not likely to decrease.

The following final report should be understood as an analysis and prediction of some of the forces acting to change gull populations in the northeast Gulf of Alaska, and an exploration of some of the consequences of those changes.

MATERIALS AND METHODS

Colony Selection and Investigation Dates

We selected Egg Island as a principal location for this study because it has the largest meadow-nesting gull population in the Gulf of Alaska. Kenton Wohl of the BLM, Dr. Pete Michelson, then of the Forest Service, and Pete Isleib "of Cordova all emphasized the importance of this colony to our study. Egg Island, one of a dozen in Alaska, lies off the south coast 10 km SE of Point Whitshed and 20 km south of Cordova, at 60° 23' N, 145° 46'W. Egg Island, a local name probably due to abundance of gull eggs, was first reported by G.C. Martin of the USGS in 1906 (Orth, 1967).

We began our 1975 field season on 16 June immediately after project approval, and continued through 23 August. In 1976 we began field work on 18 May, and remained until 24 August. We chose a survey area southwest of Egg Island Light at the suggestion of Dr. Michelson. We spent considerable time examining the rest of the island colony, which stretches for 10 km on dunes roughly along an E - W axis, and contains perhaps 8000-10,000 pairs of nesting gulls. There were 153 nests in the study area proper in 1975, and 186 in the same area in 1976. This study area, fairly representative of conditions on the island, is located on the ocean slope of stabilized, meadow-covered, high dunes at the east end of the island near the Coast Guard Light' Tower. Egg Island Light can be readily identified on nautical charts, and can be seen from some distance (Fig. 3 , 5). It should be noted that Egg Island Light has changed position several times in recent years due to radical alterations of shoreline from beach erosion (Thorne, pers. comm.; Hayes and Boothroyd, 1975 ; see also Fig. 22).

We initially hoped for a survey area of about 100 nests in this facet of the study. We measured 150 m x 150 m square with a fiberglass tape, flagged the

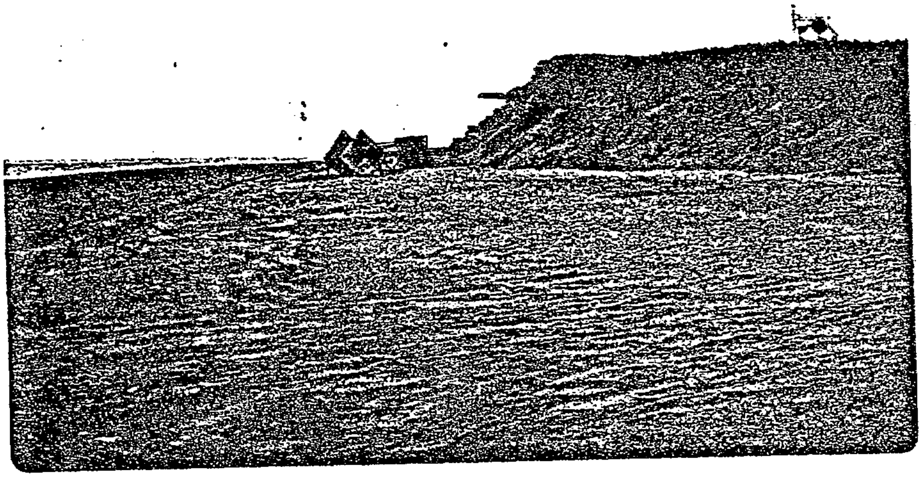


Figure 5. The southeast end of Egg Island, bearing the brunt of North Pacific Storms, was radically altered by ten to thirteen meters of erosion in nine months (Sept 75 - May 76).

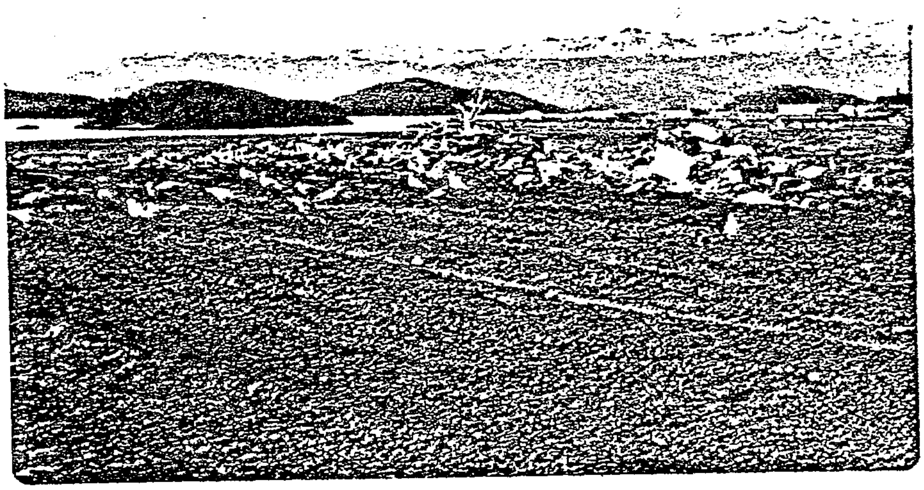


Figure 6. With the development of offshore oil resources, gull-associated problems of human waste and garbage disposal are not likely to decrease. Gulls in the Cordova dump, May 1976.

corners with survey markers, and counted all nests in a sequence of slow sweeps. Our final nest count considerably exceeded our original estimation, a fact to be remembered in future surveys,

Kadlec and Drury (1968) observed that a high level of disturbance will cause Herring Gulls to abandon efforts to breed. Coulter et al. (1971) found reproductive success in a colony of Western Gulls to be inversely proportional to the amount of disturbance. Therefore we did not enter the colonies except when absolutely necessary.

Table 1

SCHEDULE OF VISITS

year	month	day
1975	May	- -
1975	June	18 19 20 21
1975	July	07 09 14 15 16 21 23 26 27 28
1975	August	01
1976	May	21 22 25 26 30
1976	June	03 07 11 18 24 27
1976	July	05 11 15 17 23 24 25 28 29
1976	August	04

Reproductive Cycle

We used a method devised in previous gull studies to mark the nests we inspected. We marked all nests with flagged wire stakes at the beginning of each field season. Since growth of vegetation tends to obscure the stakes, each was marked with an additional numbered fluorescent streamer. Using the measure of territory defined by Harpur (1971) we used a fiberglass tape "to find the direct distance from every nest to the center of the nearest neighboring nest", one half this distance was assumed to be the radius of the territory. There are practical difficulties with this definition (Drury, pers. comm.; Hunt, pers. comm.). Nevertheless we have elected to continue this use because the measure is standardized and can be used for comparative purposes.

Each time we visited a nest site we recorded the number of eggs or chicks. The highest number of eggs per nest was assumed to be the clutch size. Due to the short notice under which the investigation was begun, completed clutch size figures are lacking for 1975. Egg loss was calculated at the end of the incubation period from the numbers of eggs remaining from the initially observed clutch. We counted young chicks in the nest. We- assumed older chicks in the study area to come from the nearest nest; such older chicks were marked with 657 series tall tarsal bands. At the end of the survey . period-each August, we made fledging counts of banded chicks for the entire study area. The results from Egg Island and Dry Bay have been compared to North Marble Island and to other gull studies.

Data Analysis

As part of each sequential visit through the gull colonies we recorded numbers of eggs and chicks from each nest site inspected. The numbers were included in NODC Format 035, principally in File Type 'F'- Flat Colony Survey, and used to compute clutch size, egg loss, hatching success, and fledging success. We are indebted to Mr. Jim Audet and Mr. Bob Stein of NODC for various data products.

Specimens

During this study we collected 112 gull specimens for taxonomic verification, food habits and serology from Egg Island, Copper Sands, Strawberry Reef, Haenke Island, Dry Bay, and North Marble Island. Specimens are maintained in the University of Washington, U.S. National Museum and the American Museum of Natural History.

RESULTS

General Timing of the Reproductive Cycle

Color-marked gulls from Egg Island leave the Cordova area in October. and return in March. Isleib (pers. comm.) reports seeing gulls at Egg Island on their snow-covered nesting areas in April. Arrival dates may vary from year to year by several weeks due to weather conditions. interior Herring Gulls and other hybrid gulls are present in the Cordova area through the winter, but. breeding populations of Glaucous-winged Gulls do not commence nest construction until snow melts, usually in late April (Isleib, pers. comm.). Streveler (pers. comm.) reports similar observations from Glacier Bay (Figure 7).

Egg-laying began May 20th in 1976 and around that date in 1975. The first chicks hatched in the middle of June both years, and most chicks hatched during the last week of June. The peak time of fledging on Egg Island both years was the beginning of August. The general timing of the reproductive cycle at Dry Bay in 1975 was two weeks delayed from that of Egg Island, since the first eggs there at the mouth of the Alsek River were pipping at the end of June. Brogle (pers. comm.) reported heavy snowfall and a late spring for the Yakutat area in 1975, accounting for the gulls nesting late. With an incubation period of 24-26 days (Patten, 1974), most egg laying thus took place in the last week of May 1975 at Egg Island; gulls at Dry Bay laid most of their eggs in the first week of June. At North Marble Island in Glacier Bay egg-laying began in mid-May 1973 and early June 1972. For comparison, Vermeer (1963) reported Glaucous-winged Gulls on Mandarte Island in British Columbia, lay most of their eggs in the last week of May and the first week of June, quite similar to further north.

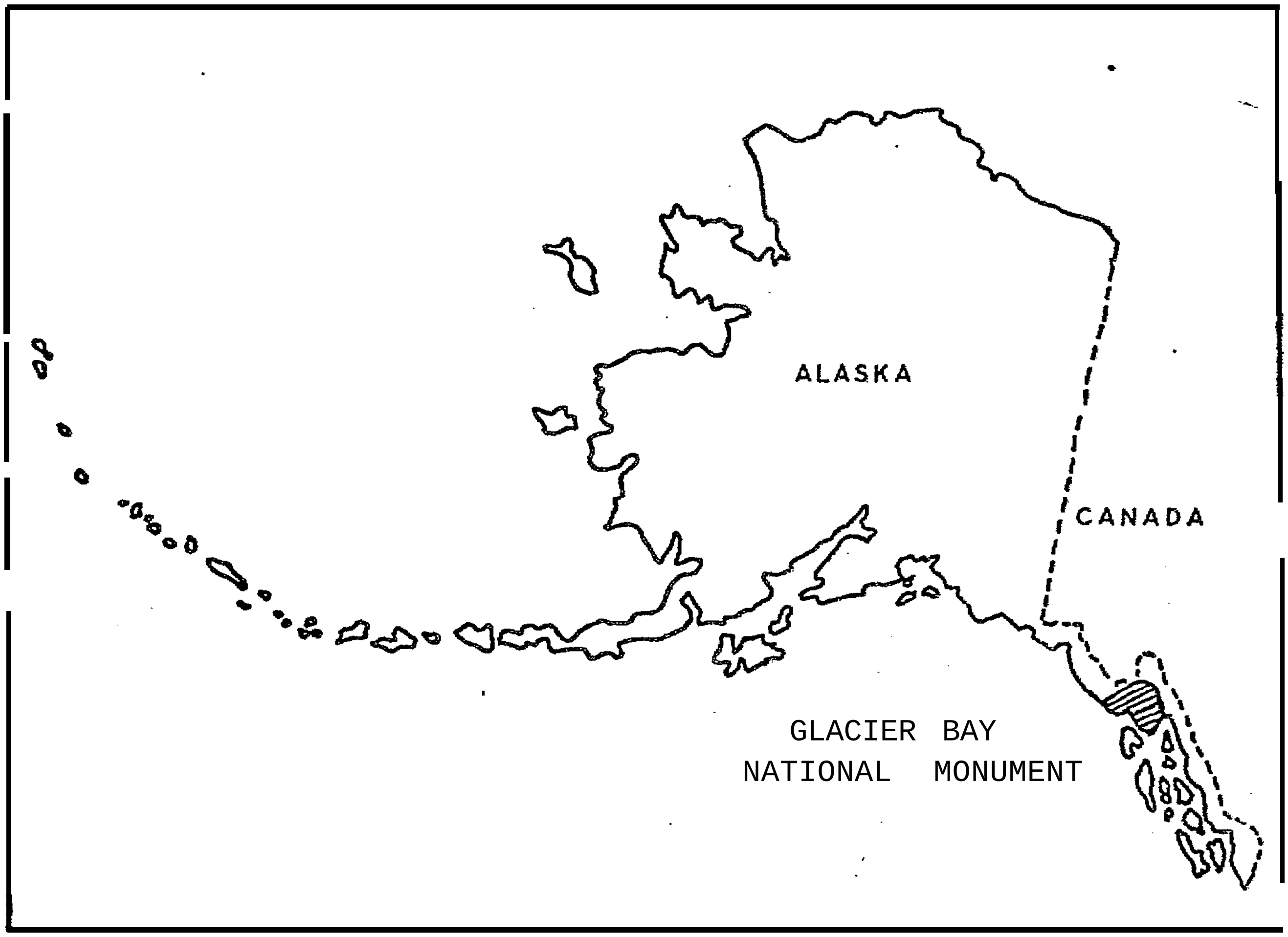


Figure 7. Glacier Bay National Monument (58° 10' - 59° 15' N. Latitude, 135° 10' - 138° 10' W. Longitude), immediately southeast of the current study area along the projected oil tanker route from Valdez, contains gull populations investigated 1971-74 under National Park Service contract, and to which portions of this study are compared.

Territory Size

The definition of territory, as Hinde (1956) states, is "any defended area". This definition does not necessarily imply the defended area is sharply delimited, but in practice many workers on territory (references in Hinde, 1956) imply the existence of such borders by measuring territory size. Using the measure of territory defined by Harpur (1971) we calculated the area of each nesting territory as a circle with a radius half the distance -- to the nearest active nest. In reality, gulls do not defend neat circles. Actual territory size depends upon the stage of the reproductive cycle, expanding with hatching of chicks, and declining as chicks grow older (Hunt & Hunt, 1975), Nevertheless we have elected to continue this measure because it is standardized and can be compared to other studies.

Mean territory size on Egg Island in 1975 was 28.9m^2 (distance to nearest neighbor 6.066m). Territory size remained practically identical in 1976, with 20% more nests in the study area (30.2m^2 ; dist.n.n.= 6.2m). This suggests gull pairs distribute themselves due to a form of social attraction at this density but clearly do not use all available space (weighted mean for'75-76 equals 29.6m^2). At Dry Bay in 1975 mean territory size was 29.8m^2, also suggesting room for more breeding pairs. (Substrates see Table 2.) Distance to nearest neighbor at Dry Bay was 6.16m. Patten (1974) previously reported a mean territory size of 18m^2 for the colony at North Marble, but territory size varied from sub-colony to sub-colony and from year to year. In comparison, Vermeer (1963) found glaucescens on Mandarte Island have a mean territory size of 15.7m^2. Harpur (1971) studying Western Gulls off southern California, reported a small colony had a mean 22.0m2 territory size.

Patten (1974) reported an inverse relationship between colony size and territory size at North Marble in Glacier Bay (Fig. 8). The inverse relationship could be due to several kinds of predation pressure on gulls. Larger colonies of gulls, with smaller territories, have the

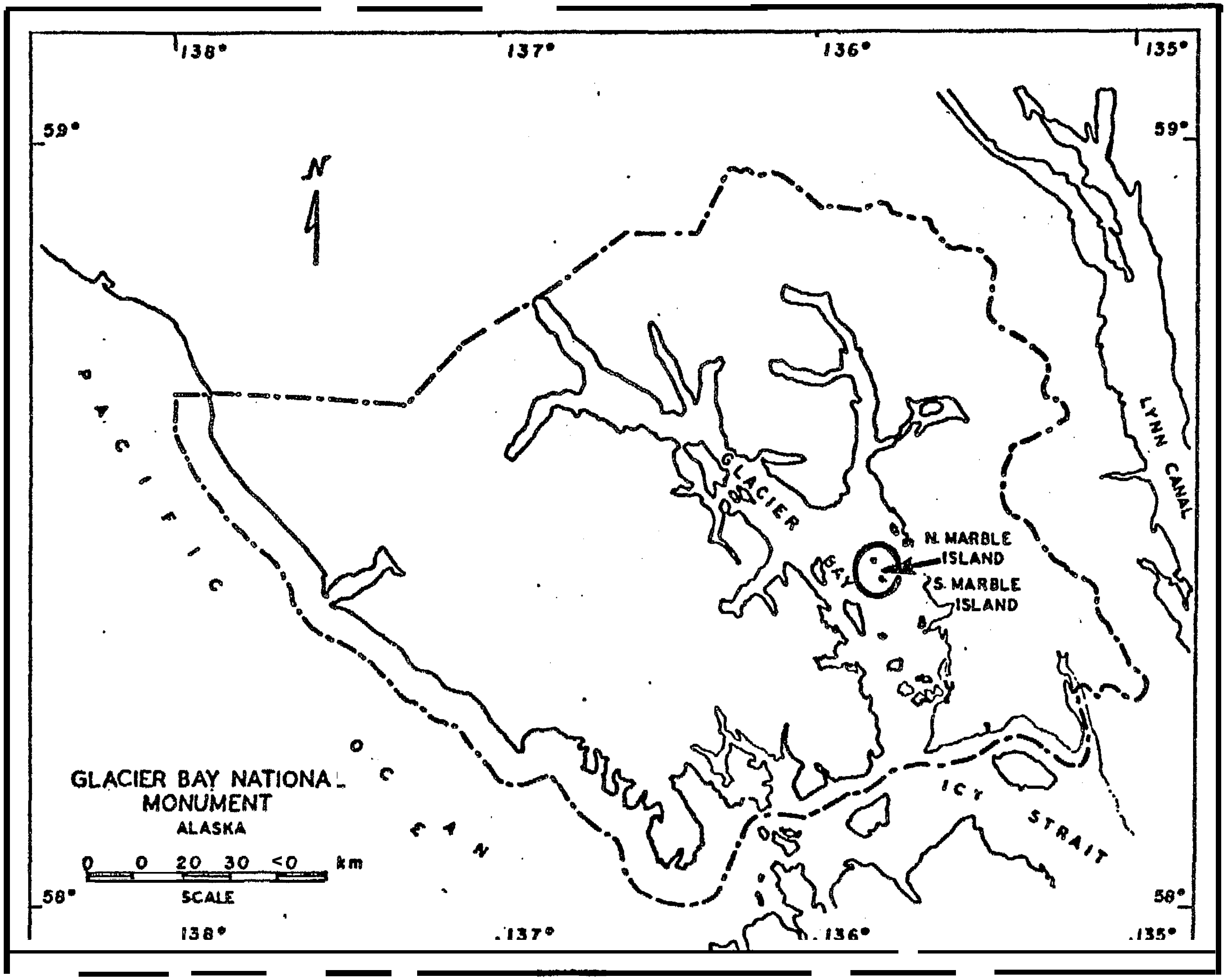


Figure 8. North Marble Island lies in the middle of Glacier Bay and contains large marine bird nesting areas. North and South Marble Islands, 2 km apart, are surrounded by cold, highly oxygenated waters and strong tidal currents.

advantage of behavioral mechanisms such as flight response to alarm calls and mass attack on predators (Kruuk, 1964), but large colonies may suffer more internal cannibalization of eggs and chicks or more territorial defense killings (Hunt, pers. comm.). Smaller gull colonies with larger territories have weaker defenses, more predation, less cannibalism, and less territorial defense killings (Darling, 1938; Brown, 1967b). Selection may operate for a range of territory values around the optimum, and against very large or very small territories, although there are presumably more advantages to nesting together. This means that one could expect gulls with very large territories or very small territories to produce fewer young over a long period of time (Hunt & Hunt, 1976),

Substrate plays a role in gull territory size (Haycock & Threlfall, 1975); these authors reported Herring Gull nests in Newfoundland were closer together on rock surfaces than on grass. We find southern Alaskan *argentatus*-group gulls nest on a variety of substrates ranging from cliff ledges in fjords in Glacier Bay to flat gravel bars at Dry Bay to grassy meadows at Egg Island and North Marble. We report large differences in mean territory size for *glaucescens* nesting on grassy meadows on Egg Island and North Marble (Table 2). Gulls nesting on gravel bars at- Dry Bay and on meadow-covered dunes at Egg Island had similar territory sizes. Notable is the large territory size at both Egg Island and Dry Bay. Portions of the meadows are not even colonized on Egg Island probably due to recent ('64) earthquake uplift which has doubled the island in size. This suggests quite strongly that *argentatus*-group gull populations are not limited by available nesting space on their NEGOA breeding sites. With an increasing food supply due to man's activities, it is not unreasonable to expect increasing gull populations.

Table 2

CLUTCH SIZE, NUMBER OF FLEDGLINGS, & TERRITORY SIZE IN ALASKAN GULLS

L. argentatus & L. glaucescens

Colony	Number of Nests	Mean clutch Size	Mean Number of Fledglings	Mean Territory Size (m^2)*
N. Marble (1972-73)	i62-191	2.9	1.77	18 m^2
Dry Bay (1975)	100	2.37	.-	29.8 m^2
Egg Island (1975-76)	153-186	2.4	1.08	29.6 m^2

* Substrates: North Marble: Willoughby" limestone with Hordeum meadows (Fig, 9)
Dry Bay: alluvial sand and gravel with sparse vegetation (Fig. 10)
Egg Island: sand dunes with Elymus meadows (Fig. 11)

The mechanism for establishing territory size is defensive behavior, according to Patterson (1956). The way in which this mechanism could produce dispersion of individuals or pairs has been discussed by Tinbergen (1957). He emphasizes that both attack and avoidance are involved in the maintenance of the territorial system. Both motivations are present in the threat displays of the territory owner and nonspecific intruders almost always respond to these displays and to actual attack by fleeing. Degree of spacing between nests and territorial individuals will then depend upon the balance of attack and and escape motivations in the established residents and intruding birds.

Two possible functions of the territorial system are: assistance to survival of adults, or insurance of their maximum reproductive success, or a compromise between the two functions. Our data on mortality agents suggests that egg and chick predation was by far the most important cause of reproductive failure (Table g).

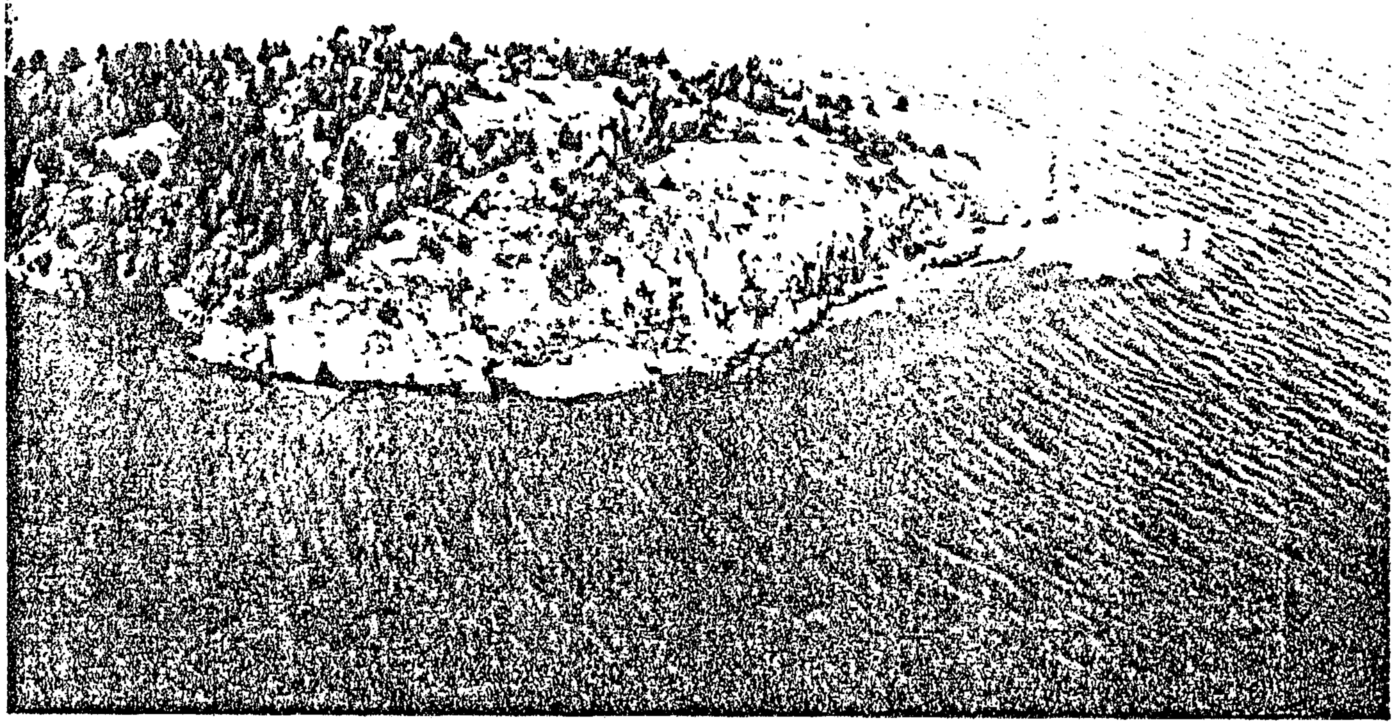


Figure 9. North Marble Island is about 600 m long and 300 m wide. Substrate is Willoughby limestone covered with scrubby Sitka Spruce and Hordeum meadows.

Figure 10. Dry Bay from a small aircraft at 200 m elevation showing gull colony (center) on low gravel bars with sparse vegetation.

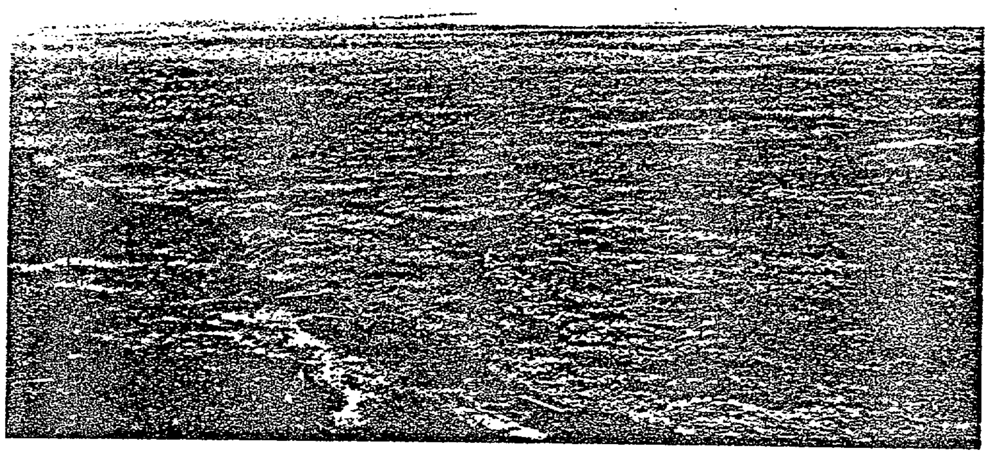


Figure 11. Egg Island from a small aircraft at 50 m, showing hundreds of gulls flying over meadow-covered dunes with scattered old drift logs providing partial cover for nests.

The most serious predation was gulls consuming eggs and chicks of their own species (see below); secondary in importance was crows, ravens, jaegers, and eagles taking gull eggs and/or chicks. Darling (1938) suggested that the much larger territory sizes of the Lesser Black-hacked Gull (Larus fuscus) allow a higher overall reproductive rate than the Herring Gull. Large territories permit chicks to wander over a larger area before they stray into another parent's nesting region and are attacked. Darling (S938) also observed, however, that the young in large colonies had better survival than those in smaller colonies. He presumed this to be due to the greater degree of synchronization in large colonies leading to a smaller percentage of chicks or eggs . taken by predators in any one period. However, Coulson & White (1958) challenged this conclusion by reporting the spread of Kittiwake breeding was greatest in larger colonies, with older birds laying sooner than young adults, Our evidence from Egg Island, a large colony, indicates a wider spread of egg dates and a lower fledging success than North Marble Island, a much smaller colony under post-glacial conditions. It should be remembered, however that Egg Island is relatively more disturbed than North Marble, with subsistence egging by fishermen continuing. North Marble is quite rigidly protected.

Another function of territory may be the spacing apart of nests. Tinbergen (1956) has stressed the importance of dispersion in cryptic prey in order to minimize the formation of search images in their predators. It would seem advantageous to have gull eggs and young spaced apart to some degree since they are cryptically colored. The arguments of spacing out as one of the main functions of territory have been summarized in the review by Hinde (1956) and by Tinbergen (1957). However, the upper limit of territory size would be influenced by the need for colonial nesting discussed above, and the lower limit influenced by the possibility of increasing intraspecific predation (see below). In addition, the spacing apart of nests in a gull colony is adaptive mainly against predatory birds, normally the most important for gulls, which tend to nest on islands or cliffs (Patterson, 1965).

The most obvious factor in dense breeding populations of meadow-nesting gulls is that smaller territories increase the chances that wandering chicks will be attacked (see Ashmole, 1963 for a similar argument concerning terns). Hunt and McLoon (1975) have recently argued that decline in food availability will lessen the ability of adult gulls to provide-their chicks with food. . When the begging chicks fail to receive food, their increased activity (wandering) will increase their chances of being killed by territorial neighboring adults. This in turn suggests food as the ultimate limiting factor. Since Egg Island gulls are at least partially dependent upon gurry from the Cordova fish-processing plants, a strike by commerical fishermen could depress the reproductive rate of local gull populations, Indeed we have observed increased foraging in the local dump and on Egg Island beaches when the canneries are not producing fish waste. If the above sort of chick mortality is combined with Darling's hypothetical effect of breeding synchrony, then there would be an optimum density for gull breeding. Whether gulls have reached this density in the northeast Gulf of Alaska is not yet clear. Our evidence indicates sufficient room for larger breeding populations on nesting islands if sufficient food becomes available.

Nesting Activities

Thousands of gulls at Egg Island nest on stabilized meadow-covered dunes, usually in proximity to old drift logs or *Sambucus* bushes (Fig. 11, 14, 15). Slope of the dunes is shallow, averaging slightly over 1%. The highest dunes are only ten meters above sea level. Egg Island can be compared to North

Figure 12. View from Egg Island, June 1975, showing Elymus meadows, Egg Island Channel, part of the Copper River Delta, and the Chugach Mountains.

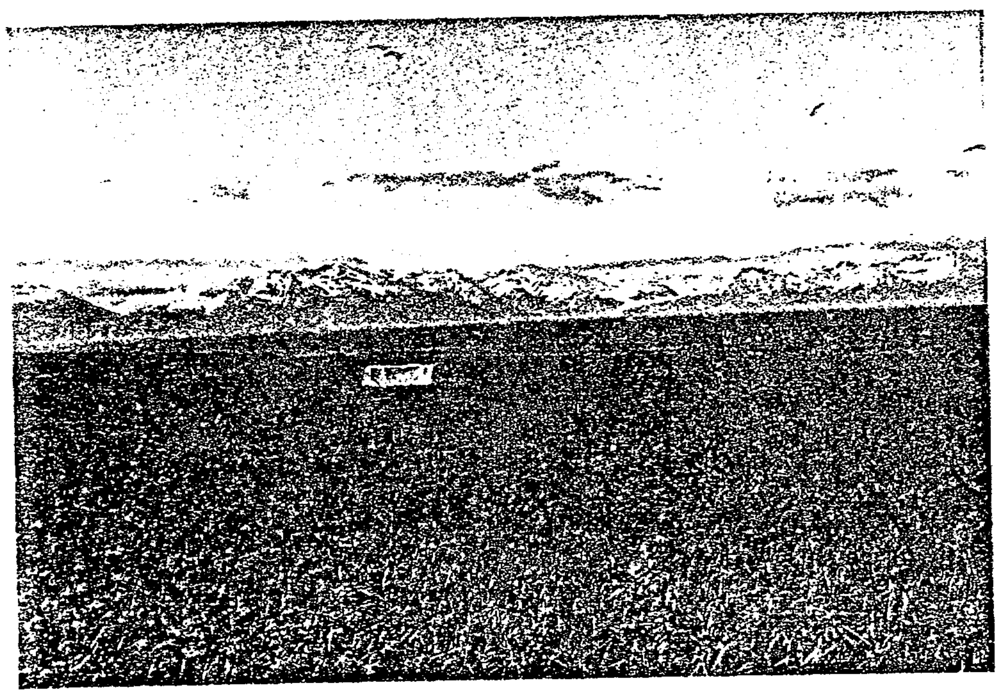


Figure 13. Campsite on Egg Island, June 1975 with Egg Island Channel and the Chugach Range in the background.

Figure 14. Study area southwest of Egg Island Light, showing gulls on territories and nest survey markers, June 1975.

Figure 15. Survey Area, Egg Island, West View, June 1975.

Marble, where highest densities of nesting gulls are found on completely open meadows. Some sites on North Marble are precipitous, approaching 50% slope. Gulls both places tend to select breeding habitat where approaching predators can be easily detected. Few gulls nested in brush fringes on North Marble, but not uncommonly gulls nest directly beneath bushes on Egg Island. Brush-nesting glaucescens have been previously reported by Vermeer (1963) on Mandarte Island, B.C., and by Manuwal (pers. comm.) in the San Juan Islands, Washington State. Tinbergen (1960) noted nesting Herring Gulls react positively to bushes, the only instinct in which adult gulls are definitely attracted to vertical elements. Haycock and Threlfall (1975) observed Herring Gulls in Newfoundland nesting in proximity to some prominence such as a boulder, tree, or stump. This form of nest site selection may represent previous affinity for cliff-nesting. Glaucous-winged and Herring Gulls are known to nest sympatrically on cliffs in Alaska (Patten & Weisbrod, 1974).

The southeast end of Egg Island, bearing the brunt of North Pacific storms, was radically altered by ten to thirteen meters of erosion in nine months (Sept 75 - May 76). The Coast Guard Light Tower collapsed onto the beach and was replaced (Figure 5). Erosion three meters into the SE edge of the gull survey colony certainly influenced colony structure, perhaps displacement accounting for the increased number of nests in 1976. Deposition of sand, according to the 'drumstick theory', is now occurring at the thin western end of Egg Island, downstream of the longshore drift, slowly closing Strawberry Channel (Hayes & Boothroyd, 1975). These authors. report "phenomenal changes" of Egg Island since the '64 earthquake--it fact, it has al-most doubled in size. These sand deposits and uplifted areas will undergo successional changes and become suitable for gull nesting " (Fig. 4, 22).

Copper Sands, one of a series of barrier islands at the mouth of the Copper River, lies SE of Egg Island (Fig. 3, 4) 60° 18' N, 145° 31' W ; (Fig. 23). Copper Sands has risen in elevation since the '64 earthquake, shows much less vegetation and successional changes, and consists of a series of unstabilized dunes extending from SE to NW. The gull colony of 800 pairs is on the only 3 dunes covered with *Elymus* at the SE tip of Copper Sands.

Other barrier islands between Copper Sands and Strawberry Reef contain few nesting gulls due to lack of suitable vegetation, a result of intense wind-sand scour down the Copper River Valley from winter high pressure weather systems (Michelson, pers. comm.). Gulls use unvegetated islands as resting areas. One small, unnamed island off the mouth of the Eyak River, which did not exist before 1964, now contains several *Elymus*-covered dunes and an estimated 150 pairs of *glaucescens* (Fig. 4).

Strawberry Reef, the easternmost barrier island at the mouth of the Copper River, contains the second largest *glaucescens* colony off the Copper River Delta (Fig. 3, 4) 60° 13' N, 144° 51' W ; (see also Fig. 24). Strawberry Reef is separated from the mainland by shallow tidal channels and is undergoing successional changes on post-'64 uplifted areas which will become suitable to nesting gulls. Strawberry Reef is similar to Egg Island in that it consists of wide ocean beaches, unstabilized dunes, *Elymus* dunes colonized by gulls, and sand or mud flats, but differs from Egg Island in spruce and alder patches, which may also spread with time. About 2000 pairs of gulls nest on this island.

Oil spill danger in the Egg Island-Strawberry Reef-Copper Delta barrier system is high due to proximity to Valdez, counter-clockwise onshore currents, strong tidal interchange, shallow slope of the islands, and huge concentrations of birds including the largest gull colonies in the NEGOA.

Dry Bay, at the mouth of the Alsek River, south of Yakutat, provides somewhat different conditions. About 500 pairs of gulls nest on flat gravel bars at the river mouth (Fig. 10). The low alluvial islands are washed by high waters during spring melt and following summer storms. Vegetation as a consequence of unstabilized substrate plus flooding is sparse and consists mainly of Salix, Festuca, Achilles, Elymus, and Epilobium, indicating combined maritime and fresh-water influence. The gull population, hybrids between Herring ar Glaucous-winged Gulls, reflects these mixed coastal and interior conditions. Vegetation cover is important for nest site selection, since nests are clumped near drift logs, willow bushes, and grass patches. Fewer nests are located on exposed gravel. Nests are similar to those on Egg Island, although nest cups are more shallow due to the complete lack of slope and scarcity of suitable vegetation. Some nests are hardly more than a depression in the sand with a few strands of Elymus around the edge.

Gravel beds where gulls do not nest divide parts of the island at Dry Bay (Fig.16,17). When glacier melt-waters combine with heavy rainfall (as after days of sunshine), the river rises and fills the gravel beds. Gulls on gravel beds or too close to the periphery of the island find their nests washed away under these conditions. Thus physical conditions subject to rapid changes influence gull colonies both at Dry Bay and off the Copper Delta.

Glaucous--winged and Herring Gulls nest together at Dry Bay and hybrids are common. These gulls are flexible in nesting habitat selection perhaps due to the dynamic condition% in which they nest (Patten,1976; Patten & Weisbrod, 1974). Western and Glaucous-winged Gulls also nest in a variety of habitats (Vermeer, 1963; Coulter et al, 1971; Hoffman, 1976). Nesting habitat selection does not serve as an isolating mechanism between these species when sympatric.

The partially enclosed location of Dry Bay makes it less susceptible to oil pollution although it is subject to disturbance and egging by fishermen.

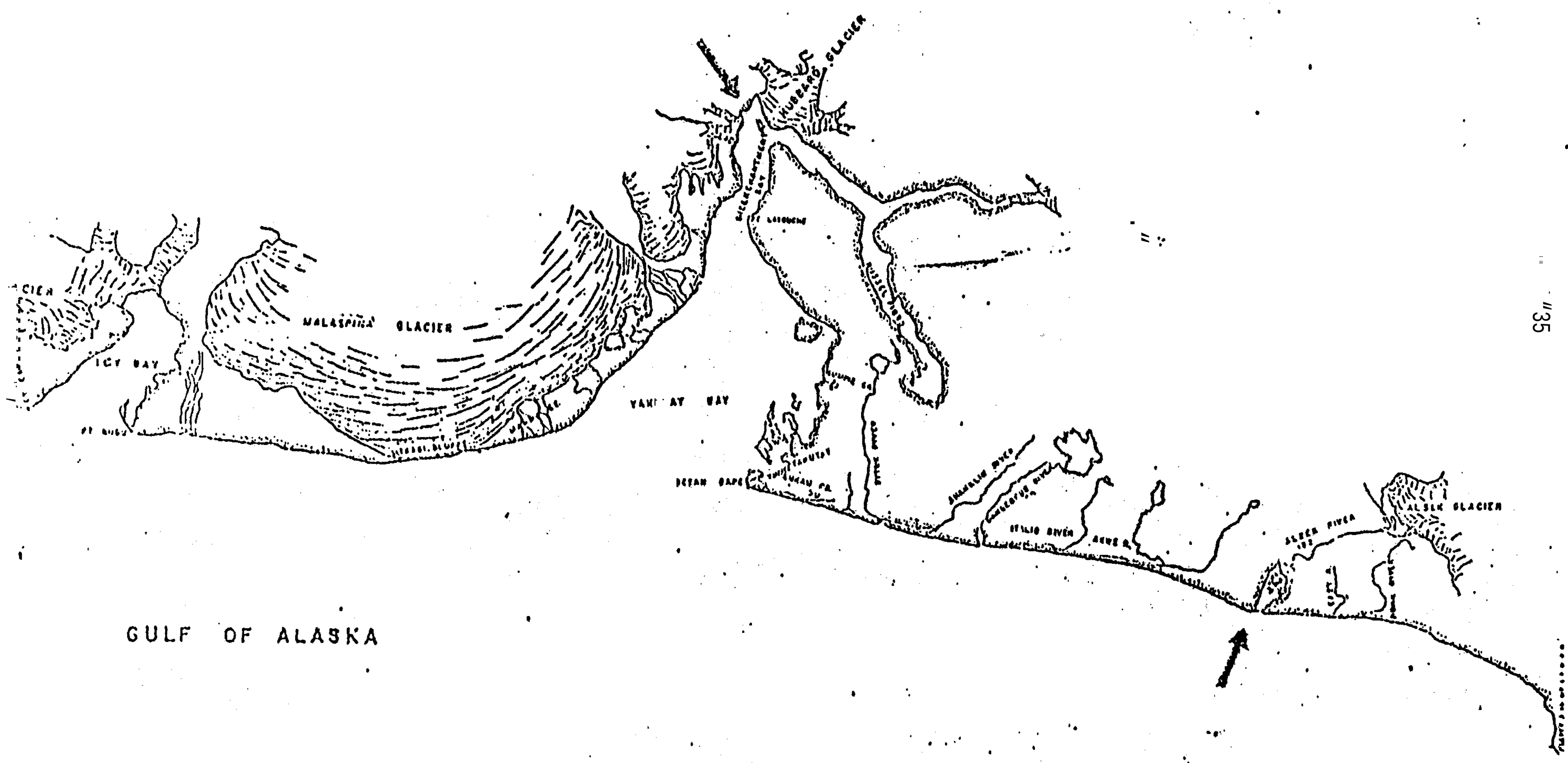
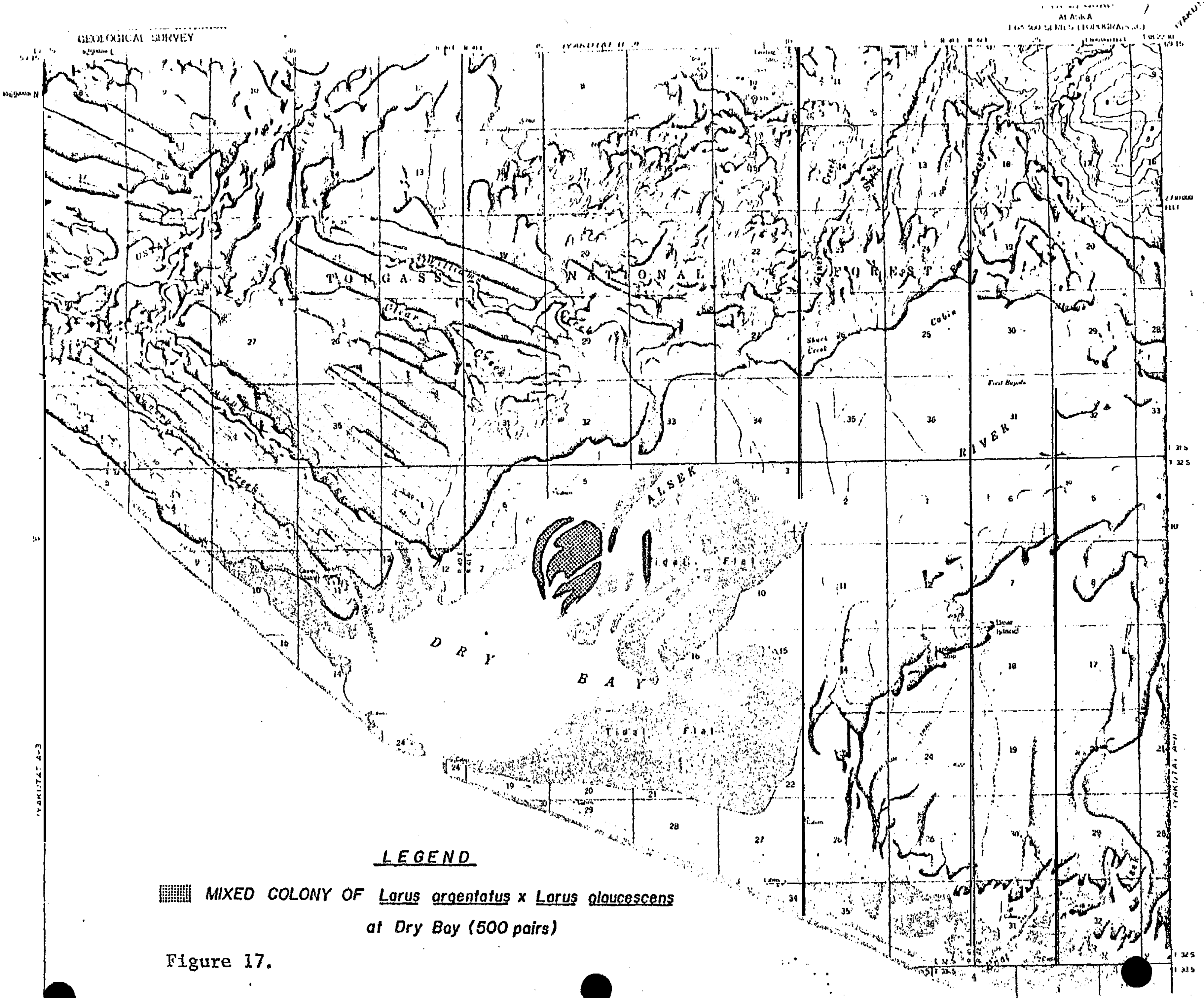


Figure 16. Map of the Yakutat area, showing location of gull colonies at Dry Bay, mouth of the Alsek River (lower arrow) and Haenke Island in Disenchantment Bay (upper arrow).



LEGEND

MIXED COLONY OF *Larus argentatus* x *Larus glaucescens* at Dry Bay (500 pairs)

Figure 17.

Haenke Island, about 1 km wide and 1 km long, is located in Disenchantment Bay near Yakutat (Fig. 16, 18), and has 200-500 pairs of nesting Glaucous-winged Gulls. The east side of the island, facing the active Hubbard Glacier, gradually slopes up to an elevation of 75-100 m and then drops precipitously in a series of narrow terraces down a large west-ward facing cliff. Vegetation on the terraces is Alnus, Sambucus and Ribes, with meadows of forbs, fireweed and mosses. Gulls nest on the terrace meadows and disturb conditions enough so that the resistant Hordeum becomes dominant. Gull nests in 1974 were widely spaced; we observed many 'false' nests. The gulls did not nest close to the water perhaps due to wave action; the closest nest was 25 m above the high tide line. The dominance of alders on this island may indicate recent deglaciation which in turn would account for wide spacing of gull nests due to lack of population pressure. We believe the location of this island and the placement of the gull nests make this colony less susceptible to oil pollution and disturbance than other gull colonies in the NEGOA.

Gulls in southern Alaskan colonies build nests of material available in the immediate vicinity of the nest site, that is usually within the territory. Colonies located on different vegetation substrates show the corresponding structural material in the nests. Thus on Egg Island the predominant nest material is Elymus and mosses (Fig. 14); at Dry Bay Salix, Epilobium and detritus; and on North Marble Hordeum, Epilobium, Festuca and Elymus and mosses, depending on colony location (Patten, 1974). Similar use of vegetation close to the nest site has been reported by Harpur (1971) and Strang (1973). Nest dimensions resemble those of other large white-headed gulls (Patten, 1974; Patten & Patten, 1975; Haycock & Threlfall, 1975).

Vermeer (1963) stated that either male or female Glaucous-winged Gulls may initiate nest building. After the beginning of nest construction, apparently both sexes share equally in building, in contrast to Herring Gulls,

Figure 18. Haenke Island (center) is located in Disenchantment Bay, off Yakutat Bay, near the active front of the Hubbard Glacier at the foot of the St. Elias Range.

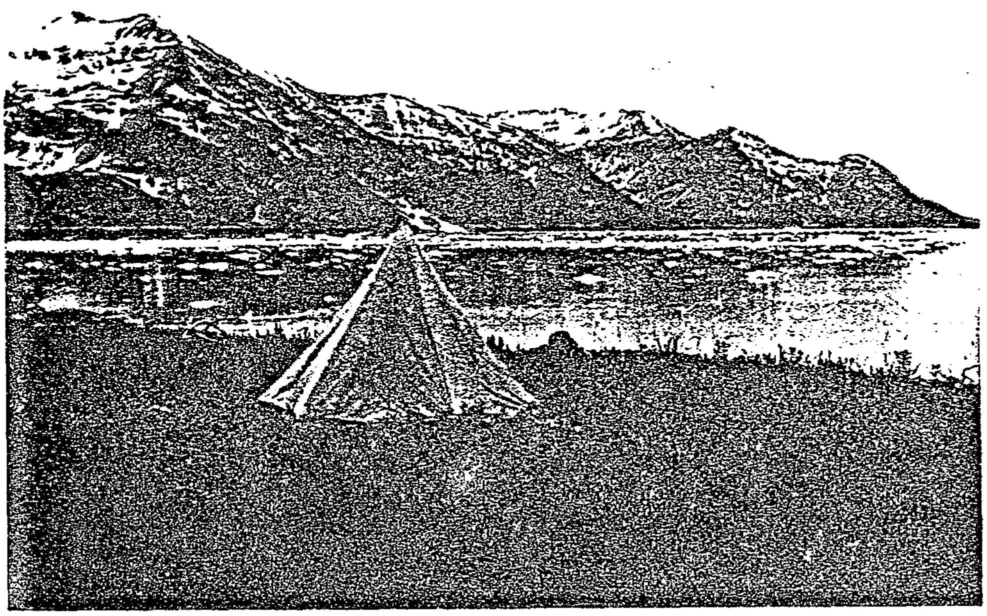


Figure 19. Campsite on Haenke Island, June 1974, at the foot of the gull colony on the grassy cliff face (not visible). Pack ice from the Hubbard Glacier in the background. Gulls feed on seal placentae scavenged on the ice.

where males collect more material than females (Tinbergen 1960; Goethe, 1937). Nests are maintained until chicks hatch, after which the nests disintegrate and rarely survive winter storms, although some gulls may nest again in the same place.

We observed the construction of 'false' or 'play'nests at Egg Island, Haenke Island, Dry Bay, and North Marble, as did Goethe (1937), Paynter (1949) and Tinbergen (1960) elsewhere. Construction of 'false' nests may relate to the amount of available vegetation, may prevent the formation of search images in predators (Tinbergen, 1960) or may simply result from the release of the nest-building drive, but the consequence can be the utilization of. a large amount of vegetation, A colony of 500 gull pairs on North Marble removes about a metric ton of vegetation in one season, Added to the effects of trampling, fertilization, and physical damage done to the meadows during spring and summer, the total gull activity may act to retard herbaceous succession in areas in which they nest. Tree reproduction, however, around the edges of gull colony meadows, may eventually displace the gulls (Figure 9). This is especially true on islands off the Copper River Delta. For a discussion see Patten (1974).

Egg Laying

The gulls at both Egg Island and North Marble begin to lay eggs in mid to late May. A remarkable degree of synchronization was apparent (Fig. 20) comparing percentages of eggs found on sequential dates of observation through the nesting period. Egg-laying on North Marble was very closely synchronized in all colonies, although peak egg-laying was two weeks earlier in 1973 than 1972. Darling (1938), Coulson and White (1956), Coulter et al, (1971) and Brown (1966b) have reported synchronous egg-laying in gulls. There is considerable debate, however, about the relation of colony size and density to egg-laying synchrony (see above). At North Marble _argentatus_ and _glaucescens_ are clearly not reproductively isolated by time of breeding.

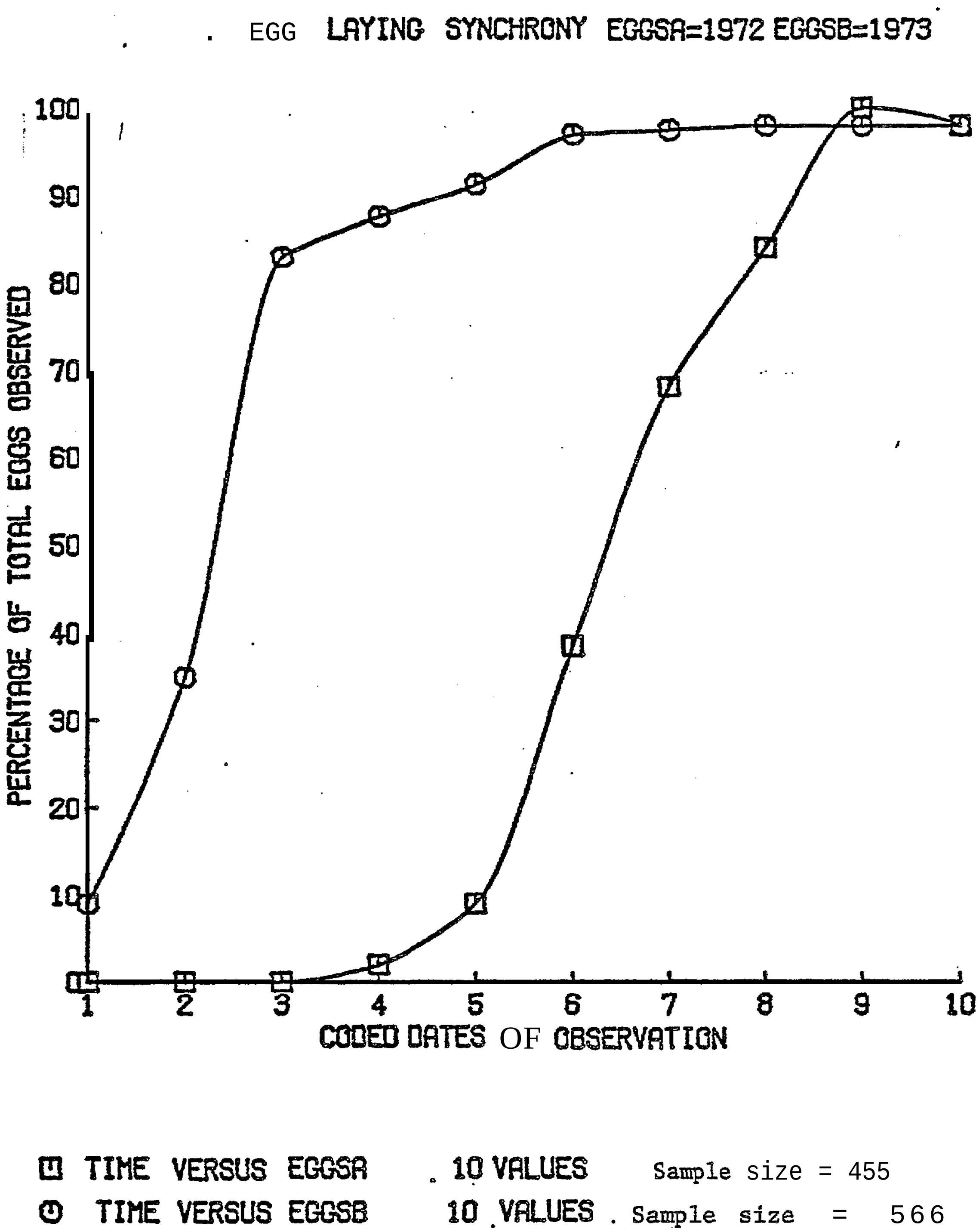


Figure 20. Percentages of eggs found on sequential dates of observation through the nesting period demonstrate synchronization of egg laying on North Marble Island 1972-73,

Synchronization of the breeding cycle leaves marine bird populations open to. catastrophic events such as a major oil spill.

The NEGOA gull study was not funded early enough in 1975 to provide sufficient data on egg synchrony, but our 1976 data clearly suggests such (Fig. 21). Our 1975 observations and those made in 1976 from certain portions of Egg Island suggest a wider spread of egg dates than synchrony in the study area indicates. The most likely explanation for the observed spread of egg dates in portions of Egg Island is egging by fishermen. Intensive spring salmon fishery in the Egg Island area enables boatmen to collect gull eggs during periods closed to commercial fishing. We observed shore parties collecting bucketfuls of eggs during early June, just after gulls completed their clutches. Predation by other gulls may also eliminate eggs, but easy access from boat mooring usually meant egg collecting by humans, particularly along Egg Island Channel where dunes are low and fishermen numerous. Smaller colonies at Haenke Island may show less spread of egg dates, although evidence is incomplete. We also report evidence of egging at Dry Bay in 1974. The spread of egg dates on Egg Island is most likely due to gulls re-nesting following clutch removal by foraging fishermen.

Both colonial nesting and synchronization of egg-laying have an anti-predator function. The mechanisms through which these two phenomena reduce predation on the population have been discussed by Darling (1938) and Kruuk (1964} , They suggest the concentration of gull reproduction into the shortest possible time will reduce egg and chick losses since the numbers of predators is limited by amount of food available during the rest of the year, and by intra-specific aggression. Brown (1967b) suggest a possible for synchronous egg-laying. He suggests that "social attraction" in gull colonies functions beyond colonial defense, and that this function increases efficiency. Brown (1967b) postulates that in gulls copulation may be the key factor in stimulating ovulation, and that copulation by one pair stimulates others to do the same.

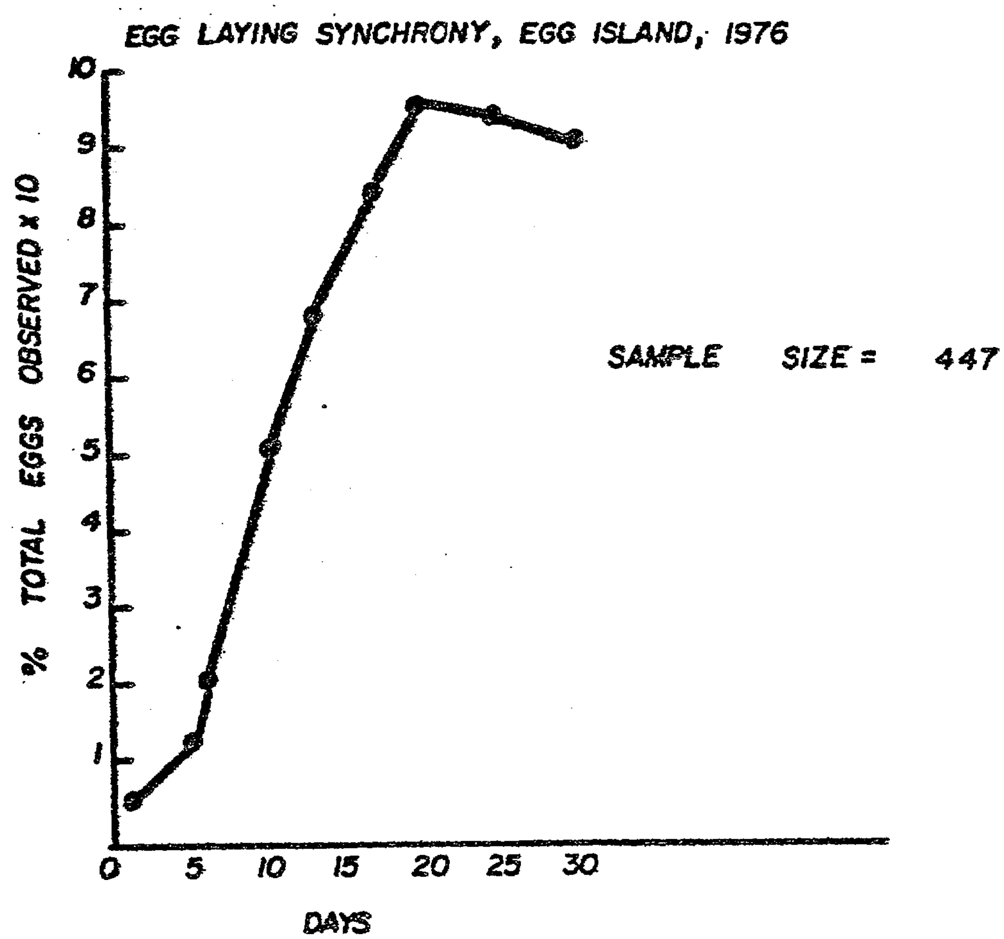


Figure 21. Percentages of eggs found on sequential dates of observation through the nesting period demonstrate synchronization of egg laying in the Egg Island study area, 1976.

Day "0" is the beginning of the 1976 egg and chick cycle, the date upon which the first eggs were found: 20 May,

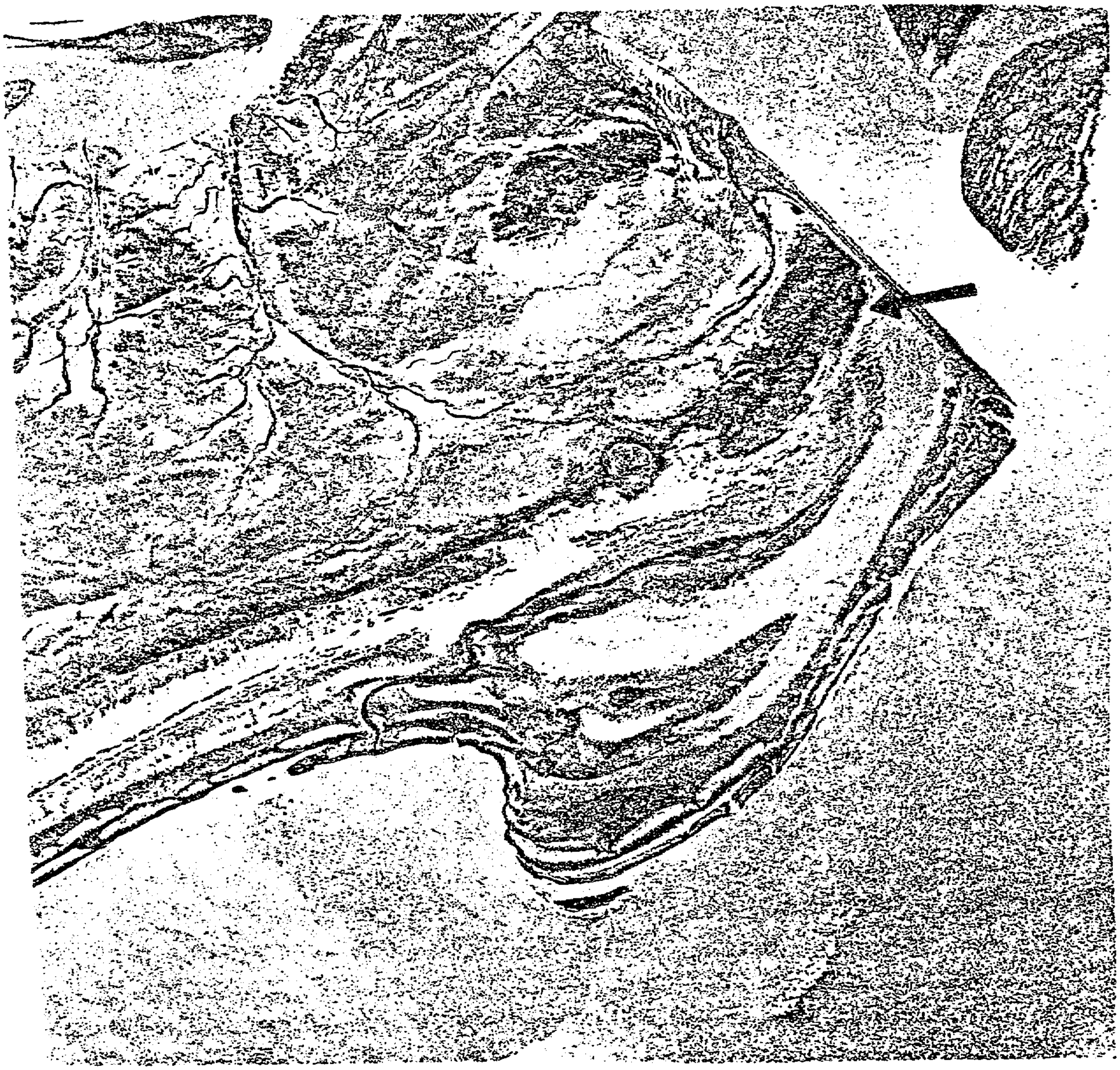


Figure 22. National Ocean Survey aerial photograph of E end of Egg Island, Off Copper River Delta, 9 July 1971, at low tide. Study Area (arrow) is located near the Light Tower. New ridges of sand dunes have formed after the 1964 earthquake, joining the series of islets together. Scale 1:30,000.

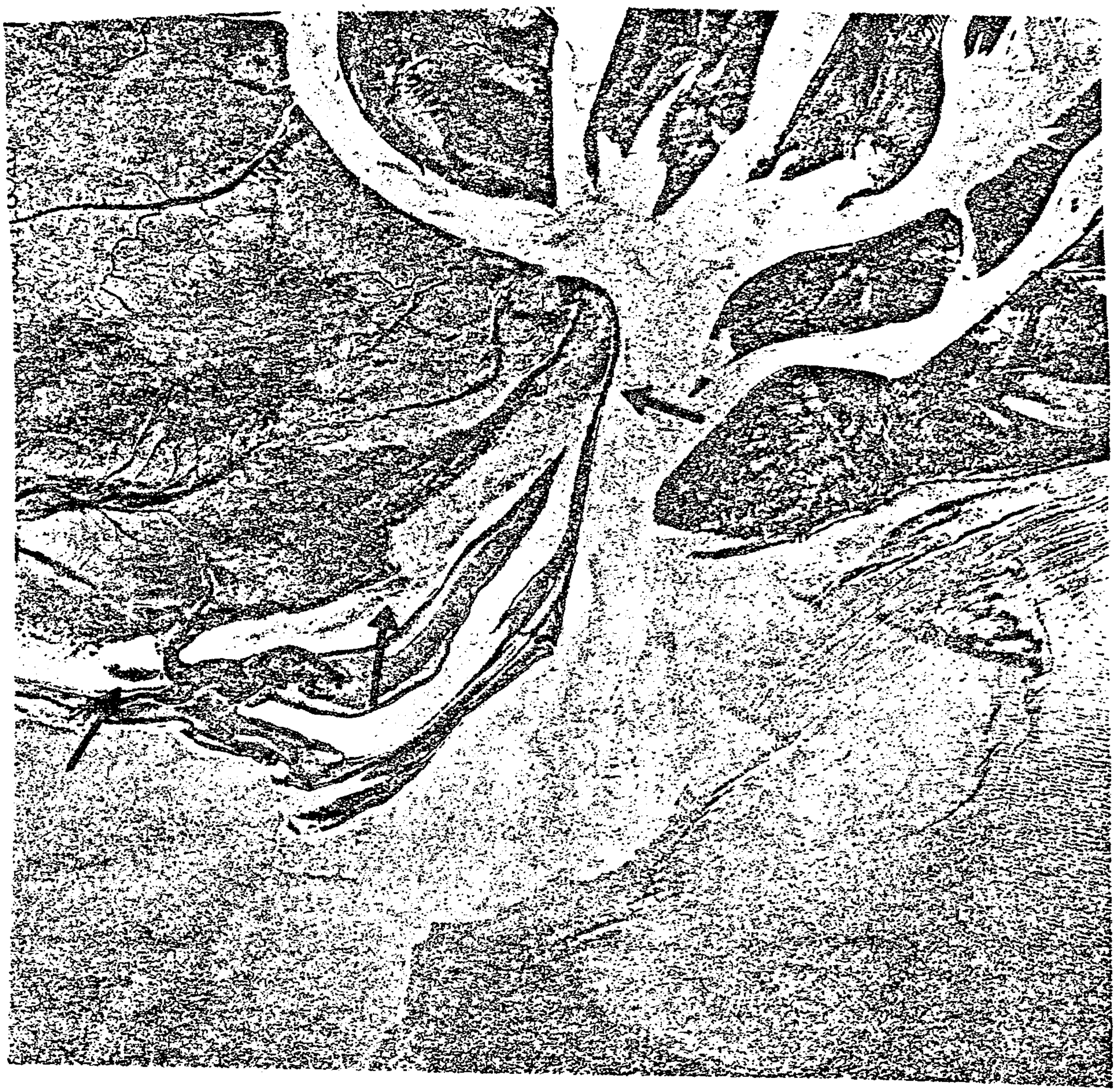


Figure 23. National Ocean Survey aerial photograph of SE end of Copper Sands, off Copper River Delta, 9 July 1971, at low tide. Gull colonies are located on three small *Elymus*-covered dunes (arrows), Scale 1;30,000.

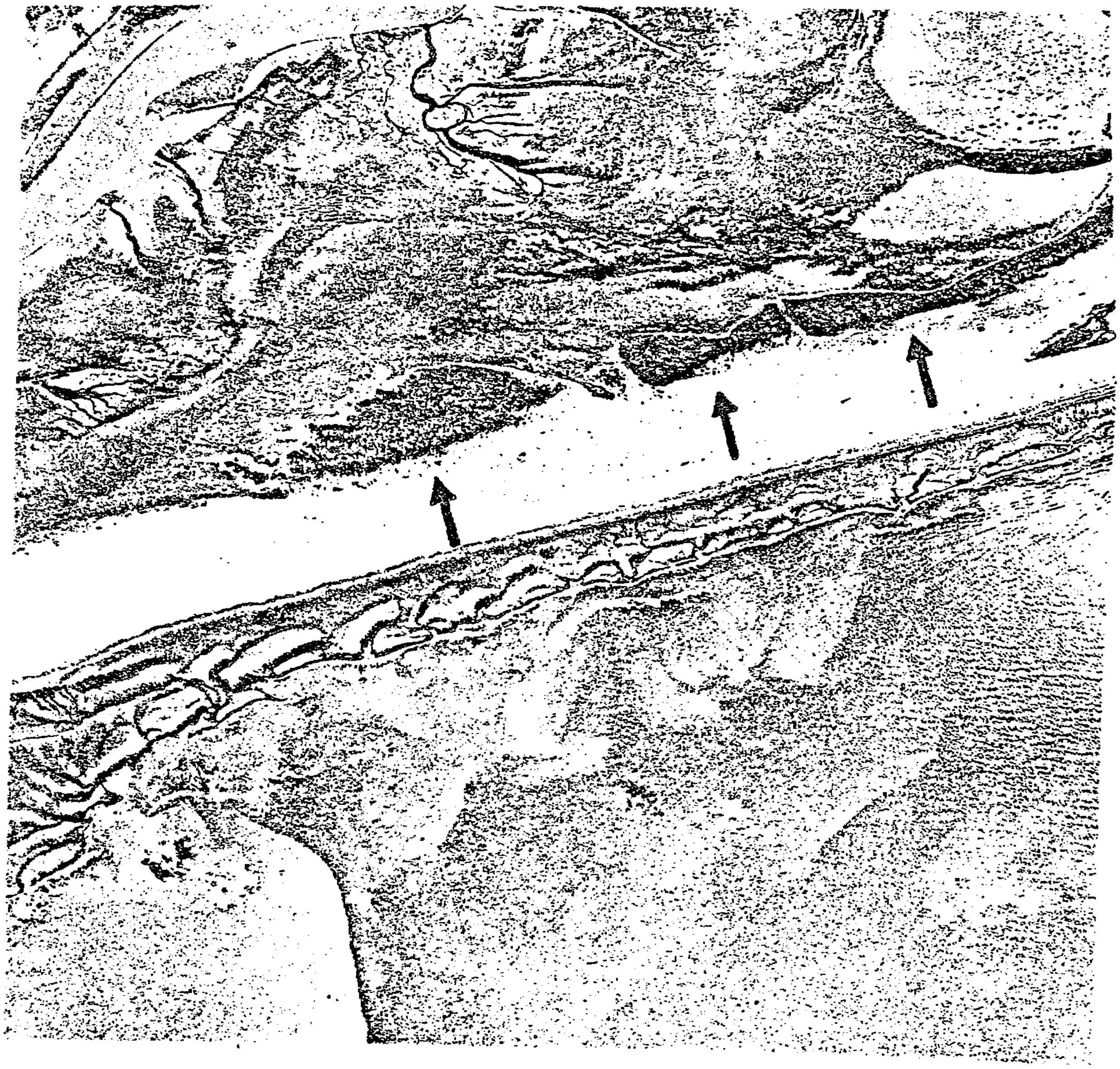


Figure 24. National Ocean Survey aerial photograph of the central portion of Strawberry Reef, off E end of Copper River Delta, 20 July 1970, at high tide. Gull colonies are located on *Elymus*-covered dunes (arrows). Scale 1:30,000.

Judging from Coulson and White's records on the effect of density on breeding in the Kittiwake, the result would probably be a local synchrony, rather than the colony-wide one suggested by Darling (1938); presumably the birds in the denser areas would be the first to breed. Either way, their breeding is likely to be more efficient than birds in less dense areas or colonies (Brown, 1967b).

The evidence from North Marble (Patten, 1974) indicates not only a colony-wide synchrony, but a synchronous egg-laying in four partially contingent colonies (Fig.20). This in turn suggests gulls on North Marble are acting as one large colony. It should be pointed out that North Marble contains about 500 breeding pairs of gulls and is protected. Egg Island contains vastly more gulls and is not protected.

Incubation in Alaskan glaucescens does not begin until after the clutch of three is completed, usually about a week after the first egg is laid (Fatten, 1974). The onset of incubation at both North Marble and in the Egg Island study area was quite synchronized, and began immediately after the peak egg-laying weeks. This meant that gull eggs are subjected to ambient temperatures for a week. Gull eggs, however, apparently tolerate Temperature fluctuations under natural conditions, even after incubation commences (Baerends, 1959; Vermeer, 1963). Gull eggs were left uncovered during the time we examined the survey area on Egg Island, about once every three days. Weather ranged from cold drizzle to brilliant sunshine (Fig. 13). We found no adverse effect on eggs hatching resulting from interrupted incubation due to our presence in control and experimental areas on North Marble. Vermeer (1963) found gull eggs to be resistant to noctural exposure in a series of experiments. He found no adverse effect on hatching and fledging rates in an experiment involving preventing gulls from incubating during the night.

Clutch Size

Within the observation period of 16 June to 18 Aug 1975, we found a total of 339 eggs in the 153 study nests on Egg Island. In 1976 we found 447 eggs in 186 study nests from 20 May to 15 Aug. At Dry Bay in 1975 we counted 237 eggs in 100 nests, In both colonies the modal number of eggs per clutch was three. At Egg Island the mean was 2.2 eggs per clutch on 17 June 75, and at Dry Bay the mean was 2.37 on 28 June 75. Both dates are late in the incubation period and egg loss may have occurred. In 1976 at Egg Island the mean was 2.? eggs per nest. These clutch size data are within the range of other studies of glaucescens, argentatus and occidentals in North America and Europe (references in Patten, 1974). Patten (1974) previously reported a mean clutch size of 2.9 for glaucescens in Glacier Bay, Alaska .(Table 2). This leads to the questions "Why do-Alaskan gulls lay this number of eggs rather than fewer or more and what accounts for the difference between colonies?" As Lack (1968) stated, the factor limiting clutch size is not the number of eggs a bird is potentially capable of laying and incubating, but rather the number of young a pair of birds is able to rear to fledging with success. The upper and lower limits of clutch size have been determined by natural selection which acts through several channels. The lower limit of clutch size in gulls has been influenced by predation, and the upper limit presumably through the inability to feed young in poor years, although gulls in the argentatus group have only three brood patches. Harpur (1971) has previously reported no gulls were successful in experiments involving the ability to brood clutches larger than three. We examined a sample size of 750 nests on Egg Island each season for evidence of egg pathologies prior to the development of oil resources. We report two supernormal clutches each year in different nests. At least one of these clutches hatched successfully in 1975, producing 4 chicks of normal weight (Table 4). We found no clutches larger than three on North Marble Island with a "sample size of 500 nests. Hunt and Hunt (1973) have reported supernormal clutches in occidentals (see below) and are investigating the possibility that supernormal clutches are the result of female-female pairs (fertilized by males otherwise paired). Tinbergen (1960) repeatedly saw four-egg clutches but doubted whether the four eggs were from one female, "The optimum clutch in argentatus, glaucescens and occidentalis is evidentially around three but as in other species there is variation in optimum number from locality to locality and from year to year.

Among the factors influencing clutch size is the age at which birds breed (Paynter, 1949). An expanding gull population on Copper Delta barrier islands would account for a large number of young adults breeding for the first time and producing smaller clutches. Gulls (probably young pairs) colonizing a marginal site (Top Colony) at North Marble laid smaller clutches (l-2 eggs) in 1972 but normal clutches the next year (Fig. 25, 26). Coulson and White (1956) demonstrated in the Kittiwake (R. tridactyla) the female's age, breeding experience and time of breeding all effect clutch size. There is colonial and geographic variation in percentage full clutches, and this has direct effect on population reproduction.

Another agent which has been suggested as modifying clutch size is availability of food (Paynter, 1949; Ward, 1973). We suggest food availability as a limiting factor for the gull population at Egg Island since breeding space is unfilled (see above). As we have indicated we believe the gull population in the Cordova area is partially dependent on artifical food (gurry, garbage]. Constriction of the food source (strike by commercial fishermen) in the spring may produce smaller clutches in the gull colony.

Another factor enters into the discussion of clutch size. Harris (1964), Keith (1966), Kadlec and Drury (1968) and Vermeer (1963) have independently decided that with repeated egg counts over time, the closer the mean clutch

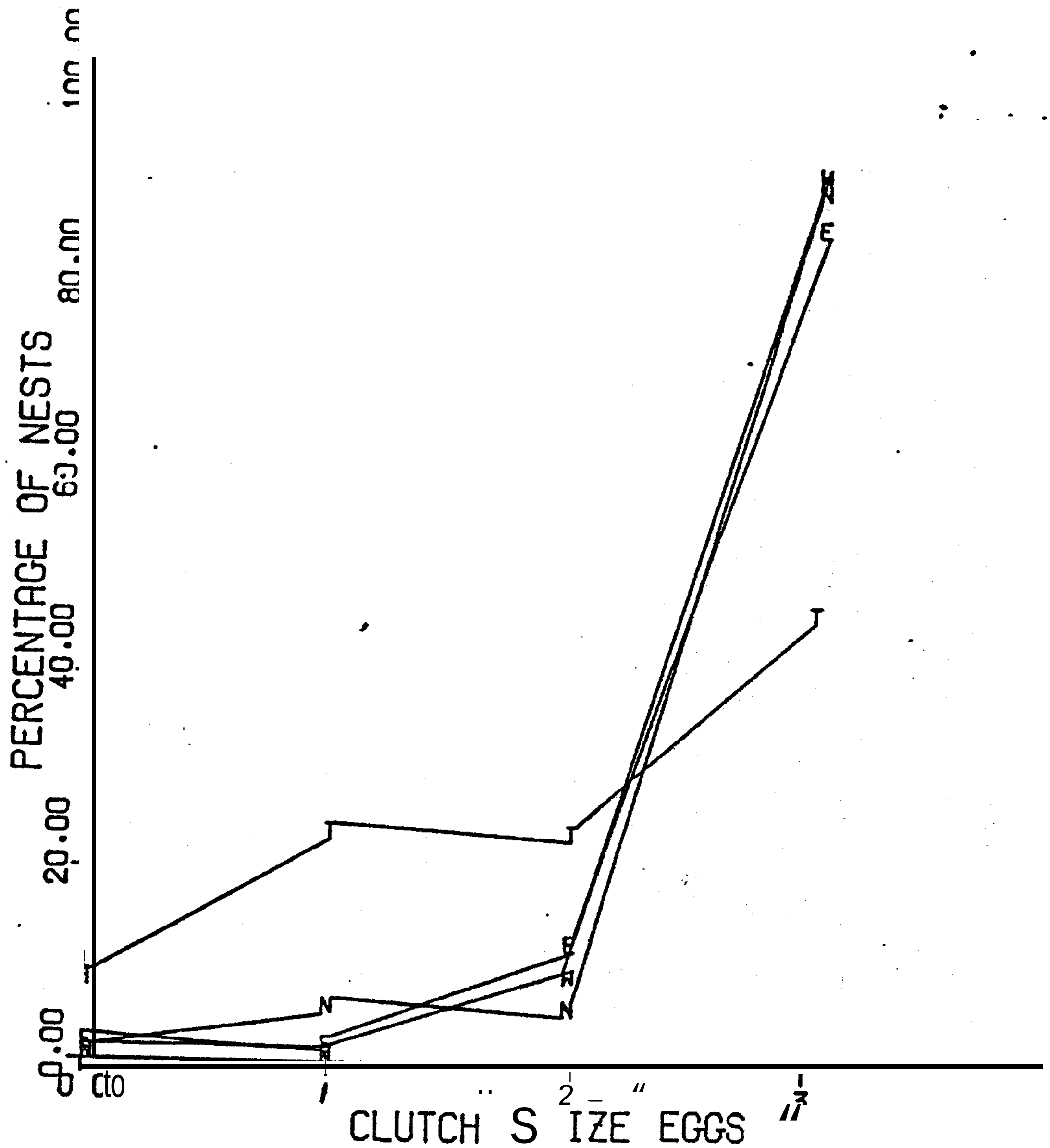


Figure 25. Clutch size plotted against percentage of nests, North Marble Island, 1972.
E = East Colony, W = West Colony, N = North Colony, T = Top Colony.
Top colony is different in clutch size; East, West and North are similar.

The most likely explanation for the difference is young females laying for the first time produce smaller clutches.

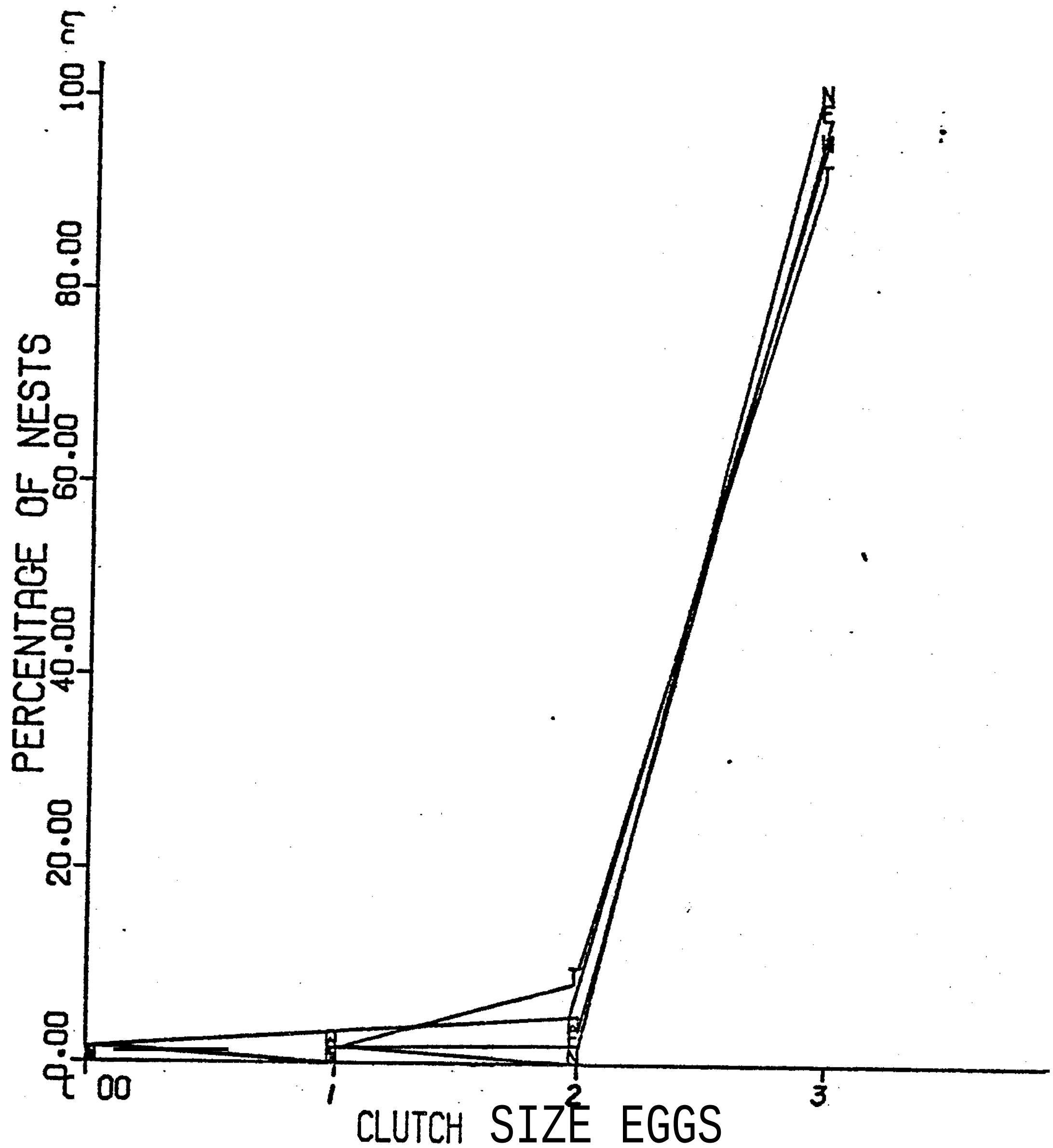


Figure **26**. Clutch size plotted against percentage of nests, North Marble Island, 1973.
E = East Colony, W = West Colony, N = North Colony, T = Top Colony.
All colonies show similar tendencies.

approaches three, in the sense that most single counts will show only 60 to 80 percent three-egg clutches. Egg loss is widespread, in some cases occurring immediately after egg-laying. Egg-dates of females in the same colony may be spread over several weeks. Thus there is no one day on which all nests have the full number of eggs, and gulls do not lay again unless the completed clutch is destroyed.

We examined 750 nests each season at Egg Island for evidence of egg pathologies. Both years we found nests with eggs stikingly subnormal in size and weight (Table 3; Fig. 27,28, 29). These nests contained one "runt" egg each in addition to one or two other "normal" eggs. The "runt" eggs were not viable and" contained little tissue or fluids. Ohlendorf (pers. comm.). informs us of "runt" eggs in museum collections. Haycock and Threlfall (1975) found abnormally small eggs in an *argentatus* colony in Newfoundland; Goethe (1937) also reported such eggs in gull colonies and speculated that the eggs were formed when albumen and membranes were deposited on traces of yolk. Female gulls laying for the first time tend to produce smaller and fewer eggs (see above). The most likely reason for "runt" eggs and smaller clutch size in the Egg Island population is the greater proportion of young females.

Table 3

Egg Pathologies:
Weights and Measurements of "Runt"
Eggs Compared to Normal Range

Egg/yr.	Weight (gin)	Length (mm)	Width (mm)
A (1975)	8.5	44	28
B (1975)	10.0	40	29
C (1975)	34.8	48	38
D (1975)	5.0	46	37
E (1976)	35.0	56	42
F (1976)	20.0	49	40
"Normal" Range	60.0 - 110.0	70 - 80	50 - 60

Weight varies with the state of incubation but does not drop below 60.0.

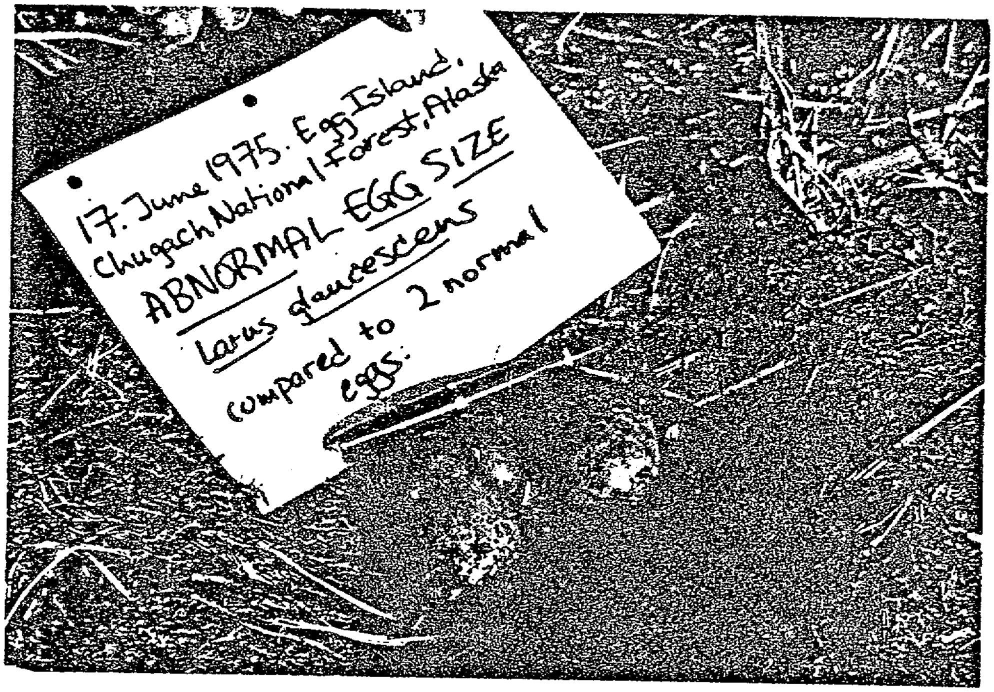


Figure 27. Abnormal egg size, example #1.

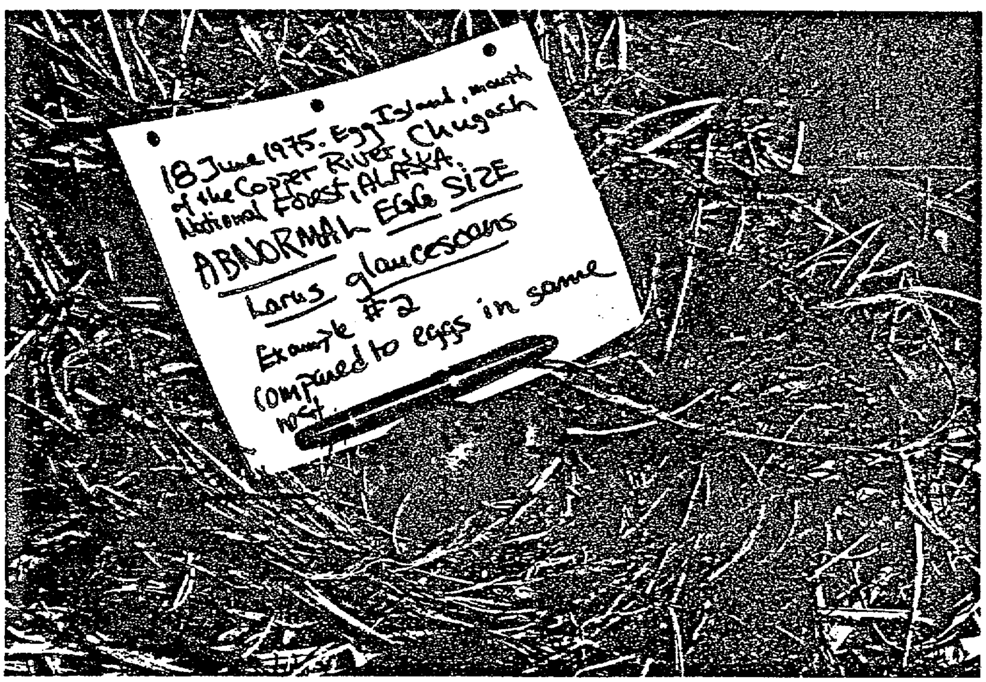


Figure 28. Abnormal egg size, example #2.

Table 4

Egg Pathologies:
Supernormal Clutches, Egg Island

Clutch 1 17 June 75 Weights (gins)	clutch 2 9 July 75 Weights (gms) & Size (mm)		Clutch 3 1976	Clutch 4 1976
A 80	68	76 x57	4 eggs :	5 eggs:
B 83	70	76 x57	1 died pipping	nest abandoned;
C 85	68 (chick <1 day old)*		1 predated	eggs destroyed"
D 79	68 (chick 1 day old)		2 hatched.	

* eggshell 7.5 gms

Egg Loss

Patten (1974) previously reported a mean clutch size of 2.9 for glaucescens in Glacier Bay. Clutch size at Egg Island is lower, probably due to greater proportion of young females in the population. For purposes of discussion, we assume a clutch size of 2.4 at the beginning of the 1975 incubation period at Egg Island, similar to what we report for 1976. Our figures at the end of the 1975 season indicated we had observed 339 eggs in the study area of 153 nests. Of these 339 eggs, 254 hatched. Nine (9) eggs were apparently infertile or pipped but failed to hatch (see below). Total egg loss amounted to 114 eggs or nearly 31% in the study area (Table This is on an island with 8000-10,000 pairs of gulls--all potential egg predators. Results of our 197'2-73 investigation on North Marble indicate a 26-27% egg loss there, in a colony of 500 pairs. These figures suggest a general 30% egg loss to predation in the northeast Gulf of Alaska, principally due to other gulls, raven, crows and jaegers, but not necessarily including subsistence egging by fishermen or Natives, in which egg loss can be quite high in certain areas (Fig. 31, 32, 33, 34).

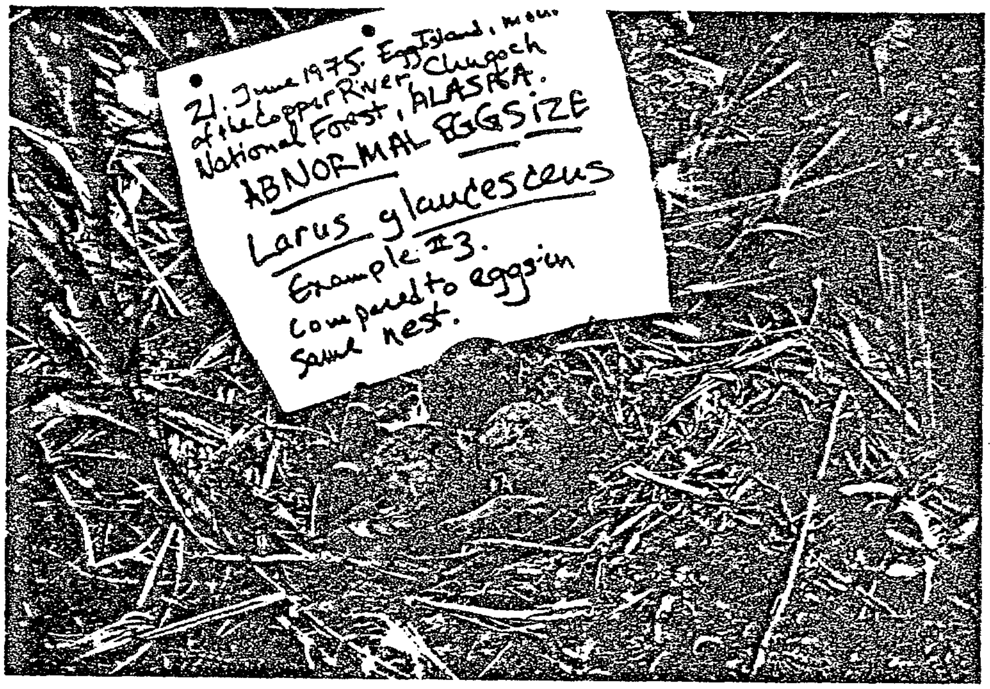


Figure 29. Abnormal Egg Size, Example # 3.

Figure 30. Supernormal Clutch, Example # 1.

Hatching failure can be conveniently divided into three classes (Paynter, 1949): eggs disappearing (lost) from the nests during incubation; eggs which remained in the nests but did not hatch (dying); and eggs which were pipped but the chick died before emerging, Loss of eggs through predation (including other gulls) was the principal factor influencing hatching rate on Egg Island (1975-76) and on North Marble (1972-73) (Table 5). We observed gulls, ravens and crows on Egg Island and North Marble taking gull eggs. At Dry Bay we noted Parasitic Jaegers foraging on gull eggs. In all three colony locations the gulls appear to be the more serious predators simply because of their overwhelming numbers (excluding human predation). A major difference between human and gull predation is that humans remove complete clutches, while gulls tend to take only one egg at a time. Loss of the complete clutch will stimulate gull pairs to re-nest if loss is early enough in the season. It is the large clutch size and ability to re-nest following clutch loss that allows gull populations to absorb considerable punishment in comparison to murres, for instance .

L. argentatus loses eggs most commonly through predation from nonspecific adults according to Paynter (1949) and Paludan (1951). Vermeer (1963) reported the opposite for glaucescens on Mandarte; more eggs in his study failed to hatch than were taken by predators. Keith (1966) found a population of Lake Michigan argentatus, contaminated by DDT, in which the chief cause of egg mortality was embryonic death. Gulls lack the ability to deal with this sort of chemical mortality agent because the gulls will continue to incubate dead eggs and not re-nest during the season (see Egg and Clutch Replacement, below). Hunt and Hunt (1973) located a colony of Western Gulls (occidentals) in which many clutches containing four or five eggs were found (Santa Barbara Island, CA). It is particularly interesting that in these

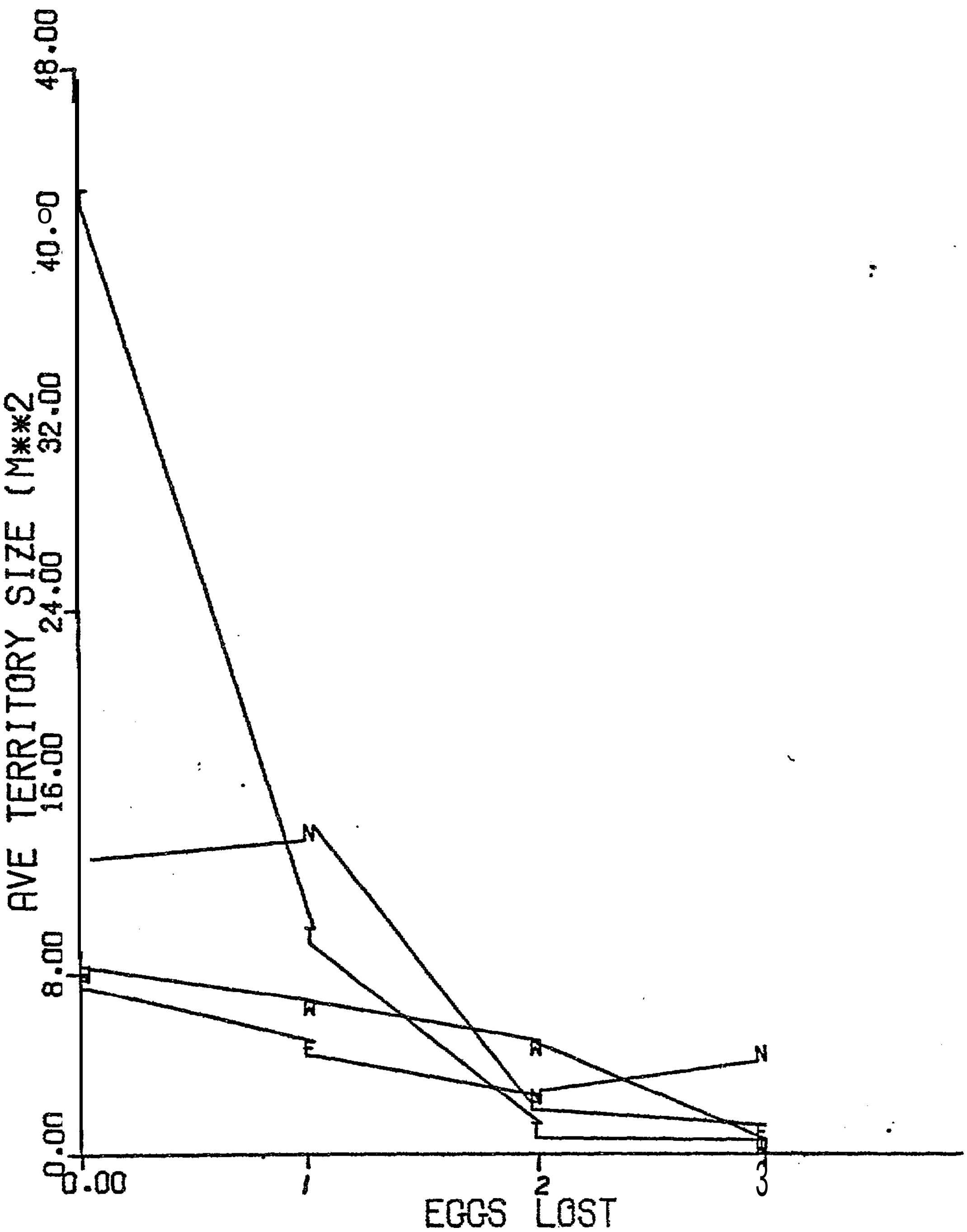


Figure 31. Eggs lost plotted against average territory size, North Marble Island, 1972.
E = East Colony, W = West Colony, N = North Colony, T = Top Colony.
Although Top Colony is significantly different in average territory size, proportionate eggloss is similar to the other colonies.

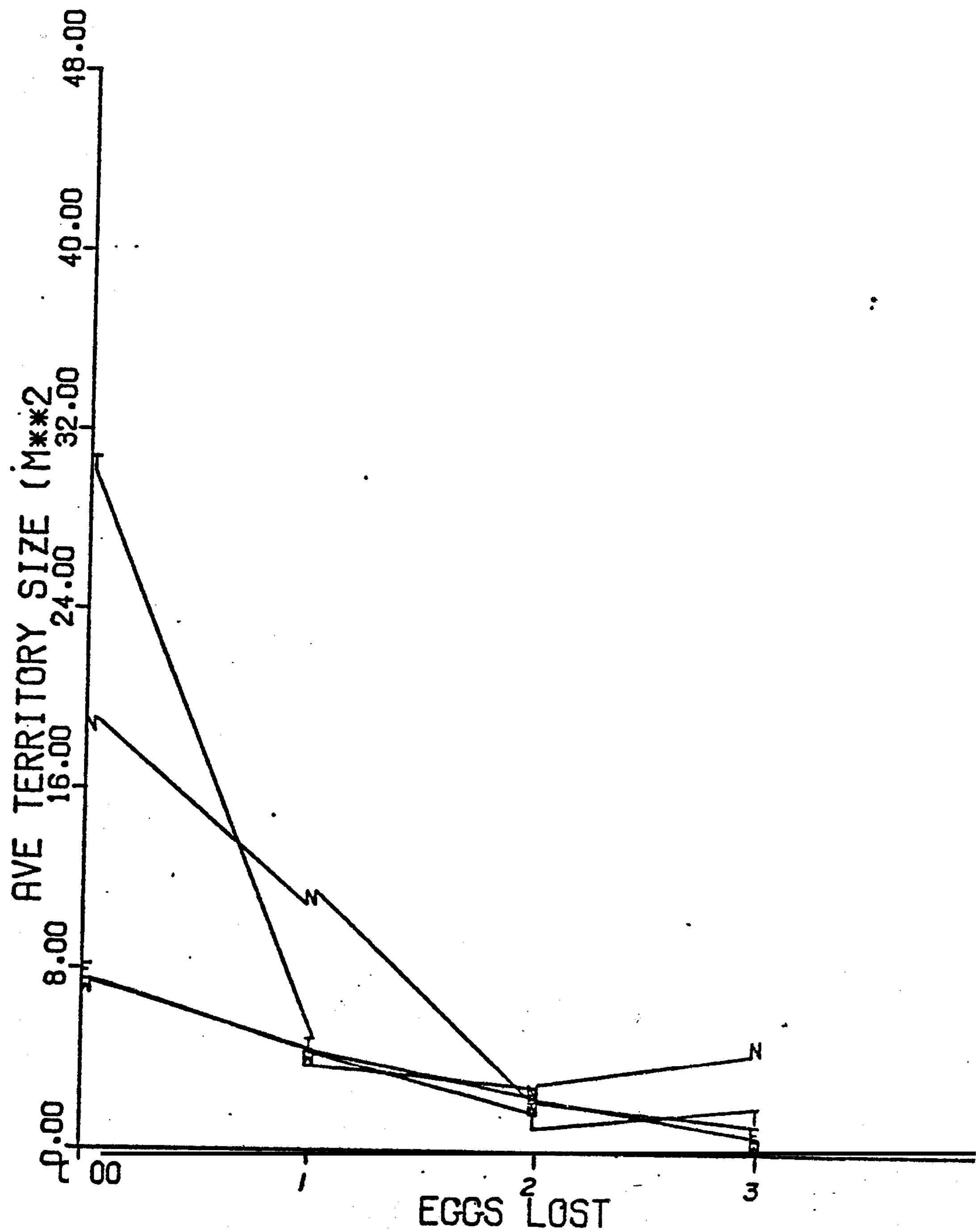


Figure 32. Eggs lost plotted against average territory size, North Marble Island, 1973.
E = East Colony; W = West Colony, N = North Colony, T = Top Colony.
All colonies show similar trends in egg loss.

large clutches not only was hatching success low but also eggshell thickness was reduced. Hunt and Hunt originally suggested the eggs may have been contaminated with pesticide residues but now offer an alternate explanation (see above).

Table 5

Numbers of "Lost", "Infertile" and "Pipped" Eggs Which Did Not Hatch in the Study Areas: Egg Island (1975-76); North Marble (1972-73)

Colony & Year	Total Eggs	Lost Eggs	Infertile Eggs	Pipped, but Did Not Hatch
Egg Island (1975)	386	114	8	1
Egg Island (1976)	447	104	9	1
North Marble (1972)	455	125	22	2
North Marble (1973)	566	150	26	1

A low cause of non-productivity on Egg Island and North Marble was failure to hatch. Incubation and et-her influences seemed normal from gross field examination. Study of the few decayed eggs did not reveal developed embryos or any specific reason for mortality (cf. Paynter, 1949). We have tentatively concluded the eggs were infertile since the relative percentage of unhatched eggs was very low, and eggshells showed no signs of fragility or pesticide contamination. Ohlendorf (F&WS Patuxent) is examining samples of gull eggs from Egg Island, Copper Sands and Strawberry Reef for petroleum hydrocarbon residues prior to the development of offshore oil resources. Paynter (1949) and Brown (1967) also reported low numbers of "infertile" eggs in their gull studies.

Study Area

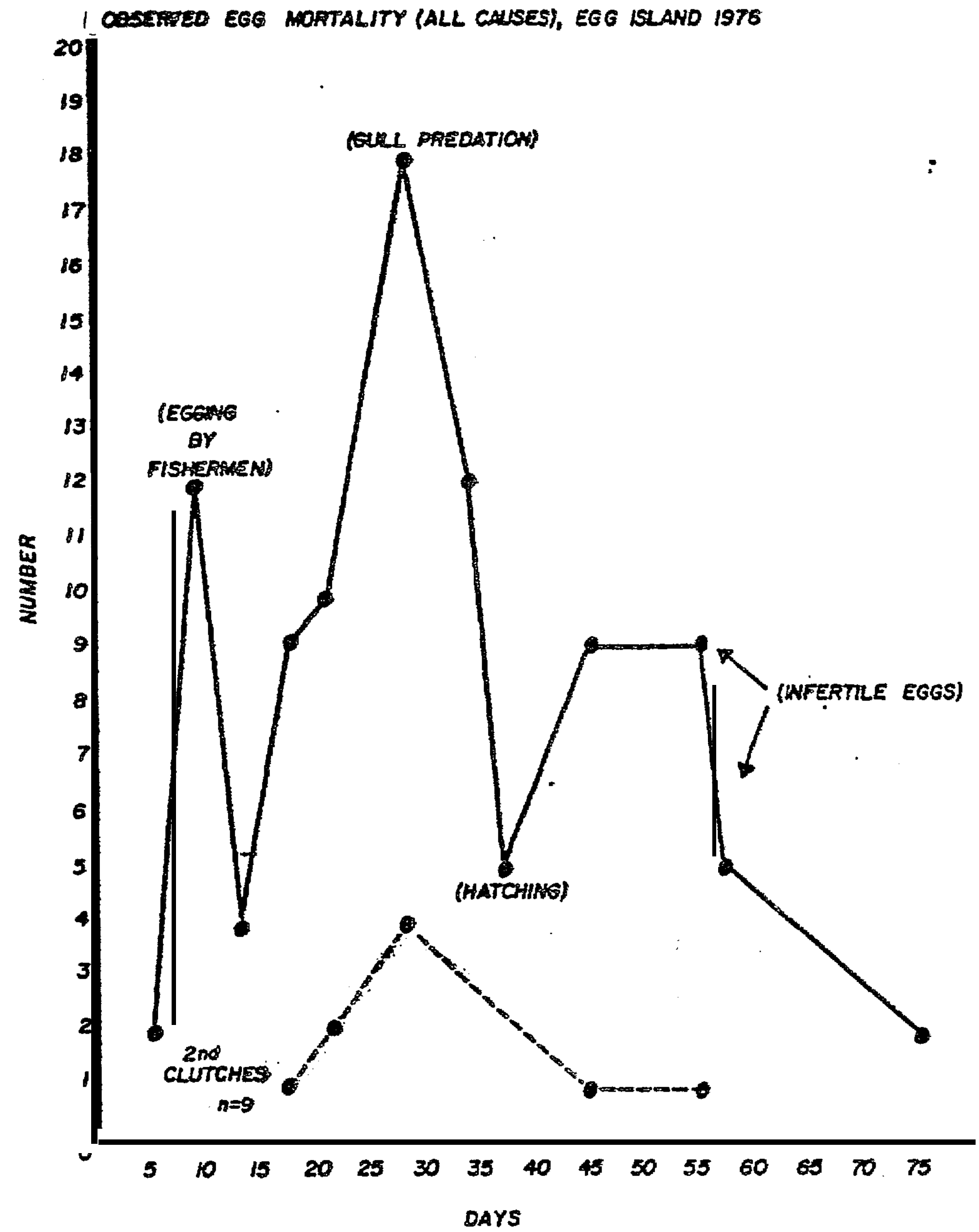


Figure 33. Observed egg mortality (all causes), Egg Island, 1976. Day "0" is 20 May. Note replacement clutches.

Study Area

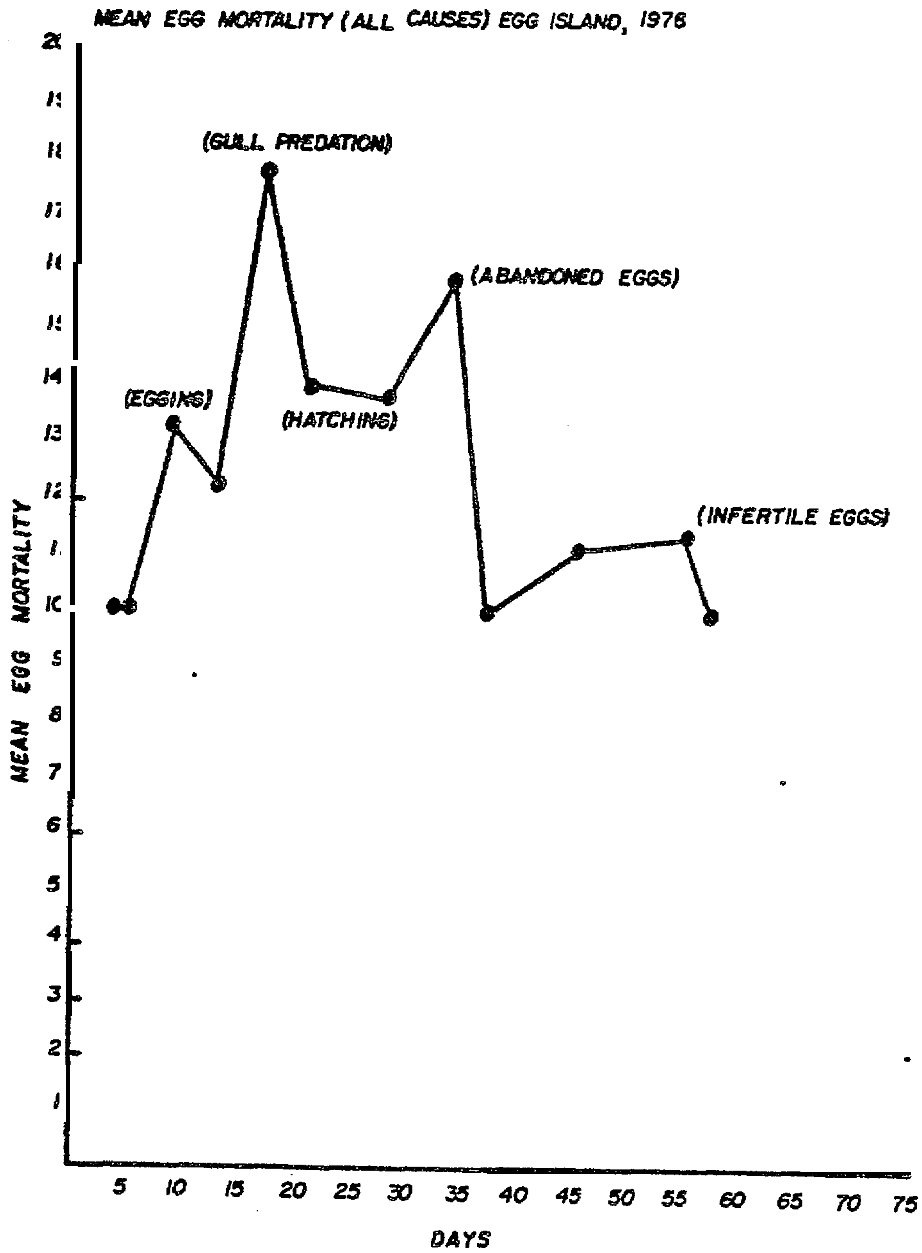


Figure 34. Mean egg mortality per day (all causes), Egg Island, 1976.

The last cause of failure to hatch occurred when the chick pipped the shell but failed to emerge and died. There was only one case of this in the Egg Island study area in 1976; one case on Egg Island in 1975; and three cases on North Marble (1972-73]. These are insignificant figures.

Pigmentation of eggs on Egg Island was observed to be quite variable, ranging from virtually none (pale blue with no spots) to dark olive with many spots. Variation in eggshell pigment has been widely reported and is not directly involved with hatching or fledging success (Tinbergen, 1960), although light-colored eggs in grassy meadows may be more susceptible to predation (Kruuk, 1964).

Egg and Clutch Replacement

Replacement clutches seem to be important only when large disturbances occur to colonies (Vermeer, 1963). Paludan (1951) recorded Herring Gulls laid replacement clutches after a snowstorm. We encountered no such major disturbance on North Marble but our figures show some egg-laying still continuing in July each year on Egg Island. This may represent replacement clutches following sequential egg predation by other gulls, but as we have indicated most likely represents recovery from egging by fishermen. Loss of the entire clutch after sufficient incubating to supress the fourth follicle results in a replacement clutch in *argentatus* and *fuscus* in 11-12 days (Paludan, 1951) and in *ridibundus* in a similar period (Weidmann, 1956 *in* Vermeer, 1963). Vermeer (loc. tit] found replacement clutches in *glaucescens* took a slightly longer time, probably due to his experimental procedure (trapping).

Sequential loss of eggs as they are laid enables production of four eggs, as evidenced by *argentatus* and *fuscus* (Paludan, 1951) and *ridibundus* (Weidmann, 1956 *in* Vermeer, 1963). Vermeer (loc. tit) demonstrated the same for *glaucescens* and that the interval between eggs was similar to undisturbed clutches. The reason for egg loss in Vermeer's (1963) study was crow predation resulting from human disturbance. Vermeer (loc. cit) found more eggs in both years of his study failed to hatch than were taken by predators. Perhaps this represents lack of predators close to Victoria, B.C. or some form of chemical pollution resulting from the Greater Vancouver area.

Attempts have been made to control the New England Herring Gull population by treating eggs with a mixture of formaldehyde and oil (Gross, 1950). An egg destruction program was planned to inhibit the growth of the gull population During the first years of the gull control program, Gross (F&WS) punctured eggs. However, the eggs so treated then rotted, burst, and the gulls again laid complete clutches in the usual pattern. Gross then shifted to spraying eggs with formaldehyde and oil. Formaldehyde is of course cytotoxic, but we wish to point out that oiling of the eggs also acted to inhibit the respiration of the developing embryo by sealing the egg in addition to the toxic effects of the oil itself. Indeed experiments carried out during our study indicate that mineral oil (non-toxic) applied to the surface of gull eggs in sufficient quantity leads to high embryonic mortality. If adult gulls resting on contaminated water become oiled about the breast feathers, then oil could be transferred to eggs during incubation, causing embryonic mortality through physical or chemical activity. If the embryos died, and the oil prevented much bacterial action, then adult birds would continue to incubate the eggs for long periods and not re-nest during the season. Gross (1950) found 95% mortality of gull eggs treated in the above manner, and reported the numbers of gulls nesting on treated (oiled) islands decreased more rapidly than could be attributed to adult mortality, indicating a net emigration of adults from these colonies. We indicate the possibility of such occurrences in the NEGOA, with unfortunate consequences for marine birds including gulls.

Incubation Period

Patten (1974) has previously reported a range of onset of incubation on North Marble Island from 29 May to 10 June. Beginning of incubation in colonies at Egg Island, Haenke Island and Dry Bay apparently falls within this time range, suggesting that gulls along this entire stretch of coastline breed at about the same time., The beginning of incubation was synchronized in all colonies on North Marble; most gulls began brooding at about the same time, despite the somewhat. larger spread of egg-dates from colony to colony. The abrupt synchrony of chick hatching both years of the North Marble study reflected the synchronized onset of incubation (Fig. 35) . The wider spread of chick ages on Egg Island reflects less synchrony in onset of incubation as well as greater spread of egg-laying following egg collecting by humans (Fig. 33,34,36).

Median dates from onset of incubation to hatching established an incubation period of 24 to 27 days on North Marble. Modal hatching dates indicate the usual eggs were incubated for a period of 26 days. On Egg Island, 50% of eggs in the colony were laid by Day 10, and 50% of eggs in the colony hatched by Day 35 (Fig. 21, 35), demonstrating a median incubation period of 25 days. Similar incubation periods have been reported by Tinbergen (1960), Vermeer (1963), Keith (1966), Schreiber (1970) and Harpur (1971).

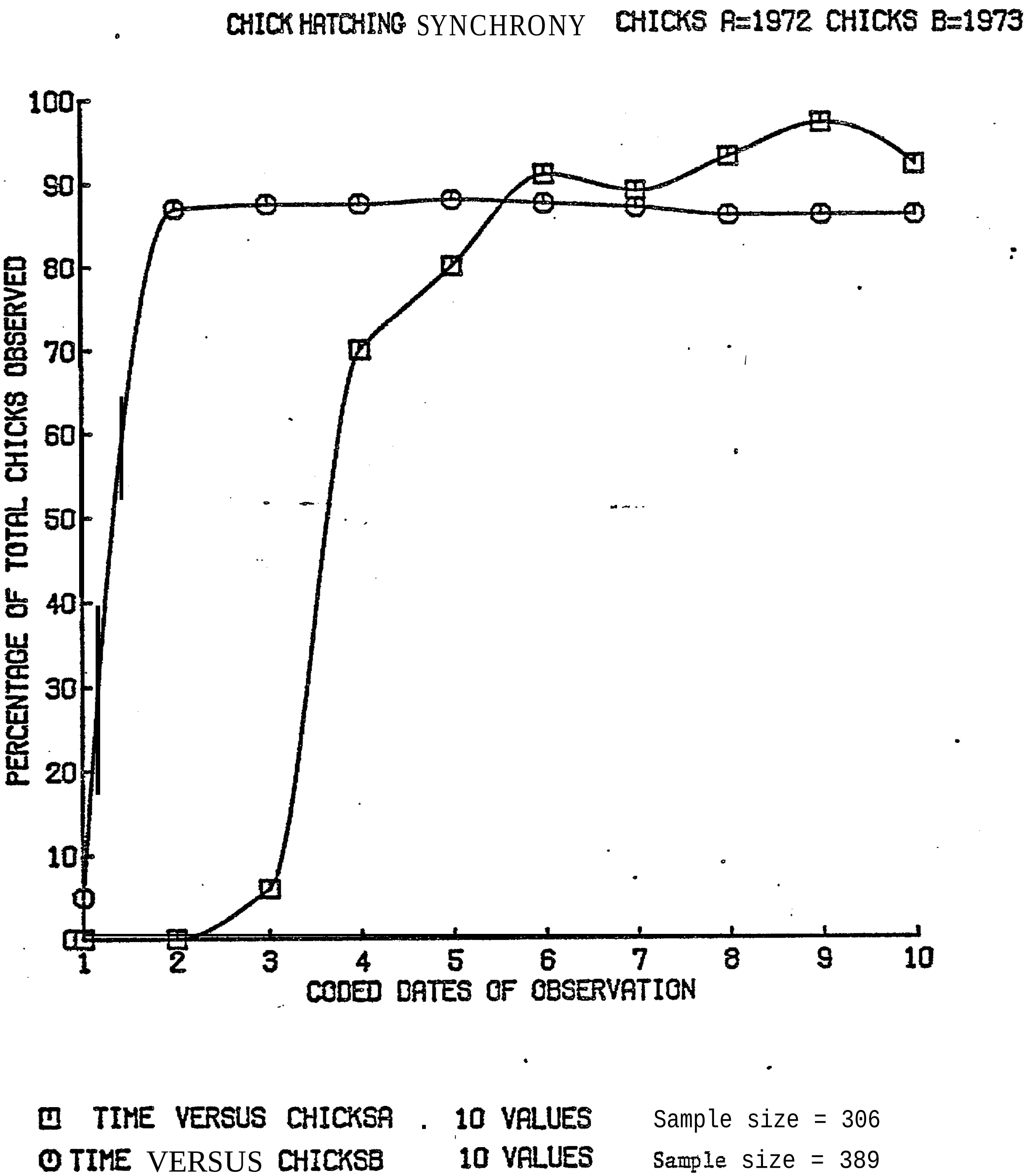
Eggs on North Marble lost about 18% of their weight during incubation, beginning incubation at a mean 97.6 gins/egg. The eggs weighed 80.5 gins/egg at the end of incubation. Calculations based upon egg weights at Dry Bay in 1975 indicated an onset of incubation of 10 June and a mean hatching date of 5 July.

Chick Stage

A chick, as defined by Schreiber (1970) is a bird from time of hatching until departure from the nesting island, after which it becomes a -juvenile gull in our terminology.

Chick hatching was quite synchronous both years of the North Marble study. In 1972, 70 percent of gull chicks hatched between 4 and 9 July; in 1973,87 percent of chicks hatched between 23 and 25 June. In general, chick hatching was two weeks earlier in 1973 than in 1972; hatching was also more synchronous. Synchronous hatching reflects both egg-laying and incubation synchrony. Chick hatching was not especially synchronous on Egg Island in 1975. We observed two peaks of hatching; the majority of chicks hatched in late June, while a smaller group hatched in mid-July. The most likely explanation f-or this spread of hatching is re-nesting by gull pairs following subsistence egging by fishermen in early June. Presumably, synchrony of egg and hatching dates provides better protection from natural predators (eagles, ravens, crows) which can take only a certain percentage of eggs or chicks at any one time {Darling, 1938) (Figures 20, 21, 35, 36).

Gulls are unusually quiet during incubation. When chicks hatch, adult gulls give long (territorial) calls much more frequently, and also become more aggressive when chasing other gulls or corvids from their territories which may be expanded at hatching time (Hunt & Hunt, 1975, 1976; also Tinbergen, 1960; Vermeer, 1963). Adult gulls continue incubation during hatching, although the intensity of the drive apparently decreases rapidly, correlated with the development of homeothermy in the chicks. Adult birds remove eggshells up to 20m away from nests by picking up and dropping eggshells in flight. Presumably there is a strong selective pressure for removal of eggshells in the nests as an anti-predator device, Gulls are extremely wary with young in the nests, and fly up at the slightest alarm. Defensive adult gulls defecate on observers or strike them with lowered feet. Adult gulls react to all newly hatched young



Sample size = 306

Sample size = 389

Figure 35. Chick hatching was quite synchronous both years of the North Marble Island investigation, although chick hatching occurred two weeks earlier in 1973.

Study Area

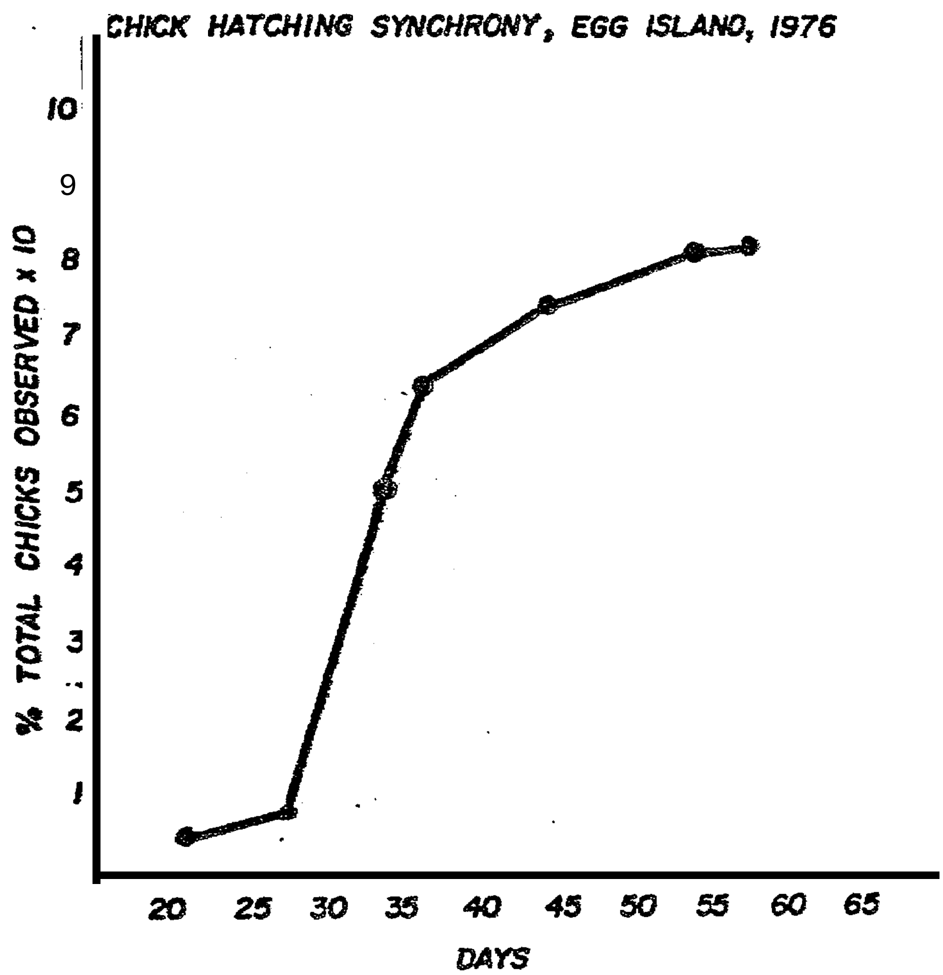


Figure 36. Chick hatching synchrony, Egg Island, 1976. "Days" are read from the date of first eggs observed.
Chick hatching on Egg Island was less synchronous than North Marble Island.

by directing parental behavior towards them (Tinbergen, 1960). Gulls rapidly learn to know their own young, and hostile behavior towards strange chicks develops within a week (Tinbergen, 1960). Gull parents react to the call of their own chicks, even when they cannot see them (Goethe, 1956), while they do not react to strange chicks under similar circumstances. Goethe (1956) thus concluded that voice is an important factor in adults recognizing young.

The cryptic pattern of dark vs. light on the chick's head may in addition be important for individual recognition by parents (Goethe, 1956; Tinbergen, 1960; Lorenz, 1970). In this context we wish to emphasize the results of some of our 1975 color-dyeing experiments on Egg Island. We planned originally to color-dye all 1975 chicks produced in our study area in order to trace their movements. In accordance with the plan we completely dyed 21 chicks with nyansol, a purple-black dye. We found immediately thereafter (in two days) seven of the 21 chicks dead, a 33 percent mortality (Table 6). The parents may not have continued to feed the young due to non-recognition, or the young birds may have died from exposure resulting from evaporation of the isopropyl alcohol which is the solvent for the dye. The color-dyeing of the complete plumage of young gulls was immediately dropped due to the mortality rate. Outside of the study area proper on Egg Island, we dyed 80 chicks with nyansol on the tail, rump, abdomen and axillaries, in other words parts of the body that are probably not important for individual recognition. Marking parts of young birds unrelated to individual recognition led to no observed mortality. Tinbergen (1960) suggests this is certainly an interesting field for experimental work (supported by Goethe, 1956). With this background in mind, we wish to point out that if young gulls are oiled for whatever reason about the head, individual recognition of chicks by parents may be destroyed, leading to mortality of the young. This topic will be covered in the 1977 field season (R.U.#96-77).

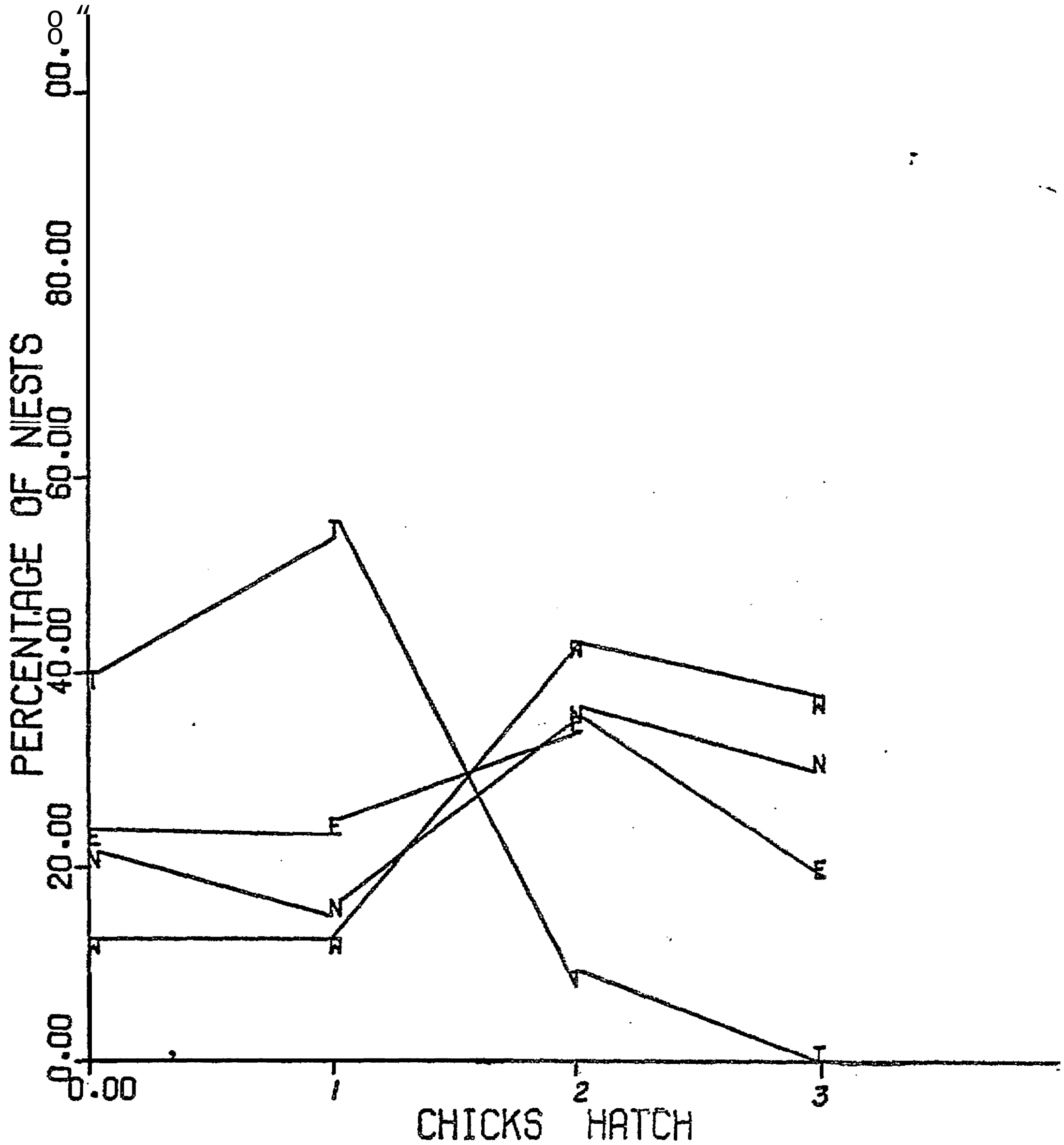


Figure 37. **Chicks** hatching plotted against percentage of nests , North Marble Island, 1972.
E = East Colony, W = West Colony, N = North Colony, T = Top Colony.
East, West, and North Colonies are quite similar in number of chicks hatching per nest. Top Colony, due to smaller mean clutch size, produced fewer chicks hatching in proportion.

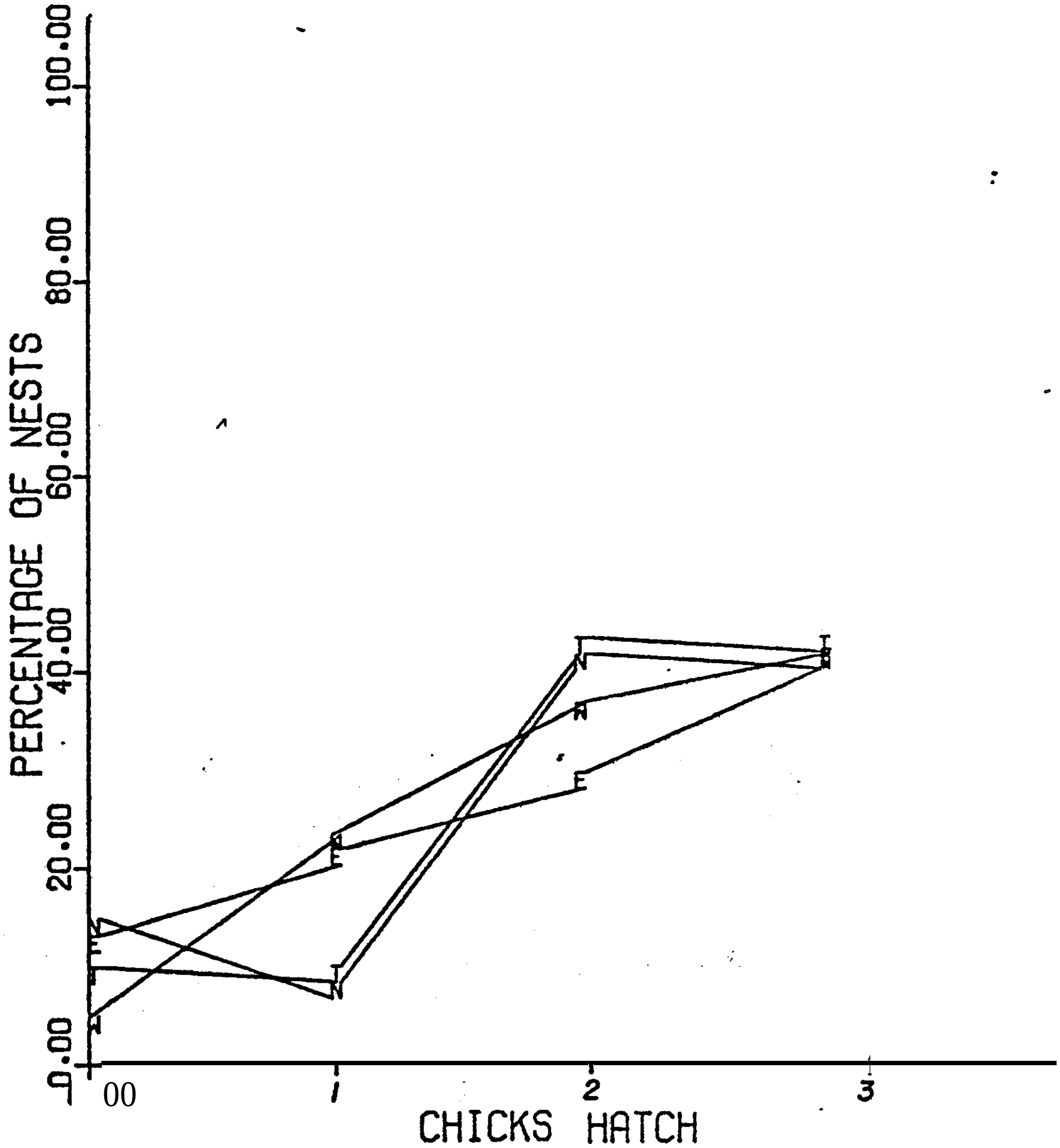


Figure 38. **Chicks** hatching plotted against percentage of nests, North Marble Island, 1973.
E = East Colony, W = West Colony, N = North **Colony,**
T = Top Colony.
All colonies show quite similar tendencies in proportion of chicks hatching.

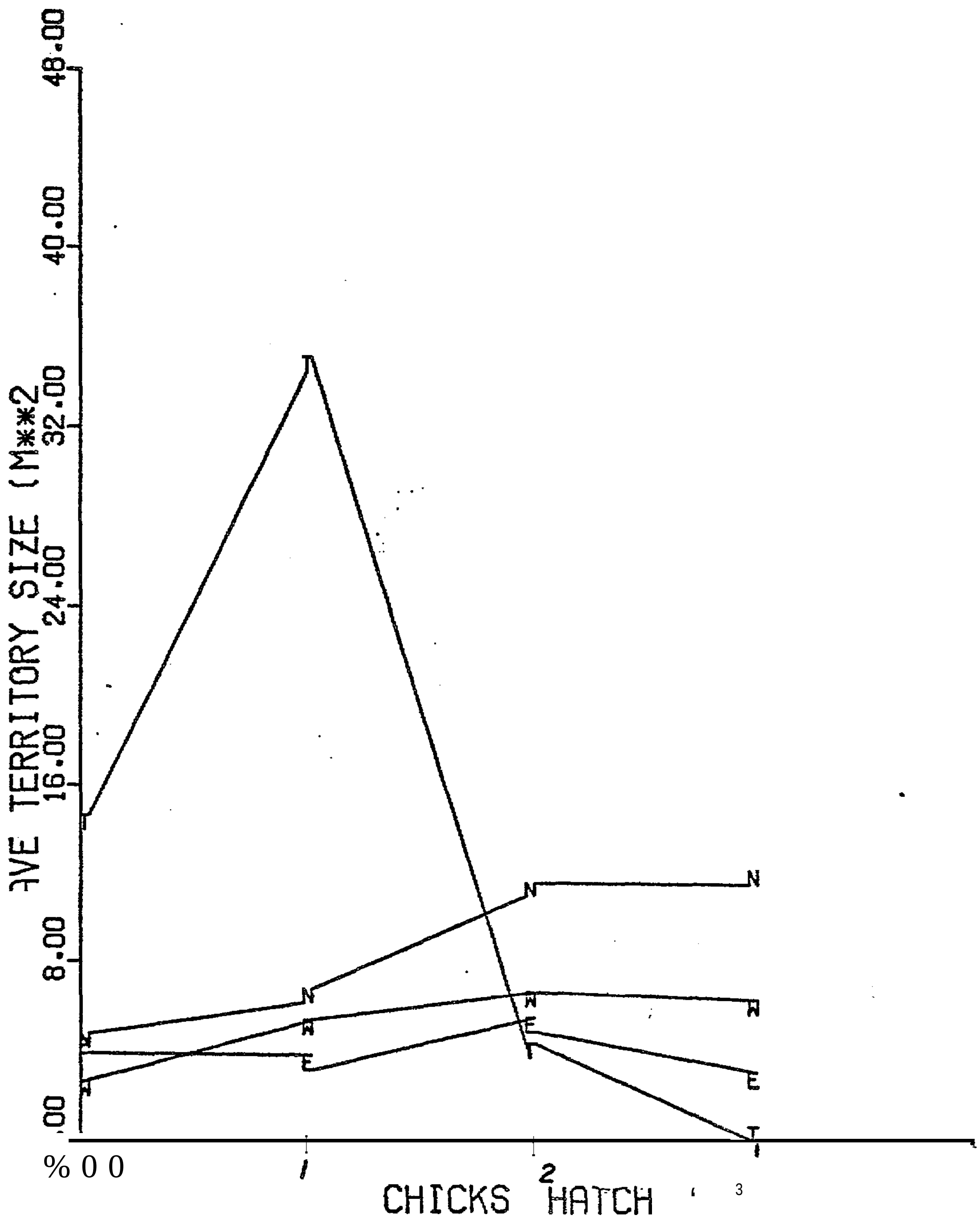


Figure 39. Chicks hatching plotted against average territory size, North Marble Island, 1972. E = East Colony, W = West Colony, N = North Colony, T = Top Colony. East, West and North Colonies are quite similar in number of chicks hatching in relation to average territory size. Top Colony is significantly different, with large territory size and fewer chicks produced.

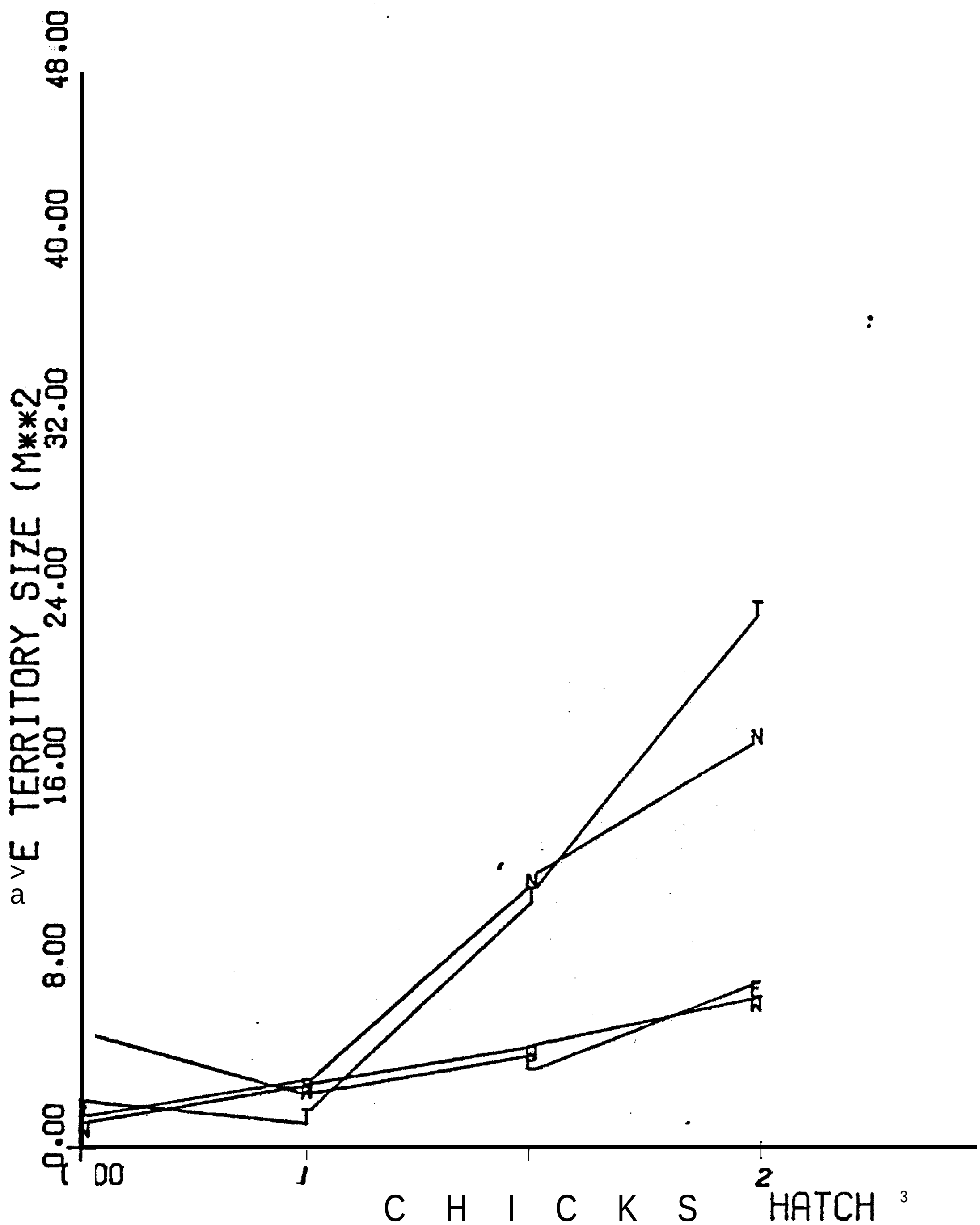


Figure 40. Chicks hatching plotted against average territory size, North Marble Island, 1973.
E = East Colony, W = West Colony, N = North Colony, T = Top Colony.
Top and North Colonies, with similar territory sizes this year, are closer to each other than to the East and West Colonies in proportion of chicks hatching. However, all colonies show similar tendencies.

Table 6

Analysis of Seven Mortalities
Associated with Color-Dyeing
With Nyansol (purple-black),
Egg Island, 1975.

Chick	Mortality Reasons (apparent)
A	intrusive skull fracture posterior to orbital region
B	acute inflammation of distal portion of right wing
C	consolidation of upper left lung
D	unknown; had been feeding
E	unknown
F	unknown
G	unknown

Sample size: 21 nearly-fledged gull chicks, completely color-dyed in the study area. None had blood samples taken.

'Control': 80 chicks outside study area proper were partially color-marked on lower portions of body: no observed mortality. Most of these birds had 3 - 5 cc blood removed from wing vein for serological survey.

We also point out that if chicks become oiled on other parts of the body, development or maintenance of homeothermy may be prevented, leading to death from exposure (McEwan & Koelink, 1973). Since chicks have little energy reserves, and often expire during periods of bad weather (see below), impairment of homeothermy through oiling must be regarded as a possibility.

The period of hatching, which in the northeast Gulf of Alaska is centered around the last week of June, is a critical time in the gull reproductive cycle. Adult gulls must shift their behavior from incubating to brooding, food-gathering, and feeding young (Vermeer, 1963).

Even under normal" circumstances, some adult gulls do not complete this shift in behavior patterns, or are inept at it. Paynter (1949), Paludan (1951) and Harris (1964) agree that major chick mortality occurs within a few days of hatching. It is during this period that gull colonies are most vulnerable to human disturbance because chicks are weak and defenseless, not mobile, and adults are changing behavior, giving at times inappropriate responses to environmental stimuli.

Physical characteristics and boundaries of the territory are learned by chicks as they develop. Chicks run to accustomed hiding places when adults give alarm calls (Tinbergen, 1960). Fortunately this made the chicks easier for the investigators to locate. For about two days after hatching, chicks remained in or next to the nest and made no consistent attempts to hide other than remaining quietly on the bottom of the nest. Then for several days chicks hide behind grass tussocks near the nest and were more difficult to locate. Goethe (1956) found attachment of young to territory is very strong; in experiments young returned to home territory over distances ranging from 20m to 70m although long detours may take several days. Chicks begin to swim on their own at about two weeks of age, and with increasing mobility and coordination they attempt to move down and away from main colony sites when disturbed. 'Chicks close to the edge of the island flee into the water. Water apparently does not provide the proximate stimulus for this behavior since chicks from high dunes at the center of Egg Island move out into open sandy areas when disturbed. While swimming, chicks from the edge of the island aggregate into small flocks. Small groups of chicks swim back to the island and creep back up to nest sites following disturbance in submissive posture, with heads down. If young birds must cross many territories to have access to water, mortality is increased due to interaction with defensive adult gulls. If aquatic borders of island colonies become heavily oiled during the times when chicks exhibit this behavior pattern (in July) avoidance behavior (to terrestrial predators such as humans) by chicks would lead them into oil S licks. The synergism between disturbance and oiling would lead to high mortality.

Nearly fledged chicks wander extensively in and out of less defended territories towards the end of the breeding season. A flightless chick with a tall tarsal band, indicating origin in the Egg Island study area near the Light, was found in late July 1975 1 km further west along the main dune line. Banding activities early in the chick season may have created severe disturbance in the study area. This may need to be taken into account in reporting this baseline data. In order to reduce disturbance associated with colony surveys and banding chicks, we concentrated our banding activities late in the season in 1976 (see above). A certain amount of disturbance is unavoidable here individual counts are necessary, Wandering chicks at the close of the season form small flocks at the base of the dunes near the water, or if no water was nearby, chicks grouped at the edge of open sandy areas, where they were fed by parents. Southern (1968) noted response to disturbance of *L. delawarensis* that were similar to other observations of *glaucescens* young in Alaska (Patten, 1974);(see also Gillett, 1975; Robert, 1975).

Mortality Factors

Observed chick mortality was low (30 chicks) in the 1975 season in the Egg Island study area. Most chicks (74) failing to fledge simply disappeared (Table 7, 8). If we include the seven chick mortalities associated with color-dyeing, then productivity in the study area on Egg Island was 157 individuals. Similarly in 1976 observed chick mortality was 27 individuals, 108 disappeared, and 208 fledged (Table 7, 8).

As indicated in previous discussions above, one of the main factors affecting chick mortality and fledging rate in this and other gull studies was the habit of adults to attack strange chicks (Paynter, 1949; Tinbergen, 1960: Vermeer, 1963; Patten, 1974). It was not unusual to note adult gulls attacking chicks that had wandered from their natal territories into neighboring areas. We found most dead chicks on Egg Island about three weeks of age, in contrast to North Marble, where most dead chicks were found during the first week after hatching. Killing at North Marble does not seem confined to any particular age group, but is greatest when chicks are small, unable to retreat rapidly, or give appeasement displays. On Egg Island chick mortality seems most related to the age at which chicks begin to wander widely, at which time they trespass into neighboring territories (Fig. 41).

The dead chicks on Egg Island and North Marble were usually away from any nest site, and typically exhibited head injuries. Small chicks are easily swallowed by adult gulls (Brown, 1976b), perhaps accounting for some "chick disappearance. Vermeer (1963) noted that most chick mortality on Mandarte Island, B.C., occurred in the first week after hatching where gull territories were smaller ($15.7 m^2$ vs $29.6 m^2$). Paynter (1949) and Paludan (1951) also ascribe most of the chick mortality in Herring Gulls to aggressive behavior in adults.

There has been much speculation about the reasons for this killing (Paynter, 1949). Tinbergen (1960) believes that it may be due to the highly developed territorial defense of breeding adult gulls towards any moving abject. It may be that selection is operating so that chicks remaining strictly on their natal territory will have a better chance of survival.

Harpur (1971) suggested that chick mortality may be more a function of crowding than of absolute colony size. The rise in mortality in crowded colonies could be due to the increase probability that small chicks wander into nearby territories and are killed (see also Hunt & Hunt, 1975; 1976; Hunt and McLoon, 1975). The high average (about 85%} from the larger colonies reported by Harris (1964) support this hypothesis. However, Patterson (1965) and Vermeer (1963) could find no significant differences in chick mortality related to various colony sizes.

Table 7
Chick Mortality, Egg Island, 1975-76
North Marble Island, 1972-73

Study Area/Year	Chicks Hatching	Observed Mortality	Disappeared	Fledged
Egg Island 1975 (153- nests)	254	30	74	157
Egg Island 1976 (186 nests)	343	27	108	- 208
North Marble 1972 (162 nests)	304	16	5	283
North Marble 1973 (191 nests)	390	31	16	343

Total mean chick mortality on Egg Island was 38% (mean of both seasons). Chick mortality was lower (7%) during Patten's Glacier Bay study, where conditions are considerably different (Table 8). Coulter et al (1971) reported a mean 11% chick mortality for Western Gulls on the Farallons, and Harpur (1971) found chick mortality for Western Gulls in a colony in the Channel Island off Los Angeles to be 37%. Harpur (1971) stated that except for human disturbance, chick mortality might have been as low as 7%. We believe the Egg Island situation represents disturbed conditions due to easy access by boatmen, picnickers and dogs, all of which we have observed, and which probably account for the larger numbers of chicks which disappeared.

Table 8
Percent Chick Mortality, Egg Island 1975-76
North Marble Island 1972-73

Study Area	(%) Hatching	(%) Observed Mortality	(%) Disappeared	Fledged as % hatched
Egg Island 1975 (153 nests)	69	12	26	62
Egg Island 1976 (186 nests)	77	8	31	61
North Marble 1972 (162 nests)	67	5	2	93
North Marble 1973 (19 1 nests)	69	8	4	88

Study Area

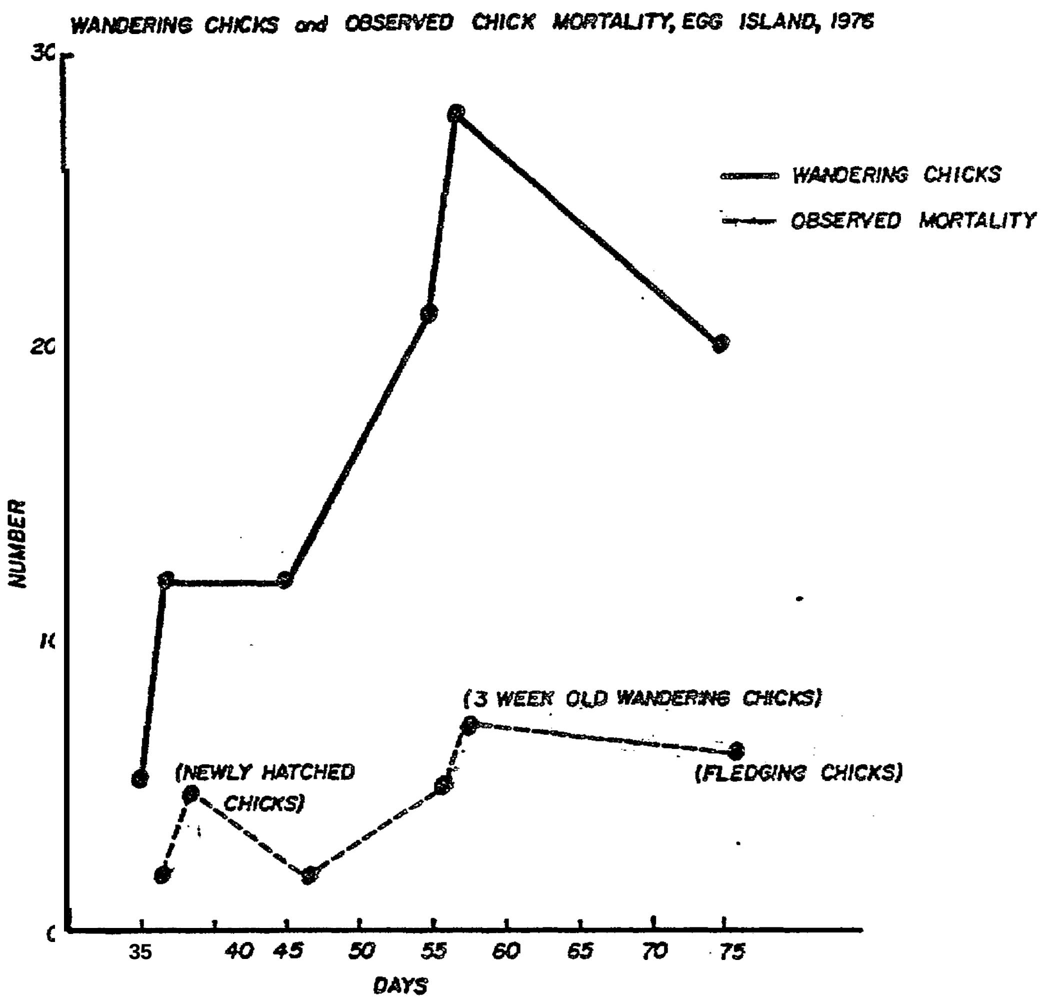


Figure 41. Wandering chicks and observed chick mortality, Egg Island, 1976.
On Egg Island chick mortality seems most related to the age at which chicks begin to wander widely, at which time they tresspass into neighboring gull territories.

Table 9

Hatching Success, Mortality, Reproductive Success
Egg Island, 1975-7.6; North Marble Island, 1972-73

Colony	Hatching success (%)	Egg and Chick Combined Mortality (%)	Total Reprod. success (%)
Egg Island (153-186 nests)	73	65	44
North Marble (161-192 nests)	68	34	61

Avian predators other than gulls were not uncommon on Egg Island or North Marble, although relative to gulls, their numbers were low. Terrestrial mammals, namely coyote Canis latrans (skull USNM# 511958), vole Microtus oeconomus (USNM# 511959) and a small mustelid (tracks) were found on Egg Island, but none were observed on North Marble. Egg Island Channel freezes in severe winters allowing predator access. Holliday of Chitina Air Service, (pers. comm.) has observed as many as three coyotes on Egg Island during the winter. It is unlikely they survive long, since We do not record tracks, sign or other evidence of them during the summers. 'We report both coyote and brown bear tracks on Strawberry Reef at the east end of the Copper Delta; the channel separating island and mainland can be swum at low tide. Michelson and Wohl (pers. comm.) confirm presence of brown bears on Strawberry Reef. The potential effect of these large omnivores on the gull colony at Strawberry Reef is unknown.

We have included a discussion of avian predators in our 1976 annual report. We believe that on the large colony at Egg Island, in comparison with other factors, their effect is minimal. This of course excludes other gulls.

Weather was also a factor affecting chick mortality in this study. Both June and July 1975 and 1976 were favorable months on Egg Island, with periods of a day or two of rainfall and moderate winds followed by fair, calm weather. Cover in the gull meadows was excellent due to growth of vegetation, and air temperatures were moderate. A week of quite poor weather occurred in early August both years, with cooler temperatures, very strong winds, and heavy rainfall. Vegetation in the meadows began to die down after the growing season-. The main group of chicks, hatched in late June, had fledged and was foraging around the island beaches. However, a second group of chicks, probably the result of second nesting following egging, was still in the meadows. There was heavy mortality of the smaller chicks after the stretch of poor weather. The mortality may have two reasons, although they are related. Partially fledged chicks under scanty ~~scanty~~ cover may have died from exposure. We observed much cannibalism, and found many chick bodies picked clean. The inclement weather may have prevented both adults and recently fledged juveniles from foraging efficiently, and the half-grown chicks suffered accordingly. Whether. the mortality of younger chicks was due directly to attacks from other hungry gulls or was only indirectly related to other gulls scavenging on chicks dead from exposure, is unclear. 'i'he effect was the same: chicks hatched later than the main group apparently had much lower survival rates. Drury and Nisbet (1972) found a similar relationship between hatching dates and survivorship in argentatus in New England as did Parsons et al (1976) in Scotland. A selective pressure for egg and chick synchrony may be due to weather, predation, cannibalism, and lack of food acting in concert.

Michelson (pers. comm.) pointed out that for several years a severe storm has occurred in the Cordova area in early August. Our observations of chick mortality after August storms were made in meadows outside the study area. The productivity figures for the study areas may not include weather-induced mortality affecting other parts of Egg Island. By mid-August few gulls are left.

We compared the results of our investigation of factors influencing reproductive success on Egg Island and North Marble with data from other colonies and from other species of gulls, since so little is otherwise known of Glaucous-winged Gulls in Alaska. Natality, or hatching success, was calculated to be 73% percent on Egg Island, and 68% on North Marble. These figures can be compared to Western Gulls, in which hatching success has been reported to be 55% by Schreiber (1970), 78% by Harpur (1971) and 78% by Coulter et al, (1971).

The mean combined mortality from egg to fledging on Egg Island was about 65%. This compares to 34% percent on North Marble and to 30% combined egg and chick loss for Western Gulls on the Farallons (Coulter et al, 1971). Egg loss was higher but chick loss was lower on North Marble compared to Southeast Farallon. On Egg Island, egg loss-was similar to North Marble but chick loss was higher (Table 9).

Total reproductive success was about 44% on Egg Island for the study years. In comparisons North Marble had a total fledging success of 61% under undisturbed post-glacial conditions. On North Marble, hatching and fledging success were not significantly different from colony to colony and from year to year, suggesting the gulls there may be acting as one large colony and that the environmental conditions were relatively static for the two study years. The exception was a small, newly colonized area at the top of the island, which had significantly larger territory sizes, smaller clutch. size (Fig. 25, 26), lower hatching success (Fig. 37, 38, 39, 40), and fledging-success, parameters which are remarkably similar to those at Egg Island. The Top Colony at North Marble showed increased reproductive rate the second year of the investigation there (Fig. 26, 38, 40) with smaller territories, larger clutch size, and greater hatching success. It is our conclusion that the Egg Island population will show increased reproductive rate in coming years, concurrent with decreased territory size, larger clutch size, and increased hatching and fledging success, IF given continued access to sufficient food supply and reasonably undisturbed conditions.

Fledging Success

We determined the median length. of the nestling period to be 40-45 days on Egg Island, similar to that on North Marble. Other investigators have reported similar fledging periods for Herring Gulls in Michigan (Keith, 1966), Western Gulls in California (Schreiber, 1970; Harpur, 1971), and Glaucous-winged Gulls in British Columbia (Vermeer, 1963).

At the end of the fledging period on Egg Island, counts were made to determine fledging success. Fledging success, while a difficult measurement (Keith, 1966; Schreiber, viva vote) is crucial in understanding the reproductive biology of birds. The fledging rate of 1.03-1.12 chicks per nest on Egg Island is normal when compared to other gull species, but lower when compared to a colony in post-glacial surroundings (Table 10), probably due to the abundant natural food supply in the "unfilled niche" at Glacier Bay.

Paynter (1949) reported a production of 0.92 chicks per nest per year sufficient to maintain a stable population of argentatus on Kent Island, New Brunswick. Ludwig (1966) found a recruitment rate of 0.63 is sufficient to maintain a stable population of delawarensis on the Great Lakes, and argentatus populations increased between 1960 and 1965 at an annual rate of 13% with a mean fledging rate of 1.47. This population growth was due to the unusual abundance of the alewife (Alosa pseudoharengus), a major food source (in Harpur, 1971). At the same time, delawarensis populations were increasing on the Great Lakes at 30% per year-with a mean fledging rate of 1.74, which is practically identical to the gulls on North Marble. Glaucous-winged Gulls studied by Vermeer (1963) on Mandarte Island, B.C., fledged 1.0 and 1.7 chicks per nest in his two-year investigation. Harpur (1971) published fledging rates of 1.33 and 0.96 per nesting pair of Western Gulls. The highest mean fledging success encountered in the literature has been the 2.00 chicks per nest reportedby Coulter et al,(1971).

Other fledging successes, as summarized by Keith (1966) ranged from 0.3 to 1.17. The gulls on Egg Island during this study, in comparison with the above studies, fledged roughly in a "normal" pattern. This rate, if continued, would indicate a population expanding at a 4% rate per year. For example, at this rate, in five years the 20,000 gulls breeding at Egg Island would number 24,333. This is nearly a 25% increase in five years. This is similar to conditions replicated in the recent past in the eastern United States, and due to a similar reason, that of an increasing food supply due to man's activities.

Table 10

Comparative Index of Gull Reproductive Success
In Chicks Per Nest (Productivity)

Colony Location	Species	Chicks/nest	reference
California	L. occidentals	2.00	(Coulter et al, 197:
North Marble (1972-73)	L. glaucescens	1.77	(Patten, 1974)
Great Lakes	L. delawarensis	1.74	(Ludwig, 1966)
Great Lakes	L. argentatus	1.47	(Ludwig, 1966)
British Columbia	L. glaucescens	1.35	(Vermeer, 1963)
California	L. occidentals	1.14	(Harpur, 1971)
Egg Island (1975-76)	L. glaucescens	1.08	(this report)
New Brunswick	L. argentatus	0.92	(Paynter, 1949)
Michigan	L. argentatus*	0.35*	(Keith, 1966)

* Population contaminated by DDT

Task A-5 .

Banding Recoveries and Sightings of Color-marked Gulls

To answer questions of migration routes and wintering areas we banded 4457 Glaucous-winged Gulls during this project. Included in this total are 1300 flightless chicks--of-the-year for 1975, and 2696 such chicks for 1976. These young birds were ringed on their left tarsi with standard size 7A F&WS 'short' bands of the 1047 and 1077 series. All 1300 of the 1975 young were captured on Egg Island dunes outside the study area proper. In 1976, we banded 2500 chicks at Egg Island, 95 chicks at Strawberry Reef at the east end of the Copper Delta, and 101 young birds at Copper Sands, a barrier island off the middle of the delta. Thus in 1976 we banded 2696 chicks on Copper Delta barrier islands.

In addition at our survey colony (150m x 150m) southwest of Egg Island Light we captured during 1975 every chick surviving to two weeks of age. These 222 individuals had their left tarsi enclosed in aluminum 'tall' bands of the F&WS USARP 657 series. We counted as fledged 150 of these 222 banded chicks in early August, Due to disappearance of chicks banded early in 1975, we did not band until chicks were -nearly fledged in 1976. We then counted as fledged those 208 chicks which we banded in an intensive effort in late July. This methods change was done to reduce disturbance.

Four study area juveniles have been recovered to date. The first, banded on 1 Aug 1975, was shot by a small boy at the end of Sunny Point, 8 kmwest of downtown Juneau, on 4 Ott 1975 (King, pers. comm.) In January 1976, a second juvenile from the Egg Island study area was found dead near Vancouver, B.C. The third recovery, a year-old juvenile, was caught due to injury at Valdez on 19 July 1976. The temporal sequence of these recoveries suggests strongly migratory tendencies. Another l-year-old study area juvenile has been found dead at Valdez (Dayville) on 19 July 1976.

All other band returns to date have been from young gulls originating outside the study area proper on Egg Island. Several of these have wider implications to be understood within the context that gull problems will increase. At 0712 hrs on 21 Aug 1975, a Polar Airlines AC/68 Aero Commander hit two juvenile, gulls on runway 6 threshold landing at the Valdez airport. Both gulls had been banded as flightless chicks just a month earlier on Egg Island. Small numbers of gulls congregated around a shallow gravel pool at the west end of the Valdez airport. The FAA informed all aircraft approaching or leaving Valdez on 21 and 22 Aug 1975 of bird strike hazard (AIRAD) (Peavyhouse FAA, pers. comm.).

Another recently fledged Egg Island gull was found dead on the road at Valdez on 29 Aug 1975. On 30 Aug 1975, 45 days after it had been banded at Egg Island, a young gull was found dead at Anchorage. Still another banded juvenile was found on 1 Sept 1975 on the Copper Delta 17 km east of Cordova being eaten by an eagle. During Ott 75, a further young bird from Egg Island was found dead at Yakutat. On .20 January 1976, a large juvenile gull was found on the beach at Ketchikan near where oil had been reported. Wood (ADF&G) kept the partially incapacitated bird overnight and released it after noting the band number (King, pers. comm.), which indicated Egg Island origin. Bartonek (pers. comm.) has recently informed us of our first recovery of a chick banded during the 1976 field season. On 31 Ott 1976 a juvenile gull was caught due to entanglement at the Juneau boat harbor. The gull wore both F&WS and a red plastic band provided to Us by OBS-CE, which indicated this year's age class and origin on the closest inshore Egg Island islet. These recoveries support the emerging migratory pattern (Table 10) .

We color-dyed over 100 fledgling gulls with nyansol, a purple-black marker, at the close of the 1975 season on Egg Island (see Chick Stage above). Isleib (pers. comm.) noted dark-pigmented young of the year in and near Cordova

Table 11

Banding Recoveries of Juvenile Gulls
from Egg Island

	Location	Date	Reason
1)	Valdez	22 Aug 75	aircraft strike
2)	Valdez	22 Aug 75	aircraft strike
3)	Valdez	29 Aug 75	dead on road
4}	Anchorage	30 Aug 75	found dead
5)	Copper Delta	1 Sept 75	eaten by eagle
6)	Yakutat	- Ott 75	found dead
7)	Juneau	4 Ott 75	shot by boy
8)	Ketchikan	20 Jan 76	oiling
9)	Vancouver, B. C.	- Jan 76	found dead
10)	Valdez	19 July 76	injury
11)	Valdez	19 July 76	frond dead
12)	Seward	5 Sept 76	found dead
13)	Yakutat	8 Ott 76	found dead
14)	Juneau	31 Ott 76	entangled

Note radiation to Prince William Sound region after breeding seasons and then strongly migratory tendencies in chronological sequence of banding recoveries.

during Sept 1975. None were reported after the third week of September and the highest number observed at one time was three at the Cordova dump on 7 Sept 75. The nyansol marking was phased out after 1975 due to poor visibility on juvenile plumage.

We marked 31 adult gulls and one third-year juvenile during this project. These gulls were dyed bright yellow with picric acid, a collagen stain. The yellow color gradually oxidizes to orange. We captured our first gull at Cordova OceanDocks, took. a blood sample, and dyed it on the head and upper breast. Our subsequent observation indicated this bird remained in Cordova for the summer of 1975, feeding on cannery effluent, and resting on Eyak Lake or at the docks. When the canneries shut down due to strike by commercial fishermen, this gull appeared at the Cordova dump. Isleib (pers. comm.) continued to observe this gull at the Cordova waterfront until 9 Ott 1975. Most reports of the bird were between Ocean Dock and Observation Island, that is, in front of the canneries. The local movements of the color-dyed gull lead us to the conclusion that it is part of a summering non-breeding population exploiting concentrated food resources.

We color-dyed eight other gulls at Egg Island in 1975. These gulls were colored yellow on lower breast feathers, belly, axillaries and tail, Our initial observations indicated these birds, which were breeding adults with eggs or chicks when captured, remained close to the colony in July. In August we observed these gulls progressively further from Egg Island, first at the mouth of the Eyak River a few km away, then in Cordova 20 km away, and then as far away as Deep Bay, Hawkins Island, 40-50 km from Egg Island. (Thorne, pers. comm.). In Sept. 75 "canary yellow" to "golden" gulls were seen by various parties in the Juneau area (King, pers. comm.).

Between mid-October 1975 and early March 1976 no color-dyed gulls were reported in the Cordova-Orca Inlet area. Isleib (pers. comm.) informed us of heavy movement of _Larus_ into the Cordova area during the period of 7-10 March 1976. Snow cover was 1.-1.3 m at the time but weather conditions southeast along the coast. were good. Many migrant species and population shifts were occurring in the same period. Isleib and Isleib (pers. comm.) report four observations of orange gulls in the Cordova waterfront from 10 to 19 March 1976. In June 1976 we observed a faded orange gull nesting within ten meters' of where it had been captured the year before at the east end of Egg Island (Table 11).

Our observations of 22 (1976) color-dyed gulls are similar to our previous sightings. Our 1976 birds were marked on right side only to distinguish them from other F&WS marking programs. Gulls cluster around the Cordova dump, cannery effluent, or street sewer outfall. Senner (pers. comm.) reported a a color-dyed adult feeding young on octopus at Hartney Bay in August. Lensink (pers. comm.) saw an orange gull on the Cordova City Airport runway in August. We captured a third-year juvenile at Egg Island in early July; the bird was light enough in plumage so we dyed the right wing, belly and tail. Within the month Frazer and Howe (F&WS) observed a color-dyed juvenile _glaucescens_ on Middleton Island 100 km away in the Gulf of Alaska (Howe, pers. comm.).

With observations reported to us by cooperating biologists we are able to suggest local and then southeastern movements of adult gulls in post-breeding dispersal. Egg Island adults apparently leave the Cordova area by October and return in March. Recently fledged juveniles disperse explosively to Anchorage and Valdez but then drift south. January recoveries are from Ketchikan and Vancouver, B.C. A first year bird was found summering in Valdez; a third year bird demonstrated lateral movement between the Copper Delta and Middleton Island in July. We report more band recoveries (36%) from Valdez than any other location. Whether this represents environmental disturbances capitalized by gulls or simply concentration of human observers remains to be determined.

Table 12

Observations of Color-dyed Gulls

	Location	Date	Activity
1)	Cordova docks-canneries	July-Aug 75 Sept-Ott 75	feeding
2)	Cordova dump	July-Aug 75 Sept-Ott 75	feeding
3)	Egg Island	July-Aug 75	breeding
4)	Eyak River, Copper Delta	Aug 75	resting
5)	Hawkins Island, Prince William Sound	Aug 75	flying
6)	Juneau	Sept 75	resting
7)	Cordova docks--canneries	March 76	resting
8)	Egg Island	June 76	breeding
9)	Middleton Island,. Gulf of Alaska	July 76	resting
10)	Hartney Bay, Orca Inlet	Aug 76	feeding
11)	Cordova City Airport	Aug 76	resting
12)	Cordova dump	July-Aug 76 Sept-Ott 76	feeding

Note artifical food sources, winter absence, suggestion of migration pattern, and airport sighting (see aircraft strike hazard, in text).

We have reviewed recent literature on wintering areas and F&WS observations of large gulls in the NEGOA, for which we grateful to Dr. Calvin Lensink (OBS-CE). The review amplifies our banding and color-dyeing studies and we attempt to generalize from the results.

Isleib and Kessel (1973) suggest part of the NEGOA glaucescens population winters offshore on the continental shelf. Isleib (pers. comm.) reports argentatus, glaucescens and hybrids are common during the winter in the Cordova area, where argentatus and hybrids are quite uncommon during the summer. Hoffman (pers. comm.) also finds glaucescens, argentatus and hybrids offshore between Yakutat and Kodiak in November. These observations, with results of our color-dyeing studies, which show Egg Island gulls departing the Cordova area in October and returning in March, indicate major population shifts and/or migratory movements southward in fall and winter.

Sanger (1973) and Barrington (1975) reported pelagic argentatus and glaucescens 80-640 km off southern California from January to April. Herring Gulls increased until mid-February and then rapidly decreased from mid-March to -mid-April. Gulls collected in April had enlarged gonads in near breeding condition. Further north, F&WS ship surveys in the NEGOA found marked shifts in relative abundances of gulls which may indicate migration from more southern regions :

Table 13

Large Gulls Observed on Transects in
The Northeast Gulf of Alaska (Lensink, pers. comm.)

Species	Number/km^2			
	Feb.	Apr.	May	June
Unidentified Gull	0	.08	.05	.07
Glaucous Gull	.02	.23	0	0
Glaucous-winged Gull	3.33	1.69	1.89	.19
Herring Gull	.03	.21	3.23	.41

We believe the sharp increase and then decline in May of *argentatus* per km^2 represents a migration from more southern regions (e.g. off California) towards interior breeding localities in Alaska, B.C., and the Yukon (Table 12). Herring Gulls appear on interior lakes across Alaska in late May just before spring break-up. Non-breeding *argentatus* may summer at sea, since inland lakes are not especially productive. Breeding pairs on inland lakes are more scattered than colonial and clutch size is smaller than coastal gull populations (Anderson, viva vote). Our observations indicate that post-breeding adult gulls depart abruptly from interior lakes in late August. Major rivers (Copper, Alsek, Taku, Stikine) provide migratory pathways to the sea

The more gradual decline in *glaucescens* per km^2 from Feb. to June represents coastal breeders returning to colonies. From February to April pelagic *glaucescens* decrease by 50%. Gulls from Mandarte Island, B.C., are on site in February; gulls are present at North Marble in Glacier Bay in March (Streveler, pers. comm.) and appear on territories at Egg Island in April (Isleib, pers. comm.).

F&WS standing stock estimates of pelagic gulls exceed known breeding pairs in the NEGOA (Lensink, pers. comm.). Non-breeders comprise a large portion of the pelagic population as well as gulls originating from other than coastal NEGOA colonies. Offshore gull populations utilize food resources (including offal from foreign fisheries) which may reduce competition with onshore breeding populations.

Development of offshore oil resources and increasing tanker traffic in the Gulf of Alaska thus has the potential to affect not only onshore gull breeding populations but also wintering and migratory populations from interior Alaska, B.C., and the Yukon.

The F&WS provided us with information which suggests, gulls return to the Cordova canneries year after year. Mssrs. Schilmoeller and Lettis of the Forest Service observed an adult glaucescens at the St. Elias Floating Cannery, Cordova Ocean Dock, on 11 July 1975. The gull wore a band on the left tarsus and had the outer left web on the left foot cut in a 'V' fashion as an additional marker. The bird was in a feeding flock around the cannery effluent. Schilmoeller and Lettis read the band number, and the F&WS subsequently informed us this gull was banded by personnel of the Denver Wildlife Research Center (F&WS) on 19 July 1970 near Cordova as part of research concerning gulls around the canneries. The gull was at least one year old when banded.

We are hopeful of additional reports of gulls from our Copper River Delta banding and marking program. Initial results indicate that gull banding and color-dyeing are highly promising research aspects, and will pay most returns over an extended period of time. We have provided the basis for an intensive study of site tenacity of one of the most abundant, intrusive avian species in the Gulf of Alaska, breeding in huge colonies in a highly vulnerable delta ecosystem.

Task A - 6

Sympatry and Interbreeding of Herring and Glaucous-winged Gulls

The evolution and systematic of the Herring Gull group (Larus argentatus and relatives) are complex. A circle of interbreeding races extends around the Northern Hemisphere (Stresemann and Timofeef, 1947). Where the presumed end-points on the circle overlap, the extreme varient races may act as good species (Paludan, 1951; Goethe, 1955). These gulls provide a good example of a dynamic evolutionary system in which animals may act as distinct species in one region while hybridizing extensively in another (Ingolfsson, 1970).

Hybridization results from breakdown or incomplete development of interspecific isolation in such factors as nest site selection, time of breeding and morphological and behavioral characters concerned with or influencing mate selection (Smith, 1966b).

Early Pleistocene Herring Gull stock broke up into isolated populations . . . in refugia in Europe, Asia, and North America during glaciation (McPherson, 1961; Rand, 1948). Populations resembling Herring Gulls may have been pushed back by continental glaciation to an interior refugium along the Yukon-Kuskokwim-Bering Sea land bridge. Other populations of gulls may have been forced to retreat southward along the Pacific coastline to the Puget Sound area where they evolved in proximity to glacier fronts (the lighter-colored *glaucescens* resembles high-arctic species). While these gulls may have shared a common gene pool at one time, enough evolution has occurred to account for certain observed differences between Herring and Glaucous-winged Gulls, for instance in the amount of melanin in primaries, or in iris and orbital ring color. However, populations broken up by glaciation may have evolved incomplete isolating mechanisms not sufficient to prevent hybridization upon post-glacial range expansion.

The Pacific Coast *Larus argentatus* complex including *hyperboreus*, and *occidentals* as well, is not usually included with the rest of the circumpolar *Formenkreis* but recent information indicates there is gene flow between *hyperboreus* and *glaucescens* in northwestern Alaska (Strang, 1974); between *glaucescens* and *argentatus* in southwestern and southern Alaska (Williamson & Peyton, 1963 ; Patten & Weisbrod, 1974); and between *glaucescens* and *occidentals* in western Washington State (Scott, 1971; Hoffman, 1976).

There is thus good evidence that a chain of interbreeding groups extends up and down the Pacific Coast and that members of this group are members of the Holarctic Herring Gull Formenkreis. The Glaucous-winged Gull is apparently the 'key' species in the Pacific Coast gull complex (Fig. 42).

As the availability of human-generated refuse increases with the development of oil resources in Alaska, populations of gulls previously more isolated may come into closer contact with one another. The refuse associated with increased oil operations may result in genetic changes in the gull populations (Hunt, pers. comm.).

Williamson and Peyton (1963) collected a series of specimens intermediate between the Herring and Glaucous-winged Gulls from Cook Inlet, near Anchorage, Alaska. They suggested that sympatry between breeding Herring and Glaucous-winged Gulls occurs in southeastern Alaska. This section will document briefly current knowledge of sympatry and interbreeding of Herring and Glaucous-winged Gulls in southcentral and southeastern Alaska (Patten, 1976).

Glacier Bay, Alaska, just to the south of the current study area, is quite recently deglaciated (less than 200 years). Gene flow between previously isolated populations in this area must be as recent as the deglaciation. Herring and Glaucous-winged Gulls have been found nesting together in at least three colonies in Glacier Bay. The colonies are found on (1) a near vertical cliff; (2) a flat low gravelly island; and (3) sloping grassy hillsides. During the summer of 1971, suspected intermediates were observed at a cliff colony. These gulls showed intergradation from one form to the other in primary feather pigmentation. During the next two summers, mixed, nonspecific, as well as 'intermediate' to Glaucous-winged Gull pairs were observed on North Marble Island in Glacier Bay, which contains a colony of 500 pairs. Relative numbers of Herring Gulls to Glaucous-

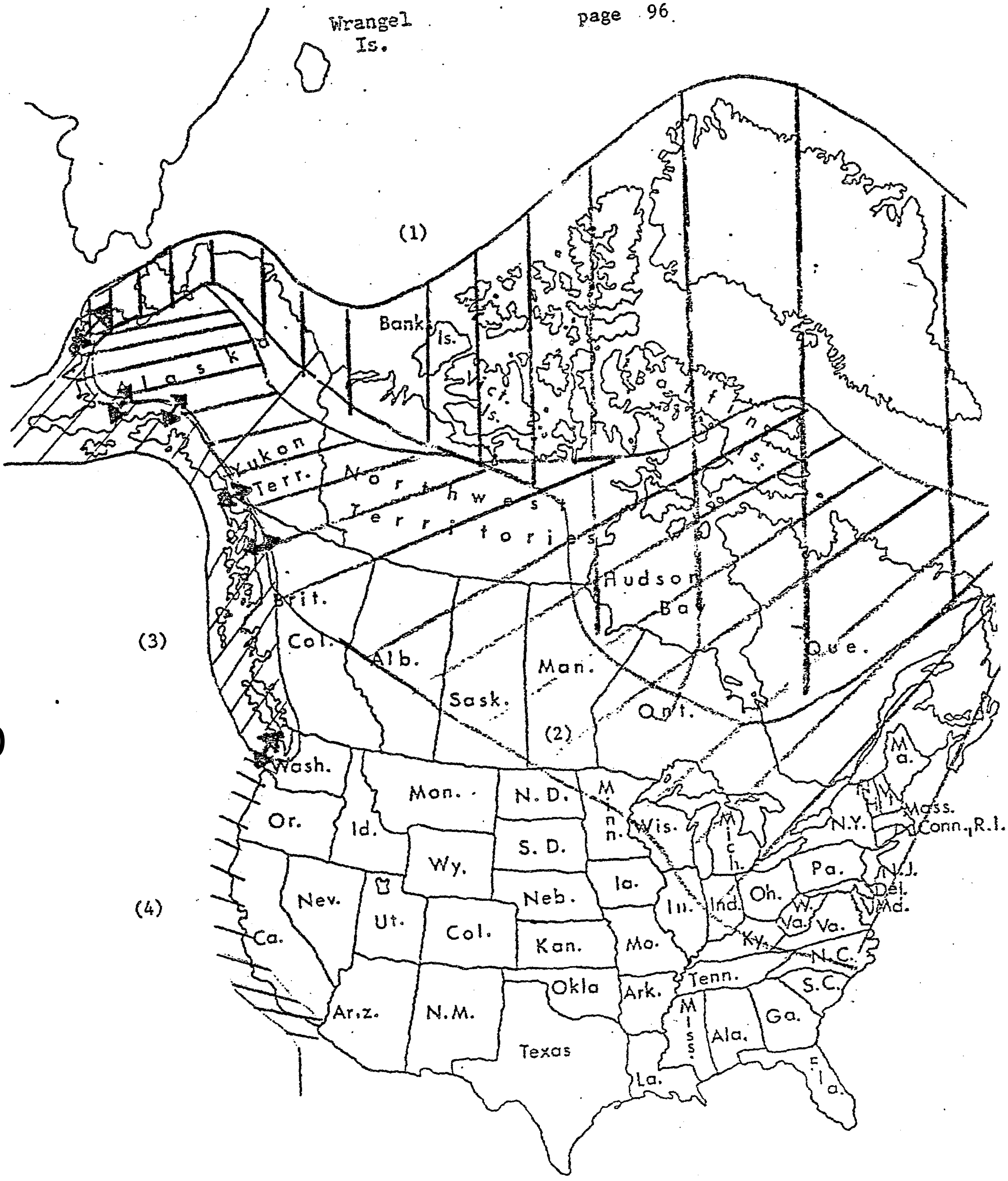


Figure 42*
North American Large White-headed Gull Distribution

(1) Larus hyperboreus
(2) Larus argentatus
(3) Larus glaucescens
(4) Larus ~~occidentals~~

↔ (genetic exchange)

winged Gulls were low. The mixed, apparent backcross and 'pure' pairs successfully fledged young. Some individual birds proved impossible to categorize. Primary feather pigmentation varied in both amount and pattern. Iris color also varied apparently independently of primary feather pigmentation

Dry" Bay, mouth of the Alsek River, approximately 75 km south of Yakutat, that is, within the boundaries of the current study area, contains about 500 pairs of Herring and Glaucous-winged Gulls nesting sympatrically on low gravel bars at the mouth of the River. Dry Bay has apparently never been glaciated but may have been the location of catastrophic flooding from glacially dammed lakes in the interior Yukon within the last 1000 years. The Alsek River is a known migration route connecting coastal with interior populations of vertebrates through the St. Elias Range (5000m - 6500m). Collections of specimens in June 1974 and June 1975 revealed both Herring Gull and Glaucous-winged Gull types as well as a wide range of variation in primary feather pigmentation. Relative proportions of Herring Gulls to Glaucous-winged Gulls are considerably higher in Dry Bay than Glacier Bay, reflecting influence from interior Yukon.

Haenke Island lies off Yakutat in Disenchantment Bay and has about 200 pairs of Glaucous-winged Gulls nesting on a 100m grassy cliff. The St. Elias Range and the Malaspina Glacier prevent the influence of interior conditions in the area. The gull population here is currently less variable in primary feather pigmentation than the population at Dry Bay.

Apparently the largest Glaucous-winged Gull colony in the northeast Gulf of Alaska is located on Egg Island near the mouth of the Copper River near Cordova. Conditions on this island have been previously discussed in this report. Gull specimens collected in the summer of '75 show a limited range of variability. The large number of glaucescens may serve to "swamp" argentatus-type genes.

N.G. Smith (1966) suggests there are insufficient isolating mechanisms between the Herring and Glaucous-winged Gulls. Field evidence from this portion of the study indicates that the *Larus argentatus* - *Larus glaucescens* species group is in an exceptionally fluid state evolutionarily, with populations at least partially isolated by glaciation and mountain ranges now interbreeding where in contact, and producing a variety of morphological types in a geologically rapidly changing environment. Superimposed upon the geological forces will be the future explosive industrial development. The gene flow between gull populations in the Gulf of Alaska may be further increased in coming years as a secondary influence of human activities, which may lead to a new adaptive peak in this commensal bird species, with consequences for municipal health and sanitation.

Task A - 4 & A - 6

Gull Food' Habits

A central theme in this report is that gulls will increase in the northeast Gulf of Alaska with continued access to food resulting from human activities. This food supply is not likely to decrease with the development of oil resources. We discuss in this section why gulls exploit artificial food due to natural plasticity of food selection and dichtomy of foraging pathways. NEGOA gull populations currently exhibit both food selection under natural conditions and response to artificial food supply.

Alaskan gulls of the argentatus group show under natural. conditions two major foraging pathways: first, gulls scavenge the intertidal from lowermost to uppermost regions, taking a wide variety of food items. This includes larger cast-up fishes such as Gadidae, Scorpaenidae, Cottidae and Theragra . and invertebrates such as Mytilus, Thais, Balanus and Pagurus (Table 13) Invertebrates are broken, dropped, pried open or swallowed whole. Secondly, gulls dive from several meters above water to well beneath the surface in areas of tidal disturbances, at river mouths, near surfacing whales (Jurasz, pers. comm.; Divoky, 1976) or when opportunity presents, taking small fishes such as Osmeridae, Clupea and small shrimp such as Pandalus. Other small fishes, e.g. Pholidae are taken from rocky intertidal pools by stalking.

Alaskan gulls also exploit marine mammals under natural conditions (cf. Divoky, 1976; Tuck, 1960). In the NEGOA seals give birth on pack ice at Haenke Island near Yakutat and in Muir Inlet in Glacier Bay. Gulls (argentatus and glaucescens) scavenge seal feces, stillborn pups, other carcasses, and placentae (Streveler & Paige, pers. comm.). Remains of seal placentae and hair form the most common item in gull castings at Haenke Island in June,

The affinity of gulls for human sewage is discussed below in this report. This behavior may have originated from following marine mammals.

Table 14

NEGOA Known Gull Food Items

Colony/ Foraging Area	Glacier Bay	Dry Bay	Strawberry Reef	Copper Sands	Egg Island
Food items:					
Phylum Mollusca					
Class Pelecypoda					
	Mytilus edulis				Mytilus edulis
					Clinocardium nuttallii
Gastropod					
	Fusitriton oregonensis				
	Neptunea lyrata				
Cephalopod					
					octopus Sp,
Phylum Arthropoda					
Class Thoracica .					
	Balanus glandula				
Decapoda			Pandalus borealis		
	Pagurus beringanus				
	Hyas lyratus				
	Chionoetes bai rdi				
Insects					
					Tipulidae sp.
Phylum Echinodermata					
Class Echinoidea					
	Strongylocentrotus drobachiensis				

Table 14 (cont.)

NEGOA Known Gull Food Items

Colony/ Foraging Area	Glacier Bay	Dry Bay	Strawberry Reef/ Haenke Island	Copper Sands	Egg Island	Valdez Cordova Yakutat Juneau
Food items:						
Phylum Chordata						
Class Osteichthyes				*Clupea harengus*	*Clupea harengus*	
					Oncorhynchus sp. (eggs)	
	Gadidae sp. *Theragra chalcogramma*					
					Sebastes sp.	
		Osmeridae sp.		Osmeridae sp.	Osmeridae sp.	
					Pholidae sp.	
	Cottidae sp. *Hemilepidotus hemilepidotus*					
Class Aves	*Larus glaucescens* (eggs & chicks)				*Larus glaucescens* (eggs & chicks)	
Class Mammalia	*Phoca vitulina* (carcasses, placentae, feces)		*Phoca vitulina* (carcasses, placentae)		*Phoca vitulina* (carcasses)	
Food of Human Origin						garbage sewage salmon & crab gurry

The gull colony at Egg Island 'exhibits parameters of an expanding population as discussed above in this report. The population is expanding as a result of increase in nesting space as plant succession follows earthquake uplift of island colonies, and availability of artificial food in Cordova. In 1972 fish and crab processing plaints in Cordova discharged about 2.6 million pounds of seafood waste into Orca Inlet (USDI, BLM, 1976; underlining mine). EPA regulations require dumping of waste where material is not visible but in summers 1975-76 the gulls find the material highly visible, attracting huge foraging flocks (10,000 individuals/hr), notably during salmon-packing season (July-August). This is precisely when gulls feed young on Egg Island 20-30 km away. Color-dyed breeding birds from Egg Island join in these flocks as well as non-breeding adults and second and third year juveniles. There is constant interchange of gulls from Eyak Lake, Eyak River, Orca Inlet to the ocean and colonies on sandbar islands at the mouth of the Copper River, (Fig. 4). The gulls feed in circling swarms on the effluent which is hosed from the floors of the seafood processing plants, ground up and dumped from pipes at the ends of the docks or wharf in front of the respective institutions ("A", "B", "C", "D", "E").

Newly fledged -juveniles appear at the docks and seafood plants in late July and early August. Gulls also feed on detritus in the harbor and on fishing boats. Many fewer gulls are found in the area when the canneries/ fish-processing houses are not packing, e.g. when ADF&G closes the season or when commercial fishermen strike. The Cordova municipal dump provides an alternate food source for gulls when canneries are not packing. The dump has a more limited but also more constant food supply and is used by fewer birds when effluent is available from seafood plants.

"Seagull nuisance" resulting from discharge of floating seafood waste is a cause of community and State of Alaska concern in Cordova (Bayliss, pers. comm.). Cannery "E" has been cited for violations of dumping regulations and it is this cannery which also attracts greatest concentration of gulls. Recommendations have been made for gull control measures. It is our position that the gull concentration in Cordova is symptomatic of food availability and not causal of he larger problem of "seagull nuisance". The gulls are responding in a normal manner to an underexploited food source, The dumping of salmon and crab gurry in Cordova for years has led directly to the-increase in gulls since they feed young with it on Egg Island. When young gulls are disturbed on Egg Island, regurgitated gurry samples are freely available for verification.

We support the State of Alaska Dept. HSS viewpoint as expressed in the letter from Torgerson to Cavanaugh (Appendix II) that gull control is only symptomatic treatment for the larger problem of industrial waste, improper garbage disposal and inadequate sewage disposal. We see the gull problem increasing in coming years with further explosive industrial development and attendant social problems, among which is garbage and waste disposal.

Proper treatment of these problems will be expensive. For instance, relocation fencing, hauling and grading a new Cordova municipal dump would cost an intial $250,000 and thereafter require a yearly expenditure of $50,000, sums which are currently beyond the fiscal capacity of the town (Cordova City Manager, viva voce). Federal aid will doubtless be requested.

The Role of Gulls (Larus argentatus & Larus glaucescens) in the Transmission of Human Parasitic and Enteric Diseases in Alaska; A Review

Part I. Human Parasitic Diseases and Gulls

The exposure of untreated or poorly treated sewage to gulls in Alaska may lead to human health hazards from bacterial and helminth infections. One of the traditional safety factors relied upon for prevention of dispersal of pathogens which may be present in sewage has been the dilution of the effluent with an abundance of river or sea-water (Silverman & Griffiths, 1956). Overloading, however, or construction of new sewage plants with outfalls into already heavily polluted waters e.g. Cordova dockfront (USDI, 1976), reduces the dilution factor, and certain organisms such as gulls may actively concentrate human pathogens through their foraging behavior. For instance, in primary sewage treatment plants there is little evidence that continuous aeration adversely affects helminth ova, nor is rapid sand filtration an effective means of removing helminth ova from sewage effluent (Silverman & Griffiths, 1956). Varying percentages of viable helminth eggs (_Ascaris_, _Trichurus_, _Enterobius_, _Diphyllobothrium_ and _Taenia_ - all human pathogens) have been found in sludge of primary sewage treatment (Silverman & Griffiths, loc. cit.). Eggs may persist in a viable state in the sludge for years.

The role of birds in the dissemination of helminth ova is difficult to evaluate, but is highly suggestive (Silverman & Griffiths, loc. cit.) Götzsche (1951) suggested that gulls might be responsible for dissemination of tapeworm eggs from sewage outfalls. Gulls may come into contact with sewage at every stage of treatments and it is well known that gulls frequent canneries, fish-packing houses and garbage dumps in Alaska in addition to roosting on municipal water supplies, e.g. Ketchikan, Cordova (Wilson & Baade, 1959; USDI, 1976). Dumping of raw sewage from coastal towns in Alaska attracts gulls, which as natural scavengers forage on the fecal matter e.g. at Valdez (Bayliss, pers. comm.) and Juneau (Williams, pers. comm.) and Ketchikan (Wilson & Baade, 1959) (Fig. 43,44). Silverman and Griffiths (1959) found gulls attracted to sewage outfalls especially in winter (see Ketchikan epidemic below). These authors reported that feeding experiments with Herring Gulls revealed that tapeworm eggs (*Taenia* spp.) can pass through the digestive tract of gulls and still retain infectivity. The eggs appear in the feces about an hour after ingestion. Mature eggs may hatch in the gut of the gull, and the activated hexacanth embryo may be found in the droppings,

Sewage treatment and disposal problems in isolated areas are varied and complex (Silverman & Griffiths, loc. cit.) Pollution from inadequate disposal of human excreta is a potential source of health problems along the Alaskan coast, and is complicated by the scavenging nature of abundant Alaskan gull populations.

Part II. Naturally Occurring Human Helminth Infections Associated with Gulls in Alaska

Eskimos in western Alaska depend upon several species of fish for much of their food. These fishes are often eaten raw and thus transmit certain species of *Diphyllobothrium* tapeworms for which the fish are intermediate hosts (Rausch et al, 1967). Kuskokwim Eskimos eat raw or partially frozen smelt (*Osmerus*), blackfish (*Dallia*), and sticklebacks (*Pungitus*) which often contain larval tapeworms (Rausch et al, 1967). Rate of tapeworm infection reached highest level in winter and early spring, after greatest consumption of blackfish and sticklebacks (Rausch et *al*, 10C cit.). Uncooked fish comprises over a third of the diet of these Eskimos (Heller & Scott, 1967). Levels of infection with *Diphyllobothrium* tapeworms ranges from 16% to 30% (Rausch et al loc. cit.)

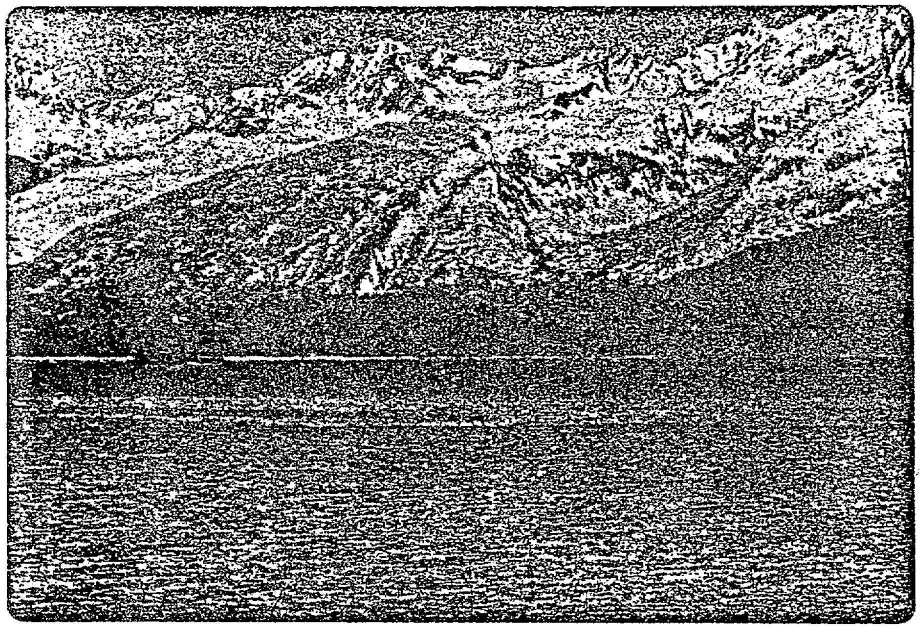


Figure 43. Dumping of raw sewage from coastal . towns in Alaska attracts gulls, which as natural scavengers forage on the fecal matter. Gulls in the sewage outfall at Valdez, May 1976. A surface slick extends some hundreds of meters downwind.

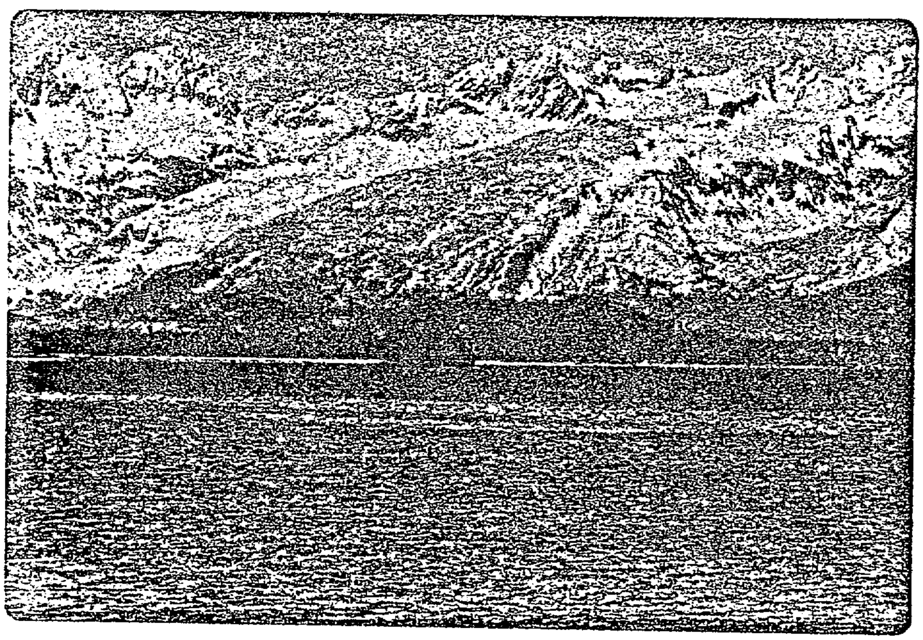


Figure 44. Pollution from inadequate disposal of human excreta is a potential source of health problems along the Alaskan coast, and is complicated by the scavenging nature of abundant Alaskan gull populations. Valdez, May 1976.

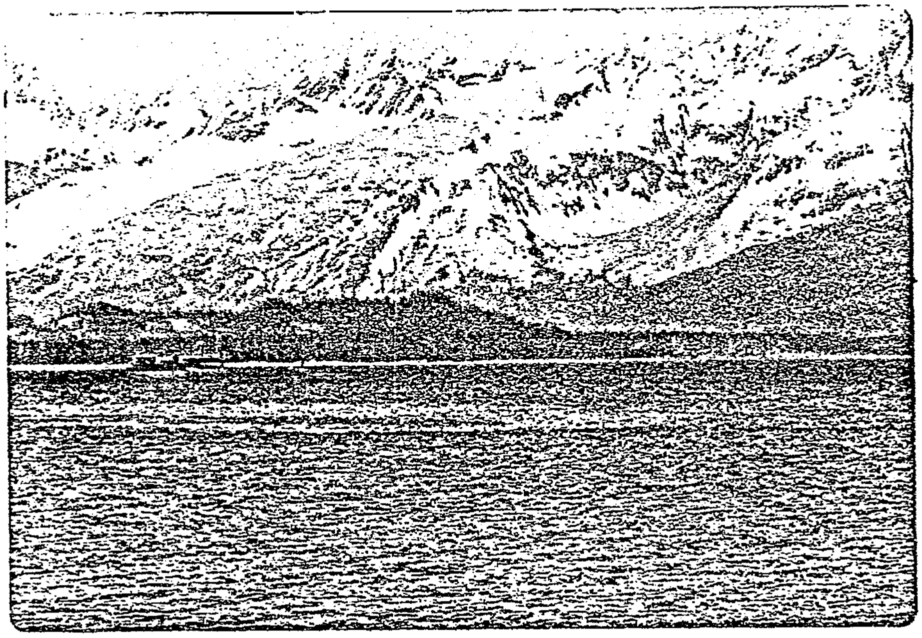


Figure 43. Dumping of raw sewage from coastal towns in Alaska attracts gulls, which as natural scavengers forage on the *fecal* matter. Gulls in the sewage outfall at Valdez, May 1976. A surface slick extends some hundreds of meters downwind.

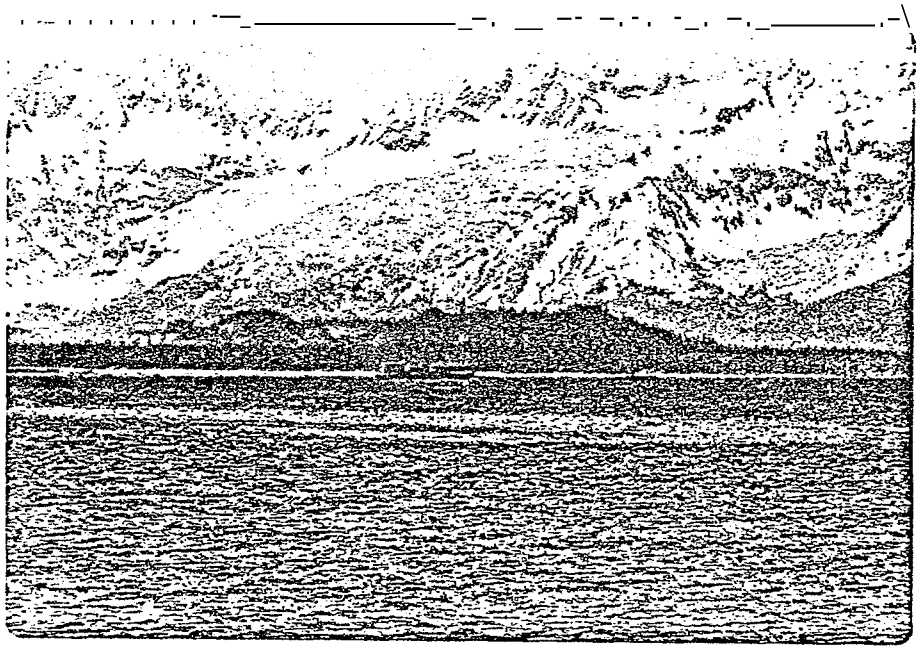


Figure 44. Pollution from inadequate disposal of human excreta is a potential source of health problems along the Alaskan coast, and is complicated by the scavenging nature of abundant Alaskan gull populations. Valdez, May 1976.

One of the most frequently found tapeworms in this region was identified by these authors as D. dalliae; the adult stage is in humans and dogs. Early life stages inhabit the blackfish, Dallia pectorals, an abundant and economically important species in the Kuskokwim River region (Rausch et al, loc. cit.). Rausch (1956) obtained infectious tapeworm plerocercoid larvae from blackfish trapped on the lower Kuskokwim, and raised adult tapeworms from these larvae at the Anchorage laboratory in Glaucous-winged Gulls, which had been hatched in an incubator and maintained parasite-free until the experimental infection. Rausch (1956) stated that the occurrence of the tapeworm Diphyllobothrium dalliae is to be expected in gulls in Alaska. Gulls are implicated in the dissemination of this parasite, transporting eggs to various aquatic areas where the eggs develop through several life stages to plerocercoid larvae in fish infective for humans.

Another cestode commonly found in man in Alaska is a Diphyllobothrium species undetermined. This type appears identical with a tapeworm reared experimentally in humans, dogs, and Glaucous-winged Gulls from plerocercoids (infectious larvae) encysted on the stomach of salmonid and coregonid fishes (Rausch et al, loc. cit.). We report salmon gurry from the Cordova canneries frequently contains large numbers of tapeworms and this gurry is scavenged by gulls. Rausch et al found Glaucous-winged Gulls naturally infected with the above Diphyllobothrium in Alaska. The presentation of fish gurry harboring tapeworms to gulls provides ample opportunity for parasite dissemination.

Rausch (1956) collected other adult cestodes morphologically resembling D. dendriticum from various species of gulls in Alaska. Kuhlow (1953) * established infections by feeding encysted tapeworm plerocercoids from the

* in Rausch, 1956

stomach of Osmerus eperlanus, a smelt. Chizhova (in Rausch, 1956) observed a tapeworm parasitizing Herring Gulls, humans, and dogs at Lake Baikal; similar cross-parasitism is expected in Alaska. Rausch (1954) observed specimens of still another Diphyllobothrium species in dogs; foxes, cats, and gulls in Alaska after feeding plerocercoids from infected steelhead (rainbow) trout. Rausch (1954) experimentally infected Glaucous-winged Gulls with the tapeworm Diphyllobothrium ursi, a parasite of brown bears. It is readily apparent that tapeworms associated with gulls infect a variety of hosts including humans.

Thomas (1938) reported the life cycle of the tapeworm Diphyllobothrium oblongatum involved Herring Gulls, herring (Leucichthys sp.), and copepods. Tapeworm eggs were deposited in the feces of the gulls. Thomas (1938) reported that freezing the tapeworm eggs solid in ice for a month did not destroy their ability to hatch normal coracidia (early developmental stages). This suggests tapeworm ova survive through the Alaskan winter to continue their life cycle in the spring.

Although the pernicious-like anaemia associated with human Diphyllobothrium tapeworm infection in Eurasia has not been observed in Alaska, the potential for such disease has been examined by Rausch et al, (1967). These authors reported that there was no evidence that infection of Alaska natives by diphyllobothriid tapeworms contributed to the development of microcytic anaemia. However, in view of the often poor nutritional level of these people, the infection may be detrimental due to tapeworm absorption of B-vitamins (Rausch et al, 1967). Caucasians, however, especially those descended from northern European stock, may be genetically susceptible to anaemia associated with Diphyllobothrium tapeworm infections (Tötterman, 1947).

In addition to fish tapeworms, gulls have been demonstrated as part of the marine cycle of trichinosis, a roundworm which typically infects Eskimos in arctic Alaska. Marine mammals may become infected through consumption of encysted trichinae in the feces of carrion feeding birds such as gulls (Schwabe, 1964). Eskimos become infected with trichinosis upon consuming raw flesh of marine mammals, including polar bears, seals, walrus, and beluga whales, all of which carry Trichinella spiralis (Rausch et al, 1956).

Summarizing Parts I & II: Alaskan gulls associated with cannery effluent and sewage outfalls are implicated with the dissemination of human cestode and nematode" parasites.

Part III. Gulls and Enteric Disease in Alaska

Reports originating from all parts of Alaska of human gastroenteric diseases associated with high fever, marked diarrhea, and dysentery have been received by Alaska Department of Health and Social Services on occasion (Williams, 1950). Outbreaks of intestinal diseases occur in Alaska where water supplies are unprotected (anon.*, Alaska's Health, 1954). Alaska Public Health Laboratories have conducted studies indicating improper sewage disposal, Herring and Glaucous-winged Gulls, *and* public water supplies in the spread of the pathogenic bacteria Salmonella manhatten. First, a definition: salmonellosis is the term applied to infections caused by any of a group of more than 1,100 microorganisms (Steele & Galton, 1969). Salmonellosis usually occurs as an intestinal infection resulting in enteritis, or may terminate in septicemia and death (Steele & Galton, 1969).

Technically, the bacterial genus Salmonella is composed of gram-negative, aerobic, non-spore-forming microorganisms that grow well on artificial media and reduce nitrate to nitrite (Edwards & Galton, 1967). All members of the genus are potentially pathogenic for man and animals. Salmonella inhabit most species of warm-blooded animals (Steele & Galton, lot. cit.). Salmonella typhimurium has been recovered from gulls found dead near a cannery (Nielson, 1960). S. paratyphi B has been discovered in

Herring Gulls (Wilson & MacDonald, 1967) as well as S. derby (Faddoul & Fellows, 1966).** Gulls carry many other kinds of Salmonella (Steele & Galton, 1967). Enteritis in gulls may be the only sign of infection, increasing the probability of disease transmission (Nielson, 1960).

Herring and Glaucous-winged Gulls became suspect in the Salmonella epidemic at Ketchikan because of scavenger feeding habits at the city sewer outfall (anon.*, Alaskars Health, 1954). Gulls leave the Ketchikan waterfront with the advent of winter storms and fly approximately four km to Ketchikan Lake, the municipal water supply (Wilson & Baade, 1959). Epidemics of gastrointestinal disease have occurred at this time of year. Subsequent epidemiological investigation indicated a common vehicle (the community water supply) for the etiological agent. Literally thousands of gulls roosted on the lake at the time of the 1953 epidemic, and the water showed gross contamination *not* explainable by any other source (Wilson & Baade, 1959).

Specimens from gulls collected at the lake proved positive for Salmonella manhatten (Paratyphoid C group). Cultures from gulls as well as patients hospitalized with gastroenteritis were verified by CDC, Atlanta GA. Over 100 persons in Ketchikan were treated by physicians. At the time of the outbreak, drinking water was not purified by any method. Subsequent chlorination of the water supply drastically reduced the incidence of this disease in Ketchikan, but the situation must be monitored to assure constant levels of chlorination. Similarly, gulls roost on the lake forming the Cordova water supply and the chlorination is monitored (Morley AEH, pers. comm.).

The city of Valdez in Sept 76 was still dumping raw sewage below waterline in that harbor (Bayliss, pers. comm.). Photographs (Fig. 43,44)

* Dr. F. Pauls, APHL, has recently informed us the author is Ms. Edna Foster, cd., Alaska's Health.

** in Steele & Galton, 1969

show gulls at Valdez foraging directly at the sewage outfall with slick extending some hundred of meters downwind. Bayliss (pers. comm.) informs us Valdez will soon complete sewage treatment facilities (Appendix I).

Pollution of reserviors by aquatic birds has been recorded from Massachusetts, New York City, San Francisco, Los Angeles, Vancouver, B.C., and London, England (Wilson & Baade, loc. cit.). Typhoid bacillus has" been . . isolated from gull excreta collected in the vicinity of a town in Scotland where typhoid epidemics had first occurred (Wilson & Baade, 10C. cit.). Salmonellae were recovered from 78% of gull droppings collected near sewage disposal works at *Hamburg, Germany.* Samples taken from sewage-free areas were consistently negative (Muller, 1965).

According to Pauls (1953), providing safe and adequate water supply and sewage disposal is intricately linked with prevention of enteric disease outbreak. The role of gulls is an added phase to the study of both enteric and parasitic diseases in Alaska. The Ketchikan Salmonella outbreak underlines the need for proper, adequate *sewage* disposal systems preventing gull contamination with disease organisms transportable to public water or food supplies. Sewage disposal. in many smaller communities' in Alaska is accomplished by single premises or scavenger systems (underlining mine) (Pauls, in Alaska's Health, 1954). Contaminated water supplies and improper sewage disposal have historically (since 1807, the first reporting date) been major causes of gastrointestinal disease outbreaks in Alaska (Pauls, 1953).

The influx of people to Alaska will increase health hazards since carriers of typhoid and parasitic infections are undetected within this group (Pauls, 1953). The present explosive immigration to Alaska and projected rapid industrial growth of offshore oil operations may lead to conditions where gulls act *as* vectors for rapidly spreading human diseases.

Task A-28

Influenza in Avian Populations - A Review

Interactions between human and gull populations will increase with the development of coastal oil resources in Alaska, We include 'here under Task A - 28 a discussion of another potential aspect of the increase in gulls in Alaska as it relates to oil development.

Animals can be important as potential reservoirs or. contributors to new pandemic strains of influenza virus {Kaplan and Beveridge, 1972). Pandemics of type-A influenza are caused by "new" strains of virus appearing suddenly in human populations. These new strains may arise by genetic recombination with animal or avian influenza viruses, For instance, Hong Kong virus (A/Hong Kong/1/68) probably arose as a genetic recombinant formed as a rc.suit of a mixed infection of an animal or bird with an animal or bird influenza virus and a human A/Asian (Asian flu) strain (Kaplan and Beveridge, 1972) .

Individual influenza viruses contain two different virus-coded surface antigens, known as the haemaglutinin and the neuraminidase. Webster and Laver (1972) suggest that because the haemaglutinin of Hong Kong virus is completely different from the preceding Asian strains, such a great difference is not likely to have arisen by mutation. It seems more likely that the new Hong Kong virus arose by recombination. An animal or avian virus could have donated the haemaglutinin of A/Hong Kong/1/68 and the neuraminidase could have come from the human A/Asian strain. This sort of genetic recombination can be produced in live animals under experimental conditions. Since this kind of recombination can occur in laboratory animals it could occur in nature.

Avian influenza is caused by type-A viruses and infects both wild and domestic species around the world. Depending upon the virus strain, host species, and age of bird infected, avian influenza produces symptoms ranging from a drop in egg production to extraordinarily high mortality (Beard, 1970).

The virus A/tern/South Africa/61 caused very severe disease in terns, with mortality running into the millions (Becker, 1966). The epizootic in terns was first noted because of the high mortality, but high mortality rates are probably an exception. Becker (1966) suggested that wild birds might act as unapparent carriers of avian influenza viruses. This has since been demonstrated by Homme and Easterday '(1970), who showed that exposed ducks were infected for two weeks, long enough to carry the virus long distances and transmit the infection to wild and domestic birds along the way.

Antibodies specific for type-A influenza viruses have been demonstrated by serological surveys of wild birds in the U.S., Australia, and the USSR (Slemons et al, 1974). At least 100 distinct types of avian influenza virus have been isolated from various bird species with signs of respiratory illness or from flocks showing mortalities of unknown origin. Influenza viruses in birds not only affects the upper respiratory system, but also causes a drop in egg production, fertility, and matchability. Experiments have indicated that strains of avian influenza have a marked effect upon the reproductive systems of birds (Samadieh & Bankowski, 1970). Kleven et al (1970) reported chalky-white, unpigmented, shoft-shelled eggs increased up to 30% when breeding flocks are struck by influenza. The effect of influenza upon wild bird population reproduction is" completely unexplored (see above discussions of egg pathologies- in Egg Loss section).

Environmental factors can play a very important role in infection and disease, and it is here we relate influenza and offshore petroleum development. Studies have revealed that more severe manifestations of influenza result from interactions of virus and other factors, particularly cold stress. For instance, apparently recovered birds stressed by chilling show further infection as measured by virus isolations and rises in antibody titers (Homme et al, 1970). There was a consistent correlation between cold stress and disease; birds subjected to low ambient temperatures developed much more severe, chronic virus disease. Petroleum exposure is known to lead in hypothermia in birds (McEwan & Koelink, 1973). Logically petroleum exposure could lead to the onset of virus disease. We point out the complete lack of information concerning the interactions between petroleum exposure, hypothermia and disease, especially in seabird populations in northern seas. (See above Chick Mortality section for a discussion of weather factors on survivorship).

Avian influenza viruses can be dispersed by migrating birds. Becker (1966) suggested that some species of seabirds carry virus in a latent state. Under stress, such as stormy weather, or oil exposure, the viruses become active, resulting in epizootics. During migrations, seabirds with active virus infect susceptible species with which they come into contact. Rosenberger et al (1974) isolated type-A influenza viruses from migratory waterfowl. In this study, the cloaca appear-to be a better site than the trachea for isolations of the virus. If the cloaca or feces are a prime site of influenza isolations, this is an important implication for dissemination of *these* viruses.

Sera collected from seabirds in the northern USSR, among which were Herring Gulls, have shown antibody activity not only to avian influenza virus but also to A/Hong Kong/1/68 (Zakstel'skaja et al, 1972). Webster and Laver (1972) found sera from Australian pelagic birds specifically inhibited the neuraminidase of Asian/57 strain of human influenza, in addition to the neuraminidase of A/Hong Kong/1/68, indicating presence. of specific antibodies to these viruses. The antibodies to A/57 neuraminidase were found in sera of Short-tailed Shearwaters (Puffinus tenuirostris) and several other species. Webster and Laver (1972) suggest that these birds exchange avian influenza virus from areas in the Northern Hemisphere with Australian coastal waters. The Short-tailed ShearWaters possessing antibody to A/57 neuraminidase are known to migrate around the Pacific from Australia to the Bering Strait off Alaska (underlining mine), returning to Australia (Webster & Laver, 1972).

Slemons et al (1974) showed that ducks in the California Flyway, which includes Alaskan birds, are involved in the natural history of type-A influenza viruses, and that the migration patterns and daily foraging flights provide one mechanism by which the viruses can be transported over long distances and be disseminated at each stopping place. Multiple strains of virus circulating simultaneously in bird populations provide excellent conditions for genetic recombination in nature. Thus wild birds play an important role in the dissemination of type-A influenza viruses, and may provide conditions for genetic. interaction of type-A viruses of both human and animal types, resulting in, new hybrid strains.

Experimental Challenge of Gulls with Human Influenza

To test susceptibility of partially immune and non-immune gulls to human influenza virus, Messrs. J. Klein, M.Sc., J. Markowitz, M. Sc., and S, Patten, M.Sc., under the direction of I.L. Graves, DVM, inoculated two species of gulls (Larus argentatus and Larus delawarensis) with the virus Influenza A/Port Chalmers/1/73, (H3N2), a recent human strain. Both test animals had been caught in the wild and maintained in captivity in Johns Hopkins Animal Facilities. The Herring Gull showed a weak antibody titer in serum (1:16) prior to laboratory challenge; the Ring-billed Gull showed no such titer. The presence of antibodies specific to Port Chalmers influenza in the Herring Gull serum was confirmed by Radial Diffusion (Ouchterlony) test, and replicated three (3) times. The gull could have been exposed previously to the influenza strain in the wild or in captivity.

Under experimental conditions, both gulls were inoculated intranasally and into the trachea with .2cc undiluted stock virus. Under normal circumstances influenza is spread by droplet (respiratory) transmission. Incubation period is one to three days. Characteristically an abrupt onset of disease follows, indicated in humans by chills, fever, headache and myalgia. Recovery of uncomplicated cases begins three to four days-after onset of symptoms . Immune-competent individuals should be able to mount a response to an influenza infection within five days. Passage of the test virus used in this experiment through embryonated chicken eggs showed the strain to be very infectious to the 10^{-7} dilution.

Four days after the initial challenge with the virus, the non-immune gull was found dead. The first day post-challenge, the gull showed a slight rise in temperature. On the third day the gull still exhibited good reactions and normal behavior. Gross pathology observed in autopsy was consolidation of the lower left lung (evidence of a pneumonia-like infection). Heart, brain, kidneys, lung and liver were cultured for bacteria with mostly negative results. Only the brain evidenced presence of a slight bacterial-growth, likely a post-mortem occurrence.

Five days post-challenge with the virus, the partially immune Herring Gull showed poor behavior, with nictitating membrane fibrillation (CNS symptom), loss of weight, cyanotic soft-parts (pneumonia-like symptoms), and died with a very acute illness on the evening of the fifth day. Autopsy revealed no lung consolidation, air sacks asymptomatic, no tracheal blockage or other gross pathology other than infestation with mallophaga. Bacteria were cultured on nutrient agar plates from several organs, indicating possible bacteremia.

Tissue specimens from trachea, pharynx and internal organs were cultured for viruses and passed again through egg and tissue culture to determine which organs were virus-postive. Virus recovery was confined to specimens from the upper respiratory tract of both birds, suggesting a response similar to the course of fulminating human influenza infections.

Influenza Virus Antibody Assay (Task A - 28)

To answer the question of whether gull populations in the northeast Gulf of Alaska have been exposed to Type-A influenza Viruses, we performed a series of tests on gull *sera* collected during the course of this investigation.

Methods involved the use of multiple-well Single Radial Diffusion Plates supplied by WHO with the following antigens in gel medium: 1) Bel RNP (all influenzas); 2) A/Chick''N" Ger RNP (all avian influenzas); and 3) A/Hong Kong/68 (a human influenza).

Results are as follows: 1) Adult gull sera (n=19) ran against Bel RNP (all influenzas) showed 5% exposure to influenza virus of unspecified nature. Positive serum was from an adult gull breeding at the Alsek River (Dry Bay) in 1975. 2) Gull chick sera (n=56) collected from the large population at Egg Island in 1976 and ran against A/Chick "N" Ger RNP (all avian influenzas) gave positive antibody response in 7% of the cases and a weak response in 1.7% of the cases. 3) In the initial run against the A/Hong Kong/68 antigen (human influenza), 16% of the adult gull sera (n=19) showed positive antibody response. These reactive sera were from adult gulls collected at Egg Island and Dry Bay. However, on the second run against the HK antigen, the previous positives did not react, giving equivocal results. On the third run, 9.5% of sera collected from adult gulls breeding at Egg Island in 1975 (n=21) indicated some response to the Hong Kong antigen, forming precipitin rings around the wells in which the sera had been deposited. These precipitin rings were not as strong as the positive control, suggesting either a weak antibody response, exposure at some time in the past with subsequent decreasing antibody titer, or cross-reactivity with another influenza antigen.

These results *to* date indicate avian influenza is present in the NEGOA gull populations and some exposure to a Hong Kong or similar antigen.

Newcastle Disease Virus Antibody Assay (Task A - 28)

Newcastle disease virus (NDV) is considered a pathogen for most avian species (Hanson, 1972). Newcastle disease can be a mild illness with transient respiratory signs or it can be fatal with severe respiratory and neurological symptoms (Beard and Brugh. 1975). It can also cause hemorrhage and necrosis of the intestinal tract (Beard and Brugh, 10C. cit.). Bradshaw and Trainer (1966) gave evidence of NDV infection in wild ducks and Canada geese by demonstrating hemaglutination-inhibiting (HI) antibody in 14-17% of birds tested. Palmer and Trainer (1970) reported 31% of Canada goose sera contained antibody to NDV. Rosenberger et al. (1974) described isolation of NDV from several species of migratory waterfowl. The cloaca or feces may be a prime site of virus isolations in migratory waterfowl with implications for dissemination (Rosenberger et al., 1974).

We observed three dead or dying immature Black-legged Kittiwakes and many Glaucous-winged Gull chicks in the meadows on Egg Island; the kittiwakes and some gull chicks showed no external *injury (see* Chick Stage and Mortality Factors, above.). The kittiwakes were totally unexpected in the meadows since they are cliff-nesters and pelagic feeders. In the Hopkins laboratories we *are* examining an adequate sample (250) of sera from Egg Island gull chicks for evidence of common virus diseases, among which is NDV. We are using the HI test, which is the most convenient, rapid and economical method for evaluating antibody titer to NDV (Beard and Brugh, 1975).

Our procedures are *as* follows: all sera are heat-treated at 56° C for 30 minutes to remove non-specific inhibitors; positive control is NDV hyperimmune chicken antisera; negative control is normal chicken serum (both controls heat-treated 56°C, 30 min.). HI tests are performed on microtiter plates using 0.5 or 1.0% chicken red blood cells in buffered saline. In the initial screening antibody activity has been detected in 8 of 125 sera (6.4%). We are continuing our examination of these sera and suggest an NDV strain in this gull population.

SUMMARY. AND CONCLUSIONS

We carried *out* a concentrated investigation of several gull colonies located. in the northeast Gulf of Alaska during the summers of 1975 and 1976. We compared the results of our investigation to data gathered in our previous Alaskan research and to other studies in the literature.

Egg Island lies a few kilometers offshore from the mouth of the Copper River, near Cordova, Alaska, and contains the largest Glaucous-winged Gull colony in the northeast Gulf of Alaska. Some 8000 - 10,000 pairs of gulls nest on meadow-covered dunes on Egg Island. The gull population is not limited by available nesting space *due* to uplift of the island and the surrounding area in the '64 earthquake. Most egg-laying took place in late May and early June; there was a wide spread of egg dates outside the study area following egging by fishermen. Mean egg loss was 27% in the study area due *to* human and gull predation. Hatching success was high other than those eggs predated. We noted egg pathologies ("runt" eggs and supernormal clutches) on Egg Island prior to the development of oil resources, most likely due to the proportion of young females in the gull population. Considerable chick mortality occurred when chicks began to wander at about three weeks of age; the large territory size may slow the rate of earlier mortality. Death of many wandering chicks was due to attacks from other adult gulls. Fledging took about 40-45 days , and overall productivity was moderately high both years, averaging about 1.08 chicks produced per nest. The Egg Island gull population is partially dependent upon artificial food sources in Cordova. Other gull colonies on Copper River Delta barrier islands are located at Copper Sands and Strawberry Reef. Plant succession on earthquake-uplifted areas in these colonies will provide increasing nesting space for gulls.

About 500 pairs of Herring and Glaucous-winged Gulls nest sympatrically in a mixed colony on low gravel bars at Dry Bay, mouth of the Alsek River, south of Yakutat, Alaska. Hybrid gulls are common in the area. The reproductive biology of this colony was examined in June 1974 and 1975. Territory size was practically identical to that on Egg Island and also suggests room for population expansion. The reproductive cycle at Dry Bay was two weeks behind Egg Island, probably due to *heavy* snowfall and late spring in the Yakutat area in 1975. The gravel bars at Dry Bay may be flooded on occasion disturbing the gull reproductive cycle. The gull population at Dry Bay indicates strong influence from interior Yukon Herring Gulls.

The North Marble Island gull population, which is technically outside the borders of the current study area, but which forms part of the Gulf of Alaska gull group, has been investigated in 1972-73 for the National Park Service. This population shows quite a high reproductive rate under post-glacial conditions, averaging 1.77 chicks fledged per nest.

Comparison of the Egg Island and North Marble Island gull population reveals that in parameters such as territory size, clutch size, hatching success and fledging success, the Egg Island" population resembles a newly colonized site inhabited by *young adults.* Investigation of the North Marble Island population indicates that reproductive *rate* increases after the initial season. The gull population reproduction on Egg Island will increase as the proportion of experienced females increases, given continued access to sufficient food sources.

This information indicates the gull populations *in* the Gulf of Alaska have the potential for rapid increase with access to human garbage, sewage, and refuse associated with increased oil operations. Gulls are associated with canneries, fish-packing houses, garbage dumps, sewer outfalls and municipal water supplies along the coast of Alaska, and are clearly implicated with human bacterial and parasitic diseases in Alaska, As the availability of human-generated refuse increases with the development of oil resources in the Gulf of Alaska, populations of gulls previously more isolated may come into closer contact with one another. The gene flow between gull populations will probably be increased in coming years as a secondary consequence of human activities, which may lead to a new adaptive peak in this commensal bird species, with implications for municipal health and sanitation.

Banding returns and sightings of color-marked gulls indicate that breeding birds depart from the Cordova *area* in October and return in March. Juveniles disperse widely from Anchorage to Vancouver, B.C. We report more band recoveries from Valdez than any other location. There is a southward shift of this gull population in winter along the *coast* of the Gulf of Alaska, with more northern and interior gulls replacing breeding birds.

We report antibodies to Newcastle disease virus, probably a lentogenic strain, and avian influenza present in the Egg Island gull population. We are suspicious of antibody activity to Hong Kong influenza in gull sera although the work needs further investigation.

This report examines some of the factors influencing gull reproductive biology in the northeast Gulf of Alaska during the 1975 and 1976 and previous field seasons, and indicates a gull population reproducing at a good to normal rate under relatively wild conditions. We suggest this gull population is already responding to human influence in the area, notably around Cordova. The moderately high reproductive rate of the large population breeding on Egg Island could account for, if continued, an expanding number of gulls, due *to* increasing availability of food resulting from human activity. The development of oil resources could affect gull reproduction positively through access to this food supply, or negatively through disturbance of colonies at certain critical periods in the breeding cycle, detailed herein.

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STATE OF ALASKA
DEPT. OF ENVIRONMENTAL CONSERVATION
PRINCE WILLIAM SOUND REGIONAL OFFICE / POUCH E – VALDEZ 99686
JAY S. HAMMOND, GOVERNOR

October 4, 1976

Sam Patten, M. Se.
Associate Investigator
Dept. Pathobiology
School of Hygiene & Public Health.
The Hopkins University
615 N. Wolfe Street
Baltimore, MD 21205

Sam:

Attached are copies of letters to and from the Coast Guard regarding solid waste pollution on Egg Island.

The Valdez City outfall continues to pour raw sewage onto intertidal lands for the moment. We expect that the new force main and treatment works will be operational soon, maybe this week. If so, the City will be way ahead of their July 1, 1977 deadline for compliance with PL 92-500.

A minor uproar has occured at Cordova because of seagull "nuisance" and discharge of floating seafood waste from processing plants. Some correspondence is attached for your information. Health and Social Services had issued a Nuisance Abatement Order to control the waste discharge but decided not to back it up and turned it over to us for "the need for their involvement in this matter." So long as they are in compliance with their existing EPA permit [certified by the State], any major additional requirement would require hearings or public notice, with much red tape. With no major source of raw sanitary sewage being around, I'm not convinced of the "nuisance" potential, as far as environmental considerations are concerned. I'd appreciate your views on this matter.

So far no yellow-orange gulls; have advised Perkins and local Coast Guard.

Keep in touch.

Randolph Bayliss

Randy Bayliss, P.E.
Regional Environmental Supervisor

cc: Coast Guard - Valdez
George Perkins

STATE OF ALASKA

DEPT. OF HEALTH AND SOCIAL SERVICES

JAY S. HAMMOND, GOVERNOR

DIVISION OF PUBLIC HEALTH
ENVIRONMENTAL HEALTH SECTION

POUCH H-06F — JUNEAU 99811

CERTIFIED MAIL

DEPT. OF IN?. CONSV.
SEP 23 1976

September 20, 1976

Mr. Robert E. Cavanaugh, R.S.
Quality Assurance Office
Ocean Beauty Seafood, Inc.
Pier 54
Seattle, Washington 98104

Re: Your August 25, 1976 Letter
St. Elias Ocean Products, Inc.
Cordova, Alaska
Attractive Nuisance to Seagulls

Dear Mr. Cavanaugh:

I have been asked to respond to your August 25, 1976 letter concerning matters discussed in the August 4, 1976 and August 6, 1976 letters from this department to your firm.

On August 4, 1976, Dr. Pauls determined legal or administrative action was not appropriate for this instance of a public nuisance, in view of attempted, although not fully successful, corrective action taken by St. Elias Ocean Products, Inc. Now that the season of processing aboard the vessel is over, the matter is "moot", unless the vessel will again be used for processing at this location. Your firm apparently does forsee the utilization of the processing vessel in 1977 prior to finished construction of the proposed land based facility. A waste disposal method which substantially eliminates floating organic materials attractive to seagulls should be functional at that time; approval of the system would be secured from Mr. Randy Bayliss, Regional Engineer, Alaska Department of Environmental Conservation, Pouch E, Valdez, Alaska 99686.

I believe that Mr. Heidersdorf expresses the view of this department in his August 6, 1976 letter. If Cordova garbage disposal and seafood industry waste discharge were proper in all instances the seagulls would reduce their own numbers by starvation or migration to "easier pickings". As in rodent control, reduction of food availability is the prefered control step over the attempted elimination of the problem animals. However, as in rodent control, often, at least at first, both must be followed, with continuing control of food accessibility being the only long term control necessary to maintain.

If proper garbage dump and industry waste discharge operations were instituted, this office would favorably support the elimination of excessive numbers of seagulls, if their numbers did not decrease on their own. However, to reduce the seagull numbers without reducing the food supply would simply allow the problem to be recreated next season by anew generation of young-plus migrating individuals from areas of less abundant food.

However, if it can be demonstrated that the city and the seafood industry either will not or cannot adequately control their waste disposal, this office would, regretfully, support seagull control by itself, for temporary nuisance reduction,

Again, as Mr. Heidersdorf stated, we are *not* able to provide direct nuisance control; we would be willing to support an application by the seafood industry and/or City of Cordova for a control permit. Investigation has determined that it would not expedite nor assure issuance of a control permit, if our department were to apply for the permit in the name of the city or seafood industry.

A copy of the August 6, 1976 letter to you was transmitted to the Alaska Department of Environmental Conservation. No other letter or request was formulated, since the letter seemed to be self-explanatory for the purpose of initiating interest by that department in assisting city and industry waste disposal methods. Consequently, there were no copies of other letters or materials to send to you. Since that department apparently has not, in turn, contacted your firm or the city, we trust a copy of this letter will further alert that department to the need for their involvement in this matter. We will also be in telephone contact with Mr. Ron Hansen in Juneau. As was mentioned earlier in this letter, a "recent" ADEC change created a Valdez, Alaska based regional office; Mr. Randy Bayliss, not Mr. Kyle Cherry, now has the responsibility for the Cordova area waste disposal systems approval.

We doubtlessly will have several further discussions concerning waste disposal and other seafood sanitation matters during the winter and spring. As always, your continuing interest and cooperation are appreciated.

Sincerely yours,

Kenneth L. Torgerson

Kenneth L. Torgerson
Seafood Sanitation Coordinator

cc: James Poor, President, St. Elias Ocean Products, Inc., Cordova, Alaska
James C. Allen, Regional Sanitaria Supervising, SCRO - Anchorage
Everett Stone, Seafood Sanitaria, Kodiak
Ron Hansen, Chief, Water Quality, ADEC, Juneau
Randy Bayliss Regional Engineer ADEC, Valdez
James Davis, director, Investigations Branch, FDA, Seattle

STATE OF ALASKA

JAY S. HAMMOND, Governor

DEPT. OF HEALTH AND SOCIAL SERVICES

DIVISION OF PUBLIC HEALTH

Environmental Health Section
Room 203, State Office Bldg.
415 Main Street
Ketchikan, Alaska 99901

June 4, 1976

Mr. Sam Patten
P.O. Box 280
Cordova, Alaska 99574

SUBJECT : Salmonella in Seagulls
Ketchikan, 1953/54

Dear Mr. Patten:

Regional Sanitaria Joseph Cladouhos has requested that I forward you our file materials on an investigation of salmonella in seagulls in the winter of 1953-54.

These documents are arranged in as near chronological order as possible. At the time this study occurred, the City of Ketchikan water supply was not chlorinated. Periodic outbreaks of gastro-intestinal illness had been noted in the community since 1946. Epidemiological investigation indicated a common vehicle for the etiological agent, such as the community water supply. This study, which documented the role of seagulls in contaminating the City reservoir, played a significant role in efforts to have a chlorinator installed in 1955.

Of the principals involved in the study, Dr. A. N. Wilson continues as the City of Ketchikan Health Officer. Mrs. Baade and Mr. Baker have since retired and have moved from Ketchikan. To the best of my knowledge, the study was never written up for submission to a professional journal. A copy of the the paper Dr. Wilson presented to the Alaska Territorial Medical Society on February 28, 1955, is included in the attachments.

If you have any additional questions regarding this study, I would be happy to forward them to the principals, or provide you with their current addresses.

Sincerely,

Earl E. May

Earl E. May, District Sanitarian

EM:mb
Attach:
CC: Joseph Cladouhos

Ketchikan, Alaska.
December 3rd, 1953.

Regional Director
U.S. Fish & Wildlife Service,
Box 2021,
Juneau, Alaska.

Dear Sir:

For the past several years we have noticed sea gulls swimming on the waters of Ketchikan Lake, especially at this time of year. Perhaps it is only coincidental, but I have noticed that shortly after the sea gulls appear on Ketchikan Lake there seems to be an epidemic of gastro-intestinal disturbances among the residents of Ketchikan. This fact has been borne out by the records of our local doctors and hospital patients. This lake is the major source of drinking water for the city. There is no treatment, the water being delivered to the residences in an entirely natural state.

It is our desire to conduct a survey and laboratory investigation to determine what parasites, especially Endameba Histolytica, and other endo parasites, may be polluting the water from alementary tract discharges of sea gulls.

We request your permission to shoot 25 sea gulls for laboratory examination. I have talked with Fish & Wildlife representatives here in Ketchikan and these men offer their cooperation in this research project. Laboratory work will be done in the Alaska Department of Health laboratory here in Ketchikan, with possible verification of results in other Public Health laboratories.

Because of the time factor, may we suggest that the necessary communications regarding this permit be accomplished by telegraph. The permit should be made to Alfred Baker, Senior Sanitarian. This plan has been discussed and approved by the local Health Officer, Dr. A. N. Wilson, who is also a member of the Alaska Board of Health.

Thank you for your cooperation.

Sincerely yours,

Alfred Baker
Senior Sanitarian.

AB: co

cc - Mr. Amos J. Alter.

ADH-Adm.—Form 3a
11-51—20M

Appendix V

MEMORANDUM

TO Mr. Alfred Baker, Senior Sanitarian

DATE December 9, 1953

FROM Ralph B. Williams, Director

SUBJECT Study of Gulls for Pathogeni Organisms

We have just been informed by Mr. A.J. Alter, Chief, Section of Sanitation and Engineering, of your letter to the Regional Director of the Fish and Wildlife Service with reference to the study planned in connection with the possibility that gulls may play a role in the mechanical if not the biological transfer of organisms pathogenic for man through contamination of his water supplies.

There are a number of additional methods that may be used to detect the presence of pathogenic organisms in the gull, or other birds like the ducks and shore birds which may have roles of varying degrees in this possible epidemiological pattern. We would suggest that in addition to the sample of 25 gulls to be collected, that a plan to trap gulls be incorporated into the study. The samples thus taken could be studied for Salmonella spp., by the use of the Hardy Swab Technic, which is known to Mrs. Dixie M. Baade. The use of this method would give you a greater sample and at the same time it would be possible to mark the gulls with the official bands of the U.S. Public Health Service. The latter technic could include color banding which in addition to the possible emigration would make local spread of the gulls easy to determine. A gull thus banded in a sewage contaminated marine situation and observed later in the fresh water of Ketchikan Lake, would add weight to the support of your observations and associations of gastro-intestinal upset among the citizens of Ketchikan. These are merely suggestions which may aid in drawing your final conclusions.

At the Juneau Laboratory we have examined the castings (pellets) of two species of gull that feed in the marine situations ahout sewage outfalls along the Juneau waterfront. Our study has been directed at the isolation of the Salmonella spp., those that are most frequently associated with human disease as well as those found in aquatic and other birds. Thus far we have not isolated any suspicious organisms. Nor have we had any reported cases of Salmonellosis among the human population that might contribute to the presence of these organisms in the sewage. Evidence that the gulls feed on sewage can be supported by the demonstration of sanitary tissue in the pellets cast along the docks. Pellets formed by gulls feeding in the sewage outfalls of the City of Ketchikan could be cast into the waters of Ketchikan Lake. If it is practical to collect such samples, you may wish to make this a part of your study technic.

If the 25 gulls are collected as suggested in your letter of December 3, 1953, we would suggest that, after the bacteriological samples are collected, the birds be examined for parasites. The intestinal parasites maybe collected by opening the intestine its full length and washing the contents into a large petri dish, to be examined under the Quebec Colony Counter for the helminths. Worms found in this manner may be removed to fresh water or

D"

or saline (nematodes) solution until relaxed. Once relaxed they should be killed, using the following solution:

A.F.A.

Alcohol (85%)	80 parts
Formaldehyde	10 parts
Glacial acetic acid	5 parts
Glycerine	5 parts

The solution is carefully brought to a boil (do not use open flame) and after the excess water is removed from the worms, the contents of the petri dish are rapidly flooded with the solution.

Information as to the accession number of the gull, species, location, organ of the body in which found, date, collector, etc., should be placed on a small card which can be inserted into the vial containing the helminths . If thorny-headed worms (Acanthocephala) are found attached to the intestine they can sometime be teased from the tissue or gently pulled free. These worms should be left in tap or cool water until completely relaxed and the head is extended before killing in AFA.

We are very much interested in the possibilities and the success of your study. However, our experiences with these species would suggest that a large sample might have to be taken to demonstrate the presence of any organisms pathogenic to man. It is true that only a few gulls maybe the vehicle in the transmission, therefore the sample must be as large as possible to detect their presence in the total gull population. If the organisms are not found in the digestive tract or material from same it is still a possibility that the birds could carry the organisms on their bodies. The banding might give evidence to support such a theory. Chlorination would be the means of reducing this hazard where it is not possible to screen, net or wire the water supply to keep the birds out.

We will be interested in hearing of your progress with this study. We do not know how much progress can be made with our study here, but if anything comes to hand, you will be advised of our findings.

Ralph B. Williams

RBW:bb

The source of one outbreak of gastrointestinal disturbance "has been traced to seagulls on the Ketchikan Lake. Each winter the gulls gather on the lake by the thousands and each winter we have an outbreak such as the one seen here in November and December. Each winter the water from Ketchikan Lake shows gross pollution which cannot be explained by runoff from the water shed, or from any other source. Birds are known to be a common source of Salmonella infection. In addition to containing organisms harmful to man in their intestinal tracts, the gulls here have an additional chance to carry infection in their daily travel between the sewer outfalls at low tide and the untreated water of the lake.

For these reasons a permit was. obtained by Department of Health personnel from the U. 'S. Fish and Wildlife Service to collect seagulls for study. Shooting was done by Fish "and Wilflife personnel. and 14 seagulls were collected in the first group. In addition to various worm parasites, the Alaska Department of Health Laboratory found Salmonella (Paratyphoid) organisms in one of the gulls. In November and December there were human cases with symptoms of salmonella " (Paratyphoid) infection. These symptoms are vomiting, diarrheas abdominal cramps and" fever. The term most commonly used to refer to this set of symptoms is "stomach flu". Symptoms vary from mild cases. of only a day or two of illness to severe cases requiring hospitalization.

Specimens were obtained from hospital cases during the above epidemic and these were found to be Salmonella (Paratyphoid). Medical records indicate that there were at least a hundred cases seen by physicians in December. The organisms isolated from the gull and from the hospital patients were sent to the U. S. Public Health Service Laboratory in Atlanta, Georgia, for typing. The cultures from the gull and from the patients were all identified as Salmonella manhattan (an organism of the Paratyphoid C group). Here we have a case of gulls carrying infection to the people of a town through their water supply.

Seagulls are carriers of Salmonella (Paratyphoid) spread through our largest source of drinking water. Chlorination can break this chain of infection.

GULLS IN WATER POLLUTION STUDIES

The city of Ketchikan was founded about 1900. Reason: for its cliffside location was the existence of a salmon-spawning creek, for subsequently a saltery was built. Later a lumber mill was established and the homes were placed conveniently near these two industries. Streets were not planned and neither were public utilities For some time the creek was used for domestic water purposes. The creek was also a convenient means of garbage and sewage disposal. As modern living developed it was deemed advisable to set up a hydroelectric. plant.

Ketchikan Creek flows from two mountain lakes measuring about three miles long and one and a half miles wide. The elevation is about 600 feet, and the distance from town is roughly two miles. In 1925 a rock-and-earth-fill dam was constructed across one end of the lake nearer town thereby raising the water level, and a penstock was installed to provide pressure for the hydroelectric plant. This lake became the drinking water supply for the town. The amount of water used from the first lake frequently necessitates the pumping of water from the second lake to the first, there being difference in levels of the two. The early settlers considered these lakes to be remote from human trespassers and therefore not in need of protection against water contamination. No thought was given to the possibilities of disease being carried by mammals, birds or humans. For at least ten years various persons have noted that gulls have flown to the lakes during the cold and stormy weather. Just why this habit is maintained by the gulls is a matter of conjecture. It was also the subject of some discussion that the gulls walk and wade about on the sewage polluted beaches and sometimes eat particles of human fecal material.

Three years ago tentative plans were made to carry on an investigation as to the possibilities that these birds could carry disease-producing organisms to the water supply. In December 1953 a permit was secured from the Fish and

Wild, Life Service to take 25 gulls for scientific study. The first lot consisted of 14 specimens Four were glaucous-winged gulls, Larus glaucescens , and 10 were herring gulls, Larus argentatus. The birds were shot on the lake and brought to town where the 'body cavities were opened and viscera removed. The entire alimentary tracts were opened by splitting lengthwise with scissors and scalpels. The contents were scraped out and placed in clean paper cartons, cultures were made and eliminated in the search for salmonellosis organisms. All cultures were done by Mrs. Dixie M. Baade in the Ketchikan Laboratory. Exact techniques used are entirely in the province of Mrs. Baade's research, In one culture from a glaucous-winged, gull, Larus glaucescens, salmonella manhattani was isolated. The material was sent to the U. S. Public Health Service Communicable Disease Center laboratories in Atlanta, Georgia, for verification by authorities

It was planned to continue further studies of specimens secured on sea water. Ten specimens were taken in Tongass Narrows, similarly examined and cultured, with all results being negative. Because of popular demand newspaper releases were made in an effort to secure water protection for the City of Ketchikan. At the time these specimens were taken, five patients were in the Ketchikan General Hospital suffering from gastro enteric distress. The Ketchikan Laboratory isolated salmonella manhattani from two of these patients,

Significant in this study is the fact that a leading publisher has made a statement in print: "The Alaska Department of Health has never found a disease-producing organism in the Ketchikan public water supply." This salmonella organism came from the alimentary tract of a sea gull swimming in the water of Ketchikan Lake. Future plans include the use of membrane filter. Gauze filters have been placed near the intake pipeline in an effort to secure pa&o-genie organisms directly from the water. "We note that small reservoirs have

B made use of wires stretched across them about a foot above the water surface to prevent alighting and take-off of water birds. It is probably impossible to protect a large lake in this manner.

We have the statement of a local doctor that he has seen children in state of shock from ingestion of coliform organisms, presumably found in untreated city water. For at least ten years laboratory tests taken at weekly intervals have shown coliforms in water samples. This is especially true during periods of heavy rainfall. and run-off from mounts.fnsides—likewise during thaw periods. In our local health education efforts we have reiterated frequently that the presence of B. Coli indicates possibilities of other pathogens in drinking water.

Attention is being focused on the need for proper and adequate disposal systems to prevent contamination of' animals, birds and insects with disease-producing organisms which they can carry back to water and food supplies for

D humans. "

These facts point out that a good water supply, properly treated, can further limit the possibilities of human illness being spread by a siwage-animal-water-human being chain. .

Agnes Baker
Associate sanitarian.

Appendix VIII

Plant Species List, Egg Island, mouth of the Copper River, 20 km south of Cordova, Alaska. Collection made in summer, 1975.

Lichen spp.

Mosses

- Rhytidiadelphus triquetrus - used by gulls for nesting
- Rhytidiadelphus squarrosus - used by gulls for nesting

Spruces

- Picea sitchensis - one tree on islet closest to mainland prob. pre-'64

Grasses

- Poa eminens
- Calamagrostris canadensis
- Festuca rubra
- Hordeum brachyantherum
- 1* Elymus arenarius subsp. mollis var. mollis - used by gulls for nesting
- Carex macrocephala

Irises

- Iris setosa

Deciduous Trees

- Populus balsamifera subsp. trichocarpa - one tree an main dunes prob. post-'64
- Salix spp.-dozens of post-'64 individuals in moist areas
- Alnus crisps subsp. sinuata - same as Salix

B

Forbs

- Urtica sp.
- Stellaria humifusa
- Rorippa sp.
- Parnassia palustris
- Fragaria chiloensis
- Potentilla Egedii
- 3* LathrUS maritimus
- Epilobium angustifolum
- Epilobium adenocaulon
- Ligusticum scotium
- Angelica lucida
- Heracleum lanatum - scattered bushes on grassy dunes
- Rhinanthus minor
- Sambucus racemosa - scattered bushes on grassy dunes
- Anaphalis margaritacea
- 2* Achilles borealis
- Senicio pseudo-Arnica

* dominants in descending order