Environmental Assessment of the Alaskan Continental Shelf

Final Reports of Principal Investigators
Volume 16. Biological Studies

U.S. DEPARTMENT OF COMMERCE
National Oceanic & Atmospheric Administration
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The facts, conclusions and issues appearing in these reports are based on interim results of an Alaskan environmental studies program managed by the Outer Continental Shelf Environmental Assessment Program (OCSEAP) of the National Oceanic amd Atmospheric Administration (NOAA), U.S. Department of Commerce, and primarily funded by the Bureau of Land Management (BLM), U.S. Department of Interior, through interagency agreement.

DISCLAIMER

Final Report

Contract No. 03-5-002-72

Research Unit No. 83

1 January 1980-30 September 1981

Pelagic Distribution of Marine Birds

and

Analysis of Encounter Probability for the Southeastern Bering Sea

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ACKNOWLEDGEMENTS

Throughout the years of this project, we have become indebted to many people, without whose help our task would have been impossible. The success of our pelagic studies was aided and supported by the captains and crews of the Discoverer, Moana Wave, Surveyor and T.G. Thompson and the helicopter pilots assigned to the Surveyor. Others helped us gather data: Zoe Eppley, Doug Forsell, Sue Hills, Bobbie Mayer, Maura Naughton, Jay Nelson, Bill Rodstrom, Melody Roelke, Doug Schwartz, Sam Sharr, Doug Siegal-Causey and Doug Woodby. These people all put in unreasonably long hours of hard work. The project would not have succeeded without their enthusiasm and support. In addition, for the analyses the proportion of transects with large densities (Figures 1-8) and the evaluations of encounter risk (Figures 17-26), data gathered by other OCSEAP contractors (J. Wiens, P. Myers and the U.S. Fish and Wildlife Service) were used.

Grace Bush, Mike Crane, and Jim Mershman were instrumental in our data management processes. Hal Petersen and the Data Projects Group, University of Rhode Island were instrumental in the analysis and development of computer graphics for our pelagic studies. Zoe Eppley played a major role in production of the final report. Karin Fouts provided illustrations, and Pam McDonald and Tana Forstrom typed the manuscript.

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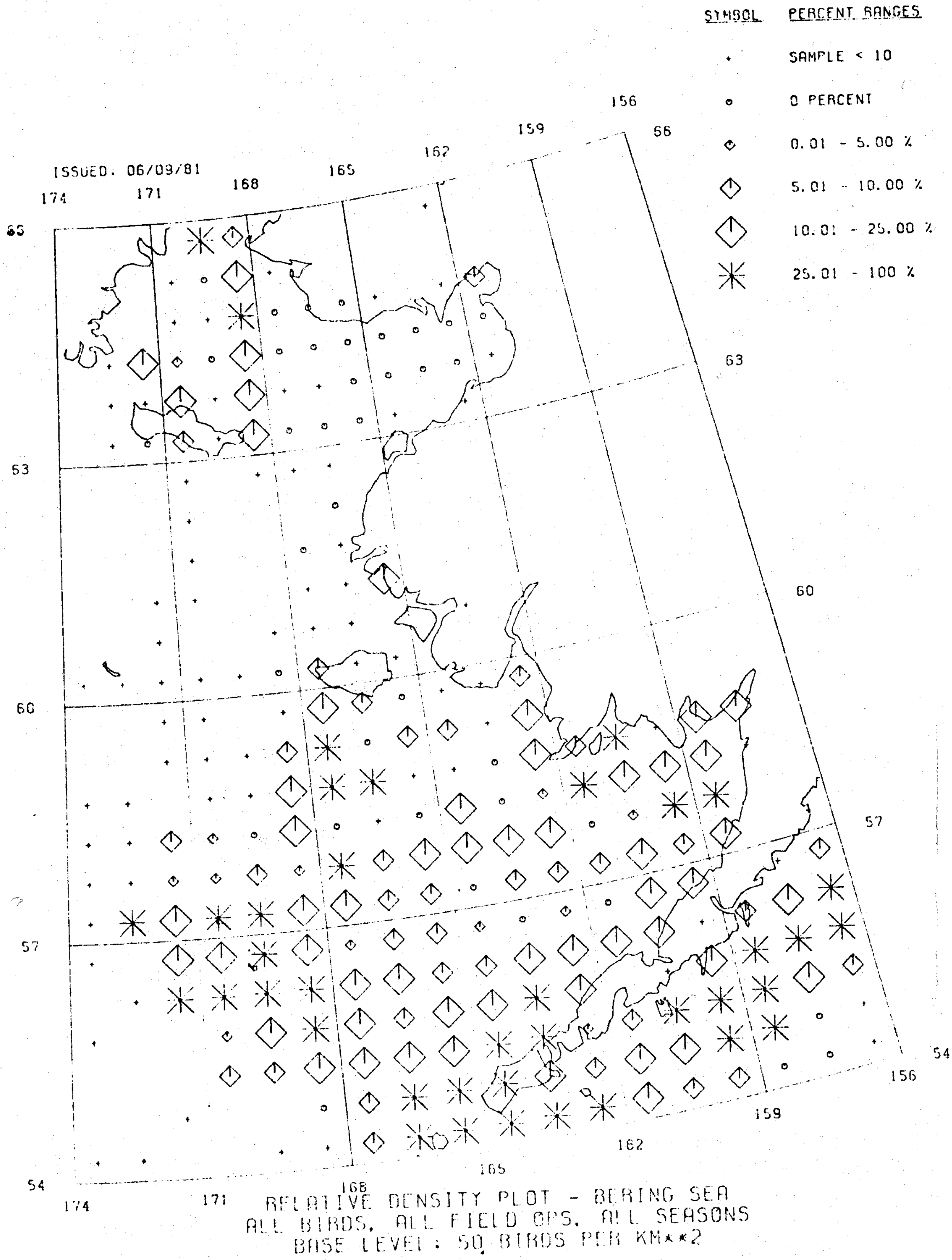
SUMMARY OF OBJECTIVES, CONCLUSIONS AND IMPLICATIONS WITH RESPECT TO OCS OIL AND GAS DEVELOPMENT

The objective of this project was to investigate the pelagic distribution of birds in the southeastern Bering Sea and to identify areas in which high densities of birds were frequently found (sensitive areas). We also wished to identify the characteristics of areas supporting large numbers of birds and to develop a rationale for sampling programs for the examination of new regions.

Around the Pribilof Islands, foraging seabirds are concentrated within 50 km of the colonies, although a few species (e.g. Northern Fulmar, _Fulmaris glacialis_, Red-legged and Black-legged Kittiwakes, _Rissa brevirostris_ and _R. tridactyla_) forage at greater distances from their colonies. Crucial foraging areas for Pribilof seabirds are located at the shelf break southeast of St. George Island, on the shelf 100 km east of St. Paul, and generally within 50 km of the islands. The reduction of food resources, or the occurrence of oil spills in these areas would affect a great number of birds.

Figures 1-8 show the geographic distribution and frequency of transects with densities of birds greater than or equal to 50, 100, 500 and 1000 birds/km^2. Areas where high densities were frequently encountered should be considered as areas of great avian sensitivity to oil spills. The Bering Strait, the vicinity of St. Lawrence Island, the area around the Pribilofs, the shelf-edge and Bristol Bay inside the 50 m curve are all sensitive areas. These highly sensitive areas are most readily seen in Figure 3. This assessment of sensitive areas is also born out by the analysis using means and coefficients of variation in Figures 13 to 22. Note, there are large areas which have yet to be surveyed which may contain very sensitive areas (e.g. the west end of St. Matthew Island).

Our zonal analysis of bird distribution showed that the areas close to the



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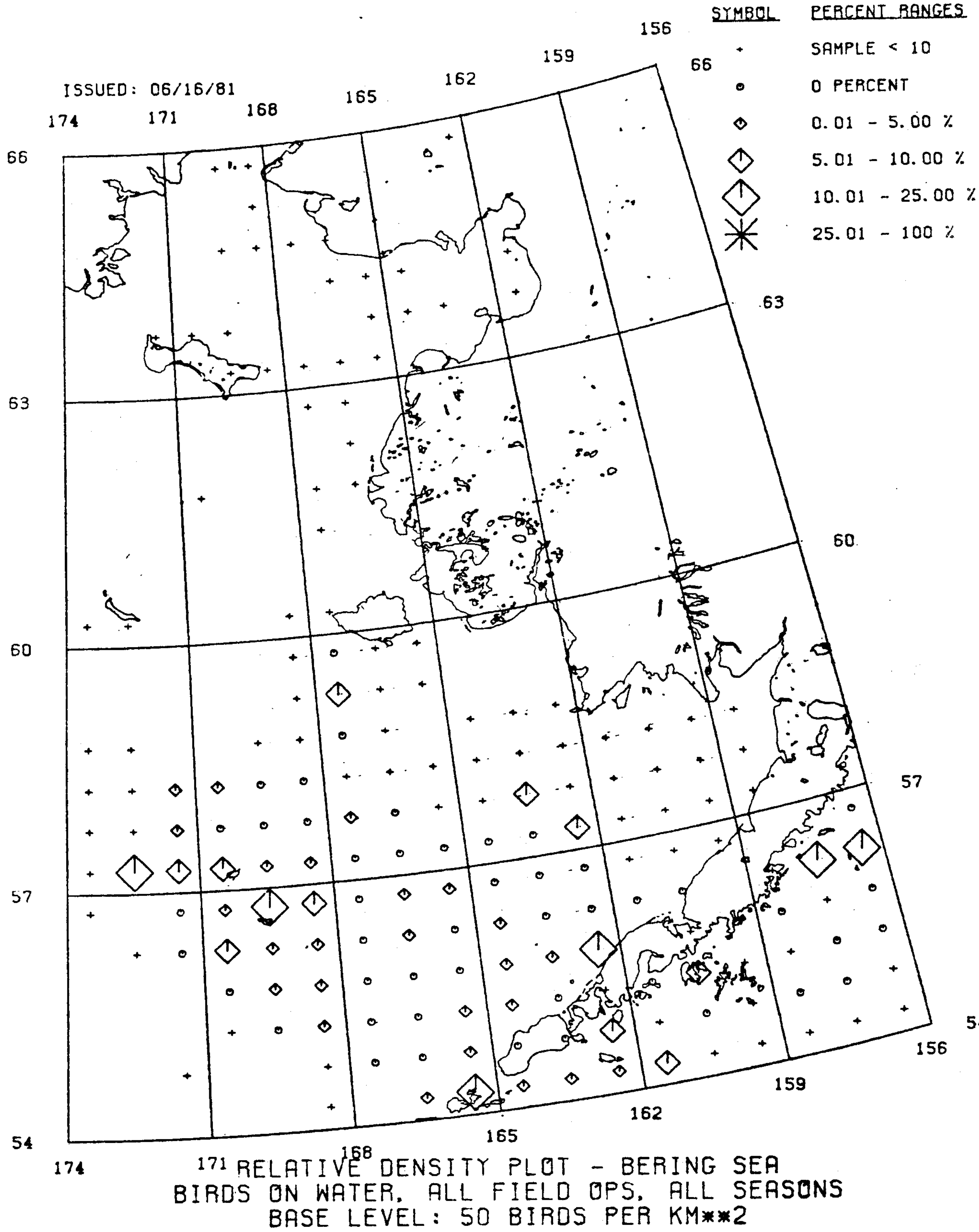
RELATIVE DENSITY PLOT - BERING SEA
ALL BIRDS, ALL FIELD OPS, ALL SEASONS
BASE LEVEL: 50 BIRDS PER KM**2

Figure 1



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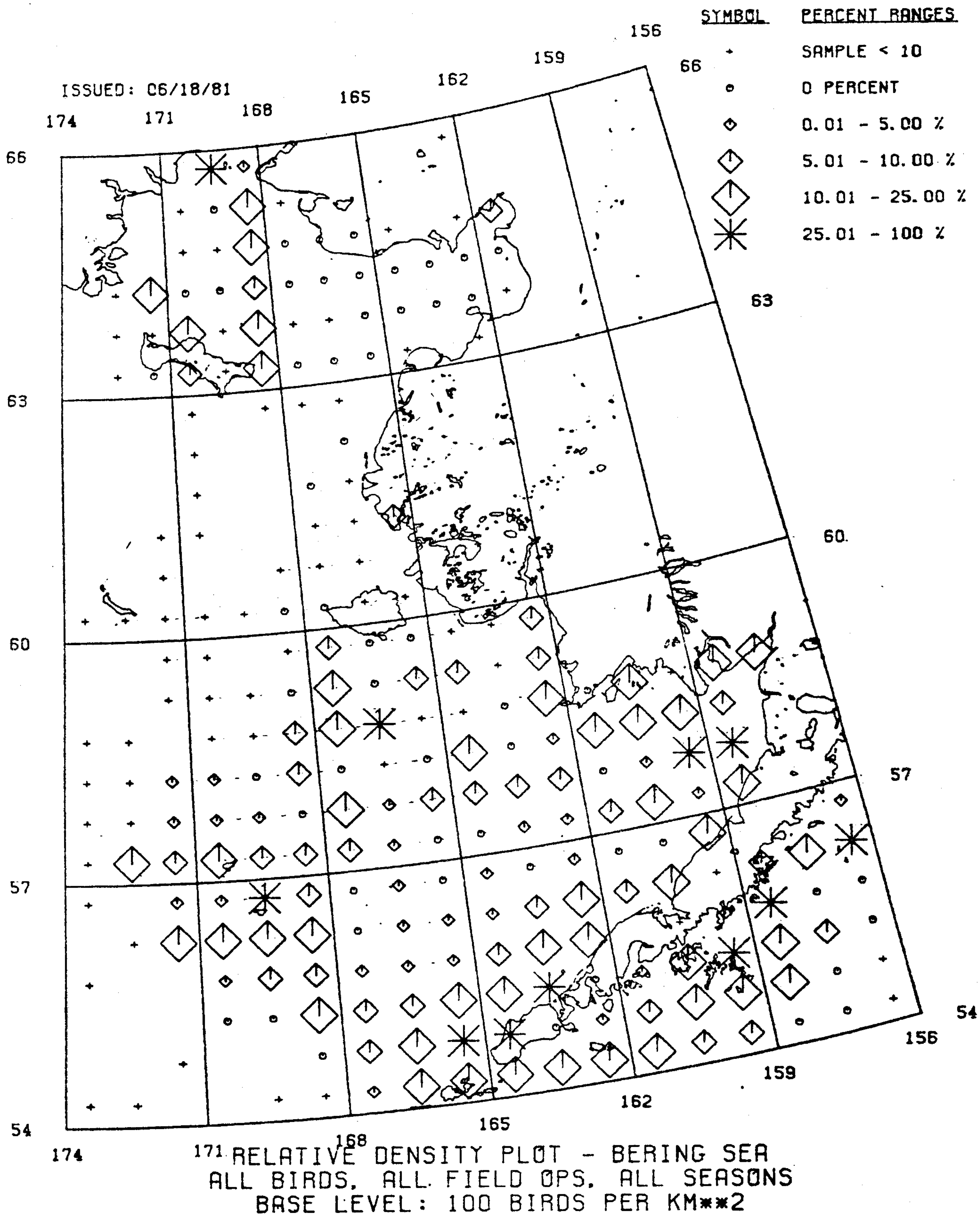
RELATIVE DENSITY PLOT - BERING SEA
BIRDS ON WATER, ALL FIELD OPS, ALL SEASONS
BASE LEVEL: 50 BIRDS PER KM**2

Figure 2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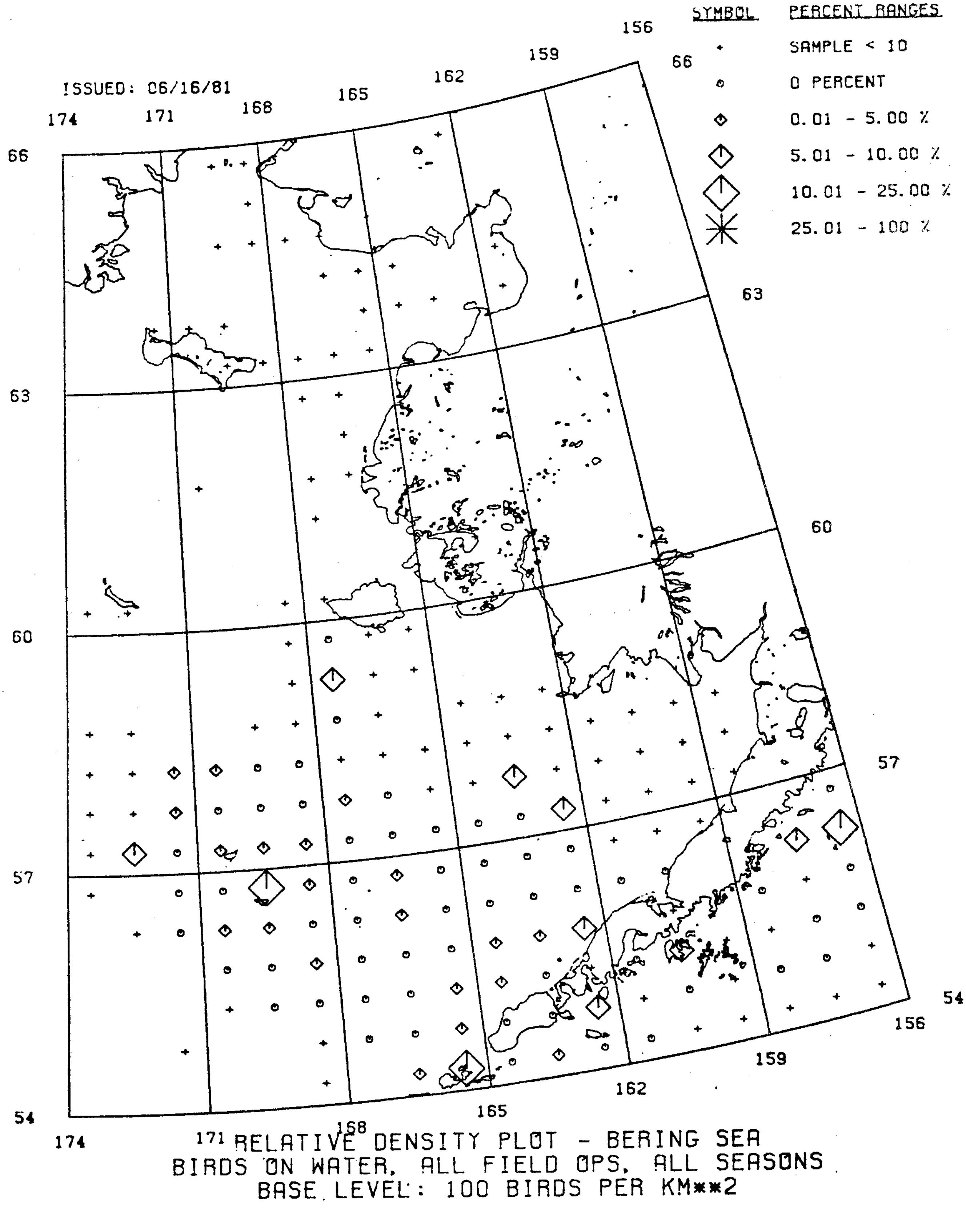
RELATIVE DENSITY PLOT - BERING SEA
ALL BIRDS, ALL FIELD OPS, ALL SEASONS
BASE LEVEL: 100 BIRDS PER KM**2

Figure 3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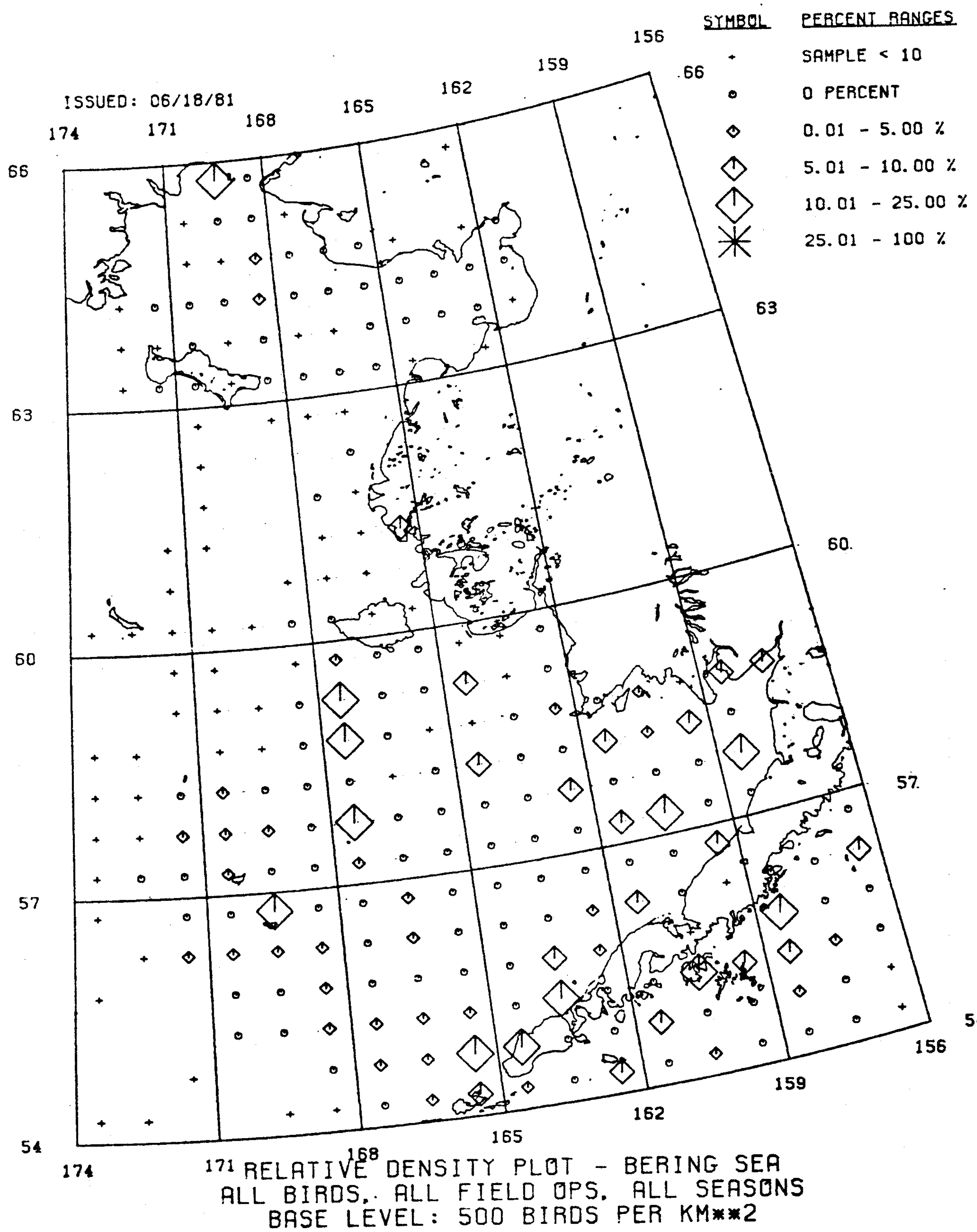
BIRDS ON WATER, ALL FIELD OPS, ALL SEASONS
BASE LEVEL: 100 BIRDS PER KM**2

Figure 4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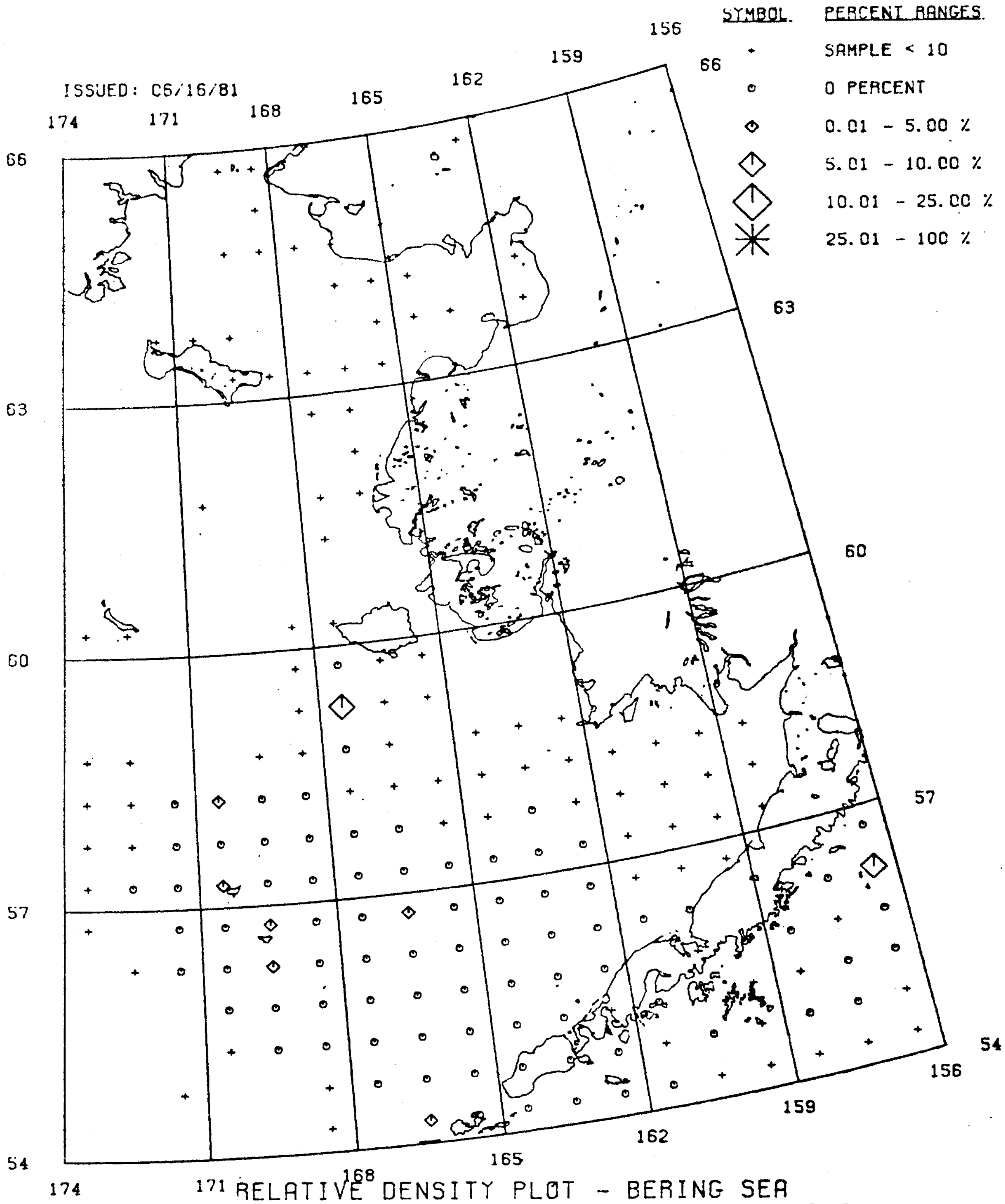
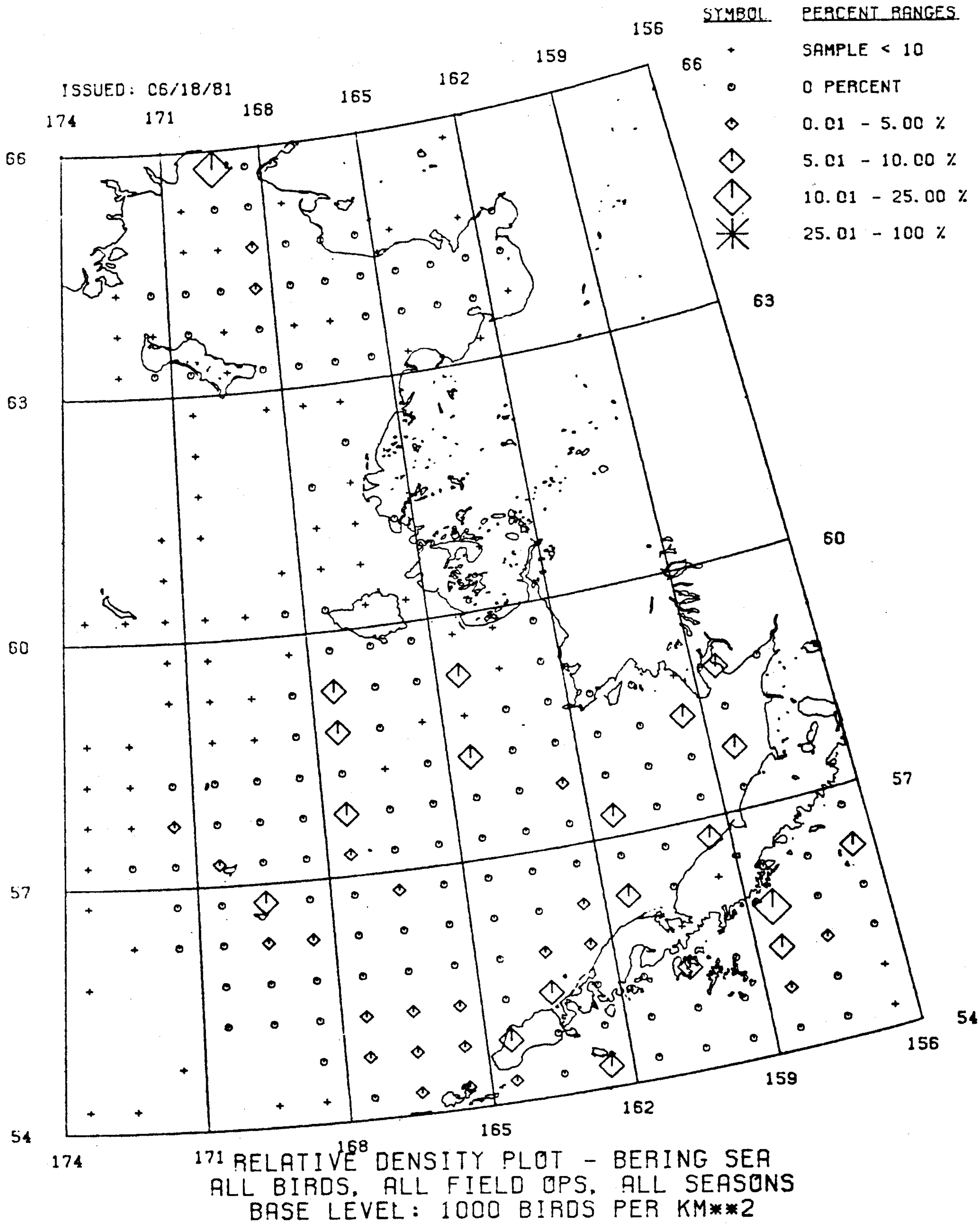
RELATIVE DENSITY PLOT - BERING SEA
ALL BIRDS, ALL FIELD OPS, ALL SEASONS
BASE LEVEL: 500 BIRDS PER KM**2

Figure 5



RELATIVE DENSITY PLOT - BERING SEA
BIRDS ON WATER, ALL FIELD OPS, ALL SEASONS
BASE LEVEL: 500 BIRDS PER KM**2

Figure 6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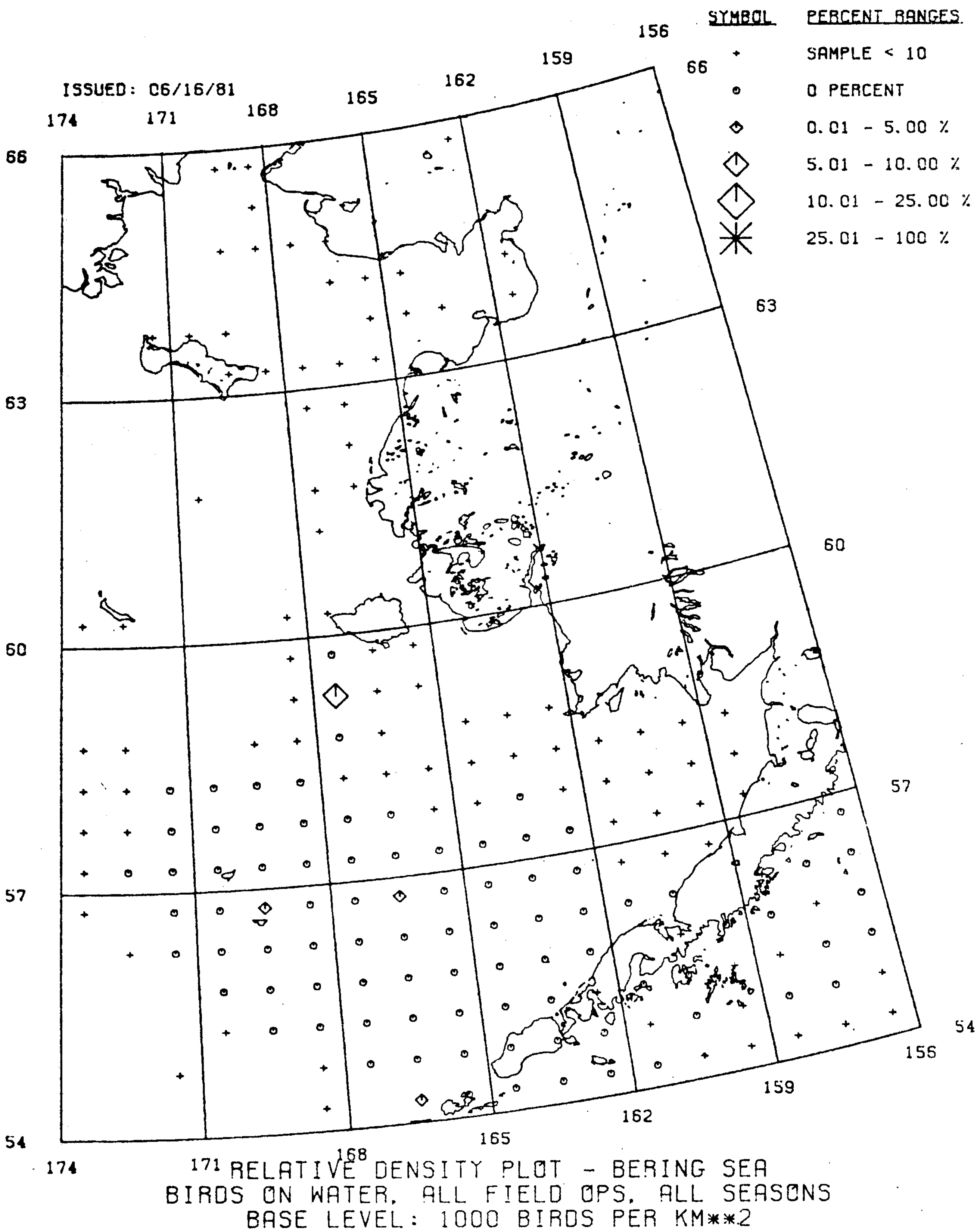
RELATIVE DENSITY PLOT - BERING SEA
ALL BIRDS, ALL FIELD OPS, ALL SEASONS
BASE LEVEL: 1000 BIRDS PER KM**2

Figure 7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RELATIVE DENSITY PLOT - BERING SEA
BIRDS ON WATER, ALL FIELD OPS, ALL SEASONS
BASE LEVEL: 1000 BIRDS PER KM**2

Figure 8

colonies, particularly on the side toward the shelf-edge have the greatest densities of birds and the most frequent occurrence of transects with high densities. Away from the colonies, areas near the shelf-edge have high densities, as do the areas along the 50 m curve in Bristol Bay.

A proposed sampling rationale suggests that regions to be surveyed be divided into zones by distance from colonies and by oceanographic domains away from colonies. A random sample of at least 100 transects within each zone, per season, will provide data on the frequency distribution of transects of different densities ± 10% at the 95% confidence level. This level of statistical certainty should be sufficient to provide reasonable confidence in the credibility of recommendations based on the survey effort. Because of seasonal variation, samples should be spread over three or four seasons.

INTRODUCTION

The purposes of this study were 1) to assess the relative likelihood of encountering birds in various areas of the eastern Bering Sea shelf waters surveyed, 2) to provide descriptions of those areas where birds have been found to congregate in order to predict where, in still-to-be explored waters, birds are likely to be common, and 3) to provide a statistically valid rationale for designing future bird survey efforts.

To assess the risk of bird loss in the event of an oil spill, several approaches can be taken. King and Sanger (1979) have concentrated upon developing an index of vulnerability that assesses the relative impact of oil on each of the species of marine birds frequenting Alaskan waters. Their approach, while directing attention to those species for which spilled oil poses the greatest threat, provides no information on the likelihood of encountering those species in any given area. The studies of Wiens et al. (1979) provide models for predicting the long term impact of a spill in the vicinity of a colony or other area for which a large data base on distribution, reproductive success and energetic relations of the birds is available.

The present effort focuses on where on the ocean spilled oil is likely to come into contact with large numbers of birds. There are two ways of assessing where large numbers of birds are likely to be encountered. First, we can focus on the locations of transects that have encountered high densities of birds, regardless of the variation in the density of birds at these locations. The percentage of transects encountering high densities gives an indication of the probability that a spill would impact large numbers of birds. Second, we can focus on the mean density of birds and the variation of the mean for a given area. Under this approach areas with high means and low variance would be considered high risk areas while those with low means and low variance would be considered low risk areas. Intermediate levels of risk would be assigned to areas having both a high mean and a high variance or a low mean and a high variance.

The second aspect of this report is an attempt to provide a description of the areas most preferred by birds so that reasonable predictions about where large numbers of birds are likely to be encountered can be made for unsurveyed areas. We first attempted to describe these areas of known high usage using linear regression models. However, due to the highly skewed distributions of seabirds, no clear association was found between oceanographic features and high bird densities using standard multivariate techniques. Our approach was therefore to first partition the available data base into biologically significant geographical zones and time (season) intervals. After imposing this structure on the data, we were able to categorize the sample densities into intervals which yielded probability estimates based on very few assumptions about the population distribution in general. The results of these two methods can be examined to identify, on the basis of our present knowledge, the most sensitive areas.

Finally, using the data in hand and our efforts at predicting where different densities of birds should be found, we have provided suggestions on the quantity and distribution of sampling effort required to give various types of information concerning bird densities. While one can always argue that the greater the sampling effort, the better the estimate of the population being studied, it is clear that there are neither adequate funds nor is there sufficient time to survey intensely all offshore oil lease-sale areas. We have therefore attempted to develop a rationale for distributing sampling effort in order to gain the maximum information possible per unit effort.

CURRENT STATE OF KNOWLEDGE

1) Pelagic Distribution

The pelagic distribution of seabirds is relevant to OCS oil production because bird density and location determines their potential vulnerability to oil spills. The relationship between the distribution of marine birds in the North Pacific/Bering Sea and the oceanographic features of these waters has been the subject of study in recent years. Kuroda (1960) attempted to correlate numbers of seabirds with food availability and sea surface temperature, while Shuntov (1972) stressed the importance of upwelling near the shelf break, as well as the higher productivity and the large bird concentrations associated with shelf waters. Swartz (1966) discussed bird distribution in the Chukchi Sea and Bering Strait regions.

Prior to OCSEAP cruises, knowledge of the pelagic distribution of seabirds over the eastern Bering Sea shelf was limited. Irving et al. (1970), Bartonek and Gibson (1972) and Wahl (1978) reported on birds seen in the course of single cruises, made for other purposes, which spent only brief periods in shelf waters. Wahl (1978) found a marked increase in the density of birds and species composition as he crossed from the deep oceanic waters to waters over the shelf. In particular, storm-petrels (*Oceanodroma* sp.) were less common over the shelf, while murres (*Uria* sp.) and shearwaters (*Puffinus* sp.) increased in density. Wahl estimated a density of 3.9 birds/km^2 for the oceanic waters compared to 14.9/km^2 for shelf waters. These values were similar to those obtained by Shuntov (1972) of 2.7/km^2 and 18/km^2, respectively. Sanger (1972) provided estimates of pelagic bird density over the Bering Sea shelf and oceanic basin based on extrapolations from other ocean regions. More recently, Iverson et al. (1979) have shown that seabird densities over the southeastern Bering Sea shelf are related to frontal systems. In a series of cruises, bird densities were highest from the Outer Front (Figure 10, p.22), at the 200 m isobath, shoreward to the Middle Front, at the 100 m isobath.

Hunt et al. (1980a) provide the most recent summary of new data from the eastern Bering Sea as a whole, while Hunt et al. (1980b) provide an update on seabird distributions near the Pribilof Islands. Schneider and Hunt (MS) and Hunt and Schneider (MS) discuss energy flow and pelagic distribution, respectively, for the region near the PROBES line. The present report will attempt to integrate and present the major portion of these recently accumulated data.

2) Oil Effects

A vast literature exists on the effects of oil pollution on seabirds. Vermeer and Vermeer (1974) provide an annotated bibliography. More recently Holmes and Cronshaw (1977) have reviewed the biological effects of petroleum on birds with particular emphasis on physiological effects. OCSEAP sponsored studies have investigated the effects of oil on seabird reproduction (Patten and Patten 1977, 1978), and OMPA has supported additional physiological work initiated by Graw et al. (1977).

There are conflicting reports as to the behavior of seabirds when encountering oil slicks; Curry-Lindahl (1960) reported that Oldsquaw (Clangula hyemalis) were attracted to slicks. In contrast, Herring Gulls (Larus argentatus), Black-legged Kittiwakes and Common Murres (U. aalge) are reported to leave slicks once they encounter one (Bourne 1968). Differences in the reaction of birds to oil slicks affects the vulnerability of a species and the potential for population loss when oil is spilled. The Bureau of Land Management is presently sponsoring studies of this problem in southern California (Gordon Reetz, Los Angeles BLM/OCS office, personal communication).

Other studies have concentrated on the effects of oil spills on populations.

Milon and Bougerol (1967, in Vermeer and Vermeer 1974) document changes in populations of seabirds on the Ile Rouzic in France subsequent to the Torrey Canyon disaster. Within a month the populations of Common Puffins (Fratercula arctica) and Razorbills (Alca Torda) were reduced by 88% while the population of Common Murres was reduced by 75%. Populations of fulmars and gulls were affected to only a minor degree. Studies by O'Connor (1967), Phillips (1967) and Monnat (1967) report on the effect of the Torrey Canyon spill on alcids and gannets (Sula bassana) at other locations. The lack of a baseline hindered the study of effects of the Torrey Canyon spill on seabird numbers and reproductive success.

These studies, although fragmentary, show that alcids and sea ducks are particularly vulnerable to oil. King and Sanger (1979) developed an oil vulnerability index for marine birds for the North Pacific and Bering Sea regions. The sensitivity of alcids to oil pollution is a critical problem in relation to Alaskan oil recovery, as the large colonies are predominately populated by alcids. In Fall and Spring, sea ducks may occur in vast numbers, also creating the potential for the devastation of populations. Wiens et al. (1979) have modeled the effects of oil spills under various conditions on the Pribilof seabird colonies, and made predictions about the time for population recovery.

Sublethal doses of oil may affect reproduction; Patten and Patten (1978) found that injested oil caused aberrent incubation behavior in Herring Gulls, which included a failure to replace lost eggs. Grau et al. (1977) reported that injested oil caused inhibition of egg-laying or altered yolk structure, while oil transferred from the plumage of adults onto eggs greatly reduced their viability (Macko and King 1980).

Sublethal doses of oil may also lower the viability of adults by ruining the insulation provided by the feathers (Hartung 1967, McEwan and Koelink 1973). Since oiled birds usually stop eating (Hartung 1967), starvation, accelerated by depletion of fat reserves for thermoregulation, rapidly follows oiling.

METHODS

1) Risk Assessment

An assessment of the environmental risk associated with oil spills and potential bird losses due to the impact of such events must be based, at least in part, on judgements as to the location and number of birds which might be encountered. In this report, the quantitative data available for such judgements are based on estimates of population densities obtained by ship-based and aircraft-based observers. The results described here are based on two methods of organizing these data. Both methods require a preliminary choice of areas used in the analysis. The first describes each area in terms of a mean and a coefficient of variation while the second categorizes density estimates within each area into predetermined intervals.

Bird densities were estimated using a line transect method (Burnham et al. 1980) modified for use at sea (Cline et al. 1969, Sanger 1976, Hunt et al. 1980). Counts were made from ships, using a 90° sector extending 300 m abeam and forward. Counts were made while the ship was underway at speeds ranging from 10 to 20 km/hr. Ship following birds were noted and excluded from counts. Ship's position to the nearest tenth of a degree was recorded at the start and end of each 10 minute count. Identifications were made to the lowest possible taxonomic level. Bird densities were computed for each count, about the time taken to scan a square kilometer at usual cruising speeds.

A. Means and Coefficient of Variation:

A preliminary identification of high risk areas in the Bering Sea was made by computing the average number of birds encountered in areas measuring 1 degree of longitude and 30 minutes of latitude. Average densities were computed for all birds in each of the four seasons, all birds on the water in each of the four seasons, and for each of the abundant species in each of the four seasons. As a convenient measure of the relationship between the mean and standard deviation for each block, a coefficient of variation (CV) was also calculated. This coefficient is the ratio of the standard deviation to the mean, chosen because it provides an obvious comparison of the relative shapes of the density distributions in each block. In keeping with the idea that high risk should be associated with large numbers of birds, those blocks having a high mean (high rate of encounter) and a low coefficient of variation (i.e. a reliably high rate of encounter) were identified as high risk areas. Variable risk areas were identified as those with a high coefficient (i.e. high and low counts of birds in the area), subdivided into two types: those with high means and those with low means. Low risk areas were deemed to be those in which both the average number of birds encountered and the variability of this figure (coefficient of variation) were low.

Four criteria were established to identify risk areas: I=high risk (# of birds ≥ 75.1 and $CV \leq 2$); II=variable high risk (# of birds ≥ 75.1 and $CV \geq 2.1$); III=variable low risk (# of birds ≤ 75 and $CV \geq 2.1$); and IV=low risk (# of birds ≤ 75 and $CV < 2.1$).

For this analysis, the Data Processing Group of Dr. Hal Peterson at the University of Rhode Island used all available bird data generated by OCSEAP investigators in the Bering Sea. These included contributions by the U.S. Fish and Wildlife team under the direction of Dr. Calvin Lensink, by the team under the direction of Mr. John Wiens and Juan Guzman working with M.T. Myers at the University of Calgary.

This method of assigning risk presents several difficulties. First, of course, is the obviously subjective nature of the cut-off values used to separate high and low coefficients of variation and also high and low means. These cut-off values were selected on the basis of arbitrary considerations and must therefore be evaluated on those terms. Other criteria might prove more useful. Another difficulty involves the actual sample statistics used to calculate the coefficients of variation. Having at this time no reliable method of mathematically describing the true overall distribution of the bird population, at best only moderate confidence can be placed on the stability of means for small areas and thus, also, on the resulting coefficients of variation. As future sampling provides further information, it may be possible to make stronger claims concerning the reliability of these estimates. Unfortunately, local instability seems to be an inherent property of seabird distributions and therefore the data used in this analysis are unlikely to be improved upon. Our second method of organizing the available data is designed to overcome, as much as possible, this very high local uncertainty.

B. Frequency Distributions of Density Categories

i. Statistical Rationale

Given the very serious complications involved with applying parametric statistical techniques directly to bird density data, we have summarized the available data by constructing eight mutually exclusive categories such that each transect in the data base is assigned to exactly one category according to the value of the observed density for that transect. This method greatly minimizes the number and strength of the assumptions required for analysis and allows the application of relatively simple discrete probability models to the problem of estimating the likelihood of encountering large numbers of birds.

For each sampling area, mean density estimates for several species were placed in the following eight mutually exclusive and exhaustive categories:

category	1	2	3	4	5	6	7	8
density/km	0	0.1-10	10.1-30	30.1-50	50.1-100	100.1-500	500.1-1000	over 1000

Confidence limits for the proportions observed in each category were computed using the formula (see Appendix 1),

(1) $$N \geq 1/4d^2\ (1-\alpha)$$

where N = total number of transects (samples), d = the absolute value of the difference between the observed sample proportion and the population proportion, and α = the confidence level.

Using formula (1) we were able to calculate both a confidence level and confidence interval for any particular category or combination of categories, based on the existing sampling effort. We were also able to determine what future effort would be required to achieve various confidence levels and confidence intervals. For example, if $\alpha = 0.95$ and $d = 0.1$ then from (1), $N \geq 1/4(0.1)^2\ (1-0.95) = 500$. This means if we take a random sample of at least 500 observations, then the probability is at least 0.95 that the observed relative frequency of success for category i will differ from the true proportion by less than 0.1. Similarly, if N and α are fixed, we can also determine the value of d by

(2) $$d = 1/2\ \sqrt{N(1-\alpha)}.$$

In addition to these estimates, we also calculated values for d and N when the proportion of successes (the observed relative frequencies) is assumed to be approximately normal. In this case, the formula is

(3) $$N \geq 1/4(k/d)^2$$

where k is the standard score from the cumulative normal distribution corresponding to a given α. Appendix 1 includes the derivation of formulae (1) through (3) and an explanation of the normal assumption. A discussion of the multinomial model which underlies this method, Chebyshev's Inequality and Khintchine's theory as they are used in Appendix 1 can be found in most intermediate statistical texts, for instance Chou (1963).

Data for this analysis were obtained entirely through the efforts of individuals working through RU83 or PROBES.

ii. Sampling Rationale

In order to provide useful sized areas within which: 1) sampling effort was sufficient to provide meaningful frequency distributions, 2) there would be a spatial, biological or oceanographic rationale for the boundaries, and 3) for which we could construct similar bounds for other regions as yet unsampled, we set up a series of zones around the Pribilof Islands and in the central southeastern Bering Sea along the PROBES line.

The boundaries of the zones around the Pribilof Islands are given in Figure 9 along with the number of transects completed in each zone. These zones divide the waters near the Pribilofs into shelf (east) and shelf-break (west) regions, and into regions at distances of 20 km, 40 km and 60 km from the nearest shore. These bounds let us compare both distance-from-colony effects and the oceanographic influence of distance from the shelf-break.

In the central southeastern Bering Sea region, all transects were classified in zones according to PROBES domains (Iverson et al. 1979). Boundaries for this classification were drawn by bathymetry, with each of the three areas (middle shelf, outer shelf, and slope) centering on the main PROBES transect and distant from the influence of the immediate vicinity of colonies (Figure 10). Seasonal variation in seabird abundance was controlled by making comparisons between domains for those seasons when a species was abundant in the southeastern

Zonal Analysis of the pelagic distribution of seabirds near the Pribilof Islands. Number of observations per zone

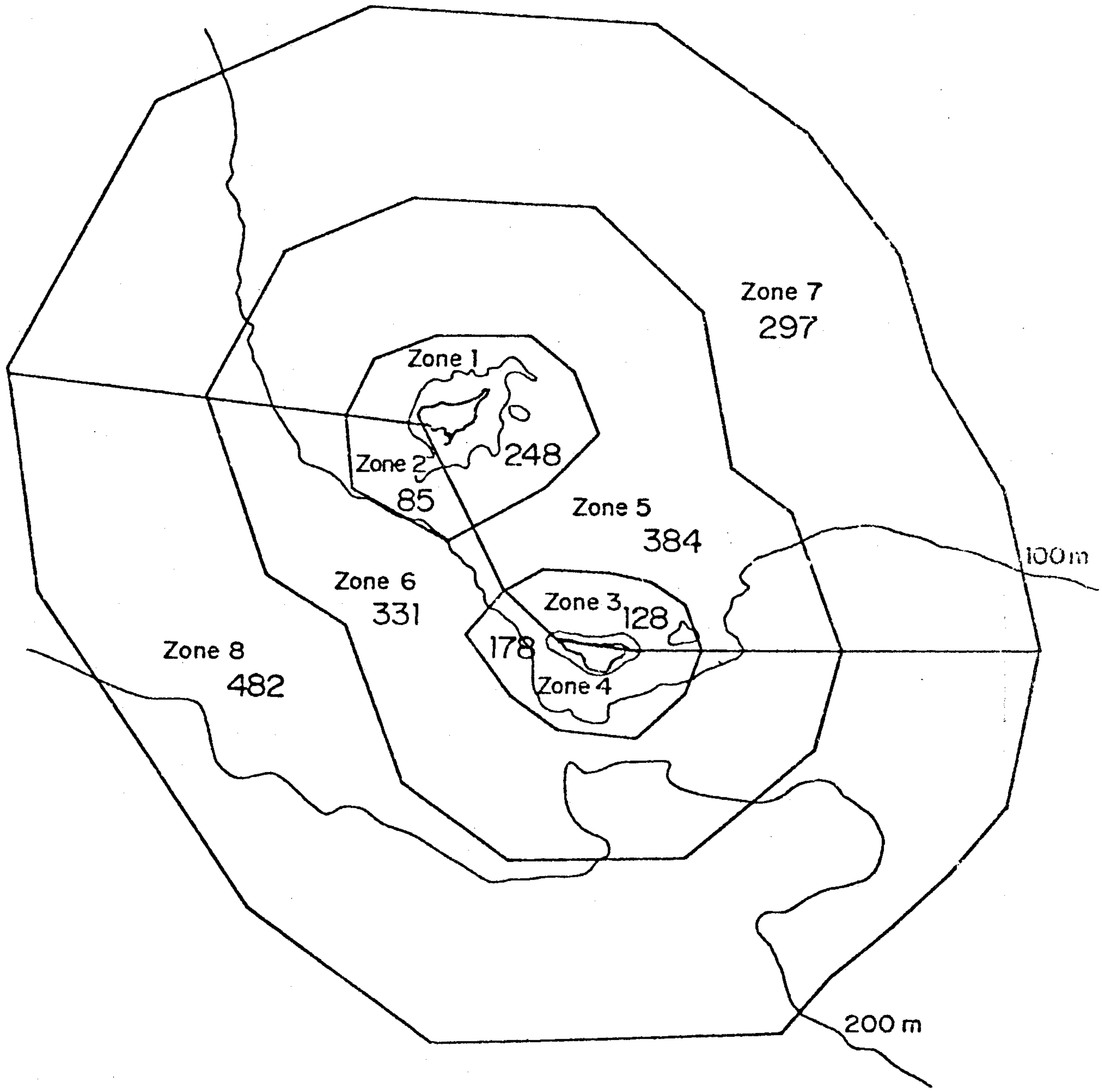


Figure 9

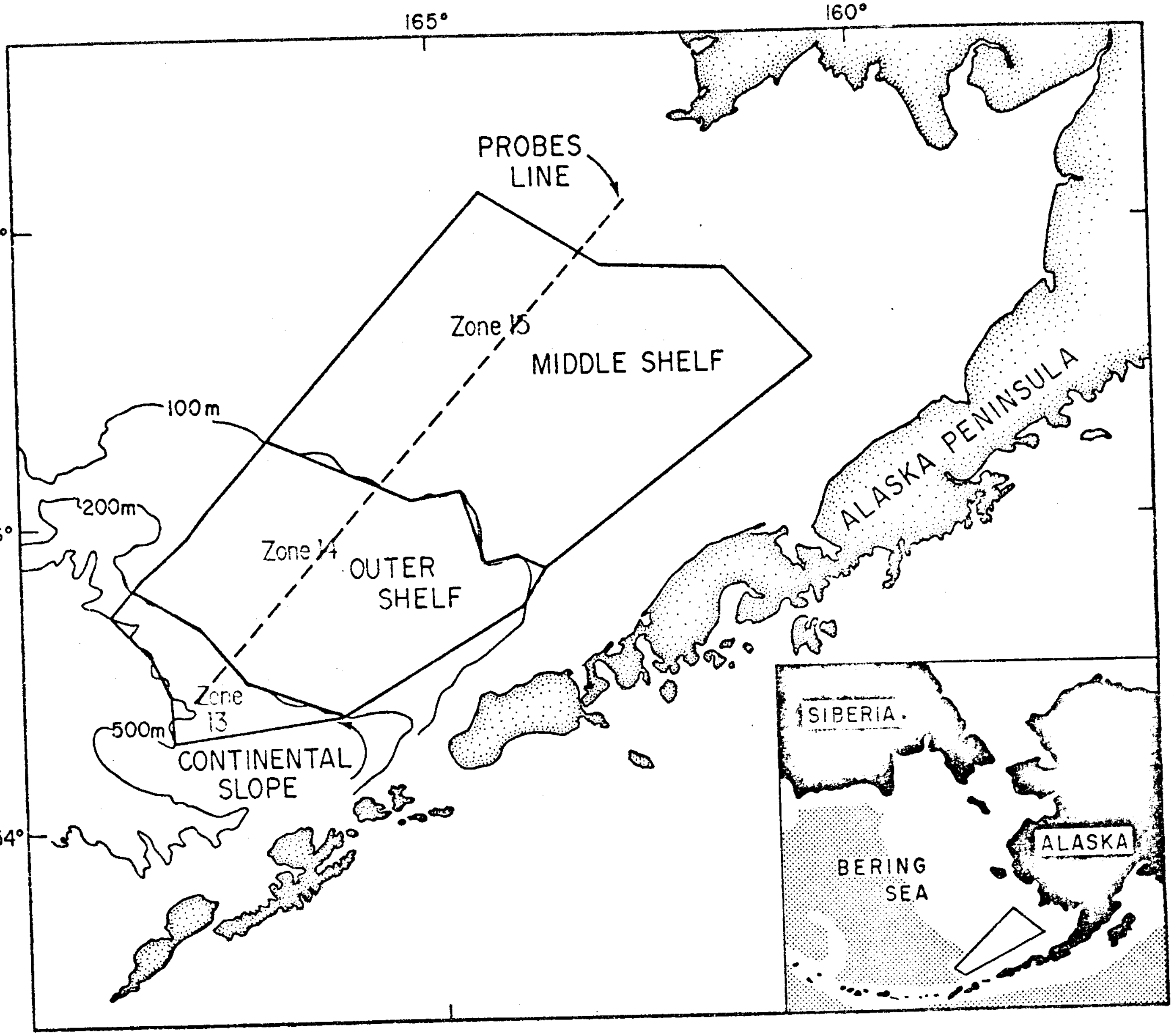


Figure 10. Zones near the PROBES line.

Bering Sea. A correction for ship attraction was not introduced in this analysis since there was no indication that this varied across the shelf. Division of this pelagic area into zones determined by the varying mixing regimes of the shelf domains permits us to relate the bird distribution to the underlying oceanography, and to develop predictions about bird numbers and species composition of as yet unsurveyed areas based upon that new area's oceanographic domains.

2) Description of Regions Used by Birds

If we are to be able to generalize from well studied areas to areas that have received little or no study, it is essential to be able to predict, based on present knowledge, where one would expect to find large numbers of birds. This requires relating bird distributions to features of their environment. We attempted to describe the habitats used by birds first with step-wise correlation analysis and then by analysis of variance (ANOVA) of transect data by zones.

A. Correlation Analysis

Preliminary analyses of single tracks or cruises suggested that step-wise multiple correlation analysis might be profitable. We therefore examined the combined 1975-1978 data set for the correlations between the density of individual bird species (and of all species combined) and environmental variables such as: distance to land, water depth, distance to shelf-edge, sea surface temperature and sea surface salinity. This effort was notably unsuccessful with r values generally less than 0.05. For this reason regression techniques were abandoned.

B. Zonal Analysis

Our second approach was to compare bird densities in the zones described above. These zones in the vicinity of the colonies were organized with respect to distance to colony and distance to shelf edge, while in the open ocean they were organized with respect to oceanographic domains.

Standard analysis of variance (ANOVA) techniques were used to test whether the observed differences between zones exceeded the expectations of chance. The hypothesis of relation of bird distribution to mixing regime in the zones along the PROBES line was tested by a two-step design. Outer shelf and slope averages were first compared. If this comparison was not significant, the average density over both outer shelf and slope waters was compared to average density over middle shelf waters. If slope and outer shelf averages differed, then just the outer shelf average was compared to the average in the adjacent middle shelf domain. Analyses were confined to common species or to species groupings if identification to the species level was unreliable.

Data used in this analysis were obtained entirely through the efforts of individuals associated with RU 83 or PROBES.

RESULTS

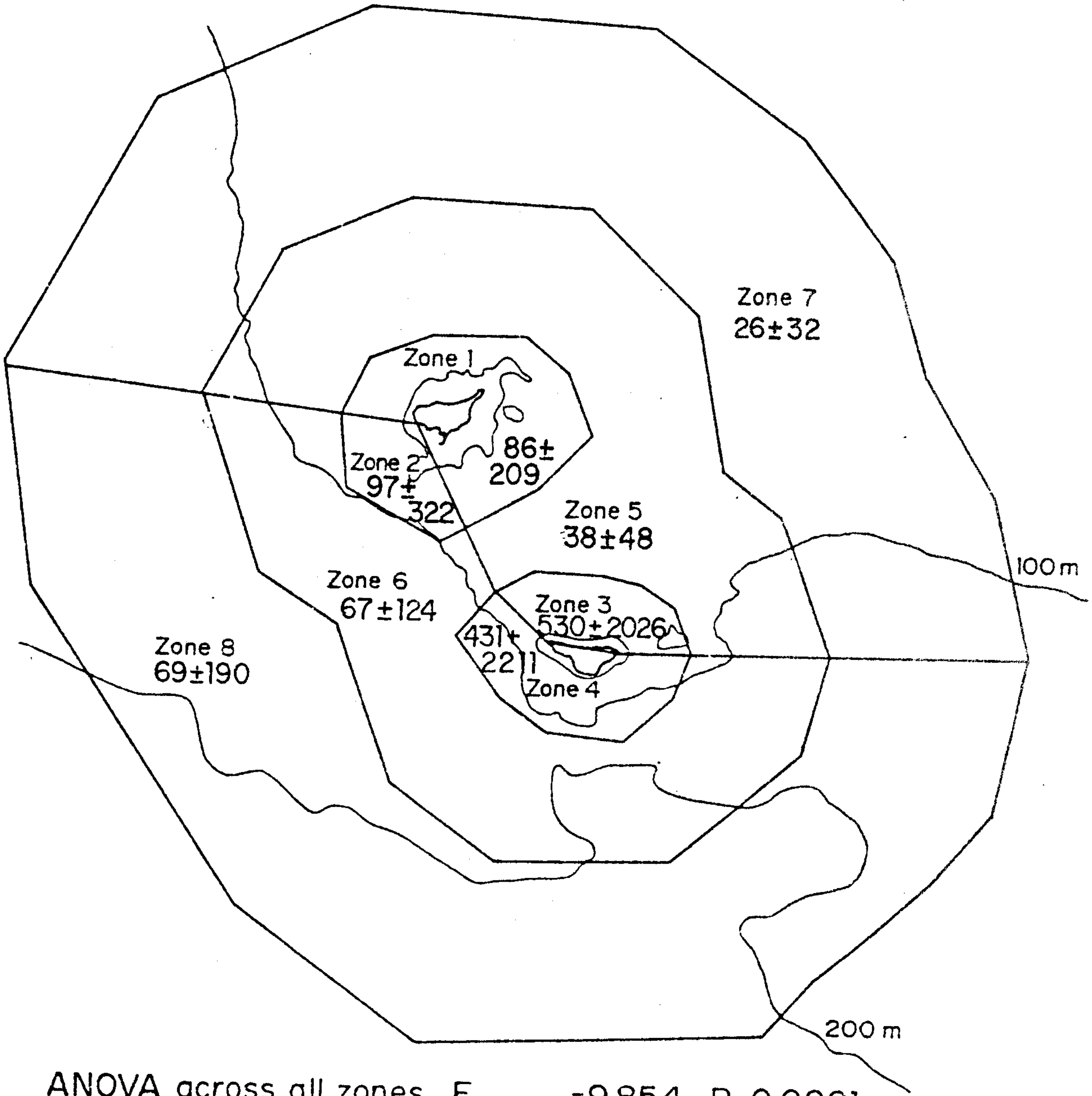
1) Pelagic Distribution

The distribution of birds in the vicinity of the Pribilof Islands in particular, and the southeastern Bering Sea in general, was covered thoroughly by Hunt et al. (1980a and b). Therefore, in this report we will briefly summarize their findings and concentrate on the area near the PROBES line for which detailed summaries have not been provided.

Figure 11 summarizes the use of zones around the Pribilof Islands by all species combined. The important generalities to take from this figure are that both toward and away from the shelf-break, bird densities drop off rapidly as one moves away from the colonies, but bird densities for any given distance from the island are higher on the side toward the shelf-break rather than northeastward over the shelf. The preference for shelf-edge waters rather than shelf waters is particularly pronounced for Northern Fulmars (Figure 12) and Red-legged Kittiwakes (Figure 13), while distance from colony and colony size, regardless of direction, appear to be the major determinants of murre (Figure 14) and small auklet (Aethia sp., Cyclorrhynchus psittacula, Figure 15) distributions. Other species show relatively weak patterns or virtually no pattern with respect to distance from colony or direction with respect to the shelf-break.

These results suggest that the only variables that need be considered near colonies are distance to colony and distance to shelf-break. However, Kinder et al. (in prep.) have demonstrated a front at about 50 m depth at which there is a shift between a well-mixed water column and a two layered water column. Murres appear to preferentially gather on the water near this front, and murre densities there are significantly greater than would be predicted by chance either inshore or offshore the front (Kinder et al., in prep.).

Distribution of seabirds by zones
near the Pribilof Islands, 1975–1979 ($\bar{x} \pm s$)*



ANOVA across all zones, $F_{7,2125}=9.854$, P=0.0001

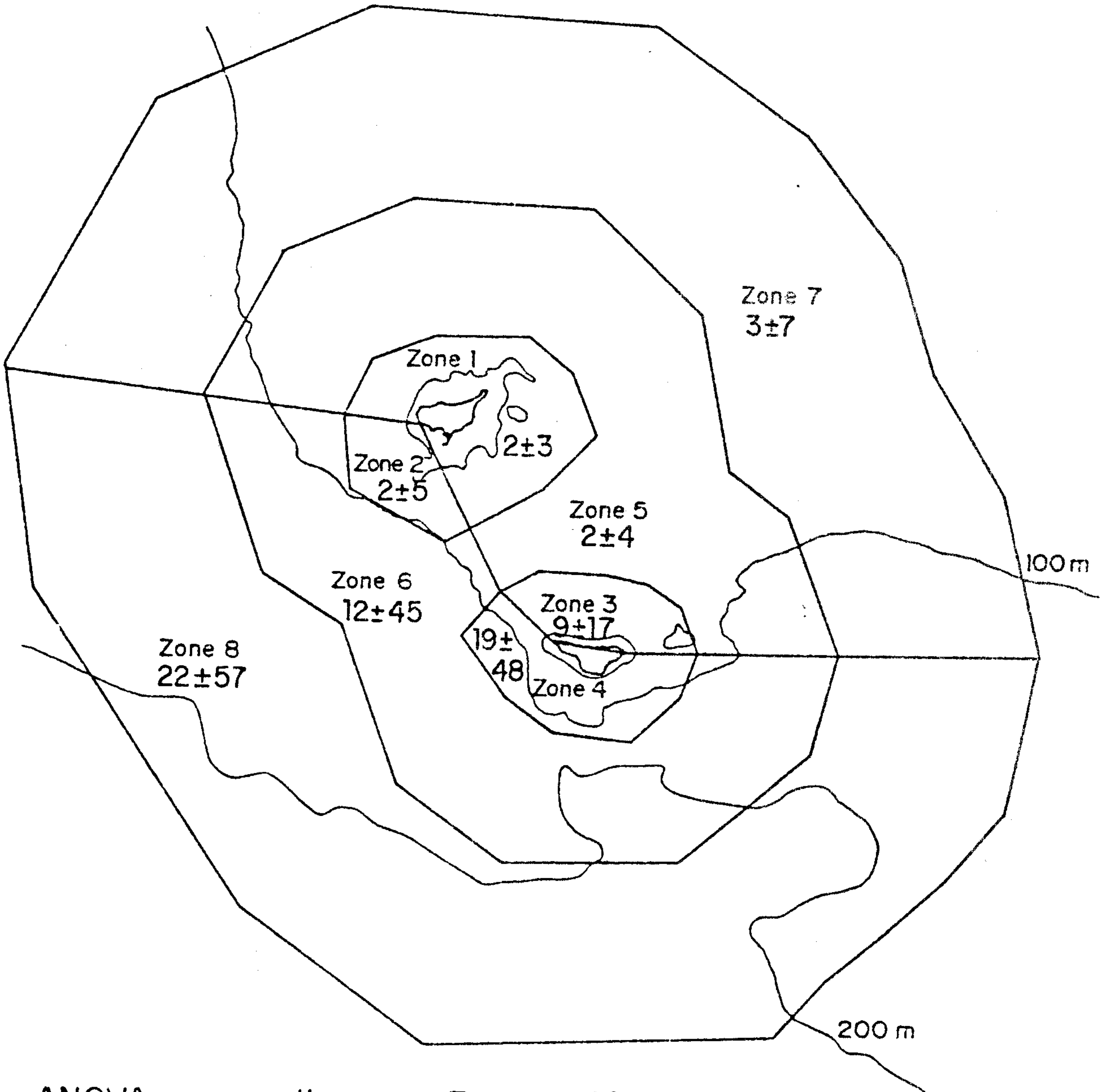
Homogeneous subsets by modified LSD Procedure, $\alpha=0.05$

Subset 1 Zones 7,5,6,8,1,2
Subset 2 Zones 2,4
Subset 3 Zones 4,3

*rounded to whole numbers

Figure 11

Distribution of Northern Fulmars by zones near the Pribilof Islands 1975–1979 ($\bar{x} \pm s$)*



ANOVA across all zones, $F_{7,2132} = 16.731$, $P = 0.00001$

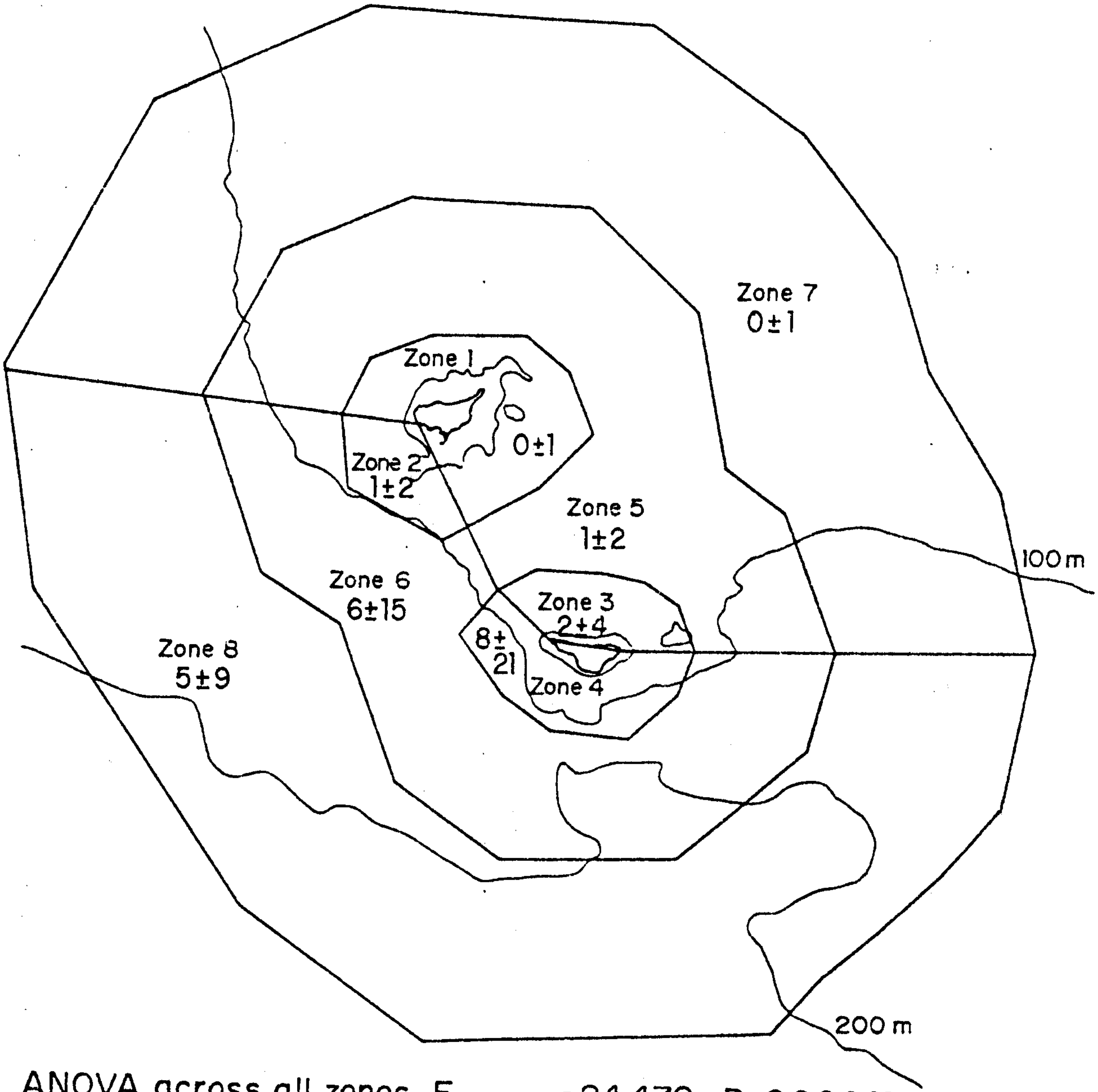
Homogeneous subsets by modified LSD Procedure, $\alpha = 0.05$

Subset 1 Zones 1,5,2,7,3
Subset 2 Zones 2,7,3,6
Subset 3 Zones 3,6,4
Subset 4 Zones 4,8

*rounded to whole numbers

Figure 12

Distribution of Red-legged Kittiwakes by zones near the Pribilof Islands 1975-1979 ($\bar{x} \pm s$)*



ANOVA across all zones, $F_{7,2154} = 24.479$, $P = 0.00001$

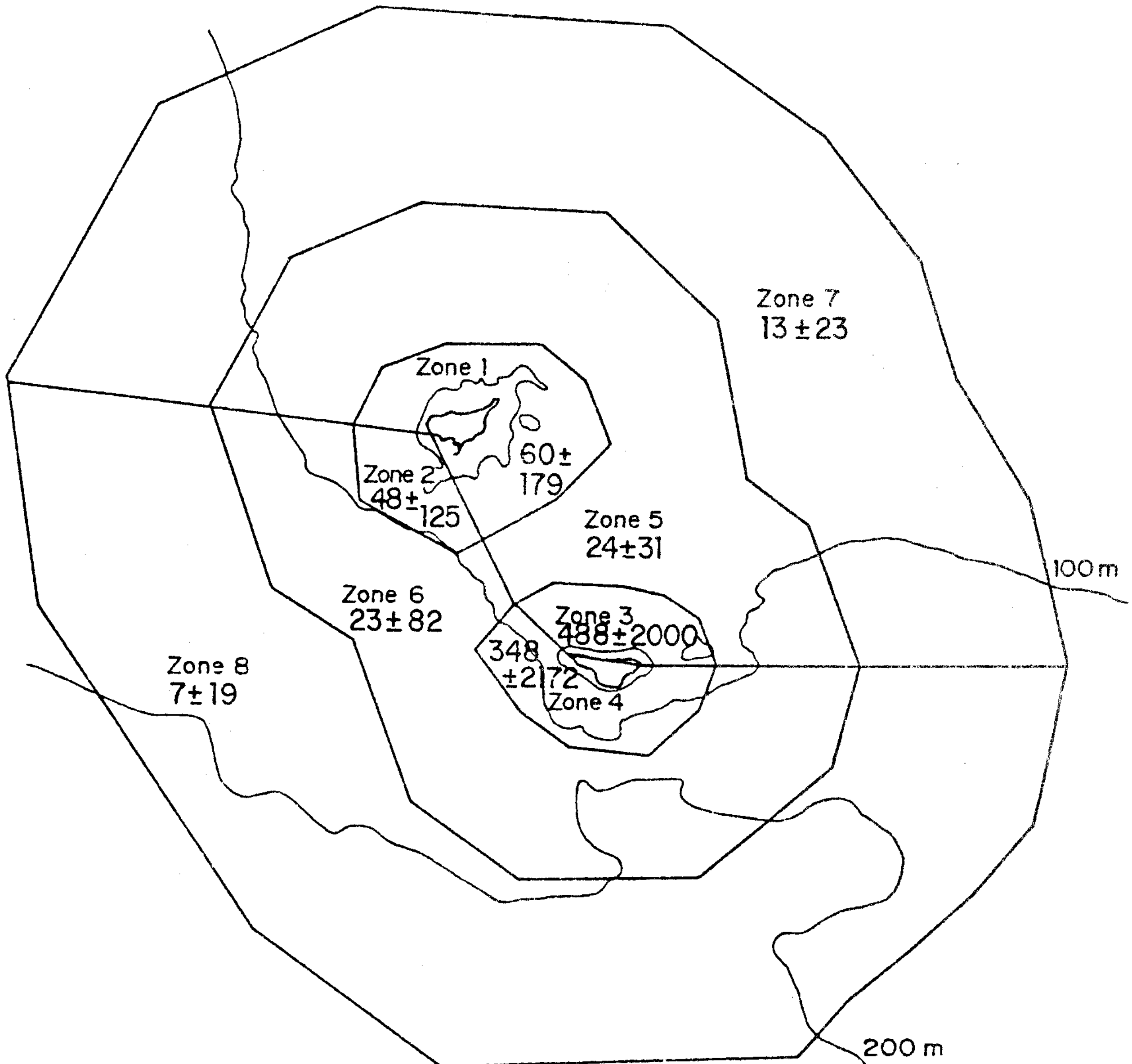
Homogeneous subsets by modified LSD Procedure, $\alpha = 0.05$

Subset 1 Zones 7,1,5,2,3
Subset 2 Zones 3,8
Subset 3 Zones 8,6
Subset 4 Zones 6,4

*rounded to whole numbers

Figure 13

Distribution of Murres by zones near the Pribilof Islands, 1975-1979 ($\bar{x} \pm s$)*



ANOVA across all zones, $F_{7,2128} = 9.084$, P=0.0001

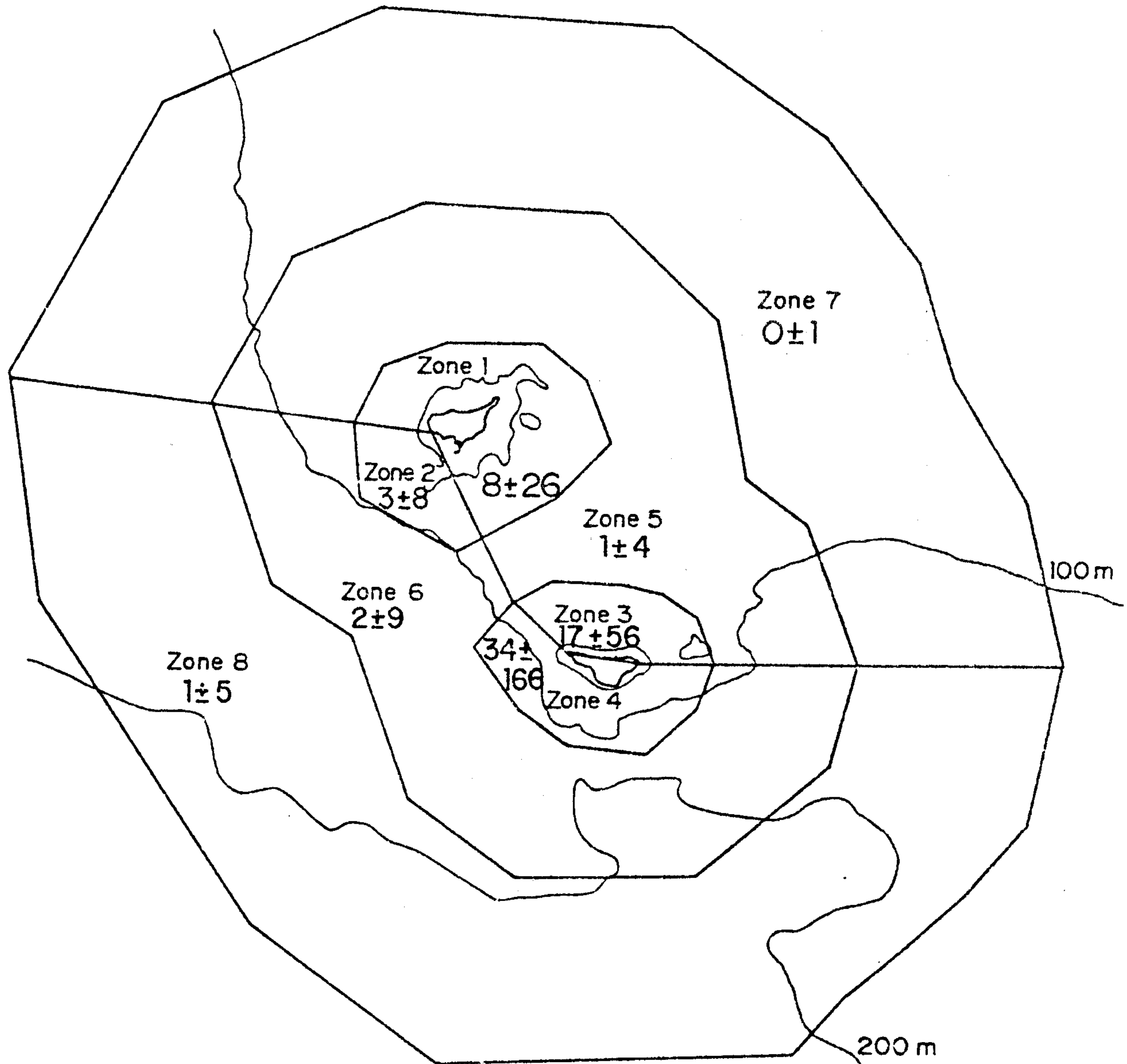
Homogeneous subsets by modified LSD Procedure, α=0.05

Subset 1 Zones 8,7,6,5,2,1
Subset 2 Zones 2,1,4
Subset 3 Zones 3,4

*rounded to whole numbers

Figure 14

Distribution of Small Auklets by zones near the Pribilof Islands 1975-1979 ($\bar{x} \pm s$)*



ANOVA across all zones, $F_{7,2154} = 10.870$, $P = 0.00001$

Homogeneous subsets by modified LSD Procedure, $\alpha = 0.05$

Subset 1 Zones 7,8,5,6,2,1,3

Subset 2 Zones 3,4

*rounded to whole numbers

Figure 15

Therefore, one should take into account the potential influence of fronts at this position (50 m isobath) in detailing factors responsible for seabird distribution.

In the central southeastern Bering Sea region along the PROBES line, six of eight seabird groups analyzed showed significant differences in density between domains (Figure 16). Five groups showed the same pattern, that of high densities at the shelf-break, intermediate to high densities over the outer shelf, and low densities over the middle shelf. This pattern was most pronounced in Red-legged Kittiwakes, Fork-tailed Storm-Petrels (O. furcata), and Tufted Puffins (Lunda cirrhata). A similar pattern can be seen for Northern Fulmar (Fulmarus glacialis), but the role of chance could not be excluded in this case (Figure 16). Black-legged Kittiwakes showed a weak but significant pattern of reduced density over the middle shelf relative to the outer shelf and slope waters (Figure 16). Monthly variation was weak in Black-legged Kittiwakes, so all counts (April through August) were included in the analysis. Thus the sample sizes for this analysis (89, 497, and 395 counts over slope, outer shelf, and middle domains) were larger than for the four preceding species (33, 232, and 339 counts).

Dark-bellied shearwaters (P. tenuirostris and P. griseus) appear in the Bering Sea in early Summer (Hunt et al. 1980), so analysis was confined to June and July. During this period shearwaters showed a pattern of greater density of birds in the coastal domain as compared to the shelf-edge (Figure 16). The difference was not significant, perhaps because the coastal domain was not included in the analysis for lack of adequate sampling.

The analysis of murre and auklet densities was confined to April, before these species retreat to their breeding colonies. Auklet density was significantly higher in the middle domain than in the outer shelf or slope waters (Figure 16).

Density of seabirds in middle shelf (M), outer shelf (O), and slope (S) waters of the southeastern Bering Sea, 1975–1979. Bars show two standard errors on either side of the mean.

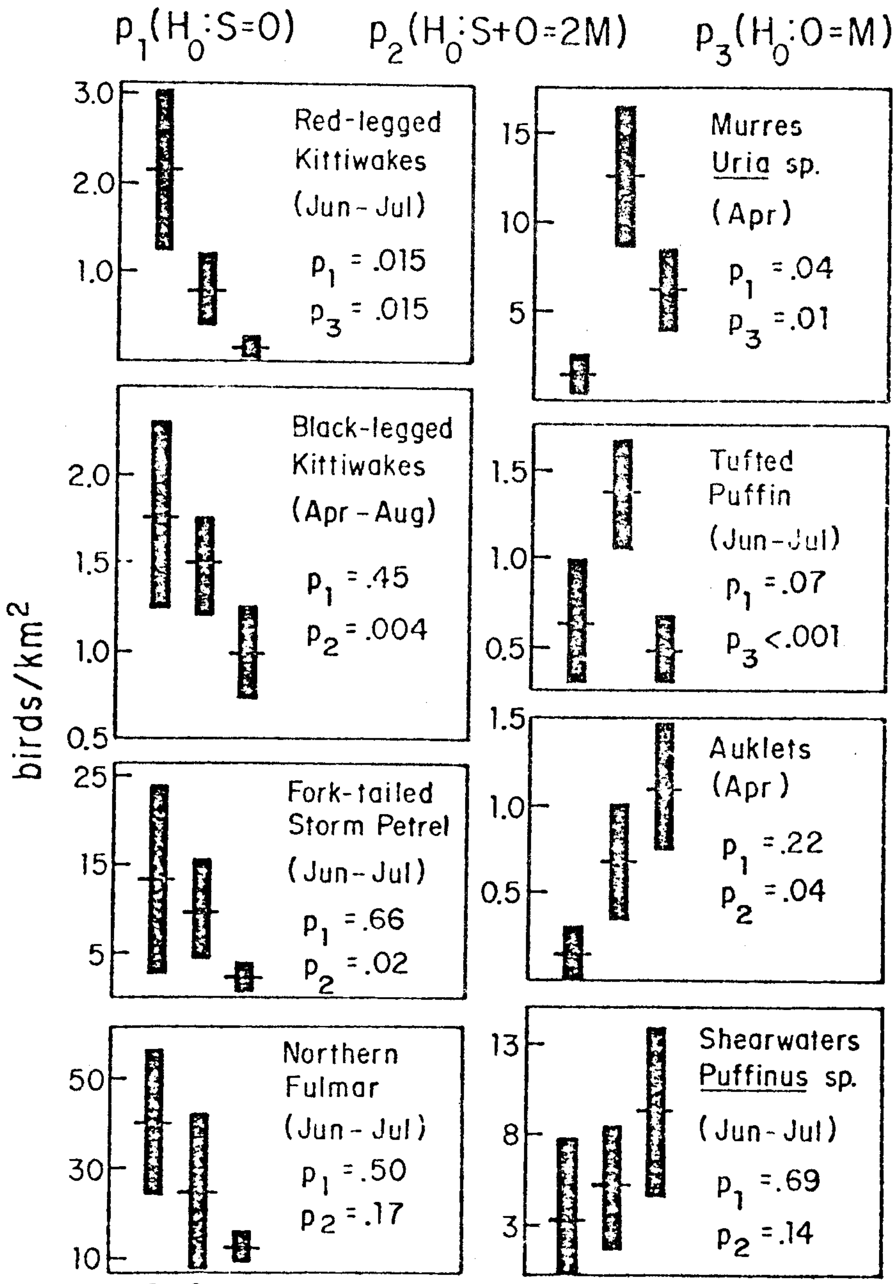


Figure 16

The three major species present were Least Auklets (*A. pusilla*), Crested Auklets (*A. cristatella*), and Parakeet Auklets (*Cyclorrhynchus psittacula*). No attempt was made to analyze individual species because of the small numbers involved. Murres showed a pattern of high density in the outer domain, intermediate density in the middle domain, and low density beyond the shelf-break (Figure 16).

The observed patterns of distribution relative to mixing regime were associated with the feeding capabilities of the seabird groups analyzed. Auklets and murres search for food while sitting on the water and are capable of diving to considerable depths. These were the only two groups that did not show a significantly reduced density in the middle shelf domain, with its poorly developed pelagic food web. Surface feeding groups (kittiwakes, Fork-tailed Storm Petrels, and Northern Fulmar) showed reduced densities over the middle shelf.

2) Risk assessment based on coefficients of variation

Figures 17 through 26 illustrate the distribution of encounter risks based on means and coefficients of variation derived from survey data obtained during the period 1975-1979. Figure 17 gives the coefficients for all birds encountered on the water throughout the entire survey effort. Consistently high risk areas (coefficient ≤ 2 and $\bar{X} \geq 75.1$) are confined to the shelf area south of Nunivak Island. High but variable risk areas (coefficients ≥ 2.1 and $\bar{X} \geq 75.1$) occur only next to St. George Island and just southwest of Unimak Pass. Consistently low (coefficients ≤ 2 and $\bar{X} \leq 75$) and low but variable risk areas (coefficients ≥ 2.1 and $\bar{X} \leq 75$) tend to be rather uniformly distributed throughout the southeastern Bering Sea and the region encompassed by St. Lawrence Island, Norton Sound, and the Bering Straits. For much of the northern Bering Sea, data are insufficient to support this type of analysis.

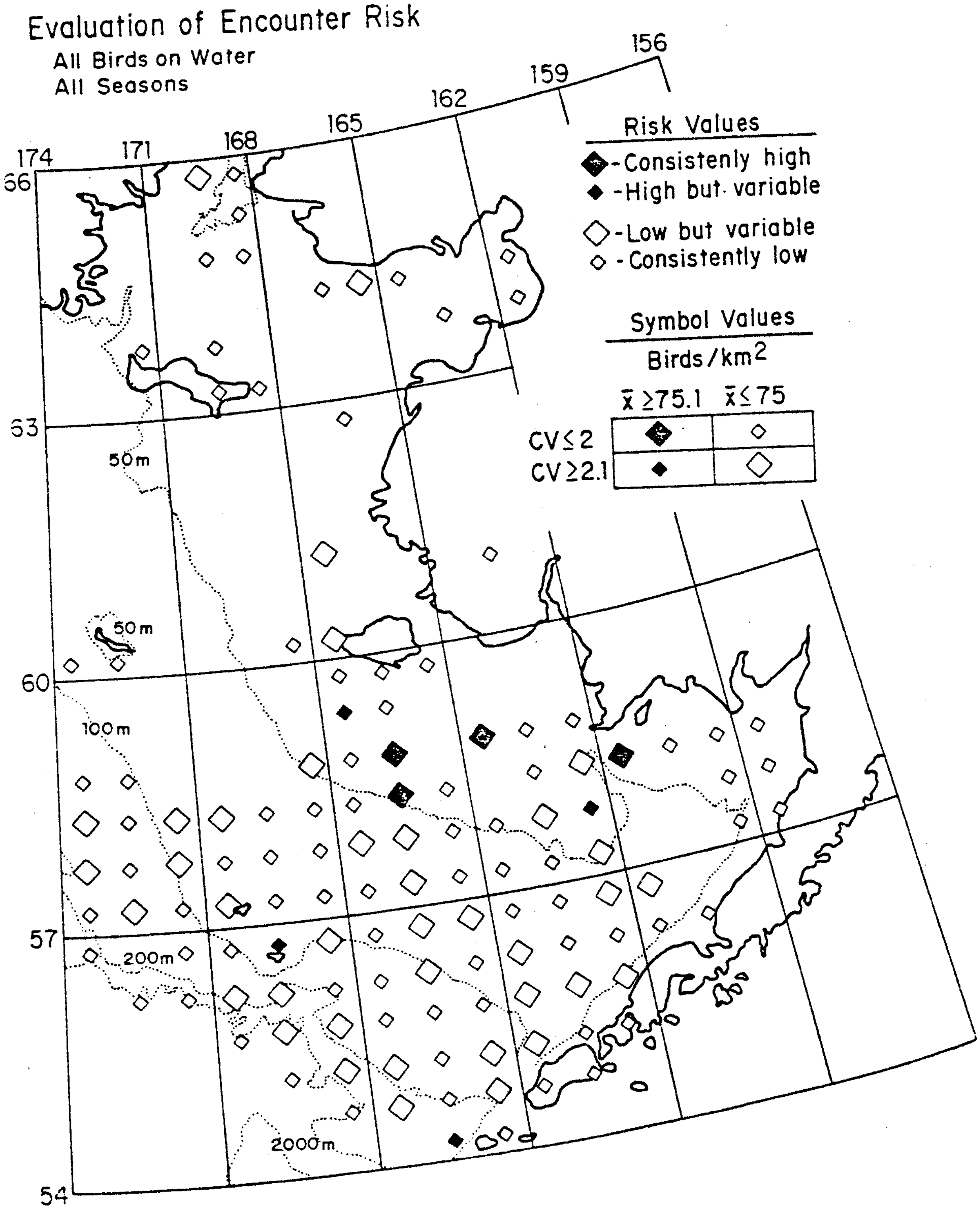

Evaluation of Encounter Risk
All Birds on Water
All Seasons
Risk Values
-Consistenly high
-High but variable
-Low but variable
-Consistently low
Symbol Values
Birds/km2
x̄ ≥75.1
x̄ ≤75
CV≤2
CV≥2.1
174
171
168
165
162
159
156
66
63
60
57
54
50m
50m
100m
200m
2000m

Figure 17

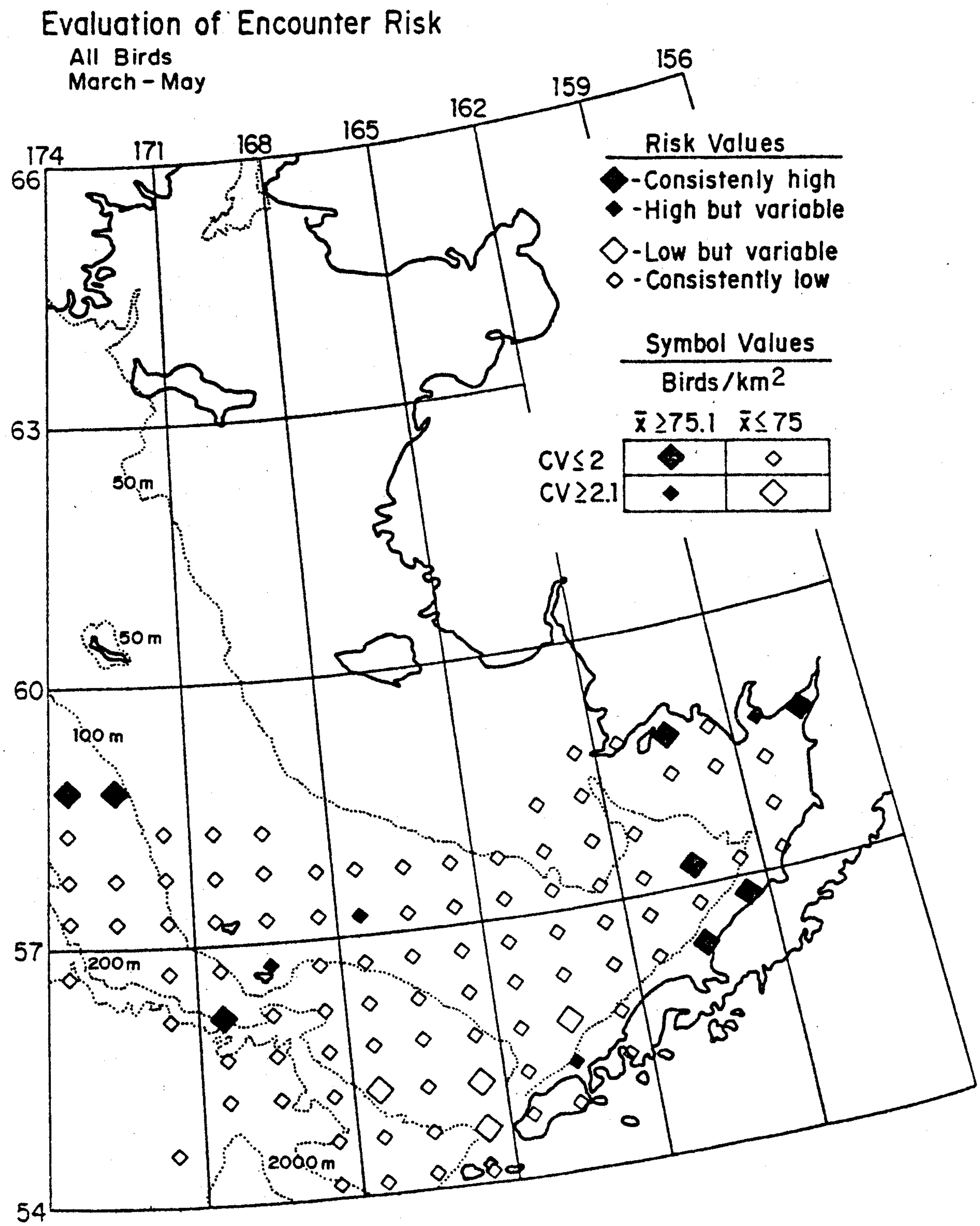
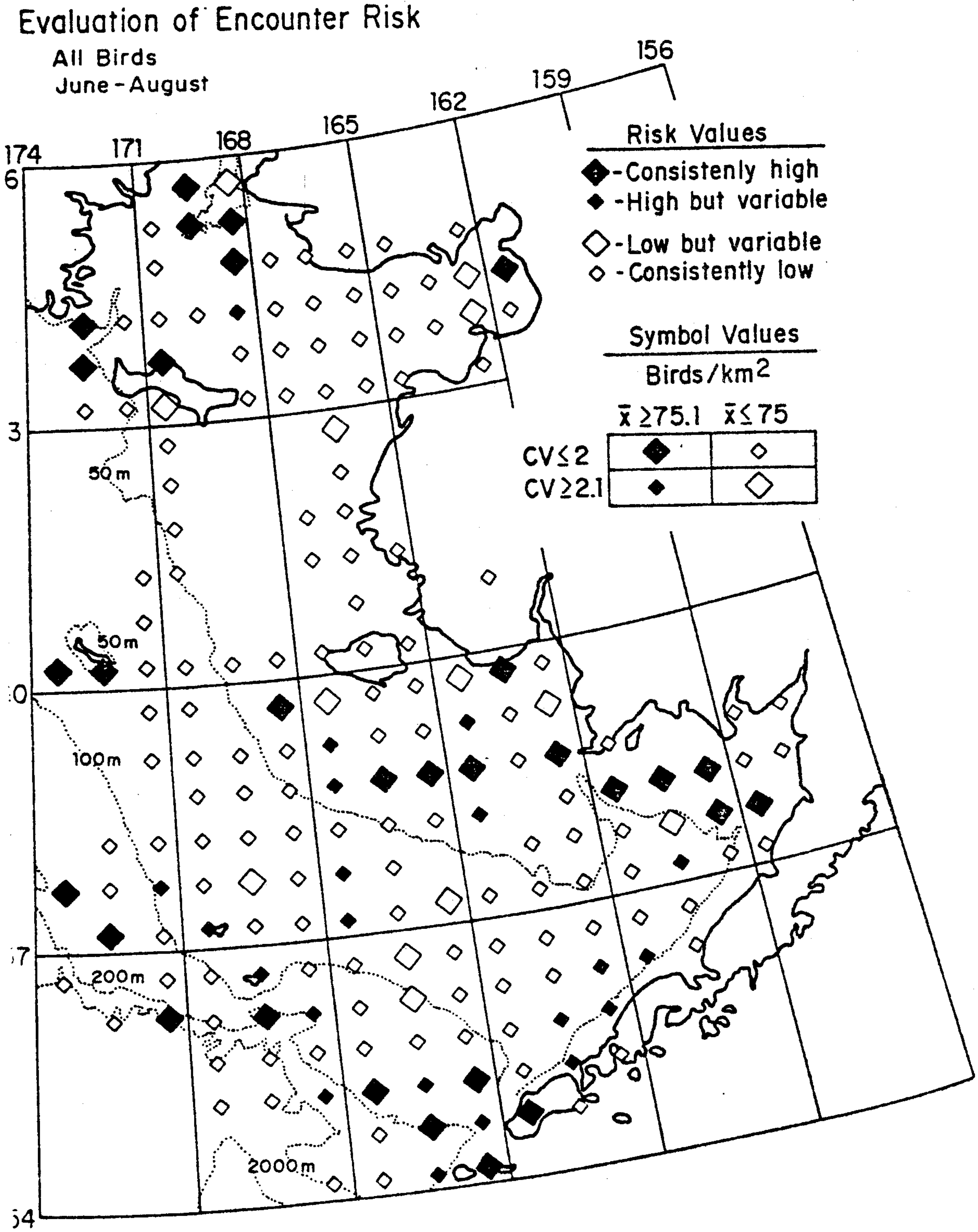

Evaluation of Encounter Risk
All Birds
March - May
Risk Values
-Consistenly high
-High but variable
-Low but variable
-Consistently low
Symbol Values
Birds/km2
x̄ ≥75.1
x̄ ≤ 75
CV≤2
CV≥2.1
174
171
168
165
162
159
156
66
63
60
57
54
50 m
50 m
100 m
200 m
2000 m

Figure 18



Evaluation of Encounter Risk
All Birds
June - August
174
171
168
165
162
159
156
Risk Values
-Consistenly high
-High but variable
-Low but variable
-Consistently low
Symbol Values
Birds/km2
x̄ ≥75.1
x̄ ≤75
CV≤2
CV≥2.1
50 m
50m
100m
200m
2000m

Figure 19

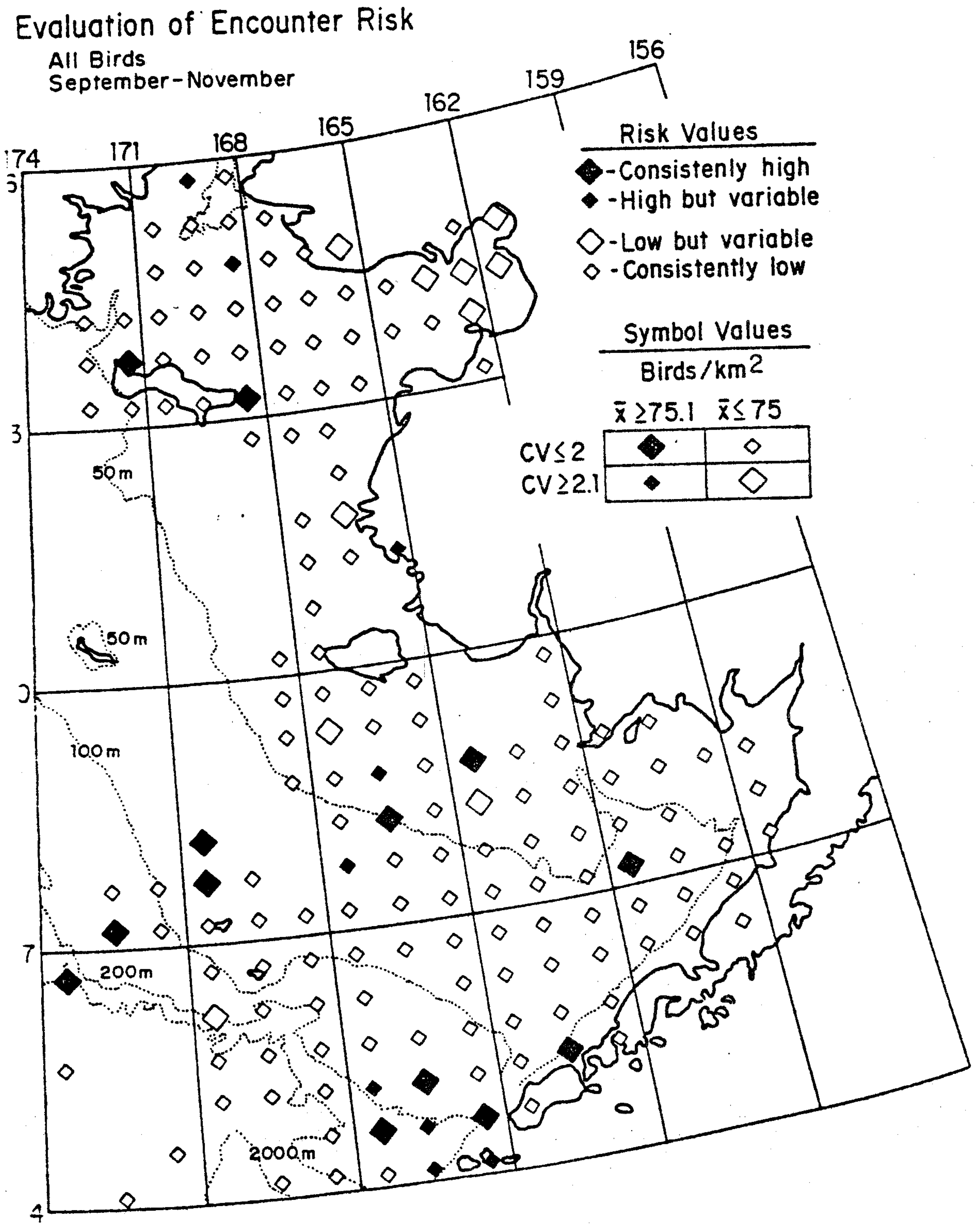
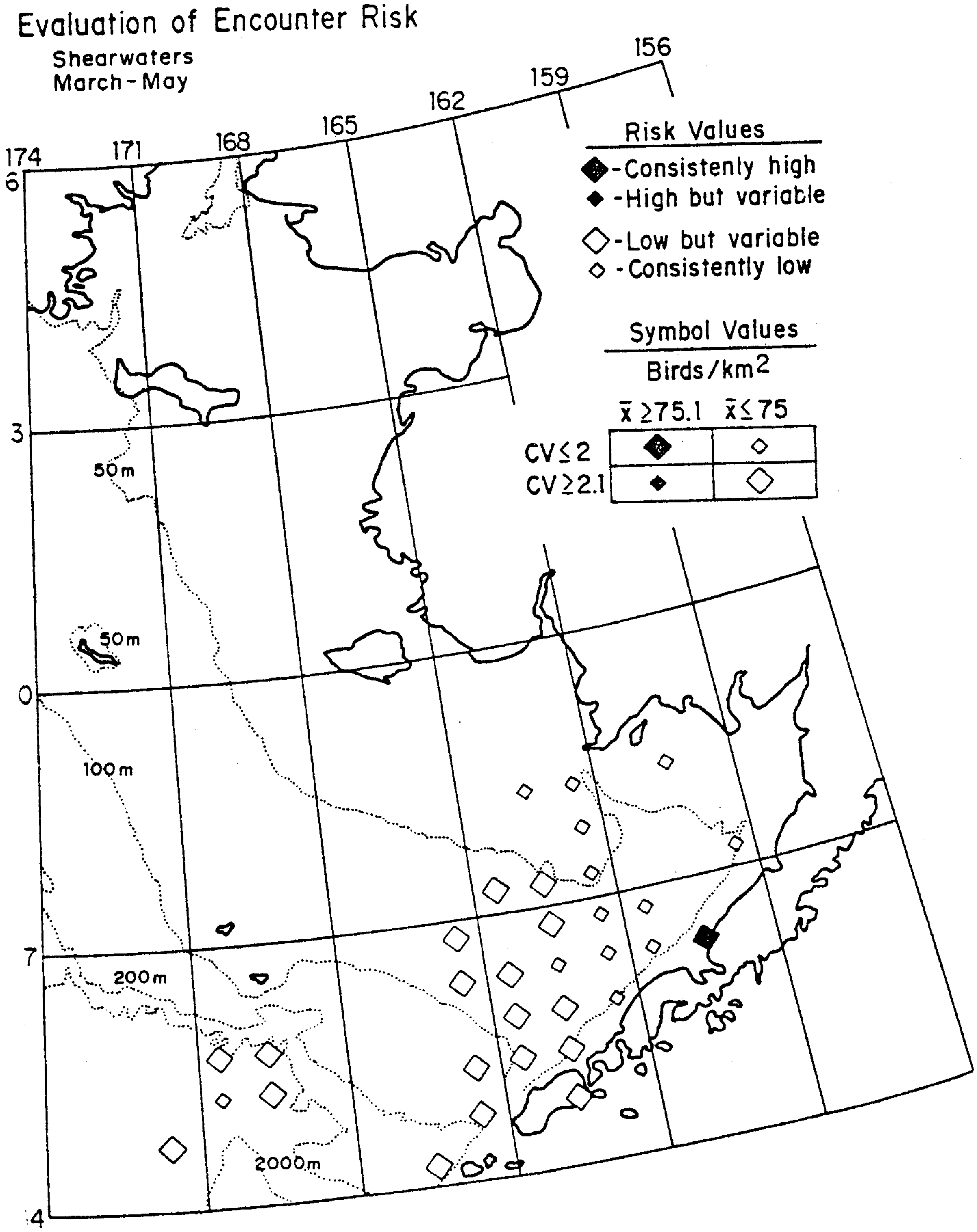
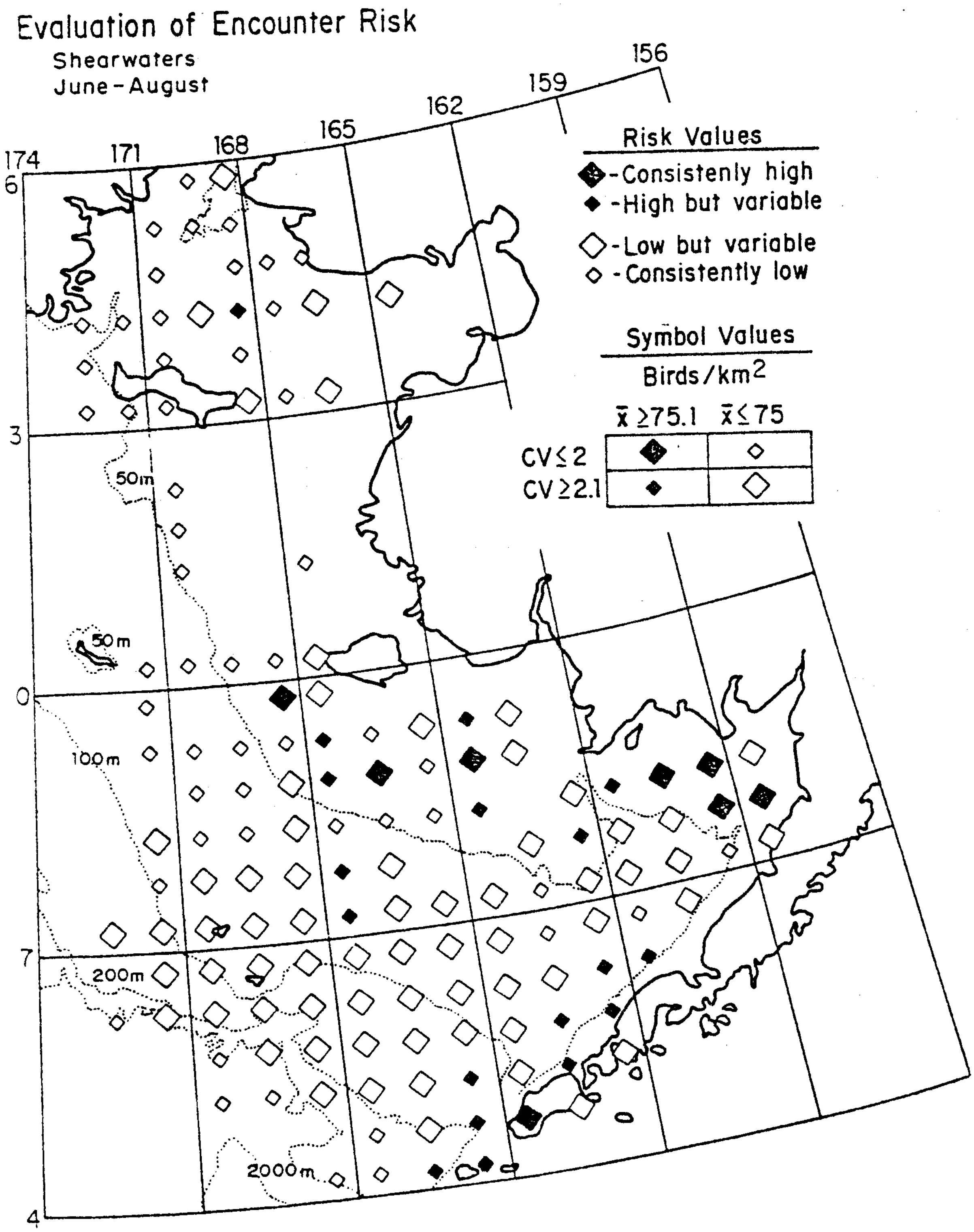

Evaluation of Encounter Risk
All Birds
September-November
Risk Values
-Consistenly high
-High but variable
-Low but variable
-Consistently low
Symbol Values
Birds/km2
x̄ ≥75.1
x̄ ≤75
CV≤2
CV≥2.1
156
159
162
165
168
171
174
50m
100m
200m
2000m

Figure 20



Evaluation of Encounter Risk
Shearwaters
March - May
174
171
168
165
162
159
156
6
3
0
7
4
50m
50m
100m
200m
2000m
Risk Values
-Consistenly high
-High but variable
-Low but variable
-Consistently low
Symbol Values
Birds/km2
x̄ ≥75.1
x̄ ≤ 75
CV≤2
CV≥2.1

Figure 21


Evaluation of Encounter Risk
Shearwaters
June - August
174
171
168
165
162
159
156
6
3
0
7
4
Risk Values
-Consistenly high
-High but variable
-Low but variable
-Consistently low
Symbol Values
Birds/km2
x̄ ≥75.1
x̄ ≤75
CV≤2
CV≥2.1
50m
50m
100m
200m
2000m

Fiqure 22

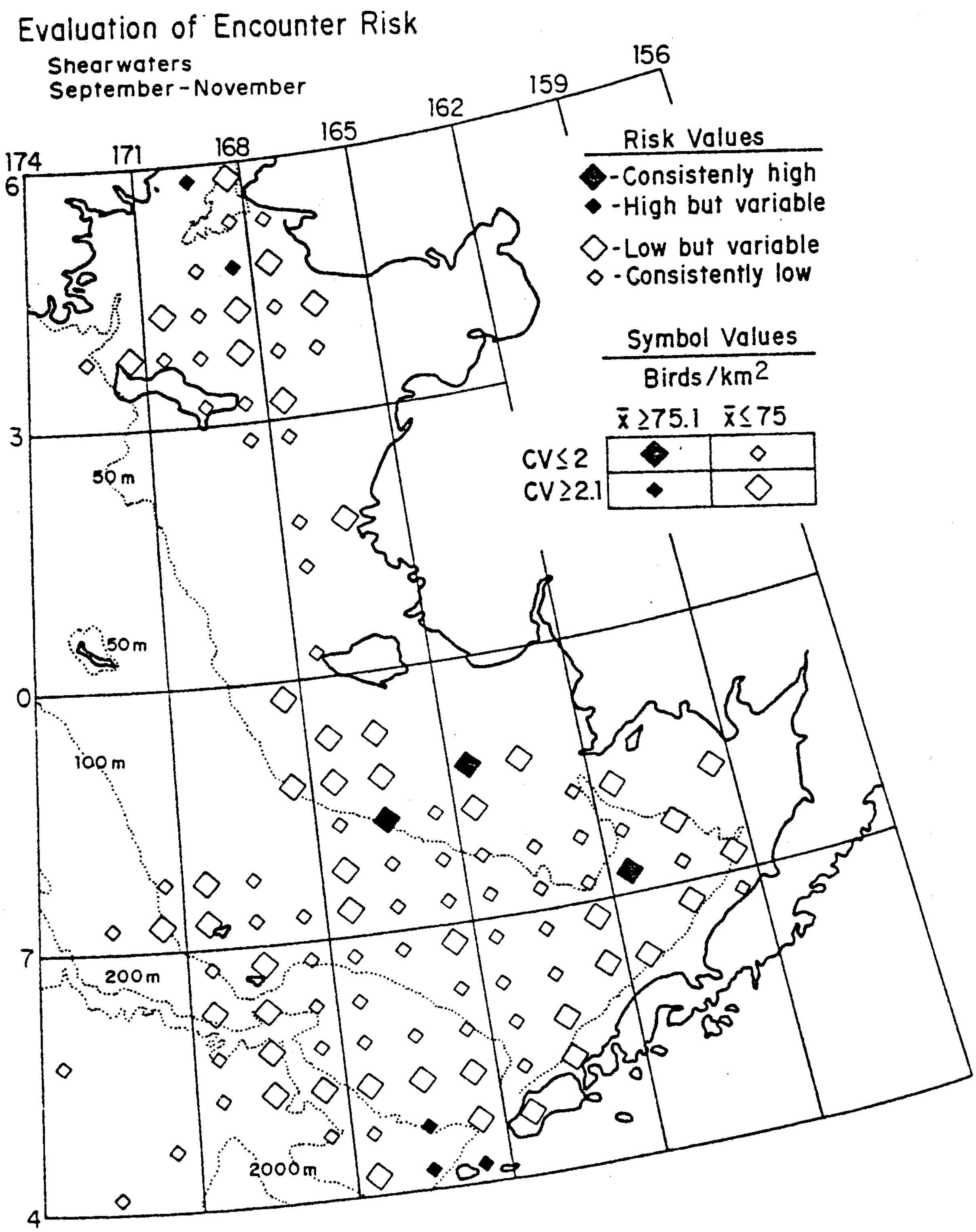

Evaluation of Encounter Risk
Shearwaters
September-November
174
171
168
165
162
159
156
6
3
0
7
4
50 m
50 m
100 m
200 m
2000 m
Risk Values
-Consistenly high
-High but variable
-Low but variable
-Consistently low
Symbol Values
Birds/km2
x̄ ≥75.1
x̄ ≤75
CV≤2
CV≥2.1

Figure 23

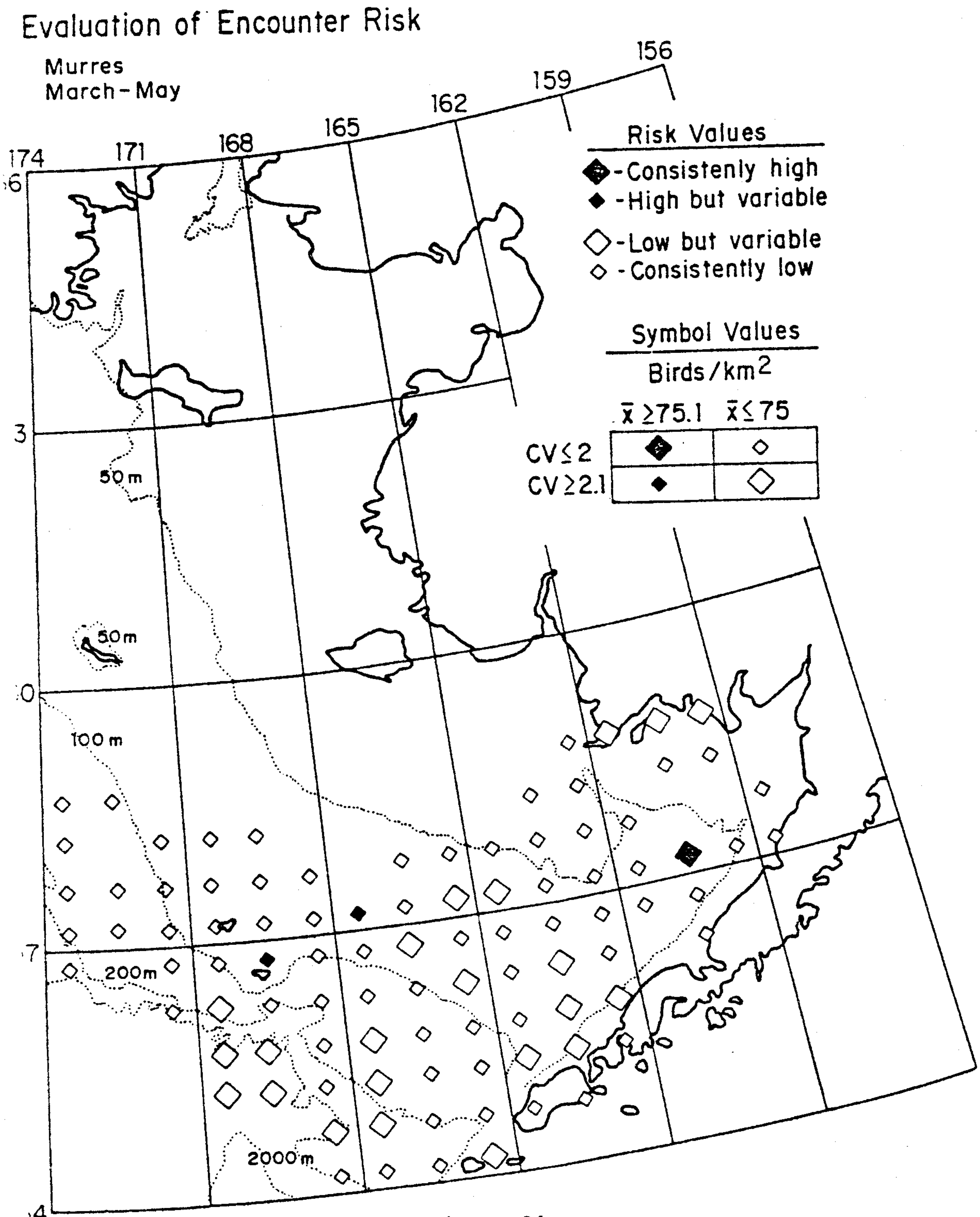

Evaluation of Encounter Risk
Murres
March-May
156
159
162
165
168
171
174
56
53
50
57
54
50 m
50m
100 m
200m
2000m
Risk Values
-Consistenly high
-High but variable
-Low but variable
-Consistently low
Symbol Values
Birds/km2
x̄ ≥75.1
x̄ ≤ 75
CV≤2
CV≥2.1

Figure 24

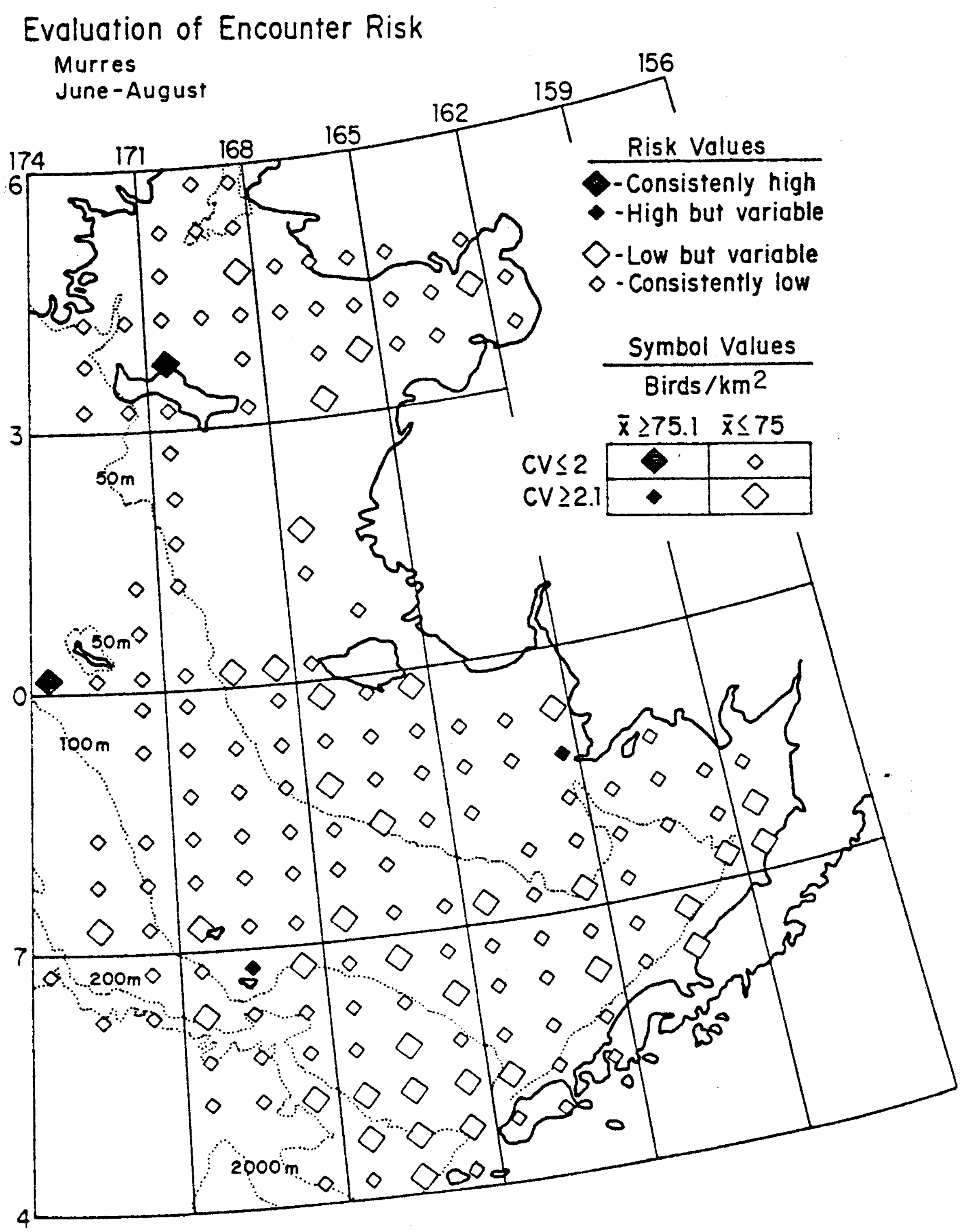
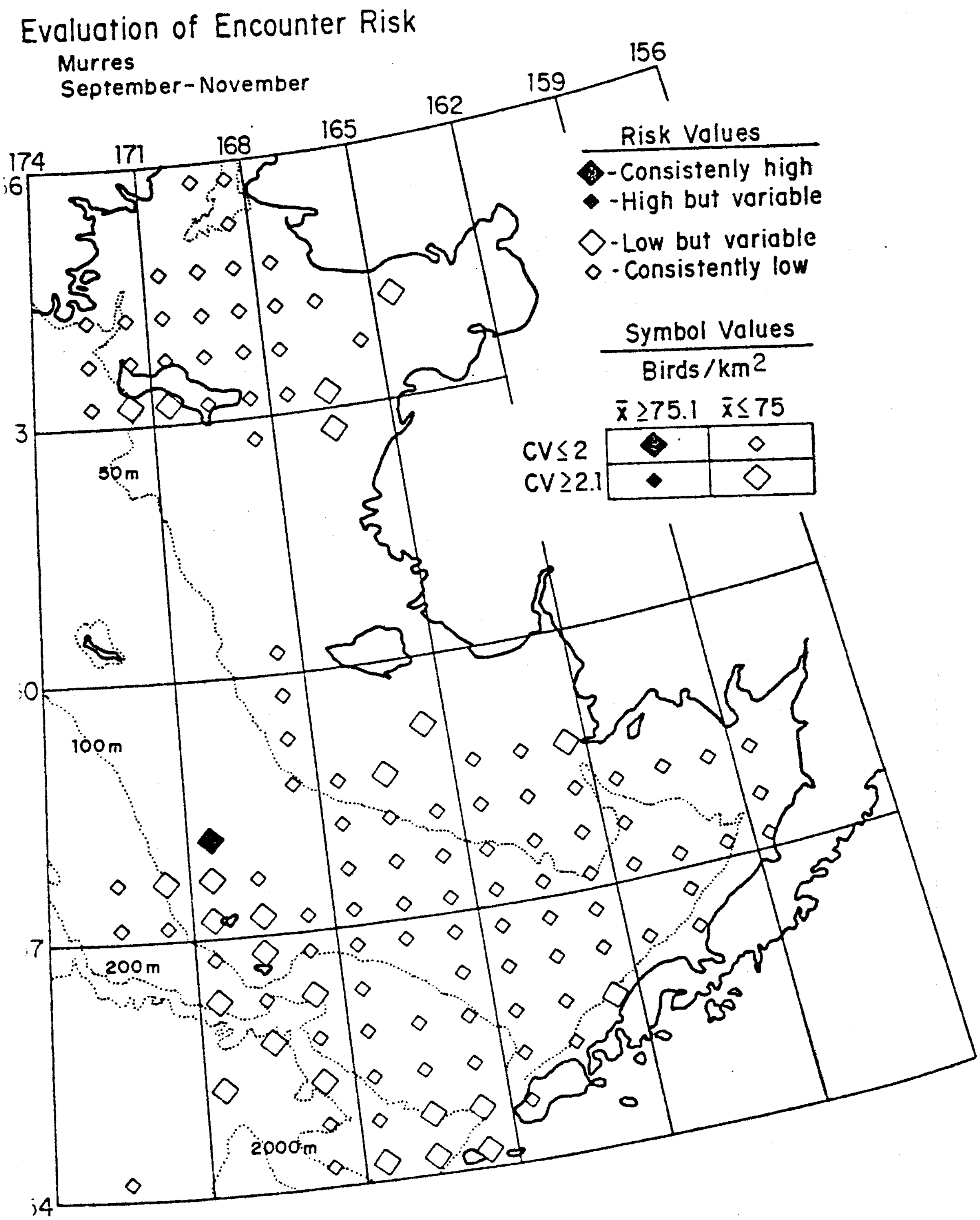

Evaluation of Encounter Risk
Murres
June-August
174
171
168
165
162
159
156
6
3
0
7
4
50m
50m
100m
200m
2000m
Risk Values
-Consistenly high
-High but variable
-Low but variable
-Consistently low
Symbol Values
Birds/km2
x̄ ≥75.1
x̄ ≤ 75
CV ≤ 2
CV ≥ 2.1

Figure 25



Evaluation of Encounter Risk
Murres
September-November
156
159
162
165
168
171
174
3
50m
100m
200m
2000m
Risk Values
-Consistenly high
-High but variable
-Low but variable
-Consistently low
Symbol Values
Birds/km2
x̄ ≥75.1
x̄ ≤ 75
CV≤2
CV≥2.1

Figure 26

Figures 18 through 20 show quite clearly the very strong seasonal variation in the distribution of the risk levels for all birds combined during the survey period. During Spring (Figure 18), high risk areas were found only within Bristol Bay, along the north coast of the Alaskan Peninsula, over the outer shelf near St. George Island and midway between the Pribilof Islands and St. Matthew Island. In the Summer, however, high risk areas - both consistently high and high but variable - were found more than twice as frequently as in the Spring (Figure 19). The entire shelf south of Nunivak Island possesses a large proportion of high risk areas, as does the shelf-break north and south of the Pribilof Islands, Unimak Pass, St. Matthew Island, St. Lawrence Island, and the Bering Strait.

In the Fall, the distribution of risk areas approaches that seen in the Spring with the middle shelf mostly devoid of consistently large numbers while high risk areas are found primarily in a relatively small region north of the Pribilof Islands, near Unimak Pass and south of Nunivak Island. Consistently large numbers of birds are still found around St. Lawrence Island but not nearly to the degree they are found in the Summer.

In addition to all birds surveyed, Figures 21-26 were prepared based on shearwater and murre densities. Shearwaters show a very marked change over Spring, Summer and Fall in the frequency and location of high risk areas. In Spring, a single consistently high risk area was found just north of the Alaskan Peninsula while in the Summer, high risk areas were encountered throughout the inner shelf region south of Nunivak Island and all along the Alaskan Peninsula from below Unimak Pass north. Summer and Fall distributions of risk areas seem to be quite similar in the Bering Strait. In the southeast Bering Sea, Summer and Fall season differ primarily in the decreased frequency of high risk areas in the Fall and the very high proportion of low but variable risk areas in the Summer. The most obvious feature of the seasonal patterns for murres is that high risk areas are few and very localized. Only the Pribilof Islands show a high risk area for all three seasons with other high risk areas encountered only near St. Matthew Island, St. Lawrence Island, and just off Cape Newenham during the Summer. In Spring, a consistently high risk area was found just north of the Alaska Peninsula in Bristol Bay.

3) Location of Large Densities

In order to reduce somewhat the uncertainty associated with the patchy population distribution of seabirds, the available survey data for the eight zones near the Pribilof Islands and the three PROBES area zones were organized into eight categories. The resulting categorical information for all birds, All birds on water, murres, and Red-legged Kittiwakes is displayed in Tables 1-4. In addition, Table 5 gives frequency data for small auklets, Horned Puffins, and Tufted Puffin, species which typically occur in rather low densities. The error, d (see Appendix 1), for each zone at the α = 0.95% level is given in Figures 27-28. As can be seen in the list of d values, even with the crude approximation required when ignoring the underlying distribution of densities, the sample sizes for the eight zones tend to be large enough so that the error is on the order of $\pm$ 13% (excepting zone 2). This means for instance, that we can estimate the proportion of all bird encounters within zone 1 (Table 1) in the range 0.1 birds/km to 30.0 birds/km^2 to be between 13% and 41%. This estimate can be improved upon if the sampling procedure is assumed to be reasonably random. In this case (see Appendix 1), the proportion of samples falling within any particular interval should be approximately normally distributed if the sample size is large (>50). Figures 27 and 29 give the error, d, for each zone calculated under these assumptions. Now, in zone 8 (Table 1) for

Table 1. Proportions of transects in various intervals: All Birds

Zone	N	0	0.1-10	10.1-30	30.1-50	50.1-100	100.1-500	500.1-1000	1000
1	253	2.0	17.0	26.9	18.6	11.9	21.7	1.6	0.4
2	88	3.4	5.7	30.7	31.8	13.6	12.5	0.0	2.3
3	130	3.8	3.1	11.5	7.7	17.7	35.4	13.1	7.7
4	178	2.8	5.1	23.6	10.7	11.2	34.3	6.2	6.2
5	387	2.1	19.4	38.2	16.3	17.6	6.2	0.3	0.0
6	343	4.7	12.2	30.6	19.0	20.4	11.4	1.2	0.6
7	297	0.7	33.3	39.7	15.2	7.4	3.7	0.0	0.0
8	487	1.2	13.1	32.9	17.7	20.1	14.2	0.4	0.4
13	89	2.2	20.2	44.9	12.4	6.7	13.5	0.0	0.0
14	497	0.4	20.5	48.5	17.3	10.3	2.6	0.2	0.2
15	395	3.8	50.1	29.4	9.6	5.6	1.5	0.0	0.0

Zone	1	2	3	4	5	6	7	8	13	14	15
% transects 50/km	35.6	28.4	73.9	57.9	24.1	33.6	11.1	35.1	20.2	13.3	7.1

Table 2. Proportions of transects in various intervals: All Birds on Water

Zone	N	0	0.1-10	10.1-30	30.1-50	50.1-100	100.1-500	500.1-1000	1000
1	253	29.6	37.2	15.0	7.1	6.3	4.3	0.4	0.0
2	88	29.5	53.4	11.4	1.1	2.3	1.1	1.1	0.0
3	130	16.2	41.5	17.7	3.8	7.7	7.7	3.1	2.3
4	178	12.4	44.4	16.3	6.7	9.0	7.0	1.7	1.7
5	387	22.2	47.8	23.8	2.8	2.8	0.5	0.0	0.0
6	343	30.0	50.4	13.7	2.6	1.5	1.5	0.3	0.0
7	297	31.0	53.2	9.8	3.0	1.7	1.3	0.0	0.0
8	487	41.9	46.6	7.0	1.6	2.3	0.6	0.0	0.0
13	89	50.6	39.3	6.7	1.1	1.1	1.1	0.0	0.0
14	497	38.6	52.9	6.4	1.4	0.2	0.4	0.0	0.0
15	395	50.6	42.3	6.1	0.3	0.8	0.0	0.0	0.0

Zone	1	2	3	4	5	6	7	8	13	14	15
% transects 50/km	11	4.5	20.8	20.3	3.3	3.3	3.0	2.9	2.2	0.6	0.8

Table 3. Proportions of Transects in various intervals: Red-legged Kittiwakes

Zone	N	0	0.1-10	10.1-30	30.1-50	50.1-100	100.1-500
1	253	84.2	15.4	0.4	0.0	0.0	0.0
2	88	71.6	27.3	1.1	0.0	0.0	0.0
3	130	64.6	30.8	4.6	0.0	0.0	0.0
4	178	37.1	45.5	11.2	3.4	1.7	1.1
5	387	78.0	20.9	1.0	0.0	0.0	0.0
6	343	40.5	43.4	12.5	2.0	0.9	0.6
7	297	90.6	9.4	0.0	0.0	0.0	0.0
8	487	37.8	51.3	8.4	1.4	1.0	0.0
13	89	58.4	38.2	2.2	0.0	1.1	0.0
14	497	82.7	16.3	0.8	0.2	0.0	0.0
15	395	95.9	4.1	0.0	0.0	0.0	0.0

Table 4. Proportions of transects in various intervals: Murres

Zone	N	0	0.1-10	10.1-30	30.1-50	50.1-100	100.1-500	500.1-1000	1000
1	253	14.6	21.7	25.3	12.3	11.5	13.4	0.8	0.4
2	88	10.2	18.2	44.3	11.4	10.2	3.4	2.3	0.0
3	130	18.5	6.9	6.9	6.2	16.2	28.5	10.0	6.9
4	178	15.7	21.9	11.2	6.7	14.6	20.8	5.1	3.9
5	387	14.2	32.3	24.8	13.2	12.9	2.6	0.0	0.0
6	343	23.3	36.4	27.4	6.4	2.9	2.9	0.3	0.3
7	297	12.1	53.9	22.2	7.4	3.0	1.3	0.0	0.0
8	487	42.3	44.6	8.4	1.4	2.7	0.6	0.0	0.0
13	89	58.4	37.1	4.5	0.0	0.0	0.0	0.0	0.0
14	497	39.0	45.5	12.9	1.8	0.6	0.2	0.0	0.0
15	395	46.6	46.6	5.8	0.5	0.3	0.3	0.0	0.0

Zone	1	2	3	4	5	6	7	8	13	14	15
% transects 50/km	26.1	15.9	61.6	44.4	15.5	6.4	4.3	3.3	0.0	0.8	0.6

Table 5. Proportions of transects in various intervals for species with typically low densities

		Frequency of Transects								
		0			0.1-10.0			10.1		
Zone	N	SmAuk	HP	TP	SA	HP	TP	SA	HP	TP
1	253	59.3	74.7	73.1	26.5	24.1	26.9	4.2	1.2	0.0
2	88	61.4	68.2	59.1	29.5	30.7	40.9	9.1	1.1	0.0
3	130	53.8	57.7	72.3	26.2	36.9	26.2	9.9	5.4	1.6
4	178	55.1	66.9	67.4	25.3	32.0	31.5	9.7	1.1	1.2
5	387	77.3	82.4	73.4	19.4	17.6	26.4	3.1	0.0	0.3
6	343	86.3	88.6	71.4	9.6	11.4	28.3	4.1	0.0	0.3
7	297	87.9	90.2	81.1	12.1	9.8	18.9	0.0	0.0	0.0
8	487	89.7	97.9	78.4	7.4	2.1	21.4	2.9	0.0	0.2
13	89	93.3	89	74.2	6.7	11	25.8	0.0	0.0	0.0
14	497	90.5	95.6	75.3	9.1	4.4	24.3	0.4	0.0	0.4
15	395	82.3	98.2	89.9	17.2	1.8	10.1	0.5	0.0	0.0

Sm Auk = Small Auklet

HP = Horned Puffin

TP = Tufted Puffin

ZONE	1	2	3	4	5	6	7	8
N	253	88	130	178	387	343	297	487
d	.14	.24	.20	.17	.11	.12	.13	.10

$$d = \frac{1}{2}\sqrt{N\ (1-\alpha)}$$

Error rate (d) for zones around the Pribilof Islands, $\alpha = 0.95$

Figure 27

ZONE	1	2	3	4	5	6	7	8
N	253	88	130	178	387	343	297	487
d	.06	.14	.09	.07	.05	.05	.06	.04

$$d = \sqrt{\frac{k^2}{4N}} \text{ , } k = 1.96$$

Error rate (d) for zones around the Pribilof Islands. α = 0.95, normal approximation

Figure 28

example, we can estimate the proportion of all bird encounters in the range 10.1-30.0 birds/km^2 to be between 29% and 37% at the 95% confidence level. Further refinement is of course possible if the sample size is increased. Figures 29 and 30 give the error with and without the normal approximation for combinations of the at PROBES area. For instance, if the three at PROBES area zones are combined, the normal approximation (Figure 30) yields an error of only 1%.

In keeping with previous observations of seasonal redistribution of densities, seasonal information from four zones (Tables 6-13) has been included for all birds, all birds on water, shearwaters, storm-petrels, Black-legged and Red-legged Kittiwakes, murres, and auklets. Error estimates for these tables are given in Figures 31 and 32. An examination of these tables shows that the frequency data tends to be consistent with the distribution of coefficients of variation discussed above. Once again moderate to high densities ($\geq$50 birds/km^2) occur most often near the Pribilof Islands in the Summer and more so in the Spring than in the Fall.

4) Future Sampling Efforts

As pointed out earlier, if sample estimates of bird densities are organized into disjoint intervals, then rather straightforward formulas can be derived that relate confidence levels and errors of estimate to sample size. Two methods of calculating the error, d, were derived, one with and one without assumptions concerning the distribution of proportions. In summarizing the data available for this report, a confidence level of 95% was used throughout and estimates of the sampling errors were computed based on existing sample sizes. Of course, the same data could be described using different confidence levels and for comparison, Figures 33 and 34 have been provided giving the required sample size associated with four values of α and two values of error.

ZONE	13	14	15	13+14	13+14+15
N	89	497	395	586	981
d	.24	.10	.18	.09	.01

$$d = \frac{1}{2}\sqrt{N(1-\alpha)}$$

Error rate (d) for PROBES zones, $\alpha = 0.95$

Figure 29

ZONE	13	14	15	13+14	13+14+15
N	89	497	395	586	981
d	.10	.04	.05	.04	.01

$$d = \sqrt{\frac{k^2}{4N}}, \quad k = 1.96$$

Error rate (d) for PROBES zones, $\alpha = 0.95$, normal approximation

Figure 30

Table 6. Seasonal variation in Bird Density % occurrence in frequency categories: All Birds

Zone	N	0	0.1-10	10.1-30	30.1-50	50.1-100	00.1-500	500.1-1000	1000
5 sp	59	3.4	44.1	42.4	8.5	1.7			
5 su	256	2.3	9.0	33.2	21.4	25.0	8.6	0.4	
5 fa	72	0.0	36.1	52.8	4.2	5.6	1.4		
6 sp	62	1.6	12.9	40.3	22.6	12.9	8.1	1.6	
6 su	224	6.7	11.2	23.2	16.1	26.3	14.3	1.3	0.9
6 fa	57	0.0	15.5	49.1	26.3	5.3	3.5		
8 sp	134	0.0	20.9	43.3	12.7	14.9	8.2		
8 su	308	1.9	7.5	25.3	20.8	25.0	18.2	0.6	0.6
8 fa	-	-	-	-	-	-	-	-	-
14 sp	259	0.0	26.6	53.7	10.8	7.7	1.2		
14 su	238	0.8	13.9	42.9	24.4	13.0	4.2	0.4	0.4
14 fa									

Sp = Spring (March, April, May)

Su = Summer (June, July, August)

Fa = Fall (September, October, November)

Table 7. Seasonal Variation in Bird Density % occurrence in frequency categories: All Birds on Water

Zone	N	0	0.1-10	10.1-30	30.1-50	50.1-100	100.1-500	500.1-1000	1000
5 Sp	59	39.0	45.8	15.3	-	-	-	-	-
5 Su	256	18.4	44.5	28.9	3.5	3.9	0.8	-	-
5 Fa	72	22.2	61.1	12.5	2.8	1.4			
6 Sp	62	35.5	35.5	14.5	6.5	3.2	4.8		
6 Su	224	32.6	51.3	11.6	2.2	0.9	0.9	0.4	
6 Fa	57	14.0	63.2	21.1	0.0	1.8			
8 Sp	134	47.0	41.8	6.0	3.0	1.5	0.7		
8 Su	308	40.6	46.8	7.8	1.3	2.9	0.6		
8 Fa	-	-	-	-	-	-	-	-	-
14 Sp	259	39.4	51.4	7.3	1.9				
14 Su	238	37.8	54.6	5.5	0.8	0.4	0.8		
14 Fa									

Sp = Spring (March, April, May)

Su = Summer (June, July, August)

Fa = Fall (September, October, November)

Table 8. Seasonal Variation in Bird Density % Occurrence in frequency categories: Red-legged Kittiwakes

Zone	N	0	0.1-10	10.1-30	30.1-50	50.1-100	100.1-500	500.1-1000	1000
5 Sp	59	94.9	5.1	-	-	-	-	-	-
5 Su	256	84.8	14.5	0.8					
5 Fa	72	40.3	56.9	2.8					
6 Sp	62	38.7	45.2	12.9	1.6	1.6			
6 Su	224	46.9	36.6	12.1	2.7	0.9	0.9		
6 Fa	57	17.9	68.4	14.0					
8 Sp	134	44.0	47.8	7.5	0.7				
8 Su	308	38.6	50.0	8.1	1.6	1.6			
8 Fa	-	-	-						
14 Sp	259	88.0	12.0						
14 Su	238	76.9	21.0	1.7	0.4				
14 Fa	-	-							

Sp = Spring (March, April, May)

Su = Summer (June, July, August)

Fa = Fall (September, October, November)

Table 9. Seasonal Variation in Bird Density, % Occurrence in frequency Categories: Murre

Zone	N	0	0.1- 10	10.1- 30	30.1- 50	50.1- 100	100.1- 500	500.1- 1000	1000
5 Sp	59	8.5	57.6	28.8	3.4	0.0	1.7	-	-
5 Su	256	4.3	25.0	29.3	18.8	19.1	3.5		
5Fa	72	54.2	37.5	5.6	1.4	1.4			
6 Sp	62	17.7	35.5	30.6	6.5	1.6	6.5	1.6	
6 Su	224	14.3	37.1	33.5	8.0	4.0	2.7	0.0	0.8
6 Fa	57	64.9	35.1						
8 Sp	134	38.8	35.1	12.7	3.7	8.2	1.5		
8 Su	308	36.4	54.2	7.8	0.6	0.6	0.3		
8 Fa	-	-							
14 Sp	259	21.6	52.1	21.2	3.5	1.2	0.4		
14 Su	238	58.0	38.2	3.8					
14 Fa									

Sp = Spring (March, April, May)

Su = Summer (June, July, August)

Fa = Fall (September, October, November)

Table 10. Seasonal Variation in Bird Density, % Occurrence in Frequency Categories: Shearwater

Zone	N	0	0.1-10	10.1-30	30.1-50	50.1-100	100.1-500	500.1-1000	1000
5 Sp	59	-	-	-	-	-	-	-	-
5 Su	256	66.8	25.0	5.9	0.4	1.2	0.4	0.4	-
5 Fa	72	63.9	33.3	1.4	0.0	1.4			
6 Sp	62								
6 Su	224	63.4	26.8	6.3	1.8	1.3	0.4		
6 Fa	57	61.4	35.1	3.5					
8 Sp	134	99.3	0.7						
8 Su	308	49.0	35.4	7.1	2.6	2.6	3.2		
8 Fa	-								
14 Sp	259	96.5	2.3	0.4	0.4	0.0	0.4		
14 Su	238	73.9	20.2	2.0	0.4	1.3	1.3		
14 Fa									

Sp = Spring (March, April, May)

Su = Summer (June, July, August)

Fa = Fall (September, October, November)

Table 11. Seasonal Variation in Bird Density, % Occurrence in Frequency Categories: Storm Petrel

Zone	N	0	0.1- 10	10.1- 30	30.1- 50	50.1- 100	100.1- 500	500.1- 1000	1000
5 Sp	59	-	-	-	-	-	-	-	-
5 Su	256	93.0	5.9	0.8	0.4				
5 Fa	72								
6 Sp	62	98.4	1.6						
6 Su	224	67.0	20.1	8.5	1.3	0.4	2.2	0.4	
6 Fa	57	80.7	19.3						
8 Sp	134	90.3	8.2	1.5					
8 Su	308	34.1	42.5	10.1	2.6	6.2	3.2	1.0	0.3
8 Fa	-								
14 Sp	259	79.2	20.1	0.8					
14 Su	238	29.0	49.6	16.8	2.5	1.7	0.4		
14 Fa									

Sp = Spring (March, April, May)

Su = Summer (June, July, August)

Fa = Fall (September, October, November)

Table 12. Seasonal Variation in Bird Density, % Occurrence in Frequency Categories Black-legged Kittiwakes

Zone	N	0	0.1-10	10.1-30	30.1-50	50.1-100	100.1-500	500.1-1000	1000
5 Sp	59	28.8	69.5	1.7	-	-	-	-	-
5 Su	256	40.2	59.0	0.8					
5 Fa	72	8.3	81.9	8.3	1.4				
6 Sp	62	30.6	61.3	8.1					
6 Su	224	42.9	45.5	9.4	1.8	0.4			
6 Fa	57	35.1	63.2	1.8					
8 Sp	134	42.5	51.5	5.2	0.7				
8 Su	308	37.3	52.3	9.4	1.0				
8 Fa									
14 Sp	259	56.0	41.7	2.3					
14 Su	238	60.9	36.1	2.9					
14 Fa									

Sp = Spring (March, April, May)

Su = Summer (June, July, August)

Fa = Fall (September, October, November)

Table 13. Seasonal Variation in Bird Density, % Occurrence in Frequency Categories: All Auklets

Zone	N	0	0.1-10	10.1-30	30.1-50	50.1-100	100.1-500	500.1-1000	1000
5 Sp	59	62.7	32.2	5.1	-	-	-	-	-
5 Su	256	75.0	21.2	3.5	0.0	0.4			
5 Fa	72	97.2	2.8						
6 Sp	62	59.7	24.2	11.3	1.6	1.6	1.6		
6 Su	224	91.1	7.1	1.3	0.4				
6 Fa	57	96.5	3.5						
8 Sp	134	70.9	18.7	7.5	2.2	0.7			
8 Su	308	97.4	2.6						
8 Fa	-	-							
14 Sp	259	84.6	14.7	0.8					
14 Su	238	97.1	2.9						
14 Fa	-								

Sp = Spring (March, April, May)

Su = Summer (June, July, August)

Fa = Fall (September, October, November)

Sp = spring (March, April, May), Su = summer (June, July, August), Fa = fall (September, October, November)

ZONE	5 Sp	5 Su	5 Fa	6 Sp	6 Su	6 Fa	8 Sp	8 Su	14 Sp	14 Su
N	59	256	72	62	244	57	134	308	259	238
d	.29	.14	.26	.28	.18	.30	.19	.13	.14	.15

$$d = \frac{1}{2}\sqrt{N(1-\alpha)}$$

Error estimates (d) for Tables 1 - 6, $\alpha = 0.95$

Figure 31

Sp = spring (March, April, May), Su = summer (June, July, August), Fa = fall (September, October, November)

ZONE	5 Sp	5 Su	5 Fa	6 Sp	6 Su	6 Fa	6 Sp	8 Su	14 Sp	14 Su
N	59	256	72	62	224	57	134	308	259	238
d	.13	.06	.11	.12	.07	.13	.09	.06	.06	.06

$$d = \sqrt{\frac{k^2}{4N}}, \quad k = 1.96$$

Error estimates (d) for Tables 6 - 13, $\alpha = 0.95$, normal approximation

Figure 32

	d		
α	.1	.25	k
.99	2500	400	2.58
.95	500	80	1.96
.90	250	40	1.65
.75	100	16	1.16

$$N = \frac{1}{4} d^2 (1-\alpha)$$

Sample size (N) required for a given confidence level (α) and error rate (d)

Figure 33

	d		
α	.1	.25	k
.99	665	166	2.58
.95	384	96	1.96
.90	272	68	1.65
.75	135	34	1.16

$$N = \frac{1}{4}(k/d)^2$$

Sample size (N) required for a given confidence level (α) and error rate (d), with the normal approximation

Figure 34

Future survey efforts are likely to have as objectives both the refinement of current estimates and the acquisition of information about previously unsurveyed regions. The formulas used in Figures 33 and 34 can be used to give planners clear criteria for consistent decisions in this regard.

To illustrate, zone 3 (Table 1) shows a higher proportion of density estimates of ≥ 50 birds/km^2 than any other zone, but with a sample size of only 130 the error is approximately 20%. Zone 5 on the other hand, which is adjacent to zone 3, has only about one-third the proportion of density estimates ≥ 50 birds/km^2 but almost three times the number of transects. Clearly, if other considerations are judged equal, an allocation of new survey resources to zone 3 rather than zone 5 would be preferred since reducing the error of estimates for the former is likely to be of more value. Similarly, if seasonal data are examined, density estimates for Red-legged Kittiwakes (Table 11) tend to be found in more restricted ranges during the Fall but the sample sizes for this season are relatively small.

Turning now to the question of which of the two available formulas should be used in planning survey efforts, the choice will depend primarily on just how closely a proposed survey will approximate a random sample. A comparison of Figures 33 and 34 show that a survey including 100 transects would yield an error of 10% at the .95% confidence level if the normal approximation is assumed while the same precision would require 500 transects if the normal approximation does not hold. This considerable increase in efficiency suggests that, even though in the majority of surveys random observations might be costly in terms of resources, a fewer number of random observations would be more cost-effective than a larger number of more convenient efforts.

In developing a sampling rationale for any new area, zones in the vicinity of colonies should be organized to sample different distances from the colony

(10, 20, 40km bands) and toward and away from the shelf-edge, assuming that no currents or fronts are nearby. If fronts or currents are within 100-150km of the colony (as near the Bering Strait colonies), then sampling should include these areas.

In pelagic surveys removed from colonies, our experience suggests that it is valuable to organize sampling on the basis of oceanographic domains. So doing provides a biologically rational basis for partitioning sampling effort.

For all zones, seasonal variation needs to be considered, although annual variation is not significant. Thus sampling should be spread over Spring, Summer and Fall and if possible Winter with sufficient transects in each zone in each season to provide the desired level of confidence and error.

DISCUSSION

1) Mixing Regimes and Seabird Distribution

Our analysis showed that both surface feeding and diving seabirds exhibited significant differences in density between shelf domains that differ in mixing regime and food webs. Our results establish, at a relatively fine scale, a connection between seabird numbers and mixing regimes that differ in the timing of algal productivity and the type of marine food web. Large scale correlations between seabird abundance and physical parameters have been presented by Pocklington (1974) for the Indian Ocean, and by Shuntov (1974) and Sanger (1972), who described latitudinal variation in seabird abundance associated with temperature gradients in the North Pacific. A mesoscale analysis of seabird abundance has been presented by Joiris (1978) for a single cruise in the North Sea in July. Joiris found a reduced number of Northern Fulmar, storm-petrels, and alcids in "North Sea water" (middle shelf) as compared to the numbers of these species in "Atlantic water" (outer shelf). Our analysis of seabird abundance relative to domains in the Bering Sea closely parallels some of the results of Joiris. We found a reduced density of fulmars, storm-petrels, and one alcid (Tufted Puffins) in the middle domain. Black-legged Kittiwakes differed little in density between domains. For murres we found a lower density in the middle shelf than in outer shelf waters.

Our results do not indicate that usage of the middle shelf is uniformly reduced in all seabird species. Auklet densities were higher in the middle shelf than on the outer shelf, and there was some indication that shearwater density increases as one moves from the shelf-break toward the coastal domain. Murre densities on the middle shelf were lower than on the outer shelf, but still far above those recorded beyond the shelf-break.

An association between bird densities and surface water temperatures has been noted in other studies at high latitudes (Brown 1968). Our results for the southeastern Bering Sea offer an explanation for this, since surface waters are warmer for the middle shelf regime (two-layer system) than for the outer shelf (three-layer system). This suggests that the relation that we have established between bird densities and mixing regimes in the southeastern Bering Sea may be generally true of those seabirds that inhabit the wide continental shelves found at high latitudes.

2) Comparison of Density Estimates

Significant differences in bird density among domains can affect estimates of density for an entire shelf, especially if effort is not proportional to the area of each domain. A similar consideration applies to seasonal fluctuations, if sampling effort and seabird numbers fluctuate from month to month. If sampling effort and bird numbers do vary greatly from region to region and month to month, then these differences need to be taken into account when developing density estimates. Using seasonal data presented by Schneider and Hunt (in prep), we computed integrated averages for the entire area covered by the three shelf regions shown in Figure 10. The slope, outer, and middle regions accounted for 6%, 34%, and 60% respectively of the total area of 89,780 km^2. An integrated estimate was obtained by computing the number of birds in each of these three regions, taking the sum, then dividing by the total area. The integrated average was 12 birds/km^2 in April, 14 birds/km^2 in May, 29 birds/km^2 in June, and 56 birds/km^2 in July.

These values are roughly the same as a colony based estimate (Hunt et al. 1980a), while differing from previous pelagic estimates (Hunt et al. 1980a, Shuntov 1974, Wahl 1978). Hunt et al. (1980a) took a value of 60%

of the birds in all colonies in the eastern Bering Sea as an estimate of the number of birds at sea at any one time, added the total estimated shearwater population, and divided this figure by shelf area (807,000 km^2). This method yielded an estimate of 32 birds/km^2 during the breeding season. Using counts made at sea, Wahl (1978) reported a value of 15 birds/km^2 for the southeastern Bering Sea. Shuntov (1974) reported 20 birds/km^2 on the eastern Bering Sea shelf in May-June, 18 birds/km^2 in July-August. Hunt et al. (1980a), using both ship and air counts, report values of 56, 41, and 12 birds/km^2 for the continental shelf, shelf-break, and oceanic waters of the eastern Bering Sea in March through May. For June through August they report 109, 58, and 11 birds/km^2 for shelf, shelf-break, and oceanic waters respectively. Their higher values in summer were due primarily to the inclusion of nearshore counts, including counts near Unimak Pass. Shearwaters are concentrated in these areas, and accounted for 80% of the largest zonal average, 109 birds/km^2.

The discrepancies between pelagic estimates can be attributed to differing sampling efforts and designs, in conjunction with a highly aggregated bird distributions. If sampling is controlled by an equalization of effort or by a stratified design, then at-sea counts are likely to underestimate total birds unless effort is great enough to detect large feeding flocks, which can account for the major proportion of the birds at sea at any one time. For highly aggregated species, increased sampling effort will increase the probability of encounter with large flocks, thereby increasing the observed average. The estimates that we present are based on 163.5 hours of observation (981 counts). The lower estimate of Wahl was based on 20.3 hours. Shuntov's estimates were based on 170 (Spring) and 280 (Summer) counts of unknown duration and location.

3) Areas of Great Sensitivity to Oil Spills

Considerable between and within season variability notwithstanding, Figures 3 and 18-20 delineate areas in which spilled oil would be likely to encounter high concentrations of birds. Whether one concentrates on regions in which a high percentage of transects encountered high densities of birds (Figure 3), or regions where high means and low coefficients of variation coincide (Figures 18-20), the conclusions are the same. The areas near Unimak Pass, along and inshore of the 50m isobath in Bristol Bay, along the shelf-edge, and near major colonies (Pribilof Islands, Cape Newenham, St. Matthew, St. Lawrence, King Island, and the Diomedes) all support large numbers of birds. While the impact would vary with season (Figures 18-20), at virtually any time a spill would have serious consequences. The blank areas on the figures represent regions with inadequate survey coverage and some of these areas may also contain high densities of birds.

It is also clear that the species of birds at risk differ with location and season. For instance, shearwaters predominate in inner Bristol Bay, particularly in Summer (Figures 21-23), while murres are most concentrated near their major colonies (Figures 24-26). Most of the birds seen near St. Lawrence Island and northward into the Bering Strait were small auklets. All of these species are found in large, dense aggregations on the water and hence are exceedingly vulnerable to floating oil.

4) Statistical Considerations

The most dominant characteristic of sea-bird density estimates is the extreme local instability found throughout the entire Bering Sea. This is illustrated both by the wide range of coefficients of variation calculated for small blocks of ocean area and the inability of simple linear regressions based on oceanographic variables to significantly reduce the observed variability.

The prediction of bird populations in particular locations must take this fact into account and this report offers the suggestion that a useful step in this direction is to categorize bird density estimates into intervals.

The Binominal model and certain associated equations described in this report seem to have considerable merit in terms of their applicability to seabird data if the statistic of interest is the proportion of density estimates that fall within specified ranges. With very few underlying assumptions, quantitative relationships can be derived that yield useful confidence levels and estimates of error for past sampling efforts and also provide reasonably precise criteria for planning decisions concerning future sampling efforts. The requirement that sampling be done randomly and that the observations be as independent as possible can of course be only approximated and not achieved exactly. However, the sensitivity of this approach to violations of randomness and independence is likely to be less than that of any other practical quantitative program.

Finally, if one of the purposes of obtaining quantitative estimates of seabird populations is to provide input to evaluations of the biological risk associated with oil spills in specific regions, then the analysis described in this report bears directly on this task. For example, if two or more areas or locations are to be compared in terms of their relative "riskiness", then an important component of this decision is the potential value of additional information and what it would cost to obtain it. The relationships between the acquisition of new or better information and the methods used in this report were discussed in the preceeding section on future sampling efforts.

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APPENDIX 1

Density estimates derived from transect samples can be categorized into c disjoint intervals with the following assumptions:

(1) Each sample is considered to be an independent Bernoulli trial.

(2) For each i, $i = 1,\ldots,C$, π_i is the probability that the sample statistic (in this case the mean) will fall within interval i and therefore belong to category i. For categories $1,\ldots,C$;

$$\pi_1 + \pi_2 + \ldots + \pi_c = 1 \quad .$$

(3) The number of transects (samples) belonging to category i is the number of successes S associated with the category;

$$N = S_1 + S_2 + \ldots + S_c \quad .$$

(4) The probability of obtaining a particular set of successes is given by the multinomial model as follows:

$$m(S_1,S_2,\ldots,S_c;\ \pi_1,\pi_2,\ldots,\pi_c) = \binom{N}{S_1,S_2,\ldots,S_c} \pi_1^{S_1}\ \pi_2^{S_2} \ldots \pi_c^{S_c}$$

where $$\binom{N}{S_1,S_2,\ldots,S_c} = \frac{N!}{S_1!S_2! \ldots S_c!} \quad .$$

(5) If the number of categories is reduced by combining two or more of the original set then, for example,

$$m(S_1, S_2, S_3'; \pi_1, \pi_2, \pi_3') = \binom{N}{S_1, S_2, S_3'} \pi_1^{S_1} \pi_2^{S_2} \pi_3'^{S_3'}$$

where $$S_3' = N - (S_1 + S_2)$$

and $$\pi_3' = \pi_3 + \pi_4 + \ldots + \pi_c \quad .$$

(6) If only one category is of interest then the multinomial model given in (4) reduces to the Binomial model so that:

$$b(S_i;\ N, \pi_i) = \binom{N}{S_i} \pi_i^{S_i} (1 - \pi_i)^{N - S_i} \quad .$$

The practical application of statements (1) through (6) requires estimations of the probabilities $\pi_1, \ldots, \pi_c$. This entails the derivation of a formula which provides, for any given confidence level and interval, a lower bound on the required sample size. This formula, for any given sample size and confidence level, also yields an upper bound on the associated confidence interval. The derivation is straight-forward and requires only Chebyshev's Inequality and the weak law of large numbers. The version of the former used here can be stated as follows: at least $1 - 1/h^2$ of the probability associated with any random variable will lie within h standard deviations of the mean. In particular,

(A) $$\Pr(|x - \mu| < h\sigma) \geq 1 - \frac{1}{h^2}$$

which is read as: the probability that the absolute value of the difference between a random variable and its mean is less than $h\sigma$ is equal to or greater than $1 - 1/h^2$. The Chebyshev Inequality holds for any distribution so long as it has a mean and variance and therefore can be used to validate Khintchine's Theorem for the weak law of large numbers, described next.

Given a random sample of n observations taken from a population with mean μ and variance σ^2, the expectation of the sample mean $\bar{x}$ is σ^2/N. This last statement implies that as n gets large the variance of the sample mean approaches zero which is the significant implication of the law of large numbers. That is, for any $d > 0$,

(B) $$\Pr(|\bar{x} - \mu| < d) \rightarrow 1 \quad \text{as} \quad N \rightarrow \infty \quad .$$

To show this analytically, Chebyshev's Inequality can be written as

(C) $$\Pr(|x - \mu| < d) \geq 1 = \frac{1}{h^2}$$

where $$d = h\sigma \quad \text{and} \quad h = \frac{d}{\sigma} \quad .$$

Consequently, if we substitute $\bar{x}$ for x and σ^2/N for σ^2, the result is Khintchine's theorem:

$$\Pr(|\bar{x} - \mu| < d) \geq 1 - \frac{1}{\left(\frac{d}{\sqrt{\sigma^2/N}}\right)^2} = 1 - \frac{\sigma^2}{Nd^2}$$

Since σ^2 and d^2 are fixed, as $N \rightarrow \infty$, $\sigma^2/Nd^2 \rightarrow 0$ giving (B).

The equation relating sample size to confidence level and confidence interval can now be derived using the Bernoulli model and statements (A) through (C). In this model, each transect is considered to be one of N independent Bernoulli trials with population probability π_i associated with category i. If S is the number of transects in cateogry i (i.e., the number of successes) then the sample mean is S/N and

$$\Pr\left(\left|\frac{S}{N} - \pi_i\right| < d\right) \to 1 \quad \text{as} \quad N \to \infty \quad .$$

This is the Bernoulli law of large numbers, first published in 1713. In words, as N gets large the proportion of successes in the sample will get arbitrarily close to the population proportion π_i. The question is, how large must N be for S/N to be a "good" estimate of π_i? To answer this we wish to estimate the size of N such that the observed frequency of success in the sample will be within a specific distance d of π_i at a given high level of probability α. Formally, we wish to find an integer N such that

$$\Pr\left(\left|\frac{S}{N} - \pi_i\right| \leq d\right) \geq \alpha \quad \text{for all} \quad \pi_i \quad \text{in} \quad 0 \leq \pi_i \leq 1 \quad .$$

To find a lower bound on N, note that from (C)

$$\alpha = 1 - \frac{\sigma^2}{Nd^2} \quad ,$$

and from the Bernoulli model the variance of S/N is $\pi_i(1 - \pi_i) / N$.

Furthermore,

$$\pi_i(1 - \pi_i) = \pi_i - \pi_i^2$$

$$= \frac{1}{4} - \left(\frac{1}{4} - \pi_i + \pi_i^2\right)$$

$$= \frac{1}{4} - \left(\frac{1}{2} - \pi_i\right)^2$$

so $\pi_i(1 - \pi_i)$ is maximum at $\pi_i = 1/2$. Therefore,

(D) $$\Pr\left(\left| \frac{S}{N} - \pi_i\right| \le d\right) \ge 1 - \frac{1}{4Nd^2}$$

since $$\frac{\sigma^2}{N} = \pi_i(1 - \pi_i)/N \le \frac{1}{4N} \quad .$$

The relation in (D) is satisfied if

$$N \ge \frac{1}{4d^2(1 - \alpha)} \quad .$$

The estimates given above for sample sizes required for particular values of α and d can be improved if S is the sum of a large number of independent trials (usually greater than 30). If this is true then the Central Limit Theorem holds approximately and S/N can be assumed to be nearly normal. In this case, the error

$$d = k\sigma_{S/N}$$

$$= k\sqrt{\frac{\pi_i(1 - \pi_i)}{N}}$$

and $$N \geq \pi(1 - \pi) \left(\frac{k}{d}\right)^2 .$$

Once again $\pi(1 - \pi)$ is a maximum at $\pi = 1/2$. Therefore

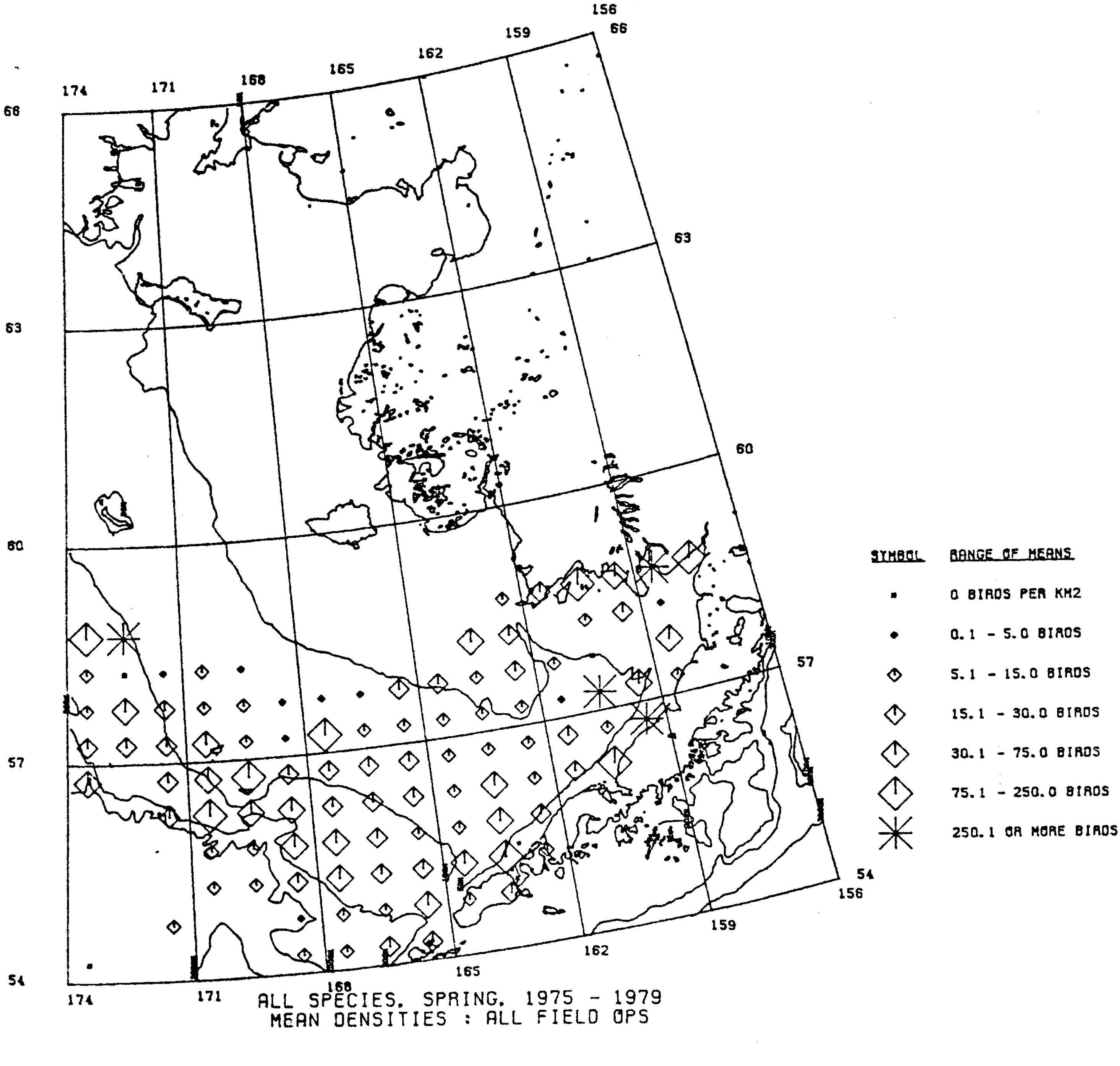
$$N \geq \frac{1}{4} \left(\frac{k}{d}\right)^2$$

and also,

$$d = \sqrt{\frac{k^2}{4N}} .$$

APPENDIX 2

Maps of Mean Densities and Associated Coefficients of Variation



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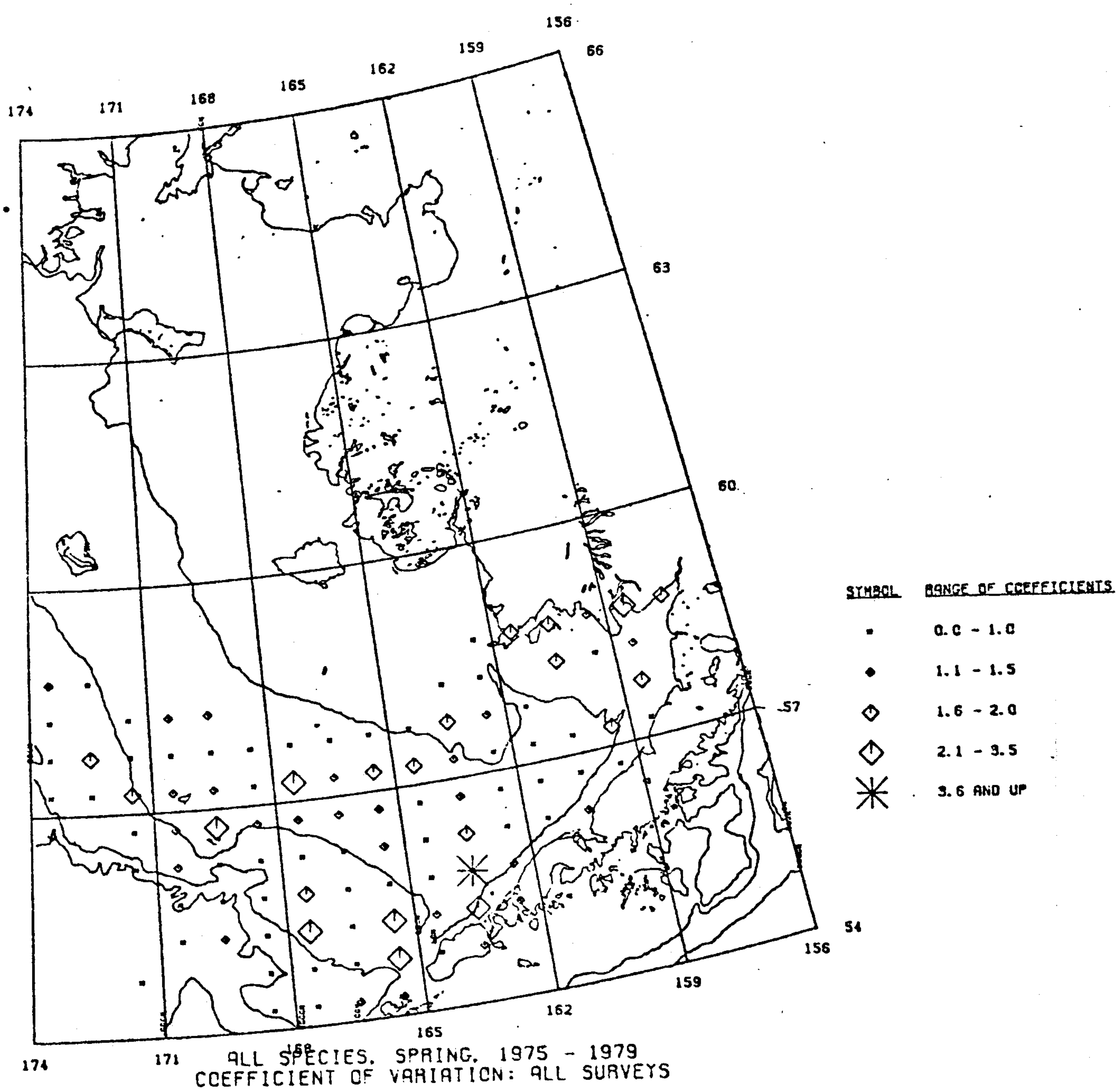
SYMBOL
RANGE OF MEANS
0 BIRDS PER KM2
0.1 - 5.0 BIRDS
5.1 - 15.0 BIRDS
15.1 - 30.0 BIRDS
30.1 - 75.0 BIRDS
75.1 - 250.0 BIRDS
250.1 OR MORE BIRDS
ALL SPECIES, SPRING, 1975 - 1979
MEAN DENSITIES : ALL FIELD OPS

Figure 35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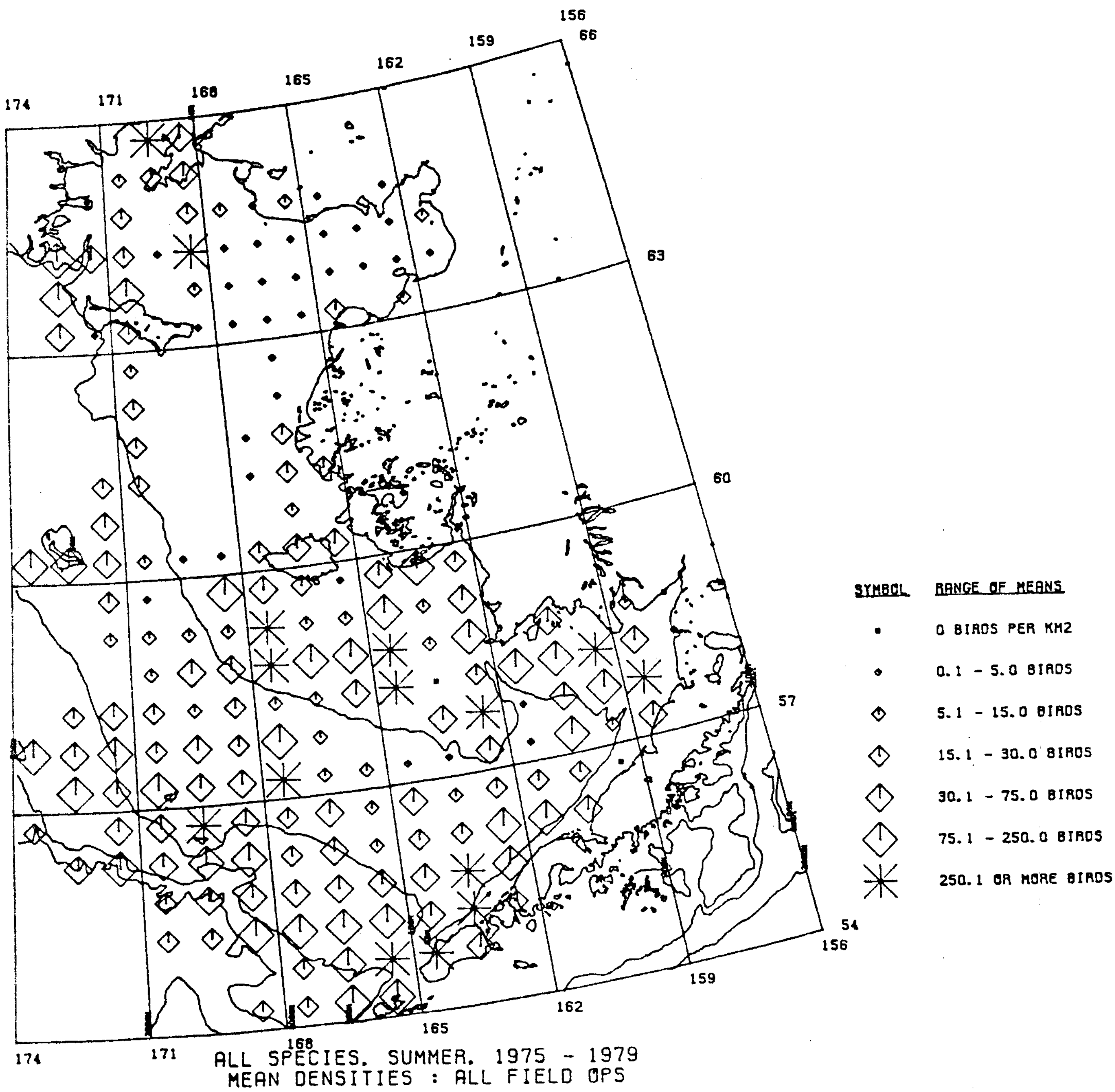
SYMBOL RANGE OF COEFFICIENTS
0.0 - 1.0
1.1 - 1.5
1.6 - 2.0
2.1 - 3.5
3.6 AND UP
ALL SPECIES, SPRING, 1975 - 1979
COEFFICIENT OF VARIATION: ALL SURVEYS

Figure 36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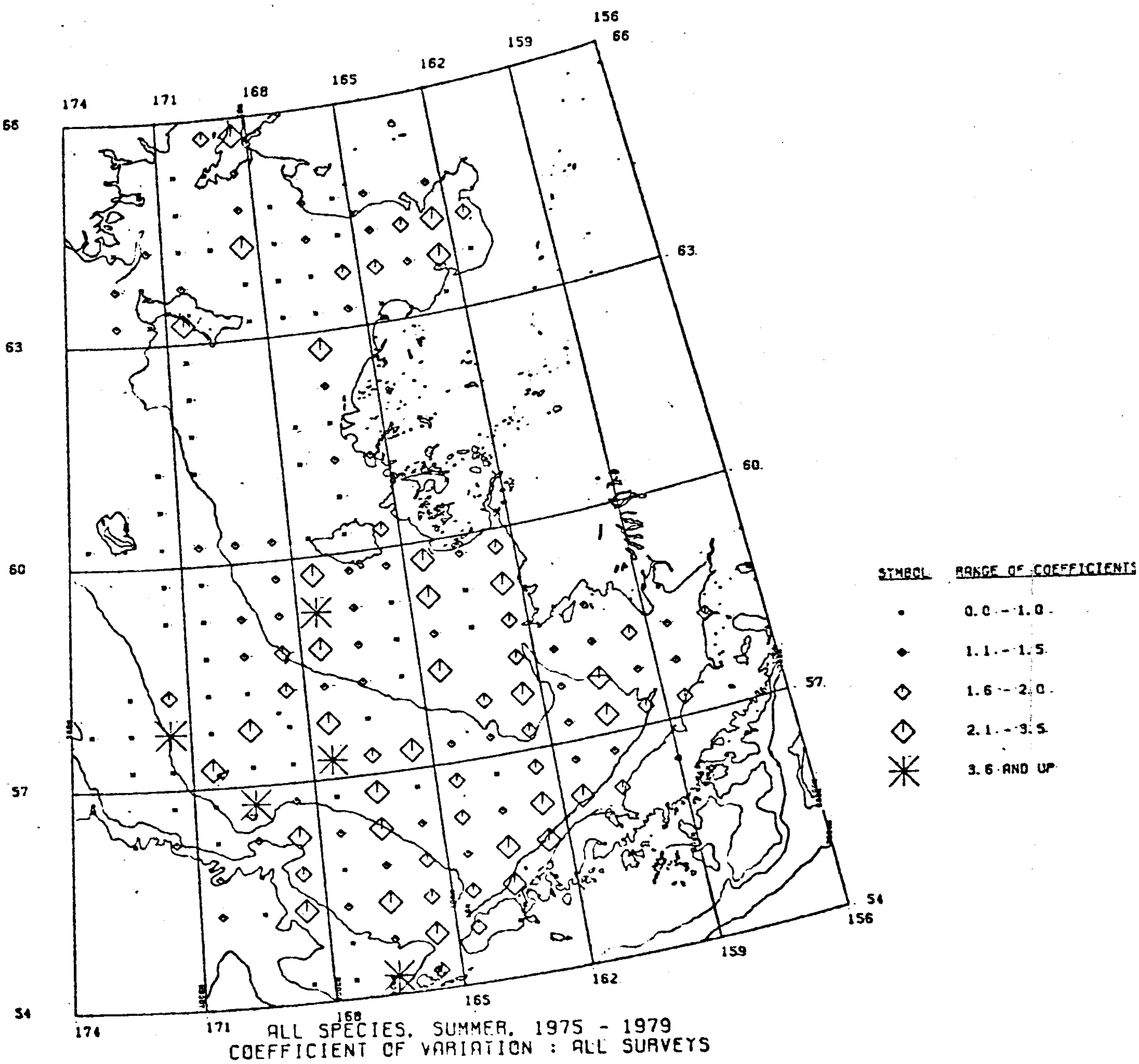
SYMBOL
RANGE OF MEANS
0 BIRDS PER KM2
0.1 - 5.0 BIRDS
5.1 - 15.0 BIRDS
15.1 - 30.0 BIRDS
30.1 - 75.0 BIRDS
75.1 - 250.0 BIRDS
250.1 OR MORE BIRDS
ALL SPECIES. SUMMER, 1975 - 1979
MEAN DENSITIES : ALL FIELD OPS

Figure 37



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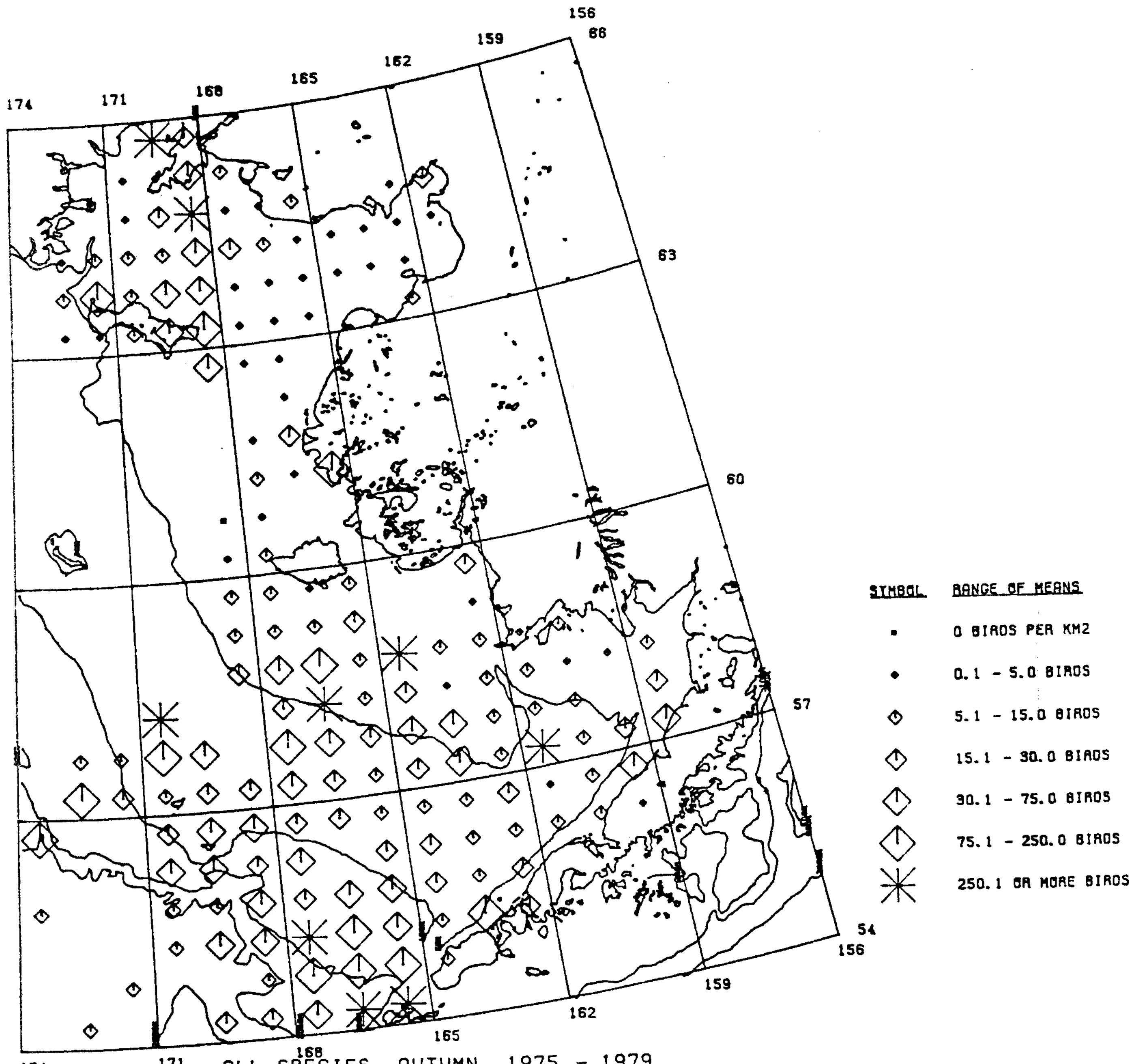
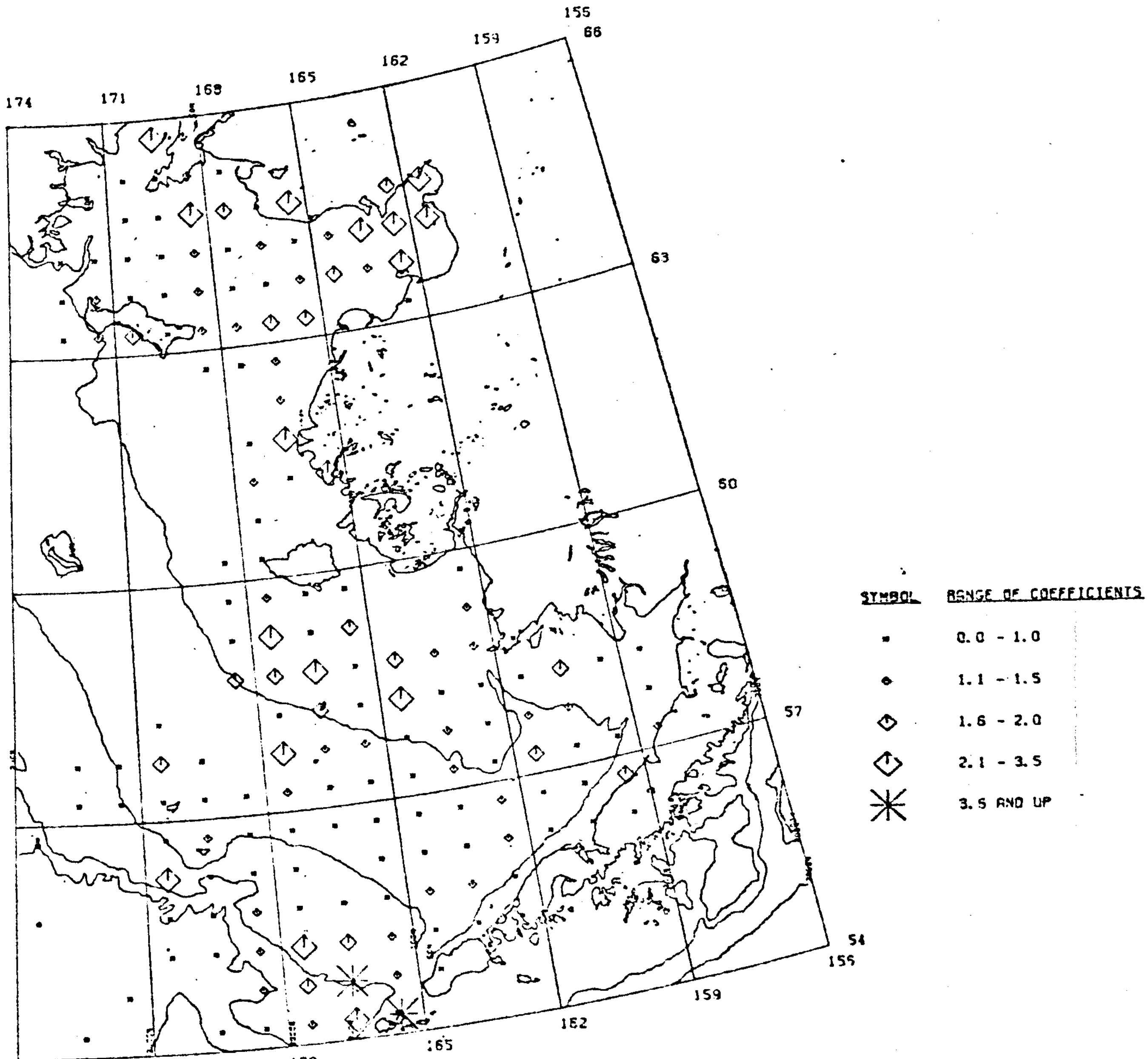
SYMBOL
RANGE OF COEFFICIENTS
0.0 - 1.0
1.1 - 1.5
1.6 - 2.0
2.1 - 3.5
3.6 AND UP
ALL SPECIES. SUMMER, 1975 - 1979
COEFFICIENT OF VARIATION : ALL SURVEYS

Figure 38



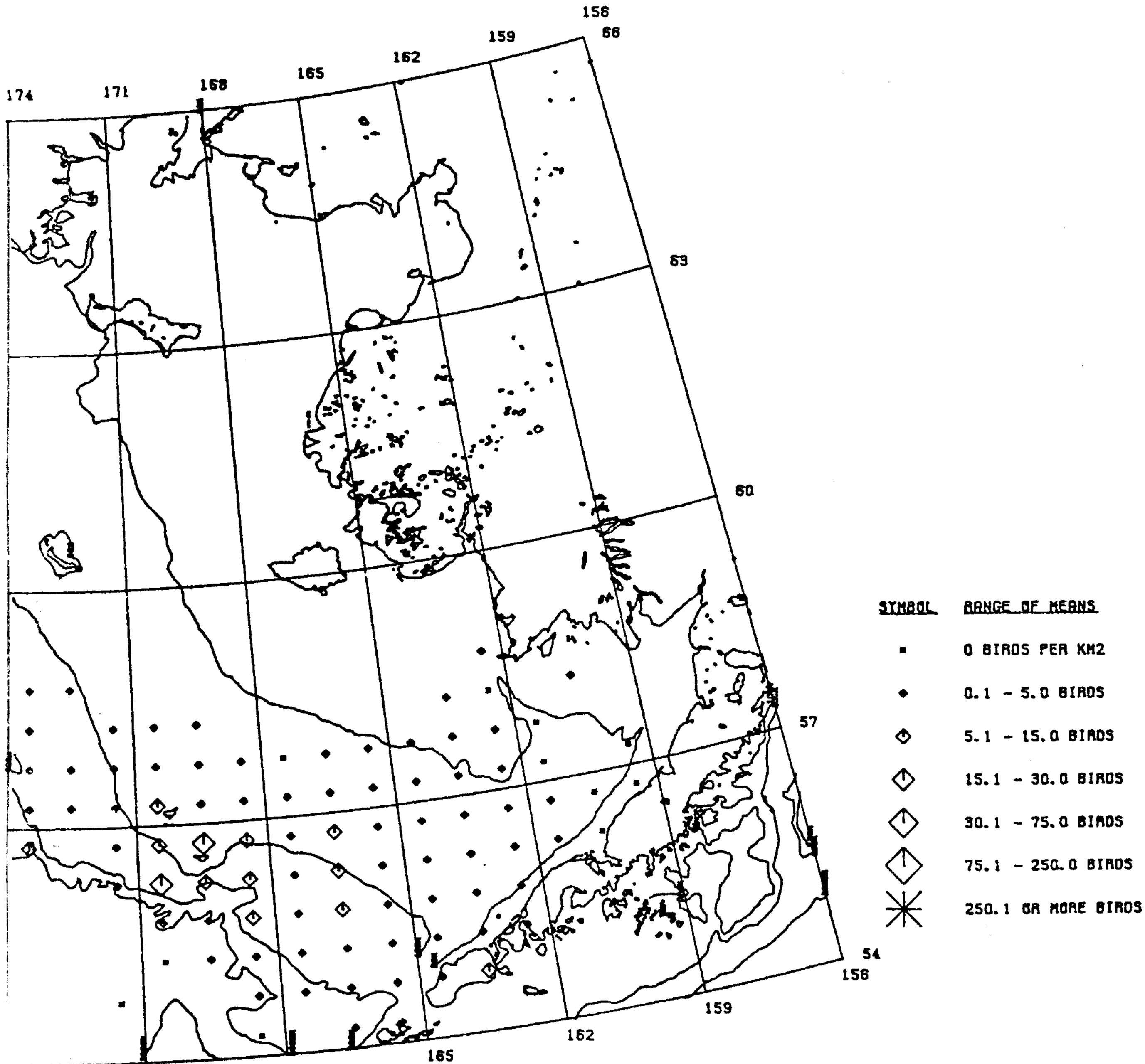
ALL SPECIES, AUTUMN, 1975 - 1979
MEAN DENSITIES : ALL FIELD OPS

Figure 39



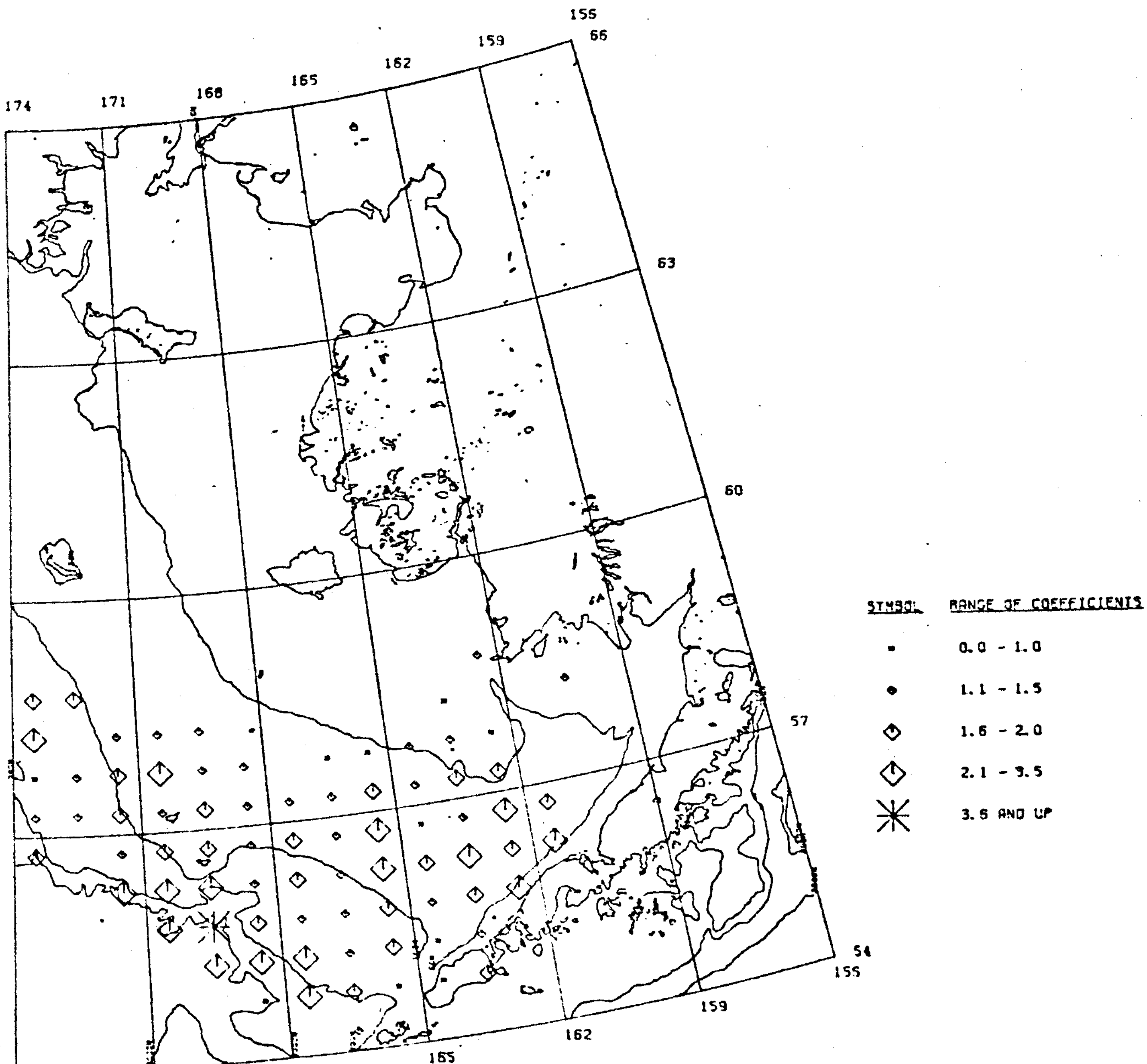
ALL SPECIES. AUTUMN. 1975 - 1979
COEFFICIENT OF VARIATION : ALL SURVEYS

Figure 40



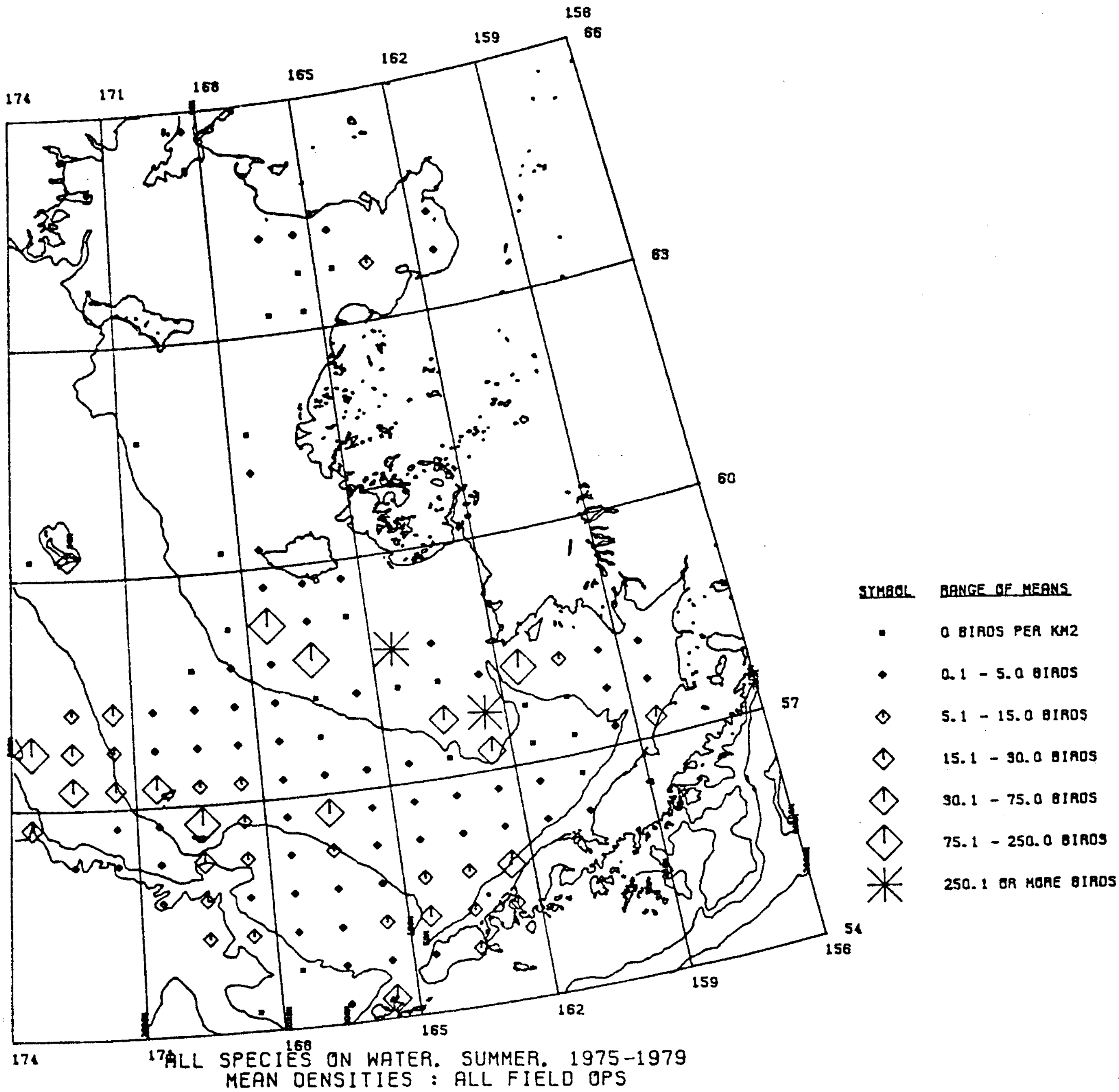
ALL SPECIES ON WATER, SPRING, 1975-1979
MEAN DENSITIES : ALL FIELD OPS

Figure 41



ALL SPECIES ON WATER, SPRING, 1975-79
COEFFICIENT OF VARIATION : ALL SURVEYS

Figure 42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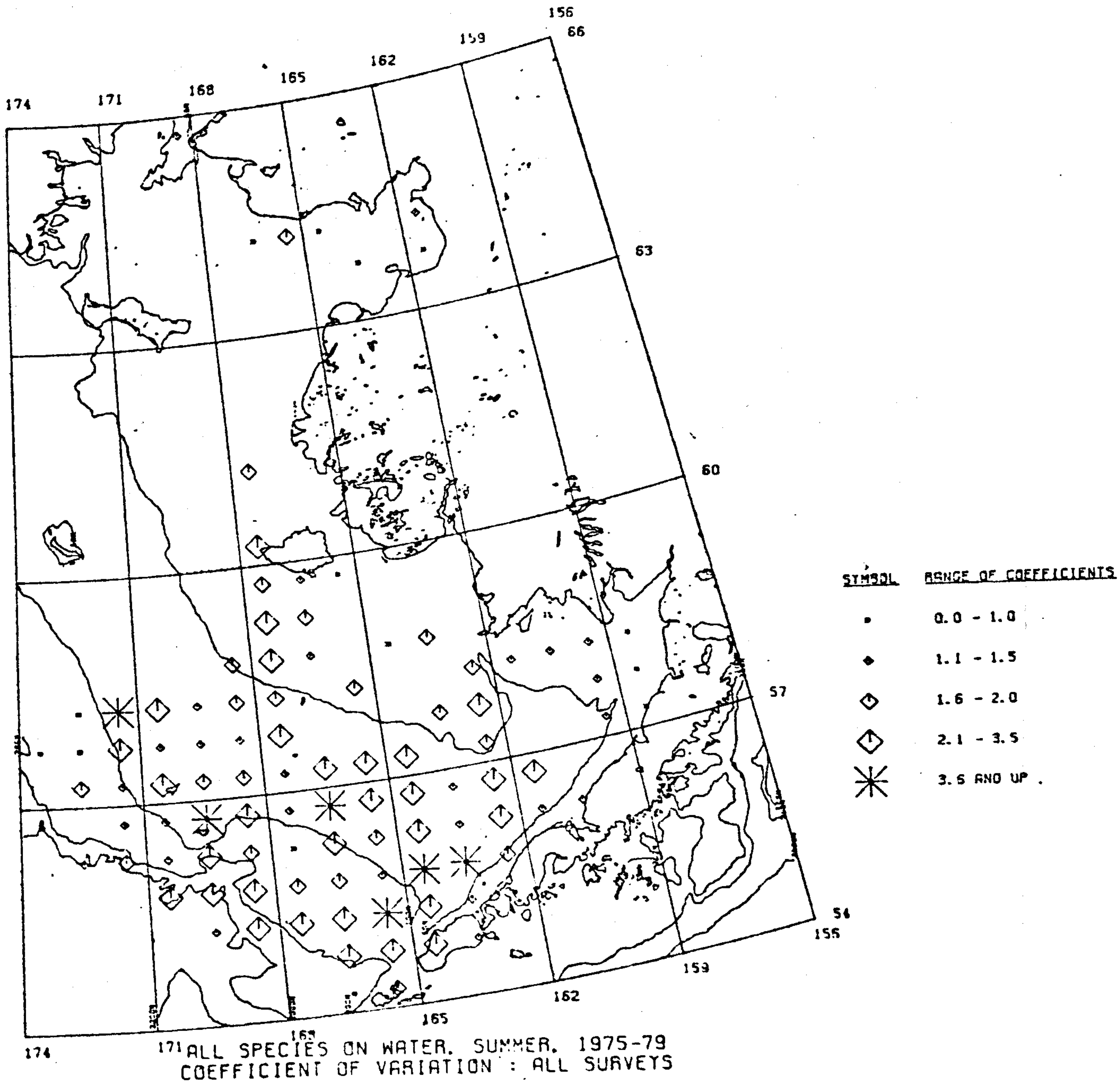
SYMBOL RANGE OF MEANS
0 BIRDS PER KM2
0.1 - 5.0 BIRDS
5.1 - 15.0 BIRDS
15.1 - 30.0 BIRDS
30.1 - 75.0 BIRDS
75.1 - 250.0 BIRDS
250.1 OR MORE BIRDS
ALL SPECIES ON WATER. SUMMER. 1975-1979
MEAN DENSITIES : ALL FIELD OPS

Figure 43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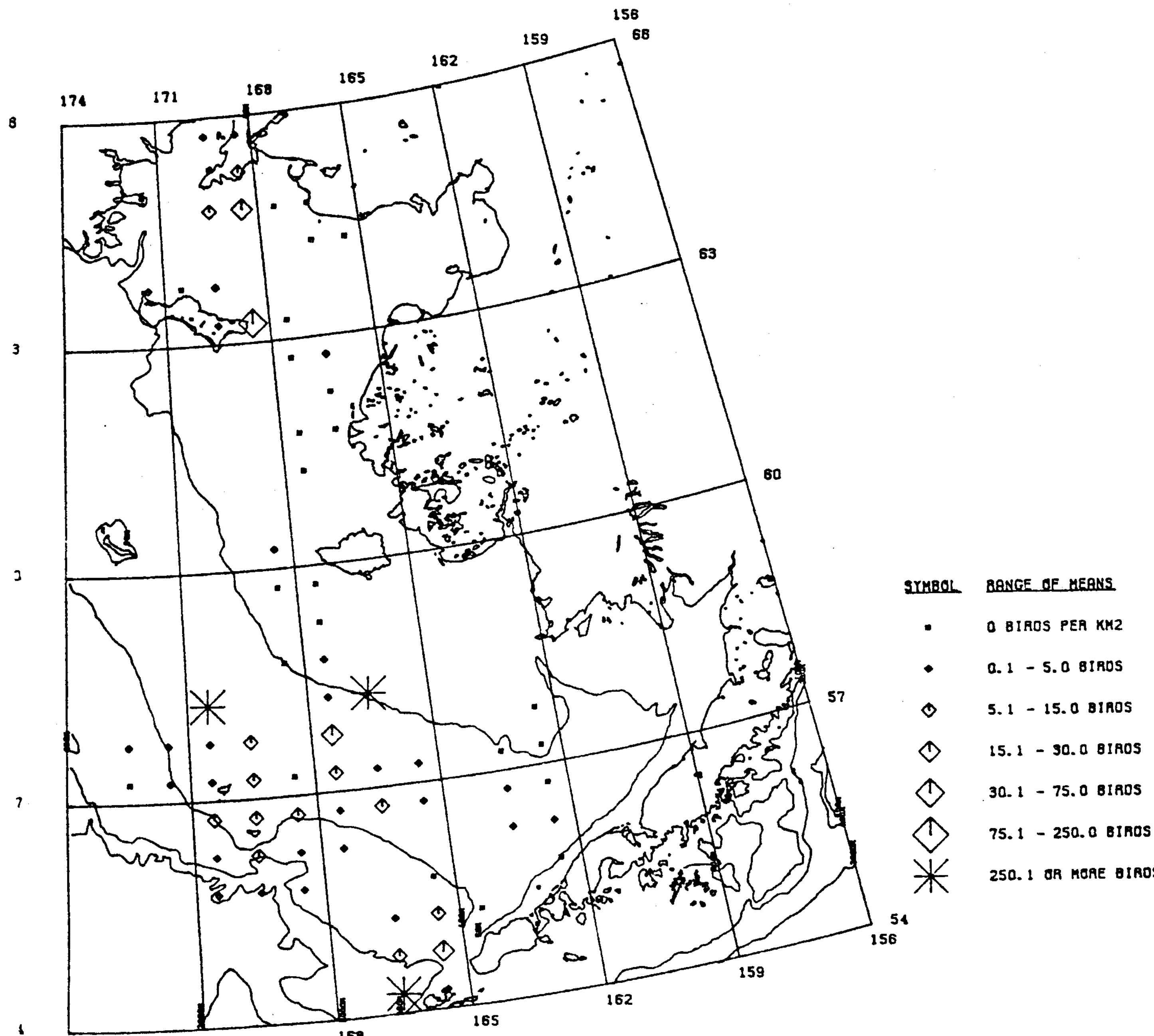
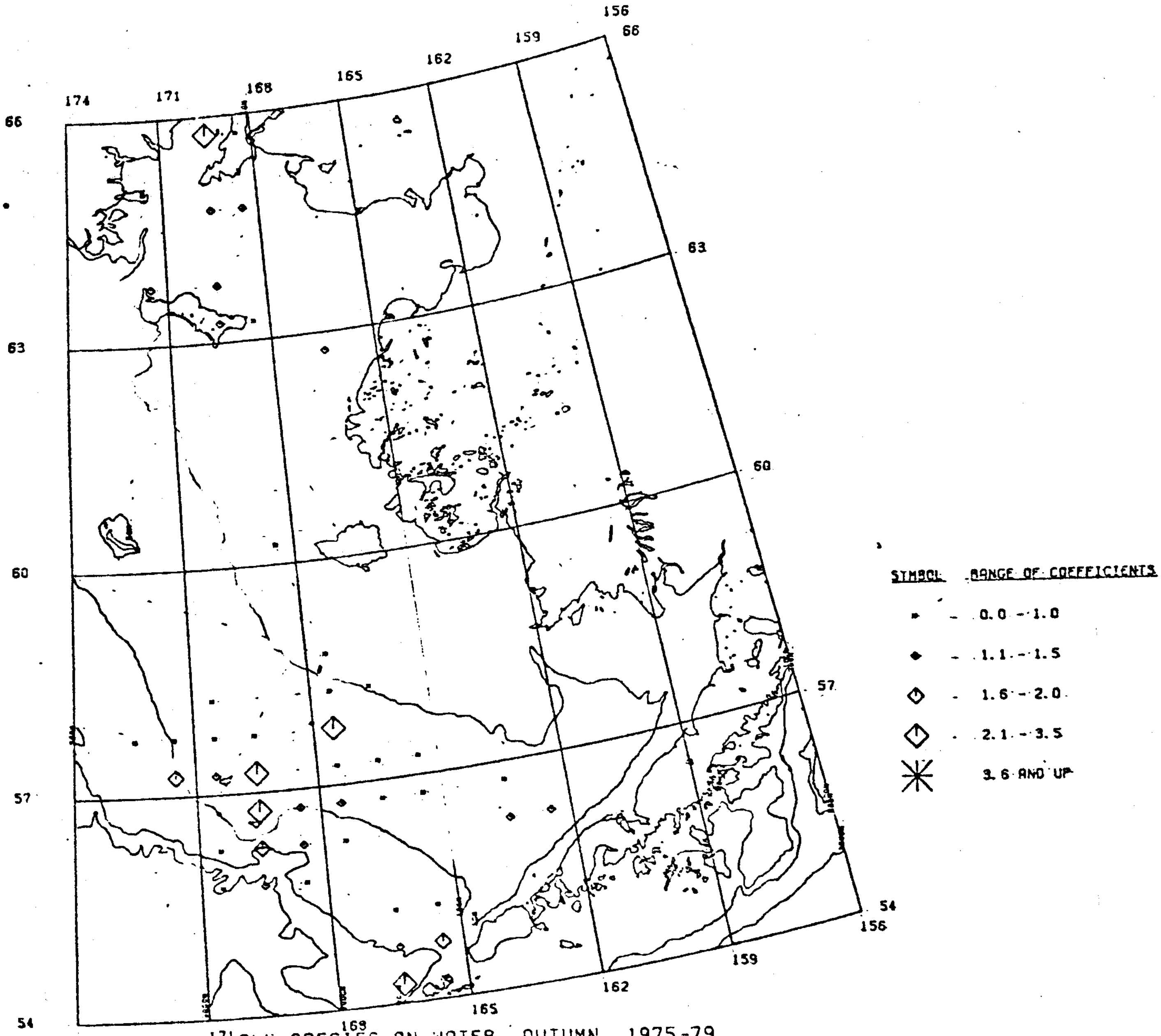
SYMBOL
RANGE OF COEFFICIENTS
0.0 - 1.0
1.1 - 1.5
1.6 - 2.0
2.1 - 3.5
3.5 AND UP .
ALL SPECIES ON WATER. SUMMER. 1975-79
COEFFICIENT OF VARIATION : ALL SURVEYS

Figure 44



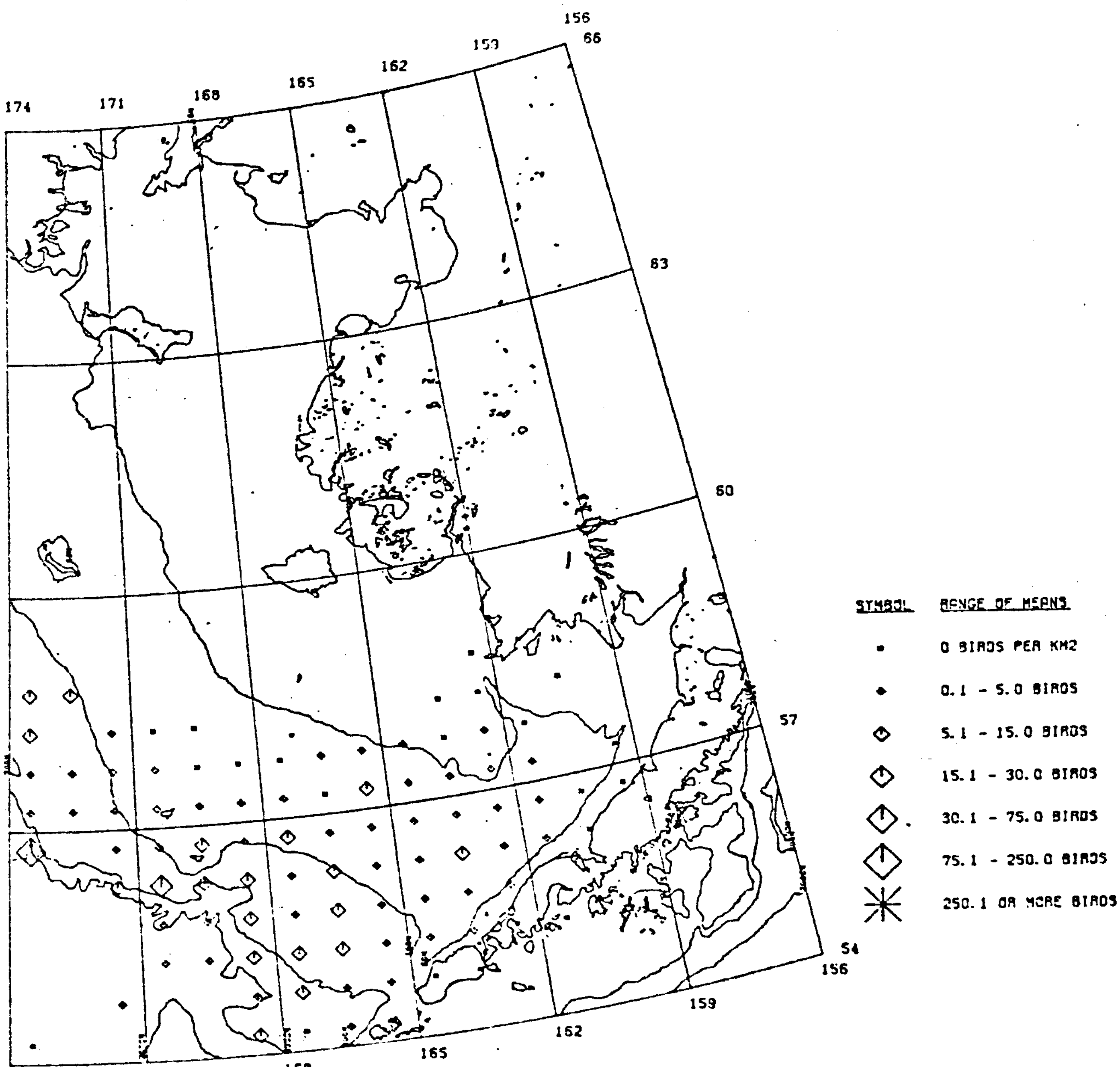
ALL SPECIES ON WATER, AUTUMN, 1975-1979
MEAN DENSITIES : ALL FIELD OPS

Figure 45



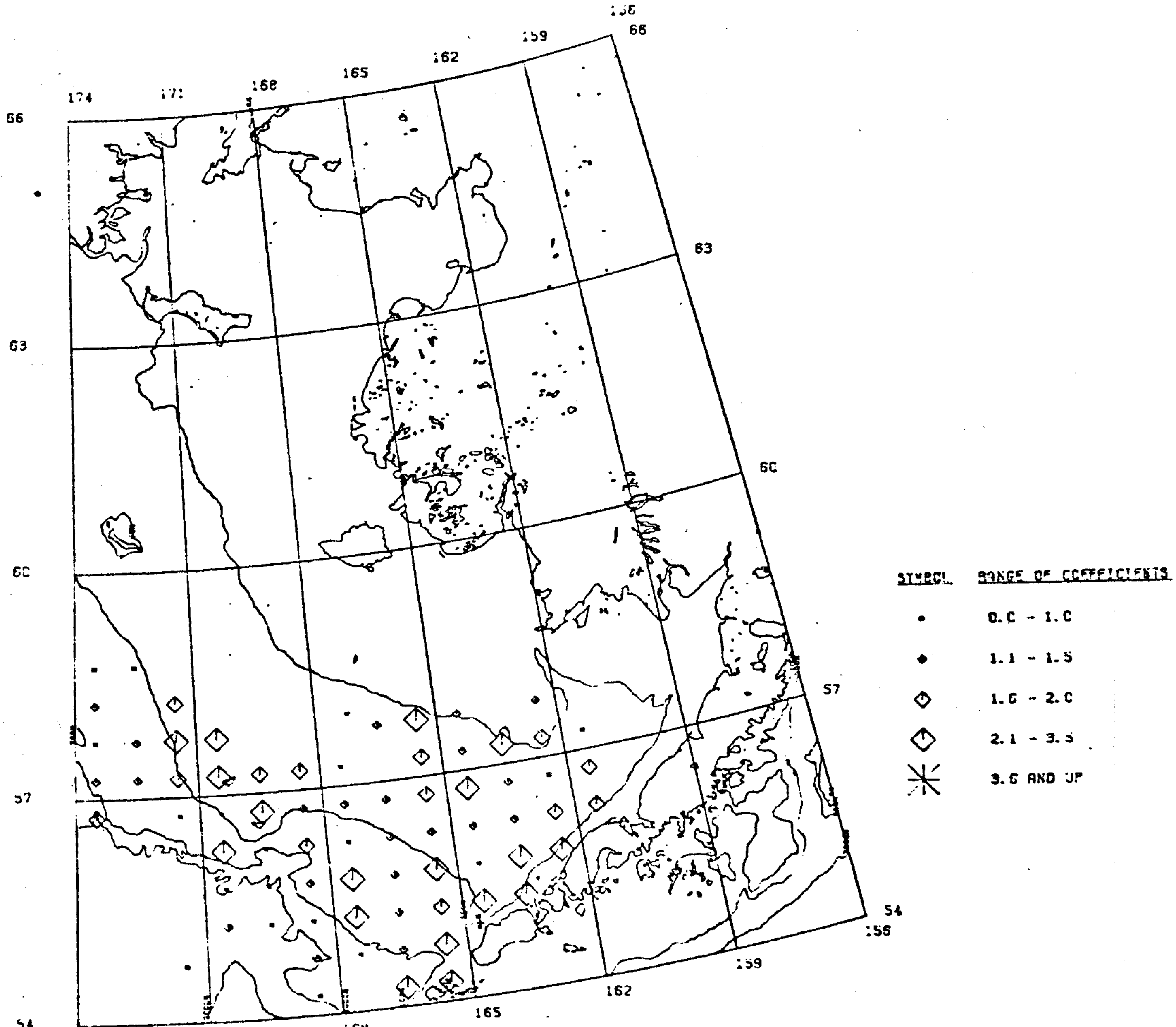
ALL SPECIES ON WATER. AUTUMN. 1975-79
COEFFICIENT OF VARIATION : ALL SURVEYS

Figure 46



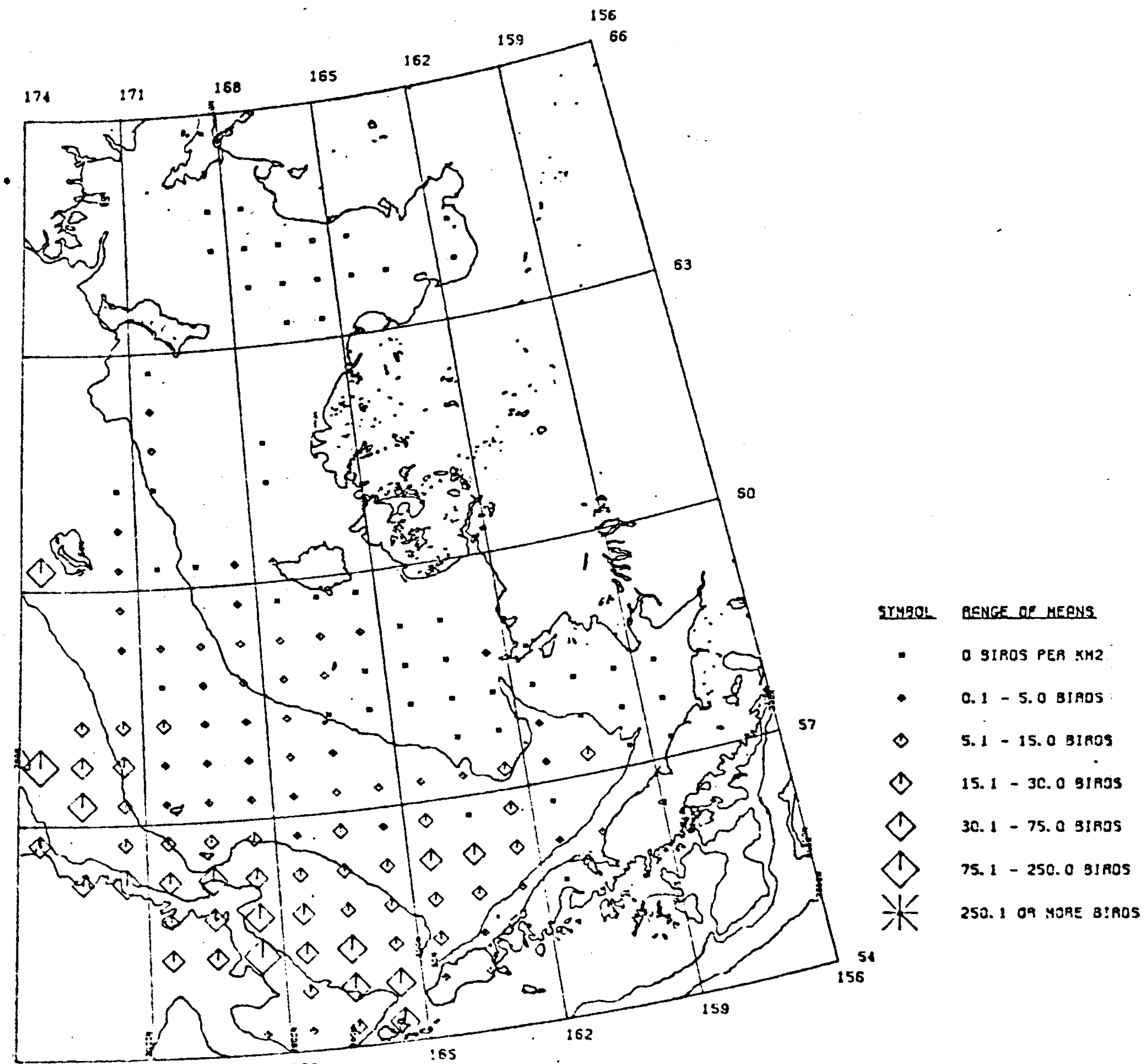
NORTHERN FULMAR, SPRING
MEAN DENSITIES: SHIP SURVEYS, 1975-1979

Figure 47



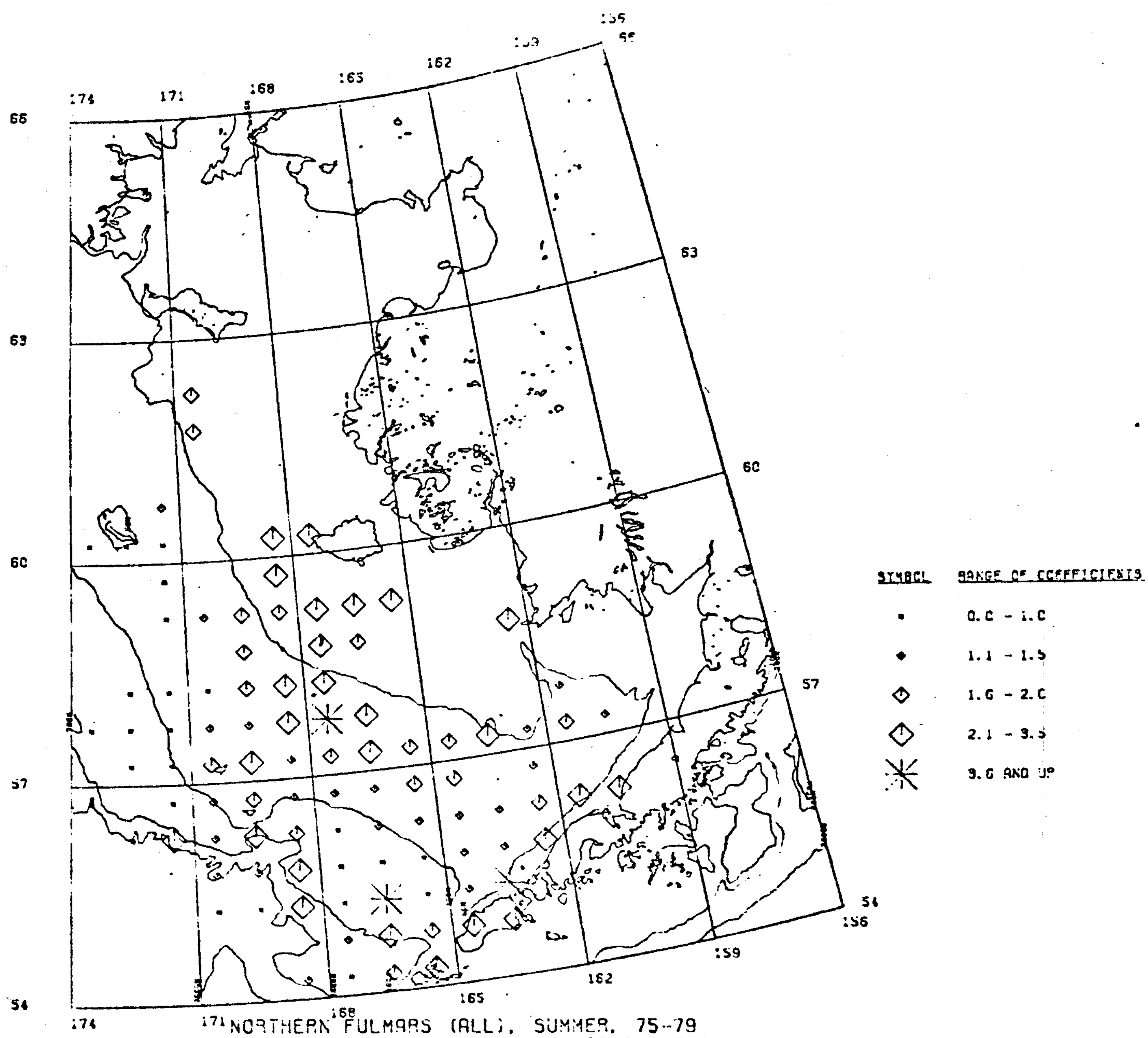
NORTHERN FULMARS (ALL). SPRING. 75-79
COEFFICIENT OF VARIATION : SHIP SURVEYS

Figure 48



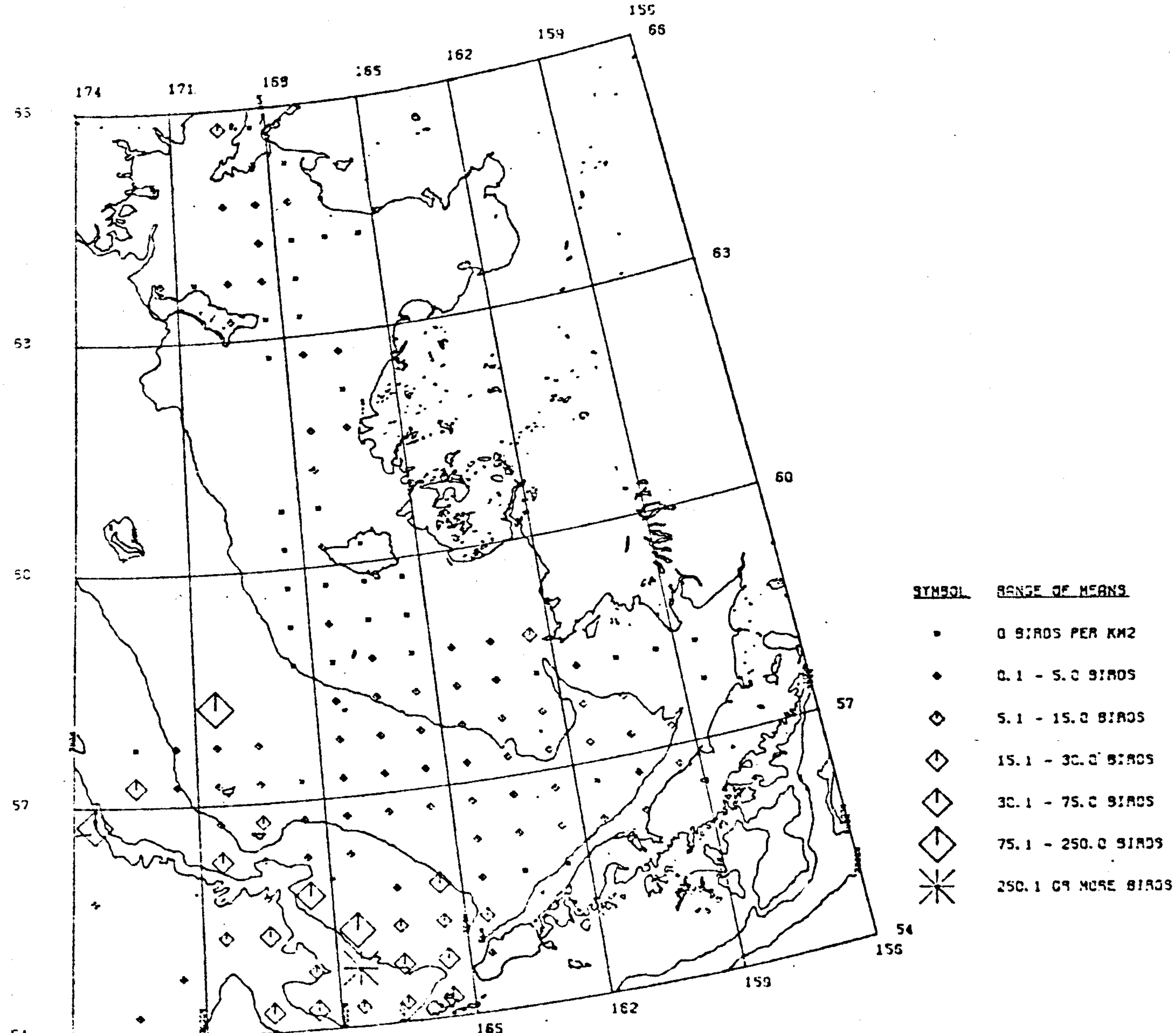
NORTHERN FULMAR, SUMMER
MEAN DENSITIES: SHIP SURVEYS, 1975-1979

Figure 49



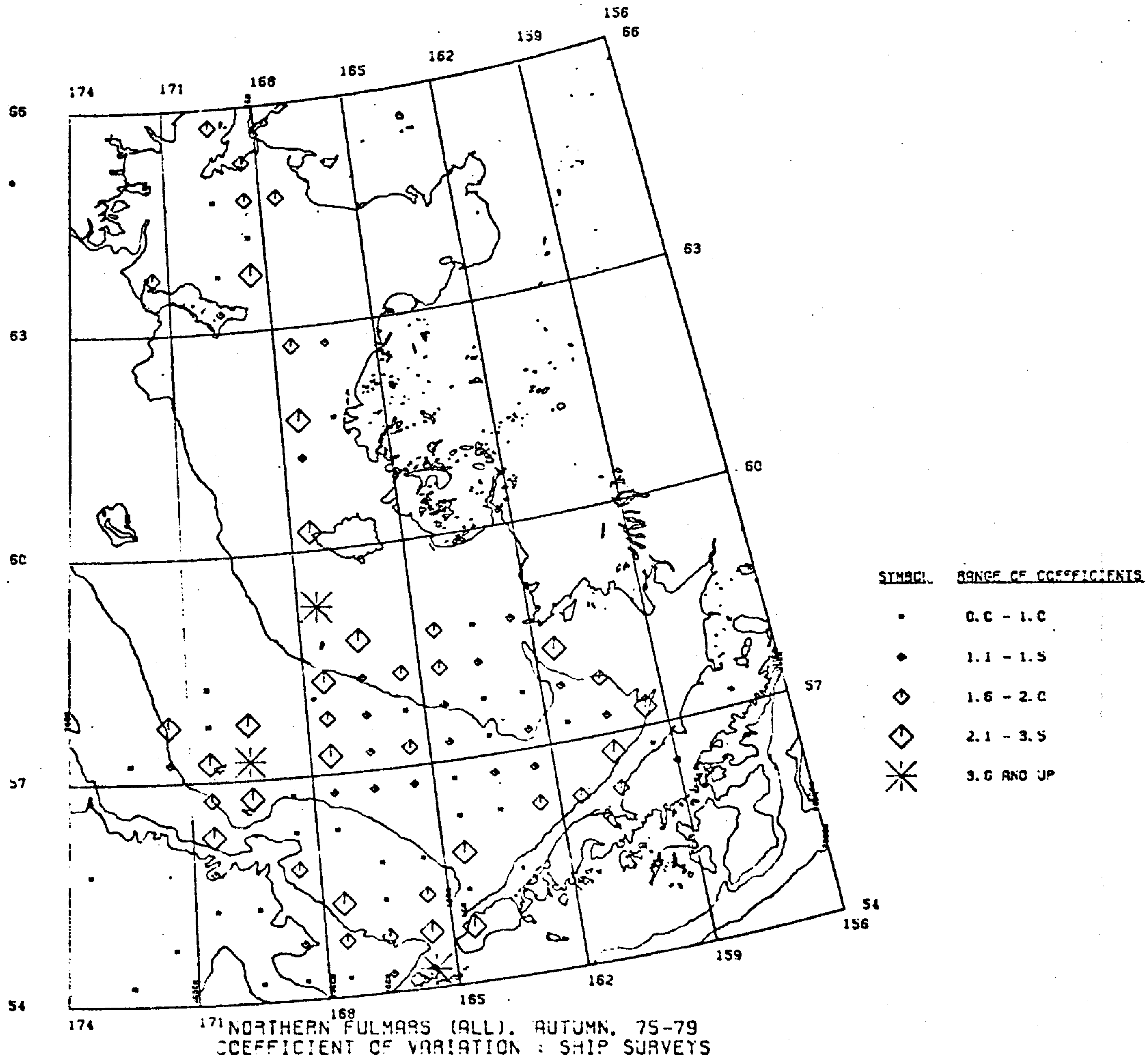
NORTHERN FULMARS (ALL), SUMMER, 75-79
COEFFICIENT OF VARIATION : SHIP SURVEYS

Figure 50



NORTHERN FULMAR, AUTUMN
MEAN DENSITIES: SHIP SURVEYS, 1975-1979

Figure 51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SYMBOL RANGE OF COEFFICIENTS
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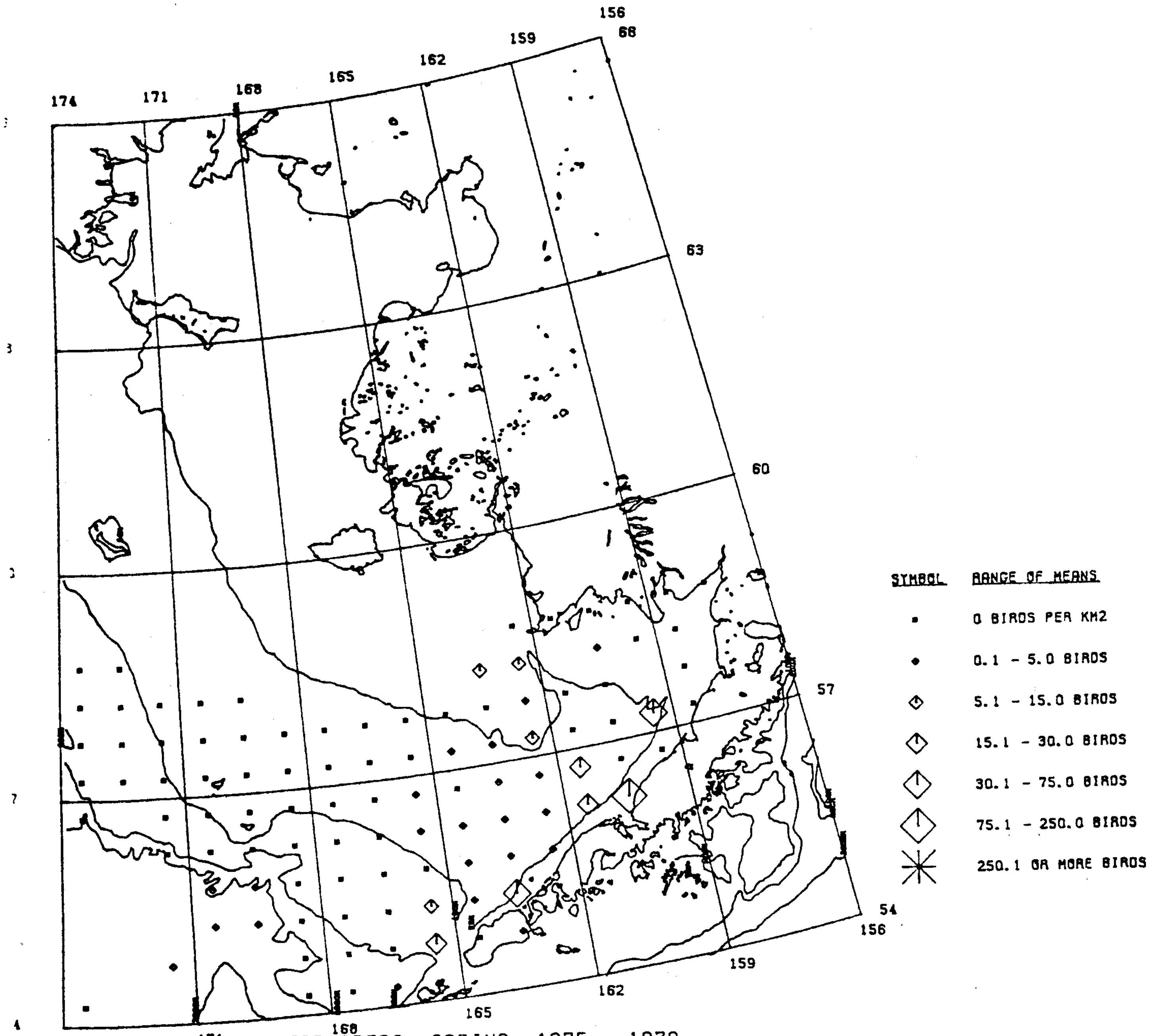
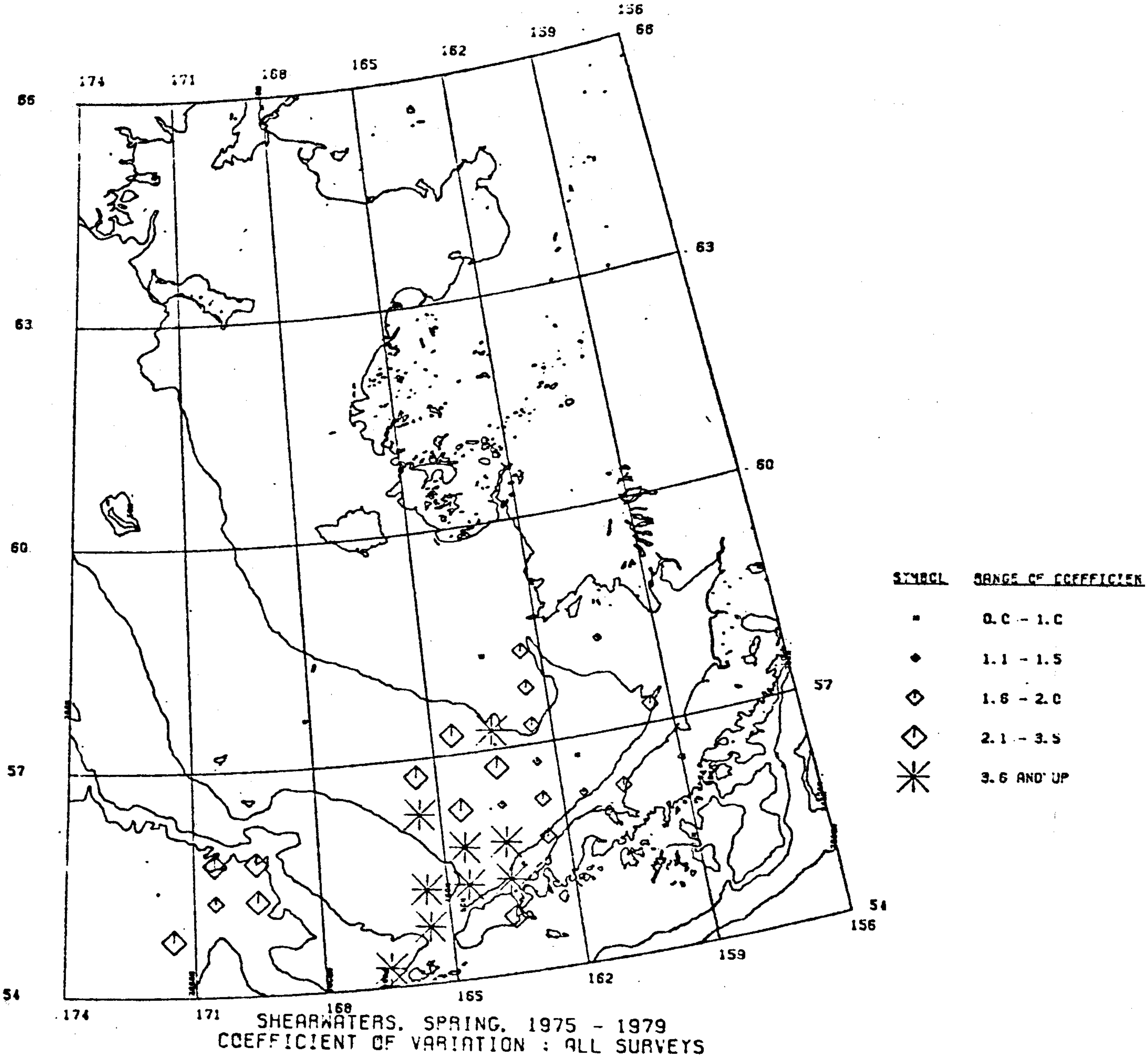
3.6 AND UP
NORTHERN FULMARS (ALL), AUTUMN, 75-79
COEFFICIENT OF VARIATION : SHIP SURVEYS

Figure 52



SHEARWATERS. SPRING, 1975 - 1979
MEAN DENSITIES : ALL FIELD OPS

Figure 53



SYMBOL
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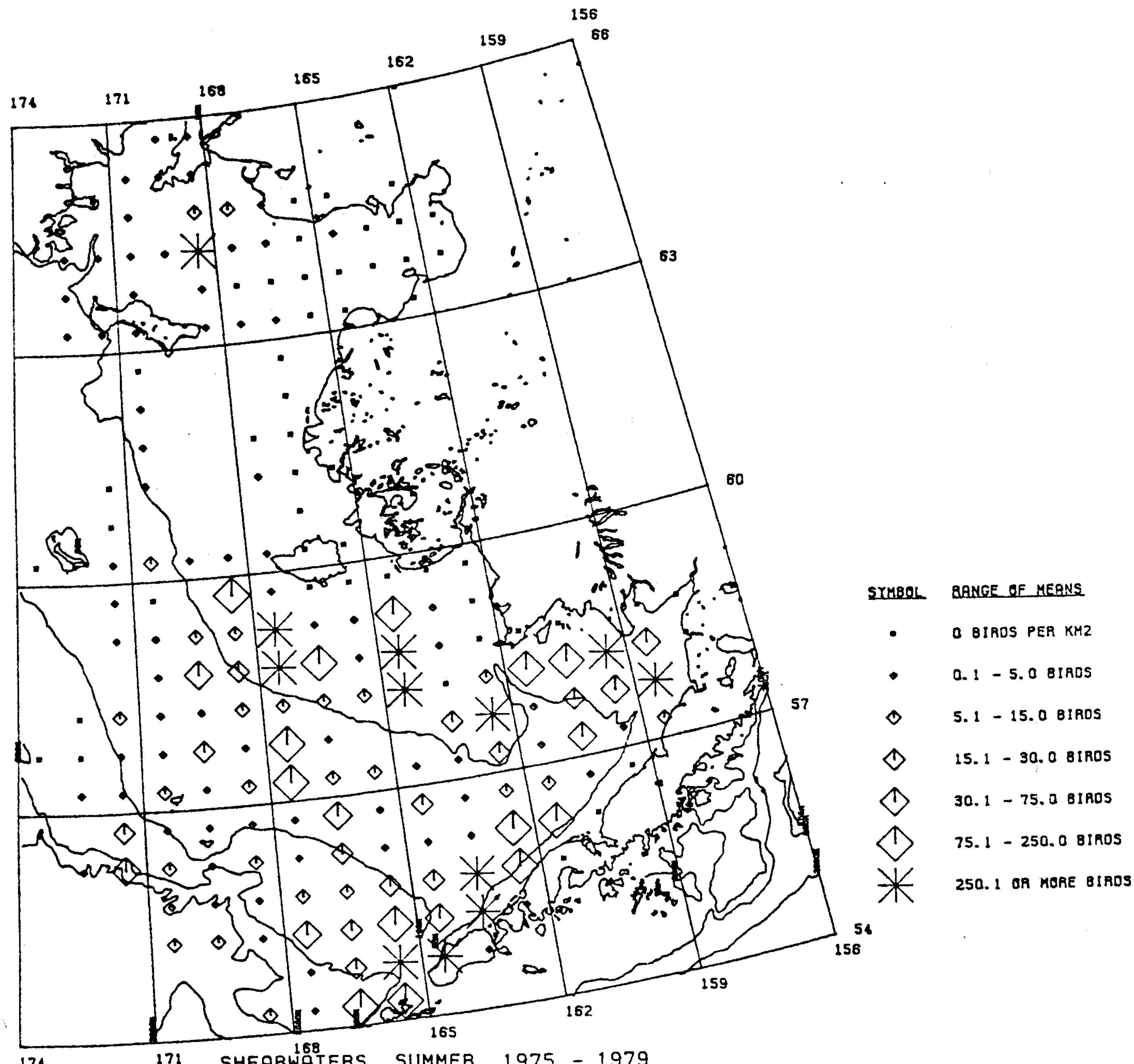
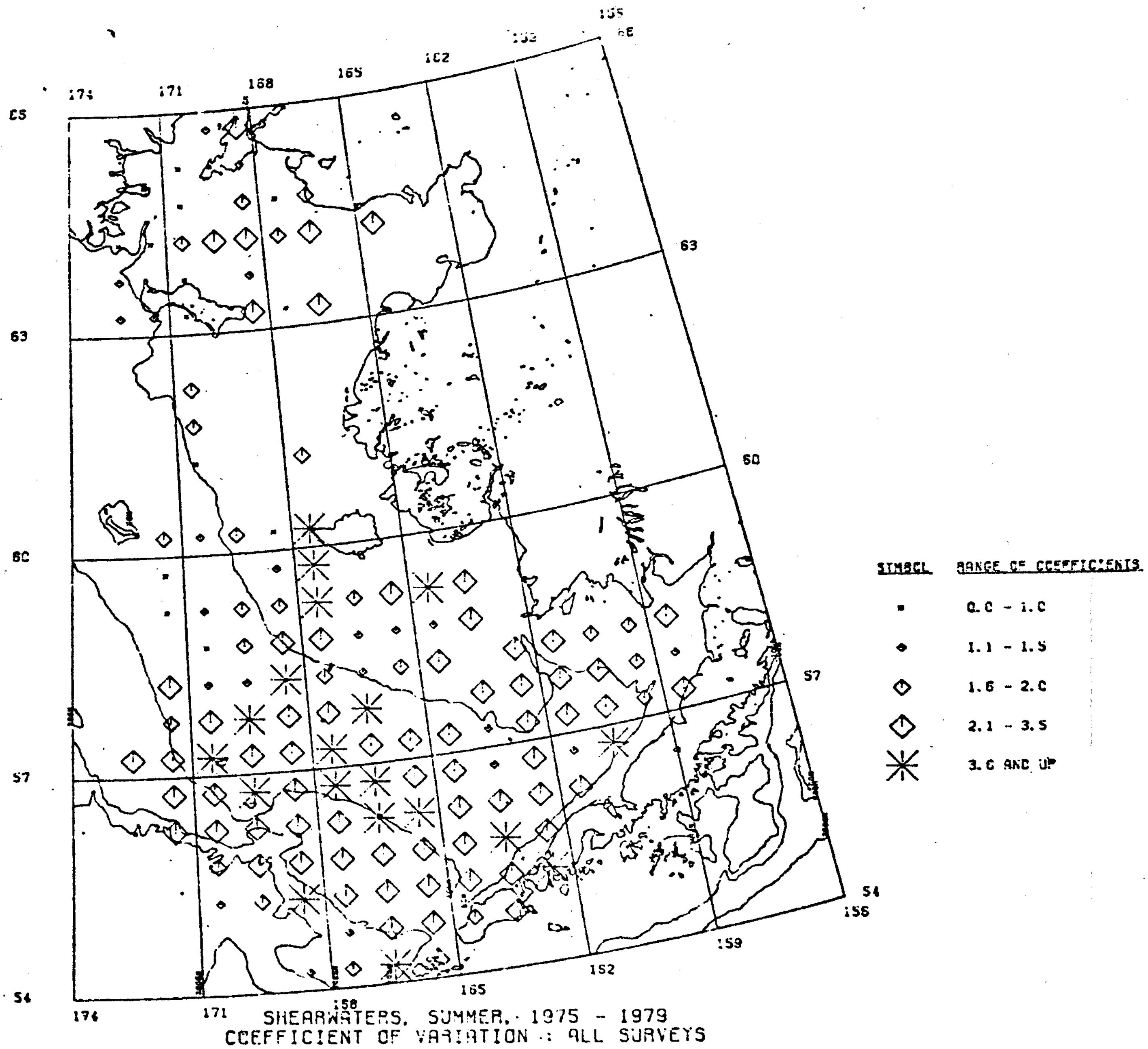
SHEARWATERS. SPRING. 1975 - 1979
COEFFICIENT OF VARIATION : ALL SURVEYS

Figure 54



SHEARWATERS. SUMMER. 1975 - 1979
MEAN DENSITIES : ALL FIELD OPS

Figure 55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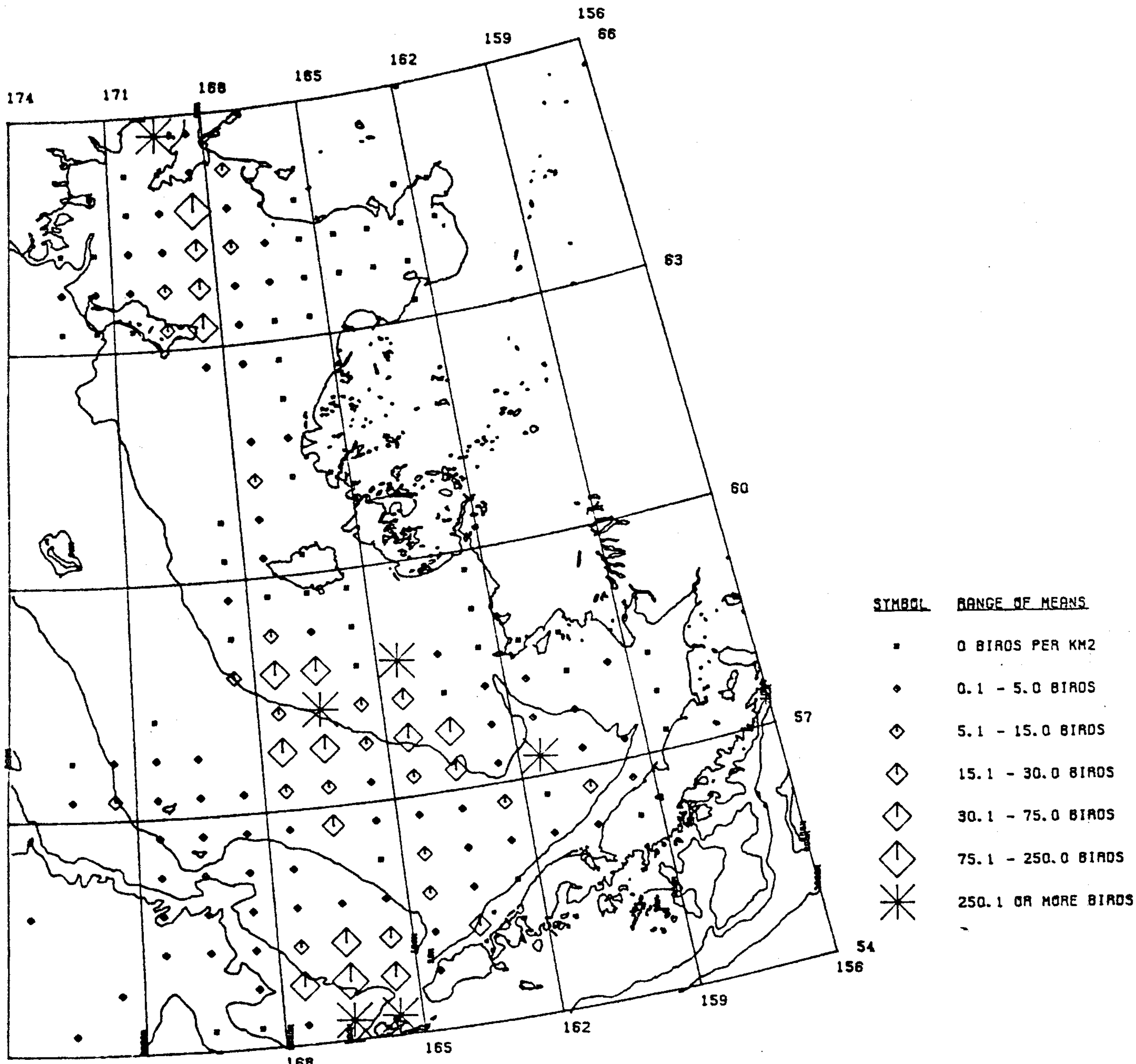
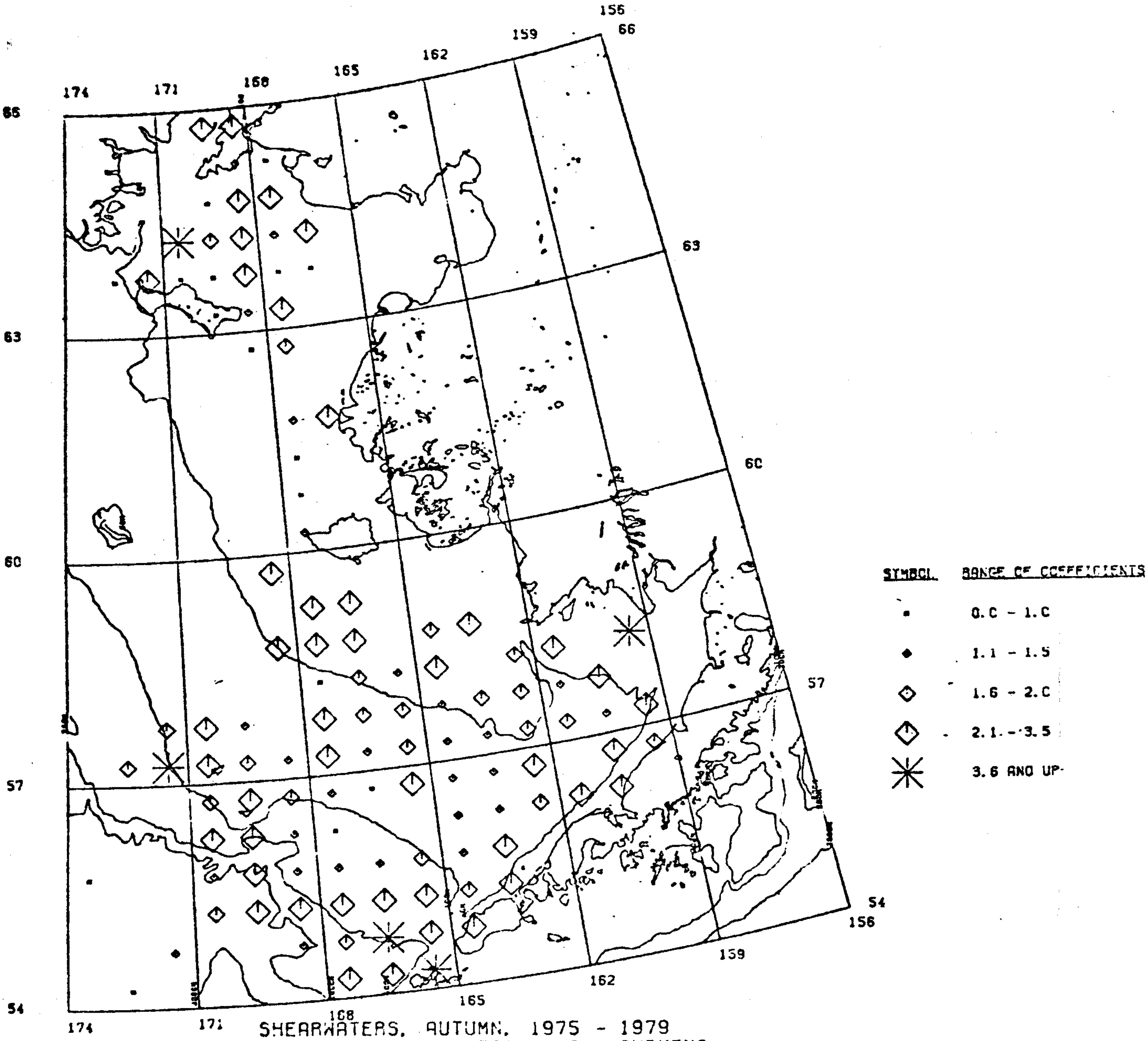
SHEARWATERS, SUMMER, 1975 - 1979
COEFFICIENT OF VARIATION : ALL SURVEYS

Figure 56



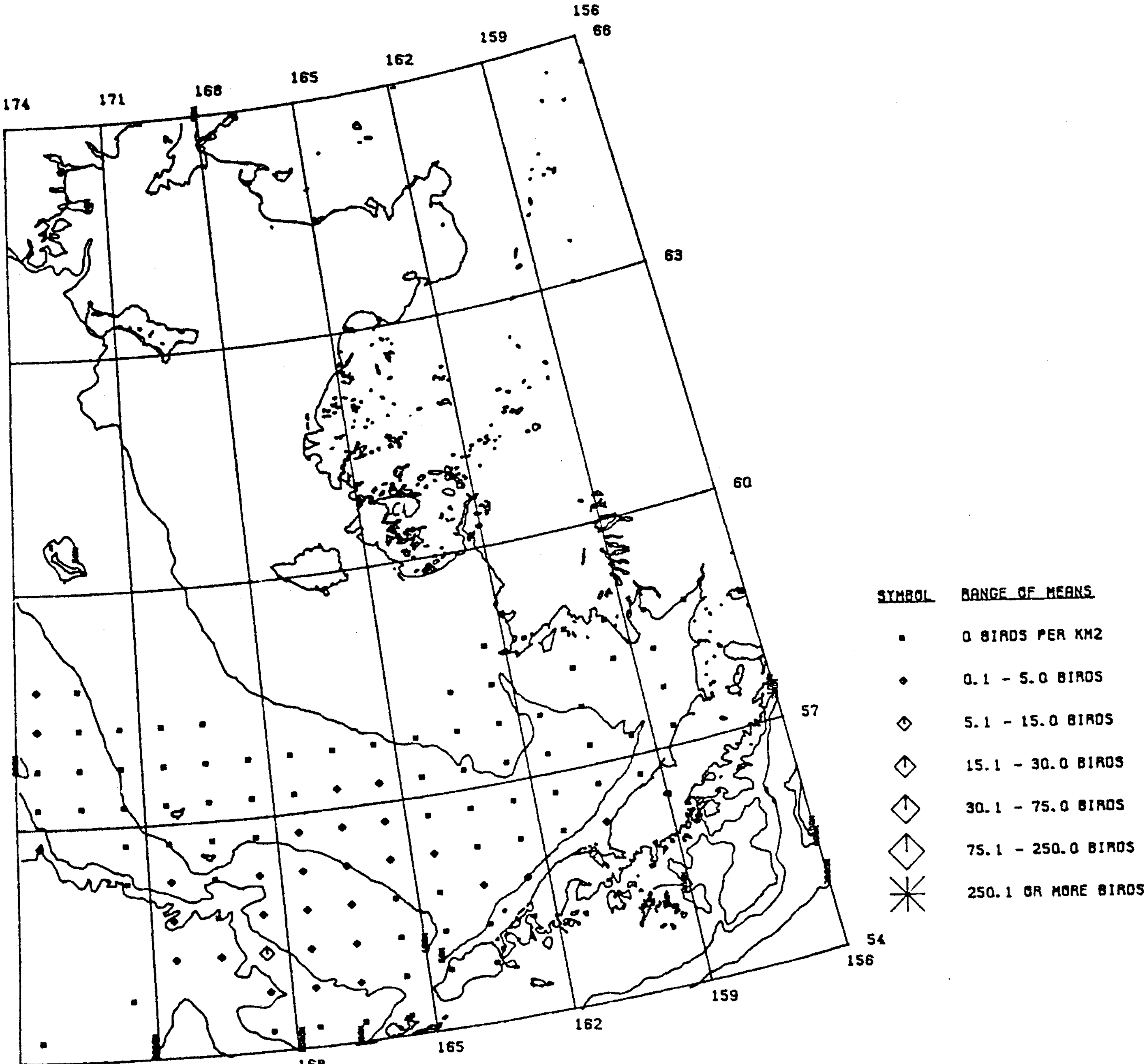
SHEARWATERS, AUTUMN, 1975 - 1979
MEAN DENSITIES : ALL FIELD OPS

Figure 57



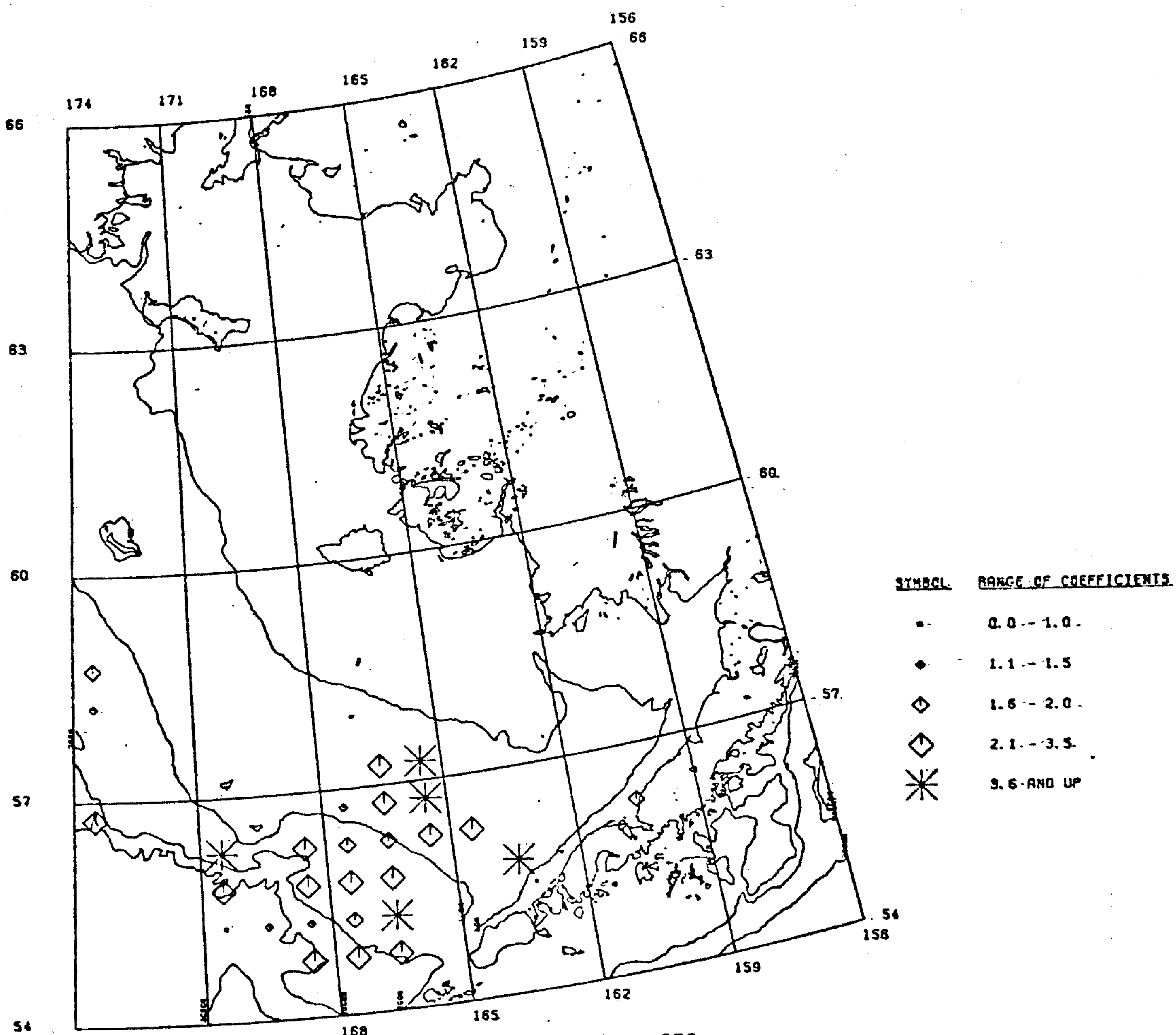
SHEARWATERS, AUTUMN, 1975 - 1979
COEFFICIENT OF VARIATION : ALL SURVEYS

Figure 58



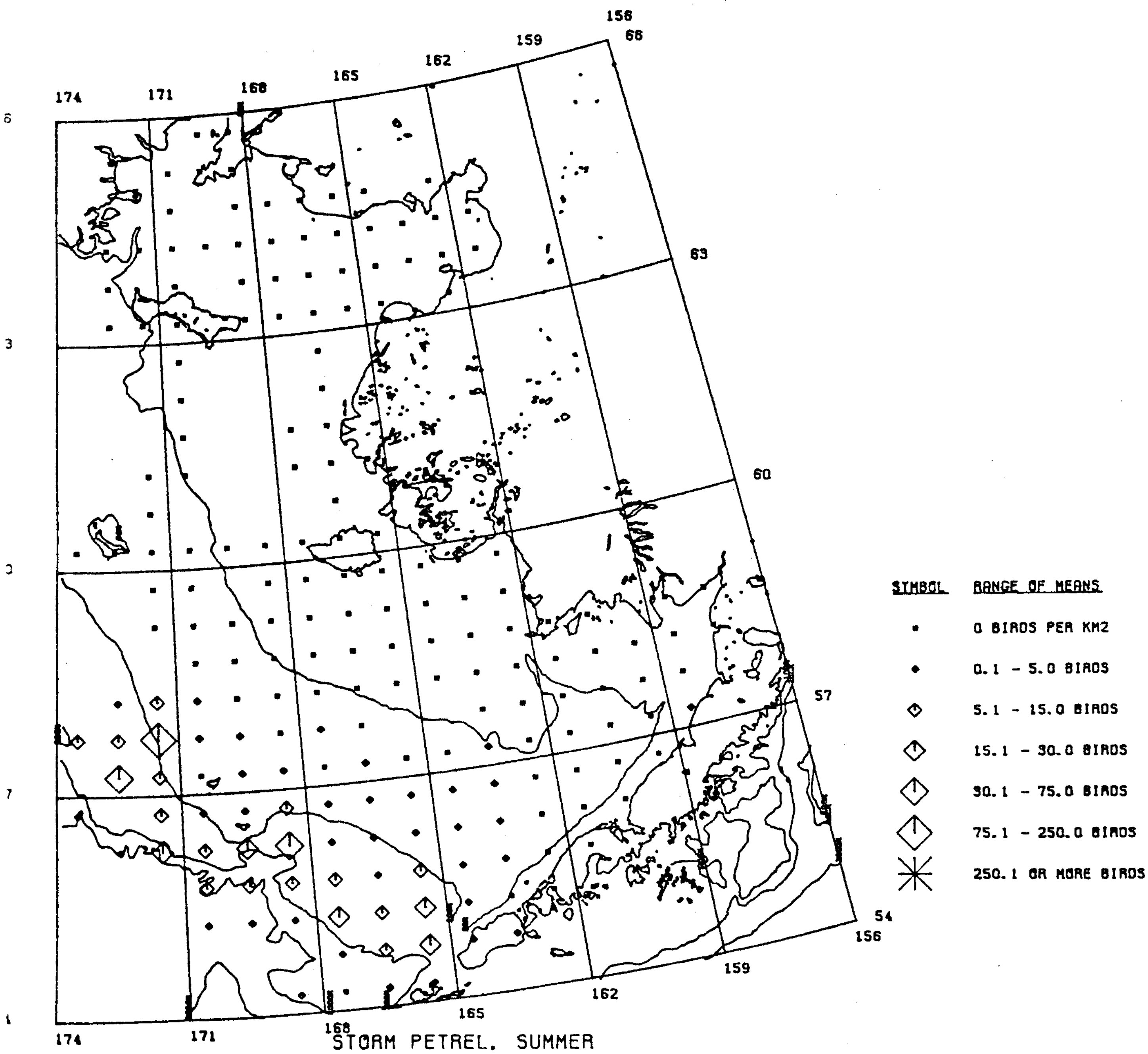
STORM PETREL, SPRING
MEAN DENSITIES: ALL FIELD OPS. 1975-1979

Figure 59



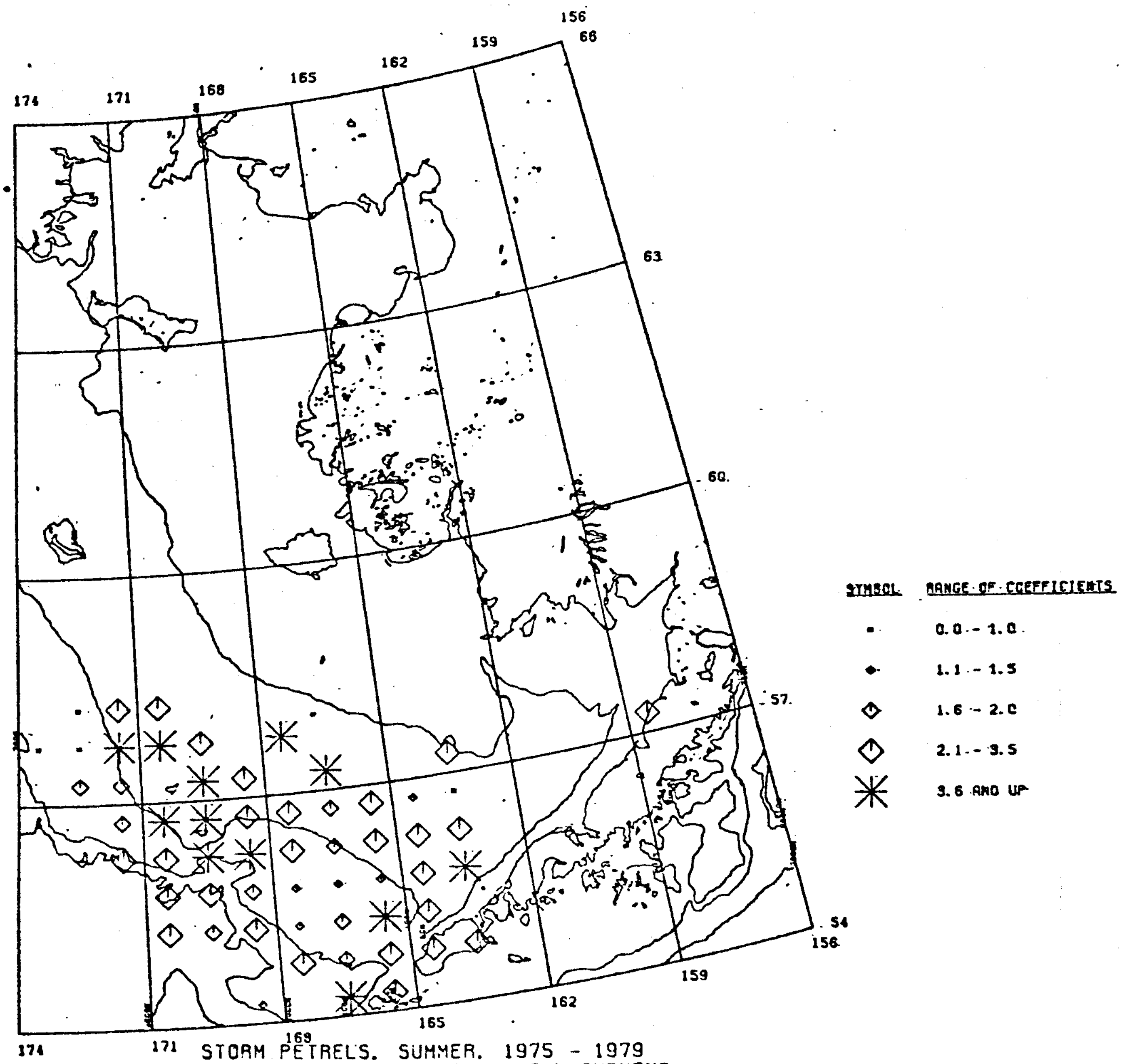
STORM PETRELS. SPRING. 1975 - 1979
COEFFICIENT OF VARIATION : ALL SURVEYS

Figure 60



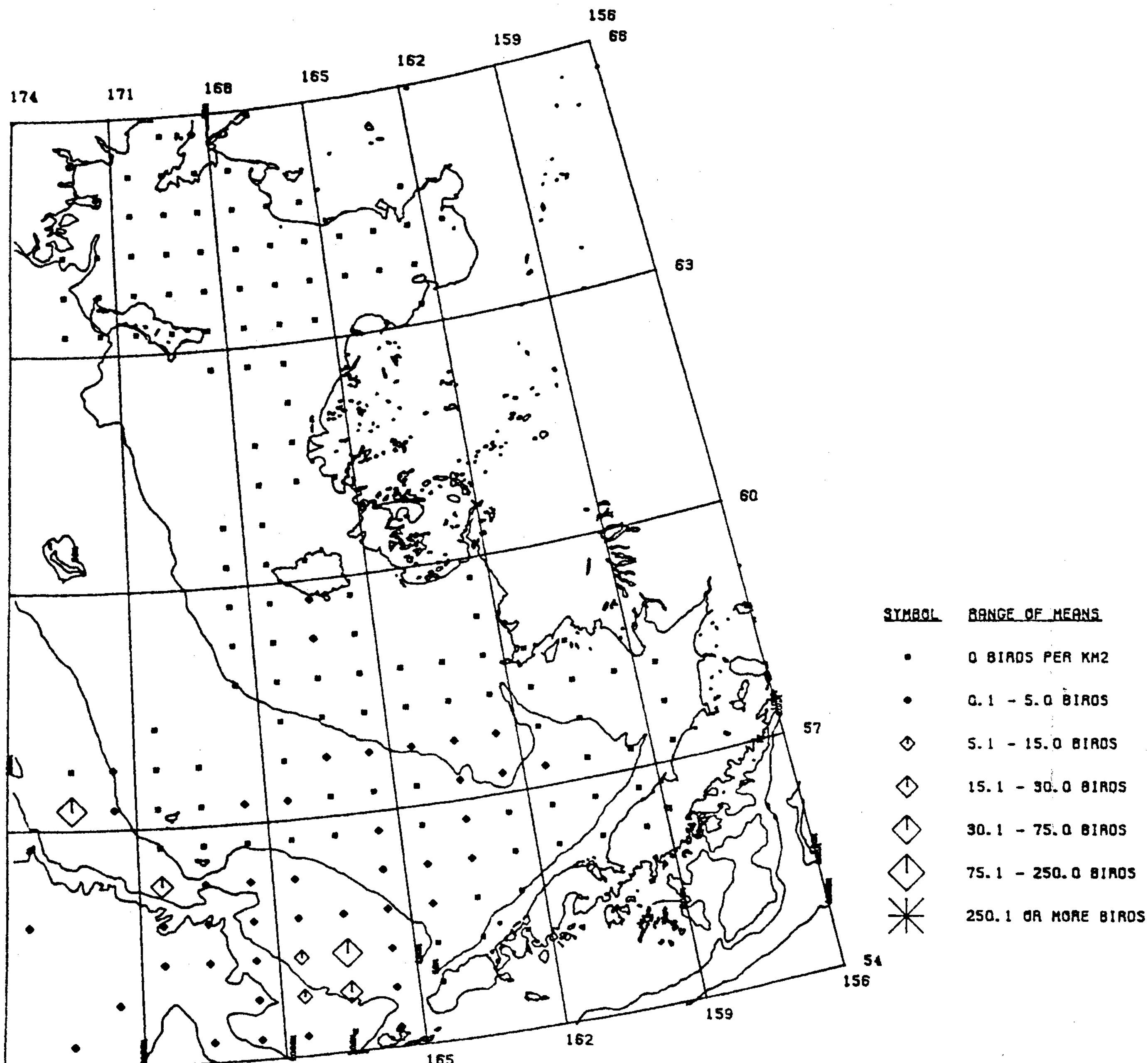
STORM PETREL. SUMMER
MEAN DENSITIES: ALL FIELD OPS. 1975-1979

Figure 61



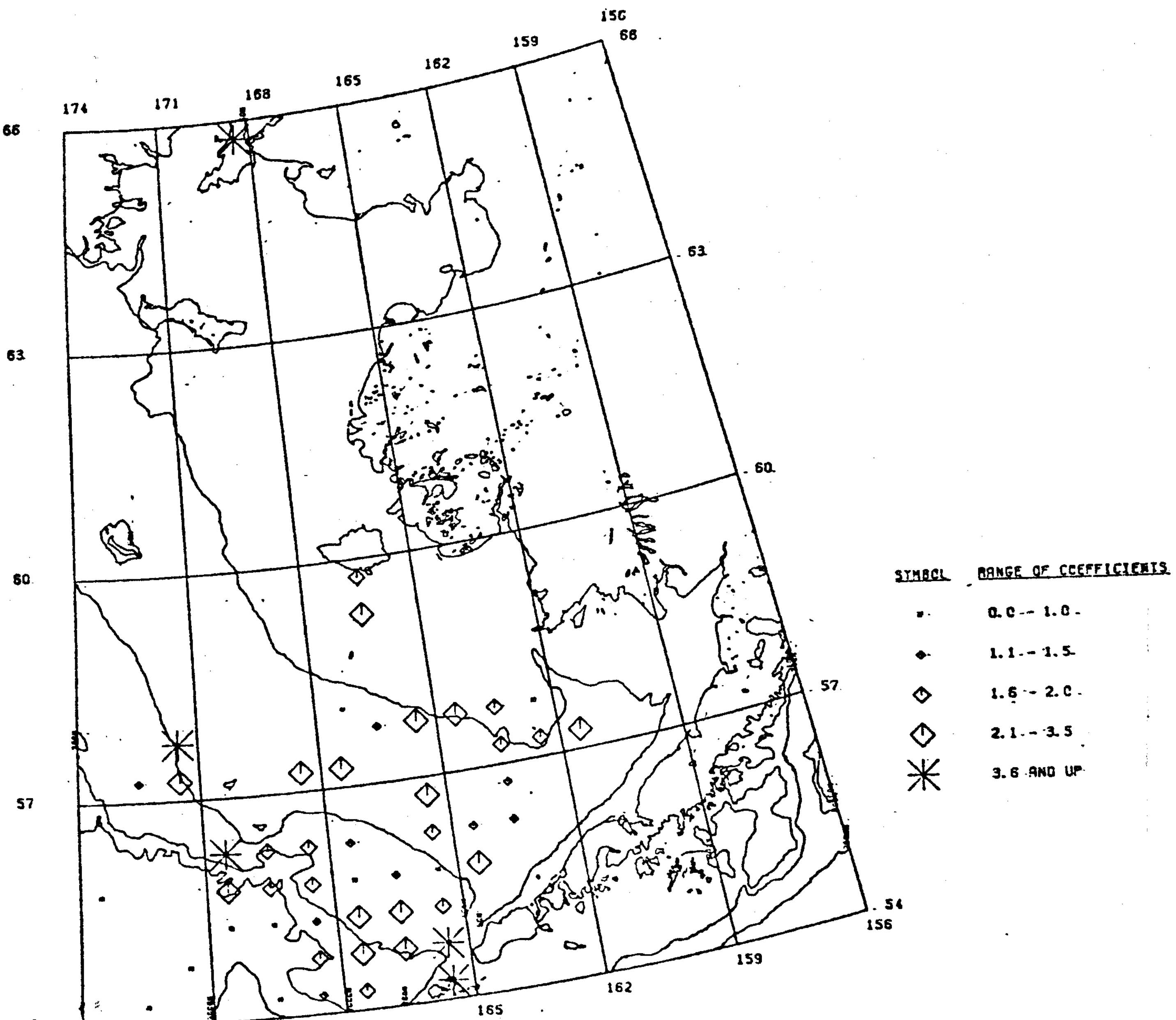
STORM PETRELS. SUMMER. 1975 - 1979
COEFFICIENT OF VARIATION : ALL SURVEYS

Figure 62



STORM PETREL, AUTUMN
MEAN DENSITIES: ALL FIELD OPS, 1975-1979

Figure 63



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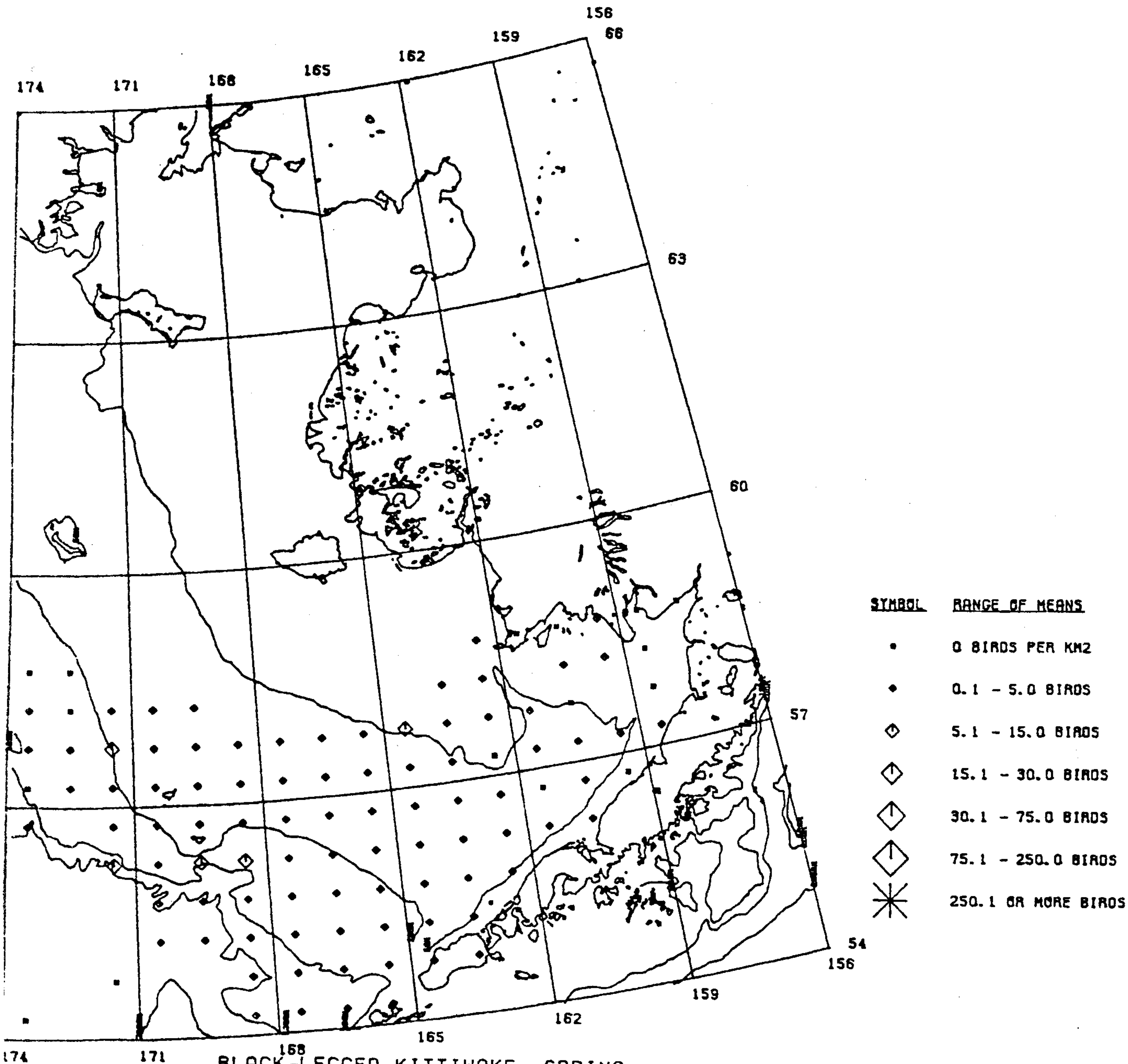

BLACK-LEGGED KITTIWAKE, SPRING
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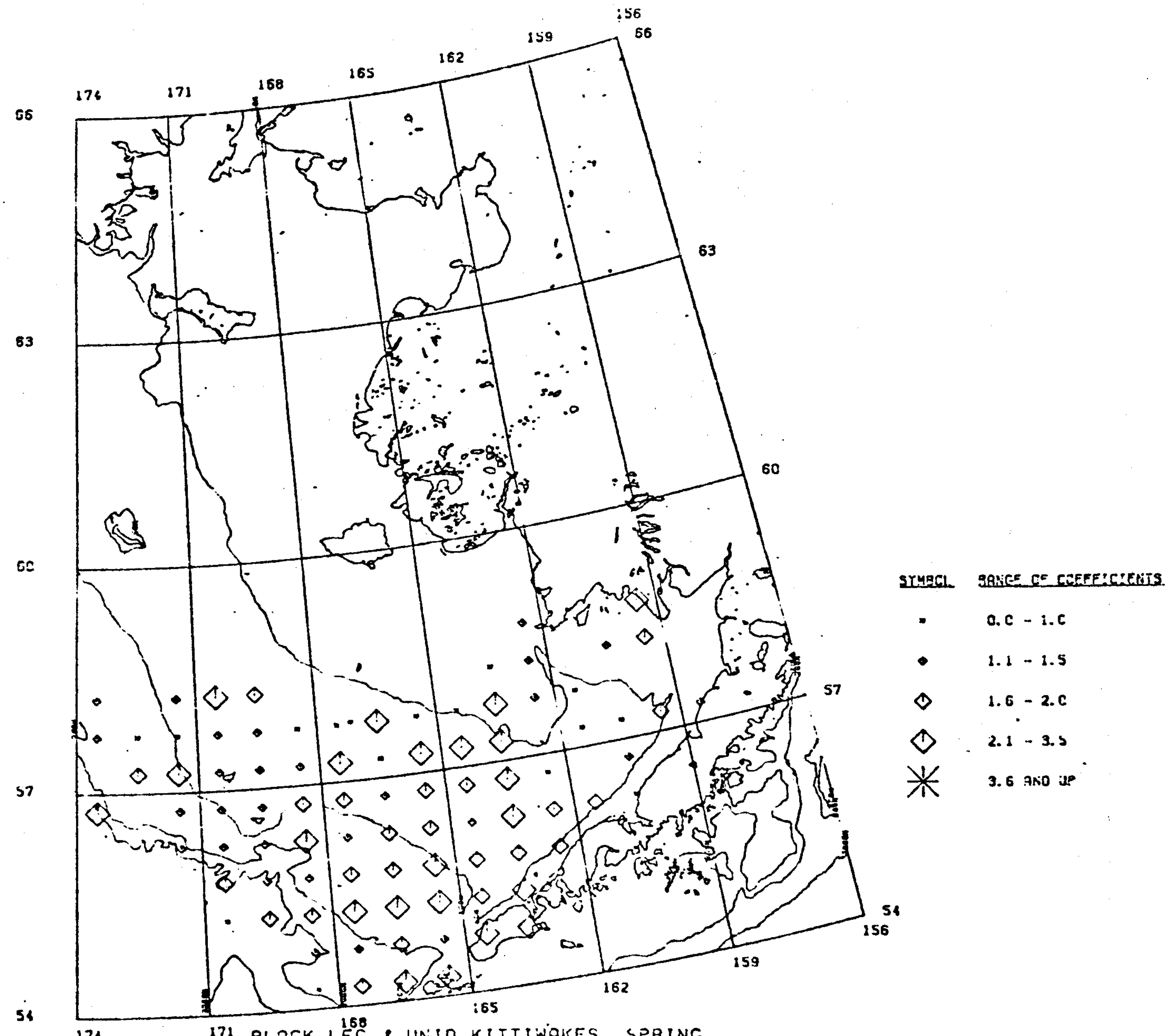

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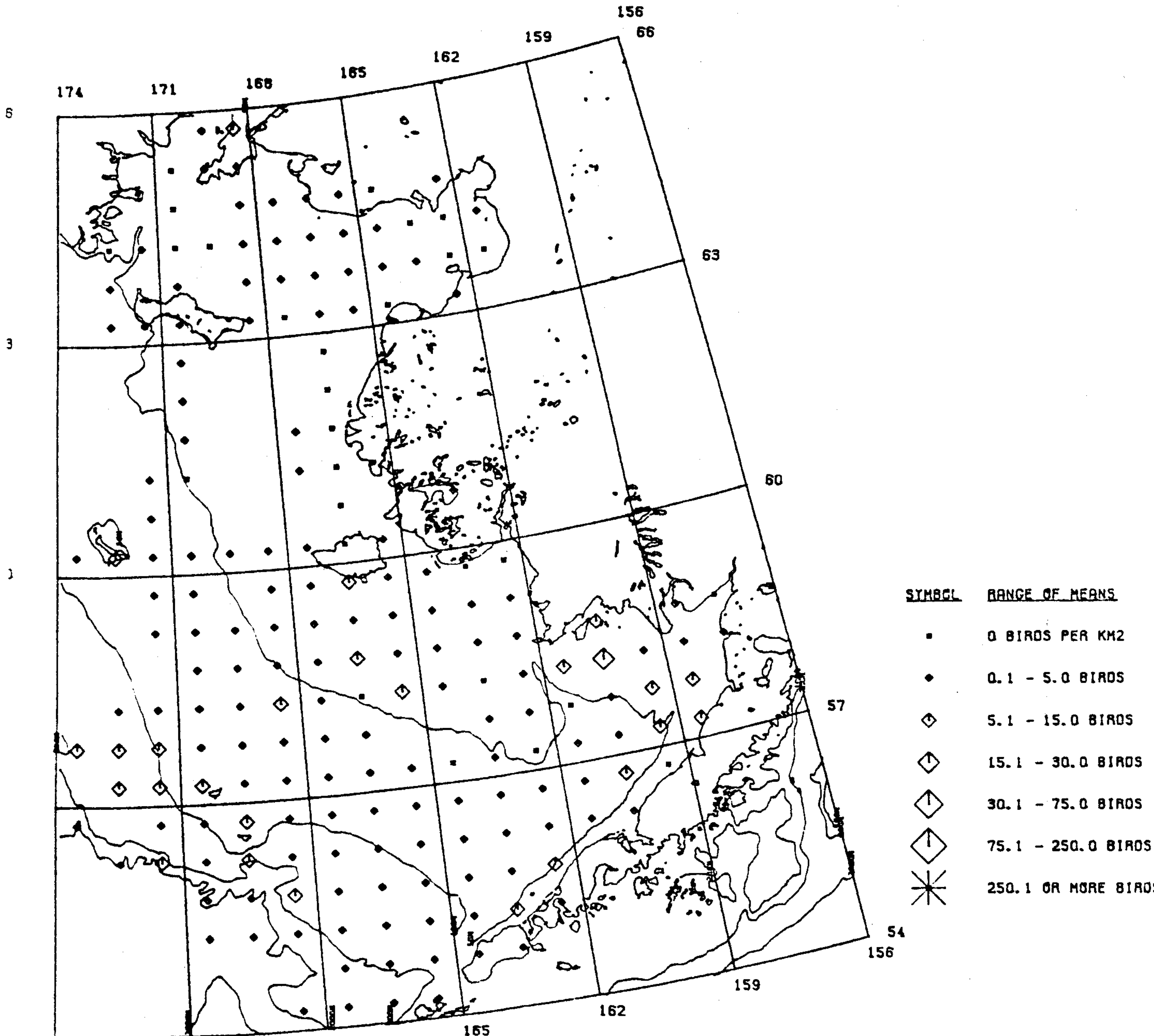

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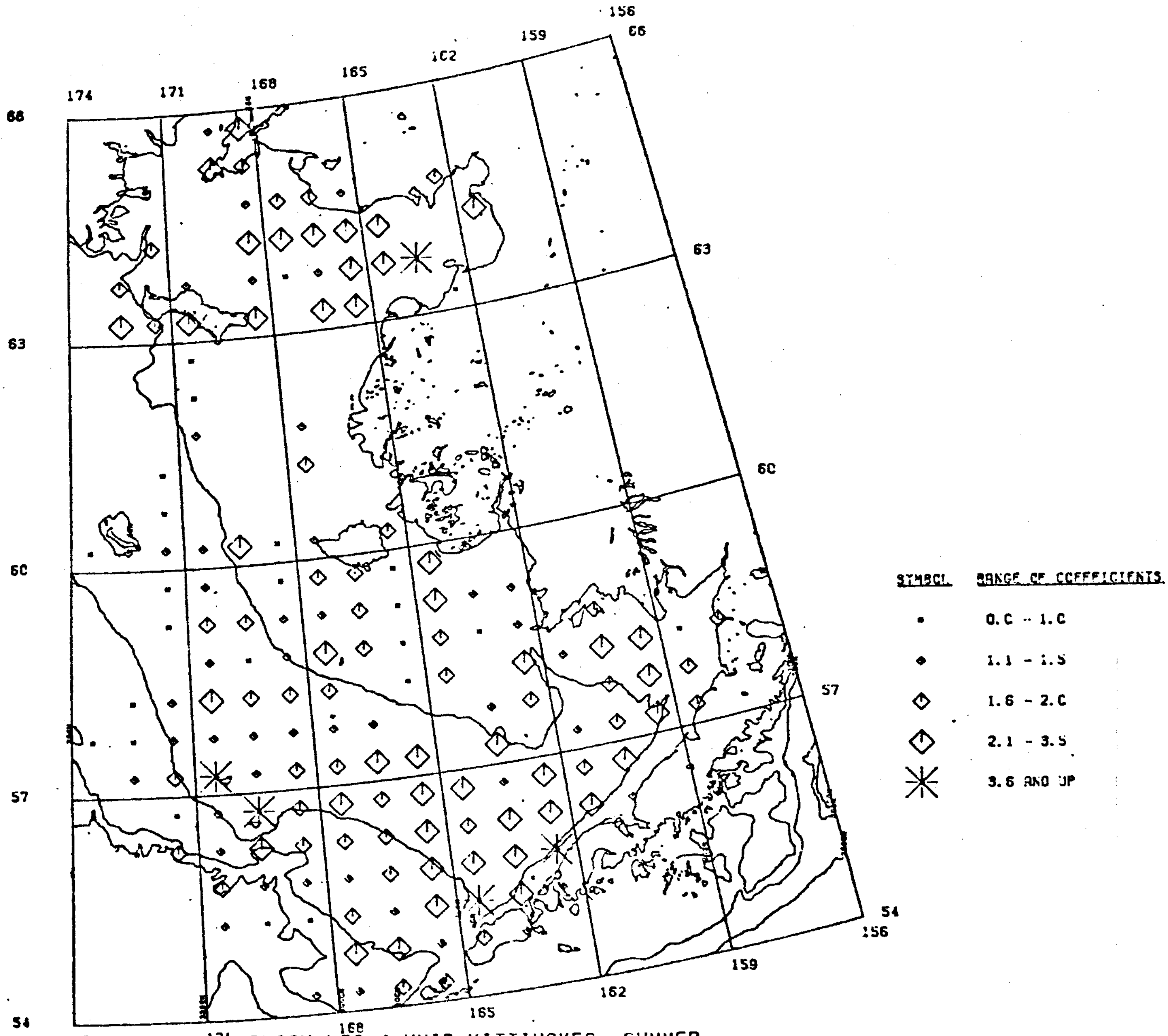

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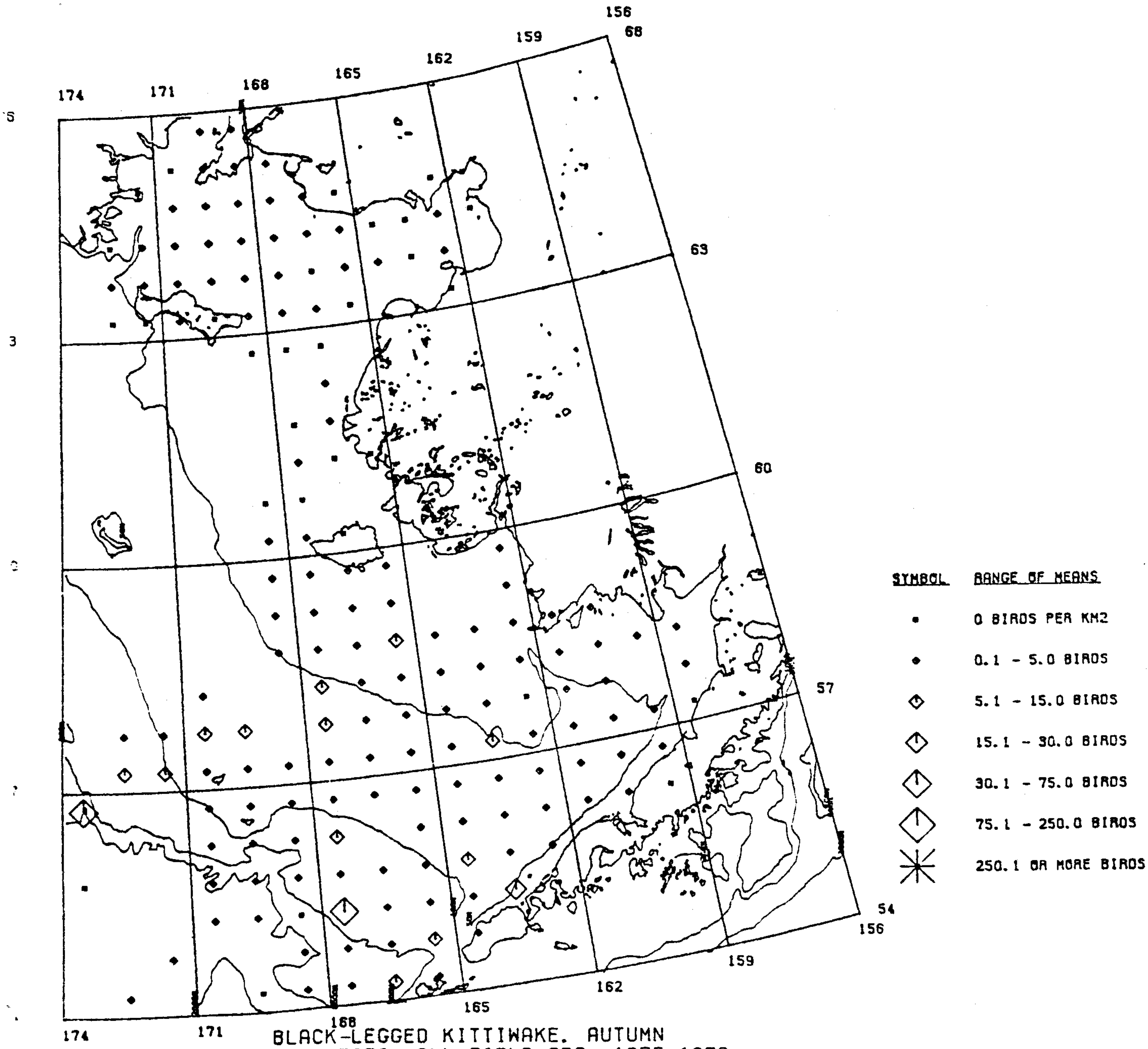

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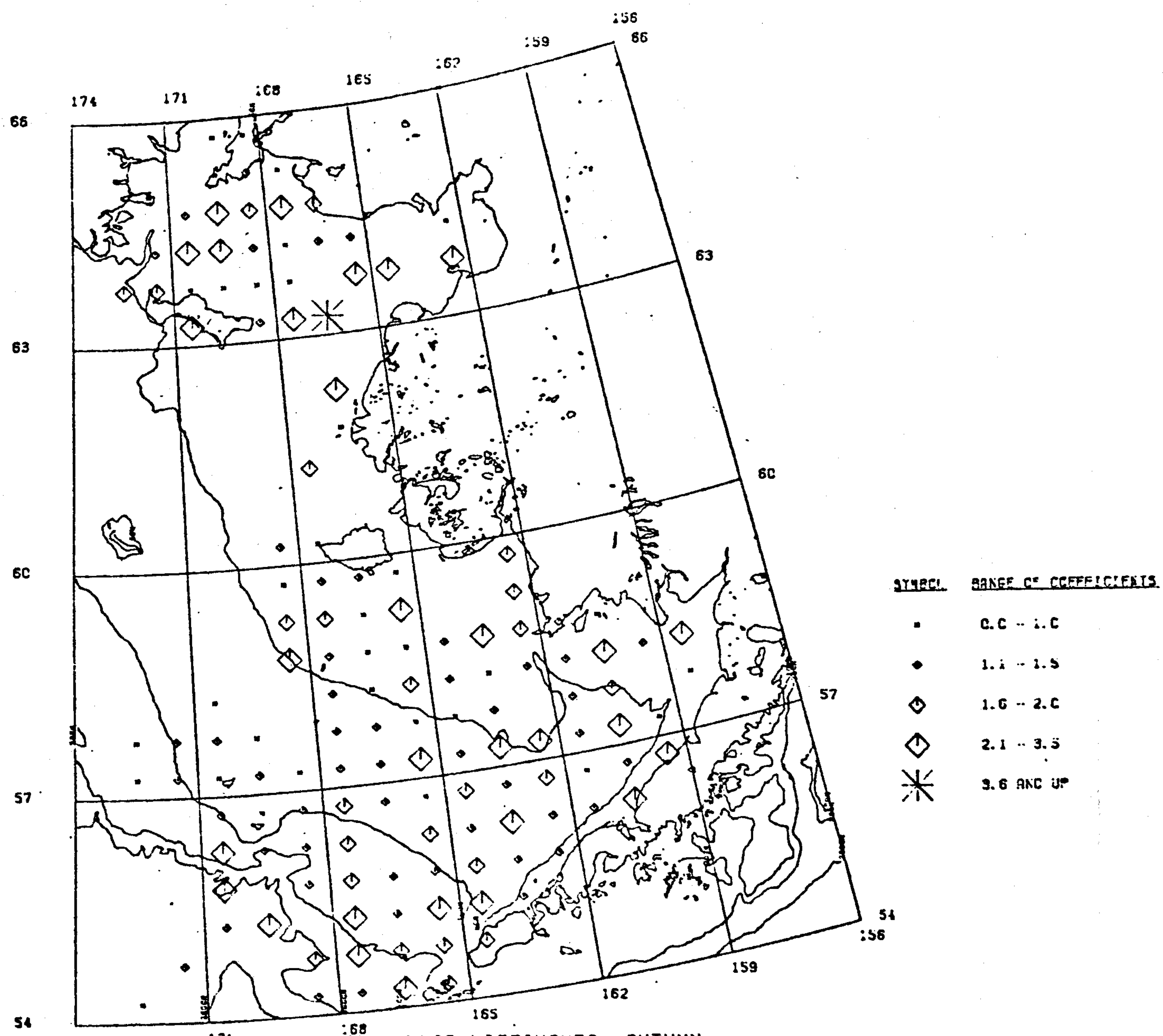

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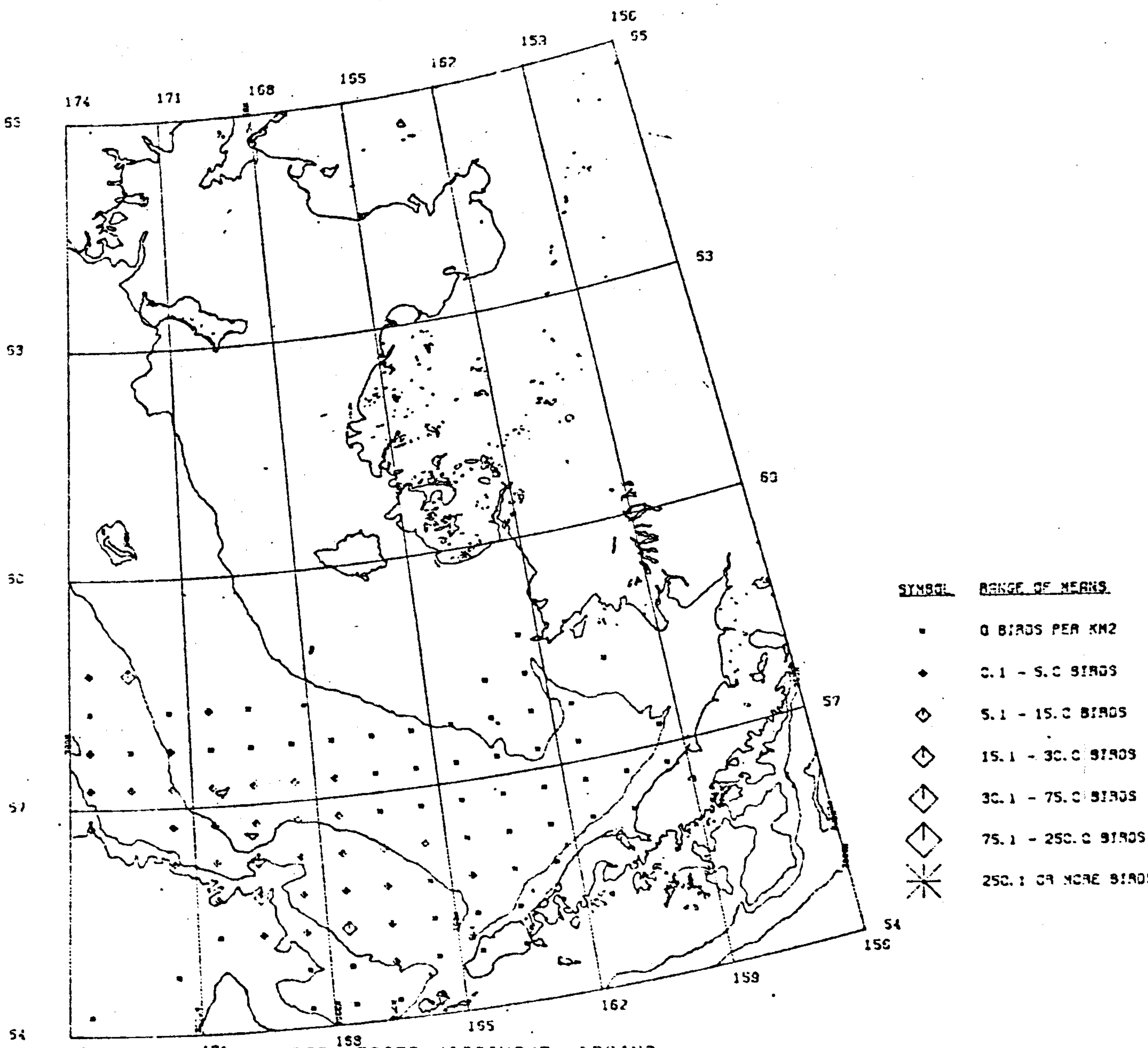

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MEAN DENSITIES: SHIP SURVEYS, 1975-1979

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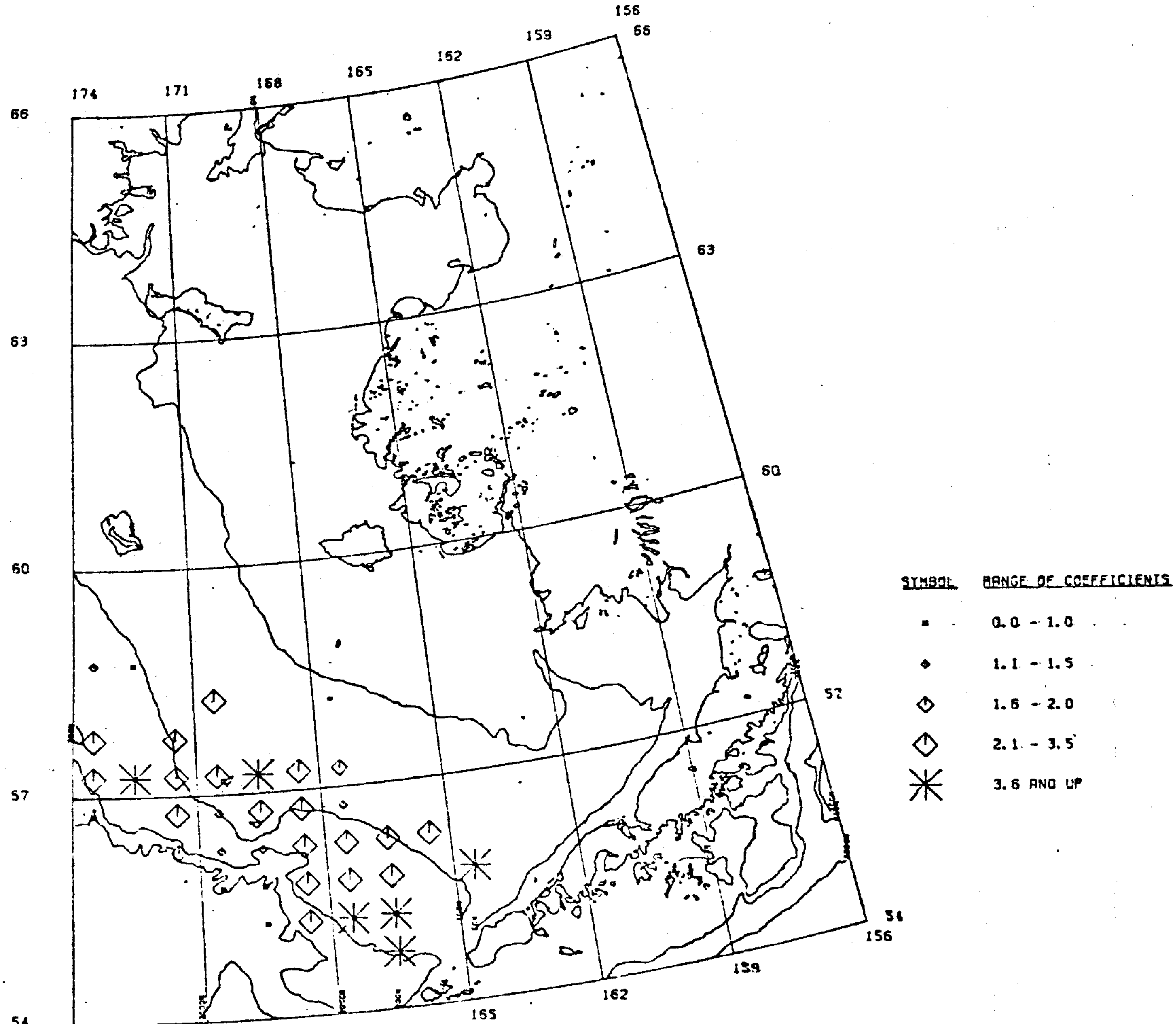

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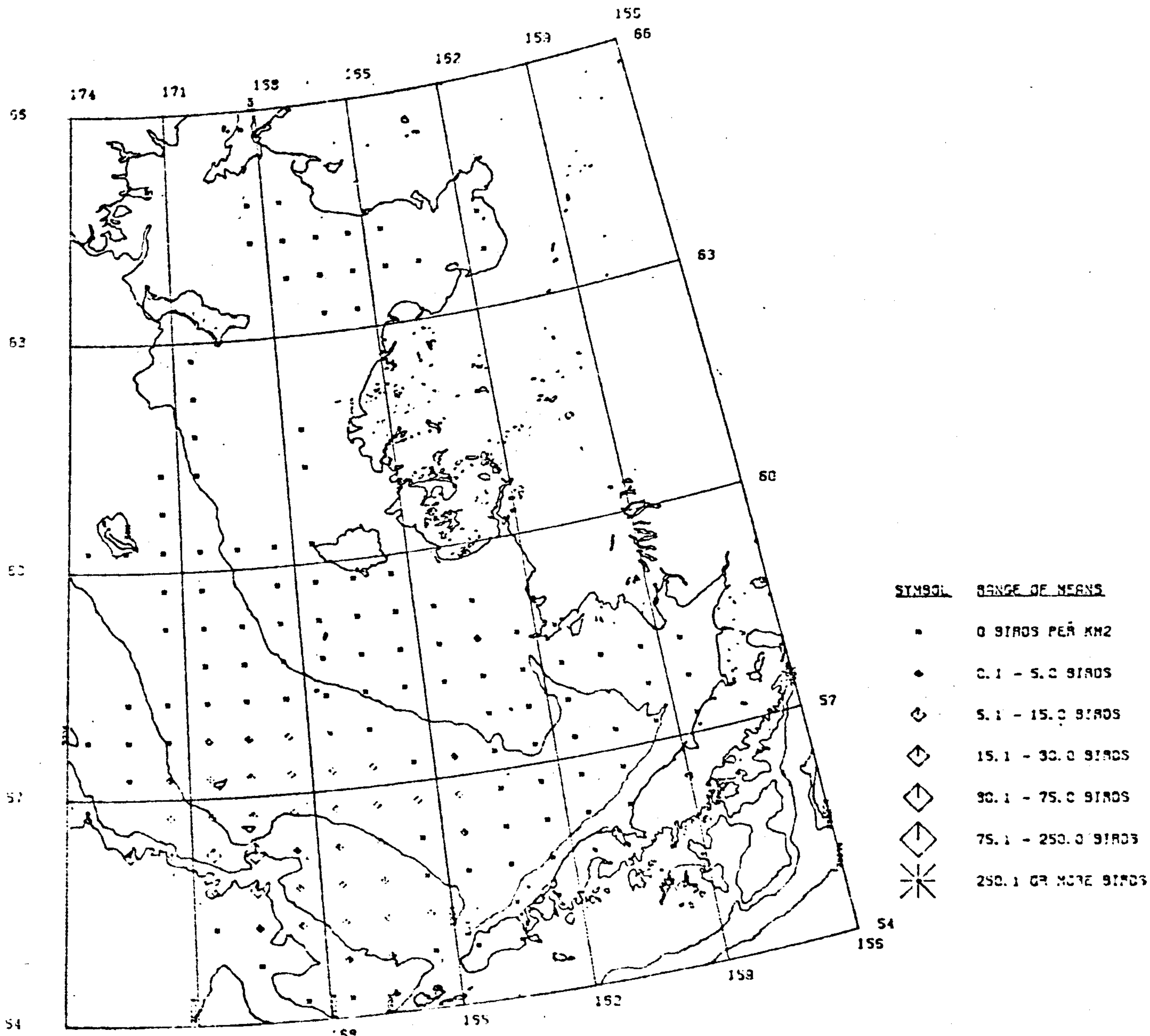

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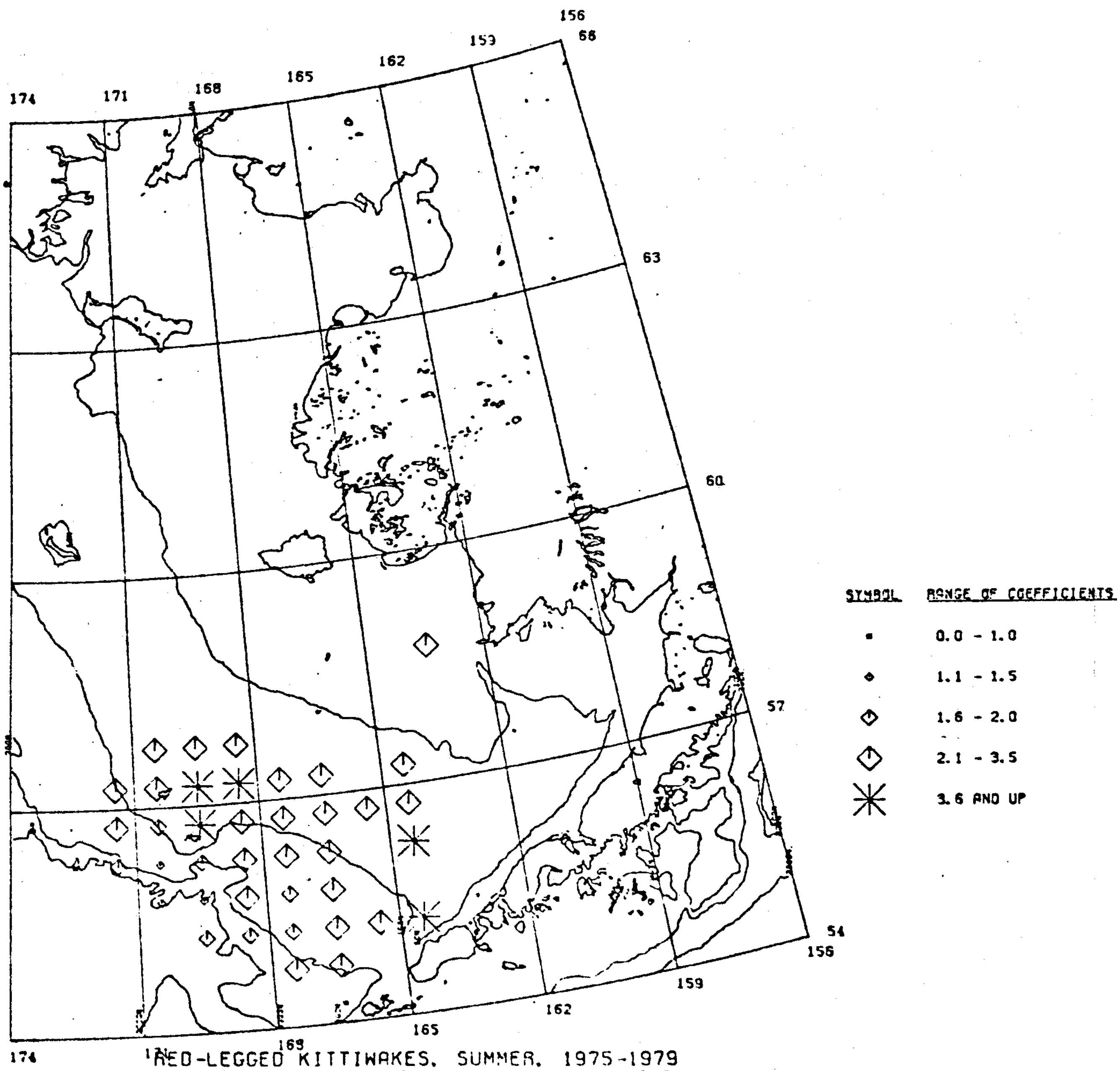

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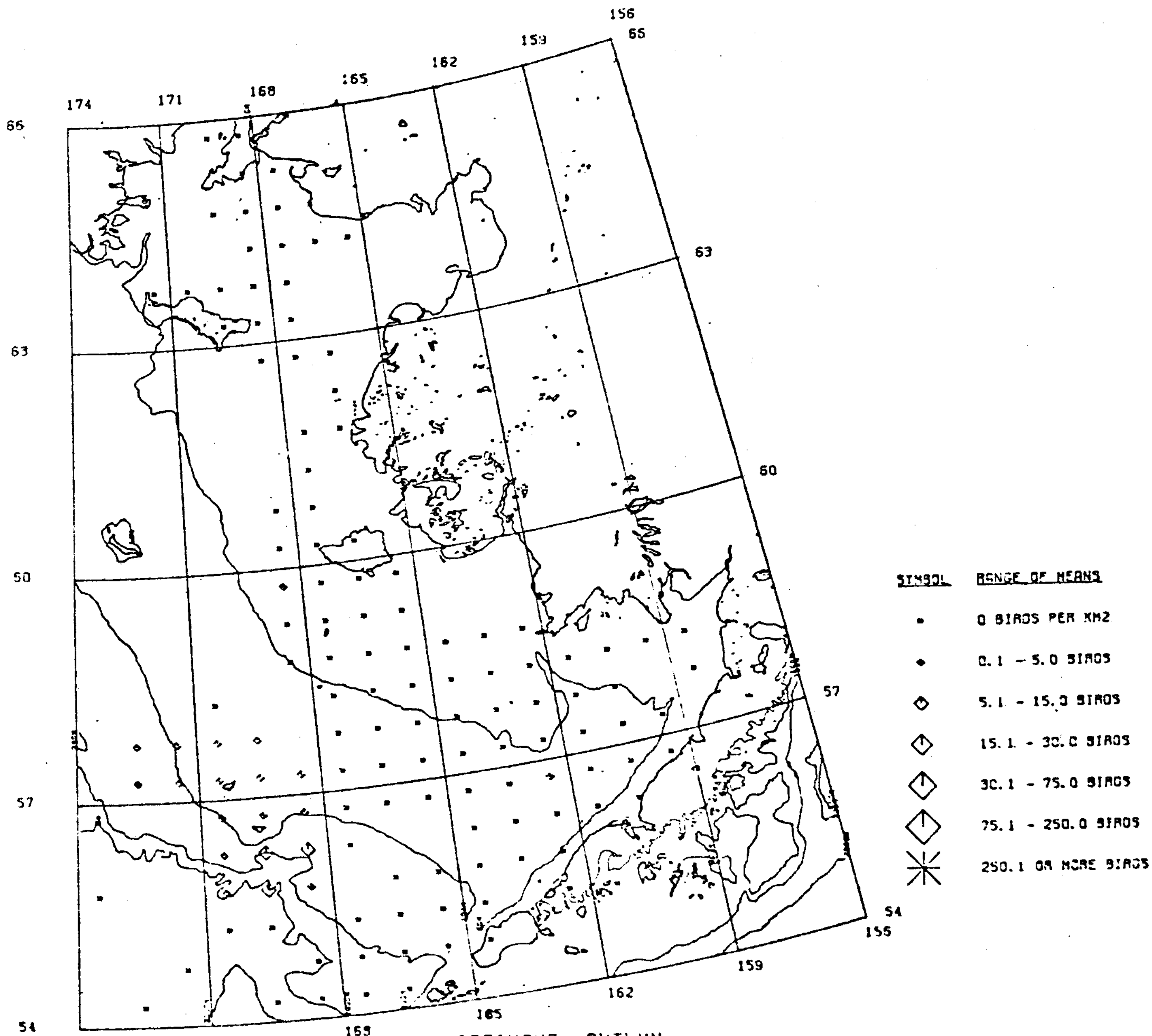

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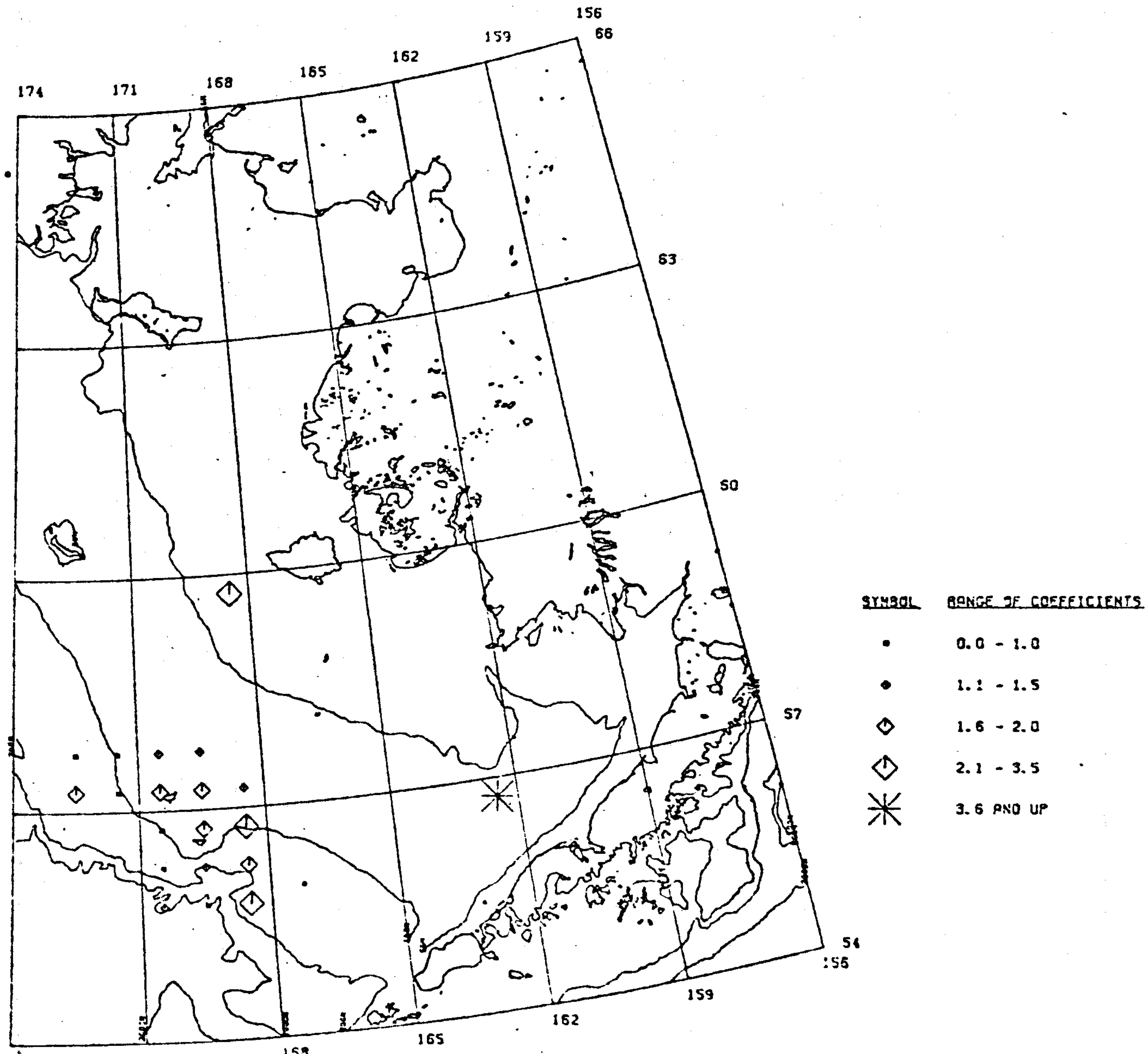

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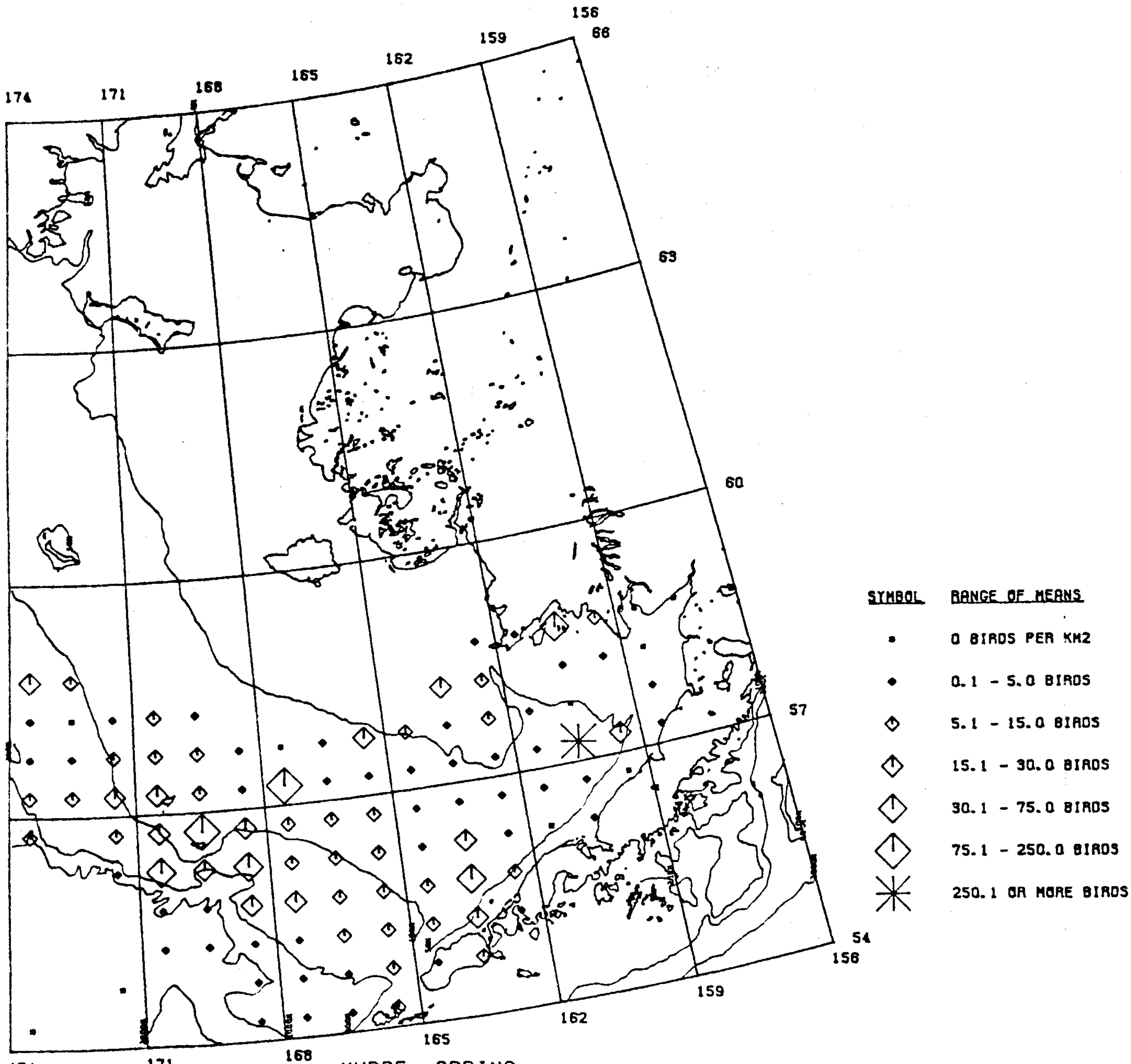

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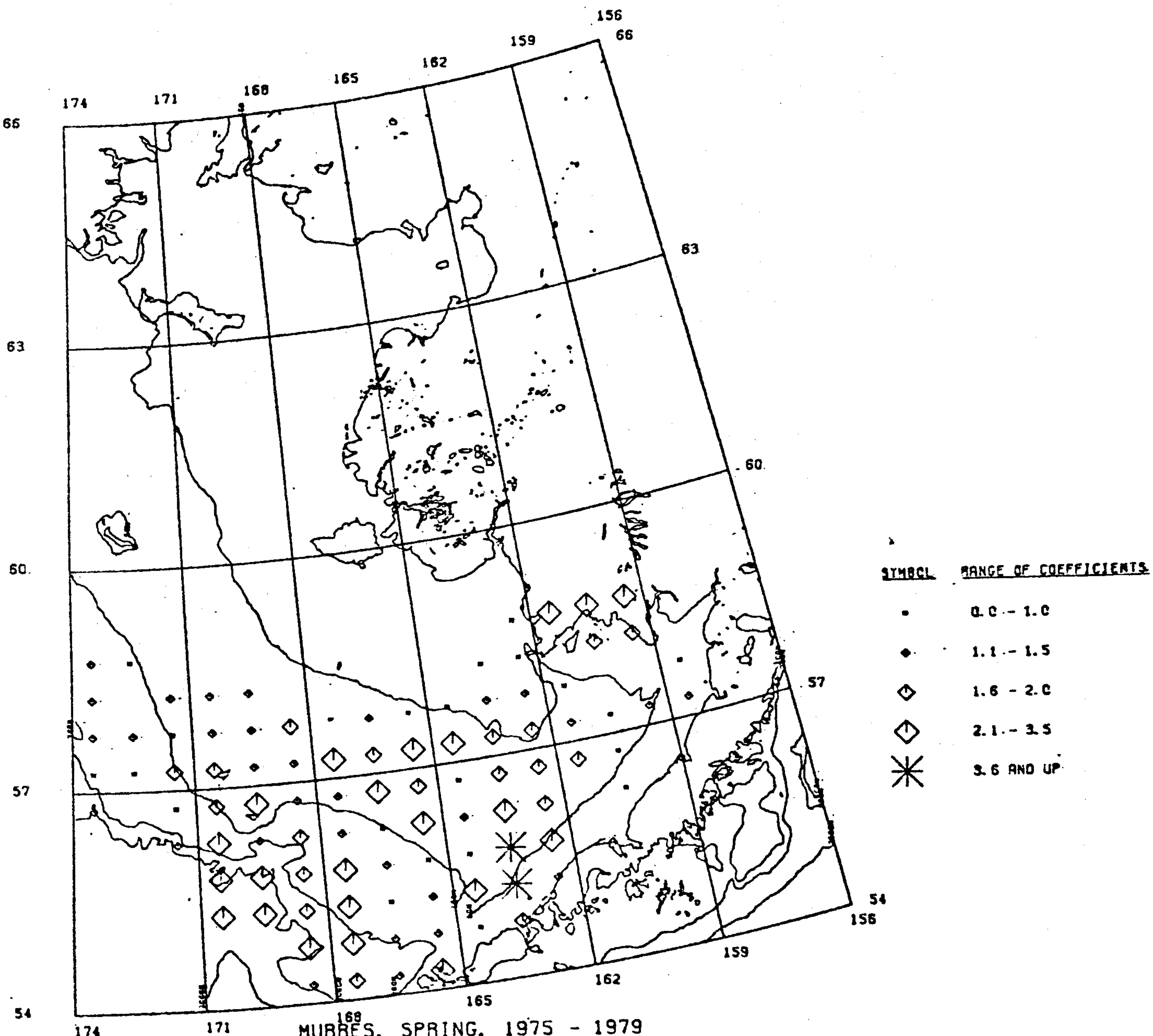

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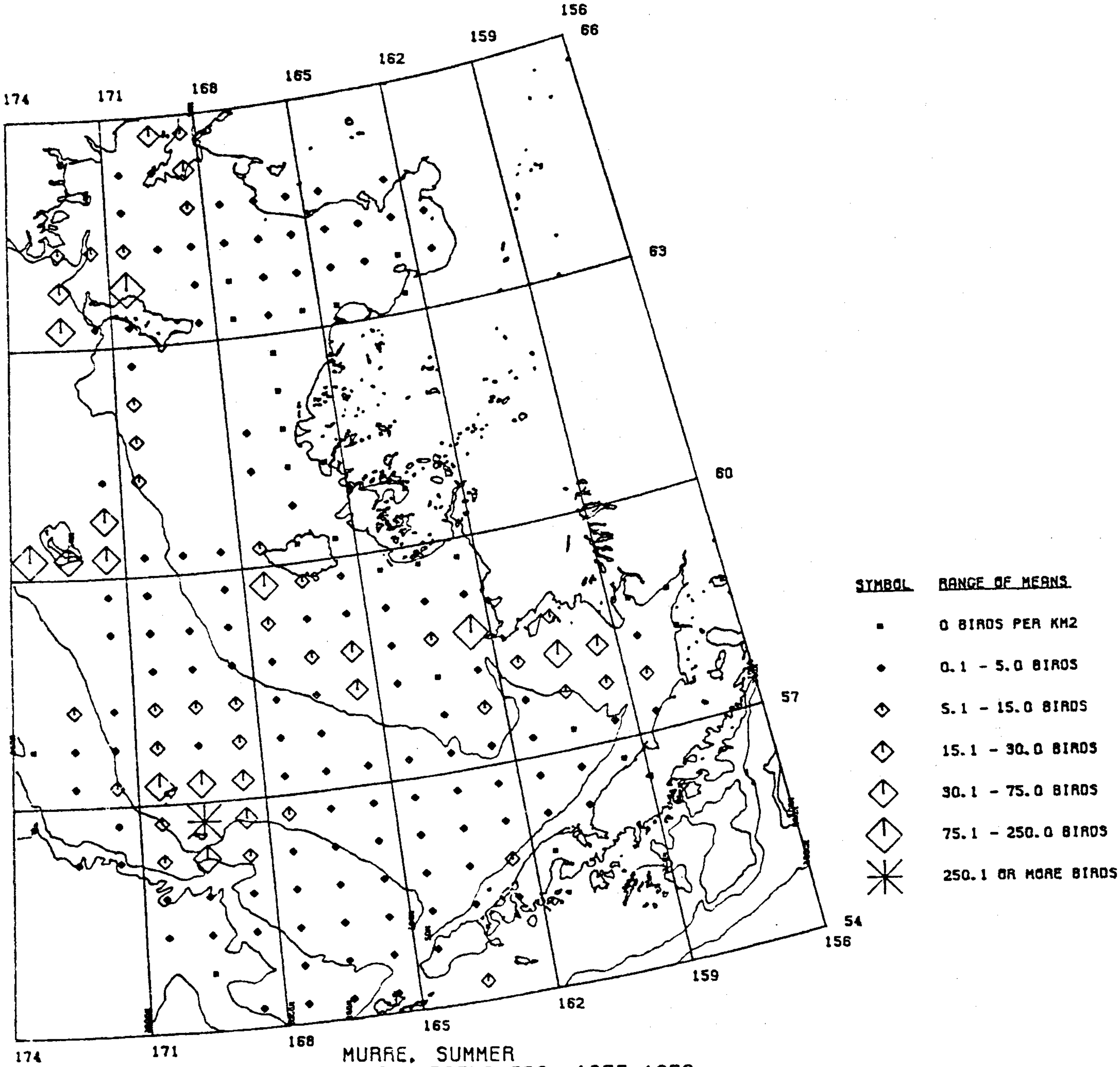

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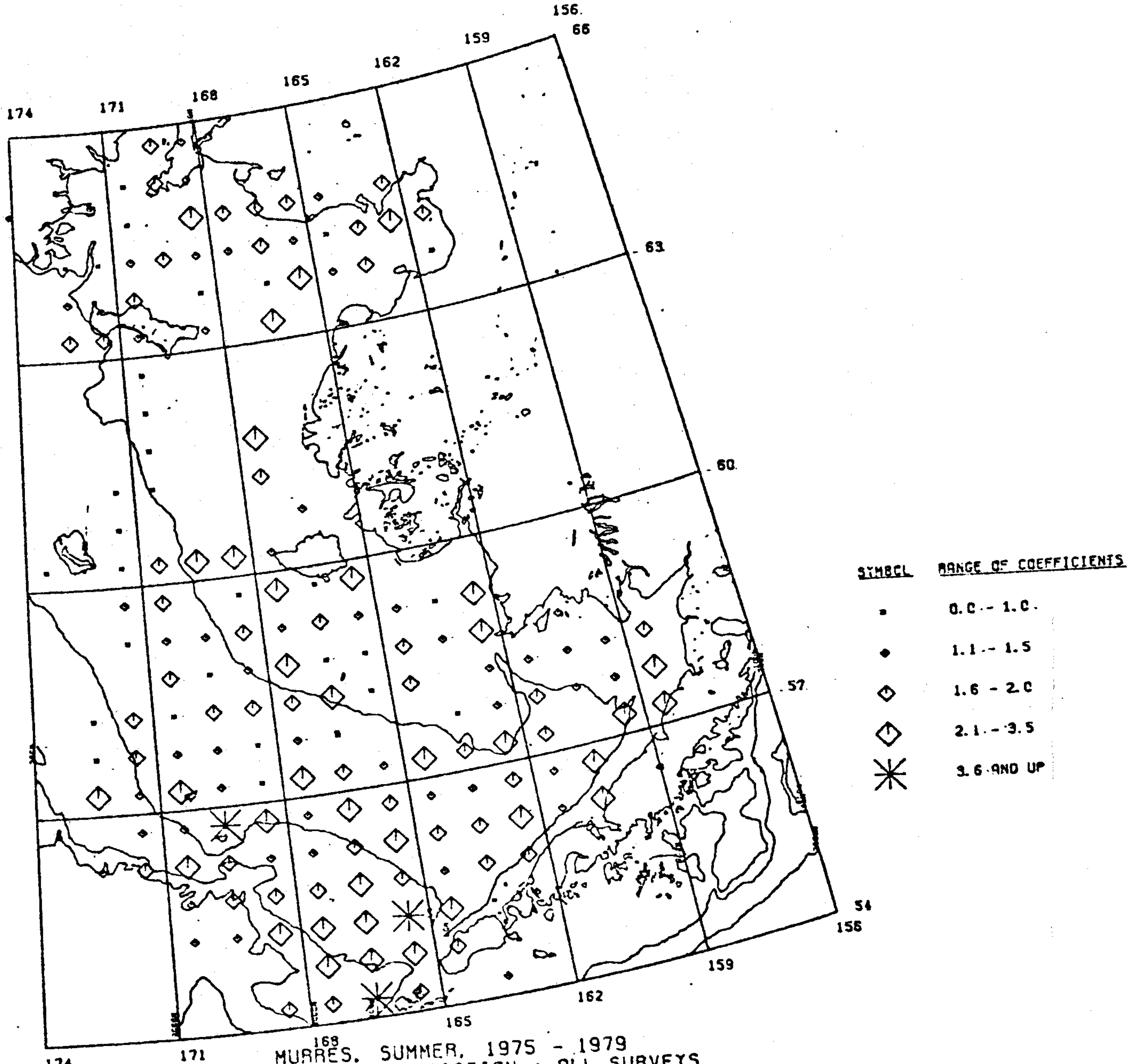

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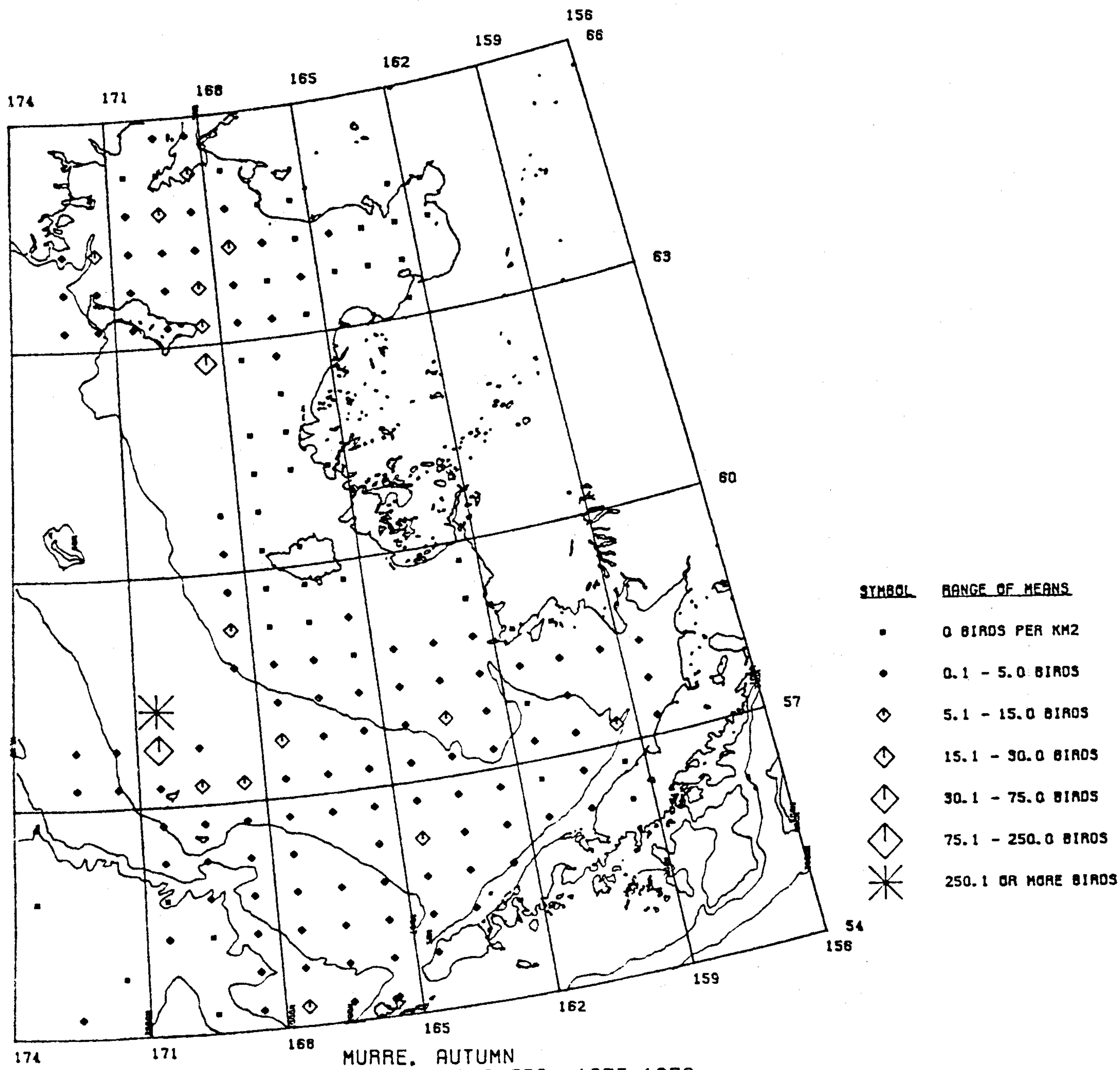

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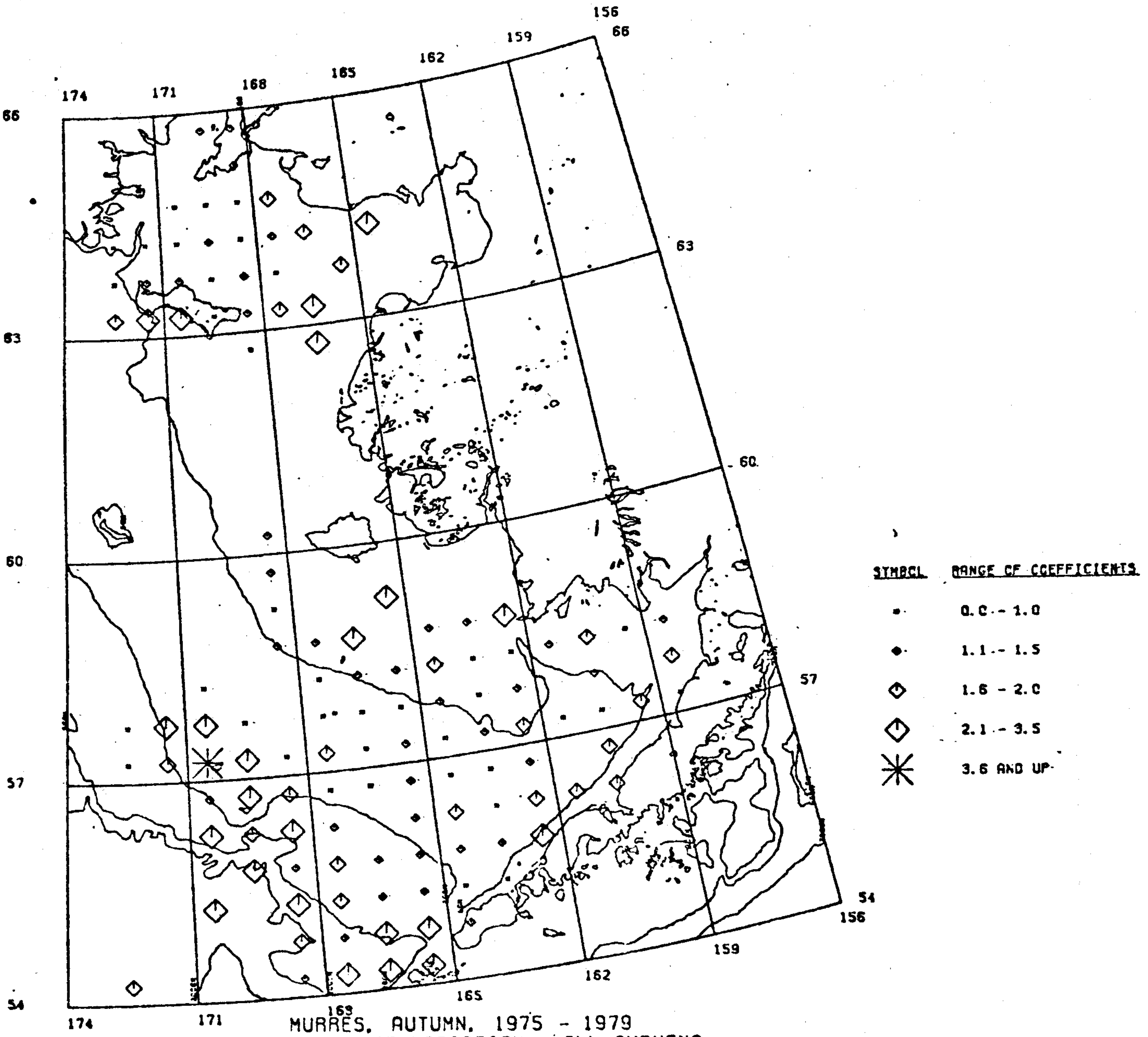

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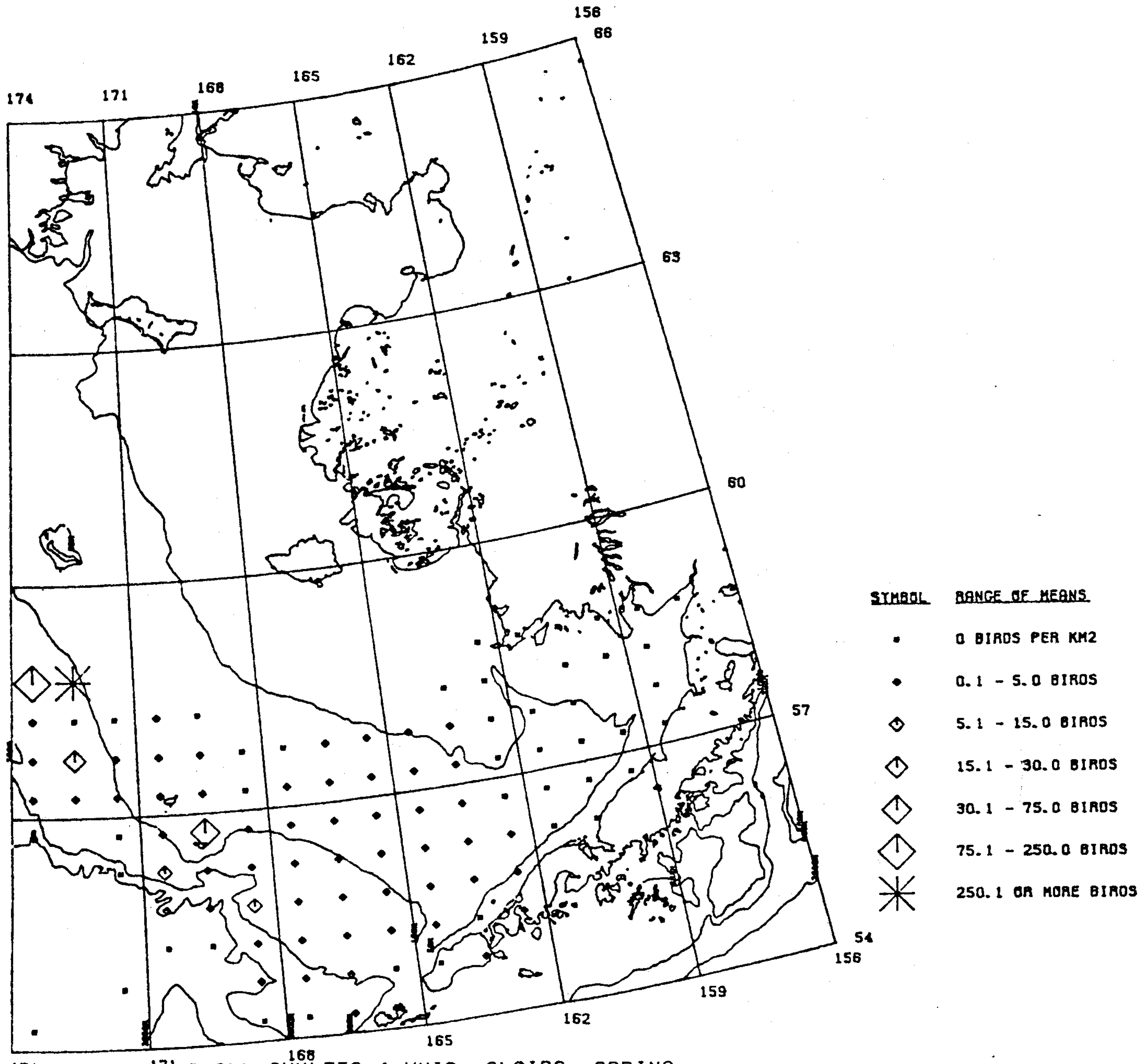

SMALL AUKLETS & UNID. ALCIDS. SPRING
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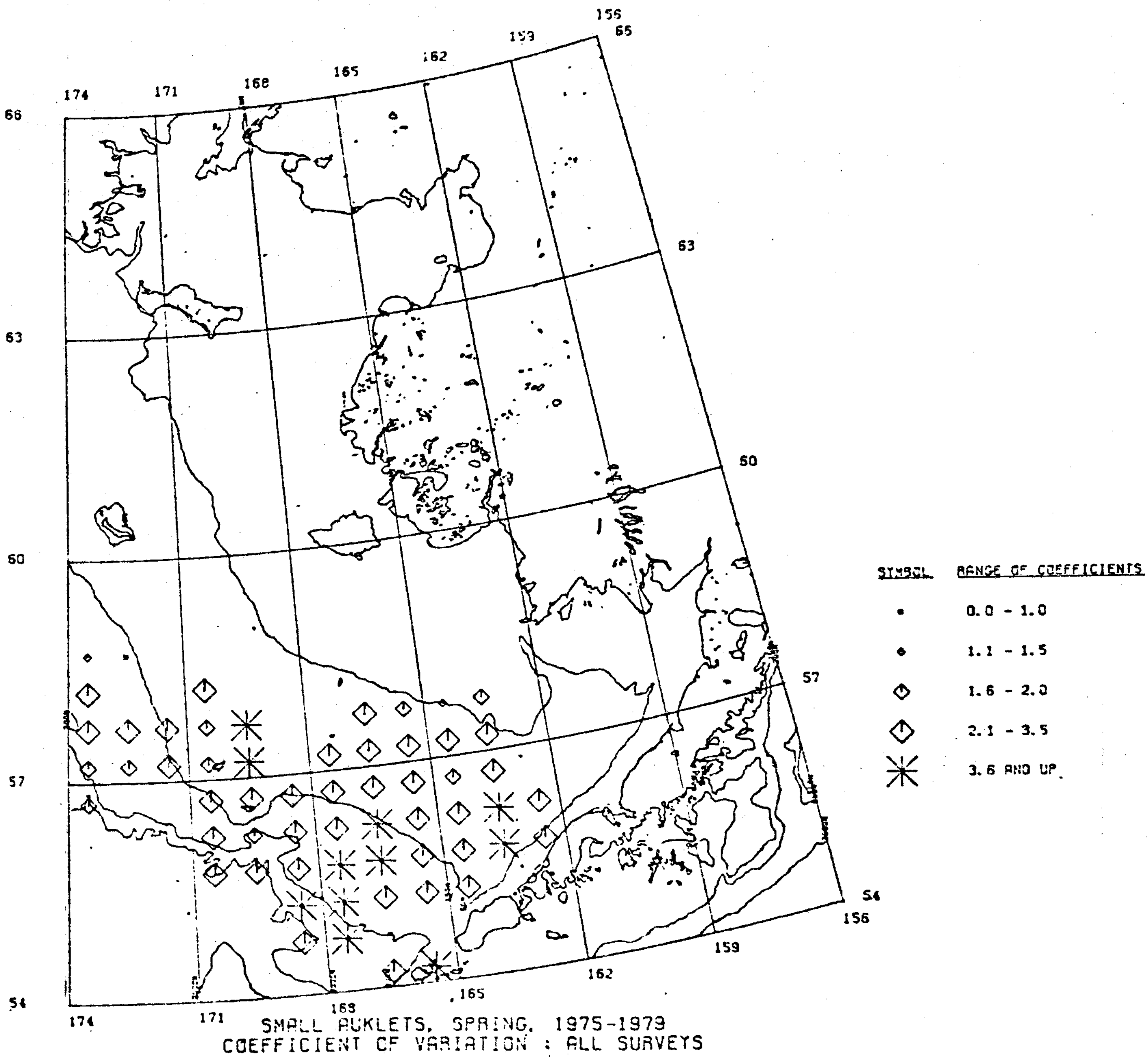

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SYMBOL
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0.0 - 1.0
1.1 - 1.5
1.6 - 2.0
2.1 - 3.5
3.6 AND UP
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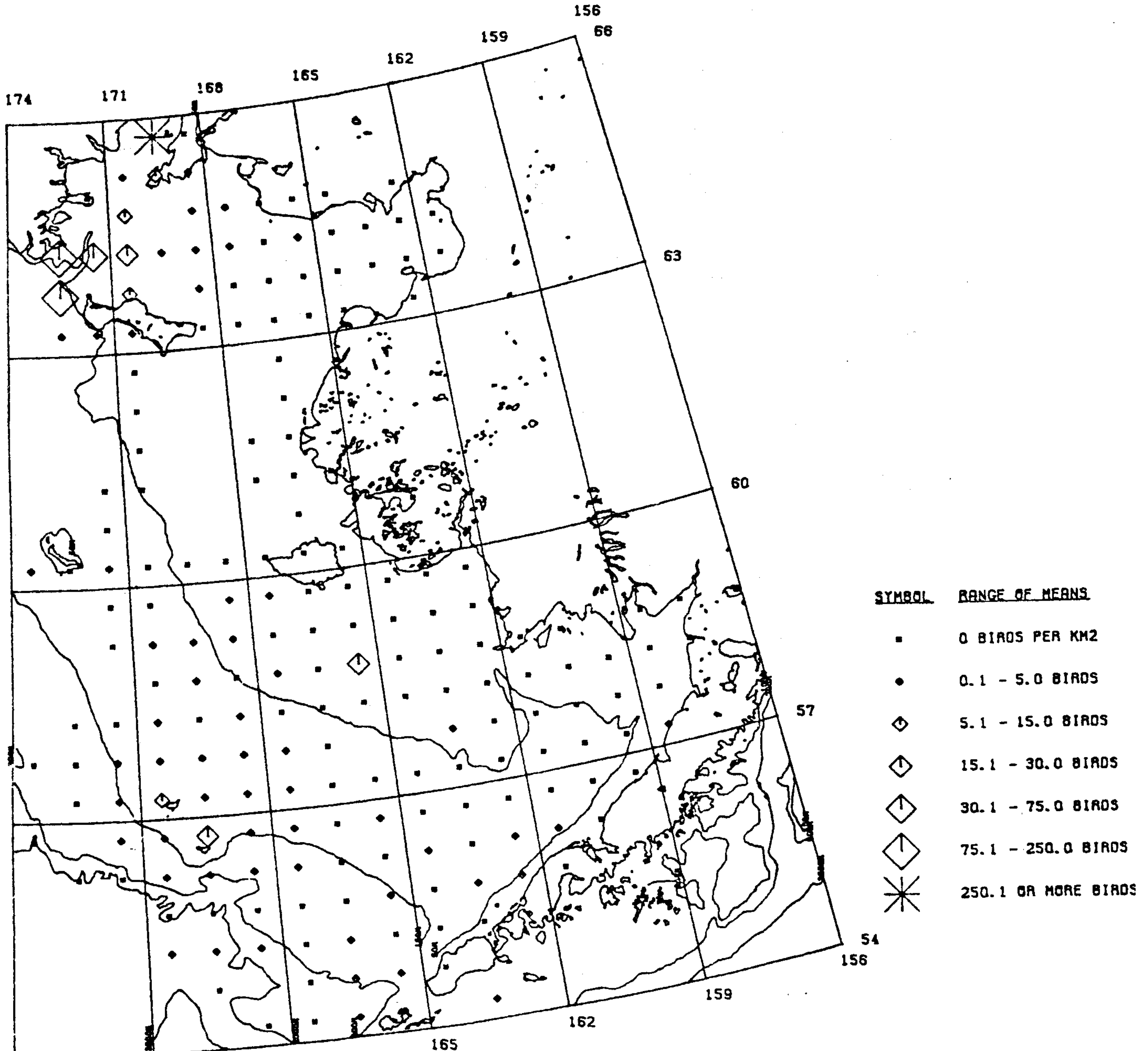

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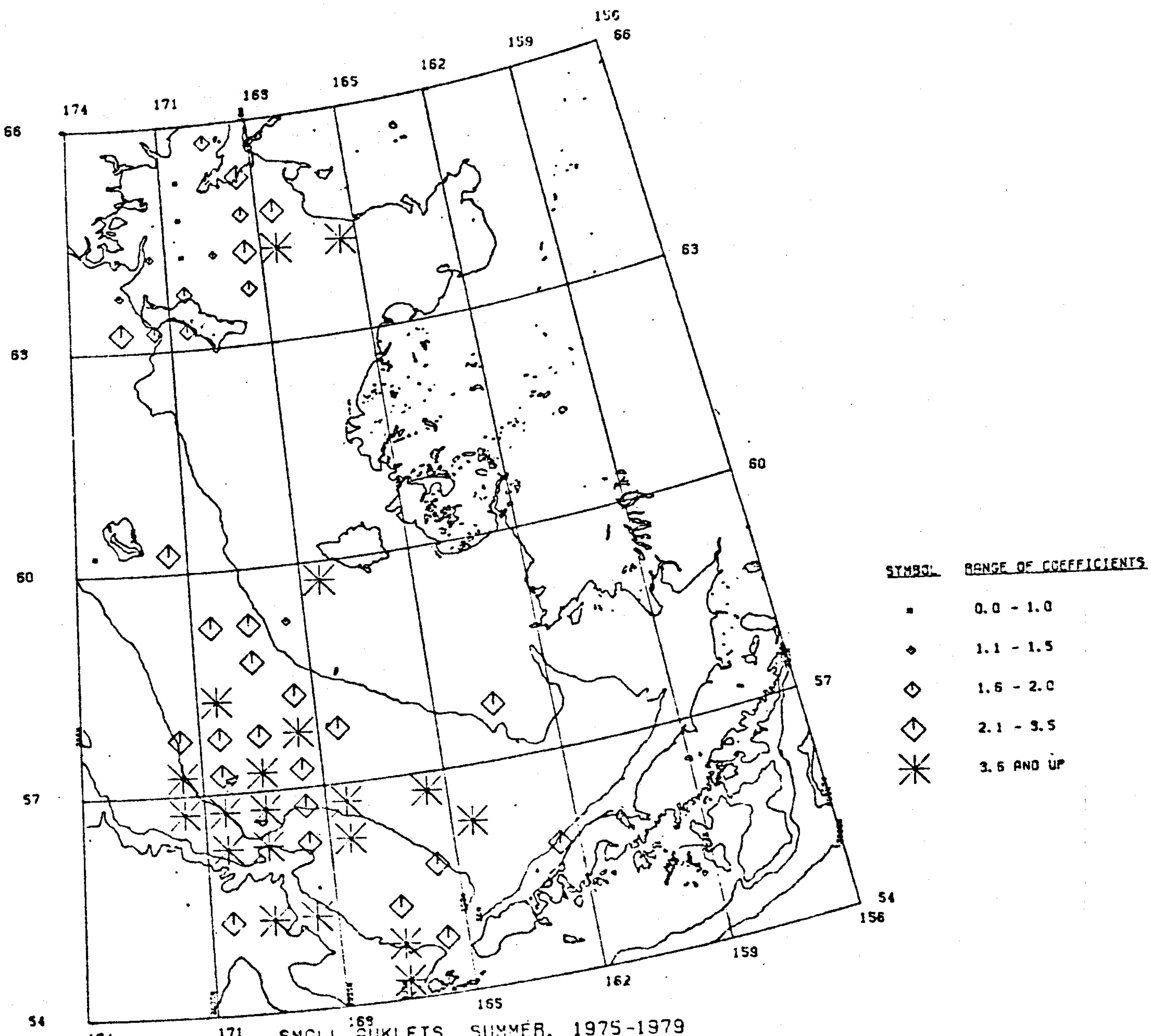

SMALL AUKLETS, SUMMER, 1975-1979
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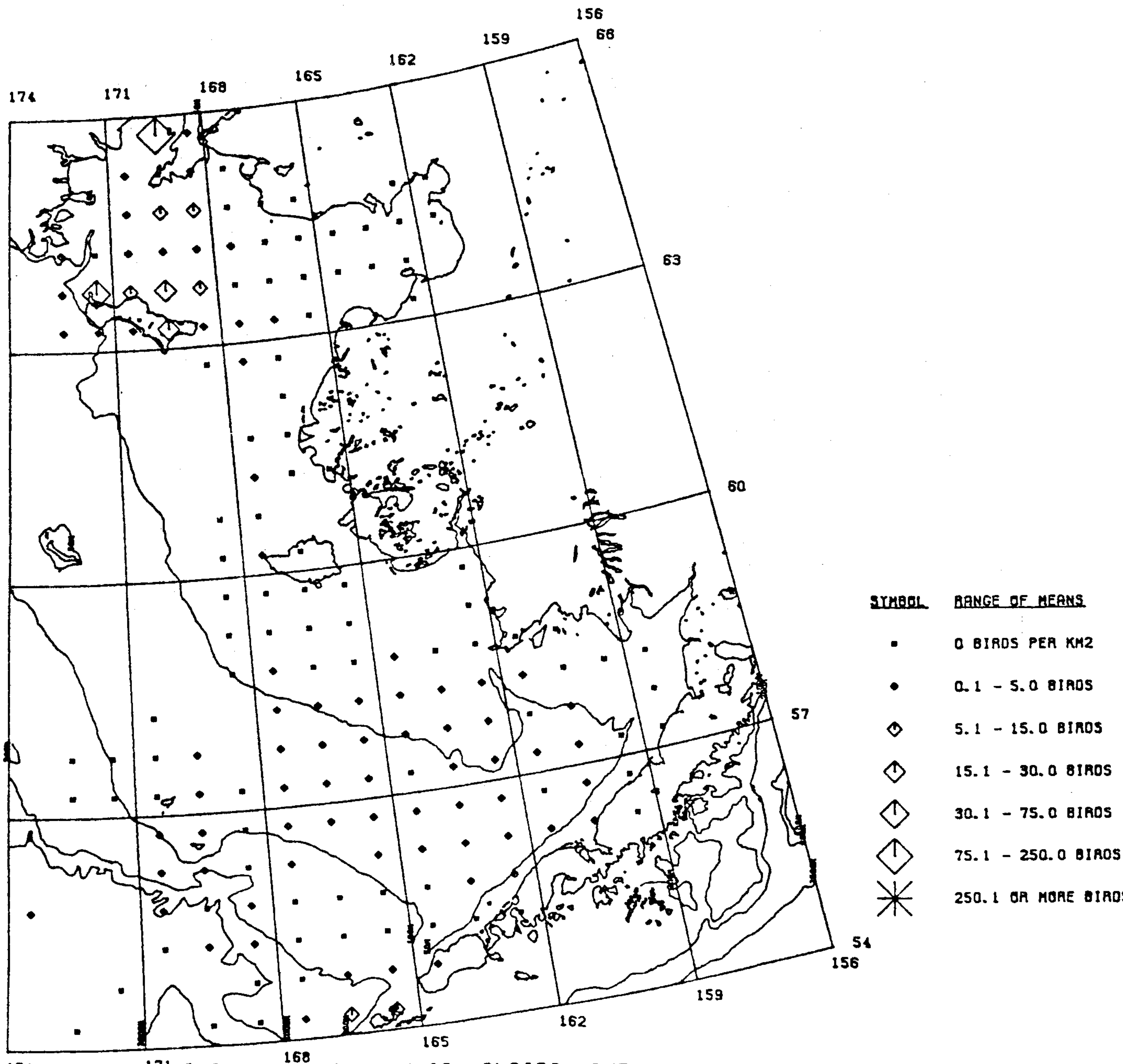

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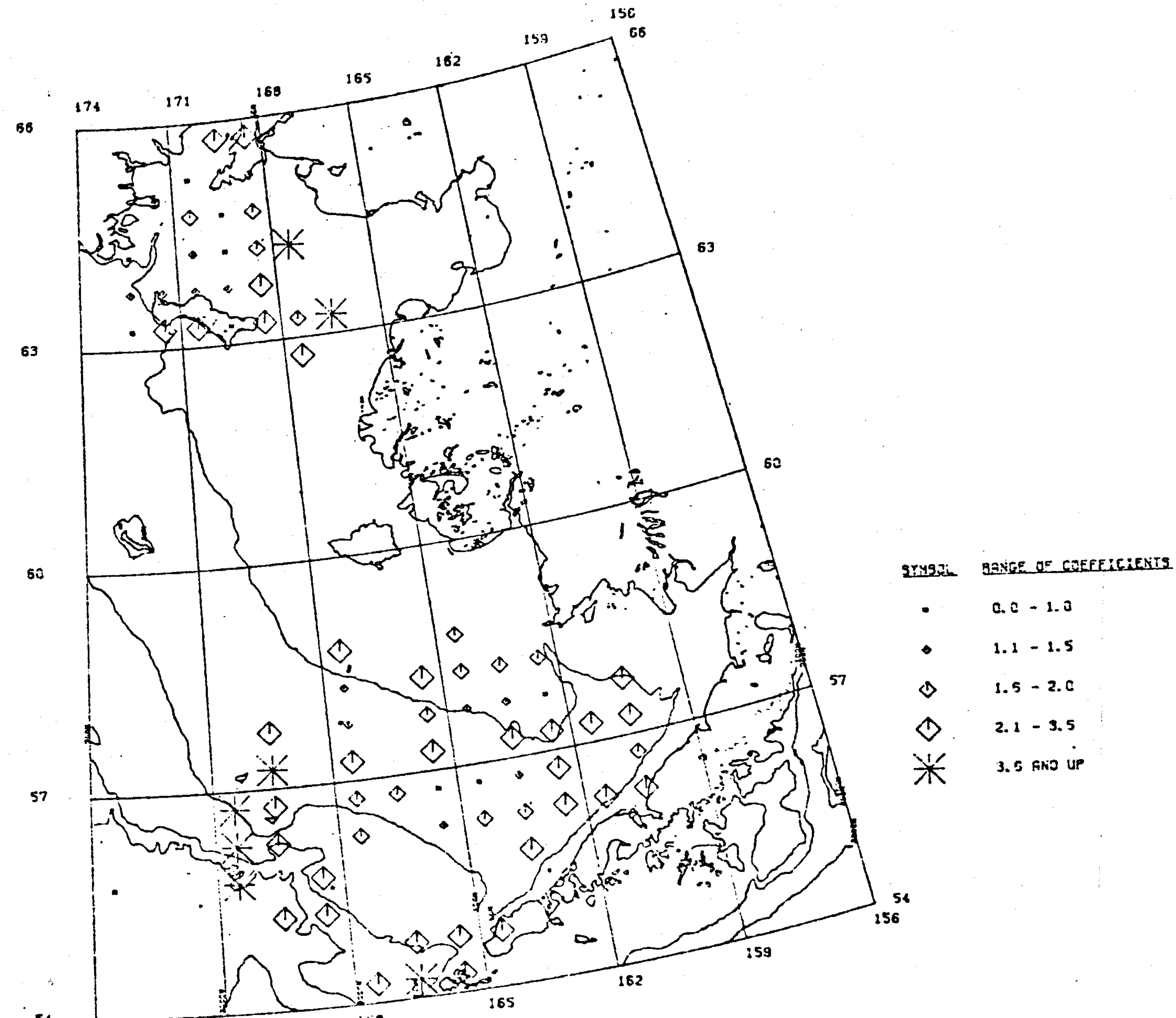

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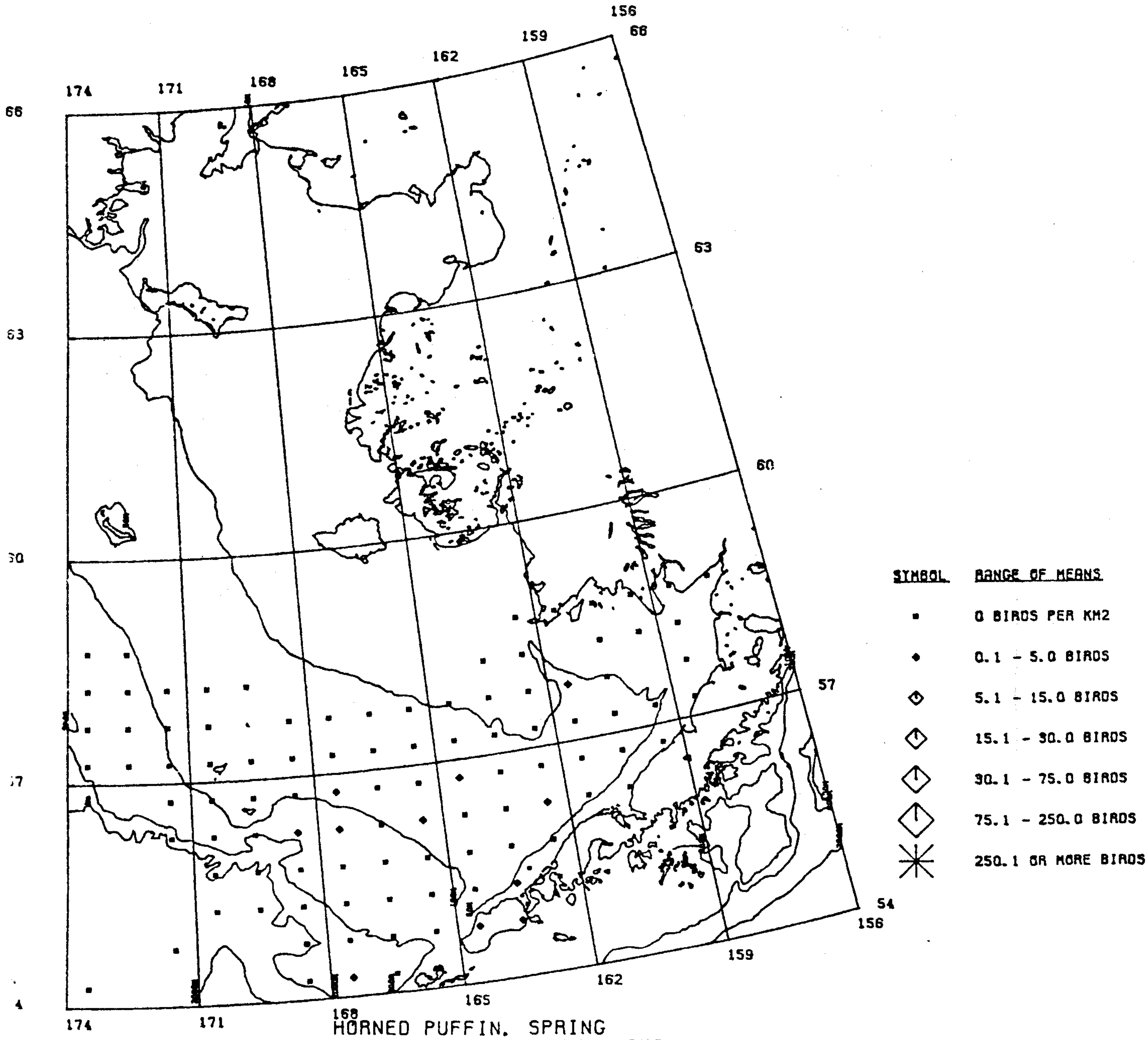

HORNED PUFFIN, SPRING
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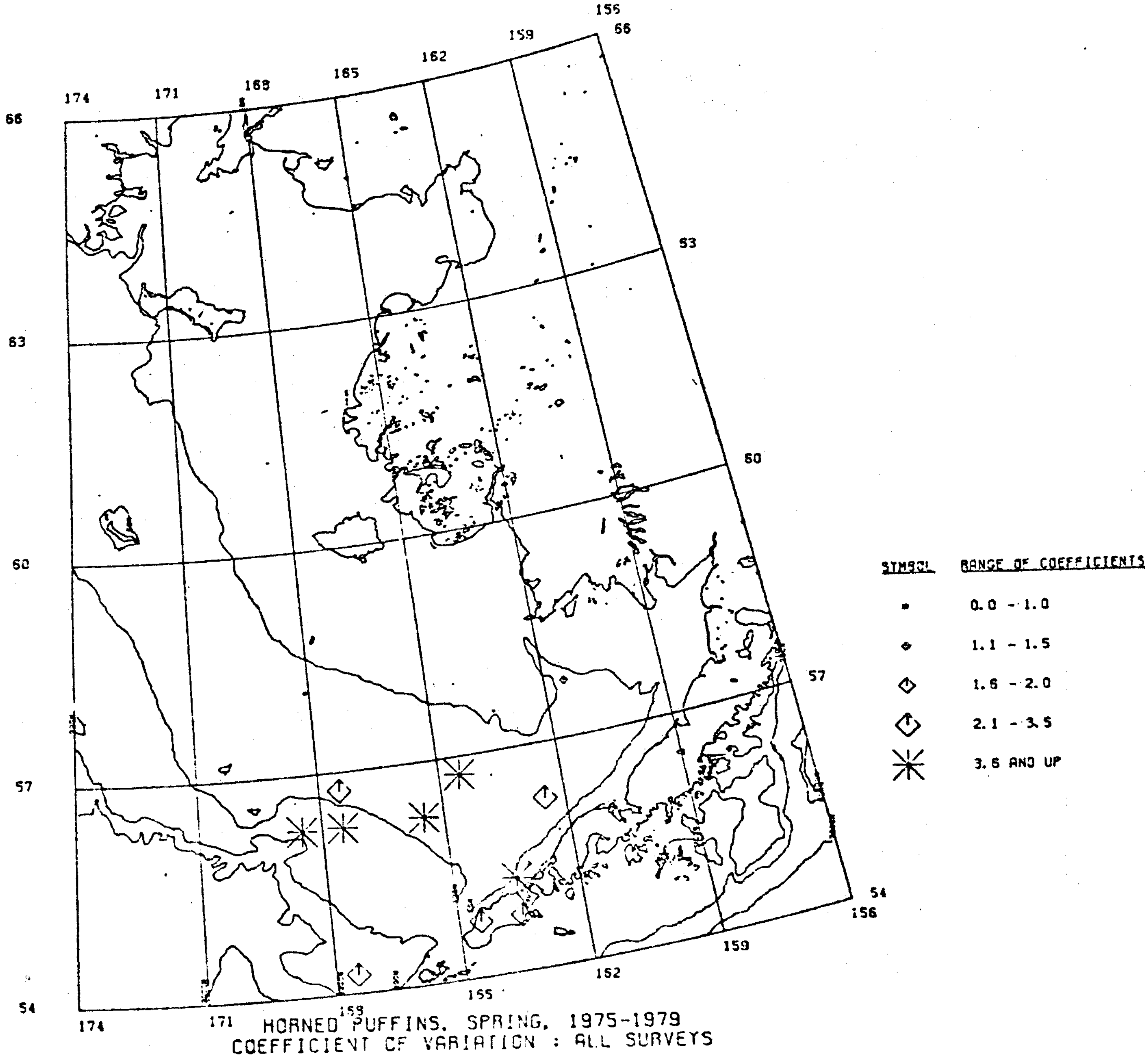

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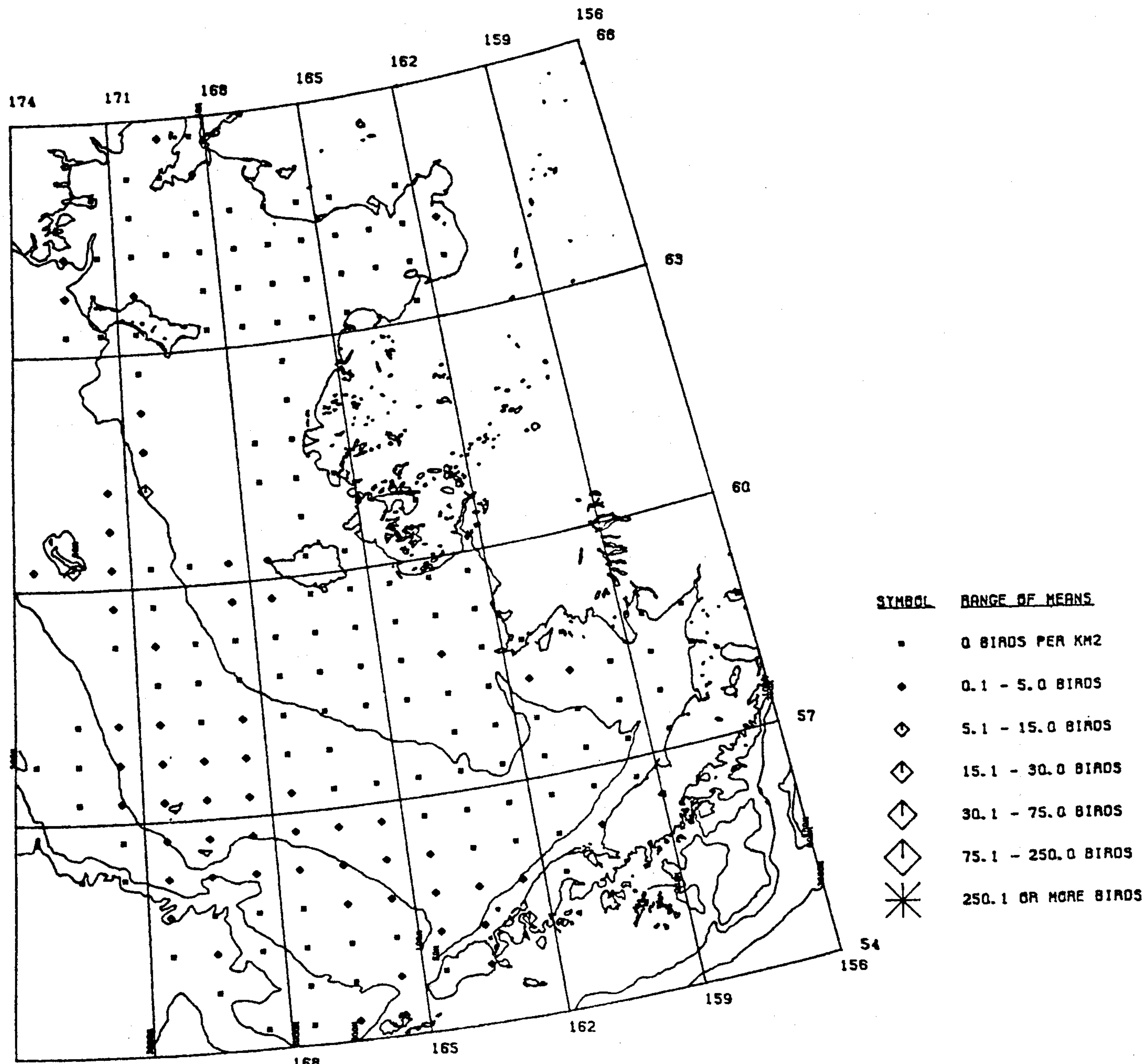

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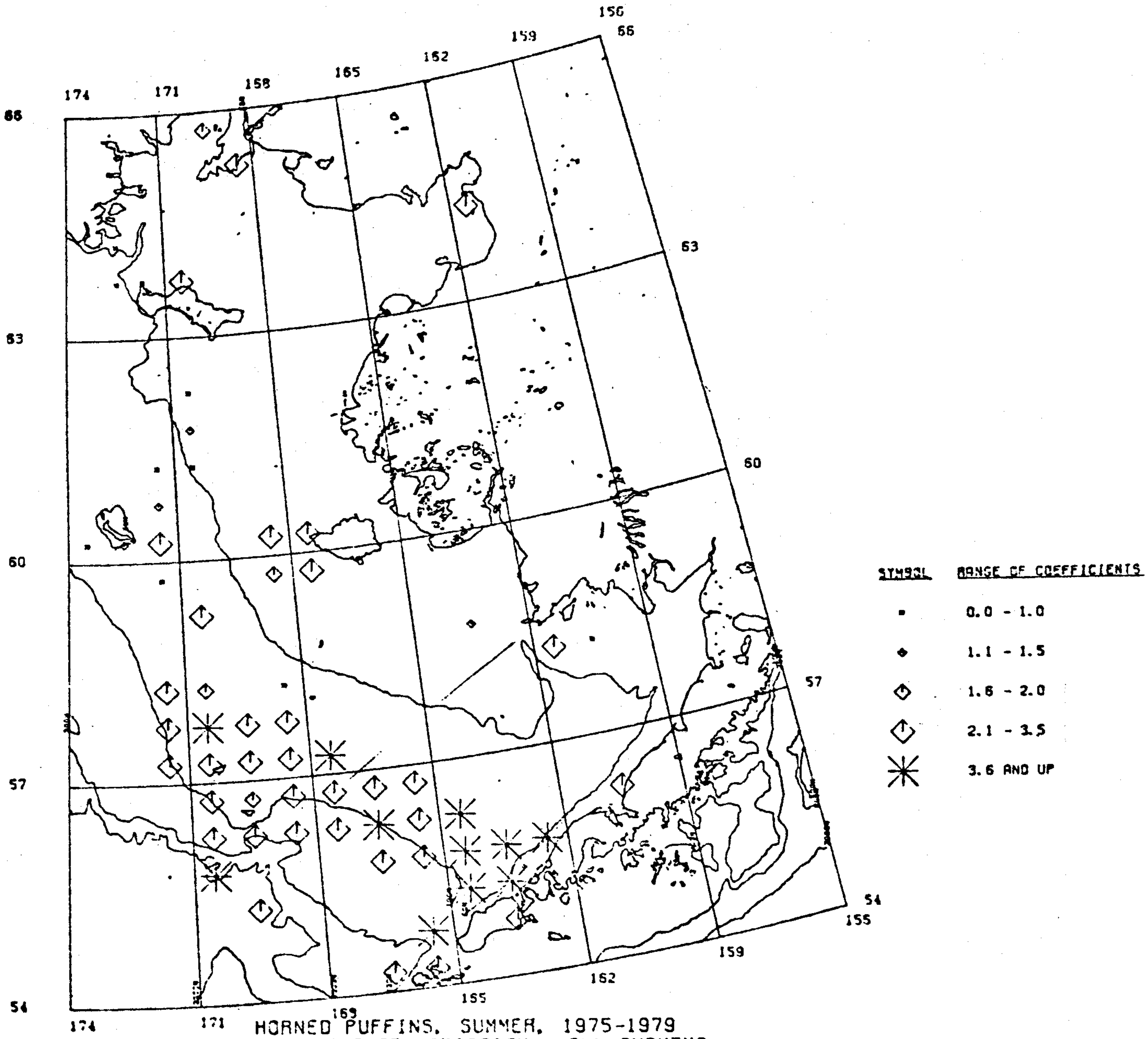

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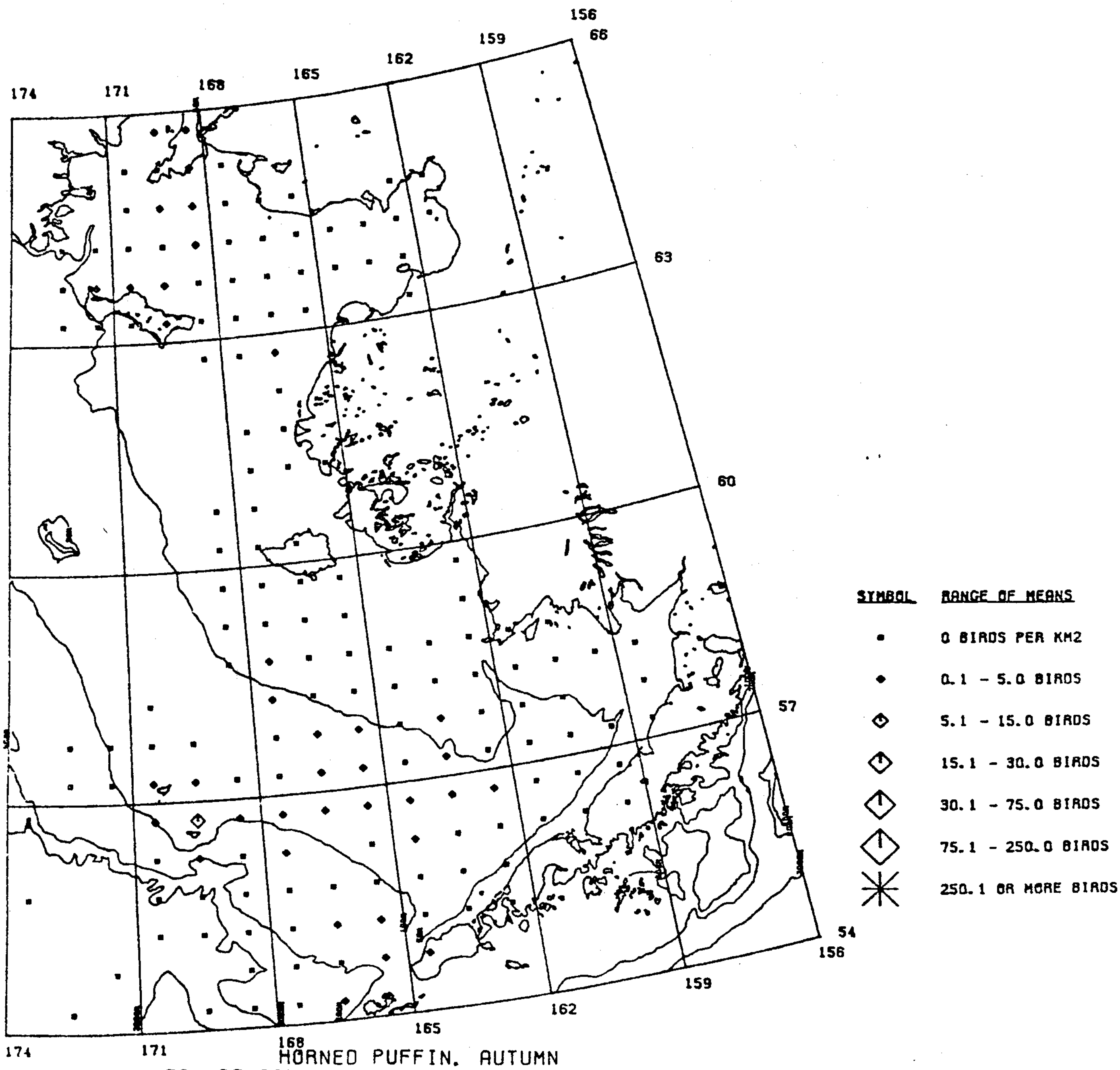

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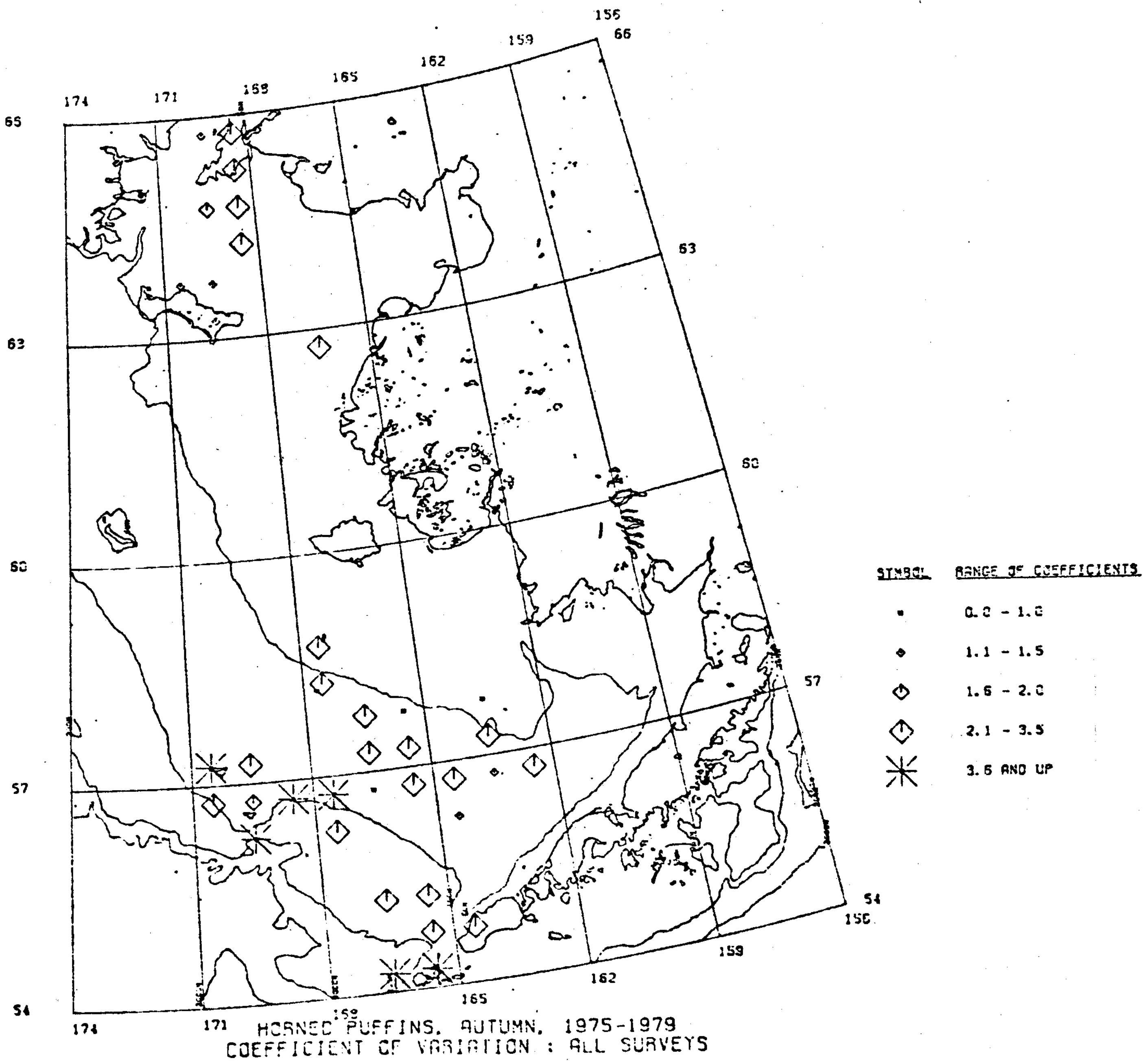

SYMBOL
RANGE OF COEFFICIENTS
0.0 - 1.0
1.1 - 1.5
1.6 - 2.0
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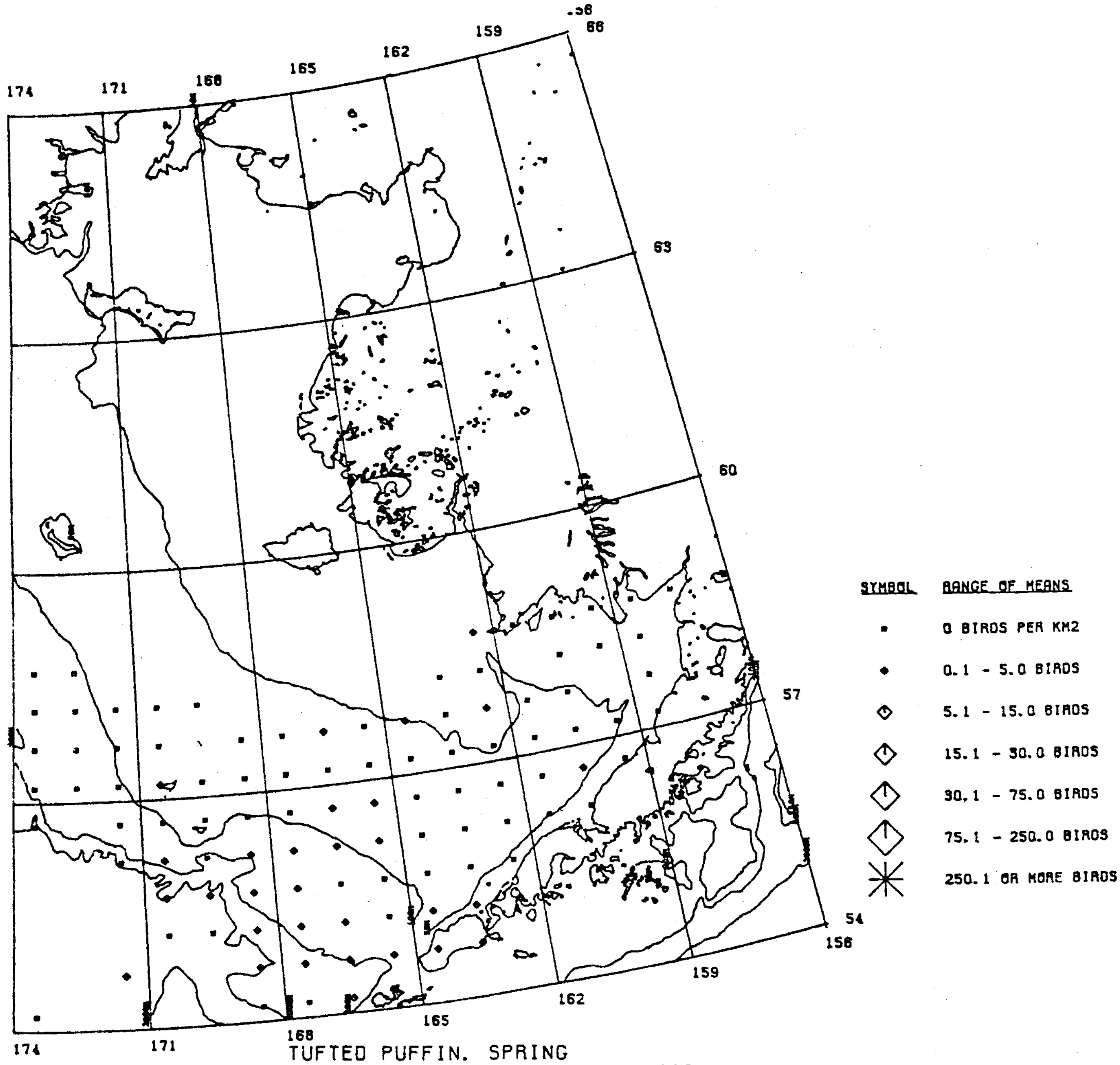

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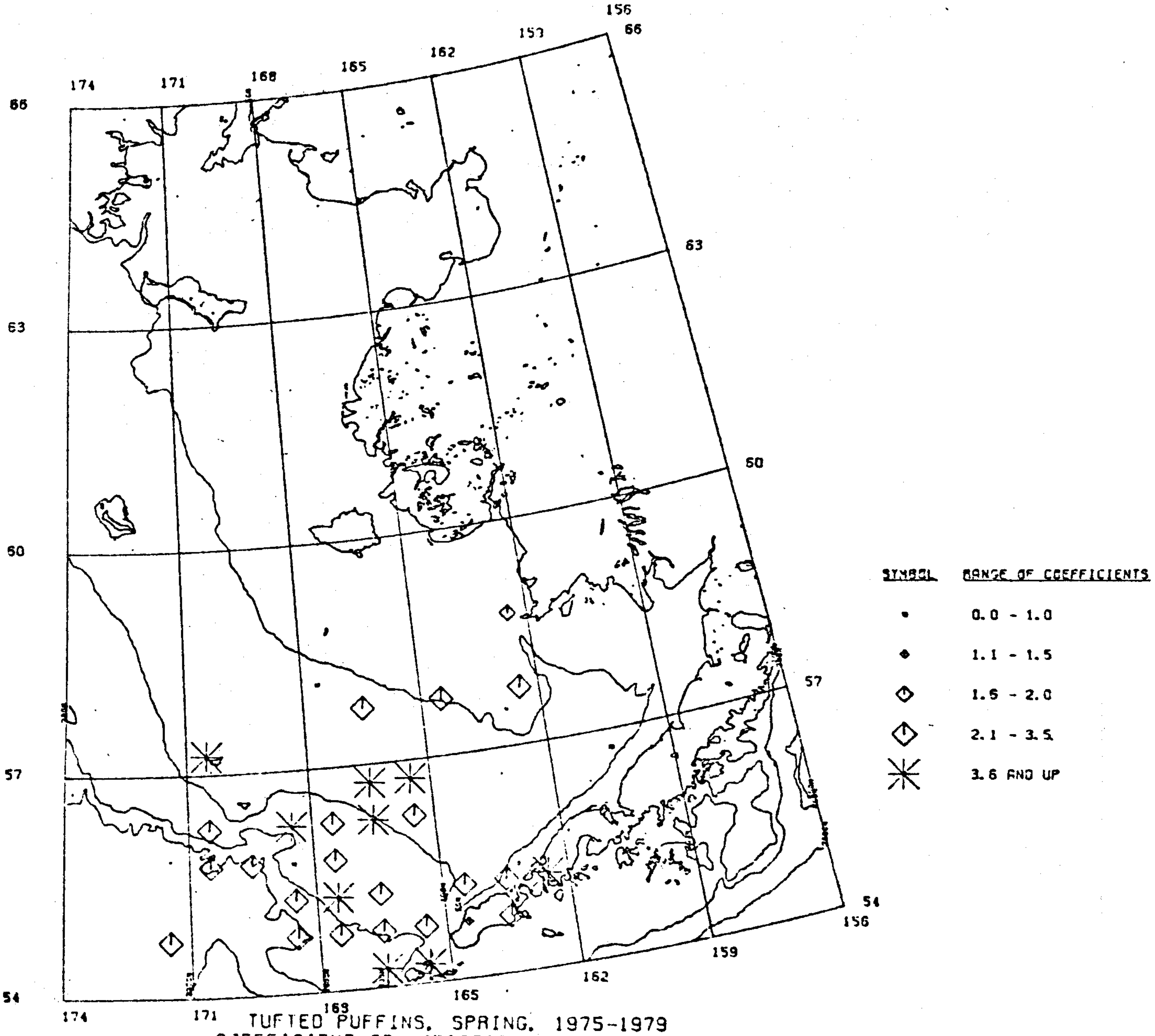

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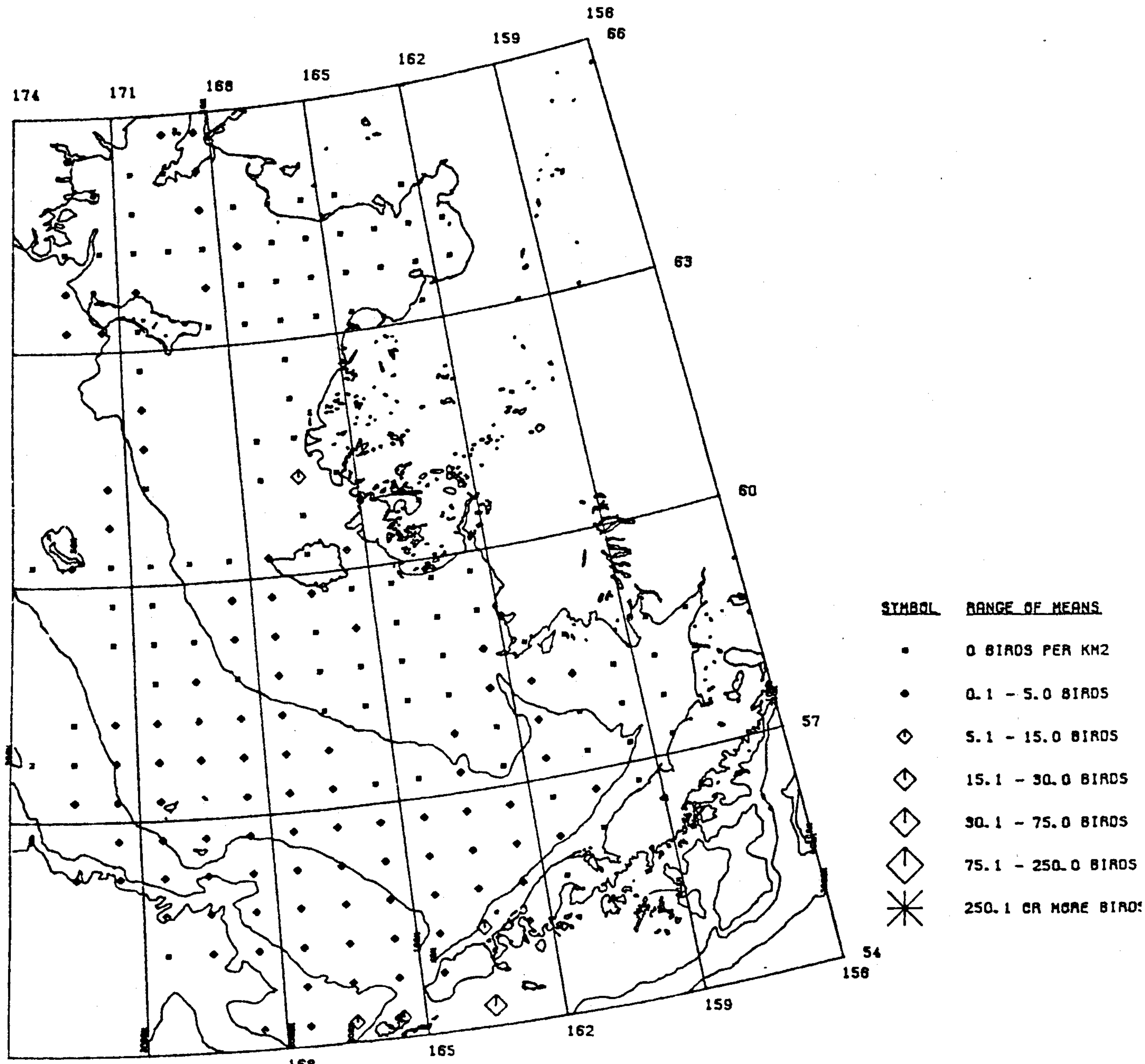

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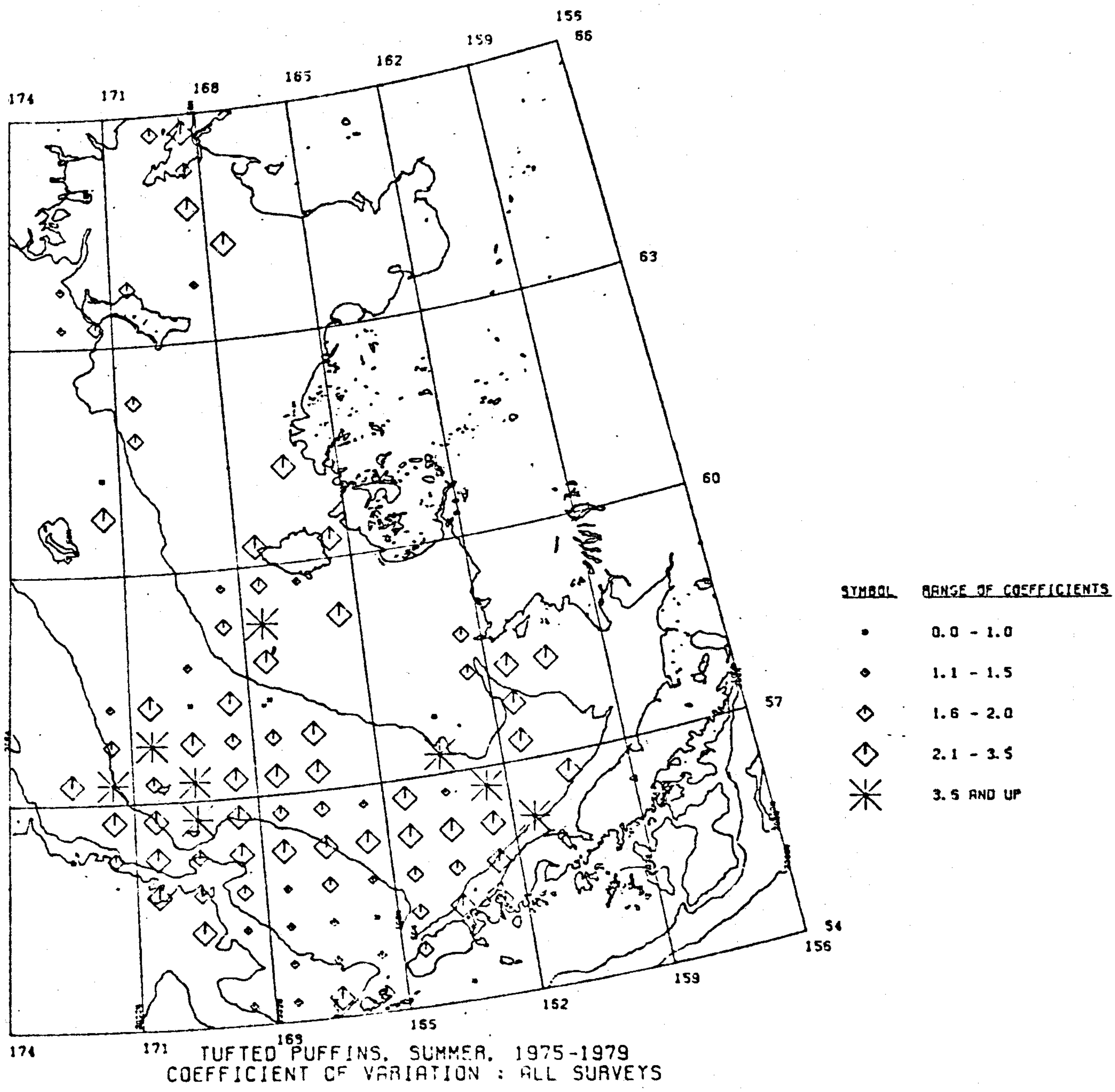
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1.1 - 1.5
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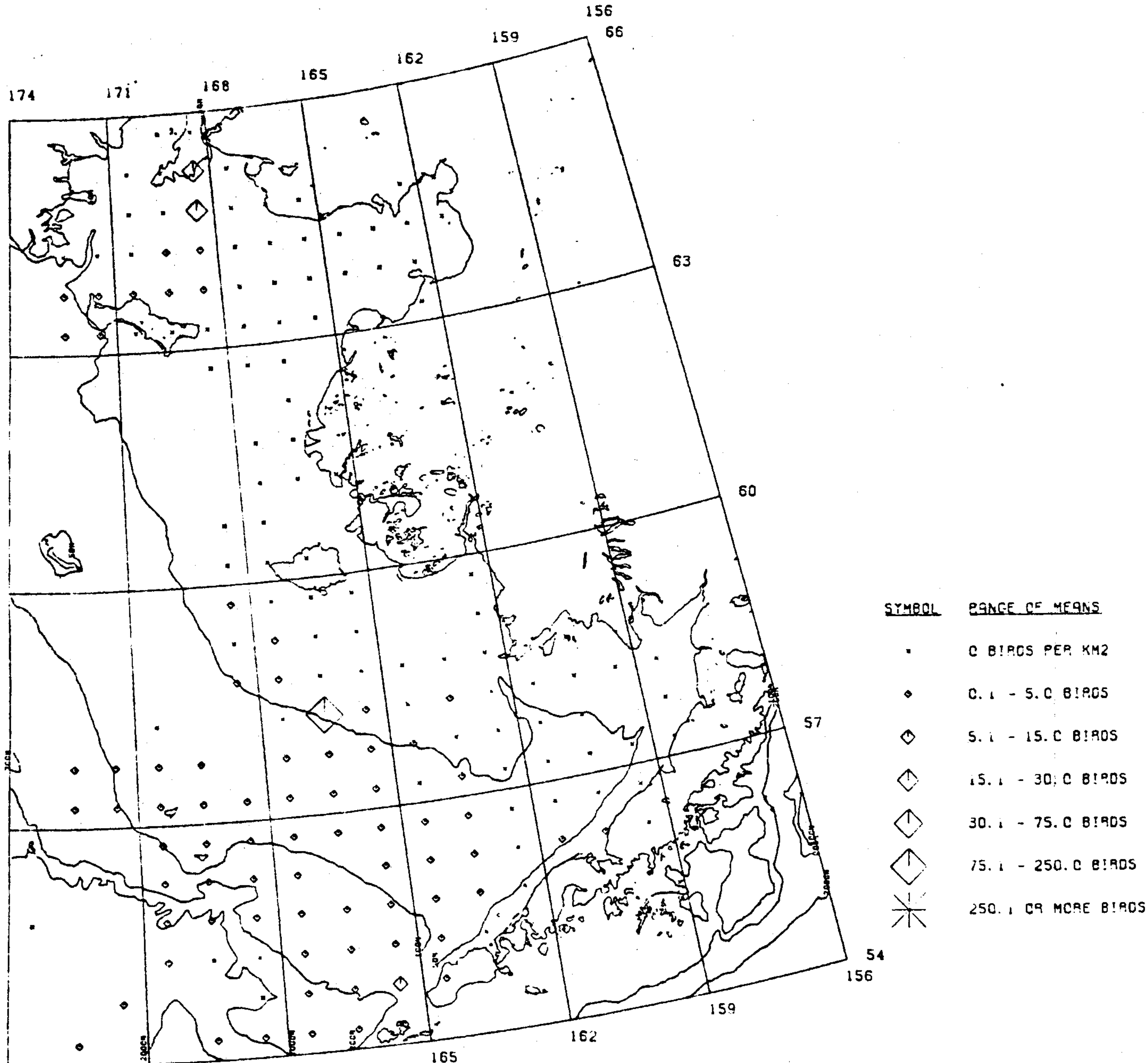
Figure 98



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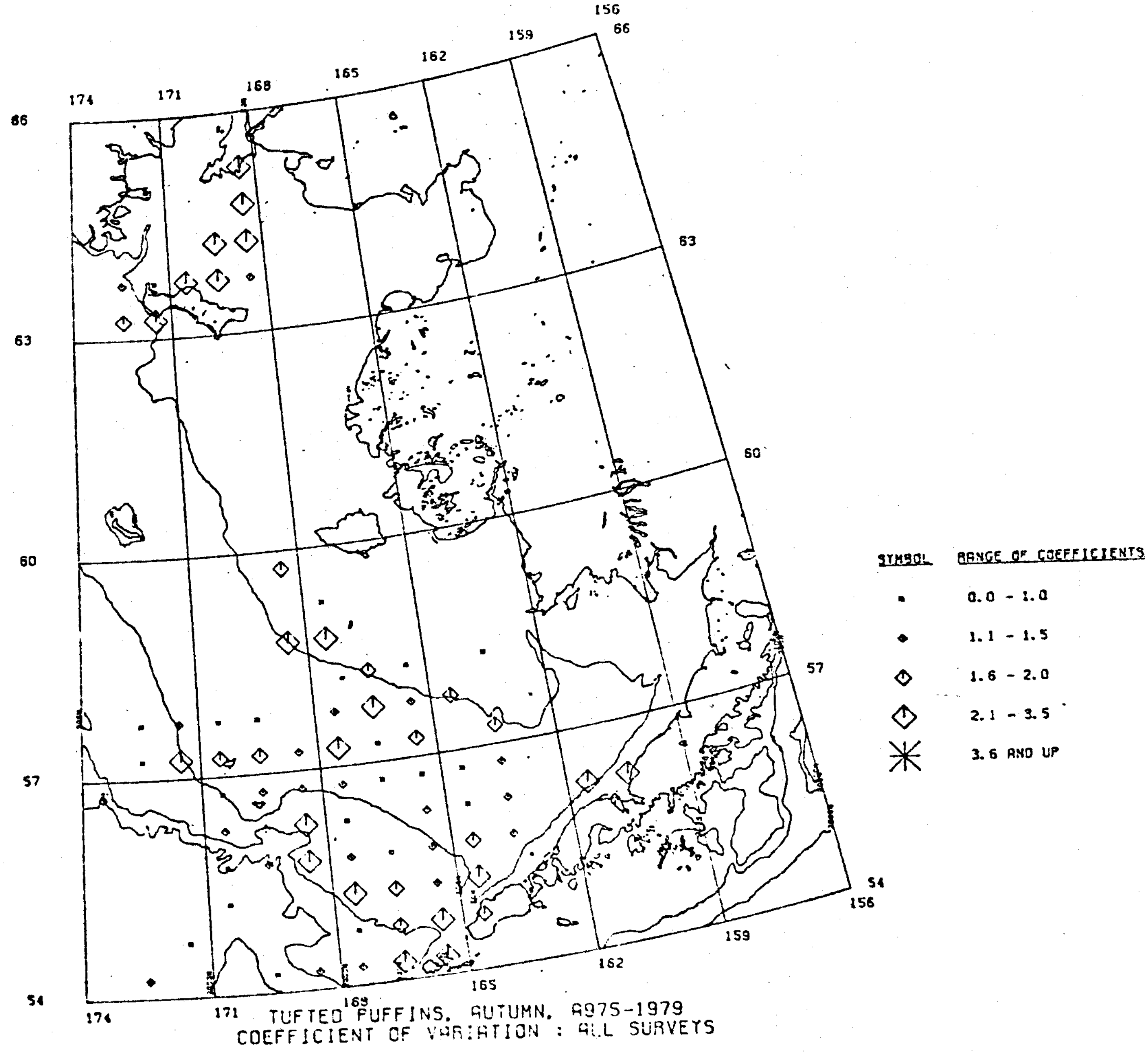

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FINAL REPORT

TO THE

OUTER CONTINENTAL SHELF ENVIRONMENTAL ASSESSMENT PROGRAM (OCSEAP)

Contract: 01-5-022-2538
Research Unit: 341
Reporting Period:
November 1977 to April 1978
Number of Pages: 123

THE WINTER FEEDING ECOLOGY AND TROPHIC RELATIONSHIPS OF MARINE BIRDS IN KACHEMAK BAY, ALASKA

by

Gerald A. Sanger and Robert D. Jones, Jr.

Reporting partially on the final results of research conducted under OCSEAP Research Unit 341, "Population Dynamics and Trophic Relationships of Marine Birds in the Gulf of Alaska," Calvin J. Lensink, Patrick J. Gould, and Gerald A. Sanger, Principal Investigators.

U.S. Fish and Wildlife Service
National Fishery Research Center
Migratory Bird Section
Anchorage, Alaska 99503

March 1981

LIST OF ERRATA AND TYPOGRAPHIC ERRORS

"The winter feeding ecology and trophic relationships of marine birds in Kachemak Bay, Alaska." Final report (in part) to the OCSEAP, Research Unit 341, "Population dynamics and trophic relationships of marine birds in the Gulf of Alaska," C. Lensink, P. Gould and G. Sanger, Principal Investigators.

Page.Para.Line(s).	Correction
Abstract.7.8	needs: drop "s"
2.2.2.	seven-bird: drop hyphen
2.2.7.	" . . . demersal crustaceans . . ."
9.1.2-3.	"microhabitats" one word; add hyphen after micro-
11.1.5.	influenced: drop "d"
11.3.3.	lower case "b" in Bay
11.3.4.	lower case "s" in Spit
12.1.3.	drop underline in spece between "et al"
12.5.1.	lower case "c" in Capelin
14.3.3.	add "d" to recorded
14.4.7.	"specimens were" should be "specimens was"
23.3.6.	drop comma after "...Table 1)"
40.5.2.	Capital "G" in glycymeris
48.1.5.	"are" should be "ate"
48.2.6.	unidentifiable
52.1.2.	drop first "y" in Neomysis
56.2.3.	April
56.5.5.	add "e" to murrelets
81.3.last.	add period at end
82.4.1.	existing
83.last.4.	Replace "Figure 40" with Appendix Table 4
84.3.3.	Sundberg
84.4.10.	". . . side of Cook Inlet . . ."
86.2.6.	". . . shore would appear . . ."
87.3.3.	ectoproct
87.4.1.	benthos
89.3.1	"We thank Paul Arneson . . ."

ABSTRACT

The winter feeding ecology of oldsquaw, white-winged scoters, common murres and marbled murrelets was studied on Kachemak Bay, Alaska, from November 1977 through April 1978. The birds together ate a minimum of 79 prey species. The sea ducks ate mostly benthic bivalves and gastropods, with fish and crustaceans sometimes important, while the alcids ate mostly pelagic and demersal crustaceans and fish.

Oldsquaw were extreme generalists, eating at least 60 prey species. The most important were sand lance, and the bivalves Spisula polynyma and Mytilus edulis. Scoters were generalists on molluscs, mostly bivalves. They ate at least 22 species; the most important were the bivalves Protothaca staminea and Mytilus, and the snail Margarites pupillus. Both sea ducks generally foraged in water less than 20 m, the oldsquaw over substrates of sand and mud, and the scoters over bottoms of shell debris and cobbles.

Murres ate at least 11 species of mid-water and demersal prey, mostly the crustaceans Neomysis rayii (mysid) and pink shrimp. Murrelets ate at least 8 prey species, primarily fish; capelin was the most important, followed by sand lance, the euphausiid Thysanoessa raschii, and mysids. Both alcids generally foraged in water deeper than 20 m over rocky bottoms, but the murrelets occurred relatively closer to shore.

Highly significant differences in average prey length were observed between oldsquaw and scoters, and between murres and murrelets.

The birds studied appear to have minimal impact on commercially important species of fish and shellfish.

The base of the food web in Kachemak Bay depends on the production and availability of organic detritus, which apparently originates largely from winter die-off of extensive kelp beds. However, little is known about ecological processes between kelp production, and production and availability of the birds' filter- and deposit-feeding prey.

Birds wintering in Kachemak Bay appear to be at high risk from both acute and chronic oil spills. Most of the wintering community of birds are either waterfowl or alcids, the two major groups of birds most susceptible to oiling. Pollution that interferes substantially with the production of organic detritus, particularly from the extensive beds of kelp, could have more serious long-term consequences to the birds than direct oiling. In general, any potential threats to the bird community from petroleum activities needs to be evaluated in terms of the pattern of ocean currents. Accidents which may occur on the south side of the outer Kachemak Bay, and around the southern primeter of the Kenai Peninsula would threaten the birds and their ecosystem more seriously than ones on the north side of the bay, which are "downstream" from most of Kachemak Bay.

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INTRODUCTION

Kachemak Bay, located at the southern end of Cook Inlet in southcentral Alaska, has long been recognized for its high biological productivity, important commercial fisheries, and recreational uses. The marine birds in Kachemak Bay recently received attention when Erikson (1977) studied their populations throughout 1976 as part of broadly based environmental studies of lower Cook Inlet by the Alaska Department of Fish and Game (Trasky, Flagg, and Burbank 1977). In winter, over 90% of the marine birds found in lower Cook Inlet were in Kachemak Bay. Erikson believed this was because Kachemak Bay remained essentially ice-free in winter, and that food was abundant in intertidal and nearshore subtidal waters.

Despite Erikson's (1977) study, the food habits and trophic relationships of this community of wintering birds remained essentially unknown. This was recognized as a major gap in the knowledge of lower Cook Inlet at the first "synthesis meeting" of the Outer Continental Shelf Environmental Assessment Program (OCSEAP) in November 1976. This study of the winter food habits and trophic relationships of birds in Kachemak Bay was subsequently added as a part of OCSEAP Research Unit 341 (Population Dynamics and Trophic Relationships of Marine Birds in the Gulf of Alaska).

Field studies were initiated in November 1977, and continued at monthly intervals through April 1978. The primary objectives of the study were: (1) to determine the kinds, amounts and trophic levels of prey used by the main species of marine birds wintering on the bay; and (2) to relate these findings to the physical and biological environment of the bay, particularly as related to potential petroleum development.

The species we studied and collected were limited to those present in the areas we could reach consistently. These were the oldsquaw (Clangula hyemalis), white-winged scoter (Melanitta deglandi), and common murre (Uria aalge). Erikson (1977) listed these species as abundant in lower Cook Inlet in winter. We discovered the location of marbled murrelets (Brachyramphus marmoratum) wintering in the bay in January and collected samples of this species from then until April. Erikson considered marbled murrelets common residents in lower Cook Inlet. No other species was consistently present in the areas we worked, but we collected small samples of surf scoters (M. perspicillata), black scoters (M. nigra), and pigeon guillemots (Cepphus columba). Glaucous-winged gulls (Larus glaucescens) and mew gulls (L. canus) were abundant near Homer Spit, but their proximity to human activities prevented our collecting them.

CURRENT STATE OF KNOWLEDGE

Ainley and Sanger (1979) reviewed the food habits of marine birds in the eastern subarctic North Pacific Ocean and coastal waters from literature published through spring 1975. However, there has been little effort to define and analyze the trophic relationships *per se* among marine birds. Wiens and Scott (1975) and Wiens *et al.* (1979) studied the feeding energetics of marine birds, but these and prior studies have stopped short of examining the interrelationships of energetics, food webs and prey trophic levels among ecological communities of marine birds and their prey. These topics are at the heart of understanding trophic relationships among animals, and much additional work is needed in this area.

Table 1 lists the general prey categories previously reported for the seven-bird species considered here. The three scoters prey mainly on bivalves and gastropods. In addition, benthic fish and fish eggs and larvae are minor dietary items of white-winged scoters; fish eggs, larvae, and plant matter are minor items to surf scoters; and, black scoters occasionally eat plant matter and benthic crustaceans. Oldsquaw prey mainly on benthic and emersal crustaceans and they also eat a variety of bivalves, gastropods, and benthic fishes. Common murres eat mostly mid-water fishes and benthic fishes, and mid-water crustaceans are less important in their diet. Benthic fishes are the major prey of pigeon guillemots, but they also eat cephalopods and benthic crustaceans. Mid-water fishes and crustaceans are reported as major prey of marbled murrelets.

STUDIES IN KACHEMAK BAY

Crow (1978) studied the foods of marine ducks shot by hunters in the China Poot Bay area of Kachemak Bay during two fall months in 1978. He did not indicate collection sites, but the birds were presumably taken close to shore over relatively shallow water. The mussel *Mytilus edulis* comprised the highest estimated volume of prey for scoters and other bivalves (possibly *Macoma* or *Tellina*) were less important. Marine algae and flower parts of beach rye (*Elymus mollis*) were minor prey items in white-winged scoters, as were algae and unidentified fish bones in surf scoters, and gastropods and sponge tissue in black scoters.

Knowledge of the distribution, abundance and species composition of the wintering marine bird community on Kachemak Bay is important to understanding their trophic relationships. During Erikson's (1977) study, numbers of sea ducks increased from Cook Inlet into Kachemak Bay. Numbers of gulls increased dramatically along the north shoreline of the outer bay near Bluff Point, and large numbers were seen feeding on cannery waste at the end of Homer Spit. In the same study, a pelagic survey on March 17, 1976 across the mouth of the inner bay revealed sizeable populations of oldsquaw, common murres, pigeon guillemots, and lesser numbers of marbled murrelets.

Table 1. General Categories of Prey Reported for Selected Species of Marine Birds Along the Pacific Coast of North America. X = major dietary item; o = minor item; . = incidental item. Adapted from Ainley and Sanger 1979

	General Type of Prey							
	Fish			Mollusca		Crustacea		Plants
Bird Species	Midwater	Benthic	Eggs/Larvae	Cephalopod	Clams/Snails	Midwater	Benthic	
Oldsquaw *Clangula hyemalis*		o			o	o	X	
White-winged Scoter *Melanitta deglandi*		o	o		X			
Surf Scoter *M. perspicillata*			o		X			o
Black Scoter *M. nigra*					X		o	o
Common Murre *Uria aalge*	X	o				o		
Pigeon Guillemot *Cepphus columba*		X		o			o	
Marbled Murrelet *Brachyramphus marmoratus*	X		o			o		

On March 30, 1976, a similar survey from the end of Homer Spit due westward for ca. 22 km into the outer bay encountered an enormous flock of white-winged scoters, which Erikson estimated at 10,000 birds; he believed that these birds spent the entire winter in Kachemak Bay. He saw fewer common murres, pigeon guillemots, and marbled murrelets. There were large numbers of white-winged scoters along the 20-fathom isobath between Yukon Island and Seldovia Bay in February 1977 (unpublished USFWS data).

Sea ducks collected for food studies in spring 1976 in Kachemak Bay (David Erikson, unpublished data) showed that oldsquaw preyed mostly on the clam Nucula tenuis and ate some Macoma balthica in the northern part of the inner bay. Surf and black scoters ate mainly Macoma balthica in the same area. White-winged scoters had a more diverse diet, but had mainly eaten the clam Nuculana fossa. All three species of scoters on the south side of the bay between Halibut Cove and China Poot Bay had preyed heavily on the mussel Mytilus edulis.

OTHER PERTINENT STUDIES

Stott and Olson (1973) studied the populations and food habits of seven species of marine ducks on the New Hampshire Coast in winter. Oldsquaw had the most generalized diet, consisting mainly of bivalves, gastropods, sand shrimp, and isopod crustaceans. The three scoters selectively used areas of sandy substrate and had quite similar food habits, preying principally on bivalves. All sea ducks were generally concentrated near the mouths of estuaries. A major conclusion of the study was that "...food availability, coupled with the physical structure of the substratum in the different coastal habitats, is apparently a major determinant in the way that coastal water fowl selectively use habitat types."

The feeding ecology of oldsquaw and black scoters was studied along the coast of south Sweden in winter (Nilsson 1972). The bivalves Mytilus edulis and Macoma balthica dominated in 156 oldsquaw stomachs. Other species of bivalves, polychaetes, mysids, gammarid amphipods, plant matter, and occasionally flatfish were also present, but gastropods were conspicuously absent. Most oldsquaw foraged to depths of 22 m, over stoney and gravelly substrates with concentrations of Mytilus, or over sandy bottoms rich with Macoma. Mytilus and Macoma also dominated in 14 black scoter stomachs. Scoters seen during boat surveys were usually in water of 0-15 m, but ocasionally to 20 m.

Similar results were obtained for wintering oldsquaw collected along the coast of Denmark (Madsen 1954). By percent frequency of occurrence, bivalves accounted for 47% of the prey, gastropods 13%, crustaceans 28%, fishes 7%, polychaetes 3%, and echinoderms 2%. The most important genera of prey were the bivalves Cardium and Mytilus, the amphipod Gammarus, and isopod Idothea. Madsen (1954) observed that oldsquaw foraged mainly at sea at night, but in daytime they foraged nearer the coast. Black scoters foraged in depths of 20-30 m, and the frequency of occurrence of major prey were: Bivalves, 95% (mainly Mytilus and Cardium); gastropods, 16%; crustacea, 11%; polychaetes, 13%; echinoderms, 4%; and vegetable matter, trace. Madsen concluded that the birds he studied had eaten the same broad categories of prey reported by other authors. He believed that the maximum prey size was "fairly fixed" for each bird species, but the minimum sizes varied with the availability and abundance of smaller prey. The birds ate larger sizes of soft-bodied prey such as fishes and soft-shelled crustacea than hard-shelled kinds.

Common Murres prey principally on mid-water fishes up to seven inches (178 mm) (Tuck 1960, and papers he cites). Capelin (Malotus villosus) are of particular importance off Newfoundland in winter. In summer in the eastern Bering Sea (Ogi and Tsujita 1973) and in the Sea of Okhotsk (Ogi and Tsujita 1977), mid-water schooling fishes, primarily walleye pollock (Theragra chalcogramma) dominated the stomach contents of murres. Squid and euphausiids were less important, although the latter accounted for 15% by weight of food eaten by murres in the southeastern Bering Sea. There appears to be little information on the feeding habits of common murres in protected waters such as Kachemak Bay.

Sealy's (1975) study of the feeding ecology of marbled and ancient murrelets in British Columbia during the breeding season is one of the few with data on prey lengths. He noted that the marbled murrelets consistently foraged within 500 m of shore, in areas sheltered from prevailing winds and in water depths less than 30 m. Four marbled murrelets collected in winter near Vancouver Island (Munro & Clemens 1931) contained remains of shiner perch (Embiotocidae), and mysids.

STUDY AREA

Trasky et al. (1977) provide extensive information on the geography, climate, oceanographic environment, fisheries, and other living resources of Kachemak Bay. Descriptions below are from this report, unless cited otherwise.

PHYSIOGRAPHY AND GEOGRAPHIC SETTING

Kachemak Bay is a major geographic feature of the Kenai Peninsula and Cook Inlet (Figure 1). The bay is 38 km wide at its entrance, defined as a line from Anchor Point on the north to Point Pogibshi on the south; and it is approximately 62 km long. The extreme upper 6 km are mud flats which are exposed most of the time. Away from shore, water depths are relatively shallow throughout the bay, mostly ranging from about 35 to 90 m (20-50 fm). Maximum depths, occurring just offshore between Yukon and Gull Islands, range from about 110 to 165 m (60-90 fm). At about the midway point of the north shore, Homer Spit projects for about 7 km into the bay. This Spit divides the bay into physically and biologically distinct sub-areas termed the "inner" and the "outer" bays.

Kachemak Bay is bordered on the north by rolling hills up to about 460 m and the northern shoreline is unbroken by inlets. The rugged Kenai Mountains border the south side of the bay and rise to elevations of 1,200-1,500 m (4,000-5,000 ft.) within 9 km of shore. The southern shoreline, in marked contrast to the northern one, has several islands, fjords and shallow bays. Extensive shoals lie adjacent to the north shore. For example, the 5 fm contour is about 3-4 km off the north shore of the inner bay, and from Homer Spit to a point opposite Bear Cove, about 25-40% of the inner bay is comprised of water less than 5 fm at mean lower low water (NOAA Nautical Chart 16645). An area of about 36 km^2 at the extreme head of the bay upstream of Chugalak Island is comprised entirely of mud flats or water of less than a fathom.

Areas shallower than 5 fm near Homer and Homer Spit in the outer bay are more subject to tidal currents than the inner bay and the type of substrate is markedly different. The bottom of the outer bay has been classified into various substrate types (Figure 2, after Driskell and Lees 1977). Boulders and cobbles predominate in depths less than 10 fm along the north shore. From here to the 20 fm line, an area which comprised a major foraging habitat for benthic feeding birds, the substrate is shell debris, muddy sand, or rippled sand. In the inner bay, an important foraging area for oldsquaw, mud flats with scattered boulders (NOAA Nautical Chart #16645) occur immediately adjacent to the north shore. Clays originating from the glacial streams at the head of the bay and from erosion of bluffs extend from here to the 10 fm line. Presumably, scattered boulders also

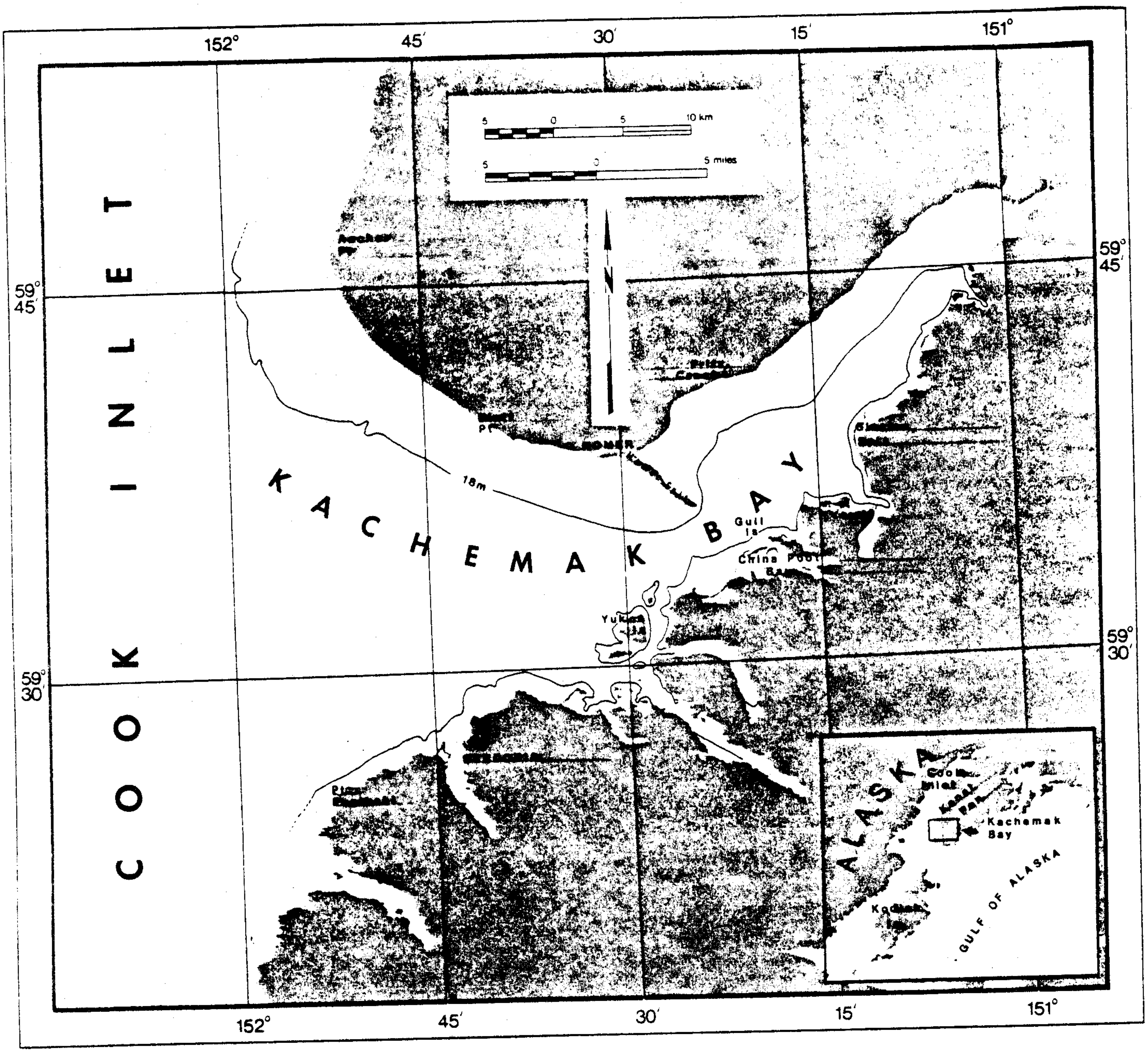

Figure 1. Kachemak Bay, Alaska , indicating features mentioned in text.

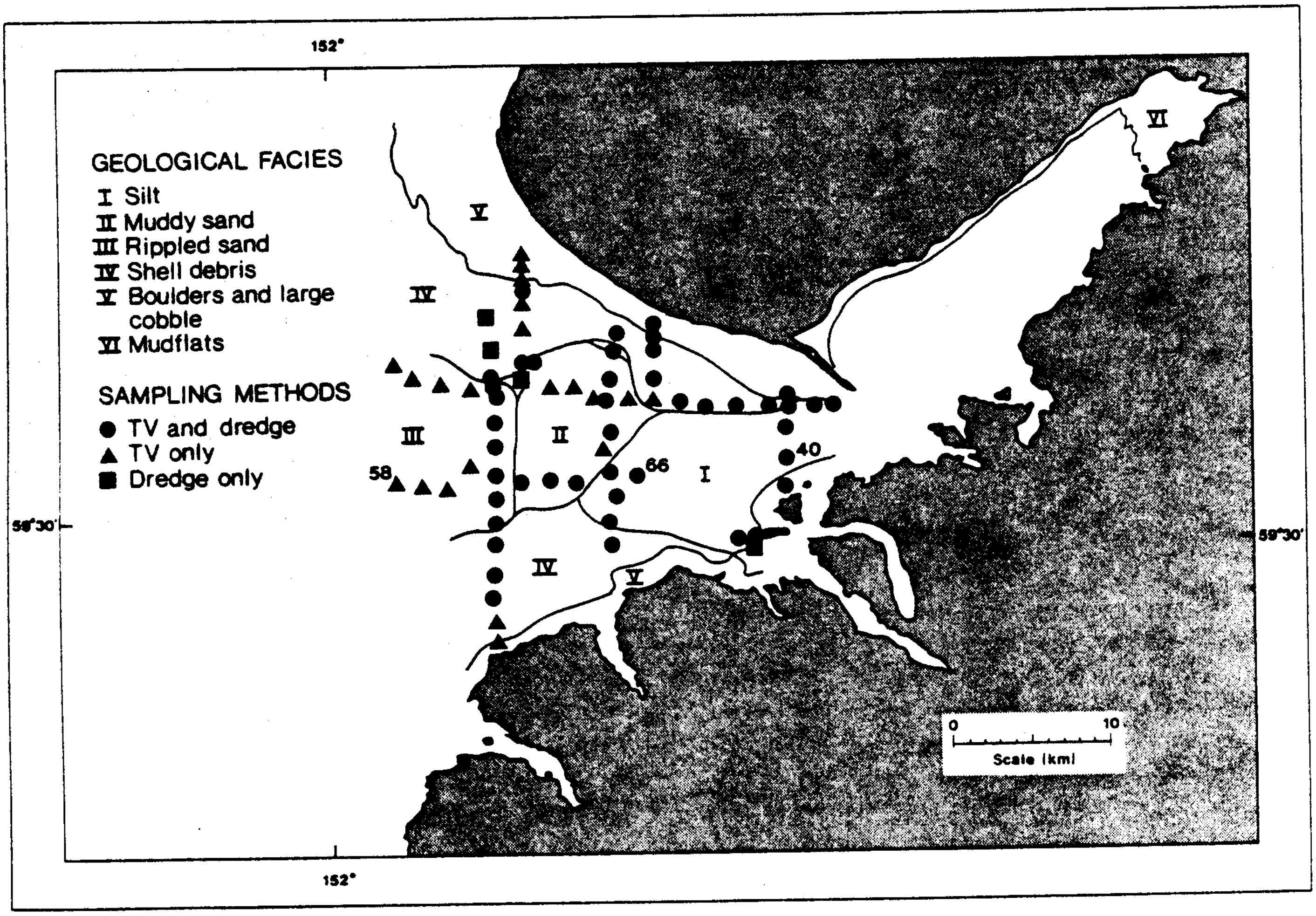

Figure 2. Types and locations of bottom substrates in Kachemak Bay. After Driskell and Lees 1977, and SAI 1979.

occur in adjacent subtidal depths. These boulders contain communities of mussels (*Mytilus edulis*) and other biota, thus constituting rocky micro habitats amid the mud and sand bottom (Less 1978).

OCEANOGRAPHY AND THE MARINE ENVIRONMENT

Climate and Weather

Climatically, Kachemak Bay is transitional between the maritime Gulf of Alaska and the continental climate of interior Alaska. Cool summers, mild winters, and frequent storms characterize the area. Precipitation averages 71 cm (28 in.) per year, including 257 cm (101 in.) of snow. Air temperatures in winter generally range from -8.3 to 5.6°C (17 to 42°F), with occasional lows below -18°C (0°F). During this study, temperatures ranged from -13°C in December to 4°C in April.

Local topography exerts a strong influence on wind direction (Hayes, Brown and Michel 1977) and prevailing north and northeast winds parallel the northeast-southwest axis of the bay. Wind speeds at Homer average 5.7 knots in winter, with extremes up to 50 knots and occasionally as high as 75 to 100 knots.

Physical Oceanography

Information on water circulation and general features of physical oceanography are summarized from Burbank (1977) and Trasky *et al.* (1977), unless noted otherwise. Most water in Kachemak Bay is normally intruded from the Gulf of Alaska via Kennedy Entrance. A variety of evidence suggests that this water originates with coastal upwelling northwest of Elizabeth Island located just south of southernmost Kenai Peninsula. The general scheme of surface and subsurface circulation in outer Kachemak Bay in summer (Figure 3) indicates two adjacent, counter-rotating gyres on the south side of the bay and a net northwest current out of the bay, parallel to the north shore between Homer Spit and Anchor Point. It is uncertain how accurately Figure 3 reflects winter conditions; variations in the observed pattern are frequent, even in summer.

The inner bay is a positive estuary in summer when river runoff and precipitation exceed evaporation. The surface circulation (Figure 3) is characterized by two adjacent, counter-clockwise gyres over the southern, deep water part of the bay, and a southwest, longshore current over the shallow northern part of the bay.

There is little direct evidence, but relatively saline water from below 30 m is probably entrained into the inner bay from deeper than 30 m, coinciding with a net outward flow of low salinity water at the surface. The inner bay is well-mixed, with salinities ranging from near zero at the

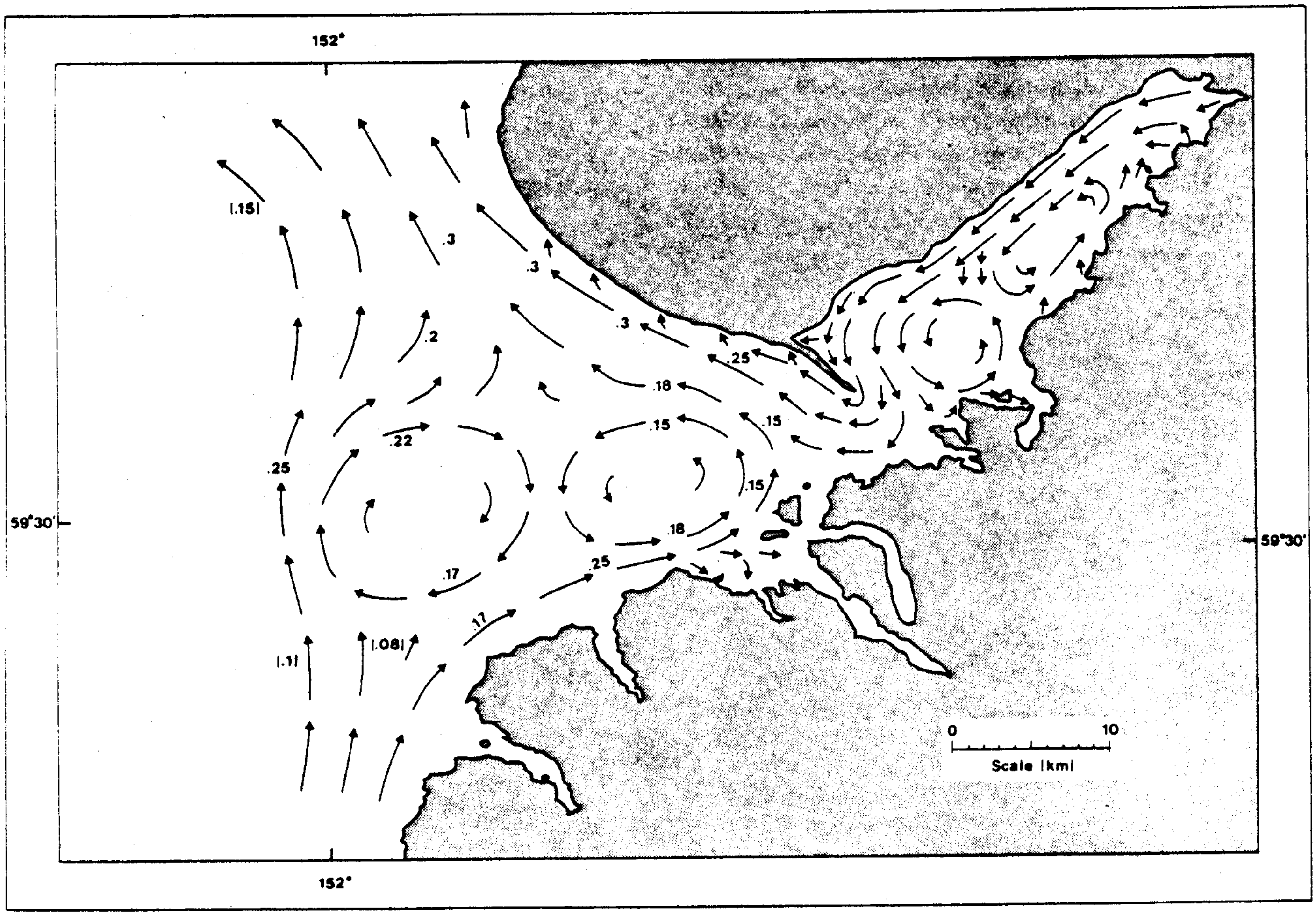

Figure 3. Surface circulation in Kachemak Bay in spring and summer, with typical net surface current velocities in knots. After Burbank 1977 and SAI 1979.

head of the bay near river mouths, to as high as 32.5‰ (parts per thousand) at the entrance to the inner bay (Bright, Durham and Knudsen 1960, as cited by Burbank 1977). However, typical salinity values for summer 1973 were 29-30‰ even in the more saline outer bay (Shumacher, Sillcox, Dreves & Muench 1978). Circulation patterns directly influenced the transport of mineral sediments and organic detritus. Sedimentation affects substrate type and thus, the nature of benthic animal communities, and organic detritus is believed to form the base of the ecosystem in Kachemak Bay (Lees et al. 1980).

There is little oceanographic information for Kachemak Bay in winter. In early March 1977, temperatures were 6°C and salinities were about 32‰ in Kennedy Entrance from the surface to the bottom, indicating a well-mixed water column (Shumacher et al. 1978). Given the current pattern noted above, temperatures and salinities were likely similar in outer Kachemak Bay. During this study, surface water temperatures generally ranged from 4 to 5°C.

In severe winters, ice builds up considerably in the inner bay behind Homer Spit. Most ice probably forms from freshwater runoff at the head of the Bay and is carried by ebbing tides and the prevailing northeast wind to the Spit. During this study, moderate amounts of pan and brash ice were encountered in Homer Harbor and adjacent areas of the inner bay during each month from December to March. In particularly severe winters, fast ice has extended up to three miles off the north shore of the outer bay, but such ice was not seen during this study. Ice scouring of the bottom in intertidal and shallow subtidal depths can adversely affect the benthos (Lees et al. 1980), thus directly influencing the distribution and abundance of the birds' prey.

Primary Productivity

The classical view of primary production in the sea emphasizes the role of phytoplankton in the water column (e.g., Sieburth and Jensen 1970; Strickland 1970; Steele 1974). Larrance and Chester (1979) believe that zooplankton grazing on the phytoplankton and the subsequent production and sinking of fecal pellets was the main source of organic detritus reaching the floor of outer Kachemak Bay. Phytoplankton productivity in the water column was consistently high from May to August 1978. The significance of phytoplankton production during the remaining two-thirds of the year from September to April remain unknown, but it is probably insignificant in mid-winter. The existence of phytoplankton production within and beneath the ice (cf. McRoy and Goering 1974) has not been observed (nor suspected) in Kachemak Bay, because of the ice's freshwater origin, instability, and relatively short duration.

The importance of phytoplankton production should not be minimized, but organic detritus from other sources may play a major role in driving coastal marine ecosystems (Tenore 1977; Sieburth and Jensen 1970; Strickland 1970; Mills 1975). This may be particularly true for Kachemak Bay. Lees et al. (1980) contend that laminarian and fucoid kelps around the southern end of the Kenai Peninsula and in Kachemak Bay are the major source of this detritus. Other sources of the total load of organic detritus in the bay are of terrestrial origin via streams, from salt marshes bordering the bay (Crow 1978), and from peat sloughing directly into the bay from the bluffs along the north shore (M.P. Wennekens, personal communication). While the relative importance of phytoplankton productivity and organic detritus from its various sources remains quite unclear, it seems likely that the seasonal die-off and abrasion of kelp during winter storms could be a major source of detritus in Kachemak Bay, when productivity of phytoplankton is at its lowest.

Another unexplored source of productivity in Kachemak Bay could be water soluble organic fractions from kelp (Lees et al. 1980). Up to 40% of all production by kelp may result in such material (Sieburth and Jensen 1970). This material has been shown to be important in collating and precipitating detritus, and it may be used directly as an energy source by bacteria (Sieburth 1968).

Regardless of the origins of organic detritus in Kachemak Bay, the important point concerning the winter feeding ecology of marine birds is that most of the birds' prey species are deposit or filter-feeders (Lees et al. 1980; Feder and Paul 1979). As such, they are able to use organic detritus and its bacterial coating and associated microfauna (Tenore 1977) for food, so the birds' food supply is closely linked to the existence and production of organic detritus.

Distribution of Pelagic Fauna

Given the dynamic nature of the movements and numbers of pelagic fauna and the incomplete picture of their status in Kachemak Bay in winter, it is difficult to relate distribution or abundance of birds to that of their pelagic prey. However, general ideas of distribution and abundance of some organisms are available (Blackburn 1978; Haynes 1977; Barr 1970; and information from these and other sources as summarized by SAI 1979).

Birds ate a number of fish species (see below) but only three, Capelin (*Mallotus villosus*), walleye pollock (*Theragra chalcogramma*), and Pacific sand lance (*Ammodytes hexapterus*), were important to one or more bird species. There is little data available for these species in winter, but it seems likely that juvenile capelin (age classes I and II) occur from the surface to mid-depths, or perhaps even to the bottom. Although juvenile capelin stay near the surface above the thermocline in the western Atlantic in summer (Jangaard 1974), winter temperatures are likely uniform from the surface to the bottom in Kachemak Bay, and capelin may be distributed throughout the water column.

Even less is known about the winter habits of pollock and sand lance. Presumably pollock occur mainly at mid-water and demersal depths (Smith 1979) and sand lance are found mainly in, on, or near the bottom (Meyer _et al._ 1979). Sand lance were very important to oldsquaw collected in the shallow inner bay and, with the distinctive benthic character of the rest of the prey of oldsquaw, it seems quite possible the birds captured sand lance while they were buried in the bottom sediment (Meyer _et al._ 1979). Salmonids were not recorded in the diets of any birds, most likely because they are not abundant in the bay until late May (Blackburn 1978).

In the southern, deep portion of the outer bay in January 1967, pink shrimp (_Pandalus borealis_) were found from the surface to the bottom at night, but mainly concentrated at the 20-30 m level. During daylight hours they remained below 50 m (Barr 1970). Shrimp are thus available to the birds throughout the water column at some time in their diurnal cycle.

There is very little information on the distribution of the birds' benthic prey. This circumstance is discussed subsequently.

METHODS

FIELD METHODS

We collected birds for stomach samples and observed their distribution and feeding behavior during monthly field trips of three to five days, from November 1977 to April 1978 (Table 2). We worked in three general areas of the bay, largely determined by the prevailing weather and by the birds' distribution in areas safely reached from Homer Harbor in the 6.7 m (22 ft.) work boat. We collected sea ducks in two areas within a few kilometers of shore: 1. Between Homer Spit and Anchor Point in the outer bay; and 2. Between Homer Spit and Fritz Creek in the inner bay (Figures 4 and 5). In addition, we had available two white-winged scoters that had been collected off Seldovia Bay in February 1977. Most murres and murrelets were collected in a third area on the south side of the inner bay between Gull Island and Glacier Spit (Figure 6 and 7). In addition, we collected murrelets in China Poot Bay in January.

We patrolled one of the three areas until adequate concentrations of a desired species were seen. The behavior of birds to be collected was observed briefly before we attempted to obtain samples of at least five birds. Due to the constant threat of storms and the short winter daylight, we worked in a given area as quickly as possible and moved on to another area to seek the other desired species. The stomachs of all specimens were injected with 10% buffered formalin to arrest digestion (van Koersveld 1950). Specimens were then frozen until laboratory processing. Field data recorded for individual specimens included the location, date and time of collection.

LABORATORY METHODS

Frozen specimens were stored in a laboratory freezer until processing, which was usually completed within two weeks. For initial processing, specimens were thawed and we recored standard ornithological measurements and a "fat index," a qualitative evaluation of the amount of body fat (Table 3). We determined the sex and age of the specimen, removed the upper digestive tract (esophagus, proventriculus, and gizzard), and stored it in 50% isopropanol until analyzing the stomach contents.

To analyze the stomach contents, we carefully opened the digestive tract with fine pointed scissors and removed any non-food items such as rocks. The stomach contents were drained of excess moisture, weighed to the nearest 0.1 g, and their volume measured to the nearest ml by water displacement. We then counted and identified the prey items to the lowest possible taxon, and visually estimated the volume of each kind of prey as a percent of the total. The greatest length of whole specimens were measured

Table 2. Dates and numbers of birds collected in Kachemak Bay, Alaska, in winter for feeding ecology studies.

	Number of Birds Collected							
	1977			1978				
Species	Feb. 22	Nov. 9-13	Dec. 6-10	Jan. 9-12	Feb. 8-12	Mar. 6-9	Apr. 3-5	TOTALS
Oldsquaw		5	5	5	5	6	2	28
White-winged scoter	2	1	2	14	10 [c]	5 [a]	5	39
Black scoter		1					1	2
Surf scoter			1			1	2 [b]	4
Common murre			6	9	5 [b]	6 [c]	5	31
Pigeon guillemot				1		1	1	3
Marbled murrelet				6	5 [c]	5 [d]	5	21
Totals	2	7	14	35	25	24	21	128

a no prey volume data on 1 bird
b 2 empty stomachs
c 1 empty stomach
d No prey volume on 2 birds

Table 3. Criteria for determining the fat index of marine birds, modified after scheme designed for use on freshwater waterfowl (U. S. Fish & Wildlife Service, Northern Prairie Wildlife Research Center, Jamestown, ND).

Fat Index	Visibility of Feather Papillae on Breast	Presence of Fat on			
		Viscera and Neck	Skin	Humerus and Femur Region	Bifurcation of Clavicles
1	Very Evident	Very little	None	Little fascia and grey-orange fat	None
2	Still visible	Some	Some	Slight streak along femur	Slight streak along trachaea anterior to
3	Visible in dorsal half of belly tracts only	Moderate	Partially covered	Present	Present
4	Not visible through skin	Consolidated masses	Completely covered	Moderate	Moderate
5	Not visible through skin	Consolidated masses	3-6mm thick extending over lower belly	Heavy	Heavy

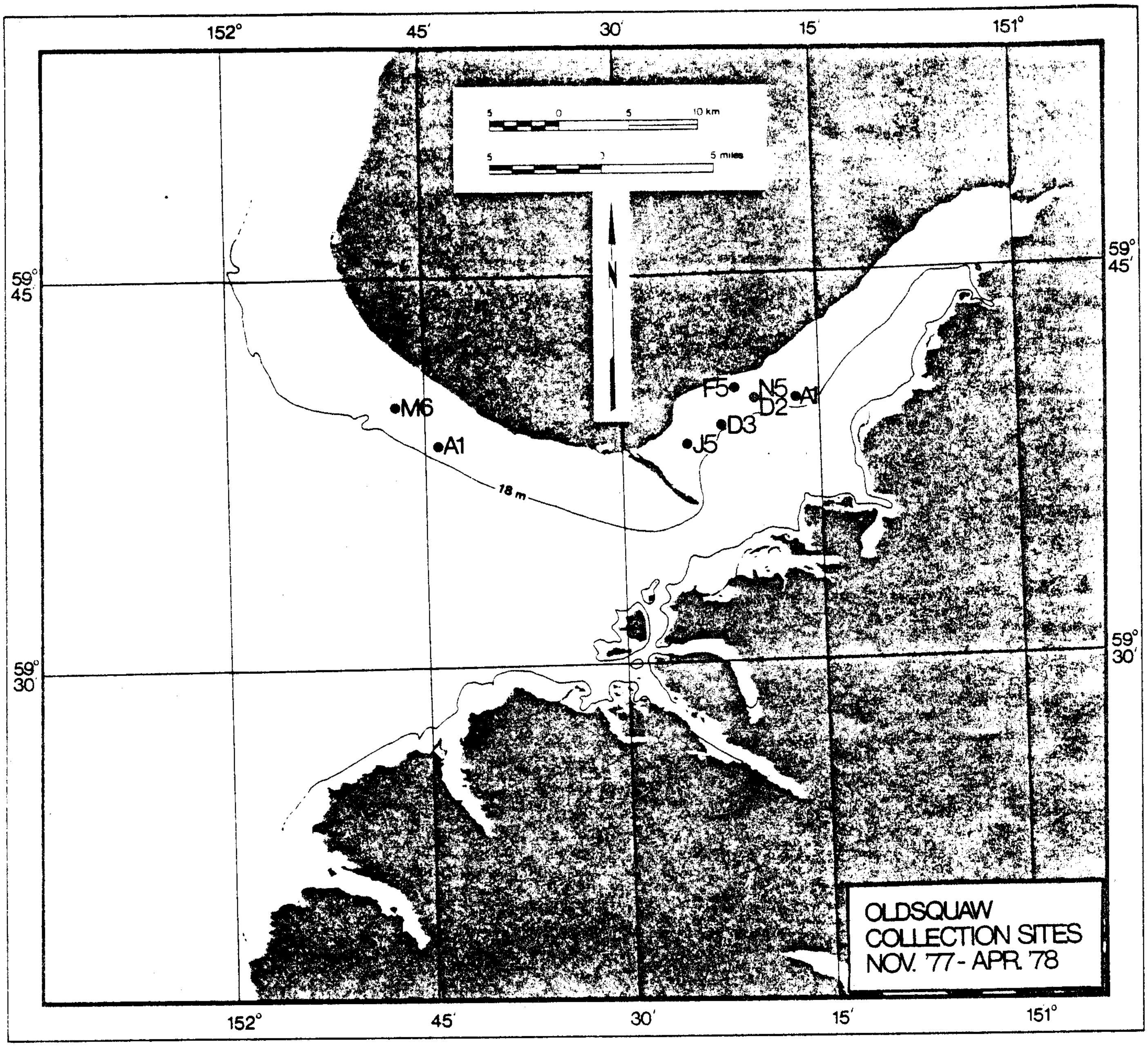

Figure 4. Collection sites of oldsquaw ducks. Letters and numbers indicate month and number of birds collected.

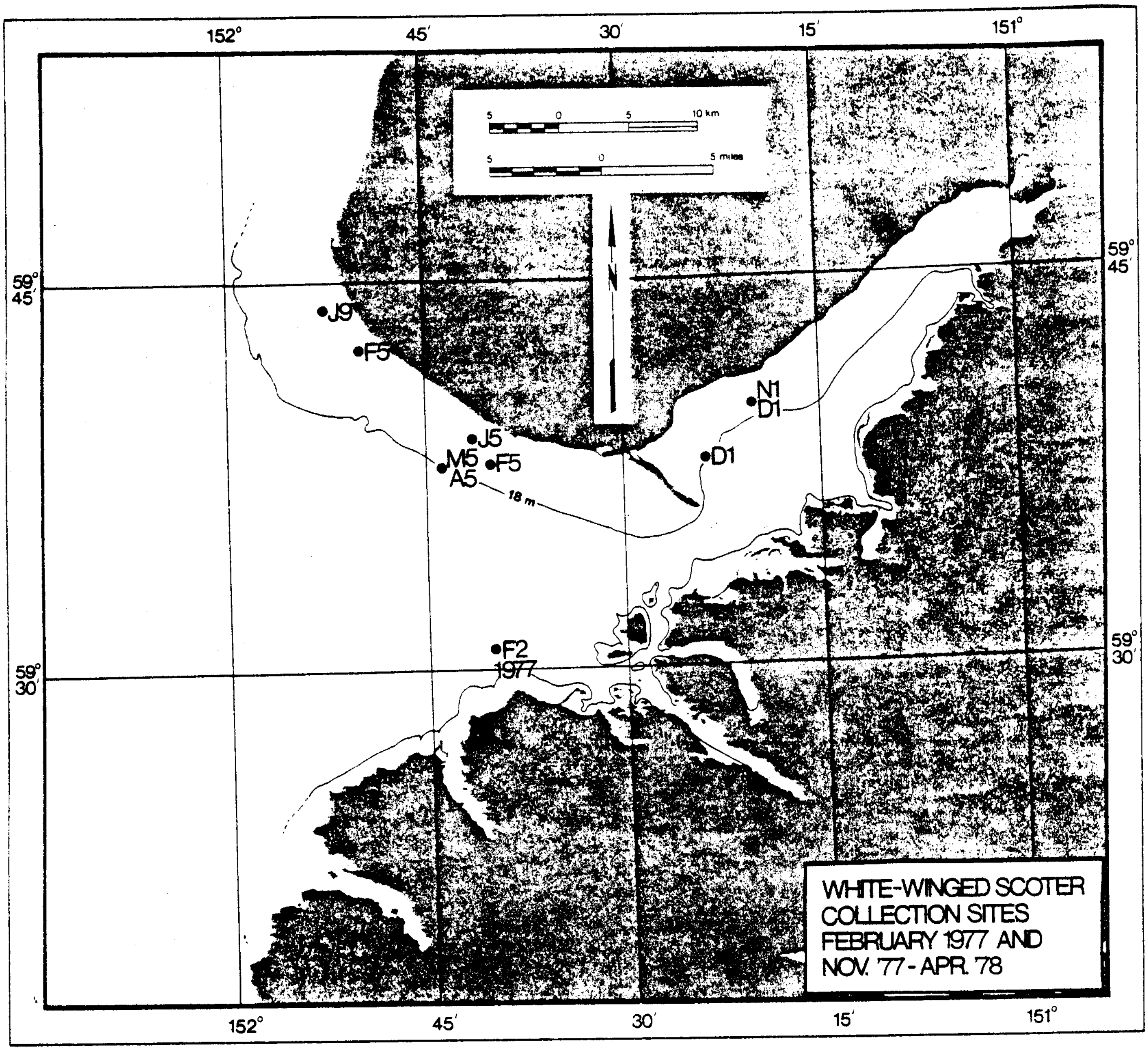

Figure 5. Collection sites of white-winged scoters. Letters and numbers indicate month and number of birds collected.

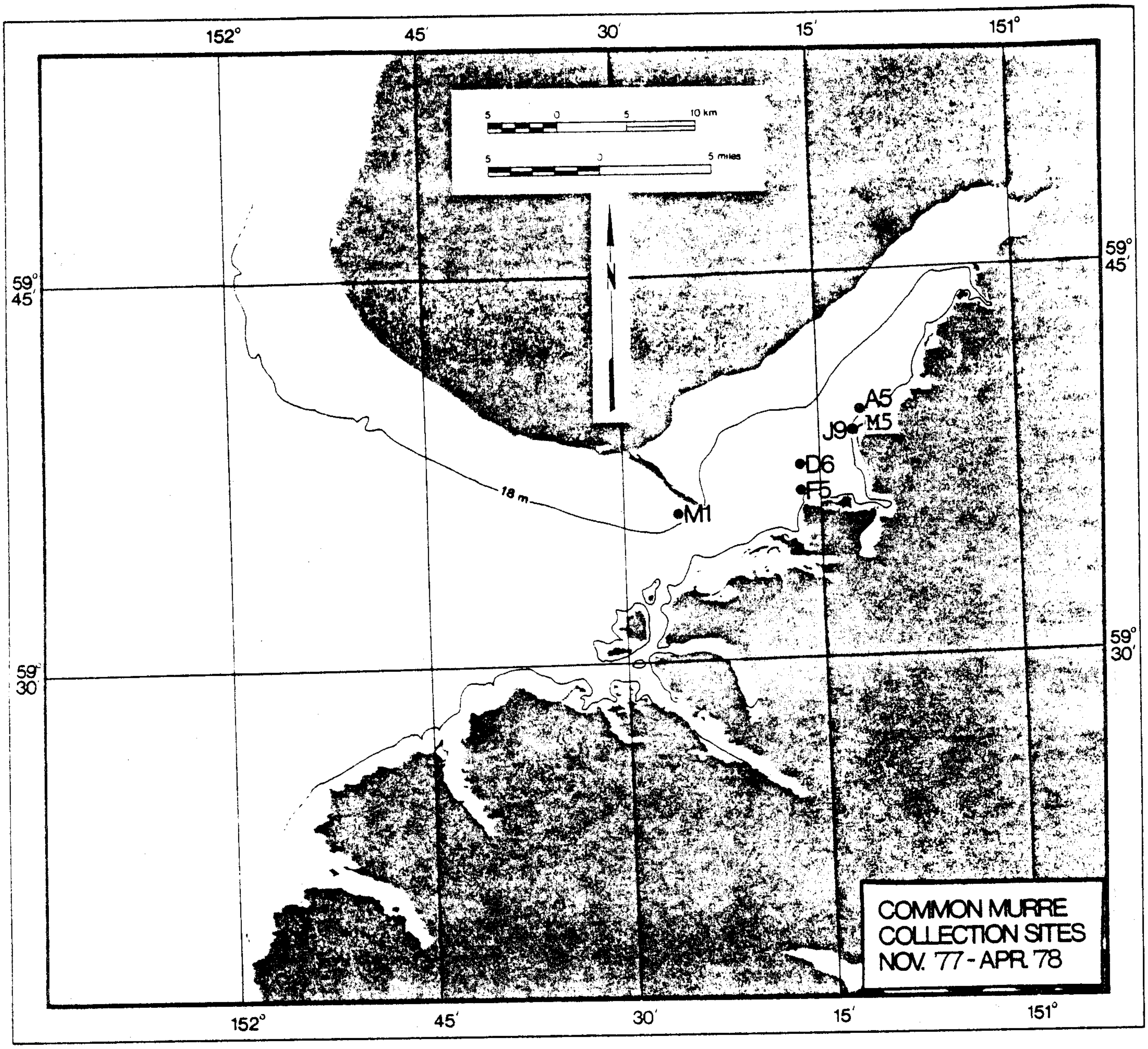

Figure 6. Collection sites of common murres. Letters and numbers indicate month and number of birds collected.

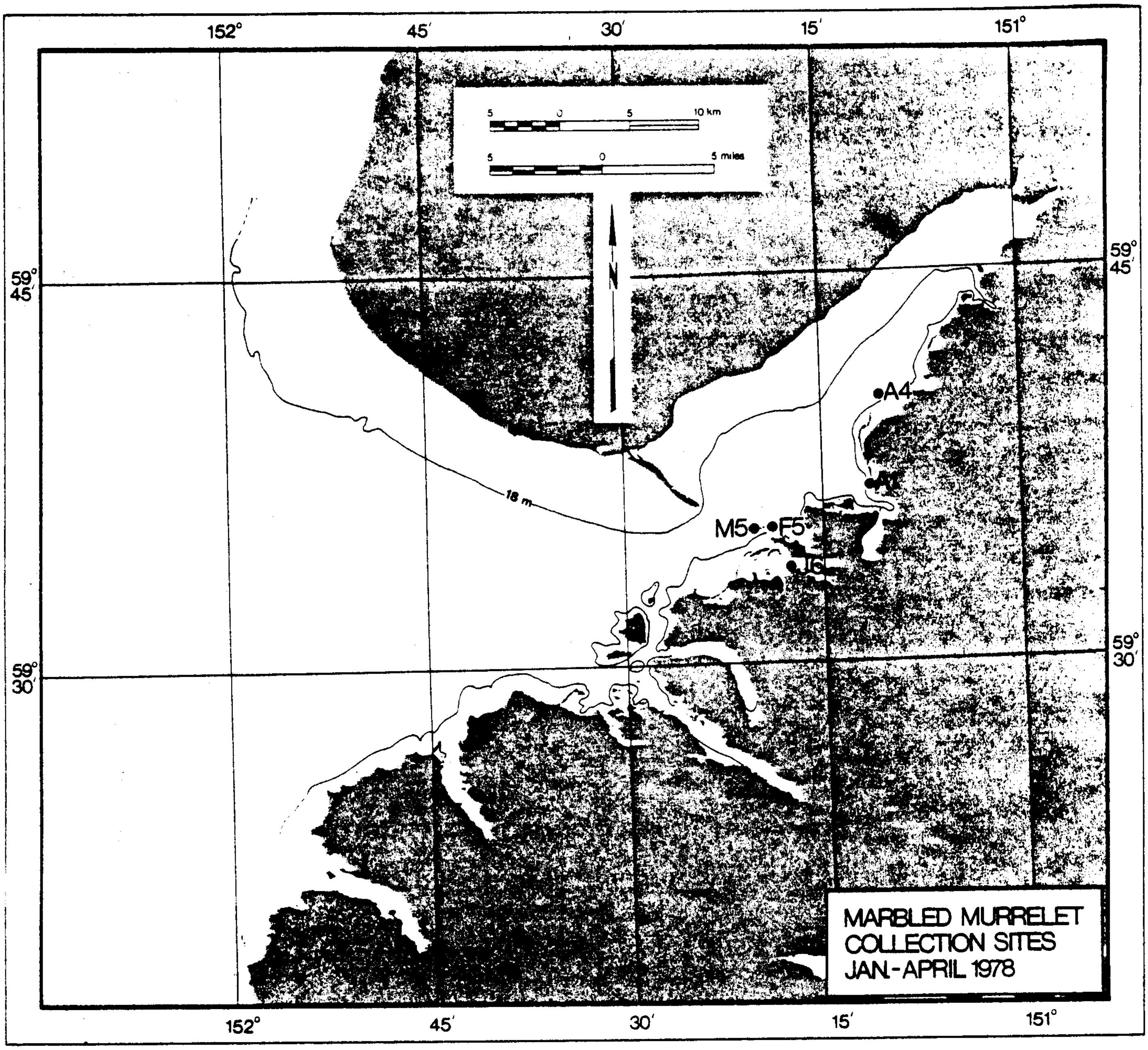

Figure 7. Collection sites of marbled murrelets. Letters and numbers indicate month and number of birds collected.

to the nearest mm, or in the case of fish otoliths (Frost and Lowry, in press) and fish vertebral columns and parasphenoid bones (Sanger et al. 1978), to the nearest 0.1 mm. We verified our prey identifications by consultation with taxonomic specialists (see Acknowledgments) and maintained a collection of voucher specimens for comparison with subsequent collections.

DATA ANALYSES, INTERPRETATION, AND PRESENTATION

This report analyzes the feeding ecology of the birds by examining their food habits, their feeding behavior, and their geographic distribution in relation to feeding habitats. We analyzed trophic relationships per se among the birds and their prey by comparing the relative importance of each prey among the birds and the sizes of the prey when known.

The term "feeding habitat" is defined as the location a bird captures its prey in terms of water depth, and in proximity to the sea surface, the sea bed, and for bottom-feeding birds, by the type of substrate. At times, it may be possible to use oceanographic features to describe feeding habitats, but this seems unlikely in Kachemak Bay in winter when the water column is probably well mixed.

A certain amount of speculation is needed to categorize the feeding habitat(s) of each bird species. However, by comparing the substrate types beneath the birds' collection sites (Driskell and Lees 1977) with what is already known about a bird's feeding behavior and the normal habitats of the prey in their stomachs, such speculation is credible. We collected birds only if they were sitting on the water, and have assumed that they captured their prey in the immediate vicinity. We often saw oldsquaw, common murres, marbled murrelets, and pigeon guillemots diving and presumably feeding before we collected them.

Three basic parameters were used to describe prey taxa in the stomach samples: The aggregate percent volume (cf. Martin, Gensch and Brown 1946; and Swanson et al. 1974); the aggregate percent numbers; and the percent frequency of occurrence. To calculate the aggregate percent volume of a prey taxa, we summed its measured volumes from all stomachs with food and then expressed this total as a proportion of the combined volumes of all prey. Aggregate percent numbers were calculated similarly. We also calculated these parameters for related groups of taxa (total fish, total crustaceans, total shrimp, etc.) to enable us to evaluate the importance of taxonomically related groups of prey. The percent frequency of occurrence is the percent of a sample of stomachs with any prey in which a particular prey taxa was found.

Pinkas, Oliphant and Iverson (1971) discussed the shortcomings of using any of these values alone to depict the importance of prey to a predator. In brief, differential digestion rates of hard and soft-bodied prey may distort their original relative volumes; percent numbers can make an abundant small prey seem more important than sparse larger ones, and percent frequency of occurrence ignores numbers and volume.

To overcome these shortcomings, Pinkas et al. (1971) combined these three values into an Index of Relative Importance (IRI), which we use here. The IRI is defined as:

IRI = %FO (%V + %N), where

%FO = percent frequency of occurrence of a prey taxa or group of taxa in a sample of n birds

%V = percent aggregate volume of a prey taxa, or group of taxa in the combined volume of all taxa in the stomachs of the sample of n birds

%N = aggregate percent numbers of a prey taxa or group of taxa in the combined numbers of all taxa in the stomachs of the sample of n birds.

Depending on the size of the three input parameters and by rounding them to the nearest 0.1%, IRI values can theoretically range from a low of 0.02 i.e., [0.1% (0.1% + 0.1%)] to a high of 20,000, i.e., [100% (100% + 100%)]. Although all of the IRI values and their input parameters appear in appendix tables, we simplified the graphical presentation of the monthly IRI data by assigning "importance levels" of each prey taxa to each bird species. These are based on exponential increments of the IRI values, as follows:

Prey Importance Level	Range of IRI Values
+ ("trace")	1 - 9
1	10 - 99
2	100 - 999
3	1,000 - 9,999
4	10,000 - and up

RESULTS - SPECIES ACCOUNTS

OLDSQUAW

Collection Sites and Sample Sizes

We collected 28 oldsquaw during the study (Table 2), including five each month from November through February in the inner bay, six in March in the outer bay, and one each in the inner and outer bays in April (Figure 4). We collected all specimens within a few kilometers of the north shore of the bay in water less than 18 m. All birds had food in their stomachs, although one taken in April contained only unidentifiable remains.

Food Habits

With a minimum total of 60 prey species (appendix Table 1), oldsquaw had by far the most diverse diet among the four primary bird species studied. The minimum numbers of prey species per month were: November, 22; December, 18; January, 11; February, 24; March, 23; and April, 2. The minimum grand total of 60 species includes at least eight species of gammarid amphipods, which are treated as a group here.

Oldsquaw ate a diverse array of higher taxa as well as prey species. These included: one foraminifera; 9 polychaetes; 14 gastropods; 12 bivalves; 19 crustaceans (including one each, barnacle, mysid, cumacean, and isopod; at least eight gammarid amphipods, three shrimps, and two crabs); one ectoproct, three echinoderms (including two brittle stars one sea urchin); and two fish. IRI values (appendix Table 1), indicate that the most important higher taxa were: bivalves, 2,838; crustaceans, 1,435; fish, 1,168; gastropods, 374; and polychaetes, 321.

Despite the plethora of prey species in the overall diet of the oldsquaw, the Pacific sand lance was considerably more important than any other, based on overall IRI values (appendix Table 1). The next most important taxa overall were the bivalves *Spisula polynyma*, *Mytilus edulis*, *Nucula tenuis*, *Glycymeris subobsoleta*, *Nuculana fossa*, and the snail *Oenopota*. However, except for the sand lance and perhaps *Spisula* and *Mytilus*, it is difficult to say if these species were truly more important than many of the others. The species composition in the diet changed radically from month to month, and many taxonomic groups like crustaceans were collectively more important than some of the individual species of molluscs.

Prey Lengths. The lengths of the 1,150 measurable prey pooled from all of the oldsquaw stomachs ranged from 1 mm *Lacuna* snails, and *Macoma* and *Mytiulus* bivalves, to sand lance of 115 mm; 95% of the prey were less than 10 mm,

Table 4. Total lengths, in 10 mm increments, of all measurable prey from 28 oldsquaw collected in Kachemak Bay in winter

Prey Species	No. of Prey in Length Increments (mm)								
	0-9	10-19	20-29	30-39	80-89	90-99	100-109	110-119	Total
POLYCHAETA/FORAMINIFERA									
Foraminifera	1								1
Pectinaria sp.		2							2
GASTROPODA									
Admete couthouyi	2	1							3
Aglaja diomedeum	2								2
Alvinia compacta	11								11
Cerithiopsis sp.	1								1
Lacuna variegata	13								13
Mitrella tuberosa	19	3							22
Natica clausa	4								4
Odostomia sp.	6								6
Oenopota sp.	19								19
Onchidoris bilamellata		1							1
Turridae	2								2
BIVALVIA									
Glycymeris subobsoleta	80								80
Macoma sp.	200	6							206
Mya sp.	4								4
Mytilus edulis	503								503
Nucula tenuis	41								41
Nuculana c.f. *fossa*	35	2							37
Orobitella sp.	1								1
Protothaca staminea	19								19
Saxidomus gigantea	1								1
Spisula polynyma	107								107
CRUSTACEA									
Gammarid Amphipods	13	7	3	2					25

Table 4 (continued)

Prey Species	No. of Prey in Length Increments (mm) 0-9	10-19	20-29	30-39	80-89	90-99	100-109	110-119	Total
Cancer oregonensis	1	8							9
Crangon septemspinosa			1						1
Cumacea	2								2
Gnorimosphaeroma oregonensis	1								1
Hyas lyratus	3	1							4
Mysids		1							1
Spirontocaris spina			1						1
ENCHINODERMATA									
Echinoidea				1					1
Ophiuroidea	3	1							4
FISH									
Ammodytes hexapterus					5	4	2	4	15
TOTALS	1094	33	5	3	5	4	2	4	1150
Percent of Total	95.1	2.9	0.4	0.3	0.5	0.3	0.2	0.3	

and only 2% were over 19 mm (Table 4). The mean length of all measurable prey was 6.8 mm (S.E. = 0.33) (Table 5). Most of the measurable prey were gastropods (n = 84) and bivalves (n = 99).

Data on the length frequencies of the prey are plotted by 2- mm increments for the invertebrates (Figures 8 through 11) and by 10- mm increments for sand lance (Figure 11). The gastropod Mitrella tuberosa ranged from 1- to 12- mm (Figure 8), the large individuals being considerably larger than the ca. 6.4 mm (1/4 inch) size normally attained by the species (Abbott 1974). However, about 73% of the 84 measurable gastropods were less than 6 mm (Figure 8).

Similarly, most of the bivalves were less than 6 mm but the data for Macoma and Mytilus (Figure 9), and Nuculana (Figure 10) suggest the presence of at least a few older animals. If the age-length ratio of Nuculana fossa in Kachemak Bay is similar to Cook Inlet in general, those eaten by oldsquaw were mostly in year classes 0, 1, or 2, with a few 4's and 5's (Feder and Paul 1980). Similarly, Nucula tenuis clams eaten by oldsquaw were less than 10 mm (Table 4), and ranged up to age 7. By the same inference, Glycymeris subobsoleta, also less than 10 mm, were age 3 or less, while Spisula polynyma, 88% of them 2-4 mm (Figure 10), were all age class "0" (Feder and Paul loc cit.). Abbott (1974) notes 76 mm as the maximum length attained by Mytilus edulis, so those of less than 10 mm eaten by oldsquaw were clearly juveniles.

Most of the gammarid amphipods were less than 16 mm, but a few were 26 to 36 mm (Figure 11). The sand lance, probably mostly two-year old fish, ranged in length from about 80- to 115- mm and averaged about 98- mm (Figure 10).

Monthly Changes In Prey Importance. The small sample sizes and variation in collecting sites preclude statistical evaluation of monthly changes in the importance of individual prey species or groups, but general trends are indicated. Fish, mostly sand lance, were present in the oldsquaw diet each month except February and April (Figure 12). Crustaceans were consistently of moderate importance throughout the study (Figure 12), although no one species nor taxonomic group was of particular significance. Total shrimp and total crabs (Figure 12), and total gammarid amphipods (Figure 13) fluctuated in their importance in no apparent orderly fashion. The shrimp Spirontocaris (Figure 12), mysids (Figure 13), and echinoderms (brittle stars and sea urchins, Figure 12) occurred only in the diet of birds collected in the outer bay during March.

Table 5. Mean lengths of all measurable prey from marine birds collected in Kachemak Bay in winter.

Species	N Prey	Length of Prey, mm $\bar{X}$	S.E.	Min.	Max.
Oldsquaw	1,150	6.8	0.33	1	115
White-winged scoter	103	13.6	1.42	4	105
Surf Scoter	4	7.5	0.85	6	9
Common Murre	174	44.6	1.67	31	179
Pigeon Guillemot	15	28.3	2.94	17	66
Marbled Murrelet	138	26.3	2.02	4	135

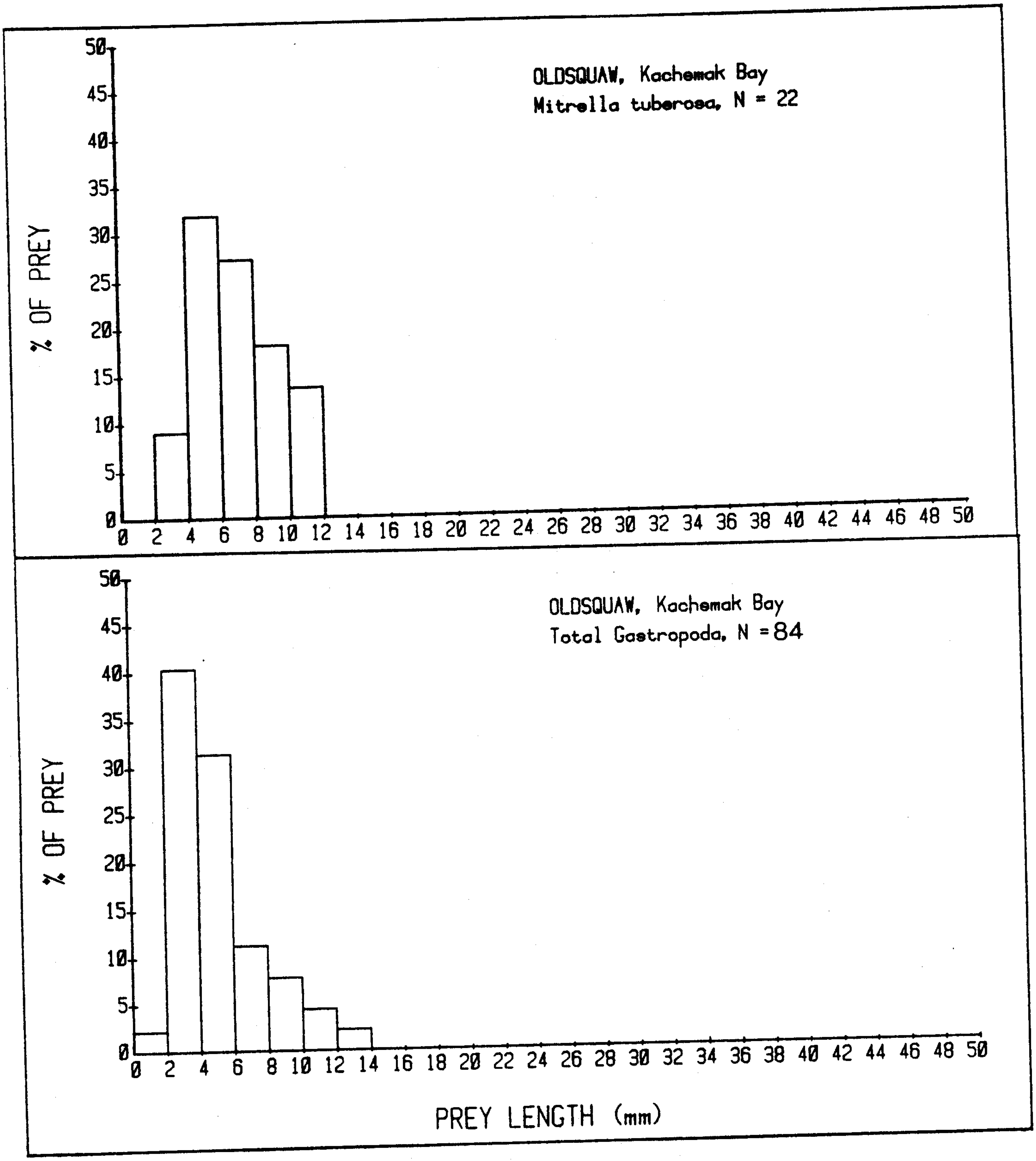

Figure 8. Length frequencies of the columbellid gastropod Mitrella tuberosa (top) and all gastropods (bottom) in the stomachs of oldsquaw from Kachemak Bay in winter.

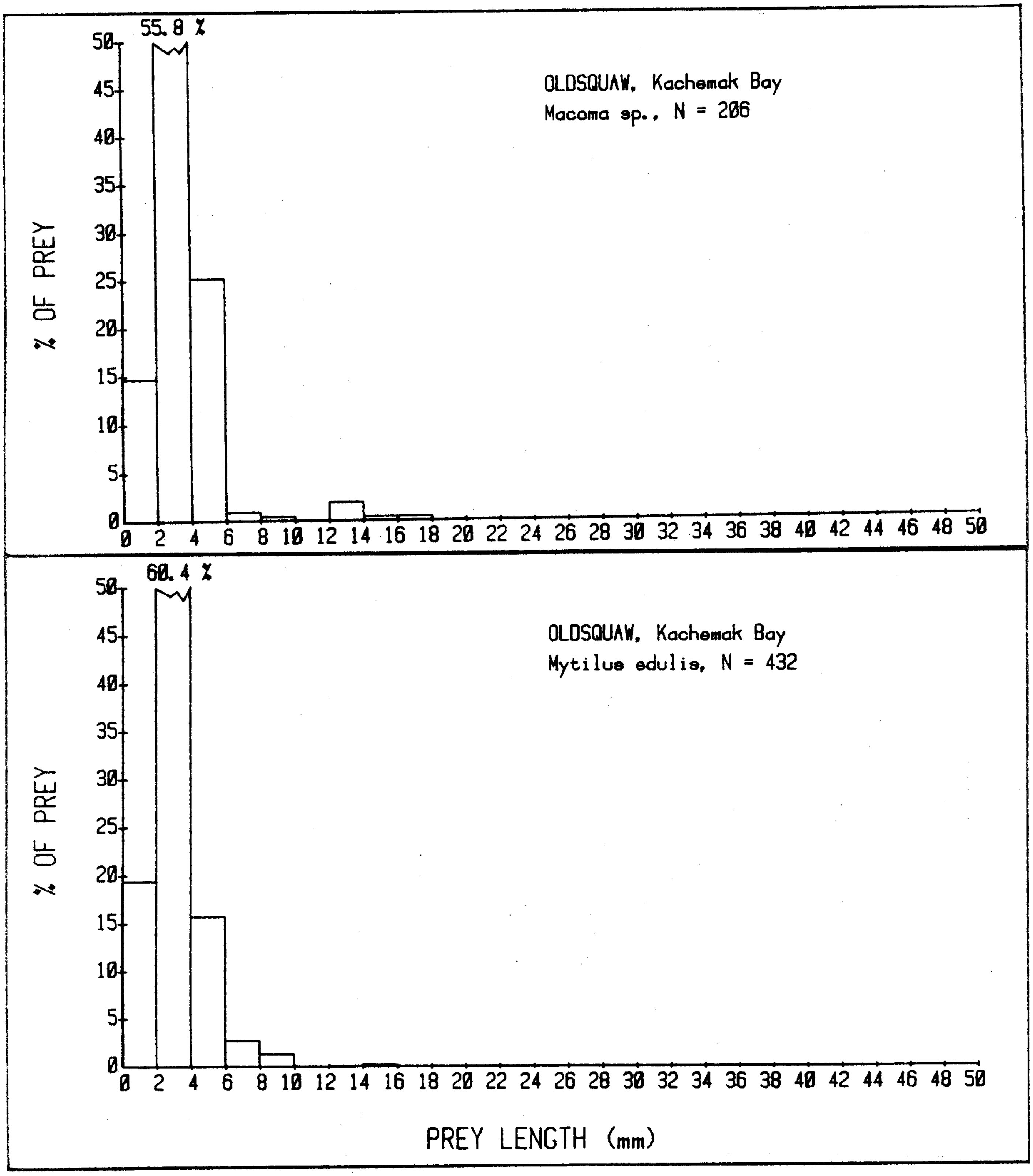

Figure 9. Length frequencies of the tellinid clam Macoma sp. and the blue mussel, Mytilus edulis, in the stomachs of oldsquaw from Kachemak Bay in winter.

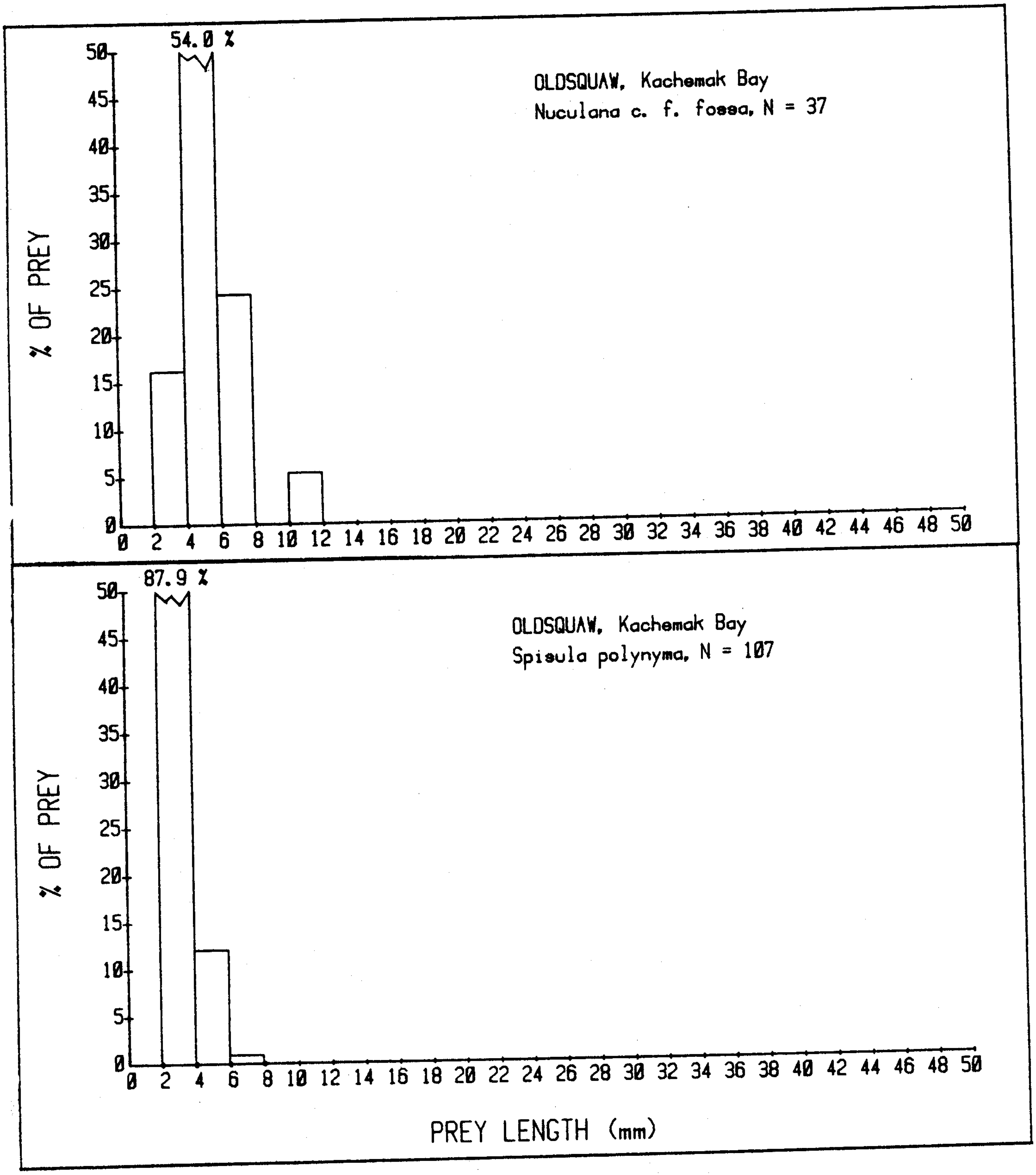

Figure 10. Length frequencies of the nuculanid clam Nuculana fossa and the mactrid clam Spisula polynyma in the stomachs of oldsquaw from Kachemak Bay in winter.

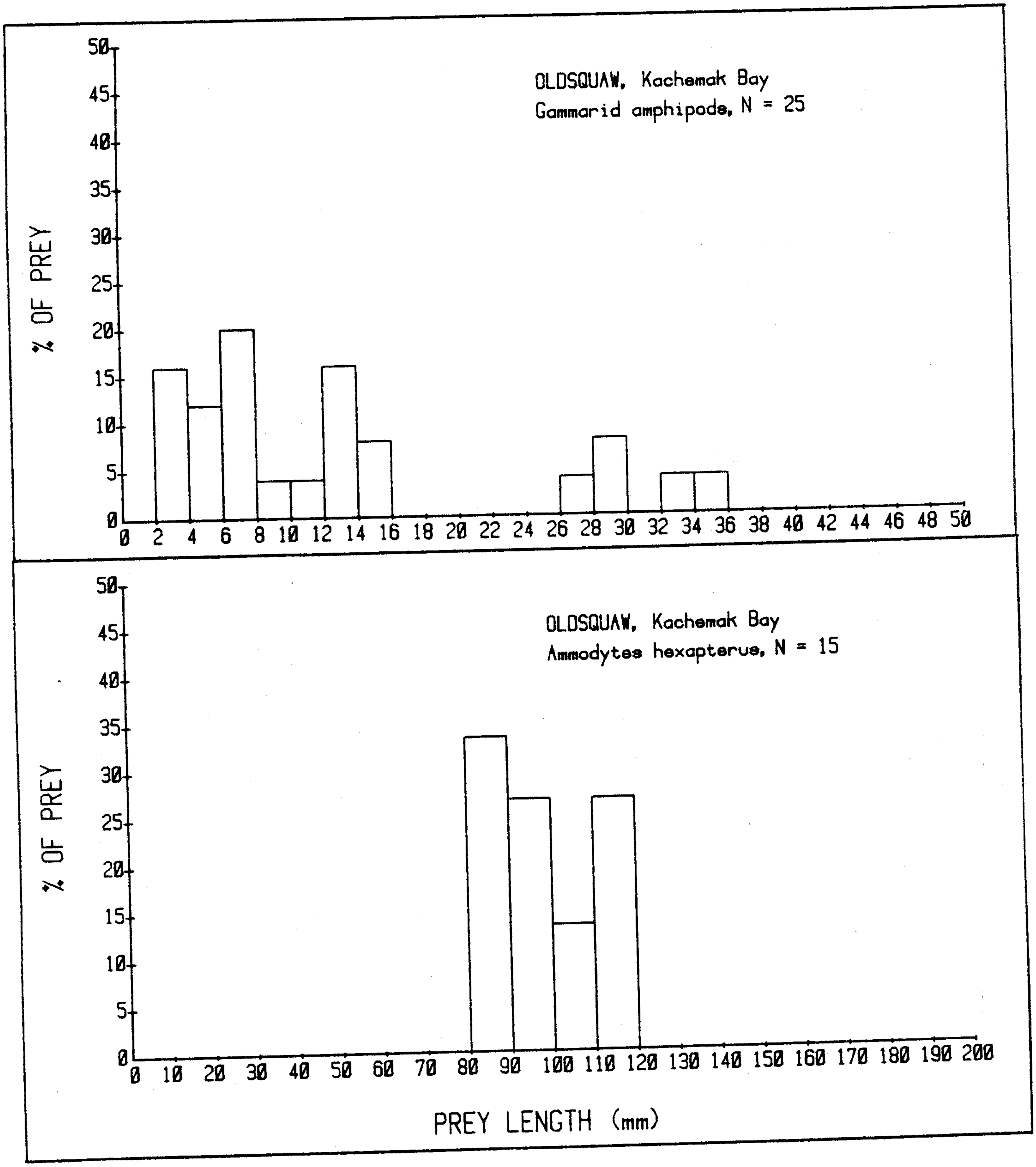

Figure 11. Length frequencies of gammarid amphipods (crustacea) and Pacific sand lance, Ammodytes hexapterus, in the stomachs of oldsquaw from Kachemak Bay in winter.

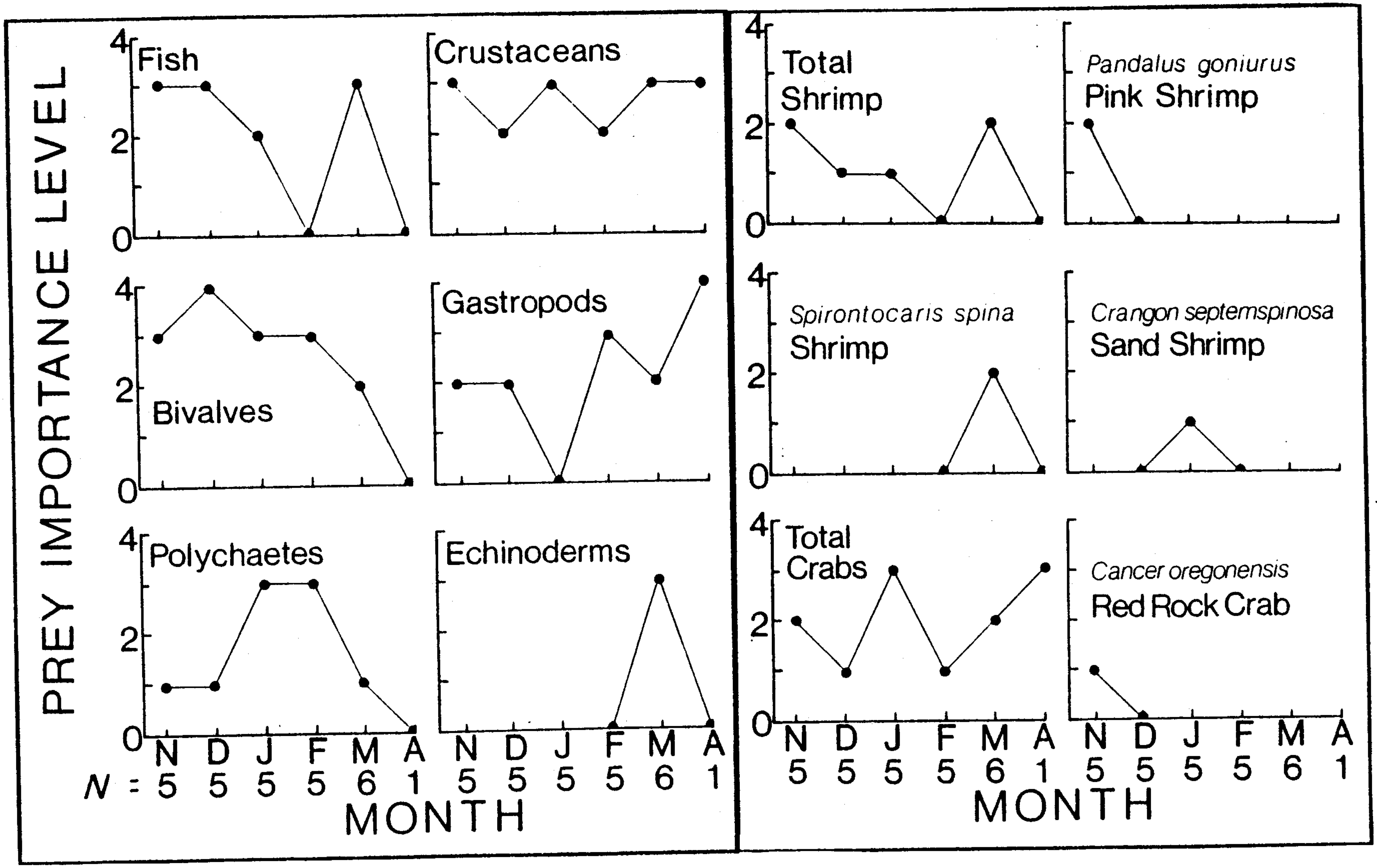

Figure 12. Monthly changes in the importance of major groups of prey (left panel) and crustaceans (right) in the diet of oldsquaw from Kachemak Bay in winter.

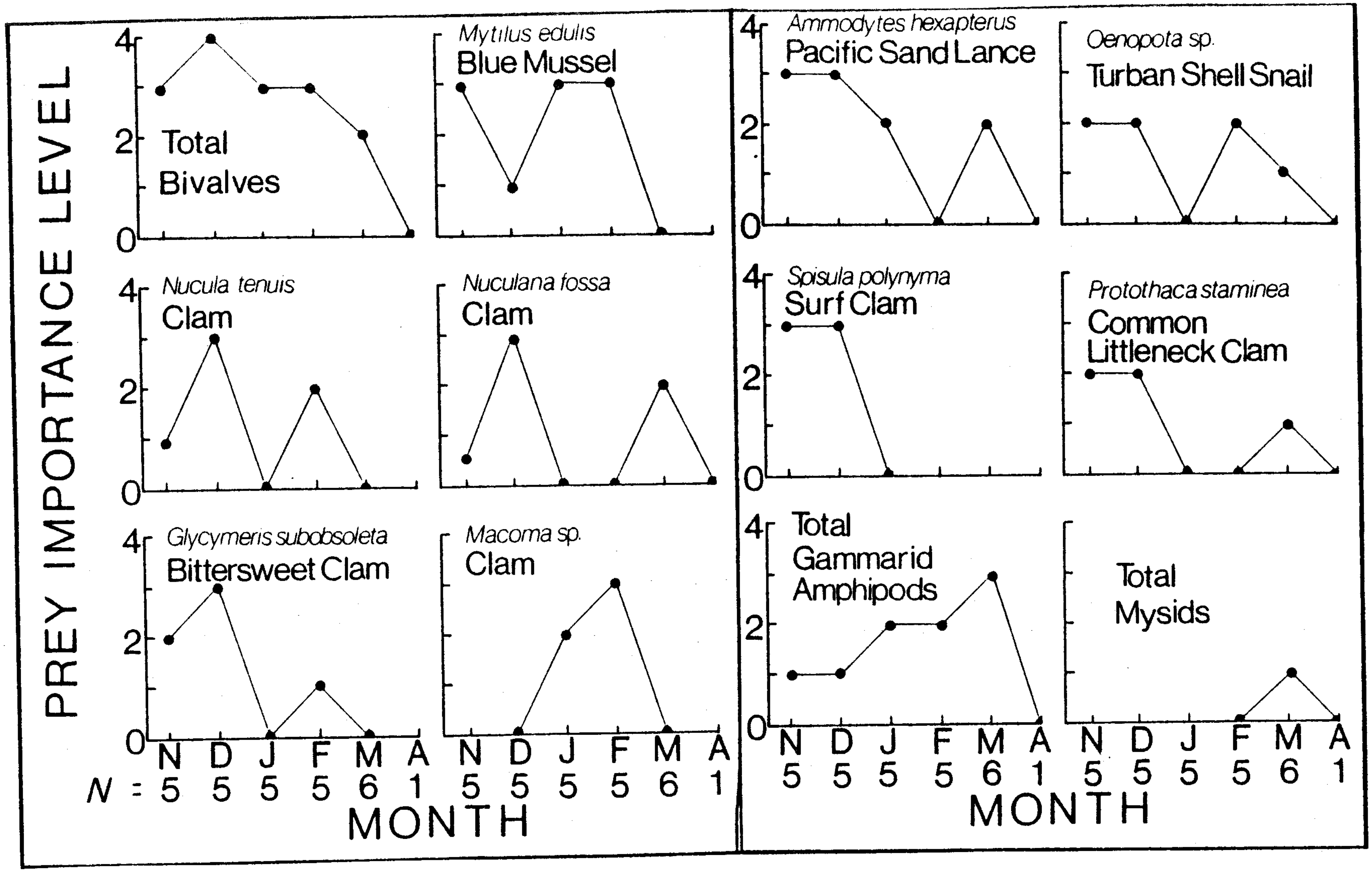

Figure 13. Monthly changes in the importance of bivalves (left panel) and miscellaneous prey (right) in the diet of oldsquaw from Kachemak Bay in winter.

Food Weight as Percent of Body Weight. The weight of food in stomachs as compared to the weight of individual birds ranged from a low of 0.2% in November and February, to a high of 3.0% for a bird in March (Table 6). The maximum value was the result of 20 g of food in a 674 g bird. Average monthly values were very low, ranging from 0.45% (S.E. = 0.15) in April, to 1.6% (S.E. = 0.32) in March, and with an overall average for the 28 specimens of 1.0% (S.E. = 0.19) (Table 6). Sixteen birds (57%) had values less than 1.0, and only four birds (14%) had values greater than 1.5. The oldsquaw, however, was the only species studied which had no empty stomachs.

Feeding Behavior and Feeding Habitats

The locations of the oldsquaw collection sites (Figure 4) and the known habitats of their prey indicate that oldsquaw fed benthically on both infauna and epibenthos (Figure 14). The oldsquaw were distributed mainly in the northern inner bay over mud/sand substrates, but they occasionally fed in shell debris and cobble habitats. With the exception of the sand lance and the various species of shrimp, the oldsquaws' prey are sessile, or only very weakly mobile. The birds' mode of capturing the sand lance may only be surmised, but it is possible that they captured these fish when they were buried in the sand (Meyer et al. 1979). Indeed, the preponderance of sessile animals in their diets may indicate a limited adaptation for capturing quickly moving fauna.

Net Body Weight and Fat Index

The net body weights of 15 male oldsquaw ranged from 753 g to 956 g and averaged 868 g; similar weights for 13 females ranged from 670 g to 888 g, and averaged 777 g (Table 7). An analysis of variance by the least squares method (1 and 16 degrees of freedom, F = 14.56) showed these means to be different at the 99% level of significance. A least squares analysis of variance also showed no significant differences in mean body weights among months.

The fat index (Table 8; Figure 15) ranged from one to five for individual birds. Monthly means ranged from a high of 4.2 (S.E. = 0.80) in November to a low of 2.5 (S.E. = 0.50) in April with decreasing monthly values throughout these months. A one-way anlaysis of variance suggested a 95% probability of significant difference among the monthly means at the 0.5 level (F = 2.28; p = 0.80). Figure 15 shows considerable overlap in standard errors for oldsquaw between November and December, and from January through April, with a break between December and January. This suggests that the birds were significantly fatter early in the winter than later.

Table 6. Food weight as a % of net body weight for marine birds collected in Kachemak Bay, November 1977 - April 1978.

Species	November n $\bar{X}$ S.E. min - max	December n $\bar{X}$ S.E. min - max	January n $\bar{X}$ S.E. min - max	February n $\bar{X}$ S.E. min - max	March n $\bar{X}$ S.E. min - max	April n $\bar{X}$ S.E. min - max	Total[a/] n $\bar{X}$ S.E. min - max
Oldsquaw	5 0.7 0.22 0.2-1.3	5 1.0 0.24 0.4-1.7	5 0.8 0.14 0.5-1.3	5 0.9 0.30 0.2-1.9	6 1.6 0.32 0.8-3.0	2 0.45 0.15 0.3-0.6	28 1.0 0.19 0.2-3.0
White-winged Scoter[a/]	1 2.5 -- - - -	2 2.6 -- 2.3-2.8	14 2.1 0.21 1.1-3.4	10 2.6 0.32 0.0-4.1	5 2.0 0.63 0.6-4.1	5 2.1 0.63 0.8-3.9	39 2.2 0.16 0.0-4.1
Black Scoter	1 0.6 -- - - -					1 0.0 -- - - -	2 0.3 -- - - -
Surf Scoter		1 0.5 -- - - -			1 0.8 -- - - -	2 0.2 -- - - -	4 0.4 0.14 0.0-0.8
Common Murre		6 1.6 0.39 0.4-2.9	9 1.0 0.21 0.1-2.1	5 0.1 0.09 0.0-0.5	6 0.8 0.22 0.0-1.5	5 1.0 0.32 0.1-1.8	31 1.0 0.14 0.0-2.9
Pigeon Guillemot			1 0.8 -- - - -		1 3.1 -- - - -	1 0.7 -- - - -	3 1.5 0.64 0.7-3.1
Marbled Murrelet			6 1.6 0.66 0.4 - 3.7	5 1.7 0.94 0.0-5.3	3 3.0 1.8 0.8-6.6	5 1.5 0.6 0.4-3.2	19 1.8 0.42 0.0-6.6

a/ Includes white-winged scoter data for Feb. 77:n=2(2.5 and 0.7), $\bar{X}$ = 1.6

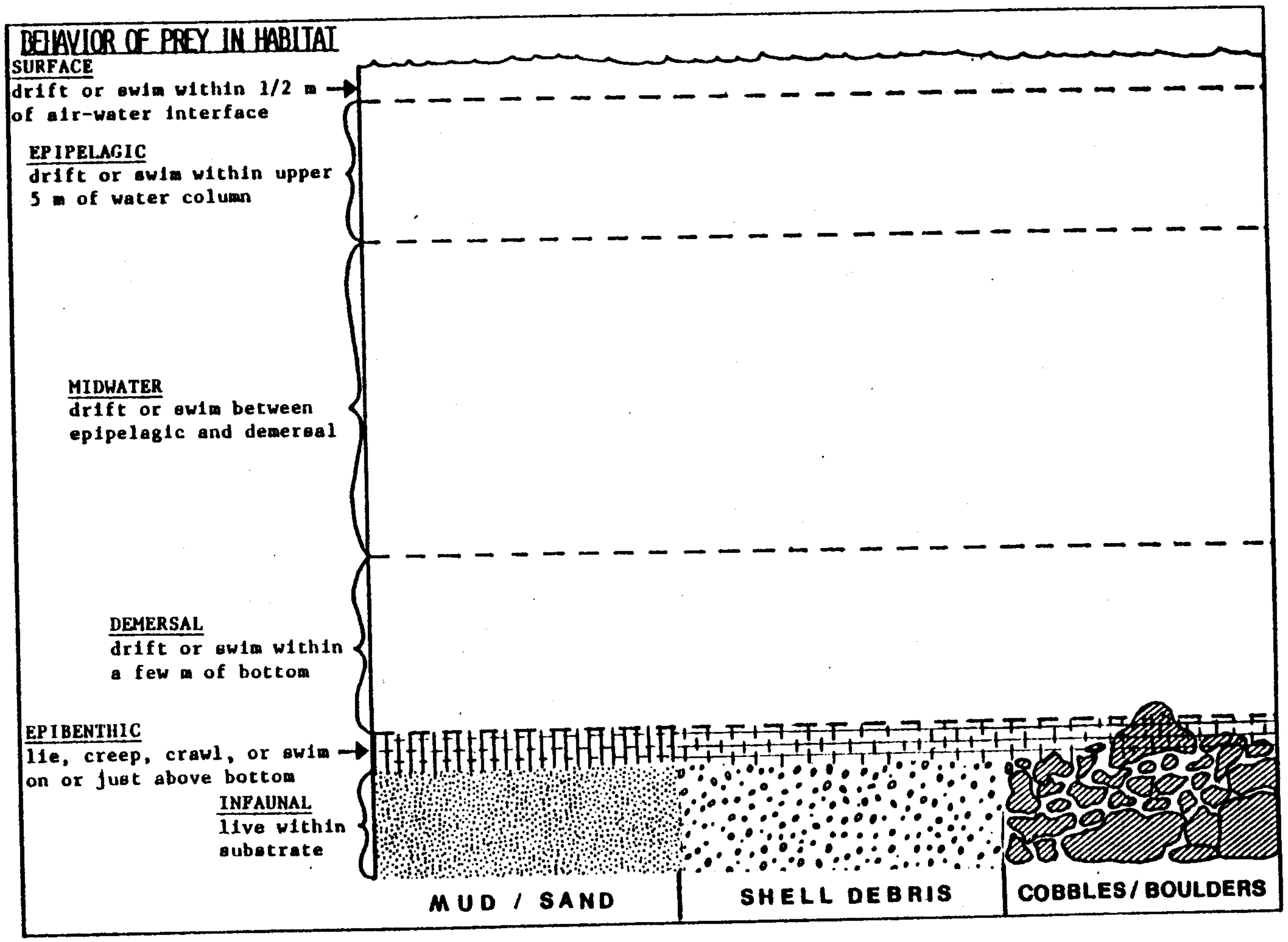

Figure 14. Schematic representation of the feeding habitats of sea ducks in Kachemak Bay in winter, in relationship to all subtidal feeding habitats. Oldsquaw = vertical lines; solid is primary habitat, dashed secondary. Scoters = horizontal lines; solid primary habitat, dashed secondary.

Table 7. Net body weights[a] of marine birds collected in Kachemak Bay, November 1977 - April 1978.

	Males				Females				Totals			
Species	n	$\bar{X}$	min	max	n	$\bar{X}$	min	max	n	$\bar{X}$	min	max
Oldsquaw	15	868	753	956	13	777	670	888	28	826	670	956
White-winged Scoter[a]	29	1,917	1,388	2,128	10	1,732	1,566	1,946	39	1,869	1,388	2,128
Black Scoter	2	1,184	1,118	1,249	-	--	--	--	2	1,184	1,118	1,249
Surf Scoter	3	1,152	1,038	1,223	1	1,053	--	--	4	1,127	1,038	1,223
Common Murre	20	1,111	914	1,253	6	1,119	950	1,214	26	1,113	914	1,253
Pigeon Guillemot	3	566	545	583	-	--	--	--	3	566	545	583
Marbled Murrelet	7	245	220	270	12	233	212	281	19	237	212	281

[a] All birds were in adult plumage, except for five (5) juvenile white-winged scoters collected in January; three males weighed 1,897, 1,936, and 1,966 g; two females weighed 1,704 and 1,762 g. White-winged data includes one each male and female collected February 1977.

Table 8. Fat indices[a/] of marine birds collected in Kachemak Bay, Alaska, November 1977 - April 1978

Species	November n $\bar{X}$ S.E. min - max	December n $\bar{X}$ S.E. min - max	January n $\bar{X}$ S.E. min - max	February n $\bar{X}$ S.E. min - max	March n $\bar{X}$ S.E. min - max	April n $\bar{X}$ S.E. min - max	Total n $\bar{X}$ S.E. min - max
Oldsquaw	5 4.2 0.80 1-5	5 3.8 0.37 3-5	5 3.0 -- 3	5 2.8 0.21 2-4	6 2.7 0.21 2-3	2 2.5 0.50 2-3	28 3.2 0.20 1-5
White-winged Scoter [a/]		2 3.0 -- 3	14 3.1 0.13 2-4	10 2.6 0.13 2-3	5 2.8 0.37 2-4	5 2.0 -- 2	38[a/] 2.8 0.11 2-4
Black Scoter						1 2 -- -	1 2 -- -
Surf Scoter		1 3 -- -			1 4 -- -	2 2.5 -- 2-3	4 3.0 0.35 2-4
Common Murre		6 4.0 0.26 3-5	9 3.2 0.22 2-4	5 3.2 0.20 3-4	5 2.6 0.24 2-3	5 2.8 0.37 2-4	30 3.2 0.15 2-5
Pigeon Guillemot			1 3 -- -		1 2 -- -	1 2 -- -	3 2.3 0.27 2-3
Marbled Murrelet			6 3.0 -- 3	5 2.8 0.20 2-3	5 2.2 0.49 1-4	5 2.2 0.20 2-3	21 2.6 0.15 1-4

[a/] Includes white-winged scoter data for Feb. 77:n=2, both 4

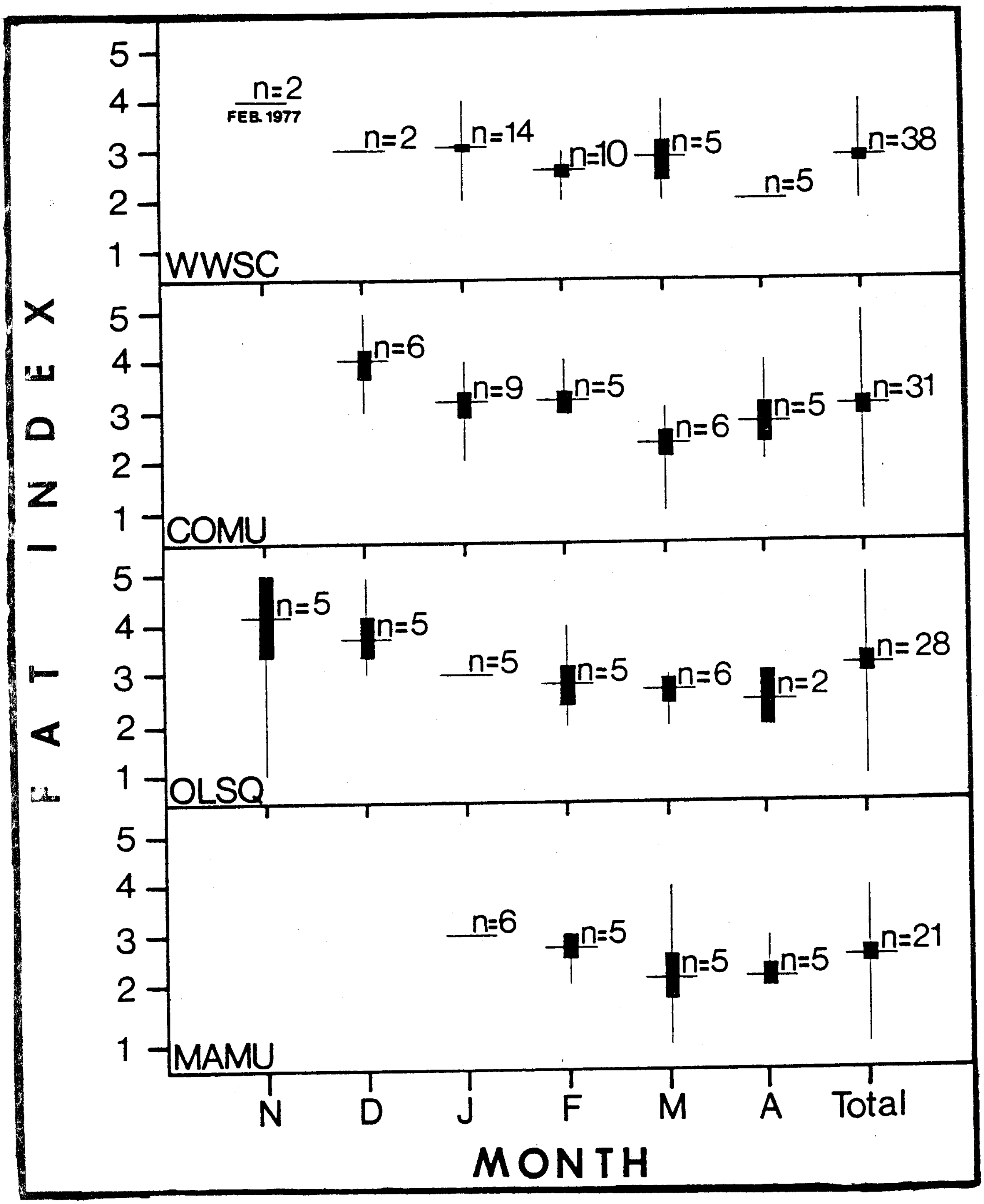

 Figure 15. Monthly changes in the mean fat index of marine birds in Kachemak Bay in winter.

WHITE-WINGED SCOTER

Collection Sites and Sample Sizes

We collected 39 white-winged scoters (Table 2). In November and December specimens were collected in the shallow northern part of the inner bay, but during subsequent months we collected scoters only in the outer bay between Anchor and Bluff Points over water shallower than 18 m (Figure 5). Two birds collected in February 1977 were taken in about 40 m of water on the south side of the outer bay. The stomach of one specimen in February 1978 was empty, but the remaining 38 birds (97%) had food in their stomachs.

Food Habits

White-winged scoters had a fairly diverse diet, eating a minimum of 22 species of prey (appendix Table 2). There was one prey species in the birds collected in November and December, six species in the stomachs each month from February through April, and a high of 12 prey species in January.

Overall, bivalves (IRI=6,112) and gastropods (IRI=1,510) dominated the diet of the scoters, and polychaete worms (IRI=16), crustaceans (IRI=16), and echinoderms (IRI=6) were of relatively minor importance (appendix Table 2). The bivalves *Mytilus edulis* (IRI=1,158) and *Protothaca staminea* (IRI=1,996) were overwhelmingly the most important prey species. The puppet margarite snail, *Margarites pupillus* (IRI=151), was relatively important compared to the remaining prey, none of which had an IRI value higher than 60 (appendix Table 2).

Monthly Changes in Prey Importance. Bivalves, and in some habitats gastropods, were consistently important in the diet of the scoters (Figure 16). Other groups of prey were sporadic in their monthly occurrence. *Mytilus* was the only prey in the three birds collected in the shallow inner bay in November and December (Figure 16). However, the mussels were in an advanced state of digestion, indicating the possibility of their being eaten elsewhere. The littleneck clam, *Protothaca staminea*, was consistently the most important prey of scoters collected in the outer bay from January through April.

Two birds collected on the south side of the outer bay in February 1977 had eaten mostly clams, *Astarte rollandi* and *glycymeris subobsoleta*. One of these birds contained a single Kennerly's venus clam, *Humilaria kennerlyi*, plus sea urchin spines and fragments of barnacles. Differences in prey species compared to areas on the north side of the bay probably reflect different species in the two areas, rather than differences in prey selection.

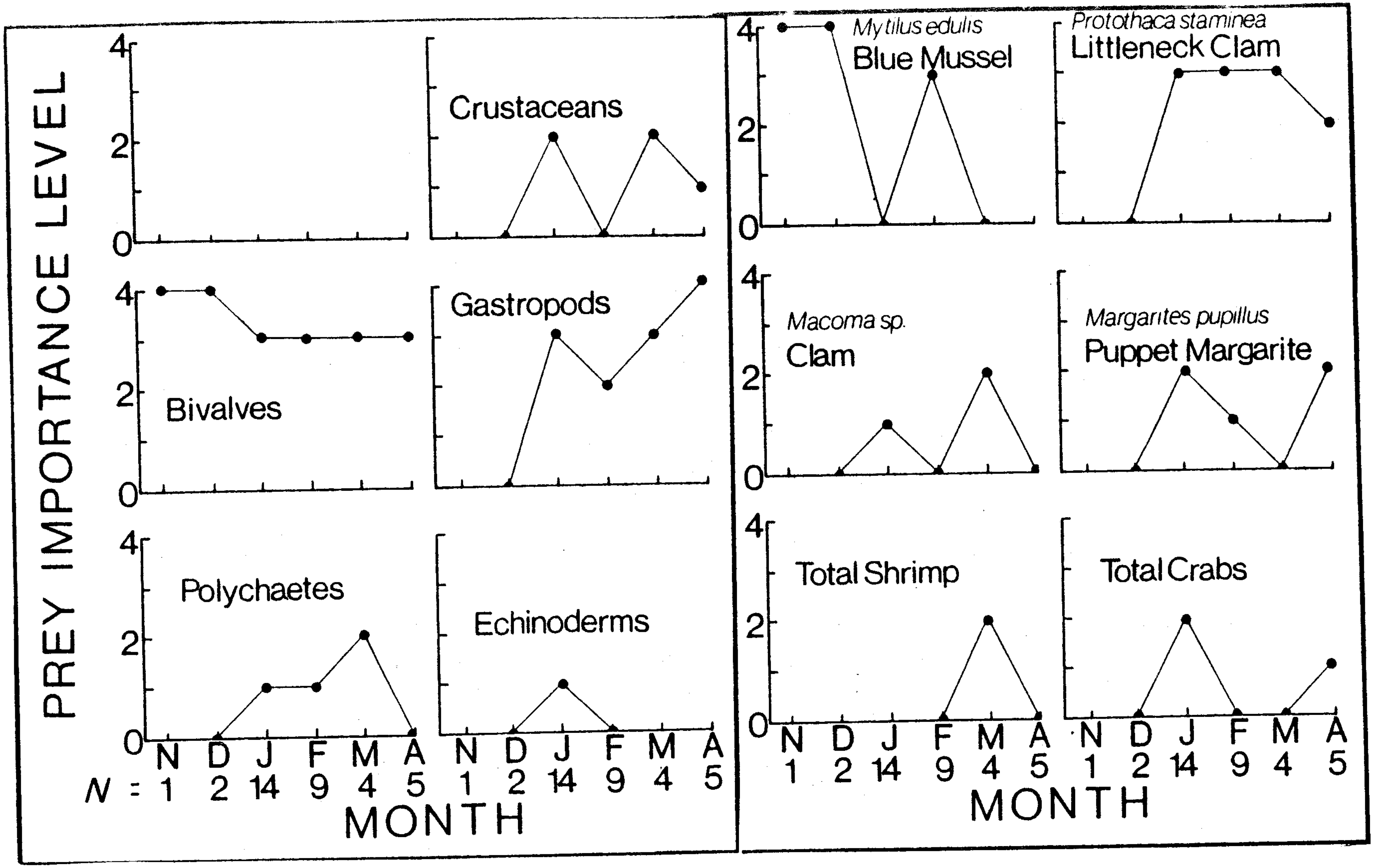

Figure 16. Monthly changes in the importance of major groups of prey (left), and shrimp, crabs, and molluscs (right) in the diet of white-winged scoters from Kachemak Bay in winter.

Prey Lengths. The lengths of the prey eaten by white-winged scoters ranged from common northern admete snails (Admete couthouyi) of 4 mm to a Nephtys polychaete worm of 105 mm (Table 9). The average length of 103 measurable prey pooled from all stomachs was 13.6 mm (S.E.=1.42) (Table 5). In contrast to the sub-10 mm size of the Mytilus eaten by the oldsquaw, the three measurable Mytilus in the white-wings were in the 50-70 mm range (Table 9). Some 90% of the measurable prey in the scoters were less than 20 mm, although the occasional presence of bivalves (Mytilus and Protothaca) and the snail Neptunea lyrata over 40 mm in the scoters shows that they are able to take advantage of larger prey.

Length frequencies of 28 Margarites pupillus snails pooled from the stomachs (Figure 17) indicate that those snails over 8 mm were adults within the maximum size range of 8 to 13 mm attained by the species (Abbott 1974). In contrast, the length frequencies of 37 Glycymeris clams (Figure 17) are smaller than maximum size (about 25 mm) for that species (Abbott 1974). According to Feder and Paul's (1980) data for Cook Inlet in general, G. subobsoleta eaten by scoters were 3 to 7 years old, with a median age of about 5.

Food Weight as a Percent of Body Weight. The weights of food in stomachs as compared to weights of individual birds ranged from zero (empty stomach) in February 1978, to a high of 4.0% for one bird each in February and March 1978 (Table 6). The latter bird, weighing 1,911 g, had 78 g of food in its stomach, the maximum observed in white-winged scoters. The average value for February 1977 was 1.6% (S.E.=0.9), and the average values from November through April were consistently in the 2.0% to 2.6% range. The overall mean for the 39 birds was 2.2% (S.E.=0.16). Only five birds (13%) had values less than 1.0%. This, considered with the fact that only one bird had an empty stomach, suggests that the birds were consistently able to find at least some food.

Feeding Behavior and Feeding Habitats

The locations of collection sites (Figure 5) and the known habits of their prey suggests that scoters fed exclusively in benthic habitats, usually in areas with shell debris and boulder/cobble substrates, but occasionally in sand/mud substrates (Figure 14). The distribution patterns of the birds observed by us and by Erikson (1977) indicate that white-winged scoters occur relatively infrequently in the shallow inner bay over sand/mud substrates. It thus seems possible that the scoters could have captured prey such as Macoma clams and Natica clausa snails, animals typical of sand/mud substrates (Keen and Coan 1974), in pockets of mud/sand amid the shell debris and cobbles typical of the shallow subtidal area of the northern outer bay (Driskell and Lees 1977).

The fairly wide range in prey sizes indicates that while scoters are able to selectively locate and sieze single large molluscs (to 105 mm),

Table 9. Total Lengths, in 10 mm Increments, of all Measurable Prey from 37 White-winged Scoters Collected in Kachemak Bay in Winter

Prey Species	No. of Prey in Length Increment (mm)								
	0-9	10-19	20-29	30-39	40-49	50-59	60-69	100-109	Totals
POLYCHAETA									
Nephtys sp.								1	1
GASTROPODS									
Admete couthouyi	3	10							13
Littorina sp.	1								1
Margarites pupillus	25	3							28
Natica clausa		1		1					2
Neptunea lyrata			1	1		1			3
Oenopota sp.	1								1
BIVALVIA									
Astarte rollandi	2	5							7
Glycymeris subobsoleta	10	27							37
Mya sp.		1							1
Mytilus edulis						1	2		3
Protothaca staminea		2	1		1				4
CRUSTACEA									
Cancer oregonensis	1								1
ECHINODERMATA									
Strongelocentrotus droebachiensis	1								1
TOTALS	43	50	2	2	1	2	2	1	103
Percent of Total	41.8	48.6	1.9	1.9	1.0	1.9	1.9	1.0	100.0

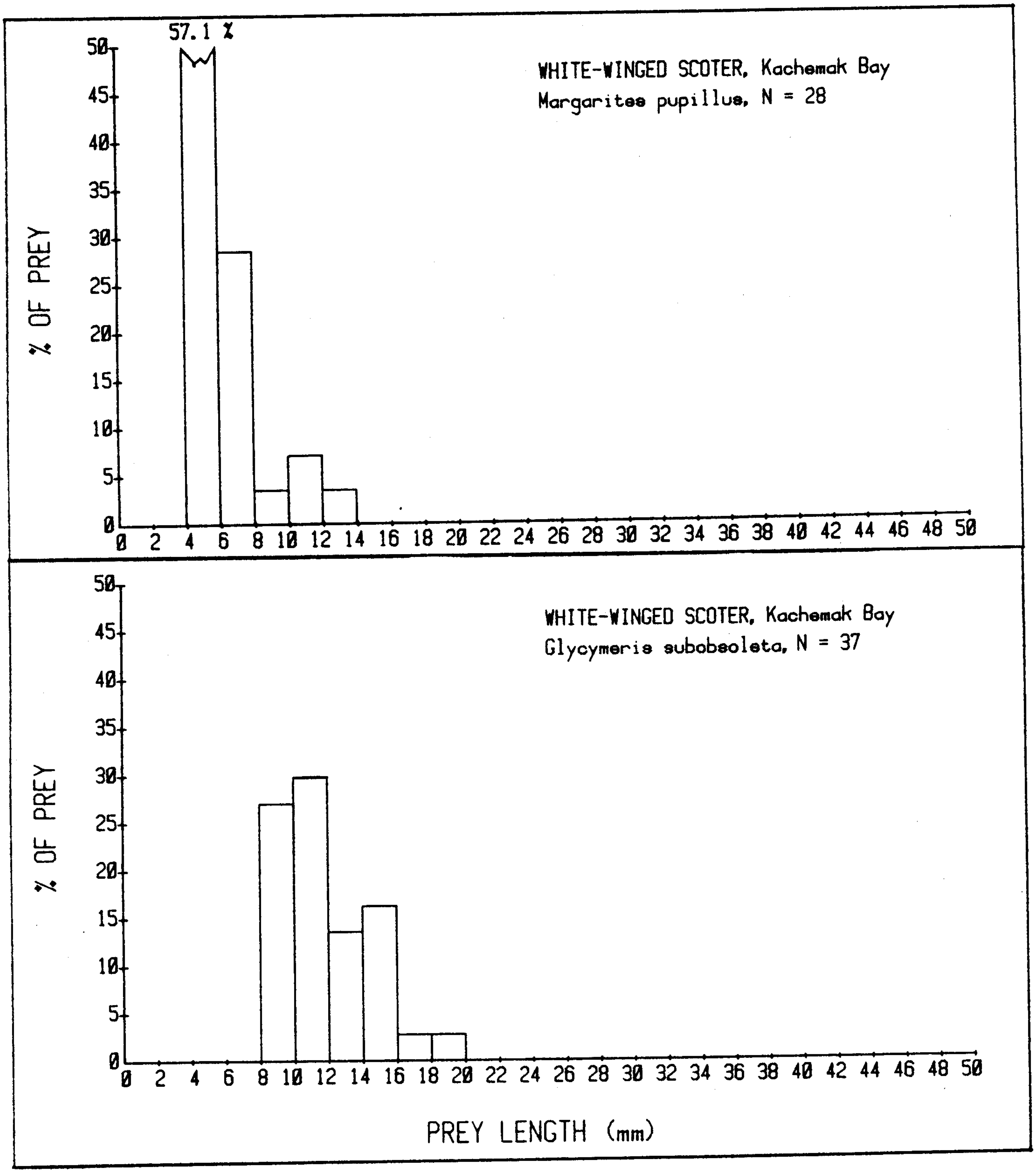

Figure 17. Length frequencies of the puppet margarite snail, *Margarites pupillus* and the clam *Glycymeris subobsoleta* in the stomachs of white-winged scoters from Kachemak Bay in winter.

they probably use a certain amount of indiscriminant seiving through the substrate to capture smaller prey. There is likely little or no light in the feeding habitats of the scoters during much of the winter, which suggests that the birds may use a sense other than sight to locate their food.

Net Body Weight and Fat Index

Pooled net body weights of 29 male white-winged scoters ranged from 1,388 g to 2,128 g, and averaged 1,917 g; similar weights of 10 females ranged from 1,566 g to 1,966 g, and averaged 1,732 g (Table 7). These averages were significantly different at the 99% level, as determined by a least squares anaslysis of variance (df=1 and 28; F=15.05). However, there were no significant differences in the monthly mean weights of adult birds (total n=34), nor of adults and juveniles combined (n=5, all collected in February), as determined by a least squares analysis of variance.

Fat indices for 38 individual birds ranged from highs of four in January and March 1978, and February 1977, to lows of two each month from January through April (Table 8; Figure 15). A one-way analysis of variance indicated large differences in fat index among the six monthly means at the .05 level of significance (F=5.97; p=0.0005). The results of a Duncan's multiple range test to determine which month(s) varied significantly from the other(s) are summarized below:

Month	N	Mean, ranked in descending order	Means connected by same letter are not statistically different			
Feb 1977	2	4.00	A			
Jan 1978	14	3.07	A	B		
Dec 1977	2	3.00	A	B	C	
Mar 1978	5	2.80		B	C	
Feb 1978	10	2.60			C	
Apr 1978	5	2.00				D

These results show that the fat index fluctuated, though decreased throughout winter and early spring, and culminated with a value for April that was significantly lower than any other month.

BLACK SCOTER

We collected one black scoter each in November and April on the north side of the inner bay (Table 2; Figure 18). Only the November bird contained food, consisting entirely of blue mussels, Mytilus edulis (appendix Table 3). The Mytilus weighed 6.8 g, or 0.6% of the body weight (1,118 g). The Mytilus were well digested, so the scoter possibly ate them elsewhere than the area of sand/mud substrate over which it was collected.

Both black scoter specimens were males. The bird collected in November had a net body weight of 1,118 g (Table 7), its stomach contents weighed 0.6% of the net body weight (Table 6), and the amount of body fat was undetermined (Table 8). The bird collected in April weighed 1,249 g (Table 7), its stomach was empty and it had a fat index of two.

SURF SCOTER

We collected one surf scoter in the outer bay in March, and in the inner bay, one in December and two in April (Table 2; Figure 18). Only the December and March specimens had food in their stomachs, one of the April bird's stomach was empty and the other had only unidentifiable remains.

The surf scoters ate a minimum of seven prey species (appendix Table 3). The December bird had two polychaetes, two clams and a shrimp, and the March bird had one gastropod, and a clam different from the above two. The polychaete Nephtys and unidentified bivalves were the most important prey. The bivalve Mytilus was conspicuously absent in the stomachs of the surf scoters.

The weight of the stomach contents ranged from '0' (empty) to 0.8% of net body weight, and averaged 0.4% (S.E.=0.14) (Table 6). The net body weight of three males ranged from 1,038 to 1,223 g, and a female collected in April weighed 1,053 g (Table 7). The fat index of the four birds ranged from two to four and averaged 3.0 (S.E.=0.35) (Table 8).

COMMON MURRE

Collection Sites and Sample Sizes

We collected five to nine common murres each month from December to April for a total of 31 specimens (Table 2). All specimens were taken in water deeper than 18 m on the south side of the inner bay, generally between Halibut cove and Glacier Spit (Figure 6). Twenty-eight birds (90%) had food in their stomachs.

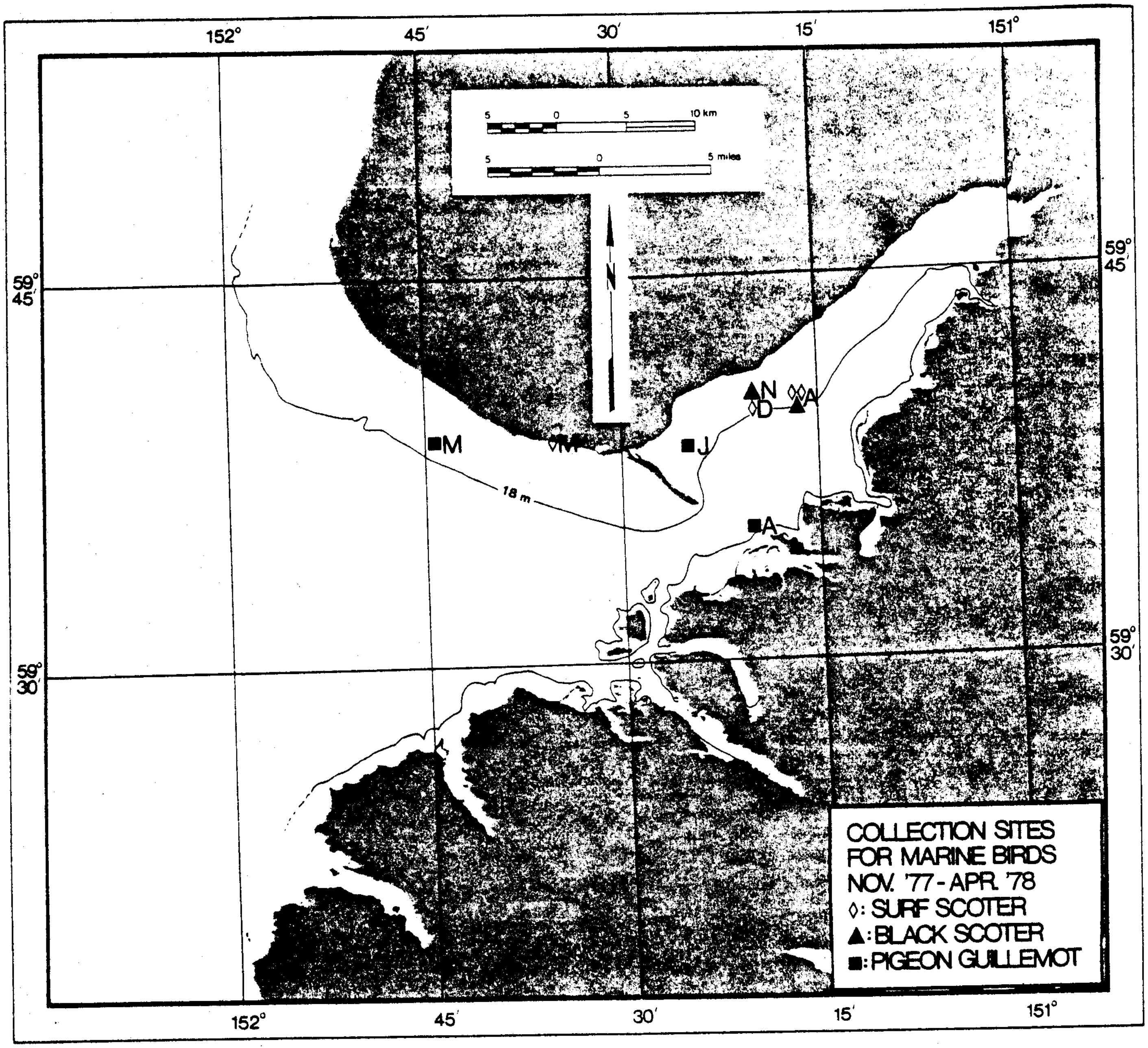

Figure 18. Collection sites of surf and black scoters, and pigeon guillemots. Letters indicate month of collection.

Food Habits

Crustaceans dominated the diet of the murres. Fish were relatively less important, and a trace of polychaetes was present in one bird. Five species of crustaceans contributed to an overall IRI of 6,944, while five species of fish accounted for an IRI of 417 (appendix Table 4). Overall, the murres are a minimum of 11 prey species, although the minimum number of prey in a given month fluctuated between three and five (Appendix Table 4), probably indicating varying differences in prey availability.

With a total IRI of 5,200, the most important prey species was the mysid shrimp, *Neomysis rayii*, followed in descending order of IRI values by: Pink shrimp (*Pandalus borealis*), 398; walleye pollock (*Theragra chalcogramma*), 117; capelin (*Mallotus vilosus*), 22; and Pacific herring (*Clupea harengus*), 20 (Appendix Table 4). Pandalid shrimp as a group (including *P. borealis*, *P. goniuris*, *P.* sp., and unidentifiably pandalids) were relatively important with an IRI of 1,049. Considering the predominantly piscivorous feeding habits of common murres elsewhere (Ainley and Sanger 1979) the preponderance of crustaceans in the diet of the Kachemak birds was unexpected.

¶ Prey Lengths. The lengths of the measurable prey pooled from the murre stomachs ranged from *Neomysis* mysids of 31 mm to a walleye pollock of 179 mm, and the mean of all 174 prey was 44.6 mm (S.E.=1.67) (Table 10). Eighty-seven percent of the prey, all except one a crustacean, were less than 50 mm, while only 4% of the prey, all fish (one *Lumpenus* and the remainder pollock) were over 100 mm (Table 10).

Nine measurable pandalid shrimp ranged from 40 to 80 mm (mode about 55 mm). One-hundred-fifty-one *Neomysis rayii* accounted for 87% of the measurable prey. Their lengths (Figure 19) ranged from 31 to 52 mm, with a mode of about 39 mm.

Monthly Changes in Prey Importance. Crustaceans were consistently important to the murres (Figure 20). *Neomysis* was particularly important in December and January, but was not eaten thereafter when pandalid shrimp were important in the murres' diet. This relationship is particularly noticeable in the percent of the monthly aggregate volume comprised by these two kinds of crustaceans. Summarized from Appendix Table 4, these data may be compared:

Table 10. Total lengths, in 10 mm increments, of all measurable prey from 28 common murres collected in Kachemak Bay in winter.

Prey Species	No. of Prey in Length Increment (mm)						
	30-39	40-49	50-59	60-69	70-79	80-89	Totals
CRUSTACEA							
Neomysis rayii	98	52	1				151
Pandalus borealis			5	2	1		8
P. goniuris		1					1
Crangon franciscorum				1	1	1	3
FISH							
Mallotus villosus						1	1
Unid. Osmerid		1		2			3
Theragra chalcogramma a/							
Lumpenus maculatus b/							
TOTALS	98	54	6	5	2	2	167
Percent of Total	56.3	31.0	3.4	2.9	1.1	1.1	

a/ Six T. chalcogramma in length increments, as follows: 1,110-119; 1,120-129; 2,130-139; 1,150; 1,170-179.

b/ One L. maculatus in 100-109 increment

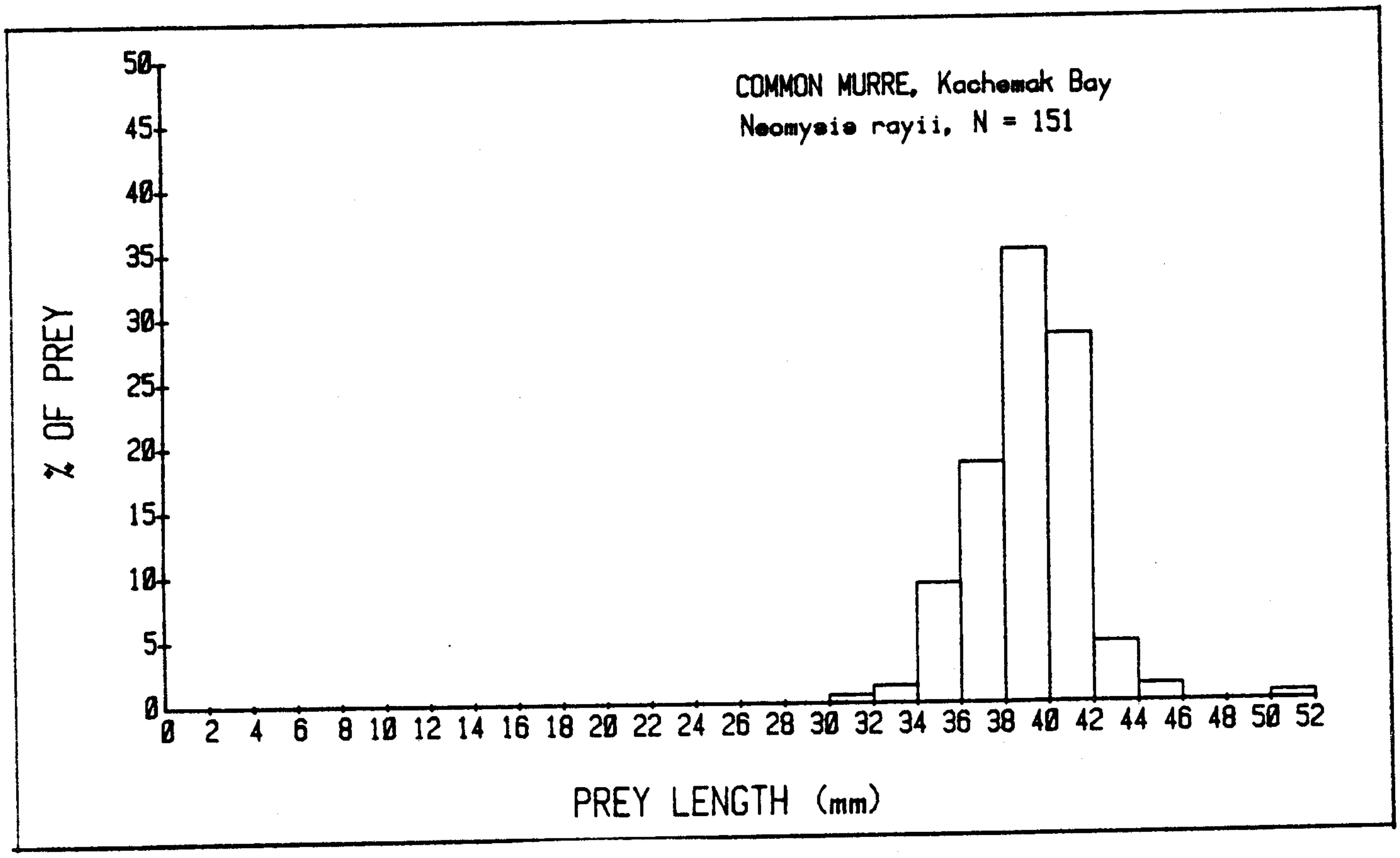

Figure 19. Length frequencies of the mysid crustacean Neomysis rayii in the stomachs of common murres from Kachemak Bay in winter.

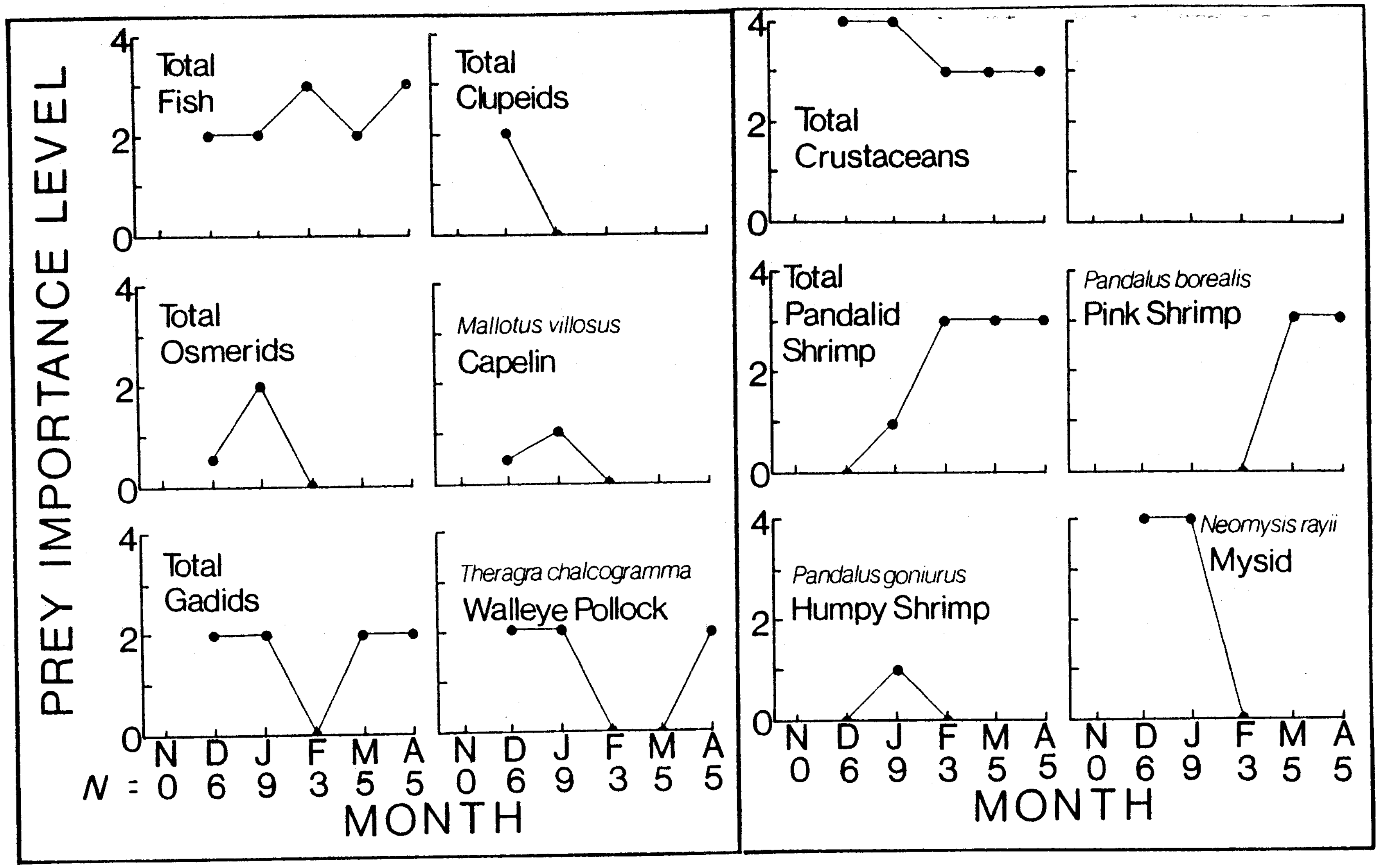

Figure 20. Monthly changes in the importance of fish (left) and crustaceans (right) in the diet of common murres from Kachemak Bay in winter.

Month	N Birds	Percent of Aggregate Volume	
		Neomysis rayii	Pandalid Shrimp
December	6	73.0	0
January	9	75.9	1.3
February	3	0	54.4
March	5	0	70.2
April	5	0	58.0

Despite the fact that the murres ate mysids only in December and January, they were still the most important prey overall. Although Neyomysis occurred in only 39% of the birds, they comprised 83% of the aggregate numbers of prey and 49% of their aggregate volume (Appendix Table 4).

Fish were also consistently present in the diet of the murres, but were generally less important than crustaceans (Figure 20). There was no pattern apparent in the monthly occurrence of any one species of fish. Total clupeids (including Pacific herring) occurred only in December, capelin only in December and January, and walleye pollock in December, January, and April.

Food Weight as a Percent of Body Weight. The weight of stomach contents ranged from "0" (empty stomach) for two birds in February and one in March, to a maximum of 2.9% of net body weight for a bird in December, and averaged 1.0% (n=31, S.E.=0.14) (Table 6). The maximum value was the result of 36 g of food in a bird of 1,224 g. Seventeen (55%) of the birds had values less than 1.0% of body weight and only four (13%) had values of 2.0% or greater.

Feeding Behavior and Feeding Habitats

Murres feed by pursuit diving (Ashmole 1971). The locations of their collection sites (Figure 6), and the known habits of their prey indicates that the birds probably fed over rock substrates at depths ranging from midway in the water column to or very near the bottom (Figure 21). The murres' principal prey, mysids and pandalid shrimp, typically occur at demersal or epibenthic depths, but the occasional occurrence of prey such as herring and capelin in their diet indicates that the murres probably fed part of the time at mid-depths in the water column.

Net Body Weight and Fat Index

Least squares analyses of variance showed no significant difference between mean weights of 20 male and six female murres and between mean monthly weights. Weights of individual birds ranged from 914 g to 1,253 g,

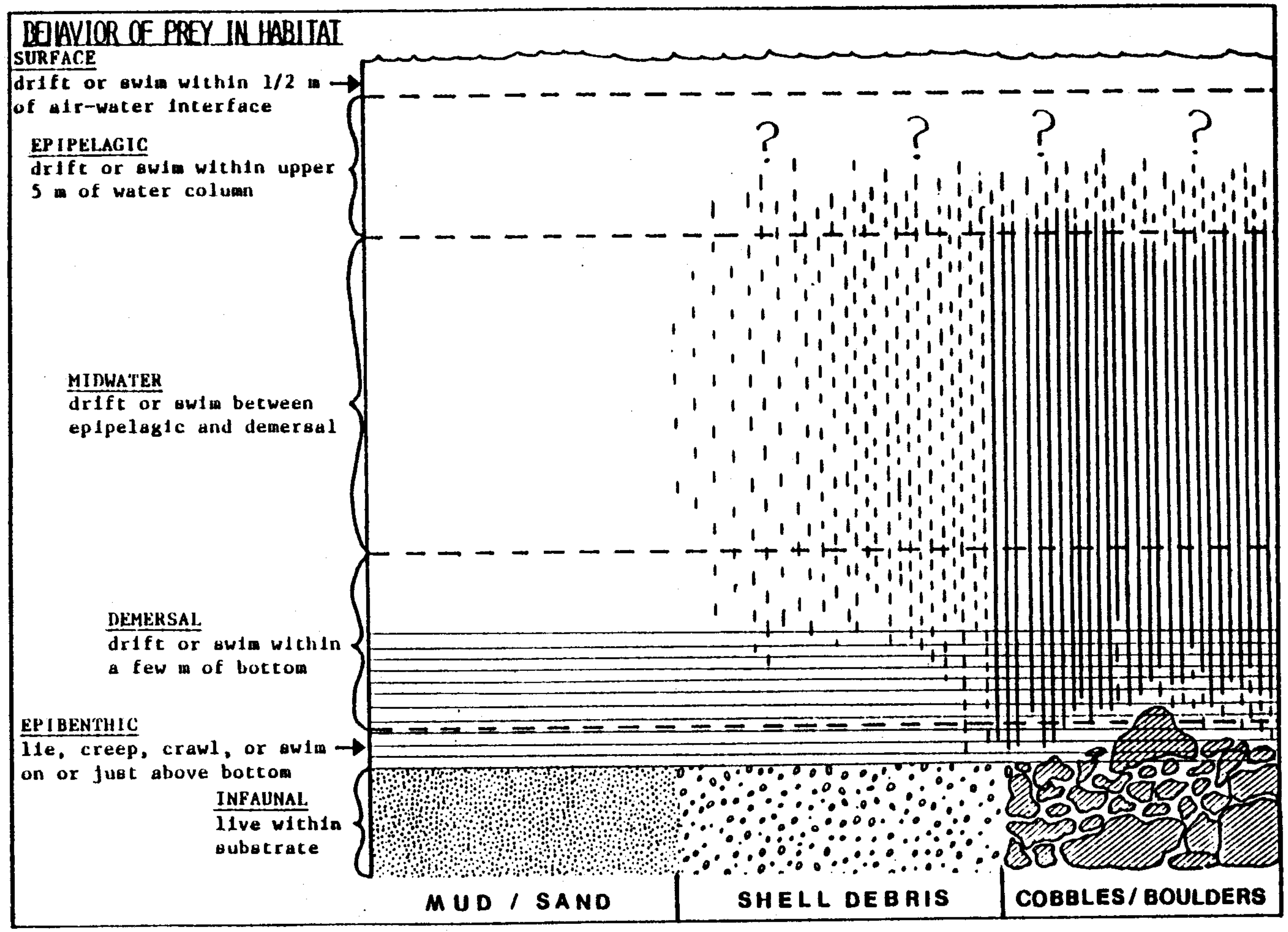

Figure 21. Schematic representation of the feeding habitats of alcids in Kachemak Bay in winter, in relationship to all subtidal feeding habitats. Common murres and marbled murrelets = vertical lines; solid are primary habitat, dashed secondary. Pigeon guillemot = horizontal lines.

and averaged 1,113 g for all 26 birds (Table 7).

The fat index (Table 8, Figure 15) ranged from two to five for individual birds, and averaged 3.1 (S.E.=0.15) for all birds. A one-way analysis of variance revealed significant differences between monthly means at the .05 level (F=4.68; p=0.0056). Inspection of the fat index data for the common murres suggests that fat indices declined from December through March.

PIGEON GUILLEMOT

We collected three pigeon guillemots--one on the north side of the inner bay in January, one on the north side of the outer bay in March, and one on the south side of the inner bay in April (Table 2; Figure 18). All three birds had food in their stomachs.

Food Habits

Together the guillemots ate a minimum of nine species of prey, including at least one polychaete, seven crustaceans, and at least one fish (Appendix Table 5). No one prey species occurred in more than one bird specimen, perhaps because each was collected in a different part of the bay. Unidentified fish and unidentified crabs were found in two of the birds. The shrimp together comprised 81% of the aggregate prey volume. The shrimp were dominated by *Pandulas goniuris*, which accounted for 50% (IRI=2,832) of the aggregate volume of all prey, and by *Crangon septemspinosa*, which comprised another 26% of the volume (IRI=1,693) (Appendix Table 5).

Although the limited sample size prevents speculation about the guillemot's preference of substrates for feeding, the kinds of prey suggests that they fed at demersal and epibenthic depths.

Weight of the stomach contents for the three birds was 0.7%, 0.8%, and 3.1% of the net body weight, and it averaged 1.5% (S.E.=0.64) (Table 6).

Prey Lengths. The lengths of 15 measurable prey pooled from the guillemots ranged from 17 to 66 mm, and averaged 28.3 mm (S.E.=2.94) (Tables 5 and 11). Seventy-three percent of the prey were less than 30 mm.

Body Measurements

Net body weights of the three birds, all males, were 545, 571 and 583 g, with an average of 566.2 g (S.E.=9.2) (Table 7). Fat indices (n=3) were either two or three, and averaged 2.3 (S.E.=0.27) (Table 8).

Table 11. Total Lengths, in 10 mm Increments, of all Measurable Prey from three Pigeon Guillemots Collected in Kachemak Bay in Winter

Prey Species	No of Prey in Length Increments (mm)				Totals
	10-19	20-29	30-39	60-69	
CRUSTACEA					
Mysids	1				1
Pandalus goniuris		6	2		8
Crangon septemspinosa		2		1	3
Sclerocrangon alata	1	1	1		3
TOTALS	2	9	3	1	15
Percent of Total	13.3	60.0	20.0	6.7	

MARBLED MURRELET

Collection Sites and Sample Sizes

We collected 21 marbled murrelets (Table 2), six of them in the shallow water of China Poot Bay in January and five each month thereafter in the inner bay in water deeper than 18 m (Figure 7). Twenty (95%) of the birds had food in their stomachs.

Food Habits

Marbled murrelets had the least diverse diet among the four primary species studied (Appendix Table 6). The numbers of prey items in the stomach samples ranged from at least six in February to two in Arpil, and the total number of prey species for the entire study period was at least eight. Total numbers of prey items are uncertain because gammarid amphipods were not identified to species.

Marbled murrelets ate only fish and crustaceans and, except for February, fish was the most important category of prey in their diet (Appendix Table 6). Capelin (IRI about 3,000) was by far the most important prey species. Sand lance, the euphausiid *Thysanoessa raschii*, and unidentifiable mysids were equally important, with IRI's of about 400. The mysids were unidentifiable, but they may have been juvenile *Neomysis rayii*, the species eaten by common murres. The low IRI's of walleye pollock, the euphausiids *T. inermis* and *T. spinifera*, and gammarid amphipods reflect their minor importance to the murrelets. Amphipods occurred in their diet only in February.

Prey Lengths. The lengths of the prey eaten by the murrelets ranged from 4 mm *Thysanoessa* euphausiids, to a 135 mm sand lance (Table 12), and the mean length of all prey (n=138) pooled from all stomachs was 26.3 mm (S.E.=2.02) (Table 5). About 66% of the prey, mostly crustacea, were 10- to 19-mm, and another 285, mostly fish, were between 20- and 59-mm (Table 12).

Length frequencies of capelin (Figure 22) and sand lance (Table 12) suggest the presence of 0- and 1-year classes, with the younger fish predominating. The euphausiids (*Thysanoessa raschii*) eaten by the murrelets ranged from 10 to 22 mm, with a mode of about 14 mm (Figure 23). The lengths of the mysids eaten by the murrlets (Figure 23) ranged from 10 to 40 mm, and may suggest the presence of at least two or three year classes.

Although the average length of all measurable prey of the murrelets was about 26 mm (Table 5), the modal length increment was 10 to 19. Prey in this length increment were mostly euphausiids, with some mysids and amphipods. The modal length increment of the measurable fish from the murrelets was about 40 to 49 mm. These lengths are similar to lengths of

Table 12. Total lengths, in 10 mm increments, of all measurable prey from 18 marbled murrelets collected in Kachemak Bay in winter.

Prey Species	No. of Prey in Length Increments (mm) 0-9	10-19	20-29	30-39	40-49	50-59	Totals
FISH							
Mallotus villosus [a/]			1	2	6	8	17
Ammodytes hexapterus [b/]				2	9		11
Unid. larvae		3					3
CRUSTACEA							
Gammarid Amphipods		6					6
Mysids		16	1	4			21
Thysanoessa inermis		1	1				2
T. raschii		42	2				44
T. spinifera			2				2
T. sp.	1	23					24
TOTALS	1	91	7	8	15	8	130
Percent of Totals	0.7	65.9	5.1	5.8	10.9	5.8	

a/ Plus six M. villosus in length increments as follows: 2,60-69; 1,70-79; 1,80-89; 1,90-99; 1,100-109.

b/ Plus two A. hexapterus in length increments as follows: 1,100-109; 1,130-139.

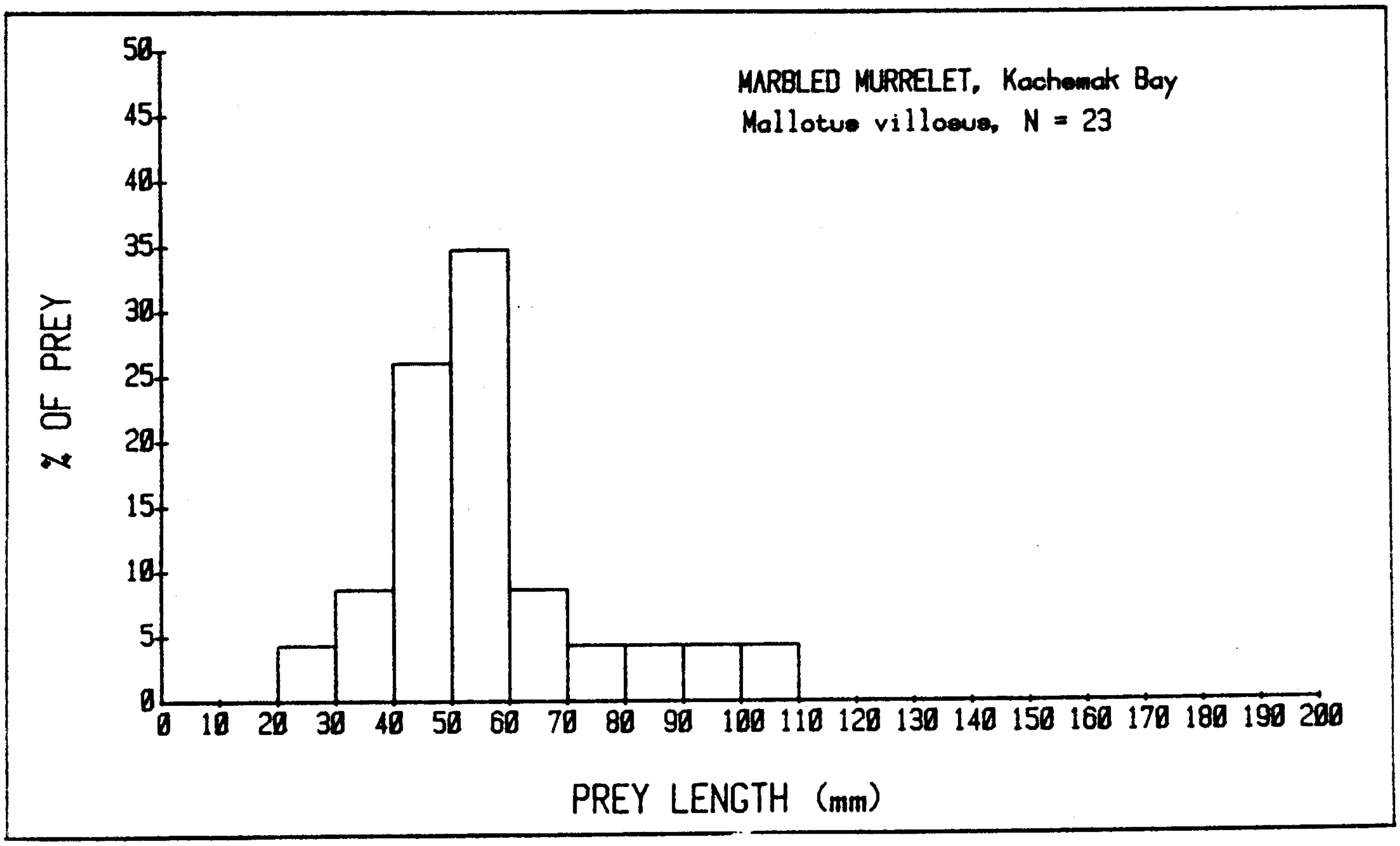

Figure 22. Length frequencies of capelin, Mallotus villosus, in the stomachs of marbled murrelets from Kachemak Bay in winter.

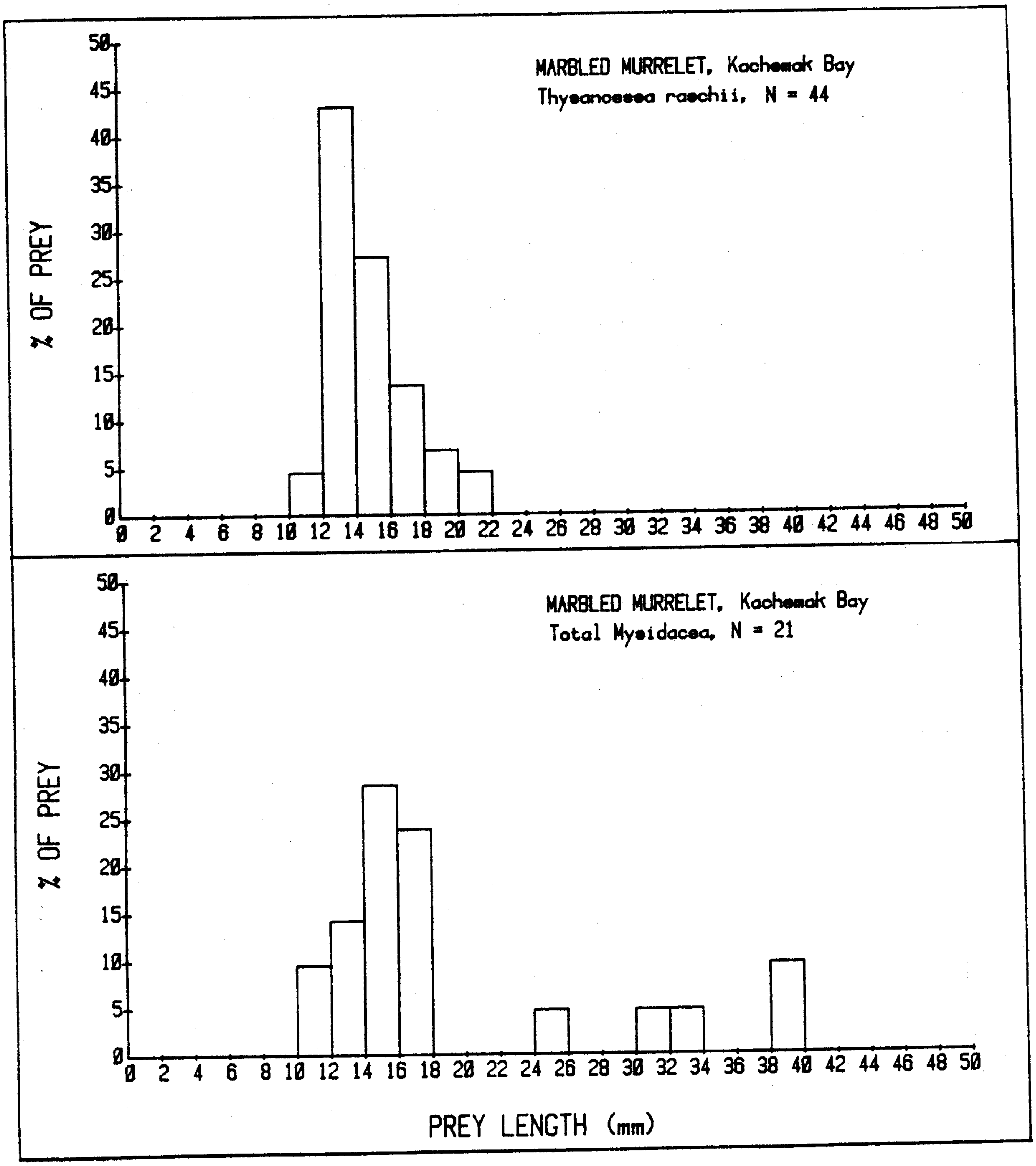

Figure 23. Length frequencies of the euphausiid crustacean Thysanoessa raschii and mysid crustaceans in the stomachs of marbled murrelets from Kachemak Bay in winter.

prey of marbled murrelets off British Columbia during the breeding season (Sealy 1975).

Monthly Changes in Prey Importance. The small sample sizes (3 to 6) preclude statistical inferences about monthly changes in the importance levels of prey, but some interesting trends are suggested. The prey importance levels of capelin and sand lance (Figure 24) appear to vary in inverse proportion, a possibility also suggested for total mysids and total euphausiids. The prey importance levels of both total fish and total crustacea remained consistently high (three or four) from January through April.

Food Weight as a Percent of Body Weight. Food weight ranged from 0 (empty stomach) for one bird in February, to a maximum of 6.6% of net body weight for a bird in March (Table 6). The latter value resulted from 15 g of food in a 228 g bird. Average values were low, ranging from 3.0% (S.E.=1.8) in March to 1.5% (S.E.=0.6) in April. Twelve birds (67%) had values less than 2.0% and only five birds (285) had values greater than 5.0%.

Feeding Behavior and Feeding Habitats

The locations of the murrelet collection sites (Figure 7) and the known habits of their dominant prey species (capelin, euphausiids) suggest that the birds fed mostly over rocky habitats, at mid-water depths. However, the presence in their diet of sand lance, gammarid amphipods, and mysids shows that the murrelets spent some of their time feeding in epibenthic/demersal habitats (Figure 30).

Net Body Weight and Fat Index

There were no significant differences in overall mean weights of seven males (245 g) and 12 females (233 g) (Table 7) nor among monthly mean weights of both sexes combined, as determined by least squares analyses of variance. Weights of individual birds ranged from 212 to 281 g.

The fat index (Table 8; Figure 15) ranged from one to four for individual birds, and averaged 2.6 (S.E.=0.15) for the 21 birds sampled. A one-way analysis of variance between the monthly means indicated no significant difference at the .05 level (F=2.43; D=0.10). This suggests that there was little change in the nutritional state of the murrelets throughout the study.

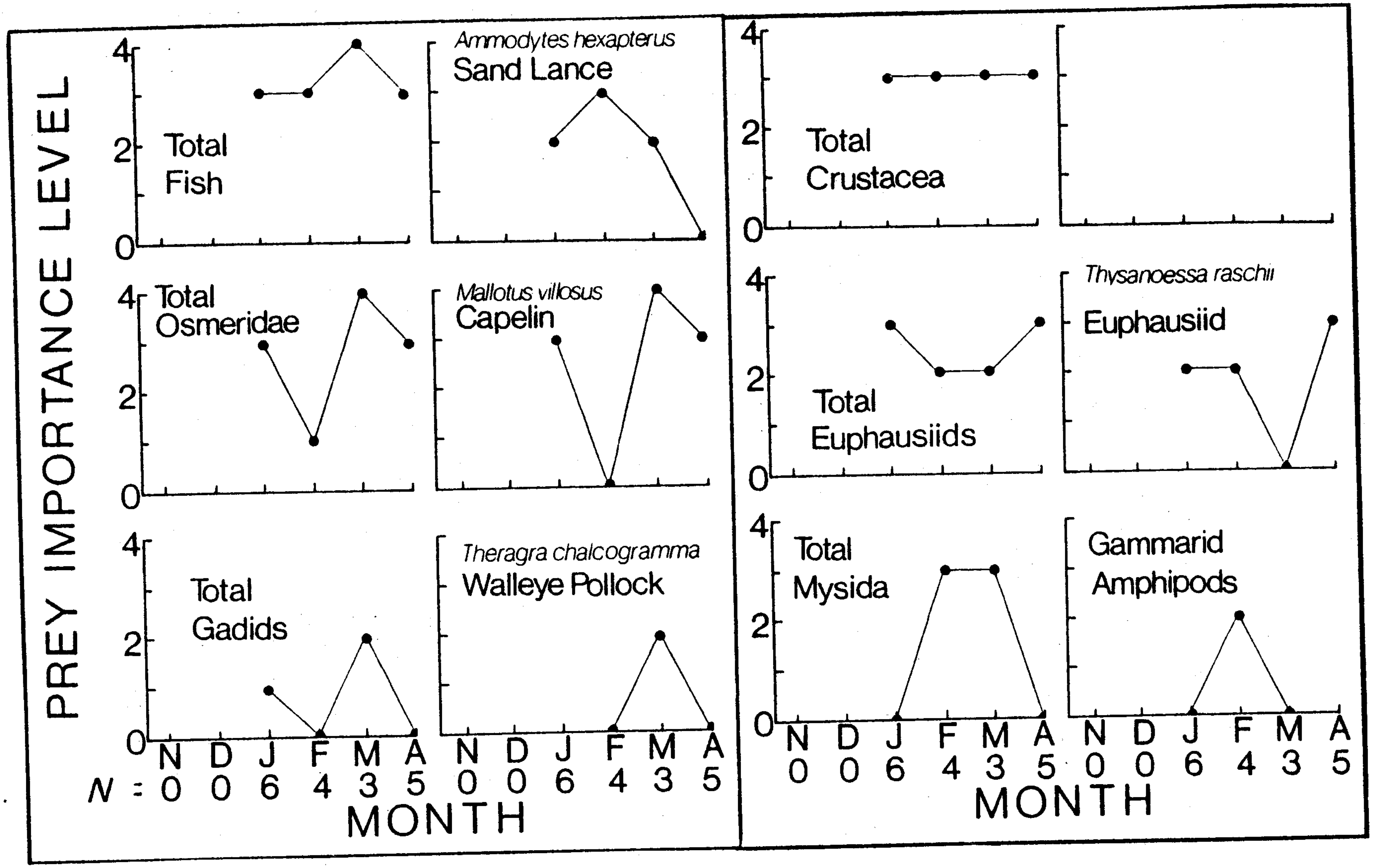

Figure 24. Monthly changes in the importance of fish (left) and crustaceans (right) in the diet of marbled murrelets from Kachemak Bay in winter.

RESULTS - TROPHIC RELATIONSHIPS

Table 13 lists and compares the importance levels of all of the prey taxa for the seven species of birds we studied. In sum, the birds ate a minimum of 79 prey species which occurred in eight phyla, including one protozoan (foraminifera), 12 polychaetes (annelida) in 10 families, 29 molluscs, including 16 gastropods and 13 bivalves, 25 crustaceans (arthropoda), one sipunculid, one ectoproct, four echinoderms, and six fishes.

Forty-seven (66%) prey species occurred in only a single species of bird, and 19 (27%) occurred in only two species. Only five (7%) of the prey species occurred in three species of birds, and none were found in four or more species. A general rule seems to be that if a species of prey was eaten by more than two bird species, it was a major prey of at least one. In contrast, if a prey species was eaten by only one bird species, it was of minor importance. Each of five prey species eaten by three bird species were of major importance to at least one of the birds. Mytilus edulis, eaten by oldsquaw, white-winged scoters, and black scoters (n=1), was a major prey of white-wings; mysids were important to both murres and murrelets; humpy shrimp (Pandalus goniuris) was a major prey of pigeon guillemots; and sand lance was a major prey of oldsquaw.

Table 14 lists the principal prey species of the bird community and indicates their probable habitats. A certain amount of conjecture (noted above) was used to assign "probable" habitats to many nektonic prey, but we believe this assessment is essentially correct. We arbitrarily classified an animal as a "principal" prey if it had a prey importance level of at least two (IRI=100) in one or more of the bird species. This assessment suggests a major conclusion about the trophic structure of the bird community: The overall diet of the birds is dominated by benthic and demersal fauna, of which most are filter- or deposit-feeders.

A detailed analysis of the trophic structure of the bird community is beyond the scope of this report. Nevertheless, it is reasonable to assume that the lower trophic levels of the Kachemak Bay ecosystem are similar to those typical of detrital food chains in other coastal marine ecosystems (Tenore 1977). That is, organic detritus--microbenthos (animals less than 0.1 mm)--meiobenthos (animals 0.1-1.0 mm)--macrobenthos (animals greater than 1 mm)--fish.

In Kachemak Bay, starfish are apex predators along with fish and birds (Dennis Lees, personal communication). However, it is difficult to state precisely the trophic level(s) at which a bird species feeds because the nature of the links among the microbenthos and meiobenthos are virtually unknown. The filter- and deposit-feeding animals comprising most of the prey of the bird community could feed on any of these kinds of animals, and also directly ingest the bacterially enriched detritus. Thus, depending on

Table 13. The relative importance of 79 species of prey to seven species of marine birds in Kachemak Bay, Alaska in winter. The importance categories are based on the Index of Relative Importance values of the prey species, as follows: + = 0-9; 1 = 10-99; 2 = 100-999; 3 = 1,000 and up.

	Importance Level of Prey to Bird Species[a/]						
	OLSQ	WWSC	BLSC	SUSC	COMU	PIGU	MAMU
Number of Specimens	28	39	2	4	31	3	21
Number with Prey	27	37	1	2	28	3	18
PREY SPECIES							
PROTOZOA							
Foraminifera							
Unidentified	+						
POLYCHAETA							
Unidentified	1	+				2	
Polynoidae							
Halosydna brevisetosa		+					
Harmothoe extenuata	+						
Sigalionidae							
Phloe minuta	+						
Phyllodocidae							
Anaitides mucosa	+						
Eteone sp.	+						
Unidentified	+						
Nereidae							
Unidentified	+				+		
Nephtyidae							
Nephtys sp.		+		3			
Goniadidae							
Glycinde sp.	+						

	BIRD SPECIES[a]						
	OLSQ	WWSC	BLSC	SUSC	COMU	PIGU	MAMU
Number of Specimens	28	39	2	4	31	3	21
Number with Prey	27	37	1	2	28	3	18
Lumbrineridae							
Lumbrinereis sp.	+						
Pectinariidae							
Pectinaria sp.	1						
Ampharetidae							
Ampharete sp.	+						
Unidentified	+						
Terebellidae							
Unidentified				2			
MOLLUSCA							
Gastropoda (Snails & allies)							
Unidentified	1	2					
Limpet species	+						
Trochidae							
Margarites pupillus		2					
Margarites sp.		1					
Lacunidae							
Lacuna variegata	1	+					
Lacuna sp.		+					
Littorinidae							
Littorina sp.		+					

	OLSQ	WWSC	BLSC	SUSC	COMU	PIGU	MAMU
Rissoidae							
Alvina compacta	1						
Cerithiidae							
Cerithiopsis sp.	+						
Trichotropidae							
Trichotropis cancellata		1					
Naticidae							
Natica clausa	+	1					
Muricidae							
Trophonopsis pacificus	+						
Pyrenidae							
Mitrella tuberosa	+						
Neptuneidae							
Neptunea lyrata	+	1					
Neptunea sp.		1					
Cancellariidae							
Admete couthouyi	+	1					
Turridae							
Oenopota sp.	2						
Unidentified	+			2			
Pyramidellidae							
Odostomia sp.	+						
Aglajidae							
Aglaja diomedeum	+						

Table 13. Cont'd, p. 4 of 9

	OLSQ	WWSC	BLSC	SUSC	COMU	PIGU	MAMU
Retusidae							
Retusa sp.	+						
Onchidorididae							
Onchidoris bilamellata	1						
Bivalvia (Clams and mussels)							
Unidentified	1	2		3			
Nuculidae							
Nucula tenuis	2			2			
Nuculanidae							
Nuculana c.f. *fossa*	2						
Glycymerididae							
Glycymeris subobsoleta	2	1					
Glycymeris sp.	+						
Mytilidae							
Mytilus edulis	2	3	3				
Montacutidae							
Orobitella sp.	+						
Astartidae							
Astarte rollandi		+					
Cardiidae							
Clinocardium sp.	+						
Mactridae							
Spisula polynyma	2						

	OLSQ	WWSC	BLSC	SUSC	COMU	PIGU	MAMU
Tellinidae							
Macoma balthica	+						
Macoma sp.	2	1					
Veneridae							
Saxidomus gigantea	+			2			
Psephidia lordi	+						
Protothaca staminea	1	3		2			
Unidentified		1					
Myidae							
Mya sp.	1	+					
CRUSTACEA (Phylum Arthropoda)							
Cirripedia *(Barnacles)*							
Unidentified	+	+					
Mysida (Opossum shrimp)							
Neomysis rayii					3		
Unidentified	+					2	2
Cumacea							
Lamprops sp.	+						
Unidentified	+						
Isopoda ("Pill bugs")							
Gnorimosphaeroma oregonensis	+						

	OLSQ	WWSC	BLSC	SUSC	COMU	PIGU	MAMU
Gammaridea Amphipoda[b/]							
Unidentified	2						1
Ampeliscidae (?)							
Unidentified	p						
Atylidae							
Atylus sp.	p						
Beaudettidae							
Unidentified	p						
Gammaridae							
Melita sp.	p						
Haustoriidae							
Unidentified	p						
Lys ianassidae							
Anonyx (laticoxae ?)	p						
Anonyx sp.	p						
Oedicerotidae							
Unidentified	p						
Phoxocephalidae							
Unidentified	p						
Euphausiacea (Euphausiids or krill)							
Thysanoessa inermis							+
Thysanoessa raschii							2
Thysanoessa spinifera							+

	OLSQ	WWSC	BLSC	SUSC	COMU	PIGU	MAMU
Thsanoessa sp.							2
Unidentified							1
Decapoda Natantia (Shrimp)							
Spirontocaris spina	+					2	
Eualus fabricii						1	
Eualus sp.					+		
Pandalus borealis					2		
Pandalus goniurus	1				+	3	
Pandalus jordani	+						
Pandalus sp.					+		
Unidentified pandalidae	+				1		
Crangon septemspinosa	1					3	
Crangon franciscorum					1		
Crangon sp.				2			
Sclerocrangon alata						2	
Unidentified	+	+			1	1	
Decapoda Reptantia (Crabs)							
Hyas lyratus	1						
Cancer oregonensis	1					3	
Cancer sp.	1						
Unidentified		1				2	

	OLSQ	WWSC	BLSC	SUSC	COMU	PIGU	MAMU
SIPUNCULA (Peanut Worms)							
Sipunculus sp.		+					
ECTOPROCTA (Bryozoans)							
Microporina borealis	+						
ECHINODERMATA							
Ophiuroidea (Brittle Stars)							
Ophiopholis aculeata	1						
Amphipholis pugetana	+						
Unidentified	1						
Echinoidea (Sea Urchins)							
Strongelocentrotus droebachiensis		+					
Unidentified	+	+					
Holothuroidea							
Unidentified		+					
OSTEICHTHYES (Bony Fish, Phylum Vertebrata)							
Unidentified	+				1	2	2
Clupeidae (Herring)							
Clupea harengus (Pacific Herring)					1		
Osmeridae (Smelts)							
Mallotus villosus (Capelin)					2		3
Unidentified					1		+

Table 13. Cont'd, p. 9 of 9

	OLSC	WWSC	BLSC	SUSC	COMU	PIGU	MAMU
Gadidae (Cods)							
Theragra chalcogramma (Walleye Pollock)					2		+
Unidentified					+		+
Cottidae (Sculpins)							
Unidentified	+						
Stichaeidae (Pricklebacks)							
Lumpenus maculatus (Daubed Shanny)					+		
Unidentified					+		
Ammodytidae							
Ammodytes hexapterus (Pacific Sand Lance)	3				+		2

Footnotes

a/ Bird Species: OLSQ = Oldsquaw; WWSC = White-winged Scoter; BLSC = Black Scoter; SUSC = Surf Scoter; COMU = Common Murre; PIGU = Pigeon Guillemot; MAMU = Marbled Murrelet

b/ For gammarid amphipods, "P" indicates animal was present, but volume, numbers, or frequency of occurrence were undetermined.

Table 14. Probable habitats of the main prey species of marine birds in Kachemak Bay in winter. Prey species are included if they have an importance level of 2 or 3 in at least one bird species. species. ? = Uncertain of habitat.

Prey Importance Level	Prey Species and Their Probable Habitats		
		SURFACE/EPIPELAGIC	
3		Capelin	
2		*Thysanoessa raschii* (Euphausiids)	
		MIDWATER	
3	? *Neomysis rayii* (Mysids)	*Pandalus goniuris* (Humpy Shrimp)	Capelin
2	*Thysanoessa raschii* (Euphausiids)	*Pandalus borealis* (Pink Shrimp)	Walleye Pollock Sandlance
		DEMERSAL	
3	? *Neomysis rayii*	*Pandalus goniuris*	
2	*Spirontocaris spina* (Shrimp)	*Pandalus borealis* (Pink Shrimp)	Walleye Pollock Sandlance

Table 14. Continued

EPIBENTHIC

3	Mud/Sand	*Crangon septemspinosa* (Sand Shrimp)	Boulders/Cobbles	*Cancer oregonensis* (Red Rock Crab)
		Sandlance		*Mytilus edulis* (Blue Mussel)
				? *Neomysis rayii* (Mysids)
2	Mud/Sand	*Oenopota* (Turrid Snail)	Shell Debris	*Margarites pupillus* (Puppet Margarite Snail)
		Gammarid Amphipods		? *Spirontocaris spina* (Carid Shrimp)
		Sclerocrangon alata (Crangonid Shrimp)		Gammarid Amphipods
				Mytilus edulis (Blue Mussel)

****

INFAUNAL

3	Mud/Sand	*Protothaca staminea* (Common Littleneck Clam)	Shell Debris	*Protothaca staminea* (Common Littleneck Clam)
2	Mud/Sand	*Nucula tenuis* (Clam)	Mud/Sand	*Spisula polynyma* (Clam)
		Nucula foss (Clam)		*Macoma* sp. (Clam)
		Glycymeris subobsoleta (Clam)		Gammarid Amphipods

which of these links are present in the food web of Kachemak Bay, a bird species may function as a first-to fourth-order carnivore.

With these points in mind, it is possible to depict the ecological processes and energy pathways probably operating at the base of the trophic structure of birds wintering in Kachemak Bay (Figure 25). These processes and pathways may be summarized as follows:

1. Stocks of kelp around the southern perimeter of Kachemak Bay and in Kennedy Entrance grow intensively in spring and summer, before and during the period when phytoplankton stocks in Kachemak Bay and adjacent lower Cook Inlet also bloom intensively;

2. Fecal pellets produced by zooplankton grazing on phytoplankton, and the abrasion and seasonal die-off of kelp both produce a rich source of organic detritus;

3. Ocean currents carry the kelp detritus from Kennedy Entrance into Kachemak Bay;

4. At some point in this sequence, bacteria colonize the detritus;

5. The microbially-enriched detritus supports a rich community of deposit- and filter-feeding demersal and benthic fauna, probably via one or two trophic links in the form of micro- and meiofauna;

6. The deposit- and filter-feeding animals in turn support the marine birds wintering in Kachemak Bay, as well as a host of other apex predators.

Food web relationships between the birds and their principal prey are shown schematically as "sink food webs" (cf. Cohen 1978). For this purpose, only those prey species with an IRI of at least 100, and which also comprise at least 1% of the aggregate prey volume are considered "principal prey." Such food webs are indicated for oldsquaw (Figure 26), white-winged scoters (Figure 27), common murres (Figure 28), pigeon guillemots (Figure 29), and marbled murrelets (Figure 30). Also shown are the probable feeding habitats of the oldsquaw, white-winged scoters, and marbled murrelets. It seems likely that the guillemots and the murres captured their prey in demersal and epibenthic habitats; and the locations of the murre collection sites (Figure 6) indicate that they were over rocky substrates.

RELATIVE SIZES OF PREY

Insight is gained into the trophic relationships between ecologically similar bird species by comparing their mouth areas (culmen length x bill width) and the lengths of their prey (Figure 31). Comparisons of the mean

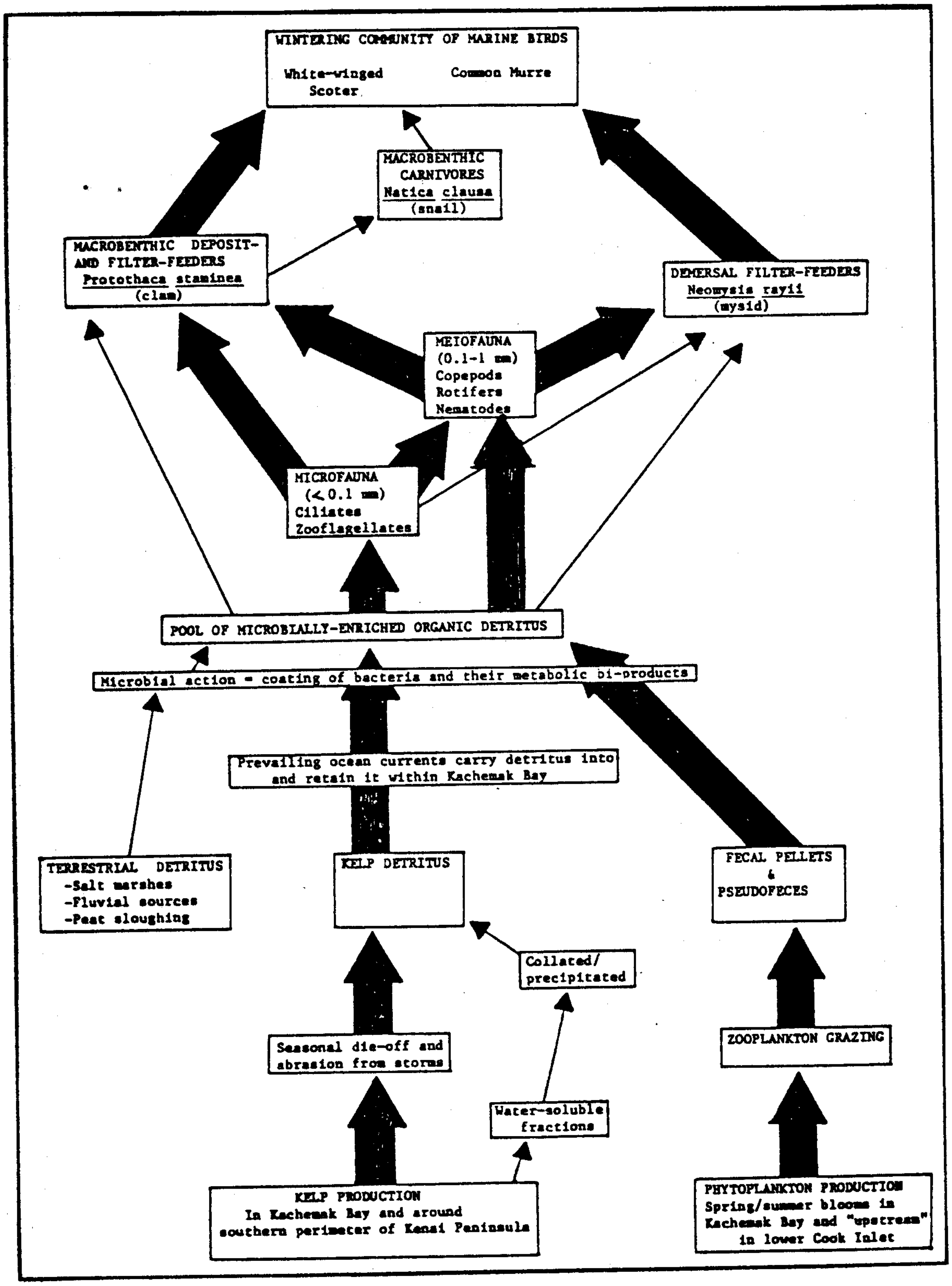

Figure 25. Hypothetical scheme of the trophic relationships and environmental mechanisms operating in the ecosystem of marine birds wintering in Kachemak Bay. Representative species or kinds of animals indicated.

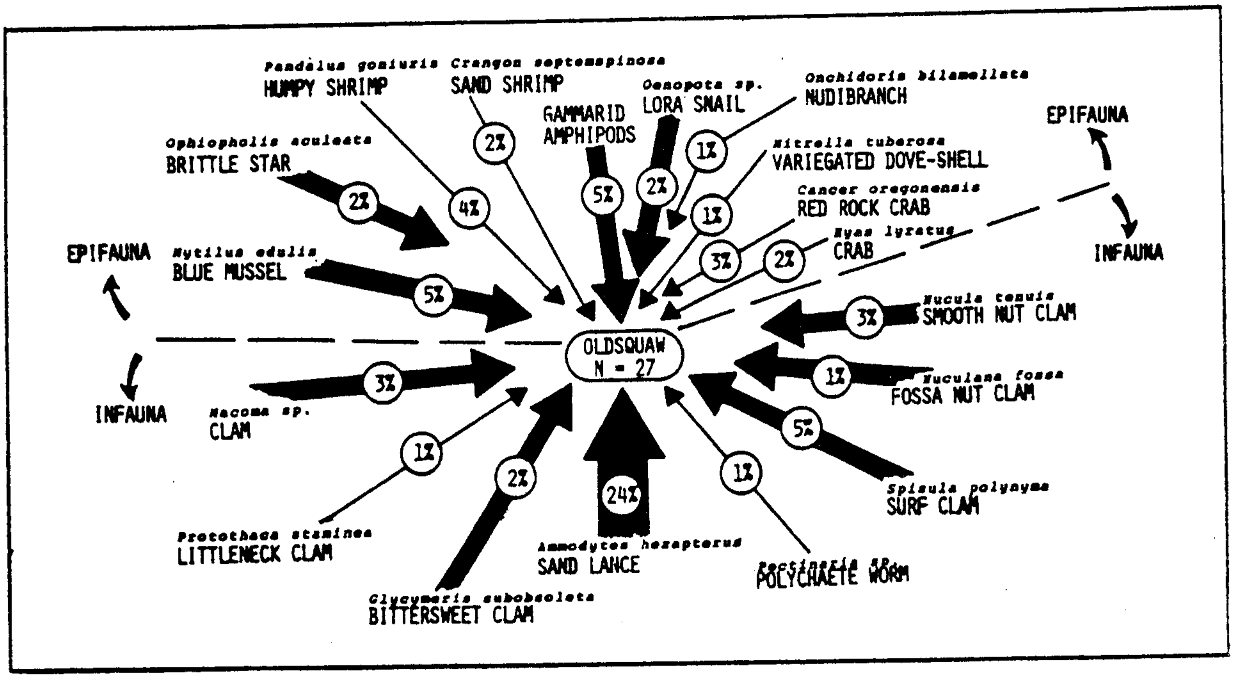

Figure 26. Food web for oldsquaw wintering in Kachemak Bay, indicating the 18 primary prey species and their relative importance. Percent volume of prey indicated, and arrow thickness proportional to prey's index of relative importance (IRI).

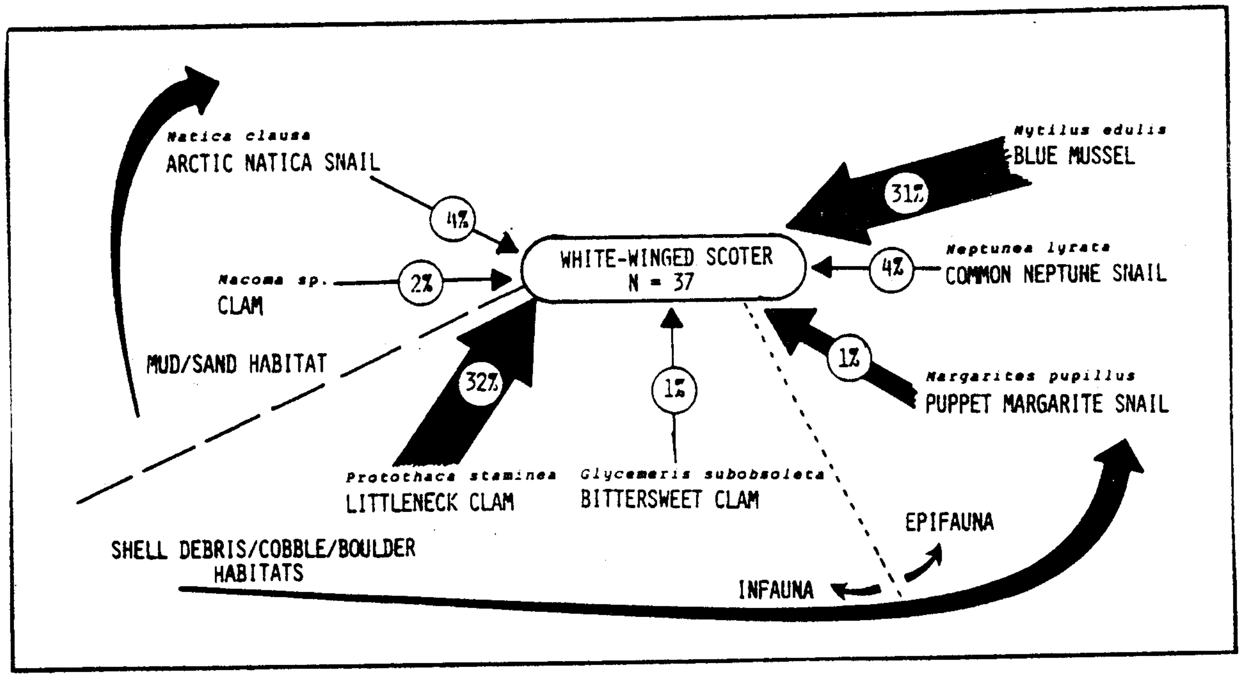

Figure 27. Food web for white-winged scoters wintering on Kachemak Bay, showing the 7 primary prey species, their relative importance and the habitat where the birds most likely captured them. Percent volume of prey indicated, and arrow thickness proportional to prey's index of relative importance (IRI).

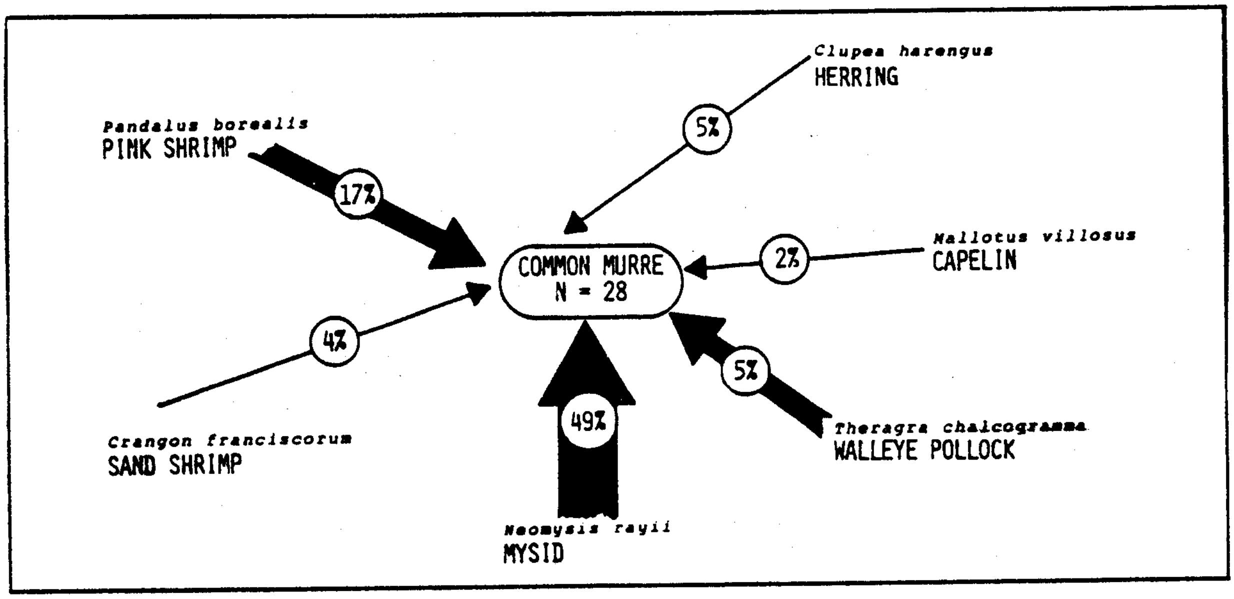

Figure 28. Food web for common murres wintering on Kachemak Bay, showing the six primary prey species and their relative importance to the birds. Percent volume of prey indicated, and arrow thickness proportional to prey's index of relative importance (IRI).

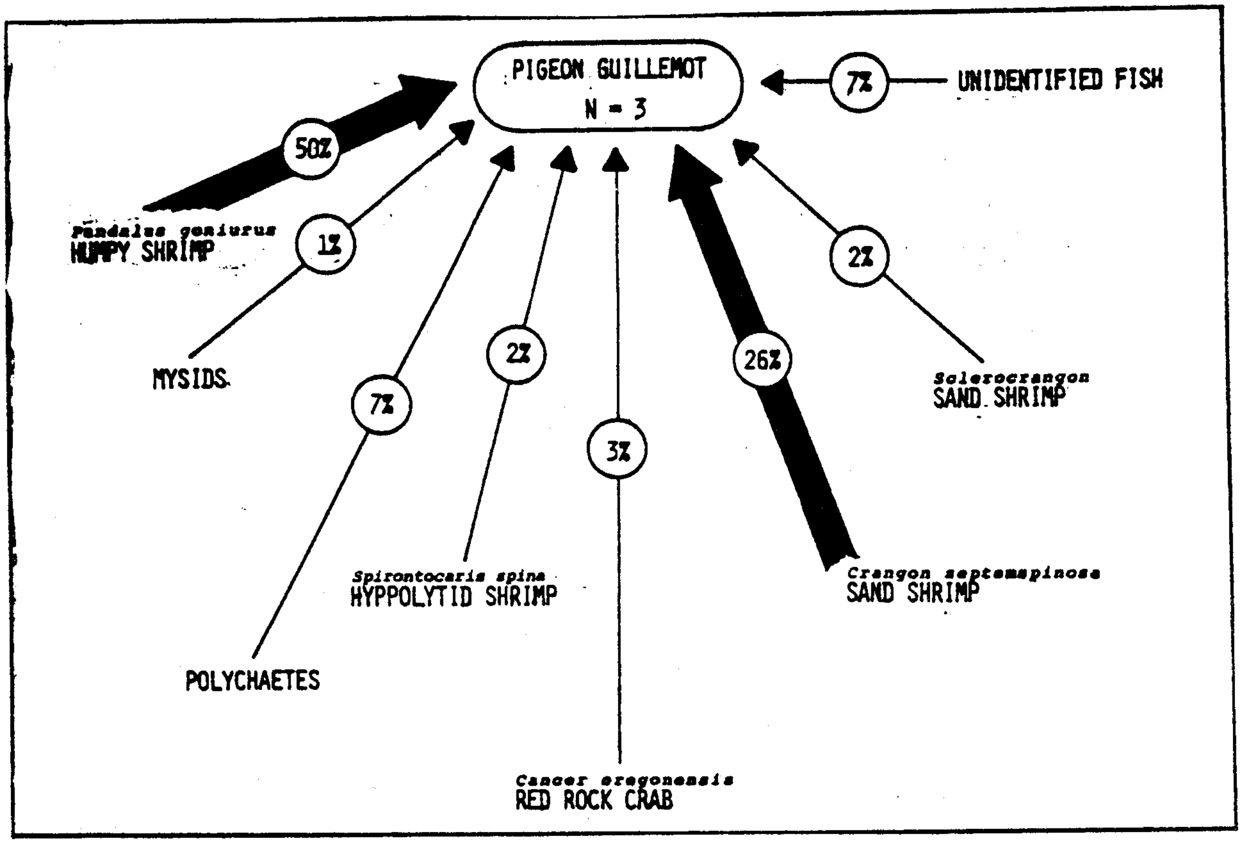

Figure 29. Food web for pigeon guillemots wintering on Kachemek Bay, showing the eight major prey species and their relative importance to the guillemots. Percent volume of prey indicated, and arrow thickness proportional to prey's index of relative importance (IRI).

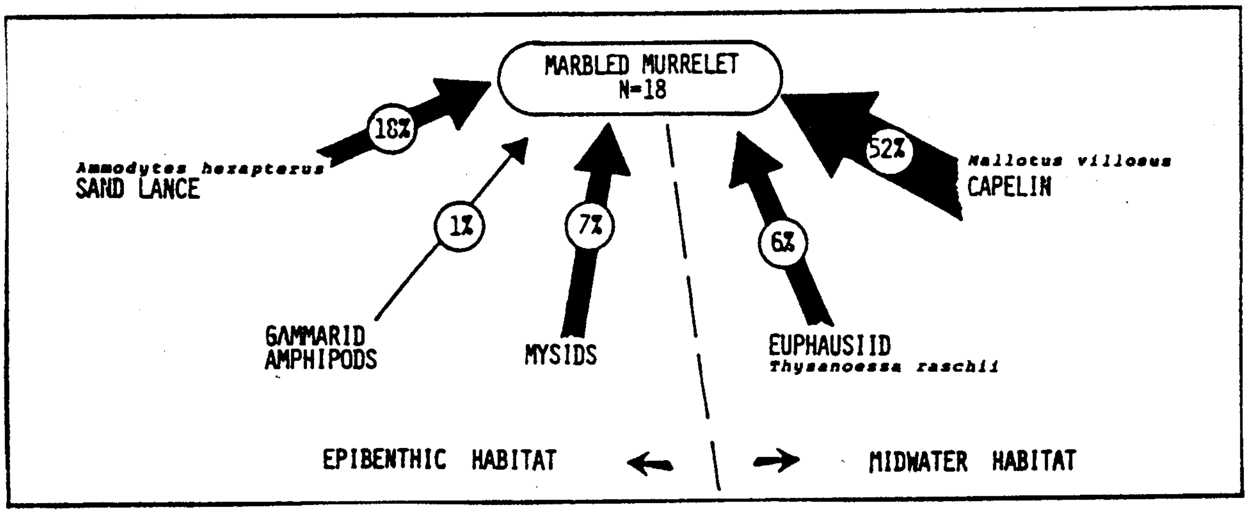

Figure 30. Food web for marbled murrelets wintering on Kachemak Bay, showing the five primary prey species and their relative importance to the birds. Percent volume of prey indicated, and arrow thickness proportional to prey's index of relative importance (IRI).

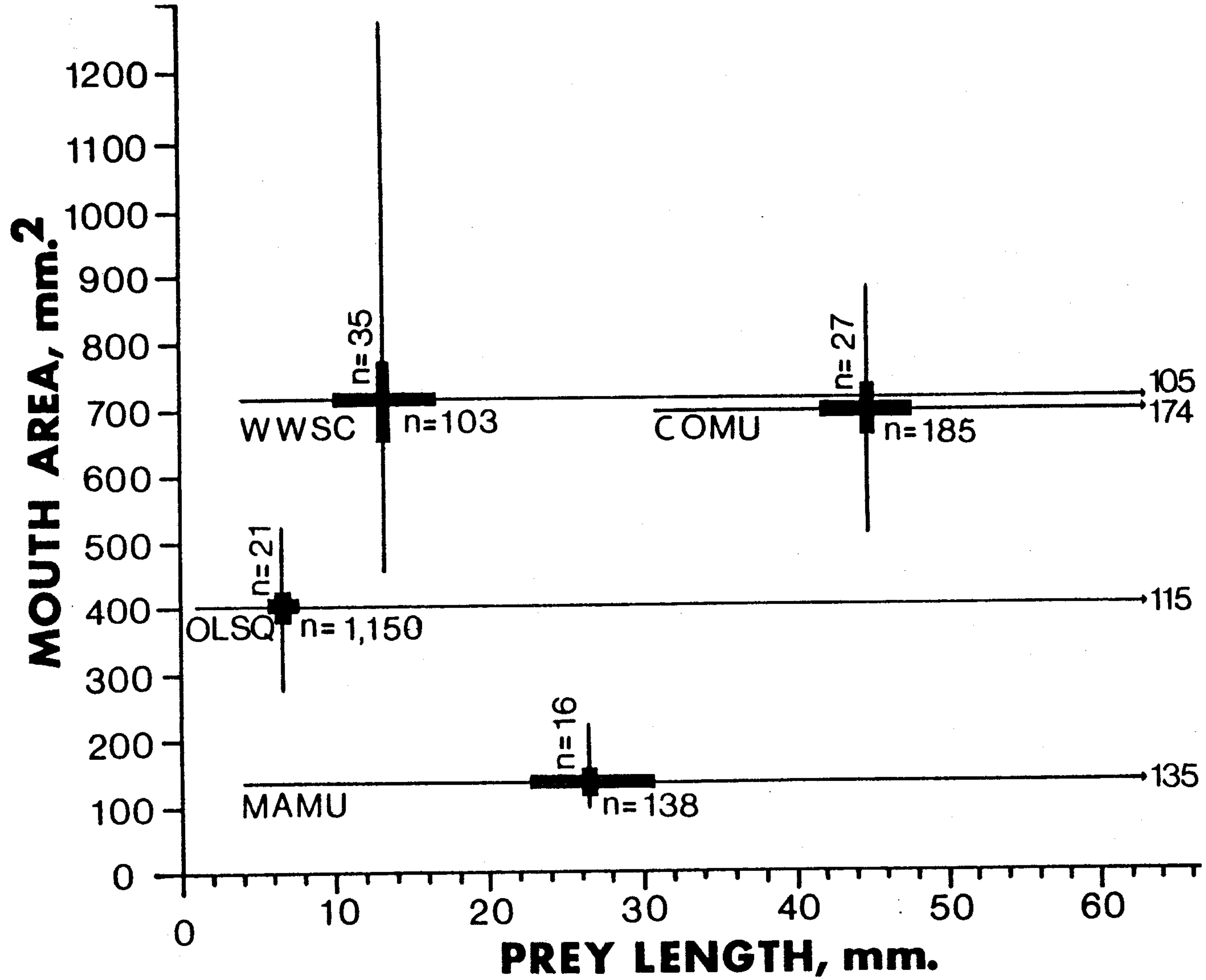

Figure 31. Relationship between mouth area (bill width X culmen length) and prey length for oldsquaw (OLSQ), white-winged scoters (WWSC), common murres (COMU), and marbled murrelets (MAMU), showing mean, ± two standard errors of the mean, and maximum and minimum values. Sample sizes (n) indicate number of birds and number of all prey pooled from the sample of birds.

mouth areas between the benthic-feeding oldsquaw and white-winged scoters, and between the pelagic-feeding murres and murrelets both showed differences at the 99% level of significance (t-test of the differences between two means, Sokal and Rohlf 1969:222). Similar comparison between the mean lengths of the prey of the two waterfowl, and of the two alcids also each showed differences at the 99% level of significance.

These differences are further illustrated when the lengths of prey taxa eaten by two bird species are compared. Mytilus was eaten by both oldsquaw and white-winged scoters, but the 503 mussels from the oldsquaw were all less than 10 mm (Table 4), while the three from the scoters were 50 to 69 mm (Table 9). Similarly, the 19 Protothaca clams from the oldsquaw were less than 10 mm, while the four Protothaca from the scoters ranged from 10 to 49 mm.

Similarly, 151 mysids eaten by the murres ranged from about 30 to 50 mm, while the 21 measurable mysids from the murrelets ranged from about 10 to 40 mm, with 16 (76%) of these being less than 20 mm (Table 10).

Although the height or girth of a prey may be indicative of the maximum size a seabird may choose in experimental conditions (Swennen and Duiven 1977), these data show highly significant differences in the lengths of prey eaten by the birds we studied. A reasonable general conclusion seems to be that any number of parameters could be used to compare prey sizes.

GENERAL DISCUSSION

BIOLOGICAL AND ECOLOGICAL CONSIDERATIONS

Oldsquaw and white-winged scoters ate the same general categories of prey reported previously (Stott and Olson 1973; Nilsson 1972; Madsen 1954; Cottam 1939). Both species eat mostly bivalves, gastropods and crustaceans in varying proportions, depending on the species of benthos present locally.

The dominance of pandalid shrimp and mysids in the diet of common murres contrasted markedly with the dominance of fish in their diets elsewhere in summer (e.g., Ogi and Tsujita 1973; Sanger et al. 1978). This may have reflected a greater abundance or at least availability of these crustaceans over forage fishes in Kachemak Bay in winter, although we have no corroborating data.

Despite recent surveys of the benthos in Kachemak Bay, knowledge of the distribution, abundance and availability of the prey species of the benthic feeding oldsquaw and scoters remains sketchy. Specimens of oldsquaw and scoters were collected in water depths between one and 10 fathoms (2-20 m) at mean lower-low water (NOAA Nautical Chart #16645). Other than visual, SCUBA diving surveys along the north shore of the outer bay mostly in summer (Lees 1978; Rosenthal and Lees 1977), there have been no systematic surveys of benthos in the depth ranges frequented by waterfowl during this study. We do not know precisely the depths at which sea ducks fed, but we assumed that a bird specimen had eaten its prey in the general vicinity of its collection site. Regardless, it is likely that white-winged scoters collected in the outer bay fed mostly at depths shallower than those studied by Feder and Paul (1980) (ca. 29 m) and by Driskell and Lees (1977) (ca. 12-65 m), and deeper than the intertidal areas studied by Lees et al. (1980). However, the presence of *Mytilus edulis* in both oldsquaw and white-winged scoters indicates that they fed at least part of the time over intertidal areas at high tide (Lees 1978; Rosenthal and Lees 1977). Moreover, the absence of horse mussels (*Modiolus modiolus*) from their diet suggests that they did not feed over rocky areas when they fed subtidally (Lees 1978; Rosenthal and Lees 1977)

The studies noted above are the only surveys of macrobenthos in Kachemak Bay; and besides the intertidal surveys of Lees et al. (1980) at Homer Spit, none were in winter. Differences in the kinds of prey eaten by the birds and the species reported by these authors (see below) suggests that there may be real differences between the animal communities in the birds' feeding habitats and the areas studied by these authors. It is also possible that their sampling schemes missed major components of the birds' diets, and that the birds selected prey in different proportions to their occurrence in nature.

Regardless of dissimilarities, the incomplete nature of information on the distribution and availability of the birds' prey is illustrated by comparing the present results with those of the authors noted above. In February and March 1977, Lees et al. (1980) sampled the intertidal fauna on the outer beach of Homer Spit. Polychaete worms comprised 76% to 85% of the numbers of prey, gammarid amphipods comprised another 13 to 17%, and clams (Spisula polynyma) and sand lance were minor components. Of these animals, only Spisula, the polychaete Nephtys, and sand lance were important prey of one or more of the bird species. A host of other species of crustaceans, clams, and gastropods, not found by Lees et al. (1980) were important to the birds in the subtidal epibenthic and infaunal habitats. Many species of crustaceans, at least, are highly mobile, and likely migrate to intertidal areas to feed at high tide.

Similar marked differences exist between prey species of the white-winged scoters collected off the north shore of the outer bay, and species observed as dominant there by Lees (1978) and Rosenthal and Lees (1977) during diving surveys. These investigators reported a number of benthic species as dominant on rocky substrates between depths of about four and 15 m. They listed the horse mussel (Modiolus modiolus), the matting polychaete Potamilla and the butter clam Saxidomus as the most important suspension feeders, the sea urchin Strongylocentrotus droebachiensis as a conspicuous grazer, and the moon snail Neptunea lyrata as an important predator. Of these species, only Neptunea lyrata was moderately important to white-winged scoters, and Strongylocentrotus was of minor importance; none of the other species was present in the scoters' diet.

Although Driskell and Lees (1977) indicate well defined boundaries between types of bottom substrates off the north shore of the outer bay (Figure 2), substrates within the general area actually consist of a mosaic of rocky areas, shell debris, mud and sand (Dennis Lees, personal communication). It thus appears that white-winged scoters feed largely in shell debris substrates, which was not specifically studied during diving surveys (e.g., Lees 1978). The scoters also appear to select fauna smaller than normally seen during the visual diving surveys in rocky areas (Dennis Lees, personal communication).

In sum, the exisitng surveys of benthic fauna in intertidal (Lees et al. 1980) and deeper areas (Driskell and Lees 1977; Feder and Paul 1979) have limited use in interpreting the results of studies of benthic-feeding birds in Kachemak Bay. A field program is needed which is specifically tailored to study the feeding habits of the birds concurrently with sampling the epibenthos and infauna within the 1- to 20-m depth zone, and to sample the epibenthos in intertidal areas at high tide.

Even less is known about the pelagic fauna of the murres and murrelets. However, the dominance of the mysid Neomysis rayii of 30-45 mm in the diet of the murres, which usually eat prey of at least 80-100 mm (e.g., Sanger *et al*. 1978), suggests very high densities of mysids in the deep portion of the inner bay in January and February. The mysids would have to have been abundant and fairly concentrated for it to have been energetically feasible for the murres to eat them to the extent that they did. Similarly, the dominance of pandalid shrimp in the diet of murres from February through April suggests an abundance of these shrimp then. Feder and Paul (1980) noted the highest densities of pink shrimp (*Pandalus borealis*) in the lower Cook Inlet area in summer in inner Kachemak Bay. The consistent importance of euphausiids in the diet of murrelets from January through April indicates like high concentrations of these crustaceans in the deepwater portion of the inner bay.

Amounts of food in the birds--expressed as percent of net body weight--were generally low. They ranged from empty stomachs in a few specimens of all species except oldsquaw and pigeon guillemots, to a high of 6.6% for a marbled murrelet (Table 6). Average values for the four primary species ranged from 1.0% for common murres, to 2.2% for white-winged scoters (Table 6). Despite this seeming paucity of food, however, data on net body weights (Table 7) and fat indices (Table 8) generally reflect a healthy physiological condition throughout the study. Thus, adequate amounts of food were available for benthic feeding species as well as pelagic species. These data also imply rapid rates of digestion (van Koersveld 1950) and frequent small feedings, rather than sporadic gorging as in the case with short-tailed shearwaters, whose stomach contents can approach 20% of their net body weight (Sanger *et al*. 1978).

Since the species of waterfowl we studied spend their nesting season in freshwater/terrestrial habitats, the birds should be unaffected by changes in salinity in itself. On the other hand, water and air temperatures can have a profound influence on the birds by increasing their rate of metabolism, and therefore, their need for food in colder temperatures (Calder and King 1974). In south Sweden, food seeking rates of oldsquaw and other species were highest during the coldest winter months (Nilsson 1970), indicating an increased energetic cost to the birds. Similarly, particularly cold winters can be expected to place added energetic stress on birds wintering on Kachemak Bay. The presence of ice in the shallow inner bay, however, appeared to have no effect on the birds. Oldsquaw readily occurred and dived within the ice, which may have actually shielded the birds from the wind.

IMPACTS OF BIRDS ON COMMERCIAL FISHERIES

In most cases, impacts of birds wintering on Kachemak Bay on commercial species of fish and shellfish appear to be minimal. Juvenile walleye pollock were a minor component of the diet of common murres (5% by aggregate volume, Figure 40), but neither salmonids nor other species of commercial fin-fishes were present in the stomach samples. Juvenile salmonids are not abundant in the bay until late May (Blackburn 1978).

Although pink shrimp (Pandalus borealis) comprised 17% of the aggregate volume of food eaten by common murres (Figure 40), it is difficut to translate this into degree of impact on the fishery without having better information on the size of the population of murres wintering in Kachemak Bay. Similarly, humpy shrimp (P. goniuris) comprised 50% of the volume of the stomach contents of the three pigeon guillemots sampled, but larger sample sizes of birds and a better idea of their population size in the Bay would be needed to calculate their impact on the shrimp stocks.

The highest densities of settling juvenile king crabs (Paralithodes camchatica) in Kachemak Bay were in the cobble-boulder area off the north shore of the outer bay (Haynes 1977; Gundberg and Clausen 1977) where we found maximum concentrations of white-winged scoters, but crabs were not part of the diets of the birds. The crabs do not settle to the bottom until late spring, after the wintering, bottom-feeding birds have migrated out of the bay, and the crabs themselves migrate to deeper waters before the birds return (SAI 1979).

POTENTIAL FOR IMPACT TO WINTERING BIRDS FROM OCS OIL AND GAS ACTIVITIES

Any potential impact to marine birds in Kachemak Bay resulting from oil exploration, development, processing, or transport must be weighed in light of the ocean current patterns summarized in a preceding section of this report. To briefly review, water enters Kachemak Bay from the Gulf of Alaska, via Kennedy Entrance. Gyral currents in outer Kachemak Bay imply residence times of the water in the outer bay on the order of several days, or perhaps longer. Water enters the inner bay from the outer bay at depth. Water exits Kachemak Bay in a northwesterly direction along the north shore of the outer bay, to join a moderately strong northerly flow along the east side Cook Inlet which extends at least as far north as the Forelands. Thus, the potential severity of acute or chronic oil spills to marine birds in Kachemak Bay, or to any of the biota for that matter, depends on whether the mishap is "upstream" or "downstream" from the bay.

Drilling Platforms

Depending on wind and current patterns during and immediately after an oil spill from any of the drilling rigs projected for lower Cook Inlet in the Bureau of Land Management (BLM) developmental scenario, it appears that the rigs would be far enough west of the normal current patterns that they would not directly affect Kachemak Bay. If a spill did reach the bay, however, the general habitat of greatest importance to the birds includes the entire perimeter of the bay at depths shallower than 20 m. None of the bird species we studied feed intertidally on low tides. Murres, murrelets, and occasionally white-winged scoters, utilize habitats over deeper water, but areas less than 20 m seem to be the main habitat for most of the wintering bird community.

The species we studied included waterfowl or alcids, the two major groups of seabirds most susceptible to direct oiling (King and Sanger 1979). Although most of the prey species eaten by the bird community are probably eaten subtidally, Mytilus, at least, is probably eaten by the waterfowl in intertidal areas on high tides.

Secondary effects could result with contamination or reduction of food organisms if spilled oil precipitated to the bottom in subtidal areas. Such effects could be of greater long-term significance than oiling of birds, but are not easily observed nor measured. The loss of benthos which would have the greatest potential for adverse impact to the marine bird community are the bivalves Mytilus, Protothaca, Spisula, Nucula, and Macoma, in descending order of importance. Similarly, pelagic prey of greatest importance to the wintering bird community include the mysid Neomysis rayii, pink shrimp Pandalus borealis, the euphausiid Thysanoessa raschii, and two fishes, capelin and sand lance.

Any other potential environmental threat from drilling platforms would appear to be confined to the immediate vicinity, and would be unlikely to have a discernible effect on birds wintering in Kachemak Bay. These would include drill cuttings and drilling muds, entrainment by cooling systems, and chronic contamination from formation waters.

Potential Shore-Based Facilities-Tanker Terminals

The BLM development scenario lists two general areas for potential shoreside facilities, one in the vicinity of Anchor Point, and another in an area adjacent to Kennedy Entrance extending generally from Port Graham to the Chugach Islands. Of these two areas, it appears that Kennedy Entrance would pose the highest threat to marine birds in Kachemak Bay, since oil spilled from tankers and pipelines at this location is most likely to be carried by the prevailing ocean currents into the bay. Conversely, the Anchor Point area is downstream from most of Kachemak Bay and oil is likely to be carried away from Kachemak Bay.

Pipelines

The laying of pipelines in the areas suggested as pipeline corridors in the BLM development scenario would appear to have little effect on marine birds wintering in Kachemak Bay. However, in areas immediately adjacent to shore, they may temporarily disrupt the local distribution of foraging birds. Depending on where pipeline breaks and chronic leaks occurred, they could pose a severe threat to the birds, their prey, and organisms and processes at the base of their food web. The main consideration is the proximity of the break/leak to Kachemak Bay. A break or leak near shore in the Kennedy Entrance area would be particularly threatening to the birds and to fauna at lower trophic levels in their food web. The key habitats and species would be the same as those mentioned above.

Tanker Routes

The BLM development scenario indicates tanker routes roughly paralleling the north and south shores of outer Kachemak Bay. Any spill here could have dire consequences for marine birds, both by direct oiling and by contaminating their food and organisms at lower trophic levels in the food web. The key habitats and species would be the same as those mentioned above. Routes along the south shore woud appear to pose the greatest threat, however, because they are upstream from most areas of the Bay. Spills here would have a greater chance of remaining within the gyral currents of the bay, thus exposing the birds and their prey to contamination for greater periods of time.

Physical Disturbances

It is difficult to assess the possible negative effects of disturbance to the wintering birds from aircraft and boat traffic. The main problem is the lack of comparative quantitative information on "before and after" conditions on populations of birds in other areas. All of the species of birds we studied are known to inhabit other areas in Alaska and elsewhere on the Pacific Coast which have aircraft and particularly boat traffic. Chiniak Bay on Kodiak Island and Puget Sound, Washington, are two such examples. During our studies, the white-winged scoters were particularly skittish at the approach of our boat, a situation we also experienced in the Kodiak Area. However, fishermen are known to shoot marine birds for crab bait and it is possible that the scoters have learned to be wary of the approach of any boat.

SUMMARY AND CONCLUSIONS

1. We studied the food habits, feeding behavior, and trophic relationships of selected species of birds wintering on Kachemak Bay, Alaska, from November 1977 to April 1978. Studies were concentrated on oldsquaw (Clangula hyemalis), white-winged scoters (Melanitta deglandi), common murres (Uria aalge), and marbled murrelts (Brachyramphus marmoratus). We gathered peripheral information of surf and black scoters (M. perspicillata and M. nigra), and pigeon guillemots (Cepphus columba).

2. Marine birds winter in Kachemak Bay because of an abundant food supply and the presence of ice-free resting areas.

3. The above species ate a minimum of 79 species of prey in eight phyla, including one protozoan, 12 polychaetes, 16 gastropods, 13 bivalves, 25 crustaceans, one sipunculid, one extoproct, four echnioderms, and six fishes. In general, waterfowl ate mostly benthic bivalves and gastropods, and some crustaceans and fish, while the alcids ate mostly pelagic and demersal crustaceans and fish. Although species differed, the birds ate similar kinds of prey as reported for other areas.

4. Oldsquaw were extreme generalists on bethos, eating a minimum of 60 prey species. In descending order of importance, the oldsquaw ate bivalves, crustaceans, fish, gastropods, and polychaetes. The most important species of prey were sand lance (Ammodytes hexapterus), and the bivalves Spisula polynyma and Mytilus edulis. Oldsquaw usually foraged in water less than 18 m over substrates of sand and mud, but occasionally over shell debris, cobbles and boulders.

5. White-winged scoters were generalists on benthic molluscs, primarily bivalves. They ate a minimum of 22 species of prey, the most important being the bivalves Mytilus edulis and Protothaca staminea, and the gastropod Margarites pupillus. Scoters foraged generally in water less than 20 m over substrates of cobbles and shell debris, but occasionally over substrates of mud and sand.

6. Common murres ate a minimum of 11 species of mid-water and demersal prey, mostly crustaceans, but including some fish. The most important prey species were the mysid crustacean Neomysis rayii, and pink shrimp, Pandalus borealis. Murres generally fed over rock substrates in water depths greater than 20 meters, at mid and demersal depths in the water column. The preponderance of crustaceans in the diet of the murres was unexpected, since murres are generally considered to be piscivorous.

7. Marbled murrelets ate at least eight species of prey, primarily fish, but also included some crustaceans in their diet. Capelin (Mallotus villosus) was the most important prey species, followed by sand lance,

the euphausiid crustacean *Thysanoessa raschii*, and mysids. The feeding habitat of the murrelets was basically similar to the murres, although they tended to occur closer to shore.

8. There was very little overlap in the prey species eaten by different species of birds. When overlap did occur, a prey species was generally important to only one bird species, or the two species of birds ate different sizes of prey.

9. Among the four primary species of birds studied, there were significant differences between "mouth area" (culmen length x bill width) and average length of prey.

10. The base of the trophic structure of Kachemak Bay in winter apparently depends on the production and availability of organic detritus. The main source of the organic detritus appears to be mainly from extensive beds of kelp in Kachemak Bay and around the southern perimeter of the Kenai Peninsula, and from fecal pellets produced by zooplankton grazing on spring blooms of phytoplankton. Assuming that the ecosystem of Kachemak Bay is similar to other coastal marine ecosystems, the organic detritus is colonized by bacteria, which provides food for communities of microfauna (animals less than 0.1 mm) and meiofauna (0.1-1.0 mm), all of which are ingested by the filter- and deposit-feeding fauna comprising the bulk of the prey eaten by the birds.

11. Existing knowledge of the distribution and abundance of the prey species in winter is inadequate to determine their availability to the birds. Waterfowl feed in shallow subtidal depths out to about 20 meters, a zone which has been largely unsampled by both shore-based and vessel-based studies. Winter studies of the principal pelagic prey of the birds such as mysids, euphausiids, juvenile shrimp and capelin have been sketchy or non-existent.

12. The birds appear to have a minimal impact on the commercial fisheries of Kachemak Bay.

13. Birds wintering in Kachemak Bay appear to be at high risk from both acute and chronic oil spills. Most of the wintering community of birds are either waterfowl or alcids, the two major groups of birds most susceptible to oiling. Pollution that interferes substantially with the production of organic detritus, particularly from the extensive beds of kelp, could have more serious long-term consequences to the birds than direct oiling. In general, any potential threats to the bird community from petroleum activities needs to be evaluated in terms of the pattern of ocean currents. Accidents which may occur on the south side of the outer Kachemak Bay, and around the southern perimeter of the Kenai Peninsula would threaten the birds and their ecosystem more seriously than ones on the north side of the Bay, which are "downstream" from most of Kachemak Bay.

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Appendix Table 1. Percent Aggregate Numbers and Volume, Percent Frequency of Occurrence and Index of Relative Importance (IRI) of the Prey of Oldsquaw Collected in Kachemak Bay.

Prey Form	Percent No.	Percent Vol.	Percent F.O.	IRI
Pooled Samples, November 1977 - April 1978, n = 27				
PROTOZOA				
Unidentified Foraminifera	0.0	0.0	3.7	0
POLYCHAETA				
Unidentified species	0.5	2.8	25.9	85
Harmothoe extenuata	0.0	0.2	3.7	1
Phloe minuta	2.0	0.3	3.7	8
Anaitides mucosa	0.0	0.2	3.7	1
Eteone sp.	0.0	0.3	3.7	1
Unidentified Phyllodocid	0.0	0.0	3.7	0
Unidentified Nereid	0.0	0.1	3.7	1
Glycinde sp.	0.0	0.2	3.7	1
Lumbrinere sp.	0.0	0.0	3.7	0
Pectinaria sp.	0.8	1.3	14.8	32
Ampharete sp.	0.2	1.3	3.7	6
Unidentified Ampharetid	0.9	1.3	3.7	8
Total Polychaeta	4.4	8.0	25.9	321
GASTROPODA				
Unidentified species	3.3	0.9	18.5	78
Unidentified Limpet	0.0	0.2	3.7	1
Lancuna variegata	0.9	0.2	18.5	20
Alvina compacta	0.8	0.3	25.9	28
Cerithiopsis sp.	0.0	0.1	3.7	0
Natica clausa	0.2	1.9	3.7	8

Appendix Table 1 (continued)

Prey Form	Percent No.	Percent Vol.	Percent F.O.	IRI
Trophonopsis pacificus	0.0	0.0	3.7	0
Mitrella tuberosa	1.2	1.3	3.7	10
Neptunea sp.	0.0	0.1	3.7	0
Admete couthouyi	0.1	0.1	3.7	1
Oenopota sp.	3.7	2.5	18.5	114
Unidentified Turrid	0.2	0.3	7.4	4
Odostomia sp.	0.4	0.1	18.5	10
Aglaja diomedeum	0.1	0.0	3.7	0
Retusa sp.	0.0	0.0	3.7	0
Onchidoris bilamellata	0.1	1.2	7.4	10
Total Gastropoda	11.0	9.2	18.5	374
BIVALVIA				
Unidentified species	0.2	1.7	18.6	35
Nucula tenuis	2.4	3.4	37.0	219
Nuculana c.f. *fossa*	2.2	1.4	29.6	108
Glycymeris subobsoleta	7.1	1.7	22.2	196
Glycymeris sp.	0.0	0.1	3.7	0
Mytilus edulis	21.9	4.9	33.3	894
Orobitella sp.	0.0	0.0	3.7	0
Clinocardium sp.	0.0	0.0	3.7	0
Spisula polynyma	26.5	5.1	29.6	937
Macoma balthica	0.0	0.0	3.7	0
Macoma sp.	9.8	3.0	11.1	142
Saxidomus gigantea	0.0	0.0	3.7	0
Psephidia lordi	0.2	0.1	3.7	1

Appendix Table 1 (continued)

Prey Form	Percent No.	Percent Vol.	Percent F.O.	IRI
Protothaca staminea	1.2	1.1	29.6	66
Mya sp.	0.8	0.4	22.2	26
Total Bivalvia	72.3	22.9	29.6	2,818
CRUSTACEA				
Unidentified Barnacle	0.1	0.8	7.4	6
Unidentified Mysid	0.0	0.1	3.7	0
Lamprops sp. (Cumacean)	0.1	0.1	3.7	1
Unidentified Cumacean	0.0	0.1	7.4	2
Gnorimosphaeroma oregonensis (Isopod)	0.0	0.1	3.7	0
Unidentified Gammarid Amphipoda	2.0	5.4	51.8	382
Unidentified Decapod	0.2	0.7	7.4	7
Decapoda Natantia (Shrimp)				
Spirontocaris spina	0.1	0.8	7.4	7
Pandalus goniurus	0.8	3.6	7.4	32
Pandalus jordani	0.0	0.3	3.7	1
Unidentified shrimp	0.1	0.2	3.7	1
Total Shrimp	1.7	6.3	7.4	59
Decapoda Reptantia (Crabs)				
Hyas lyratus	1.5	2.1	14.8	54
Cancer oregonensis	0.7	2.8	14.8	52
Cancer sp.	0.4	1.7	11.1	23
Unidentified species	0.3	0.4	7.4	5
Total Crabs	2.9	7.0	14.8	147
Total Crustacea	7.1	20.6	51.8	1,435

Appendix Table 1 (continued)

Prey Form	No.	Percent Vol.	F.O.	IRI
ECHIURA				
Echiurus echiurus alaskanus	0.0	0.8	3.7	3
ECTOPROCTA				
Microporina borealis	0.0	0.2	3.7	1
ECHINODERMATA				
Ophiuroidea				
Ophiopholis aculeata	1.3	2.3	3.7	13
Amphipholis pugetana	0.2	0.4	3.7	2
Unidentified species	0.3	8.4	7.4	64
Total Ophiuroidea	1.8	11.1	7.4	95
Unidentified Echinoid	0.0	0.1	3.7	1
Total Echinodermata	1.8	11.2	7.4	96
OSTEICHTHYES				
Unidentified species	0.1	0.3	7.4	3
Unidentified Cottid	0.0	2.3	3.7	9
Ammodytes hexapterus	2.1	23.9	40.7	1,059
Total Osteichthyes	2.1	26.5	40.7	1,168
		November 1977, n = 5		
POLYCHAETA				
Unidentified species	0.1	0.3	20.0	9
Pectinaria sp.	0.4	3.5	20.0	78
Total Polychaeta	0.5	3.8	20.0	86
GASTROPODA				
Lacuna variegata	0.8	0.2	20.0	21

Appendix Table 1 (continued)

Prey Form	Percent No.	Percent Vol.	Percent F.O.	IRI
Alvina compacta	0.8	0.8	60.0	94
Neptunea sp.	0.1	0.4	20.0	10
Oenopota sp.	3.5	3.9	40.0	299
Odostomia sp.	0.3	0.1	20.0	7
Onchidoris billamellata	0.3	1.8	20.0	40
Total Gastropoda	5.8	7.2	60.0	780
BIVALVIA				
Nucula tenuis	0.7	0.9	40.0	62
Nuculana c.f. *fossa*	0.1	0.3	20.0	9
Glycymeris subobsoleta	9.1	3.8	40.0	518
Mytilus edulis	14.8	2.7	60.0	1,051
Spisula polynyma	60.3	23.6	60.0	5,033
Psephidia lordi	0.5	0.7	20.0	25
Protothaca staminea	0.7	2.1	60.0	167
Mya sp.	1.4	1.4	20.0	55
Total Bivalvia	87.6	35.5	60.0	7,386
CRUSTACEA				
Lamprops sp. (Cumacean)	0.3	0.7	20.0	19
Unidentified Gammarid Amphipoda	0.5	0.9	20.0	28
Unidentified Decapod	0.3	3.5	20.0	75
Pandalus goniurus (Shrimp)	2.2	22.1	40.0	970
Decapoda Reptantia (Crabs)				
Hyas lyratus	0.4	1.2	40.0	64
Cancer oregonensis	1.2	3.4	20.0	92
Cancer sp.	0.1	0.3	20.0	9

Appendix Table 1 (continued)

Prey Form	Percent No.	Percent Vol.	Percent F.O.	IRI
Total Crabs	1.7	4.9	40.0	264
Total Crustacea	5.0	32.1	40.0	1,484
OSTEICHTHYES				
Ammodytes hexapterus	1.0	21.6	60.0	1,350
December 1977, n = 5				
PROTOZOA				
Unidentified Foraminifera	0.3	0.2	20.0	10
POLYCHAETA				
Unidentified species	0.3	0.2	20.0	10
Pectinaria sp.	0.6	0.6	20.0	23
Total Polychaeta	0.9	0.8	20.0	34
GASTROPODA				
Unidentified species	0.3	0.0	20.0	6
Alvina compacta	2.5	0.8	60.0	199
Trophonopsis pacificus	0.3	0.9	20.0	7
Oenopota sp.	4.7	1.5	20.0	123
Odostomia sp.	0.6	0.3	40.0	35
Total Gastropoda	8.4	3.5	60.0	714
BIVALVIA				
Nucula tenuis	10.5	15.1	100.0	2,557
Nuculana c.f. *fossa*	11.8	3.5	100.0	1,534
Glycymeris subobsoleta	20.9	4.8	60.0	1,546
Glycymeris sp.	0.3	0.3	20.0	12
Mytilus edulis	0.3	0.2	20.0	10

Appendix Table 1 (continued)

Prey Form	Percent No.	Percent Vol.	Percent F.O.	IRI
Spisula polynyma	30.6	6.2	100.0	3,675
Protothaca staminea	5.0	3.2	80.0	654
Mya sp.	0.8	0.5	60.0	82
Total Bivalvia	80.2	33.9	100.0	11,410
CRUSTACEA				
Unidentified Cumacean	0.3	0.2	20.0	10
Unidentified Gammarid Amphipoda	0.3	0.6	20.0	17
Unidentified Shrimp	0.6	0.9	20.0	30
Unidentified Crab	1.4	0.9	20.0	46
Total Crustacea	2.6	2.6	20.0	104
OSTEICHTHYES				
Ammodytes hexapterus	8.0	59.7	100.0	6,768
January 1978, n = 5				
POLYCHAETA				
Unidentified species	3.1	17.4	60.0	1,229
Unidentified Phyllodocid	0.6	0.2	20.0	17
Glycinde sp.	0.6	1.4	20.0	40
Lumbrinereis sp.	0.6	0.2	20.0	17
Amphareté sp.	3.1	9.8	20.0	256
Total Polychaeta	8.0	29.0	60.0	2,220
BIVALVIA				
Unidentified species	1.2	6.6	40.0	314
Mytilus edulis	72.4	11.2	20.0	1,671
Clinocardium sp.	0.6	0.2	20.0	17

Appendix Table 1 (continued)

Prey Form	Percent No.	Percent Vol.	Percent F.O.	IRI
Macoma sp.	6.1	11.2	20.0	346
Total Bivalvia	80.3	29.2	40.0	4,380
CRUSTACEA				
Unidentified Cammarid Amphipod	3.1	2.8	20.0	117
Grangon septemspinosa (Shrimp)	0.6	2.4	20.0	61
Decapoda Reptantia (Crabs)				
Cancer magister	3.7	16.4	60.0	1,203
Cancer sp.	3.1	8.7	20.0	236
Unidentified Crab	0.6	1.7	20.0	46
Total Crabs	7.4	26.8	60.0	2,052
Total Crustacea	11.1	32.0	60.0	2,586
OSTEICHTHYS				
Ammodytes hexapterus	0.6	9.8	20.0	207
February 1978, n = 5				
POLYCHAETA				
Harmothoe extenuata	0.2	1.6	20.0	34
Phloe minuta	6.2	2.1	20.0	166
Anaitides mucosa	0.2	1.6	20.0	34
Eteone sp.	0.2	2.1	20.0	45
Unidentified Nereid	0.2	1.0	20.0	24
Pectinaria sp.	1.8	4.5	40.0	254
Ampharete sp.	2.7	9.4	20.0	242
Total Polychaeta	11.5	22.3	40.0	1,352

Appendix Table 1 (continued)

Prey Form	Percent No.	Percent Vol.	Percent F.O.	IRI
GASTROPODA				
Unidentified species	10.2	5.2	40.0	616
Lacuna variegata	1.5	0.6	60.0	125
Alvina compacta	0.2	0.1	20.0	6
Oenopota sp.	4.3	10.4	20.0	293
Unidentified Turrid	0.5	0.4	20.0	16
Odostomia sp.	0.6	0.4	40.0	41
Aglaja diomedeum	0.3	0.4	20.0	13
Retusa sp.	0.2	0.4	20.0	10
Onchidoris bilamellata	0.2	6.8	20.0	138
Total Gastropoda	18.0	24.7	60.0	2,562
BIVALVIA				
Unidentified species	0.2	2.8	20.0	59
Nucula tenuis	1.4	1.5	60.0	174
Glycymeris subobsoleta	0.9	0.7	20.0	32
Mytilus edulis	35.1	21.0	80.0	4,492
Orobitella sp.	0.2	0.1	20.0	6
Macoma balthica	0.2	0.4	20.0	10
Macoma sp.	29.6	10.8	40.0	1,616
Saxidomus gigantea	0.2	0.4	20.0	10
Mya sp.	0.5	0.5	40.0	38
Total Bivalvia	68.3	38.2	80.0	8,520
CRUSTACEA				
Unidentified Gammarid Amphipoda	2.3	6.1	80.0	668

Appendix Table 1 (continued)

Prey Form	Percent No.	Percent Vol.	Percent F.O.	IRI
Cancer sp. (Crab)	0.3	3.5	20.0	76
Total Crustacea	2.6	9.6	80.0	976
ECHIURA				
Echiurus echiurus alaskanus	0.2	5.6	20.0	114
March 1978, n = 6				
POLYCHAETA				
Unidentified species	2.0	0.9	33.3	99
GASTROPODA				
Unidentified species	1.4	0.5	33.3	63
Unidentified Limpet	0.7	0.5	16.7	20
Lacuna variegata	1.4	0.3	16.7	27
Cerithiopsis sp.	0.7	0.3	16.7	16
Natica clausa	3.4	5.7	16.7	151
Admete couthouyi	2.0	0.3	16.7	38
Oenopota sp.	4.1	0.2	16.7	72
Unidentified Turrid	1.4	0.7	16.7	34
Total Gastropoda	15.1	8.5	16.7	394
BIVALVIA				
Unidentified species	1.4	1.1	33.3	82
Nuculana c.f. *fossa*	1.4	2.0	33.3	112
Protothaca staminea	0.7	0.2	16.7	15
Total Bivalvia	3.5	3.3	33.3	226
CRUSTACEA				
Unidentified Barnacles	1.4	2.3	33.3	123

Appendix Table 1 (continued)

Prey Form	Percent No.	Percent Vol.	Percent F.O.	IRI
Unidentified Mysid	0.7	0.2	16.7	15
Unidentified Cumacean	0.7	0.2	16.7	15
Gnorimosphaeroma oregonensis (Isopod)	0.7	0.3	16.7	16
Unidentified Gammarid Amphipoda	11.6	11.5	66.7	1,541
Unidentified Decapoda	2.0	0.4	16.7	40
Decapoda Natantia (Shrimp)				
Spirontocaris spina	1.4	2.4	33.3	126
Unidentified Pandalidae	9.5	4.0	16.7	226
Total Shrimp	10.9	6.4	33.3	576
Hyas lyratus (crab)	17.7	4.0	16.7	362
Total Crustacea	45.7	25.3	66.7	4,736
ECTOPROCTA				
Microporina borealis	0.7	0.7	16.7	23
ECHINODERMATA				
Ophiuroidea				
Unidentified Ophiuroid	4.1	25.0	33.3	970
Ophiopholis aculeata	19.0	6.8	16.7	430
Amphipholis pugetana	2.7	1.4	16.7	68
Total Brittle Stars	25.8	33.2	33.3	1,965
Unidentified Echinoid	0.7	0.4	16.7	17
OSTEICHTHYES				
Unidentified species	1.4	0.8	33.3	72
Unidentified Cottid	0.7	6.8	16.7	124
Ammodytes hexapterus	4.8	20.2	16.7	417

Appendix Table 1 (concluded)

Prey Form	Percent No.	Percent Vol.	Percent F.O.	IRI
Total Fish	6.9	27.8	33.3	1,156
April 1978, n = 1				
GASTROPODA				
Mitrella tuberosa	89.7	70.0	100.0	15,966
CRUSTACEA				
Hyas lyratus (crab)	10.3	30.0	100.0	4,034

Appendix Table 2. Percent Aggregate Numbers and Volume, Percent Frequency of Occurrence and Index of Relative Importance (IRI) of the Prey of White-winged Scoters Collected in Kachemak Bay.

Prey Form	Percent No.	Percent Vol.	Percent F.O.	IRI
Pooled Samples, November 1977 - April 1978, n = 35				
POLYCHAETA				
Unidentified species	1.1	0.5	5.6	9
Halosydna brevisetosa	0.4	0.3	2.8	2
Nephtys sp.	0.4	0.2	2.8	2
Total Polychaeta	1.9	.9	5.6	16
GASTROPODA				
Unidentified species	4.4	2.3	25.0	167
Margarites pupillus	17.2	0.9	8.3	151
Margarites sp.	4.4	0.5	2.8	13
Lacuna variegata	0.4	0.0	2.8	1
Lacuna sp.	0.7	2.4	2.8	9
Littorina sp.	0.4	0.0	2.8	1
Trichotropis cancellata	4.4	0.3	2.8	13
Natica clausa	1.5	3.5	2.8	14
Neptunea lyrata	3.6	3.6	8.3	60
Neptunea sp.	5.5	0.3	2.8	16
Admete couthouyi	3.6	0.5	2.8	11
Total Gastropoda	46.1	14.3	25.0	1,510
BIVALVIA				
Unidentified species	7.3	14.4	38.9	845

Appendix Table 2 (continued)

Prey Form	Percent No.	Percent Vol.	Percent F.O.	IRI
Glycymeris subobsoleta	6.2	1.4	2.8	21
Mytilus edulis	21.2	30.6	22.2	1,158
Astarte rollandi	1.1	0.1	2.8	3
Macoma sp.	1.1	1.6	8.3	22
Protothaca staminea	9.8	32.4	47.2	1,996
Unidentified Venerid	0.7	1.1	5.6	10
Mya sp.	0.4	0.1	2.8	1
Total Bivalvia	47.8	81.7	47.2	6,112
CRUSTACEA				
Unidentified Barnacle	0.4	0.4	2.8	2
Unidentified Shrimp	0.4	0.1	2.8	1
Unidentified Crab	2.2	0.4	13.9	36
Total Crustacea	3.0	0.9	13.9	54
SIPUNCULA				
Sipunculus sp.	0.4	1.4	2.8	2
ECHINODERMATA				
Strongylocentrotus droebachiensis (Echinoid)	0.4	0.7	2.8	3
Unidentified Strongylocentrotidae	0.4	0.0	2.8	1
Unidentified Holothuroidea	0.4	0.4	2.8	2
Total Echinodermata	1.2	1.1	2.8	6
November 1977, n = 1				
BIVALVIA				
Mytilus edulis	100.0	100.0	100.0	20,000

Appendix Table 2 (continued)

Prey Form	Percent No.	Percent Vol.	Percent F.O.	IRI
	December 1977, n = 2			
BIVALVIA				
Mytilus edulis	100.0	100.0	100.0	20,000
	January 1978, n = 14			
POLYCHAETA				
Unidentified species	0.8	1.4	7.1	16
Nephtys sp.	0.8	0.8	7.1	11
Total Polychaeta	1.6	2.2	7.1	27
GASTROPODA				
Unidentified species	2.5	0.2	7.1	20
Margarites pupillus	39.0	2.3	14.3	590
Littorina sp.	0.8	0.0	7.1	6
Trichotropis cancellata	10.2	0.9	7.1	79
Neptunea lyrata	1.7	1.9	7.1	26
Neptunea sp.	12.7	1.0	7.1	98
Total Gastropoda	66.9	6.3	14.3	1,047
BIVALVIA				
Unidentified species	9.3	25.5	57.1	1,991
Macoma sp.	1.7	4.4	14.3	87
Protothaca staminea	10.2	50.7	64.3	3,914
Unidentified Vernerid	1.7	3.4	14.3	73
Total Bivalvia	22.9	84.0	64.3	6,874
CRUSTACEA				
Unidentified Barnacle	0.8	1.4	7.1	16

Appendix Table 2 (continued)

Prey Form	Percent No.	Percent Vol.	Percent F.O.	IRI
Unidentified Crab	4.2	1.3	28.6	158
Total Crustacea	5.0	2.7	28.6	220
SIPUNCULA				
Sipunculus sp.	0.8	1.4	7.1	16
ECHINODERMATA				
Strongelocentrotus droebachiensis (Echinoid)	0.8	2.0	7.1	20
Unidentified Strongylocentrotidae	0.8	0.1	7.1	7
Unidentified Holothuroidea	0.8	1.3	7.1	16
Total Echinodermata	4.0	5.5	7.1	67
February 1978, n = 9				
POLYCHAETA				
Unidentified species	4.3	0.3	11.1	50
GASTROPODA				
Margarites pupillus	2.1	0.6	11.1	31
Neptunea lyrata	14.9	1.9	11.1	187
Total Gastropoda	17.0	2.5	11.1	216
BIVALVIA				
Unidentified species	4.3	5.0	22.2	206
Mytilus edulis	51.1	62.8	55.6	6,327
Protothaca staminea	21.3	29.0	55.6	2,792
Mya sp.	2.1	0.4	11.1	28
Total Bivalvia	78.8	97.2	55.6	9,786

Appendix Table 2 (continued)

Prey Form	Percent No.	Percent Vol.	Percent F.O.	IRI
		March 1978, n = 4		
POLYCHAETA				
Halosydna brevisetosa	5.3	2.0	25.0	183
GASTROPODA				
Unidentified species	21.0	8.2	75.0	2,195
Natica clausa	21.0	26.3	25.0	1,184
Total Gastropoda	42.0	34.5	75.0	5,738
BIVALVIA				
Unidentified species	21.0	18.8	50.0	1,993
Macoma sp.	5.3	0.8	25.0	151
Protothaca staminea	21.0	42.9	50.0	3,200
Total Bivalvia	47.3	62.5	50.0	5,490
CRUSTACEA				
Unidentified Shrimp	5.3	0.9	25.0	154
		April 1978, N = 5		
GASTROPODA				
Unidentified species	13.9	11.0	100.0	2,488
Margarites sp.	33.3	4.4	20.0	756
Lacuna variegata	2.8	0.2	20.0	59
Lacuna sp.	5.6	22.8	20.0	566
Neptunea lyrata	2.8	22.8	20.0	511
Admete couthouyi	27.8	4.4	20.0	643
Total Gastropoda	86.2	65.6	100.0	15,180

Appendix Table 2 (concluded)

Prey Form	Percent No.	Percent Vol.	Percent F.O.	IRI
BIVALVIA				
Unidentified species	8.3	20.1	40.0	1,138
Protothaca staminea	2.8	14.3	20.0	341
Total Bivalvia	11.1	34.4	40.0	1,820
CRUSTACEA				
Unidentified Crab	2.8	0.1	20.0	58

Appendix Table 3. Percent Aggregate Numbers and Volume, Percent Frequency of Occurrence, and Index of Relative Importance (IRI) of the Prey of Black Scoters and Surf Scoters Collected in Kachemak Bay.

Prey Form	Percent No.	Percent Vol.	Percent F.O.	IRI
Black Scoter, November 1977, N = 1				
BIVALVIA				
Mytilus edulis	100.0	100.0	100.0	20,000
Surf Scoter, December 1977, N = 2				
POLYCHAETA				
Nephtys sp.	15.4	42.6	50.0	2,900
Unidentified Terebellid	7.7	0.5	50.0	408
GASTROPODA				
Unidentified Turrid	7.7	0.5	50.0	408
BIVALVIA				
Unidentified	23.1	51.6	50.0	3,733
Nucula tenuis	7.7	0.5	50.0	408
Saxidomus gigantea	7.7	0.5	50.0	408
Protothaca staminea	15.4	0.5	50.0	796
CRUSTACEA				
Crangon sp. (Shrimp)	7.7	1.0	50.0	432

Appendix Table 4. Percent Aggregate Numbers and Volume, Percent Frequency of Occurrence, and Index of Relative Importance (IRI) of the Prey of Common Murres Collected in Kachemak Bay.

Prey Form	Percent No.	Percent Vol.	Percent F.O.	IRI
Pooled Samples, December 1977 to April 1978, n = 28				
POLYCHAETA				
Unidentified Nereid	0.3	0.0	3.6	1
CRUSTACEA				
Unidentified Species	1.1	2.2	14.3	46
Neomysis rayii (Mysids)	83.3	49.0	39.3	5,200
Decapoda Natantia (Shrimp)				
Eualus sp.	0.3	0.6	3.6	3
Pandalus borealis	5.6	16.7	17.9	398
Pandalus goniurus	0.3	0.4	3.6	2
Pandalus sp.	0.3	1.4	3.6	6
Unidentified Pandalidae	0.8	3.9	10.7	51
Total Pandalid Shrimp	6.9	22.5	35.7	1,049
Crangon franciscorum	0.8	3.9	10.7	50
Crangon sp.	0.3	1.1	3.6	5
Unidentified Species	0.8	3.9	10.7	51
Total Shrimp	9.1	32.0	17.9	736
Total Crustacea	93.5	83.2	39.3	6,944
OSTEICHTHYES				
Unidentified Species	1.3	1.1	17.9	42
Clupea harengus	0.3	5.3	3.6	20
Mallotus villosus	0.5	2.5	7.1	22
Unidentified Osmerid	1.8	0.8	14.3	37

Appendix Table 4 (continued)

Prey Form	Percent No.	Percent Vol.	Percent F.O.	IRI
Total Osmeridae	2.3	3.3	14.3	80
Theragra chalcogramma	1.3	5.2	17.9	117
Unidentified Gadid	0.3	0.1	3.6	1
Total Gadidae	1.6	5.3	17.9	123
Lumpenus maculatus	0.3	1.3	3.6	5
Unidentified Stichaeid	0.3	0.6	3.6	3
Total Stichaeidae	0.6	1.9	3.6	9
Ammodytes hexapterus	0.3	0.0	3.6	1
Total Fish	6.4	16.9	17.9	417
December 1977, n = 6				
CRUSTACEA				
Neomysis rayii (Mysids)	96.0	73.4	83.3	14,116
OSTEICHTHYES				
Unidentified Species	1.2	1.4	33.3	36
Clupea harengus	0.6	15.8	16.7	273
Mallotus villosus	0.6	3.2	16.7	6
Theragra chalcogramma	0.6	6.0	16.7	109
Ammodytes hexapterus	0.6	0.0	16.7	10
Total Fish	3.6	26.4	33.3	999
January 1978, n = 9				
POLYCHAETA				
Unidentified Nereid	0.6	0.1	11.1	8
CRUSTACEA				
Unidentified Species	1.8	5.8	33.3	255

Appendix Table 4 (continued)

Prey Form	Percent No.	Percent Vol.	Percent F.O.	IRI
Neomysis rayii (Mysids)	90.8	75.9	66.7	11,111
Decapoda Natantia (Shrimp)				
Pandalus goniurus	0.6	1.3	11.1	22
Unidentified shrimp	0.6	0.7	11.1	15
Total Shrimp	1.2	2.0	11.1	36
Total Crustacea	93.8	83.7	66.7	11,839
OSTEICHTHYES				
Mallotus villosus	0.6	4.4	11.1	56
Unidentified Osmerid	3.7	2.2	33.3	195
Total Osmeridae	4.3	6.6	33.3	363
Theragra chalcogramma	1.2	9.6	22.2	241
Total Fish	5.5	16.2	33.3	723
February 1978, n = 3				
CRUSTACEA				
Unidentified species	25.0	11.1	33.3	1,204
Decapoda Natantia (Shrimp)				
Eualus sp.	25.0	23.3	33.3	1,611
Pandalus sp.	25.0	54.4	33.3	2,648
Total Shrimp	50.0	77.7	33.3	4,252
Total Crustacea	75.0	88.8	33.3	5,454
OSTEICHTHYES				
Unidentified species	25.0	11.1	33.3	1,204

Appendix Table 4 (concluded)

Prey Form	Percent No.	Percent Vol.	Percent F.O.	IRI
	March 1978, n = 5			
CRUSTACEA (All Shrimp)				
Pandalus borealis	60.0	47.3	40.0	4,295
Unidentified pandalidae	13.3	22.8	40.0	1,446
Total Pandalidae	73.3	70.2	40.0	5,740
Crangon franciscorum	6.7	12.3	20.0	379
Unidentified species	13.3	17.2	40.0	1,221
Total Shrimp	93.3	99.6	40.0	7,716
OSTEICHTHYES				
Unidentifies species	6.7	0.4	20.0	140
	April 1978, n = 5			
CRUSTACEA (All Shrimp)				
Pandalus borealis	54.6	58.0	60.0	6,750
Crangon franciscorum	9.1	17.1	40.0	1,045
Crangon sp.	4.6	0.0	20.0	91
Unidentified species	4.6	10.2	20.0	294
Total Shrimp	72.9	85.3	60.0	9,492
OSTEICHTHYES				
Unidentified Species	9.1	2.9	40.0	470
Theragra chalcogramma	9.1	0.9	40.0	400
Lumpenus maculatus	4.6	11.3	20.0	316
Unidentified Species	4.6	0.0	20.0	91
Total Fish	27.4	15.1	40.0	1,700

Appendix Table 5. Percent Aggregate Numbers and Volume, Percent Frequency of Occurrence and Index of Relative Importance (IRI) of the Prey of Three Pigeon Guillemots Collected in Kachemak Bay. One Specimen Each Collected in January, March, and April 1978.

Prey Form	Percent No.	Percent Vol.	Percent F.O.	IRI
POLYCHAETA				
Unidentified species	1.5	6.9	33.3	281
CRUSTACEA				
Unidentified Mysida	3.1	0.8	33.3	130
Decapoda Natantia (shrimp)				
Spirontocaris spina	4.6	1.7	33.3	209
Eualus fabricii	1.5	1.1	33.3	88
Pandalus goniurus	35.4	49.7	33.3	2,832
Crangon septemspinosa	24.6	26.2	33.3	1,693
Sclerocrangon alata	6.2	1.7	33.3	260
Unidentified species	1.5	0.3	33.3	61
Total Shrimp	73.8	80.7	33.3	5,145
Decapoda Reptantia (crabs)				
Cancer oregonensis	13.8	3.4	33.3	576
Unidentified species	3.1	0.8	66.7	261
Total Crabs	16.9	4.2	66.7	1,407
Total Crustacea	93.8	85.7	66.7	11,973
OSTEICHTHYES				
Unidentified species	4.6	7.4	66.7	402

Appendix Table 6. Percent Aggregate Numbers and Volume, Percent Frequency of Occurrence and Index of Relative Importance (IRI) of the Prey of Marbled Murrelets Collected in Kachemak Bay, January - April 1978.

Prey Form	Percent No.	Percent Vol.	Percent F.O.	IRI
Pooled Samples, January - April 1978, n = 18				
CRUSTACEA				
Unidentified species	0.8	1.2	5.6	11
Unidentified Mysida	34.4	6.7	11.1	456
Unidentified Gammarid Amphipoda	1.2	1.4	11.1	30
Euphausiacea				
Thysanoessa inermis	0.5	1.2	5.6	9
Thysanoessa raschii	19.4	5.7	16.7	418
Thysanoessa spinifera	0.2	0.9	5.6	6
Thysanoessa sp.	22.1	4.0	16.7	435
Total *Thysanoessa*	42.2	11.8	16.7	902
Total Crustacea	78.6	21.1	16.7	1,665
OSTEICHTHYES				
Unidentified species	3.4	7.8	22.2	249
Mallotus villosus	11.1	51.8	50.0	3,146
Unidentified Osmerid	0.2	0.1	5.6	1
Theragra chalcogramma	0.2	0.2	5.6	2
Unidentified species	0.2	0.5	5.6	4
Ammodytes hexapterus	6.4	18.5	16.7	415
Total Fish	21.5	78.9	50.0	5,020

Appendix Table 6 (continued)

Prey Form	Percent No.	Percent Vol.	Percent F.O.	IRI
January 1978, n = 6				
CRUSTACEA (All Euphausiids)				
Thysanoessa raschii	14.7	4.2	16.7	315
Thysanoessa sp.	61.2	9.6	33.3	2,358
Unidentified species	2.2	4.2	16.7	107
Total Euphausiacea	78.1	18.0	33.3	3,200
OSTEICHTHYES				
Mallotus villosus	21.0	51.2	50.0	3,612
Unidentified species	0.4	1.7	16.7	35
Ammodytes hexapterus	0.4	29.2	16.7	494
Total Fish	21.8	82.1	50.0	5,195
February 1978, n = 4				
CRUSTACEA				
Unidentified Mysida	72.2	17.9	25.0	2,252
Unidentified Gammarid Amphipoda	2.8	6.4	50.0	460
Euphausiacea				
Thysanoessa inermis	1.0	5.6	25.0	166
Thysanoessa raschii	5.2	3.6	25.0	219
Total Euphausiacea	6.2	9.2	25.0	385
Total Crustacea	81.2	33.5	50.0	5,735
OSTEICHTHYES				
Unidentified species	4.9	21.5	50.0	1,317
Unidentified Osmerid	0.4	0.4	25.0	20
Ammodytes hexapterus	13.5	44.6	25.0	1,455
Total Fish	18.8	66.5	50.0	4,265

Appendix Table 6 (concluded)

Prey Form	Percent No.	Percent Vol.	Percent F.O.	IRI
	March 1978, n = 3			
CRUSTACEA				
Unidentified Mysida	34.3	9.8	33.3	1,469
Thysanoessa spinifera (Euphausiid)	2.9	3.3	33.3	204
Total Crustacea	37.2	13.1	33.3	1,675
OSTHEICHTHYES				
Unidentified species	2.9	6.5	33.3	313
Mallotus villosus	54.3	78.9	100.0	13,320
Theragra chalcogramma	2.9	0.9	33.3	124
Ammodytes hexapterus	2.9	0.6	33.3	117
Total Fish	63.0	86.9	100.0	14,990
	April 1978, n = 5			
CRUSTACEA (All Euphausiids)				
Thysanoessa raschii	82.6	17.6	20.0	2,005
Thysanoessa sp.	4.3	5.9	20.0	205
Total Euphausiacea	86.9	23.5	20.0	2,208
OSTEICHTHYES				
Unidentified species	7.6	5.9	20.0	270
Mallotus villosus	5.4	70.6	60.0	4,561
Total Fish	13.0	76.5	60.0	5,370

Appendix Table 7. Data on culmen length (CL), bill width (BW) and mouth area (CL X BW) for birds collected in winter on Kachemak Bay, Alaska.

	Culmen Length, mm		Bill Width, mm		Mouth Area, mm^2	
Species	n	$\bar{X} \pm SE$ (range)	n	$\bar{X} \pm SE$ (range)	n	$\bar{X} \pm SE$ (range)
Oldsquaw	28	27.6±0.2 (25.5-29.8)	21	14.8±0.6 (10.0-18.0)	21	404±18 (273-529)
White-winged Scoter	38	38.6±0.4 (31.4-44.0)	35	18.4±0.8 (12.0-31.0)	35	717±32 (463-1,283)
Black Scoter	1	41.0	1	14.0	1	574
Surf Scoter	4	38.2±1.4 (35.3-42.0)	3	17.7±2.8 (12-21)	3	720±147 (442-941)
Common Murre	30	45.2±0.4 (41.0-50.0)	28	15.6±0.4 (11.0-19.0)	27	703±19 (517-885)
Pigeon Guillemot	3	35.0±0.2 (34.6-35.4)	3	11.7±0.7 (11.0-13.0)	3	408±21 (385-449)
Marbled Murrelet	18	15.9±0.2 (14.3-17.3)	18	9.0±0.6 (6.0-14.0)	16	140±10 (100-224)

Technical Report No. 1960

SEASONAL USE OF COASTAL HABITAT FROM YAKUTAT BAY TO CAPE FAIRWEATHER BY MIGRATORY SEABIRDS, SHOREBIRDS AND WATERFOWL

Prepared by:

Dr. Samuel M. Patten, Jr.

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Assessment Program
U.S. Department of Commerce
Juneau, Alaska 99802

ORI
Silver Spring, Maryland 20910

FINAL REPORT

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Research Unit Number: 591

I. Summary of Objectives, Conclusions and Implications with Respect to OCS Oil and Gas Development

The primary objective of the NOAA Alaska OCS environmental studies program is to provide background information for management decisions that may be necessary to protect the OCS marine environment from damage during oil and gas exploration and development.

Limited information on habitat utilization by birds in the Yakutat, Alaska, region adjacent to lease area for OCS Sale #55 is available from previous research. Marine-associated avian species utilize this coast extensively as evidenced by repeated sightings, but the extent of utilization has been poorly quantified until the current study. Significant possibilities exist for serious disturbance of this coastal environment by OCS development.

The objectives of this study have been to identify particularly important habitats near Yakutat and the nature of timing of their use by birds in order to develop a well-founded base for decisions concerning measures to minimize or mitigate impacts of petroleum development.

The Yakutat Forelands, in brief, are made up of sandy beaches, deciduous shrublands, spruce forests, and muskegs, with a series of relatively short, mostly clear-running rivers.

Geological time is short in the Yakutat area. Conditions change extremely rapidly. Earthquakes, storm tides, glacial activity, siltation from outwash moraines, streams, and rivers all affect the landscape. The shallow slope of the Pacific shoreline exposes the entire ocean slope of the Yakutat Forelands to Fall and Winter storms which wash over many square kilometers of sandy beaches, estuaries, and nearby inland areas.

In terms of the greatest number of birds observed, the most important avian habitats in the Yakutat area were (in decending order): marine beaches, rivers, coastal waters, and salt marshes.

Most avian biomass in 1980 was tied up in a few bird species per habitat. The most important species per habitat, numerically, were: Glaucous-winged Gull (marine beaches and rivers); Surf Scoter (coastal waters); Western Sandpiper (salt marshes); Aleutian Terns (supratidal meadows); American Wigeon (fresh water marshes); Black-legged Kittiwake (rocky marine shores and cliffs); Hermit Thrush (deciduous shrublands); and Mew Gull (barren moraines and outwashes). The Glaucous-winged Gull was numerically the most important species of seabird in the Yakutat area in 1980; the Surf Scoter was numerically the most important species of waterfowl, and the Western Sandpiper was numerically the most important species of shorebird.

Adequate knowledge of the nature of the lakes, rivers, streams, sloughs, and estuaries in the Yakutat area was crucial to the proper understanding of the avian biology and distribution in the region. The two most important estuaries on the Yakutat Forelands were the Situk - Ahrnklin estuary and the East River - Doame River estuary. While not an estuary, the south end of Russell Fiord attracted large numbers of waterfowl. The most important and geographically restricted area on the Yakutat Forelands for the largest number of individual birds in 1980 was the Situk - Ahrnklin Flats.

Deciduous shrublands and coastal waters (those less than 5 km from shore) were the most diverse avian habitats in the Yakutat area in 1980. Barren moraines, outwashes, cliffs and gullies, especially at the Haenke Island seabird colony, were the least diverse avian habitats. Geographic areas at the interface between rivers and deciduous shrublands had high avian diversity.

Yakutat Bay had areas of remarkably low avian diversity, with high concentrations of particular species. Large groups of scoters and murrelets at the north and south ends of Khaantak Island and from Point Latouche to Knight Island were considered particularly vulnerable to disruption from petroleum-related activity. Dense flocks of wigeon in the East Alsek River and the Upper East Alsek estuary were also considered vulnerable.

Eulachon, a small species of schooling anadromous fish, attracted huge numbers of foraging birds, most notably 1500 Bald Eagles, to geographically confined and sensitive areas in late Winter and early Spring, especially at the mouths of the Dangerous, Italio, Akwe and Alsek Rivers. This is one of the largest wintering Bald Eagle concentrations in the United States.

Eulachon runs began in late February to coastal streams and rivers of the Yakutat Forelands. The importance of the eulachon as a late winter food supply for tremendous numbers of Bald Eagles between Yakutat and Cape Fairweather has been previously completely overlooked. Eulachon runs continued until early June, attracting as many as 27,000 Glaucous-winged Gulls and additional thousands of kittiwakes and Mew Gulls to river mouths southeast of Yakutat. These birds were observed during single 2-hour aircraft surveys.

Up to 200 Bald Eagles were found around the Yakutat airport during the Winter, especially in January. Coho salmon spawning in shallow streams and ditches near the airport attracted the eagles, which constituted a significant air strike hazard.

Waterfowl were attracted during Spring migration to submerged and floating aquatic vegetation in the East - Doame Estuary and to the lower Akwe River. Over 740 Trumpeter Swans were found in the Akwe, Italio and Situk - Ahrnklin estuaries in early April.

The main wave of bird migration passed through the Yakutat area in the last week of April. Tens of thousands of gulls, geese, and other waterfowl were found at Dry Bay in May. Dry Bay, the delta of the Alsek River, is a major migration staging area. The Alsek River valley serves as a migration route to the interior Yukon lake district and perhaps to the Mackenzie Delta. The most important seabird colonies in the Yakutat area in 1980 were located at Dry Bay, Blacksand Spit, and Haenke Island.

In June, thousands of immature and other presumably nonbreeding kittiwakes, Glaucous-winged Gulls, Herring Gulls and occasional Glaucous Gulls rested on outer beaches near river mouths of the Yakutat Forelands and near the Sitkagi Bluffs on the Manby (west) side of Yakutat Bay. Over 3,000 scoters and 2,000 kittiwakes were found offshore from the Sitkagi Bluffs and resting near adjacent stream mouths.

Nonbreeding (resting, moulting and foraging) birds outnumbered breeding seabirds, shorebirds, and waterfowl by at least several orders of magnitude in the Yakutat area during the Summer of 1980.

A huge colony of Aleutian Terns (3,000 individuals), the world's largest known concentration, was located on Blacksand Spit in July 1980. This colony was located near the mouth of the Situk River. Large concentrations of southward migrating Western Sandpipers (5,000+ individuals) were found in the Situk - Ahrnklin Flats, near Old Italio Slough, and in the Ankau Lagoons in July. Gull chicks fledged in August at Dry Bay and Haenke Island. Waterfowl concentrations began in late August in the East River - Doame Estuary.

Heavy salmon spawning in September in rivers and streams of the Yakutat Forelands in attracted hundreds of scavenging gulls, eagles, ravens, magpies, and blackbirds. Large concentrations of American Wigeon, Common Pintails, Green-winged Teal, and later Mallards and Trumpeter Swans were found in the relatively small East Alsek River and in the East River - Doame Estuary. Large groups of scoters and other diving ducks were found at the south end of Russell Fiord in late September. The main waves of waterfowl migration passed through the Yakutat region in September and October after intense southeast storms. Thousands of Sandhill Cranes flew over the Yakutat Forelands during autumn migration. Flocks of Sandhill Cranes at altitudes to 1,250 m in September also constituted a significant air strike hazard.

Thousands of Canada Geese, Snow Geese, and Whistling Swans concentrated in October in the Situk - Ahrnklin estuary. Diving ducks appeared in large numbers in early October in the Yakutat Bay Islands, the south end of Russell Fiord, and in the East River - Doame estuary.

Very severe storms in November forced birds from exposed estuaries to sheltered locations such as the lee (southeast) side of Yakutat Bay and Russell Fiord. Exposed estuaries froze in late December and January, forcing waterfowl to retreat from the coast to the Ankau - Tawah Creek - Lost River drainage, the Italio River, and the Akwe River.

This research has indicated that certain areas, with high numbers of individual birds and a low number of species, are most sensitive to gas and oil exploration and development. These areas are the Situk - Ahrnklin Estuary, the East River - Doame Estuary, the south end of Russell Fiord, Haenke Island, the north and south ends of Khaantak Island, Knight Island to Point Latouche, the Sitkagi Bluffs, the lower Akwe River, Dry Bay, and clear streams in general of the Yakutat Forelands.

These areas are important for large concentrations of birds, as major foraging areas, breeding sites, and migratory staging areas.

Less sensitive habitats are deciduous shrublands (early successional stages with comparatively high numbers of avian species and low numbers of individuals) and turbid rivers. The turbid rivers are generally unproductive, and with striking exceptions (eulachon runs) attract fewer birds than clear rivers. Deciduous shrublands are widespread in the Yakutat Forelands.

The estuarine regions listed above are considered particularly important, because of their productivity and maintenance of high avian biomass. These areas are also occasionally exposed to severe storms. Winds of velocities greater than 160 kph drive waves over 20 in height onto outer beaches, inundating large estuarine and terrestrial areas with salt water, and potentially with oil spills. Salt water and spilled oil potentially may extend as much as five kilometers inland, through estuaries and up adjacent river valleys, because of the shallow ocean slope of much of the Yakutat and Malaspina Forelands.

II. Introduction

A. General Nature and Scope of Study

The Yakutat coastal zone qualifies as the most important area in southeast Alaska for bird migration. Over 200 bird species (mostly migratory) have been recorded by Yakutat observers (Brogle, ADF&G, pers. comm.). Tens of thousands of waterfowl use the lagoons, estuaries, and fiords near Yakutat during spring, summer moulting periods, and during fall migration. Shorebirds and seabirds are seasonally abundant in coastal and estuarine habitats. Gulls, terns, kittiwakes, guillemots, and cormorants breed in Yakutat Bay, at Dry Bay and on Blacksand Spit in the Situk River estuary. Nevertheless, a thorough study of avian numbers and a precise qualification of habitat utilization have not been previously completed for the Yakutat area. The U.S. Fish and Wildlife Service stated:

"...a complete resurvey of the Yakutat Bay is recommended because much of the information in this region dates from the early part of the century, and other data are fragmentary and from a variety of sources..." (Sowls, Hatch, and Lensink, 1978).

The Principal Investigator has conducted surveys of avian populations of the entire Glacier Bay, Copper River Delta, and Yakutat areas. These surveys were conducted from charter aircraft, by small boats, and on foot during eight previous field seasons. The research has resulted in a considerable amount of published and unpublished information. Additional and comprehensive surveys have been carried out in the Yakutat area during the 1980 field season and Winter and Spring 1981.

The results presented here are a logical outgrowth of Patten's previous investigations in the Yakutat and Glacier Bay regions. This study also is supported by Patten's experience with precise methods of quantifying avian habitat utilization.

B. Specific Objectives

The objectives of this study have been to gain information on the following topics.

1. Identification of all avian species present in the study area, their phenology, and seasonal use of specified habitats detailed below.

2. Documentation of the presence of unusual or rare, or other Species of Concern, such as the Peregrine Falcon, Bald Eagle, Golden Eagle, Trumpeter Swan and Aleutian Tern. An important Aleutian Tern colony has been investigated at Blacksand Spit in the Situk estuary. A report on this rediscovery is included below.

3. Assessment of migratory shorebird and waterfowl concentrations, including determination of abundance, density, and spatial and temporal distribution patterns during Spring, Fall and Winter. This has included the qualitative extent, timing and character of habitat use by migratory birds. Those habitats most crucial for foraging and maintenance activi-

ties have been identified. Total numbers of birds have been verified for each concentration site, including numbers of each species present. The geological and geographical placement of the concentrations, i.e., in proximity to insular, peninsular, offshore, coastal, bay and estuarine environments has been recorded for mapping purposes. Particularly important habitats are located in bay and estuarine environments discussed below.

4. Investigation of seabird breeding colonies. The following information has been obtained during the spring and summer nesting season: the location of laird, alcid, and cormorant breeding sites, the species composition of those colonies; the time of breeding of the individual species; the temporal and spatial relationships within the colonies, and the enumeration of total numbers for each colony, including the numbers of each species present. The relation of the colonies to topography has been established. The nesting requirements of each important species have been investigated, including the vegetational associations of the nesting sites. Food items and feeding localities have been studied. Considerable information is available on two major seabird breeding colonies from Patten's previous investigations. Additional tern colonies have been located during the 1980 field season.

5. Evaluation of habitat use by both migratory and breeding species. Avian habitat utilization has been quantified by means of straightforward enumeration and supported by the use of diversity indices. Habitats and geographic areas have been ranked from most diverse to the least diverse, enabling a precise comparative approach to habitat evaluation. Those bird assemblages most susceptible to perturbation have been identified. Diversity indices have also been used in Patten's previous research on avian populations on the outer coast of Glacier Bay National Monument, and have proven satisfactory as a practical tool to assess potential environmental impact (cf. Patten, 1975). Results of three studies (Yakutat, Dixon Harbor, and Lituya Bay) have been compared.

C. Relevance to Problems of Petroleum Development

Projected gas and oil operations and associated transport and supply activities will influence use of coastal habitats by migratory waterfowl, seabirds, and shorebirds, between Point Manby and Cape Fairweather, near Yakutat, Alaska (Figure 1). Quantified information on habitat utilization by birds in the Yakutat area has been completely lacking until this research effort. Identification of important coastal habitats, and the nature and timing of habitat use by birds, is essential for the development of sound management policies to minimize and mitigate potential impacts of petroleum-related activities. This knowledge is especially important to the City of Yakutat, which controls prospective on-shore sites for petroleum support facilities.

Baseline data for long-term management is necessary to understand future avian population changes. The prospect of industrial development on the outer coast of the Yakutat and Glacier Bay regions brings with it the danger of environmental pollutants, serious disturbance of the coastal environment, and possible loss of critical habitats for very large numbers of birds.

III. Current State of Knowledge

There is little published information about the avifauna of the Yakutat area. In particular, the published information on coastal birds is limited to a few sources. Walker (1923) first reported the Aleutian Tern colony in the Situk estuary. Shortt (1939) published results of a summer study of birds near Yakutat. Mickelson (1975) briefly studied birds and their habitats at Yakutat, and Batten and Murphy (1978) studied the vegetation and birds in the Situk estuary. Patten and Patten (1975-1978) investigated the breeding ecology, evolution, and effects of petroleum exposure on the reproductive biology of Glaucous-winged Gulls and Herring Gulls at Dry Bay and Haenke Island near Yakutat; Sowls, Hatch and Lensink (1978) included information on breeding colonies of seabirds near Yakutat in their catalog of Alaskan seabird colonies; Isleib and Kessel (1973) provided a general work on the birds of the North Gulf Coast; and Isleib and Isleib (1968) briefly surveyed the Situk River and adjoining area. Other general surveys of Yakutat avifauna include Arneson's (1976) identification of coastal migratory bird habitat in Alaska, and the State of Alaska's (1975) fish and wildlife inventory of the Northeast Gulf of Alaska.

To date, Patten and Patten are the only research biologists to have completed extensive field studies of coastal bird populations in the Yakutat area with the exception of the recently completed U.S. Fish and Wildlife Service study of bird migration through the Yakutat area (M. Peterson, 1981). Patten's studies were carried out in the 1974, 1975, and 1977 field seasons in partial fulfillment of the requirements for the Doctor of Philosophy degree at the Johns Hopkins University, under contract to the National Oceanic and Atmospheric Administration, and with support from the American Museum of Natural History. The work included identification of seabird colonies and reproductive surveys of selected species.

Patten previously conducted field investigations on coastal bird populations in Glacier Bay National Monument, immediately south of the proposed study area. These investigations included a marine bird survey of Glacier Bay (1971); research in marine bird population ecology in Glacier Bay proper (1972-1973) and a marine bird survey of the Dixon Harbor area on the outer coast of Glacier Bay National Monument (1974). The outer coast of Glacier Bay National Monument, including Cape Fairweather, supports similar habitat types and coastal bird species (migratory waterfowl, shorebirds, and seabirds) to those of the Yakutat Forelands, although the habitats differ in geographic extent and biotic importance.

IV. Description of the Study Area

A description of the study area summarizes knowledge of the environment, geology and habitats of the Yakutat region.

The General Environment

The principal area examined was the Yakutat Forelands, located on the south coast of Alaska between Point Manby on the west side of Yakutat

Bay, and Cape Fairweather on the outer coast of Glacier Bay National Monument. This coastal region, between 30-70 km wide, and 175 km long, oriented NW to SE along the Pacific Coast, is delimited by the St. Elias and Fairweather Ranges to the north, the Pacific Ocean to the south, Glacier Bay National Monument to the east, and Yakutat Bay to the west.

The climate is West Coast Marine, with nearby ocean areas moderating daily and seasonal temperatures at, and near, sea level. The area is exposed to frequent low pressure systems moving out of the Gulf of Alaska, providing abundant precipitation. Maximum precipitation over the entire area usually occurs from August through November. Yakutat receives 338 cm precipitation annually (*Alaska Geographic*, 1975). Snowfall occurs principally from November through March, and has an average annual depth ranging from 310 to 866 cm, with a mean at Yakutat of 370 cm. Much greater amounts of snowfall in the mountains have caused the formation of glaciers. The activity of the glaciers has been extremely important in determining the landforms of the area, and in conjunction with major earthquakes, has created a dynamically changing environment. Scenic values are stunning, spectacular, and world-class.

The mouth of Yakutat Bay is 30 km wide between Ocean Cape and Point Manby. Yakutat Bay is relatively shallow, and bordered on the north and east by an abrupt range of mountains, including Mt. St. Elias, which reaches to 5,800 meters within 60 km of saltwater. The Malaspina Glacier, larger than the state of Rhode Island, lies immediately WNW of Yakutat Bay. The St. Elias Range and the Malaspina Glacier prevent influence of interior conditions in the area. The partially submerged glacial valley forming Disenchantment Bay opens southwest to the Pacific Ocean. The seabird colony at Haenke Island is located at this point. The valley is closed to the northeast by the advancing Hubbard Glacier, which extends to within a few kilometers of Haenke Island. The Hubbard Glacier is one of the notably few glaciers in Alaska to advance yearly, and now threatens to close Russell Fiord and form a freshwater lake (*Alaska Geographic*, 1975).

Russell and Nunatak Fiords extend south and east from this junction. Russell and Nunatak Fiords are deep canyons between sloping mountain walls, except for the shallow south end of Russell Fiord.

The western side of Yakutat Bay from Point Manby to below Bancas Point is composed of moraines and outwash plains of the Malaspina and adjoining glacier systems. A number of streams, the largest of which are the Manby, Oscar, Kame, and Kwik, drain the icefields. These streams carry so much sediment load that the coastline is rapidly spreading outward. Offshore bars enclose lagoons with shallow openings.

There is a variety of landforms along the eastern shore of Yakutat Bay. The eastern shore of Yakutat Bay is a low terminal moraine of the former Yakutat Bay glacier and is covered with dense spruce and hemlock forest. The coastline is highly irregular and is faced by a series of islands, among which small colonies of Aleutian Terns are found.

The Ankau saltchucks, heavily used by waterfowl in season, are located in the Phipps Peninsula southwest of the town of Yakutat (pop. 500). The Ankau saltchucks are a series of shallow saltwater lagoons, separated from the Pacific by glacial moraine and a narrow beach.

The Yakutat Forelands lie between Yakutat and Clear Creek, a distance of 120 km. This coastal plain is bounded to the north by the 1300+ - 2000 meter high Brabazon Range, and to the southwest by the Gulf of Alaska. Glaciers feed the silty Alsek and Dangerous Rivers. The Italio, a clear stream, drains the area between the Akwe and Dangerous Rivers. The clear Situk River, vital to the economy of Yakutat, drains Situk Lake, and forms an important estuary with the Ahrnklin River.

From the mouth of the Situk to the mouth of the Italio River, extensive muskegs (bogs) extend inland from the shoreline. This expanse is divided by small, shallow streams, with black cottonwood trees and willow shrublands. Shallow ponds and slow streams with submerged aquatic vegetation attract waterfowl and shorebird concentrations during Spring and Fall migrations, and large numbers of gulls, kittiwakes and eagles during late Winter and Spring eulachon runs.

South of the Dangerous River, sandy beaches bordered by dunes and spruce forest extend towards Dry Bay (see below). The exposed sandy beaches continue southeast of Dry Bay to Cape Fairweather, with occasional rocky points, streams and small estuaries.

In summary, the main study area encompasses the coastal zone of the Yakutat Forelands from Point Manby on the west side of Yakutat Bay to Cape Fairweather on the outer coast of Glacier Bay National Monument.

The environment of the coastal study area is dynamically changing as a result of glaciation and earthquakes. Fiords, bays, river deltas, estuaries, and sandy beaches are characteristic of the coastline. The coastal zone contains major waterfowl, shorebird and eagle concentration sites and seabird breeding colonies.

V. SOURCES, METHODS AND RATIONALE OF DATA COLLECTION

A. Sampling Methods

Aerial reconnaissance. The study area has been divided into three sections for comprehensive aerial reconnaissance and survey (see Figure 2). These areas are the Yakutat - Cape Fairweather coastal environment, the Russell and Nunatak Fiords, and the Yakutat Bay region. The Yakutat - Cape Fairweather coastal environment, which includes the sandy beaches of the outer coast, and the drainages of the Situk, Dangerous, and Akwe Rivers, the Dry Bay, the East Alsek, and the Doame River estuaries, has been surveyed to record waterfowl, shorebird, eagle and seabird concentrations during Spring, Summer, Fall and Winter. Russell and Nunatak Fiords have been surveyed to locate moulting, migratory, and wintering waterfowl concentrations. The south end of Russell Fiord has proven to be intensively used by waterfowl.

The Yakutat Bay region, including the lee of Khaantak Island, Ocean Cape, Knight Island, Logan Bluffs, Disenchantment Bay, Haenke Island, and the west side of Yakutat Bay to Point Manby and to Icy Bay as well has been examined for seabird colonies, Spring and Fall migratory bird concentrations, and overwintering populations of seabirds and waterfowl.

Aerial surveys have been conducted at repeated intervals during Spring and Fall migrations, and during the breeding and Winter seasons. Actual flying times were dependent upon weather conditions.

Gulf Air Taxi, based at Yakutat Airport, has been the charter service for aerial surveys. Mr. Bob Robertson, Mr. Pete Peterson, and Mr. Mike Ivars have been employed by the Principal Investigator to locate bird populations between Icy Bay and Cape Fairweather, with Cessna 180 and 206 high-wing monoplanes.

Survey flights originated from and returned to Yakutat. Aircraft speed was regulated between 80 and 120 knots depending upon conditions. An altitude of 30 to 125 meters was maintained as a balance between ease of visibility below the aircraft and the necessity to identify species and describe habitats. At least two experienced observers identified and recorded avian species on each flight. In linear beach transects, the aircraft flew slightly seaward of the waterline, and the landward observer counted all birds visible to the beach ridge. All birds to 200 meters of the shoreline were counted by the seaward observer. Russell and Nunatak Fiords and Yakutat Bay were also surveyed by flights parallel to their entire shorelines. River valleys between Yakutat and Cape Fairweather were flown in spring and summer.

All observations were recorded on cassette tape recorders. Data were transcribed into appropriate NODC Format (cf. also Patten's 1976 NOAA aerial survey of the Copper River Delta sandbar barrier islands).

Key species. Representative "key" species and their habitats were selected for intensive study. Such investigations took place "on foot" and by means of small boat (Zodiac Mk III Grand Raid). Habitats of "key" species included the Situk River estuary, the Yakutat Bay Islands, and Dry Bay. These are known important locations for birds such as Aleutian Terns. Species accounts have been prepared for "key" species.

Breeding colonies in the coastal environment were studied. Onset of breeding and time of final departure from the nesting colonies was recorded. Fledged young and adults of Glaucous-winged and Herring Gulls were banded. Special high visibility coded bands, placed on gulls in Patten's previous OCS contracts, were observed and recorded. Over 11,000 marine birds, including gulls, plovers, kittiwakes, and cormorants, have been banded and recoveries from previous years in Yakutat demonstrate extensive coastal movements, dispersal, and migration of gulls. Adult and juvenile gulls were trapped and color-dyed to study local movements, long-distance migration, and return to colony sites.

Migratory concentrations. Migratory concentrations were investigated by the following methods: Population densities were estimated by repeated individual counts. Data was recorded in the appropriate NODC formats. Temporal relationships of species in migratory concentrations were recorded during observation periods. Spatial relationships were verified by compass and elementary mapping techniques. Birds in estuarine and open coast environments were identified and counted from selected observation points during period of peak migratory movements.

General species diversity. General species diversity was measured by repeated transects "on foot" through eleven important representative coastal habitats outlined below. Identification of species involved use of binoculars and telescope. Data was transcribed into the appropriate NODC formats. Diversity indices, including species richness and equitability, were calculated to quantify habitat utilization during Spring, Fall, Summer and Winter.

Literature search. Existing literature on Glacier Bay and Yakutat migratory bird populations was searched by the Principal Investigator. Relevant comparisons were made between avifauna of the Yakutat, Lituya Bay and the Dixon Harbor areas with information from previous studies (Walker, 1923; Shortt, 1939; Michelson, 1975; Patten, 1975; Rugh, 1977; Batten et al., 1978, and Weisbrod, 1980).

B. Analytical Methods

Quantification of avian habitat utilization. Avian species were assigned to various habitats in the Yakutat area by virtue of their identification in transects which covered a number of geographical locations (see Section VI. A, above). Transect notation included date, species identification, number of observations (i.e., sightings of the particular species) and a description of habitat and behavior. Numbers of observations for each species in a particular habitat were summed for analysis.

Quantitative analysis included at eleven representative avian habitats in the Yakutat area (CoW, Bb, Bs, M, H, Ds, L, Fm, Sm, Mo, and Cg)[1] described below. These habitats were chosen for numerical analysis

[1] CoW - Coastal waters; Bb - Rocky shores; Bs - Beaches of marine silts, sands and gravels; M - Supratidal meadows; H - Mixed hemlock, spruce forests; L - Lake, pond, slough, and river waters; Fm - Freshwater marshes; Cg - Cliffs and gullies; Ds - Deciduous shrublands; Sm - Saltmarshes and Mo - Barren moraines and outwashes

because research in the Yakutat area indicated their prevalence and distribution included almost all avian species occurring in the study area (with the exception of H habitat--see below).

Initially, habitats were ranked by number of species identified in those habitats during the field season. While this richness listing, "Ranking Order A" is informative, it does not include equitability (evenness of distribution among species). Indices of species diversity include both richness (species number) and equitability, and enable a unified comparative approach to habitat analysis. In this study, equitability was based upon abundance values. Species diversity is felt by some authors to be a measure of community stability, by increasing the number and complexity of biological interactions (references in Streveler, Worley et al., 1973).

Brillouin's formula (Brillouin, 1962) was used for diversity determinations:

$$H = \frac{1}{N} \left\{ Ln\,(N!) - Ln\,(N_i!) \right\}$$

where

$N = \sum N_i$

$H =$ Diversity in bits per avian unit

$N_i =$ Abundance value for the ith species

$Ln =$ Logarithm to base e (natural log)

Calculations, including factorials and logarithms of factorials, were handled by computer at the University of Alaska. Data was normalized as necessary for comparative purposes.

Habitats were ranked ("Ranking Order B") by diversity, as determined through Brillouin's formula, from the most diverse to the least diverse. Results were described in narrative form in tables. Where special conditions led to changes in diversity, these conditions were elucidated in the written section of the results.

"Ranking Order C" offered comparisons between habitats in overall numbers of birds observed. Most bird observations were clearly associated with marine or littorial habitats. Avian diversity and geographical locations were related and presented in table form, and ranked from the most diverse to the least diverse. The ranking order of habitats and geographical locations by diversity within the Yakutat area enabled a precise, quantified commentary on avian habitat utilization and susceptibility to perturbation.

In summary, the use of diversity indices, based upon abundance values of individuals, and number of species recorded, provided a unified comparative approach to habitat analysis. This practical approach was useful in predicting and assessing environmental impact of petroleum-related activities, and has been previously used by the Principal Investigator to evaluate disruption of bird habitats by prospective nickel mining on the outer coast of Glacier Bay National Monument.

Habitat description. R. Gorden (1973) used a set of 13 avian habitats to assign bird abundances to environmental conditions in the Dixon Harbor area, 75 km southeast of Cape Fairweather. These habitats were related to the vegetation classification devised by the USNPS Dixon Harbor study team (Streveler, Worley et al., 1973).

We used the same classification of habitats for the Yakutat area as Steveler, Worley et al. (1973) did for the outer coast of Glacier Bay National Monument. Further, we added a marine habitat (CoW) defined by Gorden (loc. cit.) which we also previously treated in a quantitative fashion in analysis of avian habitats in the Dixon Harbor area (Patten, 1975).

Each of the ten most important habitats investigated in the Yakutat area (CoW, Bb, Bs, M, Ds, L, Fm, Sm, Mo and Cg) is described below, with notations on avian species in those habitats.

Coastal waters (CoW). Coastal waters are bays and near-shore oceanic waters less than 5 km from shore. Bird species and numbers of individuals were striking within this habitat in the Yakutat area, especially during migration periods and when small fishes (*Clupea*, *Thaleichthys*) spawned inshore. Coastal waters are a crucial habitat for many avian species in the Yakutat area, since the order *Charadriiformes* (gulls, terns, auks, and sandpipers) is a dominant group of birds, which feed in coastal waters, and breed in proximity to the marine environment.

Rocky shores (Bb). Birds inhabiting or breeding on rocky shores are common and easily observed in Yakutat Bay. Both Pelagic and Double-crested Cormorants occur in this habitat, with Pelagic Cormorants definitely breeding and Double-crested Cormorants appearing on migration, or breeding in low numbers (Shortt, 1939). Harlequin Ducks, Bald Eagles, Black Oystercatchers, Glaucous-winged Gulls, Pigeon Guillemots, Tufted Puffins and Aleutian Terns, Spotted Sandpiper, Mew Gull, Bonaparte's Gull, Marbled and Kittlitz's Murrelets appear in this habitat after breeding elsewhere.

Beaches of marine silts, sands, and gravels (Bs). This habitat classification includes the expanse of sandy beaches characteristic of the entire outer coast of the Yakutat area. The habitat is critical for many kinds of seabirds, shorebirds, and landbirds, and supports a broad spectrum of avian species, and is utilized primarily as a foraging area. Great Blue Heron, White-fronted Goose, Semipalmated Plover, Whimbrel, Greater Yellowlegs, Least Sandpiper, Long-billed Dowitcher, Western Sandpiper, Northern Phalarope, Arctic Tern, and Belted Kingfisher, among others, were recorded in this habitat. Large numbers of migratory species occur in this habitat in Spring and Fall, many of them collecting in sloughs a few meters from marine beaches.

Supratidal meadows (M). These herbaceous communities above the high tide line near marine beaches, attract migratory waterfowl such as Canada Geese and White-fronted Geese. Breeding species include Aleutian Terns, Mew Gulls, Parasitic Jaegers and Semipalmated Plovers.

Hemlock, spruce forests (H). Bird species composition in mixed forests of western hemlock and Sitka spruce resembles the bird species composition in single-stand spruce forests, but is more diverse (Patten, 1975). This indicates that the avian species respond not to the three species concerned, but rather to the physiognomic character of the forest environment.

Lake, pond, slough, and river waters (L). This is an important freshwater habitat for a number of avian species, both for breeding and on migration. American Wigeon, Mallards, Pintails, Green-winged Teal, Barrow's Goldeneye, Common Merganser, Bald Eagles, Mew, Glaucous-winged and Herring Gulls, use this habitat extensively. River waters, historically, are susceptible to rapid environmental impact from industrial development. Further, the Situk River salmon fishery supports an important part of the Yakutat economy. This habitat should be further monitored for disruption by petroleum-related industrial activity.

Deciduous shrublands (Ds). Willows, alders and seral black cottonwood stands are widespread in the Yakutat Forelands and inhabited by a variety of passerine species.

Salt marshes (Sm). Salt marshes are geographically restricted on the Yakutat Forelands, but are characterized by intensive bird use during Fall migration. Dominant plant species is *Carex lyngbyaei*.

Freshwater marshes (Fm). This habitat is most extensive near Yakutat in the East River - Doame Estuary. Migratory species of waterfowl and shorebirds are abundant in this estuary, especially where freshwater marshes adjoin marine beaches.

Cliffs and gullies (Cg). Steep bedrock slopes facing the open ocean, especially at Haenke Island, provide habitat for the breeding of seabirds. Black-legged Kittiwakes, an important species nesting at Haenke Island, are concentrated into a geographically confined area, and would be particularly vulnerable to a large-scale disturbance such as a major oil spill. Pelagic Cormorants, Tufted Puffins, and Glaucous-winged Gulls also nest here. The Peregrine Falcon is found in this habitat and nests on steep bedrock slopes.

In summary, coastal waters (CoW), rocky shores (Bb), supratidal meadows (M), deciduous shrublands (Ds), beaches of marine silts, sands, and gravels (Bb), lake, pond, slough and river waters (L), freshwater marshes (Fm), saltmarshes (Sm), and cliffs and gullies (Cg) are important habitats for waterfowl, shorebirds, seabirds and eagles in the Yakutat area. Barren moraines and outwashes (Mo) are of minor importance for most coastal birds.

VI. Results

Introduction

An ornithological survey was conducted in the Yakutat study area during the period May 24 to October 22, 1980, and at intervals during January, February, March, and April 1981. The survey consisted of aircraft, boat and foot transects through a variety of habitats and localities. The survey was conducted in order to identify areas of high bird concentrations prior to potential offshore gas and oil development.

Aircraft surveys during Summer and Fall 1980 were flown with a Cessna 206 piloted by Mr. Bob Robertson of Gulf Air Taxi. Aircraft surveys during Winter and Spring 1981 were flown with a Cessna 180, piloted by Mr. Mike Ivars or Mr. Pete Peterson of Gulf Air Taxi. These aircraft surveys followed regular patterns between Icy Bay and Cape Fairweather, including over Russell and Nunatak Fiords. The 104 aircraft transects were conducted during 15 days flying time, and averaged 20 minutes per transect, over prescribed geographical areas. Boat surveys were conducted from a Zodiac Mk III GR and a small inflatable pack raft, following major river systems and watercourses from Disenchantment Bay to the Doame River estuary. The 25 boat transects were conducted over 21 days in Summer and Fall 1980 and averaged seven hours per transect. Foot surveys were completed on the Yakutat Forelands between the Phipps Peninsula and the East Alsek River during Summer and Fall 1980. The 28 foot transects were carried out over 26 days and averaged 7.5 hours per transect. At least two experienced observers (Patten, Primrose or Mace) recorded data during each aircraft, boat, or foot transect.

Coastal lowlands, estuaries, and aquatic habitats on the Yakutat Forelands from the Ankau Lagoons to the East Alsek River were most thoroughly studied. Particular emphasis was placed upon the identification of important estuarine habitats and on quantitative characterization of bird distribution and abundance within major habitats. This was done in order to avoid duplication with on-going Fish and Wildlife studies of bird migration in the Yakutat area (cf. M. Peterson, 1981).

Straightforward field observation was the principal investigative tool. Descriptive habitat observations were made on a nearly continuous basis by the Principal Investigator and field assistants. Interviews were conducted with local pilots, biologists, guides, and commercial fishermen concerning the biota of the Yakutat region.

Bird species presence and abundance along 157 transects were recorded to determine diversity and richness within delineated habitat types. The taxonomic and quantitative results were compared to previous adjoining coastal study areas (Lituya Bay and Dixon Harbor) in Glacier Bay National Monument, immediately to the southeast of the current study area (Fig. 1) (cf. Gorden, 1973; Patten, 1975; Rugh, 1977, and Weisbrod, 1980). Qualitative status and abundance of birds in the Yakutat area were compared to the previous results of Shortt (1939), Mickelson (1975), and Batten, Murphy and Murray (1978).

Taxonomic Analysis

One hundred and thirty-nine (139) species of birds comprising 14 orders were recorded in the Yakutat study area in 1980 (Tables 1 & 2). Passeriformes (perching birds - 43 species), Charadriiformes (sandpipers, auks, gulls, and terns - 38 species), and Anseriformes (ducks, geese, and swans - 28 species) were the most widely represented groups (Tables 2, 3, & 4). Two of the three best-represented orders consisted primarily of aquatic birds, as did six of the 14 orders combined. Aquatic-oriented birds comprised over half (75) of the species recorded in the Yakutat area in 1980.

The information gathered in the Yakutat area can be compared with the material compiled by Gorden, Patten and Rugh (1973-1977) in the Dixon Harbor area, and with the data gathered by Weisbrod (1980) in the Lituya Bay area, of Glacier Bay National Monument. In 1973-1975 there were 14 orders of birds with 115 species present in the Dixon Harbor area (Gorden, 1973; Patten, 1975; Rugh, 1977). In 1976-1977 there were 15 orders of birds with 135 present in the Lituya Bay area (Weisbrod, 1980) (Table 2). The overall ranking of the avian orders (by the number of species recorded in each order) was similar for the three adjoining Northeast Gulf of Alaska study areas. Avian diversity indices at the ordinal level for Dixon Harbor and Yakutat were essentially the same; Lituya Bay had a slightly more diverse avifauna (at the ordinal level) because of greater evenness of species distribution among the orders, and two more species of Procellariform birds (shearwaters and petrels) were recorded near Lituya Bay (Table 2).

The Passeriformes or passerines (perching birds) were the most widely represented order in all three coast study areas (Table 3). The Fringillidae (finches, sparrows) was the most widely represented family in all three study areas. The Hirundinidae (swallows) and Parulidae (titmice) were tied for the second most widely represented passerine families at Yakutat. At both Dixon Harbor and Lituya Bay, the Corvidae (crows and allies) and the Turdidae (thrushes) were tied for second. The richness of the passerine families, dependent upon the number of

TABLE 1

Scientific and Common Names of Birds Observed in the Yakutat Area
(Icy Bay - Cape Fairweather)
1980-81

(Scientific Nomenclature follows latest A.O.U. Checklist Committee Recommendations)

Scientific Name	Common Name
GAVIIFORMES	
Loons; Gaviidae	
Gavia immer	Common Loon
Gavia adamsii	Yellow-billed Loon
Gavia arctica	Arctic Loon
Gavia stellata	Red-throated Loon
PODICIPEDIFORMES	
Grebes: Podicipedidae	
Podiceps grisegena	Red-necked Grebe
Podiceps auritus	Horned Grebe
PELECANIFORMES	
Cormorants: Phalacrocoracidae	
Phalacrocorax auritus	Double-crested Cormorant
Phalacrocorax pelagicus	Pelagic Comorant
CICONIIFORMES	
Herons, Bitterns: Ardeidae	
Ardea herodias	Great Blue Heron
ANSERIFORMES	
Waterfowl: Anatidae	
Swans: Cygninae	
Olor columbianus	Whistling Swan
Olor buccinator	Trumpeter Swan
Geese: Anserinae	
Branta canadensis	Canada Goose
Branta nigricans	Black Brant
Anser albifrons	White-fronted Goose
Chen caerulescens	Snow Goose
Marsh Ducks: Anatinae	
Anas platyrhynchos	Mallard
Anas strepera	Gadwall
Anas acuta	Common Pintail
Anas clypeata	Northern Shoveler
Anas crecca	Green-winged Teal
Anas discors	Blue-winged Teal
Anas penelope	Eurasian Wigeon
Anas americana	American Wigeon

Scientific Name	Common Name
Diving Ducks: Aythyinae	
Aythya americana	Redhead
Aythya collaris	Ring-necked Duck
Aythya valisineria	Canvasback
Aythya marila	Greater Scaup
Aythya affinis	Lesser Scaup
Bucephala islandica	Barrow's Goldeneye
Bucephala albeola	Bufflehead
Clangula hyemalis	Oldsquaw
Histrionicus histrionicus	Harlequin Duck
Melanitta deglandi	White-winged Scoter
Melanitta perspicillata	Surf Scoter
Melanitta nigra	Black Scoter
Mergansers: Merginae	
Mergus merganser	Common Merganser
Mergus serrator	Red-breasted Merganser
FALCONIFORMES	
Accipiters: Accipitrinae	
Accipiter gentilis	Northern Goshawk
Accipiter striatus	Sharp-shinned Hawk
Buteos, Eagles: Buteoninae	
Buteo jamaicensis	Red-tailed Hawk
Buteo lagopus	Rough-legged Hawk
Aquila chrysaetos	Golden Eagle
Haliaeetus leucocephalus	Bald Eagle
Harriers: Circinae	
Circus cyaneus	Marsh Hawk (Northern Harrier)
Falcons: Falconinae	
Falco peregrinus	Peregrine Falcon
Falco columbarius	Merlin
Falco sparverius	American Kestrel
GALLIFORMES	
Grouse: Tetraonidae	
Lagopus lagopus	Willow Ptarmigan
GRUIFORMES	
Cranes: Gruidae	
Grus canadensis	Sandhill Crane
CHARADRIIFORMES	
Oystercatchers: Haematopodidae	
Haematopus bachimani	Black Oystercatcher

Scientific Name	Common Name
Plovers: Charadriidae	
Charadrius semipalmatus	Semipalmated Plover
Charadrius vociferus	Killdeer
Pluvialis dominica	Golden Plover
Pluvialis squatarola	Black-bellied Plover
Aphriza virgata	Surfbird
Sandpipers, etc.: Scolopacidae	
Numenius phaeopus	Whimbrel
Tringa melanoleuca	Greater Yellowlegs
Tringa flavipes	Lesser Yellowlegs
Actitus macularia	Spotted Sandpiper
Arenaria interpres	Ruddy Turnstone
Arenaria melanocephala	Black Turnstone
Lobipes lobatus	Northern Phalarope
Capella gallinago	Common Snipe
Limnodromus scolopaceus	Long-billed Dowitcher
Calidris canutus	Red Knot
Caladris alba	Sanderling
Calidiis pusilla	Semipalmated Sandpiper
Calidris mauri	Western Sandpiper
Calidris minutilla	Least Sandpiper
Calidris melanotos	Pectoral Sandpiper
Calidris alpina	Dunlin
Heteroscelus incanum	Wandering Tattler
Jaegers, Skuas: Stercorariidae	
Stercorarius parasiticus	Parasitic Jaeger
Gulls, Terns: Laridae	
Gulls: Larinae:	
Larus hyperboreus	Glaucous Gull
Larus glaucescens	Glaucous-winged Gull
Larus argentatus	Herring Gull
Larus thayeri	Thayer's Gull
Larus canus	Mew Gull
Larus philadelphia	Bonaparte's Gull
Rissa tridactyla	Black-legged Kittiwake
Terns: Sterinae	
Sterna paradisaea	Arctic Tern
Sterna aleutica	Aleutian Tern
Auks (Alcids): Alcidae	
Uria aalge	Thin-billed Murre
Cepphus columba	Pigeon Guillemot
Brachyramphus marmoratum	Marbled Murrelet
Lunda cirrhala	Tufted Puffin
Brachyramphus brevirostre	Kittlitz's Murrelet

Scientific Name	Common Name
STRIGIFORMES	
Typical Owls: Strigidae	
Otus asio	Screech Owl
Bubo virginianus	Great Horned Owl
Surnia ulula	Hawk Owl
Asio flammeus	Short-eared Owl
APODIFORMES	
Hummingbirds: Trochilidae	
Selasphorus rufus	Rufous Hummingbird
CORACIIFORMES	
Kingfishers: Alcedinidae	
Megaceryle alcyon	Belted Kingfisher
PICIFORMES	
Woodpeckers: Picidae	
Colaptes auratus	Common Flicker
Picoides villosus	Hairy Woodpecker
Picoides pubescens	Downy Woodpecker
PASSERIFORMES	
Flycatchers: Tyrannidae	
Empidonax difficilis	Western Flycatcher
Empidonax alnorum	Alder Flycatcher
Swallow: Hirundinidae	
Tachycineta thalassina	Violet-green Swallow
Iridoprocne bicolor	Tree Swallow
Riparia riparia	Bank Swallow
Hirundo rustica	Barn Swallow
Petrochelidon pyrrhonota	Cliff Swallow
Pipits: Montacillidae	
Anthus spinoletta	Water Pipit
Crows: Corvidae	
Cyanocitta stellerii	Steller's Jay
Pica pica	Black-billed Magpie
Corvus corax	Northern Raven
Corvus brachyrhynchos	American Crow
Titmice: Paridae	
Parus atricapillus	Black-capped Chickadee
Parus rufescens	Chestnut-backed Chickadee
Nuthatches: Sittidae	
Sitta canadensis	Red-breasted Nuthatch

Scientific Name	Common Name
Dippers: Cinclidae	
Cinclus mexicanus	Dipper
Wrens: Troglodytidae	
Troglodytes troglodytes	Winter Wren
Thrushes: Turdidae	
Turdus migratorius	American Robin
Ixoreus naevius	Varied Thrush
Catharus guttatus	Hermit Thrush
Catharus minimus	Grey-cheeked Thrush
Kinglets: Sylviidae	
Regulus satrapa	Golden-crowned Kinglet
Regulus calendula	Ruby-crowned Kinglet
Shrikes: Laniidae	
Lanius excubitor	Northern Shrike
Starlings: Sturnidae	
Sturnus vulgaris	European Starling
Wood Warblers: Parulidae	
Vermivora celata	Orange-crowned Warbler
Dendroica petechia	Yellow Warbler
Dendroica coronata	Yellow-rumped Warbler
Geothlypis trichas	Yellowthroat
Wilsonia pusilla	Wilson's Warbler
Blackbirds: Icteridae	
Euphagus carolinus	Rusty Blackbird
Finches: Fringillidae	
Pinicola enucleator	Pine Grosbeak
Carduelis flammea	Common Redpoll
Carduelis pinus	Pine Siskin
Loxia leucoptera	White-winged Crossbill
Passerculus sandwichensis	Savannah Sparrow
Junco hyemalis	Dark-eyed Junco
Zonotrichia leucophrys	White-crowned Sparrow
Zonotrichia atricapilla	Golden-crowned Sparrow
Passerella iliaca	Fox Sparrow
Melospiza lincolnii	Lincoln's Sparrow
Melospiza melodia	Song Sparrow
Calcarius lapponicus	Lapland Longspur

TABLE 2

Bird Orders and Number of Species Represented in Yakutat - Glacier Bay Outer Coast Study Areas 1973-1980

Order	# Species in Study Areas 1973-1980		
	Dixon Harbor	Lituya Bay	Yakutat
Passeriformes	38	42	43
Charadriiformes	32	39	38
Anseriformes	21	22	28
Falconiformes	7	8	10
Gaviiformes	3	4	4
Strigiformes	1	3	4
Piciformes	1	5	3
Pelecaniformes	2	2	2
Podicipediformes		2	2
Ciconiiformes	1	1	1
Galliformes	3	1	1
Gruiformes	1	1	1
Apodiformes	2	2	1
Coraciiformes	1	1	1
Procellariiformes	3	2	
Total Orders	14	15	14
Total Species	115	135	139
Diversity	1.80	1.85	1.78

TABLE 3

Perching Birds: Passeriformes
1973-1980

Family	# Species in Study Areas 1973-1980		
	Dixon Harbor	Lituya Bay	Yakutat
Tyrannidae	2	3	2
Hirundinidae	3	4	5
Corvidae	4	5	4
Paridae	1	1	2
Certhiidae	1	1	
Cinclidae	1	1	1
Troglodytidae	1	1	1
Turdidae	4	5	4
Sylviidae	2	2	2
Motacillidae	1	1	1
Parulidae	4	1	5
Icteridae	1	2	1
Fringillidae	13	15	12
Sittidae			1
Sturnidae			1
Laniidae			1
Total Families	13	13	14
Total Species	38	42	43
Diversity	2.13	2.08	2.24

species observed in the respective families, is similar for all three study areas. There were thirteen families of perching birds recorded both at Dixon Harbor and Lituya Bay, and 14 families were recorded in the Yakutat area.

There were 38 total species of perching birds recorded at Dixon Harbor, 42 at Lituya Bay, and 43 total passerine species near Yakutat. Diversity indices indicate that the passerine community at Yakutat was more diverse than either Dixon Harbor or Lituya Bay (Table 3). Deciduous shrublands, preferred by many passerine species, were widespread in the Yakutat Forelands. Also, more fringillid species (per family) were observed in the latter two (Dixon Harbor and Lituya Bay) study areas. Diversity as a result for both these areas was lower than at Yakutat (Table 3).

Shorebirds (Charadriiformes) were the second most widely represented order in all three study areas (Table 4). Sandpipers, gulls, and alcids were the best represented families within this order. Diversity indices for the shorebird communities show Dixon Harbor and Yakutat to be essentially the same. Lituya Bay was slightly more diverse. There were 32 species of shorebirds recorded in the Dixon Harbor area, 39 in the Lituya Bay area, and 38 species recorded in the Yakutat area (Table 4). More species of sandpipers were observed in Lituya Bay and near Yakutat than near Dixon Harbor; the coastline of the Dixon Harbor area is predominantly rocky and not sandy or estuarine.

The third most widely represented bird order, the ducks, geese, and swans (Anseriformes) was analyzed in terms of subfamilies and species, similar to the ranking of orders and families of the two previously discussed groups (Table 5). Five anatid subfamilies were recorded in all three study areas. There were 21 species of anatids listed for Dixon Harbor, 22 for Lituya Bay and 28 for the Yakutat area. Dixon Harbor was lower in anatid subfamily diversity than either Lituya Bay or the Yakutat area. The larger estuarine areas may account for the greater prevalence of diving and puddle ducks near Yakutat (20 species near Yakutat versus 16 at Dixon Harbor and 14 at Lituya Bay).

The fourth most widely represented group of birds, the order Falconiformes (birds of prey) was also analyzed in terms of subfamilies, as were the Anseriformes. All three study areas supported four Falconi-

TABLE 4

Shorebirds: Charadriiformes
1973-1980

Shorebird Family	Dixon Harbor	Lituya Bay	Yakutat
	# Species in Study Areas 1973-1980		
Haematopodidae	1	1	1
Charadriidae	2	5	5
Scolopacidae	13	16	17
Phalaropodidae	1	1	1
Stercorariidae	1	1	1
Laridae	6	8	9
Alcidae	8	7	5
Total Families	7	7	7
Total Species	32	39	38
Diversity	1.29	1.33	1.30

TABLE 5

Ducks, Geese and Swans: Anseriformes
Anatid Sub-families in 1973-1980

	# Species in Study Areas 1973-1980		
Anatid Sub-family	Dixon Harbor	Lituya Bay	Yakutat
Cygninae	1	1	2
Anserinae	2	4	4
Anatinae	6	5	8
Aythyinae	10	9	12
Merginae	2	3	2
Total Sub-families	5	5	5
Total Species	21	22	28
Diversity	1.29	1.41	1.36

TABLE 6
Birds of Prey: Falconiformes
1973-1980

Sub-family	# Species in Study Areas 1973-1980		
	Dixon Harbor	Lituya Bay	Yakutat
Buteoninae	3	3	4
Falconinae	2	2	3
Accipitrinae	1	2	2
Circinae	1	1	1
Total Sub-families	4	4	4
Total Species	7	8	10
Diversity	1.27	1.31	1.27

form subfamilies (Table 6). Seven species of birds of prey were recorded at Dixon Harbor; eight species were represented at Lituya Bay, and ten species of Falconiforms were recorded near Yakutat (Table 6). Dixon Harbor and Yakutat had essentially the same diversity of Falconiform subfamilies; Lituya Bay was slightly more diverse. However, Yakutat had more species of Buteoninae (hawks and eagles) and Falconinae (falcons) recorded than did either Dixon Harbor or Lituya Bay.

Quantitative Analysis

Avian species were assigned to various habitats by virtue of their identification in transects which covered a number of geographical locations in the Yakutat study area. Transect notation included date, species identification, number of observations (i.e., sightings of the particular species), descriptions of the habitat intersected, and comments on bird behavior. Numbers of observations for each species in a particular habitat were summed for analysis and listed in Tables 18-27. It is our belief that these summations are indeed conservative estimates, but are representative of bird use of particular habitats. Methodology here follows Patten (1975), and present results are compared to the previous study on the outer coast of Glacier Bay National Monument.

Analyses included ten of the most important avian habitats in the Yakutat area (Ds, CoW, Fm, M, Sm, Bs, Bb, L, Mo, and Cg) (Table 7). Almost all bird species occurring in the study area were observed in these habitats, with the exception of spruce - hemlock forest (H habitat) and muskegs, which are analyzed separately below (Appendix I).

The principal results to note are: the largest number of avian species and the largest number of individual birds in the Yakutat area were associated with freshwater habitats, (L and Fm) i.e., rivers, streams, sloughs, and marshes (Figs. 4, 9, Tables 8, 12). This is in contrast to the Dixon Harbor region of Glacier Bay National Monument, where the greatest number of bird species and number of individuals was associated with coastal waters and marine shores (CoW and Bb). However, marine beaches (Bs), which are extensive near Yakutat, had the largest number of individuals of all species observed per habitat in this study (Table 8). The junctions of river mouths with sandy beaches (L and Bs) were clearly the most important locations in the Yakutat Forelands for

TABLE 7

HABITAT CODE DEFINITIONS

Keyed to USNPS Dixon Harbor Biological Survey, 1973-74,
National Park Service, Juneau, Alaska,
I.A. Worley, G.P. Streveler, Eds.

L	--	fresh water: lakes, rivers, streams, sloughs
Bb	--	rocky shores
Bs	--	sandy shores
CoW	--	coastal waters, here considered those less than 5 km from shore
M	--	supratidal meadows
Ds	--	deciduous shrublands, here including seral black cottonwood stages
S	--	coniferous forest dominated by spruce, including seral stages
Cg	--	cliffs and gullies, here confined to Häenke Island seabird colony
Fm	--	freshwater marshes
Sm	--	estuarine marshes dominated by salt-tolerant species
Mo	--	barren moraines and outwashes
H	--	old growth mixed spruce-hemlock forest

TABLE 8

Habitats Ranked in Order of Total Numbers of Individuals of All Species Observed per Habitat - Yakutat Area 1980*

Ranking Order	Habitat Code	Habitat	Total Number of All Species Observed Per Habitat 1980
1.	Bs	beaches of marine silts, sands and gravels	46,416
2.	L	fresh waters: lakes, rivers, streams and sloughs	44,387
3.	CoW	coastal waters	31,743
4.	Sm	salt marshes	17,673
5.	M	supratidal meadows	7,770
6.	Fm	freshwater marshes	7,087
7.	Bb	rocky (marine) shores	5,512
8.	Ds	deciduous shrublands	2,473
9.	Cg	cliffs and gullies	1,059
10.	Mo	barren moraines and outwashes	555
10		Habitats Individuals of All Species Observed in 1980	164,675

(S-H) 1980 Habitat data were not of sufficient magnitude for classification in this Table. See Appendix I.

The four habitats, most important numerically, contained 140,219 birds or 85% of the total number of birds observed in the Yakutat area in 1980 (Table 8). In terms of the greatest number of birds observed, the most important avian habitats were (in descending order): marine beaches (Bs), rivers (L), coastal waters (CoW), and salt marshes (Sm) (Table 8). The first three most important habitats were relatively widespread in the Yakutat area. The last most important habitat was relatively restricted, reaching its greatest extent in the Situk - Ahrnklin estuary, in an area known as the Situk - Ahrnklin Flats. Thus, the most important geographically restricted area in the Yakutat Forelands for the largest <u>number</u> of individual birds in 1980 was the Situk - Ahrnklin Flats.

*For most important species per habitat see Table 19-28 below.

large numbers of bird species and large numbers of individual birds. This was especially true during late Winter, Spring, and early Summer. Notable is the remarkable discovery of 1,500 Bald Eagles at river mouths southeast of Yakutat in late February 1981 (Table 9). This striking concentration of eagles was associated with spawning runs of eulachon, (*Thaleichthys pacificus*) a small anadromous fish. Sites with large numbers of eagles were the lower Dangerous River, the lower Akwe River and the mouth of Clear Creek (Table 9; see also Discussion below).

Habitat Diversity, Richness and Most Important Avian Species Per Habitat

Ds

Deciduous shrublands were widespread in the Yakutat Forelands east of the forested terminal moraine of the former Yakutat Bay Glacier and south of the Brabazon Range (Fig. 3). Deciduous shrublands had the highest avian diversity of any habitat in the Yakutat area during 1980 (Table 10). Deciduous shrublands were characterized by a high number of species, especially passerines (Table 12), but a low total number of observations of individuals per habitat (Tables 8, 26). There was a strong correlation between high bird diversity and the interface between deciduous shrublands and rivers i.e., riparian habitat (Table 11). The Hermit Thrush was the numerically most important bird species in deciduous shrublands in 1980 (Tables 14, 26).

Deciduous shrublands in the Dixon Harbor area were comparatively low in number of bird species observed, as well as number of individuals per habitat. Bird species diversity was thus comparatively low. When deciduous shrublands were combined with freshwater marshes, the geographical avian diversity became very high, but in themselves deciduous shrublands were not especially diverse compared to other habitats in the Dixon Harbor area (Patten, 1975). The geographical extent of deciduous shrublands in the Dixon Harbor area was limited.

CoW

Coastal waters had a high avian diversity in the Yakutat area, with moderate species richness, and relatively large number of individual birds (Tables 10, 12, 8). The numerically most important species occurring in

TABLE 9

Bald Eagles Observed Near Estuaries, Beaches and River Mouths Along the Yakutat Forelands (Proceeding SE) Between the Dangerous River and Cape Fairweather (~100 km linear distance)
Aircraft Survey: Evening of February 24 and Morning of February 25, 1981

Location	Dangerous River** at the beginning of the estuary; Horseshoe Island	Old Italio Slough	Lower Italio River	Lower Akwe River above mouth	Akwe River above estuary***@ (upstream from Mortensen's camp)
Number of Bald Eagles	500	2	9	31	630

→ SE

Location	Old Ustay - Dry Bay outer	Muddy Creek off Dry Bay	Lower Dry Bay	East River outer beaches	Doame River outer beaches (Doame River proper = 1)	Clear Creek parallel to beach
Number of Bald Eagles	11	15	35	1	15	152

→ SE

Location	Unnamed Creek draining Grand Plateau Glacier	Sea Otter Creek	Unnamed Creek at the base of Cape Fairweather (3 km S of Sea Otter Creek)	Total Bald Eagles Observed Between the Dangerous River and Cape Fairweather, February 24-25, 1980
Number of Bald Eagles	1	4	94	1,501+

→ SE

*Flight terminated at darkness on the Dangerous River estuary on Feb. 24, and began again at first light on February 25. Observers: Patten & Peterson (Gulf Air Taxi, Yakutat).
**Eulachon are apparently concentrated in a few small leads through the otherwise frozen estuary.
***Apparent intensive eulachon spawning site.
+Our belief is that these are conservative figures, based on head-counts from a small aircraft. Individual eagles were probably overlooked (highly likely). This is a very large number of Bald eagles, one of the largest concentrations in the United States.
@Other birds in the Akwe: 57 Trumpeter Swans; 1,245 Glaucous-winged Gulls; 1,525 Black-legged Kittiwakes; 405 Common Mergansers; 360 Mew Gulls. TOTAL: 4,222 birds in the Akwe.

coastal waters near Yakutat was the Surf Scoter (Tables 14, 16, 21).

Coastal waters in the Dixon Harbor area had a moderate avian diversity but the greatest richness and number of individuals observed in that area (Patten, 1975). Thus, while there are differences in avian diversity and species richness in coastal waters near Yakutat and Dixon Harbor, coastal waters in both areas were important for large numbers of individual birds.

Near Yakutat, wintering seabirds and diving ducks avoid exposed coastal waters during late Fall and Winter and concentrate instead in sheltered saltwater locations, i.e., in the southeast portions of Yakutat Bay, Icy Bay and at the south end of Russell Fiord. Formation of ice in the southern end of Russell Fiord in late February 1981 forced wintering waterfowl to open water further north in Russell Fiord, but the birds remained south of Nunatak Fiord.

Fm

Freshwater marshes in the Yakutat area were similar in avian diversity to supratidal meadows and salt marshes (Table 10). Freshwater marshes (Fm) were the second richest avian habitat in the Yakutat region, after lakes, rivers, streams, and sloughs (L) (Table 12). Geographically, freshwater marshes were especially diverse in bird species near the lower East Alsek estuary, in the middle East Alsek estuary, and along the lower reaches of the East Alsek River itself (Table 11, Fig. 4). The East Alsek estuary, partially made up of freshwater marshes, was the second richest geographical area for bird species examined in 1980 (Table 13; see Discussion, pp. 102-107). Apparent high plant species diversity, especially submerged aquatic vegetation, contributed to the large number of waterfowl and other bird species in the East Alsek area. The American Wigeon was numerically the most important species in freshwater marshes near the East Alsek River.

Freshwater marshes were limited in extent in the Dixon Harbor area and bird life in that habitat was not analyzed quantitatively.

M

Supratidal meadows were nearly identical in avian species diversity to freshwater marshes (Table 10). Supratidal meadows were also similar in diversity to salt marshes (Table 10), although avian species composition of the three habitats was different. These three habitats (salt

TABLE 10

Yakutat Avian Habitats Ranked in Order of Highest Diversity, with Data Gathered During Repeated One-Day Transects 1980 Field Season (May-October)

Ranking Order	Habitat Code	Habitat	Diversity	Groupings Between Habitats by Diversity Index
1.	Ds	deciduous shrublands, including seral black cottonwood stages	2.76	
2.	CoW	coastal waters, i.e., those less 5 km from shore	2.28	
3.	Fm	freshwater marshes	2.15	marshes and supratidal meadows (3–5)
4.	M	supratidal meadows	2.14	
5.	Sm	estuarine marshes dominated by salt-tolerant species	2.10	
6.	Bb	rocky (marine) shores	1.84	marine shores (6–7)
7.	Bs	sandy (marine) shores	1.73	
8.	L	fresh waters: lakes, rivers streams, sloughs	1.41	
9.	Mo	barren moraines and outwashes	1.37	rocky or outwash terrain (9–10)
10.	Cg	cliffs and gullies, confined here to the Haenke Island seabird colony	0.94	

NOTE: S-H: Spruce-hemlock (old-growth) forest avian abundance data were not of sufficient sample size to allow computation of a diversity index for this forest type in Yakutat in 1980. However, the avian diversity index for this forest type in the Dixon Harbor area in 1974 was 2.21 (Patten, 1975). Methods used in computation of diversity indices were similar in both studies. (See Appendix I). Deciduous shrublands in the Dixon Harbor area were geographically limited and there had lower avian diversity than spruce-hemlock forests.

TABLE 11

Geographic Areas of Higher Avian Diversity (Yakutat - 1980)

Ranking Order	Area	Diversity	Habitat Classification (in order of importance)	Date	Transect Mode and Number
1.	Middle to Lower Italio River	2.88	L - Ds	June 30	boat - 29
2.	Middle Dangerous Trail	2.80	Ds - L	June 24	foot - 26
3.	Upper Alsek - slough	2.75	Ds - L	May 28	foot - 8
4.	SE shoreline - Harlequin Lake	2.74	Ds - L	June 25	foot - 27
5.	Italio Lake - Upper Italio R.	2.66	L - DS	June 29	boat - 28
6.	Lower East Alsek Estuary	2.54	L - Ds - Fm	Sept. 9	boat - 43
7.	Situk River (bridge to estuary)	2.49	L - Ds - S	May 26	boat - 5
8.	East Alsek - Bear Island	2.45	Ds - L	Sept. 30	foot - 52
9.	Middle East Alsek Estuary	2.40	Fm - L	Sept. 6	foot - 42
10.	East Alsek River	2.39	L - Ds	Sept. 2	boat - 40
11.	Lower Dangerous River	2.37	L - Ds	June 23	boat - 24
12.	Lower East Alsek River	2.34	Ds - L	June 2	foot - 11
13.	Upper East Alsek River	2.23	L - Ds	Sept. 28	boat - 51
14.	Lower East Alsek Estuary	2.22	L - Bs	Sept. 10	boat - 44
15.	East Alsek River	2.21	L - Ds - Fm	Oct. 2	boat - 53
16.	SE (lee) side of Khaantak Is.	2.10	Bb - Bs - CoW	June 9	boat - 14a
17.	New Italio River Estuary	2.09	Ds - Bs - L - CoW	July 1	foot - 30
18.	Lee side of Khaantak Island	2.06	Bb - CoW	June 9	boat - 14c
19.	Upper Dangerous River	2.06	L - Ds	June 22	boat - 22
20.	Middle East Alsek Estuary	2.03	L - Fm	Oct. 4	foot - 55

TABLE 12

Habitats Ranked in Order of Species Richness
(Number of Species Per Habitat) Yakutat Area - 1980

Ranking Order	Habitat Code	Habitat	Total Number of Species per Habitat	Groupings of Habitats
1.	L	fresh waters: lakes, rivers, streams, and sloughs	69	fresh water habitats 130
2.	Fm	fresh water marshes	61	
3.	Ds	deciduous shrublands	52	52
4.	Sm	salt marshes	51	
5.	Bs	beaches of marine sands, silts, and gravels	39	marine habitats 172
6.	CoW	coastal waters	36	
7.	M	supratidal meadows	29	
8.	S-H	spruce-hemlock forests	29	29
9.	Bb	rocky (marine) shores	17	
10.	Cg	cliffs and gullies	11	rocky or outwash
11.	Mo	barren moraines and outwashes	10	terrain 38

(Cg) and (Mo) habitats were the least diverse, had fewer bird species and had fewer numbers of individuals of species than other habitats in the Yakutat area in 1980 (Tables 10, 12, 8). (Ds) and (Fm) were among the most diverse and richest habitats for bird species (Tables 10, 12). (CoW) is among the most diverse habitats, but is only moderate in numbers of species (Tables 10, 12). Fresh water marshes (Fm), supratidal meadows (M), and saltwater marshes (Sm) had similar diversities, but different species composition (Table 12). All bordered the marine/estuarine environment. Marine beaches (Bs) and rocky shores (Bb) had similar species diversities, but different species composition and richness. Fresh waters (L) (lakes, rivers, streams, and sloughs) had a relatively low diversity, but had the highest species richness recorded in the Yakutat area in 1980 (Tables 10, 12).

TABLE 13

Avian Species Richness Per Geographical Area
Yakutat - 1980

Ranking Order	Geographical Area	Number of Species Recorded	Habitat Codes	Date of Transect
1.	East Alsek River	32	L-Ds	Oct. 2
2.	East Alsek Estuary	31	L-Fm-Bs	Oct. 5
3.	Lower Italio River	31	L-Ds	Jun 30
4.	SE side of Harlequin Lake	29	L-Ds	Jun 25
5.	Italio Lake - Upper Italio River	29	L-Ds	Jun 29
6.	Lower Dangerous River	28	L-Ds	Jun 23
7.	Situk River	27	L-Ds-S	May 26
8.	Middle Dangerous Trail	27	Ds	Jun 24
9.	East Alsek River	27	L	Sept. 2
10.	East Alsek River	27	L	Sept. 28
11.	Dry Bay	25	L-Bs	May 30
12.	East Alsek Estuary	25	L-Bs	Jun 2
13.	Blacksand Spit - Situk-Ahrnklin Estuary	23	L-Bs-Sm M	July 5
14.	Haenke Island	19	Cg-Bb-Ds	Jun 10
15.	Phipps Peninsula	12	S-H	Aug 30

The East Alsek River and Estuary dominated the ranking order of geographical area species richness in 1980 (5/15 sites) (Table 13). In general, rivers had the largest numbers of avian species in the Yakutat area. The richest areas for numbers of avian species were clearly at the interface between the (L-Ds) habitats, e.g., rivers and deciduous shrublands (Table 13), i.e., riparian habitat.

marshes, supratidal meadows, and freshwater marshes) often occur in juxtaposition in the Yakutat area and the similarity in diversity is striking (Table 10). Supratidal meadows, however, were not especially rich in number of bird species (Table 12). This habitat was also not included in geographic areas of higher avian diversity. Numbers of individual birds observed in supratidal meadows in the Yakutat area were moderate (Table 8). This habitat was most important on Blacksand Spit in the Situk - Ahrnklin estuary, where it was inhabited during Summer of 1980 by large numbers (3,000) of Aleutian Terns (see Species Account, Appendix II).

Supratidal meadows near Dixon Harbor had a relatively high avian diversity but relatively low numbers of species and individuals (Patten, 1975).

Sm

Estuarine marshes, dominated by salt-tolerant species, were moderate in avian diversity, similar to freshwater marshes and supratidal meadows (Table 10). Salt marshes were not especially important as diverse or rich geographical areas for birds near Yakutat (Tables 11, 12). Apparent plant species diversity was lower than in freshwater marshes. Aquatic plants in salt marshes near Yakutat were dominated by *Carex lyngbyaei*. However, large numbers of individual birds, especially migratory waterfowl and shorebirds, were observed in this habitat (Table 8). This habitat was relatively restricted, and was considered important because of the concentration of large numbers of waterfowl and shorebirds in the Situk - Ahrnklin Flats during fall migration. Batten, Murphy, and Murray have discussed the vegetation and ornithology of the Situk estuary in their report (1978). The Western Sandpiper was numerically the most important avian species observed in this habitat in 1980.

Both freshwater and salt marshes near Yakutat were frozen and devoid of bird life in January and February 1981. Birds also avoided the exposed supratidal meadows in Winter, but these three habitats were heavily used in Spring, Summer, and Fall.

The limited bird life in salt marshes near Dixon Harbor was not analyzed quantitatively (Patten, 1975).

Bb

Rocky (marine) shores were moderate in avian species diversity in the Yakutat area in 1980. Rocky shores were similar in diversity to sandy (marine) shores (Table 10). Total number of species observed in this habitat was moderate (Table 12). Geographically, rocky shores are limited on the outer coast of the Yakutat Forelands, but reach their greatest extent on the east side of Yakutat Bay, in the Yakutat Bay archipelago, and in Russell and Nunatak Fiords (cf. Discussion, pp. 113, 114). Rocky shores were most rich in number of avian species near the Haenke Island seabird colony (Table 13). Rocky shores as a habitat in the Yakutat area were not large in total number of individuals of all species of birds observed (Table 8). The Black-legged Kittiwake was the most commonly observed species on rocky shores (Tables 14, 25). Black-legged Kittiwakes occurred on rocky shores especially near the Sitkagi Bluffs (Discussion, pp. 119).

Rocky shore habitat in the Dixon Harbor area had moderate species richness but low equitability because of large numbers of kittiwakes. The numbers of kittiwakes sharply depressed habitat diversity. However, a comparatively large number of other birds was observed in this habitat, near Dixon Harbor, where rocky shores were widespread. The prevalence of this habitat there is in distinct contrast with most of the outer coast of the Yakutat and Malaspina Forelands.

Bs

Sandy beaches are extensive in the Yakutat area (cf. Discussion, pp. 70-71). Sandy (marine) shores, as a habitat, included beaches of marine silts and gravels. Sandy (marine) shores were similar in moderate avian diversity to rocky (marine) shore habitat near Yakutat (Table 10).

Sandy shores near Yakutat were also moderate in avian species richness (Table 12). A notable geographic exception was the rich lower East Alsek estuary. There sandy beaches occur close to the river and also close to freshwater marshes (Table 13). Marine beaches, however, had the largest total number of individuals of all species recorded per habitat in the Yakutat area in 1980. The numerically most important species observed on sandy beaches was the Glaucous-winged Gull (Tables 14, 15, & 19). (See Species Account, Appendix III).

TABLE 14

Avian Species Most Frequently Observed per Habitat
Yakutat Area - 1980

Ranking Order	Habitat Code	Habitat	Species Most Frequently Observed Per Habitat	Percentage of Total Observations of All Species per Habitat	Percentage of Most Important Species per Habitat*
1.	Bs	marine beaches	Glaucous-winged Gull	48	62
2.	L	rivers	Glaucous-winged Gull	40	50
3.	CoW	coastal waters	Surf Scoter	32	44
4.	Sm	salt marshes	Western Sandpiper	34	42
5.	M	supratidal meadows	Aleutian Tern	24	29
6.	Fm	fresh water marshes	American Wigeon	34	44
7.	Bb	rocky (marine) shores	Black-legged Kittiwake	38	45
8.	Ds	deciduous shrublands	Hermit Thrush	12	21
9.	Cg	cliffs and gullies	Black-legged Kittiwake	57	60
10.	Mo	moraines and outwashes	Mew Gull	22	57

The Yakutat area, in brief, is made up of sandy beaches, deciduous shrublands, spruce forests and muskegs, with a series of relatively short, mostly clear-running rivers (see Discussion, pg. 70). Most avian biomass in 1980 was tied up in a few bird species per habitat (Tables 14-16, 19-28).

*For most important species per habitat see Tables 19-28 below.

Sandy beaches in the Dixon Harbor area were high in avian diversity because of a large number of species and high equitability among shorebirds and waterfowl. The total number of individuals of all bird species was moderately large in this habitat, despite the limited geographic size of the habitat. This further emphasizes the importance of marine beaches for avifauna along this section of the Alaskan coastline, except during the Winter.

L

Fresh waters (lakes, rivers, streams, and sloughs) had the highest avian species richness of any habitat examined in 1980 in the Yakutat area (Table 12). However, this habitat was relatively low in avian diversity (Table 10). Geographic areas at the interface between rivers and deciduous shrublands (e.g., riparian habitats) were clearly the richest locations for sheer numbers of avian species (Table 13). Rivers, combined with deciduous shrublands, also supported diverse assemblages of birds in certain geographical areas (cf. Table 11). Freshwater habitat, in addition, supported the second highest total number of individual birds recorded near Yakutat in 1980 (Table 8). The Glaucous-winged Gull was the most frequently recorded species in (L) habitat (Table 14). Over 27,000 Glaucous-winged Gulls and 730 Trumpeter Swans were recorded in the lower reaches of rivers (especially the Akwe) southeast of Yakutat in early April 1981 (Table 17). The birds were associated with the simultaneous occurrence of eulachon runs, spring migration, and submerged aquatic vegetation. Clear running rivers near Yakutat, especially riparian and estuarine zones, are considered vital to the maintenance of large numbers of bird species including over 1,500 Bald Eagles (Table 9). (See Discussion, pp. 122). Low diversity, high species richness, large numbers of birds (some of which, i.e., Bald Eagles and Trumpeter Swans, are "Species of Concern") and common sense indicate this (L) habitat is particularly vulnerable to any development, including logging and petroleum-related activities. In addition, this habitat (rivers) is critical to the human economy of Yakutat because of commercial salmon fishing. Further, riparian zones are prime big game (brown bear and moose) areas. The importance of this habitat for the Yakutat area, especially in riparian and estuarine zones, cannot be over-emphasized.

TABLE 15

Species of Seabirds Numerically Most Important in the Yakutat Area - 1980

Ranking Order	Species	Habitat Code	Habitat	Total Number of Observations per Habitat
1.	Glaucous-winged Gull*	(Bs)	sandy beaches	22,251
2.	Glaucous-winged Gull	(L)	rivers	17,838
3.	Black-legged Kittiwake	(L)	rivers	5,210
4.	Aleutian Tern**	(Bs)	sandy beaches	3,298
5.	Arctic Tern	(Bs)	sandy beaches	2,221

*See Species Accounts, Appendix III.

**These are very large numbers of Aleutian Terns. See Species Accounts, Appendix II.

TABLE 16

Species of Waterfowl Numerically Most Important in the Yakutat Area - 1980

Ranking Order	Species	Habitat Code	Habitat	Total Number of Observations per Habitat
1.	Surf Scoter	(CoW)	coastal waters	10,231
2.	American Wigeon	(L)	lakes, streams, small rivers, sloughs	4,637
3.	White-winged Scoter	(CoW)	coastal waters rivers	3,819
5.	Snow Goose	(Sm)	salt marshes, esp. Situk - Ahrnklin Flats	2,005

TABLE 17

Glaucous-winged Gulls, Trumpeter Swans, Bald Eagles and Mallards
Near Estuaries of the Yakutat Forelands
April 3, 1981 Aircraft Survey

Location	Tawah Creek	Lost River	Situk Mouth	Divide Slough	Seal Creek	Lower Ahrnklin	Kunayosh Creek
Glaucous-winged Gulls	750	200	75	60	200	2,700	
Trumpeter Swans	6				3	50	2
Bald Eagles						8	

→ SE

	Lower Dangerous River	Old Italio	Drainage above Old Italio	New Italio	Akwe	Old Ustay-barrier beaches	Square Lake
Glaucous-winged Gulls	200	150	750	2,500	11,435*		
Trumpeter Swans					470	4	3
Bald Eagles	5	3		52	28	18	

→ SE

	Dry Bay	East Alsek Estuary	Doame Estuary
Glaucous-winged Gulls	6,150	1,720	225
Trumpeter Swans		187	13
Bald Eagles	7	17	2
Mallards		1,017	

→ SE

	Totals Between Tawah Creek and Doame River Estuary	Total Birds in Akwe	Total Birds in East Alsek Estuary	
Glaucous-winged Gulls	27,115			
Trumpeter Swans	738			
Bald Eagles	140			
Mallards	1,017			
	29,010 birds observed in 2 hours	11,933	2,941	(minimum figs.)

*apparent intensive eulachon spawning site

TABLE 18

Known Trumpeter Swan Nests (on small ponds)
Between Point Manby and the Doame River
Near Yakutat, Alaska 1980

Area of Nest Site(s)	Number of Adults and Young Observed	
North of Point Manby	2 pair	
Lake Redfield	1 pair	
Situk Lake (?)	1 pair	
Near Cape Stoss	1 pair	
Near Lower Seal Creek	1 pair	
Near Upper Antlen River	2 pair	
East of the Dangerous River and NE of the mouth of Old Italio Slough	1 pair	
Immediately SE of Harlequin Lake	1 pair	
NW of Triangle Lake	1 pair	
Triangle Lake	1 pair	
SE of Triangle Lake	1 pair	2 yg
Just north of the Lower Akwe mouth	1 pair	3 yg
SW of Akwe Lake	1 pair	
Near Akwe River NW of Mortensen's Camp	1 pair	
SW of Square Lake	1 pair	
Square Lake	1 pair	
Old Ustay Drainage	1 pair	
Near Muddy Creek	1 pair	
North of Tanis River, west of Tanis Lake	1 pair	6 yg
NW of Gines Creek, near Dry Bay	3 pair	
East of the Doame River (Deception Hills)	2 pair	
	25-26 pair Trumpeter Swan	

[Note:] Productivity is probably far higher than the few young swans observed in this general survey of avian habitats near Yakutat (Table 18). The total of breeding Trumpeter Swans near Yakutat is far out-numbered by migratory and non-breeding Trumpeter Swans (i.e., 470 Trumpeter Swans on the Akwe River alone on April 3, 1981) (Table 17). Trumpeter Swan nests on the Yakutat Forelands are characteristically located on small ponds near two general geographical locations: at the base of the Brabazon Range and on a NW-SE axis inland of old, now forested dune lines between Seal Creek and Dry Bay. Almost half the Trumpeter Swan nests observed on the Yakutat Forelands in 1980 were located within 8 km of Triangle and Square Lakes, 50-60 km SE of Yakutat (Fig. 12).

The Situk - Ahrnklin and East River - Doame estuaries were frozen in January and Februry 1981, exposed to intense SE storms and barren of bird life. Wintering waterfowl and gulls were found in sheltered portions of unfrozen clear-running rivers near the coast, such as the Italio, the Lost, the Akwe and Tawah Creek.

Freshwater habitat in the Dixon Harbor area was relatively low in number of bird species, low in diversity, and low in number of individuals observed per habitat (Patten, 1975). Thus this habitat was not considered nearly as important as in the Yakutat area.

Mo

Barren moraines and outwashes in the Yakutat area were low in avian species diversity (Table 10), very low in richness (Table 12), and unimportant as geographic areas for either species richness or total numbers of birds (Table 8). The Mew Gull, breeding on the outwash flats of the Malaspina Glacier on the west side of Yakutat Bay, was the most commonly recorded species in this habitat (Table 14). The number of individuals observed was small (Tables 8, 28). Barren moraines and outwashes were not analyzed quantitatively in the Dixon Harbor area (Patten, 1975).

Cg*

Cliffs and gullies, as an avian habitat, are addressed here only in relation to the Haenke Island seabird colony (on a 180 m cliff). This habitat had the lowest avian diversity of any habitat examined in the Yakutat area in 1980 (Table 10). The immediate geographic area of Haenke Island was also relatively low in species diversity (Table 29). The number of individuals observed in this habitat was relatively low (Table 8). The most important species in this habitat was the Black-legged Kittiwake (Tables 14, 27), breeding in the study area only at Haenke Island (cf. Discussion, pp. 112). Haenke Island also supported the Yakutat area's second largest Glaucous-winged Gull colony. However, nonbreeding gulls and kittiwakes near Yakutat far outnumbered breeding ing populations in the Summer of 1980.

Relatively high numbers of kittiwakes and low species richness at the Boussole Head seabird colony near Dixon Harbor gave the cliffs and gullies habitat a dramatically lower diversity than any other habitat in that study (Patten, 1975). Thus, the Cg* habitat and the seabird colonies at Haenke Island and at Boussole Head had the lowest species

TABLE 19

Avian Species Numerically Most Important in
(Bs) Habitat (Beaches of Marine Silts, Sands, and Gravels)
Yakutat Area 1980

Ranking Order	Species	Total Number of Individuals Per Species in (Bs) Habitat
1.	Glaucous-winged Gull	22,251*
2.	Western Sandpiper	5,143
3.	Aleutian Tern	3,298*
4.	Common Merganser	3,010
5.	Arctic Tern	2,221
Total Observations of the Five Species Numerically Most Important in (Bs) Habitat:		35,923
Total Observations of All Avian Species in (Bs) Habitat:		46,416

The five species above accounted for 77% of all individual birds observed in (Bs) habitat in 1980. Glaucous-winged Gulls alone accounted for 48% of total observations in (Bs) habitat, or 62% of the observations of the five most important species occurring in (Bs) habitat. In other words, Glaucous-winged Gulls numerically totally dominated the (Bs) habitat in the Yakutat area in 1980 (Table 19).

*See Species Accounts, Appendix II and III.

TABLE 20

Avian Species Numerically Most Important In
Fresh Water (L) Habitat: (Lakes, Rivers, Streams and Sloughs)
Yakutat Area 1980

Ranking Order	Species	Total Number of Individuals Per Species in (L) Habitat
1.	Glaucous-winged Gull	17,838*
2.	Black-legged Kittiwake	5,210
3.	American Wigeon	4,637
4.	Aleutian Tern	4,145*
5.	Common Merganser	2,936
6.	Canada Goose	1,838

Total Observations of the Six Most Numerically Important Species Occurring in Fresh Water (L) Habitat: Lakes, Rivers, Streams and Sloughs:	35,604
Total Observations of All Species in Fresh Water Habitat:	44,387

The above six species accounted for 80% of individuals observed in fresh water (L) habitat: lakes, rivers, streams and sloughs (Table 20). (Most observations were made along rivers.) Glaucous-winged Gulls alone accounted for 40% of the total numbers of birds observed in the (L) habitat, or 50% of the six most important species observed in this habitat in 1980. In other words, Glaucous-winged Gulls, especially near the mouths of rivers, numerically dominated the (L) habitat, as well as the (Bs) habitat (Tables 19, 20). Notable also was the occurrence of large numbers of Black-legged Kittiwakes in fresh water (L) habitat in the Yakutat area (Table 20). This species, as the Glaucous-winged Gull, was attracted to rivers during the late Winter and Spring eulachon* runs. The Glaucous-winged Gull was also prevalent along rivers during late Summer and Autunm salmon runs. The number of Glaucous-winged Gulls observed was an order of magnitude larger than the number of breeding Glaucous-winged Gulls in the Yakutat area in 1980. The U.S. Fish and Wildlife Service reports a similar disparity between the number of breeding Glaucous-winged Gulls in the Gulf of Alaska and the number of Glaucous-winged Gulls which winter offshore (Lensink, pers. comm.)

*See Species Accounts, Appendix II, III and IV.

TABLE 21

Avian Species Numerically Most Important In
Coastal Waters (CoW) Habitat
Yakutat Area 1980

Ranking Order	Species	Total Number of Individuals Per Species in (CoW) Habitat
1.	Surf Scoter	10,231
2.	White-winged Scoter	3,819
3.	Black-legged Kittiwake	3,376
4.	Aleutian Tern	3,260
5.	Arctic Tern	2,367

Total Observation of the Five Numerically Most Important Species in Coastal Waters (CoW) Habitat:	23,053
Total Observations of All Avian Species in Coastal Waters (CoW) Habitat:	31,743

The above five species accounted for 73% of individuals of all species observed in the (CoW) habitat (Table 21). Surf Scoters alone accounted for 32% of the total number of birds observed in the (CoW) habitat, 44% of the total observations of the five species most numerically important in the (CoW) habitat.

TABLE 22

Avian Species Numerically Most Important In
Saltmarsh (Sm) Habitat
Yakutat Area 1980

Ranking Order	Species	Total Number of Individuals Per Species in (Sm) Habitat
1.	Western Sandpiper	5,975
2.	Aleutian Tern	3,128
3.	American Wigeon	2,047
4.	Snow Goose	2,005
5.	Canada Goose	930

Total Observations of the Five Numerically Most Important Species in Saltmarsh (Sm) Habitat:	14,085
Total Observations of All Species in Saltmarsh (Sm) Habitat:	17,673

The above five species accounted for 80% of all individuals observed in (Sm) habitat during 1980 (Table 22). Western Sandpipers alone accounted for 34% of total observations of all species occurring in (Sm) habitat, 42% of the total observations of the five most important species in the (Sm) habitat. (The Western Sandpiper dominated the (Sm) habitat with percentages similar to the Surf Scoter in the (CoW) habitat) (Tables 21, 22).

None of the five species numerically most important in the (Sm) habitat is an important breeder in this habitat at Yakutat. All use this habitat heavily during restricted migratory periods.

TABLE 23

Avian Species Numerically Most Important In
Supratidal Meadow (M) Habitat
Yakutat Area 1980

Ranking Order	Species	Total Number of Individuals Observed in Supratidal Meadow (M) Habitat
1.	Aleutian Tern	1,854*
2.	Western Sandpiper	1,500
3.	Glaucous-winged Gull	1,400
4.	Arctic Tern	1,102
5.	Canada Goose	460

Total Observations of the Five Numerically Most Important Species Occurring in Supratidal Meadow (M) Habitat:	6,316
Total of All Avian Species Observed in Supratidal Meadow (M) Habitat:	7,770

The above five species accounted for 81% of all individuals observed in supratidal meadow (M) habitat during 1980 (Table 23). All except the Western Sandpiper bred in this habitat. Aleutian Terns accounted for 24% of the total observations of all species in the supratidal meadow (M) habitat (Table 23). Aleutian Terns were most frequently observed on Blacksand Spit in the Situk - Ahrnklin estuary and at Dry Bay (see Aleutian Tern Species Accounts, Appendix (II).

*Additional Aleutian Terns were observed in nearby Sm and CoW habitats (Tables 21, 22).

TABLE 24

Avian Species Numerically Most Important In
Fresh Water Marshes (Fm) Habitat
Yakutat Area 1980

Ranking Order	Species	Total Number of Individuals Observed Per Species in (Fm) Habitat
1.	American Wigeon	2,396
2.	Pintail	1,458
3.	Canada Goose	751
4.	Mallard	459
5.	Snow Goose	439
Total Observations of the Five Numerically Most Important Species in (Fm) Habitat:		5,503
Total Observations of All Avian Species in (Fm) Habitat in 1980		7,087

The above five species accounted for 78% of the individuals of all avian species observed in fresh water marshes (Fm) habitat in 1980 (Table 24). The American Wigeon was numerically the most important species in (Fm) habitat, accounting for 34% of the total number of observations of individuals of all species in (Fm) habitat, 44% of the observations of the five most important species in the (Fm) habitat. The above five species are migratory waterfowl, using this habitat most extensively in Spring, late Summer and during Autumn migration. This habitat is most widespread in the East River - Doame estuary, and attracts a large number of species.

TABLE 25

Avian Species Numerically Most Important In
Rocky Marine Shore (Bb) Habitat
Yakutat Area 1980

Ranking Order	Species	Total Number of Individuals Per Species in (Bb) Habitat
1.	Black-legged Kittiwake	2,123
2.	Glaucous-winged Gull	1,017
3.	Arctic Tern	842
4.	Bonaparte's Gull	427
5.	Harlequin Duck	303
Total Observations of the Five Numerically Most Important Species in (Bb) Habitat:		4,712
Total Observations of All Species in (Bb) Habitat:		5,512

The above five species accounted for 85% of all individuals observed in (Bb) habitat in 1980 (Table 25). Black-legged Kittiwake alone accounted for 38% of the total number of birds of all species observed in the (Bb) habitat, 45% of the five most frequently observed species in the (Bb) habitat (Table 25).

The (Bb) habitat is relatively restricted in the Yakutat area, reaching its greatest extent on the east side of Yakutat Bay, in the small Yakutat Bay archipelago, in the Russell and Nunatak Fiords, and at the Sitkagi Bluffs on the Manby (west) side of Yakutat Bay. Most of the observations of Black-legged Kittiwakes on rocky shores were made at the Sitkagi Bluffs in June, 1980.

TABLE 26

Avian Species Numerically Most Important In Deciduous Shrublands (Ds) Habitat Yakutat Area 1980

Ranking Order	Species	Total Number of Individuals Observed or Heard Per Species In (Ds) Habitat
1.	Hermit Thrush	300
2.	Tree Swallow	270
3.	Varied Thrush	254
4.	Fox Sparrow	193
5.	Pine Siskin	189
6.	Orange-crowned Warbler	188

Total of the Six Avian Species Most Frequently Seen or Heard in (Ds) Habitat in 1980:	1,394
Total of All Species Seen or Heard in (Ds) Habitat:	2,473

The figures above are of comparative, not absolute importance. Individual birds are difficult to observe in (Ds) habitat and singing ceases after July. The habitat is widespread in the Yakutat area, and actual numbers of individuals of these species must be far higher. The figures above thus serve as an index to relative abundance of passerine species in the Yakutat area (Table 26). Passerines were not a major focus of this study, but an effort was made to evaluate the importance of this habitat in the Yakutat area. The above six species accounted for 56% of all individual birds seen or heard in (Ds) habitat in 1980 (Table 26). Hermit Thrushes accounted for 12% of the total recordings (sight and sound notations), or 21% of the six most frequently noted species in (Ds) habitat. This (Ds) habitat had the highest avian diversity in the Yakutat area (Table 10). The number of species was comparatively high but the number of individuals was relatively low (Tables 12, 8).

TABLE 27

Avian Species Numerically Most Important In
Cliffs and Gullies (Cg) Habitat
Yakutat Area 1980

Ranking Order	Species	Total Number of Individuals Per Species in (Cg) Habitat
1.	Black-legged Kittiwake	600
2.	Glaucous-winged Gull	400

Total Observations of the Two Species Numerically Most Important in (Cg) Habitat: 1,000

Other species were an order of magnitude less frequently observed in this (Cg) habitat.

Total Observations of All Species in (Cg) Habitat: 1,059

The above two species accounted for 94% of all species observed in the (Cg) habitat (Table 27). The Black-legged Kittiwake accounted for 57% of the total number of observations of birds of all species in (Cg) habitat, 60% of the two most important species in (Cg) habitat (Table 27). This habitat is restricted in the Yakutat area, reaching its greatest extent at the seabird breeding colony on the 180 m cliff at Haenke Island, where the above observations were made.

TABLE 28

Avian Species Numerically Most Important In the Barren Moraines and Outwashes (Mo) Habitat Yakutat Area 1980

Ranking Order	Species	Total Number of Individuals Per Species in (Mo) Habitat
1.	Mew Gull	230
2.	Bank Swallow	170

Total Observations of the Two Numerically Most Important Species	400

Other species were an order of magnitude less frequently observed in this (Mo) habitat.

Total Observations of All Species in (Mo) Habitat: 555

The above two species accounted for 72% of the total number of individuals of all species observed in (Mo) habitat in 1980 (Table 28). Mew Gulls accounted for 41% of the total number of observations of birds of all species in the (Mo) habitat, or 57% of the two most important species in the (Mo) habitat (Table 28).

This habitat is most widespread NW of Malaspina Lake, at the base of the Malaspina Glacier, on the Manby (west) side of Yakutat Bay. Mew Gulls breed on the outwash flats of the Malaspina Glacier, but the number of individuals is small.

diversity per habitat along hundred of kilometers of coast between Yakutat Bay and Cape Spencer. Each site concentrated hundreds of breeding kittiwakes and other seabirds into geographically tiny areas. Diversity has not been calculated for the kittiwake colony on Cenotaph Island in Lituya Bay (Weisbrod, 1980), but Haenke Island, Boussole Head, and Cenotaph Island must be considered vulnerable to gas and oil exploration, development, transport, and associated disturbance.

Other Geographic Areas of Lower Avian Diversity

Other geographic areas of lower avian diversity in the Yakutat area were important as bird foraging areas. These areas, both in Yakutat Bay, included the north and south ends of Khaantak Island, and Point Latouche to Knight Island (Table 29). Concentrations of scoters and murrelets repeatedly occurred in these locations (Table 29). Eulachon runs in the lower East Alsek estuary during late Winter and Spring attracted huge numbers of a few species of gulls, terns, kittiwakes, and Bald Eagles (Table 29). Concentrations of American Wigeon also occurred repeatedly near submerged aquatic vegetation in the upper East Alsek estuary and along the East Alsek River in late Summer and Fall (Table 29). Black-sand Spit in the Situk - Ahrnklin estuary supported a very large concentration of breeding Aleutian Terns (3000) in early Summer 1980, and Dry Bay attracted large numbers of individuals of a few bird species during eulachon runs, spring migration, and seabird breeding (Table 29) (see Discussion below). (See also Fig. 4).

Qualitative Status and Abundance of Birds in the Yakutat Area

Qualitative status and abundance of birds in the Yakutat area were compared to the previous results of Shortt (1939), Mickelson (1975), and Batten et al (1978) (Table 30). Note that status and habitat classifications <u>in this Table only</u> follow Mickelson (1975) for comparative purposes. The number of bird species observed by Shortt (1939) and Patten (this report) are similiar for the Yakutat area, with the exception of procellariform species (Table 30).

TABLE 29

Geographic Areas of Lower Avian Diversity (Yakutat - 1980)

Ranking Order (Ascending)	Area	Diversity/Special Conditions	Habitat Classifications (in order of importance)	Date	Transect Mode and number
1.	N end of Khaantak Is. to Knight Island	0.44 scoters, Arctic Terns, Harlequin Ducks in concentrations	Bb - CoW	June 10	boat - 15
2.	Lower East Alsek Estuary	0.51 eulachon run attracts huge numbers of gulls, terns, kittiwakes and eagles	L - Bs - CoW - Fm	June 4	boat - 13
3.	Outer (SE) end of Khaantak Island (Yakutat Bay)	0.72 concentration of scoters	Bb - Bs - CoW	June 9	boat - 14b
4.	Upper East Alsek Estuary	0.80 concentration of ducks (wigeon)	L - Fm	Sept 5	foot - 41
5.	Lower East Alsek Estuary	1.02 eulachon run;large number of foraging birds	L - BS - CoW - M	June 2	boat - 12

TABLE 29 (Cont.)
Geographic Areas of Lower Avian Diversity (Yakutat - 1980)

Ranking Order (Ascending)	Area	Diversity/Special Conditions	Habitat Classifications (in order of importance)	Date	Transect Mode and number
6.	Old Italio Estuary	1.04 shorebird concentrations	Sm - Fm - L	July 1	foot - 31
7.	Blacksand Spit (Situk Estuary)	1.11 Aleutian Tern colony	Bs - M - L - CoW	July 5	foot - 32
8.	Pt. Latouche to Knight Island (Yakutat Bay)	1.16 murrelet and scoter concentrations	CoW - Bb	June 11	boat - 19
9.	East Alsek River	1.22 concentrations of ducks (wigeon)	L - Ds	Sept 27	boat - 50
10.	Upper East Alsek Estuary	1.32 concentration of ducks (wigeon)	Fm - L	Sept 13	foot - 46
11.	Dry Bay (Alsek River Estuary)	1.36 eulachon run; seabird colonies; migratory staging area	L - Bs - M	May 30	boat - 9
12.	Haenke Island (Disenchantment Bay)	1.37 seabird colony	Cg - Bb - Ds	June 10	foot - 17

Table 30. Qualitative status and abundance of birds in the Yakutat area. Compiled from the sightings of Shortt (1939), Mickelson (1975), Batten, Murphy and Murray, (1978) and Patten (this report).

Abbreviations are as follows:

Status: R=resident; M=migrant; S=summer inhabitant; B=breeder; W=winter inhabitant; ( )=probable.

Habitat: O=offshore waters; C=coastal waters; T=tidelands; M=marsh; W=woodlands; U=upland.

Capital letters indicate primary habitat; lower case letters indicate secondary habitat.

Status and habitat classifications in this table only follow Mickelson (1975) for comparative purposes.

Species	Status	Habitat	Observed by Shortt	Observed by Mickelson	Observed by Batten, Murphy	Observed by Patten, Primrose, Mace
Common Loon	RB	CMw	x	x		x
Yellow-billed Loon	M(W)	C	x			x
Arctic Loon	R	C	x			x
Red-throated Loon	RB	CM	x			x
Red-necked Grebe	MW	C	x			x
Horned Grebe	M(B)	CM	x			x
Black-footed Albatross	S	Oc	x			
Northern Fulmar	S	Oc	x			
Sooty Shearwater	S	Oc	x			
Fork-tailed Storm Petrel	S	Oc	x			
Double-crested Cormorant	RB	Ct	x	x	x	x
Pelagic Cormorant	RB	Ct	x	x		x
Great Blue Heron	R(B)	MWt	x			x
Whistling Swan	M	TM				x
Trumpeter Swan	SB	TM				x
Canada Goose	B	TM	x	x	x	x
Black Brant	M	TM				x
White-fronted Goose	M	TM		x		x

TABLE 30 Contd.

Species	Status	Habitat	Observed by Shortt	Observed by Mickelson	Observed by Batten, Murphy	Observed by Patten Primrose, Mace
Snow Goose	M	TM				x
Mallard	RB	TMw	x	x	x	x
Gadwall	M	TM				x
Pintail	B	TM	x	x	x	x
Green-winged Teal	B	TMw	x	x	x	x
Blue-winged Teal	M	TMw				x
Eurasian Wigeon	MS	TM				x
American Wigeon	B	TMw	x	x	x	x
Northern Shoveler	(B)	M				x
Redhead	M	TM				x
Ring-necked Duck	M	TMw				x
Canvasback	M	TM	x			x
Lesser Scaup	M	TM				x
Greater Scaup	MW	TM		x		x
Barrow's Goldeneye	RB	TMW	x	x	x	x
Bufflehead	M(RB)	TMW		x	x	x
Oldsquaw	MW	Om	x			x
Harlequin Duck	RB	Om	x			x
White-winged Scoter	RB	Om	x	x	x	x
Surf Scoter	RB	Om	x		x	x
Black Scoter	MS	O	x	x	x	x
Common Merganser	RB	Mtw	x	x	x	x
Red-breasted Merganser	RB	Mtw	x	x	x	x
Northern Goshawk	RB	W	x			x
Sharp-shinned Hawk	RB	W	x			x
Red-tailed Hawk	M	W	x			x
Rough-legged Hawk	M	W	x			x
Golden Eagle	B	WU	x			x
Bald Eagle	RB	TMW	x	x	x	x
Marsh Hawk	B	TM				x

TABLE 30 Contd.

Species	Status	Habitat	Observed by Shortt	Observed by Mickelson	Observed by Batten, Murphy	Observed by Patten Primrose, Mace
Osprey	B	WM	x			
Peregrine Falcon	SB	CM	x			x
Merlin	S(B)M	W	x			x
Kestrel	M	W				x
Willow Ptarmigan	RB	MU	x			x
Rock Ptarmigan	RB	U	x			x
Sandhill Crane	M	TM				
Black Ostercatcher	B	T	x			x
Semipalmated Plover	SB	TM	x		x	x
Killdeer	M	T	x			x
Golden Plover	M	T				x
Black-bellied Plover	M	TM	x	x		x
Surfbird	M	T	x			x
Ruddy Turnstone	M	T	x			x
Black Turnstone	M	T	x			x
Common Snipe	B	M	x	x		x
Spotted Sandpiper	B	M	x	x	x	x
Solitary Sandpiper	M	M	x			
Wandering Tattler	M	T	x			x
Whimbrel	M	T				x
Greater Yellowlegs	B	Mw	x	x	x	x
Lesser Yellowlegs	B	Mw	x	x	x	x
Rock Sandpiper	M(W)	T	x			
Least Sandpiper	B	TM	x	x	x	x
Dunlin	M	TM	x	x		x
Long-billed Dowitcher	M	TM	x	x		x
Red Knot	M	T				x
Short-billed Dowitcher	B	TM	x	x	x	x
Semipalmated Sandpiper	M	TM				x
Western Sandpiper	M	TM	x	x		x
Pectoral Sandpiper	M	TM				x
Northern Phalarope	B	TM	x	x	x	x

TABLE 30 Contd.

Species	Status	Habitat	Observed by Shortt	Observed by Mickelson	Observed by Batten, Murphy	Observed by Patten Primrose, Mace
Parasitic Jaeger	B	M	x	x	x	x
Long-tailed Jaeger	M	C				
Glaucous Gull	SW	TM				
Glaucous-winged Gull	RB	TM	x	x	x	x
Herring Gull	B	TM	x		x	x
Thayer's Gull	M	TM				x
Mew Gull	RB	TM	x	x	x	x
Bonaparte's Gull	B	TMw	x	x	x	x
Black-legged Kittiwake	B	CT	x	x		x
Arctic Tern	B	TM	x	x	x	x
Aleutian Tern[1]	B	TM				x
Thin-billed Murre	SW	C				x
Pigeon Guillemot	RB	C	x			x
Marbled Murrelet	RB	OCU	x			x
Kittlitz's Murrelet	RB	OCU	x			x
Rhinoceros Auklet	S	OC	x			
Tufted Puffin	R	OC	x			x
Screech Owl	RB	W	x			
Great Horned Owl	RB	W	x			x
Pygmy Owl	RB	W	x			
Great Grey Owl	RB	W	x			
Short-eared Owl	B	M	x	x		x
Hawk Owl	M	W				x
Nighthawk	M	m	x		x	
Rufous Hummingbird	B	WM	x		x	x
Belted Kingfisher	RB	TWM	x	x		x

[1]Reported by Walker (1920, 1923) from the mouth of the Situk River. Observed again in large numbers by Patten and Primrose in 1980. See Species Accounts, Appendix II.

TABLE 30 Contd.

Species	Status	Habitat	Observed by Shortt	Observed by Mickelson	Observed by Batten, Murphy	Observed by Patten Primrose, Mace
Common Flicker	M	W	x			x
Hairy Woodpecker	RB	W	x	x		x
Downy Woodpecker	RB	W				
Western Flycatcher	B	W	x			x
Alder Flycatcher	B	W				
Violet-green Swallow	B	MW	x			x
Tree Swallow	B	MW	x	x	x	x
Barn Swallow	B	Wm	x	x	x	x
Bank Swallow	B	Wm				x
Cliff Swallow	B	Wm				x
Water Pipit	M(B)	TM	x	x		x
Steller's Jay	RB	Wm	x	x	x	x
Black-billed Magpie	RB	WUM	x			x
Common Raven	RB	TMU	x	x	x	x
Common Crow	RB	TW	x	x	x	x
Black-capped Chickadee	W	Wm	x			x
Chestnut-backed Chickadee	RB	W	x	x		x
Red-breasted Nuthatch	(B)	W				x
Dipper	RB	W	x			x
Winter Wren	RB	W	x			x
American Robin	B	Wm	x	x	x	x
Varied Thrush	B	Wm	x	x	x	x
Hermit Thrush	B	Wm	x	x	x	x
Gray-cheeked Thrush	B	W	x		x	x
Golden-crowned Kinglet	B	W	x			x
Ruby-crowned Kinglet	B	W	x		x	x
European Starling	M	W				x
Northern Shrike	M	W				x
Orange-crowned Warbler	B	W	x		x	x
Yellow Warbler	B	W	x			x

TABLE 30 Contd.

Species	Status	Habitat	Observed by Shortt	Observed by Mickelson	Observed by Batten, Murphy	Observed by Patten Primrose, Mace
Yellow-rumped Warbler	RB	WUM				x
Yellowthroat	B	W				x
Wilson's Warbler	B	W	x		x	x
Rusty Blackbird	B	W				x
Pine Grosbeak	RB	W	x			x
Common Redpoll	MW	WM	x			x
Pine Siskin	RB	W	x	x		x
White-winged Crossbill	M	W	x			x
Savannah Sparrow	B	M	x	x	x	x
Dark-eyed Junco	B	W	x	x		x
White-crowned Sparrow	MB	W		x	x	x
Golden-crowned Sparrow	B	WM	x	x	x	x
Fox Sparrow	B	MW	x	x	x	x
Lincoln's Sparrow	B	Wm	x		x	x
Song Sparrow	B	TM	x	x		x
Lapland Longspur	M	Um		x		x

VII. DETAILED DISCUSSION OF THE YAKUTAT STUDY AREA, INTENSIVE STUDY SITES, AND DESCRIPTION OF COASTAL AND ESTUARINE HABITATS

The Yakutat Area: Biogeographical Comments

Biogeographically, the vegetation of the Yakutat area is the northern most extension of the Pacific Coast rainforest, which extends from northern California to Alaska. The Yakutat area has been greatly disturbed by recent geological events (glaciation, and deglaciation, fluvial action, and earthquakes). The Yakutat area has a narrow strip (30-50 km) of lowlands between the Gulf of Alaska and extensive areas of high mountains, alpine regions, glaciers, and boreal interior environments. This narrow strip of lowlands is known as the Yakutat Forelands. Geological time is short in the Yakutat area. Conditions change extremely rapidly. Earthquakes, storm tides, glacial activity, siltation from outwash moraines, streams, and rivers all affect the landscape.

The coastal plain of the Yakutat Forelands is supported by sedimentary rocks of Tertiary age covered by glacial, fluvial, and marine deposits of Quaternary and Holocene age (Miller, 1958; Batten, Murphy and Murray, 1978). The southeast shore of Yakutat Bay rises to a low but massive terminal moraine (AD 1200) of the former Yakutat Bay glacier, from which a nearly level outwash plain extends southeast across the Yakutat Forelands (Tarr, 1909). The moraine is forested and is marked with many small ponds, but the outwash plain primarily supports bog vegetation (Batten, Murphy and Murray, 1978). The glaciers retreated from Yakutat Bay, Russell Fiord and nearby lowlands about 800 years ago (USDA Forest Service, 1981).

Many, if not most, areas in the Yakutat Forelands have naturally disturbed, early-successional stages of vegetation. This is especially true along present river courses, old river courses, and in recently deglaciated areas. Deciduous shrublands with emergent spruces (*Picea sitchensis*) are widespread in the Yakutat Forelands. Long stretches of exposed sandy beaches are also characteristic of the Yakutat area, on the east from Ocean Cape to the Doame River estuary, and on the west (Manby) side of Yakutat Bay. The east side of Yakutat Bay is predominantly rocky. The band of mature spruce trees just behind many of the marine beaches in the Yakutat area results from an uplift of an old beach line. Glaciological influences and shoreline modifications are even more recent on the Malaspina Forelands of the west side of Yakutat Bay. The shallow slope of the Pacific shoreline exposes the entire ocean slope of the Yakutat Forelands to winter storms which wash over many square kilometers of sandy beaches and adjacent areas inland.

The Yakutat Forelands contain large areas of bogs (muskegs) with scattered spruce stands concentrated along actual or former waterways. The lower mountain slopes on the northeast side of Yakutat Bay and adjoining old terminal moraines are heavily vegetated with old-growth spruce-hemlock (*Picea sitchensis* and *Tsuga heteophylla*) forest. Willows (*Salix spp.*) and alders (*Alnus crispa* subsp. *sinuata*) grow along stream margins. The old-growth coniferous forest near Yakutat Village has been intensively harvested in rectangular, clear-cut patterns. There are scattered fresh water ponds both in the muskeg and in the spruce forest. The large areas of muskeg, principally to the east and south of the spruce forest, contain standing water and stunted spruce (*Picea sitchensis*) trees.

Adequate knowledge of the nature of the lakes, rivers, streams, sloughs and estuaries in the Yakutat area is crucial to the proper understanding of the avian biology and distribution in the region. Drainage in the Yakutat area is roughly from north to south, from the mountains to the Gulf of Alaska. The watercourses, with the exception of the Alsek River, are usually of short length and divide the nearshore land areas into a series of roughly rectangular features, which can be characterized by the names of the adjoining rivers.

The watercourses considered to be of major (and minor) importance to an understanding of the avian biology of the Yakutat area are shown in Tables 31-32.

TABLE 31

Watercourses of major importance to avian biology in the Yakutat Forelands: (Proceeding W -- E)

Name	Water Condition - 1980
Ankau Saltchucks, incl. Kardy Lake	clear, salt
Tawah Creek Drainage (Aka Lake, Summit Lake, Tawah Creek)	clear, fresh
Situk River (single brackish (turbid) estuary with Ahrnklin River)	clear, fresh
Ahrnklin River (single brackish (turbid) estuary with Situk River)	partially turbid, fresh
Dangerous River	turbid, fresh
Italio River	clear, fresh
Akwe River	partially turbid, fresh
Alsek River	turbid, fresh
East (Alsek) River (single estuary (clear) with Doame River)	clear, fresh
Doame River (single estuary (clear) with East (Alsek) River)	clear, fresh
Clear Creek	clear, fresh

TABLE 32

Watercourses of minor importance to avian biology in the Yakutat Forelands: (Proceeding W -- E)

Name	Water Condition - 1980
Lost River	clear, fresh
Seal Creek	clear, fresh
Antlen River	turbid, fresh
Ustay River	turbid, fresh
Tanis River	turbid, fresh

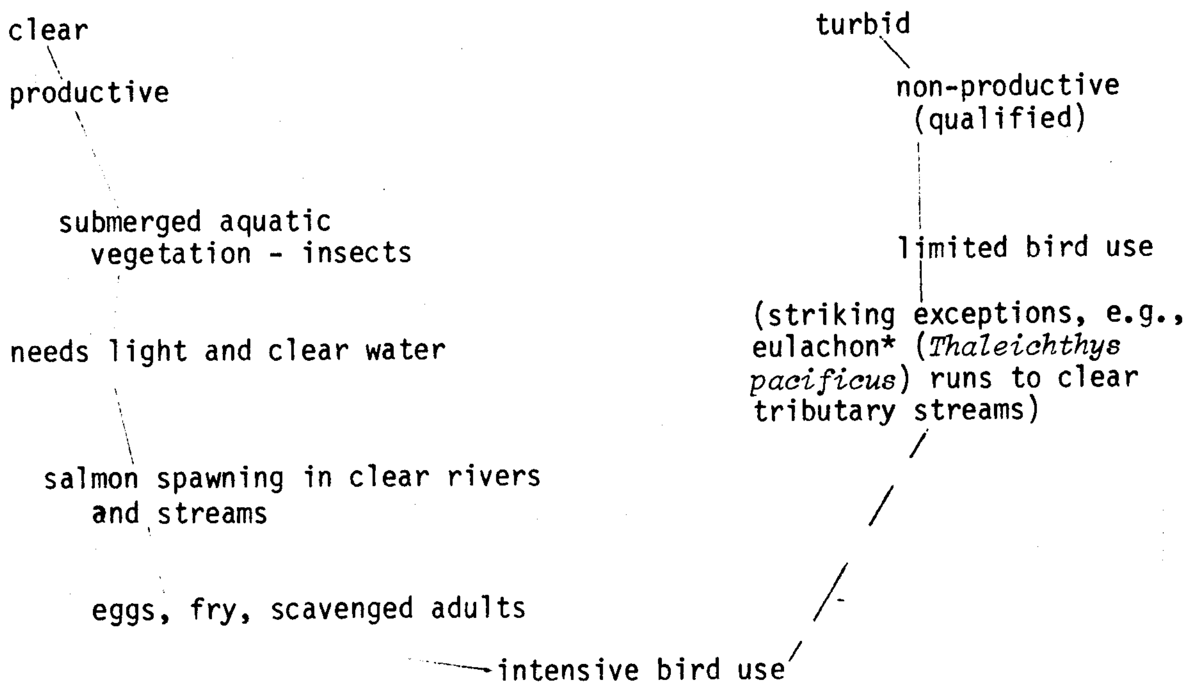
Each river is different in avian diversity, vegetation, bird species assemblages, size of estuary, and habitat. The Italio, however, resembles a small Situk, and the Dangerous River resembles a small Alsek.

In general, rivers in the Yakutat area which are clear tend to be productive in that being clear they allow growth of underwater vegetation which attracts insects and fish. The vegetation, insects and fish all attract birds and for these reasons the streams are biologically active. By contrast, turbid streams are unproductive and, with striking exceptions attract fewer birds (Figure A).

FIGURE A

Yakutat Forelands - Major Watercourses - Use by Waterfowl, Eagles, Shorebirds, and Seabirds (such as Gulls, Jaegers)

Yakutat Forelands
Waterbird Use
Major Watercourses



*See Species Accounts, Appendix IV.

The outer sandy beaches of the Yakutat Forelands are bordered by the following important estuaries:

TABLE 33

Important Estuaries of the Yakutat Forelands
(See Figs. 1, 4, 5, 7, 9, 11, 12, 13, 14)

Name	Characteristics
Situk-Ahrnklin	Most important economically to Yakutat because of the extensive gill-net salmon fishery; extensive sedge (*Carex*) tidal marshes; large numbers of waterfowl and shorebirds during Fall migration; Aleutian Tern colony.
Dangerous	Large areas of extensive sand and mudflats; eulachon runs attract hundreds of eagles in late Winter.
Italio - Old Italio	Waterfowl and shorebirds in shallow tidal sloughs; eulachon runs in Spring attract thousands of birds.
Akwe	Hundreds of eagles and thousands of other waterbirds; most important eulachon run; other wildlife; spruce forest close to river shore near beach. Sections of the river have abundant submerged aquatic vegetation.
Dry Bay - Alsek	Migration corridor to interior; large areas of gravel bars; nesting gulls, terns, and geese; Aleutian Tern colony. Salmon processing plant. Migration staging area; eulachon run.
East River - Doame	Most important for many species of waterfowl (dabbling ducks); abundant submerged aquatic vegetation and spawning salmon in the short, clear East (Alsek) River.
Clear Creek	Over 100 eagles on February 1981 eulachon run.

Note: The current (1959) series of USGS maps for the Yakutat area is out-of-date. Conditions change so rapidly on this coast that the mouths of the rivers are not where they were when the map surveys were made.

Narrative Climatological Summary

The Yakutat area is surrounded on three sides by waters of the Gulf of Alaska, Yakutat Bay, and Russell Fiord. Consequently the climate is maritime and the weather is cool and wet. The average summer temperature is in the low fifties Fahrenheit (10° C). Both daily and seasonal average temperatures stay within fairly well defined limits. However, Yakutat has about 20 days each year with temperatures below zero F (-17° C). Normal monthly temperatures range from slightly above 26° F (-4° C) in January to about 53° F (12° C) in July and August. Maximum temperatures above 80° F (26° C) have occurred in June, July and August (NOAA, 1979).

Although the area in the immediate vicinity of the town and airport is relatively flat, rough, hilly terrain exists within short distances. The peaks of the St. Elias Range (5000 to 6600 m) are located 80 to 120 km to the north and northwest. These high mountain slopes, with exposure to moisture-laden air from the Gulf of Alaska, provide Yakutat with abundant rainfall. The average yearly precipitation is 131 inches (330 cm), one of the greatest in Alaska. Annual amounts have always been in excess of 84 inches (215 cm). June has the lowest average precipitation of any month, with about 5 inches (12 cm). Approximately seven inches (18 cm) are received in July and August. More than seven inches (18 cm) are received per month in the rest of the year. Snowfall has occurred in all months except June, July and August. October, with an average of almost 20 inches (50 cm), has the heaviest monthly rainfall. The heavy annual precipitation produces copious growth of vegetation on the predominantly gravel substrate of the Yakutat area.

Cloudy skies are commonplace, with the annual average amount from sunrise to sunset exceeding 80% sky cover. Especially during the Fall and Winter, the Yakutat area is subjected to frequent and intense storms, usually accompanied by heavy rains and high winds. During these seasons the counterclockwise low pressure systems developing in the Aleutians typically follow a path located just south of the Yakutat area, resulting in presistently cloudy weather with strong SE winds (over 120 kph) bringing extensive precipitation (NOAA, 1979) (see Appendix I).

The St. Elias Mountain Range, which borders the Yakutat area on the northeast and contains numerous glaciers, exerts a pronounced effect on the local weather, particularly during the Fall and Winter, when a high pressure system in the interior Yukon region and a low pressure cell in the Gulf of Alaska to the southwest of Yakutat results in a steep pressure gradient in the Yakutat area. Under these conditions, cold, very strong N, NW and NE winds move down mountain valleys under cloudless skies. These dry, extremely high winds ("drainage winds") are especially strong in three areas: Russell Fiord; the Yakutat Glacier-Harlequin Lake-Dangerous River drainage, and in the Alsek Canyon-Upper Alsek-East Alsek region. The sudden and severe drainage winds occasionally reach velocities of 160 kph or more (NOAA, 1979).

The pecularities of the Yakutat geography cause wide variations in weather conditions over relatively short distances. This causes problems for small aircraft. Clouds are usually lower over timbered areas and together with frequent fog, make low-level flights hazardous without knowledge of local landmarks. At the Tanis Mesa Forest Service airstrip NW of Dry Bay and west of the Alsek River Valley, very unusual ("squirrelly") winds are occasionally encountered, making takeoffs and landings difficult (FAA mimeo, Yakutat AIRAD).

The Phipps Peninsula: The Ankau Lagoons and the Tawah Creek Drainage

The Phipps Peninsula is the projection of land southwest of Yakutat. It is made up of Ankau Head and the Ankau Lagoons. Point Carrew is located inside Yakutat Bay northeast of Ocean Cape near Monti Bay which is the deep water Yakutat harbor. Aka (sic) Lake begins the fresh water drainage southeast of the Ankau Lagoons, and is adjoined by Summit Lake and Tawah Creek (Fig. 11).

Kardy Lake forms part of the saltwater Ankau Lagoons. One can proceed into the Ankau Lagoons from the Ankau bridge with a small boat at high tide. The Ankau Lagoons are connected at high tide by a series of small tidal channels. In the Ankau, the saltchucks (lagoons) are mixed with spruce-hemlock forest, bogs, and freshwater ponds. Saltwater influence ends in the Canoe Pass area connecting Aka Lake with Kardy Lake (Ankau Lagoons). There is an abrupt change between the fresh water of the Tawah Creek drainage and the saltwater Ankau lagoons. The proximity of fresh water and saltwater is a productive waterfowl habitat.

West of the mouth of Ankau Creek is a broad band of sandy beach with drift logs. This is a nesting area for at least 50 pairs of Aleutian and Arctic Terns. The Ocean Cape - Ankau area is the first landfall after Yakutat Bay for migrating birds in the Autumn, and waterfowl can be abundant in the nearby lagoons. The Yakutat Bay side of Ocean Cape has a large expanse of sandy beaches with heavy drift logs at the high tide line. At Ocean Cape the shoreline changes to mixed rock and sand. The intertidal is disturbed by heavy wave action on the ocean side of the Cape. Southeast of Ocean Cape sandy beaches extend approximately 120 kilometers towards the end of the Yakutat Forelands at the Doame River - Clear Creek estuaries.

Tawah Creek is separated from the ocean beaches by an ancient band of dunes, now heavily timbered. Landward of this old beach there are muskegs and scattered spruces. The Tawah Creek drainage is important as a resting and foraging site for waterfowl during migrations and winter. Summit Lake (known locally as Coast Guard Lake) and Tawah Creek support up to fifty wintering Trumpeter Swans and as many as 300 migrating Trumpeter Swans in Spring (Ball, ADF&G, pers. comm) (Fig. 12).

Cannon Beach bridge spans Tawah Creek. Cannon Beach is sandy, with a very wide, shallow slope, bordered by drift logs on the lower (seaward) side, and a beach rye grass (*Elymus*) zone on the upper (landward) side. The *Elymus* zone merges into beach sandwort (*Honckenya peploides*), emergent spruces, alder, and old-growth spruce forest, with an understory of strawberry (*Fragaria*) and Indian paint brush (*Castilleja unalaschcensis*). An edge effect is created by the Ophir Creek Road through the old-growth forest.

Ankau Saltchucks

The Ankau saltchucks are saltwater lagoons, forming a maze of interconnected shallow waterways and tidal pools surrounded by old-growth spruce-hemlock forest. Some of the individual hemlock trees appear ancient. The intertidal is rocky, except near the mouth of the Ankau, where a sandy beach is formed to Point Carrew. Mussels (*Mytilus sp.*) and rockweed kelp (*Fucus sp.*) predominate in the rocky intertidal with little or no other vegetation. Where the substrate is sandy, sedges (*Carex spp.*) first invade the shoreline, followed by a very narrow band of beach rye grass (*Elymus*), immediately superceded by alders (*Alnus*) and emergent spruces. In the surrounding old-growth forest, numerous snags and senescent trees of various species provide suitable nesting sites for many bird species, especially passerines and woodpeckers, associated with over-mature forest stands. The forest understory is typical of old-growth species, with alders (*Alnus*) and willows (*Salix*) in openings and edges, devil's club (*Echinopanax horridum*) in moss under the large trees, cow parsnip (*Heracleum lanatum*) on sunny sites, umbells (*Angelica lucida*), strawberry (*Fragaria chiloensis*) and salmonberry (*Rubus spectabilis*) on the forest margins. Fireweed (*Epilobium angustifolium*), nettles (*Urtica*), and mountain ash (*Sorbus*) grow along the roadsides. In wet sites, horsetails (*Equisetum arvense*) form an important ground cover, and skunk cabbage (*Lysichiton americanum*) is present. The mouth of the Ankau at Monti Bay is a feeding area for a diverse assemblage of birds. Tidal eddies are created, bringing food to or near the surface for both diving and surface-feeding birds. Tidal interchange (strong tidal currents on both rising and falling tides) is marked.

Herring (*Clupea harengus pallasi*), flounders (*Platichthys stellatus*), and silver salmon (*Oncorhynchus kisutch*) in season are found in the Ankau lagoons.

Near the mouth of the Ankau to Monti Bay, the intertidal is a mixed rocky and sandy substrate, above which grows a broader band of beach rye grass (*Elymus*), in association with beach pea (*Lathyrus maritimus*).

Brown bears (*Ursus arctos*) and red squirrels (*Tamiasciurus douglasi*) are readily observed mammalian inhabitants of the forest and openings around the Ankau saltchucks.

Cranberry (*Viburnum edule*) grows as a forest understory shrub, with wintergreen (*Pyrola asarifolia*) on exposed forest understory sites. Lupines (*Lupinus nootkatensis*) grow on open grassy areas between willows and alders near the mouth of the Ankau. Small fresh water ponds with emergent vegetation (pond lillies (*Nuphor polysepalum*), and skunk cabbage) are found in the surrounding forest. Asters (*Aster subspicatus*) and bunchberry (*Cornus canadensis*) grow in disturbed sites along the roadside. Boreal toads (*Bufo boreas*) are commonly observed.

Lost River

In the vicinity of the Lost River there are muskegs, forest of young spruce (*Picea sitchensis*), alders (*Alnus sp.*) alders, willows (*Salix spp.*) and black cottonwood (*Populus balsamifera*) along watercourses. There is much standing water after heavy rains. Lost River carries surface runoff and is also a sport fishing stream for salmon. Lost River is connected by a tidal slough to the Situk River. Waterfowl are attracted to this slough during Spring and Fall. The outer beach between the mouth of Lost River and the Situk River is exposed, with drift logs on a very shallow slope. Upper beach meadows with small spruces are found several hundred meters in back of the marine beaches. About a kilometer north of the shoreline there are extensive muskegs merging into spruce forest. The ocean slope here is extremely shallow. Dense spruce forest also occurs along former beach lines. The old-growth spruce forest ceases at Lost River and does not approach the coast until the Akwe River, approximately 35 km to the southeast. The old-growth spruce forest near the Lost River has been harvested in large rectangular clear-cuts. The most recent logging took place in 1970. Tawah Creek flows southeast along the lee side of an uplifted former beach line and joins Lost River about ten kilometers southeast of Yakutat.

Small groups of gulls feed at the mouth of the Lost River, especially near salmon nets in season (May-September).

Situk River and the Situk-Ahrnklin Estuary

The forest in the Situk drainage has large stands of mature spruce and hemlock, with devil's club (*Echinopanax*) understory. Along the Situk River there are small fresh water ponds with, during the summer, relatively dense surface vegetation. A mixture of muskegs and small ponds with abundant vegetation is found in the open areas above the lower drainage of the Situk. A small watercourse, Seal Creek, winds through this muskeg. Cow parsnip (*Heracleum*) and similar forbs are found along such small streams. The Ahrnklin River also passes through muskegs east of the Situk River, with cottonwoods and spruces along the riverbanks. When water levels are low, there are large areas of exposed gravel along this stream. The Ahrnklin is moderately clear while the nearby Antlen River is glacial-fed and turbid. The Situk is clear and an important commercial salmon stream; the Situk is also recognized as one of the outstanding sportfishing streams in Alaska (USDA Forest Service, 1975).

The Situk, Seal, Antlen, and Ahrnklin Rivers share a common river mouth, forming the Situk-Ahrnklin estuary, a major, biologically productive delta of the Yakutat area (Fig. 4). The Situk-Ahrnklin estuary resembles a small Copper River Delta:

FIGURE B

Schematic Diagram of the Situk-Ahrnklin Estuary

sea	barrier island/spit
	large channel
	islands
	small channels
	marshes
	mainland spruce forest
↓ inland	↓ muskeg

The combined estuary of these rivers forms a large tidal area (8 x 22 km), with strong tidal currents (5-8 knots) on both rising and falling tides. The estuary is only partially protected from the prevailing southeasterly winds (with a fetch across the estuary of 3-4 km). The estuarine waters can be treacherous during southeast storms. The dunes channel the wind from the southeast down the estuary. The current is rapid near the mouth of the Situk, and sweeps the tidal flats.

Blacksand Spit

Blacksand Spit is the barrier beach-dune system for the Situk-Ahrnklin estuary. It is approximately 22 km long and 400 meters wide. The intertidal areas on both estuarine and ocean sides of the spit are extensive, especially near the eastern end of the estuary. Maximum dune height is approximately 10 meters near the middle of the spit, tapering down to wave-washed areas at either end.

Active wind and water erosion is evident on both estuarine and ocean sides of the spit. The mouth of the estuary has moved westward several kilometers within the past 20 years. Drift logs are a major feature of Blacksand Spit even on the high dunes.

Vegetation on Blacksand Spit is predominantly strawberry (*Fragaria chiloensis)*, yarrow *(Achillea borealis)*, red fescue grass *(Festuca rubra)*, beach rye grass *(Elymus arenarius var. mollis)*, Indian paint brush *(Castilleja unalaschcensis)*, and a few alders *(Alnus)*.

Most colonies of terns in the Yakutat area in 1980 contained both Aleutian and Arctic Terns nesting in the same general area. Both Arctic and Aleutian Terns were present in scattered pairs along the entire Situk-East River beach-dune system. The most important Aleutian and Arctic Tern populations were found on Blacksand Spit (Fig. 7). Blacksand Spit in 1980 supported the largest concentration of Aleutian Terns in the Yakutat area. At least 3,000 Aleutian Terns were counted over Blacksand Spit, and over adjacent waters.* Approximately 500 Aleutian Terns were

*See Aleutian Tern Species Account.

counted elsewhere in the Yakutat area. Aleutian Terns were definitely more coastal in distribution than the Arctic Tern, which was also found on foothill lakes, rivers, and ponds.

The tern colony was concentrated near the ADF&G "Upper Limit to Commercial Fishing" marker on Blacksand Spit. However the tern colony extended along the Spit from the Ahrnklin Flats to the mouth of the Situk River (approximately 15 km). Both tern species were observed foraging beyond the surf and in the estuary, but in nesting these species apparently exhibited a partial habitat partitioning. Aleutian Terns were observed nesting in Indian paint brush *(Castilleja unalaschcensis)* and sparse *Elymus* zone, while the Arctic Terns on Blacksand Spit preferred to nest among drift logs in open sandy areas.

Many fisherman's cabins and tent frames are found on the west end of Blacksand Spit. Commercial salmon fishing is the main source of income for the villagers of Yakutat. The three kilometers of the Spit nearest the mouth of the Situk River seasonally (May-September) have the most dense human population in the Yakutat Forelands with the exception of Yakutat village and the airport.

Blacksand Spit also serves as a roosting area for migrating shorebirds, specifically thousands of Western Sandpipers, in early July. Semipalmated Plover nests are scattered among the drift logs on Blacksand Spit in early Summer.

Avian and mammalian predation was evident in the tern colony on Blacksand Spit. Ravens, crows, and gulls preyed heavily on eggs, and eagles were observed taking chicks. Coyote sign was noted in the colony, and there appear to be dens in the area. Predation by coyotes has been noted by Fish and Wildlife Protection officers and local pilots (Robertson, pers. comm.). Human disturbance and predation (i.e, egging) in the colony were evidenced by vehicle tracks and destroyed nests and eggs.

The synchrony of egg laying and incubation by the terns in this colony appeared to be seriously affected by the predation and disturbance. Random samples found eggs at all stages of incubation, as well as chicks in nests. We believe that most of the disturbance is caused by children, dogs, and 3-wheeler traffic.

Blacksand Island and the Situk-Ahrnklin Flats

Blacksand Island, located in the Situk-Ahrnklin Estuary between Blacksand Spit and the mainland, is surrounded by tidal channels. Blacksand Island, 8 x 2.5 km, is vegetated with upper beach meadows and Sitka spruce. Tidal gutters and embankments form the south side of the island opposite Blacksand Spit. The mainland north of Blacksand Island has herbaceous meadows, with spruce forest and alders along stream courses. There is also an extensive muskeg on the mainland northwest of Blacksand Island. Batten, Murphy and Murray (1978) have described the vegetation of that area (cf. p. 31-49 of their report).

FIGURE C

Synopsis of Vegetation - North of Blacksand Island

↓ sea	↓ Supratidal meadows (above tide line)
	shrubs *(Myrica)*
	invasive alder *(Alnus)*
	Sitka spruce *(Picea)*
	mosses
inland	some lupine *(Lupinus nootkatensis)*

A large area of tidal wetlands and marshes is located on the east-southeast side of the Situk-Ahrnklin estuary. These saltwater marshes, located near the mouth of the Ahrnklin River, are known as the Situk-Ahrnklin Flats (Fig. 10). These flats form a large area of partially protected waters, tide flats, and true tidal marsh (with sedges, *Carex lyngbyaei*). Other locations around Yakutat have tidal marshes, but not to the extent as here. The water in this estuary is turbid, which may affect the growth of submerged aquatic vegetation other than *Carex*. (The best area for submerged aquatic vegetation, and hence for waterfowl, in the Yakutat area is the clear East (Alsek) River and the freshwater East-Doame River estuary). However, the seeds of three to four species of low meadow grasses on the nearby mainland in this area apparently provide good forage for waterfowl in season (Autumn migration). Thousands of ducks, geese, swans and shorebirds are attracted to the Situk-Ahrnklin Flats during Autumn migration, including the highest numbers of some species recorded in the Yakutat area in 1980. (More species, however, are recorded in the East-Doame River Estuary). An unusual Eurasian Wigeon was recorded on the Ahrnklin Flats on October 10, 1980.

A large area of exposed, wave-washed mud and sandflats, with little vegetation, is located between the Situk-Ahrnklin Flats and the mouth of the Dangerous River. During very high tides, the area from the Ahrnklin to the Dangerous River is completely covered with water. The outer dunes, in a band 200 m wide and 5 m high, have drift logs on both the ocean and the estuary side. It is possible during good weather to move a small boat through the Ahrnklin Flats to the Dangerous River. Channels along the lee side of the main dunes allow passage of a small boat two hours before and two hours after a good high tide.

Harlequin Lake

Harlequin Lake is surrounded by mountains (to 1100 m) on the NW, N, NE sides, and is drained by the Dangerous River on the south side. It is approximately 32 km from salt water, and was created by the retreat of the Yakutat Glacier. The Yakutat Glacier now feeds into Harlequin Lake on the NNW side. An old terminal moraine of the Yakutat Glacier, forming a low ridge, now defines the southern border of the lake. It is bisected by the Dangerous River. Harlequin Lake has immense icebergs grounded near the south shore, pushed by the drainage winds and the downstream current which flows into the Dangerous River. Calving of icebergs into Harlequin Lake causes occasional very heavy, strong wave action. The wave action especially affects a canyon to the east of the front of the glacier. Drainage winds also cause very strong swells to build up on Harlequin Lake.

A few clear streams flow into Harlequin Lake on either side (E and W) of the Yakutat Glacier. Sheer rock faces border the NE side of the lake. Several 100 m high ridges, partially vegetated with stunted alder, adjoin these cliffs. Spruce and cottonwood forest is found near the lake on the NE side south of the cliffs. The shore of Harlequin Lake is vegetated with low willows and alder on the southeast side. Wind shear affects the vegetation forms on the southeastern side of the lake. Strong North winds, draining off the Yakutat Glacier, deform the vegetation, but where low hillocks provide some shelter, taller spruce and cottonwood are found. However, sites exposed directly to the north wind are covered only with 5-10 cm low meadows (e.g., dwarf willows *(Salix sp.)*. There are also distinct microclimatic effects around Harlequin Lake. Skim ice is formed on Harlequin Lake even in late June.

Narrow gravel beaches border the lake on the southeast side. The south side of Harlequin Lake rises gradually and then declines to the south along the Dangerous River. Brushy willow and alder vegetate this shoreline. Bays and coves indent the west shore of the lake. The west side of Harlequin Lake has black cottonwood trees up to ten meters high, with smaller emergent spruces. In the lee of a low ridge on the NW side of the lake, a younger spruce forest is found. The spruces become larger farther away from the lake. Southwest of Harlequin Lake in the Upper Italio region there is a large stand of old-growth spruce forest. Along the base of the mountains west of Harlequin Lake i.e., in the upper Ahrnklin area, the terrain is more open, with muskegs mixed with forest. Small ponds with emergent vegetation are located immediately WNW of Harlequin Lake.

Migratory waterfowl, Sandhill Cranes, and significant concentrations of ptarmigan (in late Fall and Winter) are found in the Harlequin Lake - upper Dangerous area. The lake itself is a moulting area in late June and July for nonbreeding Canada Geese. Mew Gulls and Arctic Terns nest on the gravel bars of the lake. Bank Swallows form colonies on 2-15 meter gravel banks above a clear stream (Harlequin Lake Inlet #1) feeding into Harlequin Lake, 1 km from the west side of the Glacier. Salmon spawn in the streams on either side of the north end of the lake. The stream located in a small canyon to the east of the Yakutat Glacier (Harlequin Lake Inlet #2) has many spawned-out salmon during the Autumn. Harlequin Ducks feed on salmon eggs in these streams. The lower portions of the valley above this canyon are quite sparsely vegetated, but alpine meadows are found above the higher talus slopes and between hanging glaciers. The hillsides below the alpine are covered with alders, willows and black cottonwood, with emergent spruces. Mountain goats *(Oreamnos* *americanus)* and black bears *(Ursus americanus)* were observed in this habitat during late Summer and Fall aerial surveys. In the Spring, black bears are found along the shores of Harlequin Lake. In Winter, Harlequin Lake is frozen and barren.

Dangerous River

The Dangerous River drains Harlequin Lake and is the largest river west of the Alsek on the Yakutat Forelands. In general, the Dangerous River is considerably wider and swifter than the Situk River, but the Dangerous does not carry the same volume of water as the Alsek River. Willows, alders, and cottonwoods line the riverbanks and partially cover the adjoining lowlands. Emergent spruces (to 8 m) grow along the upper part of the river near Harlequin Lake. The river flows through a series of high (25 m) cutbanks in the initial few kilometers and is confined to a single, swiftly flowing current. The water is turbid and carries ice floes from the breakup of large icebergs on the south shore of Harlequin Lake. Approximately half-way down the river, 8 km from Harlequin Lake, the river expands into a maze of smaller channels, gravel bars, and backwater sloughs. Small boat navigation on the Dangerous River is treacherous and difficult because of strong currents, brush piles, drift logs and snags. The Dangerous River resembles the Alsek River in many aspects, i.e., it is turbid, swift-flowing, with shifting gravel bars. The main channel can be quite difficult to find after the initial 5-8 km.

The early successional flowering plant species known as River beauty *(Epilobium latifolium)* grows on these gravel bars. Arctic Terns and Mew Gulls breed on the gravel bars, and Canada Geese are commonly observed along the river in Spring, Summer and Fall. The former channels of the Dangerous River form a vegetated floodplain, frequently reworked by the ever-changing currents. The surrounding scrub deciduous forest is early successional, inhabited by brown bear *(Ursus arctos)* and moose (*Alces alces)*. Many small backwater sloughs provide calm water for resting waterfowl. Limited areas of fresh-water marshes (8 hectares; ca. 20 acres) in the lower reaches of the river provide foraging habitat for teal and pintail ducks.

The water temperature of the river remains just above freezing throughout the Summer. The mean water depth of the river in the flood-plain is approximately 1.8 m, with many shallower areas and sloughs. Near the lower reaches of the river, occasional black cottonwood reach 15 m, and provide resting sites for hundreds of Bald Eagles in late Winter (Table 9). The width of the Dangerous River varies considerably. Where the river drains Harlequin Lake, it is approximately 50-60 meters wide; halfway to the ocean it is approximately 1½ km wide, including variegated channels and backwaters. In other sections the river may be 200-300 meters wide. Numerous Bank Swallow colonies are found along the edge of the Dangerous River. Ice floes which drift down the Dangerous River in the strong current usually become grounded and melt before they have gone four kilometers from Harlequin Lake.

Some coho salmon run up the Dangerous River to spawn in clear streams near the river and adjoining Harlequin Lake, but for the following reasons the river is not fished commercially. Ice floes, strong current, low water temperature, and log jams make the Dangerous River hazardous for small boat navigation and fishermen avoid the river.

Dangerous River Estuary

The Dangerous River estuary consists of barren, wave-washed sand-flats. The Dangerous River estuary is bordered by the Situk-Ahrnklin Flats to the west, and by the Italio River to the east. The entire area at the mouth of the Dangerous River is apparently washed by ocean storms at certain times of the year. Vegetation begins 1-2 km inland from the ocean. The area southeast of the mouth of the Dangerous is also wave-washed. North of the junction of the Old Italio slough with the Dangerous estuary, the shoreline is boggy. There has been little recent uplift in this area and the forest habitat does not approach the shore.

The windswept expanse of mud- and sandflats reaches its greatest extent on the southwest side of the Dangerous River (approximately 30 km^2) where the Dangerous River flows into the Gulf of Alaska. On the ocean side, low dunes are partially vegetated with *Elymus*. Extreme Fall and Winter stormtides deposit drift logs over these sand and mudflats. This estuary is exposed to the elements, and is flooded at various times by the river, by ocean tides and tidal backup. On the landward side of this expanse, high marshes (storm-tide influenced, with drift logs) merge into progressively denser alders, succeeded by black cottonwood, willows, and muskegs. The aspect of the entire lower Dangerous region is one of very shallow slope. There is more relief to the outer ocean dunes than where the Dangerous River emerges from the scrub forest to the estuary. Horseshoe Island is the only forested island at the mouth of the Dangerous near the beginning of the estuary. This island vegetated with large black cottonwood trees, alder and willows. Bank erosion is rapid on the southwest side of the island.

The Dangerous River estuary is frozen in Winter, but in late February 1981, at least 500 Bald Eagles were attracted to eulachon (small anadromous fish), which were running in schools through narrow leads in the otherwise frozen estuary to spawn in clear streams off the river. Hundreds of eagles rested on the ice, on the large black cottonwood trees of Horseshoe Island or along the lower reaches of the Dangerous River (Figs. 13, 14).

East of the Dangerous River

The land east of the Dangerous River rises slowly to the north before declining to Harlequin Lake. Spruces are common towards Harlequin Lake on higher ground, interspersed with open willow flats. In the lower Dangerous region, more mature black cottonwoods are found (see above). Willows are common in the flats along the lower Dangerous River. Low wet meadows separate "islands" of mature stands of black cottonwood. These "islands", located on higher ground, are perhaps former riverbanks.

Southeast of the Dangerous River, willow thickets, willows with scattered cottonwoods, and emergent spruce surround the open lowlands. The lowlands are made up of horsetails *(Equisetum)*, gravel areas with grasses, marshy locations with *Carex*, small temporary ponds, and drier muskegs with heather *(Phyllodoce aleutica)*. These low open areas are covered with standing or slowly flowing water during times of heavy rainfall, especially during Autumn storms. However, the porous nature of the gravel substrate quickly drains the water once rainfall has ceased. The willow shrublands, (1-3 m tall) are marked by emergent black cottonwood and spruce (3-10 m), indicating transient successional stages. Alder is relatively absent, suggesting hydrological influences.

A series of interconnected old river courses, former channels of the Dangerous River, carry water during times of peak rainfall (i.e., during the autumn storms). These former channels form a mosaic with the bogs on either sides of the river. The typical vegetation in these old river courses is dwarf willows; otherwise, they are poorly vegetated. These former channels are bordered by the scrub forest. The scrub forest, old river channels, and muskegs form a variegated pattern parallel to the main course of the Dangerous River. The Dangerous River has apparently moved back and forth over the passage of time, accounting for the lack of old-growth spruce forest in the area. The extant forest stages are of various ages. The former watercourses determine the area of distribution of the forest. These former watercourses are particularly evident between the Dangerous and Italio Rivers, and were probably recent post-glacial drainages of Harlequin Lake and the Yakutat Glacier.

Italio Lake, and the Italio River

Italio Lake is a 15 acre lake surrounded by old-growth spruce forest. Italio Lake is located in the foothills of the Brabazon Range, approximately 14 kilometers from salt water. On the NE side of the lake, with a sharp gain in elevation, the forest changes rapidly to alder-covered hillsides. Italio Lake has increased in level within historically recent times: many tree stumps are now below the waterline of the lake. The East Fork of the Italio River is approximately 10 m wide and ½ to 2 m deep where it drains Italio Lake. The Italio is clear-running, with a margin of willows and alders. The current is moderate. Open areas along the streambank are densely vegetated with salmonberry. Old-growth spruces (to 30 m) surround the upper reaches of the Italio River. The understory in the old-growth forest is typically devil's club *(Echinopanax)* growing out of moss. South of the junction of the main course of the Italio with the East Fork, the old-growth spruce forest changes to black cottonwood and pitch-pole size spruce. The cottonwood is associated with alders along stream banks. Younger spruces form the understory in older cottonwood stands, which reach to 20 meters height. Several kilometers below

Italio Lake, the East Fork of the river descends over a series of shallow falls.

The lower Italio region supports variegated old-growth cottonwood and younger spruce forests. Smaller cottonwood trees colonize newly exposed gravel bars created by changes in the course of the river. Beaver *(Castor canadensis)*, moose *(Alces alces)*, brown bear *(Ursus arctos)* and river otter *(Lutra canadensis)* are common along the Italio. The entire Italio river and lake system supports a sizable salmon run. Several kilometers inland from the ocean, the forest diminishes in size and brush increases. Very high dunes (to 50 meters), with alders, separate the river from the ocean beach. The Italio here turns to the west from its southerly course, and parallels the beach for approximately 5 kilometers before turning abruptly SE and entering the Gulf of Alaska about six kilometers east of where it is shown on the USGS maps (the most recent series are 1959 issue).

Italio River Estuary

The Italio estuary is bordered by sandflats and dunes. The estuary extends from dense alder stands, alder hummocks, to sandflats which merge into low dunes at the ocean shore. These flats are less continuous than those of the Dangerous River estuary, and are smaller, forming an expanse approximately 10 km^2. The Italio River at the mouth is approximately 25 m wide. East of the mouth of the Italio, the dunes increase to 15 m elevation, with drift logs, *Elymus*, and beach sandwort *(Honckenya peploides)*. Low dunes extend WNW between the mouth of the Italio and the Dangerous River, and support nesting Mew Gulls, Arctic Terns, Aleutian Terns, and Parasitic Jaegers (Fig. 7). The nests of these species are widely scattered among old drift logs with sparse vegetation. In comparison to the area between the Italio and the Akwe River, immediately to the southeast, there is little slope to the ocean beach.

The low dunes between the mouth of the Dangerous River and the present Italio River are bisected by the Old Italio slough, which forms a clear channel 0.5 km north of and parallel to the beach, now west of the present Italio River. The entire area between the mouth of the Dangerous and the Old Italio is exposed to ocean storms. There is little vegetation. The Old Italio is fed by surface runoff and tides, and expands into an extensive area of brackish shallow water following heavy rains. The mouth of the Old Italio (located SW of Horseshoe Island) is larger and deeper than the entrance to the present Italio. This tidal slough parallels the beach southeast towards the present Italio and gradually becomes shallower and more marshy. The Old Italio slough then forms a brackish marsh, with short grasses and drift logs, and occasional patches of submerged aquatic vegetation. There is no present connection between this former channel of the Italio and the main branch of the river. This estuary resembles the lower reaches of the East Alsek. It is a good area for waterfowl during migration.

The lower Italio river and estuary supports an important eulachon *(Thaleicthys pacificus)* ("hooligan") run during the late Winter and Spring (at intervals between late February and early June) (Fig. 14). These fish attract tens of thousands of birds, including gulls, kittiwakes and Bald Eagles, in very large concentrations near the river. In Summer and Autumn, thousands of shorebirds are found in the Old Italio slough, and hundreds of ducks and geese forage in the upper tidal marshes. Wolf *(Canis lupus)* sign is abundant on dunes in Italio estuary, and moose *(Alces alces)* are common in the adjacent scrub forest.

Lower Akwe River

Seaward dunes build abruptly southeast of the new mouth of the Italio River. The dune line is initially 20 m high. The 1958 earthquake raised the dunes between the mouth of the Italio and the Akwe, the next river to the east. According to local fishermen, the area between the Italio and the Akwe was formerly quite flat (Mortensen, pers. comm.). Immediately west of the mouth of the Akwe, the dunes are approximately 45-60 meters high. Young spruce forest approaches within 500 meters of the ocean shore inland of the high dunes between the Akwe and the Italio Rivers. The beach rye *(Elymus)* zone on the ocean side of these dunes is distinct, reflecting a rapid rise in elevation. Southeast of the mouth of the Akwe, the dunes become lower, forming a broad, low sandy beach with drift logs marking the limit of winter storm tides. The dunes on the ocean side of the Akwe River are approximately 200 meters wide.

The vegetation on the seaward side of the Akwe is well-developed; and is principally beach rye *(Elymus)* with scattered elderberry bushes *(Sambucus racemosa)*.

Near the mouth of the Akwe, the spruce forest approaches the shoreline for the first time southeast of the Lost River. Bluffs approximately 30 m high are located on the north side of the lower Akwe River. The bluffs are densely vegetated with spruce of medium age. Bank erosion hinders the formation of alders at the edge of this forest.

The Akwe runs parallel to the beach for approximately 12 kilometers. The lower reaches of the Akwe are clear, and slow flowing. The river flows over sandy substrate with submerged aquatic vegetation (SAV). The Akwe becomes shallow and forms a series of sloughs where the river turns inland and flows north. There is much submerged and emergent aquatic vegetation in these sloughs. As the Akwe turns north, the slope of the outer dunes is shallow and spruce forest once again approaches within several hundred meters of the dune crests. The *Elymus* zone becomes less distinct.

The Akwe is a commercial fishing stream. Along the lower Akwe, there are several camps in which commercial fishermen and their families spend the Spring and Summer months. The largest of these facilities, a collection of 6-7 buildings (Mortensen's camp), is located near the emergence of the lower Akwe from the spruce forest to the estuary.

The lower Akwe is an important wildlife area, for brown bear, moose, wolf *(Canis lupus)*, coyote *(Canis latrans)* and many water birds. Gulls and terns feed at the mouth of the river and terns nest among the drift logs in the upper beachmeadow. Gulls and eagles are found along the marine beaches near the entire lower Akwe River. Over 11,000 gulls fed on eulachon along the Akwe River on April 3, 1981. In Spring, waterfowl use of the sloughs and small embayments where the river turns inland is extremely heavy (470 Trumpeter Swans observed on April 3, 1981) (Fig. 9).

The consistent observations of large numbers of Bald Eagles along the Akwe are of special note. The Akwe is indeed a highly important eagle feeding and resting area. This is especially true during the late Winter and Spring eulachon runs. During the summer, 20-30 eagles rest along the dunes separating the Akwe River and the coast, and forage on carcasses of dead marine mammals found along the outer beaches. However, at least 660 Bald Eagles were counted along a few kilometers of the lower Akwe River (especially upstream from Mortensen's camp) on February 25, 1981. This concentration of eagles was apparently associated with an intensive eulachon spawning site (Figs. 13, 14).

It should be emphasized that the eulachon runs are the most important determinants, in late Winter and Spring, other than migration, for the distribution of birds in the Yakutat area. Large concentrations of gulls, terns, kittiwakes and eagles are found at the mouths of rivers such as the Akwe during the eulachon runs. In general, most bird concentrations along the outer sandy beaches of the Yakutat Forelands are found near the mouths of the rivers, except during the early Winter months. The total of over 1500 Bald Eagles observed on the Yakutat Forelands between the Dangerous River and Cape Fairweather on February 24-25, 1981, is one of the largest wintering concentrations of Bald Eagles reported in the United States. This winter eagle concentration is possibly second only to the Haines-Chilkat district, which is located ENE approximately 175 km up the Alsek and Tatshenshini River valleys. There may be late winter movement of eagles from the Haines-Chilkat district to the Yakutat Forelands.

The Old Ustay Area

The nearshore land area between the upper Akwe estuary and the mouth of the Alsek River at Dry Bay is made up of 300 meters of upper beach-meadow, succeeded by emergent spruce forest, followed by older spruce forest. Zonation is distinct. Southeast of the Akwe River, a former mouth of the Ustay River is known as the Old Ustay. The Old Ustay forms a clear slough from surface run-off. The Ustay now flows into the Akwe. Both the Akwe and Ustay flow from glacial lakes and are turbid in their upper reaches. These drainages receive much surface runoff so that the streams are nearly clear near their mouths.

The Old Ustay at times of less rainfall does not flow into the Gulf of Alaska. The drainage of the Ustay was formerly much larger, and was made up of small ponds and stream courses lined with willows and alders. Between the Old Ustay and Dry Bay the outer dunes increase in size and are densely vegetated with *Elymus*. Immediately inland of these dunes is a dry slough with sparse sedges *(Carex)*. North of this dry slough, young spruces on a former dune merge into an older spruce forest. Scattered drift logs lie on the outer dunes and the adjacent slough. Near Dry Bay, black cottonwood and muskeg predominate, the spruce forest diminishes, and drift logs are closer to the forest edge, suggesting that the area is wave-washed, at least under certain conditions (extreme Fall and Winter storms).

The Alsek River at Dry Bay

Dry Bay is located 75 km SE of Yakutat. It is the delta of the Alsek River. The Alsek River rises in the Yukon, but also partially drains the Fairweather Range. It has carved one of the major breaks through the range of high mountains which separates the coastal and interior environments of the Pacific Northwest. Dry Bay is an ecotone between marine, North Gulf Coast and boreal interior environments (Fig. 5).

The river level at Dry Bay changes dramatically in response to rainfall and snowmelt. In some years, late Summer high water stages wash completely over the gravel islands (Mork, pers. comm.). In Fall and Winter, powerful southeast storms cover the delta with heavy rains or snow. Winter winds with velocities greater than 160 kph drive waves over 20 m in height onto the outer beaches at Dry Bay, occasionally inundating the delta with salt water.

Dry Bay is a geologically active, earthquake-prone area. It apparently was not glaciated during Pleistocene times, but may have been the location of catastrophic flooding within the last 1,000 years from the melting of glaciers which impounded the Alsek River and formed a large lake in the interior Yukon (Brogle, pers. comm.). A minor earthquake caused the mouth of the Alsek River to shift 1 km to the west in 1975 (*Alaska Geographic*, 1975). The gravel islands of the Alsek River Delta at Dry Bay are also subject to considerable repositioning because of frequent changes in the course of the river. Vegetation on the gravel bars is a sparse mixture of alluvial and maritime forms, dominated by red fescue *(Festuca rubra)* and river beauty *(Epilobium latifolium)*, but also includes beach rye *(Elymus arenarius var. mollis)*.

The sea is discolored by the outwash of the Alsek River several kilometers from the shore. The ceiling at the mouth of the Alsek River is often low and visibility obscured by clouds and fog. There are salt marshes immediately NW of the mouth of the Alsek River, landward of the dunes with emergent spruces. The band of salt marshes extends for several hundred meters inland. On the west side of Dry Bay clear streams flow through grassy sloughs with mud bottoms near occasional black cottonwood and alder stands. The most important of these streams is known as Muddy Creek.

Dry Bay is silting up rapidly, especially since the early days of this century. Then, ocean-going ships could enter the mouth of the Alsek River. The Alsek was composed of three major channels at that time, (Moser, 1901) but now consists of one major channel. The lower reaches of the Alsek, exposed at low water, are composed of sandy substrate. The Alsek normally rises from low water during the Spring, increases through the Summer, and reaches flood stages in July, and then declines appreciably by late August. However, the river experiences both major increases and decreases in water flow during a single season. Interior sunshine, i.e., glacier and snowmelt, controls the river flow, not coastal rainfall. Advances and retreats of glaciers also divert the river flow.

The Alsek River delta is a highly important area for bird concentrations during the Spring. Dry Bay is important as a staging area during Spring migration and as an intensive feeding site during eulachon runs. The eulachon runs fortuitously correspond to aspects of the Spring bird migration. Thousands of seaducks, loons, cormorants, and gulls forage near the mouth of the Alsek River in the spring. Extensive gravel areas in lower Dry Bay, exposed during Spring low water periods, provide resting areas for thousands of gulls, terns, and kittiwakes. Additional thousands of mergansers and other waterfowl are found in Dry Bay during the Spring. Phalaropes and sandpipers feed along the river and adjacent sloughs.

Spring bird populations are concentrated in lower Dry Bay on a variegated pattern of vegetated and non-vegetated gravel bars. The nesting activities of the birds are concentrated on the vegetated parts of the gravel bars, where some elevation allows plant colonization. These gravel flats are open to ground predators during Spring low water periods and predator access may be important to avian breeding success at Dry Bay. A gull colony (700 pairs of Glaucous-winged Gulls, Herring Gulls, and hybrids) is located 5-7 km upriver from the mouth of the Alsek River in a rapidly changing, mixed alluvial-maritime habitat. Water surrounding the gull colony is fresh, although silty, and carries ice floes from the Alsek Glacier, 28 km upstream. Arctic and Aleutian Terns nest further upstream on the gravel bars with low vegetation and drift logs. Fifty to several hundred pairs of Aleutian Terns nest on the highest parts of the shoreline. Arctic Terns and Glaucous-winged x Herring Gull hybrids nest inshore from the main river (Fig. 7). Mew Gulls and Canada Geese also nest on these gravel bars. The presence of Herring Gulls and Double-crested Comorants at Dry Bay is representative of the influence of boreal interior environments.

The Alsek River, which flows from the interior Yukon, serves as a migration corridor of birds moving into the interior. The Alsek is a "short cut" to the MacKenzie Delta and points east in the Canadian Arctic, as well as to boreal interior environments. Thousands of Thayer's Gulls, Herring Gulls, Parasitic Jaegers and perhaps Northern Phalaropes move up this river valley in the Spring after staging on the Alsek delta at Dry Bay (Fig. 5).

However, there are marked differences in seasonal use of coastal habitat by birds in the Yakutat area. Very little bird life was present in late Summer after the avian breeding season, either on the outer beaches or at the river mouths such as the Alsek. There are comparatively few birds at Dry Bay during Autumn migration. Instead, the Situk-Ahrnklin Flats and the East River and Doame estuaries receive most use by migrating birds in the Fall.

Unnatural Concentrations of Food Supplies at the Alsek River at Dry Bay: Response to Artificial Food

Response to artificial food supplies is a major feature of the biota of the Alsek River at Dry Bay southeast of Yakutat. Unnatural concentrations of food supplies (salmon heads, gills, and entrails) which are processed by the ton and discarded on land near commercial salmon processing operations during the Summer attract unusually high concentrations of both terrestrial and avian animal species. The availability of this food source is sporadic, however, and is determined by the opening and closing of commercial salmon fishing operations on a weekly and daily basis. Thus, most of these animals must still maintain some use of natural food sources. During slack times at salmon processing facilities, the number of individuals of a given scavenging species decreases at the 'gut pile'. Presumably, the others move elsewhere to feed. The unnatural congregations of animals around a bacteria-ridden unnatural food source sets up conditions for the transmission of a variety of animal diseases. These include rabies, scabies, tularemia, and parasites in general.

TABLE 34

Animal Species Involved in Response to Artificial Food - Dry Bay

Birds	Mammals
Bald Eagles	Brown Bears
Herring Gulls	Wolves
Glaucous-winged Gulls	Coyotes
Mew Gulls	
Ravens	
Common (American) Crow	
Perhaps Magpies and others	

As many as eight (8) individual brown bears *(Ursus arctos)*, some of them quite large, have been observed at the "gut pile". Because of female-young ties (relationships) of brown bears, and the learning process which accompanies these ties, generation after generation of brown bears may become garbage-fed and accustomed to artificial food concentrations. It is entirely possible that brown bear reproductive success is being enhanced, as well as that of gulls, ravens, and other species. Thus, in the future, it is possible that more bears (as well as other species of scavengers) will be present at this site (Mace, pers. comm.).

In the past, brown bears have been dispatched after becoming accustomed to this food source and associated human presence (Ball, ADF&G, pers. comm.). These bears lost their natural caution of human beings and then approached the processing plant during daylight hours, posing a threat of injury to people and damage to equipment. Brown bears still approach the fish processing plant during late Summer nights, attracted by the scent of fish and garbage, and overturn barrels of fish offal.

Fishermen and other observers have noted more gulls feeding on discarded salmon during the nesting season. The gulls feed their young on these salmon parts--an artificial food source. Fledging (reproductive) success is undoubtedly enhanced by access to this food supply. Recently fledged (immature) Glaucous-winged and Mew Gulls feed on the effluent from the fish processing plant where blood and milt sacks are pumped into the Alsek River. Movement of color-marked gulls has been observed from discarded salmon piles at Dry Bay to the mouth of the East River, where the gulls rest on the ocean beaches. Gulls also feed opportunistically from set gill nets at low tide along the East River.

In the Dry Bay - East River area, mobile concentrations of scavenging birds, ravens, gulls and eagles, move from "hot spot" to "hot spot", feeding on flounders, dolly varden, and discarded non-commercial salmon (i.e., humpback salmon) removed from fishermen's nets. These observations were made at a particular locality as part of larger survey, but the implications are general in nature and widespread in scope.

Bear Island

Bear Island (75 m elevation) is not now an island. It is a solitary low ridge, approximately 2.5 km x 2.0 km, oriented NE-SW, approximately eight kilometers east of the present main channel of the Alsek River at Dry Bay (Fig. 1). Bear Island is the most prominent geographical feature rising above the Yakutat Forelands south of the Brabazon Range. Around 1900, (Moser, 1901) Bear Island was indeed an island, but is now an isolated landlocked outcropping. There were formerly three channels of the Alsek River. Now the heaviest flow is through the main Alsek and the East (Alsek) River, which is no longer connected to the main Alsek. The third (central) channel of the Alsek River apparently flowed immediately west of Bear Island, but this channel presently consists of a series of intermittent sloughs, surrounded by dense vegetation of alders and willows.

Several rock outcroppings are exposed on Bear Island but these are by no means a dominant feature of the former island. There is some soil development (a very fine silty loam), with much vegetative forest litter. Sitka spruce *(Picea sitchensis)* is remarkably absent from Bear Island. Bear Island has evidently existed longer than the surrounding cottonwood/alder/willow flats, judging from the extremely large size and apparent age of isolated overmature black cottonwood trees *(Populus balsamifera subsp. trichocarpa)*.

Two major plant species dominate the understory over much of the island: alder *(Alnus crispa)* and devil's club *(Echinoplanax horridum)*. East of the former island, extending to the East (Alsek) River, are open stands of young black cottonwood (< 10 m), willows, and some alder. Immediately west and south of the former island are hydrologically active *Alnus* and rush-dominated seep complexes. These thickets are extremely dense and provide shelter for brown bears *(Ursus arctos)*.

Vegetative foods preferred by brown bears are abundant on the island and in adjacent sloughs, i.e., cranberries *(Viburnum edule)*, umbells *(Angelica spp.)*, sweet cicely *(Osmorhiza spp.)*, and cow parsnip *(Heracleum lanatum)*. Moose sign was observed near the island along neighboring sloughs.

The following is by no means a complete plant species list for Bear Island, but these are the apparent dominants:

Black cottonwood *(Populus balsamifera)* (1.5-2 m DBH): very scattered and quite large. No Sitka spruce *(Picea sitchensis)* regeneration was observed.

Sitka alder *(Alnus crispa)*: maintains a nearly continuous canopy at the 2.5-3 m level; very robust. Associated clearly with the *Alnus* is Devil's club *(Echinoplanax horridum)*, also quite large size.

Willows *(Salix spp.)*: are well represented only on the island fringes, not on the island itself.

Cranberries *(Viburnum edule)* are also well represented on the island fringe areas, and in some cases form nearly impenetrable shrub fields. Other species include:

The umbell *(Angelica lucida)*
Hemlock parsley *(Conioselinum chinense)*
Sweet cicely *(Osmorhiza spp.)*
Wintergreen *(Pyrola secunda)*
Elderberry *(Sambucus racemosa)*
Lupines *(Lupinus nootkatensis)*

East River Sandflats

The East River sandflats are located between the southeast corner of Dry Bay and the mouth of the East (Alsek) River. These sandflats have scattered willows and alders on their northern (upper) margins. Partially buried drift logs lie scattered over the entire area. The substrate consists of gravel and sand deposited by the shifting winds. Mobile dune formations are located adjacent to the marine beaches. There is little vegetation other than scattered clumps of beach rye *(Elymus)* in a 2 km zone seaward of the alder scrub. The substrate of the sandflats can be compared to the gravel and silty substrate of Dry Bay proper. The East River sandflats are wind-swept from several directions and occassionally washed by waves in Winter. Storm tides occur during intense low pressure systems, which approach from the southeast with high winds. These storm tides occasionally bring drift logs 2 km inland from marine beaches. Further, Winter high pressure cells create a pressure gradient from interior Yukon to the Gulf of Alaska, bringing extremely high winds from the north ("drainage winds") and intense sand scour of all features, in effect, sandblasting the area (cf. "Sandstorm", *Alaska Magazine*, October 1980). No vegetation grows under these conditions of unstabilized substrate. However, near the mouth of the East River, drift logs aid dune formation and provide some shelter for resistant *Elymus* grasses. The East River Sandflats are an Arctic Tern (Aleutian Tern ?) nesting area in May and June (Fig. 7). Fishermen report dogs molest tern nests and devour eggs and young.

East (Alsek) River

The Alsek River in 1900 had three main channels (Moser, 1901). In 1934, a gravel bar built up at the entrance to the most easterly channel of the Alsek River, so that turbid water no longer flowed through this channel (Lowenstein, pers. comm.). Springs and surface runoff, however, caused this channel to continue to flow, albeit more slowly, with clear water. This former channel of the Alsek River, not now connected to the main stream, became known as the East (Alsek) River (Figs. 1, 4).

The East Alsek is shallow, with the deepest portions only several meters. The average depth is about 0.6 m; many areas are barely navigable by outboard motorboats. The river is approximately 50 to 100 m wide and consists of a series of oblong pools (ca. 0.5-1 km in length) which are 1-2 meters deep. The pools are interspersed with a series of shallow curves and riffles with a few cm of water. The larger pools are fairly constant in depth. There are no major changes in hydrology along the river, except for an occasional tidal-backup of fresh water during spring tides.

There is much submerged aquatic vegetation (SAV), of considerable importance as food for waterfowl, in the East Alsek River. The abundance of the SAV in the East Alsek River is a comparatively recent phenomenon. In 1958, an earthquake caused the channel of the East Alsek to shoal appreciably, with subsequent growth of emergent and submerged aquatic vegetation. In the slowly flowing pools, at least four species of aquatic plants form dense mats. These species are wigeon grass *(Ruppia spiralis)*, a filamentous algae, (cf. *Entermorpha sp.*), pondweed *(Potamogeton sp.)*, and water crowfoot *(Ranunculus trichophyllus)*. The bottom of the upper reaches of the East Alsek River is soft sand, mud and gravel, the SAV apparently preferring sandy bottom. The lower East Alsek has a sandy bottom. Three to four kilometers eastward from the mouth, the bottom turns to gravel and stone.

Many salmon spawning sites ("redds") are found on the gravel bottoms of the river. Salmon bones litter the streamside and river bottom. Heavy game trails are found on both sides of the river. These are principally brown bear paths, heavily used in late Summer and Autumn when the river is filled with spawning sockeye and chum salmon. Brown bear sign is abundant. Moose, coyotes, and wolves were also observed in the East Alsek area during the time of the study.

Dense alders and willows vegetate the streambanks of the East River. Ground cover along the banks is strawberry *(Fragaria)*, sorrel *(Rumex fenestratus)*, *Rhytidiadelphus* mosses, and ferns. Plant species diversity decreases away from the influence of the river. The vegetation is predominantly an open stand of black cottonwood away from the river. The willows decrease in occurrence, but are found in the cottonwood understory.

A large area of comparatively recent (post-1900 onward) seral forest stages, dominated by the cottonwood, is found between the Alsek and the East Alsek Rivers. This scrub deciduous forest physiographically resembles that of interior Alaska. The black cottonwood trees are widely spaced, forming relatively open stands 10 m in height. The forest understory is willows and alders, with mosses, grasses and forbs composing the ground cover. There is incipient spruce regeneration through the black cottonwood; with occasional ten meter spruces. This cottonwood forest, growing on old gravel bars of the Alsek River, will eventually proceed to a spruce-hemlock forest if not further disturbed, through a stage in which Sitka spruce will predominate. At present, the area between the East River and main Alsek at Dry Bay is covered with an open stand of riparian cottonwoods, except in the vicinity of Bear Island, where the vegetation is dense alders and willows. This is especially true immediately south and west of that former island along the previous central channel of the Alsek River.

Cottonwood and willow have greatly advanced between the Alsek and the East Alsek River in the last thirty years. Thirty years ago, the vegetation was low enough (scattered willows) to allow viewing of Bear Island all the way from the East River (Lowenstein, pers. comm.). This is no longer possible. In proximity to the East River, the cottonwood and willows grow closer and larger, suggesting hydrological influences.

As the East Alsek estuary is approached the ground becomes low and boggy, with dense willows and alders. These mixed deciduous shrublands become predominantly alders, and then change to open marshes with horsetails *(Equisetum)*, and drift logs, near the estuary. Occasional shallow ponds are found in these high marshes. The most important features near the estuary are small clear runoff streams, sedge *(Carex)* marshes, dense alders, tidal sandflats, and brown bears.

As the East River emerges from the cottonwoods, willows, and alders to the estuary, the water remains fresh (immediately above Lowenstein's East River Lodge). Both diving and puddle ducks, are especially numerous at this point apparently feeding on the abundant water crowfoot ("duckweed") *(Ranunculus trichophyllus)* (SAV). The East Alsek broadens to several hundred meters at the beginning of the estuary, and then flows west parallel to the beach for approximately six kilometers. Near the mouth, the river has little aquatic vegetation. Seaward of the East River estuary is a narrow strip of dunes, about 100 m wide, partially vegetated, with a shallow slope and little dune-building evident. Brown bears, wolves and coyotes traverse the barrier dunes and bird life is sparse.

East River - Doame Estuary

The East Alsek and the Doame River, the next stream to the southeast, share a common estuary. The 1958 earthquake caused the area surrounding the Doame River to uplift, with a subsequent decrease in river velocity. Fall and Winter storms caused a buildup of the outer sandbars at the mouth of the Doame River, and this stream then joined the East Alsek estuary by flowing in a southwesterly direction (Lowenstein, pers. comm.). The outer sandbars at the mouth of the Doame River have now coalesced into a single dune system extending from the mouth of the East River to Clear Creek, at the southeastern border of the Yakutat Forelands.

The East River - Doame Estuary is made up of a south-facing barrier beach, a lagoon system leading to the mouths of the clear rivers, open sand flats, drift logs, an *Elymus* zone, and grassy flats north of the extreme limit of high tides. Near the mouth of the East River, a tidal bowl with small rocks, sand and algae is inundated twice daily. Additional extensive shallow areas are covered by fresh water in this estuary during tidal back-up periods. This long, narrow estuary extends east-west parallel to the beach for approximately 16 kilometers. The estuary is approximately 1.2 km wide, and rises on the north to complex communities of salt-resistant and freshwater marsh plant species, willows, alders and black cottonwood, with emergent spruces on a shallow slope.

On the other side of the estuary the south-facing marine beaches, exposed to the Gulf of Alaska, rise within 50 meters to a 5-7 m dune line, with beach rye *(Elymus)*, beach pea *(Lathyrus)*, beach sandwort *(Honckenya)*, strawberries *(Fragaria)*, yarrow *(Achillea)* and drift logs. These dunes are washed by high waters during intense winter storms. The dunes slope to the north on their landward (lee) side within approximately 200 meters to the edge of the estuary. The estuary is bordered by the sedge *(Carex lyngbyaei)*, and consists of large areas of very shallow (mean approximately 1 meter deep), slowly flowing waters, with much submerged aquatic vegetation (cf. East (Alsek) River, pg. 102), with low islands of *(Carex)*, alders and willows. North of the estuary is dense coastal scrub. At the southeast end of the East River - Doame estuary, the coastal slope is again quite shallow. There is almost no dune formation, and the area appears wave-washed with extensive drift log deposition. There is no vegetation. The area also has the appearance of being swept by very strong winds.

Southeast of the Doame River the mountains approach the ocean on a diagonal from the NW, and spruce forest nears the coast at the southern terminus of the Yakutat Forelands. The East River - Doame estuary appears biologically much more productive than the area southeast of Clear Creek. Concentrations of birds in the East - Doame River estuary are much larger than those found in the Grand Plateau - Cape Fairweather area further southeast. Signs of human habitation, in the form of fish camps, cease east of the Doame River.

Avian Use of the East Alsek River and Estuary

Waterfowl (puddle ducks, wigeons, mallards, pintails and teal, as well as mergansers and Harlequin Ducks) are more common on the East Alsek River in late Summer and Autumn than in any other watercourse in the Yakutat region. The combination of abundant pondweed and spawning salmon along the upper reaches of the East Alsek creates excellent waterfowl habitat, supporting the densest concentrations of birds in the entire Yakutat Forelands. The East Alsek is far superior for waterfowl than the main Alsek during the Autumn because the water level of the East Alsek is relatively constant, allowing the formation of marshy areas and fostering the growth of submerged aquatic vegetation. The East Alsek is also clear-running, and visual feeding by waterbirds is possible.

In late Winter and Spring, the dense concentrations of feeding birds at the mouths of rivers such as the East Alsek are sporadic in occurrence; the distribution of the birds depends upon the eulachon runs. For instance, a total of over 6,700 gulls, terns and kittiwakes, with 14 Bald Eagles, fed on eulachon at the mouth of the East Alsek on a single day in early June 1980. Approximately 50% of this population was composed of immature gulls. The next day, with the eulachon apparently absent, bird numbers had decreased abruptly as 2,500 gulls rested on sand dunes near the mouth of the river. Migrating groups of waterfowl, such as over 1,000 Mallards, 300 Greater Scaup, and 187 Trumpeter Swans also rest in the East Alsek estuary in Spring (Fig. 9). Commercial fishermen report as many as 5,000 ducks in the East - Doame River estuary by late August, and aerial surveys indicate these observations are accurate at least to order of magnitude. Ducks are widely scattered over the estuary during August and September, feeding at low tide, and flying up the East River to roost for the night (Fig. 10).

The importance of the East Alsek in the Autumn is approached only by the Situk-Ahrnklin Flats. Larger numbers of particular species may occur on the Situk-Ahrnklin Flats, but there are more species of waterbirds and denser concentrations of birds in the East Alsek River and East - Doame River estuary. Ducks, swans and gulls and even occasional Double-crested Comorants crowd the small river in August and September. The bird density increases with the arrival of diving ducks and geese in the lower reaches of the river in October.

Major migrations of Canada Geese pass over the estuary in the Autumn. Some years these geese are reported as abundant on the grassy meadows near the black cottonwood stands along the river (Barnett, USFS, pers. comm.). Trumpeter Swans also feed along the East River in the Autumn, after breeding on small ponds in the Yakutat Forelands. In mid-October 1969, Whistling Swans used the East River in great numbers as a stopover. Lowenstein (pers. comm.) estimated a population of 20,000 swans in the area at that time. Also notable was the presence of 16 Eurasian Wigeon in open water of the East Alsek estuary on October 5, 1980, in a large mixed flock of 190 Greater Scaup, 28 Canvasback and 30 Redhead Ducks.

Plovers and sandpipers are found during Fall migration in the sand flats near the East Alsek estuary, usually near small surface run-off creeks. Raptors such as accipiters and small falcons pursue shorebirds over the East Alsek estuary. The border of the sandflats to the scrub forest serves as a migration corridor for these raptors. Considerable movement of passerines occurs at the end of the first week in September immediately before drainage winds from the interior. This suggests reverse migration down the Alsek corridor in the Fall. Ravens and magpies are abundant in Autumn along the East Alsek, feeding on dead salmon, but they are rarely seen in the Spring. Shorebirds also feed in marshy areas along the East River and along the gravel beaches near the river.

In summary, the East Alsek estuary and the East River proper are very important for waterfowl and other birds, perhaps the most important area in the Yakutat Forelands during the Autumn months.

Clear Creek and the Coastline South of the Grand Plateau Glacier to Cape Fairweather

The Yakutat Forelands cease southeast of the Doame River as the mountains near the coast. At Clear Creek are two microwave towers located on the last dunes of the Yakutat Forelands. These dunes are about 200 m wide, and are vegetated with *Elymus*. The microwave towers are used for navigation by Norwegian seismic vessels (cf. GECO ALPHA) during offshore oil exploration. A rocky point is located southeast of Clear Creek.

After that rocky point, the shoreline agains becomes sandy for approximately 30 km. The shoreline elevation increases quickly so that the *Elymus* zone, merging immediately into spruce forest is limited to a few meters.

The landforms change rapidly southeast of Clear Creek. The mountains approach the sea; lowland is almost non-existent. Black cottonwoods are found only along the streams. The coastline is typical of Southeastern Alaska. Sandy beaches diminish in width and the drift log zone is 10 to 20 meters wide. The sandy beach ends temporarily and the coastline becomes rocky at a intertidal point immediately SSW of the Grand Plateau Glacier. The large boulder intertidal is occasionally lashed by towering surf. A turbid lake is found at the base of the Grand Plateau Glacier 1 km inland from the ocean. A silty stream, flowing through a muskeg near the coast, drains the lake below the Grand Plateau Glacier. The surf is eroding the spruce forest near the shoreline southeast of the glacier.

A steeply sloping beach, with about 25 m of vegetated dunes backed by dense spruce forest, continues between Grand Plateau Glacier and Cape Fairweather. Brown bear sign is heavy on this outer beach. There is additional elevation immediately adjacent to the shoreline near Cape Fairweather. There are large boulders and eroding headlands at Cape Fairweather, but there are no cliffs. The drift log zone approaches the border of the spruce forest. Thus the land rises steeply at Cape Fairweather, but the shoreline remains heavily vegetated with spruce.

Bird concentrations are found at the mouths of the streams and short silty rivers of the Clear Creek - Cape Fairweather area in late Winter and Spring, especially during eulachon runs. Over 200 hundred Bald Eagles were observed at Clear Creek and at an unnamed stream at the base of Cape Fairweather on February 25, 1981 (Table 9) (Fig. 13). Shorebirds, gulls and eagles rest on the sandy beaches in Spring and Summer. Large aggregations of all three species of scoters are found up to several kilometers offshore during the Summer, but they are absent during the Winter. In general, compared to the estuaries of the Yakutat Forelands, bird life is less noticeable on the coastline between Clear Creek and Cape Fairweather. The number of Bald Eagles is of course exceptional.

Yakutat Bay Islands: Khaantak, Krutoi, Otmeloi, Kriwoi, Knight Island, Eleanor and Neeg Islands; the Shoreline to Point Latouche

The east side of Yakutat Bay is made up of a small archipelago: the Yakutat Bay islands. These are forested islands with many tidal inlets. The intertidal on the east side of Yakutat Bay is a mixture of rocky and sandy substrates. The rocky intertidal is vegetated with rockweed kelp *(Fucus)*, and extensive giant kelp *(Laminaria)* beds are found offshore. Other areas of shallow water and sandy bottom are vegetated with eelgrass *(Zostera marina)*, which may grow up to two meters in length.

The largest islands in Yakutat Bay are Khaantak and Knight Islands. The exposed southwest sides of these islands are open to the ocean surf. Knight Island is located north of Khaantak Island near the northeastern edge of Yakutat Bay (see below). Both islands are forested with Sitka spruce and alders. Khaantak Island is located across from the Yakutat Small Boat Harbor (Shipyard Cove). Khaantak is a relatively narrow island extending north and south. The intertidal on the southwest side of Khaantak is rocky above sandy beaches (Fig. 3).

The southeastern end of Khaantak Island borders Monti Bay with a sandy beach. Monti Bay forms the tidal Yakutat harbor. The southern tip of Khaantak Island is sandy and relatively sheltered, with drift logs along the high tide line. There is little wave action in a series of sheltered bays on the lee (east) side of the island and there are a few rocky bars. Small salt marshes are located above the high tide line. The north and south ends of Khaantak Island have important concentrations of scoters and seabirds, and with aggregations of other waterfowl found on the semi-enclosed lagoons on the lee side during the winter. Further north, the lee side of Khaantak is an mixture of rocky intertidal with *Fucus*, protected sandy beaches, and many small islands. Several small colonies of Arctic and Aleutian Terns are found on these islets. Narrow channels separate these islets. Harbor porpoises *(Phocoena phocoena)* are repeatedly sighted in these channels.

Three tern colonies have been located in the Yakutat Bay archipelago. An Arctic Tern colony (25 pairs) is found on an islet at the junction of Puget Cove and Johnstone Passage 2 km north of the small boat harbor. An

Aleutian Tern colony (30 pairs + 10 pairs Arctic Tern) is located on a small grassy islet in a lagoon 400 m SW of Dolgoi Island. A third colony is made up of approximately 40 pairs of Arctic Terns, with four pairs of Aleutian Terns, and is located on the periphery of Crab Island (off the NE side of Khaantak) (Fig. 7).

Up to 18 Great Blue Herons roost in large spruce trees immediately south of the dock in Shipyard Cove. Sawmill Cove is located on the east side of Yakutat Bay north of the Small Boat Harbor. Redfield Cove is the next cove north of Sawmill Cove. Redfield Cove has a protected rocky intertidal, succeeded by a band of alders above the beach, and then a spruce-hemlock forest typical of Southeastern Alaska. The intertidal rockweed kelp *(Fucus)* grows on stones between sandy areas. A reef projects about 200 meters from the northwest side of Redfield Cove.

Krutoi, Otmeloi, and Kriwoi Islands are arranged in a linear fashion along the east side of Yakutat Bay (Fig. 1). Krutoi Island is known locally as "Johnny's Island". The invertebrates on a reef at the lee (east) side of Krutoi attract Harlequin Ducks and scoters. Hundreds of Kittlitz's Murrelets and Marbled Murrelets forage between Khaantak and Kriwoi in June.

Another reef projects about 300 meters from the southwest side of Humpback Cove, which is the next cove north of Redfield Cove. Pink salmon spawn in Humpback Creek in August and September and attract gulls, eagles, and brown bears. There is a rock and sand intertidal on the east side of Humpback Cove. Humpback Cove becomes more rocky on the northwest side. The intertidal is composed of large rocks and sand, succeeded by spruce forest to the north.

Knight Island is relatively large and nearly circular, and Eleanor Island is smaller and nearby. Both islands lie at the foot of the mountains on the northeast side of Yakutat Bay. Neeg Island is tiny and lies between Knight Island and the mainland. The area east of Eleanor Island is known as Chicago Harbor. The spruce-hemlock forest near Chicago Harbor is dense and uniform, with abundant fresh water drainage from Mt. Tebenkoff, located immediately to the north. Harlequin Ducks and Arctic Terns feed at the mouth of the largest stream descending from Mt. Tebenkoff.

The waters west of Knight Island are shallow and rocky. A large outlying reef projects at least 500 meters from the SW end of Knight

Island. Stellar's sea lions *(Eumetopias jubatus)* frequent this reef. This reef also serves as an important bird foraging area, attracting hundreds of scoters, Double-crested and Pelagic Cormorants, gulls, Harlequin Ducks, murrelets and Pigeon Guillemots during Summer and Fall.

Yakutat Bay is bordered on the northeast by Logan Beach and on the north by Logan Bluffs. "Foul Ground" is found 2.5 km off the NW end of Knight Island near Logan Beach. Extensive giant kelp beds *(Laminaria)* parallel this submerged geological formation several hundred meters from Logan Beach. Important concentrations of loons and seaducks forage near these kelp beds during Spring, Summer and Fall.

As Yakutat Bay narrows into Disenchantment Bay, the water is 64 fathoms deep where Logan Bluffs approach Point Latouche. The shoreline near Point Latouche is exposed to heavy surf, and rises directly to alders and spruces without an intervening *Elymus* zone. Avalanche chutes funnel snowslides from the alpine to the intertidal. Thousands of presumably breeding Marbled Murrelets gather several hundred meters off Point Latouche in June. Hundreds of Arctic Terns feed beyond the boulder shoreline and the heavy breaking surf during the Summer.

Disenchantment Bay

The entire northern end of Disenchantment Bay is covered by the massive and spectacular Hubbard Glacier. Scenic values in Disenchantment Bay are spectacular and world class. Only a few hundred meters of strong tidal currents prevent the Hubbard Glacier from closing Russell Fiord to the southeast. In spring the constant thunder of falling ice is heard in the distance from the advancing Hubbard Glacier, interspersed with some huge roars. Hanging glaciers are formed on extremely steep slopes above alders, avalanche chutes, and scattered spruces on the west side of Disenchantment Bay, north of Bancas Point. One large glacier, the Turner Glacier, and two smaller icefields, the Haenke and Miller Glaciers, feed into the west side of Disenchantment Bay. Disenchantment Bay is often filled with pack ice and turbid water from these four glaciers. Gulls loaf on the pack ice which shifts constantly in both wind and tide. The front of the Hubbard Glacier in Disenchantment Bay is a feeding area for gulls, terns and jaegers. Four to five hundred harbor seals *(Phoca* *vitulina)* rest on the ice floes in front of the glacier during the summer. (Fig. 15).

No glaciers are found on the east side of Disenchantment Bay. The slopes above the shoreline are forested with alder and occasional spruce. Snow-fed streams of varying turbidity drain these slopes. The intertidal in Disenchantment Bay is extensive with rock and gravel substrates. Large cobbles form shingle beaches in Disenchantment Bay. Snow remains in the avalanche chutes until well into June.

Two small river valleys are found on the east side of Disenchantment Bay. Calahonda Creek forms a broad watershed, and Aquadulce (Indian) Creek supports scattered cottonwood trees. The entire Disenchantment Bay is cooler than the adjoining Yakutat Bay because of the proximity of large masses of ice. The valleys of Calahonda and Aquadulce Creeks resemble environments of the interior Yukon; the fjord area around Haenke Island resembles high arctic environments.

Haenke Island supports the largest seabird colony in the Yakutat Bay area. Access by boat to Haenke Island depends upon pack ice conditions during the particular day. Wind and tide determine the density of the pack ice. Rising tides may push the ice floes back from Haenke Island towards the Hubbard Glacier, but falling tides can be treacherous because of rapidly closing pack ice.

Haenke Island

Haenke Island, located in Disenchantment Bay, 50 km north of Yakutat, at the foot of the St. Elias Mountains (59° 58'N, 139° 32'W) is often completely surrounded by pack ice from the nearby Hubbard Glacier. The glacier which once filled Yakutat Bay has shown massive expansions and contractions in the last 1,000 years *(Alaska Geographic, 1975)*. Haenke Island (1.6 x 1.0 km) has little level ground, and is covered with brushy vegetation dominated by alders *(Alnus crispa)*. The intertidal at Haenke Island is rocky, with large boulders. Water surrounding the island is turbid with outwash from the Hubbard Glacier. The north side of the island, facing the Hubbard Glacier, gradually inclines upward to an elevation of 180 m, then drops precipitously, forming a south-facing cliff where 200 pairs of Glaucous-winged Gulls and 300 pairs of Black-legged Kittiwakes breed on a series of narrow terraces in June, July and

August. Vegetation on the terraces is composed of grass *(Hordeum brachyantherum)*, fireweed *(Epilobium angustifolium)*, elderberry *(Sambuscus racemosa)*, currents *(Ribes bracteosum)* and mosses such as *Rhytidiadelphus triquetrus*.

The east and northeast sides of Haenke Island have no breeding seabirds. Dense alder extends down to the shoreline. A few Sitka spruce and black cottonwood are found on the NE side of Haenke Island. Haenke Island is recently deglaciated, as indicated by the predominance of alders, but the exact date of deglaciation is not known.

An Arctic Tern colony (40 pairs) was found in June 1980 on the northwest side of Haenke Island, facing the Turner Glacier. The nests were located at the upper edge of a 10-15 meter cobble beach. *Elymus* patches and small areas of sand and driftwood marked the colony site.

No murres were observed on Haenke Island in 1980. A large sea cave (10 x 5 m) on the southwest side of Haenke Island could support such breeding seabirds, but none were found in 1980. There has been an apparent increase in the numbers of kittiwakes nesting on this island since 1974, the time of our last survey. A few Tufted Puffins breed in burrows on the cliff face, and Pigeon Guillemots breed in the rocks above the intertidal.

Russell and Nunatak Fiords

Russell Fiord extends approximately 50 km south and east from the Hubbard Glacier at the north end of Disenchantment Bay. Russell Fiord is three to four kilometers wide. Nunatak Fiord extends northeast from roughly the central portion of Russell Fiord. Russell and Nunatak Fiords formed a fresh water lake until approximately 100 years ago, when a retreat of the Hubbard Glacier from the upper reaches of Disenchantment Bay opened the entrance to Russell Fiord. At present, the Hubbard Glacier is apparently advancing again, as it has repeatedly in its geological past. The Hubbard Glacier threatened to advance over Osier Island in the spring of 1980 and once again create a freshwater lake out of Russell and Nunatak Fiords. However, the strong tidal currents between Osier Island and the front of the glacier cut away at the face of the ice, causing a net retreat of the glacier of somewhat over 100 meters during the Summer of 1980. The strong tidal currents, rapidly shifting pack ice, and the calving of massive icebergs in the immediate vicinity of Osier Island make this area precarious for small boat navigation. Approximately 100 pair of Arctic Terns nested on Osier Island in Summer 1980 (Fig. 7). The waters of Russell Fiord near the Hubbard Glacier are turbid with glacial outwash.

Russell Fiord has a distinctly interior environment at its northwestern end, and is biotically rather different from the nearby coastal spruce-hemlock forest. Extensive outwash moraines are found near the Variegated Glacier northeast of Osier Island. The moraines have dense alders and willows on the older deposits. Dense alders grow down to the shoreline. Further southeast along Russell Fiord, the trees are predominantly black cottonwood with willow-alder understory.

Drainage winds, created by winter high-pressure systems, are extremely powerful in this area, flowing downward from the mountains at over 200 kph. However, Russell Fiord is well protected from the prevailing southeasterly low pressure storms by the Yakutat Forelands. The black cottonwood trees extend about 125 m up the hillsides on either side of this fiord. More trees, including seral spruces, are found at the south end of Russell Fiord. The water in the south end of Russell Fiord is relatively clear. The south end of Russell Fiord supports important waterfowl concentrations in late Summer, Autumn and Winter.

Nunatak Bench, located on the north side of Russell Fiord west of Nunatak Fiord, has exceptionally thick alders and black cottonwoods. The alpine environment at the top of Nunatak Bench is accessible to humans only by climbing up dry creekbeds. The flat open area at the top of the bench is approximately 450 meters above sea level. Nunatak Fiord is very sparsely vegetated and is quite recently deglaciated. The peaks at the head of Nunatak Fiord are approximately 1,000 m and are abraided by montaine glaciers. Aerial surveys indicate little bird life in Nunatak Fiord, with the exception of a few grebes, loons and scoters during migration.

West Side of Yakutat Bay (Manby Side) and the Malaspina Forelands

The western shore of Yakutat Bay (the Manby side) from Point Manby to Blizhni Point is subjected to heavy surf conditions during southeast storms and to alongshore currents which cause migration of the shoreline and nearshore sandbars. Further, the February 29, 1979 earthquake decreased charted depths by as much as five to seven meters in Yakutat Bay and in an area adjacent to Schooner Beach from Point Manby to Kame Stream. Mariners should exercise extreme caution when navigating this area and throughout Yakutat Bay in general as the present magnitude of these rapidly occurring geological changes is not known. Boat landings at stream entrances on the Manby side should be made only with knowledge of local conditions and at high tide (NOS, Map # 16761).

Major features on the Manby Side of Yakutat Bay from NE to SW are Bancas Point, Grand Wash, Sudden Stream, Malaspina Lake, Schooner Beach, and Point Manby. Proceeding N-S on the Manby Side, the major watercourses with same order are: Esker Stream, Grand Wash River, Kwik Stream (feeds into the Grand Wash River), Sudden Stream, Kame Stream, Oscar Stream, and Manby Stream (Fig. 1)..

The Manby Side of Yakutat Bay supports the Malaspina Forelands which are basically the terminal moraines of the vast Malaspina Glacier, which is larger than the State of Rhode Island. The Malaspina Forelands are composed of barren outwash moraines, open meadows, lakes, and forest dominated by black cottonwood with occasional spruce. Slow-flowing streams meander through old moraines, creating sloughs behind shallow grey sand beaches. A mosaic of willows, alders, cottonwood and spruces, small ponds and streams provides excellent waterfowl and moose habitat. Typical vegetation forms are cow parsnip *(Heracleum)*, beach rye *(Elymus)*, beach pea *(Lathyrus)*, and spruces growing in a shallow soil on top of ice domes near the glacier (Fig. 3).

Southwest of Bancas Point there is a mixed spruce and black cottonwood forest on the mountain slopes. The spruce and black cottonwood grow down to the shoreline. Ice floes from the Hubbard and Turner Glaciers grind the intertidal. Meandering streams, sloughs, and open grassy areas are located in the forest above the intertidal. Further southwest, near

Esker Stream, there is mixed low vegetation adjacent to the shoreline, including herbaceous meadows above an *Elymus* zone, with small ponds and alders along gravel stream banks. Dry creek washes and tidal ponds above the gravel-sand beaches, are bordered by drift logs and large areas of supratidal meadows. The wave-washed areas on the exposed shorelines of the Manby side of Yakutat Bay are quite large, such as near Grand Wash and Kame Stream. Drumlins covered with spruce-cottonwood forest in the vicinity of Esker Stream are drained by creeks above the intertidal. The Esker Stream area is prime waterfowl habitat.

The Grand Wash region of the Malaspina Forelands is a large area of marshes mixed with slightly elevated areas of herbaceous meadows, black cottonwood, willows, alders, sloughs, and saltmarsh. The Grand Wash itself is 10 km long and approximately 5 km wide. Grand Wash is an abraided riverbed descending from the Malaspina Glacier. Brackish and freshwater marshes merge near the mouth of the Grand Wash River. The Grand Wash River resembles part of the Copper River Delta further northwest. Here the forest occurs in bands associated with higher ground. As the glacier retreated it left a series of drumlins or hummocks. In addition, larger vegetation grows on old dunes further built up by earthquakes and isostatic rebound.

A large unvegetated wave-washed gravel bar is exposed near the mouth of the Grand Wash River at low tide. The gravel bar extends for kilometers and forms a large bow shape in front of the rivermouth. The shoreline is building outward at the mouth of the Grand Wash River. Tidally influenced wetlands and mudflats with emergent vegetation are located at the mouth of the Grand Wash River. The mouth of the Grand Wash River is heavily used as a foraging and resting area by migrating shorebirds.

Sudden Stream has two branches which drain Malaspina Lake. Sudden Stream is bordered by a mosiac of dense willows, cottonwoods, scattered spruces, open marshy areas, muskegs, herbaceous meadows, and open sandy bars, i.e., prime wildlife habitat. Near Sudden Stream tremendous edge effects are created by the ongoing invasion of herbaceous meadows by alders and cottonwoods. Towards Yakutat Bay, upper beach meadows merge into windswept dunes close to Sudden Stream. The forelands between Malaspina Lake and the ocean are vegetated with black cottonwood, occasional spruces, and dense alder along slow-moving sloughs.

Malaspina Lake lies between Malaspina Glacier and the Gulf of Alaska. The shoreline on the north and west sides of Malaspina Lake is recently deglaciated and only partially covered with vegetation. There are large open areas with outwash from the glacier moraines. The scrub forest is not nearly as developed as in other areas of the Malaspina Forelands. The Malaspina Glacier is more weathered than the sheltered glaciers in Disenchantment Bay. The unobstructed southeast storms impact this glacier with full force. The terminus of the glacier is covered with gravel over ice. Mew Gulls nest on the outwash plain near the terminal moraines, and Glaucous-winged Gulls breed in Malaspina Lake on gravel islands near the glacier. Alders grow on top of gravel-covered ice at the glacier terminus. There is some soil formation over the ice. A small population of Canada Geese breeds among the islands at the northeast side of Malaspina Lake. Malaspina Lake has many small inlets and is filled with discolored glacial water. Red-throated Loons breed in the ponds on the southeast side of Malaspina Lake. There are exposed muddy areas on the northwest side of Malaspina Lake. In Autumn, these areas are covered with water after heavy rainfalls. Malaspina Lake is quite turbid, and has many small islands a few meters in diameter. Some of these islands, especially those on the northeast side, are covered with brushy willows, alders, and cottonwood.

The west-northwest side of the fresh water Malaspina Lake is a marine bird nesting area: in 1980, Mew Gulls, Arctic Terns and Glaucous-winged Gulls nested on the barren outwash plain, and on the series of small islands immediately adjacent to the outwash plain. Small clear tributaries of Malaspina Lake support sockeye runs (Robertson, pers. comm.). The slope on the south side of Malaspina Lake is relatively shallow. The south side of Malaspina Lake is bordered by a gravel beach, alders, a few black cottonwood, and sandy areas. Southwest of Malaspina Lake is a stand of relatively mature spruce forest with cottonwoods along the stream margins. Small clear ponds southwest of Malaspina Lake support nesting Mallards and Green-winged Teal, and foraging moose.

The Kame is the first stream southwest of Sudden Stream. South of the mouth of the Kame is a large, wave-washed barrier beach with drift logs. Herbaceous meadows are found above an *Elymus* zone near the beach. An old Japanese schooner, now buried in sand up to the deck, is the reason for the name "Schooner Beach." Old creek beds and small ponds with submerged aquatic vegetation support dabbling (puddle) ducks near Schooner Beach.

Southwest of Schooner Beach, approaching Osar Stream, larger, deeper lakes surrounded by mature spruce forest support diving ducks. There are additional freshwater ponds behind old dune lines now vegetated with spruce southwest of Schooner Beach.

The land north and west of Point Manby is covered with spruce forest. The spruce stand is relatively uniform without black cottonwood. Small lakes are found in the spruce forest north of Point Manby. Two pairs of Trumpeter Swans nested on these lakes in 1980. The spruce forest ceases abruptly at Manby Stream and further west muskegs begin. Manby Stream is fished commercially for coho and sockeye salmon during the Autumn (Robertson, pers. comm.).

Malaspina Forelands from Point Manby to Icy Bay

While not technically within the borders of the current study area, the Malaspina Forelands from Point Manby to Icy Bay form a single biogeographical province with the Manby Side of Yakutat Bay. For that reason, aircraft transects were continued from Point Manby to Icy Bay.

The beaches west of Point Manby are marked by wrecked barges, including those which carried railroad cars. The presence of railroad cars, rusting in disordered hulks some distance up the beach, testifies to the power of the exposed ocean surf west of Point Manby.

Alder Stream forms a large area of abraided channels west of Point Manby and east of the Sitkagi Bluffs. Air taxi operators frequently report brown bears and moose just east of the Sitkagi Bluffs. The Sitkagi Bluffs are composed of a large boulder intertidal (not gravel as elsewhere along the Malaspina Forelands) succeeded by a narrow band of *Elymus*, emergent alders, spruces and cottonwood. The land above the beach rises steeply to tree-covered moraines. Small, silty ponds are located immediately above the boulder intertidal and below the bluffs. Vegetation covers the end of the glacier at the crest of the bluffs. The bluffs rise within several hundred meters to about 125 m elevation. The bluffs are not abrupt, but are smoothly sloping. The forest on top of the glacial ice is scrubby because of limited soils.

The Sitkagi Bluffs attract a remarkable assemblage of birds and mammals. The Sitkagi Bluffs are an important feeding and loafing area for birds and mammals. At least 2,000 kittiwakes, Mew Gulls, Bonaparte's Gulls, and Glaucous-winged Gulls have been observed in proximity to the Sitkagi Bluffs. Three thousand scoters (all three species) have been observed several hundred meters offshore, and as many as 240 Stellar's sea lions *(Eumetopias jubatus)* have been reported resting on the large boulders at the foot of the Bluffs (Robertson, pers. comm.). Commercial fishermen place many crab pots offshore, and harbor porpoise *(Phocoena phocoena)* were observed here during aerial transects. Major fish and invertebrate populations must be located offshore from the Sitkagi Bluffs in order to support such concentrations of birds and mammals (Fig. 15).

Fountain Stream, located immediately west of the Sitkagi Bluffs, is also an important loafing and resting area for immature gulls and kittiwakes. As many as 1,000 immature kittiwakes have been observed at the mouth of this stream. In addition the Malaspina Forelands west of Fountain Stream are an important concentration area for waterfowl in the Autumn.

The area west of Fountain Stream is criss-crossed with big game trails. West of the Sitkagi Bluffs the seaward slope once again becomes very shallow, characterized by broad sandy beaches, mudflats, meandering rivers, and bands of spruce forest where the glacier has left higher deposits. Broad bands of *Elymus* and supratidal forb meadows above the beaches merge into young spruce forest.

Farther west, near the Yana and Yahtze Rivers, exposed marine beaches are formed by gravel on a shallow slope. Sparse dune vegetation grows landward of the beaches. Extensive marshy areas extend kilometers inland from the lower Yana and Yahtze Rivers. The Yahtze River parallels the beach for several kilometers. The forest begins several kilometers shoreward of the tidal marsh north of the Yahtze River. Large migrating of flocks of Canada Geese and Sandhill Cranes are consistently reported near the Yana and Yahtze Rivers. Moose are commonly observed near the Yana and Yahtze Rivers. Spawning runs of eulachon ("hooligan") in the Spring attract as many as 40 Bald Eagles to single gravel bars, a few hundred meters wide at the mouth of the Yahtze River.

Large black cottonwood stands with emergent spruces are found between the mouth of the Yahtze River and Icy Bay. Trumpeter Swans nest on small lakes, which typically have submerged aquatic vegetation, in the spruce-cottonwood forest. The Yahtze River and adjacent areas are washed by intense winter storms forcing salt water up streams. The salt water kills spruces and alders for several kilometers inland along the coastal streams.

Icy Bay supports a colony of 200 Glaucous-winged Gulls nesting on "Egg Island", with Arctic Terns breeding at the north end of the island. At least six eagles have been observed on this island during Summer aerial surveys. There are more signs of human activity around Icy Bay than in any other area in this study except Yakutat itself. Old seismic roads cut through the cottonwood forest east of Icy Bay. A logging camp is located on the west side of Icy Bay and there is heavy logging on state lands nearby. Several unoccupied buildings on the east side of Icy Bay were formerly used for seal hunting. Seagoing tugs, log booms, and commercial fishing boats seek refuge in Icy Bay during periods of bad weather.

Point Riou in Icy Bay supports nesting Arctic and Aleutian Terns, resting gulls, immature kittiwakes, and Canada Geese during Spring, Summer and Fall migration.

Autumnal Bird Migration - Equinox Storms

Waterfowl

Puddle ducks (teal, wigeon, pintails and later Mallards) are the first to move through the Yakutat area during Autumn migration, beginning in late August. Geese move through in September and October (Tables VII-IX, Appendix). Swan migration through the Yakutat area occurs in the first two weeks of October. Weather conditions north of the Yakutat area determine the times of peak migratory movement across the Forelands. Autumn storms cause ducks and geese to concentrate in large marshy flats along the Yahtze River NW of Yakutat Bay. Exceptionally large movements of diving ducks (scaup, Ring-billed Ducks, Redhead and Canvasback), geese, and swans occur after the autumnal Equinox storms.

The Equinox storms are a series of storms with high intensity SE winds. The isobars on the weather maps at the time are typically very close together, indicating a sharp pressure gradient into a deep low pressure system. The most ferocious storms usually occur in conjunction with the Autumn high tides, with large differences in tidal fluctuations between high water, high tides, and low water, low tides. These tides occur immediately at the end of the full moon (i.e., September 13th in 1980) or alternatively as the moon becomes full again (immediately before /after September 28th, in 1980). These annual Equinox storms are the most important factor in determining the peak of avian migration through the Yakutat area and the arrival of the large Fall flocks. Typically there are at least two major storms, and often as many as four or five, with a day or so of clearing between them. On the clear days with the NW winds, the most intensive bird migration occurs (Brogle, ADF&G, pers. comm.; based on 15 years observation).

Sandhill Cranes

The most important and large scale Sandhill Crane movement occurs after the middle of September, usually during a high pressure weather system with winds out of the NW, following a period of bad weather with winds out of the SE. The cranes congregate on the east side of Icy Bay and in the upper Yahtze River on the Manby (west) side of Yakutat Bay. These areas resemble the Dangerous/Alsek regions on the Yakutat Fore-lands. The cranes then fly across Yakutat Bay to the Dangerous/Alsek areas, and proceed over the coastal mountains, over the Yakutat-Novatak Glaciers and up to the Alsek Valley, moving northeast through the Alsek Canyon (Fig. 6). The cranes circle to about 5,000 ft., pick up thermal air currents, and move up the Alsek River Valley (cf. Appendix X). As SE storms approach, the Autumn winds may help push the birds up the canyon. The cranes then fly to the Gustavus area NW of Juneau, or to the Stikine River flats. Gustavus serves as an important landing area for the cranes, since these birds prefer its sandy marshes. In general, the main movement of cranes through the Yakutat area proceeds from the Yahtze to the Dangerous River valleys, over Harlequin Lake and the glaciers and up the Alsek River canyon to the Gustavus area (Magnus &

Brogle, ADF&G, pers. comm.; Barnett, USFS, pers. comm.). By comparison, there is not much Autumn movement of Sandhill Cranes around Cape Spencer to the southeast of Yakutat, although a certain proportion of the birds move in that direction.

Bald Eagles in the Yakutat Area: Distribution, Winter Concentrations , Feeding, Nesting and Aircraft Strike Hazard

Bald Eagles are common and widespread in the Yakutat area, but they tend to be concentrated along watercourses and near food sources. Bald Eagles prefer to forage on fish along open rivers with gravel bars since they are largely bank and shore feeders. Groups of up to 50 Bald Eagles rest on single 100 m gravel bars near the mouth of the Alsek River southeast of Yakutat and near the mouth of the Yahtze River on the Manby (west) side of Yakutat Bay during eulachon runs (pers. obs.; Robertson, pers. comm.), and a total of over 1,500 Bald Eagles was recorded between the Dangerous River and Cape Fairweather on February 24-25, 1981 (Table 9) (Figs. 13, 14).

A much lower known number (41 pair) of Bald Eagles actually nested in the Yakutat area (Table 35). The eagles prefer to nest along clear, rather than on silty or turbid rivers. The Ahrnklin, Antlen River, Dangerous and Alsek Rivers are glacially fed and have at least partially turbid watercourses. The Situk, Italio, lower Akwe, East and Doame Rivers run clear. The eagles prefer to nest near these clear-running rivers, and also to nest near the rocky shores of Yakutat Bay in proximity to clear saltwater. However, there are exceptions to these general rules.

The eagles nest in large trees near clear-running streams and rivers. Trees which serve as nest sites for eagles may be heavily loaded with water-logged branches accumulated during years of nesting activities. Such trees need other trees of the same species and similar size for protection from the wind. Eagles prefer stable platforms for their nests. Spruce trees sway considerably in high winds. Large old black cottonwood trees are somewhat brittle but do not move in storms. For that reason, large cottonwood trees with major forks provide the preferred nesting and roosting sites for eagles in the Yakutat area, and are used during the entire year (Brogle & Magnus, ADF&G; pers. comm.). Large riparian black cottonwood trees are thus important for the management of Bald Eagles in this northernmost part of southeastern Alaska.

In 1980, several Bald Eagle nests were found on the islands of the Yakutat Bay archipelago. The eagles fish in the shallow waters of the inlets, bays and channels. Up to 20 eagles, especially immatures, feed at the mouth of Humpback Creek during the salmon spawning season (July, August and September), but no nests are located there. Ankau Creek also apparently supports no eagle nests. Tawah Creek flows into the Lost River, and is not silty. However, it does have a muddy bottom. Ophir Creek drains into the Tawah. An eagle nest is located at the fork of the Tawah and Ophir Creeks. The Lost River resembles Humpback Creek. Vegetation is dense along both streams and there is little room for eagles to maneuver. The Situk River, which is more open, has a year-round fish supply and is attractive to eagles. Other rivers have more seasonal fish runs. The eagles fish in the Situk and take humpback salmon, dolly varden and small sockeyes. The eagles drag the live fish from the water and feed on the gravel bars if they cannot carry the fish off. The eagles also feed on spawned-out and dying salmon, and take merganser chicks (Magnus and Wood, ADF&G, pers. comm.).

There was an active eagle nest in 1980 near the main inlet to Mountain Lake at the beginning of the Situk drainage. It was located in a large cottonwood. It produced two eggs and two young. It had two feathered young in early July, but only one in late July (Magnus, pers. comm.). Two other nests on Mountain Lake were probably inactive in 1980. Situk Lake had one active nest on the west side, and two nests near the outlet of Situk Lake to the Situk River on the east side. At least one of these was active in 1980. There were at least six nests located on the upper Situk between Situk Lake and the Situk Bridge, and eight nests between Situk Bridge and the beginning of the estuary, a distance of approximately 21 kilometers, for an average of one eagle nest every 2½ kilometers. There were two active eagle nests along the West Fork of the Situk in Spring 1981. The Italio River, which resembles a small Situk, attracts a similar number of nesting eagles.

At least three eagle nests were found along the Akwe River between Akwe Lake and the lower Akwe fish camps. Fish (eulachon and salmon) show up well from the air in this river during low water conditions and the eagles apparently find fishing easy (660 eagles observed along the Akwe on February 25, 1980). There are no large trees at present along the East (Alsek) River to provide nesting or roosting sites for eagles. The fish spawning in the East River are mostly sockeye salmon, which breed in a limited time period (mid-August - early November).

Similarly, the eulachon run is heaviest in the lower Alsek River in March. At other times of the year few fish are available to eagles in the lower Alsek River. The number of eagles in the upper Alsek increases in late Autumn as they move up the Alsek canyon following the salmon spawning. After the second week in October, coho spawning begins in the Tatshenshini (Brogle & Magnus, ADF&G, pers. comm.). The eagles follow the salmon to the Klukshu, Haines and Chilkat districts, feeding as they progress up the Alsek valley. Some reverse movement probably occurs down the Alsek River valley later in the Winter. Eagles which remain along the lower Alsek through the Summer often take gull chicks in July since fish are few at that time in that area.

The eagles present a distinct aircraft strike hazard near the Yakutat Airport in late Autumn and Winter. Up to 200 Bald Eagles have been reported in the immediate vicinity of the airport in January. Coho salmon enter small streams and ditches near the airport, especially near Runway 29, from the last week in September onward. Peak coho spawning occurs from the second week of October on to late January or early February in small streams and ditches. These salmon are an important Winter food for eagles, and serve as a tremendous attraction to these large birds. To keep them out, iron screens have been placed in sloughs leading from the main streams to the airport area as a normal part of airport maintenance (Brogle, pers. comm.). The eagles were absent from the airport area by late February 1981 and over 1,500 eagles were counted feeding on eulachon and resting near river mouths of the Yakutat Forelands especially at the Dangerous and Akwe Rivers and near the mouth of Clear Creek (Table 9) (Figs. 13, 14). This is apparently one of the largest Winter concentrations in the United States.

A list of known Bald Eagle nesting sites in the Yakutat area in 1980-1981 is listed in Table 35.

TABLE 35
Known Bald Eagle Nesting Sites
in the Yakutat Area 1980-1981
(Magnus, Brogle, Woods & Ball, ADF&G, pers. comm.)

Number	Location	Characteristics/Description/Explanation
1	Yana Stream mouth	In large old black cottonwood
1	Osar Stream mouth	In large old black cottonwood
1	Strawberry Island - Grand Wash River	In large old black cottonwood
1	Haenke Island	On rocky knob in proximity to seabird colony
1	Knight Island	In tree on small lake inside the south shore
1	Khaantak Island	In tree in central portion of island
1	Junction of Tawah and Ophir Creeks	In tree at the fork of the the two small salmon streams
1	Mountain Lake (+ 2 inactive sites)	In large cottonwood near the main inlet to the lake
2	Situk Lake (+ 1 inactive site)	East side of lake 1.5 km below Forest Service cabin and near outlet to river
6	upper Situk River	In cottonwood trees between Situk Lake and the Situk Bridge
2	West Fork Situk River	One in tall spruce tree
8	lower Situk River (1 near Situk weir; 2 below Middle Situk Forest Service cabin	In cottonwood trees between Situk Bridge and Weir and Situk estuary along the salmon stream

TABLE 35 Contd.,

1	Italio Lake	Near fork of lake
5	Italio River	In black cottonwood trees along this clear salmon stream
1	Akwe River where joined by Ustay	In black cottonwood
3	lower Akwe River	Heavy fish runs in shallow river
3	lower Alsek River at Dry Bay	In old black cottonwood trees; sporadic fish runs and seabird colony in vicinity

VIII. Conclusions

Limited information on habitat utilization by birds in the Yakutat, Alaska, region adjacent to lease area for OCS Sale #55 is available from previous research. Marine-associated avian species utilize this coast extensively as evidenced by repeated sightings, but the extent of habitat utilization has been poorly quantified until the current study. Significant possibilities exist for serious disturbance of this coastal environment by OCS development.

The Yakutat Forelands, in brief, are made up of sandy beaches, deciduous shrublands, spruce forests, and muskegs, with a series of relatively short, mostly clear-running rivers.

Geological time is <u>short</u> in the Yakutat area. Conditions change extremely rapidly. Earthquakes, storm tides, glacial activity, siltation from outwash moraines, streams, and rivers all affect the landscape. The shallow slope of the Pacific shoreline exposes the entire ocean slope of the Yakutat Forelands to Fall and Winter storms (and potentially oil spills) which wash over many square kilometers of sandy beaches, estuaries, and nearby inland areas.

In 1980-81, in terms of the greatest number of birds observed, the most important avian habitats in the Yakutat area were (in descending order): marine beaches, rivers, coastal waters, and salt marshes. Most avian biomass was tied up in a few bird species per habitat.

The most important species per habitat, numerically, were: Glaucous-winged Gull (marine beaches and rivers); Surf Scoter (coastal waters); Western Sandpiper (salt marshes); Aleutian Tern (supratidal meadows); American Wigeon (fresh water marshes); Black-legged Kittiwake (rocky marine shores and cliffs); Hermit Thrush (deciduous shrublands); and Mew Gull (barren moraines and outwashes). The Glaucous-winged Gull was numerically the most important species of seabird in the Yakutat area; the Surf Scoter was numerically the most important species of waterfowl, and the Western Sandpiper was numerically the most important species of shorebird.

Adequate knowledge of the nature of the lakes, rivers, streams, sloughs, and estuaries in the Yakutat area was crucial to the proper understanding of the avian biology and distribution in the region. The two most important estuaries on the Yakutat Forelands were the Situk-Ahrnklin estuary and the East River - Doame Estuary. While not an estuary, the south end of Russell Fiord attracted large numbers of waterfowl. The most important and geographically restricted area on the Yakutat Forelands for the largest number of individual birds in 1980 was the Situk-Ahrnklin Flats. The most important river was the Akwe, in lower reaches above the estuary, which attracted spectacular numbers of Bald Eagles and Trumpeter Swans, "Species of Concern" during late Winter and early Spring 1981.

Deciduous shrublands and coastal waters (those less than 5 km from shore) were the most diverse avian habitats in the Yakutat area in 1980. Barren moraines, outwashes, cliffs and gullies, especially at the Haenke Island seabird colony, were the least diverse avian habitats. Geographic areas at the interface of rivers and deciduous shrublands (i.e., riparian habitats) had high avian diversity.

Yakutat Bay had areas of remarkably low avian diversity, with high concentrations of particular species. Large groups of scoters and murrelets at the north and south ends of Khaantak Island and from Point Latouche to Knight Island were considered particularly vulnerable to disruption from petroleum-related activity. Dense flocks of wigeon in the East Alsek River and the Upper East Alsek estuary were also considered vulnerable.

Eulachon, a small species of schooling anadromous fish, attracted huge numbers of foraging birds, most notably over 1500 Bald Eagles, to geographically confined and sensitive areas in late Winter and early Spring 1981, especially near the mouths of the Dangerous, Italio, Akwe, and Alsek Rivers, and at the mouth of Clear Creek at the southeastern border of the Yakutat Forelands. The importance of the eulachon as a late winter food supply for tremendous numbers of Bald Eagles between Yakutat and Cape Fairweather has been previously completely overlooked. The total of over 1,500 Bald Eagles observed on the Yakutat Forelands between the Dangerous River and Cape Fairweather on February 24-25, 1981, is one of the largest wintering concentrations of Bald Eagles reported in the United States. This wintering concentration is possibly second only to the Haines-Chilkat district, which is located approximately 175 km ENE up the Alsek and Tatshenshini River valleys. Indeed, there may be late winter movement of eagles from the Haines-Chilkat region to the Yakutat Forelands.

Up to 200 Bald Eagles were also found around the Yakutat airport during the Winter, especially in January. Coho salmon spawning in shallow streams and ditches near the airport attracted the eagles which constituted a significant air strike hazard.

Eulachon runs began in late February to coastal streams and rivers of the Yakutat Forelands. Eulachon runs continued until early June, attracting as many as 27,000 Glaucous-winged Gulls and additional thousands of kittiwakes, other gulls, and mergansers to river mouths southeast of Yakutat. These birds were observed during single two-hour aircraft surveys. It should be emphasized that the eulachon runs are the most important determinants, in late Winter and Spring, other than migration, for the distribution of birds in the Yakutat area.

Waterfowl were attracted during Spring migration to submerged and floating aquatic vegetation in the East - Doame Estuary and to the lower Akwe River. Over 730 Trumpeter Swans were found in the Akwe, Italio and Situk - Ahrnklin estuaries in early April 1981.

The main wave of bird migration passed through the Yakutat area in the last week of April. Tens of thousands of gulls, geese, and other waterfowl were found at Dry Bay in May. Dry Bay, the delta of the Alsek River, is a major migration staging area. The Alsek River valley serves as a migration route to the interior Yukon lake district and perhaps to the Mackenzie Delta.

In June, thousands of immature and other presumably nonbreeding kittiwakes, Glaucous-winged Gulls, Herring Gulls and occasional Glaucous-Gulls rested on outer beaches near river mouths of the Yakutat Forelands and near the Sitkagi Bluffs on the Manby (west) side of Yakutat Bay. Over 3,000 scoters and 2,000 kittiwakes were found offshore from the Sitkagi Bluffs and resting near adjacent stream mouths.

Nonbreeding (resting, moulting and foraging) birds outnumbered breeding seabirds, shorebirds, and waterfowl by at least several orders of magnitude in the Yakutat area during the Summer of 1980. For instance, 25-26 pairs of Trumpeter Swans breed on the Yakutat Forelands in 1980, approximately 40 pairs of Bald Eagles. However, breeding pairs were far outnumbered by wintering and migratory individuals of these species.

The most important seabird colonies in the Yakutat area were located at Haenke Island, Blacksand Spit, and Dry Bay. A huge colony of Aleutian Terns (3,000 individuals), the world's largest known concentration, was located on Blacksand Spit in July 1980. This colony was located near the mouth of the Situk River. Aleutian Terns bred in low numbers along the entire ocean beach-dune system of the Yakutat Forelands, as well as at Pt. Riou in Icy Bay. Other Aleutian and Arctic Tern colonies were located at Osier Island, Crab Island, near Dolgoi Island, at the mouth of Gonakadetseat Bay, northwest of the mouth of the Ankau at Monti Bay, and along Old Italio Spit.

Large concentrations of southward migrating Western Sandpipers (5,000+ individuals) were found in the Situk - Ahrnklin Flats, near Old Italio Slough, and in the Ankau Lagoons in July. Gull chicks fledged in August at Dry Bay and Haenke Island. Waterfowl concentrations began in late August in the East River - Doame Estuary.

Heavy salmon spawning in September in rivers and streams of the Yakutat Forelands attracted hundreds of scavenging gulls, eagles, ravens, magpies, and blackbirds. Large concentrations of American Wigeon, Common Pintails, Green-winged Teal, and later Mallards and Trumpeter Swans were found in the relatively small East Alsek River and in the East River - Doame Estuary. Large groups of scoters and other diving ducks were found at the south end of Russell Fiord in late September.

The main waves of waterfowl migration passed through the Yakutat region in September and October after intense southeast storms. Thousands of Sandhill Cranes flew over the Yakutat Forelands during Autumn migration. Flocks of Sandhill Cranes at altitudes to 1,250 m in September also constituted a significant air strike hazard.

Thousands of Canada Geese, Snow Geese, and Whistling Swans concentrated in October in the Situk - Ahrnklin estuary. Diving ducks appeared in large numbers in early October in the Yakutat Bay Islands, the south end of Russell Fiord, and in the East River - Doame Estuary.

Very severe storms in November forced birds from exposed estuaries to sheltered locations such as the lee (southeast) side of Yakutat Bay and Russell Fiord. Exposed estuaries froze in late December and January, forcing waterfowl to retreat from the coast to the Ankau - Tawah Creek - Lost River drainage, the Italio River, and the Akwe River.

This research has indicated that certain areas near Yakutat, with high numbers of individual birds and a low number of species, are most sensitive to gas and oil exploration and development. These areas are the Situk - Ahrnklin Estuary, the East River - Doame Estuary, the south end of Russell Fiord, Haenke Island, the north and south ends of Khaantak Island, Knight Island to Point Latouche, the Sitkagi Bluffs, the lower Akwe River, Dry Bay, and clear streams in general of the Yakutat Forelands.

These areas are important for large concentrations of birds, as major foraging areas, breeding sites, and migratory staging areas. The largest number of avian species and the largest number of individual birds in the Yakutat area were associated with freshwater habitats, i.e., rivers, streams, sloughs, and marshes. Freshwaters, i.e., lakes, rivers, streams, and sloughs had a relatively low avian species diversity, but had the highest species richness recorded in the Yakutat area in 1980. However, marine beaches, which are extensive near Yakutat, had the largest total number of all species observed per habitat in this study. The junctions of river mouths with sandy beaches were clearly the most important locations in the Yakutat Forelands for large numbers of bird species and large numbers of individual birds.

Less sensitive habitats were deciduous shrublands (early successional stages with comparatively high numbers of avian species and low numbers of individuals) and turbid rivers.

Deciduous shrublands, with high avian diversity, were widespread in the Yakutat Forelands in 1980. The turbid rivers were generally unproductive and with striking exceptions, (eulachon runs) attracted fewer birds than clear rivers.

The estuarine regions listed above are considered particularly important, because of their productivity and maintenance of high avian biomass. These areas are also occasionally exposed to severe storms. Winds of velocities greater than 160 kph drive waves over 20 in height onto outer beaches, inundating large estuarine and terrestrial areas with salt water, and potentially with oil spills. Salt water and spilled oil potentially may extend as much as five kilometers inland, through estuaries and up adjacent river valleys, because of the shallow ocean slope of much of the Yakutat and Malaspina Forelands.

TABLE 36

Yakutat Avian Phenology and Bird and Mammal Occurrences of Special Mention

SUMMARY

Month	Observations and Highlights
January	Seaducks and diving ducks found in sheltered saltwater locations, i.e., the south end of Russell Fiord; the east side of Yakutat Bay (especially the lee side of Khaantak Island) and in the east side of Icy Bay. Estuaries near the open coast are frozen, barren, and exposed to intense SE storms. Coho spawning in shallow streams and ditches; up to 200 Bald Eagles found around the Yakutat Airport.
February	Coho spawning ceases; eulachon runs begin in late February in the Dangerous River, Akwe River, and in Clear Creek. Fifteen hundred (1,500) Bald Eagles between Yakutat and Cape Fairweather feeding on eulachon. Estuaries otherwise still barren and frozen. Seaducks in the east side of Yakutat Bay and in the south end of Russell Fiord.
March	Eulachon runs continue in the Italio, Akwe, and Alsek Rivers. Estuaries may open in warmer years. Twenty-seven thousand (27,000) Glaucous-winged Gulls feed on eulachon runs in the Ahrnklin, Italio, Akwe Rivers, and in the lower Alsek at Dry Bay. As many as 200 Stellar's Sea Lions pursue eulachon 10 km up the Alsek River, in addition to several hundred Harbor Seals in lower Dry Bay (Fig. 15).
April	Eulachon runs continue. Spring bird migration begins. Passerines begin to sing. Waterfowl attracted to submerged and emergent aquatic vegetation in the East - Doame River estuary and to the Akwe River where it flows inland from the coast. Over 700 Trumpeter Swans found in the Akwe, Italio, and Situk-Ahrnklin estuaries. The main wave of bird migration passes through the Yakutat area in the last week of April.

Table 36 Contd.

May	Tens of thousands of gulls, geese, and other waterfowl found in Dry Bay, a staging and foraging area. Eulachon runs continue in the East Alsek, Alsek, and Italio. Thousands of Mergansers feed on eulachon at Dry Bay. Seabird breeding begins at Dry Bay and on Haenke Island in Yakutat Bay. Aleutian Terns return in late May to Dry Bay. Bird migration to interior up the Alsek Valley.
June	Eulachon runs cease in the first week of June. Thousands of immature and other presumably nonbreeding kittiwakes, Glaucous-winged Gulls, Herring Gulls, and occasional Glaucous Gulls rest on outer beaches near river mouths. Glaucous-winged and Herring Gulls, and hybrids incubate full clutches at Dry Bay, and Glaucous-winged Gulls incubate at Haenke Island. Chicks may hatch from mid-June on, depending upon the season. Small Arctic and Aleutian Tern colonies are found in the Yakutat Bay Islands and along the entire sandy beach system of the Yakutat Forelands from Ocean Cape to Clear Creek. Three thousand (3,000) scoters, 2,000 kittiwakes found at Sitkagi Bluffs.
July	Huge concentrations of Aleutian Terns at Blacksand Spit in 1980, perhaps the largest colony known in the world (3,000 individuals). This colony is located near the mouth of the Situk River southeast of Yakutat. Nesting attempts are noted as disturbed by human intrusion, and by other mammalian and avian predators. Large flocks of migrating Western Sandpipers (5,000 individuals) are found in the Situk-Ahrnklin Flats, near the Old Italio Slough, and in the Ankau Lagoons. Gull chicks may reach fledging stage in late July at Dry Bay and Haenke Island. Passerine song ceases. Ten thousand (10,000) Arctic Terns at Ocean Cape (Isleib, 1968) and 5,000 scoters in Russell Fiord (Arneson, 1976).

Table 36 Contd.

August	The last gull chicks reach fledging stage at Dry Bay and Haenke Island. Seabird colonies are vacant past the second week in August. Most bird populations are quite dispersed. Waterfowl concentrations begin in late August in the East River - Doame Estuaries.
September	Heavy salmon spawning in may rivers and streams. Dead and dying salmon attract hundreds of foraging gulls, eagles, ravens, magpies and blackbirds. Brown bears congregate along streams. Large concentrations of wigeon, pintails, teal and later Mallards and Trumpeter Swans in the East Alsek River and in the East Alsek - Doame River estuary. Large groups of waterfowl occur in the south end of Russell Fiord. Weather becomes more severe with occasional very strong SE storms. Thousands of Sandhill Cranes pass over the Yakutat Forelands on migration, flying southeasterly, some at quite high altitudes (5,000 ft.).
October	Main waves of bird migration pass through the Yakutat region in a southeasterly direction with following winds (northwesterly) after intense SE storms. Thousands of Canada Geese, Snow Geese and Whistling Swans concentrate in the Situk - Ahrnklin Estuary. Hundreds of Canada Geese are found along the Dangerous River. Diving ducks appear in large numbers in early October in the south end of Russell Fiord, the Yakutat Bay Islands, and in the East River - Doame Estuaries. Sockeye (red) salmon runs decrease and scavenging birds are more dispersed.
November	Very severe storms force birds from exposed estuaries (i.e., Situk - Ahrnklin and East - Doame) to the lee side of Yakutat Bay, among the islands, and to the south end of Russell Fiord. Coho spawning begins in shallow streams and ditches, attracting Bald Eagles to the vicinity of the Yakutat Airport.

Table 36 Contd.

December	Exposed estuaries freeze. Waterfowl retreat from the coast to sheltered locations such as the Ankau - Tawah Creek system, to the Yakutat Bay Islands, and the south end of Russell Fiord. Coho spawning continues, attracting large numbers of Bald Eagles.

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APPENDIX I

SPRUCE-HEMLOCK FORESTS, MUSKEGS, AND RIPARIAN HABITATS

Appendix I

Spruce-hemlock Forests, Muskegs, and Riparian Habitats

Mixed Sitka spruce *(Picea sitchensis)* and western hemlock *(Tsuga heterophylla)* forests are confined to comparatively upland regions on the Yakutat Forelands. These areas include the east side of Yakutat Bay from Phipps Peninsula to Mt. Tebenkoff (the terminal moraine of the old Yakutat Bay Glacier), raised dune lines near Tawah Creek and the Akwe River, and along the base of the Brabazon Range from Yakutat Bay to the Alsek River. The vegetation on the outwash plain south of the Brabazon Range and east of Yakutat Bay is primarily lowland muskegs with riparian zones (i.e., deciduous shrublands with black cottonwoods).

Spruce-hemlock forests near Yakutat are varied in age, but are characterized by rather fully stocked stands. Smaller muskegs, creeks, rivers, and lakes are found near these forest stands. Notable locations with spruce-hemlock forests include Yakutat village, Chicago Harbor, the Situk drainage, Harlequin Lake road, the Upper Italio region east of the Dangerous River, and the lower reaches of the Akwe River.

A severe but statistically not unusual windstorm in January 1981 caused significant damage to spruce-hemlock forests throughout the Yakutat Forelands, especially from the Dangerous River westward to Yakutat Bay. A large number of trees were blown down. Some forested areas experienced virtually complete blowdowns. The most severe damage was between the Situk River and Redfield Lake, and near the south end of Russell Fiord (USDA Forest Service, 1981a).

Winds on the Yakutat Forelands are strongest during Fall and Winter. The winds blow primarily out of the southeast, may be intense, and are usually accompanied by heavy rains. The winds causing the January 1981 blowdown were no stronger than those normally expected at least once every two years; however, they were sustained at over 40 mph (60 kph) for more than three hours (USDA Forest Service, 1981a). A peak gust of 81 mph (120 kph) was recorded at the Yakutat Airport during the storm. Winds in the affected areas may have been of considerably greater force than those at the airport. Winds can be highly variable at different locations around Yakutat (cf. Narrative Climatological Summary, pp. 76-77).

Over 84 million board-feet of timber were blown down by the January 1981 storm (USDA Forest Service, 1981a).

The spruce-hemlock forest on the Yakutat Forelands, as well as blowdown areas, muskegs and riparian habitats, especially in the upper Situk drainage, were studied on occasion throughout the 1980 field season and in March and April 1981. The resulting analysis of avian communities in the coniferous forests, muskegs, and riparian habitats near Yakutat utilized field data available and professional judgement. Avian diversity in similar habitat types has been previously investigated by Patten (1975) on the outer coast of Glacier Bay National Monument, immediately southeast of the current study area (cf. p. 38, Table 10).

The following assessment of bird life in spruce-hemlock forests, muskegs and riparian habitats in the upper Situk drainage was prepared by Patten as part of NOAA-sponsored research on avian habitat use and community structure on the Yakutat Forelands. An evaluation of alternative methods of salvaging major portions of blown-down timber is provided as part of a volunteer effort to the US Forest Service. Special thanks are given to Ronald Ball (ADF&G) and Vivian Kee (USFS) for cooperation, scientific criticism, and long hours of intense work in devising methods of portraying the avian community and its response to natural and artificial disturbance in these habitats. The management schemes to minimize and mitigate potential disturbance to wildlife are part of a joint effort (cf. USDA Forest Service: Wildlife Specialists Report, Yakutat Blowdown, 1981).

PREFACE FOR TABLE 37

A matrix has been prepared in an attempt to address the anticipated response of Yakutat birdlife in spruce-hemlock forests, muskegs, and riparian zones to each of three potential management schemes (Table 37). The matrix has a format which is to be used as follows:

Management Species Group - This column indicates those types of birds found within the habitat type in the Upper Situk project area. Management can occasionally be provided on a "group" basis, or may need to be applied on a species basis, since not all species in a group will always react similarly.

Species - This column lists as best as known those avian species which utilize the project area on a regular basis.

Primary Habitat Preference - This column indicates which habitat(s) (of the three primary habitat types found in the Upper Situk study area) the given species primarily uses. This column notes only habitat preferences, and it is not intended to mean that the bird species will not occur in the other habitat type(s).

Management Scheme #1

General Effect of Blowdown; No Salvage-

This column reflects the anticipated response of the avian community over time, to the changed environment, given that no timber salvage occurs. Two phases occur over this period of time and they are defined as follows:

Early (Succession) - the plant community is reduced primarily to seral forbs, grass and brush. Deciduous shrublands become established in seral stages, finally invaded by conifers.

Late (Succession) - in this stage the community is increasingly dominated by conifers, including hemlock. The community may be 80 or 90 years of age and gradually develops into a decadent, old growth stand where uneven age and size structure exists with a well developed and diverse understory.

**Two important assumptions are made in evaluating responses in these stages:

1. No increased human activity or pressure(s) has been experienced (over current levels).

2. The "Late" stage will return to the same community in both quality and quantity, as it was before the blowdown.

Management Scheme #2

General Effect of Salvage Operation-

This column reflects the anticipated response of the avian community over time, given that some form and/or extent of timber salvage occurs.

Two phases occur over this period of time and they are defined as follows:

Early (Succession) - Two cases are generally expected:

1. Partial windthrow: down timber is removed and area consists of mixed standing timber and increased brush, forbs and deciduous shrubs.

2. Complete withthrow: all timber is down and removed. Succesion starts from grass/forb/brush stage.

This stage ends in both cases when conifers, especially Sitka spruce, become dominant.

Late (Succession) - this community is the same as the "Late" phase considered in the "no salvage" column. This community also is allowed to return to old growth status.

**Five important assumptions are made in evaluating responses in these stages:

1. The disturbance caused by humans during layout, timber salvage and pull-out, and the additional hunting or depredation pressures anticipated during this time (early phase) are disregarded. These pressures and disturbances are expected to last up to approximately three years, and even though they may cause significant, adverse impacts on wildlife during that time, we believe that these impacts will be diluted adequately over time, provided assumptions #2 and 3 (below) occur.

2. We are assuming that primarily only down (or leaning) timber will be taken. If a significant portion of any standing timber is taken from any area the results forecast in this column will be invalid.

3. It is assumed that the road(s) involved in the timber salvage operations would be closed and allowed to revergitate naturally.

4. No further management of the area (beyond current levels and this salvage effort) occurs.

5. We assume that in areas where no standing trees will remain, and all windthrow is salvaged (clearcut), that the area will be unproductive for wildlife from year 0 through approximately year five.

Management Scheme #3

Even Age, Silviculturally Mature Stand-

The intent of this column is to illustrate the responses of birdlife if the subject stands are put into some form of "management", and not allowed to develop into old growth, as they have in the other two management schemes (no salvage; salvage--no further management). We are assuming that the area has received salvage treatment and thereafter will be harvested at each rotation.

This stage of development is reached when the conifers (primarily Sitka Spruce) become dominant and range in age from 80 or 90 years to 120 or 150 years. This is a silviculturally mature system (not necessarily ecologically mature) which is approaching rotation. The understory is not diverse or high in biomass. This column assumes that timber will be harvested at approximately 120-150 years age and the bird use of this community before harvest is indicated. Only the "late" phase is recognized (at approximately 120 years age) since bird utilization in the "early" phase as a "managed stand" would be similar to the use indicated in the other two "early" stages. The only difference would be that those species sensitive to human activity, hunting or disturbance would not likely occur. This is because regular or increased use of the area is anticipated in this managed scheme.

**Four important assumptions are made in evaluating responses in this column:

1. The area does not return to old growth.

2. The impacts of regular and increased encroachment and pressure from people are considered.

3. We are assuming that future blowdown will be harvested.

4. We are assuming that further harvest in the area may occur.

The scoring used in these matrices is as follows:

1. If a bird species is enhanced by the action involved (blowdown and/or management action), this is shown by a (+) sign which generally indicates that the species has experienced a net gain in a preferred habitat.

2. If a species is negatively impacted by the action involved this is indicated by a (-) sign which generally indicates one of three things:
   - a net loss in a preferred (required) habitat type
   - a net loss in forage or prey base
   - extirpation from the area because of sensitivity to human presence or excessive hunting.

3. If a species is neither positively or negatively effected by an action, this is shown by a (±) sign. This occurs when:
   - the species equally utilizes all habitat types and is therefore not adversely impacted if the timbered habitat is altered; it can use the other habitat types
   - it is able to continue to use the habitat in its altered form
   - the bird species never originally used the altered habitat.

Description of Habitat Types

Timber

The major portion of this habitat type is old growth Sitka spruce/ western hemlock forest. Early seral stages of this forest type are present at the south end of Russell Fiord and along creek bottoms. This stage includes black cottonwood, Sitka and red alder and *Salix sp.* Understory vegetation consists primarily of *Vaccinium sp.*, devil's club, salmonberry, skunk cabbage, ferns, *Ribes sp.*, and *Cornus sp.*

Muskeg

This herbaceous and low brush ecosystem is usually found in wet, flat basins. Vegetation is varied but commonly consists of a thick sphagnum moss mat, sedges, rushes, lichens, cottongrass, willow, cranberry, and blueberry. A few slow growing, poorly formed hemlock and spruce are scattered on drier sites. Shrubs are dominant over the sedge and herbaceous mat in exposed and drier areas. Ponds and creeks are often present. This habitat type includes brushy willow margins. Creeks and/or ponds are frequently associated with this habitat.

Riparian

This riverine, alluvial community consists primarily of black cottonwood, alder, willow, high bush cranberry, salmonberry, *Ribes sp.* devil's club, *Vaccinium sp.*, *Equisetum sp.*, grasses, sedges and forbs. This system may or may not include surface waters, but is a water-influenced habitat. This habitat is present in the smallest proportions within the upland project area. It is however, the habitat which produces most wildlife diversity. (See also discussion of Deciduous Shrublands as an Avian Habitat, above in main text).

Effects of Blowdown, Salvage and Management

Ecologically, this scenario is considerably different from most other timber harvest projects. The major difference is that the environment (i.e., wildlife habitat) has already been changed, and this change is already significant in those areas of complete or near complete blowdown. Therefore, the goal was to address the Upper Situk project as a salvage operation, as opposed to a complete habitat change. Given this situation, most of the major impacts are/will be associated with human disturbance, encroachment, further loss of habitat due to roading and harvest of standing trees, and the potential for increased consumptive wildlife use.

TABLE 37

WILDLIFE RESPONSE TO THREE POTENTIAL MANAGEMENT SCHEMES

THIS TABLE MUST BE USED WITH THE ACCOMPANYING PREFACE AND DISCUSSION FOR ACCURATE INTERPRETATION

Wildlife 55 Bird Species		Primary Habitat Preference			General effect of Blowdown; No salvage		General effect of salvage operation		Even age Silvicul- turally mature mature stand	
Management Species Group	Species	Timber	Muskeg	Riparian	Early	Late	Early	Late		Remarks
Finches & Sparrows	Pine Grosbeak	X			-	±	-	±	+	Spruce forest species
	Pine Siskin	X			-	±	-	±	+	Spruce forest species
	White-winged Crossbill	X			-	±	-	±	+	Spruce forest species
	Savannah Sparrow		X		+	±	+	±	-	Prefers muskegs
	Dark-eyed Junco		X	X	+	±	+	±	-	Likes brush
	Fox Sparrow			X	+	±	+	±	-	Likes brush
	Lincoln Sparrow		X	X	+	±	+	±	-	Likes brush
	Song Sparrow		X	X	+	±	+	±	-	Likes brush
	Golden-crowned Sparrow		X	X	+	±	+	±	-	Likes brush
	White-crowned Sparrow		X	X	+	±	+	±	-	Likes brush

Wildlife 55 Bird Species		Primary Habitat Preference			General effect of Blowdown; No salvage		General effect of salvage operation		Even age Silvicul-turally mature mature stand	
Management Species Group	Species	Timber	Muskeg	Riparian	Early	Late	Early	Late		Remarks
Blackbird	Rusty Blackbird		X	X	±	±	±	±	±	Human activity enhances habitat. Commensal scavengers. Managed scheme can increase population.
Warblers	Wilson's		X	X	+	±	+	±	-	Likes shrubs near water
	Yellowthroat			X	+	±	+	±	-	Likes shrubs near water
	Orange-crowned			X	+	±	+	±	±	Ubiquitous; forest understory
	Yellow			X	+	±	+	±	-	Likes shrubs & small trees near water
	Myrtle	X		X	+	±	-	±	±	Mixed Conifer forest and thickets
Shrikes	Northern		X	X	±	±	+	±	-	Uncommon; prefers open areas
Kinglets	Golden-crowned	X			-	±	-	±	+	High canopy species
	Ruby-crowned	X			-	±	-	±	+	High canopy species

Wildlife 55 Bird Species		Primary Habitat Preference			General effect of Blowdown; No salvage		General effect of salvage operation		Even age Silvicul-turally mature mature stand	
Management Species Group	Species	Timber	Muskeg	Riparian	Early	Late	Early	Late		Remarks
Thrushes	Gray-checked		X	X	+	±	+	±	-	Uncommon; thickets
	Hermit	X		X	+	±	+	±	±	Common in forest understory; requires some old growth
	Varied	X			-	±	-	±	±	Widespread in spruce forest
	Robin		X	X	+	±	+	±	-	Likes open deciduous shrublands with human habitations
Wrens	Winter	X		X	+	±	+	±	±	Found in all forest types
Creepers	Brown	X			-	±	-	±	-	Uncommon. Needs old-growth & mature conifer trunks
Nuthatches	Red-breasted	X			-	±	-	±	-	Uncommon. Needs old-growth & mature conifer trunks
Chickadee	Chesnut-backed	X			-	±	-	±	±	Old growth and mature spruce forest, snags
	Black-capped			X	+	±	+	±	-	Not common; likes willows near water; snags

Wildlife 55 Bird Species			Primary Habitat Preference			General effect of Blowdown; No salvage		General effect of salvage operation		Even age Silvicul-turally mature mature stand	
Management Species Group		Species	Timber	Muskeg	Riparian	Early	Late	Early	Late		Remarks
Corvids		Raven	X	X	X	+	+	+	±	±	Widespread species
		Steller's Jay	X			-	±	-	+	+	Spruce forest species
		Magpie			X	±	±	±	±	±	Riparian scavenger
Swallows		Tree	X		X	+	±	-	±	-	Utilizes snags
		Bank			X	±	±	±	±	-	Riparian areas
		Barn		X	X	+	±	+	±	-	Prefers areas near human habitations
Flycatcher		Western	X		X	+	±	-	±	-	Needs shade and dense vegetation near water
Grouse		Willow Ptarmigan		X	X	+	±	+	±	-	Open willow/alder thickets
Woodpeckers	FS	Hairy	X			+	±	-	±	-	Snags needed for feeding and hole nesting
	FS	Downy			X	±	±	±	±	-	Riparian with small trees
	FS	Common Flicker		X	X	+	±	±	±	-	Black Cottonwood, open areas, snags

Wildlife 55 Bird Species		Primary Habitat Preference			General effect of Blowdown; No salvage		General effect of salvage operation		Even age Silvicul-turally mature mature stand	
Management Species Group	Species	Timber	Muskeg	Riparian	Early	Late	Early	Late		Remarks
Hummingbirds	Rufous		X	X	+	±	+	±	-	Prefers openings with forbs
Owls	Great Horned		X	X	+	±	-	±	-	Uncommon; largely riparian
	Great Gray	X			-	±	-	±	-	Rare; dense forest
	Short-eared		X		±	±	±	±	-	Muskegs; open areas
	Screech	X			+	±	-	±	±	Rare; dense forest and openings; snags
	Hawk Owl		X	X	±	±	+	±	-	Snags
Falcons	Kestrel		X	X	+	±	+	±	-	Migratory here; open areas; will use snags
	Merlin		X	X	+	±	+	±	-	Migratory here; open areas
Harriers	Marsh Hawk		X	X	+	±	+	±	-	Open areas preferred near water
Hawks	Red-tailed	X	X	X	+	±	+	±	-	Uncommon; breeds in old trees; hunts in open areas
	Rough-legged		X	X	+	±	+	±	-	Migratory; open areas preferred

Wildlife 55 Bird Species			Primary Habitat Preference			General effect of Blowdown; No salvage		General effect of salvage operation		Even age Silvicul-turally mature mature stand	
Management Species Group		Species	Timber	Muskeg	Riparian	Early	Late	Early	Late		Remarks
Accipiters		Sharp-shinned Hawk	X			+	±	-	±	-	Old growth forests with openings preferred
		Goshawk	X	X	X	+	±	-	±	-	Rare; old growth species
Eagles	FS	Bald	X		X	±	±	-	±	-	Nests in old growth; sensitive to disturbance
Alcids		Marbled Murlet	X			-	±	-	±	-	Nests in high canopy old growth
Diving Ducks	FS	Barrow's Goldeneye	X		X	+	±	-	±	-	Cavity nester in snags

Totals for Table 37 are:

Habitat Preference(s)			Effect W/O Salvage		Effect W/ Salvage		Managed Stand At 120 Years
T	M	R	Early	Late	Early	Late	
25	25	38	12-	0-	22-	0-	39-
			8±	55±	6±	55±	9±
Total Bird Species 55			35+	0+	27+	0+	7+

It is extremely important to remember that these totals assume:

1. that no significant amounts of standing timber are taken in the salvage process

2. that human disturbance is not considered during or after the salvage process

3. that the area is allowed to return to old growth following salvage.

The following statements summarize these totals:

1. Avian diversity within the habitats is clearly richest in the riparian areas. Muskegs are similar in avian species richness to the forest areas. This may be overrating the richness of muskeg areas since brushy openings are included within the muskeg component.

2. Only 12 of the 55 bird species are negatively effected in the short term without salvage. Within the salvage scheme, 22 of

the 55 species receive negative short term impacts. This is directly attributed to habitat disturbance associated with salvage operations since other human activity is not considered. This assumes that standing trees will be protected. Also interesting to note that more bird species are benefited than harmed by the habitat alteration in the early phase, with or without salvage. However, fewer bird species benefit under the early salvage phase, than under the early phase without salvage.

3. In both salvage, no-salvage late phases all species are not affected since the forest will return to old growth and salvage roads will be closed and/or put to bed.

4. The "indifferent" response of all bird species to the long term effect of the blowdown and/or salvage, emphasizes the fact that blowdown is a natural part of this environment, and that the birdlife can accommodate it. This is true only if additional standing timber is not removed at this time and that human disturbance ceases after salvage, if salvage is undertaken.

5. Should human use continue in the area, and should the area not be allowed to return to old growth, 39 of the 55 species will be adversely effected for one reason or another. See the remarks column for reasons why these species are either positively or negatively effected.

The following discussion deals more clearly with the responses of individual interest species and species management groups.

Birds

Two bird Species of Concern utilize the Upper Situk project vicinity. The Trumpeter Swan, a previously threatened species (delisted 1979) which is displaying a good recovery, is known to extensively utilize the Yakutat area. No concentrated use occurs on the immediate Upper Situk project area. Regular use does not occur immediately outside of that area.

This use occurs principally in the northern Redfield Lake system, Situk Lake, and scattered ponds near Cape Stoss, (SW end of Russell Fiord). One breeding pair was reported at Redfield Lake in 1980 (Patten and Primrose). One unconfirmed breeding pair was also reported at Situk Lake in 1980. One nest was reported near Cape Stoss this same season. Jim King, U.S. Fish and Wildlife Service, Juneau, regularly observes small flocks utilizing the Redfield Lake area. King reports no known nesting on Situk Lake but states that the NE shore of the lake is quality Trumpeter Swan nesting habitat, and would probably be used if disturbance was not so great.

Two Bald Eagle nests are known to occur on the West Fork of the Situk River. They do not appear to presently be in an area of concern. Six nests are known to occur on the Situk River between the highway and Situk Lake. These nests are of no concern now, but should be considered if log jams in Situk River will be cleared. A few nests are known along Situk and Mountain Lakes, but none have been located on the Old Situk River within the proposed timber salvage area. Increased activity in the Upper Situk area is expected to disturb those eagles in and adjacent to the salvage area. The impacts of this disturbance are not fully known.

The direct disturbance of this salvage operation is expected to be minimal for most birds. The exceptions to this will be birds of prey (hawks, eagles, falcons and accipiters), and ptarmigan in the upper Situk area. Birds of prey are notoriously sensitive to disturbance and the ptarmigan may suffer increased hunting pressure.

Nine cavity nesting and snag dependent birds will be adversely impacted in areas of clear cutting. Creation of new, even-age stands does not allow for development of the snags required by these birds. See remarks column of Table III to identify snag dependent species.

Unsalvaged blowdown areas may produce additional snags, since damaged, standing trees die. Salvage efforts would ordinarily attempt to take damaged standing trees. Existing snags still standing are likely to be eliminated in any salvage effort.

Threatened, Endangered and Sensitive Species

No threatened or endangered species are known to occur within the proposed Upper Situk timber salvage area. However, five species of birds which do occur on the area are listed as Forest Service Sensitive Species. These species are:

Barrow's Goldeneye
Bald Eagle
Common Flicker
Hairy Woodpecker
Downy Woodpecker

These species are classified as "sensitive to management" because they are known to be adversely affected by management practices, or known or may reasonably be expected to occur in such limited habitats and in such low numbers that management activities might directly or ultimately adversely affect population levels.

These species are priority management species within the Upper Situk region. Proposed timber salvage activities and alternatives must consider the welfare of these birds, especially the Bald Eagle, by attempting to avoid and/or minimize adverse impacts, notably in riparian zones.

APPENDIX II

ALEUTIAN TERN SPECIES ACCOUNT WITH SPECIAL EMPHASIS ON THE NORTHEAST GULF OF ALASKA COLONIES

Appendix II

Aleutian Tern Species Account With Special Emphasis on the Northeast Gulf of Alaska Colonies

1. CATEGORY: Birds

2. CLASSIFICATION:
   Class: Aves   Order: Charadriiformes   Family: Laridae
   Subfamily: Sterninae

3. NAME: Aleutian Tern *(Sterna aleutica)* Baird

4. LEGAL STATUS: Protected by the Migratory Bird Treaty Act of July 3, 1919, 40. Stat. 755, Amended.

5. RANGE:

a. Worldwide: North Temperate areas of the North Pacific Ocean and Subarctic Bering Sea. On the North American continent the Aleutian Tern breeds only in Alaska (Gabrielson and Lincoln, 1959). The species also breeds in scattered colonies on the coast of Siberia (Dement'ev and Gladkov, 1931). The species winters in the northwestern Pacific, where it has been recorded from Sakhalin Island (USSR) to Honshu, Japan (Gabrielson and Lincoln, 1959; Kessel and Gibson, 1978).

b. Region of Concern: Aleutian Terns are found along the coast of Alaska from the southern Chukchi Sea south along the Bering Sea coast, the Yukon-Kuskokwim river deltas, the entire Aleutian Islands, the Alaska Peninsula, and east along the Pacific Coast as far as the Yakutat area and perhaps to Lituya Bay (A.O.U., 1957; Kessel and Gibson, 1978).

6. DISTRIBUTION:

a. Discrete Populations: Aleutian Terns are uncommon birds with a patchy breeding distribution. The Aleutian Tern was considered a rare bird by many (Bent, 1921; Walker, 1923; Murie, 1936-38; Dement'ev and Gladkov, 1931). Historically, the recording of locations of colonies has been considered important. Nelson (1887), Hersey (1920), Walker (1923), Friedman (1933) and Howell (1948) provided general characteristics of either colonies or nest sites.

Aleutian Terns are now known to breed on Sakhalin Island and the Chukchi Peninsula in the Soviet Union (Kistchinski, 1980). In Alaska, Aleutian Terns breed from Tasaycheck Lagoon in the southern Chukchi Sea, including Cape Krusenstern, Sheshalik, the Noatak River Delta, Kotzebue, Shismaref, and south along the Bering Sea coast, including Safety Sound, Moses Point, Koyuk River mouth, St. Michael, Hooper Bay, Goodnews Bay, to Bristol Bay and the Alaska Peninsula. Aleutian Terns also breed at Cape Constantine, Port Moller, in the Cold Bay - Izembek Lagoon area, and westward including the Aleutian Islands of Unimak, Unmak, Adak, Amchitka, Oglinga, Skagul (Day, Univ. of Alaska, unpubl. data) and Attu. Aleutian Terns breed eastward along the Pacific Coast of Alaska, including the islands of Kodiak and Amee, Kachemak Bay, the east and west sides of the Copper River Delta, the Bering River/Controller Bay area, Icy Bay, Yakutat Bay, Blacksand Spit in the Situk River estuary, the outer beaches of the Yakutat Forelands, Dry Bay and perhaps Lituya Bay on the outer coast of Glacier Bay National Monument (Isleib and Kessel, 1973; Sowls et al., 1978; Walker, 1920, 1923).

b. Concentrations:

i. Natural: Increased numbers of Aleutian Terns have been noted within the last few years as more investigators become familiar with the Alaska coastal environment. Colonies have recently been located on the east and west sides of the Copper River Delta and in the Yakutat area (Mickelson et al., 1980; Holtan, 1980; Patten, this report). Isleib and Mickelson reported a very large colony (2,000+ adults) in the Bering River/Controller Bay area in 1976. Patten and Primrose found the world's largest reported concentration of Aleutian Terns (3,000+ adults) on Blacksand Spit in the Situk River estuary near Yakutat in early July 1980. Approximately 500 Aleutian Terns were counted elsewhere in the Yakutat area.

Aleutian Terns were present in scattered pairs along the entire Situk - East River beach dune system southeast of Yakutat. Other small colonies were found on small islets in the lee of Khaantak Island on the east side of Yakutat Bay, and along the sandy beach between the mouth of Ankau Creek and Point Carrew near Monti Bay. Aleutian Terns were observed feeding at the mouth of Aquadulce Creek in Disenchantment Bay 50 km north of Yakutat. Additional colonies of Aleutian Terns are expected in the Yakutat area.

The northeast Gulf of Alaska may provide important breeding and feeding grounds for Aleutian Terns in North America; indeed it may be the current world center of their distribution.

7. HABITAT:

a. Type: Aleutian Terns breed near lagoons, river mouths, and on islands. Most are pelagic in summer and all are pelagic in winter. Colony sites are situated in vegetation ranging from very early successional stages to later developmental stages. Early seral stages compose an important part of the nesting distribution on the west side of the Copper River Delta (WCRD) (Holtan, 1980). Other areas on the central and eastern portions of the Copper River Delta represent successional stages ranging from marsh to early upland (Mickelson et al., 1980). Typical nesting sites on the Copper River Delta are located within a vegetated strip between the tidal mudflat and the inland region of dense shrubs and Sitka Spruce *(Picea sitchensis)*.

Vegetation on Blacksand Spit near Yakutat is predominantly strawberry *(Fragaria chiloensis)*, yarrow *(Achillea borealis)*, red fescue grass *(Festuca rubra)*, indian paint-brush *(Castilleja unalaschensis)*, beach sandwort *(Honckenya peploides)*, beach pea *(Lathyrus maritimus)*, and a few alder bushes *(Alnus crispa var. sinuata)*. Aleutian Terns on Blacksand Spit nest in open *Castelleja unalaschensis* and in sparse beach rye *(Elymus arenarius var. mollis)*. Arctic Terns nesting in the same general area on Blacksand Spit prefer to nest among drift logs in open sandy areas.

8. LIFE HISTORY:

a. Social Behavior: Colonial nesting, with colony size highly variable, ranging from pairs to several thousand pairs. Feeds solitarily or in small aggregations. Rests on open sandy areas, exposed river bars, and on gravel banks of low delta island adjacent to colonies.

Little is known of the non-reproductive social behavior of Aleutian Terns. The birds depart for the high seas immediately after the breeding season.

b. Biological Associations: The Arctic Tern is numerically the most important species with which the Aleutian Tern shares its nesting areas. The two species are usually found together on the breeding grounds. Aleutian Terns also often nest in proximity to Mew Gulls, Semipalmated Plovers, Savannah Sparrows, and a variety of other species with similar nesting habitat preferences. Parasitic Jaegers may nest near Aleutian Terns and force the terns to divest themselves of fish destined for their young.

c. Nutrition

i. Feeding type: small predator and piscavore

ii. Food: small fishes and crustacea such as anadromous sticklebacks *(Gasterosteus aculeatus)*, salmon smolts *(Oncorhynchus nerka* and *O. gorbuscha)*, stichaeids, sandlance *(Ammodytes hexapterus)*, shrimp and large pelagic zooplankton such as *Thysanoessa* (Holtan, 1980; Day, Univ. of Alaska, pers. comm.). In addition, opportunistically takes a wide variety of insects, including dragon flies (Aeschnidae).

iii. Feeding Behavior: Feeds by dipping and plunge-diving at or near the surface of the water. Insects are taken on the wing.

iv. Feeding Location: Nearly exclusively marine feeders, from inshore to oceanic areas near the shelf-break. Definitely more coastal and marine-oriented than the Arctic Tern, which also nests and feeds on inland lakes, rivers, and ponds. Mickelson et al. (1980) did not observe Aleutian Terns fishing in fresh water on the East Copper River Delta (ECRD). Batten et al. (1978) did not observe Aleutian Terns over freshwater ponds a few kilometers inland from Blacksand Spit. Aleutian Terns were only rarely seen fishing in the freshwater ponds on the west side of the Copper River Delta (WCRD) (Holtan, 1980). Holtan (1980) frequently observed Aleutian Terns on the WCRD flying towards the ocean and returning to colony areas carrying food items. Local fishermen reported to Holtan that Aleutian Terns forage along the edges of offshore channels and within the shallows of sandbar barrier islands 0.4 to 9.7 km from the vegetated edge of the Copper River Delta. Aleutian Terns, sighted at sea during June 1971, 50-120 km offshore from Lituya Bay, appear to have been pelagic feeders from colonies on shore (Kessel and Gibson, 1978).

d. Reproduction:

i. Mode: Sexual with internal fertilization.

ii. Location: Near lagoons, river deltas and bars, on coastal island and spits, and on partially vegetated dunes near marine beaches.

iii. Behavior: As nesters, Aleutian Terns are highly colonial. Single pairs of the species have not been found but the colonies are usually neither large nor densely packed (Mickelson et al., 1980). Density of nests averaged 84.3/ha and ranged from 36.9 to 151.9 nests/ha on the West Copper River Delta (WCRD) (Holtan, 1980). The Aleutian Tern colony at Blacksand Spit included a land area approximately 15 km - 400 m; 1500 nests/6 km^2; thus 250 nests/km^2 = 2.5 nests/ha (Patten, this report). This density is considerably lower than the nesting density of some of the other species of terns (Holtan, 1980). Larger colonies of the Aleutian Tern have more nests, lower densities and greater average nearest neighbor distance than colonies small in area (Holtan, 1980).

Mating behavior of the Aleutian Tern has been little studied. Several pairs of Aleutian Terns were observed mating on the outer sandy beaches of Strawberry Reef, Copper River Delta, on May 7, 1979 (Hawkings and Herter, Univ. of Alaska, pers. comm.).

iv. Biology: Nesting Aleutian Terns prefer high density cover in areas of low density vegetation. They avoid very wet sites, bare ground, and shrubs. Dispersion of nests within colonies and within vegetation zones appears largely random (Holtan, 1980).

The first Aleutian Tern nest reported in recent years at Dry Bay was found by Patten on 25 May 1977 on a river bar, which also supported nesting Mew Gulls and Arctic Terns. At least several pairs of Aleutian Terns were nesting on the periphery of the vegetated portion of the gravel bar. The nest specifically identified as Aleutian Tern (and photographed with two eggs and chicks) was surrounded by moss, small sticks, dwarf willows *(Salix arctica)* and the milk vetch *(Astragalus alpinus)*.

e. Development: Two, occasionally three eggs, is the usual clutch size for Aleutian Terns. The incubation period is reported as 17-21 days (Bent, 1921). The species is reported to raise one brood a season. Apparently no attempt is made to raise a second brood if the first is destroyed. On St. Michael, Aleutian Terns rarely lay eggs before 5 June; the usual egg-laying dates are from 23-28 June. Young are usually hatched from the late of June to the first of September. The first young are fledged by the last of July, although occasional eggs have been found with well developed embryos on 1 September (Bent, 1921).

The first Aleutian Tern chicks were found in the Dry Bay colony on 1 July. The first young were seen flying in late July. Aleutian Terns remained at Dry Bay through late July 1977 and late August 1980 (pers. obs.). In 1977 additional numbers of nesting Aleutian Terns (200 pairs) were observed over a wide area of the gravel bars of upper Dry Bay, although lesser numbers (50 pairs) were observed in 1980.

Holtan (1980) found nest success uniformly high (80%) in six of seven colonies examined on the West Copper River Delta, with nests producing an average of over 1.2 chicks hatched per nest. Aleutian Terns on the East Copper River Delta (ECRD) nested both in occasionally flooded saltgrass meadows and in freshwater wet meadows in open locations. These colonies were recently established since the areas were regularly flooded prior to the 1964 earthquake. Clearly, not all available nesting habitat is currently used by Aleutian Terns on the ECRD (Mickelson et al., 1980).

Aleutian Terns on the ECRD generally initiated nesting slightly later than Arctic Terns, and did not appear as highly synchronous as

Arctic Terns. Nesting success was 74% and 71%, respectively, for Aleutian Tern nests in 1978 and 1979 (Mickelson et al., 1980). These figures lie between the rates of success for open habitat colonies (80.5%) and a colony in a shrubby area (56%) found by Holtan (1980) on the West Copper River Delta.

Most terns raised their young to flight stage in the immediate area of the nesting colony. After fledging, young Aleutian Terns remained with adults in the immediate vicinity of the nesting colony on the upper Dry Bay gravel bars until late August 1980 (Patten, this report).

f. Growth: Since no young Aleutian Terns in immature spring plumage have ever been taken on the breeding grounds, the young probably do not breed during their first year; or alternatively they have acquired full nuptial plumage by this time (Bent, 1921). Adults are the size of an Arctic Tern. Life duration is unknown.

g. Movements: No evidence of onshore coastal migration exists. The birds apparently arrive and depart nesting areas directly to and from the high seas. In spring, Aleutian Terns arrive onshore earlier in eastern areas (20 April, Copper River Delta; 30 April, Kanak Island) than in western and northern areas of Alaska (18 May, Adak; 20-30 May, St. Michael; 7 June, Kotzebue) (Herter, pers. comm.; Bent, 1921; Kessel and Gibson, 1978).

9. FACTORS INFLUENCING POPULATIONS

a. Natural: Both habitat changes and disturbance factors may have significant effects on the distribution, population levels, and reproductive success of terns (Austin, 1940, 1946, 1947, 1949; Hawksley, 1957). Dramatic natural changes occurring in the ecology of the Copper River Delta since the 1964 earthquake (+2 m uplift and subsequent vegetation shifts) may have allowed a rapid population expansion of Aleutian Terns or brought about important alterations to their breeding distribution in that region. Colonies are now located in portions of the delta which were previously unsuitable for nesting terns. Alternatively, shrub invasion of parts of the Copper River Delta may make extant Aleutian Tern colony areas not suitable for nesting with the passage of time (Holtan, 1980).

However, Aleutian Terns exhibit an apparent tendency to abandon old colony sites and to colonize new sites. The reasons for this behavior are unclear, as are the reasons for the overall very patchy breeding distribution of Aleutian Terns. There must be certain factors in the ecology of Aleutian Terns which account for this unusually sporadic and ephemeral behavior. These reasons are not yet known.

Walker (1923) first reported the Aleutian Tern colony on the Situk Flats near Yakutat. He found a few nests and saw a considerable but unspecified number of adults in 1922. T. M. Shortt (1939) reported the complete absence of the Aleutian Tern colony on the Situk Flats in 1936. Shortt and companions, fully aware of Walker's discovery, visited all tern colonies in the lower Situk region and closely scrutinized the adults, but saw and collected only Arctic Terns. Gabrielson and Lincoln (1959) considered this apparent desertion of a colony site to be of special interest, especially in relation to the remarks of Bent (1921) and Friedman (1933). Bent (1921) suggested that *aleutica* is Asiatic in origin and that the Alaskan colonies are sometimes of a temporary nature. Friedman (1933) reported a similar desertion of a colony on Kodiak Island and the appearance of one at Goodnews Bay.

Mickelson (1975) also did not record Aleutian Terns in the Yakutat areas on 8-10 May 1975 (although this was probably too early in the season for Aleutian Terns). Mickelson and Isleib recorded these terns as abundant in the colony near the Bering River at Controller Bay. Murphy and Batten also did not record Aleutian Terns in the Situk estuary during 23 June - 3 July 1977 (Batten et al., 1978), although Murphy (pers. comm.) stated that their investigation was limited to the area immediately north of Blacksand Island and that they did not visit Blacksand Spit. Thus the history of the Aleutian Tern colony in the Situk estuary is a checkered one, first reported by Walker (1923), not found although looked for by Shortt (1939), and found again independently by Patten and Primrose, who spent three days examining the colony in 1980.

M. Peterson (USFWS) estimated 1500 terns over Blacksand Spit in a single pass in a small aircraft in early July 1980. Mr. R. Ball, Biologist with the Alaska Department of Fish and Game at Yakutat, confirmed the species identification and approximate size of the colony upon a second visit to the site with Patten and Primrose. Mr. Ball collected fourteen (14) Aleutian Terns and ten (10) Arctic Terns, under State of Alaska Permit, from Blacksand Spit and the mouth of Ankau Creek at Monti Bay near Yakutat. The specimens of both species (breeding adults, eggs, and a Aleutian Tern chick) are housed in the University of Alaska Museum (UAM), Fairbanks (UAM #'s 3784 - 3823).

Natural predation was evident in the tern colony on Blacksand Spit in 1980. Ravens, crows, and gulls preyed upon tern eggs, and Bald Eagles were observed taking Arctic/Aleutian Tern chicks. Coyote sign was noted in the colony, and there appeared to have been coyote dens in the immediate area. Predation on the terns by coyotes has been noted by Fish and Wildlife Protection officers and local pilots (1977-1978) (Robertson, Gulf Air Taxi, pers. comm.).

b. Man-related: Human disturbance and predation (i.e., egging) in the Aleutian Tern colony at Blacksand Spit were evidenced by vehicular tracks and destroyed nests and eggs. The synchrony of egg-laying and incubation by the terns in this colony appeared seriously affected. Random samples found eggs at all stages of incubation in early July, chicks of various ages in the nests, as well as a few recently fledged juveniles. The most serious disturbance to this colony appeared to result from the proximity of fishermen's cabins on Blacksand Spit, 3-wheeled motorcycle traffic, children, and dogs (Patten and Primrose, pers. obs.).

c. Potential: The biology of the Aleutian Tern is so poorly known that it is difficult to extrapolate from present knowledge. There are probably more Aleutian Terns than presently known, and additional research will probably locate more colonies and larger numbers of individuals. Aleutian Terns may be increasing in many places along the southern and western coasts of Alaska (Kessel, pers. comm.). However, it is apparent that the species is not common, abandons nesting colonies for unknown reasons, and that the largest known colony is seriously disturbed.

10. POPULATION SIZE:

Worldwide:

A. Siberia - unknown

B. Alaska - approximately 12,826 individuals known

Chukchi, Bering, Aleutian coasts: 1,698 individuals

Gulf of Alaska: 11,128 individuals

Kodiak: 2,000

Copper River Delta: 3,328

Bering River/Controller Bay: 2,000+

Icy Bay: 300

Yakutat area: 3,500

11. MANAGEMENT:

The primary management requirement for this species is for more information. For instance, how long has the disturbance of the colony at Blacksand Spit continued? It has been suggested that subsistence egging of the colony at Blacksand Spit dates back at least to the turn of the century, and thus is of no consequence since the terns are still there (Brogle, pers. comm.). Alternatively, is the presence of Aleutian Terns in the Yakutat area a comparatively recent phenomenon, resulting from tectonic changes and subsequent vegetation shifts, as on the Copper River Delta? What are the factors which cause such large concentrations of Aleutian Terns in the Northeast Gulf of Alaska, especially as compared to the Bering Sea, where a colony of ten individuals is considered of note? What is it about the behavior of this species that causes abandonment of sites and colonization of new ones? Such management requirements for the most basic information also dictate future research problems and needs, which are seen as similar to the considerations cited above.

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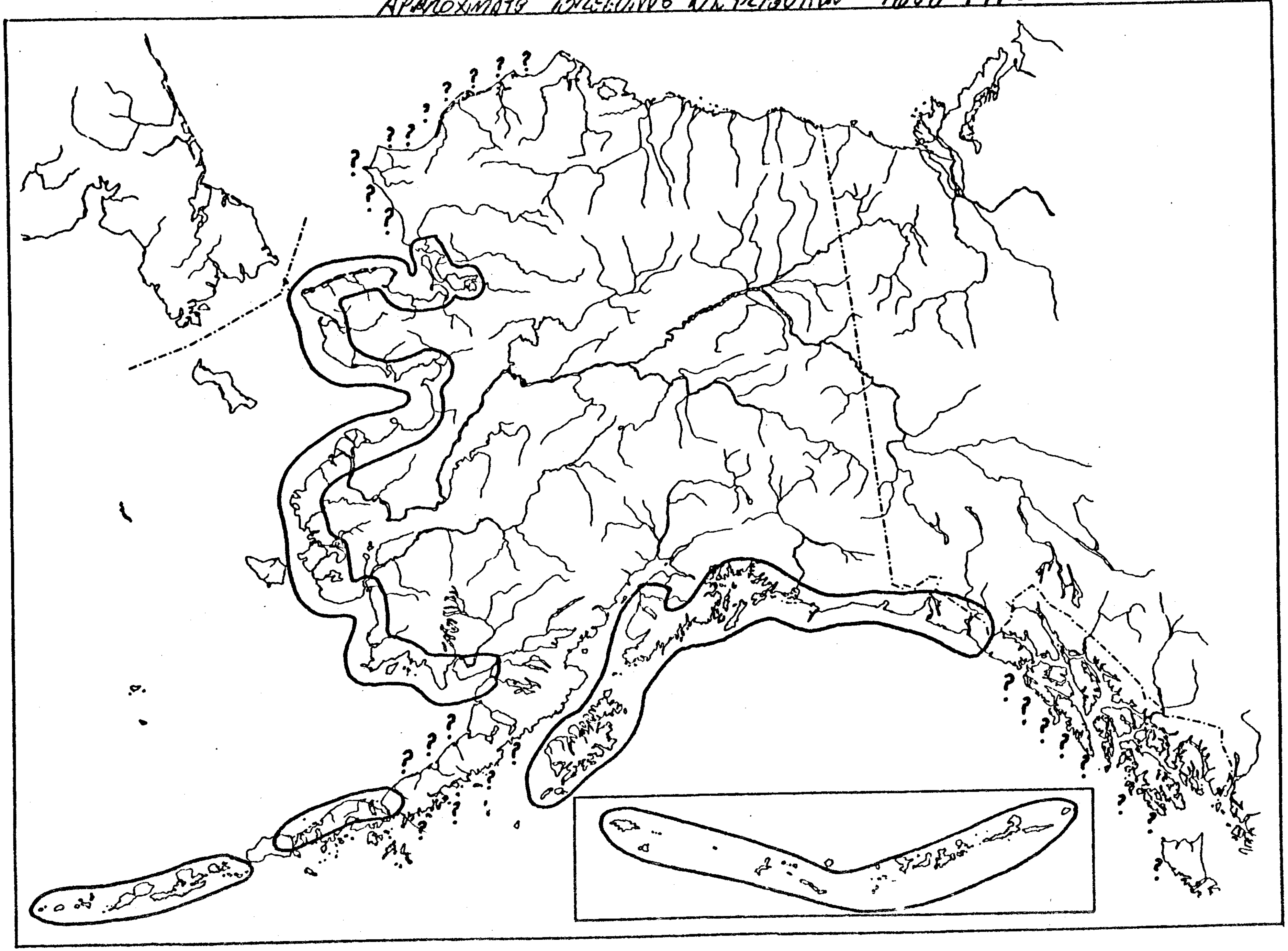
Credit: B. Gill, USFWS

Approximate Breeding Distribution 1868-1976



APPENDIX III

GLAUCOUS-WINGED GULL SPECIES ACCOUNT

Appendix III

Glaucous-winged Gull Species Account

1. CATEGORY: Birds: Seabirds

2. CLASSIFICATION:
   Class: Aves   Order: Charadriiformes   Family: Laridae
   Subfamily: Larinae

3. NAME: Glaucous-winged Gull *(Larus glaucescens)* Naumann
   This is the commonly known "seagull" of the Pacific Northwest, southern coast of Alaska, the Aleutian Islands, and Bristol Bay.

4. LEGAL STATUS: Protected under Migratory Bird Treaty Act of July 3, 1919, 40 Stat. 755, Amended. Widely regarded as a "trash" bird and rumored to be shot frequently. Said to be used as crab bait, especially around Kodiak Island.

5. RANGE:

a. Worldwide: The Pacific Coast of the United States, Canada, and Alaska, including the Aleutian Chain to the Commander Islands (USSR). Winters as far south as Japan and Mexico, including the North Pacific Ocean.

b. Region of Concern: Widespread in western and southern Alaska, reaching as far north as Point Barrow.

6. DISTRIBUTION:

a. Discrete Populations: Breeds along the Pacific Coast from Washington State north to Norton Sound, Alaska and west along the Aleutian chain to the Commander Islands. There are nesting records from as far north as St. Lawrence Island, Nunivak Island, and the Pribilofs.

b. Concentrations: The western shore of Nunivak Island; the northwest shore of Kuskokwim Bay; the north shore of Bristol Bay; the Alaska Peninsula, Bulder Island (Western Aleutians), Kodiak Island, the southeast side of the Kenai Peninsula; Prince William Sound, and the sandbar barrier islands off the Copper River Delta. Exceptionally large colonies are found near Port Moller and on northwest side of the Alaska Peninsula and on Egg Island south of Cordova, off the Copper River Delta. Outside the breeding season, concentrated at sources of natural and artificial food, i.e., on salmon and eulachon runs, near onshore fish processing plants, offshore factory ships and trawlers, and ever-present at garbage dumps and disposal sites.

7. HABITAT:

a. Type: The Glaucous-winged Gull is a ubiquitous coastal and marine scavenger, particularly oriented towards littoral and intertidal environments, although following major rivers and salmon streams inland. Also found pelagically in winter, hundreds of kilometers from mainland shores.

b. Physical/Chemical: Breeding populations of Glaucous-winged Gulls are generally confined to coastal environments. Preferred nesting sites are open grassy hillsides of islands, although nesting habitat selection is flexible and includes flat gravel bars, sand dunes, and cliff faces. Otherwise, the species is robust, instrusive, and adaptable to a variety of natural and artificial settings, including highly urbanized environments.

8. LIFE HISTORY:

a. Social Behavior: The Glaucous-winged Gull is an aggressive and colonial species, exhibiting much inter- and intraspecific antagonism. Predatory on other species of seabirds and at all times opportunistic in food habits. Hybridizes with Western Gulls *(Larus occidentalis)*, Herring Gulls *(L. argentatus)*, and Glaucous Gulls *(L. hyperboreus)*. The Glaucous-winged Gull is a generalist, filling the role of an opportunistic scavenger outside the breeding season. The species capitalizes on environmental disturbances, particularly in the form of large-scale fisheries producing large amounts of organic waste. The resulting food supply enhances the survival of coastal gull populations, and numbers increase explosively within relatively few generations. Hybridization increases the genetic variability within these gull populations and provides additional opportunities for rapid evolution into new niches, i.e., urban environments and sources of artificial food. This species also exhibits a tendency to pioneer into new natural environments, e.g., newly deglaciated areas. Continued rapid development in coastal Alaska, particularly of fisheries and petrochemical industries, will lead to increased contact between *Larus* populations, assist in the survival of hybrid forms, facilitate gene flow between colonies, and after a period of enhanced variability, may even lead to a new adaptive peak in these commensal gulls.

b. Biological Associations: Typically independent on other species for survival; associates freely with other species of scavengers, such as ravens, crows, magpies, and brown bears.

c. Nutrition:

i. Feeding Type: Omnivorous scavenging, surface-seizing predator.

ii. Food: Gulls scavenge the intertidal and sea-surface for a wide variety of food items, including cast-up larger fishes, sessile invertebrates, and dead marine mammals. Gulls also take small fishes from intertidal pools and capture other small fishes from at or near the surface of the water. Gulls also scavenge seal placentae. Lists of natural food items would be almost meaningless and would include almost all macro-species consumable. Artificial food sources include garbage, sewage, and concentrations of fish offal around processing plants.

Continued access to food resulting from human activities will increase gull numbers in Alaska. This food supply is not likely to decrease with further industrial development in Alaska. Gulls exploit artificial food because of a natural plasticity in food selection and a dichotomy of foraging pathways. Gull populations in Alaska currently exhibit both food selection under natural conditions, and response to artificial food supply.

iii. Feeding Behavior: Characteristically feeds in circling flocks over fish schools and offal on the surface of the water; also feeds socially, although with much intraspecific antagonism and territoriality, on stationary sources of food such as spawned-out salmon and garbage. Single individuals also patrol the intertidal for anything edible. Takes eggs and chicks of other seabirds.

iv. Feeding Location: Literally anywhere where food is available, including coastal and marine environments, salmon streams, large rivers near the coast, the intertidal, garbage dumps, sewage outfalls, and pelagic regions. Will dive to at least several decimeters below the surface of the water. Rests between feeding on land, water or ice. Predatory in seabird colonies.

d. Reproduction:

i. Mode: Sexual, internal fertilization, dioecious, with strong pair bonds.

ii. Location: Nests on steep rocky cliffs, sloping grassy hillsides, sand dunes, and flat gravelly islets, from 0 to 50% slope. Prefers to nest on islands, but will also nest on exposed mainland knolls and cliffs. Adaptable and flexible in nesting habitat selection, also including on rooftops and pilings. Favored sites are grassy island slopes. Renews or initiates pair bonds on open resting areas ("clubs") adjacent to colonies. Copulation in "club" area or on nesting territory.

iii. Behavior: Mates assortatively, with individuals choosing mates similar to themselves in external appearance, although exceptions are frequent. Occasionally selects mates of widely different phenotypes ("species", e.g., Herring Gull, etc.) forming mixed pairs with other gull species and apparent backcrosses. Usually nests colonially, with colony size from a few pairs to as many as 10,000 pairs (Egg Island, near Cordova, Alaska). Nesting territory of individual pairs is irregular in shape and size, depending upon stage of the reproductive cycle, expanding with the hatching of chicks, and declining as chicks grow older. Largely monogamous. Vulnerable to human disturbance during incubation and especially during the chick stage, when chicks frightened by human instrusion flee from their parent's nesting territories into areas defended by other adult gulls. Chicks are often killed by other gulls at that time. Otherwise, gulls habituate readily to human presence (if not shot at), although they are usually wary of close approach.

iv. Biology: Glaucous-winged Gulls appear on colony sites in February and March, even resting on snow if present. Territorial activities proceed as the snow melts and visual cues to borders become evident. Egg-laying occurs in mid-May to late June, with copulation immediately preceeding egg-laying. Dates of egg-laying are determined approximately within the season by the cessation of snow cover and the construction of nests. Thus, timing of breeding is flexible from year to year, although most colonies are synchronous in egg-laying once the process has begun. Incubation does not begin until after the clutch is completed, usually about a week after the first egg is laid. Chicks hatch in mid-June to late July and are fledged in early August to September. Glaucous-winged Gull colonies are empty by early September as juveniles and adults disperse, usually to salmon streams.

e. Development: Clutch size in the Glaucous-winged Gull is two to three eggs. Hatching success is usually 60 to 80 percent. Critical factors affecting hatching and fledging rate are chick and egg loss through cannibalism, chick mortality because of aggressive behavior of adults, and weather conditions during the breeding season. Incubation requires approximately 26 days; fledging requires approximately 40-45 days of parental care and feeding. Gulls are more vulnerable during the chick stage than at any other time, and are sensitive to abrupt temperature changes or prolonged high or low temperatures. Many chicks die of exposure with temperatures near freezing with rainfall occurring. Parental care ceases soon after fledging, and the cessation of parental care is followed by another sharp rise in juvenile mortality. First breeds at age four; three sub-adult age (year) classes. Chicks are raised within the nesting territory, but as they become capable of flight, disperse to "club" areas where fed by parents. Recently fledged juveniles may accompany parents for a brief period.

f. Growth: Rate of growth to fledging stage is rapid, requiring 40-45 days to reach nearly adult size and weight. Sub-adult age classes are readily distinguishable by dark grey-brown plumage. The plumage becomes lighter each year to age four, at which time the birds reach adult coloration (white with grey mantle). Adult males weigh 1,200-1,400 grams, and adult females 900-1000 grams. Once adults, gulls are typically quite-long lived, reaching ten years or more.

g. Movements: Some individuals remain within the range of the species throughout the year, although most withdraw from the ice-covered regions of the Bering Sea in winter. Abundant in the Aleutians, i.e., Dutch Harbor, especially in winter. Also winters along the Pacific Coasts of North America as far south as Baja California, the Gulf of California, and Sonora. Major wintering areas in North America are Puget Sound and San Francisco Bay. Pelagic in winter off southern California. Also occurs in winter from Bering Island to Kamchatka, the Kurile Islands, and Hokkaido. The species is classified as partially migratory, with a seasonal shift southward of some populations, especially juveniles, in fall and winter. The North American population migrates along a pathway closely following the "Inside Passageway" of southeastern Alaska and British Columbia. Fall migration takes place in September, October, and November, and is followed by a reverse migration in February, March and April. Banding results indicate juveniles straggle widely within this framework. Third-year (non-breeding) juveniles typically arrive at their natal colonies in late May, by which time the adults are fully into their reproductive process. Philopatry (return to colony of origin) is developed within the species as a behavior pattern but by no means exclusively so.

9. FACTORS INFLUENCING POPULATIONS:

Similar to those affecting the closely-related Herring Gull populations on the East Coast of the United States, in Britain and Europe.

a. Natural: Under natural conditions this species is probably limited by food availability and territorial spacing in nesting colonies. Natural infertility rate is low. Hatching success is frequently (not always) high. However, aggressive territorial interactions and cannibalism account for often high mortality of chicks. Also, considerable mortality of recently fledged juveniles occurs during the first year after dispersal from natal colonies, particularly during the winter. Gulls have few natural enemies: ravens, crows, and jaegers, as well as other gulls, take eggs; Bald Eagles take chicks, juveniles, and adults. However, this predation is not significant at the population level.

b. Man-related: The Glaucous-winged Gull is pre-adapted to disturbed environments and to utilize artificial food. It is a rapidly-reproducing "weedy" commensal nuisance species. It is adaptable, and able to withstand and take advantage of changes in the environment. The carrying capacity of this species is enhanced by development activities, leading to undesired side-effects. This and other nuisance species show marked changed associated with the rapid industrial expansion and resource development occurring in Alaska and around the Northern Hemisphere. This commensal species inhabits ecological niches that are directly or indirectly the results of human activities. The most important artificial niches for this species are garbage dumps, sewage outfalls, and concentrations of fish offal.

Previous studies on the East Coast of North American indicate nuisance species, especially gulls, increase rapidly with access to garbage, sewage, and refuse associated with the secondary effects of economic development. Continued access to artificial food resulting from human activities will increase numbers of undesired commensal species such as Glaucous-winged Gulls in Alaska. There are at least three serious aspects of unnaturally inflated gull populations in Alaska as elsewhere. First, gulls are both a public health and public safety hazard. Glaucous-winged Gulls have been demonstrated to be vectors of human pathogens in an outbreak of *Salmonella* poisoning, in which over 100 persons sought medical treatment. Gulls have also been involved in numerous bird strikes to aircraft, resulting in multiple-fatality crashes. Secondly, gulls are opportunistic, efficient predators on other avian species, threatening the population stability of Alaskan seabirds and waterfowl.

Gulls, which survive winters in unusually high numbers because of the availability of garbage, harass other birds during the breeding season, rob the parents of food destined for young, prey upon eggs and young, and usurp vital nesting areas. The unanesthetic sight of large flocks of gulls hovering above garbage dumps is an example of the third aspect of unnaturally inflated gull populations. The rapid increase in gull populations in the North Atlantic and Alaska regions in recent years has caused both disquiet to civil authorities and alarm to conservationists.

c. Potential: Artificial food supplies are not likely to decrease with further industrial and economic development in Alaska. Domestic and industrial development activities will generate large volumes of solid comestible waste in unnatural settings, precisely the sort of environment that facilitates explosive increases in juvenile gull survivorship. Sufficient knowledge of the situation is not yet available to measure the true dimensions of the nuisance species problem in Alaska. However, the above reasons to predict that a secondary effect of economic development in southern and western Alaska will be increasing populations of nuisance species such as Glaucous-winged Gulls near solid waste disposal facilities and human habitations, with negative public health and public safety implications.

10. POPULATION SIZE:

The Catalog of Alaskan Seabird Colonies (Sowls, Hatch, and Lensink, 1978), recorded a total of over 229,000 Glaucous-winged Gulls at 547 sites in Alaska. The actual statewide population is probably upwards of 500,000 birds. Nelson Lagoon is occupied by about 13,000 Glaucous-winged Gulls nesting on several sandbar barrier islands. Egg Island off the Copper River Delta supports at least 20,000 gulls. Approximately 31,000 Glaucous-winged Gulls breed on the north shore of the Alaska Peninsula and northward to Nunivak Island, while more than 27,000 individuals are known to breed in the Aleutians (Sowls, Hatch, and Lensink, 1978). This is a very low figure, most birds have not been censused (Day, pers. comm.).

11. MANAGEMENT:

Inadequate forethought and ecological understanding of abundant nuisance species such as the Glaucous-winged Gull have cost state and federal governments significantly in the past. Statewide, Alaskan large gull populations may be on the verge of explosive population growth, as happened along the Atlantic seaboard earlier this century. Gull control methods have included scare devices at airports to complete overhaul of solid waste disposal techniques. There have been health care costs from epidemiological problems related to drinking water contamination.

Man subsidizes these well-adapted scavengers to the point where they are endangering smaller, more desirable avian species. Urban landfills should be strictly controlled, and the dumping of fish offal tightly regulated. The development of foreign-flag, high seas factory ship fisheries, which process millions of kg of fish offal, also poses a significant problem for future management of large gull populations in Alaska. Various suggestions have been made for control of gull population, and none have been satisfactory to date. However, gull control is a symptomatic treatment of the larger problem of waste disposal, which is the true source of gull population growth.

12. PERSONS CONSULTED:

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APPENDIX IV

EULACHON SPECIES ACCOUNT

Appendix IV
Eulachon Species Account

1. CATEGORY: Fish

2. CLASSIFICATION:
   Class: Osteichthyes   Order: Clupeiformes   Family: Osmeridae

3. NAME: Eulachon *(Thaleichthys pacificus)* Richardson, 1936
   Widely known as "hooligan." Also called Candlefish because when dried may be fitted with a wick and used as a candle (Hart, 1973).

4. LEGAL STATUS: Take in Alaska is regulated by the Alaska Department of Fish and Game, Sport Fish Division, under the Sport Fishing Regulations, Title 5, Part 2: 5 AAC 75.030; 5 AAC 61.020, and Commerical Fishing Regulations, Title 5, Part I (State of Alaska, 1981). In northern British Columbia the eulachon is protected against commercial exploitation, which means essentially it is reserved for Native subsistence use. The eulachon is harvested commercially in southwestern British Columbia (Hart, 1973).

5. RANGE:

   a. Worldwide: Known from the Russian River, California (38.20 N) through Oregon, Washington, British Columbia and Alaska.

   b. Region of Concern: Pelagic off southeastern Alaska, throughout the Gulf of Alaska, to the eastern Bering Sea and near the Pribilof Islands (Hart, 1973; Scott and Crossman, 1973).

6. DISTRIBUTION:

   a. Discrete Populations: Abundant in spring in rivers and streams within its range. Mixing between populations using different spawning streams is not extensive since there are both significant differences in meristic characters between various river populations (Hart and McHugh,

1944) and differences in the timing of spawning runs.

b. Concentrations:

i. Natural: The eulachon is an anadromous smelt that moves short distances, in dense concentrations, in order to spawn in coastal freshwater streams, often just as the ice is breaking up.

ii. Commercial: A single commercial fishery on the spawning run in the lower reaches of the Fraser River in British Columbia averaged 100 metric tons annually in the years 1941-1970.

7. HABITAT:

a. Type: Spawns mainly in large mainland rivers, and a few rivers of intermediate size, in British Columbia, but in the Yakutat area of the northeast Gulf of Alaska, spawns in relatively small streams near coastal beaches.

b. Physical/Chemical: Eulachon will run up turbid rivers for short distances in order to spawn in clear streams. Young and maturing eulachon are taken in mid-water oceanic trawls (Barraclough, 1964; Barner et al., 1979).

8. LIFE HISTORY:

a. Social Behavior: The eulachon is an abundant small schooling fish found mostly offshore in midwater levels, i.e., in the echo-scattering layer. They remain in the depths of their spawning migration until very close to the mouths of rivers. Those adults that survive their spawning migration spend very little time in fresh water.

b. Biological Associations: The importance of the eulachon as a forage fish has been largely overlooked in the literature. Apparently the eulachon plays an important part in nearshore marine ecological cycles. For instance, eulachon runs account for the greatest concentrations of birds (other than migration) for up to five months of the year (during late winter and spring) on sections of the Alaskan coastline.

The concentrated spawning runs attract great numbers of predatory fish, marine mammals and marine birds.

c. Nutrition:

i. Feeding Type: The pelagic adults are predatory on small oceanic crustaceans. Eulachon larvae and post larvae "graze" both on phytoplankton and act as micropredators on zooplankton (Scott and Crossman, 1973).

ii. Food: The food of the smallest feeding eulachons is copepod larvae. Larval and post-larval eulachons (25 mm to 50 mm in size) feed on phytoplankton, copepod eggs, copepods, mysids, ostracods, barnacle larvae, cladocera and worm larvae, as well as smaller larvae of their own species. Juvenile and adult eulachon in the sea feed primarily on euphausiids, copepods, and cumaceans. Feeding ceases when they enter fresh water for spawning (Barraclough, 1967; Scott and Crossman, 1973).

iii. Feeding Behavior: Eulachon feed in schools on the plankton and presumably move up and down in circadian patterns with the echo-scattering layer.

iv. Feeding Locations: 1) In food-rich mid-water oceanic echo-scattering layers; 2) in pelagic regions near the surface, and 3) off mouths of large rivers.

d. Reproduction:

i. Mode: Sexual and dioecious, with external fertilization.

ii. Location: The spawning migration lasts from late February to early June, depending upon location. Not all streams in the same geographic area will support spawning runs of eulachon at the same time, but the runs will continue in the same general area over a period of months.

iii. Behavior: Males predominate early in the runs and appear to be more numerous at all times than the females, which arrive later (Hart, 1973). Spawning behavior takes place over coarse sand. Water temperature at spawning time is 4°-8° C. No nest is built; the eggs are scattered and abandoned. Females between 145-185 mm produce an average of 25,000 eggs. The eggs are irregular in shape and vary in size from 8 to 10 mm in diameter. The eggs are adhesive and stick to the coarse sand particles. Most adults die after spawning but a few survive, return to the sea, and may return to spawn a second time (Hart, 1973; Scott and Crossman, 1973). Mending spent fish are taken by trawlers off the mouth of the Fraser River in British Columbia.

iv. Biology: The exact cues which set off the spawning runs are unknown but appear to be variable, since there are differences in timing of the spawning runs of eulachon to adjoining rivers. There may be repeated spawning runs to the same river. The spawning runs appear to be related to the season, and to be proximally determined by the amount of ice in the spawning streams, at least initially.

e. Development: The eggs of the eulachon are deposited on sand grains on river bottoms and attach by means of an adhesive secondary egg membrane. The eggs take about 2-3 weeks to hatch. The newly hatched young are about 4-5 mm long; they are slender, transparent, and closely resemble young herring. The larvae, which are feeble swimmers, drift downstream and out to sea shortly after hatching. Alternatively, the larvae may remain in nearshore sounds, straits, and fjords, but growth is apparently less rapid than those which become oceanic.

f. Growth: Young eulachon in saltwater in April average 23 mm long; by December they have grown to 46-51 mm in length. The offshore stage of the eulachon was once regarded as a separate species because the teeth are large (Hart, 1973; Scott and Crossman, 1973). As the young eulachon grow, they move into deeper water and are most often caught by trawls in the echo-scattering layer. Developing sexual maturity is first observed in late Summer and early Winter when eulachon are two years old. First spawning occurs in late Winter when the fish have become three years old. Most eulachon die after spawning in their third year. Apparently some individuals live as long as five years and survive the spawning runs. 22 cm would appear to be the average maximum length.

g. Movements: The movement of the third year (recently mature) individuals in vast schools in their spawning runs from pelagic regions to short, clear mainland streams is a distinct migratory movement from February to June and is typical of this species.

9. FACTORS INFLUENCING POPULATIONS:

a. Natural: Eulachon constitute an important food item for a wide variety of secondary and tertiary consumers (predators), especially when eulachon concentrate in vast numbers during the spring spawning migrations. Reported at that time as the principal food of the spiny dogfish *Squalus acanthias)*; white sturgeon *(Acipenser transmontanus)*, the various Pacific salmon *(Oncorphynchus spp.)*, Pacific halibut *(Hippoglossus stenolepis)*, Pacific cod *(Gadus macroephalus)*; such marine mammals as harbor seals *(Phoca vitulina)*, Steller's sea lions *(Eumetopias jubatus)*, Dall porpoises *(Phocoenoides dalli)*, finback whales *(Balaenoptera musculus)* and killer whales *(Orcinus orca)*, as well as such marine birds as the gulls *(Larus glaucescens*, *L. argentatus*, and *L. canus)*, kittiwakes *(Rissa tridactyla)* and Bald Eagles *(Haliaeetus leucocephalus)*.

At other times of the year, salmon *(Oncorhynchus spp.)*, Pacific hake *(Merluccius productus)* and fur seals *(Callorhinus ursinus)* feed on smaller eulachon offshore (Hart, 1973; Scott and Crossman, 1973; Outram and Haegele, 1972; Kajimura, Fiscus and Stroud, 1980).

Usually cold winters and frozen coastal streams may delay spawning runs and further concentrate spawning, allowing for more intense predation. Mild winters may permit attenuated spawning periods.

b. Man-related: Commercial harvesting and subsistence use of this species is unlikely to depress the population as long as breeding stocks are preserved. The species apparently has different genetic groups which breed in separate rivers and watercourses. Take of each group should be managed in order to preserve genetic diversity and separate spawning populations.

Severe pollution of mainland streams, either through chemical means or by increased turbidity, could eliminate local populations and decrease the genetic diversity of the remaining stocks. Eulachon resemble other anadromous fishes in this manner.

c. Potential: Increased industrial development in coastal Alaska, particularly by the oil industry, could damage spawning streams of this species, which requires clear-running streams with relatively unobstructed sandy bottoms.

10. POPULATION SIZE:

No figures on population sizes of eulachon are available, but the numbers must be very high. Most eulachon runs are not harvested commercially at present.

The fish was first taken commercially in 1877 for its oil. Preparation of salted and smoked eulachons developed later, reaching its peak about 1903, with over one million pounds sold salted and smoked, and one million pounds sold fresh. Since that time the eulachon has declined in commerical importance. Most of the catch today goes to fur farms. The eulachon is taken commercially with drift gillnets, principally in the Fraser River of British Columbia (Hart, 1973).

Use by Native peoples has always been highly important and governed by elaborate cultural frameworks. The Native fishery still exists and the number taken probably exceeds the commercial catch (MacNair, 1971).

11. MANAGEMENT:

Management of the species should be directed at the maintenance of water quality in coastal clear-running streams, the prevention of over-harvesting and the preservation of genetic stocks. The management concerns closely parallel those of salmon although the species is mostly of ecological and not commercial importance at the present time.

12. PERSONS CONSULTED:

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APPENDIX V

COMMERCIAL FISHING IN THE EAST (ALSEK) ESTUARY

Commercial Fishing in the East (Alsek) Estuary

The East Alsek estuary is heavily fished for salmon. The lower reaches of the estuary are worked by commercial (set net) gillnetters. Sockeye, chum, humpback and silver salmon are taken from the constantly changing channels of the lower river. The salmon schools exhibit non-directional movements in the changing channels until further upstream. Most silver (coho) salmon in the East River estuary are apparently oriented towards the Doame River, since there is no spawning of coho salmon along the East River. Sport fishermen take king and coho salmon from the estuary. Small flounders and sanddabs are common over the sandy bottom of the lower East River estuary.

The East Alsek proper supports an important sockeye (red) salmon spawning run. The spawning salmon are abundant in August and September. Salmon fry of several size classes are observed in the river in the spring.

A few (ca. 12) fishermen's cabins and tent frames, used during the salmon season, and one lodge (used for sport fishing and hunting during the autumn) are located on the north side of the East Alsek-Doame estuaries. The cabins and tent frames are clustered near the mouth of the East River and are abandoned during the late Fall and Winter.

APPENDIX VI

BROWN BEARS ALONG THE EAST ALSEK RIVER

Appendix VI

Brown Bears Along the East Alsek River

Brown bear sign is abundant along the East Alsek River in August and September. The bears feed on sockeye and chum salmon spawning in the stream. Bears were avoided, not studied. Bears do not restrict their feeding to the riffles, although fish were probably easiest caught there. In the Autumn, heaviest feeding occurs before 0900 hours and after 1830 hours. The bears retire an unknown distance from the river during the day. Certain recognizable bears are known to use the entire East Alsek River. Heavily used bear trails are located on both sides of the river. During our stay in the East River area, these bears did not exhibit any aggressive behavior towards man, although they did not readily flee, either. The bears do not associate man with immediate danger. Apparently these bears have little contact with humans and have been disturbed but little in the recent past.

The diet of the bears during the salmon spawning season is not restricted exclusively to salmon; they also feed on berries, graminoids, sedges, as well as insects. The roots of the milk vetch *(Astragalus)* are evidently dug from the open *Populus/Salix* forest stands in the Spring and early Summer months. Large areas within this forest type show signs of excavation by bears. This bear sign is especially dense in the Dangerous River - East Alsek regions.

There are apparent seasonal changes in the use bears make of coastal habitat among the Spring, Summer, and Autumn seasons.

APPENDIX VII

THE ROAD SYSTEM IN THE YAKUTAT AREA

The Road System in the Yakutat Area

The road system in the Yakutat area is limited. The following figures are given in miles instead of kilometers for ease of understanding.

The Yakutat road system is made up of three major branches. One road extends approximately 16 miles from the small boat harbor at Shipyard Cove in Yakutat southeast to Situk Landing, the beginning of the Situk estuary. The first five miles are paved; beyond the Yakutat Airport the final 11 miles are gravel.

Another gravel road goes southwest, connecting Yakutat village with a former radar station at Ocean Cape, a distance of approximately eight miles along the Phipps Peninsula and around the Ankau lagoons.

The gravel Harlequin Lake road (Forest Highway 10) extends northeastward from Yakutat village for 9.5 miles to the Situk River and then turns southeastward for 20.5 miles to the Dangerous River near Harlequin Lake. Forest Highway 10 does not now extend past the Dangerous River bridge, but could connect eventually to the Alsek River (Galacia, USFS, pers. comm.). Along the Harlequin Lake Road is old-growth Sitka spruce-hemlock forest. The minimum age of this stand is 200 years and it may be as old as 800 years, dating from the retreat of the Russell Fiord glacier. This continuous stand diminishes in size from west to east towards Harlequin Lake. There is one naturally open area near the Antlen River bridge (Mile 26) and several clear-cut areas near Yakutat village. The remainder of the area is forested. There are several major wildlife crossings over this road, notably around Mile 21. Black bear, glacier bear *(Ursus americanus emmonsii)*, brown bear, moose and wolves have been observed along this road (Barnett, pers. comm.). Ponds north of the Harlequin Lake road in the vicinity of Miles 25-26 contain northern pike *(Esox lucius)* the only location in southeastern Alaska where northern pike are found.

Between Miles 26-28, the spruce stand changes to cottonwoods and muskegs, and the cottonwoods and bogs continue to Harlequin Lake. The road crosses the upper Ahrnklin River at Mile 27.5. Along the road are at least four gravel pits used now as coho rearing ponds (Brogle, ADF&G, pers. comm.)

The east side of the Dangerous River to the Italio River is a projected timber sale area, scheduled to be cut in 1983-84. To date, no intensive field work has been completed by the Forest Service. It completed preliminary work in 1977. The cost of the road extension and the road location east of the Dangerous River have yet to be determined. The wildlife and habitat within a two mile radius of Harlequin Lake are of interest to the Forest Service because of the potential logging of this area (Barnett, USFS, pers. comm.).

There is evidence of seismic roads and of seismic activity carried out during previous oil explorations in the 1950's in both the Dangerous and East Alsek areas. There are the remains of an old road in the Upper Dangerous area, on the east side of the River, along the present trail which leads from the Forest Service Harlequin Lake cabins to the Middle Dangerous cabin. An old seismic road also connects the Lower Dangerous Forest Service airstrip to the Dangerous River estuary. The seismic roads in the East Alsek area form a network, now used by commercial fishermen transporting salmon by truck to a processing plant at Dry Bay. There is a discussion of a proposed extension of Forest Highway 10 (the Harlequin Lake road) in the final Environmental Impact Statement concerning the proposed Liquid Natural Gas Facility on Yakutat Bay. This road would continue up the Alsek River to connect with the Haines Highway in British Columbia. Objections to this additional road construction have centered on potential damage to the salmon resource of the Alsek River, loss of aesthetics along the Alsek Canyon, alteration of the subsistence hunting and fishing lifestyle of the inhabitants of Yakutat village, and damage to the wildlife resources of the upper Italio drainage (Fanning, pers. comm.).

APPENDIX VIII

CANADA GOOSE OBSERVATIONS IN THE YAKUTAT AREA 1980

Appendix VIII

Table
Canada Goose Observations in the Yakutat Area
(Defined as the Area Between Icy Bay
and Cape Fairweather) - 1980
(May 24 - October 13, inclusive)

Date	Number of Individuals Sighted	Locations
May 24	4	Akwe River near coast
May 24	1	Summit Lake
May 27	21	Malaspina Lake*
May 30	20	Dry Bay
June 10	3	N. end of Khaantak Is.
June 11	4	Off Logan Beach, Yakutat Bay
June 20	45	Malaspina Lake*
June 22	70	Harlequin Lake**
June 22	20	Upper Dangerous River*
June 23	21	Lower Dangerous River*
June 24	23	Middle Dangerous River*
June 25	3	SE shore of Harlequin Lake
August 18	61	Sudden Stream (Malaspina Lake)*
August 18	30	Point Manby
August 18	250***	Yana and Yahtze Streams*
August 18	9	Russell Fiord
August 19	85	Dangerous River mouth/ Old Italio
August 19	45	Dry Bay
August 23	65	Dry Bay
August 29	40	Situk-Ahrnklin Flats
August 29	120	Dry Bay
August 29	40	East-Doame River Estuary
September 2	17	East Alsek River
September 11	30	Lower East Alsek Estuary

*Known or suspected to be breeding
**moulting flock
***first appearance of large numbers

(cont.)

Canada Goose Observations - Yakutat 1980 (cont.)

Date	Number of Individuals Sighted	Location
September 25	24	Dangerous River & Estuary
September 25	27	Situk-Ahrnklin Flats
September 25	37	Dry Bay
September 25	21	East-Doame River Estuary
September 26	150	Phipps Peninsula
September 26	137	Malaspina Lake
September 26	8	Fountain Stream
September 26	25	Yana-Yahtze Streams
September 26	147	Pt. Riou-Icy Bay
October 2	12 (Lesser Canada) flying+	East Alsek River
October 2	150 (Dusky Canada) flying	East Alsek River
October 3	120 (Lesser Canada) flying	East Alsek River
October 3	144 (Dusky Canada) flying	East Alsek River
October 5	176 (Dusky Canada) flying	East Alsek Estuary
(#1 flight)		
October 10	39 (Dusky Canada) flying	Dangerous River
October 10	138 (mixed subspecies)	Situk-Ahrnklin Flats
(#2 flight)		
October 10	57 (Dusky Canada)	Dangerous River Estuary
October 10	40 (Dusky Canada)	Sudden Stream
October 13	200 (Dusky Canada)	Upper Dangerous River

+First recorded appearance of Lesser Canada Goose subspecies in autumn migration. The subspecies observed was the Dusky Canada Goose unless indicated otherwise.

APPENDIX IX

WHITE-FRONTED GOOSE OBSERVATIONS IN THE YAKUTAT AREA 1980

Appendix IX

Table
White-fronted Goose Observations in the Yakutat Area
(May 24 - 13 October Inclusive) 1980

Date	Number of Individuals Sighted	Behavior Mode	Location
August 28	4	Flying southeast	Dry Bay
August 30	60	Flying southeast	Mouth of Situk River
August 30	30	Flying southeast	Tawah Creek
September 1	14	Flying southeast	East Alsek River
September 2	50	Flying southeast	East Alsek Estuary
September 6	9	Flying southeast	East Alsek Estuary
September 9	7	Flying southeast	East Alsek Estuary
No Observations			
October 2	100	Flying southeast	East Alsek River
October 3	158	Flying southeast	East Alsek River
October 4	8	Flying southeast	East Alsek Estuary
October 5	17	Feeding in supra-tidal meadow	East Alsek Estuary

Two peaks of migration were observed (see above)

APPENDIX X

SANDHILL CRANE OBSERVATIONS YAKUTAT AREA 1980

Appendix X

Table
Sandhill Crane Observations
Yakutat Area 1980
(May 26-13 October Inclusive)

Date	Number of Individuals Sighted	Behavior Mode	Location
June 8	1	Flying NW - 200ft	Yakutat Airport
September 2	1	Foraging - edge of river	East Alsek River
September 6	450	Flying SE - 5,000ft	Doame River
September 8	100	Flying SE - 300ft	East Alsek River
September 17-18	4,000	Flying SE - various altitudes	Yakutat Forelands
September 25	30	Flying SE - 500ft	Dangerous River
September 30	2	Foraging - edge of pond	East Alsek Flats
October 4	4	Flying SE - 100ft	East Alsek Estuary

This species may pose a significant bird strike to aircraft hazard during migration periods because of its large size and tendency to fly at various altitudes, including some relatively high altitudes (5,000 ft - 1,250 m).

APPENDIX XI

TRANSECTS, SPECIES LISTS AND DIVERSITY, YAKUTAT AREA, 1980

Appendix XI

Transects, Species Lists and Diversity*, Yakutat Area, 1980

May 24, 1980. Phipps Peninsula, Yakutat Bay Islands, Russell Fiord, Situk to Alsek Estuaries. Clear and calm. Aircraft Transect 0700 - 1010 hrs.

Phipps Peninsula (L - Bb - Bs)

6	Goldeneye	
10	Mallard	
5	Shoveler	Diversity = 1.48
42	Glaucous-winged gull	
45	Arctic Tern	
20	Large shorebirds	
(2 seals)		

Yakutat Bay Islands (Bb - CoW)

4	Oldsquaw	
5	Common Loon	
8	NW Crow	
8	Harlequin	
9	Pigeon Guillemot	
3	Bald Eagle	Diversity = 1.60
6	Arctic Loon	
1	Pelagic Cormorant	
1	Double-crested Cormorant	
12	White-winged Scoter	
1	Red-necked Grebe	
75	Arctic Tern	
(1 harbor porpoise)		

Yakutat Bay west of Knight Island

12	Harlequin	
12	White-winged Scoter	
12	Surf Scoter	Diversity = 1.27
1	Common Loon	
1	Bald Eagle	

*Diversity indices resulting from aircraft transects are not compared to those resulting from boat and foot transects because of the radical difference in transportation methods.

May 24, 1980
Phipps Peninsula, Yakutat Bay Islands, contd.

Hubbard Glacier

6	Surf Scoter	
12	Harlequin	
30	Arctic Tern	Diversity = 0.89
(1 harbor porpoise)		
(many seals)		

Russell Fiord (south of Nunatak Fiord) (CoW - Bb)

20	Mew Gulls	
1	Double-crested Cormorant	
14	Surf Scoter	Diversity = 1.05
1	Common Loon	
50	Greater Scaup	

Lost River Mouth (Bs)

4	Whimbrel
15	Arctic Tern

Situk Estuary - Blacksand Island - Blacksand Spit (Bs - L - Sm)

2	Double-crested Cormorant	
20	Arctic Tern	
3	Common Merganser	Diversity = 0.93
6	Mallard	
1	Arctic Loon	
75	Glaucous-winged Gull	

Dangerous River mouth (Bs - L)

375	Glaucous-winged Gull	
2	Bald Eagle	Diversity = 0.44
40	Arctic Tern	
10	Double-crested Cormorant	

Italio River mouth (Bs)

275	Glaucous-winged Gull	
125	Glaucous-winged Gull	Diversity = 0.81
10	Bald Eagle	

Akwe River (Bs)

50	Arctic Tern	
40	Glaucous-winged Gull	
15	Whimbrel	Diversity = 1.27
7	Bald Eagle	
4	Canada Geese	

swallows along high bluffs

May 24, 1980
Phipps Peninsula, Yakutat Bay Islands, contd.

Alsek - Dry Bay (L - Bs)

5000	Glaucous-winged Gull	
50	Arctic Tern	
4	Bald Eagle	Diversity = 0.26
50	Double-crested Cormorant	
2	Parasitic Jaeger	
200	Common Merganser	

Triangle Lake (L)

20	Mallard	
10	Green-winged Teal	Diversity = 0.92
4	Trumpeter Swan	

May 24. 1980. Cannon Beach - Upper Beach-Meadow - Alder-Spruce Forest Edge. 1400-1800 hrs. (Bs - M - Ds) Clear with wind from SW at 10mph. On foot.

26	Sanderling -- breeding plumage -- feeding at edge of surf	
36	Robin -- migratory - non-territorial	
5	Varied Thrush	
6	Stellar's Jay	
11	Wilson's Warbler	
5	Whimbrel	
1	Raven	
6	Fox Sparrow	Diversity = 2.14
7	Savannah Sparrow	
5	NW Crow	
4	Tree Swallow	
1	Barn Swallow	
2	Yellow Warbler	
18	Hermit Thrush	

<u>24 May Old Growth Spruce Forest</u> Ophir Creek Road (S - Ds)

7	Varied Thrush	
7	Hermit Thrush	
11	Robin	
15	Ruby-crowned Kinglet	
13	Orange-crowned Warbler	Diversity = 1.76
2	Chestnut-backed Chickadee	
1	Winter Wren	
1	Song Sparrow	

May 24, 1980. Summit Lake (Coast Guard Lake).
(L) 1600 hrs. Onfoot.

28	Shoveler
6	Ring-necked Duck
30	Mallard
25	Wigeon
2	Lesser Scaup
6	Pintail
4	Trumpeter Swan + nest
1	Canada Goose
1	NW Crow

Diversity = 1.66

May 25, 1980. Situk Estuary to Cape Fairweather. Aircraft Transect 0645 - 0920 hrs. 100 ft. overcast. No wind. Visibility fair - moderate. Overall habitat Classification: (Bs - L)

<u>Blacksand Spit</u> (Bs - M - Sm)

250 Arctic Tern
100 Aleutian Tern (?) — Diversity = 0.95
75 Mew Gull

<u>Dangerous River mouth</u> (L - Bs)

200 Common Merganser
150 Glaucous-winged Gull — Diversity = 1.31
75 Arctic Tern
200 small shorebirds

<u>(New) Italio River mouth</u> (L - Bs)

250 small shorebirds
1000 Glaucous-winged Gull
1500 Black-legged Kittiwake — Diversity = 1.38
100 Mew Gull — (eulachon run)
300 Common Merganser
10 Bald Eagle
15 Mallard

<u>Akwe River near coast</u> (L - Bs - M)

150 Glaucous-winged Gull
60 Mew Gull
25 Arctic Tern — Diversity = 1.08
8 Bald Eagle
7 Whimbrel

<u>Dry Bay - mouth of the Alsek River</u> (L - Bs - CoW - M)

200 Herring Gull
750 Common Merganser
4540 Glaucous-winged Gull
12 Bald Eagle
200 Mew Gull — Diversity = 1.33
25 Parasitic Jaeger — (eulachon run)
400 Arctic Tern
80 Double-crested Cormorant
420 Pelagic Cormorant
200 Surf Scoter
150 White-winged Scoter
50 Arctic Loon
(50 Seals)

May 25, 1980
Estuary to Cape Fairweather, contd.

(1 Marsh Hawk - Yakutat Airport)

East River estuary (L - Bs - Fm)

300 Greater Scaup
15 Mallard
10 Arctic Loon
15 Ring-necked Duck
25 Pintail
\+ shorebird spp.

Diversity = 0.69

Between Doame River and First Rocky Point to the SE (Bs - CoW)

5 Bald Eagle (2 ad.)
200 Surf Scoter
5 Common Loon

Diversity = 0.22

Off Rocky Coast in Cape Fairweather area (Bb - CoW)

3 Common Loon
3 Bald Eagle
200 Surf Scoter

Diversity = 0.15

Between Cape Fairweather and First Rocky Point SE of Doame River
(CoW - Bs - Bb)

8 Bald Eagle
4 Whimbrel
350 Surf Scoter
150 White-winged Scoter
6 Raven

Diversity = 0.76

May 26, 1980. Situk River from 9 mile Bridge to Situk Landing. (Approximately 18 km boat trasect by floating downstream.) High overcast. 1000 hrs - 2000 hrs. (L - Ds - S) Gradual clearing during day. Light breeze.

120	Ruby-crowned Kinglet
37	Orange-crowned Warbler
8	Common Snipe
21	Bald Eagle
67	Varied Thrush
1	Dark-eyed Junco
147	Tree Swallow
11	Song Sparrow
56	Myrtle Warbler
26	Wilson's Warbler
4	Fox Sparrow
57	Hermit Thrush
20	Savannah Sparrow
3	Dipper
3	Lesser Yellowlegs
41	Spotted Sandpiper
1	Yellow Warbler
11	Stellar's Jay
5	Robin
8	Greater Yellowlegs
2	Gadwall
4	Winter Wren
4	Least Sandpiper
17	Common Merganser
5	Arctic Tern
1	Raven
4	Belted Kingfisher

8	Bald Eagle nests

Diversity = 2.49

May 27, 1980. Haenke Island - Manby side - Malaspina Forelands - Pt. Manby. Aircraft Transect 0645 - 0845 hrs. Clear and calm weather.

Haenke Island (Cg - Bb - Ds)

4 Tufted Puffin
20 Pigeon Guillemot
400 Glaucous-winged Gull
600 Black-legged Kittiwake
80 Arctic Tern — Diversity = 1.11
12 Northwestern Crow
20 Mew Gull
4 Stellar's Jay

South of Bancas Point - Manby side (Ds - Bs)

1 Stellar's Jay
1 Glaucous-winged Gull

Grand Wash to Sudden Stream (Fm - Bs - M - Sm)

16 Glaucous-winged Gull
60 Pintail
45 Shoveler
10 Mallard
1 Parasitic Jaeger — Diversity = 1.72
10 Mew Gull
2 Bald Eagle
10 Arctic Tern
15 Common Merganser
(many small shorebirds in saltmarsh)

Sudden Stream - Schooner Beach (Bs - CoW - L)

10 Common Merganser
5 Arctic Loon
4 Common Loon
25 Arctic Tern
225 Surf Scoter
15 Mallard — Diversity = 1.17
10 Shoveler
1 Bald Eagle
15 Greater Scaup
10 Ring-necked Duck

May 27, 1980
Haenke Island - Manby Side contd.

Pt. Manby (L - S)

3	Bald Eagle	
2	Trumpeter Swan	Diversity = 0.85
10	Ring-necked Duck	

Malaspina Lake (L - Mo - Fm)

21	Canada Geese	
2	Wigeon	
80	Glaucous-winged Gull	Diversity = 1.17
1	Parasitic Jaeger	
6	Red-throated Loon	
20	Mew Gull	
2	Willow Ptarmigan	

May 28, 1980. Bird Observations. Slough immediately west of Forest Service Upper Alsek Cabin. 1900 - 2100 hrs. (Ds - L) On foot.

5	Least Sandpiper	
1	Pectoral Sandpiper	
3	Yellow Warbler	
10	Wilson's Warbler	
4	Common Snipe	
20	Herring Gull -- 200 m up migrating in groups up Alsek River	
12	Orange-crowned Warbler	
7	Hermit Thrush	
3	Varied Thrush	
2	Shoveler	Diversity = 2.75
4	Pintail	
2	Blue-winged Teal	
4	Green-winged Teal	
7	Fox Sparrow	
10	Tree Swallow	
12	Barn Swallow	
5	Semipalmated Plover	
1	Long-billed Dowitcher	
6	Robin	
12	Grey-cheeked Thrush -- common singing at Upper Alsek cabin; open black cottonwood with understory of willows and alder	

Eagle nest on SE corner of Triangle Lake

Eagle nest at east end of tall bank above lower Akwe

2 pair Trumpeter Swan on Triangle Lake

May 30, 1980. Upper Alsek to Dry Bay. (L - Bs) Forest Service Cabin. Boat Transect: 0900 - 1700 hrs. Clear; light breeze from SW.

---

70 Aleutian Tern

60 Arctic Tern

40 Mew Gull

15 Northern Phalarope

2 Raven

2 Harlequin Duck

1 Western Sandpiper

75 Parasitic Jaeger

1 Hairy Woodpecker

2300 Black-legged Kittiwake

5 Herring Gull

1 Glaucous Gull

2 Snow Geese

11 Bald Eagle -- at mouth of Alsek Diversity = 1.36

1500 Common Merganser in Dry Bay

(200 Harbor Seal)

9 Arctic Loon

1 Oldsquaw

2 Double-crested Cormorant

40 Bank Swallow

10 Barn Swallow

1 Long-billed Dowitcher

5 Greater Yellowlegs

20 Canada Geese

1400 Glaucous-winged Gull

June 1, 1980. East Alsek River. (L - Ds) On foot North along river 1½ mi. around first large pool north of Forest Service cabin. 0800 - 1400 hrs.

1	Wandering Tattler	
2	Barrow's Goldeneye	
1	Robin	
1	Fox Sparrow	
1	Orange-crowned Warbler	
1	Hermit Thrush	
1	Varied Thrush	
11	Ruby-crowned Kinglet	
2	Arctic Tern	Diversity = 1.79
2	Spotted Sandpiper	
1	Pectoral Sandpiper	
2	Bald Eagle	
37	Migrating Herring Gulls -- 1000 - 1500 ft.	
4	Least Sandpiper	
14	Mallard	

June 2, 1980. East Alsek River. Deciduous shrublands - riparian cottonwood (L - Ds) 0800 - 0930 hrs. On foot. Clear and calm.

3	Greater Yellowlegs	
4	Least Sandpiper	
10	Yellow Warbler	
14	Varied Thrush	
14	Fox Sparrow	
10	Robin	
4	Grey-cheeked Thrush	
11	Wilson's Warbler	Diversity = 2.34
4	Bald Eagle	
3	Pine Grosbeak	
3	Mew Gull	
1	Raven	
1	Yellow-rumped Warbler	
1	Willow Ptarmigan	
1	Red-tailed Hawk	

June 2, 1980. Lower East Alsek Estuary. (L - Bs - M - Fm) On foot.
1000 - 1700 hrs. Clear with SW winds after noon.

16	Semipalmated Plover
18	Savannah Sparrow
238	Arctic Tern
6	Least Sandpiper
15	Western Sandpiper
24	Common Merganser
28	Wigeon
23	Pintail
5055	Glaucous-winged Gull
1	Mallard
60	Ring-necked Duck
20	Bald Eagle
1	Long-billed Dowitcher
7	Northern Phalarope
12	Parasitic Jaeger
4	Dunlin
8	Aleutian Tern
140	Herring Gull
5	Fox Sparrow
1	Orange-crowned Warbler
135	Mew Gull
8	Green-winged Teal
1350	Black-legged Kittiwake
18	Sanderling

Diversity = 1.02

June 4, 1980. Lower East Alsek Estuary. (L - BS - CoW - Fm) 0900 - 1700 hrs. Clear and calm. On foot.

16	Wigeon
4	Mallard
15	Bald Eagle
18	Pintail
16	Whimbrel
20	Aleutian Tern
1	Raven
3	Greater Scaup
2500	Glaucous-winged Gull
35	Oldsquaw
1	Glaucous Gull
50	Black-legged Kittiwake
1	Dunlin
1	Parasitic Jaeger
22	Sanderling
5	Knot
1	Bonaparte's Gull
12	Arctic Tern
2	Green-winged Teal
8	Surf Scoter
8	Red-throated Loon
8	Arctic Loon
10	Bank Swallow

Diversity = 0.51

June 9, 1980. Lee side of Khaantak Island. Boat Transect. 2000 ft. Overcast; light breeze from SW. Some glare. Visibility otherwise excellent. Calm water. 1200 - 1900 hrs.

<u>SE end inside Khaantak</u> (Bb - Bs - CoW)

76 White-winged Scoter
150 Surf Scoter
18 Mew Gull
16 NW Crow
55 Greater Scaup
26 Black Scoter
15 Common Merganser
1 Great Blue Heron
1 Savannah Sparrow
4 Harlequin Duck
19 Arctic Tern
4 Orange-crowned Warbler
5 Whimbrel
2 Red-necked Grebe
8 Bald Eagle
6 Marbled Murrelet
2 Raven
1 Belted Kingfisher
2 Red-throated Loon
16 Glaucous-winged Gull
1 Arctic Loon
(7 Harbor seal)
(2 Harbor Porpoise)

Diversity = 2.10
(lee side)

<u>Outer (SW) side of Khaantak</u> (Bs - CoW)

150 White-winged Scoter
25 Surf Scoter
25 Black Scoter
2 Common Loon

Diversity = 0.72
(exposed side)

Remarkable change in diversity from lee - exposed sides of Khaantak Island.

June 9, 1980. Lee side of Khaantak north of Crab Bay. (Bb - CoW)

19	Northwestern Crow
64	Arctic Tern
11	Mew Gull
6	Common Loon
1	Marbled Murrelet
5	White-winged Scoter
64	Aleutian Tern
1	Harlequin Duck
3	Glaucous-winged Gull
2	Black Scoter
29	Pigeon Guillemot
18	Bonaparte's Gull
2	Bald Eagle
8	Oldsquaw
1	Red-throated Loon
1	Raven
2	Least Sandpiper
1	Parasitic Jaeger
2	Whimbrel
(6	Harbor Porpoise)

Diversity = 2.06
(lee side)

June 10, 1980. Ahduck Bay (Khaantak Island) to Knight Island (Yakutat Bay Islands). (Bb - CoW) Overcast with 200 ft. ceiling. Light wind from WSW. Boat transect 0700 - 1200 hrs.

Ahduck Bay to N tip of Khaantak

160 Surf Scoter
13 White-winged Scoter
1 Pigeon Guillemot
3 Orange-crowned Warbler
15 Aleutian Tern
22 NW Crow
80 Arctic Tern
2 Black Oystercatcher
38 Harlequin Duck
21 Pelagic Cormorant
10 Common Loon — Diversity = 0.44
2 Bald Eagle
1 Hermit Thrush
2 Lincoln's Sparrow
3 Canada Geese
34 Bonaparte's Gull
2 Oldsquaw
14 Marbled Murrelet

Between Khaantak and Kriwoi (CoW)

150 Murrelets (75 Kittlitz's; 75 Marbled)
40 Arctic Tern — Diversity = 1.10
2 Arctic Loon

Krutoi (Bb)

2 Black Oystercatcher
1 Hermit Thrush
1 Ruby-crowned Kinglet — Diversity = 0.74
2 Common Loon
25 Marbled Murrelets

2.5 km off SE end of Knight Island (CoW)

208 Oldsquaw in Laminaria bed
50 White-winged Scoter
50 Surf Scoter
25 Black Scoter — Diversity = 1.47
90 Marbled Murrelets
10 Kittlitz's Murrelets
4 Bald Eagle
1 Parasitic Jaeger
1 Kingfisher

June 10, 1980. Haenke Island Seabird Colony. On foot 1500 - 200 hrs. (Cg - Bb - Ds) Overcast with 2000 ft. ceiling. Light wind from WSW.

400	Glaucous-winged Gull
600	Black-legged Kittiwake
4	Tufted Puffin
3	Bald Eagle
12	Black Oystercatcher
25	Fox Sparrow
1	Parasitic Jaeger
15	Hermit Thrush
4	Raven
20	Mew Gull
5	White-growned Sparrow
1	Rufous Hummingbird
1	Savannah Sparrow
4	Barn Swallow
4	Wilson's Warbler
90	Arctic Tern
21	Pigeon Guillemot
12	NW Crow
4	Stellar's Jay

Diversity = 1.37

June 11, 1980. Disenchantment Bay. Boat transect: 11 hrs. - 1200 hrs.
(CoW - Bb) Overcast with lowering clouds from SE.

1	Bald Eagle
7	Marbled Murrelet
18	Harlequin Duck
15	Barn Swallow -- at stream mouth of Calahonda Creek
4	Black Oystercatcher
12	Aleutian Tern -- feeding and flying over mouth of Aquadulce Creek
6	Arctic Tern -- flying
1	Parasitic Jaeger
1	Pigeon Guillemot
3	NW Crow
1	Raven
1	Mew Gull

Diversity = 1.99

June 11, 1980. Yakutat Bay: Point Latouche to Knight Island. Boat Transect. Wind from WE; moderate rain increasing to heavy after Knight Island. Overcast 1200 - 1300 hrs. with low clouds and fog. (CoW - Bb)

Marbled Murrelets concentrated outside Disenchantment Bay

502	Marbled Murrelets 200 m offshore at entrance to Disenchantment Bay	
1	Aleutian Tern	
60	Arctic Tern	
7	Pelagic Cormorant	
1	Pigeon Guillemot	
2	Glaucous-winged Gull	
50	Arctic Loon in dispersed flock feeding on water off Logan Beach	
4	Canada Geese	
174	Surf Scoter	
2	Double-crested Cormorant	
8	Black Oystercatcher	Diversity = 1.16
1	Mew Gull	
1	Oldsquaw	
2	Bald Eagle	
2	Spotted Sandpiper	

June 20, 1980. Summit Pond, Phipps Peninsula, Khaantak and Yakutat Bay Islands, Manby Side and Malaspina Forelands to Ice Bay. Aircraft transect: 0770 hrs. - 0945 hrs. Overcast, broken 1100 ft., 2000 closed. Visibility good (25 miles). Wind W at 7 mph. Sunshine diffuse.

Summit Lake (Coast Guard Lake) (L) Phipps Peninsula (L - Bb - Bs)

3 Mallard
1 Pintail — Diversity = 0.42
1 Shoveler

Ankau Lagoons (Bb) - Beach east of Pt. Carrew (Phipps Peninsula)

44 Arctic Tern

Lee side of Khaantak Island (Bs - Bb - CoW)

63 Surf Scoter
85 White-winged Scoter
16 Harlequin
60 Glaucous-winged Gull
30 Pelagic Cormorant — Diversity = 1.80
10 Arctic Loon
5 Black Scoter
50 Pigeon Guillemot

Krutoi Island (Bb)

10 Harlequin Duck — Diversity = 0.48
2 Surf Scoter

Knight Island (SW reef) (Bb - CoW)

330 Surf Scoter
150 White-winged Scoter
50 Black Scoter — Diversity = 0.99
15 Pelagic Cormorant
2 Pigeon Guillemot

Logan Bluffs - Pt. Latouche - Entrance to Disenchantment Bay (CoW)

6 Harlequin Duck
2 Arctic Loon — Diversity = 0.17
215 Arctic Tern

Manby Side to Grand Wash (Bs - L -Sm)

4 Glaucous-winged Gull
3 Bald Eagle — Diversity = 0.84
15 Mallard

June 20, 1980
Summit Pond, Phipps Peninsula, contd.

Sudden Stream - Kame Stream (Bs - L)

20 Common Merganser
70 White-winged Scoter - just off sandy beach
60 Surf Scoter — Diversity = 0.98

Malaspina Lake (L - Mo - Fm)

45 Canada Geese
80 Glaucous-winged Gull
60 Arctic Tern
210 Mew Gull — Diversity = 1.21
1 Willow Ptarmigan
1 Parasitic Jaeger

Osar Stream - Pt. Manby - Alder Stream (L - Bs - CoW)

2 Bald Eagle
2 Canvasback
4 Arctic Tern
2 Trumpeter Swan
3 Glaucous Gull
350 Bonaparte's Gull — Diversity = 1.07
600 Surf Scoter
200 Black Scoter

Sitkagi Bluffs (Bb - CoW)

1500 Black-legged Kittiwake
300 Bonaparte's Gull
200 Mew Gull
1 Bald Eagle
4 Trumpeter Swan
1500 Surf Scoter
1000 White-winged Scoter — Diversity = 1.56
500 Black Scoter

Fountain Stream (Bs)

1000 Black-legged Kittiwake
4 Parasitic Jaeger — Diversity = 0.03*
1 Bald Eagle

Yaha - Yahtze Streams (L - Fm)

4 Trumpeter Swan
30 Common Merganser
4 Bald Eagle — Diversity = 1.05
14 Canada Geese

*Massive concentration of birds in the Alder Stream - Sitkagi Bluffs - Fountain Stream area.

June 20, 1980
Summit Pond, Phipps Peninsula, contd.

Icy Bay - Egg Island (Bs)

400	Glaucous-winged Gull	
80	Arctic Tern	Diversity = 0.51
6	Bald Eagle	

Icy Bay - Pt. Riou (Bs - CoW)

100	Surf Scoter	
50	White-winged Scoter	
10	Common Merganser	
75	Black-legged Kittiwake	
75	Glaucous-winged Gull	Diversity = 1.54
200	Arctic Tern	
	Aleutian Tern (?)	

June 21, 1980. Yakutat Forelands to Triangle Lake, Square Lake and Muddy Creek, Swan Survey. Aircraft as Platform. 600 ft. overcast. Visibility fair at 15 miles. Wind NE at 10 mph. 0900 - 1050 hrs.

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2 Bald Eagle 400 m above lower Forest Service cabin on Situk (nest?)

2 Trumpeter Swan - NW of Triangle Lake

5 Trumpeter Swan - SW of Triangle Lake

4 Trumpeter Swan - SE of Triangle Lake

2 Trumpeter Swan - immediately adjacent to Square Lake

4 Trumpeter Swan - above Muddy Creek

June 22, 1980. Harlequin Lake. Boat Transect - circumnavigation.
1200 - 1700 hrs. (L - Ds - Mo) High overcast. No wind.

70	Canada Goose
48	Mew Gull
14	Arctic Tern
4	Hermit Thrush
4	Tree Swallow
5	Orange-crowned Warbler
6	Spotted Sandpiper
1	Fox Sparrow
1	Barn Swallow
170	Bank Swallow
5	Harlequin Duck
1	Least Sandpiper
2	Semipalmated Plover
1	Raven
1	Robin
1	Belted Kingfisher

Diversity = 1.49

June 22, 1980. Upper Dangerous River from Dangerous River Bridge to Forest Service Middle Dangerous Cabin. Boat Transect. Floating with current. 1700 - 1900 hrs. (L - Ds) High overcast. No wind.

5	Spotted Sandpiper
57	Mew Gull
5	Orange-crowned Warbler
9	Hermit Thrush
10	Varied Thrush
4	Fox Sparrow
4	Golden-crowned Sparrow
1	Belted Kingfisher
6	Arctic Tern
1	Bald Eagle
20	Canada Geese
1	Robin
1	Rufous Hummingbird
1	Grey-cheeked Thrush
12	Tree Swallow
3	Greater Yellowlegs
2	Wilson's Warbler

Diversity = 2.06

June 23, 1980. Middle Dangerous Forest Service cabin to beginning of Dangerous Estuary (i.e., Lower Dangerous). 0700 - 1700 hrs. Boat transect. Drifting with current. (L - Ds) Clear, SW winds.

1	Bald Eagle
21	Canada Geese
18	Mew Gull
19	Fox Sparrow
5	Spotted Sandpiper
2	Golden-crowned Sparrow
12	Tree Swallow
2	Semipalmated Plover
13	Orange-crowned Warbler
17	Arctic Tern
15	Hermit Thrush
6	Grey-cheeked Thrush
3	Wilson's Warbler
7	Varied Thrush
1	Common Merganser
100	Bank Swallow
4	Barn Swallow
1	Belted Kingfisher
1	Savannah Sparrow
1	Lincoln's Sparrow
3	Yellow Warbler
1	Song Sparrow
10	Pine Siskin
1	Downy Woodpecker
1	Stellar's Jay
1	Robin
2	Raven
2	Green-winged Teal

Diversity = 2.37

June 23, 1980. Dangerous River Estuary. Boat Transect. 1300 - 1500 hrs. (L - Bs) Moderate wind from SW. Clear.

73	Common Merganser
12	Arctic Tern
5	Mew Gull
6	Wigeon
1	Spotted Sandpiper
2	Northern Phalarope
1	Semipalmated Plover
15	Pintail
2	Green-winged Teal
2	Bald Eagle
1	Least Sandpiper
7	Aleutian Tern

Diversity = 1.51

June 24, 1980. Middle Dangerous Forest Service Cabin to Harlequin Lake Forest Service Cabins. On foot transect along flagged Forest Service trail. 0545 - 1600 hrs. (L - Ds) Clear, moderate wind from SW in p.m.

25	Fox Sparrow
51	Varied Thrush
23	Canada Geese
5	Bank Swallow
40	Hermit Thrush
3	Robin
14	Grey-cheeked Thrush
27	Ruby-crowned Kinglet
3	Mew Gull
21	Orange-crowned Warbler
12	Pine Siskin
6	Yellow-rumped Warbler
3	Yellow Warbler
4	Pine Grosbeak
5	Least Sandpiper
2	Greater Yellowlegs
1	Lesser Yellowlegs
8	Savannah Sparrow
9	Wilson's Warbler
11	Dark-eyed Junco
12	Common Redpoll
1	Common Snipe
12	Golden-crowned Sparrow
1	Raven
10	Tree Swallow
20	Barn Swallow
1	Rufous Hummingbird

Diversity = 2.80

June 25, 1980. South and East Shorelines of Harlequin Lake. On foot transect. 0500 - 1000 hrs. (Ds - L) Clear and calm; some cirrostratus.

5	Common Merganser
23	Golden-crowned Sparrow
37	Fox Sparrow
3	Robin
10	Savannah Sparrow
3	Robin
10	Wilson's Warbler
6	Yellow-rumped Warbler
5	Yellow Warbler
42	Hermit Thrush
3	Canada Geese
14	Mew Gull
19	Orange-crowned Warbler
17	Ruby-crowned Kinglet
13	Spotted Sandpiper
30	Pine Siskin
2	Arctic Tern
1	Rufous Hummingbird
1	Western Flycatcher
6	Least Sandpiper
4	Semipalmated Plover
5	Varied Thrush
3	Tree Swallow
1	Belted Kingfisher
1	Greater Yellowlegs
1	Grey-cheeked Thrush
2	Stellar's Jay
1	Raven
3	Green-winged Teal
2	Marbled Murrelet

Diversity = 2.74

June 29, 1980. East end of Italio Lake, following Italio River South to Middle Italio River. Boat transect, drifting with current. 1130 - 2000 hrs. (S - L - Ds) Moderate, lowering overcast. No wind.

12	Arctic Tern
4	Stellar's Jay
59	Hermit Thrush
11	Greater Yellowlegs
6	Spotted Sandpiper
6	Bald Eagle
36	Orange-crowned Warbler
44	Varied Thrush
2	Fox Sparrow
26	Tree Swallow
10	Ruby-crowned Kinglet
6	Wilson's Warbler
1	Barrow's Goldeneye
5	Dipper
1	Grey-cheeked Thrush
10	Pine Siskin
7	Common Merganser
4	Winter Wren
2	Yellow-rumped Warbler
4	Crossbill
8	Harlequin Duck
1	Yellow Warbler
2	Savannah Sparrow
3	Song Sparrow
1	Mew Gull
1	Rufous Hummingbird
7	Dark-eyed Junco
3	Black-capped Chickadee
3	Lesser Yellowlegs

Diversity = 2.66

June 30, 1980. Middle Italio River to beginning of Italio River Estuary. Boat transect, drifting with current. 0880 - 1400 hrs. (L - Ds) Rain and fog.

2	Song Sparrow
33	Hermit Thrush
27	Varied Thrush
17	Orange-crowned Warbler
26	Common Merganser
17	Pine Siskin
3	Robin
42	Tree Swallow
6	Wilson's Warbler
2	Common Redpoll
9	Fox Sparrow
1	Yellow-rumped Warbler
1	Dark-eyed Junco
8	Ruby-crowned Kinglet
15	Least Sandpiper
3	Lesser Yellowlegs
3	Harlequin Duck
3	Bald Eagle
4	Greater Yellowlegs
12	Stellar's Jay
2	Spotted Sandpiper
9	Lincoln's Sparrow
8	Belted Kingfisher
12	Bank Swallow
1	Alder Flycatcher
6	Arctic Tern
2	Semipalmated Plover
1	Raven
4	Savannah Sparrow
1	Dowitcher
22	Western Sandpiper

Diversity = 2.88

July 1, 1980. (New) Italio River Estuary. On foot Transect. 1000 - 1400 hrs. (Ds - Bs - CoW - L) Clear. Wind from SW in p.m.

3	Robin
8	Barn Swallow
10	Fox Sparrow
6	Pine Siskin
1	Varied Thrush
1	Hermit Thrush
6	Semipalmated Plover
8	Bald Eagle
3	Green-winged Teal
6	Greater Yellowlegs
7	Common Merganser
1	Orange-crowned Warbler
52	Least Sandpiper
12	Western Sandpiper
103	Arctic Tern
33	Mew Gull
1	Lincoln's Sparrow
1	Grey-cheeked Thrush
3	Semipalmated Sandpiper
24	Parasitic Jaeger
7	Surf Scoter
4	Glaucous-winged Gull
20	Aleutian Tern
208	Black-legged Kittiwake
4	Black Scoter
2	Northern Phalarope

Diversity = 2.09

July 1, 1980. Old Italio Estuary. On foot transect. 1400 - 1700 hrs.
(Fm - Sm - L) Clear. Moderate wind from SW

4	Glaucous-winged Gull
3	Herring Gull
28	Aleutian Tern
860	Western Sandpiper
10	Semipalmated Sandpiper
134	Arctic Tern
15	Pintail
4	Black Turnstone
2	Greater Yellowlegs
2	Savannah Sparrow
75	Black-legged Kittiwake
5	Mallard
40	Northern Phalarope
2	Semipalmated Plover

Diversity = 1.04

July 5, 1980. Blacksand Spit (Situk Estuary). On foot transect. 0800 hrs. - 1700 hrs. (Sm - L - CoW - Bs) Moderate to lowering overcast. Wind from SW to SE.

26	Least Sandpiper
1500	Western Sandpiper (count) 5000 Western Sandpiper (total estimation)
290	Savannah Sparrow
1588	Aleutian Tern (count) 3000 Aleutian Tern (Total estimation)
180	Arctic Tern
8	Parasitic Jaeger
9	Mew Gull
56	Semipalmated Plover
6	Common Loon
3	Whimbrel
7	Bank Swallow
8	Glaucous Gull
137	White-winged Scoter
6	Black-legged Kittiwake
7	Raven
118	Surf Scoter
13	Glaucous-winged Gull
1	Herring Gull
18	Barn Swallow
8	Red-throated Loon
12	Marbled Murrelet
1	Arctic Loon
8	Bald Eagle

Diversity with estimations = 1.11

Diversity with counts = 1.50

August 18, 1980. Phipps Peninsula, Yakutat Bay Islands, Disenchantment Bay, Manby side to Icy Bay. Aircraft transect 1020 - 1240 hrs. Weather clear. Winds light, out of SE. Low pressure cell approaching from NW. Visibility excellent.

Phipps Peninsula - Ankau (L - Bs - Bb)

1	Trumpeter Swan	
1	Wigeon	
25	Mallard	
5	Arctic Tern	Diversity 1.09
50	Glaucous-winged Gull	
5	Whimbrel	

Lee side of Khaantak (Bs - Bb - CoW)

40	Arctic Tern	
48	Surf Scoter	
5	Glaucous-winged Gull	
19	Great Blue Heron	
4	Mallard	Diversity = 1.53
8	Mew Gull	
5	White-winged Scoter	

Krutoi, Knight Island, and Mainland Shore to Logan Bluffs (Bb - Bs - L)

25	Bonaparte's Full	
66	Glaucous-winged Gull	
17	Bald Eagle -- Humpback Creek	Diversity = 1.34
129	Arctic Tern	
2	Northwestern Crow	
25	Surf Scoter	

Logan Bluffs, Pt. Latouche, and entrance to Disenchantment Bay (CoW)

77	Surf Scoter	
54	Black Scoter	
8	Glaucous-winged Gull	
1	Pelagic Cormorant	Diversity = 1.34
5	Common Loon	
5	Arctic Tern	

Osier Island (Bb - Bs)

20	Arctic Tern

Manby Side - Grand Wash (Bs - M - Sm)

4	Glaucous-winged Gull	
1	Raven	
1	Common Merganser	Diversity = 1.18
4	Canada Geese	

August 18, 1980
Phipps Peninsula, Yakutat Bay Islands, contd.

Sudden Stream (Bs - L)

101 Glaucous-winged Gull
123 Mallard
61 Canada Geese
350 Black-legged Kittiwake
5 Green-winged Teal

Diversity = 1.19

Malaspina Lake (L)

200 Glaucous-winged Gull
1 Parasitic Jaeger
8 Mallard

Diversity = 0.19

Osar Stream - Pt. Manby - Alder Creek (L - Bs)

10 Mallard
4 Trumpeter Swan
40 Black-legged Kittiwake
19 Glaucous-winged Gull
30 Canada Geese
1 Raven
3 Bald Eagle

Diversity = 1.50

Sitkagi Bluffs (Bb - CoW)

290 Surf Scoter
135 White-winged Scoter
5 Black Scoter

Diversity = 0.80

Yana and Yahtze Streams (L - Fm)

250 Canada Geese
15 Mallard
1 Bald Eagle
6 Trumpeter Swan

Diversity = 0.34

Icy Bay (CoW - Bs)

210 Surf Scoter
50 White-winged Scoter
30 Arctic Tern
200 Glaucous-winged Gull
1 Raven

Diversity = 1.13

August 18, 1980. Phipps Peninsula, Yakutat Bay Islands, Disenchantment Bay, Russell Fiord. Aircraft transect. 1800 - 1910 hrs. 10,000 scattered, visibility unlimited. Winds SW at 10 knots. Low pressure approaching with a front arriving in the morning.

Phipps Peninsula (Bs - Bb)

2	Bald Eagle	
30	Glaucous-winged Gull	Diversity = 0.68
8	Bonaparte's Gull	

Khaantak (lee side) (Bs - Bb - CoW)

122	Glaucous-winged Gull	
156	Surf Scoter	
75	White-winged Scoter	Diversity = 1.13
2	Common Loon	
4	Arctic Tern	

Krutoi (CoW - Bb)

10	White-winged Scoter	
5	Surf Scoter	
15	Black-legged Kittiwake	Diversity = 1.21
1	Glaucous-winged Gull	
1	Common Murre	

Knight Island (Bb)

11	Glaucous-winged Gull	
50	Surf Scoter	Diversity = 0.93
25	White-winged Scoter	

West of Knight Island (Yakutat Bay) (CoW)

254	Surf Scoter	
161	White-winged Scoter	
8	Glaucous-winged Gull	
3	Arctic Tern	Diversity = 0.87
10	Black-legged Kittiwake	

Logan Bluffs - Pt. Latouche - Entrance of Disenchantment Bay (CoW)

20	Marbled Murrelet	
4	Double-crested Cormorant	Diversity = 0.59
1	Glaucous-winged Gull	

August 18, 1980
Phipps Peninsula, Yakutat Bay Islands, contd.

Russell Fiord (CoW)

(500 seals in front of Hubbard Glacier on ice pack)

3	Harlequin Duck
240	Surf Scoter
9	Canada Geese
140	White-winged Scoter
20	Common Loon
12	Double-crested Cormorant
14	Northwestern Crow
10	Common Merganser
1	Bald Eagle

Diversity = 1.23

August 19, 1980. Yakutat Forelands to Cape Fairweather, including Situk Estuary, Blacksand Spit, Ahrnklin Flats, Dangerous River mouth, Old Italio, New Italio mouths, Akwe River adjacent to Coast, Alsek River at Dry Bay, Outer Dunes from the East River to First Rocky Point SE of Clear Creek; First Rocky Pt. to Cape Fairweather, Doame River Estuary, East River proper, offshore from the mouth of the Alsek, Akwe, new Italio, Situk and Lost Rivers. Aircraft transect 1000 - 1245 hrs. Cloud conditions 700 - 800 ft. broken, 10 - 15 mi. visibility. No shadows, light winds.

Situk Estuary - Blacksand Spit - Ahrnklin Estuary (L - Bs - Sm - M)

2	Pelagic Cormorant	
49	Glaucous-winged Gull	
7	Herring Gull	
17	Sanderling	
6	Fairly large shorebird sp.	
15	Medium shorebird sp.	
5	Canada Geese	
300	Wigeon	Diversity = 1.29
115	Western Sandpiper	
5	Mew Gull	

Dangerous River mouth - Old Italio Slough (Bs - L - Fm - Sm)

1	Glaucous-winged Gull	
85	Canada Geese	
25	Mallard	
25	Pintail	
2	Bald Eagle	
20	Whimbrel	Diversity = 1.43
100	Wigeon	

New Italio Mouth (L - Bs)

2	Bald Eagle	
20	Glaucous-winged Gull	
100	Arctic Tern	Diversity = 0.98
75	Wigeon	

Akwe River adjacent to coast (L - Bs - Fm - M)

2	Arctic Tern	
15	Mallard	
90	Wigeon	Diversity = 0.77
10	Pintail	
1	Bald Eagle	

August 19, 1980
Yakutat Forelands to Cape Fairweather, contd.

Alsek River at Dry Bay (L - Bs)

7 Sanderling
4 Bald Eagle
11 Glaucous-winged Gull
2 Raven
(400 seals)
76 Herring Gull
25 Black legged Kittiwake
45 Canada Geese
4 NW Crow
22 Mallard — Diversity = 1.82
10 Aleutian Tern
2 Parasitic Jaeger

Outer Dunes - East River to First Rocky Pt. SE of Clear Creek (Bs - Bb - L)

3 Bald Eagle
1 Raven
2 Glaucous-winged Gull
8 Mallard — Diversity = 1.28
12 Wigeon

First Rocky Pt. to Cape Fairweather (offshore) (CoW)

107 Surf Scoter
98 White-winged Scoter
158 Black Scoter
4 Black-legged Kittiwake — Diversity = 1.14*
2 Glaucous-winged Gull

Cape Fairweather to First Rocky Point to WNW (inshore) (CoW)

310 Black Scoter
203 Surf Scoter
35 Common Merganser
21 Glaucous-winged Gull — Diversity = 1.01*
3 Bald Eagle

Doame River Estuary (L - Fm)

4 Bald Eagle
3 Trumpeter Swan
250 Wigeon
100 Mallard — Diversity = 1.08
105 Pintail
2 Glaucous-winged Gull

August 19, 1980
Yakutat Forelands to Cape Fairweather, contd.

East River Proper (L)

605 Wigeon
15 Common Merganser
2 Bald Eagle — Diversity = 0.20
9 Raven

Offshore--mouth of Alsek (CoW)

412 Surf Scoter
301 White-winged Scoter
251 Black Scoter — Diversity = 1.12*
10 Black-legged Kittiwake
2 Glaucous-winged Gull

Offshore--mouth of Akwe (CoW)

10 Common Merganser
27 Surf Scoter — Diversity = 1.01*
15 White-winged Scoter

Offshore--mouth of new Italio to Lost River (CoW)

50 Surf Scoter
13 White-winged Scoter
15 Bonaparte's Gull
1 Parasitic Jaeger
6 Glaucous-winged Gull — Diversity = 1.35*
10 Black-legged Kittiwake

*CoW diversities similar in different locations today.

Large increase in numbers of American Wigeon observed this date.

August 19, 1980. Aerial Survey. (Additions)

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18 Mallards in marshy slough on SW side of Dry Bay

103 Canada Geese, Ahrnklin Flats

August 23, 1980. Dry Bay - Alsek Estuary. (L - Bs - Ds - M) Boat transect. 0800 - 1800 hrs. Clear, sunny, with NE winds.

1	Great Blue Heron
1	Orange-crowned Warbler
30	Aleutian Tern
7	Raven
30	Parasitic Jaeger
65	Canada Geese
26	Glaucous-winged Gull
100	Northern Phalarope
7	Pectoral Sandpiper
9	Black Turnstone
4	Ruddy Turnstone
10	Spotted Sandpiper
5	Bald Eagle
2	Savannah Sparrow
3	Green-winged Teal
5	Sanderling
1	Short-eared Owl
1	Hairy Woodpecker
1	Common Flicker
2	Bonaparte's Gull

Diversity = 1.57

August 28, 1980.

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4 White-fronted Geese flying over gravel bars in front of Dry Bay Fish Co.

1 Kestrel over D.B. Fish Co.

2 Marsh Hawks over muskegs, marshy estuaries, dunes in back of marine beaches

1 Peregrine Falcon along Lost River Road - spruce forest and muskegs near Situk estuary

14 Short-eared Owls along Lost River Road

1 Golden Eagle along Alsek

August 30, 1980

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60 White-fronted Geese over Situk

30 White-fronted Geese over Tawah Creek

August 29, 1980. Yakutat forelands and estuaries to Doame River; Russell Fiord, Yakutat Bay. Aircraft transect 0945 - 1220 hrs. Visibility excellent. Clear blue sky, little clouds, no wind.

Situk-Ahrnklin Flats (L - Fm - Sm)

1	Glaucous-winged Gull	
1	Raven	
1	Herring Gull	
2	Bald Eagle	
40	Canada Geese	
400	Mallard	Diversity = 1.21
300	Pintail	
480	Wigeon	

Old Italio (Fm - Sm)

20 Wigeon

Akwe River adjacent to coast (L - Bs - Fm)

3	Bald Eagle	
37	Mallard	
27	Wigeon	Diversity = 0.89
1	Bonaparte's Gull	

Alsek River at Dry Bay (L - Bs)

20	small shorebirds	
4	Mallard	
30	Herring Gull	
40	Glaucous-winged Gull	
15	Hybrid gulls	
1	Bald Eagle	
120	Canada Geese	Diversity = 1.70
20	Mew Gull	
22	Wigeon	

East-Doame River Estuaries and East River (L - Fm - Bs)

34	Mallard	
203	Glaucous-winged Gull	
847	Wigeon	
20	Bald Eagle	
2	Common Merganser	
7	Trumpeter Swan	
10	Great Blue Heron	
53	Bonaparte's Gull	
40	Canada Geese	Diversity = 1.22
15	Herring Gull	
3	Mew Gull	
53	Pintail	

August 29, 1980
Yakutat Forelands and Estuaries to Doame River, contd.

South end of Russell Fiord (CoW)

860 Surf Scoter
4 Double-crested Cormorant
12 Mallard
5 Glaucous-winged Gull
6 Red-necked Grebe
54 Wigeon — Diversity = 0.40
6 Common Merganser

North(west) end of Russell Fiord (CoW - Bb)

470 Surf Scoter
2 Common Loon
17 Mallard
9 Glaucous-winged Gull
3 Black Oystercatcher
10 Common Merganser — Diversity = 0.98
25 White-winged Scoter
200 Arctic Tern

Yakutat Bay west of Knight Island (CoW)

172 Glaucous-winged Gull
50 Surf Scoter
35 White-winged Scoter — Diversity = 0.93
5 Black Scoter

Knight Island (SW reef) (CoW - Bb)

50 Surf Scoter
40 White-winged Scoter
10 Black Scoter
10 Pelagic Cormorant — Diversity = 1.35
75 Glaucous-winged Gull

Between Krutoi and Otmeloi (CoW)

(3 Sea Otter)

Khaantak (Outer SW side) (CoW - Bb)

115 White-winged Scoter
20 Common Merganser
10 Surf Scoter — Diversity = 0.76
5 Common Loon

Phipps Peninsula (L - Bb - Bs)

2 Bald Eagle
20 Mallard

August 30, 1980. Phipps Peninsula old-growth spruce-hemlock forest (H - Ds) 1000 - 1800 hrs. High overcast. On foot transect.

2	Bald Eagle	
6	Robin	
23	Chestnut-backed Chickadee	
5	Yellow-rumped Warbler	
8	Stellar's Jay	
35	Pine Grosbeak	
2	Orange-crowned Warbler	
1	Golden-crowned Kinglet	Diversity = 1.85
2	Red-breasted Nuthatch	
2	Raven	
1	Canada Goose	

<u>Mouth of Ankau Creek - Monti Bay</u> 1400 - 1500 hrs. (CoW - Bs)

10	Bonaparte's Gull	
4	White-winged Scoter	
1	Bald Eagle	
5	Black-legged Kittiwake	
5	Mew Gull	
50	Sanderling	
4	Arctic Loon	
10	Marbled Murrelet	
1	Horned Grebe	Diversity = 1.74
15	Northern Phalarope	
1	Common Loon	
1	Yellow-billed Loon	

September 1, 1980. East River (L - Ds) On foot along river adjacent to Forest Service cabin 1800 - 2030 hrs. High overcast.

14	White-fronted Geese
7	Bonaparte's Gull
1	Mew Gull
3	Great Blue Heron
15	Raven
30	Mallard
75	Wigeon
3	Green-winged Teal
1	Greater Yellowlegs
2	Belted Kingfisher
1	Varied Thrush
1	Long-billed dowitcher
1	Common Snipe

Diversity = 1.59

September 2, 1980. East Alsek -- Forest Service cabin to Lowensteins's East River Lodge. 0700 - 1400 hrs. (Beginning of Estuary) - boat transect (L - Ds) Moderate overcast. Wind SW to SE.

30	Raven
9	Varied Thrush
10	Bonaparte's Gull
71	Mallard
6	Mew Gull
11	Green-winged Teal
17	Canada Geese
50	White-fronted Geese
5	Great Blue Heron
35	Northern Phalarope
1	Ruby-crowned Kinglet
62	Wigeon
2	Black-capped Chickadee
1	Sandhill Crane
5	Common Merganser
3	Magpie
3	Pintail
1	Belted Kingfisher
3	Glaucous-winged Gull
1	Herring Gull
1	Thayers's Gull
1	Spotted Sandpiper
1	Savannah Sparrow
3	Trumpeter Swan
3	Lesser Yellowlegs
1	Rusty Blackbird
2	Merlin

Diversity = 2.39

September 5, 1980.	Upper East Alsek Estuary. On foot observation of river and river shorelines. Area immediately above Lowenstein's Lodge and surrounding coves. 1100 - 1500 hrs. (L - Fm)

705	Wigeon	
295	Pintail	
15	Green-winged Teal	
4	Mallards	
11	Glaucous-winged Gull	
3	Herring Gull	
4	Bonaparte's Gull	
1	Horned Grebe	Diversity = 0.80
1	Sharp-shinned Hawk	
1	Great Horned Owl - riparian cottonwoods	

September 6, 1980. Middle East Alsek Estuary. On foot obeservations of estuary from island in middle of river (Lowenstein's Duck Blind) - fishing cabin. (Fm - L) Clear. Wind from SW in p.m. 0900 - 1700 hrs.

6	Bald Eagle
44	Glaucous-winged Gull
14	Trumpeter Swan
4	Savannah Sparrow
1	Marsh Hawk
6	Bonaparte's Gull
14	Lesser Yellowlegs
7	Golden Plover
2	Northern Phalarope
10	Pectoral Sandpiper
3	Black-bellied Plover
24	Red-breasted Merganser
15	Wigeon
28	Greater Scaup
1	Canvasback
1	Double-crested Cormorant
9	White-fronted Geese
4	Horned Grebe

Diversity = 2.40

September 9, 1980. Lower East Alsek Estuary. Boast transect from Lowenstein's outer duck blind - fishing cabin, west down towards mouth of river. (L - Bs - Sm) 0900 - 1700 hrs.

7	White-fronted Geese
3	Trumpeter Swan
15	Raven
15	Glaucous-winged Gull
5	Bonaparte's Gull
4	Savannah Sparrow
4	Pintail
20	Greater Scaup
19	Red-breasted Merganser
2	Golden Plover
1	Harlequin Duck
6	Lapland Longspur
1	Water Pipit
30	Sanderling
2	Pectoral Sandpiper
1	Shoveler
1	Surfbird
2	Oldsquaw
1	Bald Eagle
2	Glaucous Gull
4	Ruddy Turnstone
20	Herring Gull
1	Black Turnstone

Diversity = 2.54

September 10, 1980. Lower East Alsek Estuary. Boat transect from Lowenstein's out duck blind - fishing cabin west to mouth of East Alsek River and return. (L - Bs - Sm) 0900 - 1700 hrs.

1	Marsh Hawk
1	Double-crested Cormorant
22	Raven
36	Sanderling
15	Wigeon
12	Savannah Sparrow
10	Black-legged Kittiwake
35	Herring Gull
77	Glaucous-winged Gull
4	Ruddy Turnstone
20	Northern Phalarope
1	Glaucous Gull
2	Oldsquaw
7	Bald Eagle
27	Black Scoter
3	Trumpeter Swan
2	Greater Yellowlegs

Diversity = 2.22

September 11, 1980. Lower East Alsek Estuary. Boat Transect from Lowenstein's outer duck blind - fishing cabin to sandflats near mouth of river. (Sm - Fm - Bs) 0900 - 1700 hrs.

3	Shoveler
7	Greater Yellowlegs
2	Northern Phalarope
2	Savannah Sparrow
12	Lapland Longspur
96	Sanderling
7	Water Pipit
57	Glaucous-winged Gull
14	Bonaparte's Gull
3	Ruddy Turnstone
1	Great Blue Heron
9	Herring Gull
12	Common Merganser
1	Semipalmated Plover
1	Golden Eagle
2	Bald Eagle
28	Golden Plover
1	Black-bellied Plover
15	Raven
30	Canada Geese

Diversity = 2.17

September 13, 1980. Upper East Alsek Estuary. In front of Lowenstein's East River Lodge only. On foot. (Fm - L) 1300 - 1400 hrs.

64	Pintail	
62	Wigeon	
2	Gadwall	
3	Shoveler	
4	Mallard	
1	Common Merganser	
1	Northern Phalarope	
5	Glaucous-winged Gull	
1	Herring Gull	
3	Trumpeter Swan	Diversity = 1.32
1	Golden Plover	
2	Bald Eagle	

September 25, 1980. Yakutat Forelands, Including Harlequin Lake, Dangerous River and Estuary, Ahrnklin Flats, Italio Estuary, Akwe River adjacent to Coast, Alsek River at Dry Bay, the East-Doame River Estuaries and the East River. Aircraft transect 0730 - 1000 hrs. Winds calm. 1500 ft. broken overcast.

Harlequin Lake (L)

1	Glaucous-winged Gull	
32	Common Merganser	
10	Harlequin Duck	
1	Magpie	Diversity = 1.01
6	Greater Scaup	

Dangerous River and Estuary (L - Bs)

2	Bald Eagle	
3	Glaucous-winged Gull	
3	Mallard	
24	Canada Geese	Diversity = 1.43
20	Wigeon	
20	Pintail	

Ahrnklin Flats (Fm - Sm)

2	Bald Eagle	
274	Wigeon	
27	Canada Geese	
107	Mallard	
40	Glaucous-winged Gull	
24	Northern Phalarope	Diversity = 1.42
50	Sanderling	

Italio Estuary (L - Bs)

25	Glaucous-winged Gull	
1	Bald Eagle	
1	Raven	Diversity = 0.83
12	Sanderling	

Akwe River adjacent to coast (L - Bs)

1	Bald Eagle	
1	Herring Gull	Diversity = 0.45
14	Glaucous-winged Gull	

September 25, 1980
Yakutat Forelands, contd.

<u>Alsek River at Dry Bay</u> (L - Bs)

51 Sanderling
103 Glaucous-winged Gull
5 Bald Eagle — Diversity = 1.52
37 Canada Geese
27 Raven

<u>East-Doame River Estuaries and East River</u> (L - Fm - Bs)

542 Glaucous-winged Gull
44 Bald Eagle
1 Herring Gull
388 Wigeon
21 Canada Geese
76 Mallard
1 Magpie — Diversity = 1.32
59 Common Merganser
21 Trumpeter Swan

September 25, 1980. Second survey flight. Russell Fiord (south and north ends), Nunatak Fiord. 200 ft. overcast. 30 mil. visibility. Very muted indirect light. No sunlight, no shadows. Aircraft transect 1800 - 1930 hrs. Additional sea otter observations in Yakutat Bay.

South end of Russell Fiord (CoW)

593 Surf Scoter
34 White-winged Scoter
12 Glaucous-winged Gull
4 Bonaparte's Gull
96 Common Merganser
12 Barrow's Goldeneye
2 Horned Grebe
215 Mallard
12 Double-crested Cormorant

Diversity = 1.16

Nunatak Fiord (CoW)

21 Horned Grebe
47 Mallard
2 Double-crested Cormorant
3 Wigeon
120 Surf Scoter
2 Mew Gull
8 Glaucous-winged Gull
51 White-winged Scoter
3 Red-throated Loon
5 Red-necked Grebe
3 Common Merganser
(1 Harbor Porpoise)

Diversity = 1.56

North(west) end of Russell Fiord (CoW)

151 Surf Scoter
12 Mallard
1 Northern Phalarope
(1 Wolverine)
(200 Harbor Seal)

Diversity = 0.29

Between Khaantak, Otmeloi, and Krutoi (CoW)

(6 - 12 Sea Otter)

September 26, 1980. Phipps Peninsula, Yakutat Bay Islands, Manby side to Icy Bay. 500 ft. overcast. Winds calm. Visibility 25 - 30 miles. Aircraft transect 0815 - 1045 hrs.

Phipps Peninsula (L - Bb - Bs)

10 Mallard
50 Wigeon
15 Scaup sp.
17 Pelagic Cormorant
150 Canada Geese
25 Bonaparte's Gull
30 White-winged Scoter
16 Glaucous-winged Gull — Diversity = 1.63
1 Common Loon

Khaantak (lee side) (Bs - Bb - CoW)

149 Surf Scoter
4 Pelagic Cormorant
4 Bonaparte's Gull
7 Red-necked Grebe
4 White-winged Scoter
8 Black-legged Kittiwake
3 Harlequin Duck — Diversity = 0.75
1 Glaucous-winged Gull

Knight Island - SW reef (Cow - Bb)

52 Pelagic Cormorant
152 Harlequin
200 White-winged Scoter
102 Surf Scoter
10 Double-crested Cormorant
1 Bald Eagle — Diversity = 1.42
11 Bonaparte's Gull

Knight Island - north side (Bb - CoW)

1 Yellow-billed Loon
6 Common Merganser
9 Glaucous-winged Gull
10 Bonaparte's Gull
1 White-winged Scoter
5 Pelagic Cormorant
8 Greater Scaup
2 Marbled Murrelet — Diversity = 1.94
3 Bald Eagle

September 26, 1980
Phipps Peninsula, Yakutat Bay Islands, contd.

Yakutat Bay west of Knight Island (CoW)

149 White-winged Scoter
3 Red-necked Grebe
30 Black Scoter
2 Red-throated Loon
13 Bonaparte's Gull — Diversity = 1.26
15 Glaucous-winged Gull

Manby Side (Esker Creek to and including Malaspina Lake) (Bs - L)

6 Bald Eagle
75 Wigeon
137 Canada Geese — Diversity = 0.95
17 Trumpeter Swan

Oscar Stream - Pt. Manby - Alder Creek (L - Bs)

12 Bald Eagle
24 Mallard

Sitkagi Bluffs - Fountain Stream (CoW - Bb - L)

8 Canada Geese
46 Surf Scoter
1 Bald Eagle
2 Trumpeter Swan — Diversity = 0.83
4 Mallard
(100 Stellar Sea Lion)

Yana - Yahtze Streams (L - Fm)

3 Bald Eagle
25 Canada Geese — Diversity = 0.79
8 Trumpeter Swan

Icy Bay - Pt. Riou (Bs)

147 Canada Geese
11 Glaucous-winged Gull — Diversity = 0.52
15 Bonaparte's Gull

September 27, 1980. East River, north up river from Forest Service cabin. Boat transect, rowing against current and on foot through shallows (L - Ds) 0900 - 1700 hrs.

261	Wigeon	
44	Glaucous-winged Gull	
3	Bald Eagle	
7	Raven	
1	Downy Woodpecker	
1	Hairy Woodpecker	
1	Ruby-crowned Kinglet	
8	Magpie	
27	Common Merganser	
2	Red-necked Grebe	
2	Harlequin Duck	
1	Belted Kingfisher	
1	Dipper	
10	Pintail	
1	Marsh Hawk	
2	Double-crested Cormorant	
5	Trumpeter Swan	Diversity = 1.22
1	Red-brested Nuthatch	
1	Bonaparte's Gull	

September 28, 1980. East River, from <u>origin</u> (south of the current main branch of the Alsek River) south to the Forest Service East River cabin. Boat transect 1000 - 1700 hrs. (L - Ds) High overcast, wind out of SE. Brown bear sign extremely heavy. Saw 3.

1	Common Snipe
1	Rough-legged Hawk
262	Glaucous-winged Gull
5	Belted Kingfisher
12	Magpie
5	Black-capped Chickadee
1	Ruby-crowned Kinglet
14	Varied Thrush
26	Raven
16	Bald Eagle
53	Rusty Blackbird
12	Pine Siskin
3	Pine Grosbeak
12	Trumpeter Swan
75	Bonaparte's Gull
60	Mew Gull
12	Mallard
6	Great Blue Heron
127	Common Merganser
16	Herring Gull
3	Green-winged Teal
2	Spotted Sandpiper
125	Wigeon
4	Dipper
1	Sharp-shinned Hawk
2	Song Sparrow

Diversity = 2.23

September 30, 1980. Forest Service East River Cabin to Bear Island and return. On foot. Deciduous shrublands. 0900 - 1700 hrs. (Ds - L) Overcast and light rain.

1	Goshawk
2	Black-capped Chickadee
1	Hawk Owl
1	Water Pipit
1	Hairy Woodpecker
2	Common Snipe
1	Bald Eagle
4	Raven
3	Pine Grosbeak
2	Magpie
1	Northern Shrike
2	Rough-legged Hawk
2	Golden Plover
4	Green-winged Teal
1	Mallard
2	Sandhill Crane
12	Pine Siskin
1	Kestrel

Diversity = 2.45

October 2, 1980. East Alsek River, from Forest Service East River cabin to beginning of estuary above Lowenstein's East River Lodge. 0900 - 1400 hrs. (L - Ds - Fm) Overcast and wind out of SE.

100	White-fronted Geese
150	Lesser Canada Geese + 12 Dusky Canada Geese
186	Wigeon
30	Common Merganser
2	Belted Kingfisher
157	Glaucous-winged Gull
5	Mew Gull
9	Raven
2	Rough-legged Hawk
5	Pine Grosbeak
12	Water Pipit
1	Willow Ptarmigan
1	Savannah Sparrow
22	Bald Eagle
4	Magpie
4	Great Blue Heron
8	Mallard
2	Black-capped Chickadee
1	Glaucous Gull
7	Trumpeter Swan
37	Rusty Blackbird
6	Herring Gull
1	Stellar's Jay
2	Northwestern Crow
1	Green-winged Teal
14	Bonaparte's Gull
2	Northern Phalarope
1	Sharp-shinned Hawk
12	Barrow's Goldeneye
2	Harlequin
1	Spotted Sandpiper
12	Brant

Diversity = 2.21

October 3, 1980. Observations of migrating waterfowl from the immediate vicinity of the Forest Service East River cabin. Full gale blowing in morning hours, with heavy rain squalls from the SE. Clearing at 1700 hours. Observations are subsequent to the cessation of wind and beginning of clearing. 1700 - 2000 hours. (darkness) (L-Ds)

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120 Lesser Canada Geese
90 Whistling Swan
158 White-fronted Geese
144 Dusky Canada Geese
20 Wigeon
5 Trumpeter Swan — Diversity = 1.67
25 Common Snipe
10 Willow Ptarmigan on ground near airstrip in willows

October 12, 1980. Observations of migrating waterfowl from the immediate vicinity of the Alaska Department of Fish and Game Office, Yakutat. 1100 hours.

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30 Whistling Swan
12 Trumpeter Swan in air at same time and place
12 Snipe

October 13, 1980. Ridge forming southeast border on the canyon to the NNE of Harlequin Lake. 1100 hours.

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2 Golden Eagles

Upper Dangerous River (L-Ds)

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200 Dusky Canada Geese
25 Bald Eagle
12 Pine Siskin
2 Lapland Longspur

Middle Dangerous Cabin

Heavy nocturnal migration of Whistling Swans

October 4, 1980.	Middle East Alsek Estuary (observations from Lowenstein's duck blind - fishing cabin in middle of river). 1600 - 1900 hours. Immediately prior to onset of heavy rains and wind. (L-Fm)

2	Greater Yellowlegs	
2	Savannah Sparrow	
10	Glaucous-winged Gull	
2	Red-necked Grebe	
8	White-fronted Geese	
12	Sandhill Crane	
2	Redhead Duck	
12	Canvasback	
57	Greater Scaup	
3	White-winged Scoter	
30	Wigeon	
12	Common Merganser	
1	Marsh Hawk	
3	Bald Eagle	Diversity = 2.03
1	Sharp-shinned Hawk	
1	Red-throated Loon	

October 5, 1980. East Alsek Estuary (middle) to mouth of river 0900 - 1700 hours. (L-Bs) Fog and light winds. Drizzle.

34	Red-breasted Merganser
28	Canvasback
21	Bald Eagle
2	Fox Sparrow
33	Horned Grebe
2	Red-throated Loon
22	Raven
2	Green-winged Teal
4	Double-crested Comorant
16	Eurasian Wigeon
190	Greater Scaup
31	Glaucous-winged Gull
1	Oldsquaw
2	Savannah Sparrow
4	Lapland Longspur
30	Redhead Duck
2	Common Loon
39	American Wigeon
176	Canada Geese
5	Whistling Swan
17	Herring Gull
5	Harlequin Duck
17	White-fronted Geese
1	Shoveler
1	White-winged Scoter
10	Pintail
8	Mallard
1	Mew Gull
11	Black-legged Kittiwake
90	Thayer's Gull
30	Snow Geese

Diversity = 2.44

October 10, 1980. Situk Lake, South end of Russell Fiord, Dangerous River, initial observations of waterfowl concentrations at Situk-Ahrnklin Flats. Visibility 30 mi. Winds N at 5 mph. 2000 ft. broken overcast. Local broken ceilings below 1000 ft. Visibility occasionally 4 - 6 mi. Light rain and fog. Cloud tops layered to 20,000 ft. Aircraft transect 0900 - 1000 hrs.

Situk Lake (L)

10	Common Merganser	
1	Bald Eagle	
8	Harlequin Duck	
1	Red-necked Grebe	
1	Common Loon	
20	Mallard	Diversity = 1.13
83	Greater Scaup	
3	Trumpeter Swan	

South end of Russell Fiord (CoW - Bb)

500	Surf Scoter	
25	Glaucous-winged Gull	
1	Mallard	Diversity = 0.38
25	Northwestern Crow	
1	Raven	

Dangerous River (L)

2	Common Merganser	
39	Canada Geese	
8	Trumpeter Swan	Diversity = 0.92
8	Mallard	

Situk-Ahrnklin Flats (initial counts: do not compute diversity) (Fm - Sm)

138	Canada Geese
751	Snow Geese

October 10, 1980. Situk-Ahrnklin Estuary, Dangerous River Estuary, East-Doame River Estuary. Also observations on Tawah Creek, Lost River Estuary. Visibility very good. Broken overcast at 2000 ft. No wind. Sunshine diffuse, no shadows. Aircraft transect, 200 ft. 1600 - 1745 hrs.

<u>Tawah Creek - Lost River Estuary</u> (L - Fm - Bs - Sm)

15	Common Snipe	
1	Marsh Hawk	
1	Bald Eagle	
200	Wigeon	Diversity = 0.49
12	Canada Geese	

<u>Situk-Ahrnklin Estuary</u> (L - M - Sm)

3	Bald Eagle	
6	NW Crow	
3	Bonaparte's Gull	
521	Canada Geese	
670	Wigeon	
215	Mallard	
1	Eurasian Wigeon	
55	Whistling Swan	Diversity = 1.23
4	Trumpeter Swan	
1700	Snow Geese	

<u>Dangerous River Estuary</u> (L - Bs)

2	Bald Eagle
57	Canada Geese

<u>East-Doame River Estuary</u> (L - Fm)

50	Mallard	
275	Snow Geese	
20	Bald Eagle	
205	Glaucous-winged Gull	
24	Common Merganser	
40	Canada Geese	
15	Canvasback	Diversity = 1.68
23	Trumpeter Swan	
80	Wigeon	

October 11, 1980. Russell Fiord, Malaspina Forelands (Manby side) to Sudden Stream. 1800 ft. lowering overcast. Wind 210 at 5 knots. No direct sunlight and no shadows. Low pressure system approaching from ESE. Lowering clouds and rain towards end of survey force flight to be curtained. Aircraft transect 1140 - 1325 hrs.

Russell Fiord (CoW - Bb)

149 Mallard

1404 Surf Scoter

2 Bufflehead

10 Red-necked Grebe

460 Goldeneye

95 White-winged Scoter

135 Glaucous-winged Gull

1 Oldsquaw

23 Harlequin Duck

15 Scaup sp.

2 Common Merganser

1 Pigeon Guillemot

4 Pintail

3 Double-crested Cormorant — Diversity = 1.21

1 Red-throated Loon

(2 Harbor Porpoise)

Manby side to Sudden Stream (Bs - L - Fm)

107 Mallard

20 Canada Geese

30 Wigeon — Diversity = 0.94

1 Double-crested Cormorant

3 Bald Eagle

October 14, 1980. From the Forest Service Middle Dangerous Cabin to the Harlequin Lake Cabins along the Flagged Forest Service Trail through deciduous shrublands 0900 - 1200 hrs. (Ds - S). Overcast.

6	Varied Thrush
13	Trumpeter Swan
92	Pine Siskin
1	Common Snipe
14	Lapland Longspur
5	Bald Eagle
1	Herring Gull
7	Golden-crowned Kinglet
1	Magpie
12	Pine Grosbeak
1	Downy Woodpecker
1	Merlin
1	Rough-legged Hawk
1	Redpoll
2	Raven

Diversity = 1.54

APPENDIX XII

FIGURES

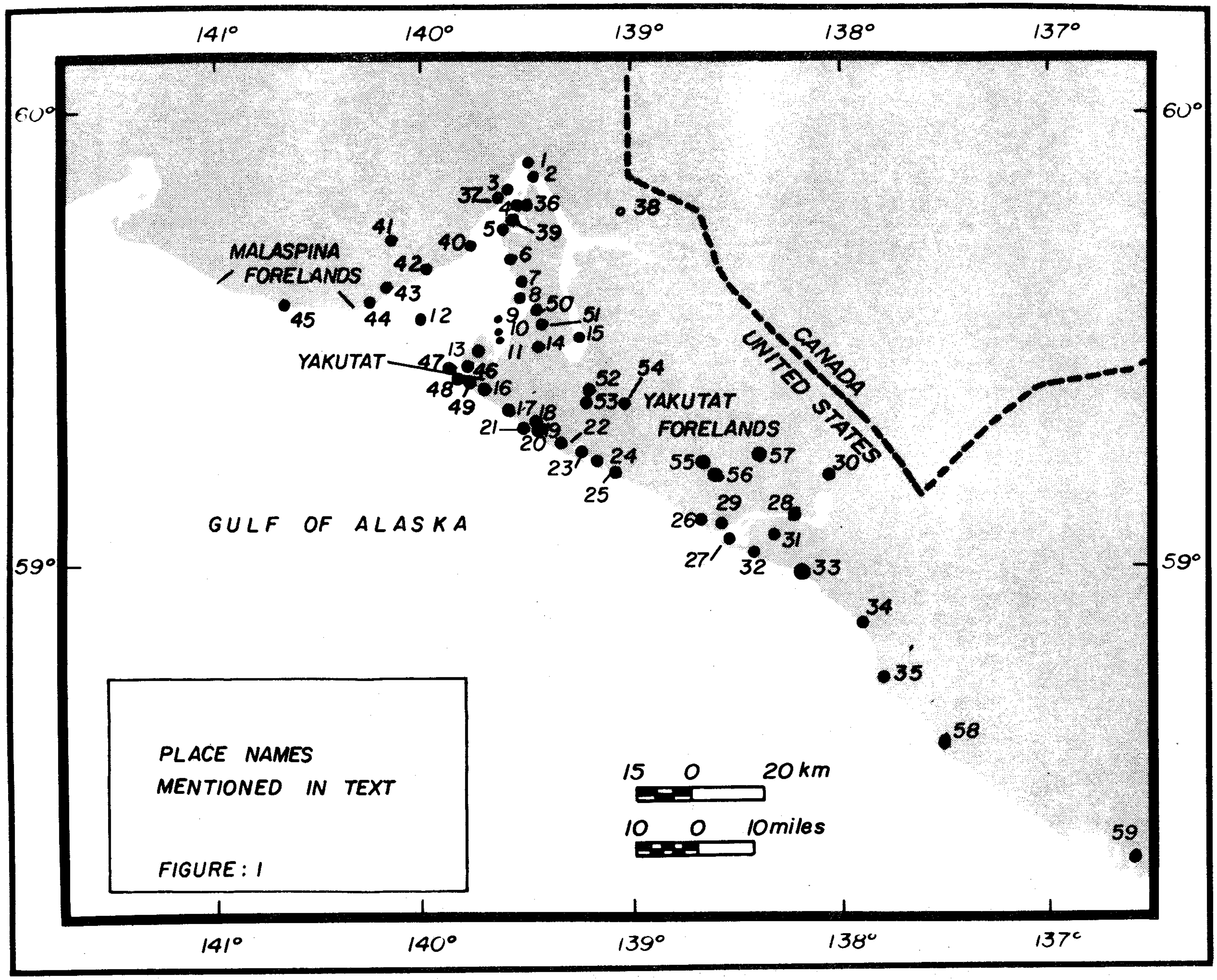


FIGURE 1. YAKUTAT & MALASPINA FORELANDS

KEY TO FIG. 1 -- Place Names Mentioned in Text

1. Hubbard Glacier
2. Osier Island
3. Turner Glacier
4. Haenke Island
5. Pt. Latouche
6. Logan Bluffs
7. Logan Beach
8. Knight Island
9. Krutoi Island
10. Otmeloi Island
11. Kriwoi Island
12. Yakutat Bay
13. Khaantak Island
14. Situk Lake
15. Cape Stoss
16. Tawah Creek
17. Lost River
18. Situk Mouth
19. Blacksand Island
20. Ahrnklin Mouth
21. Blacksand Spit
22. Situk-Ahrnklin Flats
23. Dangerous River Mouth
24. Old Italio
25. Italio River Mouth
26. Akwe River
27. Dry Bay
28. Alsek River
29. Muddy Creek
30. Alsek Canyon
31. Bear Island
32. East River Sandflats
33. East River - Doame Estuary
34. Sea Otter Creek
35. Cape Fairweather
36. Calahonda Creek
37. Bancas Point
38. Nunatak Bench
39. Aquadulce Creek
40. Grand Wash River
41. Malaspina Lake
42. Sudden Stream
43. Schooner Beach
44. Point Manby
45. Sitkagi Bluffs
46. Monti Bay
47. Pt. Carrew
48. Ocean Cape

Key to Fig. 1 - contd.

49. Ankau Saltchucks
50. Chicago Harbor
51. Upper Situk Drainage
52. Yakutat Glacier
53. Harlequin Lake
54. Italio Lake
55. Triangle Lake
56. Square Lake
57. Tanis Lake
58. Lituya Bay
59. Dixon Harbor

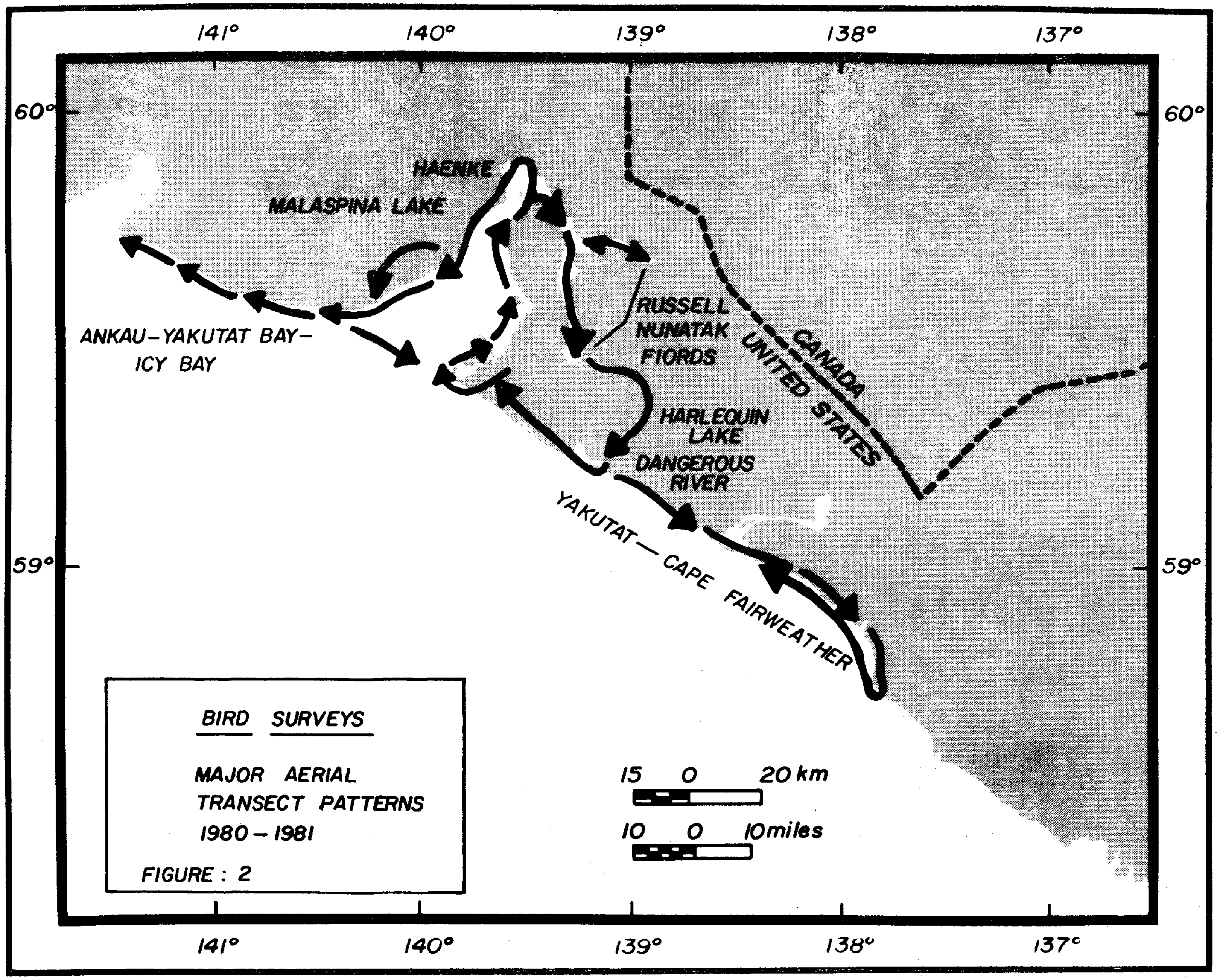
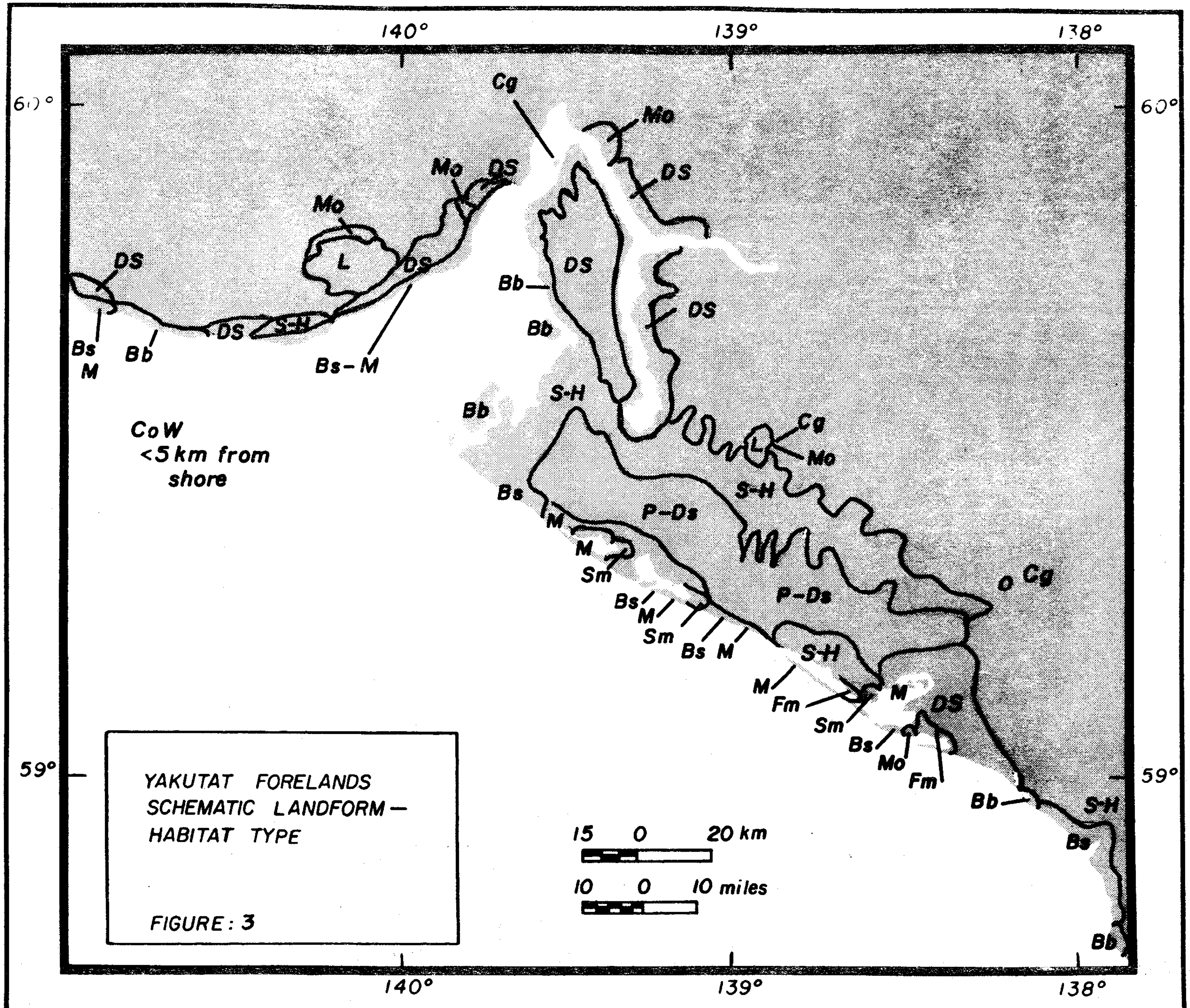


FIGURE 2. BIRD SURVEYS - MAJOR AERIAL TRANSECT PATTERNS 1980-1981

FIGURE 3. YAKUTAT FORELANDS - SCHEMATIC HABITAT TYPES



KEY TO FIG. 3

HABITAT CODE DEFINITIONS

Keyed to USNPS Dixon Harbor Biological Survey, 1973-74,
National Park Service, Juneau, Alaska,
I.A. Worley, G.P. Streveler, Eds.

L -- fresh water: lakes, rivers, streams, sloughs

Bb -- rocky shores

Bs -- sandy shores

CoW -- coastal waters, here considered those less than 5 km from shore

M -- supratidal meadows

Ds -- deciduous shrublands, here including seral black cottonwood stages

S -- coniferous forest dominated by spruce, including seral stages

Cg -- cliffs and gullies, here confined to Haenke Island seabird colony

Fm -- freshwater marshes

Sm -- estuarine marshes dominated by salt-tolerant species

Mo -- barren moraines and outwashes

H -- old growth mixed spruce-hemlock forest

P -- peatlands, bogs, muskegs

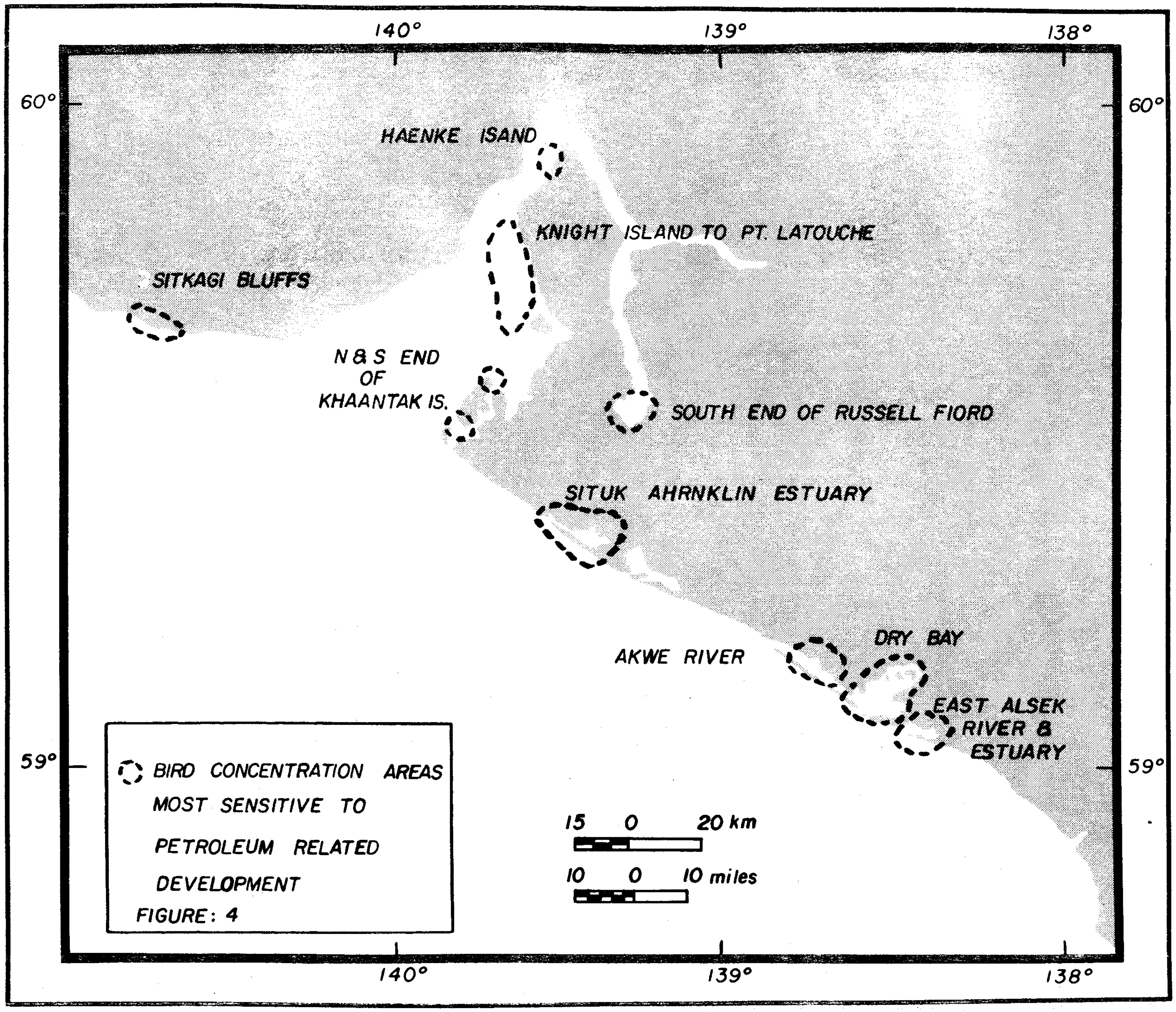


FIGURE 4. BIRD CONCENTRATION AREAS MOST SENSITIVE TO PETROLEUM-RELATED DEVELOPMENT

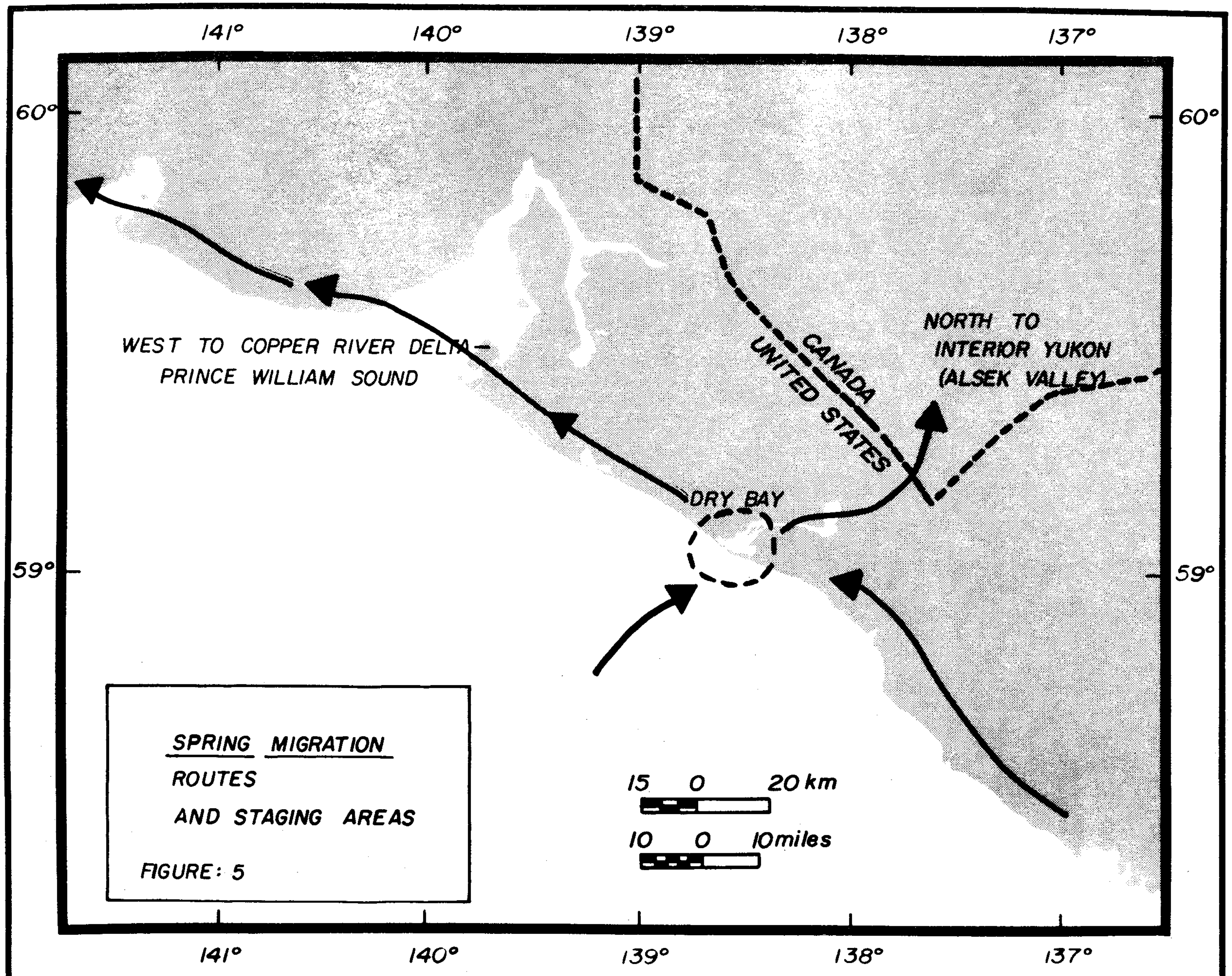


FIGURE 5. SPRING MIGRATION ROUTES AND STAGING AREA

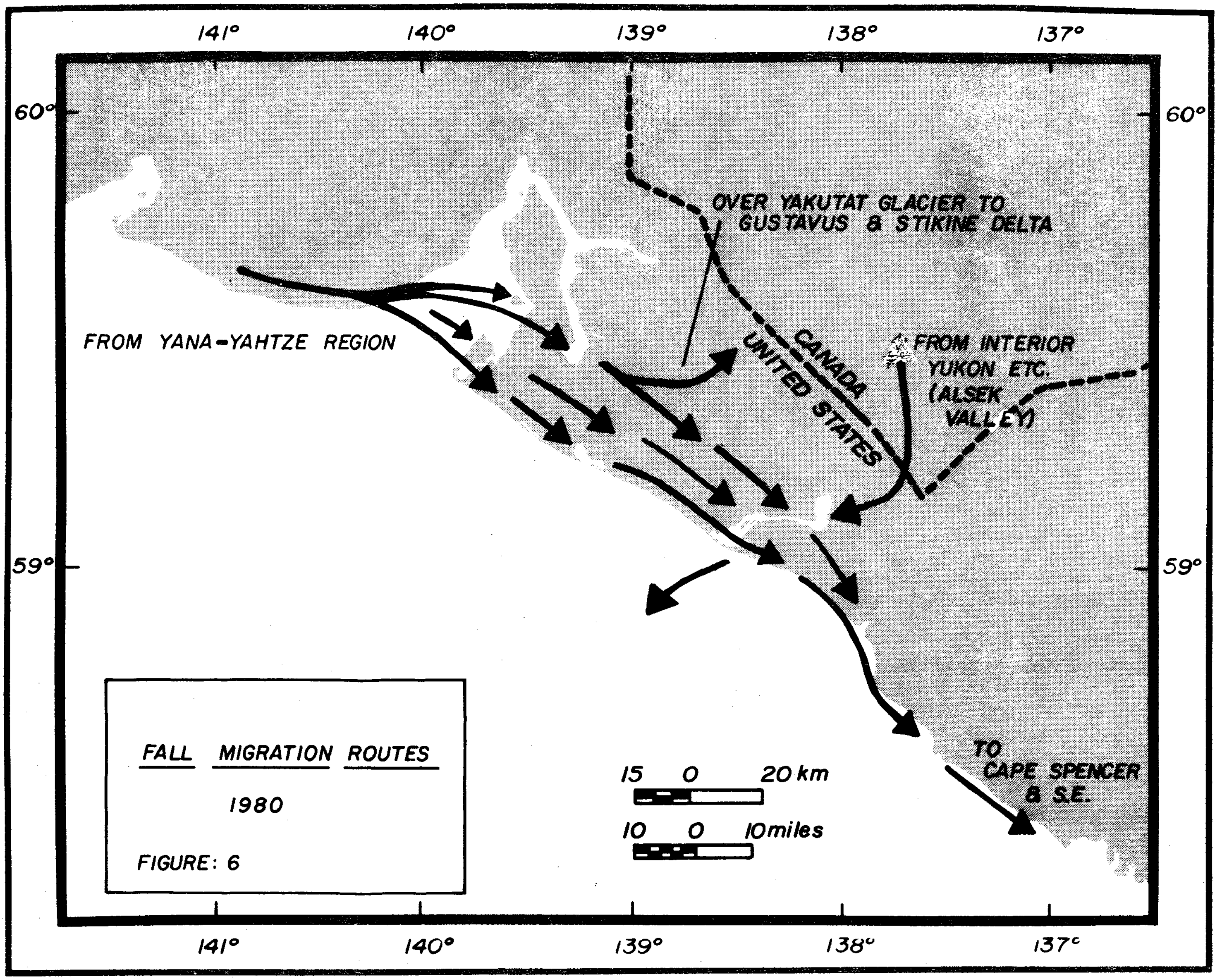


FIGURE 6. FALL MIGRATION ROUTES - 1980

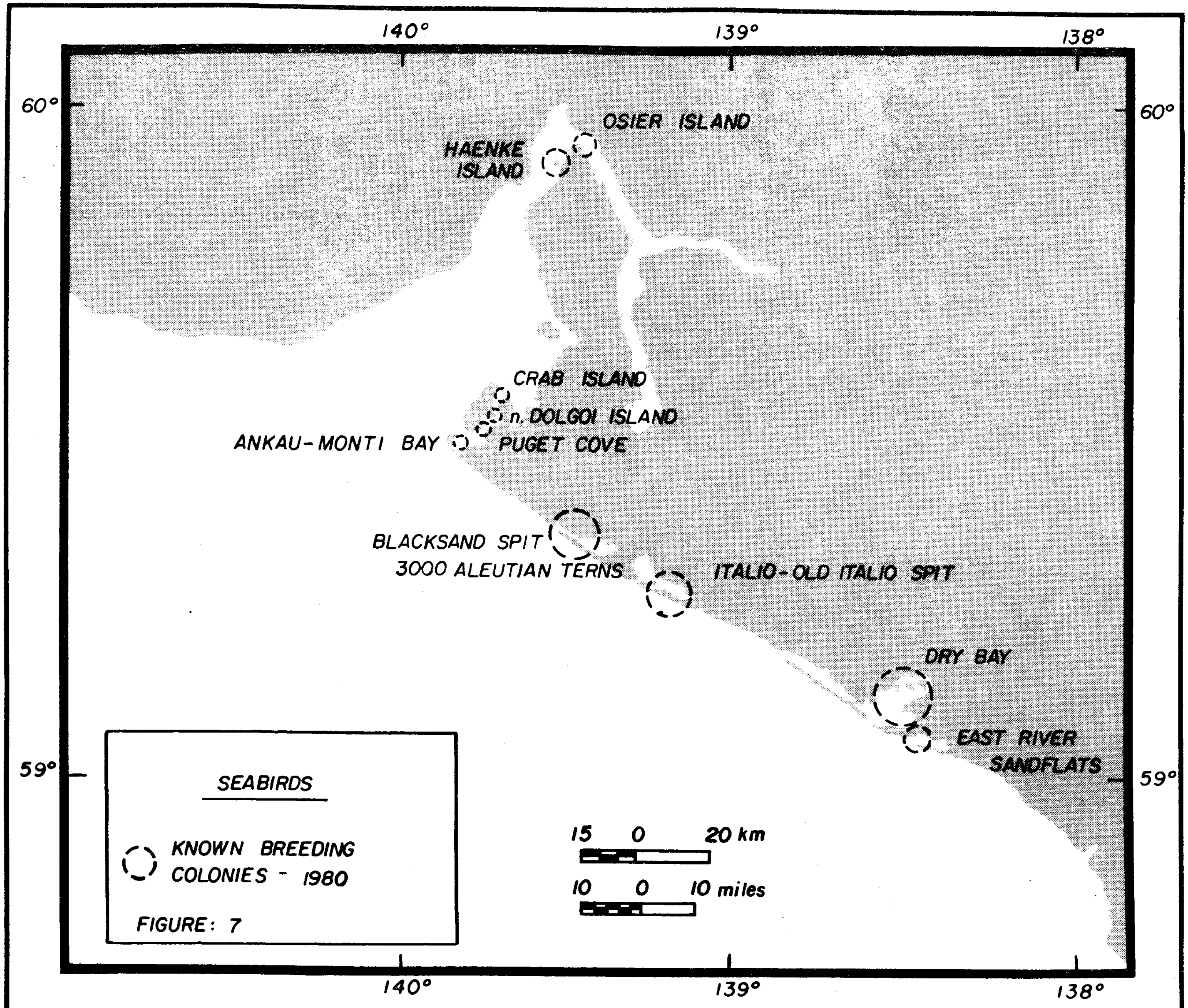


FIGURE 7. KNOWN SEABIRD BREEDING COLONIES NEAR YAKUTAT - 1980

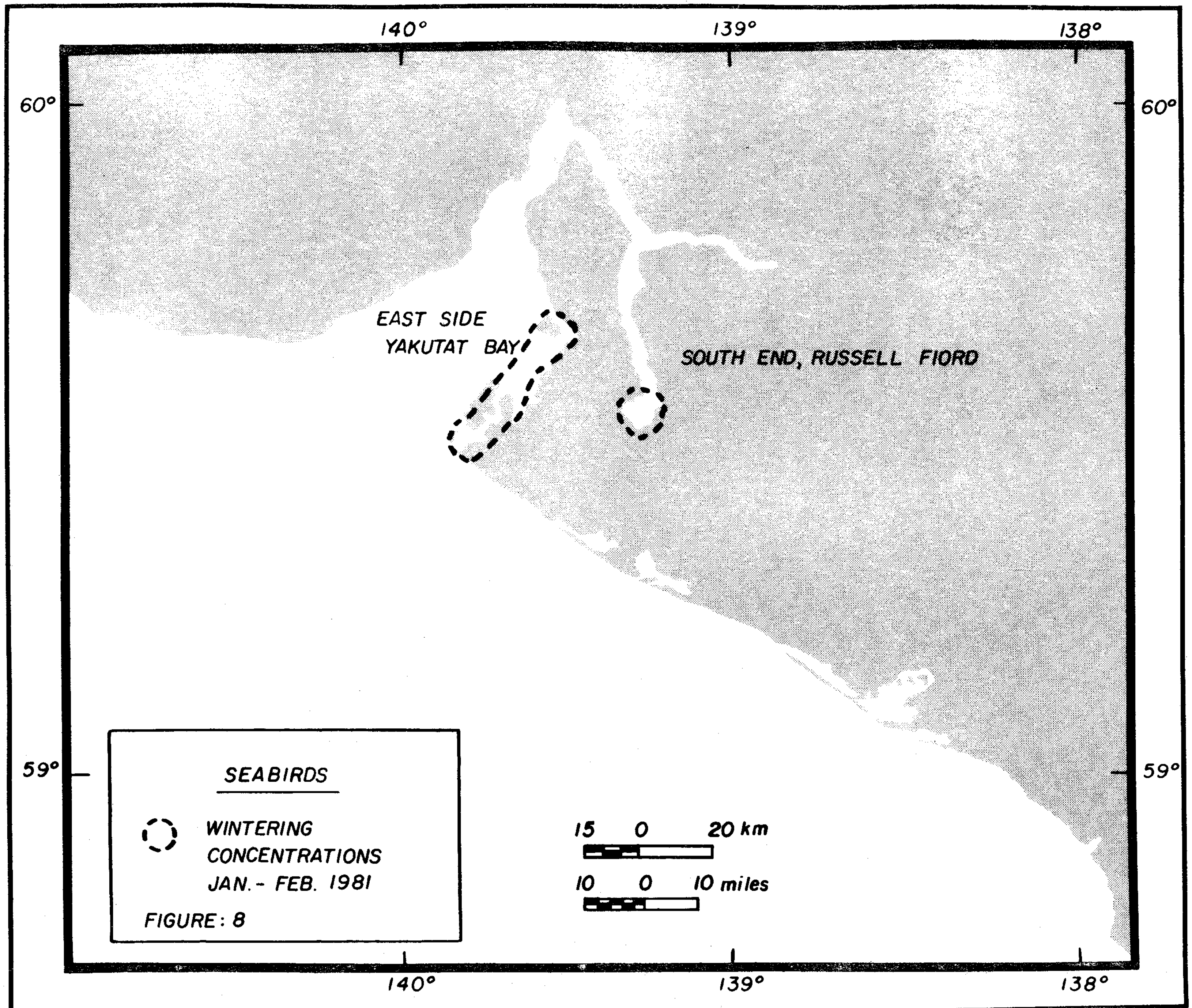


FIGURE 8. WINTERING SEABIRD CONCENTRATIONS - JANUARY-FEBRUARY, 1981

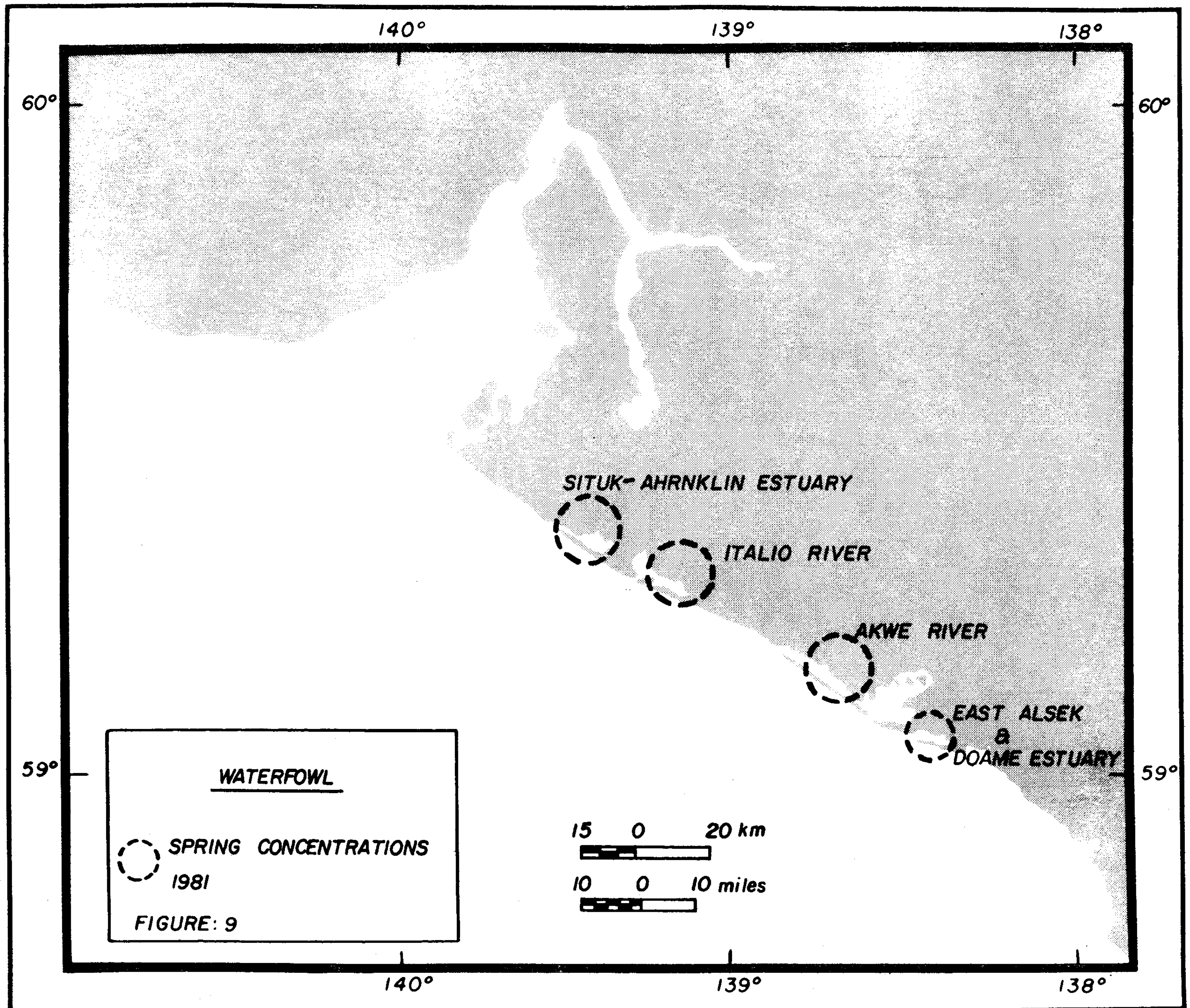


FIGURE 9. SPRING WATERFOWL CONCENTRATIONS 1981

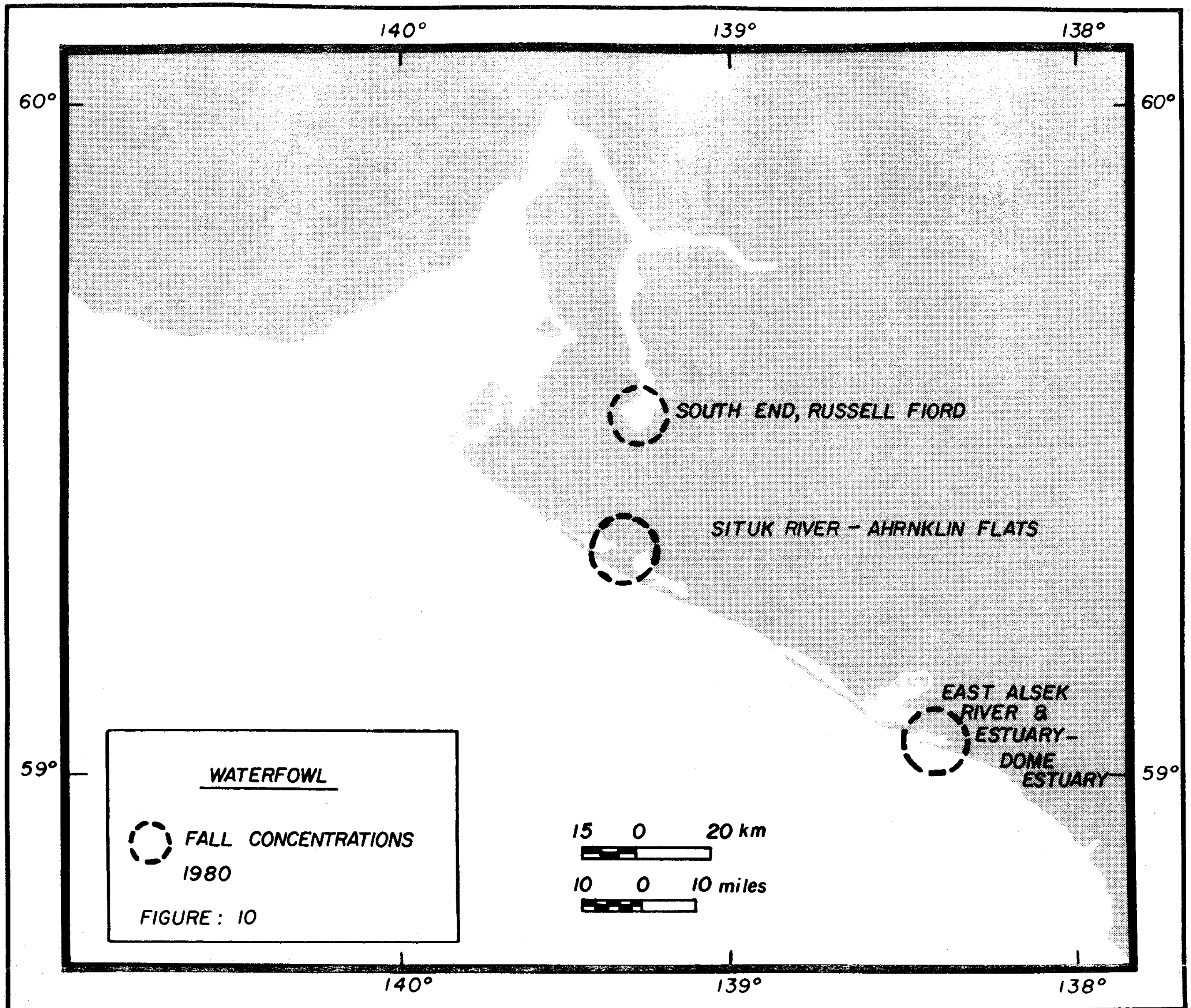


FIGURE 10. FALL WATERFOWL CONCENTRATIONS 1980-1981

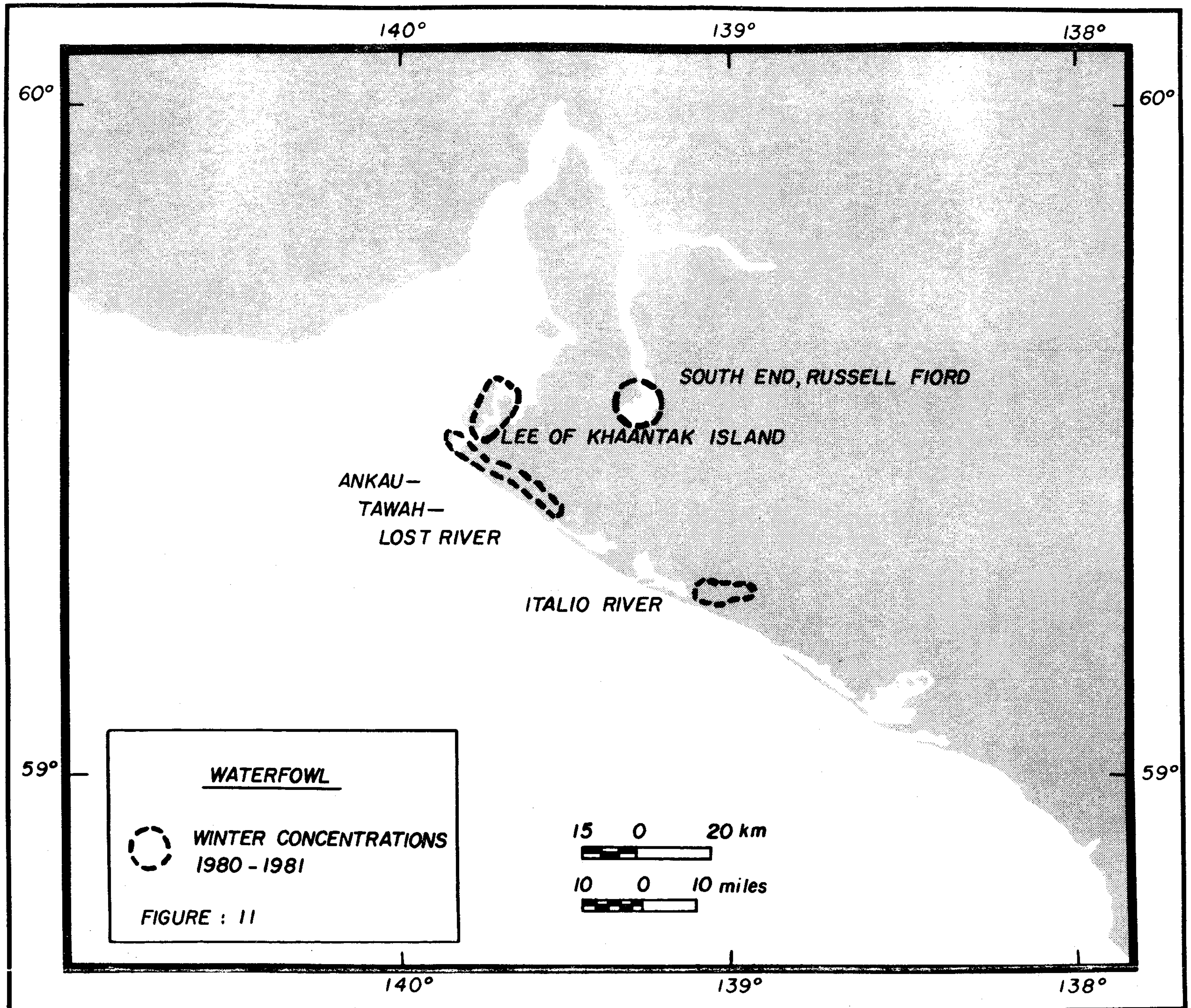


FIGURE 11. WINTER WATERFOWL CONCENTRATIONS 1980-1981

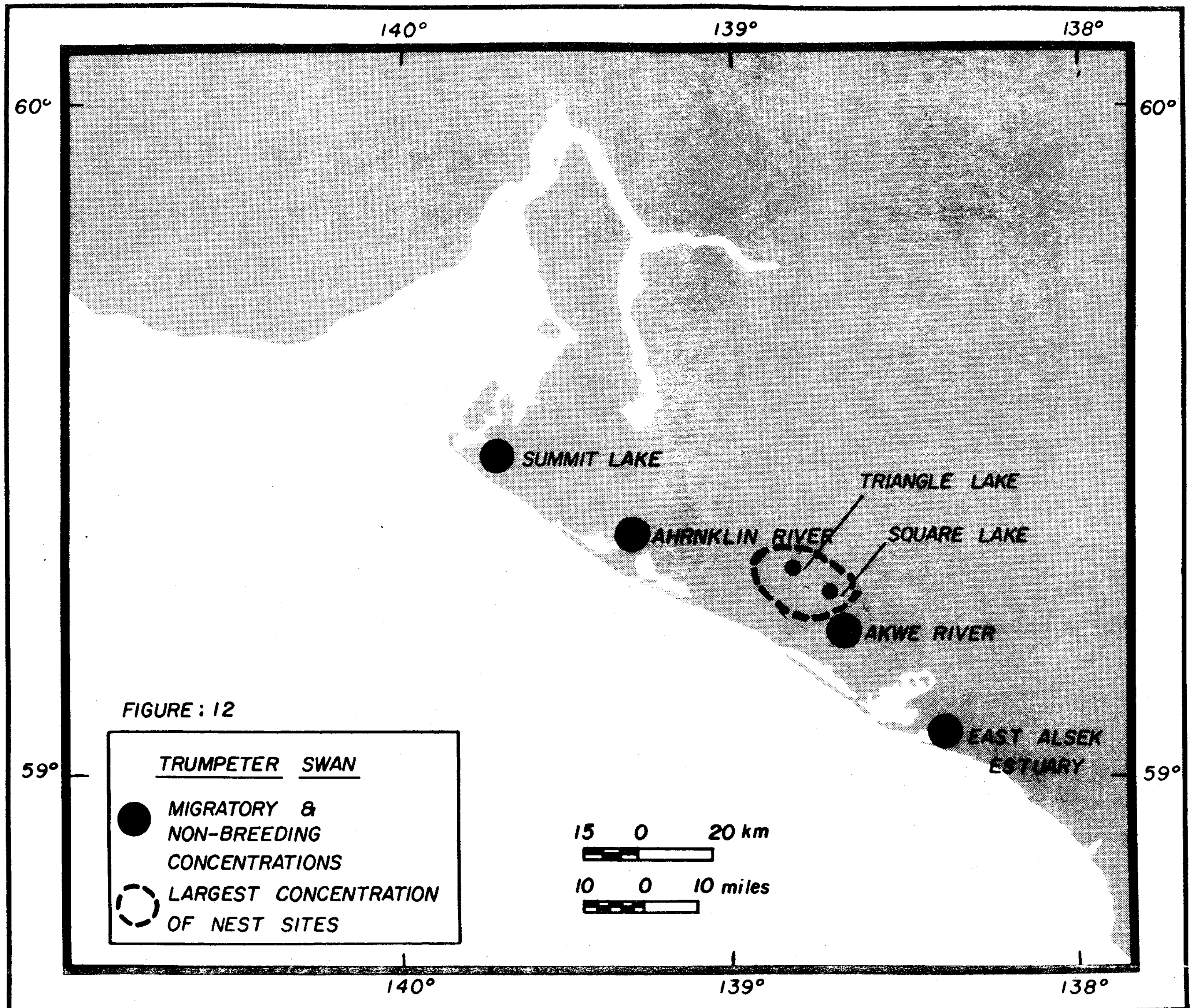


FIGURE 12. TRUMPETER SWAN NEST SITES AND MIGRATORY CONCENTRATIONS 1980-1981

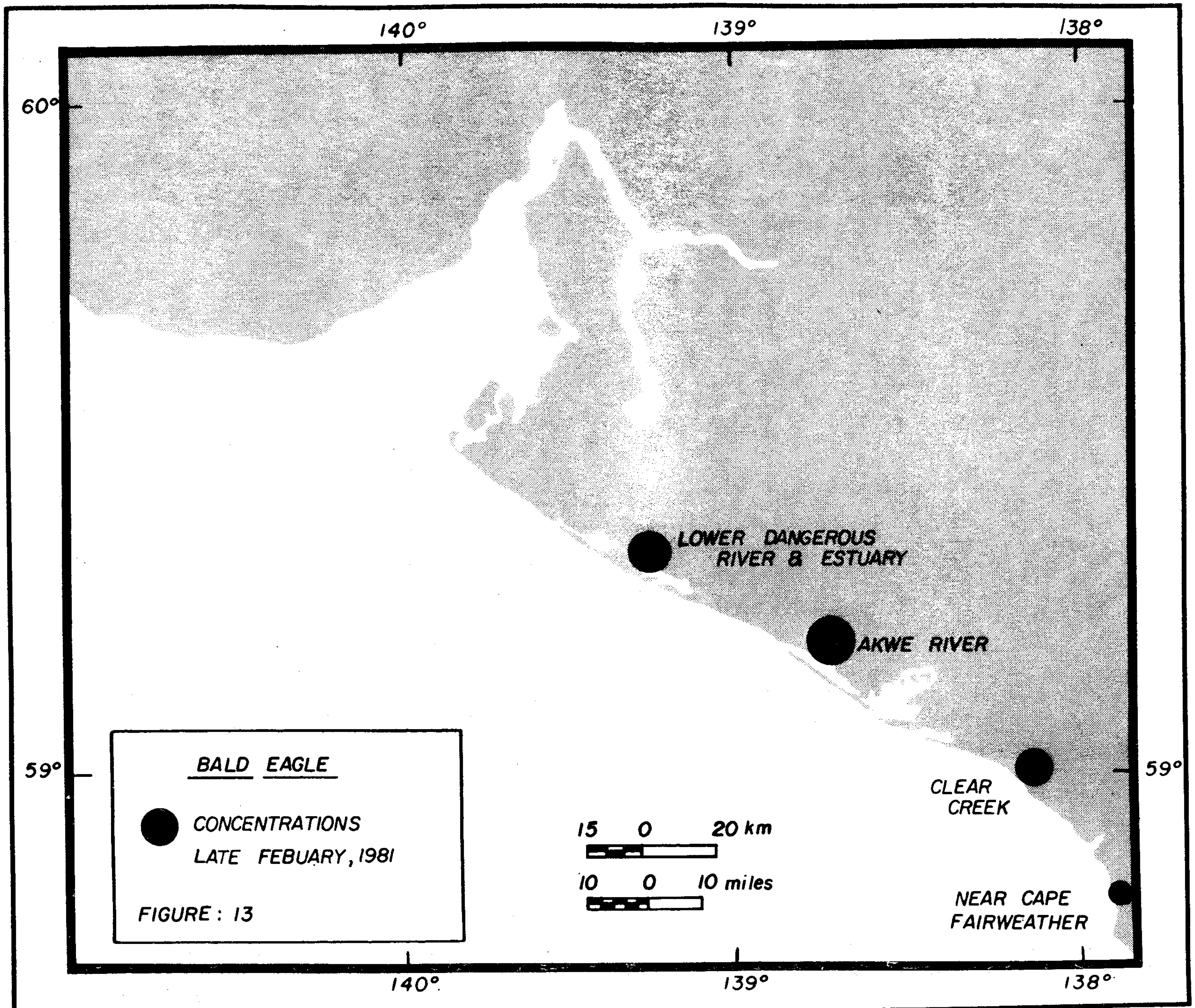


FIGURE 13. BALD EAGLE CONCENTRATIONS - LATE FEBRUARY 1981

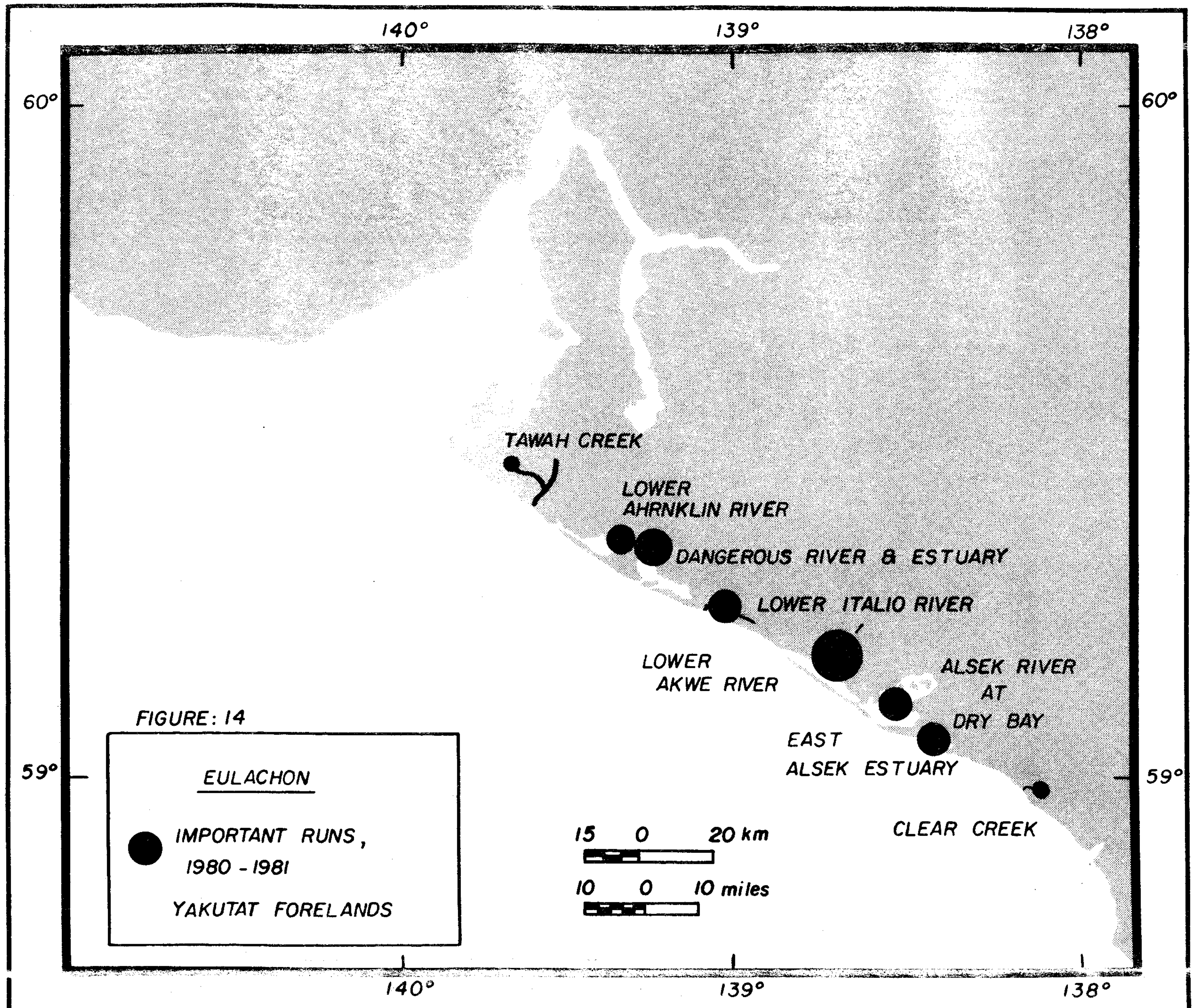


FIGURE 14. IMPORTANT EULACHON RUNS - 1980-1981

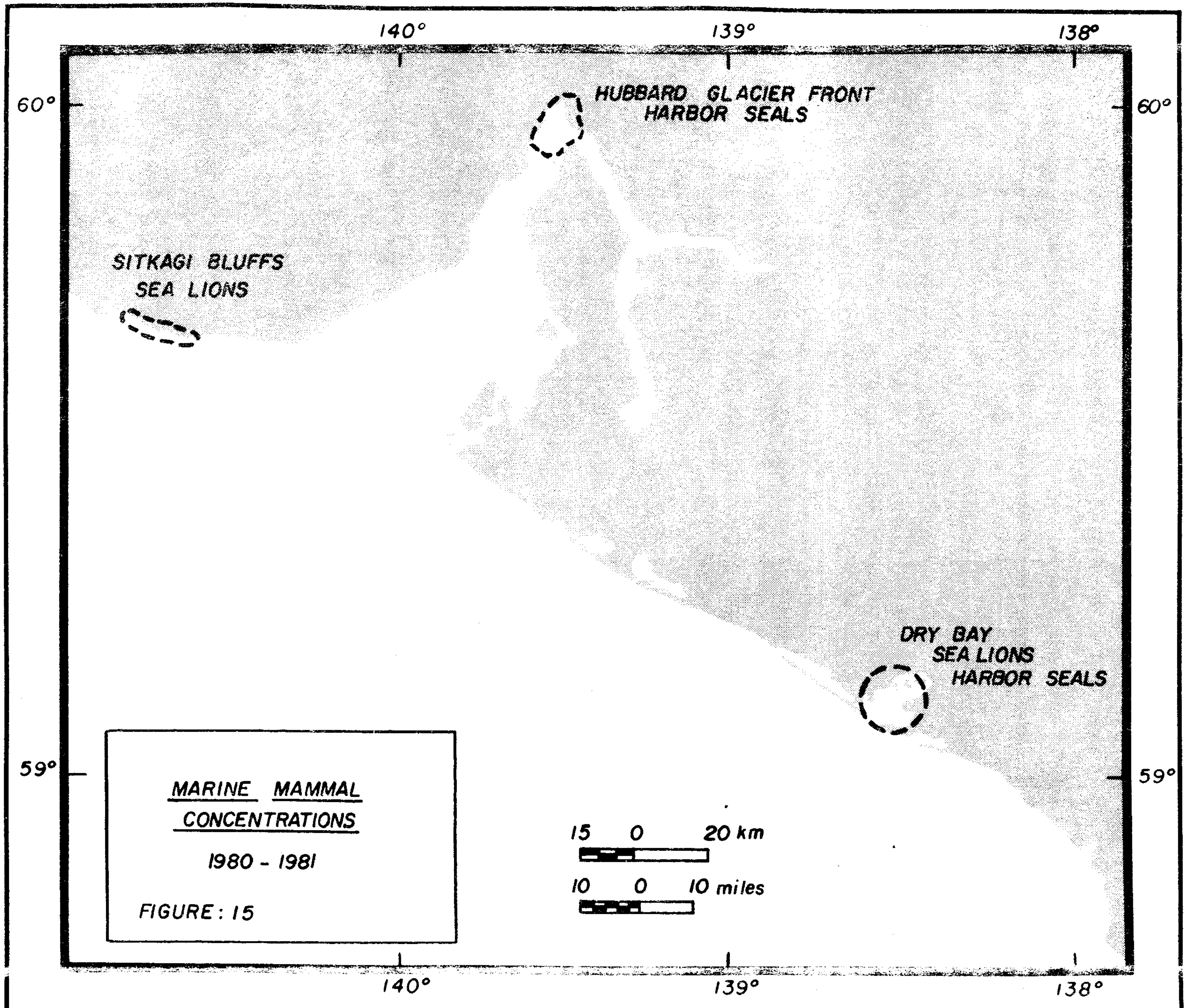


FIGURE 15. MARINE MAMMAL CONCENTRATIONS - 1980-1981

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