Environmental Assessment of the Alaskan Continental Shelf

Annual Reports of Principal Investigators for the year ending March 1978

Volume II. Receptors — Birds

U.S. DEPARTMENT OF COMMERCE
National Oceanic and Atmospheric Administration

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VOLUME I	RECEPTORS -- MAMMALS BIRDS
VOLUME II	RECEPTORS -- BIRDS
VOLUME III	RECEPTORS -- BIRDS
VOLUME IV	RECEPTORS -- FISH, LITTORAL, BENTHOS
VOLUME V	RECEPTORS -- FISH, LITTORAL, BENTHOS
VOLUME VI	RECEPTORS -- MICROBIOLOGY
VOLUME VII	EFFECTS
VOLUME VIII	CONTAMINANT BASELINES
VOLUME IX	TRANSPORT
VOLUME X	TRANSPORT
VOLUME XI	HAZARDS
VOLUME XII	HAZARDS
VOLUME XIII	DATA MANAGEMENT

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RECEPTORS -- BIRDS

Contents

ANNUAL REPORT

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SIMULATION MODELING OF MARINE BIRD POPULATION ENERGETICS, FOOD CONSUMPTION, AND SENSITIVITY TO PERTURBATION

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I. SUMMARY

This report presents the approach and results of initial applications of computer simulation modeling of avian population energetics to Alaskan OCS marine bird systems. As such, it meets some of the overall objectives of this Research Unit, namely: 1) to use simulation model analyses to estimate the energy demands and food consumption patterns of marine bird populations in the Bering Sea, emphasizing the dynamics of the Pribilof Islands colonies; 2) to develop new model structures to evaluate the spatial distribution of avian energetics; 3) to use the models as gaming tools to simulate the influences of variations in baseline conditions on the populations and their energetics; and 4) to define the feasibility of using the modeling approach as a means of synthesizing information gathered at breeding colonies by different investigators in the OCSEAP studies. The present report considers estimations of energy demands of marine birds as recorded at sea during transect censuses in the Gulf of Alaska/southeast Bering Sea and in the vicinity of the Pribilof Islands; more intensive analyses of breeding colonied will occupy the next phase of the project.

Total energy flow through pelagic bird populations in the Gulf of Alaska was greatest in the Kodiak area during August-September (24,300 kcal km^{-2} day^{-1}), but varied both between areas and with season, primarily as a consequence of movements of species populations associated with reproductive status. Shearwaters were usually the dominant species, energetically, in these systems, accounting for up to 92% of the total community energy demand. In the Pribilof Islands, total community energy demand was concentrated in the area about St. George, largely as a result of the major contribution of murres to community energetics. There also eneregy demands varied both with season and year, and different species populations exhibited different spatial patterns of energy demands in relation to distances from islands and depth of water, especially in relation to the continental shelf break. The area about St. George is obviously quite important in terms of overall avian energy demands, and some other foci of apparent feeding concentration may also be critical. Activities related to petroleum development in these areas may be especially hazardous to bird populations. The distribution of birds in the region of the shelf break to the southwest of St. George is poorly known, and should receive special attention in future transect census work.

II. INTRODUCTION

There are several ways in which one may view the structure and functioning of ecosystems: through energy fluxes, nutrient flows and cycles, biotic feedback controls, or systems sensitivity to abiotic driving variables, to name but a few. In marine ecosystems, bird populations act as primary and secondary consumers; while their dynamics may be interpreted in all of these dimensions, consideration of energy flows is perhaps most appropriate. Birds are closely linked to other systems components through feeding webs, and while ultimately these trophic relationships should be expressed as detailed estimates of the quantities of material (or individuals) taken from each prey source by specific bird populations, an initial approach may involve documentation of the energy fluxes into the bird populations alone. Such a consideration of energetics may provide a means to assess the magnitudes of utilization of various oceanic areas for feeding, or to evaluate the relative "importance" of various bird species in exploiting marine productivity.

The long-range goals of this research unit are to define a number of ways of exploring the energetic linkages of marine birds to their ecosystems, in both space and time; to provide a means of using this approach to synthesize data gathered in diverse OCSEAP marine bird investigations within a common framework; and to offer some initial estimations of the potential impacts of marine birds on marine systems, and of various petroleum-related perturbations upon the bird populations and communities. As energy demands are impossible to measure directly under field conditions, our approach rests heavily upon computer simulation modeling. In this first report of these research efforts, we describe the initial applications of energetics modeling to the estimation of energy demands of marine bird assemblages as recorded during shipboard census transects in the Gulf of Alaska and Bering Sea. Later efforts will be devoted to more intensive evaluations of the time/space patterns of energy flow into breeding seabird colonies.

III. METHODS

Model Structure.-- The initial modeling approach utilizes a computer simulation model (BIRD II) that estimates changes in population sizes and composition and their energy demands on a daily basis. The details of the model structure, assumptions, and applications are given in several publications (Wiens and Innis 1973, 1974; Innis et al. 1974; Innis and Wiens 1977; Wiens and Scott 1975; Wiens and Nussbaum 1975; Wiens 1977; Wiens and Dyer 1977) and will not be repeated here. Still, some background is essential.

The model contains three basic portions. In one, information on population size at various times, on reproductive biology and timing, and on mortality is used to project daily estimates of the population size of each age class of each of up to 15 species. Another generates estimates of individual, age class, population, and "community" energy demands from a series of metabolic functions. A third portion combines the daily energy demand estimates with information on dietary composition to project the daily consumption rates of various prey categories by the birds.

The data sets to be considered in this report contained only information on densities of birds at sea in various areas at defined points in time. Therefore, neither the population dynamics (reproduction) nor the dietary composition portions of the model were really employed in these analyses. The energetic calculations of the model were founded upon the equations presented by Kendeigh et al. (1977) for non-passerines. These relations project existence metabolic energy requirements (Kcal bird^{-1} day^{-1}) (M) from information on body weight (W, in g), as functions of ambient temperature and photoperiod:

10-h photoperiod, 30°C: $M = 1.455\ W^{0.626}$

10-h photoperiod, 0°C: $M = 4.235\ W^{0.532}$

15-h photoperiod, 30°C: $M = 1.068\ W^{0.664}$

15-h photoperiod, 0°C: $M = 4.142\ W^{0.544}$

These existence energy requirement estimates are then adjusted to consider the additional costs of free-living activity, and the final metabolic demand is then adjusted to reflect the inefficiency of the digestive process to project a final estimate of the energy demand actually required of the resource base exploited by the birds. As the analyses we considered here were confined to short time periods, all during late spring through early fall, the calculations were simplified by considering energy demands at an "average" photoperiod of 12 h for all analyses, and by arbitrarily assigning an additional cost of free-living activity of 0.2 times existence metabolism, rather than allowing this cost to vary as a function of season and reproductive status. The final estimates we report are thus derived from simplified model analyses and, in that they do not consider reproductive activities, growth, molt, or other aspects of seasonality, the values are conservative estimates.

The Data Base.-- We have conducted preliminary analyses of two series of seabird density estimates derived from shipboard transects conducted in the Gulf of Alaska/southeast Bering Sea and in the vicinity of the Pribilof Islands.

A. Gulf of Alaska/Bering Sea: Transects conducted from August 1975 to November 1976 provided estimates of the densities of marine bird species in five defined areas of the Gulf of Alaska and Bering Sea; the transect methods, ship tracklines, and census results are fully described by Wiens, Heinemann, and Hoffman (1977, 1978) and will not be further described here. For our model analyses, the population densities reported for the 13 time-area units were used directly as initially reported. In the earlier census reports, however, densities of shearwaters and of large gulls were reported for combined species, with an estimate of the abundance ratio of the component species also given. For this analysis, densities of separate shearwater species and large gull species were derived by converting the total combined density using the ratio estimate. These densities, multiplied by the per individual energy demands calculated from the BIRD II simulations, provided an estimated daily energy demand per km^2 for each species population in each area-time unit.

B. Pribilof Islands: Our more detailed analyses of at-sea energy demands of birds about St. Paul and St. George utilized the data gathered during transect censuses by Hunt and his colleagues. As the initial reports of these censuses were only summaries (Hunt 1976, 1977), we obtained the original census results for each transect directly from Hunt's laboratory. Mean densities (weighted according to total transect length censused) were calculated for each 10' X 10' latitude-longitude block in the survey area. These densities were then converted into energy flow estimates, using the model procedures outlined above.

IV. RESULTS

Gulf of Alaska/southeast Bering Sea.-- The transects conducted by our group in these areas yielded the density estimates summarized in Table 1; the areas for which individual transects were combined are shown in Fig. 1. The energy flow values estimated for these populations are given in Table 2, with the percentage contribution of each of these species to the total marine bird "community" energy flow. These data are summarized in Fig. 2. This analysis ignores various species recorded only incidentally in transect censuses, and thus although all major species are included, the total "community" is somewhat incomplete.

Several features of these data merit comment. Many of the changes in the relative contributions of species to energy flow are of course related to their seasonal movements into and out of breeding areas (see Wiens et al. 1977, 1978). The increase in total energy demand by the marine bird assemblage in the NEGOA between April and May (Fig. 2), for example, represents an influx of birds into the region to initiate breeding, as is also the case in the Kodiak area. As in the Oregon coastal marine bird communities analyzed by Wiens and Scott (1975), shearwaters were usually the dominant species in the energetics of these Alaskan bird systems, accounting for up to 92% of the total energy flow (Kodiak, August-September; Table 2). Shearwaters made minor contributions to community energetics in the Cook Inlet area in May, and were not recorded in transects in the Bering area in June (Table 1). Gulls and kittiwakes contributed importantly to community energetics only in the Kodiak area during June, chiefly as a consequence of large aggregations of Black-legged Kittiwakes in this area at this time. Energy flow through large alcid populations (murres and puffins) was substantial only in the NWGOA and Bering areas, especially during June.

Total community energy demand for these pelagic bird assemblages varied both with time and area, being least in the Kodiak area in April and greatest in the same area in August-September (Table 2, Fig. 2). Bear in mind that the calues we report are estimates of *daily* energy demand per km^2. Compared with some other ecosystem types the peak daily energy flow through these bird assemblages is not especially large: Wiens (1977) reported a peak flow of 19,000 kcal km^{-2} day^{-1} in grassland bird communities, Wiens and Scott (1975) a value of roughly 54,000 kcal km^{-2} day^{-1} for a four-species community of Oregon seabirds during the breeding season, and Wiens and Nussbaum (1975) a peak demand of 150,000 kcal km^{-2} day^{-1} for breeding birds in northwestern mesic coniferous forests. These values were for stationary and concentrated breeding populations, however. In Alaskan waters, peak

Table 1. Estimated densities (individuals km^{-2}) of bird populations in five Alaskan OCS lease areas (see Fig. 1). * = densities not calculated; no ratio available.

Species[a]	NEGOA[b]		KODIAK					COOK INLET		NWGOA[b]		BERING	
	April	May	April	May	June	Aug-Sept	Oct	May	Aug	June	Aug	June	Aug
N (transects)	49	26	9	8	5	23	14	6	13	8	5	12	8
Northern Fulmar	0.06	0.14	0.03	0.05	0.81	0.64	0.96	0	0.02	2.84	1.36	1.79	0.01
Sooty Shearwater	1.14	4.96	0	7.86	3.32	85.94	0.02	*	5.30	0.11	0.02	0	0.10
Short-tailed Shearwater	4.45	7.73	0.05	0.16	8.46	1.65	9.03	*	0	72.44	18.63	0	4.65
Fork-tailed Storm-petrel	0	1.73	0	1.54	1.27	6.45	1.10	0	0.02	15.92	1.25	6.18	1.43
Herring Gull	0.41	0.04	0.07	0.04	0	0.02	*	0	0	0	0	0	0
Glaucous-winged Gull	0.64	0.03	0.57	0.30	0.06	0.08	*	2.31	0.01	0.03	0	0	0
Black-legged Kittiwake	0.37	0.85	0	10.66	0.27	1.21	*	0.41	2.62	0.05	0	0.66	0.42
Arctic Tern	0.01	0.26	0	0.51	0	0.26	0	0	0.06	0	0	0	0
Common Murre	0.20	0.06	0.39	0.44	0.02	0.20	0.04	0.32	0.72	0.39	0.03	1.05	0.43
Thick-billed Murre	0	0	0	0	0	0	0	0	0	0.27	0	4.56	0.67
Tufted Puffin	0.99	0.09	0.04	7.25	0.09	3.56	2.33	0.07	2.30	8.85	0.97	0.42	0.86
Horned Puffin	0.01	0.01	0	0	0.05	0.07	2.82	0	1.61	0.80	0.17	0.81	0.08

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[a] Scientific names are given in Appendix I.

[b] NEGOA = Northeastern Gulf of Alaska; NWGOA = Northwestern Gulf of Alaska

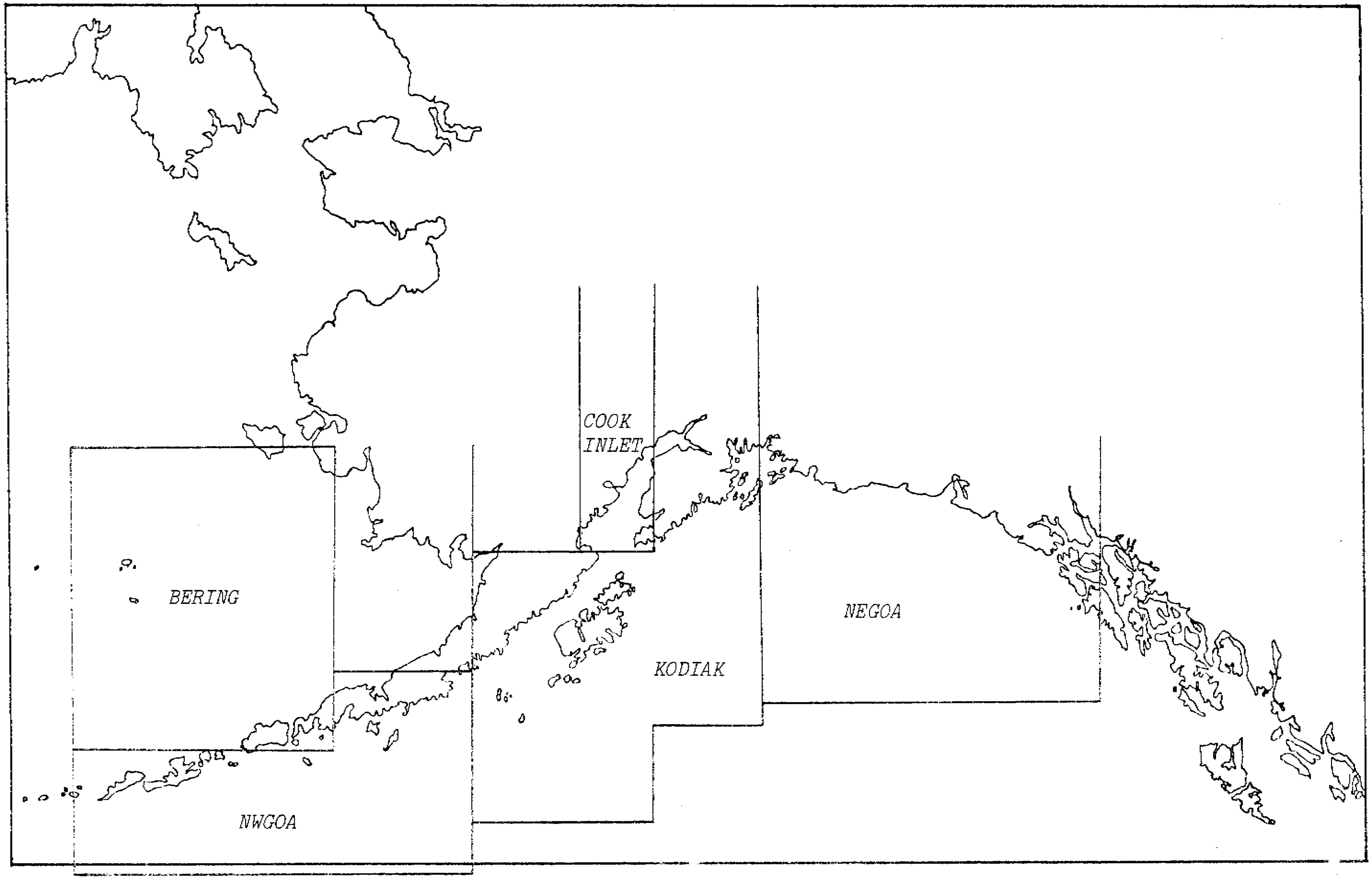

Fig. 1. Areas of the Gulf of Alaska/southeast Bering Sea used to summarize marine bird transect census results.

Table 2. Estimated energy demands ($\text{kcal km}^{-2}\ \text{day}^{-1}$) of bird populations in five Alaskan OCS lease areas. Values in *italics* are percentages of the total energy flow for a lease area at that time.

Species	NEGOA[a]		KODIAK					COOK INLET		NWGOA[a]		BERING	
	April	May	April	May	June	Aug-Sept	Oct	May	Aug	June	Aug	June	Aug
Northern Fulmar	16 *1*	37 *1*	8 *2*	13 *t*	212 *7*	168 *1*	252 *7*	-	5 *t*	745 *4*	357 *8*	469 *16*	3 *t*
Sooty Shearwater	295 *15*	1,280 *39*	-	2,030 *32*	859 *28*	22,200 *91*	6 *t*	-	1,370 *45*	29 *t*	6 *t*	-	26 *2*
Short-tailed Shearwater	938 *47*	1,630 *50*	11 *3*	34 *1*	1,780 *58*	348 *1*	1,910 *55*	-	-	15,300 *78*	3,930 *84*	-	981 *56*
Fork-tailed Storm-petrel	-	96 *3*	-	86 *1*	71 *2*	358 *1*	62 *2*	-	1 *t*	884 *5*	70 *1*	343 *12*	80 *5*
Herring Gull	124 *6*	12 *t*	21 *6*	12 *t*	-	6 *t*	-	-	-	-	-	-	-
Glaucous-winged Gull	216 *11*	10 *t*	193 *54*	101 *2*	20 *1*	27 *t*	-	781 *80*	3 *t*	10 *t*	-	-	-
Black-legged Kittiwake	70 *4*	162 *5*	-	2,030 *32*	51 *2*	230 *1*	-	78 *8*	499 *16*	10 *t*	-	126 *4*	80 *5*
Arctic Tern	t *t*	23 *1*	-	45 *1*	23 *1*	-	-	5 *1*	-	-	-	-	-
Common Murre	57 *3*	17 *1*	112 *32*	126 *2*	6 *t*	57 *t*	12 *t*	92 *9*	206 *7*	112 *1*	9 *t*	301 *10*	123 *7*
Thick-billed Murre	-	-	-	-	-	-	-	-	-	86 *t*	-	1,390 *48*	205 *12*
Tufted Puffin	260 *13*	24 *t*	11 *3*	1,900 *30*	24 *1*	934 *4*	612 *18*	18 *2*	604 *20*	2,320 *12*	255 *6*	110 *4*	226 *13*
Horned Puffin	2 *t*	2 *t*	-	-	11 *t*	15 *t*	610 *18*	-	348 *12*	173 *1*	37 *1*	175 *6*	17 *1*
TOTAL	1,980	3,290	355	6,380	3,060	24,300	3,460	974	3,040	19,700	4,660	2,910	1,740

[a] NEGOA = Northeastern Gulf of Alaska; NWGOA - Northwestern Gulf of Alaska.

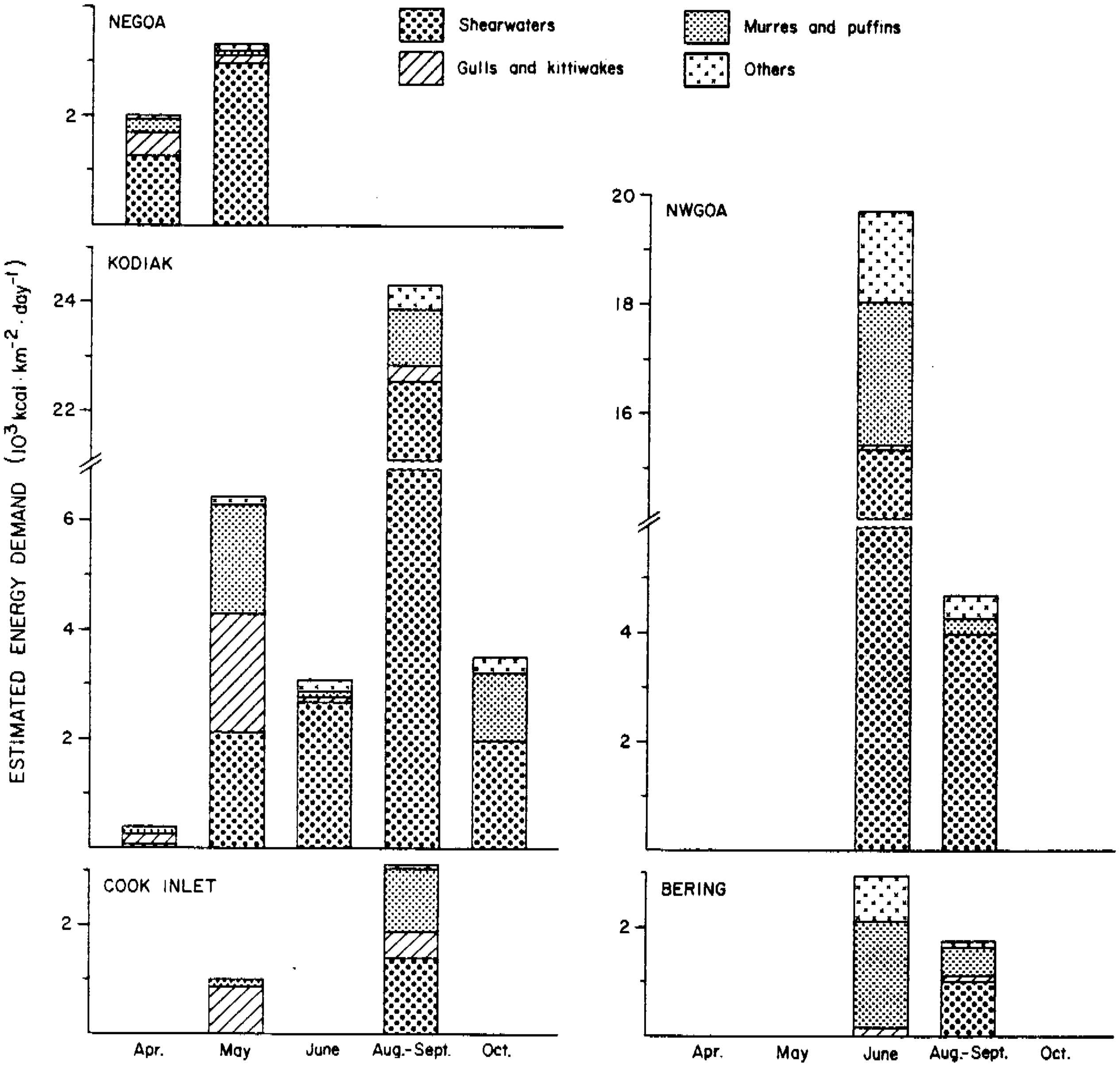

Fig. 2. Apportionment of total energy demand among the species groups recorded during transect censuses in five areas of the Gulf of Alaska/southeast Bering Sea, according to time of censusing.

energy demands are undoubtedly greater in the vicinity of breeding aggregations, and of course the total population sizes over the ocean expanses in the Gulf of Alaska are much larger than those of the terrestrial passerines in more restricted habitat types.

Pribilof Islands.-- The censuses conducted by George Hunt and his colleagues in the vicinity of the Pribilof Islands during 1975-77 provide a foundation for a more intensive and innovative analysis of energy flow magnitudes and patterns than was possible for the Gulf of Alaska/southeast Bering Sea data discussed above. A total of 978 transects provided information on seabird densities in 10' X 10' blocks, as depicted in Fig. 3.

Our initial analysis considers the energy dynamics of species populations as a function of linear distance from the nearest island (either St. Paul or St. George; distances were calculated from the center of the island to the center of a 10' block, and the data then grouped by distance intervals). Tables 3-11 present the calculated energy demands (10^2kcal km^{-2} day^{-1}) for the distance intervals according to census times; Tables 12-20 detail how the total energy flow for a given population at a specified time is allocated among the distance intervals, and Tables 21-28 present the relative contributions of species populations to the total "community" energy flow in each distance interval.

For most of the species there was moderate variability according to month and year, as well as in distance from nearest island. This, of course, is not surprising, given both the seasonal and annual fluctuations in actual densities that occur in seabird populations and the sampling error that is inevitable in ship-based censuses of wide-ranging and frequently discontinuously-distributed birds. For fulmars, for example, 74% of the total energy flow occurred within 40 km of the nearest island during July 1976, while only 31% of the July 1977 energy flow was in that distance zone. For shearwaters, on the other hand, the off-island distribution of energy flow was fairly stable at various times: 87% in the 71-120-km zone in August 1975, 62% in the 91-100-km zone in July 1976, 63% in the 81-110-km zone in August 1977, but 45% in the 199-100-km zone in August 1977. Total energy flow through the total marine bird "community" also varied in both distribution and (especially) magnitude during the four census periods (Fig. 4). The average energy flow (weighted by total transect length censused per block) was lowest in August 1977 (15,300 kcal km^{-2} day^{-1}), intermediate in August 1975 and July 1977 (30,100 and 20,700 kcal km^{-2} day^{-1}, respectively), and substantially greater in July 1976 (80,000 kcal km^{-2} day^{-1}). Associated with this was the extreme concentration of marine bird energy demands closer to islands during July 1976 than at other times. As is apparent from Fig. 4, murres accounted for most of the total "community" energy flow derived from these censuses (from 52% in August 1975 to 86% in July 1976). The distribution and magnitude of total marine bird energetics about the Pribilofs is thus driven largely by the requirements of murre populations.

Despite the monthly and annual differences in energy flow patterns, a consideration of average values for the combined censuses can provide a useful overview of the patterns typical of species populations. The overall weighted average energy flow peaked in the 11-40-km zone, trailing off with greater distances out to 200 km (Fig. 5). It is apparent that murres, the

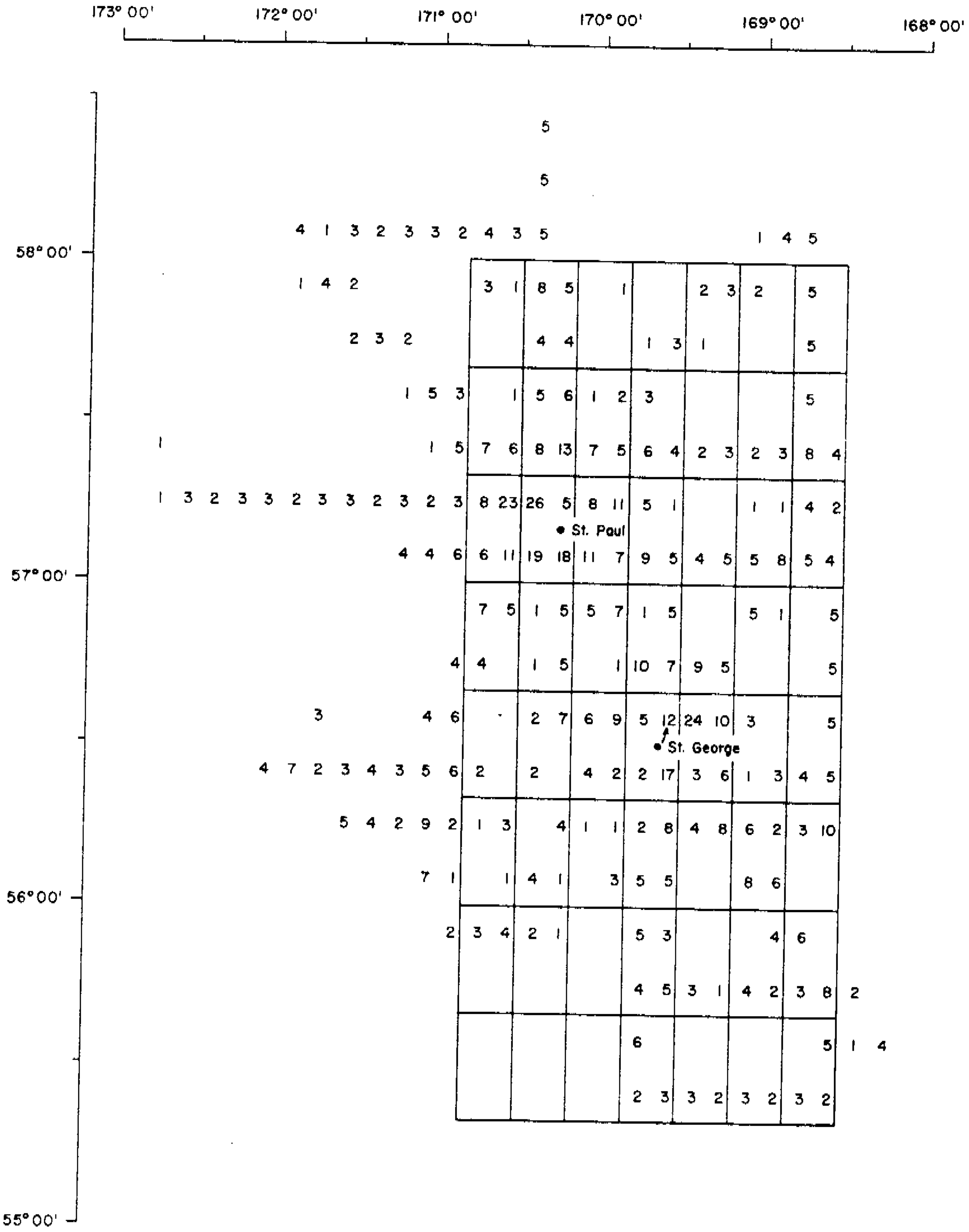

Fig. 3. Sampling intensity (number of transects censused) of marine bird surveys in the Pribilof Islands, 1975-77. Data are grouped by 10' blocks; the grid represents the set of 20' blocks used in the intensive analysis of spatial patterning of energy demands.

ENERGETIC DEMAND (KCAL x 100/DAY/KM2) FOR FUL

DISTANCE TO NEAREST ISLAND (KM)

	10	20	30	40	50	60	70	80	90	100	110	120	130	140	150	160	170	180	190	200	TOT
8/75	0	2	1	6	4	4	16	3	4	11	41	12	0	0	0	0	0	0	0	0	9
7/76	25	80	62	53	7	6	14	15	24	14	0	0	0	0	0	0	0	0	0	0	29
7/77	49	48	39	54	40	38	22	24	166	54	19	16	13	14	20	41	7	12	36	27	42
8/77	103	60	26	26	35	71	13	21	11	11	11	8	0	2	2	1	0	0	0	0	26
JULY	42	57	54	53	23	15	17	20	158	47	19	16	13	14	20	41	7	12	36	27	39
AUG	103	31	24	23	20	41	17	15	5	11	20	11	0	2	2	1	0	0	0	0	20
1977	62	52	61	39	37	61	13	22	72	31	14	15	13	11	17	37	7	12	36	27	35
ALL	53	46	56	40	21	28	17	17	52	25	20	14	13	11	17	37	7	12	36	27	29

Table 3. Estimated daily energy demand of fulmars in the Pribilof Islands area as a function of linear distance to nearest island. Values are averages for the 10' census blocks occurring in a distance interval, weighted by the total transect length in that block.

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ENERGETIC DEMAND (KCAL X 100/DAY/KM2) FOR  SHW

                                                  DISTANCE TO NEAREST ISLAND (KM)

            10      20      30      40      50      60      70      80      90     100     110     120     130     140     150     160     170     180     190     200     TOT
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Table 4. Estimated daily energy demand of shearwaters in the Pribilof Islands area as a function of linear distance to nearest island. Values as in Table 3.

ENERGETIC DEMAND (KCAL X 100/DAY/KM2) FOR FTP

DISTANCE TO NEAREST ISLAND (KM)

	10	20	30	40	50	60	70	80	90	100	110	120	130	140	150	160	170	180	190	200	TOT
3/75	0	0	0	0	0	0	0	0	0	14	0	0	0	0	0	0	0	0	0	0	1
7/76	0	0	2	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
7/77	1	1	2	1	1	1	1	0	2	0	1	1	9	1	1	16	0	0	2	19	2
8/77	1	3	[illegible]	1	11	6	2	3	1	18	10	0	0	0	0	1	0	0	0	0	5
JULY	0	0	2	1	1	0	0	0	2	0	1	1	9	1	1	16	0	0	2	19	2
AUG	1	2	[illegible]	1	5	4	1	2	1	17	7	0	0	0	0	1	0	0	0	0	4
1977	1	1	[illegible]	1	7	6	2	2	1	10	7	1	9	1	1	15	0	0	2	19	4
ALL	1	1	[illegible]	1	3	2	1	1	1	10	6	1	9	1	1	15	0	0	2	19	3

Table 5. Estimated daily energy demand of Fork-tailed Storm-Petrels in the Pribilof Islands area as a function of linear distance to nearest island. Values as in Table 3.

ENERGETIC DEMAND (KCAL * 100/DAY/KM2) FOR MUR

DISTANCE TO NEAREST ISLAND (KM)

	10	20	30	40	50	60	70	80	90	100	110	120	130	140	150	160	170	180	190	200	TOT
8/75	3	279	430	727	82	206	40	116	37	11	3	2	0	0	0	0	0	0	0	0	157
7/76	160	4132	602	1369	65	156	364	162	245	84	0	0	0	0	0	0	0	0	0	0	690
7/77	132	79	66	541	122	82	170	152	63	36	9	10	8	9	4	17	5	9	11	1	128
8/77	7	388	136	336	69	47	27	46	54	39	23	12	0	4	1	4	0	0	0	0	104
JULY	134	1175	657	894	93	136	257	156	73	45	9	10	8	9	4	17	5	9	11	1	299
AUG	7	333	229	415	75	115	30	74	47	28	17	4	0	4	1	4	0	0	0	0	122
1977	116	186	341	383	90	58	61	76	57	38	19	10	8	8	4	15	5	9	11	1	117
ALL	126	812	466	632	82	127	126	97	55	35	15	8	8	8	4	15	5	9	11	1	212

Table 7. Estimated daily energy demand of murres in the Pribilof Islands area as a function of linear distance to nearest island. Values as in Table 3.

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ENERGETIC DEMAND (KCAL X 100/DAY/KM2) FOR  KWS

                              DISTANCE TO NEAREST ISLAND (KM)

       10   20   30   40   50   60   70   80   90  100  110  120  130  140  150  160  170  180  190  200  TOT
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    !    !    !    !    !    !    !    !    !    !    !    !    !    !    !    !    !    !    !    !    !    !
    !    !    !    !    !    !    !    !    !    !    !    !    !    !    !    !    !    !    !    !    !    !
    !    !    !    !    !    !    !    !    !    !    !    !    !    !    !    !    !    !    !    !    !    !
9/75!   0   13   24   16   17   17   15   20   13   33   22   24    0    0    0    0    0    0    0    0   20
    !    !    !    !    !    !    !    !    !    !    !    !    !    !    !    !    !    !    !    !    !    !
    !    !    !    !    !    !    !    !    !    !    !    !    !    !    !    !    !    !    !    !    !    !
    !    !    !    !    !    !    !    !    !    !    !    !    !    !    !    !    !    !    !    !    !    !
7/76!   6   11   43   64   11   14   43   14   28    8    0    0    0    0    0    0    0    0    0    0   32
    !    !    !    !    !    !    !    !    !    !    !    !    !    !    !    !    !    !    !    !    !    !
    !    !    !    !    !    !    !    !    !    !    !    !    !    !    !    !    !    !    !    !    !    !
    !    !    !    !    !    !    !    !    !    !    !    !    !    !    !    !    !    !    !    !    !    !
7/77!  28   34  121   46   14   23   26    7   14    4   11    7    4    7   14    1    4    2    4    0   22
    !    !    !    !    !    !    !    !    !    !    !    !    !    !    !    !    !    !    !    !    !    !
    !    !    !    !    !    !    !    !    !    !    !    !    !    !    !    !    !    !    !    !    !    !
    !    !    !    !    !    !    !    !    !    !    !    !    !    !    !    !    !    !    !    !    !    !
8/77!  17   18   21   25    9    4   10    6    6    8   14    6    0    2    7    1    0    0    0    0   11
    !    !    !    !    !    !    !    !    !    !    !    !    !    !    !    !    !    !    !    !    !    !
    !    !    !    !    !    !    !    !    !    !    !    !    !    !    !    !    !    !    !    !    !    !
    !    !    !    !    !    !    !    !    !    !    !    !    !    !    !    !    !    !    !    !    !    !
JULY!  22   28   38   55   13   16   33   10   15    5   11    7    4    7   14    1    4    2    4    0   25
    !    !    !    !    !    !    !    !    !    !    !    !    !    !    !    !    !    !    !    !    !    !
    !    !    !    !    !    !    !    !    !    !    !    !    !    !    !    !    !    !    !    !    !    !
    !    !    !    !    !    !    !    !    !    !    !    !    !    !    !    !    !    !    !    !    !    !
 AUG!  17   16   22   23   13    9   12   11    8   18   17   20    0    2    7    1    0    0    0    0   14
    !    !    !    !    !    !    !    !    !    !    !    !    !    !    !    !    !    !    !    !    !    !
    !    !    !    !    !    !    !    !    !    !    !    !    !    !    !    !    !    !    !    !    !    !
    !    !    !    !    !    !    !    !    !    !    !    !    !    !    !    !    !    !    !    !    !    !
1977!  25   29   69   35   11   10   14    6    9    6   13    7    4    6   13    1    4    2    4    0   17
    !    !    !    !    !    !    !    !    !    !    !    !    !    !    !    !    !    !    !    !    !    !
    !    !    !    !    !    !    !    !    !    !    !    !    !    !    !    !    !    !    !    !    !    !
    !    !    !    !    !    !    !    !    !    !    !    !    !    !    !    !    !    !    !    !    !    !
 ALL!  21   23   60   41   13   13   22   11   10   13   15   11    4    6   13    1    4    2    4    0   20
    !    !    !    !    !    !    !    !    !    !    !    !    !    !    !    !    !    !    !    !    !    !
    !    !    !    !    !    !    !    !    !    !    !    !    !    !    !    !    !    !    !    !    !    !
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Table 6. Estimated daily energy demand of kittiwakes in the Pribilof Islands area as a function of linear distance to nearest island. Values as in Table 3.

ENERGETIC DEMAND (KCAL X 100/DAY/KM2) FOR AUK

DISTANCE TO NEAREST ISLAND (KM)

	10	20	30	40	50	60	70	80	90	100	110	120	130	140	150	160	170	180	190	200	TOT
3/75	0	1	1	4	1	3	4	1	1	0	2	0	0	0	0	0	0	0	0	0	1
7/76	10	13	57	71	22	19	57	5	6	1	0	0	0	0	0	0	0	0	0	0	37
7/77	1	0	0	3	2	0	2	2	1	1	3	0	0	0	0	0	0	3	0	0	1
8/77	0	0	1	4	1	0	1	1	0	0	0	1	0	1	2	0	0	0	0	0	1
JULY	4	4	23	36	12	14	35	3	1	1	3	0	0	0	0	0	0	3	0	0	12
AUG	0	1	1	4	1	1	1	1	0	0	1	0	0	1	2	0	0	0	0	0	1
1977	1	0	1	3	1	0	1	2	1	0	1	0	0	0	0	0	0	3	0	0	1
ALL	3	2	13	22	6	7	14	2	1	0	1	0	0	0	0	0	0	3	0	0	7

Table 8. Estimated daily energy demand of auklets in the Pribilof Islands area as a function of linear distance to nearest island. Values as in Table 3.

ENERGETIC DEMAND (KCAL 100/DAY/KM2) FOR PUF

DISTANCE TO NEAREST ISLAND (KM)

	10	20	30	40	50	60	70	80	90	100	110	120	130	140	150	160	170	180	190	200	TOT
8/75	0	1	3	2	3	2	3	4	1	0	0	0	0	0	0	0	0	0	0	0	2
7/76	6	9	10	8	7	6	4	4	0	1	0	0	0	0	0	0	0	0	0	0	7
7/77	3	4	3	4	2	1	2	1	1	1	1	0	1	0	0	0	1	1	1	0	1
6/77	1	3	1	1	1	0	1	1	1	1	1	0	0	0	0	0	0	0	0	0	1
JULY	4	5	6	5	5	5	6	2	1	1	1	0	1	0	0	0	1	1	1	0	3
AUG	1	2	2	2	2	1	1	2	1	0	0	0	0	0	0	0	0	0	0	0	1
1977	2	4	2	2	2	1	1	1	1	1	1	0	1	0	0	0	1	1	1	0	1
ALL	3	4	[illegible]	4	3	3	3	2	1	1	1	0	1	0	0	0	1	1	1	0	2

Table 9. Estimated daily energy demand of puffins in the Pribilof Islands area as a function of linear distance to nearest island. Values as in Table 3.

ENERGETIC DEMAND (KCAL X 100/DAY/KM2) FOR MIS

DISTANCE TO NEAREST ISLAND (KM)

	10	20	30	40	50	60	70	80	90	100	110	120	130	140	150	160	170	180	190	200	TOT
8/75	0	7	1	6	1	5	1	1	2	73	1	2	0	0	0	0	0	0	0	0	10
7/76	3	2	2	2	8	4	13	2	0	5	0	0	0	0	0	0	0	0	0	0	4
7/77	1	1	2	30	11	1	1	1	2	1	0	7	2	2	2	2	3	3	1	9	6
9/77	0	0	1	1	0	1	1	1	1	2	2	3	0	1	1	2	0	0	0	0	1
JULY	2	1	2	16	10	3	8	2	2	2	0	7	2	2	2	2	3	3	1	9	5
AUG	0	3	1	3	1	3	1	1	1	32	1	2	0	1	1	2	0	0	0	0	4
1977	1	0	1	14	5	1	1	1	1	1	1	7	2	2	2	2	3	3	1	9	4
ALL	1	2	1	10	4	3	4	1	1	20	1	6	2	2	2	2	3	3	1	9	5

Table 10. Estimated daily energy demand of miscellaneous species in the Pribilof Islands area as a function of linear distance to nearest island. Values as in Table 3.

ENERGETIC DEMAND (KCAL X 100/DAY/KM2) FOR TOT

DISTANCE TO NEAREST ISLAND (KM)

	10	20	30	40	50	60	70	80	90	100	110	120	130	140	150	160	170	180	190	200	TOT
8/75	5	317	492	765	123	270	46	425	35	237	130	314	0	0	0	0	0	0	0	0	301
7/76	213	4247	[illegible]	1569	120	206	505	202	303	121	0	0	0	0	0	0	0	0	0	0	800
7/77	245	157	135	784	203	147	225	135	250	100	46	44	43	34	47	79	21	34	57	125	207
8/77	134	424	131	336	129	132	62	35	82	86	95	36	0	11	16	9	0	0	0	0	153
JULY	234	124	[illegible]	1054	162	190	393	194	253	105	46	44	43	34	47	79	21	34	57	125	388
AUG	134	346	258	470	123	191	63	212	31	145	105	243	0	11	16	9	0	0	0	0	204
1977	217	255	41	432	158	156	101	115	147	32	79	44	43	29	43	72	21	34	57	125	184
ALL	215	397	410	492	141	131	190	207	132	129	91	118	43	29	43	72	21	34	57	125	299

Table 11. Estimated daily energy demand of the total marine bird "community" in the Pribilof Islands area as a function of linear distance to nearest island. Values as in Table 3.

RELATIVE ENERGETIC DEMAND (% OF TOTAL FOR ALL INTERVALS) FOR FUL

DISTANCE TO NEAREST ISLAND (KM)

	10	20	30	40	50	60	70	80	90	100	110	120	130	140	150	160	170	180	190	200	TOT
8/75	0	2	12	6	3	3	13	6	3	9	33	10	0	0	0	0	0	0	0	0	
7/76	8	27	21	18	2	2	5	5	3	5	0	0	0	0	0	0	0	0	0	0	
7/77	5	6	12	7	5	5	3	3	21	7	2	2	2	2	2	5	1	1	4	3	
8/77	25	15	[illegible]	6	9	17	4	5	3	3	3	2	0	0	0	0	0	0	0	0	
JULY	6	8	12	7	3	2	2	3	22	6	3	2	2	2	3	6	1	2	5	4	
AUG	31	4	7	7	6	12	5	5	2	3	6	3	0	1	1	0	0	0	0	0	
1977	10	5	9	6	6	9	3	3	11	5	2	2	3	2	3	6	1	2	5	4	
ALL	10	6	10	7	4	5	3	3	9	4	4	3	3	2	3	7	1	2	6	5	

Table 12. Percentages of population energy demand of fulmars occurring in intervals of distance from nearest island.

RELATIVE ENERGETIC DEMAND (% OF TOTAL FOR ALL INTERVALS) FOR SHW

	DISTANCE TO NEAREST ISLAND (KM)																				
	10	20	30	40	50	60	70	80	90	100	110	120	130	140	150	160	170	180	190	200	TOT
8/75	0	2	2	2	3	4	2	33	5	11	7	33	0	0	0	0	0	0	0	0	
7/76	23	0	0	8	0	6	0	0	0	62	0	0	0	0	0	0	0	0	0	0	
7/77	6	13	1	3	7	1	1	3	1	2	1	2	1	1	4	1	1	3	1	45	
8/77	6	3	1	3	3	1	3	5	10	9	44	9	0	1	4	0	0	0	0	0	
JULY	6	10	1	3	4	1	1	4	1	3	1	2	1	1	4	1	1	3	1	51	
AUG	1	2	1	1	2	3	1	22	3	8	9	45	0	0	1	0	0	0	0	0	
1977	6	6	1	3	3	1	1	3	3	3	14	2	1	1	4	1	1	2	1	42	
ALL	2	3	1	1	3	2	1	21	3	7	9	22	0	0	2	1	0	1	1	19	

Table 13. Percentages of population energy demand of shearwaters occurring in intervals of distance from nearest island.

RELATIVE ENERGETIC DEMAND (% OF TOTAL FOR ALL INTERVALS) FOR FTF

DISTANCE TO NEAREST ISLAND (KM)

	10	20	30	40	50	60	70	80	90	100	110	120	130	140	150	160	170	180	190	200	TOT
8/75	0	0	0	0	0	0	0	0	0	100	0	0	0	0	0	0	0	0	0	0	
7/76	0	0	67	33	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
7/77	2	2	3	2	2	2	2	0	3	0	2	2	15	2	2	27	0	0	3	32	
8/77	1	4	12	1	16	12	3	4	1	27	15	0	0	0	0	1	0	0	0	0	
JULY	0	0	4	2	2	0	0	0	4	0	2	2	16	2	2	29	0	0	4	34	
AUG	2	4	13	2	18	8	2	4	2	35	15	0	0	0	0	2	0	0	0	0	
1977	1	1	5	1	9	7	2	2	1	11	6	1	10	1	1	16	0	0	2	21	
ALL	1	1	5	1	4	3	1	1	1	13	8	1	11	1	1	19	0	0	3	24	

Table 14. Percentages of population energy demand of Fork-tailed Storm-Petrels occurring in intervals of distance from nearest island.

RELATIVE ENERGETIC DEMAND (% OF TOTAL FOR ALL INTERVALS) FOR KWS

DISTANCE TO NEAREST ISLAND (KM)

	10	20	30	40	50	60	70	80	90	100	110	120	130	140	150	160	170	180	190	200	TOT
8/75	0	6	[illegible]	[illegible]	5	[illegible]	7	9	5	15	10	11	0	0	0	0	0	0	0	0	
7/76	2	4	1	26	4	6	13	5	11	3	0	0	0	0	0	0	0	0	0	0	
7/77	9	4	35	12	4	6	7	2	4	1	3	2	1	2	4	0	1	1	1	0	
8/77	11	12	1	16	5	3	6	4	4	5	9	4	0	1	5	1	0	0	0	0	
JULY	6	4	26	15	4	5	11	3	4	1	3	2	1	2	4	0	1	1	1	0	
AUG	9	8	11	12	7	5	5	6	4	9	9	10	0	1	4	1	0	0	0	0	
1977	5	11	[illegible]	13	4	4	5	2	3	2	5	3	1	2	5	0	1	1	1	0	
ALL	7	5	21	[illegible]	3	[illegible]	3	4	3	5	5	4	1	2	5	0	1	1	1	0	

Table 15. Percentages of population energy demand of kittiwakes occurring in intervals of distance from nearest island.

RELATIVE ENERGETIC DEMAND (% OF TOTAL FOR ALL INTERVALS) FOR MUR

DISTANCE TO NEAREST ISLAND (KM)

	10	20	30	40	50	60	70	80	90	100	110	120	130	140	150	160	170	180	190	200	TOT
9/75	0	13	29	34	4	10	2	5	2	1	0	0	0	0	0	0	0	0	0	0	
7/76	2	55	11	16	1	2	5	2	3	1	0	0	0	0	0	0	0	0	0	0	
7/77	8	4	29	23	6	4	3	8	3	2	0	1	0	0	0	1	0	0	1	0	
8/77	1	32	11	28	5	4	2	4	5	3	2	1	0	0	0	0	0	0	0	0	
JULY	4	31	17	24	2	4	8	4	2	1	0	0	0	0	0	0	0	0	0	0	
AUG	1	24	17	30	5	9	2	5	3	2	1	0	0	0	0	0	0	0	0	0	
1977	8	12	23	26	6	4	4	5	4	3	1	1	1	1	0	1	0	1	1	0	
ALL	5	30	17	25	3	5	5	4	2	1	1	0	0	0	0	1	0	0	0	0	

Table 16. Percentages of population energy demand of murres occurring in intervals of distance from nearest island.

RELATIVE ENERGETIC DEMAND (% OF TOTAL FOR ALL INTERVALS) FOR AUK

DISTANCE TO NEAREST ISLAND (KM)

	10	20	30	40	50	60	70	80	90	100	110	120	130	140	150	160	170	180	190	200	TOT
6/75	0	[illegible]	[illegible]	22	[illegible]	17	22	[illegible]	[illegible]	0	11	0	0	0	0	0	0	0	0	0	
7/76	4	3	20	27	8	7	22	2	7	0	0	0	0	0	0	0	0	0	0	0	
7/77	6	0	[illegible]	17	11	[illegible]	11	11	[illegible]	6	17	0	0	0	0	0	0	17	0	0	
8/77	0	0	8	33	8	0	8	8	0	0	0	8	0	8	17	0	0	0	0	0	
JULY	7	3	12	26	9	10	25	2	1	1	2	0	0	0	0	0	0	2	0	0	
AUG	0	7	7	29	7	7	7	7	0	0	7	0	0	7	14	0	0	0	0	0	
1977	7	0	7	21	7	0	7	14	7	0	7	0	0	0	0	0	0	21	0	0	
ALL	4	3	15	33	6	9	19	5	1	0	1	0	0	0	0	0	0	4	0	0	

Table 17. Percentages of population energy demand of auklets occurring in intervals of distance from nearest island.

RELATIVE ENERGETIC DEMAND (% OF TOTAL FOR ALL INTERVALS) FOR PUF

DISTANCE TO NEAREST ISLAND (KM)

	10	20	30	40	50	60	70	80	90	100	110	120	130	140	150	160	170	180	190	200	TOT
8/75	0	5	16	11	16	11	15	21	5	0	0	0	0	0	0	0	0	0	0	0	
7/76	10	13	17	13	12	10	15	7	0	2	0	0	0	0	0	0	0	0	0	0	
7/77	11	15	11	15	7	4	7	4	4	4	4	0	4	0	0	0	4	4	4	0	
8/77	8	25	8	8	8	0	8	8	8	8	8	0	0	0	0	0	0	0	0	0	
JULY	9	11	17	11	11	11	13	4	2	2	2	0	2	0	0	0	2	2	2	0	
AUG	7	14	14	14	14	7	7	14	7	0	0	0	0	0	0	0	0	0	0	0	
1977	9	19	9	9	9	5	5	5	5	5	5	0	5	0	0	0	5	5	5	0	
ALL	9	12	12	12	9	9	9	6	3	3	3	0	3	0	0	0	3	3	3	0	

Table 18. Percentages of population energy demand of puffins occurring in intervals of distance from nearest island.

```
RELATIVE ENERGETIC DEMAND (% OF TOTAL FOR ALL INTERVALS) FOR MIS

                              DISTANCE TO NEAREST ISLAND (KM)

       10   20   30   40   50   60   70   80   90  100  110  120  130  140  150  160  170  180  190  200  TOT
    -------------------------------------------------------------------------------------------------------
    :    :    :    :    :    :    :    :    :    :    :    :    :    :    :    :    :    :    :    :    :
    :    :    :    :    :    :    :    :    :    :    :    :    :    :    :    :    :    :    :    :    :
    :    :    :    :    :    :    :    :    :    :    :    :    :    :    :    :    :    :    :    :    :
8/75:    0    6    1    7    1    5    1    1    2   73    1    2    0    0    0    0    0    0    0    0
    :    :    :    :    :    :    :    :    :    :    :    :    :    :    :    :    :    :    :    :    :
    :    :    :    :    :    :    :    :    :    :    :    :    :    :    :    :    :    :    :    :    :
    :    :    :    :    :    :    :    :    :    :    :    :    :    :    :    :    :    :    :    :    :
7/76:    7    5         6   20   10   32    7    0   12    0    0    0    0    0    0    0    0    0    0
    :    :    :    :    :    :    :    :    :    :    :    :    :    :    :    :    :    :    :    :    :
    :    :    :    :    :    :    :    :    :    :    :    :    :    :    :    :    :    :    :    :    :
    :    :    :    :    :    :    :    :    :    :    :    :    :    :    :    :    :    :    :    :    :
7/77:    1    1    4   27   15    1    1    1    2    1    0    9    2    2    2    2    4    4    1   11
    :    :    :    :    :    :    :    :    :    :    :    :    :    :    :    :    :    :    :    :    :
    :    :    :    :    :    :    :    :    :    :    :    :    :    :    :    :    :    :    :    :    :
    :    :    :    :    :    :    :    :    :    :    :    :    :    :    :    :    :    :    :    :    :
8/77:    1    0    0    0    0    0    6    6    6   12   12   18    0    6    6   12    0    0    0    0
    :    :    :    :    :    :    :    :    :    :    :    :    :    :    :    :    :    :    :    :    :
    :    :    :    :    :    :    :    :    :    :    :    :    :    :    :    :    :    :    :    :    :
    :    :    :    :    :    :    :    :    :    :    :    :    :    :    :    :    :    :    :    :    :
JULY:    3    1    3   20   15    4   10    3    3    3    0    9    3    3    3    3    4    4    1   11
    :    :    :    :    :    :    :    :    :    :    :    :    :    :    :    :    :    :    :    :    :
    :    :    :    :    :    :    :    :    :    :    :    :    :    :    :    :    :    :    :    :    :
    :    :    :    :    :    :    :    :    :    :    :    :    :    :    :    :    :    :    :    :    :
 AUG:    0    6    4    5    2    6    2    2    2   60    2    4    0    2    2    4    0    0    0    0
    :    :    :    :    :    :    :    :    :    :    :    :    :    :    :    :    :    :    :    :    :
    :    :    :    :    :    :    :    :    :    :    :    :    :    :    :    :    :    :    :    :    :
    :    :    :    :    :    :    :    :    :    :    :    :    :    :    :    :    :    :    :    :    :
1977:    2    0    2   24    4    2    2    2    2    2    2   12    3    3    3    3    5    5    2   16
    :    :    :    :    :    :    :    :    :    :    :    :    :    :    :    :    :    :    :    :    :
    :    :    :    :    :    :    :    :    :    :    :    :    :    :    :    :    :    :    :    :    :
    :    :    :    :    :    :    :    :    :    :    :    :    :    :    :    :    :    :    :    :    :
 ALL:    1    3    1   15    5    4    5    1    1   26    1    8    3    3    3    3    4    4    1   12
    :    :    :    :    :    :    :    :    :    :    :    :    :    :    :    :    :    :    :    :    :
    :    :    :    :    :    :    :    :    :    :    :    :    :    :    :    :    :    :    :    :    :
    :    :    :    :    :    :    :    :    :    :    :    :    :    :    :    :    :    :    :    :    :
    -------------------------------------------------------------------------------------------------------
```

Table 19. Percentages of population energy demand of miscellaneous species occurring in intervals of distance from nearest island.

RELATIVE ENERGETIC DEMAND (% OF TOTAL FOR ALL INTERVALS) FOR TOT

DISTANCE TO NEAREST ISLAND (KM)

	10	20	30	40	50	60	70	80	90	100	110	120	130	140	150	160	170	180	190	200	TOT
9/75	0	9	20	23	4	8	3	12	2	7	4	9	0	0	0	0	0	0	0	0	
7/76	3	50	12	13	1	2	6	2	[illegible]	1	0	0	0	0	0	0	0	0	0	0	
7/77	7	5	23	17	6	4	7	6	7	3	1	1	1	1	1	2	1	1	2	4	
8/77	7	24	10	20	[illegible]	7	3	4	[illegible]	4	5	2	0	1	1	0	0	0	0	0	
JULY	4	24	16	20	3	4	7	4	5	2	1	1	1	1	1	1	0	1	1	2	
AUG	5	16	11	13	5	8	3	9	3	6	4	10	0	0	1	0	0	0	0	0	
1977	8	10	17	17	6	5	4	4	5	3	3	2	2	1	2	3	1	1	2	5	
ALL	5	22	15	19	3	5	5	5	3	3	2	3	1	1	1	2	1	1	1	3	

Table 20. Percentages of total marine bird "community" energy demand occurring in intervals of distance from nearest island.

RELATIVE ENERGETIC DEMAND (% OF TOTAL FOR ALL SPECIES) FOR FUL

DISTANCE TO NEAREST ISLAND (KM)

	10	20	30	40	50	60	70	80	90	100	110	120	130	140	150	160	170	180	190	200	TOT
8/75	0	1	2	1	3	1	17	2	5	9	32	4	0	0	0	0	0	0	0	0	3
7/76	12	2	[illegible]	3	6	3	5	7	3	12	0	0	0	0	0	0	0	0	0	0	4
7/77	20	26	16	9	29	26	10	12	66	54	41	36	42	41	43	52	33	35	63	22	20
8/77	77	13	13	7	27	54	20	25	13	13	12	22	0	18	13	11	0	0	0	0	17
JULY	15	4	10	6	14	6	4	10	62	45	41	36	42	41	43	52	33	35	63	22	10
AUG	77	8	6	5	16	21	25	5	10	8	19	4	0	18	13	11	0	0	0	0	10
1977	24	16	13	6	23	44	19	19	49	34	18	34	42	38	40	51	33	35	63	22	19
ALL	25	6	10	5	15	15	9	6	39	19	22	12	42	38	40	51	33	35	63	22	10

Table 21. Percentages of total "community" energy flow contributed by fulmars in intervals of distance from nearest island.

RELATIVE ENERGETIC DEMAND (% OF TOTAL FOR ALL SPECIES) FOR SHW

DISTANCE TO NEAREST ISLAND (KM)

	10	20	30	40	50	60	70	80	90	100	110	120	130	140	150	160	170	180	190	200	TOT
8/75	0	5	2	2	15	11	18	64	32	38	47	87	0	0	0	0	0	0	0	0	34
7/76	1	0	0	0	0	0	0	0	0	7	0	0	0	0	0	0	0	0	0	0	0
7/77	4	11	0	1	5	1	0	4	0	3	4	7	2	3	13	3	5	12	4	55	2
8/77	4	0	1	1	2	1	3	5	10	8	36	17	0	9	19	0	0	0	0	0	3
JULY	3	1	0	0	3	1	0	3	0	4	4	7	2	3	13	3	5	12	4	55	1
AUG	4	2	1	1	9	7	7	50	17	27	40	65	0	9	19	0	0	0	0	0	19
1977	4	5	0	1	3	1	1	4	3	5	29	9	2	3	14	3	5	12	4	55	3
ALL	3	1	0	1	6	4	2	37	8	19	35	66	2	3	14	3	5	12	4	55	7

Table 22. Percentages of total "community" energy flow contributed by shearwaters in intervals of distance from nearest island.

RELATIVE ENERGETIC DEMAND (% OF TOTAL FOR ALL SPECIES) FOR FTP

DISTANCE TO NEAREST ISLAND (KM)

	10	20	30	40	50	60	70	80	90	100	110	120	130	140	150	160	170	180	190	200	TOT
6/75	0	0	0	0	0	0	0	0	0	6	0	0	0	0	0	0	0	0	0	0	0
7/76	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
7/77	0	1	0	0	0	1	0	0	1	0	2	2	21	3	2	20	0	0	4	15	1
8/77	1	1	4	0	4	6	3	4	1	21	11	0	0	0	0	11	0	0	0	0	3
JULY	0	0	0	0	1	0	0	0	1	0	2	2	21	3	2	20	0	0	4	15	1
AUG	1	1	2	0	4	2	1	1	1	12	7	0	0	0	0	11	0	0	0	0	2
1977	0	0	1	0	4	4	2	2	1	11	9	2	21	3	2	21	0	0	4	15	2
ALL	0	0	1	0	2	1	1	0	1	8	7	1	21	3	2	21	0	0	4	15	1

Table 23. Percentages of total "community" energy flow contributed by Fork-tailed Storm-Petrels in intervals of distance from nearest island.

RELATIVE ENERGETIC DEMAND (% OF TOTAL FOR ALL SPECIES) FOR KWS

DISTANCE TO NEAREST ISLAND (KM)

	10	20	30	40	50	60	70	80	90	100	110	120	130	140	150	160	170	180	190	200	TOT
8/75	0	4	4	2	13	6	15	5	15	14	17	8	0	0	0	0	0	0	0	0	7
7/76	3	0	-	-	9	7	10	7	9	7	0	0	0	0	0	0	0	0	0	0	4
7/77	11	18	15	8	7	16	12	4	6	4	24	16	9	21	30	1	19	6	7	0	11
8/77	13	4	11	6	7	3	16	7	7	9	15	17	0	18	44	11	0	0	0	0	7
JULY	9	2	10	5	9	8	10	5	6	5	24	16	9	21	30	1	19	6	7	0	6
AUG	13	4	8	5	10	5	13	5	10	12	16	8	0	18	44	11	0	0	0	0	7
1977	12	10	14	7	7	7	14	5	6	7	16	16	9	21	30	1	19	6	7	0	9
ALL	10	3	10	5	9	7	12	5	8	10	16	9	9	21	30	1	19	6	7	0	7

Table 24. Percentages of total "community" energy flow contributed by kittiwakes in intervals of distance from nearest island.

RELATIVE ENERGETIC DEMAND (% OF TOTAL FOR ALL SPECIES) FOR MUR

DISTANCE TO NEAREST ISLAND (KM)

	10	20	30	40	50	60	70	80	90	100	110	120	130	140	150	160	170	180	190	200	TOT
6/75	0	35	31	53	64	77	42	23	44	5	2	1	0	0	0	0	0	0	0	0	52
7/76	75	97	82	87	54	76	72	80	81	69	0	0	0	0	0	0	0	0	0	0	86
7/77	62	42	71	75	60	56	76	78	25	36	20	23	19	26	9	22	24	26	19	1	62
8/77	5	82	70	35	54	36	44	56	66	45	24	33	0	36	6	44	0	0	0	0	68
JULY	65	92	76	84	57	72	73	73	29	43	20	23	19	26	9	22	24	26	19	1	77
AUG	5	64	80	87	53	62	44	35	53	19	16	2	0	36	6	44	0	0	0	0	60
1977	53	65	71	73	57	42	61	66	33	41	24	23	19	28	9	21	24	26	19	1	64
ALL	59	90	77	85	58	66	66	47	42	27	16	7	19	28	9	21	24	26	19	1	71

Table 25. Percentages of total "community" energy flow contributed by murres in intervals of distance from nearest island.

RELATIVE ENERGETIC DEMAND (% OF TOTAL FOR ALL SPECIES) FOR AUK

DISTANCE TO NEAREST ISLAND (KM)

	10	20	30	40	50	60	70	80	90	100	110	120	130	140	150	160	170	180	190	200	TOT
8/75	0	0	0	1	1	1	4	0	1	0	2	0	0	0	0	0	0	0	0	0	0
7/76	5	0	[illegible]	5	13	9	11	2	2	1	0	0	0	0	0	0	0	0	0	0	5
7/77	0	0	0	1	1	0	1	1	0	1	7	0	0	0	0	0	0	9	0	0	0
8/77	0	0	1	1	1	0	2	1	0	0	0	3	0	9	13	0	0	0	0	0	1
JULY	2	0	3	3	7	7	9	2	0	1	7	0	0	0	0	0	0	9	0	0	3
AUG	0	0	0	1	1	1	1	0	0	0	1	0	0	9	13	0	0	0	0	0	0
1977	0	0	0	1	1	0	1	2	1	0	1	0	0	0	0	0	0	9	0	0	1
ALL	1	0	2	5	4	4	7	1	1	0	1	0	0	0	0	0	0	9	0	0	2

Table 26. Percentages of total "community" energy flow contributed by auklets in intervals of distance from nearest island.

RELATIVE ENERGETIC DEMAND (% OF TOTAL FOR ALL SPECIES) FOR PUF

DISTANCE TO NEAREST ISLAND (KM)

	10	20	30	40	50	60	70	80	90	100	110	120	130	140	150	160	170	180	190	200	TOT
8/75	0	0	0	0	2	1	5	1	1	0	0	0	0	0	0	0	0	0	0	0	1
7/76	3	0	1	1	0	3	2	2	0	1	0	0	0	0	0	0	0	0	0	0	1
7/77	1	2	0	1	1	1	1	1	0	1	2	0	2	0	0	0	5	3	2	0	0
8/77	1	1	1	0	1	0	2	1	1	1	1	0	0	0	0	0	0	0	0	0	1
JULY	2	0	1	0	3	3	2	1	0	1	2	0	2	0	0	0	5	3	2	0	1
AUG	1	1	1	0	2	1	1	1	1	0	0	0	0	0	0	0	0	0	0	0	0
1977	1	1	0	0	1	1	1	1	1	1	1	0	2	0	0	0	5	3	2	0	1
ALL	1	0	1	0	2	2	2	1	1	1	1	0	2	0	0	0	5	3	2	0	1

Table 27. Percentages of total "community" energy flow contributed by puffins in intervals of distance from nearest island.

RELATIVE ENERGETIC DEMAND (% OF TOTAL FOR ALL SPECIES) FOR MIS

DISTANCE TO NEAREST ISLAND (KM)

	10	20	30	40	50	60	70	80	90	100	110	120	130	140	150	160	170	180	190	200	TOT
8/75	0	2	0	1	1	2	1	0	2	33	1	1	0	0	0	0	0	0	0	0	3
7/76	1	0	0	0	7	2	3	1	0	4	0	0	0	0	0	0	0	0	0	0	0
7/77	0	1	0	5	5	1	0	1	1	1	0	16	5	6	4	3	14	9	2	7	3
8/77	0	0	1	0	0	1	2	1	1	2	2	8	0	9	5	22	0	0	0	0	1
JULY	1	0	0	2	6	2	2	1	1	2	0	16	5	6	4	3	14	9	2	7	1
AUG	0	1	0	1	1	2	1	0	1	22	1	1	0	9	6	22	0	0	0	0	2
1977	0	0	0	3	3	1	1	1	1	1	1	16	5	7	5	3	14	9	2	7	2
ALL	0	0	0	1	3	2	2	0	1	16	1	5	5	7	5	3	14	9	2	7	2

Table 28. Percentages of total "community" energy flow contributed by miscellaneous species in intervals of distance from nearest island.

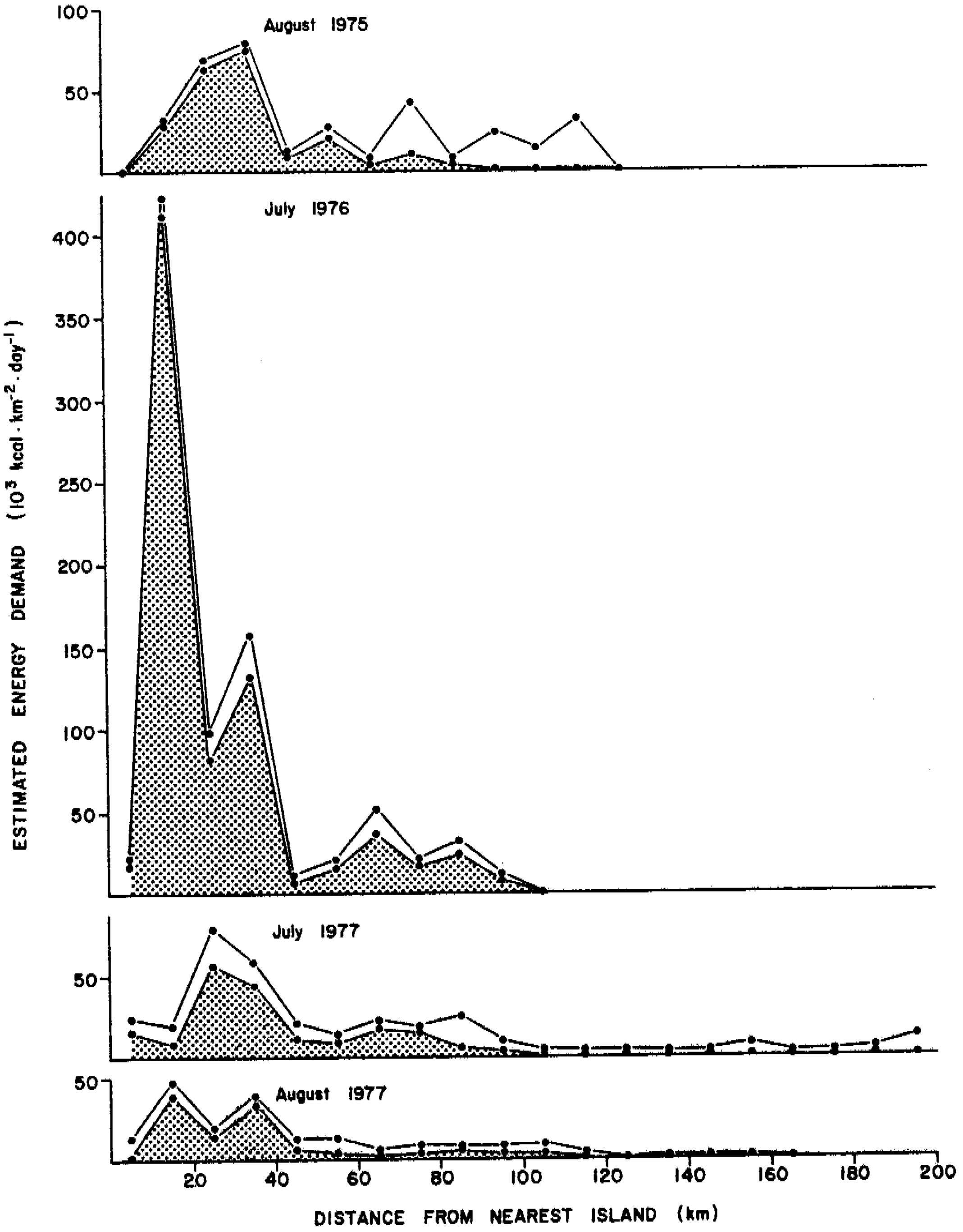

Fig. 4. Distribution of total "community" energy demand as a function of distance from nearest island in the Pribilof Islands marine bird system. The shaded area represents the energy demand of murre populations.

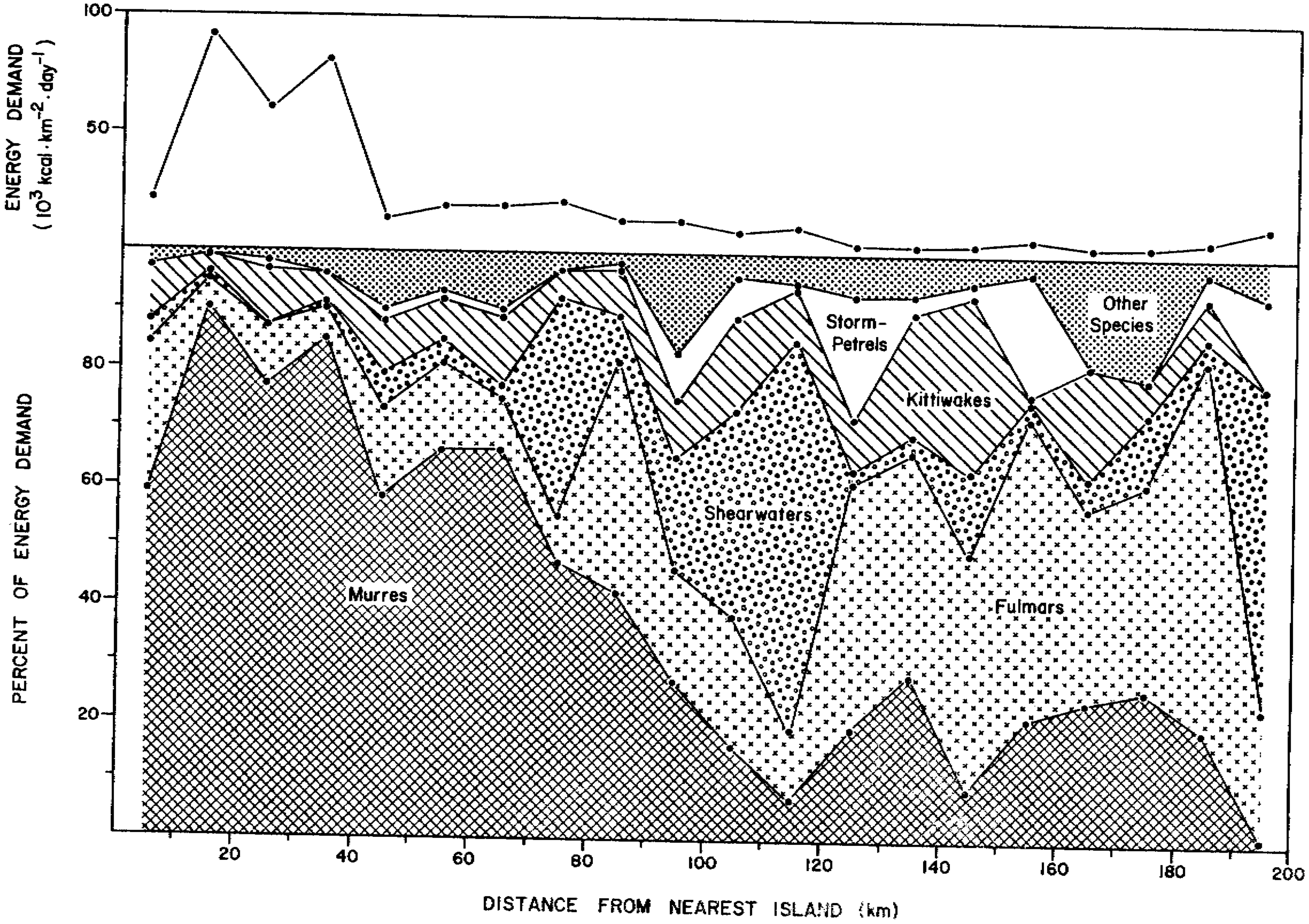

Fig. 5. Distribution of total "community" energy demand (above) and of the percentage contribution of each species or species group to that total energy flow, as a function of distance from the nearest island. This analysis represents weighted averages for all censuses in the Pribilof Islands combined.

energetically dominant species in this system, were concentrated in these relatively near intervals; 77% of the total energy flow through murre populations occurred within 40 km of the nearest island (Table 29), although energy flow was relatively low close to islands. The proportionate contribution of murres to the total community energy demand fell off beyond 60 km. Fulmars accounted for a moderate portion of the total community energetics, but assumed greatest importance at greater distances, beyond 120 km (Fig. 5); half of the total energy flow through fulmars occurred beyond 80 km (Table 29). Fork-tailed Storm-Petrels, while never an important component of community energetics, exhibited an off-island distributional pattern similar to that of fulmars, with 59% of their energy demand occurring beyond 120 km. Shearwaters contributed a major portion of the community energetics in intermediate distance intervals; 41% of their energy demand was concentrated between 80 and 120 km. The energy demand of kittiwakes occurred primarily close to islands (Table 29), although the proportional contribution of the species to the community total was rather uniform over the entire area considered (Fig. 5). Auklets and puffins also exhibited greatest energy demands relatively near to islands, although that of puffins was more widely distributed than that of auklets (Table 29); neither group contributed significantly to total community energetics.

The uneven distance patterns revealed above may be associated with fundamental variations in oceanographic conditions. To explore this possibility in a preliminary fashion, we determined the water depth for each of the 10' X 10' blocks used in the initial analysis (Fig. 3) from National Ocean Survey hydrographic charts, and then grouped the weighted average energy flow values for blocks by water depth categories. The resulting data are presented in Tables 30-55; the weighted averages for all censuses are summarized in Fig. 6. Community energy demand was greatest in relatively shallow waters, a consequence of the concentration of murre densities in such regions. Auklets as a group also demonstrated a distinct association with shallow areas. Fulmar and shearwater energy demands were greatest in 120-140-km waters and in deeper areas, and storm-petrels were distributed over areas with water depths exceeding 100 m, with their energy demands peaking in deep-water zones. The energy demands of kittiwakes were broadly distributed over depth categories, but peaked in the 200-600-m interval.

The foregoing analysis of the distribution of energy demands considered distance from the nearest island or water depth without regard to the identity of the island or the specific latitude-longitude locations or depths of zones of substantial energy flow. However, in the Pribilof group St. George supports the major portion of the islands' breeding seabirds. Hickey (1977) reported that on the order of 2.5 million seabirds bred on St. George during 1976, compared with 0.25 million on St. Paul; his group estimated a breeding population of 1.5 million Thick-billed Murres on St. George. compared with 110,000 on St. Paul. Further, the continental shelf break is not far to the south of the islands, while immediately to the north the waters are relatively shallow. We have therefore analyzed the census data from the most completely-censused areas about St. George and St. Paul more intensively. Censuses conducted within the area 55°20' to 58°00' N latitude and 168°30' to 170°50' longitude were combined to calculate overall bird densities by species within 20' X 20' blocks (Fig. 3); the intensity of transect censusing in these blocks over the

Table 29. Percentages of energy demand for species populations as a function of distance from the nearest island, calculated from weighted average values from all censuses combined.

	Distance from nearest island (km)				
Species	0-40	41-80	81-120	121-160	161-200
Fulmar	35	15	20	15	14
Shearwaters	7	27	41	3	21
Fork-tailed Storm-Petrel	8	9	23	32	27
Kittiwakes	50	22	17	8	3
Murres	77	17	4	1	0
Anklets	55	39	2	0	4
Puffins	45	33	9	3	9
TOTAL	61	18	11	5	6

ENERGETIC DEMAND (KCAL X 100/DAY/KM2) FOR FUL

DEPTH (M)

	60	80	100	120	140	200	600	1400	3000	ALL
8/75	2	2	5	16	22	13	25	28	13	9
7/76	13	21	52	67	0	151	114	0	0	29
7/77	23	6	17	52	329	58	94	60	59	42
8/77	11	5	8	52	25	65	46	46	28	26
JULY	16	11	24	56	329	72	97	60	59	38
AUG	4	4	7	43	23	48	41	41	27	20
1977	19	7	14	52	195	70	74	53	37	35
ALL	12	8	17	49	132	58	72	49	35	29

Table 30. Distribution of fulmar energy demand by intervals of water depth.

ENERGETIC DEMAND (KCAL X 100/DAY/KM2) FOR SHW

	DEPTH (M)									
	60	80	100	120	140	200	600	1400	3000	ALL
8/75	21	160	43	20	177	47	62	270	229	101
7/76	0	2	1	1	0	0	0	0	0	1
7/77	0	2	4	8	0	3	15	8	23	5
8/77	1	8	1	1	4	3	3	3	5	4
JULY	0	2	3	6	0	3	13	8	23	4
AUG	16	61	14	6	103	26	17	75	27	38
1977	0	5	3	4	2	3	10	5	10	5
ALL	5	31	8	6	66	17	15	47	26	21

Table 31. Distribution of shearwater energy demand by intervals of water depth.

ENERGETIC DEMAND (KCAL X 100/DAY/KM2) FOR FTP

	DEPTH (M)									
	60	80	100	120	140	200	600	1400	3000	ALL
8/75	0	0	0	0	5	0	0	18	0	1
7/76	0	0	1	0	0	5	7	0	0	0
7/77	0	0	0	13	3	4	2	2	2	2
8/77	0	0	0	5	8	30	12	22	4	5
JULY	0	0	0	9	3	4	3	2	2	2
AUG	0	0	0	4	6	14	9	21	4	4
1977	0	0	0	9	5	15	6	12	4	4
ALL	0	0	0	6	5	10	6	13	3	3

Table 32, Distribution of Fork-tailed Storm-Petrel energy demand by intervals of water depth.

ENERGETIC DEMAND (KCAL X 100/DAY/KM2) FOR KWS

DEPTH (M)

	60	80	100	120	140	200	600	1400	3000	ALL
8/75	14	13	7	30	29	14	35	53	39	20
7/76	35	13	26	56	0	22	80	0	0	32
7/77	10	7	4	26	28	30	134	24	24	22
8/77	1	3	9	13	33	12	27	19	11	11
JULY	28	9	8	34	28	29	126	24	24	25
AUG	11	7	6	21	31	13	29	28	14	14
1977	7	5	6	22	30	23	83	21	15	17
ALL	22	6	8	27	30	20	62	26	17	20

Table 33. Distribution of kittiwake energy demand by intervals of water depth.

ENERGETIC DEMAND (KCAL X 100/DAY/KM2) FOR MUR

	DEPTH (M)									
	60	80	100	120	140	200	600	1400	3000	ALL
8/75	372	130	33	40	90	32	449	5	0	157
7/76	955	136	1690	100	0	10	80	0	0	690
7/77	1103	80	25	15	2	2	24	8	12	128
8/77	646	118	125	102	25	20	43	11	6	104
JULY	996	94	382	37	2	3	33	8	12	299
AUG	444	122	95	86	62	26	145	10	5	122
1977	955	97	62	62	12	9	35	10	7	117
ALL	810	108	262	64	41	16	84	9	7	212

Table 34. Distribution of murre energy demand by intervals of water depth.

ENERGETIC DEMAND (KCAL X 100/DAY/KM2) FOR AUK

	DEPTH (M)									
	60	80	100	120	140	200	600	1400	3000	ALL
8/75	2	2	2	0	0	0	0	1	0	1
7/76	70	7	0	9	0	0	0	0	0	37
7/77	5	1	1	1	0	0	0	0	0	1
8/77	11	1	1	1	0	0	0	0	0	1
JULY	52	3	1	3	0	0	0	0	0	12
AUG	4	2	2	0	0	0	0	0	0	1
1977	7	1	1	1	0	0	0	0	0	1
ALL	36	2	1	2	0	0	0	0	0	7

Table 35. Distribution of auklet energy demand by intervals of water depth.

ENERGETIC DEMAND (KCAL X 100/DAY/KM2) FOR PUF

	DEPTH (M)									
	60	80	100	120	140	200	600	1400	3000	ALL
8/75	3	3	2	1	1	2	0	0	1	2
7/76	8	6	3	8	0	12	5	0	0	7
7/77	3	2	1	2	0	1	2	1	2	1
8/77	3	1	1	1	0	0	1	1	1	1
JULY	6	3	1	3	0	3	2	1	2	3
AUG	3	2	1	1	1	1	1	0	1	1
1977	3	1	1	1	0	1	2	1	1	1
ALL	5	2	1	2	1	2	2	0	1	2

Table 36. Distribution of puffin energy demand by intervals of water depth.

ENERGETIC DEMAND (KCAL X 100/DAY/KM2) FOR MIS

DEPTH (M)

	60	80	100	120	140	200	600	1400	3000	ALL
8/75	5	3	2	1	1	4	1	140	1	10
7/76	8	2	0	0	0	0	3	0	0	4
7/77	40	1	2	12	0	1	2	2	2	6
8/77	1	1	1	1	1	1	0	0	1	1
JULY	17	1	1	9	0	1	2	2	2	5
AUG	4	2	1	1	1	2	0	38	1	4
1977	27	1	1	6	0	1	1	1	2	4
ALL	12	2	1	4	1	2	1	23	2	5

Table 37. Distribution of energy demands of miscellaneous species by intervals of water depth.

ENERGETIC DEMAND (KCAL X 100/DAY/KM2) FOR TOT

	DEPTH (M)									
	60	80	100	120	140	200	600	1400	3000	ALL
8/75	419	313	94	108	325	112	573	515	283	301
7/76	1089	187	1973	241	0	200	289	0	0	800
7/77	1184	101	54	129	362	99	273	105	124	207
8/77	674	137	146	181	96	151	138	102	56	153
JULY	1115	123	-20	157	362	115	276	105	124	388
AUG	486	200	128	162	227	130	242	213	79	204
1977	1018	117	83	157	244	122	216	103	76	184
ALL	902	161	298	160	276	125	262	167	91	299

Table 38. Distribution of total community energy demand by intervals of water depth.

RELATIVE ENERGETIC DEMAND (% OF TOTAL FOR ALL INTERVALS) FOR FUL

	DEPTH (M)									
	60	80	100	120	140	200	600	1400	3000	ALL
8/75	1	1	4	12	16	10	19	21	10	
7/76	3	5	12	15	0	34	26	0	0	
7/77	3	1	2	7	44	8	13	8	8	
8/77	3	2	2	16	8	26	14	14	8	
JULY	2	1	3	7	43	9	13	8	8	
AUG	2	2	3	17	9	19	16	16	10	
1977	3	1	3	9	35	13	13	10	7	
ALL	3	2	4	11	29	13	16	11	8	

Table 39. Percentages of energy demand of fulmars occurring in water depth intervals.

RELATIVE ENERGETIC DEMAND (% OF TOTAL FOR ALL INTERVALS) FOR SHW

	DEPTH (M)									
	60	80	100	120	140	200	600	1400	3000	ALL
8/75	2	14	4	2	16	4	5	24	20	
7/76	0	40	20	20	0	0	0	0	0	
7/77	0	3	6	12	0	4	22	12	34	
8/77	3	24	3	3	12	9	9	9	15	
JULY	0	3	5	10	0	5	21	13	37	
AUG	4	16	4	2	27	7	4	20	7	
1977	0	11	6	9	4	6	21	11	21	
ALL	2	13	3	2	27	7	6	19	11	

Table 40. Percentages of energy demand of shearwaters occurring in water depth intervals.

RELATIVE ENERGETIC DEMAND (% OF TOTAL FOR ALL INTERVALS) FOR FTP

DEPTH (M)

	60	80	100	120	140	200	600	1400	3000	ALL
8/75	0	0	0	0	21	0	0	75	0	
7/76	0	0	8	0	0	38	54	0	0	
7/77	0	0	0	46	11	14	7	7	7	
8/77	0	0	0	6	9	35	14	26	5	
JULY	0	0	0	36	12	16	12	8	8	
AUG	0	0	0	6	10	23	15	34	6	
1977	0	0	0	16	9	27	11	22	7	
ALL	0	0	0	13	11	22	13	28	7	

Table 41. Percentages of energy demand of Fork-tailed Storm-Petrels occurring in water depth intervals.

RELATIVE ENERGETIC DEMAND (% OF TOTAL FOR ALL INTERVALS) FOR KWS

DEPTH (M)

	60	80	100	120	140	200	600	1400	3000	ALL
8/75	5	5	3	12	11	5	14	21	15	
7/76	13	5	10	21	0	8	30	0	0	
7/77	3	2	1	3	9	10	43	8	8	
8/77	1	2	6	13	23	8	19	13	8	
JULY	8	3	2	10	8	9	33	7	7	
AUG	6	4	5	12	18	7	16	16	8	
1977	3	2	3	9	13	10	38	9	6	
ALL	8	3	3	10	12	8	32	10	7	

Table 42. Percentages of energy demand of kittiwakes occurring in water depth intervals.

RELATIVE ENERGETIC DEMAND (% OF TOTAL FOR ALL INTERVALS) FOR MUR

DEPTH (M)

	60	80	100	120	140	200	600	1400	3000	ALL
8/75	28	10	3	3	7	2	34	0	0	
7/76	25	4	49	3	0	0	2	0	0	
7/77	79	6	2	1	0	0	2	1	1	
8/77	54	10	10	8	2	2	4	1	0	
JULY	53	5	20	2	0	0	2	0	1	
AUG	40	11	9	8	6	2	13	1	0	
1977	70	7	5	5	1	1	3	1	1	
ALL	50	7	16	4	3	1	5	1	0	

Table 43. Percentages of energy demand of murres occurring in water depth intervals.

RELATIVE ENERGETIC DEMAND (% OF TOTAL FOR ALL INTERVALS) FOR AUK

	DEPTH (M)									
	60	80	100	120	140	200	600	1400	3000	ALL
8/75	25	25	25	0	0	0	0	13	0	
7/76	57	6	0	7	0	0	0	0	0	
7/77	56	11	11	11	0	0	0	0	0	
8/77	73	7	7	7	0	0	0	0	0	
JULY	73	4	1	4	0	0	0	0	0	
AUG	44	22	22	0	0	0	0	0	0	
1977	64	9	9	9	0	0	0	0	0	
ALL	75	4	2	4	0	0	0	0	0	

Table 44. Percentages of energy demand of auklets occurring in water depth intervals.

RELATIVE ENERGETIC DEMAND (% OF TOTAL FOR ALL INTERVALS) FOR PUF

DEPTH (M)

	60	80	100	120	140	200	600	1400	3000	ALL
8/75	20	20	13	7	7	13	0	0	7	
7/76	16	12	6	16	0	24	10	0	0	
7/77	20	13	7	13	0	7	13	7	13	
8/77	30	10	10	10	0	0	10	10	10	
JULY	25	13	4	13	0	13	8	4	8	
AUG	25	17	8	8	8	8	8	0	8	
1977	25	8	8	8	0	8	17	8	8	
ALL	28	11	6	11	6	11	11	0	6	

Table 45. Percentages of energy demand of puffins occurring in water depth intervals.

RELATIVE ENERGETIC DEMAND (% OF TOTAL FOR ALL INTERVALS) FOR MIS

DEPTH (M)

	60	80	100	120	140	200	600	1400	3000	ALL
8/75	3	2	1	1	1	2	1	83	1	
7/76	47	12	0	0	0	0	18	0	0	
7/77	59	1	3	18	0	1	3	3	3	
8/77	13	13	13	13	13	13	0	0	13	
JULY	42	2	2	22	0	2	5	5	5	
AUG	7	4	2	2	2	4	0	70	2	
1977	61	2	2	14	0	2	2	2	5	
ALL	23	4	2	8	2	4	2	43	4	

Table 46. Percentages of energy demand of miscellaneous species occurring in water depth intervals.

RELATIVE ENERGETIC DEMAND (% OF TOTAL FOR ALL INTERVALS) FOR TOT

DEPTH (M)

	60	80	100	120	140	200	600	1400	3000	ALL
8/75	15	11	3	4	12	4	21	19	10	
7/76	27	5	50	6	0	5	7	0	0	
7/77	49	4	2	5	15	4	11	4	5	
8/77	40	8	9	11	6	9	8	6	3	
JULY	40	4	15	6	13	4	10	4	4	
AUG	26	11	7	9	12	7	13	11	4	
1977	48	5	4	7	11	6	10	5	4	
ALL	37	7	12	7	11	5	11	7	4	

Table 47. Percentages of total community energy demand occurring in water depth intervals.

RELATIVE ENERGETIC DEMAND (% OF TOTAL FOR ALL SPECIES) FOR FUL

DEPTH (M)

	60	80	100	120	140	200	600	1400	3000	ALL
8/75	0	1	5	15	7	12	4	5	5	3
7/76	1	11	3	23	0	75	39	0	0	4
7/77	2	8	31	40	91	59	34	57	48	20
8/77	2	4	5	29	26	56	33	45	50	17
JULY	1	9	6	36	91	63	35	57	48	10
AUG	1	2	5	27	10	37	17	19	34	10
1977	2	6	16	33	80	57	34	51	49	19
ALL	1	5	6	31	48	46	27	29	38	10

Table 48. Percentages of total community energy demand contributed by fulmars in water depth intervals.

RELATIVE ENERGETIC DEMAND (% OF TOTAL FOR ALL SPECIES) FOR SHW

	DEPTH (M)									
	60	80	100	120	140	200	600	1400	3000	ALL
8/75	5	51	46	19	54	42	11	52	81	34
7/76	0	1	0	0	0	0	0	0	0	0
7/77	0	2	7	6	0	3	5	8	19	2
8/77	0	6	1	1	4	2	2	3	9	3
JULY	0	2	1	4	0	3	5	8	19	1
AUG	3	30	11	4	45	20	7	35	34	19
1977	0	4	3	3	1	2	5	5	13	3
ALL	1	19	3	4	24	14	6	28	29	7

Table 49. Percentages of total community energy demand contributed by shearwaters in water depth intervals.

RELATIVE ENERGETIC DEMAND (% OF TOTAL FOR ALL SPECIES) FOR FTP

DEPTH (M)

	60	80	100	120	140	200	600	1400	3000	ALL
8/75	0	0	0	0	2	0	0	3	0	0
7/76	0	0	0	0	0	2	2	0	0	0
7/77	0	0	0	10	1	4	1	2	2	1
8/77	0	0	0	3	8	20	9	22	7	3
JULY	0	0	0	6	1	3	1	2	2	1
AUG	0	0	0	2	3	11	4	10	5	2
1977	0	0	0	6	2	12	3	12	5	2
ALL	0	0	0	4	2	8	2	8	3	1

Table 50. Percentages of total community energy demand contributed by Fork-tailed Storm-Pterels in water depth intervals.

RELATIVE ENERGETIC DEMAND (% OF TOTAL FOR ALL SPECIES) FOR KWS

	DEPTH (M)									
	60	80	100	120	140	200	600	1400	3000	ALL
8/75	3	4	7	28	9	13	6	10	14	7
7/76	3	7	1	23	0	11	28	0	0	4
7/77	1	7	7	20	8	30	49	23	19	11
8/77	0	2	6	10	34	8	20	19	20	7
JULY	3	7	2	22	8	25	46	23	19	6
AUG	2	3	6	13	14	10	12	13	18	7
1977	1	4	7	14	12	19	41	20	20	9
ALL	2	5	3	17	11	16	31	16	19	7

Table 51. Percentages of total community energy demand contributes by kittiwakes in water depth intervals.

RELATIVE ENERGETIC DEMAND (% OF TOTAL FOR ALL SPECIES) FOR MUR

DEPTH (M)

	60	80	100	120	140	200	600	1400	3000	ALL
8/75	89	42	35	37	28	29	78	1	0	52
7/76	88	73	96	41	0	5	28	0	0	86
7/77	93	79	46	12	1	2	9	8	10	62
8/77	96	86	86	56	26	13	36	11	11	68
JULY	89	76	91	24	1	3	12	8	10	77
AUG	91	61	74	53	27	20	60	5	6	60
1977	94	83	70	39	5	7	15	10	9	64
ALL	90	67	88	40	15	13	32	5	8	71

Table 52. Percentages of total community energy demand contributed by murres in water depth intervals.

RELATIVE ENERGETIC DEMAND (% OF TOTAL FOR ALL SPECIES) FOR AUK

DEPTH (M)

	60	80	100	120	140	200	600	1400	3000	ALL
8/75	0	1	2	0	0	0	0	0	0	0
7/76	6	4	0	4	0	0	0	0	0	5
7/77	0	1	2	1	0	0	0	0	0	0
8/77	2	1	1	1	0	0	0	0	0	1
JULY	5	2	0	2	0	0	0	0	0	3
AUG	1	1	2	0	0	0	0	0	0	0
1977	1	1	1	1	0	0	0	0	0	1
ALL	4	1	0	1	0	0	0	0	0	2

Table 53. Percentages of total community energy demand contributed by auklets in water depth intervals.

RELATIVE ENERGETIC DEMAND (% OF TOTAL FOR ALL SPECIES) FOR PUF

DEPTH (M)

	60	80	100	120	140	200	600	1400	3000	ALL
8/75	1	1	2	1	0	2	0	0	0	1
7/76	1	3	0	3	0	6	2	0	0	1
7/77	0	2	2	2	0	1	1	1	2	0
8/77	0	1	1	1	0	0	1	1	2	1
JULY	1	2	0	2	0	3	1	1	2	1
AUG	1	1	1	1	0	1	0	0	1	0
1977	0	1	1	1	0	1	1	1	1	1
ALL	1	1	0	1	0	2	1	0	1	1

Table 54. Percentages of total community energy demand contributed by puffins in water depth intervals.

RELATIVE ENERGETIC DEMAND (% OF TOTAL FOR ALL SPECIES) FOR MIS

DEPTH (M)

	60	80	100	120	140	200	600	1400	3000	ALL
8/75	1	1	2	1	0	4	0	27	0	3
7/76	1	1	0	0	0	0	1	0	0	0
7/77	3	1	4	9	0	1	1	2	2	3
8/77	0	1	1	1	1	1	0	0	2	1
JULY	2	1	0	6	0	1	1	2	2	1
AUG	1	1	1	1	0	2	0	18	1	2
1977	3	1	1	4	0	1	0	1	3	2
ALL	1	1	0	2	0	2	0	14	2	2

Table 55. Percentages of total community energy demand contributed by miscellaneous species in water depth intervals.

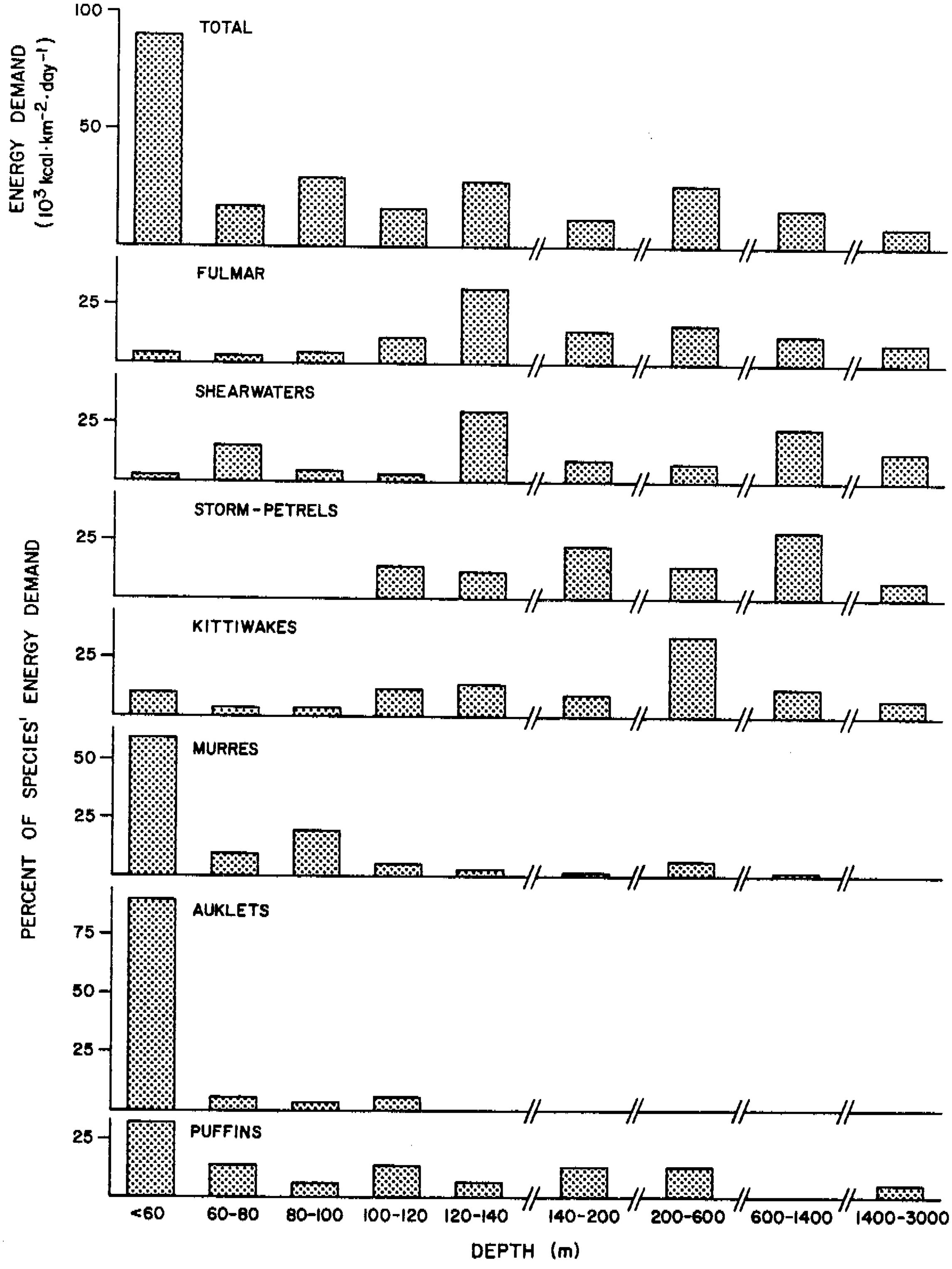

Fig. 6. Distribution of the energy demands of Pribilof Islands bird species or species groups as a function of water depth. Data are derived from weighted averages of all transect censuses.

1975-77 seasons is indicated in Fig. 7. Data were combined for all censuses within 20' blocks in order to permit us to generate continuous "contours" of species abundance and energy flow over this area. The frequency of occurrence for a given species within a 20' block was calculated as the density of individuals within that block divided by the sum of that species' densities over all 20' blocks. Contour surfaces were constructed by linear interpolation between grid block vertices using the Surface Display Library of the University of California (Berkeley) Computer Center. Interpolation was not carried out in the neighborhood of blocks for which there were no census data (5 blocks out of 56; Fig. 7). The resulting contour maps portray a probability surface in which the intervals define the proportional distributions of all individuals recorded during censusing in the area as a whole. A similar procedure was used to determine contours of total community energy demand by 20' blocks, using the calculated energy demands of species populations combined. Depth contours in this census area are shown in Fig. 8.

Over the intensive area shown in Fig. 7, murres accounted for 73.6% of the total energy flow through the collection of species populations considered in these analyses. The frequency of occurrence plotting (Fig. 9) shows that their distribution was heavily concentrated in the immediate vicinity of St. George, with two "peaks" of occurrence, southeast and southwest of the island. Although both of these "peaks" occurred in 80-100-m waters, the overall distribution of the birds, combined with the relatively small area of such depths (Fig. 8), led to an overall concentration of energy flow in shallower waters (Fig. 6). The decrease in frequency of occurrence of murres was sharper to the south of St. George, toward the shelf break, than to the north. In contrast, the birds associated with St. Paul were concentrated around the island in waters less than 60 m. and in an area to the east of the island in depths of 60-70 m.

The other alcids that we considered, auklets and puffins, contributed only 2.6% and 0.7% of the total assemblage energy demand, respectively. The spatial distribution of their occurrence, however, was basically similar to that of murres. Auklets exhibited a sharp localized association with St. George (80-100 m) and with St. Paul (less than 60 m; Fig. 10), while puffins, although showing the same foci, were much more widely scattered and were concentrated in depths of 60-80 m to the west of St. Paul (Fig. 11). Their distribution, however, was almost totally in shelf waters, extending primarily to the north of the islands. Possibly puffins, as a result of their abilities to return from foraging trips with several prey items, are less restricted in foraging flight distances from breeding colonies than are murres, which carry a single prey item per trip.

Fulmars contributed 9.3% of the total assemblage energy flow, and were rather diffusely distributed, with no strong association with the islands (Fig. 12). Their frequency of occurrence seemed greatest about and beyond the continental shelf break (100-1400 m) although the absence of censuses in the southwestern portion of the area (Fig. 7) weakens this conclusion. Kittiwakes (6.4% of the total community energetics) also showed a rather diffuse distributional pattern, but were somewhat more localized in the area to the south of St. George than the fulmars (Fig. 13). They were associated with the shelf break (200 m) south of St. George, but to the southwest of St. Paul they appeared to be concentrated in shallower waters. Kittiwakes

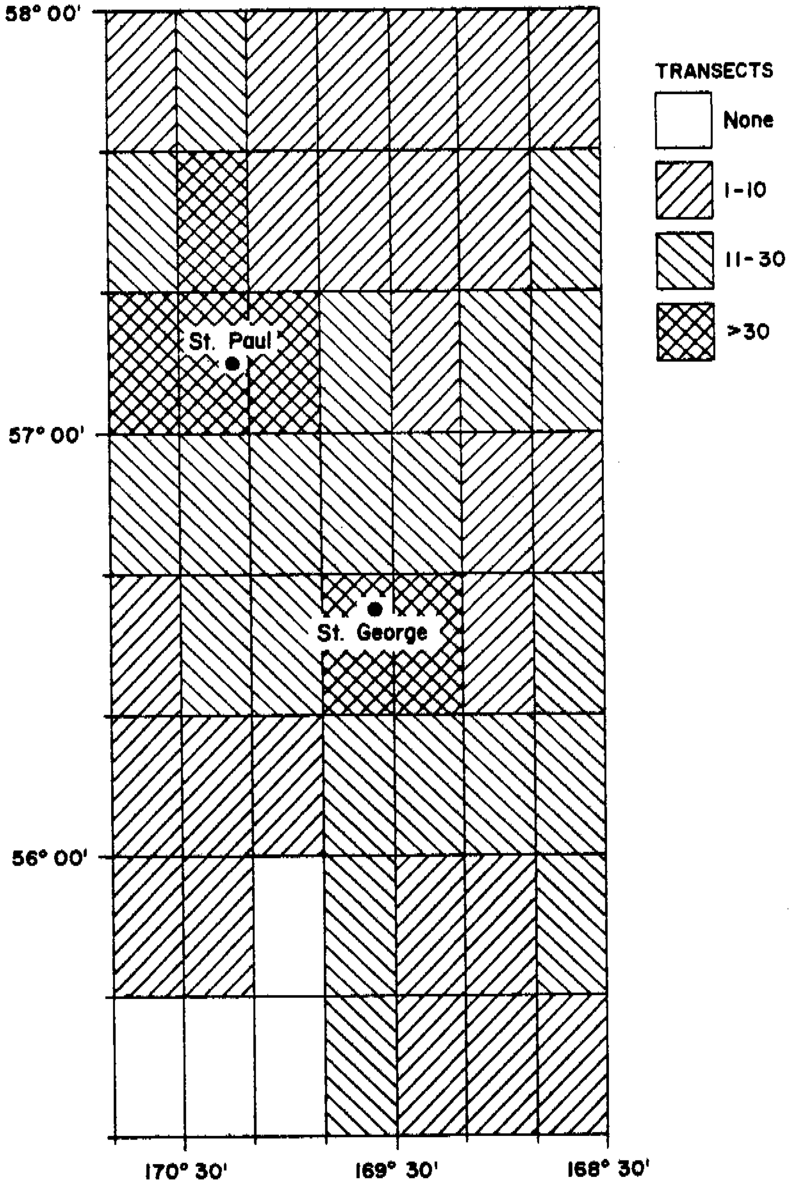

Fig. 7. Intensity of transect censusing in 20' blocks in the vicinity of St. George and St. Paul selected for intensive analysis of marine bird energetics. Shadings represent the number of transects conducted in a block during 1975-77 censusing.

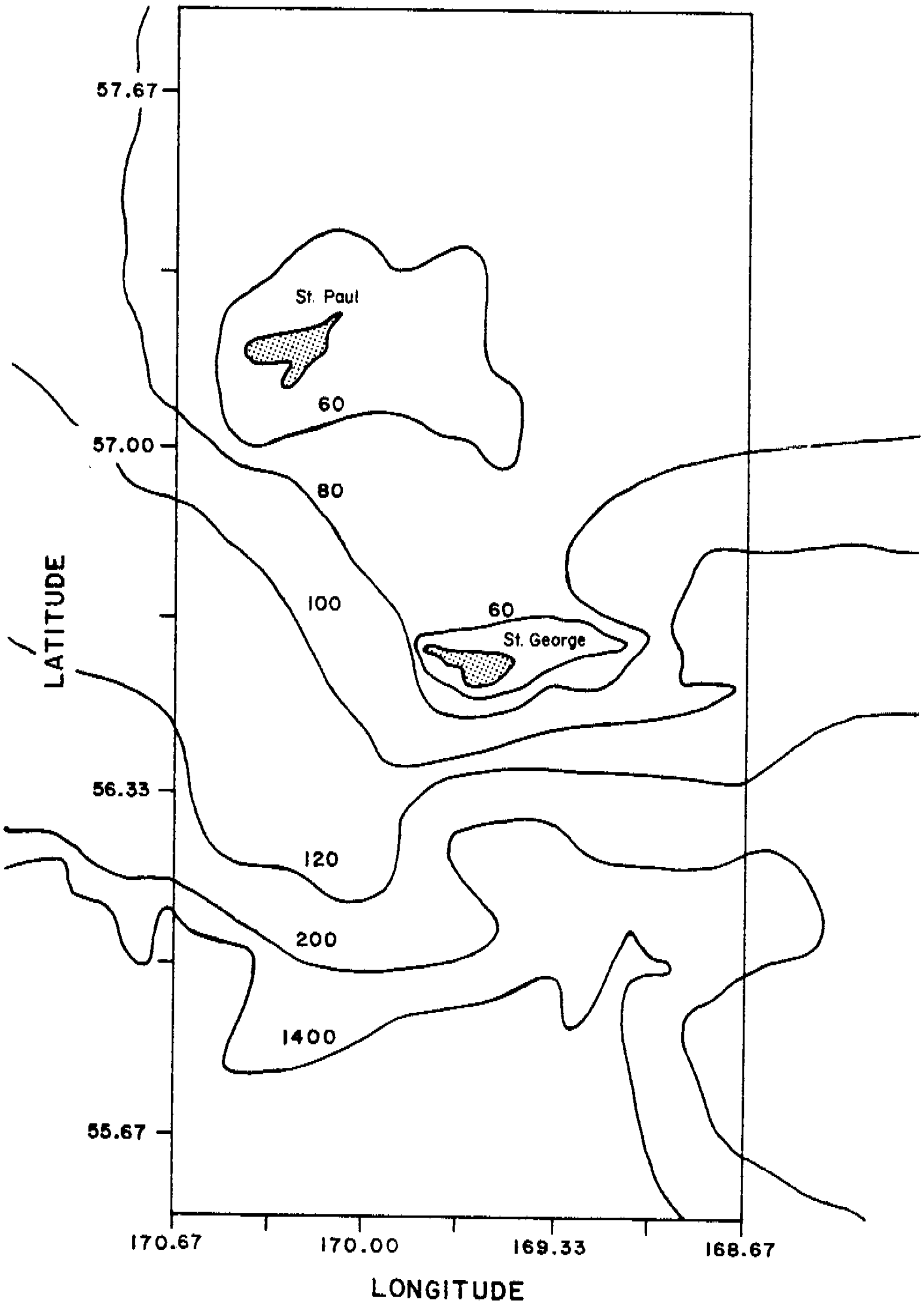

Fig. 8. Water depth contours in the vicinity of St. George and St. Paul, Pribilof Islands.

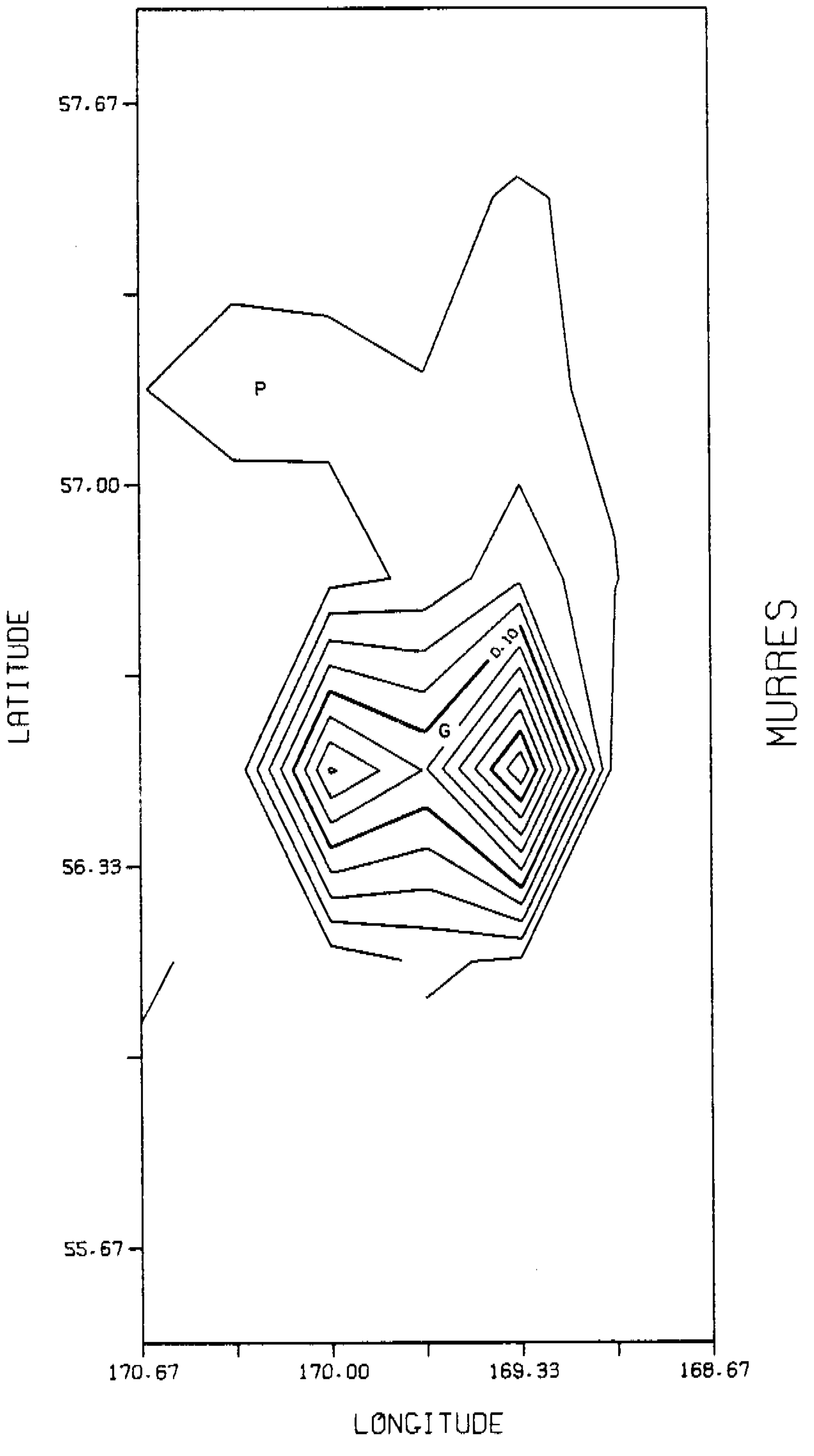

Fig. 9. Plottings of contours of frequency of occurrence of murres in the intensive analysis area of Fig. 7. Contour intervals (0.02) indicate the frequency of occurrence of the group in 20' blocks, as derived from weighted averages of transect censuses.

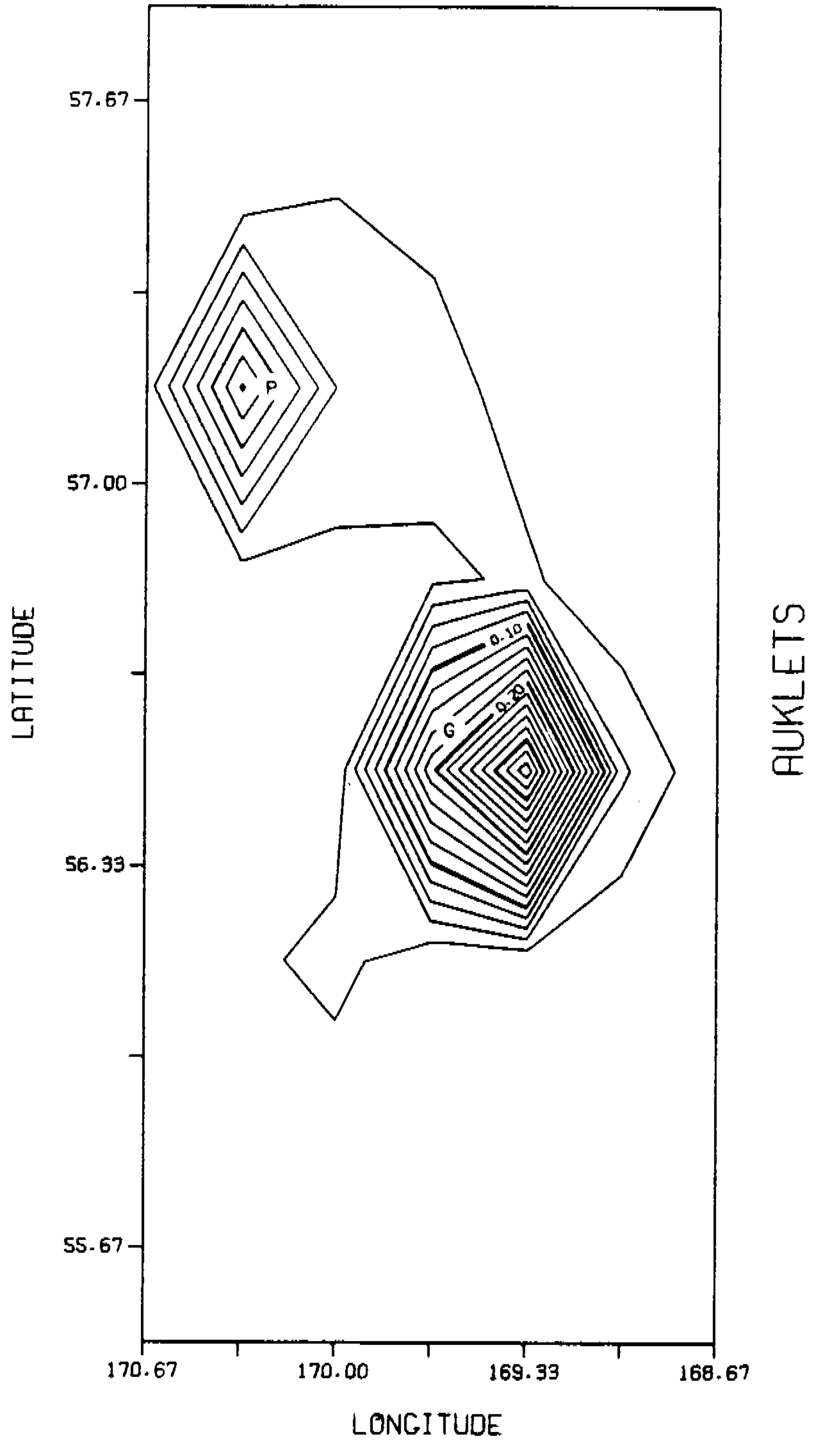

Fig. 10. Plottings of contours of frequency of occurrence of auklets in the intensive analysis area of Fig. 7. Contour interval 0.02; see Fig. 9.

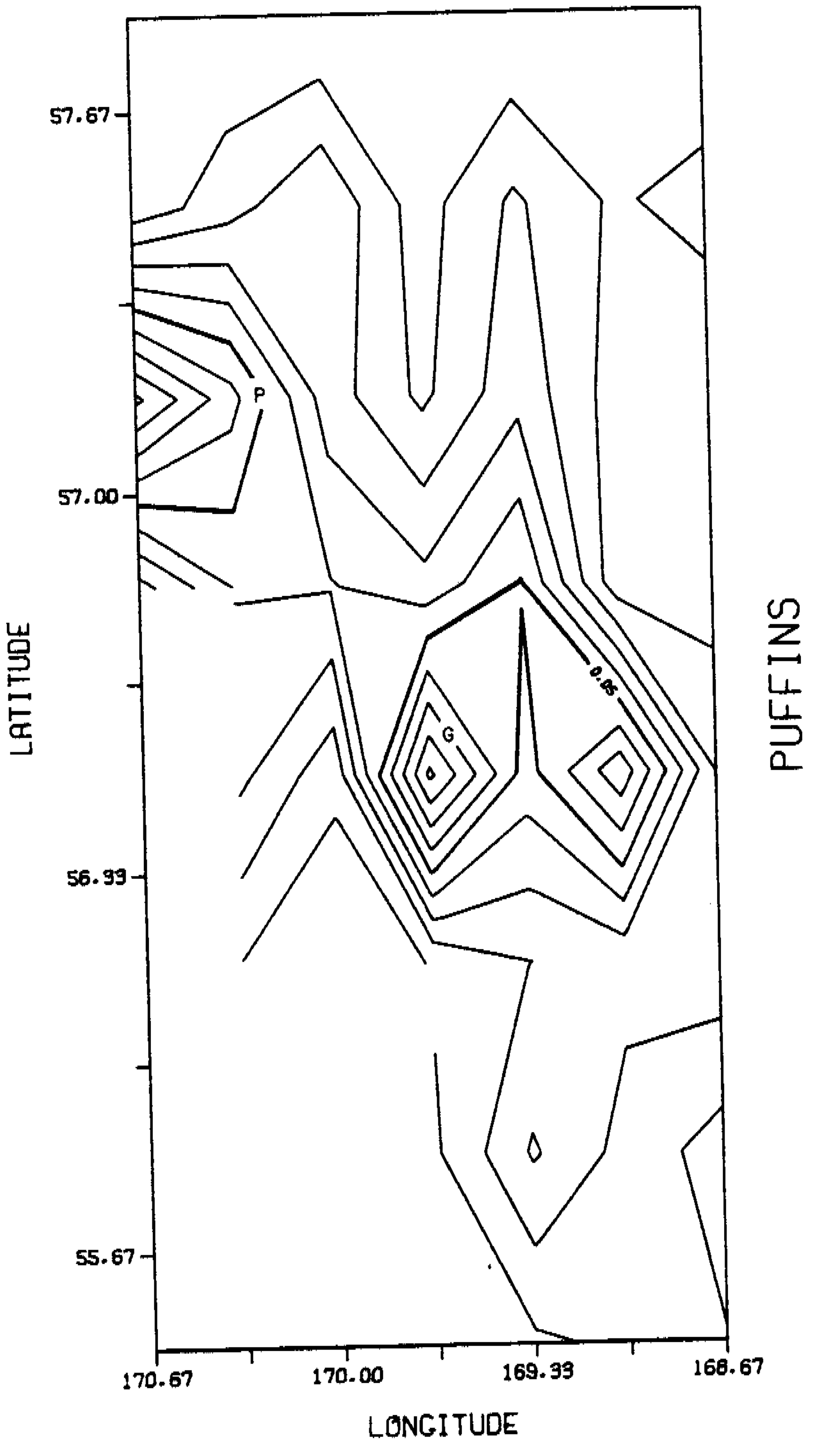

Fig. 11. Plottings of contours of frequency of occurrence of puffins in the intensive analysis area of Fig. 7. Contour interval 0.01; see Fig. 9.

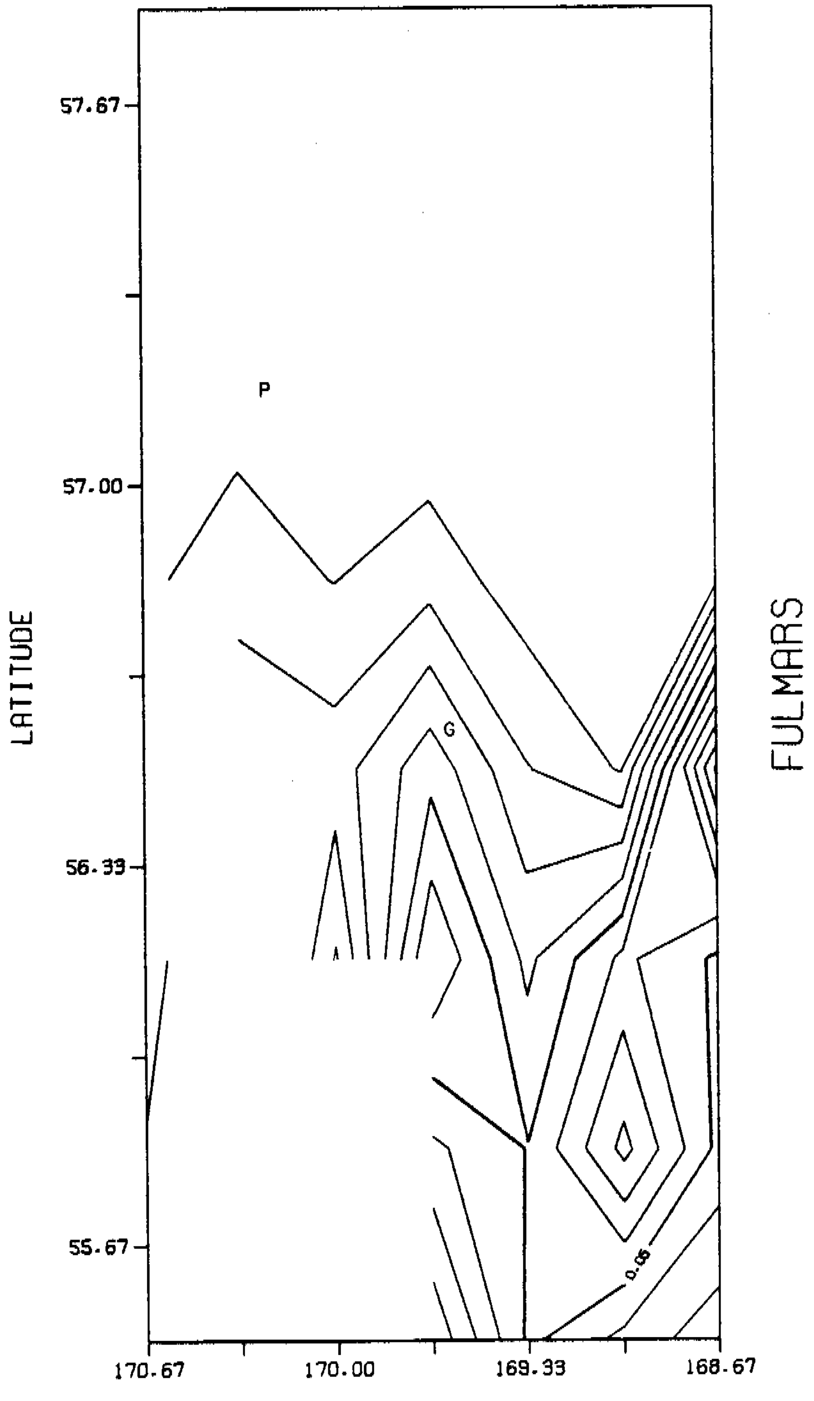

Fig. 12. Plottings of contours of frequency of occurrence of fulmars in the intensive analysis area of Fig. 7. Contour interval 0.01; see Fig. 9.

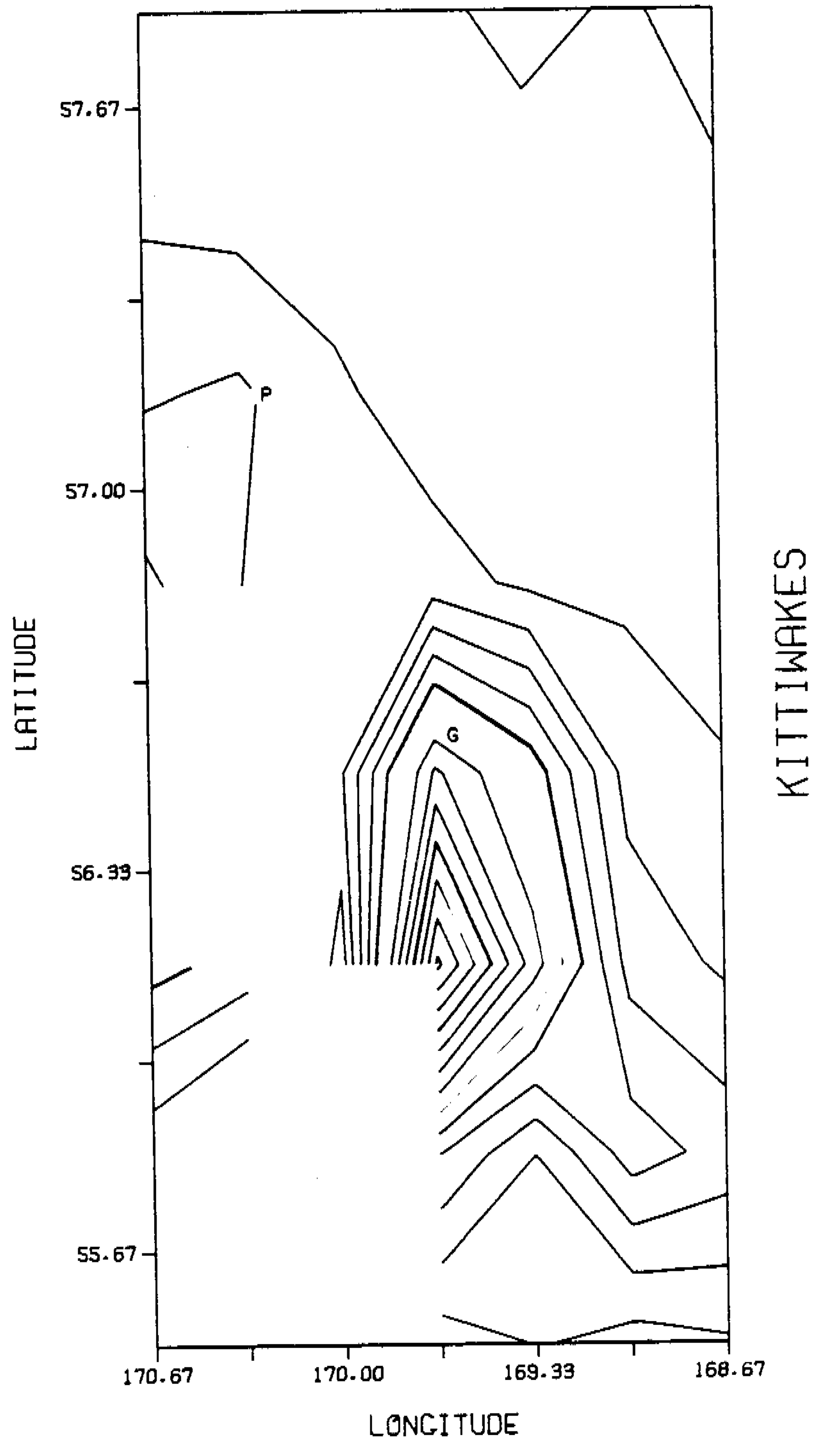

Fig. 13. Plottings of contours of frequency of occurrence of kittiwakes in the intensive analysis area of Fig. 7. Contour interval 0.01; see Fig. 9.

may be prohibited by distance from using the shelf break about St. Paul. The distance from St. Paul to the shelf break is roughly 100 km, while from St. George it is only 26 km.

Storm-petrels, accounting for 0.9% of the total energy flow, were most frequently encountered in censuses in the blocks to the southeast of St. George (Fig. 14), concentrating in waters of 100-1400 m depth along the shelf break. The spatial pattern of shearwater energy flow (6.6% of the aggregate total) is less reliable and clear than that of the other species because of the wide-ranging and erratic nature of large flocks and the fact that, unlike the other species, they do not breed on the islands. Two foci of abundance were apparent in the survey area, one in relatively shallow waters (60-100 m) directly west of St. Paul, the other along the shelf break to the southwest of St. George (Fig. 15). These patterns probably reflect the opportunistic nature of their foraging distribution.

The overall spatial distribution of total "community" energy flow (Fig. 16) not surprisingly parallels the occurrence of murres rather closely. It is apparent from this analysis that the major portion of the energy flow in the Pribilof Islands marine bird system is concentrated in the immediate vicinity of St. George, with a peak consumption rate of over 36,000 kcal km^{-2} day^{-1}.

V. CONCLUSIONS

While the analyses in this report must be regarded as preliminary estimations, they do serve to denote the "ball-park" of energy demands and their spatial distribution in two Alaskan oceanic areas. As the analyses are based upon transect censuses, they are subject to the various limitations that characterize the census techniques (Wiens et al 1978). In particular, the "communities" we have referred to are only partial characterizations of the total aggregate of bird populations present in these areas, although the major components are undoubtedly included. Further, the analysis implicitly assumed that the actual consumption of energy in a census block is a direct function of the bird densities recorded there; that is, we must assume that the birds are actually satisfying their daily energy demands in the same area in which they were recorded during censusing. This assumption is most likely to be violated in close proximity to islands, where a greater frequency of individuals flying back and forth between the colony and outlying feeding areas may be recorded. The concentration of energy flow about St. George that we have depicted (Fig. 16) may thus be somewhat overemphasized. In addition, the energy flows that we have calculated are undoubtedly underestimates, as no account has been made of the energy costs associated with foraging flights and rearing young for the breeding species. The next phase of our modeling efforts is designed to provide greater resolution of such spatial patterns of energy dynamics, as well as to include the energetics associated with breeding by the bird populations in the overall energy flow calculations.

We have been able to conduct a rather detailed assessment of the spatial distribution of energy flow in the Pribilofs largely because of the intensity of transect censusing in this area by Hunt and his colleagues. Still, there

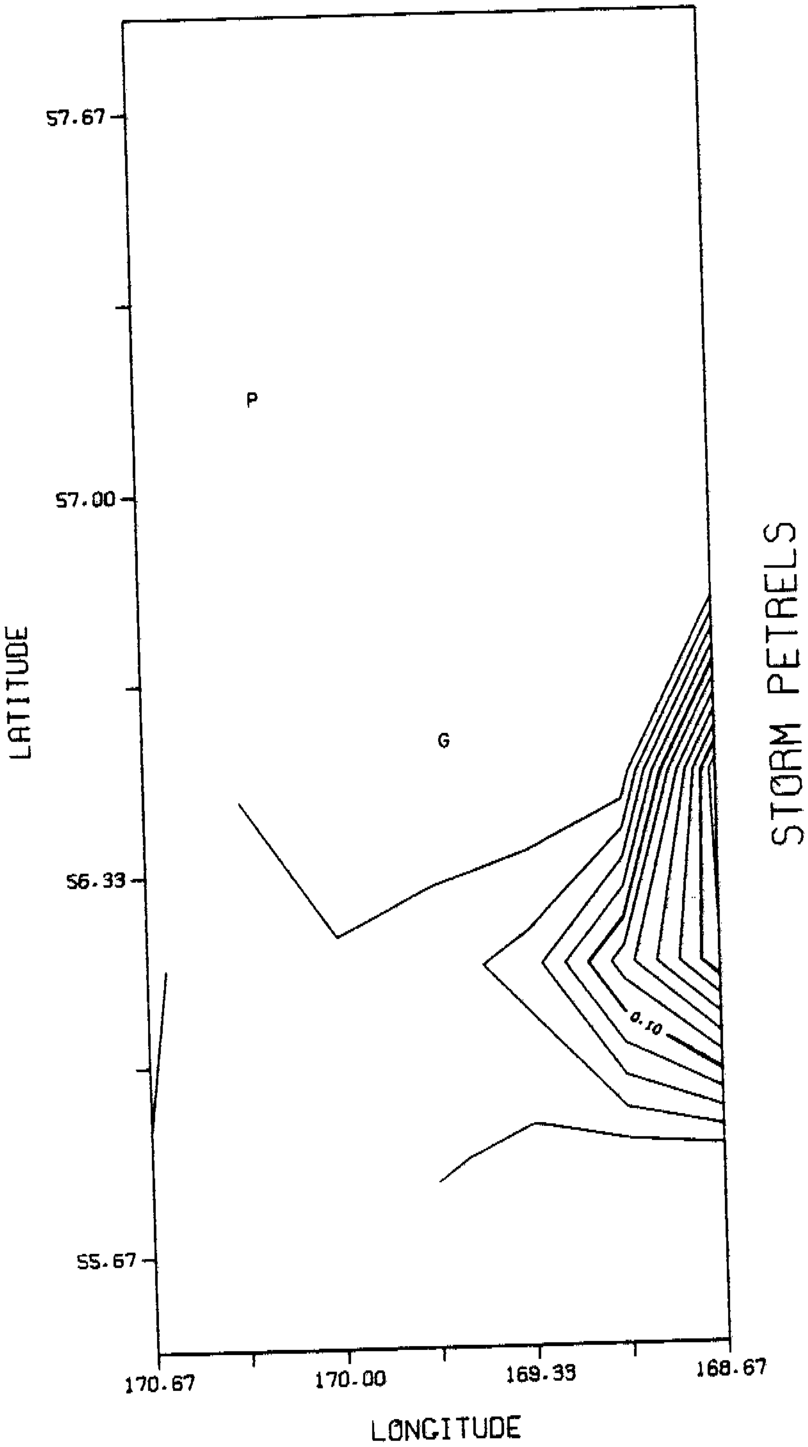

Fig. 14. Plottings of contours of frequency of occurrence of Fork-tailed Storm-Petrels in the intensive analysis area of Fig. 7. Contour interval 0.02; see Fig. 9.

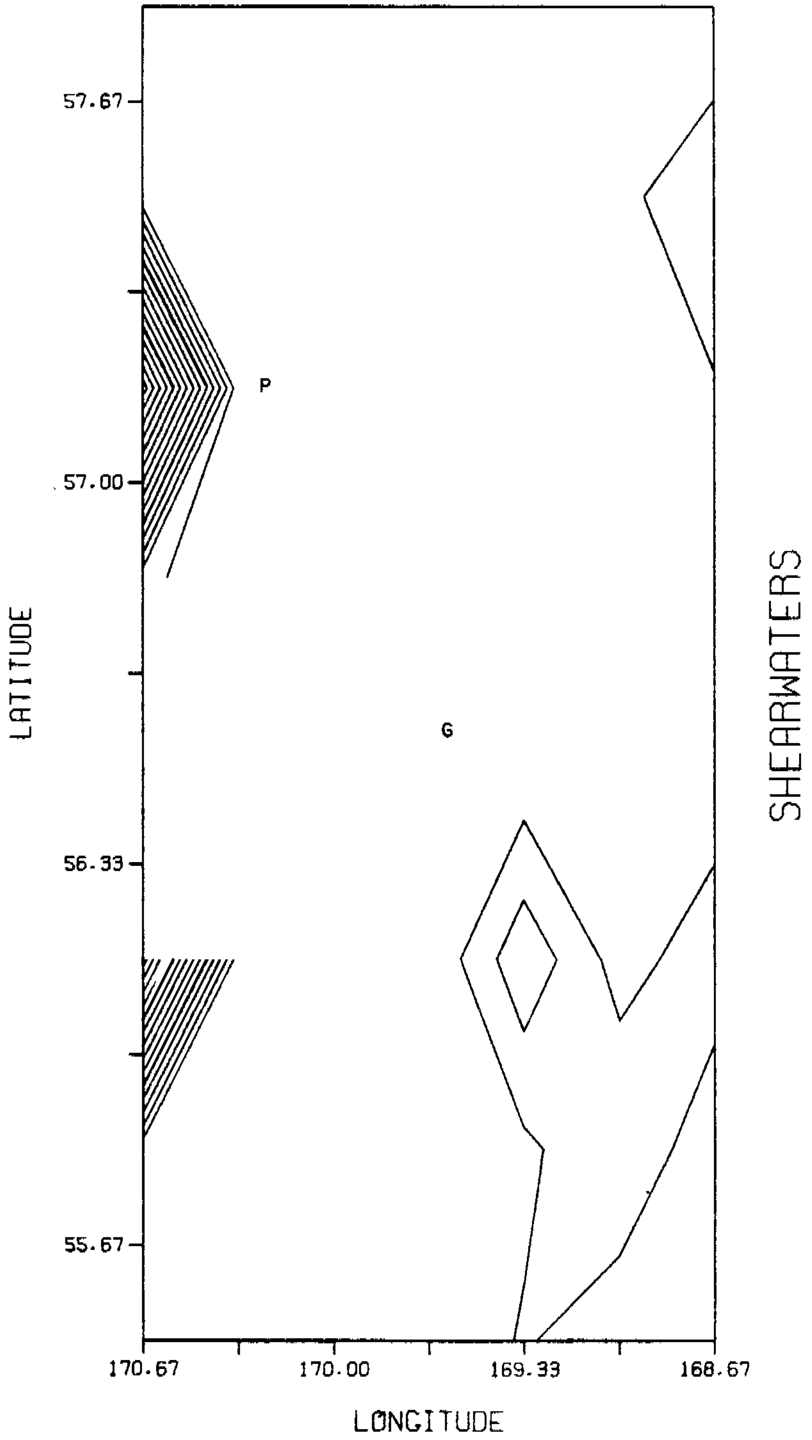

Fig. 15. Plottings of contours of frequency of occurrence of shearwaters in the intensive analysis area of Fig. 7. Contour interval 0.01; see Fig. 9.

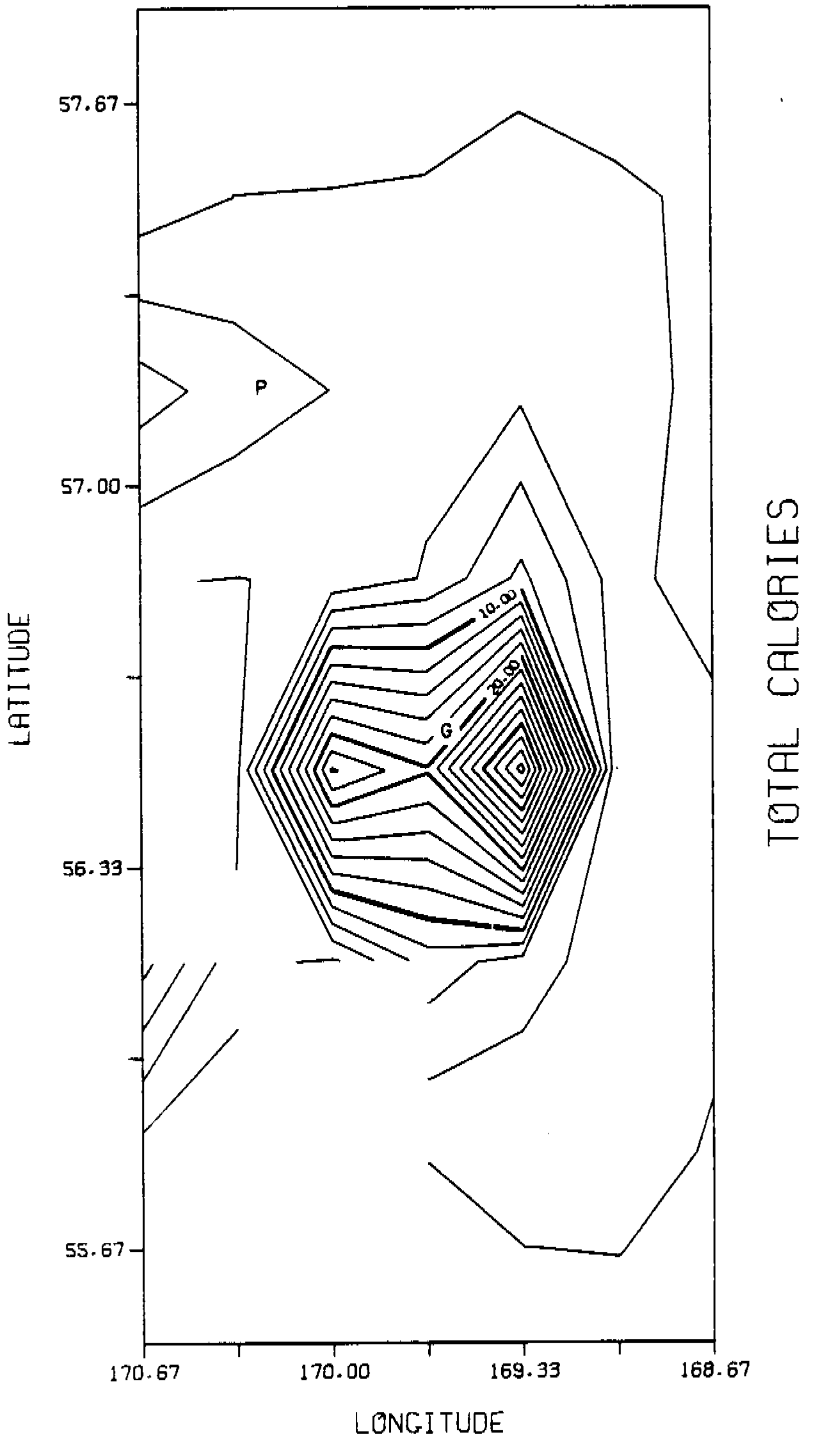

Fig. 16. Plotting of contours of total marine bird "community" energy demand for the intensive analysis area of Fig. 7.

are some important gaps in our resolution of the spatial distributional patterns, caused by inadequate censusing in some blocks, especially to the southwest of St. George (Figs. 3, 7). Steps should be taken to remedy this deficiency in future field studies.

VI. LITERATURE CITED

Hickey, J.J. 1977. A census of seabirds on the Pribilof Islands. Final Report, R.U. No. 38, OCSEAP.

Hunt, G.L., Jr. 1976. The reproductive ecology, foods, and foraging areas of seabirds nesting on St. Paul Island, Pribilof Islands. Annual Report, R.U. No. 83, OCSEAP.

Hunt, G.L., Jr. 1977. Reproductive ecology, foods, and foraging areas of seabirds nesting on the Pribilof Islands. Annual Report, R.U. No. 83, OCSEAP.

Innis, G.S., J.A.Wiens, C.A. Chuculate, & R. Miskimins. 1974. BIRD Model desrciption and documentation. U.S. IBP Grassland Biome Tech. Rept. No. 246.

Innis, G.S., & J.A. Wiens. 1977. BIRD model - version II description and documentation. Utah State Univ. Wildlife Science Dept. Rept. Ser. No. 3.

Kendeigh, S.C., V.R. Dol'nik, & V.M. Gavrilov. 1977. Avian energetics. Pp. 127-204 *in* Pinowski, J., & S.C. Kendeigh (Eds.), Granivorous Birds in Ecosystems. Cambridge, Cambridge Univ. Press.

Wiens, J.A. 1977. Model estimation of energy flow in North American grassland bird communities. Oecologia 31:135-151.

Wiens, J.A., & M.I. Dyer. 1977. Assessing the potential impact of granivorous birds in ecosystems. Pp. 205-266 *in* Pinowski, J., & S.C. Kendeigh (Eds.), Granivorous Birds in Ecosystems. Cambridge, Cambridge Univ. Press.

Wiens, J.A., W. Hoffman, & D. Heinemann. 1977. Community structure, distribution, and interrelationships of marine birds in the Gulf of Alaska. Annual Report, R.U. No. 108, OCSEAP.

Wiens, J.A., D. Heinemann, & W. Hoffman. 1978. Community structure, distribution, and interrelationships of marine birds in the Gulf of Alaska. Final Report, R.U. No. 108, Phase I, OCSEAP.

Wiens, J.A., & G.S. Innis. 1973. Estimation of energy flow in bird communities. II. A simulation model of activity budgets and population bioenergetics. Pp. 739-752 *in* Proc. 1973 Summer Computer Simulation Conference. La Jolla, Calif., Simulation Councils, Inc.

Wiens, J.A., & G.S. Innis. 1974. Estimation of energy flow in bird communities: a population bioenergetics model. Ecology 55: 730-746.

Wiens, J.A., & R.A. Nussbaum. 1975. Model estimation of energy flow in northwestern coniferous forest bird communities. Ecology 56: 547-561.

Wiens, J.A., & J.M. Scott. 1975. Model estimation of energy flow in Oregon coastal seabird populations. Condor 77: 439-452.

APPENDIX I: SCIENTIFIC NAMES OF BIRD SPECIES

Common Name	Scientific Name
Fulmar	*Fulmaris glacialis*
Sooty Shearwater	*Puffinus griseus*
Short-tailed Shearwater	*Puffinus tenuirostris*
Fork-tailed Storm-Petrel	*Oceanodroma furcata*
Glaucous-winged Gull	*Larus glaucescens*
Herring Gull	*Larus argentatus*
Black-legged Kittiwake	*Rissa tridactyla*
Arctic Tern	*Sterna paradisaea*
Common Murre	*Uria aalge*
Thick-billed Murre	*Uria lomvia*
Tufted Puffin	*Lunda cirrhata*
Horned Puffin	*Fratercula corniculata*

Shorebird Dependence on Arctic Littoral Habitats

Annual Report, R. U. 172

April 1, 1978

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Table of Contents

List of Tables

List of Appendices

I. Summary of Objectives, Conclusions and Implications

Shorebirds (sandpipers, plovers, and their relatives) are a major and important component of the Alaskan arctic avifauna. Prior to 1975, shorebird work in the Arctic had concentrated on events on the tundra, where these birds nest, and had largely been confined to the brief breeding period. In this study we have documented seasonal, and occasionally very heavy, use of littoral (shoreline) habitats by shorebirds and other birds in the Arctic.

The ultimate objective of Research Unit #172 is the assessment of the degree and nature of dependence of shorebird species on arctic habitats which are potentially susceptible to perturbation from offshore oil development activities. Within this objective, we are identifying critical habitats, critical trophic processes, and critical areas of the Beaufort and Chukchi coasts, and estimating the relative susceptibilities of each shorebird species to potential disturbances. Quantitative data of four major categories are being gathered to meet these objectives:

1) Seasonal occurrence of birds by species, age and sex in a variety of arctic littoral and near-littoral habitats. This received major effort in 1977, consisting of repeated, intensive transect censuses of many habitats at the three main study sites (Barrow, Wales, Cape Krusenstern), supplemented by further observations at other sites in the Beaufort and Chukchi Seas.

2) Trophic relationships of shorebirds and other species foraging in arctic littoral areas. Increased emphasis on this aspect is required since we have identified major fluctuations in prey resources between seasons, and important differences in the major trophic systems for shorebirds between regions.

3) Description of habitats in littoral and near-littoral areas and determination of foraging habitat preferences by species as these change seasonally.

4) Other factors affecting the dependence of species on littoral areas, including for example, schedules of premigratory fat deposition; variation in phenology and weather patterns between sites and between years; and effects of wind conditions on zooplankton and phalarope distribution.

In general terms, most of the conclusions presented in the previous annual report (Connors and Risebrough 1977) were consistent with the results obtained during 1977 at Barrow and elsewhere in the Beaufort Sea. However, summer coastal ice conditions differed markedly from the previous two seasons at Barrow, producing a very different schedule of available foraging habitats. As a result, large numbers of post-breeding male Red Phalaropes moved to ocean shorelines, utilizing marine zooplankton as a pre-migratory food source. In previous years most males had left Barrow before this habitat opened. 1977-like phenomena greatly increase the potential susceptibility of the adult male cohort, and therefore the breeding population, to oil spills in the Beaufort. Adult Ruddy Turnstones also exhibited a heavy movement to littoral areas prior to migration.

Juvenile Red Phalaropes, and several other species of shorebirds, gulls, and terns again foraged in high densities along the shores of Barrow Spit, although the exact timing and magnitude of these population movements differed between years. These species were dependent on zooplankton along the shallow gravel shores, and the extremely high variation in species composition and density of this planktonic community, identified in 1975 and 1976, was again illustrated by our zooplankton studies in 1977. However, despite the marked difference in ice conditions between 1977 and the prior years, in some respects (Red Phalarope foraging response to wind direction, and foraging vs. roosting time budgets), 1977 can be considered intermediate between the strikingly different earlier years.

With three seasons of data, we are able to refine our estimates of the relative susceptibilities of common Barrow shorebirds to potential littoral zone disturbances associated with OCS oil development; a revised list is presented in Table 16.

During 1977 we initiated studies at two sites along the southern Chukchi coast at Wales and Cape Krusenstern. Although these sites do not border any imminent lease area, their study has relevance to potential impacts associated with development of the Beaufort Sea lease area for two main reasons. All birds using Beaufort coastal habitats are migratory, and many of them pass along the Chukchi coast; strategies of resource utilization, timing of migration, and energetics of migratory processes can be best understood by considering both coasts as a single system. Of more direct application, the development of Beaufort coast oilfields carries an attendant risk to habitats along the Chukchi coast, arising from the potential for accidents associated with the marine transport of materials to and from the oilfields.

Contrasts of habitat use and phenology between Wales and Cape Krusenstern and stations farther north are striking. Although many features of shorebird distribution and timing differ as expected, two contrasts stand out. First, species assigned low relative susceptibility ratings at Barrow (Pectoral Sandpiper, Golden Plover) because of low use of littoral habitats there, must be assigned higher ratings along the coast of the southern Chukchi, where they forage extensively on mudflats and saltmarsh margins during migration. Second, whereas marine zooplankton is the focus of shoreline feeding activity by shorebirds, gulls, and terns near Barrow and at other Beaufort sites in late summer, in Kotzebue Sound and northern Seward Peninsula shoreline zooplankton foraging by these species is minor during the same period. Instead, very high concentrations of shorebirds forage on benthic invertebrates on the more extensive tidal mudflats and saltmarsh areas of these regions. We estimate that 225,000 shorebirds were present on the beach, saltmarsh, and mudflats of the lagoon barrier strip along the north shore of Seward Peninsula in mid-August. This marked difference between areas implies corresponding differences in the expected sensitivity of bird populations to environmental disturbances. Studies of the critical elements and the flexibility within these two main trophic systems are now required.

Population density and habitat use information for individual species are presented in Parts VI and VII (Results and Discussion). In general, four periods of littoral zone use, overlapping to some extent, can be recognized.

1) In early June near Barrow, small numbers of pre-breeding or breeding adults of several shorebird species forage along beaches, around saline pools, and on mudflats near sloughs. In Kotzebue Sound, with more littoral habitat open early in the season, use of these areas is considerably heavier.

2) From late June through early July, a movement of non-breeding and post-breeding adults of several species occurs, with flocks and individuals utilizing habitats at the edges of small coastal lagoons and nearby brackish pools and on tidal mudflats.

3) In mid-July through early August, adults of both sexes of most species are released from nesting duties as young birds fledge and become self-sufficient. These flocking adults, beginning their southward migration, move into littoral areas.

4) The phase of heaviest use of littoral areas occurs during all of August, stretching into September for some species. Juveniles leave the tundra areas where they have fed before fledging and flock in littoral habitats; in many species they begin their southward movements independently of, and later than, the adults.

The post-breeding movements of adults and juveniles to the littoral zone precede migration; this phase in the annual activity cycle represents an important and possibly critical period of energy storage to meet the demands of migration. For inexperienced and presumably less efficient juveniles especially, a high level of energy reserve in the form of deposited fat may be a critical factor in determining survival during migration. Our samples of Red Phalarope juveniles foraging near Barrow during August and September indicate a significant increase in fat level during this period. Rates of fat deposition in juvenile shorebirds differed considerably between species, indicating different use of available food resources, and different strategies of energy storage. These strategies, and the flexibility of species with respect to normal variation in resource conditions, will affect the potential impact of different environmental disturbances.

In spite of year-to-year variation in timing and magnitude of movements of particular shorebird species and of differences in trophic conditions, the conclusion that the Barrow Spit area is heavily used by many shorebirds, gulls, and terns in late summer is supported by the data from each season of this study. Other areas identified as sustaining very high use by several species in late summer include but are not limited to the Plover Islands, the muddy sloughs near Lonely, saltmarsh flats near Icy Cape and Oliktok, and the spit and islands around Peard Bay. Farther south in the Chukchi, principal sites of shorebird littoral zone activity are around Kotzebue Sound, especially in river delta areas, and along the northern shore of Seward Peninsula; coverage in these areas is scant, however.

The implications for OCS oil development from some of these results are clear. Leasing and development should be planned to minimize the threat to the most heavily used and most sensitive areas and habitats, and to avoid disturbances during periods of highest potential impact on bird populations.

Obviously, the effect of any oil spill could be quite serious, depending upon timing as well as magnitude of the spill and upon the dispersal behavior of oil under varying conditions of ice coverage. During open-water periods of August and September, oil carried to nearshore areas would probably cause extremely high mortality to juvenile Red and Northern Phalaropes and other swimming birds, including gulls, waterfowl, and alcids. Immediate effects might be almost as severe on other species of shorebirds feeding in affected habitats. Any drastic reduction in prey densities of plankton or infaunal invertebrates in areas where these shorebirds feed might reduce the foraging efficiency and survival of all these species. However, the flexibility of different species with respect to food conditions or location of staging areas is difficult to evaluate and is critical to predicting impacts.

Finally, many other kinds of oil development habitat disturbances in shoreline or nearshore tundra areas may affect the breeding success or survival of bird species using these habitats. To date, efforts in RU #172 have focused on evaluating the dependence of birds on all habitats which may be affected. In 1978 we will begin comparative studies of bird use of habitats which have already been subjected to a variety of disturbances near Prudhoe Bay, as the next step in predicting potential outcomes of oil development on arctic bird populations.

II. Introduction

Shorebirds (Charadriiformes: Charadrii; Sandpipers, plovers and their close relatives) constitute a major and prominent segment of the avifauna of the Beaufort and Chukchi coasts of arctic Alaska (Bailey 1948; Gabrielson and Lincoln 1959; Pitelka 1974: Table 1). All of these 27 species, which occur regularly in the Arctic during summer months, spend their winters in temperate and tropical regions of both northern and southern hemispheres. As a group, they are an international resource, with individual species dependent in varying degrees on summer conditions along the Alaskan arctic coast.

Prior to 1975, considerable effort had been expended on studies of the ecology of tundra nesting shorebirds near Barrow, Alaska (see

Table 1. Shorebird species occurring regularly along the Beaufort and Chukchi coasts of Alaska (from Connors *et al.* 1978).

Regular Breeders

Semipalmated Plover, *Charadrius semipalmatus*
American Golden Plover, *Pluvialis dominica*
Black-bellied Plover, *Pluvialis squatarola*
Ruddy Turnstone, *Arenaria interpres*
Black Turnstone, *Arenaria melanocephala*
Common Snipe, *Capella gallinago*
Whimbrel, *Numenius phaeopus*
Red Knot, *Calidris canutus*
Pectoral Sandpiper, *Calidris melanotos*
White-rumped Sandpiper, *Calidris fuscicollis*
Baird's Sandpiper, *Calidris bairdii*
Dunlin, *Calidris alpina*
Semipalmated Sandpiper, *Calidris pusilla*
Western Sandpiper, *Calidris mauri*
Stilt Sandpiper, *Micropalama himantopus*
Buff-breasted Sandpiper, *Tryngites subruficollis*
Long-billed Dowitcher, *Limnodromus scolopaceus*
Bar-tailed Godwit, *Limosa lapponica*
Red Phalarope, *Phalaropus fulicarius*
Northern Phalarope, *Lobipes lobatus*

Additional Migrants

Killdeer, *Charadrius vociferus*
Sharp-tailed Sandpiper, *Calidris acuminata*
Least Sandpiper, *Calidris minutilla*
Rufous-necked Sandpiper, *Calidris ruficollis*
Curlew Sandpiper, *Calidris ferruginea*
Sanderling; *Calidris alba*
Hudsonian Godwit, *Limosa haemastica*

Connors and Risebrough 1977 for references). These studies dealt almost exclusively with conditions on the upland tundra, primarily during the short arctic breeding season. It had been noted, at Barrow and elsewhere in the Arctic, that densities of several species of shorebirds increase near the shoreline as the summer progresses, resulting in a net increase in use of littoral habitats (Holmes 1966; Bengtson 1970). This movement begins with non-breeders and is augmented progressively by a shoreward movement of local and also inland birds, especially after the young have fledged. However, the importance of this habitat shift in the breeding cycle of arctic shorebirds had not been adequately evaluated.

This study is attempting to provide the detailed and quantitative information necessary to assess the dependence of shorebirds and other species on littoral habitats along the Alaskan arctic coast. We wish to determine the relative susceptibilities of different species to potential impacts of oil development, and to identify sensitive species, habitats, areas, and periods to aid in OCSEAP development decisions. We are addressing several aspects of shorebird ecology essential to evaluating the significance of the littoral zone for shorebirds, gulls, and terns: seasonal occurrence of these birds by species, age, and sex, in different habitats; trophic relationships of shorebirds and other birds feeding in littoral habitats, and variability and foraging habitat preferences; and behavioral patterns and other aspects of littoral zone use by shorebirds, gulls, and terns.

The relevance of this investigation to problems of OCSEAP petroleum development is clear. To the extent that shorebirds and other birds utilize and depend upon shore and nearshore habitats, any perturbation of these habitats can affect them. Use of littoral habitats in the Arctic appears to be heaviest by juveniles moving from inland nesting areas to the coast in late summer, prior to their long-distance migrations. Since post-fledging mortality of juveniles is a significant factor in determining reproductive success, alteration of required habitat conditions for these birds could affect population levels over wide areas.

III. Current State of Knowledge

Available background information prior to RU #172 is referred to in the introductory paragraphs. The principal conclusions derived from our first two seasons of field work are discussed in sections I (Summary), VII (Discussion), and VIII (Conclusions). Briefly: we now have a good understanding of many shorebird habitat use patterns, seasonal movements, distributions, and relative susceptibilities near Barrow and in the western Beaufort and northern Chukchi; and tentative information on the same topics in the southern Chukchi. Our appreciation of trophic relationships in both areas is modest but improving.

IV. Study Area

Field activities were conducted in three primary sites during 1977: (1) Barrow (71°17'N, 156°46'W), 15 July - 17 September; (2) Wales (65°38'N, 168°08'W), 2 June - 14 September; (3) Cape Krusenstern (67°8'N, 163°43'W), 26 May - 8 September. At each site a variety of littoral and nearshore tundra habitats were studied intensively. Supplementary study areas, at Oliktok (70°30'N, 149°51'W), Prudhoe Bay (70°12'N, 148°22'W), Peard Bay (70°49'N, 158°25'W), Icy Cape (70°18'N, 161°52'W), Sesualik (66°59'N, 162°48'W), and four sites along the north shore of Seward Peninsula were visited from 1 to 3 times between 15 July and 8 September.

V. Methods

For reasons discussed in the first annual report (Connors and Risebrough 1976), the arctic littoral zone is considered to extend from lowest tide level up to the limits of the regions likely to be inundated by storms at least once every few years. Within this study, data were collected throughout this zone, on the tundra above this zone, and on the nearshore water areas beyond this zone. The discussion of methods will be divided into several sections corresponding to the principal classes of data gathered:

A. Shorebird seasonal habitat use. As described in Connors and Risebrough (1976 and 1977), primary effort was focused on a permanent transect method. At the three primary sites, transects were marked at 50 m intervals in littoral and in tundra areas. A listing of names and locations of transects is given in Tables 2, 3, and 4 and Figures 2, 3, and 4. Upland transects are necessary for comparison with littoral transects to assess seasonal changes in habitat use by birds. At Barrow, transect census data for tundra habitats have been provided by J. P. Myers and F. A. Pitelka, from a continuing study of tundra habitat use by birds, sponsored by the U.S. Department of Energy.

In narrow shoreline habitat areas, as along outer beach shores, stakes defined a single row of square census plots 50 m on each side. In areas of more extensive, continuous habitat, such as mudflats or upland tundra, the stakes defined a double parallel row of 50 m plots. At all sites, transect locations were selected to include the full range of available littoral habitats. Lengths of transects within single habitats ranged from .3 km to 2.9 km; almost all transects, however, were either .5 km or 1.0 km. All transect parameters for each site are listed in Tables 2, 3, and 4.

Transects were censused at least once every five days throughout the entire field season at each main study site. All birds within each census plot were recorded, as well as any birds within 200 m on the water side of shoreline transects. Transects were censused continuously between these dates: at Cape Krusenstern, 5 June 1977 through 7 September 1977; at Wales, 5 June 1977 through 12 September 1977; and at Barrow, littoral transects 19 July 1977 through

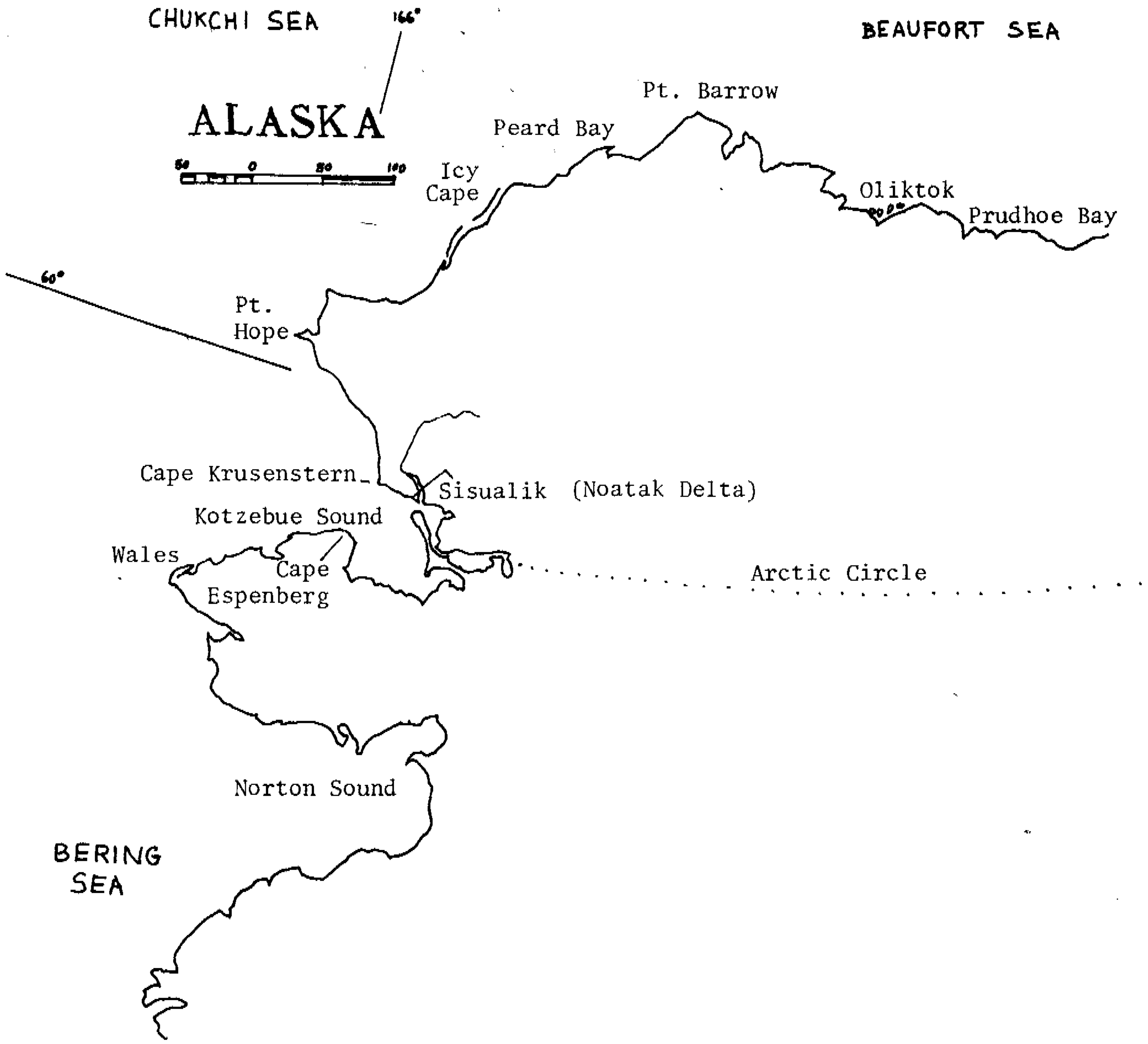


Figure 1. Map of Northern Alaska.

Table 2 Locality codes for transects and sampling stations. Wales, Alaska. (See Figure 2.)

Code	Transect or station name	(Tundra or littoral)	Transect length (m)	Transect width (m)
WB1	Sea Beach 1	L	1000	50
WB2	Sea Beach 2	L	1000	50
WB3	Sea Beach 3	L	1000	50
WB4	Sea Beach 4	L	1000	50
WB5	Sea Beach 5	L	1000	50
WB6	Sea Beach 6	L	1000	50
WBB	Breeding Bird Plot	T	1000	100
WBD	Beach Ditch	L	500	50
WBT	N. Beach Tundra	T	1000	100
WEL	S.E. Lagoon 2	L	1000	50
WHL	Hill Transect	T	1000	100
WML	W. Lagoon 3	L	1000	50
WNL	W. Lagoon 4	L	1000	50
WNM	N. Red Mud	L	300	50
WRW	Runway	T	1000	100
WSL	S.E. Lagoon 1	L	1000	50
WSM	S. Red Mud	L	300	50
WSS	S. Beach Tundra	T	1000	100
WSW	Swan	T	1000	100
WVS	Village Stream	L	300	50
WWL	West Lagoon 1	L	1000	50
	Not included in map-transects located 2 km north of B6 transect			
WBS	Sin-l-rock Sea	L	1000	50
WRL	Sin-l-rock Lagoon	L	1000	50
WRM	Sin-l-rock Mud	L	300	50

Total areas: Tundra: 60 hectares

Littoral: 73.5 hectares

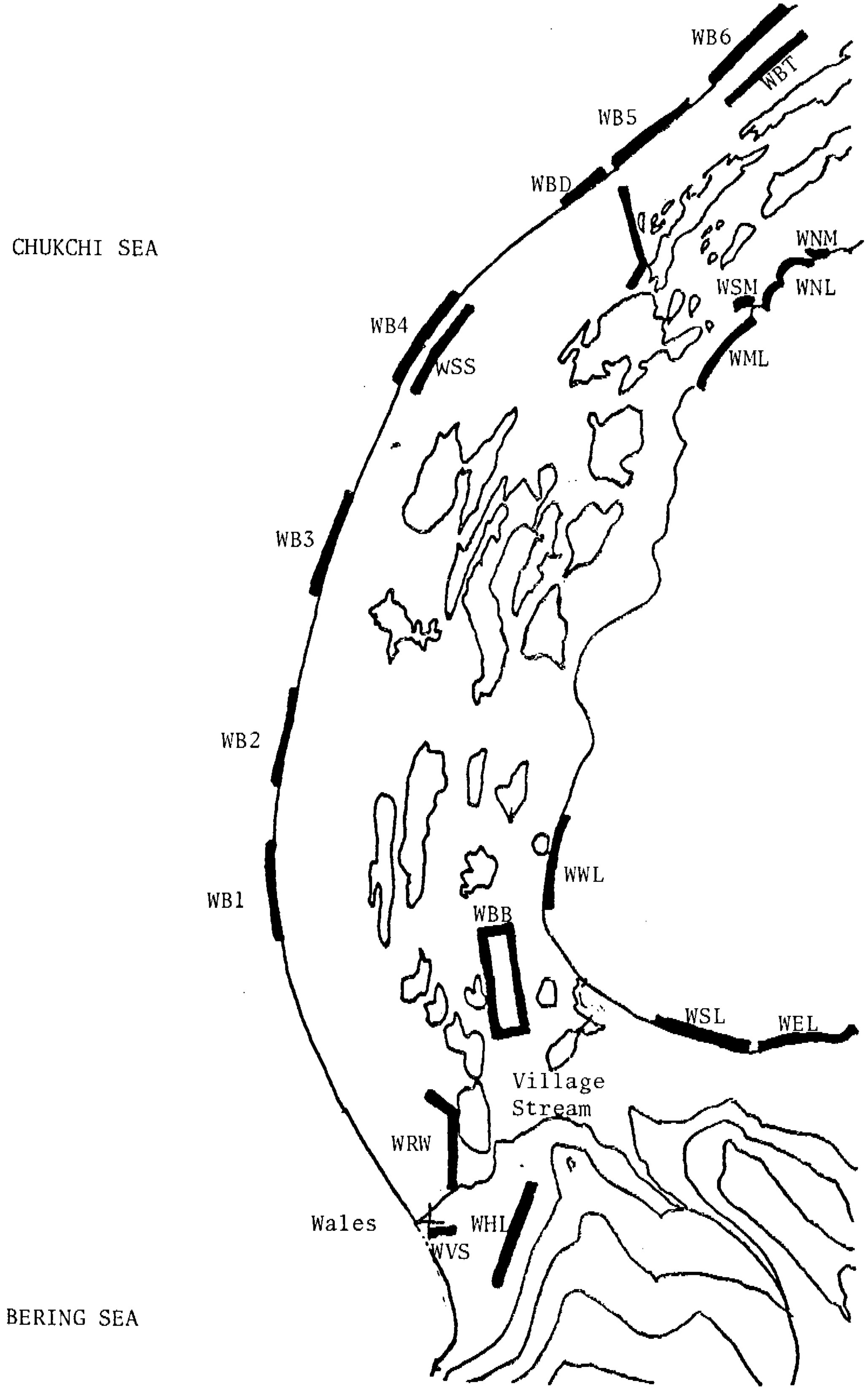


Figure 2. Locations of transects and sampling stations, Wales, Alaska.

Table 3 Locality codes for transects and sampling stations, Cape Krusenstern, Alaska. (See Figure 3.)

Code	Transect or station name	(Tundra or littoral)	Transect length (m)	Transect width (m)
KBW	Baby Walrus	L	1000	50
KCB	Cliff Beach	L	1000	50
KED	Evelukpalik Delta	L	500	100
KG1	Grid one	T	850	100
KG2	Grid two	T	850	100
KG3	Grid three	T	850	100
KGC	Gull Colony	L	500	100
KLF	Lagoon Flood	L	1000	50
KLL	Lagoon Lake	L	1000	50
KLR	Lake Ridge	T	1000	100
KMS	Moon Snail	L	500	50
KNB	North Beach	L	1000	50
KNF	North Flats	L	500	100
KNL	North Lagoon	L	1000	50
KSB	Shell Beach	L	1000	50
KSL	South Lagoon	L	1000	50
KWB	Whimbrel Beach	L	1000	50
KWS	Whistling Swan	T	1000	100
	Not included in map: Transects located 4 km north of CB transect.			
KB1	Shelter Cabin Beach (SCB)	L	1000	50
KS1	Shelter Cabin Slough (SCS)	L	500	50

Total areas: Tundra: 45.4 hectares

Littoral: 70.0 hectares

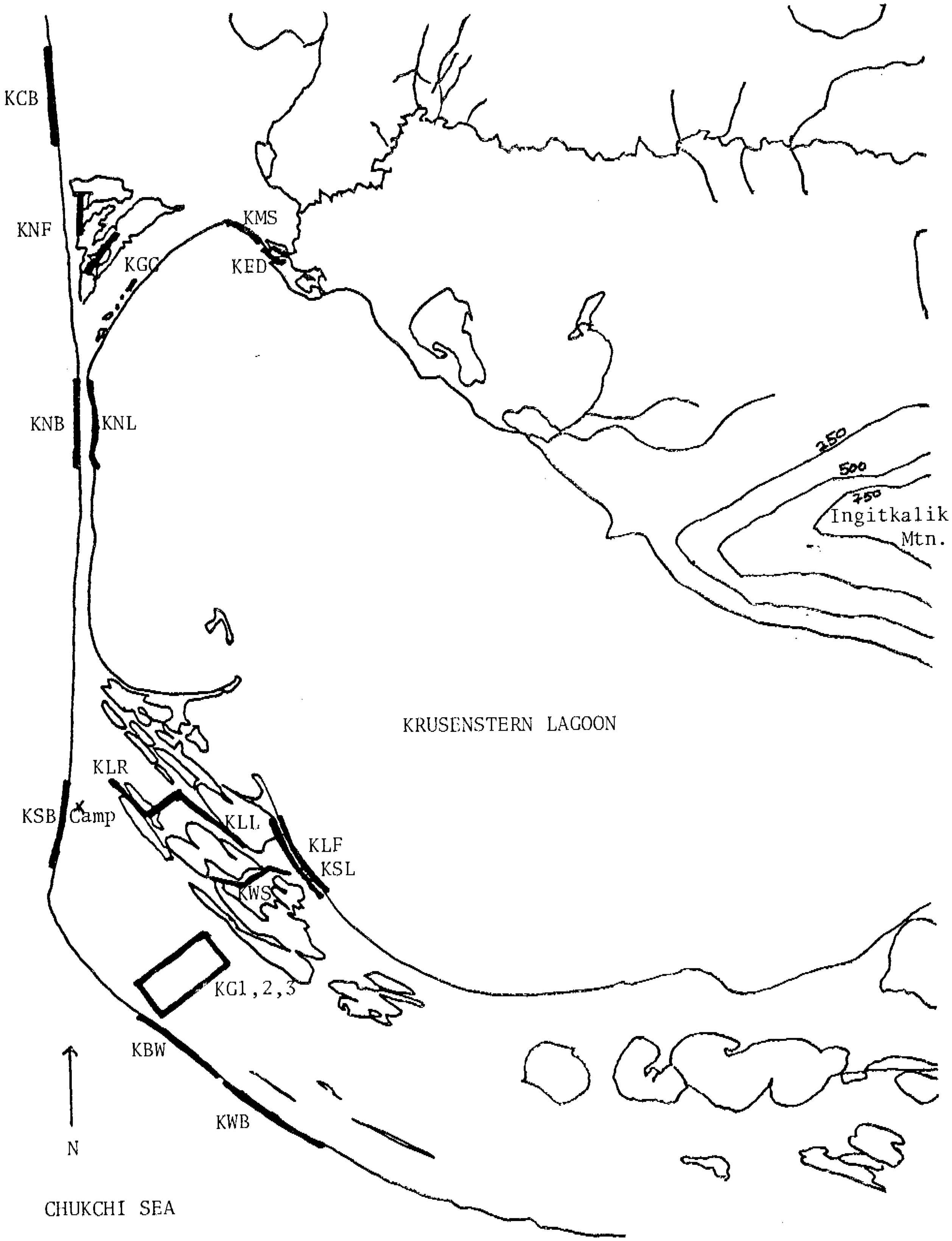


Figure 3. Locations of transects and sampling stations, Cape Krusenstern, Alaska.

Table 4 Locality codes for transects and sampling stations. Barrow, Alaska. (See Figure 4.)

Code	Transect or station name	Transect length (m)	Transect width (m)
BAP	Airport	1000	50
BBD	Barrow Dump	2900	50
BBP	Britton Ponds	300	100
BBS	Barrow Spit	1000	50
BSS	Beaufort Sea Station		
BCB	Cemetery Beach	1000	50
BCN	Chukchi Sea North	1000	50
BCS	Chukchi Sea South	1000	50
BDM	Deadman	1000	50
BGF	Graveyard Flat	500	100
BME	Middle Salt East	500	50
BMW	Middle Salt West	500	50
BNB	Nunavak Bay	1000	50
BNS-1	North Salt Lagoon-1	500	100
BNS-2	North Salt Lagoon-2	500	50
BNT	Nuwuk Tundra	500	100
BPP	Plover Point	1000	50
BPS	Plover Spit	1000	50
BRW	Rotten Walrus	1000	50
BT-1 through BT-10	Tundra Transects 1-10	1000 each	100
BTW	Top-of-the-World	1000	50
BVC	Voth Creek	500	100
BWB	Whalebone Bight		
BWS	Whalebone Spit	1000	50

Total areas: Littoral transects: 105 hectares

Tundra transects of Myers and Pitelka: 100 hectares

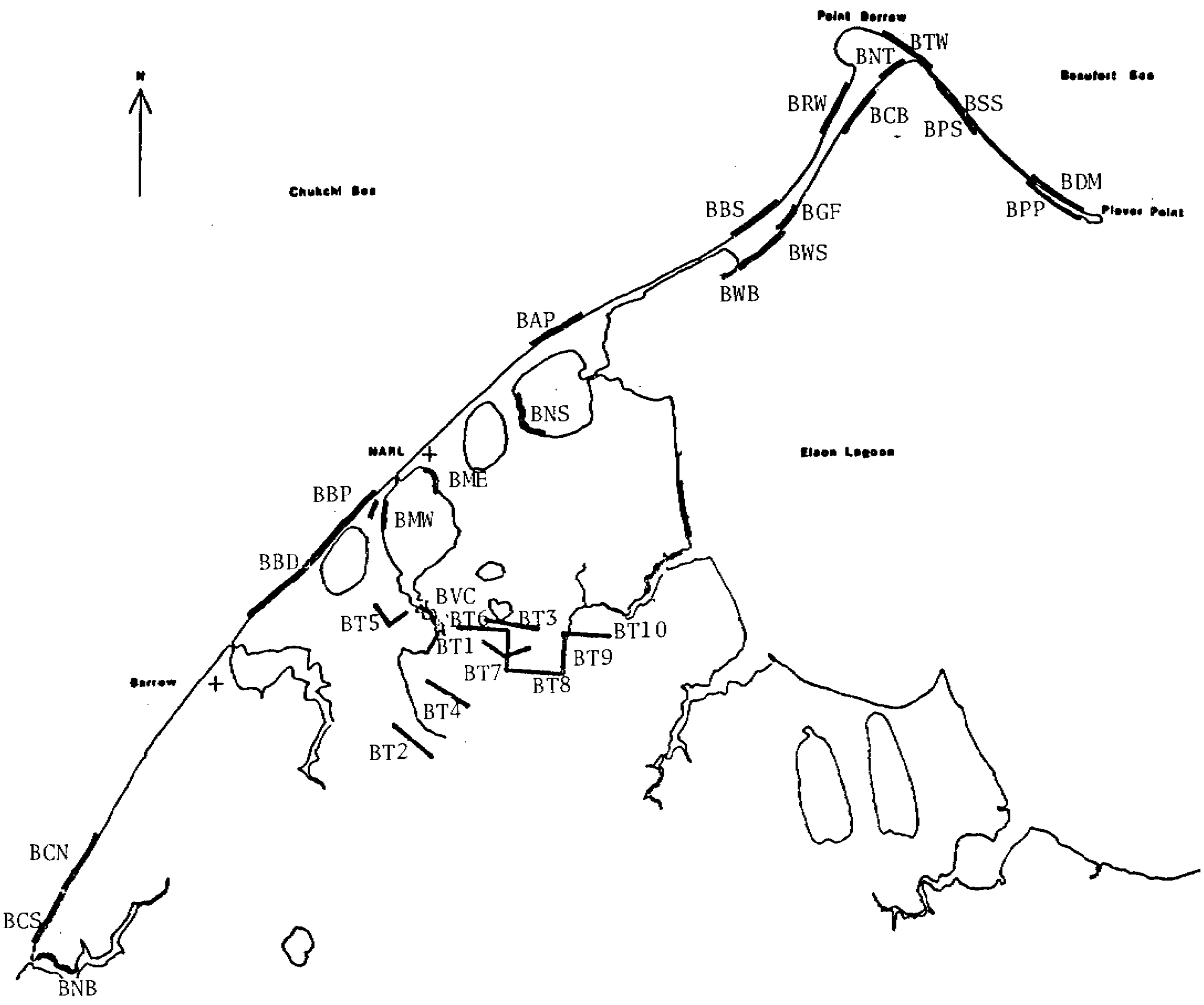


Figure 4. Locations of transects and sampling stations.

17 September 1977; Barrow, tundra transects censused by J. P. Myers et al. were censused continuously beginning in late May 1977.

The method of permanent transects regularly censused provides data which are easily analyzed to record seasonal changes in population density, as illustrated in Part VI (Results). To obtain more extensive coverage of littoral areas near the primary study sites and at other sites along the arctic coast and to increase the prospect of observing very transitory or localized phenomena, the transect method was supplemented with censuses recorded as numbers of species in a known or estimated length of shoreline or area of suitable habitat. This approach provides flexibility in treating all observations, and results can be used to explain and complement the transect results.

At three of the supplementary sites (Oliktok, Peard Bay, Icy Cape) shoreline transects of lengths from 1 to 11 km and approximate widths of 50 or 100 m were chosen, to be censused during three periods in late summer at two-week intervals. These transects were not marked at regular intervals, but were usually delineated by natural habitat boundaries, and were censused similarly on each visit, obtaining comparable bird density data. At other locations away from the main study sites, usually observed on only one occasion, unmarked transects were chosen in areas of representative littoral habitats, and these were censused comparably.

B. Tundra breeding bird surveys. For purposes of comparison of breeding bird communities between sites and measurement of seasonal habitat shifts in bird activities at each site, breeding bird surveys were obtained at Wales and Cape Krusenstern. (Breeding bird communities are well known at Barrow (Myers and Pitelka 1975 a, b; Myers et al. 1977 a, b)). Rectangular gridded study areas, overlapping the established tundra transects, were censused every five days; we attempted to locate all nests on the grids. Grid sizes were 29.8 ha at Cape Krusenstern and 25 ha at Wales.

C. Habitat descriptions. For all marked transects at the three primary study sites, we characterized littoral habitats, by plot, according to this outline:

A. Major landform
    1. Barrier Island, protected shore
    2. Barrier Island, exposed shore
    3. Spit, protected shore
    4. Spit, exposed shore
    5. Protected tundra shore
    6. Exposed tundra shore
    7. River inlet
    8. Closed lagoon
    9. Tidal slough

B. Habitat form
    1. Beach backed by gradual slope
    2. Beach backed by cliff-bank

3. Beach backed by sand dunes
4. Littoral flat (mudflat/saltmarsh/gravel flat)
5. Salt-burned tundra (rarely flooded)
6. Eroding tundra bank

C. Distance from shore: distance from center of 50 m plot to nearest major shoreline (ocean, lagoon, river)

D. Width of normal flood zone. From mean water level to highest level inundated during most years. Determined by recent driftwood lines and by vegetation.

E. Width of maximum flood zone. Determined by highest driftwood line.

F. Water cover. Per cent of the 50 m plot covered by water. Omitted for beach transects.

G. Salinity.

H. Exposed substrate. Classify by major type, as mud, fine sand, coarse sand, fine gravel, coarse gravel.

I. Vegetative cover. Per cent of exposed area.

J. Major plant taxa. List one to several taxa in order of abundance (area covered), to account for at least 80% of vegetative cover.

E. Trophic studies. At Barrow, Wales, and Cape Krusenstern, we collected shorebirds for stomach analysis and fat level information to complement our previous studies. Collection methods (by shotgun followed by immediate injection of formalin fixative solution in the field) were described in Connors and Risebrough (1976).

Plankton net samples were collected at several locations at each of the three main study sites in July, August and September, at 10-day intervals when shoreline conditions permitted. The surface net, towed parallel to shore in very shallow water to sample the phalarope foraging zone, was described in Connors and Risebrough (1977). Sampling procedures and subsequent sample analysis were also as described previously.

VI and VII. Results and Discussion

Appendix 1 provides avifaunal lists for 1977 for Wales and Cape Krusenstern. A detailed avifaunal list for Barrow has recently been published (Pitelka 1974); therefore one is not included here.

Comparative Phenologies

Phenologies for Wales and Cape Krusenstern are presented in

Appendices 2 and 3, and are compared with that of Barrow in Table 5. All three sites had temperatures average to above average and rainfall well below average during summer 1977. At Barrow, sea ice conditions were much less severe than in 1975 and 1976. Ice first moved away from shore in early July, providing shoreline foraging for phalaropes considerably earlier than in previous seasons. Snow melt and plant phenology at Cape Krusenstern preceded that of Wales and Barrow by 2 to 3 weeks, but differences in timing of bird events averaged about 6 to 10 days between Cape Krusenstern and the other two sites. Comparison of Cape Krusenstern 1977 phenology with 1976 data for Cape Espenberg (Mickelson et al. 1977), two locations which might be expected to compare closely within a season (Figure 1), suggests that in 1977 flowering events were considerably advanced, by perhaps as much as 14 days. Bird nesting, however, apparently did not advance comparably; timing of bird events may be controlled by conditions and requirements during migration as well as on the breeding grounds.

The comparative phenologies of these three coastal sites are not simply explained by latitudinal differences. The southernmost station, Wales, has temperatures similar to, and phenology slightly behind, Barrow. Coastal geography and wind directions in spring and early summer are probably important factors. The great angular exposure of Wales to winds blowing over ocean ice compared to the lesser angular exposure and resultant wind component blowing over insolated land at Cape Krusenstern probably account for the large difference between these two sites (Table 5).

Breeding Densities

Table 6 compares breeding bird densities at the three main study sites and at Meade River (Atkasook) inland on the coastal plain south of Barrow. With only a single season's data at Cape Krusenstern and at Wales (additional data are available for Barrow in other years), differences between the three outer coastal sites do not appear significant. Inland at Meade River, however, densities appear considerably higher. Contributions to this difference arise both from a greater number of nesting species and from higher densities of several species common to both inland and coastal sites.

Littoral Habitat Densities at Different Sites

In Table 7, shorebird densities measured on transects in littoral habitats at the three main study sites (Barrow, Wales, and Cape Krusenstern) are compared with densities at three supplementary sites visited during three periods July through September. Not surprisingly, densities of shorebirds on mudflats and along shores in late summer occasionally exceed by a considerable amount the densities of nests during the breeding season on the tundra. These are average densities over all littoral habitats represented at each study site. Shoreline transect densities are calculated using a 50 m transect width. Densities at all sites except Wales, the southernmost location, decreased in the final period. The higher density at Wales results from an influx of Dunlins, a species which remains late in the Arctic.

Table 5 Comparison of 1977 weather and phenology at three Alaska coastal sites.

	Cape Krusenstern	Wales	Barrow
Latitude	67°08'N	65°38'N	71°17'N
Surrounding landmass (% of compass points)	33%	21%	29%
% of winds from land, 1-15 June	14%	7%	17%
Temp: Avg. maximum °F	51.7	39.8	38.0
Avg. minimum °F	32.9	32.3	30.1
Mean °F	42.3	36.1	34.1
Relative Phenology			
Snow melt	0	+ 20 days	+ 16 days*
Plant flowering	0	+ 17 Days	+ 17 days*
Bird nesting	0	+ 10 days	+ 6 days*

*from data of J. P. Myers

Table 6 Comparison of breeding densities at arctic coastal tundra sites, 1977.

	Total pairs, hectare	Shorebird pairs/hectare	Number of species nesting	Reference
Barrow Plot 1	1.10	.67	10	Myers *et al*. 1978a
Barrow Plot 2	1.10	.69	11	" 1978b
Meade River	2.72	1.45	18	" 1978c
Cape Krusenstern	1.33	.48	14	Connors and Connors 1978
Wales	1.16	1.00	8	Hirsch and Woodby 1978

Table 7 Total shorebird densities in littoral habitat at study sites. Birds/hectare. ( ) = densities of Red Phalaropes.

	30 July to 8 August	14 August to 23 August	29 August to 7 September
Okiktok	6.3	9.1	3.4
Barrow	5.5	21.5 (19.2)	1.4
Peard Bay	5.4	3.7	1.0
Icy Cape	21.7 (14.2)	8.4	.9
Cape Krusenstern	4.3	1.7	.8
Wales	4.6	1.5	5.2

The two highest densities in Table 7 (Icy Cape, first period, and Barrow, second period) result from heavy shoreline populations of Red Phalaropes. Cape Krusenstern and Wales, lacking a heavy phalarope migration (see below) never attain shorebird densities comparable to some of the more northern sites. However, other sites in the Kotzebue Sound and southern Chukchi area are extensively used by large populations of shorebirds during the late summer period. Although surveys of this large area are seriously incomplete at present, the Noatak Delta, Cape Espenberg, and the regions around Shishmaref emerge as potentially very important.

Shishmaref Barrier Strip Shorebird Densities

On 17 and 18 August 1977, we conducted an aerial reconnaissance of the lagoon barrier strip on the north shore of Seward Peninsula running from Kividlo, east of Shishmaref, to the west end of Arctic Lagoon, west of Shishmaref. Areas in southern Kotzebue Sound, and especially at Cape Espenberg, have been studied by Mickelson *et al.* (RU #441), but we have almost no information about bird densities on the Seward Peninsula barrier strip. This strip, 130 km long by about 1 km in width, comprises an extensive area of littoral habitats of potentially high use by shorebirds and waterfowl and potentially high vulnerability to oil spills. Typically, this strip consists of a wide sand beach backed by dunes, grading to *Carex* and *Puccinellia* saltmarsh and mudflats on the lagoon (south) side. Large areas of sand or mud tidal flats occur near most of the lagoon inlets.

The aerial survey presented a rough estimate of the distribution of bird densities on the dates of the survey. Landings at four sites permitted ground identification and density estimates for 17 transects, each 100 m wide, varying in length from 350 m to 1750 m. These were distributed among four habitat classes, based principally on an intuitive estimate of the level of usefulness of habitats to shorebirds in general. Class A habitat consists of mudflats, shallow muddy pools and saltmarsh with wet mud margins. Class B habitats, usually farther from the lagoon edge, includes thickly vegetated saltmarsh with fewer ponds and less exposed wet mud. Class C consists of dried ponds, upland tundra, dunes and high beach areas, and class D refers to the ocean beach shoreline.

Table 8 lists the densities of birds recorded on these walking transects, which permit us to estimate total numbers of birds on the entire barrier strip. We assume the 130 km long strip averages 1 km in width and is composed of equal areas of habitats A, B, and C, plus a linear strip of habitat D. Resultant populations on 17, 18 August are calculated to be approximately 300,000 total birds, of which 225,000 were shorebirds. Note that this estimate does not include the potentially large numbers of gulls, seabirds, and waterfowl on the waters of the lagoons or the ocean, or the shorebirds on the mainland shore of the lagoons. We do not know whether this period represents peak annual densities; use by shorebirds and waterfowl may remain high from mid-July through late September. These numbers represent very significant populations of many species utilizing littoral habitats which are susceptible to oil spill damage.

Table 8. Bird densities on the Shishmaref barrier strip, Seward Peninsula, 17, 18 August 1977. Mean density (range).

Habitat	Number of transects	Shorebirds/ha	Total Birds/ha
A	7	44 (15-70)	50 (18-76)
B	4	7.5 (3-15)	12.5 (9-17)
C	2	.1 (0-.2)	5.2 (.4-10)
D	4	1.5 (0- 3)	1.5 (0- 3)

Averaging the densities in the three clearly littoral habitats (A, B, and D) to obtain a figure comparable to shorebird densities given in Table 7, we obtain an average littoral habitat density of 17.7 shorebirds per hectare on the Shishmaref Barrier Strip. This figure contains almost no phalaropes and represents by far the highest densities of mudflat and saltmarsh foraging shorebirds over any large region studied. Species present totaled 13; most common species were Golden Plover, Long-billed Dowitcher, Dunlin, Western Sandpiper and Pectoral Sandpiper.

Colony Locations

We located several small scattered colonies (five to approximately 100 pairs) of three seabird species (Glaucous Gull, Arctic Tern and Aleutian Tern) and possibly a fourth species, Mew Gull. All data have been submitted to the U.S. Fish and Wildlife Service, Alaska Bird Colony Register. Four small colonies of the Aleutian Tern at sites north and south of Cape Krusenstern represent a northward extension of the known breeding range.

Trophic System Contrasts Between Areas

For some species (Long-billed Dowitcher, Sanderling, *Larus* gulls) habitat use and population movements compared more closely between Wales and Barrow than between Cape Krusenstern and these two sites. In general, however, Wales and Cape Krusenstern are more closely allied ornithologically. Our previous studies supplemented by 1977 work near Barrow and at other sites in the northern Chukchi and Beaufort identified a heavy late summer movement of shorebirds to littoral habitats. The trophic system (entire food web) supporting the highest concentrations of shorebirds, gulls, and terns along these coasts involved marine zooplankton along shorelines, especially of spits and barrier islands. In contrast, at the study sites in the southern Chukchi, marine zooplankton contributes little to the overall energy base of shorebirds in these areas. Instead, shorebird littoral zone activity is highest on mudflats and in saltmarsh areas where the food source is benthic infauna. These habitats are also used to a considerable extent in the early summer. The pattern of heavier use of littoral habitats in late summer, especially by juvenile shorebirds, holds for both areas, however.

Shorebird Seasonal Habitat Use

We present bar graphs of bird densities recorded on transects in 5-day periods throughout the study season, to illustrate the seasonal changes in population density and habitat use for species and groups of species, contrasting the different study sites when appropriate. Open-ended bar-graphs indicate the beginning or end of the transect census season with species density greater than zero. In two previous annual reports, equivalent data were presented as actual transect census totals rather than densities. We hesitated to use densities in this case because of spatial differences in bird use between habitats: along shorelines most shorebird activity is concentrated within a narrow strip and is best calculated as a linear density. In contrast, mudflat and tundra habitats require areal densities. Because transect dimensions in both habitats at the Barrow study site remained constant throughout the season, transect census totals allowed seasonal comparisons in use of tundra and littoral habitats; at the same time they showed directly the numbers of individuals occurring along our transects.

In this report we convert all census totals to areal densities, using the standard width of 50 m to compute densities along shoreline transects. We adopt this procedure to facilitate comparisons between our main study sites, which differed in relative coverage of tundra vs. littoral habitats. This also permits easy comparison with densities reported from other studies, but only if care is taken to adjust for the effect of different transect widths used in shoreline transects. For example, 10 Sanderlings feeding at the shoreline in 1 km of an ocean beach transect may be reported as 10 per km (linear density), 200 per km^2 (areal density on 50 m wide transect), or 1,000 per km^2 (areal density on 10 m wide transect).

Comparisons of bird densities in different habitats appropriately portray the differences in expected effects arising from the disturbance of equal areas of these different habitats. However, to appreciate the total population dependence on a particular habitat, we must consider the total area of that habitat relative to others. In the local Barrow study area, for example, tundra habitats cover approximately 13 times the area of littoral habitats (Connors et al. 1978). Thus, equal densities in both habitats imply that 93% of the population is found on tundra sites.

A. Total Shorebird Densities

Our studies at Barrow have identified a clear and pronounced seasonal shift in habitat use by shorebirds, from predominantly tundra habitat in early summer to heavily littoral areas in late July, August and September. In Figure 5 we present data for Barrow, 1976; 1977 data were similar but littoral transects were not censused in the early summer. The extremely high August densities in Figure 5A represent

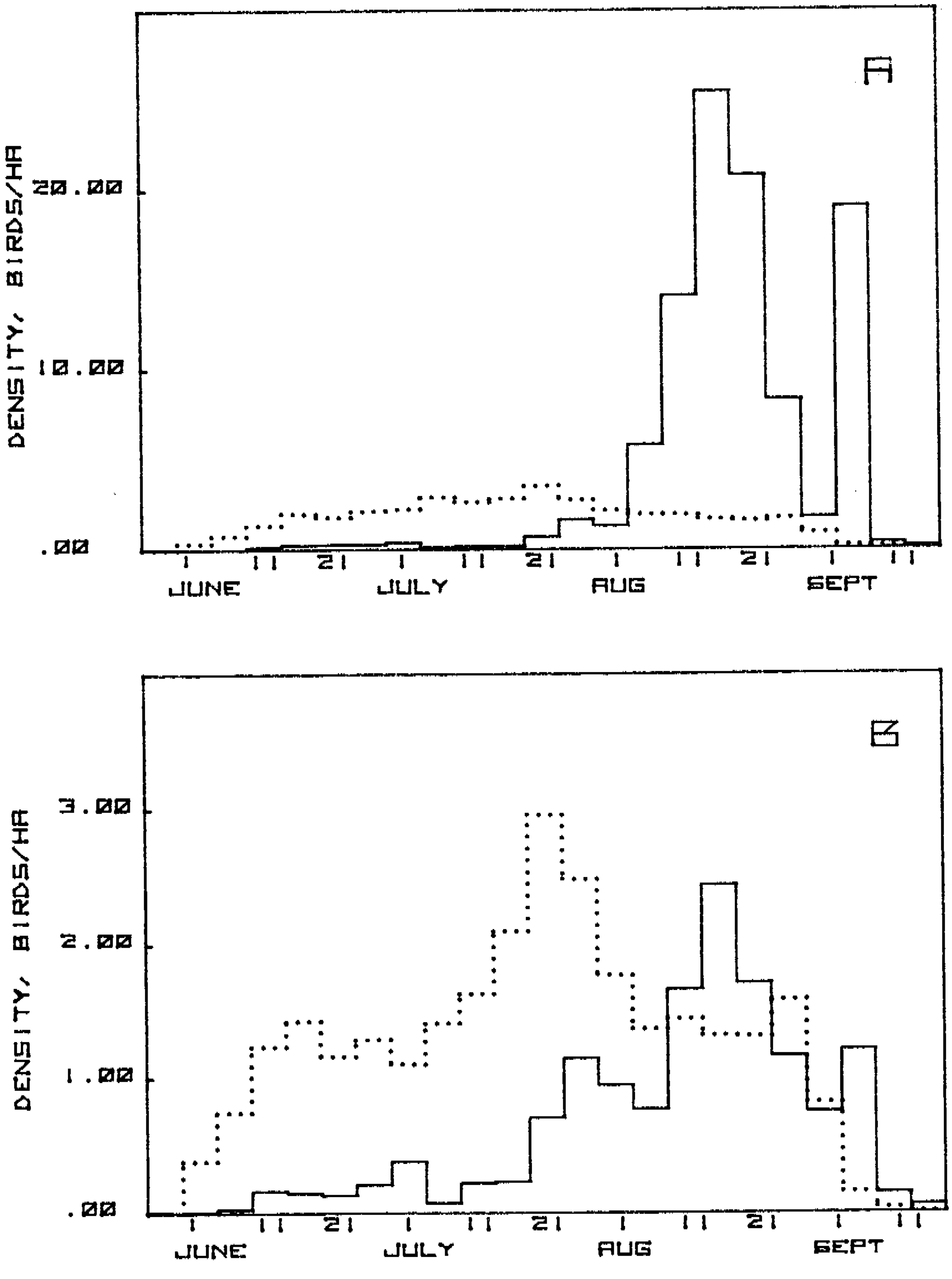


Figure 5. Transect densities, Barrow, 1976. A. Total shorebirds. Littoral (solid) vs. tundra (dotted). B. Total shorebirds excluding Red Phalarope. Littoral (solid) vs. tundra (dotted).

primarily the contribution of juvenile Red Phalaropes foraging along ocean beaches. In Figure 5B, the same transect data excluding all Red Phalaropes show the same seasonal shift in habitat use, but densities in littoral habitats of these species are comparable to densities on the tundra in late summer.

Figure 6A and 6B provide the total shorebird density comparisons for Wales and Cape Krusenstern, respectively. Densities at Wales show an apparent shift toward the littoral in late summer, but peak densities are less than at Barrow. Wales densities include, however, very few phalaropes; Western Sandpipers and Dunlins account for the largest contributions. At Cape Krusenstern, in contrast, the late season habitat shift did not occur. Outer coast shores with zooplankton as a food source were used very little by shorebirds in late summer. Saltmarsh and mudflat areas with shallow saline pools, open in late May at this phenologically early site, were heavily used by migrant shorebirds of several species, as well as by species nesting on the nearby tundra. Northern Phalaropes, Western Sandpipers, Semipalmated Sandpipers, Pectoral Sandpipers and Long-billed Dowitchers were common in these habitats in June and July. Species remaining in the Arctic during August and September, most notably Dunlin, apparently moved to areas of more extensive mudflat and saltmarsh, such as the Noatak Delta, Cape Espenberg, and the Shishmaref Barrier Strip on Seward Peninsula, as noted above.

B. Species Accounts

These results will be presented as discussions of individual species or groups of species. Since seasonal patterns for all species at Barrow in 1975 and 1976 have been presented in the two prior annual reports, only those habitat use and distributional features differing in 1977 at Barrow or at the southern Chukchi sites will be discussed. Rare or accidental species are listed in Appendix 1, and are not discussed here.

1. Semipalmated Plover (Charadrius semipalmatus). Uncommon at all three sites. Nested at Barrow and Cape Krusenstern.

2. American Golden Plover (Pluvialis dominica). Common as a breeder and migrant at all sites. However, habitat use patterns differed markedly between Barrow and the two southern Chukchi sites. Figure 7A compares the seasonal census data for tundra and littoral transects at Barrow in 1976 (chosen in preference to the similar 1975 and 1977 seasons only because the 1976 data were complete for the entire season). The minimal use of littoral habitats by this species along the Beaufort coast results in a rating of low susceptibility to disturbances related to outer continental shelf oil development there (Table 16).

   However, this clear pattern of habitat use changes abruptly for the same species (and possibly the same individuals) farther south in the Chukchi. At Wales, Cape Krusenstern, and Sesualik on the Noatak Delta, non-breeding and post-breeding adults and migrant juveniles forage in high concentrations on mudflats and the muddy

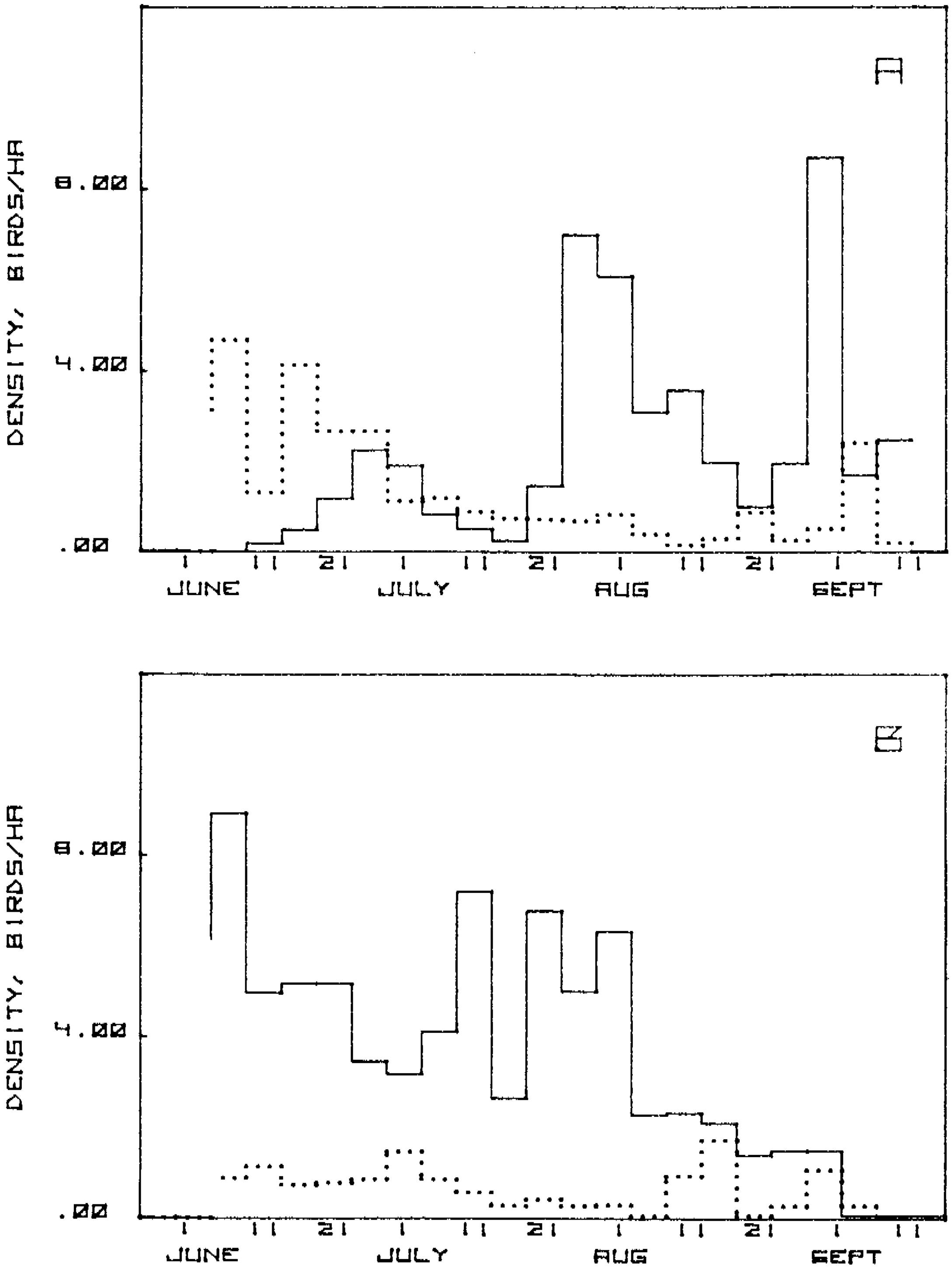


Figure 6. Transect densities, 1977. A. Wales, total shorebirds. Littoral (solid) vs. tundra (dotted). B. Cape Krusenstern, total shorebirds. Littoral (solid) vs. tundra (dotted).

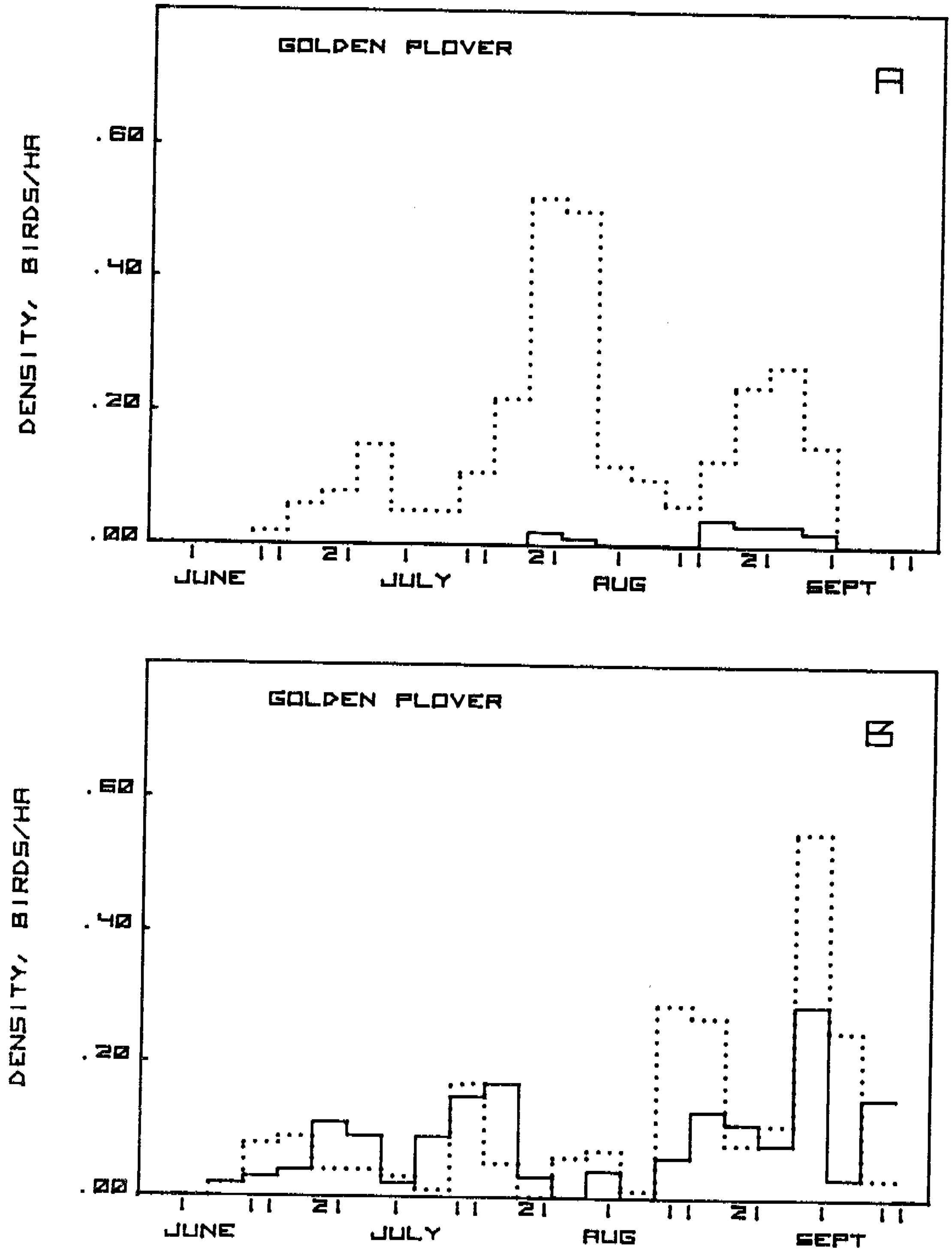


Figure 7. Transect densities, Golden Plover. A. Barrow, 1976. Littoral (solid) vs. tundra (dotted). B. Wales and Cape Krusenstern, 1977. Littoral (solid) vs. tundra (dotted).

margins of sloughs, lagoons, and saltmarshes. Figure 7B compares tundra vs. littoral habitat transect census results, combining Wales and Cape Krusenstern data. This much heavier use of habitats more susceptible to oil-related perturbations argues for a higher susceptibility rating for Golden Plovers on the southern Chukchi coast.

3. Black-bellied Plover (Pluvialis squatarola). Fairly common in the Beaufort east of Barrow, in littoral habitats. Rare in the southern Chukchi, although one pair rested at Cape Krusenstern.

4. Ruddy Turnstone (Arenaria interpres). As in previous seasons at Barrow, this species moved heavily into littoral areas in August, becoming most common on the shores of Barrow Spit (Figure 8A). Buildup in 1977 occurred earlier, however, and began declining 5 to 10 days ahead of the 1976 schedule. Figure 9B separates the 1977 peak into adult and juvenile age classes. In 1976 fewer adults used shoreline areas before migrating southward. Nevertheless the juvenile migration in 1977 was considerably earlier than that in 1976. Ruddy Turnstones were uncommon migrants at Wales and Cape Krusenstern (Figure 9B).

5. Black Turnstone (Arenaria melanocephala). Present as migrants at both Chukchi sites. Juveniles were fairly common in August in littoral habitats.

6. Dunlin (Calidris alpina). A common breeder and migrant at all three sites. Comparisons of densities on littoral vs. tundra transects at Wales, Cape Krusenstern and Barrow in 1977 are shown in Figures 10 and 11. At Cape Krusenstern tundra densities are much lower than at Barrow and Wales during the breeding season. Much of the tundra transect area at Cape Krusenstern covered a series of old gravel beach ridges and intervening moist swales, a habitat which was used very sparsely by nesting Dunlins. Older beach ridge areas closer to Krusenstern Lagoon were more densely vegetated with grasses and sedges, with some polygonization, and were favored by Dunlins as nesting areas. Dunlins used littoral habitat somewhat more heavily in early summer at Cape Krusenstern and Wales than at Barrow. In August and September, Dunlins became extremely common in large mudflat and saltmarsh areas of Kotzebue Sound and the northern Seward Peninsula, as noted above. In 1977, Dunlins remained in moderate densities on mudflats of the Noatak River Delta until about 5 October (W. R. Uhl, pers. comm.).

The comparison of 1976 and 1977 densities at Barrow in Figure 11 A and B shows a similar pattern of density on tundra transects in both years but considerable variation between years in the movement to littoral areas in late summer. In 1977, high densities were reached considerably earlier than in 1976. This pattern was also exhibited by movements of male Red Phalaropes and adult Ruddy Turnstones to shorelines in late July and may relate to the comparatively mild ice season, with shoreline habitat available at an earlier date in 1977.

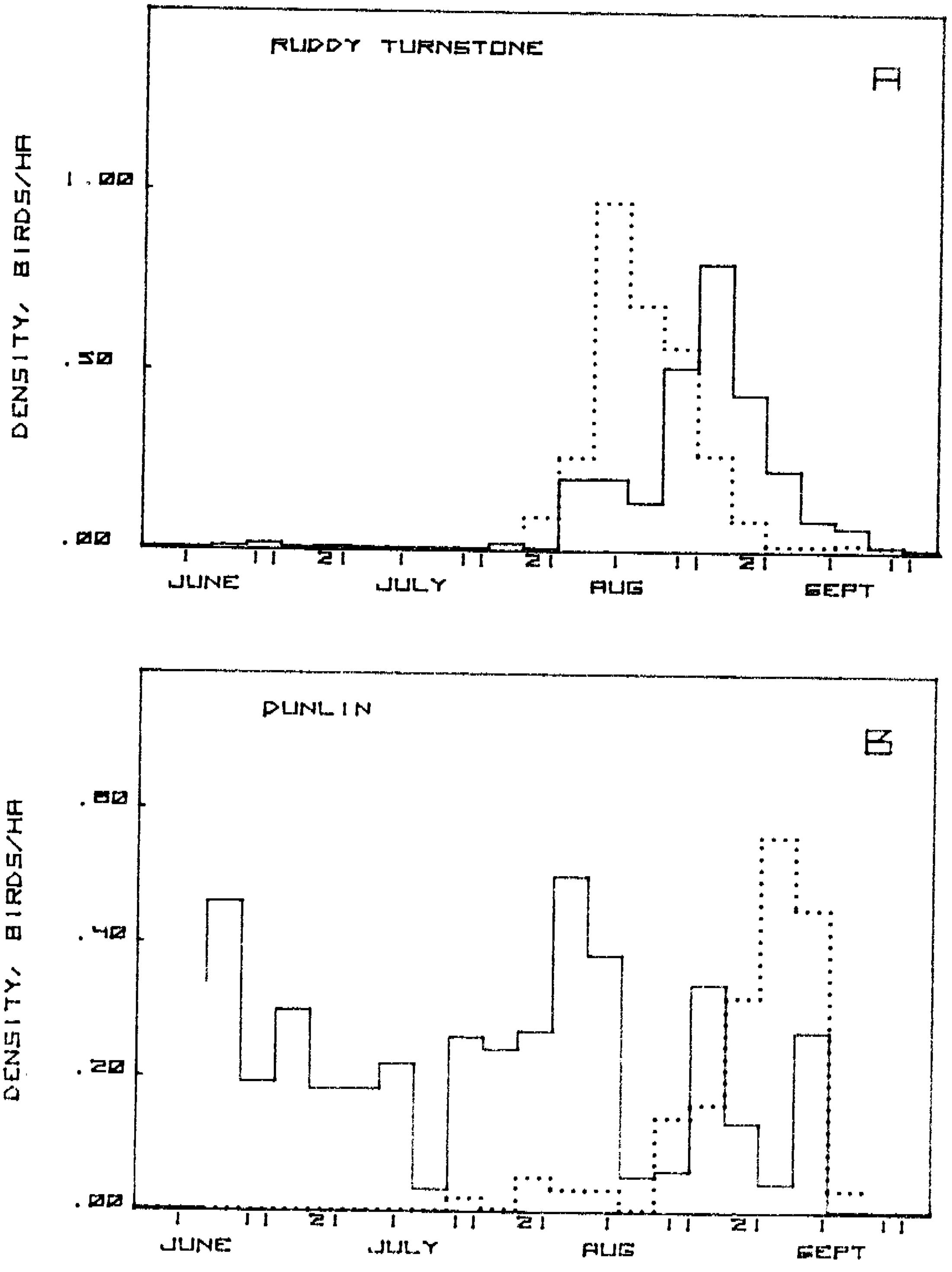


Figure 8. Transect densities, littoral. A. Ruddy Turnstone. Barrow 1976 (solid) vs. Barrow 1977 (dotted). B. Dunlin. Cape Krusenstern, 1977. Adults (solid) vs. juveniles (dotted).

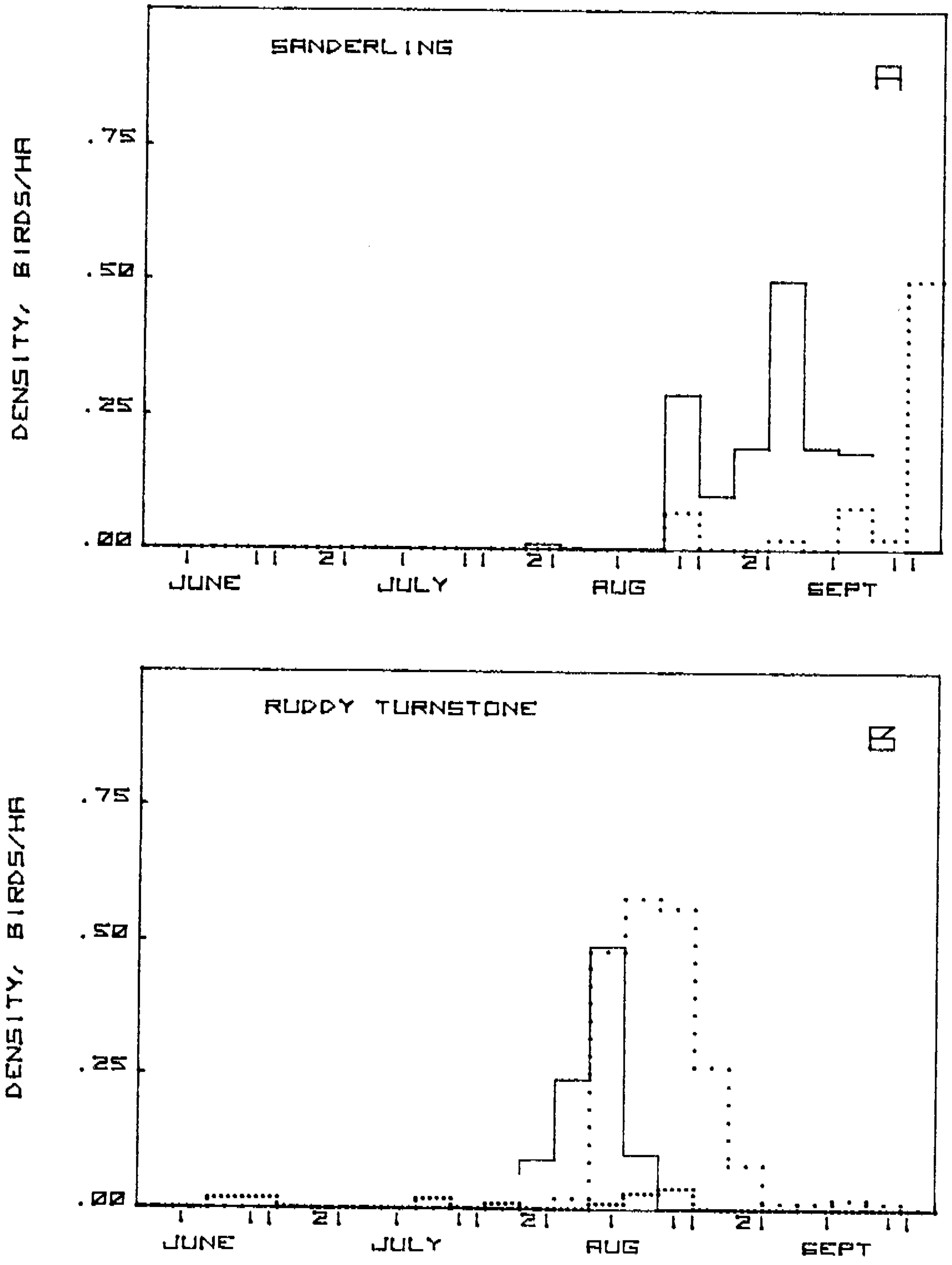


Figure 9. Transect densities, littoral, 1977. A. Sanderling. Wales (solid) vs. Barrow (dotted). B. Ruddy Turnstone. Barrow adults (solid) vs. Barrow juveniles (coarse dotted) vs. Wales and Cape Krusenstern, all ages (fine dotted).

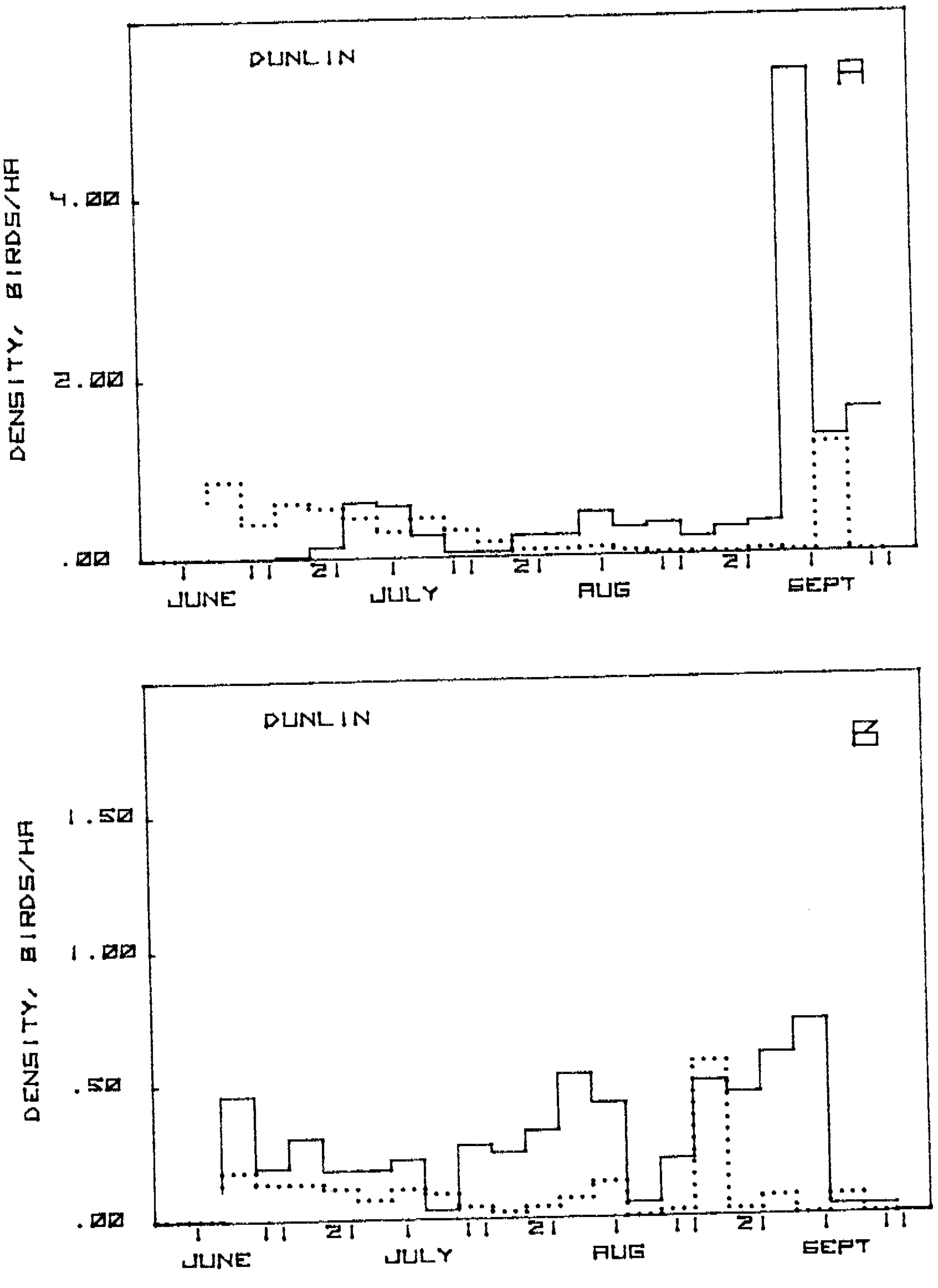


Figure 10. Transect densities, Dunlin. A. Wales. Littoral (solid) vs. tundra (dotted). B. Cape Krusenstern. Littoral (solid) vs. tundra (dotted).

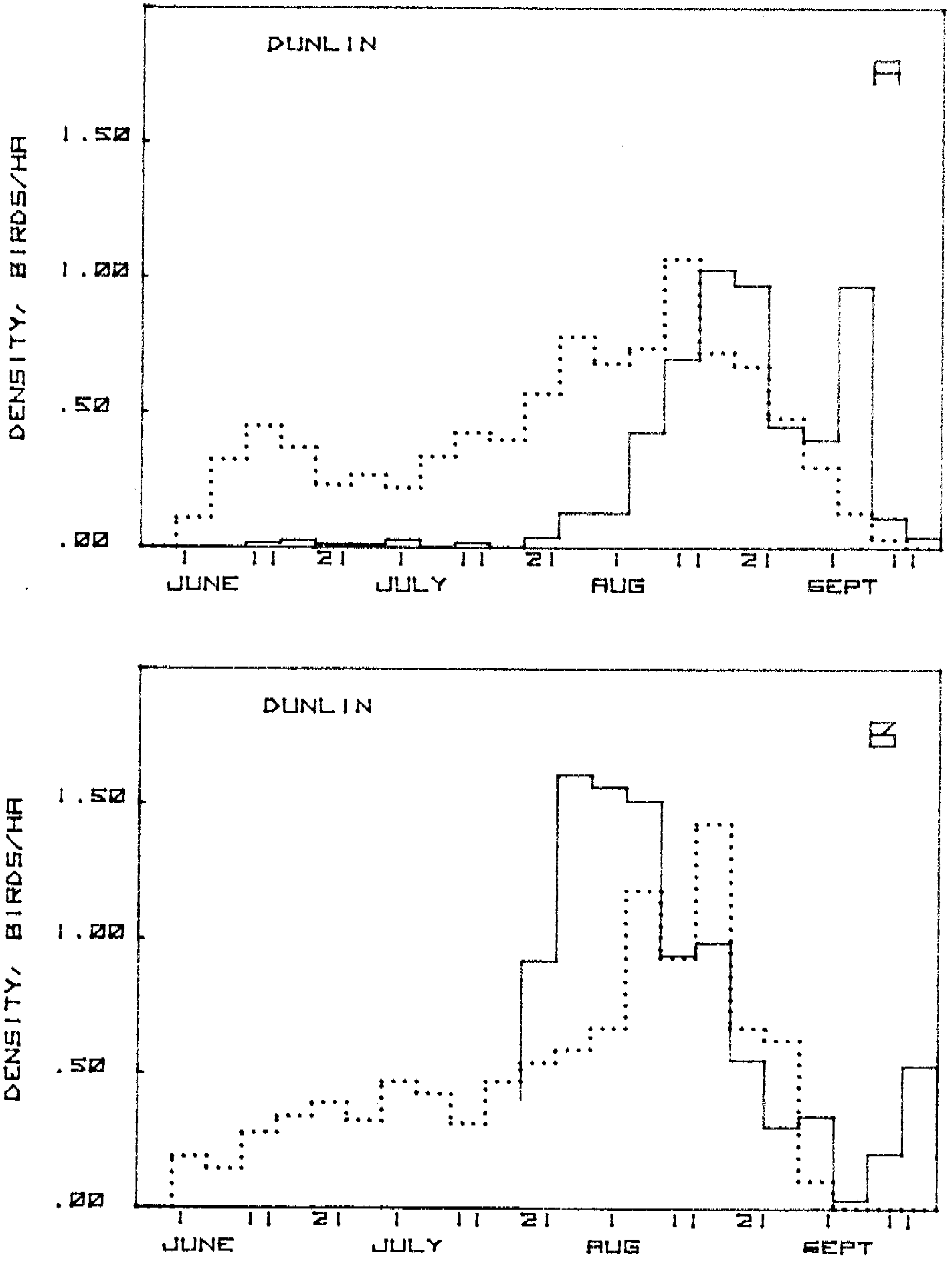


Figure 11. Transect densities, Barrow. A. 1976. Littoral (solid) vs. tundra (dotted). B. 1977. Littoral (solid) vs. tundra (dotted).

7. Red Knot (C. canutus). Adult and juvenile Red Knots were present in low densities as southbound migrants in late July and August on beaches of Cape Krusenstern and Wales. During this period no individuals were observed on tundra sites (Figure 12A).

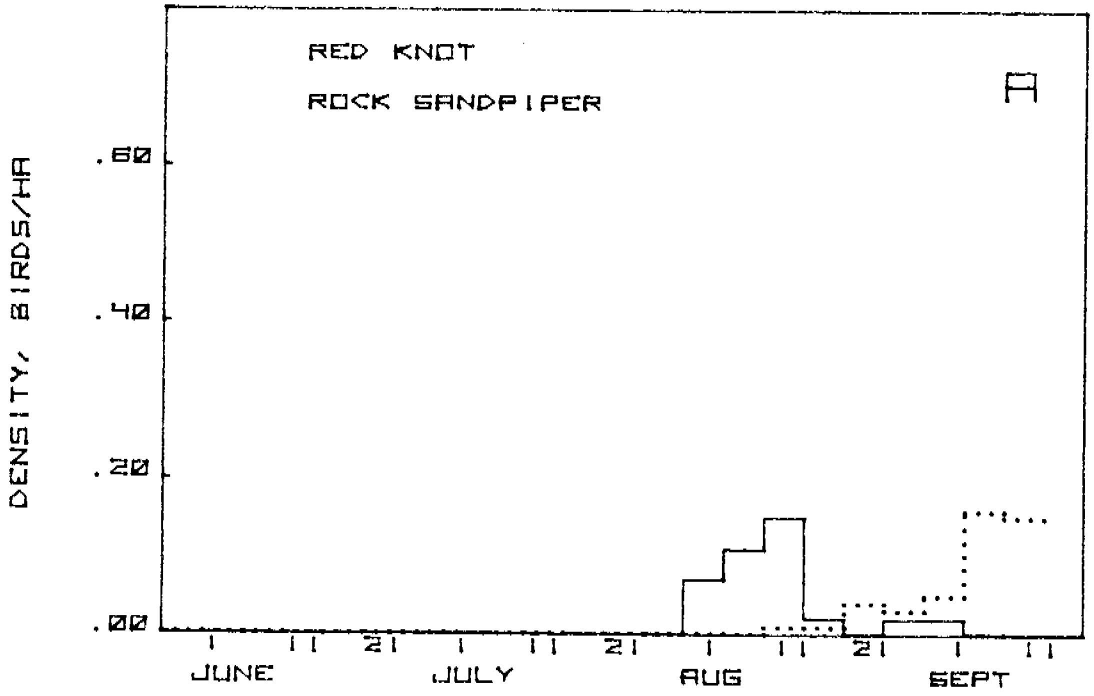
8. Rock Sandpiper (C. ptilocnemis). Rock Sandpipers breed in low densities at Wales and move into littoral habitats in late summer prior to southward migration. One bird was seen at Cape Krusenstern in early summer (Figure 12A).

9. Sharp-tailed Sandpiper (C. acuminata). A fairly heavy movement of juveniles of this species was evident at Wales at the end of August and first week of September. Birds foraged on tundra and in littoral areas. A few birds were seen during this period at Cape Krusenstern and moderate numbers were present on mudflats of the Noatak River Delta on September 2. This species nests in Siberia and winters in the central and eastern Pacific, but many juveniles apparently migrate eastward to forage on mudflats of Kotzebue Sound and Seward Peninsula before migrating southward (Figure 12B).

10. Pectoral Sandpiper (C. melanotos). Figure 13A gives the comparison of Pectoral Sandpiper densities on tundra and littoral transects at Barrow in 1976. The extremely low use of littoral habitats shown by these data results in our classification of this species as having low susceptibility to OCS disturbances (Table 16). The equivalent data for Wales and Cape Krusenstern 1977 (Figure 13B) contrast strongly, with very low densities on tundra throughout the season and occasional high densities in littoral areas. The contrast may not be as sharp as first appears, however. Figure 14A compares littoral transect densities for 1977 at Barrow vs. 1976 at Barrow and shows extremely heavy use of some littoral habitats by adult Pectoral Sandpipers during migration in July of 1977. It is clear that habitat use patterns for particular species can be quite variable from year to year, depending on interactions of resource conditions, habitat availability and timing of migratory movements.

11. Western Sandpiper (C. mauri). Western Sandpipers were fairly common at Barrow and very common at Wales and Cape Krusenstern. At all three sites relative use of littoral habitats by this species is high. Adults forage on mudflats and saltmarsh pool margins and the edges of littoral sloughs during the nesting season and prior to southward migration after breeding activities are completed. Juveniles move into these habitats in high densities in late July after most adults have left the Arctic (Figure 14B). Patterns of habitat use, age class movements, and densities in littoral habitats were quite similar at Wales and Cape Krusenstern sites (Figures 14B, 15A, 15B).

12. Semipalmated Sandpiper (C. pusilla). This species is also heavily dependent on littoral areas, using habitats similar to those of the Western Sandpiper. At Cape Krusenstern (Figure 16B) densities were higher on littoral transects throughout the season but the juvenile pre-migratory peak in late July reached densities only



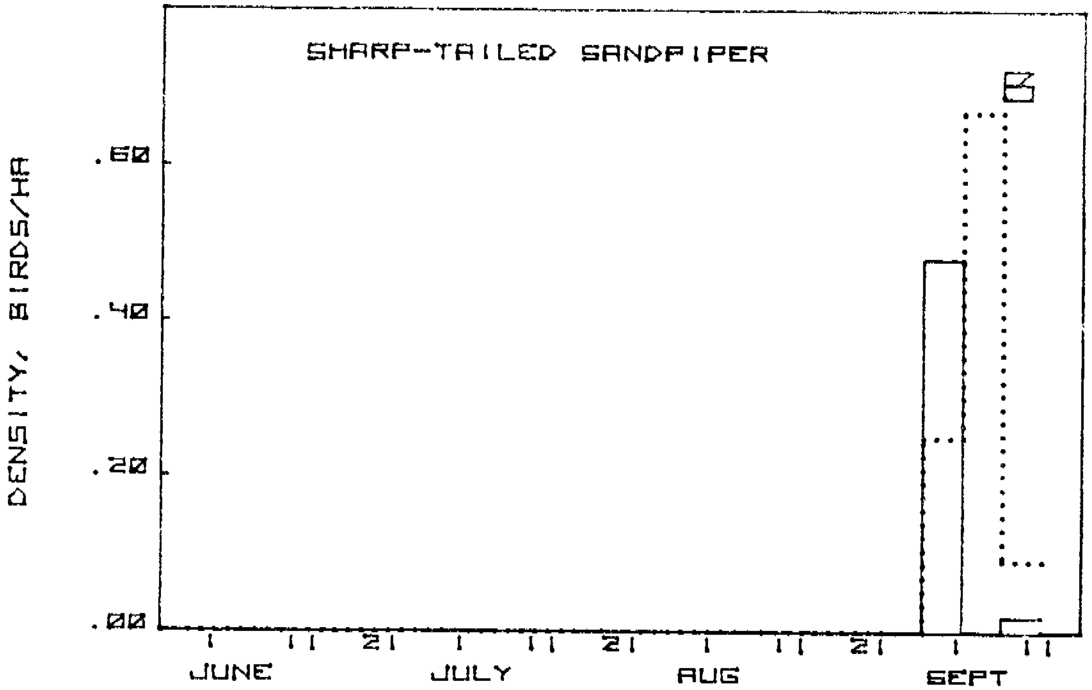


Figure 12. Transect densities, Wales. A. Red Knot, littoral (solid). Rock Sandpiper, littoral (dotted). B. Sharp-tailed Sandpiper. Littoral (solid) vs. tundra (dotted).

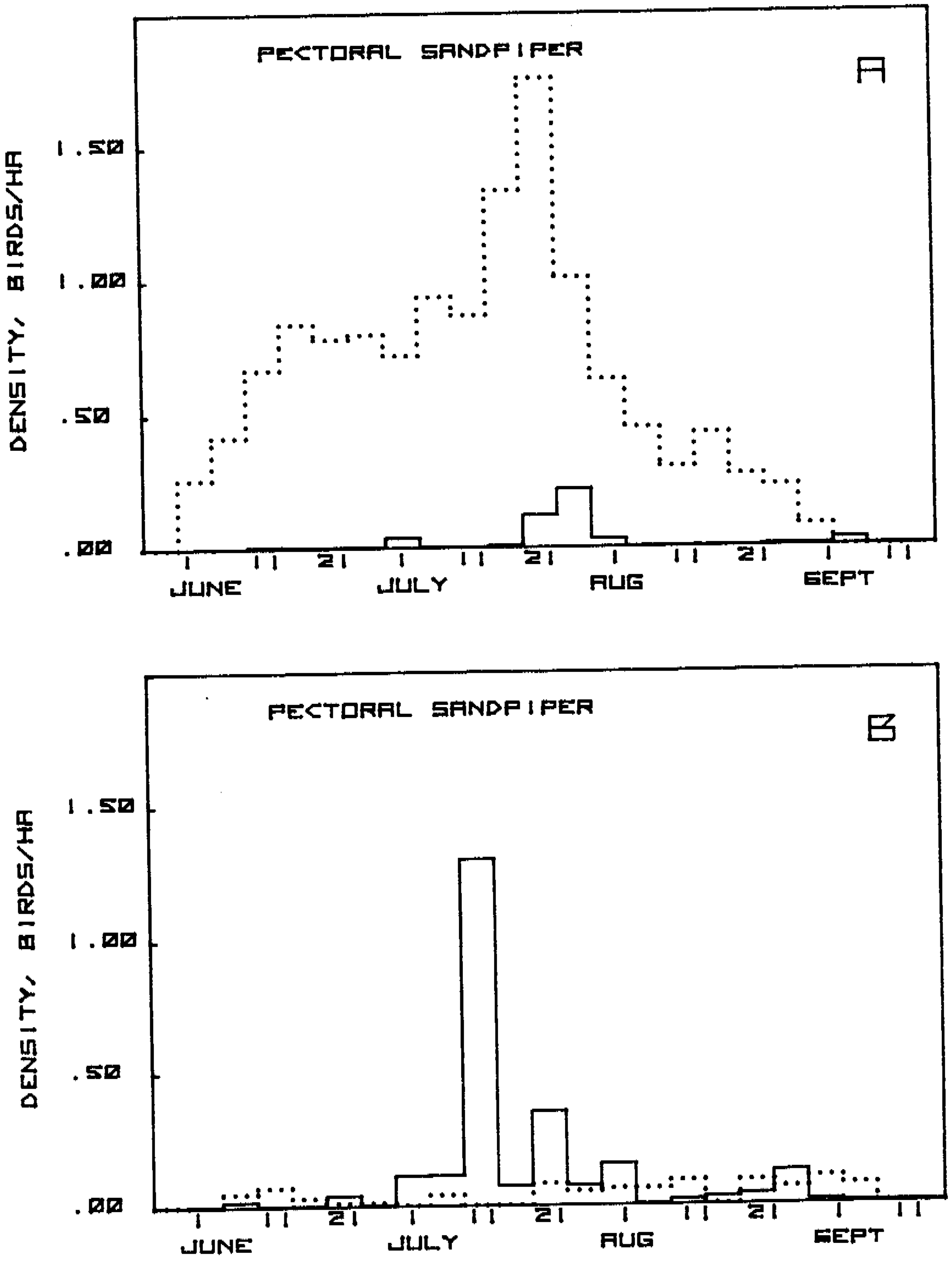


Figure 13. Transect densities, Pectoral Sandpiper. A. Barrow 1976. Littoral (solid) vs. tundra (dotted). B. Wales and Cape Krusenstern 1977. Littoral (solid) vs. tundra (dotted).

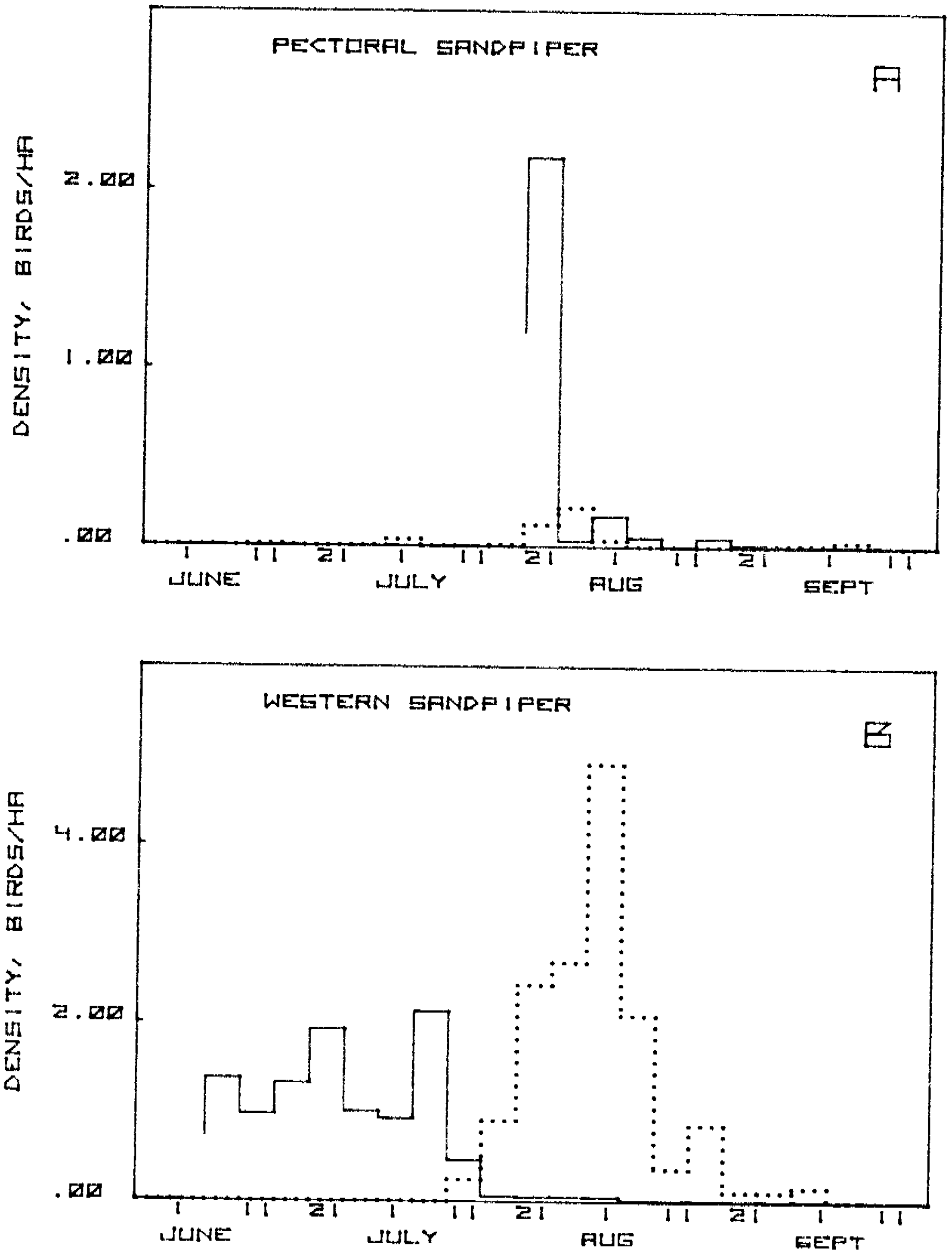


Figure 14. Transect densities. A. Pectoral Sandpiper, Barrow, littoral. 1977 (solid) vs. 1976 (dotted). B. Western Sandpiper, Cape Krusenstern, littoral, 1977. Adults (solid) vs. juveniles (dotted).

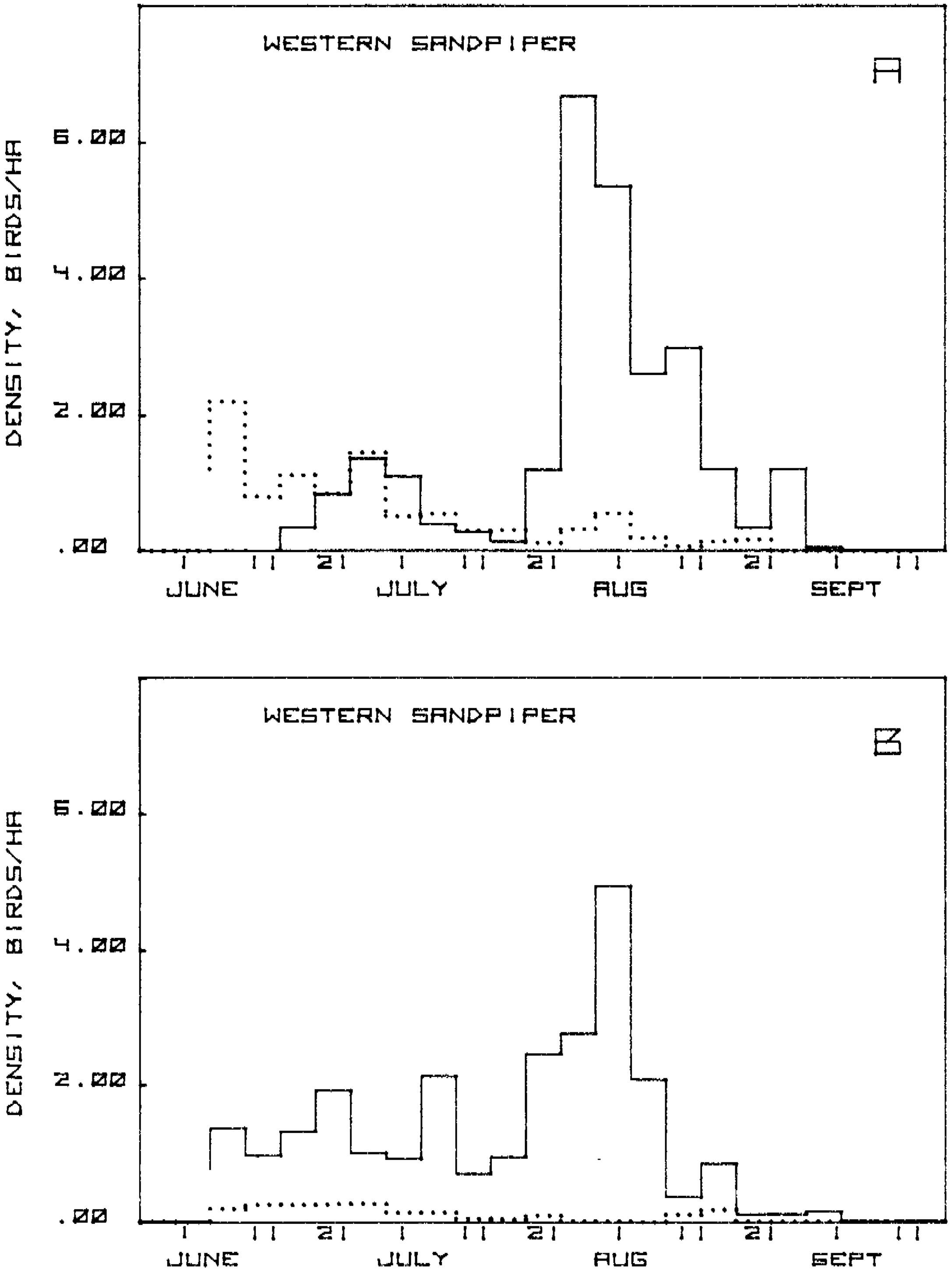


Figure 15. Transect densities, Western Sandpiper. A. Wales. Littoral (solid) vs. tundra (dotted). B. Cape Krusenstern. Littoral (solid) vs. tundra (dotted).

slightly in excess of adult densities in June on the same mudflats (Figure 16B, 17A). In contrast, the movement of juveniles into the littoral zone near Barrow was even heavier than in previous years (Figure 16A) and occurred 5 to 10 days later than the peak juvenile densities at Cape Krusenstern. Movements at Wales were similar to those at Cape Krusenstern but densities were much lower.

13. Baird's Sandpiper (C. bairdii). This species is common near Barrow and uses littoral habitats throughout the summer. Only two nests were found at Cape Krusenstern and few birds were seen during migration. At Wales no nests were located.

14. Sanderling (C. alba). Sanderlings have been a common late summer migrant along ocean shorelines at Barrow in all three years of this study. At Wales in 1977 one adult migrant and moderate densities of juveniles were present, with juveniles occurring considerably earlier than the late peak in Barrow in 1977 (Figure 9A). Sanderlings were uncommon late summer migrants at Cape Krusenstern.

15. Whimbrel (Numenius phaeopus). Whimbrels were rare at Barrow and Wales but common at Cape Krusenstern where migrant flocks occurred on tundra sites during late June and July. These birds seldom used littoral habitats. One nest was located at Cape Krusenstern.

16. Long-billed Dowitcher (Limnodromus scolopaceus). This species nests at all three sites. Wales (Figure 18A) and Barrow (Figure 19A) show a late August peak of migrant juveniles far in excess of densities recorded earlier in the year. At Cape Krusenstern, however, peak densities occurred with migrant flocks of post-breeding adults during July. The subsequent migration of juveniles at this site precedes in time the corresponding juvenile peaks at the other two sites.

17. Bar-tailed Godwit (Limosa lapponica). This species nested at Wales and probably did so at Cape Krusenstern, but in very low numbers at each location. Small flocks of migrants were present, however, in early and late summer, usually feeding in shallow, muddy areas.

18. Red Phalarope (Phalaropus fulicarius). On tundra transects Red Phalarope age and sex classes show a distinctly different timing of movements. Figure 19B for 1976 at Barrow shows the buildup of adult male and female nesting birds, followed by a migrational peak of post-breeding females. After nesting is completed, males migrate southward; fledged juveniles then gradually leave the tundra, moving to littoral areas before southward migration. Figure 20A compares densities on tundra and littoral transects for 1976 at Barrow, showing the extremely high densities reached by this coastwise movement of juveniles. At Wales and Cape Krusenstern in 1977, movements of this species contrasted sharply to those at Barrow in previous years (Figure 20B). In June low to moderate densities of this species occurred in tundra as well

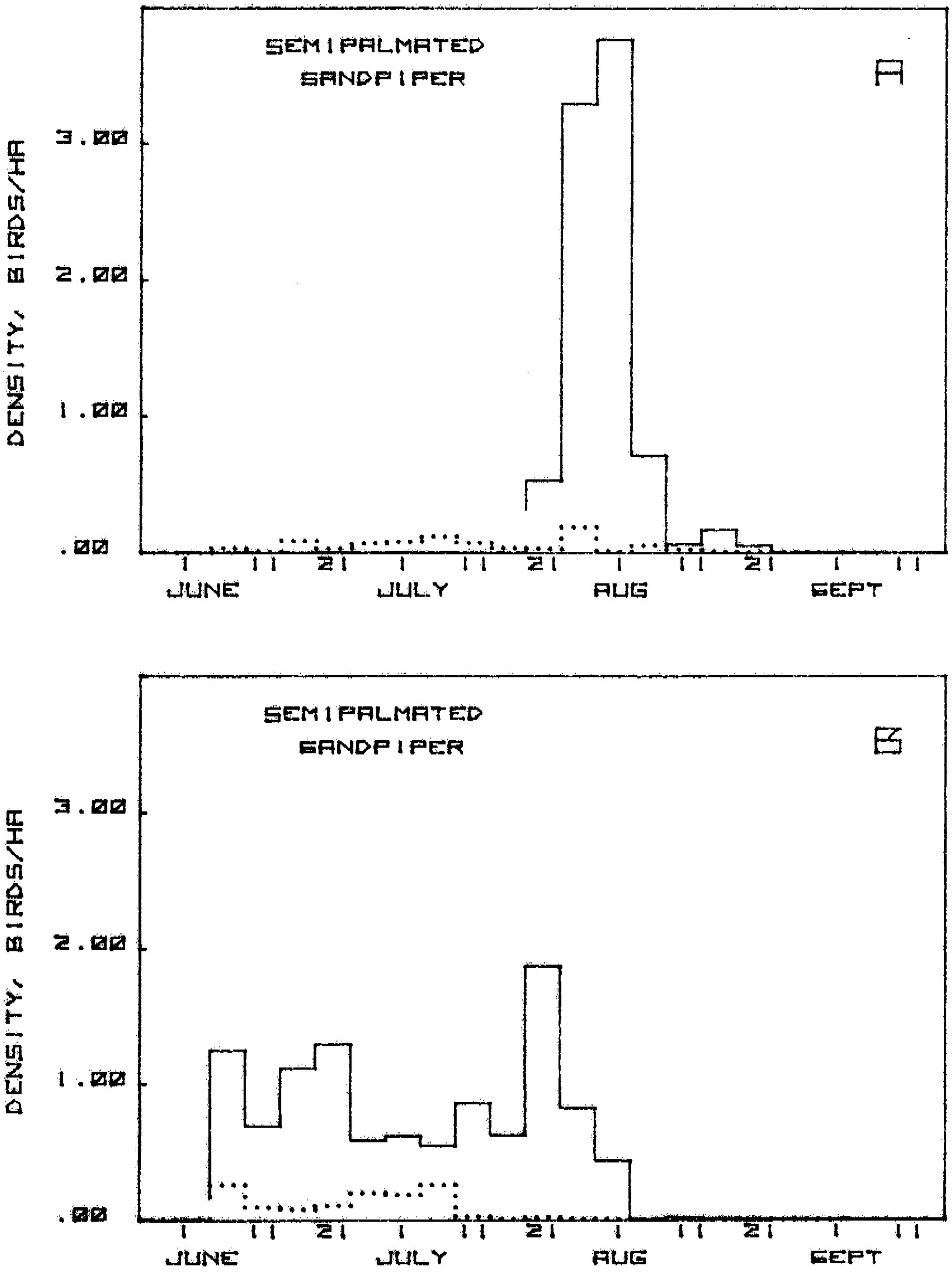


Figure 16. Transect densities, Semipalmated Sandpiper, 1977. A. Barrow. Littoral (solid) vs. tundra (dotted). B. Cape Krusenstern. Littoral (solid) vs. tundra (dotted).

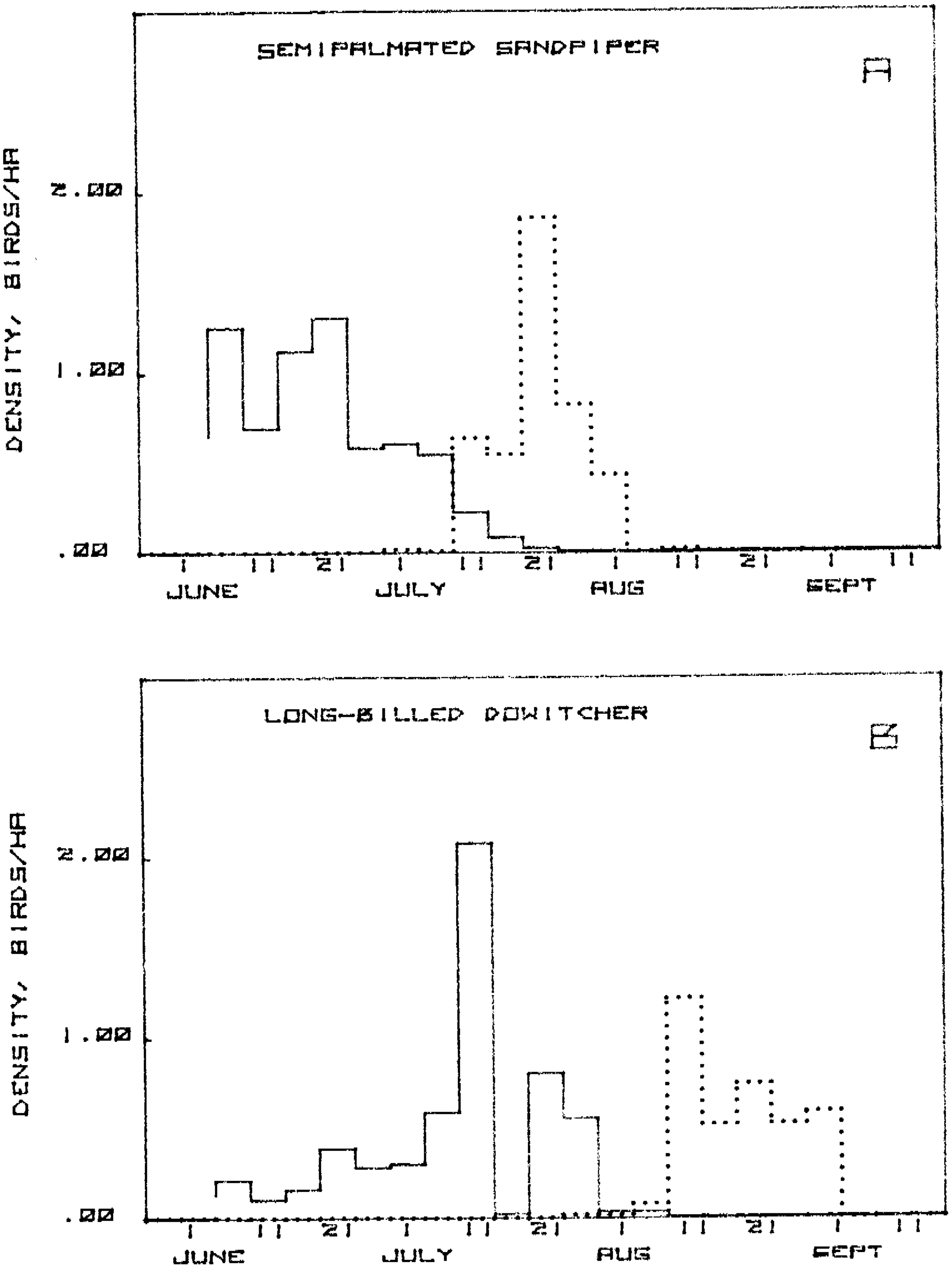


Figure 17. Transect densities, Cape Krusenstern littoral. A. Semipalmated Sandpiper. Adults (solid) vs. juveniles (dotted). B. Long-billed Dowitcher. Adults (solid) vs. juveniles (dotted).

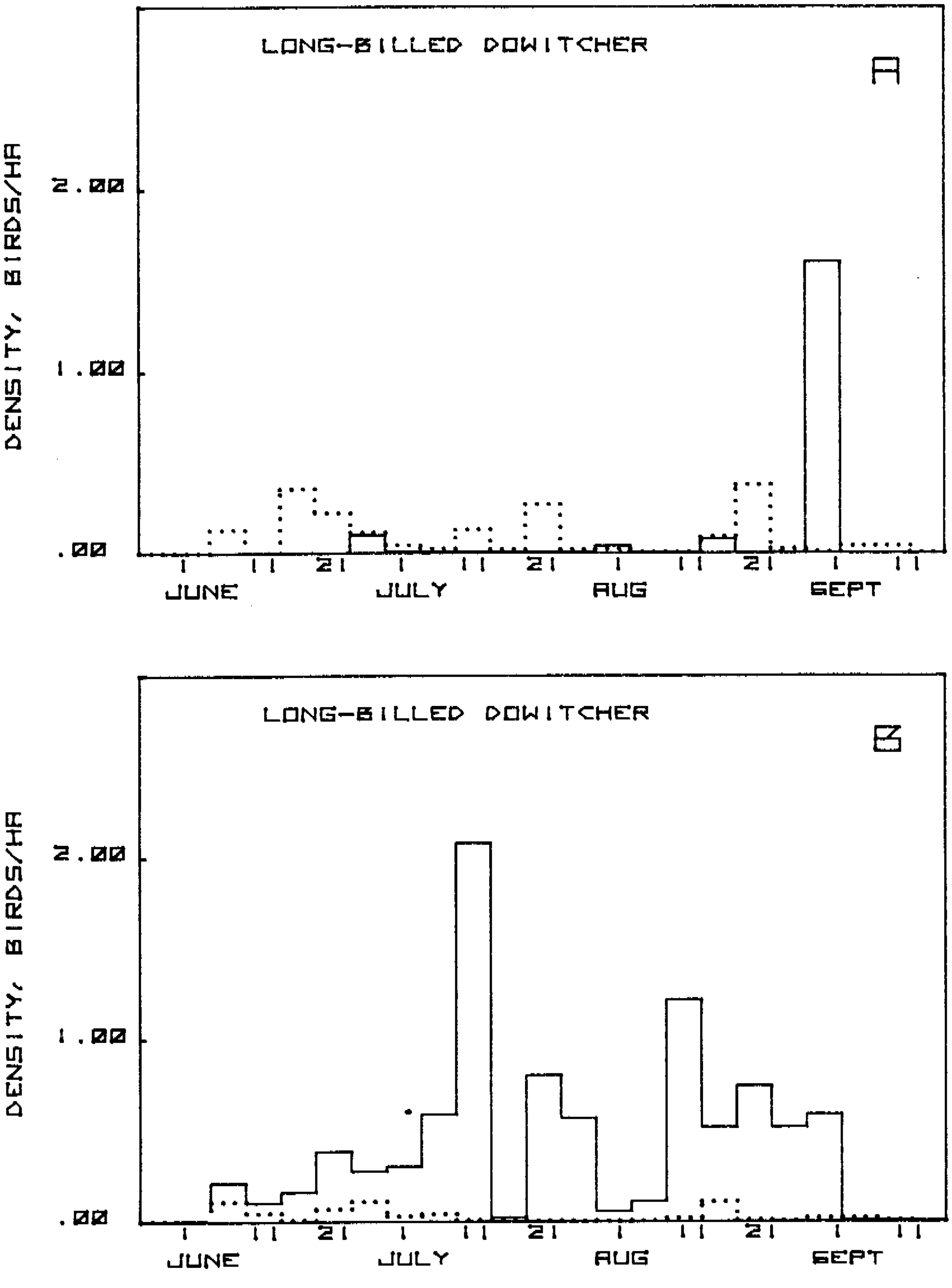


Figure 18. Transect densities, Long-billed Dowitcher. A. Wales. Littoral (solid) vs. tundra (dotted). B. Cape Krusenstern. Littoral (solid) vs. tundra (dotted).

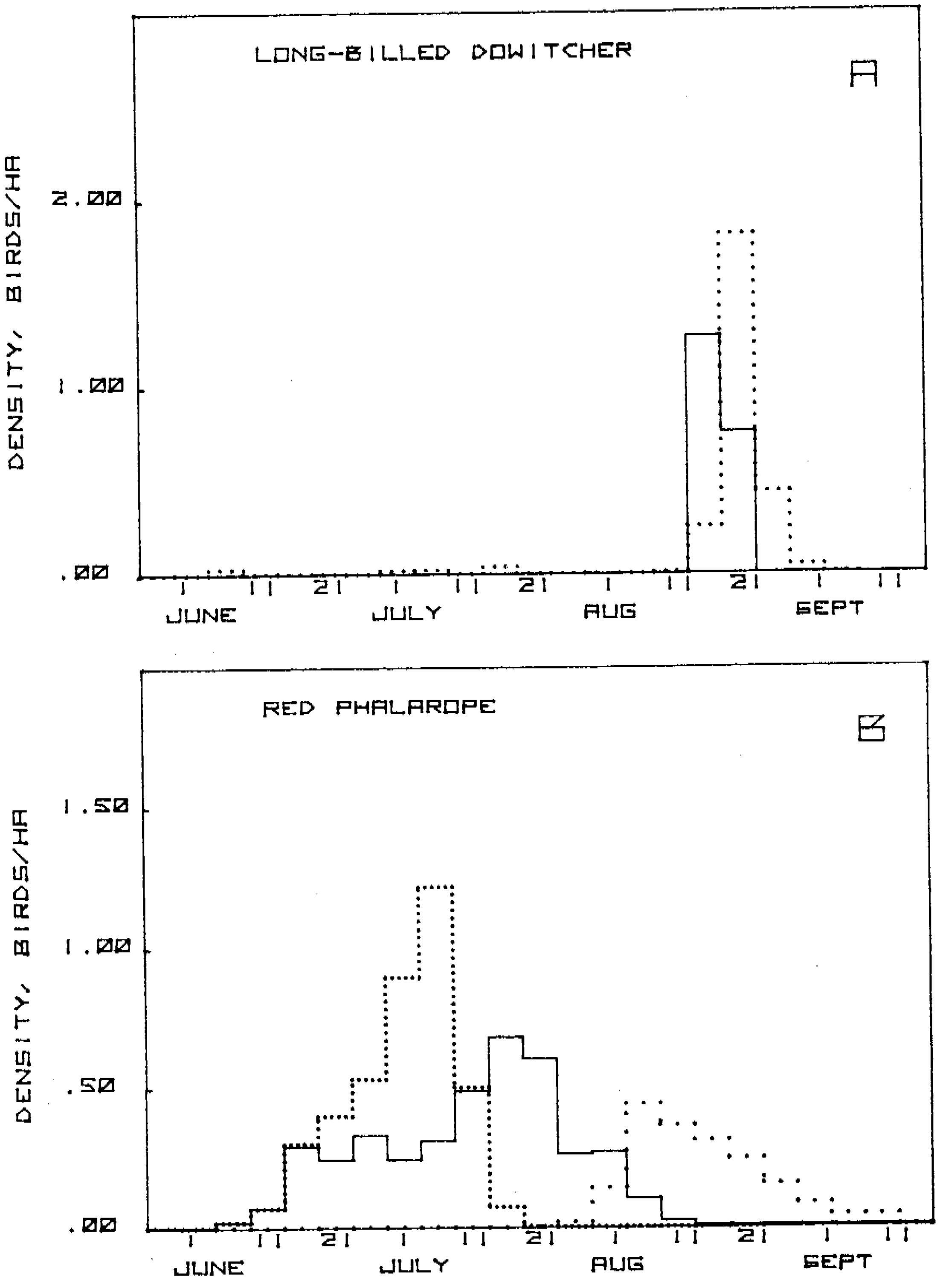


Figure 19. Transect densities, Barrow. A. Long-billed Dowitcher, 1977. Littoral (solid) vs. tundra (dotted). B. Red Phalarope, tundra, 1976. Adult males (solid), adult females (fine dotted), juveniles (coarse dotted).

as littoral sites, but no migrational peaks were evident at any time throughout the summer and densities after July 1 remained low. The dense concentrations of adult male and juvenile Red Phalaropes foraging on marine zooplankton along shorelines, which is so evident at Barrow and at other northern Beaufort and Chukchi sites, did not occur by September 7 at Cape Krusenstern, or by September 12 at Wales. Reports of local observers indicate that phalaropes can become more common in September after these dates (pers. comm.: Clarence Ongtowasruk, Wales; W. R. Uhl, Kotzebue).

Figures 21 A and B compare littoral zone densities at Barrow between 1976 and 1977 for adult males and juveniles, respectively. The juvenile movement was quite similar in both seasons. However, as discussed above, adult males moved to marine shores in heavier numbers and at an earlier date in 1977. This change probably arose from the early availability of shoreline foraging sites resulting from the mild ice conditions in 1977. The importance for OCS development of this contrast with the two previous seasons of our work arises from the potential exposure of the adult male cohort to littoral zone perturbations such as oil spills.

19. Northern Phalarope (Lobipes lobatus). Northern Phalaropes occurred at Barrow in extremely low densities in 1975 and 1976. In 1977, however, a heavy movement of juveniles occurred in mid-August, with most individuals foraging on brackish water copepods in Middle Salt Lagoon. This represents another strong contrast between seasons and leads us to add this species to the list of birds potentially affected by littoral zone disturbances in the Barrow vicinity (Table 15). Densities at Wales on both tundra and littoral transects were considerably less than the peak density at Barrow (Figure 22A). High densities in the littoral zone were recorded at Cape Krusenstern, however (Figure 22B), in early June. This pattern of early high density, progressively decreasing, is in marked contrast to the pattern of late season shoreline buildup of most other shorebird species. As noted under Red Phalaropes above, late season marine zooplankton foraging, such as is prominent in the Beaufort and northern Chukchi, did not materialize at Wales and Cape Krusenstern, and birds became progressively scarcer through the summer. The steady decline in density at Cape Krusenstern also correlates with a gradual drying of a brackish pond mudflat area on two transects and the predation-caused failure of approximately 25 Northern Phalarope nests on the borders of this pool area.

Other shorebird species occurring in lower densities are listed in Appendix 1. Some of these, occurring at Barrow, have been discussed in previous reports. Notes which follow address several species or groups of species which also use littoral habitat in our transect areas.

20. Loons (Gavia spp.). Loons, principally Red-throated and Arctic, occur at low densities at all three sites on tundra and in

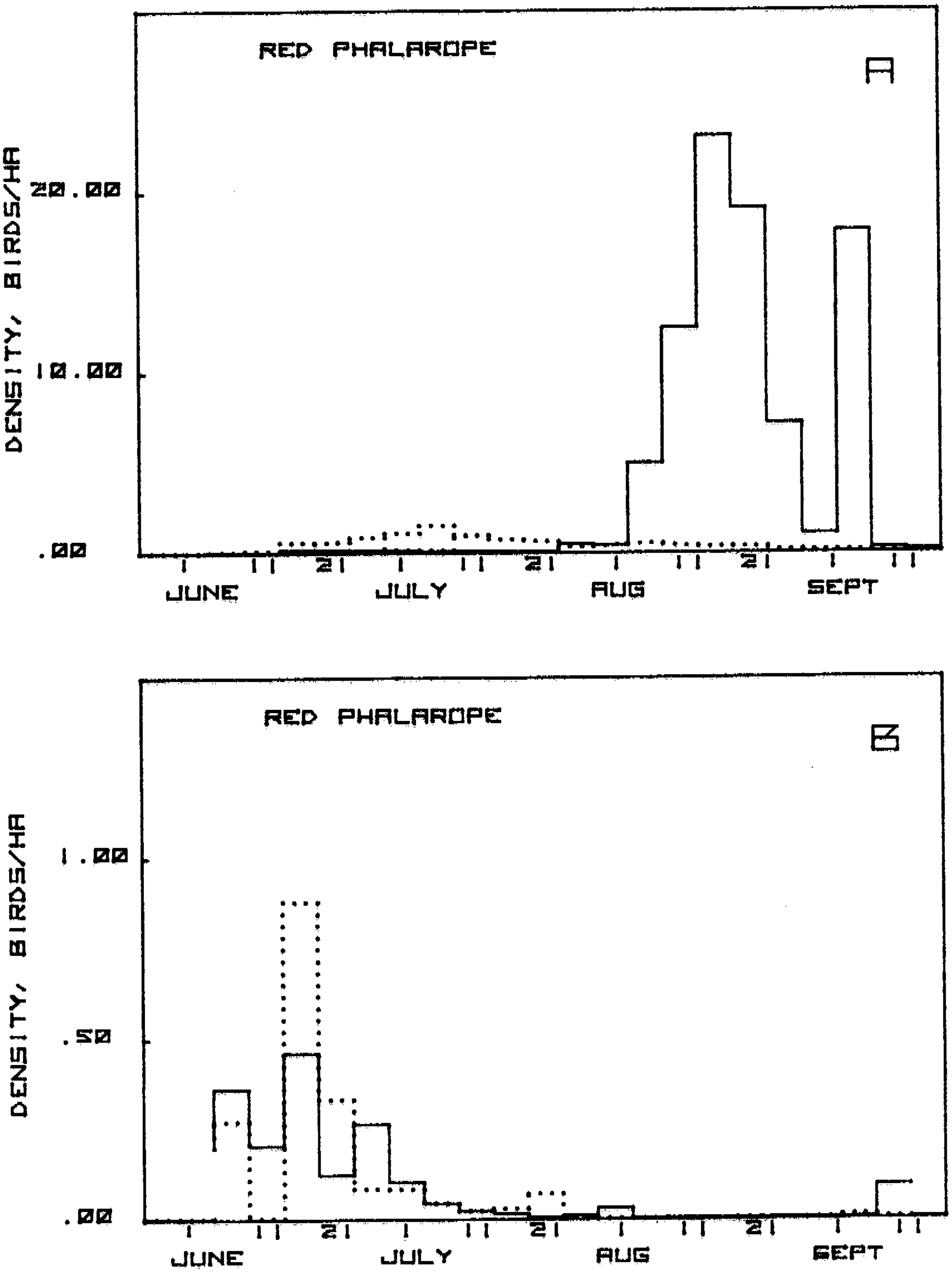


Figure 20. Transect densities, Red Phalarope. A. Barrow, 1976. Littoral (solid) vs. tundra (dotted). B. Wales and Cape Krusenstern 1977. Littoral (solid) vs. tundra (dotted).

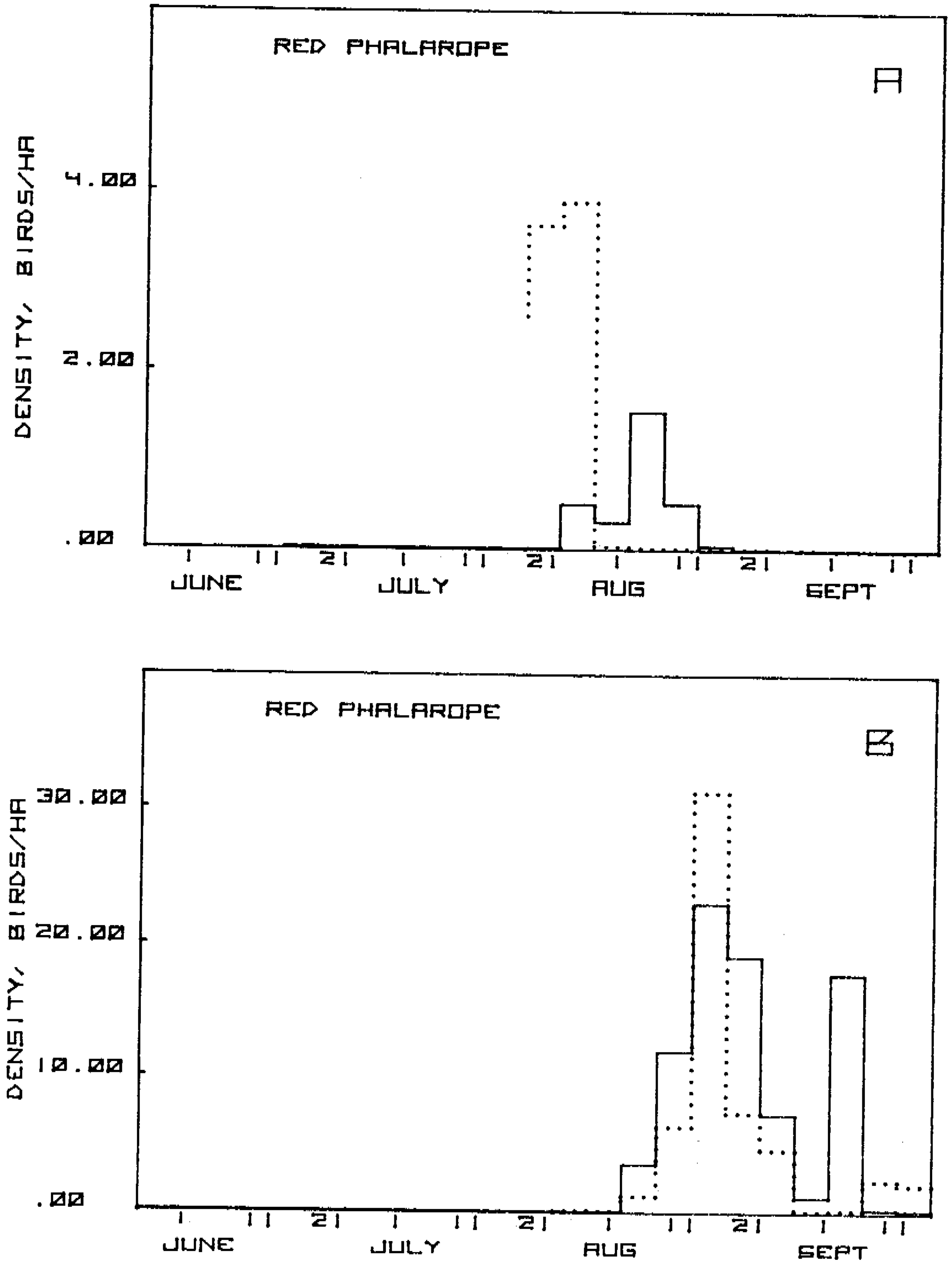


Figure 21. Transect densities, Red Phalarope, Barrow littoral. A. Males 1976 (solid) vs. males 1977 (dotted). B. Juveniles 1976 (solid) vs. juveniles 1977 (dotted).

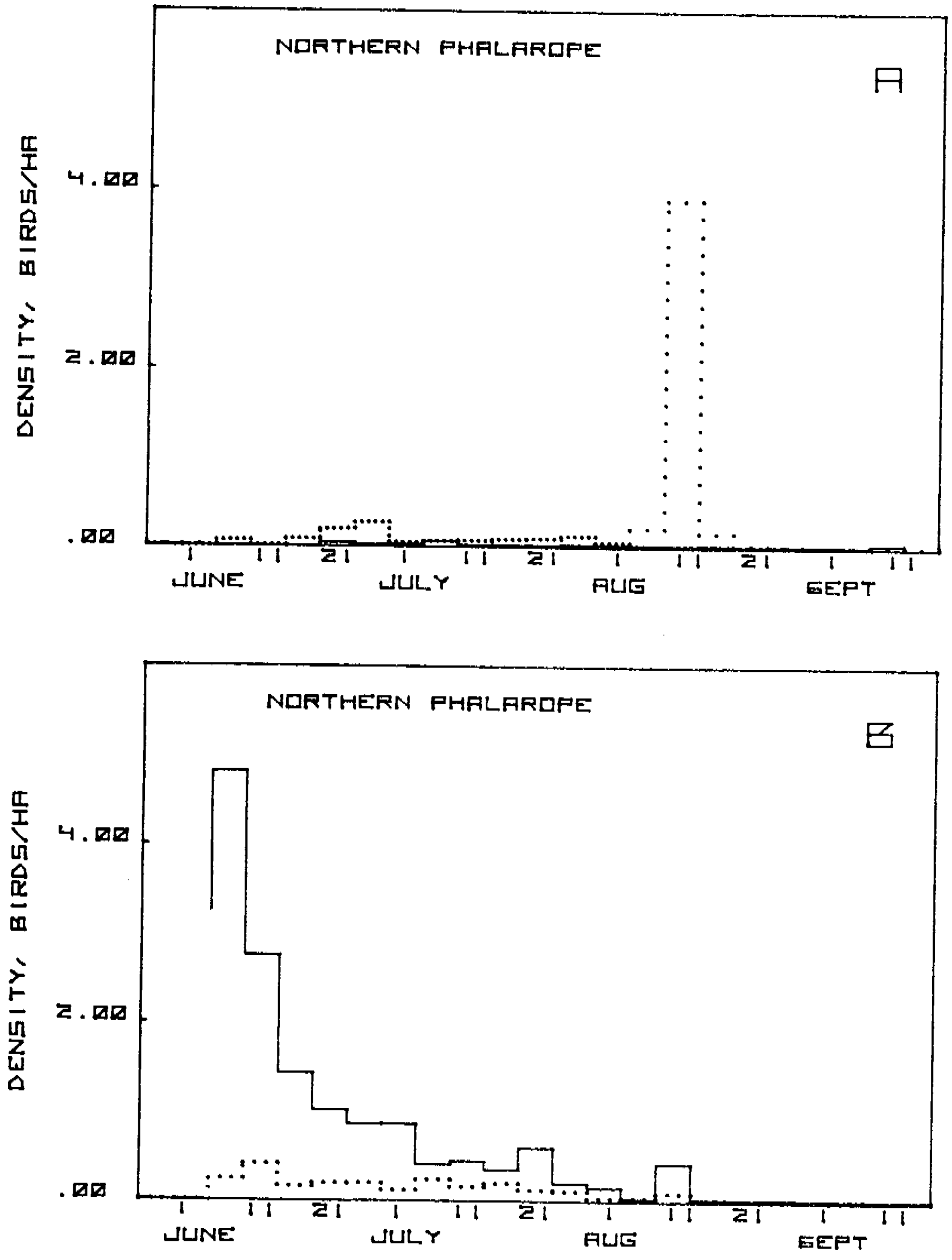


Figure 22. Transect densities, Northern Phalarope, 1977. A. Wales littoral (solid) vs. Wales tundra (fine dotted) vs. Barrow littoral (coarse dotted). B. Cape Krusenstern. Littoral (solid) vs. tundra (dotted).

littoral areas during open water conditions. Highest densities were recorded at Wales (Red-throated Loon, tundra transects, .20 per hectare).

21. Waterfowl (includes ducks, geese and swans). Moderate densities of several species of waterfowl occur at all three sites throughout the summer. Densities increased greatly in late August and early September at Barrow when large flocks of Oldsquaws occurred off Barrow Spit. Brant were most numerous at Icy Cape (Figure 23A).

22. Larus gulls (mainly Glaucous Gull, Larus hyperboreus). Moderately high densities of large gulls occurred on all ocean shorelines during the summer, but densities were consistently less at Cape Krusenstern (Figure 24B).

23. Black-legged Kittiwake (Rissa tridactyla). This species is much more common at Wales than at the other two sites; Wales is closest to nesting colonies (Little Diomede Island). Immature Kittiwakes are common near Barrow but almost absent from Wales and Cape Krusenstern (Figure 24A).

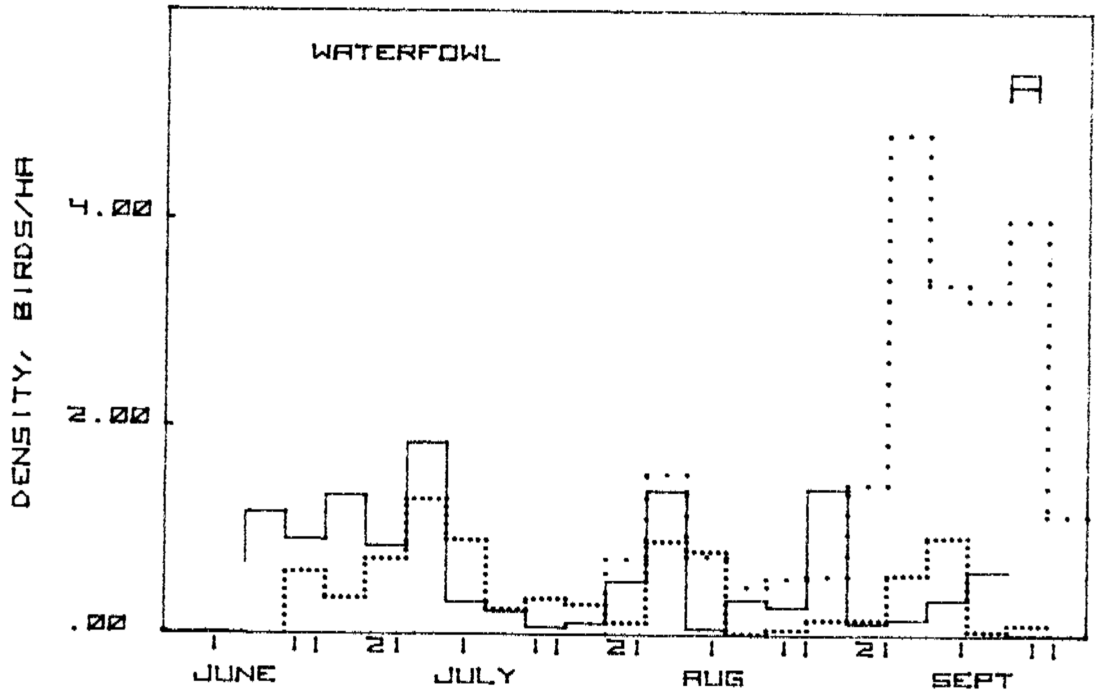
24. Sabine's Gull (Xema sabini). Sabine's Gulls are a prominent member of the group of species which forages heavily on marine zooplankton along Beaufort and Chukchi shorelines in late August and early September. Consistent with the results found for Red and Northern Phalaropes, this species was not seen in numbers prior to the end of the field season on 11 September at either site in the southern Chukchi.

25. Arctic Tern (Sterna paradisaea). Arctic Terns nest in scattered small colonies on beaches and in saltmarsh and lagoon island areas in the Cape Krusenstern region. They were present throughout the summer in densities somewhat higher than those recorded at Wales. The late season concentration of migrating terns at Barrow was much greater than densities recorded at either southern site (Figure 23B).

26. Aleutian Tern (Sterna aleutica). Present and apparently nesting at four sites between Kotzebue and Kivalina, including two areas in the Noatak Delta, one at Cape Krusenstern and one at Tasaychek Lagoon north of Cape Krusenstern. Maximum number of nests was about 10 at any of these colonies, but all colonies represent a northward extension of the known breeding range of this species.

27. Lapland Longspur (Calcarius lapponicus). This very common passerine behaved similarly at all three sites, moving into littoral habitats in late summer when juveniles foraged in flocks prior to southward migration. Figures 25A and 25B contrast the occurrence of adults and juveniles in tundra and littoral habitats at Cape Krusenstern.

28. Snow Bunting (Plectrophenax nivalis). Snow Bunting juveniles also move heavily into littoral areas at Barrow. Densities at Wales were considerably lower than at Barrow. At Cape Krusenstern Snow Buntings did not nest in 1977, and migrants were almost absent during our field season.



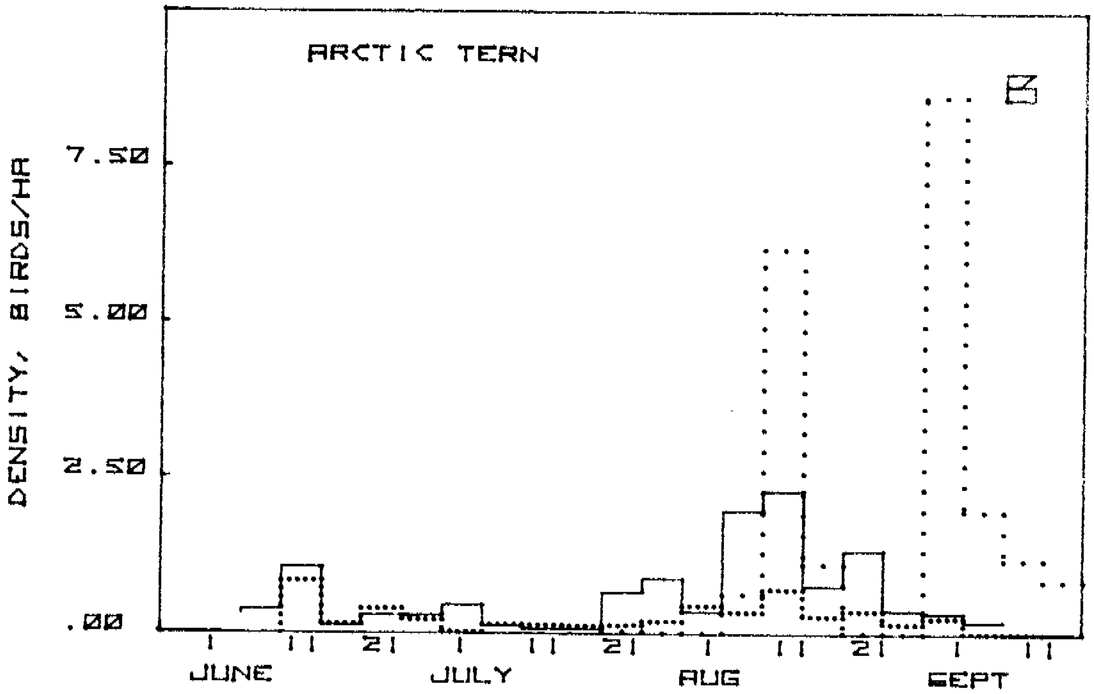


Figure 23. Transect densities, littoral, 1977. A. Waterfowl. Cape Krusenstern (solid) vs. Wales (fine dotted) vs. Barrow (coarse dotted). B. Arctic Tern. Cape Krusenstern (solid) vs. Wales (fine dotted) vs. Barrow (coarse dotted).

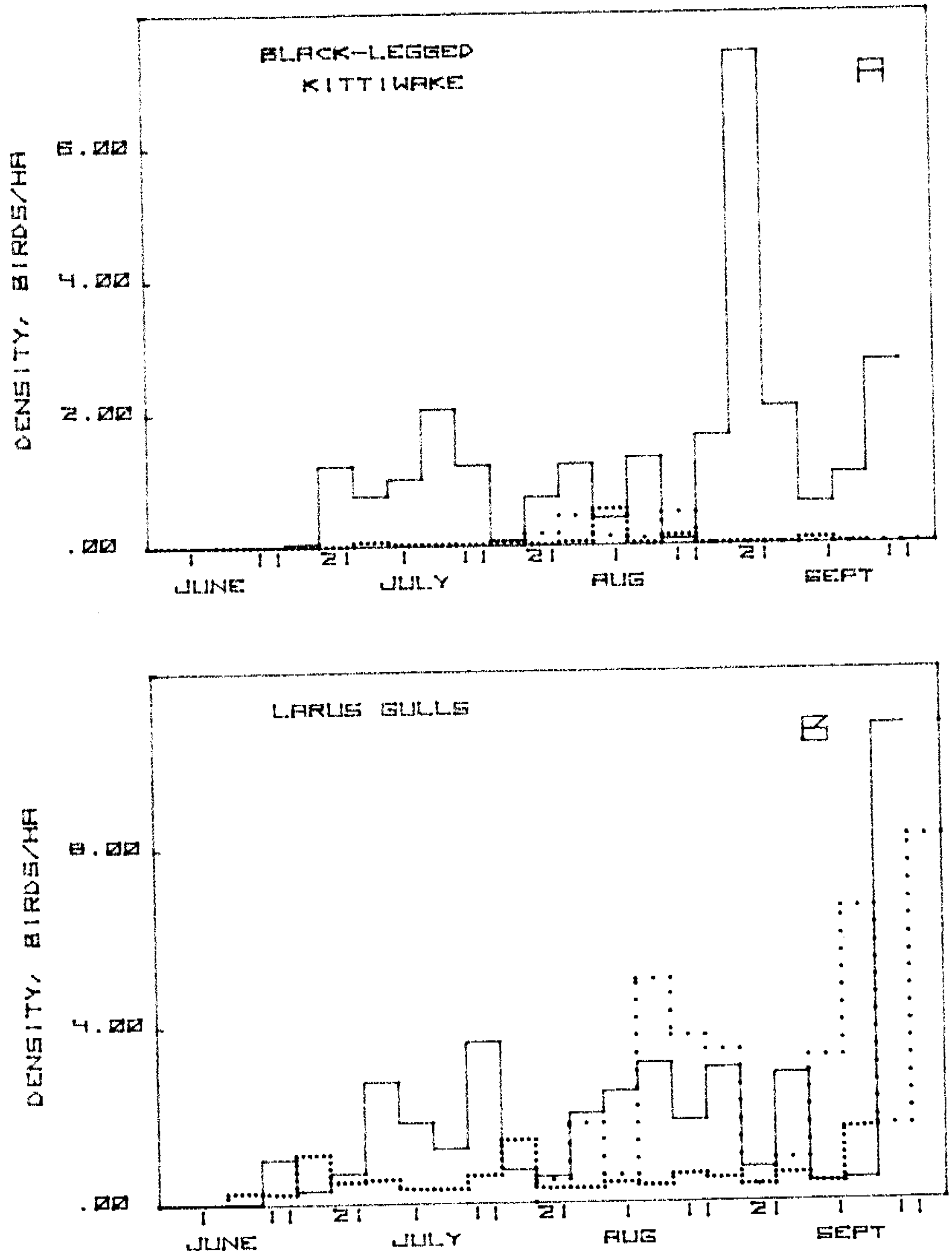


Figure 24. Transect densities, littoral, 1977. A. Black-legged Kittiwake. Wales (solid) vs. Krusenstern (fine dotted) vs. Barrow (coarse dotted). B. Larus gulls. Wales (solid) vs. Krusenstern (fine dotted) vs. Barrow (coarse dotted).

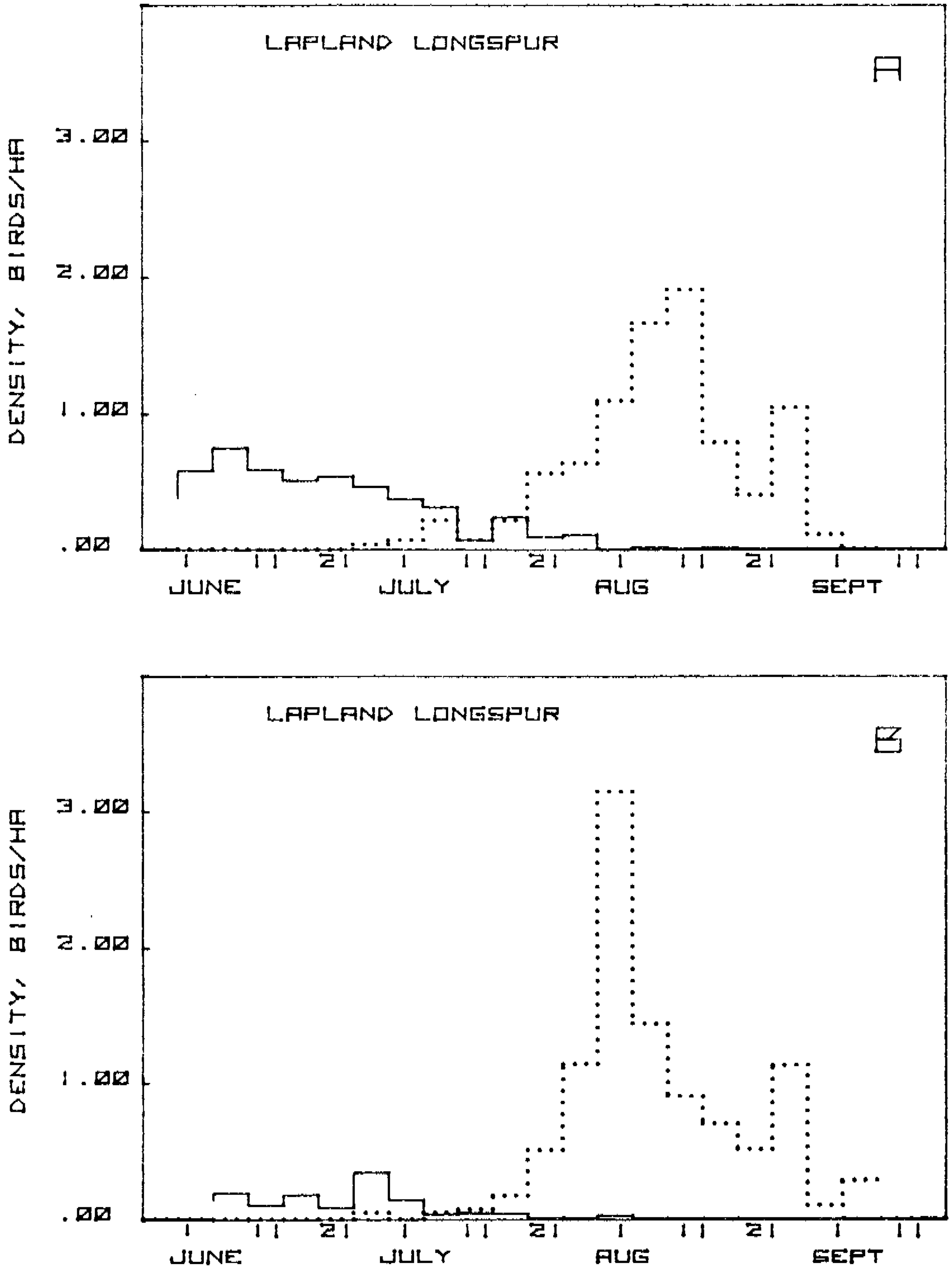


Figure 25. Transect densities, Lapland Longspur, Cape Krusenstern. A. Tundra. Adults (solid) vs. juveniles (dotted). B. Littoral. Adults (solid) vs. juveniles (dotted).

Bird Trophic Studies

In the 1977 season, 61 specimens of 17 shorebird species were collected which had identifiable stomach contents (Table 9 and Appendix 6). The prey items taken are shown in Table 9, along with bird species, station data, and relative per cent of stomach contents. Four phyla of invertebrates (annelids, mollusks, arthropods, and chaetognaths) are represented in the stomach contents, including approximately 14 species of non-insect invertebrates. Seeds from a variety of plants comprise a minor portion of most diets. Arthropods, primarily insects, comprise the majority of prey items.

For 1975 and 1977 at Barrow and Lonely, 20 of 84 specimens (24%) of shorebirds, including 7 of 9 species (78%) had 70% or more of their stomach contents consisting of chironomid flies or larvae. Comparative figures for Wales, Cape Krusenstern, and the Noatak Delta in 1977 are 40 of 54 specimens (74%), including 12 of 17 species (71%). Samples of this type are inevitably biased due to the habitats sampled for shorebirds. Nonetheless, these results correspond with the bird habitat use data discussed earlier in this report. These striking differences are related to the distinct major trophic systems between the Beaufort Sea (Barrow and Lonely) and the southern Chukchi Sea. In the Beaufort Sea, foraging shorebirds heavily use marine shoreline zooplankton, while in the southern Chukchi, closed lagoons, brackish pools, saltmarshes, and mudflats comprise the main focus of foraging birds. Specific comparisons of these habitats, both within and between sites, are shown in Table 10. The marine zooplankton system in the Beaufort is most heavily used by Red and Northern Phalaropes, Ruddy Turnstones, Sanderlings, Baird's Sandpipers, and Dunlins (as well as Arctic Terns and Sabine's Gulls), while the bulk of the foraging activity on the southern Chukchi mudflats is by Dunlins, Western Sandpipers, Semipalmated Sandpipers, Pectoral Sandpipers, Long-billed Dowitchers, and Golden Plovers. However, at any one site within a habitat, birds of several species have frequently been found to utilize the same prey (Table 11).

Plankton Studies

Large marine zooplankters were rare in our studies of nearshore plankton at Barrow, Krusenstern, and Wales, in 1977. The most common zooplankters at all three sites (Table 13) consisted of small hydromedusae and small calanoid copepods, neither of which generally has comprised a major food resource for most shorebirds in our samples. Other relatively common species, which were either localized and/or transitory in the plankton, are given in Table 13. Major descriptive distinctions between plankton stocks at the three sites concern the absence or presence of particular species that showed transitory high numbers. For example, cladocerans were present only at Cape Krusenstern in late July and early August; cumaceans were present only at Wales in early July, while mysids (*Boreo mysis*) were common occasionally at Krusenstern and Wales, but never at Barrow. As another example, *Mysis relicta* occurred only once in early September in relatively high numbers at Wales.

Table 9 Prey Items of Shorebirds, 1977.

Key: "B: 30, 50(2)" = Three birds from Barrow: (indicated food item composing) 30 and 50% (two birds) of relative stomach mass, respectively
B, W, K = Barrow, Wales, Cape Krusenstern
* = observation only, presumed food item collected (no stomach)
\+ = present in stomach, less than 1% of contents

- ANNELIDA: Oligochaeta
  - *Dunlin (W)
  - *Western SP (W)
- MOLLUSCA
  - Bivalvia
    - Musculus sp.
      - Rock SP (W+)
      - Sharp-tailed SP (W:25)
    - undet. sp.
      - Dunlin (K+)
  - Gastropoda
    - undet. sp.
      - Red Knot (W:5)
- ARTHROPODA
  - Crustacea
    - Copepoda
      - calanoid, undet. sp.
        - Red Phalarope (B:+, 100(2))
        - Northern Phalarope (B:100(2); K:15)
    - Cladocera: ephippia
      - Red Phalarope (B:10)
      - Northern Phalarope (B+; K:10)
      - Western SP (W+; K+)
      - Dunlin (K+)
    - Cumacea, undet. sp.
      - RP (W:100)
    - Amphipoda
      - Gammarus sp.
        - Sanderling (W:10)
        - Bar-tailed Godwit (W:100)
      - Dexaminidae, undet. sp.
        - Red Knot (W:10)
      - Calliopiidae, undet. sp.
        - Red Phalarope (W:100)
      - undet. sp.
        - Western SP (K:50)
        - Rock SP (W+)
        - Red Phalarope (B+, W+)
        - Golden Plover (W:25)
      - undet. sp.: amphipod tissue
        - Rock SP (W+)
        - Sharp-tailed SP (W:75)
        - Sanderling (W:50, 100)
        - Dunlin (W:100(2))
        - Baird's Sandpiper (K:90)
    - Decapoda: zoea
      - Western SP (W:96)
  - Insecta: Diptera
    - Chironomidae: larvae
      - Pectoral SP (K:100(2))
      - Western SP (W:100(2); K:100(3), 75, 97)
      - Baird's SP (W:100; K:10)
      - Dunlin (W:100; K:100(11))
      - Red Phalarope (B:10)
      - Long-billed Dowitcher (K:100(3))
  - Insecta: Diptera: adult flies, Chironomidae and other families
    - Western SP (W:4, 100; K:100(2), 49, +)
    - Semipalmated SP (K:100)
    - Least SP (K:85, 100)
    - Dunlin (W:100; K:9)
    - Red Knot (W:90(2); K:100)
    - Sanderling (W:50, 90)
    - Red Phalarope (B:10, +; W:*)
    - Northern Phalarope (K:75, 100, *)
    - Black Turnstone (K:100)
    - Ruddy Turnstone (K:100)
    - *Arctic Tern (K)
- CHAETOGNATHA
  - Sagitta sp.
    - Red Phalarope (B:90)
- PLANTAE: seeds
  - Western SP (K:+(3), 3, 25)
  - Least SP (K:15)
  - Pectoral SP (K+)
  - Dunlin (K:+(2), 90; W:+(2))
  - Long-billed Dowitcher (K:+(2))
  - Red Phalarope (W+; B:+(2))
  - Red Knot (W:+(2))
  - Sharp-tailed SP (W+)

Table 10 Major prey items in two habitat types (Barrow includes 1975, 1976, and 1977 data). (n) = number of birds; * = observation

Ocean Stations			Closed Lagoons, Brackish Pools, and Mudflats		
Barrow	Krusenstern	Wales	Barrow	Krusenstern	Wales
WESTERN SANDPIPER					
	(3) adult flies	(1) decapod zoea	(1) chironomid larvae	(5) chironomid larvae and flies	(3) chironomid larvae and flies (*) oligochaetes, chironomids
DUNLIN					
(2) *Thysanoessa*			(6) chironomid larvae and oligochaetes	(12) chironomid larvae; seeds	(4) chironomid larvae and flies; amphipods (*) oligochaetes
SANDERLINGS					
(10) *Thysanoessa*, *Apherusa*		(3) adult flies; amphipods	(1) chironomid larvae; seeds		
RUDDY TURNSTONE					
(3) *Thysanoessa*	(1) flies		(4) chironomid larvae; oligochaetes		

	Ocean Stations			Closed Lagoons, Brackish Pools, and Mudflats		
	Barrow	Krusenstern	Wales	Barrow	Krusenstern	Wales
RED PHALAROPES						
	(27) *Onisimus*, *Apherusa*, euphausiids, calanoids, Zoea, *Sagitta*, *Spiratella*, insects, seeds		(2) cumacea; amphipods	(10) calanoid copepods; chironomids		(*) chironomid flies
NORTHERN PHALAROPES						
		(*) flies		(2) calanoid copepods	(3) chironomid flies, calanoids, ephippia	

Table 11 Bird species utilizing the same prey resource at the same time and place. B, Barrow; W, Wales; K, Cape Krusenstern.

Prey Item	Location	Birds Feeding on Prey Item	Date
Oligochaeta	B: GF/CB pool	Ruddy Turnstone Red Phalarope	11 Aug 76
Bivalvia: *Musculus* sp.	W: NL/SM	Rock SP Sharp-tailed SP	3 Sep 77
Copepoda: calanoids	B: MSE	Red Phalarope Northern Phalarope	8 Aug 77
Amphipoda: tissue, undet. sp.	W: NL/SM	Rock SP Sharp-tailed SP Golden Plover	3 Sep 77
	K: N of SB	Baird SP Western SP	28 Jul 77
Onisimus litoralis	B: BD	Red Phalarope Baird SP	1 Aug 76
Euphausiacea: *Thysanoessa raschii*	B: WS	Sanderling Dunlin Ruddy Turnstone	17 Aug 76
	B: BSS	Red Phalarope Ruddy Turnstone	14 Aug 76
Insecta: chironomid larvae	W: VS	Western SP Dunlin	23 Jul 77
	K: NF	Pectoral SP Long-billed Dowitcher	15 Jul 77
	K: Tasaychek Lagoon	Dunlin Western SP	21 Jul 77
	K: Noatak Delta	Dunlin Long-billed Dowitcher	2 Sep 77
	B: BP	Ruddy Turnstone Semipalmated SP	29 Jul & 30 Jul 76

Prey Item	Location	Birds Feeding on Prey Item	Date
Insecta, continued			
	B: NSL	Dunlin Semipalmated SP	3 Aug 76
adult flies	K: Tasaychek Lagoon	Western SP Least SP Ruddy Turnstone Red Phalarope	1 Aug 77

Comparisons between the 1976 and 1977 Barrow seasons are difficult because of the striking differences in species composition and abundance. Table 5 (page 47) of our 1977 report (for 1976) contrasted Sagitta, Calanus, and decapod zoea for 1975 and 1976. In 1977, Sagitta and decapod zoea were present in small numbers only once each in mid-August, while small (approximately 1 mm in length) calanoid copepods occurred in consistently very large numbers (many times that of either 1975 or 1976) at Barrow from mid-August through early September. Euphausiids (Thysanoessa) were strikingly absent in our 1977 Barrow shoreline samples.

Because of limited sampling in 1977 directed to specific synchronous samples of birds with co-occurring plankton stocks, analysis of correlations between diet (stomach contents) and resources (plankton) is limited. Thus, five specimens of Red Phalaropes, Dunlins, Baird's Sandpipers, and Western Sandpipers, at Barrow, Wales, and Cape Krusenstern show a limited correlation between prey and plankton resources (Table 12), but do not permit any analysis of prey selection by the birds.

Because of the high variability in plankton composition which we have found at each site within a season and between seasons at Barrow, and within and between stations at Barrow, comparisons between sites based on a single year's data are tenuous. Therefore we are unable to state whether the lack of a heavy late summer occurrence of zooplankton-foraging shorebirds, gulls, and terns in the southern Chukchi relates to differences in availability of zooplankton prey between northern and southern sites. In 1977 at least, simple explanations were not evident from our plankton sampling.

Premigratory Fat Deposition by Shorebirds

Fat conditions of collected bird specimens are included in Appendix 6. The OCS Fat Code can be compared to a scale similar to that of McCabe (1943) with the following definitions: Code 2, little fat; Code 3, moderate fat; Code 4, very fat; Code 5, excessive fat. Combining these data with data from 1975 and 1976 supports the trends suggested last year. Considerable variation in fat accumulation schedule exists among the species for which we have sufficient samples. Juvenile Semipalmated and Western Sandpipers have low fat levels (mean scores 2.6 and 2.0, respectively); both species leave the Arctic in late July and early August, and must replenish fat supplies at foraging sites during migration. Red Phalarope juveniles and all ages of Dunlins have low fat levels in early August, but our data show an increase in fat score with date after August 1 (Red Phalarope, $\bar{x} = 2.6$, Spearman Correlation Coefficient $r_s = .40$, $p<.01$; Dunlin, $\bar{x} = 2.5$, $r_s = .41$, $p<.05$). This suggests strongly that the long period in which these species forage in arctic habitats is important for the deposition of fat prior to southward migration. Arrival of these species at the latitude of California occurs in middle October or later in most years, considerably delayed compared to Sanderlings and Ruddy Turnstones. These latter species apparently accumulate higher fat reserves during August (Sanderling $\bar{x} = 3.8$; Ruddy Turnstone $\bar{x} = 3.3$) and migrate southward more rapidly.

Table 12 Comparison of prey (stomach and esophageal contents) and corresponding plankton samples.

Rare $< 10/m^3$

PREY					PLANKTON			
Station, Date	Species	No.	Size (mm)	% Total Mass	Station, Date	Species	$\#/m^3$	Size (mm)
BARROW (1) Red Phalarope: GF, 24 Aug 77	Sagitta	c.4	8-10	90	WS, 24 Aug	calanoid copepods	3,952	1+
	fly fragments	--	2-3	10				
	calanoid copepods	c.3	c.2	in esophagus				
WALES (2) Red Phalarope: BD, 2 Sept 77	Calliopiid amphipods, amphipod tissue and fragments	--	--	100	BD, 2 Sept.	calanoid copepods	124	1.0
						Sagitta	24	5-10
						echinoderm larvae	14	1.0
						rare: Calliopiidae ($6/m^3$) and other gammarids		
(3) Dunlin: EL, 9 Sept 77	gammarid amphipod tissue	--	--	100	SL, 9 Sept	Mysis relicta	368	10-30
						Gammarus (rare: $6.3/m^3$)	--	4-6
KRUSENSTERN (4) Baird sp.: 1 km N of camp 29 July 77	gammarid amphipod tissue	--	--	90	SB, 27 July	calanoid copepods	24	1.0
						rare: juvenile gammarids ($3.2/m^3$)		

(TABLE 12 cont'd)

	chironomid larvae fragments	--	--	10			
(5) <u>Western SP:</u> (as (4))	gammarid juveniles	c.3	4-5	50	(as 4)		
	adult flies and fragments	c.2	5	49			
	seeds	7	1.5	1			

Table 13 Most common zooplankton at Barrow, Cape Krusenstern, and Wales, 1977 (species occurring more than once at numbers greater than $10/m^3$).

( ) = station and number/m^3

Species	Barrow	Krusenstern	Wales*
Coelenterata			
Hydromedusae	4 Aug (BS, 25) 24 Aug (BSS, 357)	13 Aug (NB, 12)	31 July (NB, 37; BD, 94) 19 Aug (SL, 22) 30 Aug (SL,38; NL, 14)
Mollusca			
Spiratella helicina	3 Aug (BSS, 16) 14 Aug (BS, 21)		
Crustacea			
cladocerans		23 July (NB: 794) 1 Aug (NB: 48)	
cumaceans			12 July (SB, 149; NB: 21)
calanoid copepods	14 Aug (BS: 306; WS: 101; PS:6786; BSS: 4311) 24 Aug (WS: 3952; PS: 516) 29 Aug (BS: 14; WS:7258; BSS: 54)	15 July (SB: 635) 23 July (NB: 238) 27 July (SB: 24) 1 Aug (NB: 556) 4 Aug (NB: 397) 13 Aug (NB: 36) 21 Aug (NB: 76) 1 Sept (SB:>1350; NL: 289)	11 July (SL: 190) 12 July (NB:794; NL: 476) 21 July (SL: 10, 100; SB: 190; NB: 95; NL: 1587) 30 July (SL:5630; SB:20 31 July (NL: 1138; NB: 278; BD: 556) 4 Aug (SL: 12, 640) 10 Aug (NL: 1, 110; SB: 29) 20 Aug (SB: 570) 2 Sept (NB: 124; SB: 49) 11 Sept (NL: 19)

(TABLE 13, cont'd)

Species	Barrow	Krusenstern	Wales
gammarid amphipods, juvenile, unidentified		1 Aug (NB: 21) 21 Aug (NB: 19)	12 July (SB: 19, NL: 78)
mysids: <u>Boreomysis</u> sp.		23 July (NL: 102) 1 Aug (NL: 12)	4 Aug (SL: 205) 11 Sept (NL: 33)
Chaetognatha			
<u>Sagitta</u> sp.	14 Aug (WS: 20) 4 Sept (BSS: 113)		30 July (SB: 10) 2 Sept (NB: 24)
Appendicularia			
<u>Oikopleura</u> sp.	3 Aug (BSS:968) 4 Aug (BS:933)		

* SB, South Sea Beach
NB, North Sea Beach

Phalarope Foraging in Relation to Wind Direction

The distribution of juvenile Red Phalaropes foraging along the shores of Barrow Spit, when compared to the concurrent wind direction, showed strong contrasts between 1975 and 1976. In 1975, the correlation between per cent of birds on each shore and the number of degrees deviation from onshore wind direction was high (Spearman r = .811, p<.001). This suggested a reason for the high use of spits and barrier islands by shoreline zooplankton foraging birds: these structures offer a protected shore during more different wind conditions than do mainland shores.

In 1976, however, the correlation vanished (r = -.015, p>.50). We interpret this as arising from the generally much lower concentrations of shoreline zooplankton in 1976, combined with the presence of broken ice grounding on the beaches during most wind conditions. The grounding ice released under-ice amphipods, providing an alternate food source available only on the exposed shores. Grounding ice was present during August in 1975 and 1976. Thus the lower concentrations of marine zooplankton (copepods, euphausiids, decapod zoea, chaetognaths) in 1976 produced a change in phalarope foraging behavior, in this interpretation.

In 1977, the correlation improved considerably (r = .443, p<.07) but did not match the 1975 data. Concentrations of marine zooplankton along the Barrow Spit shorelines were low (Table 13), but grounded ice was not available during August of 1977. With no alternate food source, the birds apparently followed the 1975 pattern, which presumably optimizes foraging efficiencies on the marine zooplankton resource.

VIII. Conclusions

Many of the conclusions from this study have been presented in sections I and VII. Only the major points will be summarized here.

In the Beaufort and northern Chukchi, the general pattern of seasonality in habitat use by shorebirds, gulls, and terns was similar to that of previous years, with heavy use of littoral areas developing in August and September. Timing and magnitude of several species movements differed considerably, however.

The trophic system of principal activity in the Beaufort littoral zone involves foraging by many species on marine zooplankton along shorelines. In the southern Chukchi, the greatest activity centers on mudflats and saltmarsh areas, where high concentrations of several shorebird species forage on benthic invertebrates. This difference between areas implies corresponding differences in the sensitivity of bird populations to environmental disturbances.

In Table 14 we categorize the seasonal habitat use patterns of common Barrow shorebirds, based on 1975 and 1976 data. From these and from subsequent 1977 data, we have refined two tables (15 and 16) presented in a similar form in the 1977 annual report. These present rankings of the relative susceptibilities of Barrow shorebirds to disturbances associated with OCS development. Our studies in Kotzebue Sound and on Seward Peninsula indicate higher relative susceptibilities in those areas for Golden Plover and Pectoral Sandpiper, and possibly also for Western Sandpiper, Long-billed Dowitcher, and Dunlin.

Table 14. Habitat use patterns of common shorebirds near Barrow, Alaska. (T = Tundra; L = Littoral) (from Connors *et al.* 1978)

Category	Breeding	Post-breeding Adult	Post-fledging Juvenile	
I	T	T	T	Golden Plover, Pectoral Sandpiper
II	T	T+L	T+L	Dunlin, Long-billed Dowitcher
III	T+L	T+L	T+L	Western, Semipalmated, Baird's Sandpipers
IV	T	T+L	L	Red Phalarope, Ruddy Turnstone, Sanderling

IX. Needs for Further Study

In three seasons of work in the Arctic on RU #172, we have identified as a critical biological system the late summer concentrations of several species of birds foraging along gravel shorelines of spits and barrier islands in the Beaufort Sea. Both Red and Northern Phalaropes, as well as several other species of shorebirds, gulls, and terns are dependent upon a prey base of marine zooplankton for accumulation of energy reserves prior to southward migration. But the density and composition of the zooplankton community near Barrow has been extremely variable over the past three summers, with corresponding variations in the foraging behavior of some bird species. We do not yet understand the causes of this variability; nor do we know how flexible birds are to these fluctuations or to potentially greater fluctuations which may occur in the future as a result of oil development in the Beaufort. We need to increase our understanding of this trophic system in order to predict the probable effects of potential environmental insults to the system.

Table 15 Shorebirds potentially affected by oil development near Barrow, Alaska (from Connors *et al*. 1978).

COASTAL PLAIN TUNDRA		LITTORAL AND OFFSHORE
Lowland	Upland	
Red Phalarope	Golden Plover	Red Phalarope
Pectoral Sandpiper	Ruddy Turnstone	Northern Phalarope
Long-billed Dowitcher	Semipalmated Sandpiper	Sanderling
?	Baird's Sandpiper	Ruddy Turnstone
?	Dunlin	Semipalmated Sandpiper
	?	Western Sandpiper
	?	Baird's Sandpiper
		Dunlin
		Long-billed Dowitcher
		?
		?

Table 16 Relative susceptibility of common Barrow shorebirds to littoral zone disturbances (from Connors *et al*. 1978).

High	Moderate	Low
Red Phalarope	Semipalmated Sandpiper	Golden Plover
Sanderling	Western Sandpiper	Pectoral Sandpiper
Ruddy Turnstone	Baird's Sandpiper	
	Dunlin	
	Long-billed Dowitcher	

A second trophic system has emerged from our 1977 studies in the southern Chukchi (and from Mickelson et al. 1977) as parallel in importance to the Beaufort zooplankton system. Large numbers of several species of shorebirds forage during July, August, and September on tidal mud and sand flats and in saltmarshes in Kotzebue Sound and along the north shore of Seward Peninsula. Benthic invertebrates are the prey base supporting these bird populations, and the entire system is potentially very vulnerable to the effects of spilled oil. At present we know very little of the prey community structure, the trophic dependencies or energetic requirements of the foraging birds, or even the geographic or seasonal extent of this phenomenon. Although this occurs outside any presently planned lease areas, the potential interactions involving transport between the Bering Sea and the Beaufort lease area argue for continued study in the Chukchi.

Finally, in all areas where significant populations may face disturbances, we need to know specifically what the disturbances will be and how severe will be the resultant population effects. Comparison of bird use in disturbed and undisturbed habitats, as well as study of the impact of actual environmental results, planned or unplanned, and of the recovery of populations following such impacts promises to be extremely useful in meeting OCSEAP objectives.

X. Fourth Quarter Operations

1. Field Schedule.

   No field activities during this quarter.

2. Scientific party.

   Peter G. Connors, University of California Bodega Marine Laboratory, research coordinator.
   James T. Carlton, University of California, Davis, research assistant.
   Carolyn S. Connors, Bodega Marine Laboratory, research assistant.
   Katherine Hirsch, University of California, Davis, research assistant.
   Douglas Woodby, University of California, Davis, research assistant.
   Eileen Kiera, Western Washington University, research assistant.

3. Methods.

   Laboratory analysis:

   (1) Summary and computer plotting of shorebird seasonal distributions.

   (2) Continuing analysis of bird data.

   (3) Final analysis and identification of invertebrates in stomach samples and plankton samples.

   (4) Interpretation of results and preparation of annual report.

4. Sample localities.

   None.

5. Data analyzed.

   (1) Analysis of data from 11 bird surveys.

   (2) Analysis and identification of 200 bird stomach and invertebrate samples.

   (3) Analysis of 1100 transect censuses.

   (4) Identifications of 60 saltmarsh specimens.

6. No serious problems encountered.

7. Total funds expended, 1 April 1975 - 28 February 1978: $105,657.

Appendix 1 Birds of Cape Krusenstern and Wales, Alaska.

The following list presents the status of bird species observed in the vicinities of Cape Krusenstern and Wales, Alaska (see map, figure 1) between 26 May 1977 and 11 September 1977. Status categories are:

RB, rare breeder: 1 or 2 nests (or broods) located in 1977.
CB, common breeder: 2 nests or territories located in 1977.
PB, probable breeder: breeding suspected, but no nests located.
CM, common migrant: present on at least 5 days; at least 10 individuals.
V, visitor: includes less common migrants and stragglers.

The second column lists additional species reported as nesting occasionally at Cape Krusenstern in other years by W. Robert Uhl in *Subsistence Use Patterns in the Proposed Cape Krusenstern National Monument* (approximate title). Report to the National Park Service, 1977.

	Cape Krusenstern		
	1977 Status	Additional breeders other years (Uhl 1977)	Wales 1977 Status
Common Loon, *Gavia immer*	V		V
Yellow-billed Loon, *G. adamsii*	V		PB
Arctic Loon, *G. arctica*	CB		PB, CM
Red-throated Loon, *G. stellata*	CB		CB
Horned Grebe, *Podiceps auritus*	V	X	
Red-necked Grebe, *P. grisegena*	V		
Short-tailed Shearwater, *Puffinus tenuirostris*	V		CM
Pelagic Cormorant, *Phalacrocorax pelagicus*			PB, CM
Whistling Swan, *Olor columbianus*	RB		RB
Canada Goose, *Branta canadensis*	CM	X	CM
Brant, *Branta bernicta*	CM	X	CM
Emperor Goose, *Philacte canagica*			PB, CM
White-fronted Goose, *Anser albifrons*	CM	X	RB
Snow Goose, *Chen caerulescens*	CM		V
Mallard, *Anas platyrhynchos*	CM	X	V
Pintail, *A. acuta*	CB		CB
Green-winged Teal, *A. crecca*	CM	X	PB
American Wigeon, *A. americana*	CM		
Northern Shoveler, *A. clypeata*	CM		V
Redhead, *Aythya americana*	V		
Canvasback, *A. valisineria*	CM		
Greater Scaup, *A. marila*	RB, CM		
Oldsquaw, *Clangula hyemalis*	CB		CB
Harlequin Duck, *Histrionicus histrionicus*	V		V
Steller's Eider, *Polysticta stelleri*			CM
Common Eider, *Somateria mollissima*	CB		CB

King Eider, *Somateria spectabilis*	V		CM
Spectacled Eider, *S. fischeri*	V		PB, CM
White-winged Scoter, *Melanitta deglandi*			V
Surf Scoter, *M. perspicillata*	CM		
Black Scoter, *M. nigra*	V	X	V
Red-breasted Merganser, *Mergus serrator*	CM	X	CM
Sharp-shinned Hawk, *Accipiter striatus*			V
Red-tailed Hawk, *Buteo jamaicensis*	V		V
Golden Eagle, *Aquila chrysaetos*			V
Marsh Hawk, *Circus cyaneus*	V		
Gyrfalcon, *Falco rusticolus*	V		V
Peregrine Falcon, *Falco peregrinus*	V		
Willow Ptarmigan, *Lagopus lagopus*	CB		V
Rock Ptarmigan, *Lagopus mutus*			PB, V
Sandhill Crane, *Grus canadensis*	CB		RB, CM
Semipalmated Plover, *Charadrius semipalmatus*	RB		PB
American Golden Plover, *Pluvialis dominica*	CB		CB
Black-bellied Plover, *Pluvialis squatarola*	RB		V
Ruddy Turnstone, *Arenaria interpres*	V		PB, CM
Black Turnstone, *Arenaria melanocephala*	CM		
Common Snipe, *Capella gallinago*	CB		V
Whimbrel, *Numenius phaeopus*	RB, CM		V
Greater Yellowlegs, *Totanus melanoleucus*			V
Tattler, *Heteroscelus* sp.			V
Red Knot, *Calidris canutus*	CM		CM
Rock Sandpiper, *C. ptilocnemis*	V		CB
Sharp-tailed Sandpiper, *C. acuminata*	V		CM
Pectoral Sandpiper, *C. melanotos*	RB, CM		CB
Baird's Sandpiper, *C. bairdii*	RB		V
Least Sandpiper, *C. minutilla*	V		
Rufous-necked Sandpiper, *C. ruficollis*	V		PB
Dunlin, *C. alpina*	CB		CB
Sanderling, *C. alba*	V		CM
Semipalmated Sandpiper, *C. pusilla*	CB		CB
Western Sandpiper, *C. mauri*	CB		CB
Stilt Sandpiper, *Micropalama himantopus*	V		
Buff-breasted Sandpiper, *Tryngites subruficollis*	V		
Ruff, *Philomachus pugnax*			V
Long-billed Dowitcher, *Limnodromus scolopaceus*	CB		CB
Bar-tailed Godwit, *Limosa lapponica*	PB, CM		RB, CM
Hudsonian Godwit, *L. haemastica*	V		V
Red Phalarope, *Phalaropus fulicarius*	CM		CB
Northern Phalarope, *Lobipes lobatus*	CB		CB
Pomarine Jaeger, *Stercorarius pomarinus*	CM		CM
Parasitic Jaeger, *S. parasiticus*	CM		CM
Long-tailed Jaeger, *S. longicaudus*	PB, CM		PB, CM
Glaucous Gull, *Larus hyperborea*	CB		CB
Glaucous-winged Gull, *L. glaucescens*			CM
Slaty-backed Gull, *L. schistisagus*			V
Herring Gull, *L. argentatus*	V		CM
Mew Gull, *L. canus*	PB, CM		V
Black-legged Kittiwake, *Rissa tridactyla*	CM		CM

Sabine's Gull, Xema sabini	V	V
Arctic Tern, Sterna paradisaea	CB	CB
Aleutian Tern, S. aleutica	CB	
Common Murre, Uria aalge)	CM	CM
Thick-billed Murre, U. lomvia)		CM
Black Guillemot, Cepphus grylle	V	
Least Auklet, Aethia pusilla		V
Horned Puffin, Fratereula corniculata		CB
Tufted Puffin, Lunda cirrhata		V
Snowy Owl, Nyctea scandiaca	V	V
Short-eared Owl, Asio flammeus	V	
Common Flicker, Colaptes auratus	V	
Eastern Kingbird, Tyrannus tyrannus	V	
Say's Phoebe, Sayornis saya	V	
Olive-sided Flycatcher, Nuttallornis borealis		V
Horned Lark, Eremophila alpestris	V	
Tree Swallow, Iridoprocne bicolor	RB	CM
Bank Swallow, Hirundo rustica	V	
Common Raven, Corvus corax	RB	PB
Gray-headed Chickadee, Parus cinctus	V	
Swainson's Thrush, Catharus ustulatus	V	V
Gray-cheeked Thrush, C. minimus		V
Wheatear, Oenanthe oenanthe	CM	CM
Bluethroat, Luscinia svecica	V	V
Arctic Warbler, Phylloscopus borealis	V	V
White Wagtail, Motacilla alba		CB
Yellow Wagtail, Motacilla flava	PB	CM
Water Pipit, Anthus spinoletta	V	CM
Red-throated Pipit, Anthus cervinus	V	PB, CM
Orange-crowned Warbler, Vermivora celata		V
Yellow Warbler, Dendroica petechia	V	
Northern Waterthrush, Seiurus noveboracensis		V
Wilson's Warbler, Wilsonia pusilla	V	V
Brown-headed Cowbird, Molothrus ater		V
Redpoll, Acanthis sp.	PB	CM
Savannah Sparrow, Passercula sandwichensis	CB	PB, CM
Dark-eyed Junco, Junco hyemalis		V
Tree Sparrow, Spizella arborea	V	V
White-crowned Sparrow, Zonotrichia leucophrys	PB	CM
Lapland Longspur, Calcarius lapponicus	CB	CB
Snow Bunting, Plectrophenax nivalis	V	CB
Total species recorded, 1977:	95	96

Appendix 2 Phenology. Cape Krusenstern, 1977.

Date	Observations
21 May	First Sandhill Crane egg (W. R. Uhl report).
27	Tundra snow cover less than 10%; large ponds still frozen; most shorebirds present, displaying.
29	Pintails, Lapland Longspurs with nests; some shorebirds may have nests.
2 June	*Pedicularis kanei* first flowering.
6	*Caltha palustris* first flowering.
8	First completed nests of Semipalmated Sandpiper, Western Sandpiper, Golden Plover, Whimbrel located.
10	First Chironomid adults; *Potentilla villosa* and *Parrya nudicaulis* first flowering.
14	First eggs of Arctic Tern, Oldsquaw; Lapland Longspur hatched; *Myosotis alpestris* first flowering.
17	Krusenstern Lagoon 70% ice covered; about 30 species flowering.
20	Ocean ice at 1 km from shore.
23-27	First chicks of Dunlin, Western Sandpiper, Semipalmated Sandpiper, Long-billed Dowitcher, Golden Plover, Black-bellied Plover; first flowering of *Tripleurospermum phaeocephalum*.
5 July	First heavy mosquito day.
10	First Arctic Tern chick.
18	Flocking juvenile Semipalmated and Western Sandpipers common.
20	Last ice washed up on shore.
28	First flying juvenile Arctic Tern.
10 Aug	Last annoying mosquito day.
29	First migrant Sharp-tailed Sandpiper.
8 Sept	Most of *Betula*, *Salix*, *Arctostaphylos* recently changed to fall colors of red and yellow.

Appendix 3 Phenology. Wales, 1977.

Date	Observations
2 June	Tundra snow cover 90%; shorebirds on open tundra patches and in flocks on mud by stream.
10	Snow cover 80%; small ponds melting; passerines and shorebirds beginning to nest.
16	First flowering: *Pedicularis kanei*.
20	Low tundra free of snow; 10% remains on slopes; ocean ice decomposing rapidly. Black-legged Kittiwakes, Glaucous Gulls, Murres common near shore.
25	*Parrya nudicaulis* first flowering.
27	*Caltha palustris* first flowering.
30	Lagoon free of ice; sea ice almost gone; shorebird hatching begins. *Potentilla villosa* first flowering.
10 July	Male Oldsquaw and eiders rafting on lagoon; passerines fledging; shorebirds mostly with chicks.
20	Semipalmated and Western Sandpipers fledged. Flocks of adult Long-billed Dowitchers; juvenile Western Sandpipers feeding on mudflats.
30	Juvenile Dunlins feeding in littoral areas. Western and Semipalmated Sandpipers gone.
20 Aug	Arctic Terns migrating offshore. Brant becoming common; Sharp-tailed Sandpipers appear in flocks; Dunlin, juvenile Golden Plovers and Long-billed Dowitchers still common.
10 Sept	Most shorebirds gone; influx of Dunlin and Red Phalaropes along lagoon shore. Cranes migrating eastward.

Appendix 4 Breeding Bird Census, Cape Krusenstern, Alaska, 1977.

Wet Coastal Tundra---Location: Alaska, Cape Krusenstern, 55 km NW of Kotzebue; 67°7'11"N, 163°42'31"W; Noatak (A-4) Quadrangle, USGS. Continuity: New. Size: 29.8 ha (73.6 acres); rectangular, 350 m x 850 m, surveyed and gridded at 50 m intervals. Description of Plot: Crossed by a series of approximately 13 parallel low ridges (up to 2 m above troughs) of gravel formed as former ocean beaches. One pond (area = 1 ha), partially in plot, plus many shallow water troughs, mainly with emergent vegetation. Ridge vegetation, in decreasing order of area covered: Lichens (several species), Crowberry (*Empetrum nigrum*), Dwarf Birch (*Betula nana*), Willow (*Salix*, several species), moss (several species), *Potentilla villosa*, River Beauty (*Epilobium latifolium*). Dominant emergent in troughs is *Carex aquatilis*, with other sedges (*Carex*), Willow (*Salix*) and grasses (*Arctagrostis latifolia* and others). Other wet areas are mainly Dwarf Birch, willow, moss, sedges and grasses. By area, open water covers 5%, dry ridges 53%, emergent vegetation 20% and other wet tundra 22%. Plant names are from E. Hultén, *Flora of Alaska*, 1968. Edge: Similar beach ridge tundra continues on three sides; to the west, the present ocean beach is 200 m from the plot. Topography: Flat tundra, a series of beach ridges between the ocean and a large brackish lagoon. Maximum elevation 8 m (25 ft.); higher land (more than 100 m) beginning 7 km inland. Weather: June was unusually clear and dry. Average June temperature (mean of daily maxima and minima) was 5.2°C (41.3°F). Temperature range -3.3 to 17.8°C (26 to 64°F). Total rainfall .28 in. Snow cover less than 10% by 28 May 1977. Coverage: Censuses on 3, 8, 14, 19, 23, 28 June; 3, 9, 14, 19 July. Census periods 0400 to 1600; total person hours 31. Census: Savannah Sparrow 13 (44, 18); Lapland Longspur 8.5 (29, 12); Northern Phalarope 5 (17, 7); Semipalmated Sandpiper 2.5; Western Sandpiper 2; Long-billed Dowitcher 2; Redpoll 2; Willow Ptarmigan 1; Golden Plover 1; Pectoral Sandpiper 1; Red-throated Loon 0.5; Oldsquaw 0.5; Common Snipe 0.5; Black-bellied Plover +. Total: 14 species; 40 territorial males or females (133/km^2, 54/100 acres). Visitors: Pintail, Sandhill Crane, Whimbrel, Dunlin, Parasitic Jaeger, Long-tailed Jaeger, Raven. Remarks: Although Parasitic and Long-tailed Jaegers did not appear to nest in the area, both species were present throughout the breeding season. Mammalian predators present were Arctic and Red Foxes. No microtines were observed. P. Connors, C. Connors.

Appendix 5 Breeding Bird Census, Wales, Alaska, 1977.

Wet Coastal Tundra---*Location*: Alaska, 4 km (2.5 miles) N of Cape Prince of Wales; 65°38'N, 167°04'W; Teller Quandrangle (C-7) USGS. *Continuity*: New. *Size*: 25 ha = 61.8 acres (250 m x 1 km, surveyed and gridded). *Description of Plot*: Dominant Ground Cover (approximate percentages for vegetated area only): Sedge (*Carex*) 55%, moss 25%, willow (*Salix*) 5%, crowberry (*Empetrum nigrum*) 5%, and lichens 5%. Water cover = 12%, including 5 lakes averaging 30 meters width, 13 small ponds averaging 2 meters across, and minor areas of flooding. *Edge*: Bordered on all sides by similar tundra. *Topography*: Flat, with 1 meter ridges separating 2 wet areas of low ground from 2 moist areas of higher ground. Elevation: Less than 50 ft. *Weather*: Cool and windy. Average June temperature 3.6°C (38.4°F); Temperature range -1.7 to 12.8°C (29 to 55°F). *Coverage*: June 15, 20, 25, 30; July 7, 10, 15, 20. Census periods between 1100 and 1700; Total person hours 45.5. *Census*: Western Sandpiper 17 (68, 27); Dunlin 5 (20, 8); Lapland Longspur 2; Pintail 1; Oldsquaw 1; Long-billed Dowitcher 1; Red Phalarope 1, Northern Phalarope 1. Total: 8 species, 29 territorial males or females (116/km^2, 46/100 acres). *Visitors*: Red-throated Loon, Golden Plover, Pectoral Sandpiper, Parasitic Jaeger, Glaucous Gull, Arctic Tern. *Remarks*: Nests found: Western Sandpiper 15, Dunlin 4, Pintail 1, Oldsquaw 1, Long-billed Dowitcher 5, Red Phalarope 1, Northern Phalarope 1, Lapland Longspur 1. Reindeer (*Rangifer tarandus*) herds trampled or disturbed several nests in early July. No microtines were seen on the plot. We thank Polar Research Laboratories for supplying us with weather data. K. Hirsch, D. Woodby.

Appendix 6 Birds collected for fat and diet studies, 1977 (n = 3 or more) (B, Barrow; K, Cape Krusenstern; W, Wales).

Location[1]/Date (1977)	Sex/Age a-adults j-juveniles	Weight (gm)	OCS Fat Code
Dunlin (*Calidris alpina*)			
KTL[2]/21 July	F/a	52	2
KSS[3]/10 Aug	F/j	51	2
KND[4]/ 2 Sept	M/a	64	3
KND / 2 Sept	F/j	63	4
KND / 2 Sept	M/a	63	4
KND / 2 Sept	F/j	57	2
KND / 2 Sept	F/j	65	3
KND / 2 Sept	M/j	55	2
KND / 2 Sept	F/j	62	3
KND / 2 Sept	F/j	59	3
KND / 2 Sept	F/j	63	3
KND / 2 Sept	F/j	67	4
WVS /23 July	F/a	63	3
WVS /23 July	M/a	59	3
WSM /17 Aug	F/j	49	2
WEL / 9 Sept	M/j	53	2
WEL / 9 Sept	F/j	57	2
Western Sandpiper (*Calidris mauri*)			
KTL /21 July	F/j	21	2
KTL /23 July	F/j	25	2
KSB /28 July	M/j	21	1
KTL / 1 Aug	F/j	23	2
KSI / 1 Aug	M/j	23	2
KMS / 5 Aug	M/j	20	2
KMS / 5 Aug	M/j	21	2
KSS / 9 Aug	M/j	21	2
WVS /21 July	M/a	24	2
WVS /23 July	-/j	26	2
WVS /23 July	-/j	25	3
WBD /31 July	F/j	24	2
WBD / 8 Aug	M/j	22	2
WNM /17 Aug	M/j	23	2
Sanderling (*Calidris alba*)			
WBS /16 July	F/a	76	4
WBD /16 Aug	M/j	68	4
WBD /25 Aug	F/j	61	3
Red Knot (*Calidris canutus*)			
KWB /30 July	F/j	114	2
WBD /26 July	M/a	-	4
WBD /26 July	M/a	-	3

Location[1]/Date (1977)	Sex/Age a-adults j-juveniles	Weight (gm)	OCS Fat Code
Long-billed Dowitcher (<u>Limnodromus</u> <u>scolopaceus</u>)			
KNF /15 July	F/a	122	4
KND / 2 Sept	-/j	111	4
KND / 2 Sept	F/j	114	4
Northern Phalarope (<u>Lobipes</u> <u>lobatus</u>)			
BME / 8 Aug	-/j	39	4
BME / 8 Aug	F/j	39	4
KTL / 1 Aug	F/j	31	1
KSS /10 Aug	-/j	36	4
Red Phalarope (<u>Phalaropus</u> <u>fulicarius</u>)			
WBD /31 July	F/j	50	2
WBD / 2 Sept	M/j	46	-
(Barrow Red Phalaropes: stomachs analyzed for asterisked birds; rest for fat only)			
BRW /18 July	M/a	51	-
*BME / 8 Aug	F/j	50	3
*BME / 8 Aug	F/j	54	3
BBD / 8 Aug	M/j	47	2
BBD / 8 Aug	F/j	51	2
*BBD / 8 Aug	F/j	54	3
BMW /12 Aug	M/j	--	2
BMW /12 Aug	F/j	45	2
BMW /12 Aug	F/j	49	3
BMW /12 Aug	F/j	54	3
BMW /12 Aug	F/j	53	2
BMW /12 Aug	-/j	--	4
BMW /12 Aug	F/j	52	2
BMW /12 Aug	F/j	53	3
/16 Aug	-/j	48	3
*BGF /24 Aug	F/j	50	4
*BGF /24 Aug	M/j	46	4
BGF /24 Aug	-/j	42	3

Footnotes:

[1] nearest transect

[2] Tasaychek Lagoon, 2-1/2 km north of KBI

[3] Sisualik, 15 km NW of Kotzebue

[4] Noatak Delta

Appendix 7 Systematic List of Zooplankton Collected in 1977.

B: Barrow
W: Wales
K: Cape Krusenstern

COELENTERATA
- Hydromedusae, several species (B, W, K)

ANNELIDA
- Polychaeta
  - Phyllodocidae (B, W, K)
  - Spionidae (B, W, K)
  - unidentified larvae (B, W, K)

MOLLUSCA
- Gastropoda: Opisthobranchia: Thecosomata
  - *Spiratella helicina* (B)

ARTHROPODA: CRUSTACEA
- Cladocera (W, K)
- Mysidacea
  - *Boreomysis* sp. (B, W, K)
  - *Mysis relicta* (B)
- Cumacea, sp. undet. (W, K)
- Copepoda: Cyclopoida, Harpacticoida, Calanoida, several species of each (B, W, K)
- Cirripedia: *Balanus* sp., cyprids (B, K)
- Isopoda: *Saduria entomon* (B, W)
- Amphipoda: Gammaridea
  - *Apherusa glacialis* (B)
  - *Onisimus litoralis* (B, W)
  - *Gammarus* sp. (W, K)
  - *Gammaracanthus loricatus* (W)
  - *Dexaminidae* (W)
  - Calliopiidae, two species (B, W, K)
  - unidentified juveniles (W, K)
- Euphausiacea: *Thysanoessa* sp. (B)
- Decapoda: zoea (W)

CHAETOGNATHA
- *Sagitta* sp. (B, W, K)

ECHINODERMATA
- Asteroidea: bipinnaria larvae (W, K)
  - postlarval, undet. sp. (W, K)

APPENDICULARIA
- *Oikopleura* sp. (B)

PISCES
- fish, larvae and eggs (B, W)

Non-planktonic organisms taken:

- Plants: numerous seeds (B, W, K)
- Coelenterata: hydroid colony fragments (W)
- Annelida: Oligochaeta (B, W. K)
- Mollusca: nepionic bivalves (W, K), nepionic snails (W), operculum (W, K)
- Crustacea: cladoceran ephippia (B, W, K), caprellids (W), munnid isopod (W)
- Pycnogonida: undet. sp. (W); Arachnida: Hydrocarina (B)
- Insecta: Diptera (several families) (B, W, K); Collembola (B)

XII. Literature Cited

Bengtson, S.-A. 1970. Breeding behavior of the Purple Sandpiper Calidris maritima in West Spitsbergen. Ornis Scand. 1(1):17-25.

Connors, P. G. and C. S. Connors. 1978. Breeding bird census: wet coastal tundra, Cape Krusenstern, Alaska. Submitted to American Birds.

Connors, P. G., J. P. Myers and F. A. Pitelka. 1978. Seasonal patterns of habitat use by coastal plain shorebirds in Arctic Alaska. In Shorebirds in Marine Environments. Proceedings of the Pacific Seabird Group Shorebird Symposium, ed. F. A. Pitelka. In press.

Connors, P. G. and R. W. Risebrough. 1976. Shorebird dependence on arctic littoral habitats. In Environmental Assessment of the Alaskan Continental Shelf (Annual Reports from Principal Investigators), Volume 2:401-456.

Connors, P. G. and R. W. Risebrough. 1977. Shorebird dependence on arctic littoral habitats. In Environmental Assessment of the Alaskan Continental Shelf (Annual Reports of Principal Investigators for the year ending March 1977), Volume 3:402-524.

Hirsch, K. and D. Woodby. 1978. Breeding bird census: wet coastal tundra, Wales, Alaska. Submitted to American Birds.

Holmes, R. T. 1966a. Breeding ecology and annual cycle adaptations of the red-backed sandpiper (Calidris alpina) in northern Alaska. Condor 68:3-46.

Holmes R. T. 1966b. Feeding ecology of the red-backed sandpiper (Calidris alpina) in arctic Alaska. Ecology 47:32-45.

McCabe. 1943. The Auk (incomplete reference).

Mickelson, P. G., D. Schamel, D. Tracy and A. Ionson. 1977. Avian community ecology at two sites on Espenberg Peninsula in Kotzebue Sound, Alaska. In Environmental Assessment of the Alaskan Continental Shelf (Annaul Reports of Principal Investigators for the year ending March 1977), Volume 5:1-74.

Myers, J. P. and F. A. Pitelka. 1975. Breeding bird census: wet coastal plain tundra (I) and (II). American Birds 29(6):1135-1136.

Myers, J. P., R. S. Greenberg and F. A. Pitelka. 1977. Breeding bird census: wet coastal plain tundra (I) and (II). American Birds 31(1):82-83.

Myers, J. P., R. P. Erickson and F. A. Pitelka. 1978a. Breeding bird census: wet coastal plain tundra (I), Barrow, Alaska. Submitted to American Birds.

Myers, J. P., W. D. Shuford and F. A. Pitelka. 1978b. Breeding bird census: wet coastal plain tundra (II), Barrow, Alaska. Submitted to American Birds.

Myers, J. P., L. E. Stenzel and F. A. Pitelka. 1978c. Breeding bird census: arctic low foothills tundra, Atkasook, Alaska. Submitted to American Birds.

Pitelka, F. 1974. An avifaunal review for the Barrow region and North Slope of arctic Alaska. Arctic and Alpine Research 6(2):161-184.

Redburn, D. R. 1974. The ecology of the inshore marine zooplankton of the Chukchi Sea near Point Barrow, Alaska. M.S. thesis, University of Alaska, Fairbanks.

Vermeer, K. and G. G. Anweiler. 1975. Oil threat to aquatic birds along the Yukon coast. Wilson Bull. 87:467-480.

XIII. Research Personnel, 1977 Season

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XIV. Acknowledgments

As noted within the text of this report, data on tundra bird densities at Barrow in 1976 and 1977 are from the unpublished studies of J. P. Myers and F. A. Pitelka.

We are grateful for the help and information on phenology and natural history of the Cape Krusenstern region supplied repeatedly by Bob and Carrie Uhl and members of the Williams family.

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The distribution, abundance and feeding ecology of birds associated with pack ice

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1 April 1978

Table of Contents

List of Tables

List of Figures

I. Summary of objectives, conclusions and implications with regard to oil and gas development.

As part of an environmental assessment of the outer continental shelf of Alaska the distribution, abundance and feeding ecology of seabirds associated with pack ice are being studied. An attempt is being made to determine what factors are most important in determining distribution and abundance. This will allow the determination of which areas of the pack ice should be designated as critical habitat. Because of a complex set of variables bird distribution in the Bering Sea is hard to characterize. It appears that the area from the shelfbreak to the beginning of 8 oktas of ice cover is the most important for birds. This area corresponds to what is usually known as the "ice front". It is not known if the presence of ice plays a role in concentrating birds in the Bering Sea.

Observations in the Beaufort Sea show that distance from land is the most important variable in determining bird densities. The area from the mainland or barrier islands out to one km has the most intensive bird use. Few birds are present at more than 20 km from shore.

Birds in the Bering Sea are feeding primarily on fish and zooplankton associated with a deep warm water layer. The presence of deep warm water may be important in determining which areas are important to large numbers of birds. In the Beaufort shoreline migrants are feeding primarily on zooplankton while pelagic species are feeding on fish.

For purposes of oil development all areas within 20 km of shore in the Beaufort can be considered critical habitat. The area within one km of land is the most intensively used part of this area. It is hard to designate critical habitat in the Bering due to the dynamic nature of the ice. Further oceanographic work is needed to determine why certain sections of the ice front support such large numbers of birds while other areas have very low densities.

II. Introduction

A. General nature and scope of study

Sea ice represents a unique marine habitat. Acting as a barrier between the air and water, it has a wide range of effects on seabirds. Ways in which sea ice decreases seabird numbers include:

1. Decreasing the amount of open water available for feeding and roosting.
2. Lowering primary productivity in the water column by decreasing the depth of the euphotic zone and preventing wind mixing.
3. Reducing benthic prey by scouring the bottom in shallow water.

Ways in which sea ice can enhance bird numbers include:

1. Providing a roosting space for species that normally roost on solid substrates.
2. Providing a matrix for an in-ice phytoplankton bloom.
3. In areas of multi-year ice, providing a substrate for an under-ice community of zooplankton and fish.
4. Decreasing wind speeds and sea surface disturbance in the immediate vicinity of ice.

B. Specific objectives

The specific objectives of this study are:

1. To determine the distribution and abundance of seabirds found in the open water south of the pack ice, at the ice edge and in the pack ice. Densities in the pack ice are analyzed with regard to ice type and amount of ice cover.
2. To determine the role that pack ice plays in the yearly cycles of seabirds and identify those species that are most dependent on the pack ice environment.
3. To determine the feeding habits of the seabird species associated with the pack ice.

C. Relevance to problems of petroleum development

The ice environment of the Bering, Chukchi and Beaufort seas will present problems unique to the exploitation of oil and gas reserves under these waters. Technical means have not been developed to keep moving pack ice from affecting oil platforms. Underwater pipelines transporting oil to the mainland will be in danger of rupture by keels on ice floes. For these and a number of other reasons, the occurrence of an oil spill or similar major disturbance is more likely in the pack ice than in ice-free waters.

When a spill occurs the impacts on marine organisms associated with the pack ice probably will be more severe and longer-lasting than the impacts on biological systems in warmer waters. Water temperatures adjacent to the ice are usually near 0° C and biodegradation of oil occurs very slowly at such low temperatures. Oil spreading out on the underside of ice can be incorporated into it and affect the in-ice algae bloom and associated fauna. Oil spilled directly into leads will foul the limited amount of open water available to birds deep in the pack ice.

The birds found in and next to the pack ice will be severely impacted by oil spills. Birds are typically one of the most obvious and immediate victims of oil spills. Direct mortality is caused by oil fouling feathers resulting in loss of insulation, stress and possible ingestion of oil. More subtle effects are caused by the impacts of oil on the lower levels of trophic webs. Seabirds are at the terminal end of the marine food chain and thus are sensitive to any changes that occur at lower levels.

Research on seabirds in coastal areas (R.U. 3/4) has centered on delineating critical habitat so that precautions can be taken to minimize the impacts in these areas. The pack ice is too dynamic, however, to allow the designation of specific geographic areas as critical habitat. Critical habitat in the ice environment has to be defined in terms of distance to ice edge, amount and type of ice cover, water temperature, etcetera. These factors are constantly changing during ice formation and deformation. This project will provide pre-development information on the distribution and abundance of birds in relation to these parameters and allow the development of a predictive model. Impacts of development on pack ice birds can then be measured using the information gathered by this project.

III. Current state of knowledge

Previous studies that attempted to correlate ice with bird distribution are few. Frame (1973) reported on bird observations in the Beaufort Sea in summer. He only counted followers, however, and his work is not directly comparable to this project's. Watson and Divoky (1972) present information on birds next to and south of the pack ice in the Chukchi Sea in September and October. Irving et al. (1970) presented general information on birds at the Bering Sea ice edge in March.

Published accounts of pelagic observations in and next to the ice that do not deal specifically with ice in relation to bird distribution include Watson and Divoky's (1974) observations in the Beaufort and Jacque's (1930), Nelson's (1883) and Swartz's (1967) observations in the Chukchi. Unpublished pelagic observations deep in the Bering Sea pack ice were made by Divoky in March 1973.

The feeding habits of birds in and next to the pack ice are poorly known. The only applicable studies are those of Watson and Divoky (1972) and Divoky (1976) who report on prey items and feeding behavior of birds at the Chukchi ice edge in September.

IV. Study areas

The three seas covered by this project differ greatly in their amount and type of ice cover and their importance to seabirds. The following is a discussion of the marine and ice environment in each of these seas.

Bering Sea. Ice begins to cover the northern Bering Sea in late November. Ice coverage is at a maximum in February and March when the southern edge of the ice is usually found near the edge of the continental shelf. Decomposition of the pack ice begins in late April and continues until mid-June. This period (approximately six months) of ice cover is quite short compared to the Chukchi and Beaufort seas where some ice is present throughout the year. Because almost all of the ice in the Bering Sea is first year ice it lacks the extensive keels and pressure ridges found on ice in the Arctic. While the Bering Sea ice supports an in-ice photoplankton bloom (McRoy and Goering 1974) it is not known to have an under-ice fauna associated with its underside.

The Bering Sea ice "front" refers to the area of loose ice south of the more consolidated pack. It is composed primarily of bands of ice pans. Large floes are prevented from forming by swells on the open water to the south. When the wind is from the south the front is compacted against the main pack ice in a narrow band. When the wind is from the north the front becomes wider and more diffuse. In spring primary productivity is high in the water column under the ice front. At the same time productivity in the water column under the consolidated pack and south of the ice front is low (McRoy and Goering 1974). For this reason the ice front is an important biological area supporting large numbers of birds and mammals (Fay 1974).

Another feature of the Bering Sea pack ice of importance to birds is the open water associated with the islands found in the pack ice. These areas of open water (polynyi) are formed by the northerly winds which concentrate ice on the north side of islands and move ice away from the southern sides. These polynyi act as refugia deep in the pack ice.

The Bering Sea differs from the two Arctic seas studied by this project in that it has a high level of biological productivity. This is demonstrated by the large fishery the Bering Sea supports and by the large number of breeding and non-breeding birds present in summer.

Chukchi Sea. Ice covers the Chukchi Sea from November to May and coverage is almost complete during this period. Exceptions are the area of broken ice in the Bering Strait, a polynya associated with the shoreline in the Point Hope area (Shapiro and Burns 1975) and a lead system northwest of Point Barrow. In late May the ice in the southern Chukchi Sea begins to decompose and most of the area south of Cape Lisburne is ice free by July. The edge of the Arctic pack ice is present in the northern Chukchi throughout the summer occurring anywhere between 70° and 72° N.

The ice in the Chukchi Sea apparently supports an in-ice algae bloom similar to those found in the Bering and Beaufort seas. The multi-year ice in the Chukchi is known to support an under-ice fauna of zooplankton and arctic cod. The underside of multi-year ice has numerous keels and pockets which create a large surface area. Amphipods are known to concentrate on the ice underside presumably obtaining food from the plankton blooms occurring in and on the underside of ice (Mohr and Geiger 1968; MacGinitie 1955). Arctic cod prey on the amphipods and other zooplankton found next to the ice. The underside of multi-year ice is thus similar to a reef in that it has fish and invertebrate populations associated with a substrate. Little is known about this community. It is present in the spring and summer but nothing is known about the winter situation.

The water flowing north through the Bering Strait is a major influence on the Chukchi Sea. This water is warmer than Arctic waters and is the main reason for the rapid decomposition of ice in the southern Chukchi Sea. This water also supports high levels of primary productivity in summer (McRoy et al. 1972) and makes the southern portion of the Chukchi Sea the most biologically productive waters in the Arctic Ocean off Alaska.

Beaufort Sea. Ice covers much of the Beaufort Sea for almost twelve months of the year. The amount of open water present in the summer is dependent on wind and weather conditions. Adjacent to the coast strips of open water are present from approximately June to October; its width is dependent on the wind with south winds moving the ice offshore and north winds pushing the ice inshore. The pack ice present in the northern Chukchi and Beaufort seas in summer contains much open water between ice floes. Thus even in areas deep in the permanent pack ice there is open water available to birds in summer.

The Beaufort Sea supports an in-ice plankton bloom followed by a bloom in the open water. The Beaufort Sea is characteristic of arctic waters with productivity being reduced due to the lack of upwelling or mixing. Because of this the Beaufort is the least productive of the three seas studied by this project.

V. Sources, methods and rationale of data collection

A. Methods

1. Pelagic censusing

Pelagic censusing is conducted from the flying bridge during 15 minute observation periods. All birds seen in a 300-meter wide transect are recorded. Information is obtained on species, age, sex and activity. Ship followers are recorded once during each observation period but are not included in density computations. Information on oceanographic, meteorologic and ice conditions are recorded for each observation period. In 1977 all observations were put on coded sheets and sent to Michael Crane of AEIDC for punching, editing and conversion to magnetic tape.

All pelagic data collected by R.U. 196 has been handled in the manner described above since the project started in 1975. After one year it became obvious that the method of data processing was too cumbersome to allow rapid analysis of data by computer. The amount of person hours involved in coding the data, keypunching and editing was also large. It became obvious that after the data was on magnetic tape and sent to NODC (the National Oceanographic Data

Center) it was not possible to obtain sorted or analyzed data. These problems were dealt with in 1977 by developing a data entry and analysis system.

The system consists of a Sol-20 micro-computer, a Northstar Disc drive and a television monitor. An entry program written by Leo Karl of Custom Computing of Mill Valley, California, allows data to be entered directly from field forms and stored on a magnetic disc. The entry program is based on the "033" format used for all OCSEAP pelagic transect data. It is an interactive program in that the name of a parameter or data field appears on the screen and the operator enters the information from the field form. The entry program contains edits that prevent data from being entered that are not logical or do not fall within the values appropriate for a certain field.

The system was completed in the late summer of 1977 and was not used on any OCSEAP cruises during that year. The principal investigator of this project did use it, however, on a cruise from California to New Zealand to the Antarctic with David Ainley of the PRBO. Over 500 stations were entered on the cruise and, except for minor problems with power fluctuations caused by the ship's generator, the entry system worked perfectly.

An analysis of variance program has been developed that allows the primary factors we correlate with bird densities (ice cover, distance from land, distance from shelfbreak, sea surface temperature, etcetera) to be stratified and the densities of certain species or total densities analyzed among the strata. This program has just been developed but the few tests that have been run on it show that it will be a very useful tool for the quick analysis of data at the end of a cruise. The program has the additional benefit of allowing data to be analyzed during a cruise so that sampling in the latter stages of a cruise can be based on the analysis of the data from the first part of the cruise.

The handling of large amounts of pelagic data has been a problem for this research unit as well as the U.S. Fish and Wildlife Service. The data processing system developed by the PRBO allows the quick entry of data on board ship. At the end of the cruise the observer has a set of floppy discs that can be run through a translation device and all of the information put on magnetic tape for NODC. The discs can also be used for analysis as soon as the cruise is over. The benefits of such a system are obvious and it is hoped that OCSEAP carries out most of its future pelagic work with the aid of such a system.

2. Specimen collecting and stomach contents analysis

Specimens are collected with a shotgun from a small boat. On board ship information on weight, molt, gonad, size and fat deposition are obtained. All food items present in the mouth, esophagus, and stomach are included in the analysis. All prey items are identified to the lowest possible taxonomic level and counted and measured. Weight of each prey group is determined.

VI. Results

An attempt is made in this report to portray graphically the densities of birds encountered on the cruises listed in Table 1. While all data will be analyzed with regard to ice, oceanographic and geographic conditions, it is recognized that much of what needs to be known by OCSEAP and BLM administrators is what birds are present where and in what densities. Some cruises conducted as part of R.U. 196 are not presented in this report. They are being mapped, however, and will be presented in a later report. A complete analysis of the data will be done using the computer programs discussed in the methods section of this report.

A. Bering Sea

1. Pelagic densities

Densities of birds seen on the three Bering Sea cruises in 1977 are presented in Tables 2 through 4. Figures showing densities of all species seen on five or more transects are presented on Figures 1-122.

2. Stomach contents

The prey found in the stomachs of *Uria aalge, U. lonvia* and *Rissa tridactyla* are presented in Tables 5, 6 and 7 respectively.

B. Chukchi and Beaufort

1. Pelagic densities

Densities of all species seen on five or more transects in the Chukchi and Beaufort Seas are presented in Figures 124 through 230. Tables 8 and 9 show the density of birds by area for 1977 cruises. Tables 11 through 15 present bird densities in the Beaufort in relation to distance from land. This information is portrayed graphically in Figures 231-235.

2. Stomach contents

The stomach contents of Black-legged Kittiwakes collected in the Beaufort Sea are presented in Table 10.

VII. Discussion

A. Bering Sea

Pelagic bird distribution in the Bering Sea is determined by a complex set of parameters including distance from land, distance from shelfbreak, ice conditions, sea surface temperature and nature of the water column. As all of these factors have varying degrees of importance, the analysis of the Bering Sea data will be complex but extremely interesting. In last year's annual report an attempt was made to analyze the correlation of bird densities with distance from the northern and southern edge of the ice front. The analysis showed that certain species had affinities for specific parts of the ice front. Such an analysis is useful for predicting bird densities based on satellite photos. Cruises in 1977 showed, however, that the primary factor in determining the abundance of birds in and near the ice front is the presence of a two layered system: a cold water layer above a warmer layer. Studies by R. T. Cooney and other personnel from R.U. 246 found the bottom layer contained pollock (Theragra chlacogranna), capelius (Mallotus villosus), Parathemisto libellula and Neomysis rayi. Analysis of murre stomachs showed that the species mentioned above made up the bulk of the prey (Tables 5 and 6). A series of zooplankton tows taken during a 24-hour period by R.U. 246 showed that the fish and zooplankton migrate up into the water column at night. Because the layer of fish and zooplankton occurred at depths of 30 fathoms and more, murres may be feeding primarily in the early morning hours when prey are still present close to the surface with enough light to be visible. In order to test this assumption we collected bird specimens at three periods of the day: 800-1200, 1200-1600, 1800-2000 ADT. Common Murres (Uria aalge) fed most in the mid-afternoon (Table 5). Murres are visual feeders and can probably locate a maximum quantity of prey during maximum light penetration of the water column in early afternoon.

We now know that the concentrations of fish and zooplankton near the bottom of the water column are the major factors in producing high densities of birds at the ice edge but we do not know how the presence or absence of ice relates to these prey aggregations. Maybe the location of the shelfbreak is of critical importance and feeding flocks of birds occur in the ice only because the ice front is found near the shelfbreak. We hope the University of Alaska PROBES study will shed some light on what determines the spatial and temporal distributions of prey items of birds in the Bering Sea.

B. Chukchi and Beaufort Seas

The distribution of birds in the northern Chukchi and Beaufort Seas is, unlike in the Bering Sea, largely determined by a single parameter, distance from land. Most of the birds in the Beaufort are tundra nesters that use the Beaufort as a migratory pathway and as a feeding area prior to the fall migration. Because of low productivity in the offshore waters of the Beaufort, the nearshore waters have the highest concentrations of feeding birds. The importance of nearshore waters is increased by the large numbers of waterfowl that use the coast as a migratory pathway. In many areas the waterfowl do not roost or feed but simply pass overhead.

The densities of birds in the Beaufort Sea in relation to land are presented in Tables 11 through 15 and Figures 231 through 235. Figures 231 and 234 present data gathered on two August cruises on the Alumiak. On both cruises high average densities (over 100 birds per km^2 were found within 1 km of shore. From 2 to 10 km from shore densities averaged between 20 to 50 birds per km^2. Beyond 10 km the sample size was small but densities were low except for migrant waterfowl passing over areas of open ocean. Figures 232, 233 and 235 show densities obtained on icebreaker cruises in the offshore Beaufort. Figures 232 and 235 show August densities of birds observed in the offshore Beaufort. In general densities average less than 20 birds per km^2. Areas with higher densities had either large flocks of phalaropes or eiders. During a September cruise in the Beaufort densities were higher than in August probably due to decreasing prey densities in nearshore waters.

The trophic relations of birds in the Beaufort are also closely tied with distance from land. Nearshore species consume primarily zooplankton and pelagic species consume primarily Arctic Cod. Because Arctic Cod are closely associated with ice, offshore areas without ice have very low prey densities.

VIII. Conclusions

Bird densities in the Bering Sea need to be further studied with respect to the oceanographic conditions that cause concentrations of fish and zooplankton at the ice edge. Further cruises with biological oceangraphers will allow bird densities to be correlated with prey abundance rather than those parameters that are most easily obtained by persons studying seabirds (i.e. distance from land, ice cover, sea surface temperature, etc.). The large numbers of birds found in the ice front in the Bering Sea may have little to do with the ice conditions. The location of the ice front may just happen to coincide with an area of prey abundance.

Cruises in the Beaufort Sea in 1976 and 1977 show that the offshore waters have very low densities of birds and that the area within 20 km of shore is most important to feeding and migrating birds. Further studies should center on the area within 20 km of shore in order to see what nearshore features or processes are most important in determining bird distribution and abundance within the zone.

The only pelagic area of the Beaufort found to regularly support high numbers of birds is the area just north of Point Barrow. Observations in 1977 showed that Bering Sea water north of Point Barrow had high densities of zooplankton at the surface. The high densities of birds found from Point Barrow along the shore to the eastern Plover Islands may be due to the Bering Sea water offshore.

IX. Summary of 4th quarter operations

A. No field work was conducted during this quarter. The Pacific Seabird Group meeting and the Beaufort Synthesis were attended by the principal investigator.

B. None

C. Estimate of funds expended.

Salaries	$ 8000.
Travel	2200.
Equipment	-
Other direct costs	3000.
Overhead	3100.
Total	$16300.

X. Literature cited

Divoky, G. J. 1976. The pelagic feeding habits of the Ivory and Ross' Gulls. Condor 78: 85-90.

Fay, F. H. 1974. The role of ice in the ecology of marine mammals of the Bering Sea. In D. W. Hood and E. J. Kelly (Eds.). Oceanography of the Bering Sea. Inst. of Marine Sci., U. of Alaska, Fairbanks. pp. 383-399.

Frame, G. W. 1973. Occurrence of birds in the Beaufort Sea, summer 1969. Auk 90: 552-563.

Irving, L., C. P. McRoy and J. J. Burns. 1970. Birds observed during a cruise in the ice-covered Bering Sea in March 1968. Condor 72: 100-112.

Jacques, F. L. 1930. Water birds observed on the Arctic Ocean and the Bering Sea in 1928. Auk 47: 353-366.

MacGinitie, G. E. 1955. Distribution and ecology of the marine invertebrates of Point Barrow, Alaska. Smithson. Misc. Collect. 128: 1-201.

McRoy, C. P., and J. J. Goering. 1974. The influence of ice on the primary productivity of the Bering Sea. In D. W. Hood and E. J. Kelly (Eds.). Oceanography of the Bering Sea. Inst. of Marine Sci., U. of Alaska, Fairbanks. pp. 403-421.

McRoy, C. P., J. J. Goering and W. E. Shiels. 1972. Studies of primary production in the eastern Bering Sea. In A. Y. Takenouti et al. (Eds.) Biological oceanography of the northern North Pacific Ocean. pp. 200-218.

Mohr, J. L., and S. R. Geiger. 1968. Arctic basin faunal précis - animals taken mainly from arctic drifting stations and their significance for biogeography and water-mass recognition. In J. E. Sater (coord.). Arctic drifting stations. Arctic Inst. N. Am. pp. 297-313.

Nelson, E. W. 1883. Birds of the Bering Sea and the Arctic Ocean. Cruise of the Revenue Steamer Corwin in Alaska and the N. W. Arctic Ocean in 1881. Govt. Printing Off., Washington, D.C.

Shapiro, L. H., and J. J. Burns. 1975. Major late-winter features of ice in northern Bering and Chukchi Seas as determined from satellite imagery. Geophysical Inst. Report. UAGR-236. U. of Alaska, Fairbanks.

Schwartz, L. G. 1967. Distribution and movements of birds in the Bering and Chukchi Seas. Pacif. Sci. 21: 332-347.

Watson, G. E., and G. J. Divoky. 1972. Pelagic bird and mammal observations in the eastern Chukchi Sea, early fall 1970. U.S. Coast Guard Oceanogr. Rep. 50: 111-172.

Watson, G. E., and G. J. Divoky. 1974. Marine birds of the western Beaufort Sea. In J. C. Reed and J. E. Sater (Eds.). The coast and shelf of the Beaufort Sea. Arctic Inst. of N. Am. pp. 681-695.

Table 1. Data reported in this report were gathered on the following cruises.

Ship	Date	Location	No. of 15 min. obs.	Cruise Track Figure #
USCGC Burton Is.	22-28 July 1976	Chukchi and Beaufort Seas	88	125,191
USCGC Glacier	6 August - 3 Sept. 1976	Chukchi Sea	282	132
R.V. Alumiak	19-30 August 1976	Beaufort Sea	135	194
USCGC Glacier	5-17 Sept. 1976	Beaufort Sea	130	194
NOAA Discoverer	10-24 Sept. 1976	Northern Bering and Southern Chukchi Sea	256	148,149
NOAA Surveyor	15 March - 6 April 1977	Bering Sea	271	1,2,3
NOAA Surveyor	14 April - 6 May 1977	Bering Sea	290	36,37,38
NOAA Discoverer	20 May - 10 June 1977	Bering Sea	357	77,78
USCGC Glacier	2-5 August 1977	Chukchi Sea	43	182
R.V. Alumiak	2-25 August 1977	Beaufort Sea	226	219
USCGC Glacier	6 August - 5 Sept. 1977	Beaufort Sea	462	219

Table 2. Bird densities by area in the Bering Sea, 15 March to 6 April 1977.

Area	# of transects	Avg. density per km^2	Principal species	Avg. density per km^2
Unimak Pass	8	3230	*Uria* spp. *Aethia cristatella*	2550 666
Unimak Pass to St. George	13	5.3	*Uria* spp. *Rissa tridactyla*	4 0.9
Pribilofs to St. Matthew	17	4.2	*Uria* spp. *Rissa tridactyla*	3.5 0.3
Ice south of St. Matthew	34	591	*Uria* spp. *Larus hyperboreus*	440 139
Ice edge south of St. Matthew	14	9	*Uria* spp. *Larus hyperboreus*	6.2 1.9
Midway between Pribilofs and Cape Newenham	15	2.8	*Uria* spp.	1.9
Ice midway between Pribilofs and Cape Newenham	26	1.9	*Larus hyperboreus* *Larus glaucescens*	0.6 0.6
South of Cape Newenham	6	13	*Uria* spp.	13
Ice south of Cape Newenham	22	5.2	*Uria* spp. Eider	2.4 1
Approaching Unimak Pass from Bristol Bay	24	11	*Uria* spp.	10
Akutan Pass to Unimak Island	26	88	*Aethia cristatella* *Uria* spp. *Somateria spectabilis*	44 21 17

Table 3. Bird densities by area in the Bering Sea, 14 April to 3 May 1977.

Area	# of transects	Avg. density per km^2	Principal species	Avg. density per km^2
Unimak Pass	13	29	*Uria* spp.	16
			Anatid	5
Northwest of Unimak	6	32	*Uria* spp.	17
			Fulmarus glacialis	13
Unimak Pass to Cape Newenham	25	30	*Uria* spp.	18
			Fulmarus glacialis	6
Bristol	19	13	*Uria* spp.	7
			Clangula hyemalis	2
Leaving Bristol Bay	33	4.3	*Uria* spp.	2
			Rissa tridactyla	1
East of St. Paul	34	15	*Fulmarus glacialis*	6
			Somateria spectabilis	2
			Uria spp.	2
Ice north of St. Paul	27	17	*Uria* spp.	10
			Rissa tridactyla	3
			Larus hyperboreus	2
Ice edge south of St. Matthew	18	10	*Uria* spp.	5
			Fulmarus glacialis	2
Approaching Unimak Pass	14	12	*Uria* sp.	8
			Fulmarus glacialis	2
Unimak Pass	5	30	*Uria* spp.	21

Table 4. Bird densities by area in the Bering Sea 20 May to 10 June 1977.

Area	# of transects	Avg. density per km^2	Principal species	Avg. density per km^2
Leaving Unimak Pass	29	15	*Oceanodroma furcata*	5
			Rissa tridactyla	5
Southwest of St. Paul	12	58	*Phalaropus fulicarius*	27
			Uria sp.	17
			Fulmarus glacialis	8
Northwest of St. Paul	19	17	*Uria* spp.	8
			Aethis pusilla	3
Ice edge west of St. Matthew	13	116	*Aethia pusilla*	88
			Uria spp.	24
Ice west of St. Matthew	55	257	*Aethia pusilla*	169
			Uria spp.	33
			Rissa tridactyla	36
Ice west of St. Matthew	11	57	*Aethia pusilla*	25
			Aethia cristatella	15
			Uria spp.	6
Paralleling ice south of St. Matthew	29	89	*Uria* spp.	47
			Aethia cristatella	19
			Aethia pusilla	14
Ice between Nunivak and St. Matthew	26	47	*Uria* spp.	30
			Rissa tridactyla	4
			Fulmarus glacialis	3
Ice west of Nunivak	9	274	*Uria* spp.	213
			Fulmarus glacialis	21
			Rissa tridactyla	9
West of Nunivak	7	9.4	*Uria* spp.	5
			Aethia pusilla	2
Ice edge west of Nunivak	21	26	*Uria* spp.	19
			Fulmarus glacialis	2

Table 4 (continued).

Area	# of transects	Avg. density per km^2	Principal species	Avg. density per km^2
Ice northeast of St. Matthew	18	55	*Uria* spp. *Phalaropus fulicarius* *Aethia cristatella*	34 5 4
Ice midway between St. Matthew and Nunivak	25	21	*Uria* spp. *Rissa tridactyla*	14 2
Southwest of Nunivak	10	14	*Uria* spp.	9

Table 5. Stomach contents of *Uria aalge* collected in the Bering Sea ice front.

	Pollock	Capelin	Herring	Unid. fish	*Parathemisto libellula*	Euphausids	*Neomysis rayi*
March 1976							
n=17 wt.=773.2g							
% wt.	56	38		6	tr.	tr.	
% freq.	100	41		35	29	6	
April 1976							
n=14 wt.=486g							
% wt.	60	tr.		3	8	20	
% freq.	21	7		7	29	57	
March 1977							
n=2 wt.=6.9g							
% wt.					100		
% freq.					100		
April 1977							
n=3 wt.=36.1g							
% wt.		26			34	39	
% freq.		33			67	33	
May 1977*							
n=48 wt.=568.6g							
% wt.	1	55	7	4	7	5	16
% freq.	5	40	2	19	37	26	30

*Additional information on May 1977 specimens

48 total birds collected

Time of collection	Number of birds	Number empty	Avg. vol.
0700 - 1000 ADT	19	4	2.1
1000 - 1500 ADT	12	1	24.0
1500 - 2100 ADT	17	0	16.2

Table 6. Stomach contents of *Uria lomvia* collected in the Bering Sea ice front.

	Pollock	Capelin	Unid. fish	*Parathemisto libellula*	Euphausids	Squid	Unid.
March 1976							
n=2 wt.=10g							
% wt.				100			
% freq.				100			
April 1976							
n=9 wt.=486g							
% wt.	99		tr.	1		tr.	
% freq.	90		22	11		11	
March 1977							
n=8 wt.=255g							
% wt.		9	tr.	59	21		10
% freq.		22	6	100	17		6
April 1977							
n=10 wt.=36.1g							
% wt.		26		34	39		
% freq.		33		67	33		
May 1977							
n=26 wt.=126.6g							
% wt.	tr.	tr.	tr.	79	17	tr.	3
% freq.	35	4	4	73	35	12	12

Table 7. Stomach contents of *Rissa tridactyla* collected in the Bering Sea ice front.

	Pollock	Capelin	Unid. fish	*Parathemisto libellula*	Euphausids	*Neomysis rayi*
March 1976						
n=2 st.=.8g						
% wt.	tr.	tr.	100			
% freq.	100	100	100			
April 1976						
n=1 wt.=41g						
% wt.	95					
% freq.	100					
March 1977						
n=3 wt.=5.2g						
% wt.	100					
% freq.	100					
April 1977						
n=12 wt.=65.6g						
% wt.	6	54	37		1	
% freq.	75	75	80		17	
May 1977						
n=11 wt.=7.3g						
% wt.	96	tr.	tr.	tr.		4
% freq.	64	14	14	14		14

Table 8. Bird densities by area in the offshore waters of the eastern Chukchi and Beaufort Seas 1 August to 6 September 1977.

Area	# of transects	Avg. density per km^2	Principal species	Avg. density per km^2
Eastern Chukchi Sea	49	5.5	*Phalaropus fulicarius* *Rissa tridactyla*	2.1 1.0
Tangent Point to Oliktok Point	111	2.6	*Phalaropus fulicarius* *Rissa tridactyla*	0.8 0.3
Jones Islands to Brownlow Point	24	2.0	*Sterna paradisaea* *Larus hyperboreus* *Phalaropus fulicarius*	0.8 0.6 0.4
Ice edge off continental shelf	43	0.9	*Sterna paradisea* *Rissa tridactyla*	0.3 0.3
Approaching Demarcation Bay from north	46	3.8	*Clangula hyemalis*	2.5
Demarcation Bay to Cape Halkett (close to 10 fathom curve)	126	4.4	*Phalaropus fulicarius* *Clangula hyemalis*	2.5 0.8
Cape Halkett to Pt. Barrow	105	9.7	*Sterna paradisaea* Eider *Phalaropus fulicarius*	3.9 2.1 1.1

Table 9. Bird densities by area in the nearshore waters of the Beaufort Sea 3 to 26 August 1977.

Area	# of transects	Avg. density per km^2	Principal species	Avg. density per km^2
Barrow to Cape Simpson	26	81	Eider	38
			Phalaropus fulicarius	16
			Clangula hyemalis	8
			Sterna paradisaea	6
Cape Halkett to eastern Camden Bay	84	49	Eider	34
			Clangula hyemalis	7
			Phalaropus fulicarius	5
Eastern Camden Bay to Halkett	57	10	Eider	6
			Phalaropus fulicarius	1.8
Cape Halkett to Tangent Point	59	36	*Clangula hyemalis*	18
			Sterna paradisaea	6
			Eider	6
			Phalaropus fulicarius	3

Table 10. Stomach contents of *Rissa tridactyla* collected in the eastern Chukchi and Beaufort Seas.

	Arctic Cod	Amphipods	Mysids	*Parathemisto libellula*	Shrimp
July to Sept. 1976					
n=25 wt.=112.4g					
% wt.	89	7	1		
% freq.	76	20	8		
August to Sept. 1977					
n=15 wt.=42.3g					
% wt.	73	7		8	12
% freq.	87	20		7	7

3AL876

Distance from land	Km	≤ 1	2+3	4+5	6+7	8+9	10+11	12+13	14+15	16+17	18+19	20+21	22+23	24+25	26+27	28+29	30+31	32+33
Number of transects	n	28	40	18	11	17	5	3	2	1	1	0	1	2	2	1	2	1
<u>Gavia</u> <u>arctica</u>	$\bar{x}$	0.2	1.3	0.2	0.5	0.4	1.1	0.3	1.4	0.0	0.0	---	1.0	4.7	1.1	0.0	2.3	1.2
	% freq	18	18	11	28	29	60	33	50	0	0	---	100	100	50	0	50	100
<u>Gavia</u> <u>stellata</u>	$\bar{x}$	0.0	0.2	0.0	0.3	0.3	0.0	0.0	0.4	1.4	0.0	---	0.0	0.0	0.0	0.0	0.0	1.2
	% freq	0	13	0	17	6	0	0	50	100	0	---	0	0	0	0	0	100
All <u>Gavia</u>	$\bar{x}$	1.3	1.0	0.2	0.8	1.4	1.9	0.5	1.8	1.4	0.0	---	1.0	4.7	1.6	0.0	2.7	2.4
	% freq	29	25	17	45	59	80	33	100	100	0	---	100	100	100	0	50	100
<u>Clangula</u> <u>hyemalis</u>	$\bar{x}$	77.2	29.7	13.0	36.6	21.9	0.0	1.6	0.0	0.0	0.0	---	0.0	0.0	0.0	0.0	0.0	0.0
	% freq	79	70	50	73	59	0	67	0	0	0	---	0	0	0	0	0	0
All Eiders	$\bar{x}$	15.0	2.2	3.7	3.6	6.9	26.2	0.0	16.4	0.0	9.4	---	0.0	5.0	296.3	65.7	47.9	54.7
	% freq	11	13	22	18	24	20	0	50	0	100	---	0	100	100	100	100	100
All Phalaropes	$\bar{x}$	49.1	3.6	22.8	4.3	2.9	0.6	0.0	0.0	0.0	0.0	---	0.0	0.0	0.0	0.0	0.0	2.4
	% freq	50	35	61	27	80	40	0	0	0	0	---	0	0	0	0	0	100
All <u>Stercorarius</u>	$\bar{x}$	0.3	0.0	0.1	0.4	0.2	0.0	0.0	0.0	0.0	0.0	---	0.0	0.0	0.0	0.9	0.0	0.0
	% freq	18	0	6	27	12	0	0	0	0	0	---	0	0	0	100	0	0
<u>Larus</u> <u>hyperboreus</u>	$\bar{x}$	2.5	4.3	2.7	0.2	0.3	0.3	0.0	0.0	0.0	0.0	---	0.0	0.5	0.6	0.9	0.5	1.2
	% freq	11	23	39	18	29	20	0	0	0	0	---	0	50	50	100	50	100
<u>Rissa</u> <u>tridactyla</u>	$\bar{x}$	0.8	0.3	0.0	0.0	0.1	0.0	0.0	0.0	0.0	0.0	---	0.0	0.0	0.0	0.0	0.0	0.0
	% freq	18	13	0	0	6	0	0	0	0	0	---	0	0	0	0	0	0
<u>Xema</u> <u>sabini</u>	$\bar{x}$	2.3	0.9	0.4	0.1	0.5	0.0	0.0	0.0	0.0	0.0	---	0.0	0.0	0.0	0.0	0.0	0.0
	% freq	14	8	6	9	18	0	0	0	0	0	---	0	0	0	0	0	0
<u>Sterna</u> <u>paradisaea</u>	$\bar{x}$	175.7	1.8	3.7	0.0	1.4	0.0	0.0	0.0	0.0	0.0	---	0.0	0.0	0.6	0.0	0.0	0.0
	% freq	32	20	22	0	11	0	0	0	0	0	---	0	0	50	0	0	0
TOTAL DENSITY	$\bar{x}$	310.7	45.8	46.3	46.3	35.6	29.0	1.9	18.2	1.4	9.4	---	1.0	12.2	299.5	67.5	51.1	60.7
	% freq	100	95	94	91	94	100	100	100	100	100	---	100	100	100	100	100	100
% transects with ice		86	82	89	64	47	40	100	100	100	100	---	100	100	100	100	100	100

Table 11. Densities of birds in relation to distance from land in the Beaufort Sea in August 1976.

2GL876

Distance from land	Km	6-10	11-15	16-20	21-25	26-30	31-35	36-40	41-45	46-50	51-55	56-60	61-65	66-70	71-75	76-80	81-85	86-90	91-95	96-100
Number of transects	n	3	3	11	7	21	6	11	7	7	10	14	3	2	1	1	1	2	2	1
All *Gavia*	$\bar{x}$	0.1	0.0	0.0	0.0	0.2	0.3	0.3	0.0	0.0	0.0	0.1	0.0	0.5	0.0	0.0	0.0	0.0	0.0	0.0
	% freq	33	0	0	0	10	17	18	0	0	0	7	0	50	0	0	0	0	0	0
Clangula hyemalis	$\bar{x}$	0.0	0.0	0.0	0.0	0.0	0.0	0.8	0.0	0.3	1.6	0.0	6.4	0.0	0.0	0.0	0.0	3.4	3.4	0.0
	% freq	0	0	0	0	0	0	18	0	14	10	0	33	0	0	0	0	50	50	0
All Phalaropes	$\bar{x}$	0.0	65.9	5.6	0.0	2.3	1.2	7.6	0.8	60.3	19.8	9.5	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	% freq	0	100	18	0	10	17	18	14	57	20	14	0	0	0	0	0	0	0	0
All *Stercorarius*	$\bar{x}$	0.0	0.0	0.0	1.1	0.0	0.0	0.1	0.3	0.8	0.2	0.0	0.0	0.0	0.0	0.0	0.0	2.0	0.0	0.0
	% freq	0	0	0	29	0	0	9	14	14	10	0	0	0	0	0	0	100	0	0
Larus hyperboreus	$\bar{x}$	0.0	0.8	0.0	0.0	0.0	0.0	0.2	0.0	0.3	0.7	0.1	1.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	% freq	0	33	0	0	0	0	9	0	14	20	7	33	0	0	0	0	0	0	0
Rissa tridactyla	$\bar{x}$	0.2	3.1	0.7	0.0	0.0	0.0	0.2	0.0	0.3	0.4	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	% freq	33	67	27	0	0	0	9	0	14	10	0	0	0	0	0	0	0	0	0
Xema sabini	$\bar{x}$	0.0	3.2	0.2	0.1	0.1	0.2	0.8	16.0	18.3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1.4	0.0	0.0
	% freq	0	67	9	14	5	17	29	14	29	0	0	0	0	0	0	0	50	0	0
Sterna paradisaea	$\bar{x}$	0.0	0.0	1.1	0.0	2.3	0.0	0.0	0.0	1.0	2.3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	% freq	0	0	27	0	19	0	0	0	29	10	0	0	0	0	0	0	0	0	0
All *Uria*	$\bar{x}$	0.0	2.4	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	% freq	0	33	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
TOTAL DENSITY	$\bar{x}$	0.7	77.8	7.6	1.2	5.0	1.7	9.9	17.0	81.9	25.9	10.1	7.6	0.5	0.0	0.0	0.0	6.7	3.4	0.0
	% freq	67	100	45	29	33	50	27	14	57	40	21	33	50	0	0	0	100	50	0
% transects with ice		100	0	73	71	95	100	100	71	57	90	100	100	100	100	100	100	100	100	100

Table 12. Densities of birds in relation to distance from land in the Beaufort Sea in August 1976.

3GL976

Distance from land	Km	1-5	6-10	11-15	16-20	21-25	26-30	31-35	36-40	41-45	46-50	51-55	56-60
Number of transects	n	0	5	3	1	0	1	4	4	5	2	3	11
All *Gavia*	$\bar{x}$	-	10.8	2.3	0.0	-	0.0	0.8	0.0	1.2	0.0	0.0	3.8
	% freq	-	80	100	0	-	0	50	0	20	0	0	18
Clangula hyemalis	$\bar{x}$	-	36.5	11.5	0.0	-	0.0	0.0	5.4	13.1	0.0	2.7	0.2
	% freq	-	80	33	0	-	0	0	25	40	0	33	9
Puffinus tenuirostris	$\bar{x}$	-	0.0	0.0	0.0	-	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	% freq	-	0	0	0	-	0	0	0	0	0	0	0
All Eiders	$\bar{x}$	-	611.5	0.0	0.0	-	5.1	2.3	0.0	0.0	0.0	3.3	0.0
	% freq	-	80	0	0	-	100	25	0	0	0	33	0
All Phalaropes	$\bar{x}$	-	0.4	0.0	0.0	-	20.6	37.8	54.9	23.2	2.9	2.1	1.3
	% freq	-	20	0	0	-	100	75	100	60	50	33	27
Stercorarius pomarinus	$\bar{x}$	-	0.0	0.0	0.0	-	0.0	0.8	0.6	0.0	0.0	0.0	0.9
	% freq	-	0	0	0	-	0	25	50	0	0	0	9
Stercororius parasiticus	$\bar{x}$	-	0.0	0.0	0.0	-	2.0	0.0	0.0	0.5	0.0	1.2	0.2
	% freq	-	0	0	0	-	100	0	0	40	0	33	9
Stercorarius longicaudus	$\bar{x}$	-	0.0	0.0	0.0	-	0.0	0.0	0.3	0.0	0.0	0.0	0.3
	% freq	-	0	0	0	-	0	0	25	0	0	0	18
All *Stercorarius*	$\bar{x}$	-	0.0	0.0	0.0	-	2.0	0.8	0.9	0.5	0.0	1.2	1.3
	% freq	-	0	0	0	-	100	25	75	40	0	33	36
Larus hyperboreus	$\bar{x}$	-	0.4	1.8	2.4	-	1.0	1.0	4.2	3.4	1.5	0.9	2.4
	% freq	-	20	67	100	-	100	50	100	100	50	67	64
Rissa tridactyla	$\bar{x}$	-	0.0	0.0	0.0	-	2.0	1.3	1.8	1.0	0.8	0.0	2.0
	% freq	-	0	0	0	-	100	50	75	40	50	0	55
Rhodostethia rosea	$\bar{x}$	-	0.0	0.0	0.0	-	0.0	0.0	0.0	0.0	0.0	2.7	0.5
	% freq	-	0	0	0	-	0	0	0	0	0	33	9
Xema sabini	$\bar{x}$	-	0.0	0.0	0.0	-	0.0	8.2	18.2	2.2	0.0	0.0	2.7
	% freq	-	0	0	0	-	0	25	100	20	0	0	36
Sterna paradisaea	$\bar{x}$	-	0.0	0.0	0.0	-	0.0	6.6	2.1	6.2	0.0	0.0	0.0
	% freq	-	0	0	0	-	0	83	23	20	0	0	0
TOTAL DENSITY	$\bar{x}$	-	659.6	15.9	2.4	-	30.7	58.7	88.6	50.8	5.1	15.2	14.2
	% freq	-	100	100	100	-	100	100	100	100	100	100	73
% transects with ice		-	0	0	0	-	0	0	100	60	100	67	100

Distance from land	Km	61-65	66-70	71-75	76-80	81-85	86-90	91-95	96-100	101-105	106-110	111-115	116-120	121-125	126-130
Number of transects	n	12	5	7	9	11	5	10	14	6	1	1	0	6	2
All *Gavia*	$\bar{x}$	1.4	8.8	0.0	0.0	1.3	0.2	0.8	0.6	1.6	1.8	0.0	-	0.0	0.0
	% freq	17	20	0	0	27	20	50	36	33	100	0	-	0	0
Clangula hyemalis	$\bar{x}$	1.1	0.0	1.0	0.2	0.2	0.0	0.6	2.7	0.0	0.0	0.0	-	2.8	0.0
	% freq	33	0	14	11	9	0	20	21	0	0	0	-	50	0
Puffinus tenuirostris	$\bar{x}$	0.0	0.0	0.0	0.0	0.0	0.0	0.1	0.1	0.0	0.0	0.0	-	0.0	0.0
	% freq	0	0	0	0	0	0	10	7	0	0	0	-	0	0
All Eiders	$\bar{x}$	0.3	0.0	0.0	0.0	0.0	0.0	0.4	0.0	0.0	0.0	0.0	-	0.0	0.0
	% freq	8	0	0	0	0	0	10	0	0	0	0	-	0	0
All Phalaropes	$\bar{x}$	2.5	0.3	0.0	3.3	18.1	10.6	14.5	7.9	0.0	0.0	35.0	-	0.0	10.5
	% freq	8	20	0	11	45	20	50	36	0	0	100	-	0	50
Stercorarius pomarinus	$\bar{x}$	0.2	0.0	0.0	0.0	0.1	0.0	0.0	0.0	0.0	0.0	0.0	-	0.2	0.0
	% freq	8	0	0	0	9	0	0	0	0	0	0	-	17	0
Stercororius parasiticus	$\bar{x}$	0.2	0.0	0.0	0.0	0.0	0.0	0.0	0.1	0.0	0.0	0.0	-	0.0	0.0
	% freq	8	0	0	0	0	0	0	7	0	0	0	-	0	0
Stercorarius longicaudus	$\bar{x}$	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	-	0.3	0.0
	% freq	0	0	0	0	0	0	0	0	0	0	0	-	17	0
All *Stercorarius*	$\bar{x}$	0.4	0.0	0.0	0.2	0.2	0.4	0.2	0.1	0.0	0.0	0.0	-	0.5	0.0
	% freq	17	0	0	11	18	40	20	7	0	0	0	-	33	0
Larus hyperboreus	$\bar{x}$	1.5	0.0	0.5	1.5	0.8	0.0	2.3	1.2	0.6	0.0	0.0	-	0.3	0.9
	% freq	42	0	14	33	18	0	60	30	33	0	0	-	17	50
Rissa tridactyla	$\bar{x}$	0.6	0.0	0.0	0.5	0.2	0.4	1.9	0.4	0.9	0.0	0.0	-	0.7	1.8
	% freq	17	0	0	22	9	20	50	29	83	0	0	-	50	100
Rhodostethia rosea	$\bar{x}$	0.0	0.0	0.0	0.0	0.0	0.0	1.0	0.6	0.4	0.0	0.0	-	0.0	0.0
	% freq	0	0	0	0	0	0	40	14	17	0	0	-	0	0
Xema sabini	$\bar{x}$	0.4	0.7	0.0	0.3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	-	0.0	0.0
	% freq	17	20	0	11	0	0	0	0	0	0	0	-	0	0
Sterna paradisaea	$\bar{x}$	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	-	0.0	0.0
	% freq	0	0	0	0	0	0	0	0	0	0	0	-	0	0
TOTAL DENSITY	$\bar{x}$	8.5	9.6	1.5	5.8	20.6	11.7	21.9	13.4	3.3	1.8	35.0	-	4.4	13.2
	% freq	82	60	29	56	82	40	90	79	67	100	100	-	83	100
% transects with ice		100	100	100	89	45	60	40	43	50	100	0	-	100	100

Table 13. Densities of birds in relation to distance from land in the Beaufort Sea in September 1976.

3AL877

Distance from land	Km	≤ 1	2+3	4+5	6+7	8+9	10+11	12+13	14+15	16+17	18+19	20+21	22+23	24+25	26+27	28+29	30+31	32+33
Number of transects	n	14	21	55	47	17	18	7	21	10	3	2	3	3	2	0	2	1
Gavia arctica	$\bar{x}$	0.8	1.2	0.8	0.3	0.1	1.5	1.0	0.1	0.3	0.0	0.0	1.6	0.0	0.0	---	0.0	0.0
	% freq	29	24	16	4	6	11	29	5	20	0	0	33	0	0	---	0	0
Gavia stellata	$\bar{x}$	0.5	0.1	0.0	0.0	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	---	0.0	0.0
	% freq	14	10	0	0	6	0	0	0	0	0	0	0	0	0	---	0	0
All *Gavia*	$\bar{x}$	1.3	1.3	0.8	0.3	0.4	0.3	0.6	0.1	1.2	0.0	0.0	2.9	0.9	0.0	---	0.0	0.0
	% freq	43	33	20	13	18	17	29	10	40	0	0	76	33	0	---	0	0
Clangula hyemalis	$\bar{x}$	33.4	15.2	14.4	2.7	0.4	10.4	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	---	0.0	0.0
	% freq	43	48	36	15	6	17	0	0	0	0	0	0	0	0	---	0	0
All Eiders	$\bar{x}$	74.9	3.1	0.1	12.1	3.6	16.1	0.0	117.8	0.0	0.0	0.0	0.0	0.0	42.2	---	0.0	0.0
	% freq	43	14	5	13	18	22	0	38	0	0	0	0	0	100	---	0	0
All Phalaropes	$\bar{x}$	16.6	2.2	2.8	9.4	7.0	4.2	0.2	0.4	3.9	0.0	0.0	0.0	0.0	2.5	---	0.0	0.0
	% freq	53	29	29	26	24	39	14	5	40	0	0	0	0	100	---	0	0
All *Stercorarius*	$\bar{x}$	0.5	0.5	0.0	0.1	0.0	0.2	0.0	0.0	0.5	0.0	0.0	0.0	0.0	0.0	---	0.0	0.0
	% freq	21	5	2	4	0	6	0	0	20	0	0	0	0	0	---	0	0
Larus hyperboreus	$\bar{x}$	2.9	0.6	0.6	0.5	0.3	2.7	0.0	0.3	0.8	0.0	1.2	0.8	0.8	1.9	---	1.2	0.0
	% freq	43	33	16	26	29	39	0	19	40	0	50	33	33	100	---	50	0
Rissa tridactyla	$\bar{x}$	0.7	0.5	0.1	0.0	1.7	0.0	0.0	0.0	0.2	0.0	0.0	0.0	0.0	0.0	---	0.0	0.0
	% freq	14	14	4	2	12	0	0	0	10	0	0	0	0	0	---	0	0
Xema sabini	$\bar{x}$	0.3	0.0	0.1	0.3	1.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	---	0.0	0.0
	% freq	7	0	2	2	12	0	0	0	0	0	0	0	0	0	---	0	0
Sterna paradisaea	$\bar{x}$	2.9	0.6	5.4	3.5	2.1	2.3	0.0	0.3	0.0	3.5	4.8	0.0	0.0	0.0	---	0.0	0.0
	% freq	36	10	20	21	18	17	0	5	0	33	50	0	0	0	---	0	0
Uria species	$\bar{x}$	0.3	0.2	0.0	0.1	0.1	2.3	0.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	---	0.0	0.0
	% freq	7	5	0	4	6	11	14	0	0	0	0	0	0	0	---	0	0
TOTAL DENSITY	$\bar{x}$	133.8	30.0	24.3	32.4	16.7	41.0	1.0	119.0	7.2	3.5	6.0	3.7	1.7	46.6	---	1.2	0.0
	% freq	100	95	64	83	76	67	29	57	80	33	100	67	67	100	---	50	0
% transects with ice		57	52	25	28	35	17	29	48	33	100	100	67	100	100	---	100	100

Table 14. Densities of birds in relation to distance from land in the Beaufort Sea in August 1977.

3CL577

Distance from land	Km	1-5	6-10	11-15	16-20	21-25	26-30	31-35	36-40	41-45	46-50	51-55	56-60	61-65	66-70	71-75	76-80	81-85	86-90	91-95	96-100	101-105	106-110	111-115	116-120	121-125	126-130	131-135
Number of transects	n	2	12	13	25	18	14	26	33	48	17	9	27	30	24	17	30	15	13	14	12	7	8	7	6	3	6	2
Gavia arctica	x	0.0	0.1	0.1	0.1	0.0	0.2	0.5	0.1	0.1	0.1	0.2	0.1	0.3	0.1	0.2	0.0	0.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	% freq	0	8	8	12	0	14	23	9	5	0	11	4	13	4	6	0	7	0	0	0	0	0	0	0	0	0	0
All *Gavia*	x	4.2	0.5	0.6	0.1	0.1	0.2	0.6	0.3	0.1	0.3	0.4	0.1	0.3	0.1	0.2	0.1	0.2	0.0	0.0	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	% freq	100	25	31	12	11	21	27	18	15	29	33	11	17	4	12	3	7	0	0	8	0	0	0	0	0	0	0
Fulmarus glacialis	x	0.0	0.0	0.0	0.0	0.0	0.0	0.1	0.0	0.1	0.0	0.0	0.0	0.0	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.1	0.0	0.0	0.0	0.0	0.0
	% freq	0	0	0	0	0	0	4	0	2	0	0	0	0	4	0	0	0	0	0	0	0	13	0	0	0	0	0
Puffinus tenuirostris	x	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.1	0.0	0.0	0.0	0.0	0.1	0.1	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	% freq	0	0	0	0	0	0	0	3	0	0	0	0	3	4	6	0	0	0	0	0	0	0	0	0	0	0	0
Clangula hyemalis	x	0.0	0.8	0.0	1.9	2.2	0.0	0.1	0.1	0.1	0.0	0.0	0.1	3.6	0.1	0.3	0.1	0.4	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.4	0.0
	% freq	0	25	0	16	33	0	12	3	2	0	0	4	3	8	12	3	7	0	0	0	0	0	0	0	0	33	0
All Eiders	x	0.0	9.3	8.6	0.0	0.0	0.0	0.1	0.2	1.2	0.0	0.0	1.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	% freq	0	17	15	0	0	0	4	3	2	0	0	4	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
All Phalaropes	x	0.0	2.6	2.2	1.5	0.2	0.1	12.7	5.2	3.1	2.7	0.0	0.2	1.0	0.1	2.9	0.3	0.0	0.1	0.5	0.6	0.0	0.0	0.3	3.6	0.0	0.0	0.0
	% freq	0	8	15	12	6	7	15	42	19	24	0	11	7	13	35	7	0	15	7	17	0	0	14	17	0	0	0
Stercorarius pomarinus	x	0.0	0.0	0.0	0.1	0.1	0.0	0.0	0.0	0.0	0.1	0.0	0.0	0.1	0.0	0.0	0.1	0.0	0.0	0.0	0.2	0.0	0.0	0.0	0.3	0.0	0.0	0.0
	% freq	0	0	0	8	6	0	0	0	0	6	0	0	3	0	0	3	0	0	0	17	0	0	0	17	0	0	0
Stercorarius parasiticus	x	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.3	0.1	0.0	0.0	0.1	0.1	0.0	0.1	0.1	0.0	0.1	0.0	0.0	0.0	0.1	0.0	0.0	0.0	0.1	0.0
	% freq	0	0	0	0	0	0	0	12	6	0	0	8	3	0	6	3	0	8	0	0	0	13	0	0	0	17	0
Stercorarius longicaudus	x	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.1	0.0	0.2	0.0	0.0	0.0	0.0	0.0
	% freq	0	0	0	0	0	0	0	0	0	0	0	0	3	0	0	0	0	0	0	5	0	13	0	0	0	0	0
All *Stercorarius*	x	0.0	0.0	0.3	0.1	0.1	0.0	0.0	0.3	0.1	0.1	0.0	0.1	0.2	0.0	0.1	0.1	0.0	0.1	0.0	0.4	0.3	0.2	0.0	0.3	0.0	0.1	0.0
	% freq	0	0	8	12	17	0	0	12	6	6	0	8	10	0	6	6	0	8	0	42	14	25	0	17	0	17	0
Larus hyperboreus	x	0.7	0.6	0.4	0.4	0.4	0.5	0.6	0.3	0.3	0.1	0.1	0.3	0.3	0.5	0.1	0.1	0.0	0.0	0.1	0.0	0.2	0.0	0.0	0.0	0.0	0.0	0.0
	% freq	50	8	31	20	28	29	27	15	19	12	11	15	20	13	12	13	0	0	14	0	14	0	0	0	0	0	0
Rissa tridactyla	x	1.5	0.1	0.1	0.1	0.2	0.3	0.6	1.0	0.6	0.2	0.1	0.3	0.3	0.3	0.3	0.3	0.0	0.2	0.1	0.1	0.2	0.5	0.9	0.3	0.0	0.3	0.7
	% freq	50	8	8	8	6	29	15	21	21	12	11	30	10	25	29	20	0	15	7	17	14	13	43	17	0	17	50
Xema sabini	x	0.0	0.0	0.0	0.3	0.0	0.0	0.1	0.2	0.0	0.0	5.4	0.1	0.0	0.0	0.0	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	% freq	0	0	0	4	0	0	4	3	0	0	22	4	0	0	0	3	0	0	0	0	0	0	0	0	0	0	0
Sterna paradisaea	x	0.0	0.5	0.3	0.0	0.0	0.2	1.4	9.5	1.0	0.0	6.6	0.0	0.0	0.0	0.7	0.1	0.1	0.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	% freq	0	8	8	0	0	7	23	24	13	0	22	0	0	0	6	3	7	8	0	0	0	0	0	0	0	0	0
Uria species	x	0.0	0.0	0.0	0.1	0.1	0.2	0.1	0.1	0.1	0.0	0.0	0.1	0.0	0.1	0.0	0.0	0.0	0.2	0.0	0.0	0.2	0.0	0.9	0.3	0.5	0.0	0.0
	% freq	0	0	0	3	6	14	4	3	2	0	0	11	0	4	0	0	0	8	0	0	14	0	14	17	33	0	0
Cepphus grylle	x	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.1	0.0	0.0	0.0	0.0	0.0	0.3	0.0	0.0	0.0	0.1	0.0
	% freq	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	7	0	0	0	0	0	13	0	0	0	17	0
Small alcid	x	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.1	0.0	0.2	0.0	0.0	0.0	0.0	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.3	0.0	0.0	0.0	0.0
	% freq	0	0	0	0	0	0	0	3	0	6	0	0	0	0	6	0	0	0	0	0	0	0	14	0	0	0	0
TOTAL DENSITY	x	59.0	4.2	12.8	4.7	3.2	1.4	5.5	17.2	7.5	3.7	17.5	2.2	5.7	1.0	5.4	1.0	0.7	0.7	0.8	1.2	1.0	1.1	2.5	4.5	0.5	0.5	1.2
	% freq	100	42	62	60	56	64	69	76	67	59	56	59	50	42	46	40	20	38	29	50	43	35	43	33	33	67	100
% transects with ice		50	17	62	28	11	21	31	15	31	29	22	33	47	58	41	37	47	46	43	92	29	50	86	83	33	33	50

Table 15. Densities of birds in relation to distance from land in the Beaufort Sea in August 1977.

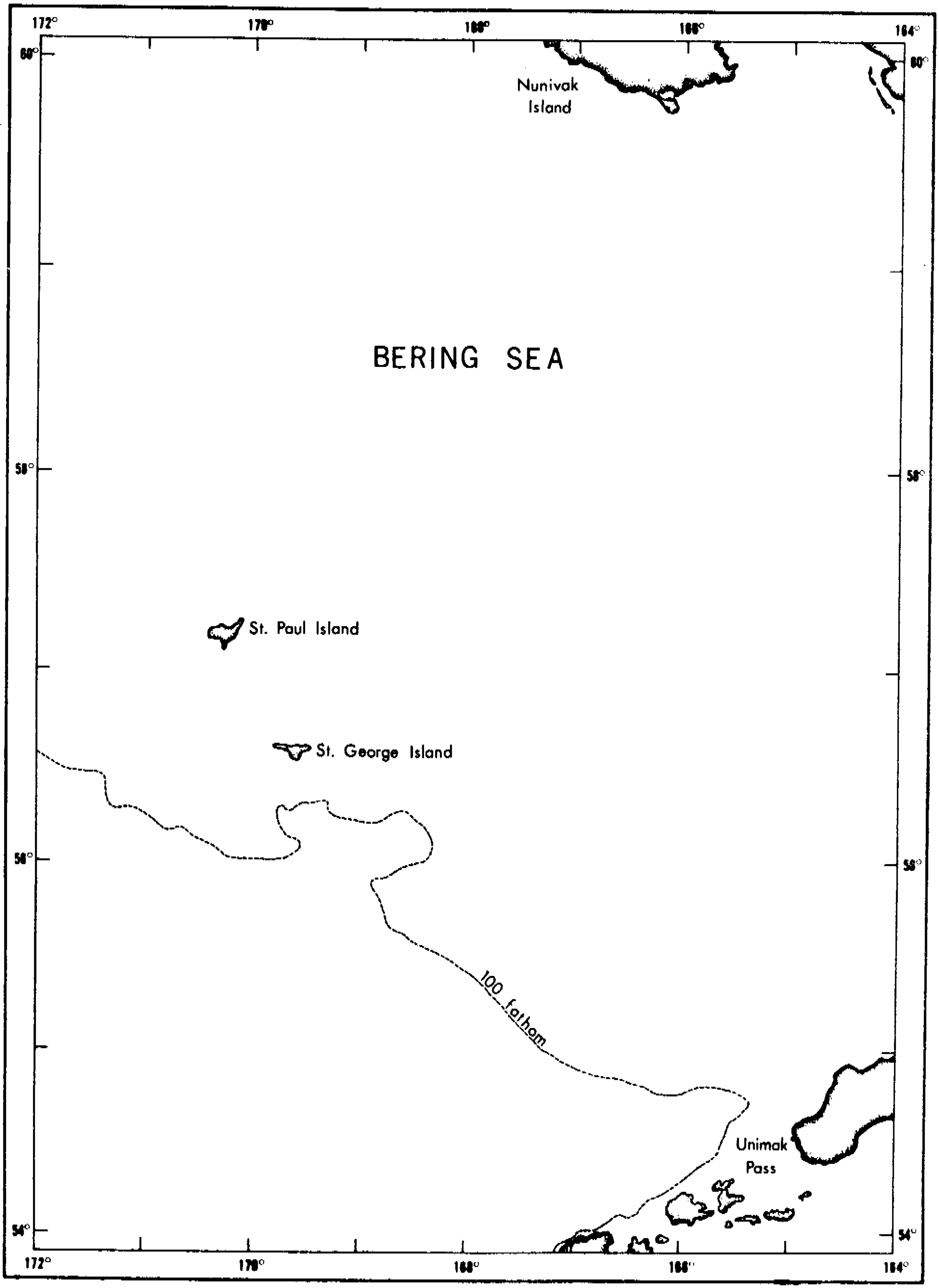


Figure 1. Southern Bering Sea showing localities mentioned in text.

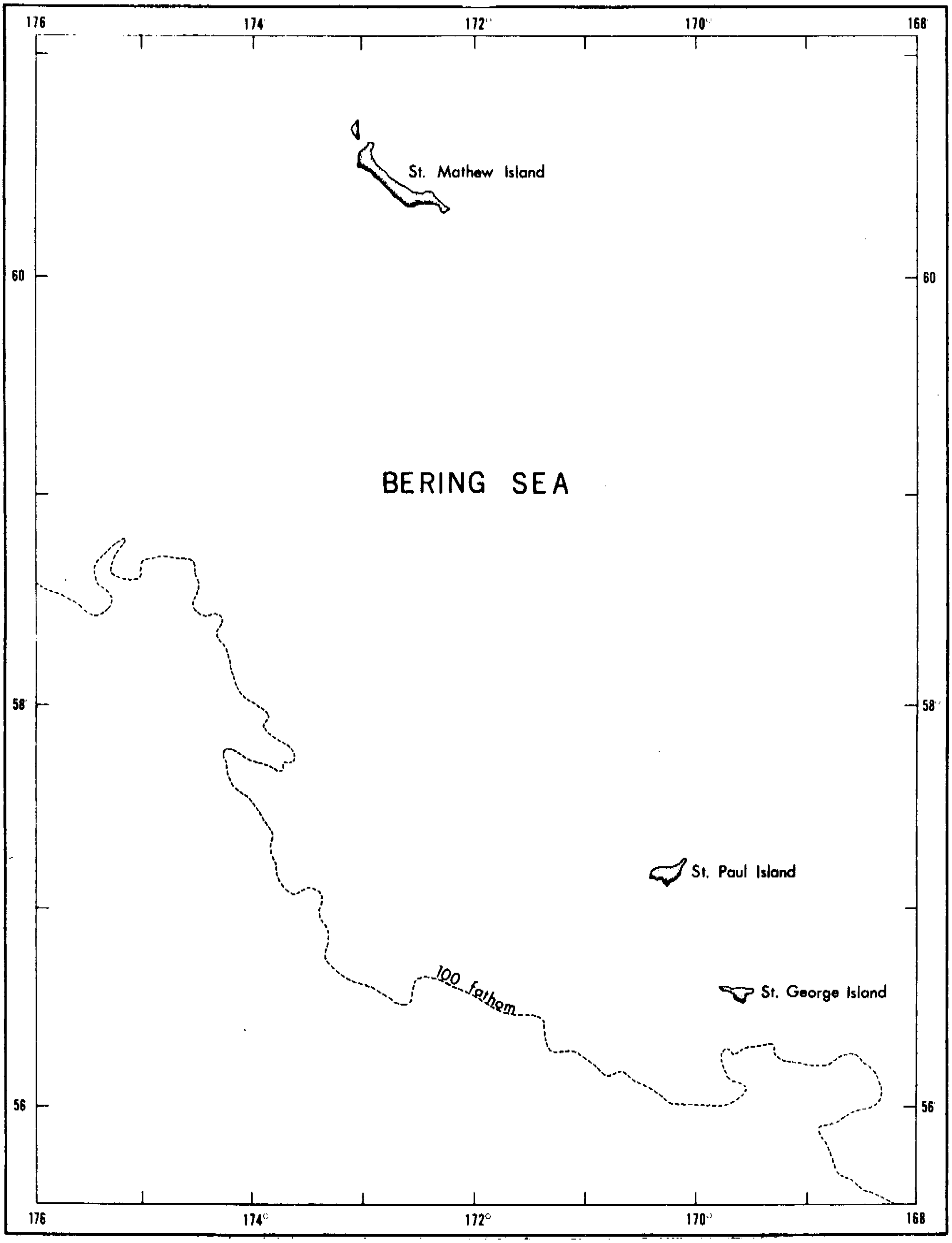


Figure 2. Central Bering Sea showing localities mentioned in text.

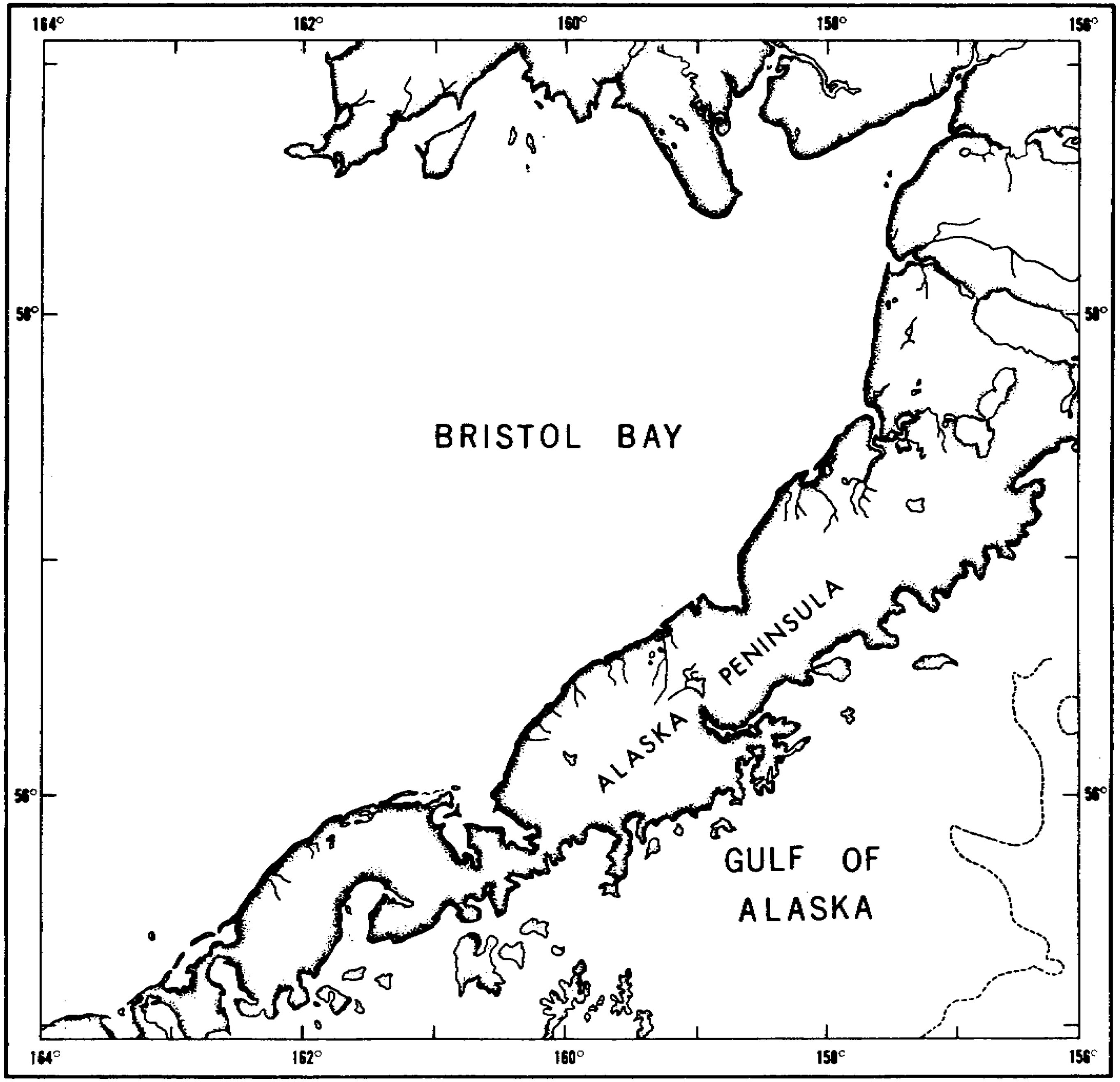


Figure 3. Bristol Bay showing localities mentioned in text.

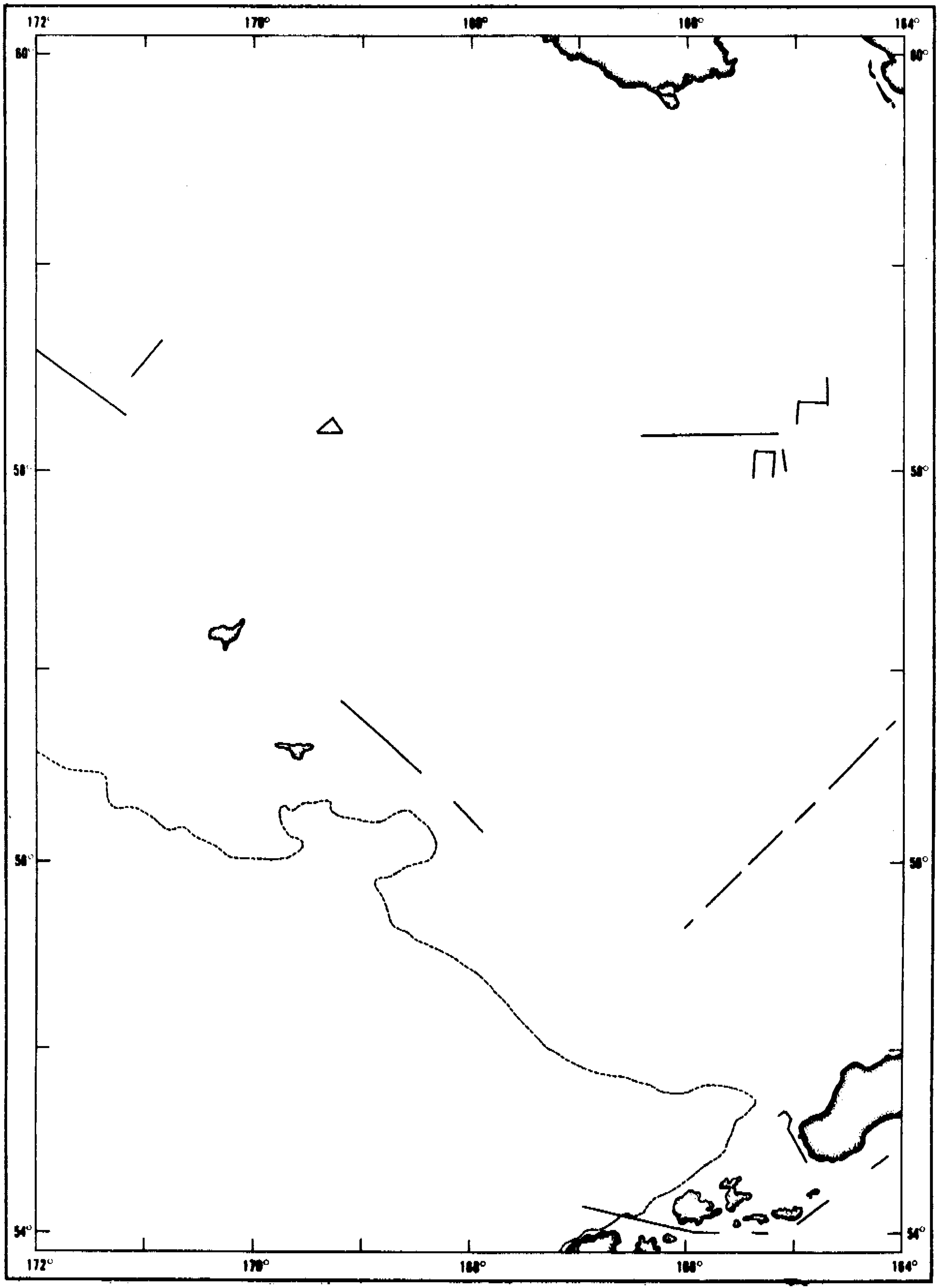


Figure 4. Cruise track during periods of observation in southern Bering Sea from 17 March to 4 April 1977.

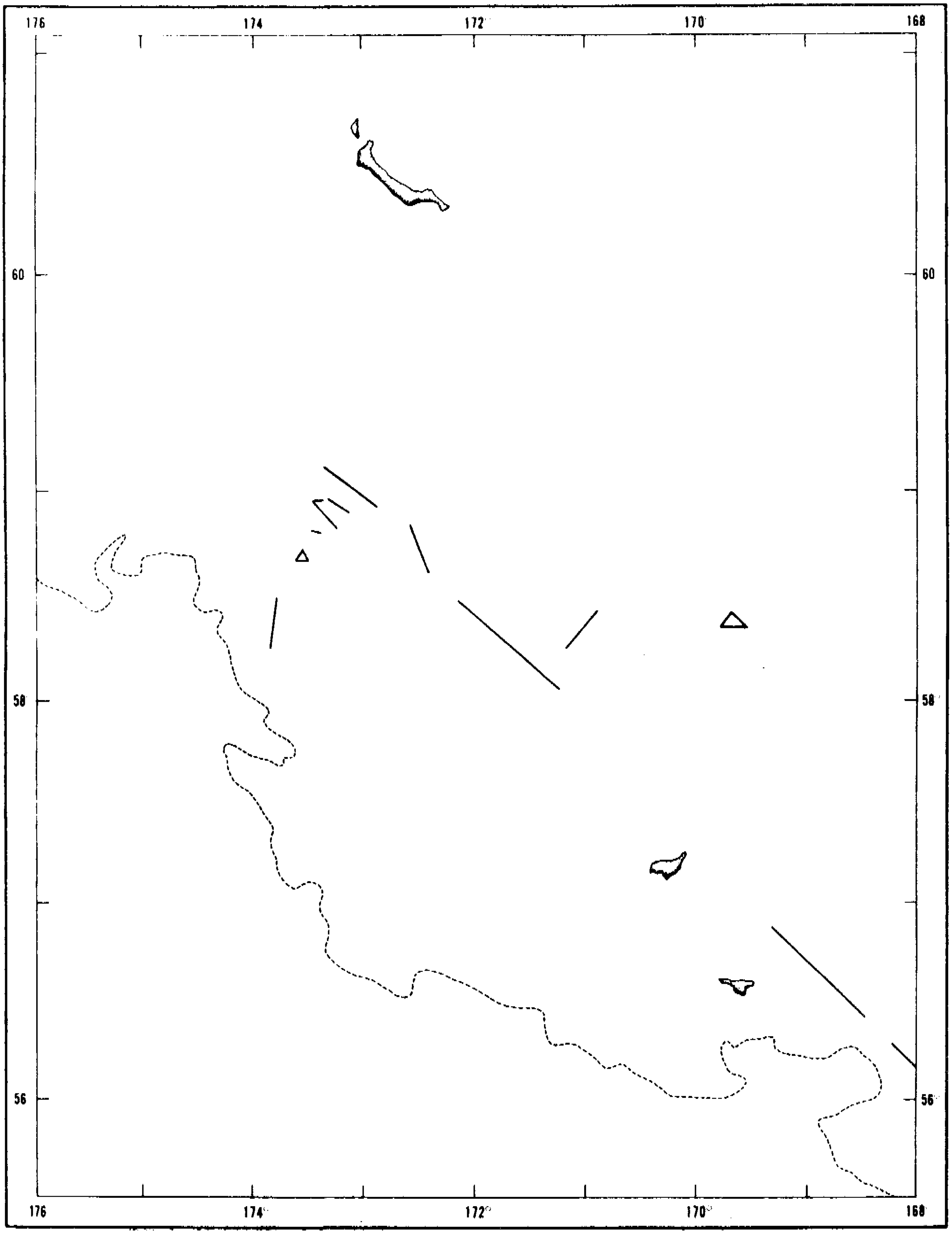


Figure 5. Cruise track during periods of observation in central Bering Sea from 18 March to 25 March 1977.

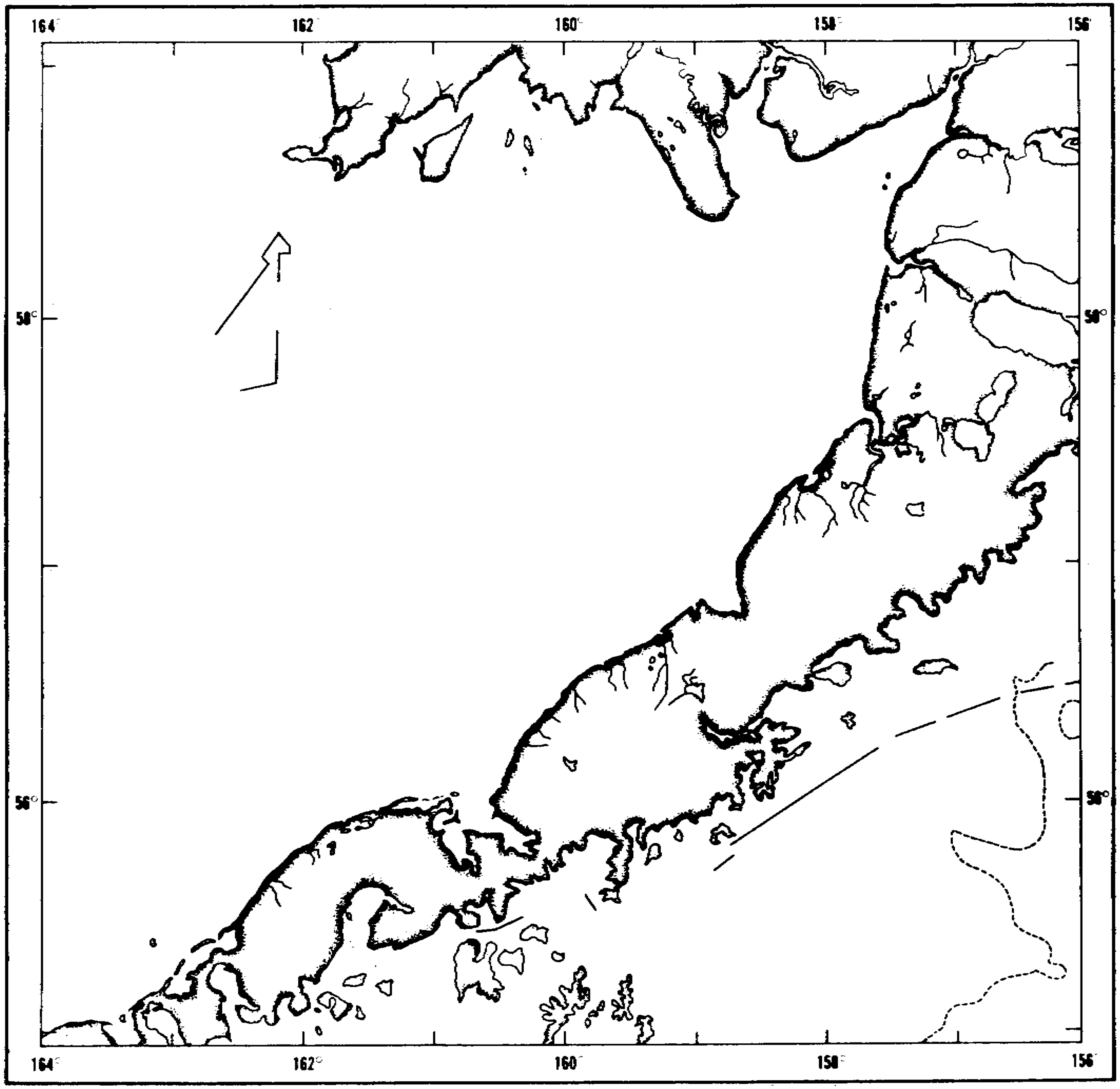


Figure 6. Cruise track during periods of observation in Bristol Bay from 1 to 2 April and in Gulf of Alaska on 16 March and 5 April 1977.

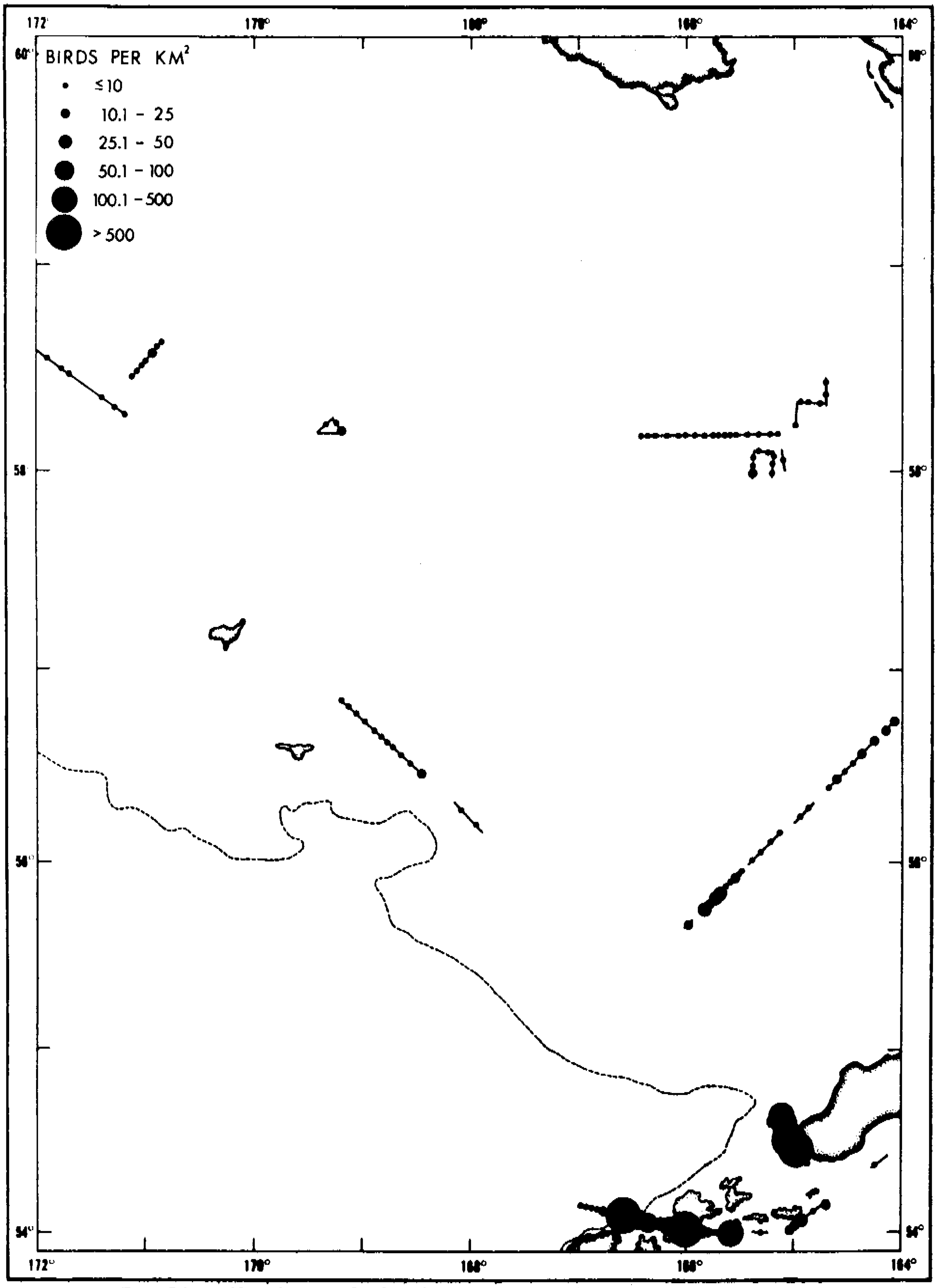


Figure 7. Distribution and abundance of seabirds in southern Bering Sea between 17 March and 4 April 1977.

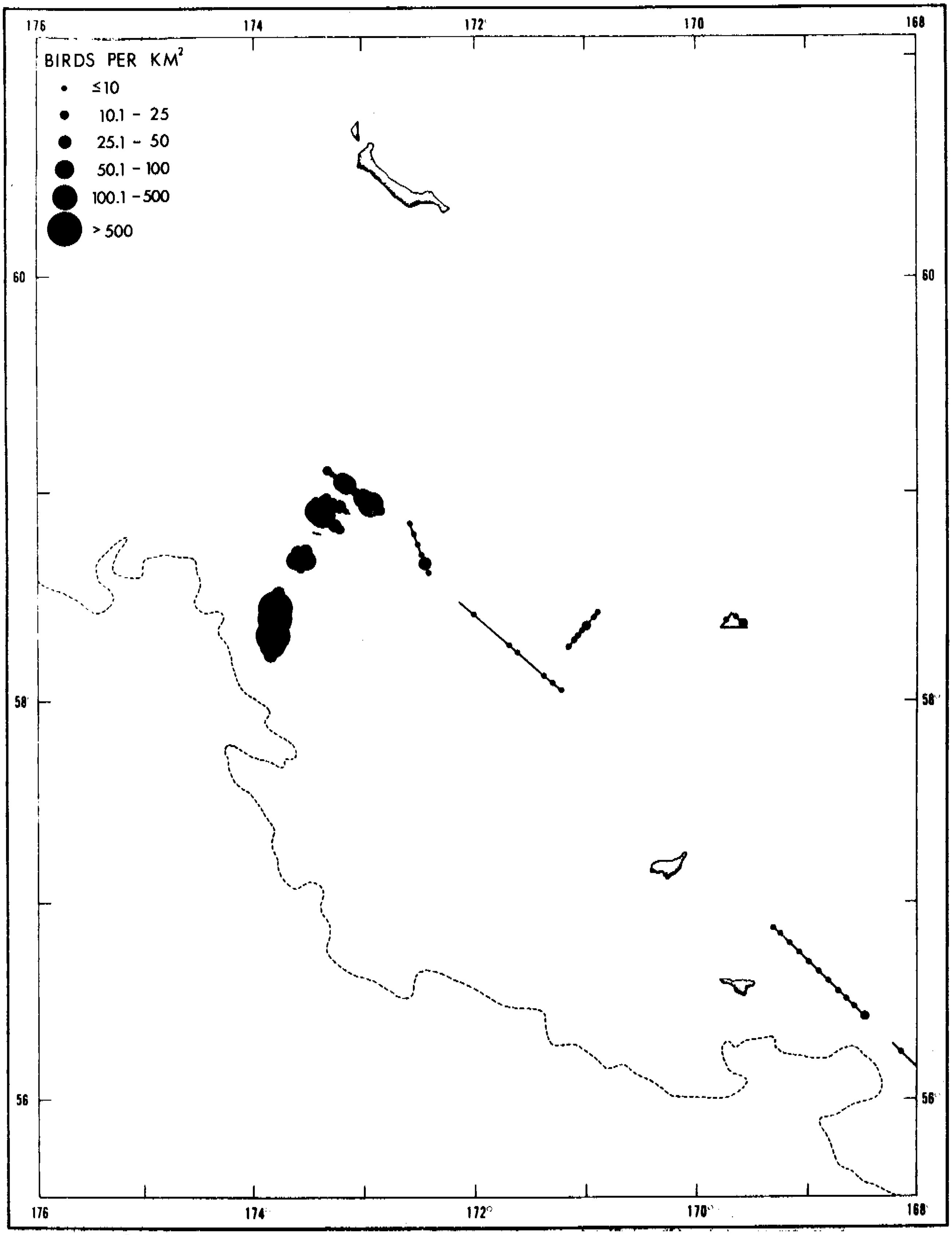


Figure 8. Distribution and abundance of seabirds in central Bering Sea between 18 March and 25 March 1977.

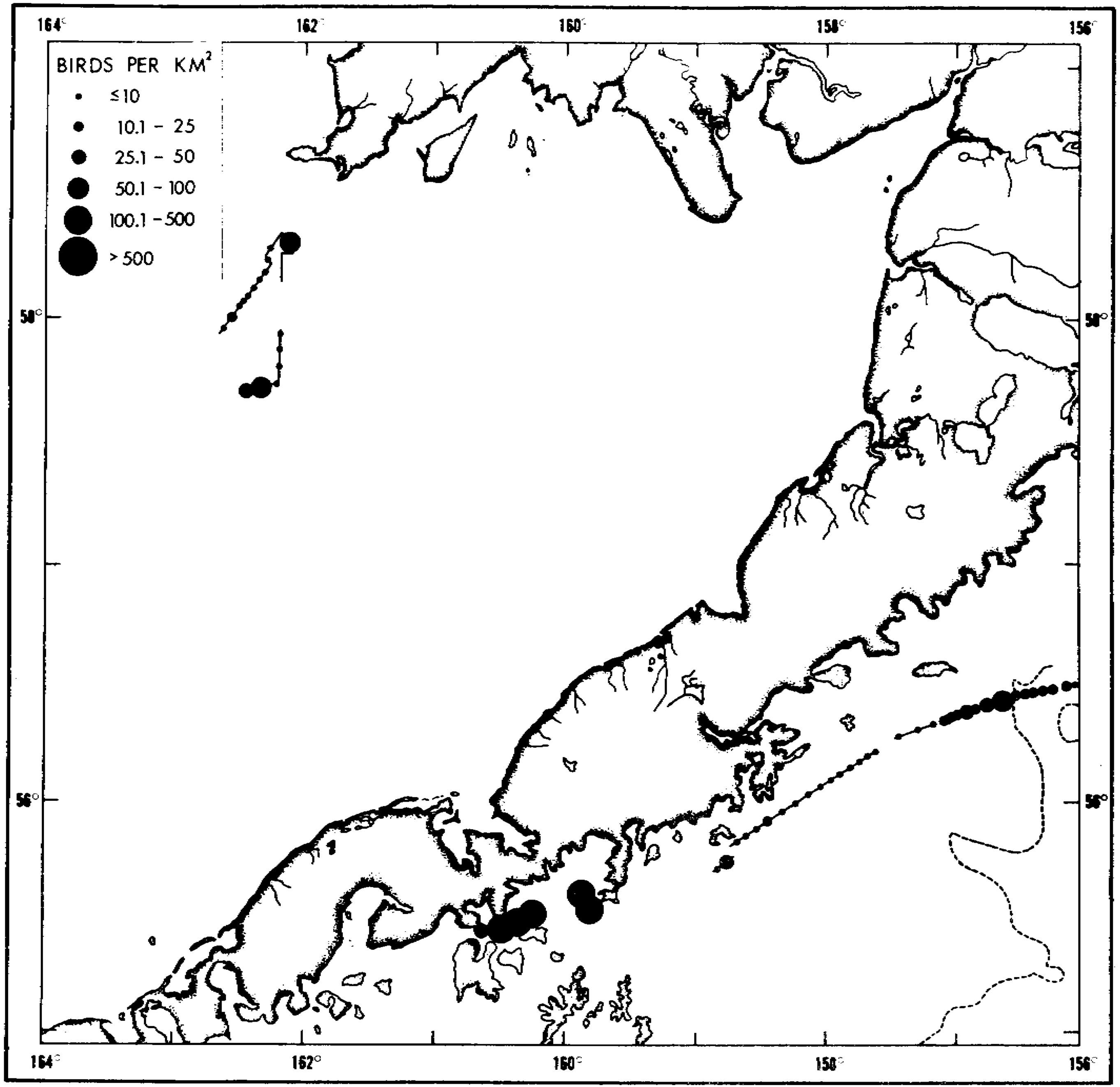


Figure 9. Distribution and abundance of seabirds in Bristol Bay from 1 to 2 April and in Gulf of Alaska on 16 March and 5 April 1977.

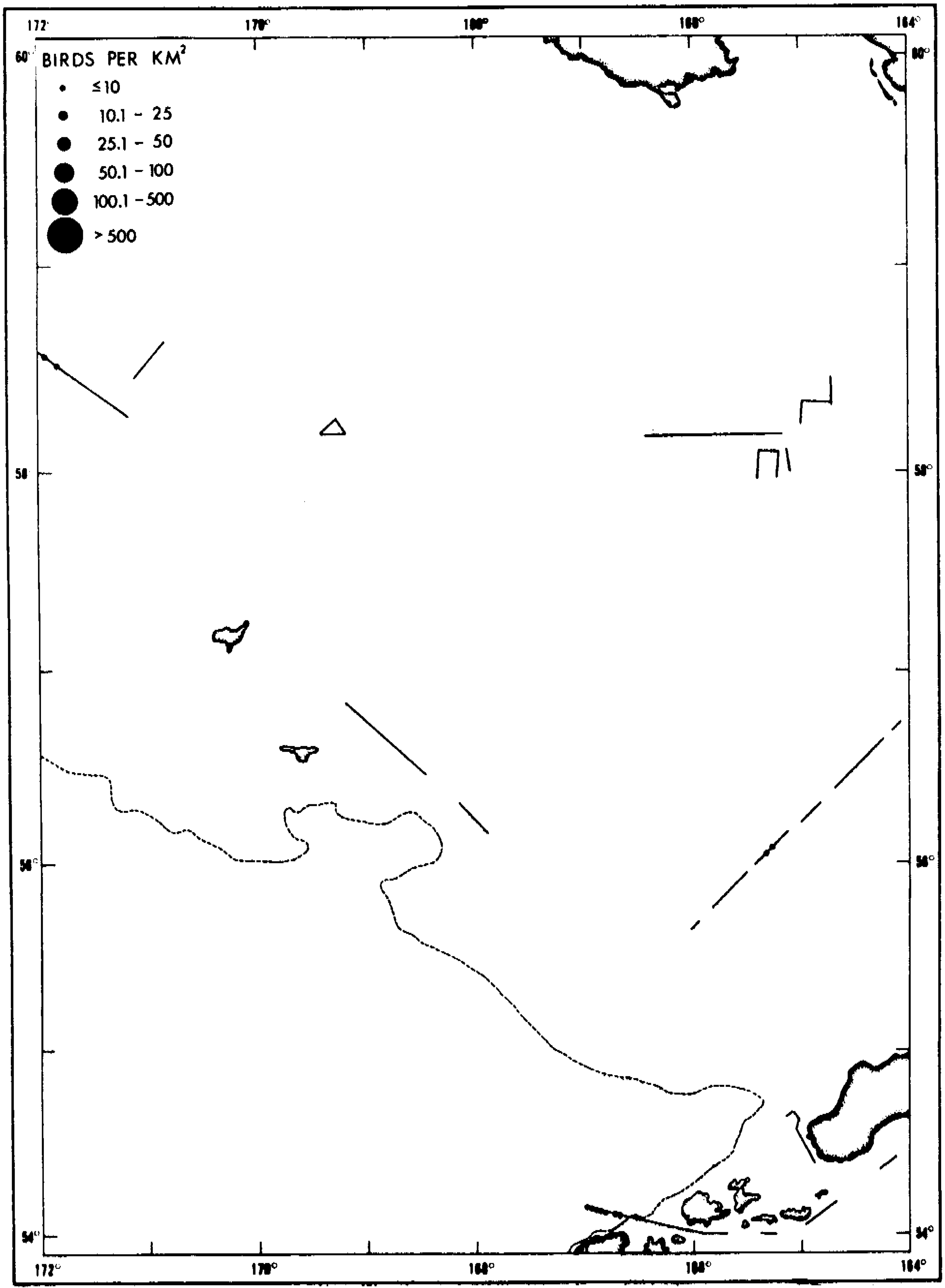


Figure 10. Distribution and abundance of Northern Fulmars in southern Bering Sea between 17 March and 4 April 1977.

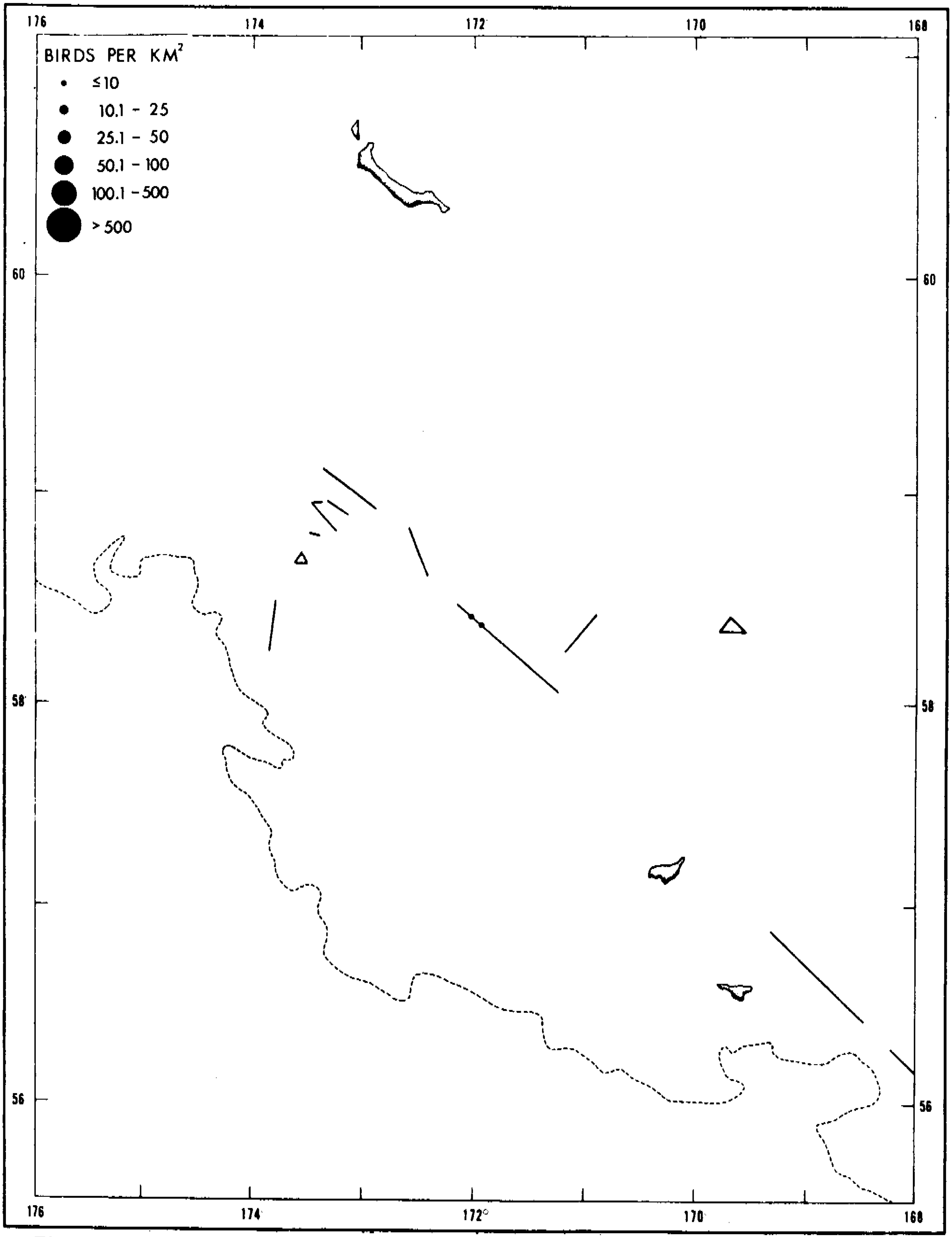


Figure 11. Distribution and abundance of Northern Fulmars in central Bering Sea between 18 March and 25 March 1977.

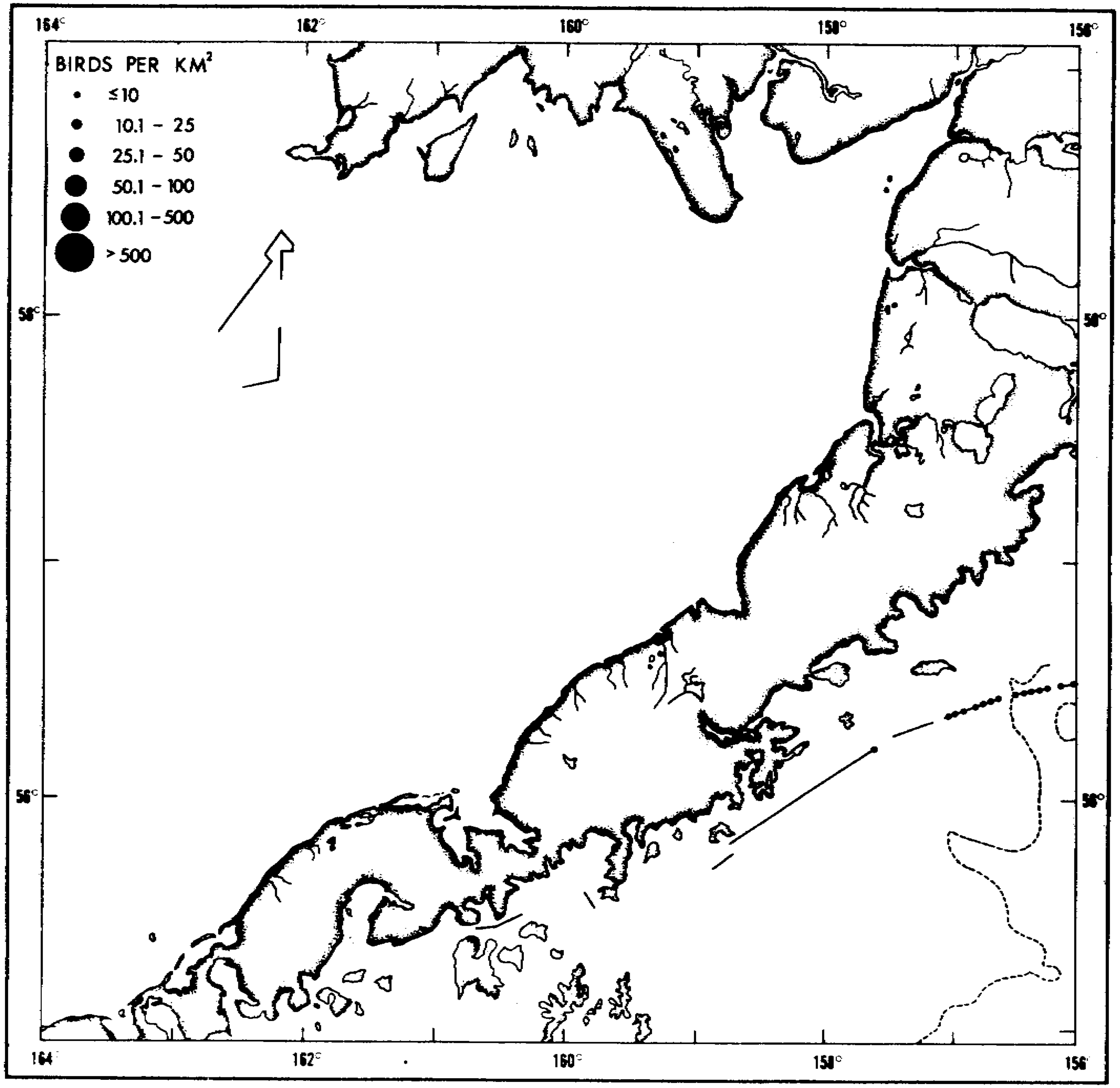


Figure 12. Distribution and abundance of Northern Fulmars in Bristol Bay from 1 to 2 April 1977 and in Gulf of Alaska on 16 March and 25 April 1977.

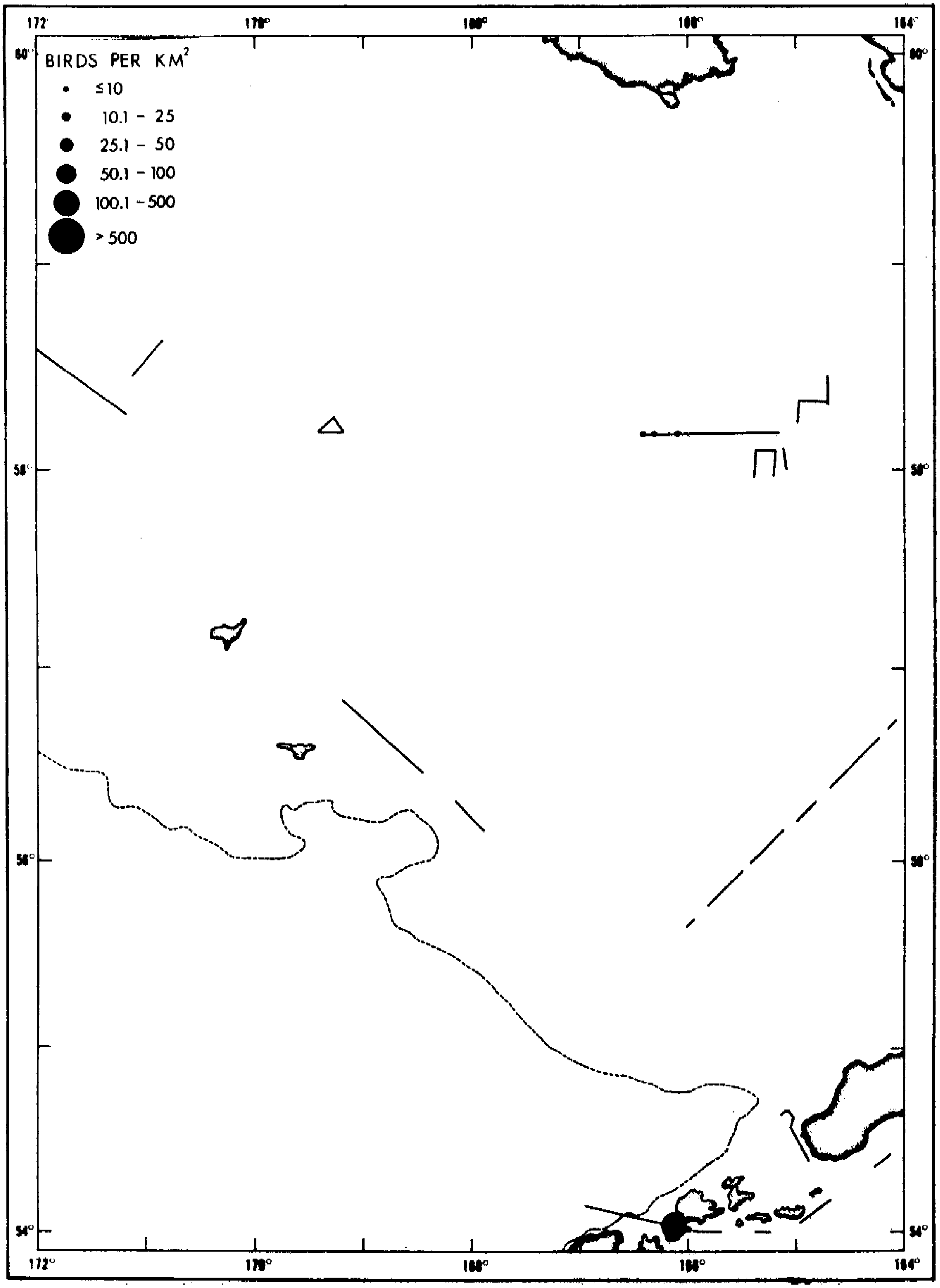


Figure 13. Distribution and abundance of eiders in southern Bering Sea between 17 March and 4 April 1977.

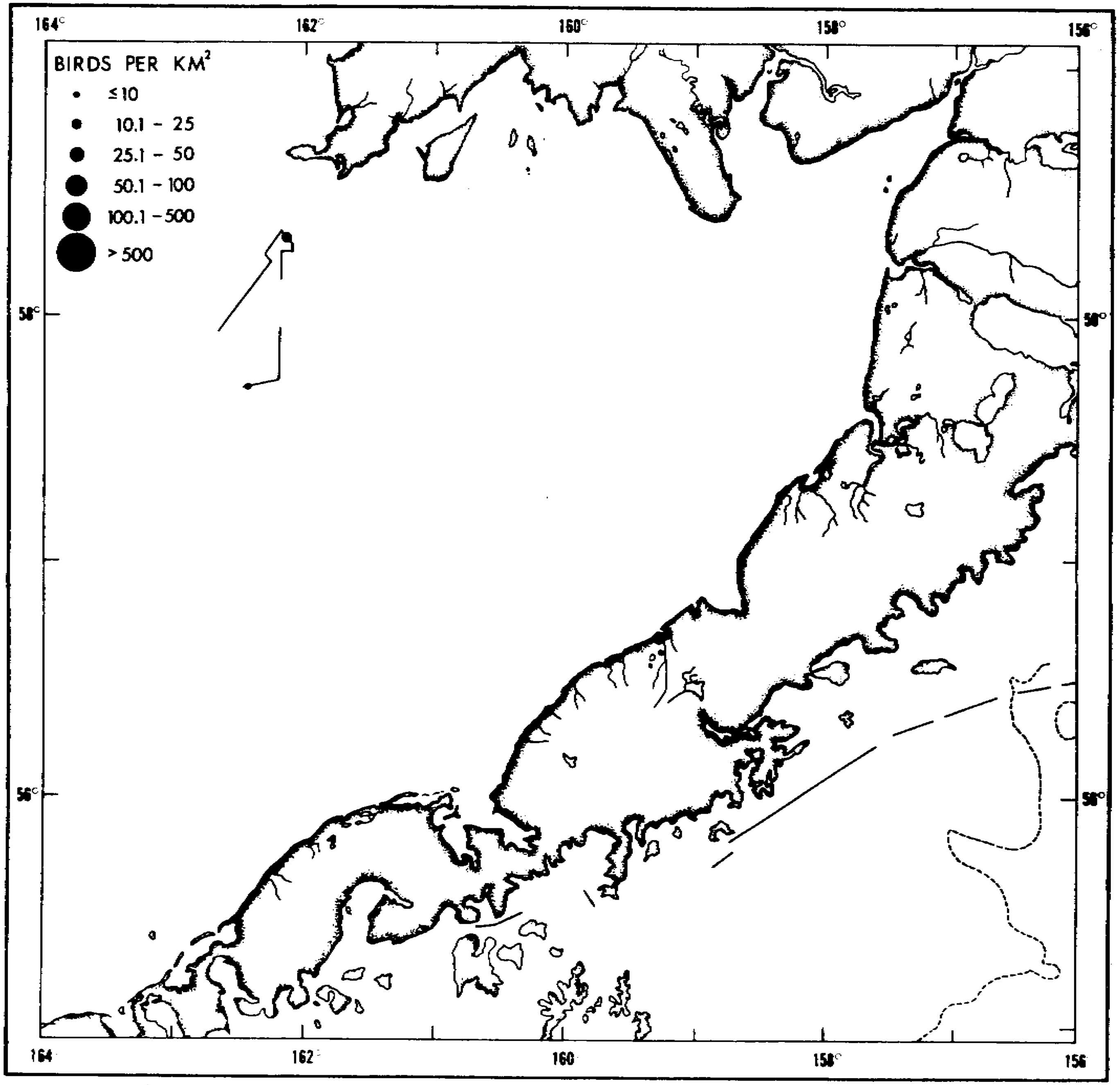


Figure 14. Distribution and abundance of eiders in Bristol Bay from 1 to 2 April and in Gulf of Alaska on 16 March and 25 April 1977.

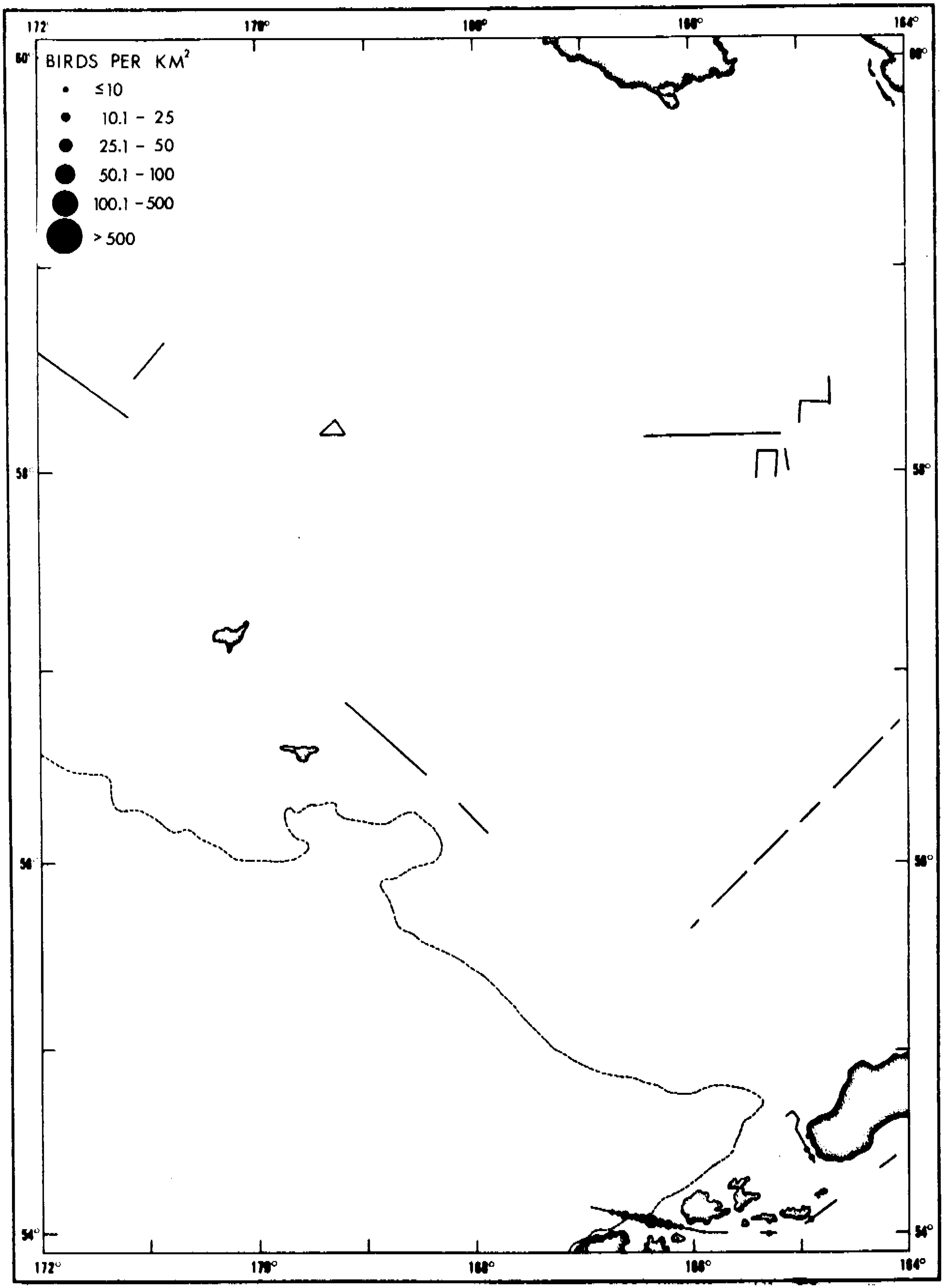


Figure 15. Distribution and abundance of cormorants in southern Bering Sea between 17 March and 4 April 1977.

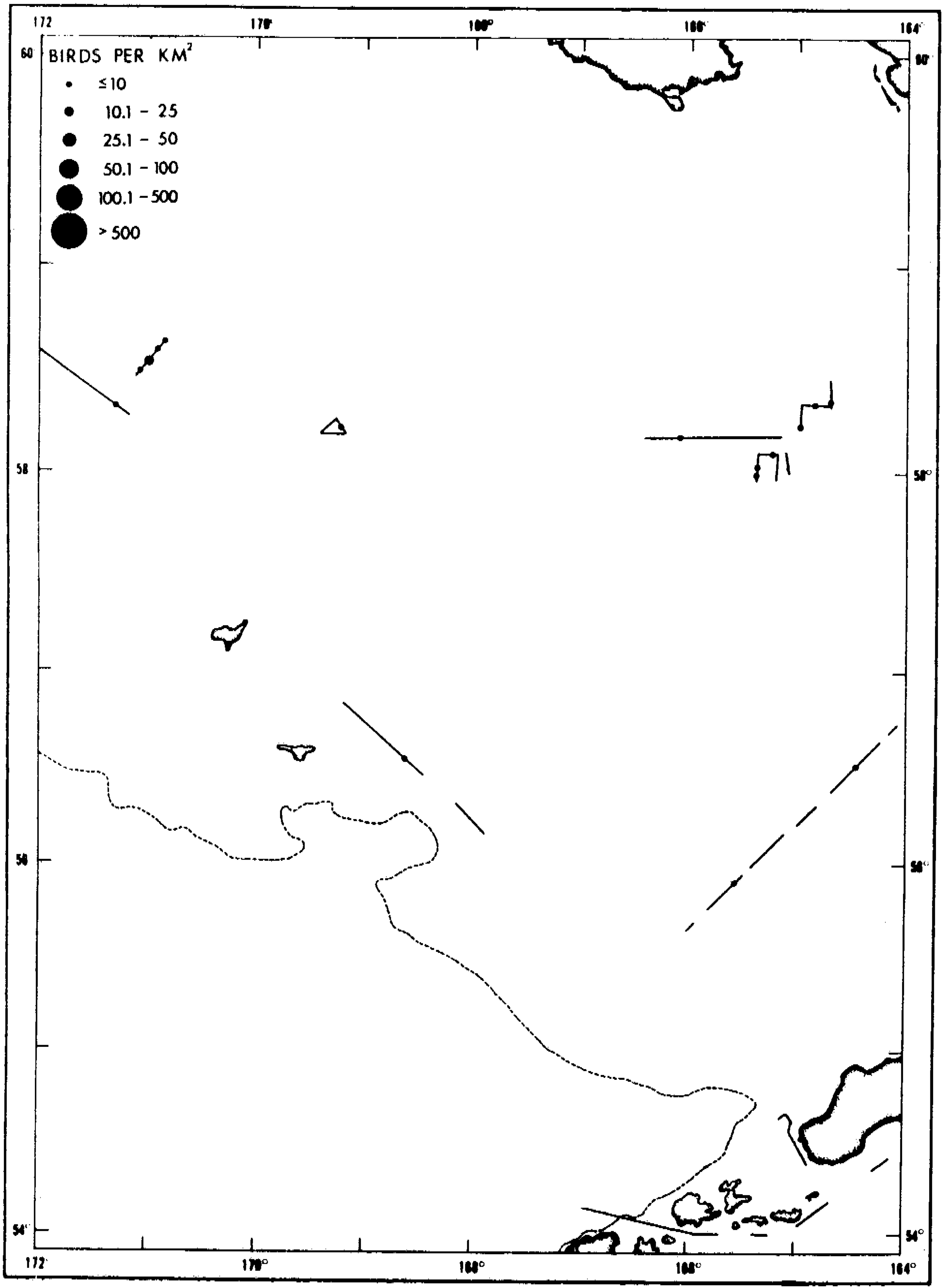


Figure 16. Distribution and abundance of Glaucous Gulls in southern Bering Sea between 17 March and 4 April 1977.

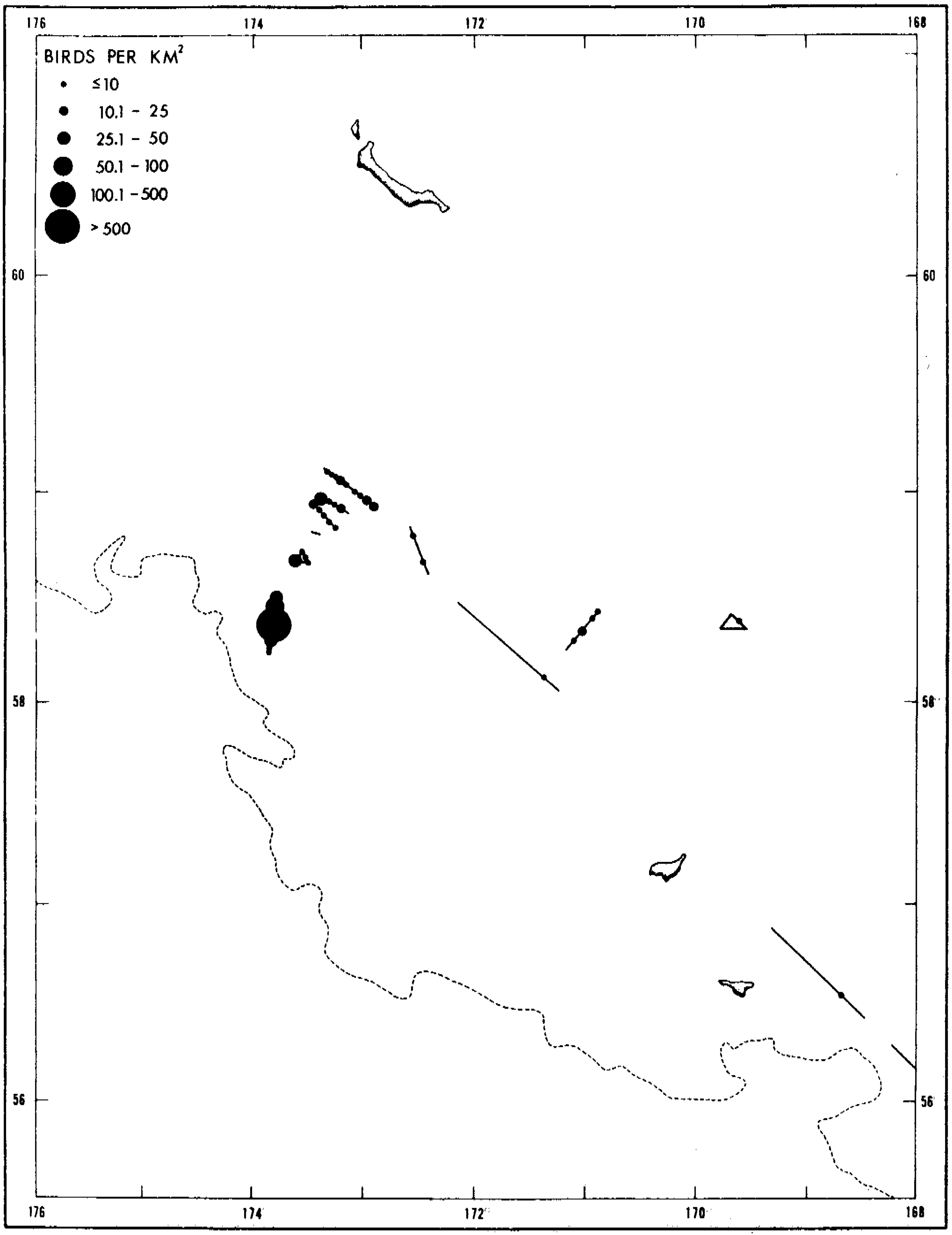


Figure 17. Distribution and abundance of Glaucous Gulls in central Bering Sea between 18 March and 25 March 1977.

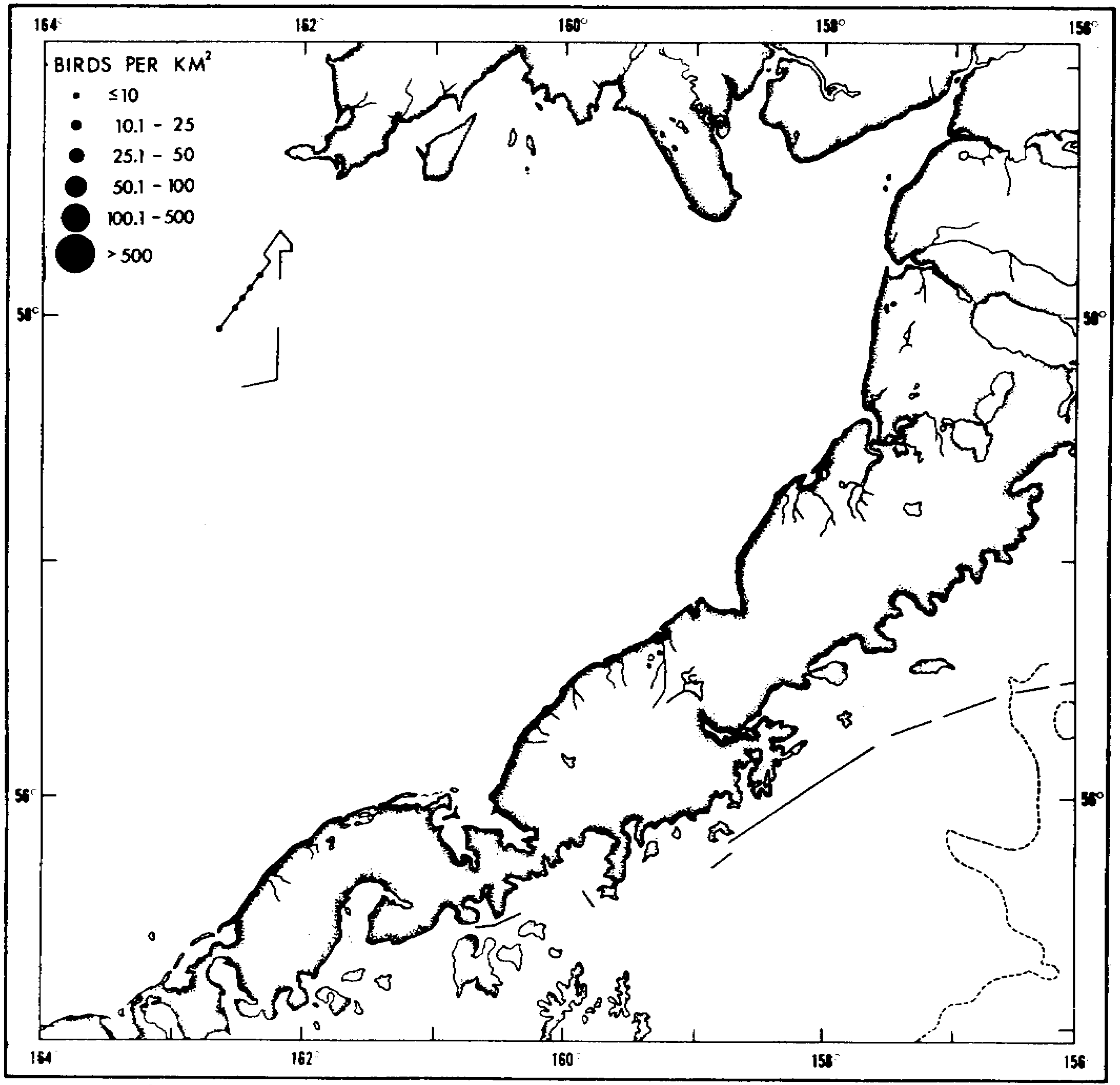


Figure 18. Distribution and abundance of Glaucous Gulls in Bristol Bay from 1 to 2 April and in Gulf of Alaska on 16 March and 25 April 1977.

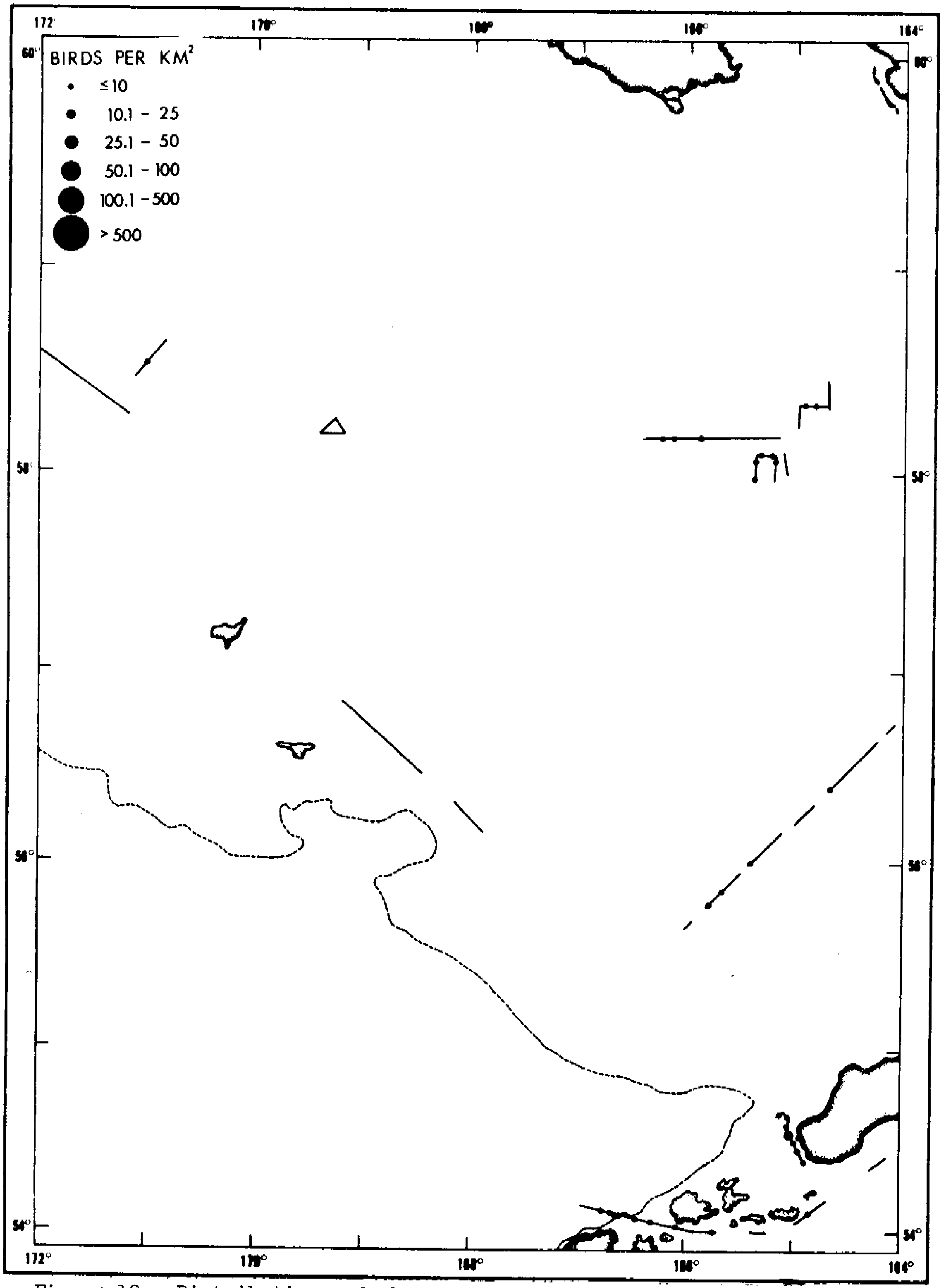


Figure 19. Distribution and abundance of Glaucous-winged Gulls in southern Bering Sea between 17 March and 4 April 1977.

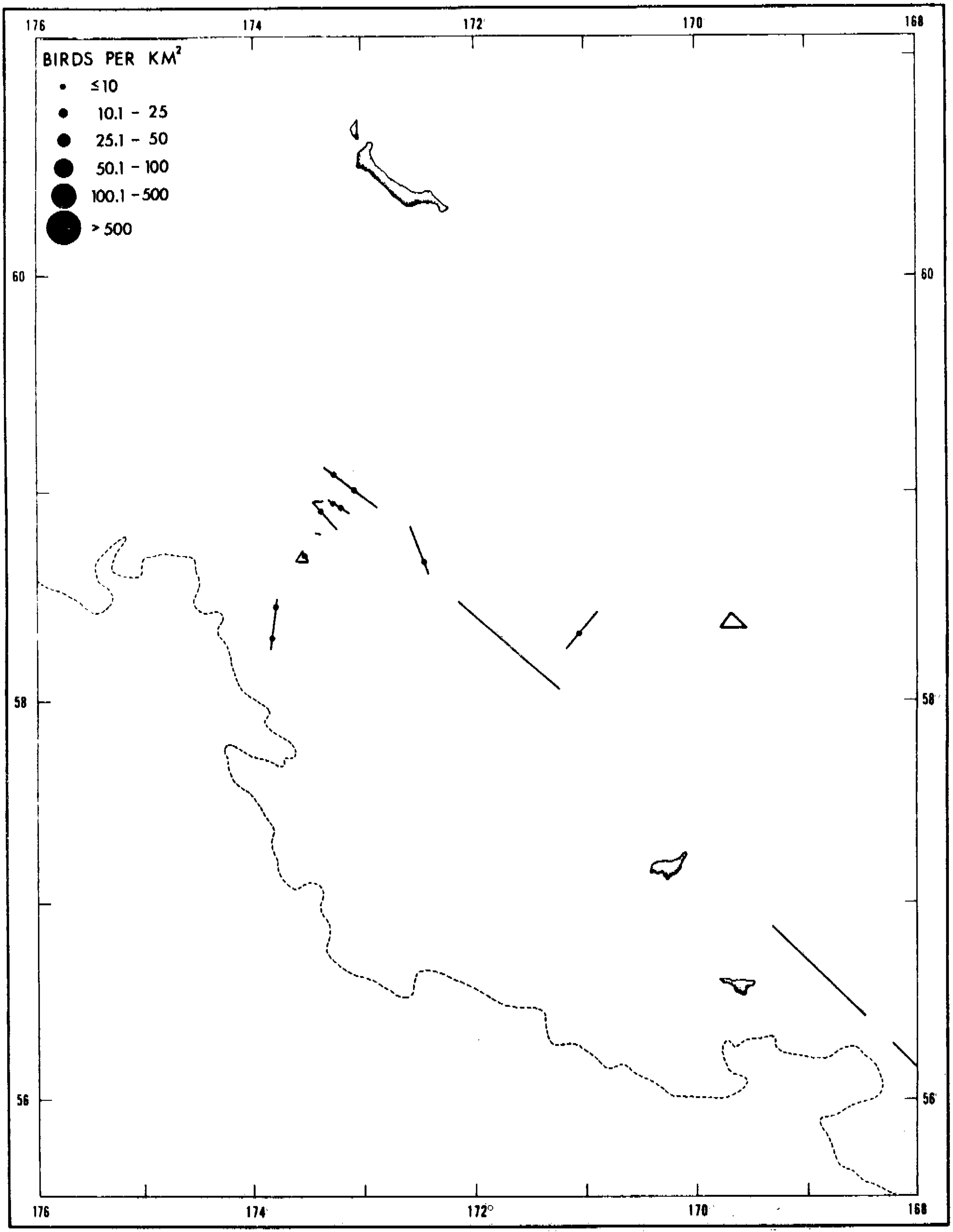


Figure 20. Distribution and abundance of Glaucous-winged Gulls in central Bering Sea between 18 March and 25 March 1977.

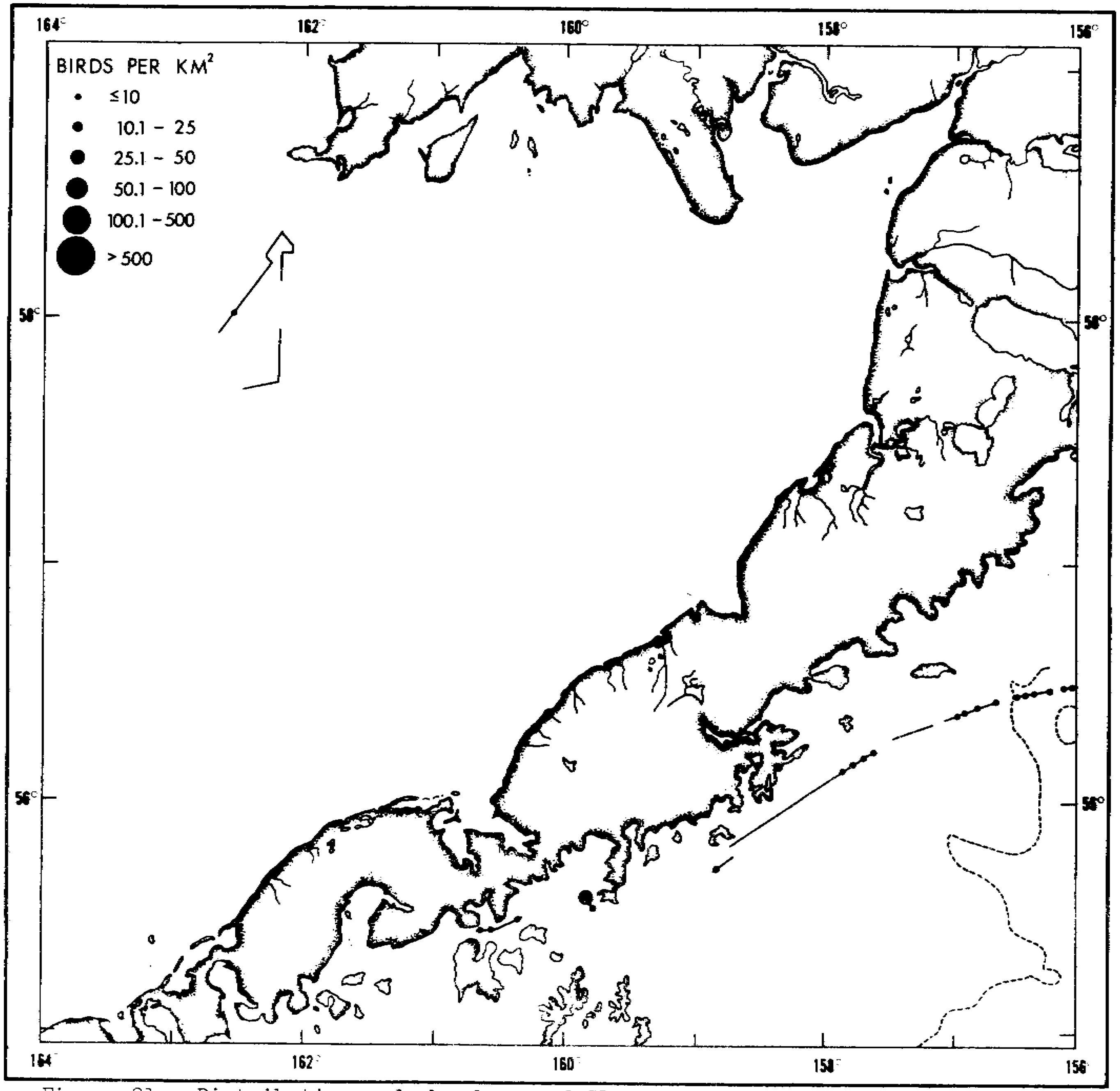


Figure 21. Distribution and abundance of Glaucous-winged Gulls in Bristol Bay from 1 to 2 April and in Gulf of Alaska on 16 March and 25 April 1977.

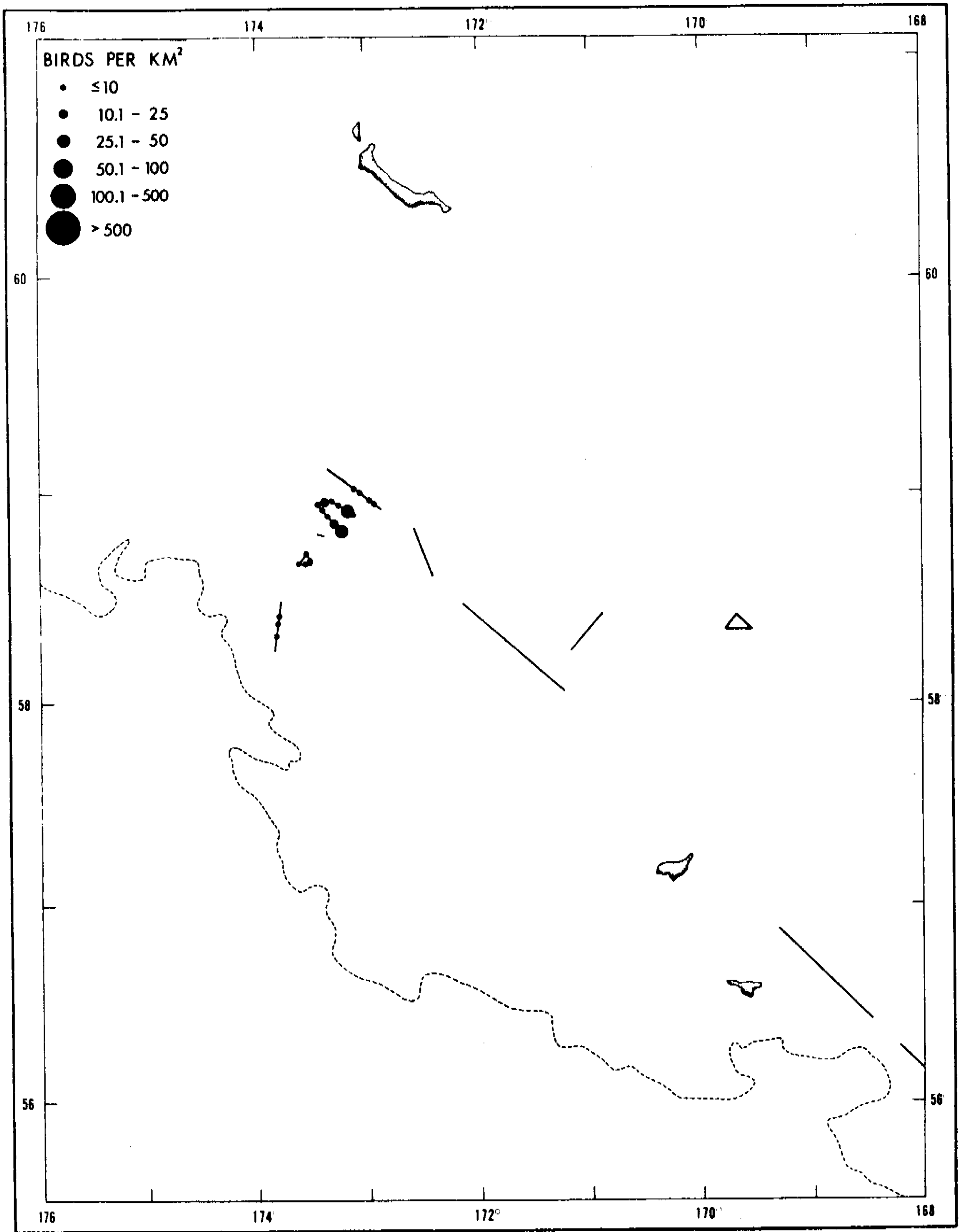


Figure 22. Distribution and abundance of Ivory Gulls in central Bering Sea between 18 March and 25 March 1977.

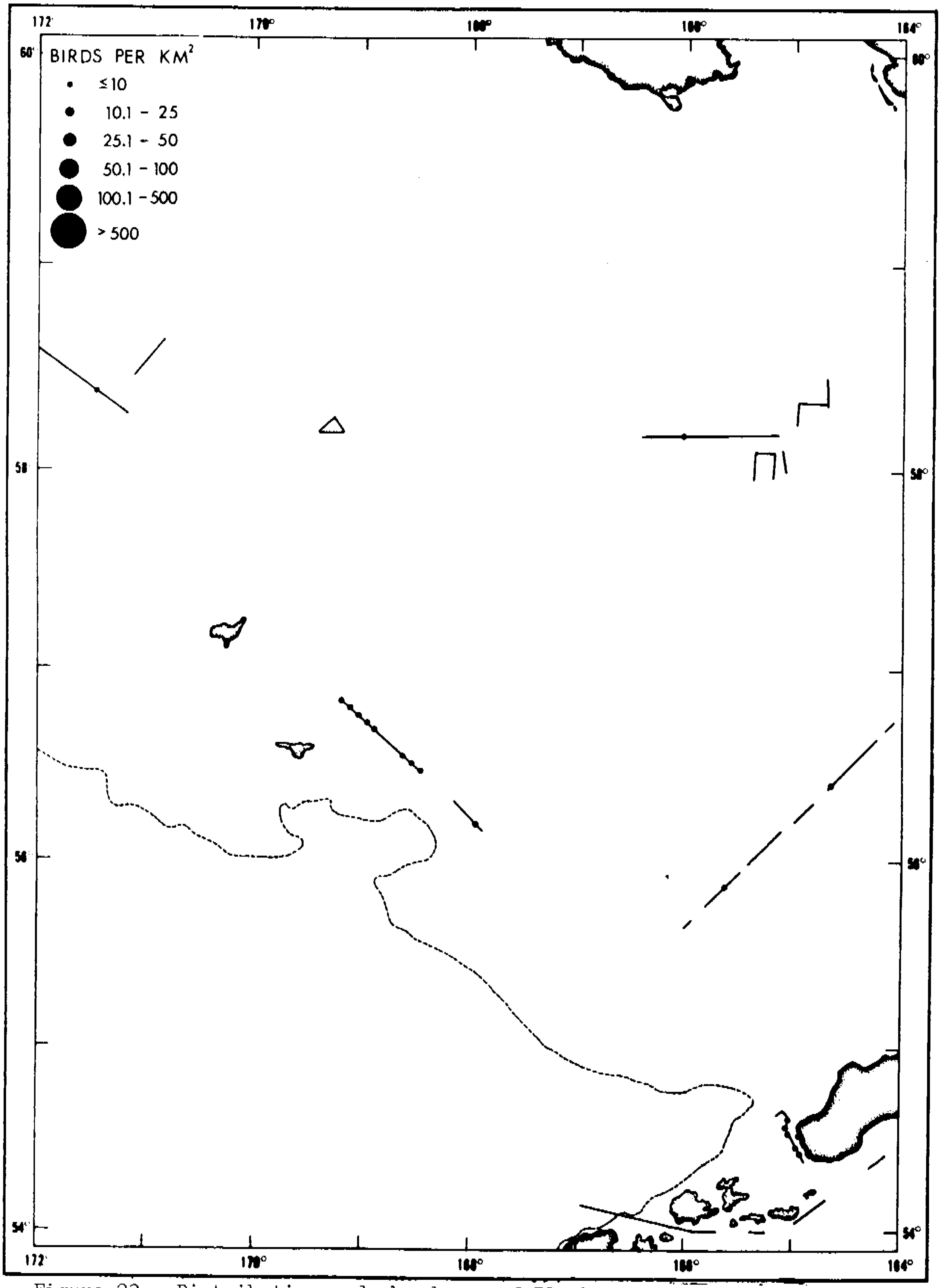


Figure 23. Distribution and abundance of Black-legged Kittiwakes in southern Bering Sea between 17 March and 4 April 1977.

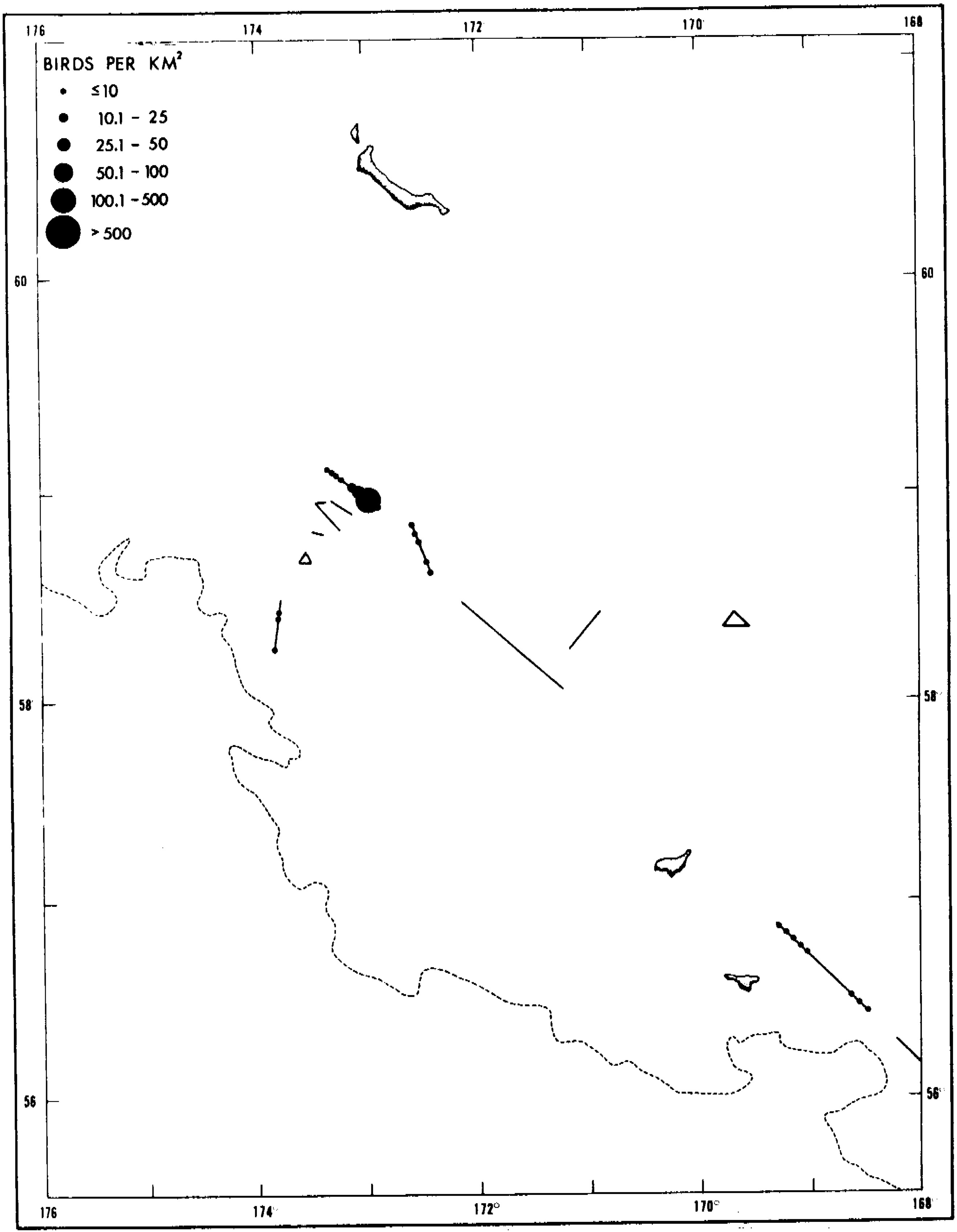


Figure 24. Distribution and abundance of Black-legged Kittiwakes in central Bering Sea between 18 March and 25 March 1977.

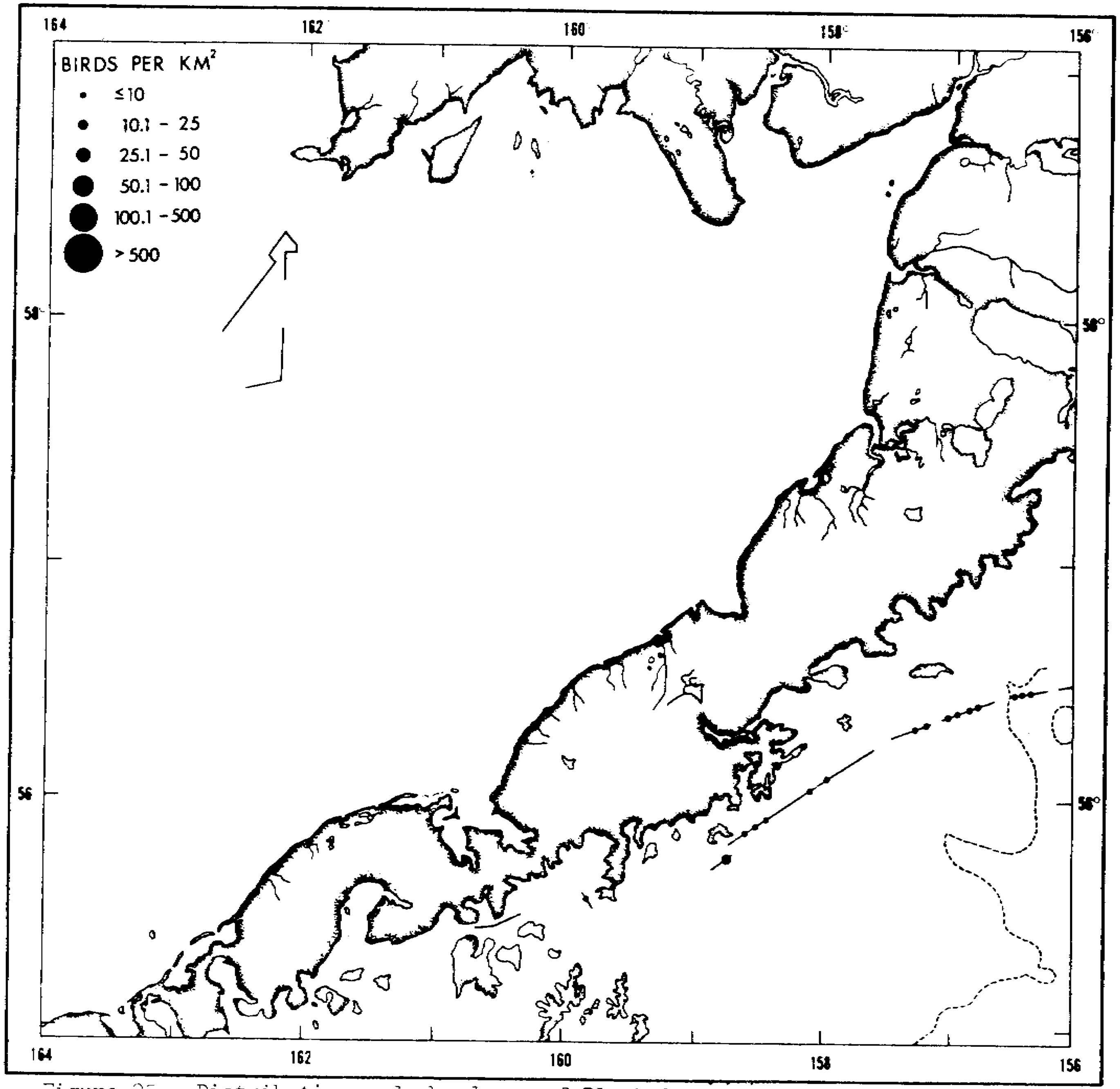


Figure 25. Distribution and abundance of Black-legged Kittiwakes in Bristol Bay from 1 to 2 April and in Gulf of Alaska on 16 March and 25 April 1977.

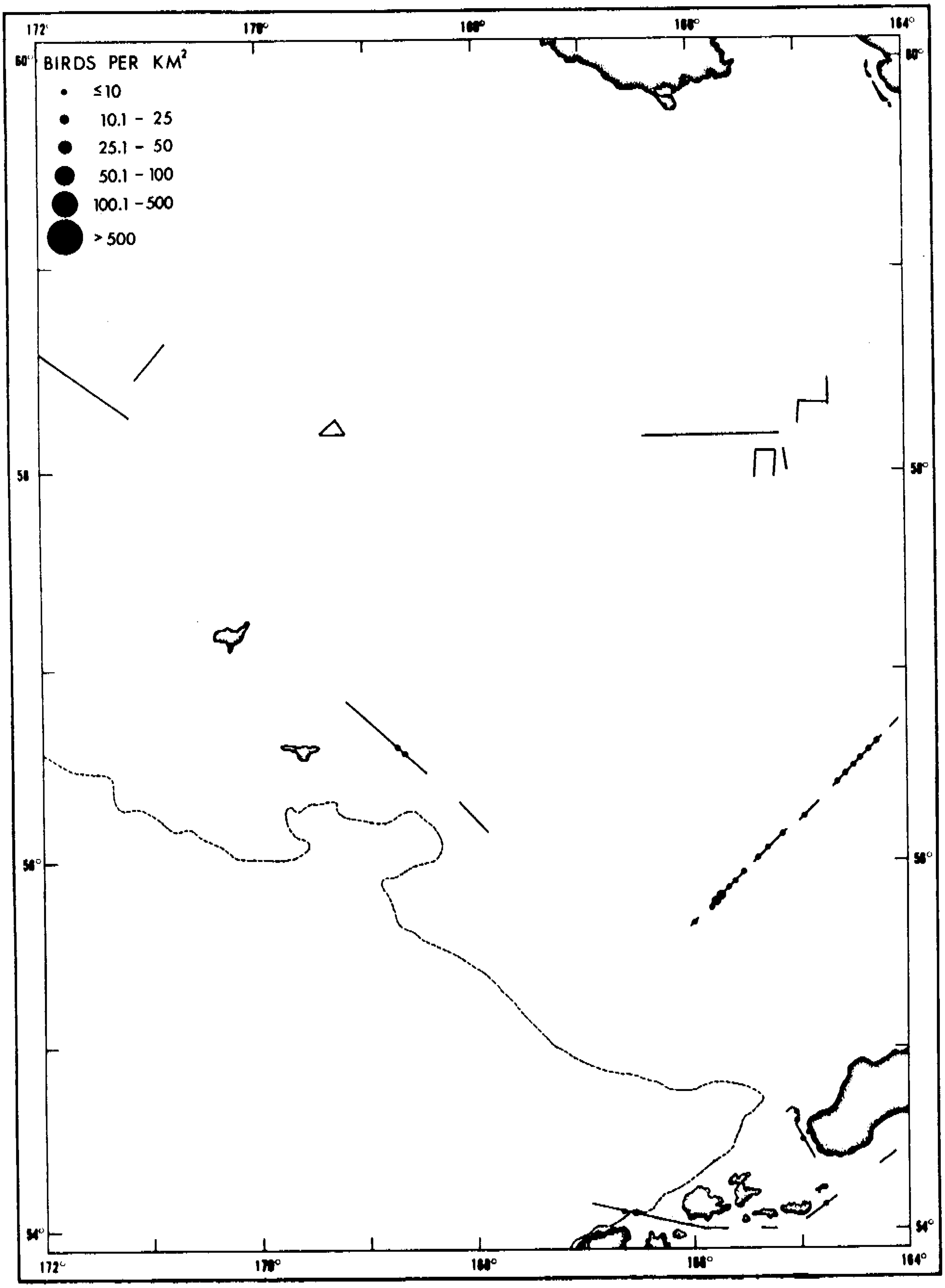


Figure 26. Distribution and abundance of Common Murres in southern Bering Sea between 17 March and 4 April 1977.

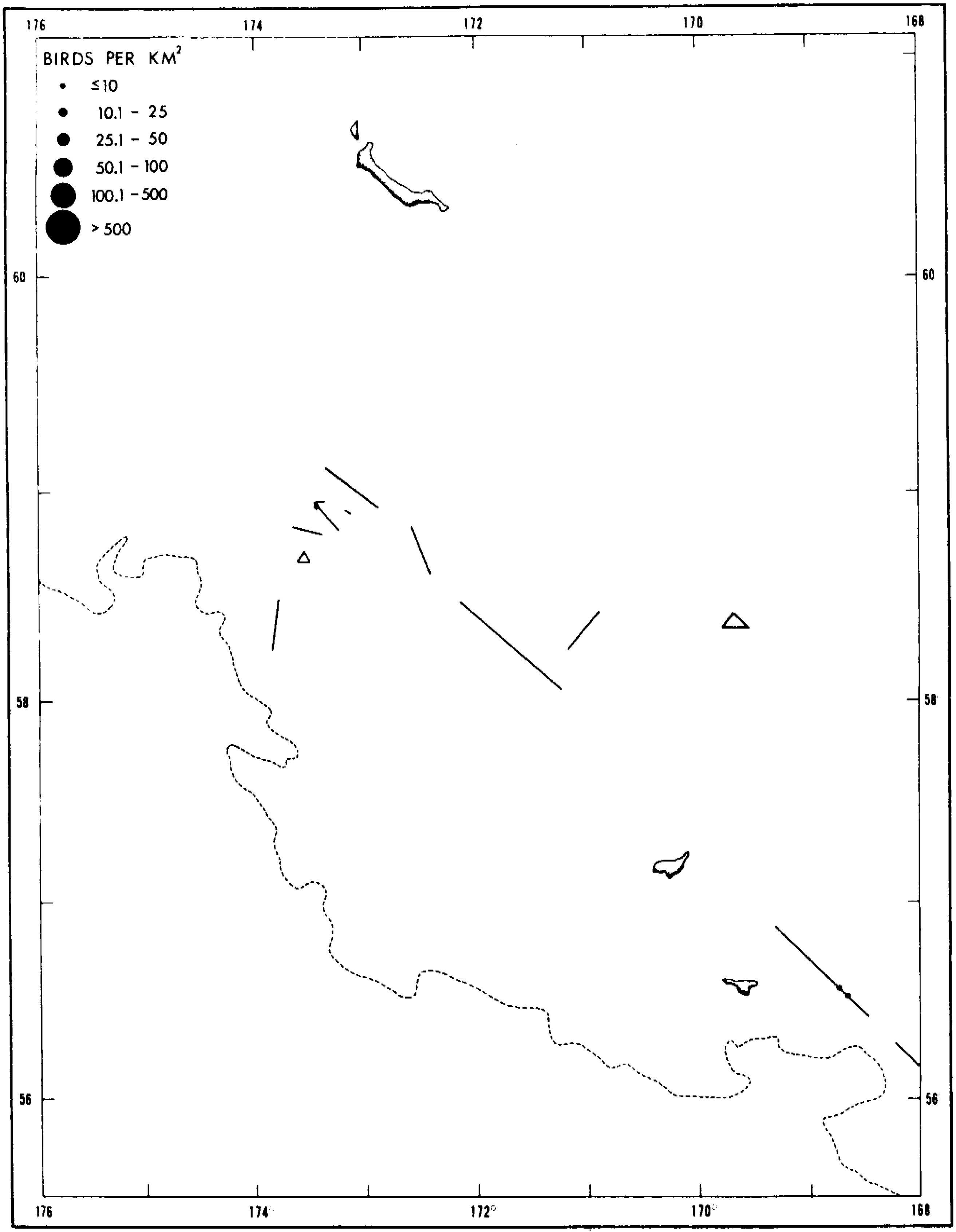


Figure 27. Distribution and abundance of Common Murres in central Bering Sea between 18 March and 25 March 1977.

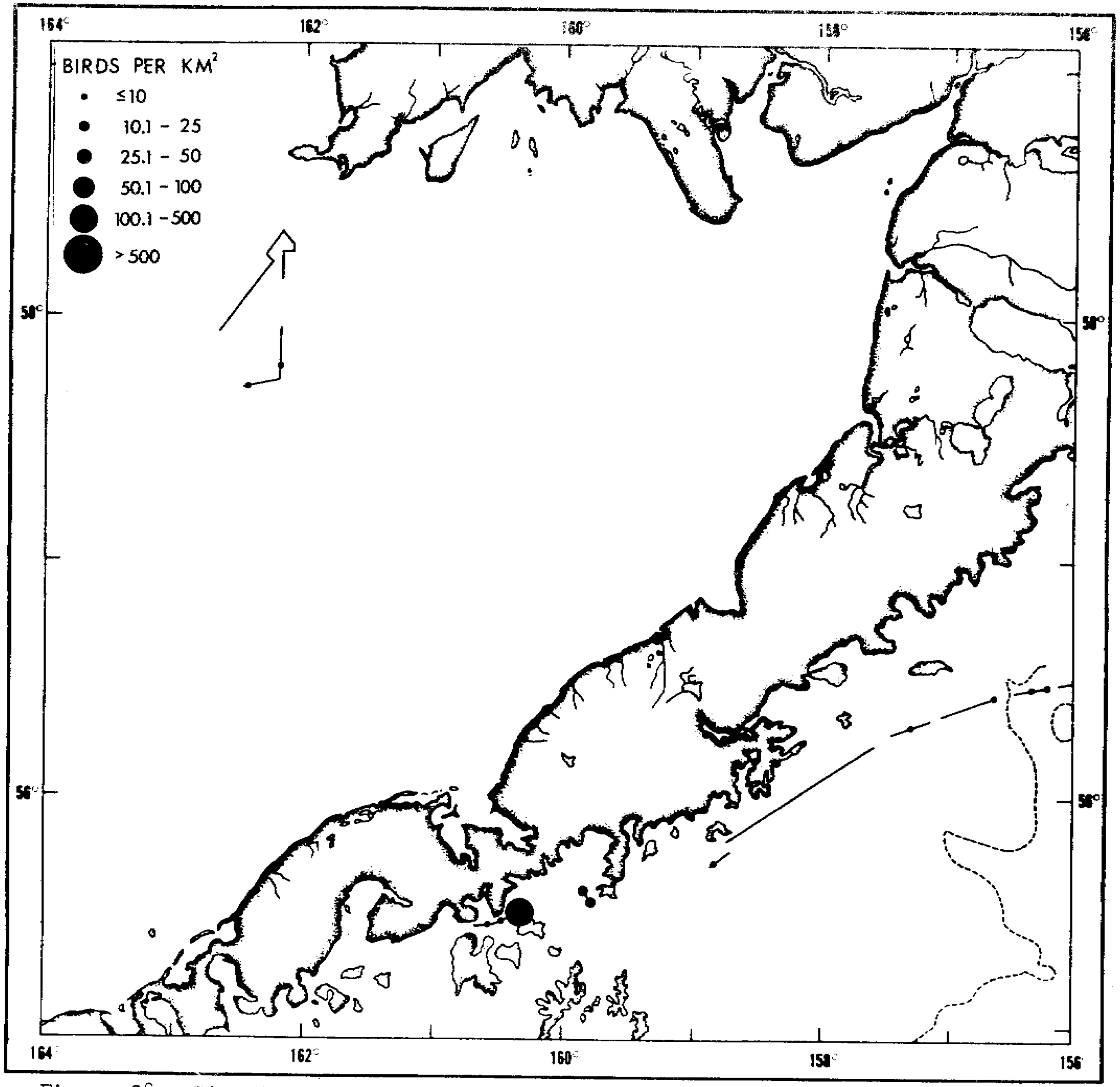


Figure 28. Distribution and abundance of Common Murres in Bristol Bay from 1 to 2 April and in Gulf of Alaska on 17 March and 25 March 1977.

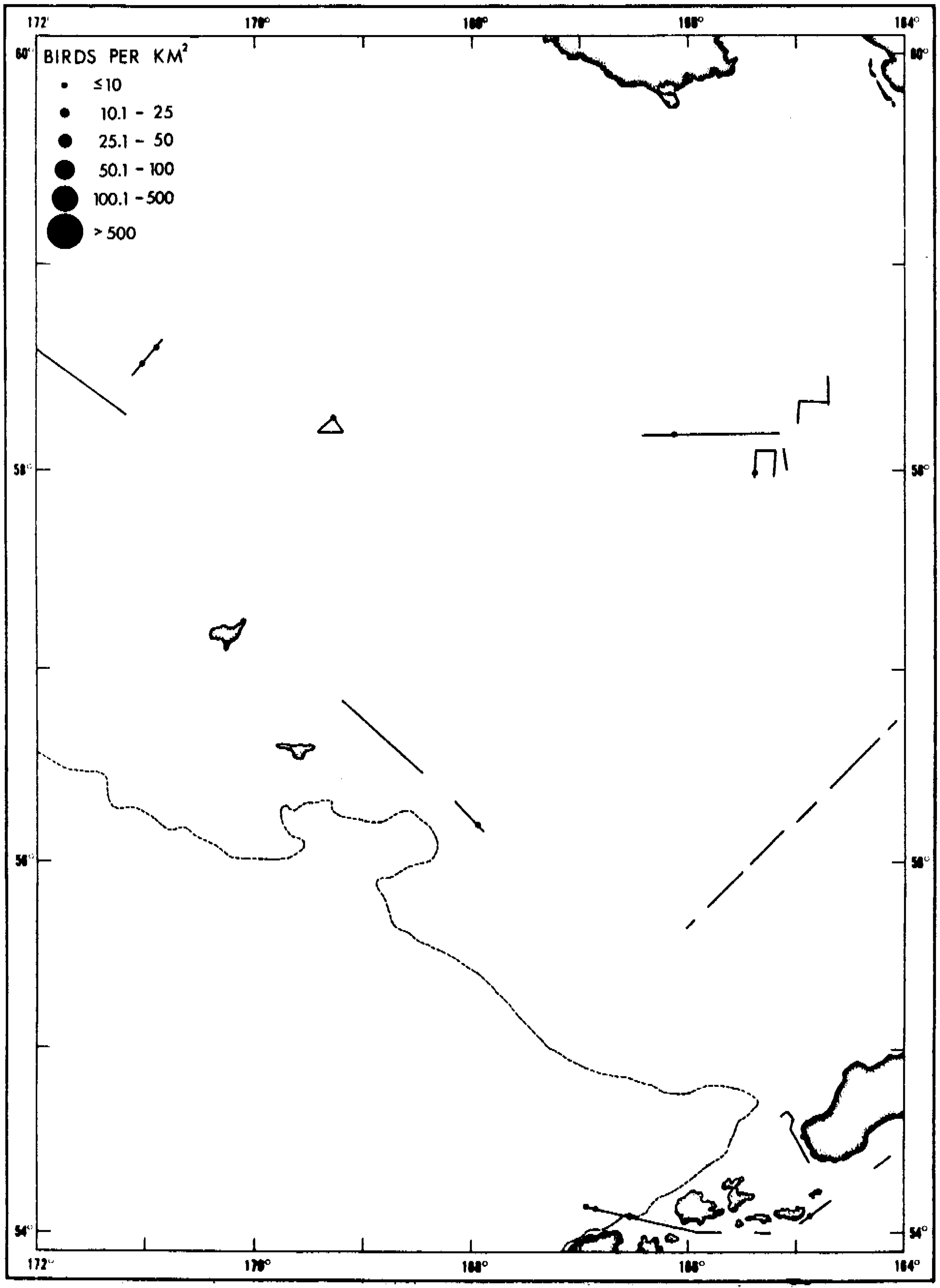


Figure 29. Distribution and abundance of Thick-billed Murres in southern Bering Sea between 17 March and 4 April 1977.

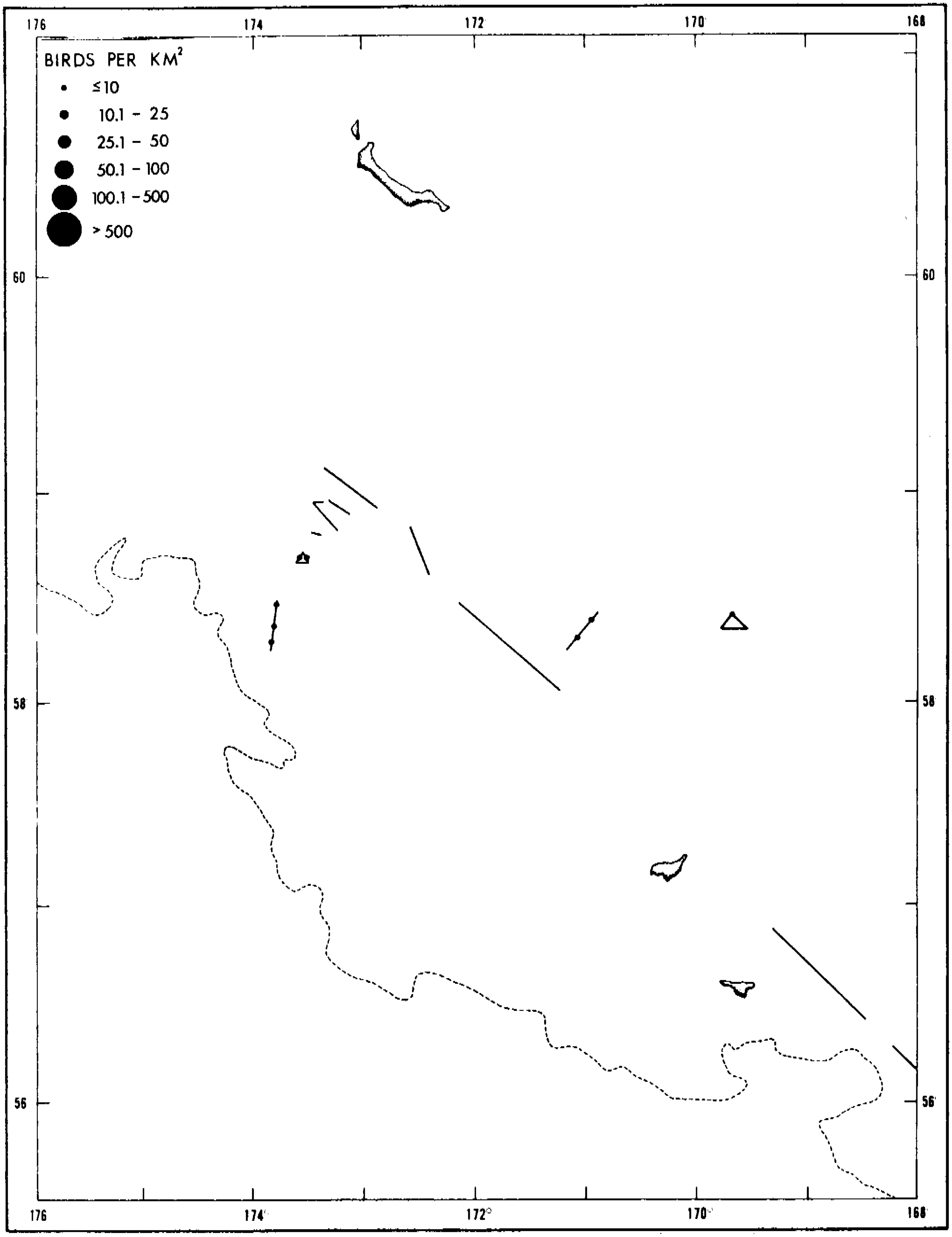


Figure 30. Distribution and abundance of Thick-billed Murres in central Bering Sea between 18 March and 25 March 1977.

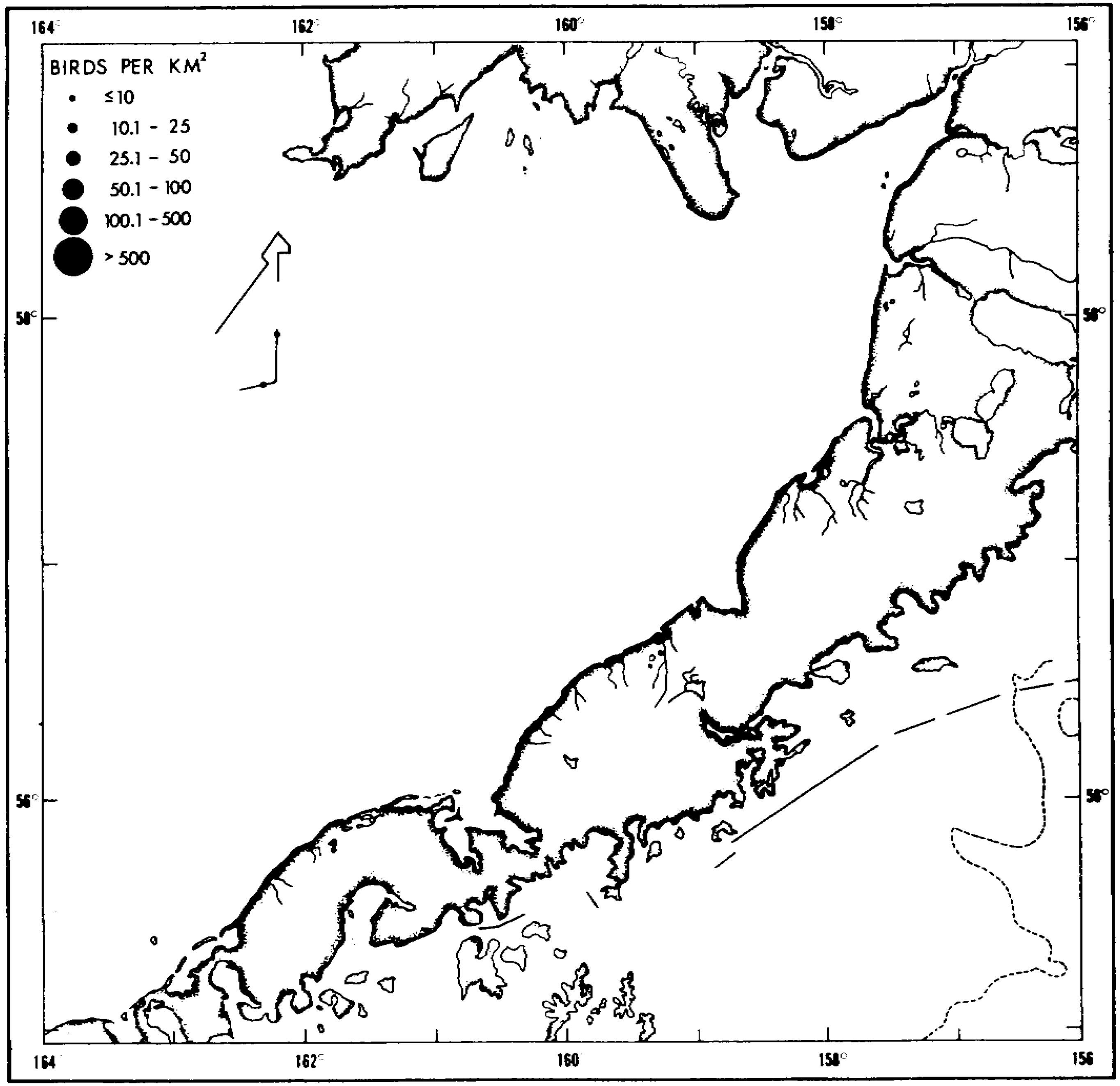


Figure 31. Distribution and abundance of Thick-billed Murres in Bristol Bay from 1 to 2 April and in Gulf of Alaska on 16 March and 25 March 1977.

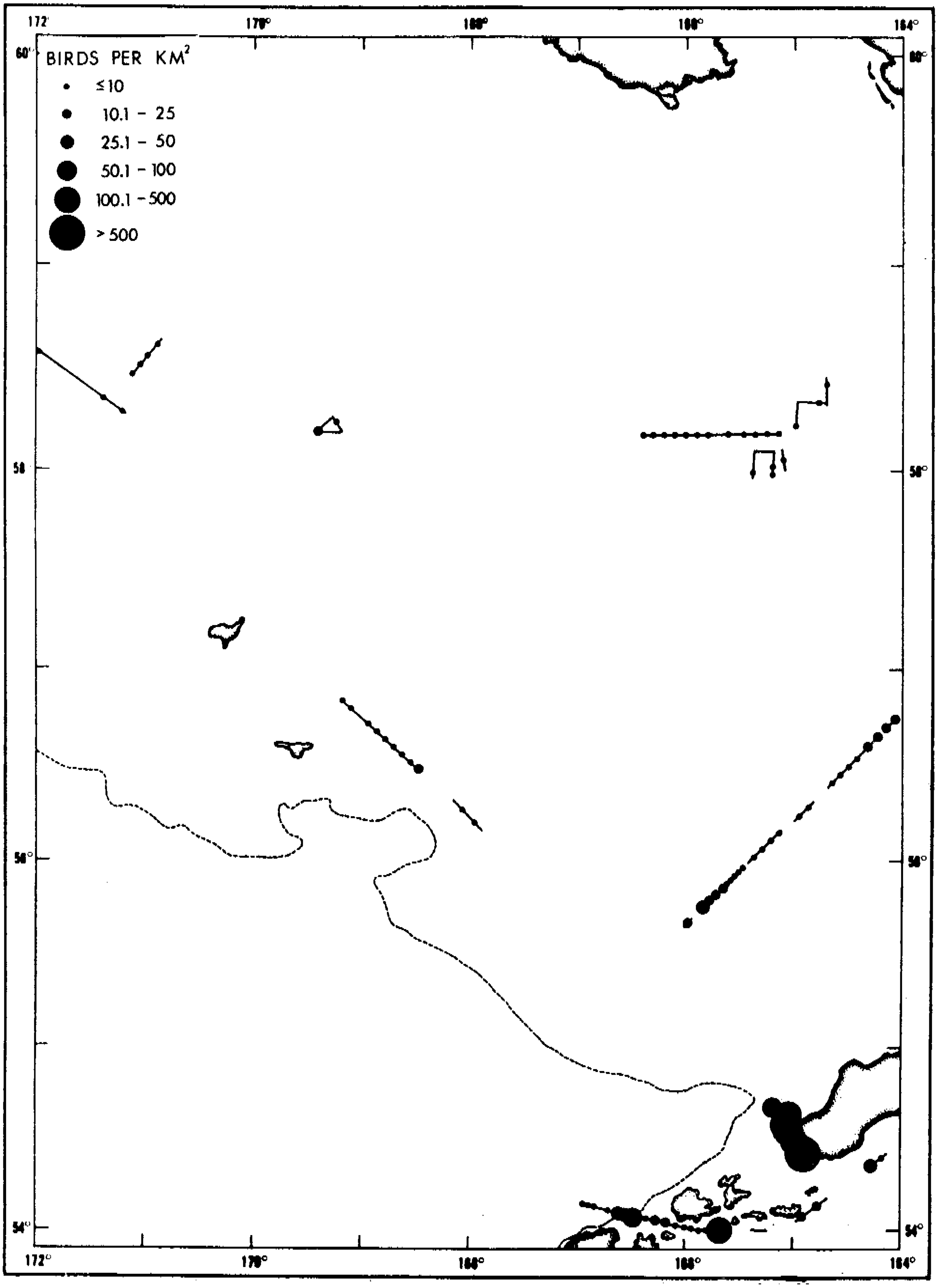


Figure 32. Distribution and abundance of all murres in southern Bering Sea between 17 March and 4 April 1977.

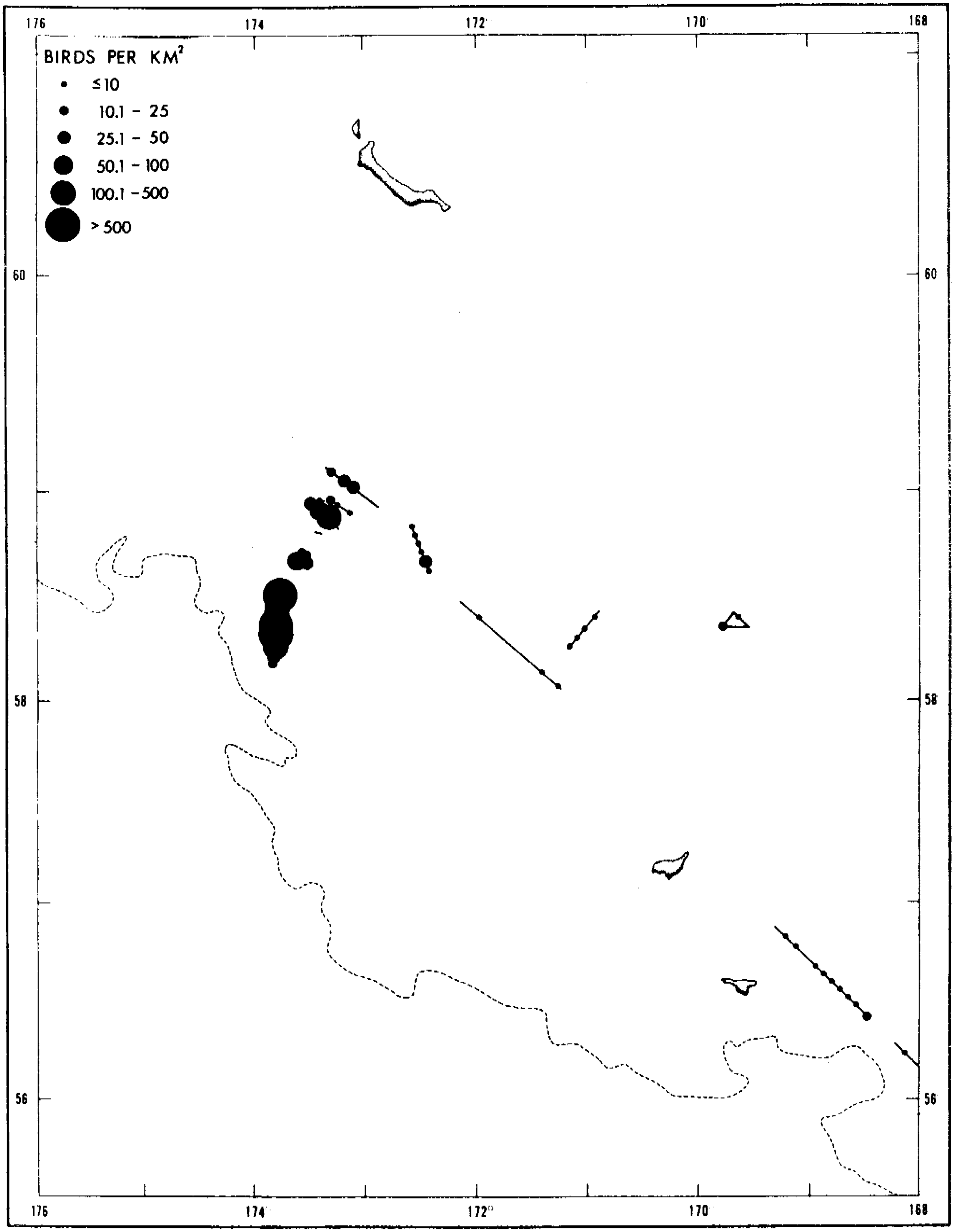


Figure 33. Distribution and abundance of all murres in central Bering Sea between 18 March and 25 March 1977.

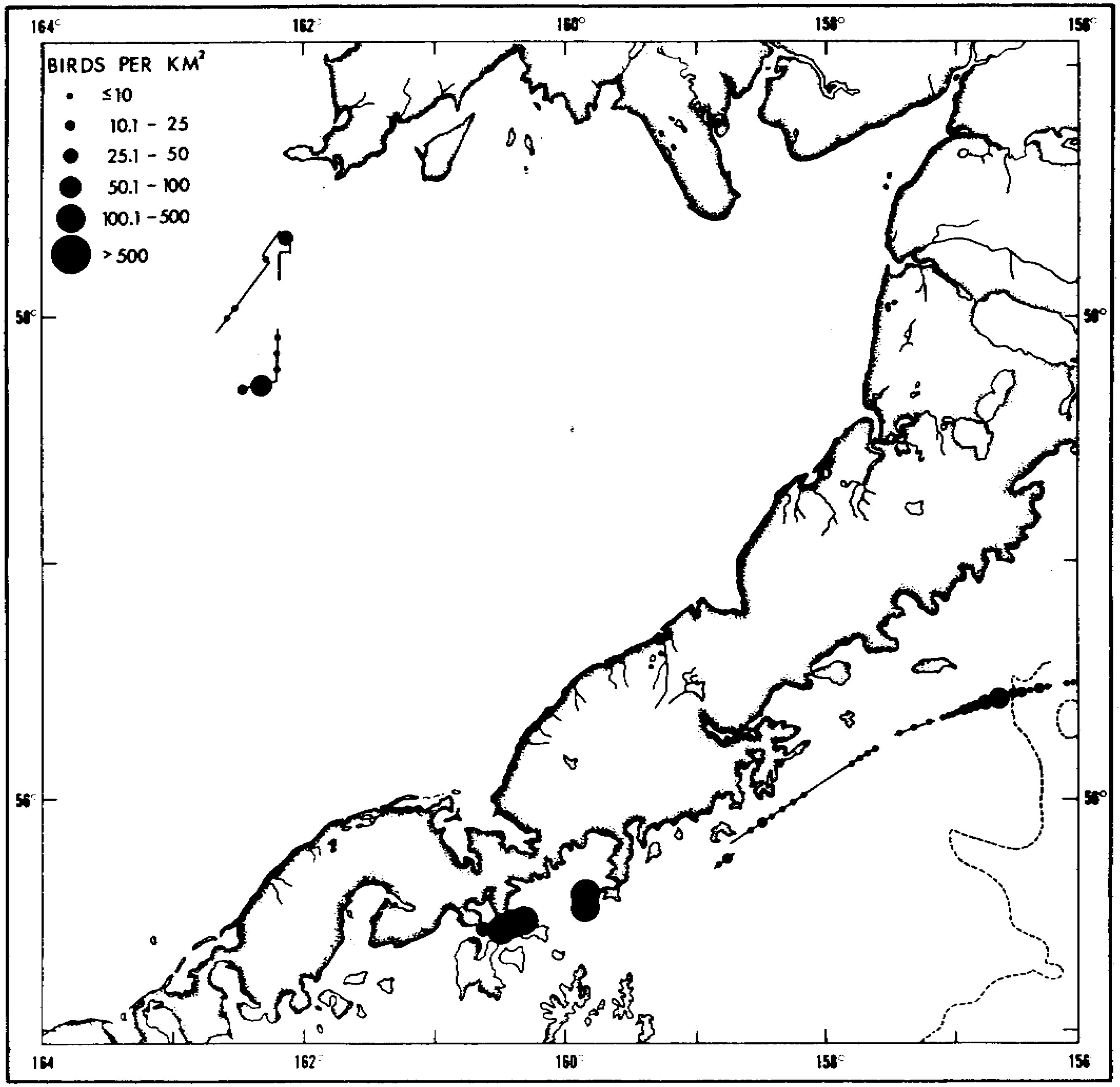


Figure 34. Distribution and abundance of all murres in Bristol Bay from 1 to 2 April and in Gulf of Alaska on 16 March and 25 April 1977.

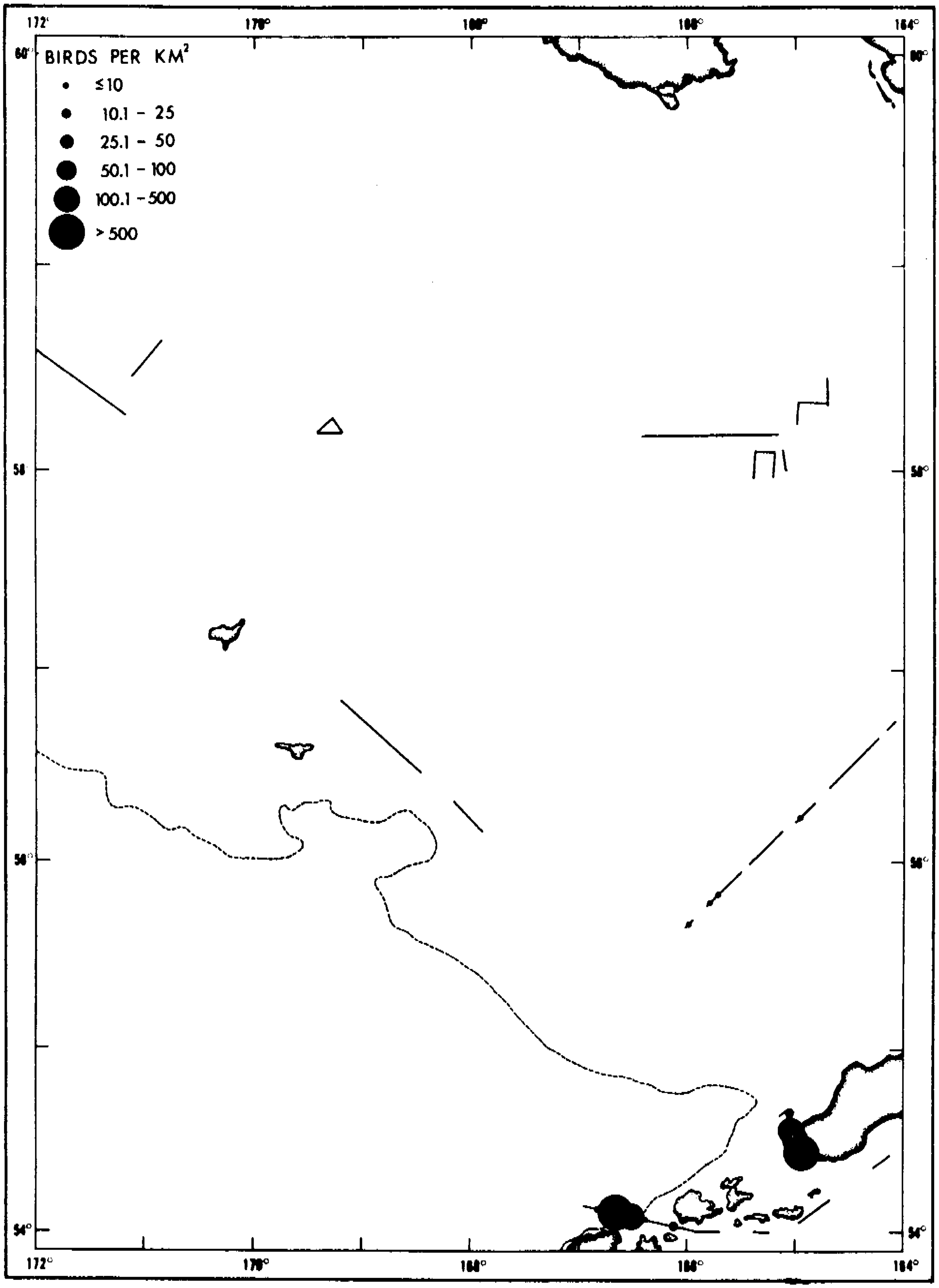


Figure 35. Distribution and abundance of Crested Auklets in southern Bering Sea between 17 March and 4 April 1977.

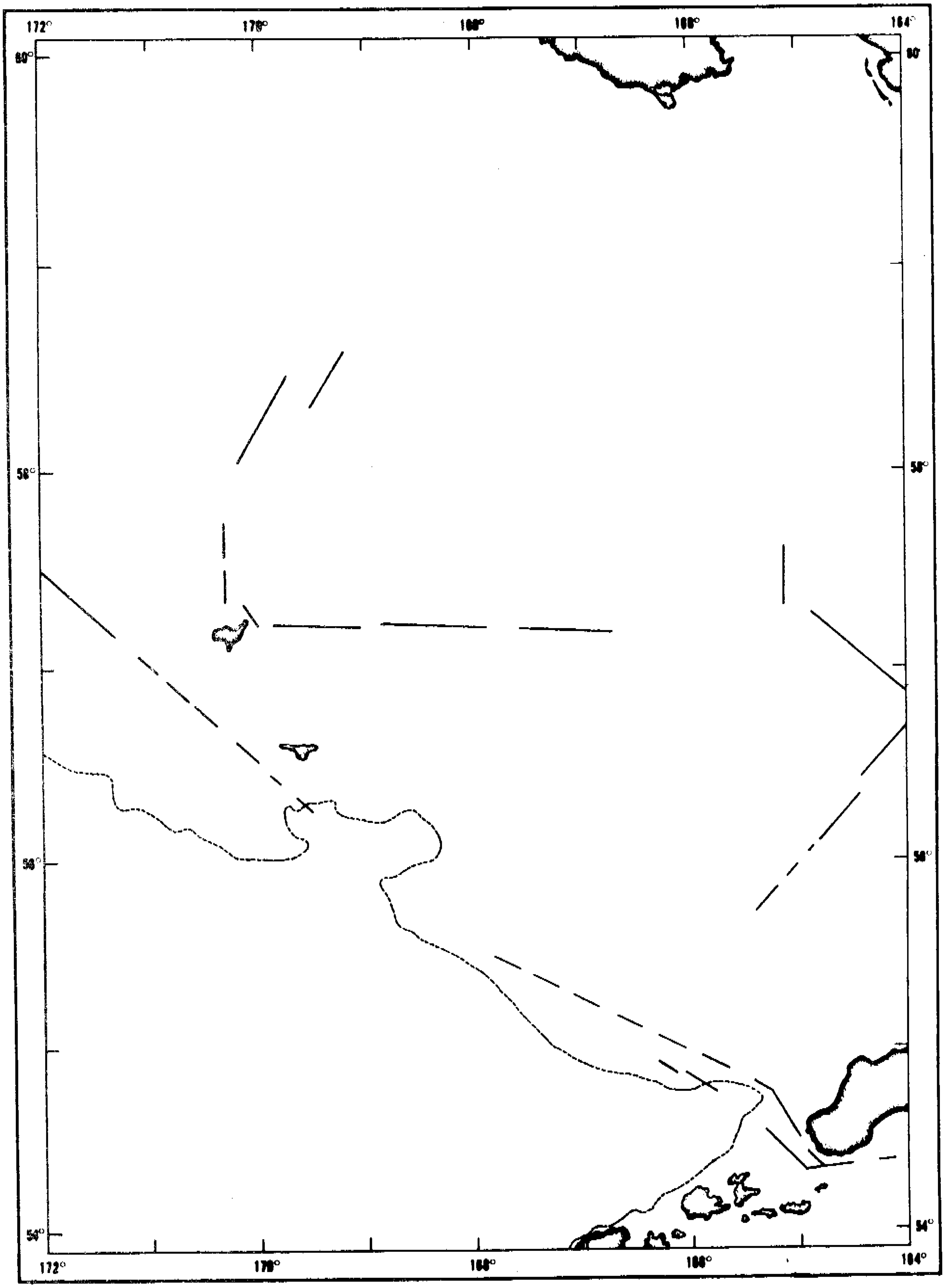


Figure 36. Cruise track during periods of observation in southern Bering Sea from 4 to 17 April, 19 to 25 April and 30 April to 1 May 1977.

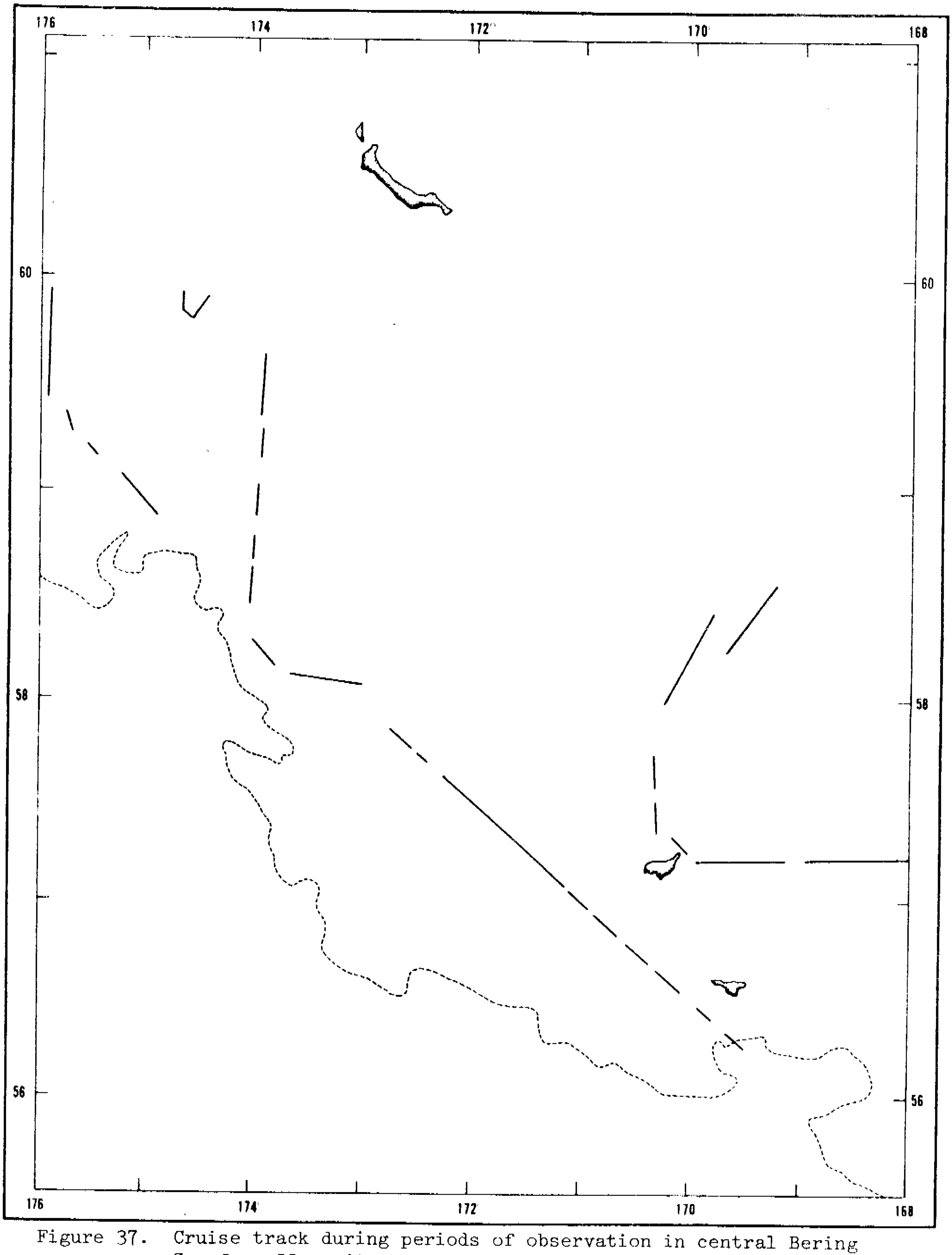


Figure 37. Cruise track during periods of observation in central Bering Sea from 22 to 30 April 1977.

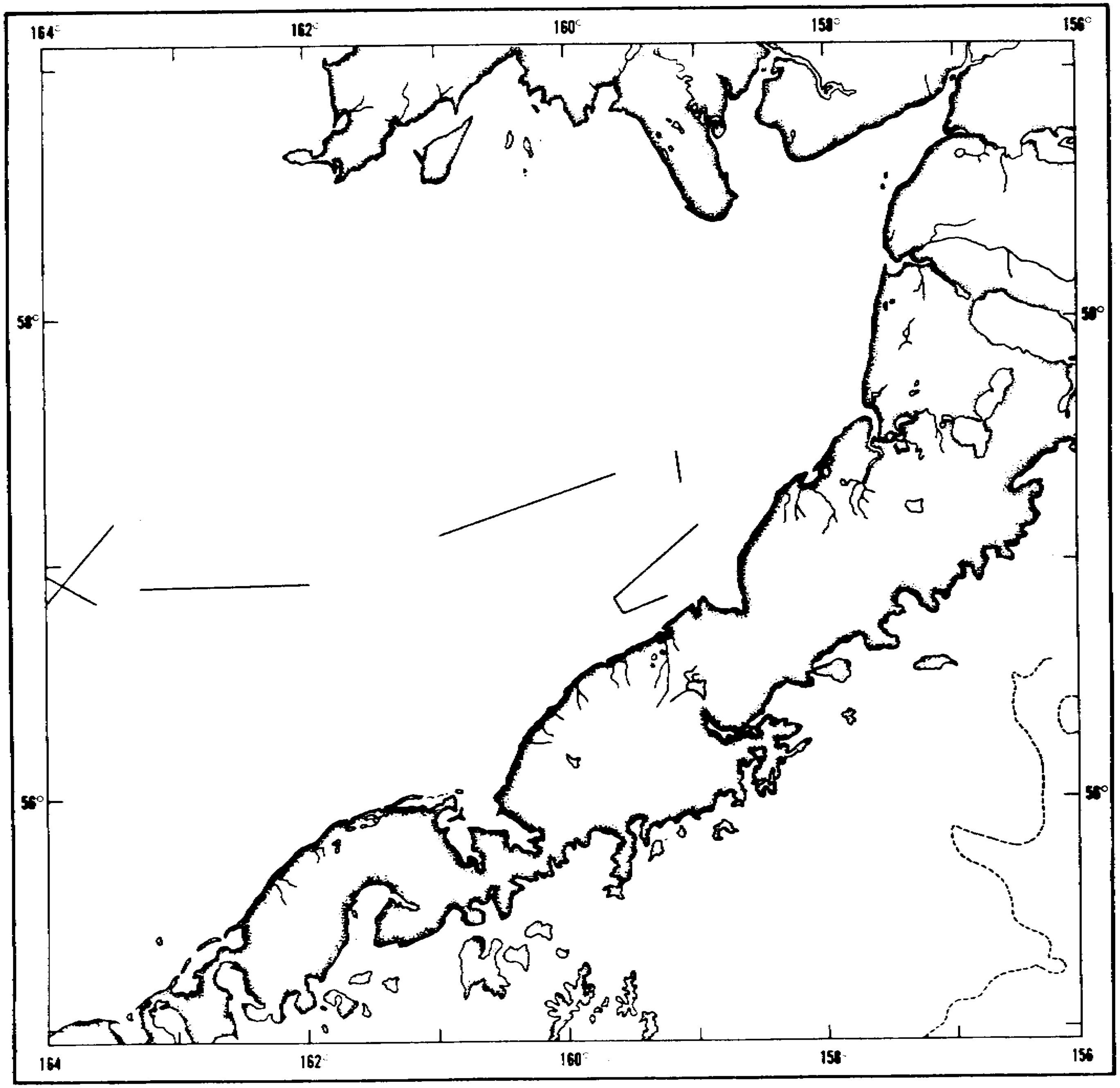


Figure 38. Cruise track during periods of observation in Bristol Bay from 17 to 19 April 1977.

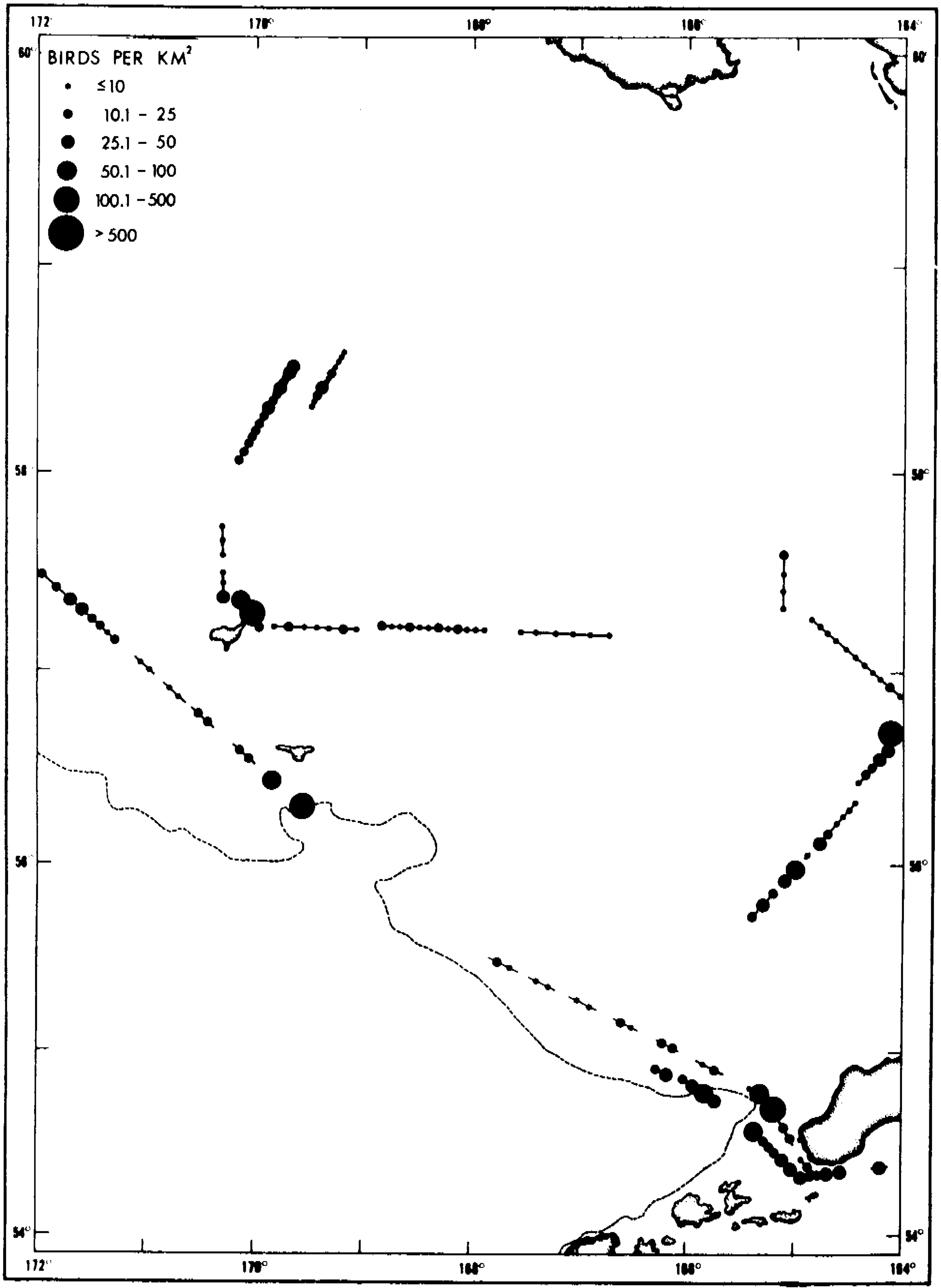


Figure 39. Distribution and abundance of seabirds in southern Bering Sea from 4 to 17 April, 19 to 25 April and 30 April to 1 May 1977.

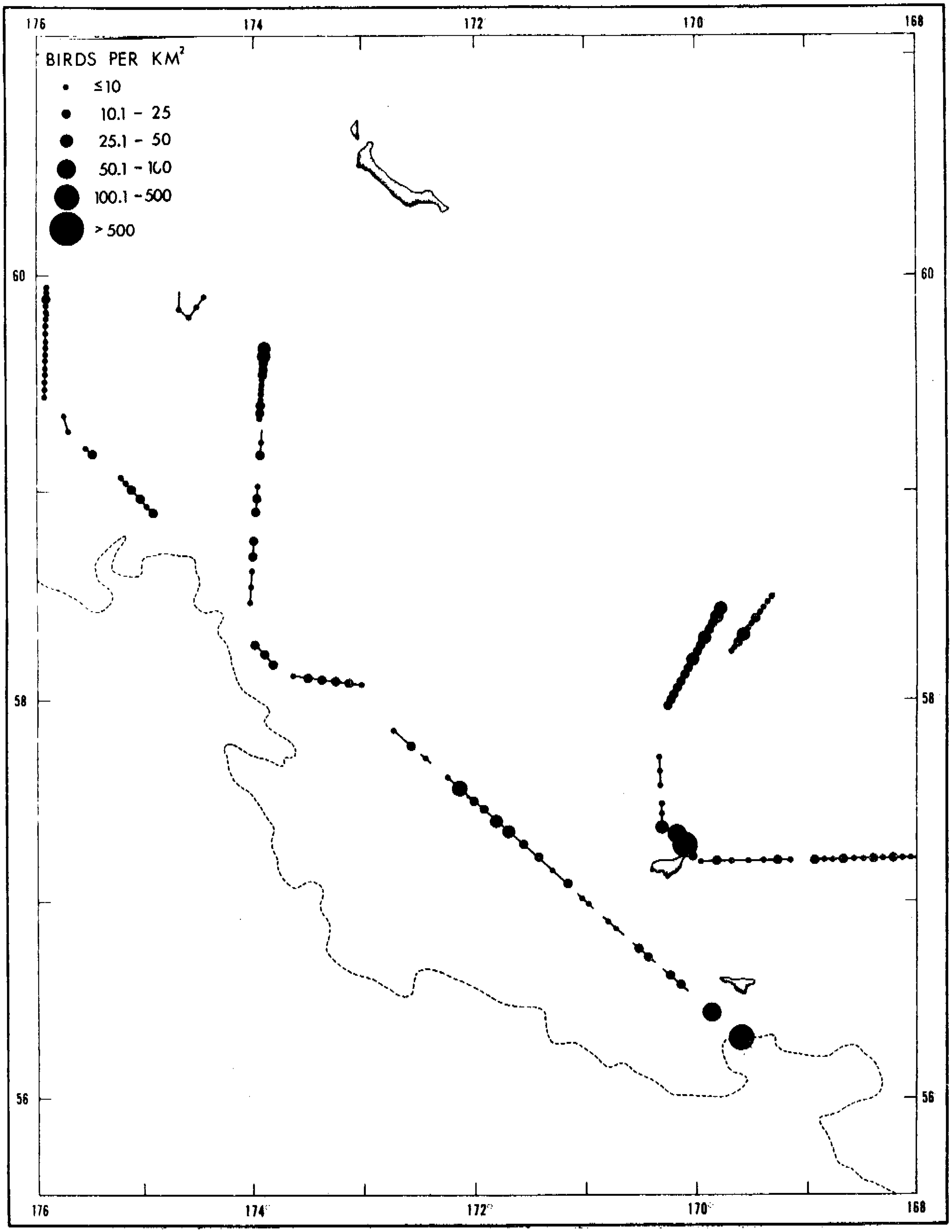


Figure 40. Distribution and abundance of seabirds in central Bering Sea from 22 to 30 April 1977.

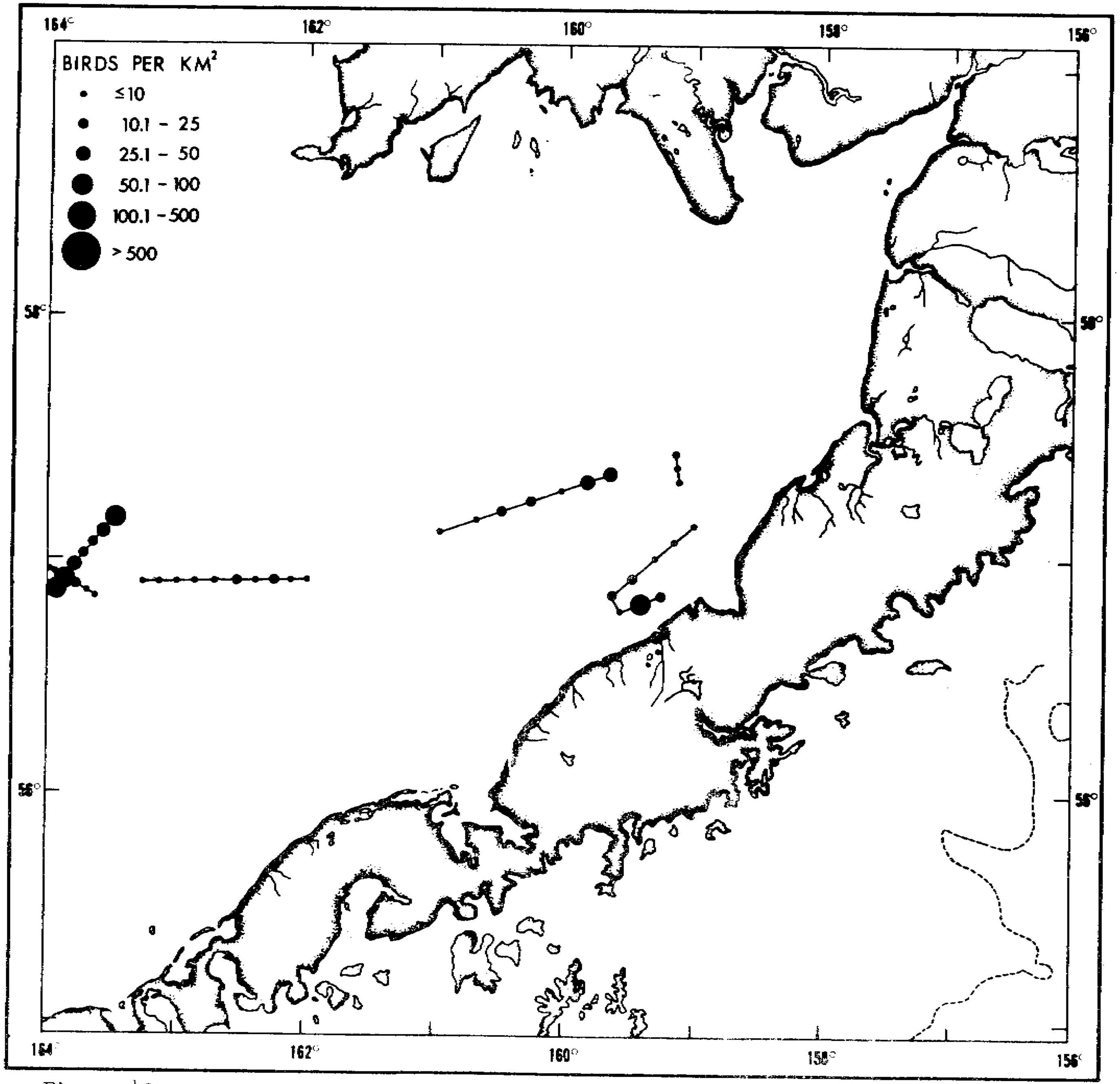


Figure 41. Distribution and abundance of seabirds in Bristol Bay from 17 to 19 April 1977.

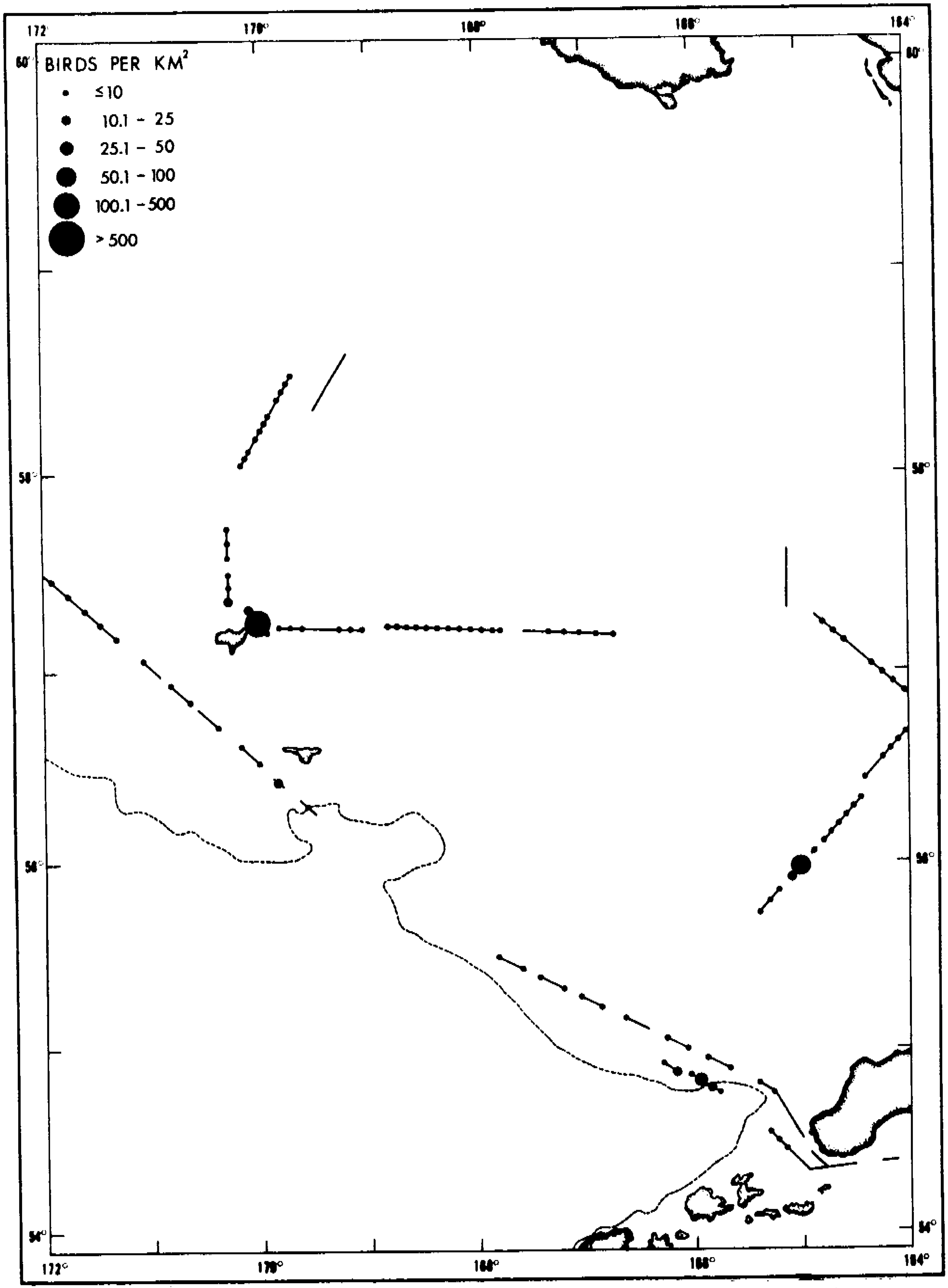


Figure 42. Distribution and abundance of Northern Fulmars in southern Bering Sea from 4 to 17 April, 19 to 25 April and 30 April to 1 May 1977.

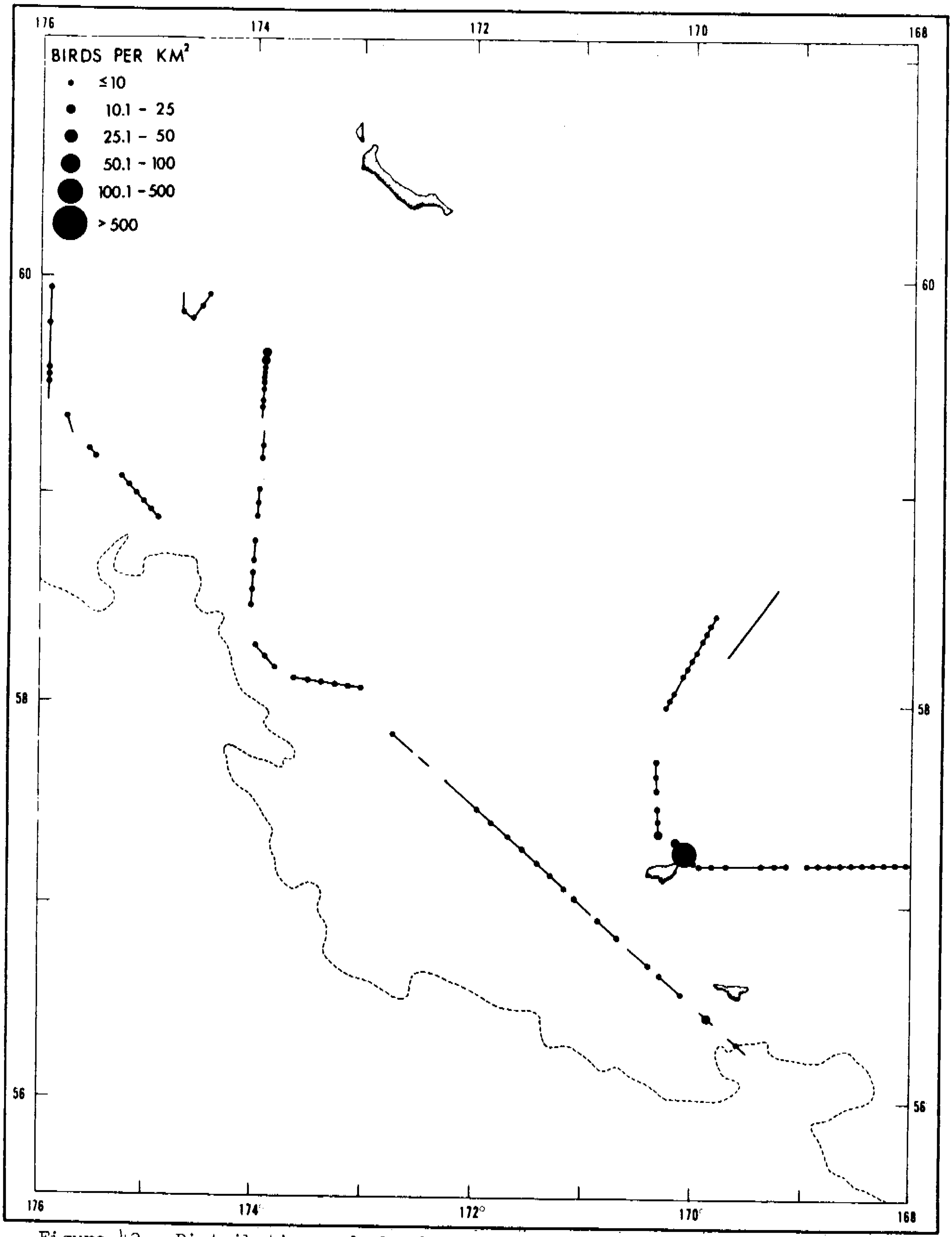


Figure 43. Distribution and abundance of Northern Fulmars in central Bering Sea from 22 to 30 April 1977.

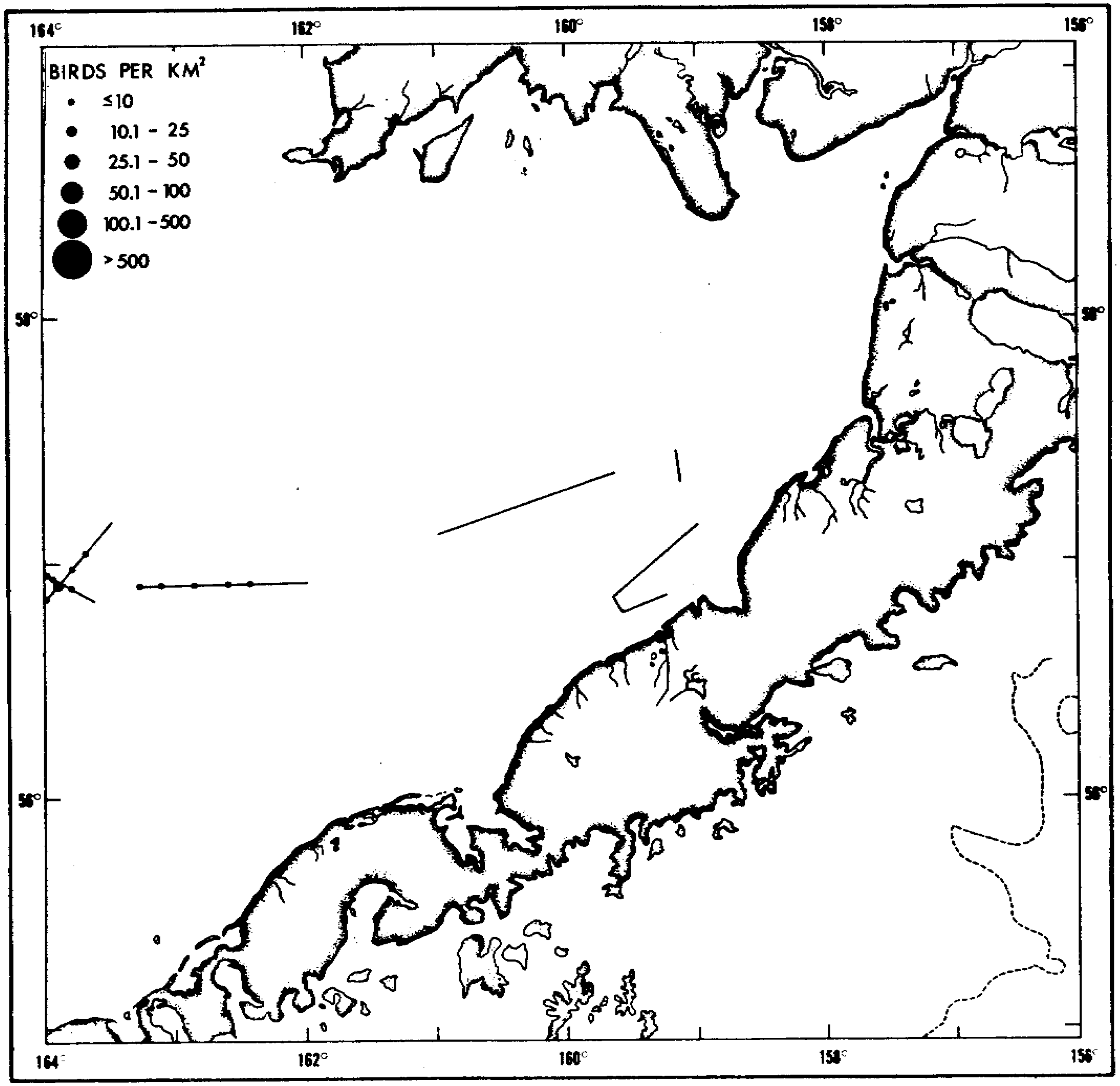


Figure 44. Distribution and abundance of Northern Fulmars in Bristol Bay from 17 to 19 April 1977.

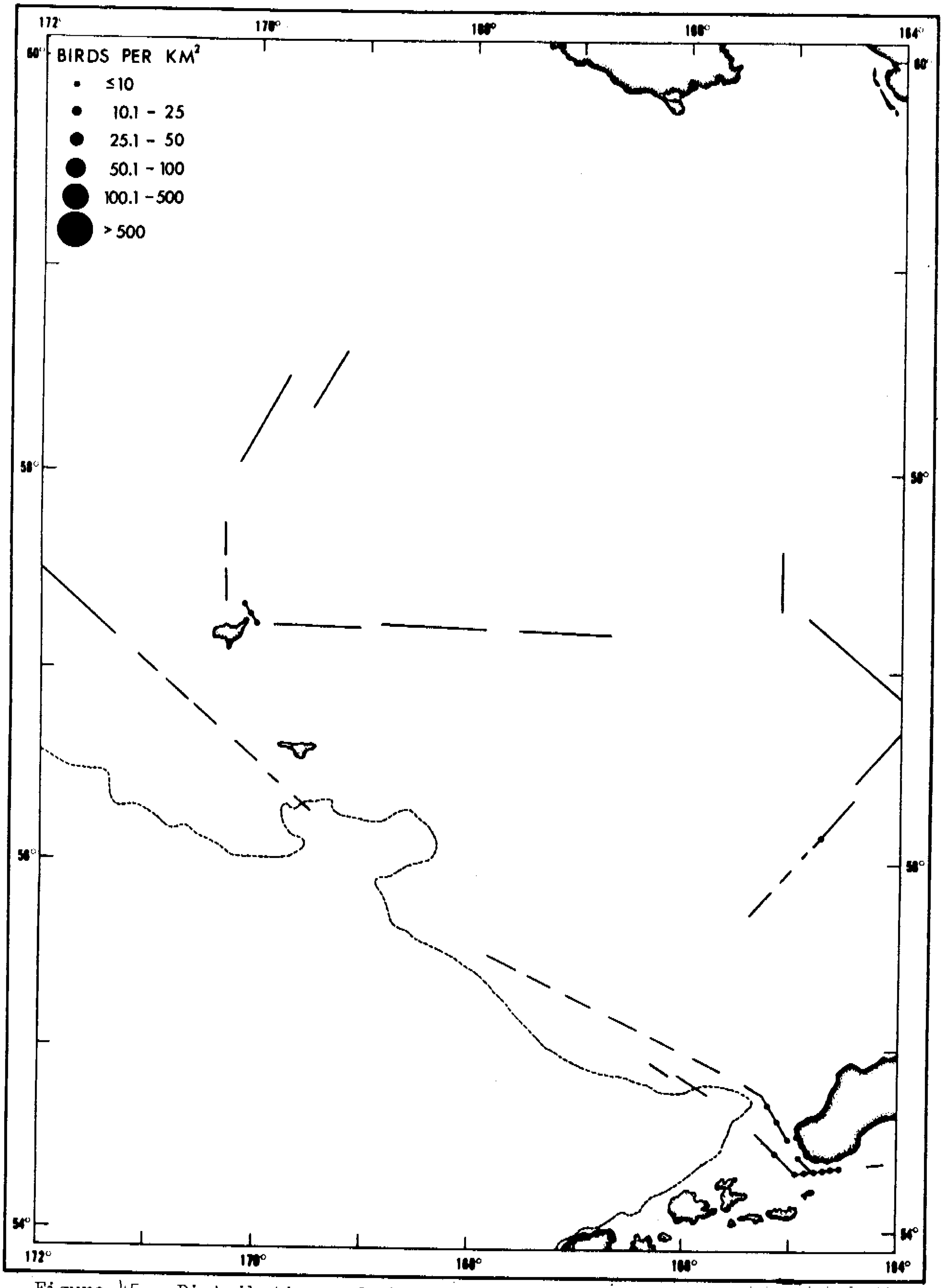


Figure 45. Distribution and abundance of cormorants in southern Bering Sea from 4 to 17 April, 19 to 25 April and 30 April to 1 May 1977.

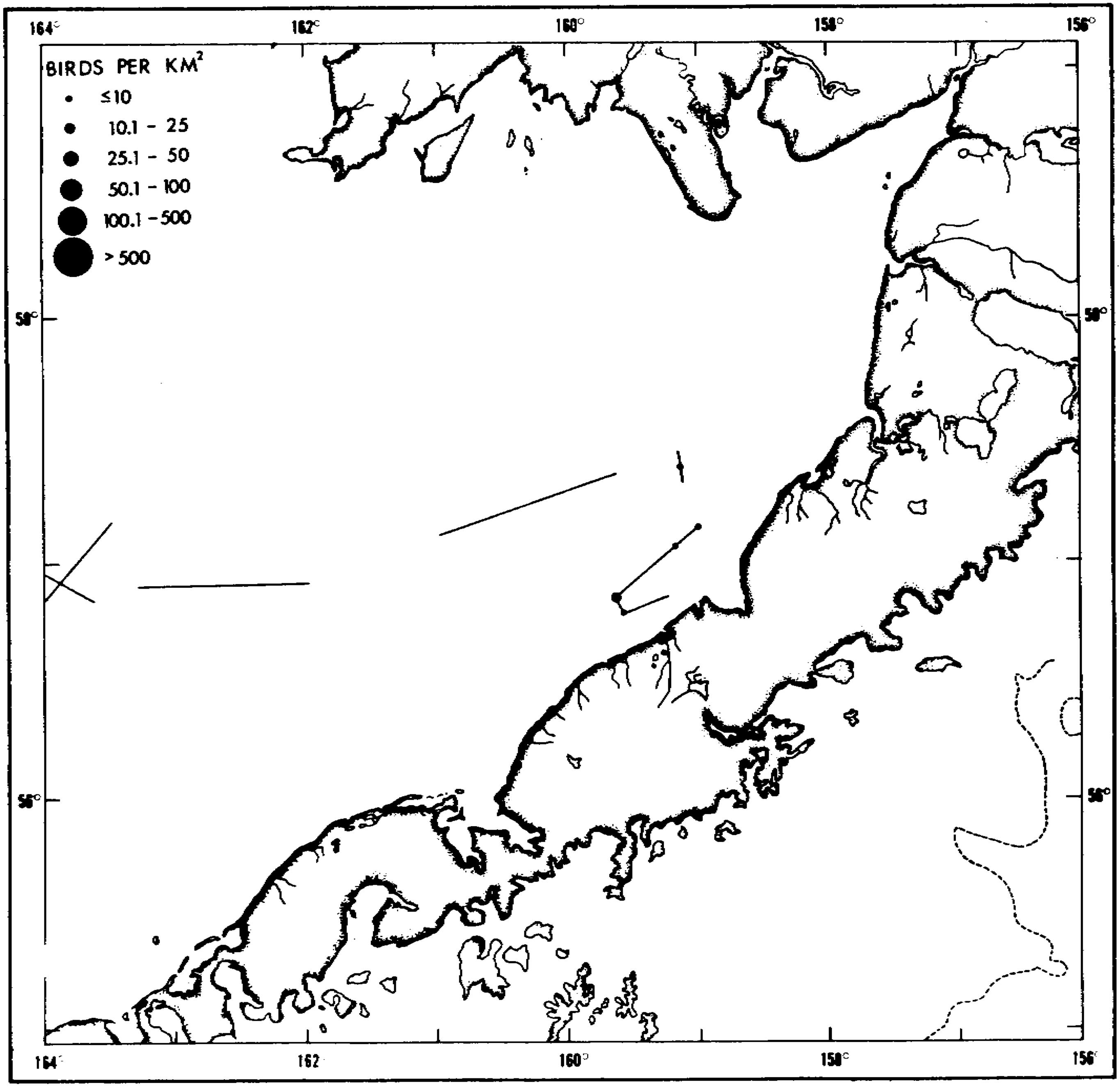


Figure 46. Distribution and abundance of cormorants in Bristol Bay from 17 to 19 April 1977.

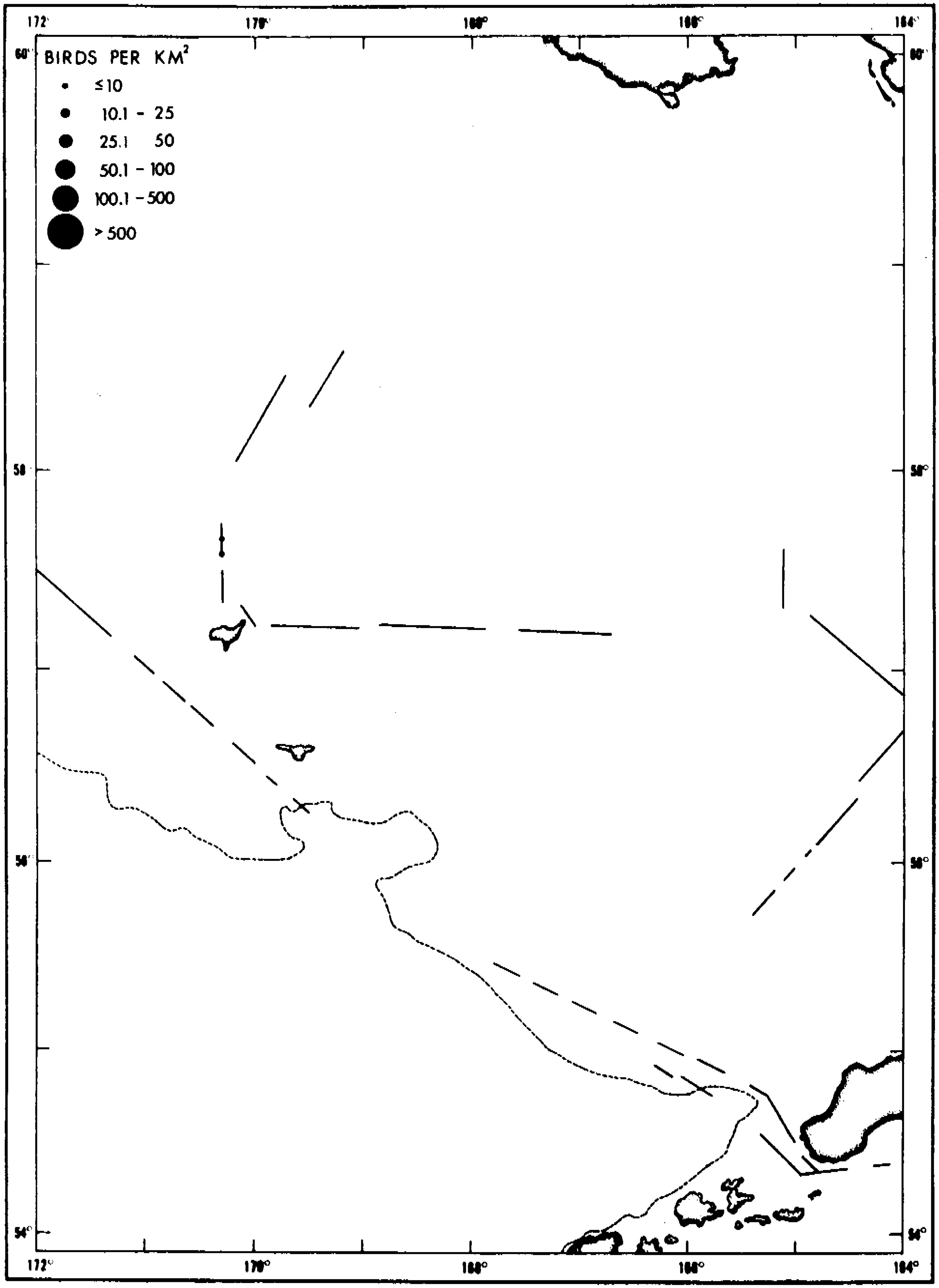


Figure 47. Distribution and abundance of Oldsquaws in southern Bering Sea from 4 to 17 April, 19 to 25 April and 30 April to 1 May 1977.

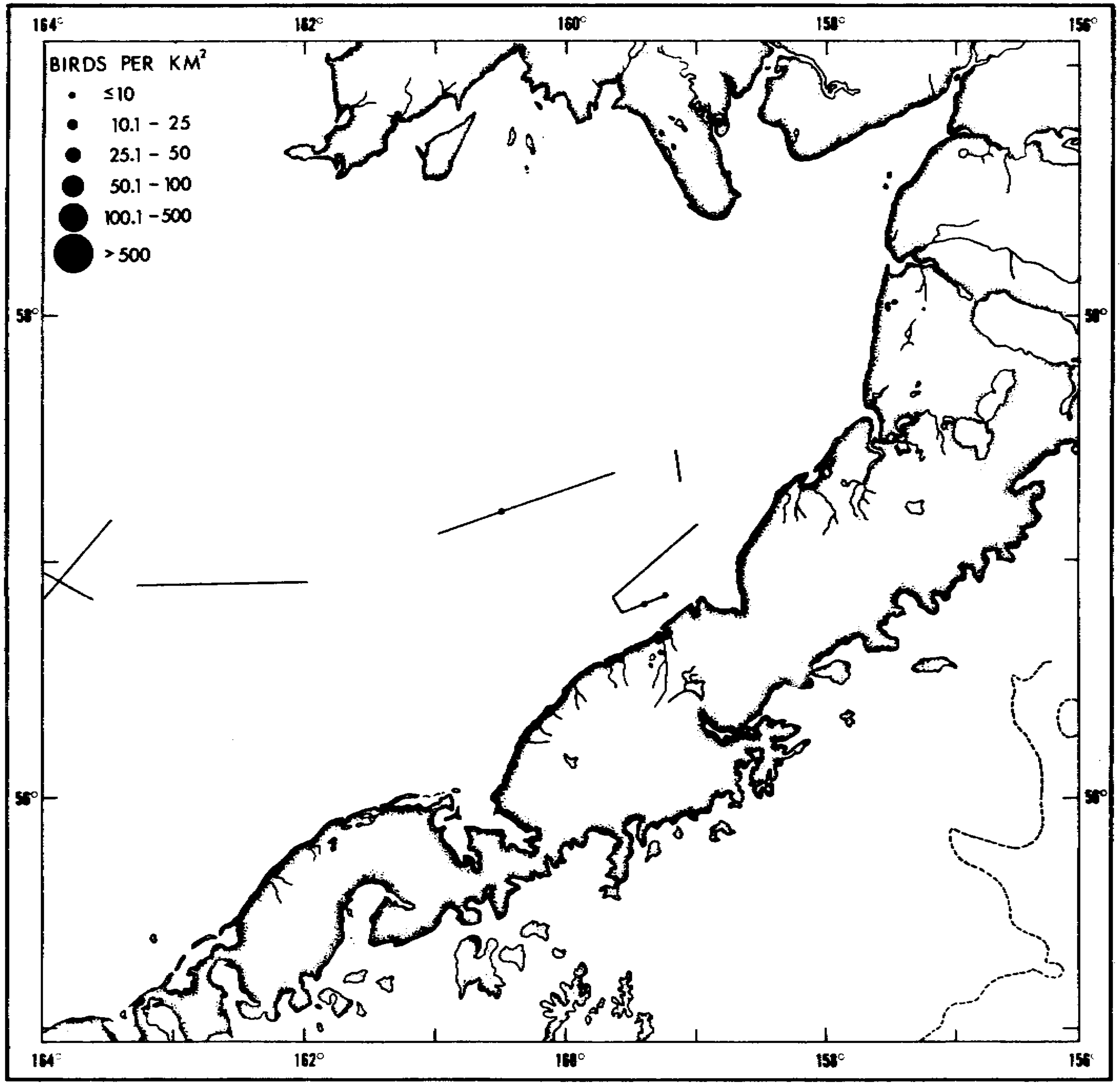


Figure 48. Distribution and abundance of Oldsquaws in Bristol Bay from 17 to 19 April 1977.

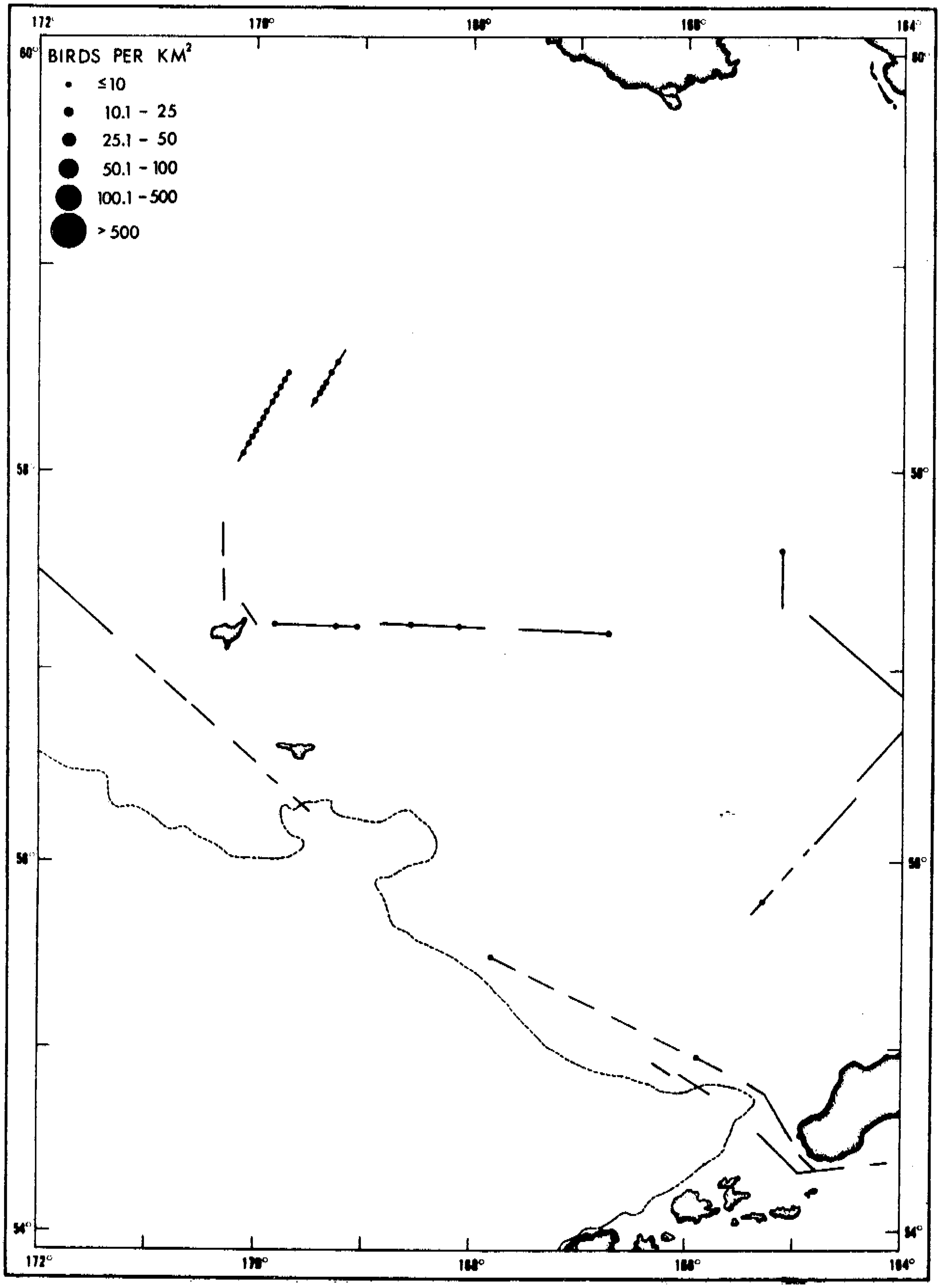


Figure 49. Distribution and abundance of Glaucous Gulls in southern Bering Sea from 4 to 17 April, 19 to 25 April and 30 April to 1 May 1977.

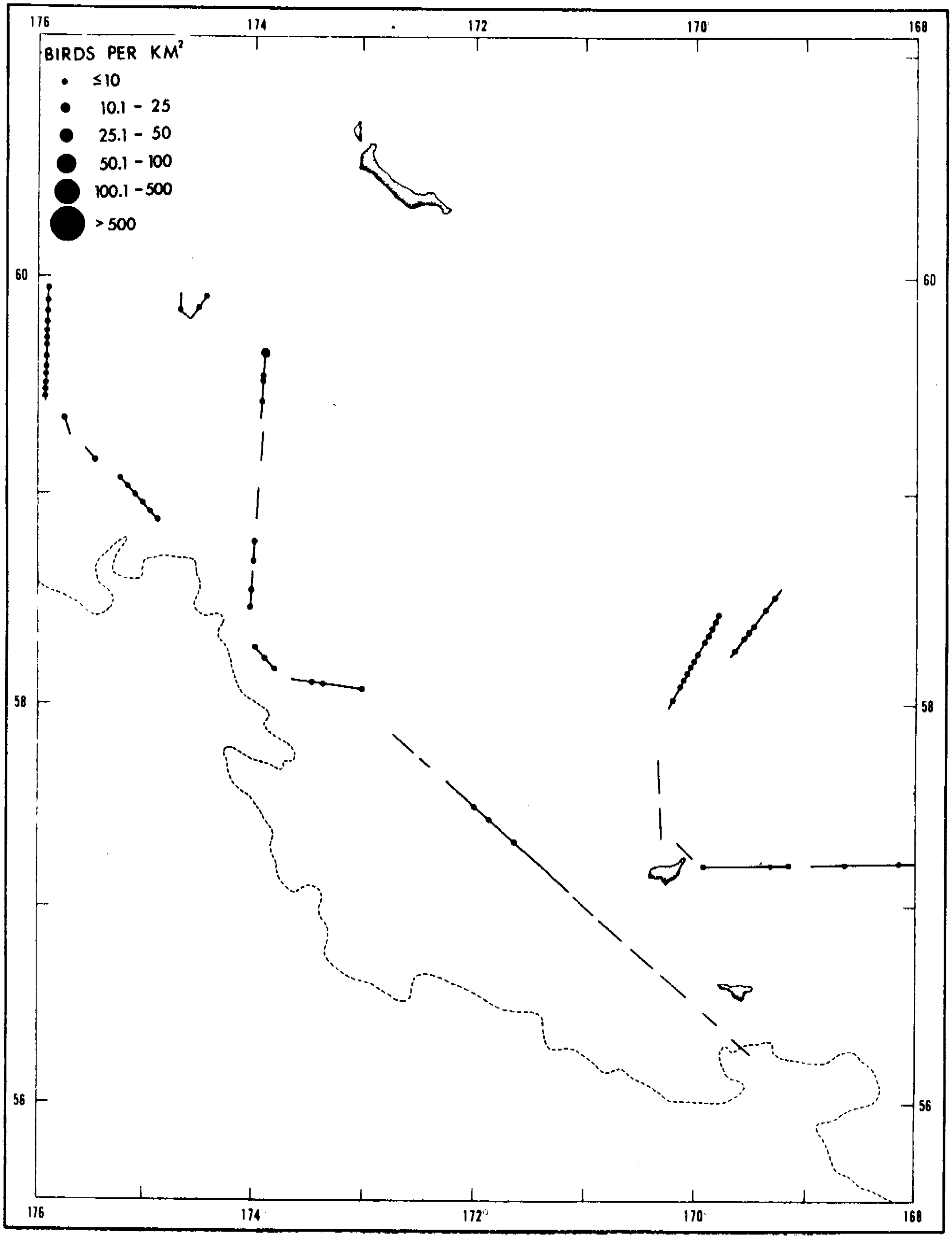


Figure 50. Distribution and abundance of Glaucous Gulls in central Bering Sea from 22 to 30 April 1977.

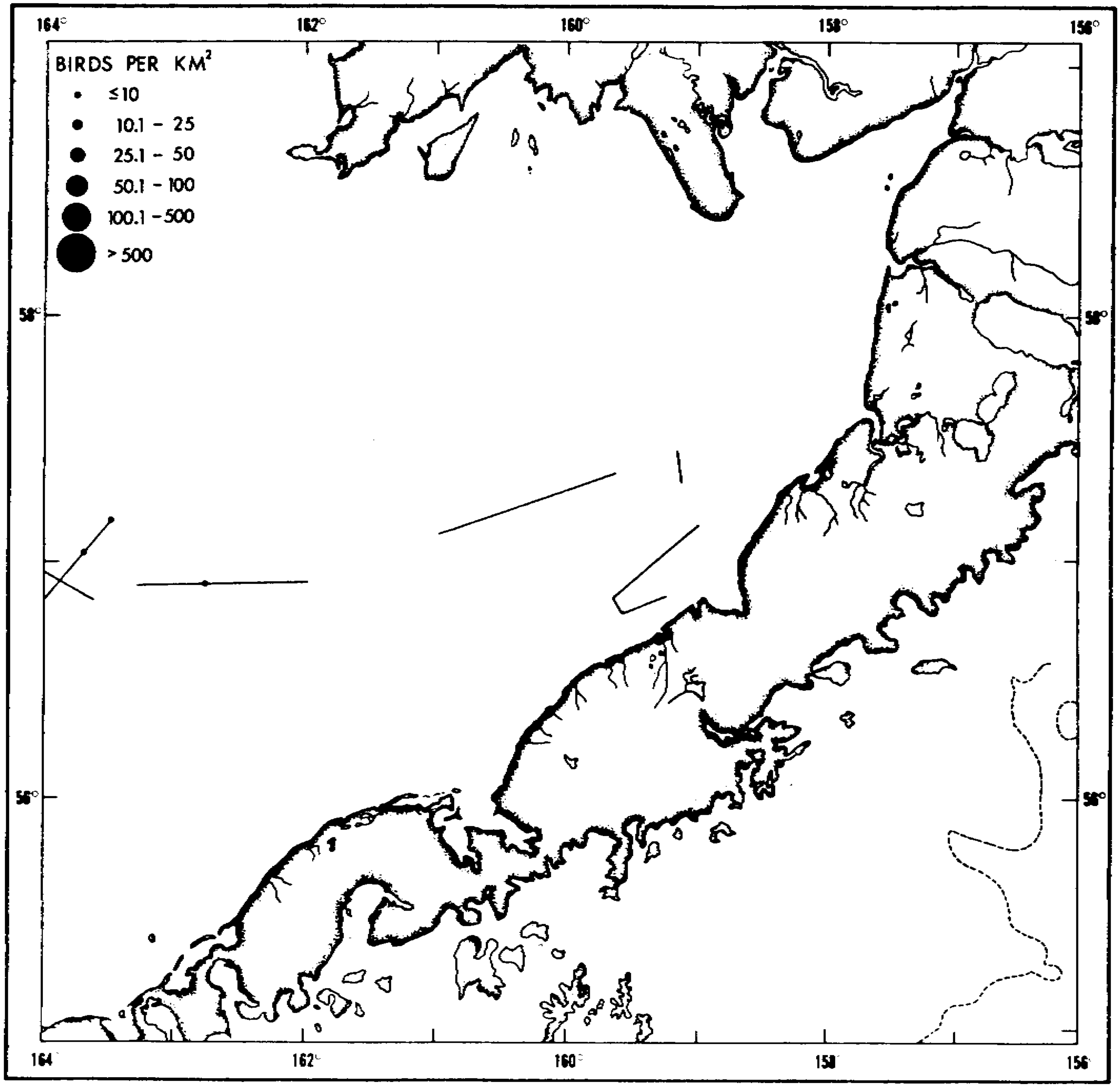


Figure 51. Distribution and abundance of Glaucous Gulls in Bristol Bay from 17 to 19 April 1977.

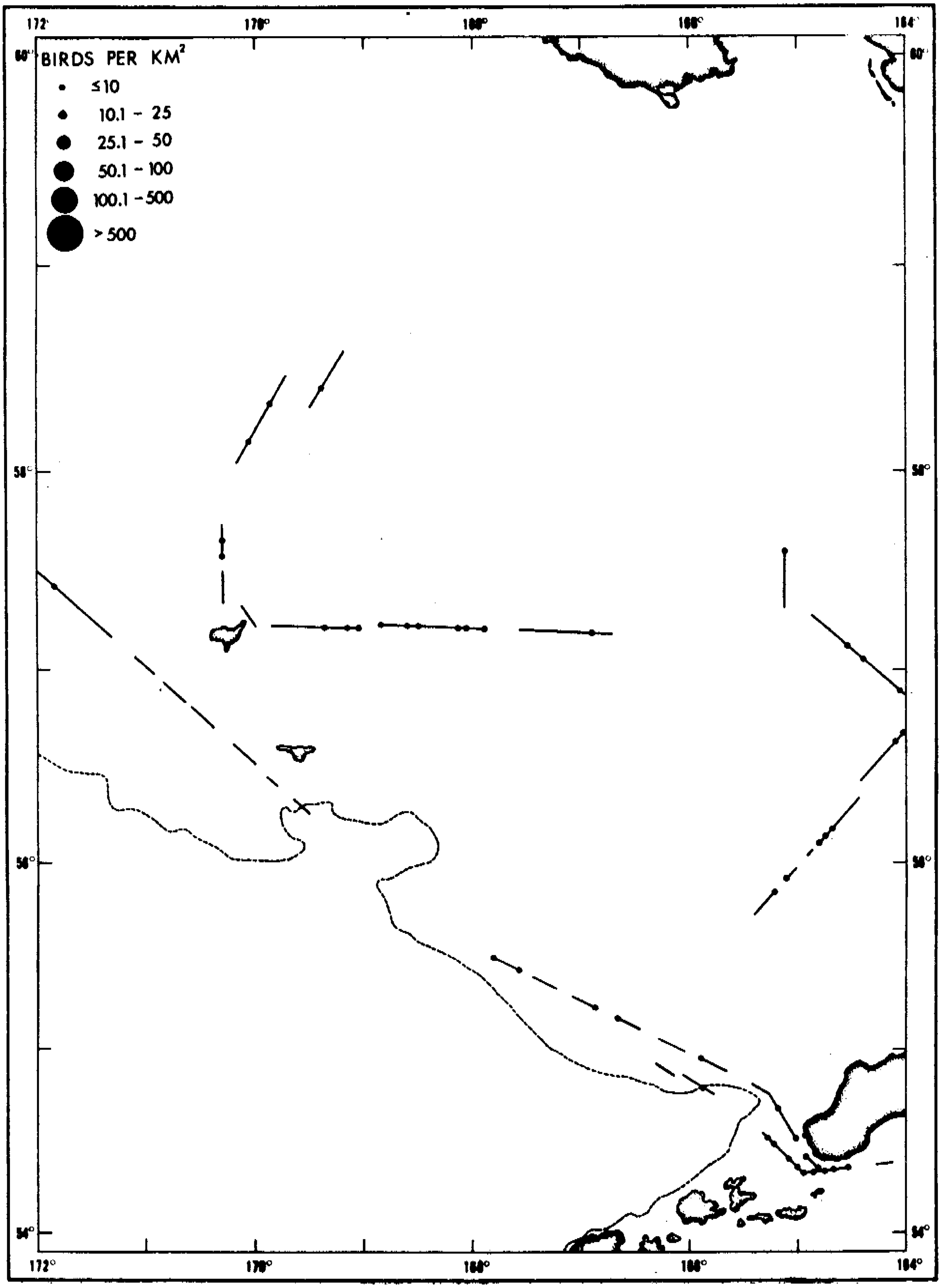


Figure 52. Distribution and abundance of Glaucous-winged Gulls in southern Bering Sea from 4 to 17 April, 19 to 25 April and 30 April to 1 May 1977.

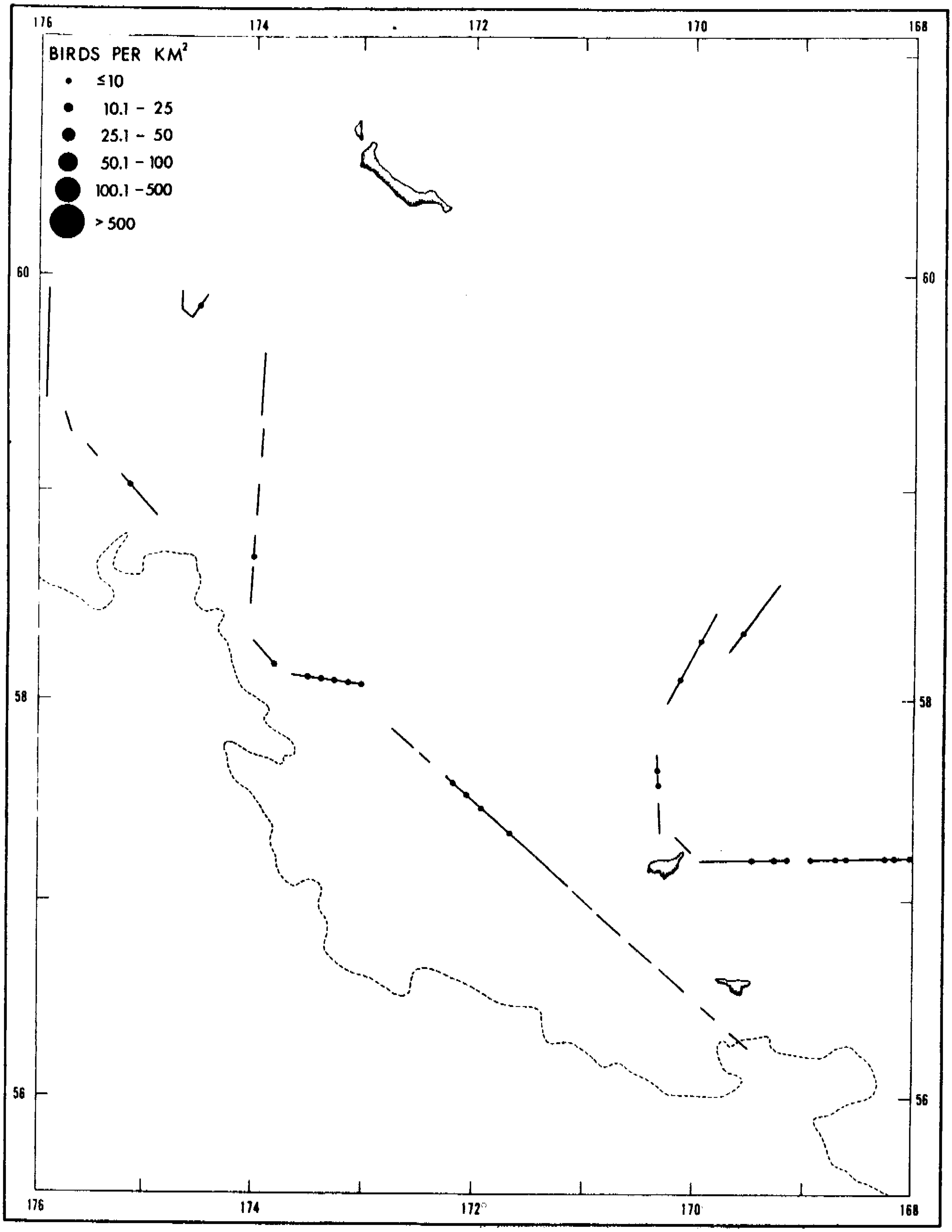


Figure 53 Distribution and abundance of Glaucous-winged Gulls in central Bering Sea from 22 to 30 April 1977.

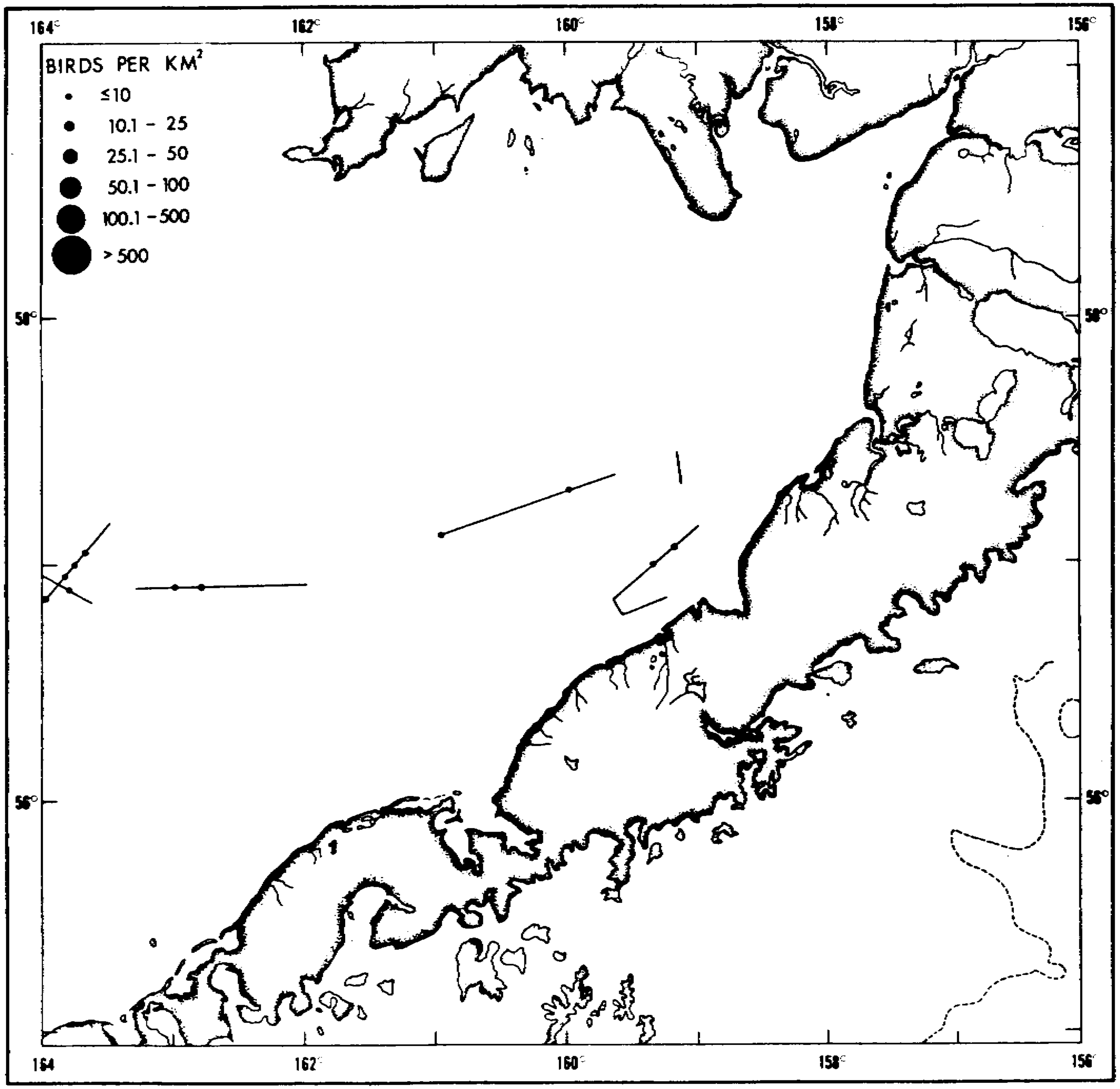


Figure 54. Distribution and abundance of Glaucous-winged Gulls in Bristol Bay from 17 to 19 April 1977.

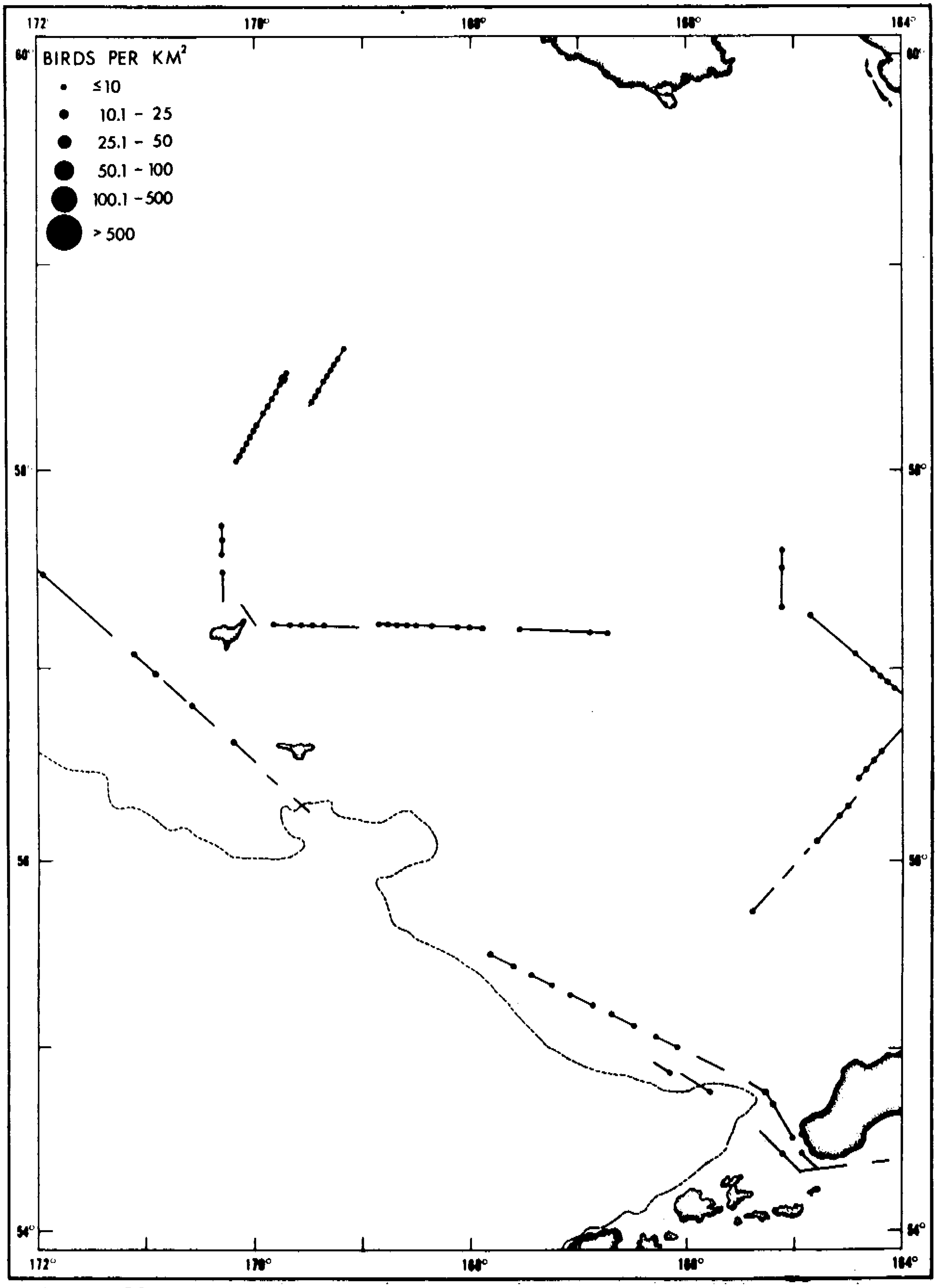


Figure 55. Distribution and abundance of Black-legged Kittiwakes in southern Bering Sea from 4 to 17 April, 19 to 25 April and 30 April to 1 May 1977.

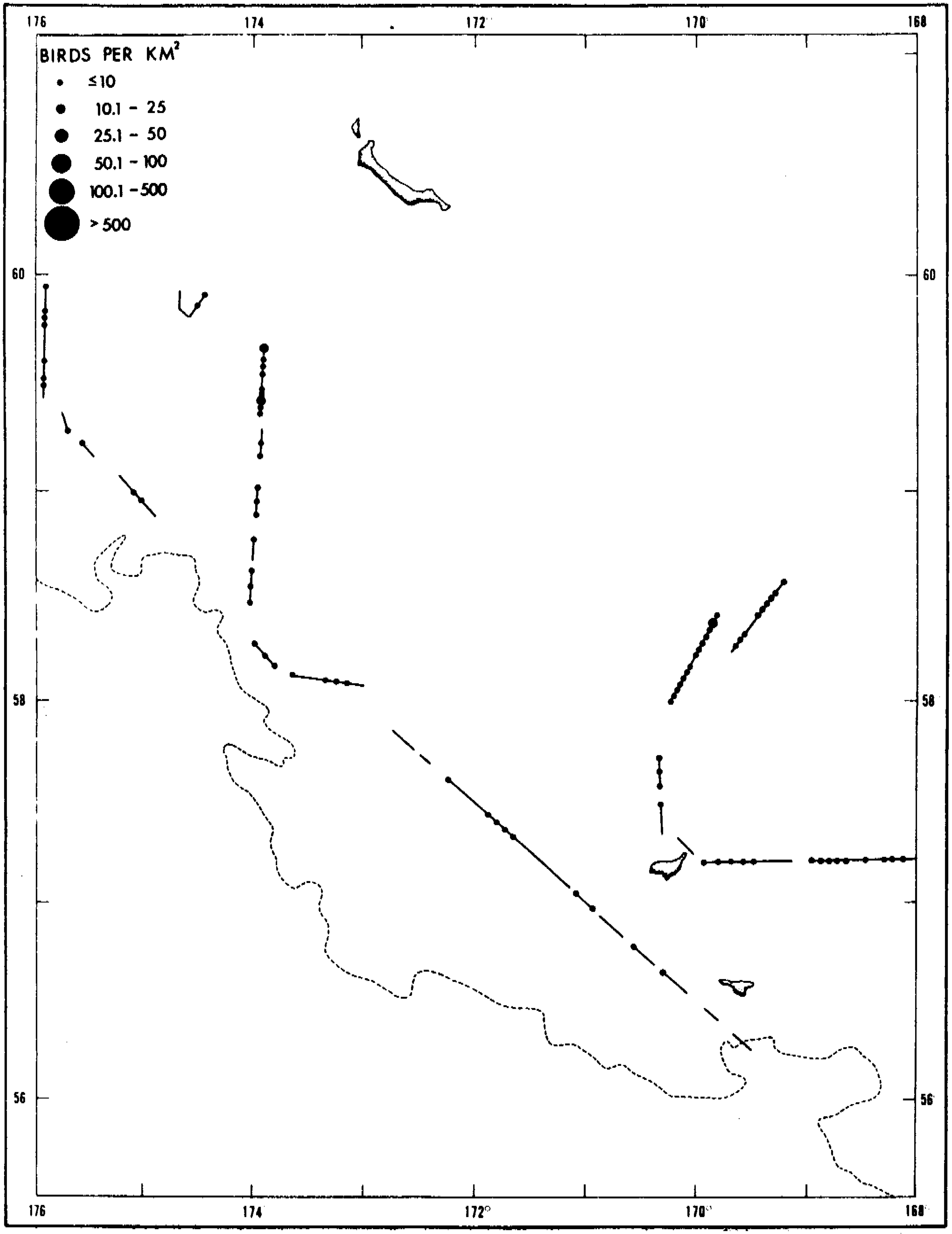


Figure 56. Distribution and abundance of Black-legged Kittiwakes in central Bering Sea from 22 to 30 April 1977.

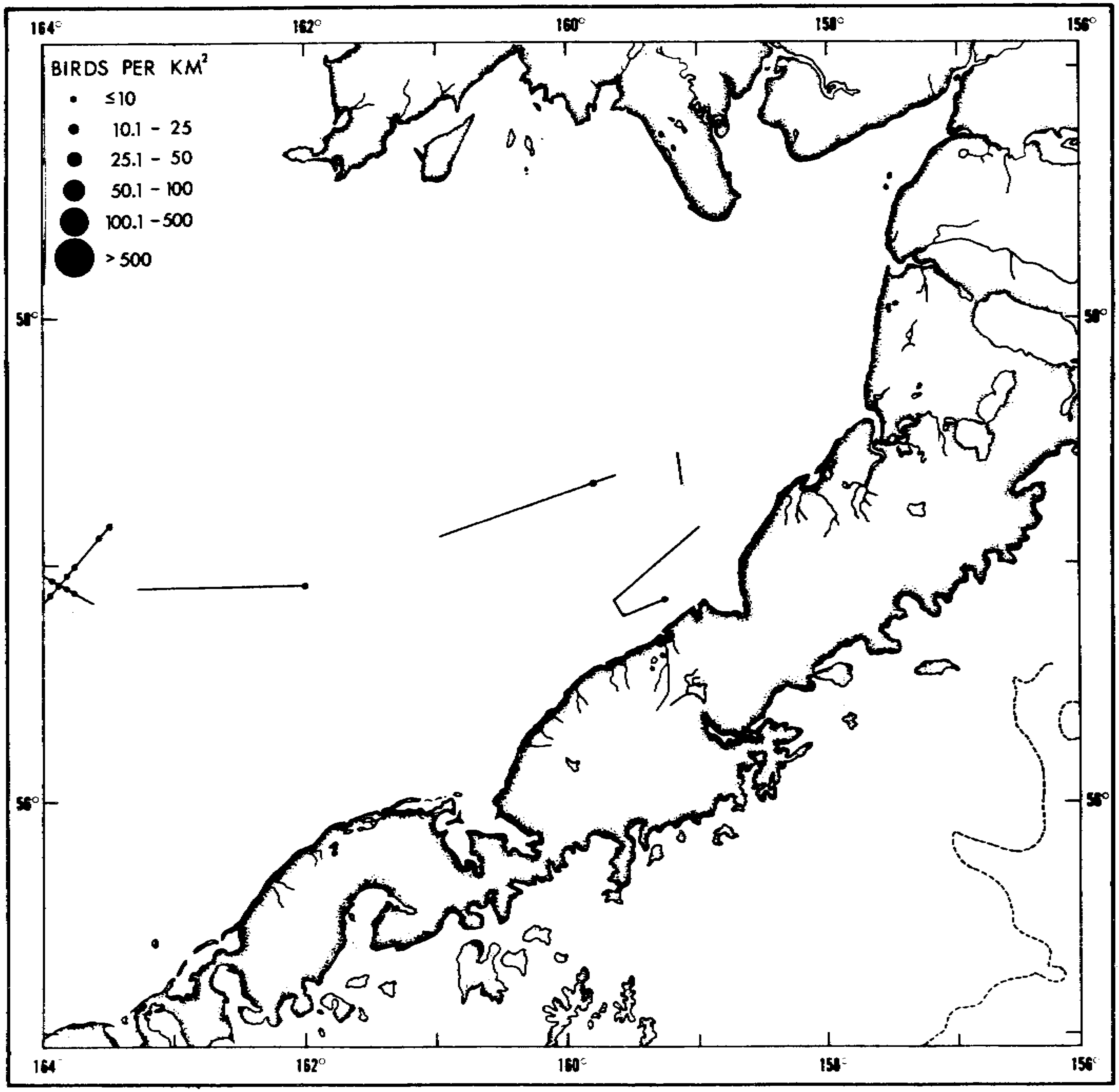


Figure 57. Distribution and abundance of Black-legged Kittiwakes in Bristol Bay from 17 to 19 April 1977.

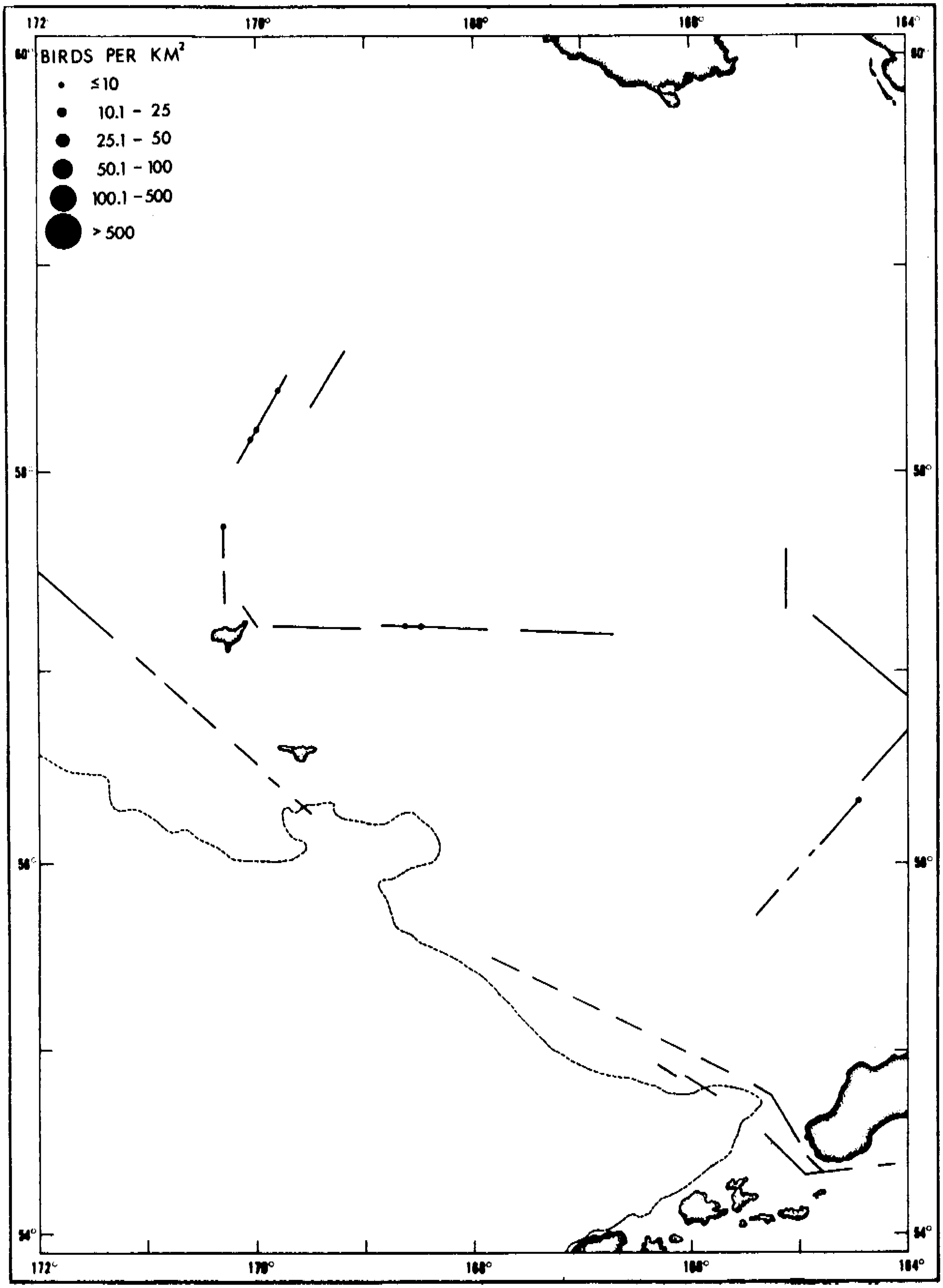


Figure 58. Distribution and abundance of Red-legged Kittiwakes in southern Bering Sea from 4 to 17 April, 19 to 25 April and 30 April to 1 May 1977.

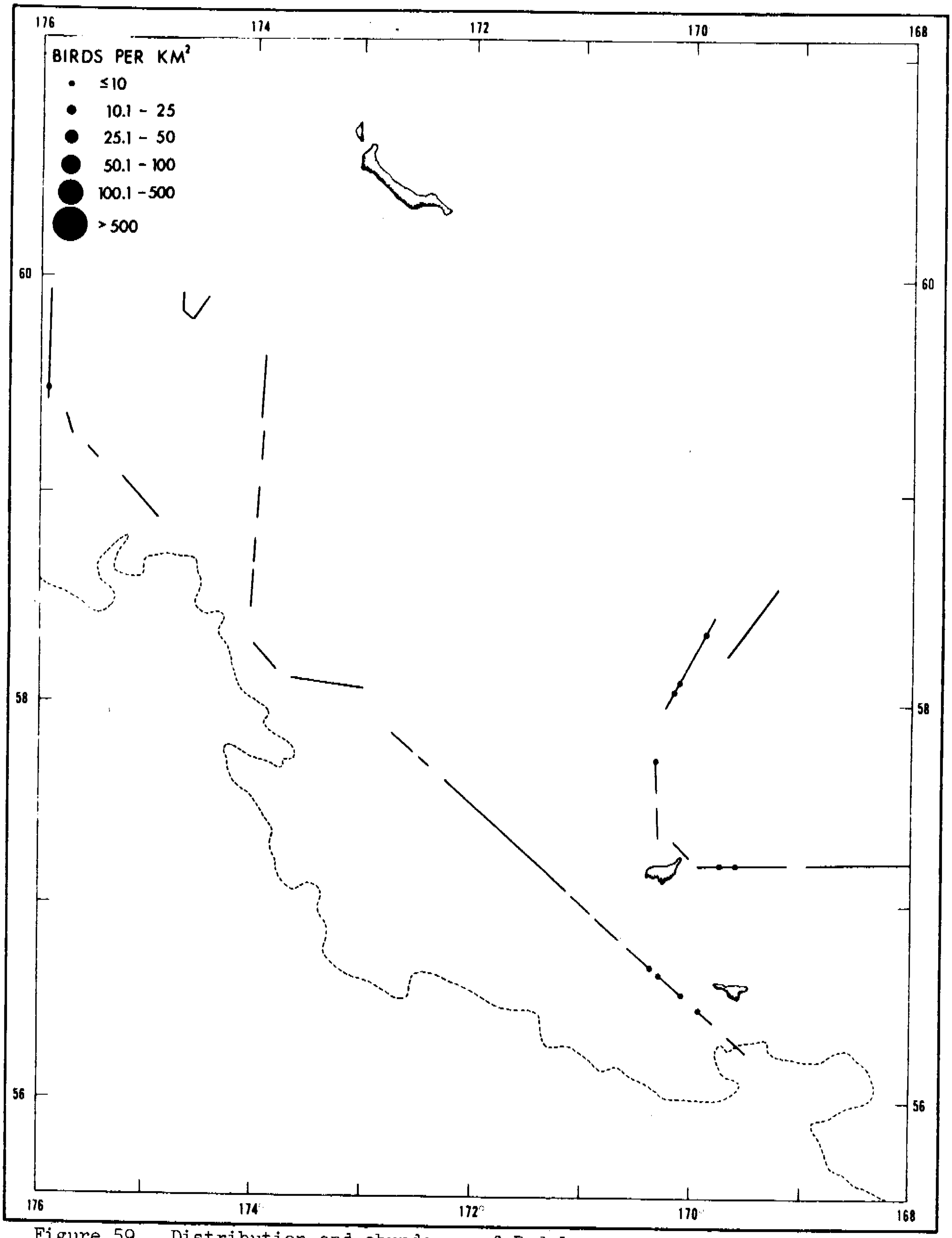


Figure 59. Distribution and abundance of Red-legged Kittiwakes in central Bering Sea from 22 to 30 April 1977.

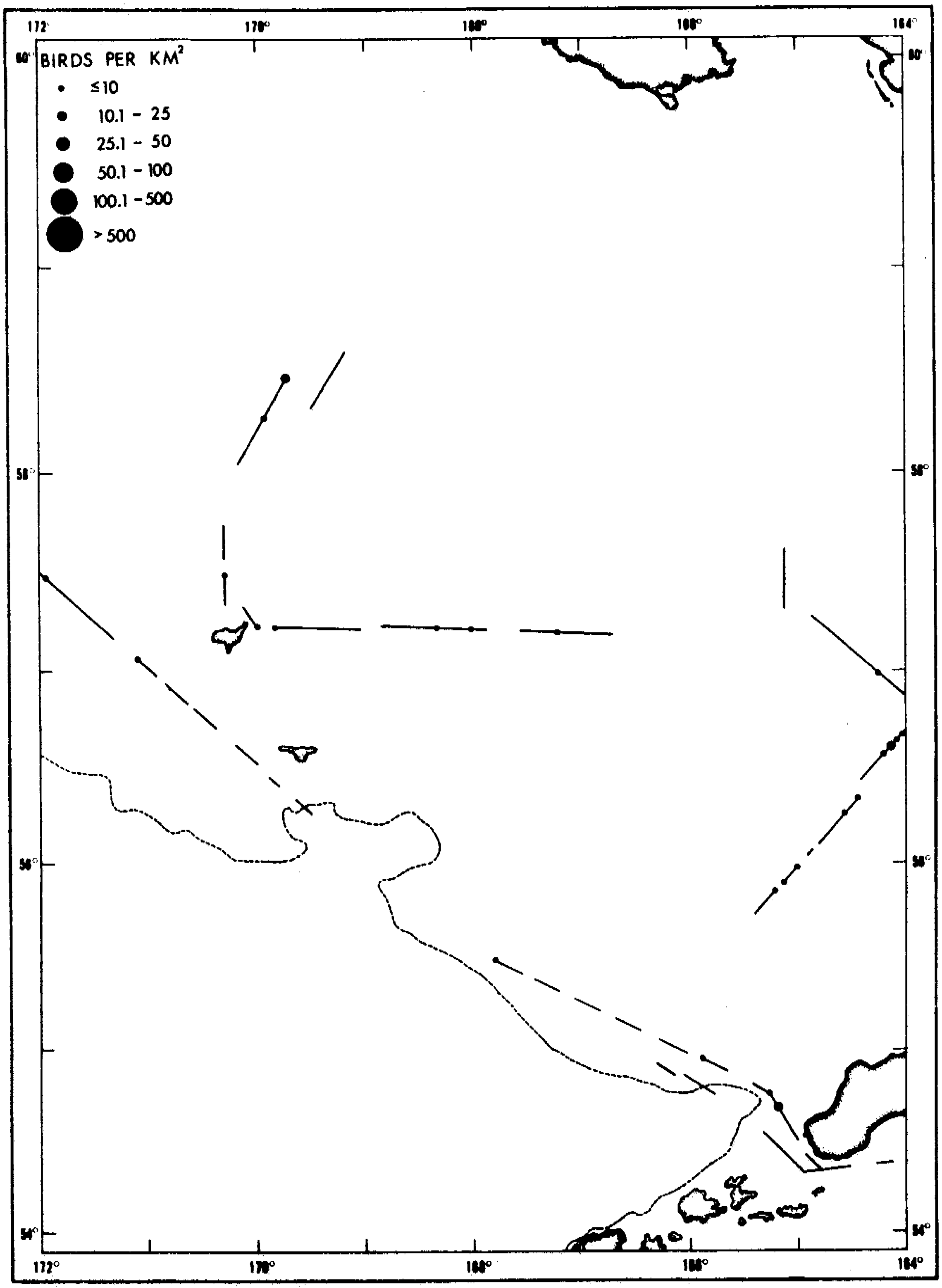


Figure 60. Distribution and abundance of Common Murres in southern Bering Sea from 4 to 17 April, 19 to 25 April and 30 April to 1 May 1977.

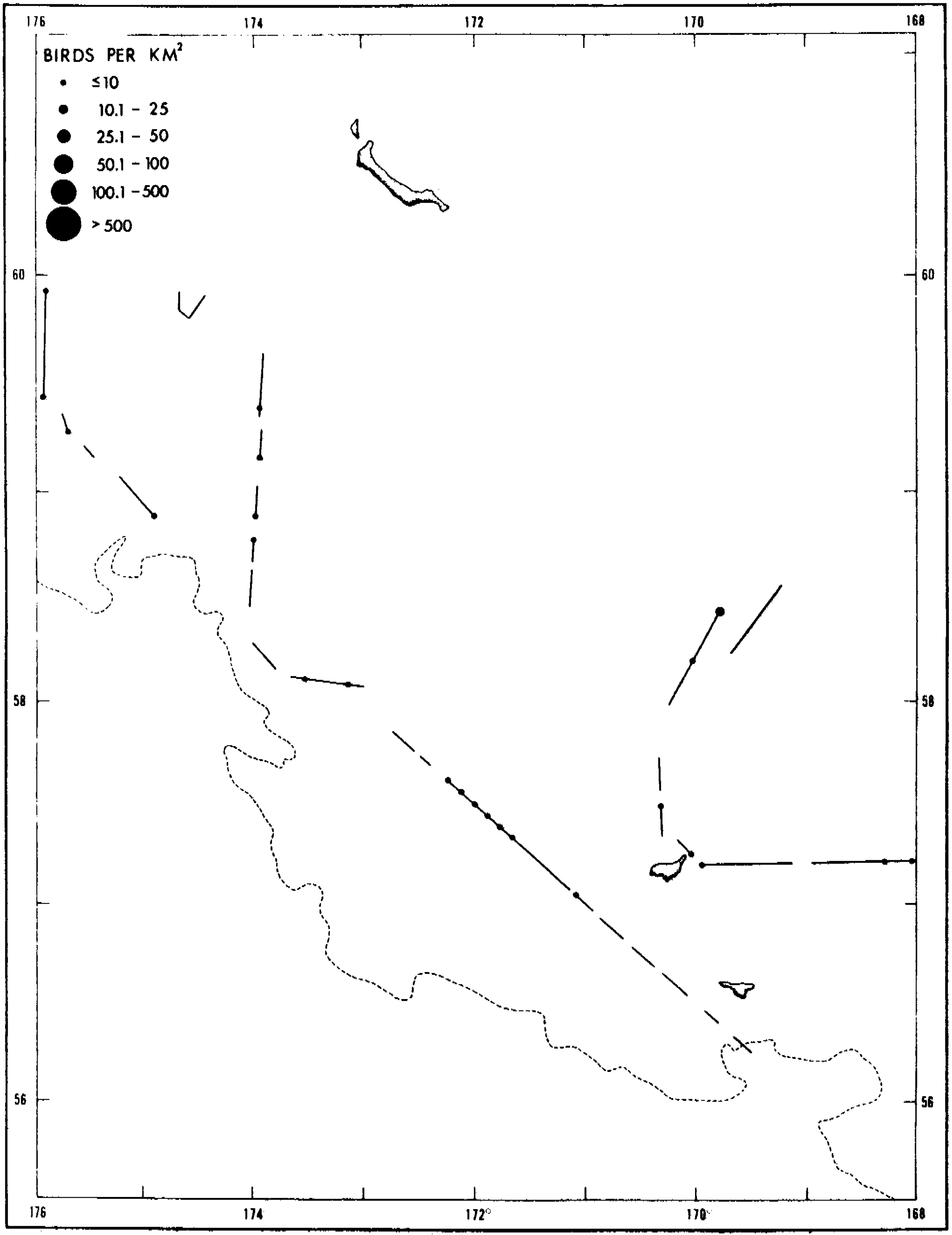


Figure 61. Distribution and abundance of Common Murres in central Bering Sea from 22 to 30 April 1977.

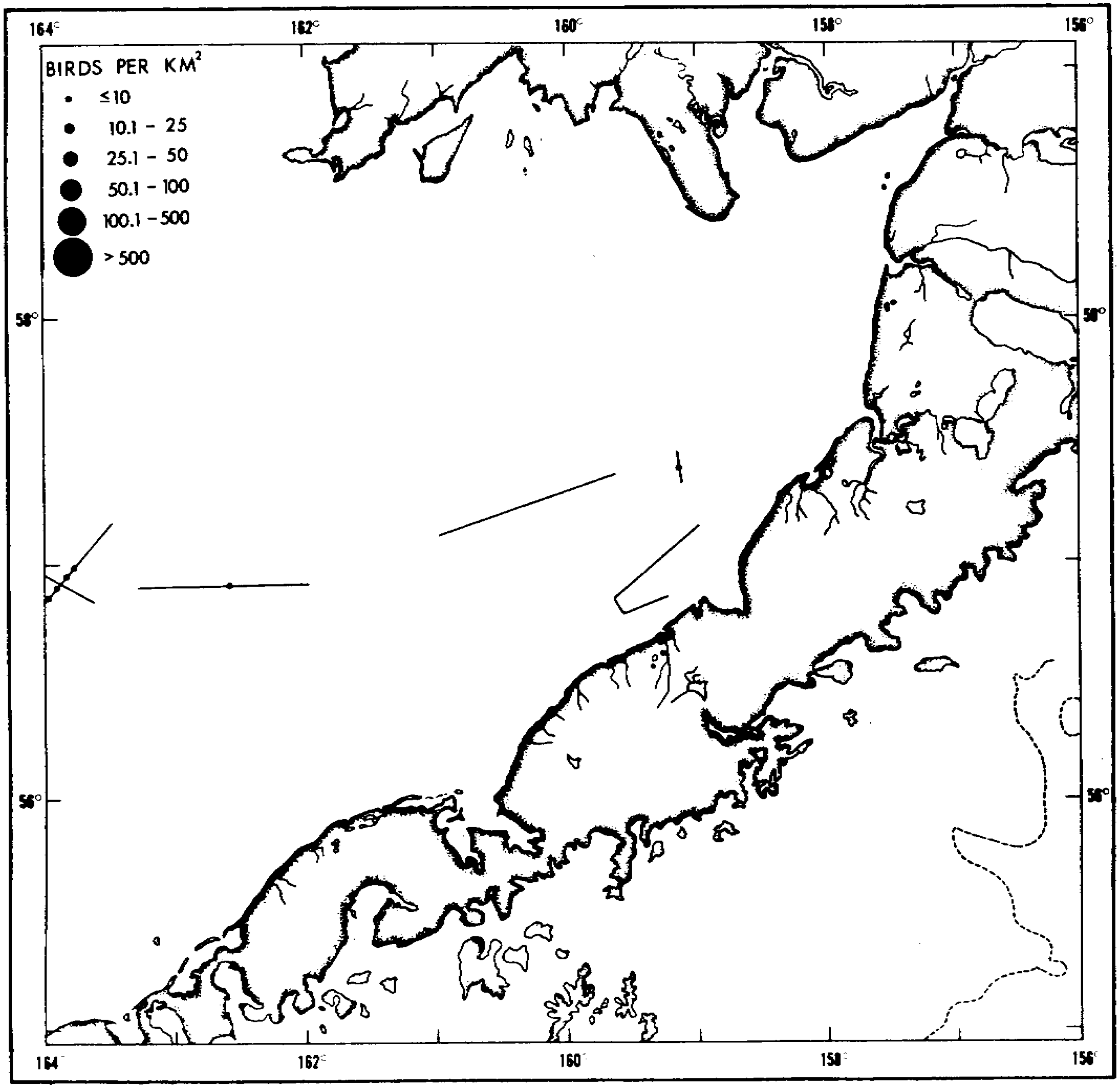


Figure 62. Distribution and abundance of Common Murres in Bristol Bay from 17 to 19 April 1977.

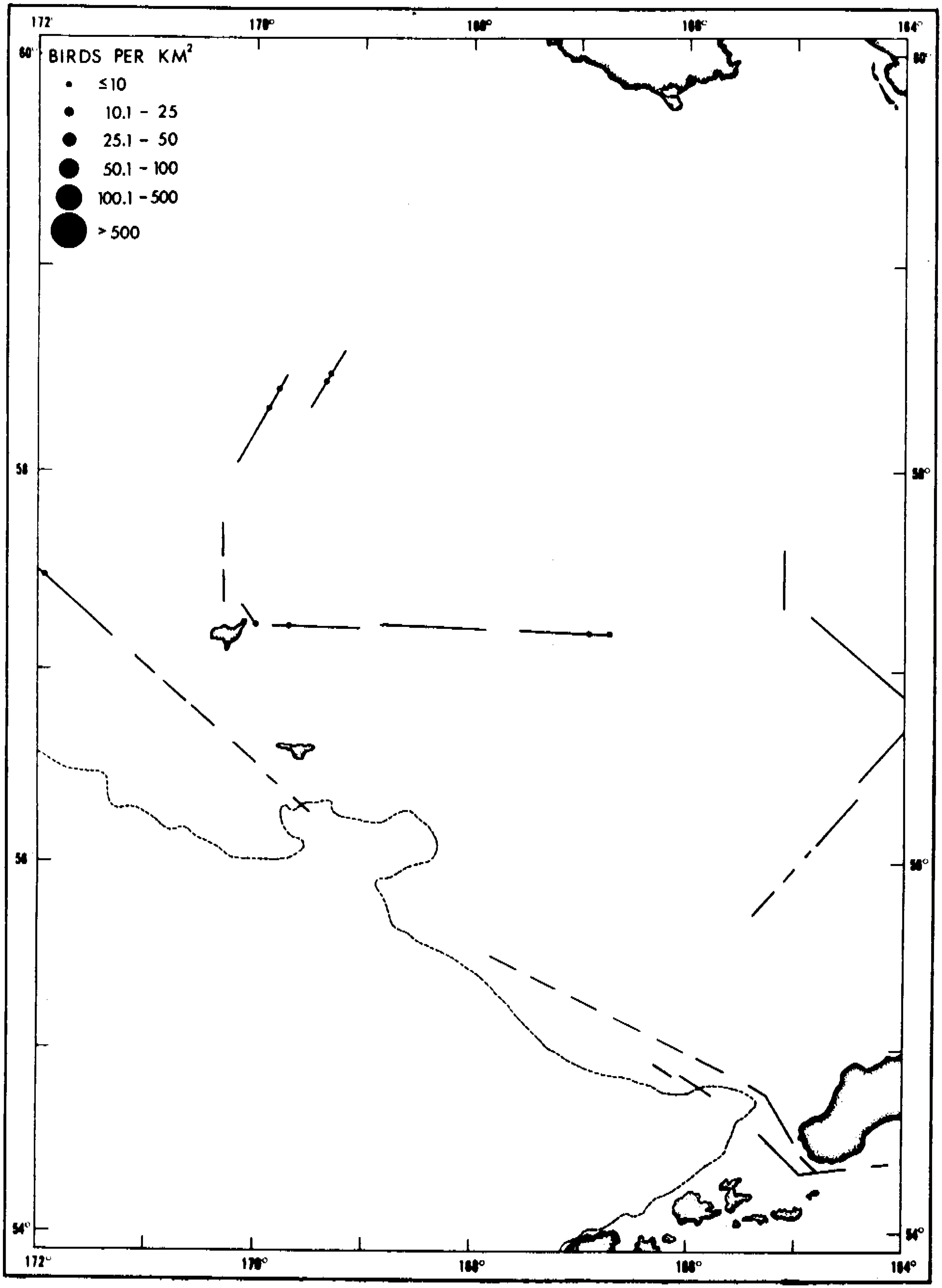


Figure 63. Distribution and abundance of Thick-billed Murres in southern Bering Sea from 4 to 17 April, 19 to 25 April and 30 April to 1 May 1977.

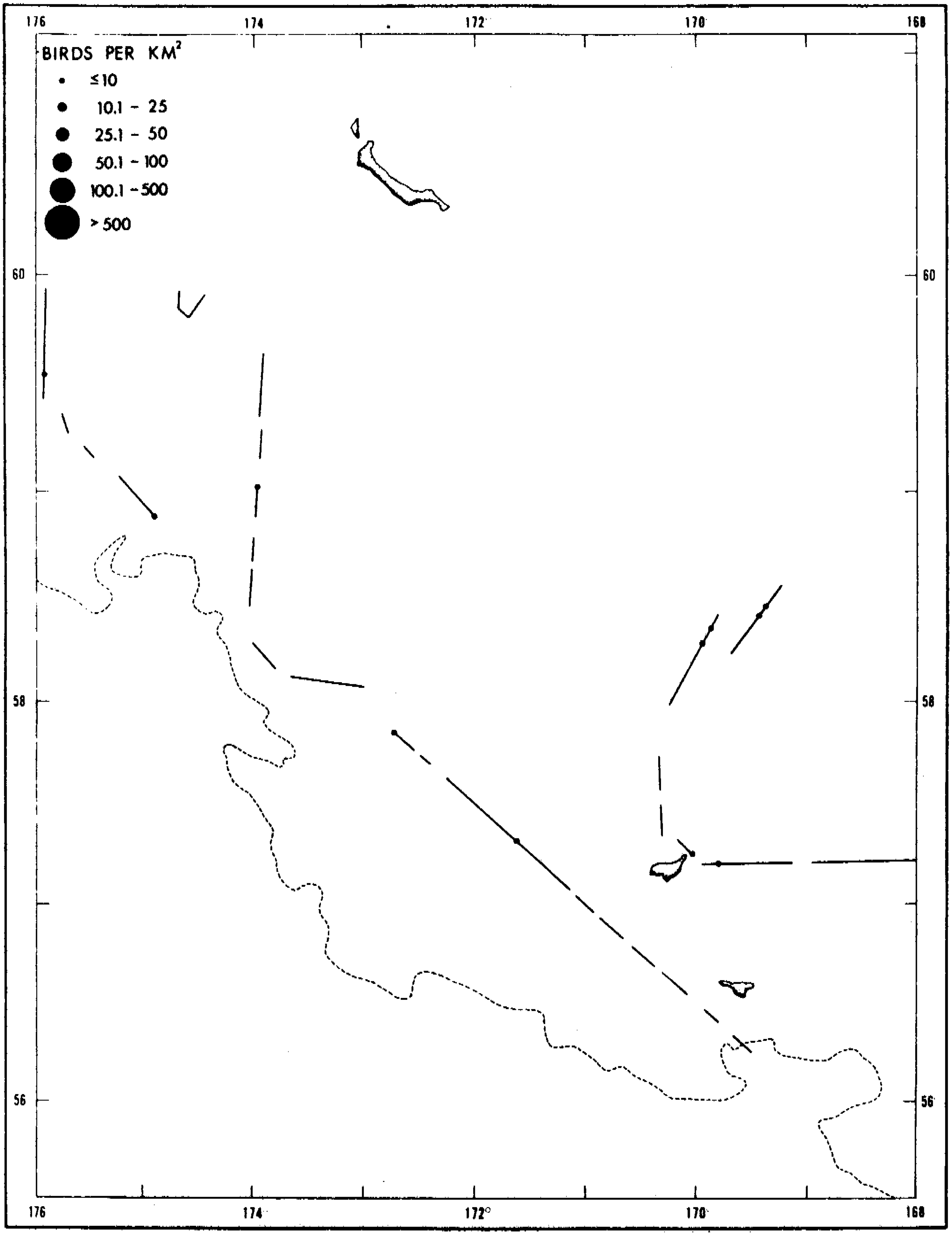


Figure 64. Distribution and abundance of Thick-billed Murres in central Bering Sea from 22 to 30 April 1977.

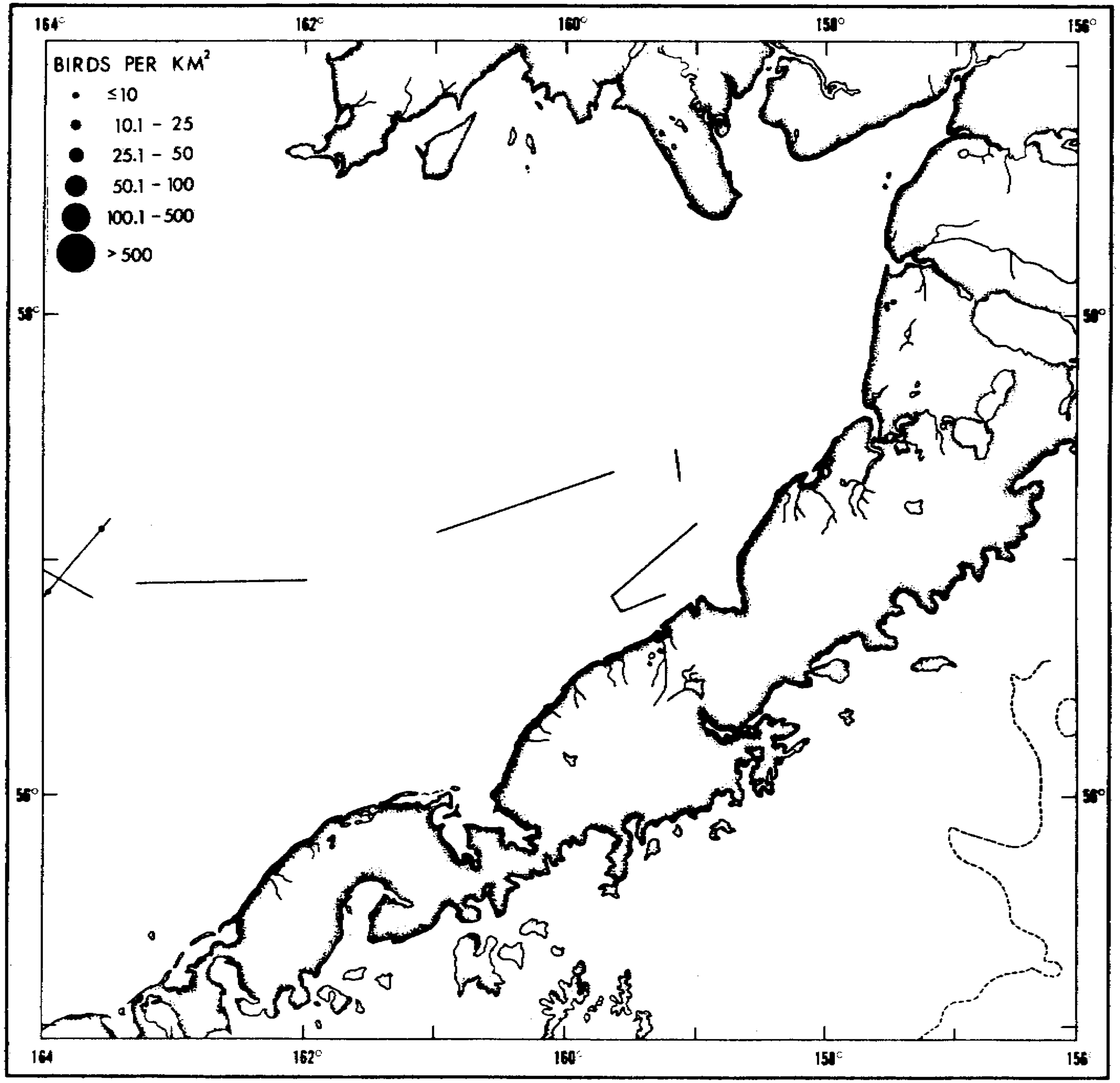


Figure 65. Distribution and abundance of Thick-billed Murres in Bristol Bay from 17 to 19 April 1977.

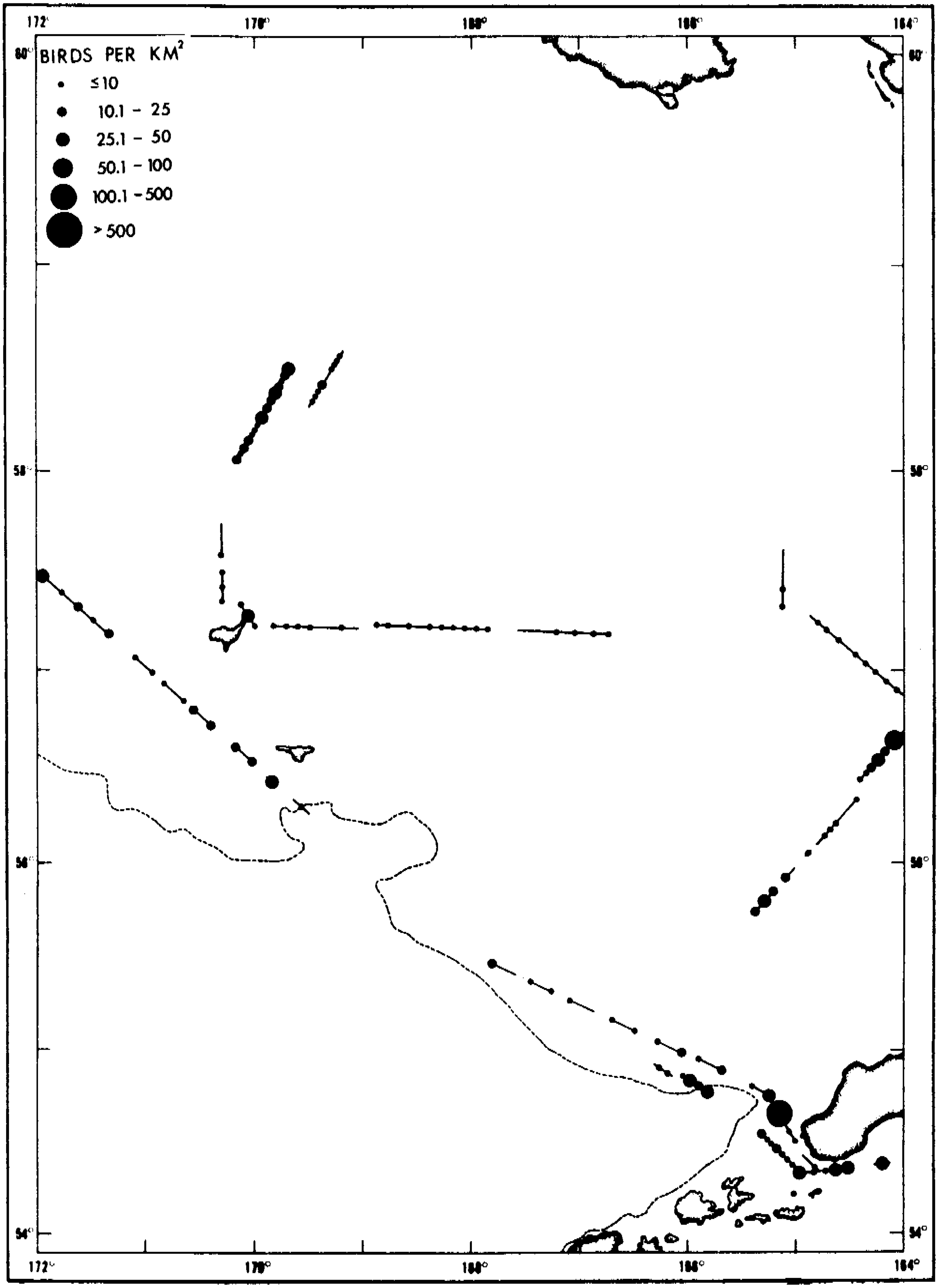


Figure 66. Distribution and abundance of all murres in southern Bering Sea from 4 to 17 April, 19 to 25 April and 30 April to 1 May 1977.

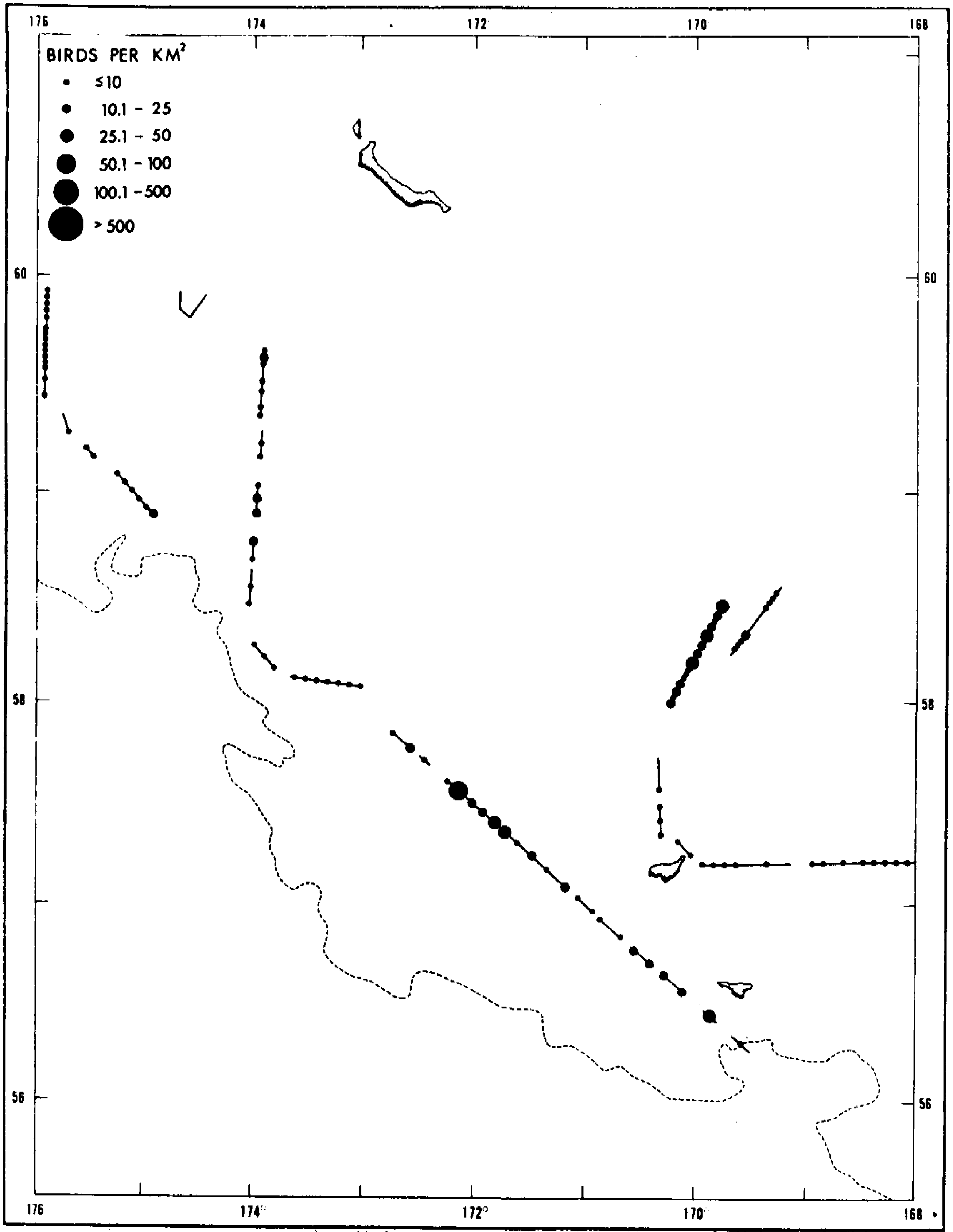


Figure 67. Distribution and abundance of all murres in central Bering Sea from 22 to 30 April 1977.

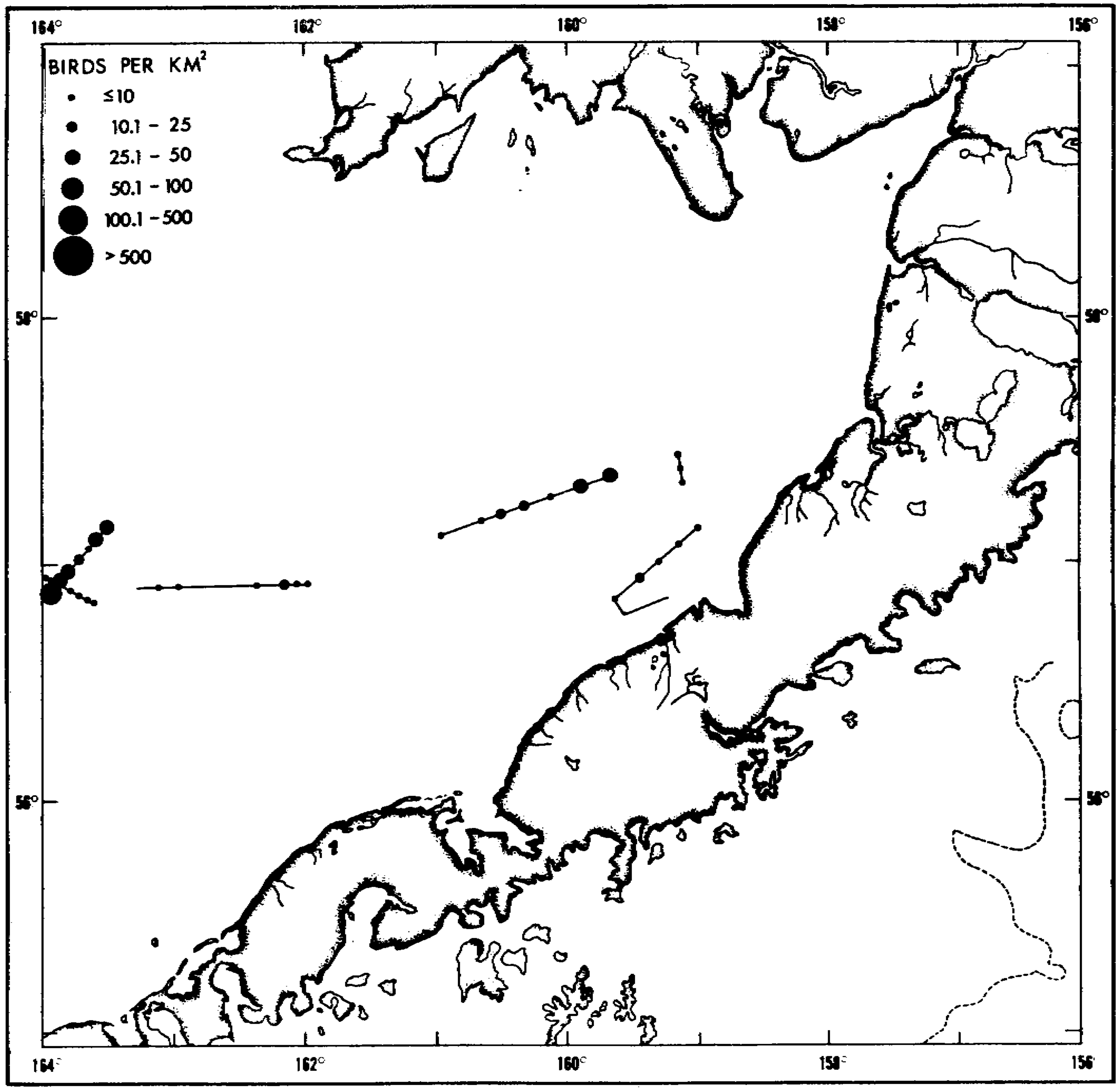


Figure 68. Distribution and abundance of all murres in Bristol Bay from 17 to 19 April 1977.

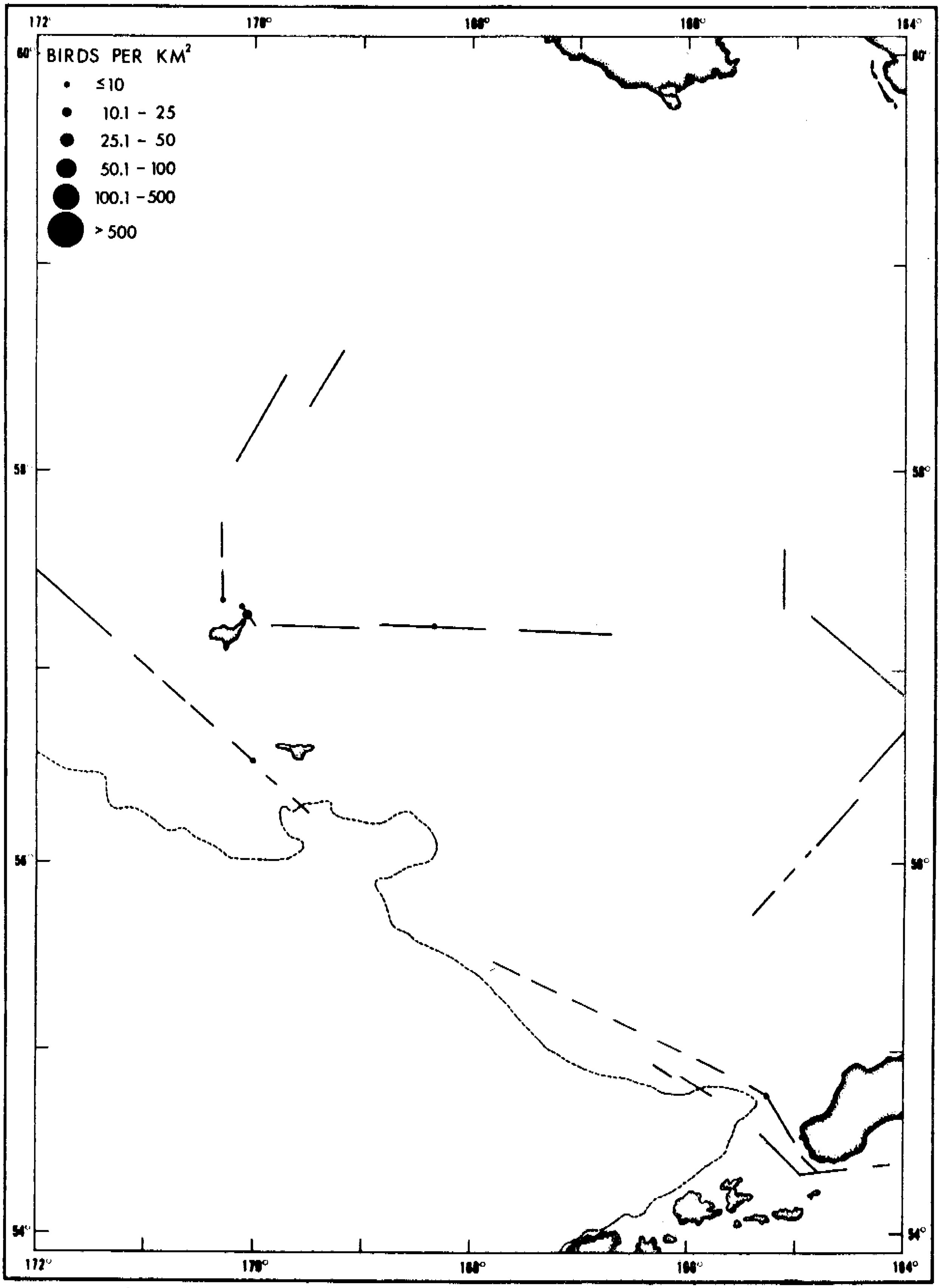


Figure 69. Distribution and abundance of Parakeet Auklets in southern Bering Sea from 4 to 17 April, 19 to 25 April and 30 April to 1 May 1977.

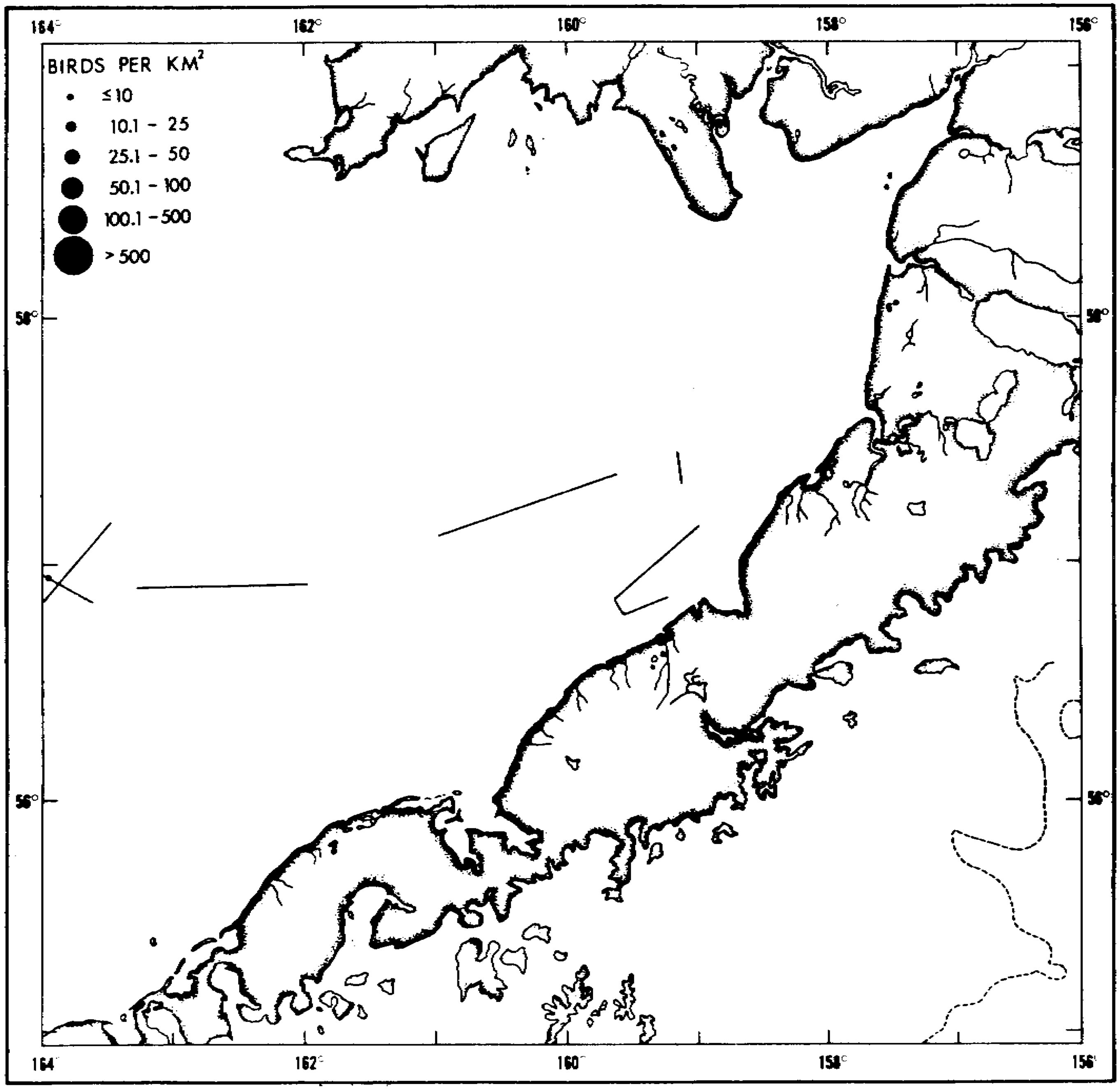


Figure 70. Distribution and abundance of Parakeet Auklets in Bristol Bay from 17 to 19 April 1977.

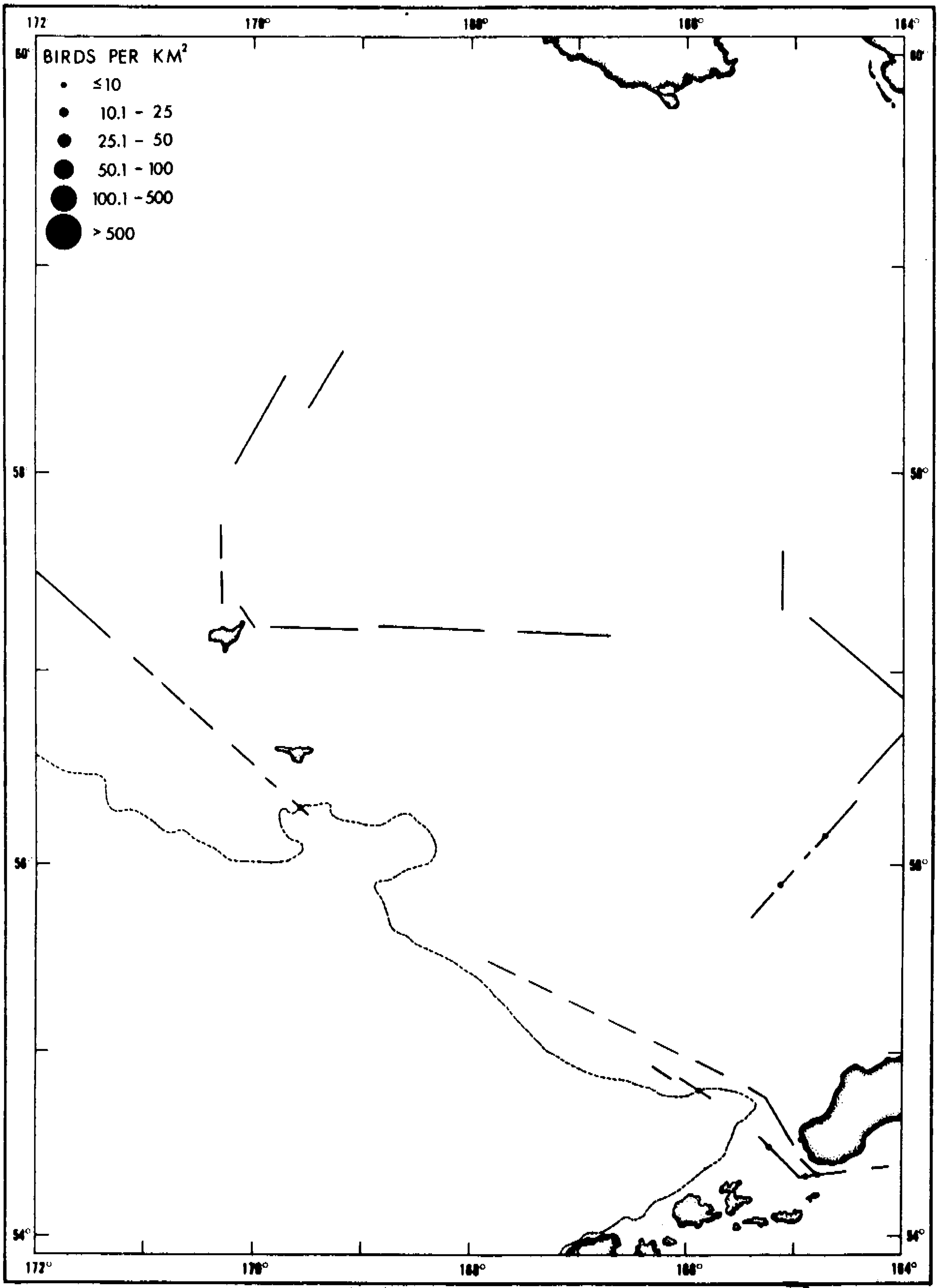


Figure 71. Distribution and abundance of Crested Auklets in southern Bering Sea from 4 to 17 April, 19 to 25 April, and 30 April to 1 May 1977.

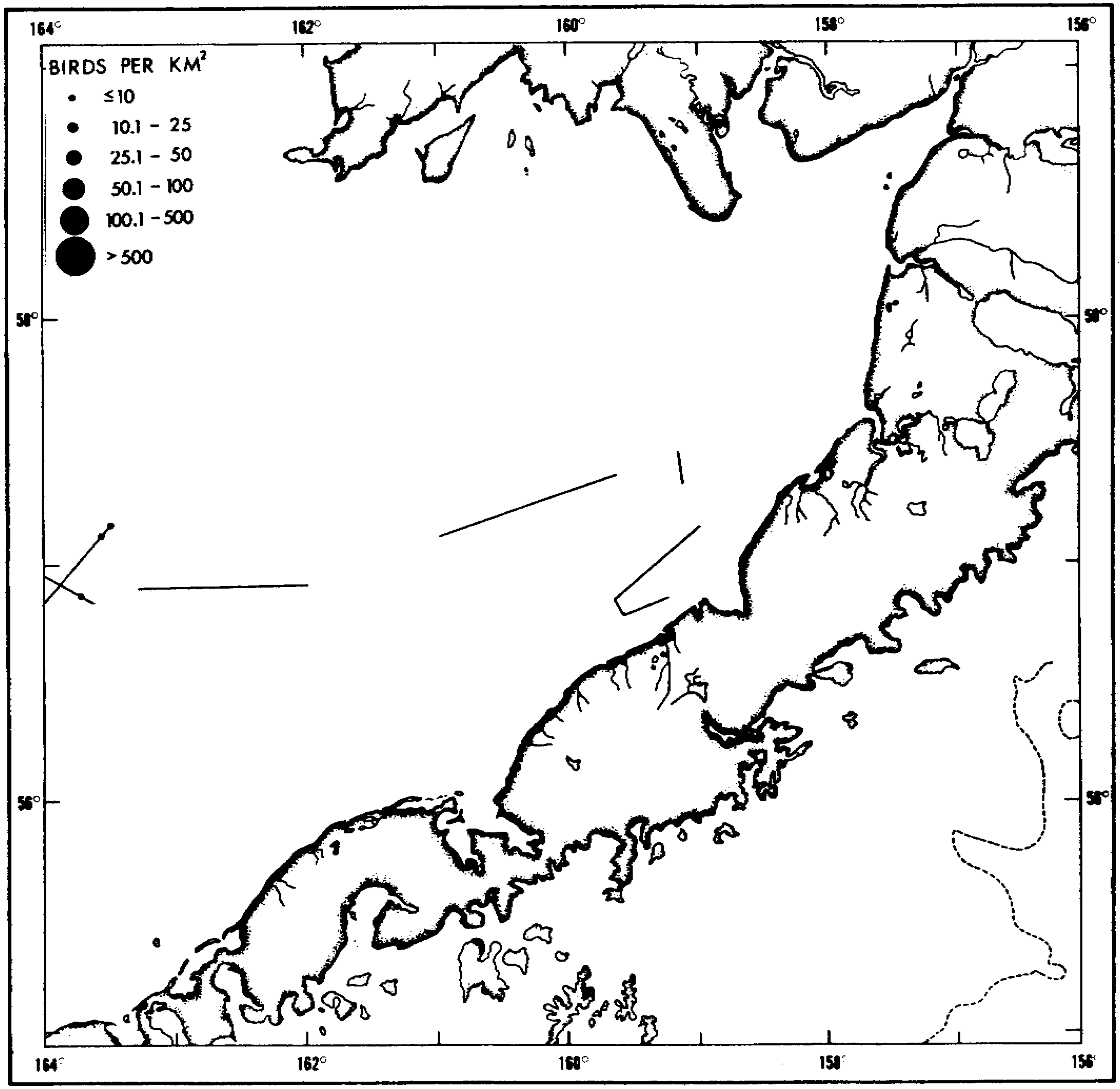


Figure 72. Distribution and abundance of Crested Auklets in Bristol Bay from 17 to 19 April 1977.

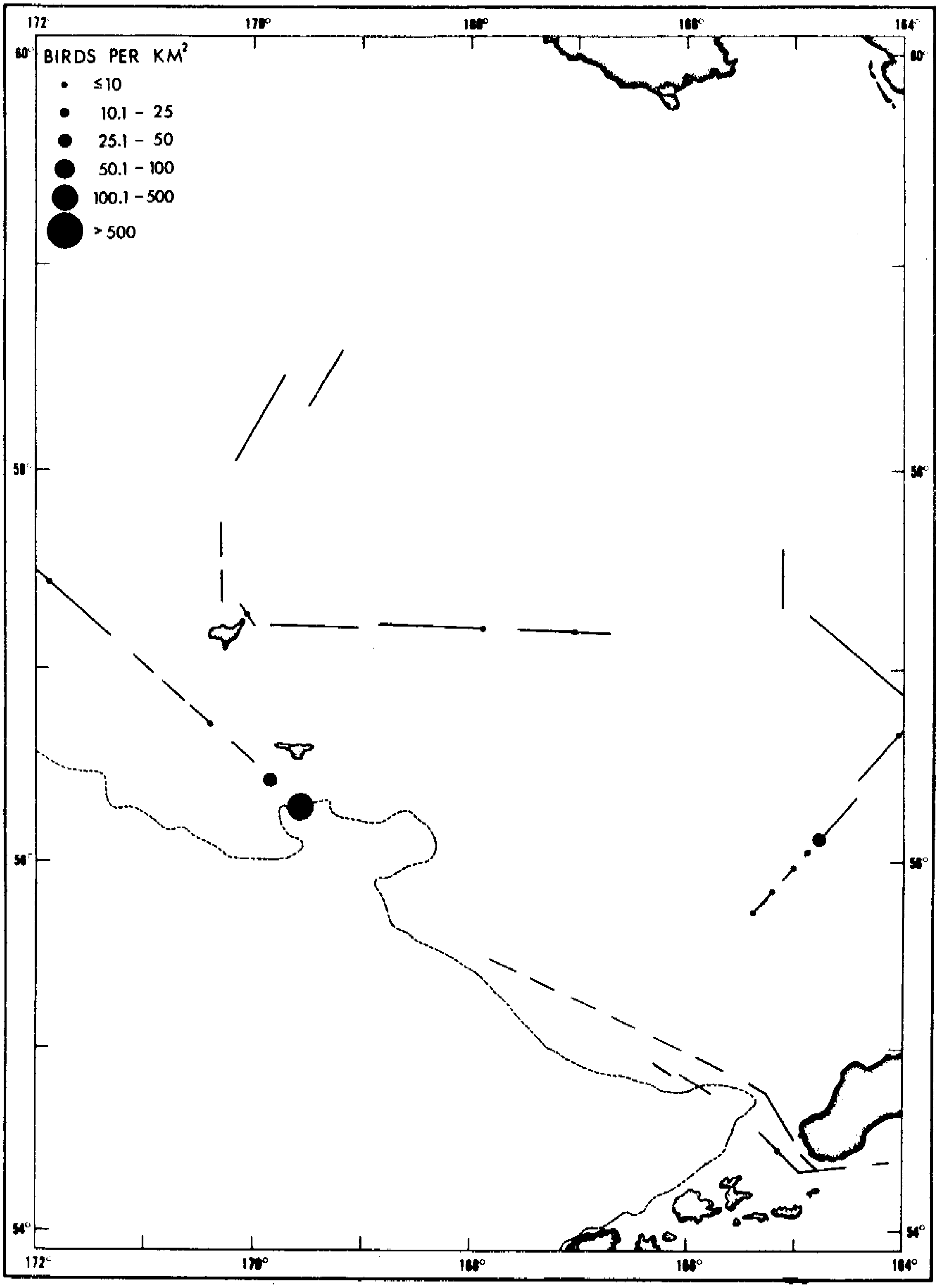


Figure 73. Distribution and abundance of Least Auklets in southern Bering Sea from 4 to 17 April, 19 to 25 April and 30 April to 1 May 1977.

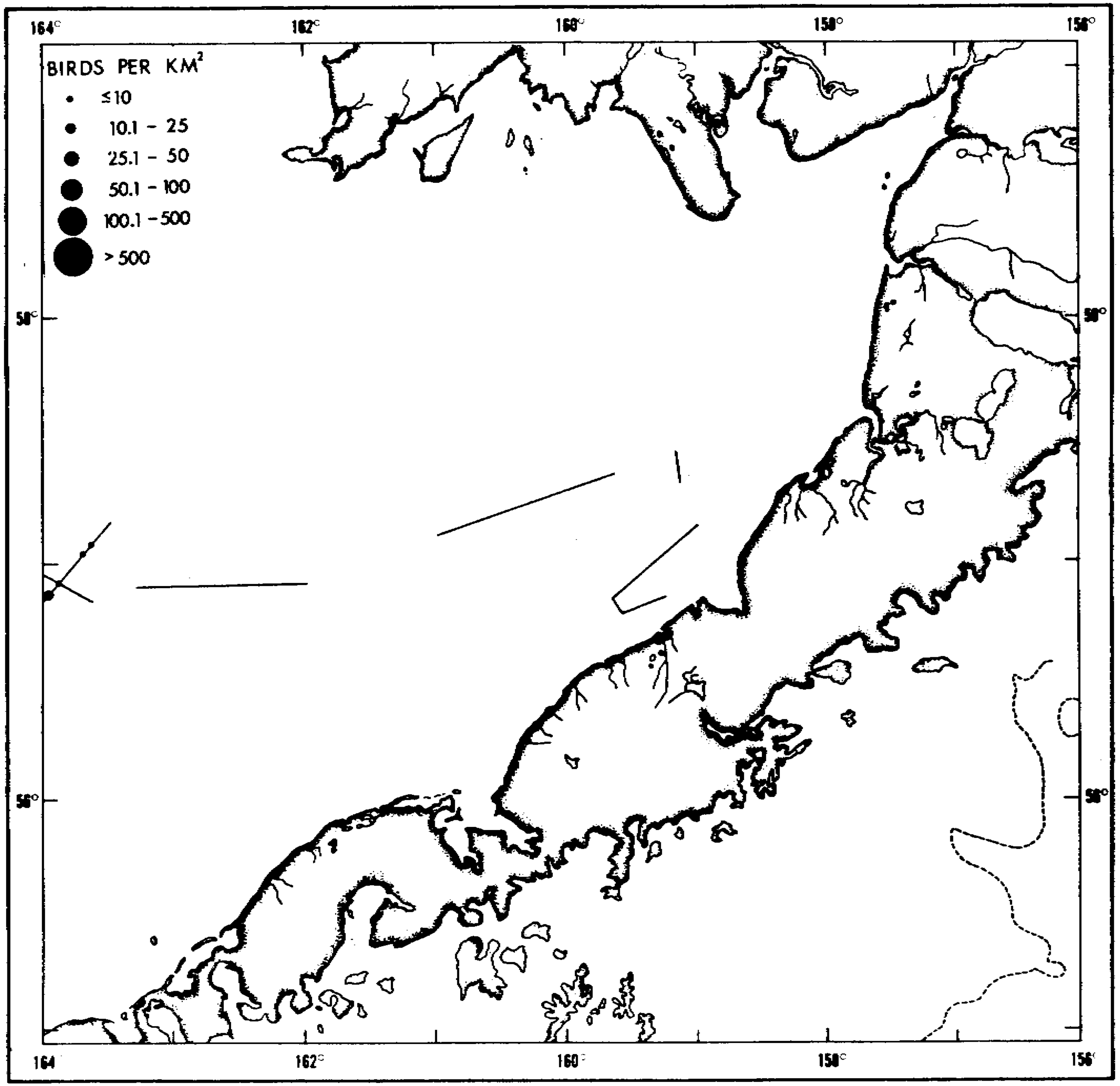


Figure 74. Distribution and abundance of Least Auklets in Bristol Bay from 17 to 19 April 1977.

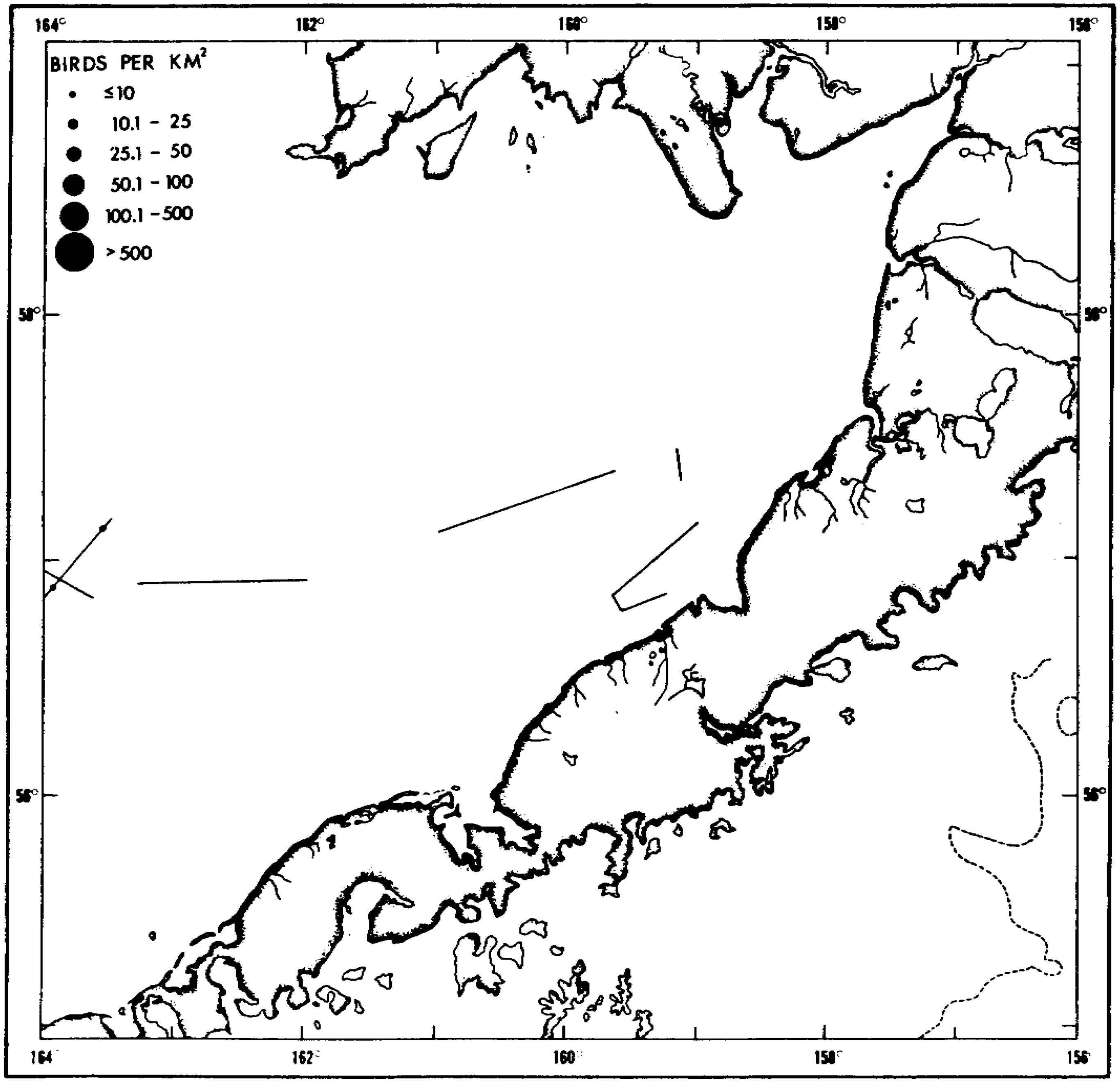


Figure 76. Distribution and abundance of unidentified small dark alcids in Bristol Bay from 17 to 19 April 1977.

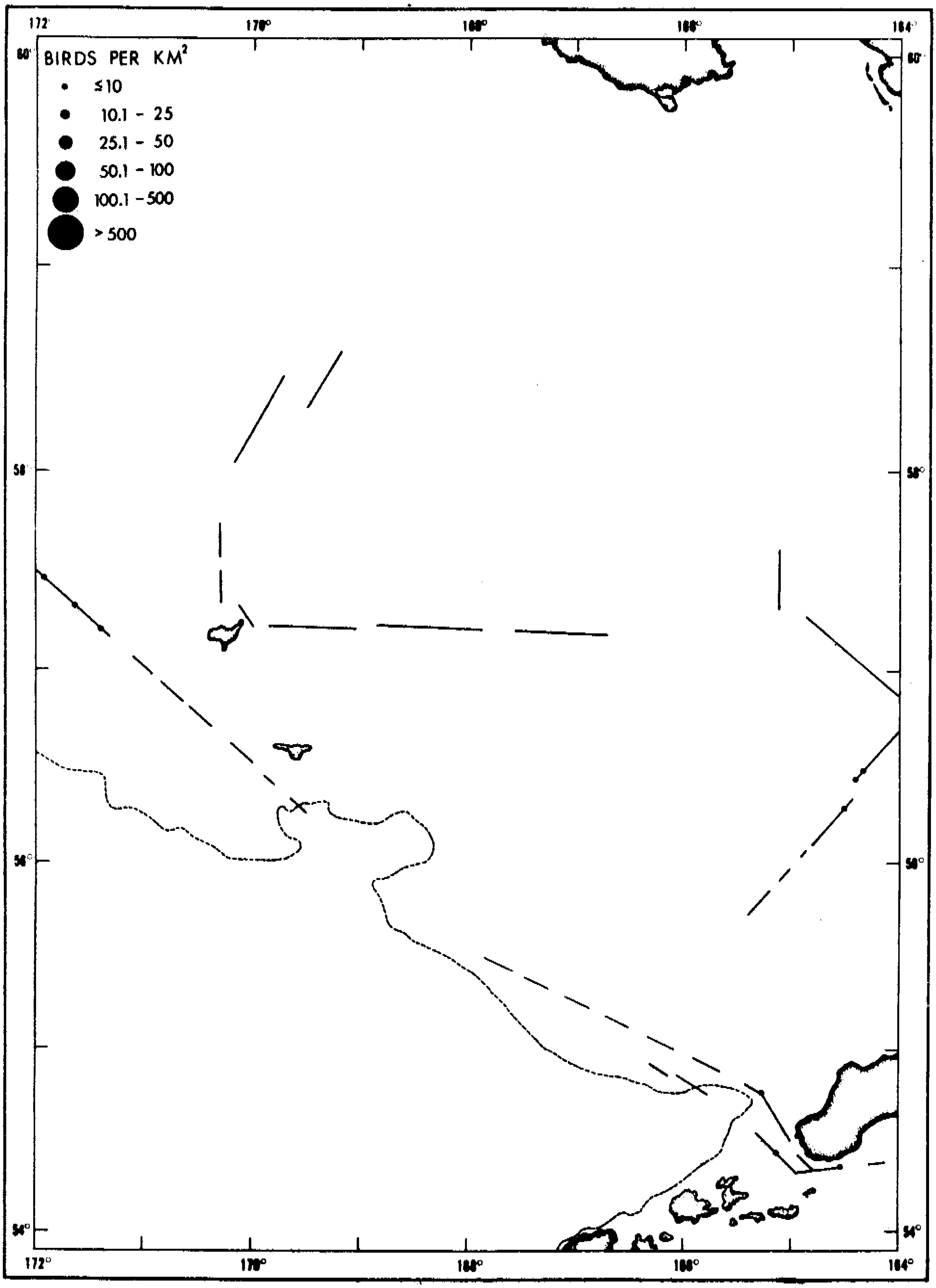


Figure 75. Distribution and abundance of unidentified small dark alcids in southern Bering Sea from 4 to 17 April, 19 to 25 April and 30 April to 1 May 1977.

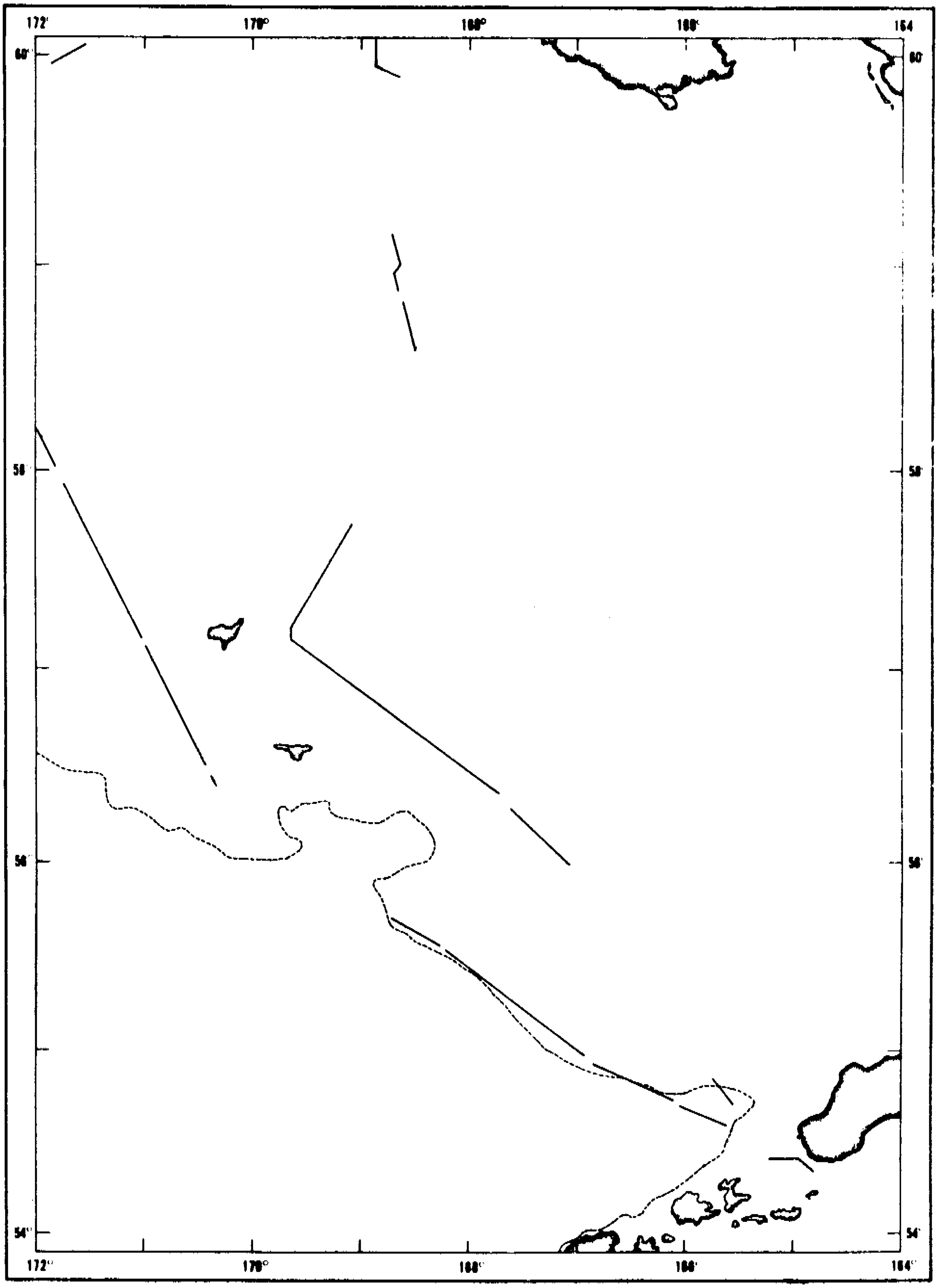


Figure 77. Cruise track during periods of observation in southern Bering Sea from 5 to 24 May, on 29 May, on 2 June, and from 8 to 10 June 1977.

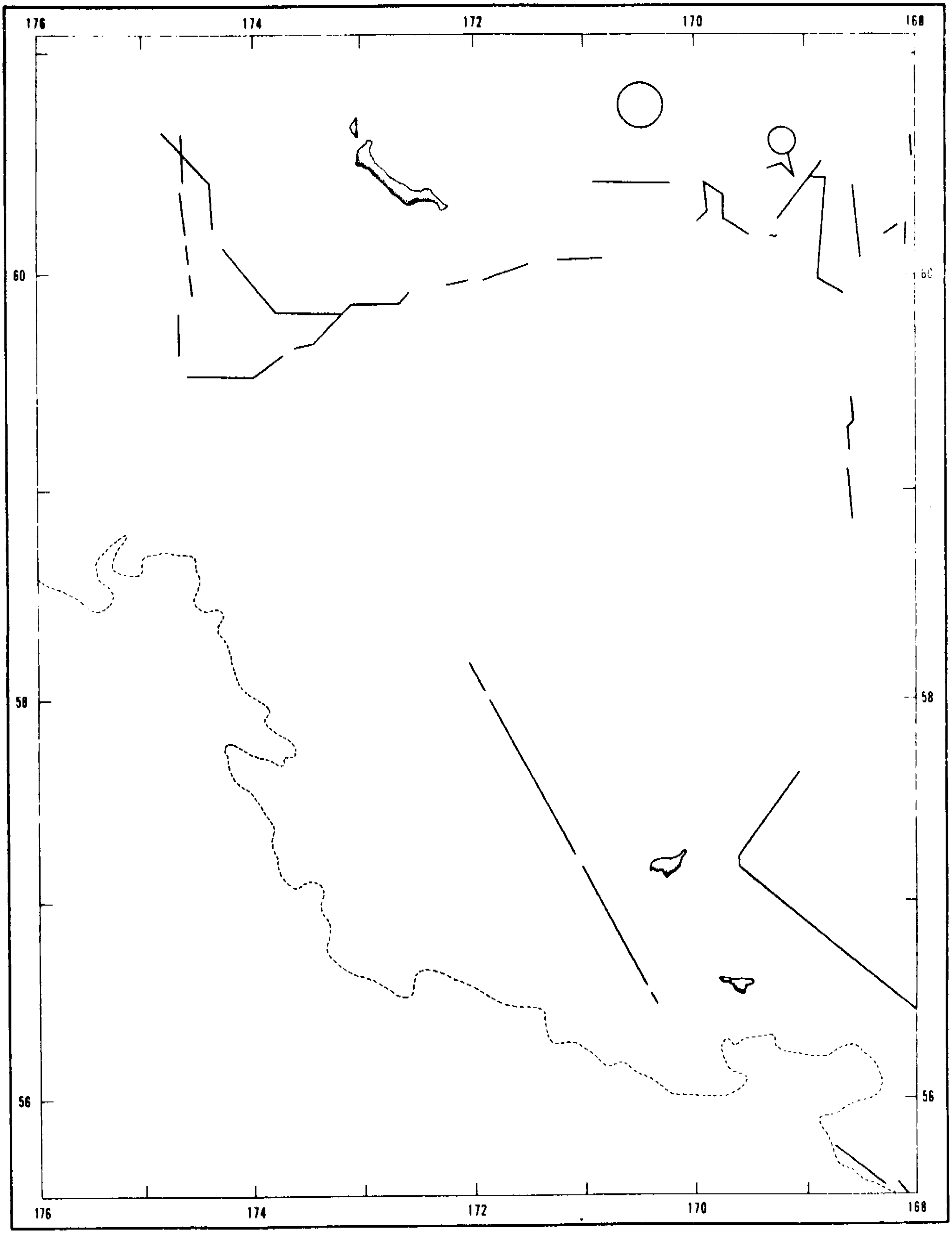


Figure 78. Cruise track during periods of observation in central Bering Sea from 23 May to 9 June 1977.

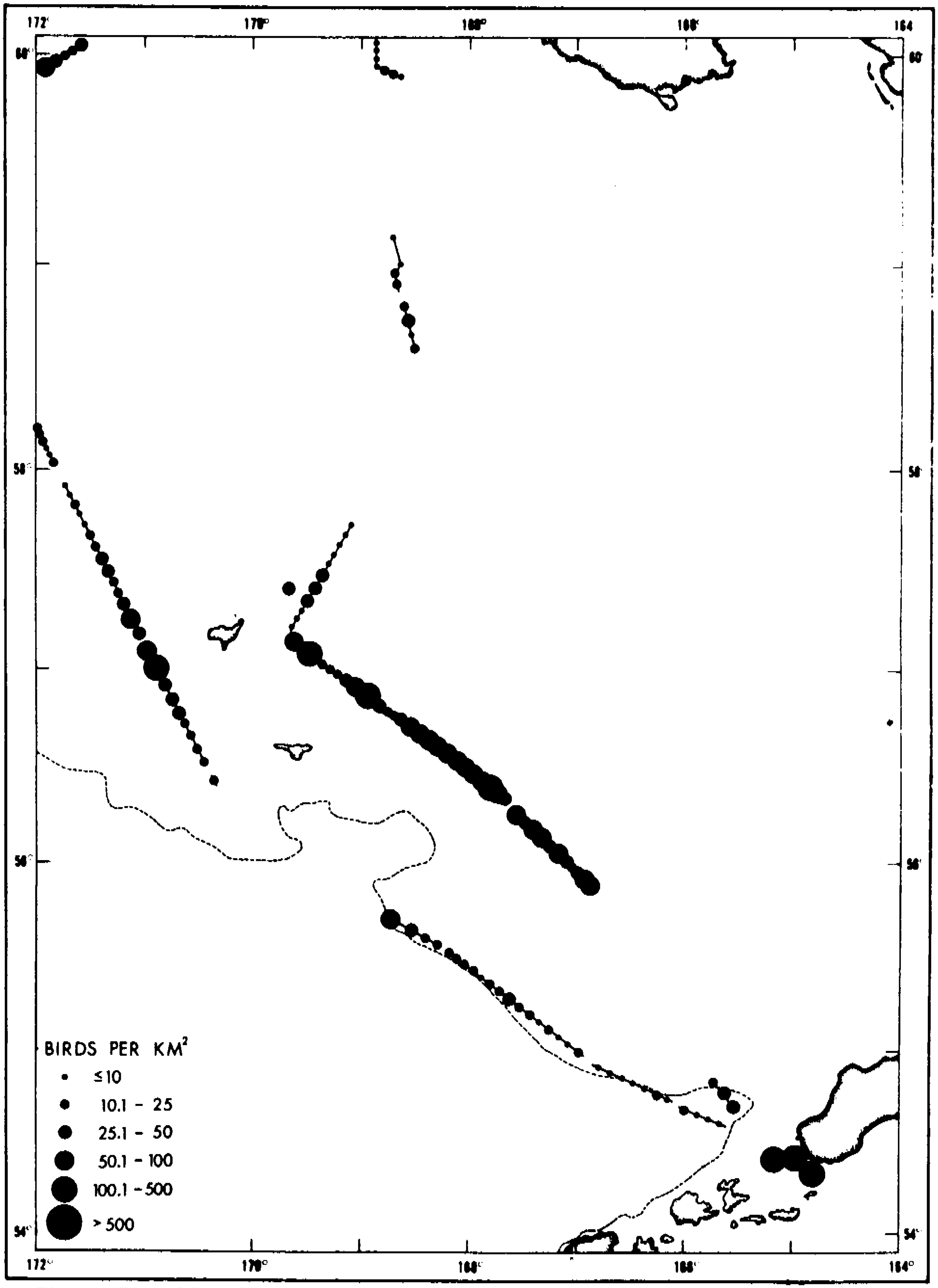


Figure 79. Distribution and abundance of seabirds in southern Bering Sea from 5 to 24 May, on 29 May, on 2 June and from 8 to 10 June 1977.

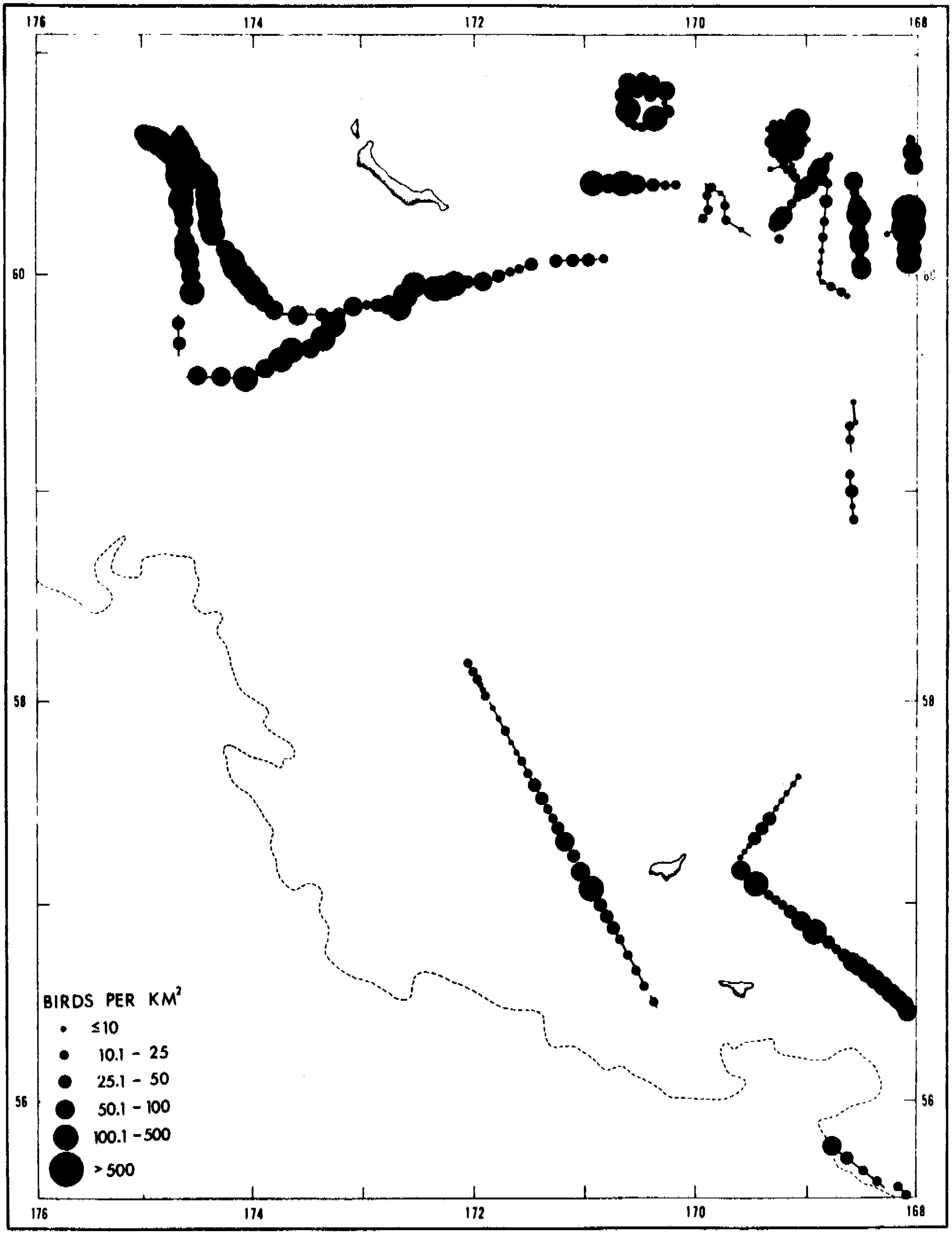


Figure 80. Distribution and abundance of seabirds in central Bering Sea from 23 May to 9 June 1977.

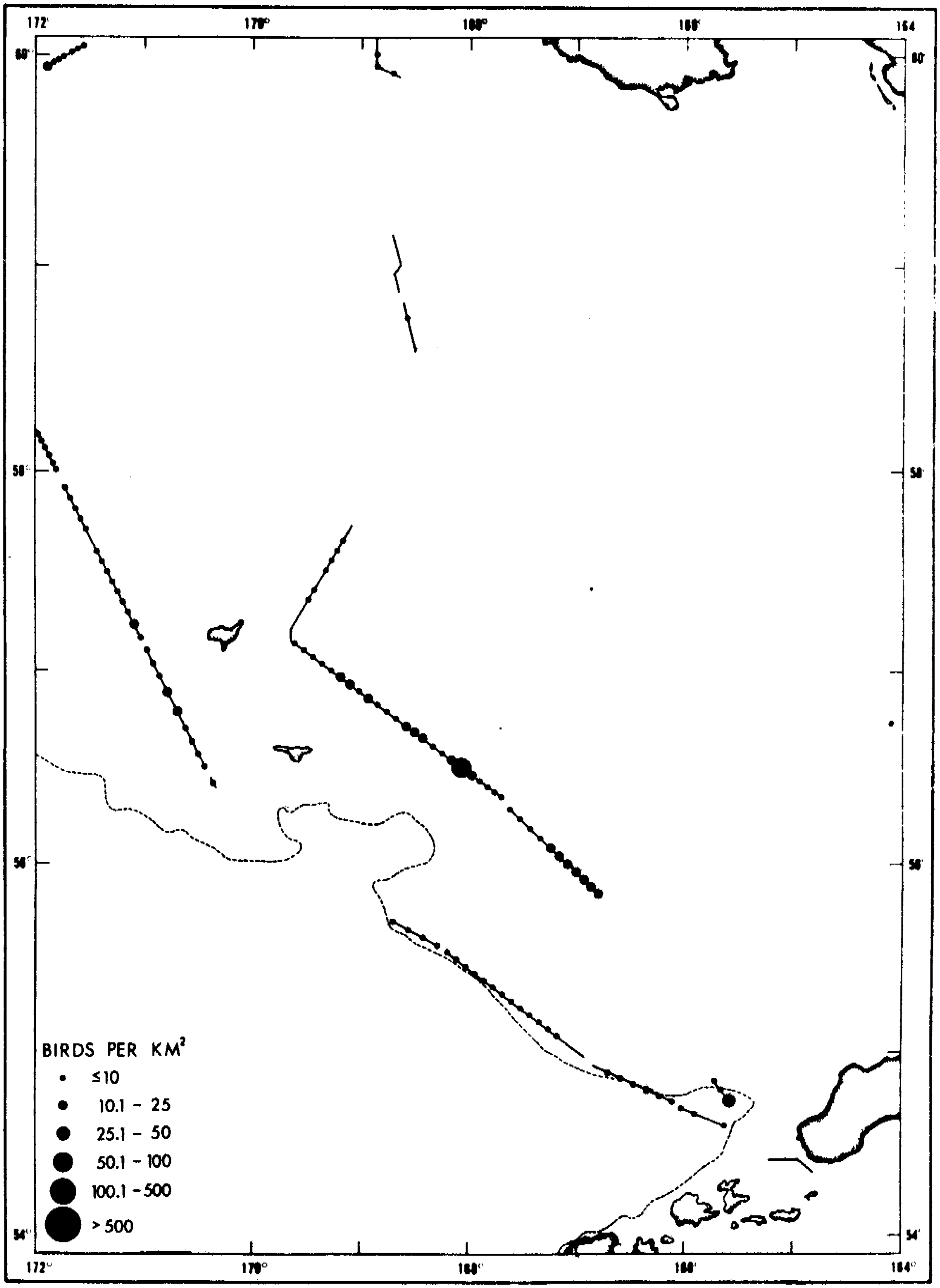


Figure 81. Distribution and abundance of Northern Fulmars in southern Bering Sea from 5 to 24 May, on 29 May, on 2 June and from 8 to 10 June 1977.

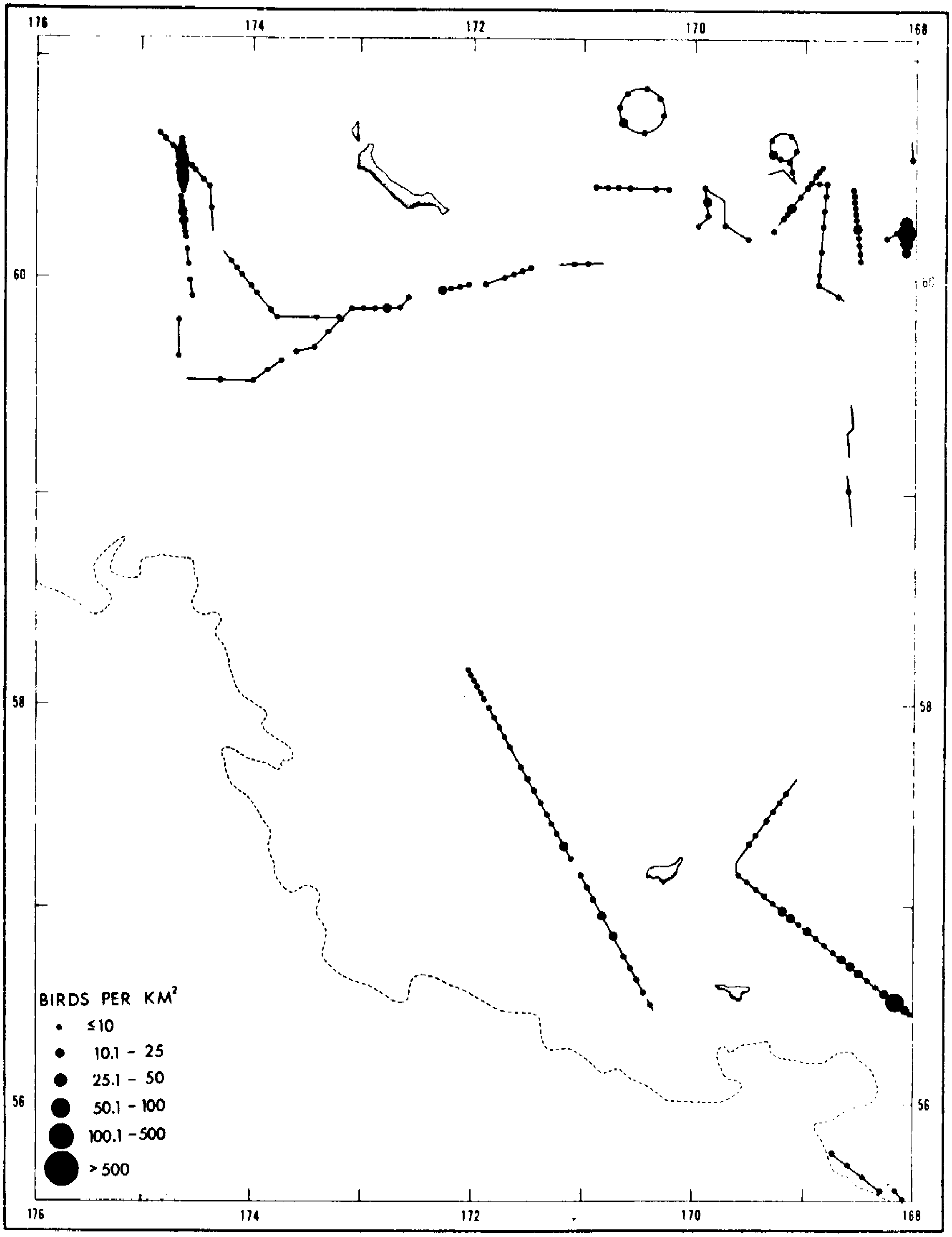


Figure 82. Distribution and abundance of Northern Fulmars in central Bering Sea from 23 May to 9 June 1977.

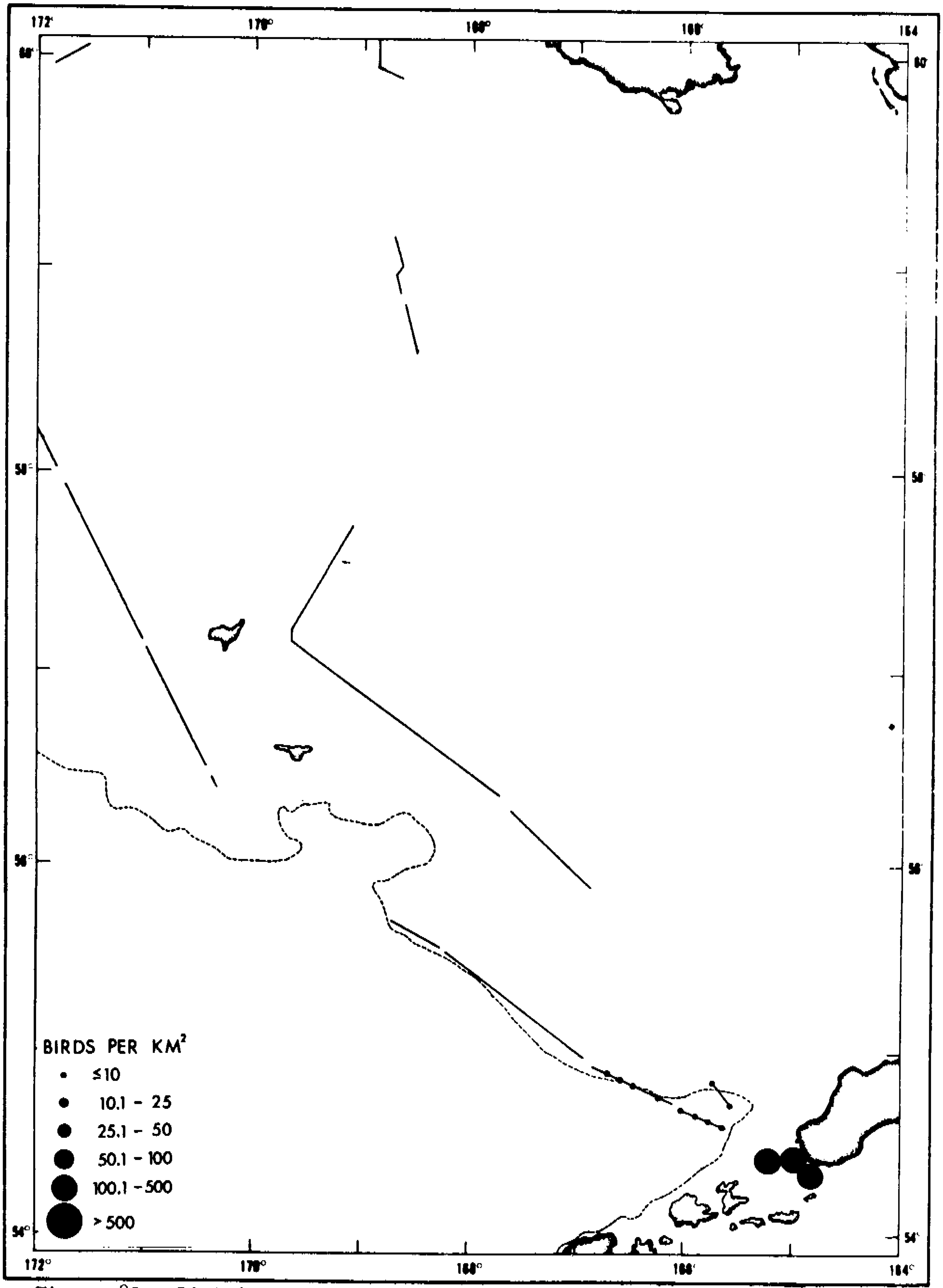


Figure 83. Distribution and abundance of shearwaters in southern Bering Sea from 5 to 24 May, on 29 May, on 2 June and from 8 to 10 June 1977.

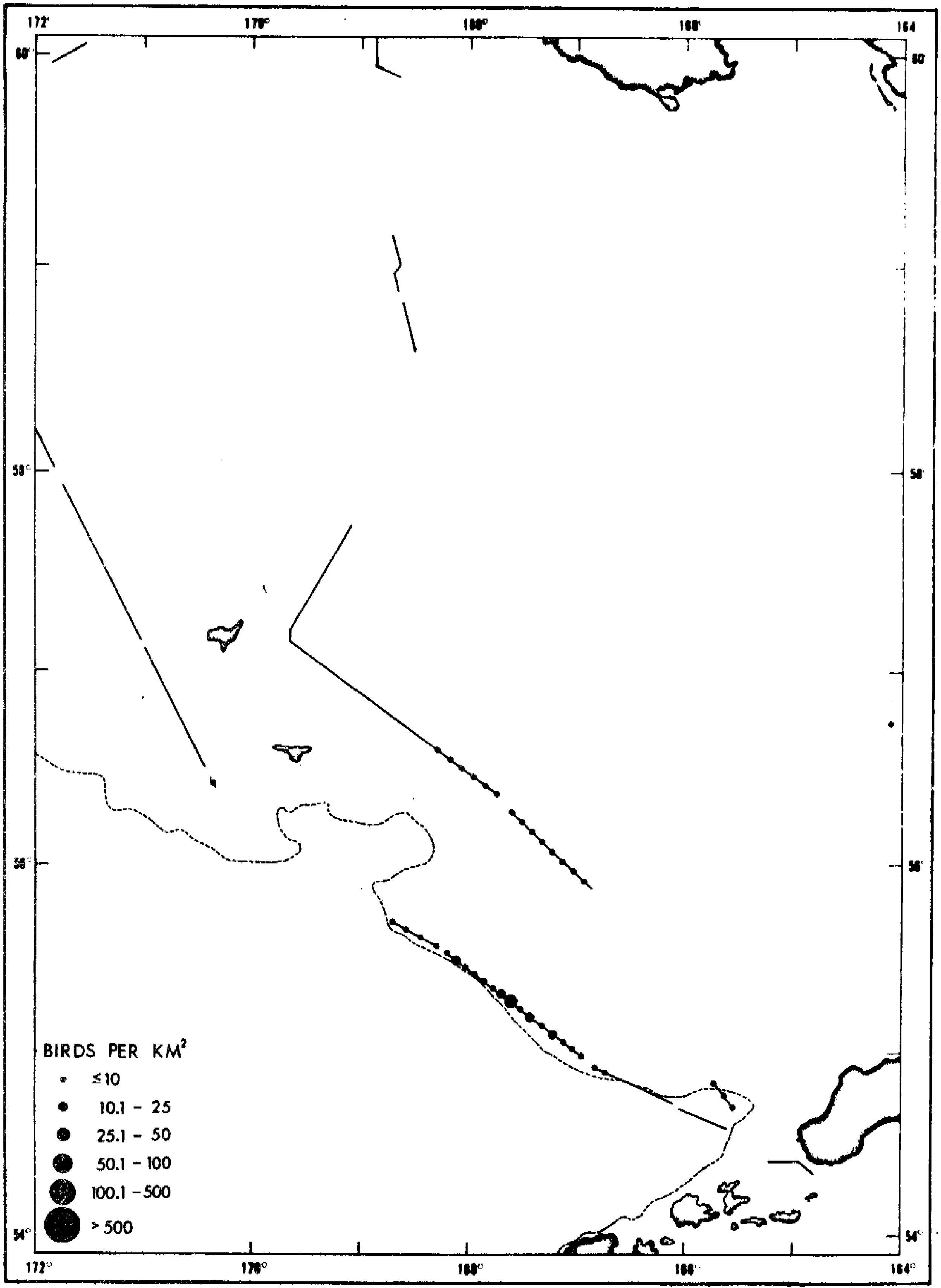


Figure 84. Distribution and abundance of Fork-tailed Storm Petrels in southern Bering Sea from 5 to 24 May, on 29 May, on 2 June and from 8 to 10 June 1977.

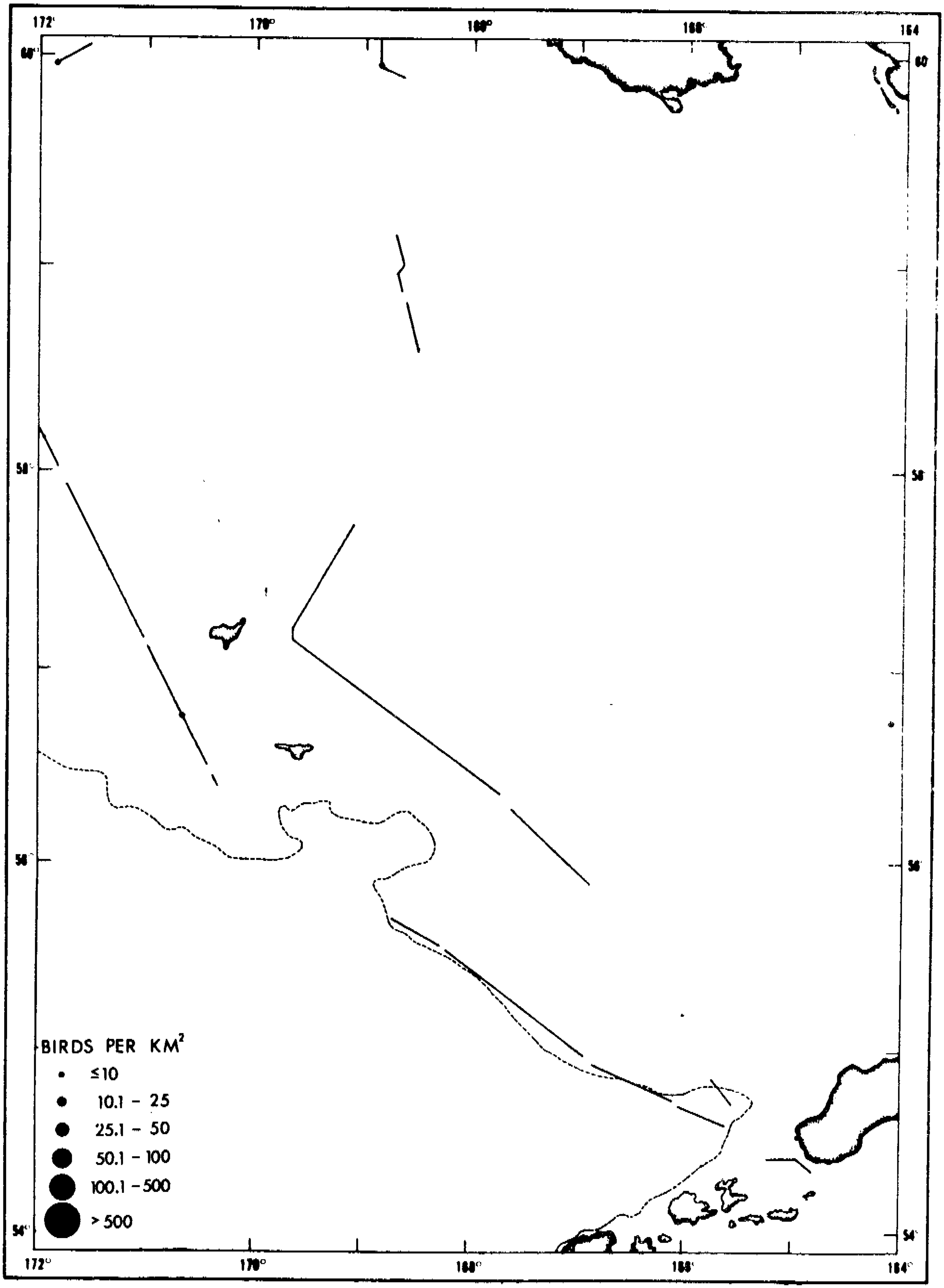


Figure 85. Distribution and abundance of cormorants in southern Bering Sea from 5 to 24 May, on 29 May, on 2 June and from 8 to 10 June 1977.

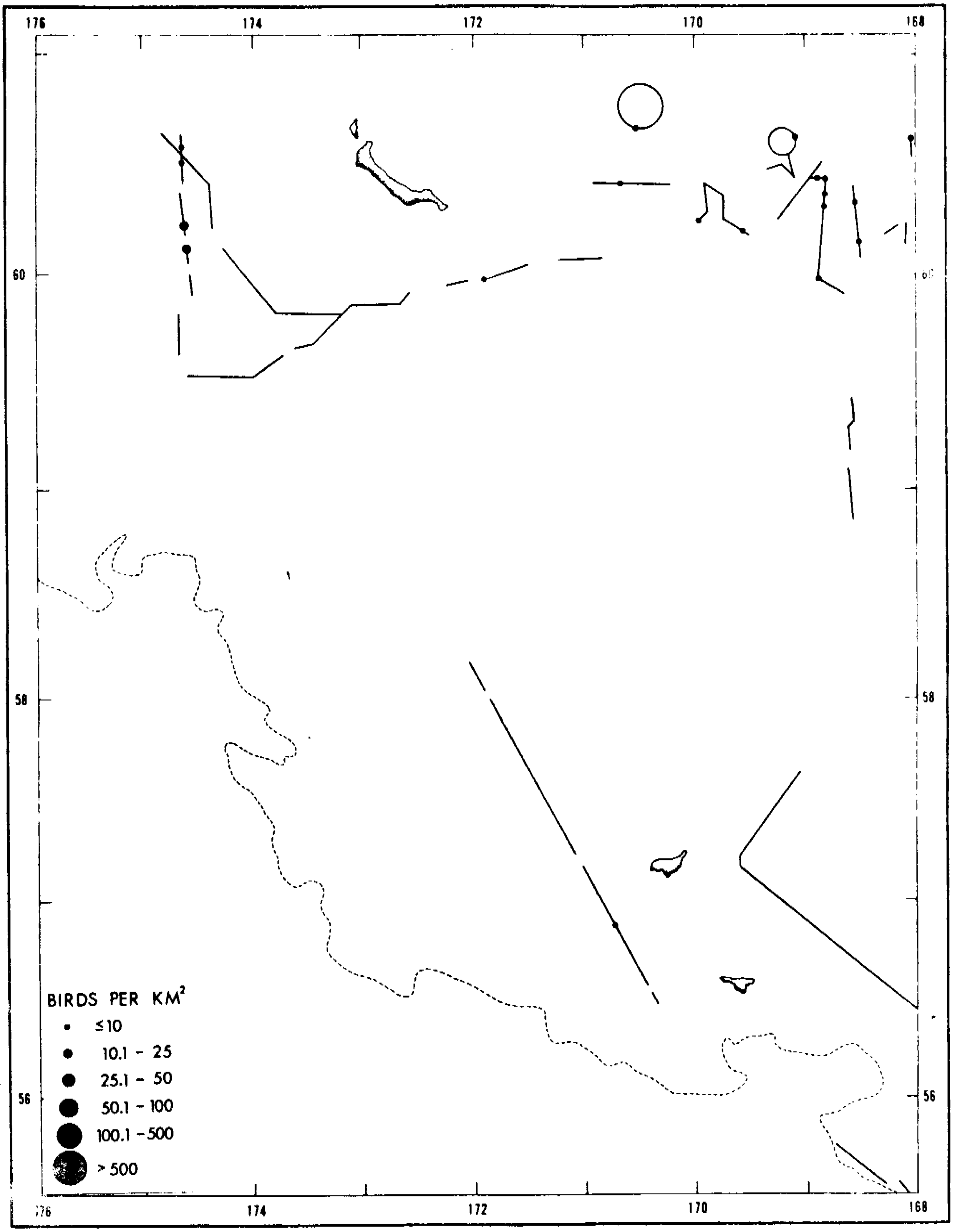


Figure 86. Distribution and abundance of cormorants in central Bering Sea from 23 May to 9 June 1977.

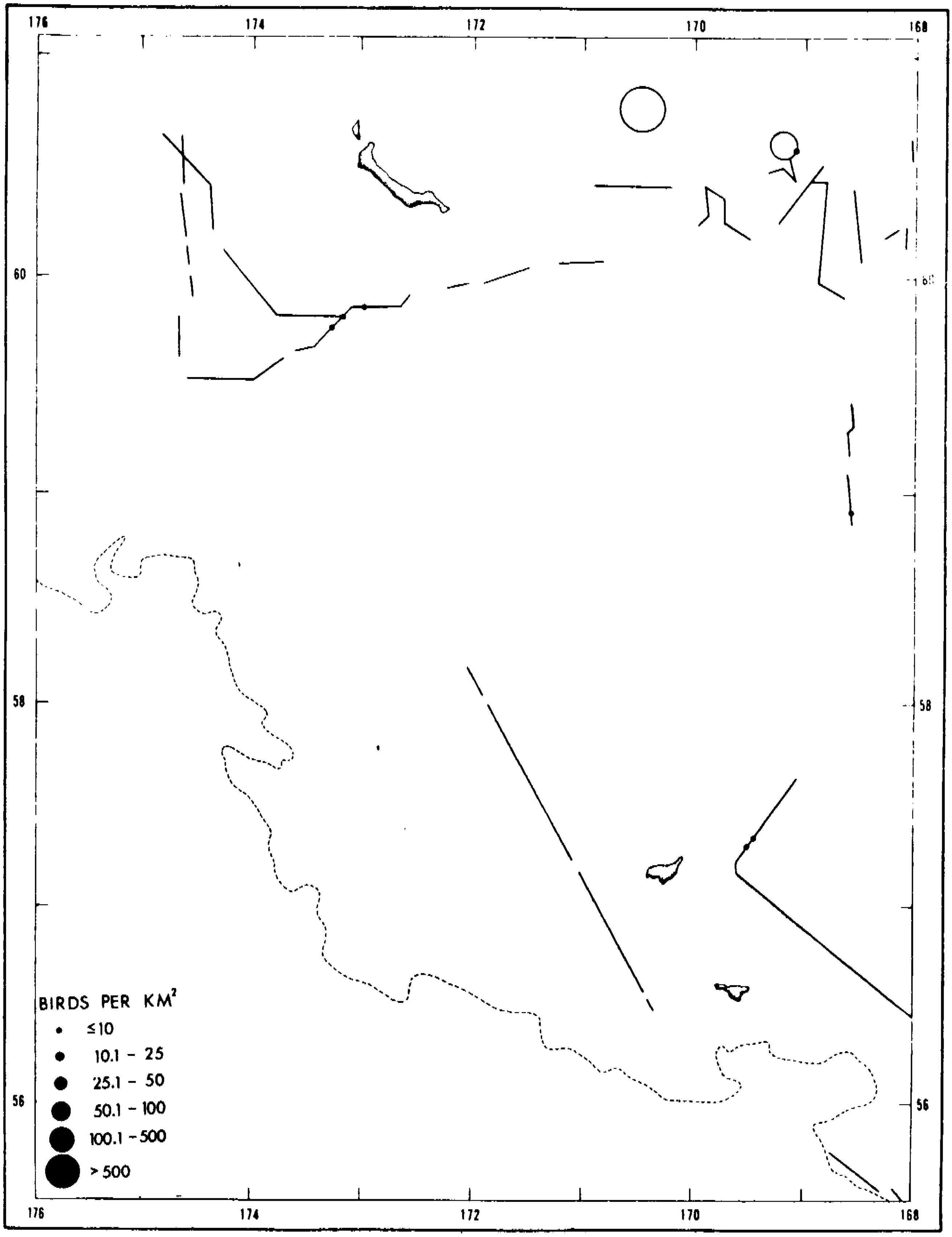


Figure 87. Distribution and abundance of Harlequin Ducks in central Bering Sea from 23 May to 9 June 1977.

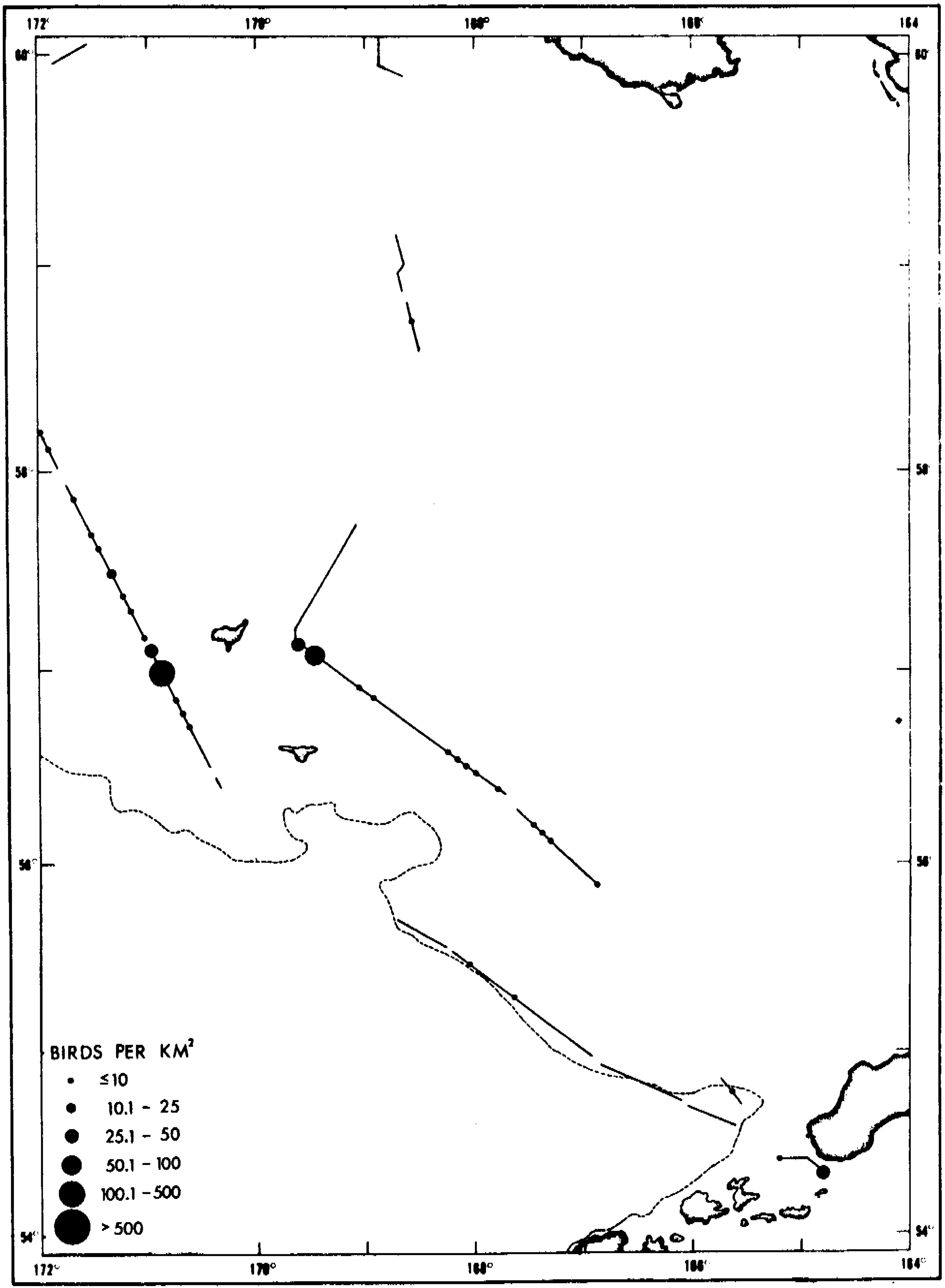


Figure 88. Distribution and abundance of phalaropes in southern Bering Sea from 5 to 24 May, on 29 May, on 2 June and from 8 to 10 June 1977.

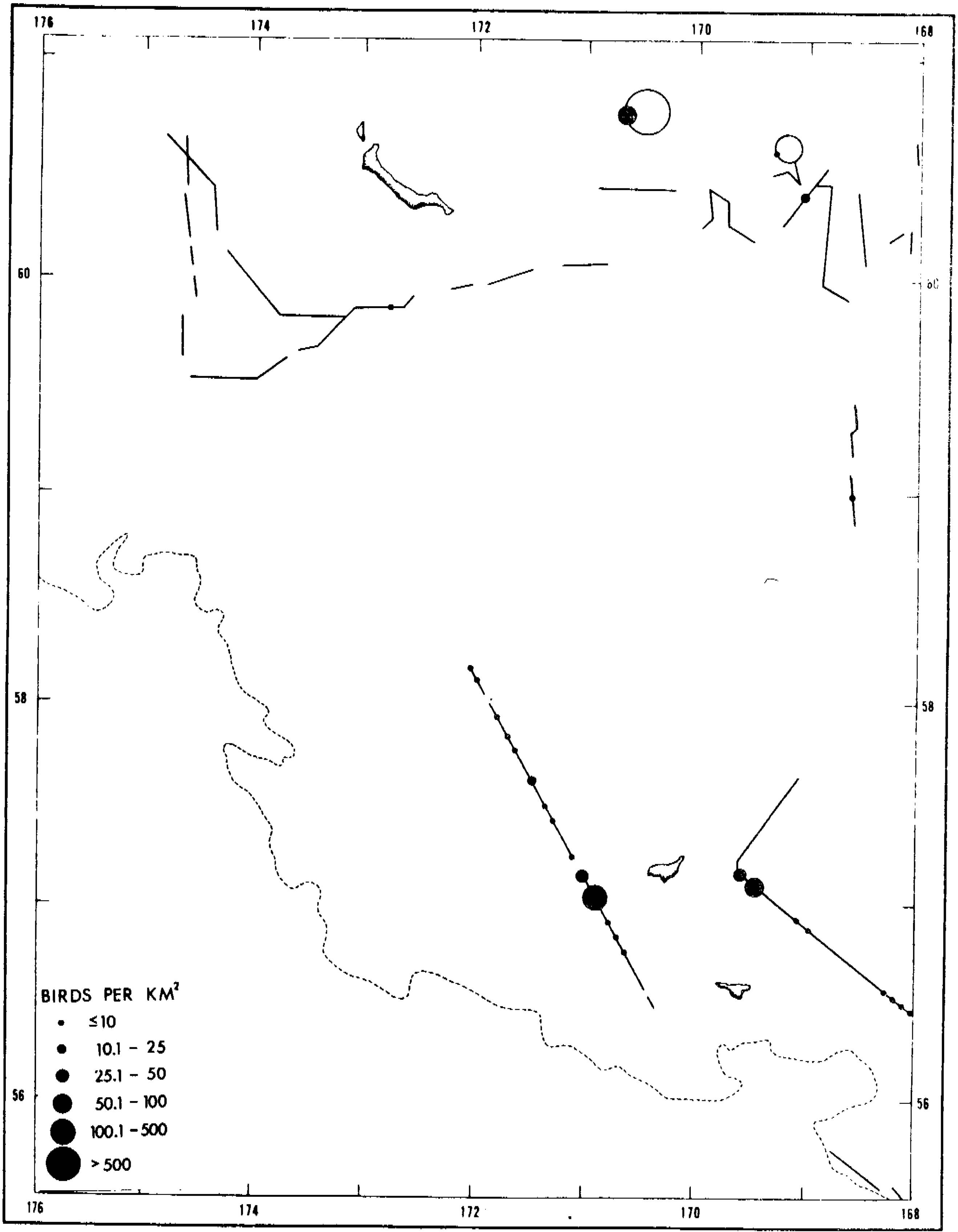


Figure 89. Distribution and abundance of phalaropes in central Bering Sea from 23 May to 9 June 1977.

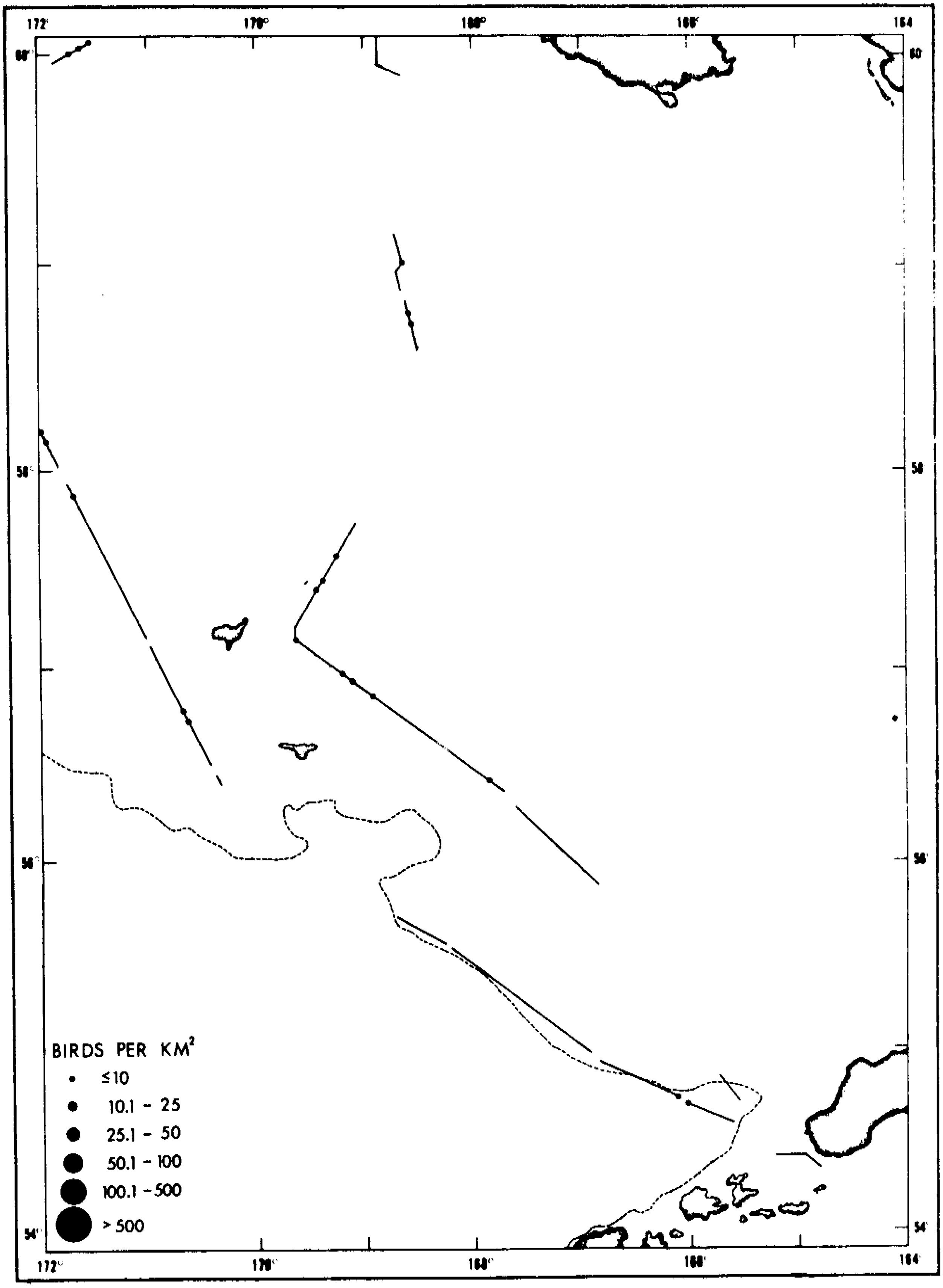


Figure 90. Distribution and abundance of Pomarine Jaegers in southern Bering Sea from 5 to 24 May, on 29 May, on 2 June, and from 8 to 10 June 1977.

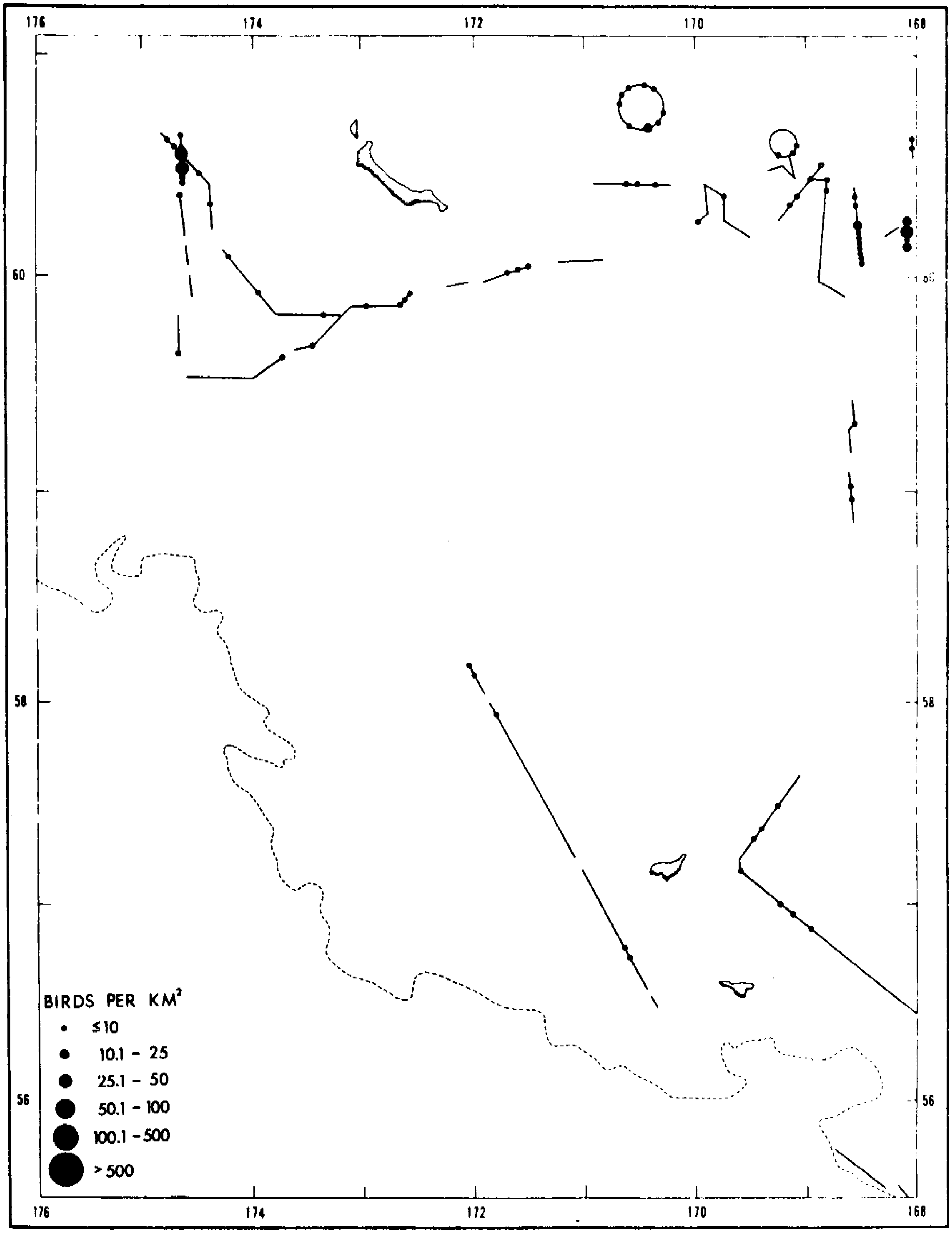


Figure 91. Distribution and abundance of Pomarine Jaegers in central Bering Sea from 23 May to 9 June 1977.

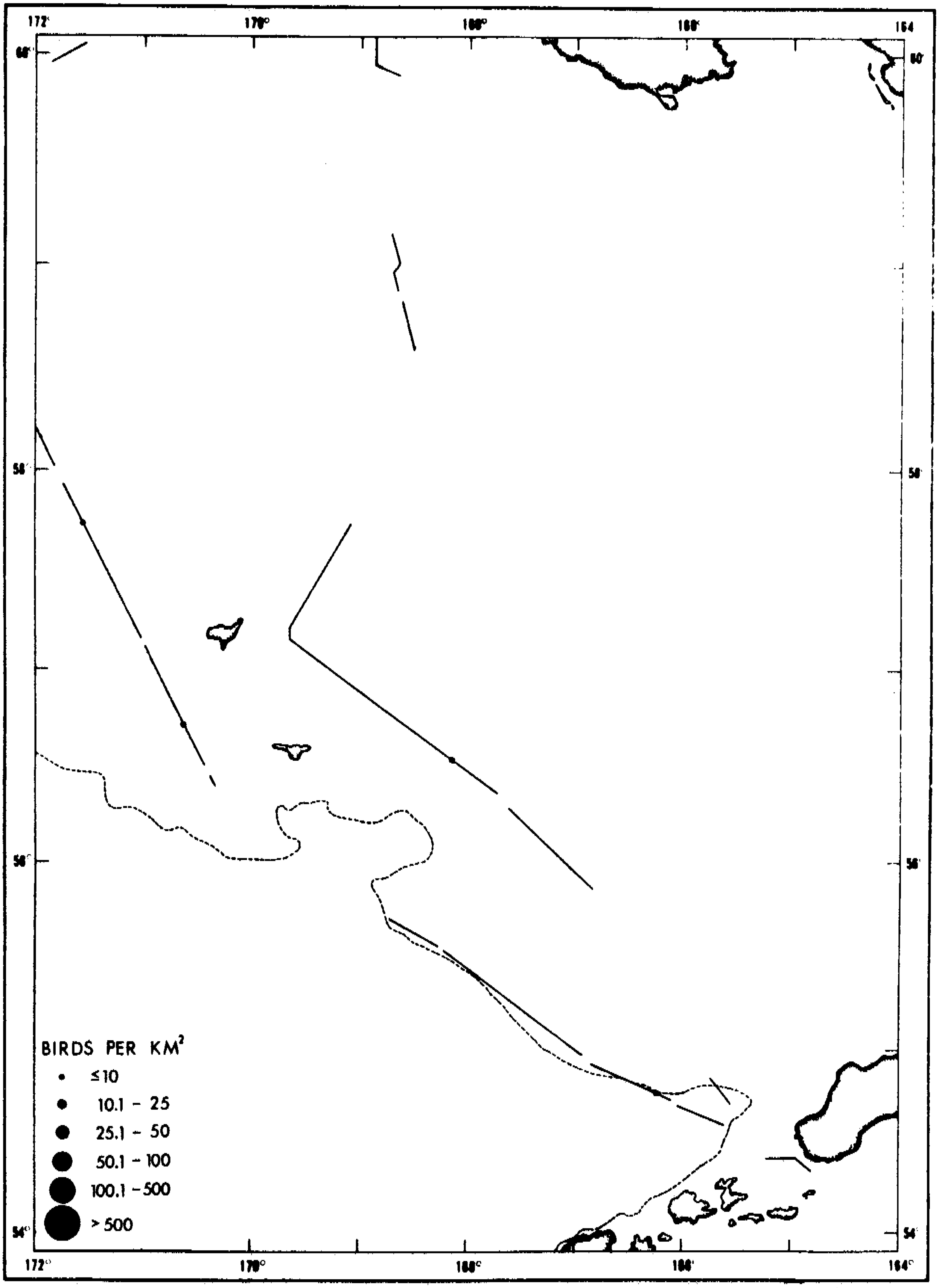


Figure 92. Distribution and abundance of Parasitic Jaegers in southern Bering Sea from 5 to 24 May, on 29 May, on 2 June and from 8 to 10 June 1977.

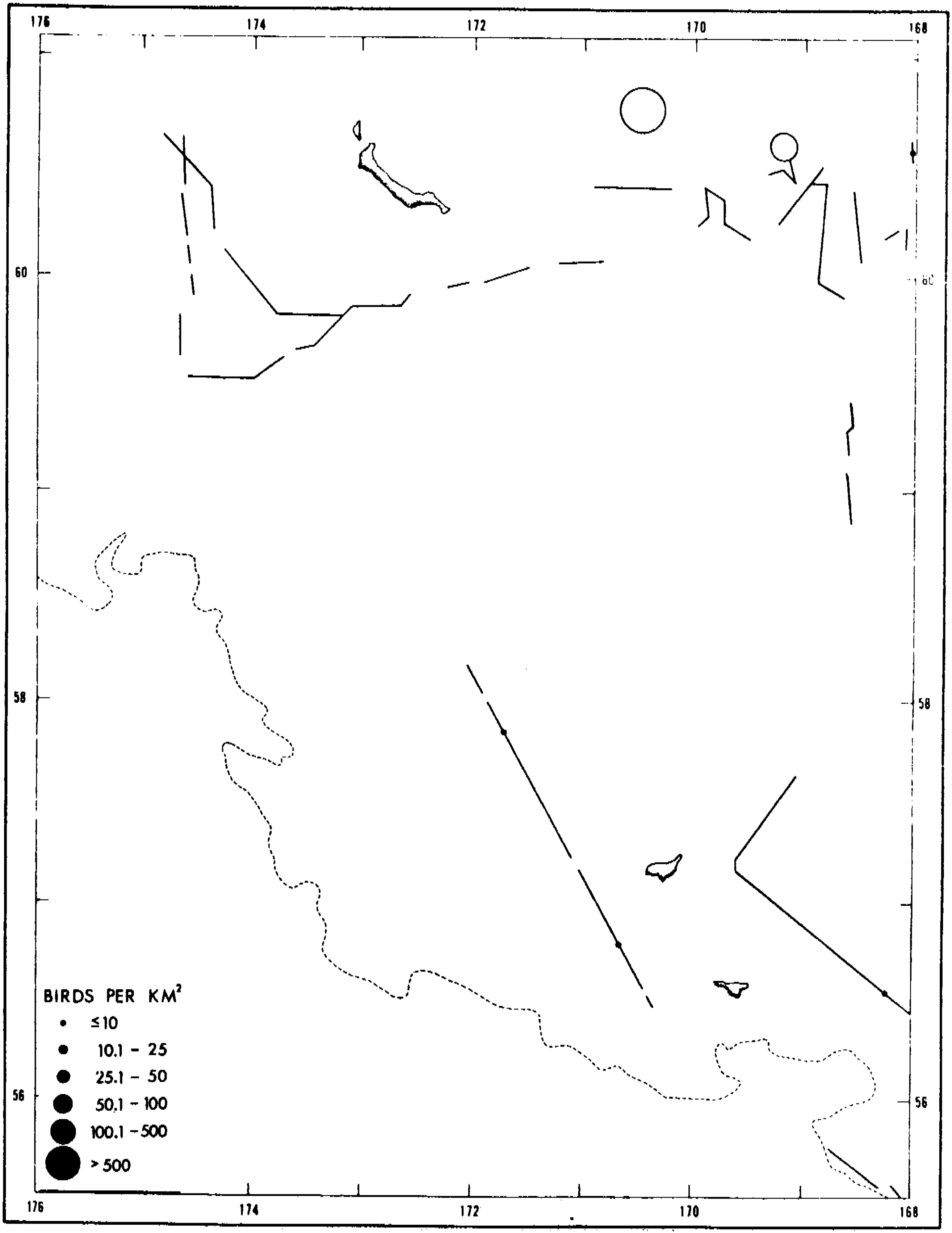


Figure 93. Distribution and abundance of Parasitic Jaegers in central Bering Sea from 23 May to 9 June 1977.

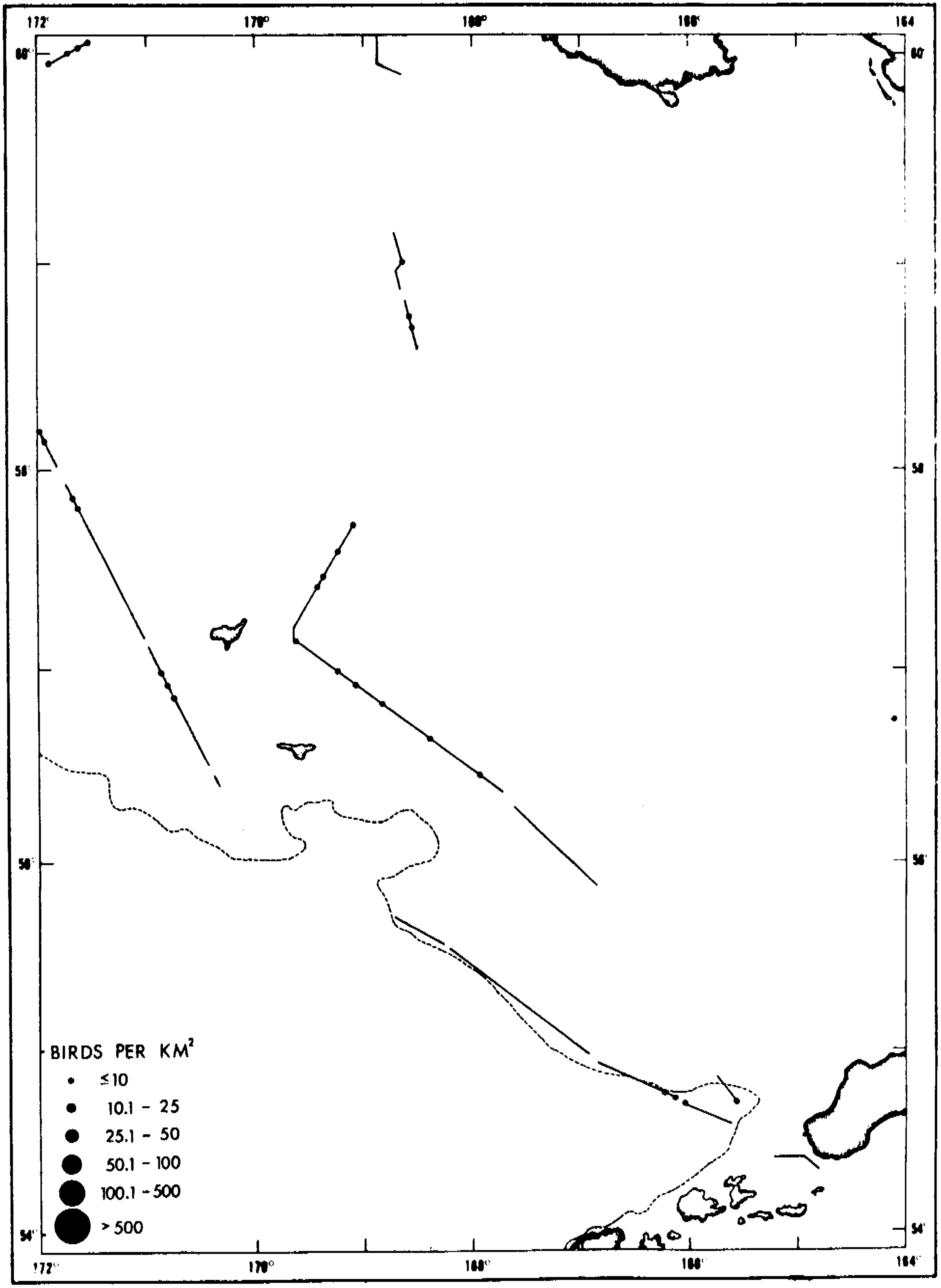


Figure 94. Distribution and abundance of all jaegers in southern Bering Sea from 5 to 24 May, on 29 May, on 2 June, and from 8 to 10 June 1977.

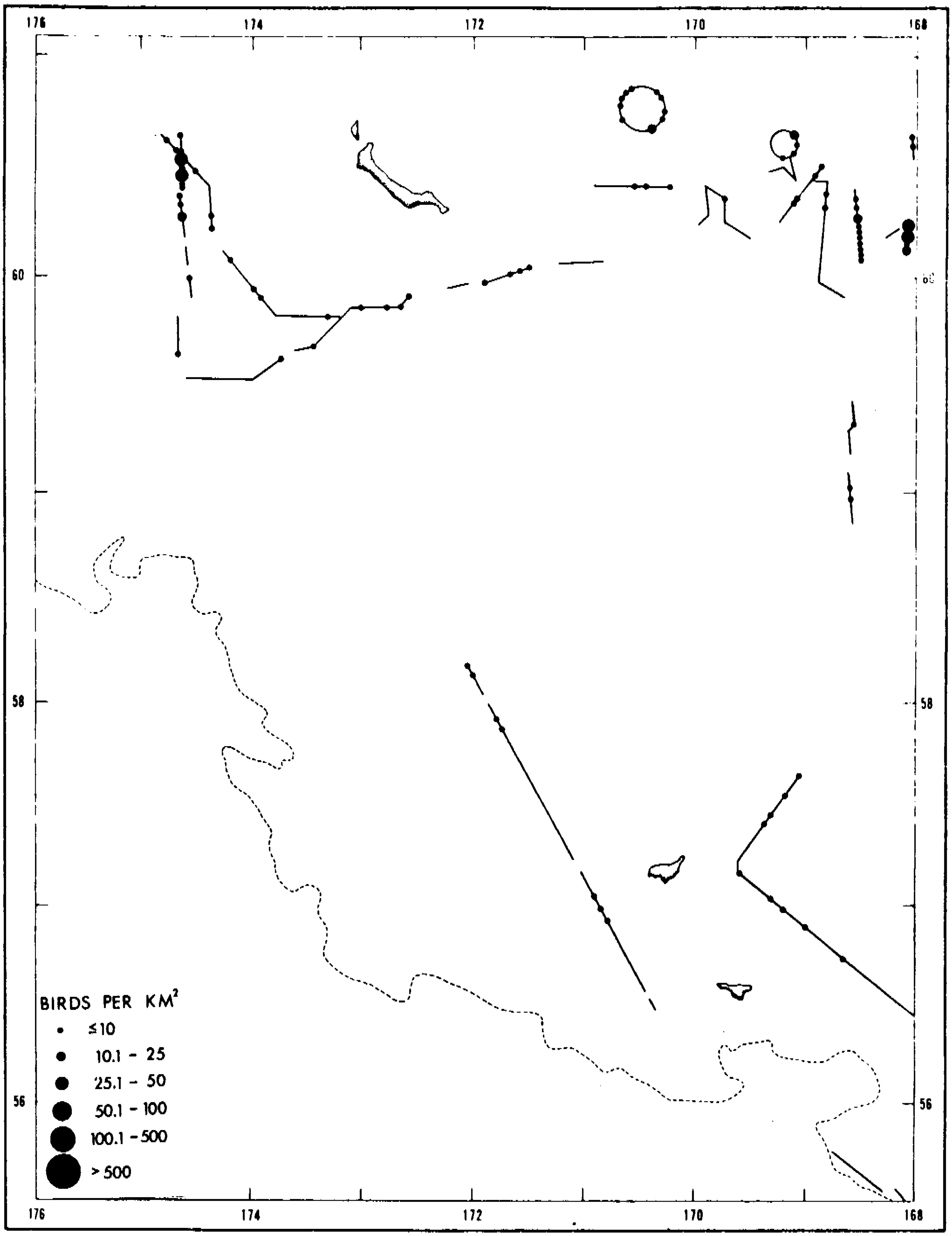


Figure 95. Distribution and abundance of all jaegers in central Bering Sea from 23 May to 9 June 1977.

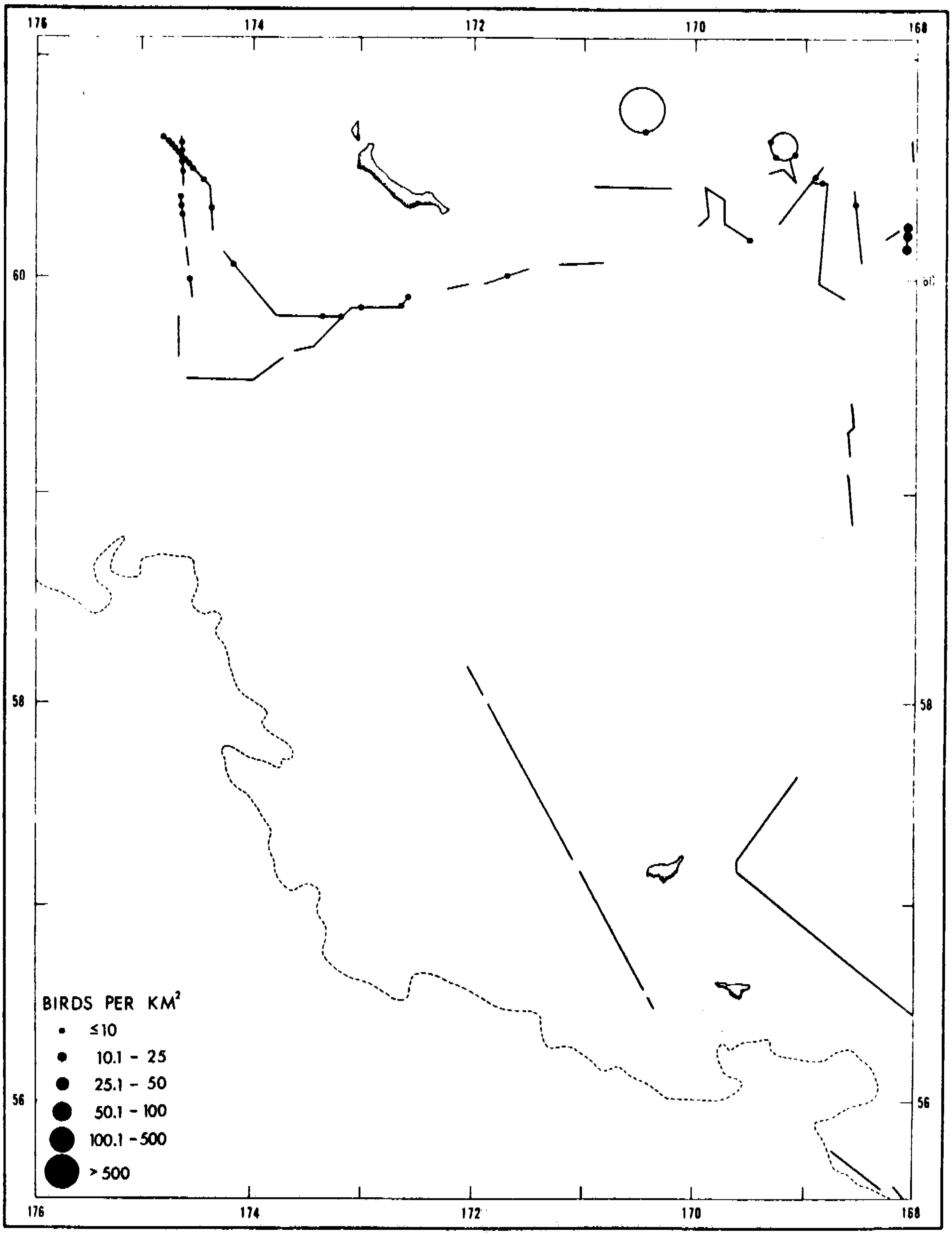


Figure 96. Distribution and abundance of Glaucous Gulls in central Bering Sea from 23 May to 9 June 1977.

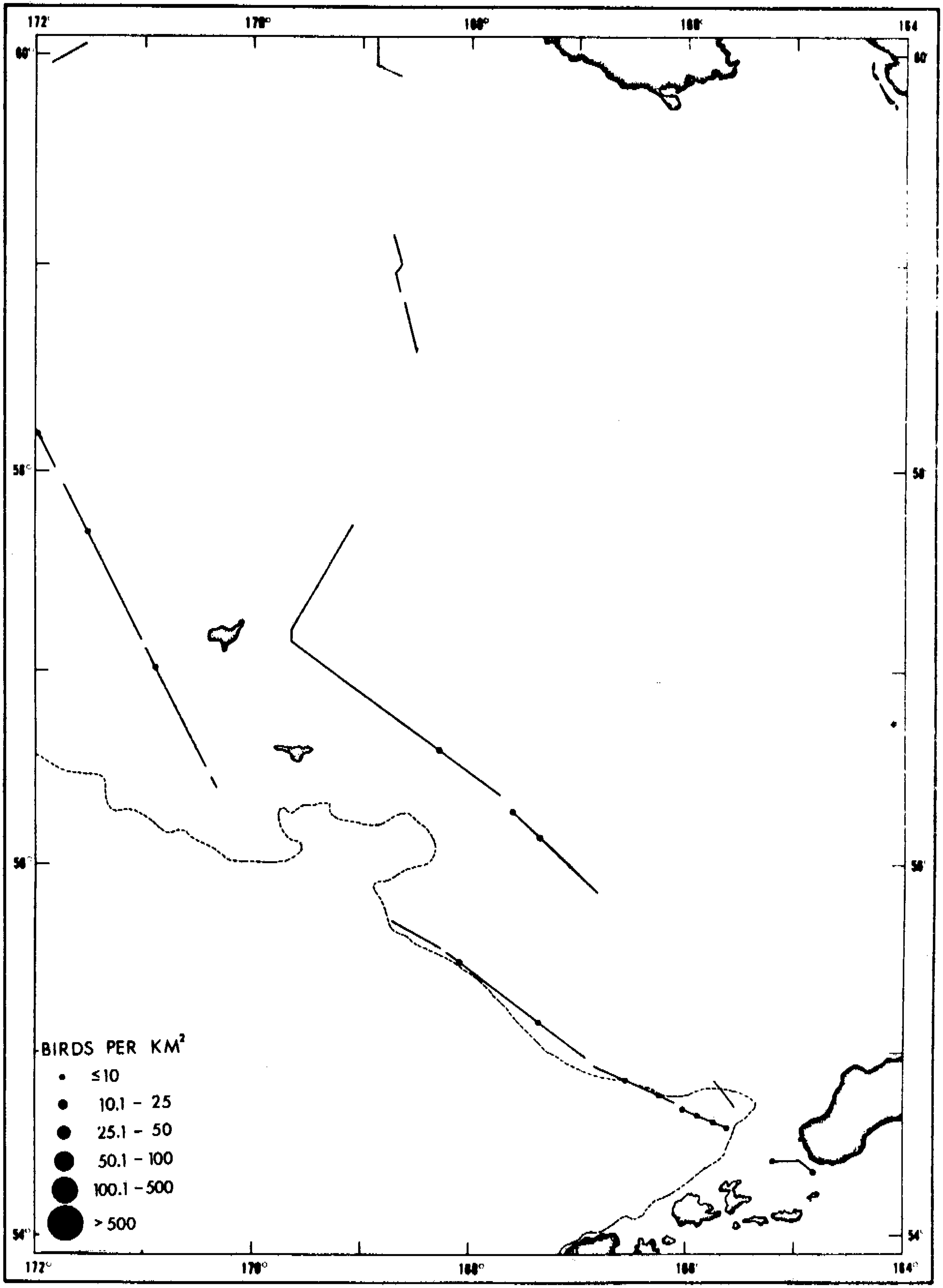


Figure 97. Distribution and abundance of Glaucous-winged Gulls in southern Bering Sea from 5 to 24 May, on 29 May on 2 June and from 8 to 10 June 1977.

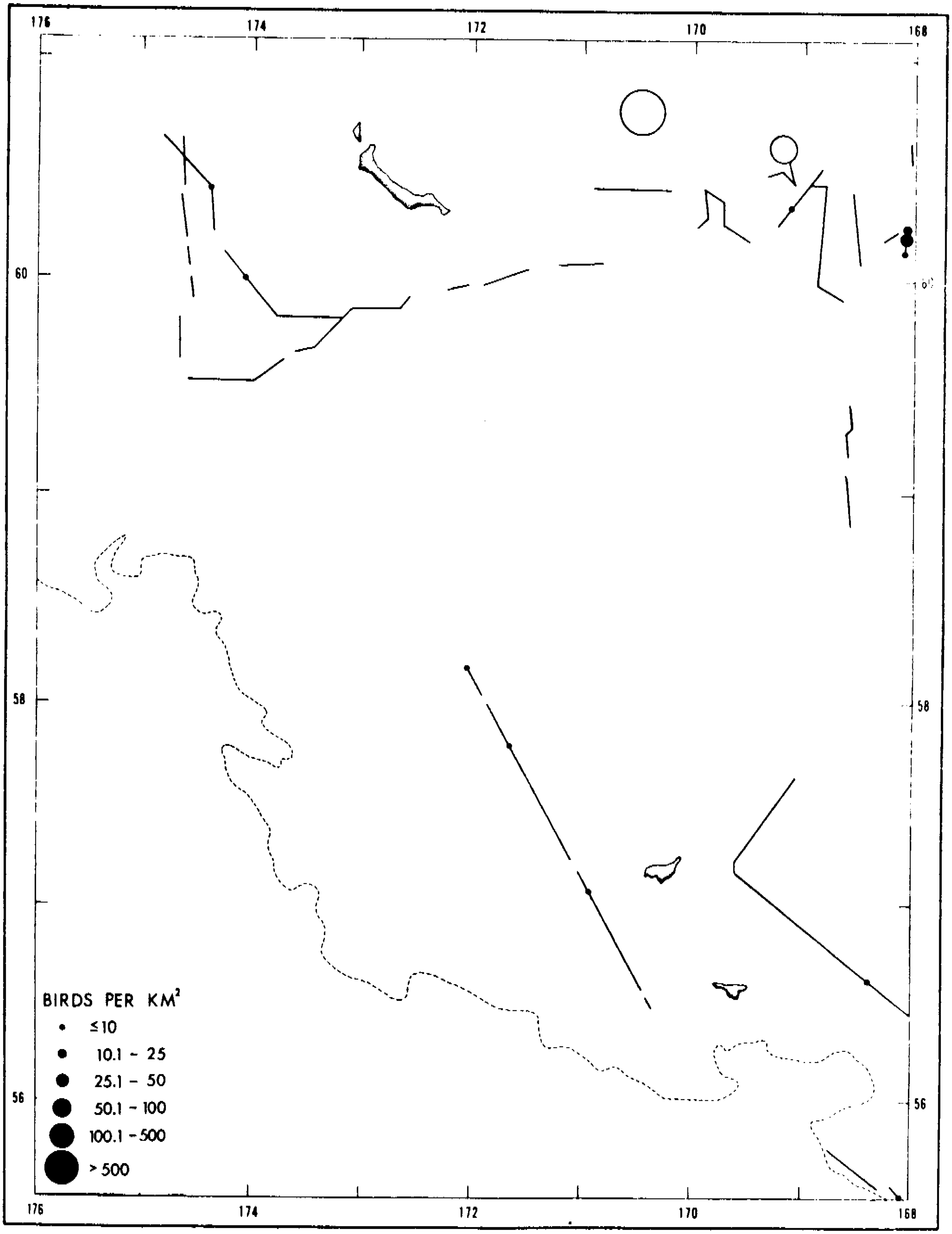


Figure 98. Distribution and abundance of Glaucous-winged Gulls in central Bering Sea from 23 May to 9 June 1977.

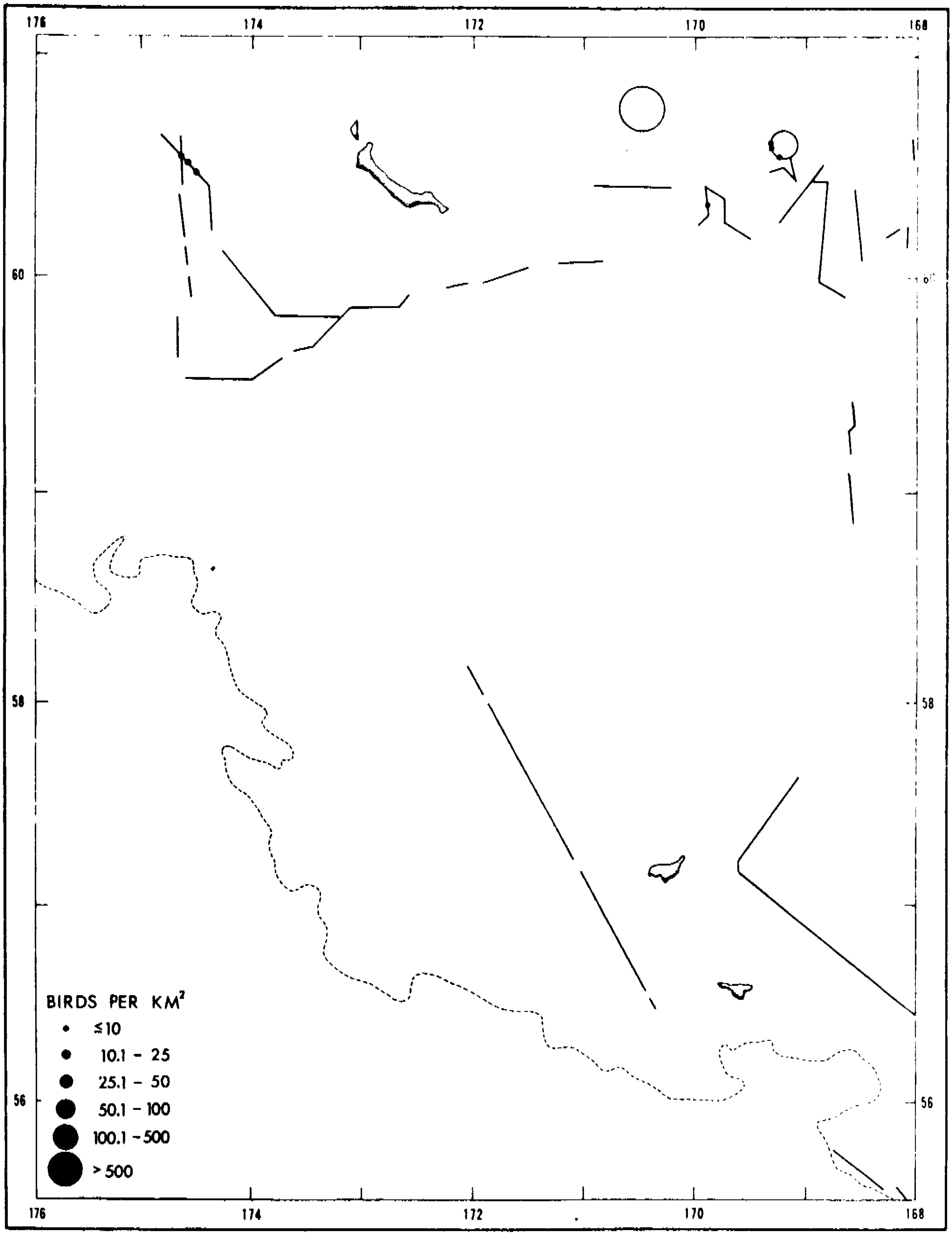


Figure 99. Distribution and abundance of Herring Gulls in central Bering Sea from 23 May to 9 June 1977.

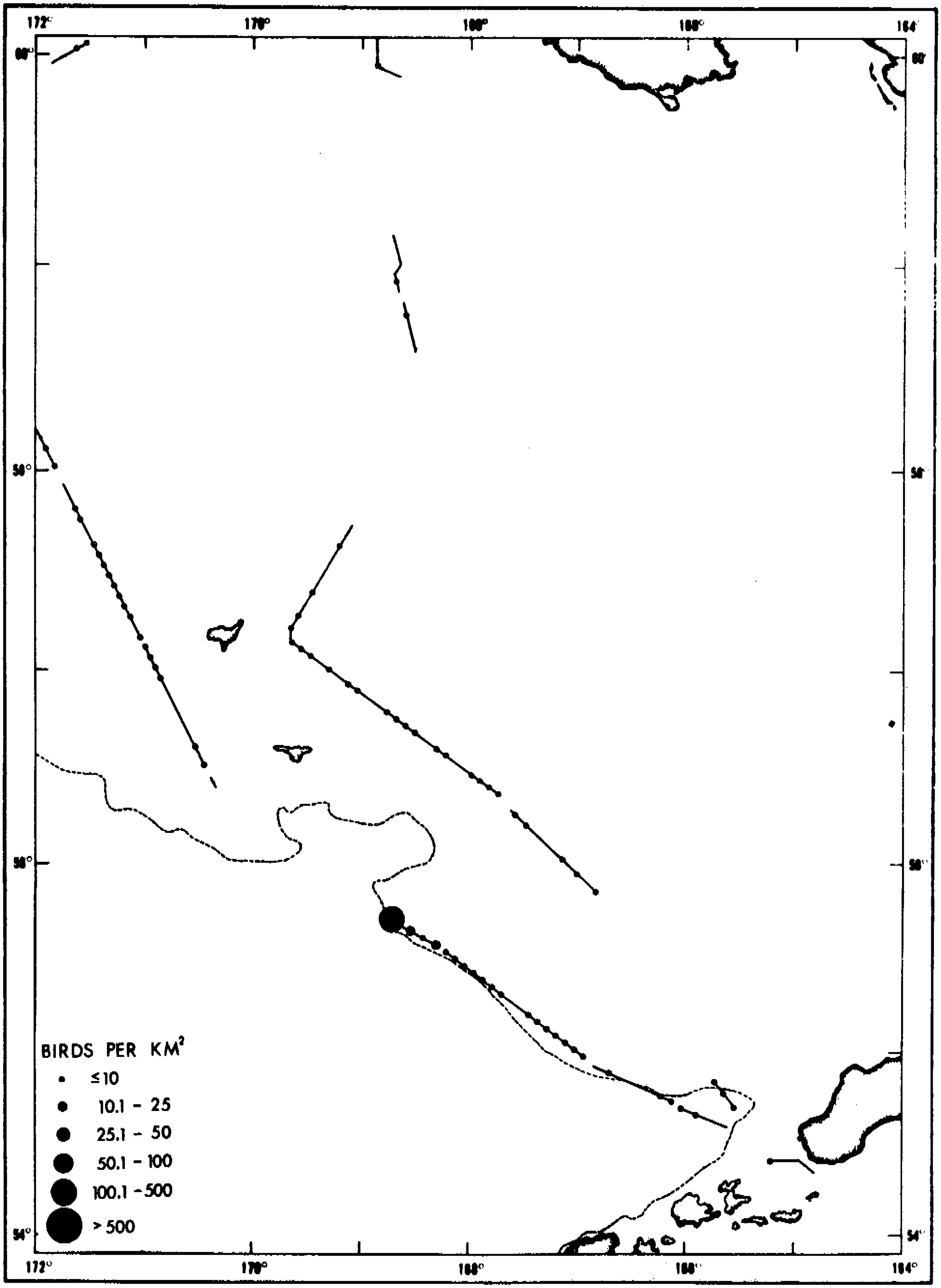


Figure 100. Distribution and abundance of Black-legged Kittiwakes in southern Bering Sea from 5 to 24 May, on 29 May on 2 June and from 8 to 10 June 1977.

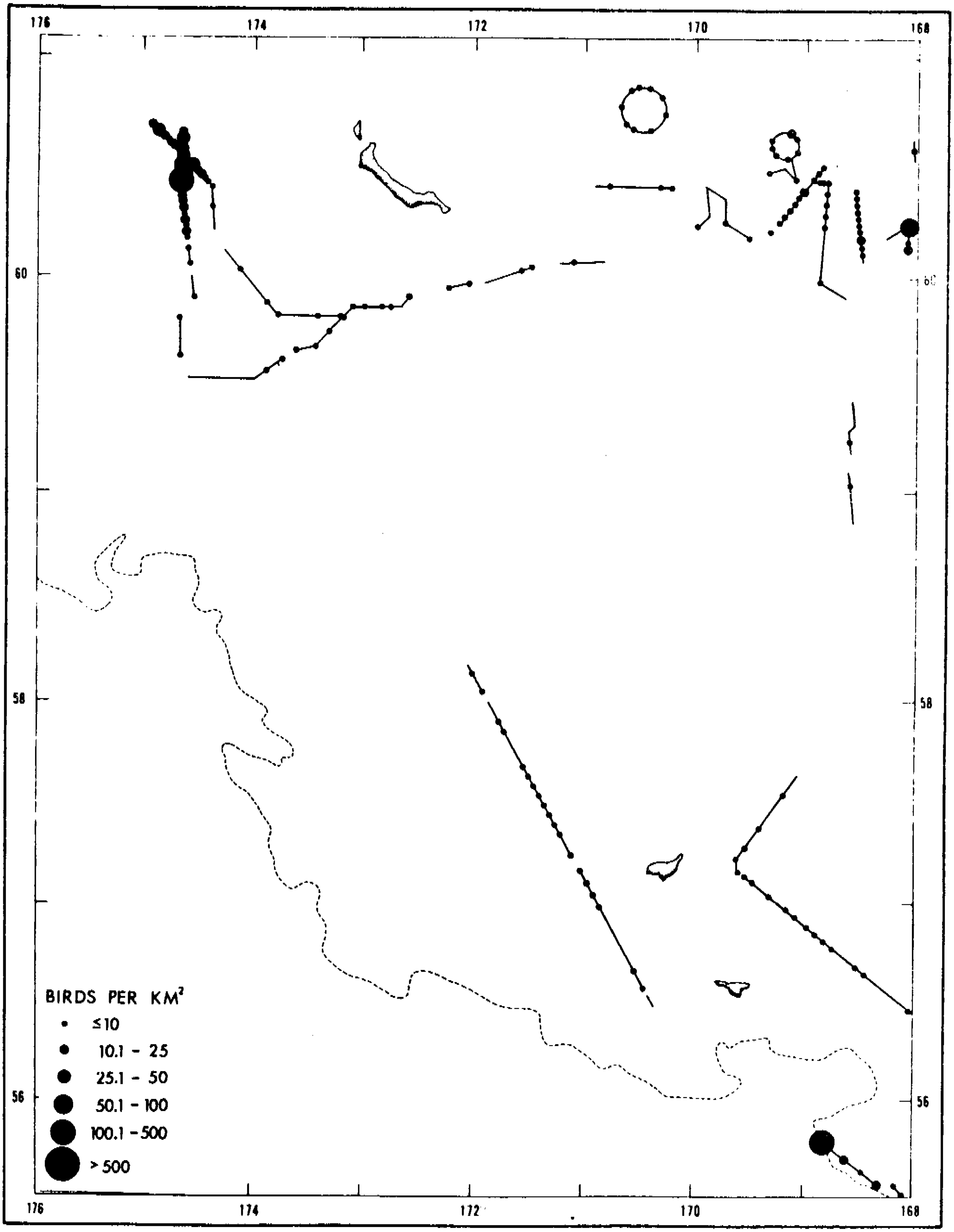


Figure 101. Distribution and abundance of Black-legged Kittiwakes in central Bering Sea from 23 May to 9 June 1977.

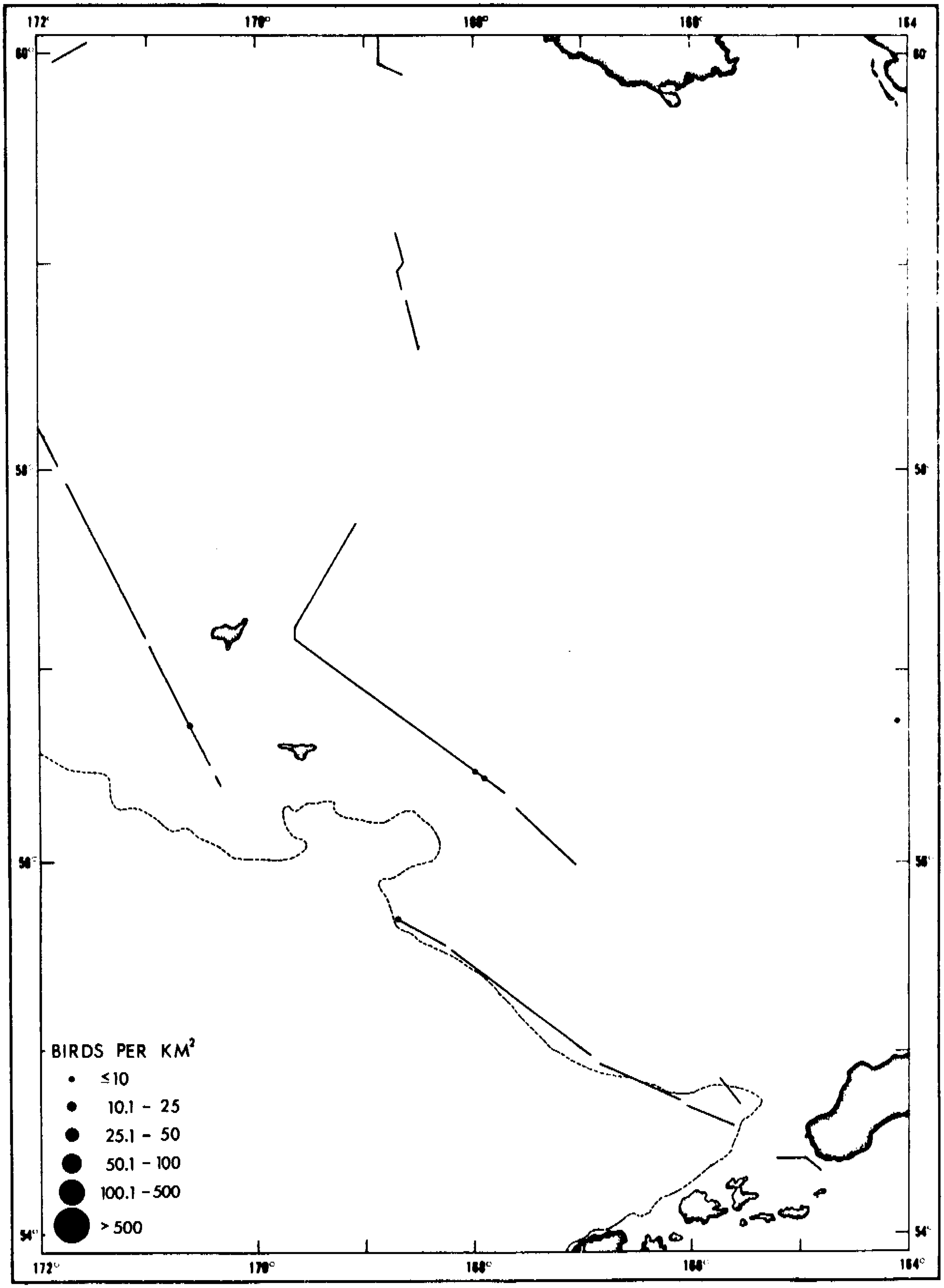


Figure 102. Distribution and abundance of Red-legged Kittiwakes in southern Bering Sea from 5 to 24 May, on 29 May on 2 June and from 8 to 10 June 1977.

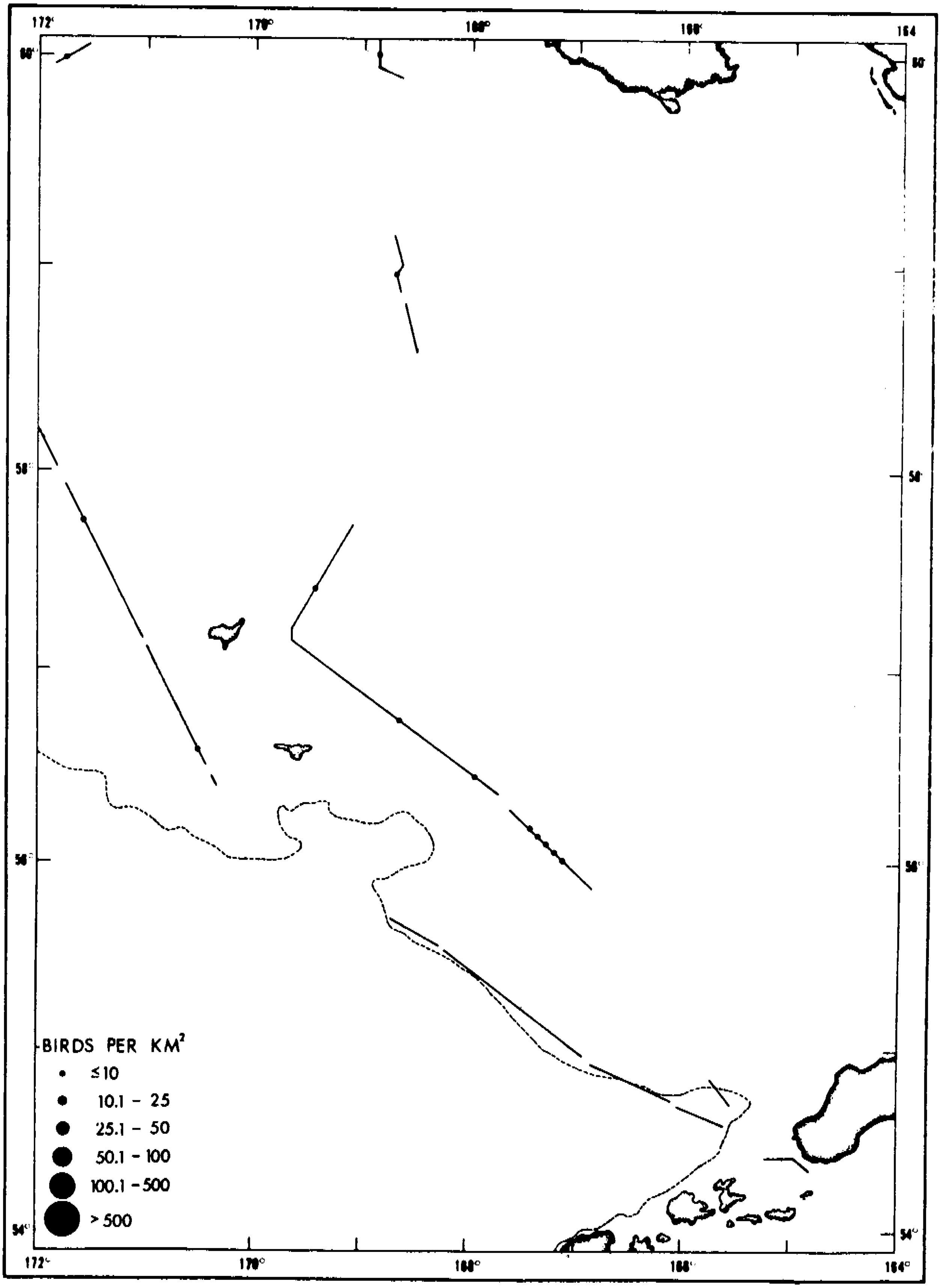


Figure 103. Distribution and abundance of Common Murres in southern Bering Sea from 5 to 24 May, on 29 May on 2 June and from 8 to 10 June 1977.

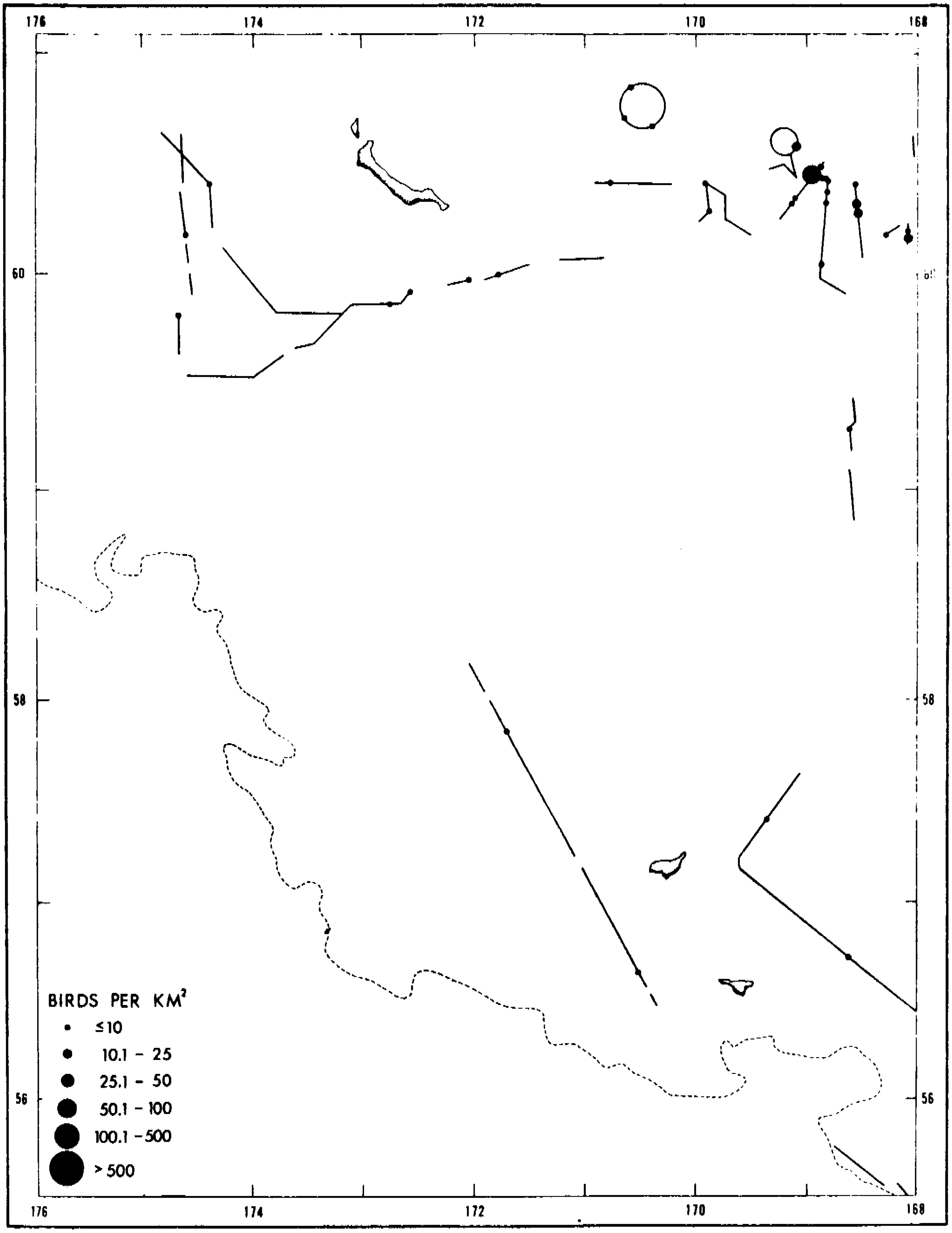


Figure 104. Distribution and abundance of Common Murres in central Bering Sea from 23 May to 9 June 1977.

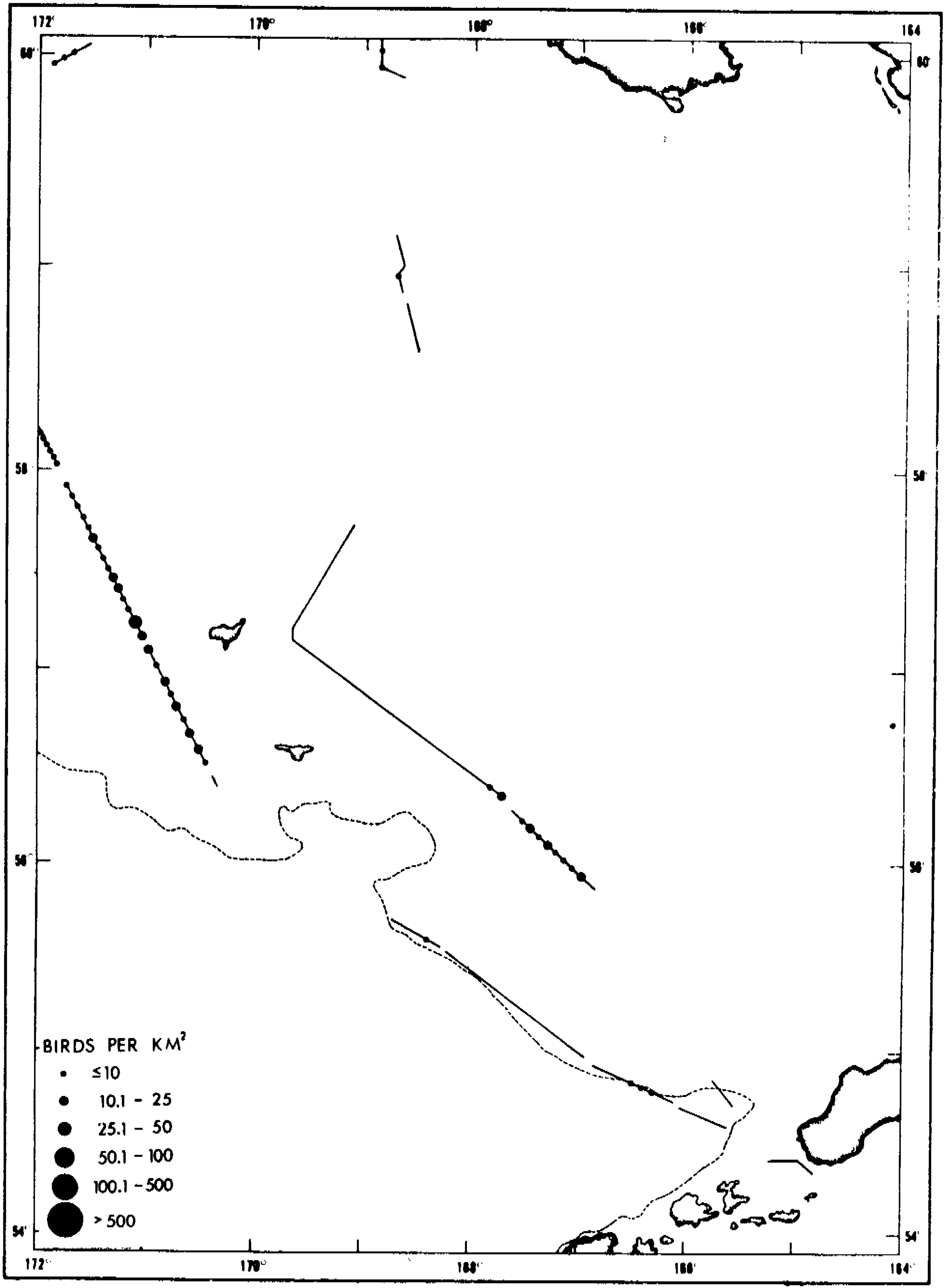


Figure 105. Distribution and abundance of Thick-billed Murres in southern Bering Sea from 5 to 24 May, on 29 May on 2 June and from 8 to 10 June 1977.

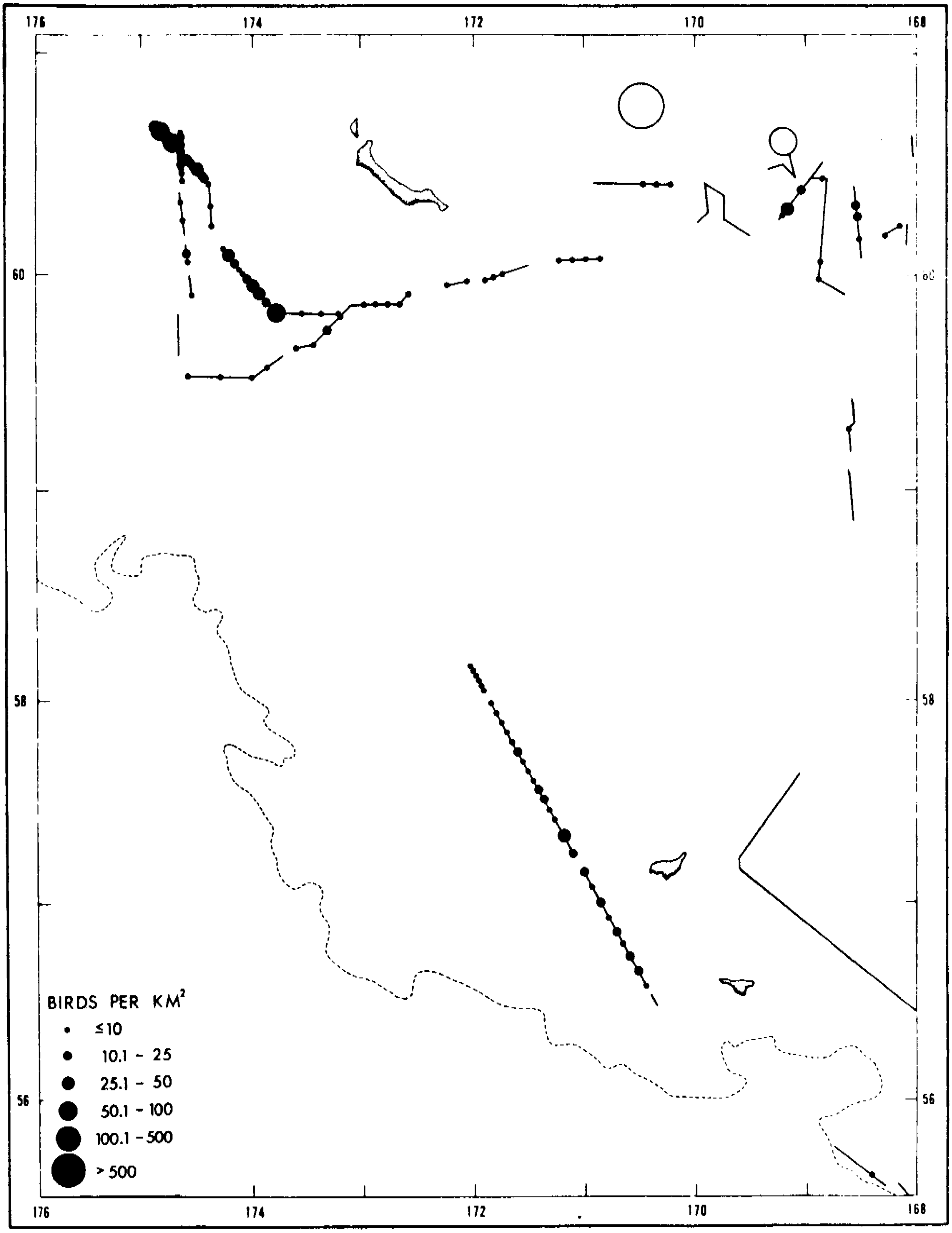


Figure 106. Distribution and abundance of Thick-billed Murres in central Bering Sea from 23 May to 9 June 1977.

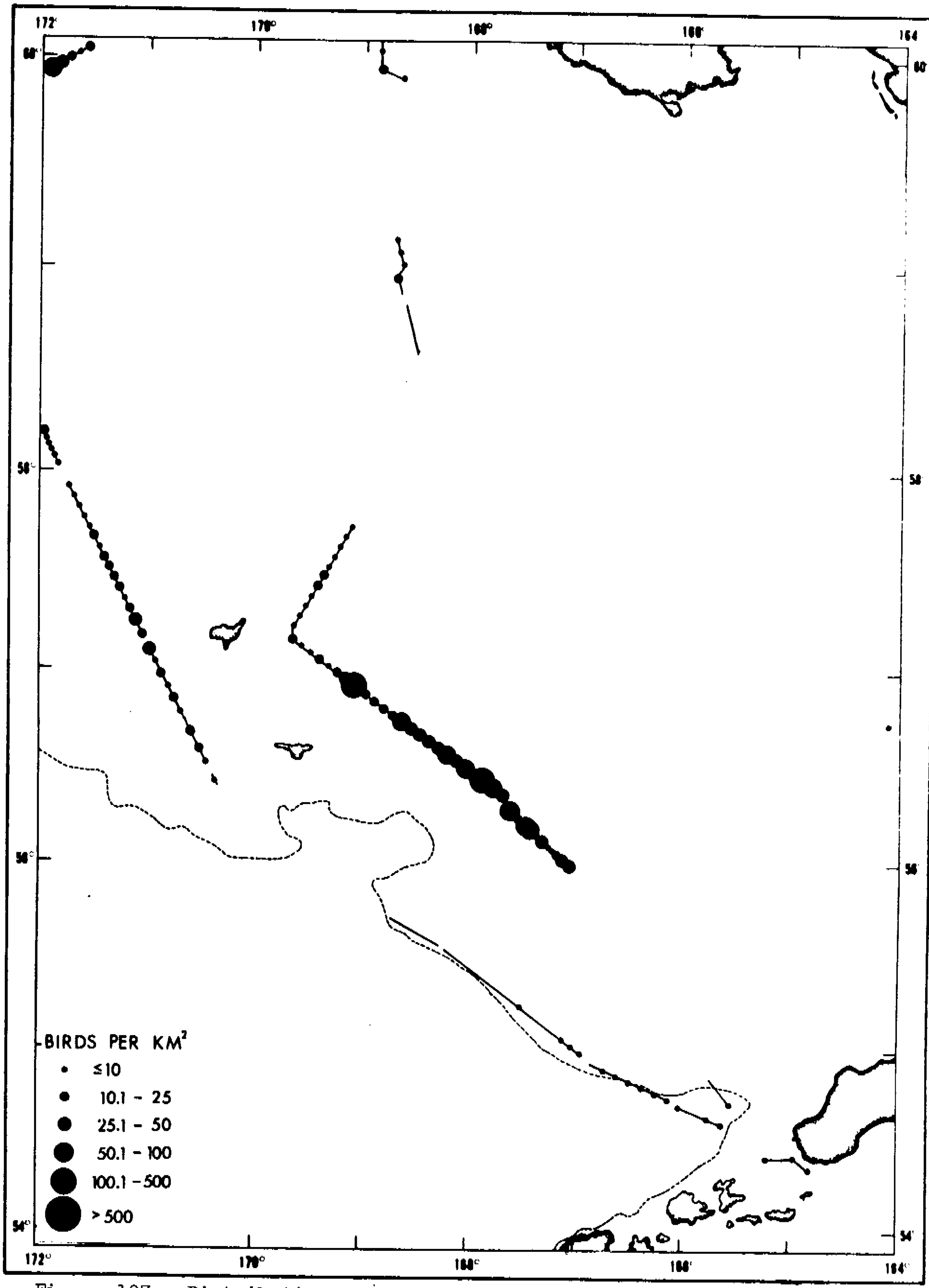


Figure 107. Distribution and abundance of all murres in southern Bering Sea from 5 to 24 May, on 29 May on 2 June and from 8 to 10 June 1977.

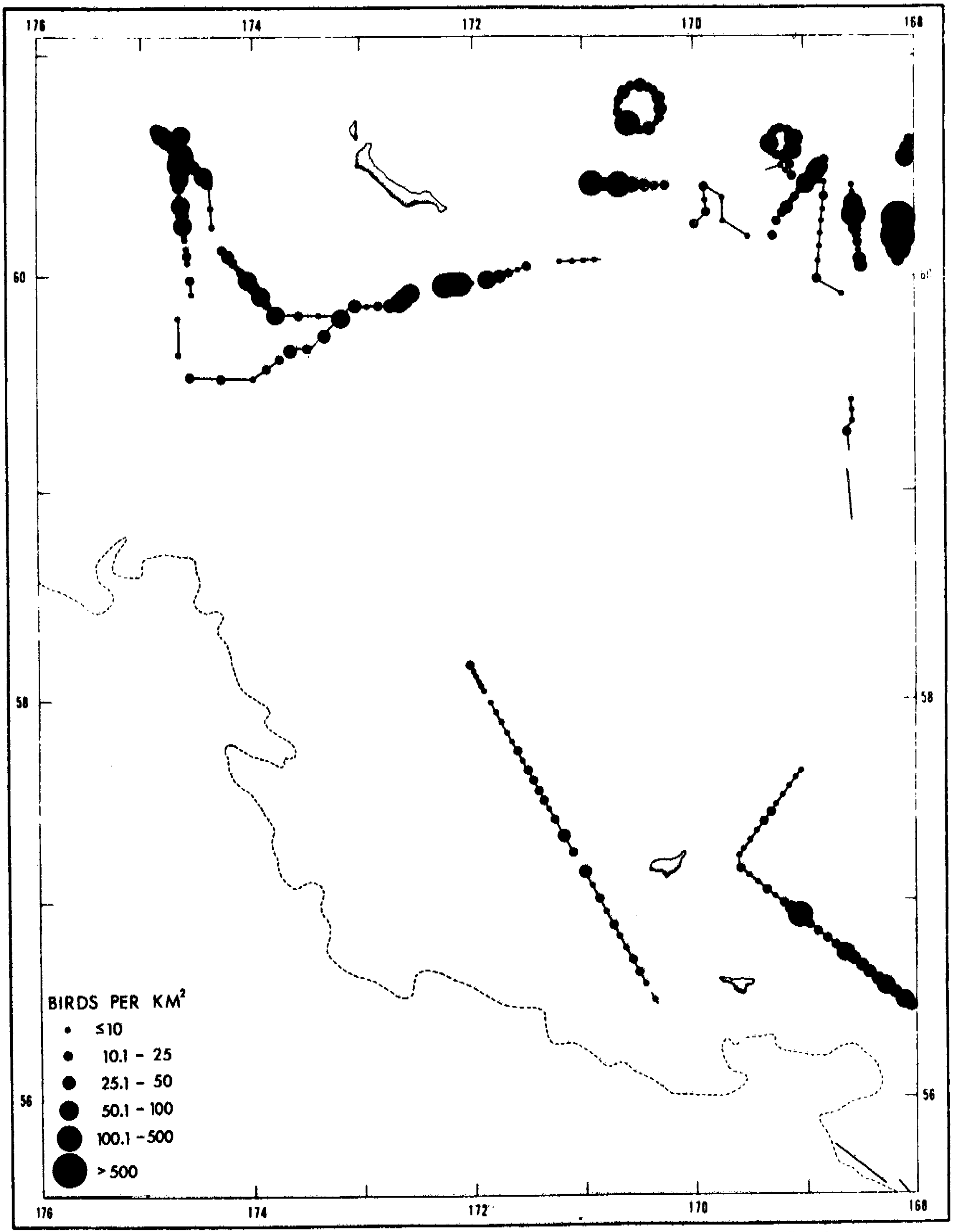


Figure 108. Distribution and abundance of all murres in central Bering Sea from 23 May to 9 June 1977.

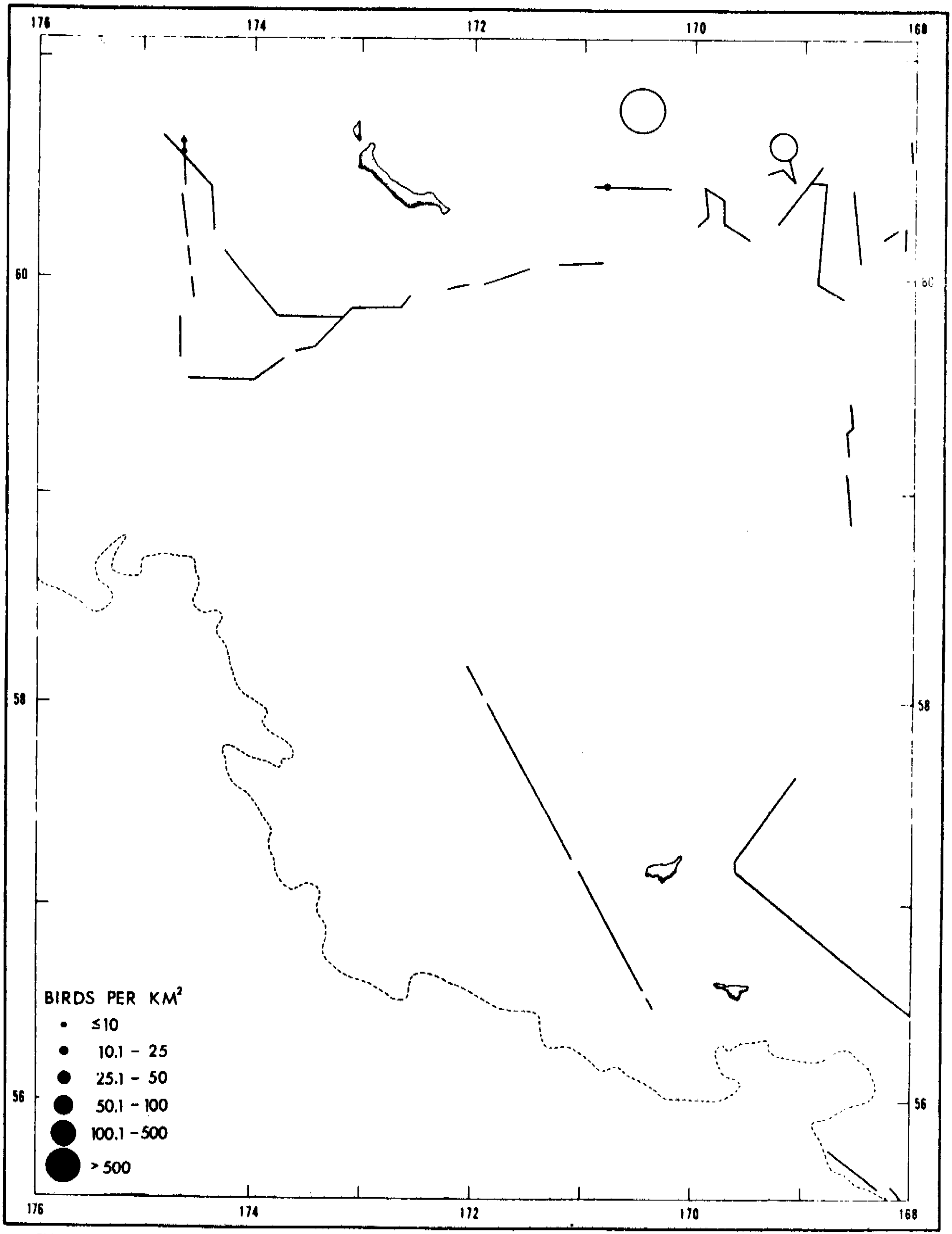


Figure 109. Distribution and abundance of Black Guillemots in central Bering Sea from 23 May to 9 June 1977.

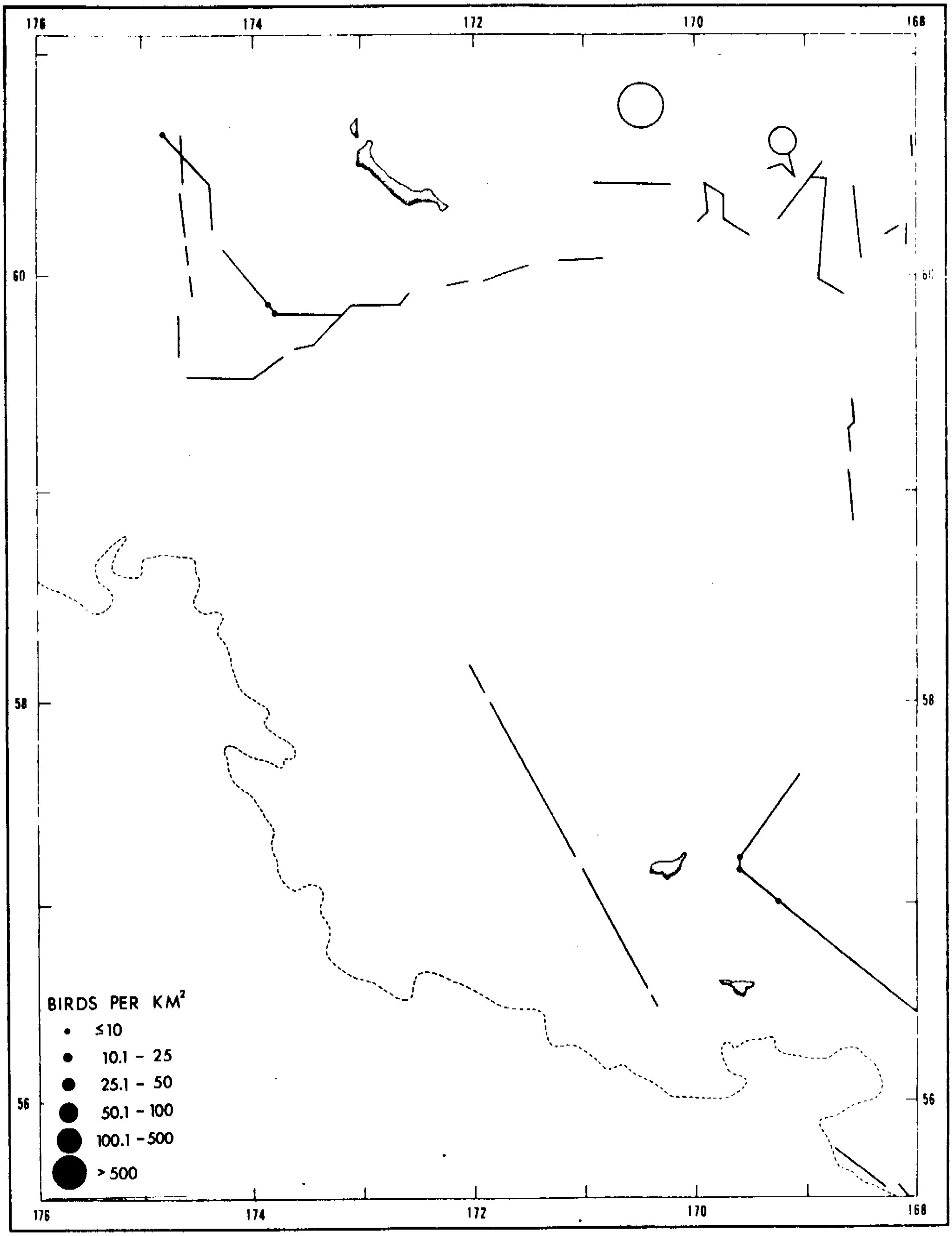


Figure 110. Distribution and abundance of Pigeon Guillemots in central Bering Sea from 23 May to 9 June 1977.

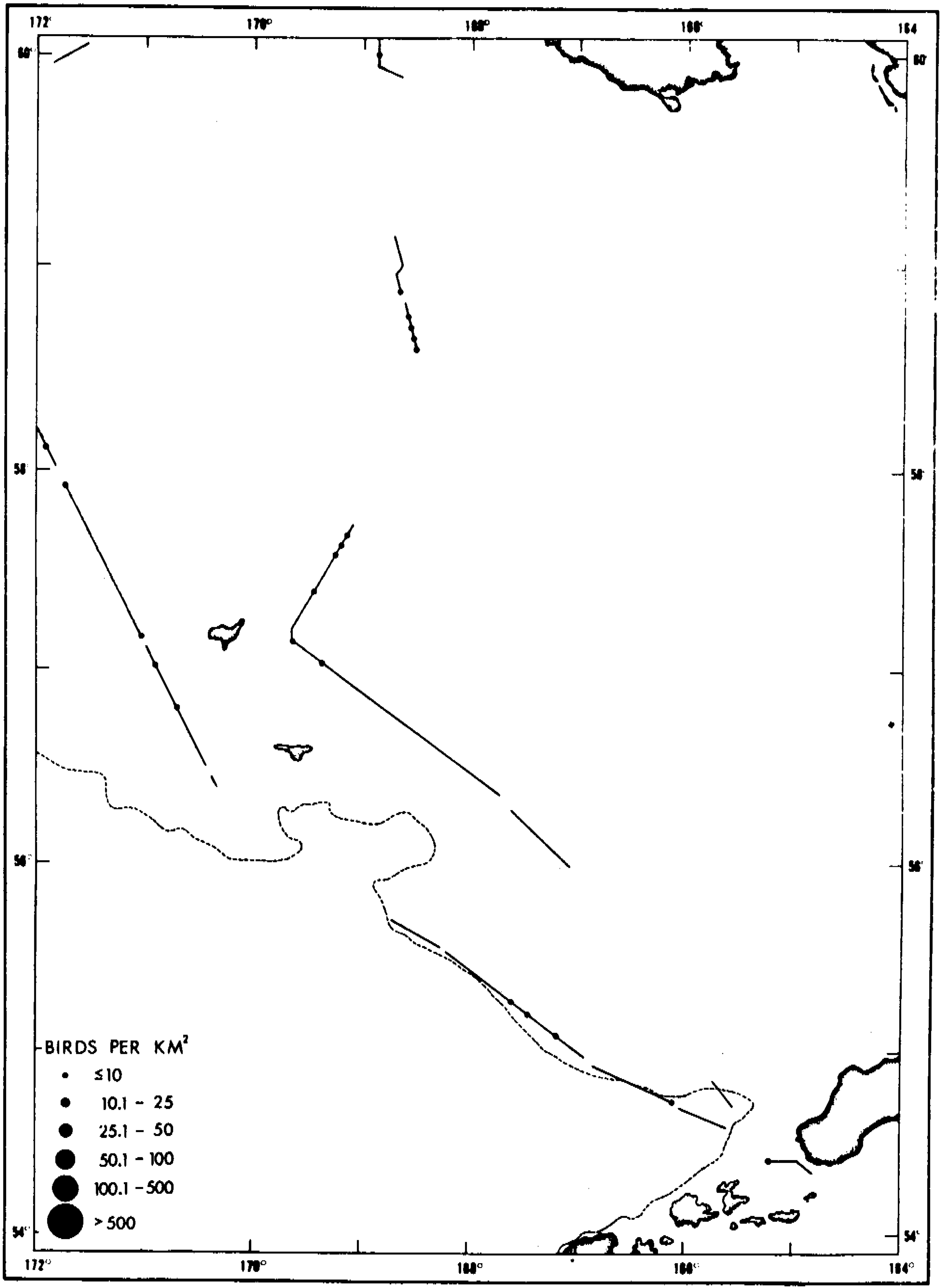


Figure 111. Distribution and abundance of Parakeet Auklets in southern Bering Sea from 5 to 24 May, on 29 May, on 2 June and from 8 to 10 June 1977.

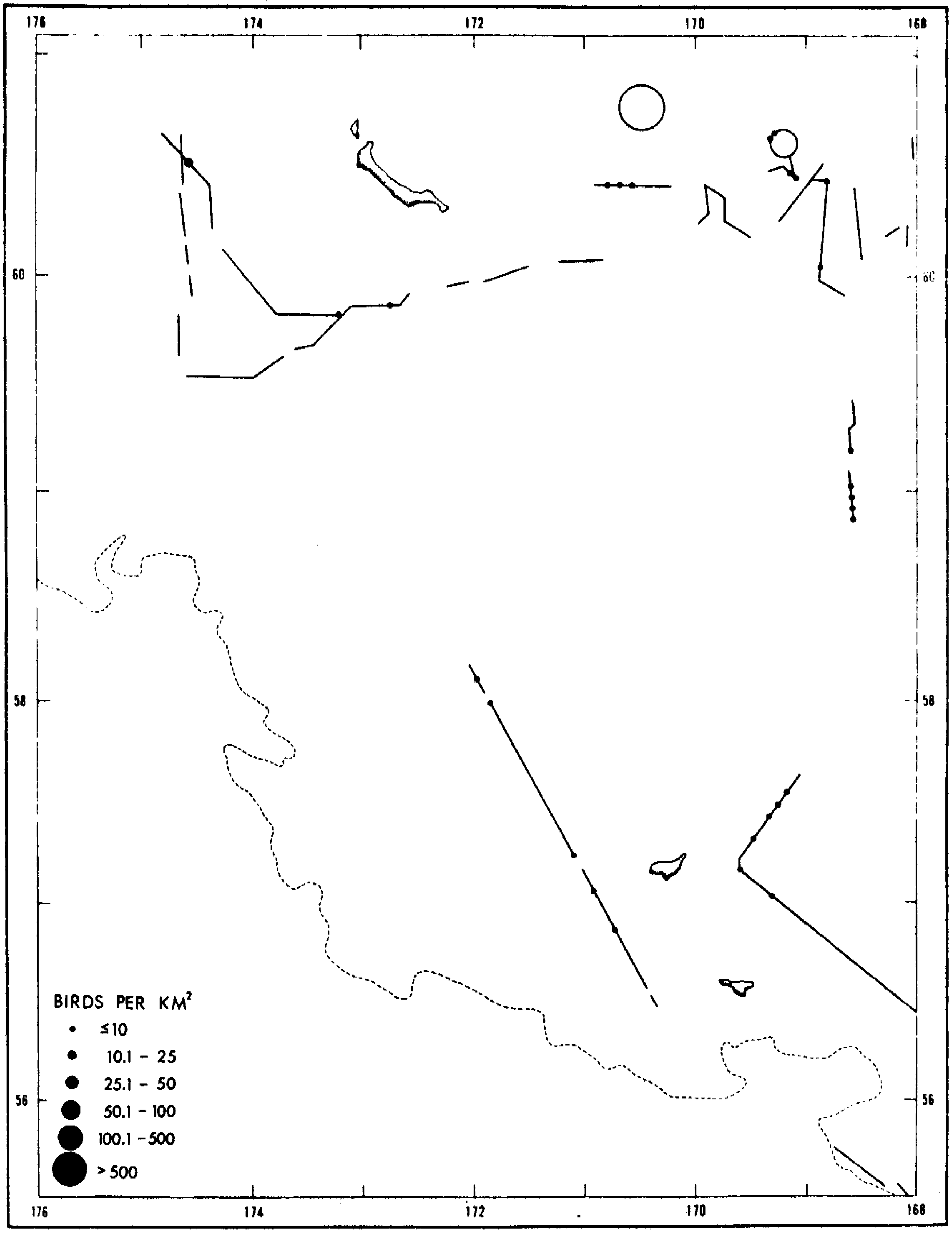


Figure 112. Distribution and abundance of Parakeet Auklets in central Bering Sea from 23 May to 9 June 1977.

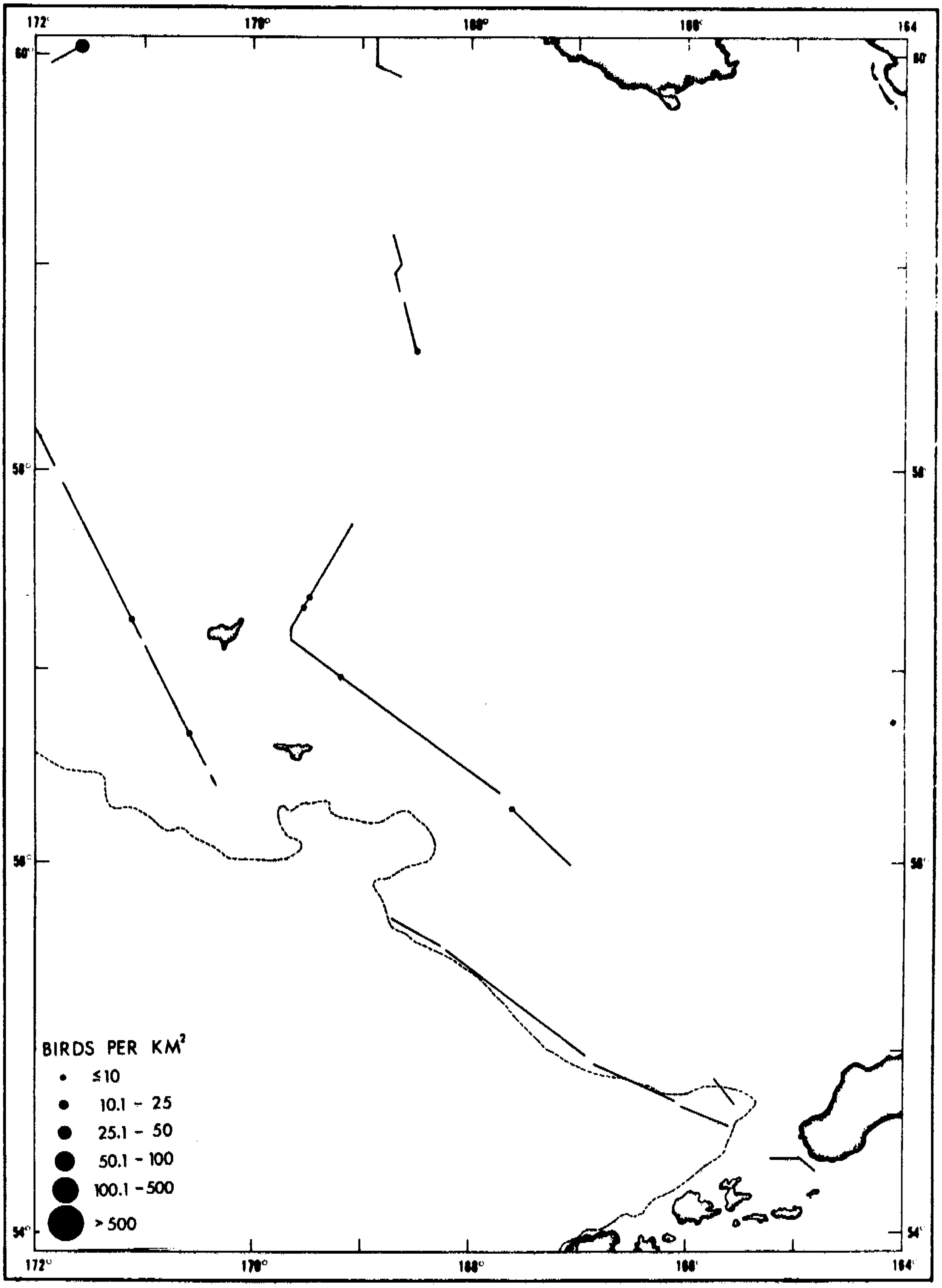


Figure 113. Distribution and abundance of Crested Auklets in southern Bering Sea from 5 to 24 May, on 29 May, on 2 June and from 8 to 10 June 1977.

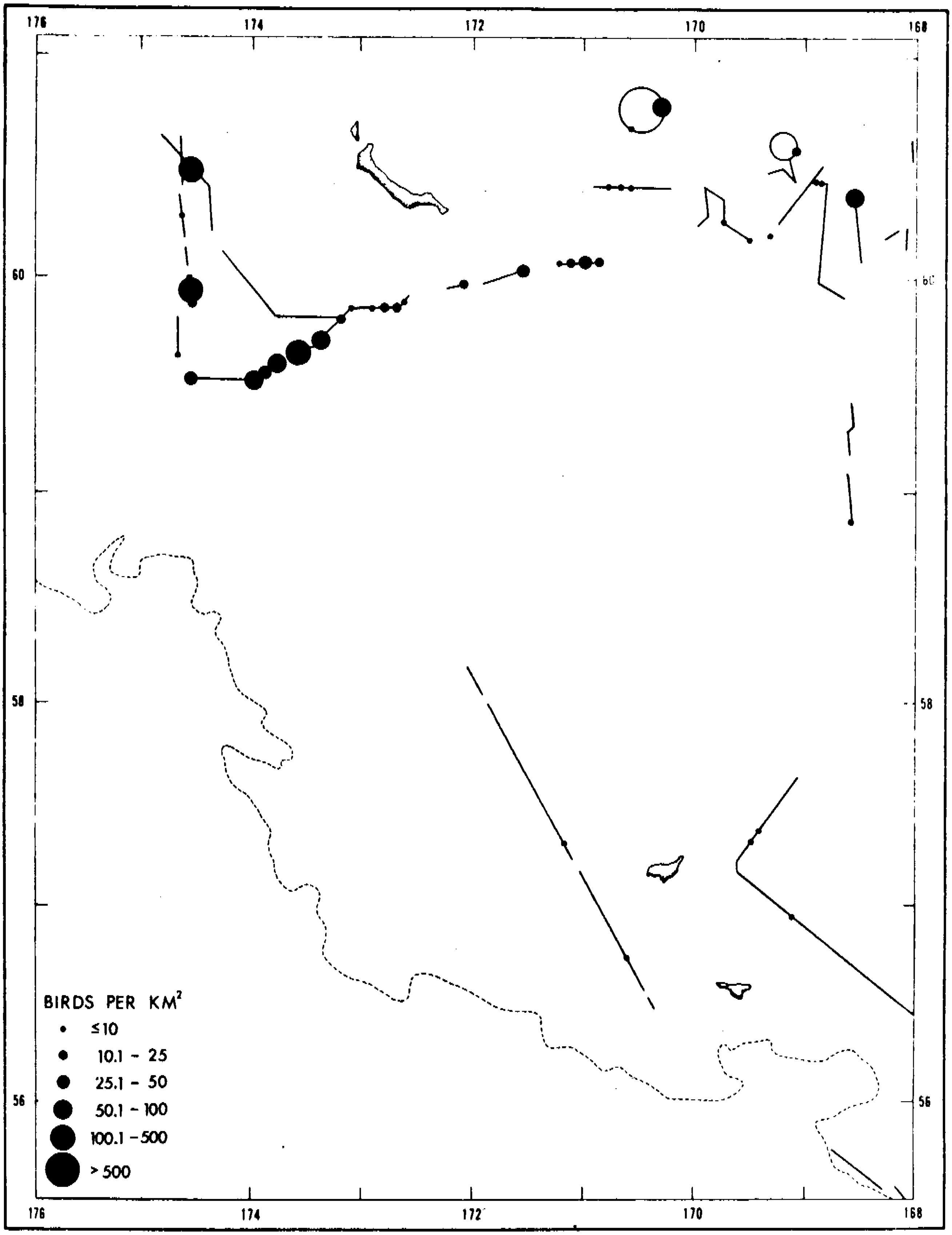


Figure 114. Distribution and abundance of Crested Auklets in central Bering Sea from 23 May to 9 June 1977.

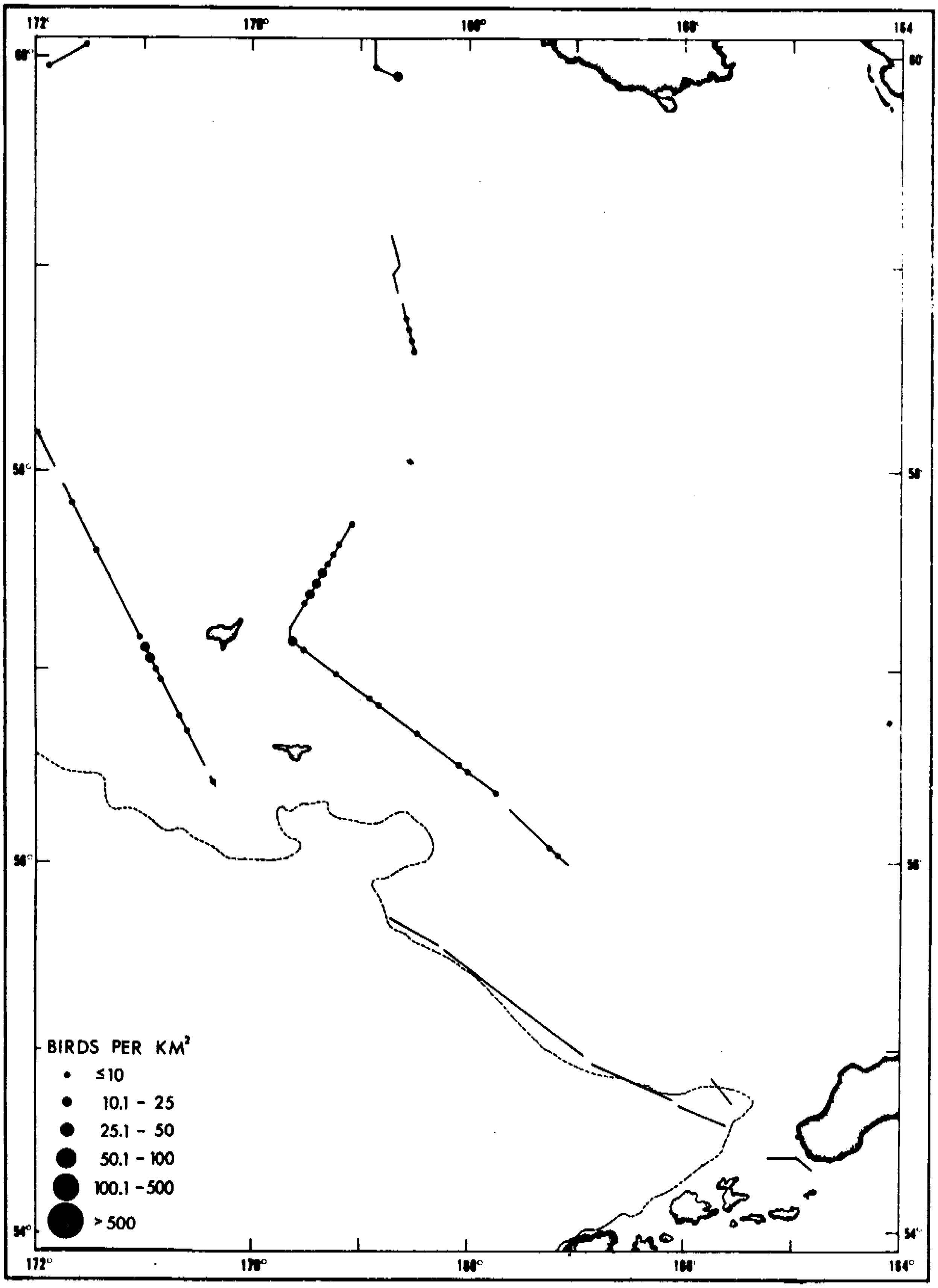


Figure 115. Distribution and abundance of Least Auklets in southern Bering Sea from 5 to 24 May, on 29 May, on 2 June and from 8 to 10 June 1977.

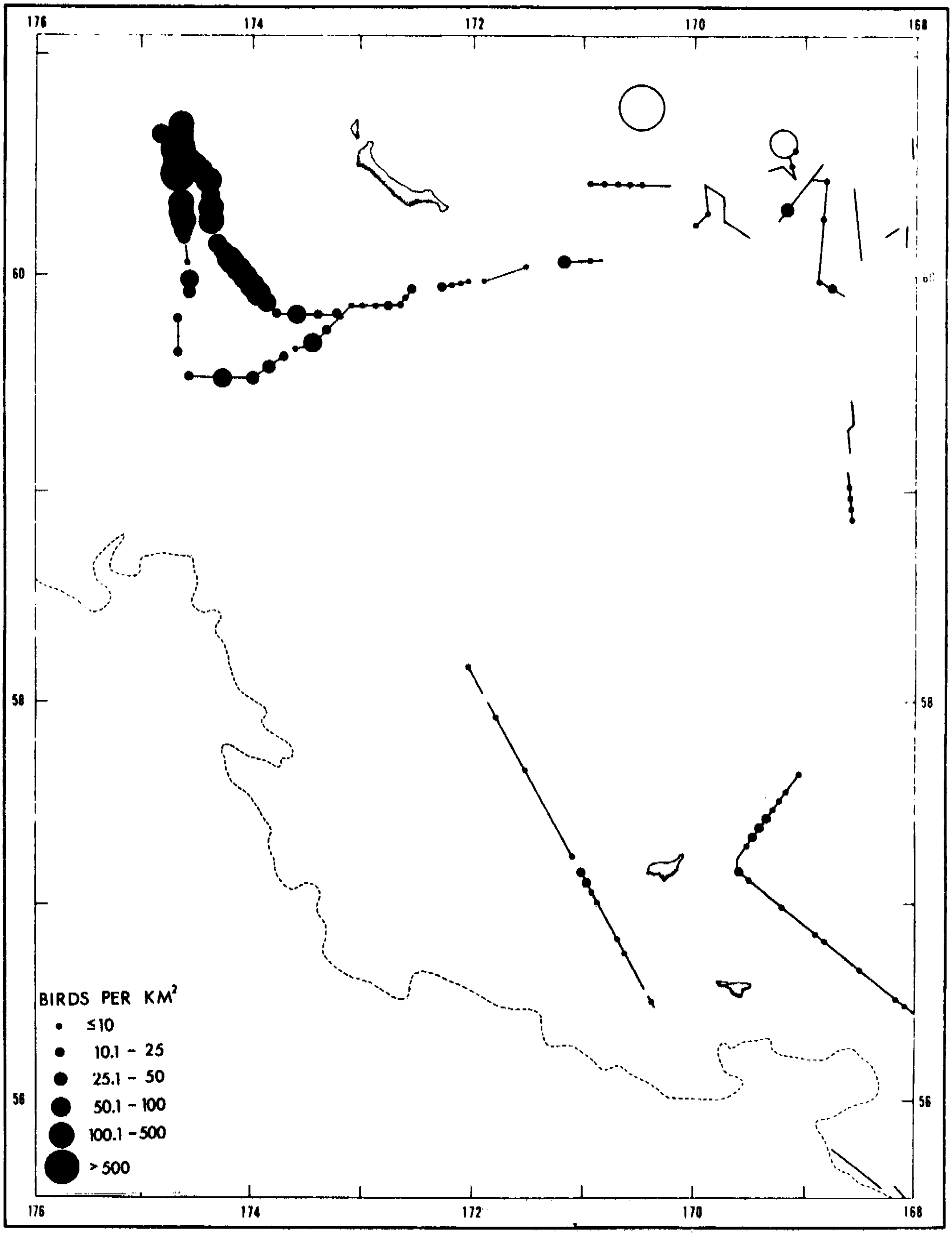


Figure 116. Distribution and abundance of Least Auklets in central Bering Sea from 23 May to 9 June 1977.

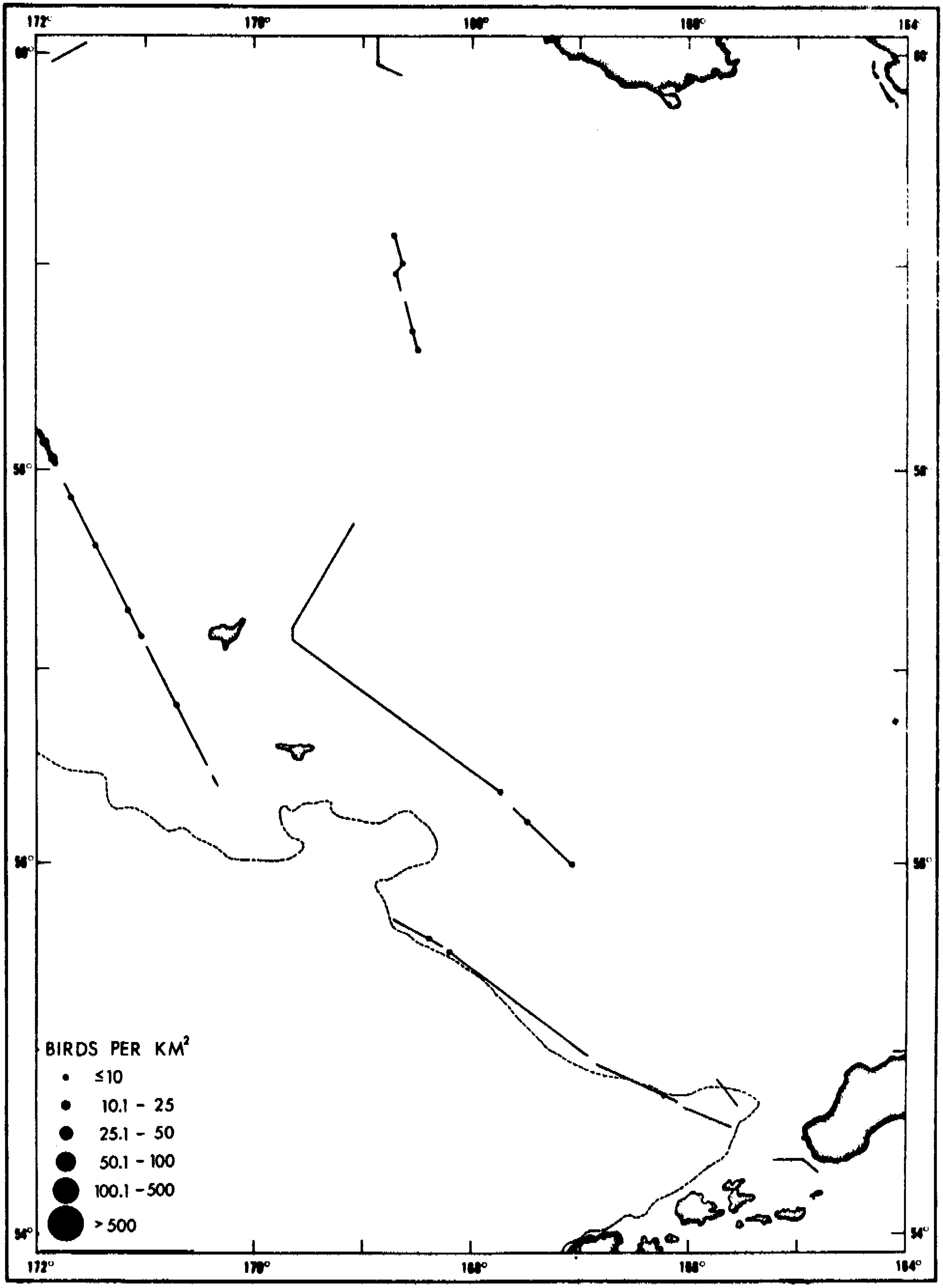


Figure 117. Distribution and abundance of unidentified small dark alcids in southern Bering Sea from 5 to 24 May, on 29 May, on 2 June and from 8 to 10 June 1977.

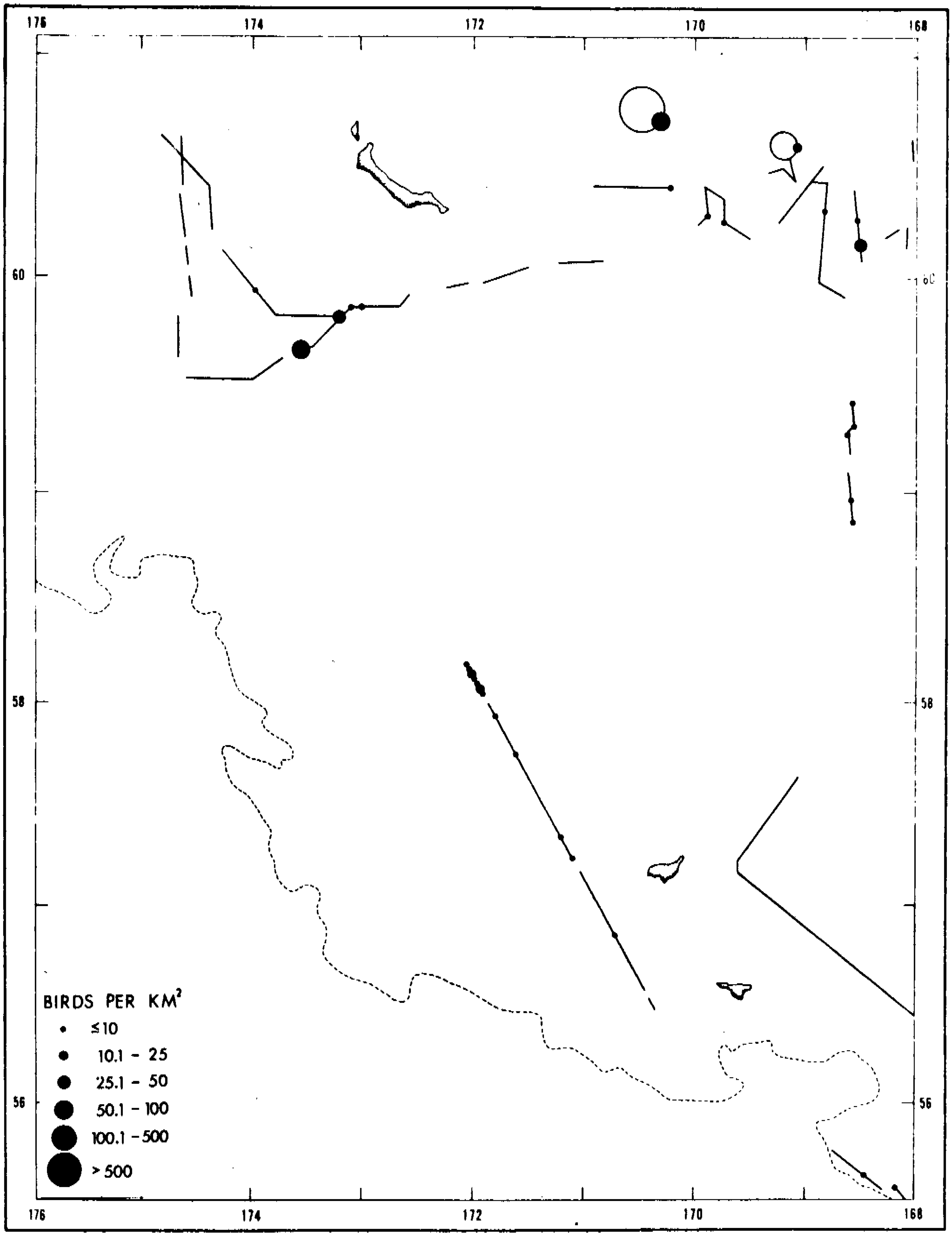


Figure 118. Distribution and abundance of unidentified small dark alcids in central Bering Sea from 23 May to 9 June 1977.

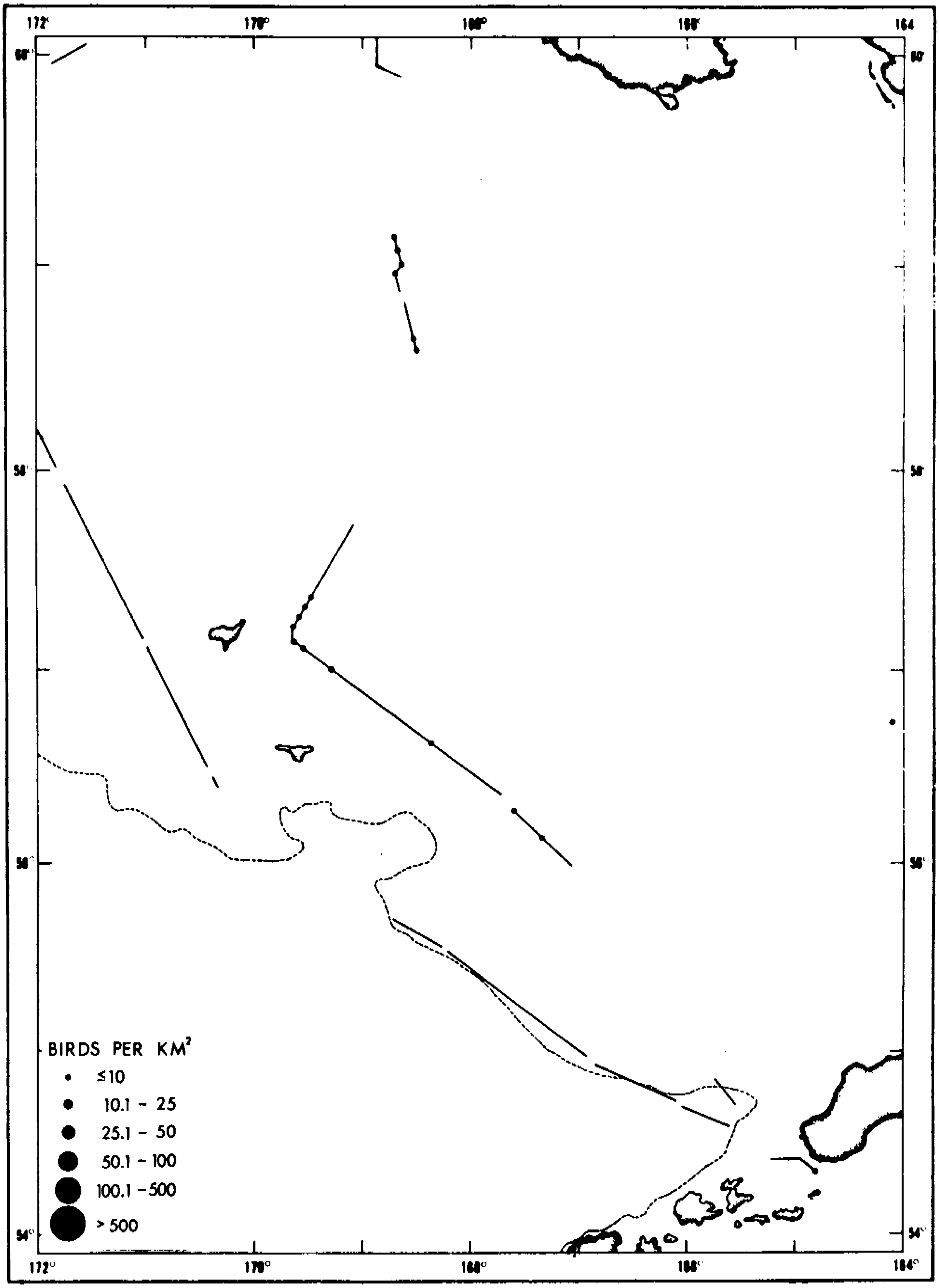


Figure 119. Distribution and abundance of Horned Puffins in southern Bering Sea from 5 to 24 May, on 29 May, on 2 June and from 8 to 10 June 1977.

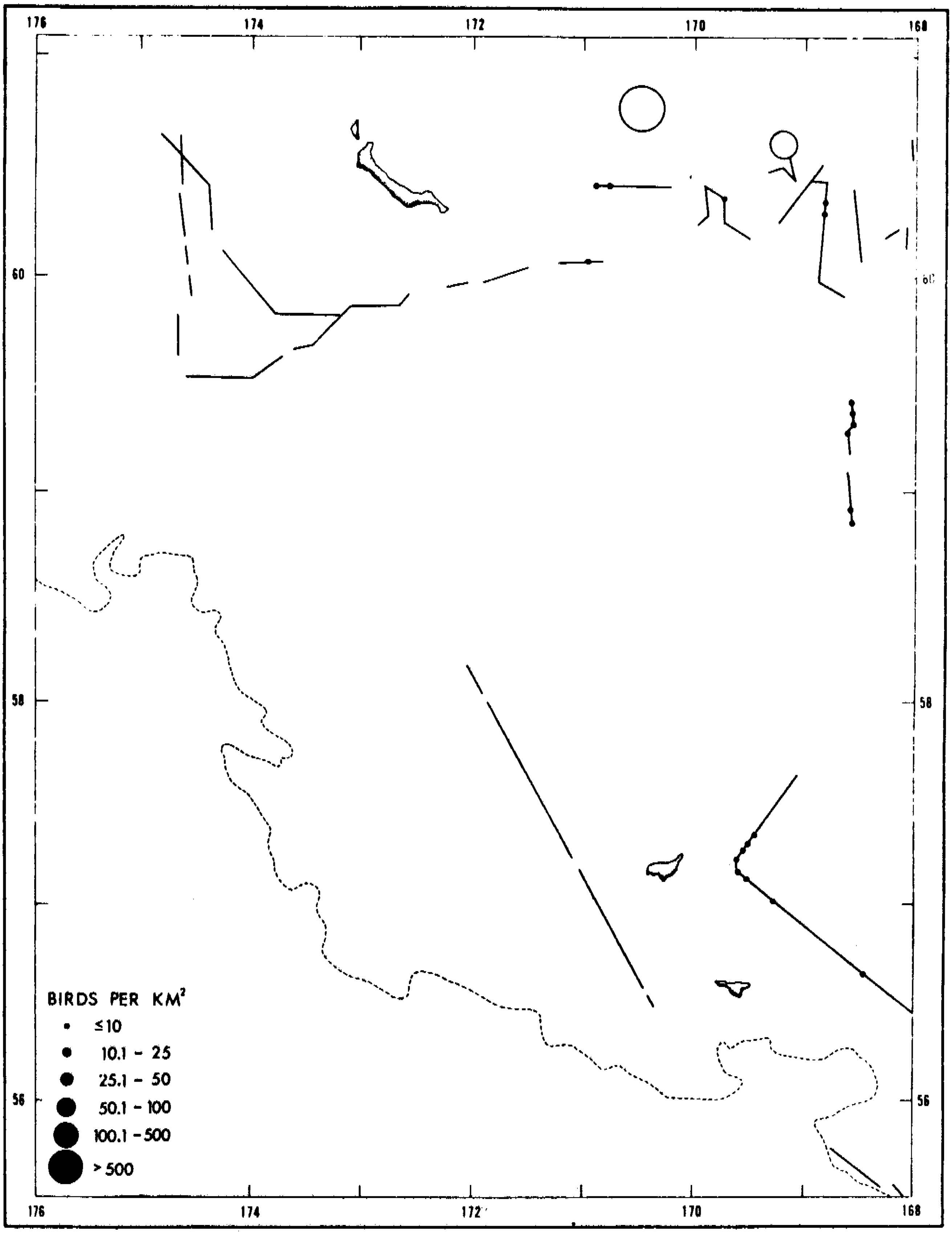


Figure 120. Distribution and abundance of Horned Puffins in central Bering Sea from 23 May to 9 June 1977.

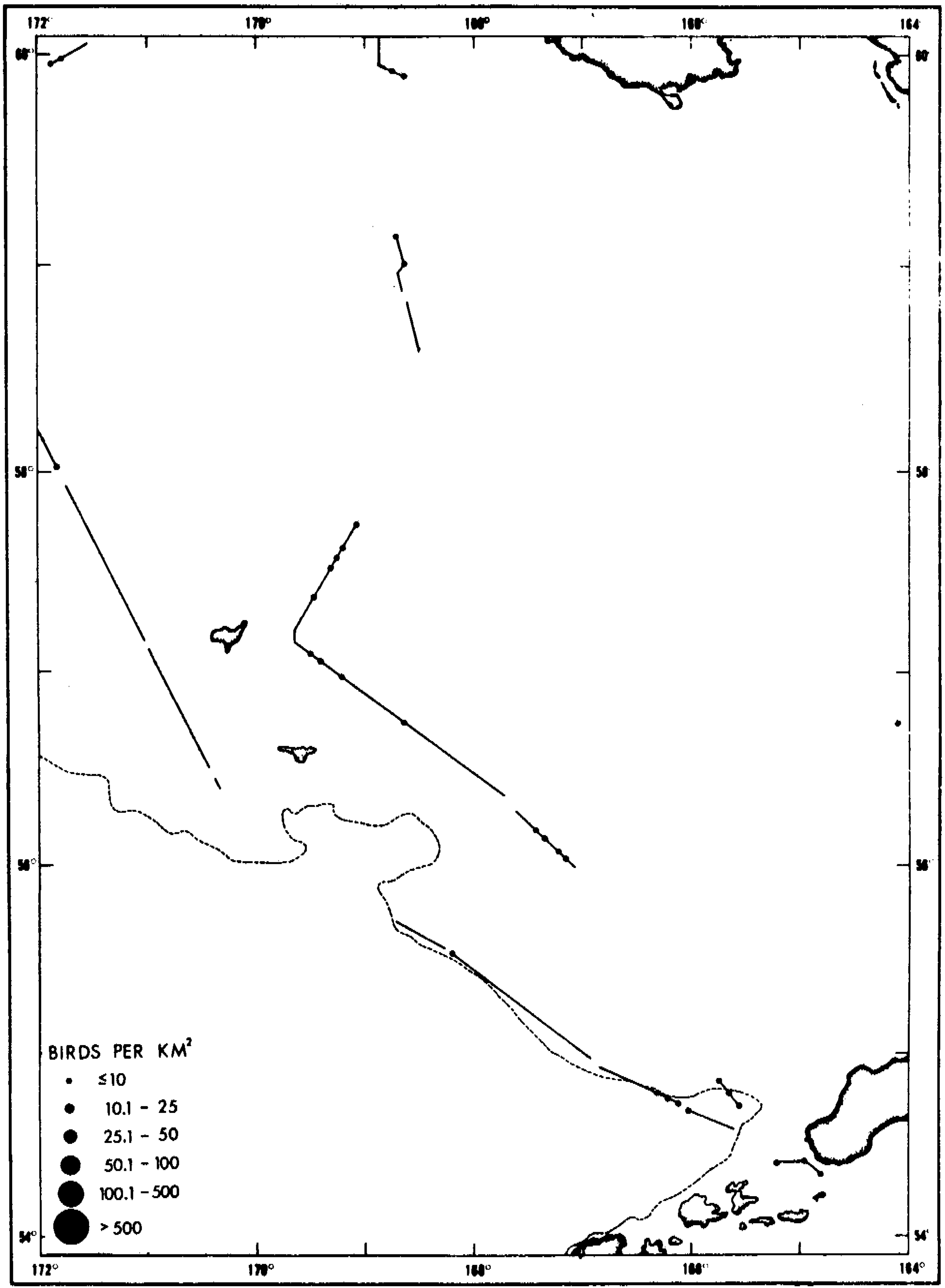


Figure 121. Distribution and abundance of Tufted Puffins in southern Bering Sea from 5 to 24 May, on 29 May, on 2 June and from 8 to 10 June 1977.

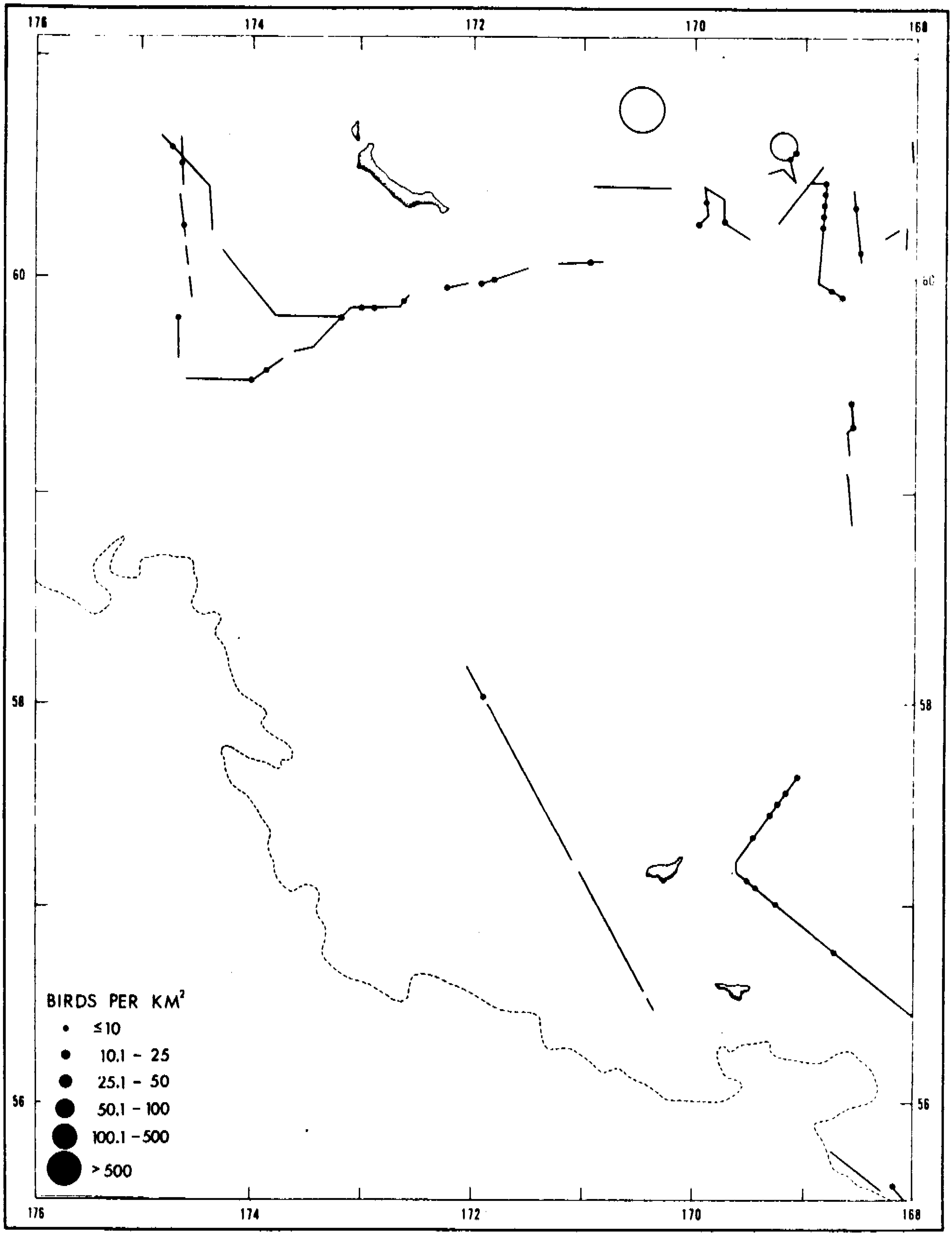


Figure 122. Distribution and abundance of Tufted Puffins in central Bering Sea from 23 May to 9 June 1977.

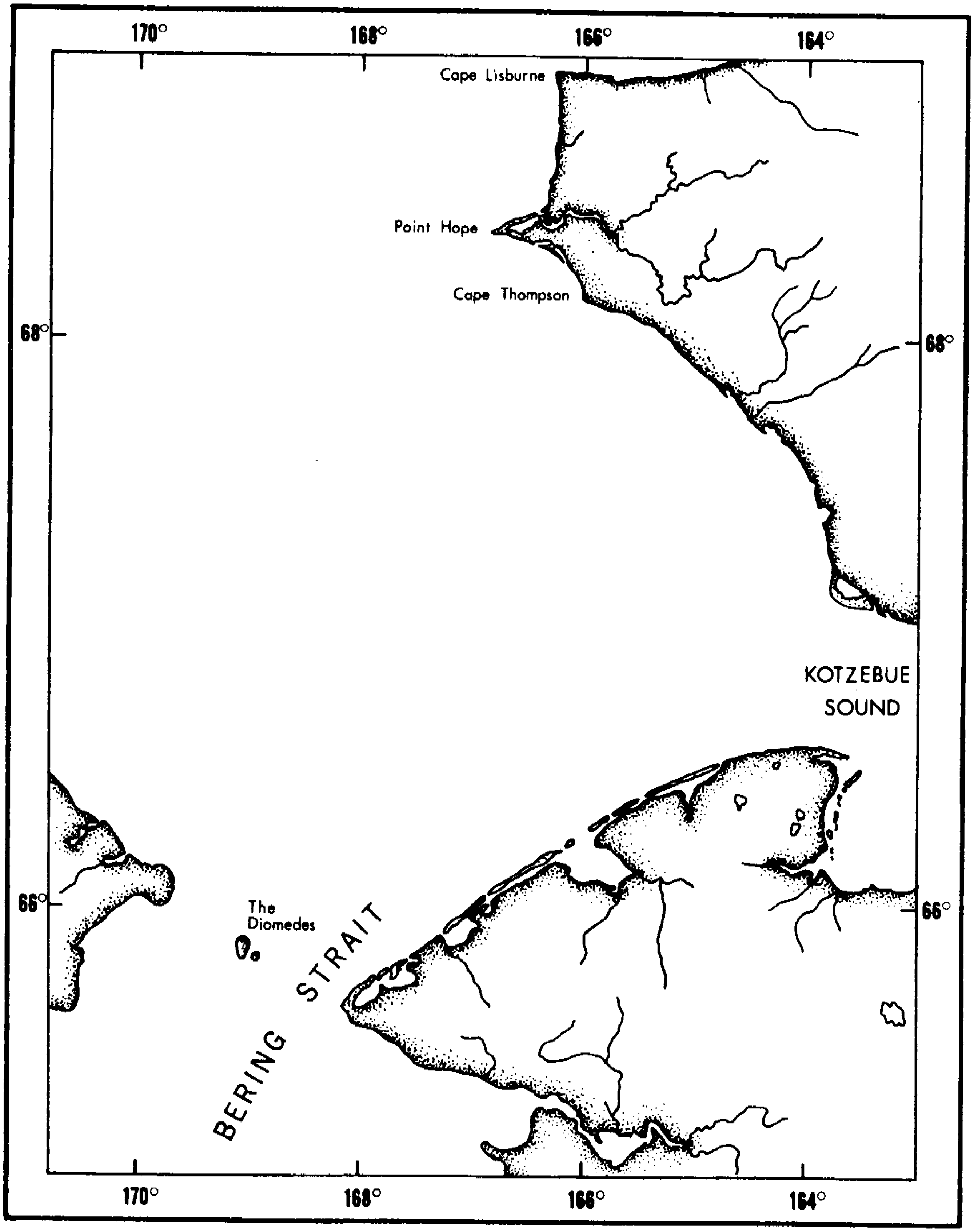


Figure 123. Bering Strait and southern Chukchi Sea showing localities mentioned in text.

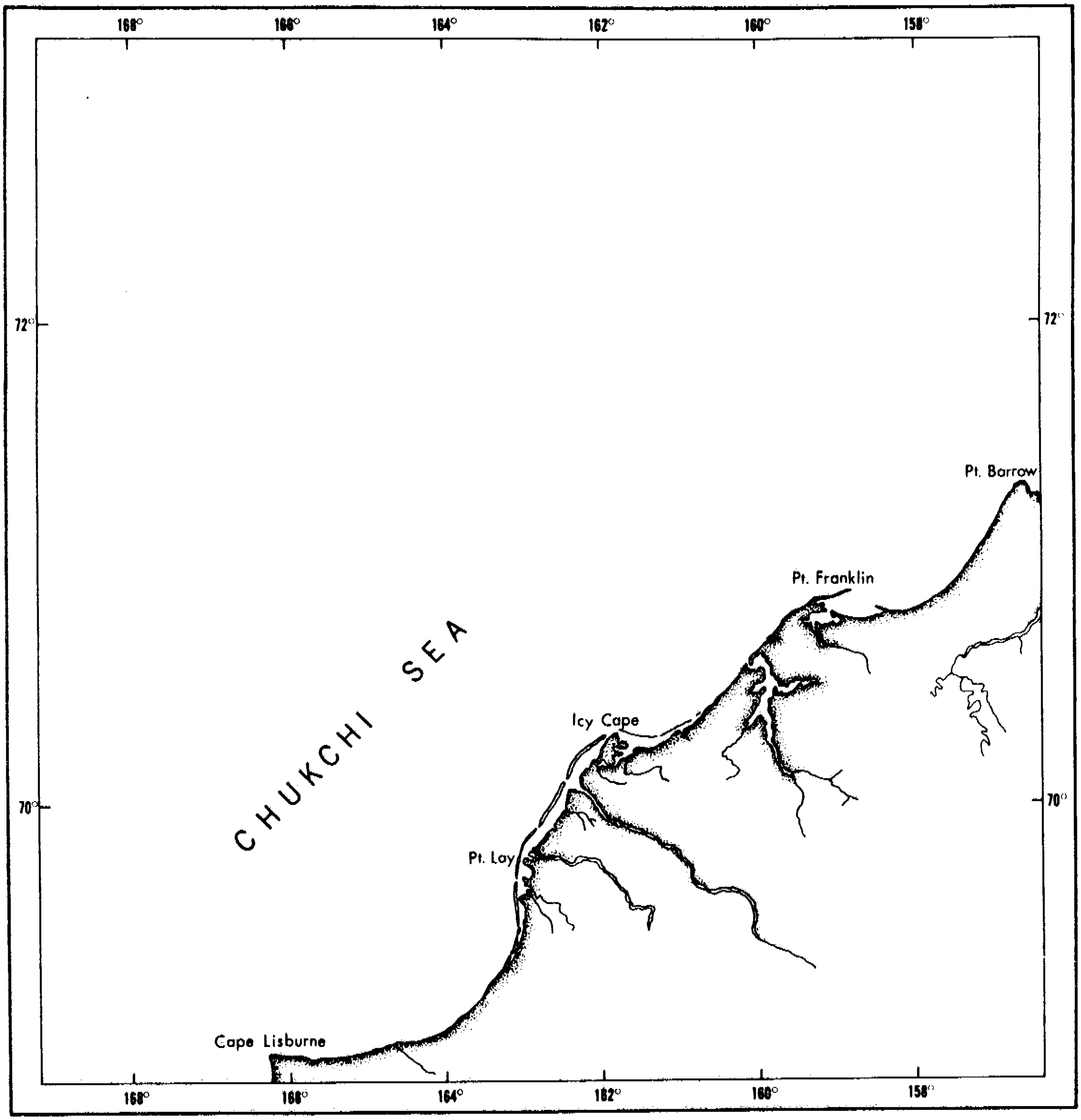


Figure 124. Northern Chukchi Sea showing localities mentioned in text.

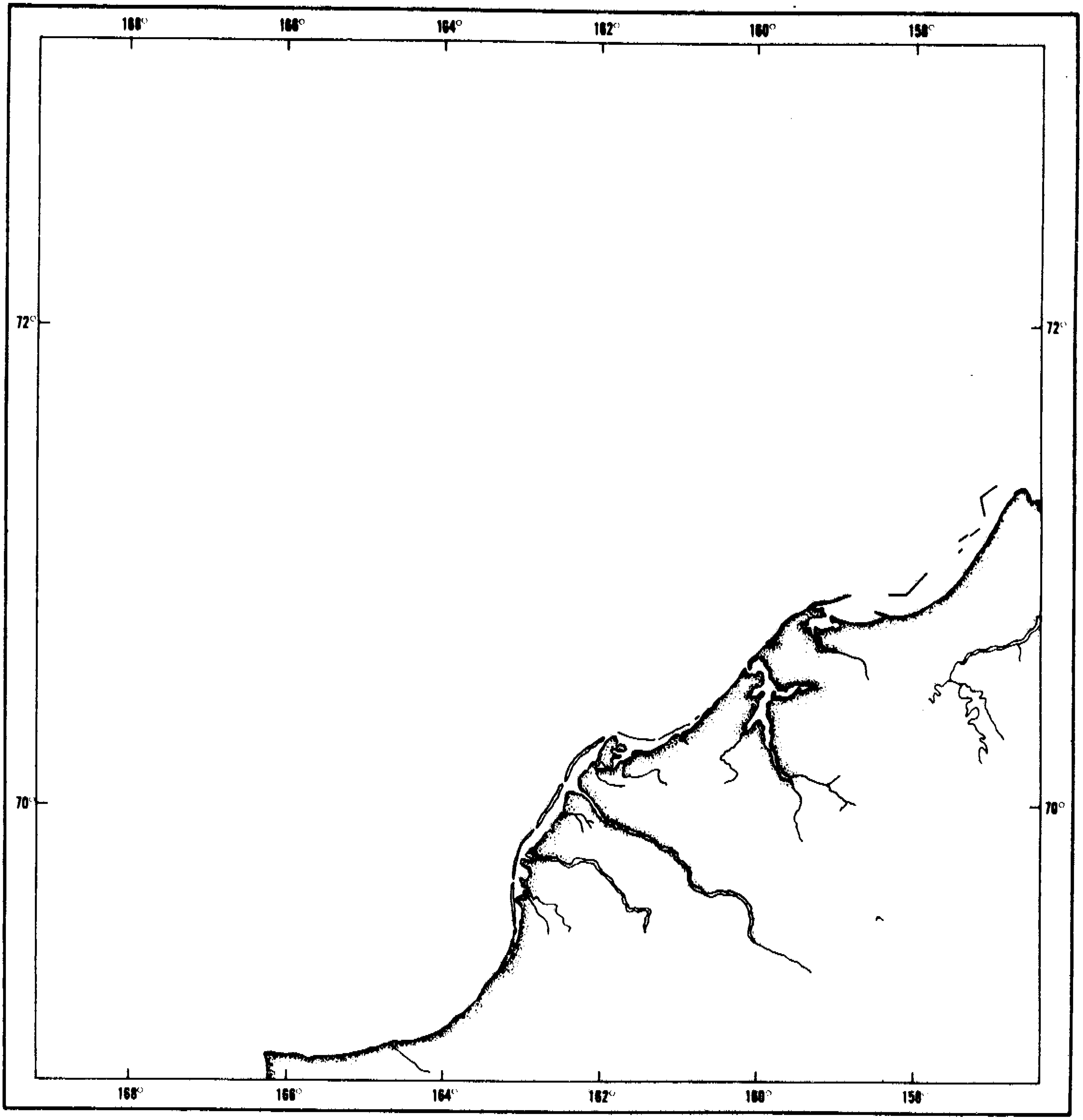


Figure 125. Cruise track during periods of observation in northern Chukchi Sea from 23 to 25 July 1976.

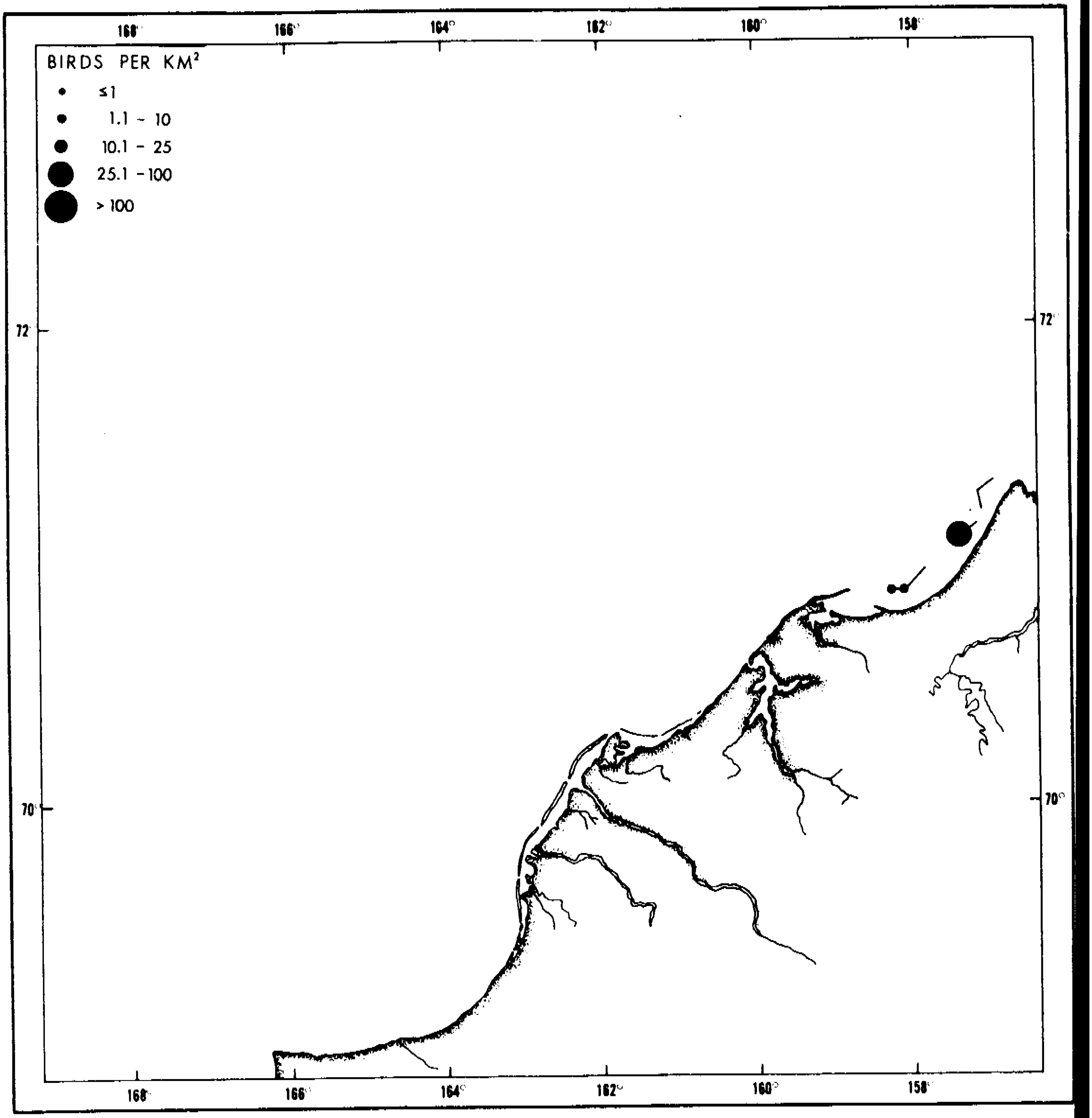


Figure 126. Distribution and abundance of seabirds in northern Chukchi Sea from 23 to 25 July 1976.

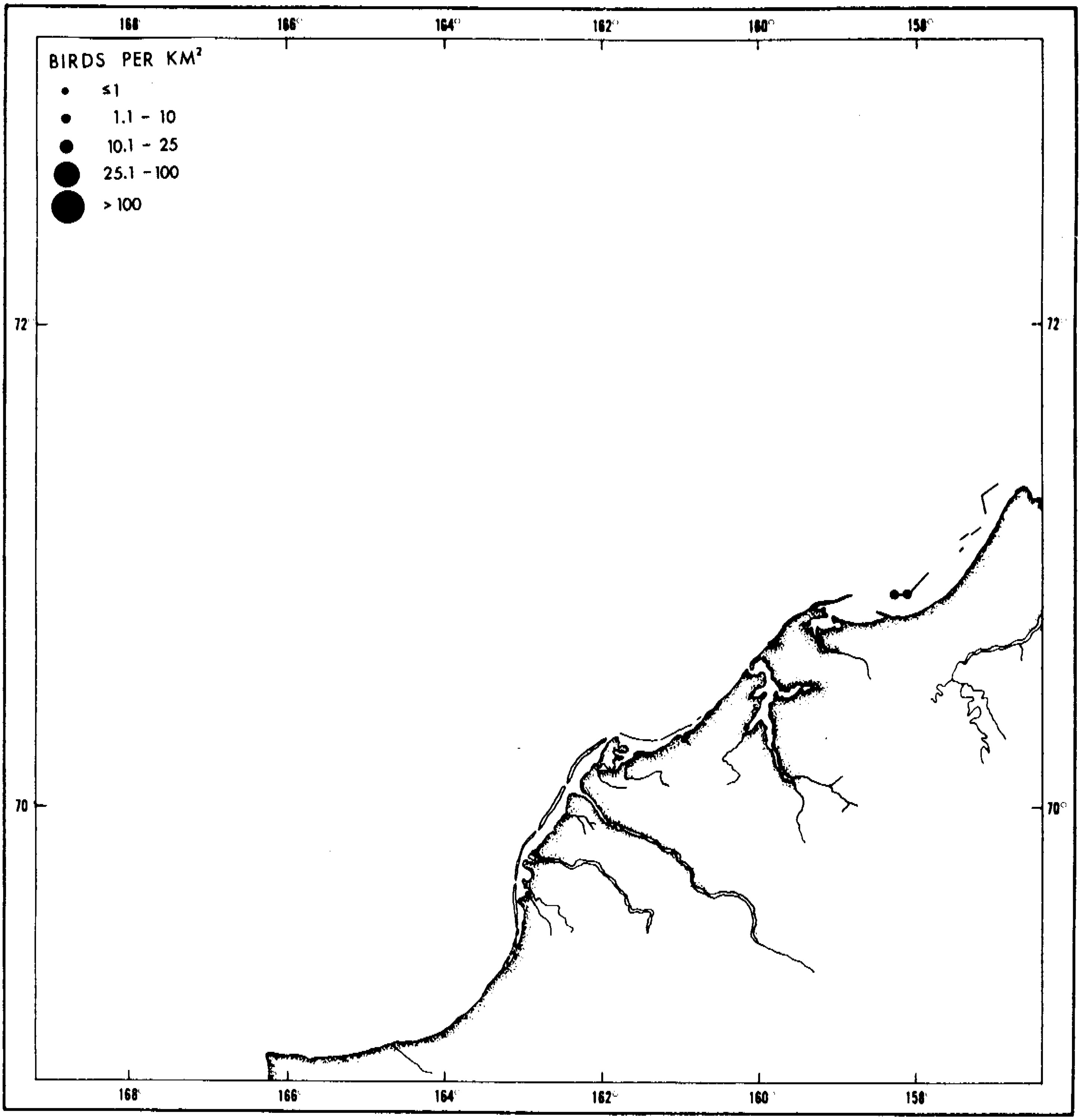


Figure 127. Distribution and abundance of loons in northern Chukchi Sea from 23 to 25 July 1976.

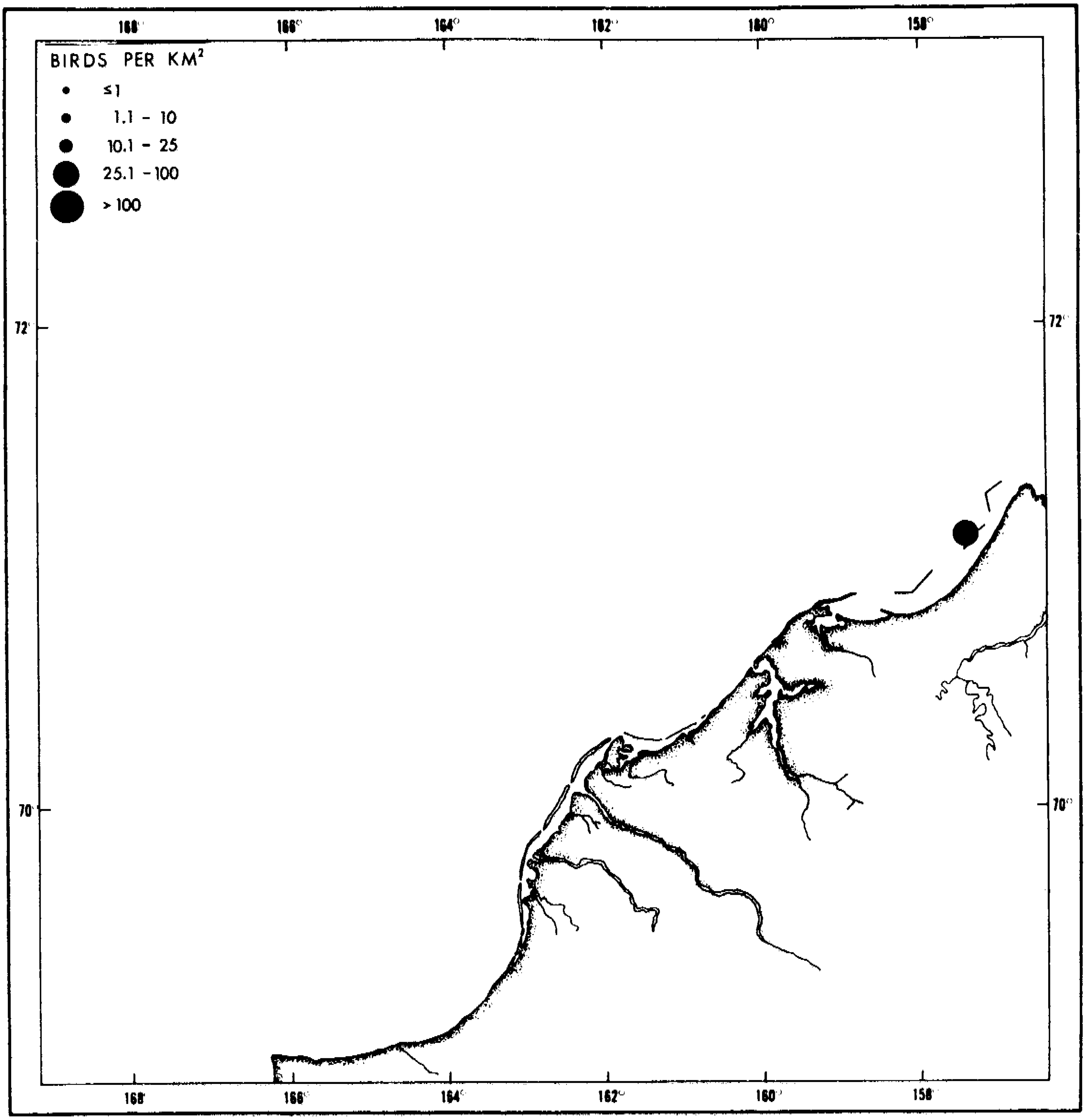


Figure 128. Distribution and abundance of eiders in northern Chukchi Sea from 23 to 25 July 1976.

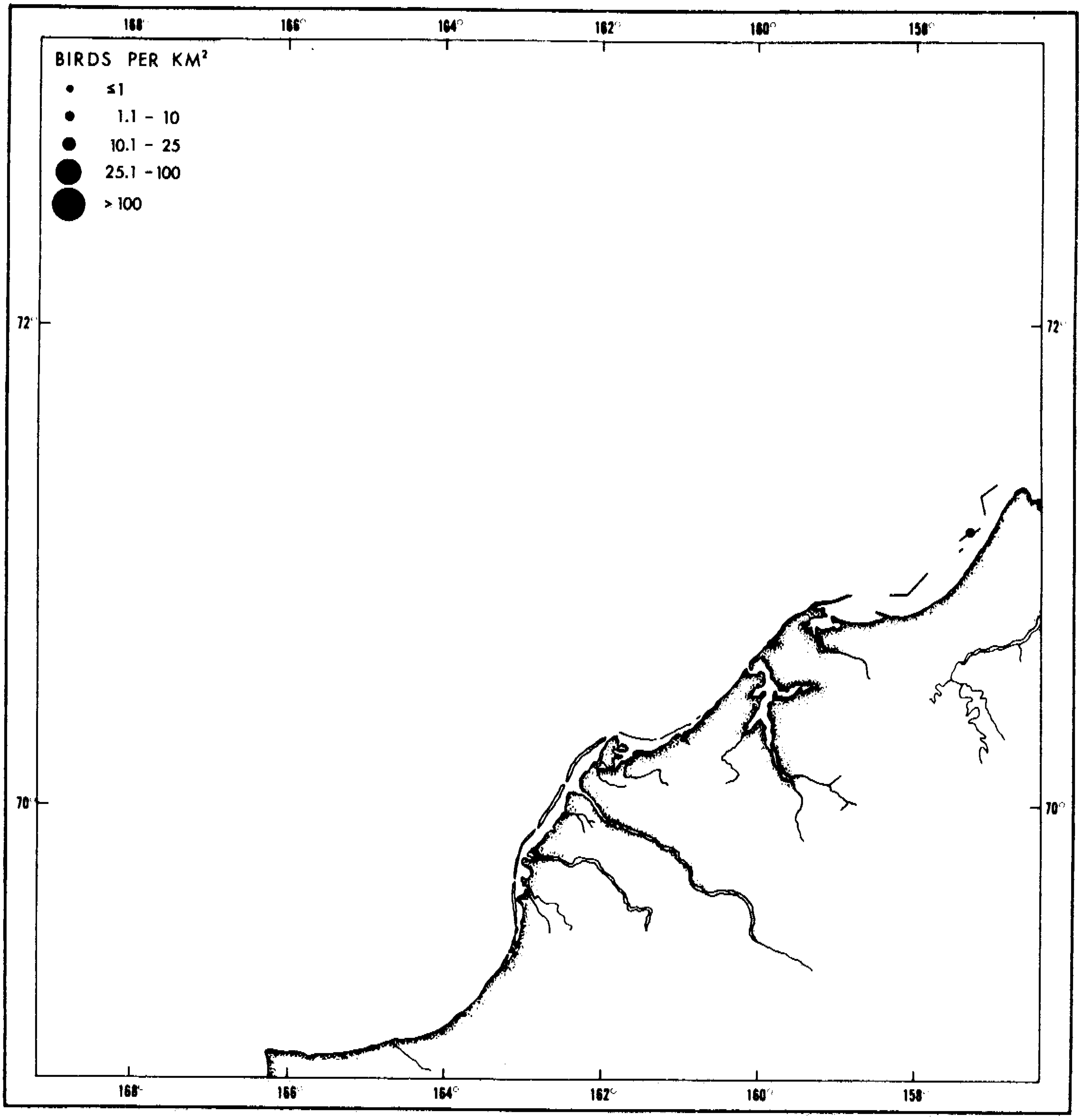


Figure 129. Distribution and abundance of Pomarine Jaegers in northern Chukchi Sea from 23 to 25 July 1976.

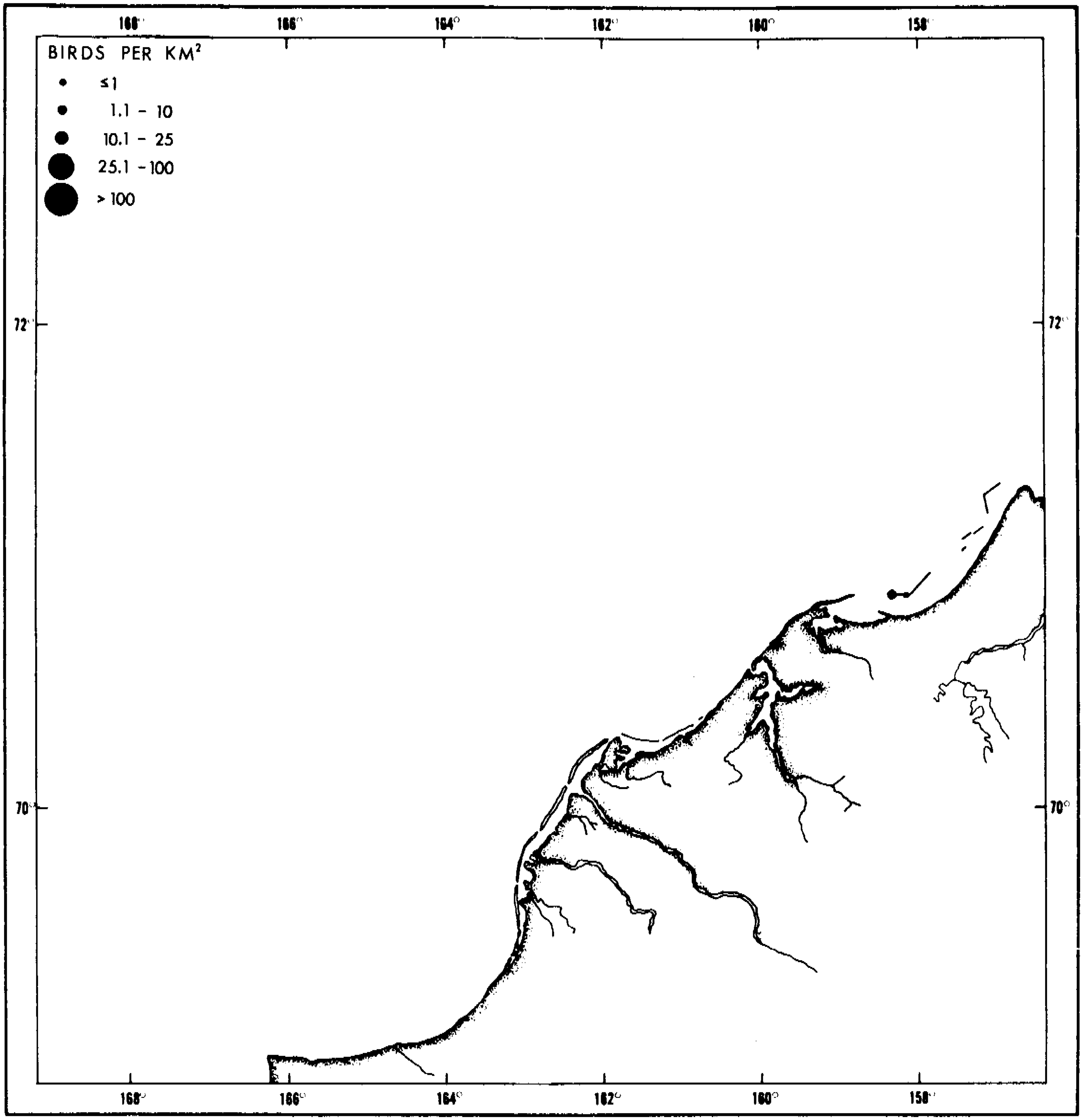


Figure 130. Distribution and abundance of murres in northern Chukchi Sea from 23 to 25 July 1976.

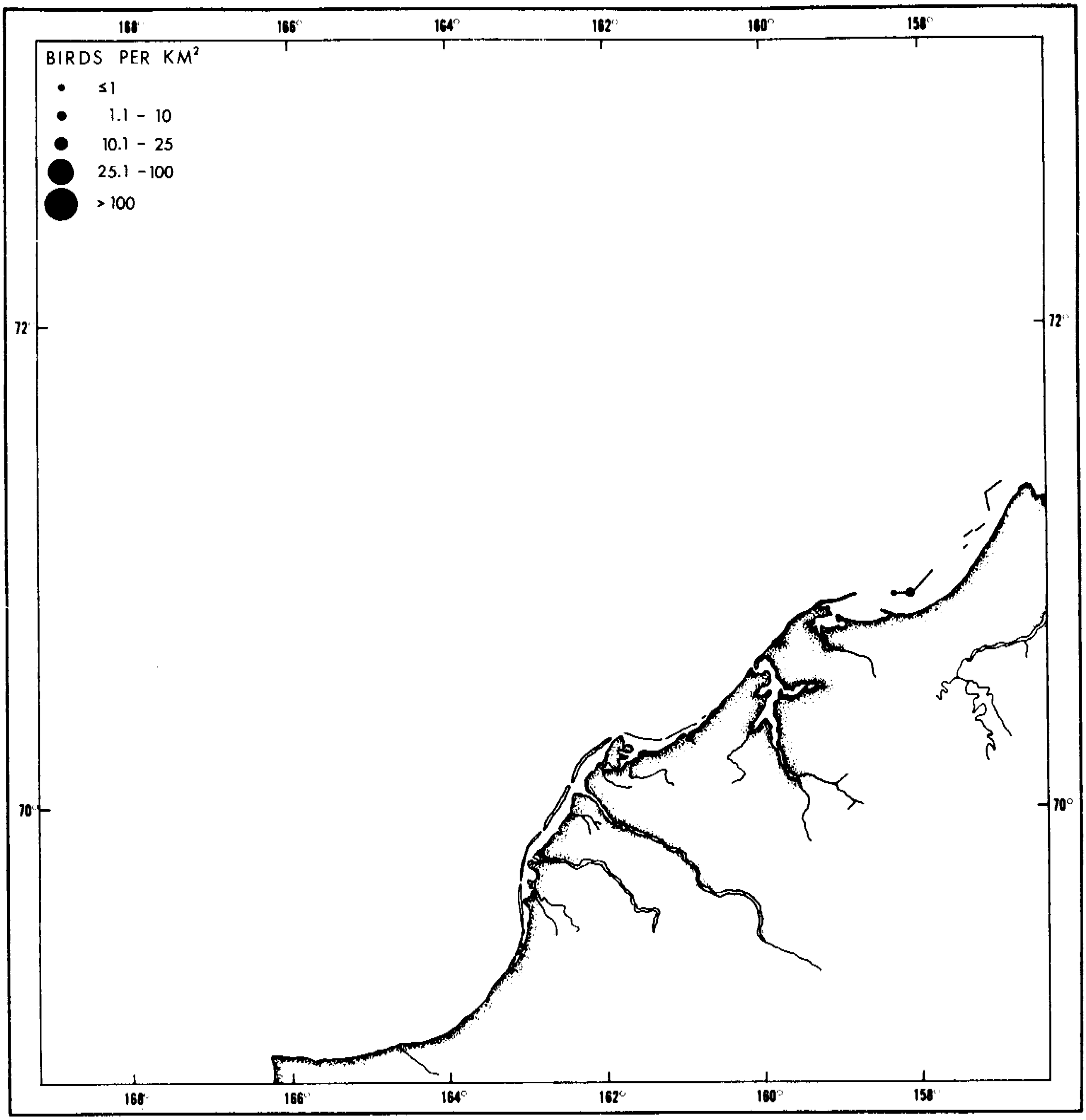


Figure 131. Distribution and abundance of Black Guillemots in northern Chukchi Sea from 23 to 25 July 1976.

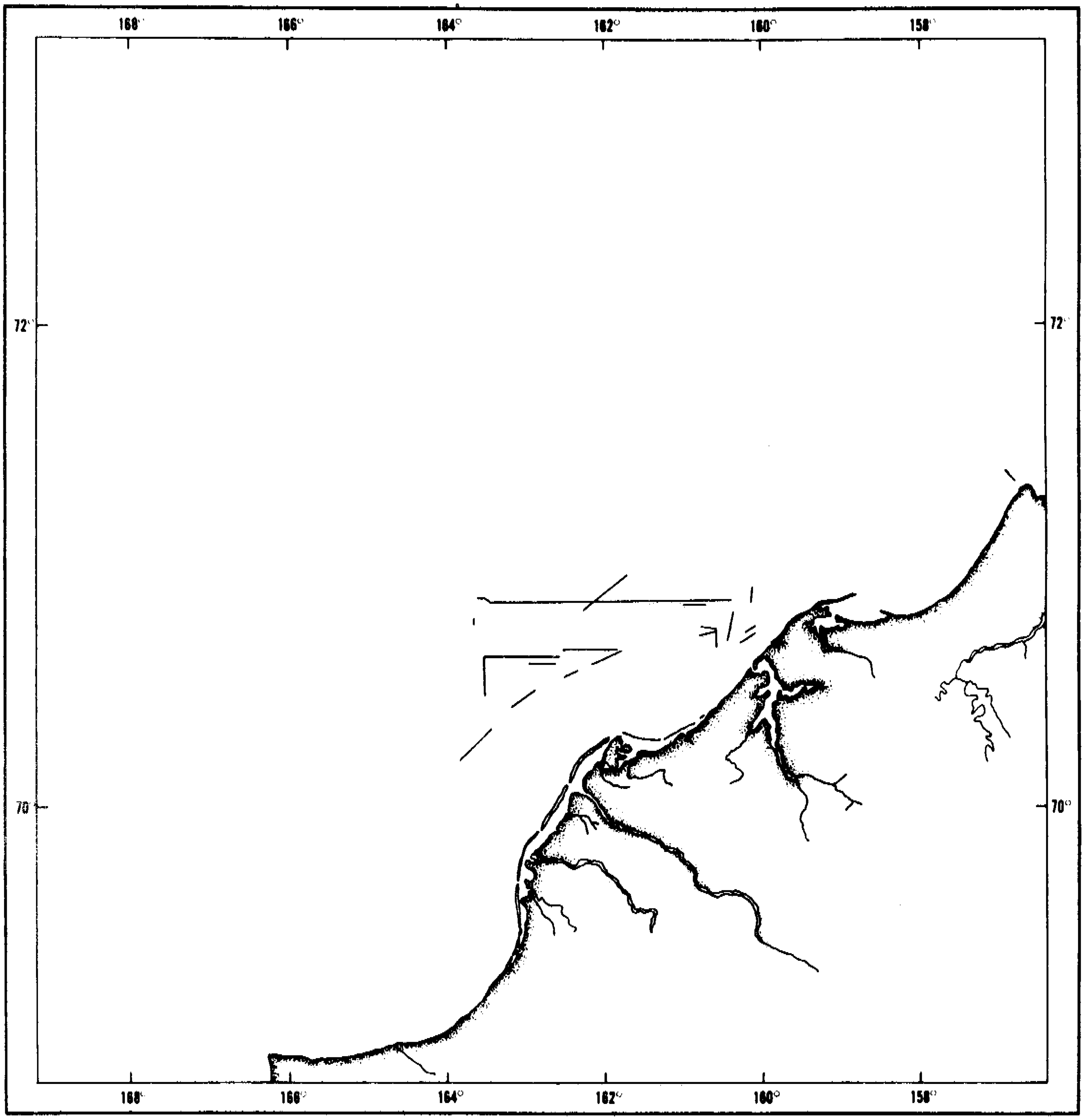


Figure 132. Cruise track during periods of observation in northern Chukchi Sea from 7 to 17 August 1976.

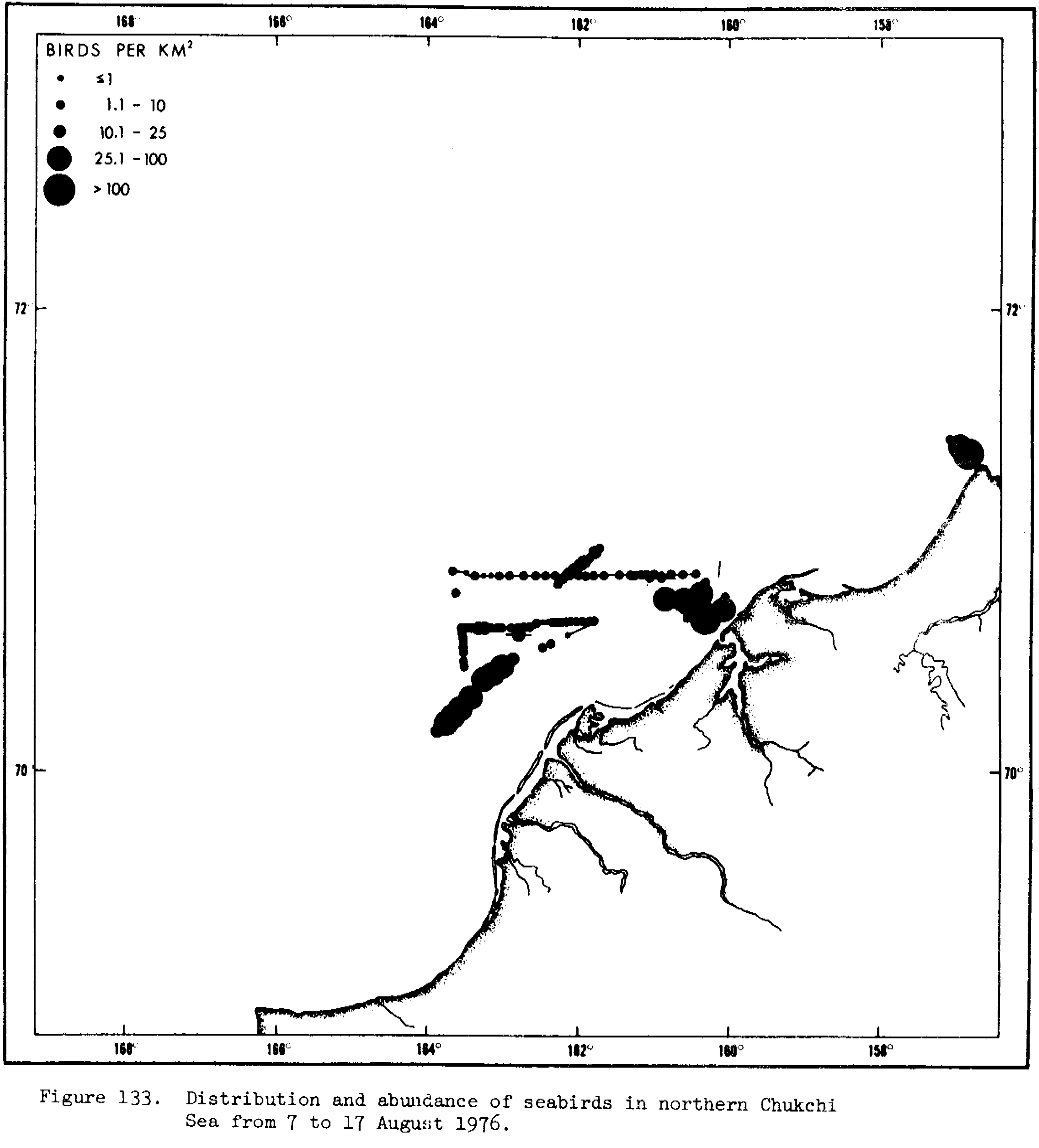


Figure 133. Distribution and abundance of seabirds in northern Chukchi Sea from 7 to 17 August 1976.

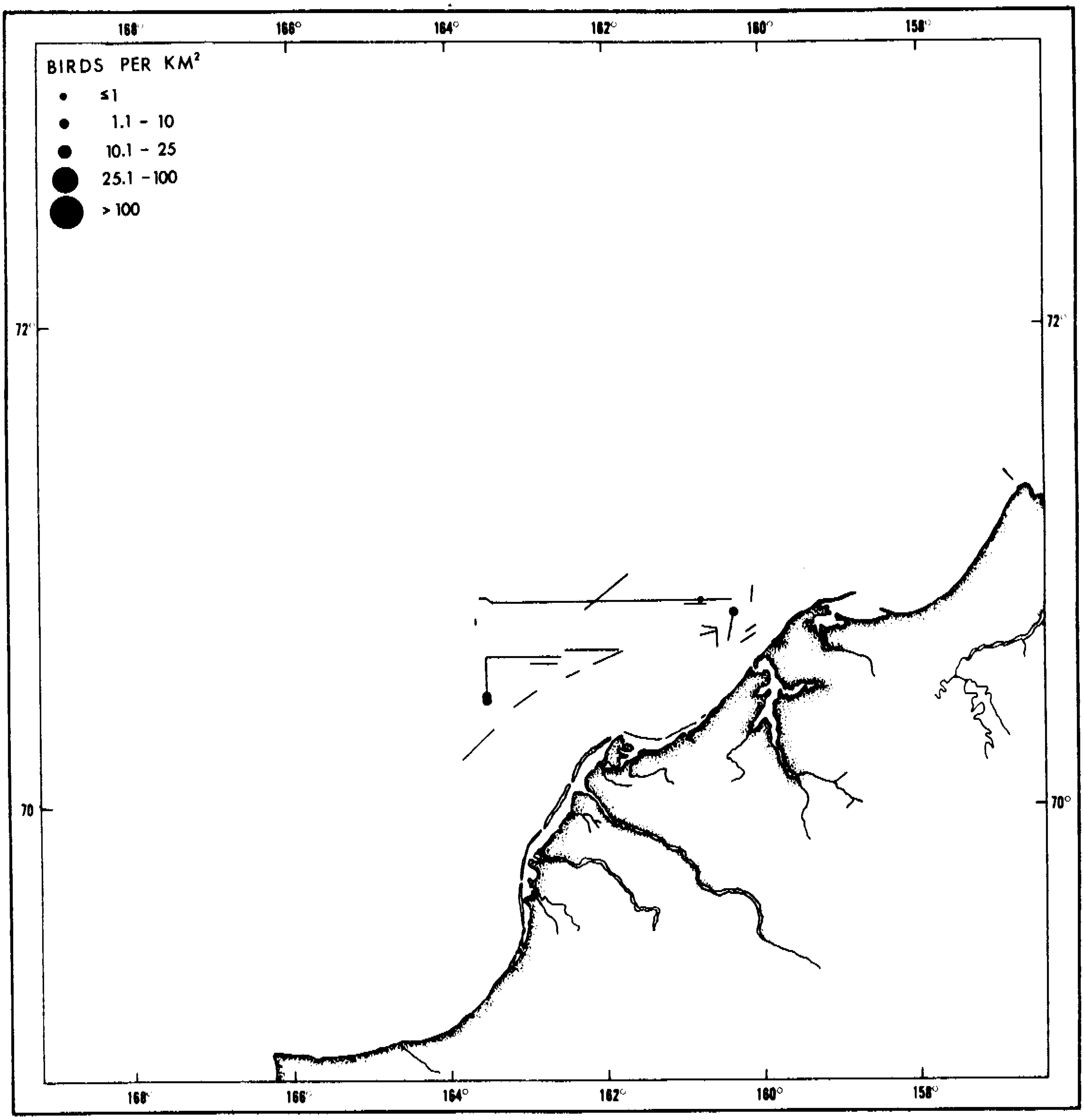


Figure 134. Distribution and abundance of loons in northern Chukchi Sea from 7 to 17 August 1976.

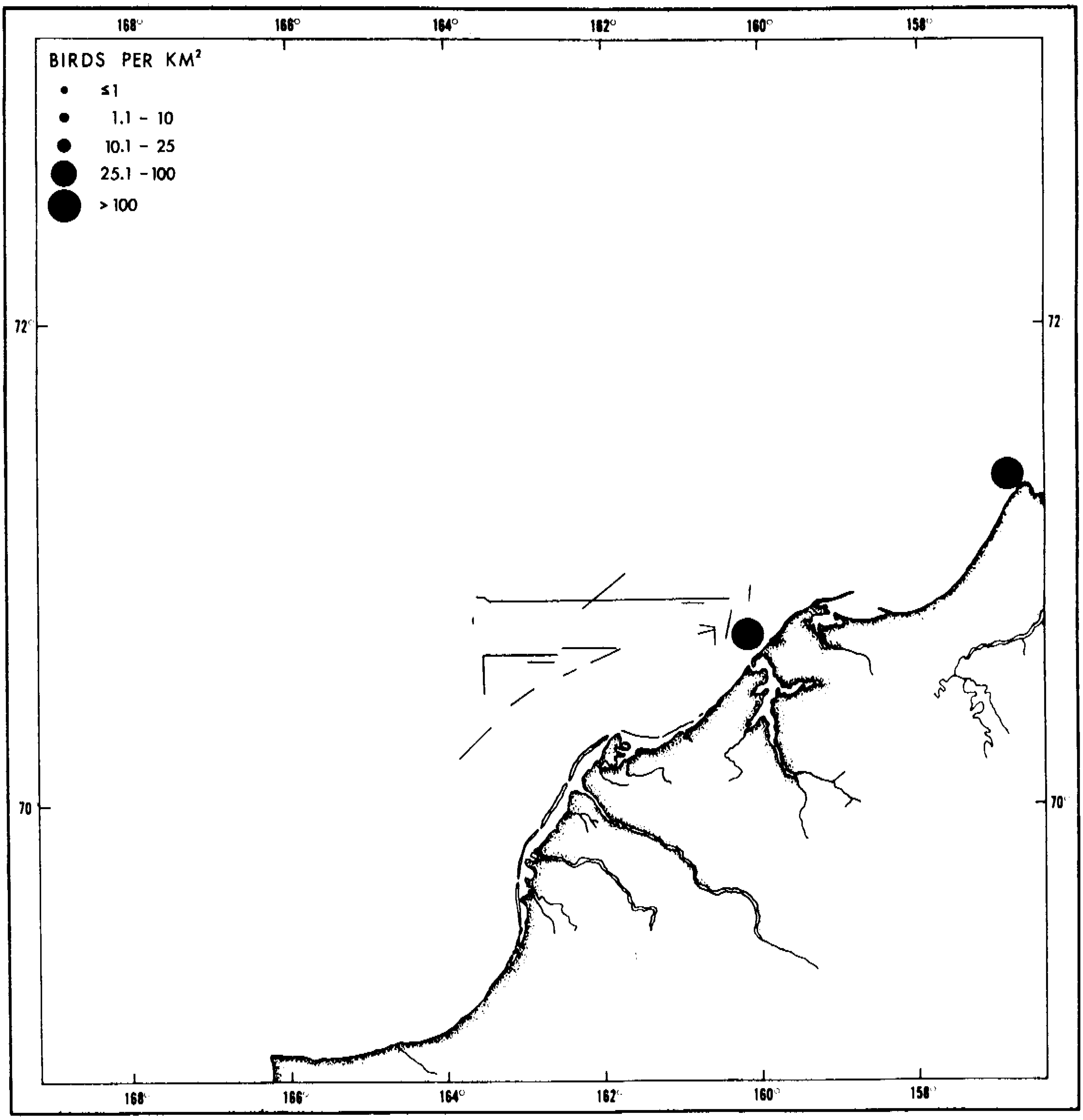


Figure 135. Distribution and abundance of eiders in northern Chukchi Sea from 7 to 17 August 1976.

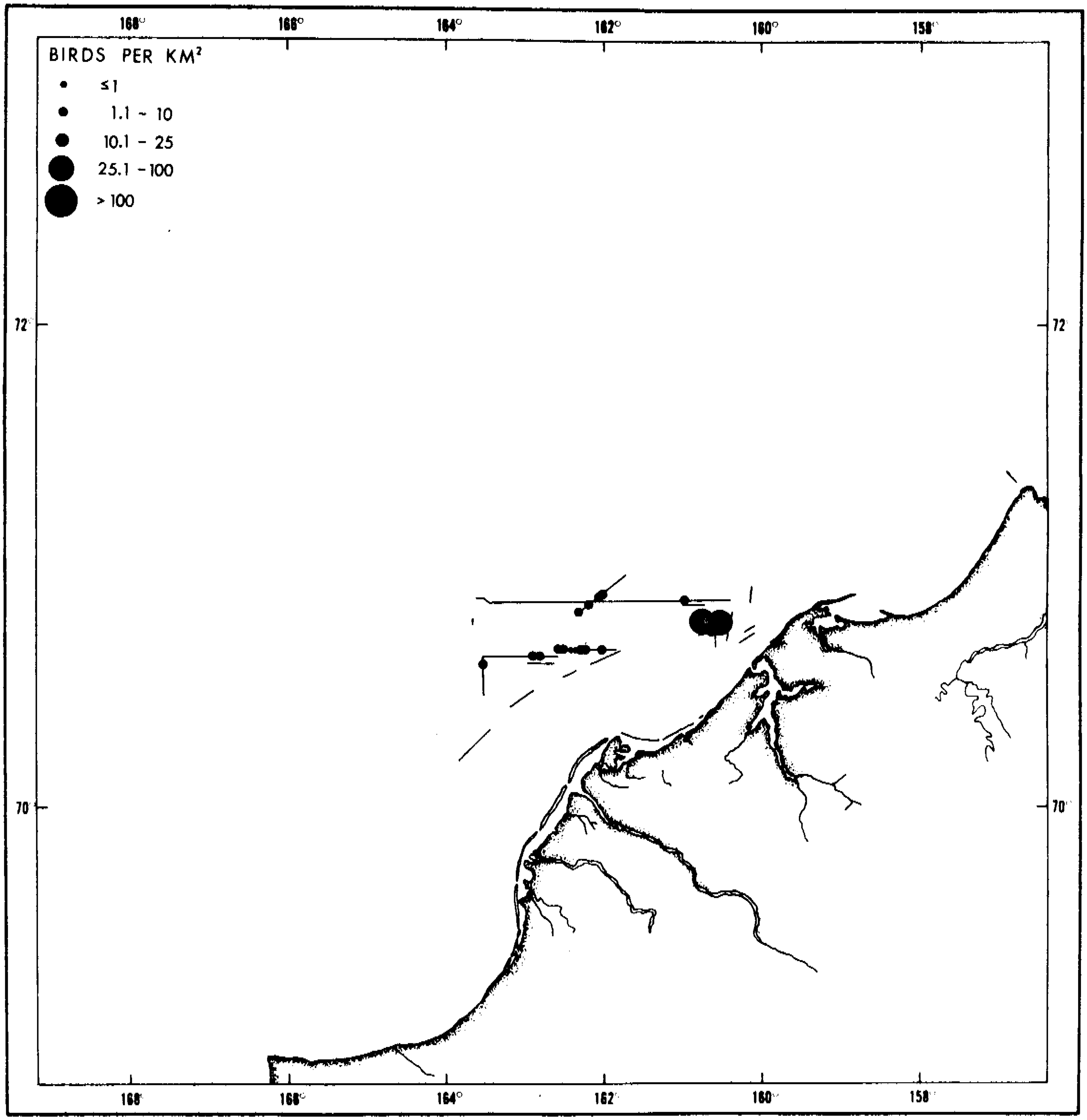


Figure 136. Distribution and abundance of phalaropes in northern Chukchi Sea from 7 to 17 August 1976.

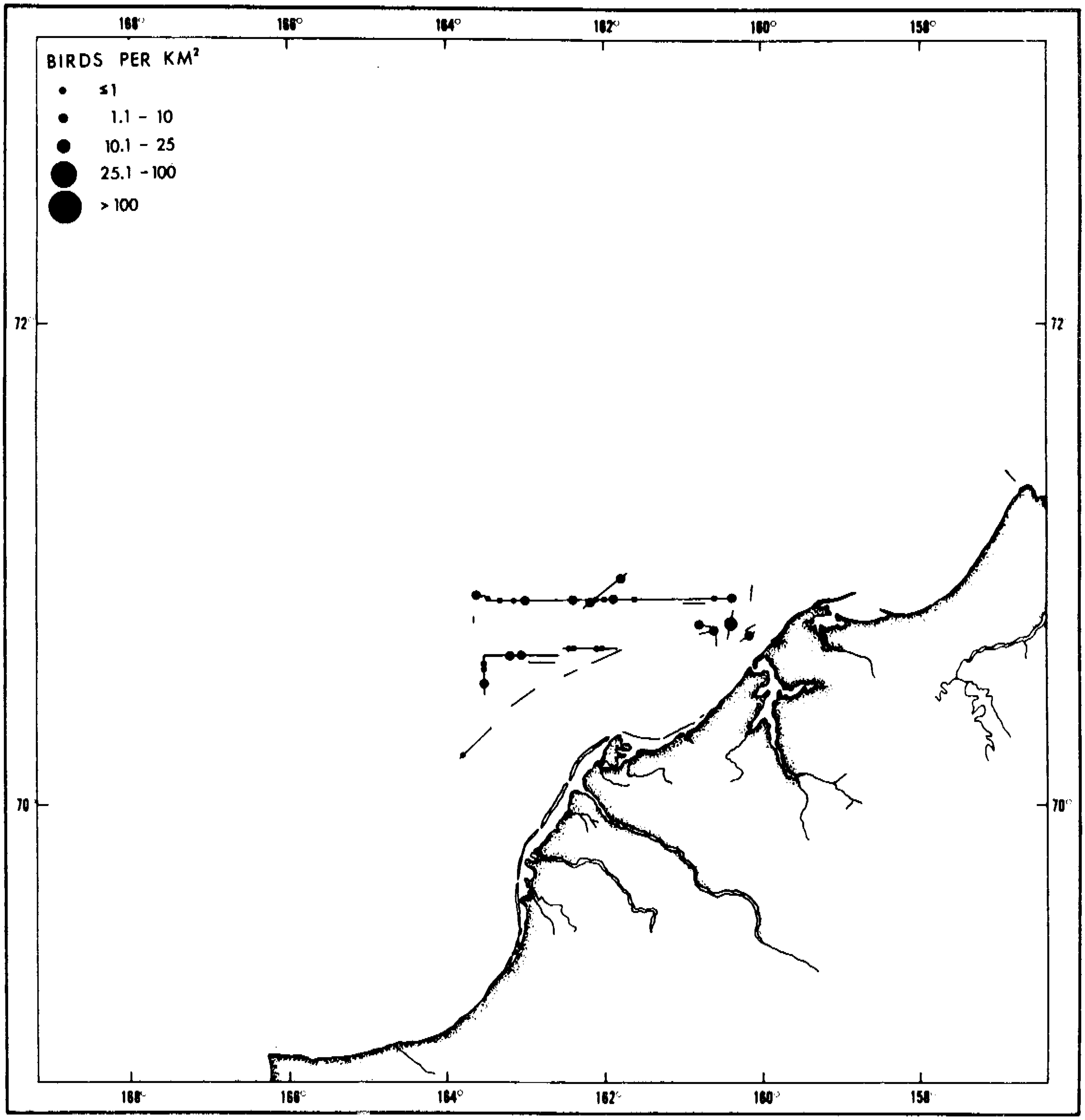


Figure 137. Distribution and abundance of jaegers in northern Chukchi Sea from 7 to 17 August 1976.

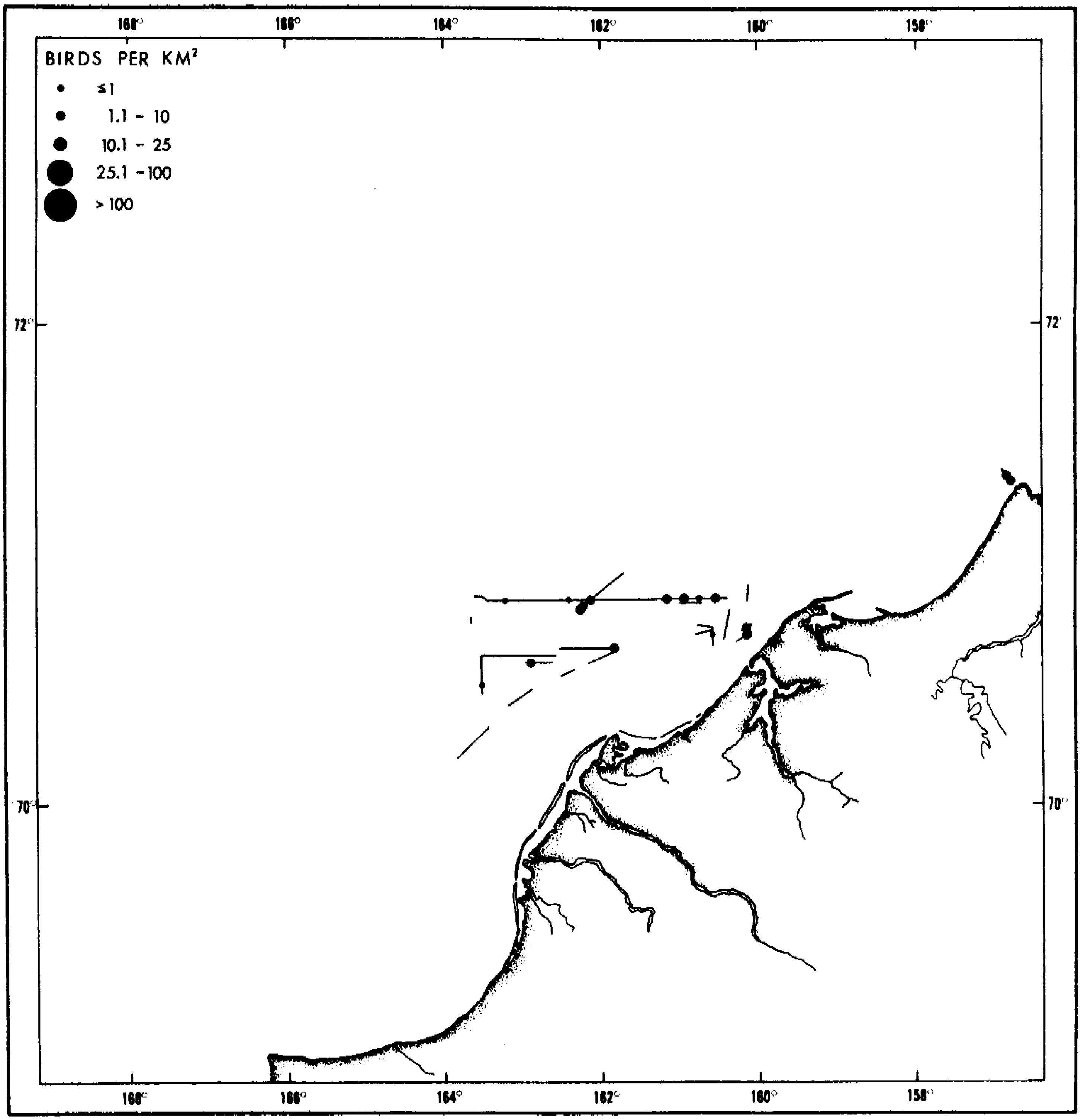


Figure 138. Distribution and abundance of Glaucous Gulls in northern Chukchi Sea from 7 to 17 August 1976.

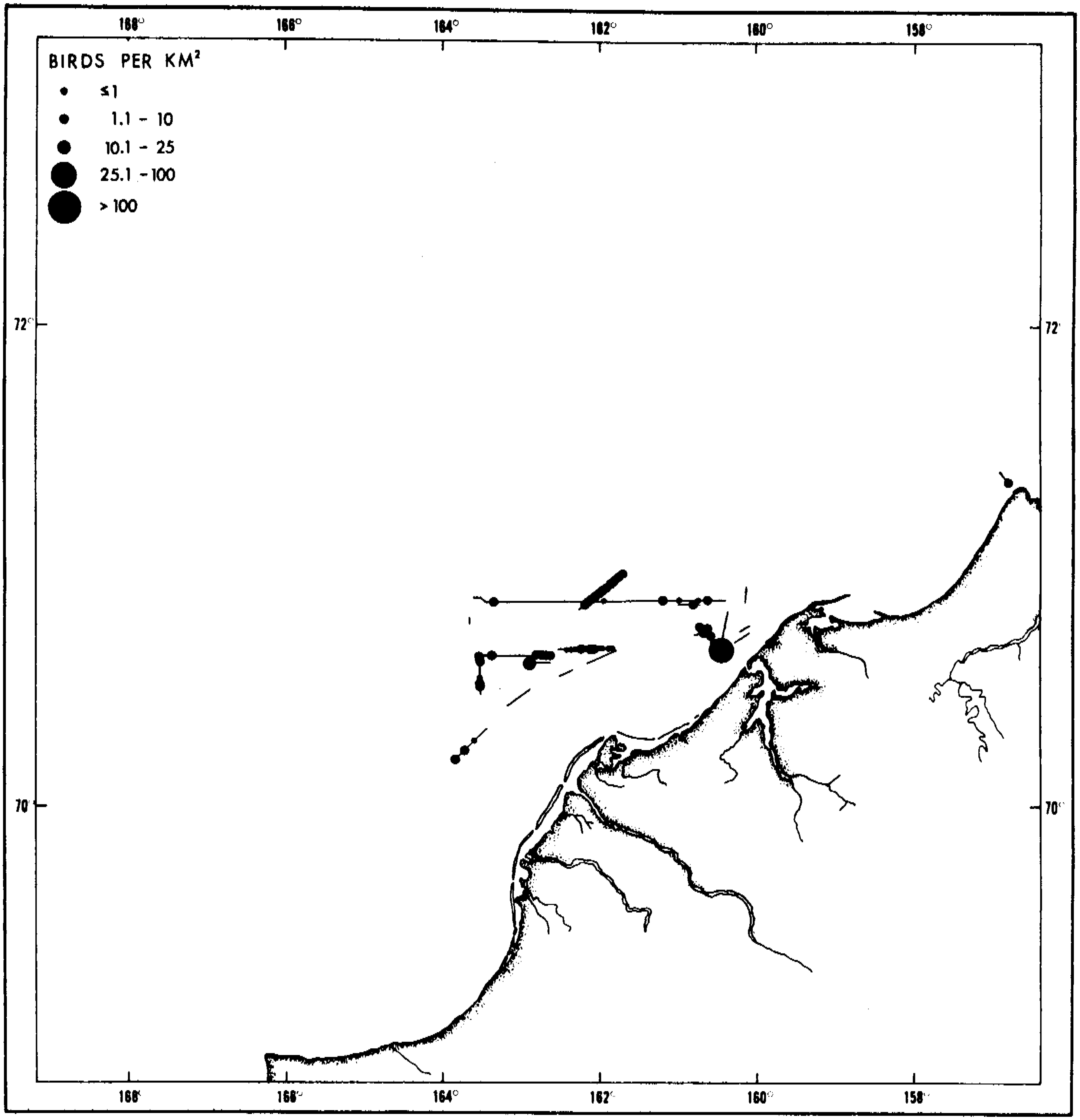


Figure 139. Distribution and abundance of Black-legged Kittiwakes in northern Chukchi Sea from 7 to 17 August 1976.

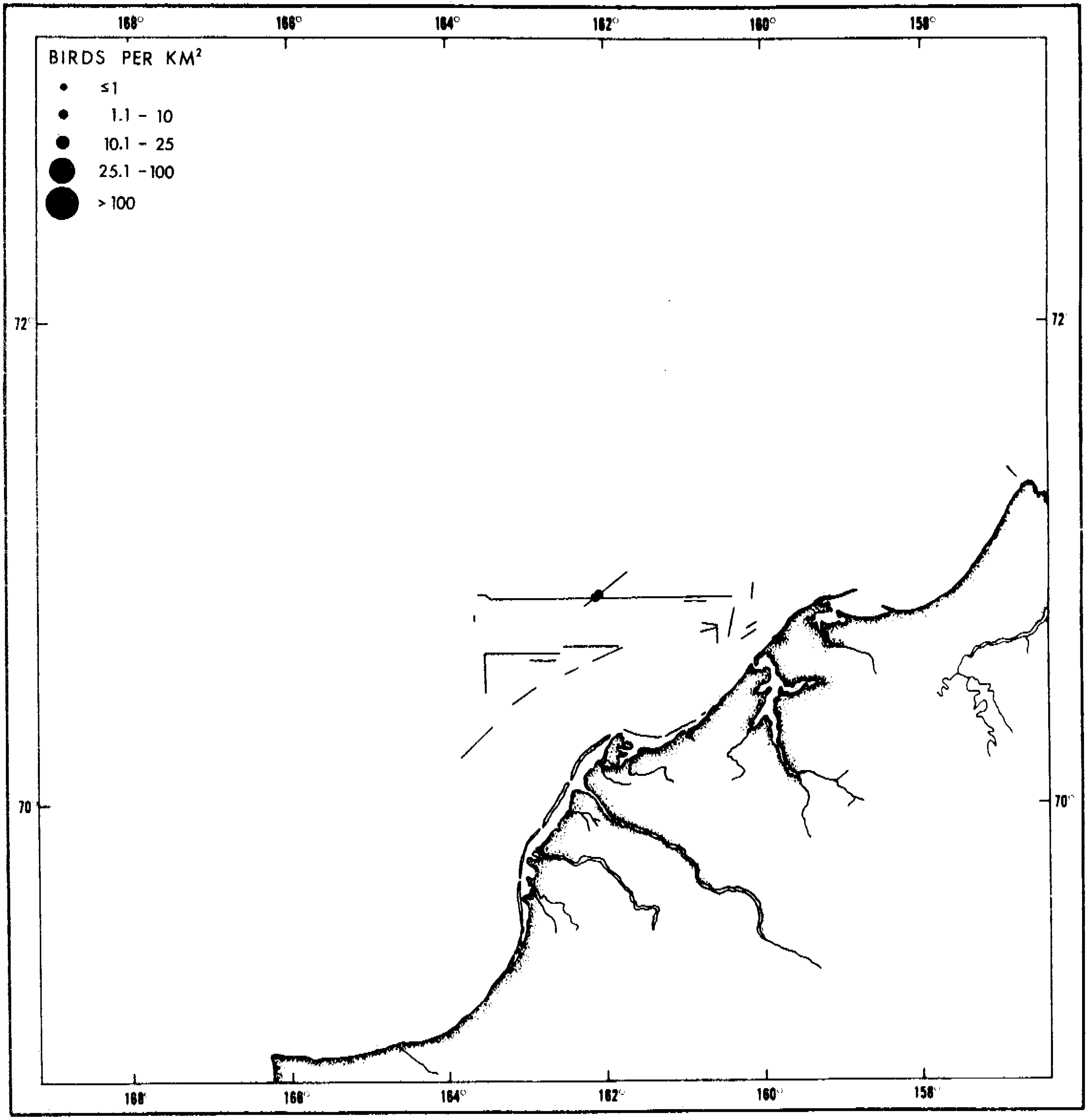


Figure 140. Distribution and abundance of Ross' Gulls in northern Chukchi Sea from 7 to 17 August 1976.

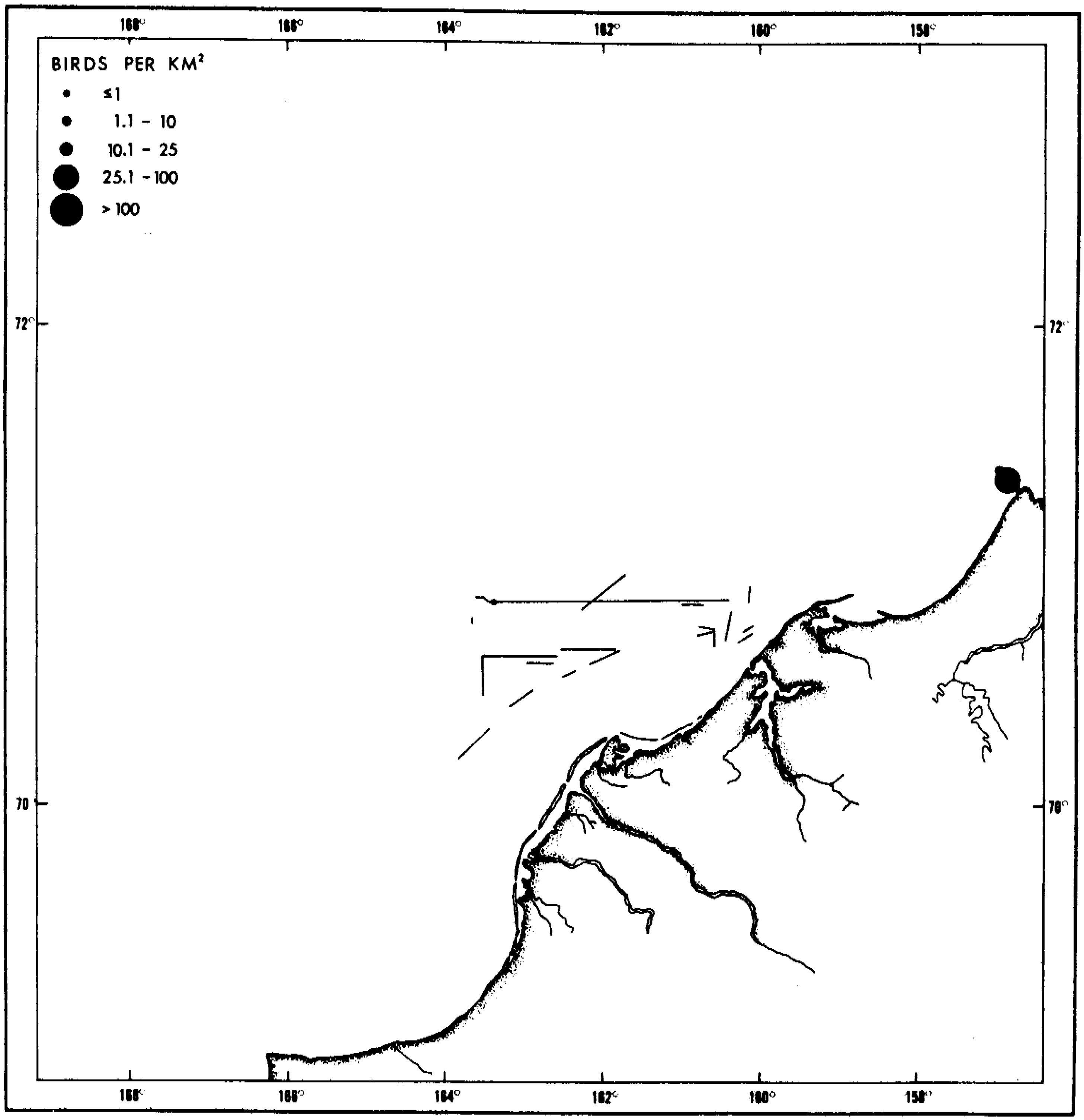


Figure 141. Distribution and abundance of Sabine's Gulls in northern Chukchi Sea from 7 to 17 August 1976.

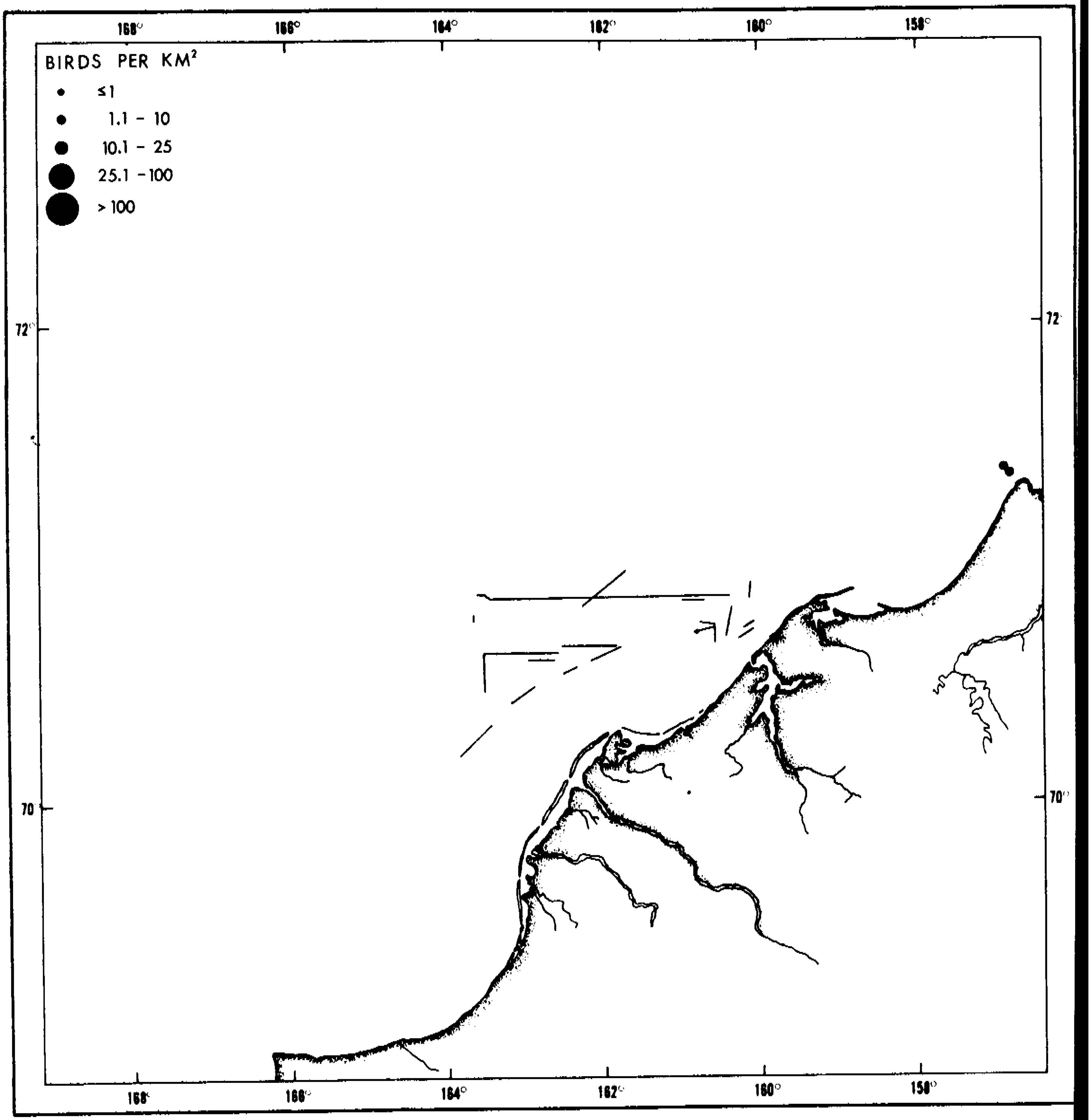


Figure 142. Distribution and abundance of Arctic Terns in northern Chukchi Sea from 7 to 17 August 1976.

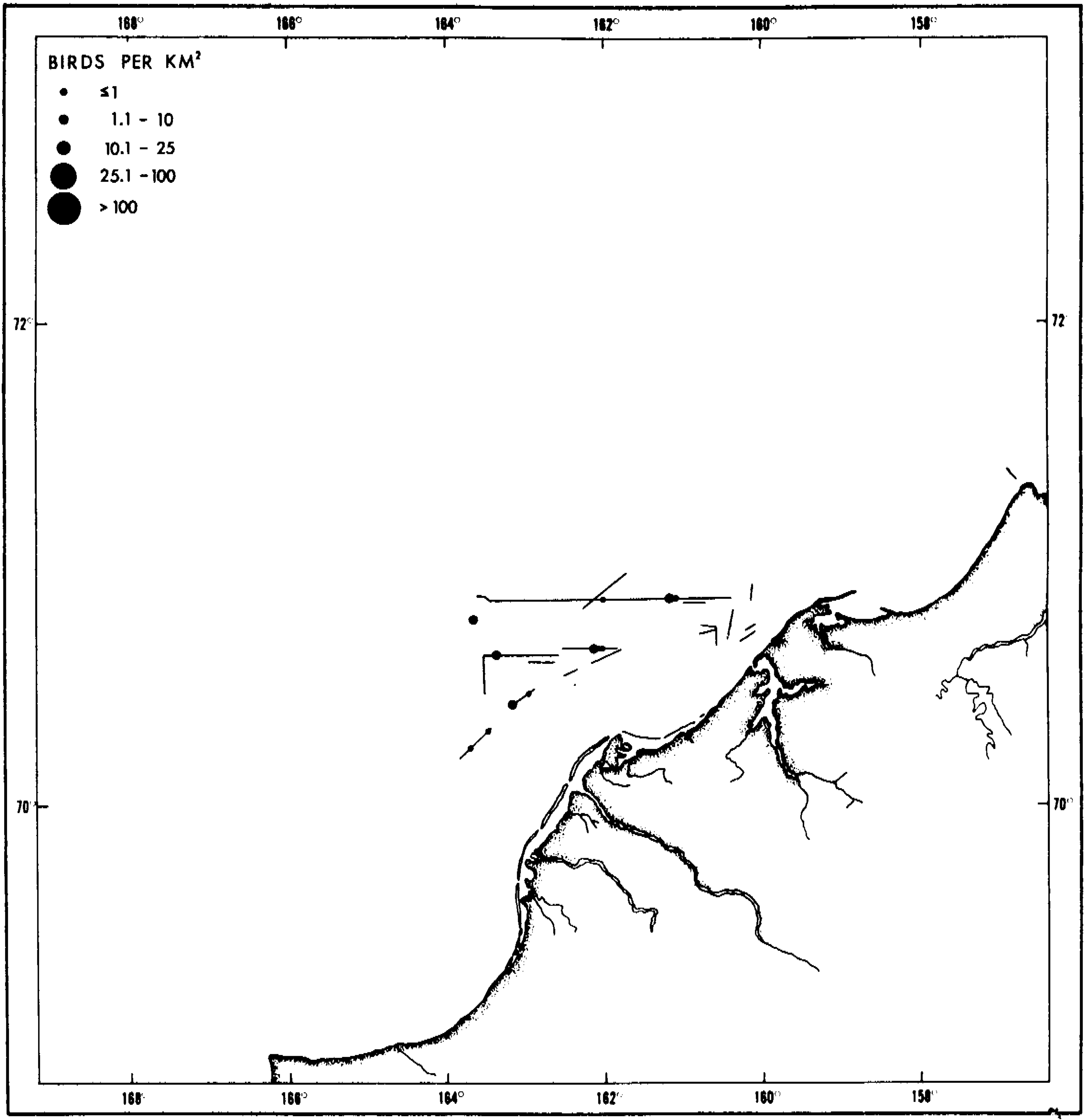


Figure 143. Distribution and abundance of Common Murres in northern Chukchi Sea from 7 to 17 August 1976.

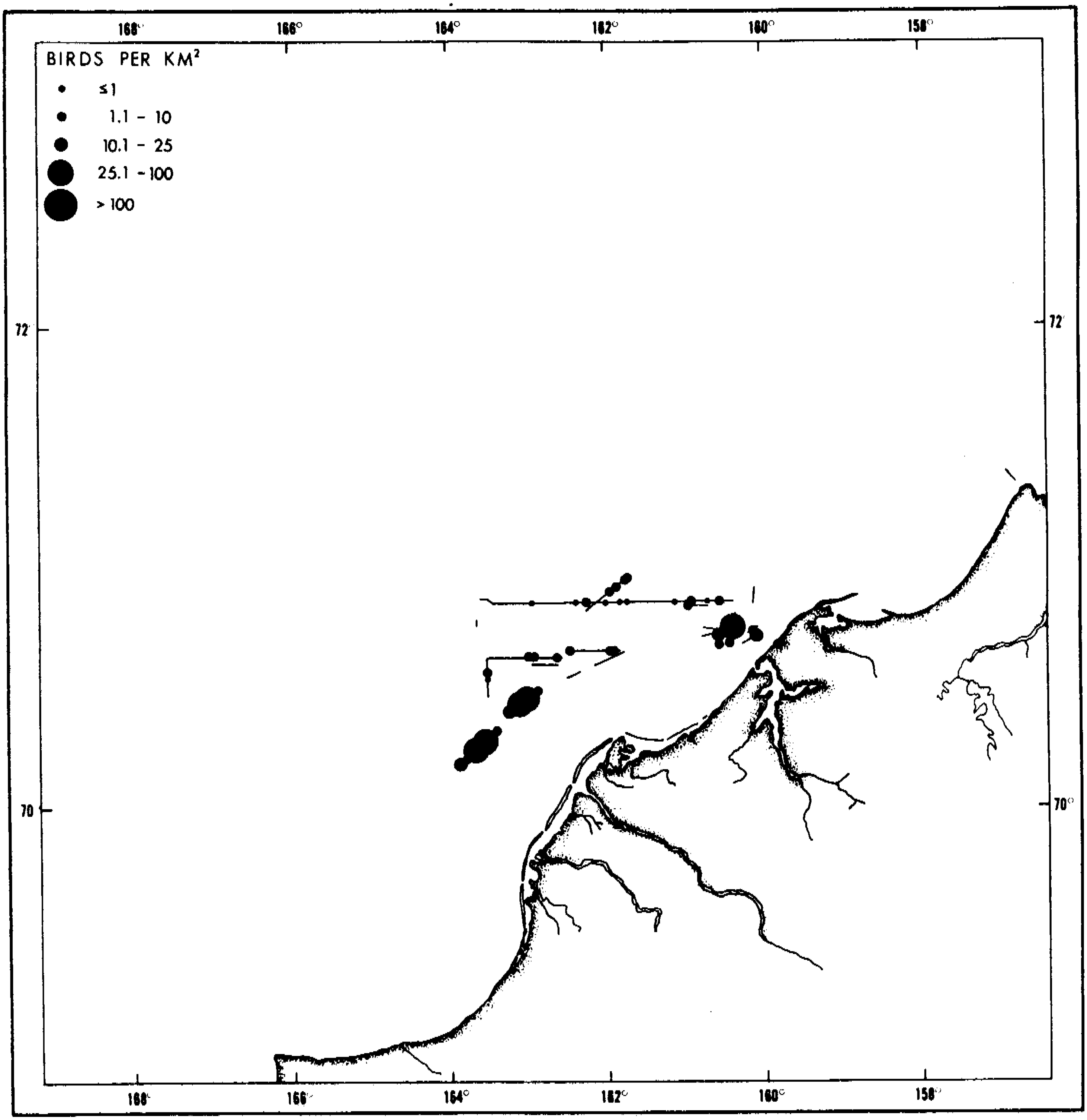


Figure 144. Distribution and abundance of Thick-billed Murres in northern Chukchi Sea from 7 to 17 August 1976.

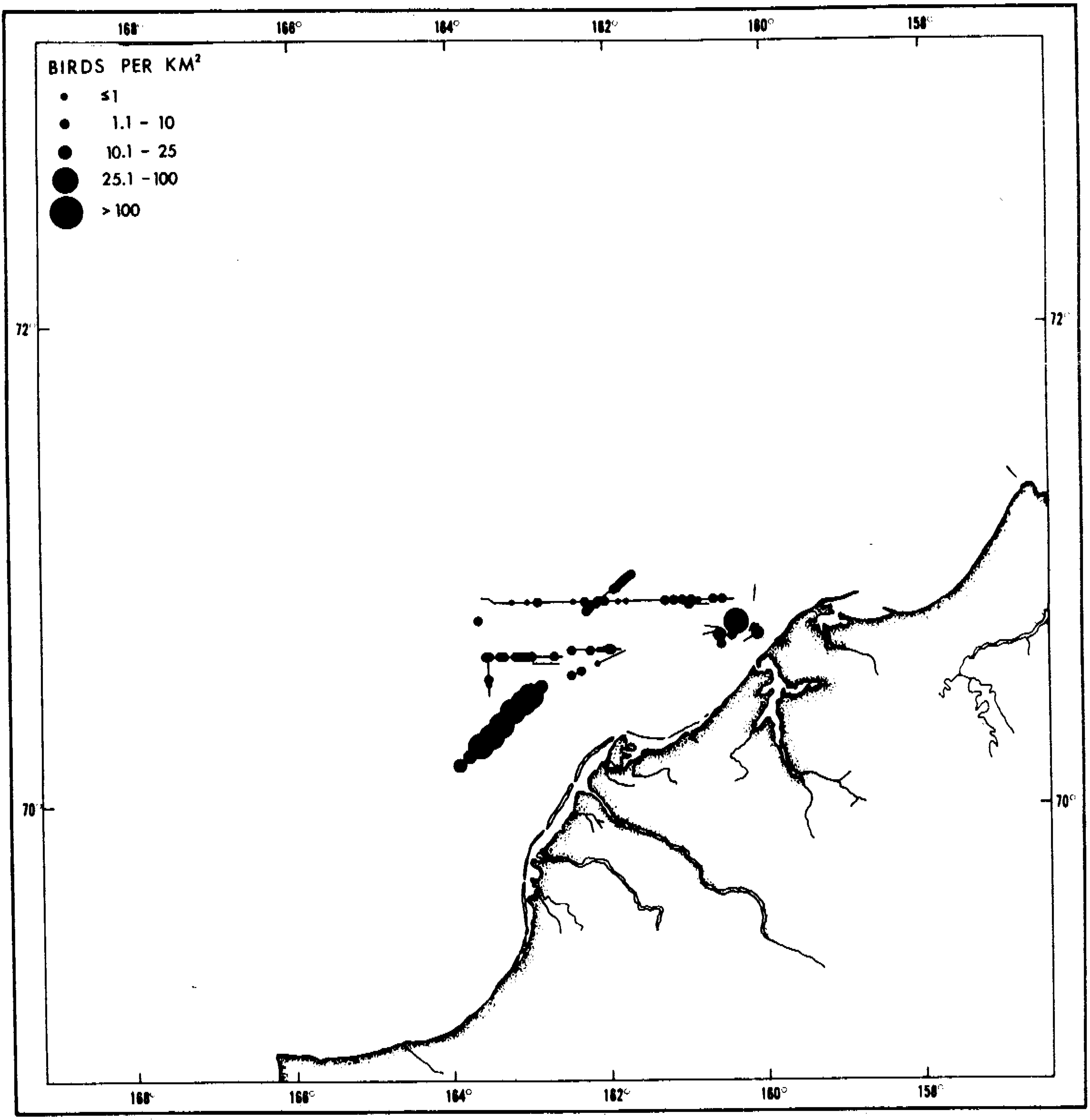


Figure 145. Distribution and abundance of all murres in northern Chukchi Sea from 7 to 17 August 1976.

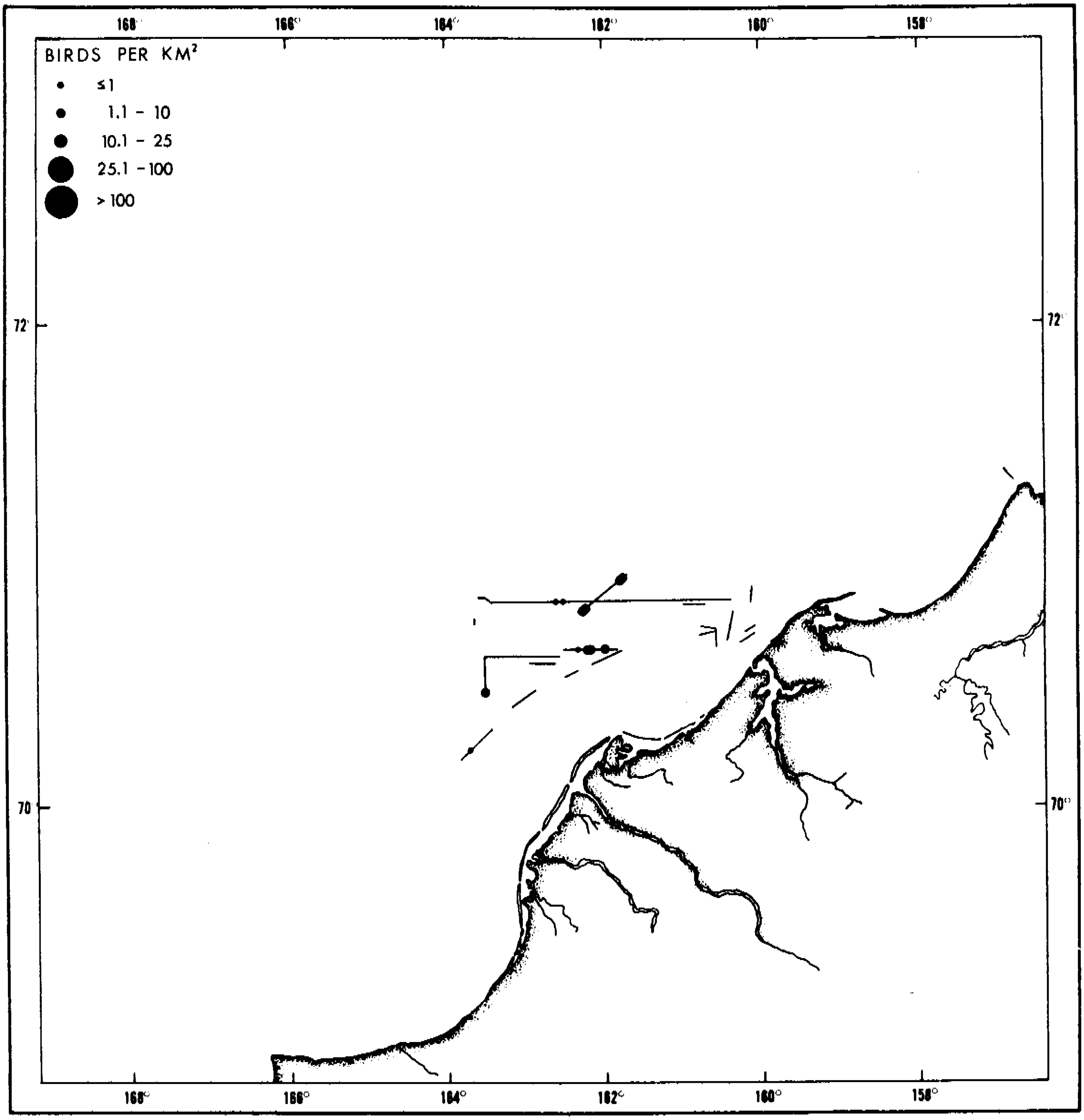


Figure 146. Distribution and abundance of Black Guillemots in northern Chukchi Sea from 7 to 17 August 1976.

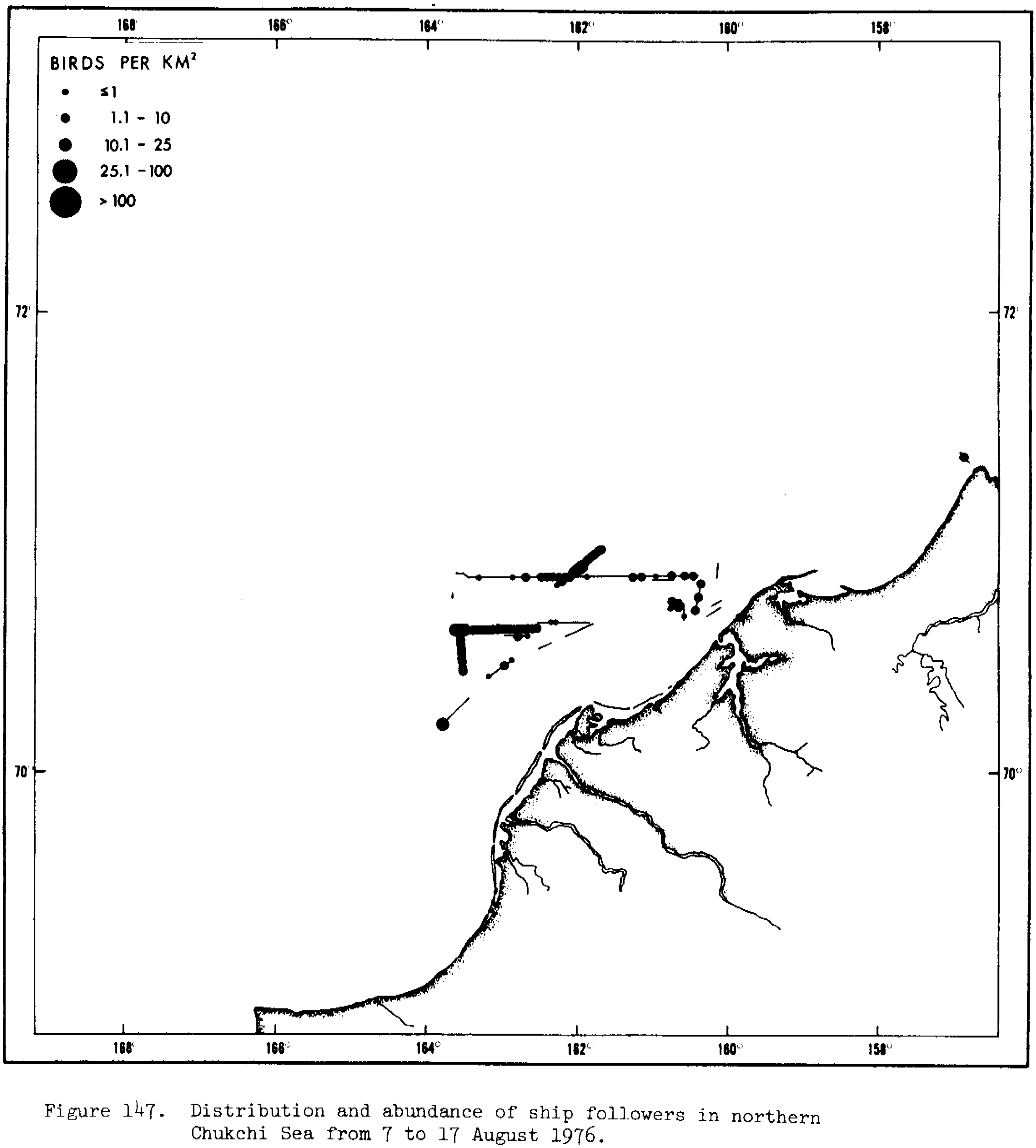


Figure 147. Distribution and abundance of ship followers in northern Chukchi Sea from 7 to 17 August 1976.

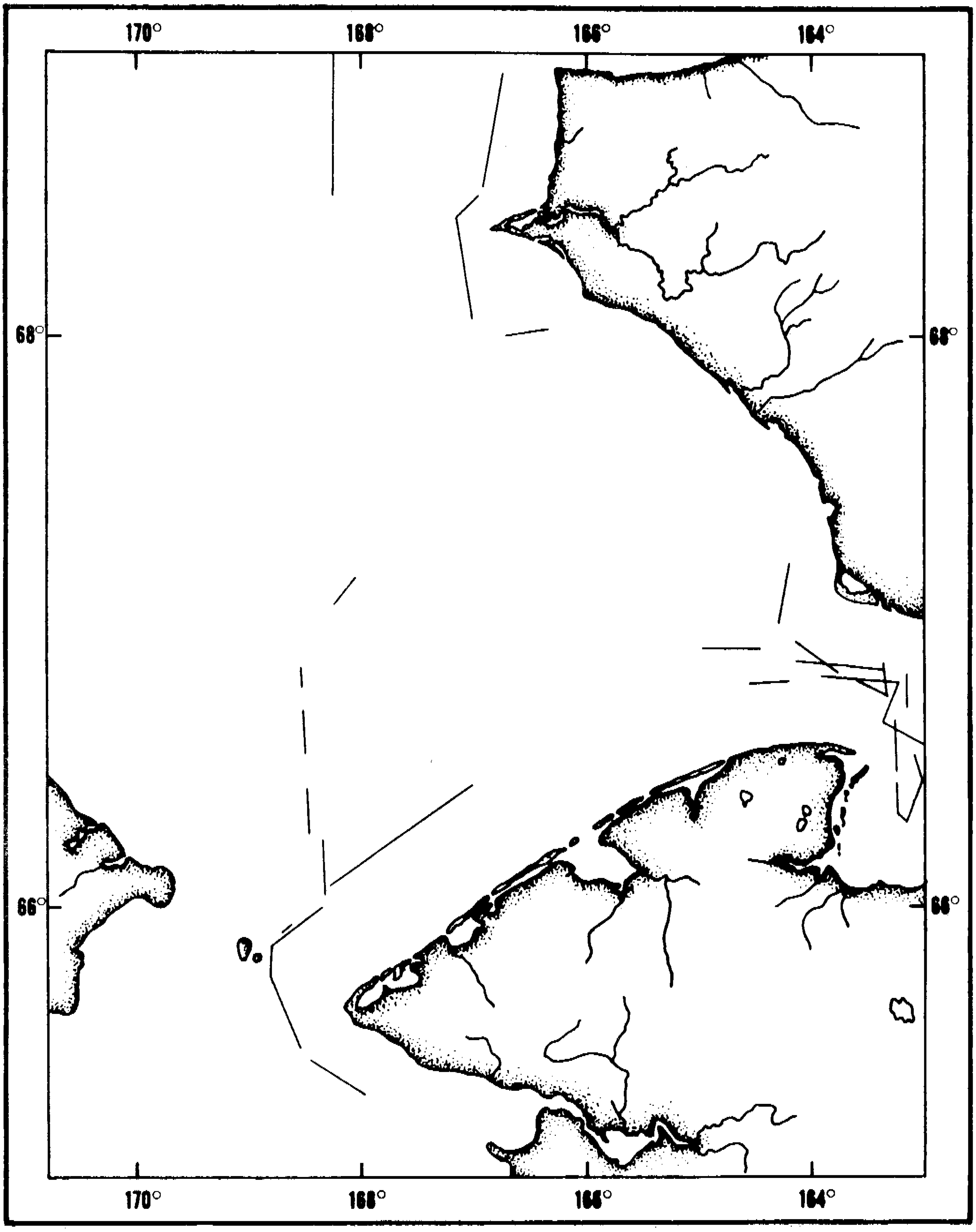


Figure 148. Cruise track during periods of observation in Bering Strait and southern Chukchi Sea from 15 to 20 September and on 22 September 1976.

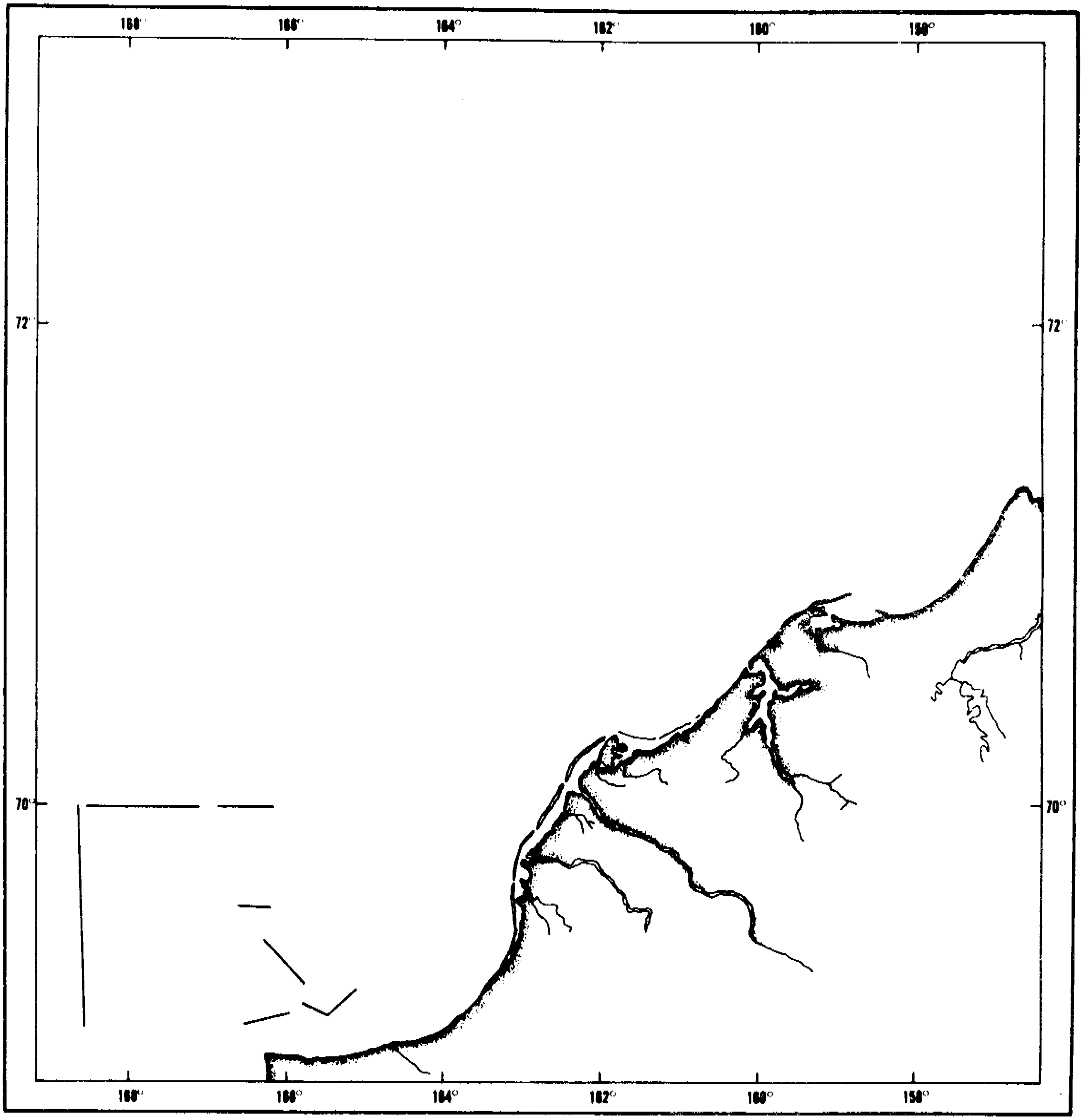


Figure 149. Cruise track during periods of observation in northern Chukchi Sea from 20 to 22 September 1976.

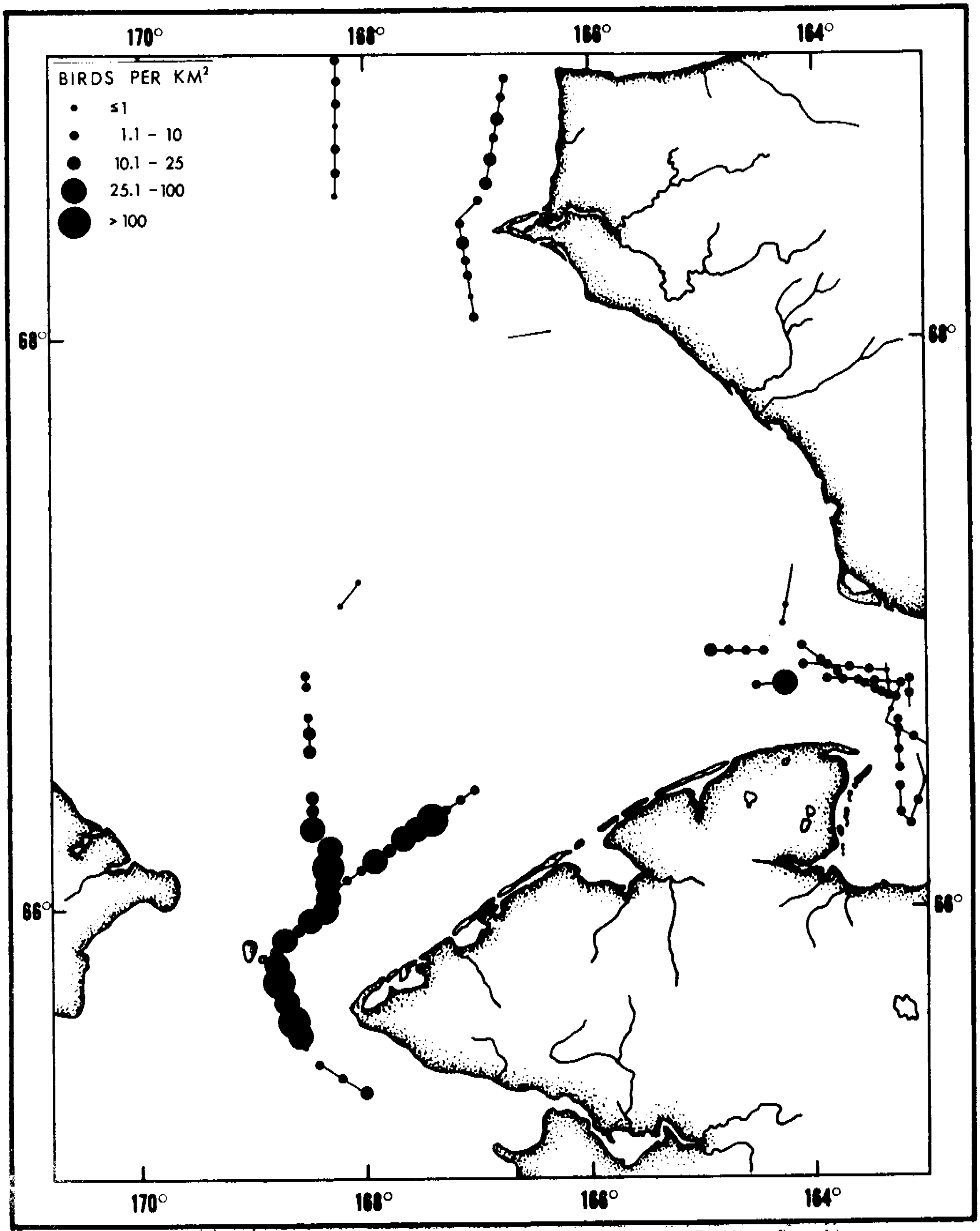


Figure 150. Distribution and abundance of seabirds in Bering Strait and southern Chukchi Sea from 15 to 20 September and on 22 September 1976.

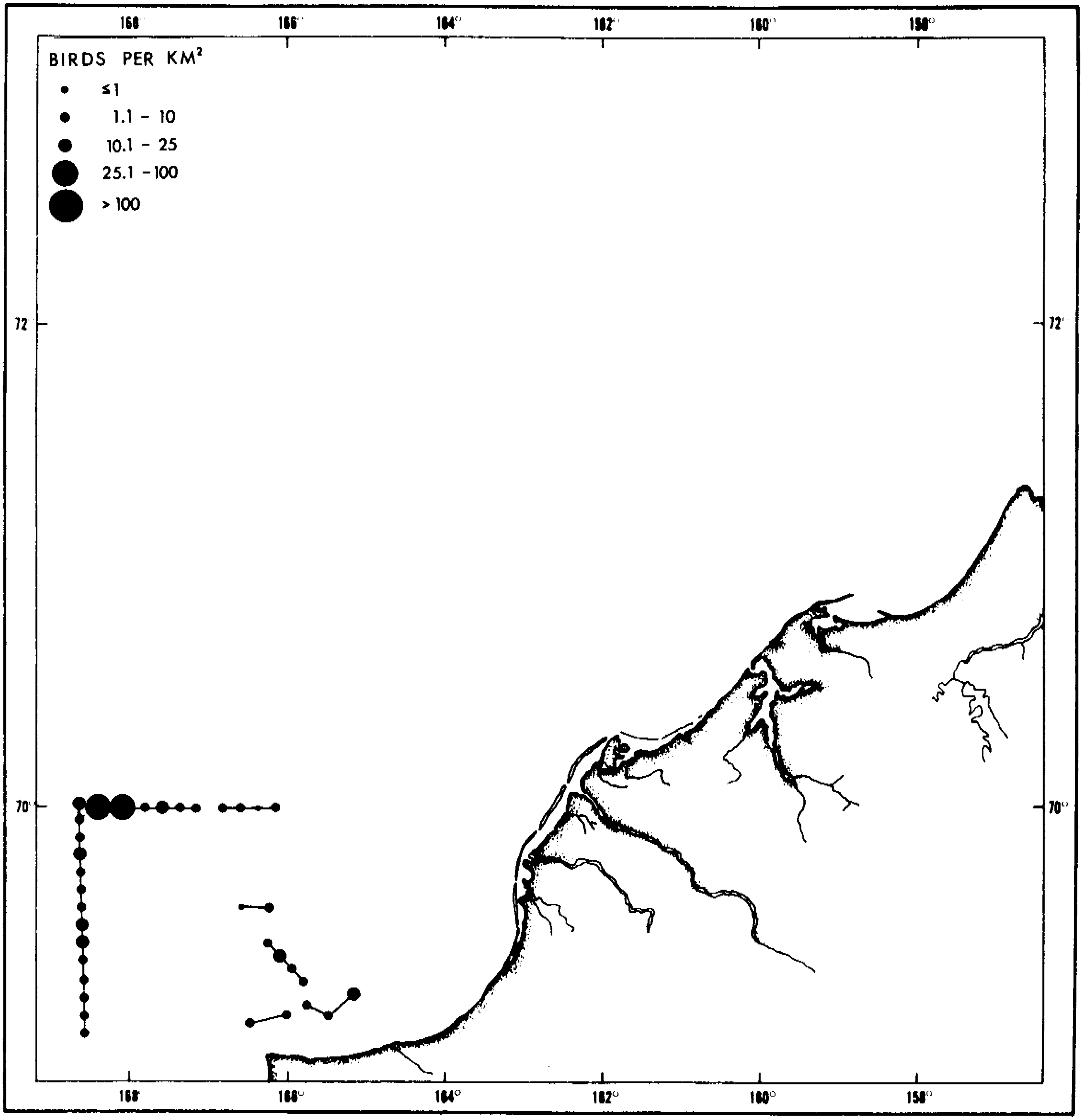


Figure 151. Distribution and abundance of seabirds in northern Chukchi Sea from 20 to 22 September 1976.

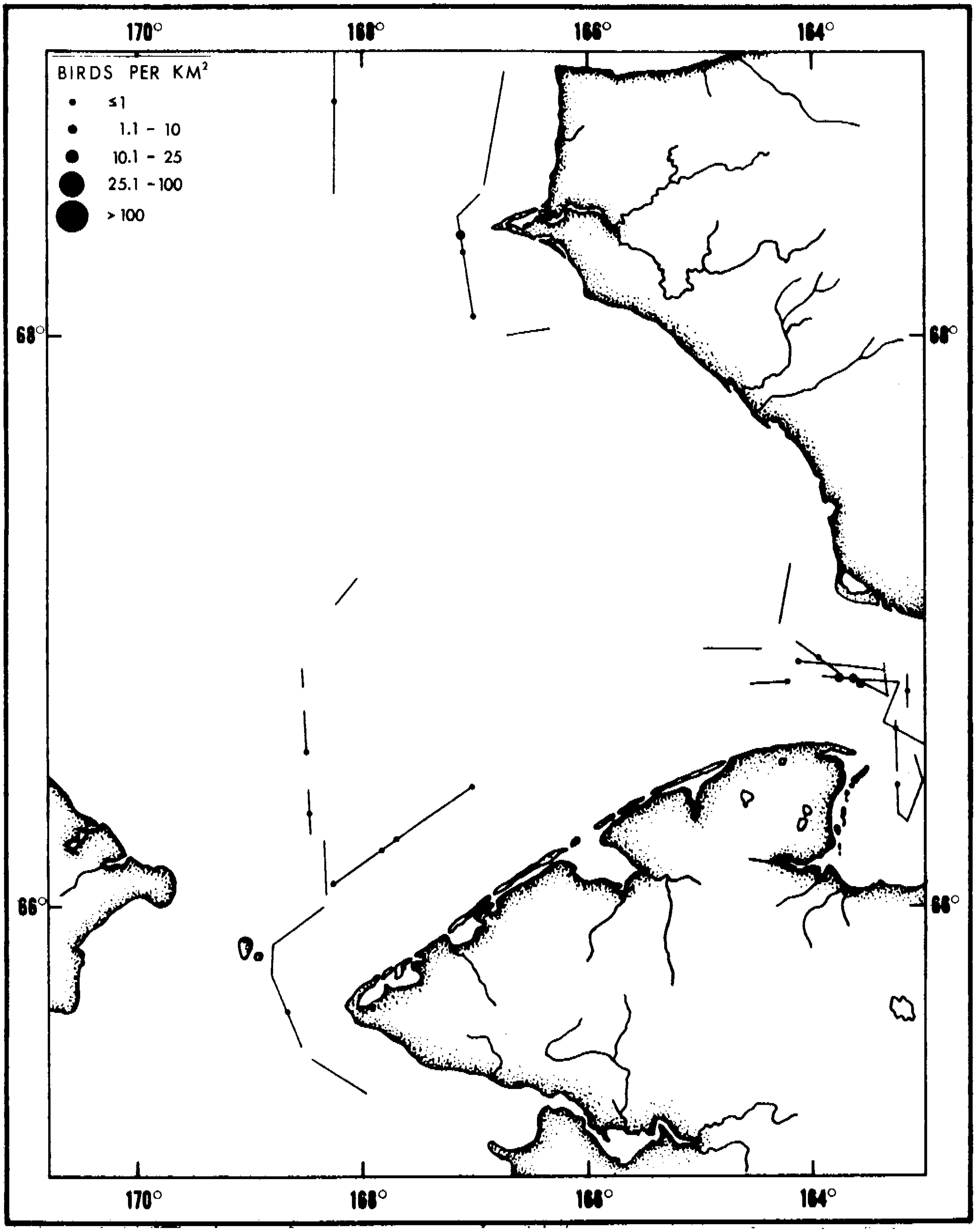


Figure 152. Distribution and abundance of Arctic Loons in Bering Strait and southern Chukchi Sea from 15 to 20 September and on 22 September 1976.

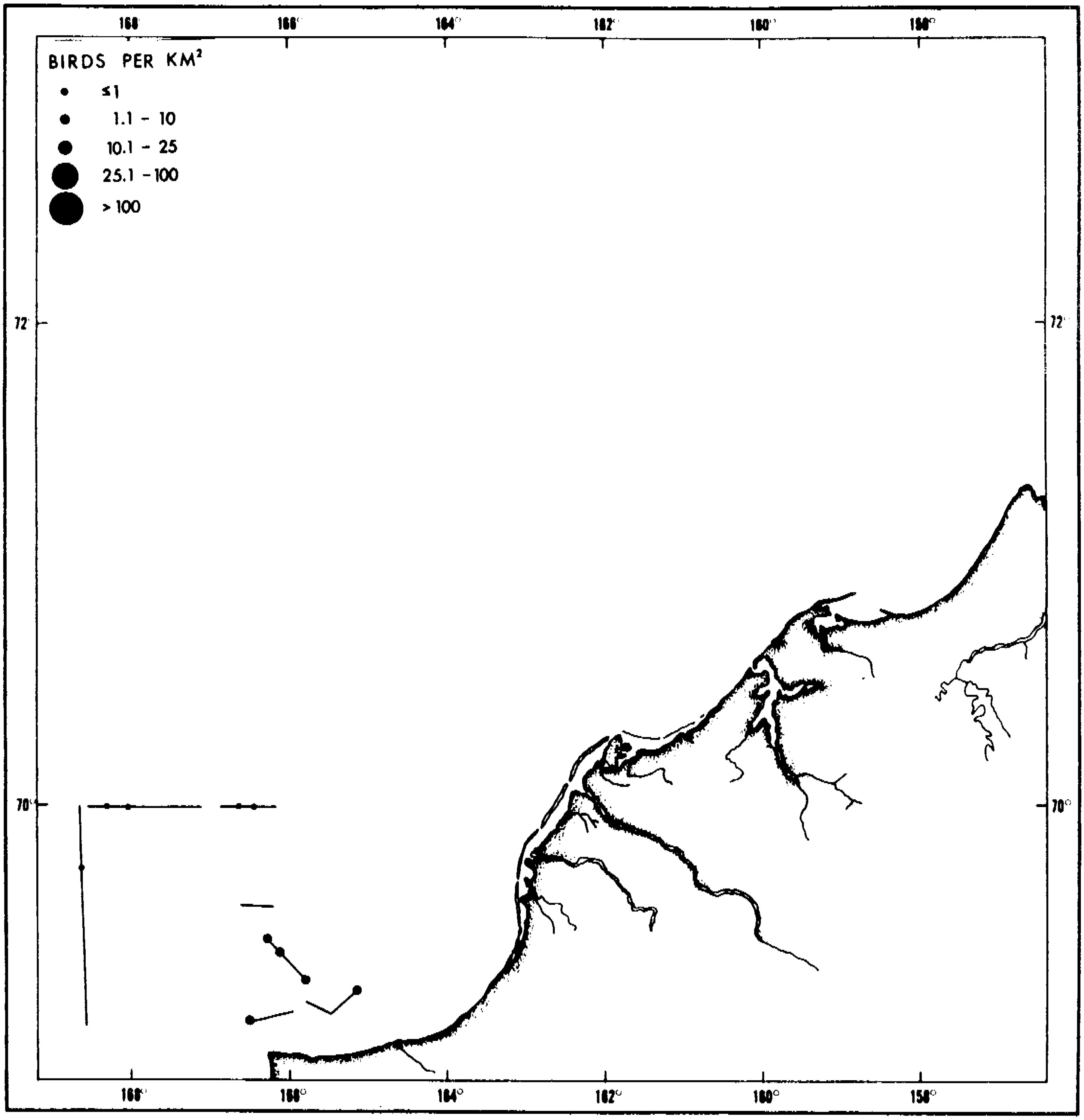


Figure 153. Distribution and abundance of Arctic Loons in northern Chukchi Sea from 20 to 22 September 1976.

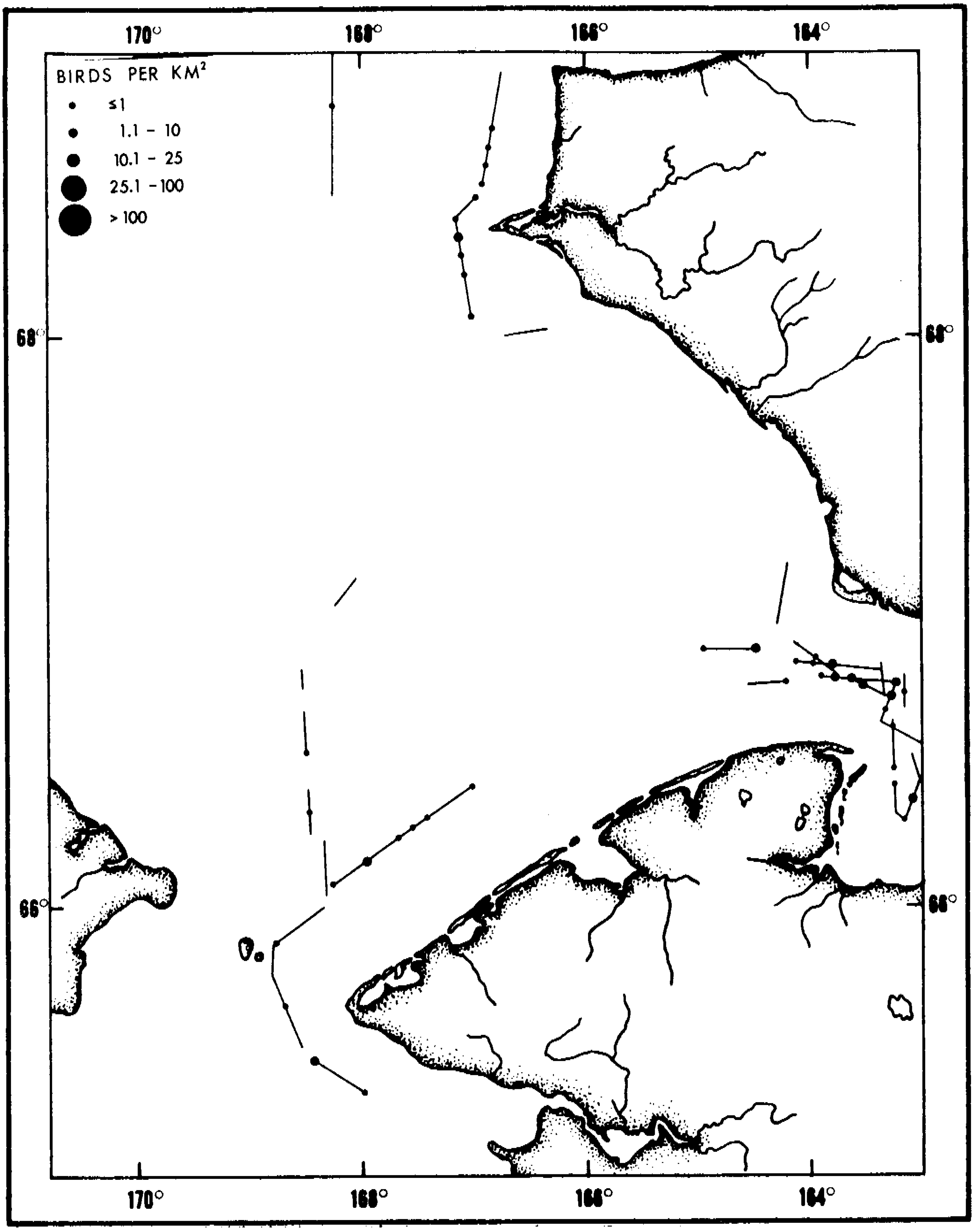


Figure 154. Distribution and abundance of all loons in Bering Strait and southern Chukchi Sea from 15 to 20 September and on 22 September 1976.

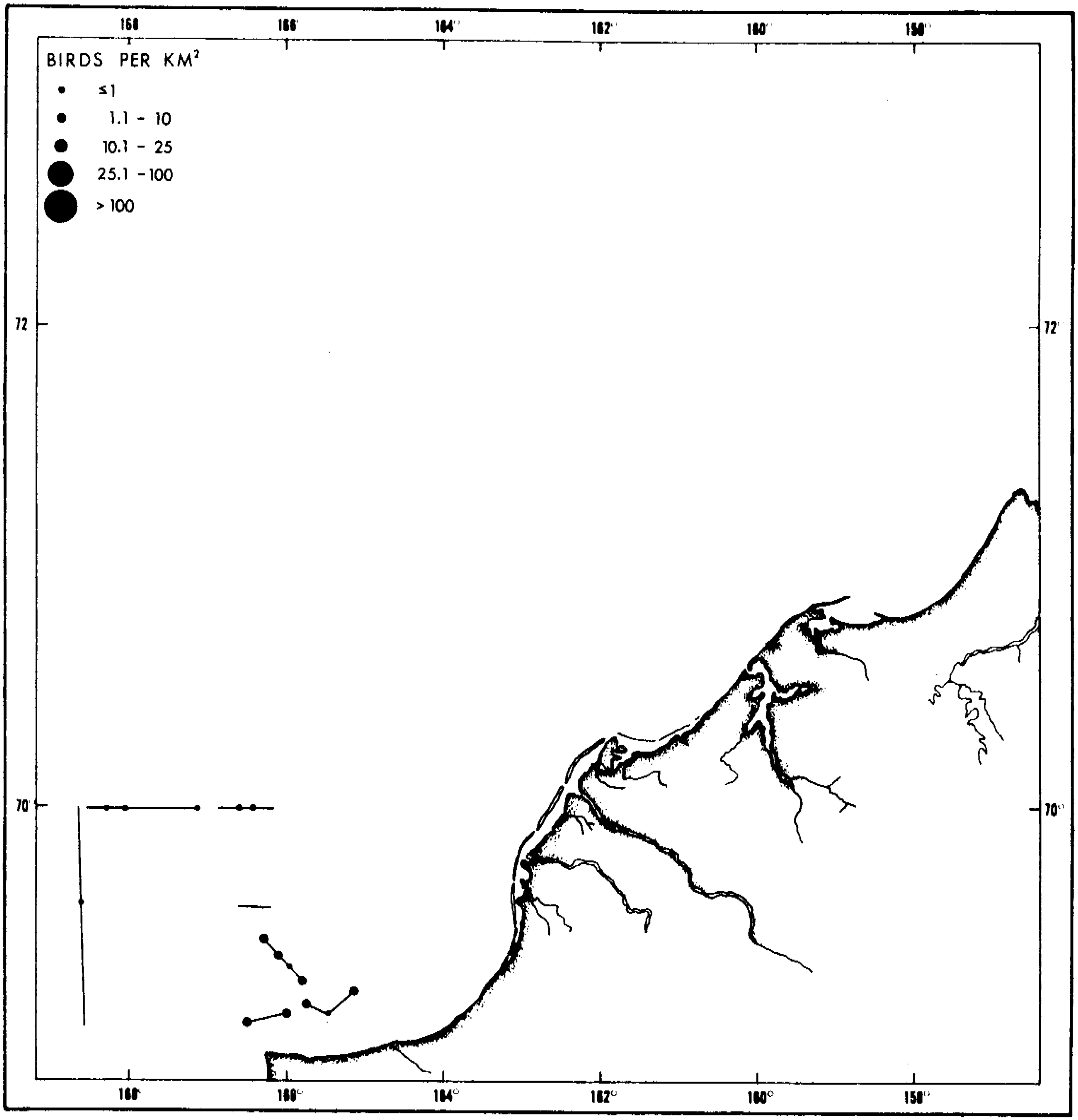


Figure 155. Distribution and abundance of all loons in northern Chukchi Sea from 20 to 22 September 1976.

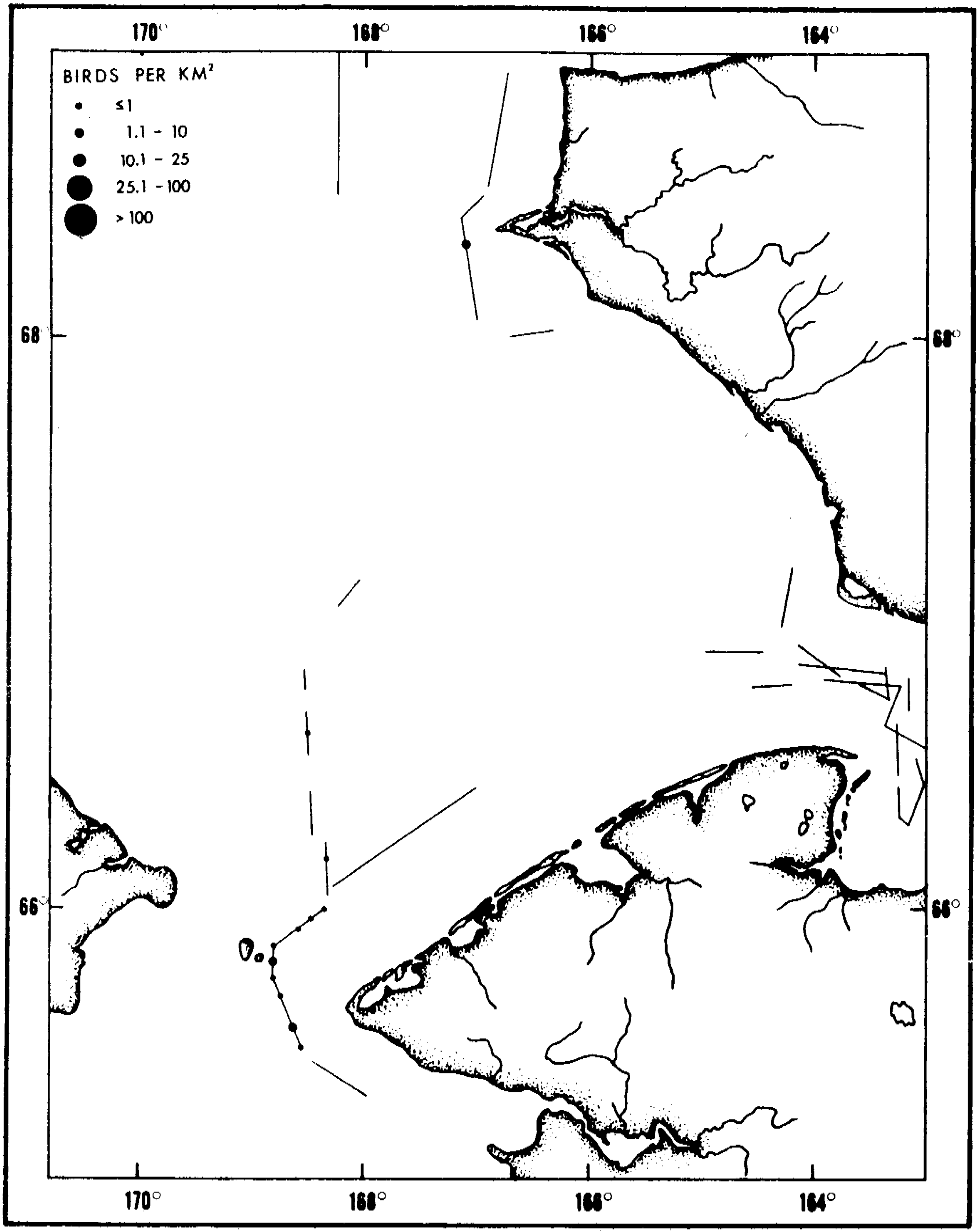


Figure 156. Distribution and abundance of Northern Fulmars in Bering Strait and southern Chukchi Sea from 15 to 20 September and on 22 September 1976.

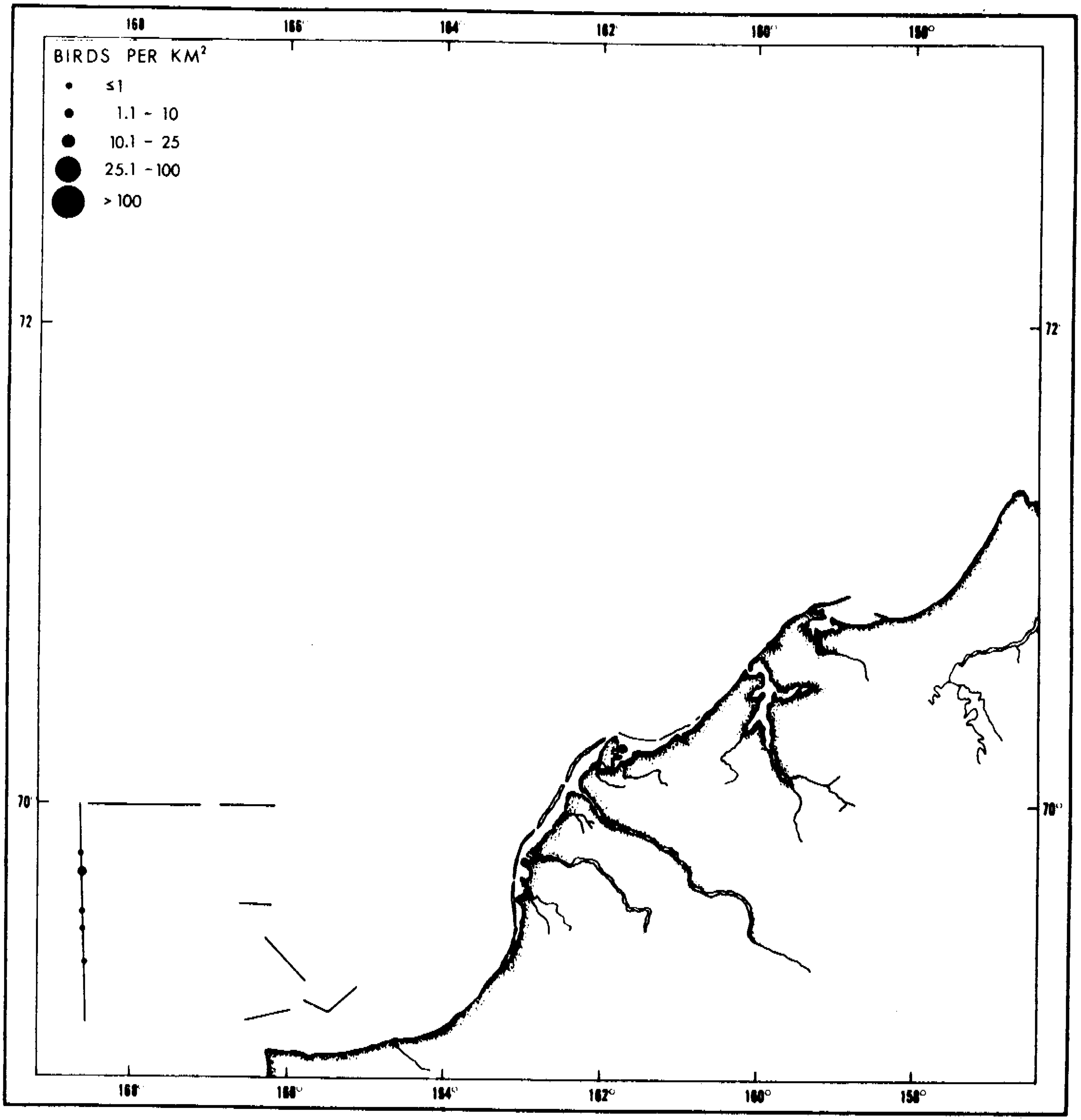


Figure 157. Distribution and abundance of Northern Fulmars in northern Chukchi Sea from 20 to 22 September 1976.

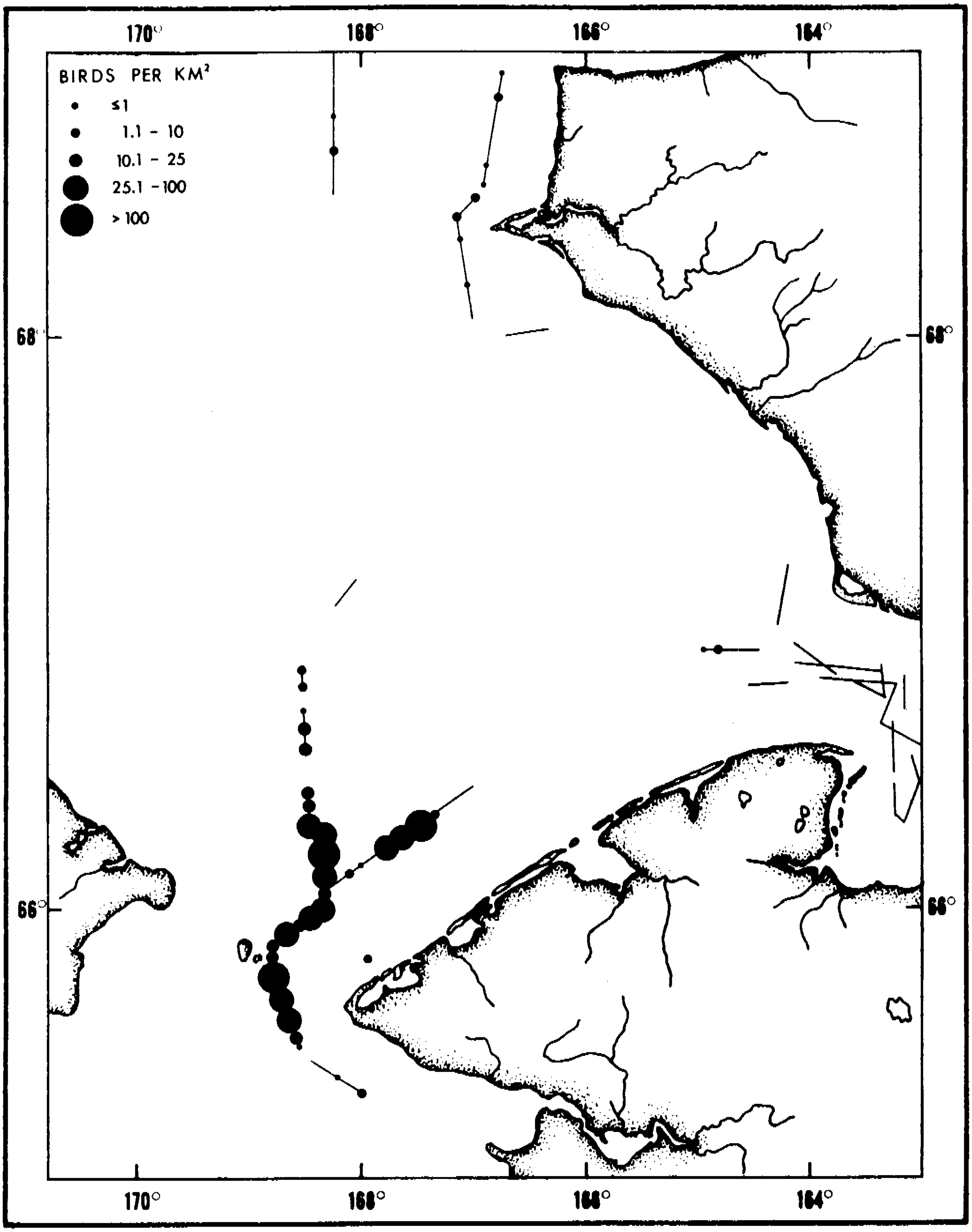


Figure 158. Distribution and abundance of shearwaters in Bering Strait and southern Chukchi Sea from 15 to 20 September and on 22 September 1976.

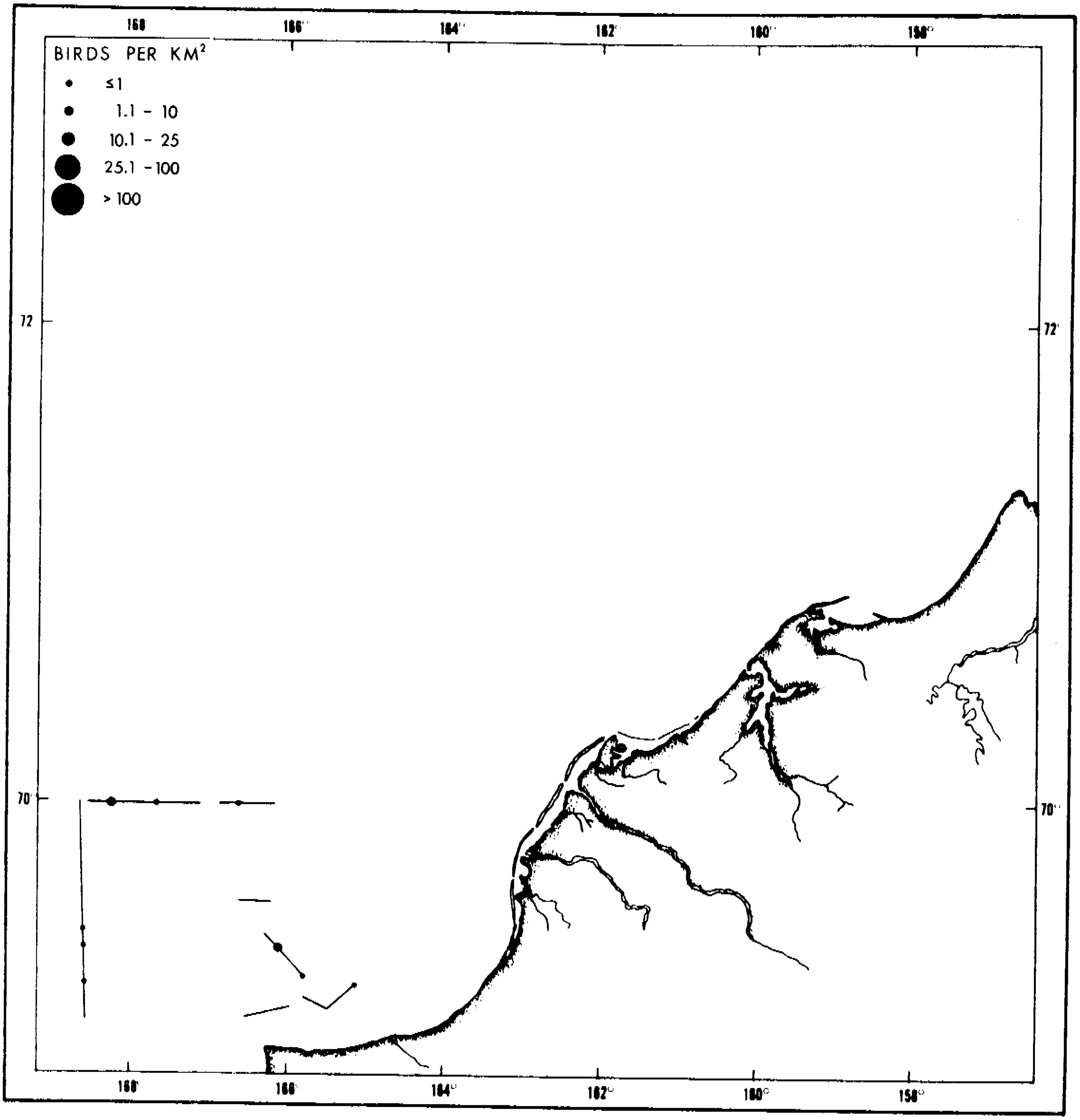


Figure 159. Distribution and abundance of shearwaters in northern Chukchi Sea from 20 to 22 September 1976.

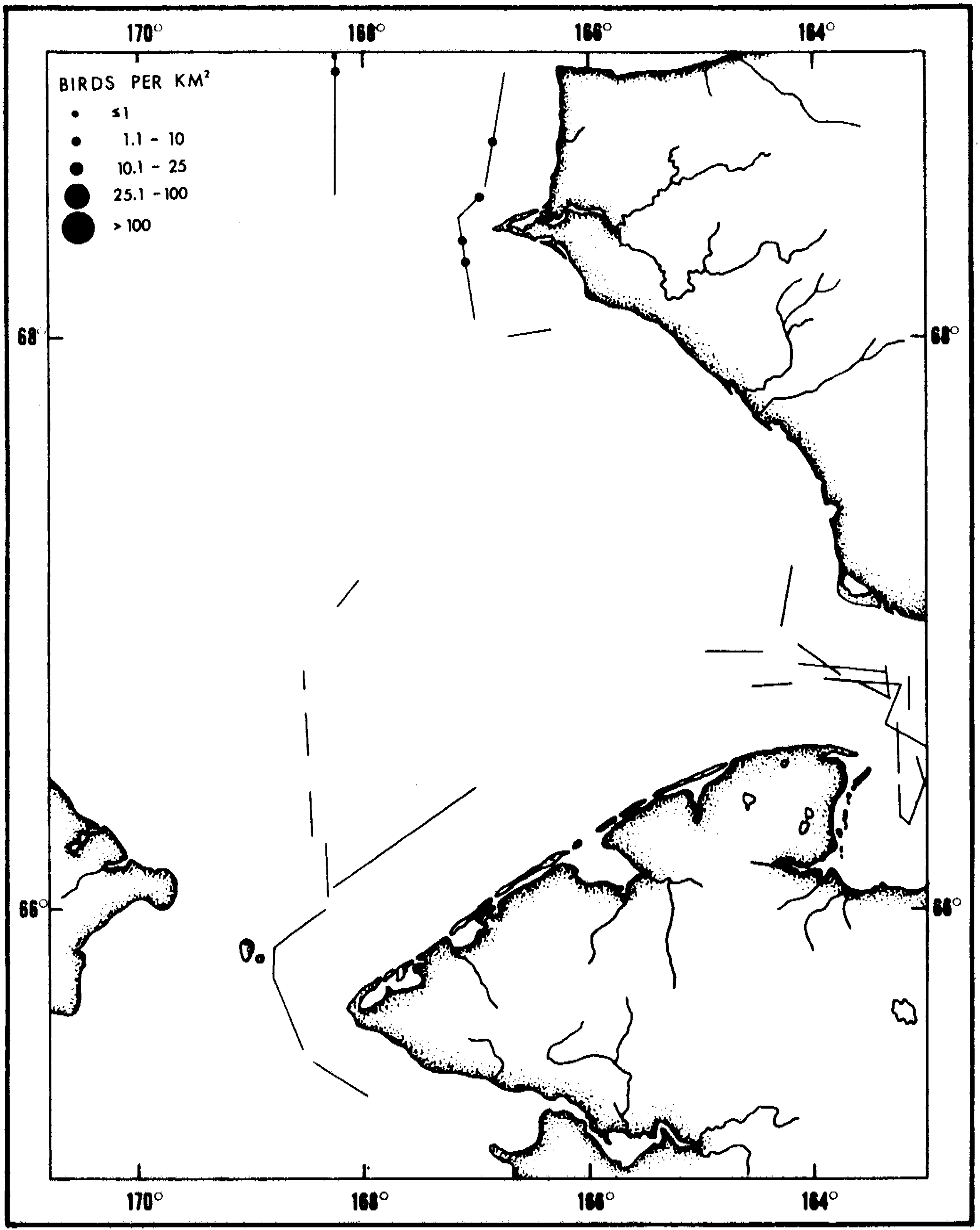


Figure 160. Distribution and abundance of Oldsquaws in Bering Strait and southern Chukchi Sea from 15 to 20 September and on 22 September 1976.

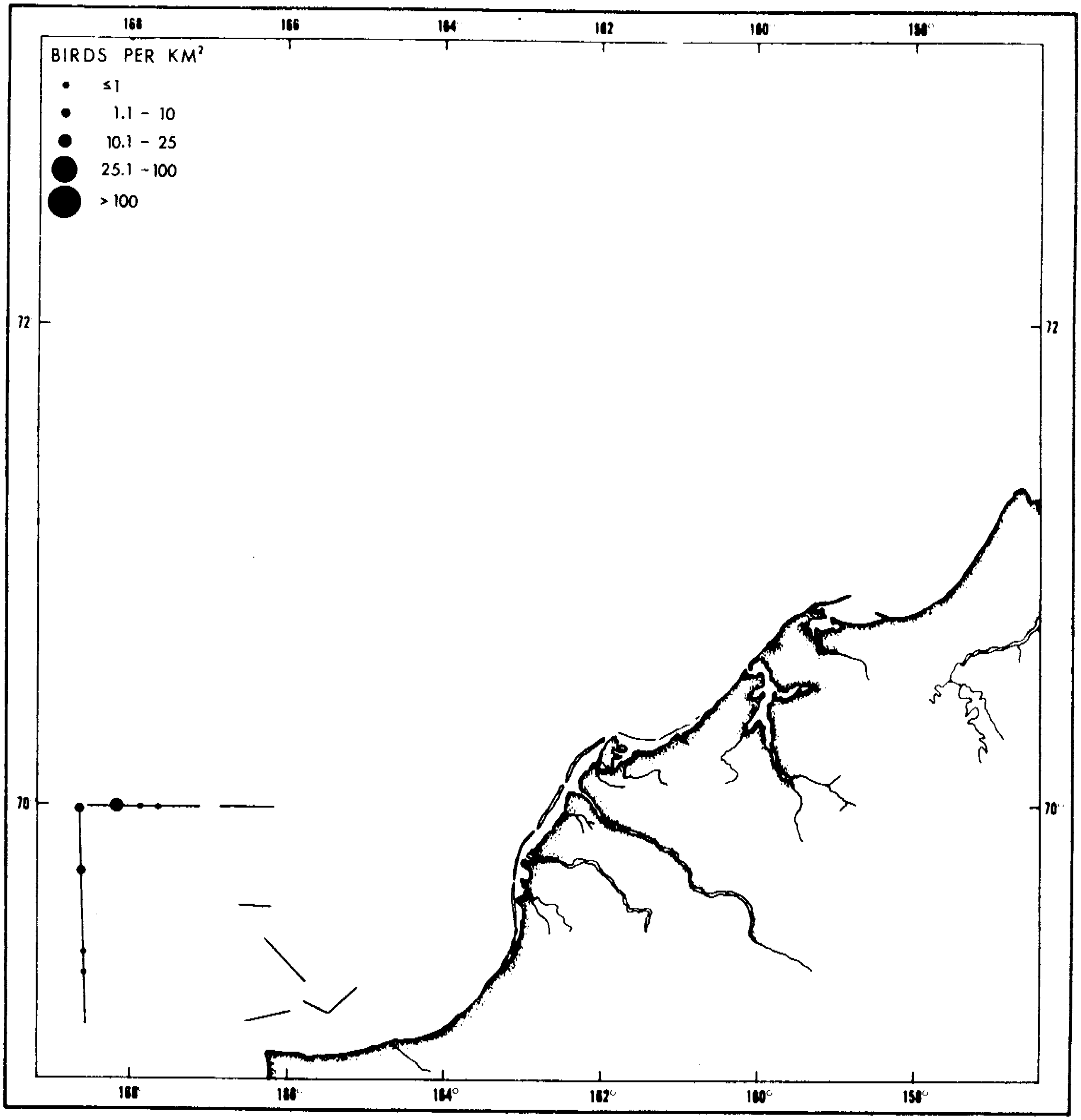


Figure 161. Distribution and abundance of Oldsquaws in northern Chukchi Sea from 20 to 22 September 1976.

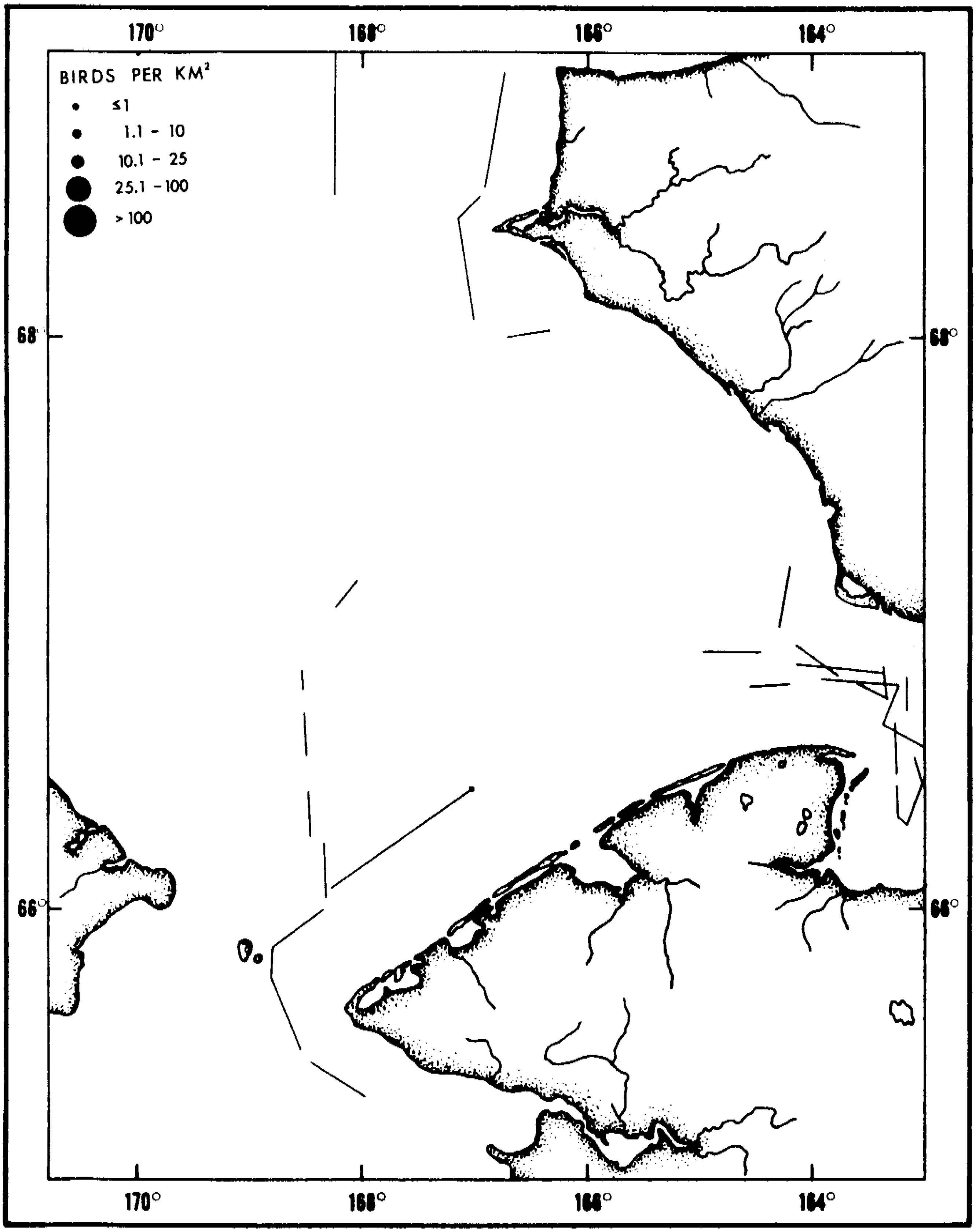


Figure 162. Distribution and abundance of eiders in Bering Strait and southern Chukchi Sea from 15 to 20 September and on 22 September 1976.

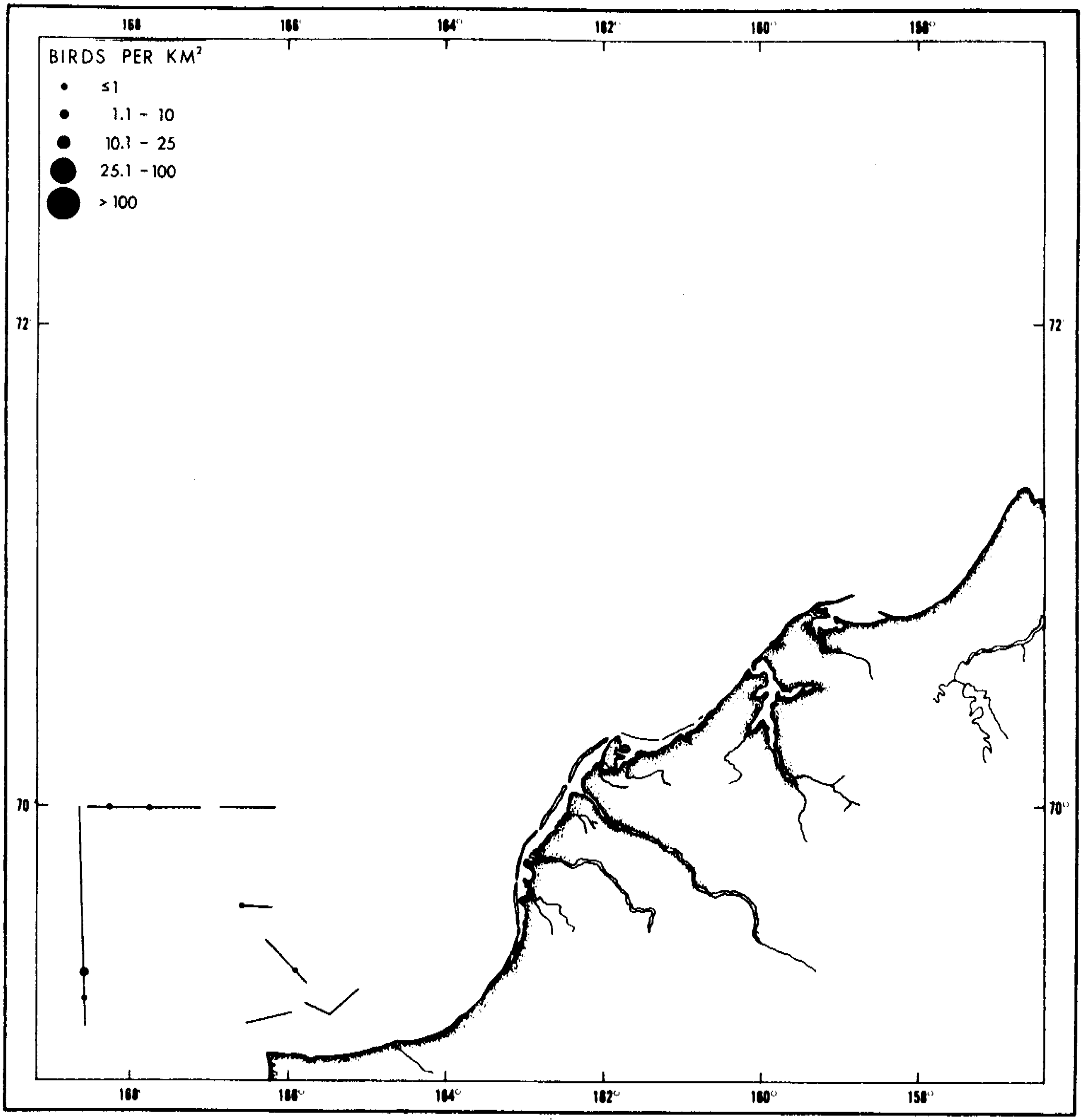


Figure 163. Distribution and abundance of eiders in northern Chukchi Sea from 20 to 22 September 1976.

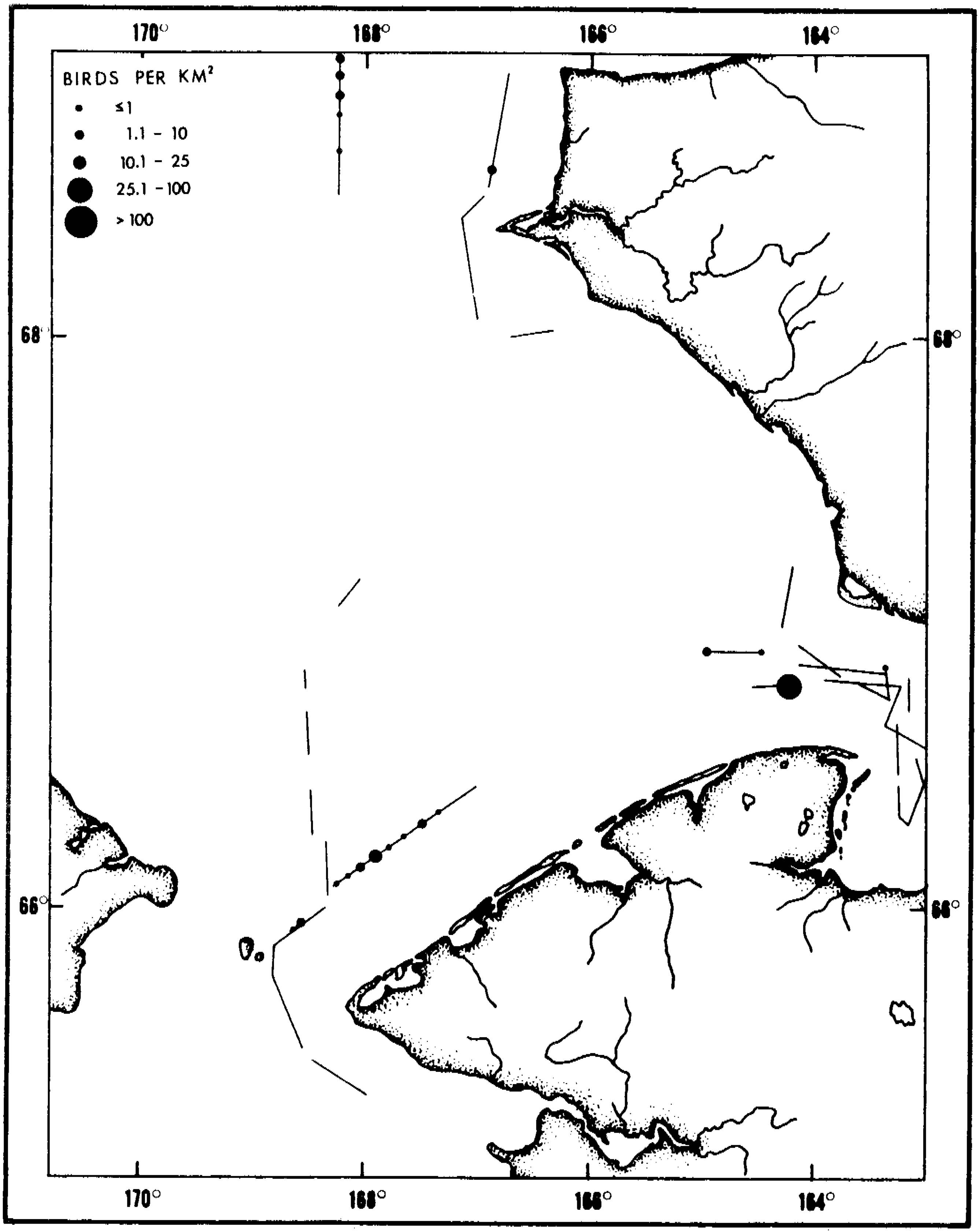


Figure 164. Distribution and abundance of phalaropes in Bering Strait and southern Chukchi Sea from 15 to 20 September and on 22 September 1976.

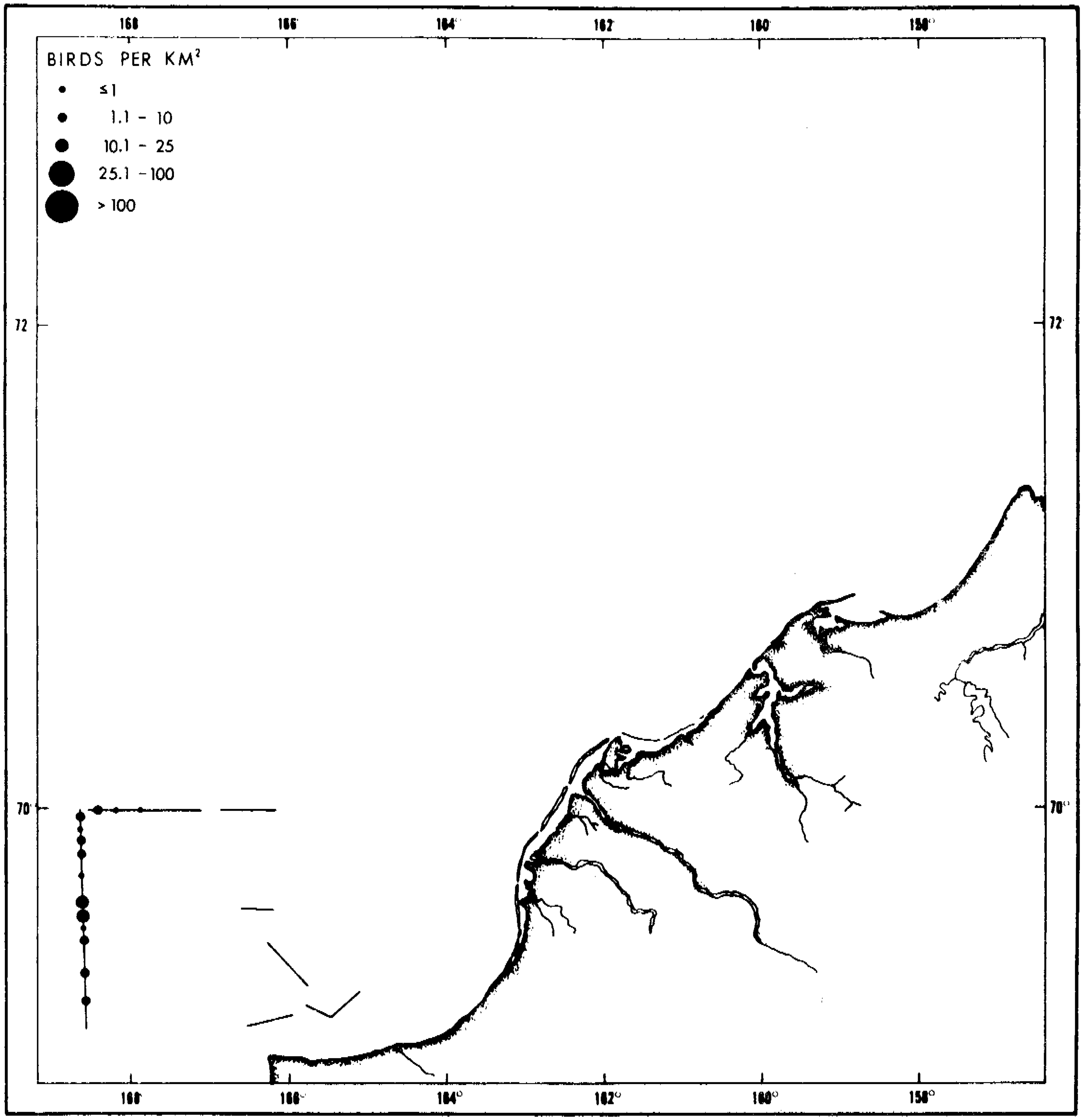


Figure 165. Distribution and abundance of phalaropes in northern Chukchi Sea from 20 to 22 September 1976.

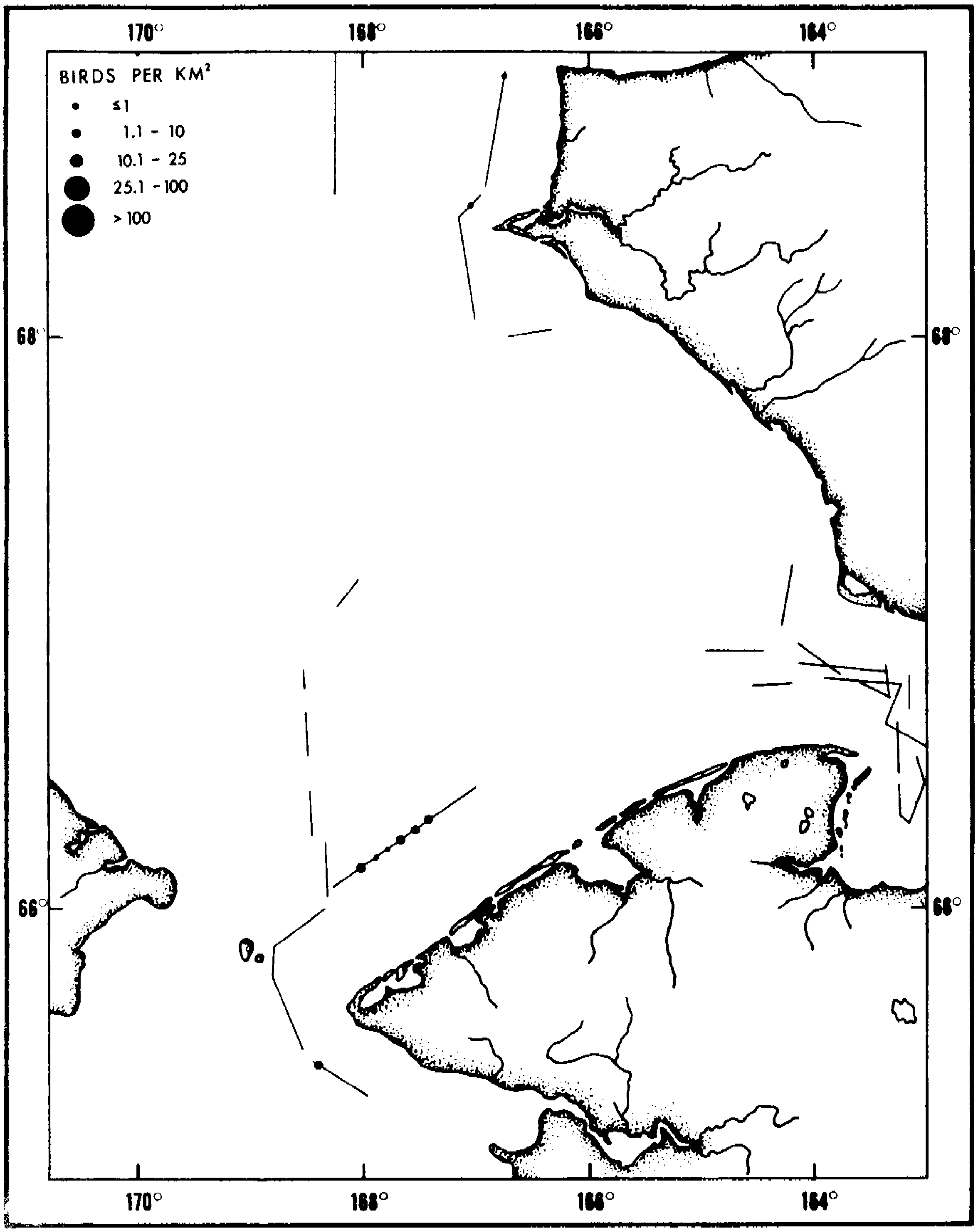


Figure 166. Distribution and abundance of jaegers in Bering Strait and southern Chukchi Sea from 15 to 20 September and on 22 September 1976.

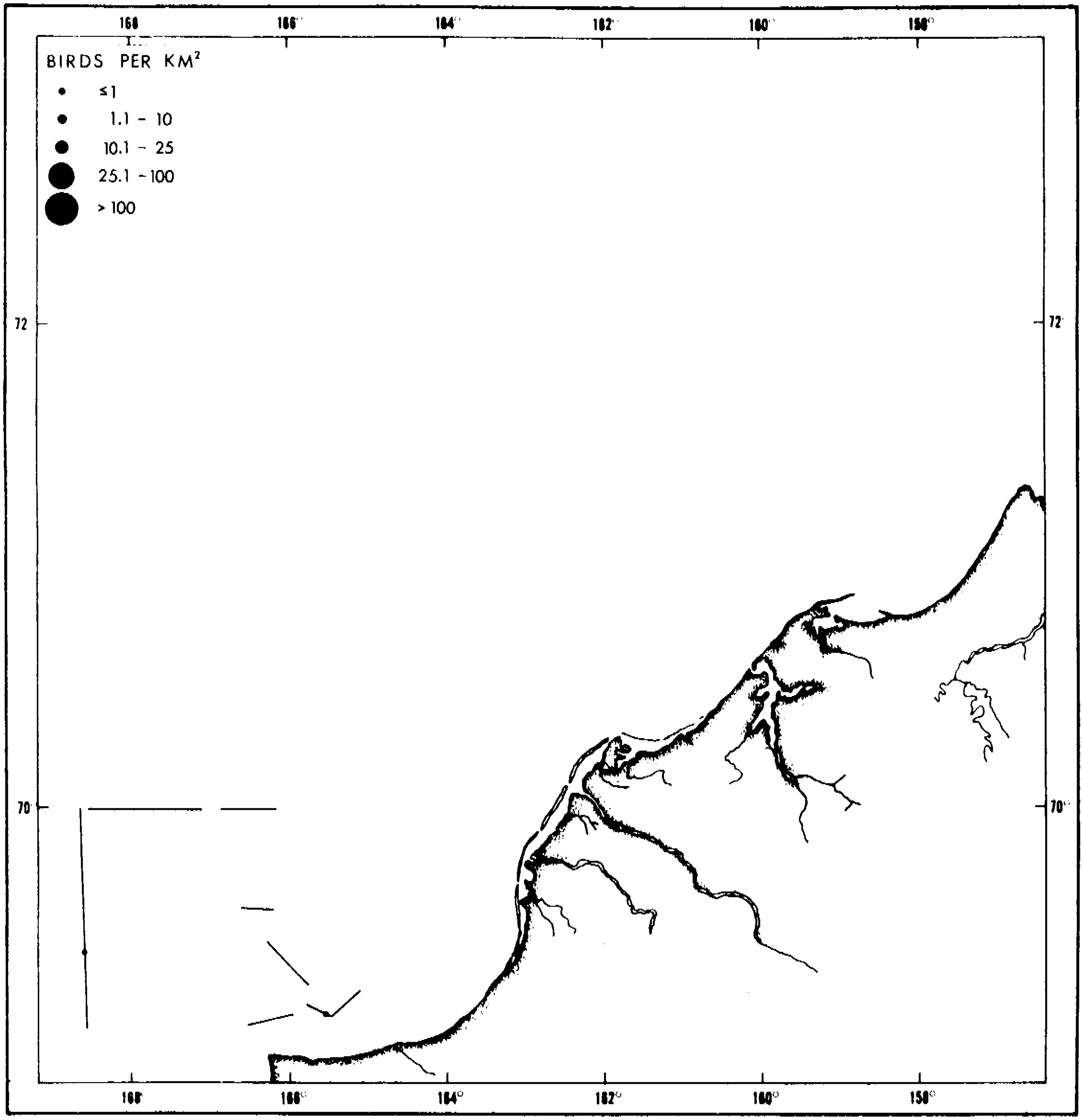


Figure 167. Distribution and abundance of jaegers in northern Chukchi Sea from 20 to 22 September 1976.

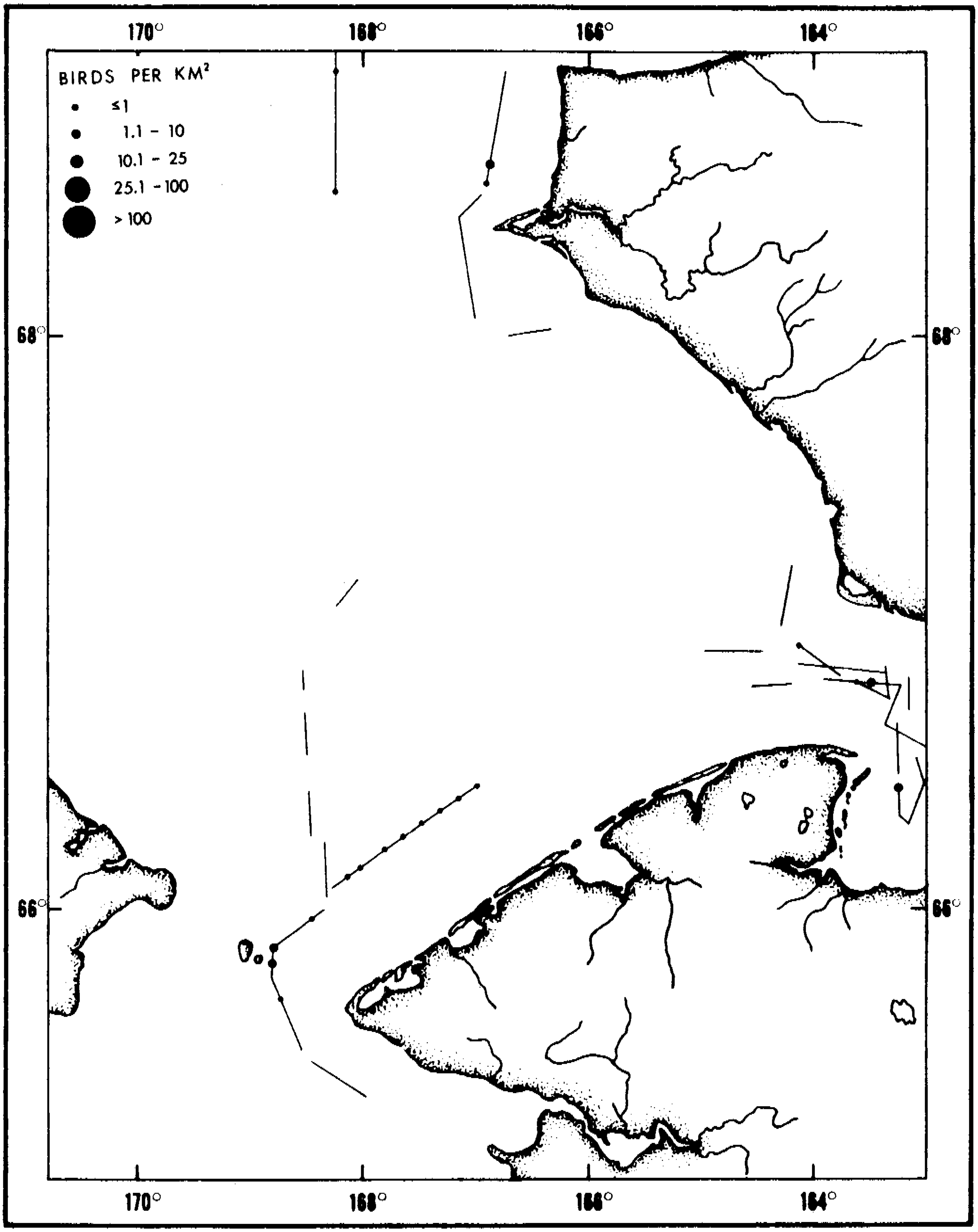


Figure 168. Distribution and abundance of Glaucous Gulls in Bering Strait and southern Chukchi Sea from 15 to 20 September and on 22 September 1976.

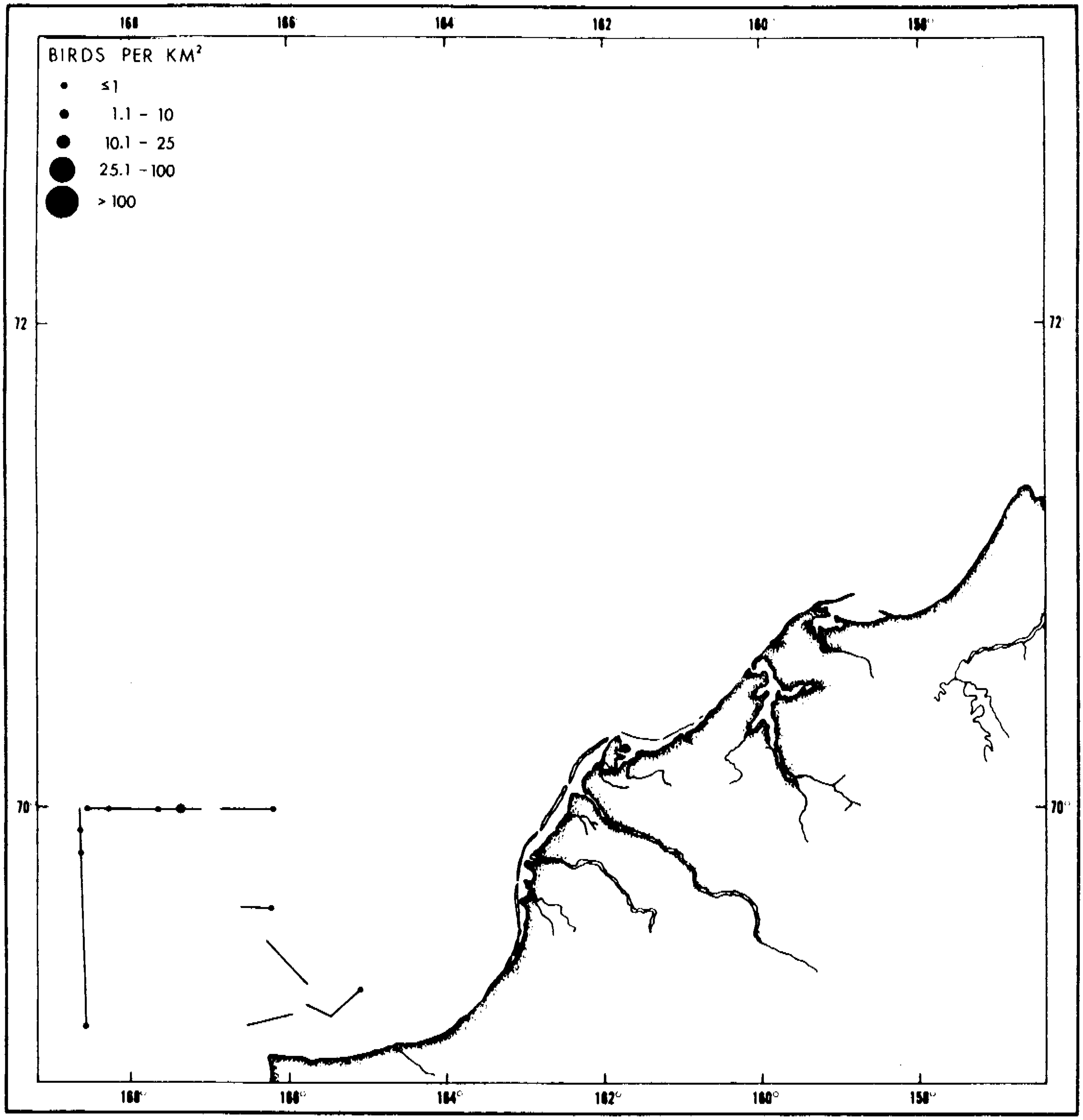


Figure 169. Distribution and abundance of Glaucous Gulls in northern Chukchi Sea from 20 to 22 September 1976.

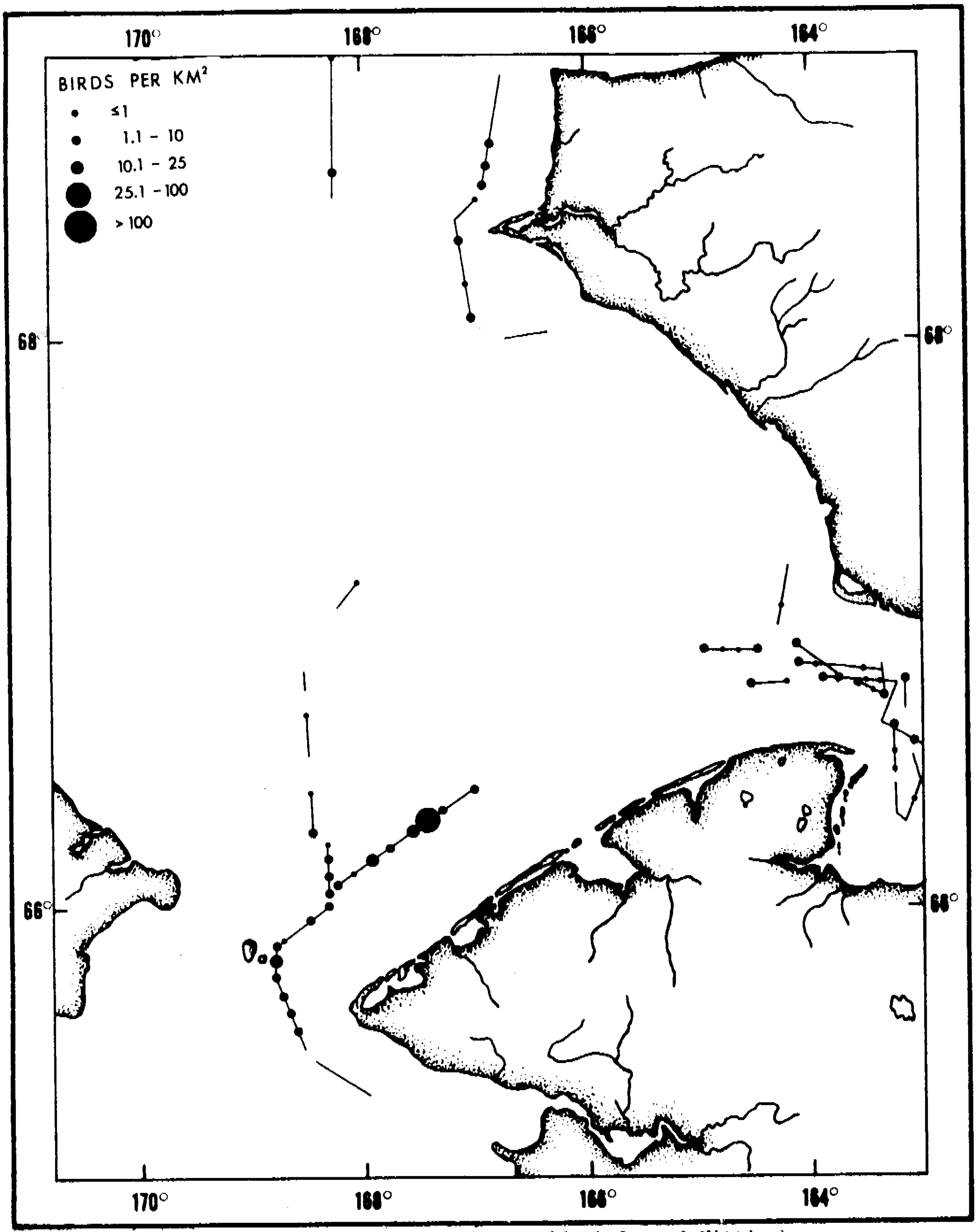


Figure 170. Distribution and abundance of Black-legged Kittiwakes in Bering Strait and southern Chukchi Sea from 15 to 20 September and on 22 September 1976.

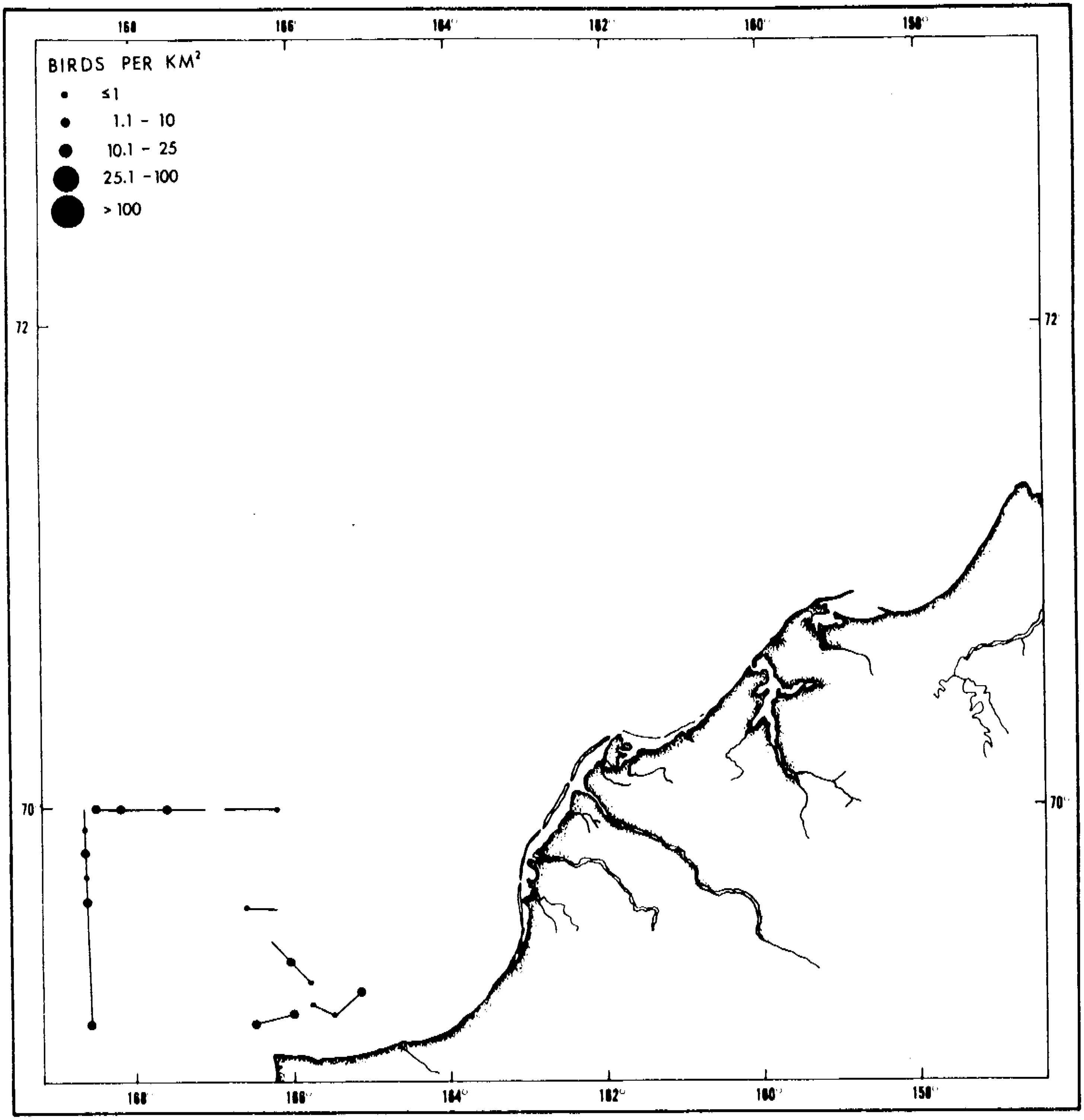


Figure 171. Distribution and abundance of Black-legged Kittiwakes in northern Chukchi Sea from 20 to 22 September 1976.

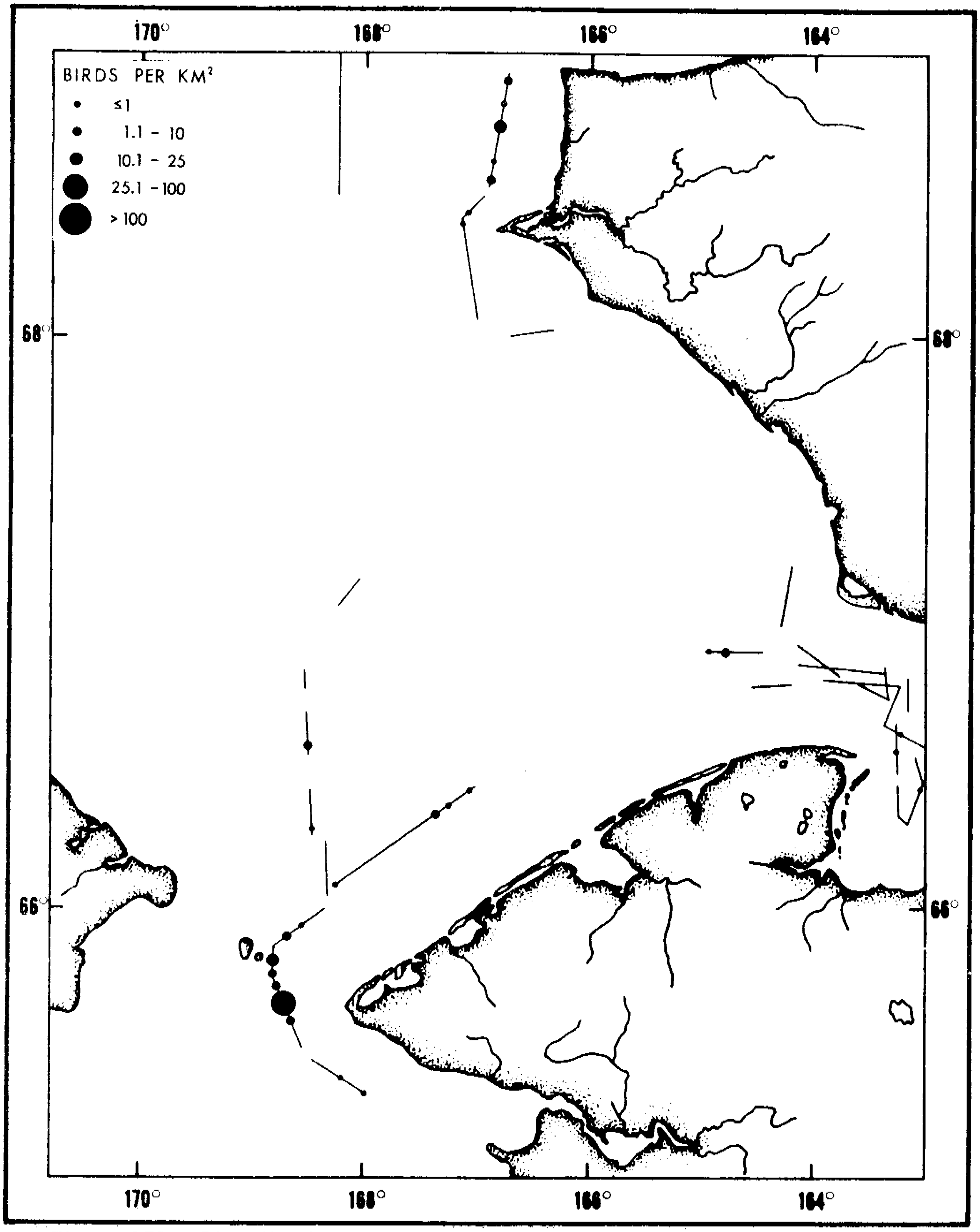


Figure 172. Distribution and abundance of murres in Bering Strait and southern Chukchi Sea from 15 to 20 September and on 22 September 1976.

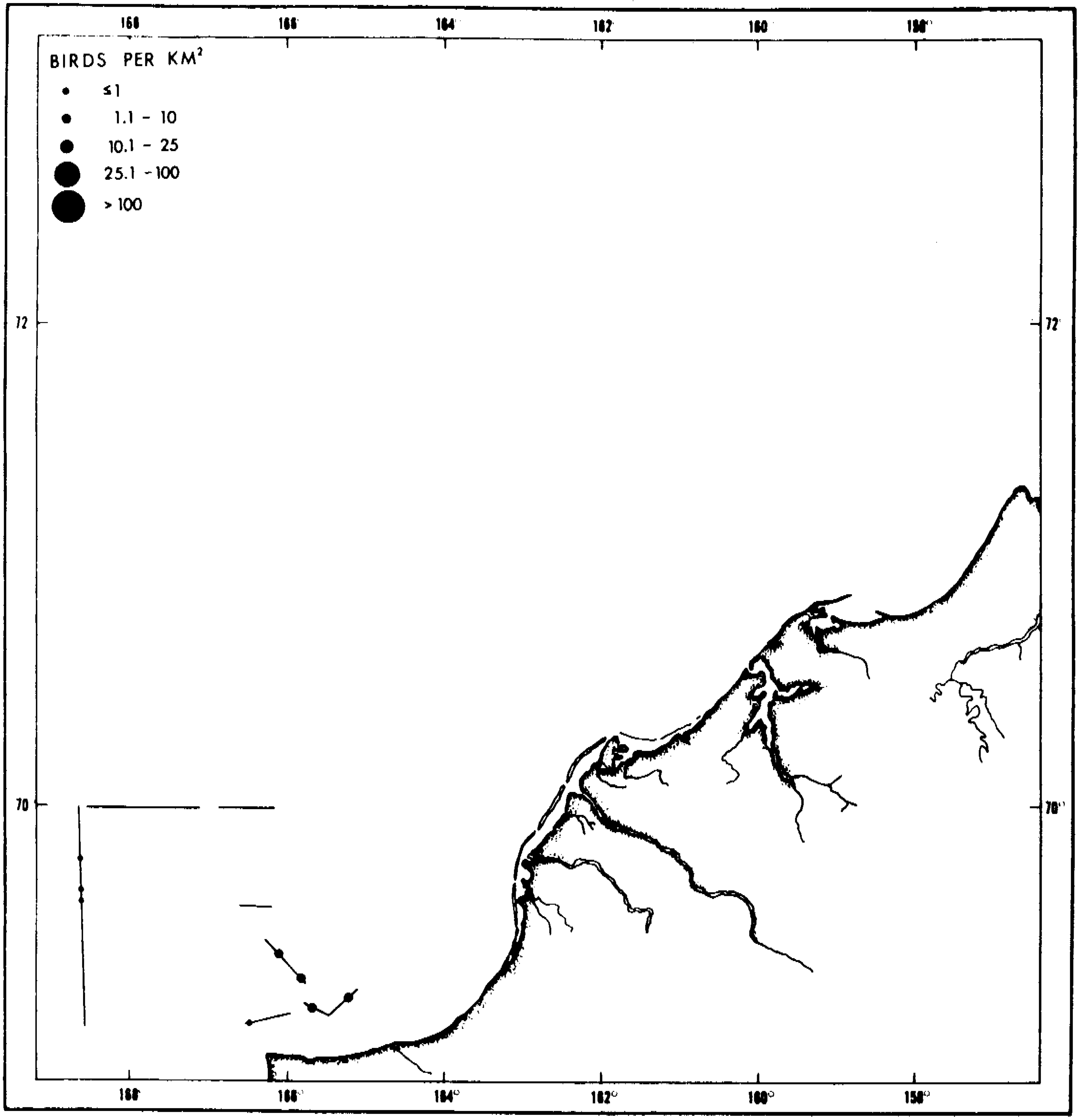


Figure 173. Distribution and abundance of murres in northern Chukchi Sea from 20 to 22 September 1976.

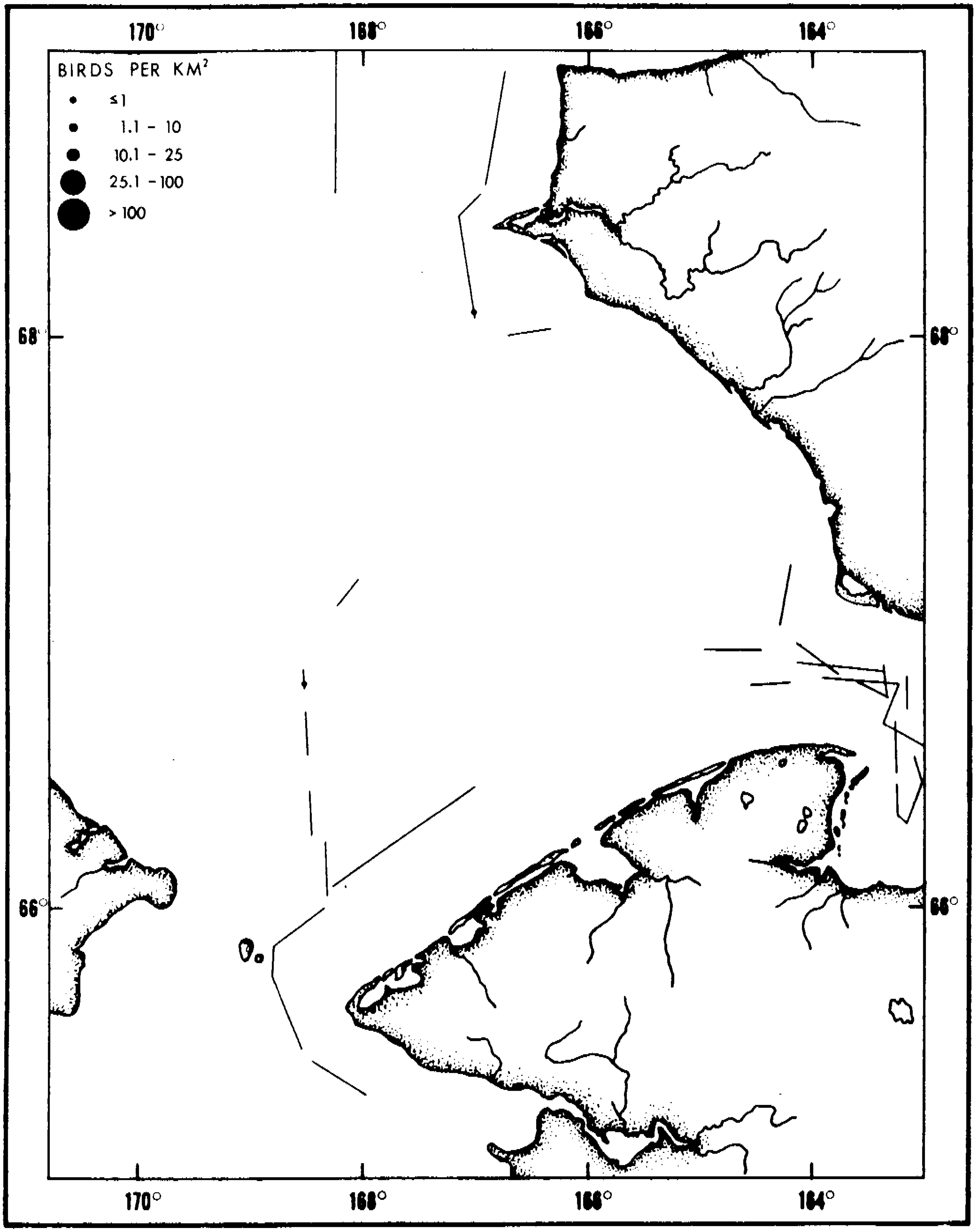


Figure 174. Distribution and abundance of Parakeet Auklets in Bering Strait and southern Chukchi Sea from 15 to 20 September and on 22 September 1976.

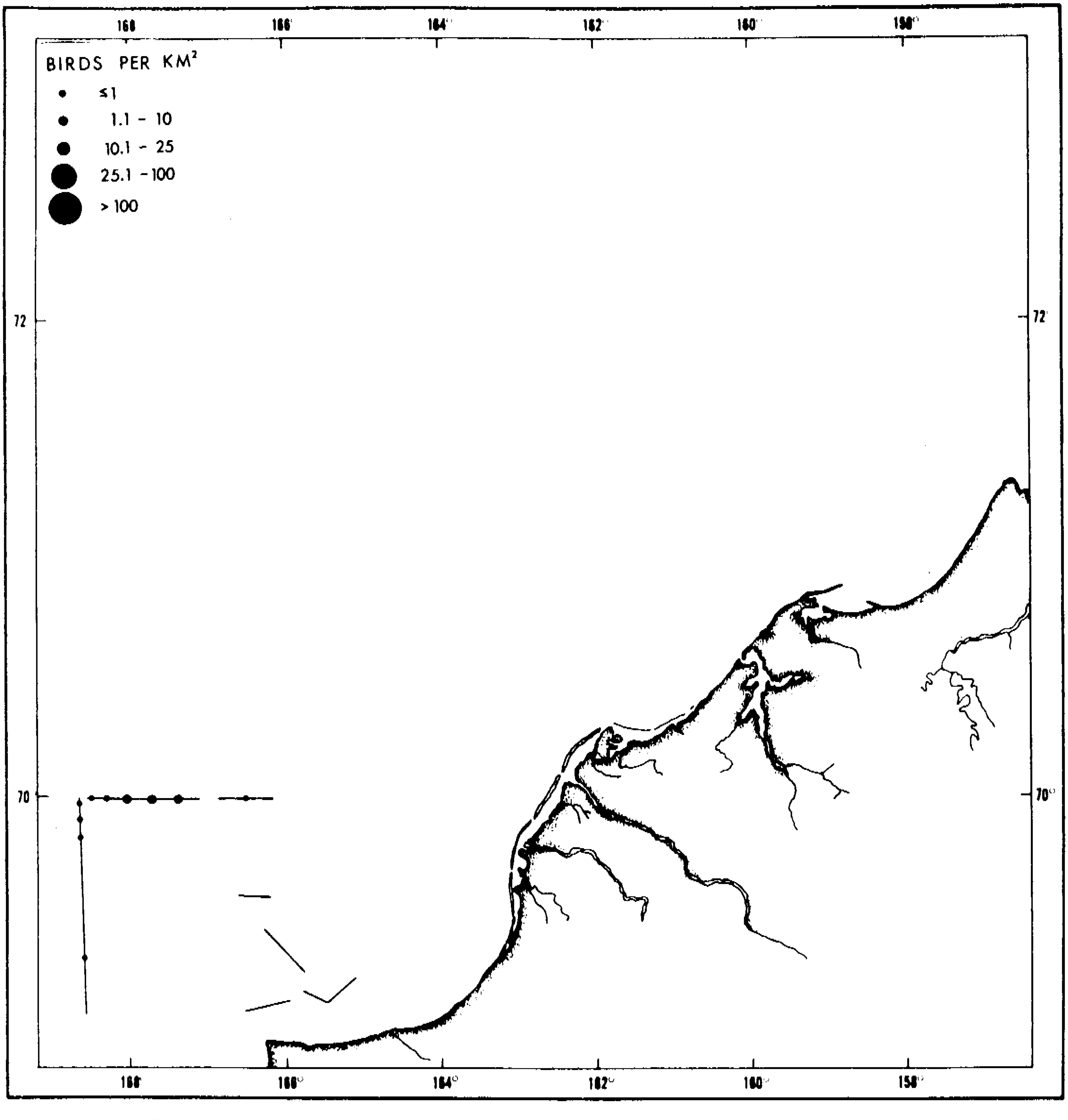


Figure 175. Distribution and abundance of Parakeet Auklets in northern Chukchi Sea from 20 to 22 September 1976.

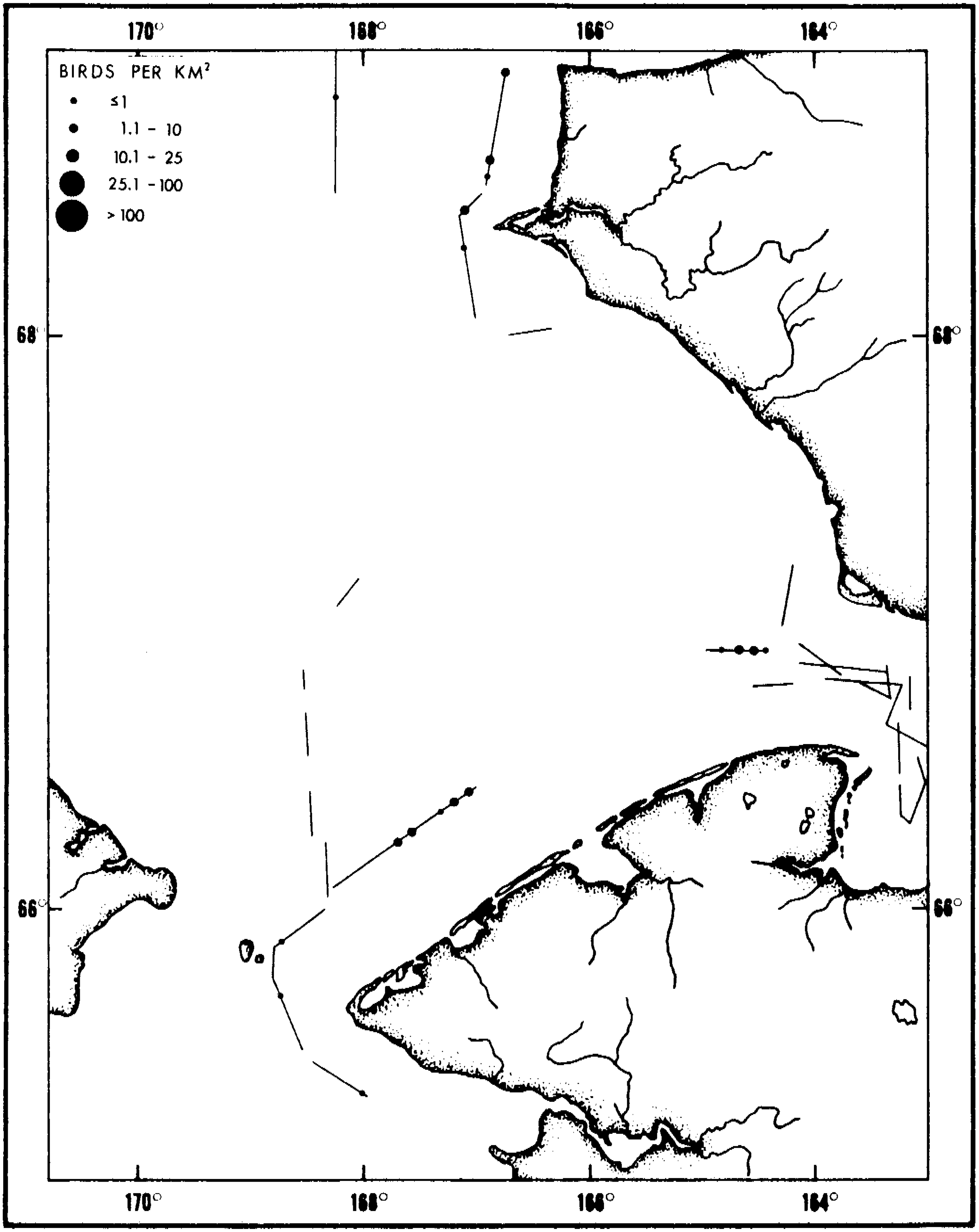


Figure 176. Distribution and abundance of unidentified small dark alcids in Bering Strait and southern Chukchi Sea from 15 to 20 September and on 22 September 1976.

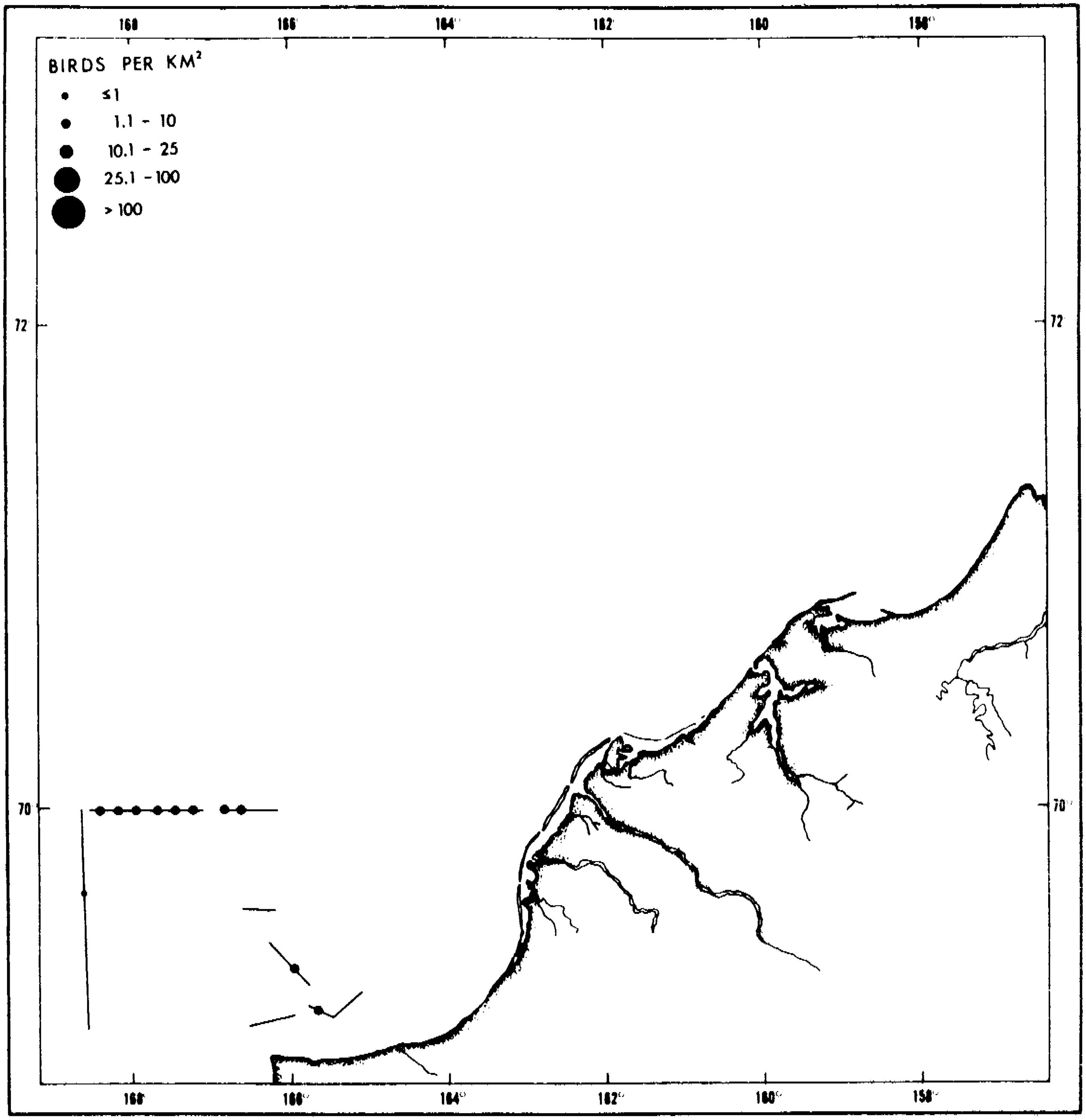


Figure 177. Distribution and abundance of unidentified small dark alcids in northern Chukchi Sea from 20 to 22 September 1976.

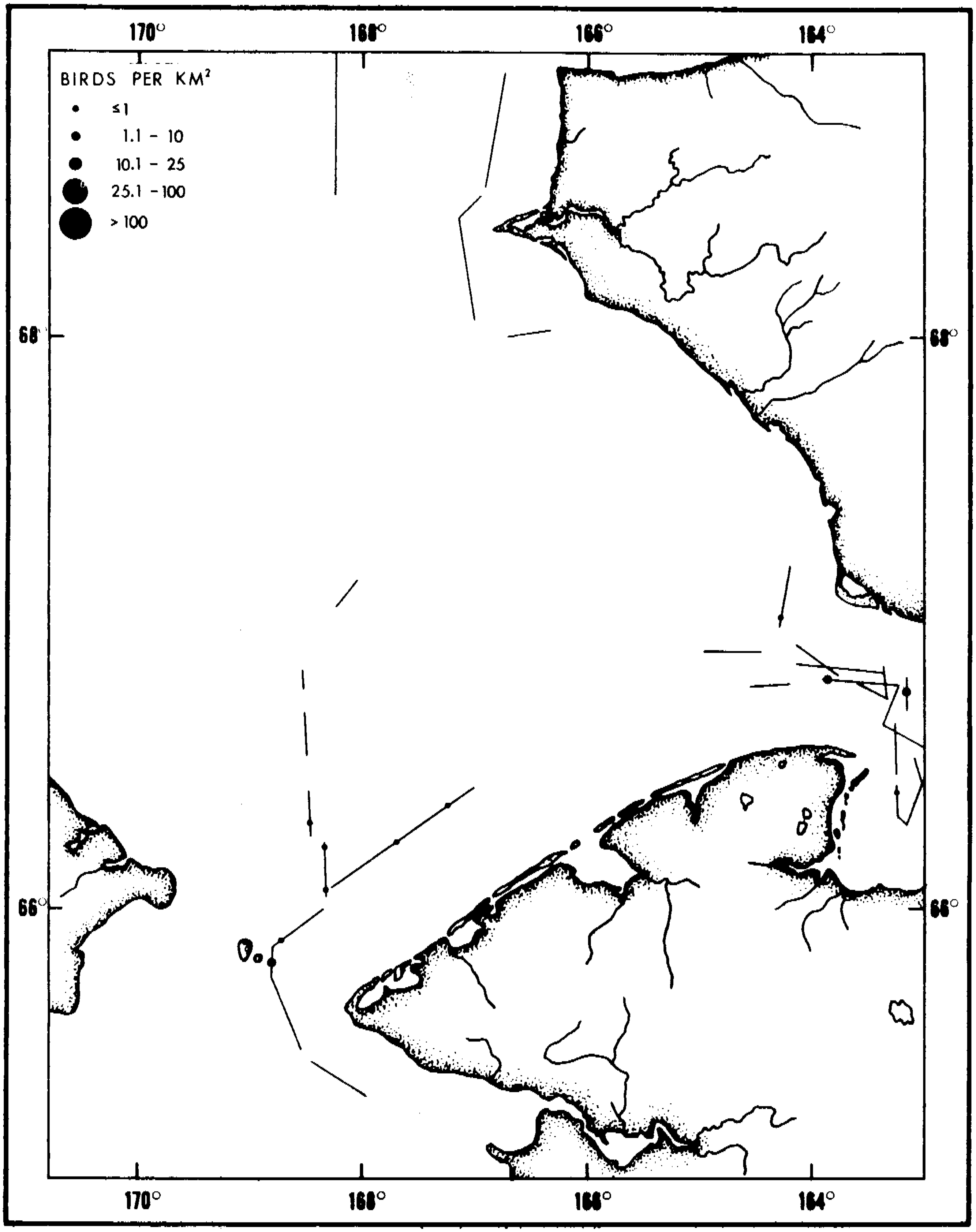


Figure 178. Distribution and abundance of Horned Puffins in Bering Strait and southern Chukchi Sea from 15 to 20 September and on 22 September 1976.

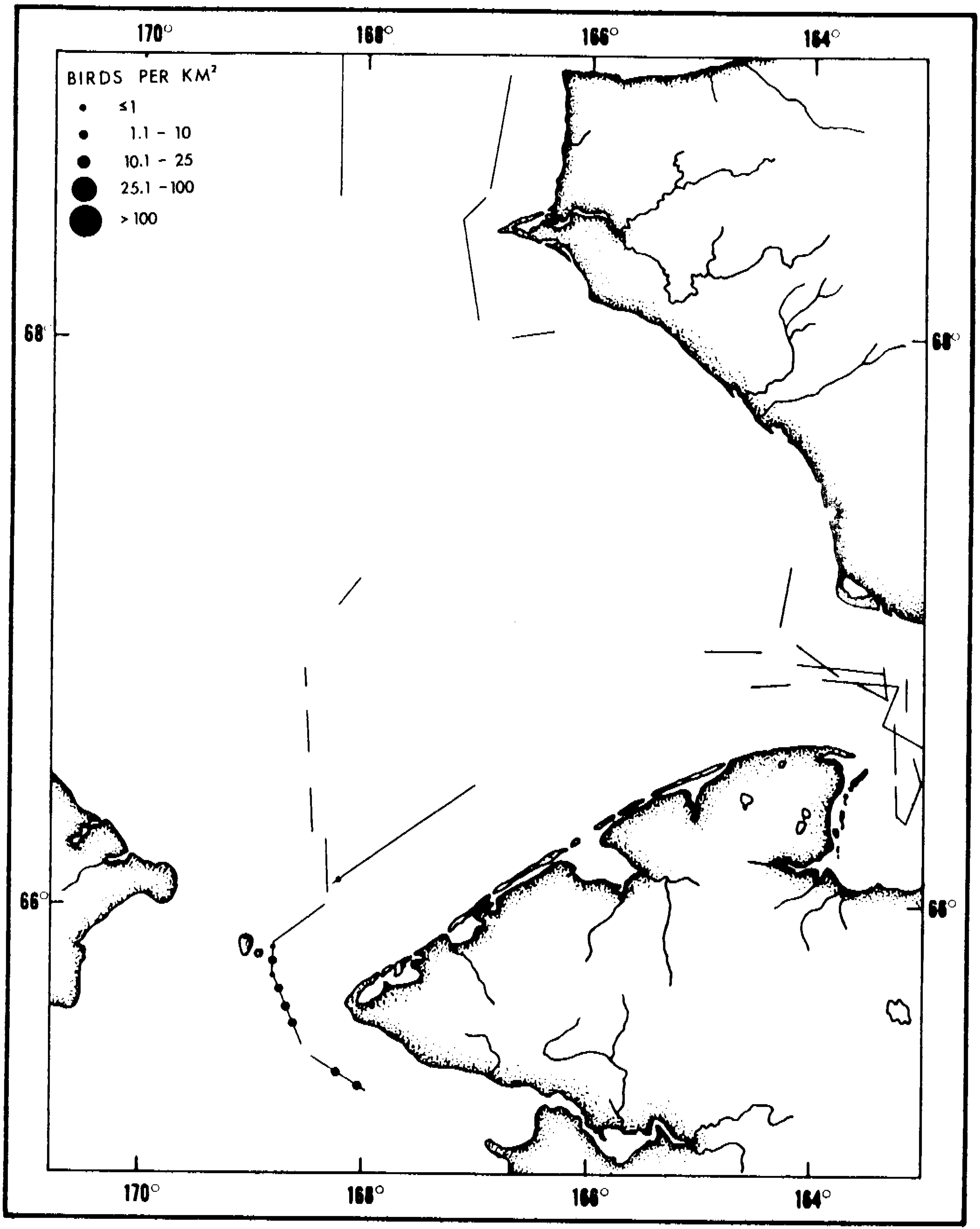


Figure 179. Distribution and abundance of Tufted Puffins in Bering Strait and southern Chukchi Sea from 15 to 20 September and on 22 September 1976.

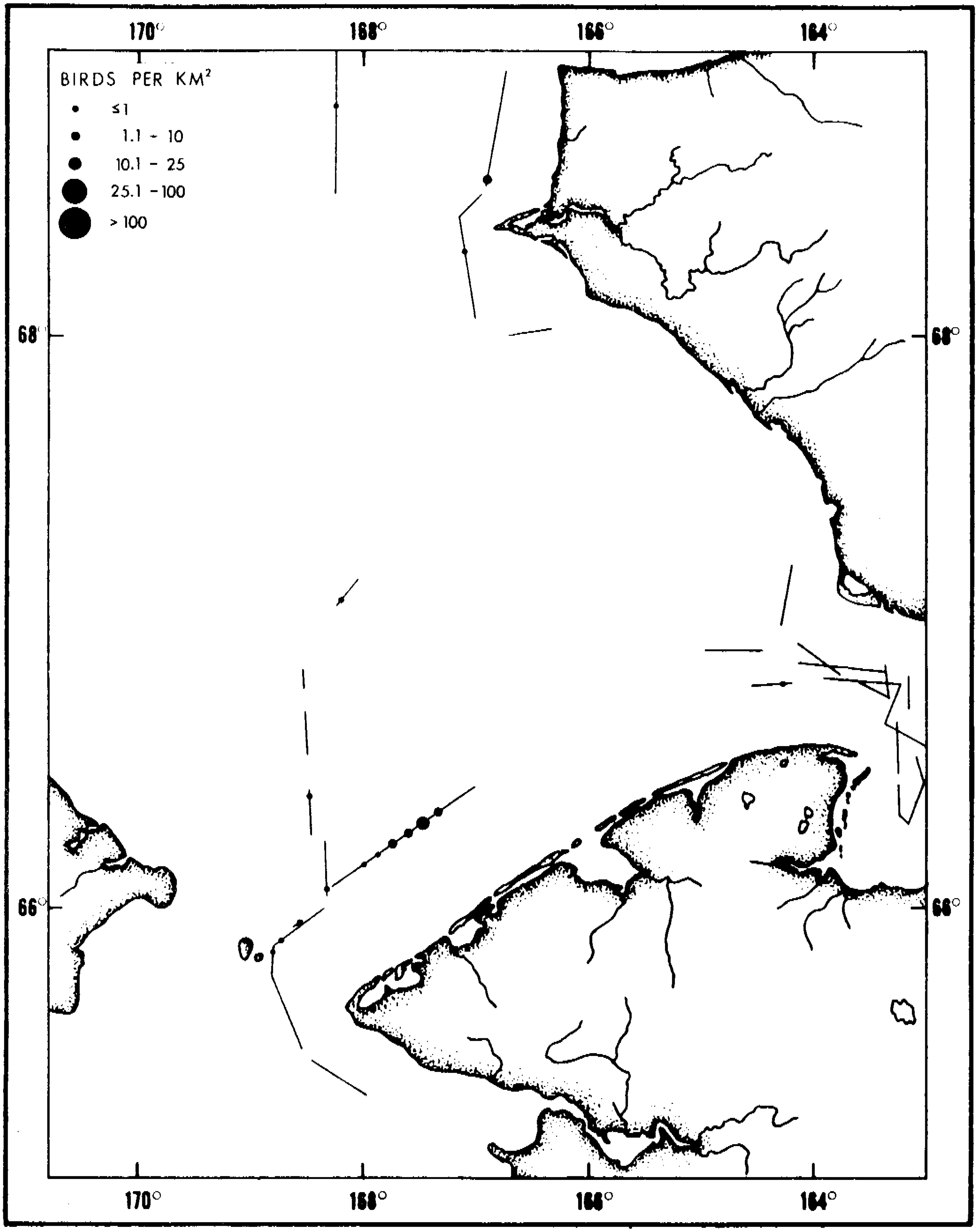


Figure 180. Distribution and abundance of unidentified alcids in Bering Strait and southern Chukchi Sea from 15 to 20 September and on 22 September 1976.

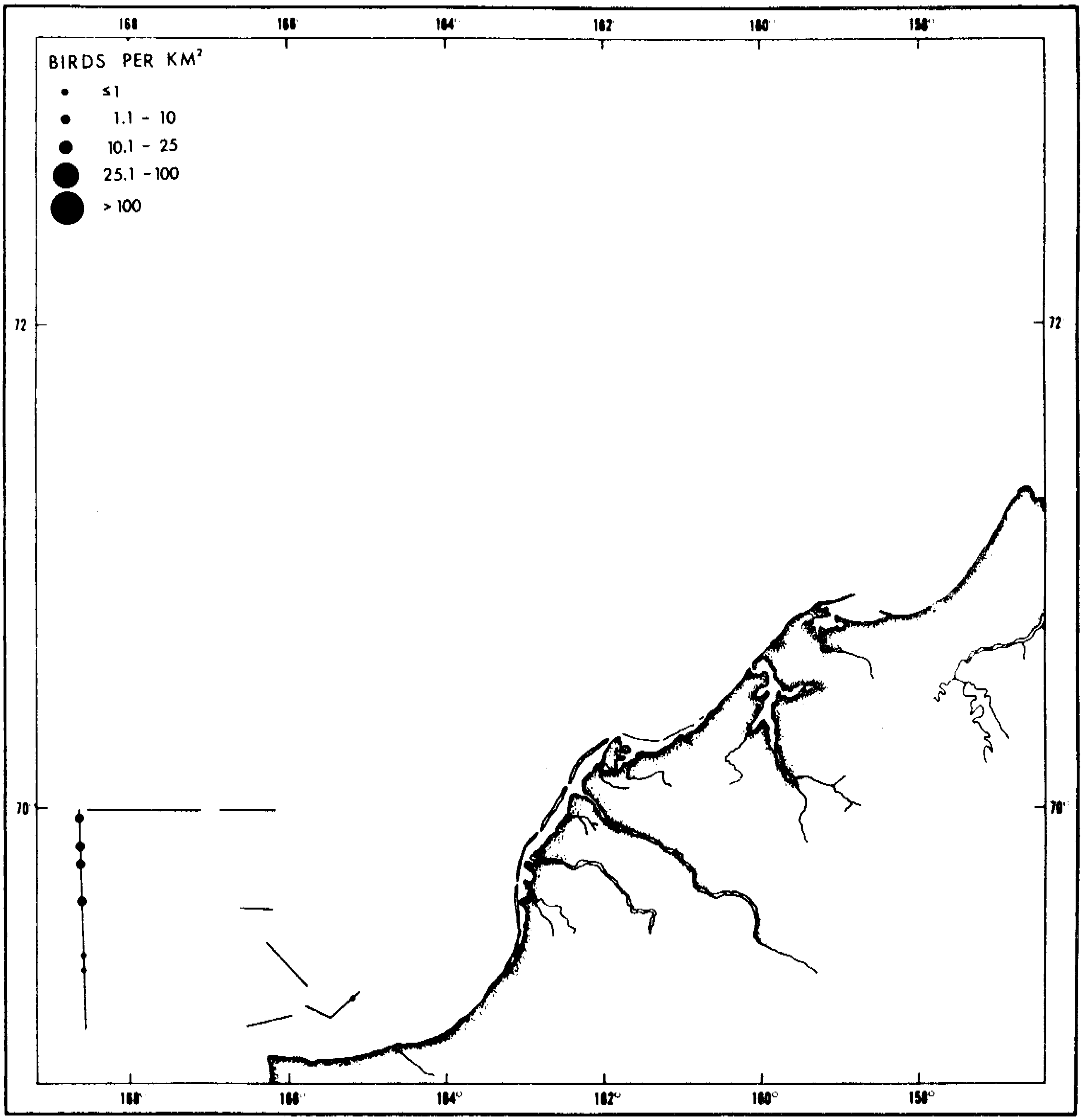


Figure 181. Distribution and abundance of unidentified alcids in northern Chukchi Sea from 20 to 22 September 1976.

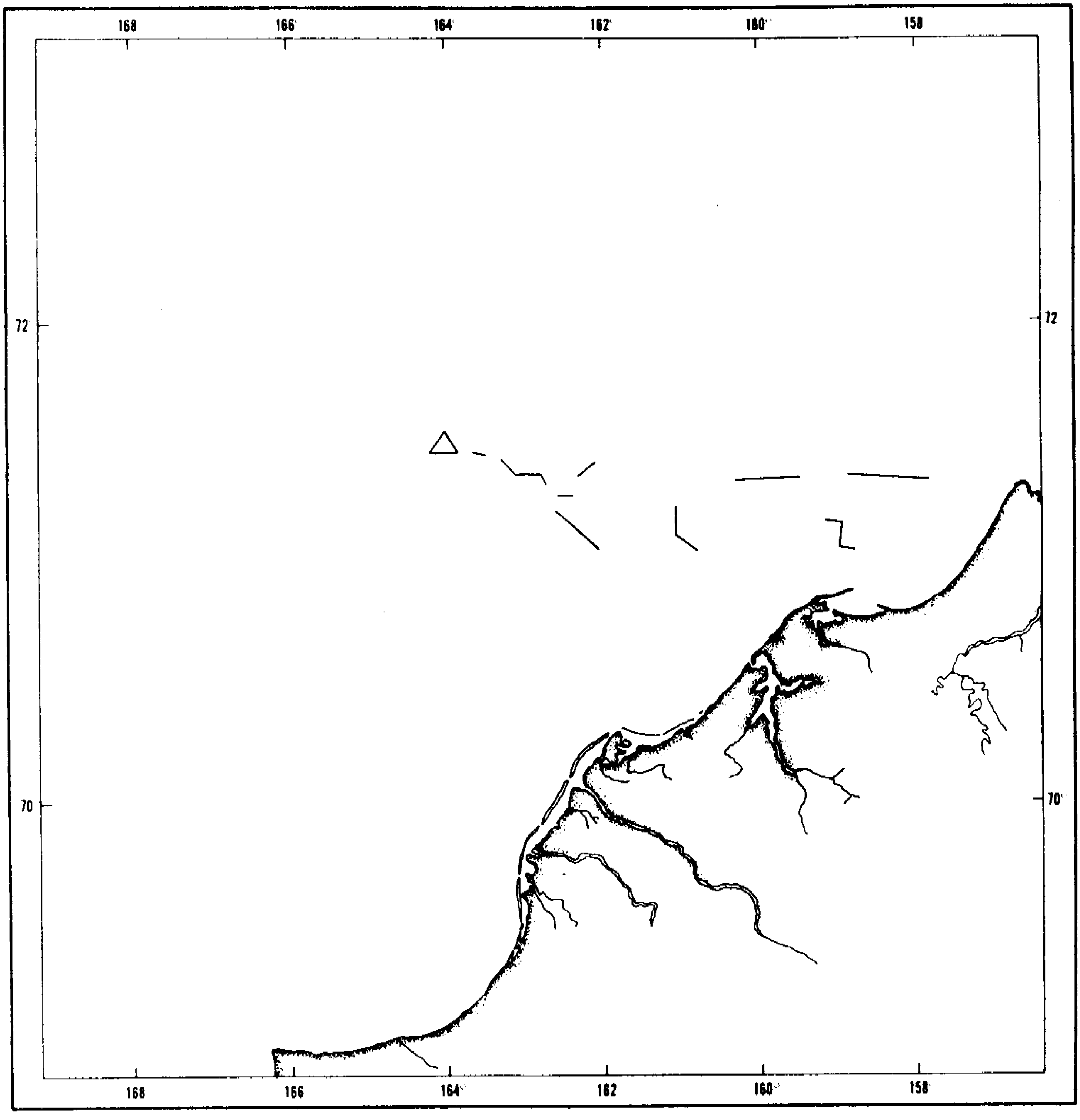


Figure 182. Cruise track during periods of observation in northern Chukchi Sea from 2 to 5 August 1977.

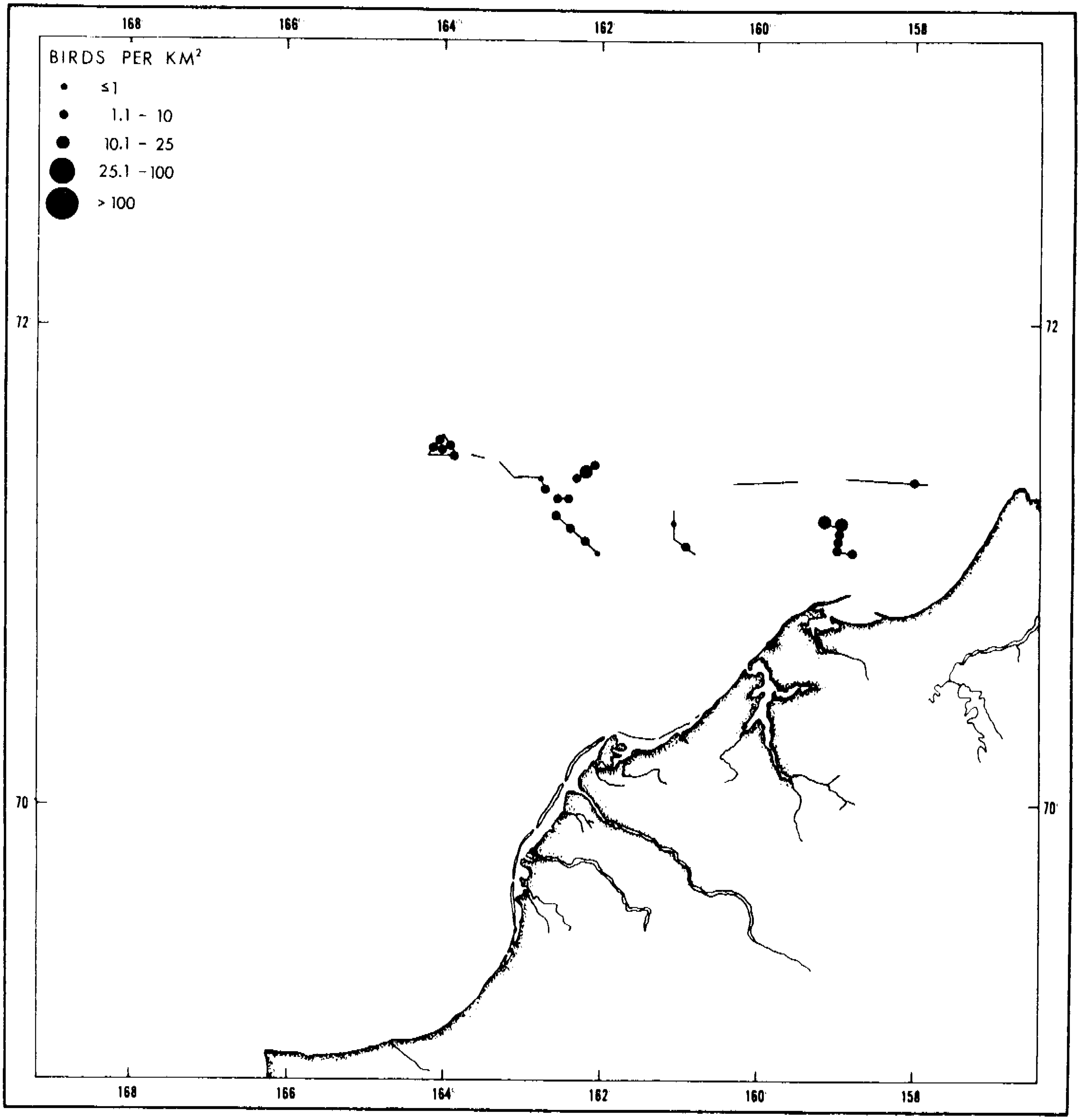


Figure 183. Distribution and abundance of seabirds in northern Chukchi Sea from 5 to 8 August 1977.

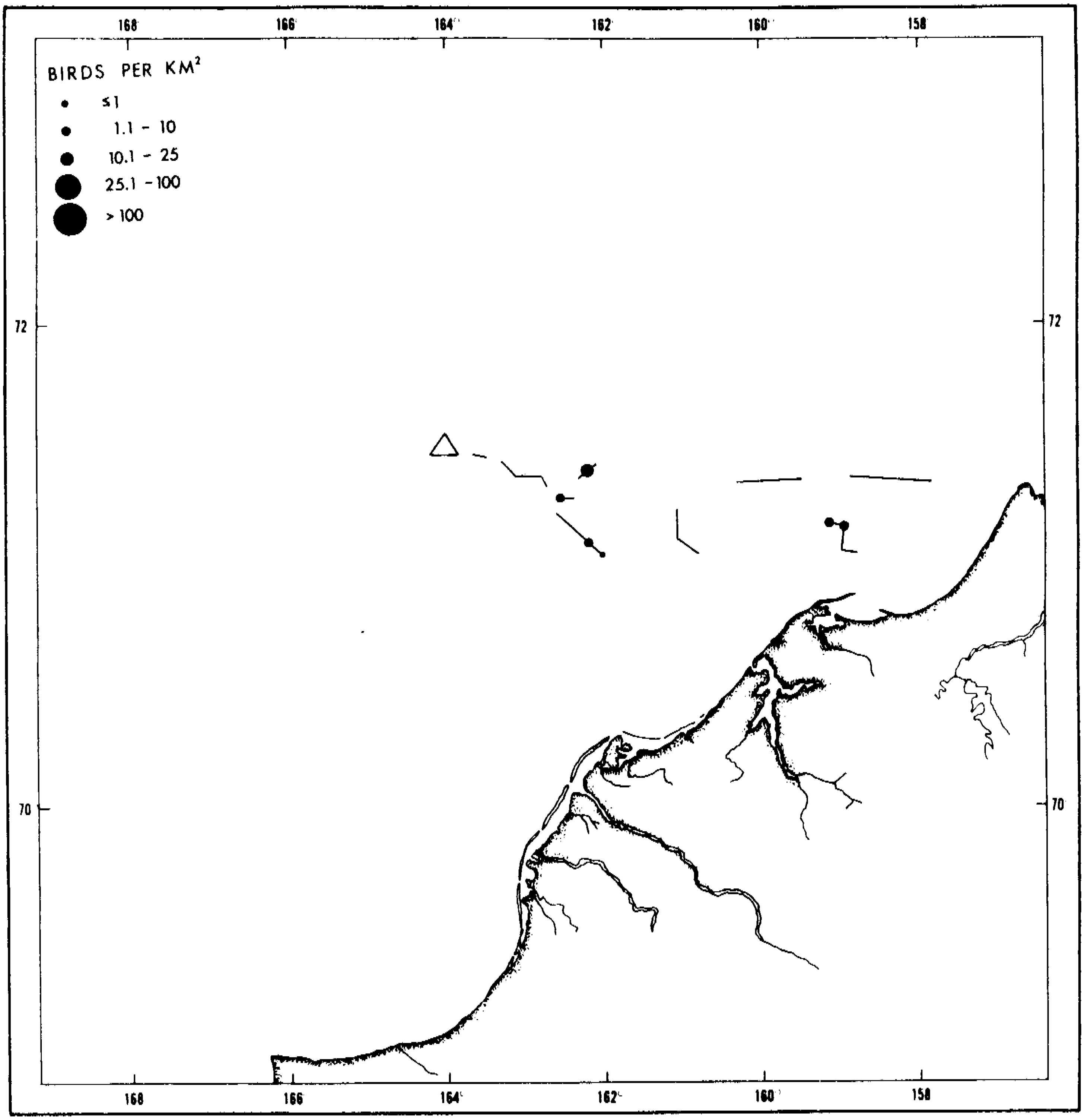


Figure 184. Distribution and abundance of phalaropes in northern Chukchi Sea from 5 to 8 August 1977.

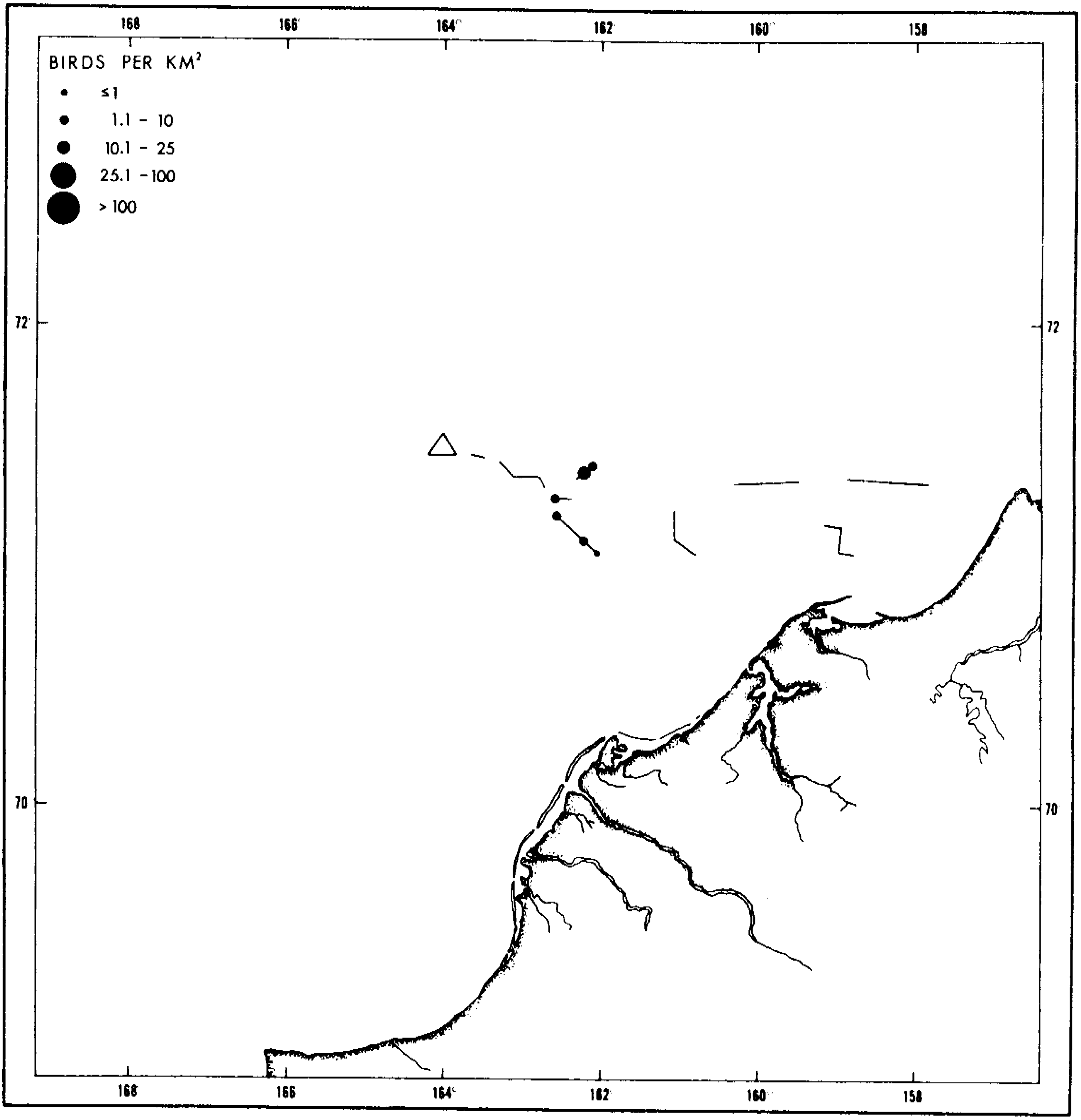


Figure 185. Distribution and abundance of jaegers in northern Chukchi Sea from 5 to 8 August 1977.

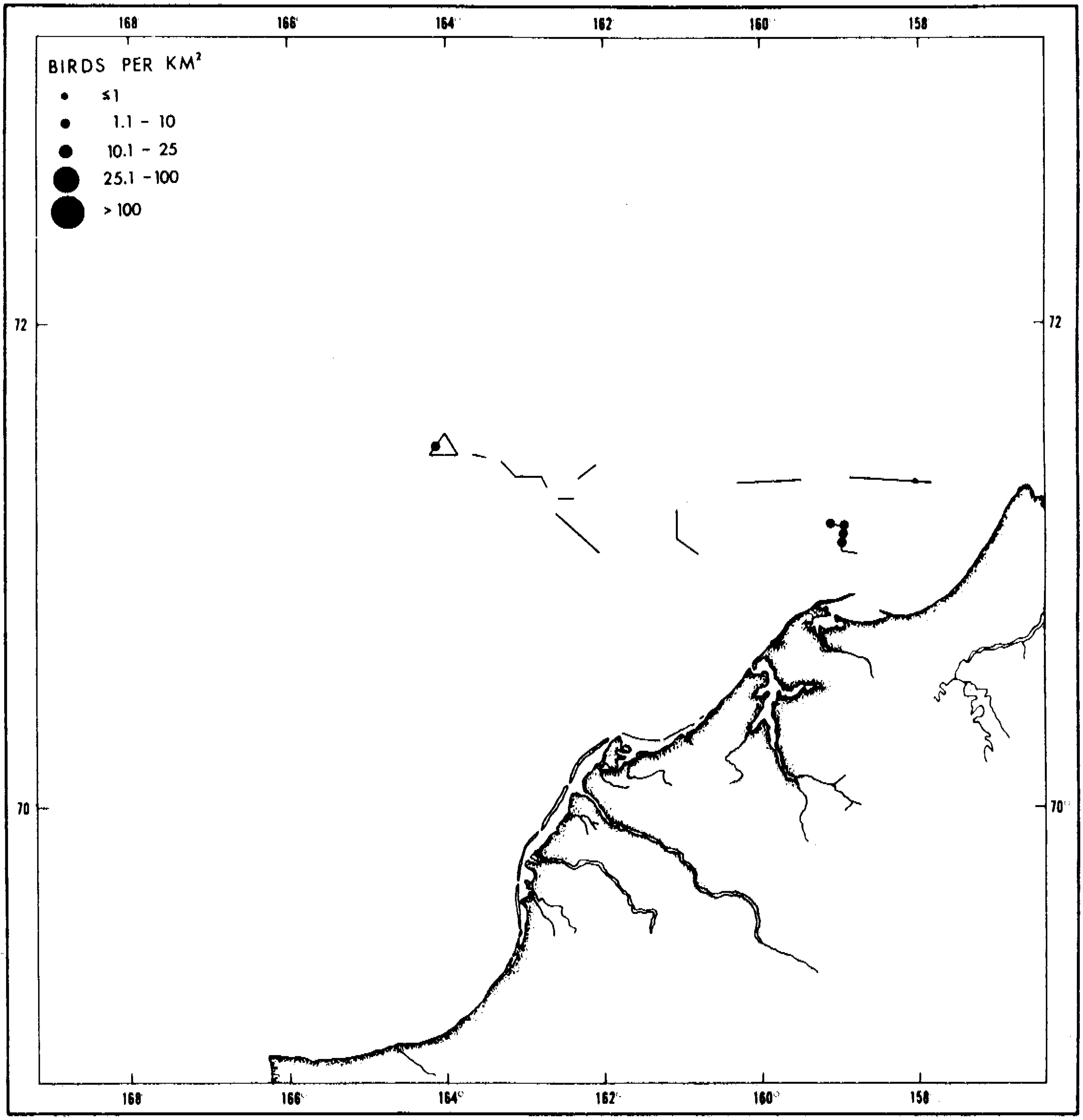


Figure 186. Distribution and abundance of Glaucous Gulls in northern Chukchi Sea from 5 to 8 August 1977.

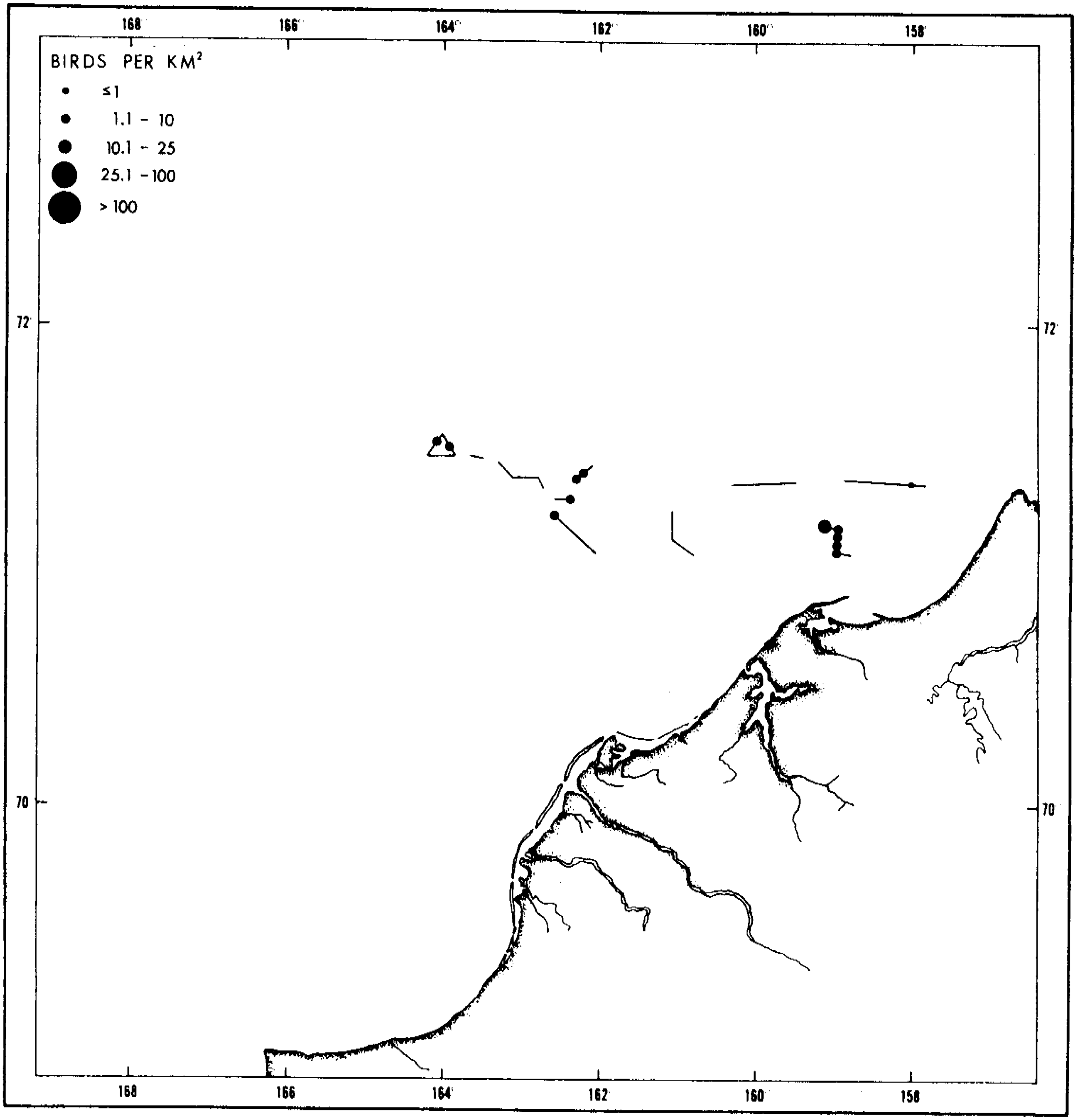


Figure 187. Distribution and abundance of Black-legged Kittiwakes in northern Chukchi Sea from 5 to 8 August 1977.

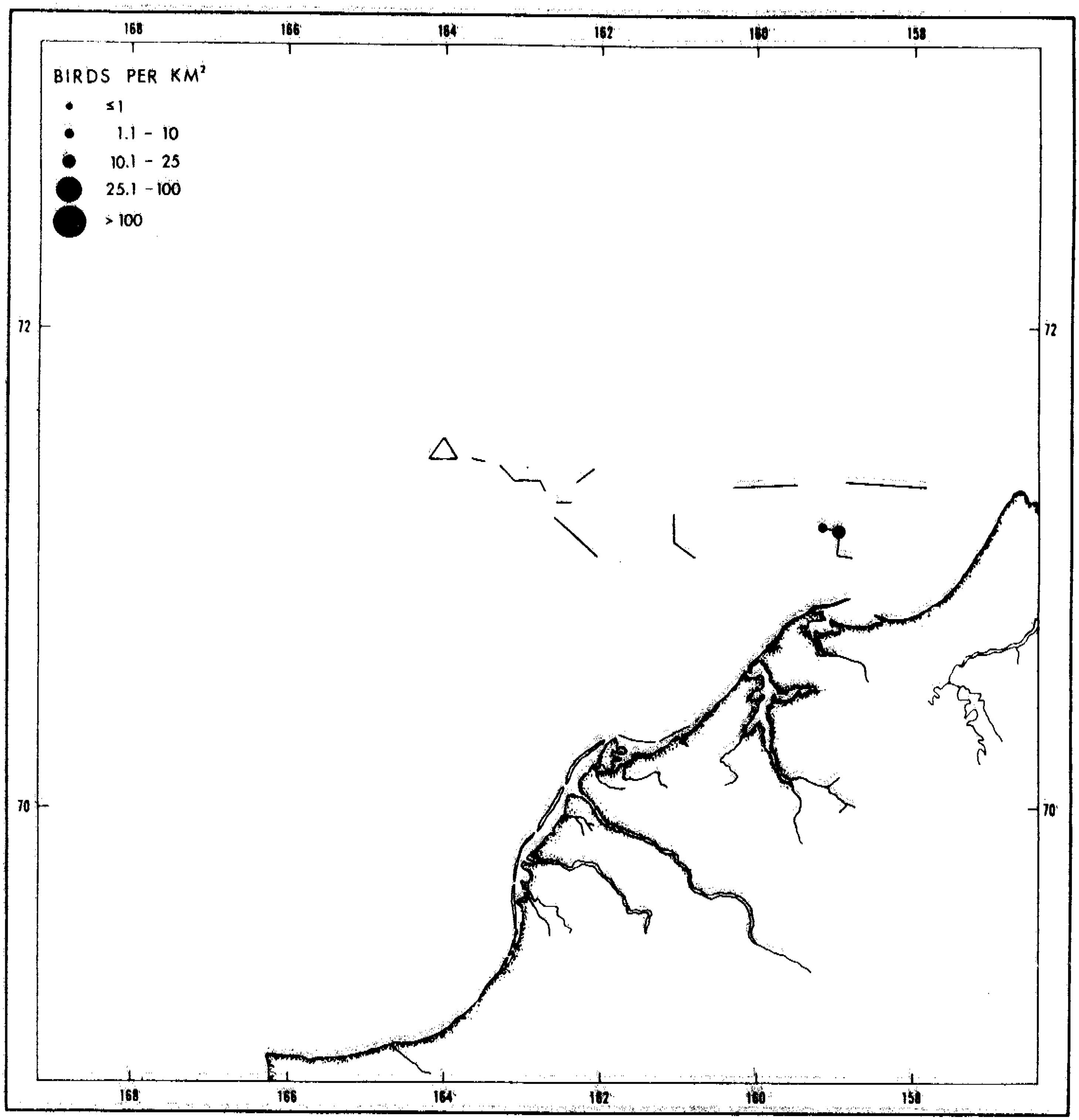


Figure 188. Distribution and abundance of Arctic Terns in northern Chukchi Sea from 5 to 8 August 1977.

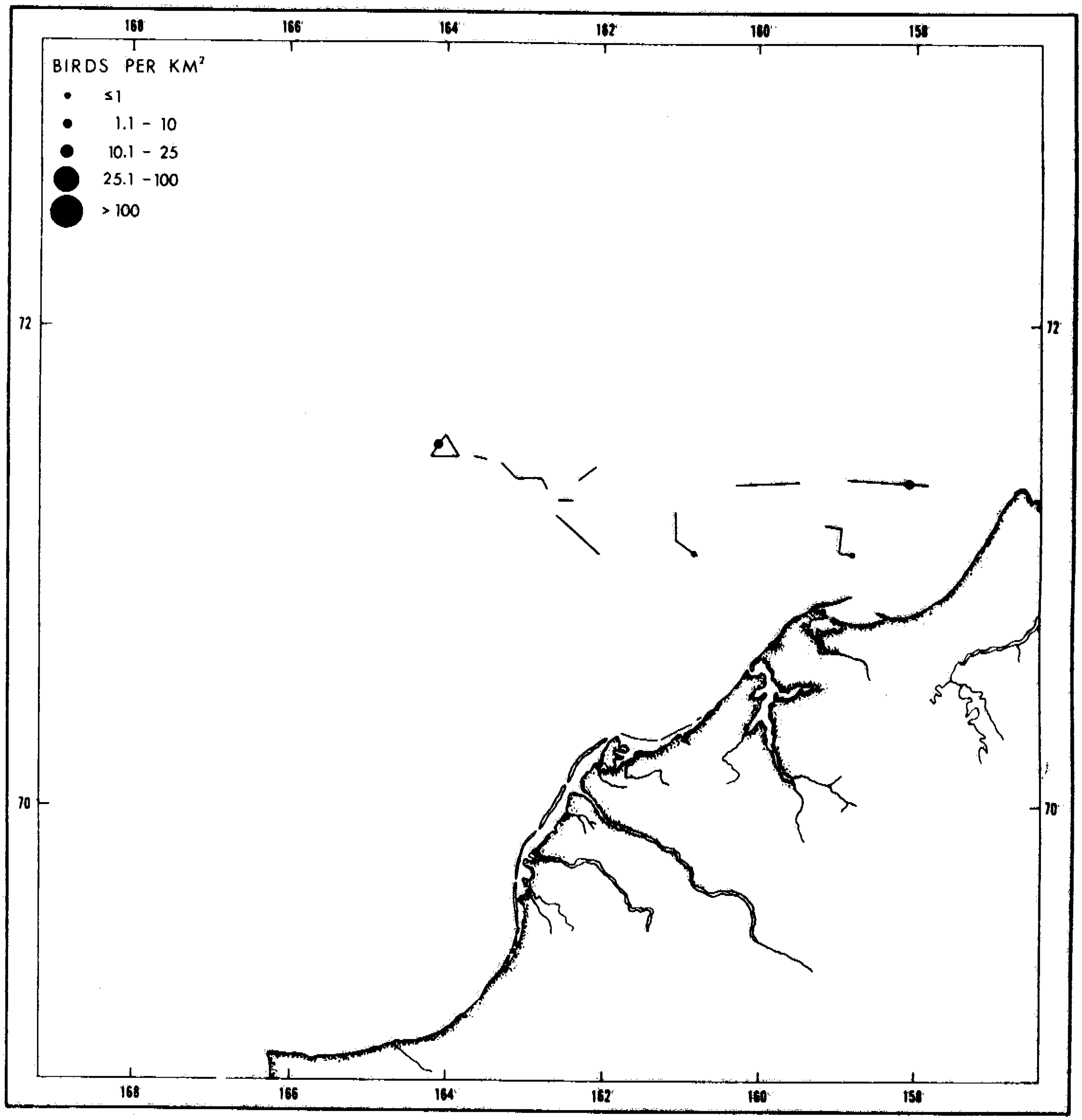


Figure 189. Distribution and abundance of ship followers in northern Chukchi Sea from 5 to 8 August 1977.

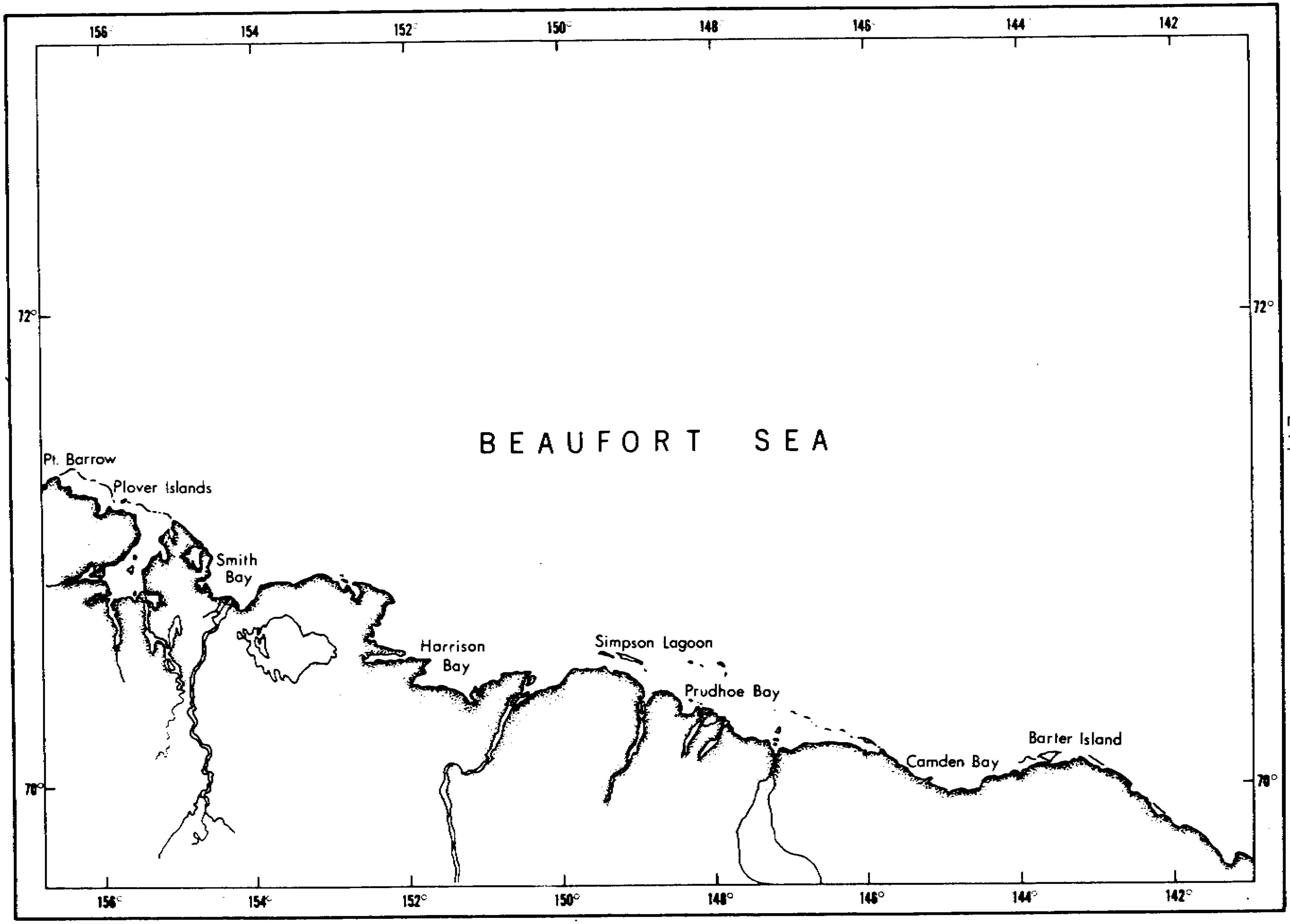


Figure 190. Beaufort Sea showing localities mentioned in text.

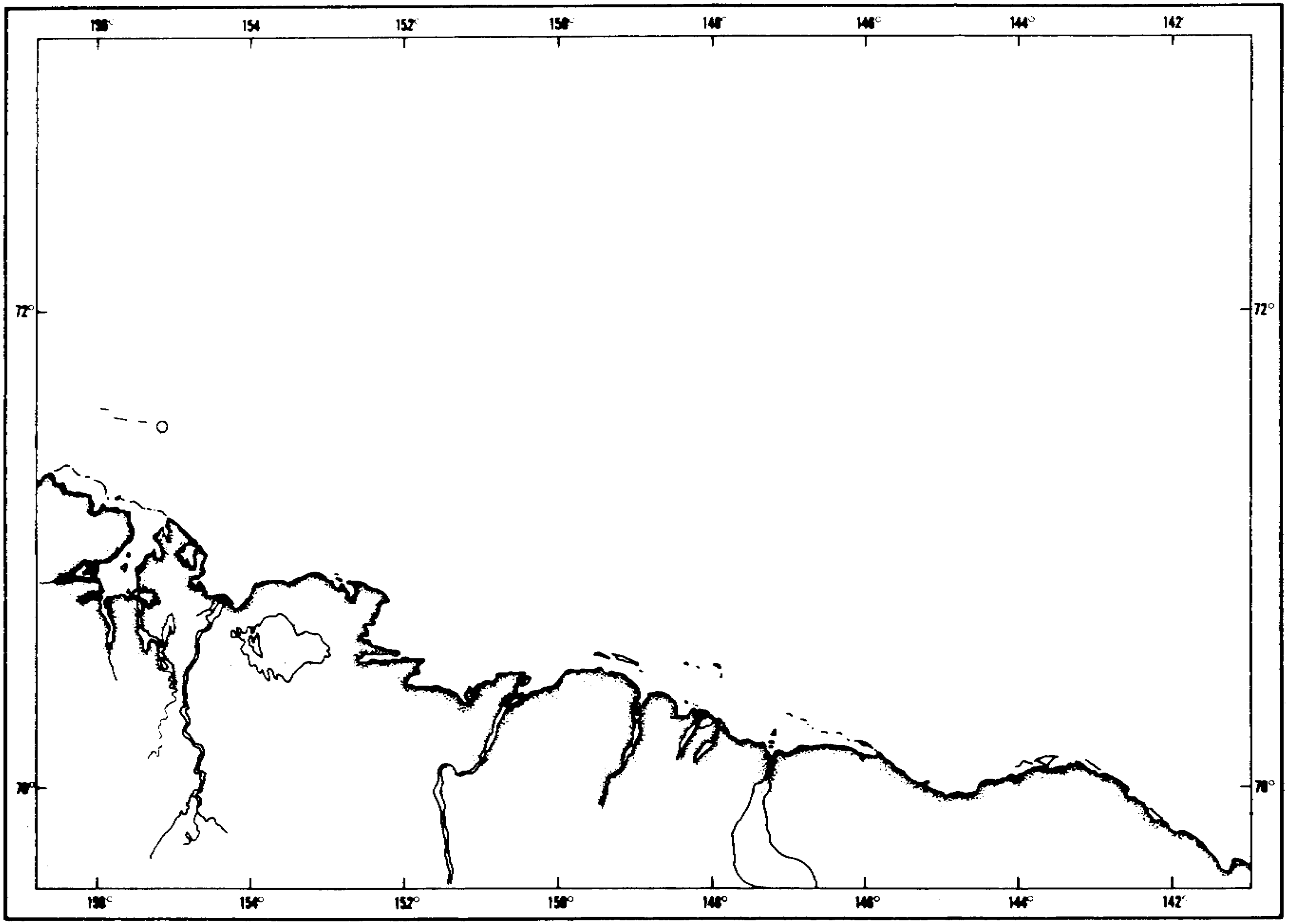


Figure 191. Cruise track during periods of observation in Beaufort Sea from 26 to 28 July 1976.

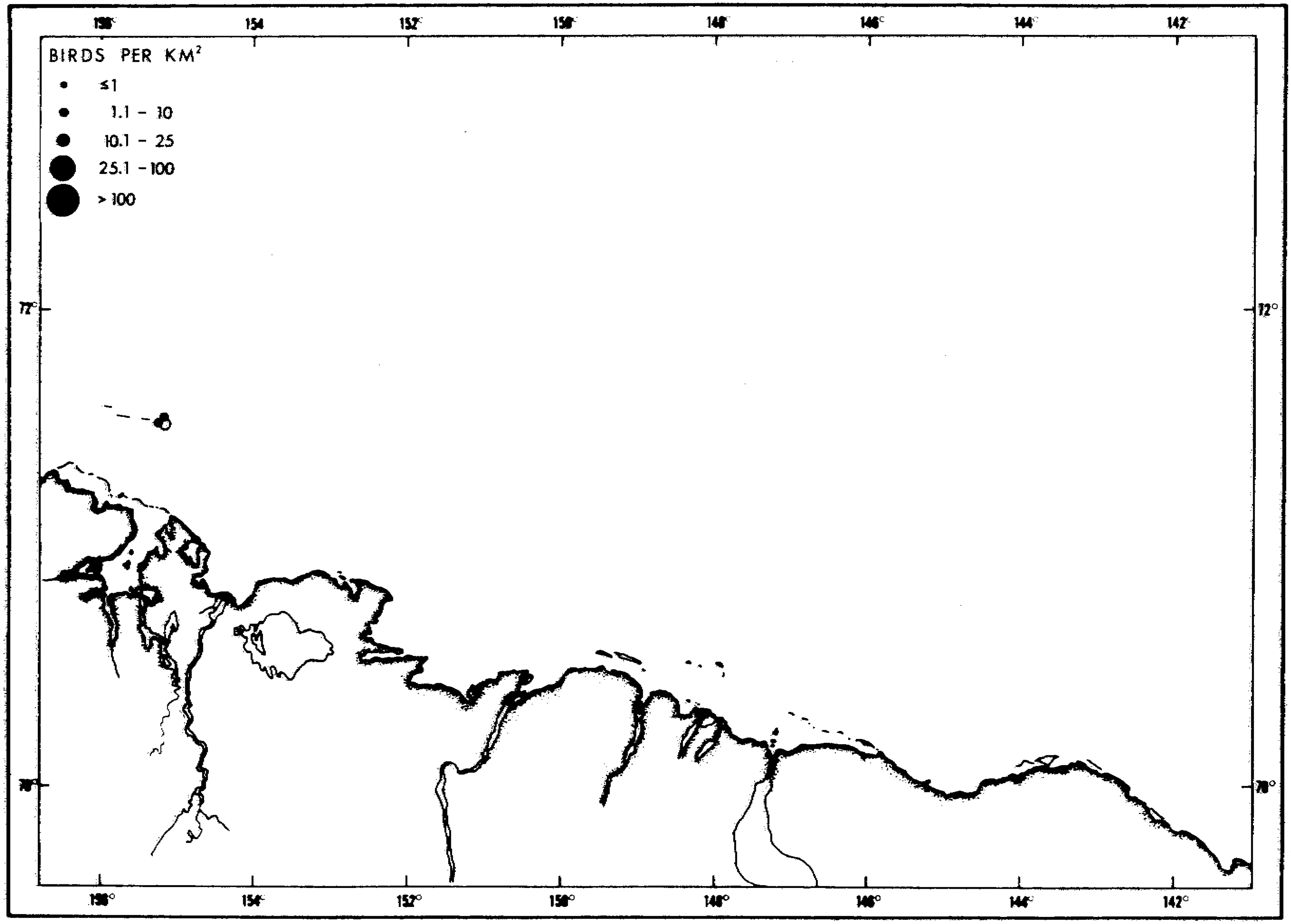


Figure 192. Distribution and abundance of seabirds in Beaufort Sea from 26 to 28 July 1976.

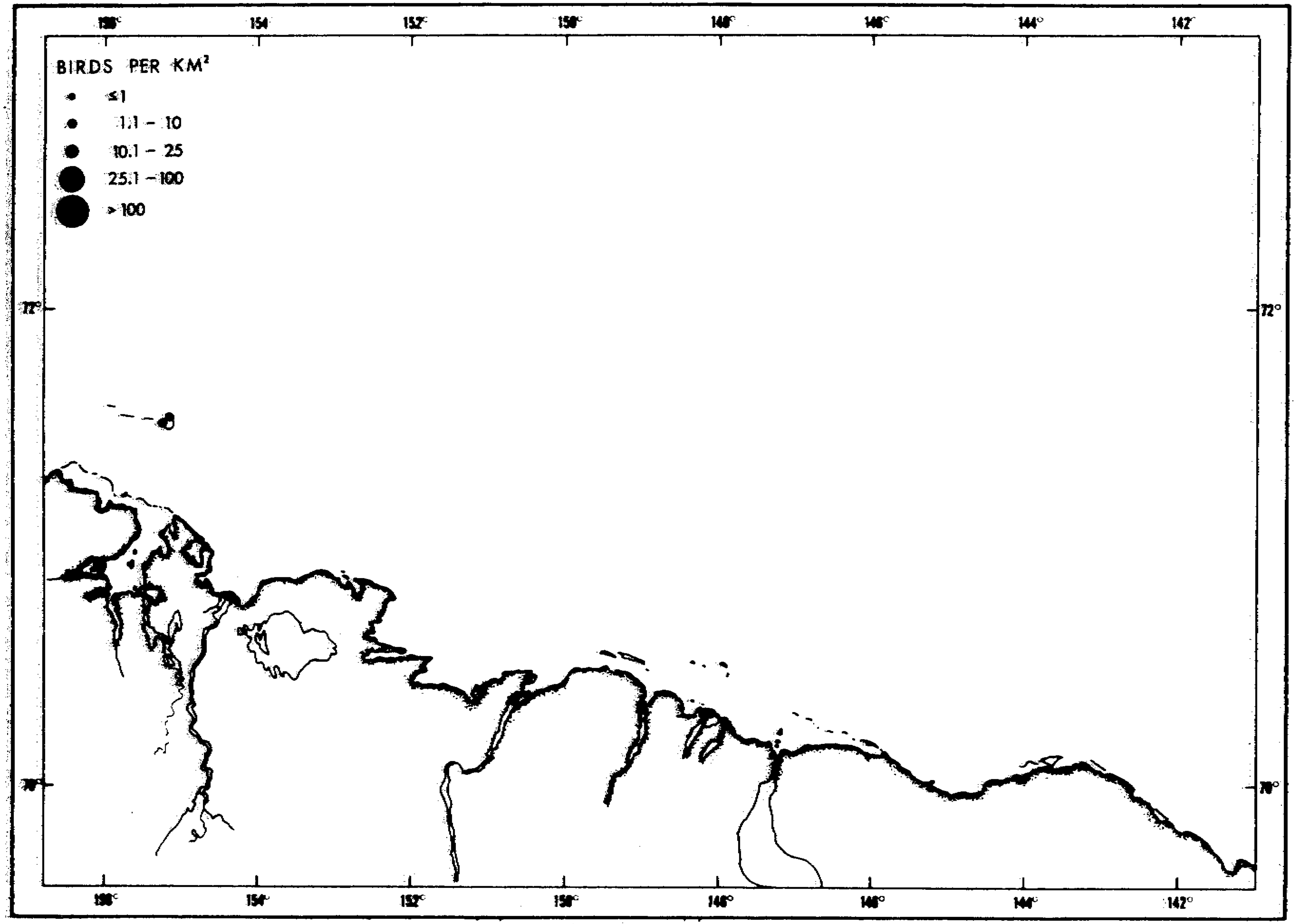


Figure 193. Distribution and abundance of murres in Beaufort Sea from 26 to 28 July 1976.

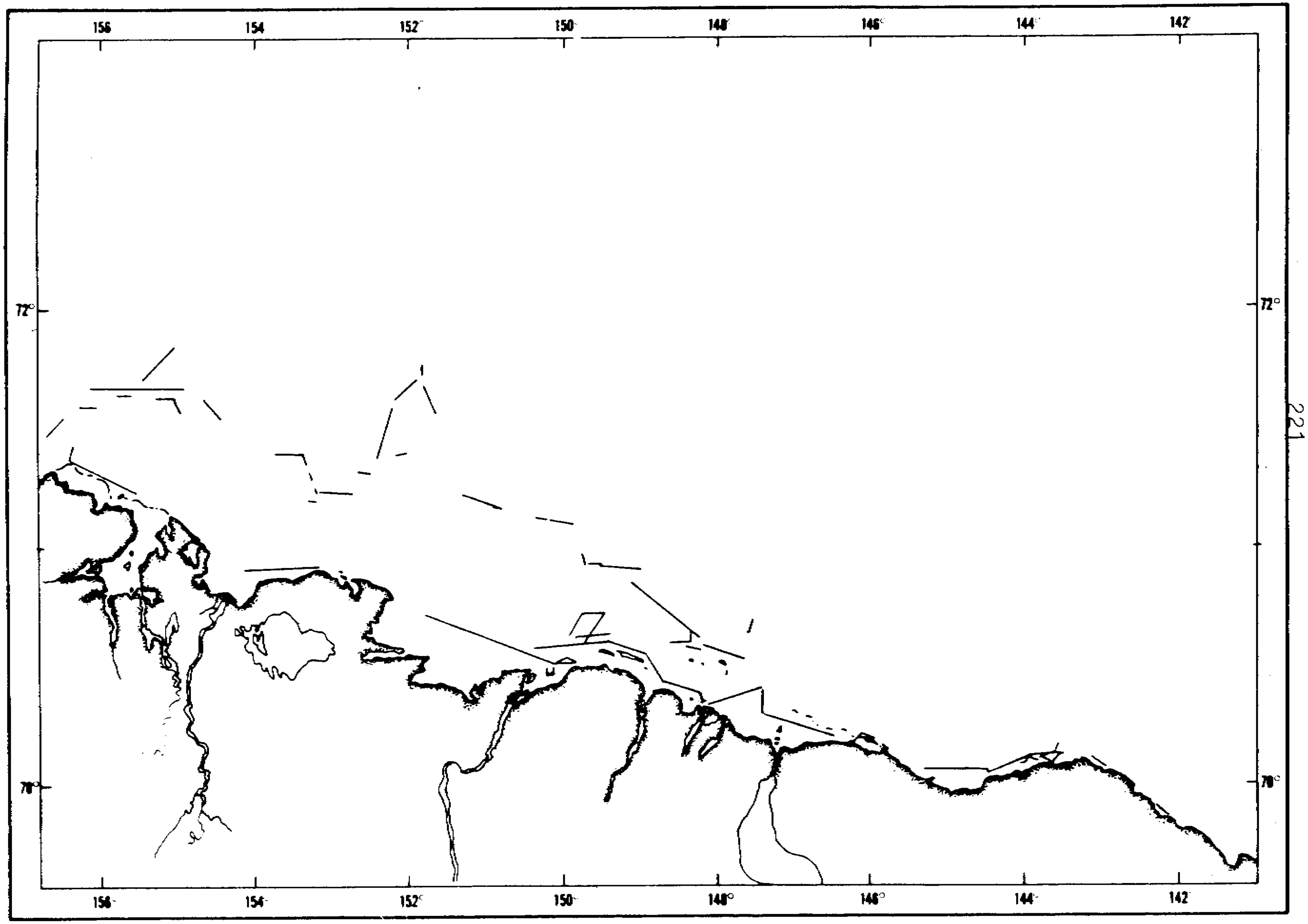


Figure 194. Cruise track during periods of observation in Beaufort Sea from 17 August to 3 September 1976.

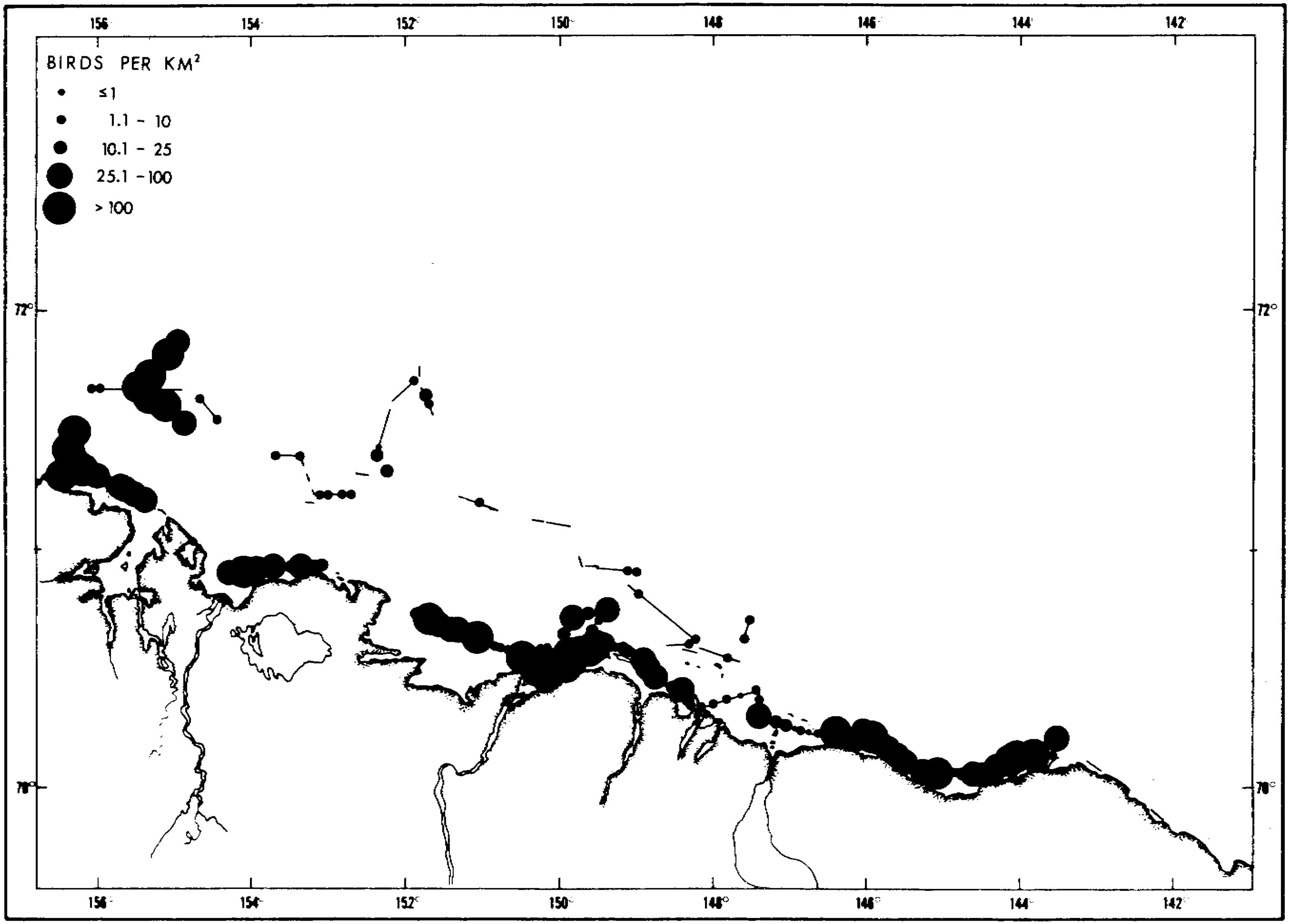


Figure 195. Distribution and abundance of seabirds in Beaufort Sea from 17 August to 3 September 1976.

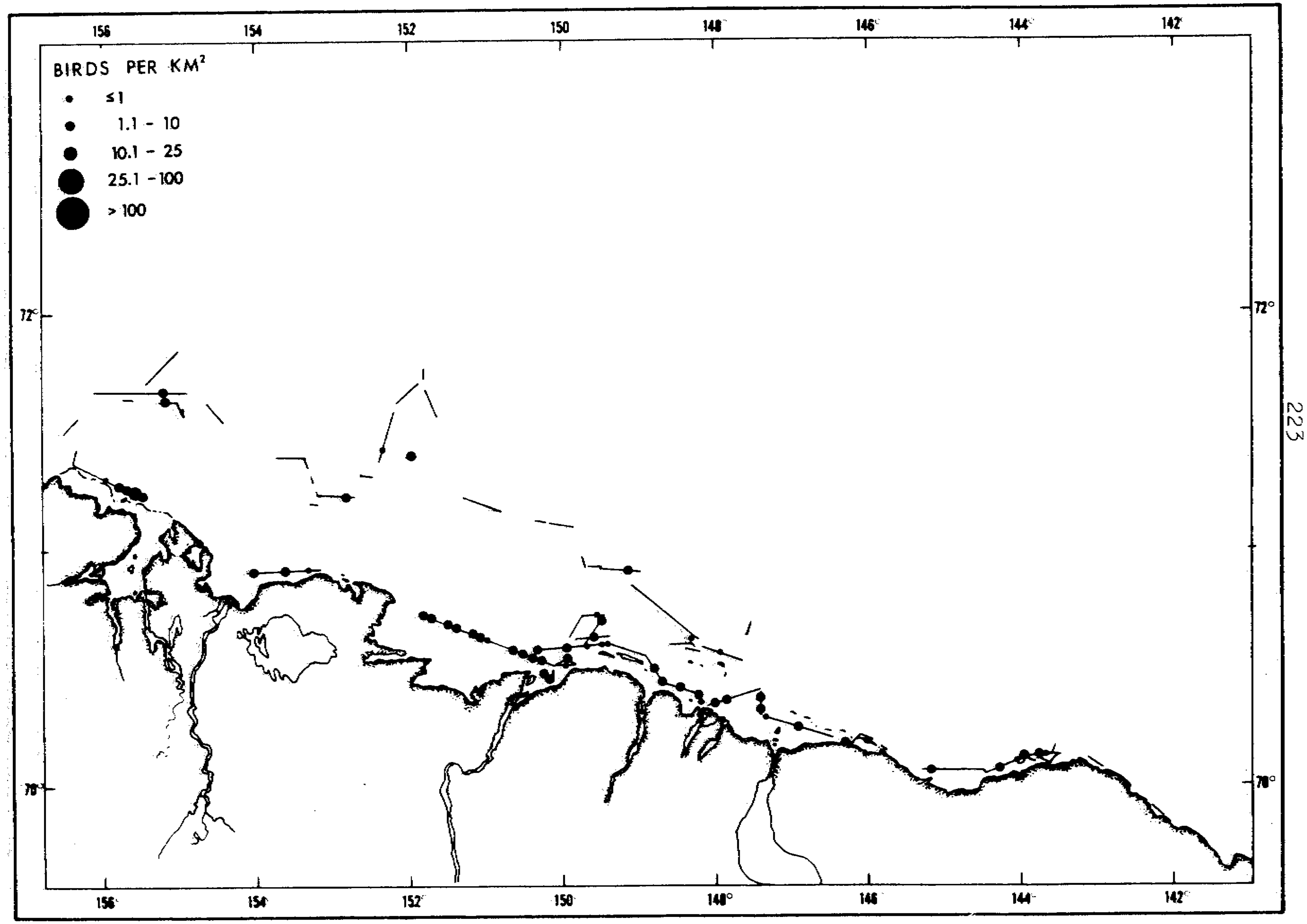


Figure 196. Distribution and abundance of loons in Beaufort Sea from 17 August to 3 September 1976.

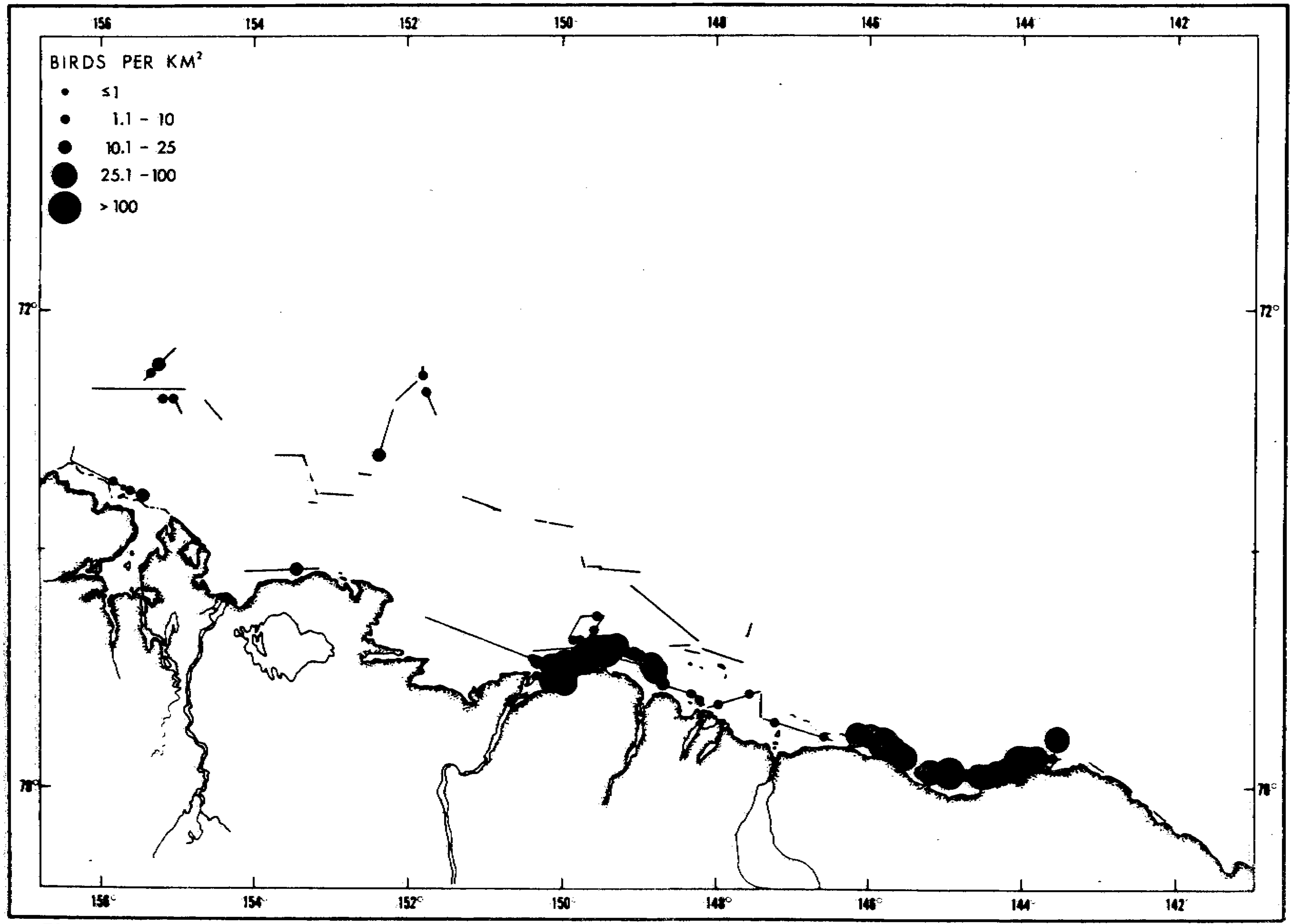


Figure 197. Distribution and abundance of Oldsquaws in Beaufort Sea from 17 August to 3 September 1976.

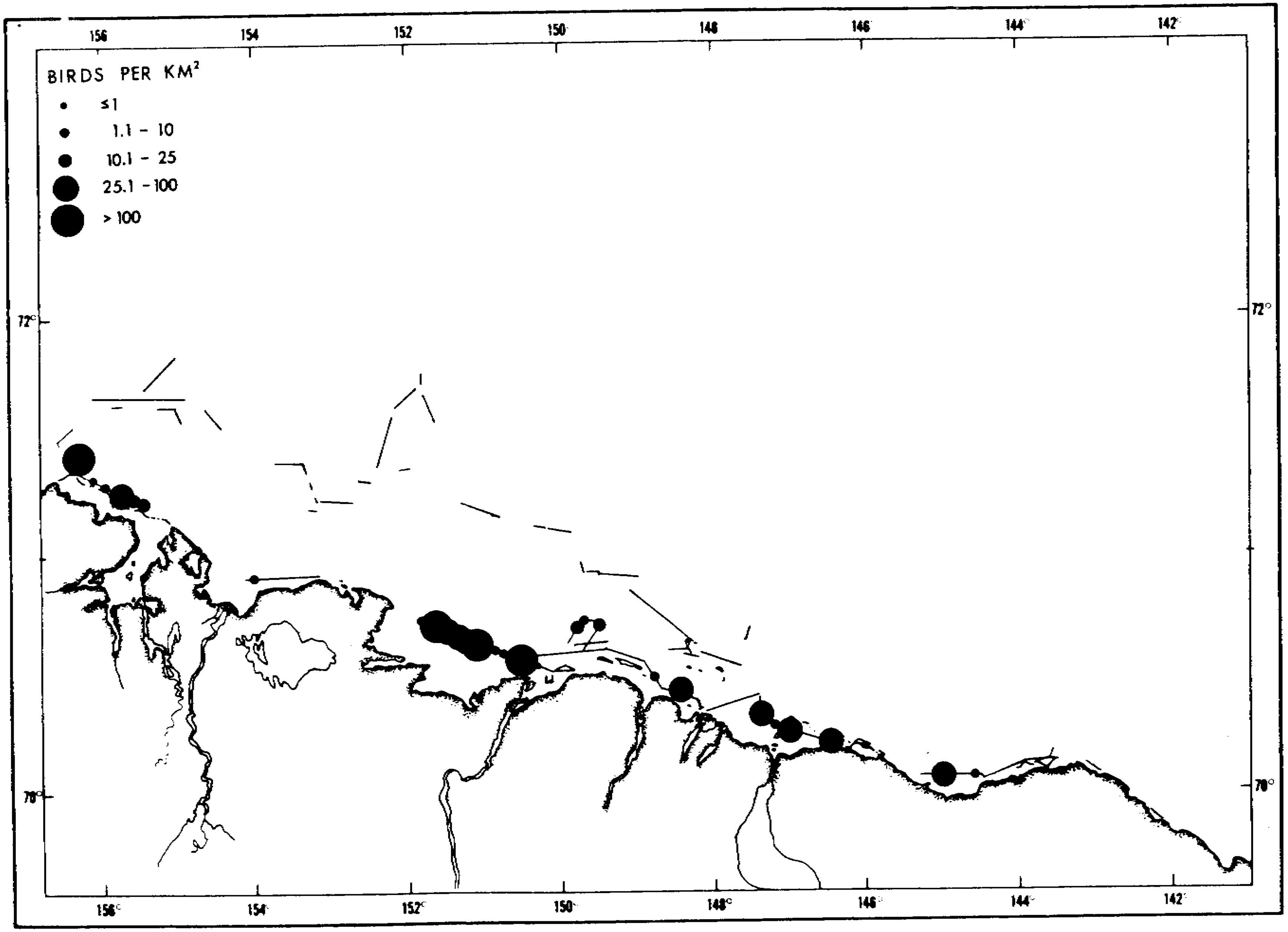


Figure 198. Distribution and abundance of eiders in Beaufort Sea from 17 August to 3 September 1976.

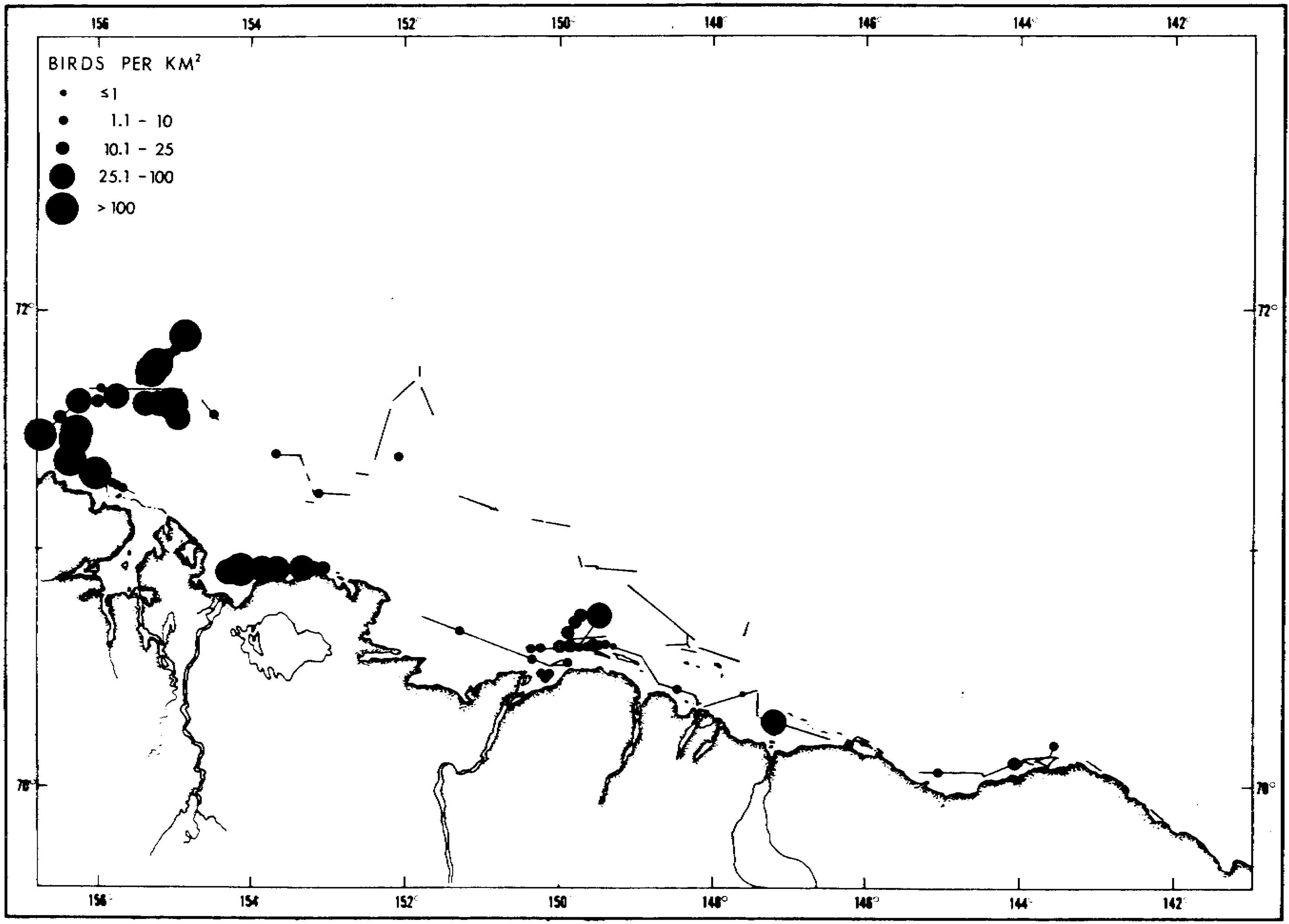


Figure 199. Distribution and abundance of phalaropes in Beaufort Sea from 17 August to 3 September 1976.

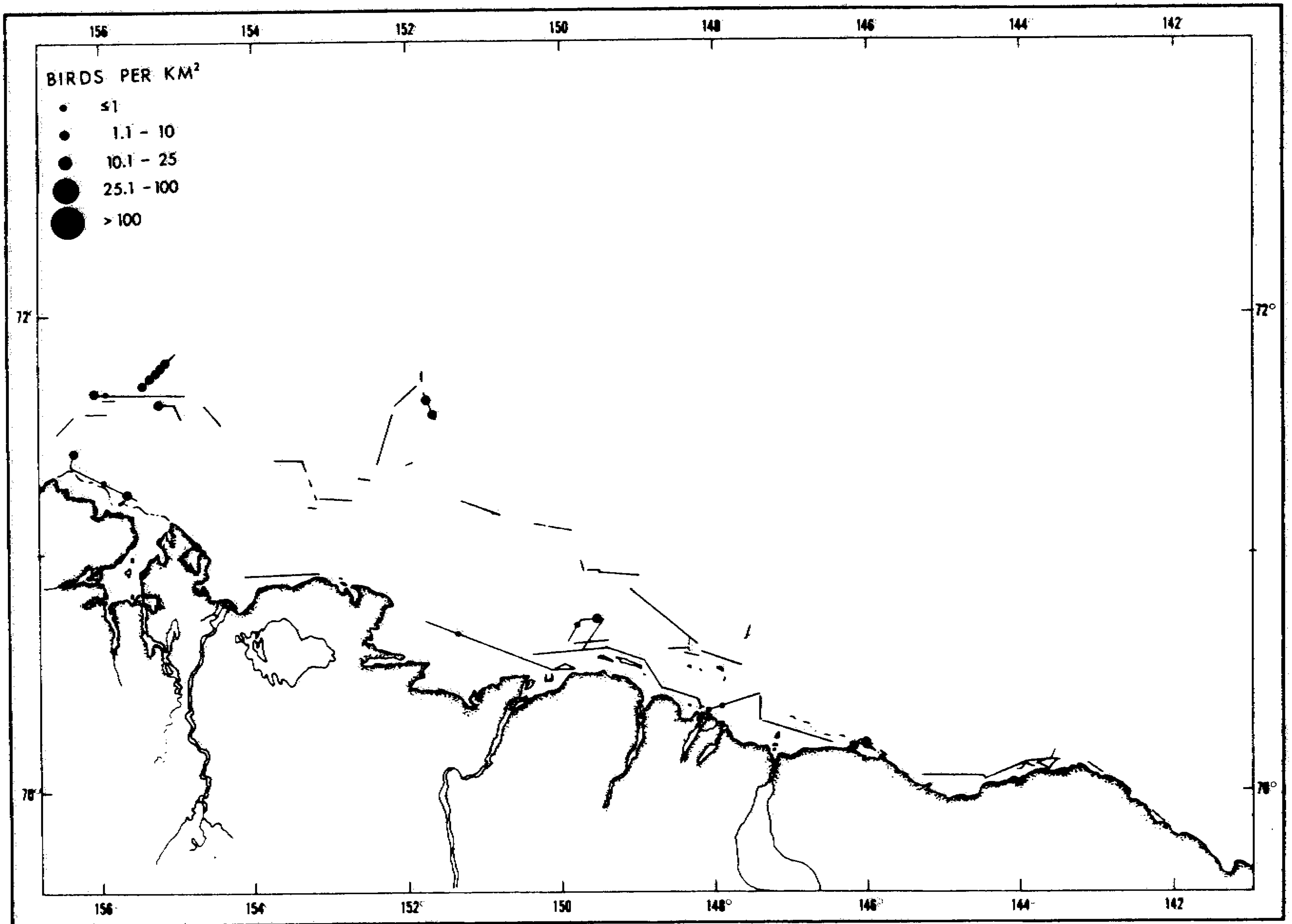


Figure 200. Distribution and abundance of jaegers in Beaufort Sea from 17 August to 3 September 1976.

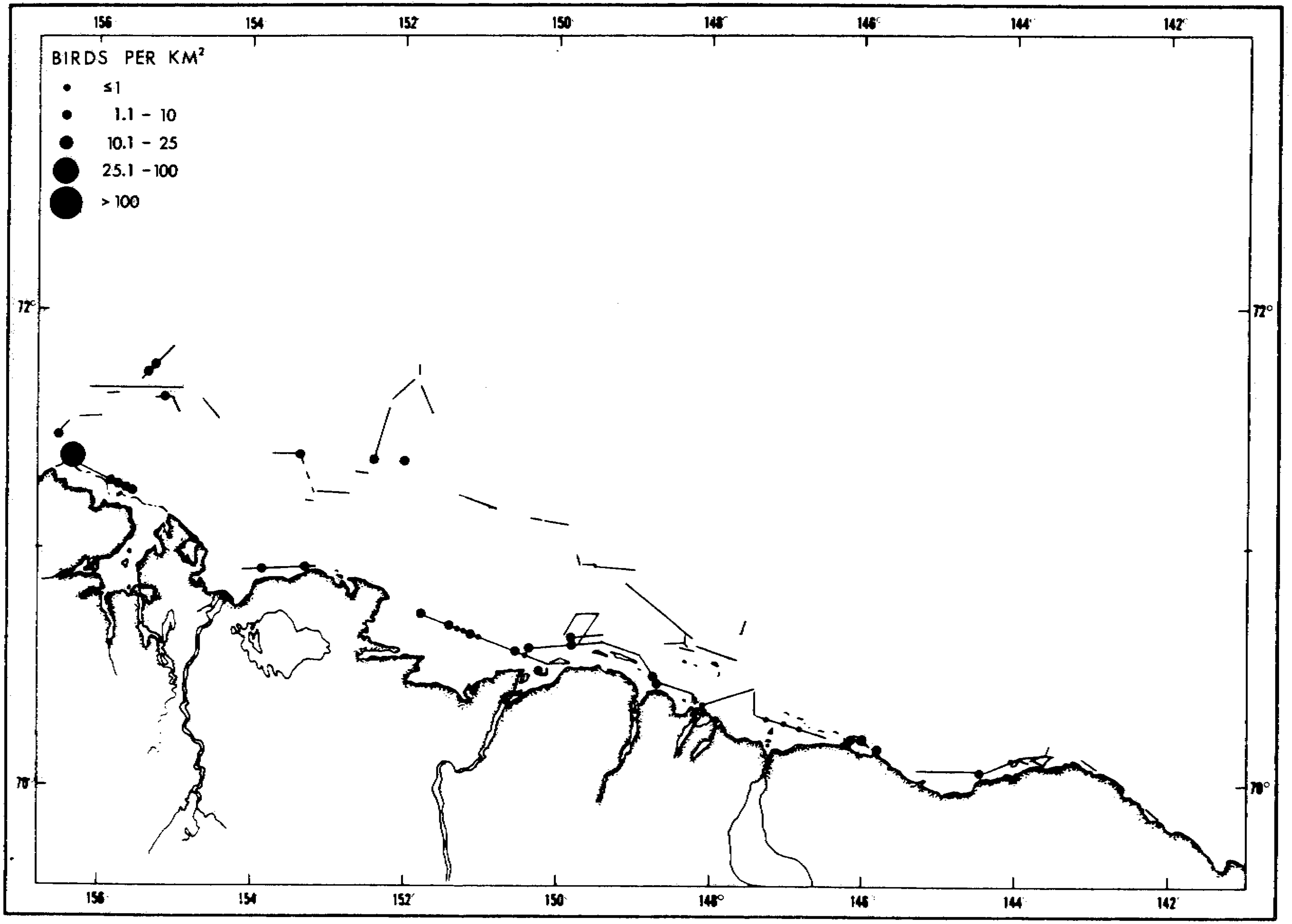


Figure 201. Distribution and abundance of Glaucous Gulls in Beaufort Sea from 17 August to 3 September 1976.

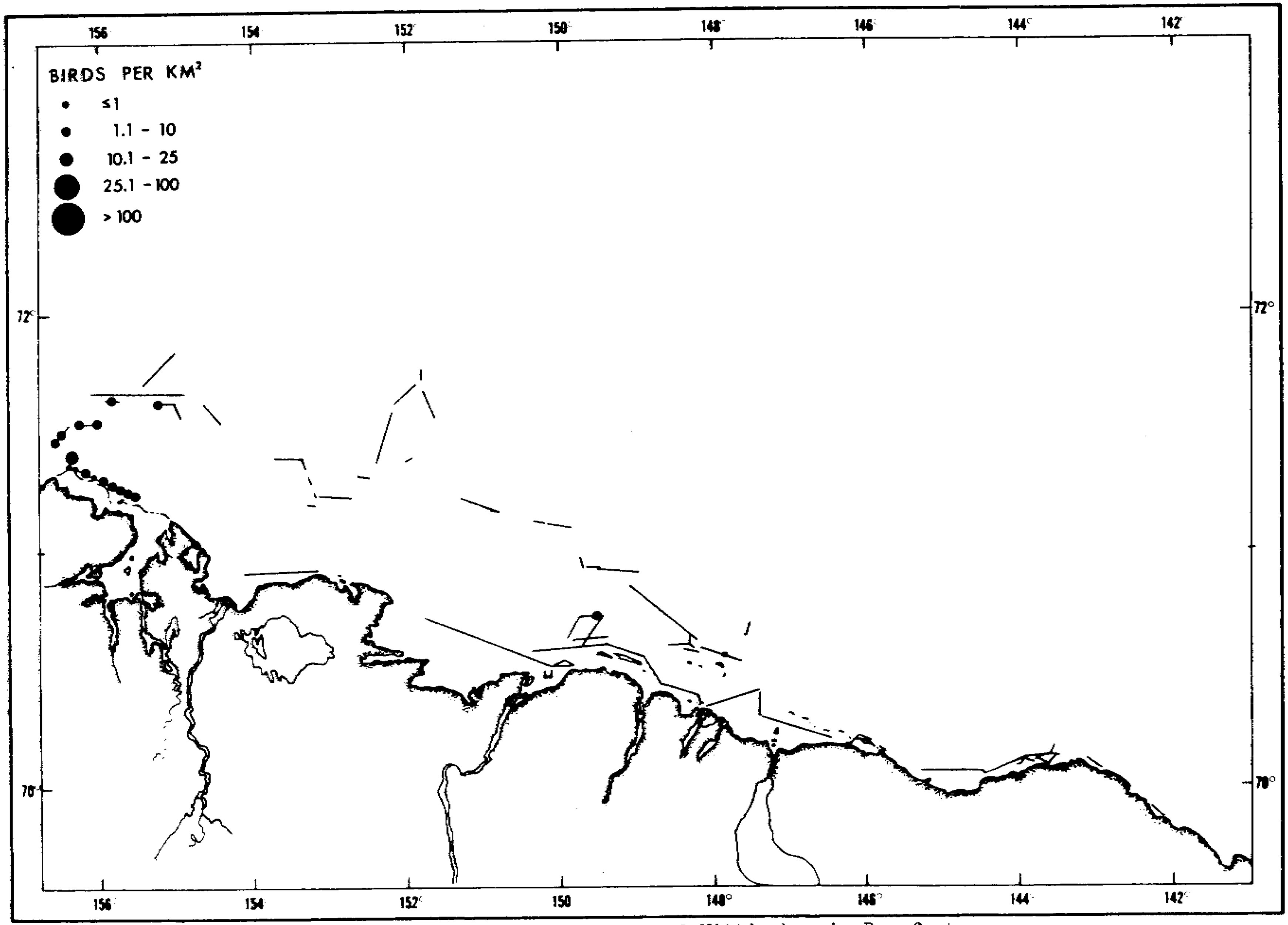


Figure 202. Distribution and abundance of Black-legged Kittiwakes in Beaufort Sea from 17 August to 3 September 1976.

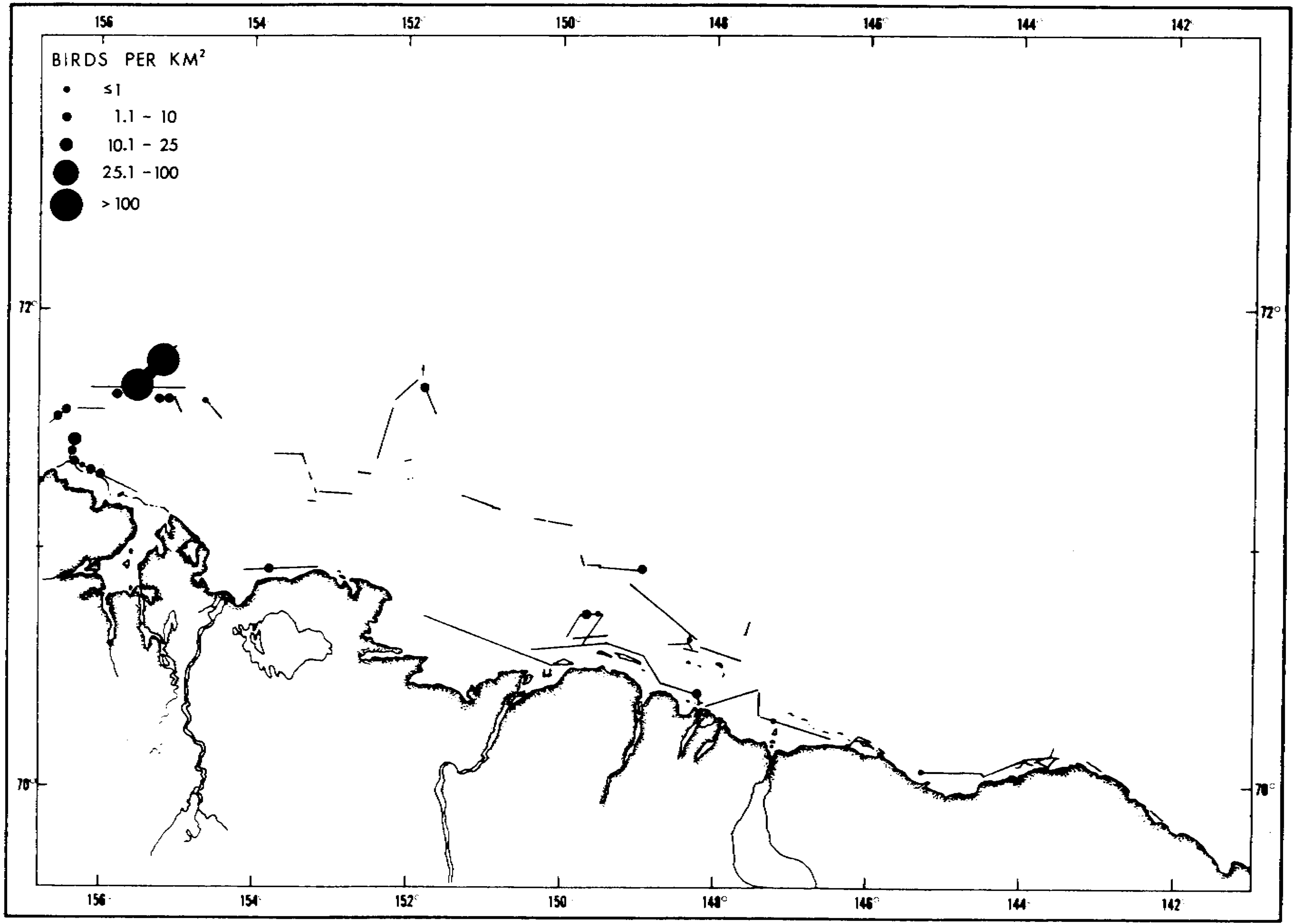


Figure 203. Distribution and abundance of Sabine's Gulls in Beaufort Sea from 17 August to 3 September 1976.

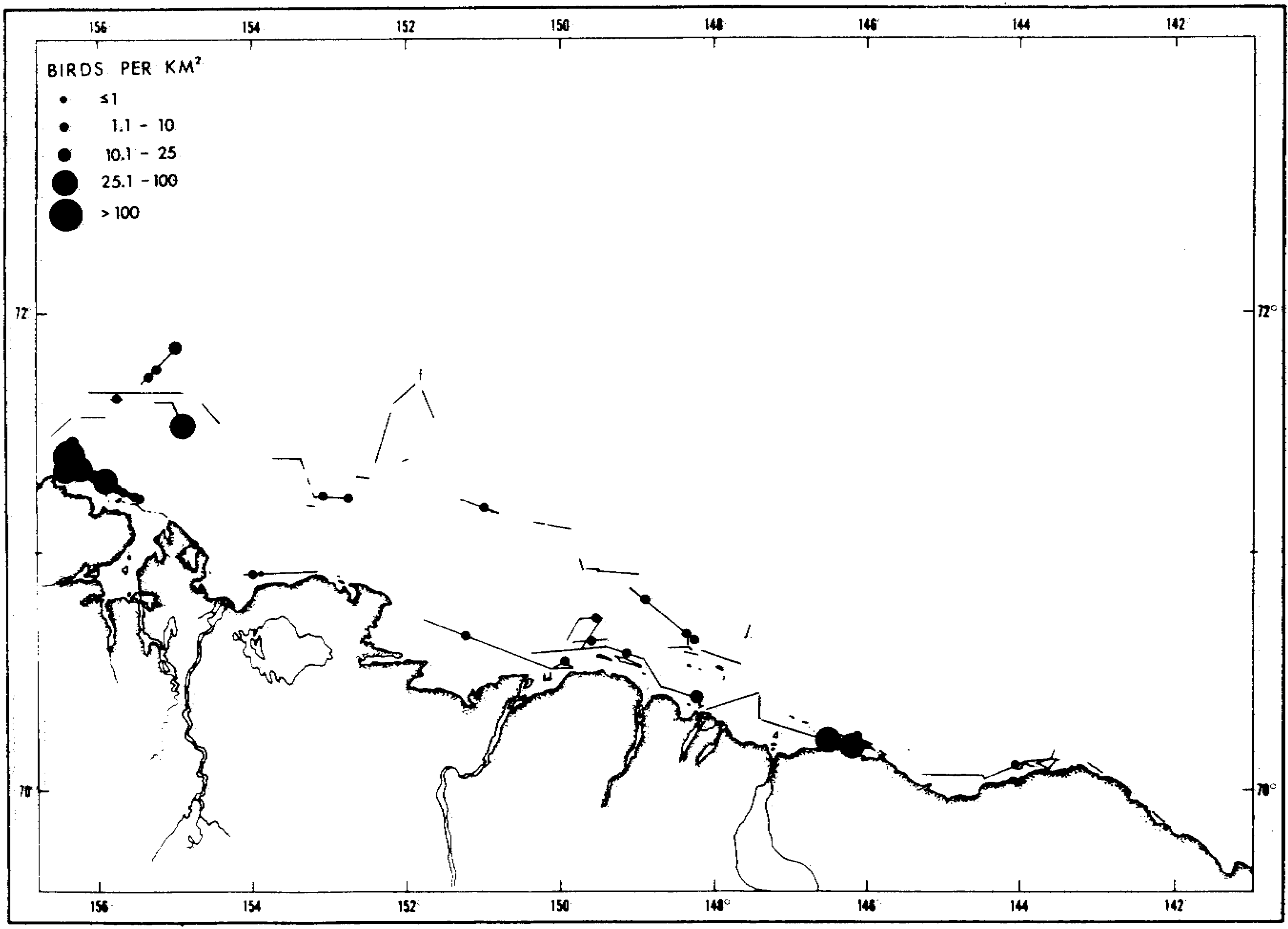


Figure 204. Distribution and abundance of Arctic Terns in Beaufort Sea from 17 August to 3 September 1976.

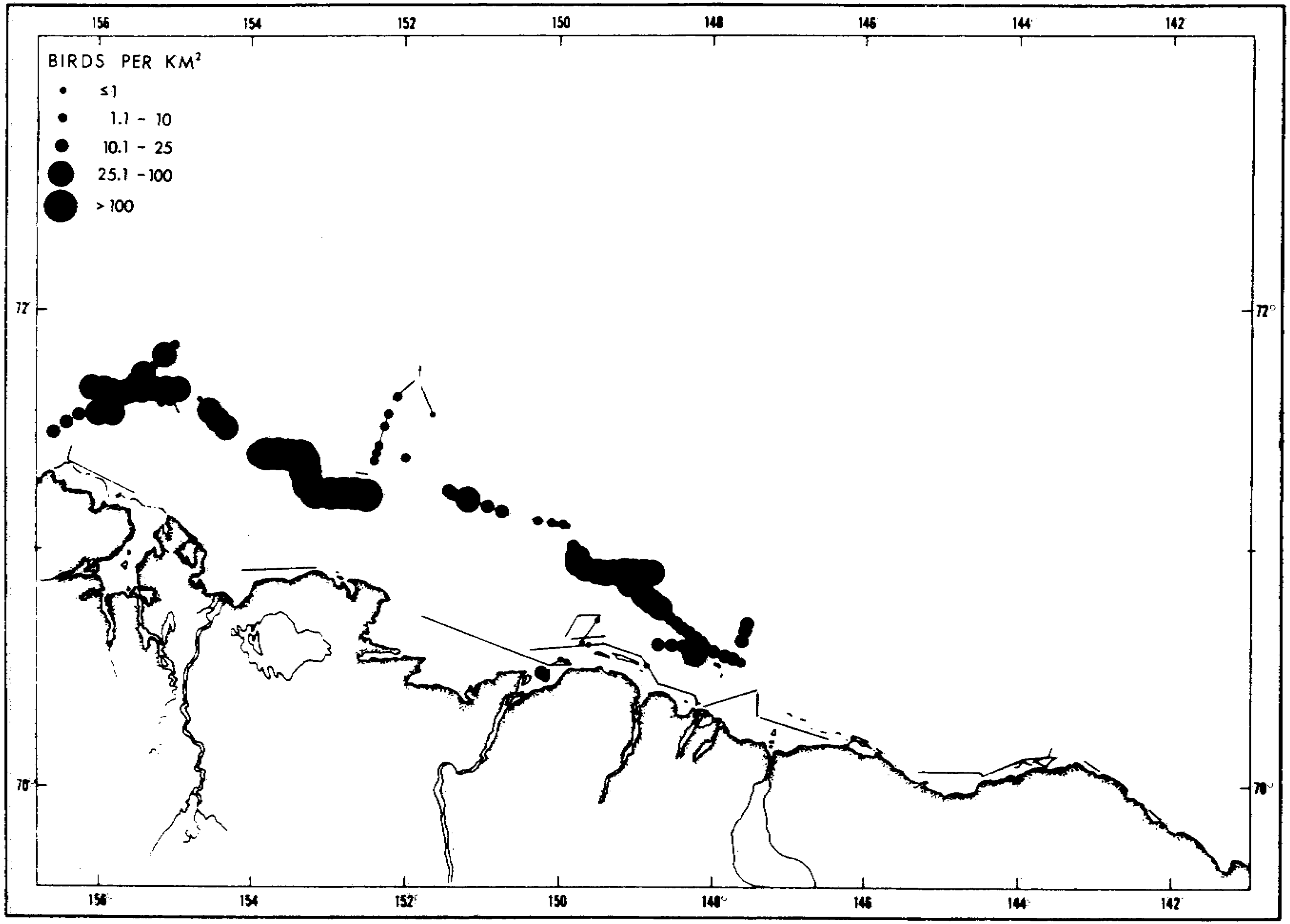


Figure 205. Distribution and abundance of ship followers in Beaufort Sea from 17 August to 3 September 1976.

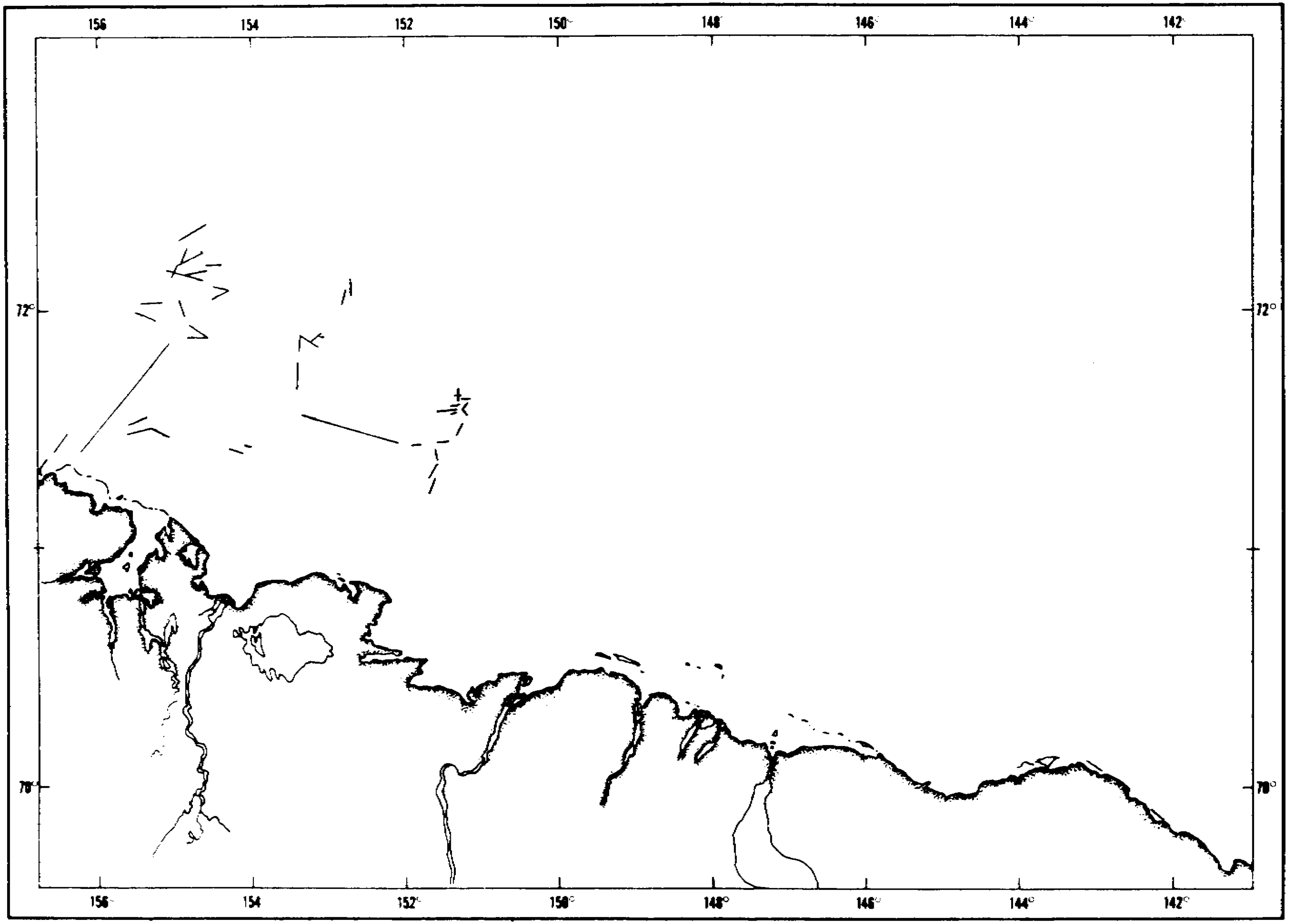


Figure 206. Cruise track during periods of observation in Beaufort Sea from 6 to 18 September 1976.

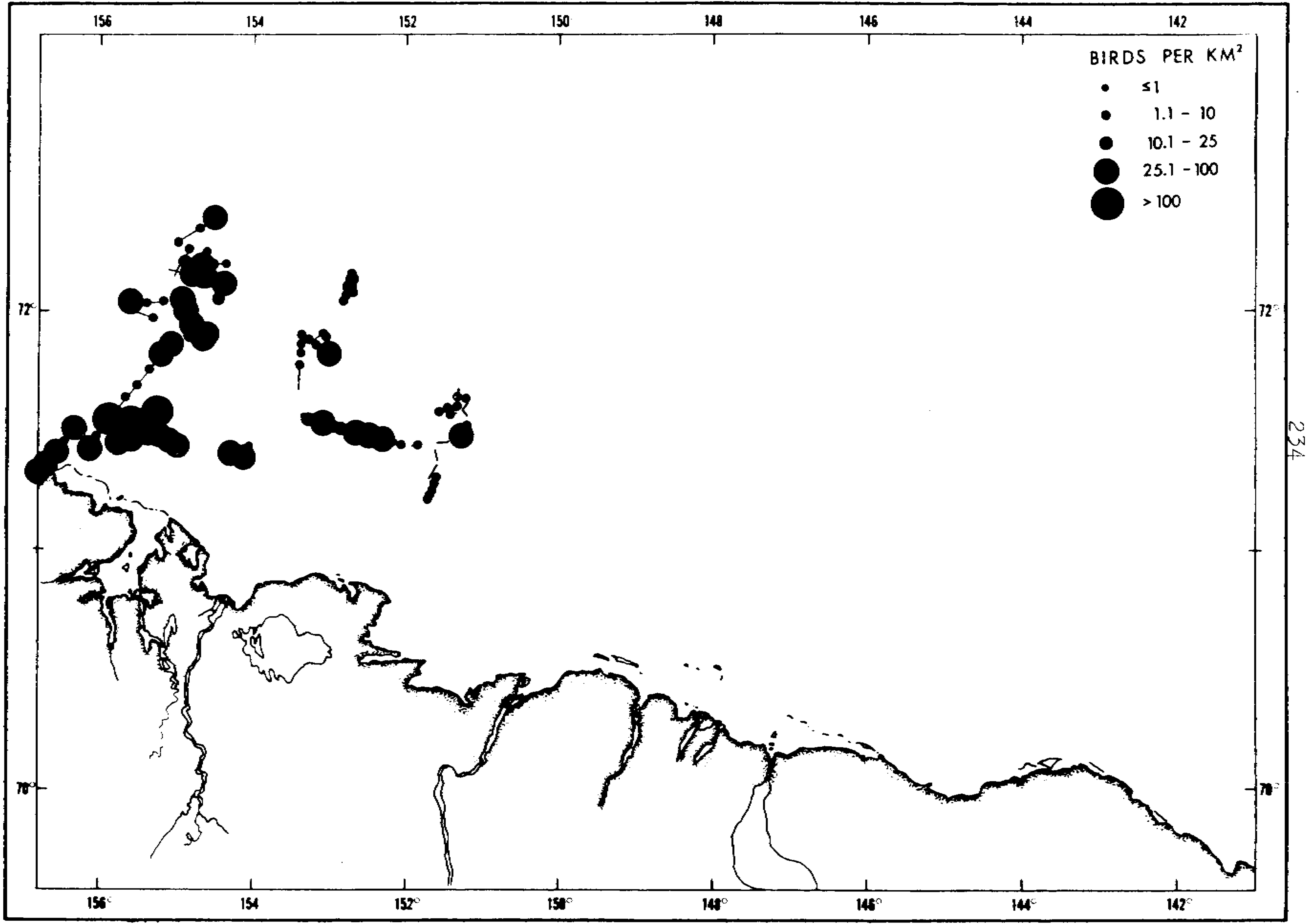


Figure 207. Distribution and abundance of seabirds in Beaufort Sea from 6 to 18 September 1976.

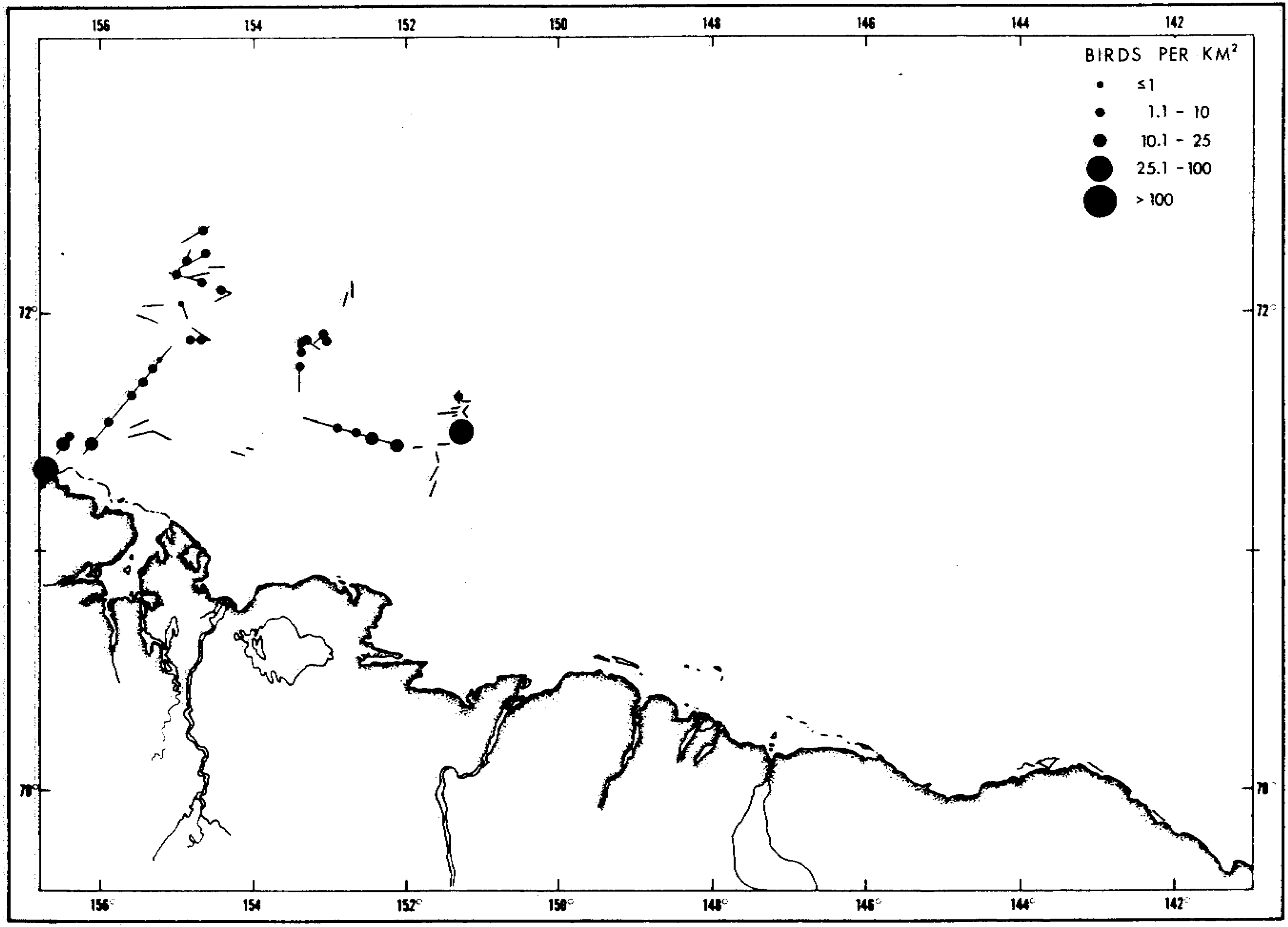


Figure 208. Distribution and abundance of loons in Beaufort Sea from 6 to 18 September 1976.

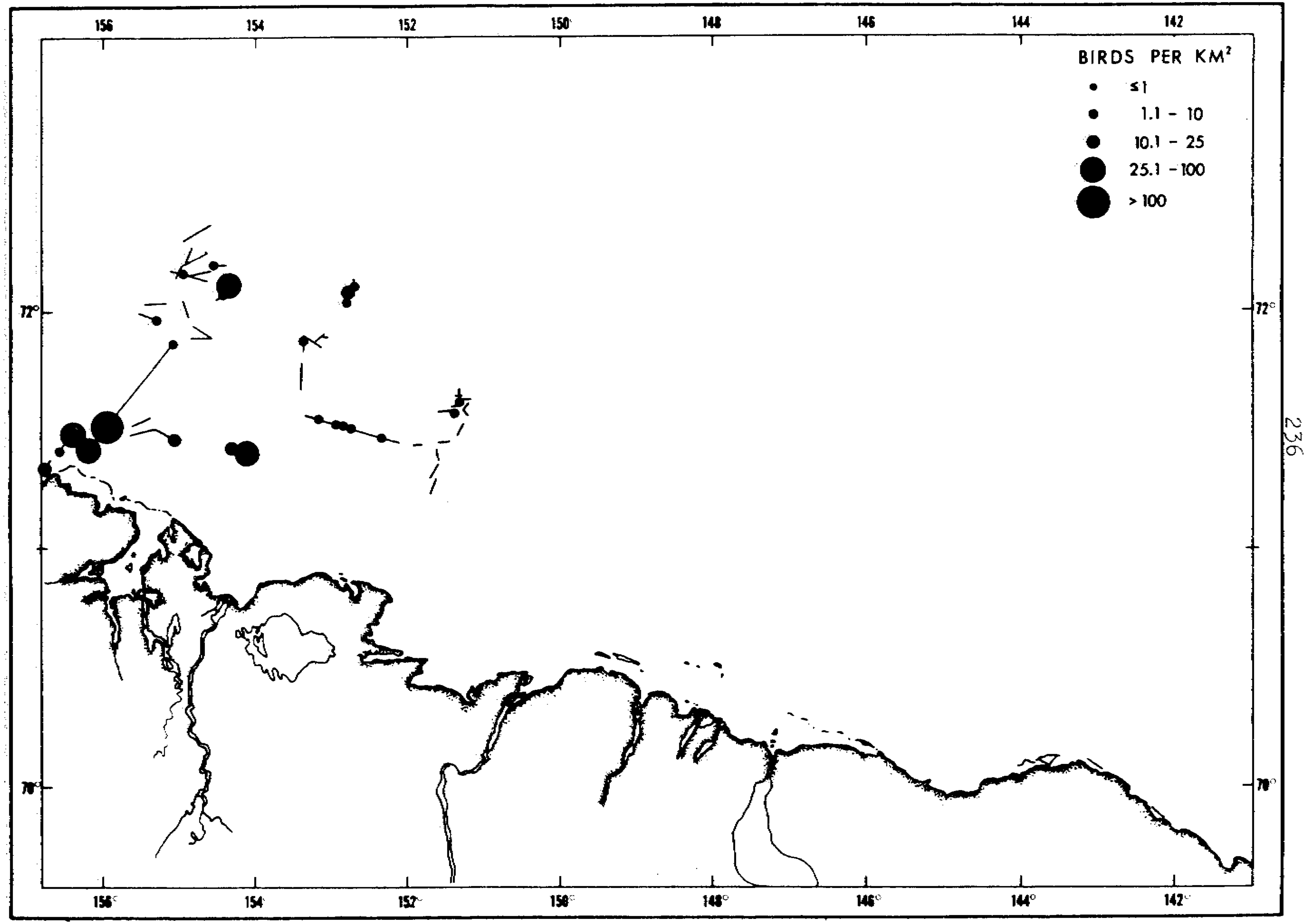


Figure 209. Distribution and abundance of Oldsquaws in Beaufort Sea from 6 to 18 September 1976.

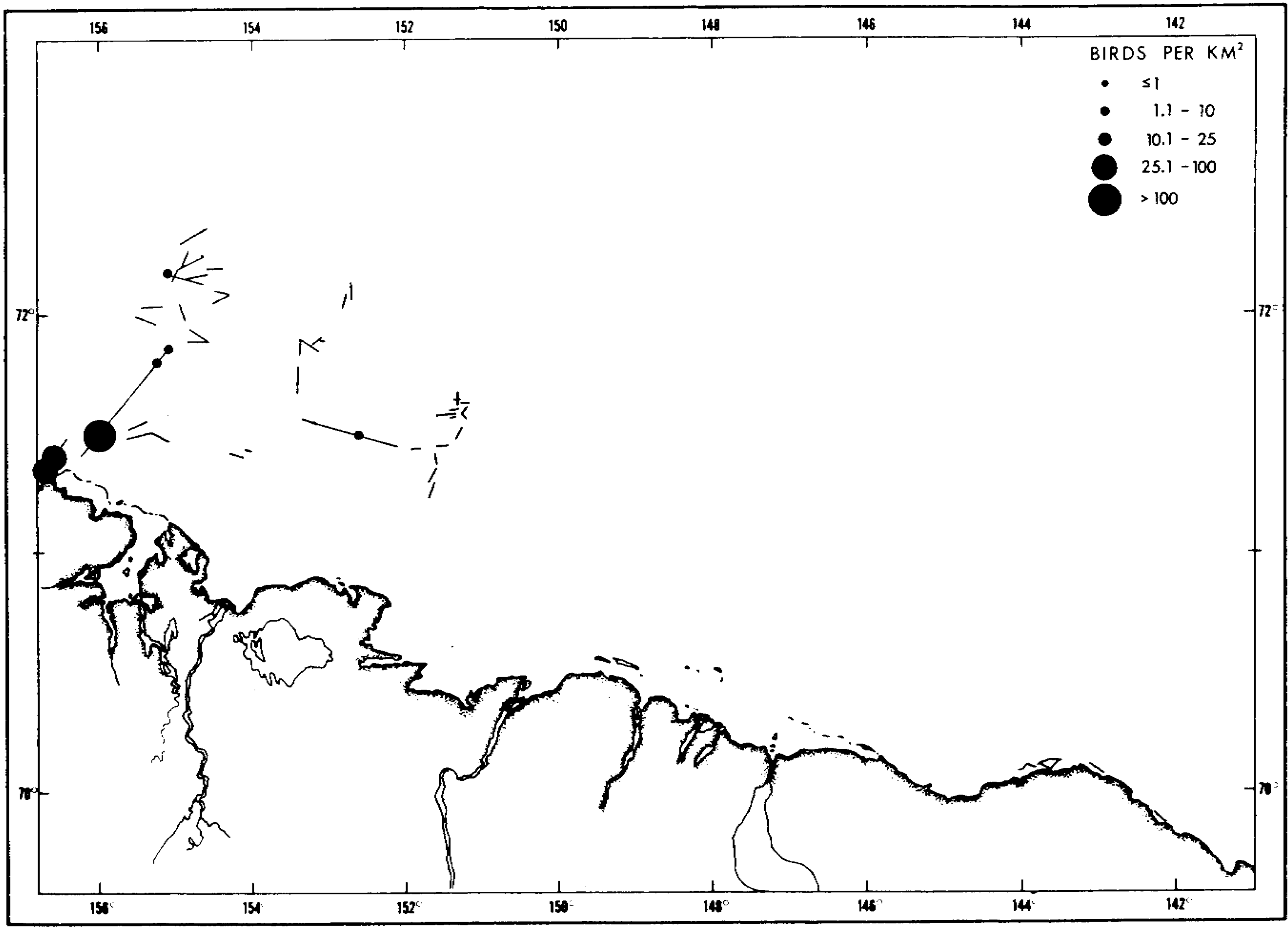


Figure 210. Distribution and abundance of eiders in Beaufort Sea from 6 to 18 September 1976.

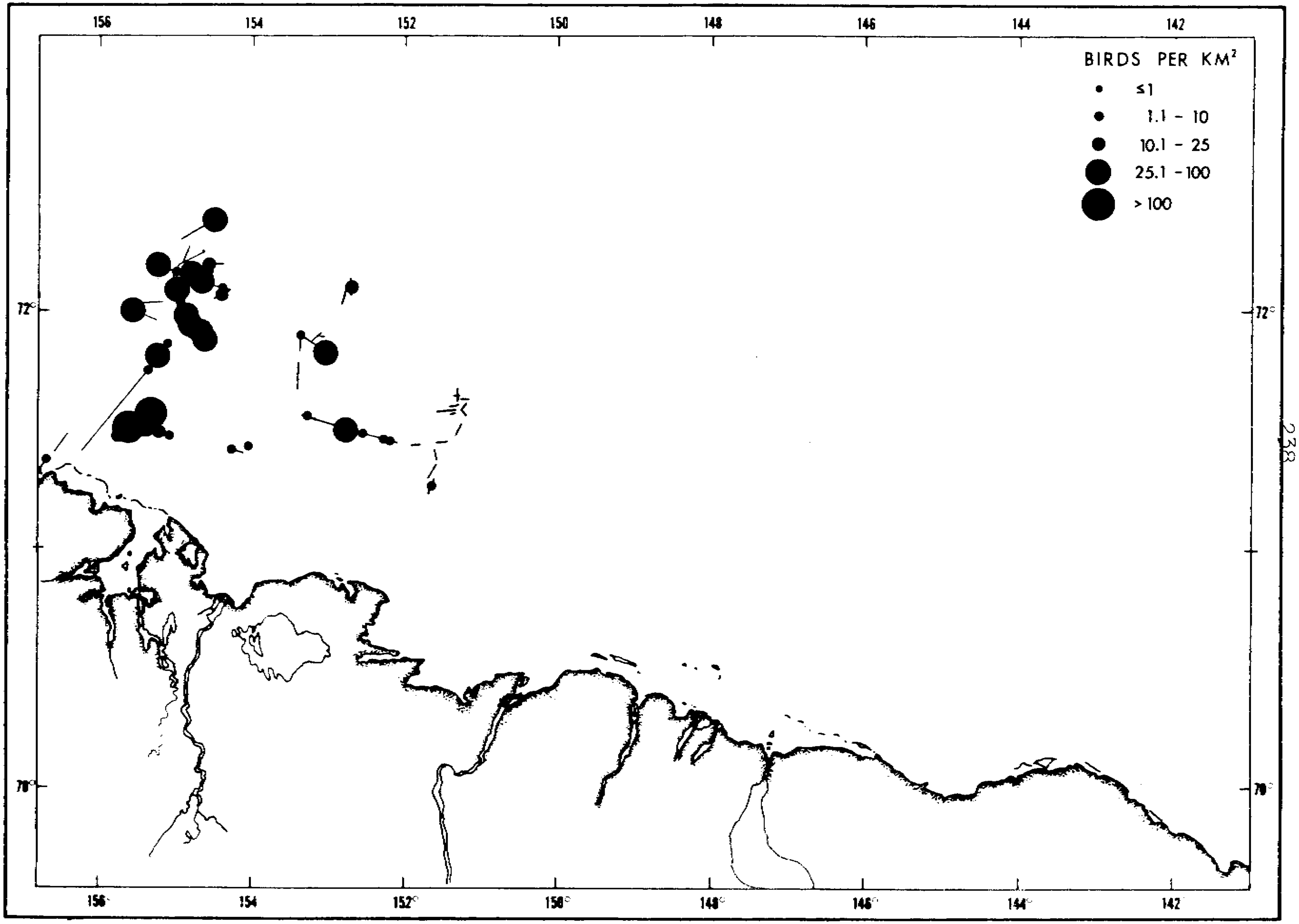


Figure 211. Distribution and abundance of phalaropes in Beaufort Sea from 6 to 18 September 1976.

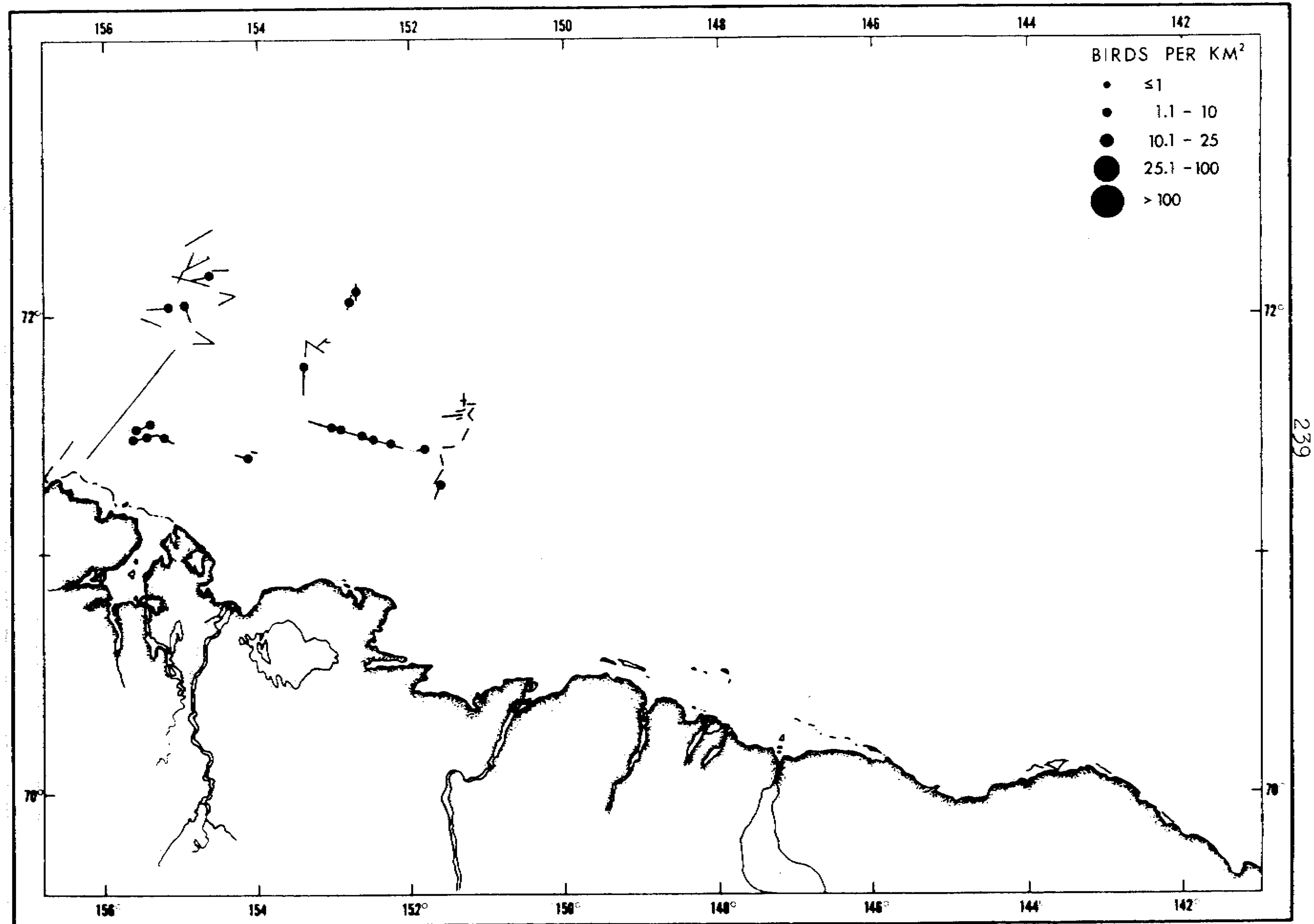


Figure 212. Distribution and abundance of jaegers in Beaufort Sea from 6 to 18 September 1976.

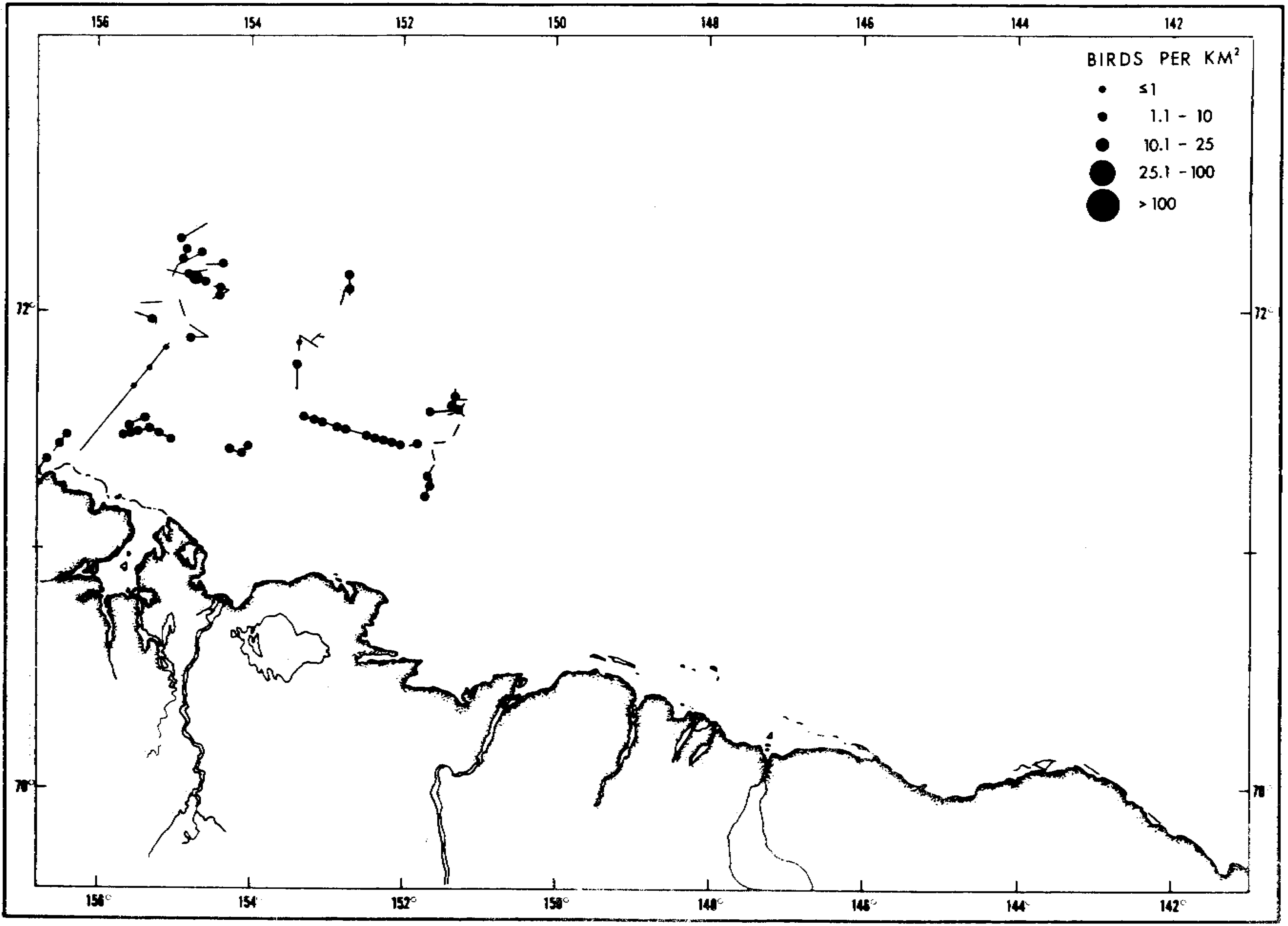


Figure 213. Distribution and abundance of Glaucous Gulls in Beaufort Sea from 6 to 18 September 1976.

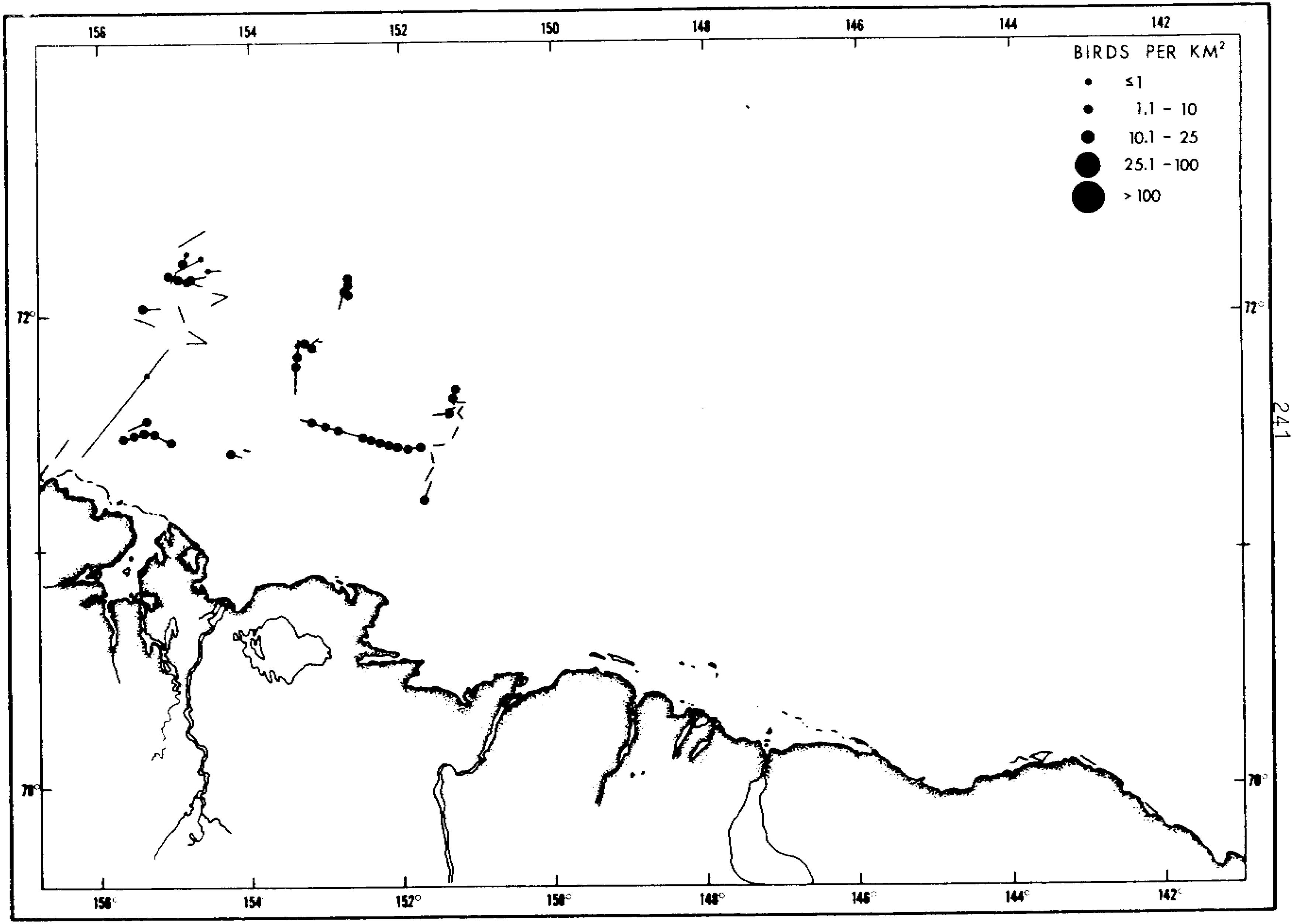


Figure 214. Distribution and abundance of Black-legged Kittiwakes in Beaufort Sea from 6 to 18 September 1976.

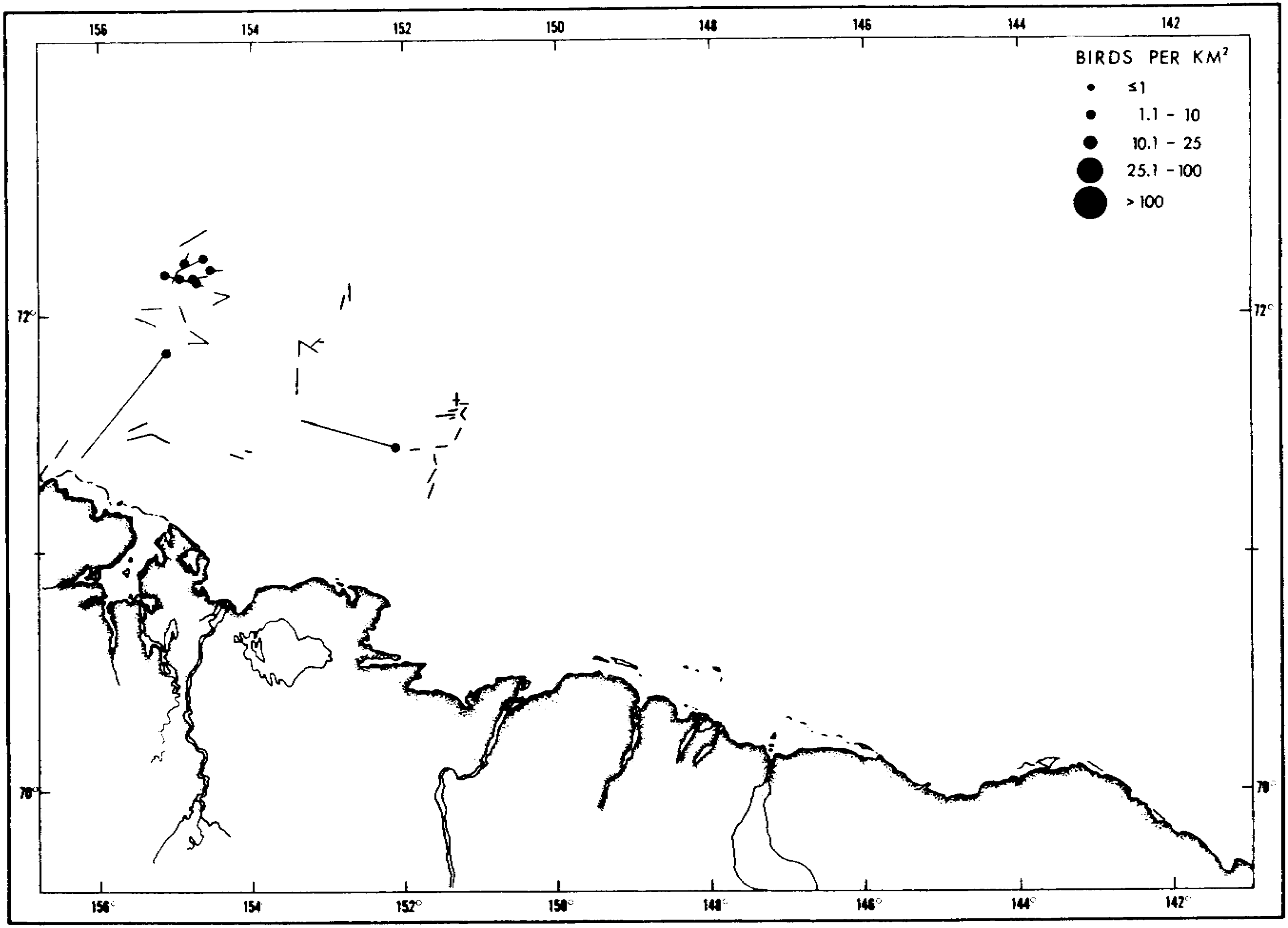


Figure 215. Distribution and abundance of Ross' Gulls in Beaufort Sea from 6 to 18 September 1976.

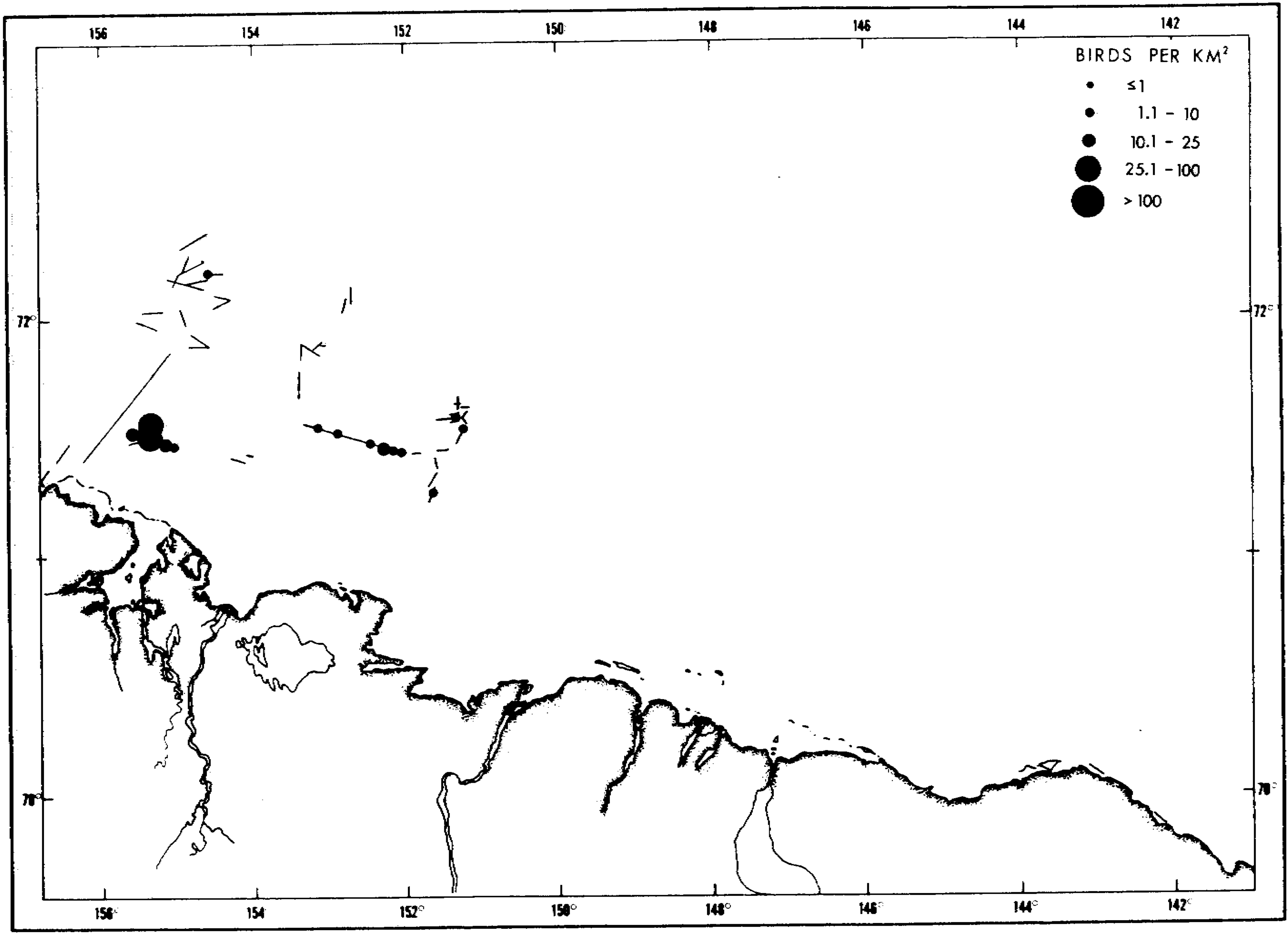


Figure 216. Distribution and abundance of Sabine's Gulls in Beaufort Sea from 6 to 18 September 1976.

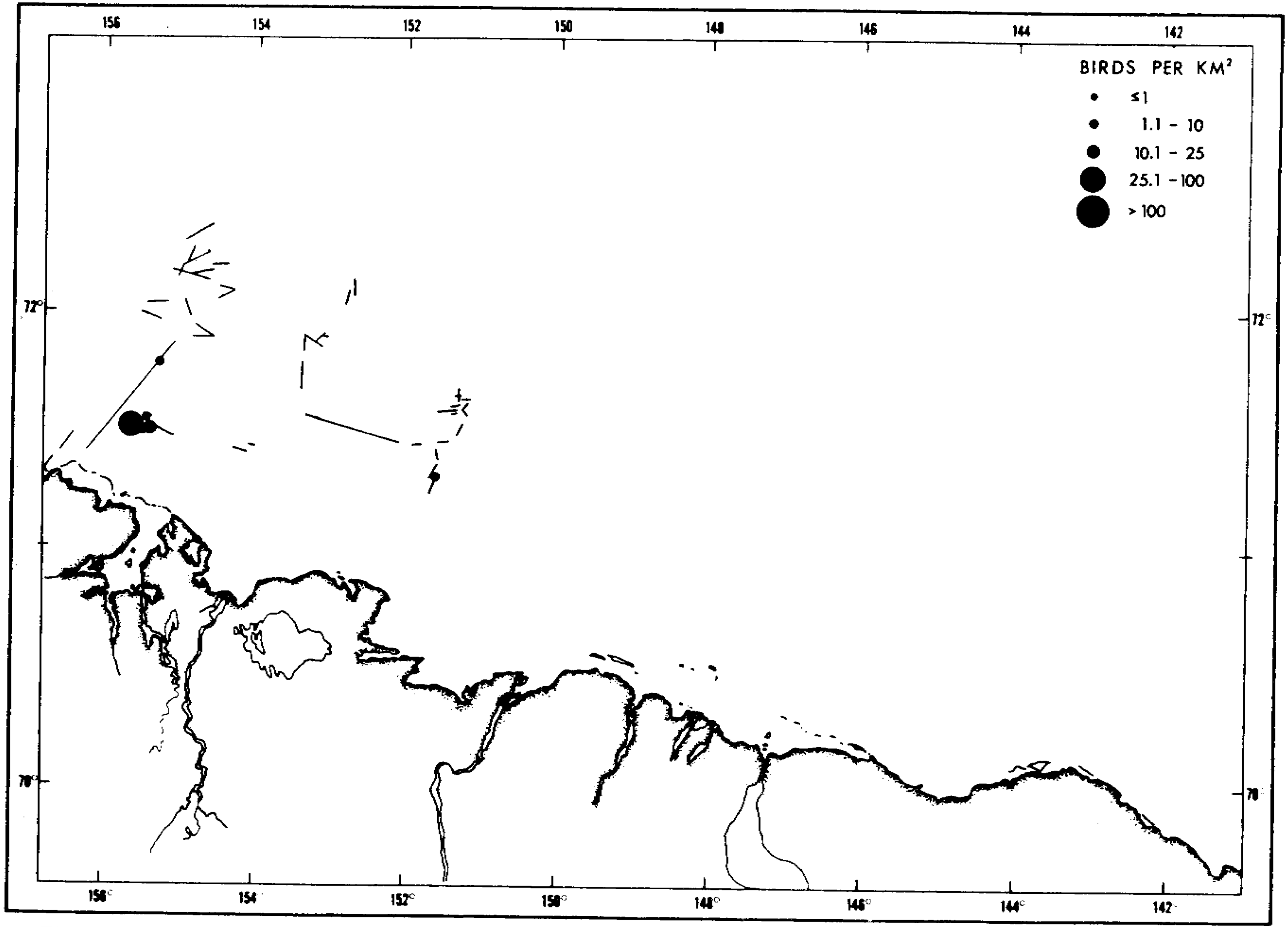


Figure 217. Distribution and abundance of Arctic Terns in Beaufort Sea from 6 to 18 September 1976.

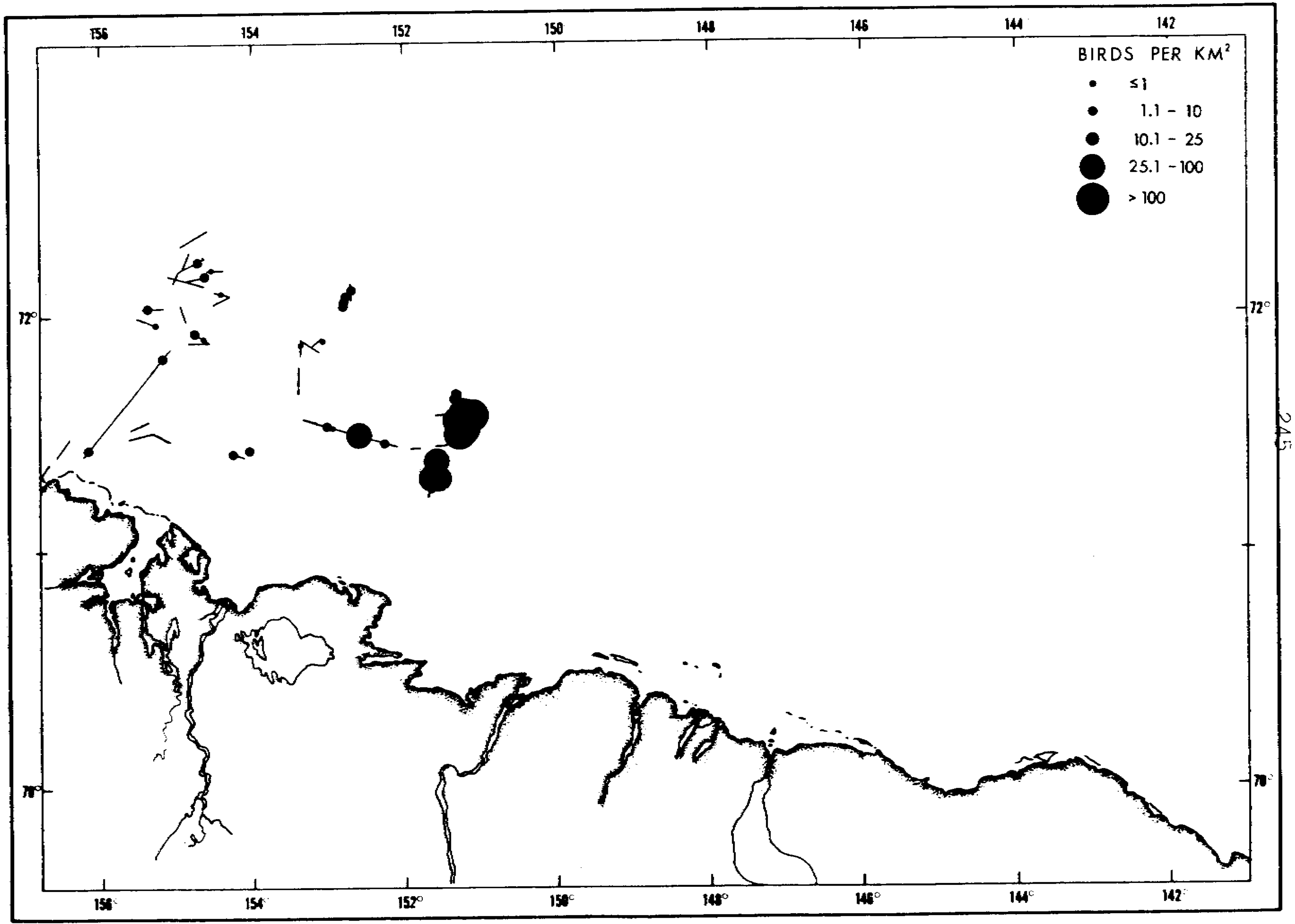


Figure 218. Distribution and abundance of ship followers in Beaufort Sea from 6 to 18 September 1976.

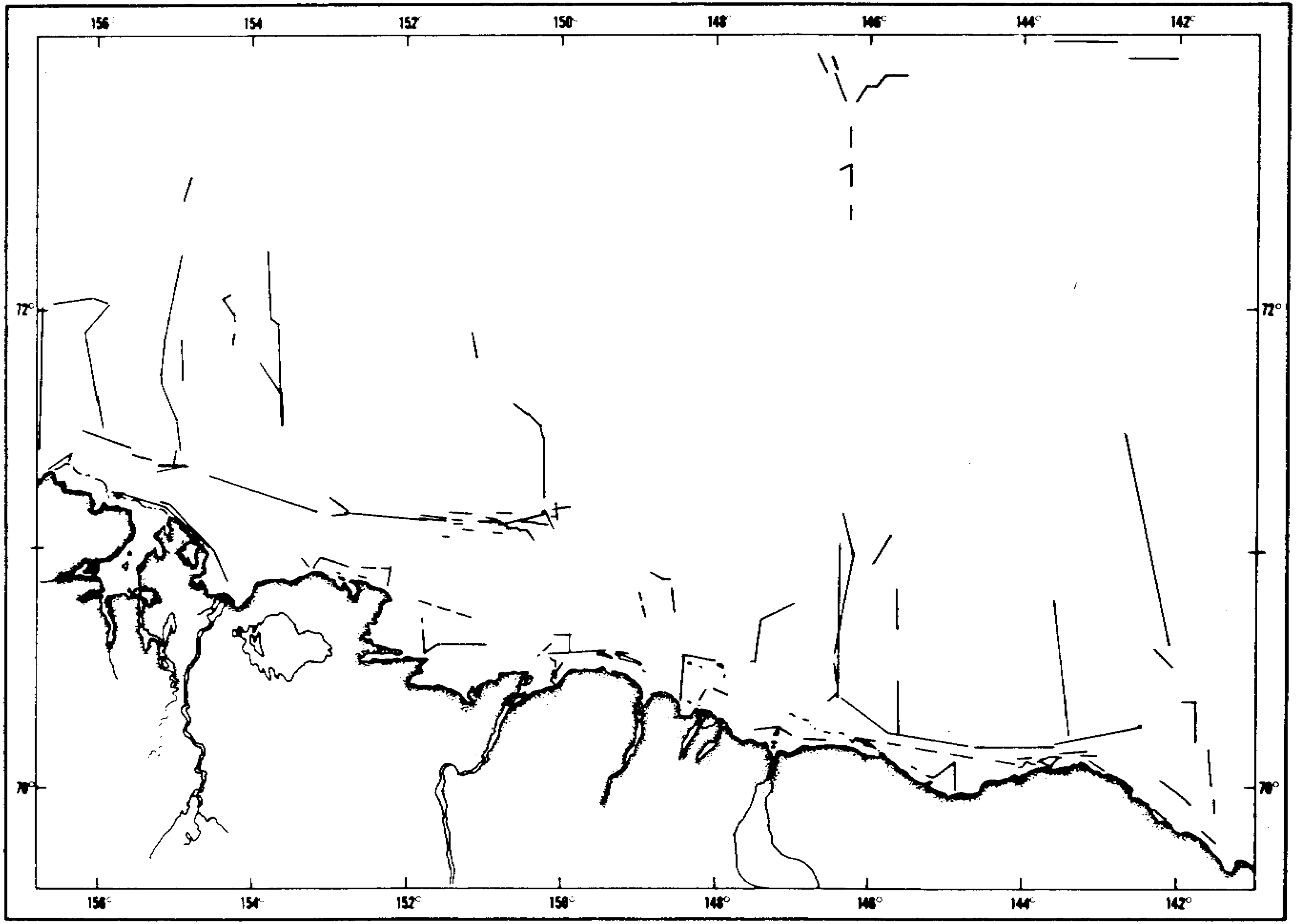


Figure 219. Cruise track during periods of observation in Beaufort Sea from 8 August to 5 September 1977.

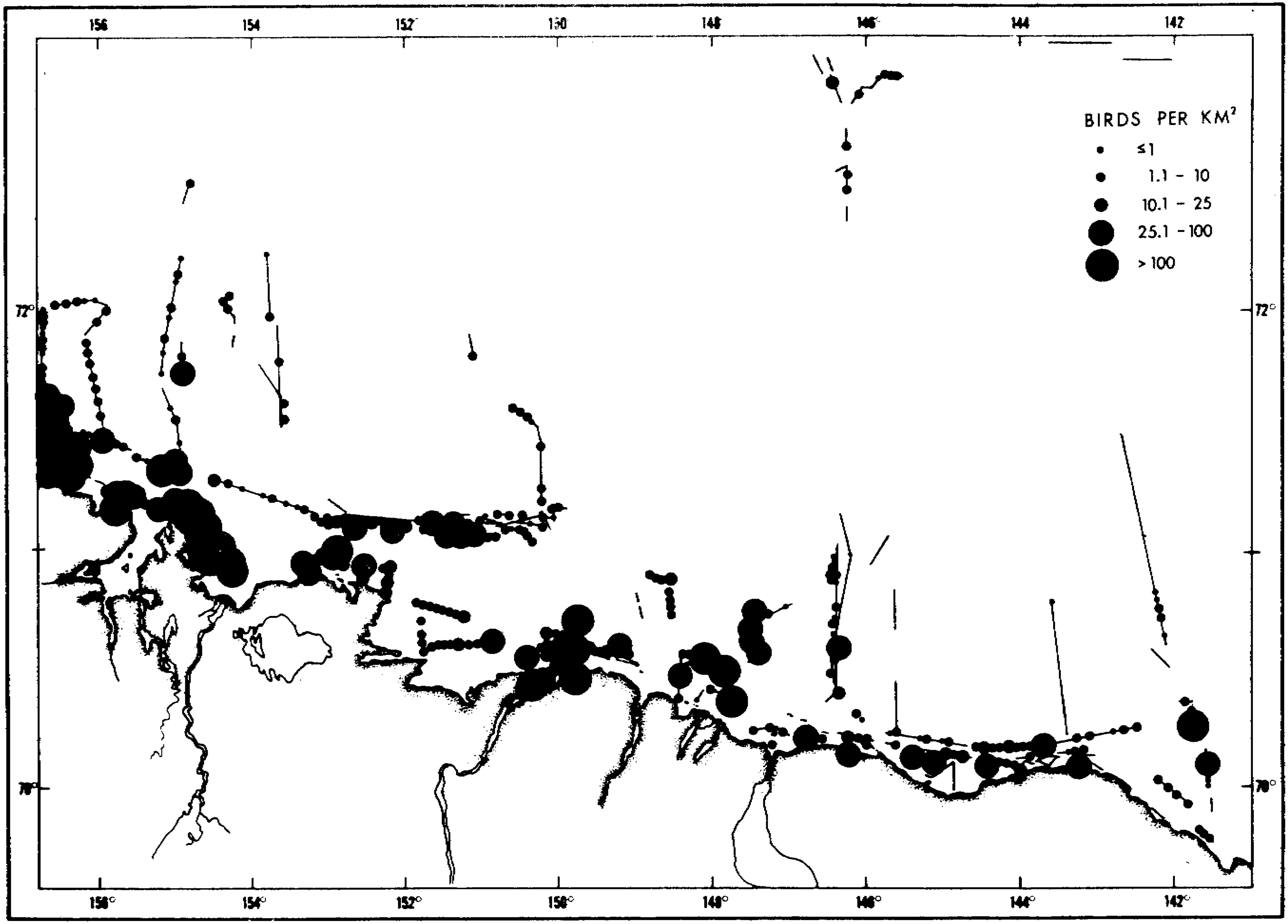


Figure 220. Distribution and abundance of seabirds in Beaufort Sea from 2 August to 5 September 1977.

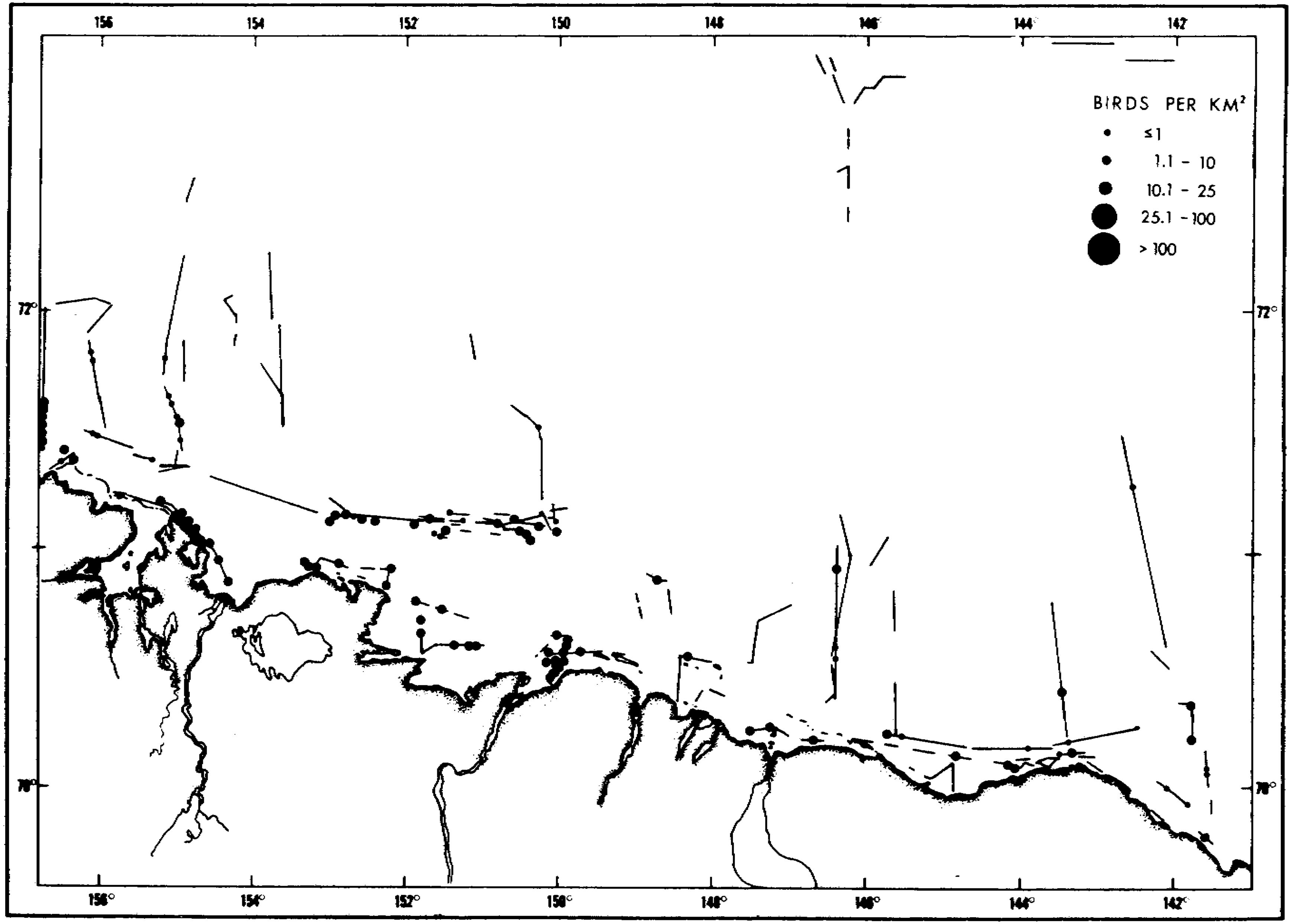


Figure 221. Distribution and abundance of loons in Beaufort Sea from 2 August to 5 September 1977.

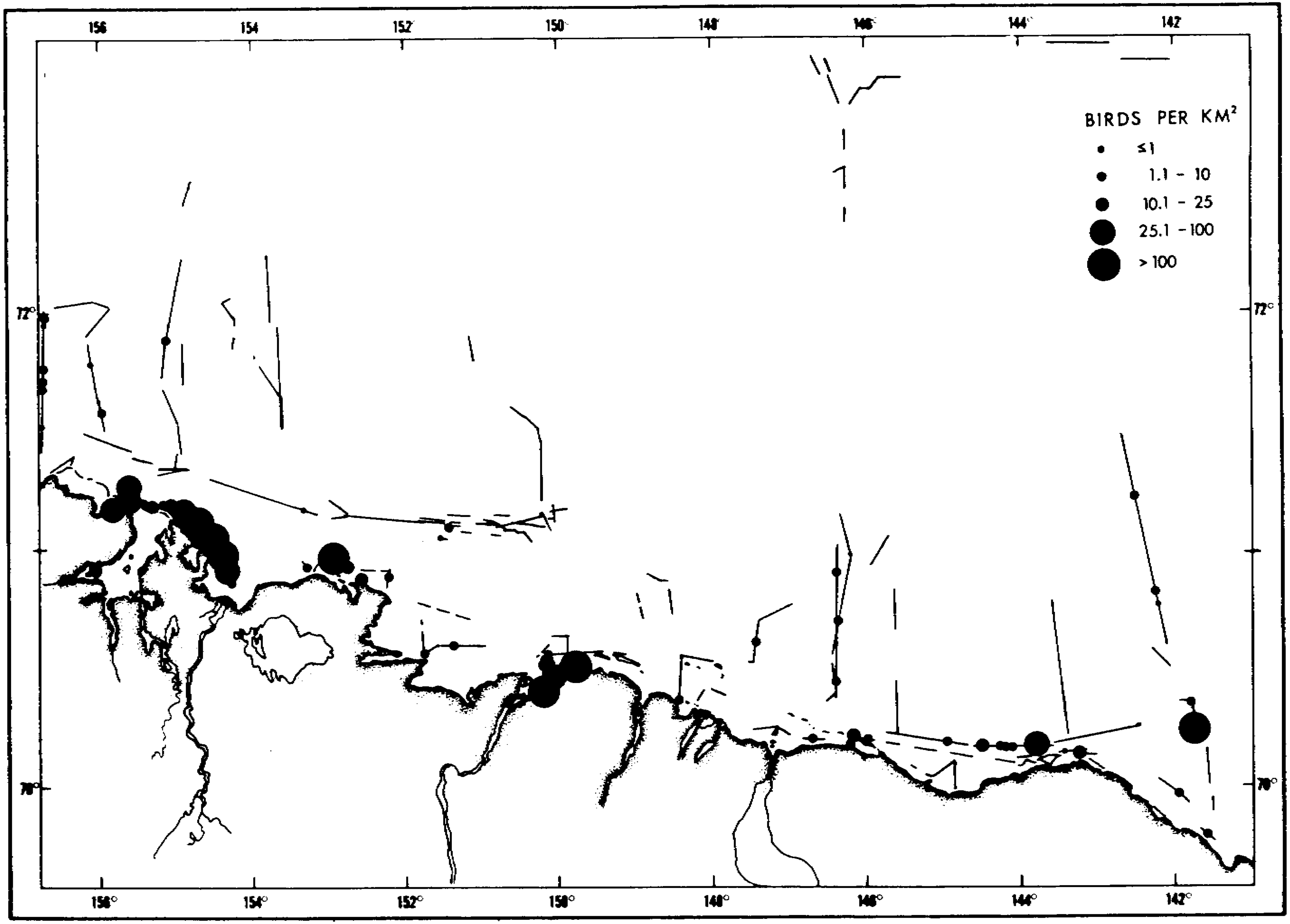


Figure 222. Distribution and abundance of Oldsquaws in Beaufort Sea from 2 August to 5 September 1977.

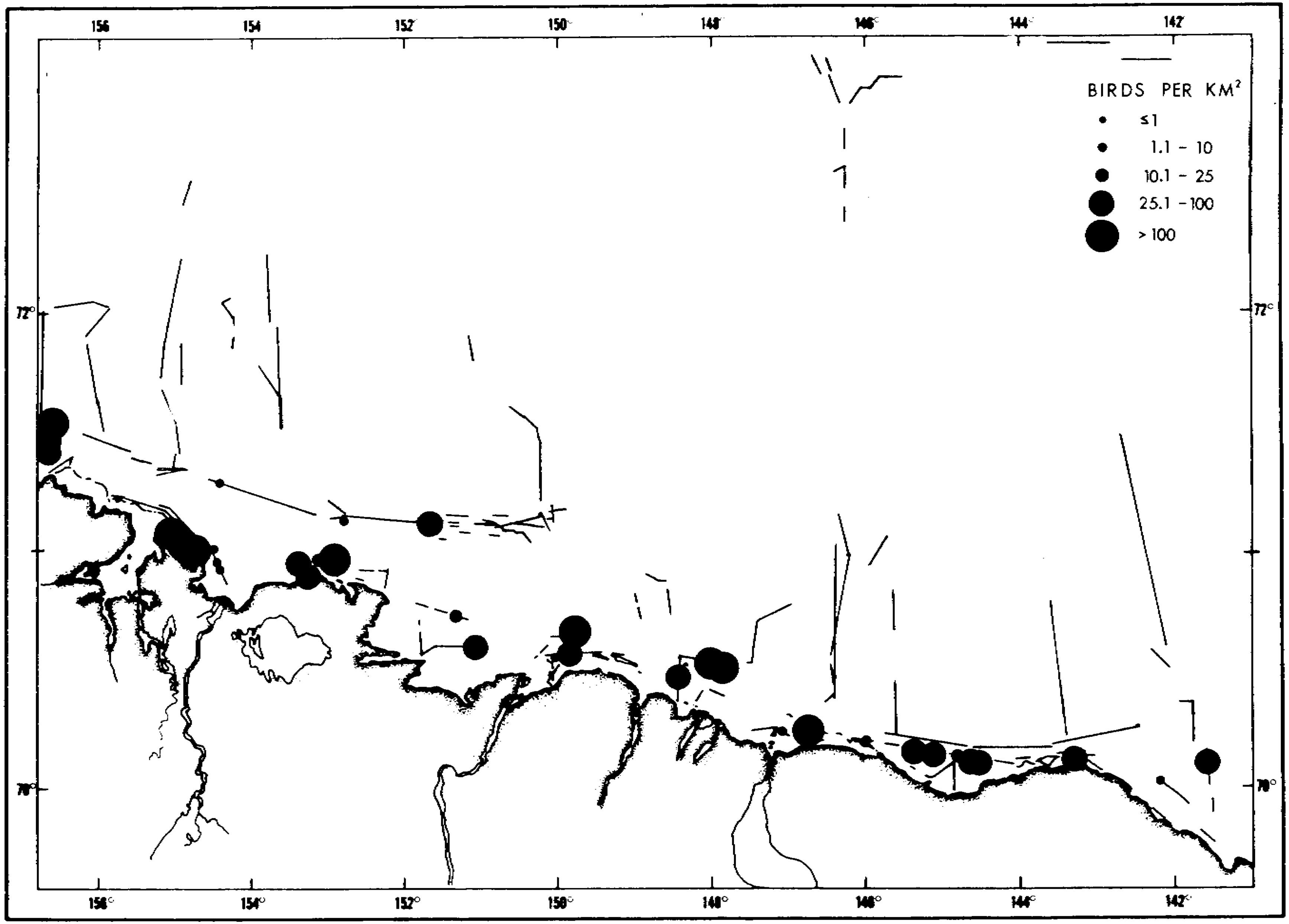


Figure 223. Distribution and abundance of eiders in Beaufort Sea from 2 August to 5 September 1977.

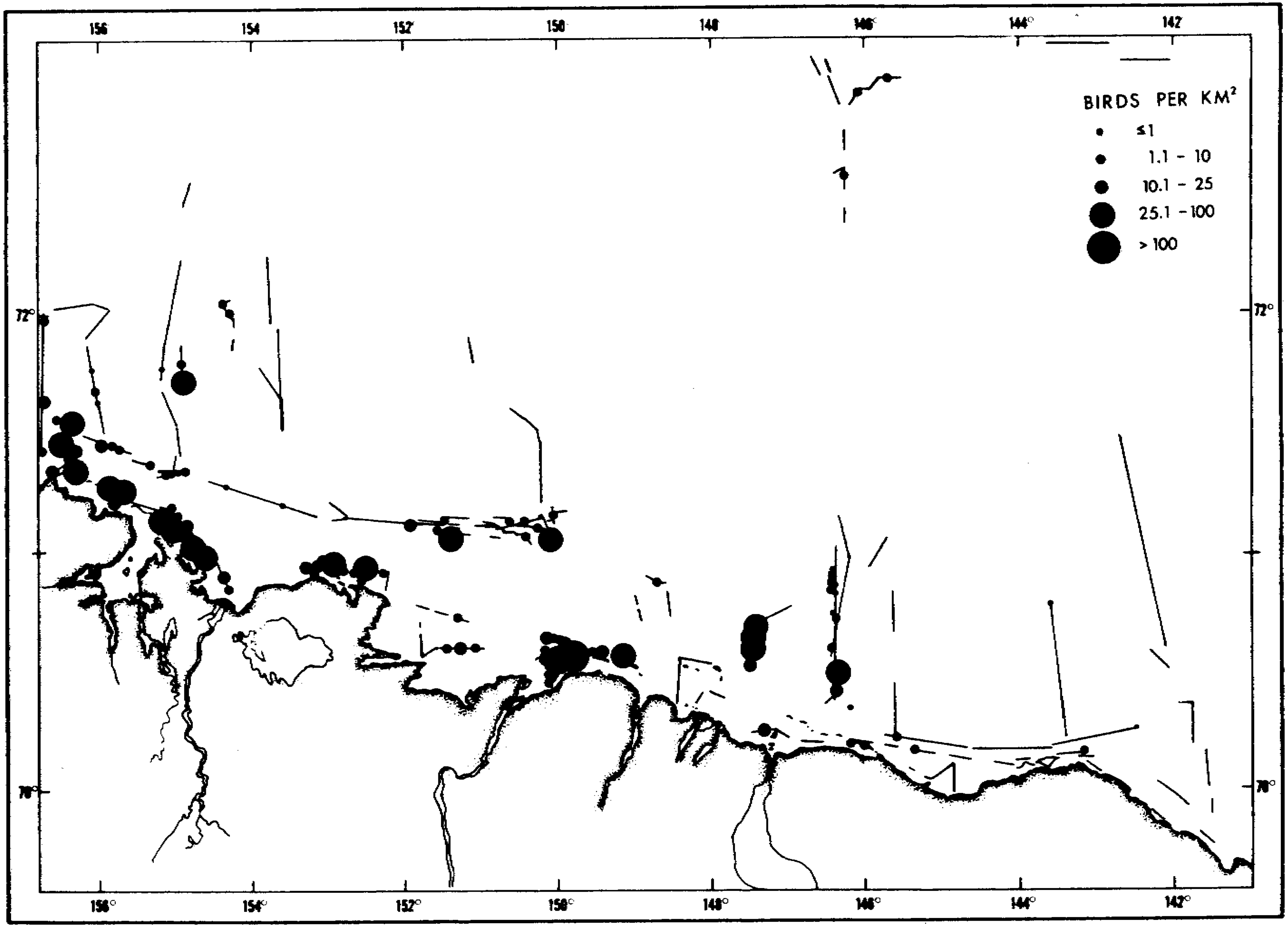


Figure 224. Distribution and abundance of phalaropes in Beaufort Sea from 2 August to 5 September 1977.

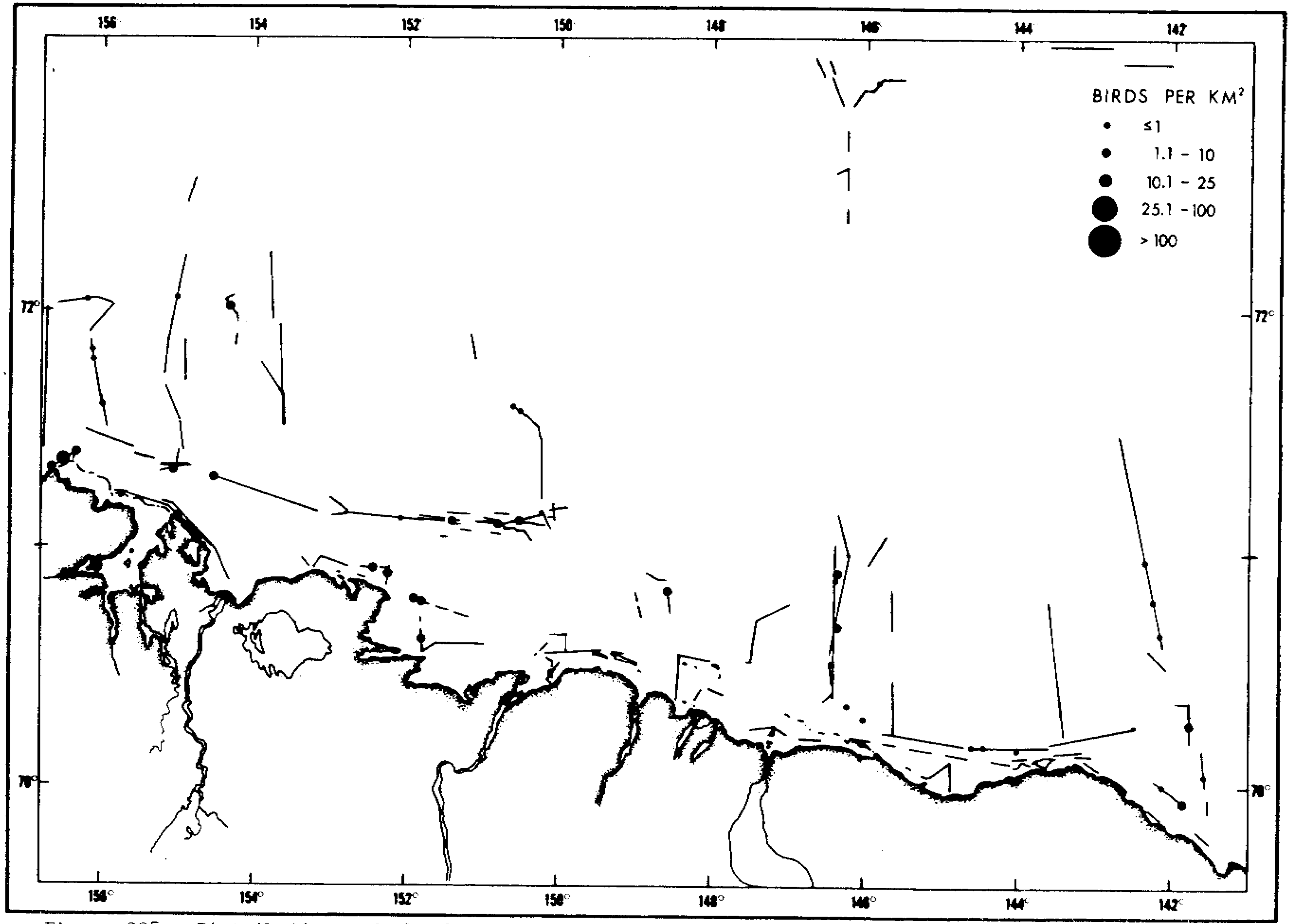


Figure 225. Distribution and abundance of jaegers in Beaufort Sea from 2 August to 5 September 1977.

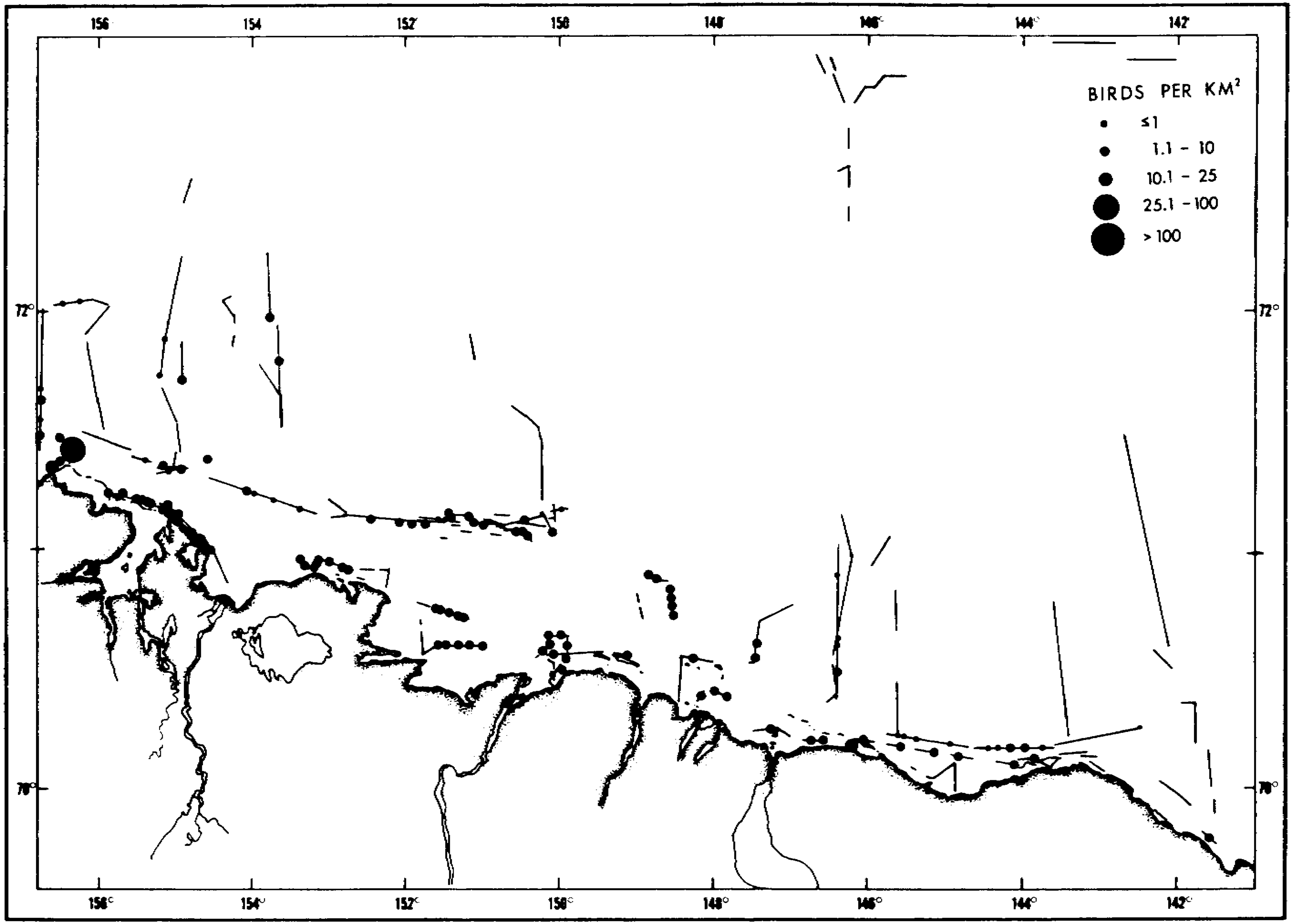


Figure 226. Distribution and abundance of Glaucous Gulls in Beaufort Sea from 2 August to 5 September 1977.

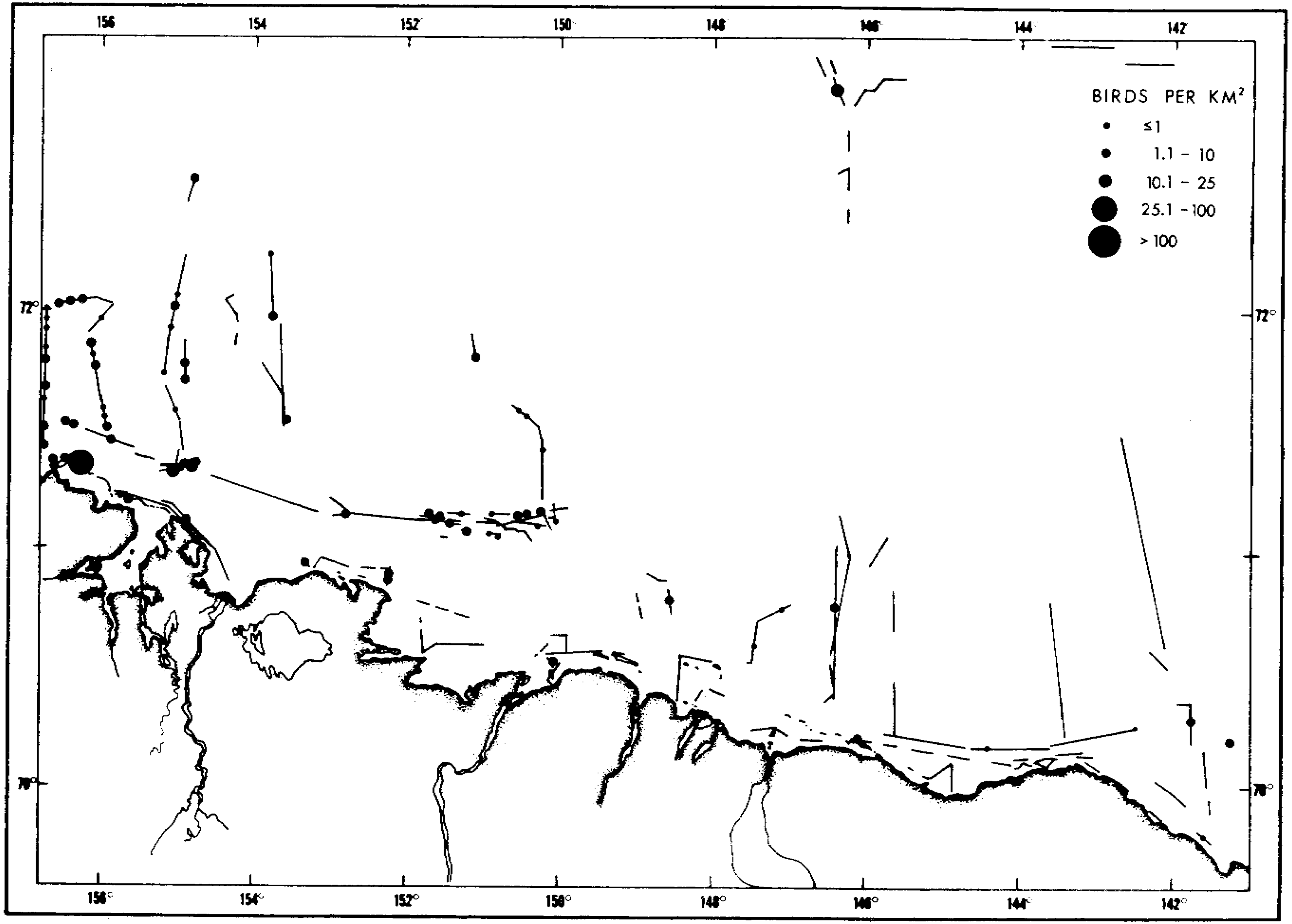


Figure 227. Distribution and abundance of Black-legged Kittiwakes in Beaufort Sea from 2 August to 5 September 1977.

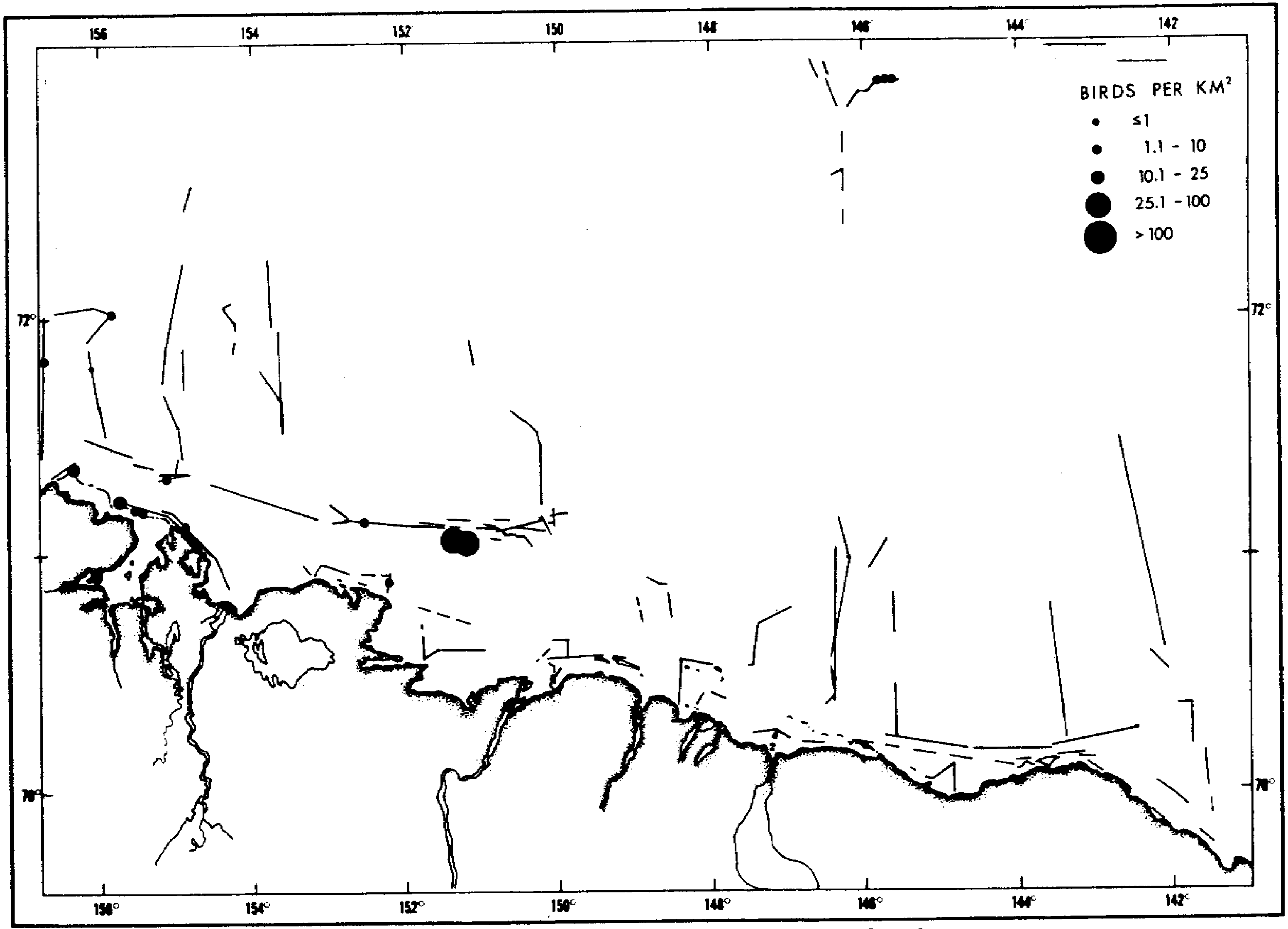


Figure 228. Distribution and abundance of Sabine's Gulls in Beaufort Sea from 2 August to 5 September 1977.

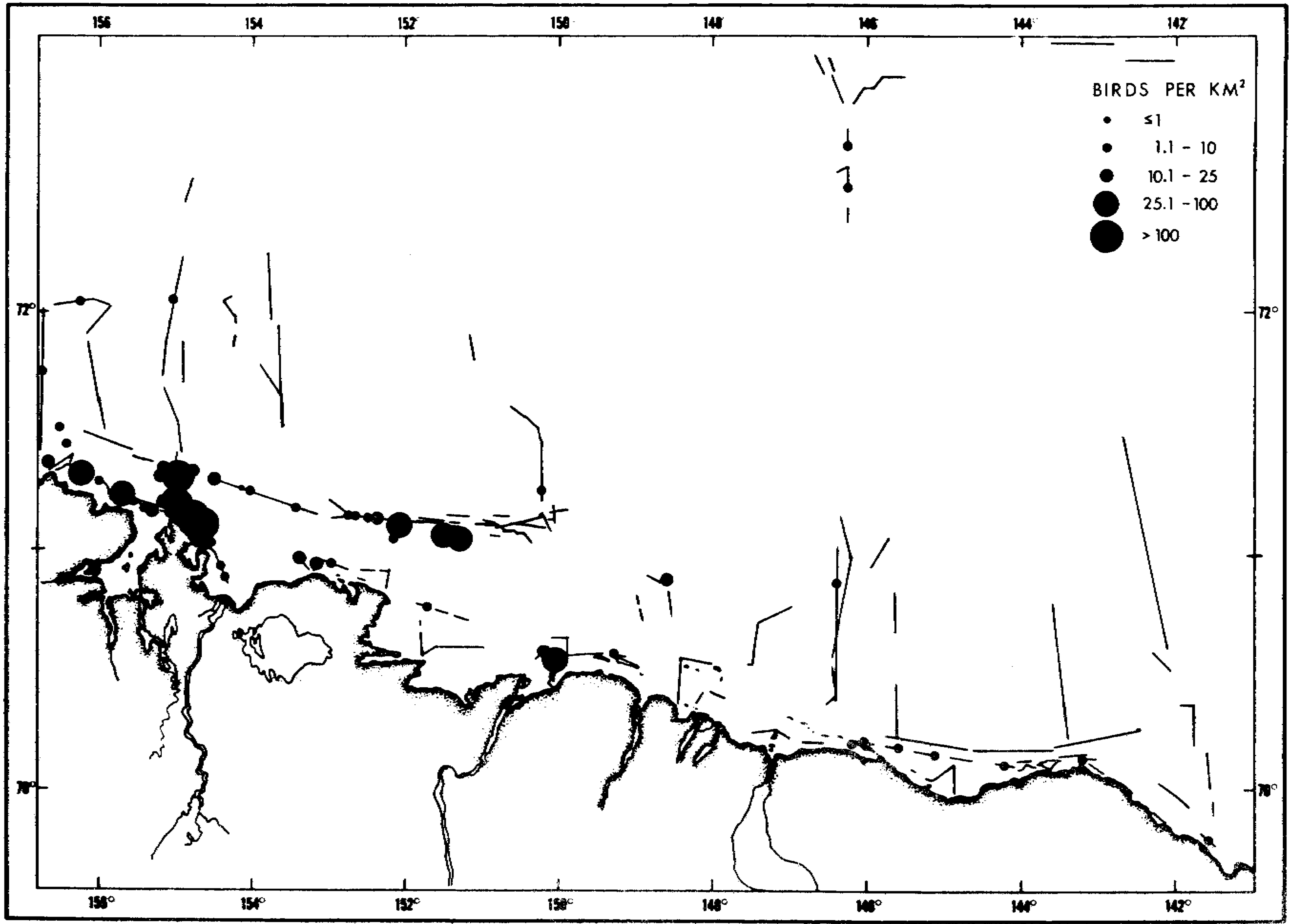


Figure 229. Distribution and abundance of Arctic Terns in Beaufort Sea from 2 August to 5 September 1977.

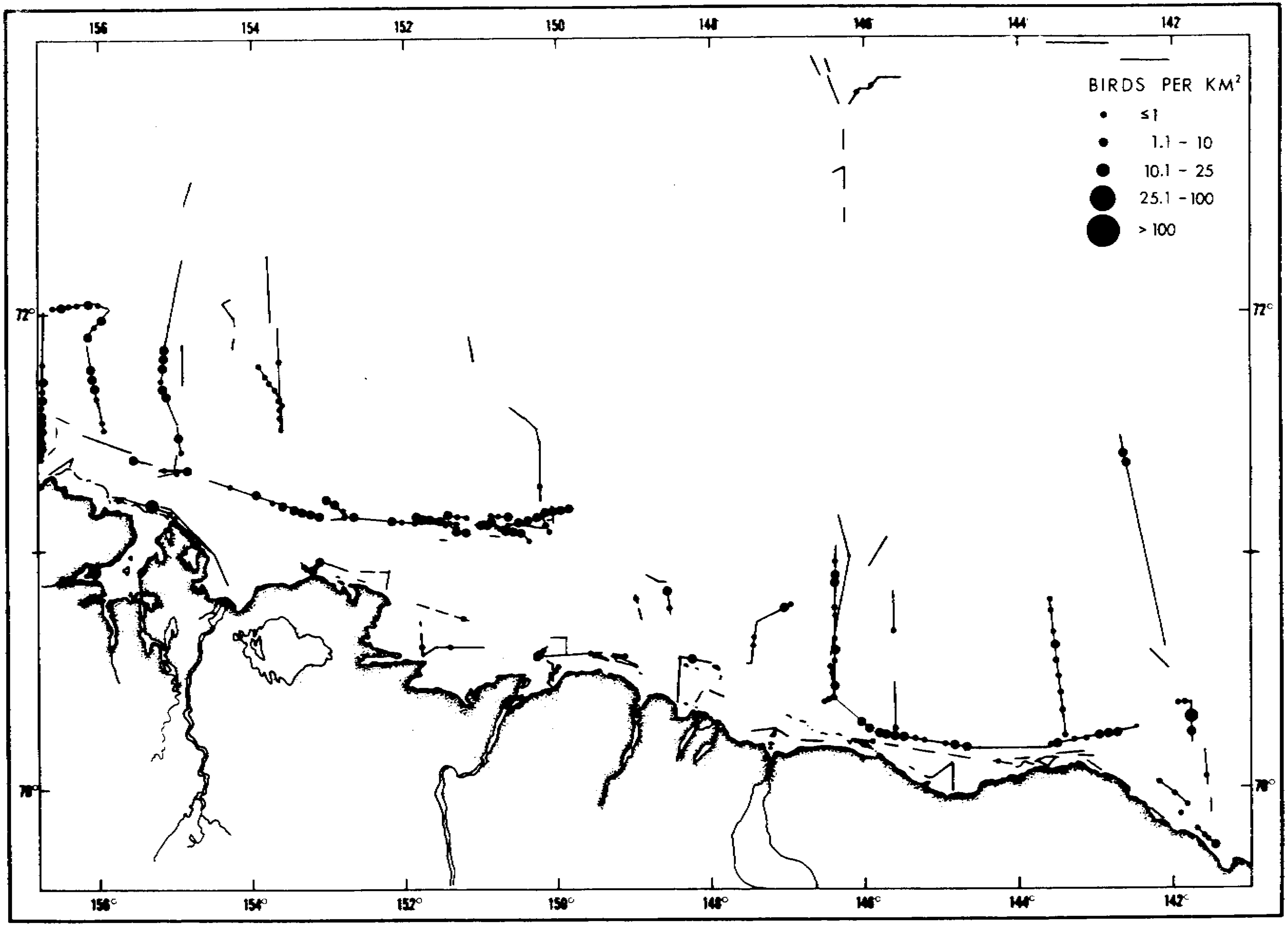


Figure 230. Distribution and abundance of ship followers in Beaufort Sea from 2 August to 5 September 1977.

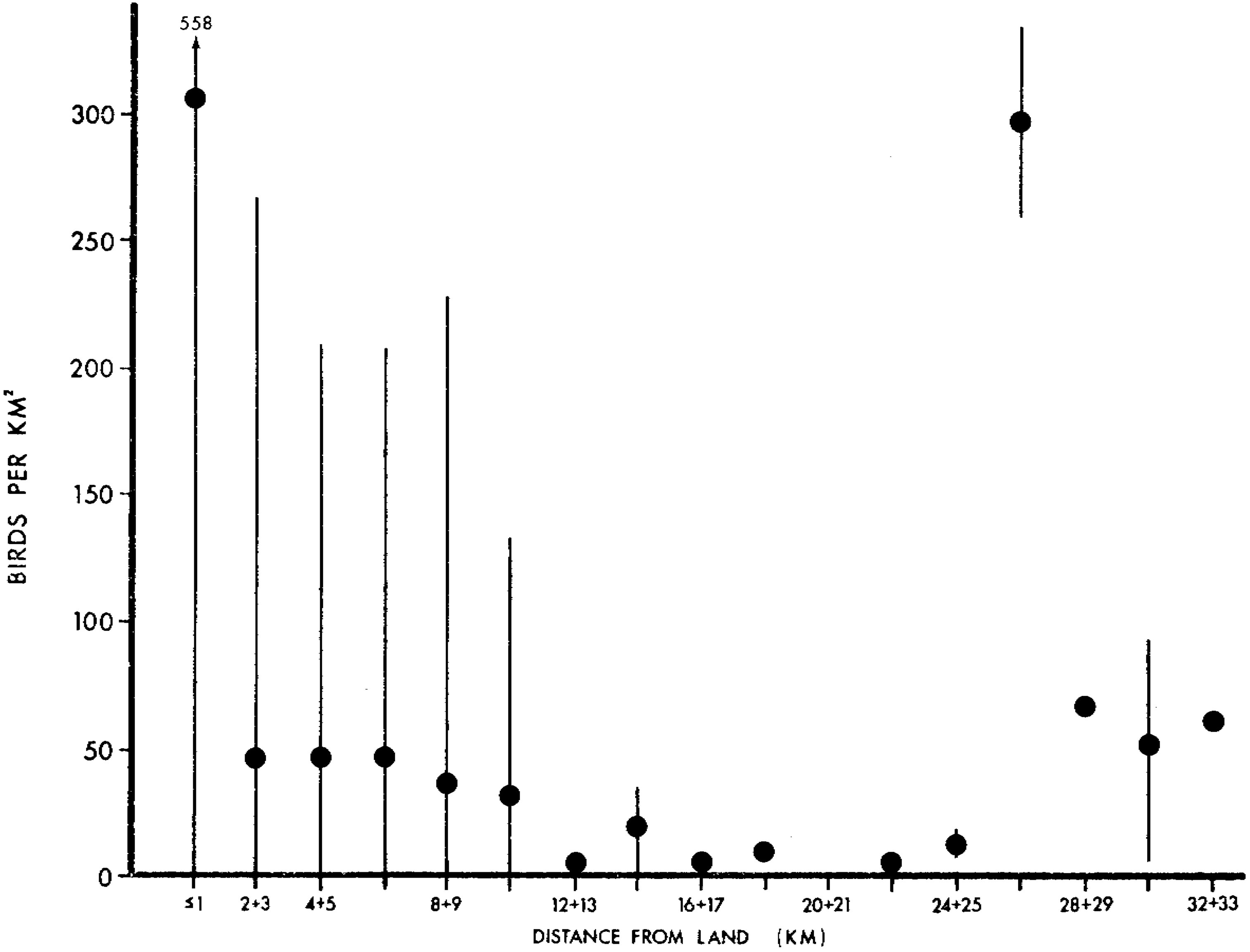


Figure 231. Mean (dot) and ranges (line) of seabird densities in relation to distance from land in the Beaufort Sea in August 1976. 3AL876.

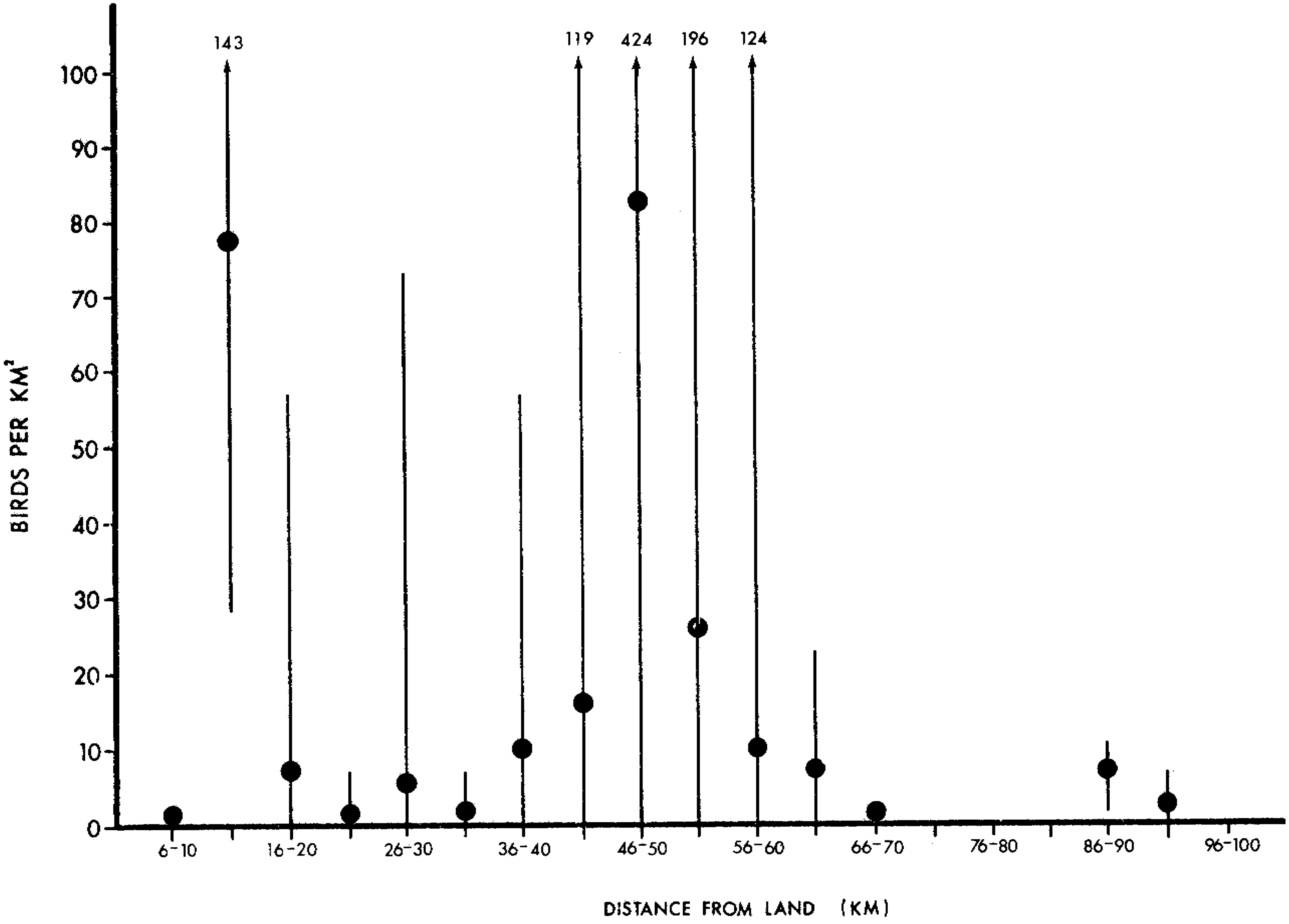


Figure 232. Mean (dot) and ranges (line) of seabird densities in relation to distance from land in the Beaufort Sea in August 1976. 2GL876.

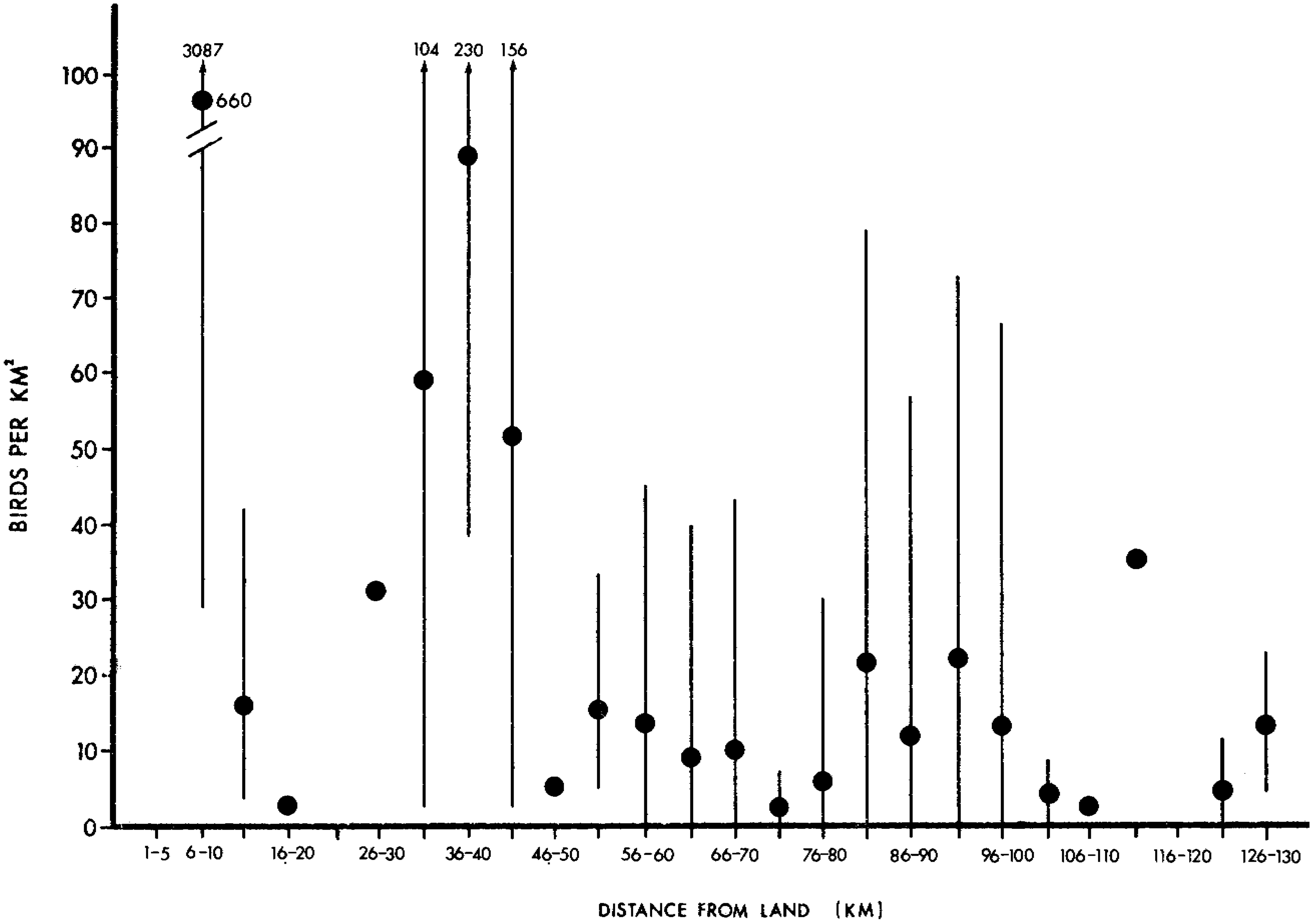


Figure 233. Mean (dot) and ranges (line) of seabird densities in relation to distance from land in the Beaufort Sea in September 1976. 3GL976.

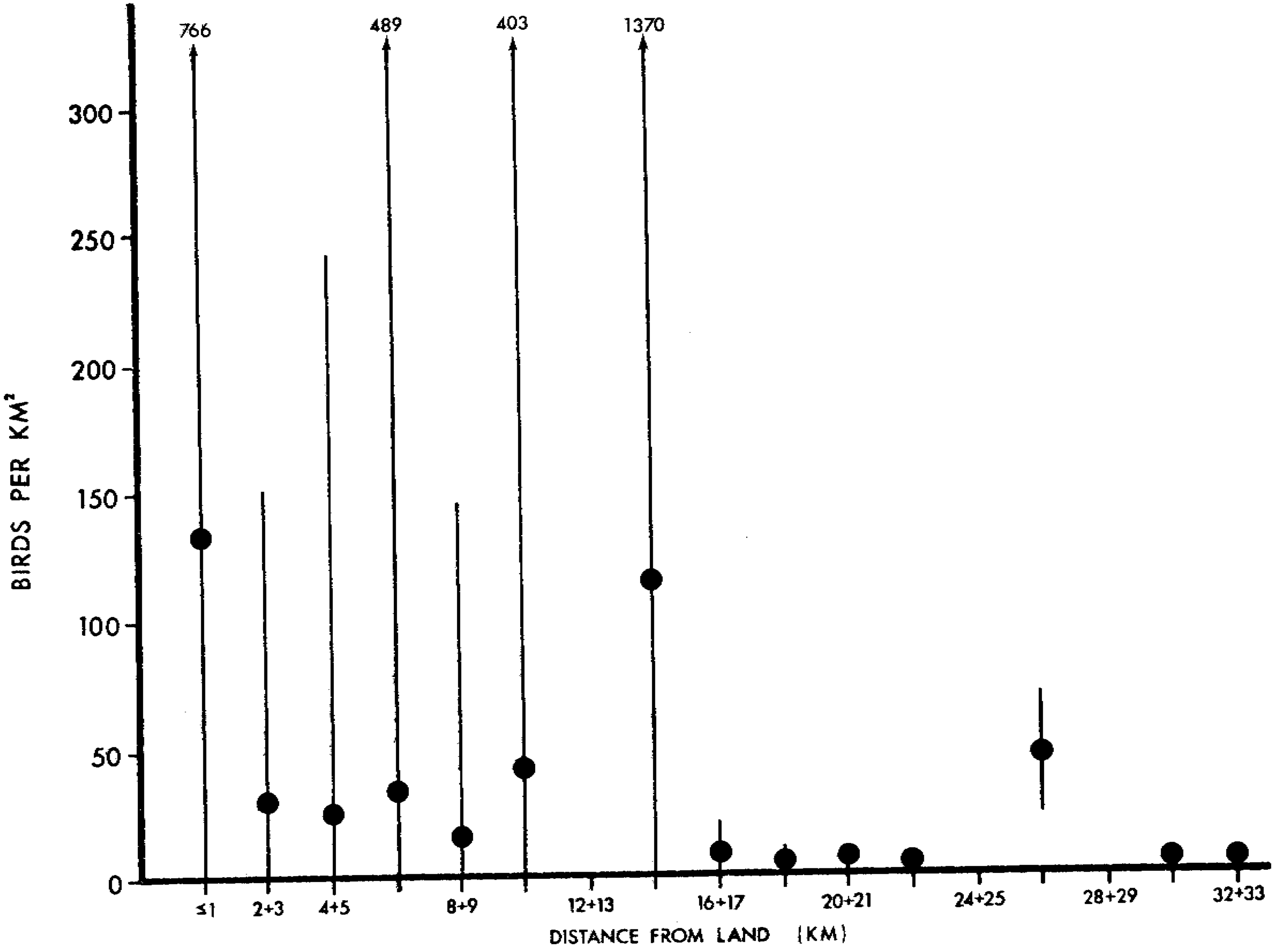


Figure 234. Mean (dot) and ranges (line) of seabird densities in relation to distance from land in the Beaufort Sea in August 1977. 3AL877.

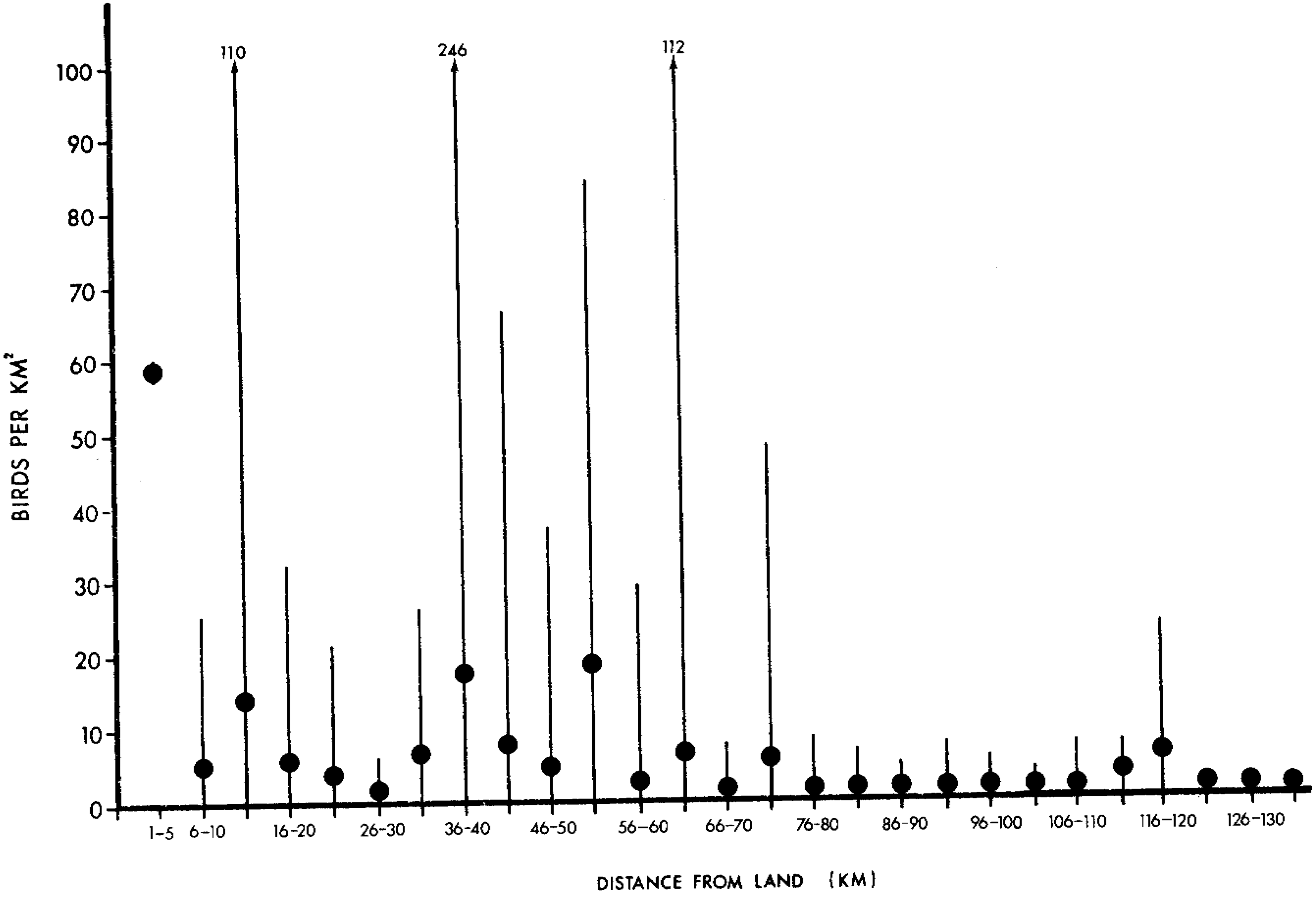


Figure 235. Mean (dot) and ranges (line) of seabird densities in relation to distance from land in the Beaufort Sea in August 1977. 3GL877.

Cooper Island Supplement

Table of Contents

Cooper Island Supplement
List of Tables

Cooper Island Supplement
List of Figures

COOPER ISLAND ANNUAL REPORT - supplement to RU 196, Divoky.

I. Introduction

A. General nature and scope of study

The general nature of studies concerning breeding bird populations dealt with preferred habitats, nest site selection, chronology of breeding, breeding success and causitive factors, and trophic relationships during chick feeding. Major emphases dealt with how these events, especially chronology, success, and feeding, varied with seasonal ice conditions in inshore waters. We sought the influence of critical factors, such as changing ice conditions and apparent variation in availability of preferred prey species, on the breeding biology of these populations.

Non-breeding bird studies centered on migration chronology and abundances of migrant birds using inshore habitats. We sought to determine why migrant species use various habitats and what prey species are preferred or critical for non-breeding birds. An additional goal, one we hope to further pursue in future research, is to determine factors concentrating particular prey species in inshore waters near barrier islands.

B. Specific objectives

Marine bird research on Cooper Island, Alaska, was devised to provide information on four topics:

1) General bird use of a northwest Alaska barrier island during the reproductive and post-reproductive seasons, especially in response to variations in seasonal sea-ice conditions.

2) Breeding phenology, success, and feeding patterns of breeding sea-bird populations on an arctic Alaska barrier island affected by sea-ice during reproductive periods.

3) Patterns of migration in inshore waters of the Beaufort Sea.

4) Responses of avian populations to environmental and biotic effects, such as weather, ice, oceanographic conditions, predation, and food resources, during reproductive and post-reproductive seasons.

C. Relevance to problems of oil development

The Plover Islands, of which Cooper Island is part, lie adjacent to National Petroleum Reserve 4. Development in the area seems likely within the next ten years. Barrier islands such as Cooper Island suffer potential oil development impact by two possible methods: 1) as a platform site for drilling operations, and

2) as a gravel source for tundra or artificial island drilling operations. Both these forms of development could adversely affect marine bird populations by destroying nesting habitat or inhibiting nesting through disturbance. To minimize future impacts, pre-development knowledge of critical factors affecting bird populations is essential.

Catastrophic events after development, such as oil spills, threaten not only marine birds with immediate mortality, but also substantially reduce or make inaccessible prey species on which these birds depend. As will be discussed, the Plover Islands appear especially critical for migrant bird populations which feed at the surface on patchy zooplankton species. Such prey could be effectively depleted in the event of oil spills.

Cooper Island is somewhat unique in that one breeding species, the Black Guillemot, solely uses artificial materials (wooden boxes, plywood, oil barrels) for nesting cavities. This illustrates how certain species, through plastic behavior patterns, can possibly benefit from human activities. The maintenance and enhancement of barrier island marine bird populations appears possible through well-planned development, minimal on-site disturbance, and concern for trophic dependencies.

II. Study area

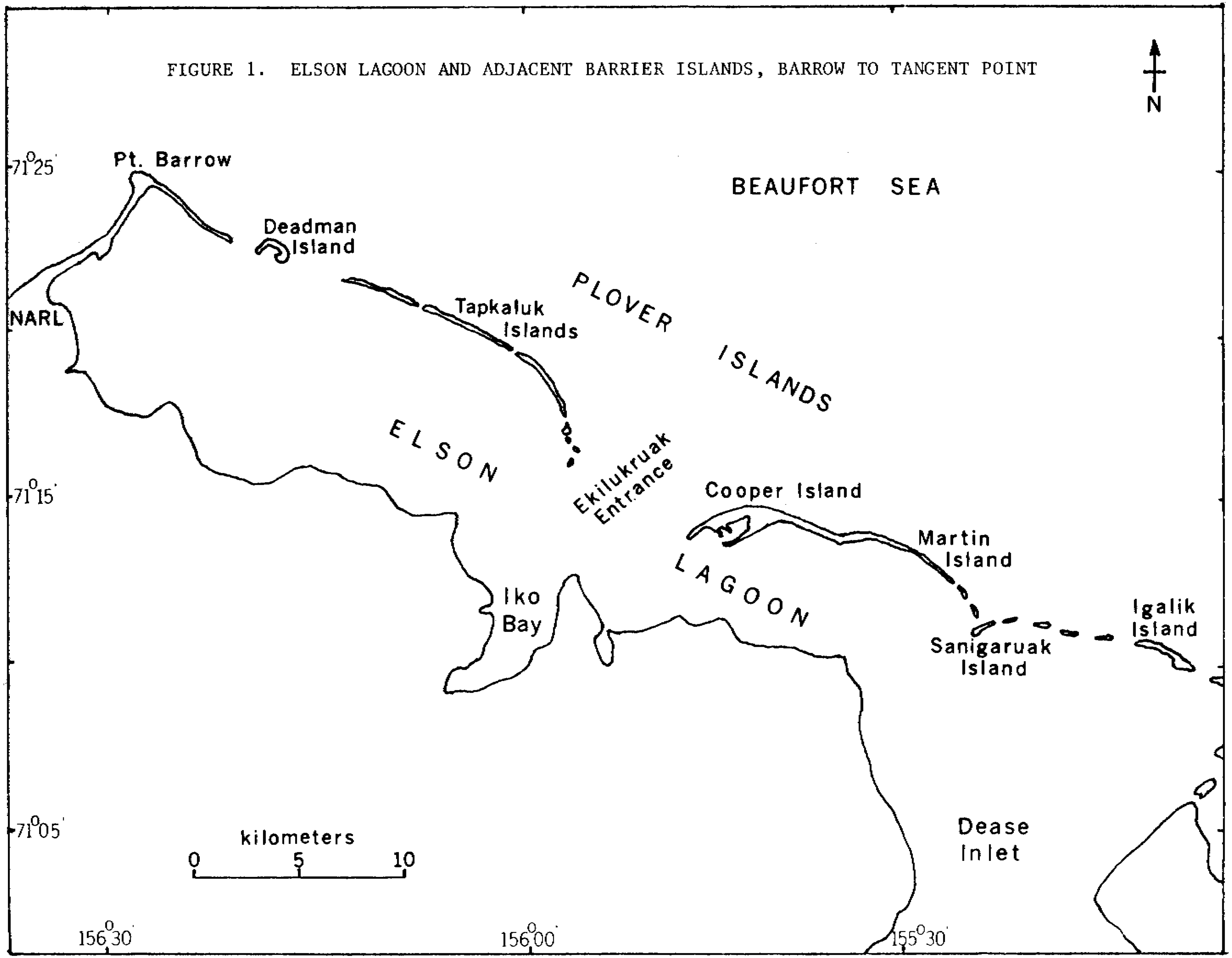
The bulk of our observations were made on Cooper Island, a barrier island lying 35 km E of Barrow Alaska (Fig. 1). The nearest mainland site is Tulageak Point, 3.5 km S of the island. Cooper Island is 4.5 km long and averages less than 0.5 km wide, but is 0.8 km at its widest point. The highest elevation is approximately 3 m above sea level.

Major substrates are sand and gravel, although small areas of tundra appear to contain sandy loams. A small. approximately 20 ha, tundra patch encircles several small brackish ponds at the island's greatest width. The tundra patch is little used by breeding species other than Baird's Sandpiper and Oldsquaw.

The island's origin, similar to other eastern Plover Islands, appears due to sediment transport from the vicinity of Tangent Point (D. M. Hopkins, pers. comm.). Sediment transport occurs primarily during the open water period in late August and September. The dynamics of sediment transport are illustrated by Cooper Island's present connection to Martin Island, an adjacent barrier island. Maps from the 1950s show these islands separated by as much as 1 km.

Major plant species include Carex subspathacia, Puccinellia spp., Stellaria humifusa, Elymus arenarius, Honckenya peploides, and Cochlearia officianalis. Most island substrates are not vegetated, and most nesting activity occurs in unvegetated areas (Fig. 2).

FIGURE 1. ELSON LAGOON AND ADJACENT BARRIER ISLANDS, BARROW TO TANGENT POINT



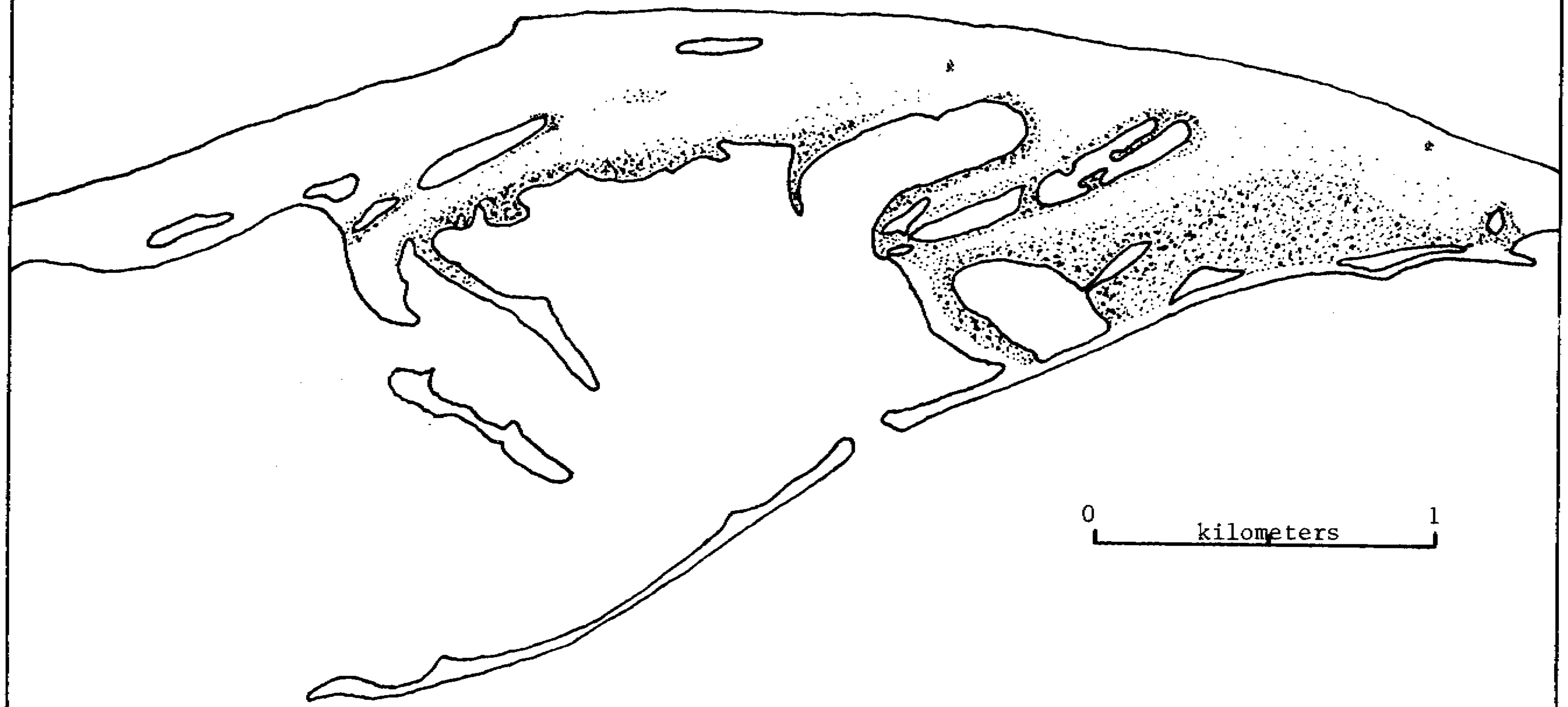


FIGURE 2. VEGETATION PATTERNS ON COOPER ISLAND, ALASKA. Stippled areas are vegetated primarily by *Puccinellia* and *Carex* spp. Unstippled areas are primarily sand and gravel.

Past human use of Cooper Island appears extensive. At least two collapsed sod huts lie on the island's east side. An eskimo family visiting the island in 1976 claimed their parents trapped Arctic Foxes on the island. Luther Leavitt, an Inupiat hunter using Cooper Island as a base-camp in 1976, stated Barrow hunters used the island to hunt Polar Bears after fall freeze-up.

Large amounts of natural and man-related driftwood and metal occur on the island. Sources of natural drift possibly include Yukon and Mackenzie river drainages. Man-related artificial drift includes boxes, sleds, wallboards, oil barrels, and assorted other debris. Sources of artificial drift possibly include waifed materials from Barrow and cargo dumped at sea by shipping. Three barges grounded on nearby Plover Islnds are possible additional sources. Several breeding species, most notably Black Guillemot, use artificial debris for nest sites.

An extremely important factor affecting marine bird populations on Cooper Island is sea-ice. Sea-ice chronology during an average season appears to be:

1. Shorefast ice period

   Shorefast ice surrounds the island nearly 10 months every year, from October to July. Surface deterioration of shorefast ice begins in late May to early June and continues through mid-July. Progression of shorefast ice melt is: 1) surface melt pond formation, 2) thaw hole formation as melt ponds erode through to the water column below the ice, and 3) thaw channel formation as thaw holes widen and connect. During this period, the effects of solar radiation in shallow waters melts ice immediately adjacent to island and mainland shorelines, forming narrow "moats" of open water.

2. Shorefast ice breakup period

   As shorefast ice deterioration continues, thaw channels connect and form sizable leads. Ice cakes of varying sizes split off from the shorefast ice mass and drift with winds and currents in leads. This condition continues until all shorefast ice is decomposed and removed from inshore waters, usually in late July.

   In 1976, following the extremely heavy ice year of 1975, shorefast ice breakup occurred from 25 July to 1 August. In 1977, a year of relatively light ice conditions, shorefast ice breakup occurred from 9 to 20 July.

3. Drifting pack ice period

With the removal of shorefast ice, offshore drifting pack is pushed inshore by predominant NE winds. Ice concentrations vary during this period from 1 to 7 oktas, depending upon wind conditions and offshore pack concentrations. This condition continues until the first major storm in August or September with wind direction and magnitude capable of blowing ice far offshore.

Such storms occurred on 20 to 22 August in 1976 and 8 to 11 August in 1977. Ice remained nearshore throughout all of summer, 1975, due to a lack of major storms and persistent heavy ice in inshore waters.

4. Open water period

Open water persists until freeze-up in late September or early October. Occasional drifting cakes, usually of multi-year ice, appear in inshore waters during this time.

River outflow does not significantly affect inshore ice conditions in Elson Lagoon, in contrast to other lagoon systems, such as Simpson Lagoon, on the arctic Alaska coastline (S. R. Johnson, pers. comm.).

Inshore oceanographic patterns are not well known. Large-scale offshore currents are dominated by the clockwise-rotating Beaufort Gyre and the Chukchi Coastal Current, which flows northeastward past Point Barrow (Sater et al., 1971). Small-scale oceanographic events, such as convergences at entrances between barrier islands and Langmuir spirals in nearshore waters, seem most important as factors concentrating prey for neritic marine birds.

III. Methods of data collection

Visits to Cooper Island occurred on 30 June to 23 July, 26 August, and 1 to 5 September, 1975; 16 June to 30 July and 2 August to 16 September, 1976; and 21 June to 13 August, 19 to 20 August, 30 August, 3 September, and 10 September, 1977. Six major methods of data collection were used during these visits:

A. Shoreline transects

In 1976 six numbered transects were staked along geographically distinct sections of Cooper Island shoreline. Three transects censused the island's north shoreline facing the Beaufort Sea. The three remaining transects censused the south shoreline and inshore waters of Elson Lagoon.

We censused all transects every day in 1976 and 1977 except during unfavorable weather conditions. One observer walked each transect, using notebook and pen to record sightings. Most birds were sighted by eye, but identified and counted using 7 or 8 power binoculars. All birds observed were counted regardless of their distance from the observer. When possible, sightings of birds included age, sex, plumage, molt conditions, behavior, and habitat occupied at the time of observation. Data were totaled as number of birds sighted per kilometer walked. Environmental data collected during each transect included weather and ice conditions.

B. Habitat watches

Two hour stationary habitat watches were usually conducted twice daily during periods in 1975, 1976, and 1977. Two observers conducted each watch; one observer on the north shoreline recording bird passages north of the island and one observer on the south shoreline recording bird passages over inshore lagoons and bays. This method also separated breeding bird feeding movements to and from the island to the north and south.

Eight hours of watch data were collected on an average day (2 watches X 2 observers X 2 hours/observation period). Habitat watches were staggered so over time observations included all daylight hours.

We recorded all birds sighted during habitat watches except local breeding bird movements within the breeding colony. We recorded breeding bird flights away from the colony as well as all non-breeding bird movements over the island and adjacent waters. 7 or 8 power binoculars were used to search out distant migrants. When possible, habitat watch data included age, sex, plumage, molt condition, behavior, and habitat occupied at the time of observation. Environmental data collected during each watch included weather and ice conditions.

C. Breeding bird surveys

Breeding bird surveys were usually held every two days. Surveys comprised of locating new nest sites, checking conditions of known nests (number of eggs and number of living and dead chicks), collecting chick growth data, and noting other pertinent information such as distances to nearest neighboring nest in meters and nest substrates. Chick growth data included weight measured to the nearest gram by Pesola scale, and flattened wing chord measured to the nearest mm by metric ruler.

D. Colony watches

We periodically observed numbered Arctic Tern and Black Guillemot nests from a blind in the breeding colony. Information recorded at the blind included time of departure and arrival at nest sites, time of nest reliefs, and type and size (in bill lengths) of prey returned to nests. An average blind watch lasted about two hours per person, although back-to-back watches extending several hours were often held.

E. Plankton tows

In 1976 plankton tows were taken approximately once a week at a series of ten shoreline stations. The towing methods consisted of wading with hip boots until water reached above the knee (0.5 to 0.7 m deep), throwing the net out a distance of 3 m, and returning the net as slowly as possible yet fast enough to maintain the desired water column depth (approximately ½ m/sec.). The diameter of the net's mouth was 0.254 m, consequently each tow sampled 0.152 m^3 of water. Five surface tows were made at each station with each tow series from June to September. Two additional bottom tows were made at each station from mid-July to September.

After each tow, specimens were identified, counted, and grossly measured to the nearest mm. Only macroorganisms (>2 mm) were identified. Voucher specimens were kept to confirm identification.

F. Specimen collections

Birds were periodically collected with 12 guage shotgun for stomach sample analysis. Stomachs and esophagi were removed after collection and stored in 10% formalin. Results of these collections are reported with other stomach analyses of RU 196.

IV. Results

A. Breeding

Six species nested on Cooper Island in 1975, 1976, and 1977. These included Arctic Tern (Sterna paradisaea), Black Guillemot (Cepphus grylle), Oldsquaw (Clangula hyemalis), Sabine's Gull (Xema sabini), Baird's Sandpiper (Calidris bairdii), and Snow Bunting (Plectrophenax nigalis).

1. Chronology of breeding

All species began breeding activities in June. Egg laying for all commenced in mid- to late June. Most species completed breeding activities in August, although late Black Guillemot chicks did not fledge until mid-September.

The bulk of Arctic Tern egg laying occurred in late June and early July (Fig. 8). Modal peak of laying for years 1975 to 1977 was 29 to 30 June. Egg hatching primarily occurred in the last two weeks of July, with modal peak of hatching for 1975 to 1977 occurring on 22 to 23 July. Average incubation period was 26.3 days (N=16) in 1976 and

and 21.6 days (N=65) in 1977. Dates of fledging centered in mid-August, but ranged from 2 to 28 August. Modal peak of fledging was 17 to 18 August.

Peak egg laying for terns in 1977 was about one week later than peak egg laying in 1976, despite lighter ice conditions in 1977. The difference in these two years appears due to Arctic Fox activity on Cooper Island. In 1976, tern eggs began disappearing on 30 June, and two foxes were eventually shot on 12 and 13 July. During this two week period, in which the foxes came ashore only intermittently, they consumed 52 tern eggs, 12 Sabine's Gull eggs, 58 Oldsquaw eggs, and 3 Baird's Sandpiper eggs. Egg laying by terns in 1976 concentrated in the last week of June prior to fox activity on the island, and essentially ceased while foxes worked the island in early July. In 1977, however, one fox intermittently raided nests on the island from 24 June until it was shot on 28 June, and another was shot on 7 July before it apparently took eggs. The first fox in 1977 ate 4 tern eggs, at least 12 guillemot eggs, and a minimum of 9 Oldsquaw eggs. The pattern of tern laying in 1977 was the reverse of 1976, in that laying was slow in late June while the fox occupied the island and peaked in early July during a period of no fox activity. Clutch sizes were substantially reduced in 1977 (Table 3). This strongly suggests the fox's presence in late June, 1977, inhibited egg laying and decreased the overall egg production of Cooper Island terns.

Black Guillemot egg laying for years 1975 to 1977 ranged from 22 June to 22 July, with modal peak on 30 June to 1 July (Fig. 9). The egg laying period was substantially lengthened in 1977, apparently due to Arctic Fox activity in late June and the number of inexperienced birds occupying nest sites for the first time. We suspect at least 3, and possibly 5, guillemot pairs relayed in July after losing their clutches to an Arctic Fox in June. Hatching dates ranged from 23 July to the third week in August, with modal peak occurring on 28 to 29 July. Average incubation period was 28.2 days in 1976 and 27.6 days in 1977. Although exact observations of guillemot fledging dates were not possible, we estimate that fledging ranges from the last week in August to the third week in September, peaking around 31 August.

Breeding chronologies of other species are only generally known, as emphasis was placed on numerically important breeding species.

Oldsquaw

Egg laying period - last two weeks of June and first two weeks of July.

Observed brood departure dates - two on 20 July, one on 29 July, one on 1 August, two between 3 and 6 August, and one on 12 August.

Sabine's Gull

Egg laying period - last two weeks of June.

Observed hatching period - third week of July.

Fledging period - mid-August.

Baird's Sandpiper

Egg laying period - late June.

Hatching period - mid-July.

Last observation of fledged young - 11 August.

Snow Bunting

Egg laying period - mid-June.

Hatching period - early July.

Final departure of island fledged young - late August to early September.

2. Nest site selection

Primary nesting areas of exposed nesting species, such as Arctic Tern. Sabine's Gull, and Oldsquaw, centered around vegetated shorelines of small brackish ponds and open areas of sand-gravel substrate. Cavity nesters, such as Black Guillemot and Snow Bunting, out of necessity restricted their nest sites to suitable driftwood and metal covers.

Arctic Tern nesting habitat included open sand-gravel areas and sparsely vegetated margins of island ponds (Fig. 3 and 4). Sand, gravel, and sand and gravel in combination were primary mest substrates (Table 1). Similar nesting habitats are reported by Hawksley (1957) on Machias Seal Island in New Brunswick. 76% (N=55) of 1977 Cooper Island nest sites were located by driftwood or similar objects.

Many unused nest scrapes existed on the island, suggesting nest sites were not limiting for Arctic Terns. Distances to nearest neighboring nests were quite far in 1976 (mean distance = 50.8 ± 9.4 (95% C. L.), N = 56) and 1977 (mean distance = 53.9 ± 10.6 (95% C. L.), N = 55), also suggesting that terns did not breed at maximum densities. By comparison, Pettingill (1939) estimated 2000 tern nests in 7.5 acres on Machias Seal Island, New Brunswick. His density observations equal approximately 15 m average distance to nearest neighboring nests, assuming uniform spacing of nest sites.

FIGURE 3. ARCTIC TERN NEST SITES, COOPER ISLAND, 1976

FIGURE 4. ARCTIC TERN NEST SITES, COOPER ISLAND, 1977

TABLE 1. ARCTIC TERN NEST SUBSTRATES, COOPER ISLAND, 1976 and 1977

SUBSTRATE	1976		1977	
	NUMBER	PERCENT	NUMBER	PERCENT
Sand	5	9	15	27
Gravel	9	16	14	26
Sand and gravel	36	63	18	33
Vegetation	2	3	0	0
Vegetation, sand, and gravel	5	9	3	6
Other (wood chips, feathers)	0	0	4	7

Cooper Island Black Guillemots solely used man-related artificial covers for nest cavities, consequently their nests concentrated where covers were available (Fig. 5). Nest site covers included prone and inclined wooden boards and boxes and a punctured oil barrel (Table 2). The expansion of the Cooper Island guillemot breeding population is due in part to our creation of nest cavities from available wood on the island (see Divoky et al., 1974). At least 68% of occupied nest sites in 1977 were created by us from 1972 to 1976.

Oldsquaw nested exclusively in driftwood windrows (36% of sites in 1976, 55% in 1977) and patches of Lyme Grass, Elymus arenarius (64% in 1976, 45% in 1977). Most nests clustered near shorelines of island ponds (Fig. 6).

Of the three remaining species, Sabine's Gull also nested primarily along sparsely vegetated margins of island ponds (Fig. 7). All three Baird's Sandpiper nests were located on the island's tundra patch in short-grass tundra. Lastly, Snow Bunting nest covers included oil barrels, plywood, and other debris providing suitable nesting cavities.

3. Breeding success

Breeding success of non-passerine populations is presented in Tables 3 to 7. Tremendous year to year variation in breeding success occurred in all species. Primary factors increasing mortality of eggs and chicks were Arctic Fox predation, Glaucous Gull predation, and starvation due to decreased food availability. Greatest breeding success for all species occurred in 1975, a year of zero fox predation and persistent pack ice in inshore waters of the Beaufort Sea. Poorest breeding success for most species occurred in 1976, primarily due to heavy fox predation of open nesting species.

Arctic Tern breeding success in 1975 compares favorably with very successful years observed in other populations (see discussion). Ice associated prey species appeared readily available well into September, 1975. 1976 success was very poor, due to fox predation during the egg period and high mortality of very young chicks (Table 8). In 1976 parent terns deserted their nests during diurnal periods while foxes worked the island. This resulted in extended incubation periods (26.3 days in 1976 vs. 21.6 in 1977), possible depletion of yolk reserves in eggs prior to hatching, and increased mortality of chicks during the first days of life. 1977 success was fair, decreased in part due to fox predation of eggs in late June. A large storm in early August, 1977, blew the drifting pack ice far offshore during

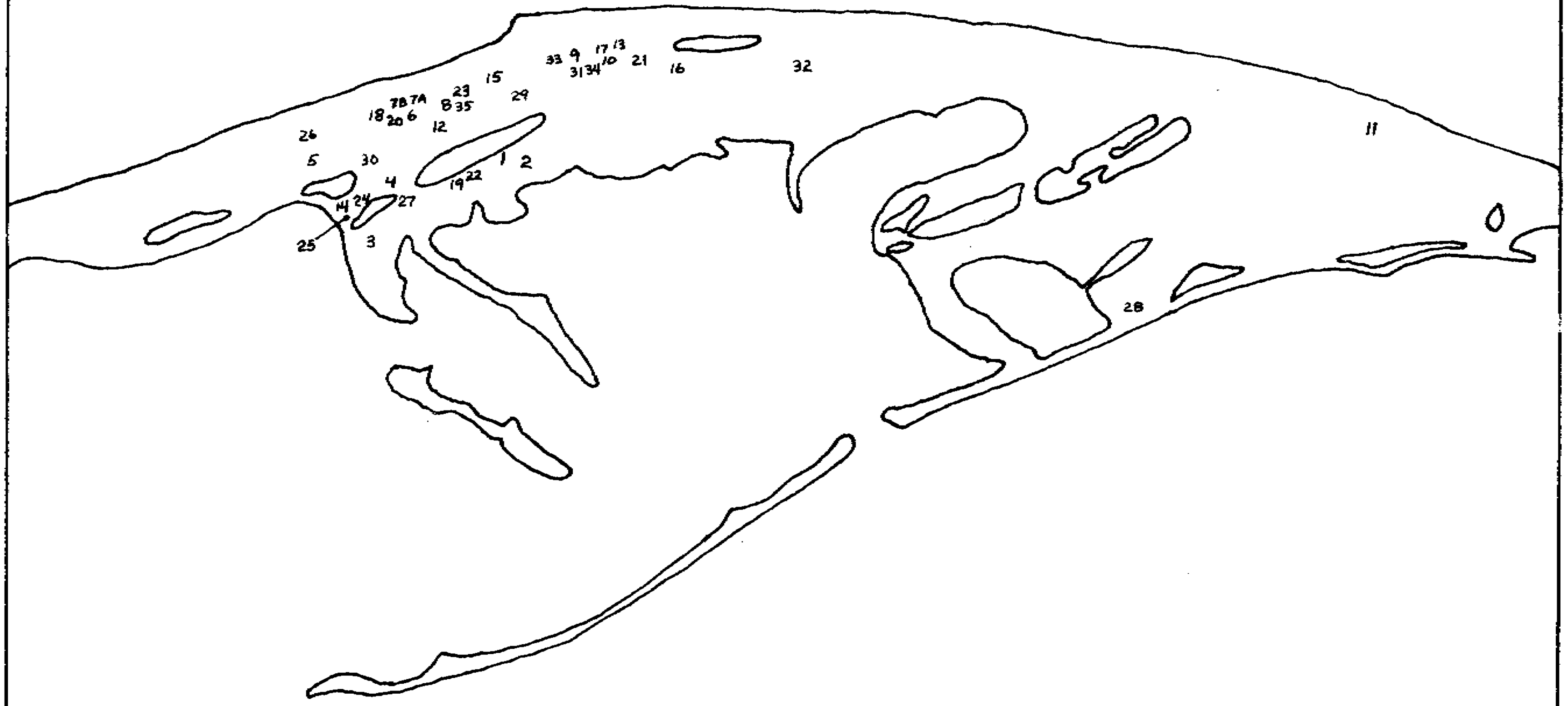


FIGURE 5. BLACK GUILLEMOT NEST SITES, COOPER ISLAND, 1975 - 1977

NEST USE: 1975 - 1-7A, 8-18; 1976 - 1-17, 19-21; 1977 - 1-17, 19, 21-35

TABLE 2. BLACK GUILLEMOT NEST COVERS, COOPER ISLAND, 1975 - 1977

COVER	NUMBER USED	PERCENT	CUMULATIVE USE 1975 - 1977	PERCENT
Plywood	17	47	28	38
Box	8	22	20	27
Wallboard	6	16	15	21
Wood sled	3	8	8	11
Door	1	3	1	1
Oil barrel	1	3	1	1

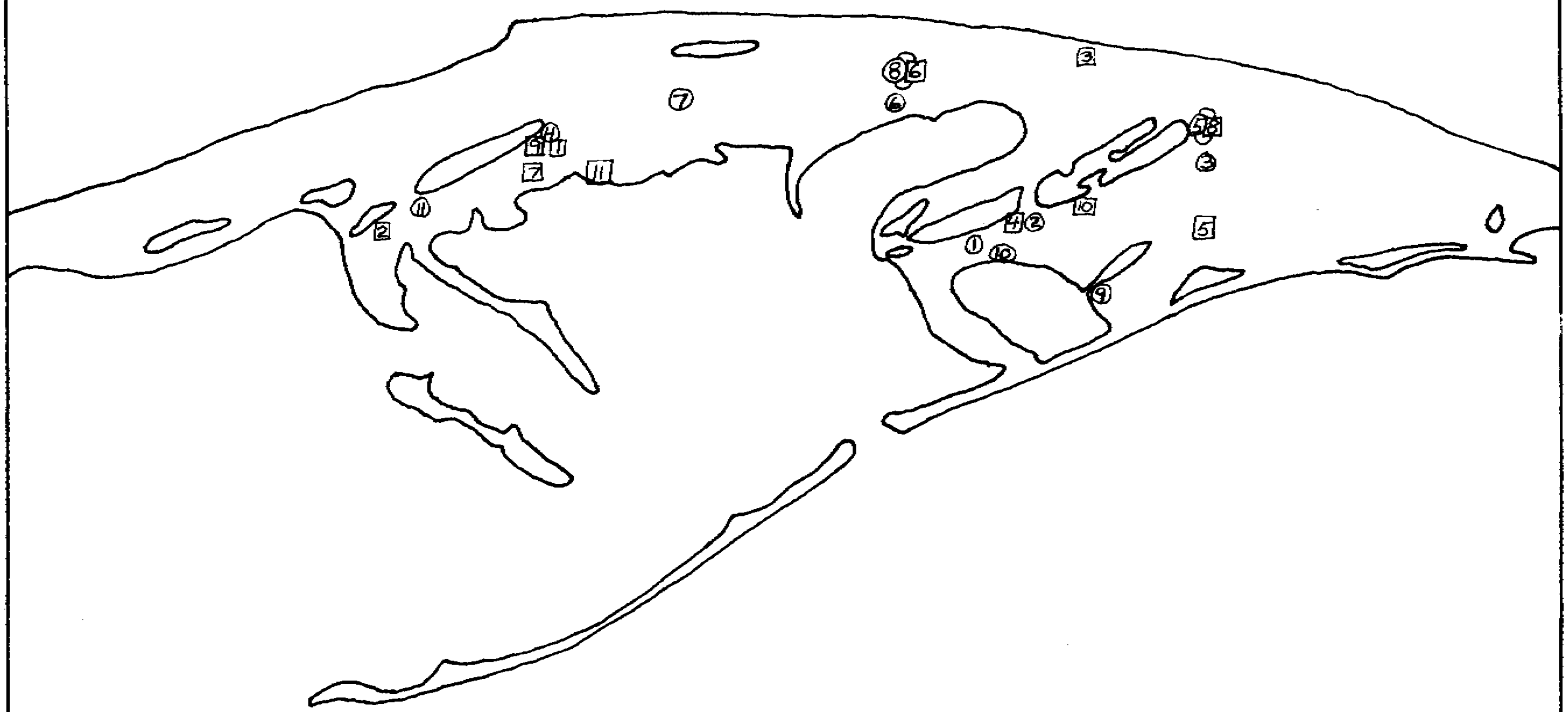


FIGURE 6. OLDSQUAW NEST SITES, COOPER ISLAND, 1976 (CIRCLES) AND 1977 (SQUARES).

FIGURE 7. SABINE'S GULL NEST SITES, COOPER ISLAND, 1976 (CIRCLES) AND 1977 (SQUARES)

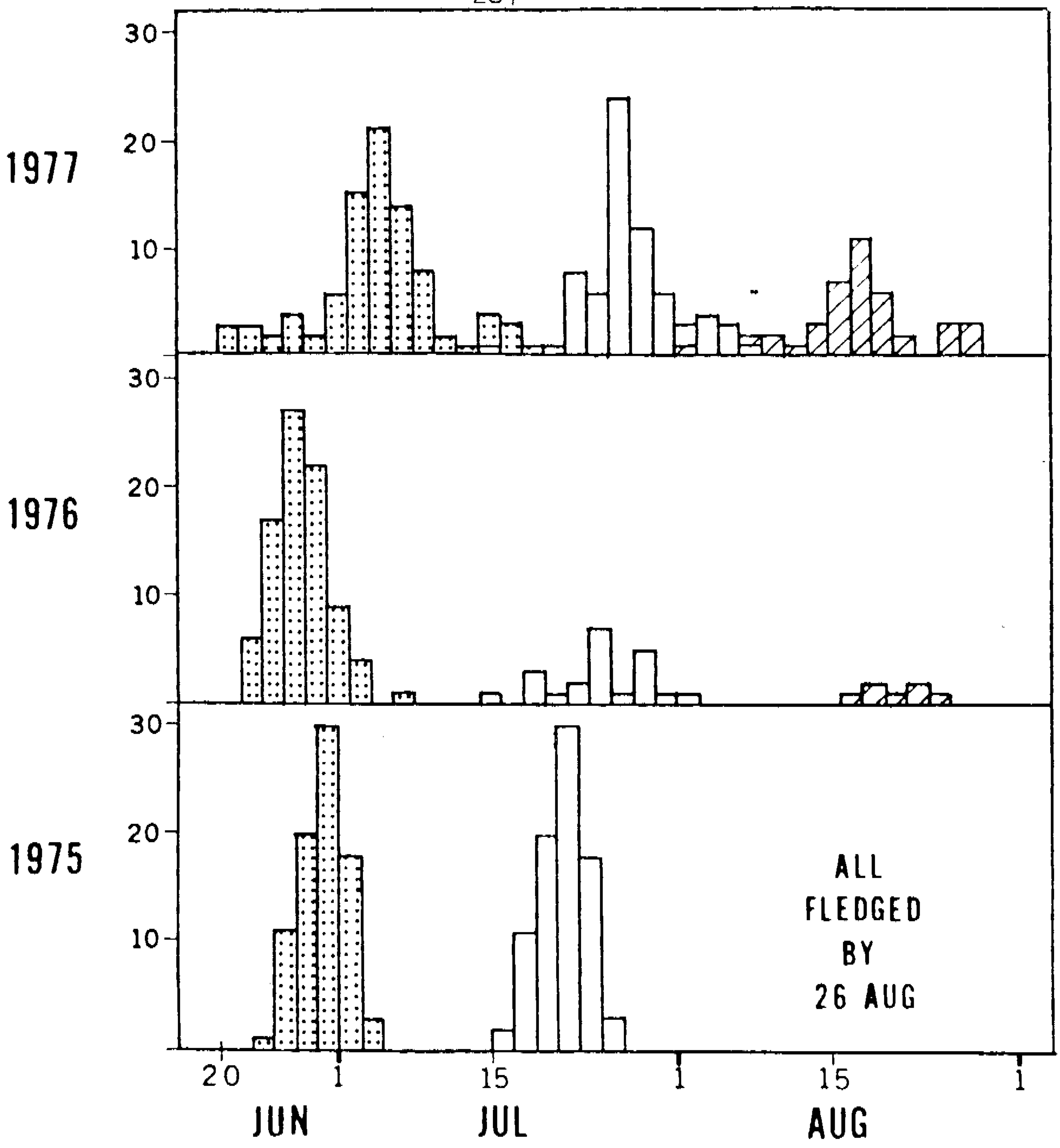


FIGURE 8. ARCTIC TERN BREEDING CHRONOLOGY, 1975 - 1977, COOPER ISLAND. Ordinate denotes numbers of eggs or chicks. Dotted columns are laying dates, open columns are hatching dates, and barred columns are dates of first flight. 1975 laying dates based on 22 day incubation period prior to observed hatching dates.

the chick period. This apparently had great effect on the availability of ice-related prey species used by terns for chick feeding, leading to starvation of old chicks prior to fledging (Table 8).

Black Guillemots had near perfect breeding success in 1975. 1976 and 1977 saw decreased success due to Arctic Fox predation and mortality factors as yet unexplained. A possible cause of decreased overall success in 1976 and 1977 was the increased number of new nest sites, hence the number of previously inexperienced and unpaired birds, in the Cooper Island colony. At least 38% of guillemot nest sites in 1977 were occupied for the first time, and one additional site not used in 1975 and 1976 was previously occupied in 1972. First time nest sites had smaller clutches (1.6 vs. 1.8 eggs) and poorer breeding success (29% vs. 36%) than previously used sites, despite the fact that all fox predation occurred at previously used sites. Increased chick mortality in 1976 and 1977 may also be due to Horned Puffin disturbances. Several guillemot chicks died of crushed skulls and body lacerations at nest sites frequented by a lone Horned Puffin, but only circumstantial evidence suggests the puffin caused these deaths.

Arctic Fox and Glaucous Gull predation had greatest impact on the breeding success of other species (Tables 5 to 7). Open nesting species, particularly Oldsquaw and Sabine's Gull, were especially vulnerable to Arctic Fox predation on the island.

4. Feeding

Prior to breakup of shorefast ice in July, marine prey were largely inaccessible in inshore waters for Cooper Island breeders. Before breakup Black Guillemots flew north from the island, presumably to feed in leads beyond the shorefast ice margin. Most Arctic Terns and Sabine's Gulls flew south to the mainland on a daily basis during the shorefast ice period, presumably to feed on tundra arthropods. One tern collected in 1975 while returning to the island from the south had Diptera larvae in its stomach, a prey item obtainable at the mainland. The major shift to marine prey did not occur until the shorefast ice had begun substantial deterioration.

The principle and probably preferred prey species of Cooper Island Arctic Terns during chick feeding was Arctic Cod (Boreogadus saida) (Table 9). Arctic Cod seemed readily available in inshore waters during the shorefast ice breakup and drifting pack ice periods. Crustaceans also made up a significant portion of tern chick diets, depending on availability. For three days in early August, 1976, a

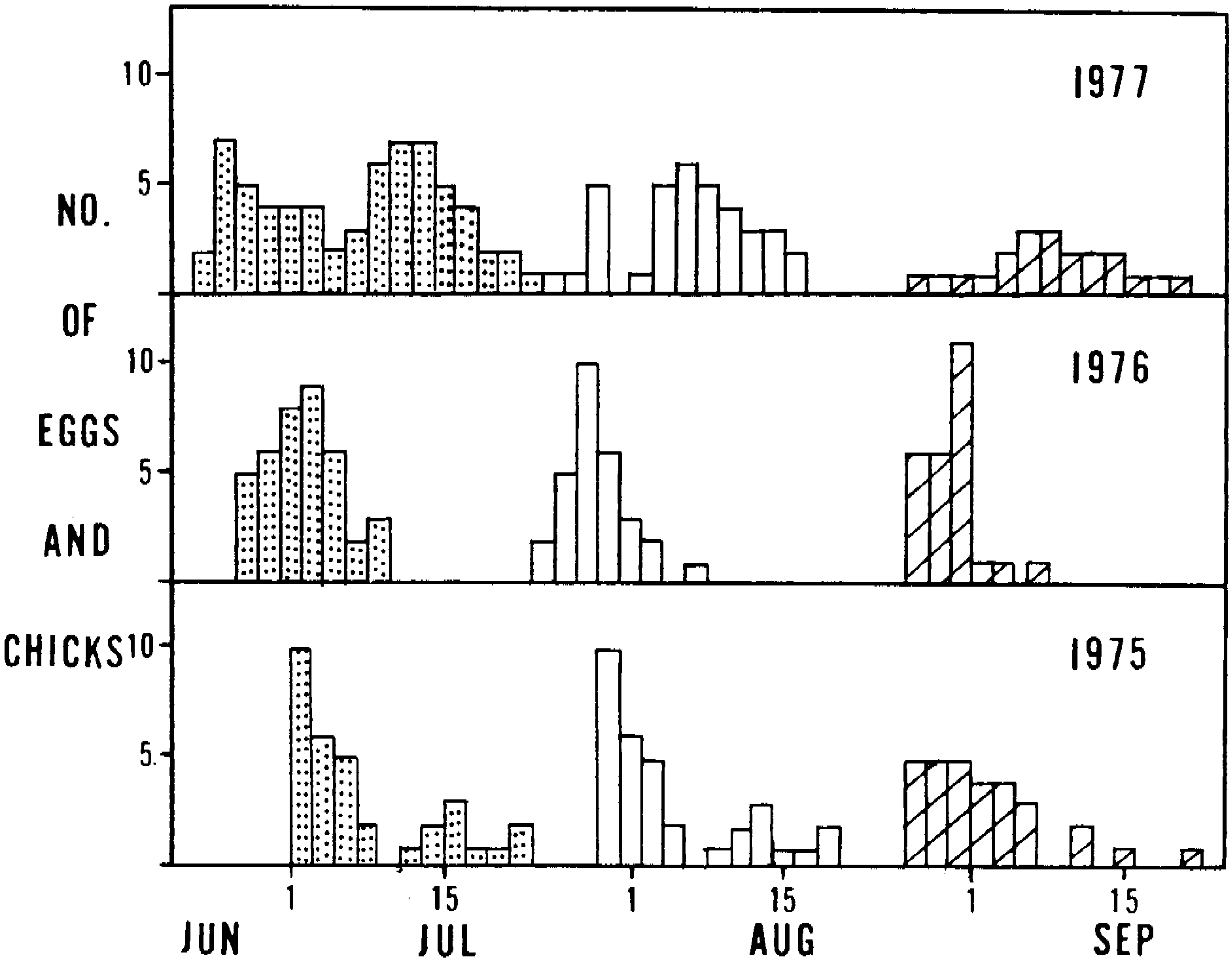


FIGURE 9. BLACK GUILLEMOT BREEDING CHRONOLOGY, 1975 - 1977, COOPER ISLAND, ALASKA. Dotted columns are laying dates, open columns are hatching dates, and barred columns are nest desertion dates. Several nest desertion dates are estimates based on late season visits to Cooper Island. 1975 hatching dates based on 28 day incubation period after observed laying dates.

TABLE 3. ARCTIC TERN BREEDING SUCCESS, COOPER ISLAND, ALASKA

Year	1975	1976	1977
Number of Nests	51	58	61
Average Clutch Size	1.9	1.7	1.4
% Hatching Success	86	21	79
% Eggs Taken by Arctic Fox	0	53	5
Number of Eggs Hatched/Nest	1.6	0.4	1.1
% Fledging Success	79*	33	57*
Number of Chicks Fledged/Nest	1.3*	0.1	0.7*
% Breeding Success	68*	7	46*

* Estimates based on number of dead chicks found during late-season visits to Cooper Island.

TABLE 4. BLACK GUILLEMOT BREEDING SUCCESS, COOPER ISLAND, ALASKA

	1975	1976	1977
Number of Nests	18	21	39[2]
Average Clutch Size	1.8	1.95	1.75[3]
% Hatching Success	97	78	59
% Eggs Taken by Arctic Fox	0	0	17
Number of Eggs Hatched/Nest	1.8	1.5	1.0
% Fledging Success	97[1]	84	56
Number of Chicks Fledged/Nest	1.7[1]	1.3	0.6
% Breeding Success	94[1]	66	33

1. Assuming remaining chicks fledge (4 remaining on 5 September).

2. 39 attempted clutches in 34 nest sites.

3. Data for known completed clutches only. Average clutch for all nests, including those suffering Arctic Fox predation before completing clutches, 1.69.

TABLE 5. OLDSQUAW BREEDING SUCCESS, COOPER ISLAND, ALASKA

	1975	1976	1977
Number of Nests	9	11	11
Average Clutch Size (completed cluches only)	7	6.4	6.4
% Hatching Success	–[1]	10	82
% Eggs Taken by Arctic Fox	–	83	13
% Nests Taken by Arctic Fox	–	82	45
Number of Eggs Hatched/Nest	–	0.6	2.8
% Departure Success	–	9	71

[1] 1975 information unavailable

TABLE 6. SABINE'S GULL BREEDING SUCCESS, COOPER ISLAND, ALASKA

	1975	1976	1977
Number of Nests	4	5	2
Average Clutch	3.0	2.4	2.5
% Hatching Success	83	0	40
% Eggs Taken by Arctic Fox	0	100	0
% Eggs Taken by Glaucous Gull	0	0	60
Number of Eggs Hatched/Nest	2.5	0	1.0
% Fledging Success	60[1]	0	50[1]
Number of Chicks Fledged/Nest	1.5[1]	0	0.5[1]
% Breeding Success	50[1]	0	20[1]

1. Estimates based on number of dead chicks found in late season.

TABLE 7. BAIRD'S SANDPIPER BREEDING SUCCESS, COOPER ISLAND, ALASKA

	1975	1976	1977
Number of Nests	2	2	1
Average Clutch	–[1]	3.5	3.0
% Hatching Success	–	57	100
% Eggs Taken by Arctic Fox	–	43	0
Number of Eggs Hatched/Nest	–	2.0	3.0
% Fledging Success	–	25	0
Number of Chicks Fledged/Nest	–	0.5	0
% Breeding Success	–	14	0

1. 1975 information unavailable

TABLE 8. AGE OF ARCTIC TERN CHICK MORTALITY, COOPER ISLAND, ALASKA

Year	1975	1976	1977
% Chicks Dead <1 week old	19	52	4
% Chicks Dead 1-2 weeks old	0	10	6
% Chicks Dead >2 weeks old	1*	5	33*
% Fledging Success	79*	33	57*

* Estimates based on number of dead chicks found during late-season visits to Cooper Island

TABLE 9. PREY RETURNED TO COOPER ISLAND BY ARCTIC TERNS DURING CHICK PERIOD, 1976 AND 1977

PREY	% OF TOTAL PREY ITEMS		MEAN SIZE* (mm) ± 95% C.L.	
	1976 N=264	1977 N=261	1976	1977
Arctic Cod (<u>Boreogadus</u>)	21.6	31.4	79 ± 10	81 ± 8
Unknown Fish	2.3	21.5	N<5	69 ± 10
Large Amphipod	3.8	2.3	26 ± 4	28 ± 6
Small Amphipod	15.2	3.4	11 ± 2	14 ± 2
Euphausid (<u>Thysanoessa</u>)	53.0	0.0	Not Sizable	
Isopod (<u>Saduria</u>)	0.8	0.0	N<5	-
Pteropod (<u>Limacina</u>)	0.0	3.4	-	12 ± 2
Unknown Invertebrate	3.4	37.9	16 ± 10	13 ± 7

* Based on estimated bill lengths of prey items observed with binoculars.

large patch of Euphausiids (Thysanoessa spp.) washed ashore on the island's south shoreline. Terns fed frantically at this patch, sometimes returning prey to chicks every 45 seconds. Due to observations during this frantic feeding activity Euphausiids appear numerically important in 1976 chick diets; over the entire chick period, however, their importance was probably slight. Nevertheless, concentrations of superabundant invertebrate prey may at times provide an important food source for chick feeding Arctic Terns.

Similar to terns, Black Guillemots seem to have overwhelmingly preferred Arctic Cod during chick feeding (Table 10). Arctic Cod was apparently quite available in inshore waters near Cooper Island, as most feeding during the shorefast ice breakup and drifting pack ice periods occurred within 1 km of the island. Adult guillemots captured and returned cod on feeding trips lasting as little as five minutes. Four-horned Sculpin did not become a major prey species for guillemots until the removal of drifting pack ice from inshore waters.

B. Non-breeding bird use

Migratory patterns were fairly similar in 1976 and 1977 (Fig. 10 and 11). During June and the first half of July sightings primarily included breeding species. The first significant influx of non-breeding birds occurred in the last half of July, and in both years migrant numbers peaked in August. Several migrant species, however, occupied Cooper Island habitats 5 to 10 days earlier in 1977 and in 1976, most notably shorebirds and small Larids. The departure of these species also took place earlier in 1977, apparently due to poor weather conditions and the associated removal of pack ice and its prey fauna from the Cooper Island vicinity in early to mid-August. In 1976 migrant densities of over 1000 birds per kilometer of shoreline occurred in the third week of August, mostly Red Phalaropes, Arctic Terns, and Sabine's Gulls feeding on under-ice amphipods. In 1977, however, with the removal of pack ice from inshore waters 11 to 12 days earlier, migrant densities decreased to less than 100 per kilometer by 19 August. Thus the presence of drifting pack ice and its associated prey seem to have an important influence on the timing of departure by several species from the Plover Islands and the Beaufort Sea.

A summary of major species follows:

1. Loons

Loons were regular visitors to inshore waters near Cooper Island (Fig. 12). Prior to shorefast ice breakup, loons,

TABLE 10. PREY RETURNED TO COOPER ISLAND BY BLACK GUILLEMOTS DURING CHICK PERIOD, 1976 AND 1977

PREY	% OF TOTAL PREY ITEMS		MEAN SIZE* (mm) ± 95% C.L.	
	1976 N=71	1977 N=37	1976	1977
Arctic Cod	83	54	73 ± 6	70 ± 10
Four-horned Sculpin	1	19	N 5	139 ± 11
Capelin	0	3	-	N 5
Unknown fish	16	22	unable to size	67 ± 11
Large amphipod	0	3	-	N 5

* All sizes except sculpin based on estimated bill lengths of prey items observed with binoculars. Sculpin sizes based on fish found at nest sites or in dead chicks.

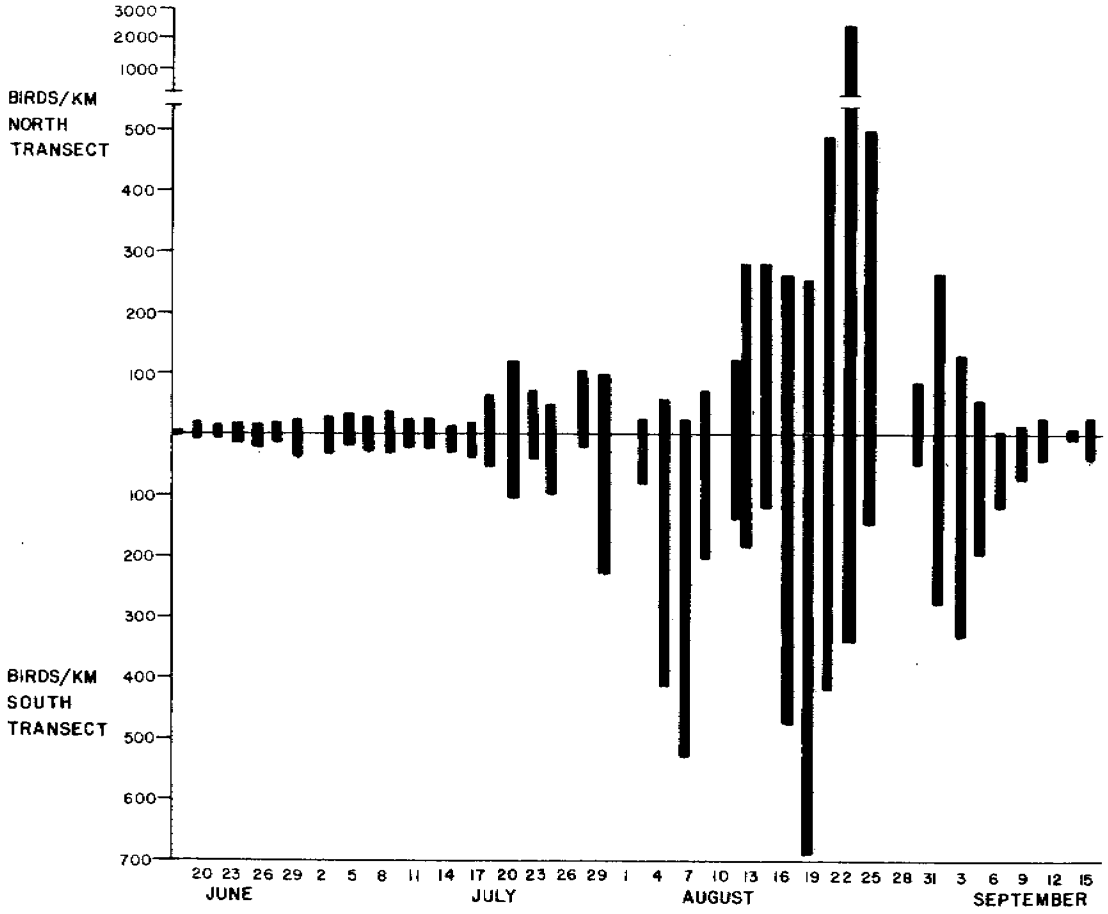


FIGURE 10. TRANSECT DENSITIES, BIRDS USING COOPER ISLAND HABITAT, 1976 (BIRDS OBSERVED/KM WALKED)

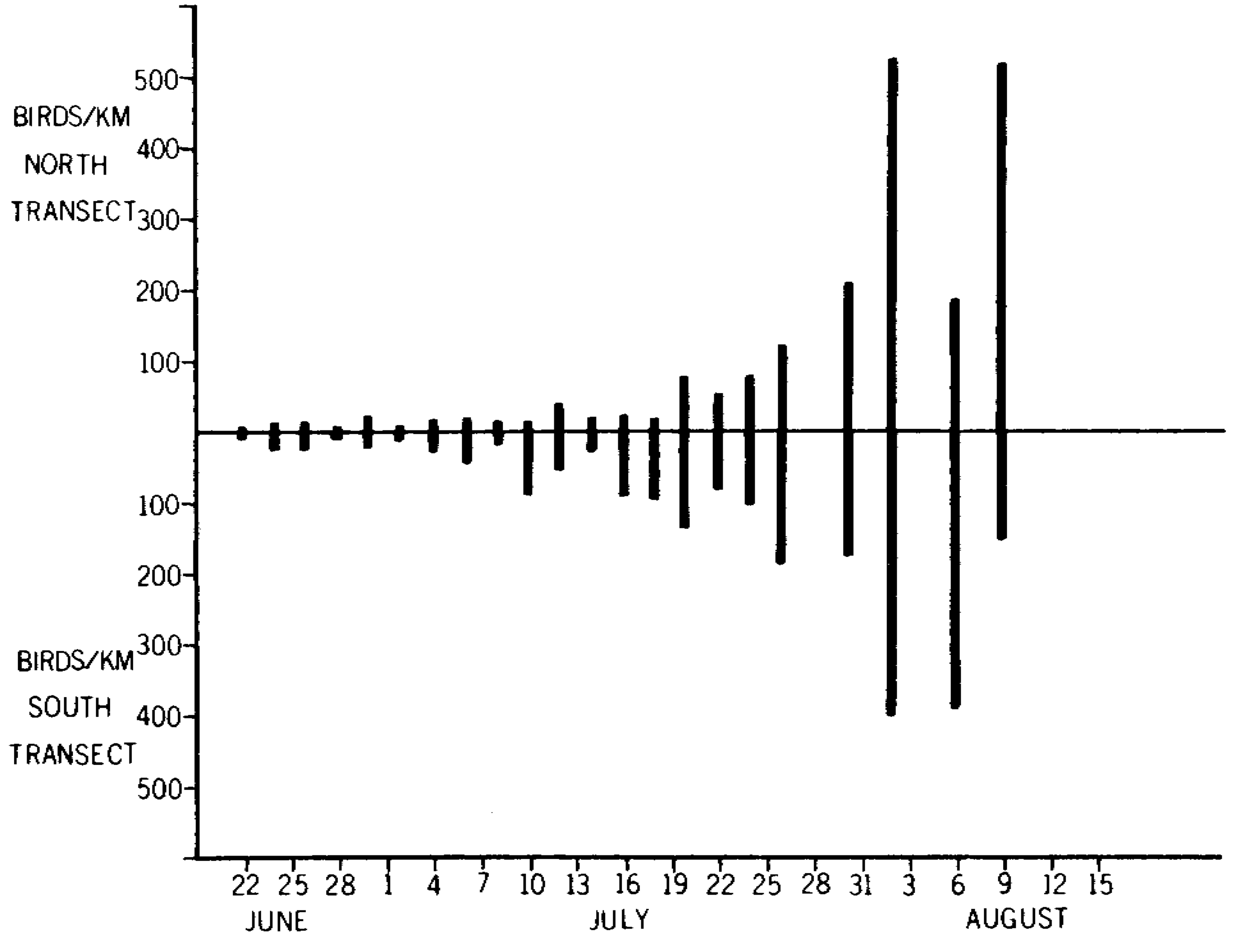


FIGURE 11. TRANSECT DENSITIES, BIRDS USING COOPER ISLAND HABITAT, 1977 (BIRDS OBSERVED/KM WALKED)

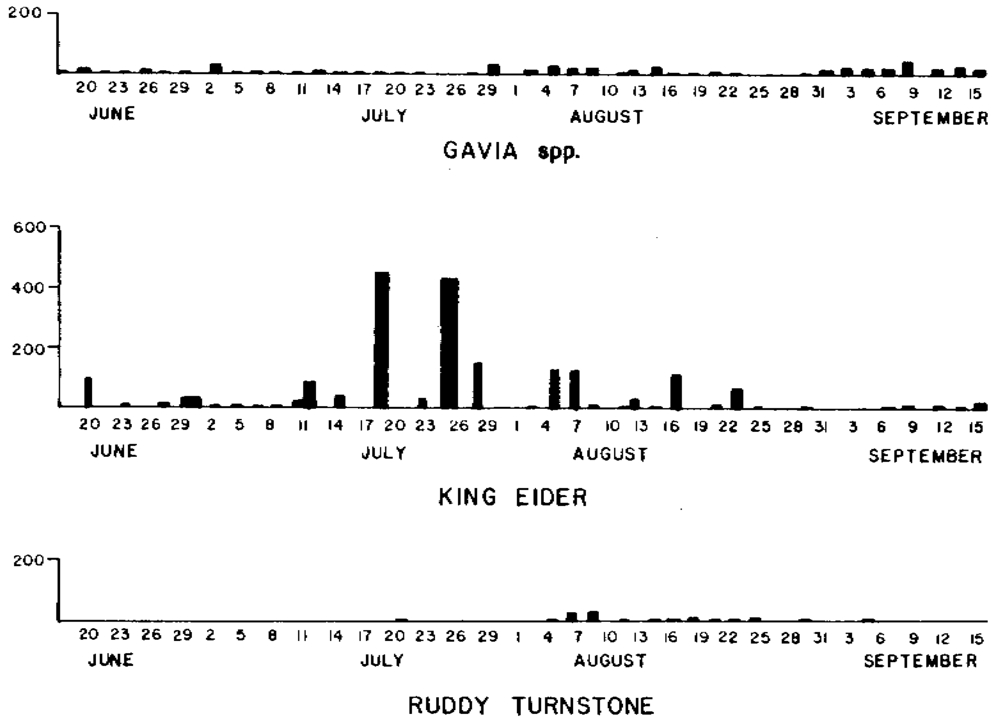


FIGURE 12. LOON, KING EIDER, AND RUDDY TURNSTONE ABUNDANCES ON SHORELINE TRANSECTS, COOPER ISLAND, 1976

particularly Arctics, swam and dove in moats surrounding the island. The birds preferred the west end of the island, swimming in mid-moat or near the shorefast ice edge.

After breakup loons often swam solitarily or in pairs near light concentrations of ice, such as Ekilukruak Entrance and waters north of the island. Most individuals, however, flew over the island in north-south directions without stopping, suggesting these were mainland nesters flying to offshore marine waters for food. Yellow-billed Loons did not become abundant until the drifting pack ice period of late July and August.

Post-breeding migration of loons was heaviest in September, 1976. Frequent flocks of 5 to 15 birds passed from east to west during this time.

2. Brant

Small groups of Brant were common on the island during late June and early July, 1976 and 1977, and September, 1976. Individuals in the early summer were one of the few non-breeding users of Cooper Island terrestrial habitats prior to post-breeding migration. All Brant flocks restricted their activities to Carex patches on the island's south side. September flocks sighted in 1976 contained both adults and juveniles.

3. Pintail

Pintails were infrequent in 1976. In 1977, however, they were common during most of the summer, peaking at 118 on 2 August. Females comprised almost all flocks. Few birds dabbled in shallow waters of Elson Lagoon and Ekilukruak Entrance, but most merely roosted on vegetated shorelines of island ponds.

4. Eiders

Few eiders used the island or surrounding habitats. Occasionally a migrating eider flock landed in mid-Elson Lagoon, especially on late summer evenings. Perhaps these birds roosted overnight on the water. Up to 15 King and Common Eiders, primarily sub-adult males and females, used the Cooper Island north shoreline in August and September for possible wing molt. These birds quietly roosted on the beach, entering the water only when disturbed. A small flock of female Stellar's Eiders roosted on the island's south shoreline for several days in September, 1976.

Passing flocks of migrating eiders were visible almost daily in both 1976 and 1977, all flying west. King Eiders far outnumbered other species, although most flocks were too distant for identification (Fig. 12). Many large eider strings were visible over the mainland coastline, suggesting these birds predominantly flew over the mainland coast rather than the barrier islands while migrating. It appears this section of coastline is of little value to eiders other than as a migratory route.

5. Oldsquaw

Oldsquaw was the most consistent and abundant species near the island (Fig. 13). 1000 to 2000 males underwent wing molt in Elson Lagoon near Cooper Island in both 1976 and 1977. Their period of flightlessness stretched from about 20 July to 20 August. Many other Oldsquaw occupied adjacent sections of Elson Lagoon at this time. Molting birds roosted in large flocks on lagoon shorelines of barrier islands. These birds fed primarily in mid-lagoon 200 m to 2 km offshore.

Heaviest post-breeding migration of Oldsquaws occurred during September, as observed in 1976. Intense flights of Oldsquaw occurred in the evening at this time. From about 1600 to 1900 flocks numbering 50 to 1000 appeared far offshore to the northeast, flew directly south over the barrier islands, and landed in Elson Lagoon. On following mornings from 0600 to 0800, large flocks took off from the lagoon, crossed the islands, and proceeded offshore in a west to northwest direction. Peak numbers visible on one evening were 12,650 ± 500 on 9 September, 1976. We observed no feeding behavior after these birds landed, merely great rafts of ducks which persisted until darkness.

6. Ruddy Turnstone

Ruddy Turnstones were regular migrants in August (Fig. 12). The first turnstone arrivals occurred about 10 days earlier in 1977 than in 1976, in the last week of July rather than the first week of August. They fed on beaches by walking and pecking, apparently on invertebrates beached by wave action. Highest counts occurred in early August, 1976, but several individuals remained into September of that year.

7. Semipalmated Sandpiper

In both 1976 and 1977 a large wave of juvenile Semipalmated Sandpipers occurred in the last week of July and the first week of August (Fig. 14). These birds fed primarily on mud shorelines of tundra ponds, although many walked and pecked on beaches with other shorebirds. Numbers rapidly declined in August, although few individuals remained past mid-August.

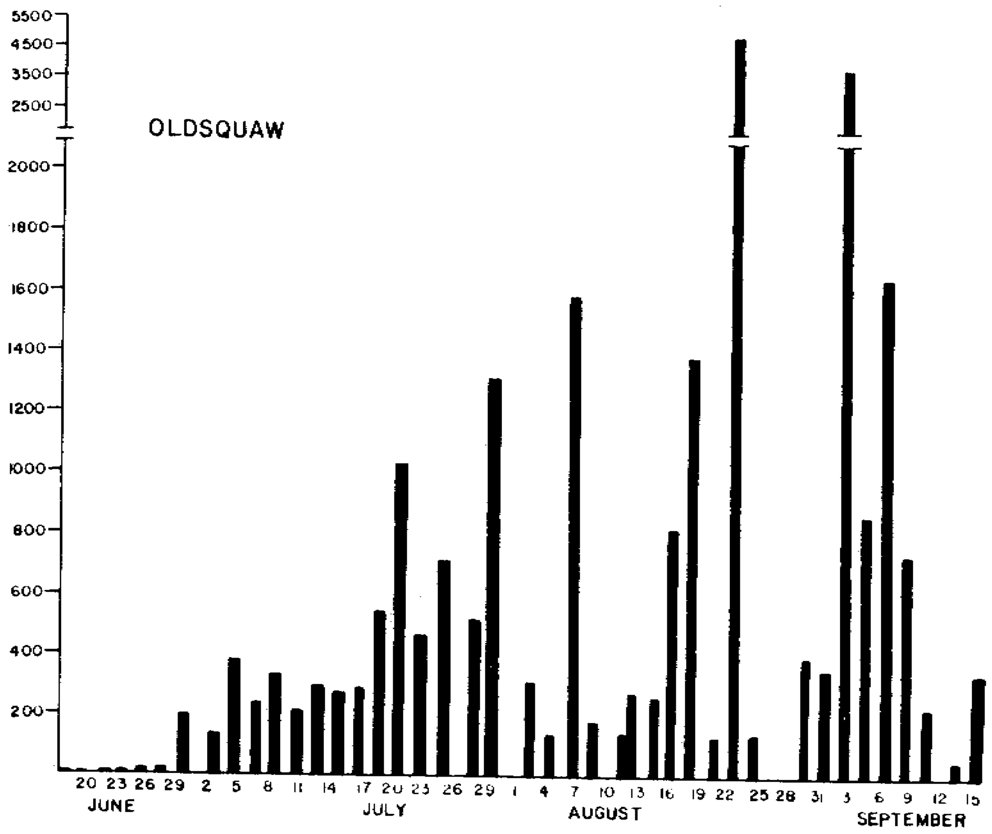
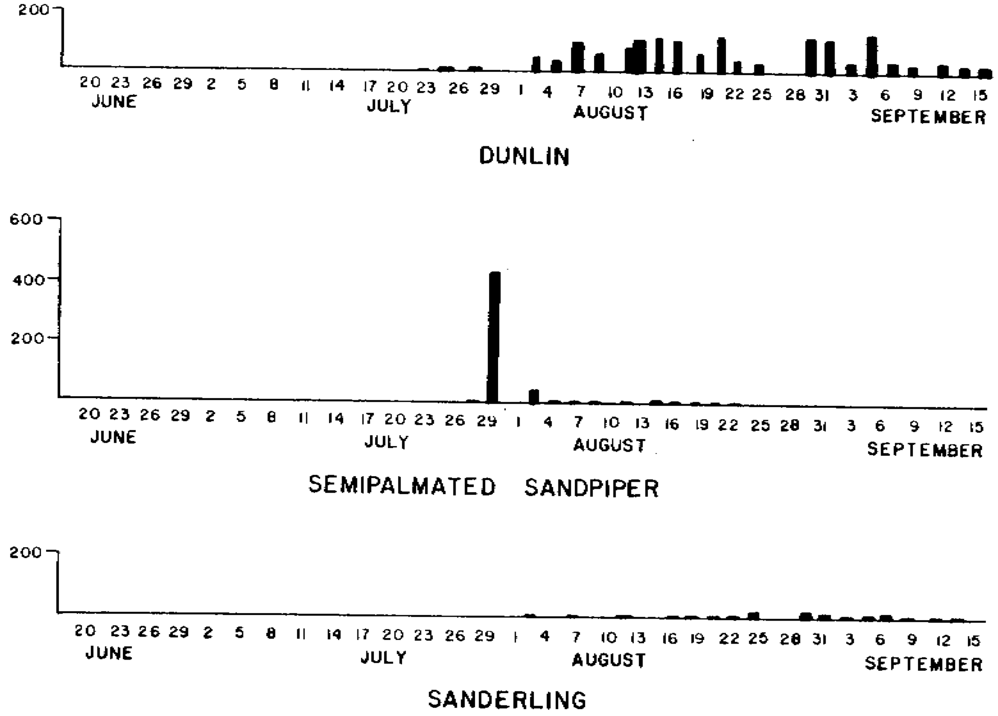


FIGURE 13. OLDSQUAW ABUNDANCES ON SHORELINE TRANSECTS, COOPER ISLAND, 1976



DUNLIN

SEMIPALMATED SANDPIPER

SANDERLING

FIGURE 14. DUNLIN, SEMIPALMATED SANDPIPER, AND SANDERLING ABUNDANCES ON SHORELINE TRANSECTS, COOPER ISLAND, 1976

8. Western Sandpiper

Scattered Western Sandpipers fed along beaches and mud shorelines of tundra ponds during the first two weeks of August in both 1976 and 1977.

9. Pectoral Sandpiper

Pectorals were sighted infrequently in both 1976 and 1977. Most birds roosted with other shorebirds in terrestrial habitats, and none remained on the island for extended periods.

10. Dunlin

Adult Dunlin began arriving in mid- to late July (Fig. 14), although they arrived at least a week earlier in 1977 than in 1976. The first juvenile birds were sighted in late July. Over 100 birds were present on several days in August and September, 1976. They fed with Ruddy Turnstones and Sanderlings by walking and pecking where beached invertebrates washed ashore.

11. Sanderling

Migrant Sanderlings were infrequent in early August of 1976 and 1977. Numbers peaked at 25 during the last week in August in 1976, but they continued conspicuous until mid-September (Fig. 14). Sanderlings fed individually at plankton washups on sand and gravel beaches.

12. Red Phalarope

This species occurred throughout 1976 and 1977 seasons (Fig. 15). Low numbers, primarily adult females, occupied mud shorelines of tundra ponds and Elson Lagoon in June and early July. Some jousting occurred between females as they chased males over the island and the lagoon. A small influx of males occurred in mid- to late July in both 1976 and 1977.

Juvenile phalaropes arrived in large numbers in late July and early August, and continued abundant until the first large storm in August. Peak numbers in one transect series were over 8000 in 1976 and nearly 3500 in 1977. In both 1976 and 1977 the greatest juvenile phalarope feeding flocks occurred where <u>Apherusa glacialis</u>, an under-ice amphipod, was the dominant available prey. Large flocks roosted on the island, especially on unvegetated flat areas near the breeding bird colony. Numbers quickly dwindled when the pack ice blew offshore. Several late season aggregations of feeding

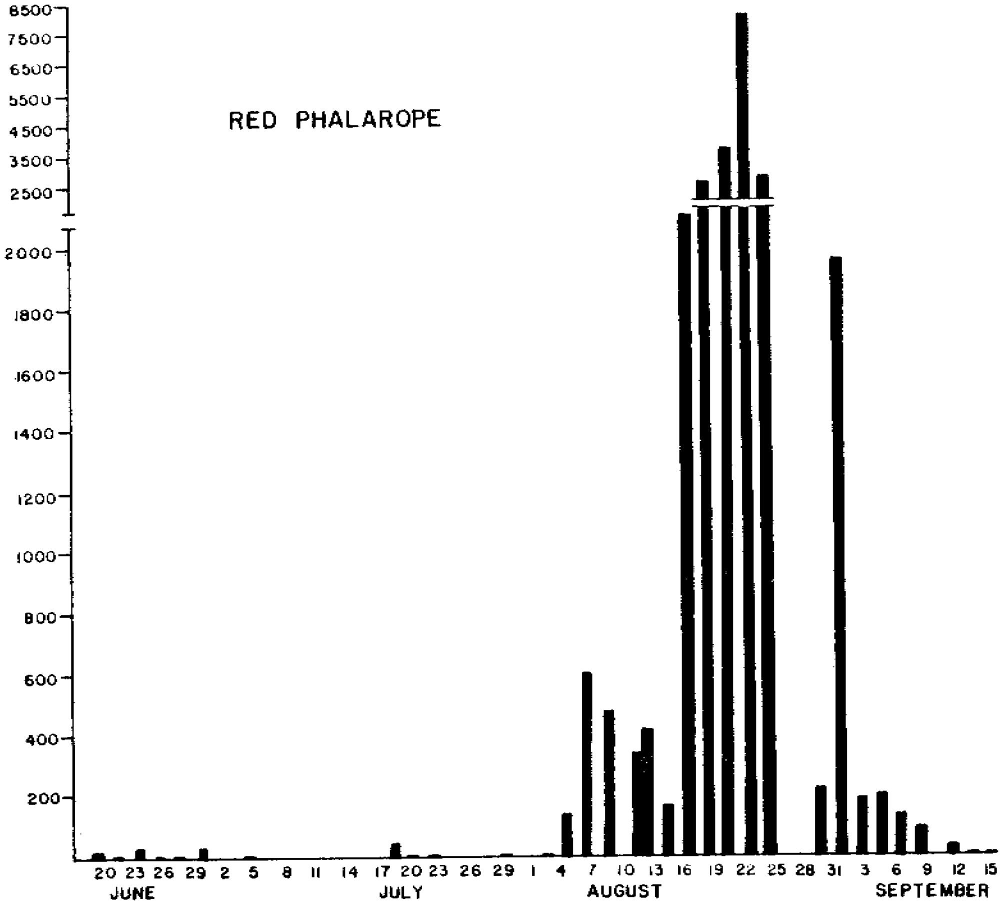


FIGURE 15. RED PHALAROPE ABUNDANCES ON SHORELINE TRANSECTS, COOPER ISLAND, 1976

phalaropes occurred during the open water period in 1976 when patches of zooplankton washed on barrier island beaches.

13. Jaegers

Passing jaegers were sighted nearly every day in 1976 and 1977. Pomarine Jaegers were common in June and early July, but were infrequent later in the summer. Parasitic Jaegers were the most abundant jaeger of late July and August, oftentimes parasitizing terns returning fish to the island. Long-tailed Jaegers were seen steadily only during early to mid-July, although rare individuals fed in feeding flocks of Arctic Terns, Sabine's Gulls, and Red Phalaropes associated with Apherusa glacialis. Few jaegers used island habitats, as breeding Arctic Terns vigorously mobbed most passing jaegers.

14. Glaucous Gull

We observed Glaucous Gulls daily (Fig. 16). Most were individuals or small groups which flew over the island without stopping. Buildups of feeding gulls occurred whenever patches of suitable plankton species, especially Euphausiids and Copepods, washed onto shallow beaches. After feeding activity slowed or stopped at a feeding flock site, perhaps due to depletion of prey or changes in conditions decreasing food availability, Glaucous Gulls often roosted onshore for several hours or days before departing the island. These roosting birds were very wary of human activity, taking flight with minimal disturbance.

15. Sabine's Gull

The Plover Islands lie along a major migratory route of this species (Fig. 16). Sabine's Gulls were a major component of August feeding flocks associated with Apherusa glacialis and other plankton species. Habitats used by Sabine's Gulls for feeding included almost all shorelines of the island and entrances between barrier islands. Feeding methods of these birds were quite flexible, icluding dipping, surface siezing, and walking and pecking on beaches. Many Sabine's Gulls, however, flew by the island in large flocks without feeding.

Prior to 1 August, all birds were either breeding adults or speckled-headed non-breeders (subadult one year olds?). The first juveniles arrived with their parents in early August. Sabine's Gulls rapidly decreased in numbers after the pack ice blew offshore in August of both 1976 and 1977.

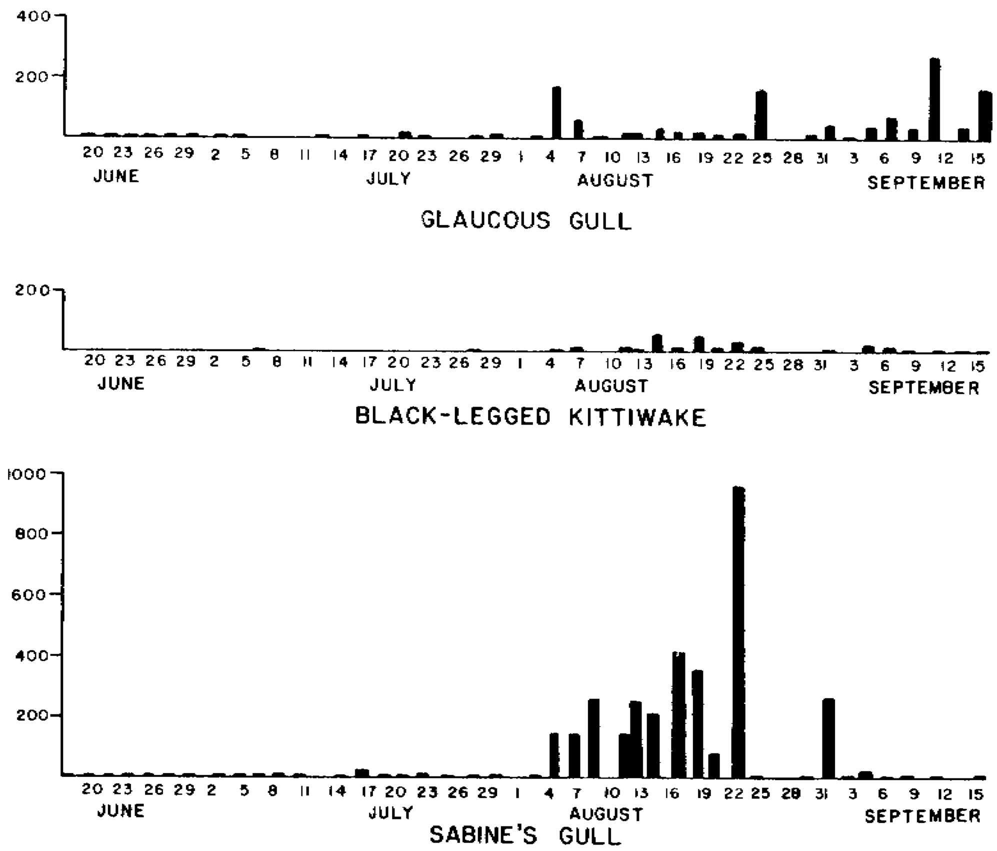


FIGURE 16. GLAUCOUS GULL, BLACK-LEGGED KITTIWAKE, AND SABINE'S GULL ABUNDANCES ON SHORELINE TRANSECTS, COOPER ISLAND, 1976

17. Arctic Tern

Like Sabine's Gulls, Arctic Tern migration patterns suggest the Plover Islands lie along a major tern migratory route (Fig. 17). Beginning in late July, and depending upon the continued presence of prey into September, large numbers of terns used Cooper Island habitats for feeding and roosting. Major tern feeding habitats were shallow waters at barrier island beaches and at entrances between barrier islands where patchy zooplankton concentrations washed ashore. The largest buildups of terns occurred at feeding flocks associated with *Apherusa glacialis* and *Thysanoessa* spp.

The first flocks of non-breeding terns, all adults, arrived in mid-July in both 1976 and 1977. Juveniles first arrived with their parents in late July, but the bulk of tern migration occurred during the first three weeks of August in 1976 and early August in 1977. Numbers of birds in feeding flocks decreased rapidly after the removal of sea-ice from inshore waters, but terns also joined feeding flocks during the open water period when patches of Euphausiids and other zooplankters washed ashore.

18. Lapland Longspur

A wave of 100 to 200 immature longspurs occurred in mid-August in both 1976 and 1977. These birds occupied the island's tundra patch, usually milling in small groups, but also pecking around vegetation as if feeding.

C. Plankton tows

Surface plankton tow results are presented in Figures 18 - 22. These tows were intended to provide seasonal trends in relative plankton abundances in nearshore waters of Cooper Island. Many sampling errors are inherent in such tows, consequently, depending on the species, such information may be an incomplete representation of real conditions. Major problems encountered are patchiness of plankton species, net avoidance, and the fact that we cannot perceive and capture prey items similarly to feeding marine birds.

1. Plankton species present in inshore waters during the entire summer season

The only species present in ample numbers throughout all ice periods were amphipods occupying primarily benthic habitats, such as *Gammarus* spp. and *Onissimus* spp. These animals did not display overt patchiness, but instead seemed evenly dispersed in suitable

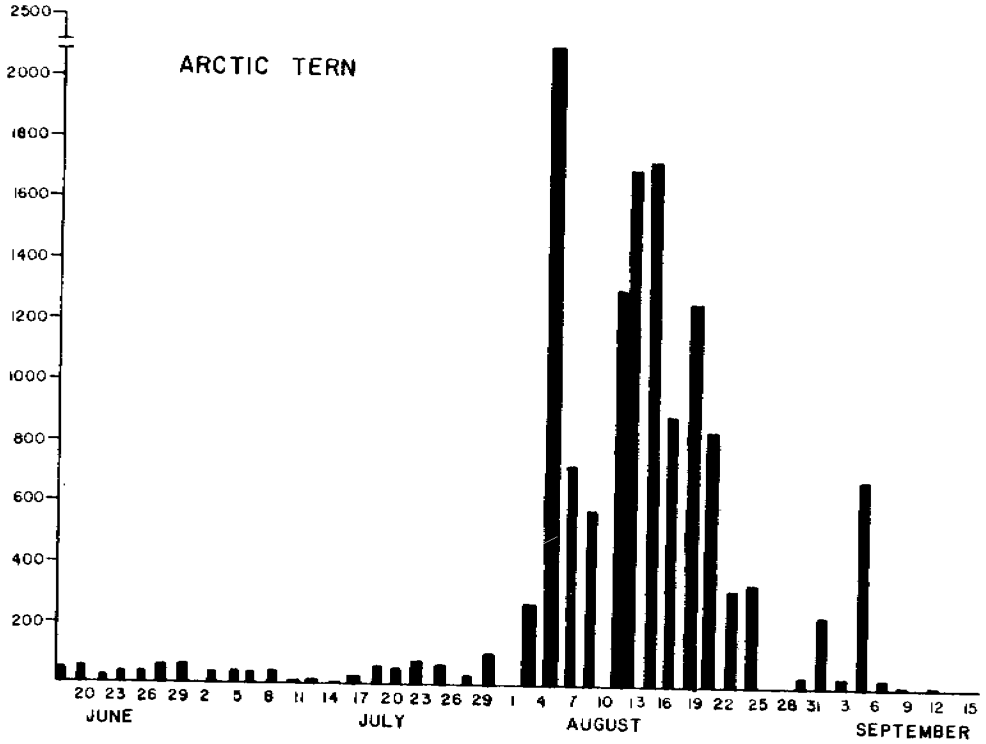


FIGURE 17. ARCTIC TERN ABUNDANCES ON SHORELINE TRANSECTS, COOPER ISLAND, 1976

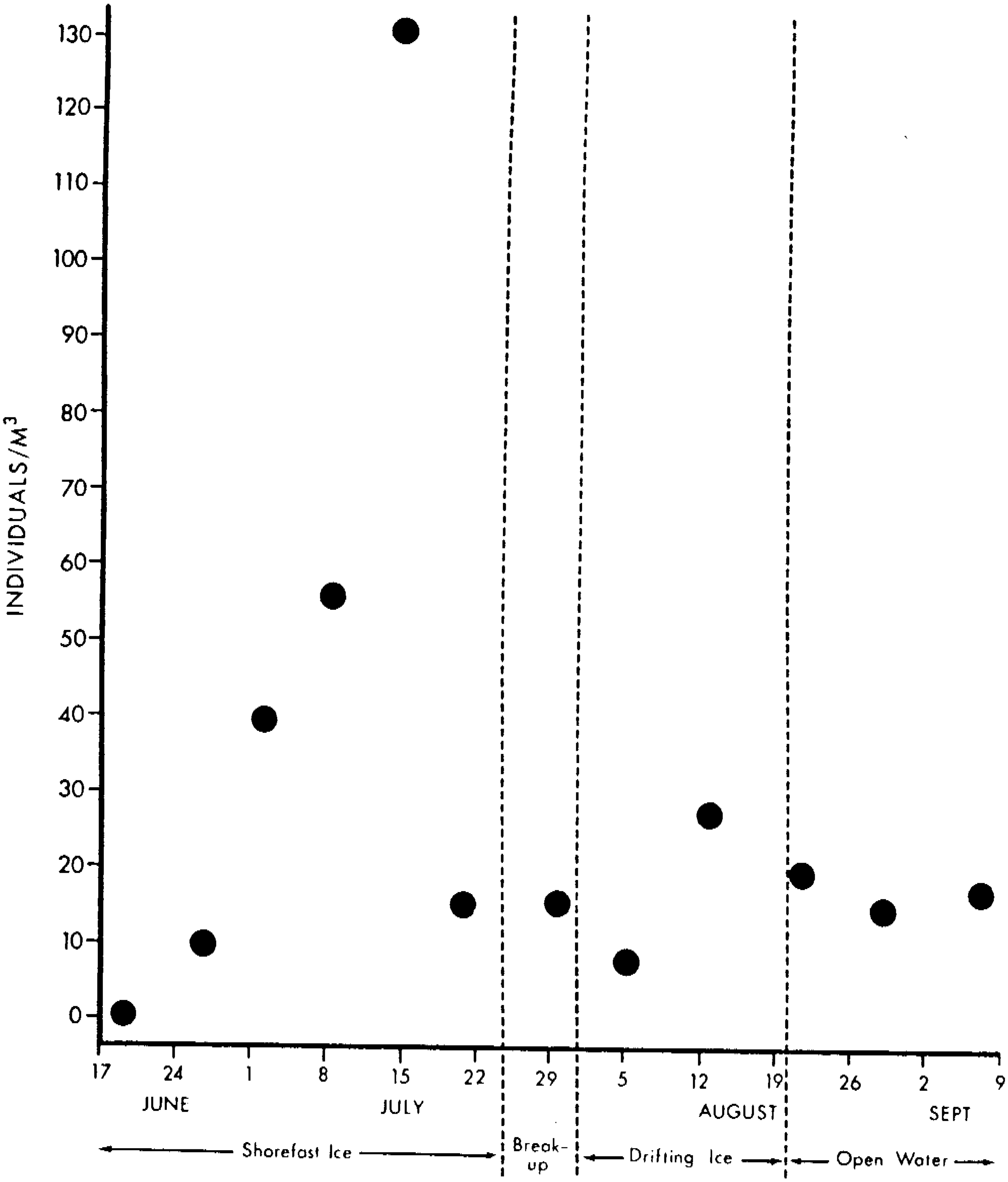


FIGURE 18. ZOOPLANKTON DENSITIES, ALL SPECIES, COOPER ISLAND, 1976

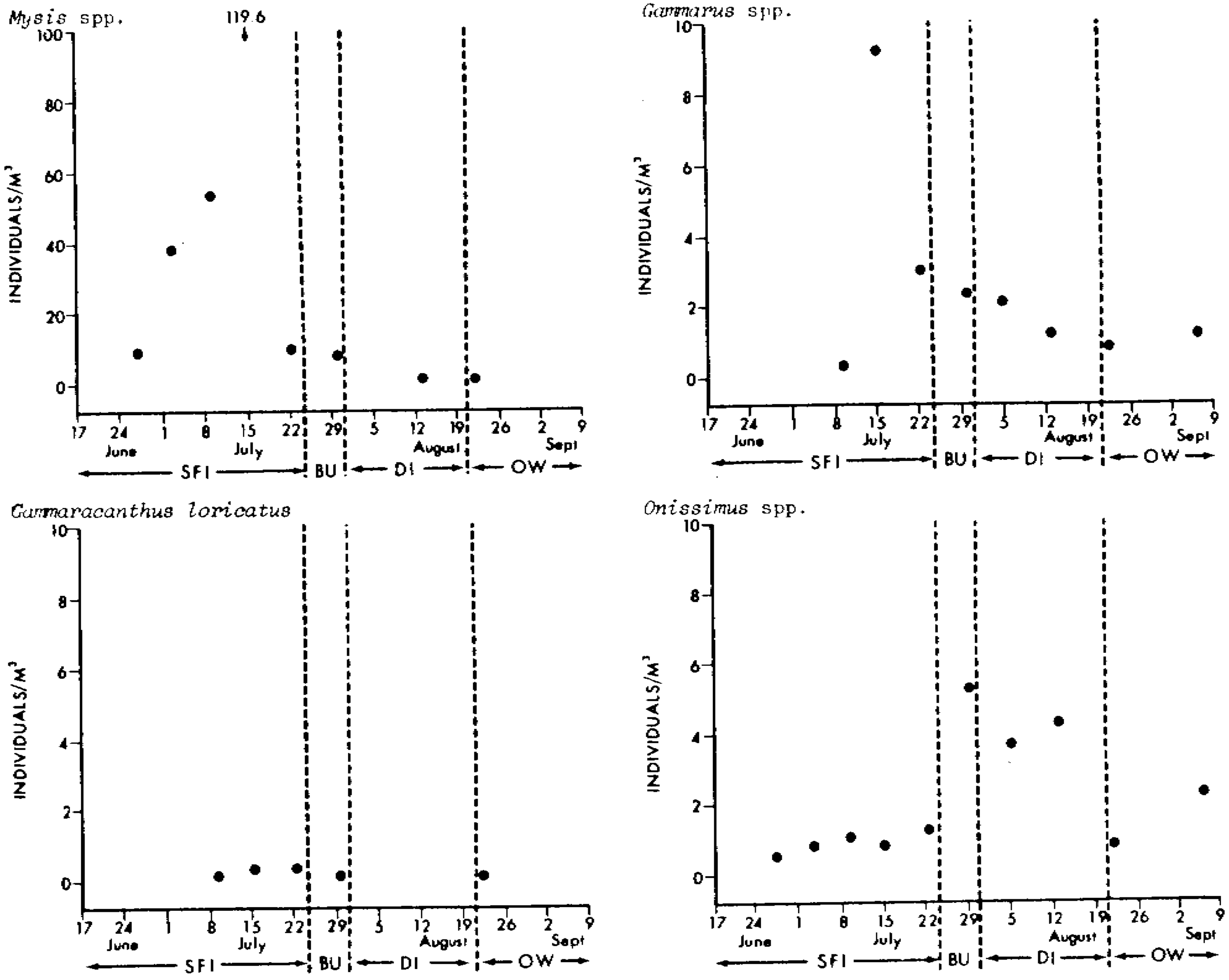


FIGURE 19. DENSITIES OF MYSIS SPP., GAMMARUS SPP., GAMMARACANTHUS LORICATUS, AND ONISSIMUS SPP. CAPTURED IN PLANKTON TOWS, COOPER ISLAND, 1976

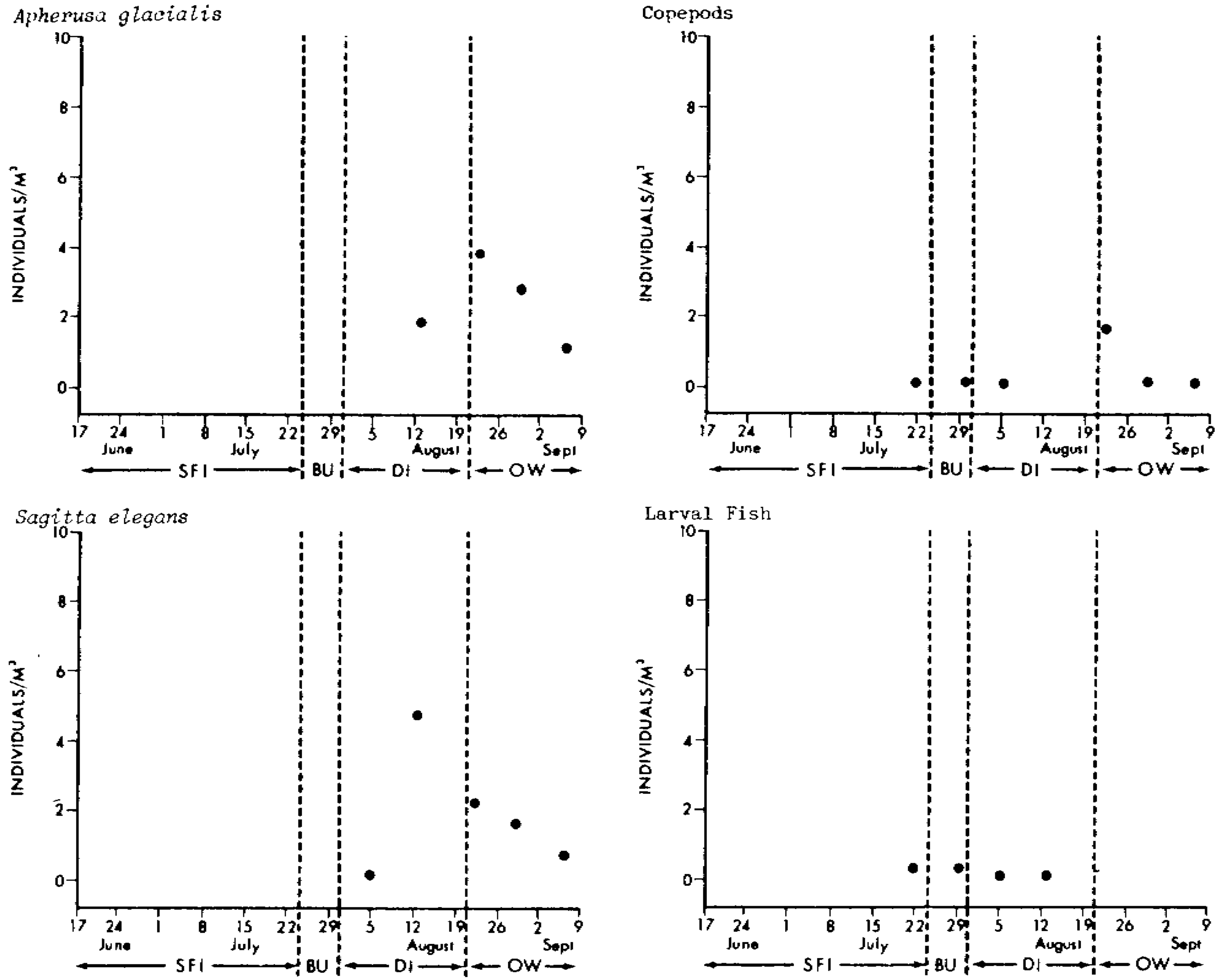


FIGURE 20. DENSITIES OF APHERUSA GLACIALIS, COPEPOD SPP., SAGITTA ELEGANS, AND LARVAL FISH CAPTURED IN PLANKTON TOWS, COOPER ISLAND, 1976

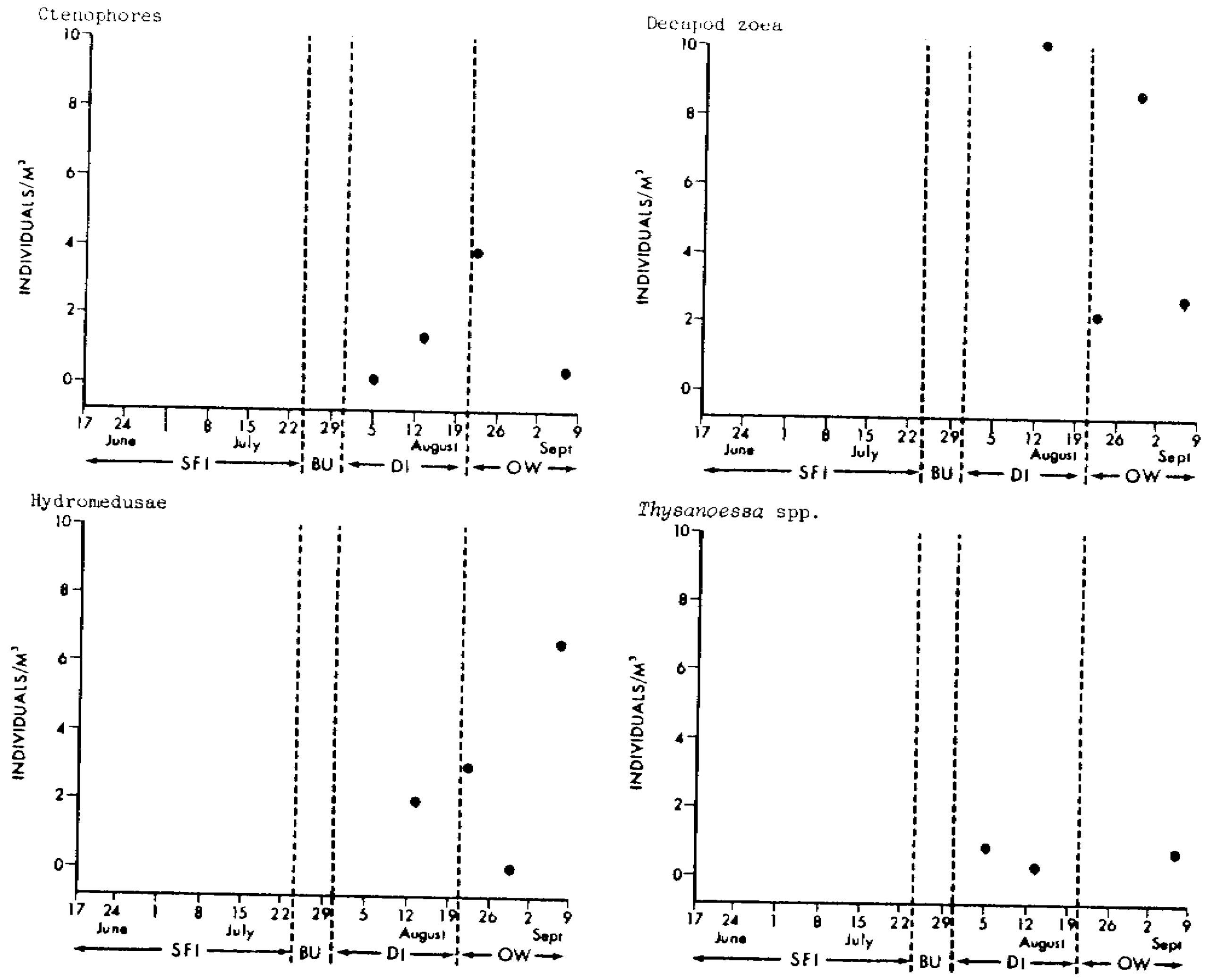


FIGURE 21. DENSITIES OF CTENOPHORES, DECAPOD ZOEA, HYDROMEDUSAE, AND THYSANOESSA SPP. CAPTURED IN PLANKTON TOWS, COOPER ISLAND, 1976.

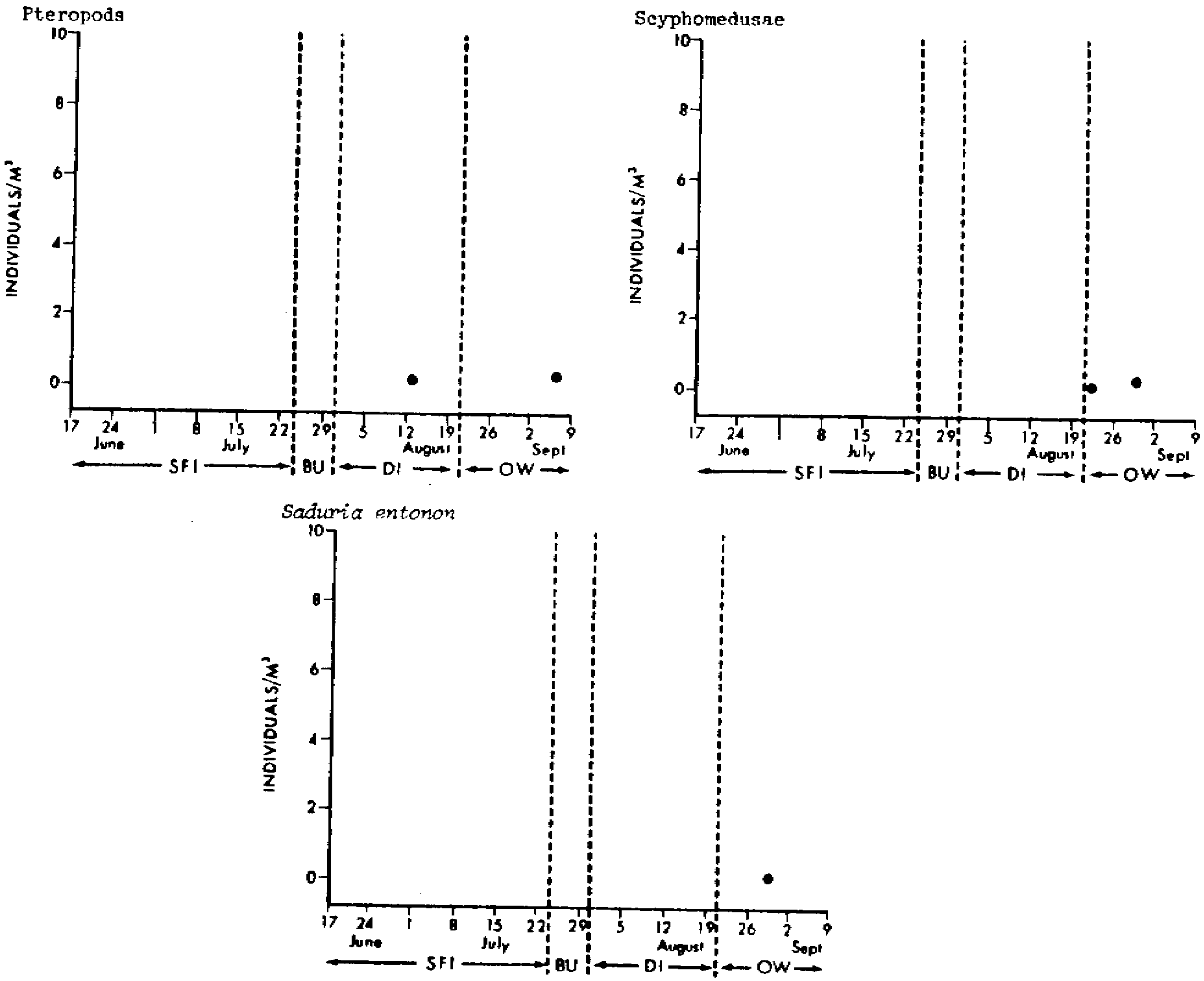


FIGURE 22. DENSITIES OF PTEROPODS, SCYPHOMEDUSAE, AND SADURIA ENTOMON CAPTURED IN PLANKTON TOWS, COOPER ISLAND, 1976

habitats. Both these genera were captured at all plankton collection sites, although Gammarus appeared most abundant in gravel substrates north of the island and Onissimus appeared to prefer mud substrates of Elson Lagoon.

During the shorefast ice and shorefast ice breakup periods Arctic Terns and Sabine's Gulls fed where these species were readily visible in shallow water. They were less important to breeding bird species later in the summer, as most birds fed at patchy concentrated prey after breakup of shorefast ice.

2. Species abundant in shorefast and shorefast ice breakup periods, but decreasing in densities later in the summer

Dense masses of juvenile Mysis spp. (most <10 mm) occupied inshore waters during the shorefast ice period. These individuals reached greatest densities near the bottom, although they also made excursions into the water column. Several times we noticed benthic amphipods (Gammarus and Onissimus spp.) with small Mysids in their mouthparts, suggesting these animals provided some input into the trophic structure of inshore waters. Larger Mysids were present, most about 15 to 30 mm long; it appears as if these larger individuals were captured by dipping Arctic Terns during the shorefast ice period. Mysids markedly decreased in plankton tows after breakup of shorefast ice.

Gammaracanthus loricatus was noticably conspicuous during the shorefast ice breakup period near the island's west end. Several large individuals (20 to 40 mm) were found on the underside of ice cakes when these cakes were inverted. Small feeding flocks of Arctic Terns occurred at West End at this time, suggesting Gammaracanthus was a likely prey species for these birds.

3. Species with noticable affinities to certain ice types during the drifting pack ice period

Apherusa glacialis reached its greatest abundance under multi-year ice cakes. These amphipods became available to surface feeding birds when the multi-year cakes they adhere to grounded and deteriorated on shorelines or in entrances between barrier islands. Apherusa was extremely patchy, obviously concentrating where cakes deteriorated onshore. Consequently our sampling techniques at fixed shoreline stations do not convey their true overall abundances.

The most persistent feeding flocks of surface feeding migrants were associated with Apherusa. Red Phalaropes, Arctic Terns, and Sabine's Gulls fed extensively on these prey items in inshore waters. Apherusa and feeding flocks associated with it were most numerous in 1976, a year of abundant multi-year ice. The great amounts of multi-year ice in this year was undoubtedly due to the extremely heavy ice conditions in 1975.

4. Species with no strong ice affinities reaching greatest abundances during drifting pack ice and open water periods

Several species apparently not associated with specific ice types, and in fact reaching greatest abundances away from ice, appeared on Cooper Island shorelines as current waifs in single and mixed species patches. These included Euphausiids (Thysanoessa spp.), Chaetognaths (Sagitta elegans), Copepods (Uritoma canadensis ?), Pteropods (Limacina and Clione), Decapod zoea, Ctenophores, and Hydromedusae. These species appeared concentrated by small-scale oceanographic conditions in nearshore waters, such as convergences between barrier islands, collisions of patches with barrier island shorelines, and Langmuir spirals. Many individuals in these patches appeared lifeless, possibly due to inhospitable environmental conditions such as abrupt temperature and salinity changes in shallow inshore waters.

Several of these species, most notably Thysanoessa, Sagitta, Uritoma, and Limacina became the focus of late season feeding flocks of marine birds. Arctic Terns, Sabine's Gulls, Glaucous Gulls, and Red Phalaropes constituted the bulk of these feeding flocks.

D. Human use

Several Eskimo groups used Cooper Island during our study, all reaching the island by boat. All appeared to be family groups containing adults and children. Most used the island as a rest stop for a few hours while traveling between Barrow and mainland campsites. One group using a site adjacent to the island's breeding colony shot one adult Arctic Tern and turned over a Black Guillemot nest site without harming the chicks. Another family of one man, one woman, and two sons, became trapped by heavy ice in Elson Lagoon and camped on the island's south shoreline for two days. This group never entered seabird breeding areas, as far as we know.

During 1976 and 1977 only two Eskimo families intentionally camped extended periods on Cooper Island. One of these was a family of one man, one woman, and two sons who camped two nights on the island's north shoreline. They stated they were vacationing away from Barrow for several days. The family frequently walked about the seabird colony, turning over several Black Guillemot nest sites. They also used a plywood guillemot nest cover as a windbreak for their tent. No apparent chick mortality resulted from these activities. A second family camped in the middle of the breeding colony for four days, waiting for improved ice conditions so they could hunt Bearded Seals to outfit their umiak. One 8 year old boy in their party shot several non-breeding birds, especially Glaucous Gulls, with a .22 rifle. One breeding adult Arctic Tern was shot near their camp, presumably because it annoyed people by attacking them near its nest. The family disturbed no guillemot nest sites, even though nests with young chicks lay less than 50 m from their camp.

Overall, Eskimo impact on Cooper Island breeding birds was slight. Deteriorating shorefast ice surrounding Cooper Island until late in the birds' incubation periods seems to preclude egging of the island by Barrow residents.

Cooper Island lies along a busy aircraft route from Barrow to points east. Many aircraft, particularly small planes and helicopters, fly very low over barrier islands. These low flights invariably scare Cooper Island breeding birds off their nests, but most return soon after disturbances subside. The quick return to nest sites after disturbance may be characteristic of species breeding on Cooper Island. Species using other barrier islands, such as eiders and geese, may remain off nest sites for extended periods, making their nests vulnerable to predation in their absence.

Aircraft disturbance has not been a regular problem during the the last two summers, although increased traffic associated with development could potentially decrease breeding success. The greatest disturbance during the last two years appears to have been due to Coast Guard helicopters constructing a radar deflection tower and NARL aircraft outfitting our field camp. Only one guillemot nest located outside the major nesting colony possibly failed due to this disturbance. Such disturbance can be avoided by eliminating over-flights of breeding areas.

The greatest potential disturbance to Cooper Island breeding birds occurred when a cleaning crew contracted by Naval Petroleum Reserve 4 attempted to burn unnatural driftwood and remove oil barrels at Cooper Island in June, 1976. Although well meaning, this cleanup attempt'ignored the fact that some bird species may adapt over time to using human associated debris for nest sites. What at one time was unnatural litter has now become essential breeding habitat for certain bird populations. Obviously, the Cooper Island Black Guillemot population would be extirpated if cleanup operations destroyed its nest cavities. Our presence on the island prevented this from occurring in 1976, but future development must be closely observed to limit the threat of well-intentioned cleanup operations.

V. Discussion

A. Breeding chronology

Cooper Island breeding birds initiate egg laying in late June when shorefast ice still lies onshore. Due to nearly 100% ice cover at this time, marine food is minimally accessible near the island. This forces terns and gulls to fly several kilometers to feed on the mainland and guillemots to fly similar distances to feed in offshore leads. The potential for predation by Arctic Foxes is also highest at this time, as foxes have easy access on the island by shorefast ice. Breeding birds, however, could avoid essentially all fox predation if they delayed egg laying two to three weeks, permitting substantial deterioration of inshore ice and effective isolation of the island from foxes. This assumes foxes would not remain on the island prior to inshore ice breakup if no food in the form of eggs were available. A basic question arises concerning why breeding birds begin egg laying at a time when food is essentially inaccessible near the island and predation pressure is the greatest.

For Arctic Terns, the answer seems to lie with Arctic Cod, the principle prey species used for chick feeding. Arctic Cod is a cryopelagic species associated with the Arctic pack ice (Andriashev, 1970). It is readily accessible for a brief period each year during the shorefast ice breakup and drifting pack ice periods. What becomes of cod after ice is blown offshore in late summer is unclear, but it appears it may either be removed with the ice or may become inaccessible due to changes in its distribution in the water column once it has lost its ice refuges. Alverson and Wilimovsky (1966) captured large numbers of adult cod in otter trawls north and west of Cape Lisburne in open water, but none in mid-water trawls. This suggests these fish descend to depth in open water. Quast (1974) also showed that cod were uncommon in surface waters away from ice. At any rate, it appears the timing of breeding in Cooper Island Arctic Terns is adapted to take advantage of this cryopelagic species in nearshore waters during chick feeding. On average, the chick period in the population begins early in the shorefast ice breakup period and concludes near the end of the drifting pack ice period, the seasonal periods in which cod and other cryopelagic fauna are readily available for these birds.

The chick period of Black Guillemots, on the other hand, usually extends into the open water period in September. There is some evidence that other fish species in guillemot diets, most notably Four-horned Sculpin, increase in importance relative to Arctic Cod during open water. Sculpin, due to their benthic habits, may not be as accessible for terns as for guillemots. Of interest is the fact that guillemots had phenomenal fledging success (97%) in 1975, an extremely heavy ice year in which drifting pack ice, and presumably Arctic Cod, remained inshore well into September. In contrast, 1977, a very light ice year in which drifting pack ice blew far offshore by mid-August, was also a year of relatively poor guillemot fledging success (56%). Consequently, it appears that guillemots also rely to a great extent on cod as a prey species during chick feeding, and have potentially greater fledging success when cod remains available throughout the chick period.

B. Arctic Fox predation

There is no doubt that Arctic Foxes have tremendous impact on the reproductive success of island bird populations. Two foxes intermittently worked Cooper Island in each of 1976 and 1977, yet none appeared in 1975. The explanation for yearly differences in fox predation may lie with abundances and availability of alternate prey sources used by foxes in early summer (Larson, 1960). Low lemming years on the mainland, such as 1977, may force foxes onto barrier islands and offshore ice in search of food. Offshore oil development may have the same result if foxes switch from natural prey to scavenging human encampments.

The condition of foxes collected on Cooper Island gives a clue to the status of foxes working barrier islands. The stomach of one fox in 1977 contained a female Oldsquaw, whereas the other fox's stomach was packed full of seal blubber. Both animals had adequate fat and appeared quite healthy. This suggests Cooper Island was not a last resort for potentially starving animals, but instead was probably only one of several feeding sites used periodically within their home ranges. Prey preferences and foraging areas of Arctic Foxes in coastal areas need closer attention to adequately assess their impact on breeding birds in relation to OCS development.

The activity of a predator at a colony may not only decrease breeding success through overt predation of eggs and chicks, but also by inhibiting egg production, inducing parental neglect, and upsetting the chronology of breeding events (Emlen et al., 1966). All these occurred on Cooper Island during the study. Subtle effects such as this are difficult if not impossible to perceive without knowledge of breeding patterns in years of little or no predator activity.

C. Arctic Tern breeding success

As stated, much variability existed in year to year breeding success of Cooper Island breeders, especially Arctic Terns. This is attributed to variation in Arctic Fox predation and the availability of prey species associated with specific ice conditions during the chick period. Other studies also show variation in year to year success of Arctic Terns at various latitudes. Bengtson (1971) and Norderhaug (1964) report breeding success at Spitsbergen colonies ranging from 14% to 78%. Pettingill (1939) and Hawksley (1957) report breeding success at Bay of Fundy in New Brunswick ranging from 16% to 35%. Causes of mortality included Arctic Fox predation (Bengtson, 1971), starvation due to food shortages (Bengtson, 1971), weather (Gollop et al., 1974) and intrinsic colonial disturbances such as chicks killed by adults, chick disappearances, and abandonment (Pettingill, 1939). It appears, therefore, that high variation in breeding success is typical of Arctic Terns, depending upon predation and environmental factors. Once these factors are reasonably understood the impacts of increased human disturbances associated with oil development are possible.

D. Zooplankton concentrations

The most important prey source for migrant surface feeding birds in inshore waters of the Plover Islands is patchily distributed zooplankton species. As stated, the Plover Islands lie along a major migratory route for barrier island and tundra nesting Arctic Terns, Sabine's Gulls, and Red Phalaropes. Feeding flocks of these and other species numbering several thousand individuals aggregate when and where plankton patches appear inshore.

Conditions promoting concentrations of zooplankton during the migratory period seem extremely important for these birds. One key plankton species, Apherusa glacialis, is consistently more abundant when the multi-year drifting pack ice it adheres to is pushed inshore by predominant NE winds. As ice deteriorates in shallow water Apherusa is robbed of its refuge, enters the water column, and becomes accessible to surface feeding birds. Year to year variation in the amount of multi-year ice obviously affects Apherusa abundance. Folowing the heavy ice year of 1975, multi-year ice was present over an extended period during the drifting iced period in 1976. Surface feeding birds fed abundantly at Cooper Island shores and at entrances between barrier islands at that time. The multi-year ice period was short-lived and relatively unspectacular in 1977, resulting in infrequent, yet at times intense, feeding on this prey.

Other patchy zooplankton species not associated with particular ice types showed greater affinities to open water. These species (Thysanoessa spp., Sagitta elegans, Copepods, Pteropods, Ctenophores, and Hydromedusae) appeared passively concentrated and transported in inshore waters by various small-scale oceanographic conditions, such as convergences of water types between barrier islands and Langmuir spirals. Their initial appearance nearshore may be regulated by large-scale water mass movements offshore.

Ctenophores and Hydromedusae make up the bulk of many patches, sometimes so abundant as to create a thick soup of protoplasmic jelly. Human skin sometimes feels prickly and irritated when dipped in water containing large numbers of these organisms, perhaps due to released nematocysts in the water. The sluggish and lifeless activity of organisms in these patches may also be due to high nematocyst concentrations, or, as previously suggested, to abrupt temperature and salinity differences at convergences of water types.

At this time it appears two primary factors have greatest impact on concentrations of zooplankton near the Plover Islands:

1) The effects of shorelines and shallow water concentrating prey species near the surface, hence accessible to surface feeding birds.

2) Local oceanographic factors creating boundary conditions which passively concentrate zooplankton in the water column.

Additional possibilities are biotic factors inherent in the populations themselves, although the lack of basic natural history facts of these populations precludes any speculation in this regard. Much more information is needed to accurately predict the spatial and temporal occurrence of zooplankton patches, and thus feeding aggregations of marine birds.

E. Human use

Human activities from 1975 to 1977 did not play a major role in the breeding success of Cooper Island birds. Increased human disturbance, however, may increase egg and chick mortality even though no overt predation, such as egging, takes place (Gillett et al., 1975; Robert and Ralph, 1975). Most eskimos used the island as a temporary stopover while traveling to and from Barrow, but few intentionally camped on the island during the breeding season. These family groups seemed curious but generally indifferent about the breeding bird populations. Ice conditions seem to limit access to the island when birds are most prone to predation by humans through egging.

Increased activities associated with oil development pose a much greater threat to breeding birds. Helicopters are a preferred mode of transportation to barrier islands because they require little runway, yet helicopters are noisy and cause intense disturbance of breeding birds when flying at low altitudes. Aircraft disturbance could easily be minimized by avoiding low over-flights of areas with high densities of breeding birds. Pilot education is perhaps the best method to decrease unnecessarily low over-flights, as many pilots seem unaware of the havoc caused by their aircraft to colonial bird populations. Permanent structures and intentional or unintentional disturbances associated with them may also substantially reduce breeding productivity, but careful monitering of human activities near breeding colonies can do much to limit overt disturbances.

Catastrophic events associated with oil developments are possibly the greatest threat to breeding and migrant populations. Oil spills near Cooper Island could result in high immediate mortality of bird species spending large amounts of time afloat on the water's surface, such as Oldsquaw and Black Guillemot. Small-scale oceanographic conditions which concentrate drifting zooplankton at shorelines and in entrances between barrier islands may also concentrate floating oil at sites used by feeding birds, killing prey organisms and preventing access to prey. Marine invertebrates in the arctic are slow growing (Dunbar, 1968), thus impacts of oil spills may be long lived if prey species are affected. Additionally, cleanup operations in ice affected areas are extremely difficult, as oil trapped below ice eludes cleanup operations (Glaeser and Vance, 1971). Also, biological degradation of oil in cold arctic regions requires long periods, upwards of 10 years (Hoult et al., 1975). It appears, therefore, that effects of oil spills near the Plover Islands can be immediately devastating yet seriously prolonged by the nature of the arctic environment.

As suggested by Vermeer and Anweiler (1975), lagoon systems inside of barrier islands are possible protected sites for ducks and other surface resting seabirds if offshore spills are prevented from entering between islands. They suggest the use of oil-blocking booms across lagoon entrances to isolate lagoons in case of spills. Such arrangements are possible in the Plover Islands area and other lagoon systems on the arctic coast. These measures could protect the sizable Oldsquaw population in the event of offshore spills during its most vulnerable wing molt period in July and August. Oil spills within lagoons, however, could cause devastating mortality to these ducks.

An additional problem deals with unnatural driftwood and metal used by cavity nesting birds for nest sites. As stated, these breeding populations, particularly Black Guillemots, can be enlarged by the placement of suitable structures in breeding colonies. Conversely, excess human materials strewn about barrier islands are potentially unsightly. Perhaps a trade-off must be made between increased populations of breeding birds and increased debris on the islands. Perhaps populations should increase only as chance events allow, such as large storms depositing much debris on islands suitable for nesting. The conditions are perfect, however, for experimentation in a field situation of populations limited in size by available nest sites. Ecological questions such as variable reproductive success of inexperienced versus experienced nesting pairs and social factors affecting populations in a saturated environment can be approached in experimental situations as presented on Cooper Island. So few people visit the barrier islands that the unsightliness of controlled amounts of litter is immaterial compared with the benefit gained by certain bird populations.

VI. Conclusions

Despite the relatively small size of Cooper Island breeding populations compared with colonial seabirds in southern Alaska, these populations are a unique aspect of marine birds in the state. The island's Black Guillemot population is the largest in Alaska. The Arctic Tern population is the largest barrier island tern colony in the Chukchi and Beaufort Seas (G. J. Divoky, 1977 Annual Report). The importance of the island for breeding species is primarily due to its available nesting habitat and the accessibility of prey organisms in nearshore waters during the chick period. The availability of principle prey species, especially Arctic Cod, is closely tied to patterns of pack ice conditions near the island.

The Plover Islands are also an important feeding and roosting habitat for post-breeding migrants. Thousands of migrating birds pass the islands in July, August, and September. The islands and the Elson Lagoon system are especially critical for molting male Oldsquaw and several surface feeding planktivores such as Red Phalaropes, Arctic Terns, and Sabine's Gulls. The geographical arrangement of the islands, their inshore topography, and wind, ice, and current factors affect local oceanographic conditions to concentrate zooplankton and make them accessible to these birds.

Breeding and non-breeding bird use during the summer season will be summarized by ice period:

1) Shorefast ice period - June to mid-July

During this period the island is surrounded by eight oktas of shorefast and grounded first year ice. Narrow inshore moats of open water widen continually during the period, from 0 to 10 m in mid-June to 20 to 200 m mid-July.

Little breeding bird use of inshore waters occurs during this period, other than occasional foraging by Arctic Terns and Sabine's Gulls. The prey of these birds appears to be two gammarid amphipods, *Onissimus* spp. and *Gammarus* spp., and a mysid, *Mysis* spp. Terns and Sabine's Gulls fly south to feed at mainland habitats during this time. Guillemots rarely feed in the moats, as their feeding areas at this time appear to be offshore leads in the Beaufort Sea.

Non-breeding bird use of the island and surrounding waters is low at this time. Oldsquaw and loons regularly use moats for feeding and loafing. Red Phalaropes and Brant occasionally occupy terrestrial habitats, especially the island's tundra patch.

2) Shorefast ice breakup period - mid-July to late July

Early in the period rotten first year ice near the island begins splitting along thaw channels, releasing cakes and floes into moats and leads. General ice coverage is 0 to 2 oktas nearshore and 6 to 8 oktas beyond. Extensive thaw holes and channels exist beside the moats and leads. Deterioration continues until the shorefast ice disappears and drifting pack ice is pushed into inshore waters. The lagoon south of the island becomes free of ice during this period.

Small Arctic Tern feeding flocks, primarily of breeding birds, occur regularly, concentrating in areas of decomposing ice. Tern feeding trips south of the island decrease, and trips north of the island increase as terns begin foraging in thaw channels offshore. Black Guillemots begin feeding closer to the island, especially along ice margins in moats and leads. Guillemots and terns begin feeding on Arctic Cod in inshore waters. The timing of inshore ice breakup appears to be an important transitional period for breeding species beginning chick feeding.

Oldsquaw males occupy the island and lagoon waters in large numbers throughout the period, feeding in moats and leads and roosting on shorelines and ice beside moats. Several species, such as Semipalmated Sandpiper, Dunlin, Red Phalarope, Arctic Tern, and Sabine's Gull begin arriving as post-breeding migrants, utilizing the island's shorelines and adjacent waters for feeding.

3) Drifting pack ice period - late July and early August until the first major storm with winds strong enough to blow ice far offshore.

Persistent NE winds push drifting small to medium cakes and floes onshore and into lagoons during this period. Cakes and brash ice concentrate at shorelines. Ice coverage on the island's north side varies from 1 to 7 oktas depending on wind and current conditions. Multi-year ice and its cryopelagic fauna becomes plentiful near the island within this period.

Breeding birds feed close to the island throughout the period. Black Guillemots feed on the north side within 1 km of shore. Arctic Cod appear easily caught, as birds are often gone from nest short periods during successful fishing trips. Breeding Arctic Terns return both fish and available planktonic crustaceans, particularly a Euphausiid, Thysanoessa spp., and numerous Amphipods to their chicks.

Throughout the period non-breeding species form variable feeding flocks near the island. The most abundant species are Red Phalaropes (nearly all juveniles), Arctic Terns, and Sabine's Gulls. Jaegers, Glaucous Gulls, and Black-legged Kittiwakes are present in lesser numbers. Patchily dispersed zooplankton populations are the major prey items for these feeding flocks. Apherusa glacialis is especially abundant under deteriorating multi-year ice. Feeding flocks associated with Apherusa occur primarily near cakes and brash ice and in entrances between barrier islands where ice deteriorates as it enters Elson Lagoon.

Dunlins, Sanderlings, and Ruddy Turnstones feed intensively on beaches during this period. Oldsquaw, undergoing wing molt at this time, regularly raft and feed in large flocks south of the island.

4) Open water period - continues from ice retreat to freeze-up in early fall.

Ice conditions are less than one okta of drifting small to medium multi-year cakes.

Seabird feeding flocks associated with zooplankton species having less affinity for certain ice types and conditions occur during this period. Most migrants leave the island at this time. By mid-September Oldsquaw and Glaucous Gulls are the only species commonly using the island and surrounding waters, but passing migrations of Loons and Oldsquaw also take place.

OCS petroleum development potentially threatens these breeding and non-breeding bird populations. Initial development will increase human activity, which in turn may have deleterious impact on reproductive success of island breeders. Human activities may concentrate predators, such as Arctic Fox, which in turn may increase predation on breeding birds. Increased air traffic over the islands and increased foot and machinery traffic on the islands may upset breeding and non-breeding birds and force abandonment of habitat. Oil spills and alterations of shorelines may decrease prey availablity. Obviously, the threat to wildlife in the Plover Island area is great if unthinking petroleum development occurs in the area.

Alternatives to disturbances are possible. Human activities can be limited to areas away from breeding colonies. Aircraft overflights can be prevented by pilot knowledge of critical nesting areas and by realization of the potential damage caused by their aircraft. Seabird species are generally long lived, consequently they can possibly recover from short term disturbances or reproductive failures. This was shown by Cooper Island Arctic Terns following a year of high Arctic Fox predation and near total breeding failure. Overt pollution caused by catastrophic oil spills can hopefully be rapidly contained and recovered, and barrier island - lagoon systems may provide some shelter for birds in the event of an oil spill. At best, OCS development in this inshore area should consider special measures to insure, or at least to not limit, conditions promoting use of these habitats by marine birds and related organisms.

REFERENCES

Alverson, D. L., and N. J. Wilimovsky. 1966. Fishery investigations of the southeastern Chukchi Sea. p. 843-860. In N. J. Wilimovsky and J. N. Wolfe (eds.), Environment of the Cape Thompson region, Alaska. U. S. A. E. C. Div. Tech. Inf.

Andriashev, A. P. 1970. Cryopelagic fishes of the arctic and antarctic and their significance in polar ecosystems. p. 297-304. In M. W. Holdgate (ed.), Antarctic Ecology. Scientific Committee for Antarctic Research. Academic Press, London.

Bengtson, S.-A. 1971. Breeding success of the Arctic Tern, Sterna paradisaea (Pontoppidan), in the Kongsfjord area, Spitsbergen in 1967. Norwegian Journal of Zoology 19: 77-82.

Divoky, G. J., G. E. Watson, and J. C. Bartonek. 1974. Breeding of the Black Guillemot in northern Alaska. Condor 76: 339-343.

Dunbar, M. J. 1968. Ecological development in polar regions; a study in evolution. Prentice Hall, Englewood Cliffs, New Jersey.

Emlen, J. T., D. E. Miller, R. M. Evans, and D. H. Thompson. 1966. Predator-induced parental neglect in a Ring-billed Gull colony. Auk 83: 677-679.

Gillett, W. H., J. L. Hayward, Jr., and J. F. Stout. 1975. Effects of human activity on egg and chick mortality in a Glaucous-winged Gull colony. Condor 77: 492-495.

Glaeser, J. L. and G. P. Vance. 1971. A study of the behavior of oil spills in the arctic. Coast Guard, Washington, D. C.

Gollop, M. A., J. E. Black, B. E. Felske, and R. A. Davis. 1974. Disturbance studies of breeding Black Brant, Common Eider, Glaucous Gulls, and Arctic Terns at Nunaluk Spit and Phillips Bay, Yukon Territory, July, 1972. In W. W. H. Gunn and J. A. Livingston (eds.), Disturbance to birds by gas compressor noise simulators, aircraft, and human activity in the Mackenzie Valley and on the North Slope, 1972. Arctic Gas Biol. Rep. Ser. 14: 153-201.

Hawksley, O. 1957. Ecology of a breeding population of Arctic Terns. Bird-Banding 28: 57-92.

Hoult, D. P., S. Wolfe, S. O'Dea, and J. P. Patureau. 1975. Oil in the arctic. Report No. CG-D-96-75, U. S. Coast Guard, Washington, D. C.

Larson, S. 1960. On the influence of the Arctic Fox Alopex lagopus on the distribution of arctic birds. Oikos 11: 276-305.

Norderhaug, M. 1964. Studies of the Arctic Tern in west Spitsbergen. Fauna 17: 137-154.

Pettingill, O. S. 1939. History of one hundred nests of Arctic Tern. Auk 56: 420-428.

Quast, J. C. 1974. Density distribution of juvenile arctic cod, Boreogadus saida (Lepechin), in the eastern Chukchi Sea in the fall of 1970. Fish. Bull. 72: 1094-1105.

Robert, H. C. and C. J. Ralph. 1975. Effects of human disturbance on the breeding success of gulls. Condor 77: 495-499.

Sater, J. E., A. G. Ronhovde, and L. C. Van Allen 1971. Arctic Environment andResources. Arctic Institute of North America, Washington D. C.

Vermeer, K., and G. G. Anweiler. 1975. Oil threat to aquatic birds along the Yukon coast. Wilson Bull. 87: 467-480.

ANNUAL REPORT

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ECOLOGICAL STUDIES IN THE NORTHERN BERING SEA: BIRDS OF COASTAL HABITATS ON THE SOUTH SHORE OF SEWARD PENINSULA, ALASKA

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April, 1978

CONTENTS

II. INTRODUCTION

VI. RESULTS AND SPECIES DISCUSSION

c. Other Species

3. Other Locations in Norton Sound

LIST OF TABLES

LIST OF FIGURES

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

The purpose of our work is to identify those aspects of the biology of wildfowl which deserve careful consideration in order to avoid unnecessary damage in the course of development associated with the extraction of oil. Our objectives are to locate major concentrations of seabirds, waterfowl and shorebirds in space and time; to establish the numbers involved and the circumstances under which the gathering areas are important; to learn the relation of selected species of seabirds to the oceanic ecosystems by measuring the birds' reproductive rates and food dependencies; and to investigate the relation of biologically important areas to the geography and ecology of the Northern Bering Sea, such as location of nesting cliffs, feeding grounds at sea, and tundra nesting habitats, as well as those wetlands and mudflats which are used for feeding and escape from hunting pressure.

These studies to date have consisted of, first, a general inventory and, second, analysis of the breeding biology of selected species. The analytical studies are intended to prepare generalizations about the relations of seabirds to their habitats, because there is not enough time or money to make studies of all the species which may be affected or to prepare models which include the necessary environmental parameters to allow prediction of ecosystem effects ahead of time.

In our work at the cliffs at Bluff, Square Rock and Sledge Island, we have concentrated on studies of Pelagic Cormorants, Glaucous Gulls, Ravens, and especially on Black-legged Kittiwakes and Common Murres. The results of these studies, when added to the knowledge of the same species obtained in other parts of Alaska's Outer Continental Shelf and in the North Atlantic, form a basis for interpreting the results of short term observations made where seabird cliffs are inhospitable or remote. They have also provided a set of techniques for making measurements of population size and breeding success of seabirds when only a short time is available.

Our work indicates that both Black-legged Kittiwakes and Common Murres are sensitive to changes in the food supply available in Norton Sound. Thus they offer the possibility of acting as indicator species for negative changes in the trophic structure of the sea. Our work also suggests that Ravens and Glaucous Gulls may act as indicator species, but of a different sort. These two species seem to benefit from organic wastes supplied by humans and thus to benefit from development. The contrast in the effects of development offered by these two pairs of species indicates that it may be dangerous to assign *a priori*, definite boundaries to the relation between a given species and what we consider to be its habitat or ecosystem. Unfortunately, the way species are 'coupled' to their 'systems' remains one of the major unanswered questions of ecology. For example there is now a good amount of information on the food of murres and kittiwakes in North Atlantic and North Pacific, Bering and Chukchi Seas which indicates that the food used varies considerably between geographic regions and between years. Yet the form and habitat of the prey remains consistent to a large extent. At this point detailed studies of food can be expected to document this variation in food resources and opportunism in the choice of prey. Hence we conclude that until detailed studies can be run by specialists in fish and crustaceans, closely coordinated with the studies of oceanic structures, sea bird research should concentrate on feeding actions of the birds and the details of their spatial distribution at sea, rather than spending more than passing time on studies of prey items in the sea. We point out below that birds at sea are distributed in patterns that suggest important oceanographic features (see also the Annual Report for R.U. 447). The reported distribution should be confirmed, because it is directly applicable to defining the area of sea which must be included as part of the habitat of the major seabird nesting islands in the Northern Bering Sea.

Work in Alaska and in the North Atlantic indicates that unwanted effects can be anticipated during the process of development. We list three and suggest how knowledge already gained in northwest Alaska can be used to clarify the processes involved and hence to prevent or mitigate the damage. In other parts of the world, economic development has been characteristically accompanied by (a) direct reduction of populations of some native species, by (b) increasing activities of people at breeding sites and the introduction of carnivores that are escaped pets, and by (c) rapid growth of aggressive species (e.g. Glaucous Gulls and Ravens) which benefit by shoddy disposal of wastes and which compete for nest sites or exert increasing predation pressure on vulnerable species.

a) The work of Springer and Roseneau (NOAA, 1978) indicate that the populations of Common and Thick-billed Murres have decreased by half at the cliffs at Cape Lisburne and Cape Thompson since Schwartz (1966) made counts in 1959 - 1961. Our counts at Little Diomede Island (see report for R.U. 447) suggest that there may have been a decrease in the numbers of murres since counts were made by Kenyon in 1958 (Kenyon and Brooks, 1960). This situation offers an opportunity to observe the short term effects of the lowered population and to follow the rate of population recovery. However, our counts of the populations of murres on the cliffs at Bluff suggest that the situation may be complex. In a good year, 1975, we counted almost an order of magnitude more murres than we did at a low count in a poor year, 1976. During other years our counts have varied between 30,000 and 60,000. Some of these differences are due to variations in numbers during the course of the day or the season, but it is clear that many more birds are on the cliffs in a 'good' year than are present when reproduction is poor. Springer and Roseneau have appreciated this and applied corrections for diurnal variation, but reproductive success observed by Schwartz was very much higher in the late 1950s than in the mid 1970s and it may not be possible to make reliable judgements of the changes in population until another 'good year' occurs.

b) King Island offers an opportunity to observe the effects of the presence of people and their pets on a seabird colony, because the natives of Ukivok have not occupied the village except temporarily since the mid-1960s. Furthermore, Arctic Foxes come to the island each spring on the sea ice and breed. Experience in eastern U.S. and elsewhere has shown that foxes and domestic dogs have virtually the same effects on the behavior of breeding seabirds at their colonies.

King Islanders Ed Muktoyuk, John Pullock and Mike Saclamana report that murres and kittiwakes now nest on many ledges which were barren of breeding birds when they were children collecting eggs on the island. The changes should be documented and further changes followed as an experimental case (although in reverse) of the impact of heavy human usage and the rates of recovery.

We have observed that Arctic Foxes have an observable impact on breeding Parakeet Auklets and the Eskimos believe that they affect Tufted Puffins even more. The people of Little Diomede believe that the reason there are many times more Tufted Puffins on Fairway Rock than on Little Diomede is the absence of foxes from the Rock which is too small to support a fox over the summer. Arctic Foxes should be removed annually from King Island and the changes in the seabird population monitored.

c) There are good reasons to expect that an increase in human population or further development will be accompanied by an increase in gulls and ravens, both of which benefit from food supplied by wastes and garbage. Studies of the effects of Glaucous Gulls and Common Ravens begun in 1977 at Bluff Cliffs should be expanded to a general study of this problem in several parts of Alaska, because the problem of gulls displacing other seabirds has proven to be serious in Europe, Eastern U.S., Australia and New Zealand.

d) Finally our studies tend to confirm the hypothesis which was offered at the start of Research Unit 237, namely that there are important oceanographic differences between Norton Sound and the Chirikov Basin which are reflected in the action of water masses, primary productivity, the detritus/benthic fauna, the crustacea and fish, nekton/plankton fauna, the marine mammals and the marine birds. The area of the Norton Basin which is approximately the size of the Gulf of Maine supports a population of sea birds in the order of 4,000,000 individuals. This number is at least twice the population of seabirds in the western Atlantic seaboard including Labrador, Newfoundland, the Gulf of Saint Lawrence, Nova Scotia and the Gulf of Maine. Because this area is clearly on the line of transportation of heavy equipment to the oil fields on the north slope and increasing secondary development in the Nome area, we should know more about the basic structure, and the similarities and dissimilarities of the natural geographical and ecological units of Norton Sound and the Chirikov Basin. This requires that attention be given to the previously little-studied oceanographic zone between 6 meters and 60 meters depth, and that studies be coordinated among experts on organisms at the several "places" to the food chains as well as chemical and physical oceanography. But to understand the biological oceanography, coordinated studies of physical and chemical oceanography should be directed towards answering the questions posed by the distribution of organisms. Although considerable progress has been made in the coordination of oceanographic studies during the Outer Continental Shelf Environmental Assessment Projects, there is still little use made by physical and chemical oceanographers of what is known about the distribution of organisms in order to identify and circumscribe physical problems that need answers.

If, as we understand it, a primary goal of OCSEAP is to develop insight into what factors may be important in order to make ecosystem models that will predict the impacts of development, it would make sense to address some obvious differences already provided by natural conditions or previous human activities.

II. INTRODUCTION

A. General Nature and Scope of the Research. We have discussed the nature and scope of this work in some detail in other reports. We are gathering data to document the distribution in space and time of the seabirds, shorebirds and waterfowl on the south shore of the Seward Peninsula. We are collecting evidence on why the areas where these birds gather are important and how they may be vulnerable to direct and indirect effects of development. We are also working to gain insight on what factors may be important in predicting the impact of development ahead of time. But neither time nor money is available to develop the knowledge of all the ecosystem factors that control bird populations. Also we do not believe that the models of population behavior prepared for terrestrial game species, song birds and insects will necessarily prove instructive in interpreting the ecology of wildfowl. Thus as we pointed out at the symposium on the Conservation of Marine Birds in Seattle in 1975, it is most efficient to pick a few critical aspects of the biology of a few key species and study them in detail in order to make generalizations applicable to other seabirds and waterfowl. In that paper we also sketched out some of the characteristics of seabirds which distinguish them from other birds.

Experience gained in studying the impact of hunting and of chemical pesticides indicates that environmental influences on reproductive rate are more important in the survival of a population than direct massive mortality. Hence it is generally agreed that studies of reproductive biology and breeding success are promising ways to identify the place of individual species in ecosystem models. We have therefore been making detailed studies of promising species of seabirds at a few breeding cliffs, gathering data and formulating our interpretations which should apply to other places. We have concentrated on Common Murres and Black-legged Kittiwakes studying activities at mapped nests, the foods brought in and the effects of the predators, Arctic Foxes, Ravens and Glaucous Gulls which live at the seabird cliffs.

B. Specific Objectives.

Marine Birds

1. To determine the number and distribution of seabirds relative to periods of the breeding season and to characteristics of available habitat within a colony or study area.

2. To provide estimates of nesting success of principal species.

3. To establish and describe sampling areas which may be used in subsequent years or by other persons for monitoring the status of populations.

4. To determine the amount and kinds of foods used by the principal species, and to determine the foraging patterns, when possible, to determine the relationship of food selected to that available.

5. To describe the chronology and phenology of events in the biology of breeding birds, including changes in population from the beginning of occupation of sites in the spring through departure in the fall.

6. To provide comparisons of current data with recent historical data.

Waterfowl and Shorebirds

1. To determine the number and distribution of principal species at spring arrival, during the breeding season and in fall gatherings, as these are related to characteristics of available habitat within the area.

2. To establish and describe sampling areas which may be used in later years or by others for monitoring the status of populations.

3. To provide a comparison of current data with recent historical data.

C. Relevance to Problems of Petroleum Development.

The primary purpose of this work is to identify those aspects of the biology of wildfowl which deserve careful consideration in order to avoid unnecessary damage in the course of development associated with oil extraction. Furthermore we feel that we should suggest management techniques and political institutions which may function to prevent or to mitigate unwanted effects.

The wildfowl resource has a direct political value which can be measured in terms of the number of people who complain and the intensity of their response if birds are harmed. The birds also have a value, being at the tops of marine food chains, as indicators of changes in the effectiveness of energy transfer from one trophic level to another. An illustration of this sort of phenomenon is supplied by the differences in the seabird fauna between Norton Sound and the adjacent region from Saint Lawrence Island to the Bering Strait. We have discussed these differences in detail in other reports. We review certain aspects of those differences in the next section.

III. CURRENT STATE OF KNOWLEDGE

We reported on the general state of knowledge of seabirds in our report for 1976 (Steele and Drury, NOAA 1978). In this section we will include summaries of: A) what we have observed as to the geographical and faunal differences between Norton Sound and the waters between Saint Lawrence Island and the Bering Strait; and of B) what is known of the breeding biology of Black-legged Kittiwakes in the waters of the Alaskan Continental Shelf.

A. Contrast Between Two Geographic Regions in the Northern Bering Sea.

As one goes west from Cape Nome along the southern shore of the Seward Peninsula, a number of biological changes can be observed. The natives of the region, speakers of Inupiat, traditionally depended primarily on the hunting of marine mammals and seabirds for their food and clothes. At sea, the great whales (Bowhead, Finback, Minke and Grey Whales), smaller whales (Belukhas and porpoises), walrus and Bearded Seals become numerous and are important food items as are the smaller seals (Ringed and Spotted). Migratory seafowl (King Eiders, Oldsquaws and Black Scoters) are numerous in spring. Auklets are a conspicuous element of the seabird fauna and Thick-billed Murres are a major percentage of the murre population. On land, tundra vegetation becomes progressively lower and more scattered and the waterfowl of fresh water and lowland tundra become progressively sparser.

As one goes east from Cape Nome and Safety Lagoon, one finds that the native people are speakers of Yupik who have traditionally depended on fishing and on caribou hunting. Other than small seals, occasional walrus and Belukhas, marine mammals are inconspicuous and most waterfowl migration consists of geese and fresh water ducks. Virtually all murres are Common Murres. They, Black-legged Kittiwakes, Pelagic Cormorants and Horned Puffins make up the seabirds, as auklets are absent. Seabird nesting colonies are smaller and scattered along the coast on small headlands. Instead of nesting in isolated pairs, Arctic Terns gather into a large colony. Aleutian Terns are present as well. Chum and Pink Salmon run the rivers in early summer, and as a consequence Glaucous Gulls gather conspicuously along the rivers and shoreline in mid and late summer. Whistling Swans, Canada Geese, Pintail, Baldpate and Greater Scaup are numerous in the lower reaches of rivers that flow into salt marshes or send out distributaries onto broad mudflats. These waterfowl congregate in late July and large numbers can be found into late September. On the uplands, the tundra vegetation is wetter and taller as more shrubs, including blueberries, grow, and East of Golovin, White Spruce is found.

The predominance of fish-eating seabirds and virtual absence of crustacean eaters (with the exception of small numbers of Parakeet Auklets, a species of catholic tastes) would appear to be related to the different system of current flow in Norton Sound as compared to the Chirikov Basin. Coastal water, largely maintained by outflow of major Alaskan rivers , enters Norton Sound and forms a counter-clockwise gyre moving out northwest past Nome and Sledge Island. The eastern third of the sound appears to be removed from this flow and it appears to be dominated by flow from local rivers. The lack of zooplankton eaters, suggests a lack of zooplankton, hence a lack of suitable floating green plants for Copepods, Euphausiids and Mysids to feed upon. Some planktonic food must be available to small 'silver fish'. These small fishes, Herring, Rainbow Smelt, Salmon smolt, Saffron Cod and especially Sand Launce provide food for the Common Murres, Horned Puffins and Kittiwakes. This conspicuous difference in seabird species abundance reflecting their differing feeding strategies (which must have extensive ramifications in the biological and physical oceanography of the region) still remains to be studied under the auspices of OCSEAP.

Such conspicuous faunal differences, especially since they are associated with distinct ecological structures, provide a natural basis for categorizing regions of Alaska's Outer Continental Shelf. It would seem efficient to base further development of the environmental assessment program on investigating the similarities and dissimilarities between neighboring systems such as these

B. Knowledge of the Breeding Biology of Black-legged Kittiwakes in the Waters of the Alaskan Continental Shelf.

The following observations result from a workshop on geographical variation in the reproductive success of Black-legged Kittiwakes together with papers on the food, foraging patterns, winter activities and mortality of this species. The reports were part of the Pacific Seabird Group Meetings.

1. Black-legged Kittiwakes have a number of characteristics that make them more easily studied at their breeding sites than other cliff-, burrow-, or rubble-nesting species. They may prove useful as an indicator of indirect effects of oil spills. Because they are relatively insensitive to the direct and catastrophic effects of oil spills, their

numbers remain relatively constant, and they are relatively inexpensive to monitor.

As a result of the studies made in four regions (Cape Lisburne to St. Lawrence Island, the Southern Bering Sea, Southwest Gulf of Alaska and Northeast Gulf of Alaska) over three years, we have identified the following kinds of information, not only as important for understanding the biology of Black-legged Kittiwakes, but also so that kittiwakes can be directly useful for environmental assessment by NOAA and BLM.

a. Reproductive Biology

i. There is a gradient in the date of laying of first egg and the peak of egglaying that varies from the GOA regions to those of the Bering Straits and Norton Sound, with those in the north being laid later. (Table 1a) There is also apparently an historical change in phenology, at least at Cape Thompson, where, in the 1960's, (Schwartz 1966) clutches were initiated earlier than in the present studies (1975-1977). (Springer and Roseneau 1978)

ii. There are important and regular variations in the size of clutches and the percent of nests in which eggs are laid from one region to another, with smaller clutches being laid and fewer nests receiving eggs in the north than in the GOA. Again, historical information suggests that in the 1950's (Pribilofs Hunt,Squib and Peterson 1978) and 1960's (Cape Thompson, Schwartz 1966) clutch size may have been larger than at present.

If one lists average clutch sizes from all available data according to date of laying (Tables 1a and 1b) it emerges that there is a trend in clutch size from largest in the earliest laid (the first week of May) to smallest in the latest (the first week of July). The trend appears to be continuous for all Kittiwakes throughout the season if data from the Barents Sea, the North Sea,the Gulf of Alaska and the Bering Sea are all shown together (Table 1b). More data are needed from early and middle June to show whether this apparent trend is in fact continuous.

iii. Important differences exist in the regularity of reproductive success in different geographic regions as well. These differences have, in the past three years, usually been expressed in the number of eggs hatching per nest, either because fewer eggs were laid or because eggs failed to hatch. In some regions there have been years of failure and years of greater success (high productivity) in which some pairs even raise two chicks per nest. In other regions, reproductive success has been consistently moderate and no parents have been able to raise twins.

iv. The reasons for reproductive failure have differed in different regions. In the north, particularly, absence of food has been suggested to be the primary influence, while in the GOA, bird predators, perhaps taking advantage in changes in kittiwake behavior in response to shortages of food, are the proximate cause of reproductive failure.

Kittiwakes in other parts of their circumpolar range, e.g. the Northeast Atlantic, where this species is reproducing very well and the population is increasing, lay earlier and lay larger clutches than in Alaska (Table 1b). One would presume according to theory that (Lack 1954 et seq.) timing of laying of the clutch, size of the clutch, and the percentage of nests receiving eggs all relate to the availability of food. The above results all suggest that Bering Sea and Bering Strait kittiwake populations are presently subject to stress due to food limitation.

b. The food used by kittiwakes varies in conspicuous ways between regions. In the GOA kittiwakes depend heavily on Capelin, which seems to be consistently available. This resource is augmented by Sand Launce, especially when parents are feeding young.

In the southern Bering Sea kittiwakes use a diverse food supply without heavy dependance on a single species.

In the northern Bering Sea different colonies use different foods, and high levels of success between 1975 and 1977 seem to have depended upon appearance of Sand Launce in the feeding range.

Kittiwakes are evidently opportunists in their feeding. They will become specialists if suitable prey is available. Whether a colony has a consistent or "boom/bust" economy seems to depend upon the kinds and numbers of small fish and crustacea and the phenology of those organisms in the surrounding area, see Discussion.

IV. STUDY AREA

The study areas in Norton Sound (Figure 1) were described and illustrated in our March 1977 report. Our efforts in seabird work this year were concentrated on intensive studies at Bluff, and short-term surveys of the colonies at Sledge Island, Topkok Head, and Rocky Point. Our waterfowl surveys covered from the base of Cape Spencer to the Cape Denbigh and Shaktoolik region.

V. METHODS AND RATIONALE OF DATA COLLECTION

In 1975 and 1976 we developed and tested various field methods for censusing the Bluff colony and sampling reproductive success. This year our emphasis was on applying those methods to intensive studies of the

Table 1A. Comparison of laying dates and clutch sizes of Black-legged Kittiwakes in Alaska.

Place	Approximate date of starting clutch	Peak of laying	Clutch size	
Cape Lisburne	1 July	10-16 July	1.02	Springer & Roseneau (NOAA 1978)
Cape Thompson	2 July	5-13 July	1.1	Springer & Roseneau (NOAA 1978)
Cape Thompson	21-25 June		1.88-1.92	Schwartz (1966)
Sledge Island	20 June		1.53	Drury et. al. (NOAA 1978)
Bluff Cliffs	19-25 June	4-12 July	1.16-1.2	Drury et. al. (NOAA 1978)
Cape Pierce	19 June	20 June		Hunt, Squib & Peterson (1978)
Saint Paul Island	29 June-5 July		1.37-1.46	Hunt, et. al. (NOAA 1978)
Saint George Island	30 June-1 July		1.36-1.46	Hunt, et. al. (NOAA 1978)
Southwest Gulf of Alaska			1.38-1.87	Moe, et. al. (1978)
Kodiak Island Area	5-10 June	12-17 June	1.56-1.96	Nysewander et. al. (1978)
Northeast Gulf of Alaska	1-10 June	19-25 June	1.76	Lehnhausen, et. al. (1978)

Table 1B. Comparison of Kittiwake clutch sizes in England, Russia and Alaska.[*]

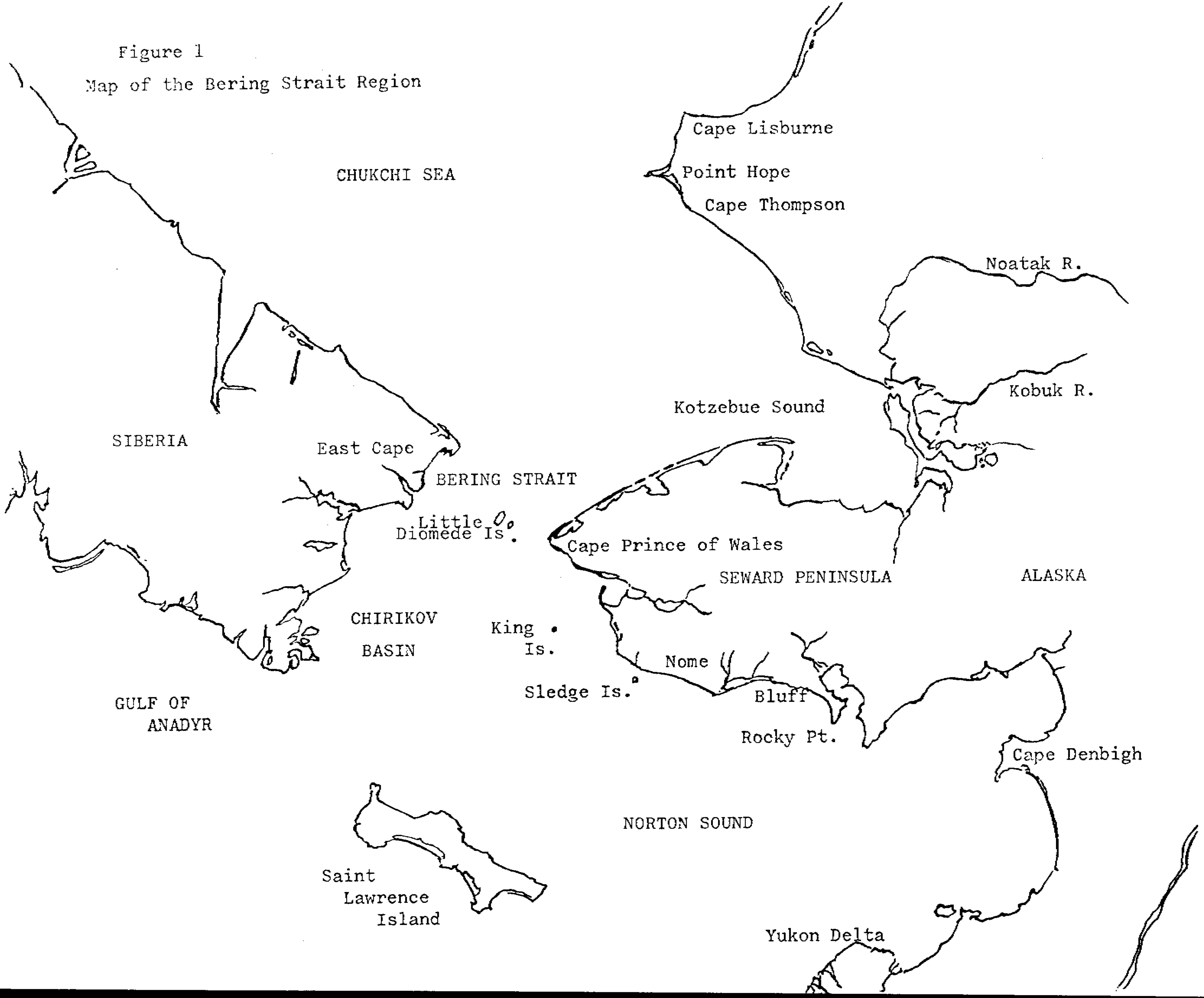
	May				June				July	
	1st wk.	2nd wk.	3rd wk.	4th wk.	1st wk.	2nd wk.	3rd wk.	4th wk.	1st wk.	2nd wk.
England	2.3-2.8 (2.4)[+]	2.0-2.4 (2.3)[+]	1.9-2.3 (2.1)[+]	1.8-2.0 (1.9)[+]	1.8-2.0 (1.8)[+]	(1.5)[+]				
Russia	2.3		2.0	1.5						
Alaska					1.8	1.6-2.0	1.5-1.9	1.4-1.5	1.4-1.5	1.0

[*] Coulson and White (1961), Belopol'skii (1957), and Uspenski (1956).

[+] Average clutch size.

Figure 1

Map of the Bering Strait Region



reproductive biology of the seabird species present, especially murres and kittiwakes. Most of these methods are described and discussed in detail in the March 1977 Annual Report for this research unit. Below, we shall briefly describe the methods used this year, and more thoroughly discuss new or modified procedures.

A. SEABIRDS

1. Bluff Cliffs and Square Rock

A party of two visited Bluff on 21-26 May and 3-11 June. From 12 June until 12 September, a permanent party, usually of four, collected data at Bluff Cliffs and Square Rock. Twenty-one study sites were visited roughly every other day beginning 14 June. The sites were illustrated in last year's annual report; in Table 1c we list the data collected at each of these sites in 1977.

Estimates of Populations

We made censuses from a small boat passing in front of the cliffs in the same way as in 1976. Our counts of the Bluff Cliffs (Figure 2) were on 28 June (murres only), 7 and 29 July, and 19 August; and of Square Rock and adjacent cliffs on 19 August.

Twenty-four Hour Counts (To determine Daily Activity Patterns)

Many investigators have noted that the number of birds occupying the cliffs varies over the course of a day. Thus, a single count may only reflect a percentage of the total birds actually occupying the cliff that day. In 1976 we used counts taken at different times of the day over the entire season to arrive at a curve for daily attendance. However, that method does not allow for possible changes in the attendance pattern over the course of the season. In 1977 we made hourly counts of murres and kittiwakes for 24 or 25 consecutive hours in delineated count areas at Bluff Cliffs (Study area 14-15) and Square Rock simultaneously. These counts were taken on 14 June, 30 June-1 July, 9,19, and 29-30 July, and 8-9 August. Increasing amounts of darkness forced us to interrupt the late July and August counts in the early hours. Also, we felt that the accuracy of the counts declined during dusk hours on the counts of 19 July and after, as the birds became difficult to see.

From these counts we calculated a correction factor relating the number of birds present on the cliff at each hour to the highest count of birds from that 24 hour cycle. This correction factor was then applied to censuses or counts at study sites to correct for differences which result from the daily activity pattern, and thus to determine the actual population totals. Cliff counts were generally made on a day adjacent to a 24-hour count.

Table 1C. List of study areas at Bluff and data collected at each.

Study Site	Kittiwake count	Kittiwake map	Murre count	Murre map	Puffin count
1	x		x		
1B			x	x	x
2				x*	x
3	x				x
4				x	x
4B		x	x	x	
5		x	x		x
6			x		x
7	x		x		x
8		x	x		x
9	x		x		x
10		x		x	x
11	x		x		x
12				x	x
13		x			
14		x			
15	x		x	x*	
16 (not used)					
17		x			
18					x
19		x	x	x	
Square Rock		x	x	x	

*Thick-billed Murre maps (all others are of Common Murres).

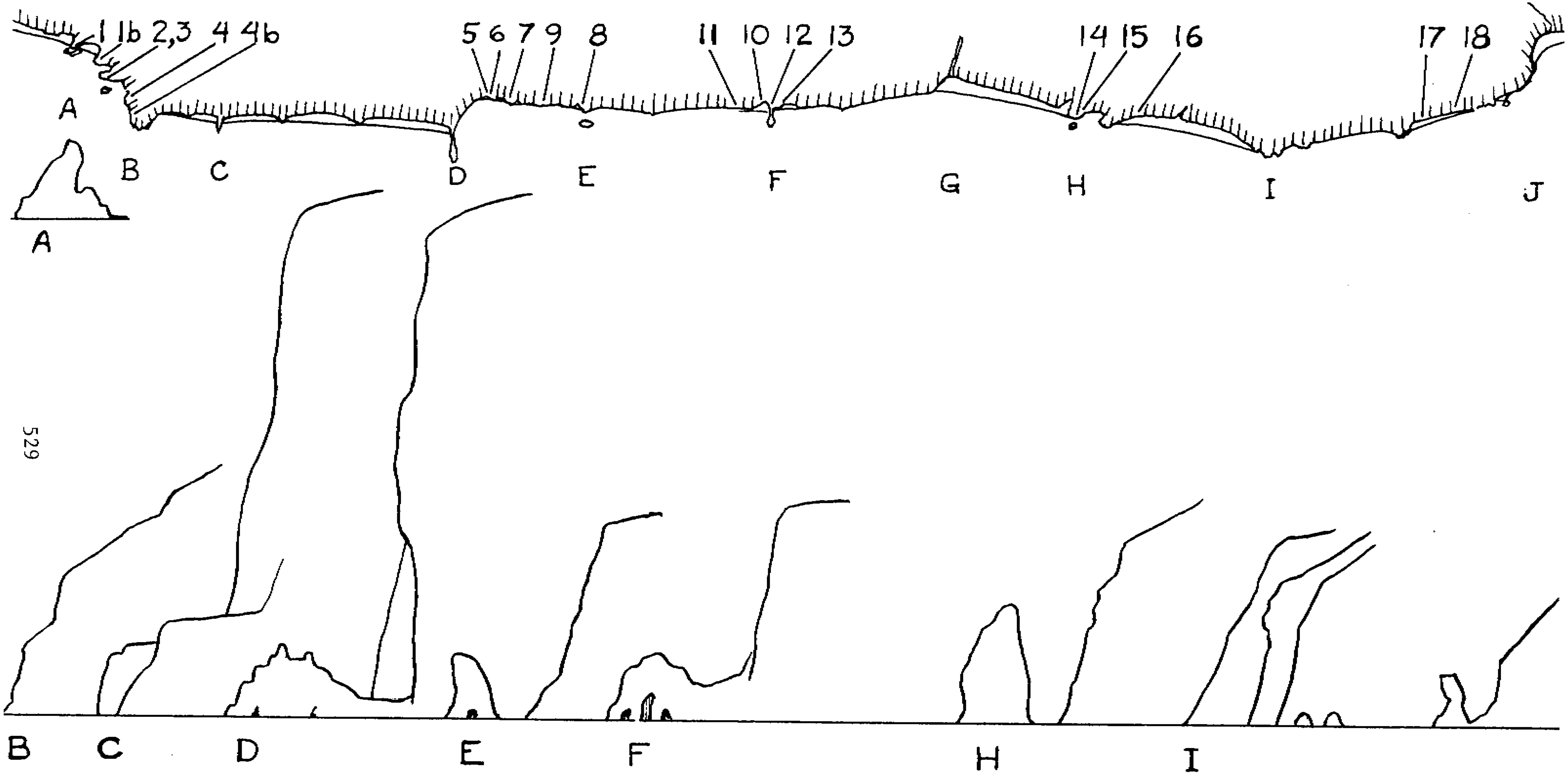


Figure 2. Diagram of the cliffs at Bluff, showing locations of study sites and landmarks used during censuses.

Reproductive Schedule and Success

a. Black-legged Kittiwakes

We established kittiwake map areas in the same way as last year. In addition to noting on each visit the number of adults, eggs and chicks at individual nests, we also recorded the physical status of the nest site and the amount of material added to it. We established three statuses: a "rock roost" or bare rock ledge with no material on it; an "old pad" of material remaining from the previous year; and a "cup" capable of holding an egg.

b. Common and Thick-billed Murres

i. Maps - The data and hence the estimates of breeding schedule and reproductive success are relatively imprecise when compared to the kittiwake data due to the difficulties in seeing which birds have eggs or chicks, and to the varying number of nonbreeding and unsuccessfully breeding birds. We have found that the best method of following the progress of the breeding season and determining reproductive success is by selecting a ledge which is visible from the top of the cliff, and noting on a sketch map or photograph the locations of all eggs and chicks seen. The situation at each of these sites is checked roughly every other day. If an adult murre does not move so that we can see under it, the status noted at the previous visit is presumed to still exist. Chicks are more easily seen than eggs,especially after they have grown larger and begun to move around. Using this method, we were able to determine the laying, hatching and departure periods and the peak of each; and to obtain relatively accurate figures for the number of eggs laid, chicks hatched, and chicks fledged for each mapped ledge.

ii. Estimates of the breeding population - This is a difficult number to determine, due to varying numbers of apparently nonbreeding birds.(See definition and description of "breeding birds" under the section on murre reproductive success.)

1) One way of estimating the breeding population of murres is to use counts of birds which are strongly attached to the cliffs, as these are the birds that are probably trying to lay an egg, or are protecting an egg or chick. The counts of birds remaining on the cliffs during the disturbance caused by the cliff counts ,made at or after the peak of laying, were used to get an estimate of the total number of breeding birds. This was also done in 1976. In 1977, the peak of laying occured from 7-10 July. The cliff census of 7 July yielded 44,736 birds of which 40,000 were "persistent". One estimate of the numbers of breeding pairs therefore is approximately 20,000 (half the number of breeding birds).

2) A second way of estimating the total breeding population, (also used in 1976, see p.30 op.cit.), is to figure a percentage of breeding birds to total birds present at study sites and relate this figure to a cliff count. Table 2 shows the probable number of breeding birds at each of the six map sites. (See also the discussion under Reproductive Success on the determination of breeding birds.) These figures taken as a percent of the season's high counts gives an average figure of 71%. If we apply this percent to the highest cliff count figure of 62,000 we get 44,000 breeding birds, again about 20,000 pairs.

3) Breeding birds, i.e. those with eggs or chicks to protect or strong territorial attachments, are likely, as mentioned before, to remain on the cliffs longer when faced with a disturbance (such as a small boat passing the cliffs), than are non-breeding birds. Note that in 1976, (see Table 3 and Figure 3) the percentage of birds remaining on the cliffs varied from 50-68%; while in 1977 the percent varied from 69-96%. In 1977 the highest percentages of persistent birds occured during the incubation period, which is as expected. In 1976, the highest percentages did not occur until August, and there was a dip around 8-11 July which was when the breeding schedule was apparently interrupted. These findings suggest that the number of birds remaining on the cliffs, i.e. the persistent birds, may correlate with reproductive success. Note that this number was much higher in 1977 than in 1976.

c. Horned Puffins

We made regular counts of puffins to determine their variation in numbers at the cliff. It is relatively dificult to obtain reproductive data on puffins, because they nest in crevices in the cliff face. We obtained limited data about their reproduction from a few nest holes visible from the top of the cliffs.

d. Pelagic Cormorants and Glaucous Gulls

We located and monitored individual nests of these species that were visible from the tops of the cliffs.

Trophic Studies

Throughout the season, we kept notes on feeding aggregations that we could see from land, and on fish that we saw murres and kittiwakes bring to the cliffs. These notes are summarized under the appropriate bird species. We lacked the logistics to collect birds for stomach contents.

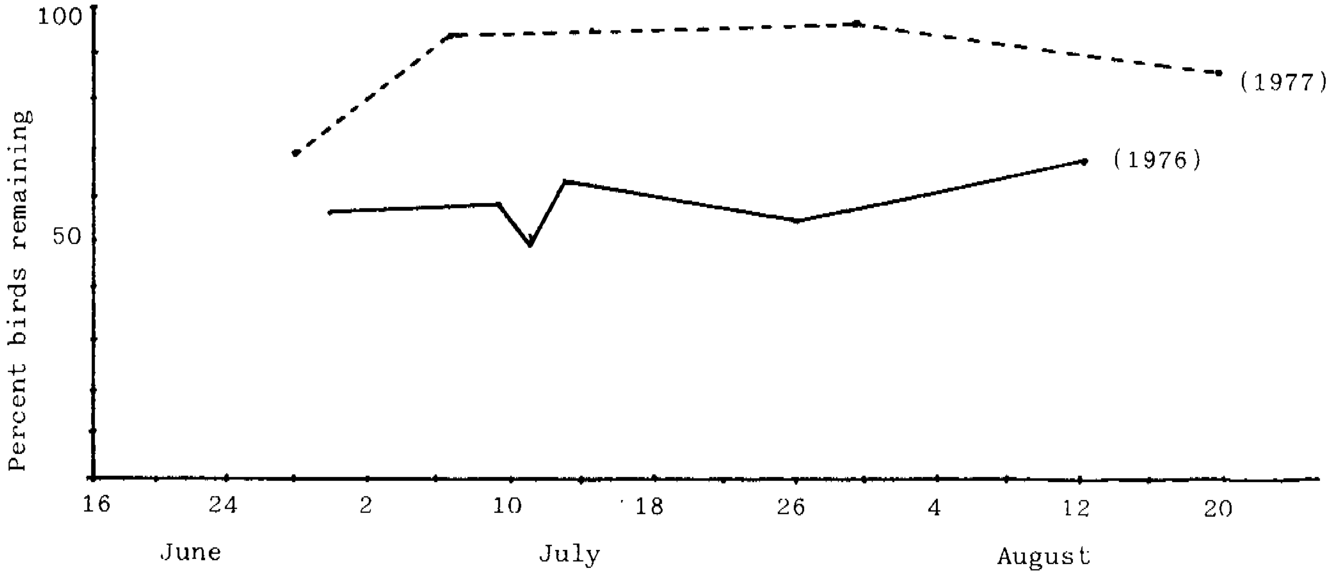
Table 2. Number of "breeding" birds at Murre map areas (as a percent of the season's high counts).

Map Area	Probable Number of "Breeding" Birds	Seasons High Count	Percent "Breeding" Birds
1B	45	63	71%
4	35	58	60%
4B left	47	55	85%
4B inside	53	74	71%
10	139	201	69%
12	51	70	72%

Table 3. Counts of Murres at Bluff - comparison of percentage of birds remaining on the cliff during censuses.

1976		1977	
Date	Percent remaining	Date	Percent remaining
June 16	58%		
		June 28	69%
June 30	57%		
		July 7	93%
July 9	58%		
July 11	50%		
July 13	62%		
July 26	55%		
		July 29	96%
August 12	68%		
		August 19	86%

Figure 3. Murres remaining on the cliff during censuses.



Predators

At the October 1976 meeting of OCSEAP Principal Investigators working on birds, there was general consensus that Ravens played a major role and Glaucous Gulls a significant role in egg and chick mortality of kittiwakes and murres. In order to examine the impact of these predators, we kept detailed notes on the species, especially of Ravens, throughout the 1977 season. We kept notes on the predatory behavior of the species and all instances in which we saw them carrying seabird eggs. We also recorded the "caches" of egg shells that we found on the tundra. In addition, we kept notes on the other raptors of the area: Golden Eagle, Rough-legged Hawk, Marsh Hawk and Gyrfalcon.

2. Sledge Island

We visited Sledge Island by boat on 22-24 June and 23 August. On each visit we circled the island in a boat and counted all species, and also visited the two study sites established in 1975 to sample reproductive success of pelagic cormorants, murres and kittiwakes.

3. Topkok Head was visited by boat on 17 July and 22 August and Rocky Point on 22 July and 20 August. On those trips, we counted all species and sampled reproductive success of Pelagic Cormorants and Glaucous Gulls.

B. WATERFOWL

The method of waterfowl transects in 1977 was the same as in 1976. We made flights in late May and early June over the small sections of open water at the mouths of rivers and in temporary ponds. In late August we flew over the major areas of coastal wetland on the south side of Seward Peninsula.

These flights were not straight-line transects, but were in the form of "reconnaisance" surveys to locate the major concentrations of waterfowl, and their critical gathering areas.

We are confident that we know where the important waterfowl gathering places are in our area in the fall. Using the maps we have prepared it will be possible to establish fixed transects if annual monitoring of the populations in sample is required.

VI. RESULTS AND SPECIES DISCUSSIONS

A. SEABIRDS

1. Censuses

Table 4 presents the rounded maximum and minimum counts of adult birds at the five colonies we monitored in Norton Sound.

Table 4. Bird populations at colonies in Norton Sound, 1977.

Maximum and minumum censuses and estimates shown for five localities.

	Sledge Island	Topkok Head	Bluff Cliffs	Square Rock	Rocky Point
Pelagic Cormorant	310 - 500 70 nests	292 - 331 140 nests	108 - 170 70 nests		650 - 920 250 nests
Glaucous Gull	6 2 nests	130 22 nests	97 - 185 30 nests	18 - 24 9 nests	250
Black-legged Kittiwake	400 - 750		6000 - 8700	1210	
Murres	2750 - 6300		28,400 - 48,900	7600	
% Common	85%		99%	100%(?)	
Pigeon Guillemot	7	13	2		
Horned Puffin	53	115 - 230	813 - 1312	400	130 - 210
Tufted Puffin	3	11 - 31	6		4

Table 5. Comparison of Murre numbers, 1975-1977.

		1975	1976	1977
Bluff	high count	90,000	56,000	62,000
	breeding pairs	25,000	13,000	20,000
Square Rock		6200	4000	7600
Sledge Island		2300	2900	2800 - 6000

Significance of year-to-year variation in murre numbers

Table 5 shows a comparison between estimates of the numbers of murres at Bluff, Square Rock and at Sledge Island for 1975, 1976 and 1977. An increase in numbers is indicated from 1976 to 1977 at all three places, ranging from 10-52% more birds. This change is interesting in that it suggests that total numbers may correlate with reproductive success. The highest numbers and figures of reproductive success occurred in 1975. Both were much lower in 1976, and in 1977 both increased again, although not to the levels seen in 1975.

2. Reproduction and Variation in Numbers

Bluff Cliffs

a. Black-legged Kittiwakes

Estimates of Numbers

Table 6 shows the results of our three boat censuses of kittiwakes at Bluff and the correction for the daily variation in numbers to show the possible maximum number of birds. The number present in 1977 was about the same as 1976. We presume the increase in the August count (which occurred in counts at study sites as well) reflects an influx of younger birds coming to the colony (cf. Coulson & White 1958).

Daily Attendance at the Cliffs

The results of our 24-hour counts are shown in Figure 4. We conclude from these data that the daily schedule of kittiwakes varied over the course of the season, and that the schedule was different between Square Rock and the Bluff Cliffs. We should test in future seasons whether the variation is the same from year-to-year. However, we have indications, discussed below, that some of the changes in the kittiwakes' attendance pattern are correlated with events surrounding the poor reproductive success.

The percent fluctuation in the number of birds present over the course of a day was lower during egg-laying but increased again in mid and late July, to reflect departure of a large percentage of the birds during the night hours. There is some effect of the increasing amount of darkness on the ability of an observer to count all of the birds on the cliff, which might make the number lower, but nevertheless the drop in kittiwake numbers at nighttime was dramatic, especially on 29-30 July. During that count, only 10% of the highest count at study site 15 was present at 01:00. We checked the kittiwake map area at study site 14 at the same time, and found that only three

Table 6. Estimates of total numbers of Black-legged Kittiwakes, Bluff 1977.

(counts made from a boat passing in front of the cliffs)

Section of Cliff	7 July		29 July		19 August	
	max.	min.	max.	min.	max.	min.
A to C	1440	1270	1800	1080	1775	1600
C to D	1370	1300	1700	1500	1670	1575
D to E	550	540	800	790	1310	930
E to F	950	890	980	760	1420	1300
F to G	520	440	650	610	740	690
G to H	300	280	210	160	440	360
H to I	750	571	966	856	950	870
I to J	150	120	280	270	280	260
TOTAL (A to J)	6030	6011	7386	6026	8585	7555
Percent on cliff*	100%		86%		99%	
CORRECTED TOTAL	6030	6011	8588	7007	8672	7631

* at same time during nearest 24-hour count

Figure 4. Twenty-four hour counts - Kittiwakes

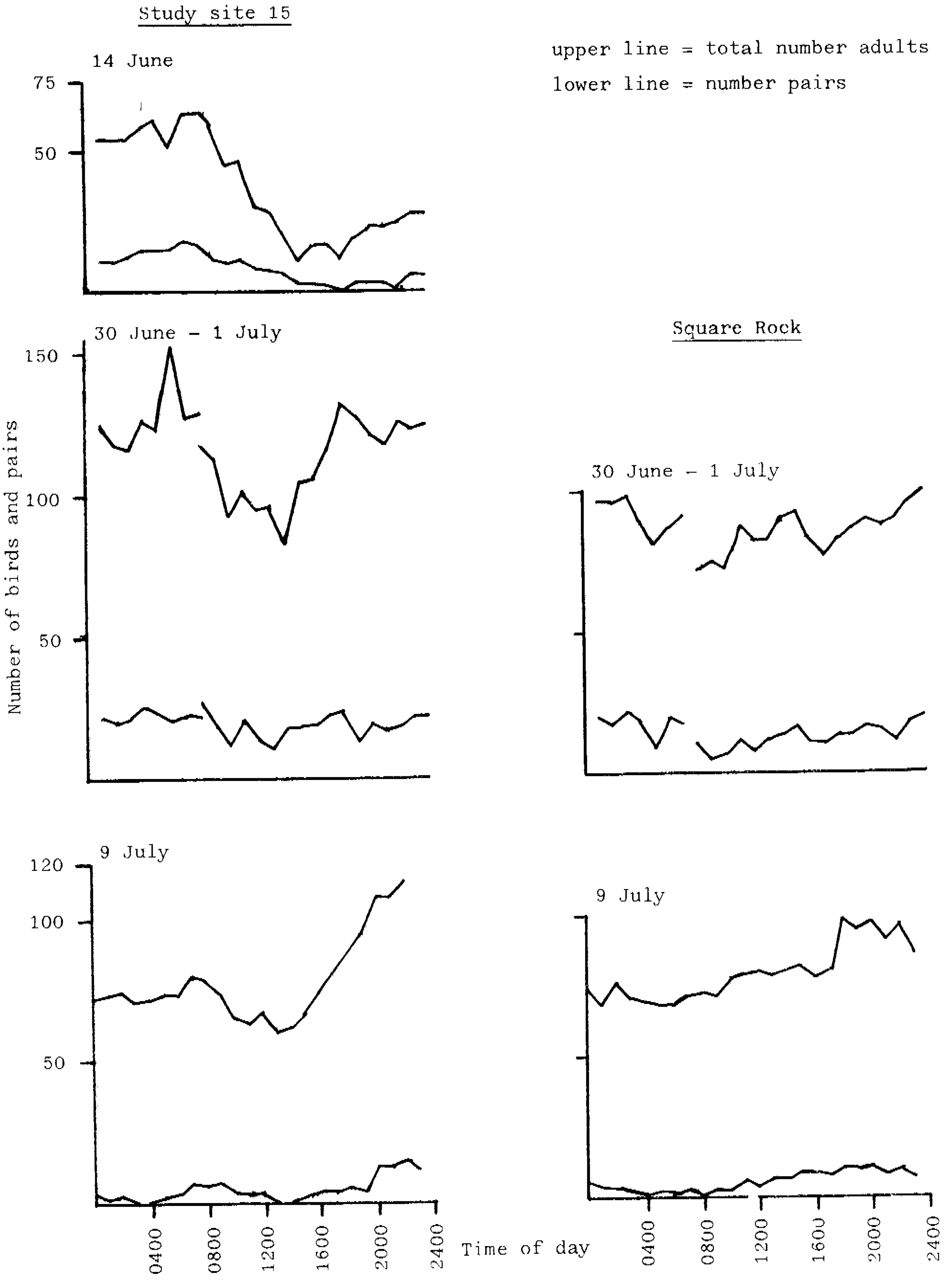
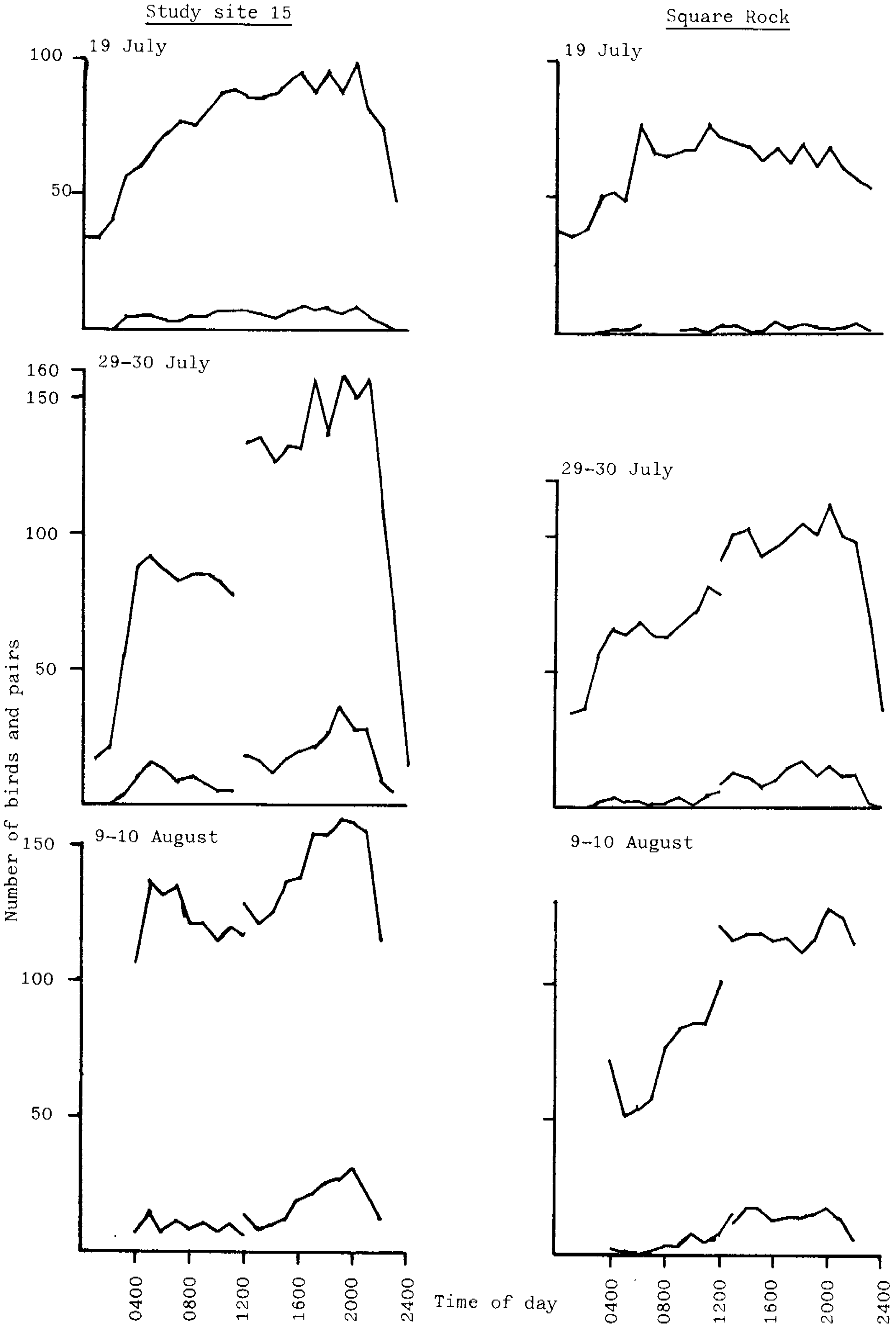


Figure 4 (cont.). Twenty-four hour counts - Kittiwakes



birds were present out of a normal count of 40. By 02:30 there was a visible stream of kittiwakes coming in to the cliffs from all directions. By 05:00 numbers had built to a first peak, yet the maximum number of birds present at the end of the count at 11:00 was only 60% of the number at the beginning of the count.

Reproductive Success

The 1977 season was another poor one for Black-legged Kittiwakes at Bluff, although not as poor as the near total failure in 1976. We have analysed the events surrounding the reproductive season, and believe we have identified a period of stress similar to, but less severe than the one that evidently occurred in 1976.

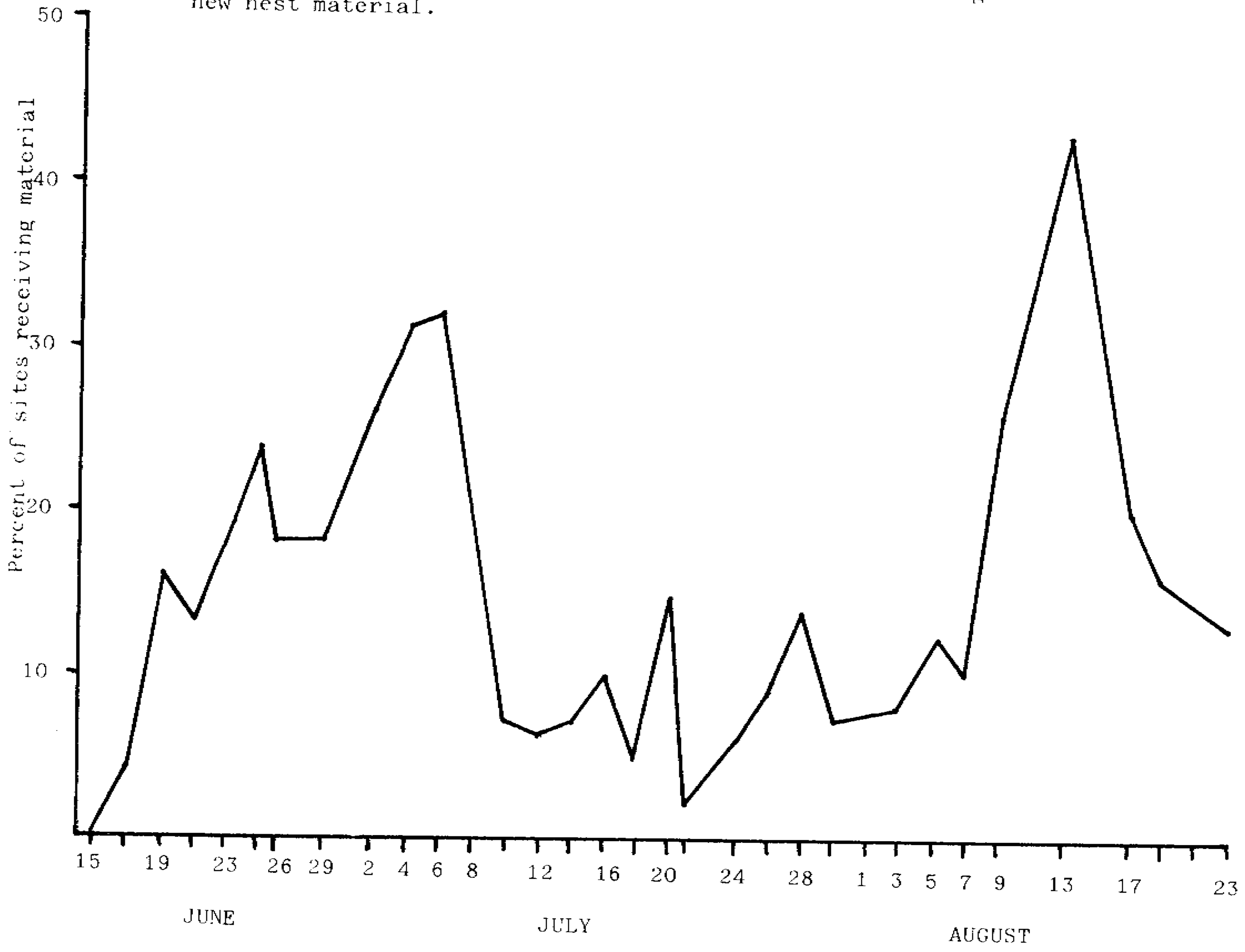
The reproductive season consists of a series of events during any of which a disruption may depress total breeding success. The events that we consider are: how many birds come to the cliffs and how many build nests in time for them to be productive; how many eggs are laid and when, how many hatch, when are eggs lost; and, finally, how many chicks fledge. In our detailed study we are able to show when a disruption occurred and to speculate as to what environmental event at sea might have affected the kittiwakes. These data ultimately are useful in determining what changes in kittiwake population size and reproductive success mean as indicators of events in the marine ecosystem.

(i) Significance of Nest Site Status

This year, part of our data are on nest-building and the physical status of a nest site, which we use as indirect indicators of the level of reproductive effort. We have given special attention to territorial establishment and nest-building because a large percentage of the birds we have studies have not "progressed" beyond that stage of the reproductive cycle. We know from our own observations, from other kittiwake studies (cf. Coulson & White 1956), and from studies of other gulls, that nest-building occurs late in the courtship sequence, primarily after copulation (we have seen pairs copulating on bare rock ledges before any nest material was placed on the site). Building activity then indicates at least that the site has a pair on it. The largest burst of building on a site generally occurs just before an egg is laid: therefore, building activity is an indication of a high level of motivation on the part of the occupants to reproduce. Figure 5 shows the percent of all sites that were improved during the season. The first peak in building occurred just before the peak of laying. The second peak, in August, occurred following the occupation of new sites and reoccupation of sites that had been attended earlier in the season and then abandoned.

Figure 5. Nest-building activity in Black-legged Kittiwakes.

Percent of Type 2 nest sites at five study areas receiving new nest material.



At the beginning of the season, some kittiwake sites are bare rock roosts, while others have old pads of nest material from a previous season. We found that only nine of the 55 sites that received eggs (17%) originated as rock roosts. There are two possible reasons: an old pad may indicate that the site is physically stable, by virtue of the persistence of material on it; and/or, old pads may be occupied by older, more experienced birds. Some rock roosts are obviously inferior sites (e.g., on seaward-sloping ledges, or loose dirt or unstable boulders) and many are not built on until late in the season.

For the purpose of a detailed estimate of degrees of reproductive success, we have defined three types of sites we think indicate three parts of the breeding population. This analysis can be used only when observations are made throughout the season. Future investigators may want to see if the percentage of each type of site is different in years when kittiwakes are more or less productive. We have excluded from this analysis sites that we saw occupied infrequently. These sites may have been used by loafing birds or birds prospecting for a site.

Type 1. Sites improved on or before the peak of laying should indicate all those pairs that were both highly motivated and on schedule so as to have a chance at being productive.

Type 2. All improved sites includes those developed late in the season. This number is biologically significant, in that it includes all those sites occupied by birds that were definitely paired, and where the pair was highly enough motivated as to build or begin building a nest even though they may not succeed in reproducing. Additionally, this number should be close to the number of "nests" that one would count when sampling reproductive success from the top of the cliff or from a boat in late August or early September.

Type 3. All regularly attended sites includes the sites that were attended on at least half of our visits, but not improved, including those seen occupied only by single birds. Few other studies of seabird reproduction try to include these birds, but we feel the persistent attenders at the cliff should be noted.

Our main argument for this analysis is that there is no single figure for reproductive success; and that the figure arrived at is affected by how we define what we are measuring and with what part of the population we are concerned.

(ii) Reproductive Data

Table 7 shows data for reproductive success as obtained at seven study sites along the Bluff Cliffs, study site 19 on the cliffs opposite Square Rock, and a section of the north side of Square Rock.

Table 7. Reproduction of Black-legged Kittiwakes at Bluff and Square Rock, 1977.

	Bluff Cliffs	Study Area 19	Square Rock	All Sites
Type 1. Sites improved on or before peak of laying	152	20	27	199
Type 2. All improved sites.	215	32	32	279
Type 3. All regularly attended sites.	234	34	32	300
eggs	64	13	26	103
clutches	55	10	21	86
chicks	18	1	15	34
broods	17	1	14	32
fledglings*	12	0	15	27
broods	11	0	14	25
eggs/clutches per 1.	.42/.36	.65/.50	.96/.78	.52/.53
2.	.30/.26	.41/.31	.81/.66	.37/.31
3.	.27/.24	.38/.29	.81/.66	.34/.29
chicks/broods per 1.	.12/.11	.05	.56/.52	.17/.16
2.	.08/.08	.03	.47/.44	.12/.11
3.	.05/.05	.03	.47/.44	.11/.11
fledglings/broods per 1.	.08/.07	0	.56/.52	.14/.13
2†	.06/.05	0	.47/.44	.10/.09
3.	.05/.05	0	.47/.44	.09/.08
chicks per egg	.28	.08	.58	.33
fledglings per egg	.18	0	.58	.26
fledglings per chick	.67	0	1.0	.79
avg. clutch size	1.16	1.30	1.24	1.20
avg. brood size (at hatching)	1.06	1.00	1.07	1.06

+ fledglings per Type 2 site is figure comparable with usual "chicks per nest"

* number of fledglings is the number of chicks known to have fledged or still in their nests as of 11 September.

Table 8. Reproductive success of Black-legged Kittiwakes as measured in large sample counts of nests and chicks, 3 September 1977.

	Bluff Cliffs			
	between D and G	between H and J	Square Rock and study area 19	All areas
no. nests* sampled	705	514	138	1357
no. chicks	72	61	32	165
broods	72	60	31	163
chicks/broods per nest	.10	.12	.23/.22	.12

On 3 September we walked most of the length of the cliff at the crest. At each place where we could see a sample of 25 or more nests we stopped and counted the "nests" and nestlings visible. Table 8 shows the results of this sample.

In 1975, we estimated .48 chicks produced per nest at Bluff, and in 1976, .02 chicks per nest. In 1977, .08 chicks were produced per improved kittiwake site at Bluff Cliffs, and .12 at Bluff and Square Rock combined. Thus the 1977 season was about four or five times more productive than 1976, but still only one fourth or one fifth as productive as 1975.

The difference in success between Square Rock and Bluff Cliffs is conspicuous and apparently inexplicable. Egg laying and hatching success per nest at Square Rock were about twice that at Bluff, and fledging success three to four times higher. Study site 19, on the cliffs next to Square Rock, had egg production higher than did Bluff Cliffs. However, high egg mortality caused total reproductive failure.

In Table 8, the fledging figure is lower than in Table 7 because the sample includes sites outside of those that were followed during the season, but the total figure for Square Rock and site 19 combined is the same as that obtained over the season for Type 2 sites. The north-facing side of Square Rock that we studied is presumably sheltered from the effects of bad weather, which comes primarily from the southeast. However, two sheltered north-facing areas at Bluff, the "Rope Stack" and "Thumb Stack", produced .07 and .10 chicks per nest respectively, so it does not seem that shelter was the main factor that increased success at Square Rock.

The productivity figure for Bluff Cliffs from our larger sample in Table 8 is higher than the one obtained at study sites over the season, and the difference is not ascribable to chick mortality (recorded at study sites) after the sweep sample of the entire cliff was taken. However, the figure for Square Rock and site 19 was the same as that for Type 2 sites over the season, and the figure for Bluff Cliffs and Square Rock combined is between the figures obtained for Types 1 and 2 sites. We conclude that samples taken from the top of the cliff at the end of the season will yield estimates of reproductive success which are probably as representative of the cliff as a whole as are study sites.

Although egg production at Bluff was lower than it must have been in 1975, it was considerably higher than in 1976. The major cause of failure appears not to have been in egg production, but in egg mortality, as only one third of all eggs laid ever hatched. In the next section, we present the data on phenology of the season, and following that we postulate a mechanism and a cause of the lowered reproduction.

Phenological Events Relating to Lowered Reproduction

(i) Laying and Hatching.

The number of eggs laid and the number of chicks hatched at Bluff and Square Rock are graphed for four-day periods in Figure 6.

In cases where we could not obtain an exact laying date, and the egg eventually hatched, we extrapolated a laying date by calculating back from the hatching date. We used 27 days as the standard incubation period. On several eggs that we followed from laying to hatching, the period was 26 to 28 days (the variation may be because we visit the sites every other day), and Coulson and White (1958) reported an average incubation period of 27.3 days.

The shapes of the curves reflect the normal distribution we would expect, which is in distinct contrast to the laying curve obtained in 1976 at Bluff Cliffs, which peaked normally but then plummeted abruptly (Figure 7). Too few chicks hatched in 1976 to make a useful graph.

(ii) Changes in Numbers of Adults in the Course of the Season.

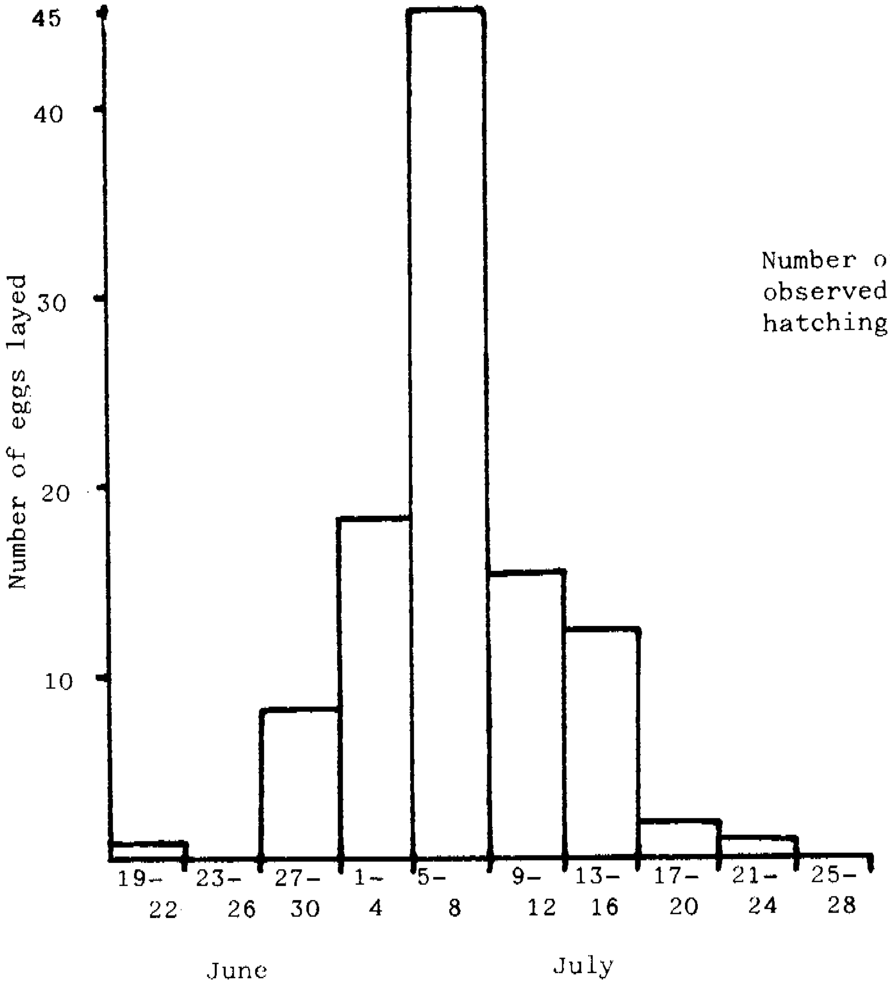
In Figure 8 we have graphed the totals of adults at five study sites as a percentage of the sum of the high counts for the season at those sites, over four-day periods. This technique enables us to show general trends in the mean number of kittiwakes present without the inevitable "noise" in the raw data, and allows us to use data for days when not all the study sites were counted.

There was a first peak in attendance at about the peak of laying, but then a gradual decline to a low point between 18 and 25 July. Attendance then increased to a new high point in early to mid-August, when renewed nest-building occurred. In Figure 9 we show the same information for 1976. A similar drop in attendance occurred then, only the decline in numbers was earlier, more rapid and deeper. This correlates with the rapid drop in egg-laying that occurred in 1976.

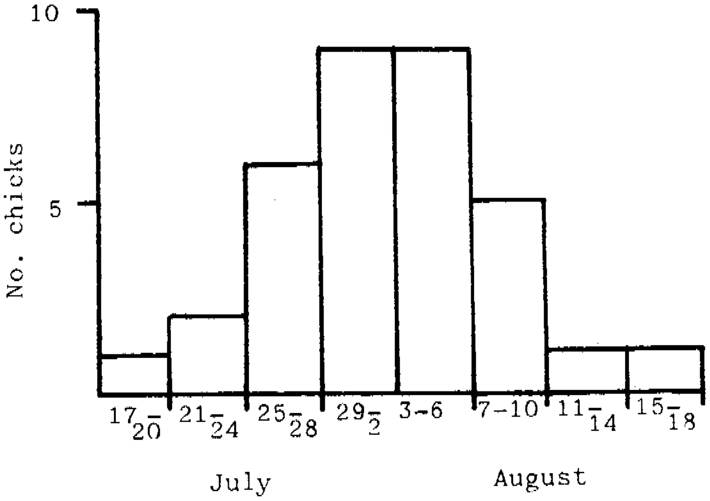
(iii) Occupation of Nest Sites Over the Season.

In Figure 10 we show the percentage of kittiwake nest sites in our map areas that were occupied by days during the 1977 season. These data have been corrected to reflect the maximum percentage of attendance recorded in the closest 24-hour count. In some cases the correction factor resulted in a figure greater than all the sites we know to have been occupied at the study area: such cases are shown as 100% attendance. The graph shows a conspicuous period of abandonment between 18 and 26 July at Bluff Cliffs and study site 19, but at

Figure 6. Egg laying and hatching of Black-legged Kittiwakes; Bluff Cliffs and Square Rock, 1977.



Number of new eggs layed; observed and calculated from hatching dates.



Number of chicks hatched. (Note different vertical scale.)

Figure 7. Egg laying of Black-legged Kittiwakes; Bluff Cliffs, 1976.

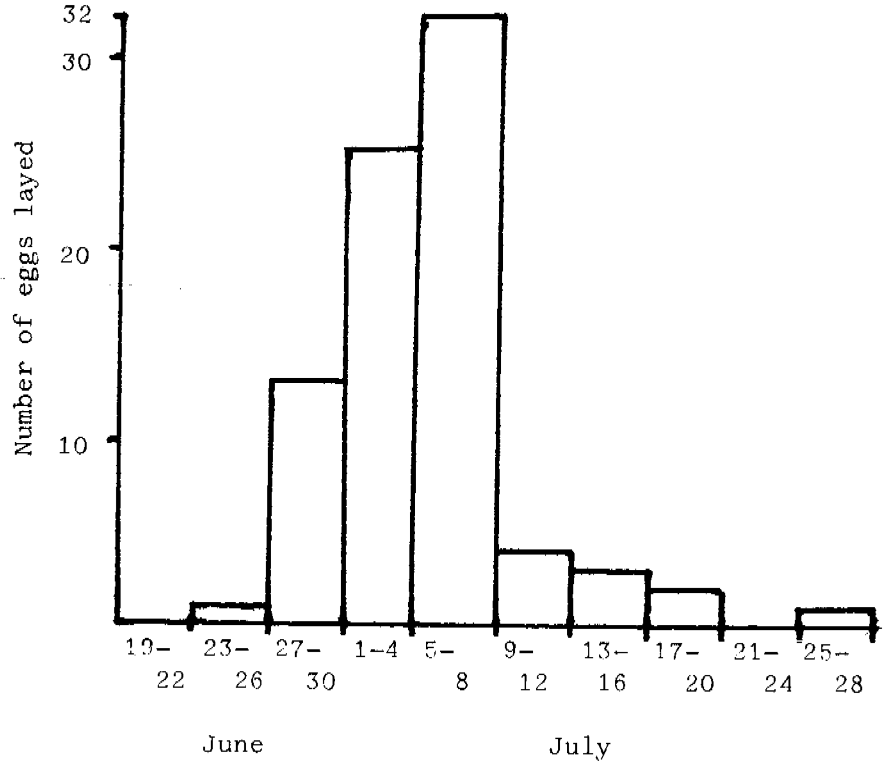


Figure 8. Variation in numbers of Black-legged Kittiwakes at the Bluff Cliffs, 1977.

Mean numbers of adult kittiwakes at five study areas, shown as a percentage of the season's highest counts.

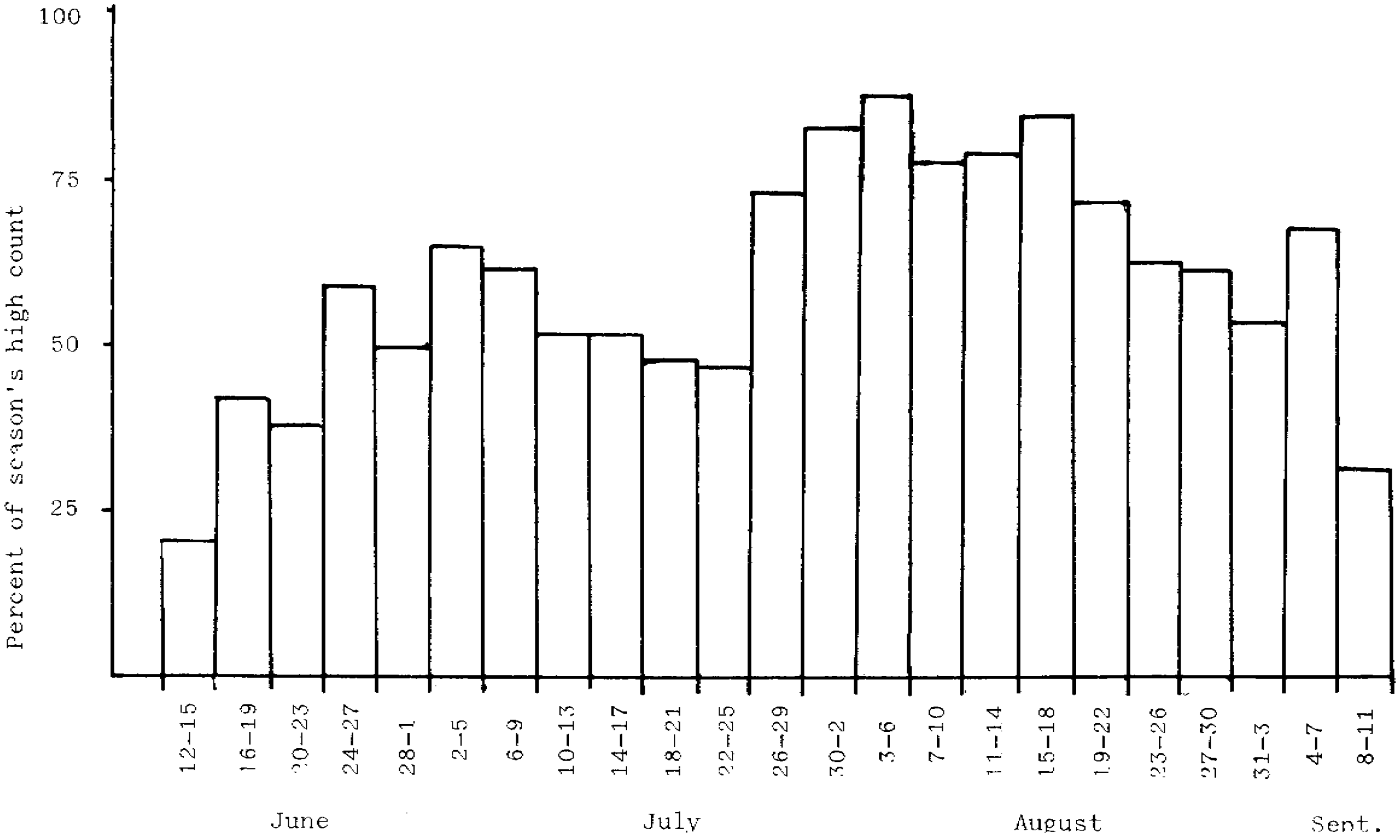


Figure 9. Variation in numbers of kittiwakes at Bluff Cliffs, 1976.

Data shown as in Figure 8.

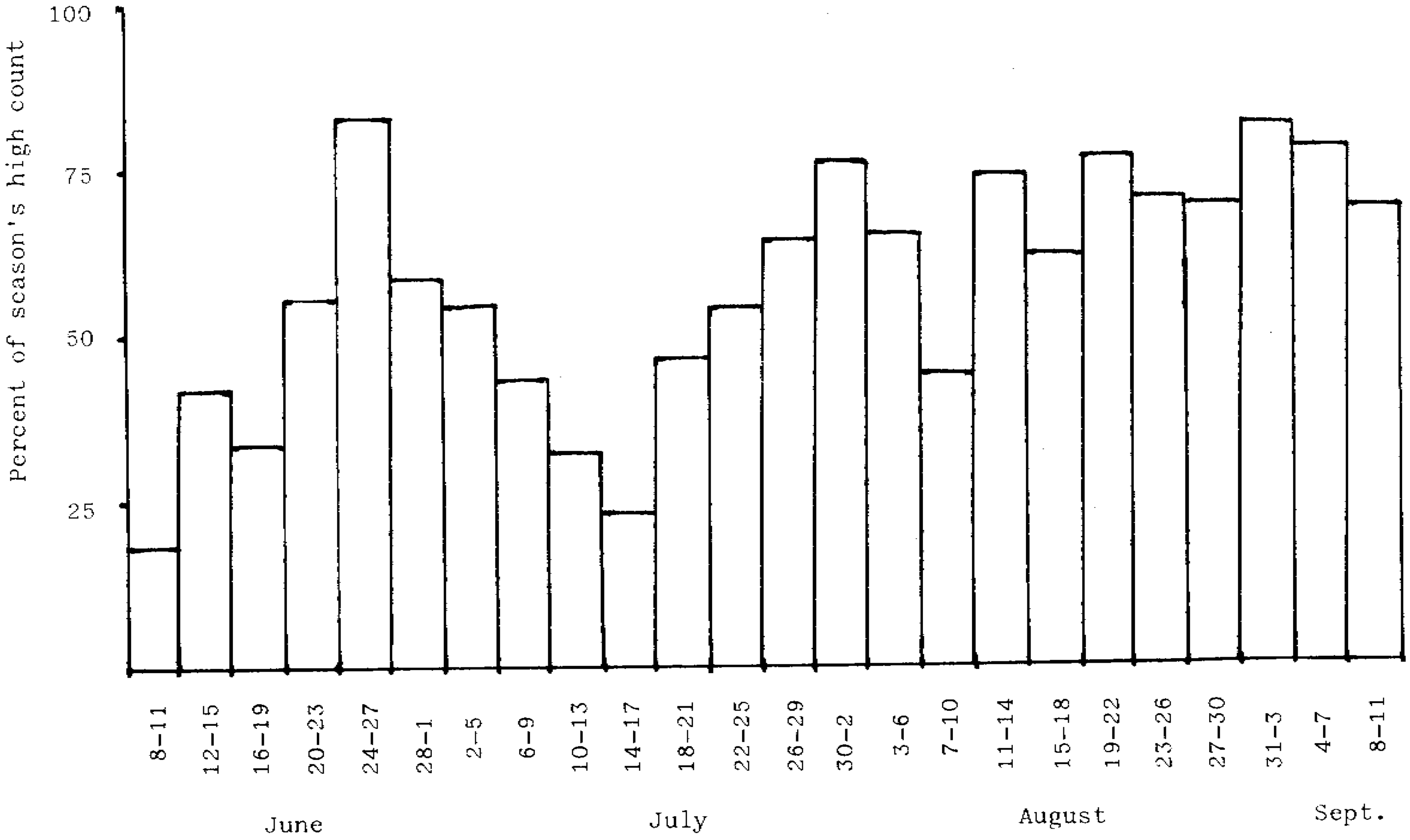
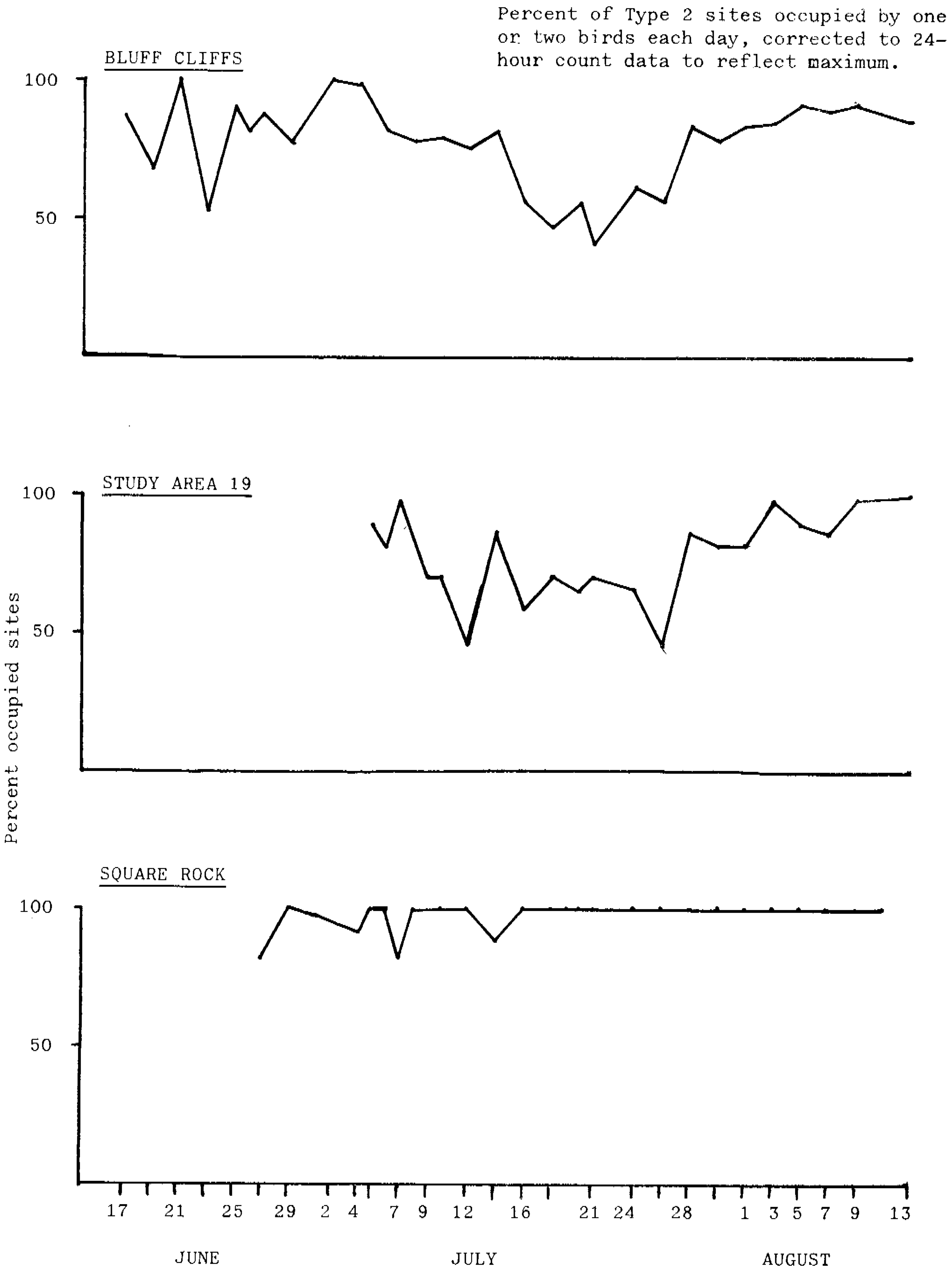


Figure 10. Attendance at nest sites by kittiwakes.



Square Rock, the most productive of our sites, attendance never dropped below 80% and stayed at 100% during the times when other sites were being abandoned. It appears that not only did birds leave the cliffs whose reproductive efforts had already failed, but some birds which still had eggs also did so. This does not help us to explain why the Square Rock site was not disrupted as the others were.

(iv) Egg Mortality and Events Surrounding Failed Eggs.

Egg mortality at Bluff and Square Rock is shown in Figure 11 as a proportion of all the eggs present at the study sites. The daily percent mortality is greatest between 13 and 24 July. The data for 1976 (Figure 12) also shows a peak of mortality in this period, but also severe early mortality and even more severe mortality at the peak. The times of mortality coincide with the times of lower attendance at the cliffs in both years.

These data indicate that many nests with eggs apparently were abandoned. Abandonment of a nest also gave Glaucous Gulls and Ravens opportunities to take the eggs. Of 51 nests that lost eggs, 15% were seen unattended before the egg was lost, 27% were unattended at the time the loss was noted, and 35% were unattended on at least two of our next four visits to the site and frequently for several visits afterward. Fifty-five percent of nests that lost eggs were seen to be physically deteriorated whether or not they were seen unattended. Physical deterioration of a site suggests that material has been stolen from it, which occurs to most sites when they are not occupied. We have observed a kittiwake stealing material from a nest with an egg in it while the nest was not attended. The kittiwake doing the pilfering repeatedly stepped on the egg and occasionally bumped it. The egg was missing at our next visit, but the pilfering continued. On the visit after that, all material was gone from the site.

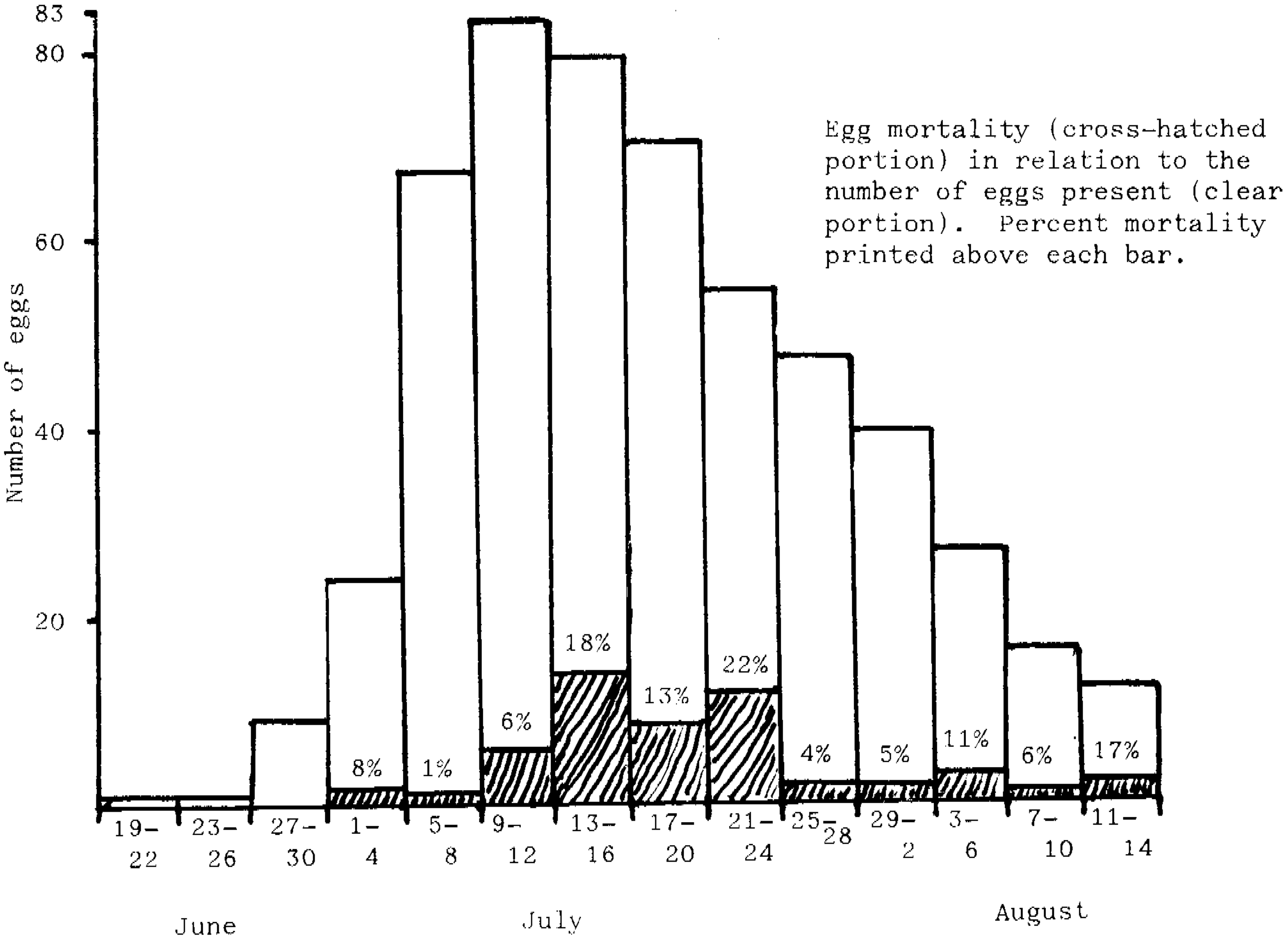
The data indicate that there was a period (presumably of stress) during mid to late July which caused the kittiwakes temporarily to abandon their sites, including some with eggs. High egg mortality in this period appears to have depressed reproductive success in a major way. We do not know why birds on the north side of Square Rock were not affected similarly.

Feeding Behavior and Food Sources

The following data are what we observed from land, and are preliminary, because we did not make observations of birds at sea.

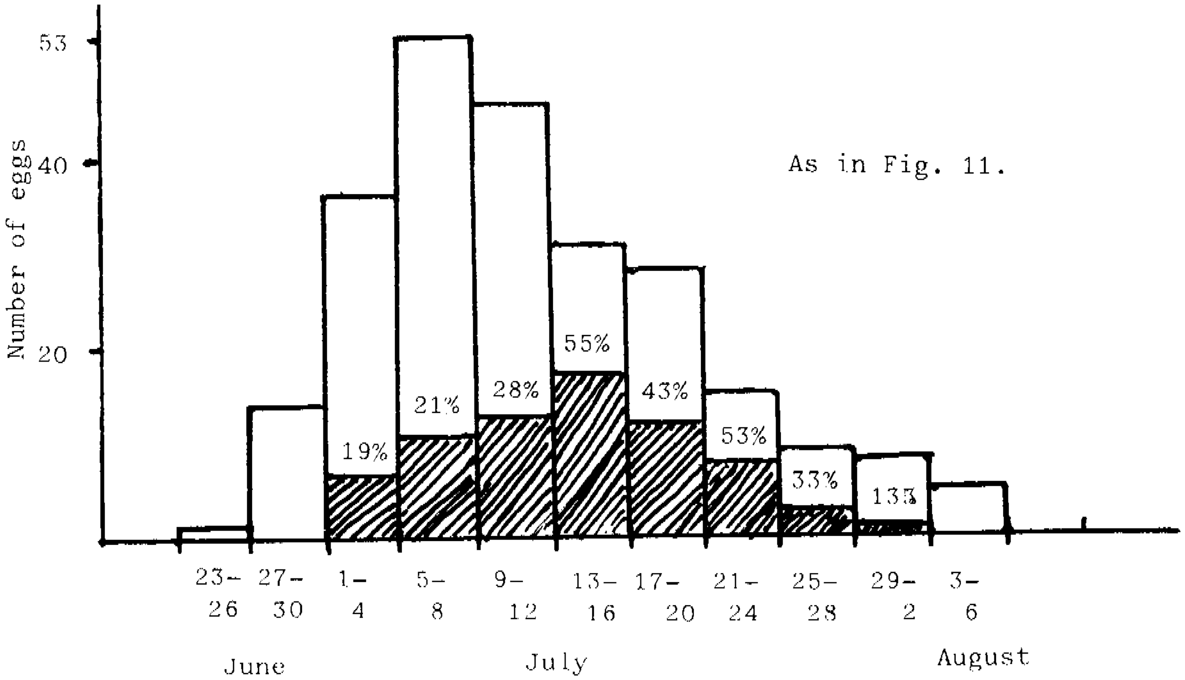
Throughout the season we saw mêlées of feeding kittiwakes. During these observations, we were able to define three types of feeding behavior: one in which the birds swim on the surface of the water and peck at the surface shallowly; a second in which they land gently on their breasts and upper bellies in the water and peck below the surface, sometimes submerging their entire head, then flutter up out of the water and repeat the action; and a third, in which they make tern-like dives below the surface from six or more feet above the surface of the water.

Figure 11. Number of kittiwake eggs present and amount of mortality, Bluff Cliffs and Square Rock, 1977.



Egg mortality (cross-hatched portion) in relation to the number of eggs present (clear portion). Percent mortality printed above each bar.

Figure 12. Number of kittiwake eggs present and amount of mortality, Bluff Cliffs, 1976.



As in Fig. 11.

Table 9. Summary of Black-legged Kittiwake feeding behavior observed near Bluff Cliffs during the summer of 1977.

	First Week	Second Week	Third Week	Fourth Week
JUNE		Infreq. in groups of 50-100 with Glaucous Gulls, taking 2 to 8 in. fish, some *Eleginus*. Dive from air.	Infreq. in mixed groups. Dive from air.	Groups 100-300 feed on surface or make shallow dunks - food too small to see (small crustacea?)
JULY	one melee of 400 birds with Glaucous Gulls, take 4 in. fish.	Groups 100-200 feed using shallow dabs at surface.	Continued infrequent melees taking indiscernible food by shallow dabs.	
AUGUST	Chicks fed *Ammodytes*. Group of 100 adults seen making shallow dives	Frequent melees 100-500 birds making shallow and deep dives. Schools of *Ammodytes* apparently moving into vicinity.	Massive schools of *Ammodytes* visible close to cliffs. Schools often close to surface allowing kittiwakes to catch multiple fish at surface. Frequent simultaneous melees of 100 birds each along entire length of cliffs.	Melees over *Ammodytes* schools continue, become smaller, fewer, more dispersed.
SEPT.	One melee of 75 kittiwakes making deep dives.			

Our observation of feeding mélées are summarized in Table 9. Almost all of these feeding bouts occurred within a mile of the shore. Apparently, the mixed aggregations we saw in early and mid-June were feeding on schools possibly of Saffron Cod (Eleginus), small trout, and young salmon. In July, the food used was crustaceans judging from the feeding behavior used (predominantly the first method described above and occasionally the second).

Our watches indicated that rates of feeding varied widely during the season. On 29 July, concurrent with a 24-hour count, we observed a chick in a nest at study site 14 for about 45 minutes out of every hour. We did not see it fed once during the entire day, even though an adult was present most of the time, and there were several changes of adults. However, on 2 and 4 August we observed three nests with chicks at study site 17, and saw them fed several times.

At all times when the food exchanged has been identifiable, it consisted of small Sand Launce (Ammodytes). Apparently, Ammodytes began to move into the waters off Bluff Cliffs in early August. We saw groups of diving kittiwakes mixed with puffins and murres on 5 August. On 13 August there were large mélées visible "everywhere". This period of abundant food reached its peak between 21 and 24 August, when schools of Ammodytes of 10 m^2 or greater in surface size were swimming within a quarter of a mile of the cliffs, and some along the base of the cliffs. Murres and puffins attacked these schools from underneath, which may have driven some of the fish close to the surface, as the kittiwakes frequently caught more than one fish in single shallow stabs. These Ammodytes were mostly one and one half inches long.

We believe as we have said before that the phenology and abundance of Ammodytes may be critical to the reproduction of kittiwakes in the northern Bering Sea area, but there is an unfortunate dearth of information on the biology of this major marine resource.

b. Common and Thick-billed Murres

Estimates of Numbers

Table 10 shows the results of the four cliff counts made at Bluff in 1977. A correction factor derived from the nearest 24 hour count (see Methods) was applied to the cliff counts to get an estimate of the total population. Table 11 shows the results of the three censuses done at Square Rock, and those done at Sledge Island. The first estimate at Sledge is probably high; the second is closer to, although still higher than, the 1976 estimates which were about 1500 birds. The count made at Sledge in August of about 3000 birds, is close to the estimates made before 1975 by members of the Alaska Department of Fish and Game.

Table 10. Estimates of total Murre numbers at Bluff, 1977.
(counts made from a boat passing in front of the cliffs)

Section of Cliff	June 28th		July 7th		July 29th		August 19th
	max.	min.	max.	min.	max.	min.	
A	1150	890	1570	940	1050	1020	1950
A to C	5200	4460	7760	4170	6800	5050	5000
C to D	14,600	9750	14,830	7670	15,600	10,600	11,875
D to E	4340	3180	3688	2890	4580	4200	4220
E to F	5660	4820	5320	4900	7260	5380	6040
F to G	2360	1530	1965	1635	2670	1960	1355
G to H	2090	1510	2480	1930	2490	1750	2060
H to I	5480	2720	4290	3830	4300	2820	3240
I to J	485	450	560	430	495	554	370
TOTAL (A to J)	41,365	29,400	42,500	28,400	45,250	33,250	36,100
Percent on cliff *	87%		95%		88%		100%
CORRECTED TOTAL	47,545	33,800	44,736	29,900	62,132	48,900	36,100

* at same time during nearest 24-hour count

Table 11. Murre censuses - Square Rock and Sledge Island.

<u>Square Rock*</u>

May 22	3,330
June 4	4,800
August 19	7,600

<u>Sledge Island</u>

June 21-24	6000[+]
August 23	2800[**]

* Direct counts

[+] High count rounded off

[**] Direct count

The highest counts of murres occurred twice during the 1977 season. On 21 May 61,900 murres were counted in the leads in front of the Bluff Cliffs. Again on 29 July a cliff count yielded 62,000 birds. These figures support the observation also made in 1976 (see p.40 of the report for the '76 field season), that most of the birds associated with the colony arrive early, and that many leave before the breeding season starts, to return later in the season.

We have no data on the total numbers of Thick-billed Murres at the Bluff Cliffs as they are impossible to distinguish from Common Murres when counting from the base of the cliff in a small boat. The percentage of Thick-bills is very small, however; it is probably less than 1%.

Daily Activity Patterns

The changing patterns of daily attendance at the cliffs were observed in the course of the 24 hour counts. These were done six times during the 1977 season at 10 day to two week intervals. Two different sites were used, Sites 14/15 at the Bluff Cliffs, and Site 19 and Square Rock. Fading light made it impractical to continue these counts past early August. The graphed results of the 24 hour counts of murres at Study Sites 14-15 and Square Rock are shown in Figure 13.

Early in the season (mid-June), the attendance patterns at Sites 14/15 and contrasted sharply with those at Site 19 and Square Rock. At 14/15, murres were present on the cliffs all night and in the very early morning and late evening (peaking at 0400 and 2300), and were all gone in the middle of the day (from 1100 to 1700). At Square Rock, murres were present on the cliffs most of the day but were all gone in the very early morning (0100 - 0500). At this early part of the season the changes in numbers occurred rapidly, and during certain portions of the day, <u>all</u> the birds left the cliff. Fighting and territorial defense behavior occurred when the birds were on the cliff, but this was apparently not yet a full-time commitment.

After egg-laying began, complete desertion of the cliff no longer occurred. The variation in numbers dropped to 40-60% in late June and early July. Presumably the birds were remaining to protect their territories and eggs. Also, the patterns of attendance at the two count areas became similar with a majority of birds present on the cliff in the early morning (from 0400 to 0800), and evening (0800-1200). The birds left the cliff at night, (with numbers decreasing after 2000, and increasing after 0100), and again at midday.

Figure 13. Twenty-four hour counts - Murres.

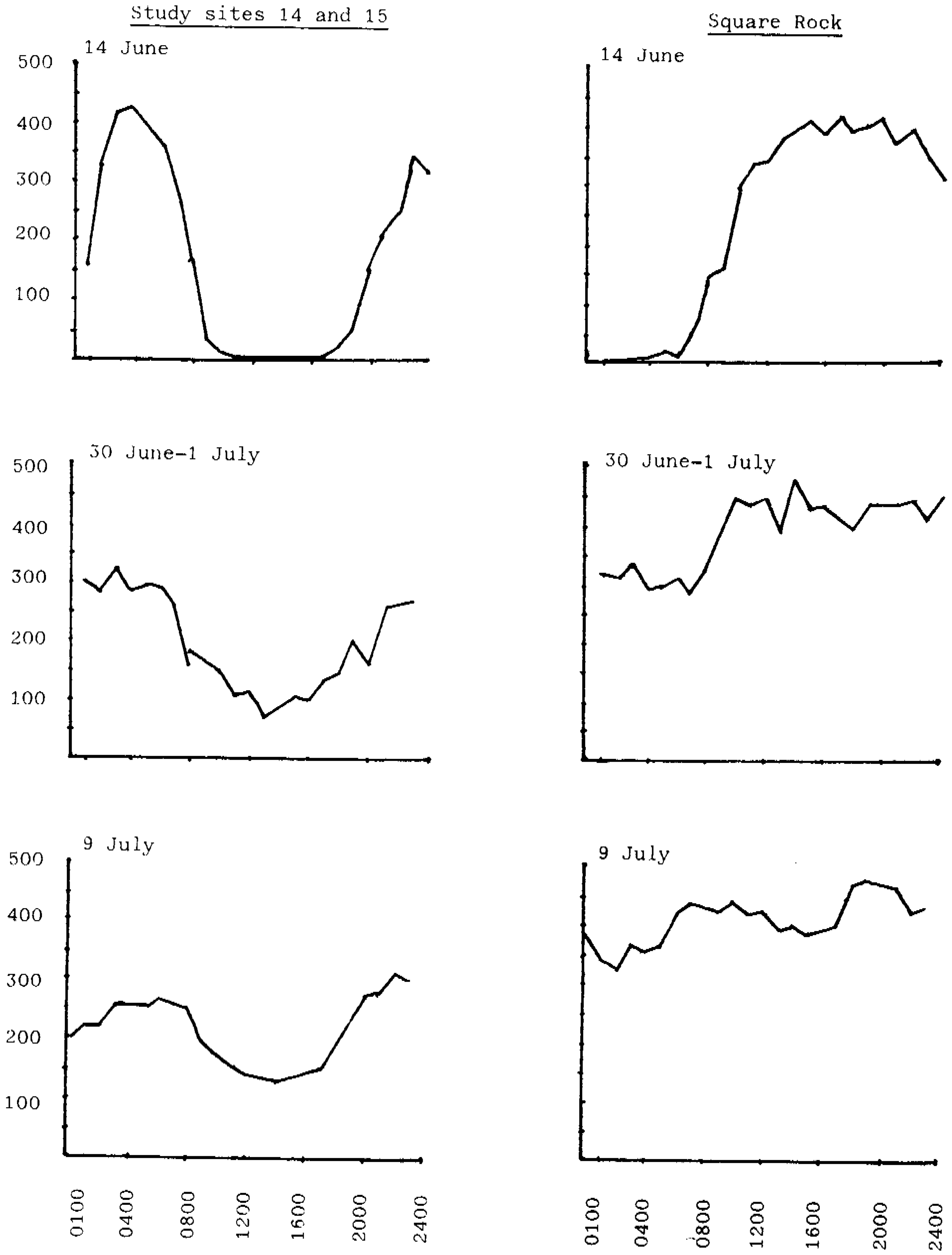
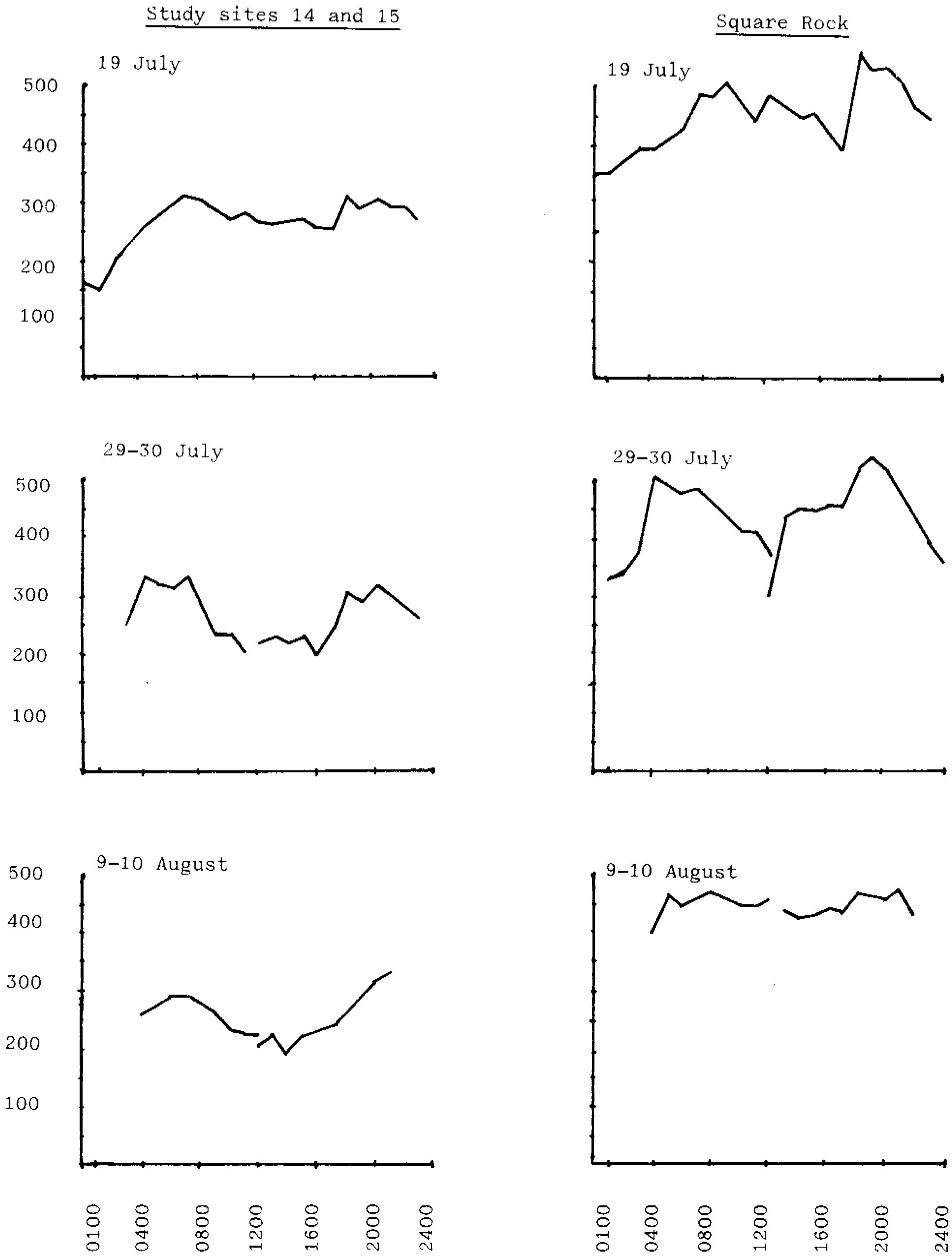


Figure 13 (cont.). Twenty-four-hour counts - Murres



The changes in numbers did not occur as abruptly as they did earlier in the season. The variation in numbers remained near 40-50% in mid and late July, but decreased to 15-30% in early August. This may be due to an influx of young birds"prospecting"for future nesting sites.

Seasonal Variation in Attendance

Seasonal variation in attendance of Common and Thick-billed Murres at the cliffs is shown in Figure 14. The variation is shown as a percent of the season's high counts at several study sites. The pattern of variation is similar in the two species. There was a first, low peak in numbers in mid-June, when 40-55% of the maximum population of birds were on the cliffs. In late June numbers decreased and only 20-30% of the birds were present. At the peak of laying, about 7-11 July, 70% of the population was present. This figure probably represents those birds most highly motivated to a reproductive effort, i.e. the "breeding population". Total numbers increased slightly after the laying peak until maximum numbers were reached in mid to late August. These late season increases were due to the arrival of young birds breeding for the first time, and then due to the arrival of nonbreeding young birds prospecting for future sites. Numbers declined after the third week in August as chicks began to depart along with the breeding and nonbreeding adults. By the time we left Bluff on 12 September, the cliffs were 99% empty of Murres.

Reproductive Schedule

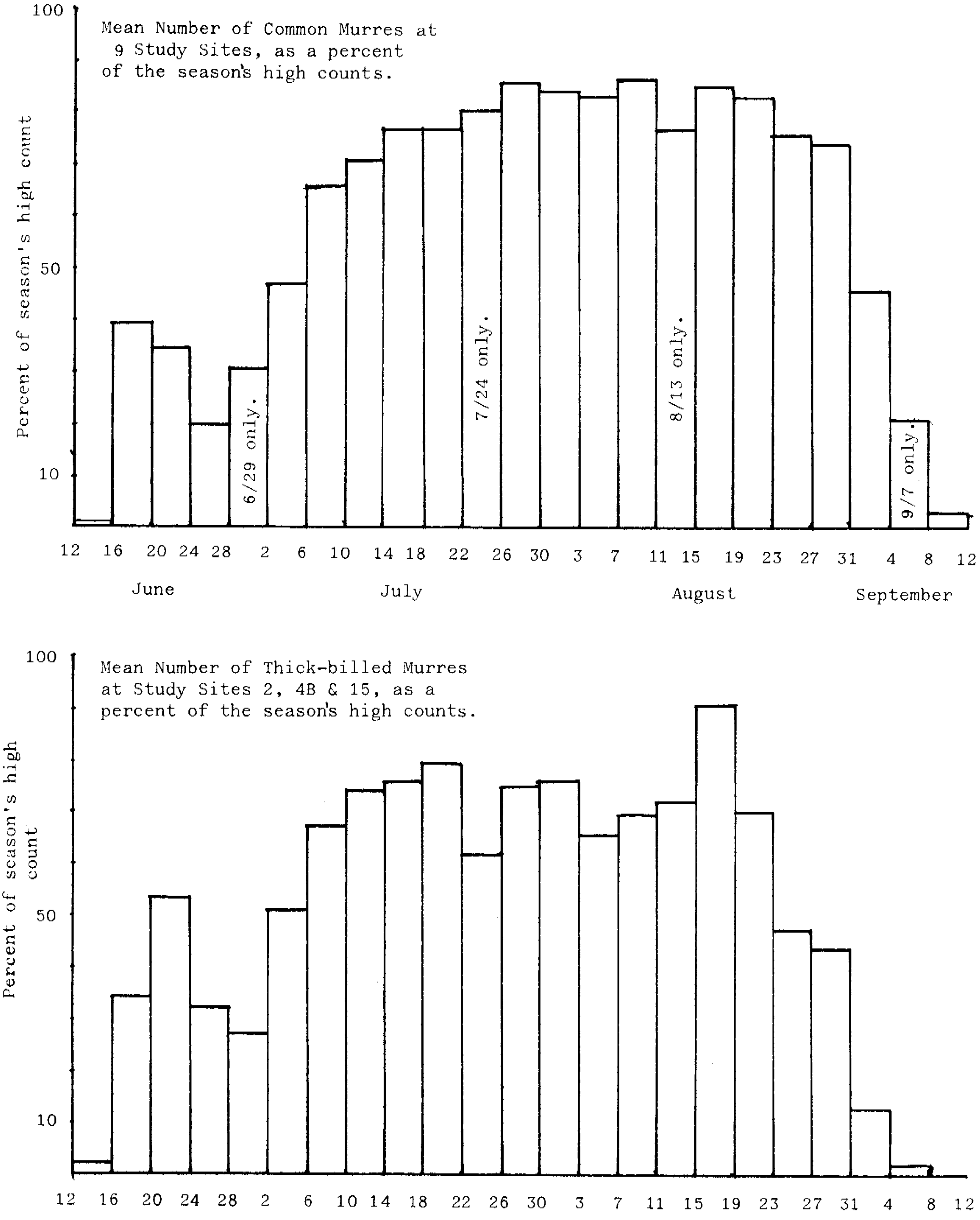
Arrival and Early Occupation of the Cliffs - When we flew in to Bluff on 21 May, we counted 30-40,000 murres on the water. A count from the top of the cliff yielded a total of 62,000 murres on the water. The birds were flocking at the base of the cliffs; some were flying to and from the cliffs, however those that landed did not remain long and were very easily scared off. Some fighting and copulations were noted among birds on the cliff.

At 1000 on 22 May, murres were seen flying en masse to Square Rock which they occupied until 2100, when all left. These changes approximate the pattern of daily activity shown by the 24 hour count made in the middle of June.

On 23 May no murres were seen at Bluff or at Square Rock all day, which suggests that their ties to the cliffs were still rather loose.

On 24 May at 1045 murres were present in the lead in front of the cliffs, but were not hugging the inshore edge. At 1930 a count was made of 2600 murres on the water in front of the Bluff Cliffs.

Figure 14. Seasonal Variation in Murre Attendance at the Cliffs



Birds started "flying in thousands" to the Bluff Cliffs at about 2000, (which is approximately when they were seen leaving Square Rock on 22 May). A total count of 12,000 birds on the water was made at this time.

A count at 0645 on 25 May showed about 17,000 birds present on the water near the Bluff Cliffs. Very few birds were actually on the cliffs at this time. A count made from the air on 2 June at 1820 yielded the similar figure of 19,000 birds.

The high count of 21 May was not repeated until the end of July, suggesting that many (nonbreeding)birds arrive early along with those that are going to breed, and that the nonbreeders leave before egg laying begins and return later in the summer.

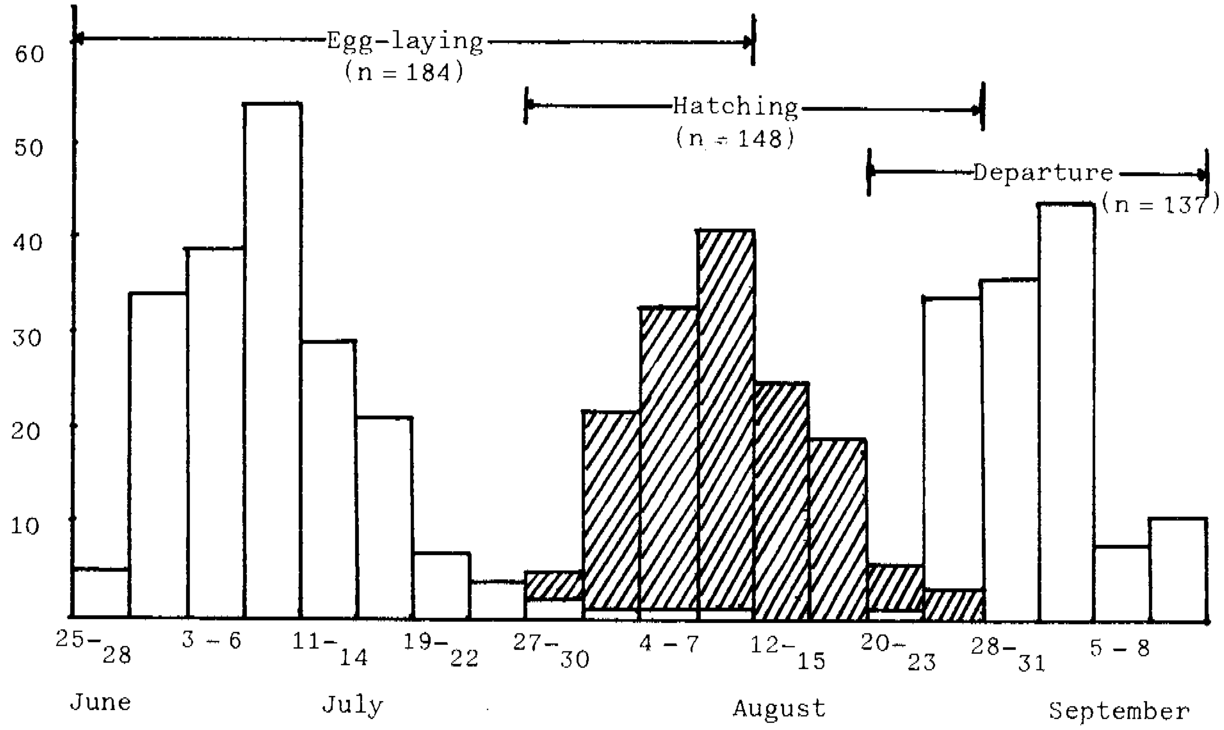
These early observations, and the 24 hour count of 14 June show that the patterns of attendance at the Bluff Cliffs and at Square Rock were, at this time, nearly opposite even though they are within three miles of one another. This suggests that they exist (to some extent) as separate colonies.

Laying and Hatching - Figure 15 shows the reproductive schedules of Common and Thick-billed Murres. These data come from the ledges at which murres were individually mapped. Since it often takes many hours of observation to determine whether a murre in an incubating posture actually has an egg, the first sightings of eggs were usually later than the actual laying dates. Our data on hatching and departure dates is much more reliable. We therefore calculated the laying curve from these, using Tuck's (1960) figure of 33 days as the length of the average incubation period. The calculated laying curve corresponded closely to the curve derived from observed laying dates which were known to be accurate. (See figure 16)

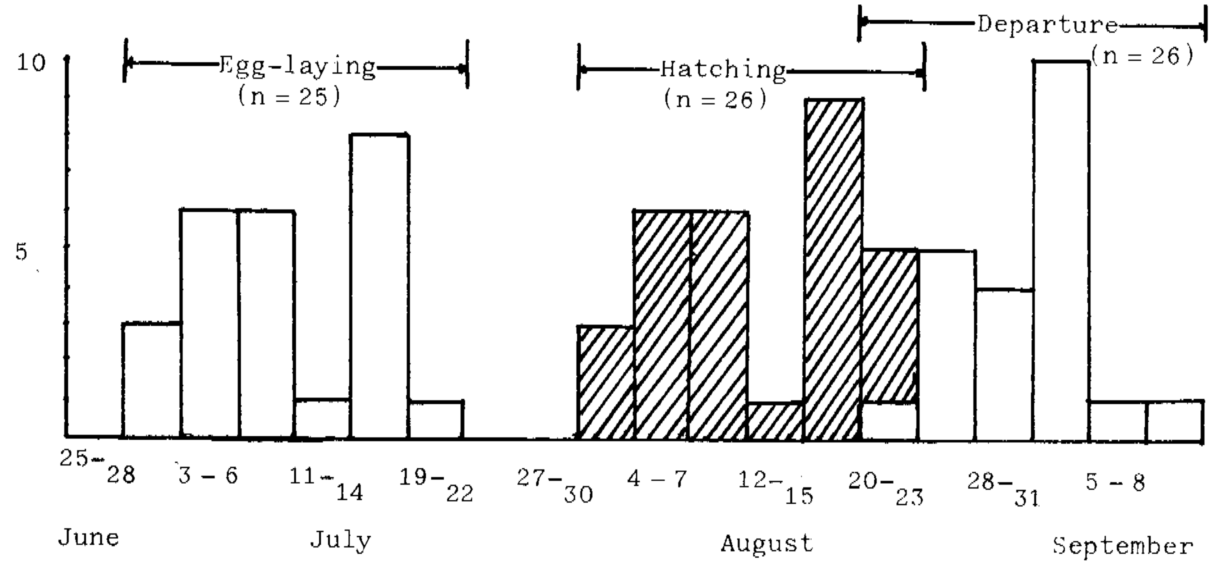
The first egg shells were seen on 21 June near a Raven's nest. Eggs were seen on the top of Square Rock on 22 June. These were heavily preyed upon by Glaucous Gulls and Ravens. The earliest eggs are particularly vulnerable to predation because the majority of birds without eggs were easy to flush from the ledges, leaving the few with eggs more open to attack. The peak of laying occurred from 7-10 July for Common Murres.

Our sample size for the laying period of Thick-billed Murres was small (a total of 33 eggs were mapped at two sites), but within this sample the laying peak occurred from 15-18 July. We saw new eggs until the middle of August; however these late eggs almost certainly failed to hatch.

Figure 15. Reproductive schedule - Common and Thick-billed Murres.

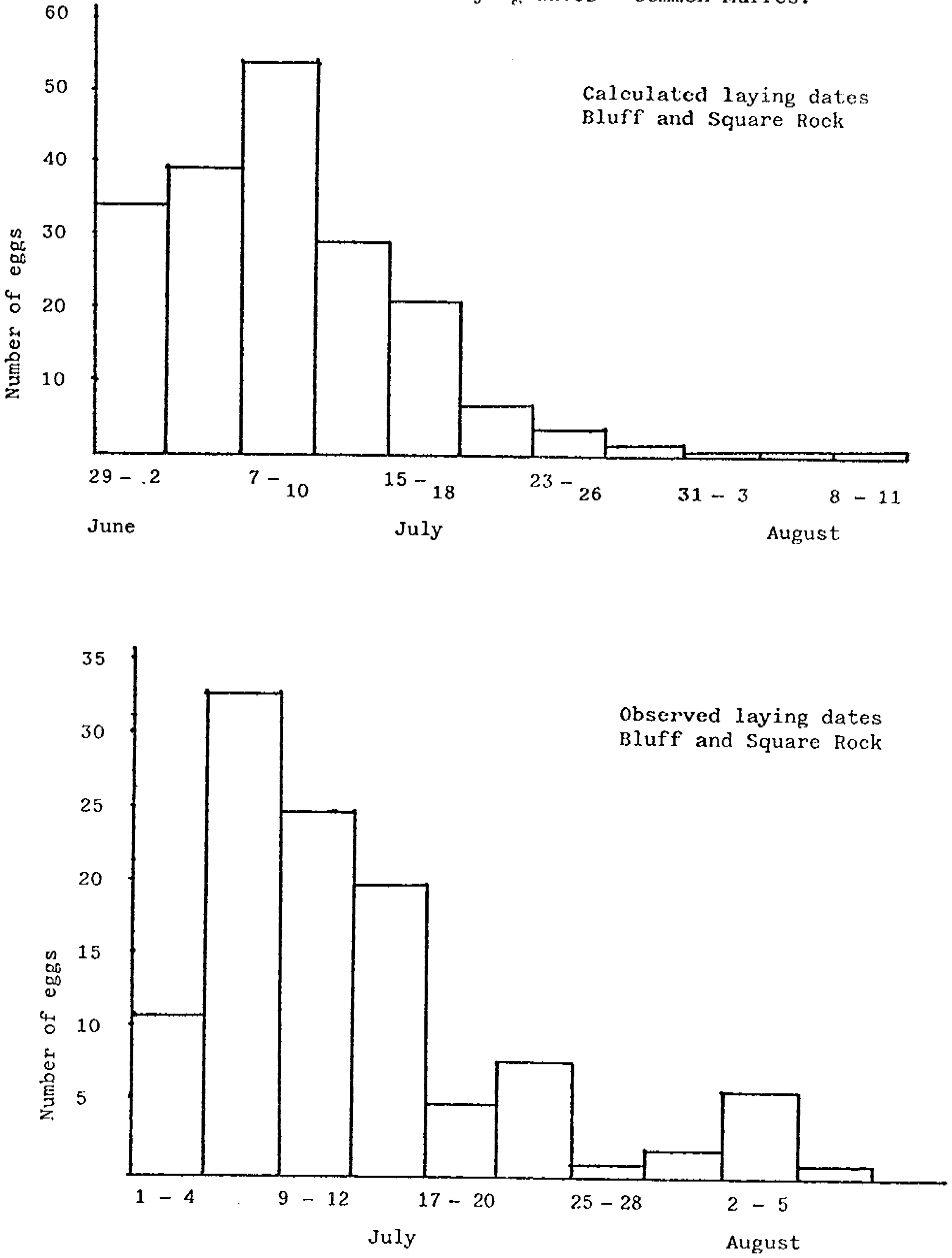


Common Murres



Thick-billed Murres

Figure 16. Calculated versus observed laying dates - Common Murres.



The first chicks were seen on 30 July at Square Rock, and on 3 August in the map areas at the Bluff Cliffs. The reproductive schedule of the murres at Square Rock seemed to be consistently a few days ahead of the birds at the Bluff Cliffs; further evidence that they exist as separate colonies. The peak of hatching occurred from 8-12 August for Common Murres, and (in our small sample) from 16-20 August for Thick-billed Murres. Hatching continued until 28 August, with the exception of one or two very late chicks (which failed to survive) that didn't hatch until the first week of September.

Fledging of Chicks - Departure dates are probably the most reliable data we have for the murre breeding schedules, because as the chicks get larger and nearer to jumping age, they move around more and often stand away from the parent making them easier to keep track of. On the map areas, we usually knew to within a day or so when each chick disappeared, and whether it was old enough to have jumped. We used Tuck's (1960) estimate of 18-25 days as the average age of chicks old enough to leave the cliffs. Chicks that were known to be less than 18 days or which still looked very small and immature when they disappeared were assumed to have been lost. Those older than 18 days were assumed to have fledged successfully.

The first Common Murre chicks jumped on 20 August, and the peak of jumping occurred from 1-5 September; most of the chicks jumped after 24 August. The first Thick-billed Murre chick also jumped on 20 August, and their peak also occurred from 1-5 September. These data on departure dates suggest that the Common Murre and Thick-billed Murre schedules corresponded rather more closely than the data on laying and hatching would indicate, but the sample may be too small to be truly representative.

A few days prior to jumping from the cliff, chicks would begin to stand apart from their parents. Jumping usually started just after dusk and would continue into the darkness. The chicks are very vulnerable to predation at this time; the darkness affords them some measure of protection.

Large groups of adults congregate at the base of the cliffs when the chicks are ready to jump. One adult usually accompanies each chick as it makes its jump, and it is surrounded by many adults after it hits the water, presumably providing more protection from predators. The chick and a group of adults then begin to move directly out to sea. Chicks were sometimes seen in the water at the base of the cliffs surrounded by adults during the daytime; they apparently also jump in the daylight although they are much more vulnerable then.

We left Bluff on 12 September in 1977, and by this date, 99% of the adults and chicks had left the cliffs.

Identifiable Stages of Chick Development - We have recorded the following stages in the development of murre chicks. At first the young do not raise their heads and are a uniformly leaden color with speckles of white on the head and neck. Next the young birds raise their heads and stand up. At this time the head and neck are covered with characteristically pointed feathers speckled with white at the tip resembling "pepper and salt". Next the bird is much larger, just less than half the length of the adult's white belly, and shows a white chin, but the cheeks are still dark or "pepper and salt". At the last stage before jumping, the chick has a white chin and "halfmoon" white cheeks. It stands for hours at a time beside its parent and often can be heard peeping when fed. Occasionally it gives the ringing double note associated with a chick which is just about to, or has,jumped from the ledge. Our observations indicate that the first two stages occupy 8 or 9 days and so do the last two. The last stage may be quite prolonged in the case of some chicks.

Late Season Territorial Activity - The amount of fighting among murres appeared to decline after egg laying and incubation began. As new birds began to arrive in early August however, there seemed to be a resurgence of fighting. These incoming birds were often seen loitering on the cliffs, yet some were seen in the incubation posture. Toward the end of August, fights were sometimes seen at reoccupied sites after chicks had left.

Reproductive Success - Reproductive Success, for both Common and Thick-billed Murres, was much higher in 1977 than in 1976. While the determination of the reproductive success of murres is difficult, by expanding our use of detailed mapping of murre ledges (see description of this method under "Methods") this year we were able to get much more complete data than we have had in the past. All of the calculations of murre reproduction came from mapped areas.

We had eight murre map areas at the Bluff Cliffs in 1977, two of which (at Study Sites 2 and 15) were only Thick-billed Murres. There was a total of 184 Common Murre "sites" (places at which an egg was seen on a ledge) and 33 Thick-billed Murre sites. (See Table 12). The map areas were chosen, and their boundaries determined mainly by their visibility from the top of the cliff. The most reliable data come from the small, narrow ledges where it is much easier for the observer to keep track of each bird, hence to check whether it has an egg or chick. The wider and more crowded the ledge, the more difficult the area is to map accurately. Our results therefore, do not reflect differences in reproductive success that may be caused by differences in ledge type. We suspect that such differences may exist.

Table 12. Number of sites monitored within each Murre map area.

Study area	Number of sites
(Common Murres)	
1B	15
4	9
4B left	20
4B inside	26
10	82
12	32
Total	184
(Thick-billed Murres)	
2	16
15	17
Total	33

Table 13. Numbers of "breeding" birds present at Murre map areas.

Study area	July 6-10 counts	average (probable number of "breeding" birds)	Highest number of incubators recorded
1B	35, 43, 56	45	40
4	27, 34, 44	35	17
4B left	40, 54	47	26
4B inside	48, 53, 59	53	32
10	136,135,141,144	139	75
12	52, 51, 49	51	22
2	17, 15, 24	19	17
15	15,17,17,13	16	17

The map areas at Stakes 2 and 15 were chosen for their high concentration of Thick-billed murres. Common murres were not included in these maps although they were interspersed with the Thick-bills. Thick-billed murres nest on small and narrow ledges, which makes them relatively easy to map. So, although our sample is small, it is probably characteristic and fairly precise. We mapped and counted Thick-billed murres only where they were concentrated; thus our data are not useful in determining the total population of Thick-bills.

The biological meaning of "incubating murres" is not yet clear. We have found no very consistent relation between the number of "incubators" and the number of eggs actually present on the ledge. Therefore, estimates of reproductive success for 1977 were not based on the numbers of birds in incubation posture (see discussion pp. 26-27,57 of report for 1976 field season) present in murre count areas, as was done in 1976.

The number of "breeding birds" at the cliffs is difficult to determine due to the presence at various times of "loafing" birds who do not seem to be involved in a breeding attempt. We believe that the level of committment of birds to a breeding effort is reflected in the strength of their attachment to the cliffs, as shown by their defense of territories, maintenance of the incubating posture, and, of course, production of eggs and chicks. By "breeding birds" we refer to those birds which have the highest level of attachment to a specific site on a ledge at the cliff. The reasoning is recognizably circular.

In 1976, three possible measures of the number of breeding pairs were compared and found to be in good agreement with each other. These were 1) the average number of birds present on the cliffs in late June (representing the birds attempting to breed); 2) the number of birds present at the peak of laying in late July; and 3) the highest numbers of incubators recorded.

It seems reasonable to assume that birds highly motivated to lay eggs will be present at the cliffs around the peak of laying. In 1976, although egg-laying began in late June, the actual peak of laying did not occur until late July due to an interruption of the breeding season (which happened around 8-11 July). The laying peak occurred from 7-10 July in 1977. An average of the counts made at the map areas during this period gives a figure which we believe approximates the number of breeding birds, and which is comparable to the 1976 figures. Our estimates of the numbers of breeding birds present at each site are shown in Table 13. In five of the eight map areas, the highest count of birds in an incubating position is approximately 50% of the average of the July 6-10 counts. This makes sense as only one of a pair of murres can incubate at a time, and the 6-10 July counts are of numbers of "breeding" "birds" (not pairs).

Table 14 shows the probable number of "breeding" birds at each site, and the number of eggs observed, chicks hatched and chicks fledged. Table 15 shows murre reproductive success for 1977. Common Murre reproductive success (chicks fledged per breeding pair) varied from .14 to .53 according to the study site. It is difficult to tell how much of the variation in success is due to the differences in ledge type and it's suitability as a breeding ledge, or to differences in our ability to measure reproductive success on these ledges. The low figure of .14 occurred at Stake 4 where the mapped ledge was wide and crowded, making it difficult to keep track of individual birds, eggs and chicks. (See disc. on p. 60 of report for 76 field season)

Our figures for eggs produced per breeding pair are probably low because on the more crowded ledges some of the eggs were most likely never seen. We have little data on egg loss and replacement.

Comparisons of Reproductive Success in 1976 and 1977 are shown in Table 16. Although our data from 1976 are much less precise some general comparisons between the years are possible. Our estimates of eggs produced per breeding pair are similar for 1976 and 1977, however there is a large difference in the figures of eggs hatched/ eggs laid, and of chicks fledged/breeding pair between the years. The low figure of reproductive success in 1976 was therefore not due to a failure to lay eggs. Our data show that the interruption of egg-laying in 1976 resulted in lower hatching success. Although similar numbers of eggs were laid many of the eggs were laid much later in 1976. These late eggs had a lower rate of hatching.

In 1977, 65-100% of the common murre eggs that were laid, hatched successfully at the different sites, average being 85%. This figure is probably high, as it is certain that we missed some eggs that were lost or replaced. Of those chicks that hatched 82-100% fledged successfully, averaging 87%.

Of the Thick-billed murre eggs laid, 69-91% (of those monitored) hatched. Of these Thick-billed murre chicks .91-100% fledged successfully.

As mentioned earlier, it is probable that we never saw a number of eggs that were laid and lost or replaced. Table 17 summarizes our egg loss data. Our figure for percent of eggs lost is undoubtedly low. The data we have are useful to some extent though, in showing the degree to which egg-loss can be attributed to various factors. Those eggs lost whose "fates" we did not know were most likely lost through either falling off the ledges or by predation. By "sterile" eggs we mean those which continued to be incubated, but which did not hatch until the adult finally gave up late in the season. Some eggs were not incubated; most of these were eventually taken by Glaucous

Table 14. Numbers of Eggs, chicks hatched and chicks fledged at Murre map areas.

Study area	Number of eggs seen	Number of chicks hatched	Number of chicks fledged
Common Murres			
1B	15	14	14
4	9	6	5
4B left	20	20	20
4B inside	26	20	20
10	82	71	58
12	(32*)	32	27
Total	184	157	137
Thick-billed Murres			
2	16	11	10
15	17	15	15
Totals	33	26	25

	Common Murres	Thick-billed Murres
Total eggs	184	33
Total chicks hatched	157	26
Total chicks fledged	137	25

* Eggs were not noted in this map area, chicks only were noted. This figure represents the minimum number of eggs present.

Table 15. Murre reproductive success.

Common Murres

Study area	Number of "breeding" birds	Eggs/ breeding pair	Chicks hatched/ breeding pair	Chicks fledged/ breeding pair
1B	45	.33	.31	.31
4	35	.26	.17	.14
4B left	47	.43	.30	.28
4B inside	53	.49	.38	.38
10	139	.59	.51	.42
12	51	(*)	.63	.53
Total	370	.48	.42	.37

Thick-billed Murres

Study area	Number of "breeding" birds	Eggs/ breeding pair	Chicks hatched/ breeding pair	Chicks fledged/ breeding pair
2	19	.84	.58	.53
15	16	1.06	.94	.94
Total	35	.94	.72	.69

	Common Murres	Thick-billed Murres
Hatched/laid	.85	.76
Fledged/laid	.74	.74
Fledged/hatched	.87	.96

* Eggs were not noted in this map area, chicks only were noted. This means that the figures for hatched/laid, and fledged/ laid may be slightly high.

Table 16. Comparison of Murre reproductive success, 1976-1977.*

Common Murres	1976	1977
Eggs/breeding pair	.45-.47	.48
Chicks fledged/breeding pair	.06-.09	.37
Eggs hatched/eggs laid	.29-.48	.85
Thick-billed Murres		
Eggs/breeding pair	1.05-1.13+	.94
Chicks fledged/breeding pair	.29-.40	.69
Eggs hatched/eggs laid	.26-.37	.76

* Comparisons cannot be exact as the methods and results from 1976 are less precise than in 1977.

\+ See p.61-62 in 1976 report on egg replacement for explanation of these figures.

Table 17. Egg loss summary.*

Total eggs observed (at map areas)	217
Total eggs known lost	34
Percent egg loss	16%

Fate unknown	9	(26%)
Never hatched (sterile)	5	(15%)
Unincubated	6	(18%)
Preyed upon	2	(6%)
Crushed (no chick seen)	2	(6%)

* Data from Murre maps only.

Figure 17. Dates of egg loss.

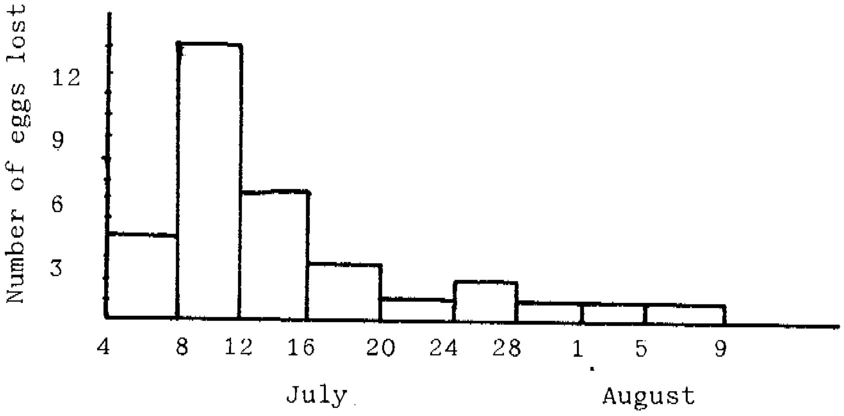


Table 18. Murre chick loss summary.*

Total chicks hatched	183
Total chicks lost	21
Percent chicks lost	11%

Age of "lost" chicks	
1-6 days	7
7-12 days	8
13-18 days**	6

* Data form Murre map areas only.

** Chicks over 18 days assumed to have fledged successfully.

Gulls or Ravens. Some apparently rolled into places which were inaccessible for incubation by the adult, such as in a crack or behind a rock.

By far the heaviest egg loss occurred during the peak laying period, from 6-11 July. (See Figure 17) The data we have shows that 5 of the 12 eggs whose 'ages' when lost are known, (42%) were less than 10 days old when they disappeared. Tuck's (1960:153) findings agree that egg loss is apt to be highest soon after the eggs are laid. He states that this is because eggs are often laid in precarious positions, and because eggs stabilize as incubation progresses due to movement of the embryo towards the small end of the egg. This causes the radius of the circle in which the egg will roll if disturbed to decrease.

Data on loss of chicks are summarized in Table 18. We assumed that chicks which reached 18 days of age fledged successfully. Chick losses are mainly due to exposure, predation and falling off the ledges. Of the 183 chicks we monitored in our map areas, 21 were lost (or 11%). We know the fate of only 3 of these 21. Two were seen dead on the ledge, possibly due to exposure or disease. These chicks were both 18 days old. One chick was seen taken by a Glaucous Gull. Seven, or 33%, of the chicks lost were less than 6 days old. According to Tuck (1960), chicks are most vulnerable to exposure during their first 6 days. Of the chicks which died 38% were 7-12 days old, and 29% were 13-18 days old. After 30 August, the number of birds left on the cliffs began to decline, leaving the remaining chicks without the protection of many other birds. Chicks remaining late in the season are more vulnerable to predation. Six chicks which were not from a mapped area, were seen (dead) on the beach above the high tide mark on 29 August. They were eventually taken by Glaucous Gulls.

If 50% of the breeding pairs produced eggs, and there were approximately 20,000 breeding pairs at the Bluff Cliffs in 1977, then about 10,000 eggs could have been laid at the cliffs. According to our data about 42% of these eggs hatched, maybe 4,200 chicks, and of these maybe 3,700 fledged.

Feeding Behavior and Food Sources

Our data on food sources of murres is again limited but it indicates that prickleback (Lumpenus) is by far the primary food brought to chicks on the ledges. Murres are seen also with Sand Launce (Ammodytes), with a fish that was probably Saffron Cod, and with a species of Herring.

We often saw adult murres bringing fish to the cliffs in their bills. They would either swallow these fish or feed them to a mate or chick after a long period of standing beside their mate, bowing and looking away. Often the fish were left lying on the ledges. Murres bringing in a fish would sometimes be attacked by another murre attempting to steal it.

Several times adults were seen attempting to feed a chick that we knew had been lost. The adult would poke the fish down in front of another bird in an incubation posture, but would sooner or later usually drop the fish. This suggests that the parent had fed itself fully before bringing load to the young.

We saw murres, usually in small numbers, feeding in association with kittiwakes and puffins in "feeding mêlées". It was usually not possible to tell what sort of small fish the birds were feeding on, though they were probably Sand Launce (*Ammodytes*).These "mêlées" were observed at the base of the cliffs and as far as 1 or 2 miles offshore.

c. Other Species

Pelagic Cormorant and Glaucous Gull

The reproductive success of these two species is summarized in Table 19. Their approximate breeding phenology at Bluff is shown in Figure 18.

We followed five of 22 nests of cormorants to positive fledging. The others were checked until the chicks were well developed. The figure for fledgings in the first column of Table 19 is for those that positively fledged; the figure in the second column, is for the number of chicks seen at the last visit; we are assuming that these chicks fledged.

In the case of Glaucous Gulls, it was impossible to see some clutches because of obscured vision. The figure for eggs per nest is determined from known clutches and by assuming that the number of chicks that hatched in the other nests was equal to the number of eggs. In the second column, the fledging rate is calculated for all nests, including those that did not hatch, for which clutch sizes aren't known.

The impact of Glaucous Gulls as predators is discussed in the section on predators below.

Table 19. Reproduction of Pelagic Cormorants and Glaucous Gulls at Bluff Cliffs, 1977.

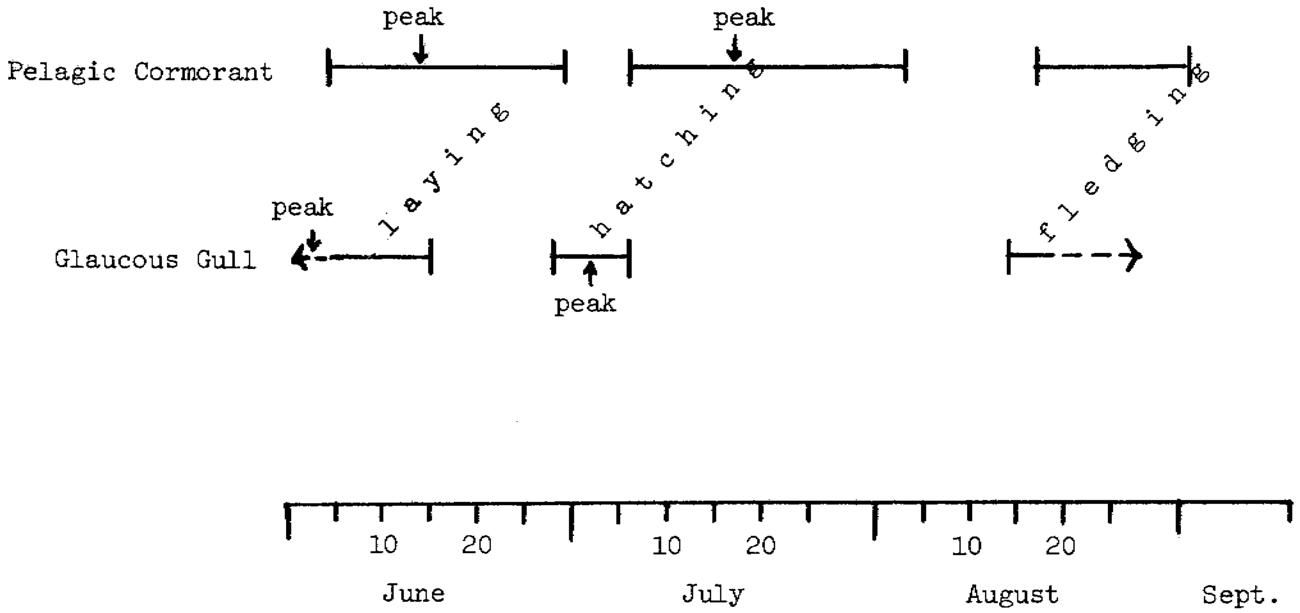
	Pelagic Cormorant	Glaucous Gull*					
		Bluff		Square Rock		All	
		prod.	all	prod.	all	prod.	all
no. nests monitored	22	6	13	5	9	11	21
eggs/nest	3.55	1.30					
chicks/egg	.78	.77					
chicks/nest	2.77	1.66	.92	2.2	1.22	1.91	1.05
fledge/egg	.67	.54					
fledge/chick	.86	.70	.66	.72	.73	.71	.70
fledge/nest	2.41	1.16	.62	1.6	.89	1.36	.73

*Data for Glaucous Gulls is separated by the nests that produced chicks and all nests that produced eggs for which clutch sizes are not known. Eggs per nest and chicks and fledglings per egg are shown for those nests whose clutch sizes are known, and assuming the number hatched = clutch size.

Clutch Size	no. nests with clutch Pelagic Cormorant	no. nests with clutch Glaucous Gull
1	0	2
2	3	8
3	9	6
4	7	
5	1	
6	1	

NOTE: The assumption that the number of chicks hatched = clutch size is arbitrary but may be misleading. Among Herring Gulls approximately 50% mortality occurs dueing a ten day period centered around hatching.

Figure 18. Breeding phenology of Pelagic Cormorants and Glaucous Gulls at Bluff, 1977.



Horned Puffin

Figure 19 shows the number of puffins counted from day to day at five study sites as a percent of the highest number counted at those stakes. It has been our experience at every colony we have worked in that the number of puffins from day to day and between weeks fluctuates widely. We have found that in general an on-shore wind will bring more puffins to the cliffs, but this is not always the case. We believe that most of these birds are nonbreeders, since they have no particular persistence at the cliff, and since many occupy ledges or boulders that do not have burrows near them.

Because of the inaccessibility of their nests, we have limited information on puffin reproduction. At Study Site 18 the five burrows in which eggs were visible from the top of the cliff were first seen to contain eggs on 1 July. Only two of these eggs hatched; the other three were noted missing on 9, 16 and 27 July respectively.

The chicks had hatched by 31 July. On that date, we removed one from its burrow. It still had its egg tooth, weighed roughly 60 grams, and its exposed culmen was 18mm long. Both chicks were noted gone from their burrows on 9 September.

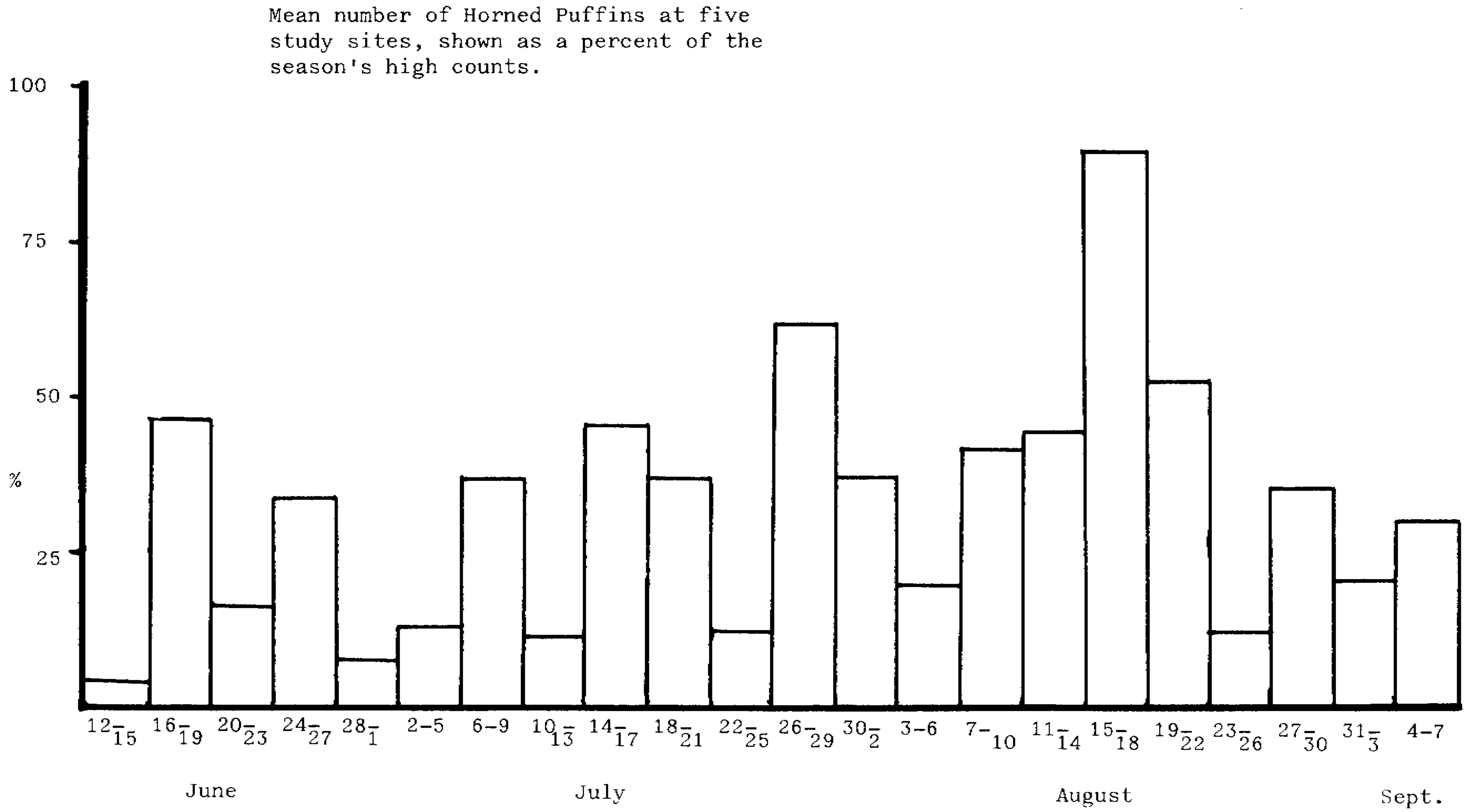
Tufted Puffin, Pigeon Guillemot, and Parakeet Auklet are present in low numbers at Bluff. Tufted Puffins are seen in suitable holes in the cliff, so we suspect that they do breed here. On 29 August an apparently flightless juvenile guillemot was found dying on the beach; this constitutes the first breeding record of the species inside Norton Sound. We counted a maximum of 36 Parakeet Auklets at Study Site 18 on 26 June and 40 on 10 August; a group of auklets was usually present at this site in the morning throughout the season, generally numbering around 20. They were most frequently seen in the water, but a few were occasionally perched at two places, one near the top of the cliff and another about one third of the way up, where there is dirt and broken rock. We do not know if they nested.

3. Other Localities in Norton Sound

a. Sledge Island

Sledge Island, is accessible in our small boats only on calm days. The owner of the one large boat for hire that we found in Nome would not go except on days when we could go just as easily in our small boat. Thus, Sledge continues to be a relatively difficult place to work. We had a party of two on the island on 21 to

Figure 19. Variation in numbers of Horned Puffins at the cliffs; Bluff, 1977.



24 June, and another party of two visited the island for one day on 23 August. The infrequency of our visits gives us limited data on reproductive success. We have used the data we have to calculate reproductive success in ways that will be comparable to data obtained on future short visits.

Table 20 summarizes reproductive success for murres, kittiwakes, and cormorants in 1977, and the method by which the figures were obtained.

Black-legged Kittiwakes reproduced about as well as they did at Bluff Cliffs. The data for murres do not allow us to make comparisons; however, our party counted more murres at Sledge in June of this year than we had ever counted there before. The figure for cormorants is made without knowing the number of chicks that had already fledged and left the nest. However, the second number provides a rough estimate for cormorant reproduction. In either case it is lower than the productivity at Topkok Head and Bluff, but possibly the same as or higher than productivity at Rocky Point.

b. Topkok Head and Rocky Point

We visited each of these colonies by boat twice.

Pelagic Cormorants - The best time to sample cormorant reproduction from the water is when the chicks are old enough to be upright and visible, but are not yet fledged. Stormy weather during two weeks in the middle of August kept us from visiting the colonies at the ideal time; by late August many juvenile cormorants were already in the water. It is difficult to distinguish fledged juveniles from adults when they fly away together at some distance from the boat. The figures for reproductive success (Table 21) are our best estimates. We have counts from late July, when not all chicks were visible, and counts from late August, when many chicks had fledged.

The higher estimate for reproductive success of the Topkok Head cormorants is close to that obtained at Bluff, but at Rocky Point our estimate shows productivity of only about half that at Bluff or Topkok. This may be an artifact of the data.

Glaucous Gulls - We were not able to see gull nests from the water at either locality, but we did census adults on both visits, and we counted airborne birds of the year on our August visits. We were able to count adults incubating in nests at Topkok during an airplane flight in late June. These data are summarized in Table 21.

Table 20. Estimates of reproductive success of cormorants, murres, and kittiwakes at Sledge Island, 1977.

Species	Estimated Reproductive Success chicks/nest	Data Used
Pelagic Cormorant	.76	counts at study sites: 42 chicks (August), 54 nests (June) (does not include fledged chicks that had left nests)
	1.6	censuses around island: roughly 160 birds of the year (August) roughly 100 nests (June)
Black-legged Kittiwake	.05	counts at study sites in August: 6 chicks, 122 nests
	.10-.15	count from boat of nests, chicks, and birds in brooding posture in August: 317 nests, 31 chicks, 17 "brooders"
Common Murre	.22	counts at study sites in August: 100 chicks, 450 pairs (900 adults)
	.18	study site 1: 425 pairs (max.adult count in June = 850) 75 chicks (max.count August)
Thick-billed Murre	.33	count at study site 2 in August: 7 chicks, 11 adults

Table 21. Estimates of reproductive success of Pelagic Cormorants and Glaucous Gulls at Rocky Point and Topkok Head, 1977.

	reproductive success chicks/nest		average brood size	
	Rocky Pt.	Topkok	Rocky Pt.	Topkok
Pelagic Cormorant	.81 - 1.2	1.04 - 2.4	2.1	1.6 (17 July)
Glaucous Gull	15 juveniles on 20 August - no nests seen	1.4*		

*31 birds of the year (22 August), 22 incubating adults counted from an airplane 15 June.

B. PREDATORS

There are two classes of predators at Bluff based on what they take; egg-chick predators, and predators of the adult birds. The egg-chick predators include the raven (*Corvus corax principalis*), Glaucous Gulls (*Larus hyperboreus*), and perhaps the Red Fox (*Vulpes fulva*), the Arctic Ground Squirrel (*Citellus parrvii*) and the Short-tailed Weasel (*Mustela erminea*). The predators on adults are the Golden Eagle (*Aquila chrysaetos*), the Peregrine Falcon (*Falco peregrinus*), the Gyrfalcon (*F. rusticolus*), and the Rough-legged Hawk (*Buteo lagopus*). These predators have varying effects on the murres and other seabirds depending on the extent and the timing of their predation.

Egg-chick predators

1. Ravens

a. Bluff birds

There were three active raven nests on and around the cliffs at Bluff (see Figure 20) and three inactive nests. Going from east to west, there was one nest at Square Rock that fledged three young. The next nest was on the Bluff Cliffs and was inactive. This nest was not noticed until July 24 and never showed any signs of use while we were there. It may have been used for a short time early in the season before we arrived at the cliffs. Ravens are known to have multiple nest sites that are used in successive years on a territory (Ratcliffe, 1962). This nest, however, looked new and was probably built this year. The next nest to the west was located near an old mine shaft, and was occupied by a pair that fledged four young. This nest was only 100 yards from a site used last year. Judging from this, and from the reports of the fidelity of ravens to their territories (Ratcliffe, 1962, Coombes, 1948), this is probably the same pair that nested nearby last year. Most of our 1977 data on ravens comes from the pair at this nest. Moving west to Study Site 7, there was a nest that had five eggs in it on May 24. On our next visit on 12 June, a raven flushed off the nest noisily and scolded us from a perch on the cliffs. We did not check the nest for eggs on that visit but the raven appeared to be incubating. When we returned again on the 15th of June, the nest had been abandoned and the eggs were gone. A fox or some other predator (another raven) may have stolen the eggs. However, even if the birds had eggs on 12 June, they may have been sterile since the other two nests had hatched their young almost three weeks before. Alternatively, this may have been a young pair that nested late, and were driven out by the more experienced pair from the east at the mine shaft. There was

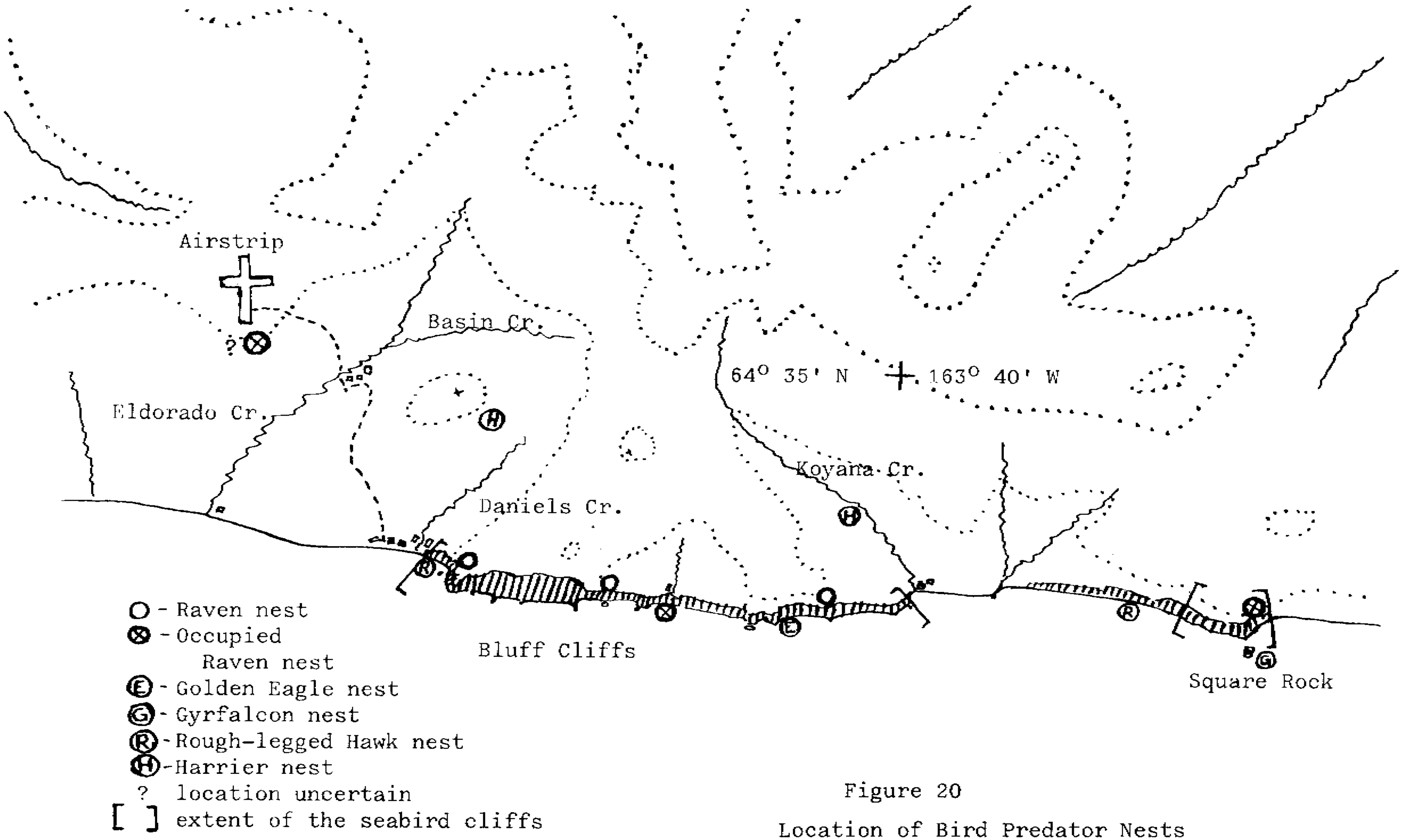


Figure 20

Location of Bird Predator Nests at Bluff Cliffs, 1977 one other nest built on the cliff near stake 2. On 24 May, melt water was dripping into the nest and adults were never seen to occupy this nest. Presumably it was abandoned when the snow started to melt. The third active nest was never found, but we deduced its presence from ,one, the persistent attendance of a pair of ravens at the west end of the cliff who regularly flew northwest carrying murre eggs, and two, the presence of a family of seven (5 chicks) later in the season in this same area of cliff and west along the beach beyond the cliffs. In 1975 a pair of ravens raised a brood of 4 young in a large wooden structure at the mouth of Daniels Creek, the western edge of the cliffs.

If we tentatively locate this undiscovered nest near the airstrip northwest of the mine camp at the west end of Bluff, the three active raven nests space out at about 3 mile intervals. Ravens are very territorial (Goodwin, 1976) and we saw frequent aerial "dog fights" between pairs of ravens on the east side of the high Bluff near stake 5. These were never injurious to either party, but both pairs eventually retreated in opposite directions. The evidence of regular spacing and territorial aggression both support the presence of another nest to the west. Ratcliffe (1962) has seen both boundary clashes and regular spacing in his British ravens.

There is also evidence from Britain that ravens nest in trees (Holyoak and Ratcliffe, 1968). Our unlocated nest is probably in a tree. The other nests are on the cliff and usually built underneath an overhang. The nest with melt dripping into it is an exception. This suggests that one function of an overhanging ledge as a nest site is to protect against the melting snow. The ravens build their nests and lay eggs before the snow has melted (see b. below).

The ravens at Bluff molted during the summer. Later in the season, this was a convenient way to tell adults from the fledged, fully feathered young. The primaries molted first starting with #1 and proceeding out to the end of the wing; the tail molted next and then the secondaries. The ravens were completing the molt of their secondaries through August.

b. Breeding season events

Period of eggs and nestlings

Goodwin (1976) reports an incubation period of 18-20 days for ravens in Germany. The mine shaft raven nest had small young on 24 May, and using Goodwin's incubation period, this means the eggs were laid during the end of April or the first week in May. Allowing one week for the construction of the nest, the fact that nests are completed one week before eggs are laid (Goodwin, op. cit.), means that the ravens were on their territories by early to middle April. These are approximate dates but illustrate the fact that the ravens start their breeding season at a time when the weather is foul; when blizzards and high winds are common.

Although we did not see the ravens hatch, we can infer from the 24 May observation of very new young in the nest hatching is around the end of the third week in May. The mine shaft raven chicks climbed out of their nests and up to the top of the cliff (25'-30' up) five to six weeks after hatching, on 28-29 June. They could not fly more than a couple of feet at this point but did use their wings for balance. A week later however, they were flying in earnest. This schedule is in rough agreement with Gwinner's (in Goodwin 1976) German birds who fledge at 6 weeks of age. The four young seen at Daniels Creed in 1975 were climbing but not yet flying on 3 July. An additional 2-3 weeks is needed to perfect their coordination in the air, and especially landing. They are very ungainly at first and seem prone to predation at this point (see below, for interaction with fox). The few days after the chicks climb out of the nest and walk around flightless at the cliff edge offers a good chance to net and band them. We managed to get only one this year before they could escape us.

Period immediately following fledging

We sat in a blind, and later in the open on the tundra, to watch feeding and daily habits of the raven family. The chicks could be told apart by the different patterns of black and flesh tones on the bill. The bill became solid black as the season progressed so the birds must be seen every two days or so to keep them straight over long periods. On June 21 the chicks were fed 28 times in 5 hours (5.8 feedings/hour) and each chick was fed about the same number of times. (The amount given each chick may have been different however. On 29 June, a four hour watch revealed a feeding rate of only 1.25 feedings/hour. One chick was not fed on either of those two days and was noticeably smaller than his three siblings. He was also the last one to leave the nest. The first three left the nest on July 29 and were on the cliff top on the 30, but the small one spent 3-4 days climbing to the top. One reason he was not fed was that the more active chicks were always higher on the cliff and begged louder and longer than he did. By mid-afternoon on the 30th, the bird stopped begging altogether and was apparently going to die. However, on 4 July, he had joined the others at the top and he subsequently progresed normally.

It may be evolutionarily expedient for the ravens to protect themselves against a season of sparse food supply by hatching their young asynchronously. Theoretically, in a poor season, the youngest, smallest chick, will die off first, leaving a family of more manageable size to rear. If the food supply is plentiful, all of the chicks may survive. Other factors besides food supply, such as the experience of the adults, may be compensated for in this way. This may be the situation for the ravens at Bluff. There are many reasons why the small chick was not being fed at the same rate as the others including size, amount of begging, position on the cliff, etc. but ultimately it may be because it is younger, having hatched later than all the others. There are conflicting reports on asynchronous hatching in ravens in the literature. Lockie (1955) states that ravens in Britain start incubating with egg-laying and the young hatch asynchronously. But Gwinner (in Goodwin, 1976) reports that the female raven sinks the eggs into the nest lining until incubation begins.

All four chicks survived however, and rapidly began to increase the area along the cliff edge that they used. By July 9, the chicks were very persistent in their begging and began to follow the adults as they left after a feed. The chicks began to fly down to the cliff ledges and land beside the adults as they take murre eggs, and even eat the eggs directly from the shells after the adult has broken them open. Also, the adults were observed to fly low over the chicks with food in their bill and fly off inland. The chicks responded by begging loudly and taking off after the adult, but following it for only about 20 feet and then landing. By the 16th of July, the family abandoned the cliff edge as the center of activity and ranged inland over the tundra. They now spend nights away from the cliff also. It is difficult to tell whether the chicks initiate this change with eager begging or the adults do so by encouraging them to follow. Both of these behavior patterns occur together and lead to the expansion of the chick's range. During this stage, the chicks' voices change. They develop a hoarse "crawl", deeper in tone than their juvenile screams.

Period of free flying young, flocking.

Around the first of August, the chicks are seen hunting alone, or in pairs, on the cliff. This is the time that we saw the family of seven (5 chicks, 2 adults) come in from the west, confirming our hunch that there was a nesting pair west of the seabird cliffs. At this same date, strange ravens begin to move through the area, most of them coming from the east. At first they were just additions to the two families making flocks of 8 to 10 which would shortly split up presumably into the family group and the interlopers. These intruders were mostly chicks, identified by their new set of feathers and were not treated with any aggression by the residents. As the month progressed, the size of the flocks became larger, culminating with a flock of 40-50 seen in early September. After the first week in August the mine shaft family was not seen together, or at least could not be identified as such though it may have been part of a larger group. Loose flocks of 8-15 were the rule during most of August at Bluff. During any one short observation of these flocks, pairs are apparent; but if a pair is followed for a length of time (~ 15 min.), it may not remain together. Perhaps the ravens tend to interact in a pairwise fashion within the flock. Coombes (1948) reports that some birds within his <u>nonbreeding</u> flocks "seem to be paired".

Several ravens were seen carrying both murre and kittiwake chicks during August. In 1975, a flock of 25-30 was seen around a walrus carcass. Thus, these late season flocks we see may congregate at the concentration of food found at the cliffs. However, none of the flocks that we saw appeared to be hunting; they were playing in the updrafts created by the high cliffs. Again, we did not see territorial aggression against these birds by the resident breeders, as we did between pairs of breeders.

Coombes (op. cit.) reports the existence of "floating flocks" of ravens during the breeding season in Britain. These flocks are nonbreeders that wander about the hills loafing for the most part, but hunting occasionally and roosting together at night. Coombes postulates that these birds are breeding surplus that stay in a flock for a few years before breeding. Ratcliffe (1962) also postulates a breeding surplus based on the rapidity with which birds that lose their mates find a new one. The flocks we see may also be breeding surplus. Our identification of most of them as birds of the year based on plumage could be faulty since nonbreeding adults may have a different molt schedule than breeders. We never saw signs of these flocks earlier in the season than August at the cliff, or on our few excursions inland, and we have seen them every year at the same time. This suggests that they may be juveniles who are dispersing away from their nests. However, Goodwin (1976) states that chicks "remain more or less under parental care for 5½-6 months". The evidence we have does not support this, but we could not follow the mine shaft family beyond the first week in August.

c. Diet

Ravens are ravenous omnivores. They eat Arctic Ground Squirrel, Tundra Hare (<u>Lepus othus</u>), small passerines, and the eggs of all the seabirds on the cliff; puffins, murres, kittiwakes, Pelagic Comorants, and even Glaucous Gulls. They will eat carrion including dead walrus and seals, and murres that the Golden Eagle has killed. Blueberries and probably other plant materials are eaten as well. The ravens carry food in their beak or in their feet and sometimes switch from foot to beak to opposite foot while flying. They also have a gular pouch that they use to carry food to their young.

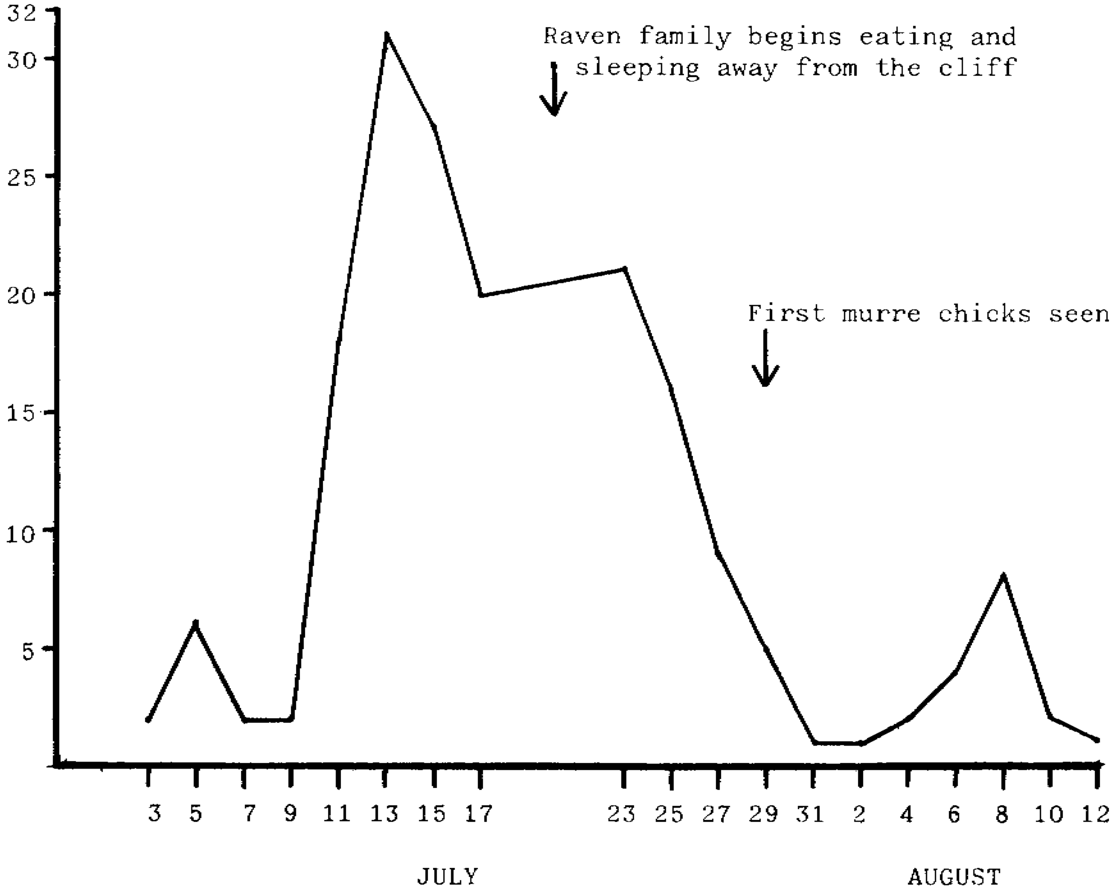
Early in the breeding season the ravens hunt on the tundra and take mostly Tundra Hares and ground squirrels. They are known to cache food (Goodwin, 1976) and they may do so at Bluff. Often the adult raven was observed to fly to specific spots on the tundra in between feeding the chicks. No food cache was ever found however. In the middle of the breeding season, starting around the first of July, murre eggs become a large percentage of their diet. As we walked along the cliff top, we recorded and then crushed egg shells each time we passed and from this can calculate a rough histogram of frequency of egg predation through the summer (see Figure 21). The ravens ate most of their eggs within 50' of the cliff edge usually on an exposed patch of tundra. They also frequently flew inland with eggs, thus the histogramis not a full measure of predation. Egg predation dropped off around the time when the raven family moved away from the cliff to hunt inland, as would be expected. This curve also roughly follows the egg-laying curve for the murres. Later in the season, the cliff was still being exploited, but to a smaller extent than during mid-season.

d. Effect on murres

The total egg production for the murres this season was on the order of 10,000. We crushed a total of 275 eggshells and assuming that this figure is about half of the total number of eggs taken by ravens, then the ravens tood 5-6% of the murre egg production. However, the ravens are the first ones to find murre eggs. We usually see a raven carrying a murre egg 3-4 days before we see eggs on the cliff. Thus, because they are looking hard for the eggs to appear they trim off the ones laid early. This may constitute a pressure on the murres for synchrony of egg production within the colony of murres. The female murre has a very loud "pa-daahh!" call that is given during copulation, and this advertisement may be a mechanism for colony breeding synchrony. More evidence is needed to substantiate the function of this call and the effect of raven predation on the eggs. Also, the raven takes some murre chicks in August but this was observed very infrequently relative to egg predation.

Eggs and chicks are most often taken from lone murres. The raven's strategy is to land on a ledge with a lone murre and try to push it off its egg. Usually both birds go tumbling off the cliff and the more agile raven can turn right back and grab the egg while the murre is taking 400 years to circle back. Murres are hefty and

Figure 21. Number of eggshells found and crushed on the cliff top at Bluff, 1977



have sharp beaks and they can defend the egg if they hold their ground, but often they fall off the cliff trying to do so. Some egg loss occurs when eggs are knocked off the cliff during these fights. It is interesting and probably significant that when even a single murre chick remains on a ledge in September, 10-20 adult murres cluster on the ledge or near to it. If a late nester still had a chick after his neighbor's chicks had jumped and all the "associated" birds had left also, the chick would be especially vulnerable. Even so, late nesters are more likely to be preyed upon than early nesters so ravens may exert some pressure on the timing of the breeding season at the end as well as at the beginning.

e. Interactions with other seabird predators

One of the most conspicuous of events at Bluff were the aerial "dog fights" between the raven and the Golden Eagle. Both birds were seen to initiate these fights and neither was consistently the victor. Most fights seemed to dissipate without a winner being established. The eagle and the raven overlap in diet (Arctic Ground Squirrel, Tundra Hares and carrion) and may compete in this way. The adult ravens stole from the eagle chick after it fledged and was being fed on the tundra (see below). One day, even the raven chicks tried to move the eaglet off a dead murre. The adult eagle protected the eaglet by diving at the ravens.

The eagle-raven antagonism may also reflect the fact that the eagle is a casual predator of the raven. A raven chick was found killed above the eagle nest and eviscerated in typical eagle fashion on 11 August. This was probably one of the ravens from the flocks moving through, since the resident ravens were very aware of the eagle's presence. Eagles are said to be "dominant competitors" of ravens in Britain where they have been observed to displace ravens from their breeding cliffs (Holyoak and Ratcliffe, 1968).

Ravens also had occasional encounters with foxes. A pair of Red Fox was very visible all summer at Bluff. They were seen walking along the edge of the cliff on June 30 the day after the raven chicks climbed out of the nest. The adult ravens stood their ground while the chicks climbed down the cliff. The adult erected every feather on its body, the tail was spread and held up and the wrists were held down and out, with the tips of the primaries on the ground - an impressive show of force. The fox came within 6 feet of this raven and backed off as the raven made short lunges at him. The raven bounced around and often pecked at the ground, reminiscent of grass-pulling in gulls, during this display. The fox may have taken the eggs from the raven nest at Study Site 7.

There were only rare antagonistic encounters with Glaucous Gulls. Gulls chased raven chicks a few times when the chick was first starting to hunt the cliff alone. Glaucous Gulls were also somewhat parasitic on hunting ravens. A Glaucous Gull is not able to move a murre off its egg and often waited until a raven had done so and then stole the murre egg. The ravens were seen eating a Glaucous Gull egg early in the season; their relationship is not a simple one. The Gyrfalcons at Square Rock (see below) sometimes harassed the Square Rock ravens. A raven was once seen to chase a Peregrine at the Bluff Cliffs.

The raven's diet overlapped with other raptors somewhat depending on the predator and the season. But the most aggressive interactions were with the Golden Eagle who is a cometimes predator of the raven.

2. Glaucous Gulls

a. Bluff birds

There are three age classes of gulls at Bluff that are easily distinguishable early in the season; 1st year birds (pink-beige plumage), 2nd year birds (all white plumage), and adults. As birds in subadult plumages both molt they become harder to distinguish as the season progresses.

There are around 20 breeding pairs at Bluff. When we arrived in late May, they had set up and were definding territories. Eggs were laid around the 10th of June and they hatched between the 8th-12th of July. We had a mixed Herring Full-Glaucous pair at the Bluff Cliffs which produced offspring this year. At the west side of Rocky Point, we observed a Slatybacked Gull (Larus shistisagus) apparently holding a territory, but no nest was seen.

b. Diet and effect on murres

Glaucous Gulls are omniverous. They eat fish, (commonly robbing kittiwakes in feeding melées), carrion from dead seals and walrus washed up on the beach, blueberries, kittiwake chicks, and murre eggs and chicks.

In general, they are unable to move a murre off its egg so they rely on disturbances at the cliff that scare the murres away and then they steal eggs. Their habit of parasitizing a raven's hunting efforts was described above. They also take eggs when an airplane flies close to the cliff or when we go close to the cliff in our outboard. The gulls follow our boat along the cliff during a cliff census, taking eggs from each newly disturbed section of cliff. Thus, Glaucous Gulls are opportunistic hunters of the cliff. Their standard hunting strategy is to soar along the edge of the cliff until they spot an unattended egg and then swoop down on it. They take the egg off to another ledge on the cliff (rarely up to the cliff edge) and either swallow it whole or peck a hole in it and scoop up the contents.

The amount of predation that the Glaucous Gulls do on murre eggs and brooded chicks is dependent on the amount of disturbance of the murres and the number of gulls around the cliff. (Gulls from Rocky Point may come this far west to hunt the Bluff Cliffs.) Glaucous Gulls do consistent damage to the murre's reproductive effort at the time when the chicks jump off the cliff into the water. If a chick lands in the water and is not immediately joined by an adult, the chick stands a good chance of being eaten by a glaucous gull. An adult murre can defend the chick in the water against Glaucous Gulls. It is very difficult to see the jumping murre chicks since they prefer to jump at dusk. Thus, an estimate of the rate of predation by gulls on jumping chicks is difficult to get.

We made some observations on the jumping of murre chicks on six nights in September of 1975. During that period our set of observations recorded 38 chicks jumping and four taken by Glaucous Gulls. We saw gulls carrying three other chicks in the same cove in the same period. It is dangerous to generalize from this small sample, but at the time we suggested that very few murre chicks jumped unaccompanied by an adult, perhaps one in 10-15. We estimated that gulls took about one in three of the chicks which jumped alone, which includes those we saw on the water. According to our observations at that time, even the chicks which jump off the ledge alone are soon joined by an adult from the groups of adults which loiter at the foot of the cliffs. We have described the behavior of those birds elsewhere.

The Glaucous Gulls which were hunting murre chicks defended sections of the water at the foot of the cliffs, each occupying a shallow cove. In this way the gulls spaced themselves out so that fewer than thirty gulls were effectively hunting chicks. We estimated in 1975 that gulls might take 2000 chicks a year under conditions favorable to the gulls.

3. Other Egg-chick Predators

Foxes can reach only a few of the ledges that murres nest on by climbing down from the top since the cliff is generally sheer. A fox has been seen only once down on the cliff so he is surely not a heavy egg-chick predator. Arctic Ground Squirrels and Short-tailed Weasels will eat eggs but no evidence of predation on murres by these animals has been observed. In 1976 we saw an Arctic Ground Squirrel (Sik-sik) working up and down a steep slope close to where a Horned Puffin carried food to a crevice at Study Site 7. It may be that ground squirrels destroy eggs in puffin burrows near the tops of the cliffs.

Predators on adults

1. Golden Eagle

The most spectacular predator at the cliff is the eagle when he folds his wings and plummets with amazing acceleration into a flock of kittiwakes which scatter in all directions. There was one pair nesting at Bluff, another at Rocky Point and perhaps a third at Topkok, making 3 pairs in about 30 miles of coastline.

The Bluff pair were very mottled, both male and female, and we were able to tell them apart by their white markings. Their nest was 100' or so from last year's and, about halfway up a 150' cliff. The nest, a huge bunch of twigs, was apparently built this year. The eagles hatched two chicks but only fledged one. The first one died fairly early in its life. The surviving chick was well feathered on the 27th of June, with only a few tufts of down left on its head. The eagles were very wary of us at this time of the year so we were reluctant to disturb them. On the 17th of July, the chick, now fully feathered, was seen in the nest but he was probably already flying. On July 24, he had definitely fledged. After the time of fledging, the adults became more tame but the chick was very wary.

The Golden Eagles at Bluff took many different kinds of prey. One day's walk along the cliff edge passing all of the eagles' eating perches revealed the carcasses of 3 Tundra Hares, 1 ground squirrel, 14 murres and 1 kittiwake. There were also twelve spots of feathers on the tundra indicating twelve murres had been recently eaten. This tally can suggest only the range of food items taken and a crude relative frequency. If the eagles took five birds per day per bird for three months, the total is 1350 murres taken by eagles in a season. This is an inconsequential 2% of the population of 50,000 to 60,000 murres. The predation rate was nowhere near as high as 15 birds per day. (Eagles also take an occasional raven, (see above), and may take ptarmigan.)

II. Gyrfalcon

The other major predator on the adult murres at Bluff was the resident pair of Gyrfalcons. Their nest was at Square Rock and hatched two chicks but only fledged one this year. The adults were very wary and were not often seen. The nest was inaccessible so we could not inspect the remains of prey there. We did find one or two feeding perches where ptarmigan remains were always evident. One day, we saw the Gyrfalcon below the main cliffs at Bluff standing on a freshly killed murre on the beach. It is difficult to measure the rate of the Gyrfalcon predation on the murres. They do take some but we only rarely saw them at the cliffs and we most often saw the adults flying north towards the interior or coming from that direction. This gyr pair probably takes about half murres and half inland species, especially ptarmigan. Cade (1960) reports that the gyr population in Alaska is divided into two groups with the coastal group taking seabirds and waterfowl almost exclusively, and supplementing their diet with inland prey (ptarmigan and ground squirrels) if they are locally abundant.

Cade also reports that the Golden Eagle and Gyrfalcon are competitors and the gyrs "fear and hate Golden Eagle with equal intensity". We never saw any interactions between the gyr and the eagle. The Gyrfalcon was observed diving at the ravens, however, that were nesting not more than 100 yards from the gyr nest.

3. Rough-legged hawk

There were two breeding pairs of rough-legs at Bluff. One at the west end of the cliff laid 3 eggs, hatched 2 young, but fledged only one. The second young was almost certainly eaten by another family member judging from the presence of the talons and leg bones of the chick in the nest on the 19th of July. The same eating of a younger by an older chick happened in 1975. The second nest was on the cliffs near Square Rock. This pair hatched and fledged two chicks on August 7.

The rough-legs were eating small rodents and Tundra Hare for the most part judging from the remains visible in the nest. The Square Rock pair also took puffins. We often saw one or two pairs of red feet and some colored bills lying around the nest. The nest was placed on a section of cliff where there was a large number of nesting puffins. Puffin remains were not seen at the nest on the west end of Bluff, although that area also has a large population of puffins.

4. Other predators

A Peregrine Falcon was seen occasionally, roving along the edge of the cliff. He probably took a few murres but did not nest at Bluff this year. The pair of Red Foxes probably could not catch adult murres but may be able to get puffins as they come out of their burrow.

There were 2 families of harriers, one in Koyana Creek and one in Daniels Creek, fledging 4 and 5 young respectively. Also, a Long-tailed Jaeger nested on the tundra nearby. This pair fledged one chick. These two predator species did not take seabirds, but may have competed for rodents with the seabird predators who took rodents: i.e. the ravens, Gyrfalcons, and Rough-legged Hawks.

C. WATERFOWL

1. Spring migration.

We arrived in the field in spring of 1977 while most of the southern Seward Peninsula was still under snow,and made flights between Nome and Point Spencer, and between Nome and Bluff. Waterfowl gathered in the first pieces of open water, usually the mouths of rivers whether they were emptying into the sea or into a lagoon. These were the Woolley Lagoons, lagoons between Nome and Cape Nome, the lower reaches of the Flambeau and Eldorado Rivers, and where Pine Creek empties into the lagoons between Bonanza River and Taylor Lagoon. In addition water collected in a number of temporary ponds where creeks or rivers in spring freshet overwhelmed the capacity of the road culverts.

While most of the sea was frozen, ducks such as Oldsquaws, Red-breasted Mergansers, and Black Scoters were to be found in the fresh water lagoons behind the sea beaches. Harlequin Ducks and Common and King Eiders were not seen on such fresh water.

By early June it was clear that 1977 was an unusual year for waterfowl on the southern shore of the Seward Peninsula. Species seldom seen in the area such as Lesser Scaup were seen in small ponds east of Nome, and Mallards and Redheads were seen in the rivers and lagoons around Safety Lagoon. By the middle of the month exceptionally large numbers of Pintails and Shovellers appeared in the lower reaches of Flambeau River, at Bonanza and Taylor Lagoon and at the head of Golovin Bay. The numbers of Canvasbacks did not seem to be unusually large. We saw one bird that appeared to be a Trumpeter Swan.

After talking with R. Jones on the Yukon Delta who reported an influx of Pintail there and remarked that the birds did not seem to be breeding, we surveyed the 'prairie ducks' to see whether this was also true in our area, in the course of air travel planned for other purposes. Our observations indicated that the 'extra' ducks were virtually all still in mixed flocks of males and females on the open water where ducks gather on migration. The Pintails on smaller ponds away from the coast were nearly all single males, and this observation applied all the way to the north end of the Kougarok Road. In late June we did see 3 broods of Pintails on ponds in mine tailings. Each brood had 5 ducklings. The Shovellers, Mallards and Redheads seemed to follow the same generalization as did the Canvasbacks in Taylor Lagoon, although the Canvasbacks in the flats west of the Flambeau River seemed to be breeding. We interpret these observations as being consistant with the idea that the 'prairie waterfowl', which had extended their spring migration to the northwest because of drought in the northern prairies, did not breed in our area.

2. Fall migration

The fall migration is usually first indicated by the gathering of waterfowl in the salt marshes at the lower reaches of rivers such as the Bonanza on the east end of Safety Lagoon. Martin Olson commented that the 'Sprigs' (Pintail) gathered there unusually early and in especially large numbers in 1977. Martin has lived near the Bonanza River for more than thirty years. We did not have sufficiently regular flights over the area to be confident, but our experience suggests that a movement of Pintails began in late July, built up to a peak in middle August and moved out about August 20-25. This movement may have been local, however, because we found large numbers of Pintails on the mudfalts at the mouths of the Fish River, Kwik River and Koyuk-Inglutalik Rivers at 'low tide' between August 26 and 31. Furthermore we noticed that if we surveyed a large group of ducks closely on our way to Nome, when we came back three hours later the ducks had dispersed. Our surveys were made over several days and we do not think that this effect has influenced our counts.

3. Distribution of waterfowl gathering areas over the southern part of the Seward Peninsula

Between August 26 and August 31 we flew waterfowl census flights over the area between Point Spencer in the northwest and Shaktoolik in the southeast. In 1977 we flew census flights over the flats north of Imuruk Basin, up river past Mary's Igloo and across the divide and down the Niukliuk River, over the Fish River flats and (as in previous years) over the flats around the lower Fish River south of White Mountain. The distribution of waterfowl was as follows:

Sparse numbers (most ponds empty, few birds on ponds and small lakes): on the coastal tundra west and northwest of Nome; over most of the flats east of the Imuruk Basin, in the tundra ponds back of the coast southwest of White Mountain; in the tundra ponds in back of the coast along the Kwik River, Koyuk River and between the Inglutalik River and Cape Denbigh.

Moderate numbers (several ponds with flocks of tens of waterfowl, most ponds empty): at the base of Cape Spencer, around the Wooley Lagoons near to the Kuzitrin River (in the lower flats east of the Imuruk Basin); in the tundra ponds along the coast from Cape Wooley to Sinuk and along Safety and Taylor Lagoons.

Large numbers (flocks of hundreds or thousands): in the lower Flambeau River; the lower Bonanza River; at Golovin Lagoon and on the mudflats at the mouth of the Fish River; at the mouth of the Kwik River and behind Moses Point; at the mouths of the Koyuk River and the Inglutalik River.

The areas inland and those to the northwest of Nome were censused in the course of a general survey. The coastal areas including Safety Lagoon and the coast to the east were censused in detail. In this entire area during the period of August 26-31 we counted, in order of frequency:

Pintail	28,000
Canada Goose	15,000
Baldpate	2,500
Whistling Swan	1,350
Greater Scaup	1,050
Green-winged Teal	210
Mallard	150
Lesser Scaup	30
Shoveller	8
Canvasback	8
Redhead	4
Sandhill Crane	400
Long-billed Dowitcher	1,300
Whimbrel	1,800

These same areas, except for the inland areas along Imuruk River, Kuzutrin River and Niukluk River, were flown looking for waterfowl in 1976. Our experience in both years is consistent with what Jim King of the U.S. Fish and Wildlife Service told us in 1975, that in general, productive waterfowl habitat decreases progressively as one goes northwest from Safety Lagoon. (See Figure 22)

The techniques used in taking these censuses, the areas censused and graphs of the relative frequencies of species within areas are shown in the 1976 report. The graphs on Figure 22 represent our best estimates of total numbers of birds within the designated areas.(As opposed to number of birds seen per minute of transect as was done in 1976.) Other than the noticeably high numbers, our observations for 1977 agree with those of 1976. Table 22 shows the August 1977 data in tabular form.

Figure 22. (On next page) Major coastal waterfowl habitat areas.

From right to left (east to west) on the following map, the outlined areas of major waterfowl habitat are:

--the base of Cape Spencer

--the Wooley Lagoons

--Cape Wooley to Sinuk

--Flambeau River to Bonanza River

--Bonanza River to Taylor Lagoon

--the Fish River flats

--Golovin Lagoon

--Moses Point to the Kwik River

--Koyuk River to the Inglutalik River

--the flats behind Cape Denbigh and Shaktoolik

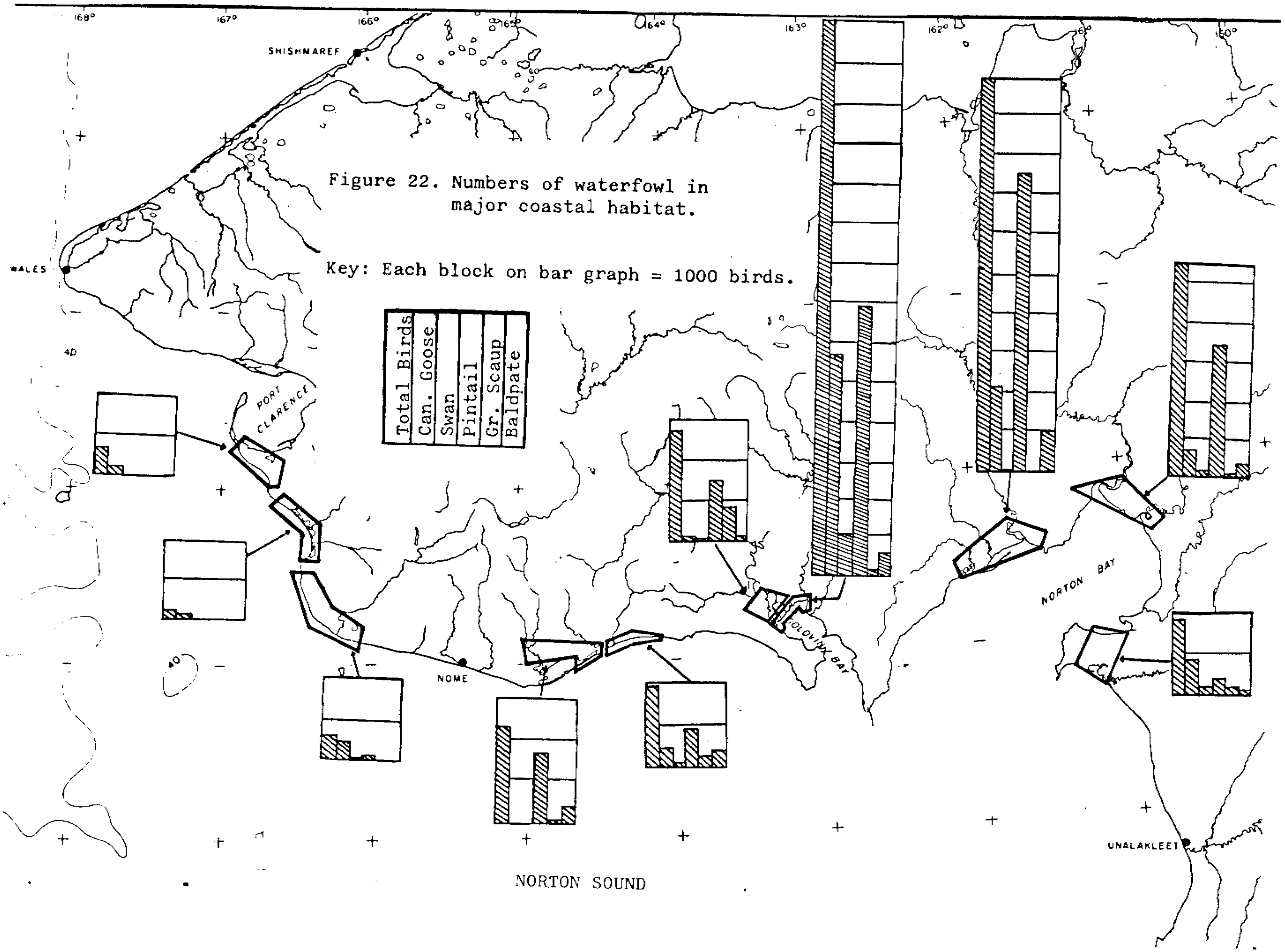


Figure 22. Numbers of waterfowl in major coastal habitat.

Key: Each block on bar graph = 1000 birds.

Table 22. 1977 Waterfowl censuscs.

Area	All Species	Canada Goose	Whistling Swan	Pintail	Greater Scaup	Baldpate
Base of Cape Spencer	650	200	6			
Wooley Lagoons	132	106				
Cape Wooley to Sinuk	570	347	16	56		
Flambeau River to Bonanza River	2351	2		1808	40	314
Bonanza River to Taylor Lagoon	1950	375	57	905	245	380
Fish River Flats	2753	87	35	1430	880	140
Golovin Lagoon	14,000	5620	1050	6940	105	573
Moses Point	9021	1630	25	7516	2	1093
Koyuk to Inglutalik River	5475	719	149	3415	256	302
Cape Denbigh Flats, Shaktoolik River Flats	1758	854	118	343	73	60
Totals	38,660	9940	1456	22413	1601	2862

4. Reproductive success of Whistling Swans

Young cygnets stay with their parents until they fledge. The young can be identified by their brown or usually gray plumage. During aerial surveys we counted the numbers of swans in flocks and recorded each single or pair of adults on the tundra ponds. For each family group we recorded the number of adults and young.

Flocks of swans which we regularly saw at the same place, such as the western part of Taylor Lagoon,were not included in our estimates of reproductive success. For the sake of our calculations, we assumed that all single birds or pairs seen on tundra ponds represented breeding pairs that had failed and that all groups of three or more without young were nonbreeding individuals.

The total reproductive success for 1977 between Teller and Shaktoolik was 1.4 young per pair. This compares to total success of 1.5 in 1976.

In 1975 we censused only the area northwest of Nome and found a reproductive success of 0.9 for 49 pairs and 43 young. In 1977 in this area we found only 15 pairs, but they had 8 young for a success of 0.5. In 1977, east of Nome we found 39 pairs of swans and 69 young, for a rate of success of 1.8.

VII & VIII. DISCUSSION AND CONCLUSIONS

The bird cliffs at Bluff have special advantages for detailed study of seabird biology. These advantages include convenient logistical support; comfortable, though primitive, living facilities; ease of access to study sites, excellent visibility of sections of the cliff from the cliff top; and,dependably good weather. Although there appears to be a conflict between the Native Land Claims and Federal requests under 'd-2' lands, the political situation appears to be very favorable for continued study. The cliffs are less ideal for other aspects of OCSEAP work. The seabirds nesting at the Bluff Cliffs are not typical of the northern Bering Sea in that the murres are more than 99% Common Murres whereas the general proportion is 50% or more Thick-billed Murres. Moreover virtually no auklets nest at Bluff and auklets are a major component of the northern Bering Seabird fauna. The cliffs are high and precipitous and because of the effect of storm waves, few birds nest near the base of the cliffs. This makes it hard to get access to nests in order to weigh nestlings or to band adults or young.

We have used our time at Bluff first to record the species using the area, their comings and goings and the breeding biology of those species accessible to continuous studies. These studies have turned into a systematic search for techniques which will be useable for gathering key biological data at colonies which are less accessible and to which students will be able to pay only short visits. With this in mind we have concentrated on detailed studies of the breeding biology of murres and kittiwakes in order to determine when and how to estimate the numbers of birds nesting on cliffs as well as when and how to measure reproductive success.

A. Techniques for measuring biological characteristics

1. Censusing. It is necessary to recognize that the numbers of the birds at the cliffs are in flux. Numbers vary widely according to the hour of the day and the day of the year. At the Bluff Cliffs we have counted 10,400 murres and 92,000 murres, almost an order of magnitude difference. An additional problem is that it is not clear which counts represent "the population". Apparently competition for nesting sites is intense and as a result many birds which come to the cliff are not able to establish a breeding territory. Moreover, some birds that are able to assert themselves and establish a site do not succeed in laying eggs. It is not clear at any given seabird cliff without detailed study what proportion of the birds present are in these two categories, which are excluded from traditional systems of measuring reproductive success.

It appears however that there are ways by which one can identify the main element of breeding birds. When the birds first come back in the spring, most of the population, including 'nonbreeders' arrive at the cliffs; in the weeks just before laying of eggs, many birds may leave and spend the time at sea. During the height of the egg-laying period only the highly motivated birds are present. That seems to be the time when one can make the most direct counts of the breeding population. Toward the end of the incubation period and when the young are in the nest an increase of birds at the cliffs becomes evident and another peak in counts occurs.

The numbers of birds at the cliffs also varies with time of day. The high and low counts vary between regions and may show marked contrast even between cliffs that are near to each other as our comparisons of numbers of murres between Bluff (Study Site 14/15) and Square Rock (Study Site 19/ Sq.Rk.) showed during June in 1977. Once eggs have been laid the peak numbers usually are present in the late evening.

Optimal times for censusing breeding adults:

There is ample evidence for murres and kittiwakes at Bluff, that the number of birds present at the peak of laying is closest to the number of birds attempting to breed. However, our three years of study have shown that the peak of laying may shift between "good" years for reproduction (1975) and poorer years (1976, 1977). The delay presumably reflects the environmental stress to which the birds are subject that causes their poor reproduction. Springer and Roseneau (NOAA 1978) found the laying peak of kittiwakes in the Cape Thomson area, where the birds have been experiencing similar low reproductive success, to be later than during the prosperous years of the late 1950's (Schwartz 1960). However, counts taken in the first week of July should be close to the laying peak for both murres and kittiwakes.

There does not seem to be any suitable single time for counting Horned Puffins because their numbers at the cliffs are so erratic (Figure 19). Even a count at the peak of laying may not deal with true breeding birds because the breeders may for the most part be inside their nest hole.

Counts of Glaucous Gulls and Pelagic Cormorants are best made when clutches have been completed and the birds are incubating. In the case of cormorants, late June is ideal; for Glaucous Gulls, most clutches are complete in early to mid-June.

Any single count of cliff-nesting seabirds will be affected by the circadian variation in attendance at the cliff, which evidently shifts over the course of the season, and by the seasonal variation in numbers of birds at the cliff, which apparently changes depending on the relative breeding success the birds are experiencing. It is necessary to make studies comparing variations within and between years in order to establish the range of variation within which single censuses fall. Studies made in England show that it is advisable to make several (a minimum of five) counts to encompass unpredicted variation. (Lloyd 1975)

2. Measuring reproductive success. We have found that the number of birds regularly resorting to the cliffs during the egg-laying period is a good indication of the total of breeding birds among murres and kittiwakes.

It is possible to make some additional tests with murres: a) a certain number of birds take on an 'incubating posture' (illustrated in report for 1976). Although this number of birds is much

higher than the number of eggs laid, the number appears to be close to the number of breeding birds i.e. twice the number of pairs.
b) During counts of the bird cliffs in July made from a boat, a certain proportion of birds fly off the cliffs as a boat approaches. If these "fliers" are omitted and only the birds which persist on the cliff are counted one gets a number which, again, is close to the total number of all breeding birds. It is worthwhile noting that during the years 1975-1977, there was an approximate correlation between the percent of "fliers" vs. "persistent" birds and the degree of reproductive success.

Among kittiwakes there is an arbitrary standard for inclusion of a pair of birds among the breeding population; which is those birds who build a nest which contains a substantial amount of material. Even though as many as 60% of these birds may not lay eggs in such nests, and as high as 20% may 'incubate' empty nests or eggs that have failed to hatch, this count gives a figure that can be used to make comparisons between areas and between years.

Our studies suggest that the best time for counting the number of murre and kittiwake chicks on sample areas of the cliffs is in the last two weeks of August. At this time kittiwake chicks are large and stand apart from their parents as do those of murres. The kittiwake chicks are large and distinctive enough to be counted from a boat before the cliffs, but the murre chicks must be counted from sites at which a detailed examination of each bird on the length of a study ledge can be made. The best time to count chicks of Cormorants and Glaucous Gulls is between 10 and 20 August.

We have identified age classes for chicks, which will allow the observer to establish within approximately 4 days the date of hatching, even on only one visit, provided a good sample of chicks is seen.

Our studies also suggest that it may be possible to predict whether a reproductive catastrophe is in progress by counts of the numbers of birds which stay at the ledges during the midnight or midday hours in the middle of July. During the years when reproductive success has been low many birds left the cliffs in the early hours of the morning even though they had eggs.

3. Food. The reproductive success of kittiwakes and murres has varied in similar ways between the three years of our study, and the birds seem to be affected similarly by an apparent shortage of food in Norton Sound even though the food which the two species use appears to be different. The items which Common Murres bring to the cliffs are almost entirely Prickle-backs even when there are large schools of Sand Launce close in front of the cliffs. Kittiwakes do not seem to use Prickle-backs presumably because they are bottom fish.

When a large school of Sand Launce is found, kittiwakes gather in a feeding mêlée and puffins rush to join; some murres are occasionally attracted too. One seldom sees murres bringing Sand Launce to their chicks, however.

Kittiwake reproductive performance, as noted in the section on Current State of Knowledge, seems to be closely correlated with the appearance of Sand Launce in the area and hence in their diet. Sanger, Gill and Moe suggested that Sand Launce is important in the Kodiak area even though kittiwakes there feed consistently on Capelin. Springer and Roseneau's (NOAA 1978) observations at Cape Lisburne and Cape Thompson most closely resemble ours. They saw almost no Sand Launce in the year of reproductive disaster, 1976. During 1977, when kittiwakes in their area did moderately well, they saw kittiwakes commuting many miles to feed on Sand Launce, found Sand Launce to be conspicuous in the stomachs of birds they collected, and saw the black masses of Sand Launce move southward past the cliffs followed by the feeding flocks of kittiwakes. In our own experience in 1975, which was a good year for kittiwakes, we saw feeding mêlées of kittiwakes and puffins first off Sledge Island in late June then, further east off Safety Lagoon in mid-July, then off the Bluff Cliffs in August. Kittiwakes commuted to the mêlées and brought Sand Launce back to regurgitate to their chicks. Nearly all the fish left on ledges near nests or regurgitated by kittiwake chicks which we handled were Sand Launce.

B. The general application of studies of seabirds to OCSEAP problems

Dr. George Hunt has prepared a short paper on the use of seabirds for interpreting conditions of the sea as part of the assessment of Alaska's Outer Continental Shelf. We subscribe to the conclusions which he presented, and will develop some ideas which apply to studies to be made at seabird colonies.

The main reason for pursuing the study of seabirds is their accessibility for study. It has been this characteristic which has allowed bird biologists to examine in detail the actual behavior of specific species and thus to test whether the ecological functions assigned to them by general theorists are valid. In fact in many cases it has been students of birds who have offered new and important insights into the operation of biological systems because of the directness of their studies and the rigor of analysis which that close contact allows.

Certain species and certain colonies are well qualified by their characteristics to be used for continued monitoring or continued study to clarify the meaning of general phenomena observed at less hospitable sites. The kittiwakes in the northern Bering Sea are a convenient group for the study of interactions with their prey and the mechanisms involved in reproductive disasters. Their part in the ecological system seems to be comparatively simple and straight forward. It is important, of course, to acknowledge that each colony of seabirds has its own peculiar characteristics in the way that individual animals do. The birds at some colonies reproduce consistently well each year, as seems to be the case at the Pribilof Islands. Some colonies occasionally do very well. Others consistently do poorly and one presumes that the individuals occupying these colonies do not reproduce well enough to replace themselves by young, hence that the colony must be maintained by immigration from other colonies which have a surplus of young. We have noted elsewhere that this is the case for Herring Gulls (Drury and Nisbet, 1972). This well known observation is the basis for the classical "Fraser-Darling Effect".

It is important for future monitoring of populations, measuring impacts and predicting effects on populations, to know which colonies produce young at a rate higher than annual adult mortality so that they, in effect, export young. It is also important to identify those colonies which do not produce enough young to maintain the population, hence, those colonies which depend upon immigration of young. This information is needed to determine what colonies are critical and at what rate a population is able to increase. Future work should identify (1) which colonies produce an excess of young and whether the fledging weights of those young are high enough to ensure post-fledging survival. We also need to determine (2) the degree of exchange of kittiwake chicks among colonies and regions, and (3) the life-expectancy and total life-long production of young per kittiwake pair.

In order to make a predictive model of population structure locally and regionally a banding program should be undertaken at several colonies which are dispersed among the regions. The purposes of a banding program are:

1. To measure life expectancy and winter mortality by age groups in order to prepare a life table and hence predict rates and directions of population changes.

2. To identify site tenacity and performance of individual birds and pairs.

3. To establish whether low rates of production of young are associated with lengthened adult lifespan (presumably reflecting lack of stress from competition for resources).

4. To identify the rates, directions and distance of movement among colonies.

Detailed studies of breeding biology are not needed every year once an intensive study has first been made to establish the baseline, but these should be repeated often enough to detect systematic shifts in breeding biology and populations.

1. The studies should include close attention to details of phenology, clutch size, hatching rate, fledging rate, growth rate, and weight of chicks at fledging.

2. The studies should also include foods used, patterns of foraging, and feeding behavior.

Some studies of basic biological questions can profitably accompany these studies of direct application to OCSEAP. Such studies include: What are the behavioral implications of nesting failure when coupled with the heavy competition for nesting sites? Why, in terms both of natural selection and in terms of hormonal (physiological) effects, do birds persist so actively on the ledges after failing? What age groups are represented among the birds that occupy sites without building nests? What are their ages and weights relative to the weights of the birds which lay eggs and to those which build nests but do not lay eggs?

This information should contribute answers to some additional important questions such as: Does the especially heavy competition for nest sites among kittiwakes indicate that sites would remain occupied even if an important percent of the population died? How readily would kittiwakes recover from a decline to reattain present or maximum numbers? What studies should be undertaken on the distribution, numbers, behavior, food, foraging patterns and feeding behavior of these birds on the wintering grounds? (The birds spend 2/3 of their lives away from the breeding grounds where our efforts are concentrated.)

C. Primary and secondary effects of oil development

1. Oil spills and seabirds

The special characteristics and problems of oil spilled on the sea have been discussed by many authors in many places. The problem was recognized as serious in the North Atlantic and especially in the Eastern North Atlantic many years before Americans took notice. The meetings of the International Committee for the Protection of Birds gave special attention to problems of oil at the annual meetings at Helsinki, Finland in 1958. At that time Tuck emphasized the serious impact of oil spills from tanker and general sea-going traffic on the seabirds of the Newfoundland and Labrador coasts. Recently Hunt in these annual reports has discussed the hazards to seabirds; and Paul Adamus of the Center for Natural Areas has prepared a table of relative vulnerability of seabirds on the Atlantic coast for BLM as part of the studies for the Outer Continental Shelf Environmental Assessment on the East Coast of the United States. Vermeer and Vermeer(1974) have also published a review.

The special vulnerability of some species of birds to oil, the predictable disaster which oiling causes and the special circumstances which makes oil spilled onto the sea virtually uncontrollable has convinced most of those concerned with both oil traffic and seabirds that extraordinary steps should be taken to avoid the transport of oil at sea if transport on land is practical.

2. Secondary development

The waters off Bluff have been suggested for a deep water port to serve the Seward Peninsula. The seabird cliffs at Bluff are critical to the population of murres and kittiwakes in Norton Sound, but are not critical to the populations of Pelagic Cormorants, Horned Puffins or Glaucous Gulls. The cliffs at Bluff have populations of murres and kittiwakes comparable to those in the Saint Lawrence Island waters, but lack auklets. Thus one could say that the cliffs at Bluff were less serious a loss than the others if one set of cliffs had to be expended. On the other hand the cliffs at Bluff are unique in the nearly pure population of Common Murres at a very high latitude. If one includes the cliffs at Topkok Head and Rocky Point the Bluff area supplies breeding sites for most of the birds of Norton Sound.

The effects of secondary development at Bluff would doubtless have an important effect on the towns of White Mountain and Golovin. In this way development would have a large effect on the mudflats at the mouth of the Fish River at the head of Golovin Bay. These are especially important waterfowl flats, probably the most important areas for waterfowl in all of the Seward Peninsula.

If development were to occur at Bluff, roads for transportation of heavy goods would be required between there and Nome. A highway system would make the area accessible and therefore much more heavily used than it is now. Such access would have an important effect on the public use of the area, increasing the hunting pressure on waterfowl, and presumably eliminating the thriving population of Grizzly Bears between Bonanza and Golovin.

We have commented in our report for R.U. 447 that future traffic of heavy equipment through the Bering Strait will have an inescapable impact on that area. It would seem to make sense that some facilities will be established in Port Clarence for large ships waiting for the sea ice to clear Point Barrow. Port Clarence appears to provide much better protection for ships and seems to be a more suitable place for port facilities than Bluff. Development in Port Clarence-Grantley Harbor would affect relatively small populations of Pelagic Cormorants and Horned Puffins. The thaw ponds and salt marsh pans at the base of Point Spencer are used by comparatively small numbers of waterfowl and moderate numbers of Geese on fall migration. The serious implications of development in the Teller-Port Clarence area is the danger of contamination of the really important seabird colonies at King Island and the two Diomede Islands, and the effect on the rich fauna of marine mammals which occupy the waters that flow north of Saint Lawrence Island through the Bering Strait and into the southern Chukchi Sea.

IX. SUMMARY OF FOURTH QUARTER ACTIVITIES

A. Ship or Laboratory activities

1. Ship or field-trip schedule. Not applicable.

2. Scientific party.

   William H. Drury, Principal Investigator — College of the Atlantic
   Bar Harbor, ME

   John O. Biderman, Research Assistant
   Sarah Hinckley, Research Assistant
   John B. French, Jr., Project Assistant, University of Wisconsin

3. Field sampling or laboratory analysis. N/A

4. Sample localities. N/A

5. Data analyzed or collected.
   Data analyzed were collected during the field season of 1977.

6. Milestone chart and digital data submission schedules.
   A meeting was held in Boulder, Colorado on 20-22 March 1978 to discuss the digitizing of data for the NOAA OCSEAP archives. Those at the meeting agreed upon the kinds of data and the formats for entering data collected at seabird colonies. Following the meeting at Boulder, other meetings were held in Calfornia to arrange for getting equipment for direct entry of digital data and for having suitable programs prepared for the direct entry process.

   Entering our data will be greatly facilitated by use of this equipment, but the submission will be delayed until the equipment and programs become available during the summer (May - September).

7. Meetings.
   a. Drury attended the meetings at the Pacific Seabird Group at Victoria, British Colombia, in January, and took part in a workshop on the breeding biology and variations in reproductive success of Black-legged Kittiwakes. There was also a workshop on the breeding biology of puffins.

   b. Drury also attended a synthesis meeting for OCSEAP studies of the Beaufort Sea and north coast of Alaska, in Point Barrow, AK.

B. Problems Encountered

The lease of a vessel which we had arranged for the summer of 1978 was cancelled in January by the owner of the vessel. We have sought other transportation and have tentatively arranged to use a NARL vessel during August.

The lease was arranged so as to study seabirds feeding away from their colonies. This study requires close cooperation of research from several areas of biology, such as studies of crustacea, fish, and primary productivity, as well as oceanographic structures, to be carried out properly. Such cooperation seems to be of highest priority in the OCSEAP now. Because seabirds are readily visible, it would seem obvious that seeking their concentrations is an effective way to find structures within the ocean which deserve study because of their biological importance. So far in NOAA OCSEAP in the northern Bering Sea, neither the cooperative studies nor suitable vessels have been available.

ANNUAL REPORT

RU337

April 1, 1977 - March 31, 1978

DISTRIBUTION AND ABUNDANCE OF MARINE BIRDS - SOUTH AND EAST KODIAK ISLAND WATERS -

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April 1, 1978

TABLE OF CONTENTS

LIST OF FIGURES

LIST OF FIGURES
continued

LIST OF FIGURES
continued

LIST OF TABLES

LIST OF TABLES
continued

LIST OF TABLES
continued

I. SUMMARY OF OBJECTIVES, CONCLUSIONS AND IMPLICATION WITH RESPECT TO OIL AND GAS DEVELOPMENT

This project is designed to provide information on the seasonal distribution and abundance of birds in Alaska's marine habitats. All waters bordering Alaska are occupied by birds, but there is a great deal of seasonal variation. Local populations are generally highest in the spring and fall migration periods and lowest in the winter. The most important marine habitats from the standpoints of abundance and species richness are the inshore, shelf and shelf edge waters of: 1) the Northwest Gulf of Alaska, especially around eastern Kodiak and the Barren Islands, 2) the Alaska Peninsula South, as around the Shumagin/Semidi Islands and in the Unimak Pass, 3) the Bering Sea, especially around the Pribilof Islands and over the major fishing banks, and 4) the Bering Straits in the vicinity of the Diomede Islands.

Most marine birds are highly mobile and foraging expeditions often cover large areas, especially over offshore waters. Local densities may thus vary greatly (*e.g.*, 0 birds/Km^2 to over 1,000 birds/Km^2) from hour to hour and day to day. Sooty and Short-tailed Shearwaters (*Puffinus griseus* and *P. tennuirostris*) dominate the marine avifauna during the summer and it is not uncommon to encounter tightly knit flocks of 25,000 to 50,000 birds. There are over eighty species of birds which make extensive use of Alaska's marine habitats. The most abundant of these are, in general descending order: Sooty/Short-tailed Shearwaters, Common/Thick-billed Murres (*Uria aalge* and *U. lomvia*), Northern Fulmars (*Fulmarus glacialis*), Tufted Puffins (*Lunda cirrhata*), Least Auklets (*Aethia pusilla*), Fork-tailed Storm Petrels (*Oceanodroma furcata*), Black-legged Kittiwakes (*Rissa tridactyla*), Parakeet Auklets (*Cyclorrhynchus psittacula*), and Crested Auklets (*Aethia cristatella*).

The most important factors influencing marine bird distribution and density appear to be: 1) location of suitable breeding areas, 2) physical characteristics of the surface water (salinity, tide rips, etc.), 3) availability of suitable food, 4) bottom topography, 5) reproductive status of the birds, and 6) location of extensive fishing and fish processing operations. All of the above factors are interrelated and affect bird distribution either directly by influencing the birds behavior or indirectly by affecting the birds food supply.

Our data on distribution and abundance of marine birds indicates that vast numbers of birds are "at risk" to pollution of Alaska's marine habitats. The kinds and numbers of birds involved will vary greatly in time and space but high impact levels, at least on a short-term basis, are inevitable. Each bird species will have a varying and unique degree of vulnerability to pollution (e.g., oil spills) depending on, in part, the following factors: 1) species spending more time in the water than in the air are the most vulnerable, 2) species forming large dense flocks are more vulnerable than less gregarious species, 3) species breeding in the area are more vulnerable than non-breeding species because productivity is affected, 4) some species are rarer than others and thus are more vulnerable because of the reduced possibility of rebuilding populations by immigration from other areas, 5) year-round residents are more vulnerable to local pollution problems than seasonal residents and migrants, 6) species preferring areas of entrained water are more vulnerable than species which prefer areas of strong currents, and 7) species going through a flightless period at-sea (e.g., heavy molt or precocial young) are more vulnerable than species capable of year-round flight.

II. INTRODUCTION

A. General Nature and Scope of Study

Research during FY77 was primarily directed toward an intensive survey of nearshore and continental shelf habitats east and south of Kodiak Island, i.e., the area proposed for FY78 integrated studies. Shipboard and aerial transects were conducted simultaneously with the food web and colony studies of RU341. Four aerial and two shipboard surveys also covered some areas outside of the Kodiak Basin to fill area and time frame data gaps existing in the 1975-76 records. These data have not yet been analyzed but will be included in our final report. A major effort was also made during FY77 to complete the editing, processing and submission of all 033 type data generated to date under RU337.

B. Specific Objectives

Studies in waters south and east of Kodiak Island were conducted to obtain monthly (March-November) information on: 1) species composition, 2) population levels of individual species, 3) differences or similarities of species and population levels between a) the Chiniak and Sitkalidak areas, b) bays, continental shelf, shelf break, and deep pelagic waters and c) banks ($<$92 meter depth) and troughs ($>$93 meter depth) within the continental shelf, and 4) principal feeding locations for dominant species.

C. Relevance to Problems of Petroleum Development

Leasing of portions of the Kodiak Basin for petroleum development is scheduled for October, 1980. The intensive studies of marine birds and other fauna are critical for development of information necessary to establish methods for preventing or mitigating impacts which will be associated with the development of petroleum resources.

Selected bays and continental shelf areas from Izhut Bay south and west to Kaiugnak Bay have been proposed as sites for intensive integrated ecosystem studies in FY78-79. These studies are primarily directed towards a trophic-level food web product but require a data base composed of distribution, abundance and life history elements. In anticipation of this project the U.S. Fish and Wildlife Service concentrated its FY77 efforts in the area proposed for integrated studies.

The Kodiak area also has some unique environmental characteristics (*e.g.*, a series of offshore banks, troughs and bays) that will allow us to gain insights into the details of marine bird distribution in relation to various oceanographic factors. This will hopefully provide us with clues which can be used in predicting seasonal impacts within other marine habitats.

III. CURRENT STATE OF KNOWLEDGE

Published accounts of the avifauna of Kodiak Island and its surrounding waters are few and, for the most part, lacking in details. Gabrielson and Lincoln (1959) summarize all published information up to their publication date including accounts by Bretherton (1896), Friedmann (1935), Howell (1948), and Arnold (1948). The major body of knowledge of seabirds of this area has been accumulated since early 1975 in the files and reports of investigators working under grants from the OCSEA Program (*i.e.*, Lensink under RU 337, 338 and 341; Wiens under RU 108; Guzman under RU 239). For summaries of these investigations see: Guzman (1976), Lensink and Bartonek (1976a, 1976b, 1976c), Lensink *et al.* (1976), Wiens (1976), Gould *et al.* (1977), Harrison *et al.* (1977), Myres and Guzman (1977), Sanger *et al.* (1977), and Wiens *et al.* (1977).

Our shipboard and aerial surveys did not generally cover estuarine habitats, coastlines, nor shallow waters immediately offshore. This, plus the lack of winter surveys, resulted in our not recording a number of species which regularly use marine waters in the Kodiak area. Several winter and nearshore surveys, however, were conducted by the Fish and Wildlife Service between 1973 and 1977 and summarized in unpublished reports (Dick *et al.*, 1976a, Dick *et al.*, 1976b, Dick *et al.*, 1976c, Dick, 1977, Dick *et al.*, 1977, Trapp, 1977). Since 1973, William Donaldson has coordinated Christmas Bird Counts in Kodiak, and each year a team has covered the local bay areas by skiff (Donaldson 1974, 1975, 1976, 1977). Kenton Wohl and Craig Harrison (1977) made an aerial and foot survey of Aiaktalik, Sundstrom and the Trinity Islands on May 25-31, 1977. Information from the above surveys has been incorporated into the species accounts of this report.

Sufficient data now exist to assess the occurrence and abundance of common marine birds in the Kodiak area, excluding the Shelikof Straits, for spring, summer and fall. Winter data are almost lacking. Preferred marine habitats for the more common summer visitors have been documented, but have yet to be confirmed by a second year's study. We still know very little about the following important life history features of local marine birds: 1) distribution, abundance and habitat preferences of different age classes, 2) effects of storms on nearshore and offshore distribution patterns, 3) effect of annual water temperature and salinity variations on distribution patterns, 4) turn over rates between birds over the water and those on colonies, 5) foraging range of resident birds or flocks, and 6) daily movement patterns.

IV. STUDY AREA

This report includes only those data collected in nearshore and offshore waters of east and south Kodiak Island: 56°00'N to 58°20'N and 150°00'W to 154°00'W (Figures 1 and 2). The coast line of this area is typified by many bays, fjords and islands which provide important shelter for marine birds as well as high quality feeding and breeding sites. The continental shelf consists of a series of banks and troughs which produce a varied and complicated oceanic environment. The whole area lies within the Coastal and Alaskan Stream Domains and is heavily influenced by the Alaska Current System (Favorite _et al_., 1976). These conditions provide for an extensive fisheries industry (_e.g._, salmon, crab, shrimp) and the presence of operating canneries and fishing boats plays an important role in the distribution and abundance of local marine birds.

A little over 100 seabird colonies have been identified in this area, three of which contain approximately 60,000 birds each. Combined, these 100+ colonies contain an estimated 286,000 birds of which Black-legged Kittiwakes and Tufted Puffins comprise about 91% (data from the Seabird Colony Catalog currently being compiled by Art Sowls of the U.S. Fish and Wildlife Service, Office of Biological Services). A large number of non-colonial seabirds (_e.g._, Pigeon Guillemots and Marbled Murrelets) also occur throughout this area.

V. SOURCES, METHODS AND RATIONALE OF DATA COLLECTION

The long-term goal of our studies is to prevent or minimize impacts likely to occur with petroleum development within Alaskan waters.

To accomplish this we need to determine as closely as possible the number, kinds and dispersal patterns of marine birds throughout the area of interest and within well defined environmental parameters. This necessitates the development and standardization of data collecting techniques.

No completely satisfactory method of determining densities of birds at-sea has ever been developed (Bailey and Bourne, 1972). This is especially true for areas which have very high population levels such as Alaskan coastal waters. Most investigators have relied on modifications of the line or strip transect method (Kendeigh, 1944) and reported their results in terms of relative abundance supplemented with anecdotal information (*e.g.*, King and Pyle, 1957; Bailey, 1966; Kuroda, 1966; Shuntov, 1972; Brown *et al.*, 1975). The problems involved in accurate censusing of at-sea populations, using line transect methods or otherwise, are numerous (Bailey and Bourne, 1972; Emlen, 1971; Wiens *et. al.*, 1978). The most obvious basic problems involve human, methodological and logistic factors as summarized below:

A. Individual observers differ in their ability to;

1) observe and identify seabirds,
2) judge distances, and
3) estimate the number of birds in a large flock.

B. At-sea transect results are weakened by;

1) the non-uniform (clumped) distribution patterns of many seabirds,
2) the unequal probability of detecting each seabird (*e.g.*, ship attraction and avoidance),
3) the variability of observation conditions (*e.g.*, seastate and atmospheric conditions),
4) rapid, frequent, and long distance movements of seabirds, and
5) variations in the speed at which the observer moves along the transect path.

C. At-sea censusing becomes expensive and time consuming when trying to:

1) accumulate a sufficient sample size for each area, time period, etc., and
2) assess large geographic regions.

The Fish and Wildlife Service techniques used in this study are basically line or strip transects. They are designed to control, as much as possible, the biases summarized above. The final experimental design, as described below, is efficient without being unduly complicated and time consuming. The resulting density indices, while not being precise "nose counts", are consistent within the entire database and represent the best approximation of population sizes which can be derived in a large geographical area containing high bird densities. Both AERIAL and SHIPBOARD survey designs are used for RU 337 studies, each having its own unique strengths, weaknesses and value. The two types of survey products cannot be pooled to produce a single density index, rather they are used as complementary studies which are useful for cross-checking density trends and distribution patterns.

A. Shipboard Methodology

Each observer collects as much data as time, conditions and initiative permit. Data are collected in three major categories:

1. Location and Time: the following data are recorded for each transect; a) starting latitude and longitude, b) date and time (GMT), c) ship speed and course made good, d) elapsed time of transect, e) transect width, and f) time zone.

2. Physical Environment: these are recorded for each transect depending on availability and need. Where possible we include at least the following:

   a) a subjective evaluation of observing conditions, b) seastate,
   c) sea surface temperature, and d) depth.

3. Biological Data: the following bits of data on birds which we collect for each sighting are listed in the order we consider to be most important to least important;

   a) identification of species, b) number of individuals (within 300 meters of the ship), c) behavior (sitting or flying), d) birds seen outside of transect zone (300+ meters), e) color phase, f) sex, g) age, h) behavior (other than in "c" above, and i) flight direction.

We employ five major experimental designs: Transect Censuses, Ship Follower Surveys, Station Surveys, General Observations, and Collecting. Only transect censuses have been analyzed for this report although some anecdotal information has been included from the other designs.

Our transect censuses are based on a 10 minute (temporal) cruising time and a 300 meter transect width. The ship must be moving along a straight path at a constant speed (usually 8-11 knots). The observer counts all birds observed forward of mid-ship to the projected end of the transect (maximum of 3,000 meters at 10 knots) and laterally, on one side, to 300 meters. The extended forward scan insures the detection of birds which may leave the area or dive before the ship reaches them. This is important for ship avoiding species. Only those birds observed within the transect boundaries during the actual time of the transect are counted. Ship following birds are recorded separately and not included in density estimates.

In theory, we would like to get an instantaneous count of birds within the transect zone. This is, of course, next to impossible from shipboard. Flying birds present a particular problem in this respect. If the observer counted all the individuals flying through the transect zone the eventual estimate of birds/Km^2 would be greatly exaggerated. We use several techniques to reduce this sort of bias:

1. Periodic instantaneous estimates are made of flying birds within a discrete portion of the transect area. These counts are then converted to the number of birds estimated to be within the transect area during the time of the transect. For example, at a speed of 10 knots we make three counts, using a 1000 x 300 meter area, beginning at the start of the transect. These counts are merely added together to produce the number of birds within the transect zone.

2. In the case of large flocks streaming across the bow, the number of birds crossing per minute within a specific distance (1,000 m for shearwaters, 500 m for storm petrels) can be counted. Three to five of these counts are made during the course of one 10 minute transect. The average time it takes for one bird to cross the 300 meter zone is also measured. With these two pieces of data the number of birds per Km^2 can be calculated. This density is then used to estimate the number of birds within the transect area during the time of the census.

   Distances were determined where possible by a range finder using the design developed by Dennis Heinemann under RU 108 (Wiens <u>et.al</u>. 1977 and 1978). In bay situations, distances were estimated by observers who had been using the range finder under good conditions and had verified their estimating ability.

   As the transect progresses, the observer frequently encounters birds outside of the counting zone. Such observations, especially of species not being seen in the count area or of large concentrations, are logged but not included in density estimates.

The timing and number of transects on each day of the cruise depend on the ships' and observers' routine and on the weather. For the Kodiak study, continuous 10-minute transects were made while the ship was underway and as observation conditions permitted. Observations from May through August were made aboard a 58' chartered vessel, the Yankee Clipper, which has a Westport, semi-planning hull. Navigation and position fixes were determined by radar and fathometer. The position of the radar on the flying bridge prevented observation from that vantage point so that all observations were made from the pilot house, ca. 4 meters above water level. The visibility forward and abeam from the pilot house was excellent. The September cruise was made aboard the NOAA ship Surveyor and the November cruise was made aboard the NOAA Ship Miller Freeman.

B. Aerial Methodology

Aerial surveys were completed along a pre-determined set of tracklines in the Gulf of Alaska east of Kodiak Island on 8-9 March, 20 April, 19 May, and 17 June, 1977 (Table 1). The specific date for each survey was contingent upon availability of survey aircraft, availability of survey personnel, and the vicissitudes of Gulf of Alaska weather conditions. When preflight consultations with National Weather Service personnel in Anchorage indicated the probability of storms, surface fog, or wind velocities in excess of 30 km/hour along the trackline, the survey was postponed. Surveys were designed within the 6-hour fuel limitation of the survey aircraft and included segments sampling nearshore, offshore, continental shelf (180 m depth), continental slope (180-1,800 m depth), and oceanic habitats. Surveys came no closer than 5 Km from any known colony sites and each survey included approximately 580 Km of continental shelf, 220 Km of continental slope, and 270 Km of oceanic trackline. The March survey required two days and a 30 Km section of trackline passing through Ugak Island could not be surveyed due to inclement weather. Otherwise, all portions of survey trackline were completed each month. Surveys were generally carried out between 10:00 and 16:00. Survey tracklines were chosen to follow whole degrees of meridians and parallels whenever possible.

The survey aircraft was a modified Grumann turbo-goose with improved forward and lateral visibility. The aircraft was equipped with a Global VLF Navigation System (Karant, 1976) which utilizes the very low frequency radio band and provides a continuous readout of longitude and latitude capable of locating tracklines within 200 m. It was flown on surveys at an altitude of 30 m and a groundspeed of 200 Km/hour.

Three biologists were utilized simultaneously on surveys. Two sat on either side of the aircraft and recorded observations to the lowest taxon possible into a cassette recorder. Strip censuses of 50 m on each side of the airplane were used, resulting in a shadow or non-censused area underneath the plane along the flight line. Transect width was estimated using a clinometer (SUUNTO CO., Finland), aircraft altitude, and elementary trigonometric functions. The third biologist monitored the Global VLF and recorded positions every one minute of latitude (1,8 Km) for north-south censuses and every five minutes of longitude (5 Km) for east-west censuses. Supplementary data for each transect segment included weather, sea state, ceiling, wind, and observations of marine mammals. Approximately every 30 minutes the biologists switched seating arrangements to combat observer fatigue and to allow a different individual to ease his eyestrain by diverting his attention to the Global VLF. Observability varied somewhat due to overcast, glare, and sea state but with experienced observers there factors are minimized and data of reasonably consistent quality are collected. Experimental design eliminated the worst of sea conditions and we experienced generally overcast conditions in which glare could be no problem. Each participating observer in these surveys had at least 100 hours of prior aerial observation experience in the marine environment.

With the above qualifications in mind we herein present the data in the following forms:

1. Maximum density index (maximum). This is the maximum possible density in any given area at any given time.

2. Mean transect densities ($\overline{X}$).

3. Two Standard Errors (2SE) for each mean of transect densities This gives the estimated density range to be expected at the 95% confidence level.

4. Frequency (F). The percent of the total transects on which a species was recorded.

5. Density indices are given for birds on the water or feeding and for flying birds. This allows some subjective evaluation of biases in our estimates. Birds on the water or feeding are also more directly indicative of habitat use since flying birds often represent individuals moving between extra limital areas rather than being "employed" over the specified area.

The basic unit of analysis in this report is the number of birds encountered per square kilometer of observation area (B/Km^2) per 10-minute transect. In viewing and interpreting these counts the reader must keep in mind the following qualifiers:

1. Because of the inherent biasis in any census technique, the B/Km^2 values represent "best approximations" rather than actual "nose counts". Small birds on the water may be underestimated while large flying birds may be overestimated.

2. Because at-sea individuals and flocks are highly mobile, each transect density is unique and represents a single point in space and time.

3. Number of observations for many species are low. This is especially true for the most gregarious species, for all uncommon species and for species with restricted habitat preferences.

4. All of the data presented in this report were collected under a rigidly maintained experimental design. Observations or counts may then be viewed as accurate indices for intra-data comparisons.

VI. RESULTS

Data from this study are presented below in a species account format. Each account is preceded by a brief summary of the species local distribution, abundance and chronology based on literature records, unpublished U. S. Fish and Wildlife Service reports and data obtained during RU 337 studies. These accounts deal strictly with marine waters. Shorebirds and freshwater bird populations are thus not included in this report. Population estimates are based on a total bay area of 2,780 square kilometers and a continental shelf area of 26,000 square kilometers. These estimates should be interpreted as the number of birds employed over the water at any one time. They do not include birds occupied on colony sites, shoreline loafing and roosting sites, nor inner-bay and estuarine sites. Figures 3-12 show the locations of all transects taken during this study.

COMMON LOON (Gavia immer)

This species may be found in low numbers throughout the year as a migrant or occasional resident.

We have three records: 1 bird in Sitkalidak Straits (March 8, 1977), 2 birds over the south shelf (May 30, 1977), and 2 birds over the north shelf (July 14, 1975).

YELLOW-BILLED LOON (Gavia adamsi)

This species occurs as an occasional winter resident or migrant.

One bird was recorded over the south shelf (May 30, 1977).

ARCTIC LOON (Gavia arctica)

Low numbers may be found throughout the year as migrants or occasionally as residents.

Our records consist of: 1 bird in Sitkalidak Straits (May 30, 1977), 1 bird in south oceanic waters (October 2, 1975), 3 birds over the northern shelf (November 2, 1977), 1 bird over the southern shelf-break (November 4, 1977), and two single birds over the south shelf (November 5 and 8, 1977).

RED-THROATED LOON (Gavia stellata)

This species may be found in low numbers throughout the year as migrants or breeding residents.

We did not find this species on our surveys.

RED-NECKED GREBE (Podiceps grisegena)

Found in small numbers throughout the year as migrants or residents. They are generally restricted to nearshore waters in protected bays.

We did not observe this species during our study.

HORNED GREBE (Podiceps auritus)

This grebe is a fairly common winter resident in bay areas.

No Horned Grebes were seen during our surveys.

BLACK-FOOTED ALBATROSS (Diomedea nigripes)

This is a common non-breeding summer resident over the shelf-break and deeper oceanic waters.

As many as 17 individuals were noted following a ship at one time. Our earliest record is one bird seen on April 20, 1977, over deep oceanic waters southeast of Kodiak. Our latest record is of four birds following the ship over the shelf-break on September 7, 1977. Some birds occasionally follow ships or stray into shallower waters of the continental shelf.

Two birds were seen in the Kiliuda Trough area on August 14, 1977, and two followed the ship for several hours over Middle Albatross Bank on September 6, 1977.

LAYSAN ALBATROSS (Diomedea immutabilis)

Small numbers may be found as non-breeding summer residents over the deeper shelf-break and oceanic waters.

We noted a maximum of two birds following the ship at any one time. Our earliest date is of one bird over the southern shelf-break on May 12, 1976. The latest record is of one bird following the ship across the south shelf-break on November 4, 1977. As with Black-foot's, Laysan's occasionally follow ships or wander into shallower waters of the continental shelf. A few birds were noted over the outer part of Middle Albatross Bank in October, 1975, September, 1977, and November, 1977.

NORTHERN FULMAR (Fulmarus glacialis)

This is a non-breeding resident in the Kodiak area. Although a small number of birds breed in the Barren Islands, the nearest major colony occurs in the Semidi Islands. We do not know if any of the Fulmars using the Kodiak area are breeding birds from these colonies.

Northern Fulmars are rare in Kodiak bays but common over the entire shelf, slope and oceanic area (Tables 2, 3 & 4). We estimate a stable population of approximately 20,000 birds over the Kodiak continental shelf throughout the summer (Figure 19). Shelf densities show small migration peaks in early spring and late fall. Associated with the April peak was a temporary influx of light phased birds.

PALE-FOOTED SHEARWATER (Puffinus carneipes)

This is an occasional visitor or more rarely a non-breeding resident of the Kodiak area. Breeding occurs only in the southern hemisphere.

We have five records of single birds within the study area: Portlock Bank (May 19, 1977), north shelf break (May 19, 1977), inner edge of South Albatross Bank (May 29, 1977), south shelf break (June 17, 1977), and Chiniak Trough (June 17, 1977).

NEW ZEALAND SHEARWATER (Puffinus Gulleri)

This species may appear within the study area as an occasional visitor or more rarely as a non-breeding resident with breeding restricted to the southern hemisphere.

We have eight records of single birds within the study area: two over the Chiniak Trough (April 20, 1977), one oceanic (May 19, 1977), four oceanic (June 17, 1977), and one over the northern shelf-break (June 17, 1977).

SCALED PETREL (Pterodroma inexpectata)

Scaled petrels are commonly found over oceanic waters of the Kodiak area as non-breeding summer residents with breeding being restricted to the northern hemisphere.

Our earliest record is May 19, 1977, and latest in September 7, 1977. We have sightings from near Chirikof Island (54.7°N + 155.2°W) on October 23, 1976. The highest local density index obtained was 1.6 B/Km^2 from an aerial survey on June 17, 1977, over oceanic waters (Table 3). We have no records of birds occurring over Kodiak's continental shelf.

SOOTY/SHORT-TAILED SHEARWATER (Puffinus griseus/P. tenuirostris)

Data for these two species has been combined because of the difficulty in telling them apart in the field. Both species are non-breeding summer residents in the Kodiak area and both breed in the southern hemisphere. Short-tailed Shearwaters were dominant from May through June comprising 89% of all birds identified to species on shipboard surveys. Sooty Shearwaters were dominant from July through September comprising 93% of all identifiable birds.

Shearwaters are abundant over the continental shelf, while lower numbers occur in bays and over the deeper slope and oceanic waters (Tables 1, 2, 3 & 5). We estimate that 1.5-2.0 million shearwaters occur over the Kodiak shelf in summer with an additional 20-40 thousand in bay areas. Highest local densities tended to be where steep slopes occurred between bank and trough areas. The largest single flock encountered was 60,000 birds, mostly Short-tailed Shearwaters, in the area west-southwest of Ugak Island. Several flocks of 20-30 thousand birds were observed at scattered locations over the continental shelf. The population tends to increase from a few birds in March to a peak in July, then decreases through November (Figures 13 & 20). Aerial survey data indicates a May peak which may represent birds migrating through the area. Both aerial and shipboard data indicate a tendency for birds to move into bay areas as the season progresses.

FORK-TAILED STORM PETREL (Oceanodroma furcata)

This species is a summer resident in the Kodiak area but we do not know if any are breeding adults. The nearest known colonies are located in the Barren Islands and in Ugaiashak Island.

Fork-tailed Storm Petrels are common over continental shelf and deeper waters, but only during June and July were large numbers found within bay areas. These birds may have moved into bays to avoid stormy conditions over deeper waters (Tables 1, 2, 3, & 6). Aerial data show a definite May peak in numbers throughout the area, while shipboard data show peaks in July and September. We estimate a stable population of 10-30 thousand birds within the study area and perhaps as many as 150,000 occurring during migration periods.

LEACH'S STORM PETREL (Oceanodroma leucorhoa)

This species is an uncommon summer resident over the shelf-break and oceanic waters surrounding Kodiak Island. The nearest known breeding colonies are on the Barren and Semidi Islands.

All but one of our records are from shelf-break and oceanic waters between May 12 and July 26. The one exception was of a single bird over the north shelf on June 17, 1977.

DOUBLE-CRESTED CORMORANT (Phalacrocorax auritus)

Small numbers may be found in major Kodiak bays throughout the year. Dick (1977) estimated 200-300 wintered in Chiniak Bay in 1976-77.

We have scattered summer and winter records within bay and nearby continental shelf areas. Our data, however, is too skimpy to allow interpretation of variation in seasonal abundance or chronology of movements within the area.

PELAGIC CORMORANT (Phalacrocorax pelagicus)

The species is an uncommon year-round resident in bay and nearshore Kodiak waters. Dick (1977) placed the wintering Chiniak Bay population at between 400 and 600 birds.

We found this species to be uncommon in bays and rare over continental shelf waters. Our survey data is inconclusive but indicates a summer population of between 200 and 1,500 birds and a winter population of over 3,000 within Kodiak bays (Table 7).

GADWALL (*Anas strepera*)

This species is a rare to uncommon winter resident and migrant. The high Christmas bird count was 11 in 1976 (Donaldson, 1977).

We have no records for this species.

PINTAIL (*Anas acuta*)

Pintails are rare to uncommon winter residents and migrants. Five birds were seen in December 1973 (Donaldson, 1974), and one in December 1976 (Donaldson, 1977) on Christmas bird counts in the Chiniak Bay area.

We recorded one bird over the northern shelf (September 22, 1975).

AMERICAN GREEN-WINGED TEAL (*Anas crecca*)

This species occurs as a rare or uncommon winter resident or migrant. Three birds were recorded in the Kodiak area in December, 1974 (Donaldson, 1975).

We have no records for this species.

AMERICAN WIGEON (*Anas americana*)

These birds are rare or uncommon winter residents or migrants. The largest number recorded on Christmas bird counts in the Chiniak Bay area was 7 in 1976 (Donaldson, 1977).

We did not record this species on our surveys.

SHOVELER (*Anas clypeata*)

The Shoveler is a rare visitor to the Kodiak area. Two birds were observed by Wohl and Harrison (1977) on a late May survey of Aiaktolik and Sundstrom Islands.

We have no records for this species.

CANVASBACK (*Aythya valisineria*)

This species is a very rare visitor or migrant. Wohl and Harrison (1977) recorded two birds on a survey of Aiaktalik and Sundstrom Islands in late May.

RED-FACED CORMORANT (Phalacrocorax urile)

This cormorant is uncommon throughout the year in the Kodiak Area. Dick (1977) found fewer than 50 in Chiniak Bay in the winter of 1976-77.

We found this species to be less common than Pelagic Cormorants but occurring in essentially the same overall distributional pattern (Table 8). Our summer estimate for Kodiak bays is 200+ and our winter estimate is around 800.

WHISTLING SWAN (Olor columbianus)

Whistling swans have been reported to breed on Kodiak Island (Gabrielson and Lincoln, 1959) and were observed on Sitkinak Island on May 30, 1977, by Wohl and Harrison (1977).

We have no records for this species.

BLACK BRANT (Branta nigricans)

This species is an uncommon winter resident and migrant in the Kodiak area.

We have two records: 26 birds in Chiniak Bay (May 2, 1975) and 14 birds over the northern shelf (May 5, 1975).

EMPEROR GOOSE (Philacte canagica)

Small numbers winter in the Kodiak area from at least December through May. As many as 300 may have wintered in Chiniak Bay in 1976-77 (Dick, 1977), and Trapp (1977) recorded 106 on his early March survey between Chiniak Bay and the Aliulik Peninsula.

We have a record of 12 birds seen in the Sitkalidak Straits on March 8, 1977.

MALLARD (Anas platyrhynchos)

Mallards are common year round residents and migrants within the protected waters of the study area. Dick (1977) estimated 300-400 to have wintered in Chiniak Bay in 1976-77.

We have one record of a pair on April 20 over the Stevenson Trough area.

We have one record of a single bird flying over the northern shelf on June 1, 1972.

GREATER SCAUP (*Aythya marila*)

Greater Scaups may be found throughout the year but are most common as a winter residentsin bays and fjords. Dick (1977) estimated 500-700 wintering on Chiniak Bay in 1976-77.

We have one record of a few birds in Chiniak Bay (May 27, 1977).

LESSER SCAUP (*Aythya affinis*)

The Lesser Scaup is a rare winter visitor to the Kodiak area. Two birds were recorded on the 1976 Christmas bird count (Donaldson, 1977).

We did not observe this species on our surveys.

COMMON GOLDENEYE (*Bucephala clangula*)

The Common Goldeneye is a rare summer and common winter visitor favoring protected waters of the Kodiak area. Dick (1977) estimates 700-1,000 wintered in the Chiniak Bay area in 1976-77. A high of 615 was recorded in the 1976 Christmas bird count (Donaldson, 1977).

We have one sighting of a goldeneye (species unknown) over the northern shelf (September 22, 1975).

BARROW'S GOLDENEYE (*Bucephala islandica*)

This species is a rare or uncommon winter resident that favors protected bays and coves. A high of 84 were found on the 1973 Christmas bird count (Donaldson, 1974).

We have no records of this species.

BUFFLEHEAD (*Bucephala albeola*)

Buffleheads are rare summer and common winter residents occurring in protected bays and coves. Dick (1977) estimates 200-300 wintered in Chiniak Bay in 1976-77. Christmas bird count numbers range from 68 to 145 (Donaldson, 1974, 1975, 1976, 1977).

We did not see this species during our surveys.

OLDSQUAW (Clangula hyemalis)

This species is an abundant winter resident and migrant. Dick (1977) found this to be the most abundant duck, 3,000-5,000 birds, wintering on Chiniak Bay in 1976-77.

We have many records of this species between January 8 and May 28. These records are scattered over the entire shelf and bay area with highest densities occurring in bays and along shorelines.

HARLEQUIN DUCK (Histrionicus histrionicus)

This species is common throughout the year in bays and along rocky coasts, generally remaining close to shore. Dick (1977) estimated 700-1,000 wintered in Chiniak Bay in 1976-77.

We have many records along rocky shorelines and in bays throughout the study area from March through September.

STELLER'S EIDER (Polysticta stelleri)

This species is an abundant winter resident particularly in sheltered waters along rocky shorelines. Dick (1977) found this was the second most abundant duck wintering in Chiniak Bay. He estimated 1,500 - 2,000 in the winter of 1976-77.

We have one record of a single bird over the southern shelf (March 8, 1977).

COMMON EIDER (Somateria mollissima)

This eider is a relatively common year round resident. Dick (1977) estimated that no more than 200 wintered on Chiniak Bay in 1976-77. Kodiak Christmas bird counts varied from a low of 2 birds in December 1973 to a high of 375 in December 1975 (Donaldson, 1974, 1975, 1976, 1977).

Our records show fair numbers in both north and south bays from March 8 to May 27.

KING EIDER (Somateria spectabilis)

King Eider are rare to uncommon winter residents. Dick (1977) estimated that 20-25 birds wintered on Chiniak Bay in 1976-77. The highest Christmas bird count was 11 in December, 1973 (Donaldson, 1974).

We have records of a few birds in the Sitkalidak Straits (April 21, 1977) and along northern shorelines (March 7, 1977).

WHITE-WINGED SCOTER (Melanitta deglandi)

This species is a fairly common winter resident and rare summer visitor. Dick (1977) estimated 200-300 birds wintered on Chiniak Bay in 1976-77. A range of 4-124 birds were recorded on Christmas bird counts (Donaldson, 1974, 1975, 1976, 1977).

We have many records scattered between March 1 and September 11. Most of these birds were in north or south bays but six were from the north and south shelf areas (May - July, 1977).

SURF SCOTER (Melanitta perspicillata)

Surf Scoters are rare to uncommon winter residents and rare summer visitors in the study area. Dick (1977) estimated fewer than 50 wintered in Chiniak Bay in 1976-77. Kodiak Christmas bird counts ranged from 6-28 birds (Donaldson, 1974, 1975, 1976, 1977).

We have three records: 2 birds in Marmot Straits (March 7, 1977), 4 birds in Sitkalidak Straits (June 22, 1977), and 1 bird in Sitkalidak Straits (September 8, 1977).

COMMON SCOTER (Melanitta nigra)

This sea duck is an uncommon summer and common winter resident. Dick (1977) estimated 1,000 - 1,500 wintered in Chiniak Bay in 1976-77.

We have five records between January 8 and April 20. These records were from north bay and shelf and south bay and shelf areas.

COMMON MERGANSER (Mergus merganser)

This species is a rare to uncommon winter resident. Dick (1977) estimated that only a few "10's" wintered in the area. The maximum Christmas bird count was 7 in 1976 (Donaldson, 1977).

We did not record this species during our surveys.

RED-BREASTED MERGANSER (*Mergus serrator*)

This merganser is an uncommon year round resident or visitor which is somewhat more abundant than Common Mergansers. A high of 24 birds was found in the 1974 and 1976 Christmas bird count (Donaldson, 1975, 1977).

We have no observations of this species.

RED PHALAROPE (*Phalaropus fulicarius*)

Red Phalaropes are uncommon migrants and occasional summer visitors to the Kodiak area. No breeding records have been documented for this region.

Most of our records are from continental shelf areas (Table 9). The exception was 61 birds recorded in the southern part of Marmot Bay on June 6, 1977.

NORTHERN PHALAROPE (*Lobipes lobatus*)

This is a common summer resident and migrant in the study area. Birds breed in suitable habitat over most of Kodiak Island.

We found these birds common within Kodiak bays and sporadic over the continental shelf from May through September (Tables 3 & 10). The earliest U.S. Fish and Wildlife Service record for Kodiak waters is May 20, and the latest is October 14. We estimate a rather stable summer bay population of about 3,000 birds.

POMARINE JAEGER (*Stercorarius pomarinus*)

This is a common non-breeding summer resident and migrant within the Kodiak Basin. Known breeding areas are far to the north.

We found this species to be uncommon in bays and common over shelf waters from May through September. Bay densities remained fairly constant except for a possible migration peak in September. Shelf densities were highest in mid-summer and lowest in May-June and September (Tables 2, 3 & 11, Figure 21). The high July density was partly due to an actual increased density and partly to the observation of 175 jaegers harassing birds within a flock of 10,000 shearwaters near Ugak Island on July 29. Increased July-August densities may have resulted from an early departure of non-breeding birds from the breeding grounds as postulated by Maher (1974). We estimate a total Kodiak bay population of 200-400 birds and a shelf population generally around 1,000 - 3,000 but sometimes reaching 10,000 or greater.

PARASITIC JAEGER (Stercorarius parasiticus)

This jaeger is a fairly common summer resident and migrant within the study area. Scattered pairs breed on suitable habitat throughout the Kodiak Basin.

Our records indicate this species to be fairly common within bays and over the continental shelf from June through September (Tables 1, 3 & 12). We estimate a rather stable bay population of 100-200 birds with perhaps an August peak of around 400. The shelf population is probably on the order of 500 - 1,000 birds.

LONG-TAILED JAEGER (Stercorarius longicaudus)

This is an uncommon summer visitor and migrant. There are no breeding records for the Kodiak Basin.

We have scattered records from May through August over the continental shelf, shelf-break, and oceanic waters. Our only non-shelf records are five sightings (total of 10 birds) in July and two sightings (total of two birds) in August in Marmot Bay (Tables 3 & 13).

SKUA (Catharacta skua)

This species is a rare visitor to the Gulf of Alaska. It breeds in the southern hemisphere.

We have three records: 1 bird on May 19, 1977, at 56°00'N x 150°30'W; 2 birds on July 31, 1976, at 56°41'N x 152°30'W; and 1 bird in Chiniak Bay on July 31, 1976.

GLAUCOUS GULL (Larus hyperboreus)

This gull is a rare to uncommon visitor or non-breeding resident which may be found at any time of the year. Dick (1977) thought that a few "10's" wintered in Chiniak Bay in 1976-77.

We have nine records scattered throughout the study area, excluding oceanic waters, from March 6 through July 15.

GLAUCOUS-WINGED GULL (*Larus glaucescens*)

Glaucous-winged Gulls are common to abundant residents throughout this region. They breed at all suitable locations within the Kodiak Basin and hybridize with Herring Gulls at colonies outside of the study area such as in Cook Inlet. Dick (1977) estimated 1-2 thousand were present in the town of Kodiak and 2-3 thousand in Chiniak Bay during the 1976-77 winter.

We found this species to be common in all areas surveyed. They were most concentrated in bays but could be found throughout the area at any time of the year. Bay populations remained stable through the summer but shelf populations tended to decrease (Tables 1, 2, 3 & 14, Figure 22). We estimate a summer bay population of 4,500 - 7,500 and a summer shelf population of 2-10 thousand. Winter populations are probably considerably higher.

SLATY-BACKED GULL (*Larus schistisagus*)

This species is an accidental visitor to the Gulf of Alaska.

We have one sight record by Patricia Baird at 58°04'N X 150°12'W on January 30, 1977.

HERRING GULL (*Larus argentatus*)

This species is a rare to uncommon year-round non-breeding resident and visitor to the study area. Dick (1977) thought that a few were present in Chiniak Bay throughout the winter.

We have 21 records scattered throughout the study area from February 4 through November 16.

THAYER'S GULL (*Larus thayeri*)

This is an accidental visitor to the Kodiak Basin.

We have one record of a single bird over the northern bank area on September 22, 1975.

MEW GULL (Larus canus)

This is a common resident within the study area. Breeding colonies are scattered through suitable coastal and island habitat along most of Kodiak Island. Dick (1977) estimated 1-2 thousand wintered on Chiniak Bay during 1976-77.

Mew Gulls were not well represented on our surveys, possibly because they tended to stay close to shore. Most of our records are for bay areas although we have a few shelf records in April and May (Tables 1, 3 & 15). Our maximum estimate for Kodiak bays is about 10,000 birds.

BLACK-LEGGED KITTIWAKE (Rissa tridactyla)

Black-legged Kittiwakes are the most abundant gull in the Kodiak Basin. They are primarily summer residents in the area but many remain throughout the winter.

Kittiwake populations are concentrated in bays during the summer and over the shelf and oceanic waters in the winter. The movement into bays begins in late June or early July and is quite rapid (Tables 1, 2, 3 & 16 Figures 14 & 23). We estimate the summer bay population to be 30-65 thousand birds and the summer shelf population to be 15-30 thousand. The early June shelf population is probably in excess of 100,000 birds. Our information on size and number of colonies in the Kodiak area indicates that the above population estimates are very conservative, and a total kittiwake population of over 200,000 is not unlikely.

RED-LEGGED KITTIWAKE (Rissa brevirostris)

This Bering Sea breeding species is a rare but apparently fairly regular winter resident or visitor to the Kodiak Basin.

We have one record of two birds over the southern shelf on November 14, 1976, and four records (a total of 12 birds) over the northern and southern shelf between February 6 and 8, 1977.

SABINE'S GULL (Xema sabini)

This is a rare or uncommon migrant in the Kodiak Basin. Individuals and small flocks pass through this area on their way to and from their more northerly breeding grounds.

We noted a small influx of birds into the study area in late July and a few birds were still present in September. Most of these records were over the continental shelf but 13 birds were seen in Marmot Bay from July 17-19.

ARCTIC TERN (Sterna paradisaea)

This is a common to abundant breeding species and migrant throughout the Kodiak Basin. Their wintering grounds are far south of Alaskan waters.

This species was common within bay areas and uncommon over the continental shelf except in migration (Tables 1, 3 & 17; Figure 24). Our data show an early May and an August migration peak over shelf waters. We estimate a rather stable summer population of 1-2 thousand birds in bays and 250 - 1,300 over the nearby continental shelf.

ALEUTIAN TERN (Sterna aleutica)

This tern is an uncommon breeding resident in the Kodiak Basin. Birds leave the area soon after the young fledge but we do not know where they go or what migration route they use.

These birds were uncommon within bays and rare over the continental shelf from at least late May through August (Tables 1 & 18). We have an unusual pelagic sight record by Craig Harrison of one bird at 55°55'N X 151°02'W on July 26, 1977. Our estimate of the summer Kodiak bay population is 200 - 700 birds and for the nearby shelf it is 300 - 800.

COMMON/THICK-BILLED MURRE (Uria aalge/U. lomvia)

These two species are combined in our data analysis because of the difficulty in telling them apart in the field. Murres are one of the most abundant birds in Alaskan waters. They are year-round residents but there are only a few, relatively small, colonies of Common Murres and no known breeding Thick-billed Murres in the study area.

Murres were equally common within bays and over shelf waters throughout the summer and into November. In March birds were concentrated over the shelf break. Densities were lowest in July and highest in May and November (Tables 1, 2, 3 & 19, Figures 15 & 25). Our population estimates for bays ranged from 2,500 in July to 29,000 in November. For the shelf area the population ranged from 21,000 in July to 170,000 in November. Most of the summer birds, especially in the Sitkalidak Straits area, were non-breeding Common murres as judged from the plumage and gonads of collected specimens. We have a small number of sightings of Thick-billed Murres scattered over the area throughout the year.

PIGEON GUILLEMOT (Cepphus columba)

This is a common summer and winter resident along rocky coast lines and in bays. Dick (1977) estimated 150-300 wintered in Chiniak Bay during 1976-77.

We found this to be a common bird within bays and uncommon over the shelf throughout the summer (Tables 1 & 20; Figure 26). Our estimates of the summer population are 1,800-2,500 for bays and 1,000-4,500 for the outer coastline and shelf area.

MARBLED/KITTLITZ'S MURRELET (Brachyramphus marmoratum/ B. brevirostris)

These two species are combined in this report because of the difficulty of telling them apart in the field. Both are summer and winter residents in bays throughout the Kodiak area. Marbled Murrelets are common to abundant and far outnumber the uncommon Kittlitz's Murrelet. Dick (1977) estimated 150-300 Marbled Murrelets in Chiniak Bay during the 1976-77 winter. He collected two Kittlitz's in April.

We found murrelets throughout the shelf and especially within the bays during our study (Tables 1, 3 & 21). We estimate a summer bay population of 5-9 thousand and a shelf population of 16-25 thousand.

ANCIENT MURRELET (Synthliboramphus antiquus)

This is an uncommon summer and winter resident in the Kodiak Basin. Some birds probably breed within the study area but no colonies have been located as of this date. Dick (1977) recorded two individuals from Chiniak Bay during the winter of 1976-77.

We found this species to be rare in Kodiak bays with our only record being a single bird in June. Sightings were more regular over shelf waters with birds recorded from May through August (Table 22). We estimate a mid-summer shelf population of 9-15 thousand birds.

CASSIN'S AUKLET (Ptychoramphus aleutica)

This species is an uncommon to common year-round resident within the Kodiak area but no current breeding records exist. The nearest breeding colony is in the Shumagin Islands.

We first recorded this species in June and the population peaked in August (Tables 1, 2 & 23). There is at least one May record for this area in the U.S. Fish & Wildlife Service files. We estimated a peak bay population of around 3,000 and a peak shelf population of 45,000.

PARAKEET AUKLET (Cyclorrhunchus psittacula)

This auklet is an uncommon year-round resident or visitor in the area with most of the population remaining over deep pelagic waters. No current breeding records exist for the Kodiak area but we suspect that at least one small colony exists in southwest Kodiak.

We found a few birds in Kodiak bays in July and August and estimate a maximum summer shelf population of about 8,000 (Tables 3 & 24).

CRESTED AUKLET (Aethia cristatella)

This is a fairly common winter resident within the Kodiak Basin. The nearest known colony is to the west in the Shumagin Islands. Dick (1977) estimated 500 - 1,000 wintered in Chiniak Bay in 1976-77. He also noted thousands in the Whale Passage area in January.

We noted a few birds in bays and over the shelf in November, and birds were found aggregated in deep water in March (Tables 3 & 25). There is one record of a single bird over the southern shelf on July 16, 1976.

LEAST AUKLET (Aethia pussila)

This is a rare visitor to the Kodiak Basin. The nearest breeding is at a small colony in the Shumagin Islands.

We have two records for the study area: 2 birds in Rolling Bay (immediately west of Sitkalidak Island) on May 29, 1977, and 3 birds over the shelf on August 14, 1977.

RHINOCEROS AUKLET (Cerorhinca monocerata)

This is a rare to uncommon non-breeding visitor and winter resident in the Kodiak area. The nearest breeding colonies are on Ugaiushak and the Barren Islands.

We have scattered records in March, June and September, but our data is too meager to allow a status assessment.

HORNED PUFFIN (Fratercula corniculata)

This is a common breeding resident and ocassional winter resident within the Kodiak Basin. Dick (1977) found only a few birds in Chiniak Bay in the winter of 1976-77.

We found this species to maintain rather consistent densities within bays during the summer. Shelf densities, on the other hand, were highest in the spring and fall with a low point in August (Tables 1,2,3, & 26; Figure 28). We estimated the summer bay population to be around 1-3 thousand birds. Shelf population estimates ranged from a summer low of 3,000-4,000 to fall high of 40,000.

TUFTED PUFFIN (Lunda cirrhata)

Tufted Puffins are the most abundant breeding species within the Kodiak study area. Only a few birds, however, remain through the winter and these tend to be very pelagic in their distribution. Dick (1977) did not find this species wintering on Chiniak Bay in 1976-77. His first record was on March 27.

We found this species abundant everywhere we went within the study area. Populations over the shelf remained very constant through the summer with a slight tendency toward higher densities in the early spring and fall. Bay densities rose rather steadily from May through August and then dropped sharply in September (Tables 1, 2, 3 & 27; Figures 16 & 27). We estimated the maximum summer population in bays to be 50-60 thousand birds. Shelf population estimates range from a low of 70,000 in mid summer to about 150,000 in spring and fall.

VII & VIII DISCUSSION AND CONCLUSIONS

During the 1977 Kodiak field surveys we recorded 54 species of marine oriented birds. We have also included in this report anecdotal information on an additional 20 species which are known to occur in the area. The most abundant species within the Kodiak area are Sooty and Short-tailed Shearwaters. These species occur as non-breeding summer residents. The next most abundant species are Tufted Puffin, Common Murre and Black-legged Kittiwake all of which are breeding residents (Figure 18).

We found that distribution patterns segregated out fairly well according to whether the species was behaviorally oriented toward oceanic (*e.g.*, albatrosses), continental shelf (*e.g.*, shearwaters), or protected bay waters (*e.g.*, Aleutian tern). We found no differences in density between bank and trough areas of the continental shelf. In fact it appears that the steeper slopes which occur between banks and troughs are probably the most important part of the shelf habitat. We have not yet been able to analyze the differences between north and south Kodiak waters. There are some species which seem to prefer one of these areas over the other, but overall there does not appear to be much difference.

Overall bird densities (Tables 3 & 28, Figures 17 & 29) were highest in mid-summer although aerial surveys indicate a migration peak in May. We estimate a summer population for all south and east Kodiak bays of 100-175 thousand birds. The summer Kodiak shelf population is estimated to be 1.9-2.2 million birds.

IX. NEEDS FOR FURTHER STUDY

The need for further studies depends entirely on two qualitative factors involving final decision making processes and user needs. What questions will be asked and what level of confidence is required of the answers? These factors must then be evaluated in terms of funds available and cost effectiveness.

A study of seabird populations in the winter and early spring is needed if avian assessments of the area are to be complete. This could be accomplished by an aerial survey in January and shipboard surveys in January and April. Surveys should be identical to those completed in the FY77 studies. The small amount of winter data we have suggests that there is an almost complete turnover in species occurrence and density in the Kodiak region from summer to winter. Many species leave the area about the same time other species enter it while still other species apparently shift from one habitat to another within the area. The nature, reasons for and magnitude of these changes is critical to our understanding of the local ecosystem and we do not feel that the small amount of data to be gained by the FY78 integrated Kodiak studies will be sufficient.

A low level monitoring program should be maintained through at least FY80. This could be accomplished by having a qualified bird observer on board a few selected cruises on a "non-interference" basis. Such a program would serve the following purposes:

1. It would allow the detection of large scale changes in distribution and density patterns related to greater-than-annual cycles.

2. The accumulation of data would considerably increase the confidence with which we can use the FY77 data. This is especially important for uncommon, rare and vagrant species.

3. It would maintain and allow updating of the FY77 database until actual assessments and decisions are made. Of particular importance in this regard would be the detection of any environmental degredation or new sources of pollution and their basic effects on the local avifauna.

Studies similar to the FY78-79 Kodiak integrated program will be needed in other lease sale areas such as the NEGOA area, Middleton and Kyak Islands in particular.

Shipboard and/or aerial studies should be incorporated into any future studies of local areas and colonies.

There are still many area and seasonal gaps in our pelagic data base. Some of these are obviously irrelevant to OCSEAP's needs while others, e.g., winter data for the Northeast Gulf of Alaska, are important. Perhaps the most important of these data gaps are for nearshore waters, especially in highly productive bays and fjords.

X. SUMMARY OF JANURAY-MARCH QUARTER

No field work was conducted during the January-March Quarter. Effort was concentrated on the processing of digital data and the development of computer program for data analysis.

To date only two sets of 033 type data have not been sent to Dr. Hal Petersen for final verification. One of these sets has not yet been keypunched. All other data sets have been verified by both the U.S.F.W.&S. and Dr. Hal Petersen's computer program, and are ready for final format conversion (1975-76 data) or final submission to NODC (1977 data).

The initial computer programs for data analysis are just about completed. Preliminary descriptions of the first two of these programs have been sent to the Juneau Project Office. Some minor modifications are still needed and the final versions of all analysis programs will be incorporated into the RU 337 final report.

XI. LITERATURE CITED

Arnold, L. W. 1948. Observations on populations of North Pacific pelagic birds. Auk 65(4):553-558.

Bailey, R. 1966. The seabirds of the southeast coast of Arabia. Ibis 108(1966):224-264.

Bailey, R., and W. R. P. Bourne. 1972. Notes on seabirds, 36:counting birds at sea. Ardea 60:124-127.

Bretherton, B. J. 1896. Kodiak Island. A contribution to the avifauna of Alaska. Oregon Naturalist 3:47-49, 61-64, 77-79, 100-102.

Brown, R. G. B., D. N. Nettleship, P. Germain, C. E. Tull, and T. Davis. 1975. Atlas of eastern Canadian seabirds. Canadian Wildlife Service, Ottawa. 220 p.

Dick, Matthew. 1977. Notes on the winter seabirds of Chiniak Bay, Kodiak Island, Alaska, Nov. 1976-May 1977. Unpublished report, U. S. Fish and Wildlife Service, Anchorage, Alaska. 32 p.

Dick, M., I. M. Warner, and R. MacIntosh. 1976a. Distribution and abundance of breeding seabirds in Chiniak and southern Marmot Bays, Kodiak Island, Alaska, 1975. Unpublished report, U. S. Fish and Wildlife Service, Anchorage, Alaska 22 p.

Dick, M., I. M. Warner, and R. MacIntosh. 1976b. Notes on the biology of breeding and other seabirds in Chiniak and southern Marmot Bays, Kodiak Island, Alaska, 1975. Unpublished report, U. S. Fish and Wildlife Service, Anchorage, Alaska. 17 p.

Dick, M., I. M. Warner, and R. MacIntosh. 1976c. Small boat census of seabirds: Marmot and Chiniak Bays, June-August, 1975. Unpublished report, U. S. Fish and Wildlife Service, Anchorage, Alaska. 10 p.

Dick, M., J. Bartonek, and C. Lensink. 1977. Birds observed in the vicinity of Kodiak, January 23-24, 1977. Unpublished report, U. S. Fish and Wildlife Service, Anchorage, Alaska. 3 p.

Donaldson, W. (compiler). 1974. Kodiak, Alaska, in The seventy-fourth Audubon Christmas bird count (L. H. Heilbrun and R. Arbib, eds.). American Birds 28(2):196-197.

Donaldson, W. (compiler). 1975. Kodiak, Alaska, in The seventy-fifth Audubon Christmas bird count (L. H. Heilbrun, ed.). American Birds 29(2):213-214.

Donaldson, W. (compiler). 1976. Kodiak, Alaska, in The seventy-sixth Audubon Christmas bird count (L. H. Heilbrun, ed.). American Birds 30(2):219.

Donaldson, W. (compiler). 1977. Kodiak, Alaska, in The seventy-seventh Audubon Christmas bird count (L. H. Heilbrun, ed.). American Birds 31(4):469-470).

Emlen, J. T. 1971. Population densities of birds derived from transect counts. Auk 88(2):323-342.

Favorite, F., H. J. Dodimead, and K. Nasu. 1976. Oceanography of the subarctic pacific region, 1960-71. International North Pacific Fisheries Commission, Bull. 33:1-187.

Friedmann, H. 1935. The birds of Kodiak Island, Alaska. Bull. Chicago Academy of Science 5:13-54.

Gabrielson, I. N., and F. C. Lincoln. 1959. The birds of Alaska. Stackpole Company, Harrisburgh, Penn., and Wildlife Management Institute, Washington, D. C. 922 p.

Gould, P. J., J. C. Bartonek, C. S. Harrison, and G. A. Sanger. 1977. Shipboard surveys of marine birds. Part I of Seasonal Distribution and abundance of marine birds. In Environmental Assessment of the Alaskan Continental Shelf. Receptors - Birds, Vol. III:192-284. U.S. Dept. Commerce and U.S. Dept. Interior.

Guzman, J. 1976. Ecology and behavior of southern hemisphere shearwaters (Genus Puffinus) and other seabirds, when over the outer continental shelf of the Bering Sea and Gulf of Alaska during the northern summer. In Environmental Assessment of the Alaskan Continental Shelf. Marine Birds, Vol. 3:1-52. U.S. Dept. Commerce and U.S. Dept. Interior.

Harrison, C. S., J. C. Bartonek, P. J. Gould, and G. A. Sanger. 1977. Aerial surveys of marine birds. Part II of Seasonal distribution and abundance of marine birds. In Environmental Assessment of the Alaskan Continental Shelf. Receptors - Birds, Vol. III:285-593. U.S. Dept. Commerce and U.S. Dept. Interior.

Howell, J. C. 1948. Observations on certain birds of the region of Kodiak, Alaska. Auk 65:352-358.

Karant, M. 1976. The global navigation system. AOPA Pilot 19:59-61.

Kendeigh, S. C. 1944. Measurement of bird populations. Ecological Monographs 14:67-106.

King, J. E., and R. L. Pyle. 1957. Observations of seabirds in the tropical pacific. Condor 59:27-39.

Kuroda, N. H. 1966. Analysis of seabird distribution in the northwest Pacific Ocean. Pacific Science 14:55-67.

Lensink, C. J., and J. C. Bartonek. 1976a. Seasonal distribution and abundance of marine birds: Part I. Shipboard Surveys. In Environmental Assessment of the Alaskan Continental Shelf. Marine Birds, Vol. 3:107-644. U. S. Dept. Commerce and U. S. Dept. Interior.

Lensink, C. J., and J. C. Bartonek. 1976b. Population dynamics of marine birds. In Environmental Assessment of the Alaskan Continental Shelf. Marine Birds. Vol. 4:345-361. U. S. Dept. Commerce and U. S. Dept. Interior.

Lensink, C. J., and J. C. Bartonek. 1976c. Preliminary catalog of seabird colonies and photographic mapping of seabird colonies. In Environmental Assessment of the Alaskan Continental Shelf. Marine Birds, Vol. 4:99-244. U. S. Dept. Commerce and U. S. Dept. Interior.

Lensink, C. J., J. C. Bartonek, and C. S. Harrison. 1976. Seasonal distribution and abundance of marine birds. Part II. Aerial Surveys. In Environmental Assessment of the Alaskan Continental Shelf. Marine Birds. Vol. 4:1-98. U. S. Dept. Commerce and U. S. Dept. Interior.

Maher, W. J. 1974. Ecology of Pomarine, Parasitic, and Long-tailed Jaegers in Northern Alaska. Pacific Coast Avifauna No. 37. Cooper Ornithological Society, L. A., Calif. 148 p.

Myres, M. T., and J. Guzman. 1977. Ecology and behavior of southern hemisphere shearwaters (Genus Puffinus) and other seabirds, when over the outer continental shelf of Bering Sea and Gulf of Alaska during the northern summer. In Environmental Assessment of the Alaskan Continental Shelf. Receptors - Birds. Vol. III:179-191. U. S. Dept. Commerce and U. S. Dept. Interior.

Poole, F. 1966. Birds of the North Pacific. The Sea Swallow 18:71-74.

Sanger, G. A. 1972. Checklist of bird observations from the eastern North Pacific Ocean, 1955-1967. Murrelet 53(2):16-21.

Sanger, G. A., P. A. Baird, J. C. Bartonek, C. J. Lensink, P. J. Gould, R. E. Gill. 1977. The trophic relationships of marine birds in the Gulf of Alaska and the southern Bering Sea. Part XIV of Population dynamics and trophic relationships of marine birds in the Gulf of Alaska and southern Bering Sea. In Environmental Assessment of the Alaskan Continental Shelf. Receptors - Birds. Vol. IV:694-757. U.S. Dept. Commerce and U.S. Dept. Interior.

Shuntov, V. P. 1972. Seabirds and the biological structure of the ocean. Translated for Bureau of Sports Fisheries and Wildlife, U. S. Dept. Interior and National Sciences Foundation, Washington, D.C. by the Agence Tunisie mne de Public Relations, Tunis, Tunesia, 1974.

Trapp, J. L. 1977. Aerial bird survey of the coastal waters of Kodiak Island, Alaska, March 9-14, 1977. Unpublished report, U. S. Fish and Wildlife Service, Kodiak, Alaska. 18 p.

Wiens, J. A. 1976. Community structure, distribution, and interrelationships of marine birds in the Gulf of Alaska. In Environmental Assessment of the Alaskan Continental Shelf. Marine Birds. Vol. 2:369-400. U.S. Dept. Commerce and U.S. Dept. Interior.

Wiens, J. A., W. Hoffman, and D. Heinemann. 1977. Community structure, distributions, and interrelationships of marine birds in the Gulf of Alaska. In Environmental Assessment of the Alaskan Continental Shelf. Receptors - Birds, Vol. II:383-401. U.S. Dept. Commerce and U.S. Dept. Interior.

Wiens, J. A., D. Heinemann, and W. Hoffman. 1978. Community structure, distribution, and interrelationships of marine birds in the Gulf of Alaska. Final Report of RU No. 108 - Phase I, August 1975 - October 1977. Submitted to NOAA OCSEA Program, Juneau, Alaska.

Wohl, K., and C. Harrison. 1977. List of birds observed on Aiaktalik, Sundstrom, and the Trinity Islands. Unpublished report, U.S. Fish and Wildlife Service, Anchorage, Alaska. 4 p.

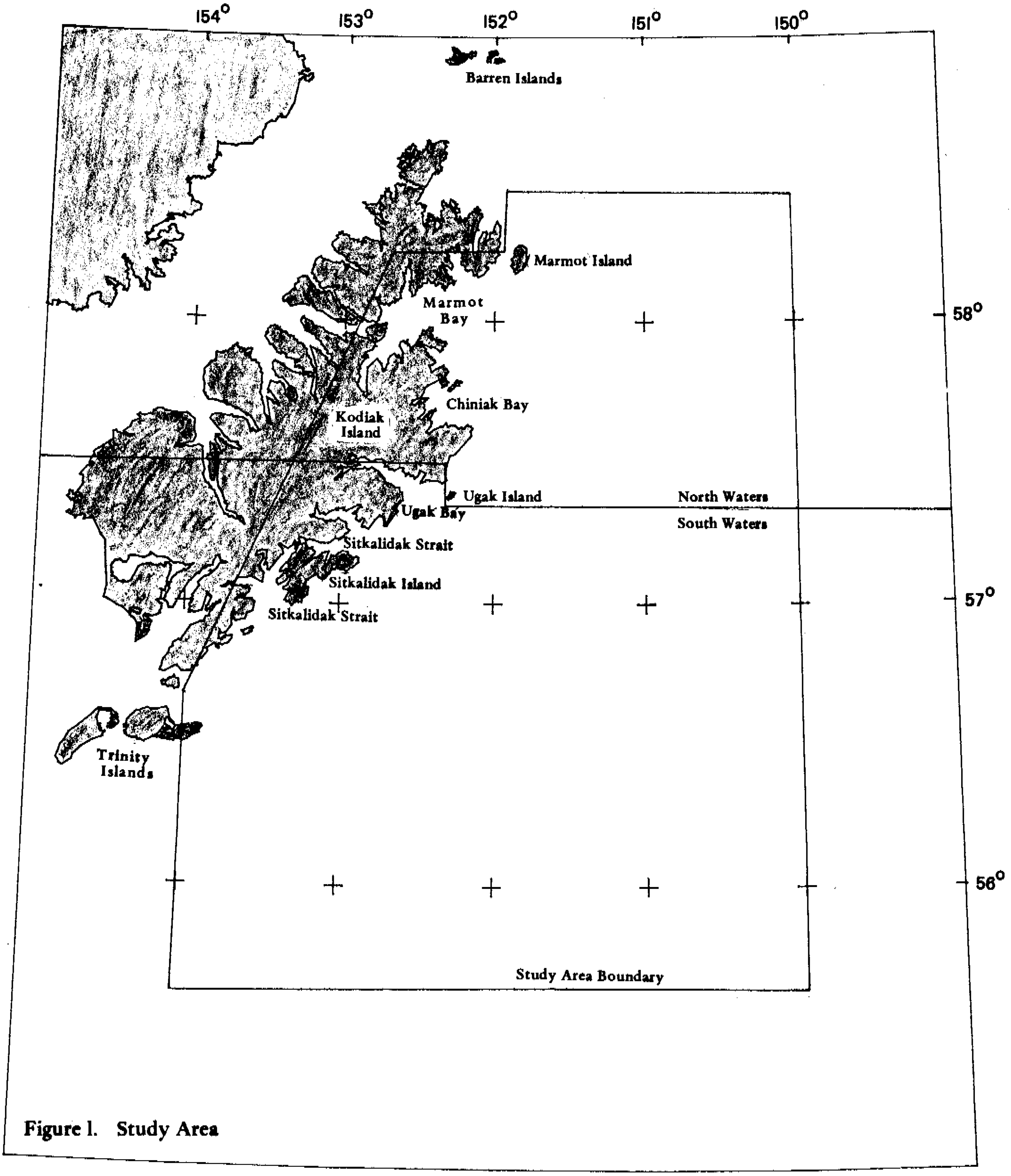

Figure 1. Study Area

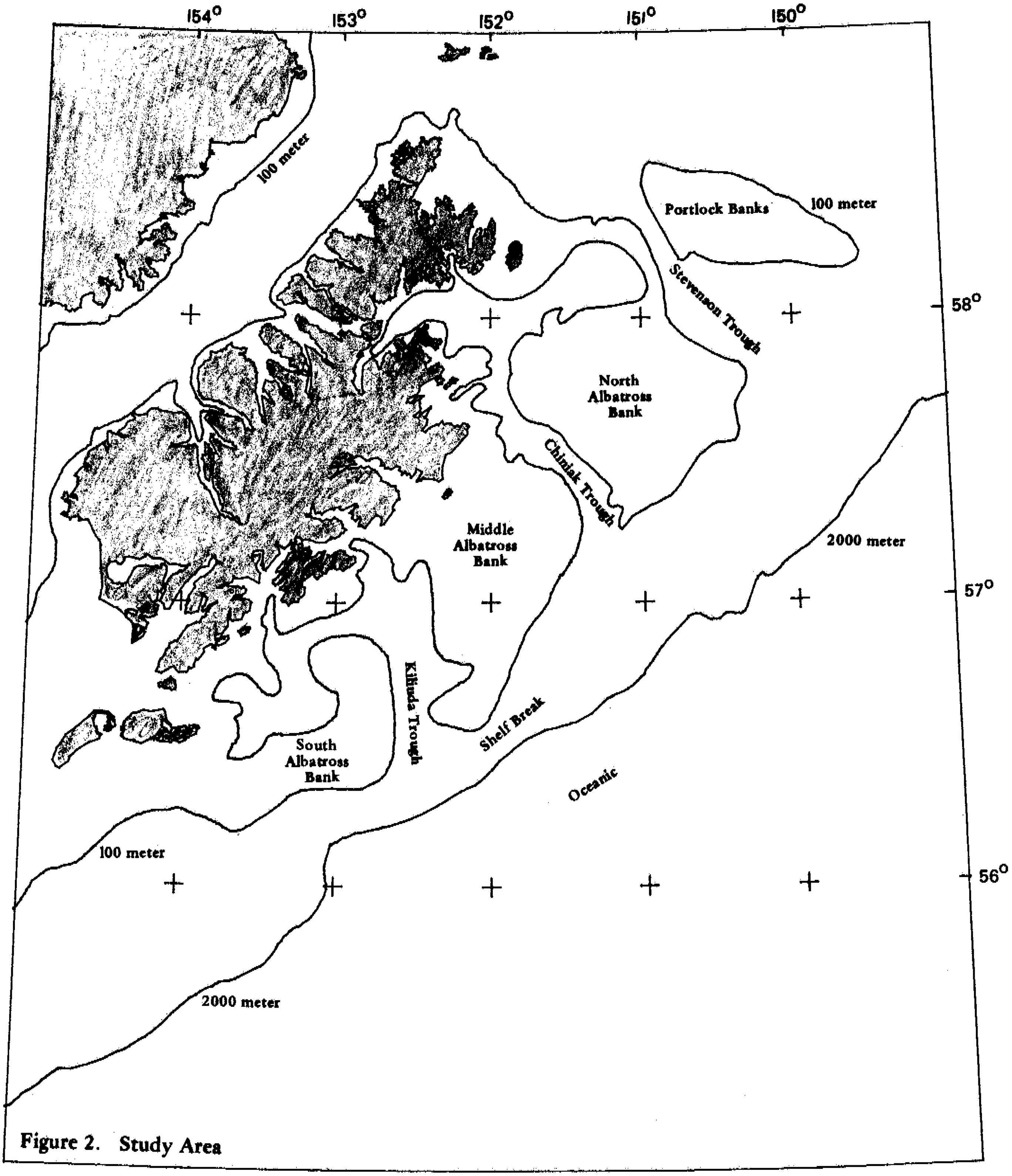

Figure 2. Study Area

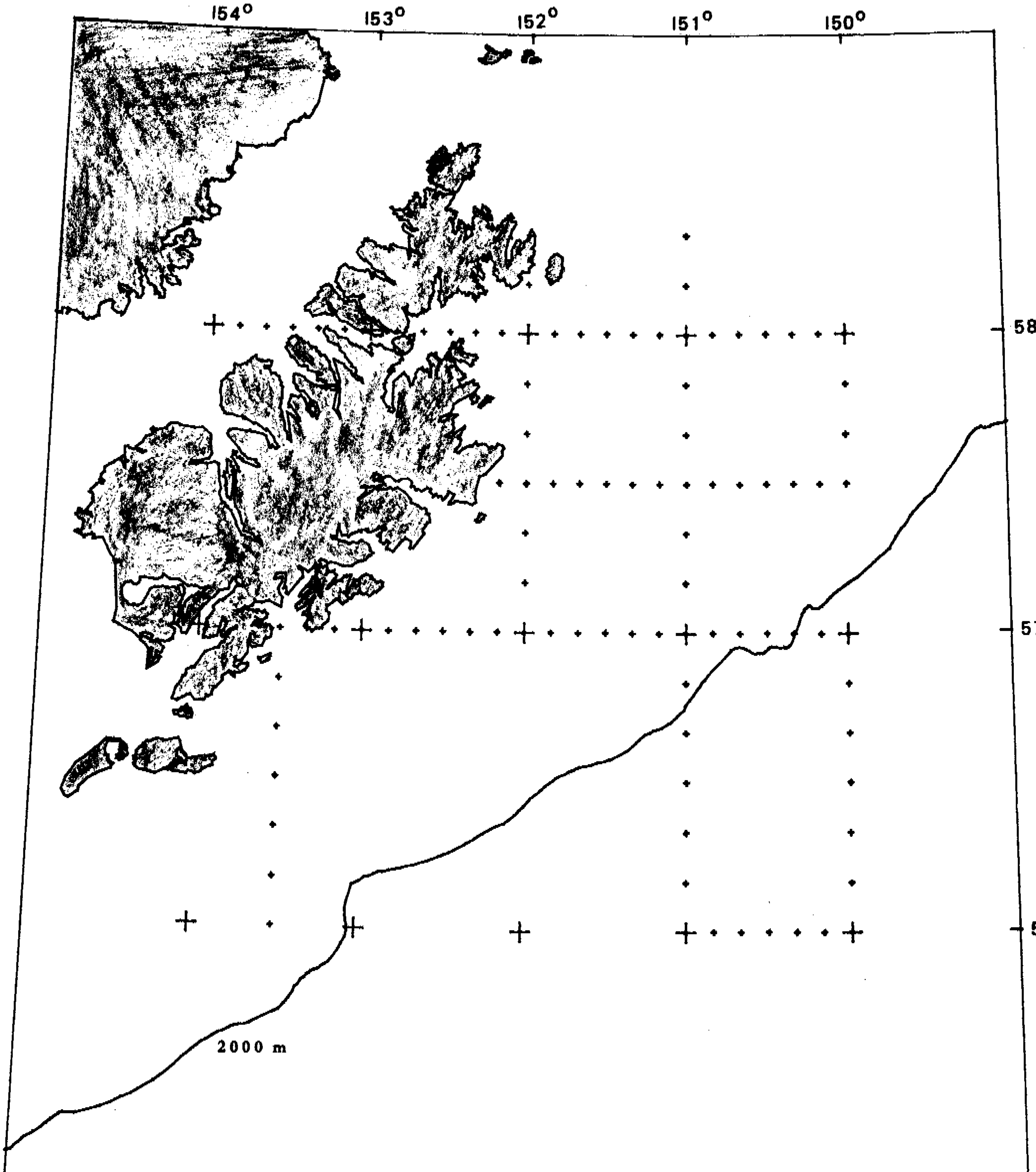

Figure 3. Transect Locations (+) For Aerial Survey FW7028, March 7 - 9, 1977.

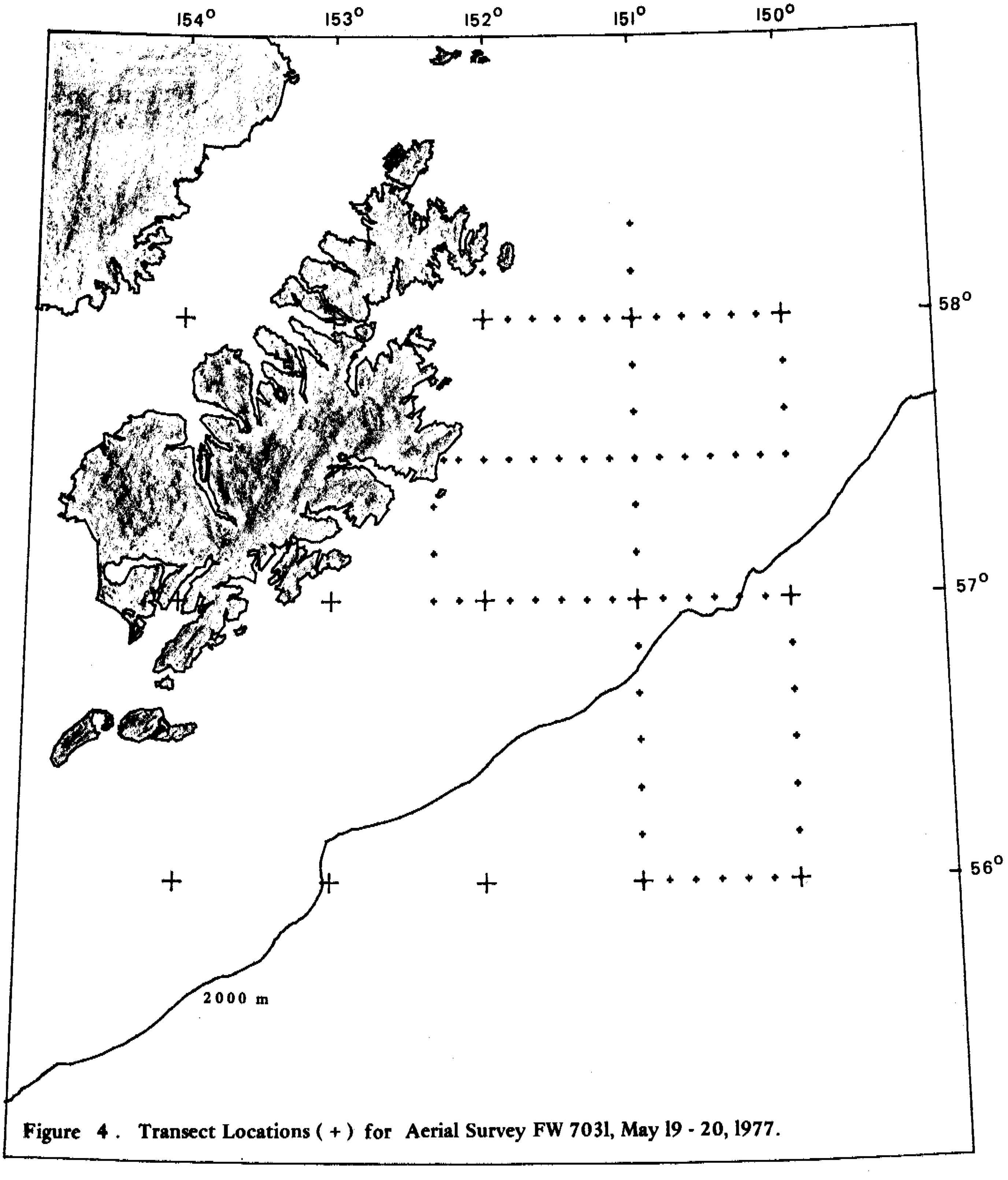

Figure 4. Transect Locations (+) for Aerial Survey FW 7031, May 19 - 20, 1977.

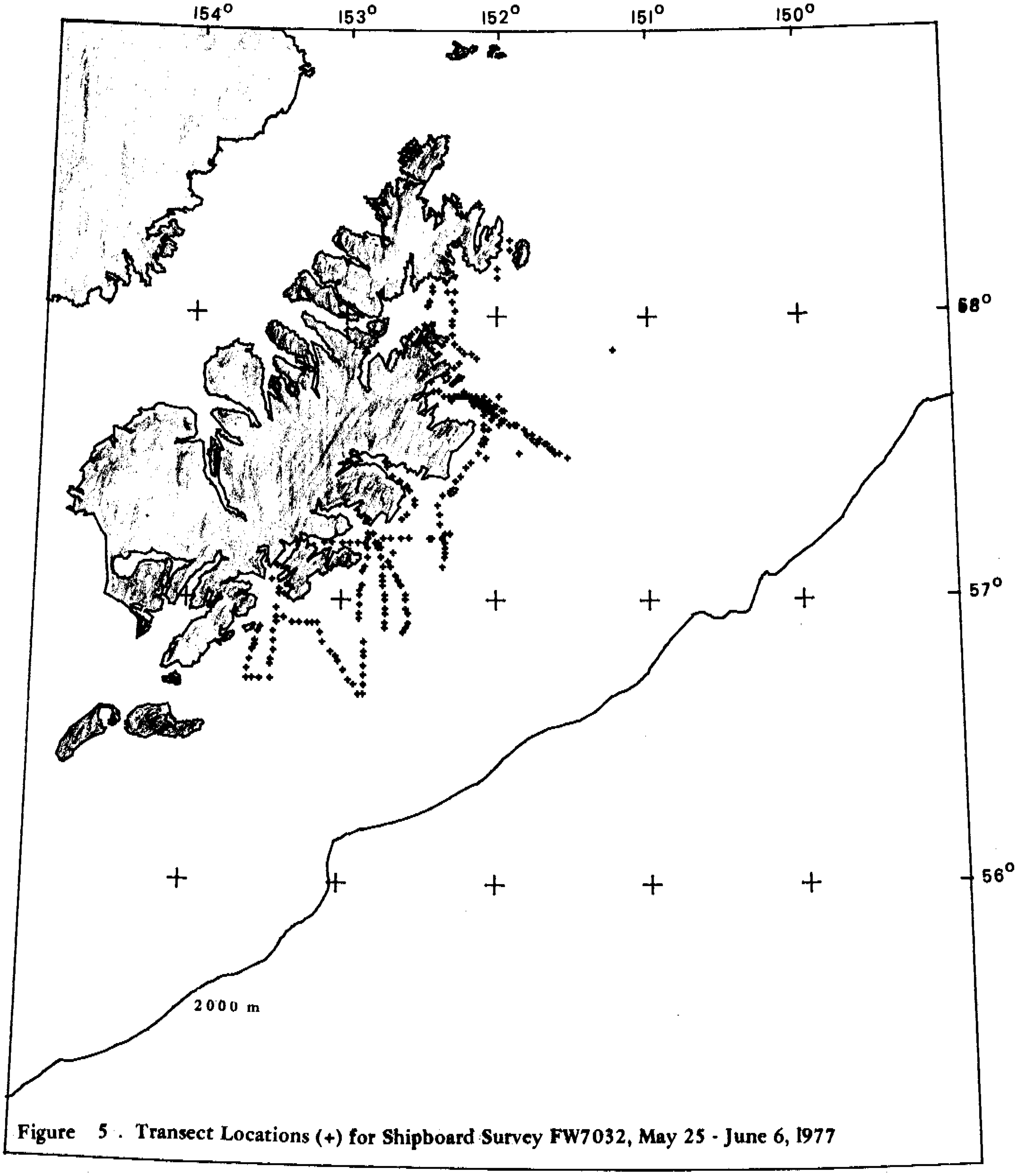

Figure 5 . Transect Locations (+) for Shipboard Survey FW7032, May 25 - June 6, 1977

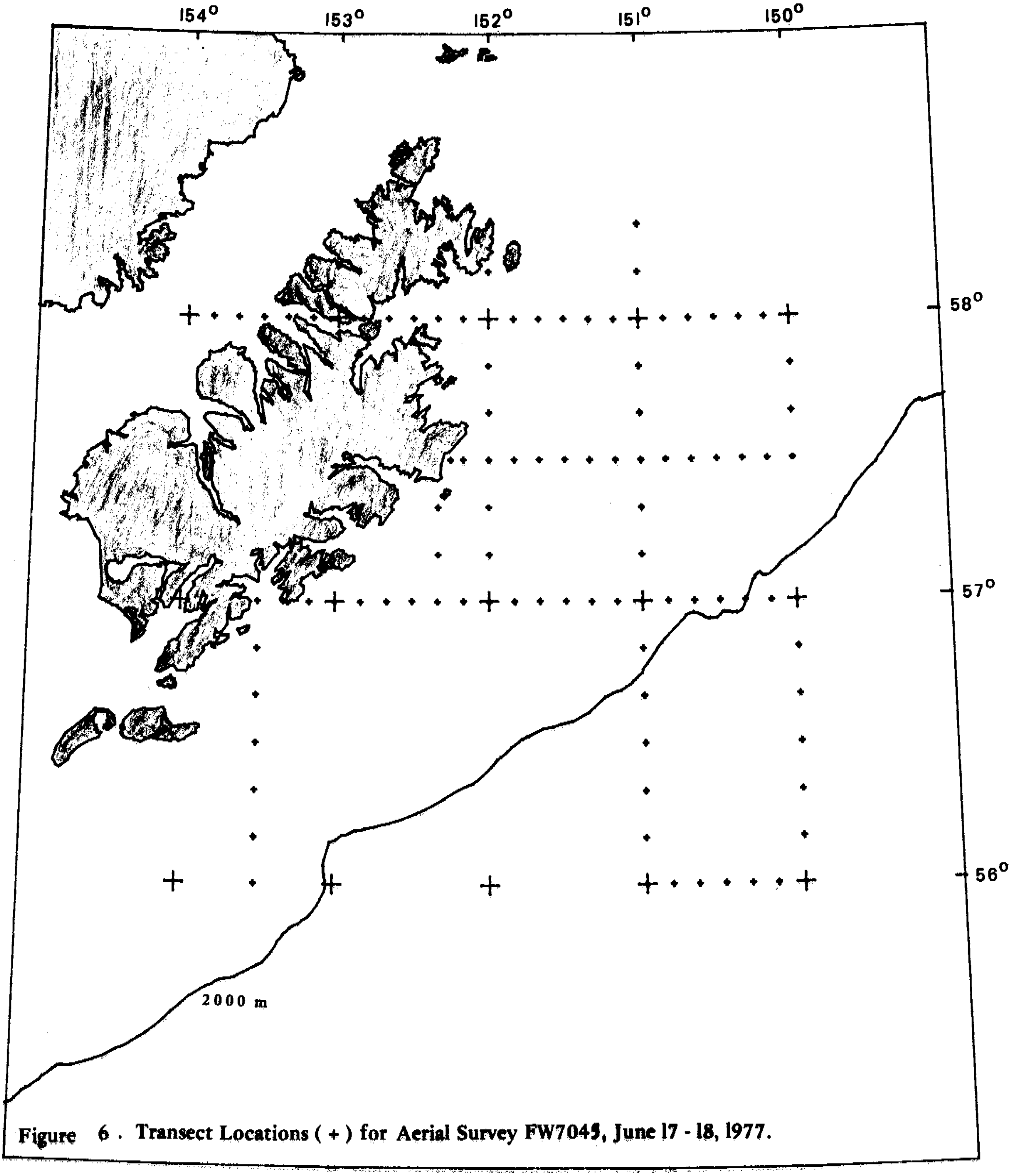

Figure 6 . Transect Locations (+) for Aerial Survey FW7045, June 17 - 18, 1977.

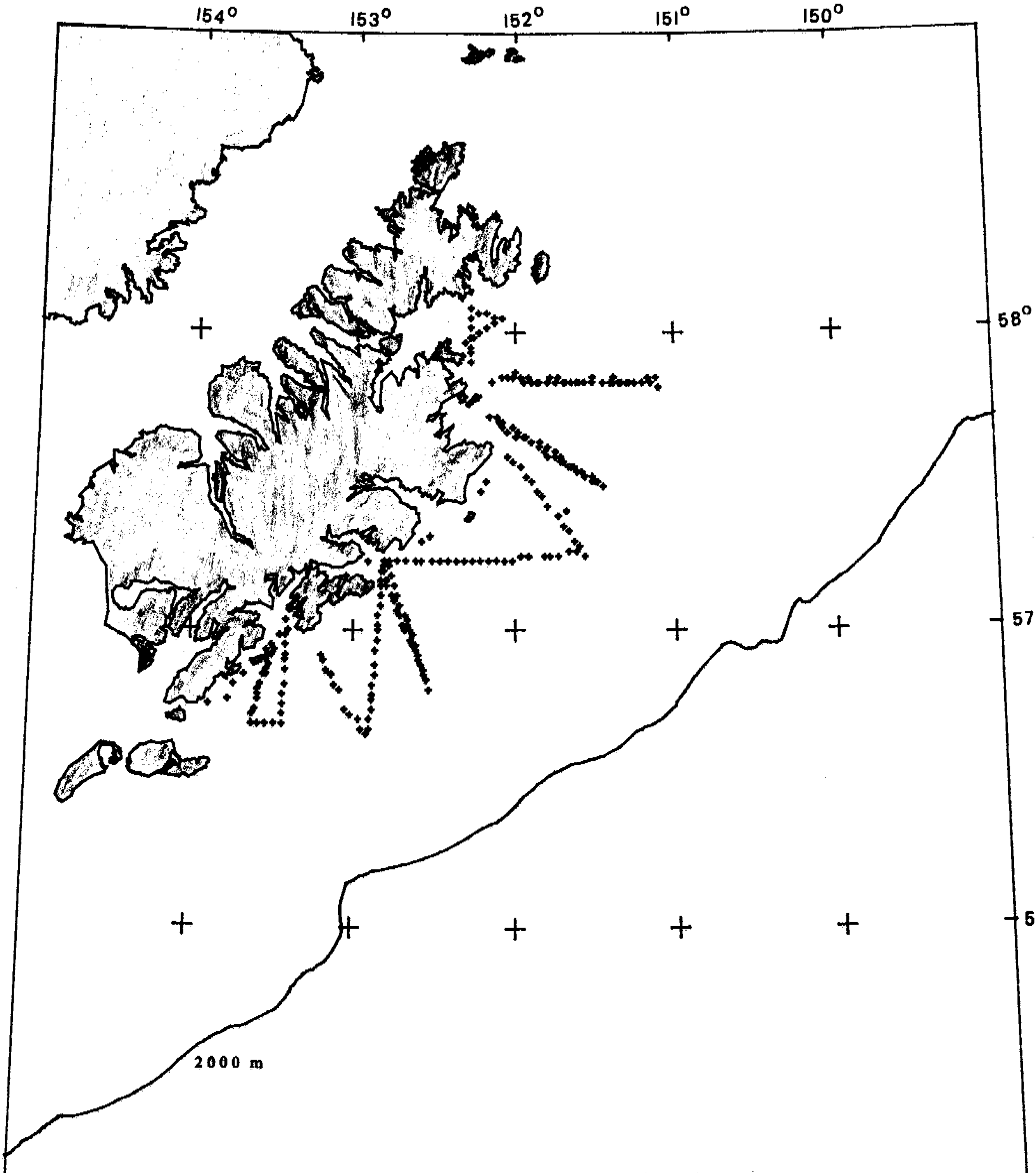

Figure 7 . Transect Locations (+) for Shipboard Survey FW7033, June 18 - 28, 1977.

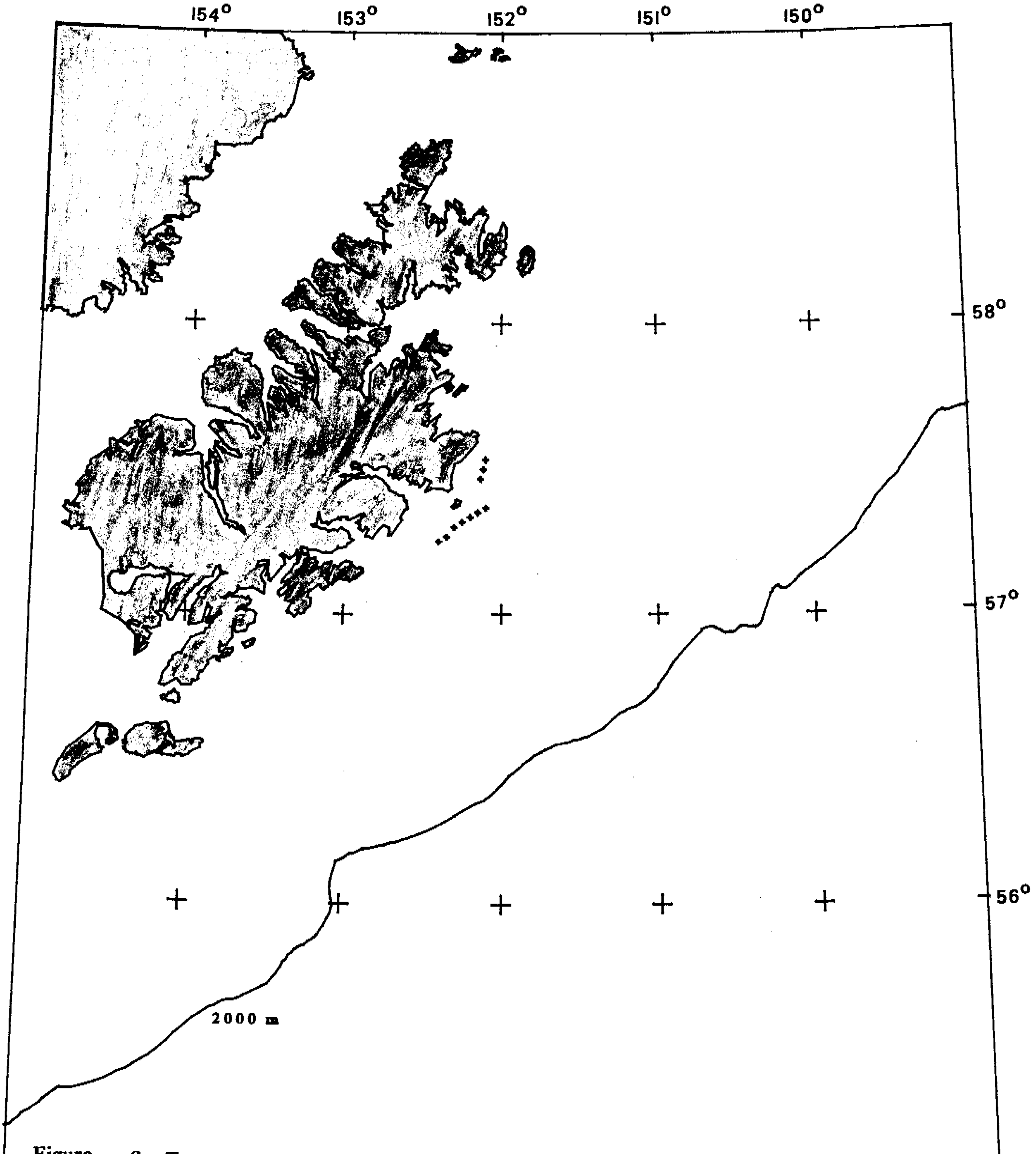

Figure 8 . Transect Locations (+) for Shipboard Survey FW7042, June 23, 1977.

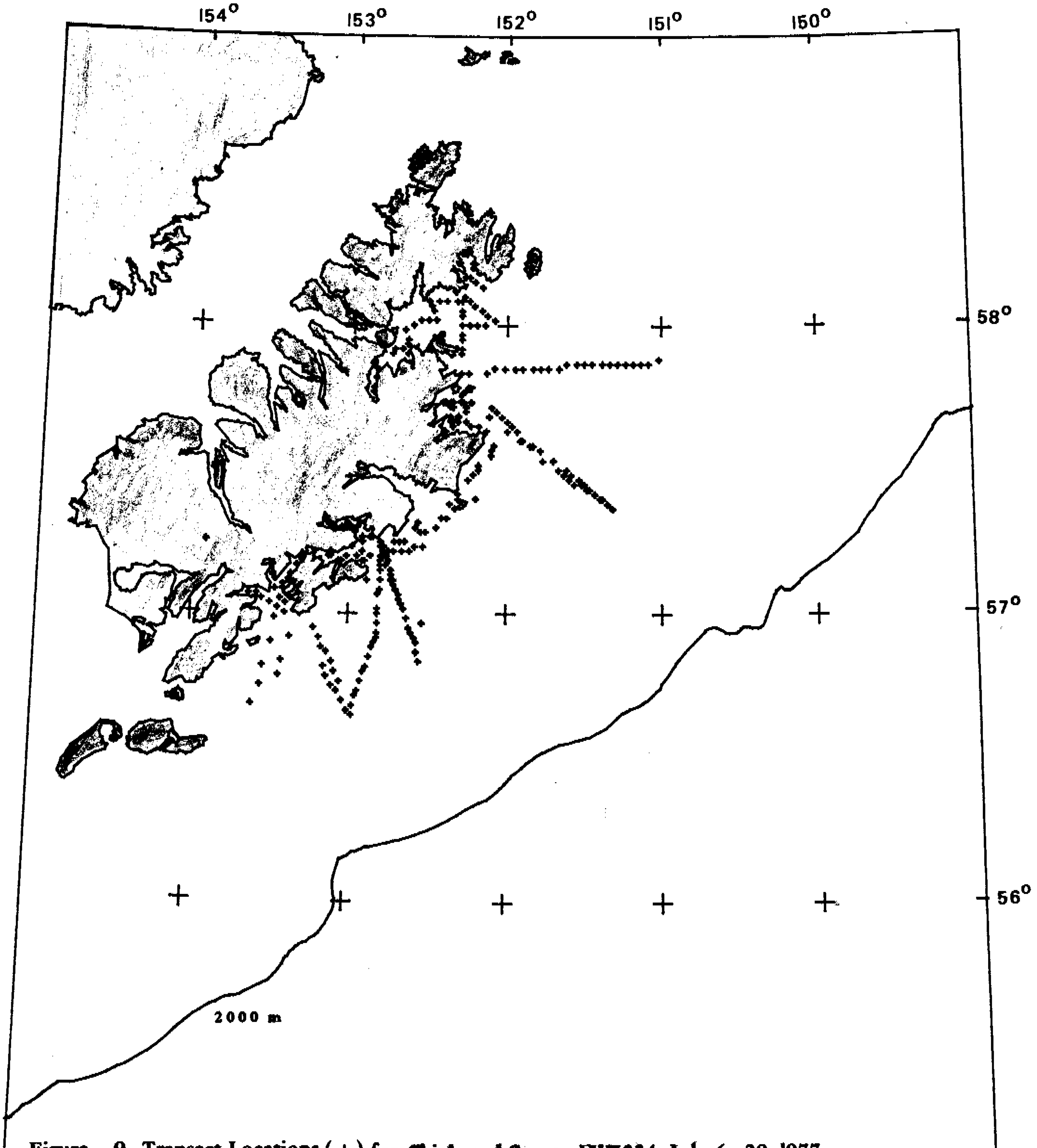

Figure 9. Transect Locations (+) for Shipboard Survey FW7034, July 6 - 29, 1977.

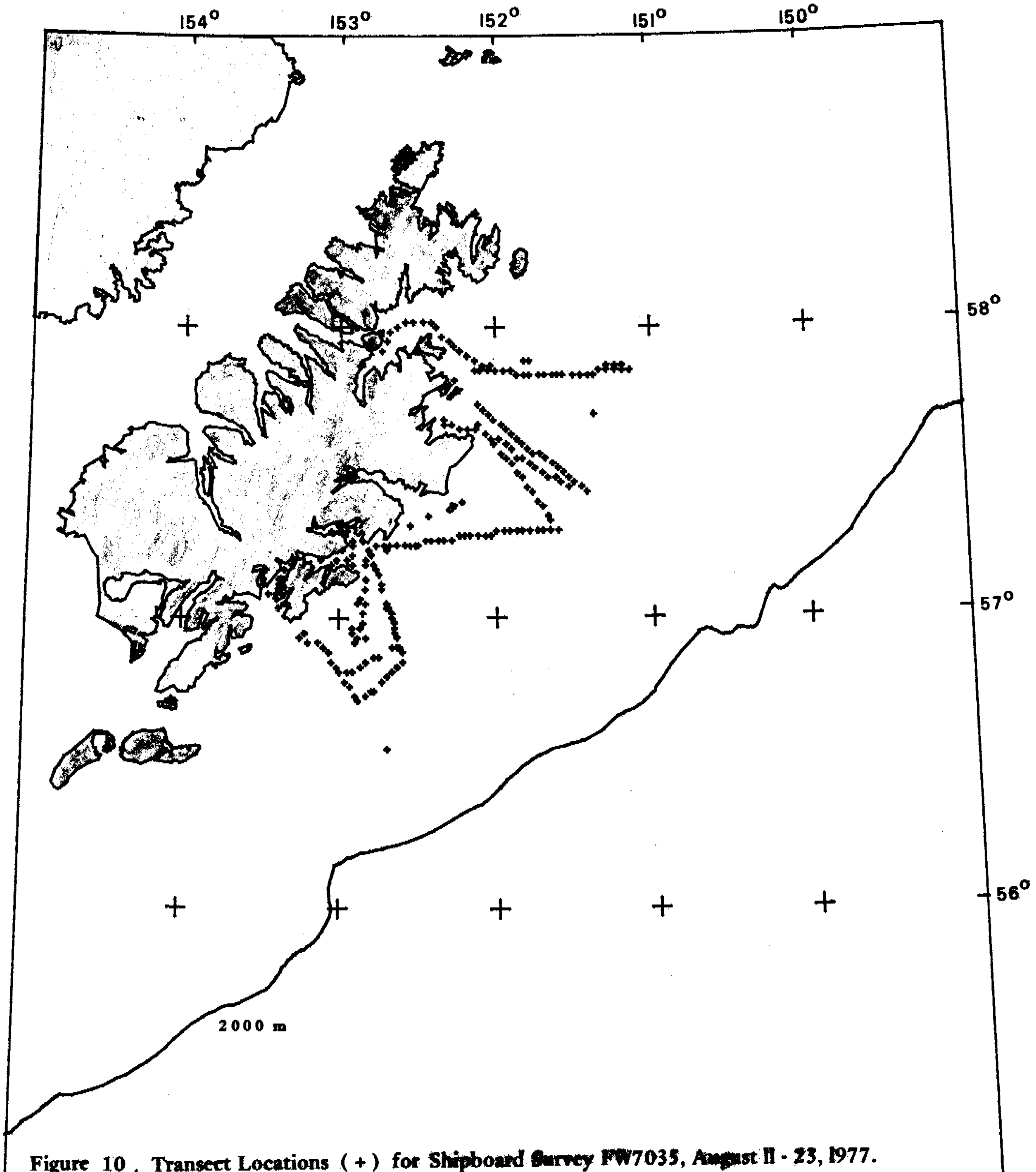

Figure 10 . Transect Locations (+) for Shipboard Survey FW7035, August 11 - 23, 1977.

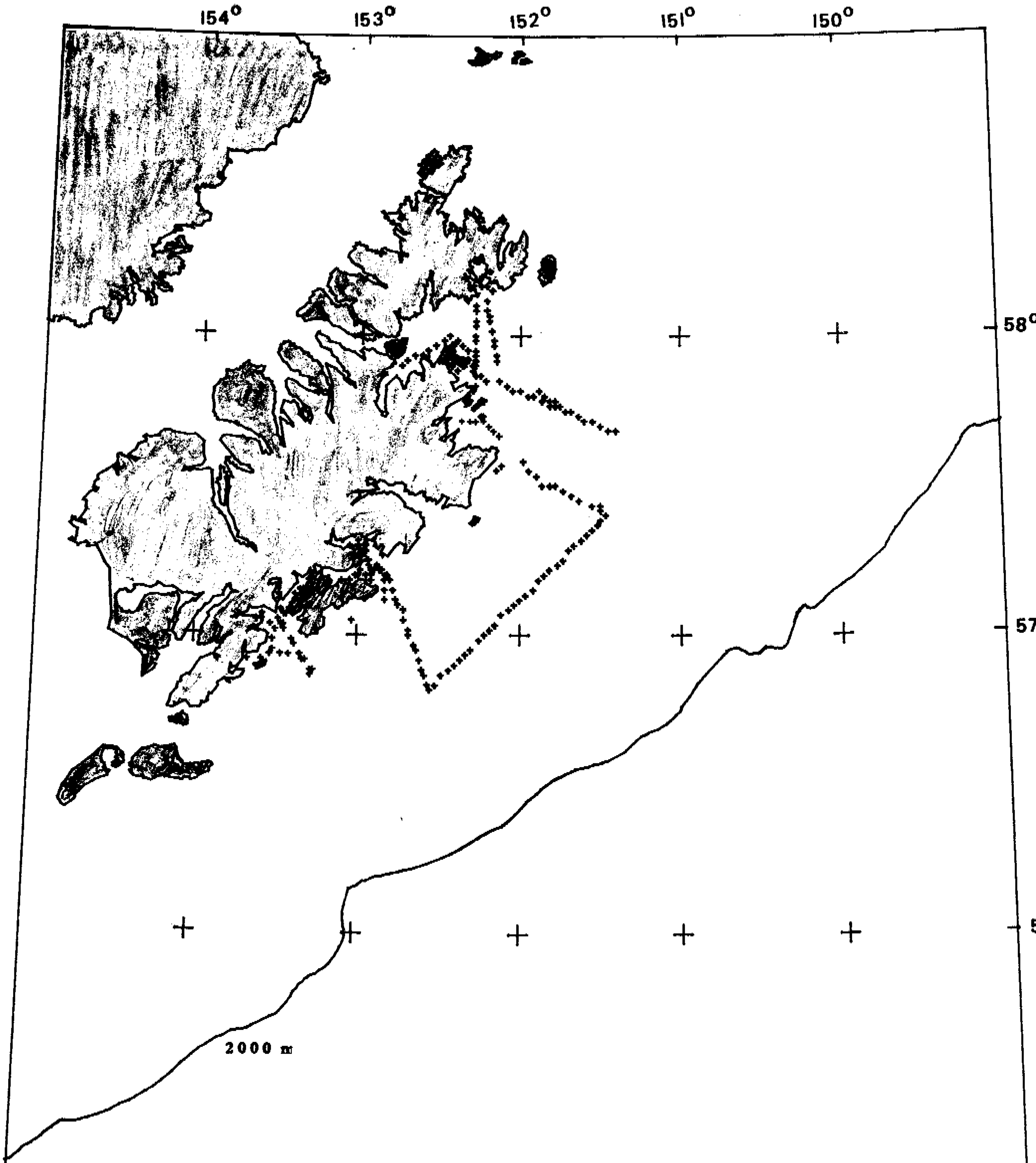

Figure 11. Transect Locations (+) for Shipboard Survey FW7036, September 7 - 19, 1977.

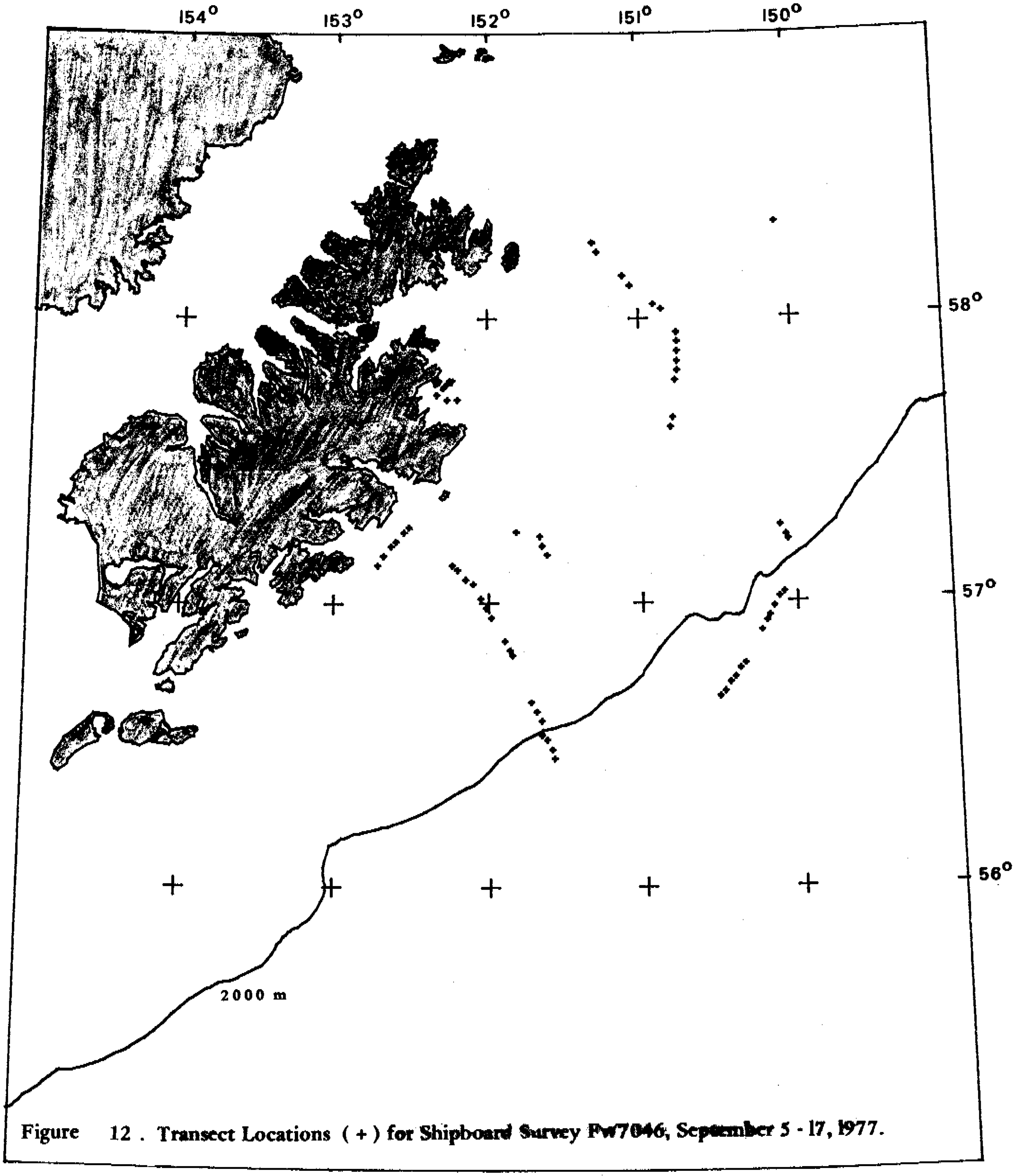

Figure 12 . Transect Locations (+) for Shipboard Survey Fw7046, September 5 - 17, 1977.

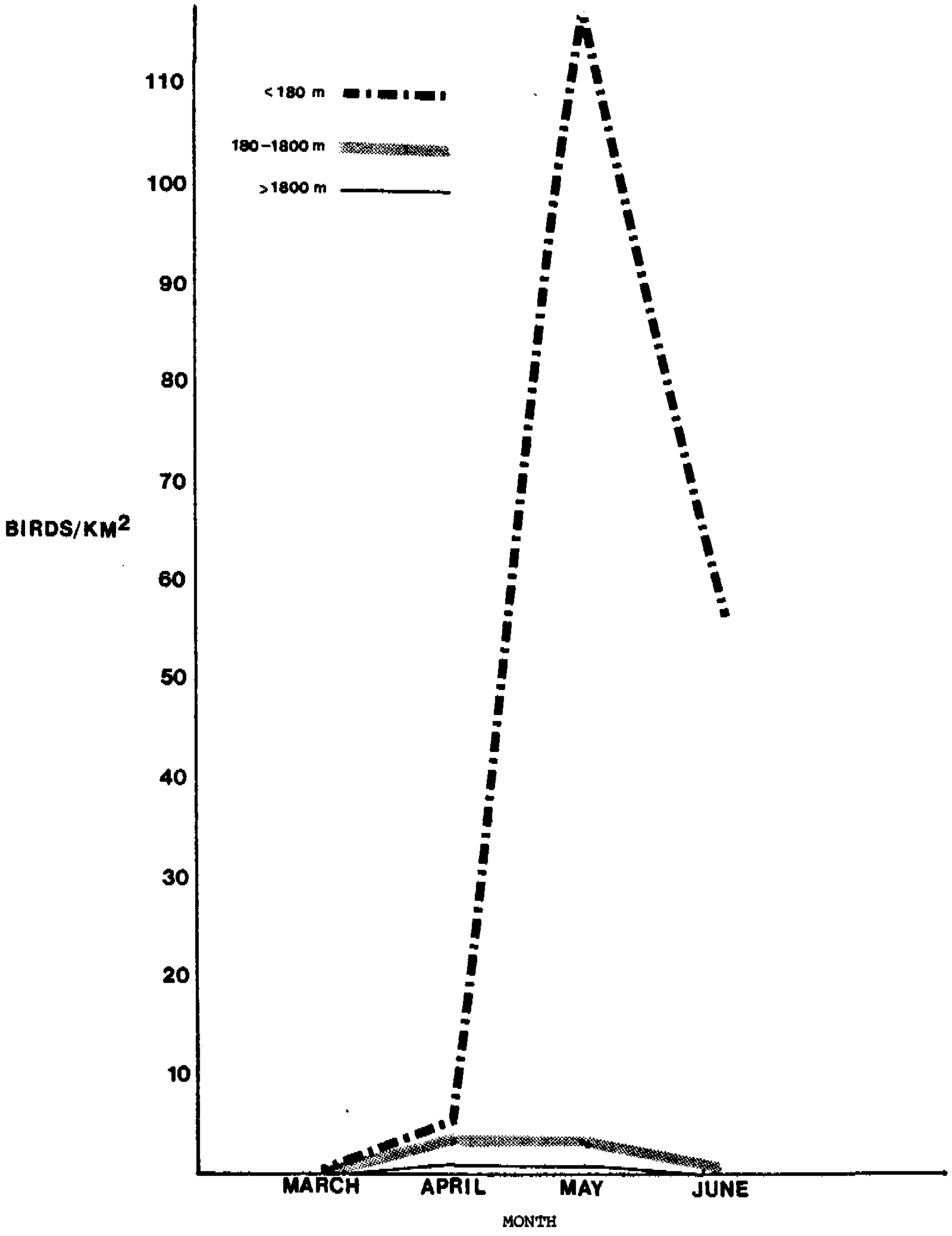

Figure 13. Sooty/Short-tailed Shearwater Density Indices From Aerial Surveys of Kodiak Island Waters, 1977.

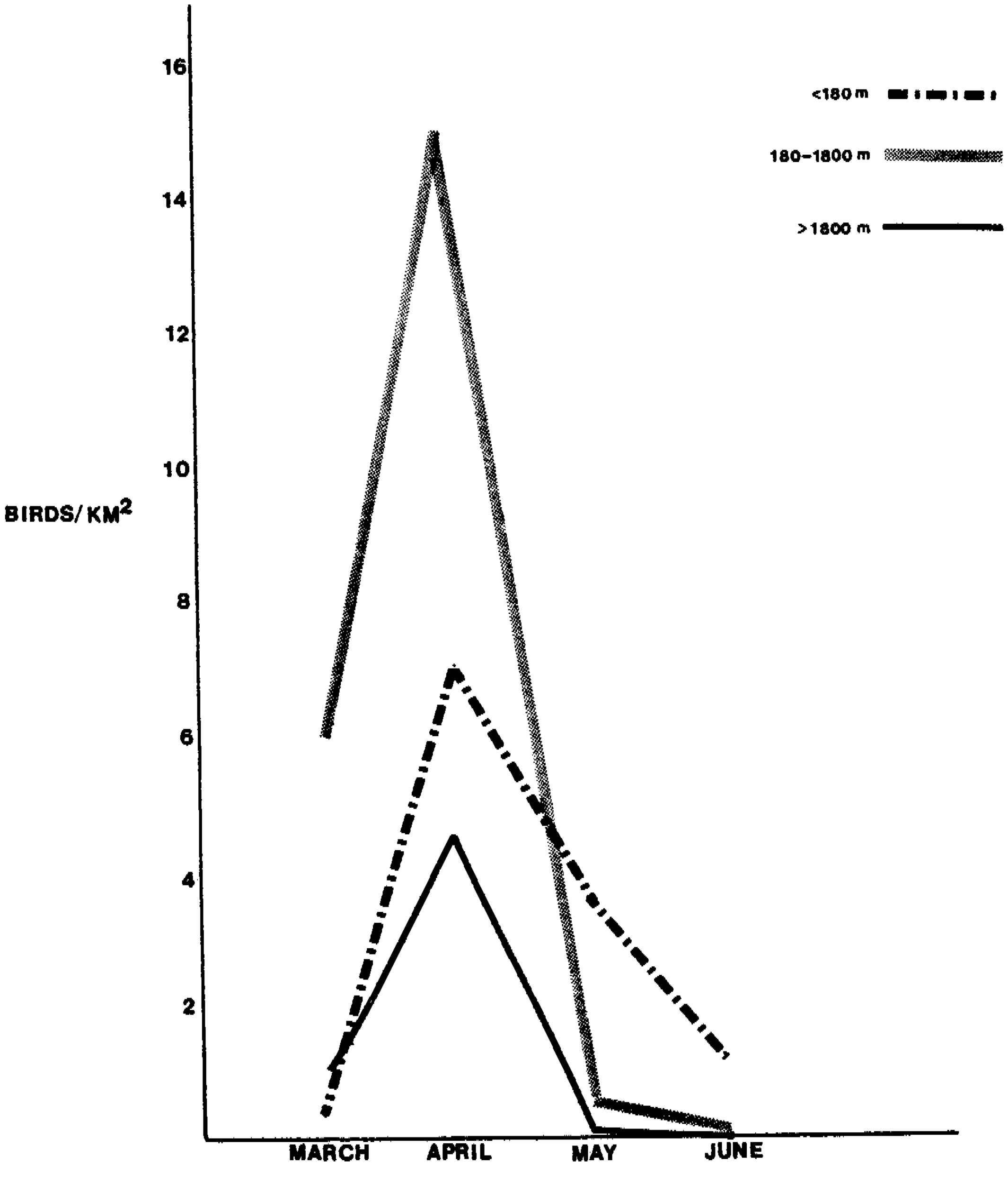

Figure 14. Black-legged Kittiwake Density Indices From Aerial Surveys of Kodiak Island Waters, 1977.

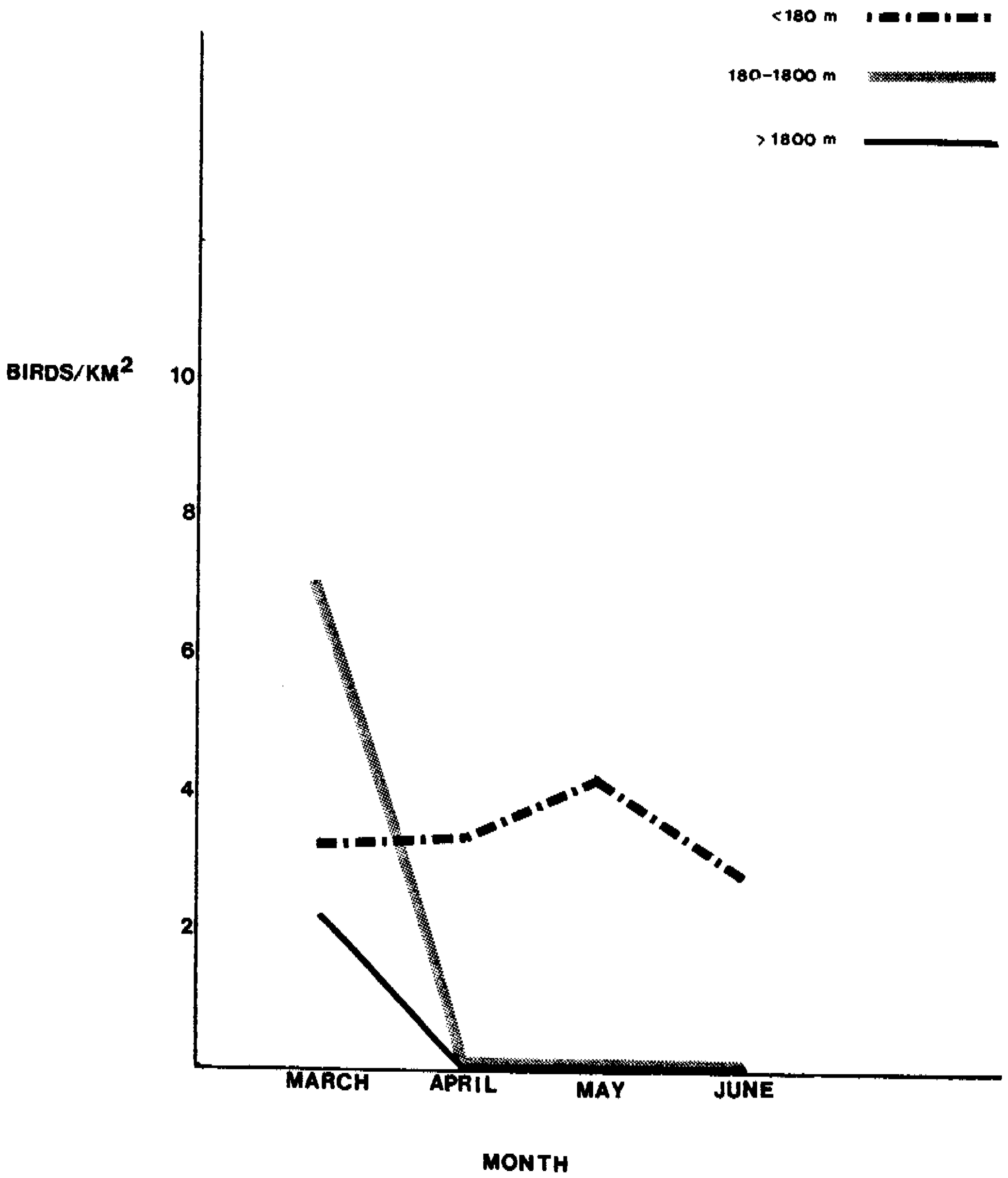

Figure 15. Common/Thick-billed Murre Density Indices From Aerial Surveys of Kodiak Island Waters, 1977.

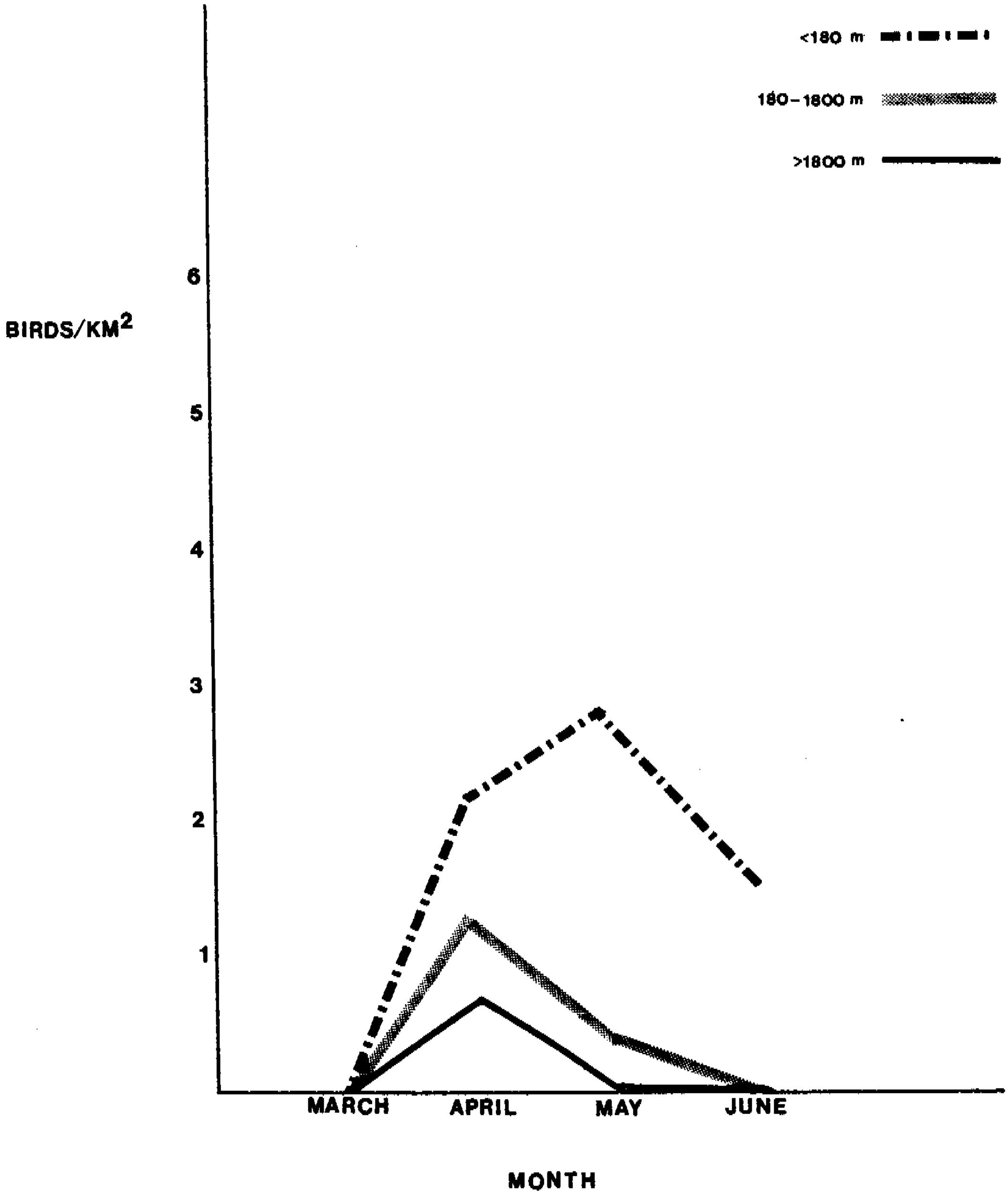

Figure 16. Tufted Puffin Density Indices From Aerial Surveys of Kodiak Island Waters, 1977.

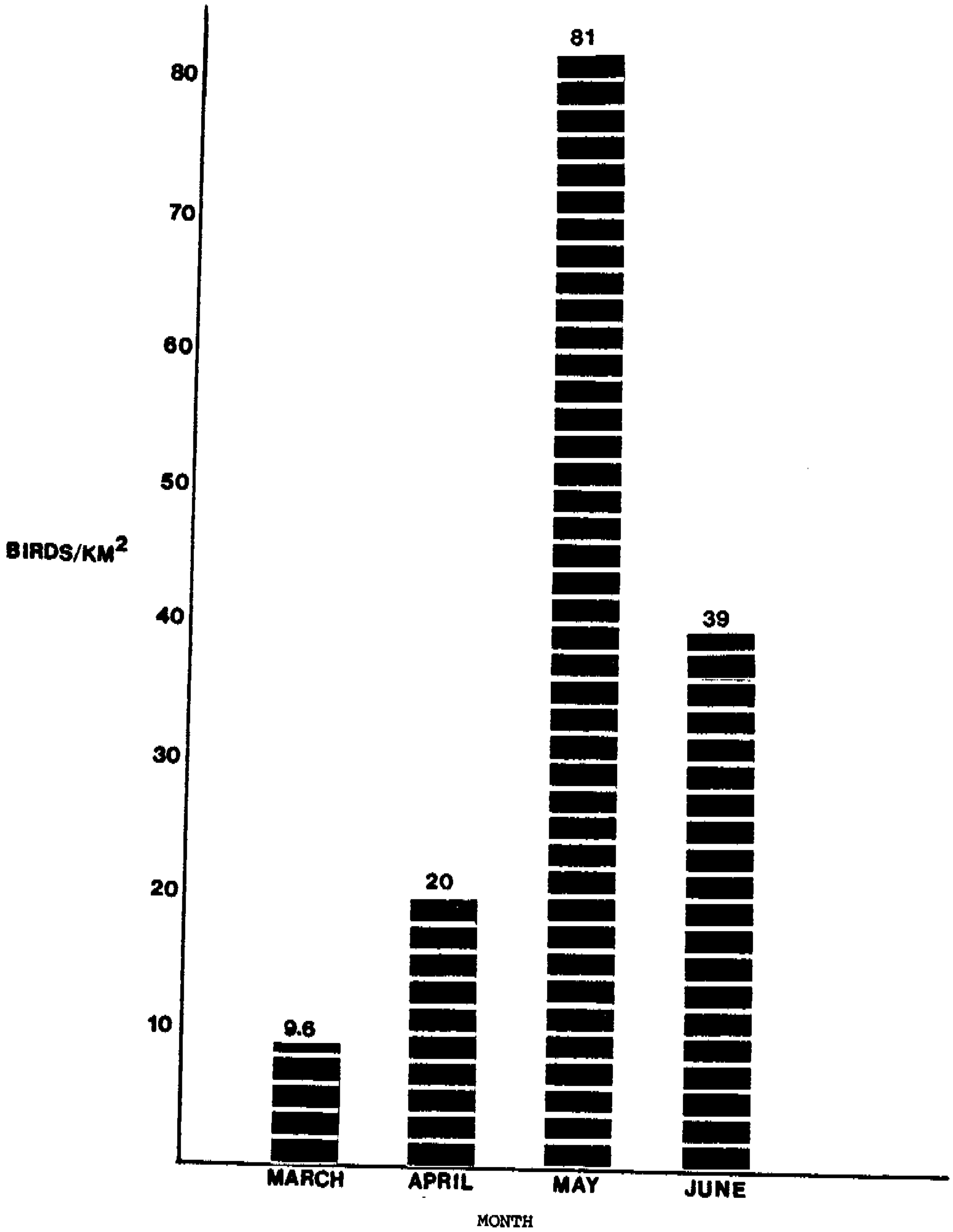

Figure 17. Total Bird Density Indices From Aerial Surveys of Kodiak Island Waters, 1977.

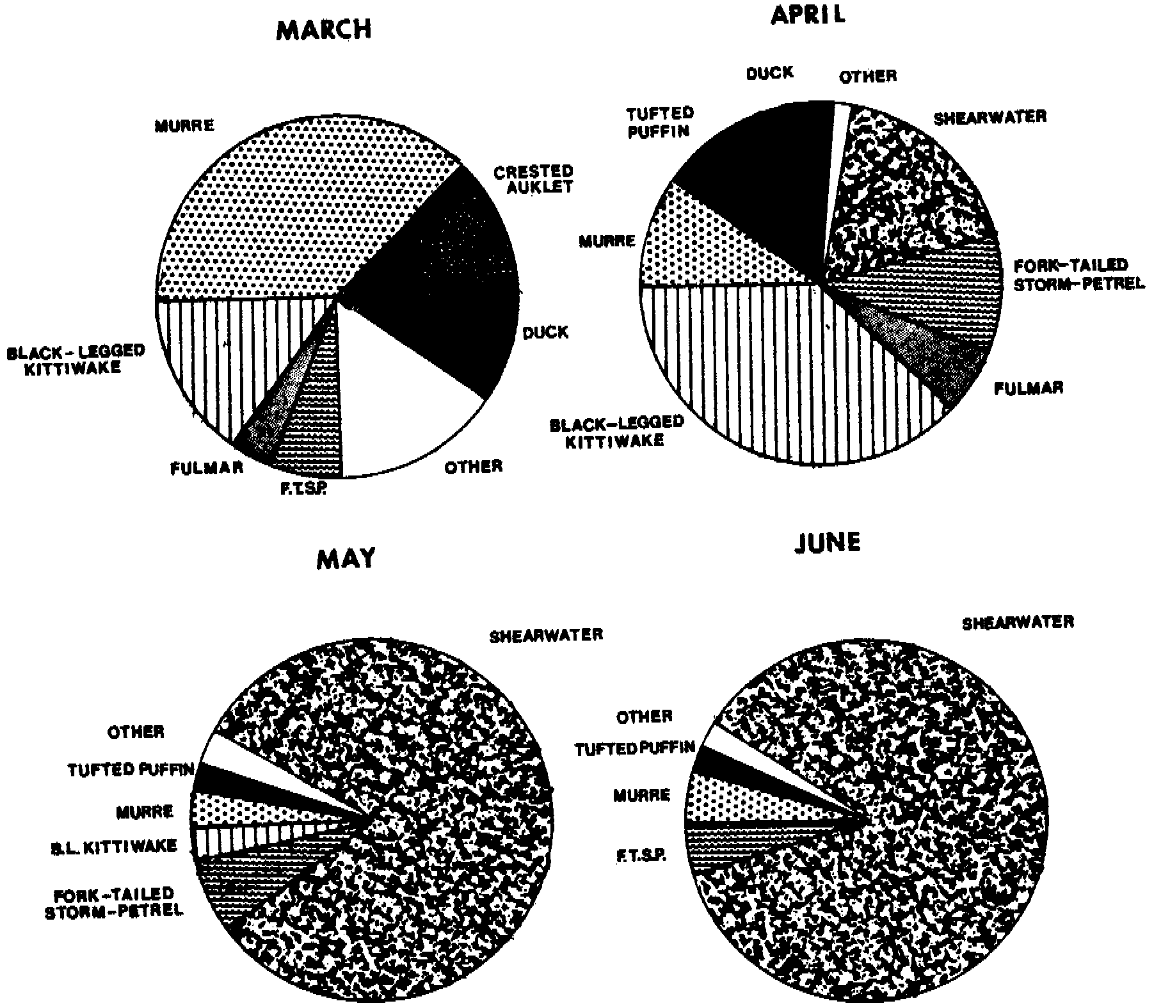

Figure 18. Relative seabird species composition From Aerial Surveys of Kodiak Island Waters, 1977.

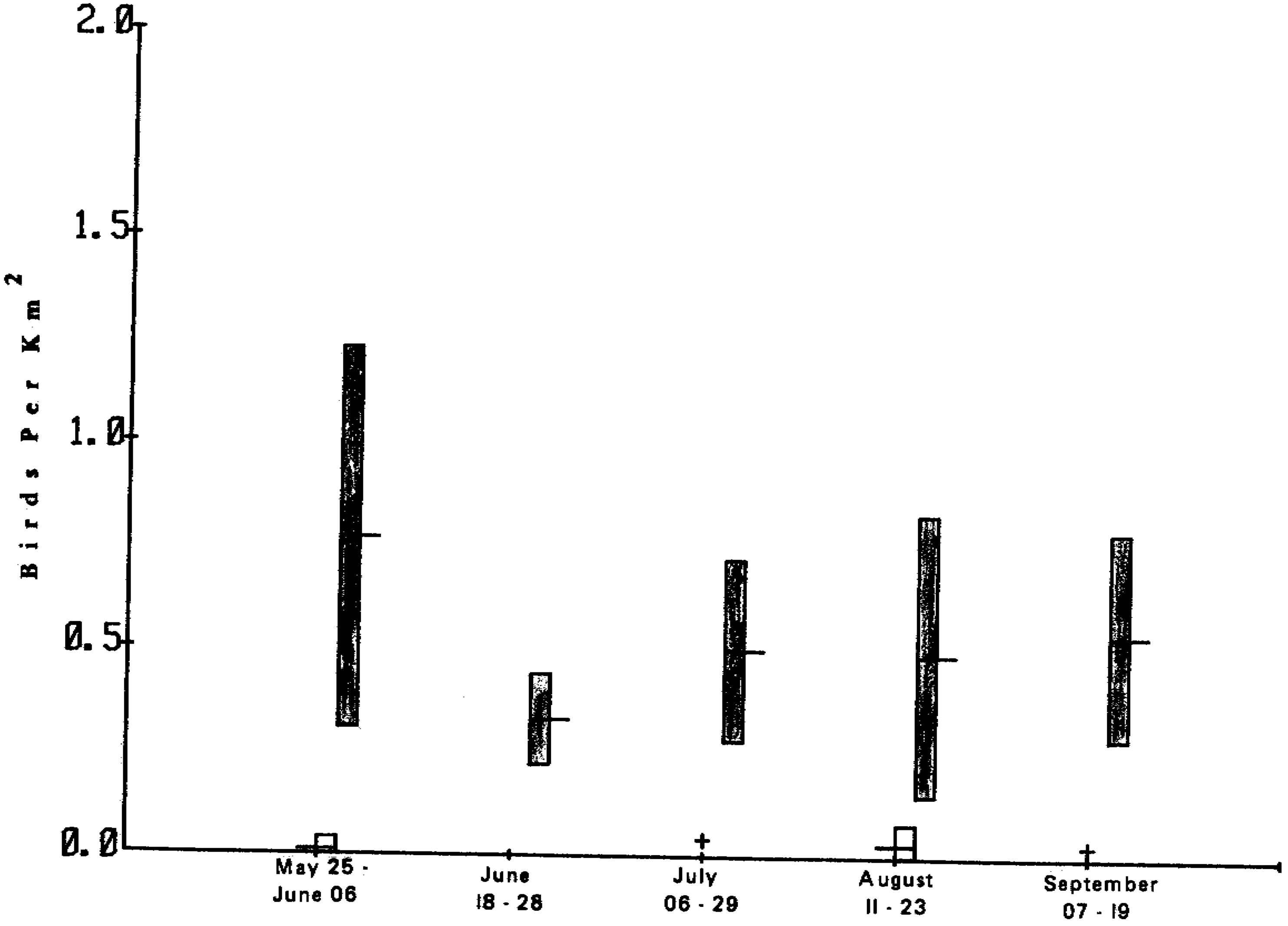

Figure 19. Northern Fulmar Density Indices From Shipboard Surveys. Mean ± 95% Confidence Limits For Bay (⊣) and Shelf (⊢) Areas of South and East Kodiak Island, 1977.

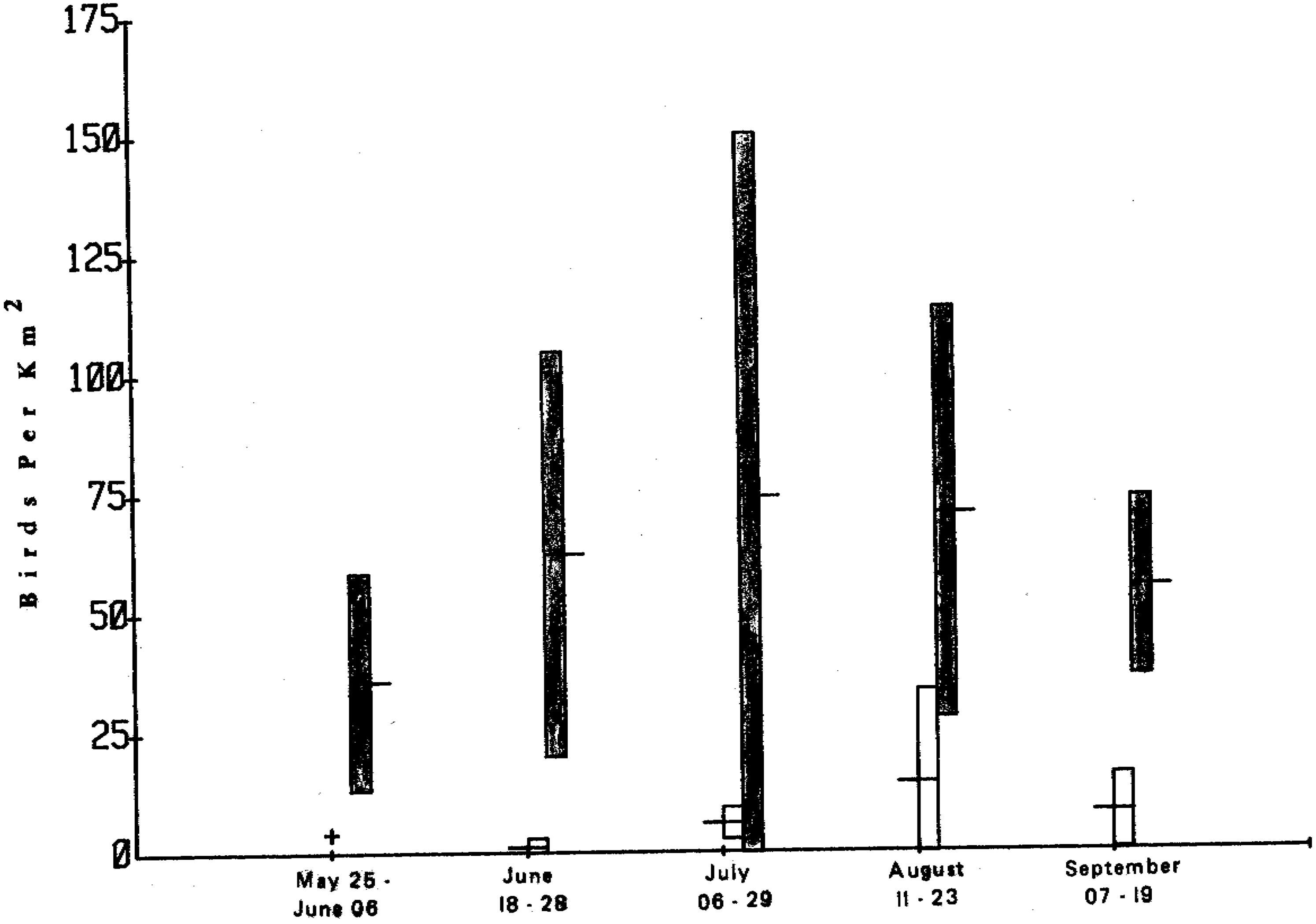

Figure 20. Total Shearwater Density Indices From Shipboard Surveys. Mean ± 95% Confidence Limits for Bay (⊣) and Shelf (⊢) Areas of South and East Kodiak Island, 1977.

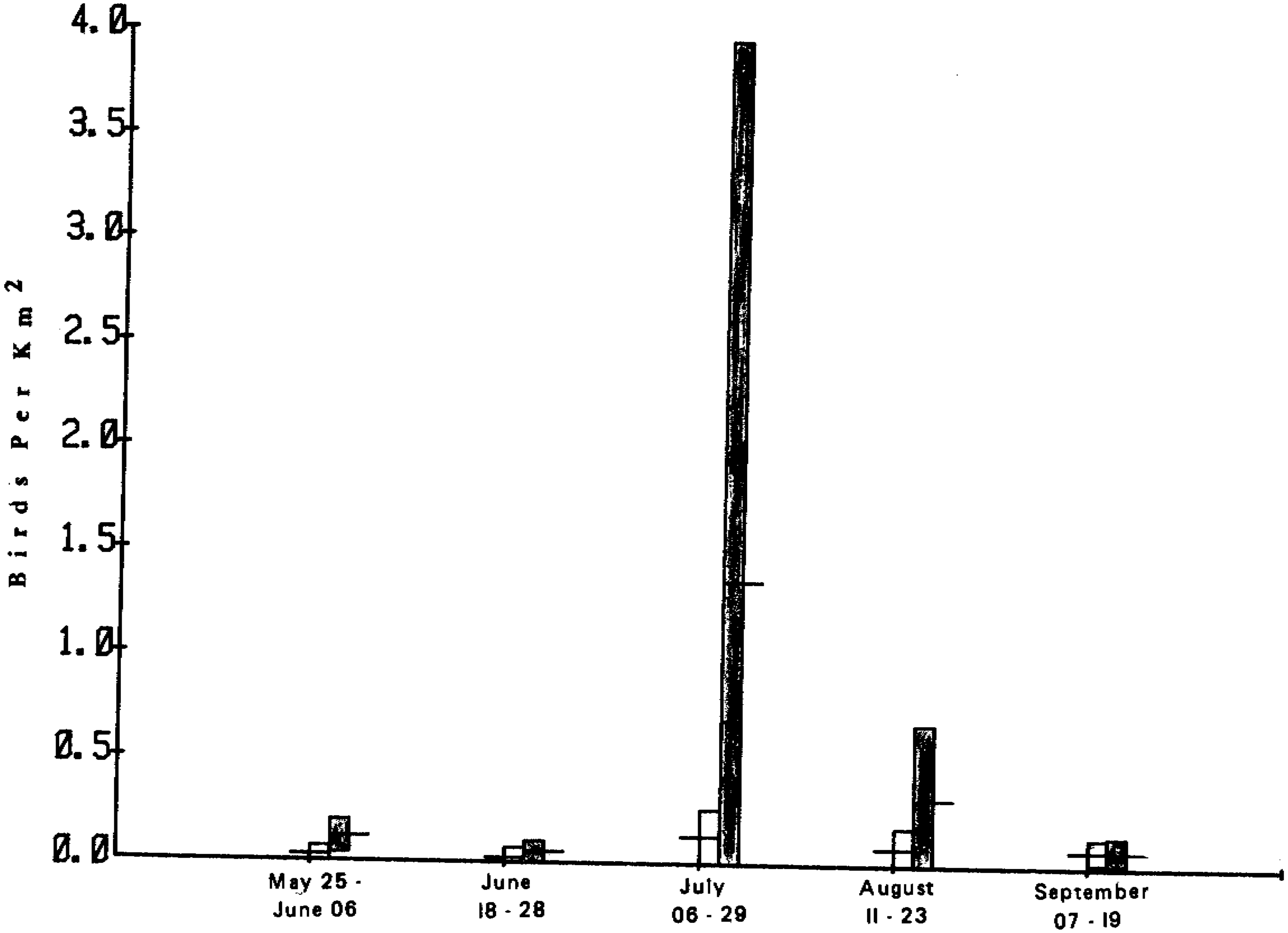

Figure 21. Pomarine Jaeger Density Indices From Shipboard Surveys. Mean ± 95% Confidence Limits For Bay (⊣) and Shelf (⊢) Areas of South and East Kodiak Island, 1977.

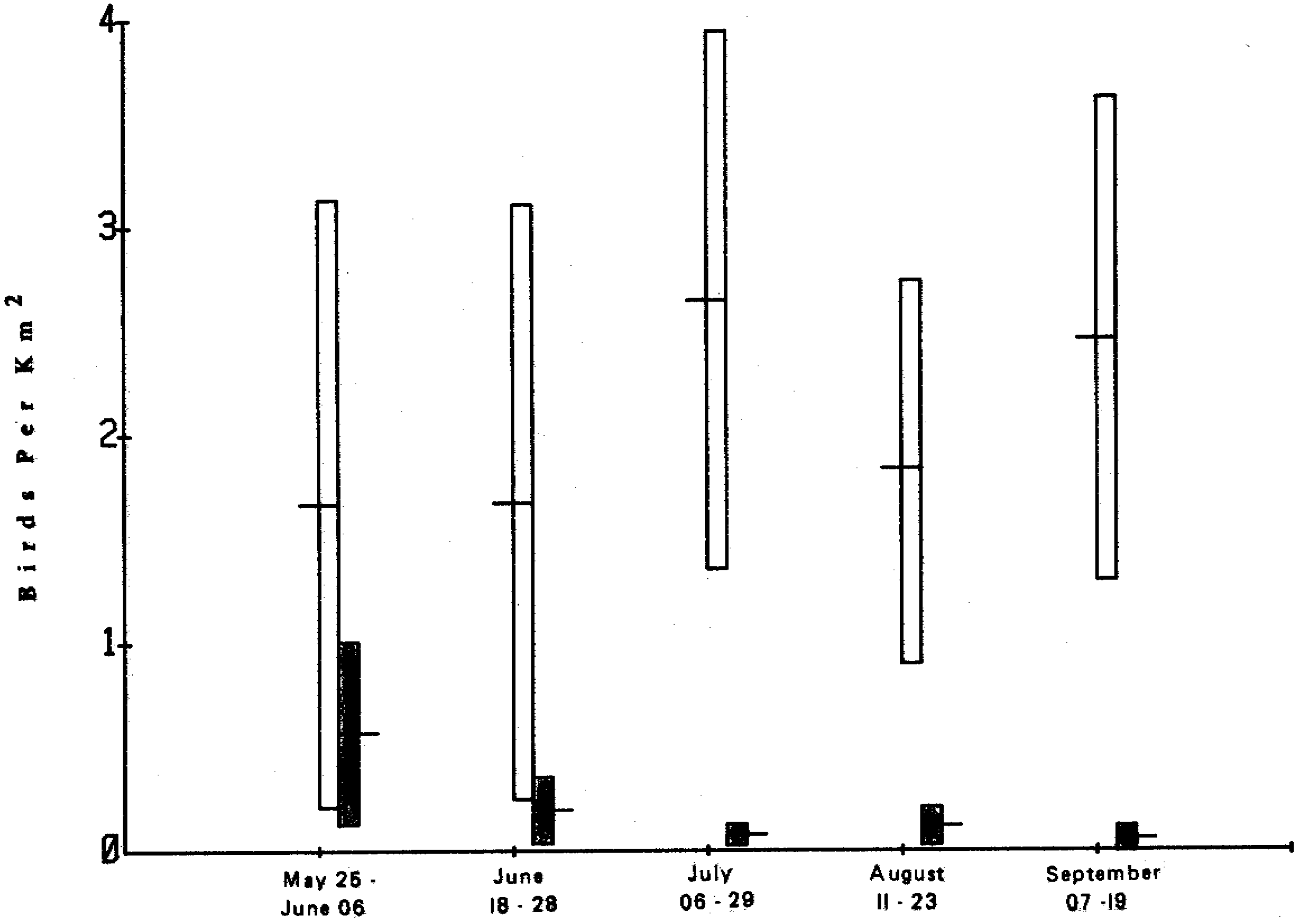

Figure 22. Glaucous-winged Gull Density Indices From Shipboard Surveys. Means ± 95% Confidence Limits For Bay (⊣) and Shelf (⊢) Areas of South and East Kodiak Island, 1977.

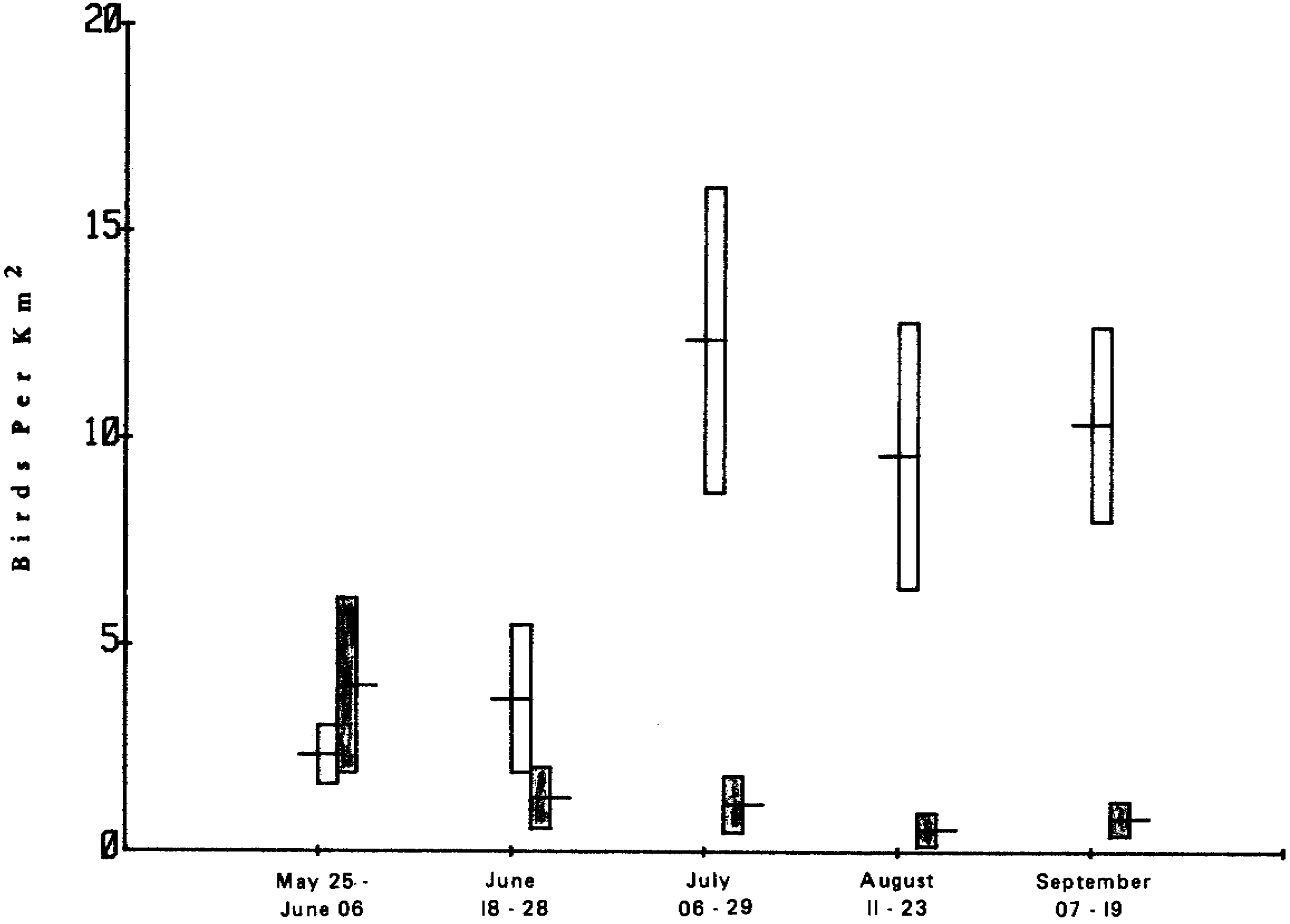

Figure 23. Kittiwake Density Indices From Shipboard Surveys. Mean ± 95% Confidence Limits for Bay (⊣) and Shelf (⊢) Areas of South and East Kodiak Island, 1977.

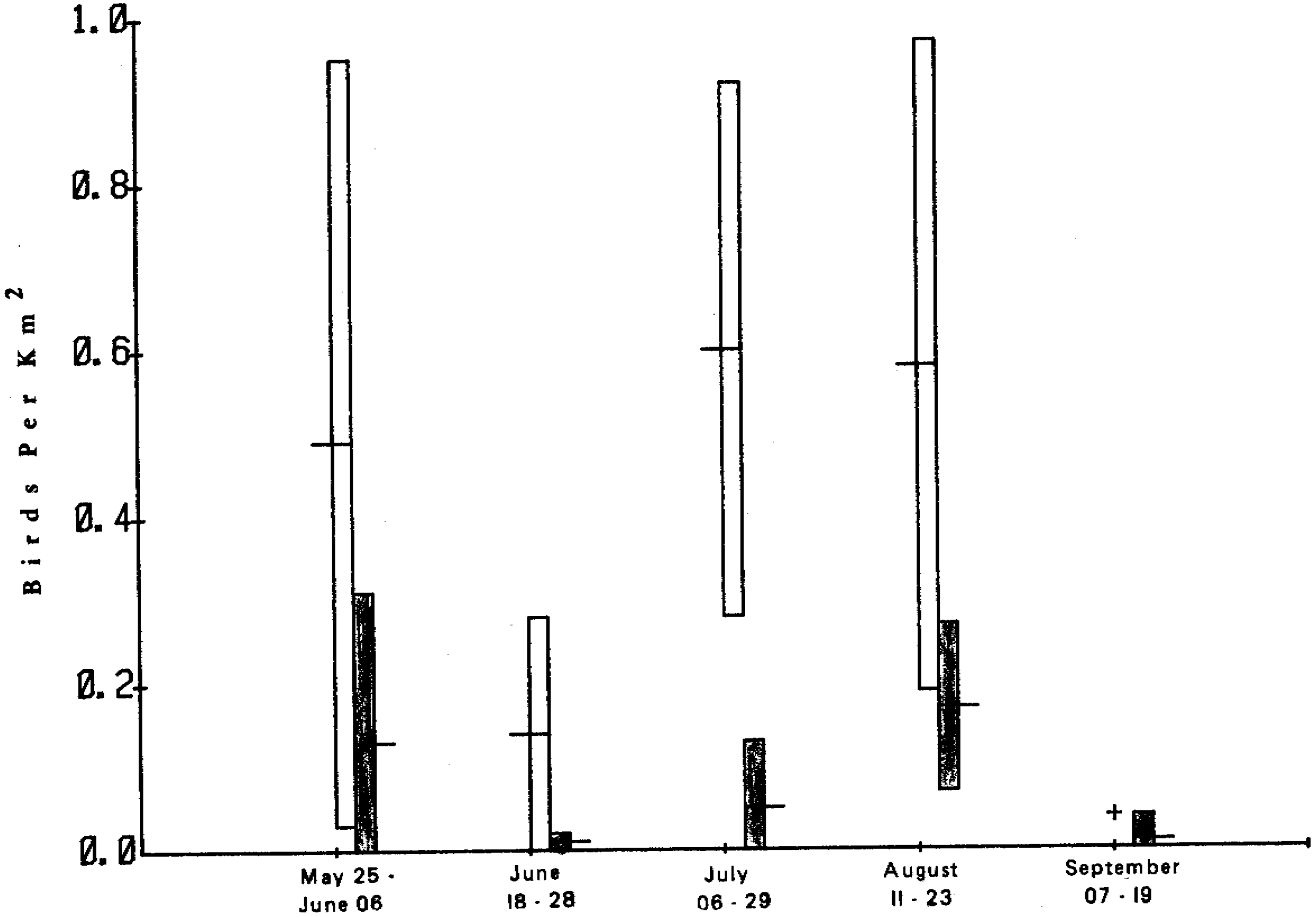

Figure 24. Arctic Tern Density Indices From Shipboard Surveys. Mean ± 95% Confidence Limits For Bay (⊣) and Shelf (⊢) Areas of South and East Kodiak Island, 1977.

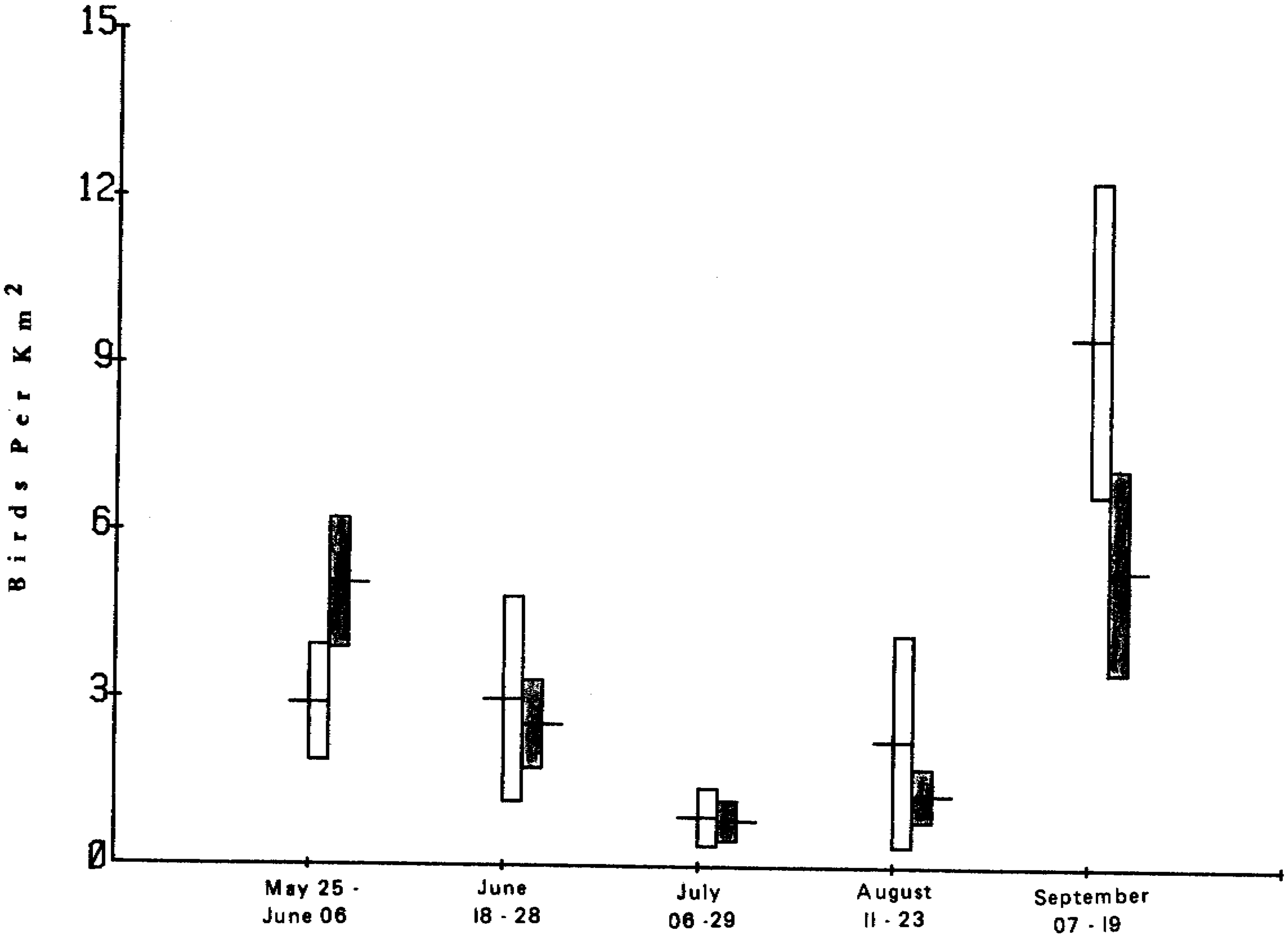

Figure 25 . Total Murre Density Indices From Shipboard Surveys. Mean ± 95% Confidence Limits For Bay (⊣) and Shelf (⊢) Areas of South and East Kodiak Island, 1977.

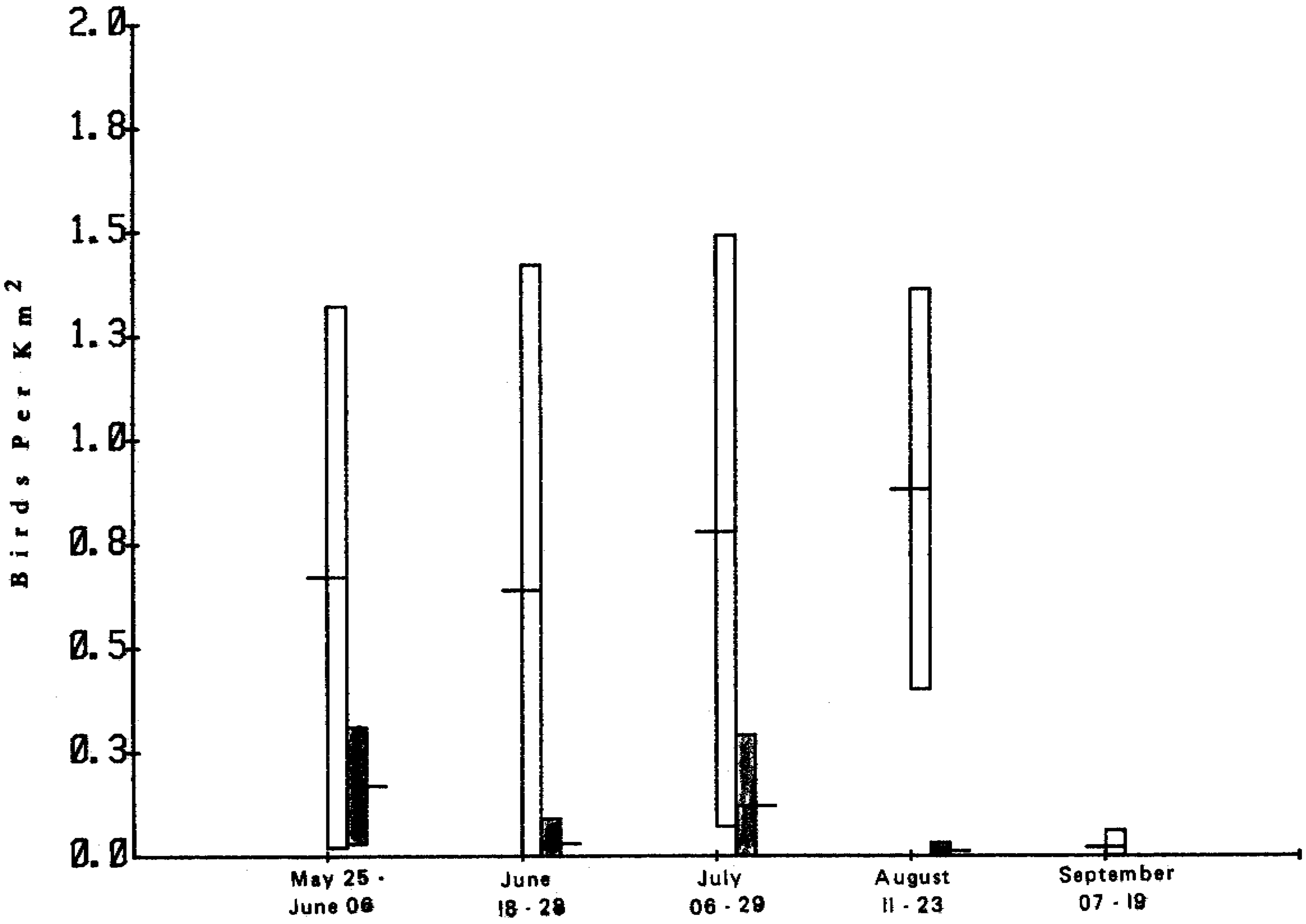

Figure 26 . Pigeon Guillemot Density Indices From Shipboard Surveys. Mean ± 95% Confidence Limits For Bay (⊣) and Shelf (⊢) Areas of South and East Kodiak Island, 1977.

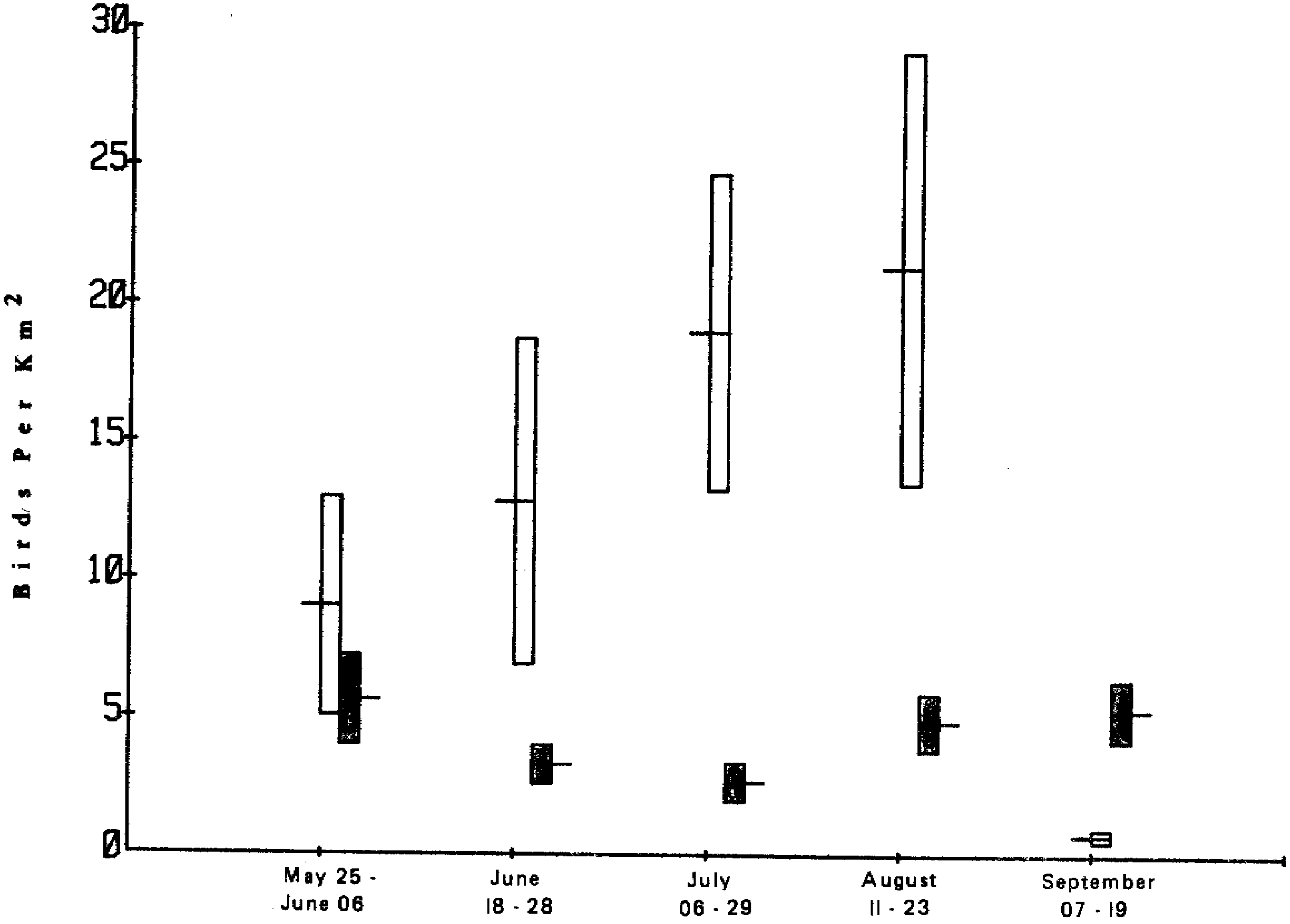

Figure 27. Tufted Puffin Density Indices From Shipboard Surveys. Mean ± 95% Confidence Limits For Bay (⊣) and Shelf (⊢) Areas of South and East Kodiak Island, 1977.

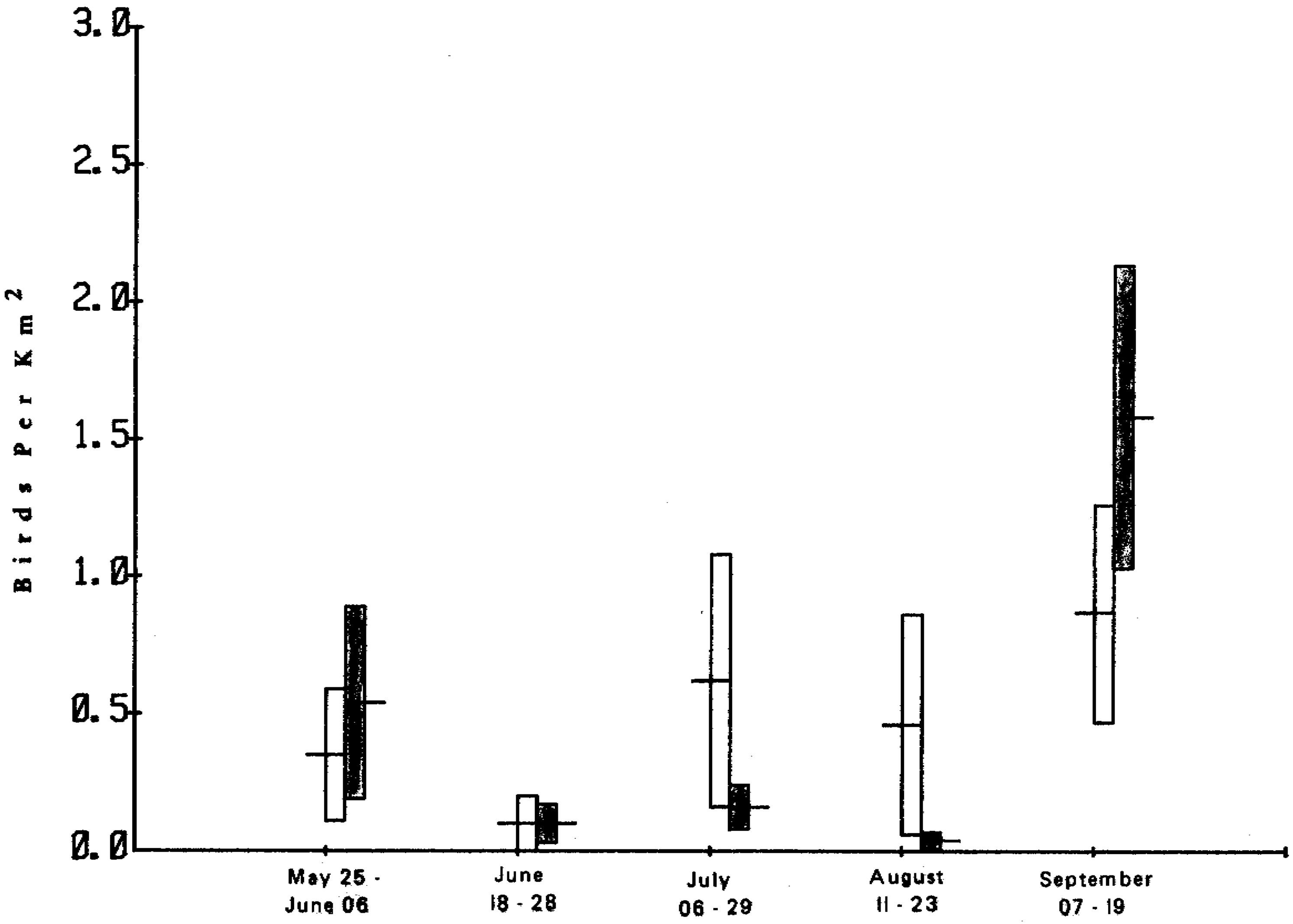

Figure 28. Horned Puffin Density Indices From Shipboard Surveys. Mean ± 95% Confidence Limits Fot Bay (—┤) and Shelf (├—) Areas of South and East Kodiak Island, 1977.

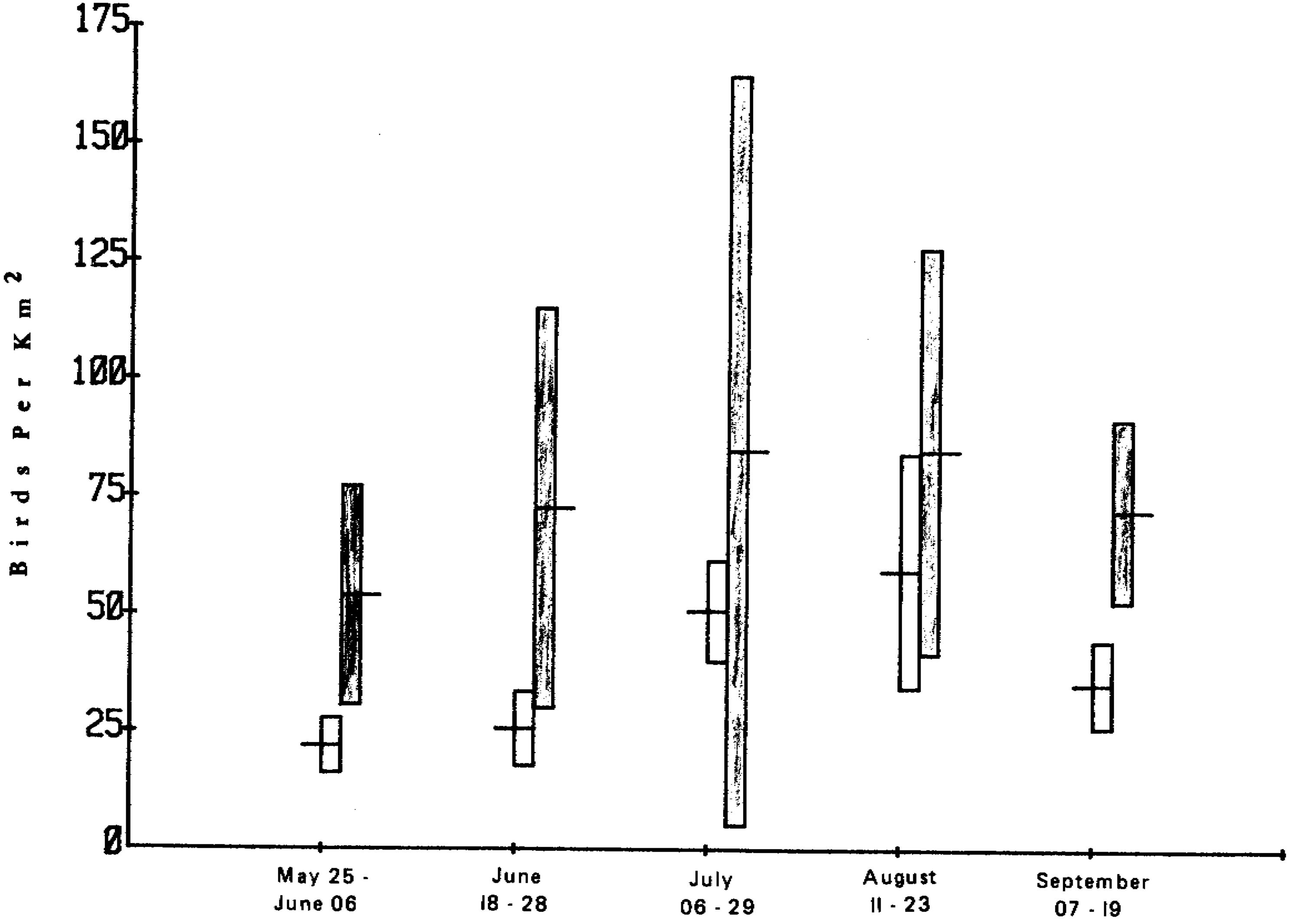

Figure 29. Total Bird Density Indices From Shipboard Surveys. Mean ± 95% Confidence Limits for Bay (⊣) and Shelf (⊢) Areas of South and East Kodiak Island, 1977.

Table 1. Frequency of Major Seabird Species in Kodiak Bays, Shipboard Surveys, 1977*

		Percent Occurrence on Transects				
Cruise	7032	7033	7034	7035	7036	7047
Month	M-J	Jun	Jul	Aug	Sep	Nov
Number of Transects	78	40	156	68	113	16
Sooty/Short-tailed Shearwater	06	15	21	34	36	00
Fork-tailed Storm Petrel	00	00	12	15	00	00
Pelagic Cormorant	03	00	02	04	02	56
Red-faced Cormorant	03	00	01	00	04	19
Northern Phalarope	00	05	00	10	08	00
Parasitic Jaeger	01	03	04	12	05	00
Glaucous-winged Gull	29	30	37	37	47	63
Mew Gull	+	00	+	01	04	63
Total Kittiwake (1)	60	78	62	66	81	38
Arctic Tern	14	10	17	19	+	00
Aleutian Tern	08	03	05	18	00	00
Total Murre (2)	47	58	24	32	61	81
Pigeon Guillemot	10	15	21	25	01	00
Marbled Murrelet	12	08	13	15	09	00
Cassin's Auklet	00	00	01	03	20	00
Horned Puffin	15	10	19	13	33	00
Tufted Puffin	64	88	60	68	35	00

* Major Species are those which occurred on at least 10% of all transects

(1) All probably Black-legged Kittiwakes

(2) 95% or more Common Murres

Table 2. Frequency of Major Seabird Species in Kodiak Shelf Areas, Shipboard Surveys, 1977*

Percent Occurrence on Transects

Cruise	7032	7033	7034	7035	7036	7046	7047
Month	M-J	Jun	Jul	Aug	Sep	Sep	Nov
Number of Transects	154	193	144	168	82	35	124
Northern Fulmar	22	20	21	20	30	17	35
Sooty/Short-tailed Shearwater	41	62	46	71	89	66	52
Fork-tailed Storm Petrel	00	14	12	36	12	26	00
Pomarine Jaeger	07	03	05	11	07	06	00
Glaucous-winged Gull	23	09	07	07	06	20	60
Total Kittiwake (1)	49	34	24	15	29	43	50
Total Murre (2)	68	49	20	31	63	54	74
Cassin's Auklet	01	00	05	24	39	17	08
Horned Puffin	16	06	10	04	54	14	26
Tufted Puffin	67	68	48	64	79	46	27

*Major Species are those which occurred on at least 10% of all transects
(1)Almost all Black-legged Kittiwakes
(2)95% or more Common Murres

Table 3. Density Indices (Birds/Km2) From Aerial Suveys Over Kodiak Island Waters, 1977.

	MARCH Water Depth (m)			APRIL Water Depth (m)			MAY Water Depth (m)			JUNE Water Depth (m)		
	<180	180-1800	>1800	<180	180-1800	>1800	<180	180-1800	>1800	<180	180-1800	>1800
Loons	+	-	-	-	-	-	-	-	-	-	-	-
Black-footed Albatross	-	-	-	-	-	+	-	-	-	-	-	-
Northern Fulmar	0.2	0.4	0.7	1.0	2.6	0.6	0.1	0.5	0.9	0.4	0.3	0.5
Pale-footed Shearwater	-	-	-	-	-	-	+	+	-	+	+	-
New Zealand Shearwater	-	-	-	0.1	-	-	-	-	+	-	0.1	0.1
Sooty/Short-tailed Shearwater	-	-	+	4.6	2.5	0.4	111.0	2.8	0.5	55.0	+	0.2
Scaled Petrel	-	-	-	-	-	-	-	-	+	-	+	1.6
Fork-tailed Storm Petrel	-	-	2.8	3.2	0.6	0.4	5.8	9.7	1.1	1.4	3.3	1.3
Leach's Storm Petrel	-	-	-	-	-	-	-	-	-	+	0.2	-
Cormorants	0.3	-	-	0.1	-	-	+	-	-	-	-	-
Mallard	-	-	-	-	+	-	-	-	-	-	-	-
Oldsquaw	0.8	-	-	0.3	-	-	-	-	-	-	-	-
Harlequin Duck	0.1	-	-	-	-	-	-	-	-	-	-	-
Unidentified Eiders	+	-	-	-	-	-	-	-	-	-	-	-
King Eider	0.1	-	-	-	-	-	-	-	-	-	-	-
Unidentified Scoters	0.8	-	-	0.4	-	-	-	-	-	-	-	-
White-winged Scoter	+	-	-	2.2	-	-	-	-	-	-	-	-
Surf Scoter	0.1	-	-	-	-	-	-	-	-	-	-	-
Common Scoter	-	-	-	0.1	-	-	-	-	-	-	-	-
Northern Phalarope	-	-	-	+	-	-	-	-	-	-	-	-
Unidentified Jaegers	-	-	-	+	-	+	0.1	+	0.1	-	-	-
Pomarine Jaeger	-	-	-	-	-	-	+	-	-	-	-	-
Parasitic Jaeger	-	-	-	-	+	-	0.1	+	0.1	-	-	-
Long-tailed Jaeger	-	-	-	-	-	-	-	+	-	-	-	-
Skua	-	-	-	-	-	-	-	-	+	-	-	-
Glaucous Gull	-	-	-	-	-	-	-	+	-	-	-	-
Glaucous-winged Gull	0.4	1.1	+	o.6	o.1	0.1	0.1	-	-	0.2	+	-

Table 3(continued).

	MARCH			APRIL			MAY			JUNE		
	Water Depth (m)			Water Depth (m)			Water Depth (m)			Water Depth (m)		
	180	180-1800	1800	180	180-1800	1800	180	180-1800	1800	180	180-1800	1800
Mew Gull	-	-	-	+	-	-	+	-	-	-	-	-
Black-legged Kittiwake	0.3	6.0	0.9	6.8	15.0	4.4	3.6	0.5	0.1	1.2	-	-
Arctic Tern	-	-	-	-	0.2	-	0.8	0.5	-	+	-	-
Common/Thick-billed Murre	3.2	6.9	2.2	3.3	-	0.1	4.1	+	-	2.9	-	-
Marbled/Kittlitz's Murrelet	-	-	-	-	-	-	+	-	-	0.3	-	-
Parakeet Auklet	-	-	-	+	-	-	+	-	-	+	-	-
Crested Auklet	-	-	5.9	-	-	-	-	-	-	-	-	-
Rhinoceros Auklet	-	-	-	-	-	-	-	-	-	+	-	-
Horned Puffin	0.1	0.2	-	0.1	-	-	+	-	-	+	-	-
Tufted PUffin	-	+	+	2.0	1.1	0.6	2.7	0.3	+	1.5	-	-
Unidentified Alcids	+	0.2	1.7	0.3	+	-	+	-	-	0.1	-	-
Total Birds	6.4	15.0	14.0	25.0	22.0	6.6	130.0	15.0	3.0	63.0	4.1	3.7

Depths taken from National Ocean and Atmospheric Administration charts 531 and 16580

Table 4. Northern Fulmar Density Indices From Shipboard Surveys of Kodiak Island Waters, 1977.

	NUMBER OF TRANSECTS		B/KM2 ON WATER & FEEDING		B/KM2 FLYING		TOTAL B/KM2	
	BAY	SHELF	BAYS	SHELF	BAYS	SHELF	BAYS	SHELF
FW7032								
May-Jun.	78	154						
MAXIMUM			0.00	0.41	0.98	28.47	0.98	29.45
$\bar{X}$			0.00	0.05	0.01	0.72	0.05	0.77
2 S.E.			-	0.07	0.03	0.44	0.03	0.46
FW7033								
Jun.	40	193						
MAXIMUM			0.00	3.24	0.00	2.95	0.00	3.93
$\bar{X}$			0.00	0.04	0.00	2.29	0.00	0.33
2 S.E.			-	0.04	-	0.09	-	0.11
FW7034								
Jul.	156	144						
MAXIMUM			0.00	4.32	+	7.56	+	9.72
$\bar{X}$			0.00	0.11	+	0.39	+	0.50
2 S.E.			-	0.09	-	0.18	-	0.22
FW7035								
Aug.	68	168						
MAXIMUM			0.00	1.20	1.20	27.00	1.20	27.00
$\bar{X}$			0.00	0.03	0.03	0.46	0.03	0.49
2 S.E.			-	0.03	0.05	0.34	0.05	0.34
FW7036								
Sep.	113	82						
MAXIMUM			0.00	1.35	+	5.40	+	6.48
$\bar{X}$			0.00	0.06	+	0.48	+	0.54
2 S.E.			-	0.06	-	0.23	-	0.25
FW7046								
Sep.	3	35						
MAXIMUM			0.00	0.83	0.00	1.66	0.00	1.66
$\bar{X}$			0.00	0.02	0.00	0.14	0.00	0.17
2 S.E.			-	0.05	-	0.13	-	0.14
FW7047								
Nov.	16	124						
MAXIMUM			0.00	?	0.00	?	0.00	15.4
$\bar{X}$			0.00	?	0.00	?	0.00	1.2
2 S.E.			-	-	-	-	-	0.5

MAXIMUM = Maximum B/KM2 on any one transect
$\bar{X}$ = Mean transect density
2 S.E. = Two standard errors of the mean
B/KM2 = Birds Per Square Kilometer

Table 5. Sooty/Short-tailed Shearwater Density Indices From Shipboard Surveys of Kodiak Island Waters, 1977.

	NUMBER OF TRANSECTS		B/KM2 ON WATER & FEEDING		B/KM2 FLYING		TOTAL B/KM2	
	BAY	SHELF	BAYS	SHELF	BAYS	SHELF	BAYS	SHELF
FW7032								
May-Jun.	78	154						
MAXIMUM			5.89	844.30	2.95	646.54	5.89	1129.0
$\bar{X}$			0.11	20.23	0.11	15.69	0.22	35.9
2 S.E.			0.17	16.46	0.11	12.60	0.23	22.7
FW7033								
Jun.	40	193						
MAXIMUM			26.51	3485.2	9.82	1589.6	36.32	3485.2
$\bar{X}$			0.72	42.3	0.40	20.2	1.12	62.5
2 S.E.			1.36	38.1	0.53	17.0	1.86	42.3
FW7034								
Jul.	156	144						
MAXIMUM			130.79	5399.6	54.00	536.4	146.39	5399.6
$\bar{X}$			4.36	61.6	1.70	12.8	6.05	74.4
2 S.E.			2.80	75.4	0.97	8.8	3.30	76.0
FW7035								
Aug.	68	168						
MAXIMUM			629.95	3243.0	48.60	881.21	646.15	3246.2
$\bar{X}$			11.40	46.0	3.14	24.86	14.53	70.9
2 S.E.			18.71	40.5	2.14	11.16	19.31	42.8
FW7036								
Sep.	113	82						
MAXIMUM			22.68	311.02	361.17	539.96	364.77	549.41
$\bar{X}$			0.83	30.98	7.46	24.32	8.29	55.30
2 S.E.			0.59	13.26	7.74	13.34	7.87	18.61
FW7046								
Sep.	3	35						
MAXIMUM			0.00	113.81	27.00	696.54	27.00	696.54
$\bar{X}$			0.00	18.44	14.84	42.94	14.84	61.38
2 S.E.			-	11.36	38.40	44.39	38.40	44.21
FW7047								
Nov.	16	124						
MAXIMUM			0.00	?	0.09	?	0.09	414.6
$\bar{X}$			0.00	?	0.01	?	0.01	8.0
2 S.E.			-	-	0.01	-	0.01	7.3

MAXIMUM = Maximum B/KM2 on any one transect
$\bar{X}$ = Mean transect density
2 S.E. = Two standard errors of the mean
B/KM2 = Birds Per Square Kilometer

Table 6. Fork-tailed Storm Petrel Density Indices From Shipboard Surveys of Kodiak Island Waters, 1977.

	NUMBER OF TRANSECTS		B/KM2 ON WATER & FEEDING		B/KM2 FLYING		TOTAL B/KM2	
	BAY	SHELF	BAYS	SHELF	BAYS	SHELF	BAYS	SHELF
FW7032								
May-Jun.	78	154						
MAXIMUM			0.00	0.00	0.00	0.00	0.00	0.00
$\overline{X}$			0.00	0.00	0.00	0.00	0.00	0.00
2 S.E.			-	-	-	-	-	-
FW7033								
Jun.	40	193						
MAXIMUM			0.00	3.24	0.00	6.00	0.00	6.00
$\overline{X}$			0.00	0.03	0.00	0.19	0.00	0.21
2 S.W.			-	0.04	-	0.09	-	0.09
FW7034								
Jul.	156	144						
MAXIMUM			21.60	1.08	25.20	5.40	33.60	5.40
$\overline{X}$			0.19	0.01	0.49	0.22	0.69	0.22
2 S.E.			0.29	0.01	0.38	0.12	0.55	0.13
FW7035								
Aug.	68	168						
MAXIMUM			6.30	1.08	6.48	5.40	9.00	5.40
$\overline{X}$			0.09	0.01	0.41	0.68	0.50	0.70
2 S.E.			0.19	0.02	0.29	0.18	0.38	0.18
FW7036								
Sep.	113	82						
MAXIMUM			?	0.00	?	3.24	+	3.24
$\overline{X}$			?	0.00	?	0.16	+	0.16
2 S.E.			-	-	-	0.11	-	0.11
FW7046								
Sep.	3	35						
MAXIMUM			0.00	0.83	0.00	3.32	0.00	3.32
$\overline{X}$			0.00	0.02	0.00	0.41	0.00	0.43
2 S.E.			-	0.05	-	0.29	-	0.30
FW7047								
Nov.	16	124						
MAXIMUM			0.00	0.00	0.00	0.00	0.00	0.00
$\overline{X}$			0.00	0.00	0.00	0.00	0.00	0.00
2 S.E.			-	-	-	-	-	-

MAXIMUM = Maximum B/KM2 on any one transect

$\overline{X}$ = Mean transect density

2 S.E. = Two standard errors of the mean

B/KM2 = Birds Per Square Kilometer

Table 7. Pelagic Cormorant Density Indices From Shipboard Surveys of Kodiak Island Waters, 1977.

	NUMBER OF TRANSECTS		B/KM2 ON WATER & FEEDING		B/KM2 FLYING		TOTAL B/KM2	
	BAY	SHELF	BAYS	SHELF	BAYS	SHELF	BAYS	SHELF
FW7032								
May-Jun.	78	154						
MAXIMUM			0.00	0.00	6.48	1.20	6.48	1.20
$\bar{X}$			0.00	0.00	0.11	0.01	0.11	0.01
2 S.E.			-	-	0.17	0.02	0.17	0.02
FW7033								
Jun.	40	193						
MAXIMUM			0.00	0.00	0.00	0.00	0.00	0.00
$\bar{X}$			0.00	0.00	0.00	0.00	0.00	0.00
2 S.E.			-	-	-	-	-	-
FW7034								
Jul.	156	144						
MAXIMUM			0.00	0.00	1.08	0.00	1.08	0.00
$\bar{X}$			0.00	0.00	0.02	0.00	0.02	0.00
2 S.E.			-	-	0.02	-	0.02	-
FW7035								
Aug.	68	168						
MAXIMUM			2.61	0.00	1.08	0.00	3.24	0.00
$\bar{X}$			0.03	0.00	0.05	0.00	0.08	0.00
2 S.E.			0.06	-	0.05	-	0.10	-
FW7036								
Sep.	113	82						
MAXIMUM			0.00	0.00	2.16	0.00	2.16	0.00
$\bar{X}$			0.00	0.00	0.03	0.00	0.03	0.00
2 S.E.			-	-	0.04	-	0.04	-
FW7046								
Sep.	3	35						
MAXIMUM			0.00	0.00	0.90	0.00	0.90	0.00
$\bar{X}$			0.00	0.00	0.60	0.00	0.60	0.00
2 S.E.			-	-	1.58	-	1.58	-
FW7047								
Nov.	16	124						
MAXIMUM			1.80	?	6.30	?	6.30	0.08
$\bar{X}$			0.20	?	1.00	?	1.20	0.02
2 S.E.			0.30	-	0.90	-	0.90	?

MAXIMUM = Maximum B/KM2 on any one transect
$\bar{X}$ = Mean transect density
2 S.E. = Two standard errors of the mean
B/KM2 = Birds Per Square Kilometer

Table 8. Red-faced Cormorant Density Indices From Shipboard Surveys of Kodiak Island Waters, 1977.

	NUMBER OF TRANSECTS		B/KM2 ON WATER & FEEDING		B/KM2 FLYING		TOTAL B/KM2	
	BAY	SHELF	BAYS	SHELF	BAYS	SHELF	BAYS	SHELF
FW7032								
May-Jun.	78	154						
MAXIMUM			0.00	0.00	1.20	0.98	1.20	0.98
$\bar{X}$			0.00	0.00	0.03	0.01	0.03	0.01
2 S.E.			-	-	0.04	0.01	0.04	0.01
FW7033								
Jun.	40	193						
MAXIMUM			0.00	0.00	0.00	0.00	0.00	0.00
$\bar{X}$			0.00	0.00	0.00	0.00	0.00	0.00
2 S.E.			-	-	-	-	-	-
FW7034								
Jul.	156	144						
MAXIMUM			0.00	0.00	1.08	0.00	1.08	0.00
$\bar{X}$			0.00	0.00	0.01	0.00	0.01	0.00
2 S.E.			-	-	0.01	-	0.01	-
FW7035								
Aug.	68	168						
MAXIMUM			0.00	0.00	0.00	0.00	0.00	0.00
$\bar{X}$			0.00	0.00	0.00	0.00	0.00	0.00
2 S.E.			-	-	-	-	-	-
FW7036								
Sep.	113	82						
MAXIMUM			0.00	0.00	2.40	0.00	2.40	0.00
$\bar{X}$			0.00	0.00	0.07	0.00	0.07	0.00
2 S.E.			-	-	0.06	-	0.06	-
FW7046								
Sep.	3	35						
MAXIMUM			0.00	0.00	0.00	0.00	0.00	0.00
$\bar{X}$			0.00	0.00	0.00	0.00	0.00	0.00
2 S.E.			-	-	-	-	-	-
FW7047								
Nov.	16	124						
MAXIMUM			0.00	?	2.50	?	2.50	0.08
$\bar{X}$			0.00	?	0.30	?	0.30	0.01
2 S.E.			-	-	0.30	-	0.30	?

MAXIMUM = Maximum B/KM2 on any one transect

$\bar{X}$ = Mean transect density

2 S.E. = Two standard errors of the mean

B/KM2 = Birds Per Square Kilometer

Table 9. Red Phalarope Density Indices From Shipboard Surveys of Kodiak Island Waters, 1977.

	NUMBER OF TRANSECTS		B/KM2 ON WATER & FEEDING		B/KM2 FLYING		TOTAL B/KM2	
	BAY	SHELF	BAYS	SHELF	BAYS	SHELF	BAYS	SHELF
FW7032								
May-Jun.	78	154						
MAXIMUM			11.78	0.00	0.00	0.00	11.78	0.00
$\bar{X}$			0.20	0.00	0.00	0.00	0.20	0.00
2 S.E.			0.32	-	-	-	0.32	-
FW7033								
Jun.	40	193						
MAXIMUM			0.00	0.00	0.00	0.00	0.00	0.00
$\bar{X}$			0.00	0.00	0.00	0.00	0.00	0.00
2 S.E.			-	-	-	-	-	-
FW7034								
Jul.	156	144						
MAXIMUM			0.00	+	0.00	+	0.00	+
$\bar{X}$			0.00	+	0.00	+	0.00	+
2 S.E.			-	-	-	-	-	-
FW7035								
Aug.	68	168						
MAXIMUM			0.00	0.00	0.00	1.20	0.00	1.20
$\bar{X}$			0.00	0.00	0.00	0.01	0.00	0.01
2 S.E.			-	-	-	0.02	-	0.02
FW7036								
Sep.	113	82						
MAXIMUM			0.00	0.00	0.00	0.00	0.00	0.00
$\bar{X}$			0.00	0.00	0.00	0.00	0.00	0.00
2 S.E.			-	-	-	-	-	-
FW7046								
Sep.	3	35						
MAXIMUM			0.00	0.00	0.00	0.00	0.00	0.00
$\bar{X}$			0.00	0.00	0.00	0.00	0.00	0.00
2 S.E.			-	-	-	-	-	-
FW7047								
Nov.	16	124						
MAXIMUM			0.00	0.00	0.00	0.00	0.00	0.00
$\bar{X}$			0.00	0.00	0.00	0.00	0.00	0.00
2 S.E.			-	-	-	-	-	-

MAXIMUM = Maximum B/KM2 on any one transect
$\bar{X}$ = Mean transect density
2 S.E. = Two standard errors of the mean
B/KM2 = Birds Per Square Kilometer

Table 10. Northern Phalarope Density Indices From Shipboard Surveys of Kodiak Island Waters, 1977.

	NUMBER OF TRANSECTS		B/KM2 ON WATER & FEEDING		B/KM2 FLYING		TOTAL B/KM2	
	BAY	SHELF	BAYS	SHELF	BAYS	SHELF	BAYS	SHELF
FW7032								
May-Jun.	78	154						
MAXIMUM			0.00	0.00	0.00	0.00	0.00	0.00
$\bar{X}$			0.00	0.00	0.00	0.00	0.00	0.00
2 S.E.			-	-	-	-	-	-
FW7033								
Jun.	40	193						
MAXIMUM			3.93	0.00	0.00	0.00	3.93	0.00
$\bar{X}$			0.12	0.00	0.00	0.00	0.12	0.00
2 S.E.			0.21	-	-	-	0.21	-
FW7034								
Jul.	156	144						
MAXIMUM			12.76	9.60	49.09	8.64	61.85	9.60
$\bar{X}$			0.23	0.08	0.99	0.06	1.22	0.14
2 S.E.			0.20	0.14	0.82	0.12	0.96	0.18
FW7035								
Aug.	68	168						
MAXIMUM			33.48	0.00	3.60	0.00	33.48	0.00
$\bar{X}$			0.93	0.00	0.12	0.00	1.05	0.00
2 S.E.			1.23	-	0.13	-	1.30	-
FW7036								
Sep.	113	82						
MAXIMUM			6.00	2.16	7.85	1.08	13.74	2.16
$\bar{X}$			0.14	0.03	0.09	0.01	0.23	0.04
2 S.E.			0.15	0.05	0.14	0.03	0.27	0.06
FW7046								
Sep.	3	35						
MAXIMUM			0.00	0.00	1.80	20.70	1.80	20.70
$\bar{X}$			0.00	0.00	0.60	0.64	0.60	0.64
2 S.E.			-	-	3.16	1.22	3.16	1.22
FW7047								
Nov.	16	124						
MAXIMUM			0.00	0.00	0.00	0.00	0.00	0.00
$\bar{X}$			0.00	0.00	0.00	0.00	0.00	0.00
2 S.E.			-	-	-	-	-	-

MAXIMUM = Maximum B/KM2 on any one transect
$\bar{X}$ = Mean transect density
2 S.E. = Two standard errors of the mean
B/KM2 = Birds Per Square Kilometer

Table 11. Pomarine Jaeger Density Indices From Shipboard Surveys of Kodiak Island Waters, 1977.

	NUMBER OF TRANSECTS		B/KM2 ON WATER & FEEDING		B/KM2 FLYING		TOTAL B/KM2	
	BAY	SHELF	BAYS	SHELF	BAYS	SHELF	BAYS	SHELF
FW7032 May-Ju.	78	154						
MAXIMUM			0.00	2.16	1.08	3.93	1.08	3.93
X			0.00	0.04	0.03	0.09	0.03	0.12
2 S.E.			-	0.04	0.04	0.07	0.04	0.08
FW7033 Jun.	40	193						
MAXIMUM			0.98	3.60	0.00	2.16	0.98	3.60
X			0.02	0.02	0.00	0.02	0.02	0.05
2 S.E.			0.05	0.04	-	0.03	0.05	0.05
FW7034 Jul.	156	144						
MAXIMUM			5.40	188.98	6.00	1.08	6.00	188.98
X			0.07	1.32	0.07	0.04	0.13	1.36
2 S.E.			0.09	2.60	0.09	0.03	3.21	2.60
FW7035 Aug.	68	168						
MAXIMUM			0.00	1.08	2.86	30.24	2.86	30.24
X			0.00	0.01	0.08	0.31	0.08	0.32
2 S.E.			-	0.01	0.10	0.36	0.10	0.36
FW7036 Sep.	113	82						
MAXIMUM			1.20	1.08	1.20	1.35	2.40	1.35
X			0.02	0.03	0.06	0.06	0.08	0.08
2 S.E.			0.03	0.04	0.05	0.06	0.06	0.07
FW7046 Sep.	3	35						
MAXIMUM			0.00	0.00	1.96	1.80	1.96	1.80
X			0.00	0.00	0.95	0.08	0.95	0.08
2 S.E.			-	-	2.99	0.12	2.99	0.12
FW7047 Nov.	16	124						
MAXIMUM			0.00	0.00	0.00	0.00	0.00	0.00
X			0.00	0.00	0.00	0.00	0.00	0.00
2 S.E.			-	-	-	-	-	-

MAXIMUM = Maximum B/KM2 on any one transect
X = Mean transect density
2 S.E. = Two standard errors of the mean
B/KM2 = Birds Per Square Kilometer

Table 12. Parasitic Jaeger Density Indices From Shipboard Surveys of Kodiak Island Waters, 1977.

	NUMBER OF TRANSECTS		B/KM2 ON WATER & FEEDING		B/KM2 FLYING		TOTAL B/KM2	
	BAY	SHELF	BAYS	SHELF	BAYS	SHELF	BAYS	SHELF
FW7032								
May-Jun.	78	154						
MAXIMUM			0.00	0.00	1.08	6.00	1.08	6.00
$\bar{X}$			0.00	0.00	0.01	0.05	0.01	0.05
2 S.E.			-	-	0.03	0.08	0.03	0.08
FW7033								
Jun.	40	193						
MAXIMUM			2.16	0.00	0.00	2.16	2.16	2.16
$\bar{X}$			0.05	0.00	0.00	0.01	0.05	0.01
2 S.E.			0.11	-	-	0.02	0.11	0.02
FW7034								
Jul.	156	144						
MAXIMUM			1.54	0.98	2.40	16.20	2.40	16.20
$\bar{X}$			0.02	0.01	0.05	0.19	0.07	0.19
2 S.E.			0.02	0.01	0.05	0.23	0.05	0.23
FW7035								
Aug.	68	168						
MAXIMUM			1.20	2.16	2.16	1.35	2.16	3.24
$\bar{X}$			0.03	0.02	0.12	0.01	0.15	0.03
2 S.E.			0.04	0.03	0.10	0.02	0.11	0.04
FW7036								
Sep.	113	82						
MAXIMUM			0.00	0.00	1.20	0.00	1.20	0.00
$\bar{X}$			0.00	0.00	0.06	0.00	0.06	0.00
2 S.E.			-	-	0.05	-	0.05	-
FW7046								
Sep.	3	35						
MAXIMUM			0.00	0.00	0.00	0.00	0.00	0.00
$\bar{X}$			0.00	0.00	0.00	0.00	0.00	0.00
2 S.E.			-	-	-	-	-	-
FW7047								
Nov.	16	124						
MAXIMUM			0.00	0.00	0.00	0.00	0.00	0.00
$\bar{X}$			0.00	0.00	0.00	0.00	0.00	0.00
2 S.E.			-	-	-	-	-	-

MAXIMUM = Maximum B/KM2 on any one transect

$\bar{X}$ = Mean transect density

2 S.E. = Two standard errors of the mean

B/KM2 = Birds Per Square Kilometer

Table 13. Long-tailed Jaeger Density Indices From Shipboard Surveys of Kodiak Island Waters, 1977.

	NUMBER OF TRANSECTS		B/KM2 ON WATER & FEEDING		B/KM2 FLYING		TOTAL B/KM2	
	BAY	SHELF	BAYS	SHELF	BAYS	SHELF	BAYS	SHELF
FW7032								
May-Jun.	78	154						
MAXIMUM			0.00	0.00	0.00	4.80	0.00	4.80
$\bar{X}$			0.00	0.00	0.00	0.04	0.00	0.04
2 S.E.			-	-	-	0.06	-	0.06
FW7033								
Jun.	40	193						
MAXIMUM			0.00	0.00	0.00	0.00	0.00	0.00
$\bar{X}$			0.00	0.00	0.00	0.00	0.00	0.00
2 S.E.			-	-	-	-	-	-
FW7034								
Jul.	156	144						
MAXIMUM			1.20	0.98	2.16	0.98	2.16	0.98
$\bar{X}$			0.01	0.01	0.04	0.01	0.04	0.02
2 S.E.			0.02	0.01	0.04	0.02	0.04	0.02
FW7035								
Aug.	68	168						
MAXIMUM			0.00	0.00	1.08	1.08	1.08	1.08
$\bar{X}$			0.00	0.00	0.03	0.01	0.03	0.01
2 S.E.			-	-	0.04	0.02	0.04	0.02
FW7036								
Sep.	113	82						
MAXIMUM			0.00	0.00	0.00	0.00	0.00	0.00
$\bar{X}$			0.00	0.00	0.00	0.00	0.00	0.00
2 S.E.			-	-	-	-	-	-
FW7046								
Sep.	3	35						
MAXIMUM			0.00	0.00	0.00	0.00	0.00	0.00
$\bar{X}$			0.00	0.00	0.00	0.00	0.00	0.00
2 S.E.			-	-	-	-	-	-
FW7047								
Nov.	16	124						
MAXIMUM			0.00	0.00	0.00	0.00	0.00	0.00
$\bar{X}$			0.00	0.00	0.00	0.00	0.00	0.00
2 S.E.			-	-	-	-	-	-

MAXIMUM = Maximum B/KM2 on any one transect

$\bar{X}$ = Mean transect density

2 S.E. = Two standard errors of the mean

B/KM2 = Birds Per Square Kilometer

Table 14. Glaucous-winged Gull Density Indices From Shipboard Surveys of Kodiak Island Waters, 1977.

	NUMBER OF TRANSECTS		B/KM2 ON WATER & FEEDING		B/KM2 FLYING		TOTAL B/KM2	
	BAY	SHELF	BAYS	SHELF	BAYS	SHELF	BAYS	SHELF
FW7032								
May-Jun.	78	154						
MAXIMUM			50.76	32.40	10.80	3.60	50.76	33.48
$\bar{X}$			1.19	0.24	0.48	0.33	1.67	0.57
2 S.E.			1.43	0.42	0.33	0.12	1.46	0.44
FW7033								
Jun.	40	193						
MAXIMUM			19.63	13.74	3.93	3.93	19.63	13.74
$\bar{X}$			1.25	0.11	0.43	0.09	1.68	0.20
2 S.E.			1.35	0.15	0.29	0.06	1.43	0.16
FW7034								
Jul.	156	144						
MAXIMUM			80.09	1.20	18.90	1.96	80.09	1.96
$\bar{X}$			1.34	0.02	1.31	0.07	2.65	0.08
2 S.E.			1.16	0.02	0.49	0.05	1.29	0.05
FW7035								
Aug.	68	168						
MAXIMUM			5.40	0.00	21.60	5.40	21.60	5.40
$\bar{X}$			0.31	0.00	1.53	0.12	1.84	0.12
2 S.E.			0.25	-	0.82	0.09	0.90	0.09
FW7036								
Sep.	113	82						
MAXIMUM			52.80	0.00	16.20	1.08	54.80	1.08
$\bar{X}$			1.03	0.00	1.43	0.06	2.46	0.06
2 S.E.			0.99	-	0.52	0.06	1.16	0.06
FW7046								
Sep.	3	35						
MAXIMUM			0.00	0.00	0.00	3.60	0.00	3.60
$\bar{X}$			0.00	0.00	0.00	0.39	0.00	0.39
2 S.E.			-	-	-	0.31	-	0.31
FW7047								
Nov.	16	124						
MAXIMUM			17.8	?	3.1	?	20.8	8.5
$\bar{X}$			12.8	?	2.0	?	14.7	1.1
2 S.E.			?	-	?	-	?	0.3

MAXIMUM = Maximum B/KM2 on any one transect
$\bar{X}$ = Mean transect density
2 S.E. = Two standard errors of the mean
B/KM2 = Birds Per Square Kilometer

Table 15. Mew Gull Density Indices From Shipboard Surveys of Kodiak Island Waters, 1977.

	NUMBER OF TRANSECTS		B/KM2 ON WATER & FEEDING		B/KM2 FLYING		TOTAL B/KM2	
	BAY	SHELF	BAYS	SHELF	BAYS	SHELF	BAYS	SHELF
FW7032 May-Jun.	78	154						
MAXIMUM			0.00	0.00	0.00	0.00	0.00	0.00
$\bar{X}$			0.00	0.00	0.00	0.00	0.00	0.00
2 S.E.			-	-	-	-	-	-
FW7033 Jun.	40	193						
MAXIMUM			0.00	0.00	0.00	0.00	0.00	0.00
$\bar{X}$			0.00	0.00	0.00	0.00	0.00	0.00
2 S.E.			-	-	-	-	-	-
FW7034 Jul.	156	144						
MAXIMUM			0.00	0.00	1.20	0.00	1.20	0.00
$\bar{X}$			0.00	0.00	0.01	0.00	0.01	0.00
2 S.E.			-	-	0.02	-	0.02	-
FW7035 Aug.	68	168						
MAXIMUM			0.00	0.00	3.60	0.00	0.60	0.00
$\bar{X}$			0.00	0.00	0.05	0.00	0.05	0.00
2 S.E.			-	-	0.11	-	0.11	-
FW7036 Sep.	113	82						
MAXIMUM			1.08	0.00	11.88	0.00	12.96	0.00
$\bar{X}$			0.01	0.00	0.13	0.00	0.14	0.00
2 S.E.			0.02	-	0.21	-	0.23	-
FW7046 Sep.	3	35						
MAXIMUM			0.00	0.00	0.00	0.00	0.00	0.00
$\bar{X}$			0.00	0.00	0.00	0.00	0.00	0.00
2 S.E.			-	-	-	-	-	-
FW7047 Nov.	16	124						
MAXIMUM			31.3	0.00	6.3	0.00	31.3	0.00
$\bar{X}$			2.5	0.00	1.0	0.00	3.5	0.00
2 S.E.			4.0	-	0.8	-	3.9	-

MAXIMUM = Maximum B/KM2 on any one transect
$\bar{X}$ = Mean transect density
2 S.E. = Two standard errors of the mean
B/KM2 = Birds Per Square Kilometer

Table 16. Black-legged/Red-legged Kittiwake Density Indices From Shipboard Shipboard Surveys of Kodiak Island Waters, 1977.

	NUMBER OF TRANSECTS		B/KM2 ON WATER & FEEDING		B/KM2 FLYING		TOTAL B/KM2	
	BAY	SHELF	BAYS	SHELF	BAYS	SHELF	BAYS	SHELF
FW7032								
May-Jun.	78	154						
MAXIMUM			14.04	138.23	11.88	49.20	16.20	138.23
$\bar{X}$			0.33	1.97	2.00	2.05	2.33	4.02
2 S.E.			0.38	1.95	0.58	0.81	0.71	2.12
FW7033								
Jun.	40	193						
MAXIMUM			22.68	54.00	9.00	27.00	30.24	61.85
$\bar{X}$			1.37	0.42	2.33	0.88	3.70	1.30
2 S.E.			1.28	0.56	0.79	0.38	1.79	0.74
FW7034								
Jul.	156	144						
MAXIMUM			130.79	19.20	79.52	36.72	133.19	36.72
$\bar{X}$			5.52	0.19	6.84	0.97	12.37	1.15
2 S.E.			2.68	0.27	2.12	0.60	3.69	0.68
FW7035								
Aug.	68	168						
MAXIMUM			32.40	1.08	70.19	27.00	70.19	28.08
$\bar{X}$			1.86	0.01	7.73	0.55	9.59	0.55
2 S.E.			1.39	0.01	2.80	0.39	3.21	0.40
FW7036								
Sep.	113	82						
MAXIMUM			12.96	5.40	68.03	10.80	68.03	10.80
$\bar{X}$			0.88	0.10	9.47	0.71	10.35	0.82
2 S.E.			0.43	0.14	2.33	0.37	2.34	0.41
FW7046								
Sep.	3	35						
MAXIMUM			0.00	0.00	48.60	5.81	48.60	5.81
$\bar{X}$			0.00	0.00	22.91	1.16	22.91	1.16
2 S.E.			-	-	70.21	0.54	70.21	0.54
FW7047								
Nov.	16	124						
MAXIMUM			25.0	?	3.8	?	26.3	9.2
$\bar{X}$			1.7	?	0.6	?	2.3	0.9
2 S.E.			3.1	-	0.5	-	3.3	0.2

MAXIMUM = Maximum B/KM2 on any one transect
X = Mean transect density
2 S.E. = Two standard errors of the mean
B/KM2 = Birds Per Square Kilometer

Table 17. Arctic Tern Density Indices From Shipboard Surveys of Kodiak Island Waters, 1977

	NUMBER OF TRANSECTS		B/KM2 ON WATER & FEEDING		B/KM2 FLYING		TOTAL B/KM2	
	BAY	SHELF	BAYS	SHELF	BAYS	SHELF	BAYS	SHELF
FW7032								
May-Jun.	78	154						
MAXIMUM			2.16	4.32	14.73	8.64	16.69	12.96
$\bar{X}$			0.08	0.04	0.41	0.10	0.49	0.13
2 S.E.			0.09	0.06	0.41	0.12	0.46	0.18
FW7033								
Jun.	40	193						
MAXIMUM			2.16	0.98	1.20	0.00	2.16	0.98
$\bar{X}$			0.08	0.01	0.06	0.00	0.14	0.01
2 S.E.			0.12	0.01	0.09	-	0.14	0.01
FW7034								
Jul.	156	144						
MAXIMUM			1.80	2.16	16.87	5.40	16.87	6.40
$\bar{X}$			0.02	0.01	0.58	0.04	0.60	0.05
2 S.E.			0.03	0.03	0.32	0.07	0.32	0.08
FW7035								
Aug.	68	168						
MAXIMUM			0.00	3.24	8.40	4.05	8.40	4.05
$\bar{X}$			0.00	0.03	0.58	0.13	0.58	0.17
2 S.E.			-	0.04	0.39	0.09	0.39	0.10
FW7036								
Sep.	113	82						
MAXIMUM			?	0.00	?	1.08	+	1.08
$\bar{X}$			?	0.00	?	0.01	+	0.01
2 S.E.			-	-	-	0.03	-	0.03
FW7046								
Sep.	3	35						
MAXIMUM			0.00	0.00	0.00	0.83	0.00	0.83
$\bar{X}$			0.00	0.00	0.00	0.02	0.00	0.02
2 S.E.			-	-	-	0.05	-	0.05
FW7047								
Nov.	16	124						
MAXIMUM			0.00	0.00	0.00	0.00	0.00	0.00
$\bar{X}$			0.00	0.00	0.00	0.00	0.00	0.00
2 S.E.			-	-	-	-	-	-

MAXIMUM = Maximum B/KM2 on any one transect
$\bar{X}$ = Mean transect density
2 S.E. = Two standard errors of the mean
B/KM2 = Birds Per Square Kilometer

Table **18**. Aleutian Tern Density Indices From Shipboard Surveys of Kodiak Island Waters, 1977.

	NUMBER OF TRANSECTS		B/KM2 ON WATER & FEEDING		B/KM2 FLYING		TOTAL B/KM2	
	BAY	SHELF	BAYS	SHELF	BAYS	SHELF	BAYS	SHELF
FW7032								
May-Jun.	78	154						
MAXIMUM			1.08	2.16	2.95	0.00	2.95	2.16
X			0.01	0.01	0.14	0.00	0.15	0.01
2 S.E.			0.03	0.03	0.13	-	0.13	0.03
FW7033								
Jun.	40	193						
MAXIMUM			2.70	0.00	0.00	0.00	2.70	0.00
X			0.07	0.00	0.00	0.00	0.07	0.00
2 S.E.			0.14	-	-	-	0.14	-
FW7034								
Jul.	156	144						
MAXIMUM			0.90	0.00	5.40	1.08	5.40	1.08
X			0.01	0.00	0.08	0.01	0.08	0.01
2 S.E.			0.01	-	0.08	0.01	0.08	0.01
FW7035								
Aug.	68	168						
MAXIMUM			0.00	0.00	2.40	2.70	2.40	2.70
X			0.00	0.00	0.22	0.03	0.22	0.03
2 S.E.			-	-	0.12	0.04	0.12	0.04
FW7036								
Sep.	113	82						
MAXIMUM			0.00	0.00	0.00	0.00	0.00	0.00
X			0.00	0.00	0.00	0.00	0.00	0.00
2 S.E.			-	-	-	-	-	-
FW7046								
Sep.	3	35						
MAXIMUM			0.00	0.00	0.00	0.00	0.00	0.00
X			0.00	0.00	0.00	0.00	0.00	0.00
2 S.E.			-	-	-	-	-	-
FW7047								
Nov.	16	124						
MAXIMUM			0.00	0.00	0.00	0.00	0.00	0.00
X			0.00	0.00	0.00	0.00	0.00	0.00
2 S.E.			-	-	-	-	-	-

MAXIMUM = Maximum B/KM2 on any one transect
X = Mean transect density
2 S.E. = Two standard errors of the mean
B/KM2 = Birds Per Square Kilometer

Table 19. Common/Thick-billed Murre Density Indices From Shipboard Surveys of Kodiak Island Waters, 1977.

	NUMBER OF TRANSECTS		B/KM2 ON WATER & FEEDING		B/KM2 FLYING		TOTAL B/KM2	
	BAY	SHELF	BAYS	SHELF	BAYS	SHELF	BAYS	SHELF
FW7032								
May-Jun.	78	154						
MAXIMUM			16.20	43.20	16.20	21.60	16.20	43.20
$\bar{X}$			1.59	3.85	0.95	1.22	2.91	5.07
2 S.E.			0.83	1.08	0.58	0.52	1.04	1.16
FW7033								
Jun.	40	193						
MAXIMUM			14.40	40.25	28.80	6.87	29.70	40.25
$\bar{X}$			1.89	2.16	1.11	0.39	3.00	2.55
2 S.E.			1.09	0.78	1.48	0.16	1.84	0.79
FW7034								
Jul.	156	144						
MAXIMUM			32.40	12.96	2.40	2.40	32.40	12.96
$\bar{X}$			0.80	0.76	0.09	0.06	0.89	0.82
2 S.E.			0.52	0.35	0.06	0.05	0.52	0.36
FW7035								
Aug.	68	168						
MAXIMUM			51.84	24.84	1.08	5.40	51.84	24.84
$\bar{X}$			2.23	1.04	0.03	0.25	2.26	1.29
2 S.E.			1.90	0.46	0.04	0.13	1.90	0.48
FW7036								
Sep.	113	82						
MAXIMUM			90.71	45.36	4.91	1.35	90.71	45.36
$\bar{X}$			9.37	5.29	0.12	0.04	9.50	5.33
2 S.E.			2.82	1.82	0.11	0.05	2.82	1.83
FW7046								
Sep.	3	35						
MAXIMUM			0.00	18.90	5.40	17.10	5.40	18.90
$\bar{X}$			0.00	2.29	3.38	1.34	3.38	3.63
2 S.E.			-	1.44	5.60	1.39	5.60	1.80
FW7047								
Nov.	16	124						
MAXIMUM			26.4	?	44.2	?	53.3	106.2
$\bar{X}$			6.0	?	4.3	?	10.4	6.5
2 S.E.			4.2	-	5.5	-	7.5	3.0

MAXIMUM = Maximum B/KM2 on any one transect

$\bar{X}$ = Mean transect density

2 S.E. = Two standard errors of the mean

B/KM2 = Birds Per Square Kilometer

Table 20. Pigeon Guillemot Density Indices From Shipboard Surveys of Kodiak Island Waters, 1977.

	NUMBER OF TRANSECTS		B/KM2 ON WATER & FEEDING		B/KM2 FLYING		TOTAL B/KM2	
	BAY	SHELF	BAYS	SHELF	BAYS	SHELF	BAYS	SHELF
FW7032								
May-Jun.	78	154						
MAXIMUM			20.52	8.10	7.85	3.24	20.52	9.00
$\overline{X}$			0.50	0.09	0.17	0.08	0.67	0.17
2 S.E.			0.60	0.11	0.22	0.07	0.65	0.14
FW7033								
Jun.	40	193						
MAXIMUM			14.04	2.16	2.16	3.24	14.04	5.40
$\overline{X}$			0.53	0.01	0.11	0.02	0.64	0.03
2 S.E.			0.77	0.02	0.14	0.03	0.78	0.06
FW7034								
Jul.	156	144						
MAXIMUM			54.90	8.64	5.40	3.60	54.90	8.64
$\overline{X}$			0.54	0.09	0.24	0.02	0.78	0.12
2 S.E.			0.70	0.14	0.12	0.05	0.71	0.17
FW7035								
Aug.	68	168						
MAXIMUM			6.48	0.00	4.80	1.08	9.60	1.08
$\overline{X}$			0.53	0.00	0.35	0.01	0.88	0.01
2 S.E.			0.33	-	0.22	0.02	0.48	0.02
FW7036								
Sep.	113	82						
MAXIMUM			2.16	0.00	0.00	0.00	2.16	0.00
$\overline{X}$			0.02	0.00	0.00	0.00	0.02	0.00
2 S.E.			0.04	-	-	-	0.04	-
FW7046								
Sep.	3	35						
MAXIMUM			0.00	0.00	0.00	0.00	0.00	0.00
$\overline{X}$			0.00	0.00	0.00	0.00	0.00	0.00
2 S.E.			-	-	-	-	-	-
FW7047								
Nov.	16	124						
MAXIMUM			0.00	0.00	0.00	0.00	0.00	0.00
$\overline{X}$			0.00	0.00	0.00	0.00	0.00	0.00
2 S.E.			-	-	-	-	-	-

MAXIMUM = Maximum B/KM2 on any one transect
$\overline{X}$ = Mean transect density
2 S.E. = Two standard errors of the mean
B/KM2 = Birds Per Square Kilometer

Table 21. Marbled/Kittlitz's Murrelet Density Indices From Shipboard Surveys of Kodiak Island Waters, 1977.

	NUMBER OF TRANSECTS		B/KM2 ON WATER & FEEDING		B/KM2 FLYING		TOTAL B/KM2	
	BAY	SHELF	BAYS	SHELF	BAYS	SHELF	BAYS	SHELF
FW7032								
May-Jun.	78	154						
MAXIMUM			37.80	14.73	6.48	3.60	44.28	16.69
X			2.28	0.25	0.67	0.06	2.95	0.31
2 S.E.			1.42	0.21	0.32	0.06	1.56	0.25
FW7033								
Jun.	40	193						
MAXIMUM			5.89	16.80	19.20	11.78	22.80	16.80
X			0.57	0.44	1.13	0.40	1.70	0.84
2 S.E.			0.43	0.22	1.06	0.20	1.31	0.33
FW7034								
Jul.	156	144						
MAXIMUM			70.79	16.20	50.40	14.04	121.19	30.24
X			1.85	0.30	1.29	0.30	3.14	0.60
2 S.E.			1.16	0.27	0.76	0.25	1.81	0.50
FW7035								
Aug.	68	168						
MAXIMUM			18.90	7.56	12.00	8.10	24.00	10.80
X			1.29	0.26	1.06	0.36	2.35	0.62
2 S.E.			0.77	0.15	0.62	0.17	1.21	0.26
FW7036								
Sep.	113	82						
MAXIMUM			10.80	3.24	7.20	2.16	16.80	5.40
X			0.50	0.04	0.35	0.03	0.85	0.07
2 S.E.			0.29	0.08	0.20	0.05	0.42	0.13
FW7046								
Sep.	3	35						
MAXIMUM			0.00	?	1.96	?	1.96	+
X			0.00	?	0.95	?	0.95	+
2 S.E.			-	-	2.99	-	2.95	-
FW7047								
Nov.	16	124						
MAXIMUM			0.00	?	0.00	?	0.00	2.5
X			0.00	?	0.00	?	0.00	0.03
2 S.E.			-	-	-	-	-	?

MAXIMUM = Maximum B/KM2 on any one transect
X = Mean transect density
2 S.E. = Two standard errors of the mean
B/KM2 = Birds Per Square Kilometer

Table 22. Ancient Murrelet Density Indices From Shipboard Surveys of Kodiak Island Waters, 1977.

	NUMBER OF TRANSECTS		B/KM2 ON WATER & FEEDING		B/KM2 FLYING		TOTAL B/KM2	
	BAY	SHELF	BAYS	SHELF	BAYS	SHELF	BAYS	SHELF
FW7032								
May-Jun.	78	154						
MAXIMUM			0.00	1.96	0.98	0.00	0.98	1.96
$\overline{X}$			0.00	0.03	0.01	0.00	0.01	0.03
2 S.E.			-	0.04	0.03	-	0.03	0.04
FW7033								
Jun.	40	193						
MAXIMUM			0.00	7.85	0.00	7.56	0.00	7.85
$\overline{X}$			0.00	0.15	0.00	0.21	0.00	0.35
2 S.E.			-	0.13	-	0.15	-	0.19
FW7034								
Jul.	156	144						
MAXIMUM			0.00	17.67	0.00	19.63	0.00	19.63
$\overline{X}$			0.00	0.26	0.00	0.30	0.00	0.57
2 S.E.			-	0.29	-	0.37	-	0.46
FW7035								
Aug.	68	168						
MAXIMUM			0.00	1.08	0.00	2.70	0.00	2.70
$\overline{X}$			0.00	0.01	0.00	0.04	0.00	0.04
2 S.E.			-	0.01	-	0.04	-	0.04
FW7036								
Sep.	113	82						
MAXIMUM			0.00	0.00	0.00	0.00	0.00	0.00
$\overline{X}$			0.00	0.00	0.00	0.00	0.00	0.00
2 S.E.			-	-	-	-	-	-
FW7046								
Sep.	3	35						
MAXIMUM			0.00	0.00	0.00	0.00	0.00	0.00
$\overline{X}$			0.00	0.00	0.00	0.00	0.00	0.00
2 S.E.			-	-	-	-	-	-
FW7047								
Nov.	16	124						
MAXIMUM			0.00	0.00	0.00	0.00	0.00	0.00
$\overline{X}$			0.00	0.00	0.00	0.00	0.00	0.00
2 S.E.			-	-	-	-	-	-

MAXIMUM = Maximum B/KM2 on any one transect
$\overline{X}$ = Mean transect density
2 S.E. = Two standard errors of the mean
B/KM2 = Birds Per Square Kilometer

Table 23. Cassin's Auklet Density Indices From Shipboard Surveys of Kodiak Island Waters, 1977.

	NUMBER OF TRANSECTS		B/KM2 ON WATER & FEEDING		B/KM2 FLYING		TOTAL B/KM2	
	BAY	SHELF	BAYS	SHELF	BAYS	SHELF	BAYS	SHELF
FW7032								
May-Jun.	78	154						
MAXIMUM			0.00	0.00	0.00	1.08	0.00	1.08
$\bar{X}$			0.00	0.00	0.00	0.01	0.00	0.01
2 S.E.			-	-	-	0.01	-	0.01
FW7033								
Jun.	40	193						
MAXIMUM			0.00	0.00	0.00	0.00	0.00	0.00
$\bar{X}$			0.00	0.00	0.00	0.00	0.00	0.00
2 S.E.			-	-	-	-	-	-
FW7034								
Jul.	156	144						
MAXIMUM			0.00	5.40	1.20	3.24	1.20	6.48
$\bar{X}$			0.00	0.16	0.01	0.04	0.01	0.20
2 S.E.			-	0.13	0.02	0.05	0.02	0.16
FW7035								
Aug.	68	168						
MAXIMUM			45.36	14.04	2.16	5.40	45.36	14.04
$\bar{X}$			1.03	0.89	0.03	0.20	1.06	1.08
2 S.E.			1.52	0.35	0.06	0.12	1.55	0.40
FW7036								
Sep.	113	82						
MAXIMUM			6.84	11.88	7.56	14.04	14.04	21.60
$\bar{X}$			0.29	0.68	0.34	1.06	0.62	1.73
2 S.E.			0.18	0.37	0.24	0.59	0.35	0.80
FW7046								
Sep.	3	35						
MAXIMUM			0.00	0.83	0.00	2.70	0.00	2.70
$\bar{X}$			0.00	0.05	0.00	0.18	0.00	0.23
2 S.E.			-	0.07	-	0.18	-	0.20
FW7047								
Nov.	16	124						
MAXIMUM			0.00	?	0.00	?	0.00	4.6
$\bar{X}$			0.00	?	0.00	?	0.00	0.2
2 S.E.			-	-	-	-	-	0.1

MAXIMUM = Maximum B/KM2 on any one transect

$\bar{X}$ = Mean transect density

2 S.E. = Two standard errors of the mean

B/KM2 = Birds Per Square Kilometer

Table **24.** Parakeet Auklet Density Indices From Shipboard Surveys of Kodiak Island Waters, 1977.

	NUMBER OF TRANSECTS		B/KM2 ON WATER & FEEDING		B/KM2 FLYING		TOTAL B/KM2	
	BAY	SHELF	BAYS	SHELF	BAYS	SHELF	BAYS	SHELF
FW7032								
May-Jun.	78	154						
MAXIMUM			0.00	1.08	0.00	0.00	0.00	1.08
$\bar{X}$			0.00	0.01	0.00	0.00	0.00	0.01
2 S.E.			-	0.01	-	-	-	0.01
FW7033								
Jun.	40	193						
MAXIMUM			0.00	2.16	0.00	3.60	0.00	3.60
$\bar{X}$			0.00	0.02	0.00	0.02	0.00	0.04
2 S.E.			-	0.02	-	0.04	-	0.04
FW7034								
Jul.	156	144						
MAXIMUM			6.00	11.88	0.00	7.85	6.00	11.88
$\bar{X}$			0.04	0.26	0.00	0.05	0.04	0.31
2 S.E.			0.08	0.25	-	0.11	0.08	0.27
FW7035								
Aug.	68	168						
MAXIMUM			0.00	0.00	1.08	0.00	1.08	0.00
$\bar{X}$			0.00	0.00	0.02	0.00	0.02	0.00
2 S.E.			-	-	0.03	-	0.03	-
FW7036								
Sep.	113	82						
MAXIMUM			0.00	0.00	0.00	0.00	0.00	0.00
$\bar{X}$			0.00	0.00	0.00	0.00	0.00	0.00
2 S.E.			-	-	-	-	-	-
FW7046								
Sep.	3	35						
MAXIMUM			0.00	0.83	0.00	0.90	0.00	0.90
$\bar{X}$			0.00	0.02	0.00	0.03	0.00	0.05
2 S.E.			-	0.05	-	0.05	-	0.07
FW7047								
Nov.	16	124						
MAXIMUM			0.00	?	0.00	?	0.00	1.7
$\bar{X}$			0.00	?	0.00	?	0.00	0.03
2 S.E.			-	-	-	-	-	?

MAXIMUM = Maximum B/KM2 on any one transect

$\bar{X}$ = Mean transect density

2 S.E. = Two standard errors of the mean

B/KM2 = Birds Per Square Kilometer

Table 25. Crested Auklet Density Indices From Shipboard Surveys of Kodiak Island Waters, 1977.

	NUMBER OF TRANSECTS		B/KM2 ON WATER & FEEDING		B/KM2 FLYING		TOTAL B/KM2	
	BAY	SHELF	BAYS	SHELF	BAYS	SHELF	BAYS	SHELF
FW7032								
May-Jun.	78	154						
MAXIMUM			0.00	0.00	0.00	0.00	0.00	0.00
$\bar{X}$			0.00	0.00	0.00	0.00	0.00	0.00
2 S.E.			-	-	-	-	-	-
FW7033								
Jun.	40	193						
MAXIMUM			0.00	0.00	0.00	0.00	0.00	0.00
$\bar{X}$			0.00	0.00	0.00	0.00	0.00	0.00
2 S.E.			-	-	-	-	-	-
FW7034								
Jul.	156	144						
MAXIMUM			0.00	0.00	0.00	0.00	0.00	0.00
$\bar{X}$			0.00	0.00	0.00	0.00	0.00	0.00
2 S.E.			-	-	-	-	-	-
FW7035								
Aug.	68	168						
MAXIMUM			0.00	0.00	0.00	0.00	0.00	0.00
$\bar{X}$			0.00	0.00	0.00	0.00	0.00	0.00
2 S.E.			-	-	-	-	-	-
FW7036								
Sep.	113	82						
MAXIMUM			0.00	0.00	0.00	0.00	0.00	0.00
$\bar{X}$			0.00	0.00	0.00	0.00	0.00	0.00
2 S.E.			-	-	-	-	-	-
FW7046								
Sep.	3	35						
MAXIMUM			0.00	0.00	0.00	0.00	0.00	0.00
$\bar{X}$			0.00	0.00	0.00	0.00	0.00	0.00
2 S.E.			-	-	-	-	-	-
FW7047								
Nov.	16	124						
MAXIMUM			5.8	?	1.7	?	7.5	12.7
$\bar{X}$			0.7	?	0.2	?	0.9	0.2
2 S.E.			0.8	-	0.3	-	1.0	0.2

MAXIMUM = Maximum B/KM2 on any one transect

$\bar{X}$ = Mean transect density

2 S.E. = Two standard errors of the mean

B/KM2 = Birds Per Square Kilometer

Table 26. Horned Puffin Density Indices From Shipboard Surveys of Kodiak Island Waters, 1977.

	NUMBER OF TRANSECTS		B/KM2 ON WATER & FEEDING		B/KM2 FLYING		TOTAL B/KM2	
	BAY	SHELF	BAYS	SHELF	BAYS	SHELF	BAYS	SHELF
FW7032								
May-Jun.	78	154						
MAXIMUM			6.48	2.16	3.24	24.00	6.48	24.00
$\bar{X}$			0.20	0.05	0.15	0.50	0.35	0.54
2 S.E.			0.19	0.04	0.13	0.35	0.24	0.35
FW7033								
Jun.	40	193						
MAXIMUM			0.00	2.95	1.20	3.93	1.20	3.93
$\bar{X}$			0.00	0.04	0.10	0.06	0.10	0.10
2 S.E.			-	0.04	0.10	0.05	0.10	0.07
FW7034								
Jul.	156	144						
MAXIMUM			30.24	2.16	4.91	3.24	33.48	3.24
$\bar{X}$			0.38	0.05	0.24	0.10	0.62	0.16
2 S.E.			0.40	0.04	0.12	0.07	0.46	0.08
FW7035								
Aug.	68	168						
MAXIMUM			9.72	1.08	7.20	1.08	10.80	1.08
$\bar{X}$			0.19	0.02	0.27	0.02	0.46	0.04
2 S.E.			0.29	0.02	0.25	0.02	0.40	0.03
FW7036								
Sep.	113	82						
MAXIMUM			15.60	10.80	7.20	5.40	16.80	12.15
$\bar{X}$			0.52	1.08	0.35	0.50	0.87	1.58
2 S.E.			0.32	0.43	0.20	0.24	0.39	0.55
FW7046								
Sep.	3	35						
MAXIMUM			0.00	1.66	1.96	8.10	1.96	8.10
$\bar{X}$			0.00	0.05	0.95	0.33	0.95	0.38
2 S.E.			-	0.10	2.99	0.49	2.99	0.49
FW7047								
Nov.	16	124						
MAXIMUM			0.00	?	0.00	?	0.00	21.5
$\bar{X}$			0.00	?	0.00	?	0.00	0.7
2 S.E.			-	-	-	-	-	0.4

MAXIMUM = Maximum B/KM2 on any one transect
$\bar{X}$ = Mean transect density
2 S.E. = Two standard errors of the mean
B/KM2 = Birds Per Square Kilometer

Table 27. Tufted Puffin Density Indices From Shipboard Surveys of Kodiak Island Waters, 1977.

	NUMBER OF TRANSECTS		B/KM2 ON WATER & FEEDING		B/KM2 FLYING		TOTAL B/KM2	
	BAY	SHELF	BAYS	SHELF	BAYS	SHELF	BAYS	SHELF
FW7032								
May-Jun.	78	154						
MAXIMUM			87.47	38.88	32.40	36.72	96.21	75.59
X			6.30	3.39	2.71	2.24	9.01	5.63
2 S.E.			3.28	1.13	1.28	0.77	3.96	1.62
FW7033								
Jun.	40	193						
MAXIMUM			93.95	37.80	20.62	12.76	100.43	37.80
X			8.39	1.73	4.44	1.56	12.82	3.30
2 S.E.			5.55	0.58	1.69	0.34	5.90	0.69
FW7034								
Jul.	156	144						
MAXIMUM			278.08	7.56	135.59	16.20	279.88	23.76
X			11.70	0.77	7.28	1.90	18.98	2.67
2 S.E.			5.16	0.27	2.37	0.53	5.73	0.69
FW7035								
Aug.	68	168						
MAXIMUM			117.71	28.08	112.49	30.24	173.87	33.48
X			7.27	2.39	14.02	2.44	21.29	4.83
2 S.E.			4.49	0.71	5.13	0.68	7.83	1.03
FW7036								
Sep.	113	82						
MAXIMUM			3.93	25.92	3.60	7.56	4.91	25.92
X			0.55	5.04	0.19	0.23	0.74	5.27
2 S.E.			0.19	1.07	0.12	0.21	0.23	1.09
FW7046								
Sep.	3	35						
MAXIMUM			0.00	18.28	2.95	9.90	2.95	18.28
X			0.00	3.72	2.18	0.49	2.18	4.21
2 S.E.			-	2.06	3.40	0.61	3.40	2.04
FW7047								
Nov.	16	124						
MAXIMUM			0.00	?	0.00	?	13.9	1.7
X			0.00	?	0.00	?	0.3	0.1
2 S.E.			-	-	-	-	0.3	0.1

MAXIMUM = Maximum B/KM2 on any one transect
X = Mean transect density
2 S.E. = Two standard errors of the mean
B/KM2 = Birds Per Square Kilometer

Table 28. Total Bird Density Indices From Shipboard Surveys of Kodiak Island Waters, 1977.

	NUMBER OF TRANSECTS		B/KM2 ON WATER & FEEDING		B/KM2 FLYING		TOTAL B/KM2	
	BAY	SHELF	BAYS	SHELF	BAYS	SHELF	BAYS	SHELF
FW7032								
May-Jun.	78	154						
MAXIMUM			106.9	844.3	48.1	699.8	126.4	1138.8
$\overline{X}$			13.4	30.4	8.5	23.5	21.9	53.9
2 S.E.			4.6	17.1	2.1	12.7	5.8	23.2
FW7033								
Jun.	40	193						
MAXIMUM			97.2	3495.0	49.5	1590.7	109.1	3498.9
$\overline{X}$			15.2	47.6	10.5	24.9	25.7	72.5
2 S.E.			6.5	38.2	3.4	17.0	7.9	42.4
FW7034								
Jul.	156	144						
MAXIMUM			471.6	5618.8	135.6	547.2	479.7	5664.2
$\overline{X}$			28.0	66.4	22.7	18.3	50.7	84.7
2 S.E.			9.1	78.4	4.2	9.1	10.7	79.6
FW7035								
Aug.	68	168						
MAXIMUM			650.7	3244.1	139.5	883.4	790.1	3250.5
$\overline{X}$			27.7	52.4	31.5	32.1	59.2	84.6
2 S.E.			20.0	40.6	7.7	11.4	24.8	43.0
FW7036								
Sep.	113	82						
MAXIMUM			114.5	320.7	368.4	544.0	393.6	568.3
$\overline{X}$			14.3	43.5	20.9	28.5	35.2	72.0
2 S.E.			3.4	14.1	8.1	13.4	9.2	19.3
FW7046								
Sep.	3	35						
MAXIMUM			0.0	122.1	55.8	711.8	55.8	711.8
$\overline{X}$			0.0	24.6	47.4	48.4	47.4	73.0
2 S.E.			-	13.2	42.1	45.6	42.1	45.2
FW7047								
Nov.	16	124						
MAXIMUM			30.8	?	3.9	?	34.6	452.3
$\overline{X}$			19.7	?	3.5	?	17.3	20.9
2 S.E.			?	-	?	-	?	8.6

MAXIMUM = Maximum B/KM2 on any one transect

$\overline{X}$ = Mean transect density

2 S.E. = Two standard errors of the mean

B/KM2 = Birds Per Square Kilometer

ANNUAL REPORT

Contract #03-5-022-56
Research Unit #441
Task Order #27
1 January - 31 March 1978

Avian Community Ecology at Two Sites on Espenberg Peninsula in Kotzebue Sound, Alaska.

Principal Investigator: P. G Mickelson, Institute of Arctic Biology

Report Prepared By: Douglas Schamel and Diane Tracy

31 March 1978

I. TASK OBJECTIVES

1. To determine phenology of events from spring arrival through departure of birds,

2. to determine the distribution and abundance of birds and their predators,

3. to describe habitat utilization of birds and their predators during migration, the nesting season, and the brood rearing season,

4. to estimate production of all avian species nesting on Cape Espenberg,

5. to determine the abundance of small mammals which are utilized by avian and mammalian predators,

6. to describe availability of food and utilization by shorebirds,

7. to determine distribution and abundance of sea mammals,

8. to provide recommendations to lessen the impact of developments on the avian community and avian habitat at Cape Espenberg,

9. to establish baseline study plots to evaluate the impact of developments on the avian community and avian habitat at Cape Espenberg,

and

10. to assess bird use of coastal habitats in southern Kotzebue Sound by flying aerial surveys at regular intervals.

II. RESULTS

Since the final report for this project will appear next quarter, this report will be brief. We have included only those data products specifically requested by OCSEAP at this time: small mammal abundance, bird measurements, birds banded, and daily bird observations. Discussion of these topics will be postponed until the final report.

Table 1. Number of *Microtus oeconomus* (tundra vole) captured in live-traps on small mammal trap lines, Cape Espenberg, Alaska, 1976-1977

Trap Line No.	No. of Trap-Days Each Year	Trapping Date Period		Location On Cape	Habitat	No. of Individuals Captured		No. of Captures	
		1976	1977			1976	1977	1976	1977
1	80	July 23- July 31	July 20- July 24	Shorebird Marsh Plot	Dry Tussocks	0	0	0	0
2	80	" "	" "	" "	Marsh	0	0	0	0
3	80	" "	" "	" "	Marsh	2	0	5	0
4	80	August 4- August 16	August 20- August 24	Shorebird Mixed Habitat Plot	*Elymus*-Dunes	7	0	14	0
5	80	" "	" "	" "	Dwarf shrub- Dunes	2	0	2	0
6	80	" "	" "	" "	Sedge-Pond edge	2	0	2	0

Table 2. Measurements of Dunlins, *Calidris alpina*, Cape Espenberg, Alaska, 1977.

Date Captured	USFWS Band No.	Sex[1]	Culmen (cm)	Wing (cm)	Wgt. (g)	Nest No.
16 June	861-63639	F	3.82	12.3	59.6	1
16	861-63641	M	3.70	12.3	53.8	5
13	861-63625	F	4.16	12.1	62.6	5
18	861-63653	F	3.80	12.5	55.1	8
19	861-63656	M	3.58	12.1	52.6	8
27	861-63664	F	3.92	12.1	56.6	9
19	861-63655	M	3.49	12.2	54.6	9
23	861-63662	M	3.73	12.1	61.1	11
18	861-63637	F	4.0	12.8	60.1	201
19	861-63635	M	3.7	12.1	56.1	201
18	861-63636	F	3.8	12.1	59.1	202

[1] Sex determination is based upon bill length. The member of the pair having the largest bill (culmen) length is considered to be the female (Soikkeli 1966).

Table 3. Measurements of Semipalmated Sandpipers, *Calidris pusilla*, Cape Espenberg, Alaska, 1977.

Date Captured	USFWS Band No.	Sex[1]	Culmen (cm)	Wing (cm)	Wgt. (g)	Nest No.
8 June	880-84102	M	1.78	9.4	23.4	103
9	880-84106	M	1.61	9.2	24.4	202
9	880-84108	M	1.70	9.8	25.0	102
10	880-84111	F	1.88	9.6	27.8	103
11	880-84116	M	1.61	9.7	22.8	5
11	880-84117	F	1.85	9.8	24.2	5
12	880-38120	M	1.68	9.6	23.9	105
12	880-84201	M	1.8	9.8	24.3	204
12	880-84202	F	1.79	9.8	25.7	203
13	880-84203	M	1.64	9.8	24.1	203
28	880-84145	M	1.69	9.4	27.3	110
28	880-84147	M	1.76	9.8	27.6	15
29	880-84168	F	1.92	9.9	28.5	15

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[1] Sex determination is based upon bill length. The member of the pair having the largest bill (culmen) length is considered to be the female.

Table 4. Measurements of Western Sandpipers, *Calidris mauri*, Cape Espenberg, Alaska, 1977.

Date Captured	USFWS Band No.	Sex[1]	Culmen (cm)	Wing (cm)	Wgt. (g)	Nest No.
6 June	880-84104	F	2.71	9.9	28.8	105
8	880-84103	M	2.21	9.2	24.1	2
9	880-84105	F	2.52	9.9	27.6	4
9	880-84107	M	2.29	9.6	27.9	201
10	880-84109	F	2.59	9.6	30.2	104
10	880-84110	M	2.30	9.9	25.9	101
10	880-84112	F	2.71	9.9	27.6	4
11	880-38113	M	2.28	10.0	24.9	103
11	880-38114	F	2.62	10.6	33.7	101
11	880-38115	F	2.37	9.6	27.8	1
11	880-38118	M	2.17	9.6	25.9	1
12	880-38119	F	2.62	10.1	27.3	201
13	880-84004	F	2.77	10.1	28.8	5
13	880-84121	F	2.65	9.9	29.4	106
13	880-84122	F	2.63	9.9	31.0	103
14	880-84123	M	2.22	9.4	25.4	104
18	880-84005	M	2.32	9.7	23.8	106
20	880-84007	F	2.45			107
21	880-84008	M	2.30	9.4	28.8	7
22	880-84010	F	2.80	9.8	29.8	8
26	880-84204	M	2.2	9.4	23.4	8
27	880-84136	M	2.28	9.9	25.4	113
27	880-84142	M	2.26	9.4	27.3	12
28	880-84155	M	2.17	9.6	26.0	14
28	880-84157	M	2.31	9.2	25.5	10
28	880-84206	F	2.51	9.9	31.1	114
29	880-84163	F	2.48	10.0	27.0	12
29	880-84164	F	2.62	9.7	27.5	13
29 June	880-84211	F	2.35	9.9	26.1	113
30	880-84169	M	2.27	9.9	26.2	114
30	880-84170	F	2.70	10.1	30.6	15
1 July	880-84015	F	2.67	10.1	26.6	10
1	880-84171	M	2.26	9.4	28.5	107
1	880-84172	F	2.63	9.8	28.0	14

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[1] Sex determination is based upon bill length. The member of the pair having the largest bill (culmen) length is considered to be the female (Kozlova 1962).

Table 5. Measurements of Red Phalaropes, *Phalaropus fulicarius*, Cape Espenberg, Alaska, 1977.

Date Captured	USFWS Band No.	Sex	Culmen (cm)	Wing (cm)	Wgt. (g)	Nest No.
2 June	861-63601	F	2.42	14.5	72.6	
8	861-63611	F	2.40	14.0	59.1	
8	861-63614	F	2.40	14.0	69.6	1
10	861-63619	F	2.27	13.8	66.8	
12	861-63622	M	2.21	13.4	49.6	
12	861-63623	M	2.10	13.6	49.6	101
12	861-63624	M	2.22	13.3	55.1	1
14	861-63626	M	2.06	13.4	48.6	102
14	861-63628	M	2.22	13.5	56.1	2
15	861-63629	M	2.23	13.0	51.1	3
15	861-63632	F	2.40	13.6	57.6	
15	861-63633	M	2.15	13.3	47.6	4
16	861-63640	M	2.30	13.1	51.8	
20	861-63659	M	2.25	13.0	53.1	9
27	861-63665	M	2.22	13.2	52.1	14
30	861-63694	M	2.35	13.1	48.8	15
7	861-63701	F	2.20	13.7	66.6	
9	861-63703	M	2.25	13.0	51.4	
3 July	861-63712	M	2.30	13.0	47.1	103
5	77-120305	M	2.19	12.5	44.6	13

Table 6. Measurements of Northern Phalaropes, Lobipes lobatus, Cape Espenberg, Alaska, 1977.

Date Captured	USFWS Band No.	Sex	Culmen (cm)	Wing (cm)	Wgt. (g)	Nest No.
2 June	861-63602	F	2.22	11.9	45.1	
5	861-63603	F	2.42	11.5		2
6	861-63604	M	2.20	11.5	33.1	
6	861-63605	F	2.26	11.3	40.6	
7	861-63606	M	2.18	11.0	30.6	
7	861-63607	F	2.33	11.0	37.1	
7	861-63608	F	2.26	11.6	38.1	
7	861-63609	M	2.21	11.0	31.1	
7	861-63610	F	2.38	11.6	41.8	
8	861-63612	F	2.49	11.5	46.8	
8	861-63613	F	2.28	11.6	42.6	
9	861-63615	M	2.26	10.9	33.1	
9	861-63616	F	2.29	11.3	31.6	
9	861-63617	M	2.26	11.4	34.1	1
10	861-63618	F	2.24	11.6	40.6	
10	861-63620	M	2.28	10.9	29.6	105
11	861-63621	F	2.29	11.9	42.6	
14	861-63627	M	2.26	11.0	34.1	3
15	861-63630	M	2.38	10.9	35.1	4
15	861-63631	F	2.23	11.4	41.6	
16	861-63638	M	2.25	11.1	32.1	102
17	861-63642	F	2.42	11.6	44.2	
19	861-63657	M	2.24	10.9	34.9	7
20	861-63658	M	2.03	10.7	34.6	6
21	861-63660	M	2.32	11.2	33.6	12
22	861-63661	M	2.07	10.8	31.6	14
27	861-63666	M	2.25	10.7	34.6	10
27	861-63667	M	2.21	11.1	33.8	21
29 June	861-63682	M	2.05	11.1		108
7	861-63702		1.92	11.2	41.3	
10	861-63704	F	2.25	11.6	39.8	103
10	861-63705	F	2.48	11.5	35.4	
6	880-84101	F	2.35	11.8	35.4	
3 July	861-63713	M	2.35	10.9	33.1	23
1	861-63748	M				111
2	112-139571	M	2.2	10.8	36.7	107
2	112-139572	M	2.01	10.4	30.1	202

Table 7. Daily bird observations. Cape Espenberg, Alaska. 19 May to 24 September 1977. (These data are not a reliable indicator of short term changes in daily abundance of avian species, but do illustrate dates of first and last observations and longer-term changes in relative abundance).

	MAY													JUNE													
	19	20	21	22	23	24	25	26	27	28	29	30	31	1	2	3	4	5	6	7	8	9	10	11	12	13	14
Yellow-billed Loon	-	-	-	-	-	-	-	-	-	-	1	-	2	1	1	1	2	5	2	2	2	2	2	1	2	-	1
Arctic Loon	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	2	6	8	2	2	4	6	6	3	4	2	4
Red-throated Loon	-	-	-	-	-	-	3	1	5	35	20	35	60	70	55	30	65	40	55	24	25	55	70	25	65	20	25
Red-necked Grebe	-	-	-	-	-	-	-	-	-	-	-	-	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Whisting Swan	-	-	-	-	-	-	-	-	-	-	-	-	2	-	-	-	1	10	6	6	-	-	4	-	4	2	-
Canada Goose	-	3	-	2	-	-	-	-	1	3	7	1	2	3	2	-	2	5	4	5	8	5	3	2	2	2	2
Black Brant	-	-	-	-	-	-	-	-	-	-	-	-	50	2	2	10	2	20	6	-	26	31	16	10	6	-	-
Emperor Goose	-	-	-	-	-	-	-	-	-	-	2	2	2	2	-	2	14	38	9	8	6	18	6	12	12	6	13
White-fronted Goose	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1	-	-	-	-	-	-	-	-
Snow Goose	-	-	-	-	-	-	-	-	-	-	-	-	4	-	17	13	-	13	-	-	-	-	-	-	-	-	-
Mallard	2	2	2	4	2	2	2	4	6	10	10	11	15	4	10	10	12	12	10	2	-	-	-	2	2	2	-
Pintail	50	50	50	50	50	50	50	15	30	60	120	100	120	70	70	16	120	125	105	50	40	90	90	60	50	15	30
Green-winged Teal	-	-	-	-	-	2	-	4	-	2	2	-	8	2	2	2	4	2	7	4	5	-	-	-	2	1	1
American Wigeon	-	-	-	-	-	-	-	-	-	-	-	15	-	2	-	5	-	-	-	-	-	-	-	-	-	-	-
Northern Shoveler	-	-	3	3	3	3	3	3	-	1	16	1	12	2	2	2	6	4	2	-	-	-	-	-	-	-	-
Redhead	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1	-	-	-	-	-	-	-	-
Canvasback	-	-	-	-	-	2	2	4	-	-	-	1	2	-	2	-	-	2	4	-	8	4	1	-	-	-	-
Greater Scaup	2	2	2	2	2	2	2	4	4	7	12	8	27	12	8	4	12	14	12	16	16	14	14	8	6	6	15
Oldsquaw	-	-	-	-	-	-	-	-	-	6	25	15	25	8	25	20	50	110	40	35	25	40	40	30	30	10	15
Common Eider	-	-	-	4	-	-	2	-	2	14	45	35	20	20	35	20	85	100	55	60	100	70	30	45	180	130	40
King Eider	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	2	2	-	-
Spectacled Eider	-	-	-	-	-	-	-	-	-	-	-	-	2	2	3	-	-	4	-	-	-	2	-	-	-	-	-
White-winged Scoter	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Surf Scoter	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Black Scoter	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	2	-	-	-	-	-	1	-	-
Red-breasted Merganser	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	3	-	-	-	4	6	2	-	-	-	-
Goshawk	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Marsh Hawk	-	1	1	-	-	-	-	-	-	-	-	-	-	1	-	-	-	-	-	-	-	-	-	-	-	-	-
Peregrine Falcon	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1	-	-	-	-	-	-	-	-	-
Willow Ptarmigan	-	-	-	15	-	-	5	1	6	8	10	8	30	3	7	9	18	8	11	7	8	9	3	6	8	1	5
Sandhill Crane	-	10	10	10	10	10	10	-	10	15	20	17	30	16	21	9	19	23	17	6	9	17	4	5	15	4	9
American Golden Plover	-	-	-	3	-	-	2	-	1	-	1	2	3	4	-	-	4	4	1	4	1	1	1	-	1	-	2
Black-bellied Plover	-	-	-	1	-	-	1	1	-	-	1	-	-	1	1	-	2	-	-	-	-	-	2	2	-	-	-
Ruddy Turnstone	3	3	3	3	3	3	7	3	3	12	6	4	7	6	5	3	8	14	10	7	6	4	5	4	9	1	6
Black Turnstone	-	-	-	2	-	-	1	1	2	5	3	8	7	6	5	-	6	20	2	4	1	-	-	-	2	-	2
Common Snipe	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1	-
Whimbrel	2	2	2	2	2	2	2	2	-	1	-	-	20	1	1	-	-	-	1	2	1	2	2	-	-	-	-
Bristle-thighed Curlew	-	2	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Red Knot	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Sharp-tailed Sandpiper	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Pectoral Sandpiper	-	-	1	5	-	-	-	4	-	15	3	1	4	1	4	4	-	-	1	-	-	1	-	-	-	-	2

Table 7. Continued

MAY													JUNE													
	19	20	21	22	23	24	25	26	27	28	29	30	31	1	2	3	4	5	6	7	8	9	10	11	12	13	14
Baird's Sandpiper	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1	-	-
Dunlin	10	10	10	15	10	10	10	-	15	15	55	30	50	13	30	35	35	45	25	25	15	20	13	30	30	4	20
Semipalmated Sandpiper	10	10	10	30	10	10	15	7	20	30	55	25	50	25	25	20	35	70	25	45	30	40	20	40	55	10	40
Western Sandpiper	10	10	10	30	10	10	15	2	8	15	20	10	13	7	12	15	30	50	30	30	15	35	20	20	20	8	25
Sanderling	-	-	-	-	-	-	-	3	3	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Long-billed Dowitcher	3	3	3	3	3	3	3	1	8	6	25	7	25	9	10	8	11	10	8	10	9	6	7	8	13	7	10
Bar-tailed Godwit	-	-	-	-	-	-	-	-	-	-	2	-	2	-	-	-	-	3	-	-	-	1	-	1	-	-	-
Hudsonian Godwit	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Red Phalarope	-	-	-	-	-	-	-	-	3	-	30	40	70	15	30	12	50	35	30	25	15	70	20	30	50	7	25
Northern Phalarope	-	-	5	2	2	2	2	1	2	5	15	10	45	15	25	10	40	60	35	35	30	55	40	40	45	8	25
Unidentified Small Shorebirds	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Unidentified Medium Shorebirds	-	-	-	-	-	-	-	-	-	-	-	20	-	-	-	-	-	-	-	15	-	-	-	-	-	-	-
Unidentified Large Shorebirds	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Pomarine Jaeger	-	-	-	3	-	-	-	-	-	14	2	-	4	1	8	-	6	9	-	1	1	-	-	-	-	1	-
Parasitic Jaeger	-	-	1	2	2	2	2	-	10	25	18	5	35	25	20	18	28	35	27	20	25	43	27	23	23	8	16
Long-tailed Jaeger	2	-	-	-	-	-	-	4	1	2	3	3	10	2	1	4	1	-	-	1	1	5	6	2	2	-	-
Glaucous Gull	20	20	20	20	20	20	20	8	25	50	120	75	110	70	65	60	100	160	110	75	50	105	115	110	180	50	110
Mew Gull	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1	1	-	-	-	-	-	-	-	-	-	-
Black-legged Kittiwake	-	-	-	-	-	-	-	-	-	80	2	1	13	20	2	-	20	24	6	20	60	80	50	10	30	10	5
Sabine's Gull	-	-	-	-	-	-	-	-	8	8	13	1	2	18	22	15	35	40	14	20	18	30	18	20	20	5	20
Arctic Tern	-	-	-	-	-	-	-	-	-	-	2	3	17	16	20	12	35	60	40	40	25	35	35	30	55	5	30
Aleutian Tern	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Murre sp.	-	-	-	-	-	-	-	-	-	-	-	-	85	-	25	-	-	-	-	-	-	-	-	-	-	-	-
Tufted Puffin	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Snowy Owl	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Short-eared Owl	1	1	1	-	-	-	-	-	-	-	-	1	-	1	-	-	-	-	-	-	-	-	-	-	-	-	-
Say's Phoebe	-	-	1	1	1	1	1	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Horned Lark	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1	-	-	-	-	-	-	-	-
Tree Swallow	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1	-	1	-	1	-	-	-	-	-
Bank Swallow	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1	-	1	-	-
Cliff Swallow	-	-	-	-	-	-	-	-	-	-	-	-	1	-	-	1	-	-	-	-	1	-	-	-	-	-	-
Common Raven	-	2	2	1	2	1	1	2	1	3	1	1	-	-	-	-	-	2	-	1	-	2	1	1	2	2	2
Wheatear	-	-	-	-	-	1	1	-	1	1	-	1	-	-	-	-	-	-	-	-	3	2	-	-	-	-	-
Arctic Warbler	-	-	-	-	-	-	-	-	-	1	-	-	-	-	-	-	-	-	-	-	-	-	-	3	2	-	-
Yellow Wagtail	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	2	2	6	4	2	3	-	-	-	-
Orange-crowned Warbler	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1	1	-	-	-
Redpoll sp.	-	-	-	3	-	-	-	5	-	-	7	2	3	1	-	1	-	4	2	2	11	-	5	-	4	2	2
White-winged Crossbill	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Savannah Sparrow	2	2	2	2	2	2	2	5	-	4	7	2	9	7	3	8	-	17	4	4	6	8	12	12	14	4	7
Dark-eyed Junco	-	1	1	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
White-crowned Sparrow	-	3	3	-	-	-	-	-	-	-	1	-	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Lapland Longspur	10	10	10	10	10	10	10	8	20	25	60	30	50	35	35	20	60	35	45	40	35	65	35	35	50	10	35
Snow Bunting	-	-	-	2	-	-	-	-	-	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-

Table 7 Continued

JUNE																	JULY										
	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	1	2	3	4	5	6	7	8	9	10	11
Yellow-billed Loon	-	-	3	1	1	-	-	-	2	-	-	-	1	1	-	-	-	-	-	-	-	-	3	-	2	1	1
Arctic Loon	-	-	8	8	4	6	6	2	6	2	2	-	7	4	3	2	6	5	6	2	7	5	7	4	6	4	8
Red-throated Loon	15	35	75	45	35	30	30	30	30	29	10	12	30	15	25	15	35	30	35	20	100	30	40	30	80	50	45
Red-necked Grebe	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Whistling Swan	4	1	6	2	2	-	-	1	-	19	-	-	4	-	-	-	-	-	-	-	-	-	-	-	4	-	-
Canada Goose	-	-	3	2	-	6	-	-	-	-	-	-	-	-	-	-	2	-	-	-	6	3	-	-	-	-	-
Black Brant	16	8	5	25	1	-	-	-	10	-	-	-	-	-	11	-	-	-	-	-	-	-	10	-	-	-	8
Emperor Goose	3	2	22	18	25	15	14	13	9	10	-	5	22	2	7	2	12	6	9	-	16	3	20	10	14	3	-
White-fronted Goose	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Snow Goose	-	-	-	-	-	-	-	-	-	-	-	5	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Mallard	6	-	5	2	-	1	-	1	-	-	-	-	-	-	-	-	-	-	-	-	-	2	1	-	-	1	1
Pintail	8	30	120	50	50	30	60	30	25	60	5	15	35	12	90	10	20	40	50	95	70	14	2	20	40	10	5
Green-winged Teal	1	6	7	3	-	4	-	1	-	-	-	2	2	-	-	-	-	2	-	-	-	2	1	-	-	-	4
American Wigeon	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Northern Shoveler	-	-	-	-	-	-	-	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Redhead	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Canvasback	2	-	3	-	1	2	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Greater Scaup	3	10	20	13	8	11	12	10	7	-	1	1	3	-	2	1	1	2	-	-	2	6	5	1	1	-	2
Oldsquaw	10	25	40	30	30	35	30	30	25	20	5	5	40	15	30	20	25	45	45	20	45	30	40	35	35	30	35
Common Eider	30	50	115	135	145	65	100	60	40	60	10	20	95	25	60	30	80	130	85	30	60	35	95	235	290	450	90
King Eider	-	-	1	1	-	-	-	-	1	1	-	-	-	1	-	-	-	-	-	-	-	-	-	-	-	-	1
Spectacled Eider	-	1	1	0	-	-	-	-	-	2	-	-	1	1	-	-	-	-	-	-	1	-	6	-	-	1	-
White-winged Scoter	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	2	-	-	-	-
Surf Scoter	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	20	-	-	-	-
Black Scoter	-	-	2	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Red-breasted Merganser	-	-	-	3	6	3	10	3	3	-	-	-	-	-	1	-	-	-	-	-	2	10	14	1	6	22	3
Goshawk	-	-	1	-	-	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1	-	-	1	-	-
Marsh Hawk	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Peregrine Falcon	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Willow Ptarmigan	2	6	11	9	6	5	4	2	2	3	-	3	4	-	8	-	14	3	8	-	3	1	15	2	4	16	2
Sandhill Crane	-	8	18	20	20	11	10	8	14	12	4	5	25	6	16	6	14	18	16	8	30	14	25	14	30	20	16
American Golden Plover	-	3	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	3	1	-	1	1	-	-	-	-
Black-bellied Plover	-	-	2	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1	-	-	2	-	-	-	-	-	2
Ruddy Turnstone	3	10	14	5	8	8	4	4	6	3	-	-	7	4	9	2	4	8	9	2	8	4	12	2	8	30	5
Black Turnstone	-	-	-	6	-	-	-	3	2	2	-	-	10	2	2	-	2	-	2	1	5	1	-	1	10	1	-
Common Snipe	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Whimbrel	-	-	-	-	-	-	-	-	-	-	-	-	8	-	-	-	2	1	-	-	-	-	-	-	-	-	-
Bristle-thighed Curlew	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Red Knot	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Sharp-tailed Sandpiper	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Pectoral Sandpiper	1	3	9	6	6	1	-	3	2	2	-	3	6	2	2	3	10	15	18	20	240	10	20	11	15	41	10
Baird's Sandpiper	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Dunlin	8	25	50	45	45	30	15	20	30	30	15	25	45	15	25	15	35	25	35	20	45	25	25	20	50	35	16
Semipalmated Sandpiper	10	40	80	45	50	40	30	30	35	40	15	16	55	25	40	25	40	40	40	30	40	35	35	25	30	25	35

Table 7. Continued

JUNE																	JULY										
	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	1	2	3	4	5	6	7	8	9	10	11
Western Sandpiper	10	20	35	25	35	30	20	25	30	30	5	6	40	25	35	20	30	30	30	20	25	20	20	15	21	10	12
Sanderling	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Long-billed Dowitcher	4	4	10	8	15	8	6	6	10	8	2	2	9	4	6	4	8	8	8	6	6	9	9	10	30	40	6
Bar-tailed Godwit.	-	-	-	-	-	-	-	-	-	1	-	-	-	-	-	-	-	-	-	-	-	1	-	-	-	-	-
Hudsonian Godwit	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Red Phalarope	15	12	20	18	25	30	25	25	30	25	10	10	40	15	20	20	40	35	33	25	25	20	20	10	25	15	15
Northern Phalarope	12	20	50	55	50	50	40	35	45	40	15	20	50	25	35	30	50	35	40	30	60	35	50	30	50	35	25
Unidentified Small Shorebirds	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	20	-
Unidentified Medium Shorebirds	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Unidentified Large Shorebirds	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	6	-	-	-
Pomarine Jaeger	-	4	-	1	2	-	-	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Parasitic Jaeger	6	15	38	37	40	20	14	16	24	21	10	14	19	10	18	12	20	18	20	10	45	17	30	18	26	28	4
Long-tailed Jaeger	-	3	3	2	4	1	-	1	2	-	2	-	13	1	5	2	4	2	3	-	-	-	-	-	2	2	10
Glaucous Gull	40	140	350	300	210	180	80	80	80	90	25	65	180	40	215	70	265	190	190	120	290	90	155	170	200	170	65
Mew Gull	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Black-legged Kittiwake	20	20	120	160	90	25	10	10	8	-	2	-	2	-	-	-	11	3	-	-	-	1	2	-	-	-	6
Sabine's Gull	4	20	25	23	30	15	16	16	20	20	-	-	16	15	25	15	16	30	16	15	35	26	25	20	30	35	25
Arctic Tern	20	50	20	90	50	30	30	40	40	35	5	10	85	25	90	30	120	55	70	40	115	32	55	65	80	75	35
Aleutian Tern	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Murre sp.	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	50	-	-	-	10	-	-
Tufted Puffin	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Snowy Owl	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Short-eared Owl	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Say's Phoebe	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Horned Lark	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Tree Swallow	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Bank Swallow	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Cliff Swallow	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Common Raven	1	4	3	-	1	1	1	-	1	-	1	-	2	-	3	-	-	-	-	-	-	1	1	-	-	2	-
Wheatear	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Arctic Warbler	-	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Yellow Wagtail	-	-	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Orange-crowned Warbler	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Redpoll sp.	-	-	2	-	-	4	-	1	1	-	-	-	-	-	-	-	-	-	4	-	-	-	-	-	3	1	-
White-winged Crossbill	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Savannah Sparrow	7	10	10	12	10	6	5	-	4	2	4	7	10	3	2	-	8	8	10	-	15	3	15	2	6	6	3
Dark-eyed Junco	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
White-crowned Sparrow	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Lapland Longspur	10	30	55	55	60	30	20	35	35	30	10	20	40	15	30	15	30	30	35	20	55	25	35	25	30	30	15
Snow Bunting	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-

Table 7. Continued

JULY																					AUGUST						
	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	1	2	3	4	5	6	7
Yellow-billed Loon	1	-	-	-	-	1	1	2	3	1	3	2	3	1	2	-	-	2	-	2	-	-	-	-	8	8	-
Arctic Loon	-	10	10	8	9	8	10	7	7	4	4	5	7	4	9	6	10	7	3	6	-	3	5	6	12	18	6
Red-throated Loon	15	40	75	-	60	50	50	100	40	50	25	20	85	55	145	20	-	90	25	50	-	20	130	65	100	85	50
Red-necked Grebe	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Whistling Swan	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Canada Goose	-	-	-	-	-	-	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Black Brant	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Emperor Goose	-	-	-	-	-	-	6	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
White-fronted Goose	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Snow Goose	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Mallard	-	2	-	-	-	-	-	-	-	-	-	-	-	2	-	-	2	-	2	-	-	3	-	-	7	15	-
Pintail	5	14	8	-	14	80	50	20	8	10	2	5	280	35	60	100	15	55	45	80	-	50	70	80	145	150	65
Green-winged Teal	-	3	1	-	-	-	-	-	-	-	-	-	-	-	-	2	4	-	2	-	-	16	25	-	75	60	6
American Wigeon	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Northern Shoveler	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Redhead	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Canvasback	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Greater Scaup	-	1	10	-	-	-	2	14	1	-	1	-	-	3	8	-	1	-	1	6	-	-	4	11	18	20	13
Oldsquaw	10	40	40	-	25	30	30	35	16	12	13	16	45	13	13	40	45	-	20	5	3	13	45	15	55	40	9
Common Eider	270	60	50	-	170	210	260	75	30	25	10	20	90	40	100	150	30	40	35	40	-	25	50	18	60	45	9
King Eider	-	-	1	-	-	1	-	-	-	-	-	-	1	-	-	1	-	-	-	-	-	-	-	-	-	-	-
Spectacled Eider	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
White-winged Scoter	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Surf Scoter	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Black Scoter	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Red-breasted Merganser	-	-	8	-	8	1	1	40	3	-	-	-	1	3	-	-	-	1	-	-	-	-	-	-	-	-	-
Goshawk	-	1	-	-	-	-	-	-	-	-	-	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Marsh Hawk	-	-	2	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Peregrine Falcon	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Willow Ptarmigan	-	1	2	-	6	6	1	1	-	22	7	2	8	1	9	-	-	2	13	10	-	10	2	3	5	13	2
Sandhill Crane	6	16	20	-	30	40	30	20	20	12	5	9	16	14	25	10	9	10	12	20	-	16	25	14	20	30	25
American Golden Plover	-	1	-	-	-	1	-	-	-	-	-	-	-	-	-	2	-	-	-	-	-	-	-	45	17	30	40
Black-bellied Plover	-	-	-	-	2	-	2	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1	2	15
Ruddy Turnstone	1	9	10	-	11	8	14	11	5	4	1	1	9	1	-	2	-	-	-	3	-	3	3	3	11	7	6
Black Turnstone	-	-	-	-	-	-	3	1	-	-	-	-	-	5	4	-	1	-	2	-	-	2	11	-	1	-	3
Common Snipe	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	2	-	-
Whimbrel	1	1	4	-	7	-	-	-	-	-	-	-	2	1	-	2	-	-	-	-	-	-	-	-	2	-	-
Bristle-thighed Curlew	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Red Knot	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	9	-	-	2
Sharp-tailed Sandpiper	-	-	-	-	-	-	-	-	1	-	-	-	3	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Pectoral Sandpiper	-	15	105	-	40	65	30	60	20	20	10	15	30	1	45	50	-	25	15	60	-	20	35	35	80	100	85
Baird's Sandpiper	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	6	-	-	-	-	-	-	-	-	-	-	-
Dunlin	6	25	25	-	50	90	1500	140	85	40	50	40	80	5	30	300	2	5	11	35	-	90	40	80	550	15	115
Semipalmated Sandpiper	2	25	20	-	30	25	25	50	25	15	15	20	50	5	25	30	-	15	7	3	-	-	-	4	10	1	-

Table 7. Continued

JULY																					AUGUST						
	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	1	2	3	4	5	6	7
Western Sandpiper	4	15	11	-	20	25	45	55	20	12	10	8	35	4	25	100	10	30	5	12	-	15	9	20	50	8	25
Sanderling	-	-	-	-	-	-	-	-	-	-	-	-	-	1	-	2	-	-	-	-	-	-	-	-	-	-	-
Long-billed Dowitcher	-	20	8	-	11	12	7	75	8	6	15	2	6	15	5	45	1	5	6	12	-	5	7	6	21	13	8
Bar-tailed Godwit	-	-	-	-	-	-	-	3	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Hudsonian Godwit	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Red Phalarope	1	20	25	-	14	30	12	8	14	6	5	5	8	2	4	8	2	1	1	1	-	-	-	2	3	-	-
Northern Phalarope	12	35	35	-	35	40	150	40	20	12	8	12	30	10	70	100	10	25	12	20	-	25	50	20	55	45	17
Unidentified Small Shorebirds	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Unidentified Medium Shorebirds	-	-	-	-	-	5	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Unidentified Large Shorebirds	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Pomarine Jaeger	-	4	1	-	3	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1	-	-
Parasitic Jaeger	8	22	14	-	20	22	27	21	10	10	8	18	23	12	13	10	2	10	11	12	-	12	20	16	35	35	20
Long-tailed Jaeger	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Glaucous Gull	50	115	65	-	100	120	100	240	90	40	20	25	100	80	190	230	35	120	85	100	-	75	155	140	200	215	160
Mew Gull	-	-	-	-	-	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Black-legged Kittiwake	1	3	3	-	1	1	2	6	-	-	-	-	-	16	11	55	50	8	35	7	-	13	25	2	65	20	7
Sabine's Gull	2	20	30	-	45	30	25	20	40	25	20	20	25	1	8	1	1	20	11	15	-	12	16	3	12	14	3
Arctic Tern	30	35	40	-	85	90	65	260	40	20	20	20	45	40	70	150	70	45	130	50	-	60	90	35	85	110	80
Aleutian Tern	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Murre sp.	-	-	-	-	-	-	-	-	-	100	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Tufted Puffin	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Snowy Owl	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Short-eared Owl	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Say's Phoebe	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1	-	-	-
Horned Lark	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Tree Swallow	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Bank Swallow	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Cliff Swallow	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Common Raven	-	1	-	-	-	-	-	-	1	-	2	1	-	1	-	-	-	-	-	-	-	-	-	-	-	2	-
Wheatear	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Arctic Warbler	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Yellow Wagtail	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1	1	-	-	2	4	14	1	15	1
Orange-crowned Warbler	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Redpoll sp.	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
White-winged Crossbill	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Savannah Sparrow	3	12	9	-	5	6	8	6	6	2	1	1	-	3	-	-	2	-	-	1	-	4	3	6	11	11	-
Dark-eyed Junco	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
White-crowned Sparrow	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Lapland Longspur	8	25	30	-	25	40	40	35	25	12	10	12	25	45	45	30	15	30	13	110	-	45	60	80	110	130	120
Snow Bunting	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-

Table 7. Continued

AUGUST																									SEPTEMBER		
	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	1	2	3
Yellow-billed Loon	1	1	-	1	-	1	-	-	1	-	-	1	-	3	1	1	-	-	1	-	2	-	-	3	-	2	1
Arctic Loon	-	-	5	4	-	5	3	10	10	2	6	6	8	11	13	7	3	3	5	15	7	7	11	-	-	-	9
Red-throated Loon	30	40	45	25	8	20	45	-	40	15	40	25	35	46	40	45	40	12	60	25	60	20	15	20	-	8	15
Red-necked Grebe	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Whistling Swan	-	-	-	-	-	-	-	-	2	-	-	5	-	-	-	-	-	-	-	-	-	2	6	-	-	-	-
Canada Goose	-	-	-	-	-	-	-	-	-	-	-	-	-	20	20	-	-	-	-	-	30	6	50	12	-	-	-
Black Brant	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	18	3	-	16	40	80	-	-	-	45
Emperor Goose	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	7	-	20	40	-	5	45
White-fronted Goose	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Snow Goose	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	18	-	-	-	-	-	-
Mallard	-	-	2	2	-	-	-	-	-	-	2	-	-	5	-	-	-	-	-	-	-	-	-	-	-	-	-
Pintail	30	5	30	16	4	50	50	-	25	20	60	100	40	35	20	30	35	6	20	15	45	20	20	30	-	3	10
Green-winged Teal	10	3	8	8	-	1	-	6	4	2	6	5	4	9	6	2	4	4	5	5	8	-	-	4	-	-	8
American Wigeon	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Northern Shoveler	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Redhead	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Canvasback	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Greater Scaup	13	12	13	13	7	-	-	-	6	6	-	6	-	-	9	-	6	-	6	6	-	-	8	-	-	6	6
Oldsquaw	5	3	3	5	1	4	1	-	-	-	15	-	-	-	-	-	-	-	3	7	8	-	-	2	-	3	3
Common Eider	7	27	-	2	-	4	1	1	1	1	10	1	-	10	-	-	1	-	-	2	-	-	-	-	-	-	-
King Eider	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Spectacled Eider	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
White-winged Scoter	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Surf Scoter	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Black Scoter	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Red-breasted Merganser	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Goshawk	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1	-	-	-	-	-	1	-	2	-	-	1
Marsh Hawk	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1	-	-	-	-	1	1	-	1	-	-	-
Peregrine Falcon	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Willow Ptarmigan	1	-	10	2	-	1	3	8	13	-	4	-	8	20	8	-	10	-	8	-	9	10	6	20	-	-	4
Sandhill Crane	15	2	18	13	6	8	14	6	12	6	25	12	17	25	18	18	13	4	14	13	35	10	10	15	-	10	19
American Golden Plover	20	9	40	25	5	70	75	35	70	20	30	50	30	60	20	30	20	15	25	80	125	60	40	50	-	45	120
Black-bellied Plover	4	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Ruddy Turnstone	3	9	-	-	-	1	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1
Black Turnstone	-	15	-	-	-	-	4	-	-	6	6	-	-	6	-	8	3	-	-	1	-	-	-	-	-	-	-
Common Snipe	-	-	1	-	-	-	-	-	1	1	-	1	1	1	-	1	-	-	1	-	-	-	-	-	-	-	-
Whimbrel	-	-	10	7	-	30	15	17	13	-	35	25	60	20	1	1	9	-	35	3	9	-	2	7	-	-	-
Bristle-thighed Curlew	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Red Knot	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	2	-	-	2	-	-	-	-	-	-	-	-
Sharp-tailed Sandpiper	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1	-	-	-	-	-
Pectoral Sandpiper	50	10	40	35	12	45	50	20	45	10	20	25	30	50	20	40	35	10	20	20	60	30	30	20	-	10	-
Baird's Sandpiper	-	3	-	-	-	-	-	-	-	1	-	4	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Dunlin	55	65	40	30	-	40	30	-	45	10	30	25	25	150	20	6	45	10	15	10	100	10	30	55	-	-	20
Semipalmated Sandpiper	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-

Table 7. Continued

AUGUST																									SEPTEMBER		
	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	1	2	3
Western Sandpiper	1	-	8	6	-	-	-	-	-	-	10	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Sanderling	-	-	1	7	-	-	4	-	3	15	6	5	1	6	1	25	1	-	4	3	15	6	-	1	2	-	2
Long-billed Dowitcher	5	-	12	8	1	6	-	2	20	1	3	2	1	1	1	2	1	-	1	20	35	2	15	25	-	10	25
Bar-tailed Godwit	-	-	-	-	-	1	-	-	-	-	-	-	-	-	-	-	-	3	-	-	-	-	-	2	-	-	-
Hudsonian Godwit	-	2	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Red Phalarope	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1	-	-	-	-	-	-	-	-	-	-	-	-
Northern Phalarope	8	-	2	6	2	1	-	-	2	2	50	5	1	1	-	-	-	-	-	-	2	-	3	2	-	-	2
Unidentified Small Shorebirds	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Unidentified Medium Shorebirds	-	6	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	60	-	-	-	-	-	-	-	-
Unidentified Large Shorebirds	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Pomarine Jaeger	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Parasitic Jaeger	18	13	16	12	6	8	12	7	11	4	18	11	16	20	17	16	15	8	13	13	22	10	10	12	-	4	4
Long-tailed Jaeger	-	-	-	-	-	-	-	-	-	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	10
Glaucous Gull	70	100	70	70	35	30	80	30	90	100	140	80	50	60	90	110	85	25	60	100	115	50	50	40	-	35	80
Mew Gull	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Black-legged Kittiwake	-	10	8	10	-	4	8	-	4	60	110	-	-	15	20	30	-	5	-	-	-	-	-	-	-	-	-
Sabine's Gull	4	3	-	3	-	2	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Arctic Tern	40	90	35	50	10	20	30	4	28	50	50	20	35	30	15	10	8	8	8	5	5	-	15	3	-	-	-
Aleutian Tern	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Murre sp.	-	-	-	-	-	-	3	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Tufted Puffin	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Snowy Owl	-	-	-	-	-	-	-	-	-	-	-	-	1	1	-	-	-	-	-	-	-	-	-	1	-	-	-
Short-eared Owl	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1
Say's Phoebe	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Horned Lark	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Tree Swallow	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Bank Swallow	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Cliff Swallow	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Common Raven	-	-	-	-	-	-	-	-	-	-	-	-	1	2	-	-	3	-	-	1	2	3	1	1	-	2	-
Wheatear	-	-	-	6	3	3	-	1	-	-	-	-	-	-	-	-	2	-	-	-	2	-	-	-	-	-	-
Arctic Warbler	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Yellow Wagtail	-	2	7	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Orange-crowned Warbler	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Redpoll sp.	-	-	-	2	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
White-winged Crossbill	-	-	-	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Savannah Sparrow	3	-	5	3	5	-	2	3	6	2	4	3	1	1	-	-	2	-	3	-	-	-	-	-	-	-	-
Dark-eyed Junco	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
White-crowned Sparrow	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Lapland Longspur	55	90	40	25	15	-	50	60	65	30	30	35	35	45	30	50	60	20	40	25	40	20	15	20	-	-	12
Snow Bunting	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-

Table 7. Continued

SEPTEMBER

	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24
Yellow-billed Loon	1	-	-	2	1	2	6	1	1	1	2	-	1	1	4	3	2	-	-	-	2
Arctic Loon	12	-	-	7	7	10	4	10	6	3	14	-	8	5	10	5	3	2	15	-	4
Red-throated Loon	20	-	-	12	18	35	13	4	-	1	4	-	5	-	2	2	-	-	-	-	-
Red-necked Grebe	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Whistling Swan	6	-	-	-	2	-	-	8	-	-	2	-	6	-	8	-	-	6	11	-	15
Canada Goose	200	-	-	-	31	18	10	9	50	13	35	-	-	-	-	-	-	-	-	-	-
Black Brant	-	-	-	50	-	18	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Emperor Goose	80	-	-	30	65	40	20	40	25	12	55	-	55	5	50	10	4	-	7	-	-
White-fronted Goose	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Snow Goose	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Mallard	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Pintail	10	-	-	2	-	10	20	10	-	-	10	-	10	-	3	1	-	20	10	-	2
Green-winged Teal	4	-	-	2	5	2	5	4	7	-	3	-	2	1	2	6	-	7	-	2	-
American Wigeon	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Northern Shoveler	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Redhead	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Canvasback	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Greater Scaup	12	-	-	6	6	8	8	10	2	-	-	-	-	-	4	-	-	-	-	-	3
Oldsquaw	3	-	-	3	3	7	3	-	-	-	17	-	6	-	6	-	-	7	-	-	7
Common Eider	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1	-	-	-	-	-	1
King Eider	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1	-	-
Spectacled Eider	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
White-winged Scoter	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Surf Scoter	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Black Scoter	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Red-breasted Merganser	-	-	-	30	170	-	14	1	-	-	-	-	-	-	2	2	-	-	18	-	8
Goshawk	3	-	-	2	-	1	1	-	-	1	1	-	-	-	2	-	-	1	-	-	-
Marsh Hawk	-	-	-	-	2	-	-	-	1	2	-	-	-	-	-	-	-	-	-	-	-
Peregrine Falcon	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Willow Ptarmigan	7	-	-	-	-	9	-	-	-	-	12	-	-	-	-	-	-	-	-	1	-
Sandhill Crane	30	-	-	5	15	20	13	30	2	-	14	-	-	-	-	-	-	-	-	-	-
American Golden Plover	70	-	-	1	12	100	25	40	15	5	20	-	4	4	30	10	5	15	-	-	20
Black-bellied Plover	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Ruddy Turnstone	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Black Turnstone	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Common Snipe	-	-	-	-	-	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Whimbrel	-	-	-	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Bristle-thighed Curlew	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Red Knot	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Sharp-tailed Sandpiper	-	-	-	-	-	-	-	-	-	-	1	-	-	-	-	-	-	-	-	-	-
Pectoral Sandpiper	-	-	-	-	-	20	20	2	1	-	-	-	1	-	1	-	-	-	-	-	-
Baird's Sandpiper	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Dunlin	70	-	-	50	20	20	150	50	10	10	55	-	5	30	150	20	20	60	70	20	120
Semipalmated Sandpiper	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-

Table 7. Continued

SEPTEMBER

	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24
Western Sandpiper	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Sanderling	1	-	-	-	-	-	9	4	-	-	-	-	-	-	2	2	2	6	2	2	10
Long-billed Dowitcher	45	-	5	-	2	1	-	30	-	-	20	-	1	-	2	-	-	-	-	-	-
Bar-tailed Godwit	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Hudsonian Godwit	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Red Phalarope	-	-	-	-	-	-	-	-	-	-	-	1	1	-	-	-	-	-	-	-	-
Northern Phalarope	-	-	-	1	-	-	-	-	-	-	-	-	1	-	6	-	-	19	35	-	250
Unidentified Small Shorebirds	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Unidentified Medium Shorebirds	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Unidentified Large Shorebirds	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Pomarine Jaeger	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Parasitic Jaeger	4	-	-	7	4	4	1	1	-	1	1	-	-	-	1	-	-	-	-	-	-
Long-tailed Jaeger	12	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Glaucous Gull	95	-	-	145	200	40	220	65	50	50	30	-	170	20	220	15	16	70	50	50	220
Mew Gull	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Black-legged Kittiwake	-	20	-	5	-	-	20	100	-	250	40	-	-	-	2	-	-	-	-	-	-
Sabine's Gull	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Arctic Tern	16	-	-	-	-	-	2	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Aleutian Tern	-	-	-	-	-	-	8	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Murre sp.	-	-	-	-	-	-	3	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Tufted Puffin	-	-	-	-	-	-	17	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Snowy Owl	-	-	-	-	-	-	-	1	-	-	-	-	-	-	-	1	-	-	-	-	-
Short-eared Owl	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Say's Phoebe	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Horned Lark	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Tree Swallow	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Bank Swallow	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Cliff Swallow	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Common Raven	-	-	-	-	1	1	-	3	-	2	-	-	2	-	-	-	-	-	-	-	-
Wheatear	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Arctic Warbler	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Yellow Wagtail	-	-	-	-	-	-	-	-	-	-	-	-	1	-	-	-	-	-	-	-	-
Orange-crowned Warbler	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Redpoll sp.	-	-	-	-	-	-	-	-	-	-	-	-	15	-	100	-	-	-	-	-	-
White-winged Crossbill	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Savannah Sparrow	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Dark-eyed Junco	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
White-crowned Sparrow	-	-	-	-	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Lapland Longspur	17	-	-	-	10	5	4	6	2	3	5	-	2	-	2	-	-	1	1	-	-
Snow Bunting	-	-	-	-	-	-	-	-	-	-	-	-	-	-	5	-	-	-	6	13	250

Master Permit No. 08459

Banding Schedule
3-860 (Rev. 1973)

Master Permittee West GC Dr

—Banding Locations—

A Cape Espenberg, Alaska
B
C
D
E
F

INCLUSIVE BAND NOS
FROM 880-84004
THROUGH 880-84038
REPORT ONLY CONTIGUOUS BAND NUMBERS

BAND PREFIX 880		COMMON NAME	AOU #	STATUS	AGE-SEX	REGION	LAT-LONG	LOC	DATE MO.—DAY—YR
	01								
	02								
	03								
840	04	Western Sandpiper	247.0	3.01	AHY-U	AK-503	663-1634	A	06-13-77
	05	"	"						06-18-77
	06	Semipalmated Sandpiper	246.0						06-20-77
	07	Western sandpiper	247.0						"
	08	"	"						06-21-77
	09	Semipalmated Sandpiper	246.0						06-22-77
	10	Western Sandpiper	247.0		↓				"
	11	"	"		L-U				06-28-77
	12	Semipalmated Sandpiper	246.0		L-U				06-29-77
	13								
	14	↓	↓		↓				↓
	15	Western Sandpiper	247.0		AHY-U				07-01-77
	16				L-U				07-02-77
	17								
	18								
	19	↓	↓						
	20	Semipalmated Sandpiper	246.0						
	21								
	22	↓	↓						↓
	23	Western Sandpiper	247.0						07-06-77
	24	Semipalmated Sandpiper	246.0						07-07-77
	25								
	26	↓	↓						
	27	Western Sandpiper	247.0						↓
	28								07-11-77
	29								
	30								
	31								↓
	32								07-12-77
	33								
	34								
	35								
	36								
	37								
↓	38	↓	↓	↓	↓	↓	↓	↓	↓
	39								
	40								
	41								
	42								
	43								
	44								
	45								
	46								
	47								
	48								
	49								
	50								

U.S. bandings to: Bird Banding Laboratory, Office of Migratory Bird Management, Laurel, Md. 20811. O.M.B. No. 42-R1435.
Canadian bandings to: Canadian Wildlife Service, Environmental Management Service, Department of the Environment, Ottawa, Ontario, Canada. KIA OH3. Approval expires May 31, 1978.

Master Permit No. 08459

Banding Schedule
3-860 (Rev. 1973)

Master Permittee West GC Dr

INCLUSIVE BAND NOS
FROM 880-84101
THROUGH 880-84200
REPORT ONLY CONTIGUOUS BAND NUMBERS

—Banding Locations—

A Cape Espenberg, Alaska
B
C
D
E
F

BAND PREFIX 880		COMMON NAME	AOU #	STATUS	AGE-SEX	REGION	LAT-LONG	LOC	DATE MO.—DAY—YR
841	01	Northern Phalarope	223.0	3.01	AHY-F	AK-503	663-1634	A	06-06-77
	02	Semipalmated Sandpiper	246.0		AHY-U				06-08-77
	03	Western Sandpiper	247.0						"
	04								"
	05	↓	↓						06-09-77
	06	Semipalmated Sandpiper	246.0						
	07	Western Sandpiper	247.0						
	08	Semipalmated Sandpiper	246.0						↓
	09	Western Sandpiper	247.0						06-10-77
	10	"	"						
	11	Semipalmated Sandpiper	246.0						
	12	Western Sandpiper	247.0						↓
	13								06-11-77
	14								
	15	↓	↓						
	16	Semipalmated Sandpiper	246.0						
	17	"	"						
	18	Western Sandpiper	247.0						↓
	19	"	"						06-12-77
	20	Semipalmated Sandpiper	246.0						"
	21	Western Sandpiper	247.0						06-13-77
	22								"
	23				↓				06-14-77
	24				L-U				06-25-77
	25	↓	↓						"
	26	Semipalmated Sandpiper	246.0						06-26-77
	27								
	28	↓	↓						↓
	29	Western Sandpiper	247.0						06-27-77
	30								
	31								
	32								
	33								
	34								
	35				↓				
	36	↓	↓		AHY-U				
	37	Semipalmated Sandpiper	246.0		L-U				
	38								
	39								
	40								
	41	↓	↓		↓				
	42	Western Sandpiper	247.0		AHY-U				
	43	Semipalmated Sandpiper	246.0		L-U				
	44				"				↓
	45				AHY-U				06-28-77
	46								
	47	↓	↓		↓				
	48	Western Sandpiper	247.0		L-U				
	49								
↓	50	↓	↓	↓	↓	↓	↓	↓	↓

U.S. bandings to: Bird Banding Laboratory, Office of Migratory Bird Management, Laurel, Md. 20811. O.M.B. No. 42-R1435.
Canadian bandings to: Canadian Wildlife Service, Environmental Management Service, Department of the Environment, Ottawa, Ontario, Canada.
KIA 0115. Approval expires May 31, 1978.

ter Permit No. 08459

BAND PREFIX 880		COMMON NAME	AOU #	STATUS	AGE-SEX	REGION	LAT LONG	LOC	DATE MO —DAY—YR.
841	51	Western Sandpiper	247.0	3.01	L-U	AK-503	663-1634	A	06-28-77
	52								
	53								
	54				↓				
	55				AHY-U				
	56				L-U				
	57				AHY-U				
	58				L-U				↓
	59								06-29-77
	60								
	61				↓				
	62				AHY-U				
	63								
	64	↓	↓		↓				
	65	Semipalmated Sandpiper	246.0		L-U				
	66	"	"		"				
	67	Western Sandpiper	247.0		AHY-U				
	68	Semipalmated Sandpiper	246.0						↓
	69	Western Sandpiper	247.0						06-30-77
	70								"
	71								07-01-77
	72	↓	↓		↓				
	73	Semipalmated Sandpiper	246.0		L-U				
	74								
	75	↓	↓						↓
	76	Western Sandpiper	247.0						07-02-77
	77								07-03-77
	78								
	79	↓	↓						
	80	Semipalmated Sandpiper	246.0						
	81								
	82								
	83								
	84	↓	↓						↓
	85	Western Sandpiper	247.0						07-04-77
	86								
	87								
	88	↓	↓						
	89	Semipalmated Sandpiper	246.0						
	90								
	91								↓
	92								07-06-77
	93								"
	94								07-07-77
	95								
	96	↓	↓						
	97	Western Sandpiper	247.0						
	98								
	99								↓
842	00	↓	↓	↓	↓	↓	↓	↓	07-09-77

REMARKS: All birds banded by Douglas Schamel

901-230

GPO [illegible]

Master Permit No. 08459

Banding Schedule
3-660 (Rev. 1973)

Master Permittee West GC Dr

—Banding Locations—

A Cape Espenberg, Alaska

B

C

D

E

F

INCLUSIVE BAND NOS

FROM 880-84201

THROUGH 880-84240

REPORT ONLY CONTIGUOUS BAND NUMBERS

BAND PREFIX 880		COMMON NAME	AOU #	STATUS	AGE-SEX	REGION	LAT-LONG	LOC	DATE MO—DAY—YR.
842	01	Semipalmated Sandpiper	246.0	3.01	AHY-U	AK-503	663-1634	A	06-12-77
	02								"
	03	↓	↓						06-13-77
	04	Western Sandpiper	247.0						06-26-77
	05								06-27-77
	06								06-28-77
	07	↓	↓						
	08	Semipalmated Sandpiper	246.0						
	09	"	"						
	10	Western Sandpiper	247.0						↓
	11	"	"		↓				06-29-77
	12	Semipalmated Sandpiper	246.0		L-U				
	13								↓
	14								06-30-77
	15								
	16								↓
	17								07-02-77
	18								
	19								
	20								↓
	21								07-03-77
	22	↓	↓						07-05-77
	23	Western Sandpiper	247.0						07-10-77
	24								
	25								
	26								
	27								
	28								
	29								
	30	↓	↓	↓	↓	↓	↓	↓	↓
	31	LOST-DSTROYED							
	32	Semipalmated Sandpiper	246.0	3.01	L-U	AK-503	663-1634	A	07-11-77
	33								07-06-77
	34								07-16-77
	35								
	36								
	37								↓
	38								07-17-77
	39	↓	↓						"
↓	40	Western Sandpiper	247.0	↓	↓	↓	↓	↓	07-24-77
	41								
	42								
	43								
	44								
	45								
	46								
	47								
	48								
	49								
	50								

U.S. bandings to: Bird Banding Laboratory, Office of Migratory Bird Management, Laurel, Md. 20811. O.M.B. No. 42-R1435.
Canadian bandings to: Canadian Wildlife Service, Environmental Management Service, Department of the Environment, Ottawa, Ontario, Canada. K1A OH3. Approval expires May 31, 1978.

Master Permit No. 08459

BAND PREFIX 112		COMMON NAME	AOU #	STATUS	AGE-SEX	REGION	LAT-LONG	LOC	DATE MO—DAY—YR.
	51								
	52								
	53								
	54								
	55								
	56								
	57								
	58								
	59								
	60								
	61								
	62								
	63								
	64								
	65								
	66								
	67								
	68								
1395	69	Lapland Longspur	536.0	3.01	AHY-F	AK-503	663-1634	A	06-06-77
	70	"	"		"				"
	71	Northern Phalarope	223.0		AHY-M				07-02-77
	72				"				"
	73				L-U				07-06-77
	74								
	75								
	76								
	77	↓	↓	↓					↓
	78	Lapland Longspur	536.0	3.00					07-07-77
	79								
	80								
	81								↓
	82								07-08-77
	83								07-07-77
	84								07-08-77
	85								
	86								
	87	↓	↓	↓					↓
	88	Northern Phalarope	223.0	3.01					07-09-77
	89								
	90								
	91								↓
	92								07-11-77
	93								
	94								
	95	↓	↓	↓					↓
	96	Savannah Sparrow	542.0	3.00					07-12-77
	97								
	98								
↓	99	↓	↓	↓	↓	↓	↓	↓	↓
	00								

REMARKS All birds banded by Douglas Schamel

901-230

GPO 1973 OF-508-76

Master Permit No. 08459	Banding Schedule 3-860 (Rev. 1973)	Master Permittee West GC Dr

—Banding Locations—

A Cape Espenberg, Alaska D

B E

C F

INCLUSIVE BAND NOS

FROM 77-120301

THROUGH -120329

REPORT ONLY CONTIGUOUS BAND NUMBERS

BAND PREFIX 77		COMMON NAME	AOU #	STATUS	AGE-SEX	REGION	LAT-LONG	LOC	DATE MO — DAY — YR.
1203	01	Red Phalarope	222.0	3.01	L-U	AK-503	663-1634	A	07-04-77
	02								
	03								
	04								
	05				AHY-M				07-05-77
	06	Northern Phalarope	223.0		L-U				
	07								
	08								
	09								
	10								
	11								
	12								
	13								
	14								
	15								
	16								
	17	Red Phalarope	222.0						07-07-77
	18								
	19								
	20								
	21								07-10-77
	22								
	23								
	24								
	25								
	26								
	27								07-21-77
	28	Dunlin	243.0						07-30-77
	29	"	"						07-31-77
	30								
	31								
	32								
	33								
	34								

Master Permit No. 08459	Banding Schedule 3-860 (Rev. 1973)	Master Permittee West GC Dr

—Banding Locations—

A Cape Espenberg, Alaska D

B E

C F

INCLUSIVE BAND NOS

FROM 77-120401

THROUGH -120401

REPORT ONLY CONTIGUOUS BAND NUMBERS

BAND PREFIX 77		COMMON NAME	AOU #	STATUS	AGE-SEX	REGION	LAT-LONG	LOC	DATE MO. — DAY — YR
1204	01	Dunlin	243.0	3.01	L-U	AK-503	663-1634	A	07-19-77
	02								

U.S. bandings to: Bird Banding Laboratory, Office of Migratory Bird Management, Laurel, Md. 20811. O.M.B. No. 42-R1435. **Canadian** bandings to: Canadian Wildlife Service, Environmental Management Service, Department of the Environment, Ottawa, Ontario, Canada. K1A 0H3. Approval expires May 31, 1978.

Master Permit No. 03459

Banding Schedule
3-860 (Rev. 1973)

Master Permittee West GC Dr

—Banding Locations—

A Cape Espenberg, Alaska
D
B
E
C
F

INCLUSIVE BAND NOS
FROM 861-63601
THROUGH 861-63700
REPORT ONLY CONTIGUOUS BAND NUMBERS

BAND PREFIX 861		COMMON NAME	AOU #	STATUS	AGE-SEX	REGION	LAT-LONG	LOC	DATE MO.—DAY—YR
636	01	Red Phalarope	222.0	3.01	AHY-F	AK-503	663-1634	A	06-02-77
	02	Northern Phalarope	223.0		"				"
	03				AHY-M				06-05-77
	04				"				06-06-77
	05				AHY-F				"
	06				AHY-M				06-07-77
	07				AHY-F				
	08				"				
	09				AHY-M				
	10	↓	↓		AHY-F				↓
	11	Red Phalarope	222.0						06-08-77
	12	Northern Phalarope	223.0						
	13	"	"						
	14	Red Phalarope	222.0		↓				↓
	15	Northern Phalarope	223.0		AHY-M				06-09-77
	16				AHY-F				
	17				AHY-M				↓
	18	↓	↓		AHY-F				06-10-77
	19	Red Phalarope	222.0		"				
	20	Northern Phalarope	223.0		AHY-M				↓
	21	"	"		AHY-F				06-11-77
	22	Red Phalarope	222.0		AHY-M				06-12-77
	23								
	24	↓	↓		↓				↓
	25	Dunlin	243.0		AHY-U				06-13-77
	26	Red Phalarope	222.0		AHY-M				06-14-77
	27	Northern Phalarope	223.0						
	28	Red Phalarope	222.0						↓
	29	"	"						06-15-77
	30	Northern Phalarope	223.0		↓				
	31	"	"		AHY-F				
	32	Red Phalarope	222.0		"				
	33	"	"		AHY-M				↓
	34	Dunlin	243.0		AHY-U				06-19-77
	35								"
	36								06-18-77
	37	↓	↓		↓				"
	38	Northern Phalarope	223.0		AHY-M				06-16-77
	39	Dunlin	243.0		AHY-U				
	40	Red Phalarope	222.0		AHY-M				
	41	Dunlin	243.0		AHY-U				↓
	42	Northern Phalarope	223.0		AHY-F				06-17-77
	43	Red Phalarope	222.0		L-U				06-29-77
	44	Dunlin	243.0						07-01-77
	45								
	46								
	47								
	48								
	49								
↓	50	↓	↓	↓	↓	↓	↓	↓	↓

U.S. banders to Bird Banding Laboratory, Office of Migratory Bird Management, Laurel, Md. 20811. O.M.B. No. 42-R1435.
Canadian banders to Canadian Wildlife Service, Environmental Management Service, Department of the Environment, Ottawa, Ontario, Canada. K1A 0H3. Approval expires May 31, 1978.

ıster Permit No. 08459

BAND PREFIX 861		COMMON NAME	AOU #	STATUS	AGE-SEX	REGION	LAT-LONG	LOC	DATE MO—DAY—YR.
636	51	Dunlin	243.0	3.01	L-U	AK-503	663-1634	A	07-01-77
	52				"				07-05-77
	53				AHY-U				06-18-77
	54								06-19-77
	55								
	56	↓	↓		↓				
	57	Northern Phalarope	223.0		AHY-M				↓
	58	"	"						06-20-77
	59	Red Phalarope	222.0						"
	60	Northern Phalarope	223.0						06-21-77
	61	"	"		↓				06-22-77
	62	Dunlin	243.0		AHY-U				06-23-77
	63								06-26-77
	64	↓	↓		↓				06-27-77
	65	Red Phalarope	222.0		AHY-M				
	66	Northern Phalarope	223.0						
	67	"	"	↓	↓	↓	↓	↓	↓
	68		DESTROYED						
	69	Dunlin	243.0	3.01	L-U	AK-503	663-1634	A	06-29-77
	70								
	71								
	72								
	73	↓	↓						
	74	Northern Phalarope	223.0						
	75								
	76								
	77	↓	↓						
	78	Dunlin	243.0						
	79	"	"						↓
	80	Red Phalarope	222.0						06-30-77
	81	Northern Phalarope	223.0		↓				06-29-77
	82				AHY-M				"
	83				L-U				06-30-77
	84								
	85								
	86								
	87								
	88	↓	↓						
	89	Dunlin	243.0						
	90								
	91								
	92	↓	↓						
	93	Red Phalarope	222.0		↓				
	94				AHY-M				↓
	95				L-U				07-01-77
	96								
	97	↓	↓						↓
	98	Northern Phalarope	223.0						07-02-77
	99								
637	00	↓	↓	↓	↓	↓	↓	↓	↓

REMARKS

Master Permit No. 08459	**Banding Schedule** 3-880 (Rev. 1973)	**Master Permittee** West GC Dr	

—Banding Locations—

A Cape Espenberg, Alaska
D
B
E
C
F

INCLUSIVE BAND NOS
FROM 861-63701
THROUGH 861-63768
REPORT ONLY CONTIGUOUS BAND NUMBERS

BAND PREFIX 861	COMMON NAME	AOU #	STATUS	AGE-SEX	REGION	LAT-LONG	LOC	DATE MO--DAY--YR
637 01	Red Phalarope	222.0	3.01	AHY-F	AK-503	663-1634	A	06-07-77
02	Northern Phalarope	223.0		"				"
03	Red Phalarope	222.0		AHY-M				06-09-77
04	Northern Phalarope	223.0		AHY-F				06-10-77
05	" "	"		"				06-10-77
06	Dunlin	243.0		L-U				06-27-77
07								
08								
09	↓	↓						↓
10	Northern Phalarope	223.0		↓				07-02-77
11	Dunlin	243.0		AHY-U				"
12	Red Phalarope	222.0		AHY-M				07-03-77
13	Northern Phalarope	223.0		"				
14	Dunlin	243.0		L-U				
15	"	"						↓
16	Northern Phalarope	223.0						07-04-77
17								
18								
19								
20								
21	↓	↓	↓	↓	↓	↓	↓	↓
22		L O S T						
23	Dunlin	243.0	3.01	L-U	AK-503	663-1634	A	07-05-77
24	"	"						"
25	Northern Phalarope	223.0						07-08-77
26								
27								
28								↓
29								07-10-77
30								"
31								07-14-77
32								
33								
34	↓	↓						↓
35	Red Phalarope	222.0						07-16-77
36	" "	"						"
37	Northern Phalarope	223.0						07-17-77
38								"
39								07-18-77
40								
41								
42								↓
43								07-21-77
44								07-01-77
45								
46								
47				↓				
48				AHY-M				↓
49				L-U				07-03-77
50 ↓	↓	↓		"	↓	↓	↓	"

U.S. bandings to: Bird Banding Laboratory, Office of Migratory Bird Management, Laurel, Md. 20811. O.M.B. No. 42-R1435.
Canadian bandings to: Canadian Wildlife Service, Environmental Management Service, Department of the Environment, Ottawa, Ontario, Canada. K1A OH3. Approval expires May 31, 1978.

..ter Permit No. 08459

BAND PREFIX 861		COMMON NAME	AOU #	STATUS	AGE-SEX	REGION	LAT-LONG	LOC	DATE MO.—DAY—YR
637	51	Red Phalarope	222.0	3.01	L-U	AK-503	663-1634	A	07-08-77
	52								
	53								
	54								07-09-77
	55								"
	56								07-10-77
	57								07-11-77
	58								
	59								
	60								
	61	Northern Phalarope	223.0						07-16-77
	62								"
	63								07-17-77
	64	Red Phalarope	222.0						"
	65	Northern Phalarope	223.0						07-21-77
	66								"
	67								07-26-77
	68	Dunlin	243.0						08-06-77
	69								
	70								
	71								
	72								
	73								
	74								
	75								
	76								
	77								
	78								
	79								
	80								
	81								
	82								
	83								
	84								
	85								
	86								
	87								
	88								
	89								
	90								
	91								
	92								
	93								
	94								
	95								
	96								
	97								
	98								
	99								
	00								

REMARKS All birds banded by Douglas Schamel

901-230

GPO 1973 OF—502-24

aster Permit No. 08459

BAND PREFIX 622		COMMON NAME	AOU #	STATUS	AGE-SEX	REGION	LAT-LONG	LOC	DATE MO —DAY—YR
	51								
	52								
	53								
	54								
	55								
	56								
	57								
	58								
	59								
	60								
	61								
	62								
	63								
	64								
	65								
	66								
	67								
	68								
	69								
	70								
	71								
	72								
	73								
	74								
	75								
	76								
	77								
	78								
	79								
	80								
	81								
	82								
	83								
	84								
	85								
	86								
	87								
	88								
	89								
738	90	Ruddy Turnstone	283.0	3.01	AHY-F	AK-503	663-1634	A	06-15-77
	91	Arctic Tern	71.0	3.00	L-U				07-03-77
	92								"
	93								07-09-77
	94								
	95								
	96								
	97								
	98								07-13-77
	99	Long-billed Dowitch	232.0						07-26-77
739	00	Arctic Tern	71.0						"

REMARKS All birds banded by Douglas Schamel

Master Permit No. 08459

Banding Schedule
3-860 (Rev. 1973)

Master Permittee West GC Dr

—Banding Locations—

A Cape Espenberg, Alaska
B
C
D
E
F

INCLUSIVE BAND NOS
FROM 762-72201
THROUGH 762-72230
REPORT ONLY CONTIGUOUS BAND NUMBERS

BAND PREFIX 762		COMMON NAME	AOU #	STATUS	AGE-SEX	REGION	LAT-LONG	LOC	DATE MO.--DAY--YR
722	01	Arctic Tern	71.0	3.00	L-U	AK-503	663-1634	A	07-07-77
	02								
	03								
	04								↓
	05								07-08-77
	06								
	07								↓
	08								07-09-77
	09								07-10-77
	10								07-11-77
	11								
	12								↓
	13								07-05-77
	14								07-06-77
	15								07-11-77
	16								07-18-77
	17								07-09-77
	18								
	19								
	20								
	21								
	22								
	23								
	24	↓	↓	↓	↓	↓	↓	↓	↓
	25		LOST						
	26	Arctic Tern	71.0	3.00	L-U	AK-503	663-1634	A	07-16-77
	27	Pectoral Sandpiper							07-21-77
	28	"	"						"
	29	Arctic Tern	71.0						07-26-77
↓	30	"	"	↓	↓	↓	↓	↓	08-11-77
	31								
	32								
	33								
	34								
	35								
	36								
	37								
	38								
	39								
	40								
	41								
	42								
	43								
	44								
	45								
	46								
	47								
	48								
	49								
	50								

U.S. bandings to: Bird Banding Laboratory, Office of Migratory Bird Management, Laurel, Md. 20811. O.M.B. No. 42-R1435.
Canadian bandings to: Canadian Wildlife Service, Environmental Management Service, Department of the Environment, Ottawa, Ontario, Canada. K1A 0H3. Approval expires May 31, 1978.

Master Permit No. 08459

Banding Schedule
3-860 (Rev. 1973)

Master Permittee West GC Dr

—Banding Locations—

A Cape Espenberg, Alaska
B
C
D
E
F

INCLUSIVE BAND NOS
FROM 1213-78501
THROUGH -78518
REPORT ONLY CONTIGUOUS BAND NUMBERS

BAND PREFIX 1213		COMMON NAME	AOU #	STATUS	AGE-SEX	REGION	LAT-LONG	LOC	DATE MO—DAY—YR
785	01	Sabine's Gull	62.0	3.00	L-U	AK-503	663-1634	A	06-28-77
↓	02	DESTROYED							
↓	03	DESTROYED							
↓	04	Sabine's Gull	62.0	3.00	L-U	AK-503	663-1634	A	06-30-77
↓	05	↓	↓	↓	↓	↓	↓	↓	
↓	06	↓	↓	↓	↓	↓	↓	↓	07-01-77
↓	07	↓	↓	↓	↓	↓	↓	↓	07-02-77
↓	08	↓	↓	↓	↓	↓	↓	↓	"
↓	09	↓	↓	↓	↓	↓	↓	↓	07-03-77
↓	10	↓	↓	↓	↓	↓	↓	↓	"
↓	11	DESTROYED							
↓	12	Sabine's Gull	62.0	3.00	L-U	AK-503	663-1634	A	07-03-77
↓	13	↓	↓	↓	↓	↓	↓	↓	"
↓	14	↓	↓	↓	↓	↓	↓	↓	07-04-77
↓	15	↓	↓	↓	↓	↓	↓	↓	07-05-77
↓	16	↓	↓	↓	↓	↓	↓	↓	"
↓	17	↓	↓	↓	↓	↓	↓	↓	"
↓	18	↓	↓	↓	↓	↓	↓	↓	07-10-77
	19								
	20								
	21								
	22								
	23								
	24								
	25								
	26								
	27								
	28								
	29								
	30								
	31								
	32								
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	47								
	48								
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U.S. bandings to: Bird Banding Laboratory, Office of Migratory Bird Management, Laurel, Md. 20811. O.M.B. No. 42-R1435.
Canadian bandings to: Canadian Wildlife Service, Environmental Management Service, Department of the Environment, Ottawa, Ontario, Canada. K1A OH3. Approval expires May 31, 1978.

ater Permit No. 08459

BAND PREFIX: 653 ←		COMMON NAME	AOU #	STATUS	AGE-SEX	REGION	LAT-LONG	LOC	DATE MO.—DAY—YR
	51								
	52								
	53								
	54								
	55								
	56								
	57								
	58								
	59								
	60								
	61								
	62								
	63								
	64								
	65								
	66								
	67								
	68								
	69								
	70								
	71								
	72								
	73								
	74								
	75								
	76								
	77								
	78								
	79								
	80								
	81								
	82								
704	83	Parasitic Jaeger	37.0	3.00	L-U	AK-503	663-1634	A	07-05-77
	84								07-08-77
	85	↓	↓	↓	↓	↓	↓	↓	07-02-77
	86	DES	TRO	YED					
	87	Parasitic Jaeger	37.0	3.00	L-U	AK-503	663-1634	A	07-08-77 07-13-77
	88	"	"						
	89	Sabine's Gull	62.0						08-03-77
	90	Parasitic Jaeger	37.0						07-05-77
	91								"
↓	92	↓	↓	↓	↓	↓	↓	↓	07-09-77
	93								
	94								
	95								
	96								
	97								
	98								
	99								
	00								

REMARKS

901-230

GPO 1973 OF-502-24

Master Permit No. 08459

Banding Schedule
3-860 (Rev. 1973)

Master Permittee West CC Dr

—Banding Locations—

A Cape Espenberg, Alaska

B

C

D

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F

INCLUSIVE BAND NOS

FROM 997-15701

THROUGH -15710

REPORT ONLY CONTIGUOUS BAND NUMBERS

BAND PREFIX 997		COMMON NAME	AOU #	STATUS	AGE-SEX	REGION	LAT LONG	LOC	DATE MO—DAY—YR.
157	01	Glaucous Gull	42.0	3.00	L-U	AK-503	663-1634	A	07-20-77
	02								"
	03								07-31-77
	04								07-24-77
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U.S. bandings to: Bird Banding Laboratory, Office of Migratory Bird Management, Laurel, Md. 20811. O.M.B. No. 42-R1435.
Canadian bandings to: Canadian Wildlife Service, Environmental Management Service, Department of the Environment, Ottawa, Ontario, Canada, K1A OH3. Approval expires May 31, 1978.

Master Permit No. 08459

Banding Schedule
3-860 (Rev. 1973)

Master Permittee West GC Dr

INCLUSIVE BAND NOS
FROM 997-15722
THROUGH -15725
REPORT ONLY CONTIGUOUS BAND NUMBERS

—Banding Locations—

A Cape Espenberg, Alaska
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BAND PREFIX 997		COMMON NAME	AOU #	STATUS	AGE-SEX	REGION	LAT-LONG	LOC	DATE MO - DAY - YR
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157	22	Glaucous Gull	42.0	3.00	L-U	AK-503	663-1634	A	07-24-77
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U.S. bandings to: Bird Banding Laboratory, Office of Migratory Bird Management, Laurel, Md. 20811. O.M.B. No. 42-R1455.
Canadian bandings to: Canadian Wildlife Service, Environmental Management Service, Department of the Environment, Ottawa, Ontario, Canada. K1A 0H3. Approval expires May 31, 1978.

Master Permit No. 08459

Banding Schedule
3-860 (Rev. 1973)

Master Permittee West GC Dr

— Banding Locations —

A Cape Espenberg, Alaska
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INCLUSIVE BAND NOS
FROM 997-15734
THROUGH -15742
REPORT ONLY CONTIGUOUS BAND NUMBERS

BAND PREFIX 997	COMMON NAME	AOU #	STATUS	AGE-SEX	REGION	LAT-LONG	LOC	DATE MO — DAY — YR
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157 34	Glaucous Gull	42.0	3.00	L-U	AK-503	663-1634	A	07-30-77
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Master Permit No. 08459

Banding Schedule
3-660 (Rev. 1973)

Master Permittee West CC Dr

—Banding Locations—

A Cape Espenberg, Alaska D

B E

C F

INCLUSIVE BAND NOS
FROM 997-15744
THROUGH -15745
REPORT ONLY CONTIGUOUS BAND NUMBERS

BAND PREFIX 997		COMMON NAME	AOU #	STATUS	AGE-SEX	REGION	LAT-LONG	LOC	DATE MO — DAY — YR
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157	44	Glaucous Gull	42.0	3.00	L-U	AK-503	663-1634	A	07-26-77
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U.S. bandings to: Bird Banding Laboratory, Office of Migratory Bird Management, Laurel, Md. 20811. O.M.B. No. 42-R1435.
Canadian bandings to: Canadian Wildlife Service, Environmental Management Service, Department of the Environment, Ottawa, Ontario, Canada. K1A OH3. Approval expires May 31, 1978.

ater Permit No. 08459

BAND PREFIX		COMMON NAME	AOU #	STATUS	AGE-SEX	REGION	LAT-LONG	LOC	DATE MO.--DAY--YR.
997									
157	51	Glaucous Gull	42.0	3.00	L-U	AK-503	663-1634	A	07-26-77
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157	57	Glaucous Gull	42.0	3.00	L-U	AK-503	663-1634	A	07-26-77
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REMARKS

Master Permit No. 08459

Banding Schedule
3-880 (Rev. 1973)

Master Permittee West GC Dr

—Banding Locations—

A Cape Espenberg, Alaska
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INCLUSIVE BAND NOS
FROM 997-15801
THROUGH -15900
REPORT ONLY CONTIGUOUS BAND NUMBERS

BAND PREFIX		COMMON NAME	AOU #	STATUS	AGE-SEX	REGION	LAT-LONG	LOC	DATE MO—DAY—YR
997									
158	01	Glaucous Gull	42.0	3.00	L-U	AK-503	663-1634	A	07-27-77
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...ter Permit No. 08459

BAND PREFIX 997		COMMON NAME	AOU #	STATUS	AGE-SEX	REGION	LAT-LONG	LOC	DATE MO--DAY--YR.
158	51	Glaucous Gull	42.0	3.00	L-U	AK-503	663-1634	A	07-29-77
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158	95	Glaucous Gull	42.0	3.00	L-U	AK-503	663-1634	A	08-04-77
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	98								08-06-77
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159	00								

REMARKS

901-230

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LITERATURE CITED

Kozlova, E. V 1962. Fauna SSSR. Ptitsy. Tom II. Vyp. 1 chast'3 Rdjankoobraznye. Pododtryad kuliki. (Fauna of the USSR. Birds. Vol. 3 Section 1 Part 3 Charadrifformes. Limicolae). Zoologicheskii Institut Akademii Nauk SSSR.

Soikkeli, M. 1966. On the variation in bill- and wing-length of the Dunlin (*Calidris alpina*) in Europe. Bird Study 13:256-269.

ANNUAL REPORT

NOAA OCSEAP
Contract No. 03-6-022-35208
Research Unit #447

ECOLOGICAL STUDIES IN THE NORTHERN BERING SEA:

STUDIES OF SEABIRDS IN THE BERING STRAIT

PRINCIPAL INVESTIGATOR

William H. Drury
College of the Atlantic
Bar Harbor, Maine 04609

Report prepared by:

John O. Biderman
and
William H. Drury

From notes made in the field by
B. Steele, E. Steele and
A. Watson

March 1978

CONTENTS

LIST OF TABLES

LIST OF FIGURES

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

Objectives: 1) To learn what species of seabirds occur, where and in what numbers in the Bering Strait Region; 2) to locate the feeding areas, breeding areas, gathering areas and other areas of great importance; 3) to learn by trophic and other ecological studies what factors are important for reproductive success and what factors cause stress; 4) to identify those human activities directly and indirectly associated with mineral development which may diminish the seabird populations of the area; 5) to prepare recommendations for stipulations for the guidance of industrial activities in order to prevent or mitigate damage.

Conclusions: 1) In the area between Cape Lisburne and Saint Lawrence Island there are 3,725,000 to 4,000,000 seabirds. 2) Little Diomede Island, the subject of this study, is a major seabird colony and the northern-most nesting colony of Parakeet, Crested and Least Auklets. 3) Drastic population reduction or steady declines are possible results of development. It has been suggested that populations be reduced at experimental colonies in order to establish the rate of recovery. Although the evidence is not clear, there is a suggestion that numbers of murres at Little Diomede Island have decreased since the late 1950s. If real, a decrease is consistent with the decrease of murres observed during the same period at Cape Thompson. Similarly, there is evidence that the numbers of Crested Auklets have decreased, which would be consistent with the reports to that effect by Orville Ahkinga and John Ayapana of Ignalook. 4) It is generally believed that arctic birds are subjected to stress by the extra effort required for breeding. Any further stress introduced by the impacts of development upon their food sources are likely to cause some degree of reproductive failure. It is important, therefore, to record the stresses to which the local populations are exposed and to establish their tolerance to further stress. At Little Diomede, as at other colonies in the northern Bering Sea, absence of adult kittiwakes during the incubation period in July is associated with losses of eggs, a major factor in lowered reproductive success. 5) An important aspect of OCSEAP is defining differences in biological oceanographic structures of the Bering Sea. Differences in the relative proportions of species among the several seabird colonies in the northern Bering Sea, such as an unusually high proportion of kittiwakes, Horned Puffins and Least Auklets at Little Diomede are, presumably, a response to local oceanographic conditions, but those structures are not known. 6) Seabirds have been observed to gather to feed in several rather well-defined areas north of Saint Lawrence Island and in the vicinity of the Bering Strait. These places suggest turbulence and shearing between the ocean currents which become progressively confined as they move northward.

Implications with Respect to OCS Oil and Gas Development:

1) Disturbance by the chronic effects of through traffic, by secondary effects such as helicopter operations and coastal development, by direct damage from oil spills or by indirect effects on the food of the seabirds will affect an area that is comparable to the plains of East Africa among the major natural wonders of the world. The breeding seabirds of this area, numbering in the several millions, are an impressive

presence. The disturbance can take two forms at least:

a. The Bering Strait will almost undoubtedly become a major route for shipping of heavy equipment to the developing oil fields on the North Slope of Alaska.

b. The ocean current systems in the northern Bering Sea virtually guarantee that a major oil spill anywhere in the Norton Basin will find its way to the heart of the feeding and breeding areas.

2) Serious damage to the seabird populations can be expected to release a tide of public indignation which will scarcely be stemmed by cosmetic actions such as attempts to clean up the coastline and to rehabilitate the victims.

3) It behooves planners to institute strict protocols and economic punishments that will make an accident as much of a disaster for the industry that causes it as it would be biologically and politically. Political institutions designed to mitigate the negative effects might include:

a. Conditions for approval of transit of the Strait can be set, such as double shell construction of the vessels to prevent leakage of bilges or damage to inner hulls, similar to the engineering requirements of ships making their way through the ice. Passage through the Strait can be allowed only during the daylight.

b. Technical improvements alone have not prevented spills in the past, because technology works only as well as the will to do a good job. It is reported that 95% of oil spills result from human "error" and that some companies have excellent safety records while others have poor ones. Yet the only measure of qualification for, as an example, oil exploration, is the amount of money offered as the bid at a lease sale. If administrators have the will, they can establish a stepwise system by which companies with a good safety record are favored over those with bad records, and in this way make the probabilities of accident work in favor of quality instead of as measures of inevitability.

II. INTRODUCTION -- THE BERING STRAIT, TRANSPORTATION TO THE NORTH SLOPE, AND IMPLICATIONS.

A. General Nature and Scope of the Research.

The work at Little Diomede Island in 1977 is part of a larger study of seabird biology in the Bering Strait. Studies made in Cape Lisburne and Cape Thompson by Schwartz (1967) and by Roseneau & Springer (NOAA 1978) belong within this area in its broad context as well as studies made at Saint Lawrence Island by Bédard (1969), Sealy (1973), Searing (1978), Johnson (1972), Friedmann (1932), and Fay & Cade (1959). Our own studies at Sledge Island and at the cliffs at Bluff in 1975-1977 contribute to defining one of the edges of the area.

This report is written largely from bi-monthly summaries prepared in the field by the members of our field party, who were Benjamin B. Steele (26 June-12 August), Alan Watson (19 May-4 August), and Edward T. Steele (19 May-12 August).

The Bering Strait will become a major avenue of transportation of heavy equipment to the western Arctic as the oil fields of northwestern Canada and the North Slope of Alaska are developed. Furthermore, because ice conditions periodically prevent the passage of ships past Point Barrow, staging areas for ships waiting to move northward will be needed in places such as the roadsteads at Nome and Port Clarence.

A relatively dense Eskimo population and concentrations of marine mammals and birds in this area are associated with a funnel-like topography in the Chirikov Basin. Although ice movements in the late winter are predominantly southward, during summer northward-flowing ocean currents are progressively confined as they move through the

Chirikov Basin and Bering Strait, then are released. The surveys reported in this Research Unit were planned to locate the areas critical to wildlife, to assess their vulnerability, and to consider how to prevent or mitigate damage.

The Bering Strait area should be considered both as an area which may become subject to heavy industrial development and as an area which is an ecological unit defined by ocean current, marine productivity, wildlife and the traditional economy of the natives.

Potential development and sea traffic. Heavy through traffic of ships related to North Slope development will presumably enter the area along lanes running east of Saint Lawrence Island. The traffic will pass through the Chirikov Basin and numbers of vessels will have to stop many weeks in Nome or Port Clarence; traffic that has passed through the Bering Strait may have to wait further in Kotzubue Sound as vessels did during the summer of 1975.

Local gas and oil development is predicted to be relatively light according to present estimates. Perhaps only gas wells will be involved. One can predict that extensive secondary development will occur in shore facilities for staging and transshipping in western Seward Peninsula.

Environmental Considerations. The Eskimos of the area perhaps set the scene by their unusually highly developed culture dependent primarily on sea mammals and seabirds. Native settlements in this area consisted of relatively large (100-250 people) settlements and many small mobile groups of single or several families. The large permanent settlements depended on hunting large marine mammals especially on moving sea ice.

Whaling was important at western Saint Lawrence Island and at Point Hope but according to Ray (1976) whaling was relatively unimportant in the settlements within the more narrow sense of the Bering Strait (that is, King Island, the Diomede Islands, and Wales). The people of King Island reportedly left the island in the summer, dispersing to use resources on the western coast of Seward Peninsula; but the other settlements were reportedly permanent.

Our observations of the distribution of wildlife suggest, as is only common sense, that natives gathered near dependable sources of game, and hence that critical sites for wildlife are the same as traditional native settlements. However, major feeding grounds of marine mammals and birds are not necessarily close to the nesting grounds of seabirds. We can draw some straightforward conclusions from the traditional distribution of native settlements, yet there are major features of the distribution of wildlife resources which still need to be clarified, especially those which were beyond the access of hunters before the arrival of modern transportation.

Whaling was pursued by the Eskimos at both limits of this area at Saint Lawrence Island in the south and Point Hope in the north. However, the language groups of the two are different. The people of Point Hope, Kotzebue Sound, the Diomede Islands, Wales, King Island and the west coast of Seward Peninsula as far southeast as Cape Nome speak Inupiat, the language of the Eskimo of the arctic coast of North America. The people of Saint Lawrence Island speak a Siberian form of Yupik.

It seems probable that this separation depends on relatively recent tribal movements, for despite this difference in language, there is an evident similarity in cultures and the food basis of the cultures.

The region of the Saint Lawrence Island waters, Chirikov Basin, Bering Strait and southern Chukchi Sea is unified by being the site of spring gatherings of tens of thousands of Walrus and summer gatherings of Gray and Finback Whales. Bearded, Ringed and Spotted Seals are numerous on the winter ice and formed the staples of the diet of the Bering Strait Eskimos. These concentrations of marine mammals reportedly extend into the southern Chukchi Sea. The Strait appears to form, on average, the southern limit of winter distribution of Polar Bears.

Another conspicuous wildlife element in the area is the several millions of seabirds. Murres, kittiwakes and puffins otherwise widely distributed in all northern seas have their northern breeding limit at Cape Lisburne. Black Guillemots, an eastern arctic species (Schwartz 1966) and sporadically south to Saint Lawrence Island (Bédard 1966), extends south to Cape Thompson thus overlapping the northern range of the Pigeon Guillemot, a closely related member of the Pacific fauna. The Diomede Islands, King Island and Saint Lawrence Island form the most northern cluster of nesting sites of millions of Least, Crested and Parakeet Auklets. These seabirds are endemic to the region of the western Gulf of Alaska, the Bering Sea and Sea of Okhotsk.

We presume that there are ecological reasons for the marked differences in the seabirds between Norton Sound and the rest of the area. 1) The three species of auklets are present in large numbers in the Bering Strait region; however, there are no breeding colonies containing auklets in the Norton Sound area, i.e., at Sledge Island or at Bluff. 2) Presumably for ecological and habitat reasons, the proportion of kittiwakes to murres and the proportion between Common Murres and Thick-billed Murres also varies widely among the colonies over the larger Bering Strait region. For example, there are about 80,000 murres at Little Diomede, King Island, and at Bluff. However, there are about 35,000 kittiwakes at Little Diomede but only 3500-4000 at King Island and Bluff. The murres at King and Little Diomede Islands are half Common Murres and half Thick-billed, but at Bluff the population is 99% Common.

The larger marine vertebrates that provided food for natives of the Bering Strait are dependent upon the same food base. Although scattered measurements of primary productivity have been made and some samples of benthic animals reported (Alton, in Hood & Kelley 1973), little is known of the important fish or invertebrate species used as food by seabirds. It is not yet clear what is the distribution of productivity and feeding areas for the region. These feeding centers are presumably indispensible parts of the habitat of the larger vertebrates and until they are mapped we do not know the location or extent of critical parts of the system.

The currents and water masses which pass northward through the Strait have been described in general terms (Hughes et. al., in Hood & Kelley (1973) and Aagard (1975)). Evidently water enters the Chirikov Basin both from the Gulf of Anadyr and from the coastal waters dominated by the Yukon and Kuskokwim Rivers. These masses shear against each other and become progressively confined as they approach the funnel-like structure of the Bering Strait. Much of the water passes through the relatively deep channel between Cape Prince of Wales and Little Diomede Island yet the effects of mixing on primary productivity are also evident west of Big Diomede where very high levels of primary productivity have been reported (Hood & Kelley 1973).

One important implication of the northward movement of water during the ice-free seasons is that virtually any pollution which gets into the waters of the northern Bering Sea (except for the eastern end of Norton Sound) will be carried through the Bering Strait and into the southern Chukchi Sea-Kotzebue Sound. Moreover, "lenses" (a discrete volume) of Bering Sea water move past Cape Lisburne and Point Barrow into the southern Beaufort Sea.

B. Specific Objectives of This Research Unit.

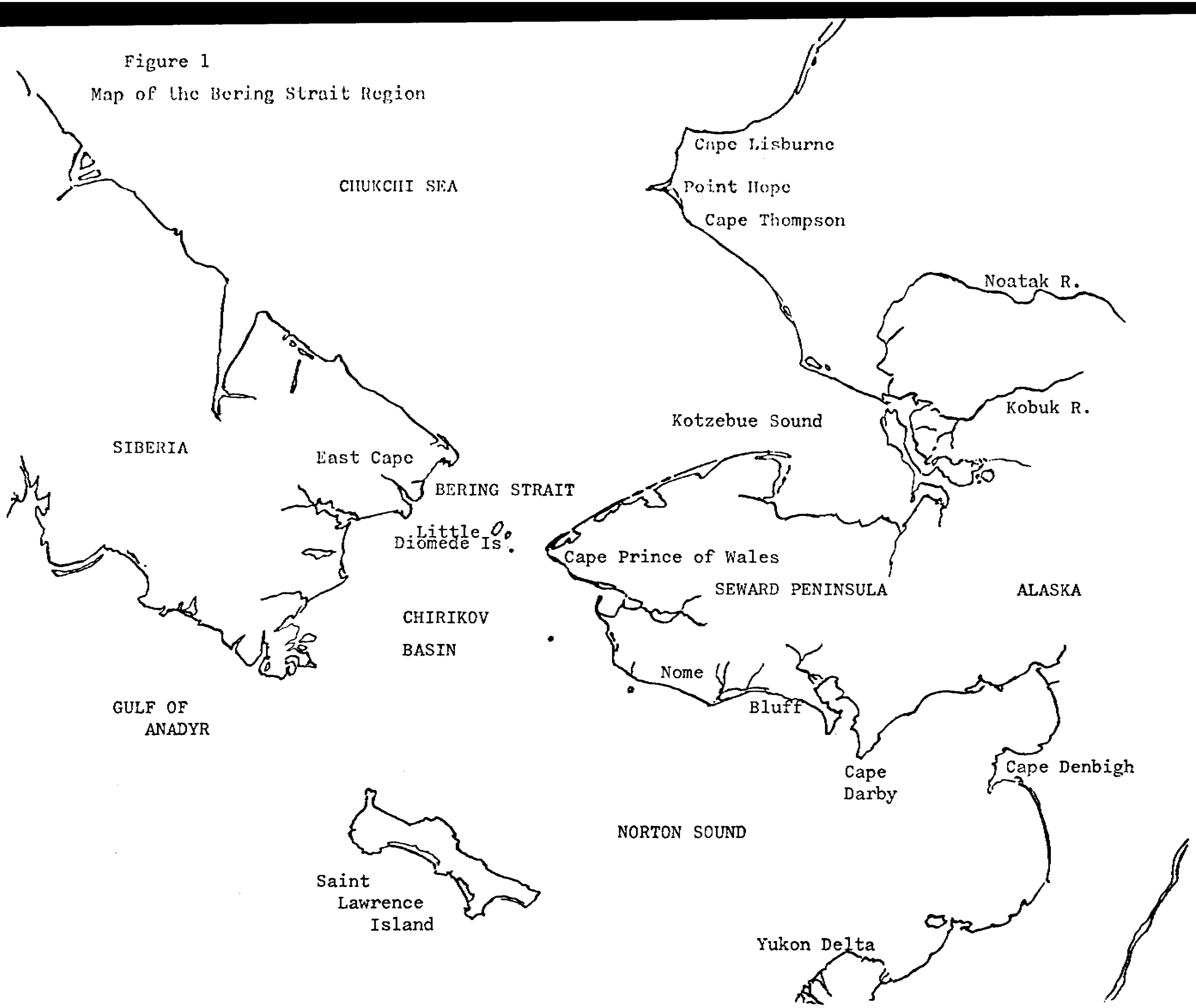
1) To learn what species of seabirds occur where and in what numbers in the Bering Strait region; 2) to locate their feeding and gathering areas and to identify other areas of great importance; 3) to learn by trophic and other ecological studies what factors are important for reproductive success and what factors cause stress on seabirds; 4) to identify those activities associated with mineral development which may diminish the seabird populations of this area; 5) to recommend stipulations to mitigate the negative effects and to maximize the positive effects of industrial development.

III. CURRENT STATE OF KNOWLEDGE.

This section was considered in detail in the report for the 1976 field season.

Figure 1

Map of the Bering Strait Region



IV. STUDY AREA -- LITTLE DIOMEDE ISLAND.

Little Diomede Island lies within the narrowest part of the Bering Strait (Figure 1). It is at 65°45'N lat., 169°W long., 20 nautical miles (37 km) west-northwest of Cape Prince of Wales, two nautical miles (3.7 km) east of Big Diomede and 23 nautical miles (45.6 km) southeast of Cape Dezhneva, Siberia.

The island (Figure 2) is characterized by steep sides, a flat top about 400 m above sea level, and a large drainage basin (area approximately 65,500 m^2) on the east side ("East Valley"). The Eskimo village of Ignalook is at the base of a boulder fan on the northwest corner. A shallow bar extends toward Big Diomede from the town and the Eskimos say this goes most of the way to Big Diomede. The north-flowing current passing over this bar results in a rip or turbulence visible in almost any weather. It is a popular feeding area for kittiwakes.

The sides of the island slope at 35°-40°(Figure 2). They consist of a mixture of 1) rock faces, 2) vegetated slopes, and 3) talus of boulders. The major areas of talus are on the west side, 1000 m to the north and south of the village, and in the East Valley. The lower 30-50 m of the sides consist of nearly vertical wave-cut cliffs. These lower cliffs are nearly continuous around the island except for many small gullies and the areas near Ignalook and the mouth of East Valley where the talus reaches the shore. The bedrock outcrops on the east side are more friable than the massive face on Fairway Rock or the great slabs and arêtes on King Island. On the north end of the island some of the vegetated slopes have poor drainage and are too wet for Parakeet Auklets to nest. Near the southeastern corner there are large areas of bare soil. Otherwise the vegetated slopes are uniform.

The flat top of the island consists mainly of mat plants on large boulders. In general, the soil is too wet for burrow-nesting birds. Murres and kittiwakes nest mainly on the lower rock faces. Auklets nest under the boulders in the talus and puffins nest on the lower cliffs and higher bedrock outcrops.

Banks of unstable snow made travel on the island dangerous in May and the first half of June, but shore-fast ice provided a useful avenue of travel until the sea ice broke up at the end of June, by which time snow had disappeared from all but the deep shaded gullies. Traces of old trails were found on all parts of the island. A trail north from the town is still used and provided access to the cliffs where murres and kittiwakes nest.

Big Diomede (Siberia) appears to be generally similar to Little Diomede although much bigger, 8.5 km from north to south. Clouds of auklets can be seen over the island but Albert Ayahuk of Ignalook reported that there are many fewer Crested Auklets than on Little Diomede. The east side of the island (the only shoreline visible) is generally very steep and appears to have densities of nesting murres and kittiwakes similar to those on Little Diomede. A talus slope extends down to the water in the middle of Big Diomede's east shore. The Eskimos said that the slopes are gentle from the top to the north and northwest.

Fairway Rock is a truncated cone 534 ft (165 m) high, 8 nautical miles (15 km) southeast of Little Diomede. The top is an outcrop of massive bedrock, apparently granite. The middle slopes are thickly covered with grassy turf and the lower slopes jumbles of boulders and rock faces.

Break-up and Movement of Sea Ice.

On our arrival on 19 May the sea ice was continuous around both Diomedes and extended unbroken to the north. There was a strip of open water extending for many miles to the south, which the Eskimos told us was a product of the prevailing northerly wind. On 20 May a southerly wind closed this lead for as far as we could see. Several small leads opened off the "North Point" on 23 May, and on 26 May ice on the north side of these leads began to move north. The leads continued to widen, and much open water was present to the north and west of the Diomedes on 10 June. On 11 June there were still aprons of shore-fast ice surrounding and connecting the islands. We were able to make our last walk around the island on the shore-fast ice on 15 June, after which the ice became unsafe. On that date a lead formed between the two islands. On 17 June the pack ice on the north side of the strait between the islands broke off and moved north, and the southern pack broke and drifted north on 19 June. Bits of ice still clung to the shore of Little Diomede by this time, and either melted away or broke off in chunks.

Currents.

During the summer, northward-flowing ocean currents are confined as they pass through the Chirikov Basin and Bering Strait.

During the 1977 season there was a consistent northward flow of several knots on both sides of the island. Back eddies sometimes occurred in-shore on the slightly indented eastern shore of Little Diomede. The Eskimos say that the northward set reaches 3 knots (6 km per hour) in the main current between the island and Wales.

Figure 2

LITTLE DIOMEDE ISLAND
showing landmarks

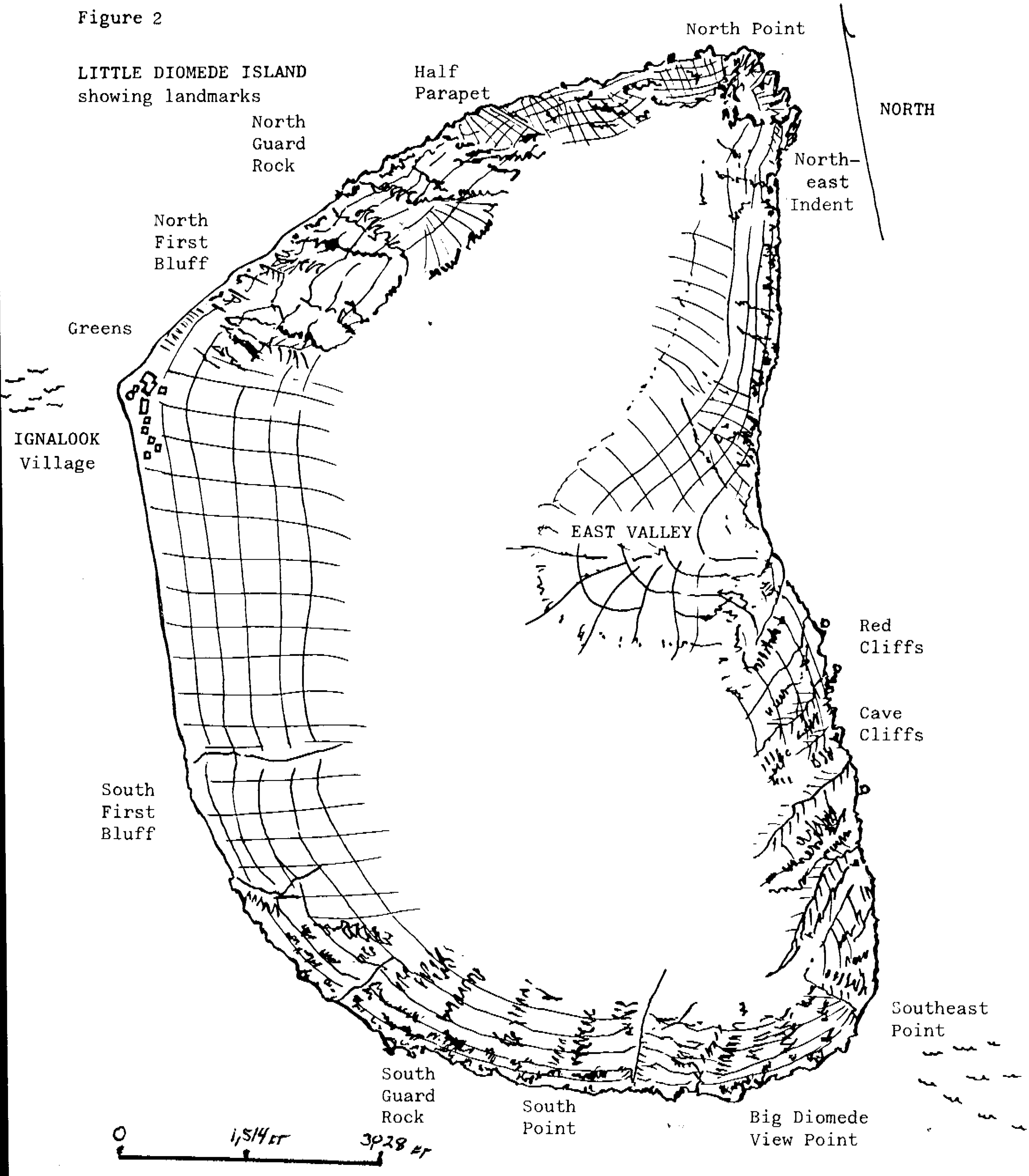
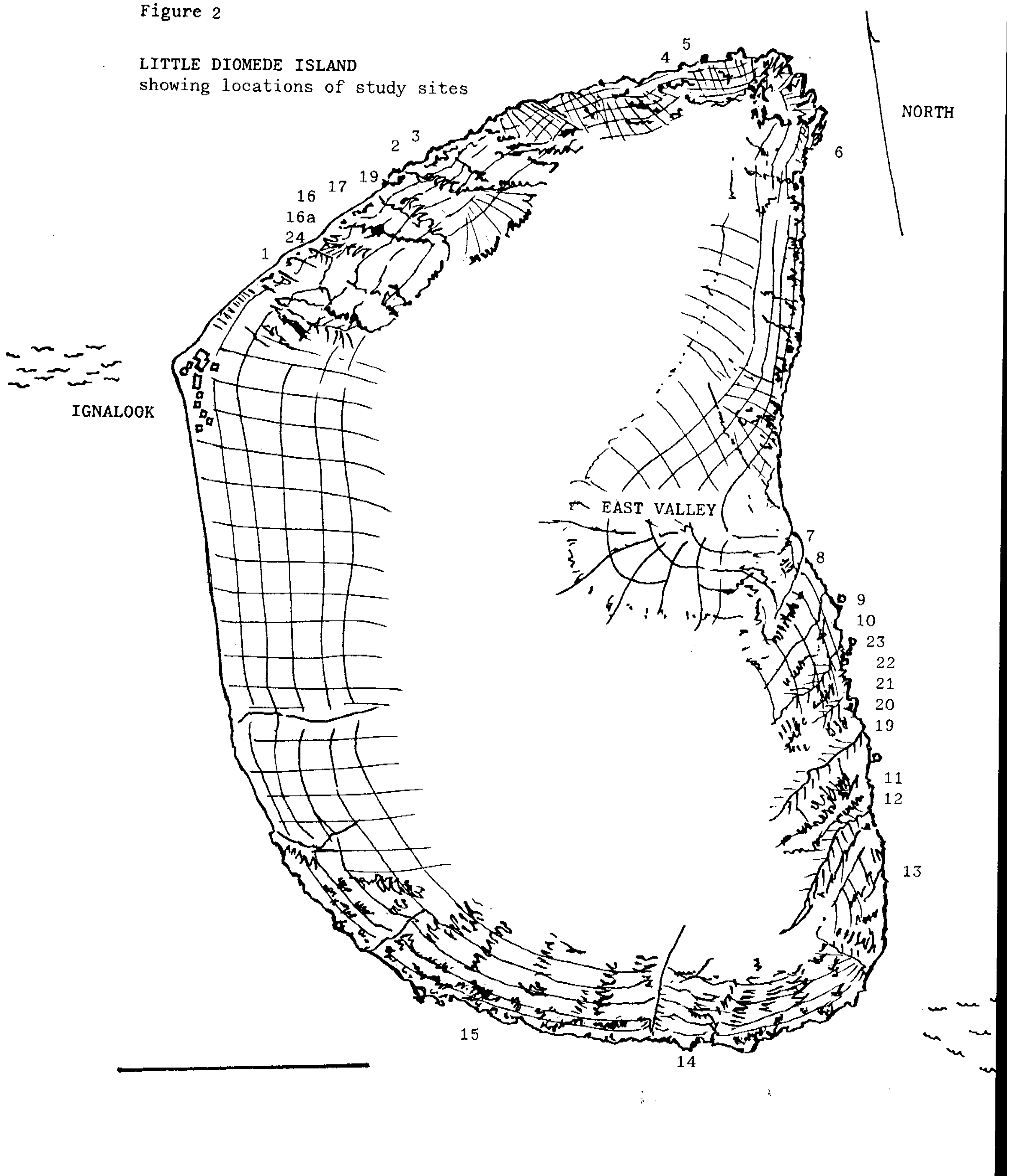


Figure 2

LITTLE DIOMEDE ISLAND
showing locations of study sites



These currents and the associated turbulence are presumably responsible in part for the very high productivity of the waters and hence rafts of feeding seabirds are to be seen on the water for tens of kilometers in all directions from Little Diomede.

V. SOURCES, METHODS AND RATIONALE OF DATA COLLECTION.

Mapping the Island and Estimating Areas of Habitats.

We made a rough working map of the perimeter of Little Diomede by taking compass bearings and pacing distances along the shore-fast ice around the base of the island. In preparing this map we located and named prominent features on the island for points of reference and measured the distances between them. We have prepared a map from a BLM aerial photograph and marked on it those landmarks (Figure 2).

Because it is impossible to make direct counts of birds nesting underground in the grass or talus slopes, we sampled the number of birds per unit area of a habitat type and multiplied that figure by an estimate of the amount of each habitat type available. We defined three major habitats: green slopes, cliffs, and talus. To arrive at an estimate for the areas of habitat, we did the following:

1) We calculated the area of slope around the sides of the island. We estimated the slope of the side to average 37° except on the talus slope above the village, where it was nearer 30°, and the height of the island to be roughly 400 m between North Point and South Guard Rock and 330 m on the east side. We then calculated the distance from the bottom to the top of the slope by trigonometry and multiplied that figure by the length of each of the sections as paced between landmarks

Table 1. Area of slopes and percent habitat type.

				Habitat Type (% of total area)			
Section of Cliff	Base Length (m.)	Slope Length (m)	Total Area (m^2)*	Area Talus	Area Grass	Area Rock	Area Other +
Town to 60% of distance to 1st Bluff	585	732	428,000	77	23	0	0
To 1st Bluff	390	610	238,000	55	38	7	0
To S. Guard Rock	975	610	595,000	25	42	33	0
To South Point	562	610	343,000	20	37	43	0
To Big Diomede View Point	637	610	389,000	17	37	46	0
To SE Point	487	610	149,000	17	37	46	0
To SE Corner	262	610	80,000	10	43	40	7
To Cave Cliff Corner	600	500	300,000	23	40	37	0
To Red Cliff Rock	487	500	244,000	33	33	33	0
To East Valley	637	500	239,000	25	58	17	0
To NE Indentation	1012	500	426,000	28	62	10	0
To North Point	637	500	239,000	10	28	37	25
To Half Parapet	750	610	378,000	3	10	47	40
To N. Guard Rock	600	610	366,000	7	60	17	16
To 1st Bluff North	525	610	320,000	15	50	23	12
To Greens	675	610	412,000	23	64	13	0
To Town	375	732	275,000	47	40	13	0
East Gully			65,500	50	50	0	0
Total			5,486,500	26.8	41.8	25.6	5.7

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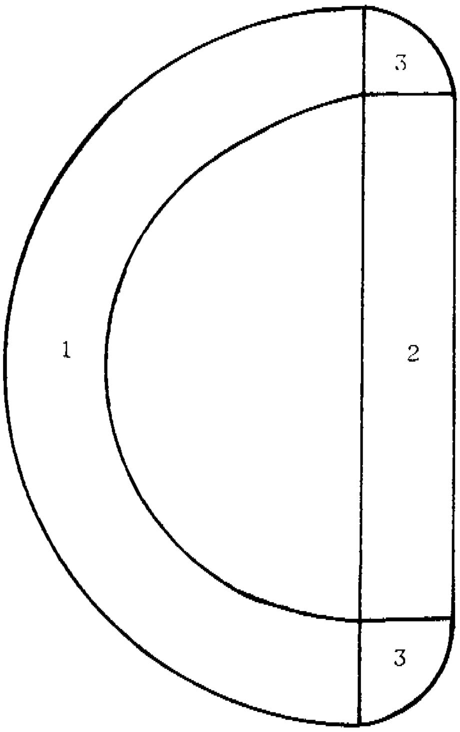
* Calculated using figures for height and degree of slope as mentioned in text, p. .

\+ Gravel and wet grass sections.

Figure 2A. Schematic diagram of Little Diomede used in alternative estimate of the area of the slope. (see text)



at the bottom of the slope. The area above each paced section was assumed to be rectangular, except for two areas more clearly trapezoidal and two triangular, which were calculated as such.

2) We estimated the percentage of each habitat type in each defined part. On 15 July we circled the island in a boat and each of three observers estimated for each section the percentage of the three major habitat types. The percentages varied generally by no more than 10 points, and frequently by as few as five.

3) We took the average of the three estimates in step (2) and multiplied it by the area in step (1). By adding up the areas so derived for each section, we arrived at a total figure for the area of each type of habitat. These results are presented in Table 1.

As an alternative method of calculating the area of the slope around the island (see (1) above) we schematized the island to appear in plane-view as in Figure 2A, tapering as a cone to an abbreviated flat top. Thus the sides of the island would be composed of: (1) a section of a cone representing the curved west side (half a large cone with base at sea level, minus half a cone with base at the top); (2) a plane on the straight east side; plus (3) two "quarter-cones" at the NE and SE corners. By estimating the height of the island as 350 m on the west and 320 m on the east, the slope as 37^{o}, and the diameter as 3600 m, we calculated the area of the slope on the perimeter of the island as about 3.4×10^{6} m^{2}, in contrast to the estimate of 5.5×10^{6} m^{2} from the method above. The difference probably lies in that this latter method makes more emphasis of the tapering quality to the sides of the island, whereas the former method assumed sections of the slope to be rectangular planes.

We have used the first, more detailed, method of calculation in making our estimates of auklet populations. Our method is only as accurate as our estimate of the consistency, suitability and amount of habitat. The data are useful for future comparisons in two ways: a) if revised calculations are made of the habitat, our figures for average bird density can be applied to them; and b) future counts of bird density can be applied to our habitat estimates. We believe the estimates are within a tolerable range of accuracy because the members of our field party were very familiar with all parts of the island.

Censuses of total populations.

Auklets. An estimate of the auklet population was obtained by sampling their density on plots of talus and multiplying by the total calculated amount of habitat. Between 16 and 24 June we made counts of Least and Crested Auklets on 20 paced sections of talus slope. Since auklets are very active, and often fly around and move in and out from under rocks, we counted the same patch repeatedly between 19:00 and 22:00, when the greatest number of auklets were present. We tried at the same time to include birds that had gone under boulders and remained there. The highest number of auklets per m^2 was used in the extrapolation.

On 10, 14, and 20 July we walked 30m-wide transects that ran up the grassy slopes to the top of the island and counted Parakeet Auklets. The transects were chosen to represent all sides of the island. Areas of talus within the grass-slope transect were subtracted. We assumed that Parakeet Auklets perched on rocks were nesting on the grassy slope. These densities multiplied by the total area of grassy slope area yield a population estimate for Parakeet Auklets and an additional number of

Least and Crested Auklets that was added to the estimate of birds on talus.

Cliff-nesting species were censused from a boat on 21 June (murres only), 15 July and 5 August. Murres and kittiwakes were counted by tens, Pelagic Cormorants, Glaucous Gulls and Pigeon Guillemots individually, and Horned and Tufted Puffins on the lower cliffs individually. Since murres and kittiwakes generally nest no more than 70 m above the water, they are visible and readily counted. Thus these numbers are directly comparable to those we have obtained by the same technique at other colonies. Horned Puffins, however, and a very few Tufteds, nest in cracks in rock outcrops all the way to the top of the slope. In order to estimate the numbers of puffins nesting on high rock faces, we made sample counts of puffins on 42 such faces, estimated the area of the face, and determined the number of birds per m^2. This figure was then multiplied by the area of rock outcrop estimated for the whole island.

On 22, 23, 31 July and 2 August we counted Thick-billed and Common Murres on 120 different areas of cliff to determine what percentage of the total population each species composed. This ratio was applied to the total census figure. The areas counted were selected to include all exposures, rock types and elevations. The number of birds counted was 30 % of the entire population, so error should be small. These counts were made at a time when birds closely tied to breeding efforts on the cliff should all be present and should be representative of the ratio of breeding birds of each species.

Fairway Rock. We visited Fairway Rock by boat on 25 June. We at first landed on the rock and climbed it to count birds on the water, then circled the rock three times in our boat, counting all species.

Breeding Phenology, Seasonal and Daily Activity Patterns, Reproductive Success.

Events over the course of the season were monitored in the following ways:

-- Between 20 May and 15 June, 25 circumnavigations of the island on the shore-fast ice were made. We established 15 count areas in sections of the cliff faces where we made day-to-day counts of murres and kittiwakes.

-- Study sites visible from the tops of the cliffs were set up after travel by foot on the island had become safe and practical. Five sites were established on the west side of the island north of the village on 19 June (16, 16B, 17, 18, 24) and were visited 20 times until 11 August, approximately every other day; six were established on the west side on 20 June (19, 19B - 23) and were visited six more times.

At these sites we followed procedures similar to those used at Bluff, described in detail in the annual report for Research Unit #237 in 1976. We made counts of adult murres, kittiwakes and puffins in defined areas; drew sketch maps on which were located individual kittiwake nests that were monitored for nest-building activity, eggs and chicks; and located murre ledges on which we could count birds in an incubating posture, and locate individuals with eggs. In addition, we irregularly monitored several nests of Pelagic Cormorants, Glaucous Gulls, and Ravens.

-- To determine the daily activity pattern of murres and kittiwakes, we made hourly counts at a study site over 26-hour periods on 1-2 July and 14-15 July. To determine the daily schedule of auklets, we made hourly counts in three defined areas of talus slope above the village for 24 hours on 5-6, 7-8, and 16-17 July.

Other Resident and Non-resident Species.

Throughout our stay on Little Diomede, we kept miscellaneous notes on the resident non-seabird species, especially predators (Snowy Owl, Raven), as well as on transients.

Distribution of Birds at Sea.

Methods. We used a Cessna Skymaster for our overwater transects during 1977, except for one flight in a DeHaviland Islander in middle May. Our protocol was to fly at 120 feet altitude and at 120 knots. In practice neither of these was precisely maintained. We had a different pilot for each of our sets of flights, and until he learned of the importance of maintaining the same altitude, each was subject to lapses of attention. Also our speed over the water changed because wind directions and speed change significantly during the course of a transect. In practice our altitude varied between 90 feet and 130 feet, 80% of the time between 100 and 120 feet. Our speed over the water varied as much as 40 knots, but to avoid the effects of this we divided each segment of our transects by a sliding scale adjusted to the known positions at the start and finish of each line run.

In practice it is unrealistic to claim any greater precision, so we must adjust our expectations of the results. The differences between the numbers of birds seen in Norton Sound and those seen south of King Island are obvious. We have chosen increments of 5-15 birds per km^2; 25-50 birds per km^2; and 100 birds per km^2, for purposes of comparison.

During most of our flights in 1977 we used four observers. We soon learned that in order to calibrate among observers, the most important step is to ensure that times are uniformly recorded. We used a standard kitchen timer that rings a bell at the end of a given length of time. This time varies over almost a minute in practice, but at least everyone's segments are the same. We have compared the records of the observers on the same side of the airplane and find that there is good agreement. Occasionally the two observers' records are completely contradictory, but the reasons are usually easily found. Identification of the species of auklets varies enough that we believe it is best to lump all species of auklets together. On certain segments we were able to separate Least Auklets from the others, but changes in altitude have an unexpectedly large effect. We believe that our separation of auklets from murres is reliable. In a small percentage of cases we can see that some murres are black and others are coffee-brown, but we cannot separate Thick-billed from Common Murres consistently. The chief reasons for differences between observers, one forward and one aft, are 1) the forward observer has a larger field of view, being able to look forward as well as down, and 2) each observer occasionally misses a flock that the other notices. It is not possible to establish whether the differences between observers in such a case is greater than would be the differences between repeated samples taken by the same observer.

We can also compare the differences in the records of observers on opposite sides of the plane, and find that in general these numbers are also similar. They give the same indications of changes in major concentrations. Occasionally the observer on one side will see several flocks not seen on the other, which suggests that some feeding aggregations are very local. When there are major differences they reflect the effects of glare on the water and the state of the sea. We believe that it is valuable to have an observer on each side, but that it is not that much more helpful to have two observers on each side.

We believe it is necessary to make generous use of common sense in using data gathered and to draw only general conclusions, not only because of unevenness of the data but also because of irregularities in the distributions of the birds at sea.

We need next to sample the times spent on the surface and compare these with times spent under water for the several species. We believe that these differences may matter in air censuses, while surface travel is so slow that these differences do not matter.

VI. RESULTS AND SPECIES DISCUSSIONS.

CENSUSES

1. Little Diomede

Data for our censuses of cliff-nesting species are shown for each species by section of the island and are totaled in Table 2. Since the number of birds counted is affected by the time of day, we have shown in Table 2 the extrapolated numbers that may have been on the cliff, based on the data on daily attendance patterns of murres and kittiwakes obtained in the previous day's 24-hour count.

The extrapolated total for puffins on rock outcrops and the total for the entire population are shown in Table 3. The results of our sample counts for the percent composition of the murre population is summarized by area of the island in Table 4.

The average densities of each species of auklet and the extrapolated figures for their total population are shown in Table 5.

Table 2. Census figures from 15 July island count.

Area	Murres	Kittiwakes	Horned Puffins	Tufted Puffins	Pelagic Cormorants	Glaucous Gulls	Pigeon Guillemot
Village to South Guard Rock	1745	1310	1142	47	3	7	14
South Guard Rock to Big Diomede View Pt.	2925	3030	1031	92	7	6	19
Big Diomede View Pt. to Southeast Point	2800	1350	520	55	0	4	3
Southeast Point to Cave Cliff Corner	6075	1230	1100	91	26	14	30
Cave Cliff Corner to Red Cliff Corner	6035	1670	200	33	9	14	19
Red Cliff Corner to East Gully	8275	1430	160	19	48	29	15
East Gully to Northeast Indentation	4380	450	1120	43	29	11	51
Northeast Indentation to North Point	3575	620	805	114	16	13	31
North Point to North Guard Rock	8195	4110	1521	118	21	33	58
North Guard Rock to Village	2070	2190	475	53	0	5	35
Totals	46,075	17,390	8074	665	159	136	275

Extrapolations of Total Murre and Kittiwake Numbers (from 7/15 Island Count and 7/14-7/15 24 Hour Count).

Murres – Island Count total : 46,000
24 Hour Count 1700-1900 Average Count : 400
Highest Count : 600
Ratio : 2/3
Extrapolation : 46,000 + 15,000 = 61,000

Kittiwakes – Island Count total : 17,400
24 Hour Count 1900-2100 Average : 300
Highest Count : 600
Ratio : 1/2
Extrapolation : 17,400 + 17,400 = 35,000

Table 2 continued. Census figures from 5 August island count.

Area	Murres	Kittiwakes	Horned Puffins	Tufted Puffins
Village to South Guard Rock	2410	710	1290	94
South Guard Rock to Big Diomede View Pt.	5390	2770	720	41
Big Diomede View Pt. to Southeast Point	4700	1320	1450	79
Southeast Point to Cave Cliff Corner	6310	1100		
Cave Cliff Corner to Red Cliff Corner	15420	4630		
Red Cliff Corner to East Gully			290	18
East Gully to Northeast Indentation	4880	610	2190	126
Northeast Indentation to North Point	2990	1000		
North Point to North Guard Rock	9160	4650	1680	97
North Guard Rock to Village	3160	3400	865	66
TOTALS	54420	20190	8485	521

Table 3. Estimate of puffin populations on Little Diomede.

Total area of rock outcrop = 1.407×10^6 m^2
Sampled area of rock outcrop = 20,540 m^2 (1.5% of total)

	Horned Puffin	Tufted Puffin
Number counted on rock outcrops	253	3
Average density on rock outcrops birds/m^2	.012	.0003
Extrapolated total birds on rock outcrops	16,884	422
Total birds on cliffs 15 July census	4,749	349
Total birds flying 15 July census	3,325	316
TOTAL POPULATION	24,958	1,087
rounded estimate	25,000	1,100

Table 4. Percent composition of Murre species (by area of the island).

	Thick-billed Murre	Common Murre
Northwest Side (From 1st Bluff North to North Point)	41%	59%
Northeast Side (From Northeast Indentation to East Valley)	52%	48%
Southeast Side (From Cave Cliffs to Southeast Point)	35%	65%
Southwest Side (From South Guard Rock to First Bluff South)	35%	65%

Total Birds Counted	-	16,380	(30% of total murre population)
Thick-billed Murres	-	40%	(6552)
Common Murres	-	60%	(9828)

Table 5. Estimates of auklet populations on Little Diomede.

Area of grassy slope = $2.294 \times 10^6\ m^2$
Sampled area of grassy slope = $69{,}825\ m^2$ for Least and Crested Auklets
$139{,}215\ m^2$ for Parakeet Auklets

Area of talus slope = $1.470 \times 10^6\ m^2$
Sampled area of talus slope = $38{,}000\ m^2 \pm$

	Least Auklet	Crested Auklet	Parakeet* Auklet
Sampled density on talus slopes birds/m^2	.645	.079	
Extrapolated number birds on talus	948,150	116,130	
Sampled density on grass slopes birds/m^2	.014	.008	west side:.0052 east side:.011
Extrapolated number birds on grass	32,116	18,352	west side: 6,567 east side:11,341
TOTAL POPULATION ESTIMATE	980,226	134,482	17,908
Rounded estimate	980,000	135,000	18,000

* We have separated our samples of Parakeet Auklets on the east and west sides of the island, using North Point and South Guard Rock as dividing boundaries.

Table 6 . Census and estimates of birds at Fairway Rock, 25 June 1977.

	Number Counted	Estimate of Total Population
Pelagic Cormorant	8 8 nests	20
Glaucous Gull	51 29 nests	125 - 150
Black-legged Kittiwake	640	500-1000
Common and Thick-billed Murres	130	4000 on cliffs* 20,000 on water*
Pigeon Guillemot	86	
Horned Puffin	12 (lower slopes)	
Tufted Puffin	62	100-500
Least Auklet		15,000
Crested Auklet		10,000
Parakeet Auklet		500
Common Raven	2	
Peregrine Falcon	2	

* estimate made from airplane 22 June

2. Fairway Rock

The data from the census of Fairway Rock are shown in Table 6. At the time we visited Fairway on 25 June, the numbers of murres were at a low point on Little Diomede; thus we believe the figure for Fairway Rock on that date does not reflect the true size of the population. For other species on the table, we have also distinguished the actual number counted from our estimate of the probable number of birds represented by our counts.

SPECIES ACCOUNTS

In these accounts, the English name of the species is followed by a phonetic spelling of the name used by the Eskimos of Ignalook.

General Breeding Phenology

The reproductive phenology of the seabirds breeding at Little Diomede is shown in Figure 4. The egg dates for auklets and puffins were obtained mostly by noting the days Eskimo children brought back eggs they had found. Thus they are accurate only within a range of about a week or so. We have limited information on Pelagic Cormorants and Glaucous Gulls because of the irregularity with which these nests were checked, but we have extrapolated from estimates of the ages of chicks to identify laying and hatching dates. Dates for the kittiwakes and murres are based on observations at the study sites. Our field party left Little Diomede on 12 August before any murre eggs were seen to hatch, and before all kittiwakes had hatched. Thus, we have no fledging or departure dates.

Kenyon & Brooks (1960) noted different arrival dates for seabirds during the two seasons -- 1953 and 1958 -- when they were on the island.

Figure 4. Approximate breeding phenology of seabirds at Little Diomede Island, 1977.

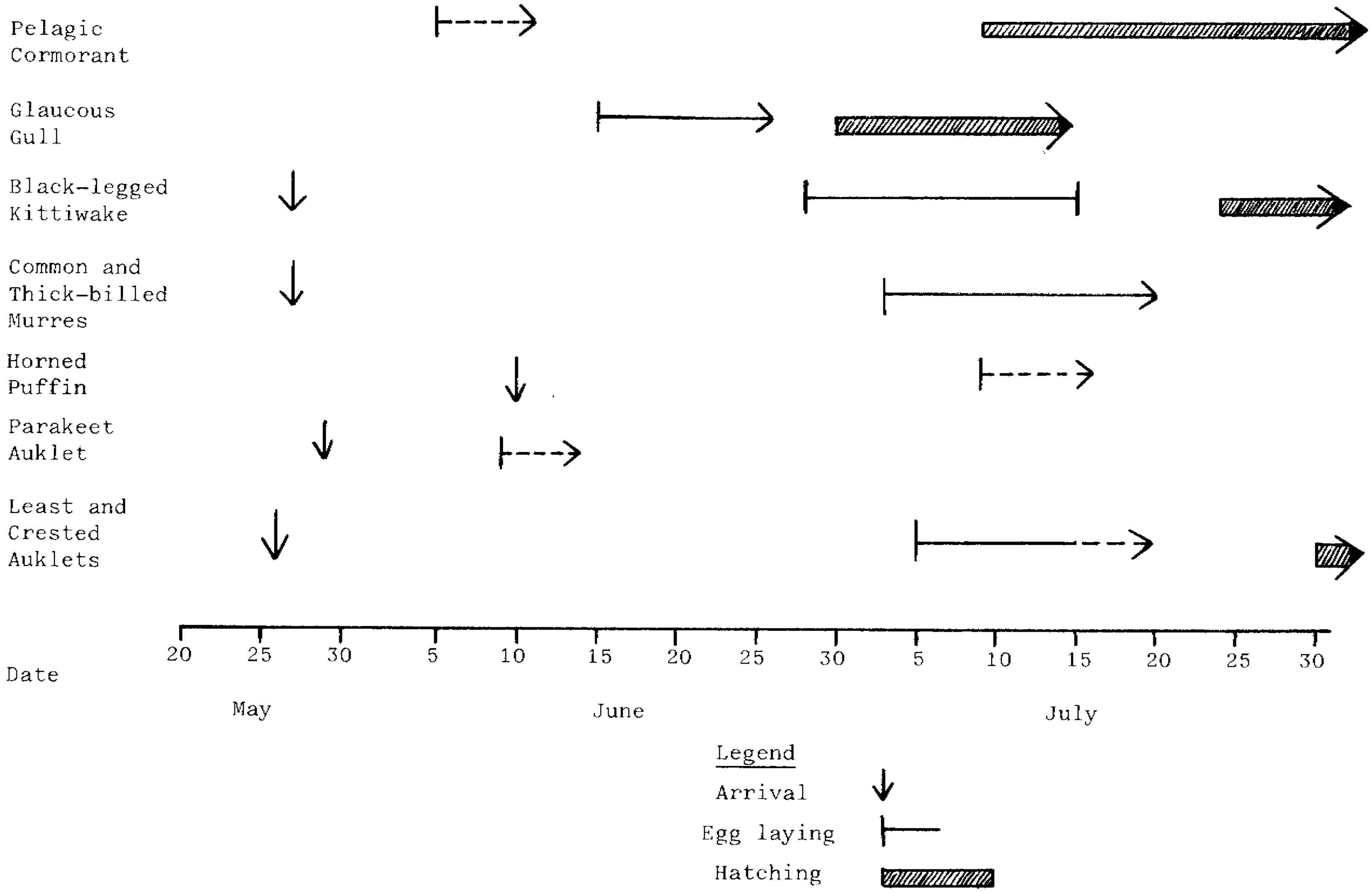


Table 7. Arrival dates of birds at Little Diomede.

Species	1953*	1958*	1977	Remarks
Kittiwakes	May 15	May 14	May 27	First sighted
	May 21	May 20	May 29	First on cliffs
Murres	April 27	May 16		First seen
	May 3	May 20	May 27	First on cliffs
Parakeet Auklet	May 29	May 26	May 30	First on rocks
Crested Auklet	May 22	May 20	May 26	First seen
Least Auklet	May 18	May 23	May 20+	First seen (+ by Eskimos)
	May 25	May 27	June 1	First on rocks
Horned Puffin	June 2	June 2	June 10	First seen
Tufted Puffin	June 2	May 26	June 15	First seen

* Kenyon and Brooks, 1960.

Arrival is apparently associated with how soon leads open near the island. However, they noted that "breeding activities commenced at about the same time" both years, regardless of when the birds were first seen. We found 1977 to be similar to 1958 when Kenyon observed few large areas free of ice until the latter half of May (Table 7).

Pelagic Cormorant (PAH-ma-sluk)

We first saw cormorants on the cliffs on 20 May, and we found one nest (empty) on 28 May. They nest on large ledges on the murre-kittiwake cliffs and on rock stacks.

On 23 June we found a nest on the Half Parapet (Figure 2) with three eggs in it. The nest contained three naked chicks on 10 July. All three had nearly fledged by 2 August.

In a sample taken at the end of July and beginning of August, four nests contained a total of 11 chicks, and one nest contained one chick and two eggs. There were three other nests which were all empty.

We often saw cormorants feeding on either side of the bar which extends west from the village.

Glaucous Gull (KAY-pok)

Glaucous Gulls were already present when we got to Little Diomede on 19 May. In addition to the breeding birds on the island, there appears to be a large number of transient non-breeding birds, including some subadults. The gulls often collect in groups of up to 50 around the piles of garbage thrown from the village onto sea ice, and around the discarded walrus and seal remains. In one such aggregation in early June, we saw 9 subadults in a group of 48 gulls.

They nest on top of rock stacks, high outcrops, and flat grassy ledges. We found a nest with one egg on 18 June, and we saw two nests each with three eggs on 23 June.

We saw an all-downy chick in a nest on 1 July. Eleven chicks were produced from the seven nests we followed. At least one three-egg clutch was lost, and another produced one chick.

Glaucous Gull pellets that we found contained songbird feathers and small bones. We saw some murre eggshells and a few Pelagic Cormorant eggshells in the vicinity of gull nests. Although we have seen the gulls feeding on Crested Auklet carcasses, we found many dead puffins and auklets that were untouched. Although the gulls clearly are predators, we could detect no serious impact of their predation on the seabirds.

Black-legged Kittiwake (KAY-po-suk)

Seasonal and daily changes in numbers --

We saw kittiwakes first on 27 May. They settled on the cliffs on 29 May. The number present from day to day fluctuated widely until 15 June (Figure 5). On 31 May we counted roughly 12,000 on a trip around the perimeter of the island.

Although we had the impression of a more stable population present after mid-June, the numbers we counted at study sites (shown in raw form in Figure 6) varied widely. Counts at study sites were made mostly at the same time of day (mid-to-late afternoon) so should be comparable between proximate dates. The number of birds present rises to a peak just after the peak of laying, but then drops by 25% two days later. Although subsequent peaks are all around 700 birds, there are conspicuous drops which we are unable to correlate with environmental events. The

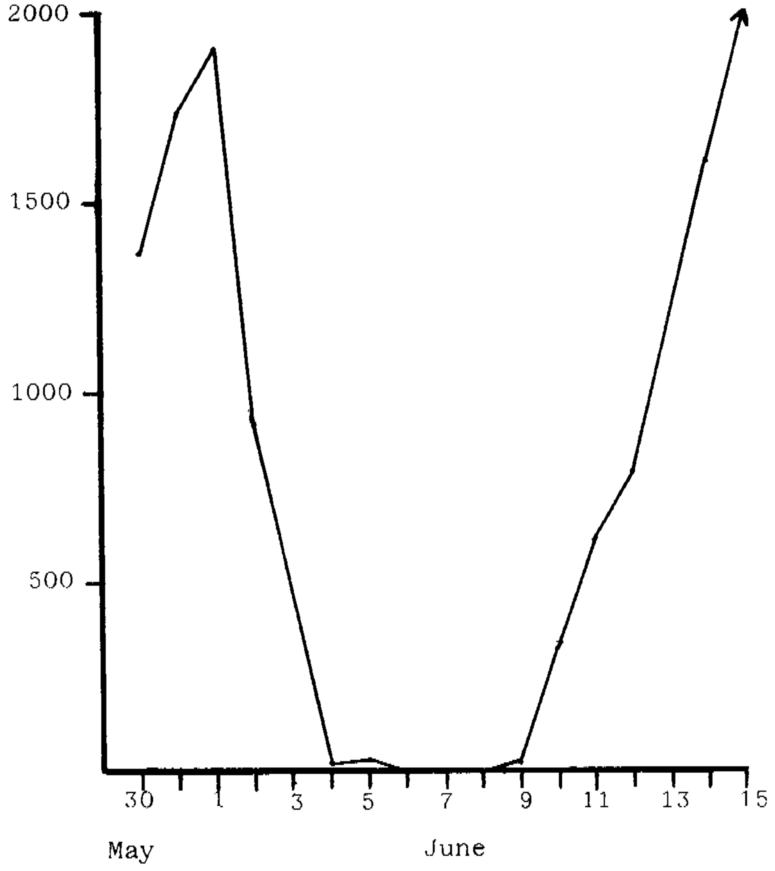


Figure 5. Number of kittiwakes counted at study sites 1 through 15, 30 May - 15 June.

Figure 6. Number of kittiwakes counted at study sites 16-18 in raw form.

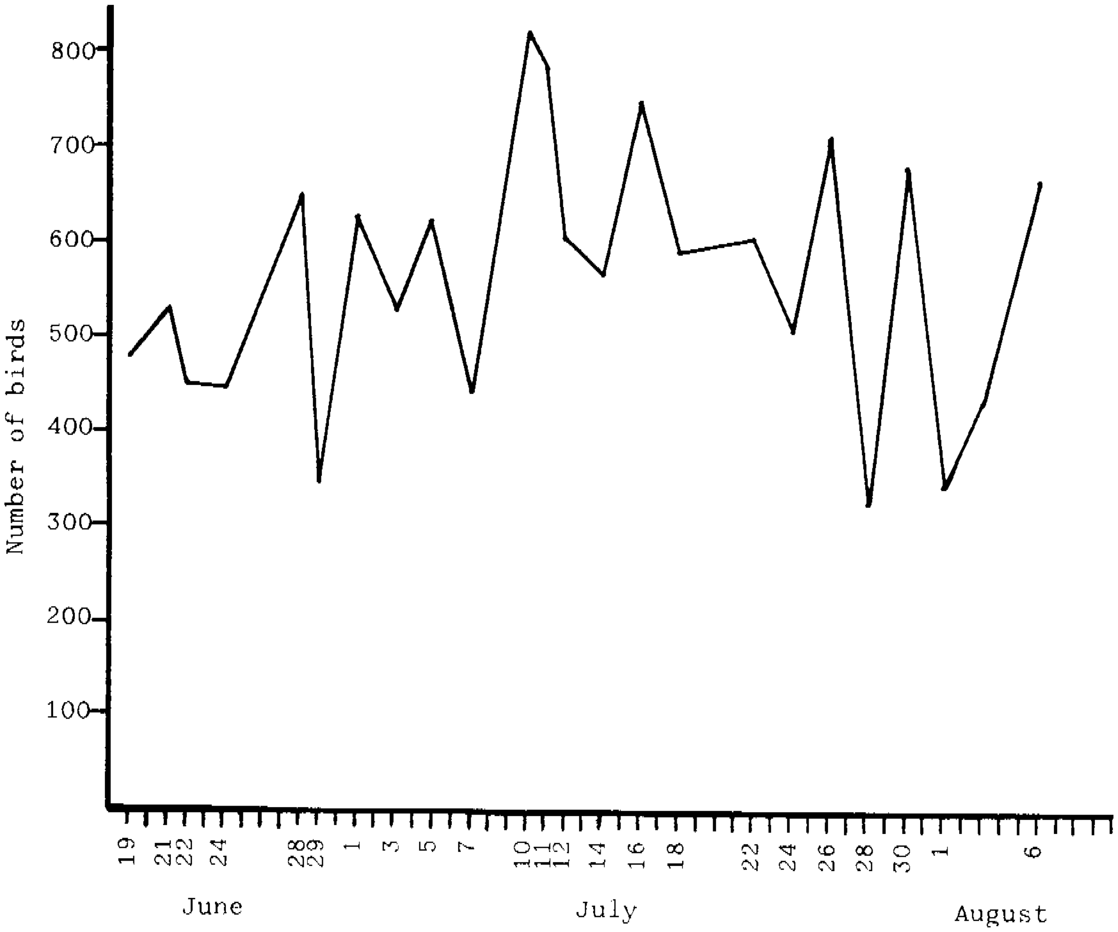
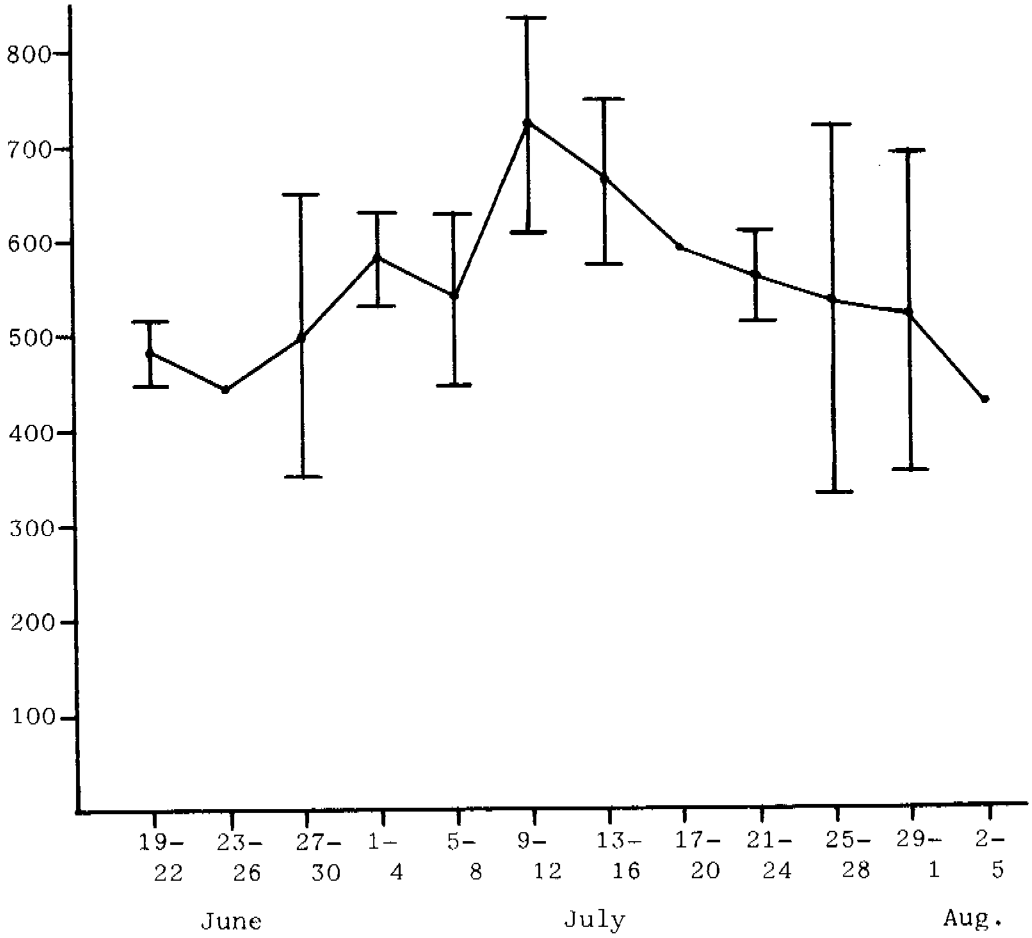


Figure 7. Four-day ranges and means of numbers of kittiwakes counted at study sites 16-18.



ranges and means of these numbers over four-day (usually two-visit) periods are shown in Figure 7.

The results of our two long counts to determine the kittiwakes' daily schedule are shown in Figure 8. The graphs show that the pattern changed between early and mid-July, which is consistent with our observations at Bluff in 1977. This means that censuses, if they are to be corrected to the daily activity pattern, should be made in close proximity to the daily activity count.

Nesting Habitat --

Kittiwakes are found on the lower cliffs; almost none are above 50 m over the water. Although larger numbers are present on the south end of the island, they appear to be more densely packed on the north and northwest sides, where there are many large, sloping ledges that are built up with pads of old nest material. Some of these pads are as much as one foot high.

Breeding Schedule --

We observed pairs of kittiwakes "choking" on nest sites the first day they landed on the cliffs. Nest building did not begin until after 15 June. We saw copulations first on 21 June. We found the first egg 28 June, and by 1 July several nests had two eggs. The first hatching was on 24 July. It appears that the breeding chronology of kittiwakes at Little Diomede was similar to that at Bluff in 1977. However, the large percentage of eggs still unhatched on 11 August suggests that the season on Little Diomede was later than Bluff for a large number of birds. Figure 9 shows the number of new eggs and chicks seen on each visit to the study sites. We evidently missed seeing some eggs when they first

Figure 8. Daily attendance pattern of Black-legged Kittiwakes at Little Diomede Island. (Study sites 17 and 18.) .

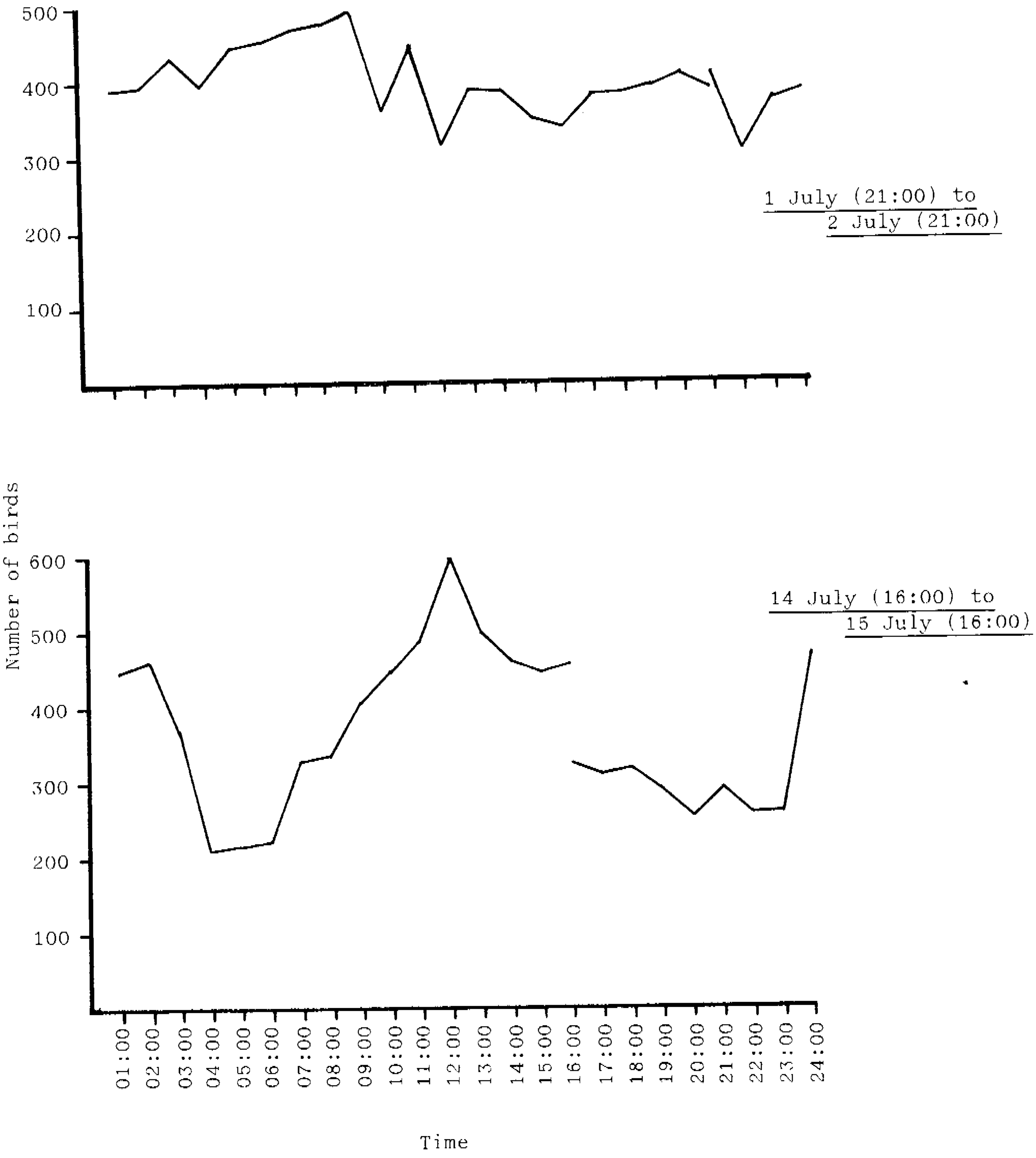
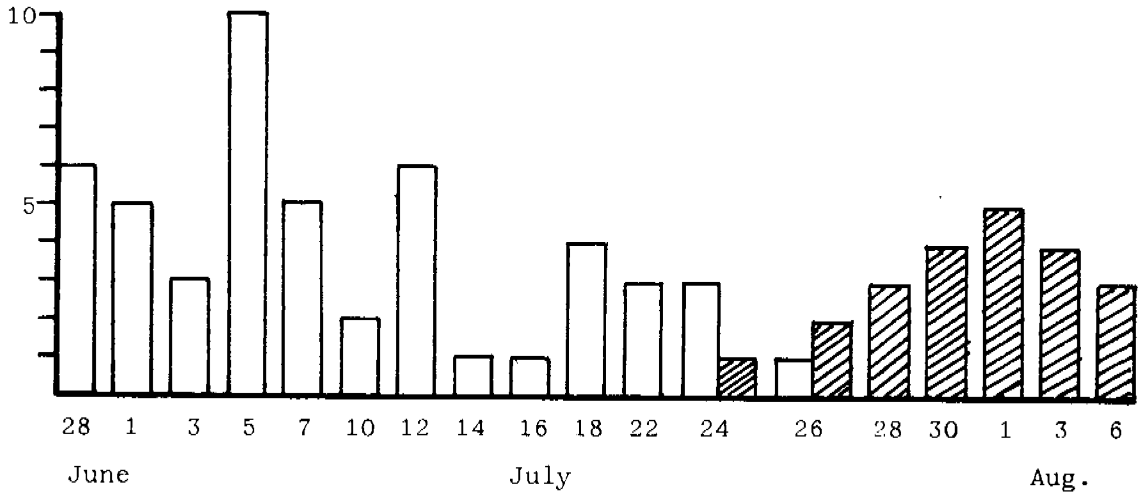


Figure 9. Laying and hatching of Black-legged Kittiwakes, Little Diomede, 1977.

Number of new eggs and chicks seen on each visit to study sites 16-18. Clear bars represent eggs; cross-hatched represent chicks.



appeared, so Figure 9 does not show complete laying or hatching curves.

Also as at Bluff, the Diomede kittiwakes had a second pulse of nest-building activity, occurring in late July. Many sites that previously had not been developed received new material, and many old sites had additional material added to them. We saw groups of 10 to 15 kittiwakes pulling grass off the slopes above the cliffs in this period. Orville Ahkinga of Ignalook told us that this second building peak occurs every year.

Reproductive Success --

Table 8 summarizes kittiwake reproduction at Little Diomede in 1977 as determined at study sites. Note that the sites on the east side of the island were visited only seven times over the season, because of their relative inaccessibility. Thus it is possible we missed recording eggs that were laid and disappeared before we saw them. The data from the east side may show higher success for that reason, and have been kept separate in the table. In the following discussions, we will refer to our more thorough data from the west side.

We have data only up to 11 August, which was before all kittiwake eggs had hatched, and before any chicks had yet fledged. It seems that reproduction to that point was better than it was at Bluff in 1977, and certainly better than the near total reproductive failure throughout the northern Bering Sea in 1976 (Searing; Springer & Roseneau; NOAA 1978).

The main cause of low reproduction in the kittiwake colonies of the northern Bering Sea during 1976 and 1977 has been poor egg production; i.e., far fewer sites receive eggs than are occupied. At Bluff in 1977, 26% of nests that were at some time built upon received eggs; at Square

Table 8. Reproduction of Black-legged Kittiwakes on Little Diomede Island, 1977.

	West Side (Study sites 16, 16B, 17, 18)	East Side (Study sites 19B, 20)
nests	116	46
eggs	57	27
clutches	45	23
chicks known hatched	23	3
broods	20	3
As of 11 August:		
eggs remaining	20	20
clutches	20	19
chicks remaining	19	3
broods	18	3
eggs per nest	.49	.59
clutches per nest	.39	.50
avg. clutch	1.27	1.17
chicks hatched per nest	.20	.07
broods per nest	.17	.07
surviving chicks per nest	.16	.07
surviving broods per nest	.16	.07
surviving chicks per egg	.33	.11
surviving chicks per clutch	.42	.13
As of 11 August: surviving eggs and chicks per nest	.34	.50

Rock near Bluff, the figure was 48%. Square Rock exhibited reproductive success four times higher than at Bluff Cliffs. At Little Diomede, about 40% of nests received eggs -- a figure closer to the one at Square Rock -- so we presume success to have been higher.

Egg mortality has also been shown to be a major cause of lowered reproductive success in Alaskan kittiwake colonies. We have evidence at Bluff in 1976 and 1977 that a period of stress during incubation forced adults to leave their nests. At Little Diomede in 1977, 33% of the eggs that were laid had hatched and 35% had not hatched and were still in their nests on 11 August, while at Bluff on 11 August, 28% of eggs had hatched, and 14% had not hatched and were still in their nests. It could be that some eggs at Diomede proved to be infertile after 11 August, and some may have been lost after hatching. If this was the case, productivity was at a maximum twice as high as that at Bluff (68% vs. 33% surviving) and at a minimum identical. It is probable, however, that the best explanation of these differences is that the breeding season on Little Diomede was later than at Bluff.

Despite the comparatively low rate of egg mortality at Little Diomede, we do have indirect evidence of some period of stress occurring in mid-July. We saw several nests with eggs left unattended for periods of 10 to 15 minutes during visits to our study sites between 10 and 15 July. This was the time when the number of kittiwakes counted at study sites dropped sharply before rising again. Nevertheless, almost no egg mortality occurred in this period.

The mean number of kittiwakes counted at study sites (Figure 7) shows a general decrease following the peak of laying. The data obtained at Bluff in 1977 was similar, and took a sharp rise after 24 July, peaking in early August at a number higher than the earlier peak. We do not know the shape of the graph after we left Diomede, and whether the numbers increased in August. There may in fact have been a period of stress through July during which the number of birds at the cliffs was depressed. However, poor weather does not seem to have occurred on the days when attendance dropped, and food (see below) seems to have been abundant close to the island.

Feeding and Food Sources --

We seldom saw feeding behavior close to the island until the end of June when large aggregations of feeding kittiwakes began to form over the bar that juts out west of the village. On 4 July we counted 4200 kittiwakes feeding there; on 15 July we counted 8000 at once. Occasionally in the first half of July we saw Gray Whales also apparently feeding in the vicinity of the bar. We assume that the current upwelling over the shallow bar makes it a convenient place to catch small crustacea. When feeding at the bar, kittiwakes landed in the water to the south of it and allowed the current to carry them over it. They repeatedly dipped their bills shallowly into the water as they drifted. When they were down-current of the bar, they flew to the south of it again and repeated the process. We interpreted the presence of red guano under many kittiwake nests to be evidence of crustacea in their diet.

Murres -- Common and Thick-billed (AHK-puk)

The arrival of murres, according to the Eskimos, occurs as soon as leads open near the island. Kenyon and Brooks (1960) saw murres moving north past the island before any birds settled onto the cliffs. This year none landed on the cliffs until 27 May, although they flew near the cliffs on 26 May. The first birds on the cliffs were Thick-billed. We did not see any Common Murres until 31 May.

The number of murres present from day to day was erratic, fluctuating between counts of zero and 2000 until 24 June, after which there were birds present continuously and the overall population appeared to increase. Figure 10 shows the variability in numbers of murres counted at sites visible from the ice before mid-June; Figure 11 shows the number of murres counted at cliff-top study sites near the village from mid-June until early August. The peak numbers get larger as the season progresses. We found this to be the case at Bluff as well in 1977.

We made two day-long counts of murres, one in early July and one in mid-July (Figure 12). The erratic nature of the murres' daily schedule, seen as a 30% fluctuation in Common Murre numbers between hours, makes it difficult to predict a preferred time for censusing. However, the census of 15 July was made just after the conclusion of a daily activity count, so we feel confident in using that count to extrapolate to the maximum and minimum number of murres from the number we counted.

Nesting Habitat --

Most murres on Little Diomede nest on the lower half of the cliffs; few (except for some on the north end of the island) are higher than 70 m from the water. Thick-billed Murres are seen on small, narrow ledges, whereas Commons are found on broad, densely-packed ledges. Thick-billed Murres are most numerous where the cliffs are composed of broken rock ledges. The predominance of such cliffs on the east side may account for the relatively higher proportion of Thick-bills there. Similarly, the

Figure 10. Number of murres counted at study sites 1-15 to 15 June.

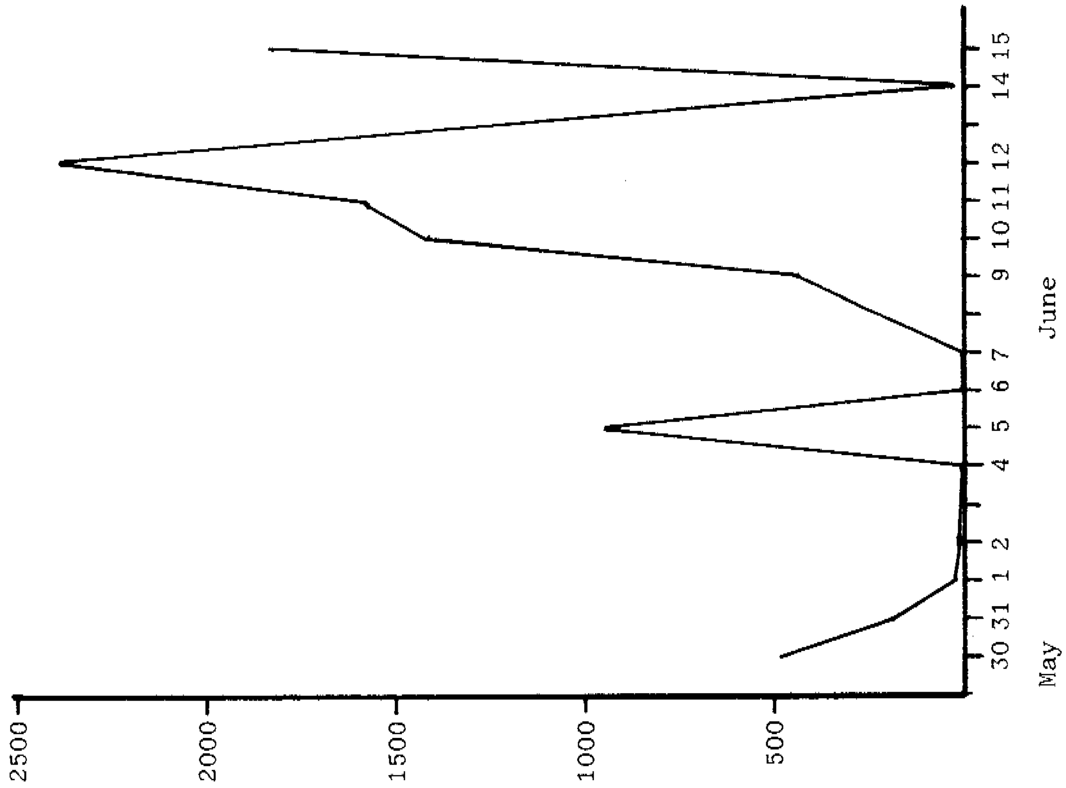


Figure 11. Number of murres counted at study sites 16-18.

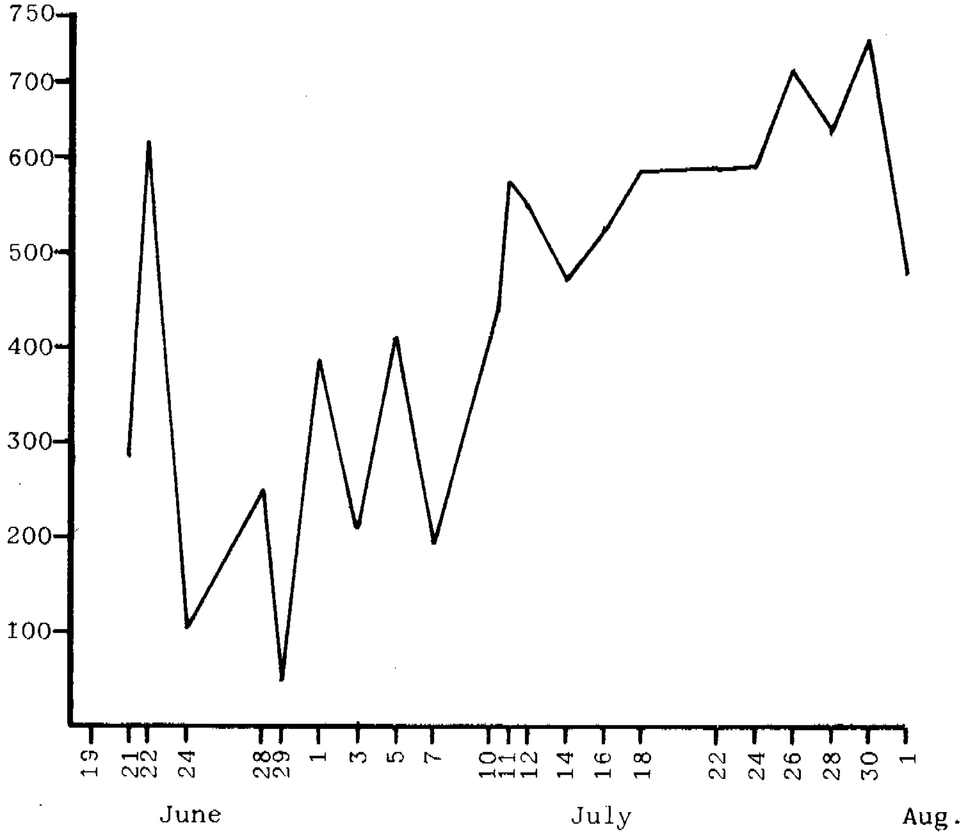
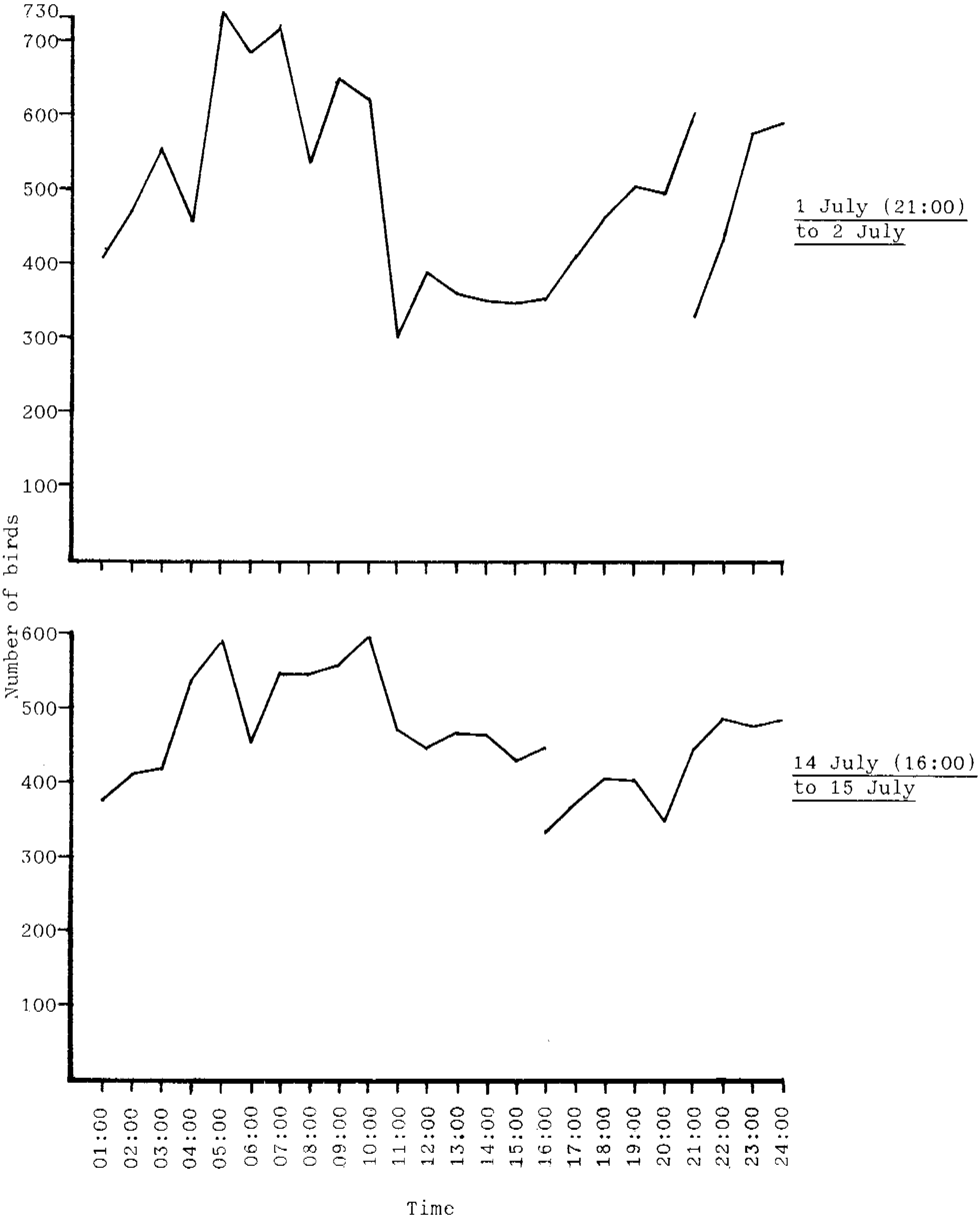


Figure 12. Daily attendance pattern of Common and Thick-billed Murres at Little Diomede Island. (Study sites 17 and 18.)



structure of the ledges on Fairway Rock may account for the overwhelming numerical superiority of Thick-bills there.

Reproductive Success --

We have no criterion on reproductive success as our field party left the island on 11 August, by which time no murre eggs had yet hatched. According to these data, hatching was at least two weeks later than at Bluff, and roughly the same as at the Cape Thompson area to the north, where Springer & Roseneau (1978) report 50% hatched by 20 August 1976.

Breeding Schedule --

The first copulations were observed on 21 June. By 24 June, murres were harder to flush off the cliffs, which led us to believe it was close to egg-laying time. On 28 June, an Arctic Fox was seen carrying what may have been a murre egg, but the first Thick-billed Murres in an incubating posture were not seen until 3 July, and Common Murres on 5 July. We definitely saw Thick-bills with eggs on 3 July, and Commons with eggs on 10 July. By 15 July there were many eggs; some of those collected by Eskimos had developing embryos.

Feeding and Food Sources --

We have commented elsewhere on the relative abundance of Thick-billed Murres in the Bering Strait as compared to Norton Sound. At Cape Thompson, Springer & Roseneau (1978) reported that Thick-billed Murres had more diverse food sources in 1976 than did Commons, including a high percentage of invertebrates, especially shrimp, in their stomachs. We saw few fish brought to the ledges by murres at Little Diomede, and were unable to identify those that we did see, but Thick-billed Murres' droppings were primarily red in color, as distinct from the greenish-yellow of Common droppings, probably indicating a higher concentration of crustacea in the Thick-bills' diet. Several authors (Tuck 1960, Uspenski 1956 , Belopolski 1957) have observed that Thick-billed Murres include more crustacea in their diet than do Common Murres.

Birds visible in the leads early in the season seem not to spend much time feeding, and later in the season most feeding seemed to be done away from the island.

Pigeon Guillemot (SIK-vuk)

Guillemots were first seen on the water on 26 May, and perched on rocks on 27 May. We found they were usually in pairs, and nested among the boulders at the base of the island. We saw a copulation on 20 June. In a search among low boulders at the southeast corner we found much guano but no nests.

Horned Puffin (KLANG-uk)

Seasonal and Daily Numbers --

Horned Puffins arrived on 10 June, when we saw both species in the water and on the island. Throughout the season, the largest numbers were on the island in the evening, arriving after 15:00 and leaving the next morning by 11:00. From day to day, as has been our observation at other colonies, their numbers were extremely erratic. In general, more seemed to be present on foggy days.

Nesting Habitat --

Horned Puffins nest in crevices at the top of the kittiwake/murre cliffs, and in rock outcrops all the way from the beach to the top of the island.

Breeding Schedule --

We first discovered eggs in burrows on 9 July, and found more in the same area on 27 July. None of these eggs had hatched, and several had been lost, by 11 August.

Reproductive Success --

Of 12 occupied nest holes into which we could see, two definitely lost eggs, and four others that were consistently occupied produced nothing. The remaining six eggs had not hatched by 11 August. It is not apparent to us how a puffin loses its egg.

We found that frequently there were no suitable burrows near where Horned Puffins perched on outcrops, and that apparently suitable crevices were unoccupied. In many areas of outcrop where we made thorough searches after flushing puffins, we could find no nest holes. We conclude from this that a large percentage of the puffins perching on the island were non-breeding birds. The same has been reported to be the case by OCSEAP workers in other colonies, and should account for the wide fluctuations in the number of puffins seen from day to day.

Tufted Puffin

We have little information on Tufted Puffins because of their relative scarcity. They were first seen on 15 June, and by 23 June were occupying some of the same areas as Horned, as well as the grassy slopes. Tufted Puffins occur mostly on the lower part of the island, and are seldom found above 100 m. Their low numbers on Diomede suggests that their numbers are limited by Arctic Foxes, since the proportion of Tufted Puffins is so much greater on Fairway Rock, where there are no over-summering foxes.

Least Auklet (AH-po-lik) and Crested Auklet (TAY-ak)

Seasonal and Daily Changes in Numbers --

We first saw Crested Auklets in small groups on the water on 26 May. The Eskimos reported first seeing Least Auklets flying over the water on 20 May; we first saw Least and Crested Auklets in a massive flight to the talus slope above the village on the evening of 1 June. During this flight, the sky became darkened with uncountable numbers of birds circling in a gyre that swept past the slope. As the flocks passed, some would break off and land, until most were sitting on the slope. These flights to the island in droves, which continued throughout June, started about 18:00 and peaked at 21:00 or 22:00. The auklets would start to leave in mid-morning, and would mostly be gone by 11:00. On days of inclement weather in the first half of June, either small flights or no flights at all occurred.

During the early part of the season, the auklets were very active and vociferous after they had landed, exploring under rocks and displaying, and were easily provoked into mass fly-offs. This makes them difficult to count, but in early June we made a rough maximum estimate of three Least Auklets per m^2 on the talus above the village. The number of auklets appeared to decrease after the first week of June and the proportion of Crested Auklets rose. If the departing birds were those who for some reason would not breed that summer, then our density counts which were made in late June, should be close to the density of birds that were breeding.

Throughout the season, the auklets were most numerous on the island at night, generally arriving after 19:00 and departing before 12:00.

Figure 13 shows their daily schedule as determined during daily activity counts made in July.

Nesting Habitat --

Least and Crested Auklets appear most dense on talus slopes with no surface soil. Cresteds tend to nest in deeper, denser talus (children are able to get few eggs compared to the number of Least eggs they find) and a few nest among broken rocks in the grassy slopes. Virtually none nest on the flat plateaus on top of the island, probably because of the poor drainage under rocks there.

Reproductive Success -- no information

Breeding Schedule --

We saw Crested Auklets engaging in fights and mutual preening from 15 June to 6 July. We first heard auklets under the rocks during daytime hours on 17 June, so it is possible egg-laying began close to that date. Eskimo children collected their first Least and Crested Auklet eggs on 5 July and continued taking some until 15 July, when they said "eyes" (embryos) were developing. Orville Ahkinga reported hearing chicks under the rocks on 30 July. We found three downy Least Auklet chicks of about three inches in length on 4 August.

Feeding and Food Sources --

All three auklet species seemed to feed far from the island; we seldom saw feeding nearby. In early July we saw a group of 80 Crested Auklets in the water near NE Cliffs. They repeatedly dove in unison and stayed submerged for about 60 seconds.

Figure 13A. Daily attendance pattern of Least Auklets at Little Diomede. (On talus slope above the village.)

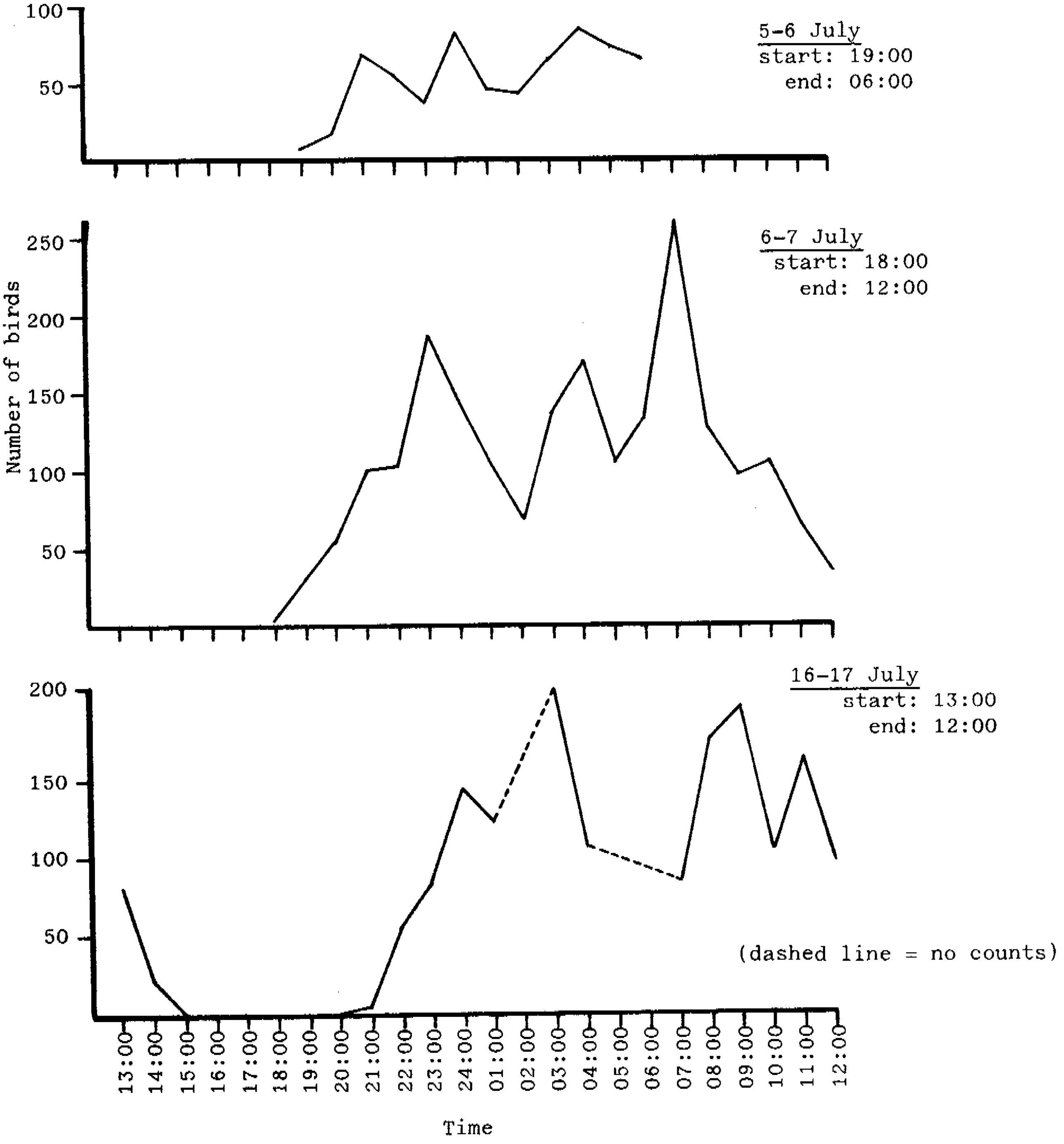
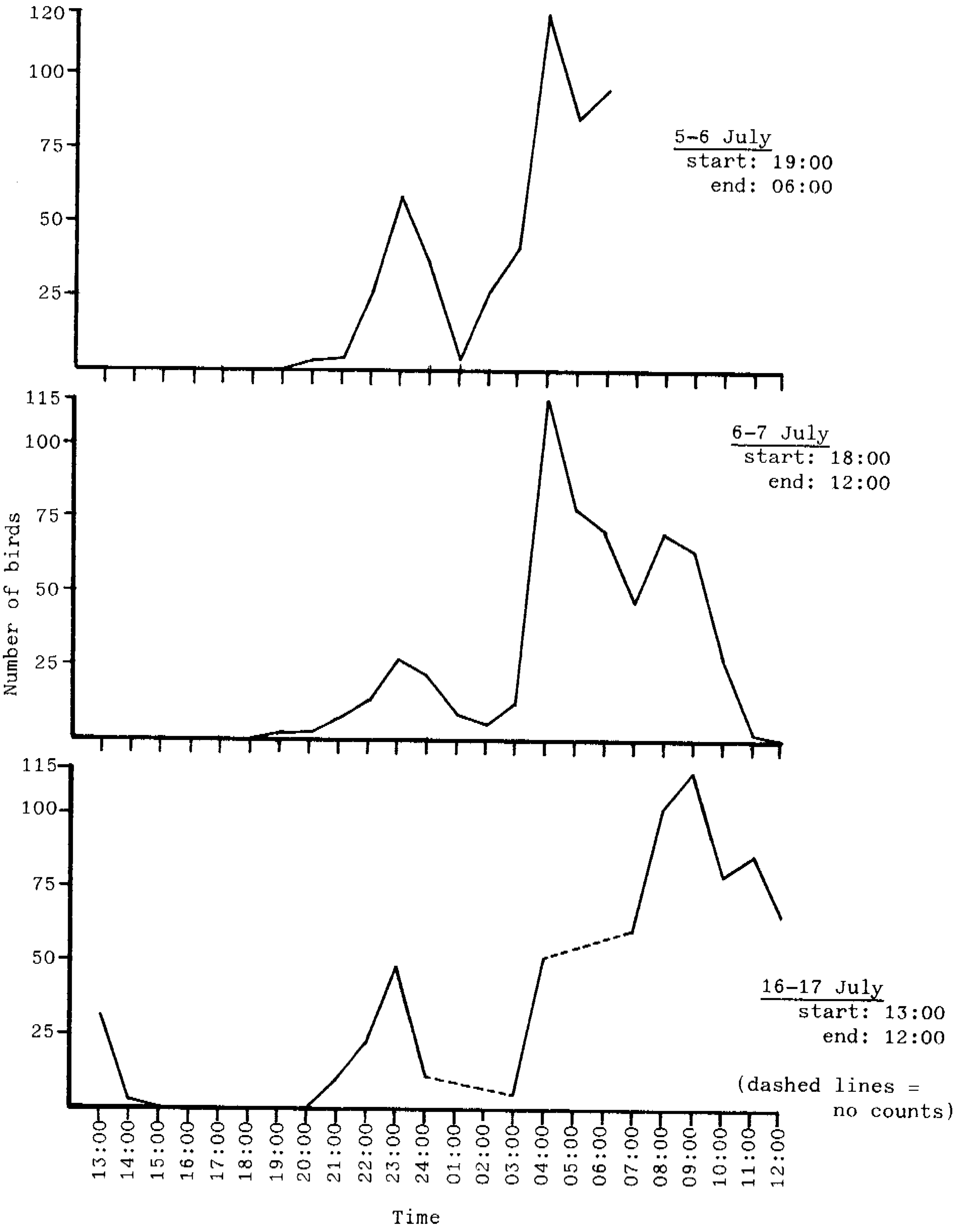


Figure 13B. Daily attendance pattern of Crested Auklets at Little Diomede. (On talus slope above the cillage.)



Parakeet Auklet (SAH-gi-uk)

Seasonal and Daily Numbers --

We first saw Parakeet Auklets on 29 May on the water; 30 May on the cliffs. They were not numerous until 9 June. Compared to Least and Crested Auklets, the Parakeet population is small. On their arrival at the beginning of June, the grassy slopes on which they nest were still snow covered; thus the auklets spent their evening hours on the edges of the murre and kittiwake cliffs and the daytime hours scattered among murres in the leads. They arrived on the cliffs about 23:00 to 01:00 and were gone by 11:00. By the first half of July, the amount of time they were evident on the island increased, with the peak between 03:00 and 09:00. Some remained around until after 12:00. By late July, they were numerous on the island until 15:00 and after.

Nesting Habitat --

Parakeets nest in burrows dug under rocks on the soft, grassy slopes. They are concentrated on the lower third of the slope, with some at the top, except at the south end of the island where they are distributed evenly along the entire height.

Breeding Schedule --

We have scant information about their reproduction. We discovered a few eggs on 9 July, but have no laying or hatching data.

Feeding and Food Sources --

They apparently feed away from the island.

Common Raven

Several were present at the time we arrived. The maximum we saw at once in early June was five, but it was difficult to census the birds because they were active in foraging.

We found one nest on the Half Parapet; there may have been another nest at the south end of the island. On 26 May there was an adult sitting tightly on the Half Parapet nest; on 23 June we saw four small downy young; on 14 July there was one fledged young perched below the nest, and two nearly fledged ones in it. On 10 August, we saw two adults and three immatures on top of the island, so we suspect one nest on the island fledged three young. Other predators on Little Diomede are Snowy Owls (possibly two pairs) and Pergrine Falcon.

OBSERVATIONS ON THE DISTRIBUTION OF BIRDS AT SEA

Our major observations are the same as those of 1976, that there is a lack of birds in Norton Sound and a concentration of birds in the Chirikov Basin. East of a line drawn from the east end of Saint Lawrence Island to Cape Spencer (Figure 14) most periods of observations have no birds. West of that line one may see as many as 200 birds in a five-minute period. Very few periods have no birds at all. Five-minute periods at 120 knots, using our angle of sight, represents 1 square kilometer of ocean surface. The data are presented of Figures 15A-D.

There is an oval area with gaps that extends 100 km to the south of King Island, to the International Date Line and beyond to the west, barely 25 km to the east of King Island and north to the Bering Strait, in which one can expect to see 10 to 50 birds per square kilometer. Inside that limit there is a smaller area, perhaps 75 kilometers from King Island to the south in which one can expect to see densities of up to 100 birds per square kilometer.

A similar area of high concentrations, 50-100 birds per square kilometer, exists extending 50 kilometers north of Gambell with a zone of moderate density, 10-50 birds per square kilometer, extending out 90 kilometers from Gambell and 50 kilometers from Savoonga.

Another area of high density is found from 25 kilometers south of Fairway Rock to 25 kilometers north of Little Diomede, up to 200 birds per square kilometer; and an area of lesser density, 10-50 birds per square kilometer, extends another 50 kilometers to the north of Little Diomede Island.

We have speculated elsewhere (Annual Reports and Proposals) on the general reasons for the spectacular differences in the concentrations of birds at sea in the Chirikov Basin as contrasted to Norton Sound. The flights in 1977 have let us outline the eastern edge of the zone of concentration more carefully, as mentioned previously, as a line extending from the east end of Saint Lawrence Island to Cape Spencer. East of this line, one must be within 10 kilometers of the cliffs at Sledge Island or 20 kilometers of the cliffs at Bluff to find concentrations as high as one finds 100 kilometers offshore to the west.

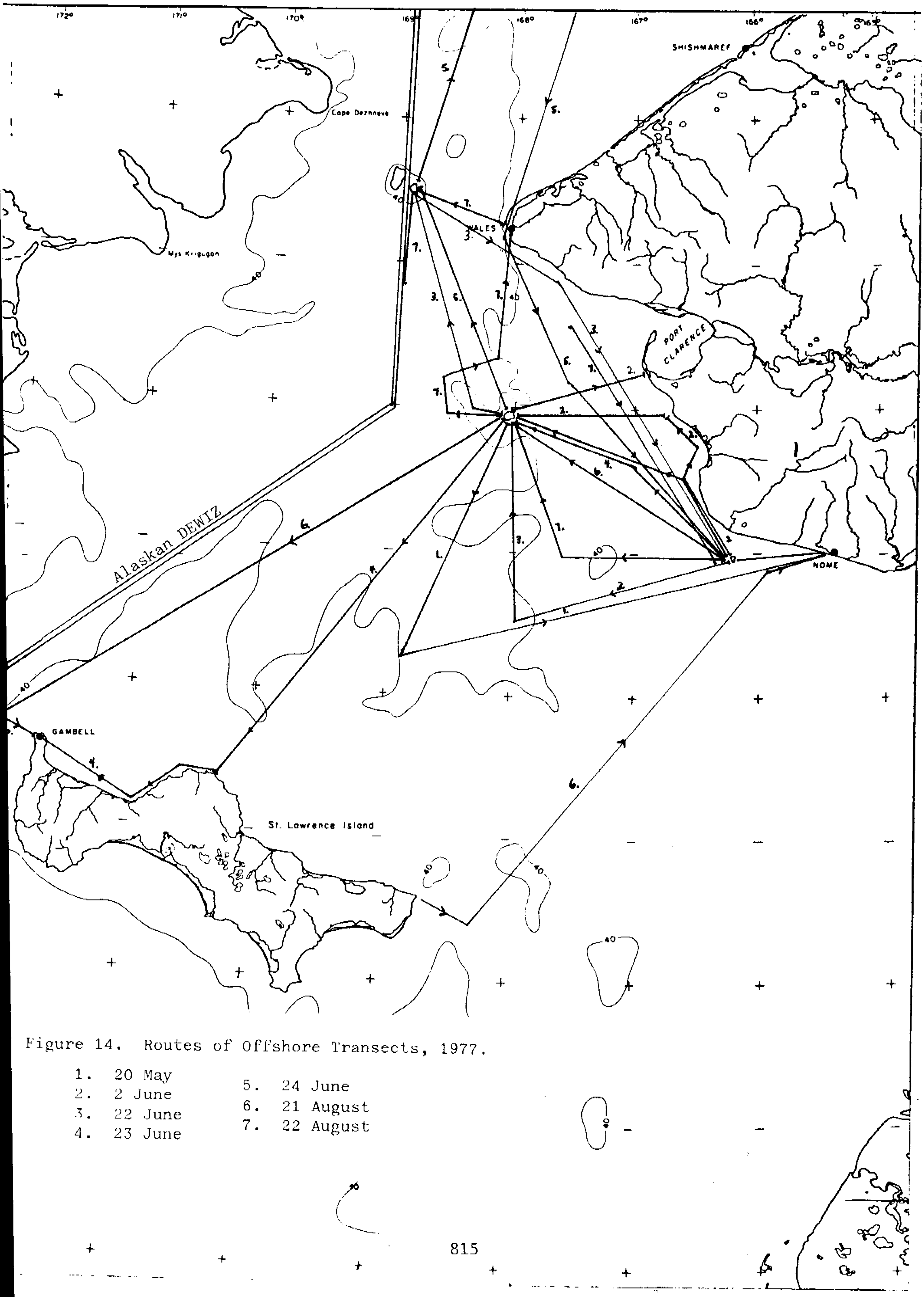


Figure 14. Routes of Offshore Transects, 1977.

1. 20 May
2. 2 June
3. 22 June
4. 23 June
5. 24 June
6. 21 August
7. 22 August

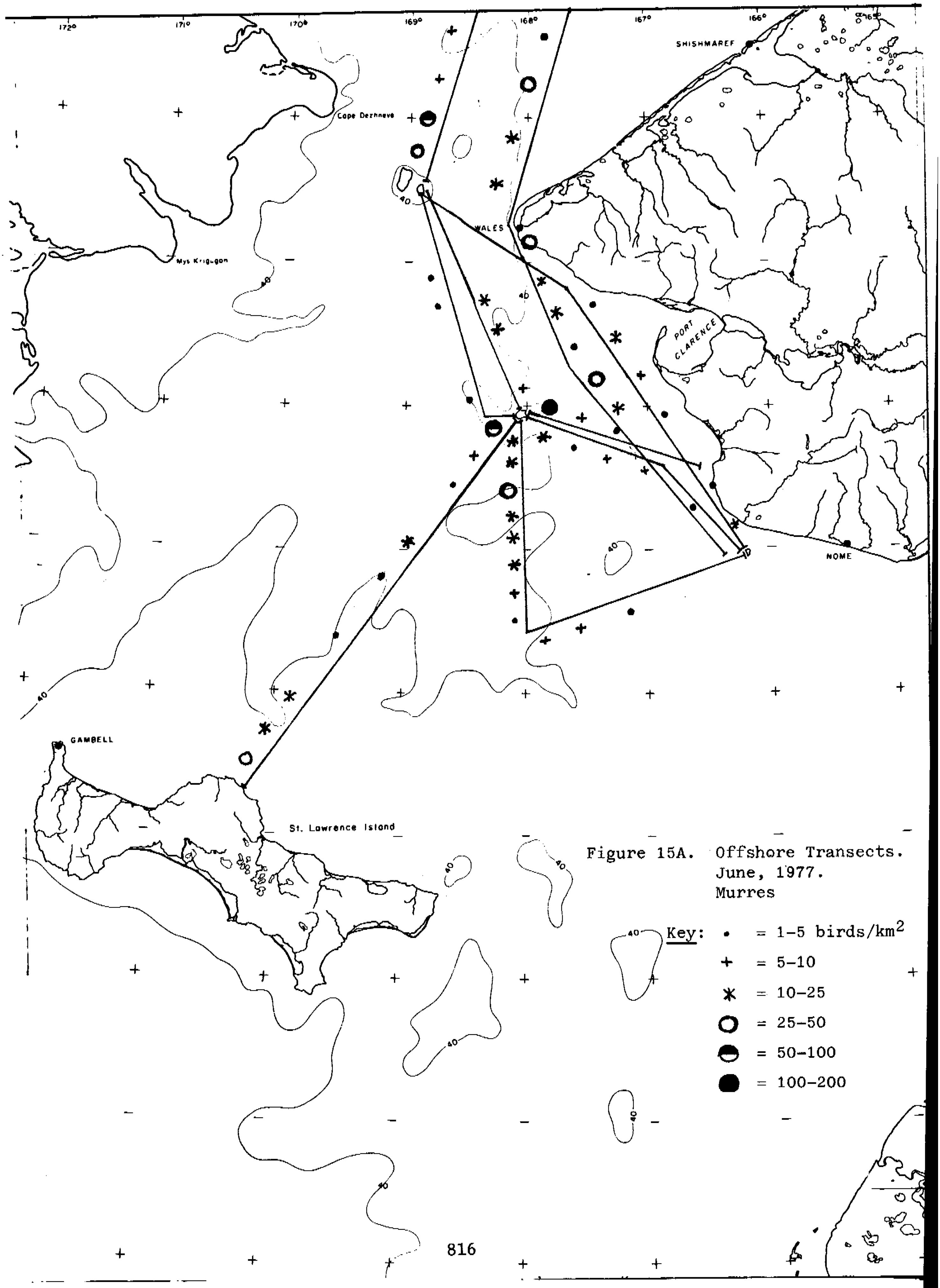


Figure 15A. Offshore Transects.
June, 1977.
Murres

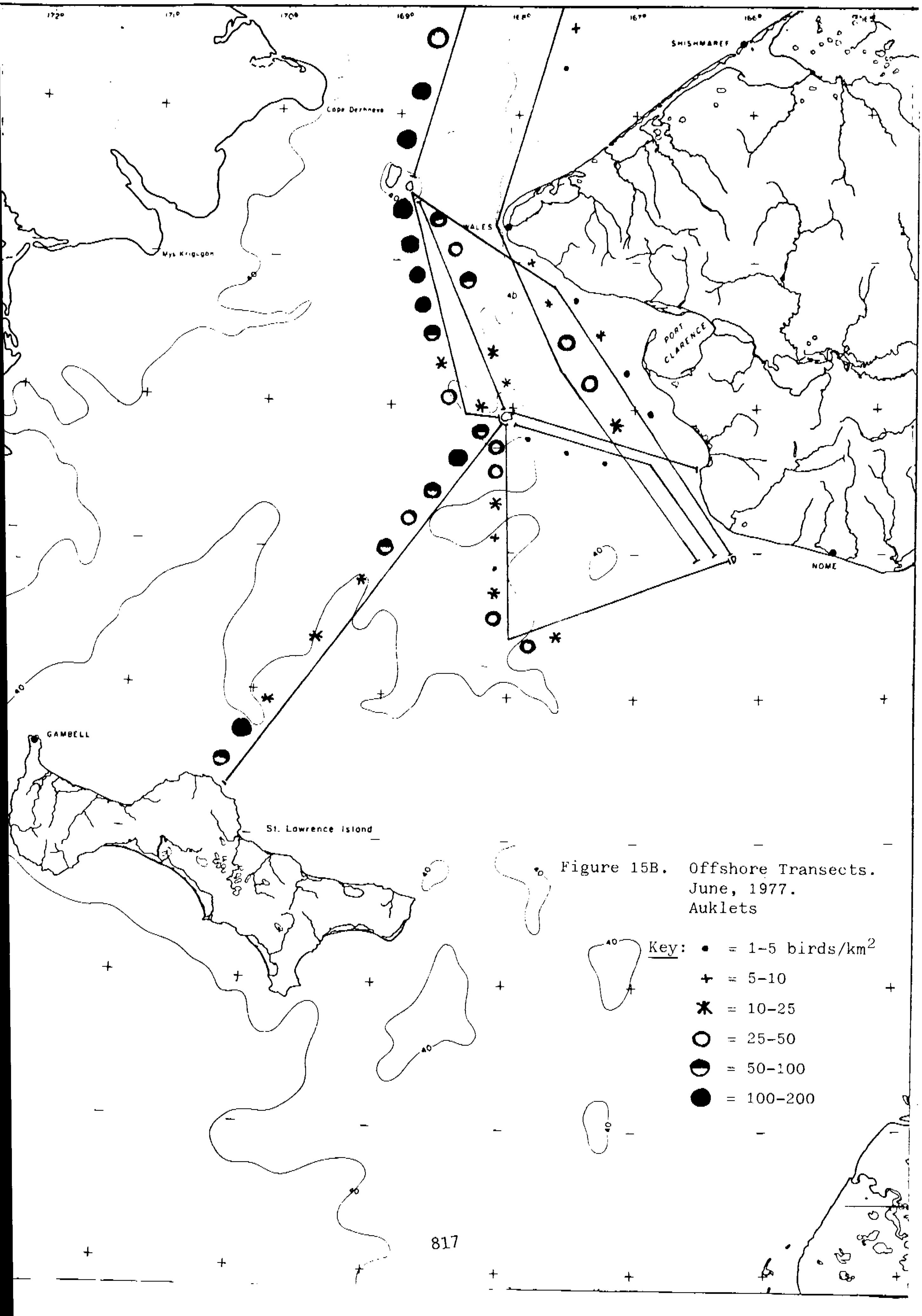


Figure 15B. Offshore Transects.
June, 1977.
Auklets

Key:
• = 1-5 birds/km^2
+ = 5-10
✱ = 10-25
○ = 25-50
◓ = 50-100
● = 100-200

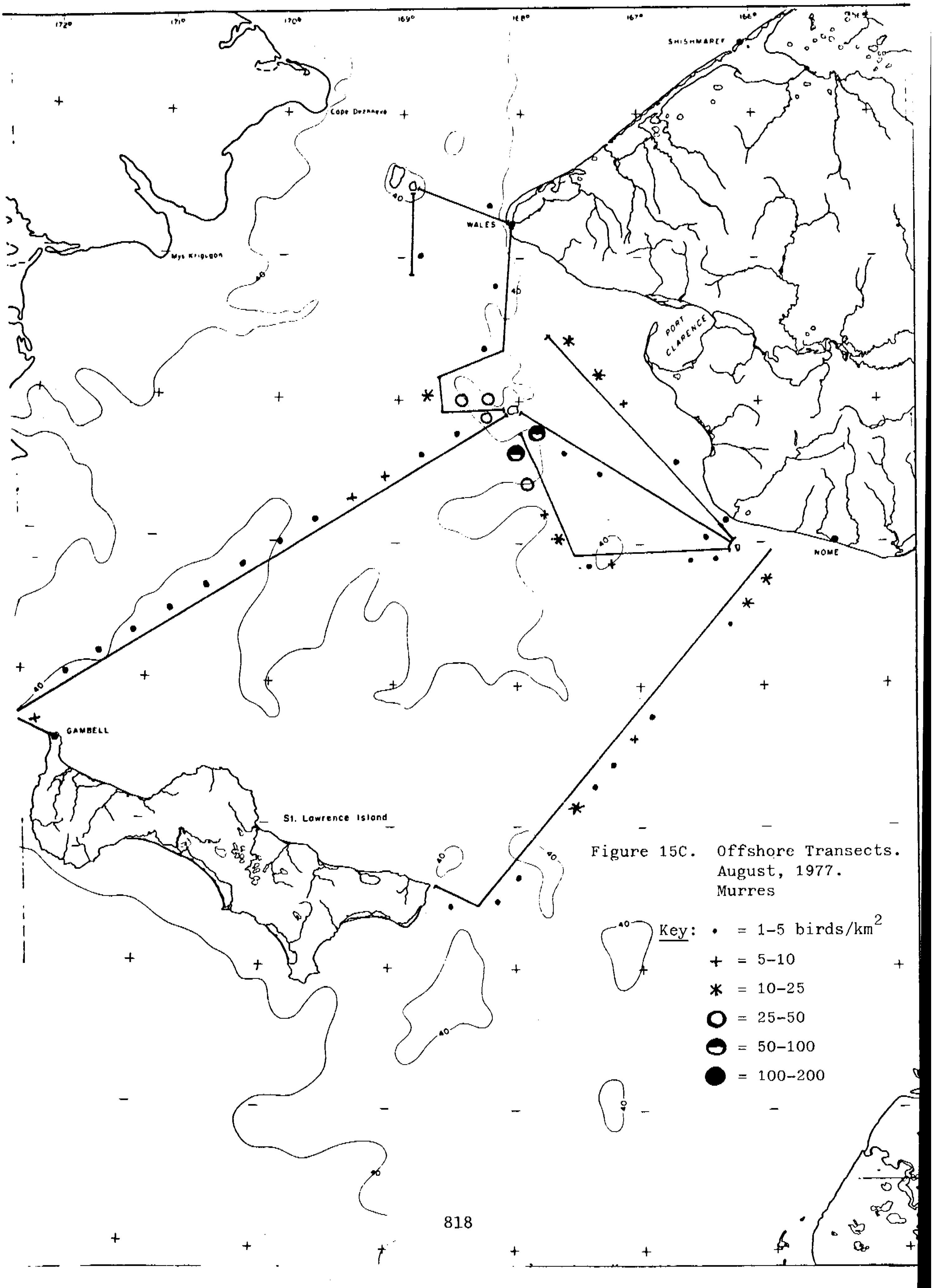


Figure 15C. Offshore Transects.
August, 1977.
Murres

Key: • = 1-5 birds/km^2
+ = 5-10
✱ = 10-25
○ = 25-50
◒ = 50-100
● = 100-200

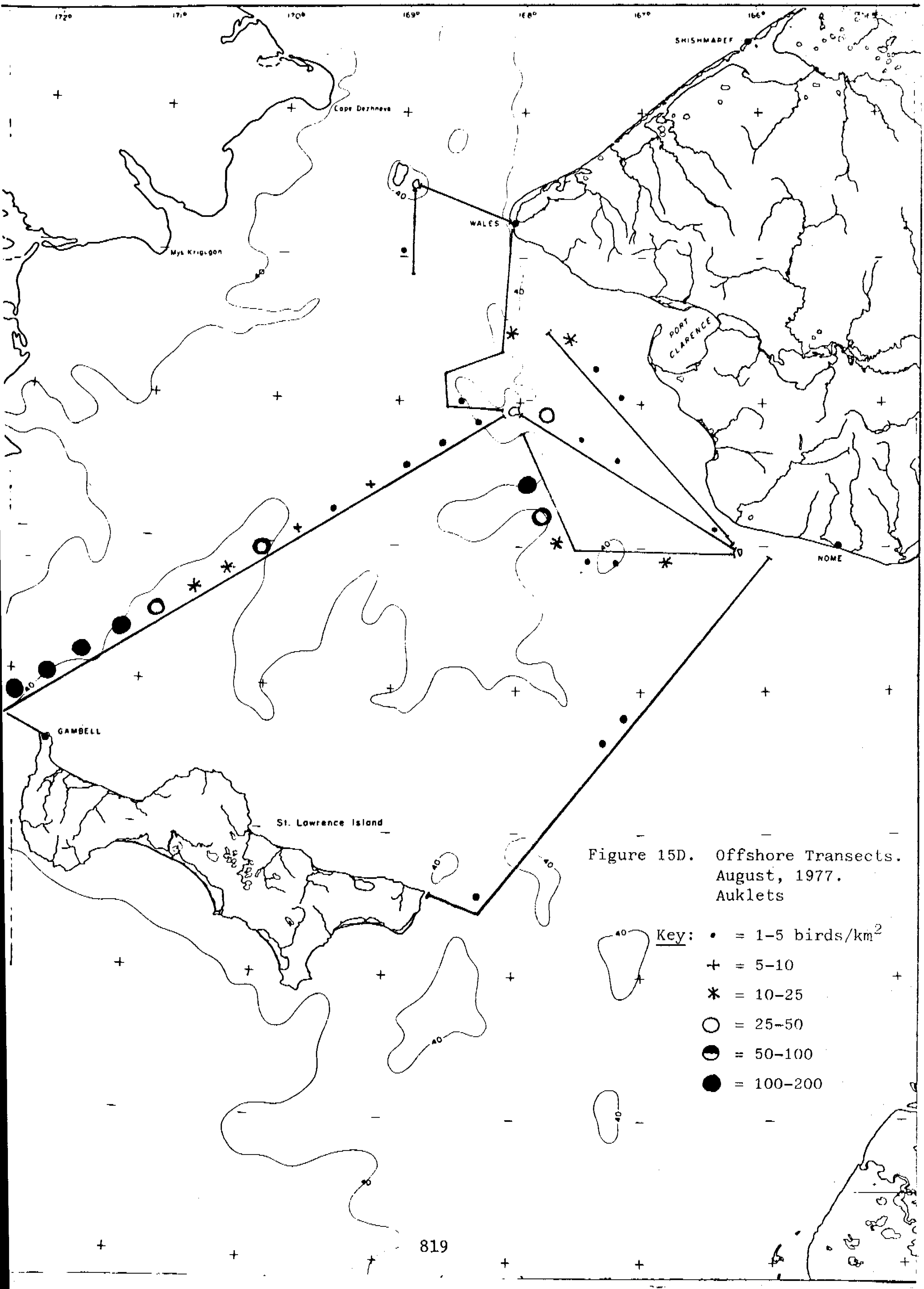


Figure 15D. Offshore Transects. August, 1977. Auklets

Key: • = 1–5 birds/km^2
+ = 5–10
✱ = 10–25
○ = 25–50
◓ = 50–100
● = 100–200

VII & VIII. DISCUSSION AND CONCLUSIONS

Importance of the bird populations at Little Diomede.

The marine birds of Little Diomede are notable for the following:

1) The island supports the major kittiwake colony in the northern Bering Sea Region (pending a more thorough estimate of the numbers at the Southwest Capes of Saint Lawrence Island), and has a relatively high proportion of kittiwakes to murres on the cliffs;

2) There is a tremendous number of Least Auklets on the island; numbers of Crested Auklets is four times and of Parakeet Auklets is half the numbers of the respective species on King Island;

3) The number of murres is relatively small compared to the 200,000 at Cape Thompson and Cape Lisburne, but is comparable to the numbers at King Island and at Bluff, i.e., 50,000 to 75,000. The proportion of Thick-billed Murres to Common Murres is about equal, as is the case at King Island.

4) The numbers of Tufted Puffins, Pigeon Guillemots and Pelagic Cormorants are small. The number of Horned Puffins is relatively large.

5) Although the breeding population of Glaucous Gulls is about what one would expect, the number of non-resident birds is large, presumably a partial result of the supply of human wastes and garbage.

Comparisons with Kenyon and Brooks estimates from the 1950s.

There are familiar difficulties in making comparisons of numbers of seabirds estimated by our party with those estimated by Kenyon and Brooks twenty years earlier.

We asked Kenyon directly how he had made his estimates and learned that his system was very similar to ours, i.e., walking around the island on the ice and climbing over the island counting and estimating numbers on each section of cliff and slope. He told us that he reported the totals which he got by this method as the minima in his paper and that he gave the maxima as an indication of the difficulty of getting precise figures.

We agree with Kenyon that getting rigorous results and even estimating error is very difficult when numbers are so large, but we must develop some way to compare between years if these data are to be useful. We believe that one way to treat this difficulty is to represent numbers of birds on a logarithmic scale (Figure 16).

We know that the numbers of some species vary widely, some more than others. For example, Glaucous Gulls will aggregate in numbers tens of times the figure for the local breeding population. Horned Puffins appear around the breeding cliffs in August in numbers several times those found in June. The numbers of murres also increase as the season progresses until about mid-August. The numbers of kittiwakes, however, are more stable, but even their numbers may vary over 30% to 50% during the course of one 24-hour period.

We have recorded the variation among counts of the murres on the cliffs at Bluff (Table 9). These counts indicate the magnitude of variation and we have confidence in each of these counts because of the convenience of the study area. The figures in Table 9 are untreated for variation during the 24-hour period and for birds flying off the cliffs. The majority of our counts at Bluff fall between 30,000 and 45,000 murres.

We presume, for comparative purposes, that Kenyon and Brooks' lower figures for Little Diomede are analagous to our counts of 27,000-

Figure 16. (next page) Comparison of numbers of seabirds at Little Diomede Island in the 1950's (Kenyon and Brooks) and 1977, with counts and estimates represented on a logarithmic scale.

⌶ Range given by Kenyon & Brooks (1960) for 1953 and 1958.

●—● Range determined in 1977. For kittiwakes, puffins and murres, the lower end is the raw count of 15 July, and the upper end is the extrapolated estimate. For auklets, the upper end is the figure derived from the larger estimate of the total area of the island's slope (5.5 x 10^6 m^2), while the lower end is the figure derived from the smaller estimate of the slope (3.3 x 10^6 m^2) as discussed under "Methods."

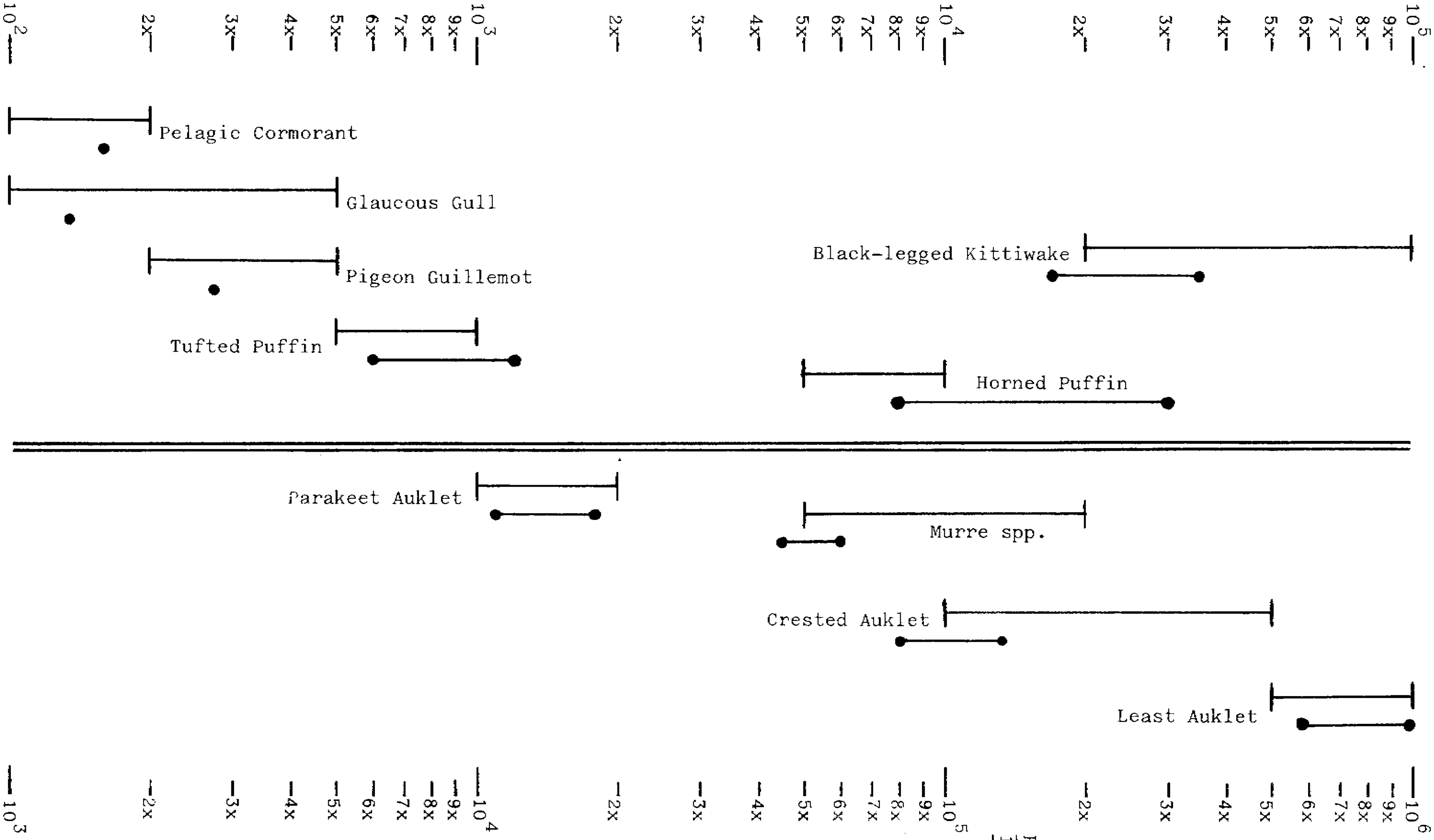

10^2
2x
3x
4x
5x
6x
7x
8x
9x
10^3
2x
3x
4x
5x
6x
7x
8x
9x
10^4
2x
3x
4x
5x
6x
7x
8x
9x
10^5
Pelagic Cormorant
Glaucous Gull
Pigeon Guillemot
Tufted Puffin
Black-legged Kittiwake
Horned Puffin
Parakeet Auklet
Murre spp.
Crested Auklet
Least Auklet
10^3
2x
3x
4x
5x
6x
7x
8x
9x
10^4
2x
3x
4x
5x
6x
7x
8x
9x
10^5
2x
3x
4x
5x
6x
7x
8x
9x
10^6

Figure 16.

Table 9. Ranges of Murre counts at the Bluff cliffs.

	Low Extreme	Normal Range	High Extreme
1975		27,000-57,000	90,000
1976	9,040	32,000-56,000	
1977		28,000-60,000	

Table 10. Comparison of seabird numbers at Little Diomede in 1958 and 1977.

	1958*		1977		
	Minimum	Maximum	Min.	Direct Count	Max.
Pelagic Cormorant	100	200		160	
Glaucous Gull	100	500		135	
Black-legged Kittiwake	20,000	100,000	20,000		35,000
Murres	50,000	200,000	45,000		60,000
Pigeon Guillemot	200	500		275	
Parakeet Auklet	10,000	20,000	11,000		18,000
Crested Auklet	100,000	500,000	80,000		135,000
Least Auklet	500,000	1,000,000	588,000		980,000
Horned Puffin	5,000	10,000	15,000		25,000
Tufted Puffin	500	1,000	600		1,000

* Kenyon and Brooks, 1960.

35,000 at Bluff, and that their upper limits are equivalent to our count of 90,000 or, potentially, an even higher number representing all the birds which may come to the cliffs (including some over-estimation).

Making comparisons using Table 10, we would say that there is no evidence of change in numbers of Pelagic Cormorants, Glaucous Gulls, Pigeon Guillemots and Tufted Puffins. We believe that we can make no comparisons between our high counts of Horned Puffins made in August and those of Kenyon and Brooks's because theirs were made in June before the major influx of Horned Puffins takes place in August. However, our party's count of 8000 birds made on 15 July is within the spread they suggested. (See also Figure 16.)

Differences seem to be suggested in the larger numbers: kittiwakes, murres, and Parakeet and Crested Auklets. The numbers of Parakeet Auklets estimated in 1977 are suggestively close to Kenyon and Brooks's upper limit, while the numbers estimated for Crested Auklets and murres in 1977 are suggestively close to his lower limit. Least Auklets, whose swarms boggle the observer's mind, appear in 1977 to be at the uppermost limit of Kenyon and Brooks's numbers. Kenyon himself doubted that we could draw any conclusions that species numbers have changed in this period.

Historical trends in numbers.

The number of Least Auklets on Little Diomede is so vast that it would require exceptionally detailed efforts to improve on the accuracy or confidence limits of the present data. However, we can draw a few conclusions about murres and Crested Auklets, even though our estimates fall within the same range as those of Kenyon and Brooks.

There was a major decrease in the number of murres at Cape Thompson between the early 1960s (400,000 _fide_ Schwartz 1966) and the last few years (200,000 _fide_ Springer & Roseneau 1978). The fact that our estimate of murres is at the minimum of what Kenyon and Brooks estimated, makes it reasonable to expect that there has been an historical decrease.

Albert Ayahuk and Orville Ahkinga said Crested Auklets have decreased in the last several decades and commented that 1977 was a particularly low year. It is likely that natives have noticed changes among the Crested Auklets because they were an important part of the traditional diet and are still involved in a notable community hunting effort in which the auklets are frightened from their burrows and caught in hand nets. The Diomeders say that their hunting effort has declined over the years, and our observation of their hunting techniques suggests that the impact of natives is minimal.

In 1976 there were repeated helicopter trips to the island during the summer while a new school was being built, and in 1977 a helicopter was making trips to the island between 25 July and 5 August for installation of a telephone antenna on the top of the island. We have observed at both King Island and Little Diomede that helicopters cause particularly severe disturbances at the colony, scaring most of the birds off the island. We saw also at Bluff in 1977 that helicopters passing even at considerable distance from the colony would cause a massive fly-off greater than that caused by a close-flying fixed-wing aircraft. The Eskimos' observation of low Crested Auklet numbers at Little Diomede in 1977 may in part be a result of the repeated helicopter disturbance in 1976. Our discovery of several rotten eggs in apparently abandoned burrows from the previous season suggests the same.

Furthermore, our estimate for Crested Auklets falls at the low end of the range given by Kenyon and Brooks, whereas the number for Least Auklets is near the top of the range. The latter seems to be explainable in terms of the differences in techniques, because the process of extrapolating the average density of birds on their habitat to the total amount of habitat should yield an estimate higher than would pure visual impression. Other investigators have noted historical decreases in the number of Crested Auklets on Saint Lawrence Island, the Pribilofs, and the Outer Aleutians. Thus the evidence is that the number of Crested Auklets has probably declined.

The 1977 Reproductive Season.

Although the breakup of the sea ice was late in 1977 and so was the arrival of nesting birds, breeding schedule and success did not seem to have been affected by the late start.

Kittiwakes at Little Diomede appear to have had a good reproductive year as compared to the performance of kittiwakes in other areas in the northern Bering Sea region, although our data at Little Diomede do not tell us how many young fledged. From what we can tell, the murres did at least better than the general failure we observed during 1976. Horned Puffins at the island during 1977 appear to have done no worse than puffins appeared to do at other seabird colonies (Reports at the workshop on puffins, Pacific Seabird Group Meeting, January, 1978).

Feeding ecology as it applies to Bering Sea seabirds.

Observations in Alaska and in northern Siberia emphasize the point that the food items of seabirds conform to categories of (a) form,

(b) abundance, and presumably (c) behavior. The food species used in different areas in the same year vary, and those used in the same area between years vary as well. Moreover, in 1976 murres and kittiwakes experienced poor reproductive success from Norton Sound to Cape Thompson which we suggested may have resulted from a shortage of a critical food resource. These facts illustrate that the distribution and reproductive success of seabirds are linked closely to their feeding ecology. In the following discussion, we will try to show how theory about feeding strategies applies to our studies, and to point the direction for future work.

A. Theoretical Framework

The theory developed from observations of rigid patterns of courtship behavior, from the work of students of simple predatory behavior among shrews (Holling 1968) and raptors (L. Tinbergen 1943) and from 'Game Theory', is that stereotyped actions and search patterns are combined through individual experience into a pattern of feeding behavior which will maximize the ratio of the food used to the energy expended (Royama 1966).

In the first case, Luuk Tinbergen's study of the interactions between European Sparrow Hawk (*Accipiter nisus*) and House Sparrows (*Passer domesticus*), Chaffinches (*Fringilla coelebs*), Great Tits (*Parus major*) and Coal Tits (*Parus ater*) indicate that the predator species has species-specific hunting techniques and each individual develops routes along which it hunts. The behavior of certain potential prey species makes them more (House Sparrows) or less (Coal Tits) vulnerable to the hunting techniques and routes used.

Therefore, we doubt that there are many deterministic interspecific interactions between species on different trophic 'levels'. But we can predict certain types of probablistic interactions which"integrate" the "specific search image" with abundance and with a factor that represents cost/benefit ratio of energy expended to energy gained. There are also generalizations based on the observations that predators are prudent (whether sea gulls or Wall Street financiers) to keep a 'mixed portfolio'. Predators can be expected to use several species as prey, to search over several different habitats (habitats defined by the habitats used by the prey species) and to move among several geographic regions. One can expect these patterns to be expressed over both space and time.

In order to investigate the feeding techniques of seabirds in our area, we need to observe how far and in what directions seabirds go to feed, how long they spend and what they do while they are feeding.

In the second case, T. Royama's study of changes in prey of Great Tits (1966) showed that efficiency of effort plays an important part in the feeding 'strategies' of birds. Royama observed that parent Great Tits feeding themselves and their young used strategies that 'integrated' abundance and size of the prey items taken. They might feed themselves or take to their nest small caterpillars when their young were small, but as the young grew the parents fed on the small items themselves and carried only larger items back to feed their nestlings. When the young fledged, the parents used smaller, more abundant, prey again, 'because' the young accompanied them on feeding forays.

One presumes that the early departure of murre chicks, at about 18 days, facilitates the murre parents' problems by shortening the distance that food must be carried. Our observations that parent murres bringing food to the cliffs, when they cannot find their young often drop the prey instead of eating it, suggests that the parent had fed to satiation before bringing the food item in.

In order to investigate this aspect of feeding, which must have an important impact on breeding success when large prey items are rare, we need to observe what foods seabirds feed on themselves at sea and how these items compare with what they bring to their young.

In the third case, Pearson (1968) described spatial segregation of seabirds feeding off the Farne Islands, Northumberland, England, suggesting that distances flown before the birds began to feed provided an important mechanism for avoiding competition for food despite the fact that several species were feeding on the same prey (Ammodytes). Cody (1972) expanded similar ideas suggesting that spatial segregation was a general rule for the seabirds off the coast of California in the United States. Lack (1966) described spatial segregation and distances flown as parts of a balanced set of social and ecological adaptations by which seabirds partition available resources. Ashmole (1963) described sets of similar feeding techniques among coexisting seabirds in tropical Pacific waters as means of avoiding competition.

The assumptions underlying all these models are attributable to Gauss's deterministic models based on closed laboratory cultures of Paramecium. The conclusions which he drew and described mathematically have, of course, become virtual ecological dogma (as wryly observed by Slobodkin (1960)). Reports of the feeding techniques and prey items used by northern seabirds present a less clear picture than the models might predict. Lack suggested that this blurring of the rules might result from the birds using superabundant resources because their numbers are regulated by factors in operation in other parts of their ranges or at other times of year.

B. Significance to Studies of Alaskan Seabirds.

Specifically, published and unpublished reports show that murres, kittiwakes and puffins use markedly different foods in different parts of their geographic ranges (Table 11). In some cases the total list of species is the same but a species that is a major food item in one place is virtually unused in another (Table 12 compares the Murman Coast with Novaya Zemlaya). In another case, Black-legged Kittiwakes in Alaska, while several species seem to be used as general maintenance, the abundance of one single species, *Ammodytes hexapterus*, was necessary for outstanding breeding success. In the Pribilof Islands, where Sand Launce does not seem to have 'epidemics' and there is a rich variety of other prey species, the kittiwakes do moderately well every year, but do not seem to have boom years and have not been reported as raising more than a single chick. In the northern Bering Sea and southern Chukchi Sea, though in some years 95% of parents fail, in other years a significant percentage of parents raise two young.

In order to investigate this phenomenon we should study the food at different places, such as Cape Lisburne/Cape Thompson, Little Diomede Island/King Island, Saint Lawrence Island, Saint George/Saint Paul, Cape Newenham region, Kodiak Island region. The studies should include 'good' and 'bad'years and just different years in the same place.

Table 11. Food of murres and kittiwakes in the Bering Sea and Chukchi Sea, showing variation among regions and between years.

Food of Murres (after Searing, NOAA 1978)

	% occurrence of:	
Locality	fish	crustacea
Bristol Bay[1]	44	40
Pribilof Is.[2]	49	51
Saint Lawrence Is.[3]	33	72
Cape Thompson[4]	74	25

Food of Murres and Kittiwakes, Cape Thompson

Percent occurrence in stomachs with any contents:

	1960[4]		1976[5]	
	% invertebrate	% fish	% invertebrate	% fish
Thick-billed Murre	34	64	78	76
Common Murre	6	96	33	92
Black-legged Kittiwake	25	91	53	67

Sources:

1. Ogi & Tsujita (1973)
2. Preble & McAtee (1923)
3. Searing (NOAA 1978)
4. Schwartz (1960)
5. Springer & Roseneau (NOAA 1978)

Table 12. Food of Murres, Puffins and Kittiwakes on the north Siberian coast showing variation in species of fish used among regions (percent occurence).*

Thick-billed Murre	Kharlov Island to East Murman Coast[1]	Bezymyannaya Inlet, Novaya Zemlya[2]
(fish species)		
Ammodytes tobyanus (Sand Launce)	23.1	0.9
Mallotus villosus (Capelin)	17.9	1.7
Clupea harengus (Common Herring)	38.5	0.6
Gadus morrhua (Common Cod)	20.5	44.3
Boreogadus saida (Arctic Cod)	--	51.3
Gymnelis viridis (Ocean Pout)	--	0.9
Myoxcephalus scorpius (Sculpin)	--	0.3

Atlantic Puffin	Seven Islands East Murman Coast[3]	Ainovy Islands West Murman Coast[4]
Ammodytes tobyanus	56.8	6.3
Mallotus villosus	21.0	43.7
Clupea harengus	19.7	50.0
Gadus morrhua	2.5	--
Black-legged Kittiwake		
Fish	70.9	59.0
Mollusks	12.1	9.8
Crustacea	7.8	31.2

* Data from Belopol'skii (1957), and Uspenski (1956).

Data from: [1] 111 stomachs
[2] 314 stomachs
[3] 100 stomachs
[4] 39 stomachs

In the last two cases there must be some selective response or 'perceived availability' on the part of the predator. (The foods are observed to be different although the same prey species are all recorded as present.) The fishes brought by the birds are often different from those recorded in samples of fish taken by fishermen. For example, in Norton Sound, Barton (NOAA 1978) reported the common fish taken in gill nets, and beach seines. Sand Launce was the most numerous fish in the beach seine hauls and is a major food item of kittiwakes and puffins. The other abundant fishes in the gill net and beach seine hauls, however, Saffron Cod, *Eleginus gracilis*, Bering Cisco, *Coregonus laurettae*, Least Cisco, *Coregonus sardinella*, Rainbow Smelt, *Osmerus mordax*, were very rarely included in the samples of fish which we have from the bird cliffs. The fishes that were most numerous in the ground surveys, Arctic Char *Salvelinus alpinus*, six other species of salmon and whitefish, Starry Flounder, *Platichthyes stellatus*, were also seldom represented except for minor but regular representation of juvenile salmon. In contrast, the most important food fish brought by the most abundant bird species -- Common Murres -- was Prickle-back, *Lumpenus fabricii*, a species not represented in nets and seines although it was reported by 'scuba' divers as being among the common fish which they saw (Cottids, Stichaeids, Gadids, and Agonids).

It is evident that there are major differences between the food species used in different parts of the same species range. There also appears to be an important and consistent, though more subtle, set of differences in food species and abundances even within a relatively unified geographic unit such as the Bering Strait in the broad sense (from

Table 13. Comparison of seabird numbers at colonies in the Bering Strait region.

	Kittiwakes	Murres	Percent Thick-billed Murres	Parakeet Auklets	Crested Auklets	Least Auklets	Horned Puffins	Tufted Puffins
Cape Lisburne	15,000-25,000	200,000	70				1500-2000	
Cape Thompson	10,500-20,000	200,000	50				2000	
Cape Lewis	3500	25,000	50				300	
Little Diomede Is.	35,000	60,000	60	15,000	135,000	1,000,000	10,000-25,000	1000
King Island	4000-6000	75,000	50	35,000	35,000	85,000	10,000	1000
Sledge Island	1000	2000-3000	15	100			200	6
Bluff Cliffs	6000-7000	50,000	<1	50			2000	25
Square Rock	1000	6000					400	6
Cape Denbigh	1800	10,000-15,000	<1	5			150	
Egg Island	500	2000	<1	5			150	
Saint Lawrence Is.[1]								
Savoonga area East	10,000	75,000		35,000	225,000	150,000	3000	
West	15,000	120,000		15,000	40,000	65,000	3000	
Gambell area				2000	75,000	110,000	1500	500
Southwest Capes	15,000	120,000		12,000-18,000	190,000	350,000	1500	750
Totals	125,000-150,000	985,000-1,200,000		85,000-100,000	700,000	1,760,000	50,000	3250

Total Birds - 3,725,000 (excluding Big Diomede Is. and the coast of Siberia)

[1] data from Bedard (1969) and Searing (NOAA 1978).

Cape Lisburne to Saint Lawrence Islands). This more subtle effect is reflected in differences in proportions among the species of seabirds (Table 13). There is, first, the change in proportion of Thick-billed Murres to Common Murres from 75% Thick-billed at Cape Lisburne to 60% at Little Diomede, and 50% at King Island to 15% at Sledge Island and less than 1% at Bluff Cliffs and Cape Denbigh. There is, second, a change in the number of kittiwakes as a percentage of the number of murres from 60% at Little Diomede and 40% at Sledge Island, to 6% at King Island, 10% at Capes Lisburne and Thompson, 13% at Bluff Cliffs, 16% at Square Rock, 15% at Cape Denbigh and 25% at Egg Island, suggesting a relatively uniform relation of about 10%-20% except for the sharp contrast between Little Diomede and Sledge as compared to King Island. There is, third, approximately the same number of Least and Crested Auklets on Saint Lawrence Island, but the Least Auklets become many times more numerous at King Island and especially at Little Diomede.

Needs for Further Study

A. Little Diomede Island.

There is a limited number of study sites for murres and kittiwakes which are accessible to us but are not disturbed by Eskimo food gathering. Thus it appears that the island does not have much to recommend it *per se* as a site for detailed, continuing studies. Yet the island is a critically important seabird colony and lies on the major route for heavy ship traffic between industrial development on the North Slope and "Outside". It will therefore be exposed to maximum hazards from transportation, and should have future work done on it for that reason.

This further work on the island should be undertaken to specify annual and seasonal variations in the numbers of kittiwakes, murres, puffins and the annual variation in reproductive success of kittiwakes and murres.

There is general need to develop techniques for estimating the breeding populations of the three species of auklets and methods for measuring their reproductive success. But because their numbers are so large and that even a small percentage error means a difference of a large number of birds, it is unlikely that the auklets will be really useful for quantitative measures of environmental impacts. On the other hand, auklets are conspicuous species and endemic species and as such deserve reasonable care in monitoring their populations because of public interest in them.

B. The Bering Strait region in general.

The most important next steps in the study of the area involve work at sea, first to define more precisely those areas of the Chirikov Basin and southern Chukchi Sea which are used by the birds for feeding grounds; second, to establish what foods are used and how do the foods used vary seasonally and regionally, i.e., what are the primary resources, secondary resources and resources of last resort.

For an adequate understanding of the populations, biogeography or trophic structure of the Bering Strait region, we need at least a survey (second hand if necessary) of 1) the seabird colonies on the Siberian Coast between the north limit of the Gulf of Anadyr and the coast north of Mys Dezhneva; and 2) the feeding areas between the International Date Line and the Siberian mainland.

ANNUAL REPORT

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ECOLOGICAL STUDIES OF COLONIAL SEABIRDS AT CAPE THOMPSON AND CAPE LISBURNE, ALASKA

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CONTENTS

LIST OF TABLES

LIST OF FIGURES

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

A. Objectives

The objective of this study is to provide current information on the ecology of seabirds nesting at Cape Thompson and at Cape Lisburne. The data obtained at Cape Thompson will be compared to recent historical studies in an attempt to describe "predevelopment" changes which may have occurred. Investigations at Cape Lisburne will further increase our understanding of seabird biology in the Chukchi Sea. By broadening the ecological data base, effects of resource development in this region may be more accurately measured.

B. Conslusions

1. Approximately equal numbers of murres occupy the cliffs at Cape Thompson and Cape Lisburne.

2. The number of murres which were counted at Cape Thompson in 1976 and 1977 were essentially the same and were significantly lower than number reported for the early 1960's. The cause of the decrease in not understood.

3. Results of food habit studies indicate that major differences exist between the trophic positions of Common and Thick-billed Murres. The results also suggest that annual and seasonal variations occur in the food base of murres at Cape Thompson and Cape Lisburne.

4. The foraging radii of murres may be large and may change yearly and/or seasonally. Murres, however, also appear to exhibit a tendency to heavily utilize an area to the south and southwest of Cape Thompson and an area to the northeast and north of Cape Lisburne.

5. Food habit studies of kittiwakes reflect yearly and seasonal variability in prey. Variations in kittiwake productivity between years and between colonies might be related to the food differences.

6. Because food availability changes between years and because particular prey appear to be more important in one season than in another, we can not list specific single critical links in the food chain of murres or kittiwakes. Prey which are probably of major importance, 'on the average', however, are cod, sculpin, Sand Launce and shrimp.

7. Populations of other seabird species inhabiting the Cape Thompson colonies appear to be essentially the same now as in 1960.

C. Implications with respect to OCS oil and gas development

The colonies at Cape Thompson and Cape Lisburne support most of the breeding seabirds in the eastern Chukchi Sea. The birds constitute a major component of the ecosystem in this region. Perturbations of the environment by resource development in the Hope Basin could threaten the health and stability of these seabird populations.

The birds nesting at Cape Thompson, Cape Lisburne and Cape Lewis could be threatened by OCS development in several ways. Murres concentrate in leads in the sea ice during spring and early summer. Breeding activities begin long before the ice has broken up or gone out from shore and the only open water available to the birds is in leads. If these leads were contaminated by spilled oil, large numbers of birds would be affected.

Currents originating south of the Bering Strait could bring spilled oil through feeding areas and into nearshore regions at Cape Thompson, Cape Lisburne and Cape Lewis. Spills south or west of Cape Thompson, Cape Lisburne and Cape Lewis would be driven closer to these colonies or onto their beaches by prevaling southerly and westerly winds. High velocity northerly winds, also prevalent in the area, could, on the other hand, prevent oil from reaching the colonies themselves if all conditions were right. Because of the currents and wind patterns in the region, however, floating oil will almost certainly impinge upon foraging areas whether or not it actually reaches the coastline.

At Cape Thompson floating oil orginating from spills in the northern Bering Strait or southern Chukchi Sea may offer the greatest potential danger to the colony. At Cape Lisburne floating oil orginating offshore of the Cape Thompson-Point Hope vicinity or originating some distance northward of Cape Lisburne may offer the greatest potential danger to this colony, since it may enter the large clockwise gyre north and east of the colony where foraging birds are generally present.

The Cape Thompson colonies also are located at a point potentially attractive for use during exploration activities, and more importantly, for the construction of a major marine terminal. The construction of a terminal facility could be harmful to the seabird populations nesting there. Increased human activity could cause a variety of disturbances that may adversely influence the reproductive success of several species.

II. INTRODUCTION

A. General nature and scope of study

The sea cliffs at Cape Thompson and Cape Lisburne provide nesting habitat for nine species of seabirds, three species of raptors and ravens. The colonies at these sites contain the largest concentrations of murres and kittiwakes in the eastern Chukchi Sea and are the northernmost colonies in western North America.

Prior to the present study the only formal investigation of seabirds nesting in this region was made at Cape Thompson during Project Chariot between 1959 and 1961. Information obtained by Swartz (1966; 1967) during the early 1960's at Cape Thompson has provided a sound base upon which we can build in an attempt to bridge gaps in our knowledge of seabird ecology within this region of Alaska.

B. Specific Objectives

The specific objectives of this study are to:

1. Determine the numbers of cliff-nesting seabirds breeding at the Cape Thompson and Cape Lisburne colonies;

2. Determine the phenology of breeding activities and reproductive success of these birds;

3. Obtain data on food habits and foraging areas of the principal species in these colonies;

4. Expand the ecological data base of the Cape Thompson and Cape Lisburne region.

C. Relevance to problems of petroleum development

The Hope Basin is subject to lease sales to allow oil and gas exploration and development. Within this part of the Chukchi Sea exist areas critical to the success of several species of seabirds. The birds are not randomly distributed throughout the region but are concentrated at breeding colonies and feeding areas. This clumped distribution makes them particularly susceptible to oil pollution and to habitat alteration.

The weather and climate, oceanography, topography and geology of the Lisburne Peninsula were studied specifically by Allen and Weedfall (1966), Kachadoorian (1966), Campbell (1966), Flemming and Heggarty (1966) and Creager and McManus (1966) during 1959-1961. Several aspects of these studies, as they related to the region's seabirds, were discussed briefly by Swartz (1966; 1967). Swartz (1966) also briefly described sea ice cover near the Cape Thompson seabird colonies.

Certain information presented by the investigators listed above has been extracted, summarized and freely incorporated here with certain of our 1976-1977 observations. Particular emphasis is placed on those environmental aspects that strongly influence the Cape Thompson-Cape Lisburne seabird habitat, and which would play major roles in the various interactions which could occur between this habitat and eventual Outer

Continental Shelf oil and gas exploration and development in the Chukchi Sea.

Sea ice is an important aspect of the Cape Thompson-Cape Lisburne seabird habitat. By February open water is greatly restricted throughout the region. The Bering Sea current flowing northward through the Chukchi Sea and the region's winter air mass circulation and high velocity surface winds, however, combine to assure that some open water is present all winter. A large persistant but dynamic lead system extends from the Bering Strait northeastward toward Cape Thompson where it then swings northward past Point Hope (Shapiro pers. comm; Barry _et al_ 1977). A review of 1975-1977 ERTS satelite imagery also reveals the presence of two persistant, large open polynya; one extends south and west of Cape Lisburne and another lies somewhat farther offshore opposite Cape Thompson (Barry _et al_ 1977).

Sea ice generally begins to break up in the region by about mid-June and is well broken up by late June. In the Cape Thompson area, shorefast ice generally persists the longest where it adheres to either side of the Point Hope spit. Shorefast ice also persists in the embayment between Point Hope and Kivalina and this ice zone is often several kilometers wide.

In the Cape Lisburne area, shorefast ice similarly persists along the north-facing coast, east of Alokut Point.

Wind and ocean currents influence the movement of the broken decomposing ice. In the Cape Thompson area, southerly and westerly winds and ocean currents cause the wide band of broken ice to be retained along the shoreline south of Point Hope well through the second week, and often the third week of July. In 1959-1961 this ice was well broken up "and going" by 7 July (Swartz pers. comm.). In 1976, ice in the embayment was well broken up and dissipating by 20 July and was last observed on 29 July. In 1977 the ice was well broken up by about 10-12 July and was gone by 22 July.

In the Cape Lisburne area, northerly winds and a large current eddy cause a several kilometer-wide band of broken ice to be retained along the north coast well through the third week of July. In 1977 the ice was well broken up by 19 July and the last ice was observed on 25 July.

Open, icefree water generally exists well through October in the Cape Thompson area. By the last week in October ice is generally present again north of Cape Lisburne, and during November ice cover begins to build in the Cape Thompson area.

Recent OCSEAP studies have produced evidence that winter-spilled oil may lie "dormant" underneath sea ice. While trapped under the ice, petroleum undergoes less weathering and retains its toxicity longer than it does when exposed to the atmosphere and to sunlight. Such oil also migrates upward through the ice and can become entrapped for long periods of time (Beaufort Sea Synthesis Meeting, Pt. Barrow, 7-11 February 1977). In addition to becoming a unique long-term source of chronic pollution, oil which has been trapped in or under the ice could appear in leads near rookeries or in critical feeding areas. Leads are important to murres and to other seabirds because they represent the only open water available for courtship and for winter and spring feeding. Oil filled leads and ice edges coated with oil would reduce the extent of already limited habitat and would present a direct danger to birds concentrated there.

The eastern Chukchi Sea is dominated by a strong northward, predominantly barotropic current flow entering it through Bering Strait. Current speeds in the summer are higher than in the winter and the currents closely parallel the isobaths. Assuming an average speed of 0.5 knots, water passing through Bering Strait would reach the latitude of Point Hope in about 15 days.

Currents, after passing Cape Prince of Wales, tend to turn eastward. Water flow tends to enter Kotzebue Sound along the southern entrance and leave it along the northern edge near Cape Krusenstern. Offshore in the large embayment between the Seward Peninsula and the Point Hope-Cape Thompson region, currents appear more diffuse but the trend in flow is northeast toward the Kivalina-Cape Thompson coast. The northeastward surface current flow was illustrated in 1976 and 1977 by floating walrus carcasses. These carcasses, which undoubtedly originated from hunting activities in the Little Diomede Island-Cape Prince of Wales-Shishmaref region, were deposited on beaches between Cape Krusenstern and Point Hope. Maximum concentration appeared to occur from about Kivalina to Point Hope.

An important discontinuity between offshore and coastal waters exists. This becomes most striking in the Cape Thompson-Point Hope vicinity. Slowly moving nearshore waters flow predominantly northwestward and parallel to the Kivalina-Cape Thompson coast. Offshore waters flowing generally parallel to the coast but at faster speeds and in a more northerly direction converge toward Point Hope. This discontinuity between coastal and offshore waters is evident in late June - mid July from the Cape Thompson cliff tops when ice floes are present. A small, weak back-eddy effect also is often present close to shore between Point Hope and the Kismilok Mountain vicinity, particularly when a north or northwesterly wind is blowing.

Currents flowing past points and islands are modified. Current flow accelerates toward Point Hope in the Cape Thompson area. North of Point Hope current flow slows and a large clockwise eddy is created downstream of this spit. Farther north, the current accelerates past Cape Lisburne. A somewhat stronger, larger gyre effect appears to be present north of this prominent coastal feature. This large clock-wise eddie is created by the prominent westward projection of the Lisburne Peninsula. A smaller, more localized clock-wise eddy is created by Cape Lisburne itself. Both the large-scale and the smaller more local eddy effects are evident during breakup when ice floes are present. North and easterly winds enhance these clock-wise flows. Near the cliffs water and ice are carried around the Cape to the south.

A weak gyre effect also may occur offshore of the Shishmaref-Cape Espenburg area, a result of eddying currents created by Bering Strait water flowing past Cape Prince of Wales.

The airmass circulation and the winds of the Cape Thompson region tend to be stronger in the winter than in the summer. Variability increases in the summer months and monthly parameters in one year may not correspond to values obtained in other years.

In general, the Cape Thompson-Cape Lisburne region experiences more wind than most other parts of Alaska. The wind tends to blow more frequently from a northerly direction except during the period May-August when southerly winds occur slightly more often. North winds generally persist longer than south winds and have a higher velocity. During the summers of 1976 and 1977 the general pattern of variable strong on-shore winds and storms, interspersed by occasional but often violent high velocity northern winds blowing offshore was the rule.

Southerly winds and storm cells moving northward through Bering Strait create longshore and onshore swells. If southerly winds associated with a storm cell persist for a day or two after sea ice is gone, surf commonly builds to over one, and often over two meters in height along all westerly-facing coastline. Southerly storms associated with rough seas and high surf may occasionally persist for up to a week, but generally do not persist as long as the northerly winds. During southerly storms, the Cape Thompson cliffs and the Cape Lisburne cliffs south of Alokut Point are exposed to the full force of these winds and the accompanying waves which may break several meters up them. This condition (southerly, changing to westerly winds as storms move up through the Chukchi Sea) is prevalent enough to 'build' and terrace the beaches once the ice dissipates in mid to late July.

The high velocity northerly surface winds, characteristic of the region, are influenced by the terrain. The Lisburne and Kemegrak hills channel these strong winds over the full length of the Cape Thompson cliffs and over the Cape Lisburne cliffs which lie south of Alokut Point, while the portion of the Cape Lisburne colony situated to the east of the Cape is exposed to their full force. These northerly winds commonly (1976-1977) reach speeds of 40-50 knots, and at Cape Thompson in 1976, an aircraft indicated about 75 knot gusts during one storm. Wind speeds are generally greater near the cliff-tops. Velocities of downdrafts created by the presence of the high seacliffs may easily reach or even exceed 100 knots. During moderate to strong southerly winds, a similar effect is created on the north side of the Cape Lisburne cliffs. During such winds the Cape Lisburne Air Force Base runway is closed to landing and departing aircraft. The violence of downdrafts and extreme turbulence is believed to be responsible for fatally flipping a large military transport aircraft into the sea near Cape Lisburne shortly after take off several years ago. We have observed murres, approaching the cliffs at altitudes of at least 50 meters, driven almost straight down into the sea, and during more moderate conditions, stall out when entering what must be bubbles of very low pressure. Swirling water spouts and plumes of water up to an estimated 30 meters high were common occurrences at the base of the cliffs and for up to one kilometer offshore. This phenomemon also occurs, though less spectacularly, along the Telavirak Hills, a few kilometers downcoast from Ogotoruk Creek.

Prudhoe Bay bound barge traffic passes through the foraging zones of seabirds nesting at Cape Thompson and Cape Lisburne. Future barge and tanker traffic will likely follow similar shipping lanes. During spring and early summer ice breaker type tanker traffic will probably follow the major Bering Stait-Chukchi Sea-Point Barrow lead system (see Barry et al. 1977).

Fuel from chronic leaks and bilge waste will become more common in the Chukchi Sea as marine transportation increases. Major oil spills, originating in the northern Bering Sea or the southeastern Chukchi Sea could be transported into the vicinities of the Cape Thompson, Cape Lisburne and Cape Lewis seabird colonies by ocean currents and wind.

Spills well to the south of Cape Thompson would be carried northward through the Bering Strait and northeasterly toward the Point Hope area by the prevailing current pattern. Oil would flow through foraging areas as it was carried towards Cape Thompson by those currents. Strong southwesterly winds, characteristic of the ice-free summer and fall months, could easily drive oil ashore between Cape Krusenstern and Point Hope.

Residues of distant spills or oil from spills originating nearer the latitude of Cape Thompson could be carried far to the north past Cape Lisburne and toward feeding grounds of this colony. Southwesterly and westerly winds also could drive oil ashore between Point Hope and Cape Lisburne.

Oil carried northward in the current flow, could become entrapped in the slower more complex currents lying off of the entrance to Kotzebue Sound; in the weak back-eddy south of Point Hope along the Cape Thompson colonies; in the stronger eddy lying north of the Point Hope spit; or in the large clockwise gyre located northeast of Cape Lisburne. Oil slowed or entrapped in the complex currents west and north of Kotzebue Sound would be circulated through a large area believed to be important foraging grounds of seabirds nesting at Cape Thompson. Similarly, oil carried into the large gyre north of Cape Lisburne would be circulated through an area which appears to include the major foraging grounds of the seabirds nesting at Cape Lisburne. These patterns of current flow would tend to prolong the presence of oil in areas essential to these large seabird colonies. Both feeding seabirds and food-web organisms, therefore, would be exposed to the direct effects of oil for a longer period of time.

If oil were driven ashore along the Cape Thompson coastline or along the coastline east of Cape Lisburne it could not only pose a problem by becoming engrained in the beach sediments, but also could contaminate the lagoon systems. Once in these lagoons, the 'building' nature of the beaches would inhibit the return of oil into the open sea and would result in long term pollution. The lagoons are important to seabirds, especially to Black-legged Kittiwakes and Glaucous Gulls as well as to waterfowl and shorebirds.

The severe storms which occur frequently during the ice-free months would make containment and cleanup operations difficult, if not impossible in the Cape Thompson-Cape Lisburne region. During these storms aircraft are often unable to land at either site and the combination of high winds and rough seas make the success of boat-based operations very doubtful.

Shore-based operations associated with OCS oil and gas exploration and development in the Hope Basin also are potential sources of conflict between people and the seabirds nesting in the Cape Thompson-Cape Lisburne vicinities. The Project Chariot site at the mouth of Ogotoruk Creek is only about 1.6 kilometers downcoast from the first of the five Cape Thompson seabird colonies. The site has been proposed as a possible marine terminal location (M. Halebsky, Global Marine Development Inc., pers. comm.). The deeper nearshore waters off of Ogotoruk Creek made this location an attractive choice. The still existent but abandoned airstrips just north of the creek mouth would be convenient for some exploration activities.

Large permanent facilities constructed so close to the Cape Thompson nesting cliffs could have adverse effects on seabird populations. Various forms of direct disturbance to the birds which nest on the relatively unstable cliffs may be of greatest concern. Any activities that could persistantly flush birds from the cliffs should be avoided. Although few data, particularly quantified data, concerning the effects of many forms of disturbance exist, we would recommend that aircraft approach and departure patterns be carefully regulated. Besides the possibility of egg loss and interruption of normal nesting behavior, large aircraft and helicopters operating near to these colonies could increase the amount of rock-fall, an important source of natural mortality at these colonies.

Tanker terminals or gathering facilities immediately adjacent to the Cape Thompson colonies could increase the likelihood of oil spills and could be sources of smaller but chronic petroleum pollution. Causeways and above surface structures could conflict with the foraging flocks returning to the cliffs particularly on foggy days. Murres fly to and from the colonies at speeds of about 50 mph (Swartz 1967), however, they exhibit poor manuverability and require relatively large turning radii. Collisions on foggy days when flights are concentrated along the beach lines are possible.

Air traffic to and from a terminal site could increase the disturbance near the colony. At Cape Lisburne we have an excellent opportunity to study that possibility. Air traffic at the Air Force Station consists of several small aircraft and at least one larger (C-130, DC-6 or Electra) aircraft per week. Almost all departures and approaches occur in front of the north-facing portion of the seabird colony and many thousands of murres and kittiwakes are usually flushed from the cliffs. The effects on productivity of murres nesting on the north shore are as yet unknown. Chicks are produced by those birds but the production might not be as great as on the west shore where aircraft disturbance is less.

A particularly strong correlation exist between human activity and the accumulation of refuse. Garbage dumps frequently attract scavengers which are generally facultative scavengers-predators, for example gulls, Ravens and foxes. At Cape Lisburne where a sizable garbage dump exists, we have not observed uncommonly high numbers of gulls or Ravens (for example, no more than at Cape Thompson) and have not seen any foxes. Ravens and Arctic Foxes are frequent at the site during the winter but the facility does not appear to act like a magnet on them during the summer.

We must stress, however, that many activities associated with OCS oil and gas exploration and development are potential sources of impact and conflict. Real situations may, in fact, pose new problems or may not pose problems to the degree originally suspected. All activities near seabird colonies, however, should be approached with caution and the effects of possible perturbations should be investigated fully.

III. CURRENT STATE OF KNOWLEDGE

Nine species of seabirds were found breeding at Cape Thompson in 1959-1961 (Swartz 1966). These were, in order of decreasing numbers, Thick-billed Murres (Uria lomvia), Common Murres (Uria aalge), Black-legged Kittiwakes (Rissa tridactyla), Horned Puffins (Fratercula corniculata), Glaucous Gulls (Larus hyperboreus), Tufted Puffins (Lunda cirrhata), Pelagic Cormorants (Phalacrocorax peligicus), Black Guillemots (Cepphus grylle) and Pigeon Guillemots (Cepphus columba). In addition to these species, Golden Eagles (Aquila chrysaetos), Gyrfalcons (Falco rusticolus), Peregrine Falcons (Falco peregrinus) and Ravens (Corvus corax) were found nesting in small numbers on the cliffs.

The majority of the birds are in the immediate vicinity of the sea cliffs from late April through mid-September. Nearly all of the nutrition which supports the colony is obtained from the sea and amounts to an estimated 13,000 metric tons per 130-day breeding season (Swartz 1966).

Swartz (1966) summarized the few references to the colonies which existed prior to his study. Those references and data we obtained at Cape Thompson and Cape Lisburne in 1976 were presented in our first annual report (see Springer and Roseneau 1977).

IV. STUDY AREA

The general locations of the Cape Thompson and Cape Lisburne seabird rookeries are illustrated in Figure 1. Detailed historical information on the environment of the Cape Thompson-Cape Lisburne regions and the seabird habitat at Cape Thompson can be found in Willimovsky and Wolfe (1966).

The Cape Thompson seabird habitat, originally described in detail by Swartz (1966) was also described briefly by Springer and Roseneau (1977). The Cape Lisburne seabird habitat, located about 88 km north of Cape Thompson, and areas nearby have not been adequately described prior to this report. For comparative purposes, some descriptive information pertaining to the Cape Thompson colonies will be repeated here.

The five distinct seabird colonies that occur at Cape Thompson are illustrated in Figure 2. These colonies comprise about 6.8 km of an approximate 11.4 km section of coastline between the southern end of Crowbill Point and the northern end of Imnakpak cliff. The colonies are separated by creek valleys, beaches and low bluffs varying from a few hundred meters to about 2.4 km in length. The colonies themselves occupy the higher more stable sedimentary cliffs formed by the southern terminus of the Kemegrak Hills.

Heights of the five colonies vary from about 9 meters to 185 meters above sea level. Colony 1 and Colony 4 are the smallest in approximate area and Colony 1 also offers the fewest ledges suitable to seabirds. Colony 2 and Colony 5 are the largest in approxiamte area, and Colony 3, the second highest, is most similar to Colony 5 and has an area approximately between that of colonies 1-4 and colonies 2-5.

While the five major cliffs supporting the five seabird colonies provide the most suitable nesting habitat, some sections of fractured low cliffs and bluffs between the colonies provide nesting habitat for occasional pairs of Glaucous Gulls and larger numbers of Horned Puffins. The most important habitat of this type, designated as Colony 0 lies

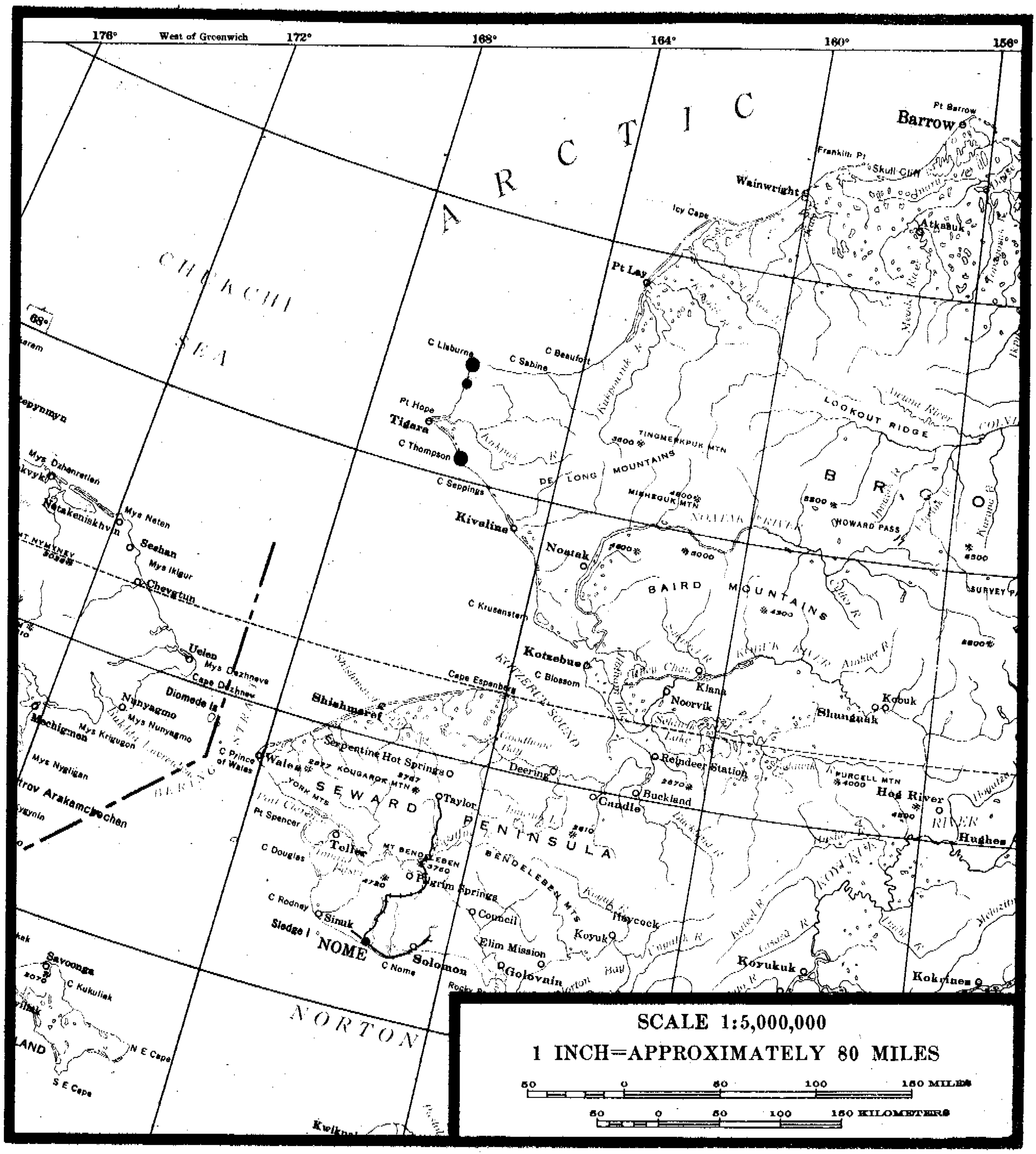


Figure 1. Locations of the Cape Thompson, Cape Lewis and Cape Lisburne seabird colonies.

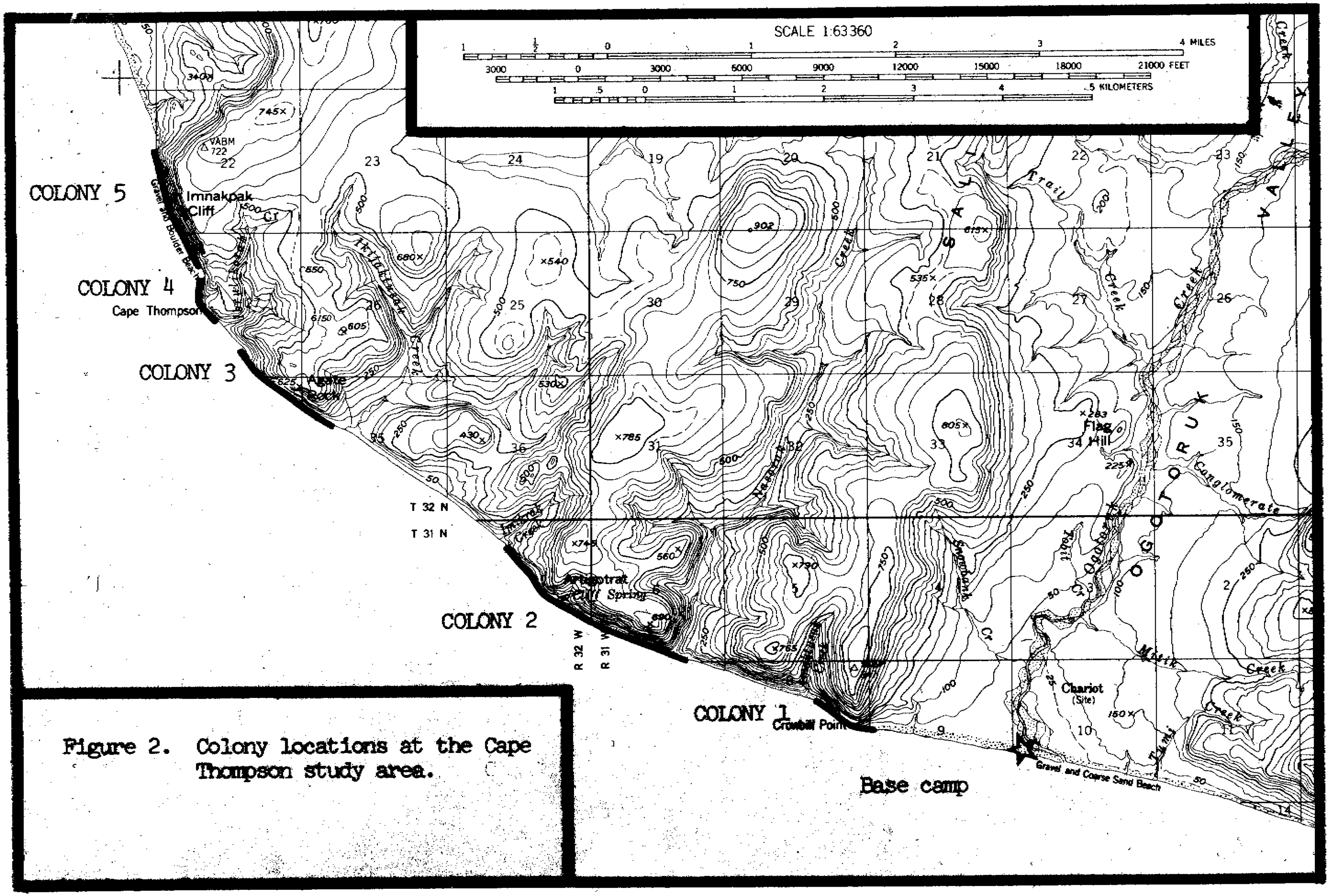


Figure 2. Colony locations at the Cape Thompson study area.

between Colonies 1 and 2.

Barrier beaches and lagoons occur both northwest (upcoast) and southeast (downcoast) of Cape Thompson. The basic physical characteristics of these lagoons and the zooplankton found in them have been described by Johnson (1966). Johnson (1966) discovered that these lagoons were, ". . . strikingly dissimilar ecologically." While all lagoons undoubtedly receive some utilization by kittiwakes and gulls, Akoviknak and Kemegrak lagoons just upcoast of Colony 5 appear to be the most important to flocks of resting and 'socializing' flocks of kittiwakes. The small lagoon formed by the natural closure of the Ogotoruk Creek mouth appears to be the preferred habitat for these activities downcoast of the colonies. Isuk, Agarak, Ikijaktusak and Nasorak creeks, though not as large as Ogotoruk Creek, offer additional important habitat to both kittiwakes and gulls. These lagoons and creeks, particularly Ogotoruk Creek, also are important sources of mud for kittiwakes during nest construction.

The seabird colony that occurs at Cape Lisburne is illustrated in Figure 3. This colony occupies a nearly continuous cliff briefly broken by three small creek valleys. The colony occupies approximately 7 km of coastline beginning at a point about 1.6 km west of the western boundary of the Cape Lisburne Air Force Base runway. From there it extends west around Cape Lisburne, then south to a point about 1 km south of Kay Creek. The cliff is the northern terminus of the higher, sedimentary Lisburne Hills. Height of the colony varies from about 15 meters to 200 meters above sea level; average height is about 125 meters.

While this major Cape Lisburne cliff series provides the most suitable nesting habitat to the seabirds, some sections of lower, fractured and less solid cliffs and bluffs to the south (downcoast) provide nesting habitat for puffins, occasional guillemots and a few pairs of gulls.

East (upcoast) of Cape Lisburne, the lagoon and barrier beaches at the mouth of Igrarok Creek and Ayugatak Creek, along with the larger Ayugatak lagoon provide important habitat to gulls and to this colony's flocks of resting, socializing and mud-gathering kittiwakes. The mouth of Setin Creek, at the east edge of the Cape Lisburne Air Force Base, may have provided some additional habitat to kittiwakes prior to the establishment of the site. South (downcoast) of Cape Lisburne, lagoons are not a prominent feature of the coastline until the Kukpuk River vicinity is reached. The mouths of Kay Creek and Niak Creek provide some important habitat for large groups of kittiwakes.

The seabird colony that occurs at Cape Lewis, approximately 18.5 km south of Cape Lisburne, is illustrated in Figure 4. This smaller colony occupies a relatively low cliff beginning at Cape Lewis that extends south approximately 1 km. Height of the colony varies from about 5 meters to 75 meters. Seabird utilization of the northern (upcoast) 0.2 km of this habitat is low. This section and cliffs to the north of the Cape itself provide some additional puffin nesting habitat.

Several other small seabird colonies occur along the Chukchi Sea coast between Cape Thompson and Cape Lisburne, and between Cape Lisburne and Thetis Creek. The locations of these colonies are illustrated in Figures 4 and 5. These colonies occupy small headlands that vary between about 5 and 45 meters high.

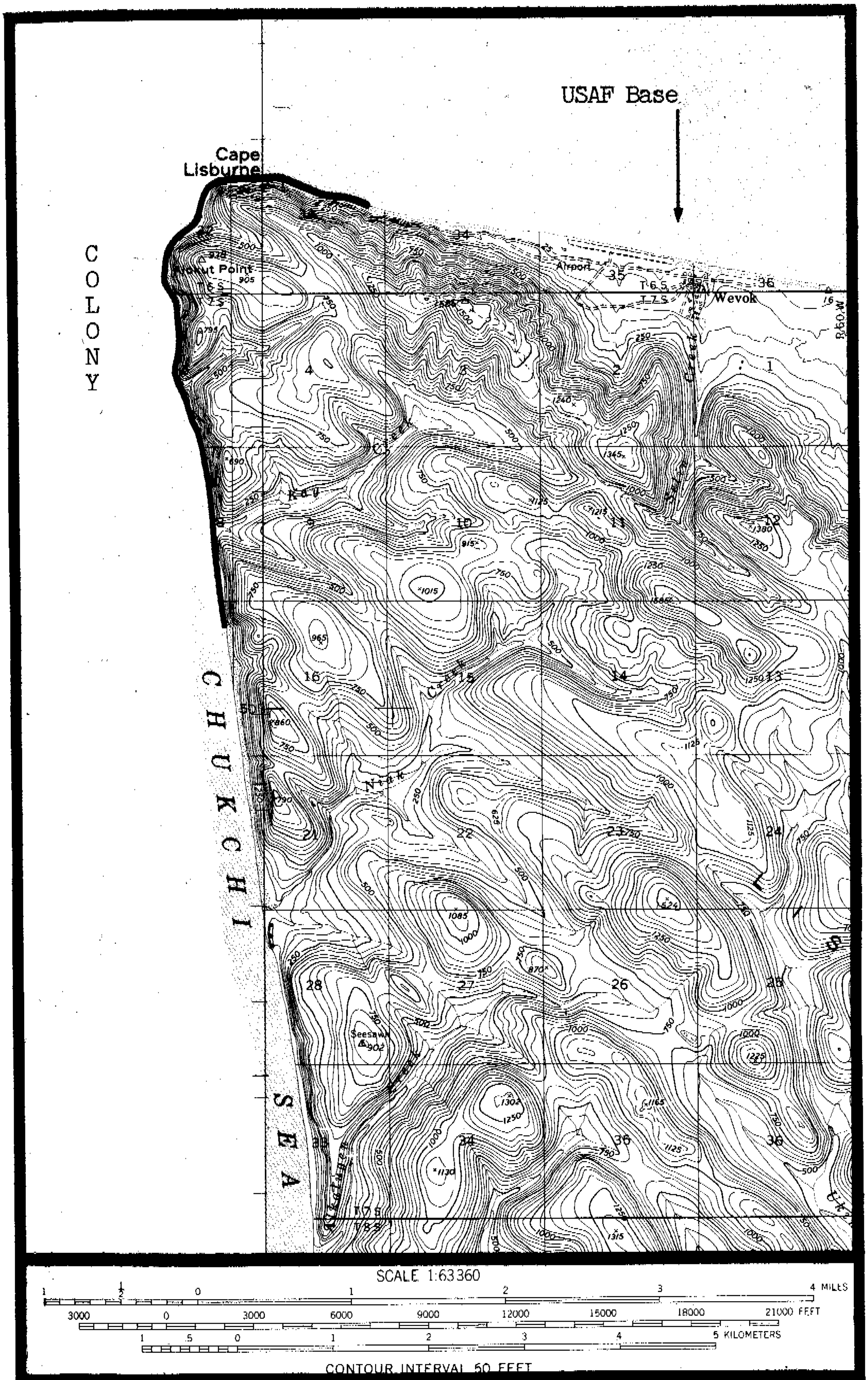


Figure 3. Colony location at the Cape Lisburne study area.

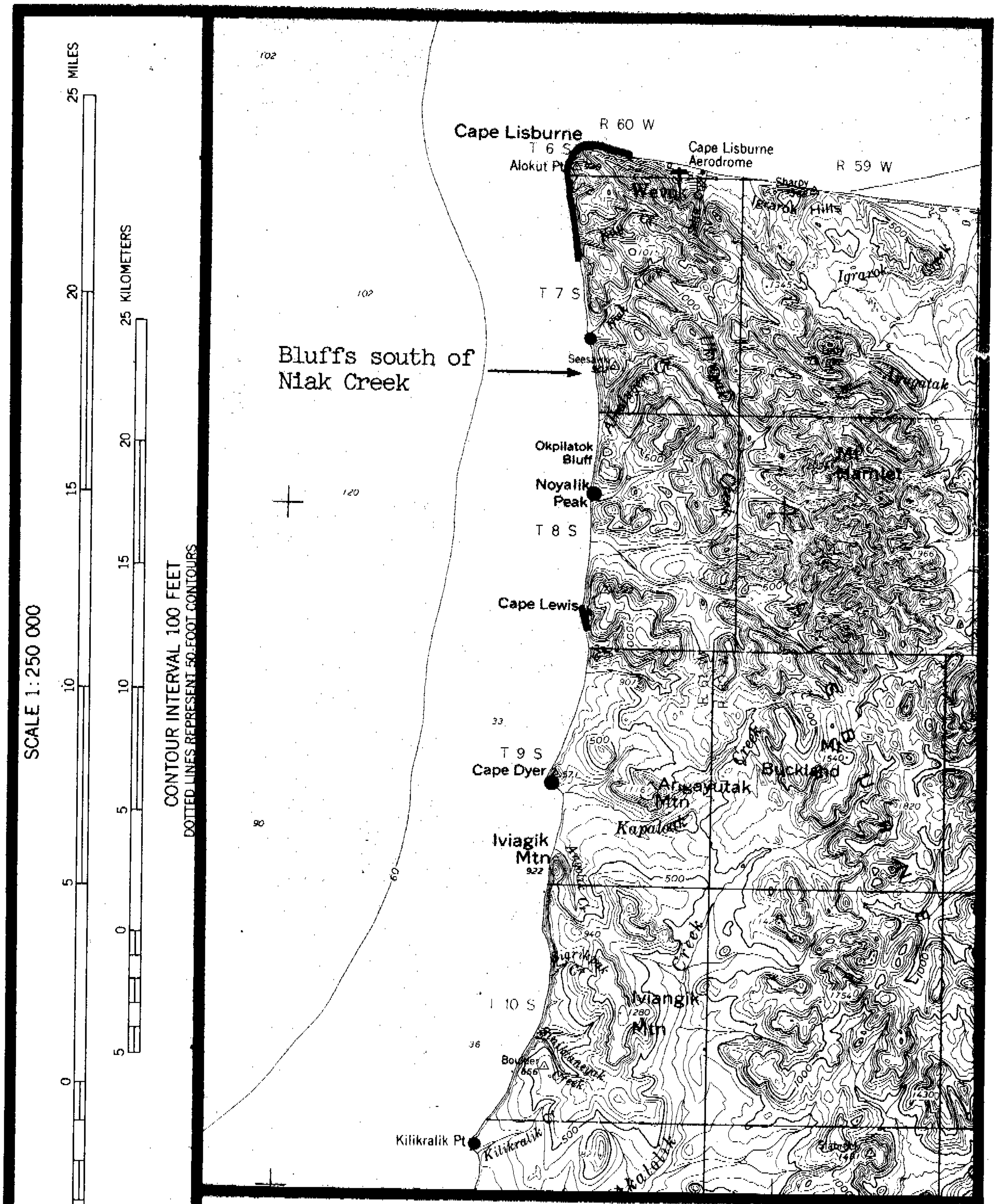


Figure 4. Small seabird colonies located south of Cape Lisburne, Alaska.

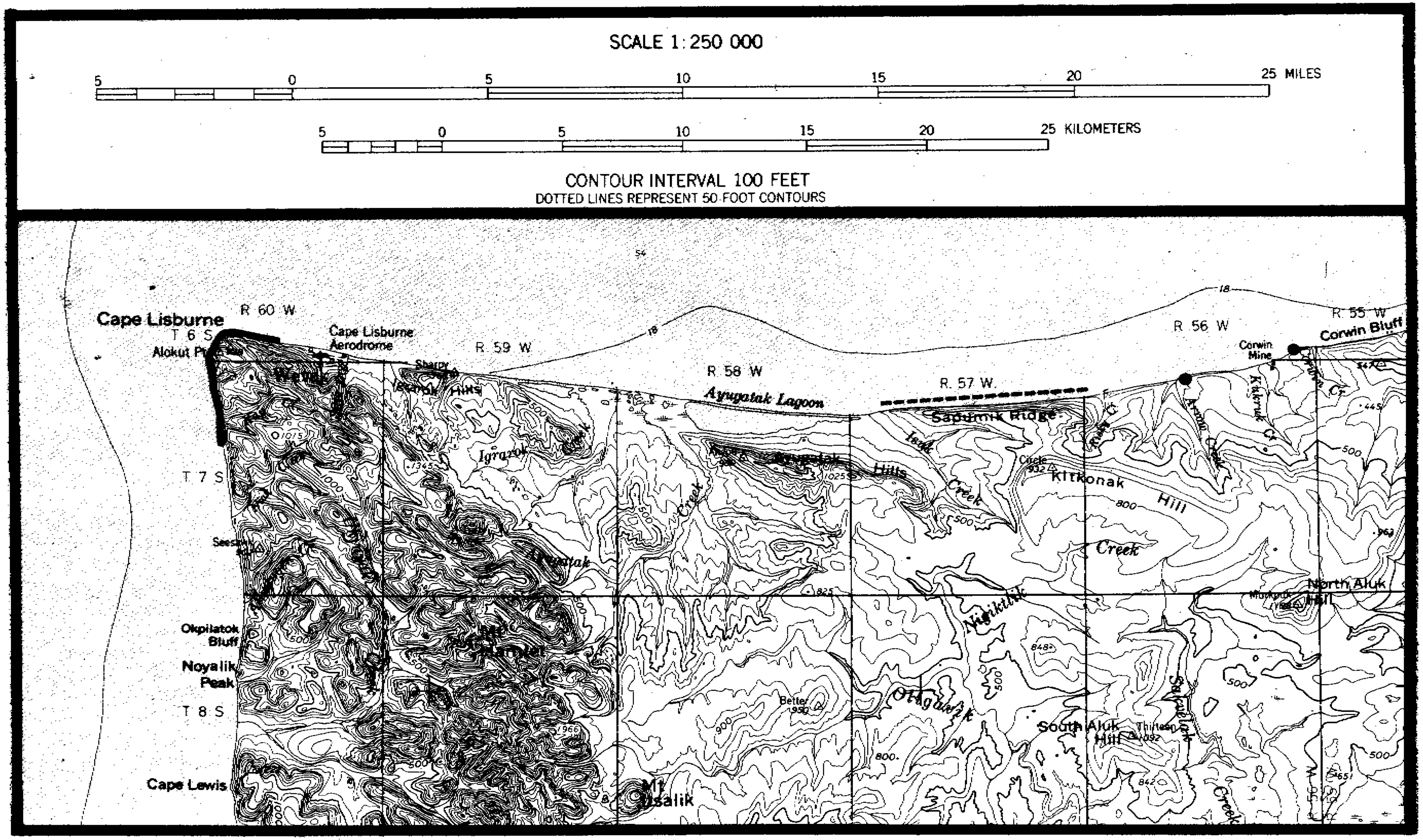


Figure 5. Small seabird concentrations located east of Cape Lisburne, Alaska

Cape Dyer, approximately 25.5 km south of Cape Lisburne, is the largest. Almost all the seabirds occupy a short (0.3 km) section of bluff facing southwest, just south of the tip of the cape. Noyalik Peak is a smaller headland about 14.5 km south of Cape Lisburne. It consists of rock and softer layers of sediments very fractured both horizontally and vertically. A small headland is located about 200 meters south of the mouth of Niak Creek, about 8 km south of Cape Lisburne. Kilikralik Point is a small low headland located about 43 km south of Cape Lisburne and 30 km from Point Hope. Sapumik Ridge begins about 27 km east of Cape Lisburne and consists of a 15 to 45 meter high crumbly bluff that continues for about 8 km farther east. A small rock headland juts out a few meters into the sea about 0.6 km east of the Arrow Creek mouth, about 36 km east of Cape Lisburne. A slightly larger, 10-45 meter high headland, exists just west of the Corwin Creek mouth, about 45 km east of Cape Lisburne.

These headlands and bluffs provide limited habitat to gulls, puffins, cormorants and guillemots. Kittiwakes do not utilize them, nor do murres, with a minor exception at Noyalik Peak where a very few murres, perhaps prospectors, occur.

V. SOURCES, METHODS AND RATIONALE OF DATA COLLECTION

Field work commenced on 8 June, with a one day visit to Cape Thompson and Cape Lisburne to observe activity about the colonies and to collect specimens. A second collecting trip to Cape Thompson was made on 21 June, however a planned stop at Cape Lisburne on that date and the following day was prevented by adverse weather. Permanent field camps were established at both Cape Thompson and Cape Lisburne on 6 July. Field work terminated at Cape Thompson on 26 August and at Cape Lisburne on 4 September.

A. Census

Swartz (1966) divided the seacliffs at Cape Thompson into five colonies which contained a total of 137 small census plots. The locations of each colony and each plot were recorded on photographs made during the study. We took copies of these photographs into the field in 1976 and in 1977. In 1976 most of the plots established by Swartz were relocated and in 1977 many of the ones which had not been determined with certainty the previous year were found. We now have in hand all 1960 census plot boundaries and in almost all cases we are able to directly compare 1976 and 1977 plot counts with those obtained in 1960 and 1961. Because all of the plots were not located in 1976, certain of the boundaries of plots counted that summer differ from the 1960 boundaries established by Swartz. In 1977 we counted the birds on the plots corresponding to 1976 boundaries and when those differed from 1960 plot boundaries the birds in the 1960 plots were also counted for comparative purposes.

The number of murres in each plot was estimated by groups of ten. These estimates were made by two observers equipped with binoculars and stationed off-shore in a Zodiac raft which was anchored in front of the plot. Colonies 1 and 4 were counted in a single day, however, Colonies 2, 3, and 5 were each counted during multiple days because of the size of the cliffs, the number of birds present and adverse weather and sea conditions. Censusing was timed as much as possible to coincide with the period of maximum cliff-attendance by the murres, and occurred during the second half of incubation.

Two observers were placed on shore to conduct diurnal activity counts of murres on the days that Colonies 2, 3, and 4 were censused. One or two sections of these colonies were selected for both visibility and bird density and were counted every hour for a 6-7 hour period. Weather conditions and dwindling daylight combined to preclude full 24 hour counts as obtained in 1976. Numbers of birds determined for different plots at different times during the day by the offshore observers were then adjusted for daily activity patterns by dividing the raw score by

$$\frac{\text{number of birds on compensation plot at time t}}{\text{max. number observed on compensation plot}}$$

where t = time a given census plot was counted. Compensation of Colony 5 was done on the basis of the activity patterns determined for Colony 4 and scores for Colony 1 were not compensated.

Black-legged Kittiwakes were counted individually by two observers offshore in the raft on different days from those of the murre counts. No corrections for daily activity patterns were made; however, one 24 hour diurnal activity count was conducted at Colony 4 shortly after most colonies had been censused.

Horned Puffins were also counted individually by two or three observers using methods identical to those employed for kittiwake counts. Counts were timed to coincide with the period of apparent maximum cliff attendance. One 24 hour diurnal activity count was conducted at Colony 4. At colonies where complete counts were obtained more than once, only the highest score is presented. A count was not obtained at Colony 5.

The population sizes of Tufted Puffins and guillemots were determined by counting individuals during all other censusing activities and by compiling all observations obtained throughout the summer. Glaucous Gulls were counted by locating nests, counting individuals present and by compiling all summer observations.

The population sizes of comorants, Ravens, Golden Eagles and Gyrfalcons were determined by locating nests.

The Cape Lisburne colony was photographed and divided into 75 plots during our reconnaissance in 1976. Copies of these photographs were taken into the field in 1977 and all plots were relocated and censused.

The number of murres in each plot was determined by the same method employed at Cape Thompson. The colony was counted over a six day interval because of the size of the cliffs and the number of birds present. The counts were performed during the second half of the incubation period, and the censusing effort was timed as much as possible to coincide with periods of maximum cliff attendance by the murres.

Two observers were placed onshore to conduct diurnal activity counts of murres each census day. These counts were made at areas of the colony approximately central to the plots being counted on that day. In each area two or three sections of the colony were selected for visibility, bird density and substrate type and were counted every hour for 6-11 hour intervals. Numbers of birds determined on census plots were then adjusted by the method described for Cape Thompson.

Black-legged Kittiwakes were counted directly by one observer from the anchored raft. At 38 of the 75 census plots total birds and total sites were counted. Total birds only were counted at an additional 19 plots. Observers were unable to count kittiwakes at the remaining 18 census plots, but were able to count sites.

Horned Puffins were counted individually by one observer at the same time kittiwakes were being counted. Counts were completed at 55 of the total 75 census plots. Counts were not obtained at the remaining 20 census plots.

The number of Tufted Puffins, guillemots, gulls, cormorants, raptors and Ravens were determined the same way as at Cape Thompson.

The entire Cape Lewis colony was counted in one day. Fourteen plots were established and photographed. No compensation counts were made; however all other censusing methods were similar to those employed at Cape Thompson and Cape Lisburne.

Counts of birds at other locations were made whenever an opportunity arose. These counts were conducted from the raft, with the exception of Kilikralik Point where numbers were estimated from a Maule fixed-wing aircraft.

B. Phenology of breeding activities

Regular visits were made to the Cape Thompson and Cape Lisburne colonies to determine laying, hatching and fledging dates of all nesting species. Specimens of Common and Thick-billed Murres and of Black-legged Kittiwakes were collected at both of these locales at intervals throughout the summer. Each collected specimen and many of the birds we found dead or injured on the beach were examined for degree of brood patch and gonadal development. Nest checks were made on only one day at Cape Lewis and phenological data were not obtained from any of the other small sites (see Figures 4 and 5) where birds were found nesting.

C. Food Habits

Murres and kittiwakes were collected at both Cape Thompson and Cape Lisburne for stomach content analyses. Birds were not collected at Cape Lewis or elsewhere. The majority of the specimens were obtained from flocks that were returning to the colonies from distant feeding areas. Those specimens were collected up to several kilometers away from the cliffs. Other birds were collected as they fed in front of the cliffs, or as they left the colonies to return to foraging areas.

Stomachs from the specimens were removed as soon as possible and the lining of the ventriculus together with the contents were preserved in 70% ethanol. A visual estimate of the percent fullness of each stomach was made and the prey items were identified using standard taxonomic keys and preserved material. Identifications of food items were made by Peter Craig and C. Low of Nanaimo, British Columbia.

VI. RESULTS

A. Murres

Census

A summary of the raw scores and compensated scores for murre censuses made during each of four years at Cape Thompson are presented in Table 1. The details of the 1977 census at Cape Thompson are presented in Tables 2-6. We have not included the plot counts for previous years' censuses at Cape Thompson in this report. Those data and the results of the 1977 counts are being computerized so that an analysis of yearly changes can be made more easily.

Table 1. Murre census summary, Cape Thompson.

	Colony					
Raw Scores	1[1]	2	3	4	5	Total
1960[3]	4186	76,174	26,814	8701	141,544	257,419
1961[3]	5630					
1976	2090	46,722	18,598	6894	79,983	154,287
1977	2472	52,828	21,377	7623	59,322	143,621
Compensated Scores						
1960[3]	4186	123,516	43,957	11,723	208,000	391,382
1961[3]	5630	108,598[2]	72,031[2]	8552	210,100[2]	404,011[2]
1976	2090	56,264	26,370	7072	89,141	180,937[4]
1977	2472	60,610	21,951	8053	61,870	154,956

[1] Colony 1 was not compensated for diurnal activity.

[2] estimate based on partial counts

[3] from Swartz's field notebooks and other unpublished data

[4] compensated for diurnal activity pattern only; figures reported in Springer and Roseneau (1977) were also compensated for observer handicaps

With the exception of Colony 5, the raw scores for all colonies are somewhat higher this year than they were in 1976 although the same situation is not true for the compensated scores. The greatest percentage change among any of the colonies occurred in Colony 5 and was large enough to indicate a decline in the overall population. This colony, however, is particularly difficult to count - it is tall with deep recesses which make visibility poor. The raw 1977 totals for Colonies 1 through 4 are uniformly higher than those of 1976. Although the direction of change in the compen-

Table 2. Murre census, Colony 1: Cape Thompson, 1977.

		11 August 1977		
		Observer F	Observer E	
Plot	Time	Raw	Raw	x̄
A	2123	0	0	0
B	--	--	--	--
C	2117	330	355	343
D	2108	395	385	390
E	2052	1125	1180	1153
F	2045	0	0	0
G	2038	580	560	570
H	2031	16	16	16
I	2030	0	0	0
Total		2446	2496	2472

Time compensation of Raw x̄ is not possible because 24 hr counts were not conducted.

Table 3. Murre census, Colony 2; Cape Thompson, 1977.

		9 August 1977			
Plot	Time	Observer F Raw	Observer E Raw	x̄	Time Comp.
A-1	1510	9	9	9	12
A-2	1512	23	23	23	30
B	1517	130	120	125	165
C	1525	490	535	513	658
D	1535	150	155	153	196
E	1540	1410	1945	1678	2111
F	1608	920	775	848	1005
G	1620	3445	2290	2868	3339
H	1715	2840	2160	2500	2694
I	1735	1860	1635	1748	1882
J	1755	2525	2305	2415	2597
K,L	1818	3220	3100	3160	3442
M	1850	2055	1945	2000	2220
N	1935	1645	1640	1643	1931
O	1940	1910	2015	1963	2320
P	2000	1275	1265	1270	1517
Q	2015	3110	2940	3025	3445
R	2035	710	670	690	752
S	2045	2260	2490	2375	2477
T	2105	2960	3550	3255	3255
U	2130	2750	2900	2825	3132
V	2150	3395	3300	3348	3995
W	1740	2170	2260	2215	2384
X	1715	1135	1220	1178	1269
Y	1635	3075	3110	3093	3535
Z	1615	1780	1515	1648	1934
AA	1600	685	720	703	850
BB	1540	1000	980	990	1245
CC	1530	1090	1235	1163	1491
DD	1505	1485	1550	1518	2071
EE	1455	710	590	650	887
FF	1445	435	445	440	617
GG	1436	370	350	360	519
HH	1425	285	270	278	401
II	1420	155	160	158	232
Total		53,467	52,172	52,828	60,610

Table 4. Murre census, Colony 3; Cape Thompson, 1977.

Plot	Date	Time	Observer F Raw	Observer E Raw	$\bar{x}$	Time Comp. $\bar{x}$
A	10 Aug	1810	150	155	153	153
B		1817	540	495	518	520
C		1835	460	500	480	482
D		1323	525	580	553	555
E		1828	545	583	564	567
F		1841	605	600	603	608
G	12 Aug	2005	1120	900	1010	1052
H	10 Aug	1850	580	550	565	571
I	12 Aug	1855	595	950	773	784
J		1745	2570	2665	2618	2621
K	10 Aug	1912	1590	1580	1585	1612
L	12 Aug	1728	1205	1460	1333	1333
M		1705	1435	1780	1608	1646
N		1656	600	670	635	650
O		1613	1685	1800	1743	1909
P		1640	1990	1825	1908	1983
Q	10 Aug	1940	3265	3200	3233	3333
R		2013	805	865	835	877
S		2020	650	670	660	695
Total			20,915	21,904	21,377	21,951

Table 5. Murre census, Colony 4; Cape Thompson, 1977.

		12 August			
Plot	Time	Observer F Raw	Observer E Raw	$\bar{x}$	Time Comp. $\bar{x}$
A	1356	160	155	158	160
B	1358	535	560	548	554
C	1408	990	960	975	985
D	1505	140	130	135	145
E	1420	980	990	985	1015
F	1445	320	300	310	323
G	1455	1075	950	1013	1089
H	1507	355	338	347	373
I	1515	100	90	95	102
J	1518	580	540	560	604
K	1522	120	130	125	135
L	1528	415	425	420	454
M	1535	480	495	487	526
N	1558	348	300	324	352
O	1530	100	95	98	106
P	1547	690	625	658	713
Q	1559	160	170	165	179
R	1540	220	220	220	238
Total		7768	7473	7623	8053

Table 6. Murre census, Colony 5; Cape Thompson, 1977.

Plot[1]	Date	Time	Observer F	Observer E	$\tilde{x}$	Time Comp.
A	17 Aug	1705	850	1055	953	963
B		1645	2480	2465	2473	2549
C		1612	3040	2790	2915	3101
D		1510	6680	6670	6675	7177
E		1602	2440	2520	2480	2696
F		1420	5910	5970	5940	6253
G	14 Aug	1807	7640	7820	7730	7730
H		1630	8800	9470	9135	9516
I		1420	9070	8775	8923	9199
J		1310	6910	7700	7305	7378
K	13 Aug	1915	2920	3190	3055	3149
L		1840	1765	1710	1738	1755
Total			58,505	60,135	59,322	61,466

[1] Plots are the same as those used in 1976.

sated scores between 1977 and 1976 was variable, the total for 1977 was somewhat higher than 1976 (see Table 7). We believe these data suggest that there has been no appreciable change in the size of the murre population at Cape Thompson between 1976 and 1977. The 1977 census results also support our conclusion from last year that there are substantially fewer murres at Cape Thompson now than in the early 1960's.

Table 7. Score totals, Colonies 1 through 4.

	1960	1961	1976	1977
Raw	115,875		74,304	84,299
Compensated	183,382	194,811	91,796	93,086

The results of our compensation counts at Cape Thompson are presented in Table 8. Because counts were made only during the times that the colony was being censused and not for complete 24-hour cycles, the times designated as 100% may not coincide with the actual peak of maximum attendance. Therefore the compensation factors may be somewhat low.

A rather quick census of the murres at Cape Lisburne was made in 1976. The numbers of birds on many of the larger plots were estimated by hundreds and no compensation counts were made during any of the days of the census. Table 9 presents the results of the 1976 counts. In 1977, all plots were estimated by tens, a method which we hoped would increase the overall accuracy and the precision between observers. The results of our 1977 census are presented in Table 10. Although somewhat more effort was expended in making the 1977 counts, a difference of only 1.5% was obtained between the totals of the raw mean scores for the two years. The raw scores from both years and the compensated scores from 1977 suggest that the size of the murre population at Cape Lisburne is about the same as at Cape Thompson (see Table 11 for compensation factors).

Estimates of the relative numbers of Thick-billed Murres and Common Murres at Cape Lisburne were not made. It is our impression, however, that Thick-billed Murres clearly predominated there as they did at Cape Thompson.

Activity patterns

One 24-hour compensation count was made at Cape Thompson in 1977. The activity pattern described by this count is very similar to patterns observed during counts at Cape Thompson in 1976, as shown by Figure 6. These data show peak attendance to occur during the mid-morning hours with a low occurring during the afternoon and another high at about 2000 hours. The bimodal shape of these activity patterns about the colonies are in contrast to the observed patterns of activity to and from the feeding areas, the peaks of which occur about 1990 to 2000 hours. We are not prepared as yet to explain the significance of this difference.

The murres at Cape Lisburne exhibited highly regular daily activity behavior throughout most of the summer. Figure 7 shows the syn-

Table 8. Compensation counts of murres; Cape Thompson, 1977 - per cents of maximum.[1]

Time	9 Aug Colony 2	10 Aug Colony 3	12 Aug Colony 4
1400			99
1430		69	
1500	73		95
1530		79	
1600	83		86
1630		96	
1700	93		96
1730		100	
1800			100
1830		100	
1900	87		98
1930		98	
2000	84		94
2030		94	
2100	100		
2200	80		
2300	67		

[1] Maxima

Colony 2 - 415

Colony 3 - 625

Colony 4 - 359

Table 9. Murre census; Cape Lisburne, 1976.

Plot	Date	Time	Observer B	Observer C	$\bar{x}$
1	25 Aug	1825	3500	2600	3050
2			900	700	800
3			450	350	400
4			150	150	150
5		1855	250	250	250
6			1300	1500	1400
7			1200	1000	1100
8			600	600	600
9		1920	2000	1400	1700
10			700	700	700
11			900	600	750
12		2000	1200	1400	1300
13			1000	1100	1050
14			1150	1200	1175
15			4300	4200	4250
16			1800	1700	1750
17		2045	5500	5450	5475
18			2300	2000	2150
19			2800	2500	2650
20			3600	3200	3400
21			2800	1800	2300
22			2100	1300	1700
23		2155	1600	1000	1300
24			1000	1100	1050
25			1050	600	825
26			550	650	600
27	26 Aug		1250	1150	1200
28			1000	1400	1200
29			1500	1800	1650
30			3900	4600	4250
31			3000	3400	3200
32			1900	2500	2200
33			2400	2950	2675
34			5900	3800	4850
35			2400	2050	2225
36			2500	2550	2525
37			550	450	500
38			650	450	550
39			950	900	925
40			2600	2850	2725
41			1000	1200	1100
42			900	700	800
43			1050	1050	1050
44			750	1100	925
45			1200	1350	1275
46			1300	1400	1350
47			900	1250	1075

Plot	Date	Time	Observer B	Observer C	$\bar{x}$
48			550	850	700
49			700	950	825
50			3500	3800	3650
51			1900	2500	2200
52			800	1150	975
53			700	1250	975
54	27 Aug		1500	900	1200
55			1100	1100	1100
56	28 Aug		2500	2800	2650
57			2600	2700	2650
58			3700	2900	3300
59			3500	4200	3850
60			1000	1200	1100
61			3200	3300	3250
62			3500	4000	3750
63			4600	3600	4100
64			2300	2400	2350
65			1200	1350	1275
66			1000	1500	1250
67			1000	1400	1200
68			1500	2400	1950
69			550	900	725
70			600	1200	900
71			600	1800	1200
72			600	900	750
73			800	1100	950
74			550	700	625
Total:			128,350	130,800	129,575

Table 10. Murre census; Cape Lisburne, 1977.

Plot	Date	Time	Observer C	Observer E	$\bar{x}$	Time Comp.
1	26 July	2100	5250	6410	5830	7571
2		2130	1470	1470	1470	1793
3		2145	520	485	503	592
4		2150	200	200	200	230
5		2045	300	300	300	400
6		2015	1955	1785	1870	2597
7		2005	1150	1380	1265	1782
8		2000	780	840	810	1141
9		1940	920	900	910	1282
10		1930	850	930	890	1271
11		1905	910	945	928	1345
12		1850	1460	1630	1545	2414
13		1825	940	880	910	1596
14		1815	1390	1390	1390	2623
15		1735	3870	3620	3745	7968
16		1705	1100	1140	1120	2383
17		1634	2260	2405	2333	5690
18		1605	1230	1040	1135	3338
19		1600	1945	2015	1980	5824
20	25 July	2245	2620	2610	2615	2696
21		2130	2610	2615	2613	2871
22		2100	3200	3355	3278	3998
23		2045	1202	1105	1154	1443
24		2040	825	845	835	1043
25		2020	1050	1120	1085	1391
26		1950	1115	1335	1225	1612
27		1940	1170	1135	1153	1537
28		1920	1260	1490	1375	1858
29		1900	1720	2005	1863	2552
30		1830	3925	3245	3585	5121
31		1735	3480	4110	3795	6325
32		1725	1875	1600	1738	2896
33		0005	2960	2815	2888	2888
34	24 July	2315	4585	4930	4757	4855
35		2350	2790	2975	2883	2883
36	25 July	1635	2710	3125	2918	5305
37	24 July	2300	635	745	690	711
38		2240	995	970	983	1023
39		2230	1270	1115	1192	1242
40		2200	3230	3030	3130	3277
41 42		2100	1160	1020	1090	1313
43		2045	1595	1595	1595	2019
44		2030	725	730	728	970
45		2015	1235	1240	1238	1768
46		2000	440	500	470	746

Plot	Date	Time	Observer C	Observer E	$\bar{x}$	Time Comp.
47		1955	735	885	810	1285
48		1945	560	600	580	966
49		1940	425	355	390	650
50		1900	3145	3855	3500	6034
51		1840	2155	2190	2173	3811
52	22 July	1900	1220	1110	1165	2080
53		1920	1000	920	960	1627
54		1950	1640	1385	1513	2440
55		2000	1170	1190	1180	1903
56	21 July	2100	2890	2610	2750	3055
57		2130	3195	3460	3328	3502
58		2210	2800	3380	3090	3090
59		2300	4350	4535	4443	4487
60		0035	1560	1890	1725	1816
61		0045	4140	3450	3795	4081
62		0115	3190	4020	3605	4097
63	22 July	1700	1750	1990	1870	3016
64		1500	1540	1880	1710	2758
65		1526	1930	2090	2010	3190
66		1535	1310	1360	1335	2119
67		1615	920	1120	1020	1594
68		1625	2000	1935	1968	3124
69		1645	440	370	405	653
70		2200	1270	1140	1205	1205
71		2215	1430	1390	1410	1410
72		2225	830	860	845	845
73		2230	1080	990	1035	1035
74		2240	1250	1430	1340	1340
75		2300	--	260	260	263
Total:			129,068	133,775	131,420	183,659

Table 11. Compensation counts of murres; Cape Lisburne, 1977 - per cent of maximum.[1]

	July			
Time	21-22	24	25	26
1500	62			
1600	64			34
1700	62		55	47
1800	59		66	48
1900	56	57	73	69
2000	62	60	76	71
2100	90	79	82	77
2200	100	97	100	87
2300	99	96	96	100
2400	99	100		91
0100	90			

[1] Maxima

21-22 July - 1629

24 July - 1298

25 July - 836

26 July - 712

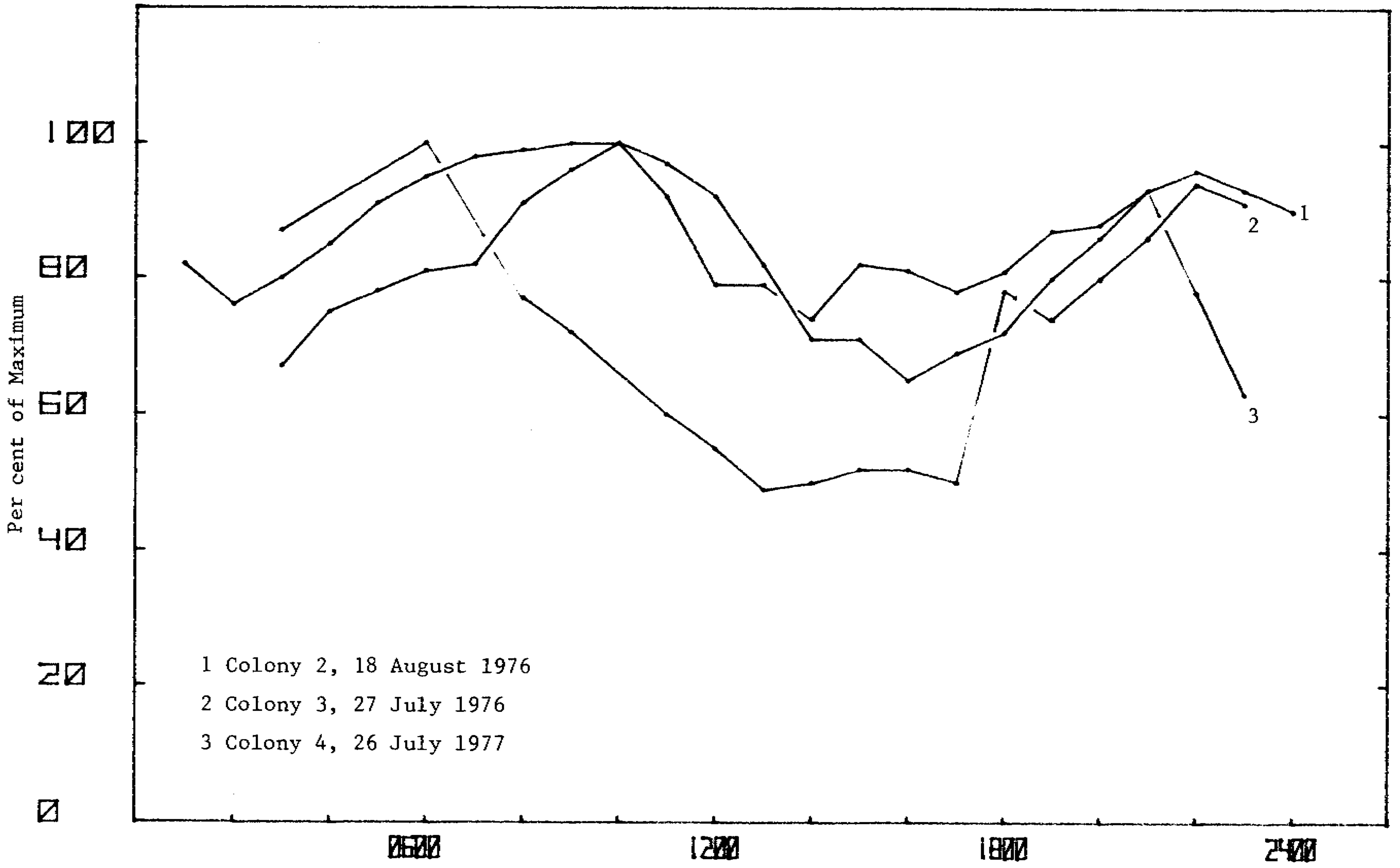


Figure 6. Diurnal activity patterns of murres at Cape Thompson.

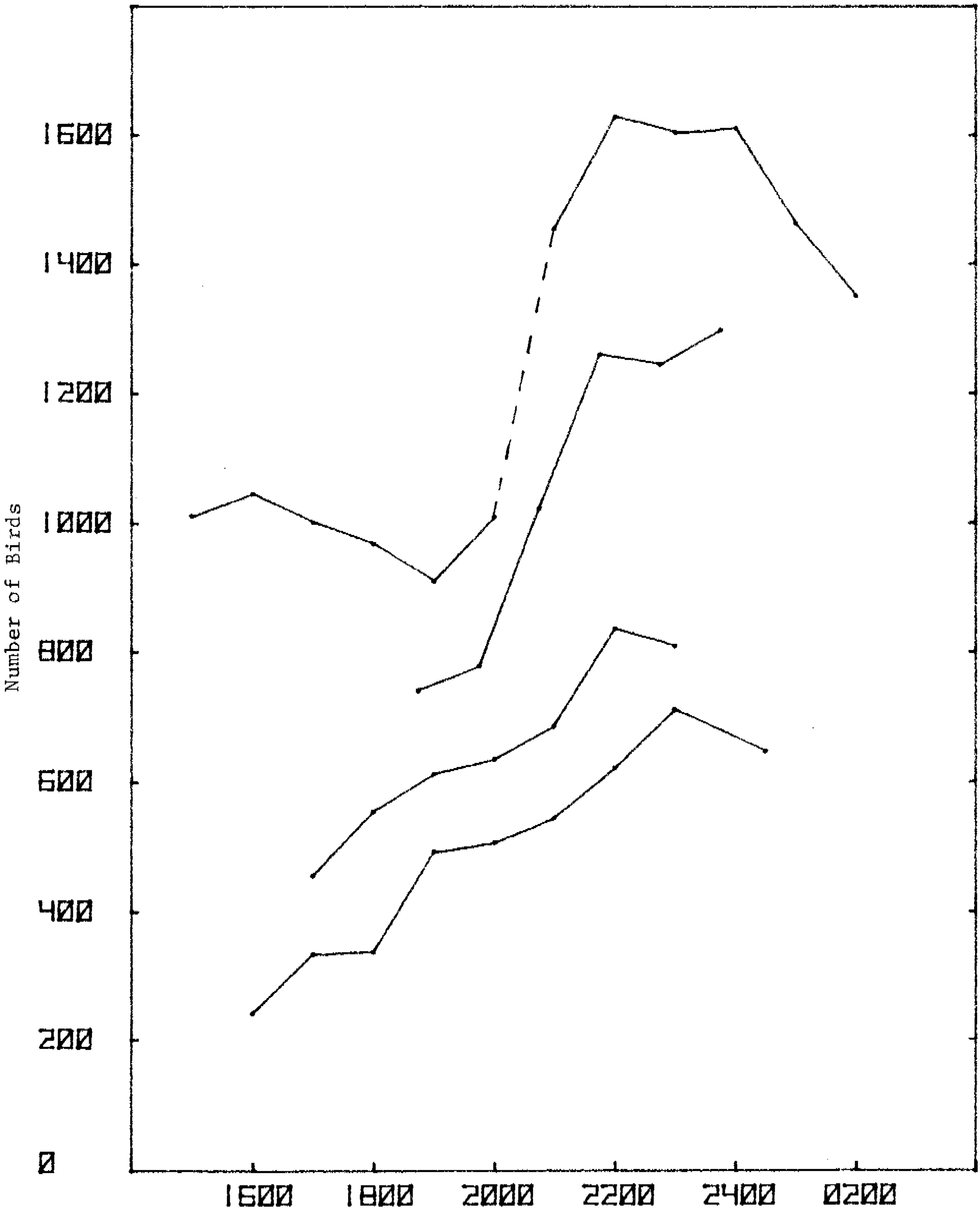


Figure 7. Diurnal activity patterns of murres at Cape Lisburne.

chronization of the movements of birds on the compensation plots. This same regularity was observed in the movement of birds between the feeding grounds and the colonies. Five-minute counts of birds flying towards the colonies from feeding areas were made on 7-8 July. Similar counts were not made at Cape Thompson this summer; however, the timing of this activity at Cape Lisburne was essentially congruent with that observed in 1976 at Cape Thompson (see Figure 8).

The regularity of the movements of birds to and from feeding areas at Cape Lisburne was remarkable,however, no more so than were the numbers of birds involved. In 1976 at Cape Thompson we counted birds during 15 minutes of each hour, an interval which we felt allowed sufficient birds to pass by our observation point to provide a good estimate of numbers. The greatest number counted during any of the 15-minute counts was 1952 birds, which equals about 7800 birds per hour. We also had expected to make 15-minute counts in 1977 at Cape Lisburne. Our first count, however, corresponded with the peak movement of birds returning to the cliffs and after five minutes the average of two observers' counts was 4300 individuals, or 51,600 birds per hour. Most of the flocks of murres returning to the colonies contained in the order of 100 birds, with a range of about 25 to about 700. The flocks were highly visible and could often be seen several kilometers away.

The magnitude of the movements of birds to and from the colonies complicates our estimate of the population size of murres at Cape Lisburne. If we add the numbers of murres estimated to have passed by the site on their return to the colonies between the peak time, 1900 hours, and midnight, we obtain a total of about 167,000 murres. We counted birds leaving the colonies toward feeding areas during the same times that counts were made of birds returning. The flocks leaving the colonies were small, generally not larger than 25 birds, and flew very near the water making them difficult to see. Between 1900 hours and midnight, we estimate that at least 49,000 murres flew away from the colonies.

We do not know what the circuit time for murres is between the colonies and the feeding grounds. Neither do we know that all of the birds observed leaving the colonies during our counts were, in fact, going to the feeding grounds, or whether they simply made a large circle and joined birds returning to the colonies. We are certain, however, that large numbers of murres were away from the colonies even at the times of peak attendance on the ledges as determined by the compensation count. Our estimate of the population therefore probably represents a minimum, and the actual number of murres at Cape Lisburne may well be in excess of 200,000.

Phenology

The timing of the events in the reproductive cycles of murres at Cape Thompson during 1977 appears to have been about a week to ten days earlier than in 1976 and 1959, and about the same or perhaps a little later than in 1960 and 1961. This conclusion is based on gonadal and brood patch development of the birds we collected as well as on observations of egg-laying and hatching and the sea-going of chicks.

Table 12 presents testes volumes and follicle sizes, and Table 13 presents brood patch development (see Swartz 1966) of Thick-billed Murres collected at intervals during last summer. These data are compared to those of 1960 and 1976 in Figures 9, 10, 11 and 12. Maximum gonadal development

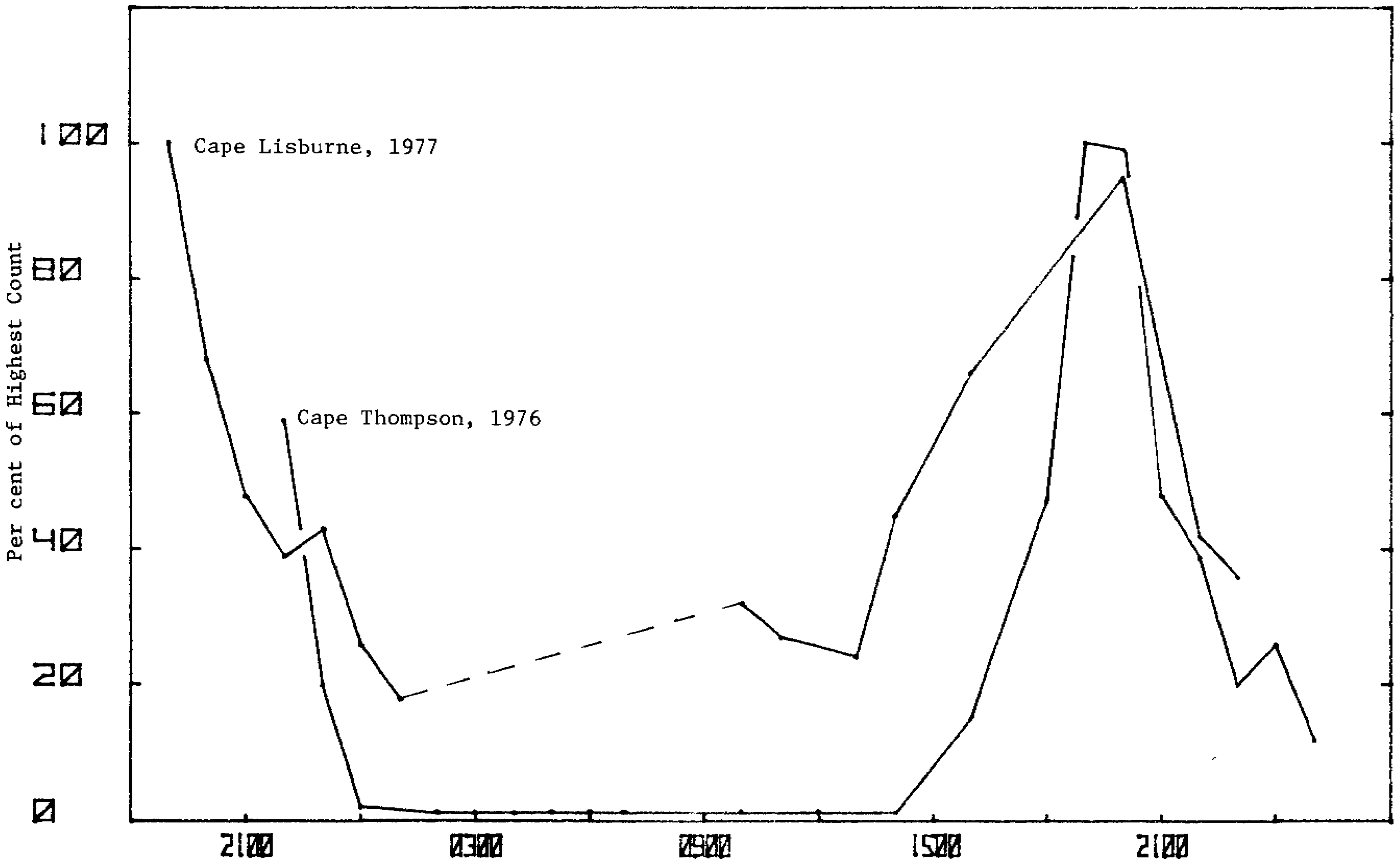


Figure 8. Movements of murres between feeding areas and the colonies.

Table 12. Testes volumes (in cubic centimeters) and diameters of largest ovarian follicles (in millimeters) of male and female Thick-billed Murres collected at Cape Thompson, 1977.

Period	Left		Right		Follicles	
	n	Average volume	n	Average volume	n	Average diameter
8 June	8	3.65±2.13	8	2.10±0.72	3	5.17±0.29
21 June	9	4.13±0.89	9	3.07±1.30	9	9.28±3.42
12-13 July	5	1.71±1.09			3	7.1 ±1.67
6-11 Aug	18	0.25±0.25	14	0.17±0.16	10	3.17±0.68
13-17 Aug	14	0.20±0.16	14	0.12±0.08	7	3.17±0.51
21-24 Aug	8	0.16±0.11	7	0.10±0.03	8	2.95±0.45

Table 13. Brood patch development of Thick-billed Murres collected at Cape Thompson, 1977.

Period	Males		Females	
	n	Average class value	n	Average class value
8 June	8	0	3	0
21 June	11	1.2	9	0.4
12 July	3	2.3	3	2.0
6-11 Aug	18	2.9	10	2.2
13-17 Aug	14	3.6	7	3.7
21-23 Aug	9	4.6	8	4.0

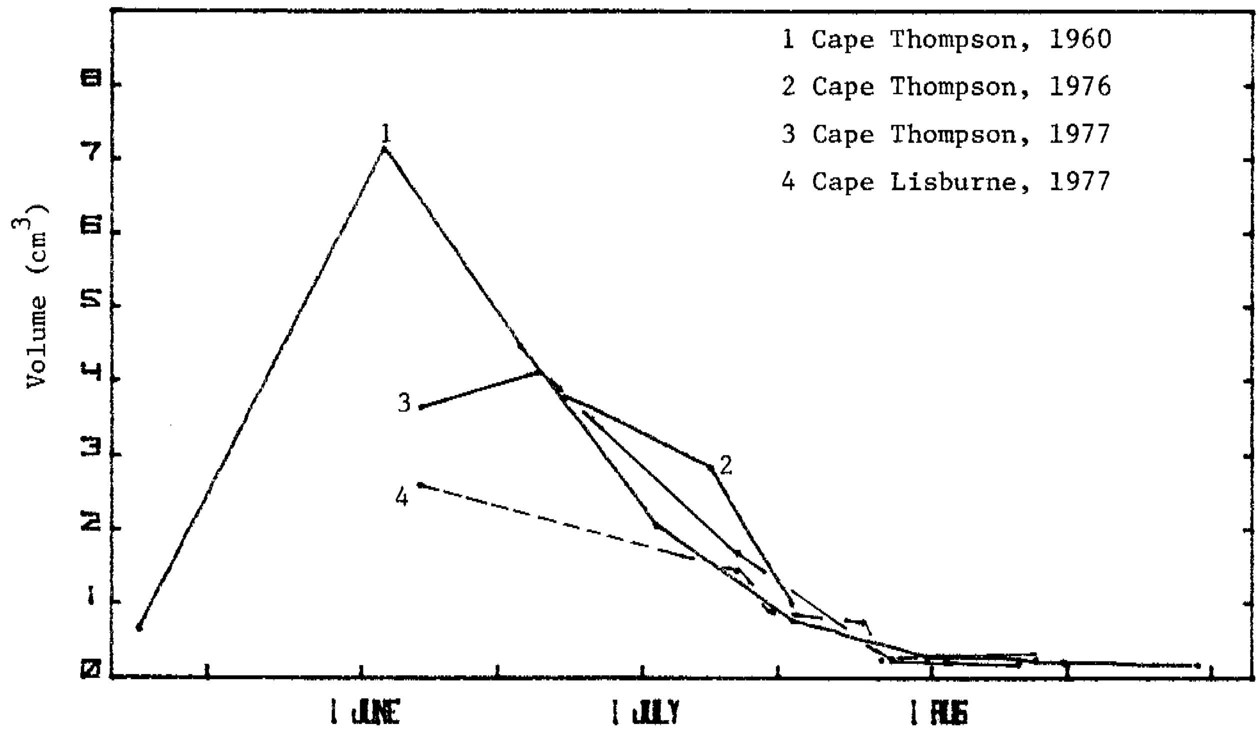


Figure 9. Testicular development of Thick-billed Murres at Cape Thompson and Cape Lisburne.

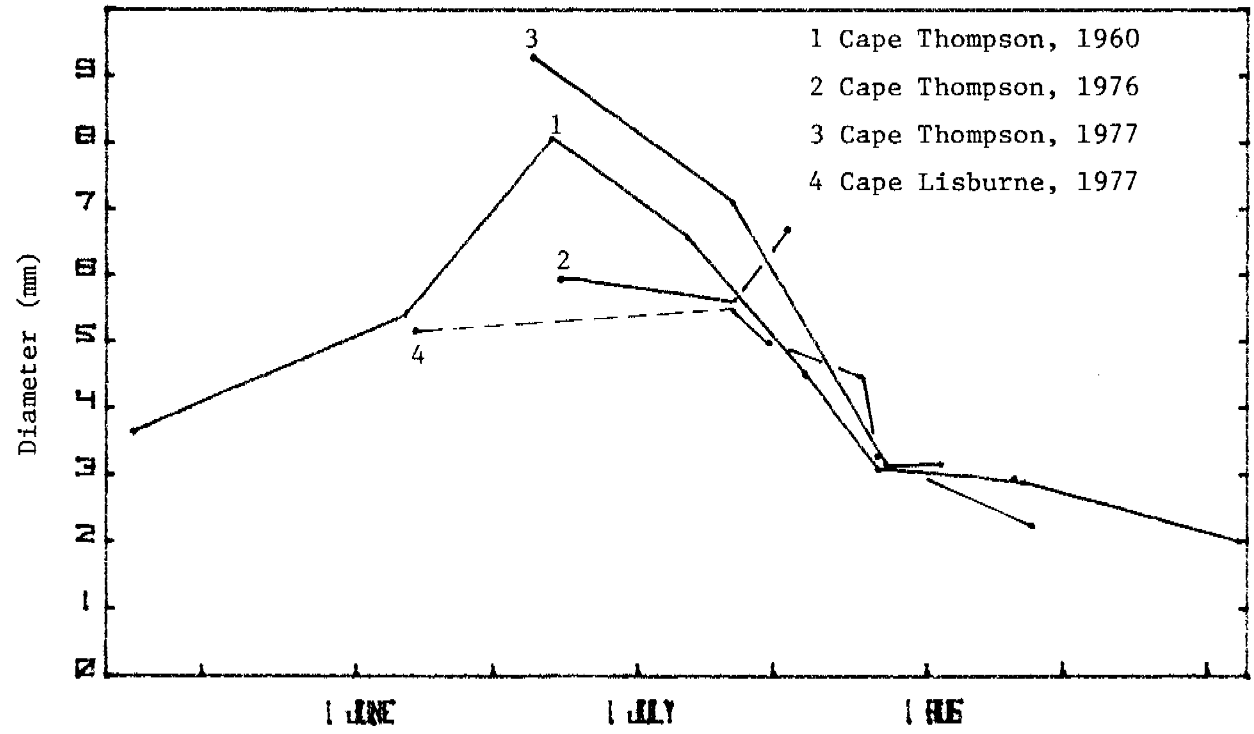


Figure 10. Follicular development of Thick-billed Murres at Cape Thompson and Cape Lisburne

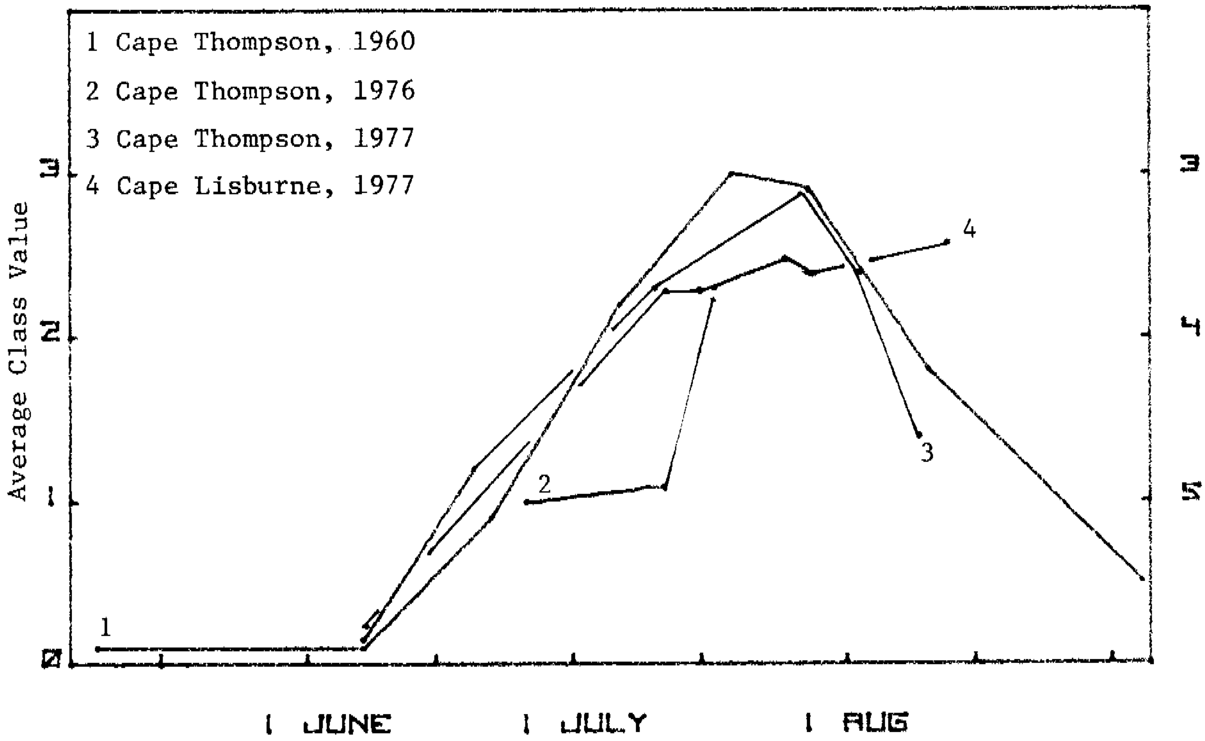


Figure 11. Brood patch development of male Thick-billed Murres at Cape Thompson and Cape Lisburne.

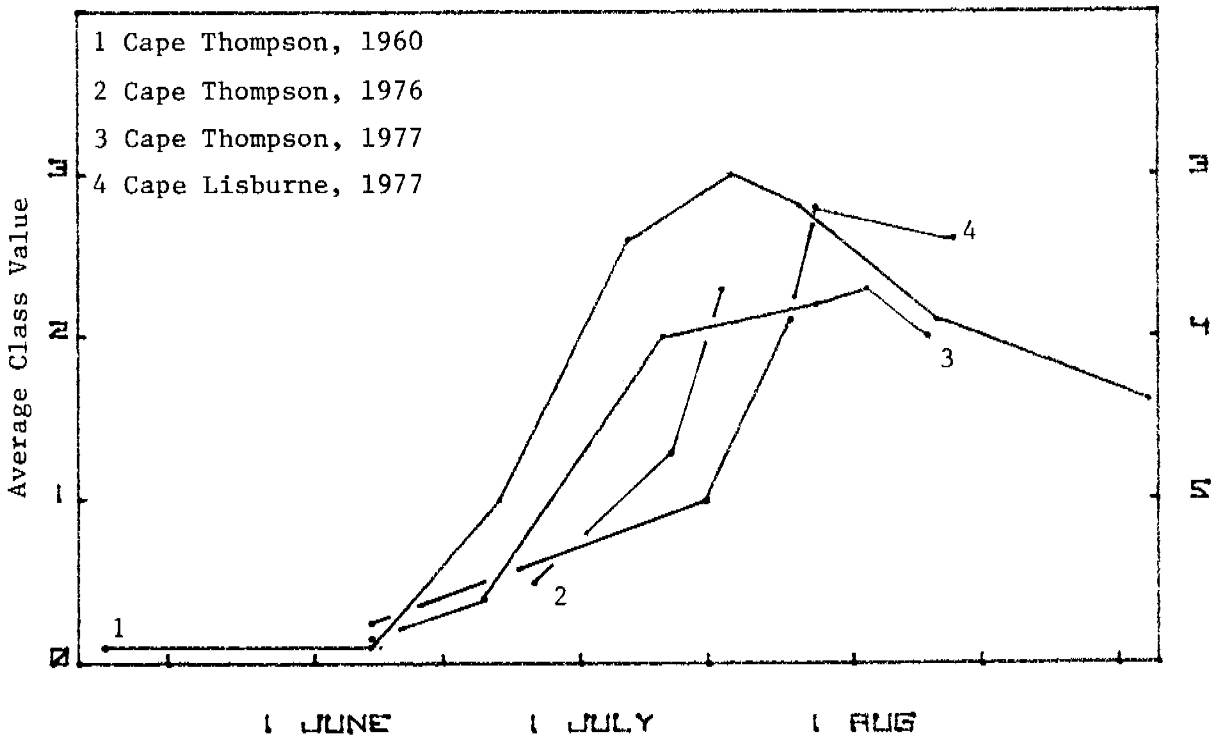


Figure 12. Brood patch development of female Thick-billed Murres at Cape Thompson and Cape Lisburne.

in 1977 of both males and females was seen in the sample collected on 21 June, and maximum brood patch development in both sexes was seen in the sample collected 6-11 August. In 1960 maximum development of testes occurred during the period 1-15 June, however, the greatest average diameter of ovarian follicles was not seen until 16-30 June, the same period as in 1977. Maximum development of brood patches in both sexes from 1960 occurred during the latter two weeks of July.

No maxima of gonadal development or brood patch development were seen in the birds collected during 1976. This is due in part to the relatively short time during which murres were collected; however, collections were made during the time when maxima would be expected to occur. The 1976 data suggested a lack of synchronization in the reproductive effort of the birds on a colony-wide basis and, together with laying and hatching dates, suggested a somewhat delayed breeding season.

Upon our arrival at Cape Thompson on 6 July 1977, many murres had already laid eggs. The first chick sighted, a Thick-billed Murre, was on 1 August. If 34 days is used as a mean incubation period for murre eggs (see Tuck 1960), then that egg must have been laid approximately 25-26 June. The majority of eggs was probably laid between 1-8 July and hatched about 4-12 August. One egg hatched on 23 August and others may have hatched as late as the first week in September.

The first sea-going of murre chicks was observed on 23 August. A large, well-developed chick was found swimming out to sea with an adult Thick-billed Murre at Colony 2. Calling-off activity began about 21 August and continued through our departure.

Dates of first eggs, first chicks and first sea-going for all years at Cape Thompson are presented in Table 14.

Table 14. Phenology of nesting activities of Thick-billed Murres at Cape Thompson.

Year	First Egg	First Chick	First Sea-going
1959	9 July	11 August	25 August
1960	27 June	30 July	18 August
1961	23 June	27 July	19 August
1976	4 July	9 August	*
1977	25 June	1 August	23 August

*no sea-going observed prior to our departure on 25 August

We were unable to collect murres at Cape Lisburne on 21 June. We therefore do not have a continuous record of gonad and brood patch development in birds at Cape Lisburne for 1977. The data presented in Tables 15 and 16, when compared to similar data from Cape Thompson (see Table 12 and 13) suggest, however, that the development of reproductive physiology in murres at Cape Lisburne essentially paralleled that at Cape Thompson.

Based on hatching dates, egg laying commenced as early as 24 June and most eggs were probably laid during the interval 27 June to 3 July. The first chick observed was on 5 August, however, inclement weather had prevailed for several days prior to that date and observations of nesting ledges were not made. The size of the oldest chicks on 5 August suggested

Table 15. Testes volumes (in cubic centimeters) and diameters of largest ovarian follicles (in millimeters) of male and female Thick-billed Murres collected at Cape Lisburne, 1977.

	Left		Right		Follicles	
Period	n	Average volume	n	Average volume	n	Average diameter
8 June	4	2.59±1.34	4	1.98±1.01	3	5.2 ±1.41
13 July	7	1.42±0.31	7	1.30±0.66	1	5.6
20 July	12	0.84±0.59	13	0.63±0.48	2	5.0 ±1.41
26-31 July	15	0.69±0.56	14	0.49±0.46	18	4.47±1.19
5-11 Aug	3	0.20±0.12	3	0.20±0.16	4	3.3 ±1.31
21-29 Aug	7	0.17±0.07	7	0.15±0.07	4	2.25±0.87

Table 16. Brood patch development in Thick-billed Murres collected at Cape Lisburne, 1977.

	Males		Females	
Period	n	Average class value	n	Average class value
8 June	4	0.25	3	0
13 July	7	2.3	1	3
20 July	13	2.3	2	1
26-31 July	17	2.5	18	2.1
5-11 Aug	7	2.4	10	3.2
21-29 Aug	8	3.4	5	3.4

that the first hatch occurred about 1 August. Most eggs probably hatched between 4-7 August. On 20 August, murres were observed concentrating below the cliffs and calling to young and three large chicks were observed swimming out to sea on that date. The number of chicks leaving the cliffs increased rapidly through 25 August, and some sea-going may have continued well into September. The majority of the murre chicks probably went to sea between 23 August and the first week in September. Murres were not observed leaving the cliffs until 28 August in 1976, about a week later than this past year.

Population characteristics

Not all of the murres at Cape Lisburne exhibited complete development of reproductive condition, especially the brood patch, and we believe that those birds did not reproduce successfully during 1977. Six male and five female Thick-billed Murres were collected which had a brood patch class 0 to 1, and 38 males and 25 females were collected which had a brood patch greater than or equal to 2. Ten Common Murres, five males and five females, were collected which had brood patch development of 0 or 1, and 18 birds, 9 males and 9 females, were collected which had brood patch development of 2 or greater. We have chosen the class value of 2 as the level below which successful incubation is probably unlikely to occur, and which we believe indicates a non-breeding condition. This does not imply, however, that all birds with brood patch development equal to or greater than 2 were successful breeders. These figures include only those birds which were collected after the second week of July. Birds which had not yet achieved full development during June, therefore, were excluded from the sample.

The above numbers of birds having little or no brood patch development relative to those having brood patch development greater than or equal to 2 is not representative of the population as a whole. Nineteen of the Thick-billed Murres collected at Cape Lisburne were obtained from in front of the colonies, either on the water or flying in the immediate vicinity of the cliffs. Eight (44%) of these had brood patches between 0 and 1. Among the remaining 55 birds on which we have brood patch data and which were all collected while returning to the cliffs from feeding areas, four (7.3%) had brood patches of 0 or 1. Fifteen Common Murres were collected from off the water or in the air in the vicinity of the cliffs, 10 (66%) of which had brood patch development of 0 or 1. None of the birds collected returning to the cliffs from sea had brood patches less than 2. These data suggest that the murres which are probable non-breeders tend to remain close to the colonies and may not feed a great distance away, or as will be discussed in a following section, may feed away from the colonies at a different time than do the breeding birds.

We collected birds generally during the evening when the largest numbers were returning to the cliffs from their feeding grounds, a practice which tended to increase our success ratios. Table 17 lists the dates, times and genders of birds collected at Cape Lisburne during July. The majority of the birds collected returning to the cliffs, 81%, were males. By 30 July we had recognized this pattern and collected birds which were not only returning to the cliffs but which were leaving the cliffs at the same time. Only 43% of the birds collected leaving the cliffs were males, while 57% were females. The six males collected on

Table 17. Proportions of male and female Thick-billed Murres collected during July at Cape Lisburne.

Direction of Flight	Date	Time	No. Males	No. Females
Toward colonies	13 July	2200	5	1
Toward colonies	20 July	2200	10	1
Toward colonies	30 July	0100	7	3
Toward sea	30 July	0100	6	8

Table 18. Average weights of male Thick-billed Murres collected during July at Cape Lisburne.

Direction of Flight	Date	N	Average Weight
Toward colonies	13 July	5	1019±62
Toward colonies	20 July	10	1032±70
Toward colonies	30 July	7	1043±45
Toward sea	30 July	6	966±65

30 July as they were leaving the colonies weighed less than any of the male groups collected which were returning to the cliffs, as shown in Table 18. The difference in weight between the two groups of males collected on the same date, 30 July, was statistically significant ($t = 2.5$; $P<0.05$). No correlation was seen between the weight of individual birds and the per cent fullness of the respective stomachs.

We are not certain what the biological significance of the observed weight difference between males is. The weights of Thick-billed Murres which had brood patches of 0 or 1 averaged less than the weights of Thick-billed Murres which had brood patches of 2 or more, and these differences were significant. These data are presented in Table 19. Murres which bred at the periphery of the colony also tended to weigh less than the average for all 'breeding birds.' This was first noticed when murres were captured alive for radio telemetry studies. The only birds which were readily accessible were those which were on the edges of the colony and they were noticeably lighter and smaller. Therefore, on 28 August, four birds were collected from the east edge of the colonies at Cape Lisburne. Three females weighed an average of 906±46 grams and one male weighed 890 grams. Although all of the birds were relatively light, they had well developed brood patches and were assumed to be breeding since chicks and eggs were visible on the ledges from which these birds were collected.

Table 19. Comparisons of body weights of Thick-billed and Common Murres at Cape Lisburne.

	Thick-billed Murres				Common Murres			
Brood Patch	Males	n	Females	n	Males	n	Females	n
0-1	908±43	6	866±36	5	888±53	5	934±24	5
≥ 2	1010±60	38	957±79	25	988±60	9	957±74	9
t	3.99		2.55		3.10		0.67	
P	<0.001		<0.02		<0.01		<0.6	

Whether or not the smaller murres are relatively younger, relatively less fit or only smaller than the larger birds is not known. These observations suggest, however, that smaller murres and females may be temporally segregated from the majority of the large males on the feeding grounds. Furthermore, small murres also may tend to be spatially segregated from larger birds within the breeding colony.

Food habits

The food items identified from stomach contents of Thick-billed Murres collected at Cape Thompson and Cape Lisburne in 1977 are presented in Table 20, as well as food habits data from 1960 and 1976 at Cape Thompson. Food items of Common Murres from all years are presented in Table 21. The data presented in these tables suggest that inter-year and inter-colony differences and similarities in the overall utilization of certain food groups and individual species exist for both Thick-billed and

Table 20. Food of Thick-billed Murres at Cape Thompson and Cape Lisburne, Alaska. Percent occurrence of food items refers only to those stomachs containing food; values in parentheses refer to the total sample.

	Cape Thompson						Cape Lisburne	
	1960		1976		1977		1977	
	n	%	n	%	n	%	n	%
Total examined	176		52		108		84	
Number empty	43	(24.4)	1	(2)	26	(24)	13	(15)
Frequency of invertebrates	45	33.8	40	78	53	65	43	61
Frequency of fish	85	63.9	39	76	69	84	64	90
FISH:								
Gadidae					16	20	17	24
Boreogadus saida	60	45.1	13	25	5	6	14	20
Eleginus gracilis			4	8	18	22	4	6
Cottidae	1	0.8	5	10	6	7	17	24
Triglops forficata	1	0.8						
Myoxocephalus quadricornis	6	4.5	1	2	3	4	1	1
Myoxocephalus sp.	3	2.3	8	16	25	30	7	10
Artidiellus sp.			4	8	9	11	4	6
Gymnocanthus galeatus					6	7		
Icelinus sp.					3	4	1	1
Hemilepidotus jordani							3	4
Zoarcidae								
Bothrocara sp.			6	12				
Lycodes sp.			1	2				
Ammodytes hexapterus	12	9	2	4	24	29	16	23
Mallotus villosus			1	2	5	6		
Liparus sp.			1	2	12	15	8	11
Chirolophus polyactocephalus	1	0.8						
Stichaeus punctatus	1	0.8			1	1		
Lyconectes aleuticus							1	1
Pleuronectidae	3	2.3						
Unidentifiable	10	7.5	8	16	3	4	6	8
INVERTEBRATES:								
Polychaeta	12	9			2	3	1	1
Polynoidae	2	1.5						
Nereis sp.			9	18	3	4	6	8
Mollusca					3	4		
Gastropoda			7	14	8	10	6	8

	Cape Thompson						Cape Lisburne	
	1960		1976		1977		1977	
	n	%	n	%	n	%	n	%
INVERTEBRATES, continued								
Trochidae	2	1.5						
Naticidae	7	5.3						
Natica sp.	3	2.3			1	1		
Clausa sp.	1	0.8						
Pteropoda	1	0.8						
Arthropoda					5	6	6	8
Amphipoda			1	2	3	4	4	6
Gammaridae			4	8	3	4	5	7
Koroga megalops					12	15	6	8
Gammaridae sp. 1	1	0.8			1	1		
Gammaridae sp. 2	1	0.8			1	1	1	1
Hyperidae							7	10
Hyperia sp.							2	3
Copepoda					4	5		
Cumacea					2	3		
Euphausiacea					1	1	5	7
Decapoda					6	7	1	1
Pandalidae								
Pandalus sp.			2	4	2	3	2	3
P. goniurus			7	14	2	2	6	8
P. jordani					3	4	13	18
P. montagui			3	6			1	1
Hippolytidae	2	1.5						
Eualus gaimardi			6	12				
Lebbius groenlandicus			3	6				
Crangonidae			3	6	1	1		
Notocrangon argis	1	0.8						
Shrimp remnants	6	4.5	15	29	11	13	9	13
Paguridae	3	2.3	1	2				
Crab remnants			2	4	3	4	1	1
Unidentified invertebrates	15	11.3	6	12				
MISCELLANEOUS								
Foraminifera					1	1	2	3
Hydroids					1	1	1	1
Barnacle					2	2	1	1
Algae	1	(0.6)	2	4				
Pebbles	48	(27.3)	14	(27)	55	(51)	34	(40)

Table 21. Food of Common Murres at Cape Thompson and Cape Lisburne, Alaska. Percent occurrence of food items refers only to those stomachs containing food; values in parentheses refer to the total sample.

	Cape Thompson						Cape Lisburne	
	1960		1976		1977		1977	
	n	%	n	%	n	%	n	%
Total examined	84		20		20		28	
Number empty	18	(21.4)	8	(40)	5	(25)	7	(25)
Frequency of invertebrates	4	6.1	4	33	2	13	4	19
Frequency of fish	63	95.5	11	92	15	100	21	100
FISH:								
Gadidae	1	1.5	1	8	2	13	9	43
Boreogadus saida	51	77.3	5	42	3	20	6	29
Boreogadus sp.	2	3						
Eleginus gracilis			4	33	2	13	5	24
Cottidae			2	17	1	7	3	14
Triglops sp.	1	1.5						
Myoxocephalus sp.	1	1.5			1	7		
Icelinus sp.					1	7		
Lycodes sp.			1	8				
Ammodytes hexapterus	18	27.3	2	17	12	80	12	57
Ammodytes sp.	2	3						
Mallotus villosus					4	27		
Liparus sp.							1	5
Chirolophus polyactocephalus	1	1.5						
Pleuronectidae	4	6.1						
Unidentifiable	5	7.6	1	8	1	7	2	10
INVERTEBRATES:								
Polychaeta	4	6.1					1	5
Nereis sp.							1	5
Pteropoda							1	5
Limacina helicina								
Ostracoda					1	7	1	5
Arthropoda					1	7		
Amphipoda	1	1.5	1	8				
Gammaridae			2	17				
Euphausiacea							1	5
Decapoda								
Pandalus sp.			1	8			1	5
Eualus gaimardi			1	8				
Shrimp remnants	1	1.5						

	Cape Thompson						Cape Lisburne	
	1960		1976		1977		1977	
	n	%	n	%	n	%	n	%
INVERTEBRATES, continued								
Unidentified invertebrates	1	1.5						
MISCELLANEOUS								
Algae	1	(1.2)						
Pebbles	20	(23.8)	4	(33)	4	(20)	3	(11)

Common Murres.

Cod (Gadidae) were important to both species of murres in all years. Arctic Cod (Boreogadus saida) may be utilized somewhat more heavily than Saffron Cod (Eleginus gracilis) although the differences were not great except in 1960 when Saffron Cod were not identified from stomachs contents of either murre species.

A total of six species of sculpin (Cottidae) has been identified from the stomach contents of Thick-billed Murres. That group of fish also appears to be relatively important in the birds' diet. On the other hand, Common Murres utilized sculpin with a very low frequency and they are probably of only minor significance to those birds.

The only year in which eelpouts (Zoarcidae), especially Bothrocara sp., occurred was in 1976 when they may have been relatively important to Thick-billed Murres. Eelpouts have not been identified in food remains of Common Murres at either colony in any year. Sand Launce (Ammodytes hexapterus) were identified frequently at both colonies in all years except 1976 at Cape Thompson. Capelin (Mallotus villosus) appear to be taken in relatively small numbers. Snail-fish (Liparus sp.) were important to Thick-billed Murres except at Cape Thompson in 1960, although only one was identified in the stomach contents of Common Murres.

A rather wide variety of invertebrate prey has been indentified from stomach contents of Thick-billed Murres, especially in 1977. Polychaetes and molluscs appear to have been taken in about equal numbers all years. Amphipods were taken relatively frequently in 1977 at both Cape Thompson and Cape Lisburne. Decapods, particularly Pandalid shrimp were probably the most important invertebrates taken by Thick-billed Murres in 1977 at both colonies, and in 1976 at Cape Thompson, although they appear to have been utilized much less at Cape Thompson in 1960.

The importance of invertebrates to Common Murres can hardly be understated. The only possible exception to this was the utilization of polychaetes at Cape Thompson in 1960. The noticeable absence of invertebrates in the stomach contents of Common Murres suggests that trophic differences between the murre species do exist at Cape Thompson and Cape Lisburne. The degree of separation can be seen in Figures 13 and 14 which summarize the frequency of fish and invertebrate utilization in both species.

The relationships illustrated in Figures 13 and 14 also suggest yearly differences in the relative utilization of fish and invertebrates by both murre species. The year which had the smallest ratio of fish: invertebrates was at Cape Thompson in 1976. The ratios were about equal at both colonies in 1977 and were about midway between 1960 and 1976.

Seasonal differences in the utilization of fish and invertebrates by Thick-billed Murres in 1977 can be seen in Figures 15 and 16. At both Cape Thompson and Cape Lisburne invertebrates appear to have been taken somewhat more often than were fish during early summer. This relationship appears to have existed through 21 June at Cape Thompson; however, on 13 July and on every other sampling date thereafter at both colonies fish were taken more frequently than invertebrates.

Figure 17 illustrates similar data for Cape Thompson in 1976. During that summer, however, the relationships changed several times and no indication about the overall importance of fish compared to invertebrates appeared.

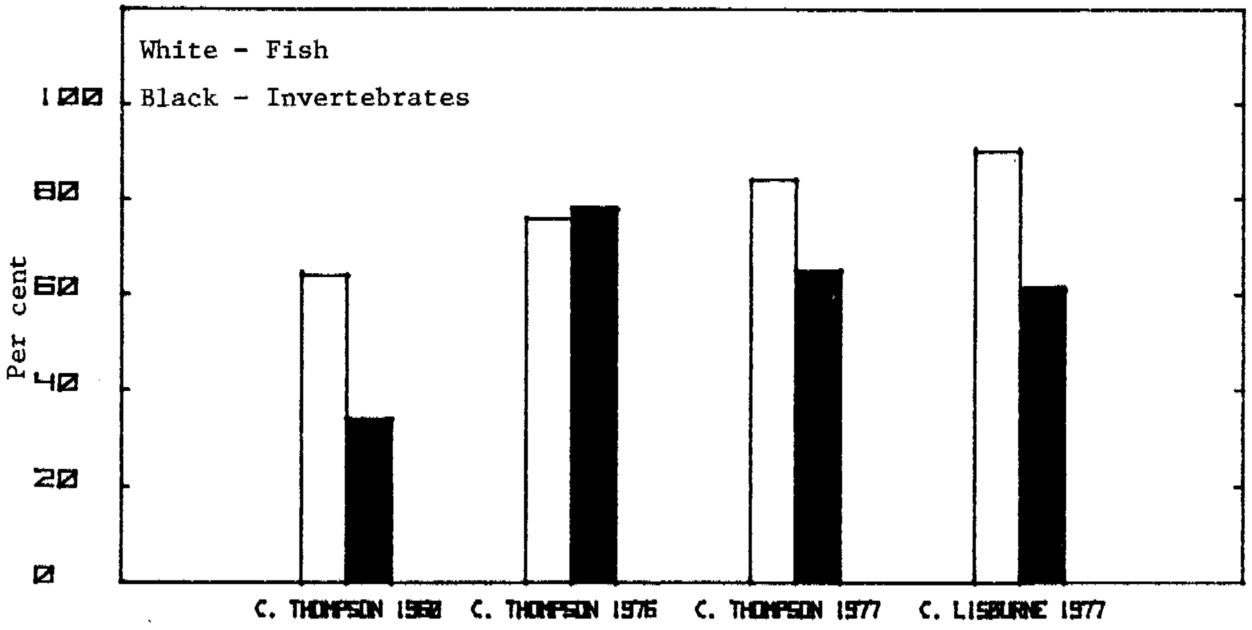


Figure 13. Relative occurrence of fish and invertebrate in stomach contents of Thick-billed Murres collected at Cape Thompson and Cape Lisburne.

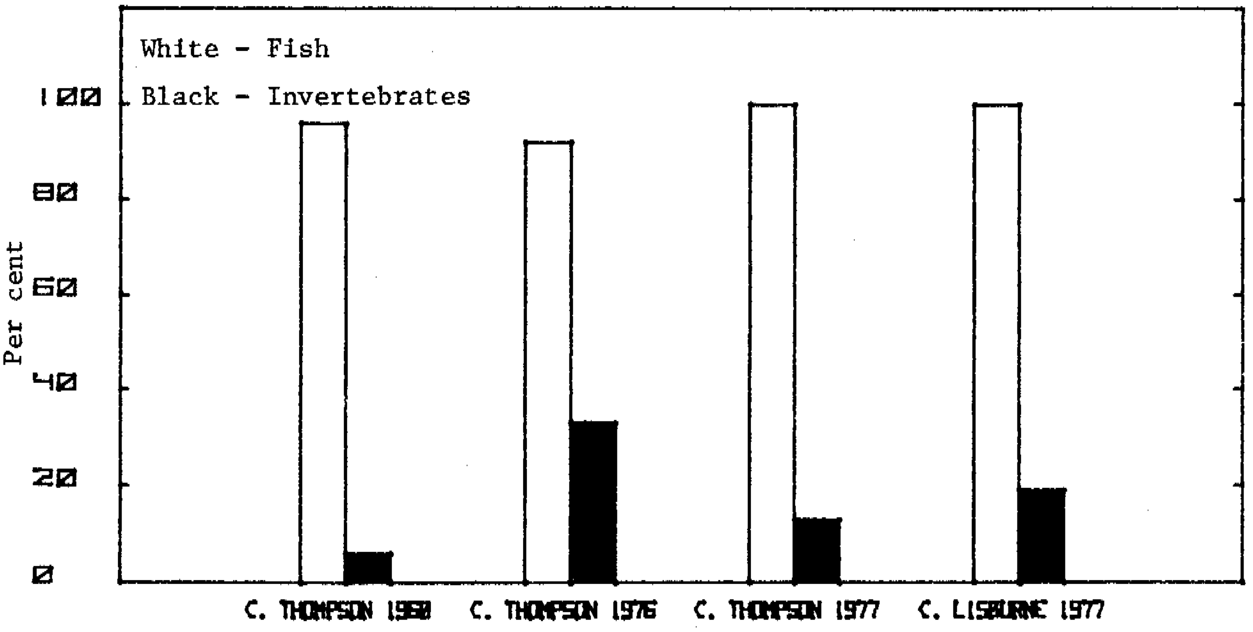


Figure 14. Relative occurrence of fish and invertebrates in stomach contents of Common Murres collected at Cape Thompson and Cape Lisburne

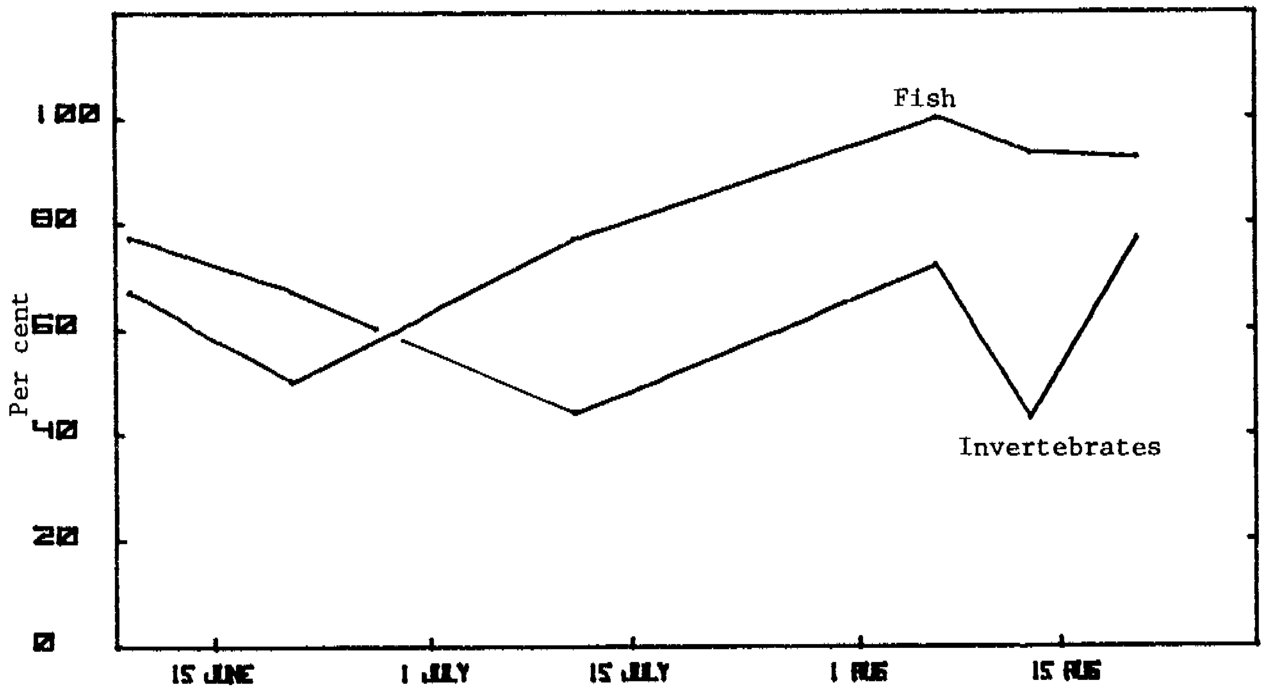


Figure 15. Seasonal utilization of fish and invertebrates by Thick-billed Murres at Cape Thompson, 1977

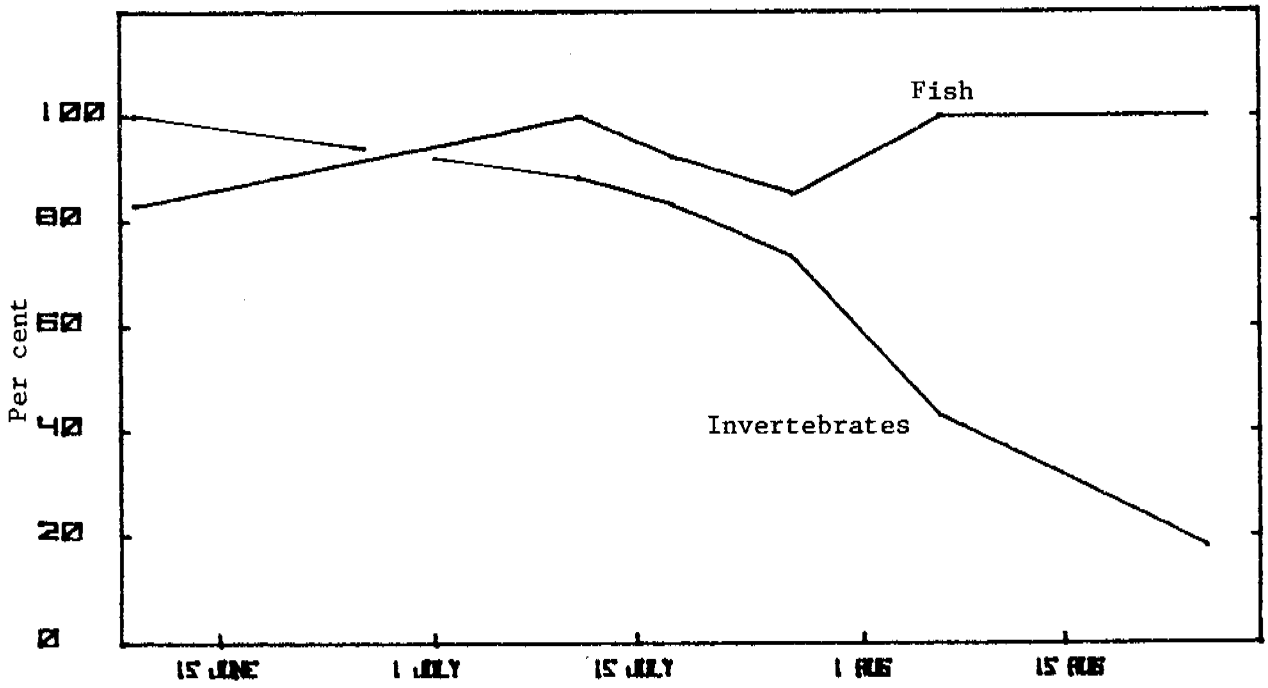


Figure 16. Seasonal utilization of fish and invertebrates by Thick-billed Murres at Cape Lisburne, 1977.

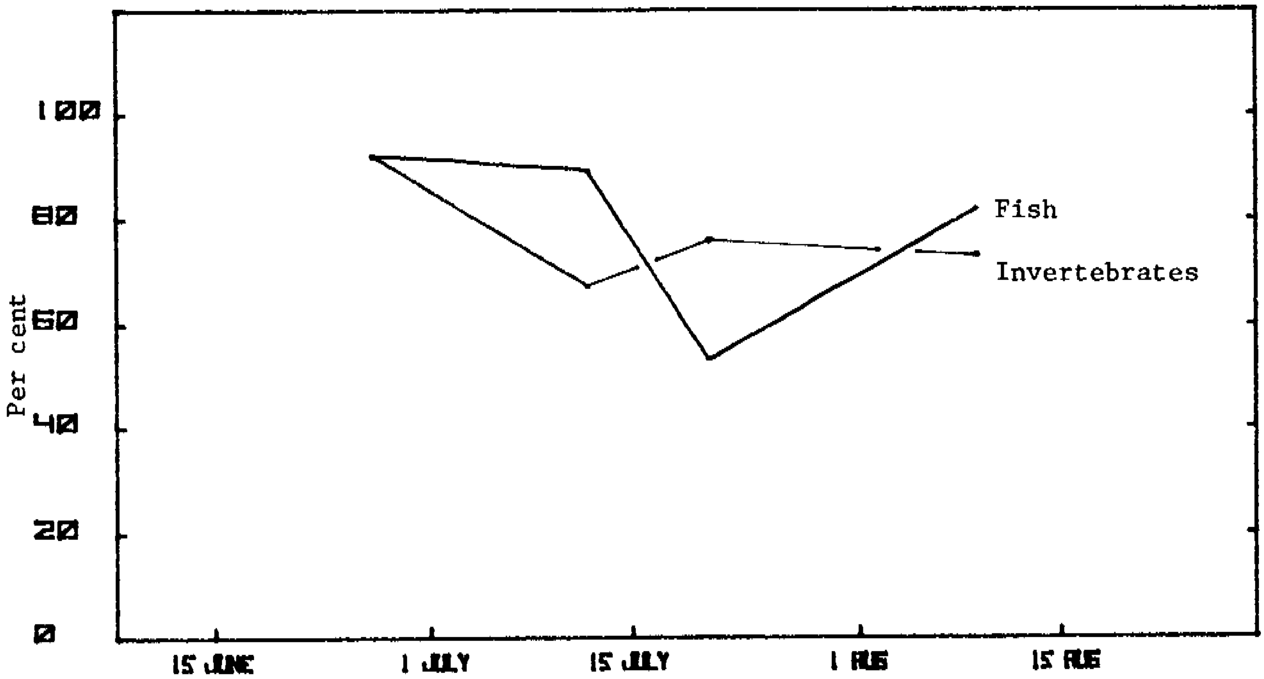


Figure 17. Seasonal utilization of fish and invertebrates by Thick-billed Murres at Cape Thompson, 1976.

Seasonal differences in the utilization of major fish groups and in the principle invertebrate prey, decapods, can also be seen. Table 22-24 present the frequency of occurrence of major food groups of Thick-billed Murres throughout the summers at Cape Thompson in 1976, Cape Thompson in 1977, and Cape Lisburne in 1977, respectively. Changes in the utilization of individual food groups throughout the summers are illustrated and compared between years and between colonies in Figures 18-22.

A pattern appears to exist in the utilization of cod by Thick-billed Murres; a peak occurred during mid-July in both years at Cape Thompson and in 1977 at Cape Lisburne. A concomitant low during mid-July in the utilization of sculpin was seen at Cape Thompson in both years with a peak occurring during the first week of August. This pattern did not exist at Cape Lisburne where sculpin were used much more evenly throughout the summer.

Sand Launce were not uncommon in the 8 June sample of thick-bills from Cape Lisburne. They were not identified at Cape Thompson until 13 July 1977, although they were not identified at Cape Lisburne on that date. During the following month the frequency with which Sand Launce were found in murre stomachs in both colonies increased rapidly. In 1976, Sand Launce were utilized infrequently and no changes similar to those in 1977 were seen.

No major differences were apparent in the utilization of snail-fish by murres at either colony in 1977. At Cape Thompson in 1976 Snail-fish were not identified, but eelpouts were and may have been utilized fairly often during mid-August.

Decapods, perhaps the principle invertebrate prey of thick-bills, were taken by a high percentage of birds during early summer at both Cape Thompson and Cape Lisburne in 1977. The importance of decapods appeared to decrease, however, as the summer progressed. Decapods were taken somewhat less frequently in mid-July of 1976 than they were during late June but by mid-August they were relatively high compared to July and compared to similar data in 1977.

Foraging patterns

Swartz (1967) reported on bird distribution at sea off of the Cape Thompson-Cape Lisburne colonies. The data were gathered during Cruise 268 of the oceanographic vessel BROWN BEAR, 6-28 August 1960. These data have been summarized in Figure 23. During the 1976 and 1977 field seasons, the direction of murre and kittiwake foraging flights were observed at Cape Thompson and Cape Lisburne. In 1977 additional observations were obtained at Cape Lewis. These data are illustrated in Figures 24-26.

The majority of the Cape Thompson murre population was observed to return daily to the cliffs from a southerly (downcoast) direction in 1959-1961. Only relatively small numbers apparently returned to the colonies from the northwest (upcoast) direction. Large murre flocks returning from the south, however, were common on foggy days when they appeared to follow the shoreline (Swartz pers. comm.; Swartz unpubl. field notes). In late July 1976, while revisiting the Cape Thompson colonies, Swartz observed flocks of murres returning from downcoast and recalled that these flights were quite common in June and July of 1960 and 1961, particularly while sea ice was still present.

Observations made at sea during August 1960 indicated that many

Table 22. Per cent occurrence of major food groups of Thick-billed Murres at Cape Thompson, 1976.

	27 June	13 July	22 July	12 Aug.
Gadidae	31	44	24	9
Cottidae	38	0	18	91
Ammodytes	8	0	0	9
Zoarcidae	0	11	6	45
Decapoda	69	44	53	66
n	13	9	17	11

Table 23. Per cent occurrence of major food groups of Thick-billed Murres at Cape Thompson, 1977.

	June		July	August			
	8	21	12	6	11	13-17	21-24
Gadidae	22	42	78	47	38	21	38
Cottidae	33	8	0	94	75	50	15
Ammodytes	0	0	11	18	50	36	85
Liparus	0	8	0	24	38	21	8
Decapoda	67	25	22	41	25	21	15
n	9	12	9	17	8	14	13

Table 24. Percent occurrence of major food groups of Thick-billed Murres at Cape Lisburne, 1977.

	June 8	July 13	July 20	July 26-31	Aug. 6-11	Aug. 21-29
Gadidae	33	75	42	62	28	27
Cottidae	33	50	58	31	43	36
Ammodytes	33	0	8	8	57	64
Liparus	17	13	17	4	0	27
Decapoda	83	63	58	23	14	9
n	6	8	12	26	7	11

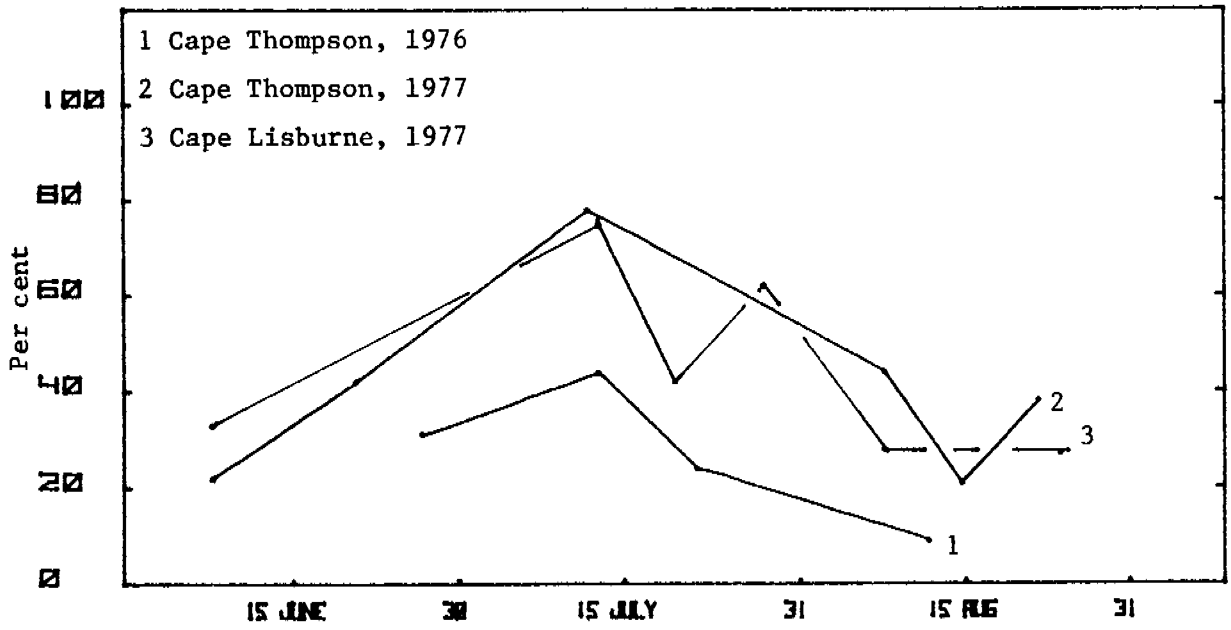


Figure 18. Seasonal utilization of Gadidae by Thick-billed Murres at Cape Thompson and Cape Lisburne.

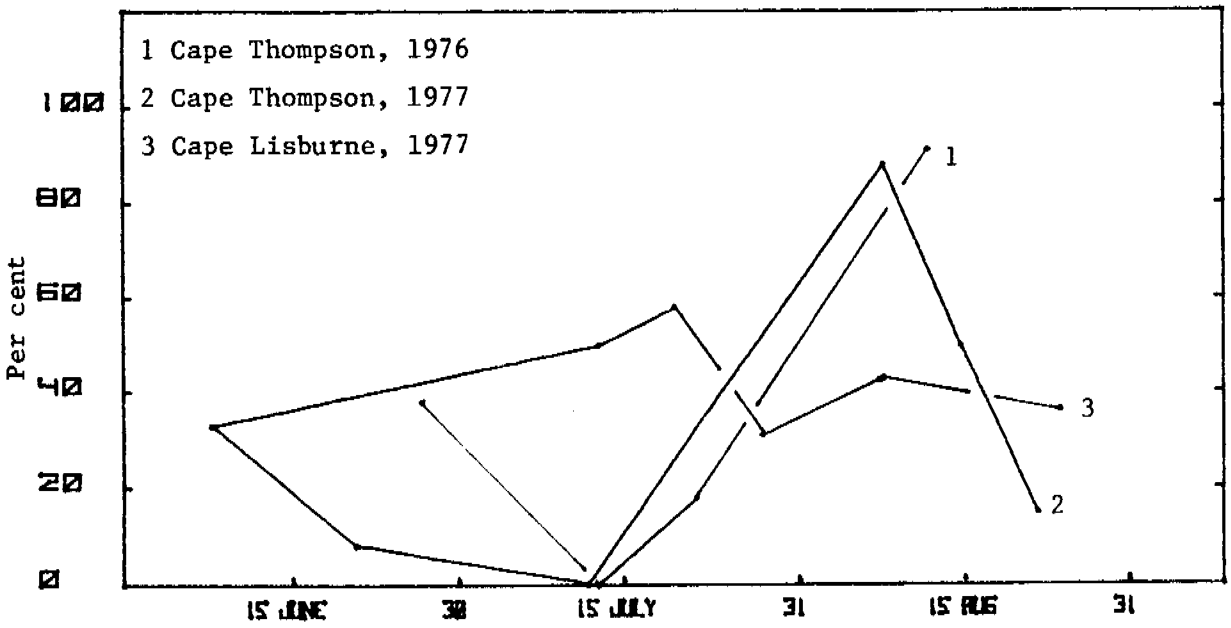


Figure 19. Seasonal utilization of Cottidae by Thick-billed Murres at Cape Thompson and Cape Lisburne.

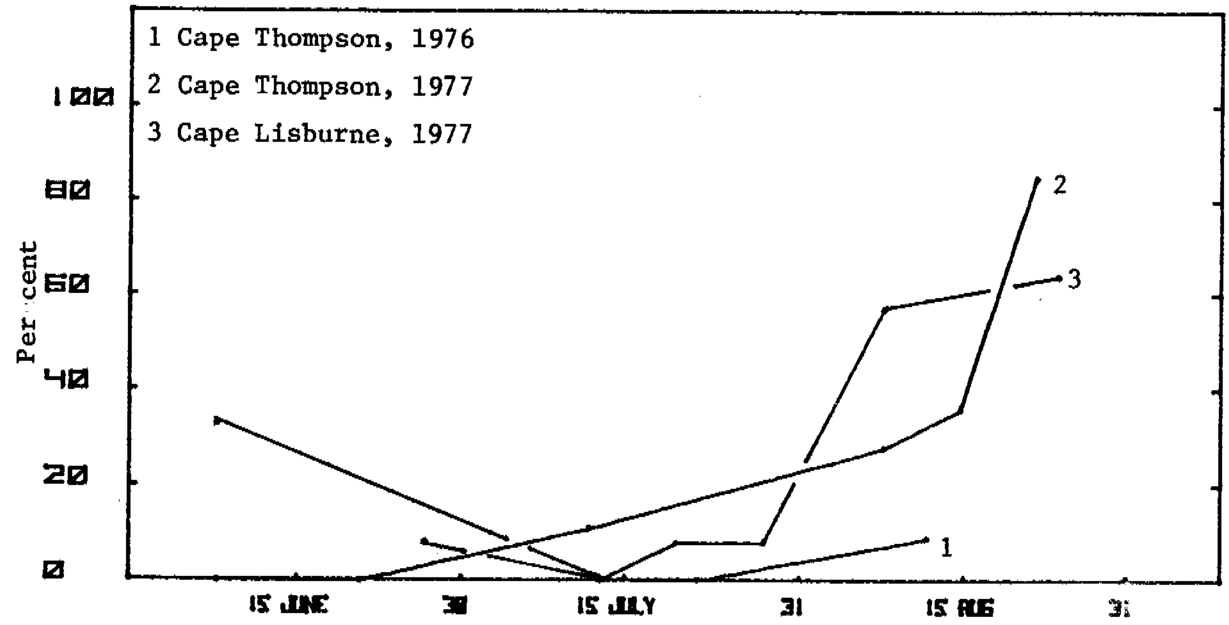


Figure 20. Seasonal utilization of Ammodytes by Thick-billed Murres at Cape Thompson and Cape Lisburne.

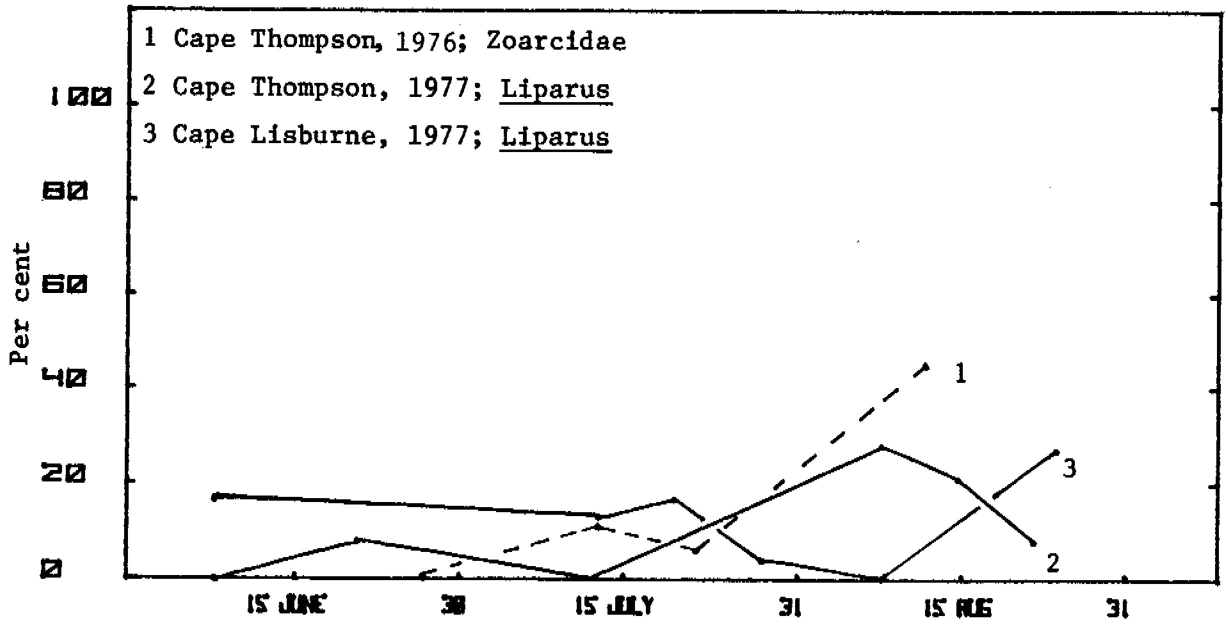


Figure 21. Seasonal utilization of Liparus and Zoarcidae by Thick-billed Murres at Cape Thompson and Cape Lisburne.

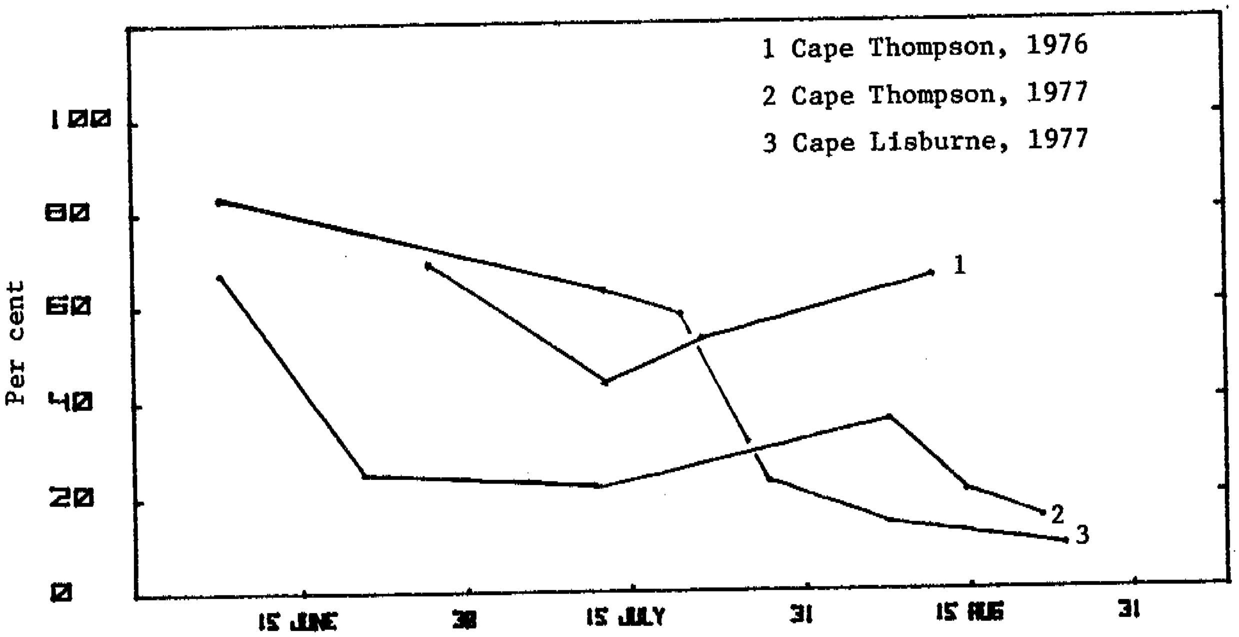
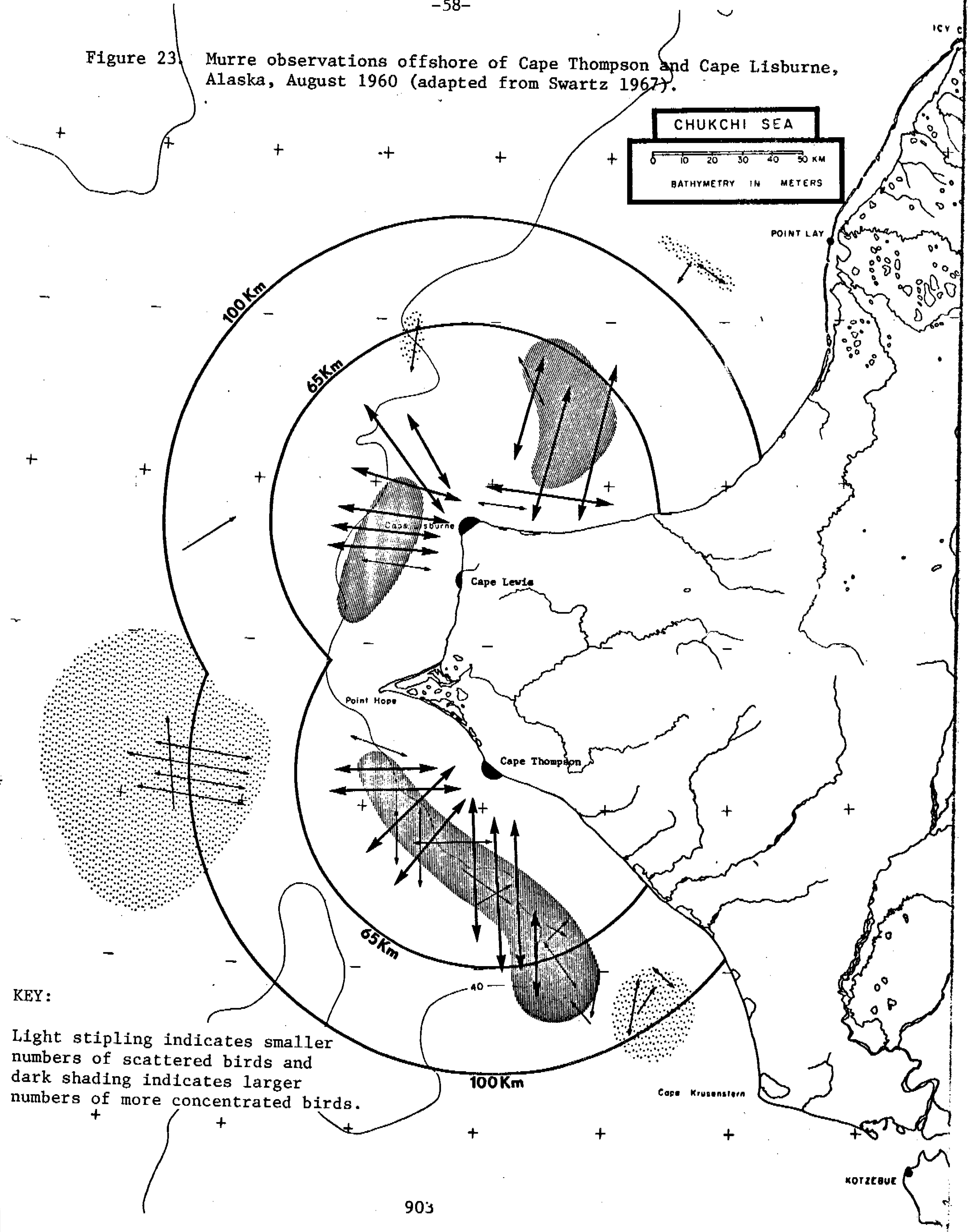


Figure 22. Seasonal utilization of Decapods by Thick-billed Murres at Cape Thompson and Cape Lisburne.

Figure 23. Murre observations offshore of Cape Thompson and Cape Lisburne, Alaska, August 1960 (adapted from Swartz 1967).



KEY:

Light stipling indicates smaller numbers of scattered birds and dark shading indicates larger numbers of more concentrated birds.

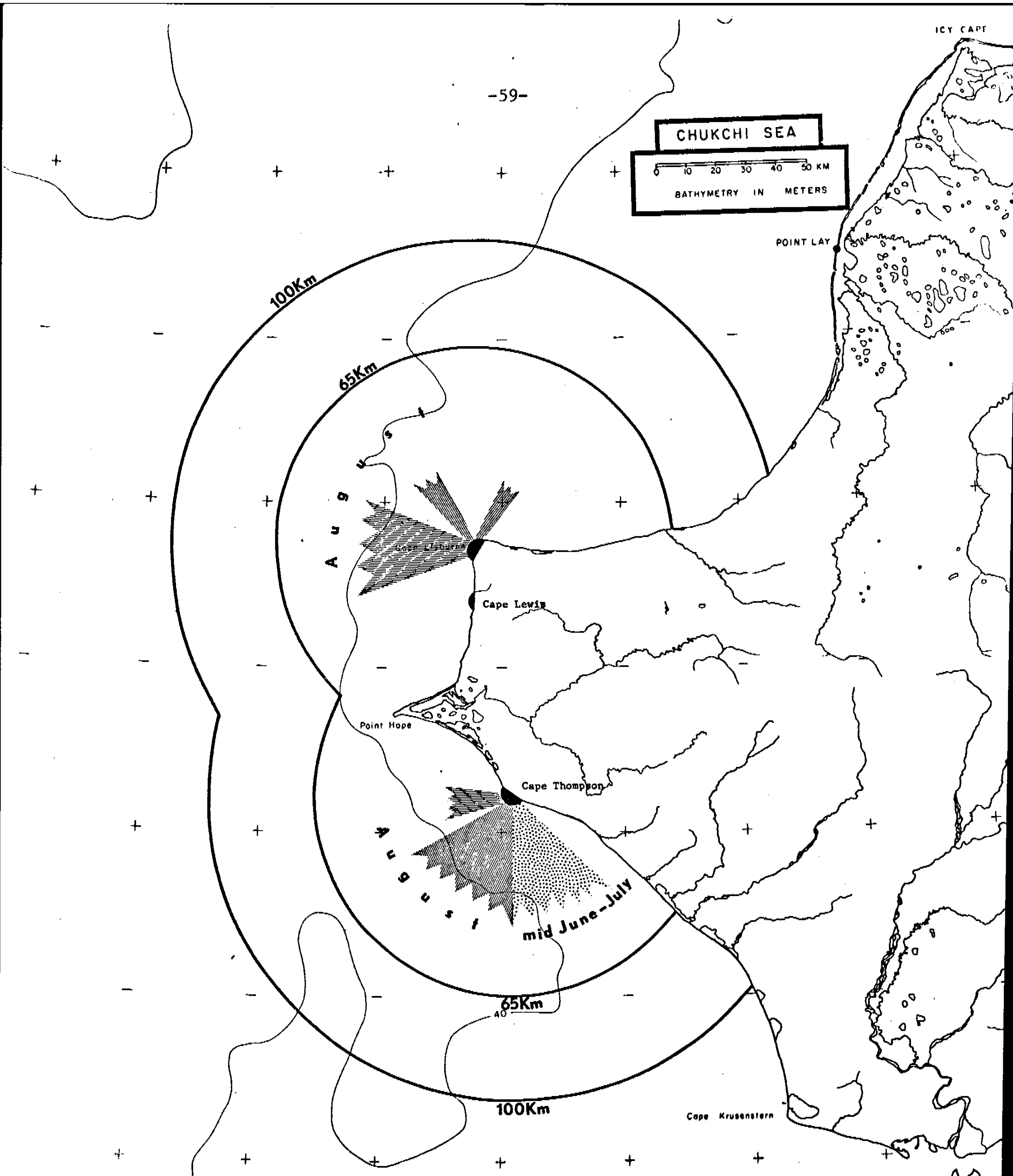


Figure 24. General murre foraging flight patterns observed during mid-June, July and August 1976 at Cape Thompson, and during late August 1976 at Cape Lisburne, Alaska.

Figure 25. General murre foraging flight patterns observed during July 1977 at Cape Thompson, Cape Lewis and Cape Lisburne, Alaska.

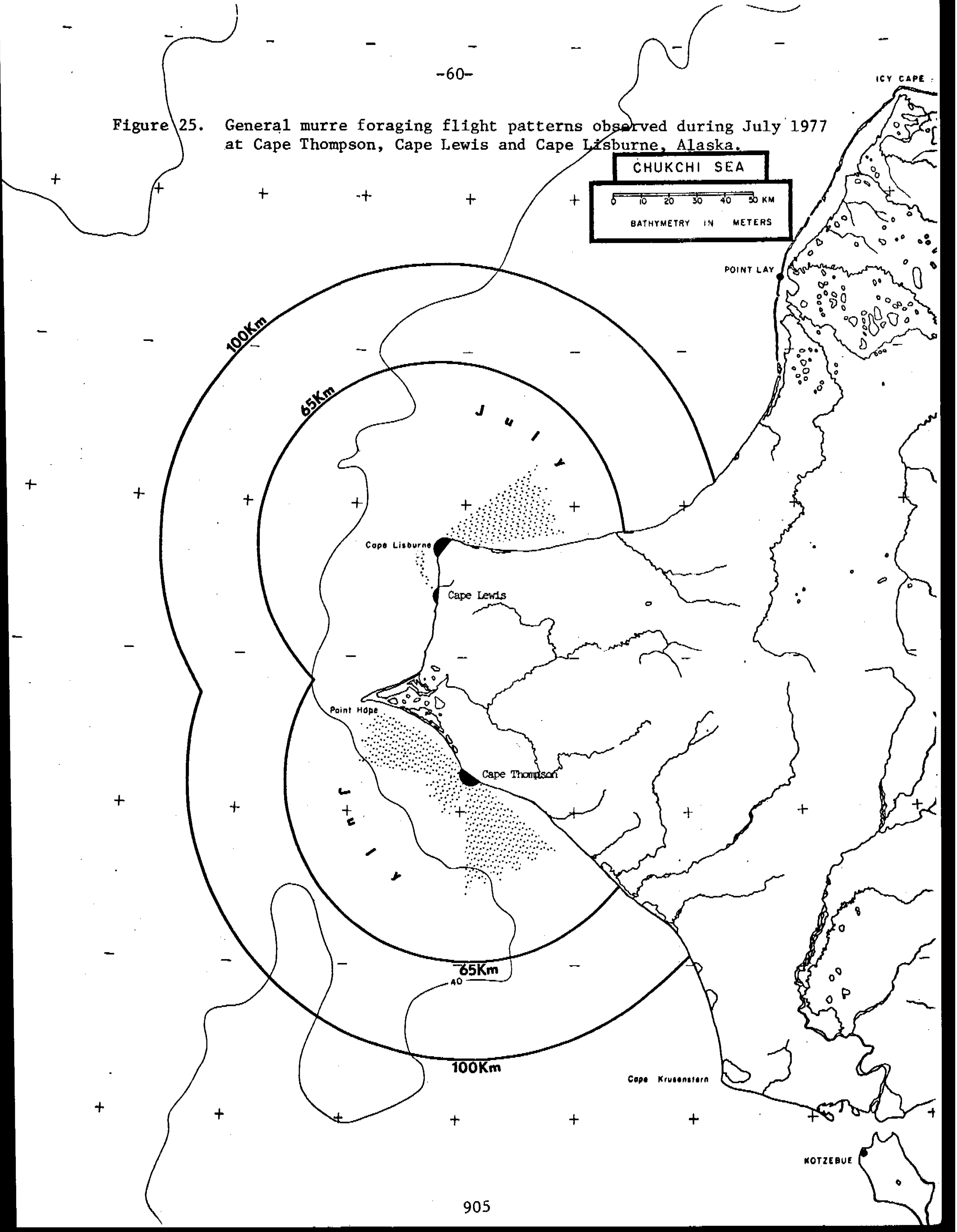
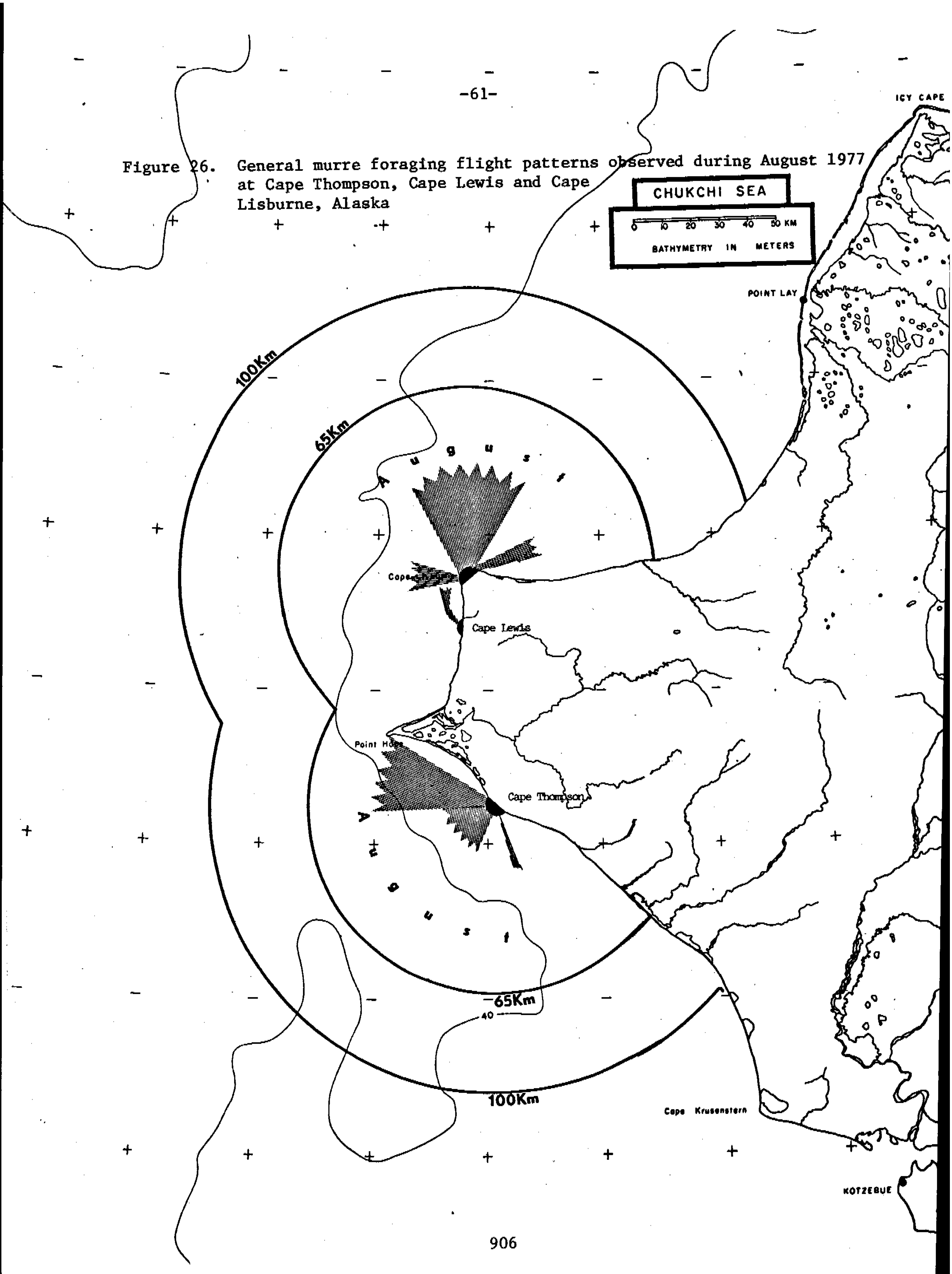


Figure 26. General murre foraging flight patterns observed during August 1977 at Cape Thompson, Cape Lewis and Cape Lisburne, Alaska



murre flocks flew out from the Cape Thompson colonies in a south and southwesterly direction and that many flocks returned to the colonies on the back-asimuths of these courses. Other flocks followed flight tracks to and from the west and west-northwest (Swartz 1967).

In 1976 observations were made of the direction that murre flocks took when leaving and returning to the Cape Thompson colonies (see Figure 24). From 19 June to about 1 August murres consistantly followed a relatively well defined southerly flight pattern. Individuals and small groups (usually 2-10) departing the cliffs flew southeast and south-southeast. Much larger flocks (usually several 10's to a few hundred) returned from these same compass directions. On foggy days flocks closely paralleled the shoreline. As fog banks retreated offshore, flocks retreated with it, flying from about one to more than several kilometers offshore. On clear days flocks departed and returned to the area farther out to sea. Departing and returning flights of birds generally fell in an arc between about south-southeast and due south. Only relatively small numbers of murres appeared to depart to and return from the southwest and west, more directly offshore of the colonies, and no birds were observed flying to or from headings above 270°.

During the first few days of August an interesting change became apparent. Few murres flew near the coastline. Instead, they departed to the south and southwest and returned from these same directions. By mid-August much larger numbers of murres also were returning from the west. This flight pattern persisted until our departure on 25 August; birds were still not observed to depart or return from the west-north quadrant.

Our observations of murre flight patterns to and from the colonies in 1977 were substantially different than those of 1976. During one visit on 21 June and on our arrival on 6 July, murres were observed following what appeared to be a flight pattern identical to the June-July 1976 pattern. It soon became apparent, however, that bird numbers returning from the southeast and south-southeast, though considerable, were not as large as those observed in 1976. Some murres appeared to be departing to and returning from the arc between south and west, while large numbers of murres, comparable to and perhaps even greater than those following the downcoast flight pattern, were returning to the colonies from the northwest and north-northwest.

By the end of the third week in July, murre flocks returning to the colonies from the southerly directions had declined markedly. By the first week of August as few as 1000 murres per hour were returning to the colonies from the southeast and south during the peak activity period. Collecting specimens downcoast of Cape Thompson became very difficult. The vast majority of all murres were departing to and returning from upcoast, a compass direction of about 300°. Within a few days time virtually all murres followed this flight pattern and only a handfull of individuals persisted in using the southerly flight pattern. By about 20 August, however, the upcoast flight pattern was shifting back to more directly offshore. Most departing and returning murres were using a more northwesterly and west-northwesterly flight pattern.

After about mid-August it also became apparent that greater and greater numbers of murres were feeding nearshore and just upcoast of and in front of the colonies. Prior to this virtually all murres were departing to and arriving from distances well beyond spotting scope range. Feeding activity near the colonies increased markedly on 21 August when many birds were observed surfacing with Ammodytes. Even greater numbers of murres fed immediately in front of the colonies on 23 August, the day large schools of Ammodytes appeared along the bases of the sea cliffs. Feeding activity along the colonies was still apparent upon our 26 August departure date. Though apparently reduced in number, some flocks of murres still persisted in using the northwesterly flight pattern; however, more and more individuals appeared to be again departing to and returning from the west and southwest.

Several raft trips along the Cape Thompson coast provided some information on murre foraging distances during 1976 and 1977. Southeast of Ogotoruk Creek departing and returning murres were still evident at our maximum travel distance of about 24 kilometers. Between about 13-16 kilometers from the colony the southerly flight pattern angled farther offshore. In 1977 murres returning to the colonies from the northwest were coming from a distance that certainly exceeded 16 kilometers.

Swartz (1967) found murres up to at least 96 kilometers south of Cape Thompson, and up to about 150 kilometers west-northwest of the colonies (see Figure 23). The bulk of his murre observations occurred between about 25 and 70 kilometers offshore. Based on August 1960 shipboard observations Swartz reported that the principal foraging area utilized by the Cape Thompson murres appeared to lie primarily south of Point Hope. His data suggested that some feeding appeared to occur as far as about 64 kilometers from Cape Thompson, although most feeding activity appeared to take place within about 48 kilometers.

During aerial transects flown 19 June 1975 concentrations of seabirds, the majority of which were murres, were located about 70 kilometers south of Cape Thompson at about $67^{\circ}30'$N, 166°W (Harrison pers. comm.). Harrison also reported fewer but substantial numbers of murres at the same location on 21 August 1976. Similar concentrations of murres were found in this same general location during early September 1976 by shipboard observers (Gould pers. comm.). Three of four murres collected on 20-22 August 1960 from this same general locale ($67^{\circ}53'$N, $166^{\circ}09'$W and $67^{\circ}38'$N, $165^{\circ}45'$W) showed evidence of breeding (Swartz 1967).

August 1960 shipboard observations in the vicinity of Cape Lisburne indicated that many murres departed to and returned from the west; others followed a northwest-southeast line and smaller numbers, observed to the northeast of the colony, followed a north-northeast, south-southwest line (Swartz 1967).

During our reconnaissance of the Cape Lisburne colony between 25 August and 1 September 1976 murres were noted predominantly departing to and returning from the north-northwest to west compass arc while smaller numbers returned from the northeast. Upon our arrival in 1977 virtually all Cape Lisburne murres were departing to and returning from the east-northeast and northeast. Murres were never observed flying to or returning from any direction in the 180°-360° arc.

On foggy days large numbers of murres followed the northern shoreline, while on clear days the southern edge of the flight pattern was often a few kilometers offshore. Observations up to about 50 kilometers east suggested that between about 16 and 24 kilometers from the colony the flight pattern curved farther offshore to the north and northeast. Although some flocks of murres were still following the shoreline from the east, many flocks of murres were intersecting the shoreline from farther offshore. This flight pattern was constant throughout July.

During the last few days of July and the first few days of August it was apparent that a change was in progress. Large numbers of murres became more common on the water off of the west side of the colony. Somewhat fewer murres followed the east-northeast and northeast flight pattern, while larger numbers departed to and returned from the region between north-northeast and north-northwest. During early August some murres began returning from a more northwesterly direction and a smaller proportion still persisted in following the northeasterly flight pattern. After a violent storm on 8-9 August when many Ammodytes washed up on the northfacing beach, tremendous feeding activity was concentrated in the coastal waters all along the colony although some murres still followed the early August flight pattern. The number of murres feeding away from the colonies continued to decline until our 4 September departure.

An attempt was made to gain perspective on how far murres were traveling eastward of the colony in 1977. A reconnaissance trip about 50 kilometers to the east revealed that flocks of returning murres were still evidently following the coastline from the east within sight of the beach. Swartz (1967) found murres up to about 50 kilometers eastward of Cape Lisburne and up to about 120 kilometers northeastward and north. Most of his murre observations to the northeast, north and west of the colony occurred within about 50 kilometers.

Some observations were obtained in 1977 that suggest murres breeding at Cape Lewis, about 18.5 kilometers south of Cape Lisburne, forage in the same areas that Cape Lisburne murres utilize. During July and early August, small flocks of murres were occasionally observed flying south, by-passing the Kay Creek vicinity of the colony. These small flocks were often 1-2 kilometers offshore.

On 27 July a reconnaissance trip was made as far south as Cape Dyer, 7 kilometers beyond Cape Lewis. Small flocks of murres were observed carrying fish past the southern terminus of the Cape Lisburne colony. Throughout that day southbound flocks were observed along the coast between Cape Lisburne and Cape Lewis, where they landed. During several hours of observation murres were observed only once departing to or returning from the west or south. Between Cape Lewis and Cape Dyer one small flock of northbound murres (approximately 10 individuals) was encountered. If Cape Lewis murres were flying distances north and east of Cape Lisburne comparable to those of murres nesting at this more northern colony, they may have foraged at least 70-90 kilometers away from their nesting site.

Growth rates

Thirty-one Thick-billed Murre chicks at Cape Lisburne were weighed periodically during intervals of 6 to 21 days. Murre chicks do not exhibit a regular increment of growth throughout their nest life, so deriving growth rate averages is difficult. We obtained a mean growth rate for the 31 chicks of 6.1±2.3 grams per day by dividing the change in weight between the lowest observed and the highest observed by the number of days between those observations.

The greatest weight obtained by any chick we weighed was 210 grams and the average of five 21-day old chicks was 170±36 grams. The maximum weight achieved by murre chicks characteristically occurs a few days before they leave the cliffs, a phenomenon described by Tuck (1960) and

Belopolskii (1957). The weight loss is attributed to rapid growth of feathers immediately preceding departure. This pattern was also evident among murre chicks at Cape Lisburne.

Mortality

Egg collecting by local people from Point Hope and Kivalina occurred at Cape Thompson during 1977. At least eight egging parties visited the cliffs during the period 6-15 July. We doubt that more than 1500 to 2000 eggs were collected in 1977 which agrees with the estimate of Swartz (1966) for 1960. To our knowledge, no eggs were collected in 1976. Because murres will re-lay after the loss of the first egg and because other mortality factors such as predation of eggs by gulls and ravens are certainly of much greater magnitude, we believe that current losses to local residents are of little significance to the murre population.

Eggs were also collected from Cape Lisburne by people from Point Hope. All collecting occurred before we arrived at the site and we do not know the numbers of eggs taken. According to one resident of Point Hope, four parties visited Cape Lisburne and probably gathered about the same number of eggs that were taken at Cape Thompson.

The greatest loss of eggs at Cape Thompson resulted from gull and raven depredation. We cannot estimate the number of eggs taken by these birds but murre eggs and chicks probably constitute the bulk of the diets of both species during the majority of the summer. The slopes above the cliffs are littered with broken shells of eggs which were carried there and eaten by gulls and ravens.

Gulls and ravens also were responsible for taking a large number of eggs and chicks at Cape Lisburne. Perhaps of greater significance to the murre population, however, were losses to a resident grizzly bear. The bear was about three years old and had an uncanny ability to navigate the most precipitous of faces on the cliffs in his search for eggs and chicks. On one occasion his position was so precarious that we dropped anchor and simply waited for him to fall. After some 45 minutes he was still maneuvering about the cliffs, and in the process undoubtedly ate several hundred eggs.

Not only did this bear prove to be a hindrance to the success of the murre reproductive effort this season but it also proved to be a hindrance to our own research efforts. Sixteen of 39 chicks we were weighing were eaten. Approximately 50 of 60 eggs on one study plot we were monitoring were eaten. Other bears, which also frequented the area, may have taken eggs and chicks as well. A grizzly bear also ate a few murre eggs and chicks in late august at Colony 4, Cape Thompson; however, this bear did not appear to rely on this food source as did the bear at Cape Lisburne.

The winds discussed earlier in the report also contributed to adult murre mortality. The winds at Cape Thompson and Cape Lisburne are probably the single most important mortality factor affecting adult birds. Murres were regularly seen along the beaches in front of the cliffs wounded, usually with broken wings and/or broken legs. Both years many birds were also found dead at the base of the cliffs after having apparently smashed headlong into the rock.

Rock falls at Cape Thompson also kill many adult murres and kittiwakes during the breeding season. A nearly constant shower of small to medium sized rocks falls along many sections of the cliffs. Some of the rocks occasionally strike birds and either kill them outright or mortally wound them. Large rock falls are infrequent but when they occur many birds and large areas of nesting habitat can be affected. One large rock fall at Colony 5 spilled over a section of cliff where murres were nesting. From the raft we could see at least six dead murres on top of the rock pile at the bottom of the cliff; however, many more birds were certainly buried beneath the large mass of rubble.

Occasionally entire sections of a cliff face will peel off and fall. At least twelve adult kittiwakes and one chick were killed when a small section of cliff at Colony 3 broke off. At Colony 2 a portion of cliff fell away and at least four adult murres, three adult kittiwakes and an adult Horned Puffin were killed.

B. Black-legged Kittiwakes

Census

The methods used to estimate the number of kittiwakes breeding at Cape Thompson in 1960 and 1961 were different than those used in 1976 and 1977. In 1960 and 1961 nest sites were counted to arrive at a total breeding population. Because so few birds were nesting in 1976, we counted the total birds on the cliffs that year. We counted total birds again in 1977 so that comparisons with 1976 could be made more easily. The summaries of all counts made at Cape Thompson are presented in Table 25 and the individual plot counts for 1977 are presented in Tables26-29.

The number of birds counted at Cape Thompson in 1977 was 10,228 which was very close to the number obtained in 1976, 10,540. Both of these values are somewhat lower than the number of nests counted by Swartz in 1960 and 1961. Most birds counted in 1976 and 1977 were sitting singly on what appeared to be nest sites, although all of the sites were obviously not successful. Pairs were occasionally present on sites, however, and the totals for our counts are certainly higher than the number of nests which were being defended. The size of the difference between the 'breeding populations' in 1960-61 and 1976-77, therefore, may be larger than our counts suggest.

Table 25. Black-legged Kittiwake census summary, Cape Thompson.[1]

			Colony			
Year	1	2	3	4	5	Total
1960	0	5253	2950	3132	3180	14,515
1961	0	4914[2]	3533[2]	3131	3214[2]	14,792
1976	0	3373	3086	1649	2432	10,540
1977	0	3445	2657	2459	1667	10,228

[1] number for 1960 and 1961 are total nests; numbers for 1976 and 1977 are total birds. Numbers reported here for 1960 and 1961 were obtained from unpublished field notes and summary sheets. Numbers reported in Swartz (1966) were derived by multiplying these figures x 2 and rouding off; this step was inadvertently omitted in the case of the published Colony 5 total.

[2] estimates based on partial counts

Table 30 presents results of the kittiwake census at Cape Lisburne for 1977. The number of birds on each of 57 plots were counted while only the total number of sites on the remaining 18 plots were counted. A site was defined as any place on the cliff where a kittiwake was present and which showed signs of repeated use. In the majority of cases, a nest or at least evidence of nest construction was visible. The total number of birds counted plus the number of sites where only sites were counted equals 14,478.

We counted the number of birds and the number of sites on 38 plots. The mean number of birds per site was 1.05±0.05. By using this calculation and by making the assumption that each site represented a nesting attempt by a pair of birds, we were able to derive an estimate of the number of "breeding" birds present at Cape Lisburne in 1977.

We counted 3798 sites on the 18 plots where only sites were counted. Based on the observed ratio of 1.05 birds per nesting site we estimate that about 3988 birds were present on those plots at the time they were counted. By adding that figure to the number of birds which were counted (10,680), we estimate that about 14,668 birds were present on the cliffs at the time of the census.

As with murres, many kittiwakes were away from the colony during the census. This figure, therefore, is a minimum estimate of the size of the kittiwake population at Cape Lisburne. If the ratio of 1.05 birds per site implies that up to 47% of all individuals comprising a pair were away from the cliffs, the 'breeding' population could exceed 28,000 birds.

Large number of kittiwakes were seen regularly at creek mouths to the south of Cape Lisburne as well as along the lagoons to the east of the cape. Flocks of 175, 913, 107 and 432 kittiwakes were observed in a distance of about 14 kilometers between Cape Lisburne and Noyalik Peak on 13 July. Five birds were collected from a flock of approximately 200 birds at the mouth of Alkalugen Creek on 14 July. All five birds were females, 4 of which had very little or no broodpatch development. These 5 females weighed an average of 400±16 grams and had an average whole body fat content of 27±4.9%. Four females were collected from feeding groups in front of the cliffs on 12 and 13 July. The average weight of these birds was 424±33 grams and the whole body fat content was 32±3.9%. Three of the four birds had well developed brood patches. These observations suggest that non-breeding females remain in large groups and tend to "hang out" in the vicinity of the nesting colonies during the summer. If all of the kittiwakes in these large flocks were non-breeding females, the size of this cohort relative to the size of the breeding population was substantial.

Activity patterns

One 24-hour activity count was made at Cape Thompson on 25-26 July. The curve generated by these counts is illustrated in Figure 27. Maximum attendance on the cliffs by kittiwakes occurred during early morning between 0500 and 0800 hours. The low occurred approximately 12 hours later when about 60% of the morning maximum was counted. Similar counts at Cape Lisburne were not made.

Phenology

The timing of events in the breeding cycle of kittiwakes at Cape Thompson were consistent with dates reported by Swartz during 1959-1961, but

Table 26. Black-legged Kittiwake census, Colony 2; Cape Thompson, 1977.

17 July				
Plot	Time	Observer F	Observer G	$\bar{x}$
A	2240	0	0	0
B		0	0	0
C-F		263	275	269
G-J		473	478	476
K-N		713	705	709
O-R		364	330	347
S,T		307	273	290
U		496	506	501
V,W		377	369	373
X,Y		63	43	53
Z,AA		121	126	124
BB,CC	0130	87	82	85
DD-FF	1900	191	197	194
GG-II	1915	24	24	24
Total		3,479	3,408	3,445

Table 27. Black-legged Kittiwake census, Colony 3; Cape Thompson, 1977.

24 July and 3 August				
Plot	Time	Observer F	Observer G	$\bar{x}$
A	2105	0	0	0
B		4	4	4
C		36	34	35
D-F		73	73	73
H		331	325	328
G,I-L		1591	1657	1624
M,N	2200	207	232	220
O		122	103	113
P		141	146	144
Q	2230	83	76	80
R,S		36	36	36
Total		2,624	2,686	2,657

Table 28. Black-legged Kittiwake census, Colony 4; Cape Thompson, 1977.

Plot	Time	18 July Observer F	Observer G	$\bar{x}$
A,B	2200	410	449	430
C		287	290	289
D,E		423	385	404
F,G		435	406	421
H		283	284	284
I		97	107	102
J-L,O		309	277	293
M,N,P-R	0130	241	234	238
Total		2485	2432	2459

Table 29. Black-legged Kittiwakes census, Colony 5; Cape Thompson, 1977.

Plot	Time	Observer F	Observer G	$\bar{x}$
		19 July		
A	0130	46	51	49
B	0130	121	115	118
C	0130	114	118	116
D	0130	46	48	47
E	0130	467	436	452
F	0330	369	315	342
G	1700	311	359	335
H	1700	182	183	183
I	1700	21	22	22
J	1800	0	0	0
K	1800	0	0	0
L	1820	2	3	3
Total		1,679	1,650	1,667

Table 30. Black-legged Kittiwake census; Cape Lisburne, 1977.

Plot	Date	Time	Total Birds	Total Sites
1	7 Aug	1730	291	285
2		1800	52	46
3			0	0
4			0	0
5			0	0
6		1815	85	81
7	12 Aug	1800	39	38
8		1810	34	32
9		1820	155	150
10		1830	169	163
11		1850	114	112
12		1900	75	73
13		1910	269	
14		1920	182	170
15	14 Aug	1900	348	
16	27 Aug		58	
17			649	
18			3	3
19			382	328
20			786	705
21			115	104
22			219	197
23			88	80
24			172	153
25			54	48
26			265	235
27	13 Aug	2120	0	
28		2105	228	
29		2100	104	104
30		2050	126	126
31	27 Aug			846
32				0
33				173
34				239
35				67
36				359
37	13 Aug	2045	4	
38		2040	0	
39		2035	114	
40		2030	168	
41	27 Aug			55
42				95
43				52
44				16
45				39
46				208
47				98

Plot	Date	Time	Total Birds	Total Sites
48				288
49				393
50				512
51				184
52	16 Aug	2030	243	243
53		2020	133	133
54		2010	135	135
55		1950	640	640
56		1935	73	73
57		1920	67	
58		1910	130	
59		1840	146	
60	15 Aug	1930	72	
61		1915	205	
62		1900	293	
63		1830	878	
64		1800	571	571
65	16 Aug	2115	247	247
66		2110	50	50
67		2105	141	
68	13 Aug	1930	182	176
69	16 Aug	2130	28	
70	11 Aug	1500	296	291
71		1440	177	172
72		1420	274	259
73		1400	349	337
74	27 Aug			174
75			0	0

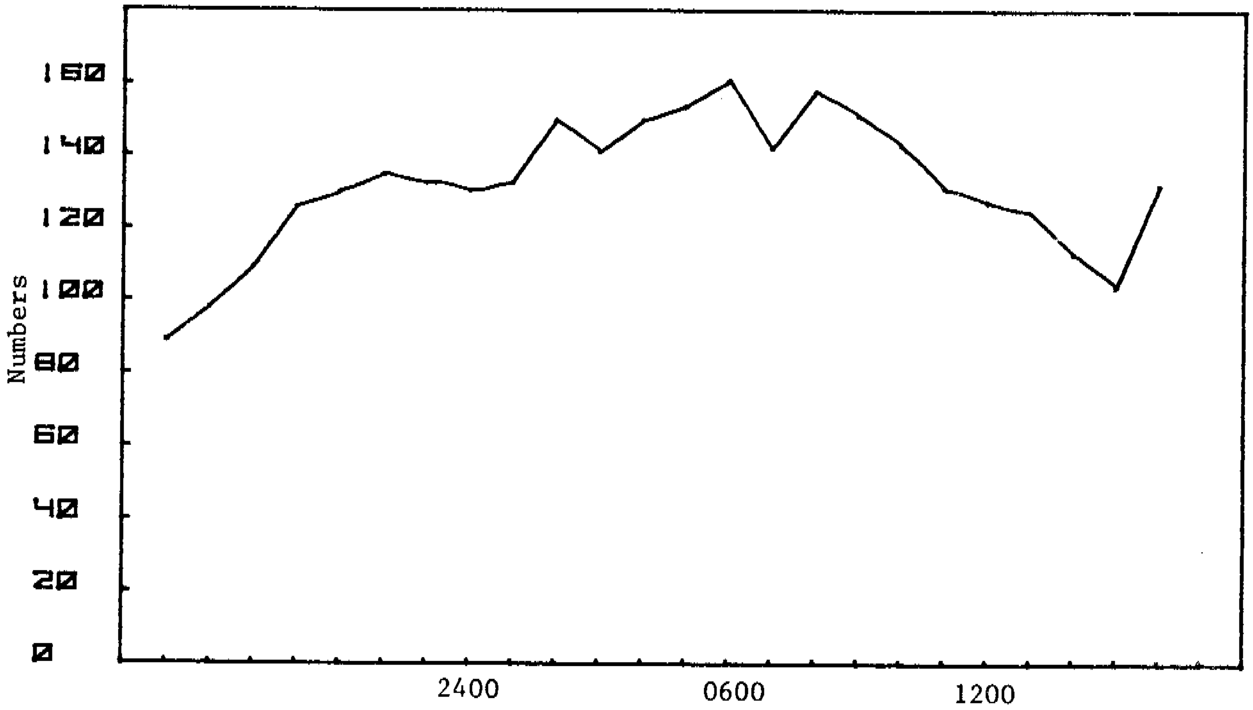


Figure 27. Diurnal activity of Black-legged Kittiwakes at Cape Thompson.

were somewhat earlier than 1976. These data are presented in Table 31. The date of first hatching in 1977 appears to be earlier than dates for hatching in other years. However, if first hatching dates for 1959, 1960 and 1961 were calculated on the basis of a 44-day nestling period (see Swartz 1966) and the date of first fledging, as was done in 1977, these hatching dates would be earlier than those reported in Table 31. Haching dates in 1977 appear to have been much earlier than in 1976, as they were during 1959-1961.

Table 31. Phenology of nesting activities of Black-legged Kittiwakes at Cape Thompson.

Year	First building	First egg	First hatching	First fledging
1959	not observed	22 June	20 July	30 August
1960	13 June	21 June	17 July	20 August
1961	18 June	25 June	22 July	27 August
1976	not observed	4 July	9 August	not observed
1977	not observed	not observed	10 July[1]	23 August

[1] calculated on the basis of a 44-day nestling period and the date of first fledging

Because the majority of kittiwake eggs had been laid by the time we arrived at the site in 1977, we have few observations of laying dates. Laying dates calculated on the basis of hatching dates (28-day incubation period, see Swartz 1966) suggest that the majority of eggs were laid about 1 July and increased to a peak about 12 July.

Eggs began to hatch towards the end of July, and most eggs had hatched by 9 August. The peak hatch probably occurred during the interval 1-5 August. These data are listed in Table 32. At least one egg hatched as late as 21 August. The first fully fledged young was observed on 23 August. If 44 days is used as the mean nestling period, then this chick hatched on about 10 July from an egg which had been laid as early as about 12 June. Several other young were within a few days of their first flight by 23 August and had virtually no down left on them. Most of the chicks, however, did not make their first flight until mid-September, and some young may have fledged as late as early October.

Kittiwakes laid later at Cape Lisburne in 1977 than they did at Cape Thompson. Laying dates calculated from hatching dates indicate that laying commenced as early as 29 June, however, most laying probably occurred during the 8-23 July interval. Hatching dates of eggs in monitored nests (see Table 32) suggest that the reproductive season at Cape Lisburne was about a week to 10 days later than at Cape Thompson. The first chick may have fledged as early as 8 September, however, most chicks probably did not make their first flight until mid-September. A few young may have fledged as late as mid-October.

Table 32. Hatching dates of Black-legged Kittiwakes, 1977.

	Cape Thompson	Cape Lisburne
Before 29 July	2	
29-30 July	2	
30 July - 1 August	8	
1-5 August	25	1
5-9 August	9	4
After 9 August	3	
9-12 August		3
12-15 August		5
15-20 August		5
20-26 August		1

Food habits

The food habits of kittiwakes at Cape Thompson as determined from stomach contents analyses for 1960, 1976 and 1977 are presented in Table 33. The data obtained from birds collected in 1977 are similar to those from 1960 but are quite different from 1976.

The relative frequencies of fish identified in 1960 and 1977 were nearly the same and were considerably higher than in 1976. By contrast, the frequency of invertebrates identified in 1960 and 1977 also were about the same but were much lower than the frequency of invertebrates in 1976.

Cod were important to kittiwakes and no major differences were seen in the utilization of this fish between any years. The only exception to this may be in the absence of Saffron Cod in 1960. Notable differences do exist, however, in the utilization of other fish species. Sand Launce and Capelin were not identified in the food from 1976, however, both were utilized to some extent in 1960 and 1977, especially Sand Launce.

The importance of Sand Launce to the kittiwake population at Cape Thompson in 1977 is not apparent from Table 33. When the food habits of kittiwakes are seen on a seasonal basis the significance of this food item is obvious. These seasonal data are presented in Table 34. Although no Sand Launce were identified from kittiwakes collected in July, by the end of August they occurred in all of the stomachs. Cod were important in early summer and progressively decreased through the end of August, while Capelin were found in only one sample, the collection of 6-11 August. Besides cod, polychaetes may be important early season food to kittiwakes.

The food items identified from the stomach contents of kittiwakes collected at Cape Lisburne in 1977 also are presented in Table 33. The relation of fish utilization to invertebrate utilization was about the

Table 33. Food of Black-legged Kittiwakes at Cape Thompson and Cape Lisburne, Alaska. Percent occurrence of food items refers only to those stomachs containing food; values in parentheses refer to the total sample.

	Cape Thompson						Cape Lisburne	
	1960		1976		1977		1977	
	n	%	n	%	n	%	n	%
Total examined	115		22		52		39	
Number empty	23	(20)	7	(32)	3	(6)	2	(5)
Frequency of invertebrates	23	25	8	53	11	22	13	35
Frequency of fish	84	91.3	10	67	48	98	34	92
FISH:								
Gadidae	1	1.1			1	2		
Boreogadus saida	50	54.3	5	33	29	59	18	49
Eleginus gracilis			5	33	23	47	3	8
Cottidae								
Myoxocephalus quadricornis	2	2.2						
Pungitius pungitius	1	1.1	1	7				
Ammodytes hexapterus	19	20.6			11	22	17	46
Ammodytes sp.	8	8.7						
Mallotus villosus	2	2.2			4	8		
Liparus sp.							1	3
Pleuronectidae			1	7				
Unidentifiable	4	4.3			3	6	2	5
INVERTEBRATES:								
Oligochaeta							1	3
Polychaeta	5	5.4	1	7			2	5
Nereis sp.					1	2	4	11
Mollusca					2	4	2	5
Pteropoda					1	2	2	5
Limacina helicina							1	3
Gastropoda			2	13				
Trochidae			1	7				
Pelecypoda					1	2	1	3
Arthropoda					1	2	1	3
Calanoida					3	6		
Onacaea					1	2		
Isopoda	2	2.2	1	7				
Gammaridae, sp. 3	3	3.3						
Cumacea	1	1.1						

	Cape Thompson						Cape Lisburne	
	1960		1976		1977		1977	
	n	%	n	%	n	%	n	%
Decapoda								
Pandalus sp.			1	7				
P. goniurus	1	1.1	1	7	1	2		
P. jordani					1	2		
P. borealis	1	1.1						
Eualus gaimardi	1	1.1	1	7				
Hyas coractatus	1	1.1						
Unidentifiable			2	14				
Coleoptera			1	7				
Hymenoptera			1	7				
Mallophaga	1	1.1						
Siphonaptera	2	2.2						
Insect larvae	1	1.1						
Unidentifiable invertebrates	12	13						
MISCELLANEOUS								
Plant matter	10	10.9						
Algae	1	1.1						
Pebbles	8	8.7	1	7	4	8	10	27

Table 34. Percent occurrence of major food groups of Black-legged Kittiwakes, 1977.

	Cape Thompson				Cape Lisburne	
	July 12-14	July 20	Aug. 6-11	Aug. 17-23	July 12	Aug. 1
Gadidae	100	84	14	0	88	0
Cottidae					12	8
Ammodytes	0	0	57	100	29	77
Mallotus	0	0	57	0	0	0
Polychaeta	7	0	0	0	29	0
n	15	19	7	7	17	13

same as at Cape Thompson. Arctic Cod occurred in about equal frequencies at Cape Lisburne and at Cape Thompson. The apparent utilization of Saffron Cod at Cape Lisburne, however, was much lower than at Cape Thompson. No Capelin were found in any kittiwakes from Cape Lisburne compared to an 8% occurrence in birds collected at Cape Thompson. Sand Launce were found in nearly twice as many stomachs from birds collected at Cape Lisburne as at Cape Thompson. We believe that this apparent difference is an artifact which results from two factors: more kittiwakes were collected early in the summer at Cape Thompson before Sand Launce had arrived, and the Sand Launce arrived earlier at Cape Lisburne.

The only major difference in invertebrate prey between the two colonies in 1977 occurred in the relatively high utilization of polychaetes (*Nereis*) at Cape Lisburne.

Some indication of seasonal differences in food habits at Cape Lisburne are seen from the data presented in Table 34. All of the cod and all of the polychaetes occurred in the 12 July sample while the majority of Sand Launce occurred in the 1 August sample. Utilization of cod was about equal between the two dates. These data are similar to those from Cape Thompson and demonstrate pronounced seasonal changes in food habits at both colonies.

Annual differences in the relative utilization of fish and invertebrates by kittiwakes can be seen in Figure 28. Fish appear to have been more important than invertebrates to kittiwakes at Cape Thompson in 1960 and 1977, and at Cape Lisburne in 1977. At Cape Thompson in 1976 fish and invertebrates were recorded in about equal frequencies. The yearly differences observed in the fish: invertebrate ratios are similar to those of murres (see Figures 13 and 14).

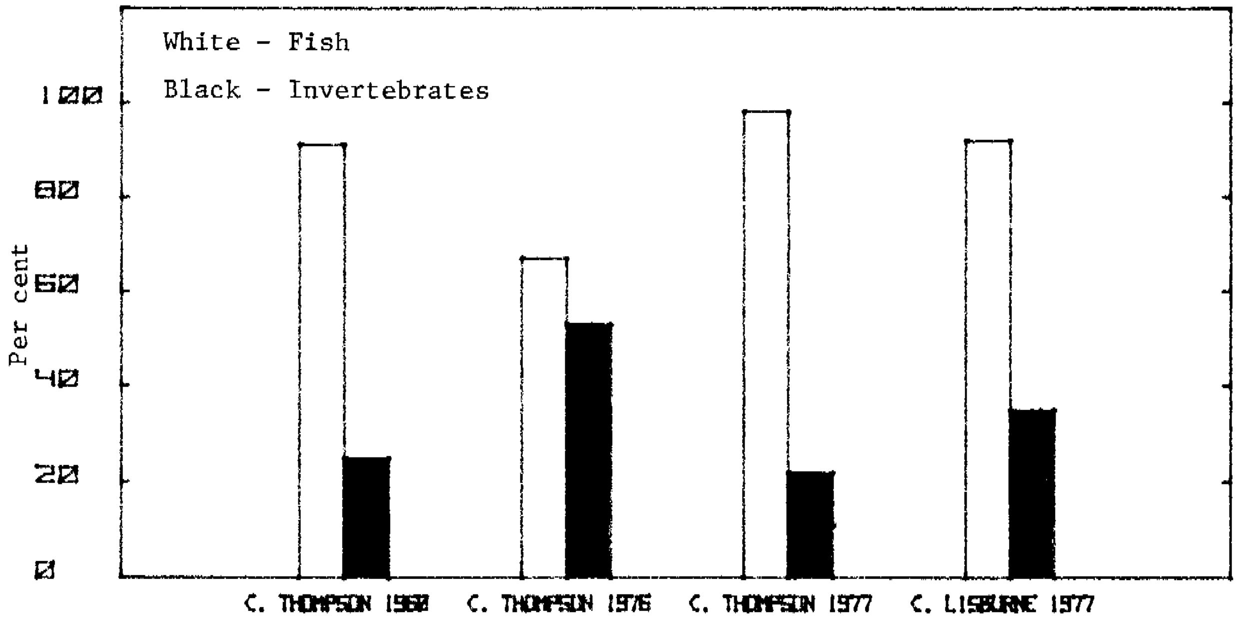


Figure 28. Relative occurrence of fish and invertebrates in stomach contents of Black-legged Kittiwakes collected at Cape Thompson and Cape Lisburne.

Foraging patterns

We are not certain how far Cape Thompson kittiwakes forage from the colonies. It is probably a shorter distance than that flown by murres. Although Swartz (1967) recorded kittiwakes as far as about 220 kilometers from the nearest colony, it is likely that many of these were nonbreeders. Most of the August 1960 kittiwake observations near Cape Thompson occurred within 16 kilometers of shore (Swartz 1967); beyond this only scattered, relatively small numbers were seen.

In 1976 kittiwakes were observed feeding offshore of the colonies and flying to the southeast (downcoast). Departing kittiwakes usually followed the surfline, while returning flocks, paralleling the beach, were usually between about 100 meters to one kilometer offshore. Kittiwakes were never observed flying upcoast toward Point Hope from the colonies that year.

On several raft trips during early August 1976 up to 24 kilometers downcoast of the Cape Thompson colonies we still encountered a few small flocks of traveling or resting kittiwakes. Beyond about 13 kilometers southeast of Ogotoruk Creek, however, kittiwakes were scarce. During August flocks of kittiwakes traveling downcoast past Ogotoruk Creek became fewer in number. It was more common to see them rafting or flying about offshore in front of the colonies. Only three feeding melees were observed all summer. All occurred directly offshore of the Cape Thompson cliffs.

Flocks of kittiwakes were observed again in 1977 feeding among ice floes off of the colonies and nearby beaches. Small feeding melees were commonly observed along the colonies. A constant progression of birds also was observed flying to and from the southeast along the coast, as observed in 1976. At least comparable, if not larger, numbers, however, were flying to and from the north-northwest along the coastline between Colony 5 and Point Hope.

The number of kittiwakes flying to the southeast of the colonies had declined by the first week of August. Instead, the birds tended to fly more directly offshore. By about 10 August larger feeding melees off of the colonies or within several kilometers upcoast of them had become more common, and by 15 August the majority of all kittiwakes followed the upcoast flight pattern.

On 23 August large schools of <u>Ammodytes</u> moved southward along the Cape Thompson coastline. Many large feeding melees of several hundred up to about 1000 kittiwakes followed this movement toward Colony 5, although flocks of kittiwakes continued to travel at least several kilometers upcoast. By 25 August large numbers of kittiwakes again followed a southeast flight pattern. On 26 August, our departure date, our pilot reported several large (approximately 150 individuals per group) melees along the coast as far southeast as about 50 kilometers. Flying the coast a few hours later we observed small flocks of kittiwakes scattered as far as the report indicated. It was not known if kittiwakes still traveled upcoast toward Point Hope; however, the number of birds observed near Colonies 1, 2 and 3 and to the southeast toward Kivalina suggested that substantial numbers probably were still feeding to the north of Colony 5 on that date.

Upon our arrival at Cape Lisaburne on 6 July 1977 kittiwakes were observed feeding among the ice floes in front of and to the north and east of the colony. Considerable foraging occurred for up to at least several kilometers offshore along the north-facing beach and for several kilometers to the east. Small schools of B. saida were discovered to be 'hiding' under the ice floes and kittiwakes were observed catching them. Kittiwakes that appeared to travel greater distances to feed departed to and returned from the east and east-north east.

Ice cover along the north coast was rapidly diminishing by about 23 July and more flocks of outward bound kittiwakes flew east along the shoreline and returned from some distant point by the same route. By 1 August virtually all kittiwakes from the Cape Lisburne colony apparently followed this flight pattern. On 2 August we was discovered that large numbers of kittiwakes could be found traveling to and returning from as far east as the Corwin Creek area, about 45 kilometers from the nearest nesting pairs. Beyond that point few kittiwakes were observed. Small feeding melees were observed between Isuk Creek and Corwin Creek. High soaring flocks of kittiwakes were continually drifting in from farther offshore to join birds returning to the Cape along the coast. Returning kittiwakes were gorged with Ammodytes.

After 5 August more feeding activity was observed offshore of the colonies. On 8-9 August a violent storm carried Ammodytes up on the north-facing beach. Between 10 August and 5 September huge feeding melees of kittiwakes were common all along the cliffs in the immediate vicinity of the colony. This situation persisted through our departure in early September.

Reproductive success

The productivity of kittiwakes at Cape Thompson in 1977 was considerably better than in 1976, although it was still well below that reported for this colony by Swartz for 1960 and 1961.

Most of the sites which were defended by kittiwakes in 1977 showed evidence of nest construction. If the presence of a site containing nesting material (mud and/or grass) is assumed to represent a nesting attempt by a pair of kittiwakes, then we estimate that approximately half of the attempts at Cape Thompson were successful in 1977.

By the end of July, we had been able to determine the contents of 157 kittiwake nests, 44(28%) of which were empty. We monitored the contents of 73 kittiwake nests through 20 August, during which time 18 nests (25%) failed. If 25% of the 113 (157 minus 44) nests which were active in late July failed, then a total of 72 (44 plus 28) or 46% would have been empty by 20 August. On 23 August, 238 nests were examined at Colony 4. One nest contained one egg, one nest contained two eggs, 128 nests contained one chick each, 4 nests contained 2 chicks each and 104 nests (44%) were empty.

The 113 active nests which we examined in late July contained a total of 136 eggs for an average clutch size of 1.20 eggs per nest. Eighty-four eggs were laid in the 73 nests (1.15 eggs per nest) which we were able to monitor, 8 of which were lost during incubation for a hatching success of 90%. Of the 76 chicks which hatched, at least 22 died before fledging, yielding a maximum possible fledging success (chick fledged/chick hatched) of 71% and a maximum possible breeding success (chick fledged/egg laid) of 64%. These data are compared in Table 35 to similar data reported by Swartz (1966) for Cape Thompson in 1960 and 1961, and for data obtained at Cape Lisburne in 1977.

The hatching success of eggs at Cape Thompson in 1977 was higher than in either 1960 or 1961. A greater percentage of the chicks died before fledging, however, and the overall breeding success may have been about equal to that in 1960 and somewhat higher than in 1961. Of the 73 nests which we monitored, 13 had two-egg clutches at the end of July, but only two of these nests contained two chicks by 20 August. Although only one egg of each of two two-egg clutches was lost before hatching, seven nests lost one each of two chicks after hatching and two nests lost both chicks. The losses tended to occur while the chicks were less than ten days old and the younger of the two chicks was generally the one which died.

Table 35. Reproductive success of Black-legged Kittiwakes.

	Cape Thompson			Cape Lisburne
	1960[1]	1961[1]	1977	1977
No. nests of known clutch size	60	29	73	19
Average clutch size	1.92	1.88	1.15-1.20	1.11-1.16
Hatching success	.75	.69	.90	.95
Fledging success	.86	.60	.71	.89
Breeding success (chicks fledged/eggs laid)	.65	.41	.64	.85

[1] data from Swartz (1966)

Between 23 July and 6 August we examined 146 kittiwake nests in six different locations at Cape Lisburne. Not all nests were well constructed but all showed evidence of recent attention. Of the total, 61 (42%) were empty while the remainder contained either eggs or chicks. The ratio of active to inactive nests was similar to that observed at Cape Thompson on 23 August.

The average clutch size of kittiwakes at Cape Lisburne in 1977, 1.11-1.16 eggs per active nest, was slightly lower than at Cape Thompson. The hatching success (95%), however, and possible fledging success of 89% were both higher than values for the same ratios in any year at Cape Thompson. The result was that the breeding success may have been as high as .85 chicks per egg laid. Admittedly this may be higher than actual; no young had fledged by the time we left and many of the chicks were not more than half grown. There was no indication that the food source was diminishing however, and unless it did drop after we left, or if severe weather occurred, we have no reason to believe that productivity would have been lower.

Growth rates

The majority of the kittiwake nests at both sites were inaccessible to us. At Cape Thompson we were able to weigh nine chicks at intervals during ten days, and five of those chicks during a period of 14 days. The average growth rate of the nine chicks during the ten-day interval was 14.2±3.4 grams per day. This growth rate continued during at least the next four days; the five chicks which were weighed at intervals for 14 days exhibited a growth rate of 14.4±4.5 grams per day.

The growth rates of kittiwake chicks at Cape Thompson are compared to growth rates of chicks from Cape Lisburne in Table 36. Fifteen chicks at Cape Lisburne were weighed at intervals for at least ten days and nine chicks were weighed for at least 14 days. Growth rates during both intervals were essentially the same and were considerably greater than growth rates at Cape Thompson. The significance of the observed difference between the growth rates of chicks weighed for at least ten days at Cape Thompson and Cape Lisburne was tested using the Student's t test; the difference was found to be highly significant ($t=4.89$; $P \ll 0.001$).

Table 36. Growth rate comparisons of Black-legged Kittiwake chicks.

	Cape Thompson		Cape Lisburne	
	n	$\bar{x}$	n	$\bar{x}$
Chicks weighed at least ten days	9	14.2±3.4	15	20.1±2.5
Chicks weighed at least 14 days	5	14.4±4.5	9	19.3±2.5

C. Horned Puffins

A summary of the Horned Puffin uncompensated counts at Cape Thompson for 1960, 1976 and 1977 is presented in Table 37, and the 1977 plot counts are detailed in Tables 38-41.

Table 37. Horned Puffin census summary, Cape Thompson (scores are uncompensated).[1]

Year	COLONY 0[2]	1	2	3	4	5	Total
1960	32	128	243	71	168	163	805
1976	75	241	387	65	180	499	1447[3]
1977	65	265	344	256	142		

[1] All 1960 totals for Colonies 1, 2, 3, and 5 listed in Tables 19, 20, 21 and 23 of our 1977 annual report are compensated scores. The 1960 total given in Table 22 for Colony 4 is uncompensated.

[2] 'zero colony' is located between Colonies 1 and 2.

[3] The Colony 1-5 (excluding Colony 0) raw total of 1345 birds reported on page 31 of our 1977 Annual Report is in error. This total should read 1372.

Table 38. Horned Puffin census, Colony 1; Cape Thompson, 1977.

	17 August	
Plot	Time	Observer E
A	2055	32
B		
C		82
D		16
E		65
F		13
G		5
H		40
I	2155	12
	Total:	265

Table 39. Horned Puffin census, Colony 2; Cape Thompson, 1977.

14-15 July		
Plot	Time	Average counts of one-three observers
A_1	2200	4
A_2,B		0
C-F		65
G-J		86
K-N		29
O-R		44
S,T		28
U		15
V,W	0100	16
X,Y	2045	14
Z,AA		13
BB,CC		18
DD-FF		8
GG-II	2300	4
		Total: 344

Table 40. Horned Puffin census, Colony 3; Cape Thompson, 1977.

		16-17 August		
Plot	Time	Observer F	Observer E	$\bar{x}$
A	2225	6		6
B,C	2025		36	36
D	2230	0	0	0
E	2228	6	6	6
F	2223	1	1	1
G	2005	6	24	15
H	2212	16	17	17
I	1945	9	9	9
J	1916	25	25	25
K	1955	14	15	15
L	1948	8	8	8
M	1940	14	14	14
N	1945	14	14	14
O	2123	28	25	27
P	1930	13	14	14
Q	2105	24	26	25
R	2100	1	1	1
S	2055	23	23	23
Total		208	258	256

Table 41. Horned Puffin census, Colony 4; Cape Thompson, 1977.

3 August				
Plot	Time	Observer F	Observer G	$\bar{x}$
A-C	2250	36	39	38
D,E		9	9	9
F,G		3	3	3
H		3	3	3
I		4	4	4
J,L		10	10	10
K,O		13	13	13
M,N, P-R	2330	62	62	62
Total		140	143	142

Horned Puffins appear to have been present in about equal numbers in 1976 and 1977 at Cape Thompson. Although Colony 5 was not counted in 1977, numerous observations of Horned Puffins during the murre counts suggested that no major upward or downward change in the numbers had occurred since 1976. We believe that about 450-500 individuals inhabited this colony.

Swartz (1966) reported a compensated total of 1902 Horned Puffins at Cape Thompson in 1960. In 1976 the highest complete counts at Colonies 0, 1 and 4, combined with compensated totals for Colonies 2, 3 and 5 totaled 1918 birds. In 1977 we counted 1072 Horned Puffins at Colonies 0-4. Those data when combined with our estimate of Colony 5, suggest that little change occurred between 1976 and 1977. It also appears that little change has occurred between 1960 and recent years. These data suggest that at least 1500 Horned Puffins currently inhabit Cape Thompson and that an estimate of 1800-2000 individuals is not unreasonable.

Some changes in numbers at the individual colonies appear to have occurred, however, these differences between years may be largely artifacts of time, date, weather and observer bias.

A complete count of Horned Puffins at Cape Lisburne was not achieved in 1977. Storms prevented the completion of the census after 55 of the total 75 plots were counted. The results of counts are presented in Table 42. The total for the 55 plots was 1034 birds, a figure similar to the total of 1072 puffins obtained at five of six colonies at Cape Thompson in 1977. These data and other general observations throughout the summer lead us to believe that the total 1977 Cape Lisburne population was quite similar to that of Cape Thompson.

Horned Puffin laying dates were not obtained at Cape Thompson in 1977. Several eggs had been discovered by early August, although none had hatched by 23 August. Two nests occupied in 1976 at Colony 1 also were occupied in 1977. On 26 August a chick could be heard in one of these nests. We believe it was hatching or had just hatched. Based on a 40 day incubation period (see Swartz 1966) that egg was probably laid about 15-20 July. That date is very similar to the one laying observation we made in 1976 at the same location when an egg appeared in this crevice between 16-20 July. Swartz (1966) reported egg laying as early as about 25 June in 1960, and during the first week of July in 1961; he reported a replacement egg was laid between 23-26 July in 1961.

We have even less phenological information for Cape Lisburne. Horned Puffins did nest; we could see many of them entering and departing regularly from crevices and holes. We found only one nest, however. One egg was present in that nest as early as 9 July. We were unable to check this site for hatching later in the summer.

D. Glaucous Gulls

Early season information on Glaucous Gulls at Cape Thompson and Cape Lisburne was not obtained in 1977. Nests were not counted but some population size, phenological and reproductive success data are available for comparisons between colonies and years.

Nesting distribution at Cape Thompson was generally similar to both 1976 and 1959-1961. The most concentrated nesting occurred at Colonies 1 and 3. At least 32 pairs nested at Colony 1. Most of these

Table 42. Horned Puffin census; Cape Lisburne, 1977.

Plot	Date	Time	Total Birds
7	12 Aug	1800	2
8		1810	17
9		1820	6
10		1830	4
11		1850	6
12		1900	24
13		1910	8
14		1920	11
15	14 Aug	1900	18
16	27 Aug	1100	8
17			17
18			26
19			9
20			8
21			1
22			6
23			29
24			2
25			9
26			3
31			4
32			9
33			17
34			9
35			21
36			32
40			7
41			4
42			6
43			13
44			9
45			0
46			3
47			13
48			12
49			2
50			21
51			18
52	16 Aug	2030	45
53		2020	6
54		2010	13
55		1950	22
56		1935	26
57		1920	38
58		1910	46
59		1840	73
60		1930	22

Plot	Date	Time	Total Birds
61		1915	96
62		1900	38
63		1830	58
64		1800	31
65		2115	37
66		2110	9
67		2105	46
69		2130	14
Total:			1034

pairs utilized the grassy slopes above the colony and were concentrated on narrow fingers which extended to the cliff edge.

Total numbers of gulls at Cape Thompson were not counted until 20-21 August. At this time all gulls between Ogotoruk Creek and Colony 5 were counted from the raft. Two hundred fifty adults, 164 juveniles (almost all fledged) and 26-27 subadults were counted. An additional 39-50 adults, 19-27 juveniles and 69-75 subadults were counted along nearby upcoast and downcoast beaches. Therefore, the minimum gull population in the vicinity of the Cape Thompson colonies totaled about 289-300 adults, 183-191 juveniles and 95-102 subadults. The number of adults present was quite similar to those figures obtained in 1960, 1961 and 1976, when 300, 300 and about 288 individuals respectively, were acounted for.

Fewer Glaucous Gulls appear to inhabit the Cape Lisburne vicinity. In 1976, during 26-29 August, we estimated that perhaps 100-200 individuals were present in the general area; no distinction was made between adults, subadults and fledged young in this rough estimate. In 1977, it was clear that only about 50 individuals at best occupied the Cape Lisburne colony. Of these, probably no more than 20 (ie., 10 pairs) nested. Only two actual nests were found and several other widely scattered pairs occupying the cliff-tops appeared to be regularly attending grassy, potential nesting sites. We believe the 1976 estimate was inflated by the presence of subadults (see below).

We have some information on the phenology of the breeding activities of Glaucous Gulls at Cape Thompson and Cape Lisburne in 1977. At Cape Thompson adults were observed incubating on 8 June at Colony 1. Hatching was nearly complete by 6 July, our arrival date, and few chicks hatched after about 1 July. Two small downy chicks (about 70 g.) were located at Colony 1 on 7 July. These chicks were estimated to be 3-5 days old and probably hatched about 2-4 July. A few other relatively small chicks were located during the next week, however, most were relatively large. As early as 15 July seven well-feathered young were discovered at Colony 3.

Some juveniles were capable of flight during the third week of July. By the first week in August many young could fly, and by 15-20 August most of the chicks had fledged. Back-calculations, based on an average 50 day nestling period (range 42 to 57 days plus; see Swartz, 1966) suggest that most eggs probably hatched about 10-25 June. From all appearances, the progression of Glaucous Gull nesting at Cape Thompson in 1977 closely followed the schedule reported by Swartz (1966) for the years 1959-1961.

In 1976 fewer than half of the eggs had hatched by 28 June and the nesting schedule was about 10-15 days later than in 1959-1961 and 1977.

At Cape Lisburne, based on the two nests located, hatching occurred about 4 July in 1977; all chicks (five) observed on 14-15 July were estimated to be about 10 days old. In general, these two gull pairs were following a schedule that coincided with that of the latest 1977 Cape Thompson pairs. These pairs laid and hatched their eggs about 10-15 days behind the schedule most gulls followed at Cape Thompson in 1977, and in 1959-1961. The 1977 Cape Lisburne schedule appeared most similar to that observed at Cape Thompson in 1976..

Some measure of Glaucous Gull reproductive success was obtained in 1977. At Cape Thompson, the greatest numbers of adults counted at Colony 1, 63 and 64, were recorded on 13 July and 20 August, respectively. On 20 August 30 juveniles were counted among those gulls on their nesting area. These data suggest a minimum of 0.47 fledged young present per adult and a minimum of 0.97 fledged young per 'pair' if all adults were present (i.e. 31 pairs).

Similar data were obtained on gull nesting areas at Colonies 2, 3 and 4. The ratios of fledged young per adult and per 'pair' respectively were: Colony 2, 0.62 and 1.24 (42 adults, 26 juveniles); Colony 3, 0.52 and 1.03 (54 adults, 28 juveniles); Colony 4, 0.55 and 1.10 (20 adults, 20 juveneles). The average of all colonies was 0.53 fledged young per adult and 1.06 per 'pair'. Our counts of all gulls in the vicinity of Cape Thompson, including those listed above, yielded ratios of about 0.63 fledged young per adult or 1.26 per 'pair'. These data suggest that gulls at Cape Thompson probably produced about the same number of young as in 1976 when 21 nests had produced an average of 1.4 young each by 4 August.

At Cape Lisburne data from only two Glaucous Gull nests were obtained. Those two nests produced one 3-chick brood and one 2-chick brood. One small juvenile was found near death in the water below the nest that had produced 3 chicks. Later, both remaining fledged chicks from this nest were found shot. Both chicks successfully fledged at the second nest.

In 1976 subadult Glaucous Gulls did not associate with birds at the Cape Thompson breeding colonies until after July; the first subadults were not observed until 1 August. In 1977 subadult gulls again appeared in the vicinity of the colonies during the first few days of August. Subadults began mingling with the adults and fledglings and their numbers increased steadily throughout the next few weeks. By 20-21 August subadult birds accounted for about 6% of the total 440-441 gulls observed at the colonies on those dates. Of the remainder, 57% were adults and 37% were juveniles. An additional 127-152 gulls were located farther from the colonies along nearby upcoast and downcoast beaches. Thirty-one to thirty-three per cent of these birds were subadults, while 49-54% were adults and 15-18% were juveniles. Area-wide, of the total 567-593 gulls counted on 20-21 August, about 17% were subadults, 51% adults and 32% juveniles.

In 1976, 164 gulls in the immediate vicinity of the colonies were observed on 20 August. About 7% were subadults, 71% adults and 23% juveniles. The 1976 data were not obtained during colony-wide counts, and upcoast and downcoast beaches were not checked.

Subadult Glaucous Gulls also began appearing in the vicinity of Cape Lisburne during early August. On 2 August 12 subadults comprised about 13% of the total (89) counted away from the colony between Cape Lisburne and Thetis Creek. By 15 August subadults had become more numerous and were observed near the colony. No counts of the relative number of adults and subadults were made.

We have no evidence to suggest that depredation of gull nests by foxes occurred in 1977. Only one sighting of a Red Fox (Vulpes fulva) was obtained. This fox was observed hunting and traveling down Ogotoruk Creek on 7 July. No foxes were seen at Cape Lisburne.

E. Pelagic Cormorants

Pelagic Cormorants were found nesting only at Colonies 1 and 4 at Cape Thompson in 1977. More than twice as many nesting pairs utilized Colony 1 as had in 1976. Total pairs nesting at Colony 1 in 1977 also exceeded the total population recorded at Cape Thompson in 1976. Nevertheless, the total population size did not change much between the two years, and was similar to the number of pairs present in 1960 and 1961. The results of all years' counts are presented in Table 43.

We found 39 cormorant nests at Cape Lisburne in 1977. The nests were concentrated in two small areas; 27 were found on plots 47 and 48 and 12 were found on plots 54 and 55.

Table 43. Nests of Pelagic Cormorants at Cape Thompson.

	Colony					
Year	1	2	3	4	5	Total
1959	1	1	0	4	0	6
1960	3	18	0	1	1	23
1961	4	18	0	1	0	23
1976	7	2	0	5	0	14
1977	16	0	0	2	0	18

Cormorant productivity appeared good in 1977. At Cape Thompson data were obtained at only two nests, which averaged 2.5 large well-developed young on 23 August. At Cape Lisburne, average brood size obtained from 36 nests on 20 August was 2.06. That figure is higher than the brood size at Cape Thompson in 1976 (1.8 young/nest) and is comparable with data reported by Drury (1977) for cormorants nesting in Norton Sound.

Few data are available on the phenology of cormorants. At both Cape Thompson and Cape Lisburne this species appeared to follow a schedule approximate to that observed at Cape Thompson in 1976.

F. Tufted Puffins

Tufted Puffins were counted during all census activities and at other times as we traveled past the cliffs at Cape Thompson and Cape Lisburne. The numbers presented in Tables 44 and 45 are the highest counts we obtained in each of these locations during the summer.

Table 44. Populations of Tufted Puffins at Cape Thompson

	Colony					
Year	1	2	3	4	5	Total
1959	4	18	0	0	0	22
1960	20	12	0	0	4	36
1961	6	34	0	0	0	40
1976	24	13	1	0	6	44
1977	13	9	4	0	3-4	29-30

Table 45. Populations of Tufted Puffins at Cape Lisburne.

Year	Number Counted	Total
1976	(up to few 100's estimated)	few 100's
1977	11	11

The population size of Tufted Puffins at Cape Thompson has been historically small and variable. The apparent decrease in numbers between 1976 and 1977 does not appear significant when viewed in relation to 1959-1961 data.

The change in numbers of puffins seen at Cape Lisburne during the past two years was much greater. We did not make a formal count in 1976, however the birds were conspicuous and there was no doubt that they were much more numerous than at Cape Thompson. We estimated that at least 100 Tufted Puffins were present within the boundaries of the murre colony and many more occurred along the bluffs south of where murres were found. In 1977, the highest count we made totaled only eleven birds.

The significance of this decline is unknown. Since both colonies are in the northern-most nesting range of both puffin species, habitat utilization may vary considerably from year to year. In the case of Tufted Puffins, by far the least numerous of the two, some Cape Thompson data (see Table 37) are suggestive of this. Colony 1, because of its location, is the most often viewed. Tufted Puffins are generally conspicuous when present because of the broad flat rock faces and size of the cliff, and counts here are likely to be the most accurate. In five census years maximum counts have ranged from as low as two pairs (1959) to as high as 12 pairs (1976).

Nesting was not confirmed at either site in 1977. We suspect that attempts, at least, were made because we occasionally saw puffins entering or leaving burrows.

G. Guillemots

Guillemots also were counted during all census activities and at other times as we traveled past the cliffs at Cape Thompson and Cape Lisburne. The numbers presented in Tables 46 and 47 are the highest counts we obtained at each of these locations during the summer.

Table 46. Populations of Pigeon and Black Guillemots at Cape Thompson.

	Year				
Species	1959	1960	1961	1976	1977
Pigeon Guillemots	<10	4	14	4-6	2-3
Black Guillemots	<10	16	4	4-6	6-10

Table 47. Populations of Pigeon and Black Guillemots at Cape Lisburne.

	Year	
Species	1976[1]	1977
Pigeon Guillemots	0	1-2
Black Guillemots	<10	136-151[2]

[1] Data from 25-29 August only
[2] Includes one immature individual

The populations of both Pigeon and Black Guillemots frequenting the Cape Thompson cliffs are small (see Table 46). Swartz (1966) noted that Black Guillemots predominated in 1960, while, for unknown reasons, Pigeon Guillemots were the most numerous of the two species in 1961. In 1976 both species appeared to occur in about equal numbers, while in 1977 we found that Black Guillemots were slightly more numerous.

Pigeon Guillemots appear to occur even less frequently at Cape Lisburne (see Table 47). During our brief 25-29 August 1976 visit to this colony, this species was not observed; all birds encountered within positive identification range proved to be Black Guillemots. In 1977, only two observations of single Pigeon Guillemots were obtained at Cape Lisburne throughout the summer. These sightings occurred on widely separated dates.

The number of Black Guillemots encountered over the entire length of the Cape Lisburne colony in 1976 also was small. Fewer than 10 individuals were counted and it was our impression that there was little difference between the total population at this colony and Cape Thompson.

In 1977, however, Black Guillemots were relatively numerous when we arrived 6 July. During the remainder of July and the first week of August a minimum of between 136 and 151 individuals were found to be regularly present. Groups of 30-40 individuals commonly perched together in the evenings at or near the same boulder piles where most 1976 sightings had occurred.

After a severe storm on 8-9 August only a few pairs remained in the area. Those pairs might have been the ones that actually attempted to nest. Many of the birds we observed throughout July and early August had not appeared to be breeding. We do not know if a similar, larger 'early season' population attended the Cape Lisburne colony in 1976.

The generally small and variable number of both species which inhabit the Cape Thompson and Cape Lisburne colonies is probably related to the fact that the southeastern Chukchi Sea region encompasses the northernmost breeding range of the Pigeon Guillemot and the southern breeding range of the Black Guillemot. The availability of nesting habitat also probably influences guillemot numbers at Cape Thompson and Cape Lisburne. At both colonies preferred habitat appears limited. Talus fans are common, but only a few rubble piles comprised of larger boulders are present at Cape Thompson. Boulder piles, favored by both species, are somewhat larger and more numerous at Cape Lisburne, but even there they are concentrated in a few locations.

Some guillemot nesting data are available. Swartz (1966) located a total of four Pigeon Guillemot nests and one Black Guillemot nest at Cape Thompson in 1960-1961. All Pigeon Guillemot nests were situated in boulder piles. The Black Guillemot nest was located in a crevice several feet above a talus slide.

We were unable to locate nests of either species at Cape Thompson in 1976 and 1977, however, one pair of Black Guillemots frequented the 'best' boulder pile throughout the 1976 summer. At Cape Lisburne in 1976 a dead Black Guillemot chick was discovered at the edge of a large boulder pile. In 1977 at this same colony two Black Guillemot nests were located in similar boulder piles and other pairs were observed to frequent them.

Swartz (1966) reported the contents and fate of two guillemot nests at Cape Thompson. A Black Guillemot nest with two eggs was discovered on 3 July 1960. One egg was collected. Later, the remaining was found broken and the nest deserted. A Pigeon Guillemot nest was discovered on 29 July 1960. It contained two eggs. An adult was captured at the nest, identified and released. One egg also was collected. The nest and remaining egg were found abandoned later.

In 1977 a Black Guillemot nest containing two eggs was located on 12 July at Cape Lisburne. Our visit was short and the nest was not revisited until 25 July. A third visit on 5 August revealed that both eggs were broken and one contained a reasonably well-developed chick. A second nest entrance was located on our 25 July visit several meters from the first nest, in the same boulder pile. One adult was repeatedly observed carrying fish into it. We did not wish to disturb the nest; its contents and fate are unknown.

Although the data are limited, the above information suggests that both nesting guillemot species at Cape Thompson and Cape Lisburne are sensitive to human disturbance.

Some phenological data for guillemots are available. Swartz (1966) reported that Pigeon Guillemots were first observed at Cape Thompson on 12 June 1960. This species may have been present as early as 16 June in 1961, but positive identification was not made until 23 June. The last adults were observed near the colonies on 29 August 1960 and 28 August 1961.

Pigeon Guillemots were already present at Cape Thompson on our arrival on 20 June 1976. A few individuals were observed well into August 1976 and 1977. Swartz (1966) also reported that Black Guillemots were first observed at the colonies on 5 June 1960, and on 7 June 1961; birds were probably present through 28 August. This species also was present at Cape Thompson on 20 June 1976 and, were still present on 25 August 1976 and 26 August 1976.

Phenological data are not available for Pigeon Guillemots at Cape Lisburne in either 1976 or 1977. The downy Black Guillemot chick found in 1976 was discovered on 26 August. It probably was less than 10 days old. The two eggs which we discovered on 12 July 1977 at Cape Lisburne probably were recently laid. The size of the developing chick suggested that hatching would not have occurred much before 25 August, the date we found it broken open.

Several Black Guillemots were still present at this colony as late as about 1 September in both years.

Some Black Guillemot food habits data were obtained at Cape Lisburne in 1977. Many birds appeared to feed near the colony just offshore. Some individuals, however, were observed flying longer distances to the east and northeast. Fourteen observations of several birds carrying fish into boulder piles were obtained 22-25 July. In 12 cases these fish could be identified as small cod; in one case the fish was clearly an Arctic Cod and in another a Sand Launce was clearly visable. Because _B. saida_ were numerous under the remaining ice floes near the colony, it is likely that most cod brought in were of that species. After 8-9 August, the primary food source of the remaining individuals was almost certainly _A. hexapterus_ .

The numbers of guillemots at Cape Thompson and at Cape Lisburne are dwarfed by the populations of murres and kittiwakes. The role which guillemots play in the local marine ecosystem is also insignificant when compared to that of other species, especially murres.

Nevertheless, we believe that the presence of breeding guillemots of both species at Cape Thompson is particularly interesting. It provides an uncommon opportunity to study two geographically separated conspecifics at the interface of their distributions.

H. Raptor and Ravens

One pair of Gyrfalcons nested at Cape Thompson in 1977. This pair utilized the same site and nest ledge that they had occupied in 1976. Two chicks fledged from this nest about 20 July and continued to frequent the area throughout the remainder of our stay. One pair of Gyrfalcons also nested on a small seacliff east of Cape Lisburne near Corwin Creek. This pair produced two young and fledging probably occurred about 5-7 August.

Peregrine Falcons were not observed at Cape Thompson in 1976 or

1977. Both nesting sites utilized by this species during 1959-1961 were unoccupied in 1976. In 1977 one of these sites, a shallow scrape behind clumped grass on a small seaward ridge of Colony 3, was occupied by a nesting pair of Glaucous Gulls. Historical records of peregrines nesting at Cape Lisburne are not available. This species was not observed in the vicinity of this seabird colony during our brief visit there in late August 1976. In 1977 peregrines did not nest there, nor at various locales to the east and south. A single peregrine, however, was observed once near Cape Lisburne on 8 July. This bird appeared to be a female; it was never seen again.

Golden Eagles re-occupied the large nest situated at the north end of Colony 2 at Cape Thompson in 1977. This pair again successfully fledged one young. The chick was full grown and fully feathered by 23 August. It probably made its first flight within a few days of that time. Murres and Arctic Ground Squirrels (Citellus parryi) appear to constitute the bulk of the prey remains above, below and in the nest.

The same nest was present and Golden Eagles were occassionally seen near it in 1959-1961, but evidence of breeding could not be found (Swartz pers. comm.). A second Golden Eagle nest was found about a kilometer inland from Colony 4; its current status is unknown.

Golden Eagles did not appear to breed at Cape Lisburne in either 1976 or 1977. One adult was occassionally observed above the cape in the vicinity of a nesting site that was active in the early 1970's (G. Notter pers. comm.).

Several subadult Golden Eagles were occassionally observed near the Cape Thompson and Cape Lisburne seabird colonies throughout the summer. On 21 August, a subadult female was observed atop Colony 3 plucking a freshly killed Thick-billed Murre.

Rough-legged Hawks (Buteo lagopus) are occassionally seen near the seabird colonies, however, this species has not nested there. At least a few nesting sites are situated several kilometers inland.

Ravens were common all summer at both Cape Thompson and Cape Lisburne. Numbers at Cape Thompson were similiar to those observed in 1976, and at least one pair nested there. At least one Raven pair also probably nested at Cape Lisburne. At both Cape Thompson and Cape Lisburne, Raven numbers increased during late July and August, as they had at Cape Thompson in 1976. Besides a few obvious family groups, occassional flocks of 10-15 individuals were observed 'working' the colonies in search of murre eggs.

I. Cape Lewis

We traveled by raft to Cape Lewis from Cape Lisburne on 27 July 1977. There we found large breeding populations of murres, kittiwakes, Horned Puffins and cormorants. In addition to those species Tufted Puffins, Black Guillemots and Glaucous Gulls were present and may have been nesting. Table 48 lists the results of our counts.

The average of two observers counts of murres was 19,130. We did not make compensation counts. If the overall percentage change between the raw mean score and the compensated mean score of Cape Lisburne murre census totals (28%) is applied to the raw census score from Cape Lewis, we

Table 48. Cape Lewis census, 27 July 1977.

Plot	Time	Murres Observer E	Murres Observer C	Murres $\bar{x}$	Black-legged Kittiwakes	Horned Puffins
1	1830	295	240	268	196	
2	1830	2120	2080	2100		2
3	1850	660	530	595		2
4	1900	750	730	740		
5	1910	1025	1330	1178	217	12
6	1920	1635	1200	1418	147	11
7	1950	2270	2330	2300	312	28
8	2020	2785	2700	2743	253	20
9	2050	1890	2030	1960	270	18
10	2100	130	130	130	50	
11	2105	1055	970	1013	280	18
12	2115	1020	800	910	240	16
13	2130	2030	2020	2025	300	44
14	2140	2020	1480	1750	40	15
		19,685	18,570	19,130	2305	186

Cormorant nests: 28

Black Guillemots: 24

Tufted Puffins: 1

estimate that at least 26,500 murres could have utilized the cliffs at this colony.

The raw score for kittiwakes is also probably lower than the total number of birds which actually utilized Cape Lewis. Many birds were seen flying in the vicinity of the cliffs and along the coast on either side of the colony during the time the counts were made.

The concentration of breeding cormorants at Cape Lewis relative to the size of the size of the colony was high. We found 28 nests, all of which appeared to be active.

The murres at Cape Lewis were feeding north of the colony. These movements were discussed earlier in this report. Similar observations of kittiwake flight directions were not made.

We determined the contents of most accessible kittiwake nests. The contents of those nests are listed in Table 49. The percentage of empty kittiwake nests at Cape Lewis (43%) was higher than the number of empty nests recorded at Cape Lisburne (28%) at about the same time.

The average clutch size determined from 23 active nests was 1.16. This was essentially the same as the kittiwake clutch size at Cape Lisburne.

Table 49. Black-legged Kittiwake nest and egg counts at Cape Lewis, 27 July 1977.

	Total Nests	Nest with 0 eggs	Nests with 1 egg	Nest with 2 eggs
No.	42	18	20	4
%	100	43	48	10

One adult Golden Eagle flushed from the pinnacles near the top of the cliffs. Several well-used perching places were evident, but we are not certain whether an active nest was present.

J. Other Areas Utilized by Seabirds

Seabirds were found at several headlands, bluffs and cliffs which occur both east and south of Cape Lisburne. Table 50 summarizes our observations, at those sites (see Figures 4 and 5).

Corwin Creek Bluff

The only seabirds apparently occupying this bluff were Pelagic Cormorants. No nests were found but the amount of white-wash on the rocks indicated that the birds perched there regularly.

Sapumik Ridge

A few Glaucous Gulls were found along the coast and could have nested there although no nests and only one fledged young were seen.

Table 50. Observations of seabirds at headlands, bluffs and cliffs east and south of Cape Lisburne, 1976 and 1977. Estimates are denoted by ( ); only th highest direct counts are listed.

Species	year	Corwin Creek Bluff[1]	Sapumik Ridge[2]	Niak Creek[3]	Bluffs south of Niak Creek[3]	Noyalik Peak[3]	Cape Dyer[4]	Kilikralik Point[5]
Murres	1976		a	a	a	(few 10's)	a	a
	1977	a	a	a	a	20	a	a
Black-legged Kittwakes	1976		a	a	a	a	a	a
	1977	a	a	a	a	a	a	a
Horned Puffins	1976		a	a	(several 10's)	(100±)	b	b
	1977	a	a	a	(few)	(30-40)	(16-30)	a
Glaucous Gulls	1976		present	?	?	12	present	b
	1977	a	(few 10's)	a	a	a	46-50	(several 10's)
Pelagic Cormorants	1976		a	?	a	(few)	50	(40-50)
	1977	33	a	6	a	9	26	(50±)
Tufted Puffins	1976		a	a	(several 10's)	(50±)	b	b
	1977	3	a	a	2	(12)	2-4	c
Black Guillemots	1976		a	a	a	a	b	b
	1977	a	9	a	14	a	a	c
Pigeon Guillemots	1976		a	a	a	a	b	b
	1977	a	a	a	a	a	a	c

[1] not visted by boat or aircraft in 1976

[2] data from 29 August 1976; 2 August 1977

[3] data from 28 August 1976; 13 and 27 July 1977

[4] data from 8 August 1976 (aerial estimate only); 27 July 1977

[5] data from 8 August 1976 (aerial estimate only); 20 July 1977 (aerial estimate only)

a - none observed from raft
b - none observed from airplane
c - none observed and presence doubtful

Niak Creek

Cormorants used a rock pinnacle just south of the creek mouth to perch on. One old nest was found. Gulls were flying in the area but we doubt they nested there.

Bluffs South of Niak Creek

Both Horned and Tufted Puffins were scattered along this section of coast, a length of about seven kilometers between Niak Creek and Noyalik Peak. We believe that both species probably nest in the steeper parts of the bluff.

Black Guillemots were seen on the water near the coast but we do not know if they nested in the area.

Noyalik Peak

In 1976 we christened this large, soft rock spire "Puffin High-rise". As many as 100 Horned Puffins and 50 Tufted Puffins were estimated to occupy this site and both species were seen entering and leaving the many burrows and crevices visible from shore. Consideralby fewer puffins were there in 1977, although most of those present probably nested.

Small numbers of murres and gulls also were found on the rocks. The gulls might have nested but we believe that the murres were loiterers.

Cormorants were present but not numerous and did not nest there in 1977, although two old nests could be seen.

Cape Dyer

Horned Puffins and gulls nested on Cape Dyer in small numbers. We found 13 active cormorant nests in 1977; the estimate made from an airplane in 1976 of 50 individuals is probably too high.

Kilikralik Point

About 50 cormorants were estimated to have been on this point in 1976 and 1977. Whether or not cormorants nested there is not known, but the point was at least a popular perch for the birds.

A few adult gulls also were seen there and were possibly nesting, although we have no direct evidence.

K. Other observations

One of the highlights of the 1977 summer at both Cape Thompson and Cape Lisburne was the arrival of Sand Launce. The fish moved from north to south and appeared first at Cape Lisburne in late July.

On 25 July Black Guillemots were seen carrying Arctic Cod and a few Sand Launce to the cliffs at Cape Lisburne. Between 25 July and 30 July, kittiwakes were noted traveling more and more regularly in larger and larger numbers upcoast so on 1 August we collected kittiwakes returning from the east and examined their stomach contents. The majority of the birds had been feeding extensively on Sand Launce. We traveled upcoast as far as Thetis Creek, a distance of approximately 50 km on 2 August, and saw several feeding melees of kittiwakes near the Corwin Bluffs area. We were able to approach these groups closely enough to determine that the birds were feeding on Sand Launce.

A major summer storm hit the Cape Lisburne region about 8 August, creating high winds and high surf. Many Sand Launce were washed up on the beach at the Air Force site during that storm which began to subside on 10 August. On 9 August we observed unprecedented numbers of murres, kittiwakes and Glaucous Gulls feeding in large concentrations close to the colonies. Enormous feeding flocks of kittiwakes could be seen regularly in several locations around the colony. On the same date, we attempted to capture an apparently injured immature Glaucous Gull. When the bird was pursued, however, it regurgitated a large volume of Sand Launce and immediately became airborne.

Common Murres, which were collected on 10 August and which had been feeding to the northeast of the colonies were filled with Sand Launce. From then on through the remainder of our stay at Cape Lisburne, Sand Launce continued to be adundant in the region. The fish were the primary food of the majority, if not all of the kittiwakes, and also were heavily utilized by murres. Most other seabird species also probably utilized this resource above all others.

The stomach contents of both murres and kittiwakes collected at Cape Thompson indicated that small numbers of Sand Launce begin arriving within the feeding range of these birds about the same time as at Cape Lisburne. Large feeding aggregations of kittiwakes at Cape Thompson, however, were not observed until about 10-12 August. From then on, Sand Launce increased in importance, and by 17-23 August were being used almost exclusively by kittiwakes and heavily by murres.

The day of 23 August was a particularly calm bright day at Cape Thompson. At 1630 hours we observed from the top of Colony 4 a large dark mass, approximately 10 meters out from the surf. This mass proved to be a shoal of Sand Launce which was moving south. During the next hour we counted at least 15 other schools moving down the coast. The largest of the schools was about 5 x 10 meters in surface area and at least 1-2 meters in depth. The smallest measured about 2 x 2 meters in surface area and also was about 1-2 meters deep. Besides these large schools of fish, numerous small groups were also observed. Regardless of size, however, all schools were very dense.

Kittiwakes would regularly surface from a plunge with their mouths full of these fish; as many as 5 or 6 individual fish could be seen protruding from their bills. Glaucous Gulls had only to sit on the water and dip their heads under in order to obtain them. Murres 'ringed' the schools and dove, pausing underwater within a meter or so of the fish before dashing through them to surface several meters away. The action of the murres tended to fragment the schools but also drove the fish upward, keeping them within reach of the circling and plunging kittiwakes.

VII. and VIII. DISCUSSION AND CONCLUSIONS.

The numbers of birds we counted at Cape Thompson in 1976 and 1977 are almost certainly minimal estimates of the total populations which occupy the cliffs. Although we have evidence of rather well developed daily rhythms of cliff attendance by murres, the factors which we derived from the activity patterns to correct raw census scores probably do not account for all of the birds in the area. Furthermore, our experience has been that we tended to underestimate rather than overestimate numbers of birds at the cliffs. That tendency would also increase the size difference between the "real" and estimated totals.

The regularity and timing of daily attendance patterns at the cliffs was probably affected by several factors. These factors include variations in weather, changing daylength, food availability and the stage of the reproductive cycle. Those variables complicate the accuracy and precision of census counts.

Because compensation factors common to counts on different days in one season are difficult to derive, comparisons of counts made at different times and in different years should be made carefully.

The raw census total obtained by Swartz in 1960 was 40% higher than our raw total for 1976 and 44% higher than our raw total for 1977. The differences between the compensated scores are greater; the 1960 compensated total was 54% higher than the compensated 1976 total and 60% higher than the compensated 1977 total. The relatively greater change observed between the compensated scores compared to the raw scores can be explained by differences between the way Swartz compensated his raw scores and the way we compensated ours.

Swartz determined daily activity patterns of murres in much the same way as we did, that is he counted the number of birds on small plots at intervals during the time that census counts were being made. Immediately after the census counts were complete, however, birds on the compensation plots were flushed and the eggs were counted. The relative number of breeding birds on the cliffs at different times were calculated by dividing the number of birds on compensation plots at time 't' by 2 x the number of eggs. From the bird and egg counts Swartz determined that, at peak times of attendance, there were 16% more birds on the plots that twice the number eggs. He suggested that those birds were attempting to breed but had lost eggs and not replaced them. The final correction factors used by Swartz to adjust raw scores took these additional birds into account. Raw scores were corrected not only for the daily activity patterns of the murres, but also were increased by 16% to correct for egg loss and replacement.

The method we used to compensate raw scores included daily variation in attendance only. Our attempts in 1976 to flush birds so that eggs could be counted were unsuccessful - enough birds always remained on the ledges to make visibility difficult and we could not be certain of how many eggs were present. Therefore, we did not correct our raw census scores for birds which might have been present but not nesting.

If the change in the murre population between 1960 and 1976-1977 is measured by the difference observed between the raw scores, the apparent decline is about 15% less than if differences between the compensated scores are used to measure the change. The magnitude of that difference (15%) is consistant with what one would predict, given knowledge of the two ways in which counts were compensated.

The differences discussed above, however, do not affect the suggestion which the data offer; that there probably were, in fact, fewer murres at Cape Thompson in 1976-1977 than there were in 1960 and 1961. Whether this change represents a gradual decline over the years or only a short-term fluctuation which might be related to yearly differences in certain environmental conditions is unknown.

With the exception of 1976, little variation has been observed in the schedule of murre nesting activities between years at Cape Thompson or between Cape Thompson and Cape Lisburne in 1977. The most reliable indicator of the breeding schedule is probably the dates when chicks begin to leave the cliffs. Because the vast majority of murres nest in places which are not visible, observations of 'first' eggs and 'first' chicks yield, at best, only a rough estimate of when eggs are first laid and first hatch. When chicks jump off the cliffs, however, they are very conspicuous and in general, the earliest chicks hatched are the earliest to jump.

The information obtained from food habits studies has shown that large yearly and seasonal differences exist in the prey utilized by both Common and Thick-billed Murres. Whether the changes are regular or random is still not clear.

Certain components of the total food resource appear to be 'more important' than others. For example, cod were taken much more frequently by thick-bills than were Capelin, and shrimp were taken more frequently than crabs. Both cod and shrimp rank high as principal components of this species' 'average' diet. The importance of these particular prey is not necessarily absolute, however. In 1977 cod were more important than sculpin in mid-July, but sculpin were more important than cod in mid-August. By late August, however, Sand Launce, which were taken in relatively low numbers through the middle of August, were more important than either cod or sculpin. The point is that, depending upon the season and/or the year, any of several species or groups of species should be considered critical to the murre populations at Cape Thompson and Cape Lisburne.

The relationship between the foraging flight patterns of murres at both colonies and the birds' food resources are not clear. We suppose that the birds feed in areas where they can optimise the energy return: effort ratio.

Alverson and Wilimovsky (1966) conducted fishery investigations in the waters around both Cape Lisburne and Cape Thompson. The areas in which they found the greatest concentrations of several fish and invertebrates coincided with areas we believe are important feeding grounds of murres.

Eight stations in the northern arc between west and east at Cape Lisburne were sampled during the last two weeks of August, 1959. The largest catches of Arctic Cod and Capelin were from two stations located generally northeast of the Cape. Those same stations also ranked high in relative numbers of decapods, particularly pandalid and crangonid shrimp.

In a large arc between Point Hope and Cape Krusenstern 63 stations were sampled. Decapods appeared to occur in greatest abundance in the deeper waters west and southwest of Cape Thompson (Sparks and Pereyra 1966). The highest catch of Capelin was at a station west of Kivalina (south-southwest of Cape Thompson) although Arctic Cod appeared to be most numerous well off-shore and west of the Cape and Point Hope.

The seasonal shifts in flight patterns observed in the murre populations may coincide with changes in food availability and 'hot spots'. Although certain areas may tend to be generally richer in prey, variations between years and seasons seem possible. That the changes in foraging areas occurred at about the same time at both colonies and approximately when murre chicks began to hatch could be significant. The paucity of information on the biological oceanography of the eastern Chukchi Sea, however, makes speculating on those relationships difficult.

As with the murres, we are not yet able to describe with certainty the relationship between the numbers of kittiwakes we have counted at Cape Thompson during the past two summers (about equal in 1976 and 1977) and the numbers which Swartz counted in 1960. The census methods were again somewhat different, Swartz counted nests and we counted birds.

We are certain, however, that recent productivity of kittiwakes at Cape Thompson, especially in 1976, has been much lower than it was in 1960. We would be surprised if the same proportion of birds even attempted to breed during the last two years as did during 1960, especially if the poor nesting success is related to a food shortage in the region of the colonies.

The average clutch size of kittiwakes at Cape Thompson has ranged from just over one in 1976 (for the few nests containing eggs) to as high as 1.92 in 1960. Likewise, the breeding success (chicks fledged/total eggs laid) of monitored pairs has varied widely between years; in 1976 the breeding success was essentially zero, but in 1977 and 1960 it was 65%.

The breeding success equality between 1977 and 1960 apparently occurred as a result of different factors. A greater percentage (25%) of the eggs laid in 1960 failed to hatch than in 1977, when only 9% failed to hatch. However, 86% of the eggs that hatched resulted in fledged chicks in 1960 while only about 70% of the chicks which hatched could have fledged in 1977.

Even though the proportion of chicks fledged to eggs laid in both years was the same, the productivity of the population at Cape Thompson in 1960 was considerably higher than in 1977. The larger average clutch size in 1960 resulted in 1.22 chicks fledged per active nest compared to 0.77 chicks per active nest in 1977.

We have also observed differences in the productivity of kittiwakes at Cape Thompson and at Cape Lisburne in 1977. Although somewhat fewer kittiwakes may have attempted to breed at Cape Lisburne, a smaller number of those pairs which produced eggs failed than did at Cape Thompson. Perhaps the most striking difference between the colonies, however, was the remarkably rapid growth rates of chicks at Cape Lisburne compared to Cape Thompson.

The factors which influence elements of the breeding biology of kittiwakes are probably many and the interrelationships are certainly complex. Like most other birds which breed in higher latitudes, kittiwakes are undoubtedly under photoperiodic control for the initiation of the physiological changes associated with reproduction. The rate of development and the ultimate success of the breeding effort are probably attenuated by local environmental factors including weather, food availability and by the previous breeding experience of individuals and pairs. If trends in seasonal utilization of different foods by both kittiwakes and murres have occurred regularly over the evolutionary history of these colonies, the breeding schedule may be timed, to some extent, to produce chicks coincident with seasonal food abundance.

Underlining many of the controling factors is the common denominator 'energetics', and an intimate relationship between energetics and productivity certainly exists. For example, severe weather could be described as the proximate cause of a general breeding failure. Unless wind actually blew nests, eggs or chicks off of the rocks or unless surf and rain washed them away, the ultimate cause of the failure might be that weather interrupted the availability of energy to the adult birds. Even if only temporary, an interruption could easily result in an unsuccessful breeding attempt by pairs and by the population as a whole.

Similarly, variations in productivity between pairs of birds in a colony can often be attributed to age and experience differences of individuals. The point is that older birds might be able to secure energy more reliably than younger birds and, therefore, would have more to 'spend' on reproduction while still maintaining themselves.

We believe that at Cape Thompson, and at Cape Lisburne, the large differences we have seen in productivity, as well as in the timing of the breeding seasons and the growth rates of chicks, might be related to yearly, seasonal and regional differences in the amount of food available to the colony as a whole.

Swartz (1966) showed that the lowest average weight of male kittiwakes occurred upon their arrival on the breeding grounds. Throughout the summer males tended to gain weight and were heaviest upon their departure in October. The pattern in females was somewhat different than in males. Females gained weight between their arrival in May and late June, when they reached their maximum. The weight maximum coincided with the peak period of egg laying, after which time the weight of female kittiwakes tended to decrease through their departure in the fall.

We were able to show that the weights of Black-legged Kittiwakes are significantly correlated with levels of extractable fat in both males and females ($r = .674$, $p<.01$ for males; $r = .627$, $p<.01$ for females), and we believe that the observed weight increase of kittiwakes during the first part of the summer is related to increasing fat levels rather than to chance differences among the birds which were collected.

On 13 July 1977, male and female kittiwakes at Cape Thompson both had higher average weights than did male and female kittiwakes at Cape Lisburne on the same date. Nine males at Cape Thompson averaged 469±28 g and seven males at Cape Lisburne averaged 455±29g. Seven females at Cape Thompson and nine females at Cape Lisburne had average weights of 440±42 g and 411±26 g, respectively. The differences were not statistically significant; however, when the weight differences, especially between females, are viewed in terms of the timing of egg laying, they might have biological significance.

The phenology of breeding activities in 1960 was perhaps a little earlier than in 1977 and was certainly no later. During the interval 1-15 July, Swartz collected eleven male and ten female kittiwakes. The males weighed an average of 486.6±8.2 g and the females weighed an average of 449.9±9.7 g. Both of these averages are higher than those obtained on similar dates in 1977 at either Cape Thompson or Cape Lisburne.

In 1976 we collected seven males and four females between 1-14 July, the weights of which averaged 452±32 and 394±55, respectively. Those averages are considerably lower than either 1960 or 1977 and the breeding schedule in 1976 was much later than in either of the other two years.

The laying dates of kittiwakes at both colonies for all years appear to be related to the average weights of female kittiwakes collected during the interval 1-15 July of the respective year. The heavier the average weight was, the earlier the date of laying. These data, together with the correlation between body weight and fat levels, suggest that certain energy requirements may have to be met by the female birds before they will lay eggs.

If an energy threshold must be reached to initiate laying, the magnitude of energy reserves above that threshold could contribute to the number of eggs laid. It may be significant therefore, that clutch sizes averaged largest at Cape Thompson in 1960 and were progressively smaller at Cape Thompson in 1977, Cape Lisburne in 1977 and Cape Thompson in 1976.

Unfortunately, we do not have early season food habits information for kittiwakes at either colony. We do know that kittiwakes were feeding heavily on cod at both sites during the period when egg-laying occurred. By the time eggs were hatching at Cape Thompson, however, we believe that cod were much less available and Sand Launce had not yet arrived. At Cape Lisburne cod had also declined, at least in utilization, by the time eggs hatched, however, Sand Launce had arrived there in large numbers and were being fed on heavily by adults and were being fed almost exlusively to chicks. The abundance of Sand Launce, coincident with the hatch of chicks at Cape Lisburne, probably explains why growth rates and fledging success were higher at Cape Lisburne than at Cape Thompson.

As with murres, we are reluctant to designate particular prey species as critical to kittiwakes. Sand Launce are undoubtedly important, at least during late summer when energy requirments are particularly high because of rapidly growing chicks. We do not know whether Sand Launce have occurred in large numbers near Cape Thompson and Cape Lisburne during early summer in other years, or whether the late arrival of these fish is characteristic. If they are not generally abundant until August then they are no more important to the kittiwake population than are those prey upon which the bird feed during May, June and July (for example cod). Both Arctic and Saffron Cod were taken frequently by kittiwakes prior to the arrival of Sand Launce, and the relative abundance of cod may well have determined the relative importance of Sand Launce. That is, Sand Launce were important in 1977 because there were chicks to feed; in 1976 Sand Launce in August would have been of much less significance since very few eggs were being laid.

Our studies and the work done by Swartz during 1959-1961 are beginning to demonstrate the magnitude of "natural" fluctuations in the breeding success of kittiwakes on a colony wide basis. We believe that those fluctuations are of particular significance with regard to oil development in the Hope Basin.

We do not know the rate at which productivity will recover following a year like 1976. Unless the kittiwake populations at Cape Thompson and Cape Lisburne rely on immigration of birds from colonies farther south, productivity can not remain low without jeopardizing the health of those populations. If food web organisms were adversely affected by oil related activities, that impact could compound the effects of a "natural" prey decline and prolong the recovery of kittiwake nesting success.

With the possible exception of puffin numbers, little overall change in the biology of gulls, guillemots, cormorants and puffins has been observed at our study sites. All of those populations are small compared to murres and kittiwakes, and except for gulls, probably contribute little to the ecology of the area. Glaucous Gulls undoubledly affect the production of murre chicks, the extent of which is difficult to assess. The availability of habitat and food for murres, however, is probably of much greater significance to the population than is gull predation.

IX. SUMMARY OF 4TH QUARTER OPERATIONS

A. Ship or laboratory or field activities

1. No field work was conducted during the 4th quarter.

2. The scientific party for the 4th quarter included: Alan M. Springer, PI; David G. Roseneau, PI; Martha I. Johnson, Research Assistant; and Peter J. Bente, Biologist.

3. Sorting of voucher specimens from stomach food samples was completed by Dr. Peter Craig, Fisheries Biologist (LGL) and Dr. C. Low, Nanaimo, British Columbia.

4. No samples were taken during the 4th quarter.

5. No field data were collected during the 4th quarter. Several parasite specimens collected in 1977 and sent to Eric Hoberg and Dr. Robert Rausch, University of Saskatchewan, have been identified. A brief summary of these data will be included in the final report.

6. Data submissions schedule:

a. We expect to begin submitting 1976 and 1977 data according to the new 'A35 Bird Colony' formats and the new USFWS food habits and specimen records after the completion of the upcoming summer field season. Data collected in 1978 will be entered on format field forms and also will be submitted at that time.

b. Discussions about the 'workability' of the old "035 Bird Colony Format" were held with Arctic Project Office personnel. The '035' format and a new format, proposed by the U.S. Fish and Wildlife Service, were reviewed and comments were submitted to Marcy Butcher, Juneau, and Mike Crane, AEIDC, Anchorage. D. G. Roseneau attended a meeting of other seabird colony PI's, NOAA, Arctic Project Office, BLM and USFWS personnel at the NOAA offices in Boulder, Colorado, 20-21 March 1978 where both formats were reviewed by the group. A colony census record was submitted for inclusion in any new format scheme. Data submissions had posed a problem since the "035" format continued to present difficulties in data entry. A new bird colony format, a result of the 20-21 March 1978 meeting in Boulder, will now allow us to prepare field forms and enter R.U. 460 colony census data.

B. Problems encountered/recommended changes

No major logistic or scientific problems were encountered. Data entry and submission had posed a problem (see above). This problem appears to be resolved.

C. Estimate of funds expended

	Project Initiation to 31 March 1977	31 March 1977-31 March 1978	Total
Cape Thompson			
Personnel	$36,584.26	$13,845.48	$50,429.74
Expenses	20,663.30	9,886.28	30,549.58
Total	$57,247.56	$23,731.76	$80,979.32
Cape Lisburne			
Personnel	$ 434.94	$ 7,081.44	$ 7,516.38
Expenses	0	6,272.81	6,272.81
Total	$ 434.94	$13,354.25	$13,789.19
Radio Telemetry Pilot Study			
Personnel	$ 0	$ 2,150.50	$ 2,150.50
Expenses	0	$ 2,477.29	$ 2,477.29
Total	$ 0	$ 4,627.79	$ 4,627.79

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The field party this summer consisted of Dr. Ed Murphy, Martha Johnson, Sony Power, John Stern, Gretch Murphy and Peter Bente. Without their effort the majority of data presented in this report would not have been collected.

The identification of foods eaten by murres and kittiwakes were conducted by Dr. Peter Craig (currently with LGL, Ltd.) and Dr. C. Low of Namaimo, Britich Columbia.

Major Joseph Zadareky, Site Commander, 711th Aircraft Control and Warning Squardron (AAC), Cape Lisburne, and his personnel were especially cooperative and hospitable during our stay. Mr. Gene Horsewood, RCA manager and many of his staff helped make our stay comfortable and productive by providing us dining privileges and materials and assistance in maintaining some of our equipment.

XI. LITERATURE CITED.

Allen, P.W. and R.O. Weedfall. 1966. Weather and climate. Pages 9-44. in: N. J. Wilimovsky and J. N. Wolfe, eds. Environment of the Cape Thompson Region, Alaska. U.S. Atomic Energy Commission, Oak Ridge, Tennessee.

Alverson, D. L. and N.J. Wilimovsky. 1966. Fishery investigations of the southeastern Chukchi Sea. Pages 843-860 in: N. J. Wilimovsky and J. N. Wolfe, eds. Environment of the Cape Thompson Region, Alaska. U.S. Atomic Energy Commission, Oak Ridge, Tennessee.

Barry, R. G., A. Belon, A. Hanson, E. Hoskins, S. Martin, C. M. Naske, R. S. Pritchard, W. M. Sackinger, L. Shapiro, W. Stinger and W. Weeks. 1977. Sea ice studies. Pages 1-28 in: Beaufort Sea synthesis report. Environmental impacts of OCS development in northern Alaska. Proceedings of a "Synthesis Meeting" of OCSEAP and other investigators working in northern Alaska, Barrow, Alaska 7-11 February 1977.

Belopol'skii, L. O. 1957. Ecology of sea colony birds of the Barents Sea (in Russian), Izdatel'stvo Academia Nauk SSSR, Moskva-Leningrad, 1957. (Transl. 1961, Israel Program for Scientific Translations, Jerusalem, 346 p.).

Campbell, R. H. 1966. Areal geology. Pages 57-84 in: N. J. Wilimovsky and J. N. Wolfe, eds. Environment of the Cape Thompson Region, Alaska. U.S. Atomic Energy Commission, Oak Ridge, Tennessee.

Creager, J. S. and D. A. McManus. 1966. Geology of the southeastern Chukchi Sea. Pages 755-786 in: N.J. Wilimovsky and J.N. Wolfe, eds. Environment of the Cape Thompson Region, Alaska. U.S. Atomic Energy Commission, Oak Ridge, Tennessee.

Drury, W.H. 1978. Ecological studies in the northern Bering Sea: Birds of coastal habitats on the south shore of Seward Peninsula, Alaska. Annual Report. Research Unit 237. Outer Continental Shelf Environmental Assessment Program. Boulder, Colorado. 56 p.

Fleming, R.H. and D. Heggarty. 1966. Oceanography of the southeastern Chukchi Sea. Pages 697-754 in: N. J. Wilimovsky and J. N. Wolfe, eds. Environment of the Cape Thompson Region, Alaska. U.S. Atomic Energy Commission, Oak Ridge, Tennessee.

Johnson, M. W. 1966. Zooplankton of some Arctic coastal lagoons. Pages 679-693 in: N. J. Wilimovsky and J. N. Wolfe, eds. Environment of the Cape Thompson Region, Alaska. U.S. Atomic Energy Commission, Oak Ridge, Tennessee.

Kachadoorian, R. 1966. Geographic setting. Pages 45-56 in: N. J. Wilimovsky and J. N. Wolfe, eds. Environment of the Cape Thompson Region, Alaska. U.S. Atomic Energy Commision, Oak Ridge, Tennessee.

Sparks, A. K. and W. T. Pereyra. 1966. Benthic invertebrates of the southeastern Chukchi Sea. Pages 817-838 in: N. J. Wilimovsky and J. N. Wolfe, eds. Environment of the Cape Thompson Region, Alaska. U.S. Atomic Energy Commission, Oak Ridge, Tennessee.

Springer, A. M. and D. G. Roseneau. 1977. A comparative sea-cliff bird inventory of the Cape Thompson vicinity, Alaska. Annual Report. Research Unit 460. Outer Continental Shelf Environmental Assessment Program. Boulder. 54pp.

Swartz, L. G. 1966. Sea-cliff birds. Pages 611-678 in: N. J. Wilimovsky and J. N. Wolfe, eds. Environment of the Cape Thompson Region, Alaska. U.S. Atomic Energy Commission, Oak Ridge, Tennessee.

Swartz, L. G. 1967. Distribution and movements of birds in the Bering and Chukchi Seas. Pacific Science 21(3):332-347.

Tuck, L. M. 1960. The Murres. Queen's Printer, Ottawa. 260 p.

Wilimovsky, N. J. and J. N. Wolfe, eds. 1966. Environment of the Cape Thompson Region, Alaska. U.S. Atomic Energy Commission, Oak Ridge, Tennessee. 1250 p.

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