PELAGIC DISTRIBUTION OF MARINE BIRDS ON THE CENTRAL BERING SEA SHELF AND ANALYSIS OF RISK FOR THE NAVARIN BASIN

by

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

The purpose of this study was to obtain information on avian use of the Navarin Basin, and to evaluate the potential risk to birds of offshore oil development in this region. We used data from our five OMPA sponsored cruises which covered the central shelf area of the Bering Sea (59°30'N to 63°N). We also used data from other OSCEAP surveys of the area, and our data from PROBES sponsored cruises.

Despite the number of cruises surveying the Navarin Basin, only about half of the area has been covered in any season and there is no coverage for the winter. Sample sizes are generally low in the Navarin Basin (a maximum of 40 transects per 30′ latitude by 60′ longitude block). Hence, we pooled observations by location into larger geographic areas on the basis of oceanographic and biological features: coastal water, middle shelf water, outer shelf water, deep water and areas within 60 km of the major breeding colonies at St. Lawrence and St. Matthew Islands (Figure 1). While the use of zones is useful for providing patterns of bird distribution and abundance within habitats, it does not reveal specific sites of high density.

Average Densities

The analysis of bird distribution by zone (Table 1) showed birds concentrated in the middle shelf and outer shelf regions of the Navarin Basin in the spring, with average densities of about 40 birds/km^2. Least Auklets (*Aethia pusilla*) were the most abundant species in both the outer shelf and middle shelf waters surveyed, although Thick-billed Murres (*Uris lomvia*) were also abundant on the middle shelf.

In summer, birds were concentrated around the colonies at St. Lawrence Island (average density 343 birds/km^2, mostly auklets) and St. Matthew Island (average density 193 birds/km^2, mostly murres). Bird densities in outer shelf waters were also high (97 birds/km^2) and represented storm-petrels (*Oceanodroma*

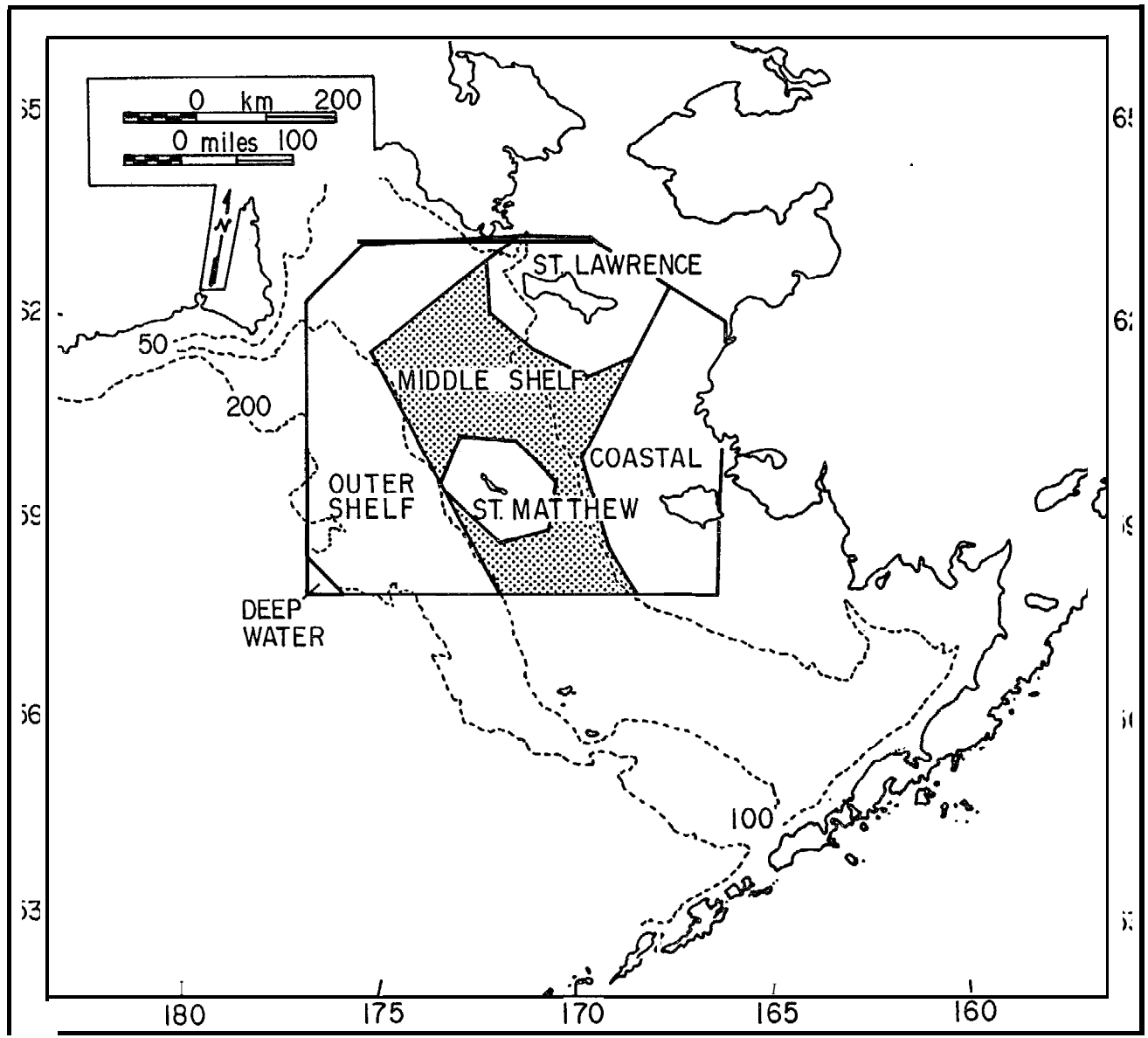


Figure 1. Zones for the central Bering Sea shelf.

Table 1. Mean densities (birds/km^2) of birds on the central Bering Sea shelf by zone and season. The abbreviations in parentheses stand for the most abundant species. See tables 3-5 for sample sizes.

	SPRING	SUMMER	AUTUMN
ZONE			
Coastal	*	75 (MURR)	3
Middle Shelf	44 (LEAU)	**19** (MURR)	**12** (SMAL)
Outer Shelf	38 (LEAU)	**97** (STPE)	**21** (SW)
Deep	6 (NOFU)	**24** (STPE)	**22** (SHER)
St. Matthew	**16** (MURR)	**193** (MURR)	**7** (BLKl)
St. Lawrence	*	**343** (SMAL)	*
Total	28	98	13
All seasons	56		

* no data

[1] **BLKI= Black-legged** Kittiwake, **LEAU = Least** Auklet, **MURR = murres, NOFU = Northern** Fulmar, **SHER = shearwaters,** SMAL **= small auklets, STPE = storm-petrels.**

sp.) and phalaropes (Phalaropus sp.). Coastal waters showed moderate use in the summer (average density 75 birds/km^2) by murres, Black-legged Kittiwakes (Rissa tridactyla) and Crested Auklets (Aethia cristatella).

In the fall, the Navarin Basin supported low densities of birds. The highest densities were found in outer shelf waters and in the deep waters beyond the shelf (average density 20 birds/km^2). Auklets were the predominant birds in outer shelf waters while shearwaters were the most abundant species beyond the shelf.

Figures 2-4 show average bird density on a finer scale (30' latitude by 60' longitude blocks) and show high average densities ($\geq$ 75 birds/km^2) within the Navarin Basin during all seasons we sampled. In general, average densities were lower and areas of high density were not as widespread in portions of the southeastern Bering Sea (e.g. the inshore waters of Bristol Bay and portions of the outer and middle shelf domains). In the spring, high bird densities were found west of St. Matthew Island, near the 100 and 200 m isobaths. Large numbers of birds were also seen in the polynyas around St. Matthew Island (N. Harrison, B. Braun, pers. ohs.), but", no formal censuses were made. In summer, average densities were highest around St. Matthew Island, the site of a breeding colony of 1.4 million seabirds (Sowls et al. 1978), St. Lawrence Island, with 1.8 million breeding seabirds, and at the shelf edge in the northwest corner of the Navarin lease sale area. In the fall, bird densities were moderate or low ($\leq$ 30 birds/km^2) except at the shelf edge in the southwest corner of the lease sale area where the average densities of Northern Fulmars (Fulmarus glacialis) and shearwaters (Puffinus sp.) reached 75 birds/km^2.

Encounter rate for high bird densities

Figures 5-8 show the encounter rate for four levels of bird density (50, 100, 500 and 1000 birds/km^2) averaged throughout the year. Since oil spills may occur in any season, these figures give a rough estimate of the number of birds that might be affected in any region. Large numbers of birds are likely to be affected near St. Matthew and St. Lawrence Islands and at the shelf break in

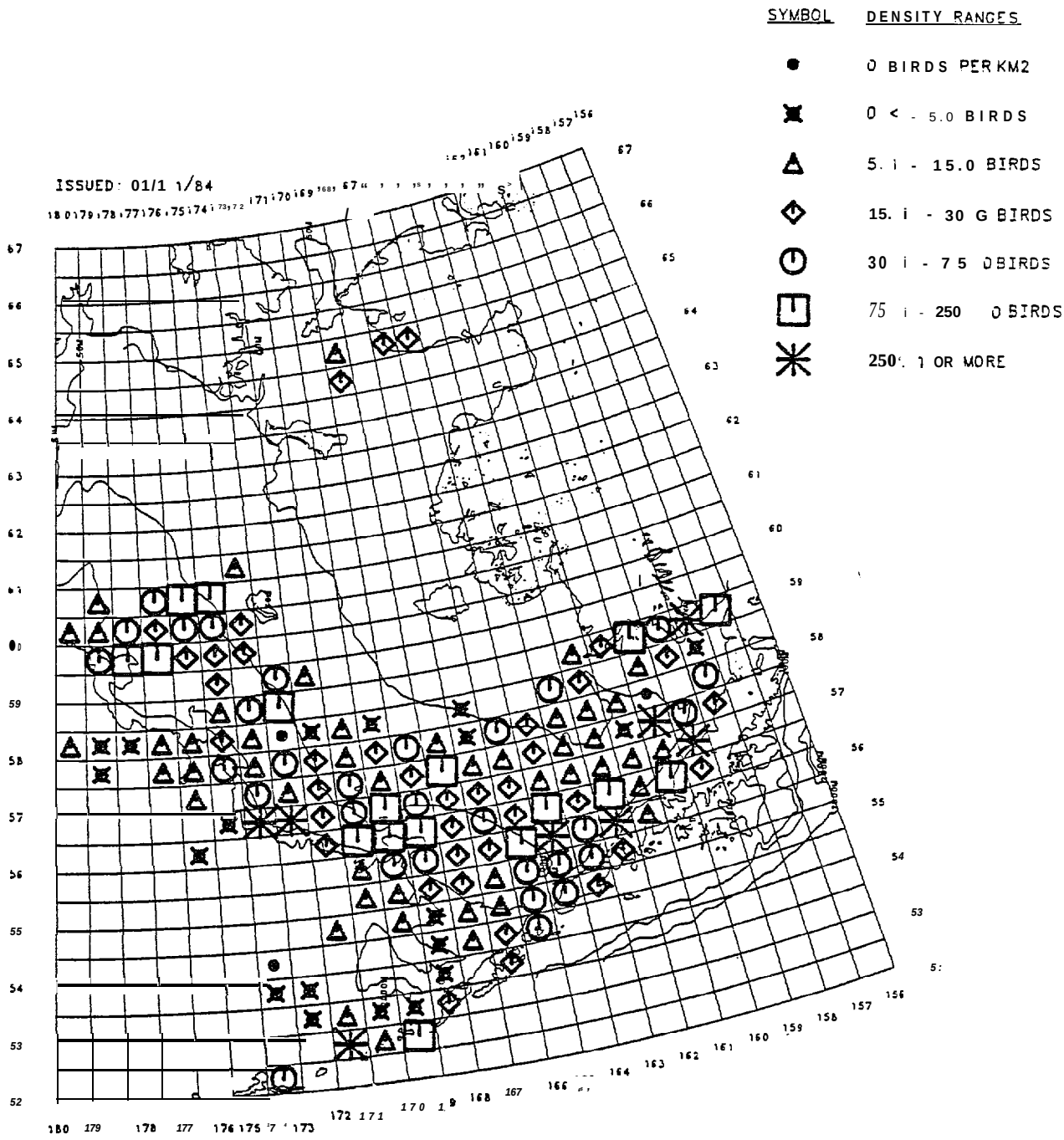


Figure 2. Mean densities, all birds: Spring.

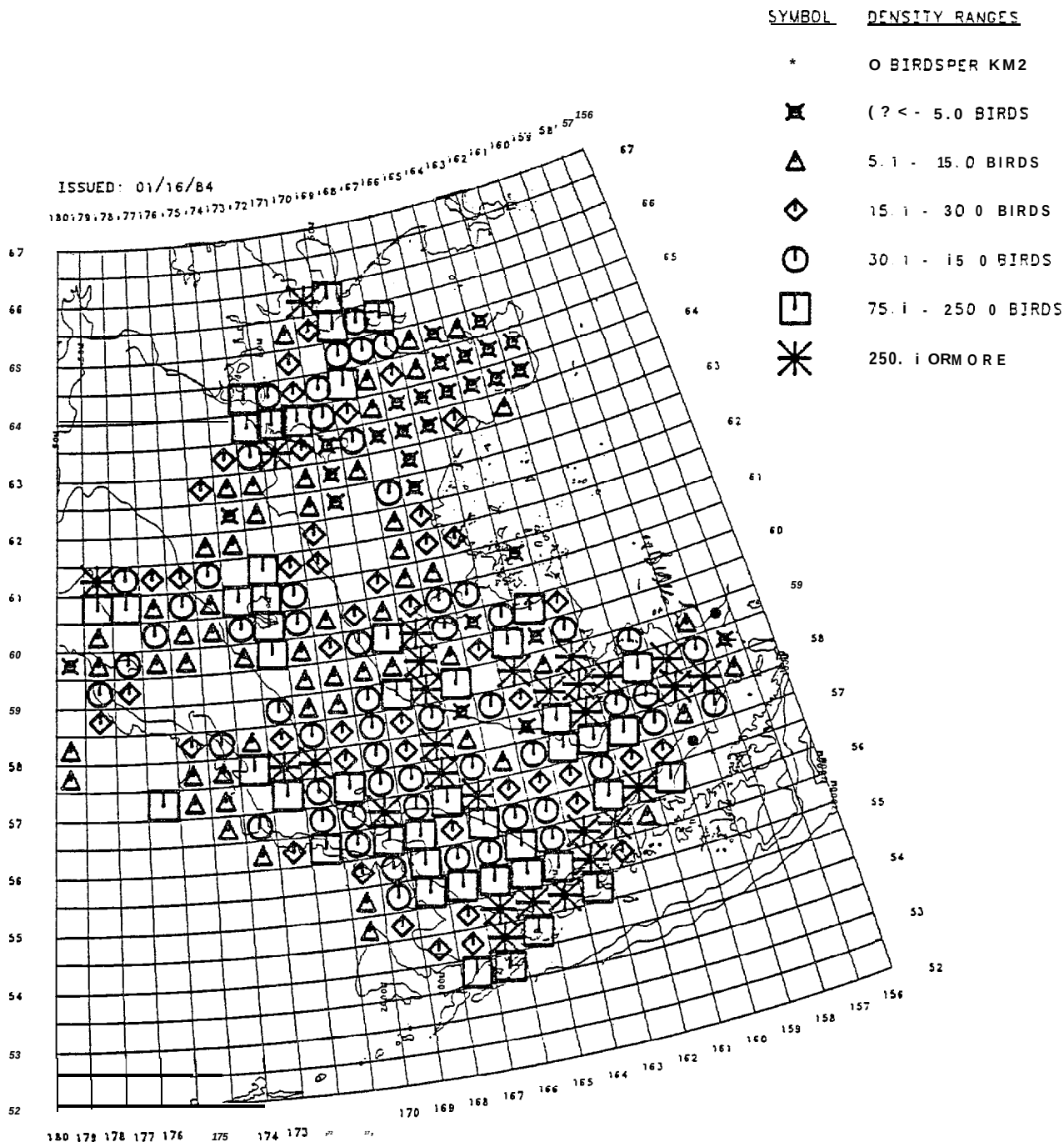
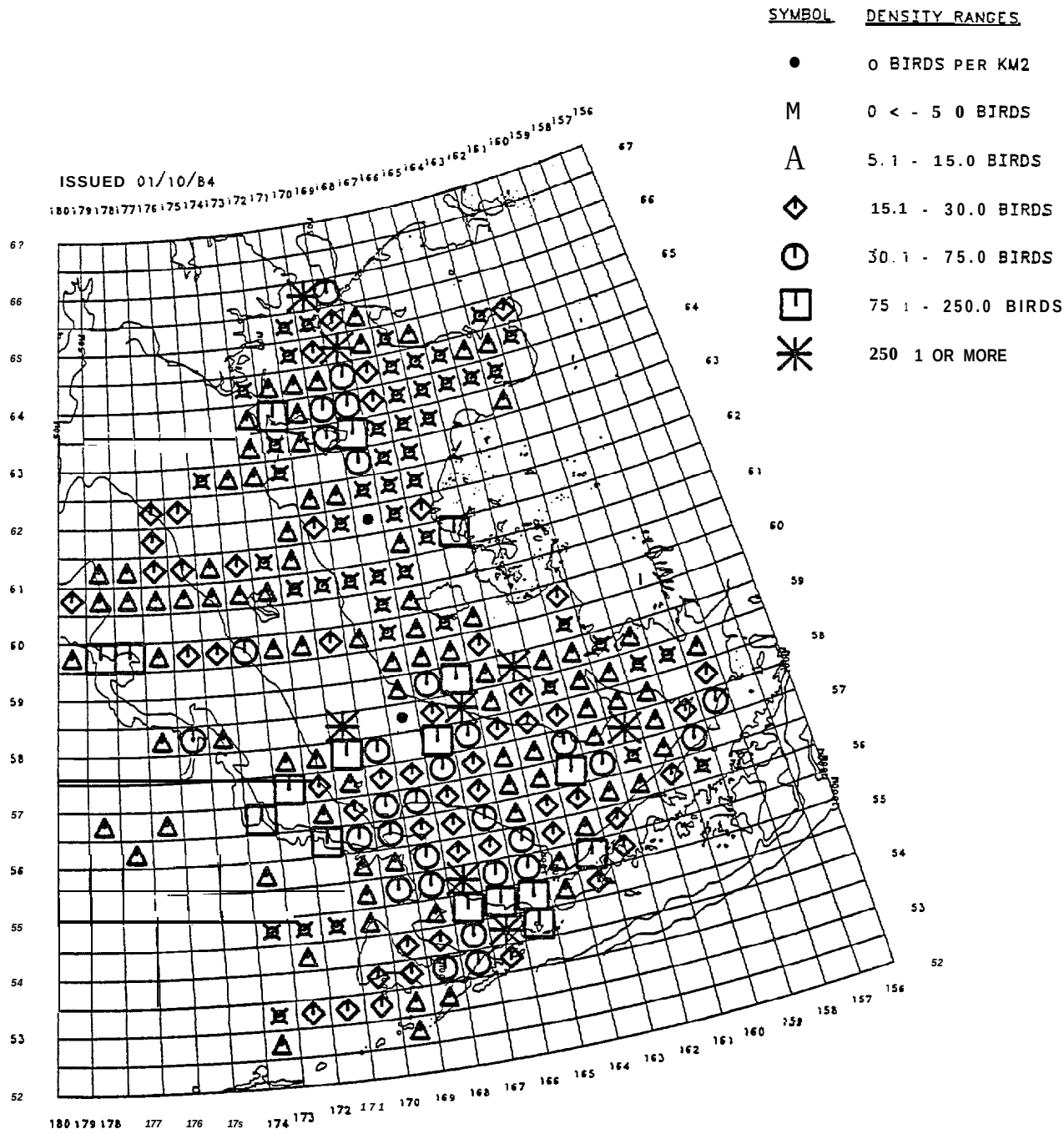


Figure 3. **Mean densities, all birds: Summer.**



BERING SEA MEAN DENSITY PLOT
ALL BIRDS
AUTUMN

Figure 4. Mean densities, all birds: Autumn.

the northwest corner of the lease-sale area (Figure 7). High bird densities in these areas were largely confined to the summer (Table 6, p. 33), when they occurred more frequently than figures 5-8 suggest. In the summer, bird densities > 250 birds/km^2 were encountered in 10% of the transects in outer shelf waters (mostly storm-petrels and phalaropes), in 22% of the transects around St. Matthew Island (mostly murres and auklets), and in 27% of the transects around St. Lawrence Island (mostly auklets).

Summary and recommendations for future work

Most of the avian biomass of the Navarin Basin was composed of resident, breeding birds, with Thick-billed Murres and Least Auklets being the most abundant species. The only migrants which occurred in large numbers were phalaropes (mostly Red Phalaropes Phalaropus fulicaria) which occurred in high densities at the shelf break during summer. Migrant shearwaters, which dominated the avifauna of the southeastern Bering Sea, were a minor constituent of the Navarin Basin avifauna, and were only found in high densities at the shelf break in the fall. Additional survey work around St. Lawrence and St. Matthew Islands in the spring could be useful given our observations of large numbers of birds and Divoky's (1980) suggestion that most bird biomass in the ice-influenced portion of the Bering Sea in spring is associated with polynyas around colonies. Although almost half of the Navarin Basin hasn't received sampling, all marine habitats have been censused and consistently low counts were found in most censused areas (Figures 14-16, pp. 30-32). Further survey efforts are unlikely to provide new insights into the locations of seabird concentrations in the Navarin. Emphasis should now focus on protecting critical habitat, particularly the areas around colonies. The development of a staging area on St. Matthew Island is of particular concern as increased ship traffic in the area may result in chronic oil pollution of the foraging areas of breeding birds. Hunt (MS) has suggested that chronic pollution may have more serious consequences for population stability than occasional spills.

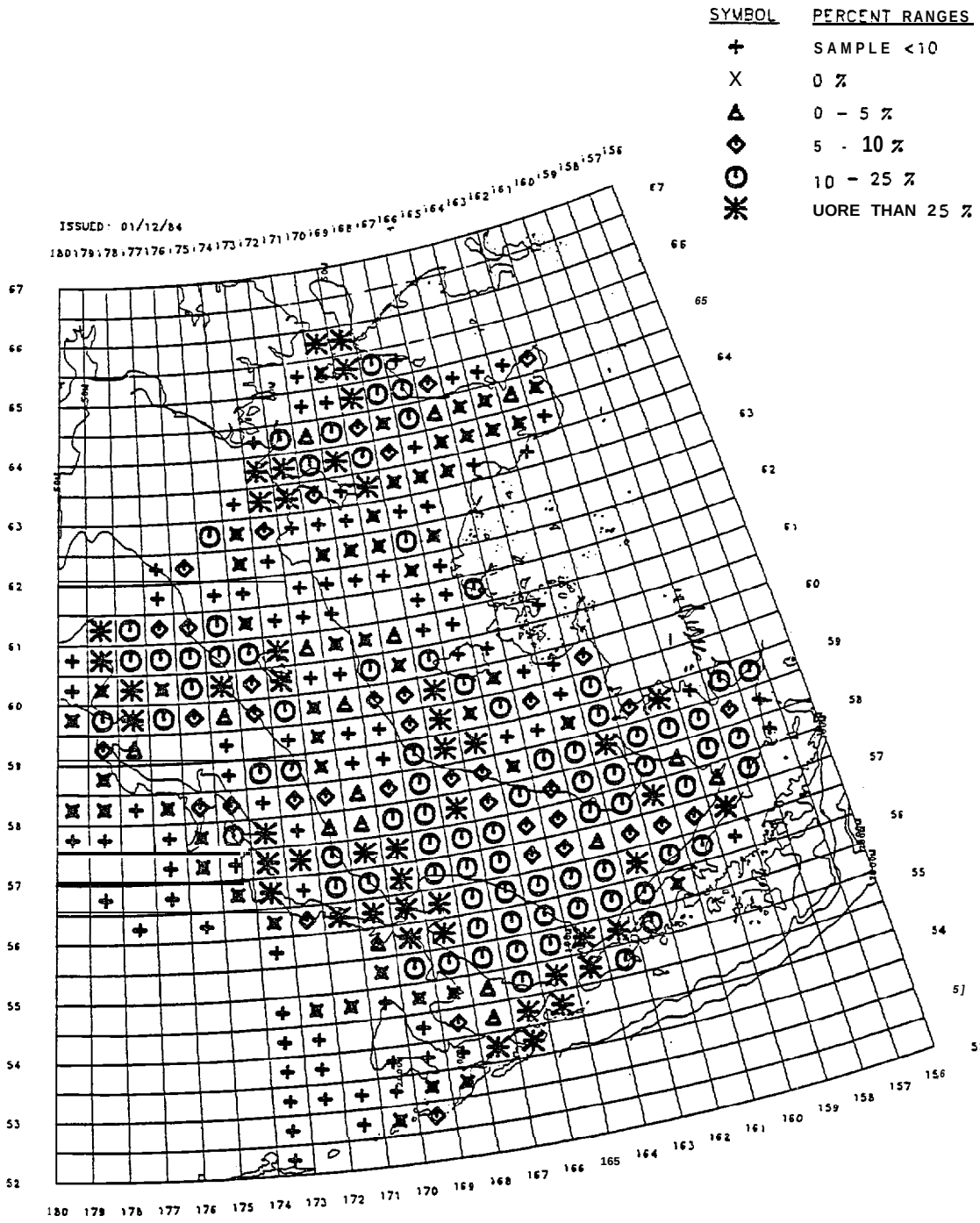
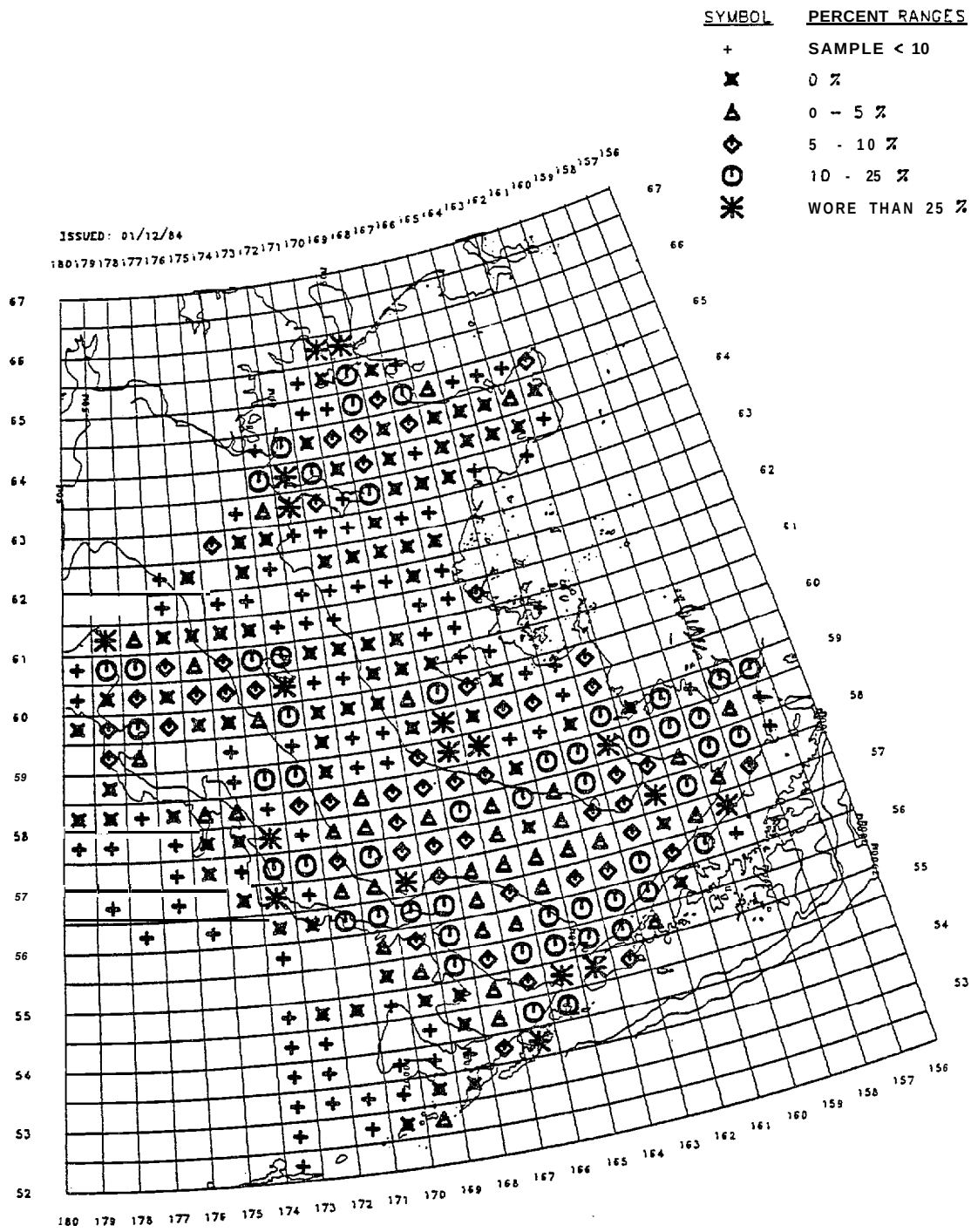


Figure 5. Frequency distribution of transects with densities ≥50 birds/km^2.



BERING SEA RELATIVE DENSITY PLOT
ALL BIRDS, ALL FIELD OPS & SEASONS
BASE LEVEL" 100 BIRDS PER KM**2

Figure 6. Frequency distribution of transects with densities ≥100 birds/km^2.

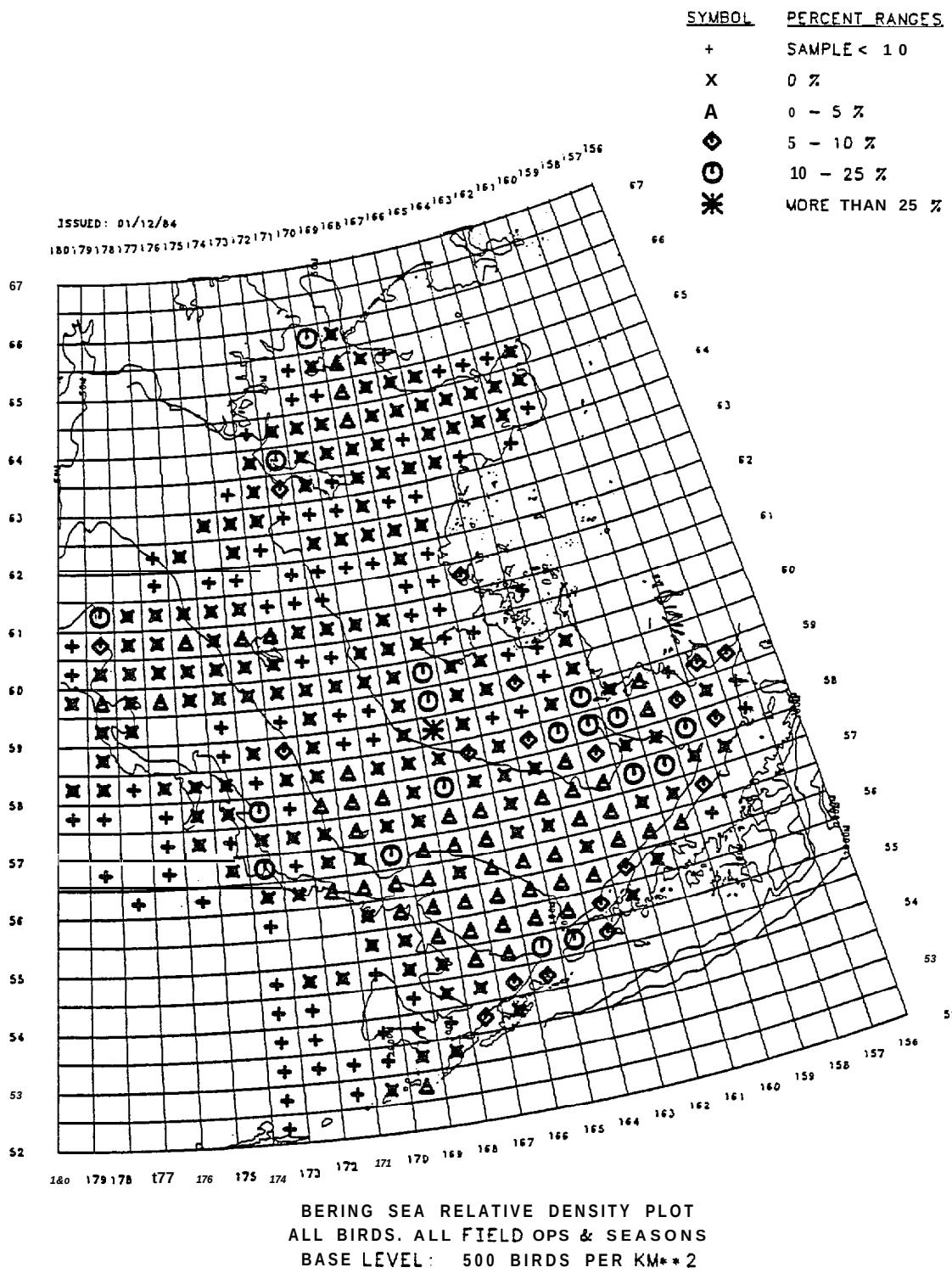
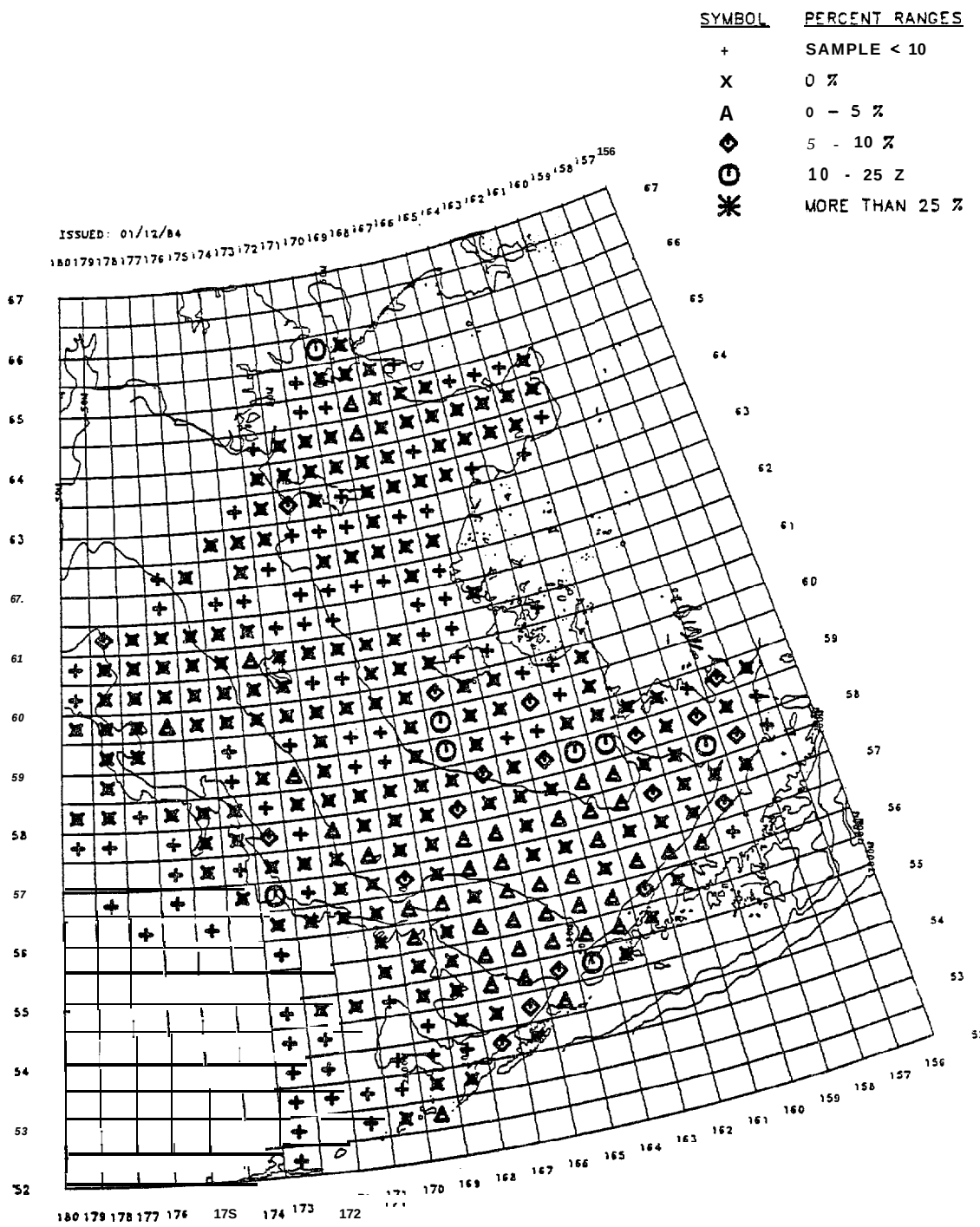


Figure 7. Frequency distribution of transects with densities ≥500 birds/km^2.



BERING SEA RELATIVE DENSITY PLOT
ALL BIRDS, ALL FIELD OF'S & SEASONS
BASE LEVEL: 1000 BIRDS PER KM**2

Figure 8. Frequency distribution of transects with densities ≥1,000 birds/km^2.

INTRODUCTION

This study examines seabird use of the Navarin Basin and central shelf region of the Bering Sea. We discuss the seasonal patterns of bird use of the Navarin Basin and compare average densities and dominant species with other regions of the Bering Sea. We discuss the importance of the region for species sensitive to oil spills and point out important habitats where high bird densities may be expected. We identify areas within the Navarin Basin which lack adequate censusing and make recommendations for future study. Here, we also present the latest compilation of bird distribution data for the eastern Bering Sea, including new data from five 1982 cruises. These cruises largely covered previously uncensured areas on the central shelf of the Bering Sea (59°30'N - 63°N). Two cruises we made in 1983 in the Navarin Basin and adjacent deep waters are not included in this presentation, but are being entered into the seabird data base available from NODC and the Data projects Group at the University of Rhode Island.

We have previously reported on the patterns of seabird distribution relative to the risk of encountering oil for the southeastern Bering Sea (Hunt et al. 1982) and for the North Aleutian Shelf (Eppley et al. 1982). Our knowledge of bird densities in the Navarin Basin is based on a relatively small data base compared to that available for the St. George Basin or the PROBES area in central Bristol Bay. For these regions which have received extensive sampling, we previously found significant differences between water masses in the abundance of birds and species present which accounted for up to 30% of the variation in bird numbers. In the Navarin Basin, for which we have a relatively small data set and where there are several water masses, it was necessary to focus on avifaunal differences among water masses in generating our estimates of bird numbers.

CURRENT STATE OF KNOWLEDGE

Oceanographic setting

The Navarin Basin contains several different hydrographic domains: deep waters beyond the shelf, outer shelf waters, middle shelf waters, and shallow water habitat around St. Matthew Island and nearby St. Lawrence Island (Figure 9). Much of the eastern Navarin Basin consists of middle shelf waters, 50 to 100 m deep. A strong thermocline develops in these waters, limiting nutrient input to the euphotic zone. The central and western part of the Navarin Basin contains outer shelf waters, which are complexly stratified. Upwelling is expected at the shelf break front, which crosses the western corner of the lease sale area. East of the Navarin Basin, there is extensive middle shelf and coastal water habitat. St. Matthew Island, which rests in middle shelf water, presents a topographic discontinuity in this two-layer system, and its coastal waters may support different prey populations.

The water masses of the Navarin Basin are similiar in their vertical structure to the domains of the southeastern Bering Sea studied by the PROBES program. In the southeastern Bering Sea, these water masses have little net horizontal advection (Coachman and Charnell 1979) and are associated with distinct faunal assemblages and food webs (Iverson et al. 1979); in the northern Bering Sea, analogous water masses form currents. While there are similarities between the faunas of the analogous northern and southern water masses, there are important differences in biomass and species composition of the faunas. Presumably the central shelf of the Bering Sea is a transitional area for these water masses and it is difficult to apply directly the results of studies done on the northern or southern water masses to this central region. The physical oceanography of the Navarin Basin is not well studied and little information is available on the fauna and food webs of this region.

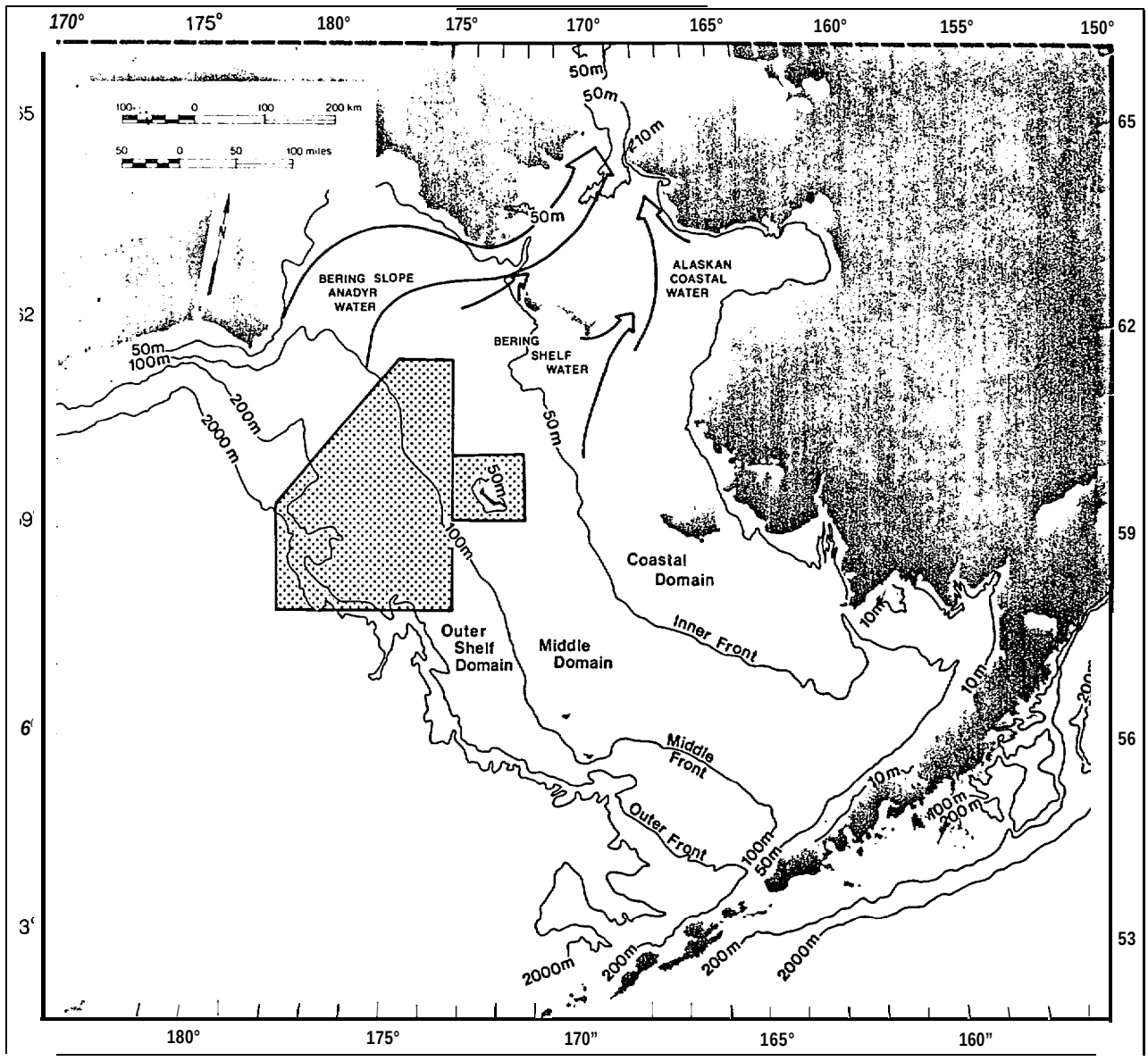


Figure 9. Navarin Basin relative to the hydrographic domains of the Bering Sea.

Ornithological background

As part of their efforts to census pelagic bird abundance in the Bering Sea, the U. S. Fish and Wildlife Service has conducted bird censuses in the Navarin Basin. These data have not been presented for the Navarin Basin per se, but have been included in the general ornithological data base and are included in the present analysis. Other ornithological work on the Bering Sea shelf has not been localized in the Navarin Basin, but the results may be applicable. previously, Shuntov (1972), Wahl (1978) and Hunt et al. (1981b) have reported summer densities of birds on the Bering Sea shelf to be between 15 and 32 birds/km^2. Surface-feeding seabirds such as kittiwakes, fulmars and storm-petrels, have been found to be associated with outer shelf waters, while sub-surface foragers have been found to be associated with middle shelf waters (Schneider and Hunt 1982). Thick-billed Murres and Sooty Shearwaters (Puffinus griseus) have also been associated with outer shelf waters (Schneider and Hunt 1982).

The number of different water masses in the Navarin Basin probably increases the local heterogeneity of the avifauna. Fronts and eddies formed at the boundaries of water masses, the upwelling region along the continental slope, and outer shelf areas may possibly support larger standing stocks of prey than surrounding waters and may therefore be areas where high bird densities are likely to be encountered.

There are two large bird colonies fairly near the Navarin Basin which serve to increase bird densities in the region, St. Matthew Island with 1.4 million birds and St. Lawrence Island with 1.8 million birds (Sowls et al. 1978). Only St. Matthew Island is close enough to the Navarin lease-sale area so that breeding birds might forage there. However, the Navarin Basin is likely to be important to birds associated with other northern colonies as a staging or recovery area before or after breeding.

The Navarin Basin has not been censused for birds during the winter, largely due to the logistical problems caused by ice cover between January and June (Brewer et al. 1977). McRoy et al. (1971) visited St. Matthew Island in February and found concentrations of murres, Harlequin Ducks (Histrionics histrionics), Oldsquaw (Clangula hyemalis) and eiders in the leads around the island. In March, Divoky (1981) found that the ice front is an important habitat for birds where high densities were common (up to 10,000 birds/km^2 with 1000 birds/km^2 occurring commonly). Murres were the most numerous species he found associated with ice. Later in the spring, high bird densities ($\geq$ 100 birds/km^2) were limited to polynyas near breeding colonies, and bird densities elsewhere were lower (30-50 birds/km^2)(Divoky 1981). The impact of oil spilled during winter on Navarin Basin avifauna may be very different than oil spilled in other seasons due to the concentrating effect of polynyas on birds and oil, the transport of oil in ice and the release of unweathered oil from the melting ice edge in the spring (Vermeer and Anweiler 1975, Gaston and Nettleship 1981, Brown 1982).

In the past few years, methods have been presented to evaluate the risk of oil to bird populations (King and Sanger 1979) and to compare the risk to birds among regions (Kaiwi and Hunt 1983). King and Sanger's oil vulnerability index for North Pacific bird species indicates the likelihood that an individual of a species will become oiled and the sensitivity of the species given its population size, breeding range and productivity. Kaiwi and Hunt (1983) developed a method to assess the relative risk to birds within segments of a lease-sale area and to compare these assessments. They polled ornithologists, conservationists and ecologists and found that respondents preferentially voted to protect areas where birds breed and those containing bird populations with low reproductive rates.

We are still a long way from being able to predict the consequences of oil spills on Alaskan seabird populations. Hunt (MS) has summarized recent literature on birds and oil pollution, emphasizing the applicability and limitations of simulation models Of seabird population response. He points out that oil-related mortality in some cases is only a small fraction of natural mortality. If oil-related mortality is additional to natural mortality, then oil spills could have major effects on seabird populations, especially if spills occurred close to large colonies. However, if most natural mortality is density-dependent, then oil-related losses could be largely compensatory. In Alaska, losses due to oil pollution might be recovered through increased production via a reduction of density-dependent depression of reproduction found at the large colonies (Hunt et al. MS). Alternatively, the concentration of birds in a few large colonies makes these populations extremely vulnerable to a single spill. Most of the information we have on the effects of oil pollution on marine bird populations comes from the North Sea where bird colonies are relatively small (<100,000 birds) and dispersed. In Alaska, marine birds are concentrated in a few very large colonies (>1,000,000 birds). The models of bird population recovery rely on age-specific survivorship curves derived from European seabird populations; these may be different from values for Alaskan seabird populations which live in a different environment.

Clark (1984) and Hunt (MS) suggest that chronic, low-level pollution may be more damaging to population stability than occasional spills. The plan to use St. Matthew Island as a staging area raises concern about increased ship traffic resulting in chronic pollution of the foraging areas of breeding birds. Preliminary results from our NSF-sponsored study of seabird foraging suggests that tidal fronts and eddies may be important foraging sites for St. Matthew birds. These features may tend to concentrate and confine oil in what may be preferred forging areas of breeding birds.

METHODS

Data collection

The data presented in this report were obtained on five OMPA sponsored cruises made in 1982, and on other cruises made by ourselves (including PROBES cruises) and other OCSEAP investigators (see Appendix 4). Bird densities were estimated using a line transect method modified for use at sea (Hunt et al. 1982). Counts were made from ships, using a 90° sector extending 300 m abeam and forward. Counts were made while the ship was underway at speeds ranging from 10 to 20 km/hr (5-11 knots). Ship following birds were counted and thereafter excluded from counts. The ship's position, to the nearest tenth of a minute of latitude and longitude, was recorded at the start and end of each 10 minute count. Bird identifications were made to the lowest possible taxonomic level. Bird densities were computed for each 10 minute count based on the area scanned (distance traveled x transect width). Data from aircraft surveys (using either fixed-wing craft or helicopters) were treated in a similar fashion, and both ship and air transects were included in the data base. The sampling effort by season is given in Figures 10-13.

Analysis

Average bird densities within 30' latitude by 60' longitude blocks for the eastern Bering Sea were calculated by season for individual species, all birds, and all birds on the water (see Appendix 4 for species groups). These figures show the seasonal pattern of species distribution and abundance, but do not reflect the great variability in bird densities. The frequency distribution of bird densities within each 30' latitude by 60' longitude block was calculated, for all seasons combined. These plots indicate how often bird densities of $\geq$ 50, 100, 500 and 1000 birds/km^2 were encountered.

To incorporate variability, a coefficient of variation (standard deviation/mean) was also calculated for each block. Blocks having a high mean (high rate of

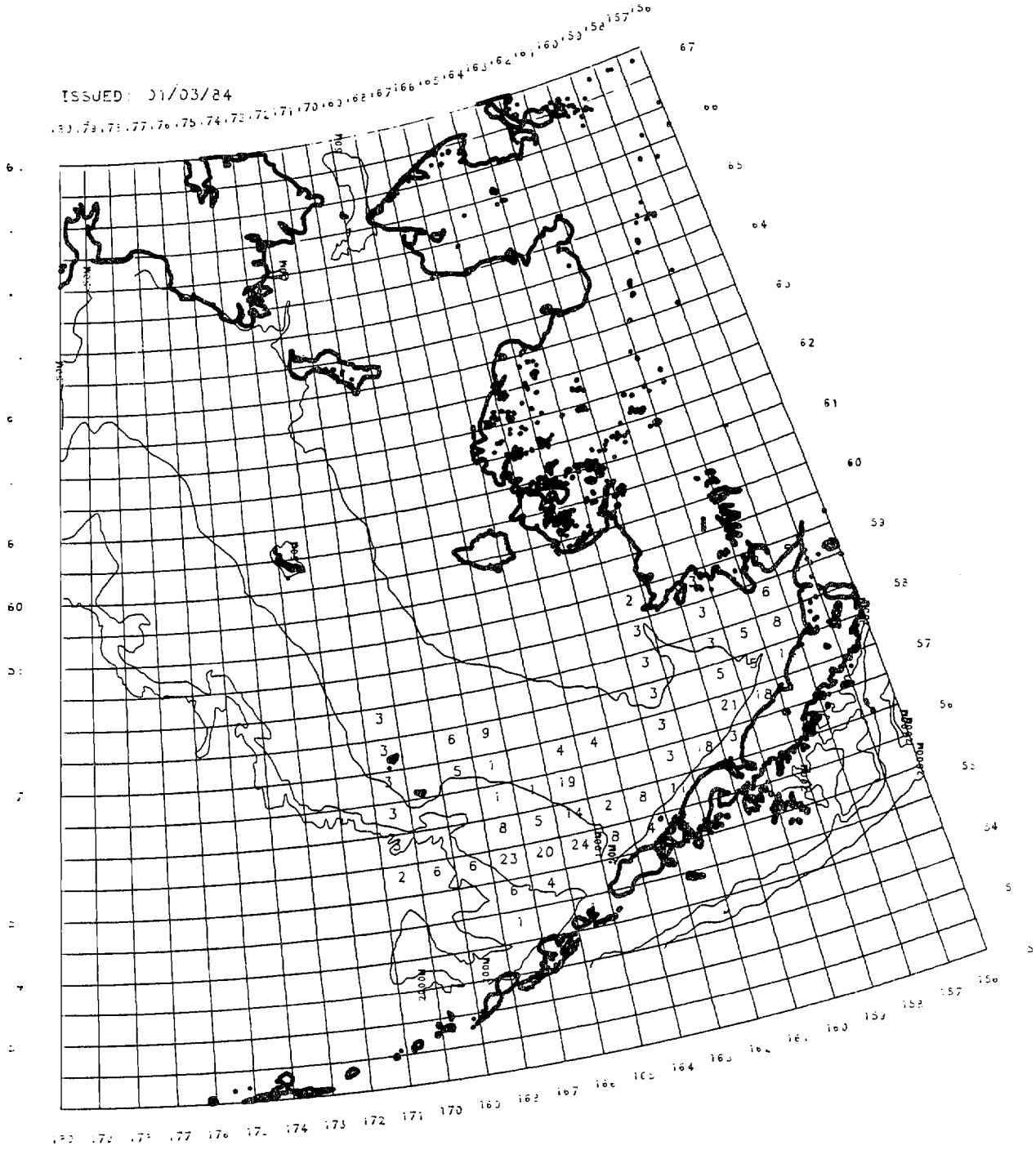


Figure 10. Effort plot, all field observations, 1975-1982: Winter.

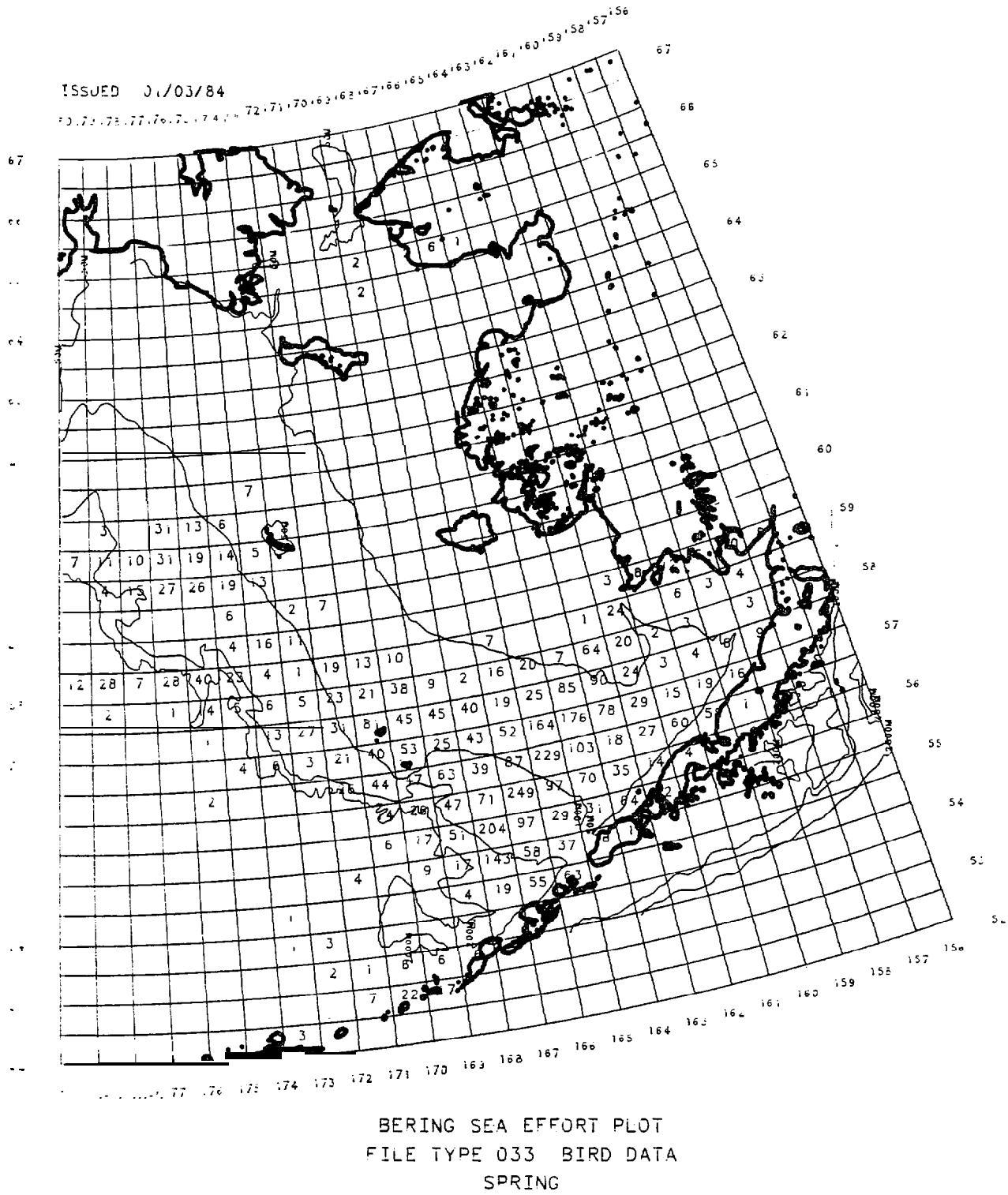


Figure 11. Effort plot, all field observations, 1975-1982: Spring.

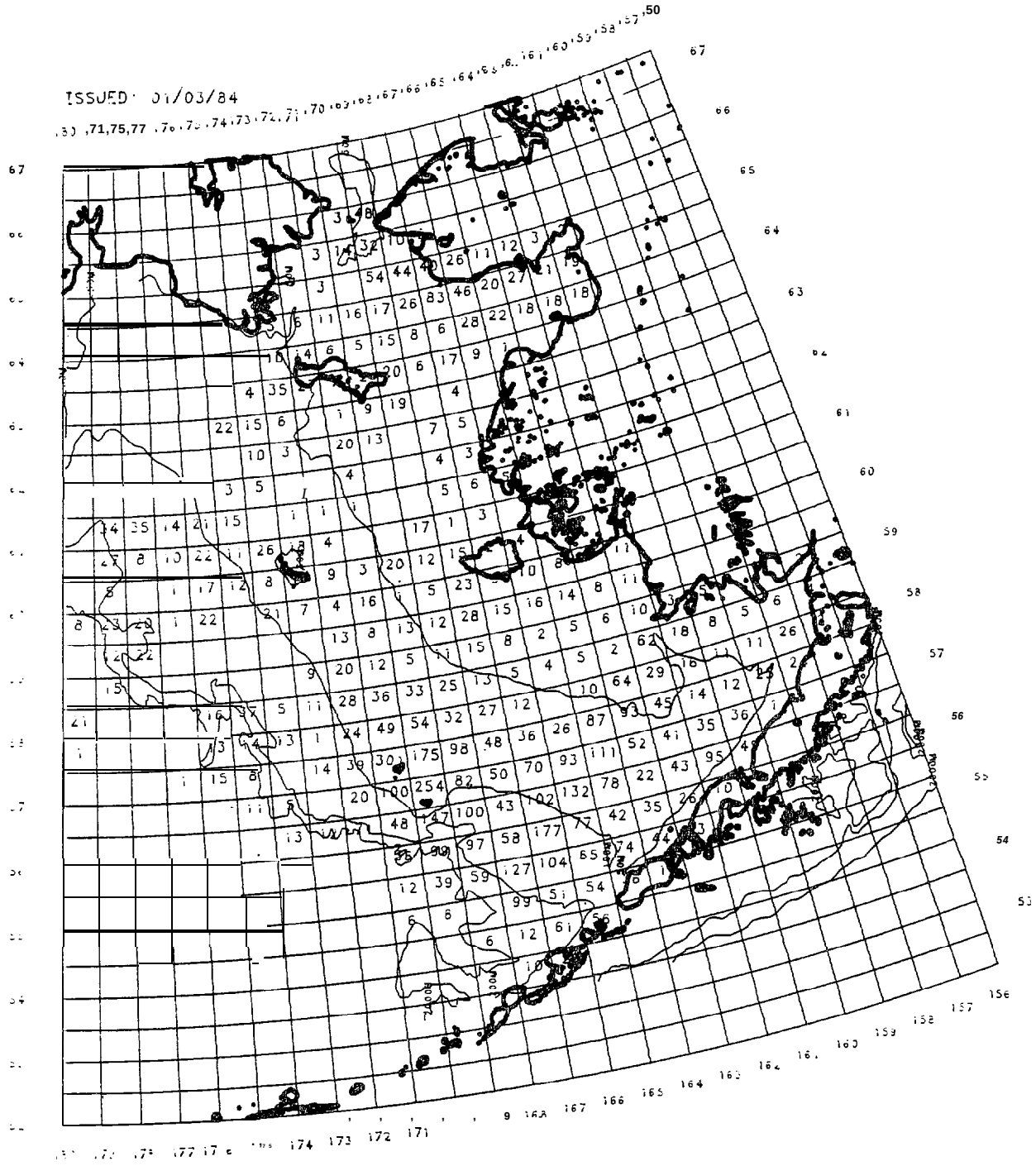
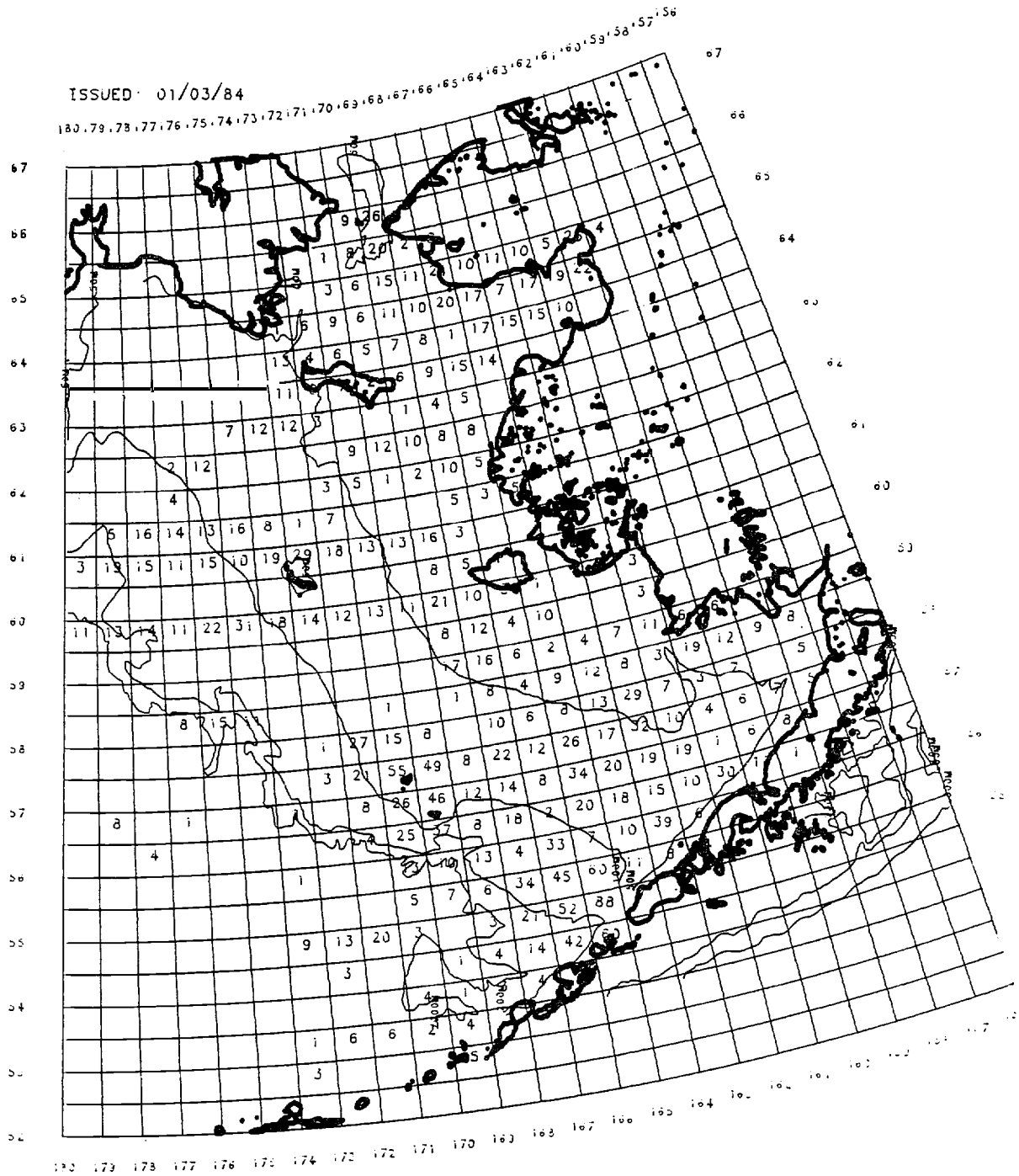


Figure 12. Effort plot, all field observations, **1975-1982: Summer.**



BERING SEA EFFORT PLOT
FILE TYPE 033 BIRD DATA
AUTUMN

Figure 13. Effort **plot,** all field observations, **1975-1982: Autumn.**

encounter) and a low coefficient of variation (a reliably high rate of encounter) were identified as high risk areas (see Hunt et al. 1982 for a more complete discussion of the use of coefficients of variation). This method uses subjective cut-off values to separate high and low means and high and low coefficients of variation. These cut-off values were selected on the basis of arbitrary considerations and must be evaluated on those terms. Also, at this time we have no reliable method to mathematically describe the true overall distribution of the bird population; only modest confidence can be placed on the stability of means for small areas and thus, also on the coefficients of variation.

To reduce the statistical problems caused by local patchiness of seabird distributions, we categorized the data into mutually exclusive density categories and looked at the frequencies of transects in the different categories. This method greatly minimizes the number and strength of the assumptions required for analysis and allows the application of relatively simple discrete probability models to the problem of estimating the likelihood of encountering large numbers of birds (see Appendix 1). Confidence limits for the proportions observed in each category were computed for the both the case where no assumptions were made about the distribution of birds (nonparametric) and for the normal approximation. The confidence interval is the observed encounter rate + the error rate (d), where

a = 0.95 and

$$d = \frac{1}{2[N(1-0.95)]^{.5}} \quad \text{or} \quad \sqrt{\frac{1.96^2}{4N}} \quad \text{for the normal approximate ion}$$

These *are* the *same* formulas used in Hunt et al. 1982 and in Eppley et al. 1982 to calculate error rates. However, a typographical error occurred in both these works for the nonparametric formula, giving it as:

$$\frac{1}{2}[N(1-\alpha)]^{.5} \quad \text{instead of} \quad \frac{1}{2[N(1-\alpha)]^{.5}}$$

In order to provide areas within which sampling effort was sufficient to provide meaningful frequency distributions and for which there would be a biological rationale for the boundaries, we divided the Navarin Basin and adjacent waters into zones (Figure 1, p. 2). The zones are drawn to represent different water masses: coastal, middle shelf, outer shelf and the deep waters off the shelf. Two other zones were constructed around St. Lawrence and St. Matthew Islands, extending 60 km around each island. We used 60 km as an approximation of the foraging range of most breeding birds, as we had previously found to be the case at for a similar suite of species at the Pribilof Islands (Hunt et al. 1981a). Only RU83 cruises were included in this analysis. Ship-following birds were excluded from this analysis, as were transects shorter than 10 minutes or with visibility less than 300 m.

The analysis of bird distribution by zone provided information on the average densities of species using each habitat by season as well as information on the frequency distribution of bird densities. We used density categories of: 0-5, 5.1-15, 15.1-30, 30.1-75, 75.1-250 and >250 birds/km^2).

RESULTS

Patterns of bird use of the Navarin Basin

The Navarin Basin is one of several areas of moderately high bird density within the eastern Bering Sea (Figures 2-4, pp. 5-7). In the spring, the middle and outer shelf regions of the Navarin Basin supported bird densities of about 40 birds/km^2 (Table 1, p. 3). The most abundant birds were auklets and murres. In the summer, birds were concentrated near breeding colonies resulting in high average densities: 193 birds/km^2 around St. Matthew Island and 343 birds/km^2 around St. Lawrence Island. Murres were the most numerous birds around St. Matthew

Island, while auklets were the predominant species at St. Lawrence Island. In the fall, the highest bird densities (about 20 birds/km^2) were found in outer shelf waters (mostly auklets) and in deep waters off the shelf (mostly shearwaters).

Surface foraging seabirds were more abundant in outer shelf waters, while there was little difference in the abundance of diving seabirds among water masses (Table 2). Particular species were more abundant in outer shelf waters: Northern Fulmar, storm-petrels, shearwaters and phalaropes (spring and summer only); while others were associated with middle shelf waters: Crested Auklet, Common Murre (Uris aalge), Black-legged Kittiwake, Thick-billed Murre (spring only).

Several species were found in the Navarin Basin in densities as high or higher than in other censused regions of the Bering Sea. These species were: storm-petrels (Figure 30, p. 64), phalaropes (Figure 42, p. 75), Black-1egged Kittiwakes (Figure 50, p. 84), Thick-billed Murres (Figure 66, p. 100), small alcids (Figure 70, p. 104) and Least Auklets (Figure 78, p. 112) during the spring; phalaropes (Figure 43, p. 77) during the summer; and murres (Figure 60, p. 94) during the fall. In addition, murres in the spring (Figure 58, p. 92), storm-petrels in the summer (Figure 31, p. 65), and shearwaters (Figure 28, p. 62) and Least Auklets (Figure 80, p. 114) in the fall occurred in high densities in the Navarin Basin, although these densities were not the highest for these species in the Bering Sea.

Risk assessment

In previous reports (Hunt et al. 1982, Eppley et al. 1982) we have used a base level of 30 birds/km^2 encountered in > 50% of the transects to identify important areas for birds. The frequency distribution of densities for each zone in the central Bering shelf region are given for spring, summer and fall in Tables 3-5. High frequencies of counts with densities > 30 birds/km^2 were relatively scarce in spring and especially fall. More than half of the transects

Table 2. Mean densities (birds/km^2) of surface and sub-surface foraging seabirds in outer shelf and middle shelf waters of the central Bering Sea shelf.

		SPRING	SUMMER	AUTUMN
SUB-SURFACE FORAGERS: alcids, shearwaters	Outer shelf	25.28	16.54	15.29
	Middle shelf	36.16	15.11	8.08
SURFACE FORAGERS: kittiwakes, fulmars, phalaropes, storm-petrels	Outer shelf	12.07	79.06	1.52
	Middle shelf	5.78	3.08	2.38

Table 3. Spring frequency distribution of bird densities (birds/km^2) by zone (percent of transects) for the central Bering Sea shelf.

ZONE	N	DENSITY CATEGORY						
		o	0.1-5.0	5.1-15.0	15.1-30.0	30.1-75.0	75.1-250.0	>250
Coastal	o							
Middle Shelf	113	0	5.3	28.3	21.2	31.9	12.4	0.9
Outer Shelf	168	0.6	11.9	36.3	28.6	15.5	5.4	1.8
Deep	146	6.8	47.3	39.0	6.8	0	0	0
St. Matthew	10	0	10.0	40.0	40.0	10.0	0	o
St. Lawrence	o							

Table 4. Summer frequency distribution of bird densities (birds/km²) by zone (percent of transects) for the central Bering Sea shelf.

ZONE	N	DENSITY CATEGORY						
		o	0.1-5.0	5.1-15.0	15.1-30.0	30.1-75.0	75.1-250.0	>250
Coastal	36	2.8	0	8.3	16.7	41.7	27.8	2.8
Middle Shelf	291	2.4	25.4	34.7	22.0	12.4	2.7	0.3
Outer Shelf	223	2.7	13.9	24.7	18.4	18.8	11.2	10.3
Deep	140	15.7	41.4	14.3	6.4	15.0	5.7	1.4
St. Matthew	67	0	0	3.0	14.9	26.9	32.8	22.4
St* Lawrence	113	3.5	10.6	8.0	8.0	15.9	27.4	26.5

Table 5. Autumn frequency distribution of bird densities (birds/km²) by zone (percent of transects) for the central Bering Sea shelf.

ZONE	N	DENSITY CATEGORY						
		o	0.1-5.0	5.1-15.0	15.1-30.0	30.1-75.0	75.1-250.0	>250
Coastal	76	22.4	63.2	11.8	1.3	1.3	0	0
Middle Shelf	223	1.3	31.4	43.0	17.5	5.8	0.9	0
Outer Shelf	137	2.2	23.4	46.7	18.2	5*1	2.9	1.5
Deep	57	3.5	28.1	49.1	8.8	7.0	0	3.5
St. Matthew	74	10.8	45.9	33.8	6.8	2.7	0	0
St. Lawrence	0							

in the coastal zone (72%) and the areas around St. Matthew (82%) and St. Lawrence (70%) Islands had bird densities $\geq$ 30 birds/km^2 during the summer. For comparison, in the southeastern Bering Sea, bird densities $\geq$ 30 birds/km^2 were encountered in the summer in more than half of the transects around the Pribilof Islands and Cape Newenham, both sites of large bird colonies, and in Unimak pass. As in the southeastern Bering Sea, important areas for birds in the central Bering Sea are the areas around colonies and the coastal zone.

To refine this classification of areas in which spilled oil would pose a high risk for birds, we analyzed the Navarin lease-sale area in 30' latitude by 60' longitude blocks in terms of mean densities and variability using coefficients of variation. Figures 14-16 classify blocks as having high ($>$75 birds/km^2) or low densities, and whether these densities were consistent (CV $\leq$ 2.0) or were highly variable. Consistently high densities were found associated with the shelf break front during spring, summer and fall; the 100 m front in the spring; and with St. Matthew Island in the summer. The high densities associated with the fronts were localized along portions of the fronts and were spatially variable. Other areas of the Navarin Basin which received sampling generally showed consistently low densities, although much of the Basin has yet to be adequately sampled.

Averaging over all seasons, bird densities $>$ 500 birds/km^2 were rarely encountered in the central Bering Sea shelf (Figures 7 and 8, pp. 11-12). The encounter rates were highest near St. Matthew and St. Lawrence Islands and at the shelf break in the northwest corner of the Navarin lease sale area (Figures 7 and 8). At St. Matthew Island, 5% of the transects contained bird densities $>$ 500 birds/km^2, while at St. Lawrence Island and at the shelf break 10-25% of the transects contained high bird densities (Figure 8).

The likelihood of encountering high densities during a particular season may be much greater than figures 5-8, averaged over a year, indicate. We therefore

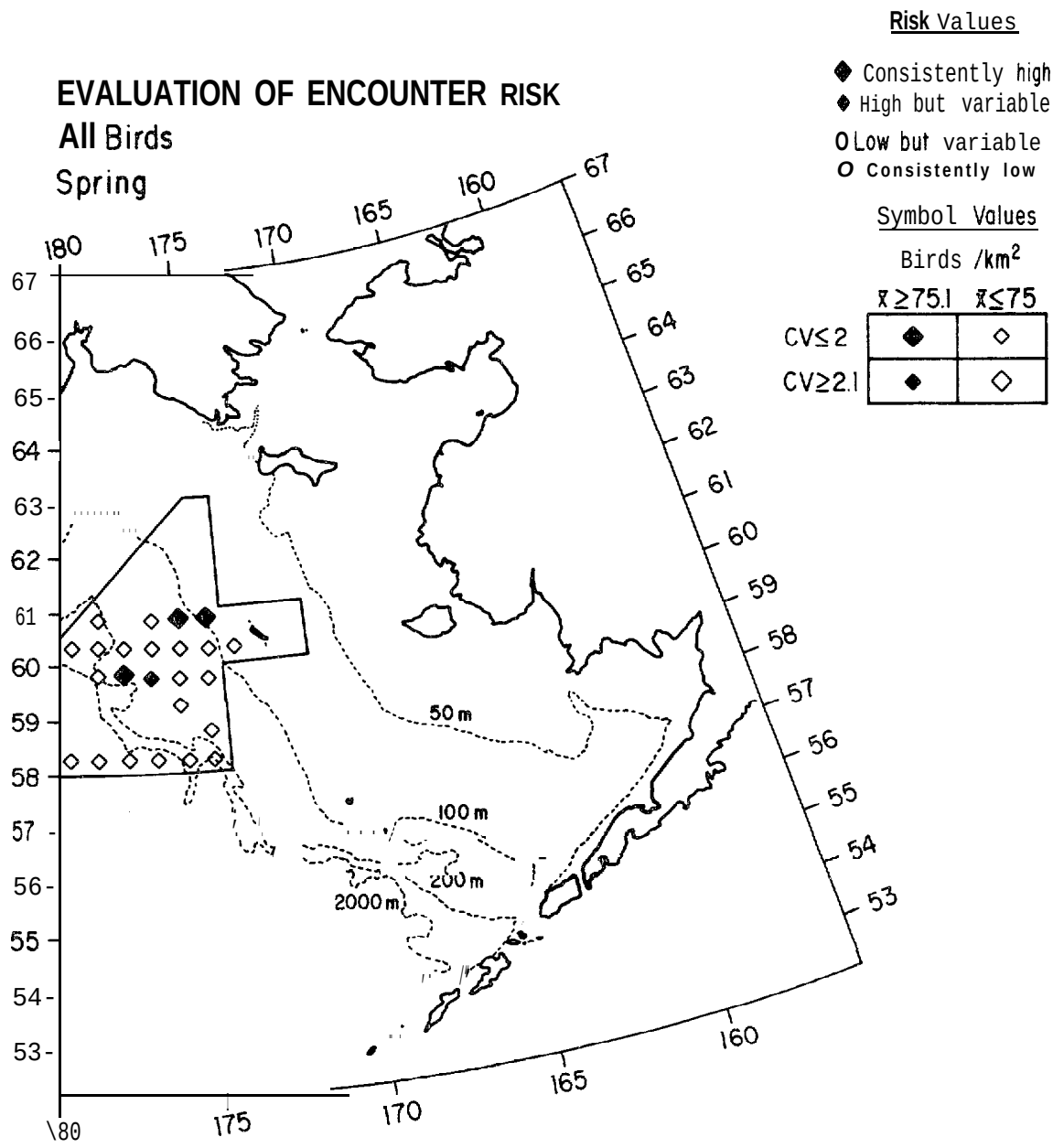


Figure 14. Evaluation of encounter risk for birds in the Navarin Basin: Spring.

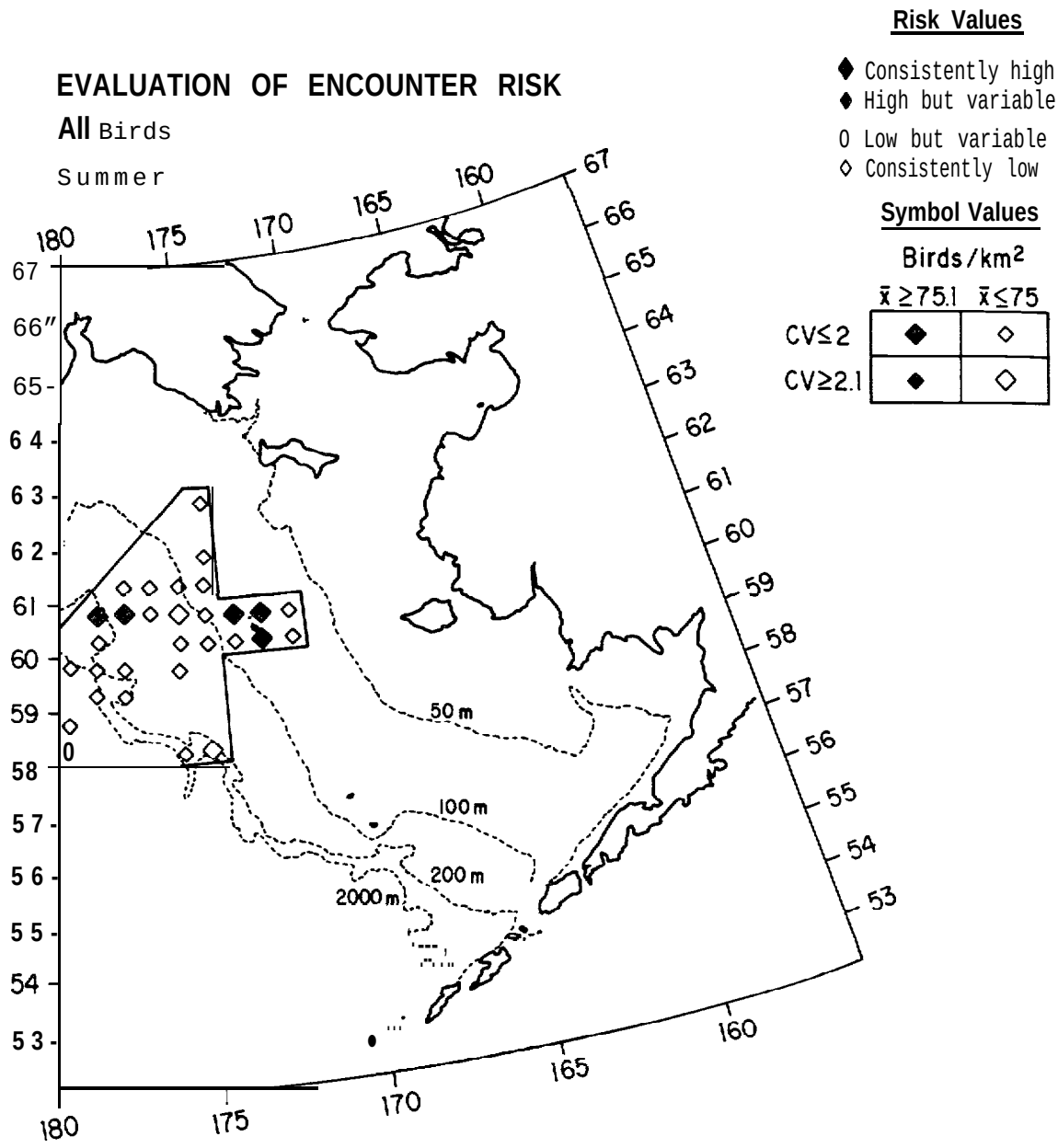


Figure 15. Evaluation of encounter risk for birds in the Navarin Basin: Summer.

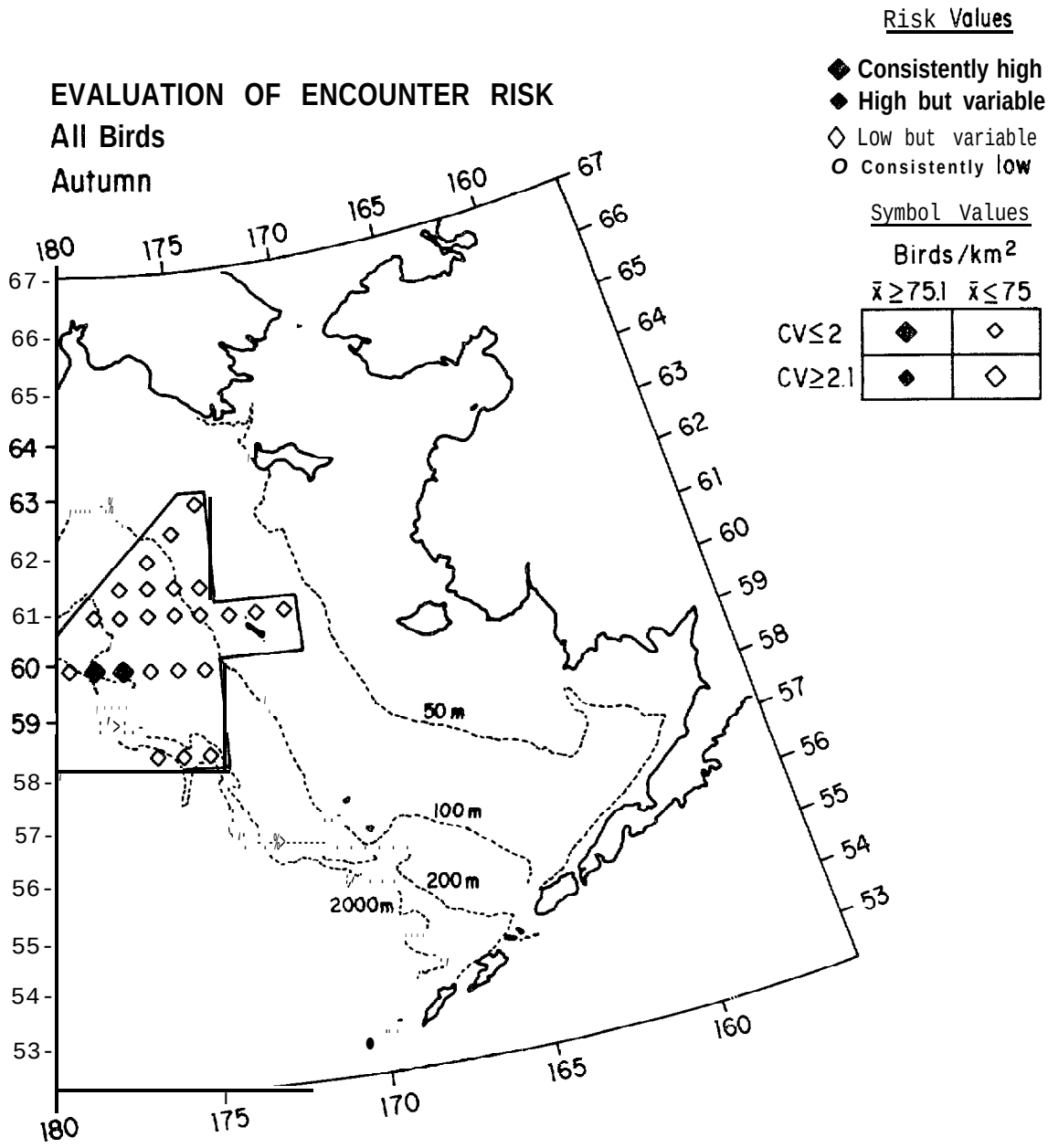


Figure 16. Evaluation of encounter risk for birds in the Navarin Basin: Autumn.

Table 6. The occurrence of bird densities greater than 250 birds/km^2 on the central Bering Sea shelf by season, zone and species, based on RU83 data only. Confidence intervals (95%) are given.

SPRING:

middle shelf	outer shelf
all 0.9%	all 1.8%
small alcids 0.9%	small alcids 1.2%
(Least Auklets 0.9%)	(Least Auklets 1.2%)
± 9%	storm-petrels 0.5%
	+ 8%

SUMMER :

middle shelf	outer shelf	St. Matthew	St. Lawrence	deep
all 0.3%	all 10.3%	all 22.4%	all 26.5%	all 1.4%
murres 0.3%	storm-petrels 5.4%	murres 16.4%	small alcids 17.7%	+ 8%
± 6%	phalaropes 3.1%	small alcids 4.5%	(Least Auklets 12.4%)	
	shearwaters 1.3%	(Least Auklets 3.0%	murres 6.2%	
	Northern Fulmars 0.4%	Northern Fulmars 1.5%	(Crested Auklets 3.5%)	
	± 7%	± 12%	Black-legged Kittiwakes 1.8%	
			+ 9%	

AUTUMN :

deep	outer shelf
all 3.5%	all 1.5%
shearwaters 3.5%	± 8%
± 13%	

used a subset of the data used in figures 5-8 (RU83 data) to examine the occurrence of transects with high bird densities within the central Bering Sea shelf (Figure 1, p. 2) for each zone and season (Table 6). In spring and fall the scarcity of counts with high densities remained as before. In summer, at St. Matthew and St. Lawrence Islands, bird densities >250 birds/km^2 occurred commonly; over 26% of the transects near St. Lawrence Island and 22% of the transects near St. Matthew Island had bird densities >250 birds/km^2. These data emphasize our finding that summer is the period when high concentrations of birds are most likely to be found, and that the waters near the two large colonies on St. Lawrence and St. Matthew Islands are particularly important. The shelf edge region (outer shelf and deep water zones) was also important in summer when concentrations of birds were frequently encountered there. Large numbers of phalaropes migrate through this region on their return to breeding areas and it is heavily used by storm-petrels that may either be from Aleutian Islands colonies, or be non-breeding birds.

DISCUSSION

Estimates of the accuracy of encounter rates

We have used a confidence level of 95% throughout this report. These data could be described using different confidence levels. For comparison, we provide tables giving the required sample size associated with four different confidence levels and two different error rates for both the nonparametric calculation (Table 7) and the normal approximation (Table 8). These tables also appeared in Hunt et al. 1982 with a typographical error, which is corrected here.

Our estimates of the encounter rates for specific bird densities are within about 10% of the true encounter rates (95% confidence) for most zones and seasons (Tables 9-11). Unfortunately, our error rates are much higher for the zones around St. Matthew and St. Lawrence Islands in spring, when Divoky's (1981) findings suggest that areas near colonies may harbor large bird concentrations.

Table 7. Sample size (N) required for a given confidence level (a) and error rate (d).

$$N = .25\ d^{2}\ (1-\alpha)$$

d	.1	.25
a		
.99	2500	400
.95	500	80
.90	250	40
.75	100	16

Table 8. Sample size (N) required for a given confidence level (a) and error rate (d), with the normal approximation (k is the z score associated with a given a level).

$$N = .25\ (k/d)^2$$

	d			
	.05	.10	.25	
a				k
.99	665	166	27	2.58
.95	384	96	15	1.96
.90	272	68	11	1.65
.75	135	34	5	1.16

Table 9. Spring error rates (d) for zones in the central Bering Sea shelf, $\alpha = 0.95$.

$d = \frac{1}{2[N(1-\alpha)]^{.5}}$, nonparametric calculation; $d^* = \sqrt{\frac{1.96^2}{4N}}$ normal approximation

	COASTAL	MIDDLE SHELF	OUTER SHELF	DEEP	ST. MATT HEW	ST. LAWREN CE
Sample size (N)	0	113	168	146	10	0
Error rate (d)		21.0%	17.3%	18.5%	70.7%	
(d*)		9.2%	7.6%	8.1%	31.0%	

Table 10. Summer error rates (d) for zones in the central Bering Sea shelf, $\alpha = 0.95$.

$d = \frac{1}{2[N(1-\alpha)]^{.5}}$, nonparametric calculation; $d^* = \sqrt{\frac{1.96^2}{4N}}$, normal approximation

	COASTAL	MIDDLE SHELF	OUTER SHELF	DEEP	ST. MATTHEW	ST. LAWRENCE
Sample size (N)	36	291	223	140	67	113
Error rate (d)	37.3%	13.1%	15.0%	18.9%	27.3%	21.0%
(d*)	16.3%	5.7%	6.6%	8.3%	12.0%	9.2%

Table 11. Autumn error rates (d) for zones in the central Bering Sea shelf, $\alpha = 0.95$.

$d = \frac{1}{2[N(1-\alpha)]^{.5}}$, nonparametric calculation; $d^* = \sqrt{\frac{1.96^2}{4N}}$, normal approximation

	COASTAL	MIDDLE SHELF	OUTER SHELF	DEEP	ST. MATTHEW	ST. LAWRFN CE
Sample size (N)	76	223	137	57	74	0
Error rate (d)	25.6%	15.0%	19.1%	29.6%	26.0%	
(d*)	11.2%	6.6%	8.4%	13.0%	11.4%	

Further sampling around these islands in winter and spring could be useful but would require an icebreaker. We already know that high bird densities may be expected around the colonies, at the shelf break and at the 100 m front and that encounter rates for high densities are greatest in spring and summer. Further sampling is unlikely to provide major new insights about the locations of bird concentrations in the Navarin Basin for spring, summer and fall. While much of the Navarin Basin has not received sampling (Figures 10-13, pp. 20-23), consistently low counts were found in most censused areas (Figures 14-16, pp. 30-32). Although surveys are still needed for winter and spring, effort should now be focused on protecting the critical areas around the colonies and perhaps also the shelf break region. The areas around the colonies are particularly important because they harbor large concentrations of breeding birds of species which are suspectible to oiling. The development of a staging area on St. Matthew Island is of great concern, not only because of the direct disturbance of the colony, but also because of the likelihood that the foraging areas around the colony used by breeding birds will be affected by chronic, low-level pollution due to increased ship traffic.

In contrast to the southeastern Bering Sea, where almost all high density counts of birds away from the Pribilof Islands were due to non-breeding, migrant shearwaters (Table 12), many species of locally breeding birds were found in high densities on the central Bering Sea shelf (Table 6). In both the central and southeastern Bering Sea shelf, we found large concentrations of vulnerable species close to colonies (Table 6 and 12). These were diving species which are likely to become oiled (King and Sanger 1979). In pelagic waters, high bird densities in the southeastern Bering Sea involved less vulnerable populations, either non-breeding birds (shearwaters) or species whose foraging method reduces their probability of becoming oiled (aerial foragers: storm-petrels, fulmars) (King and Sanger 1979). On the central Bering Sea shelf, high pelagic bird densities involve species which are vulnerable because 1) they are breeding (small auklets,

Table 12. The occurrence of bird densities greater than 250 birds/km²* in the southeastern Bering Sea by season, zone and species. Confidence intervals (95%) are given.

SPRING:

Alaska Peninsula
all 5%
shearwaters 4.2%
± 9%

Unimak
all 2.3%
shearwaters 2.3%
± 34%

outer shelf
all 0.9%
shearwaters 0.9%
i- 4%

Pribilof Islands*
all 10.3%
murres 7.5%
Black-legged Kittiwakes 1.8%
small alcids 0,9%
± 7%

SUMMER :

coastal
all 16.1%
shearwaters 15.2%
± 9%

Alaska Peninsula coastal
all 6.3%
shearwaters 6.3%
+ 9%

Alaska Peninsula offshore
all 5.8%
shearwaters 5.8%
± 8%

Pribilof Islands*
all 28.1%
murres 12.3%
small alcids 1.8%
storm-petrels 0.7%
shearwaters 0.6%
Black-1egged Kittiwakes 0.4%
Red-legged Kittiwakes 0.4%
+ 3%

Cape Newenham
all 30.4%
shearwaters 30.4%
+ 47%

middle shelf
all 2.5%
shearwaters 2.5%
± 4%

middle shelf
all 2.5%
shearwaters 2.5%
± 4%

outer shelf
all 3.1%
Northern Fulmar 1.6%
shearwaters 0.9%
storm-petrels 0.1%
± 4%

Unimak
all 7.4%
shearwaters 6.2%
± 11%

AUTUMN :

Unimak
all 30%
± 71%

middle shelf
all 2.4%
+ 9%

outer shelf
all 2.7%
± 11%

Pribilof Islands*
all 3.3%
+ 7%

* Pribilof Islands, densities ≥ 100 birds/km²

kittiwakes, murres, fulmars), or 2) their foraging method makes them likely to become oiled (small auklets, phalaropes), or 3) because a large proportion of the world's population of the species is concentrated in the region, as may be the case with the Aethia auklets and the Red Phalarope during their spring migration.

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APPENDIX 1

Derivation of statistical analysis of density categories

J. Kaiwi

APPENDIX 1

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

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

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

$$\pi_1 + \pi_2 + \ldots + \pi_c = 1 \text{ ,,}$$

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

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

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

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

where $$\binom{N}{S_1, S_2, \ldots, S_c} = \frac{N!}{S_1! S_2! \ldots S_c!} \text{ ''}$$

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

Furthermore,

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

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

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

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

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

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

The relation in (D) is satisfied if

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

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

$$d = \sigma/N$$

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

and

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

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

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

and also,

$$d = \sqrt{\frac{k^2}{m}} \quad *$$

APPENDIX 2

Distribution maps for individual species in the Bering Sea

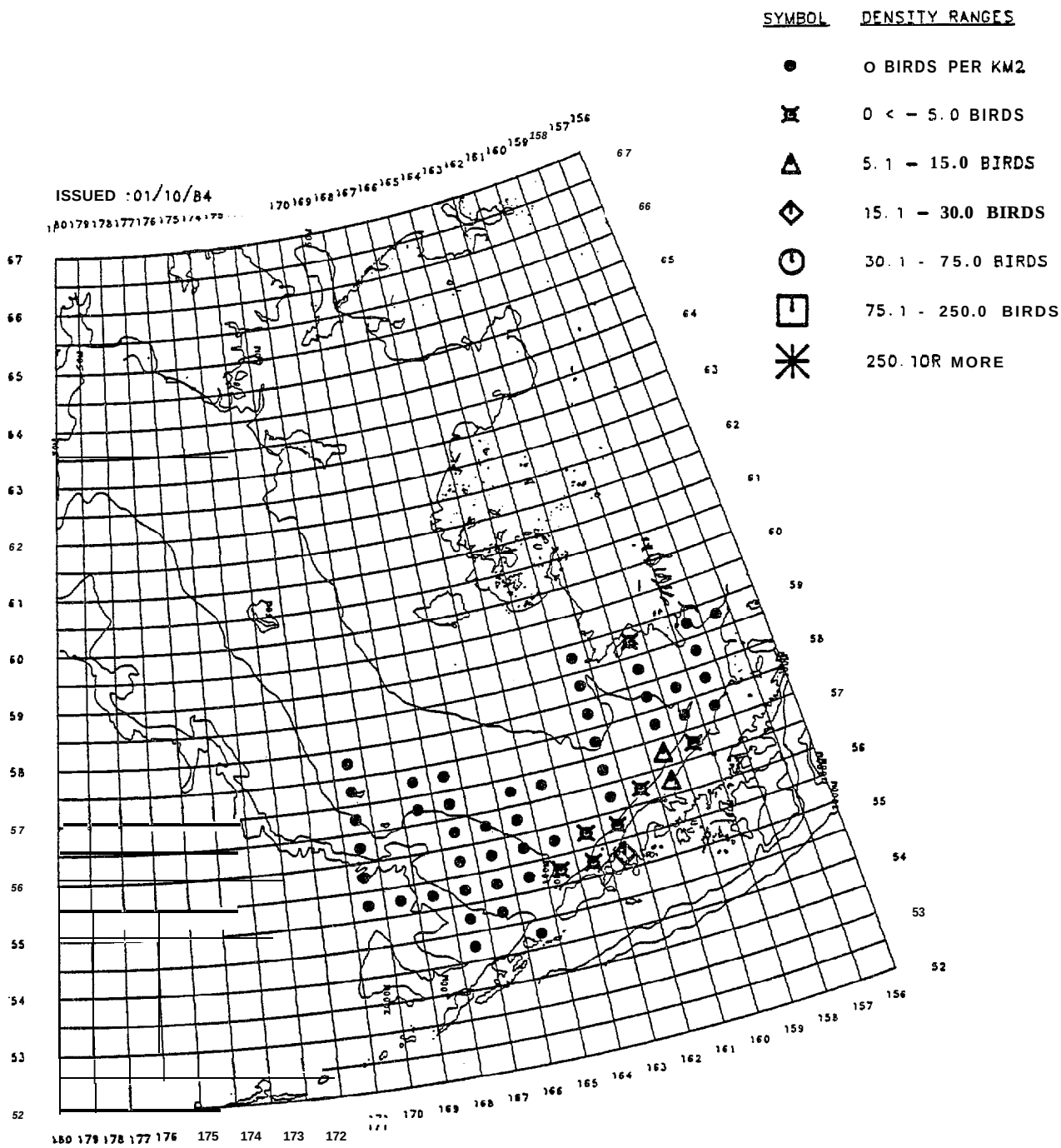
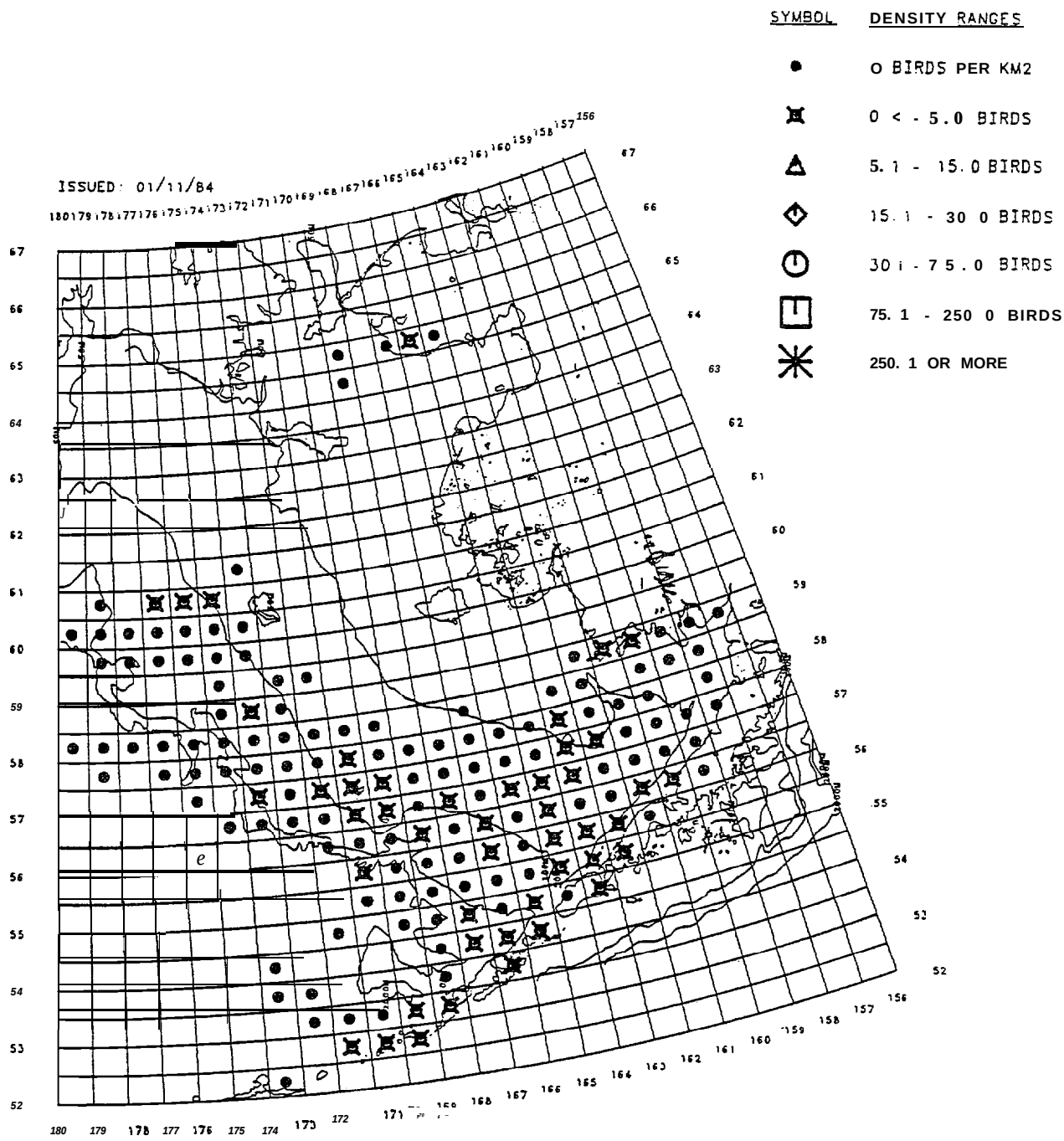


Figure 17. Mean densities, cormorants: Winter.



BERING SEA MEAN DENSITY PLOT
CORMORANTS (F)
SPRING

Figure 18. Mean densities, cormorants: Spring.

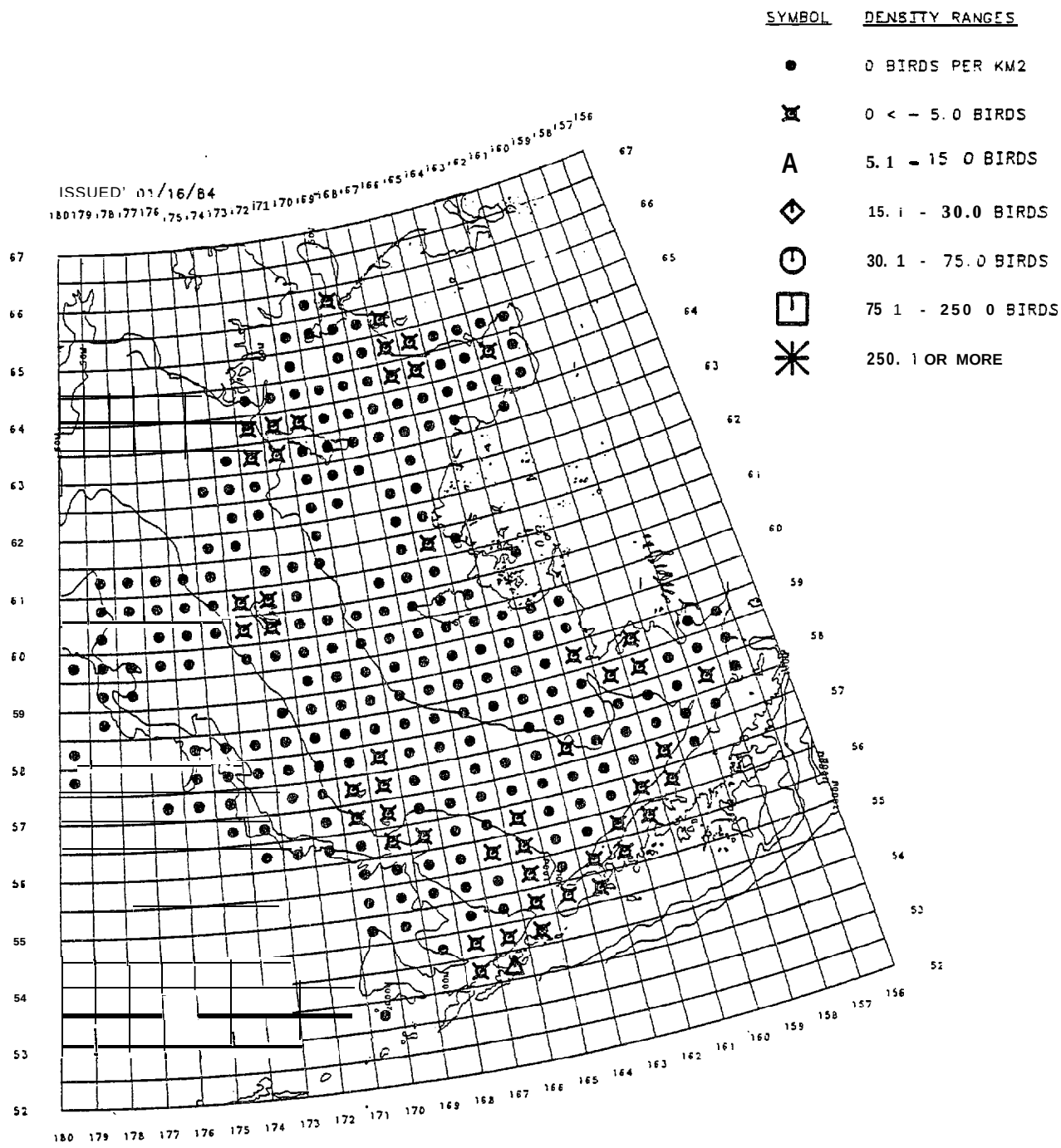


Figure 19. Mean densities, cormorants: Summer.

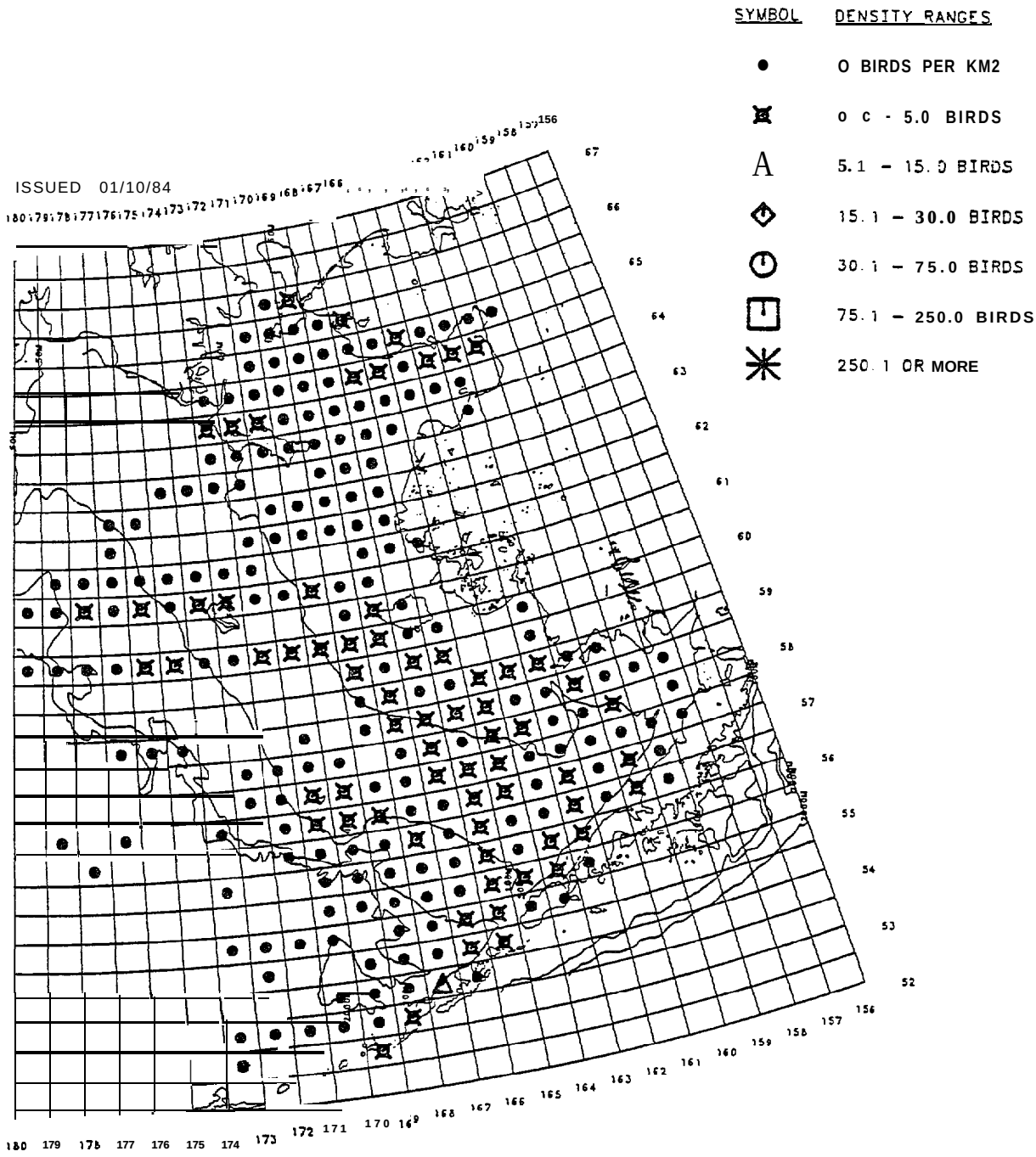


Figure 20. Mean densities, cormorants: Autumn.

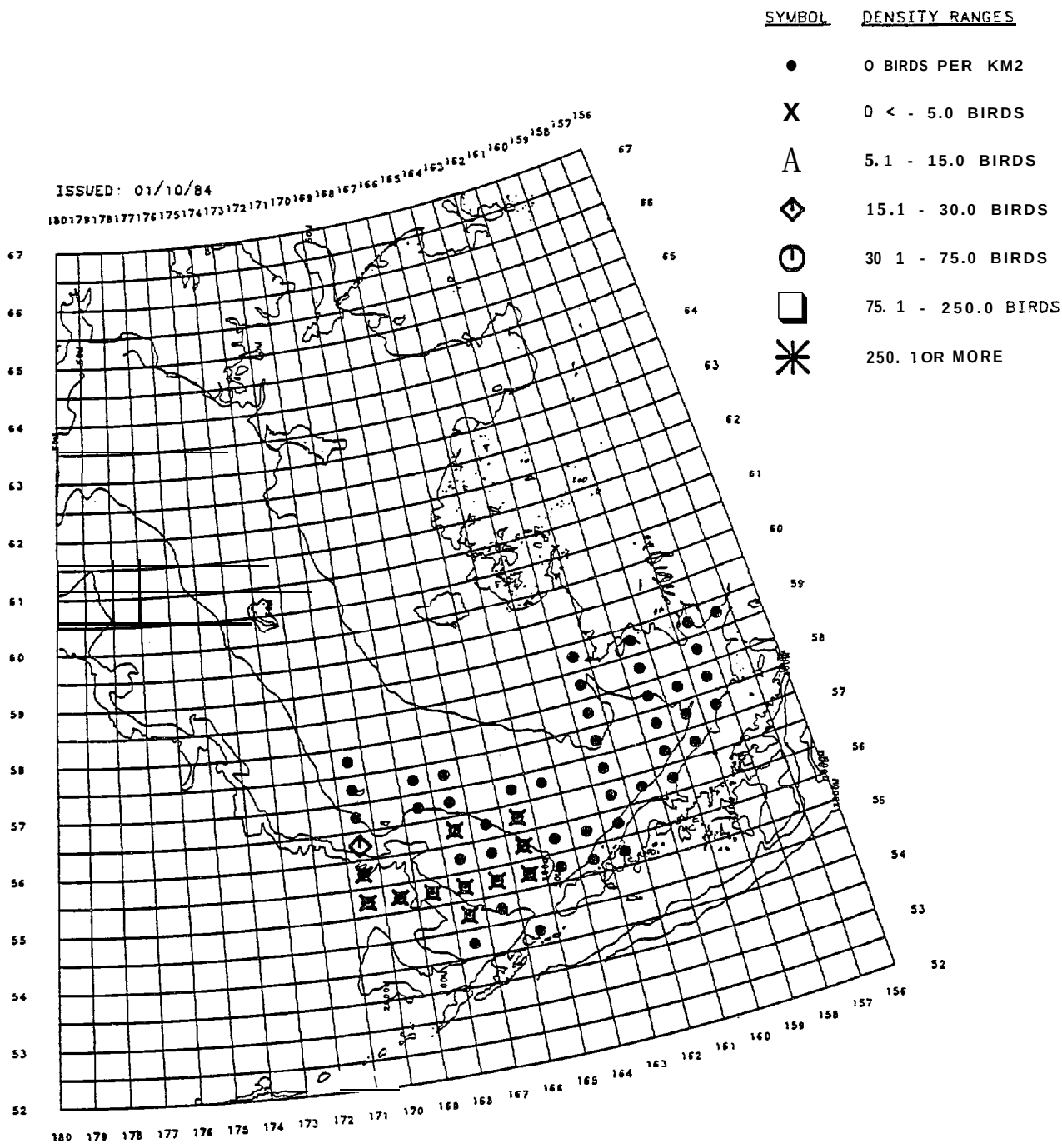


Figure 21. Mean densities, Northern Fulmars: Winter.

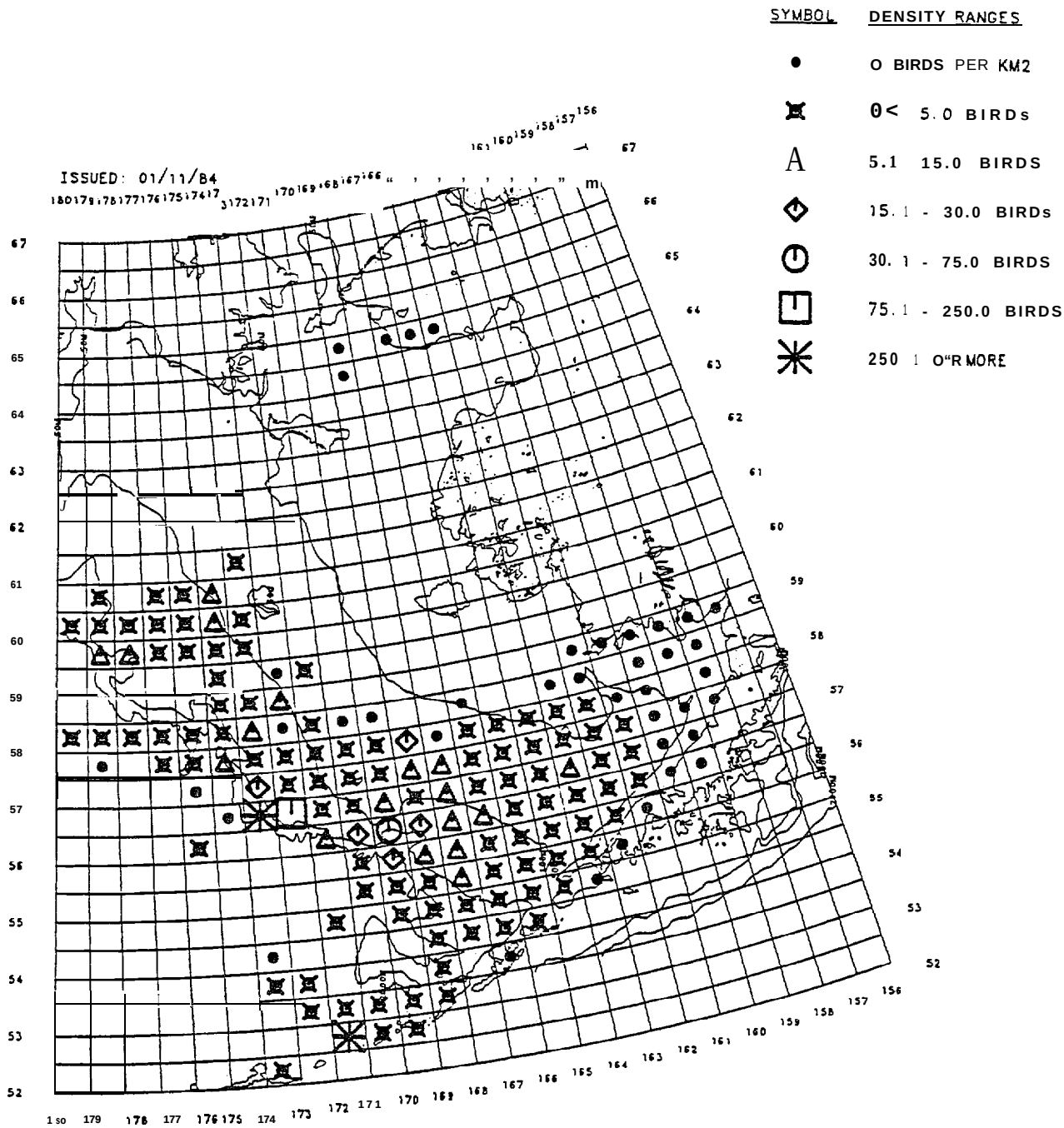


Figure 22. Mean densities, Northern Fulmars: Spring.

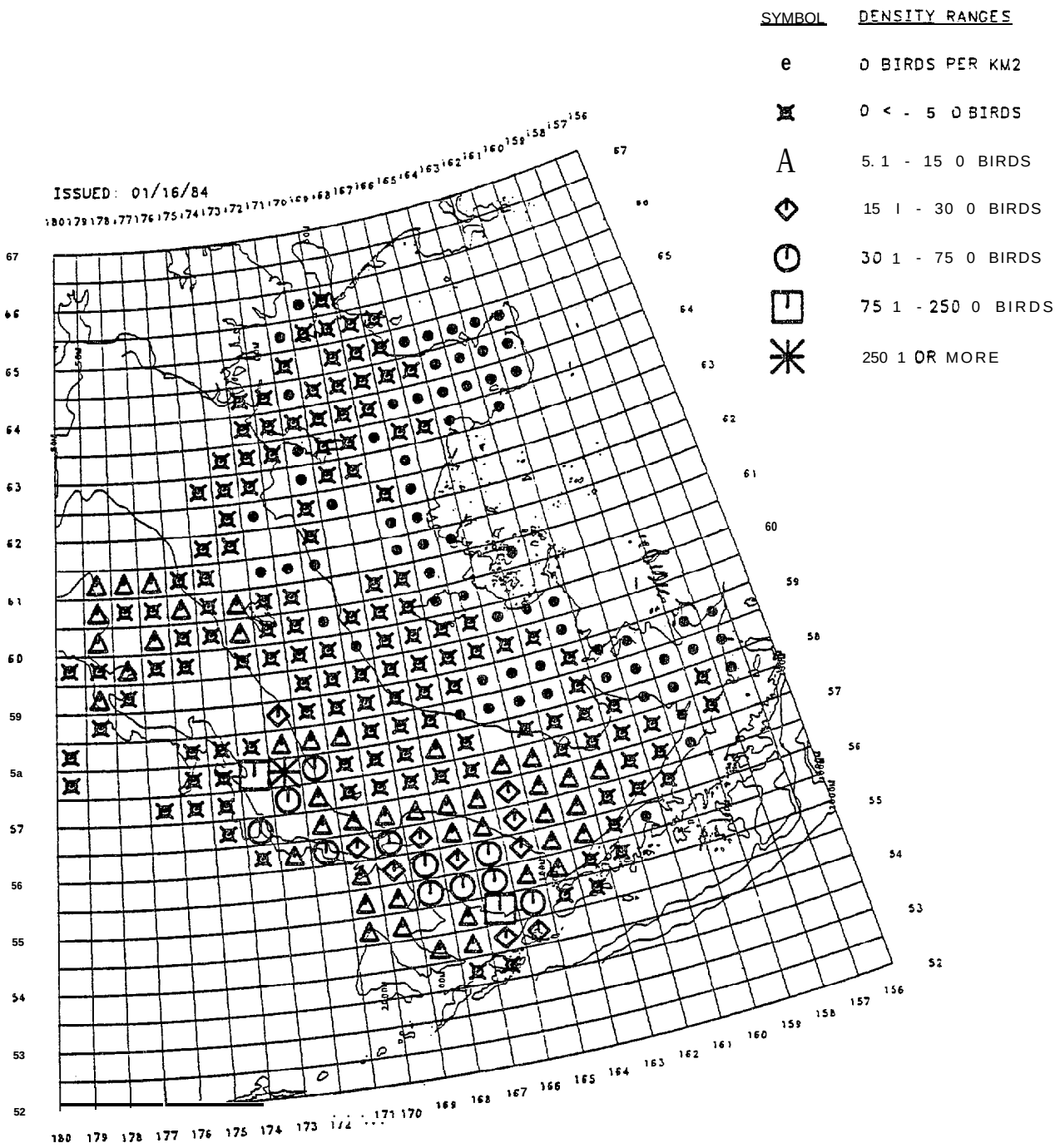


Figure 23. Mean densities, Northern Fulmars: Summer.

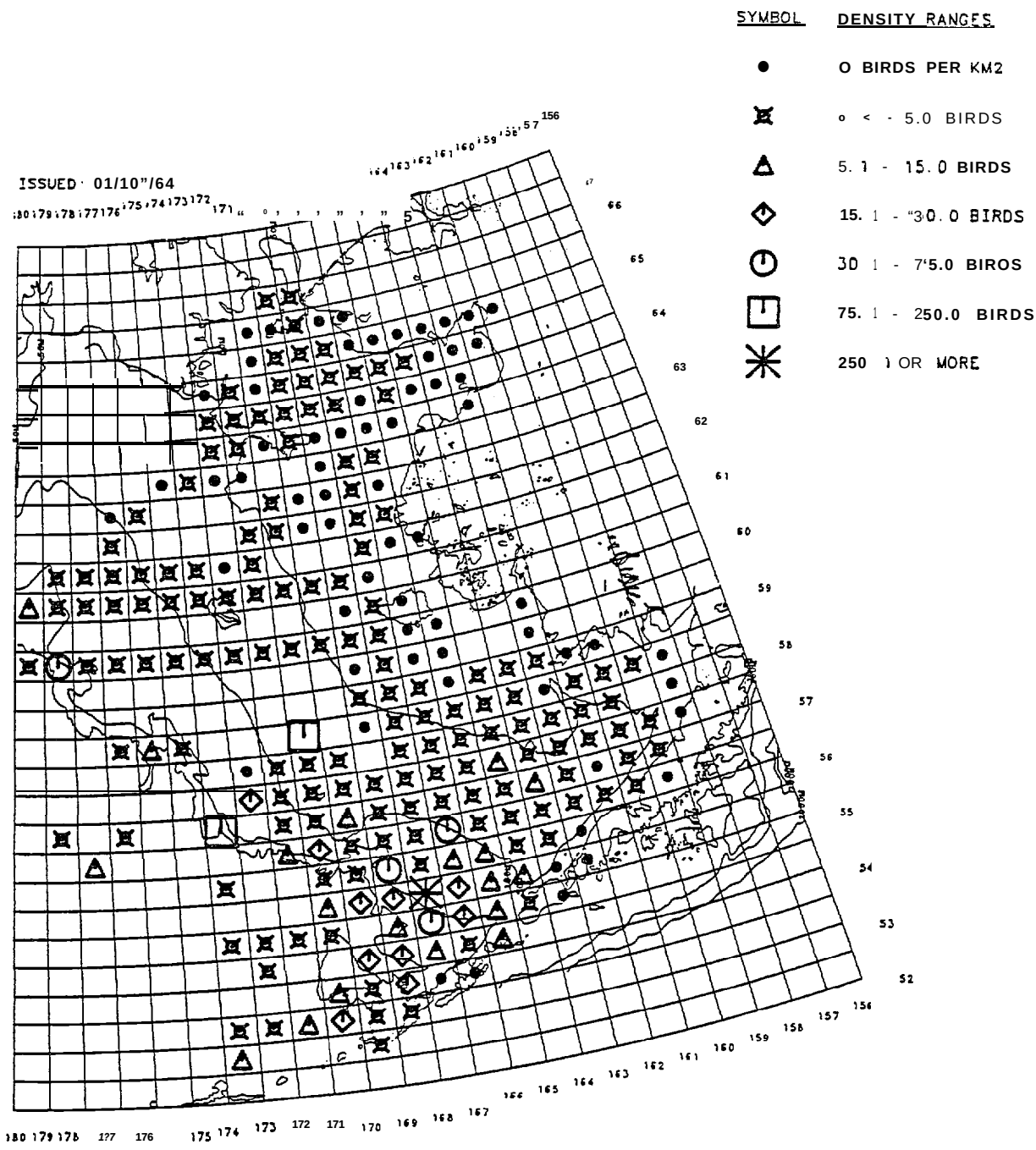


Figure 24. Mean densities, Northern Fulmars: Autumn.

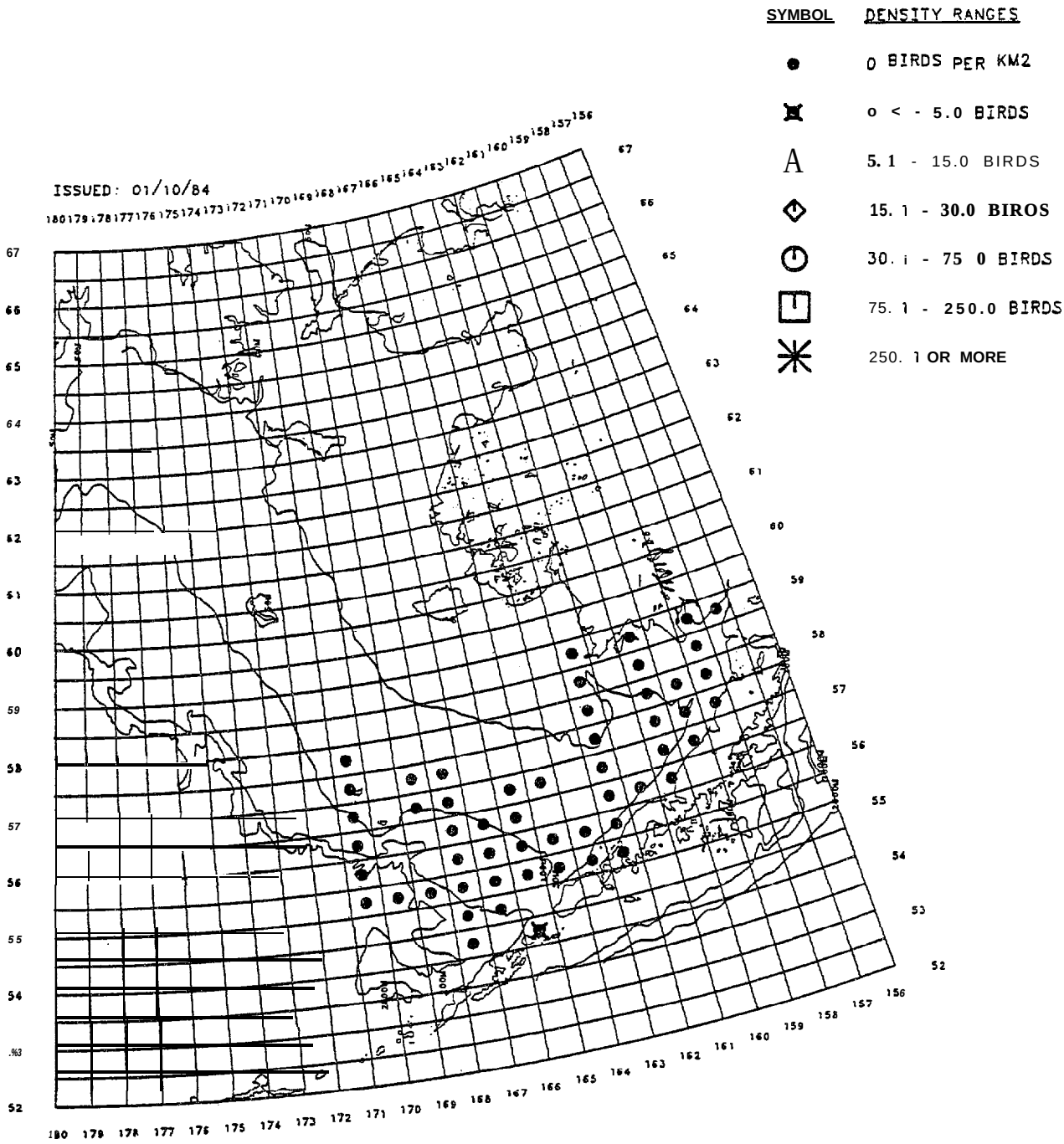


Figure 25. Mean densities, shearwaters: Winter.

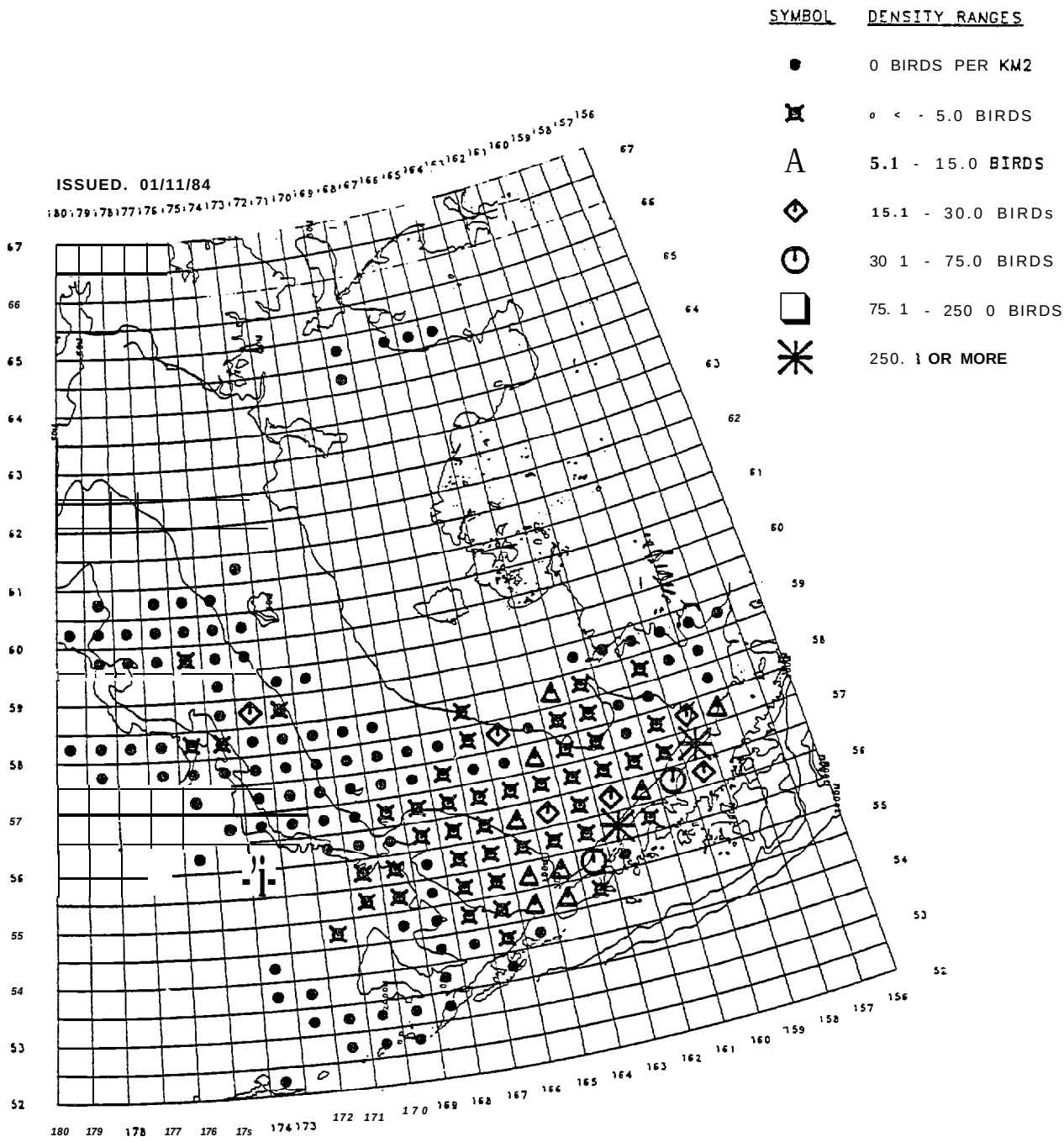
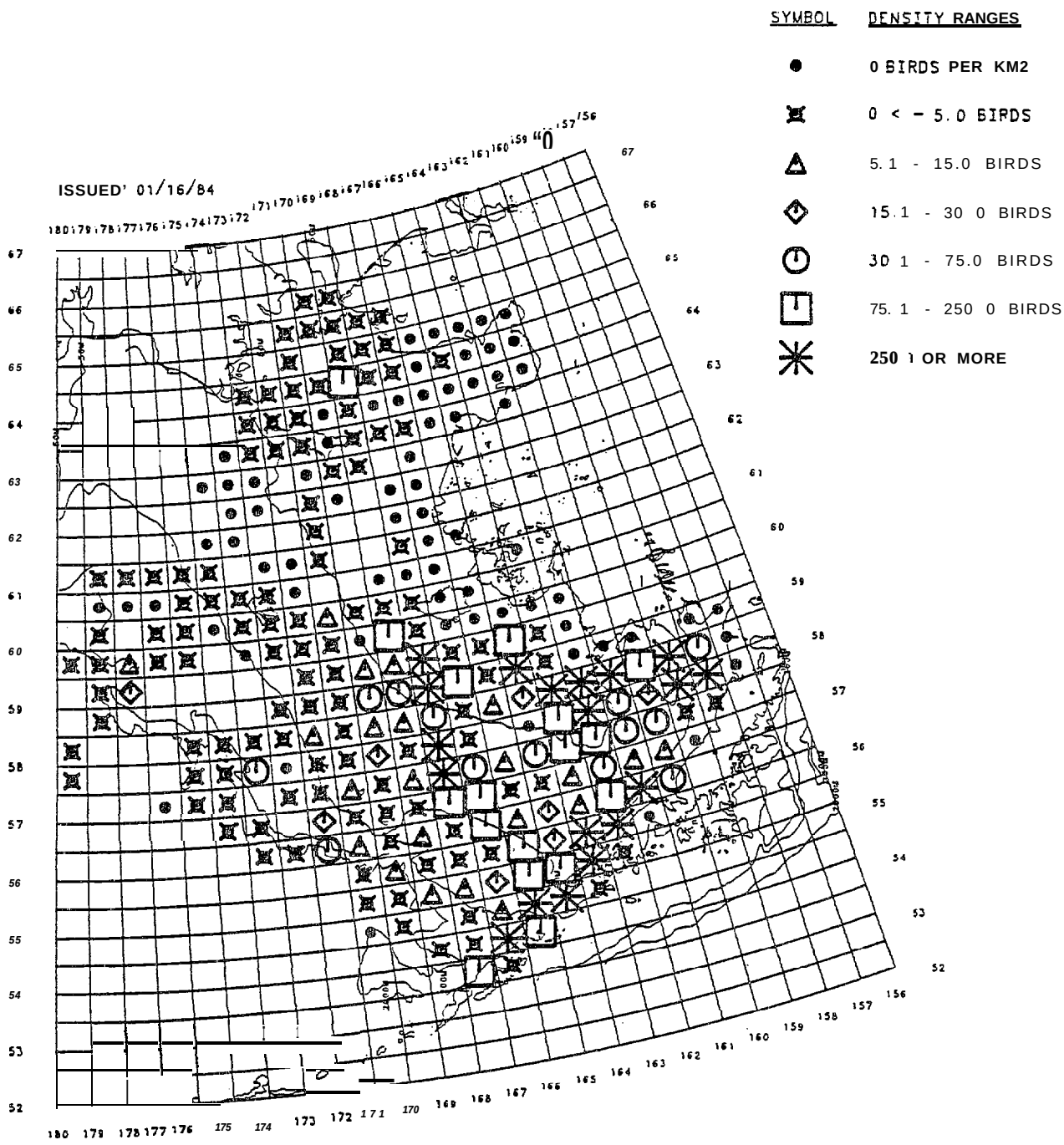


Figure 26. Mean densities, shearwaters: Spring.



BERING SEA MEAN DENSITY PLOT
SHEARWATERS SHER.SOSH.STSH
SUMMER

Figure 27. Mean densities, shearwaters: Summer.

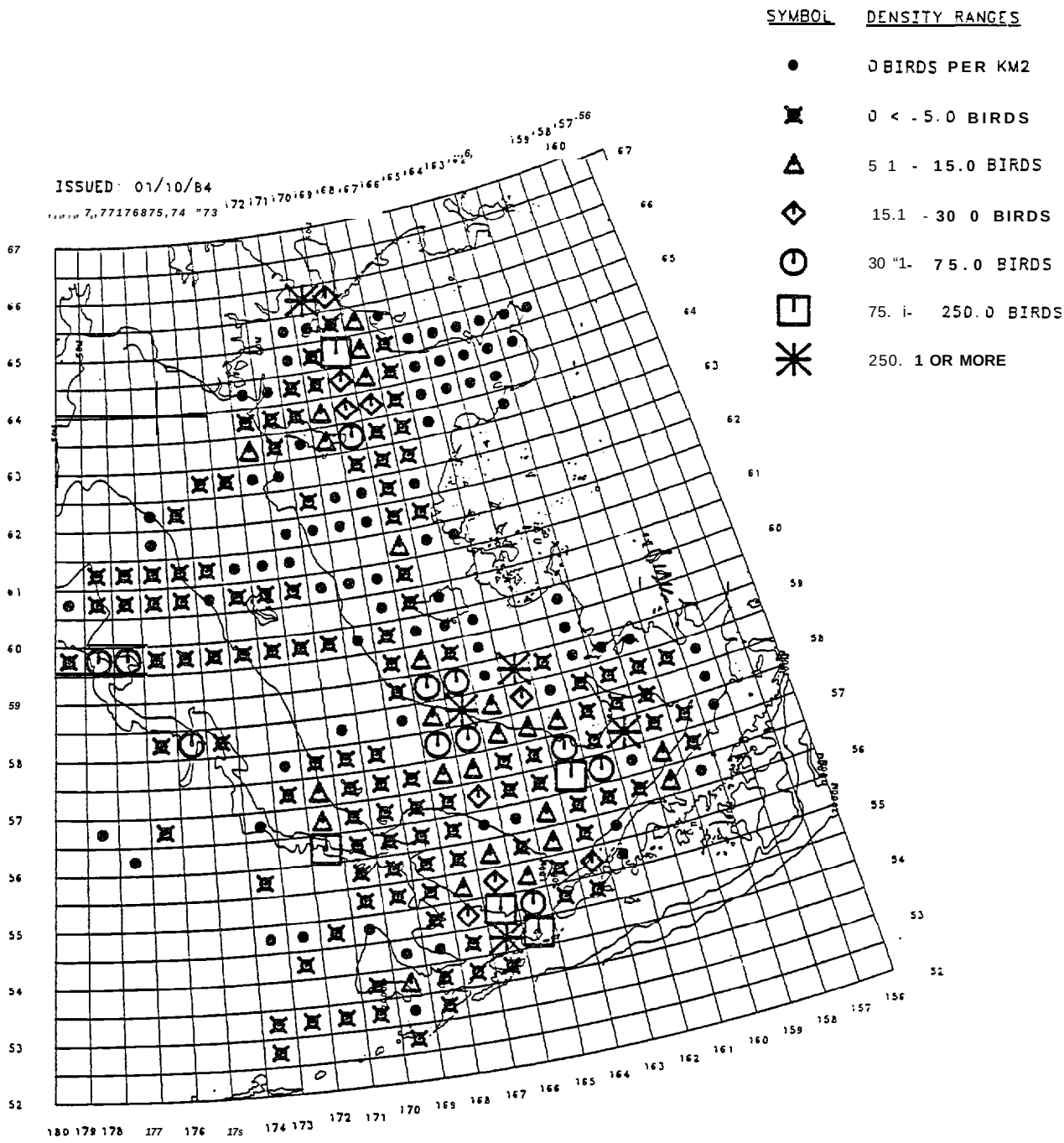
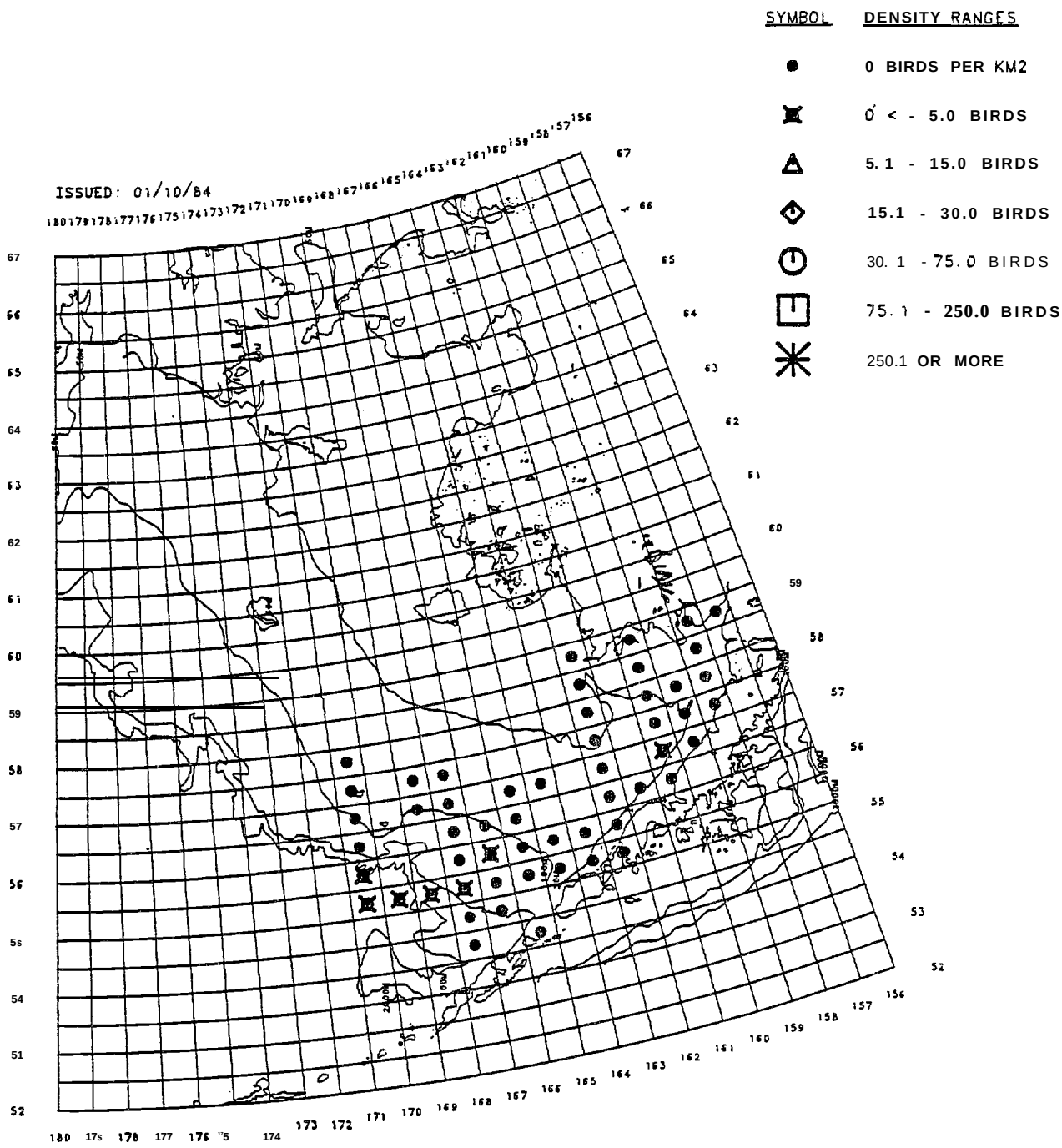


Figure 28. Mean densities, shearwaters: Autumn.



BERING SEA MEAN DENSITY PLOT
STORM PETRELS STPE.FTSP
WINTER

Figure 29. Mean densities, storm-petrels: Winter.

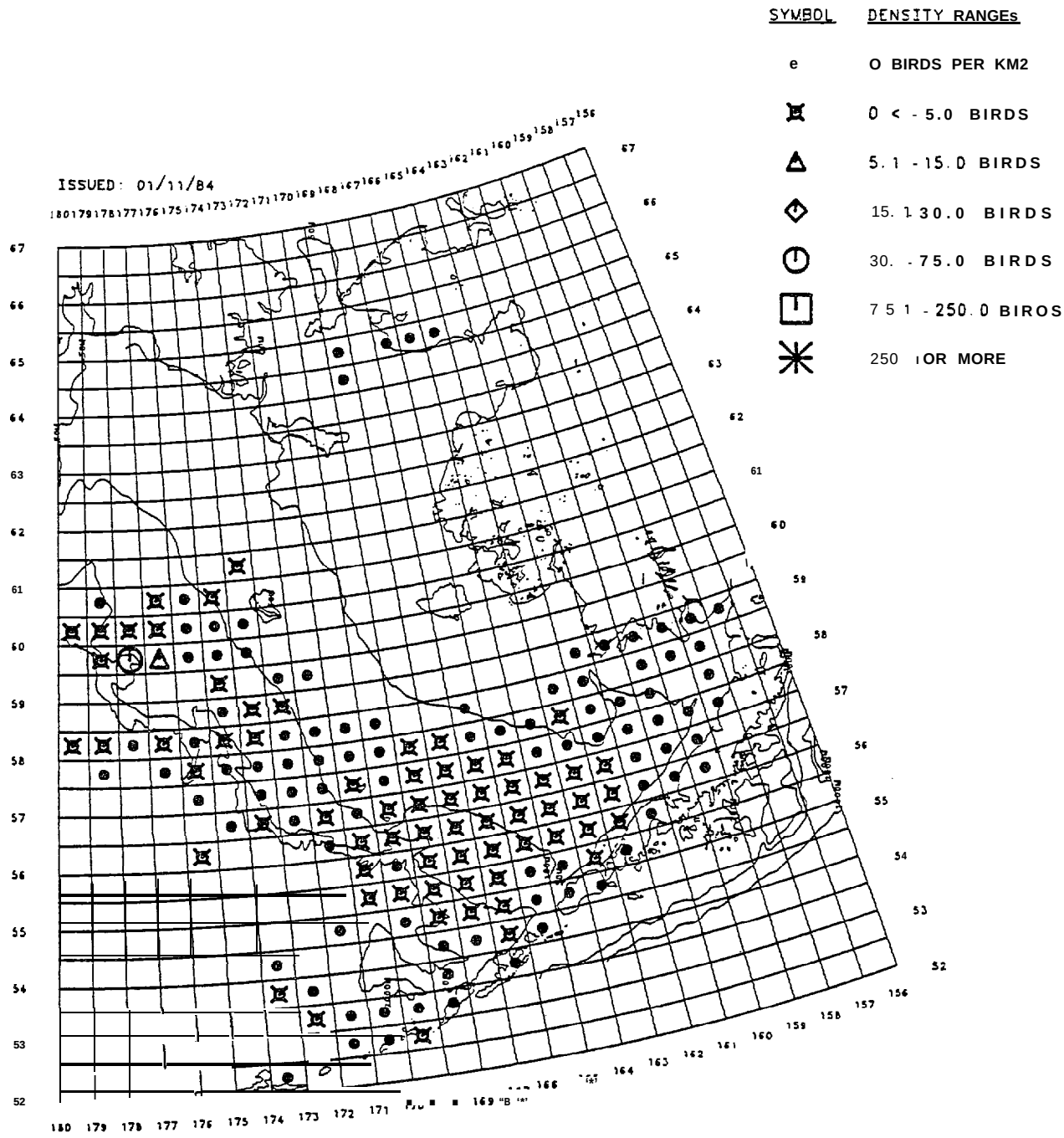


Figure 30. Mean densities, storm-petrels: Spring.

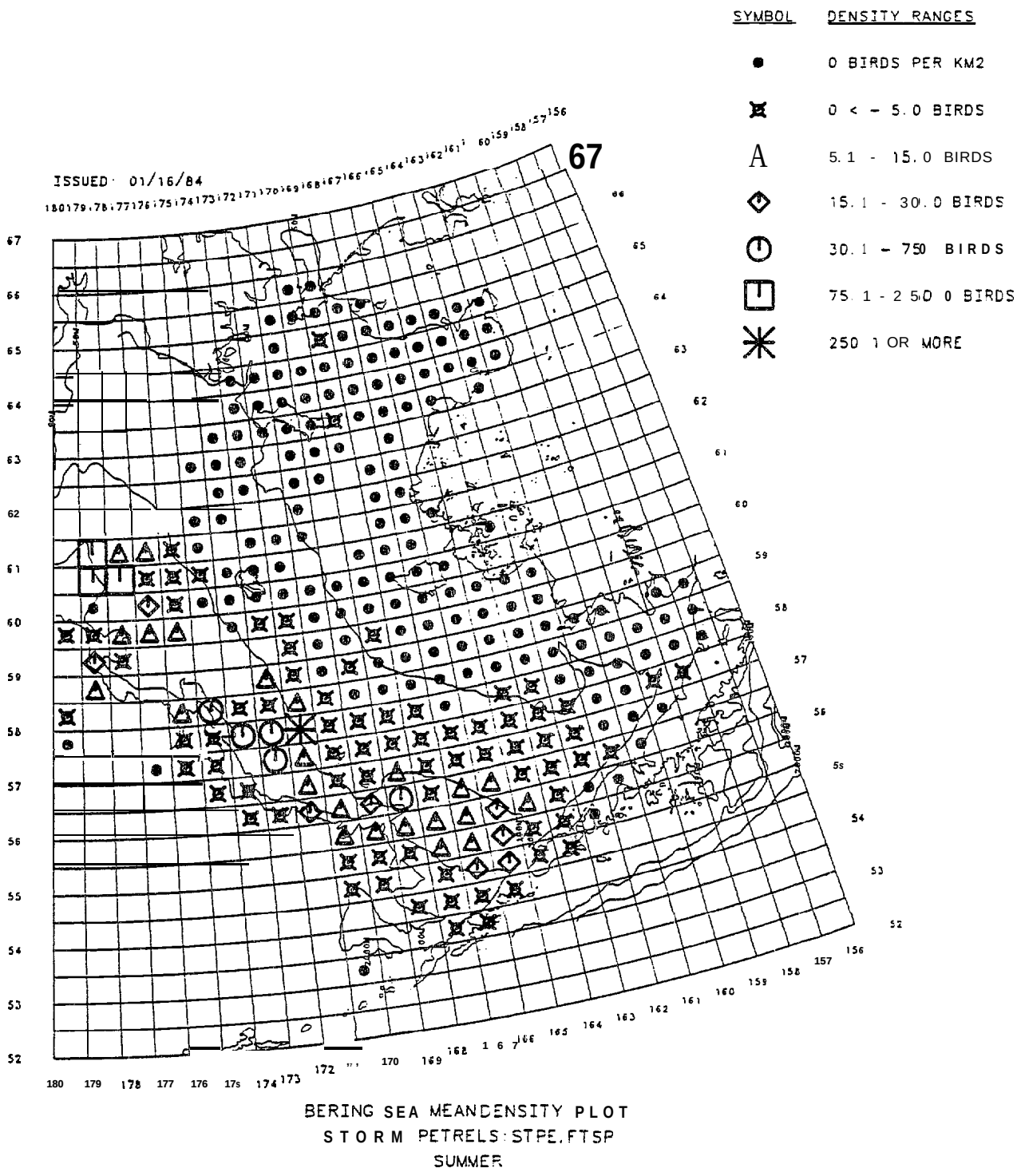
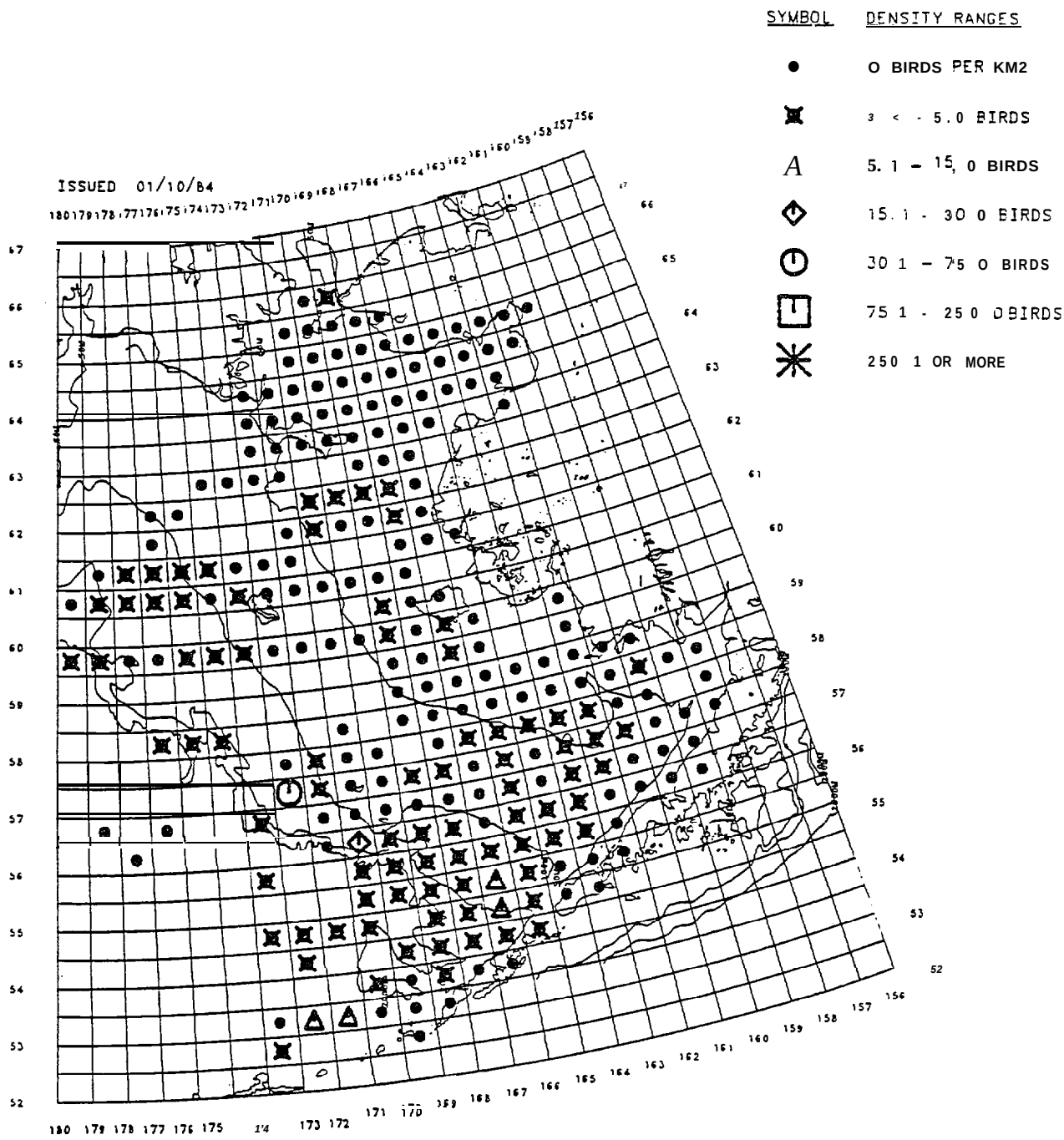
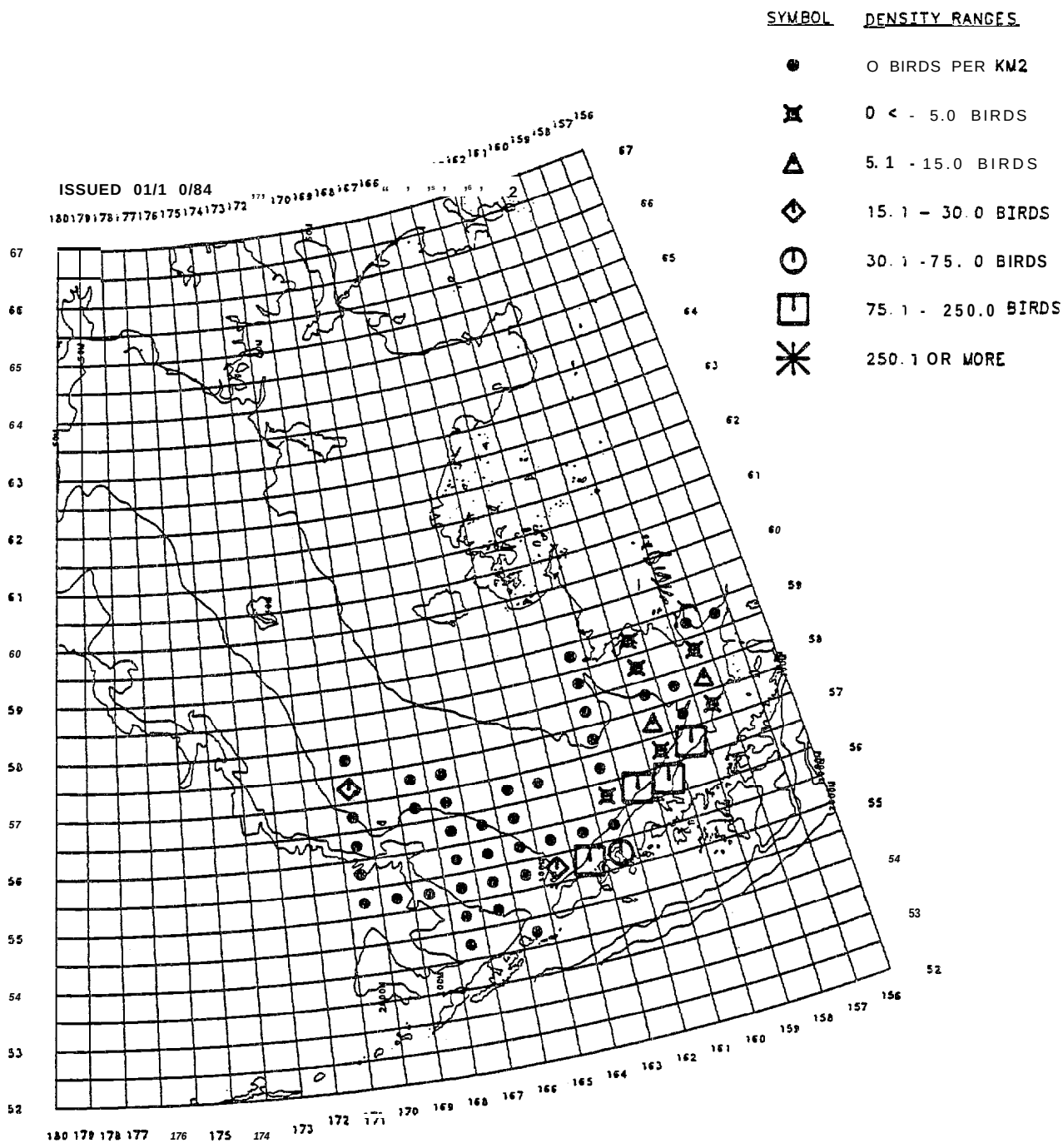


Figure 31. Mean densities, storm-petrels: Summer.



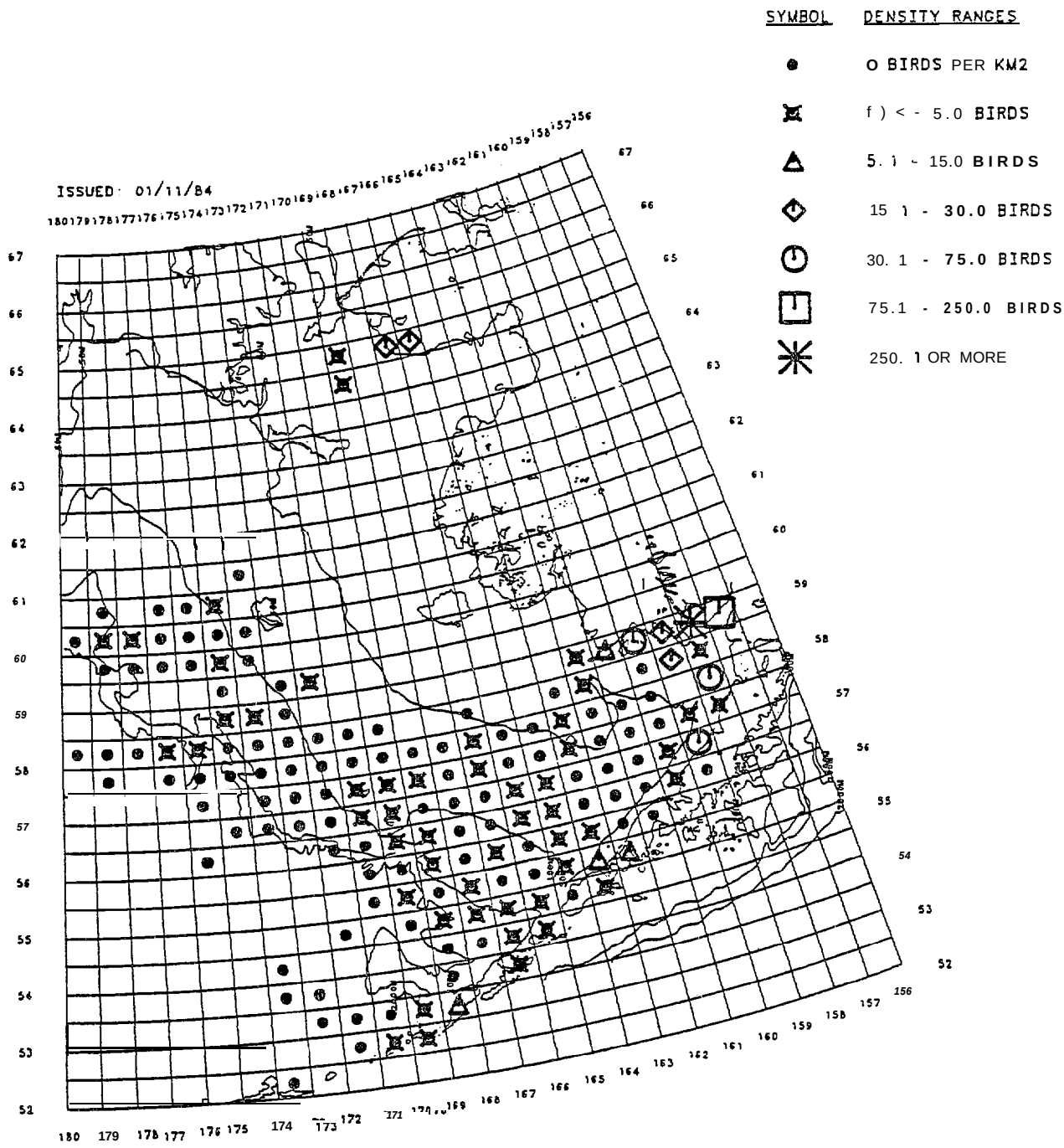
BERING SEA MEAN DENSITY PLOT
STORM PETRELS STPE.FTSP
AUTUMN

Figure 32. Mean densities, storm-petrels: Autumn.



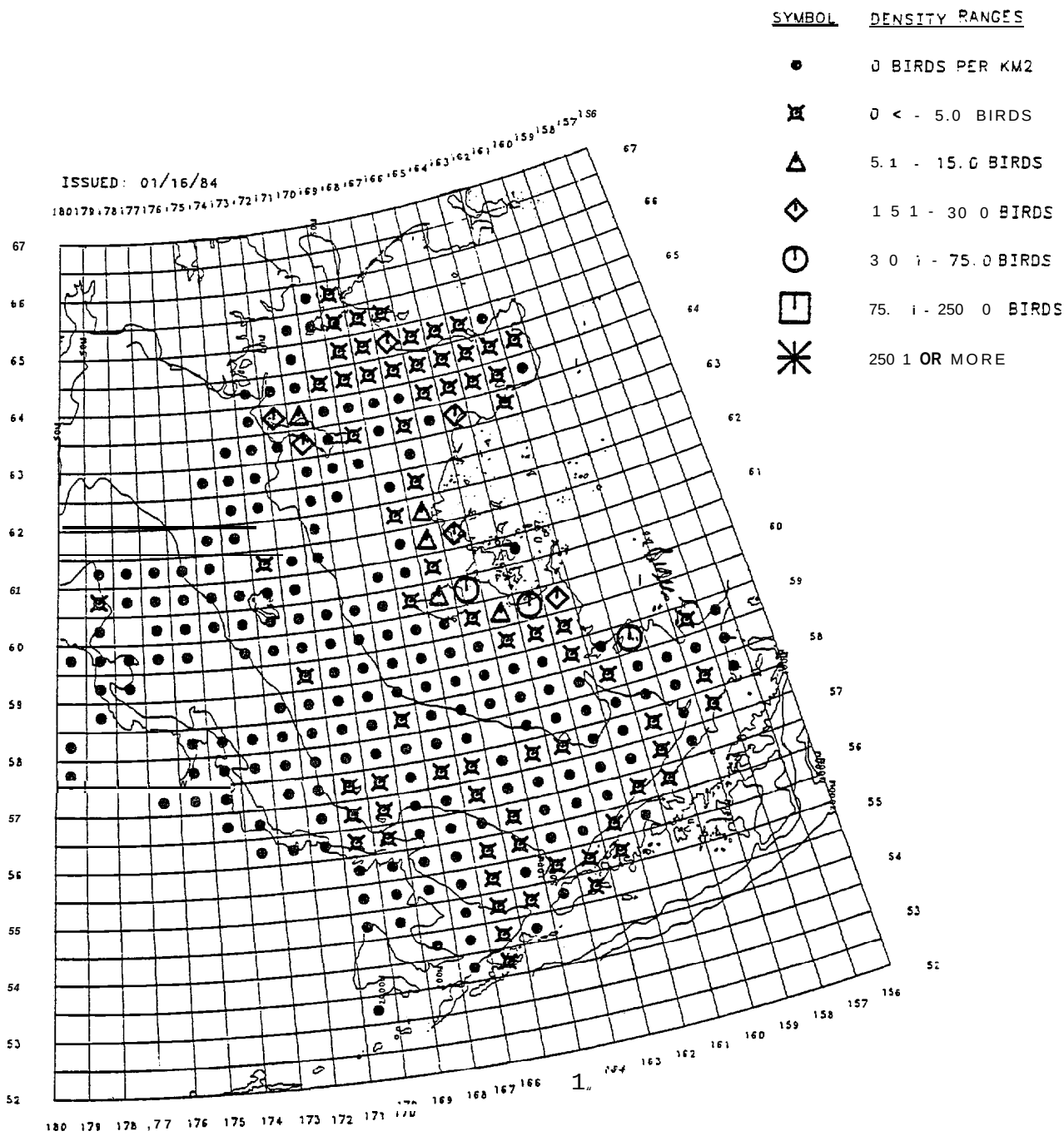
BERING SEA MEAN DENSITY PLOT
WATERFOWL(0)
WINTER

Figure 33. Mean densities, waterfowl: Winter.



BERING SEA MEAN DENSITY PLOT
WATERFOWL (0)
SPRING

Figure 34. Mean densities, waterfowl: Spring.



BERING SEA MEAN DENSITY PLOT
WATERFOWL(O)
SUMMER

Figure 35. Mean densities, waterfowl: Summer.

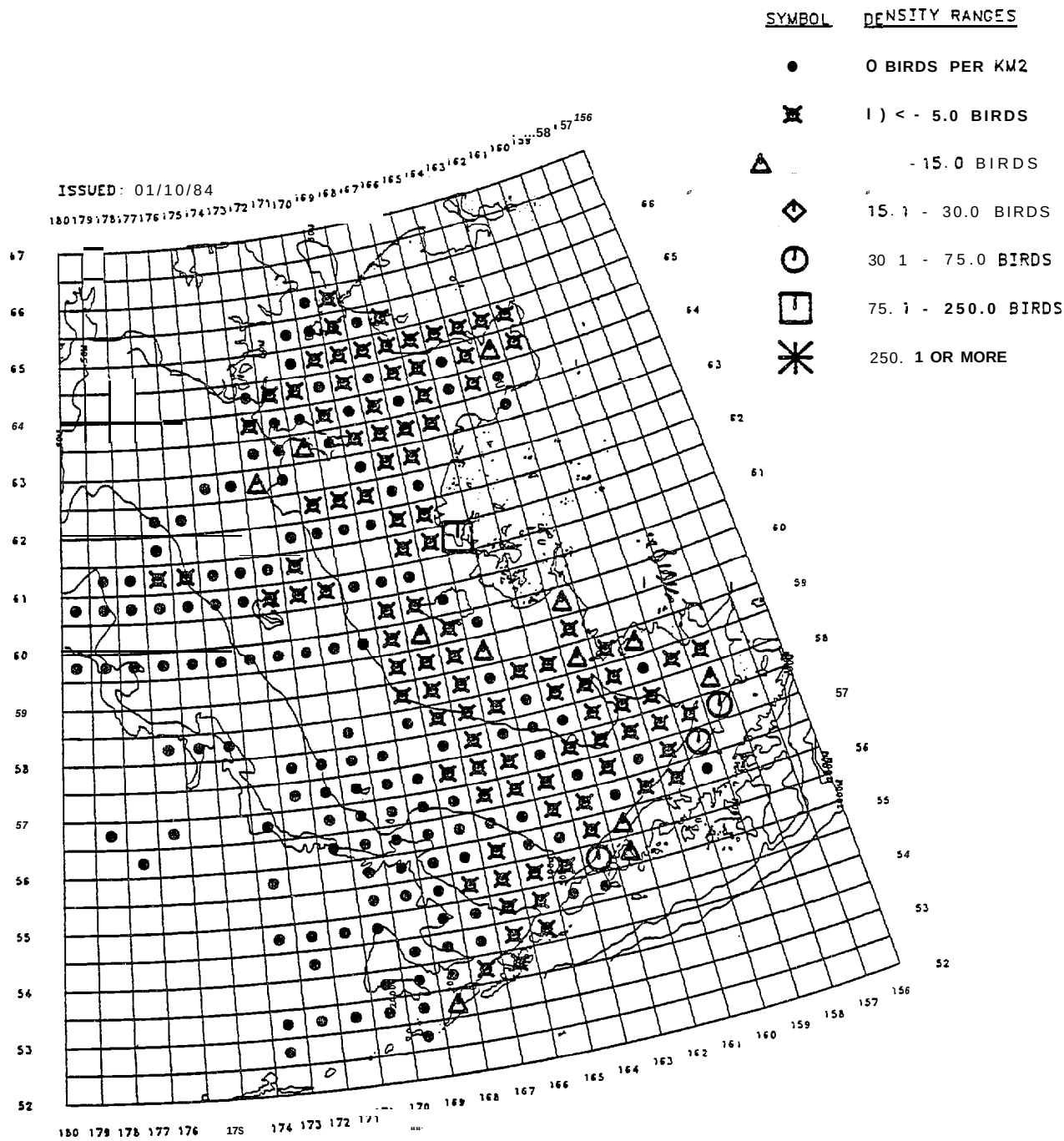
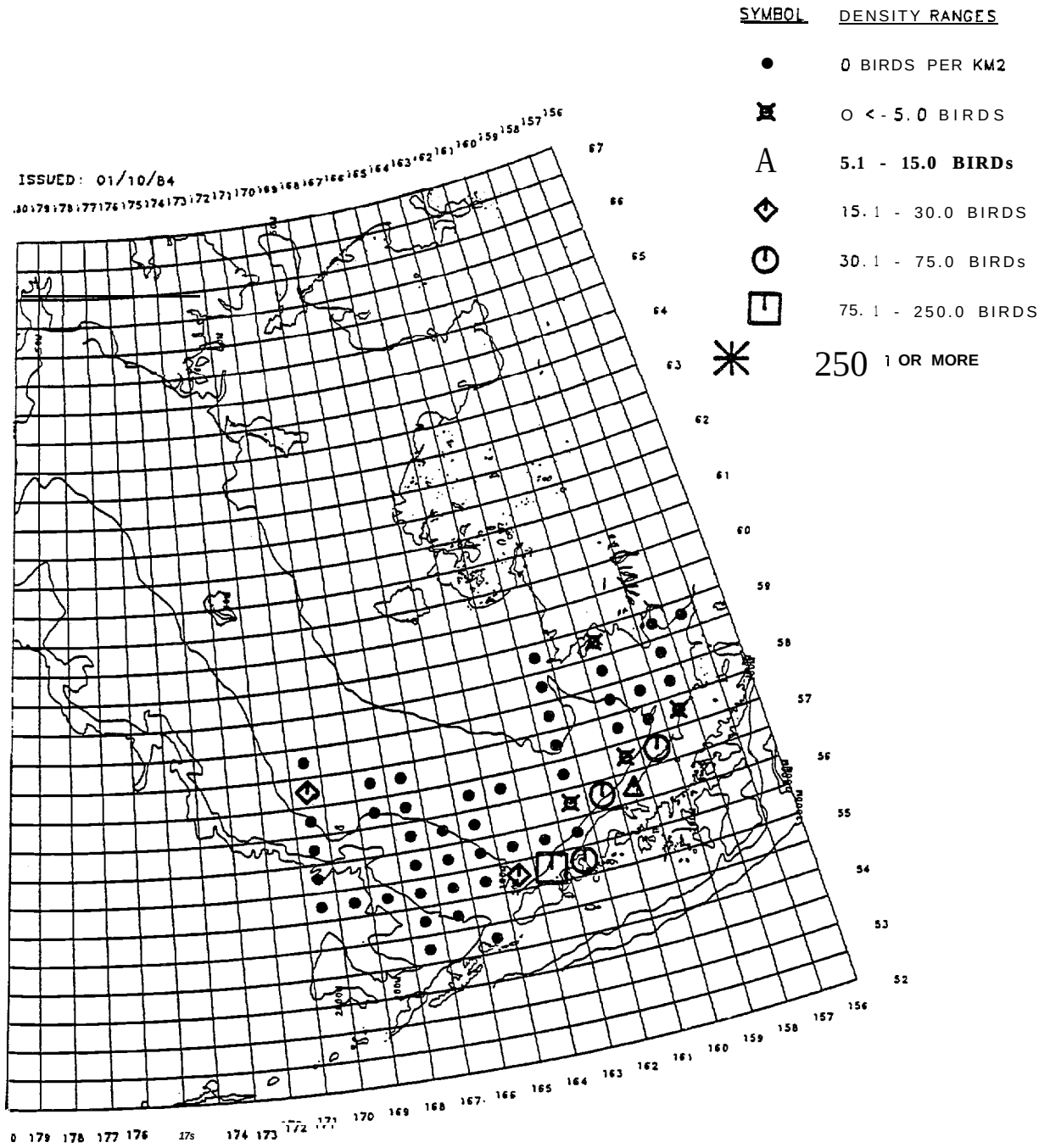
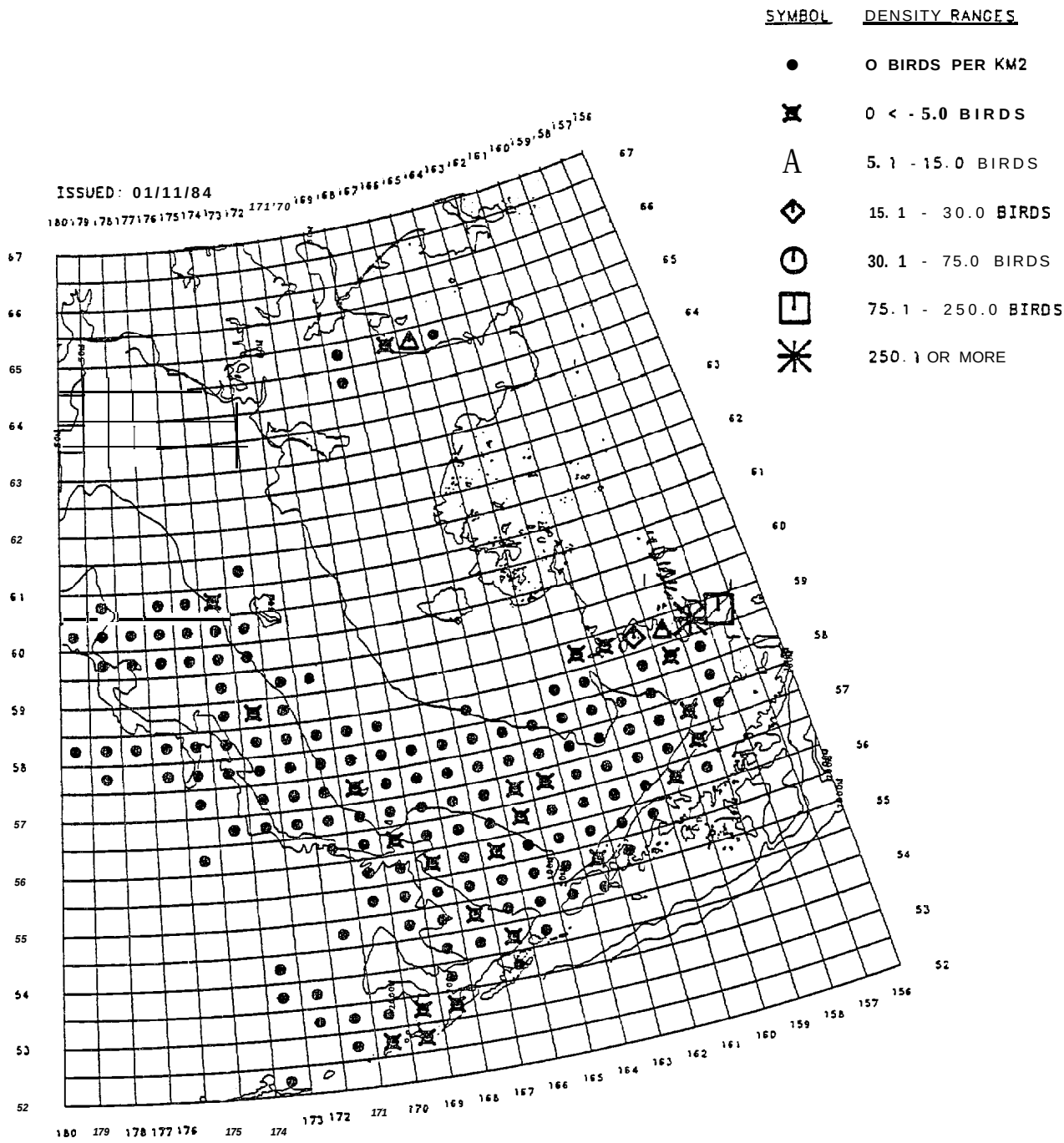


Figure 36. Mean densities, waterfowl: Autumn.



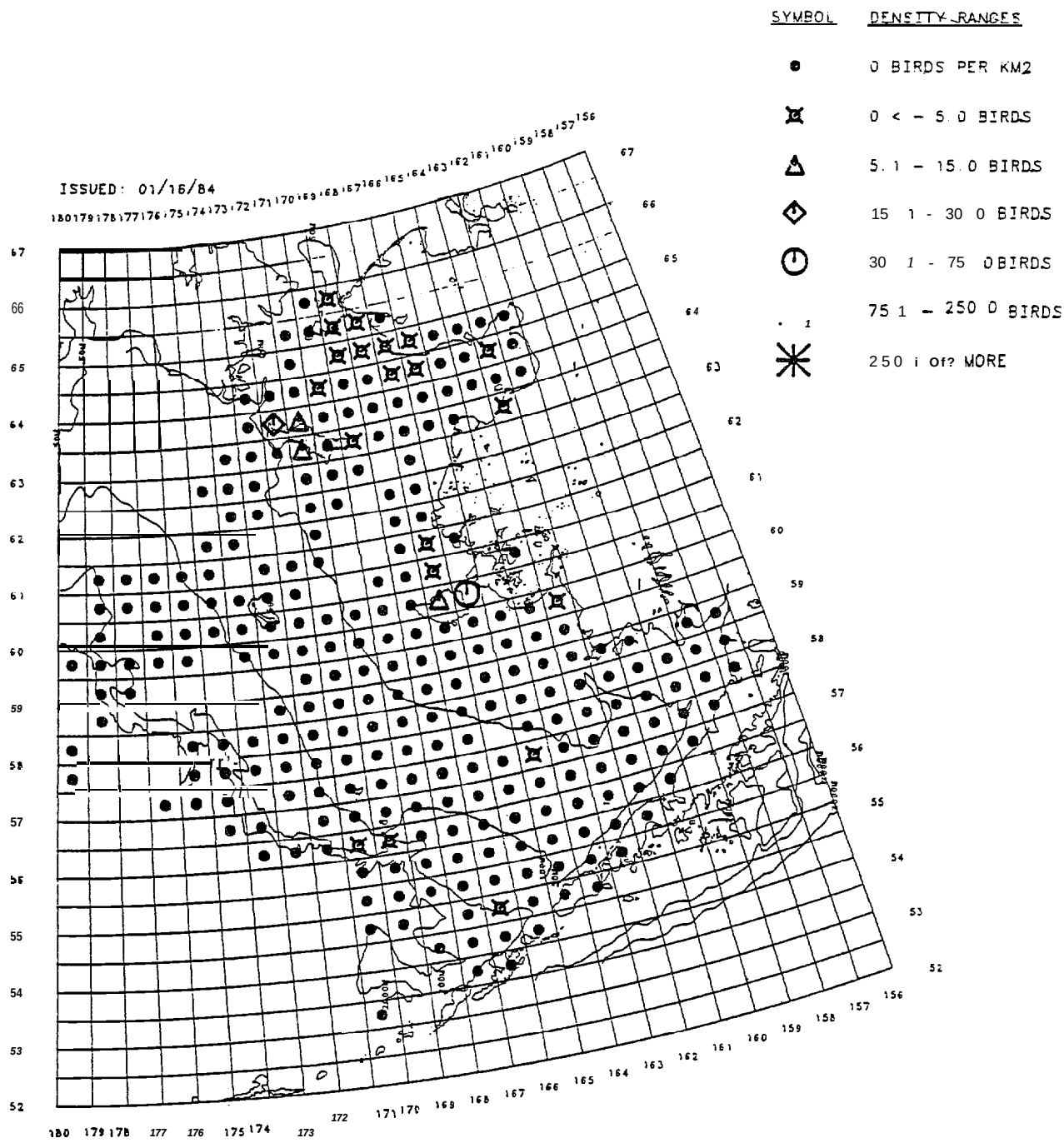
BERING SEA MEAN DENSITY PLOT
EIDERS (G)
WINTER

Figure 37. Mean densities, eiders: Winter.



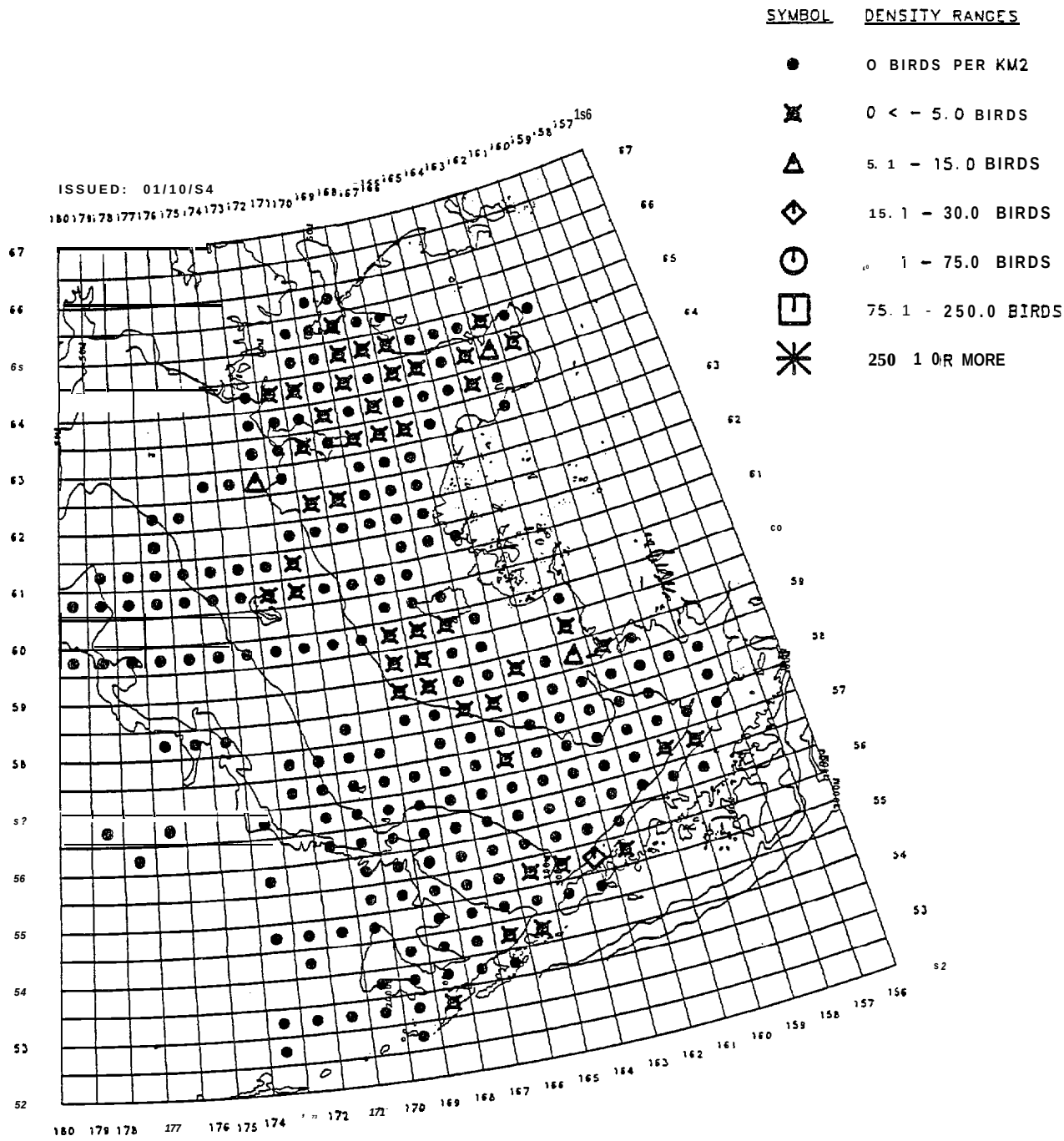
BERING SEA MEAN DENSITY PLOT
EIDERS (G)
SPRING

Figure 38. Mean densities, eiders: Spring.



BERING SEA MEAN DENSITY PLOT
EIDERS (G)
SUMMER

Figure 39. Mean densities, eiders: Summer.



BERING SEA MEAN DENSITY PLOT
EIDERS (G)
AUTUMN

Figure 40. Mean densities, eiders: Autumn.

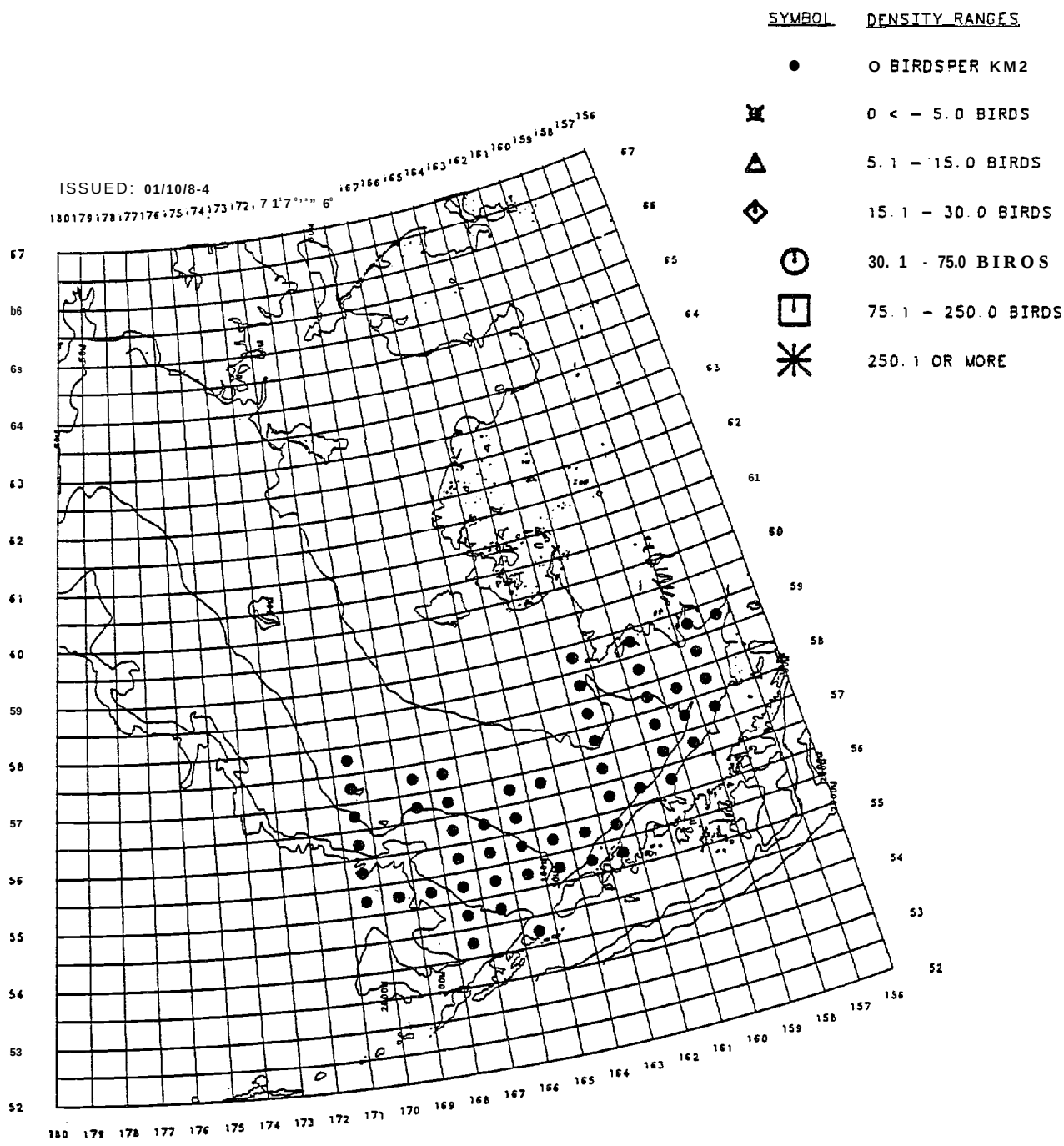


Figure 41. Mean densities, phalaropes: Winter.

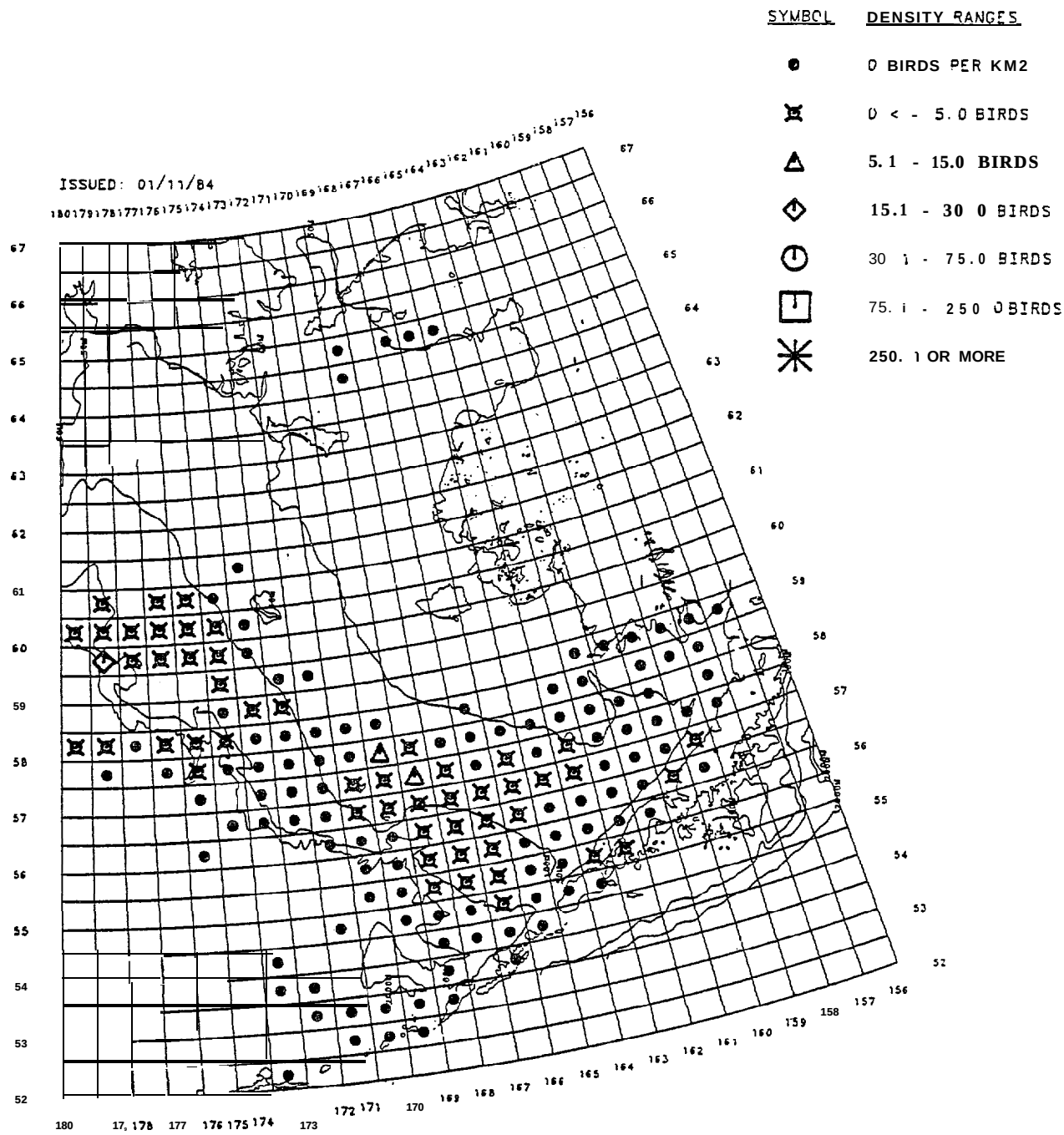
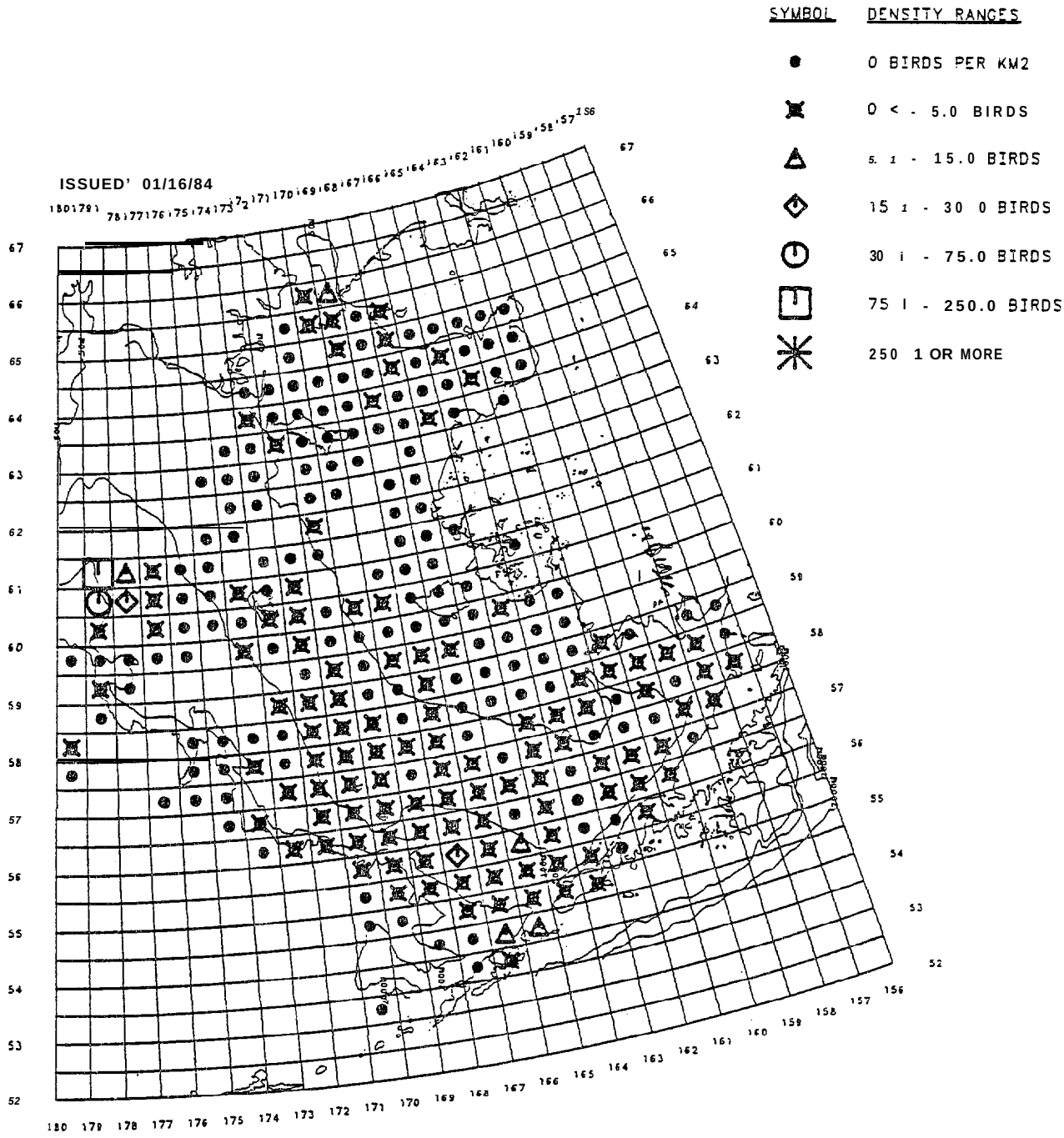
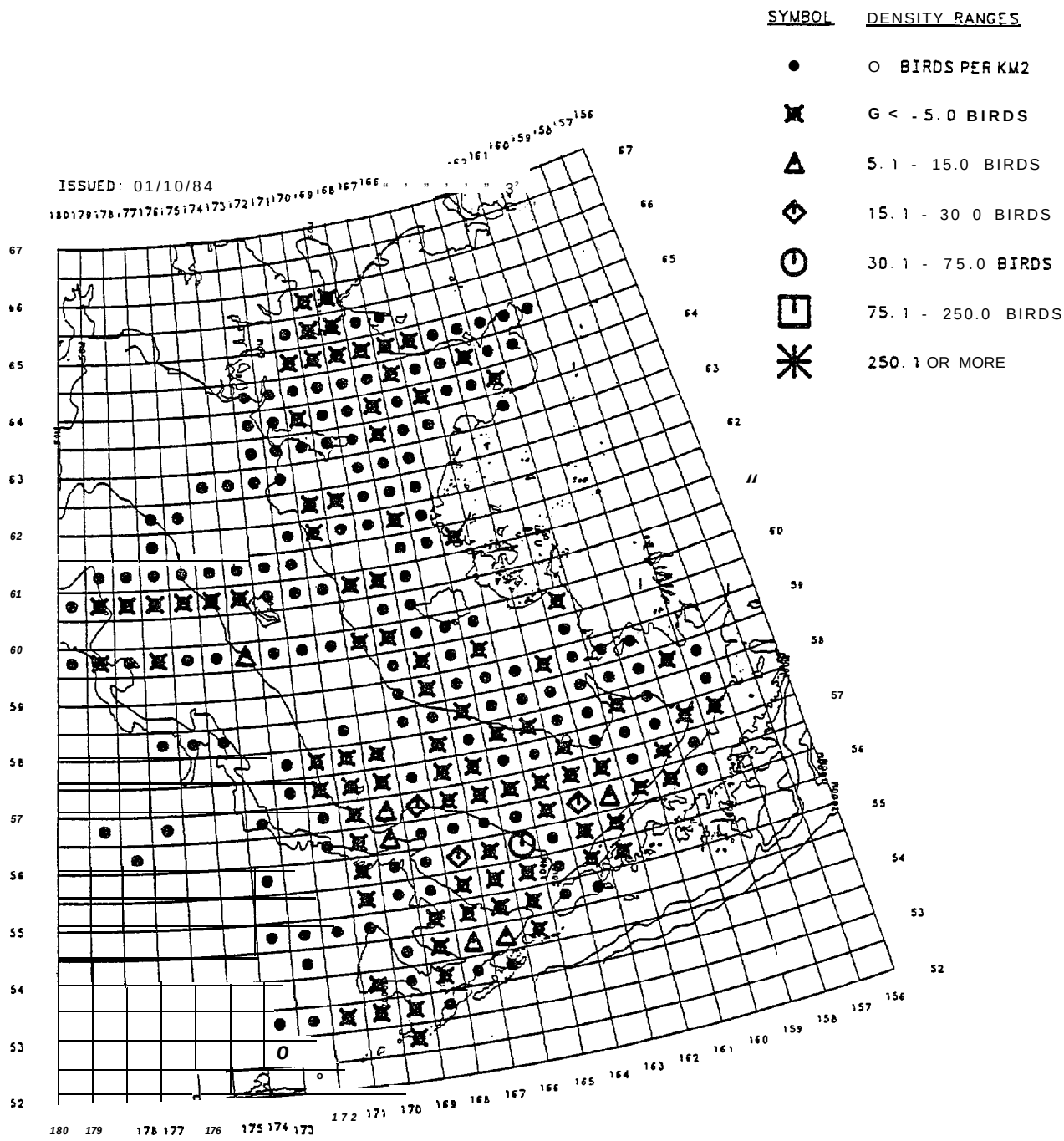


Figure 42. Mean densities, phalaropes: Spring.



BERING SEA MEAN DENSITY PLOT
PHALAROPES (F)
SUMMER

Figure 43. Mean densities, phalaropes: Summer.



BERING SEA MEAN DENSITY PLOT
PHALAROPES (F)
AUTUMN

Figure 44. Mean densities, phalaropes: Autumn.

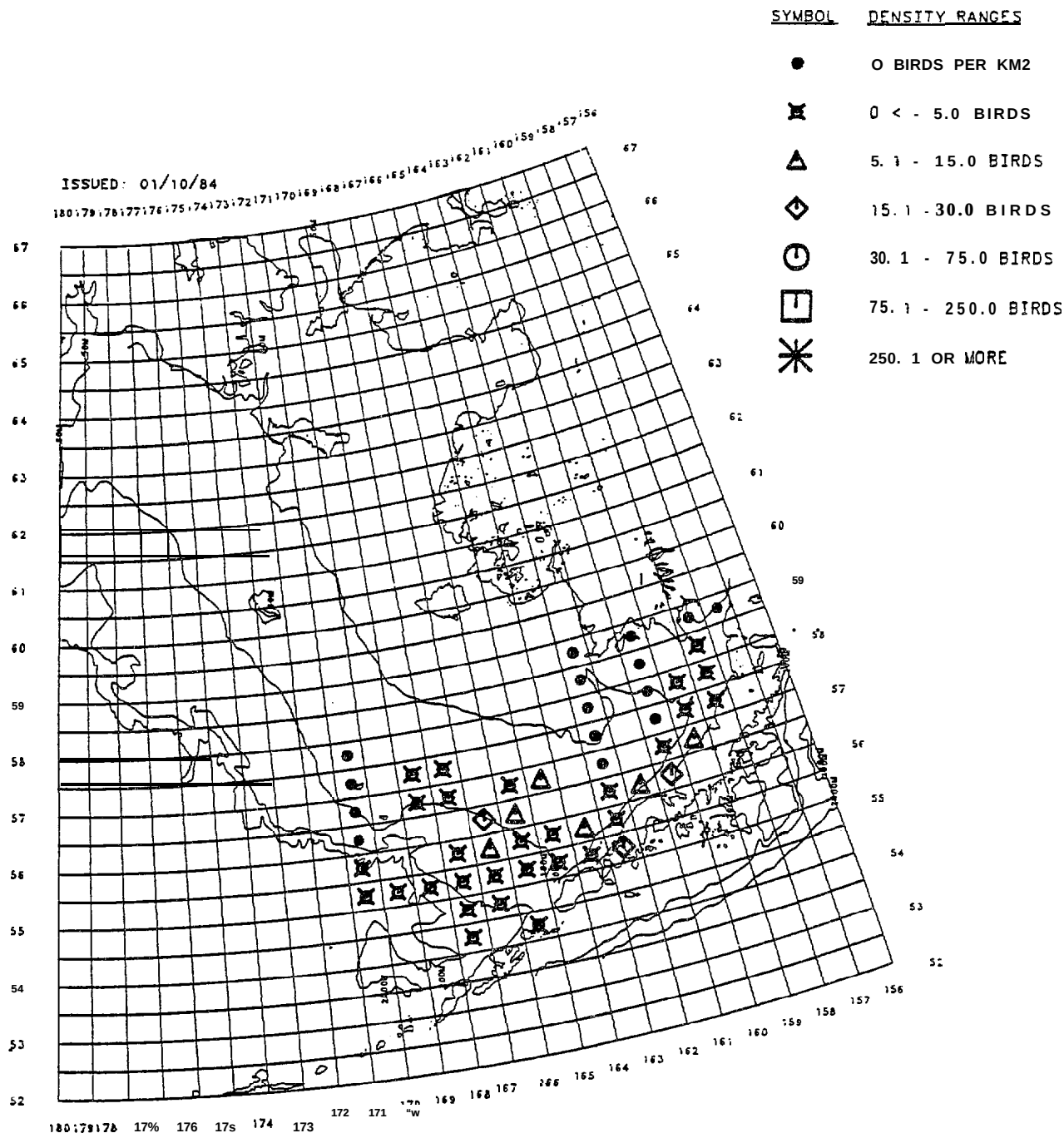


Figure 45. Mean densities, *Larus* gulls: Winter.

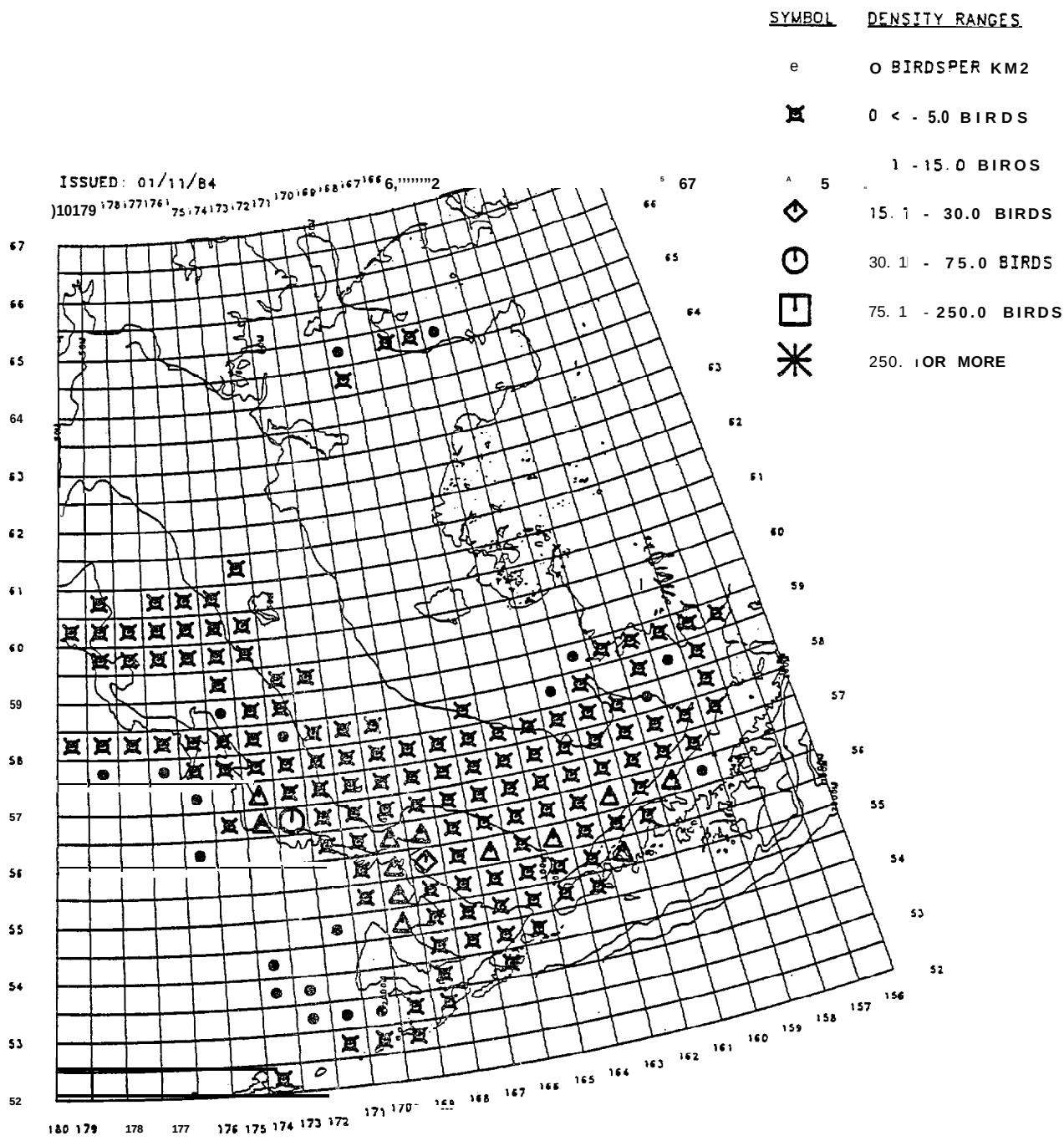
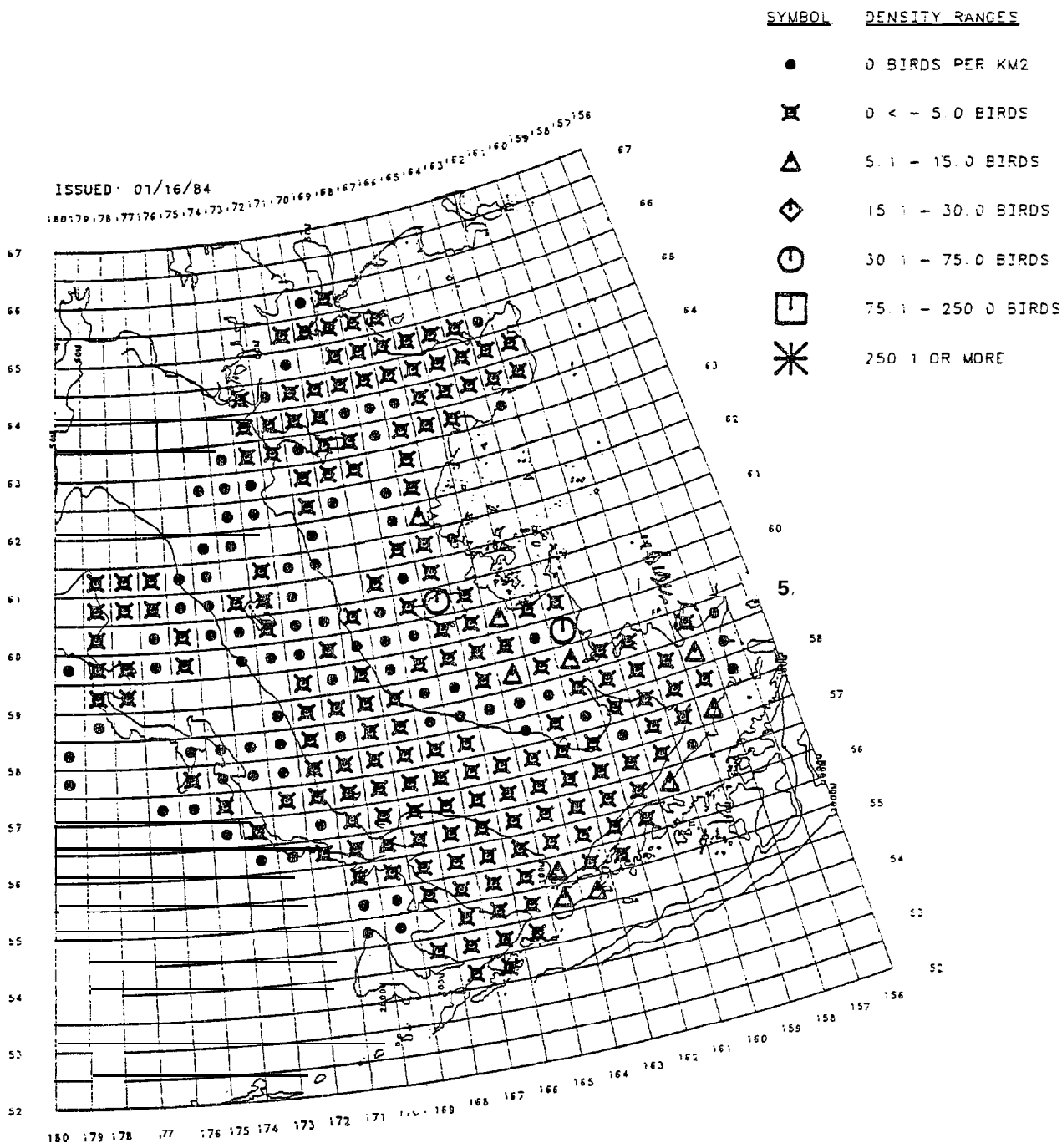
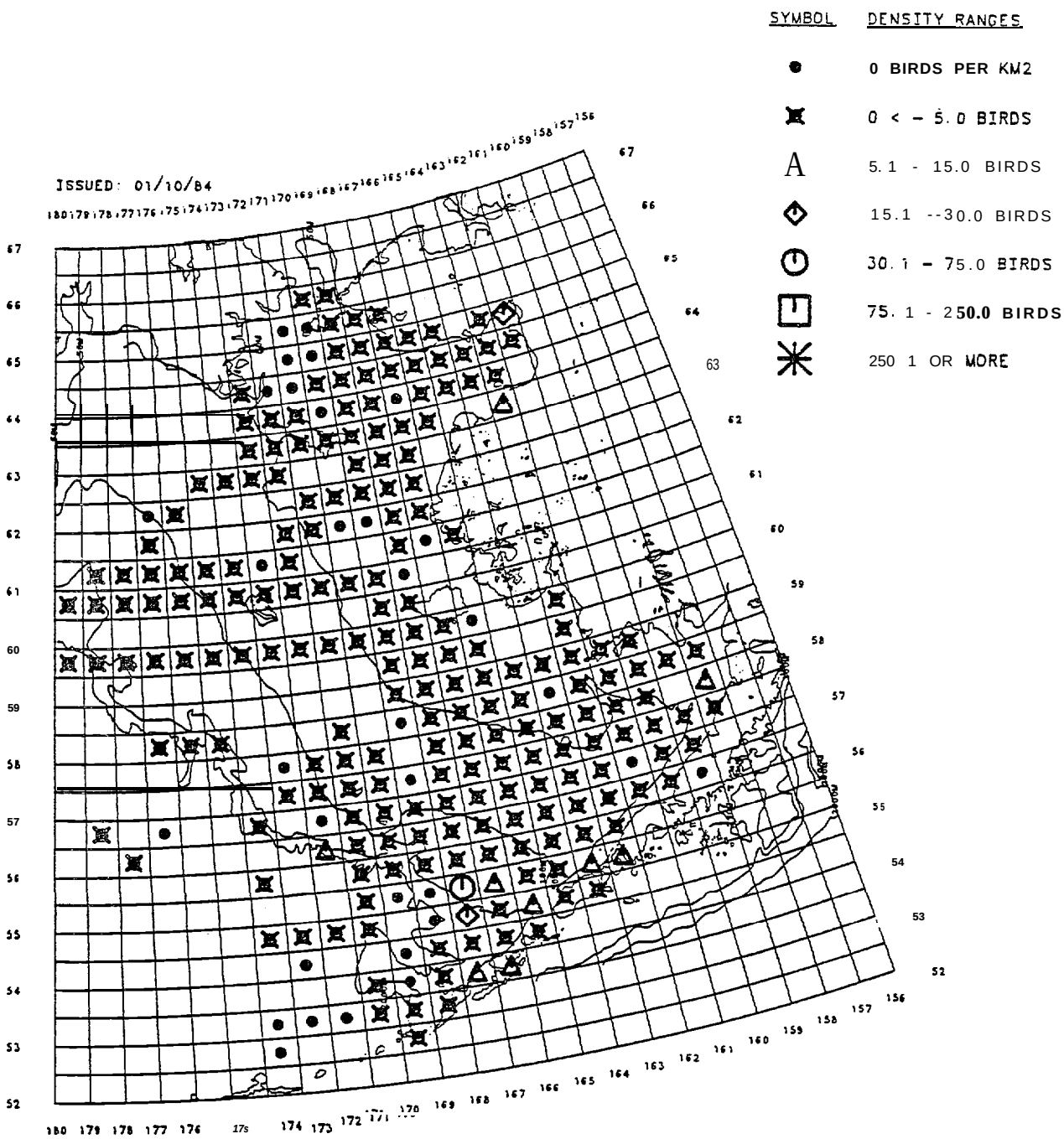


Figure 46. Mean densities, Larus gulls: Spring.



BERINGSEA MEAN DENSITY PLOT
GULLS (EXCEPT KITTIWAKES)
SUMMER

Figure 47. Mean densities, *Larus* gulls: Summer.



BERING SEA MEAN DENSITY PLOT
GULLS (EXCEPT KITTIWAKES)
AUTUMN

Figure 48. Mean densities, Larus gulls: Autumn.

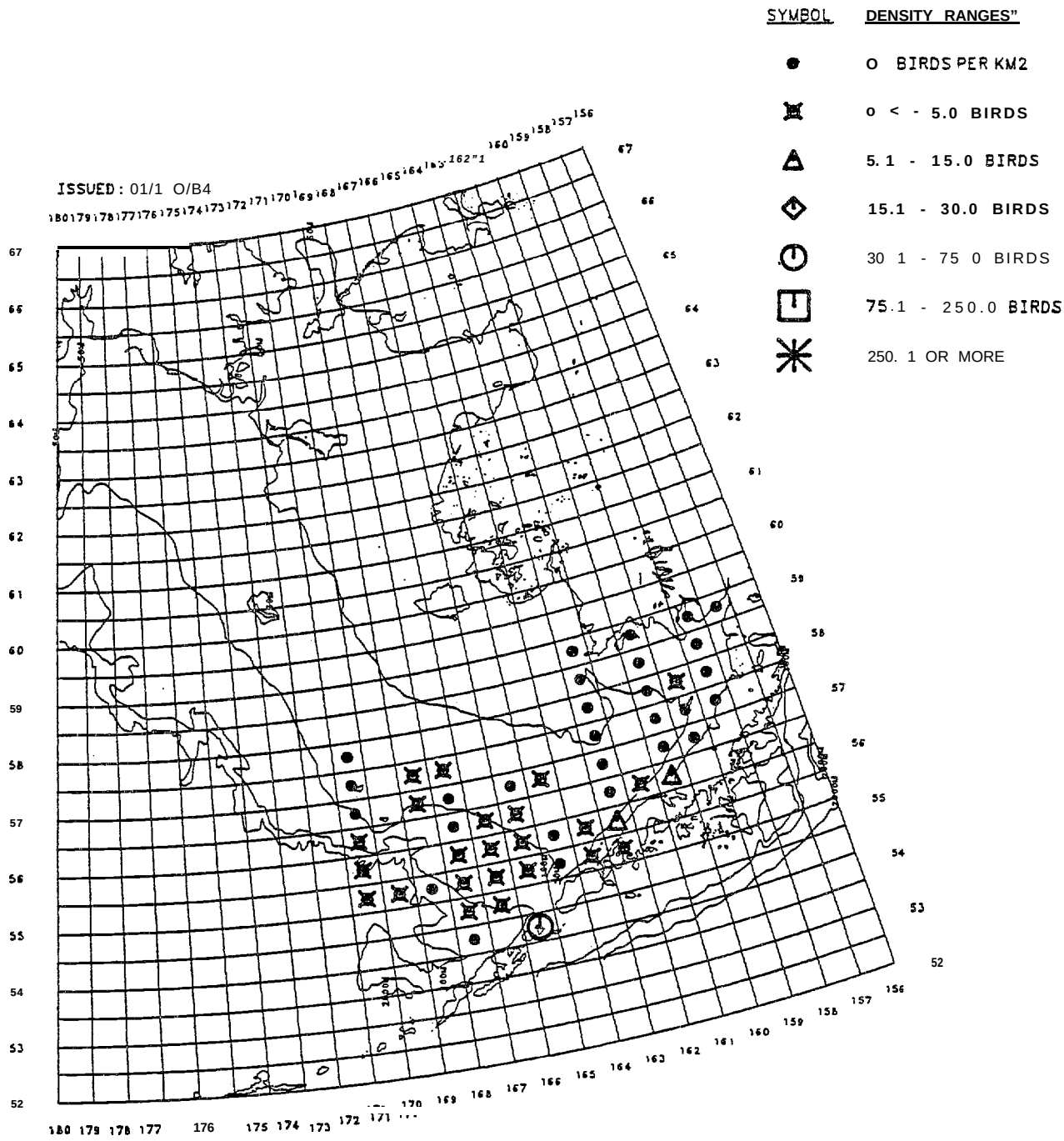
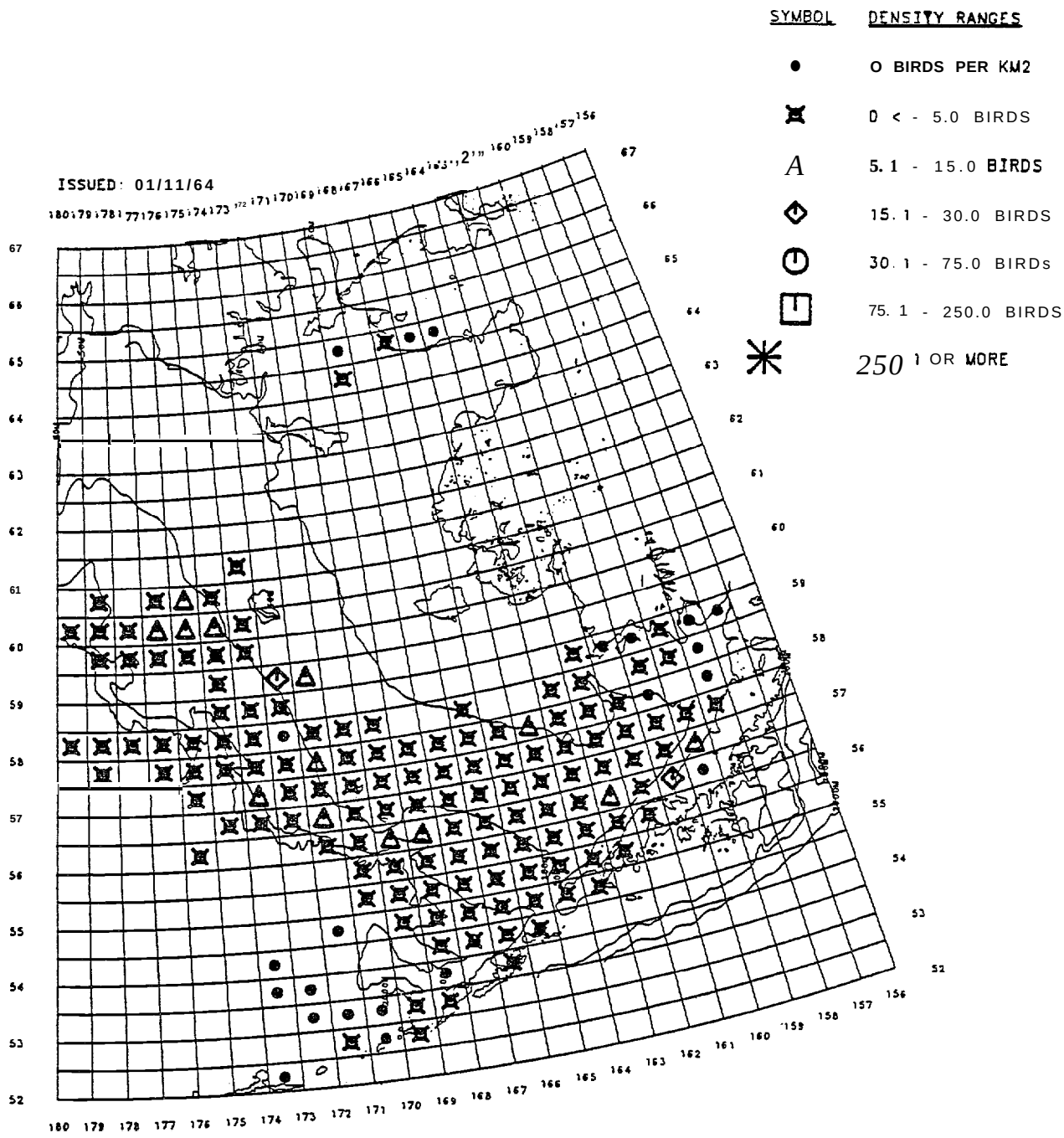


Figure 49. Mean densities, Black-1egged Kittiwakes: Winter.



BERING SEA MEAN DENSITY PLOT
BLACK-LEGGED KITTIWAKE
SPRING

Figure 50. Mean densities, Black-legged Kittiwakes: Spring.

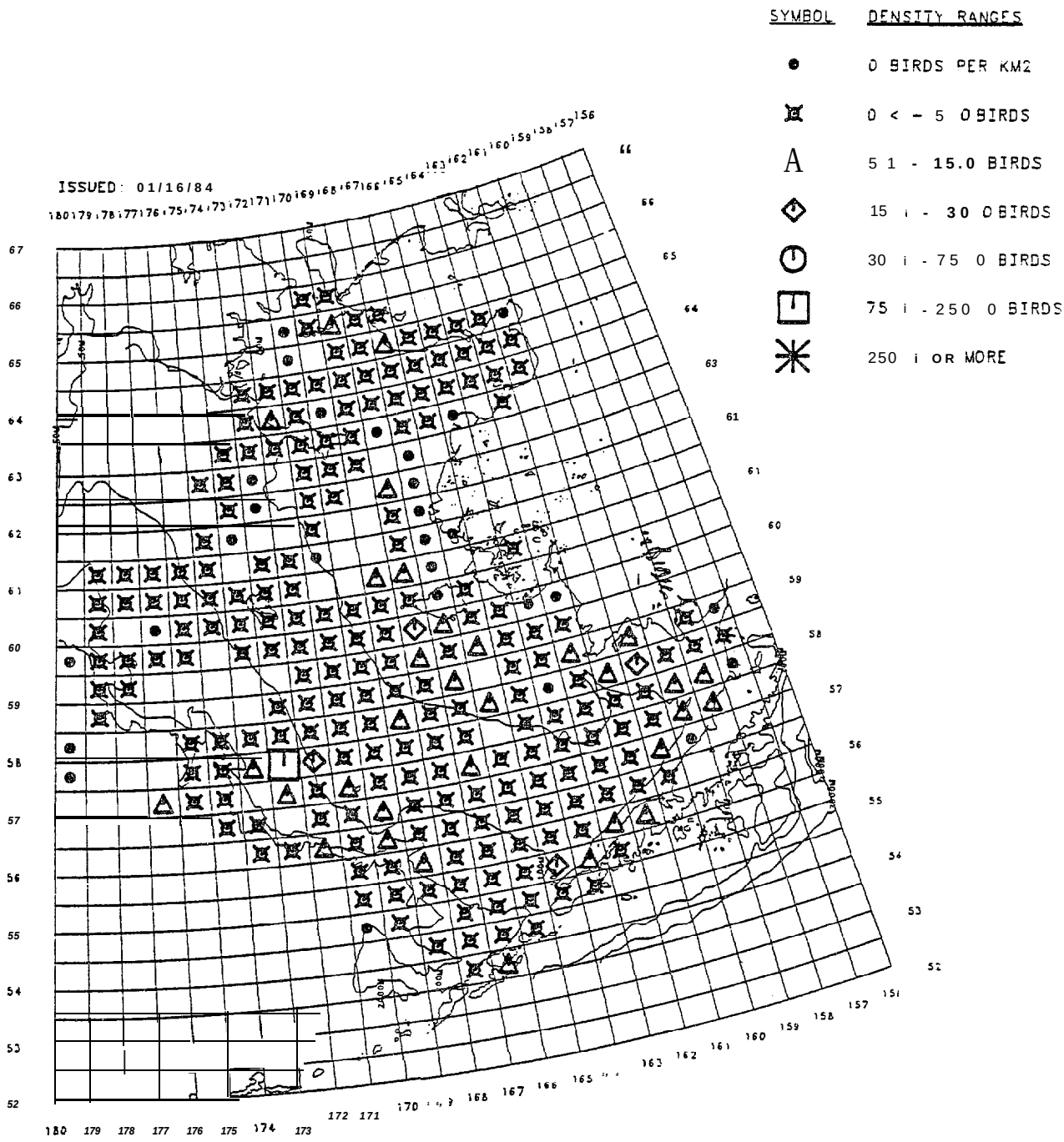
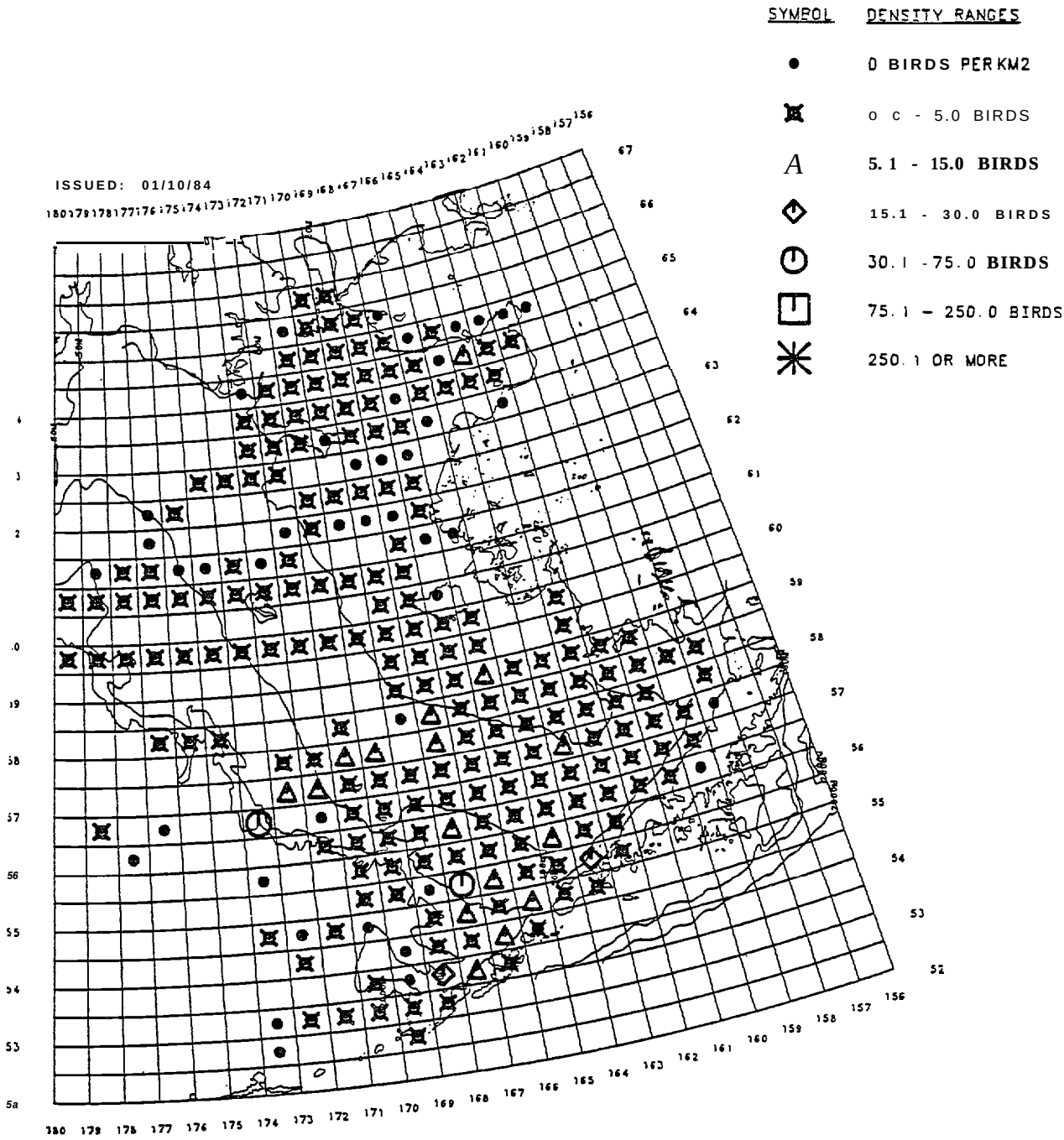
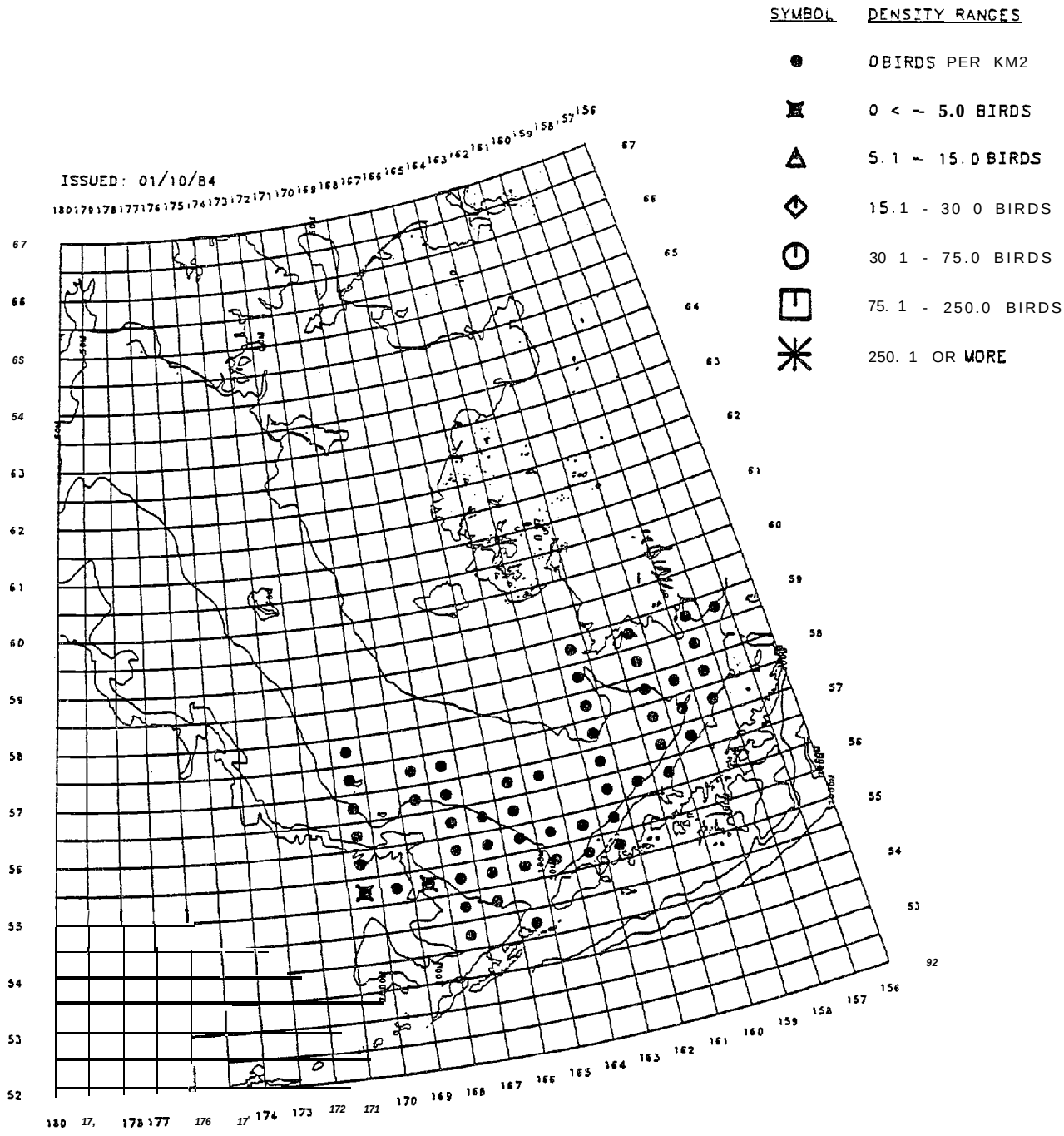


Figure 51. Mean densities, Black-legged Kittiwakes: Summer.



BERING SEA MEAN DENSITY PLOT
BLACK-LEGGED KITTIWAKE
AUTUMN

Figure 52. Mean densities, Black-legged Kittiwakes: Autumn.



BERING SEA MEAN DENSITY PLOT
RED-LEGGED KITTIWAKE
WINTER

Figure 53. Mean densities, Red-legged Kittiwakes: Winter.

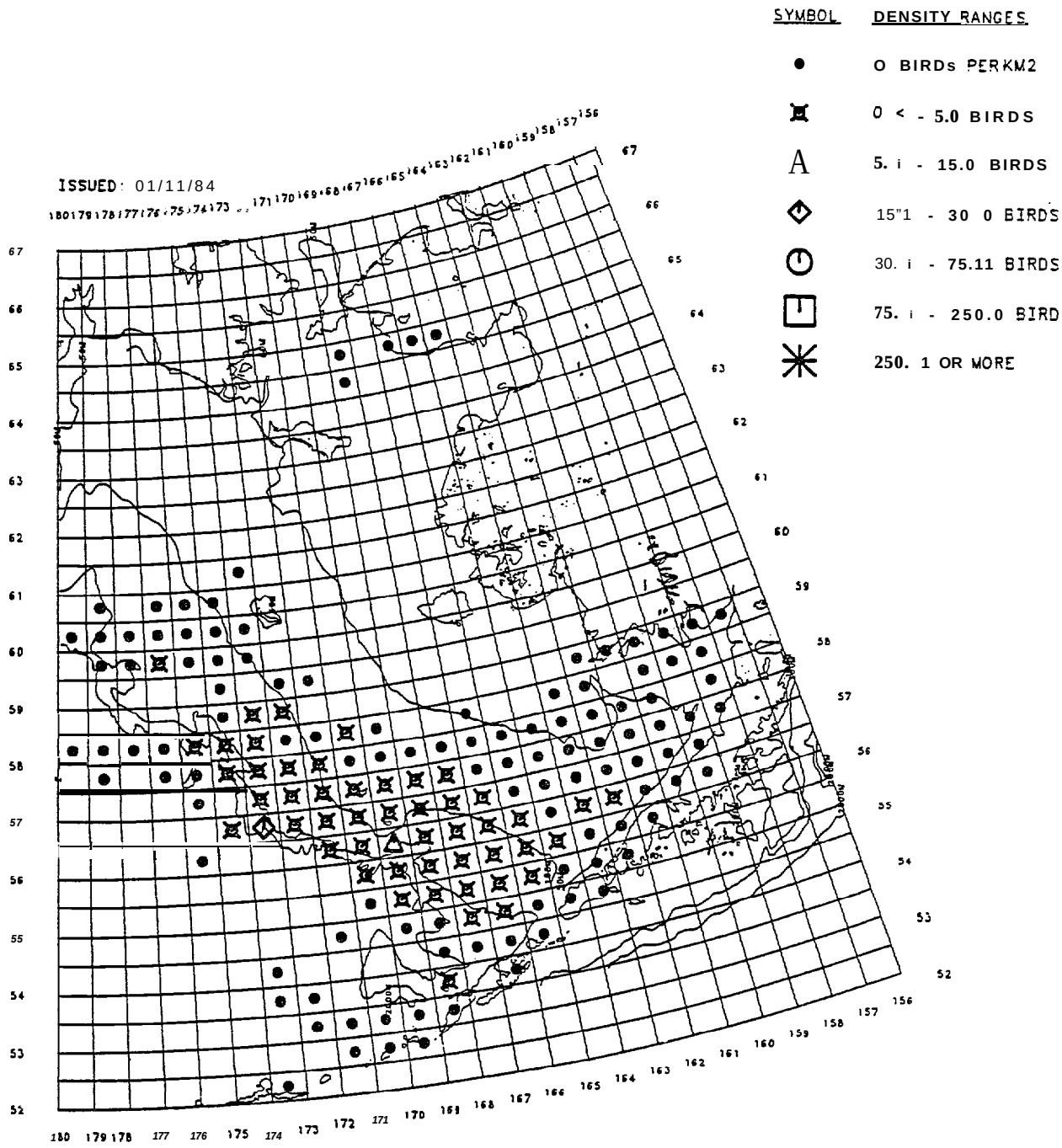
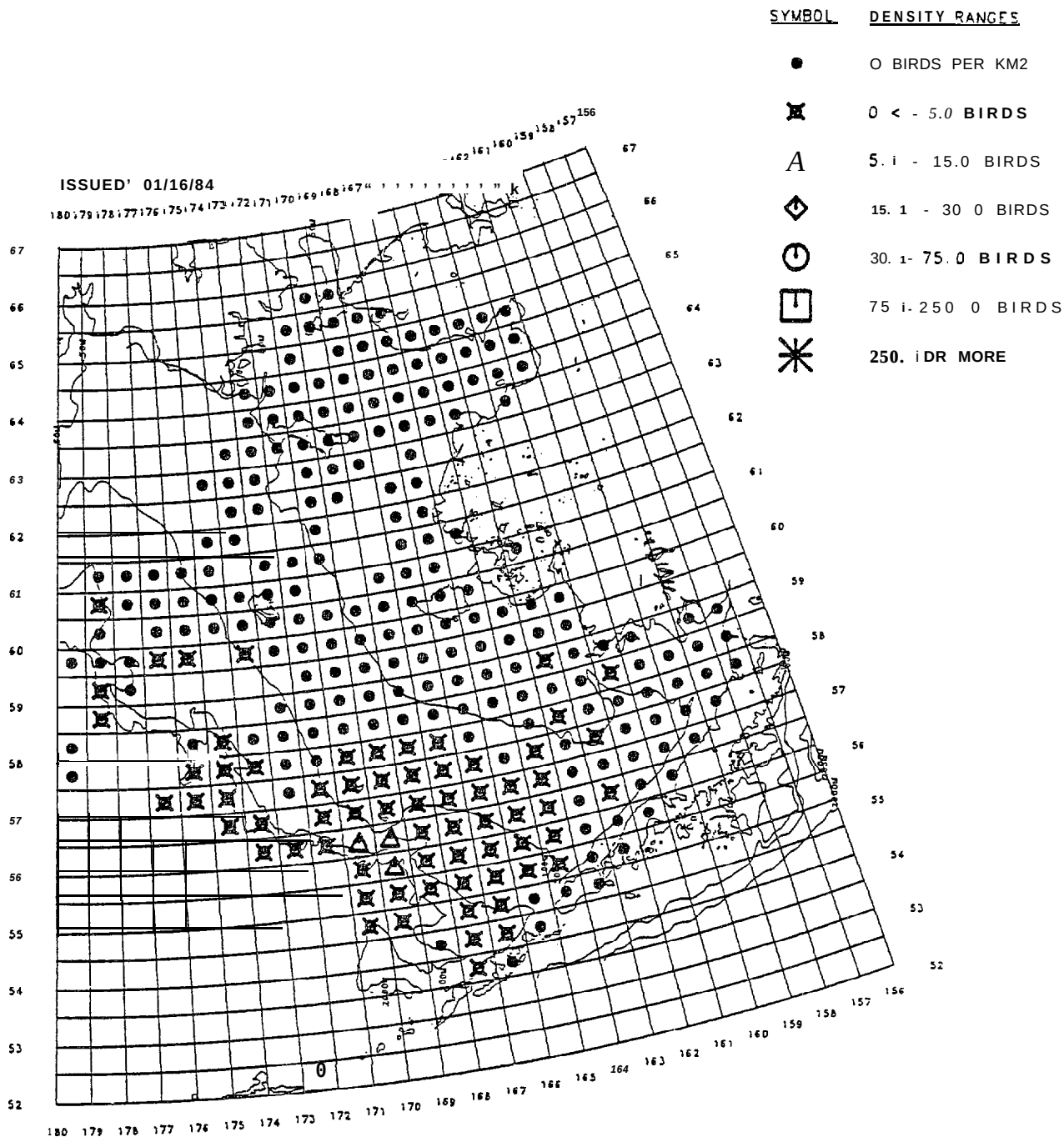
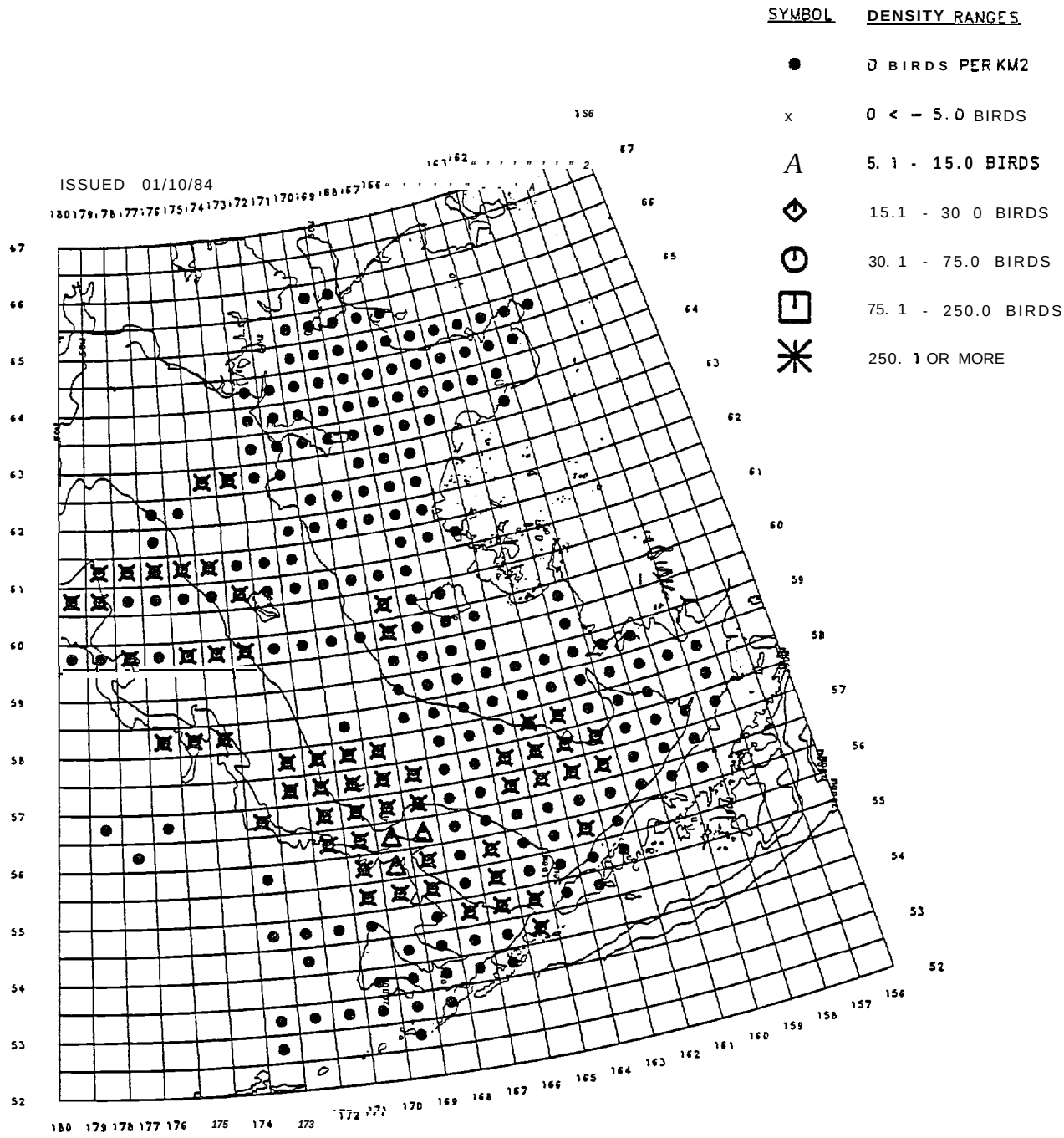


Figure 54. Mean densities, Red-legged Kittiwakes: Spring.



BERING SEA MEAN DENSITY PLOT
RED-LEGGED KITTIWAKE
SUMMER

Figure 55. Mean densities, Red-legged Kittiwakes: Summer.



BERING SEA MEAN DENSITY PLOT
RED-LEGGED KITTIWAKE
AUTUMN

Figure 56. Mean densities, Red-legged Kittiwakes: Autumn.

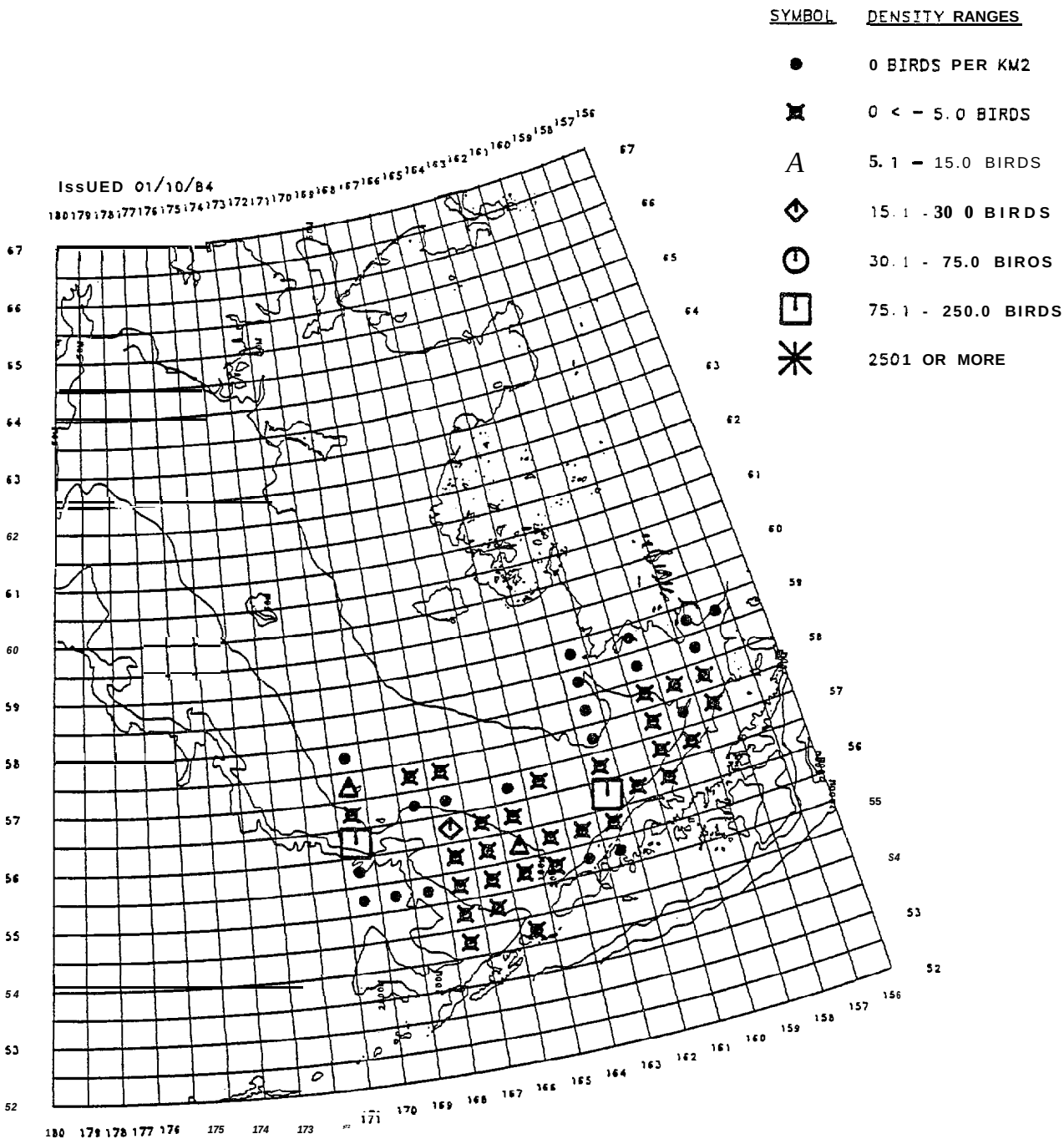
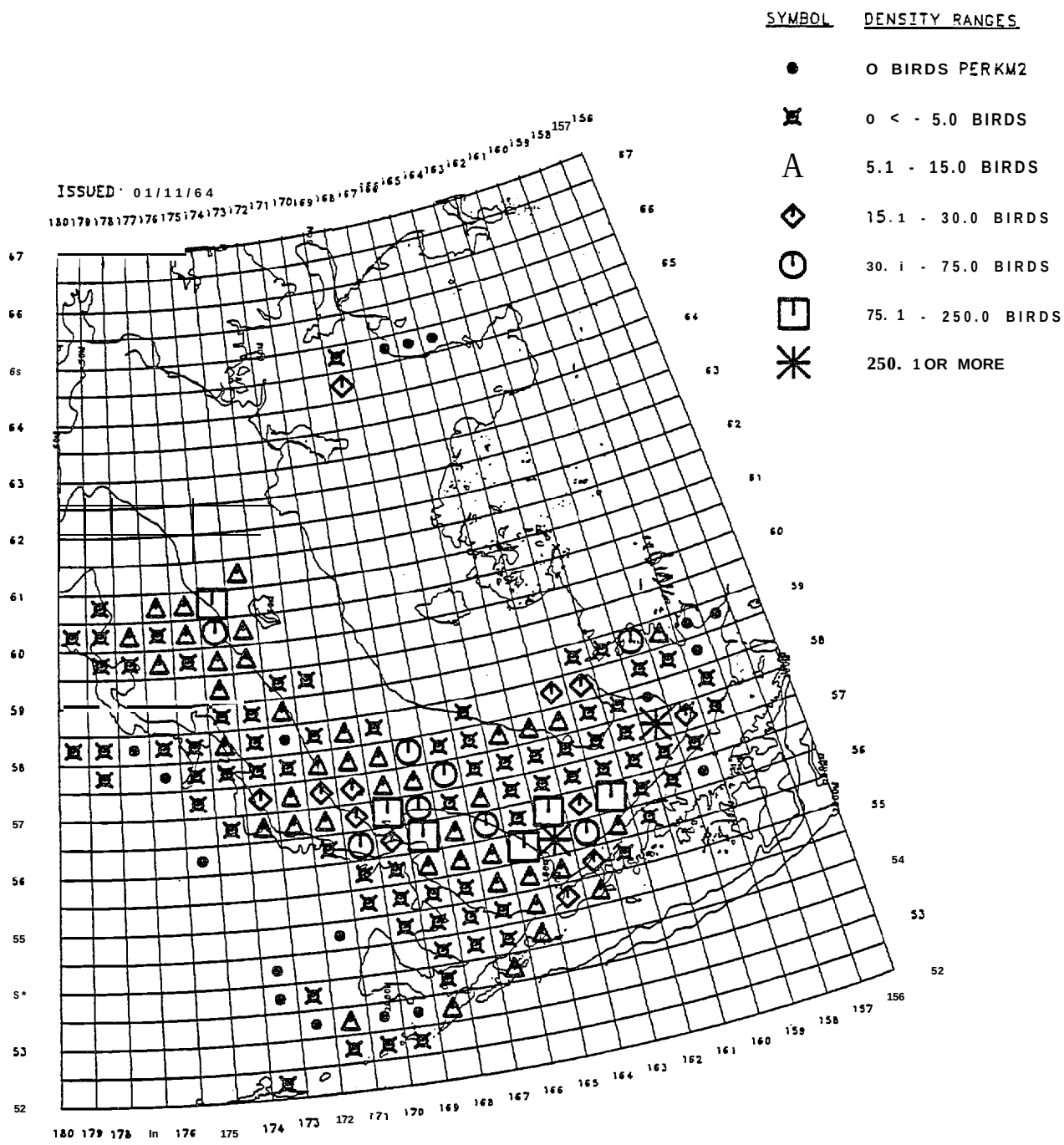


Figure 57. Mean densities, murres: Winter.



BERING SEA MEAN DENSITY PLOT
MURRES (G)
SPRING

Figure 58. Mean densities, murres: Spring.

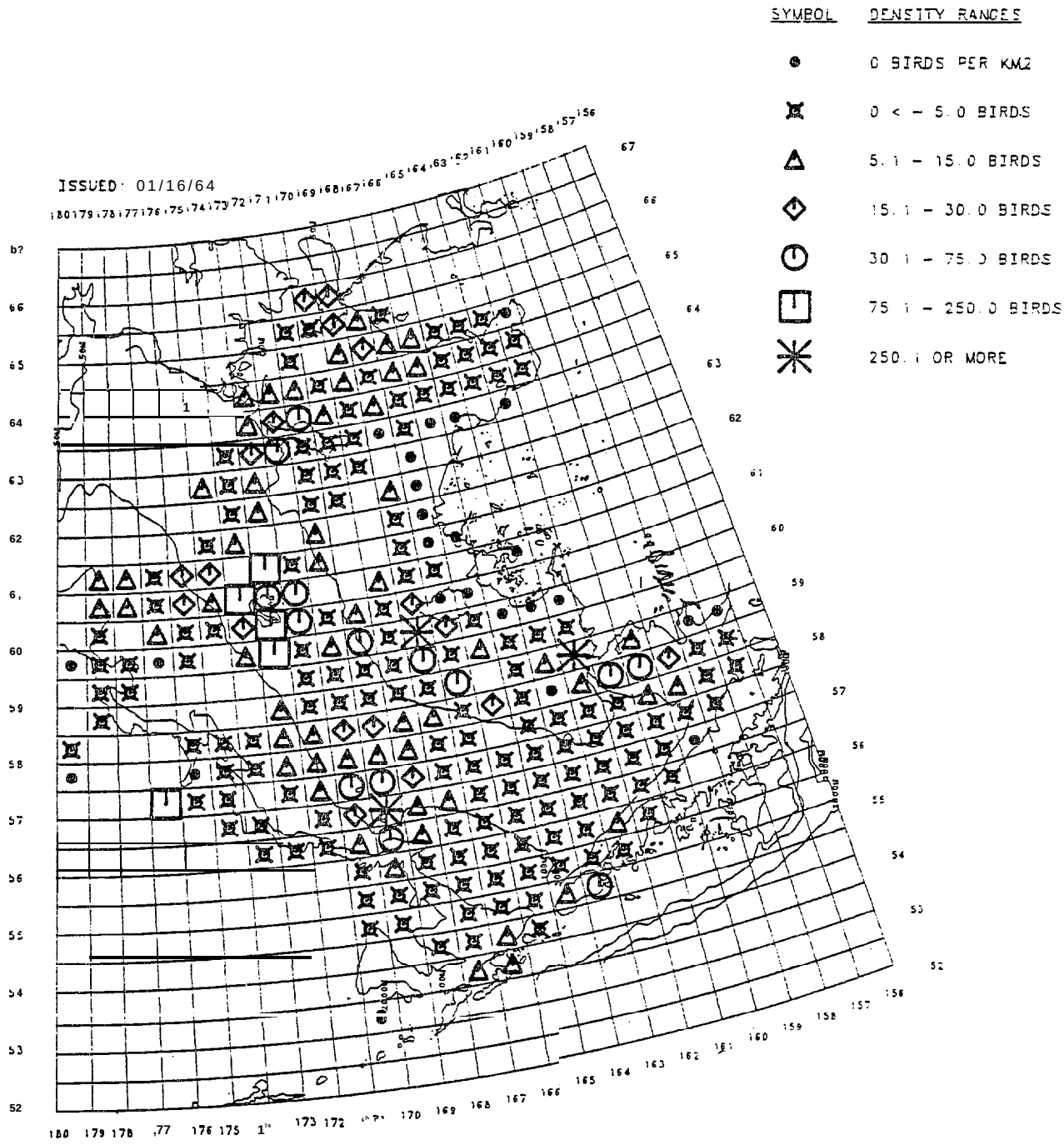
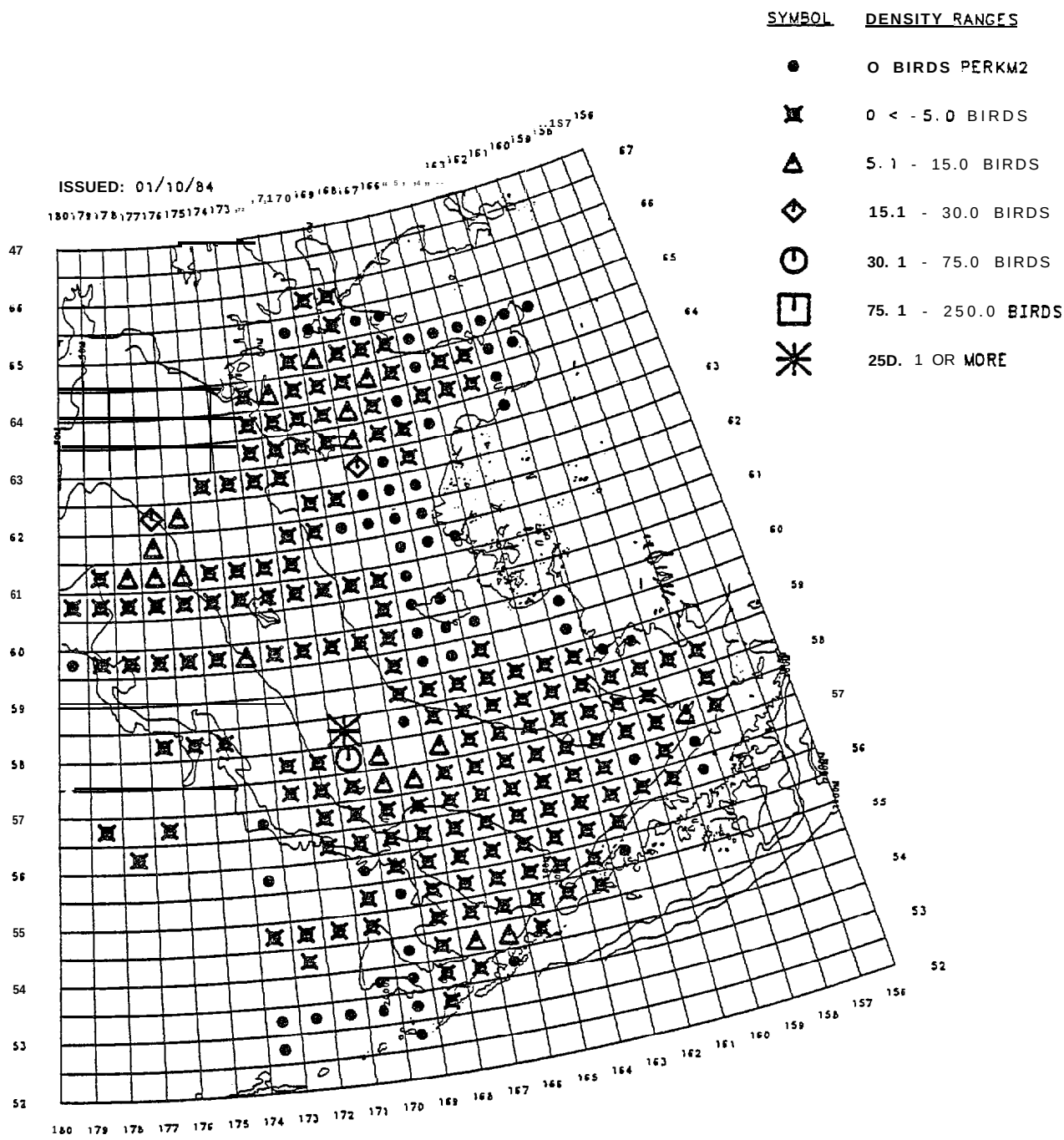


Figure 59. Mean densities, murres: Summer.



BERING SEA MEAN DENSITY PLOT
MURRES (G)
AUTUMN

Figure 60. Mean densities, murres: Autumn.

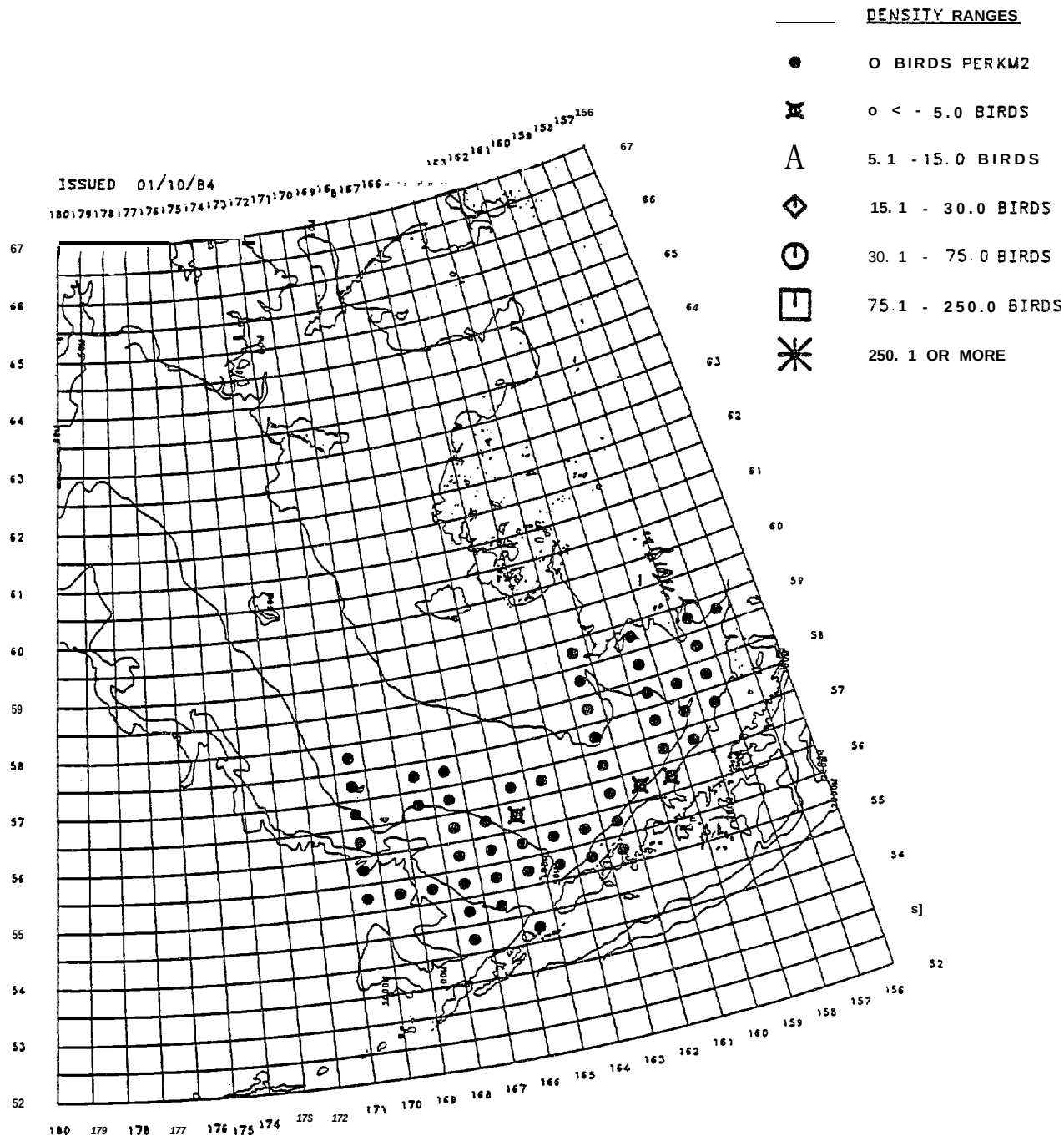
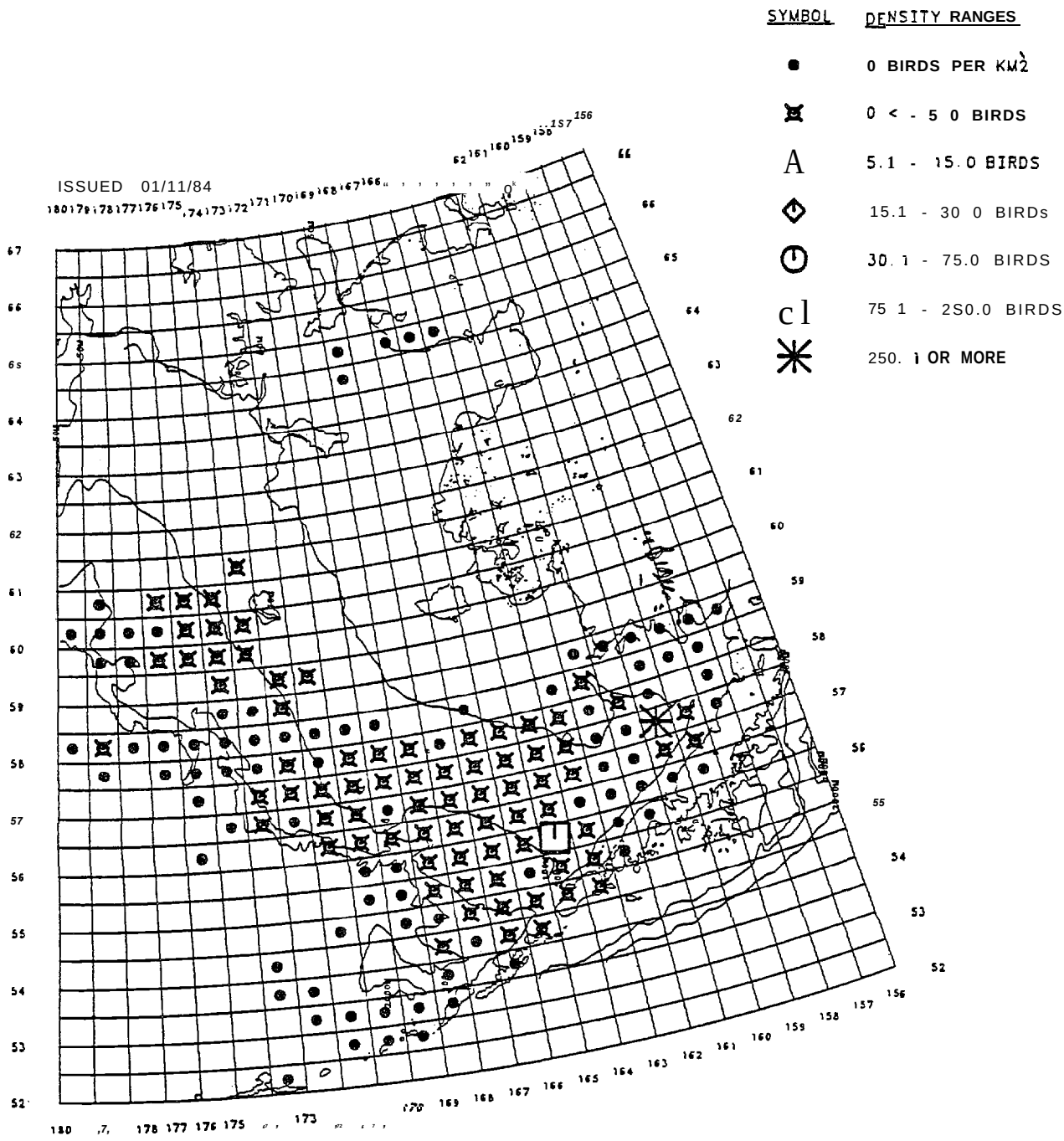
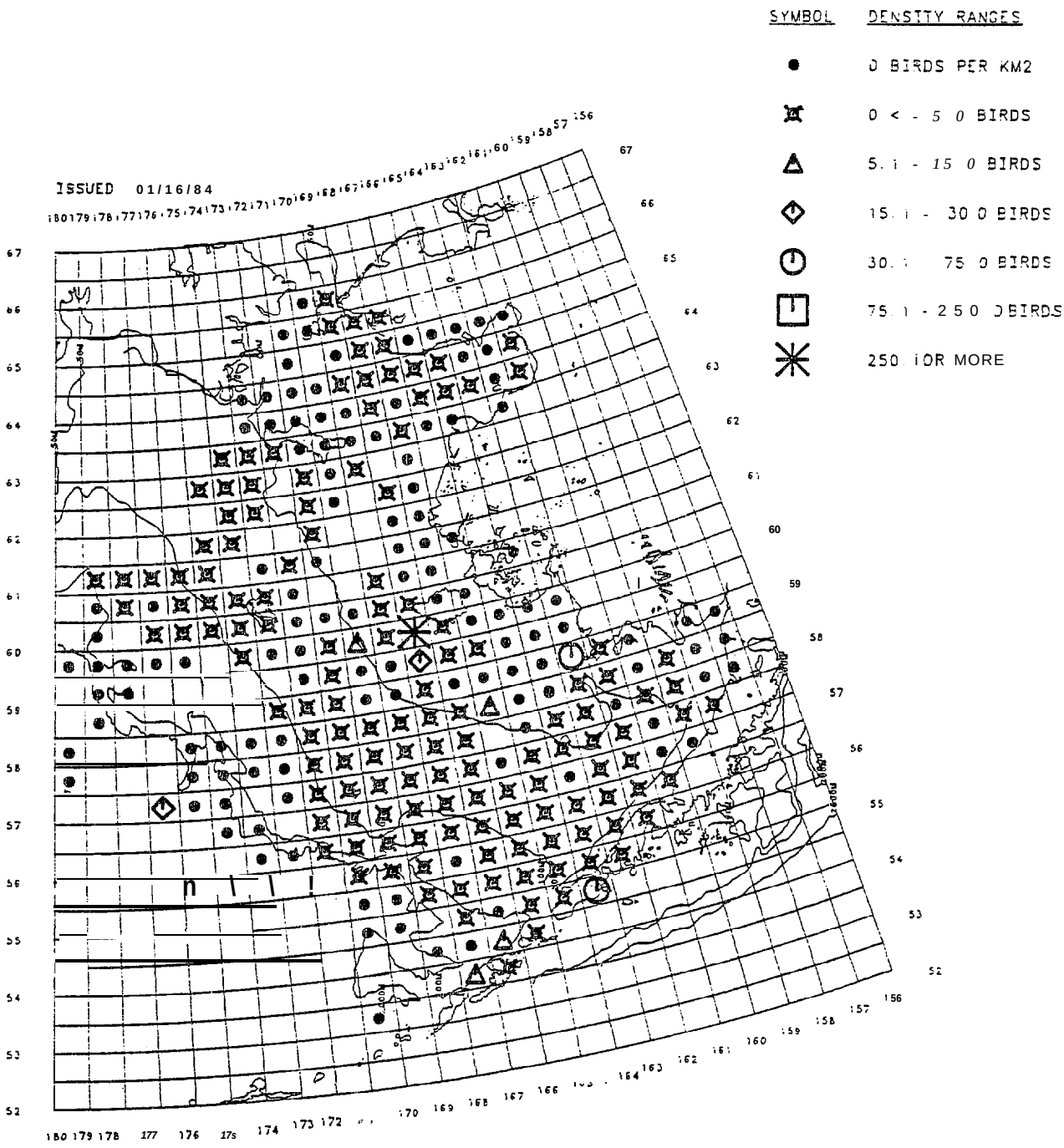


Figure 61. Mean densities, Common Murres: Winter.



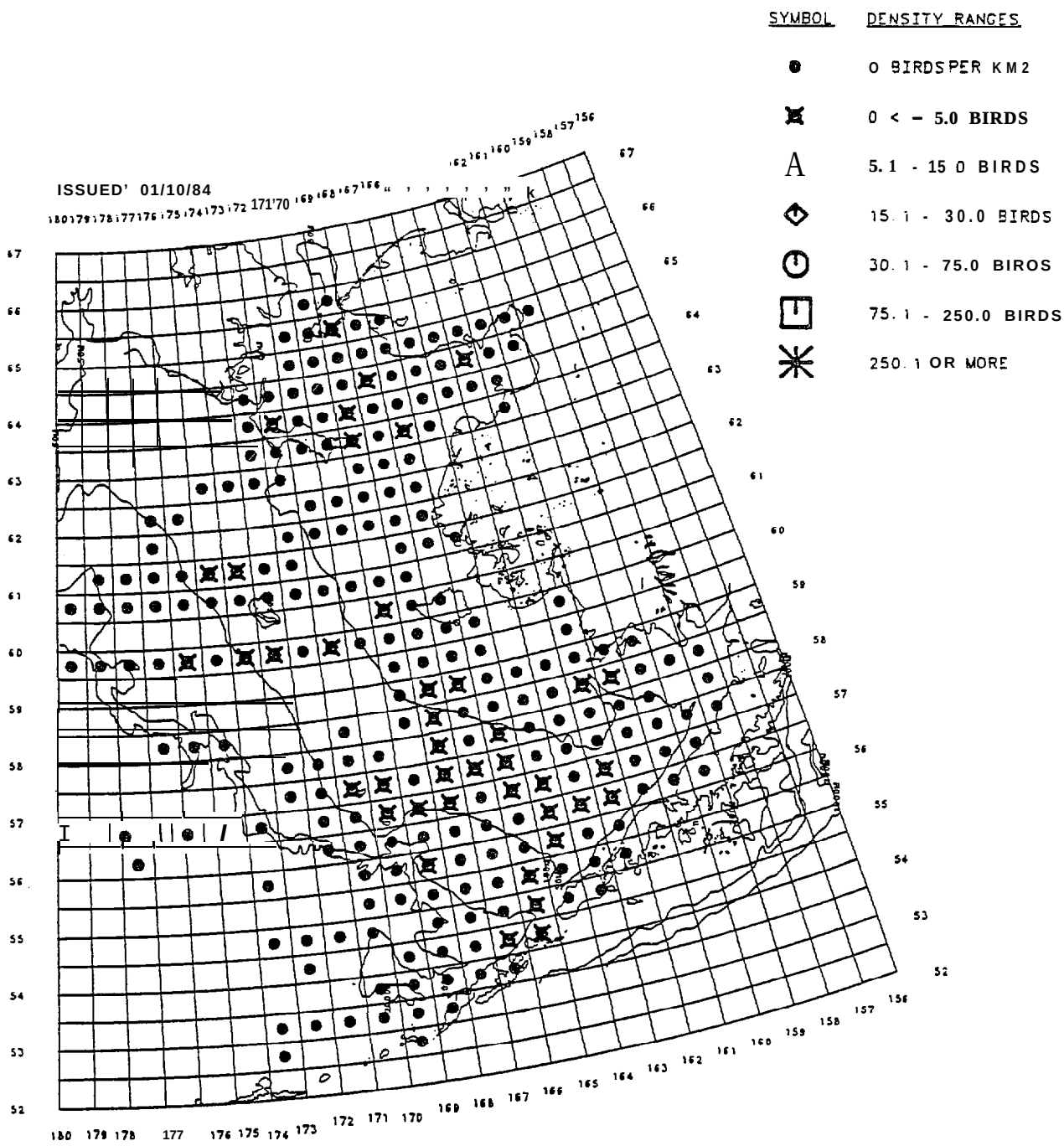
BERING SEA MEAN DENSITY PLOT
COMMON MURRE
SPRING

Figure 62. Mean densities, Common Murres: Spring.



BERING SEA MEAN DENSITY PLOT
COMMON MURRE
SUMMER

Figure 63. Mean densities, Common Murres: Summer.



BERING SEA MEAN DENSITY PLOT
COMMON MURRE
AUTUMN

Figure 64. Mean densities, Common Murres: Autumn.

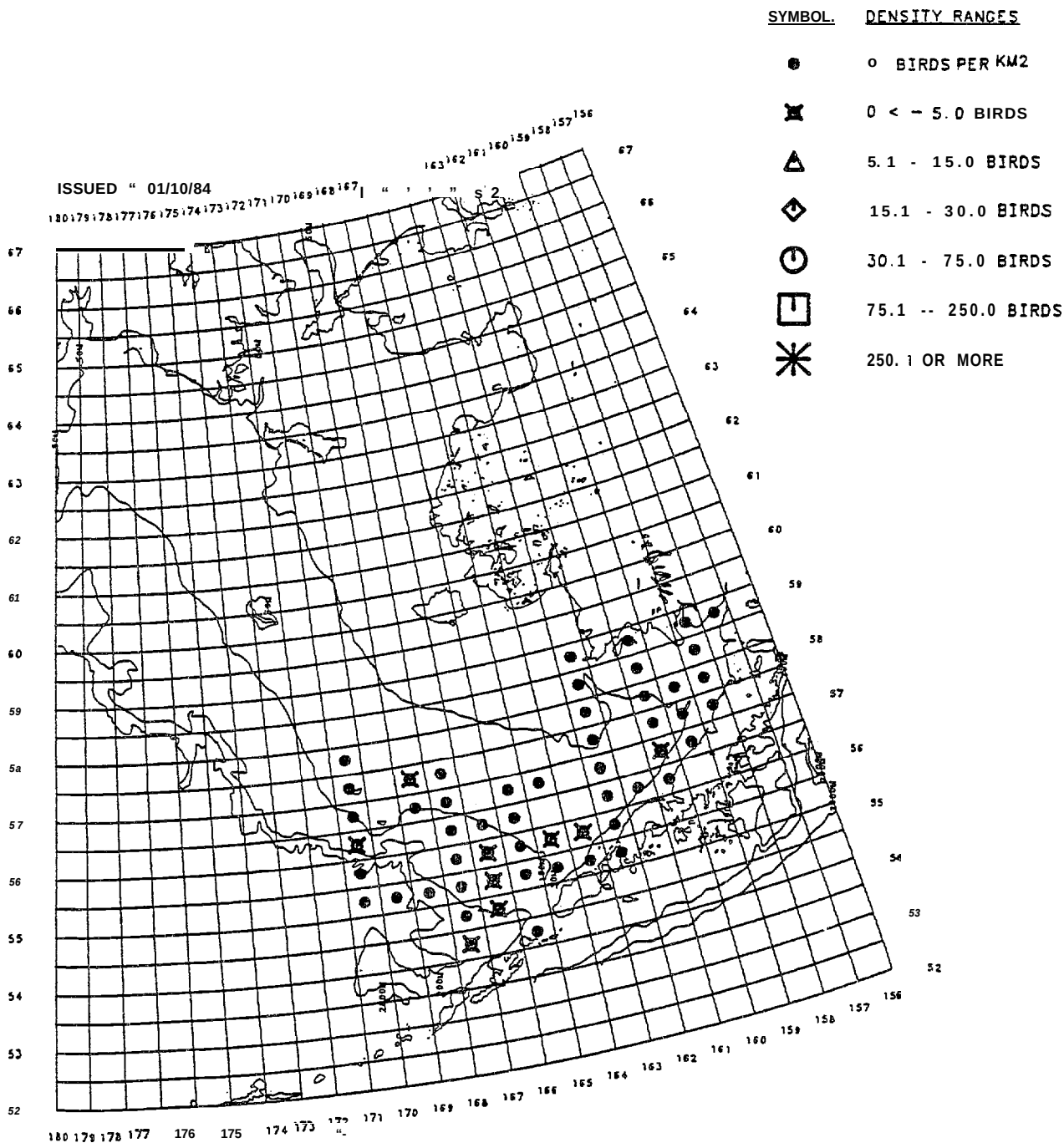


Figure 65. Mean densities, Thick-billed Murres: Winter.

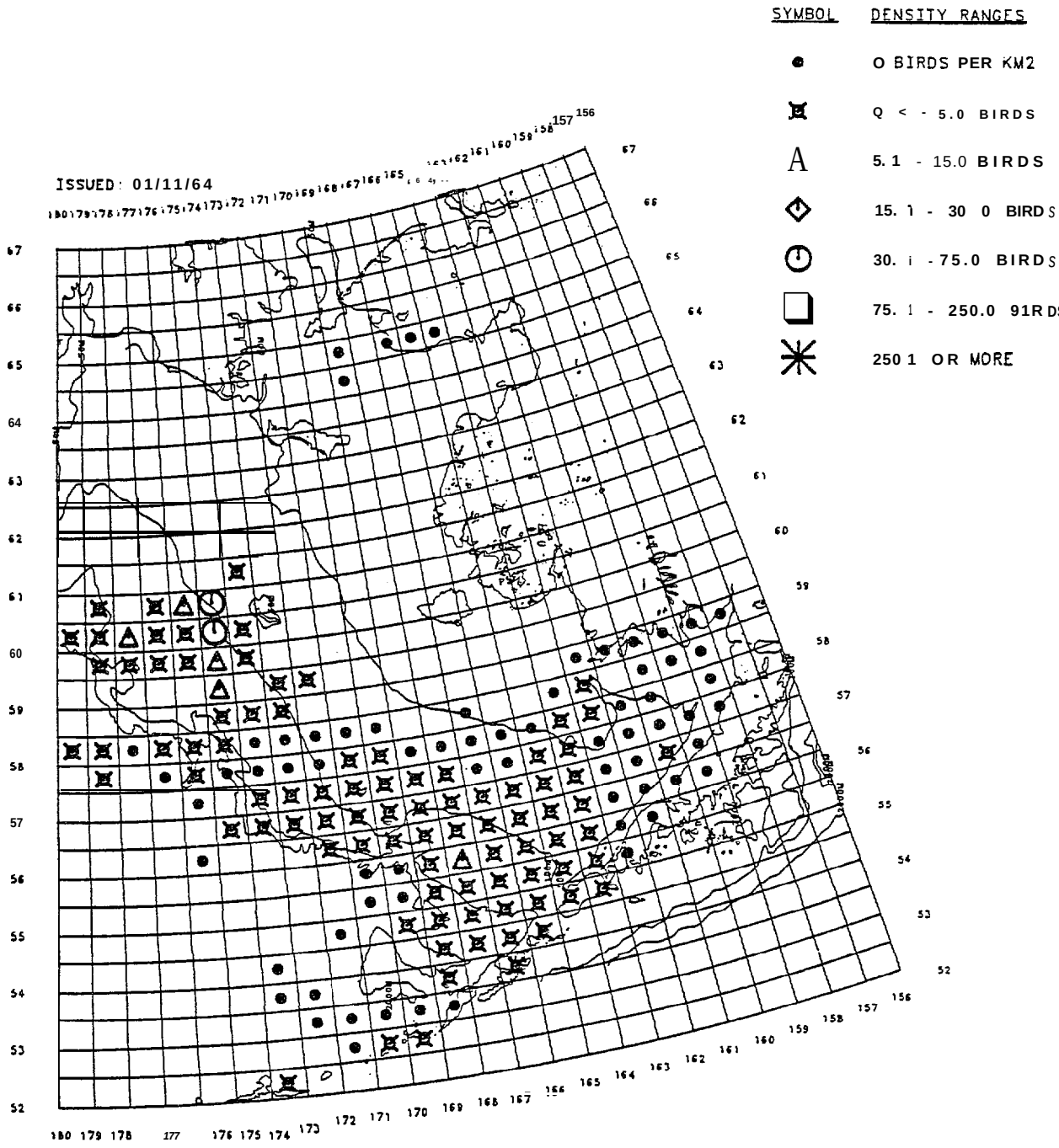


Figure 66. Mean densities, Thick-billed **Murres:** Spring.

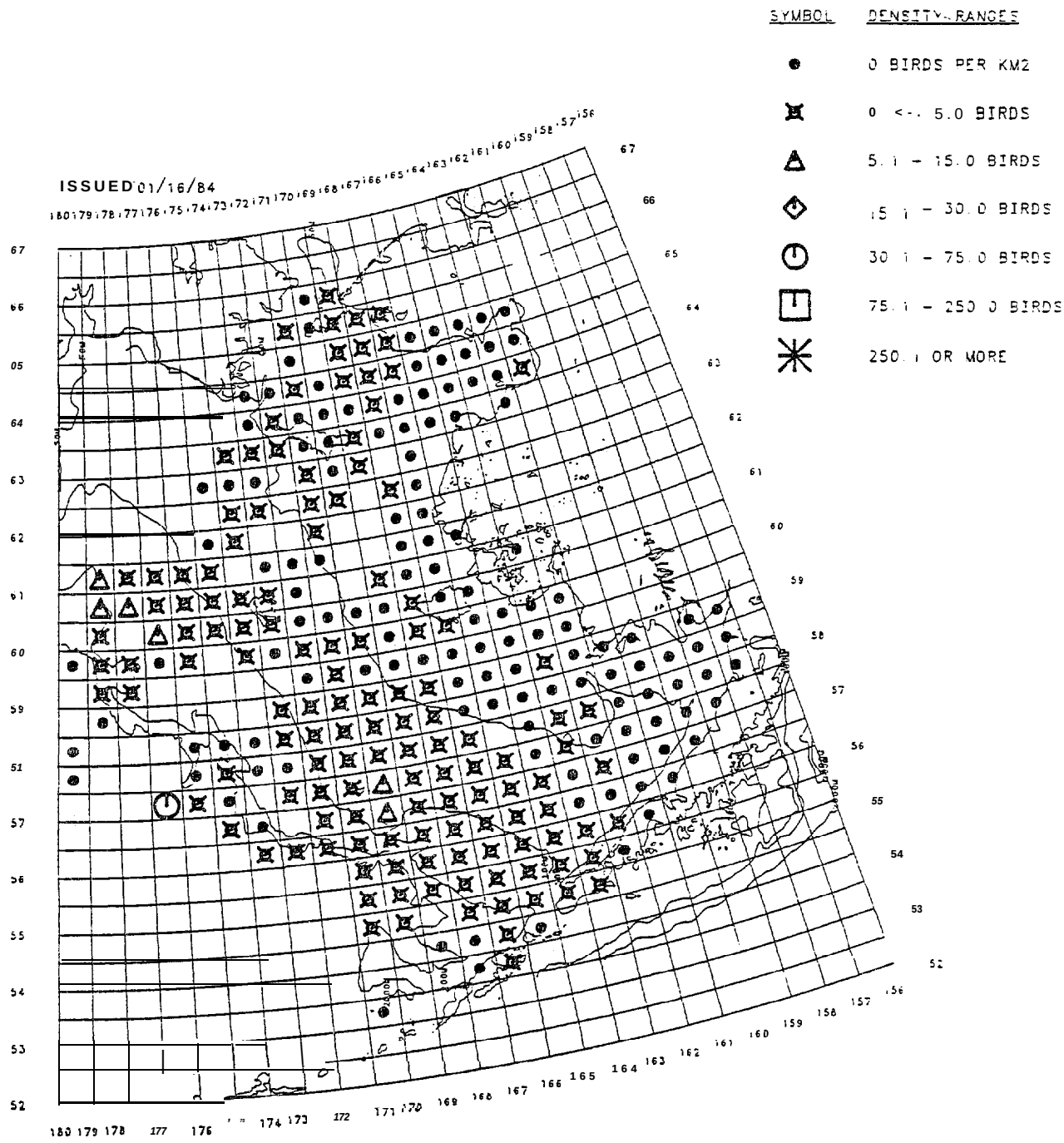


Figure 67. Mean densities, Thick-billed Murres: Summer.

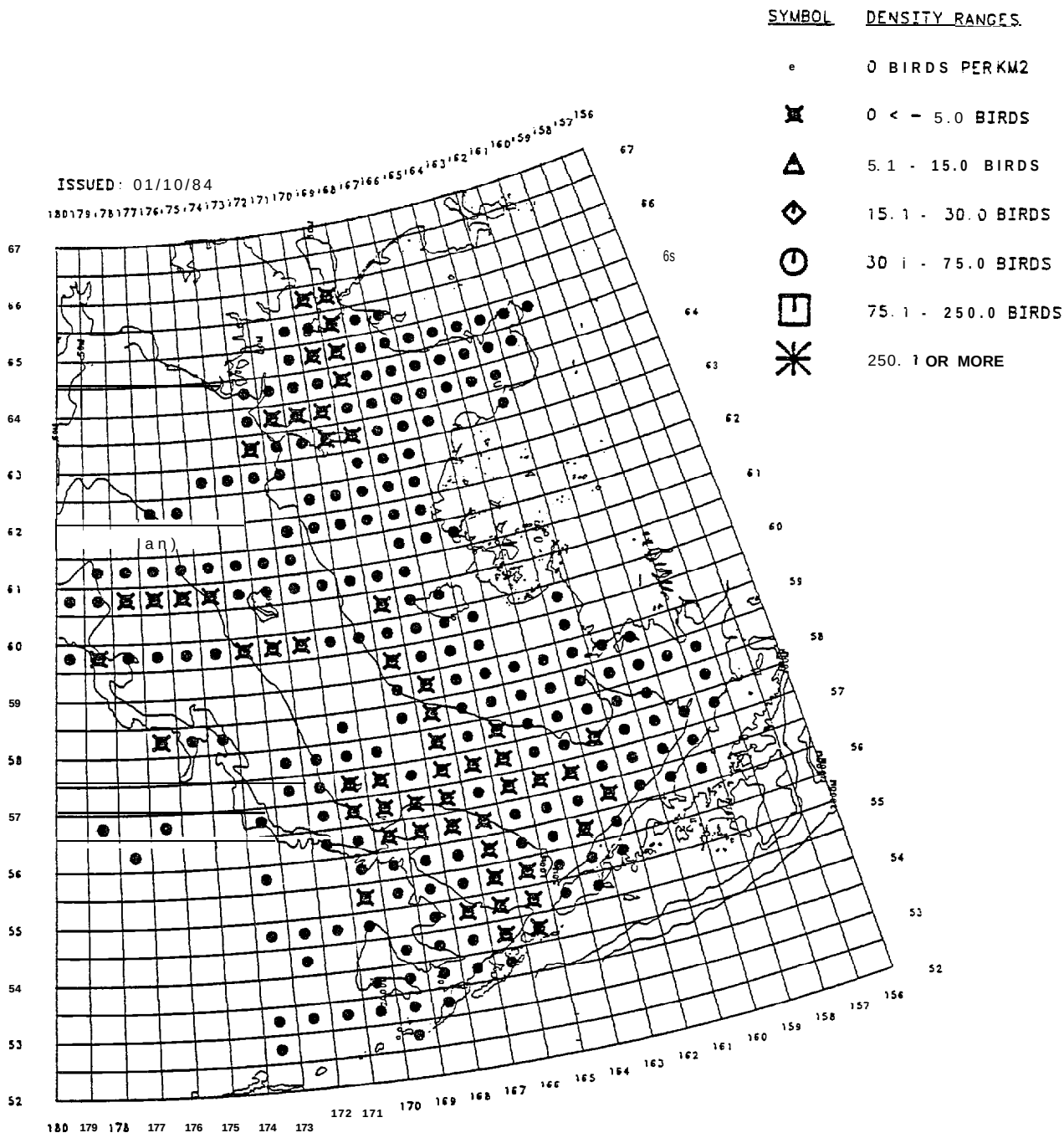
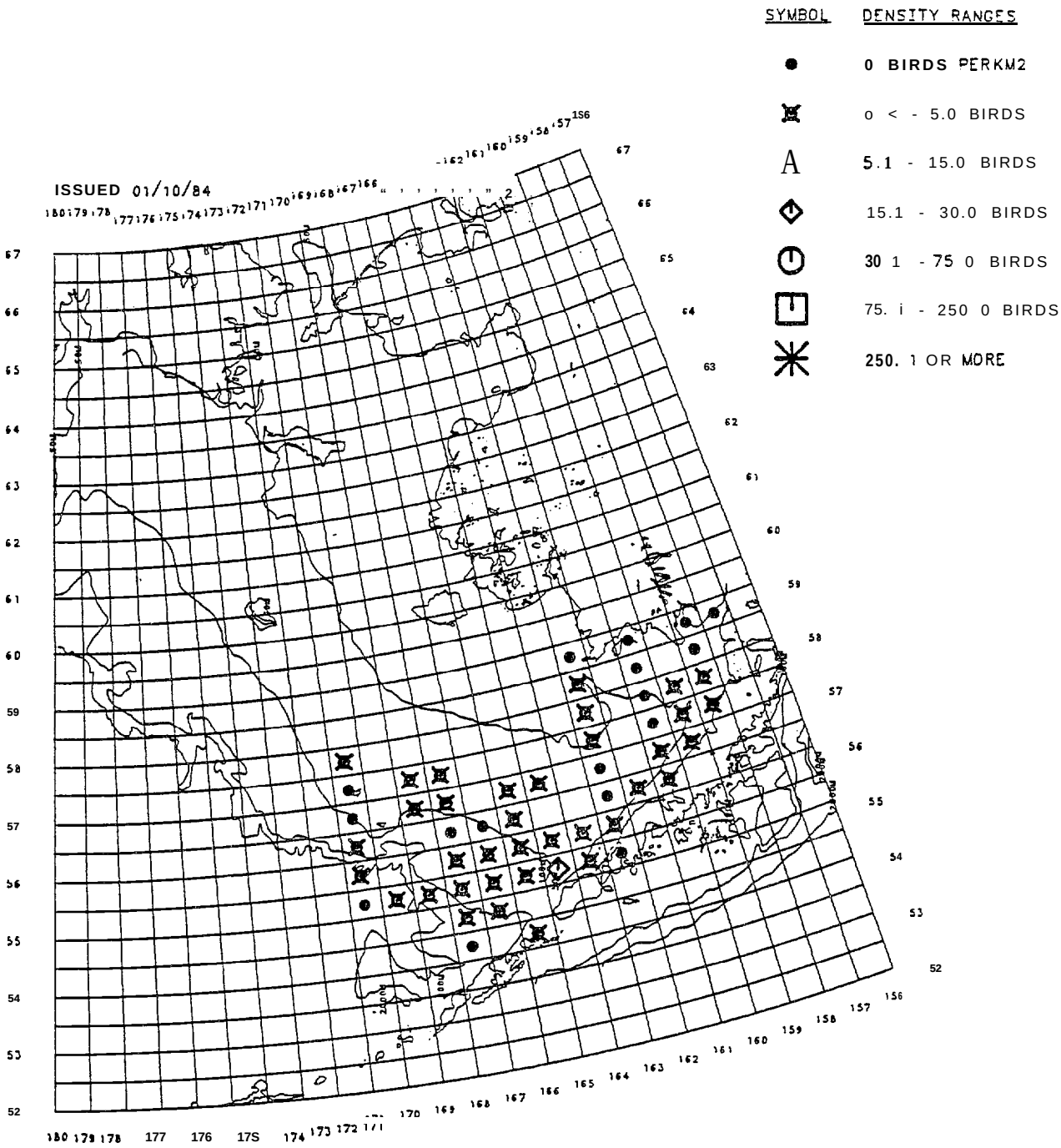
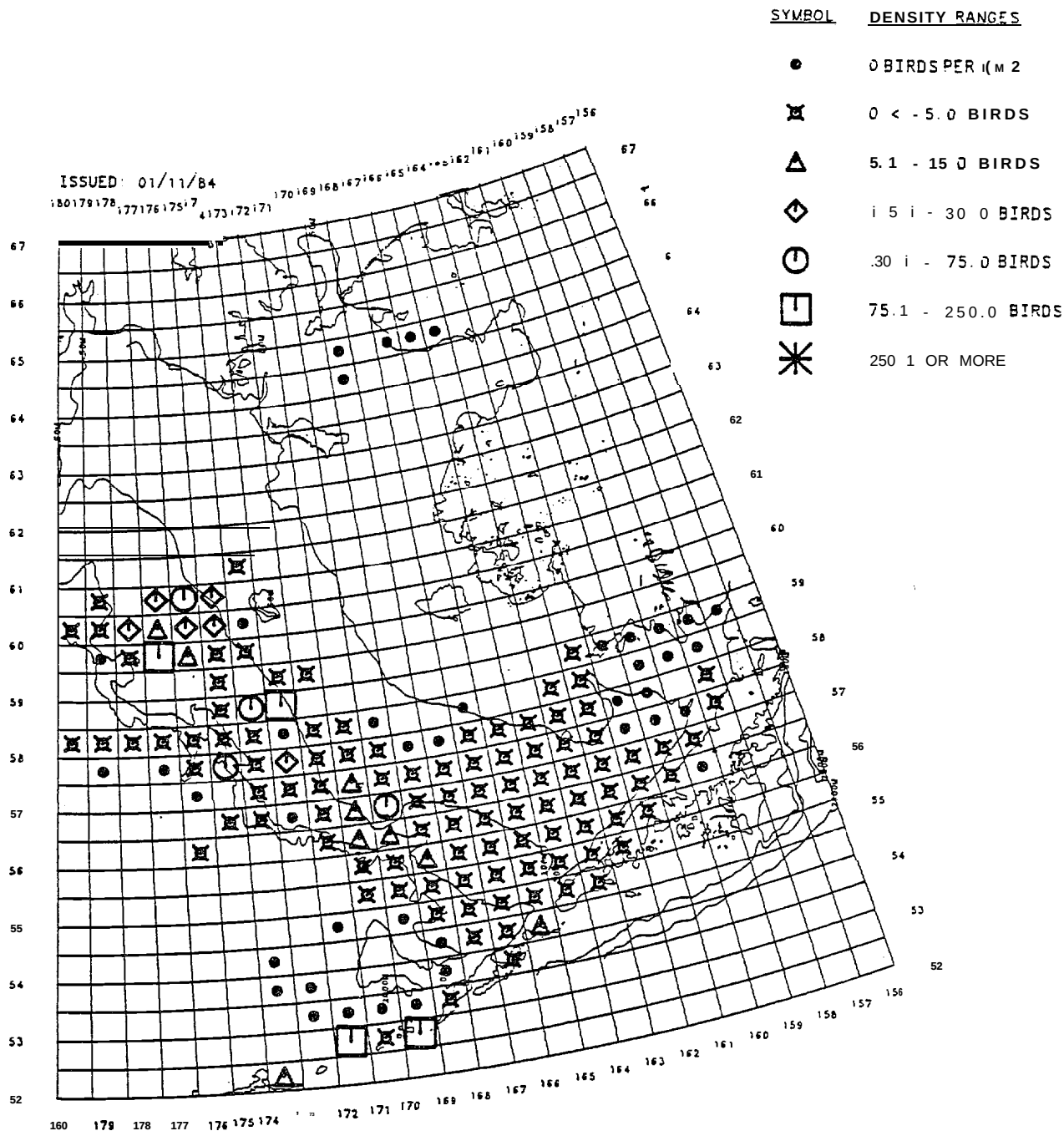


Figure 68. Mean densities, Thick-billed Murres: Autumn.



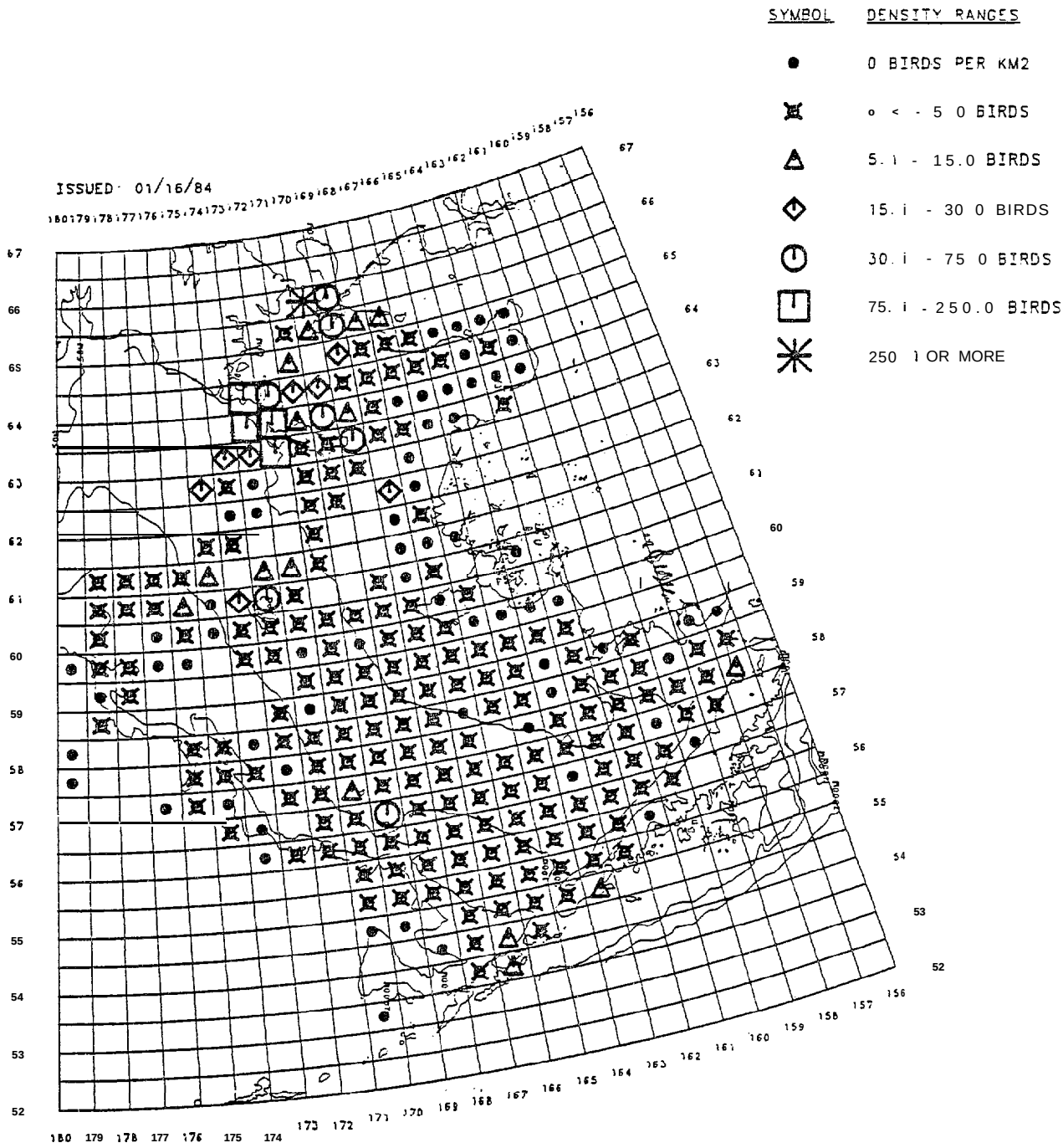
BERING SEA MEAN DENSITY PLOT
SMALL & UNIDENTIFIED ALCIDS
WINTER

Figure 69. Mean densities, small alcids: Winter.



BERING SEA MEAN DENSITY PLOT
SMALL & UNIDENTIFIED ALCIDS
SPRING

Figure 70. Mean densities, small alcids: Spring.



BERING SEA MEAN DENSITY PLOT
SMALL & UNIDENTIFIED ALCIDS
SUMMER

Figure 71. Mean densities, small alcids: Summer.

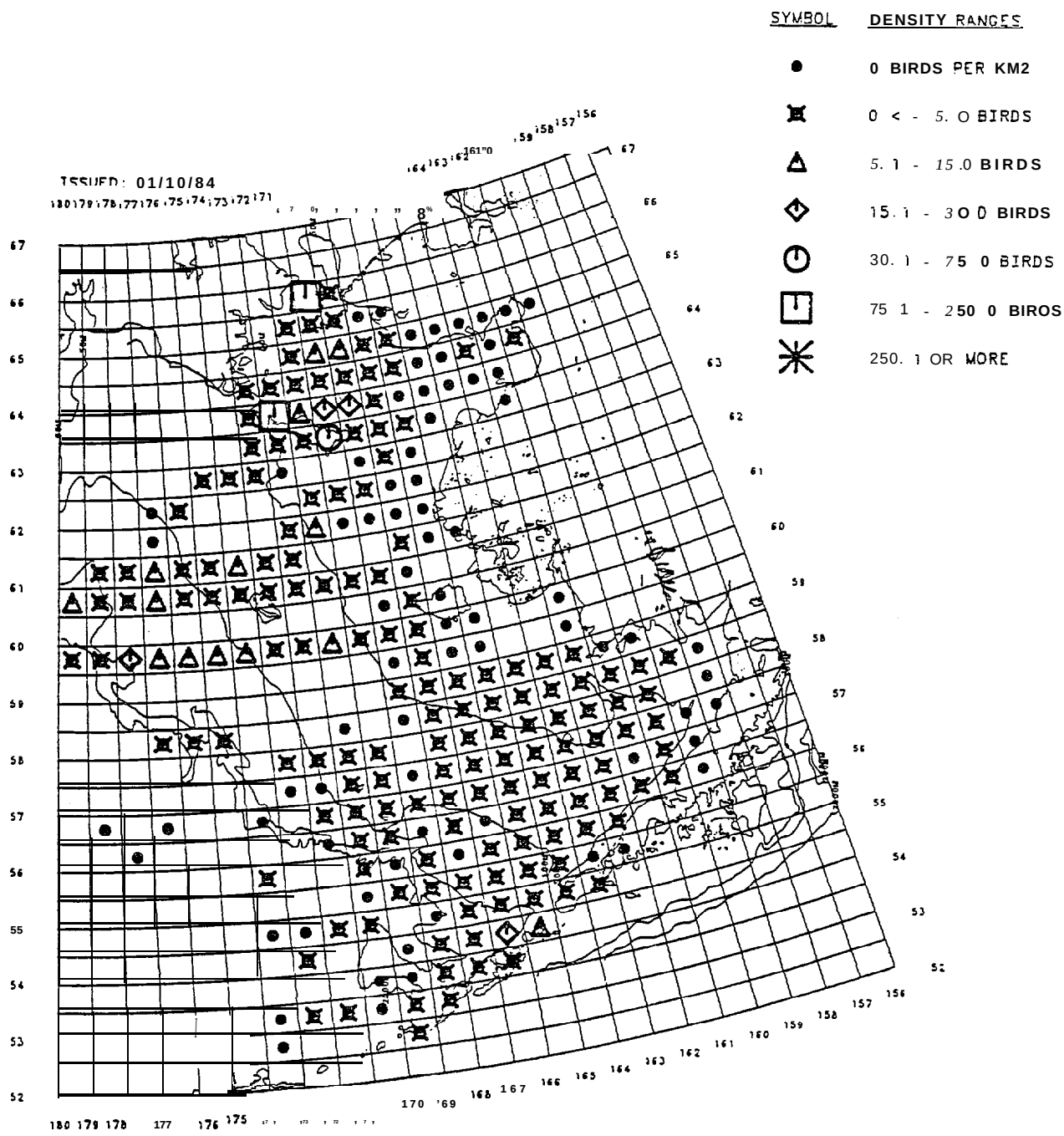


Figure 72. Mean densities, small alcids: Autumn.

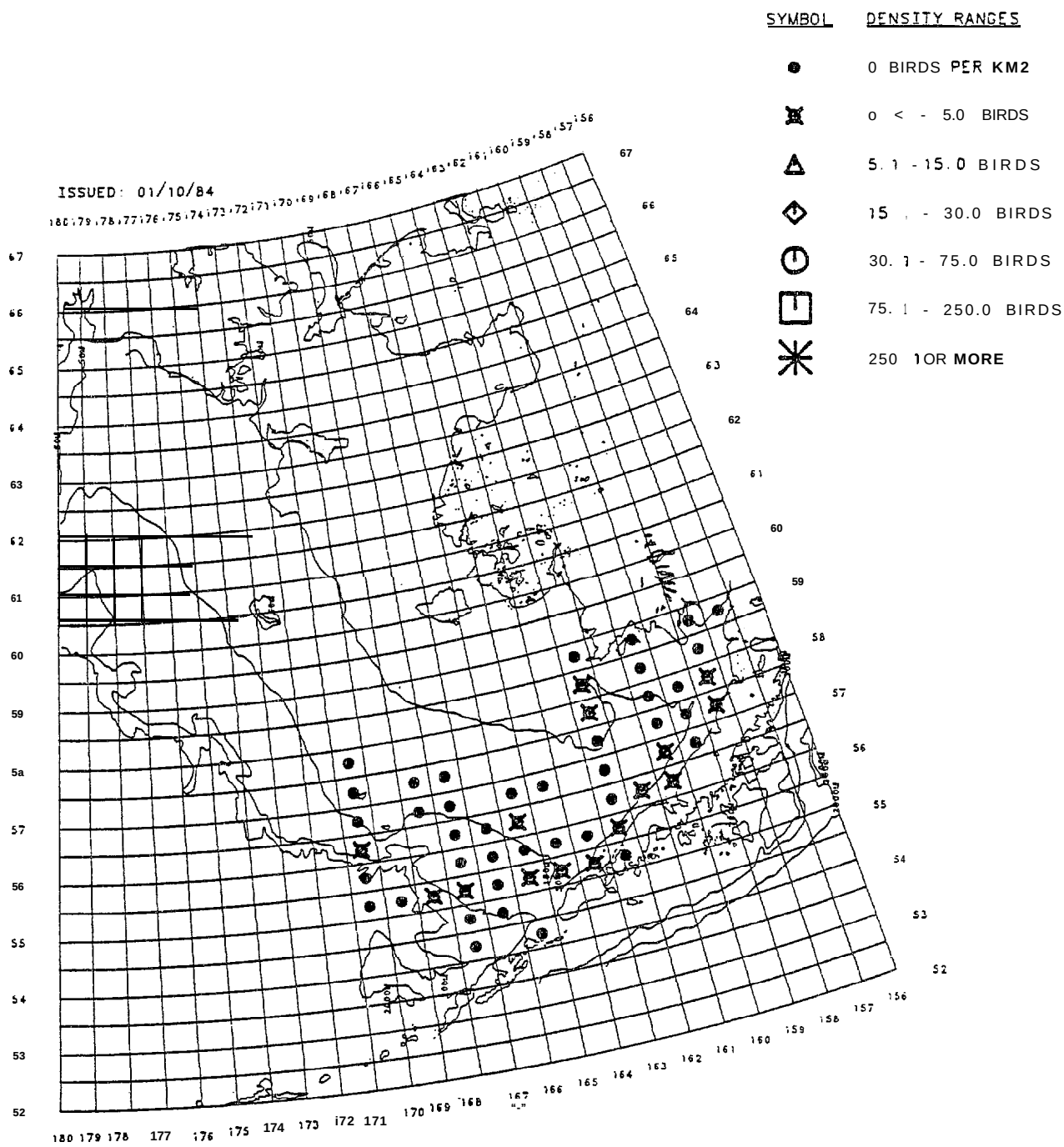


Figure 73. Mean densities, Parakeet Auklets: Winter.

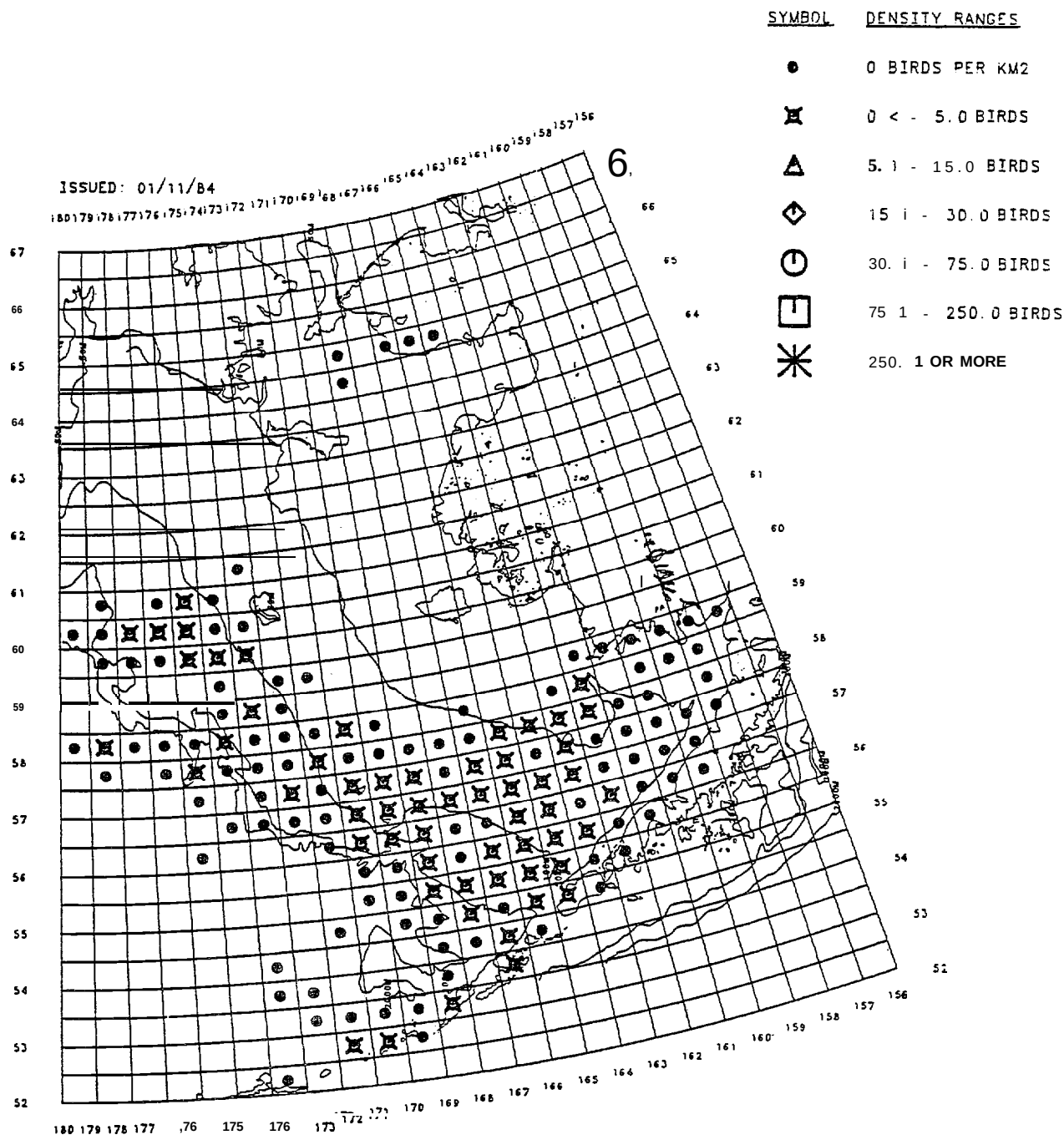
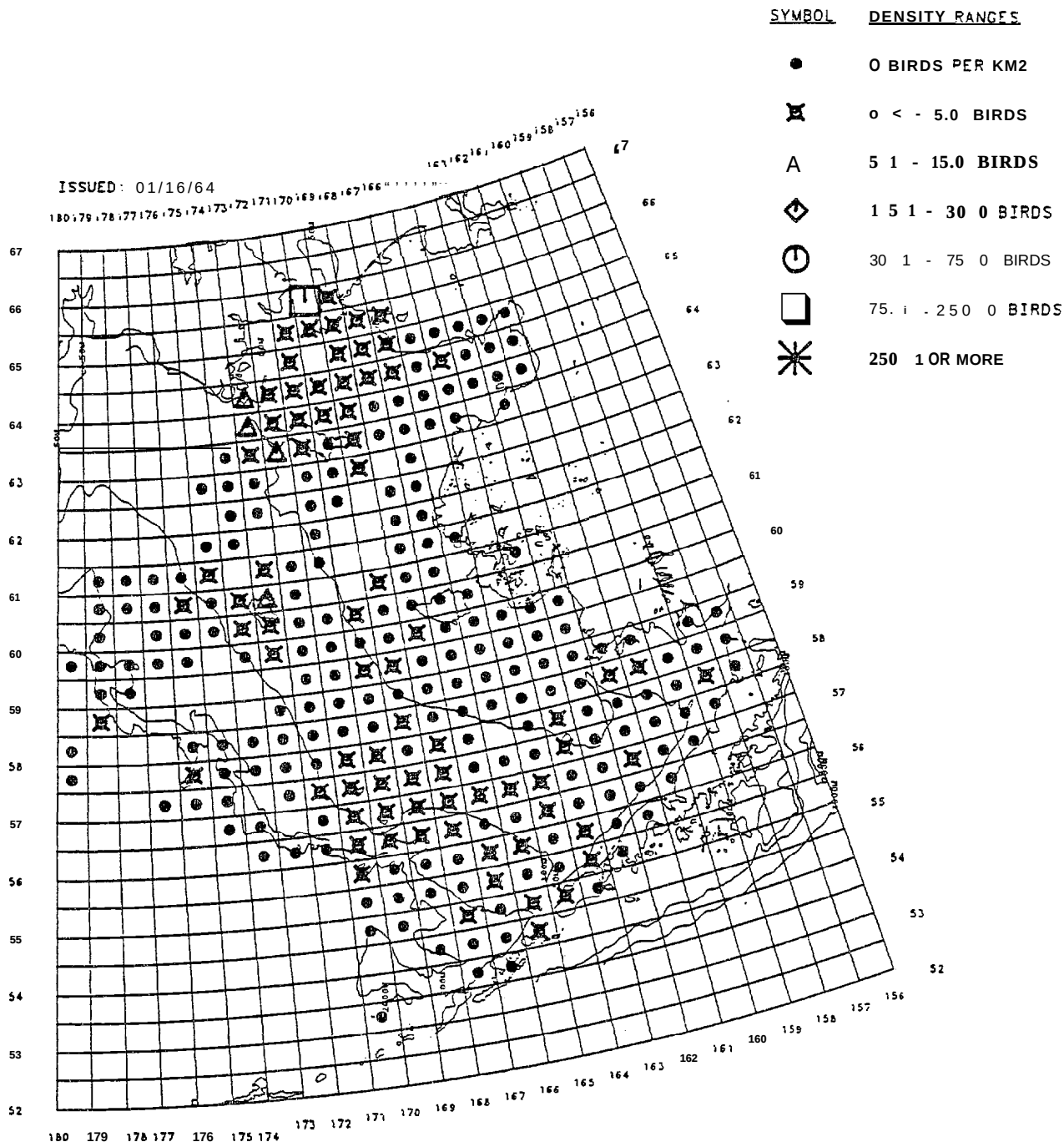
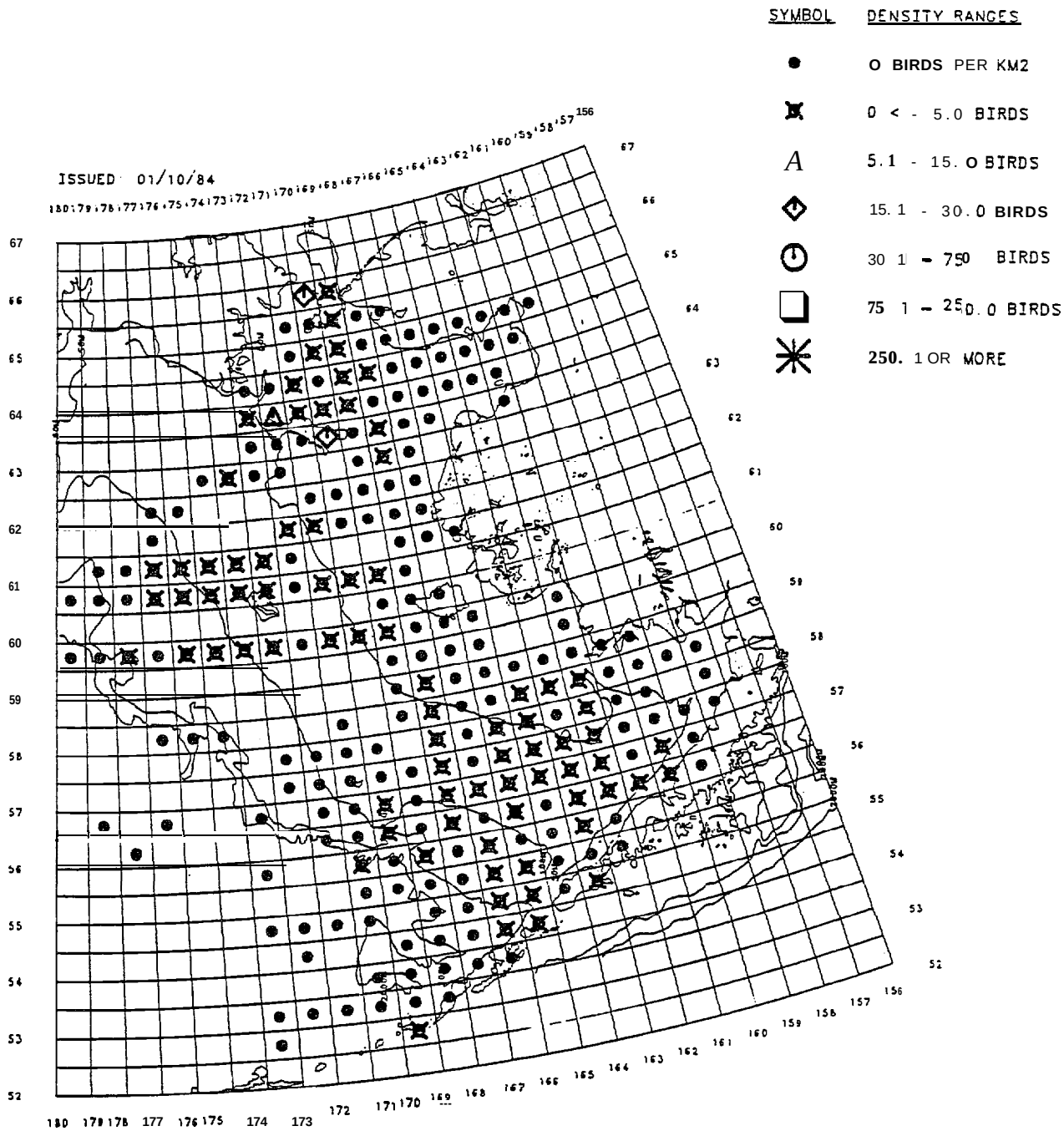


Figure 74. Mean densities, Parakeet Auklets: Spring.



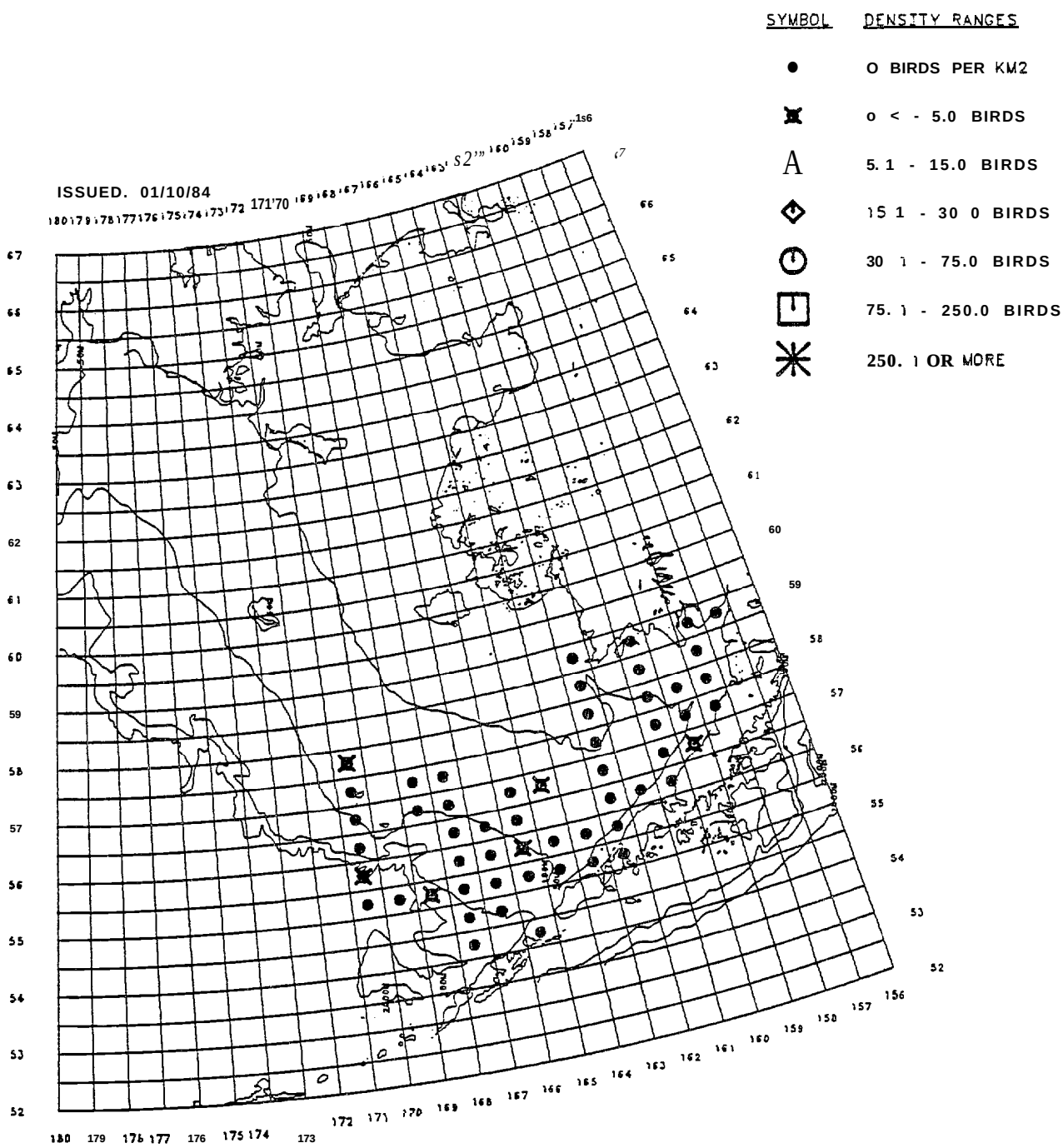
BERING SEA MEAN DENSITY PLOT
PARAKEET AUKLET
SUMMER

Figure 75. Mean densities, Parakeet Auklets: Summer.



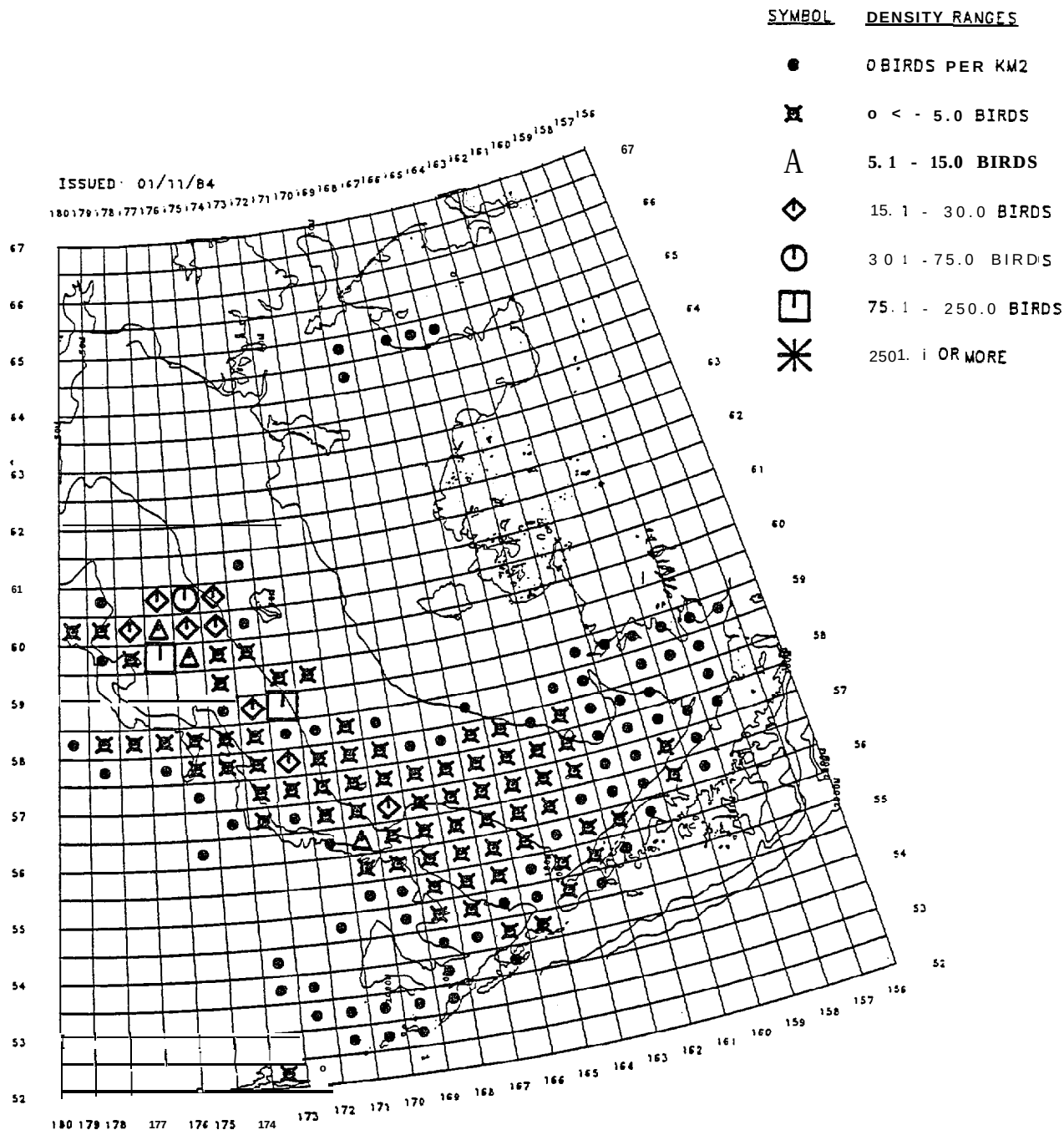
BERING SEA MEAN DENSITY PLOT
PARAKEET AUKLET
AUTUMN

Figure. 76. Mean densities, Parakeet Auklets: Autumn.



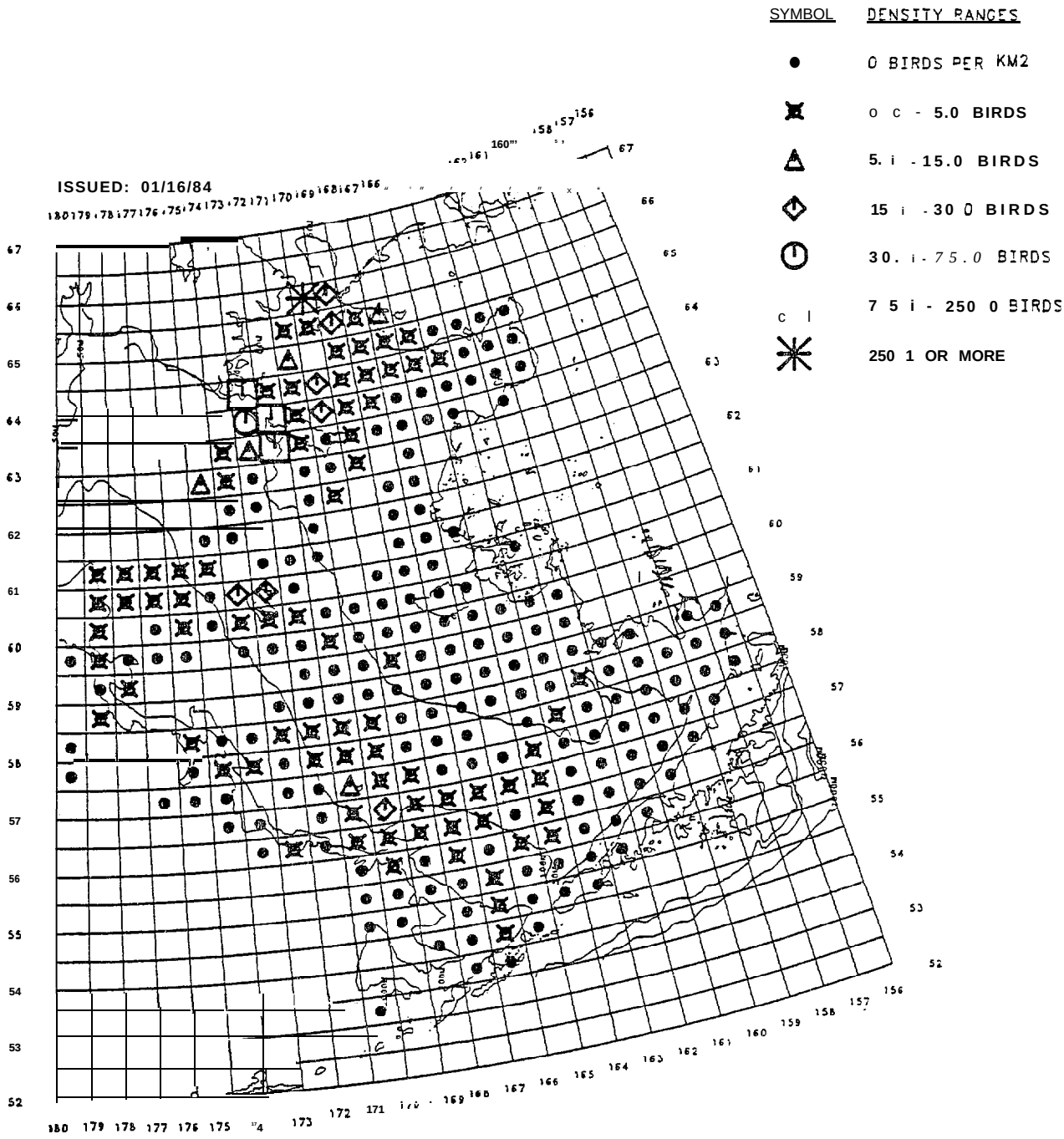
BERING SEA MEAN DENSITY PLOT
LEAST AUKLET
WINTER

Figure 77. Mean densities, Least Auklets: Winter.



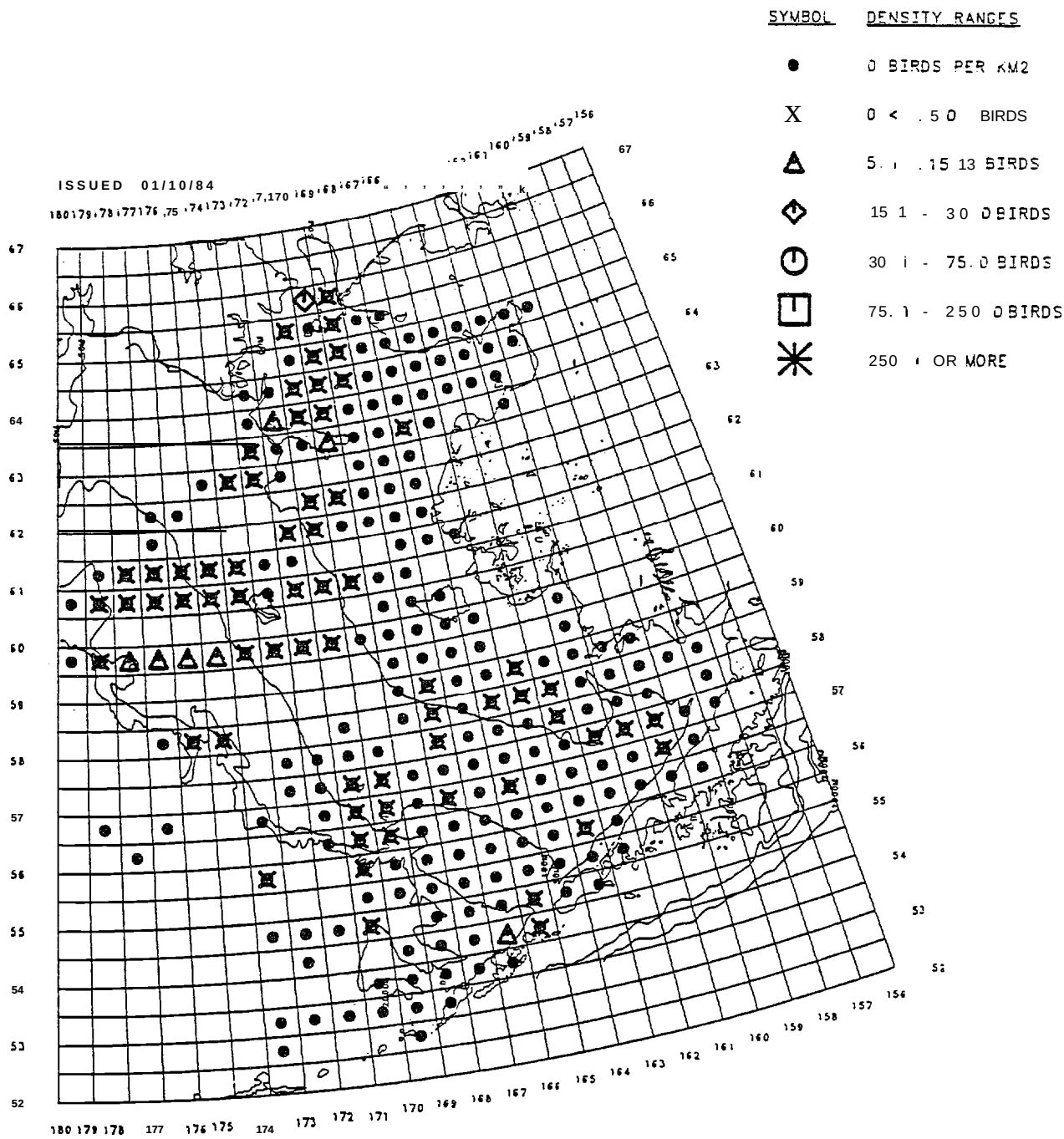
BERING SEA MEAN DENSITY PLOT
LEAST AUKLET
SPRING

Figure 78. Mean densities, Least Auklets: Spring.



BERING SEA MEAN DENSITY PLOT
LEAST AUKLET
SUMMER

Figure 79. Mean densities, Least Auklets: Summer.



BERING SEA MEAN DENSITY PLOT
LEAST AUKLET
AUTUMN

Figure 80. Mean densities, Least Auklets: Autumn.

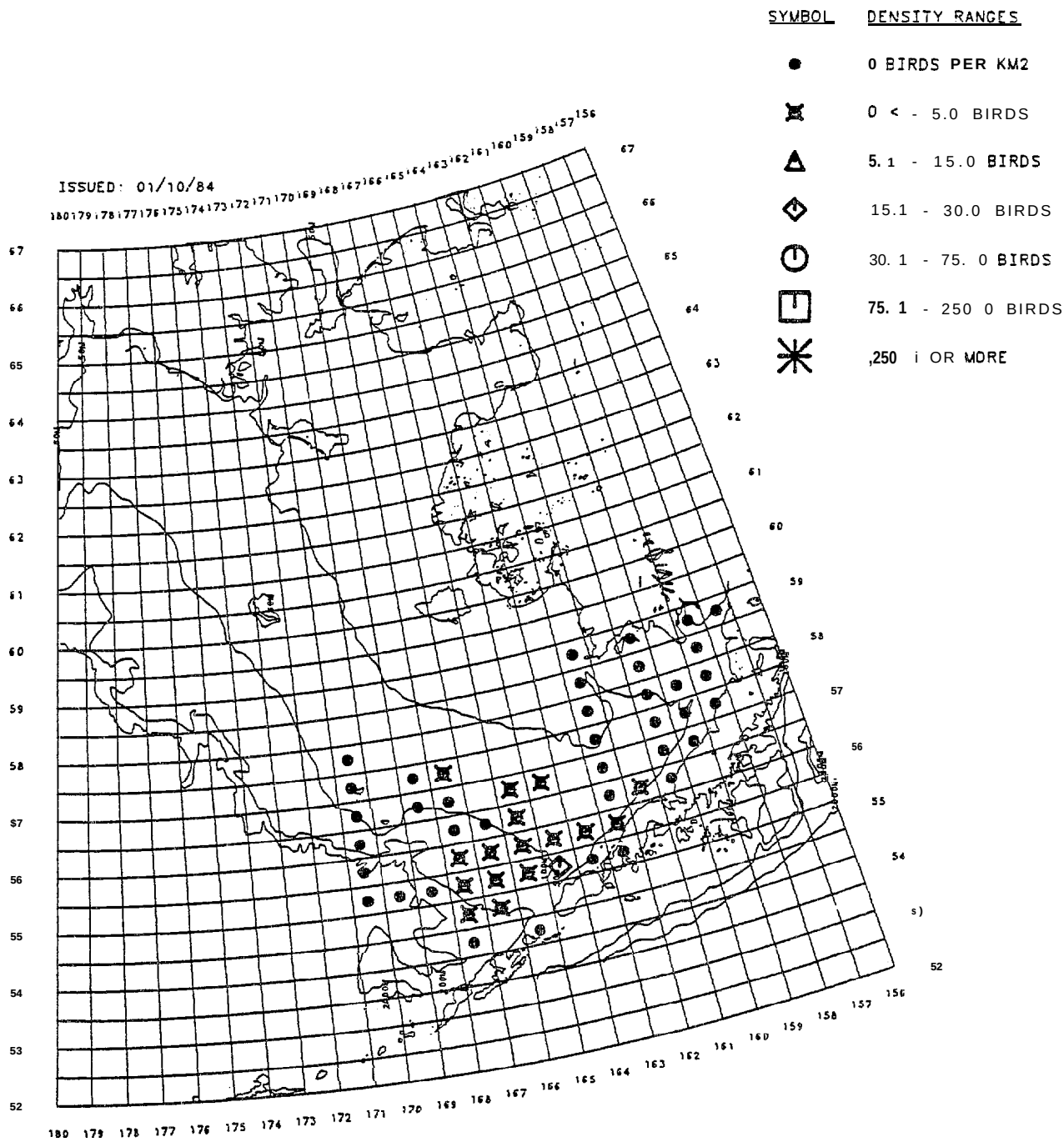
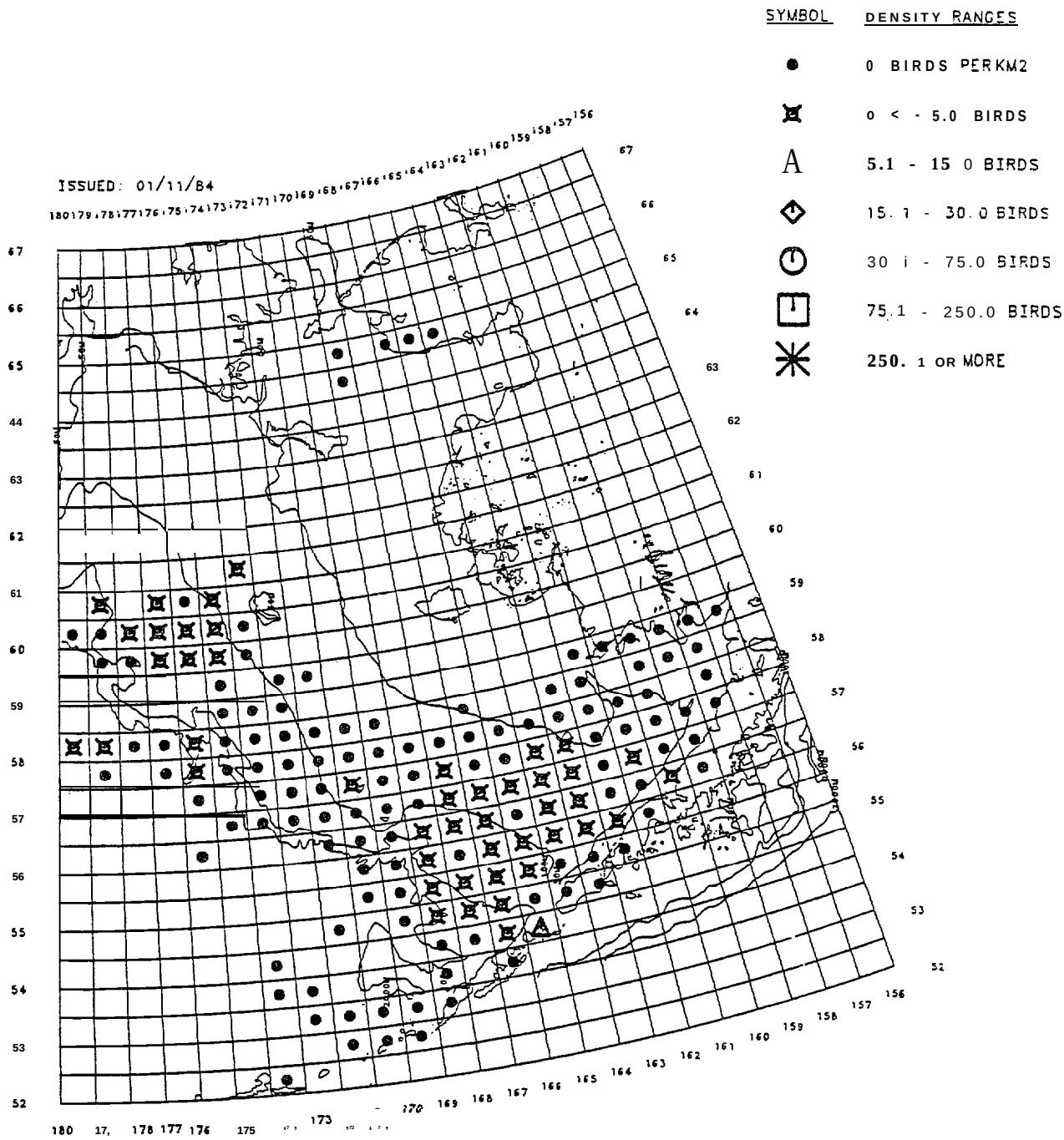
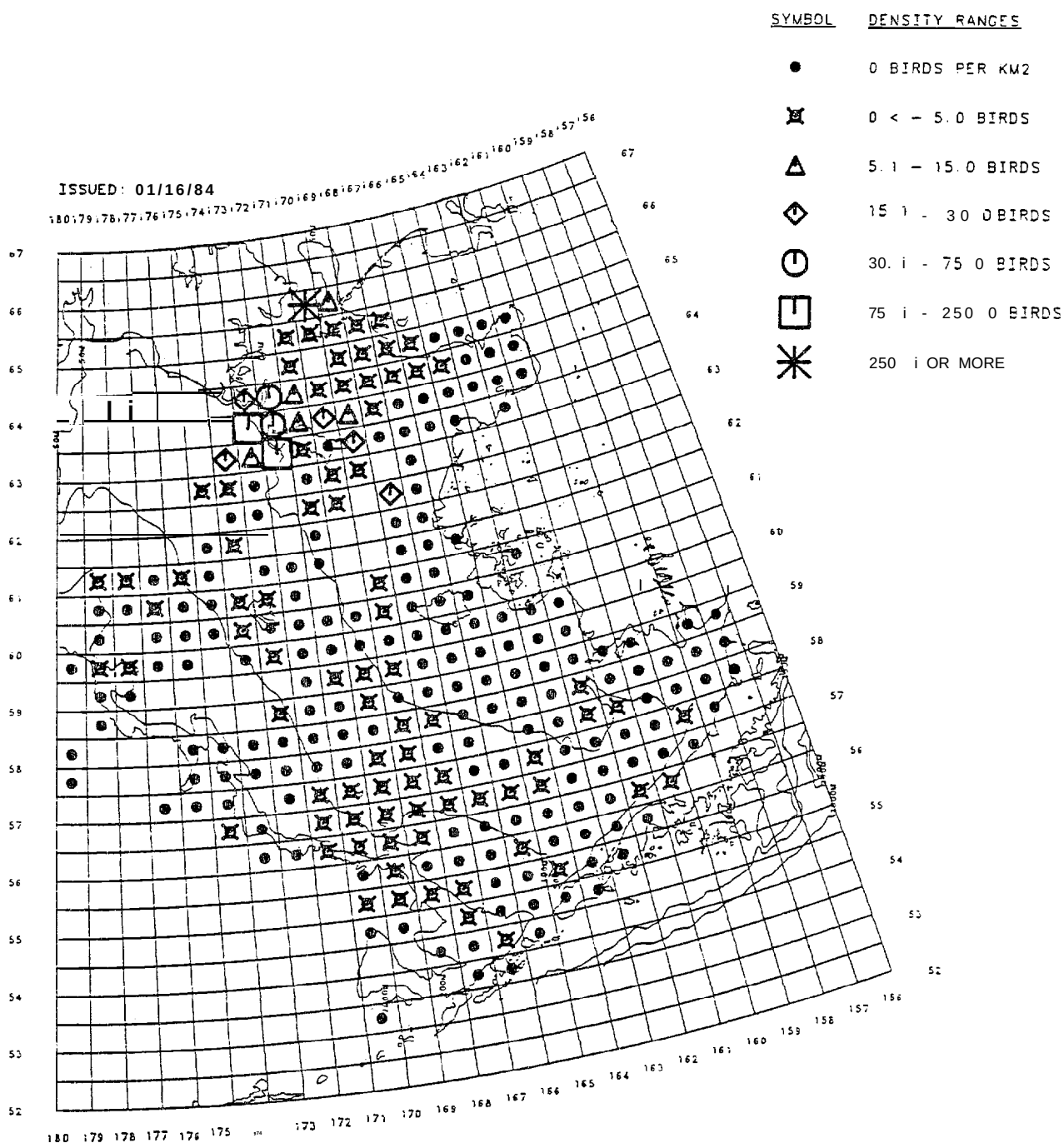


Figure 81. Mean densities, Crested Auklets: Winter.



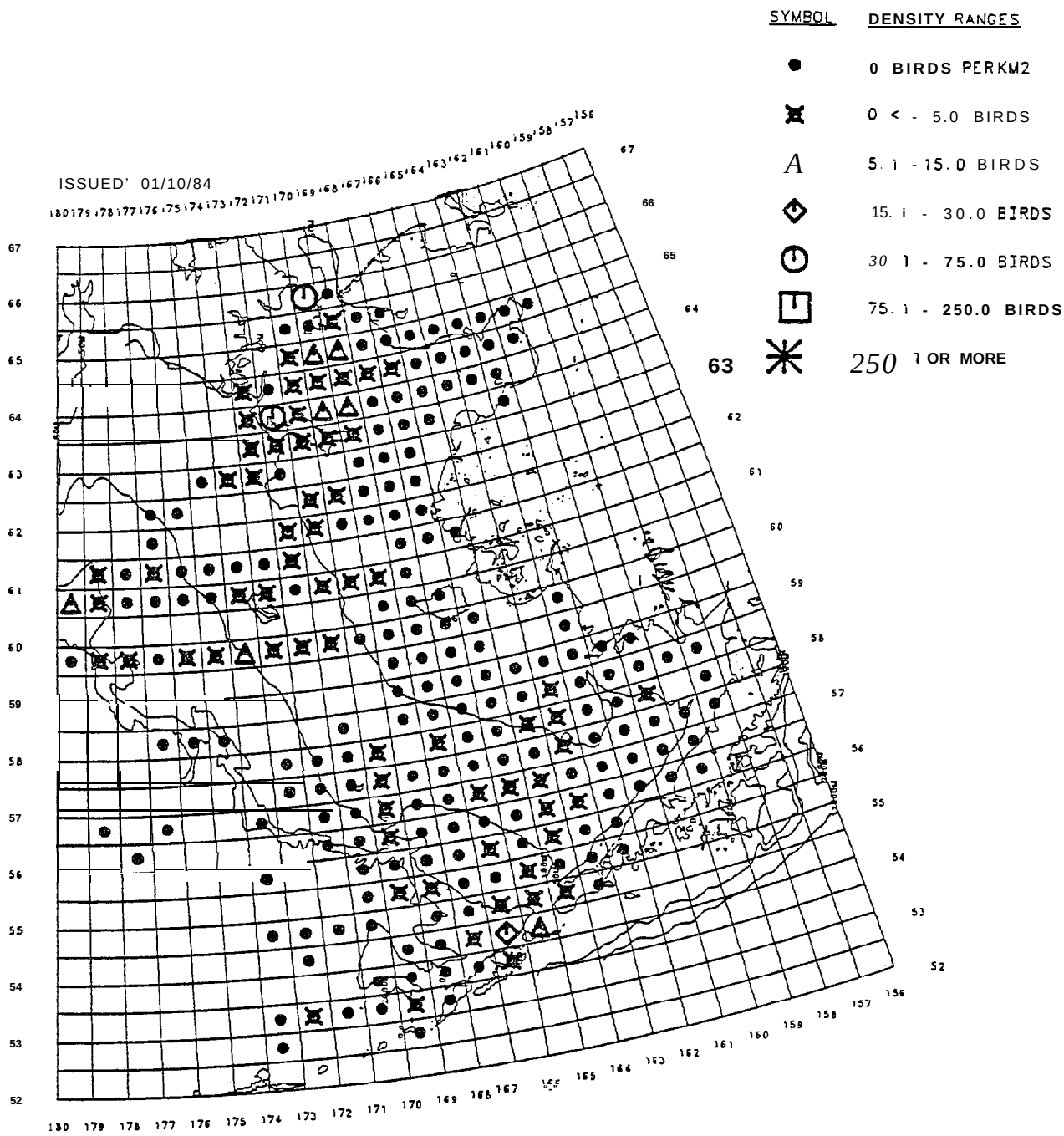
BERING SEA MEAN DENSITY PLOT
CRESTED AUKLET
SPRING

Figure 82. Mean densities, Crested Auklets: Spring.



BERING SEA MEAN DENSITY PLOT
CRESTED AUKLET
SUMMER

Figure 83. Mean densities, Crested Auklets: Summer.



BERING SEA MEAN DENSITY PLOT
CRESTED AUKLET
AUTUMN

Figure 84. Mean densities, Crested Auklets: Autumn.

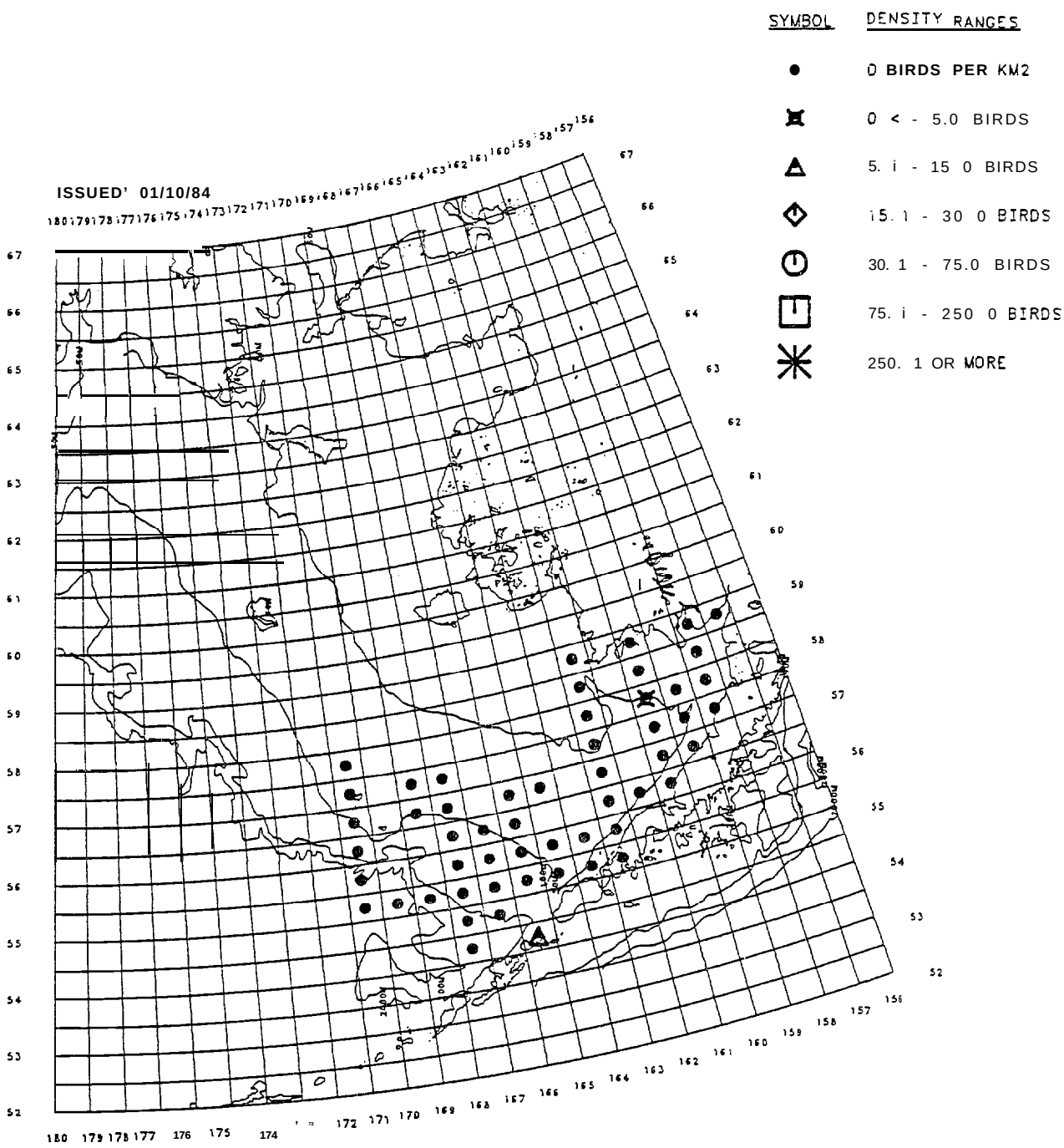


Figure 85. Mean densities, Horned Puffins: Winter.

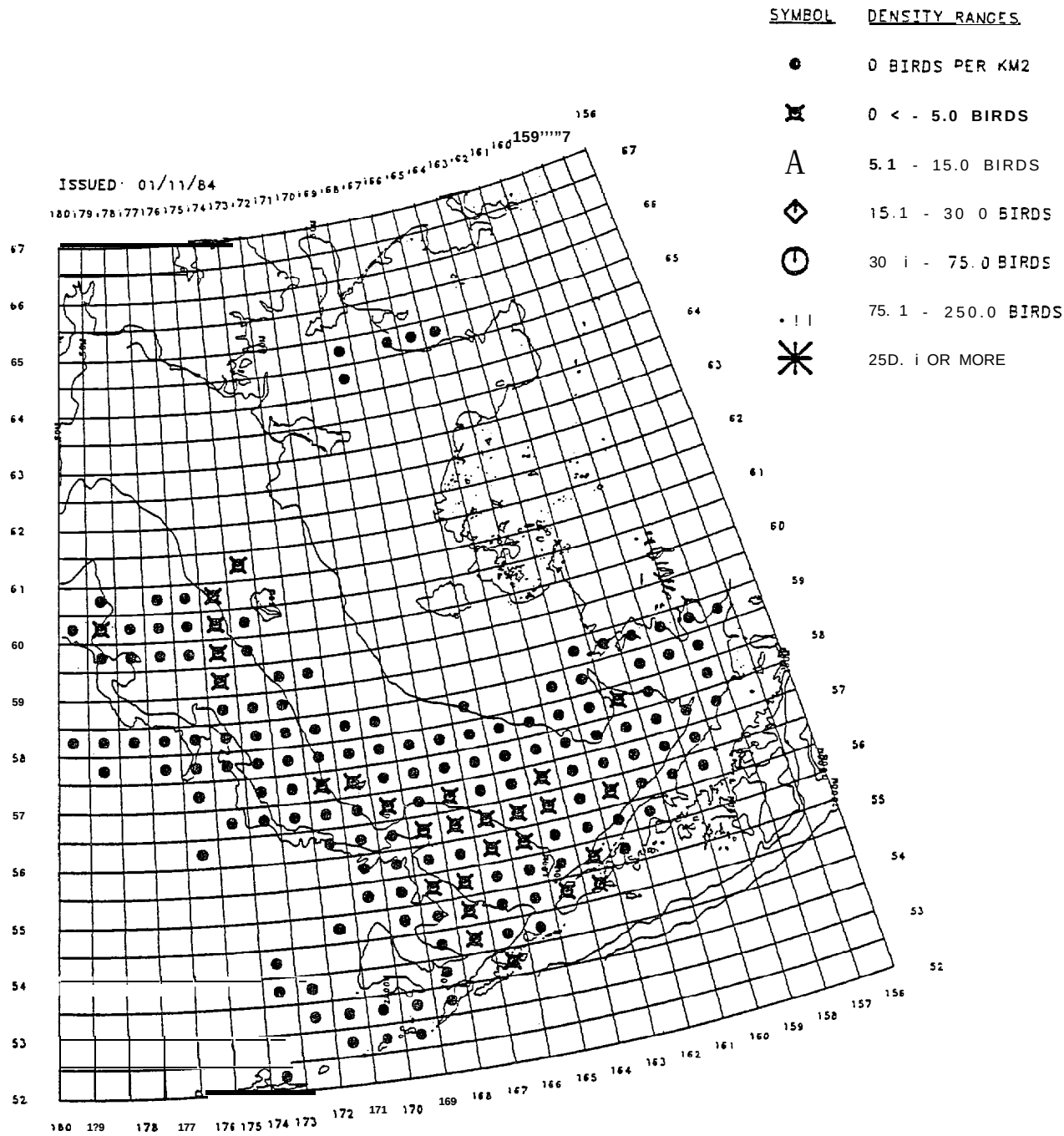
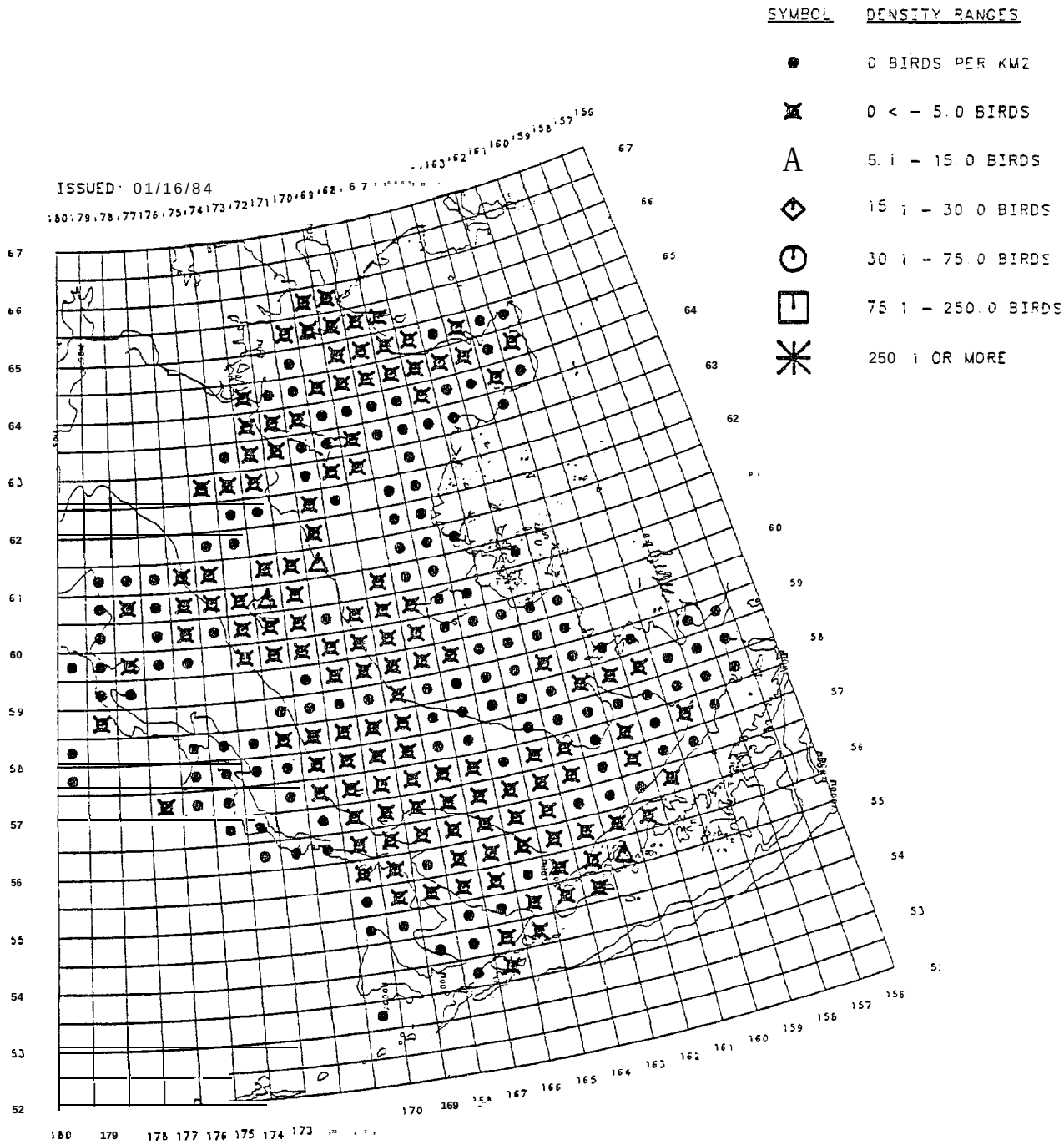
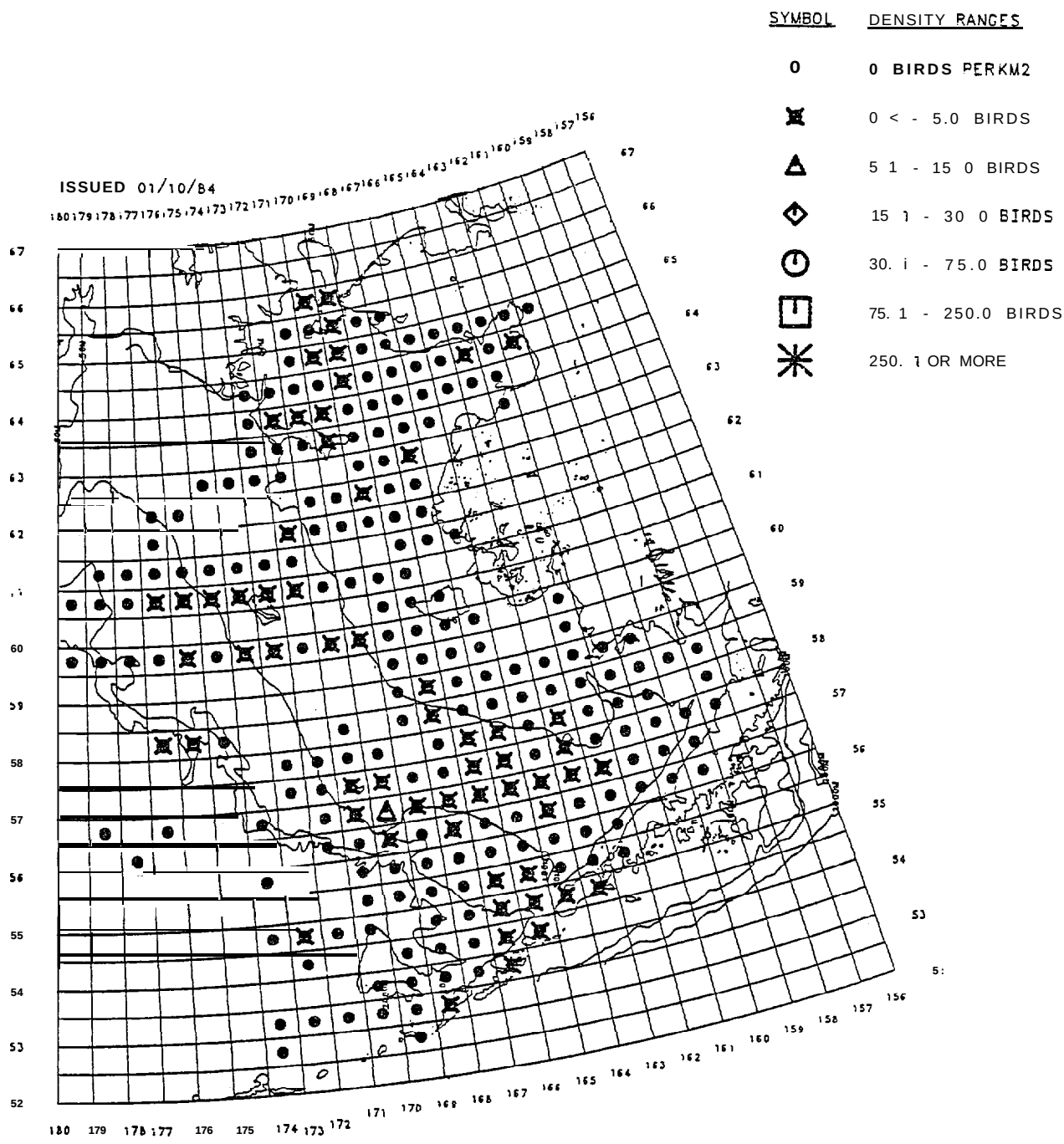


Figure 86. Mean densities, Horned Puffins: Spring.



BERING SEA MEAN DENSITY PLOT
HORNED PUFFIN
SUMMER

Figure 87. Mean densities, Horned Puffins: Summer.



BERING SEA MEAN DENSITY PLOT
HORNED PUFFIN
AUTUMN

Figure 88. Mean densities, Horned Puffins: Autumn.

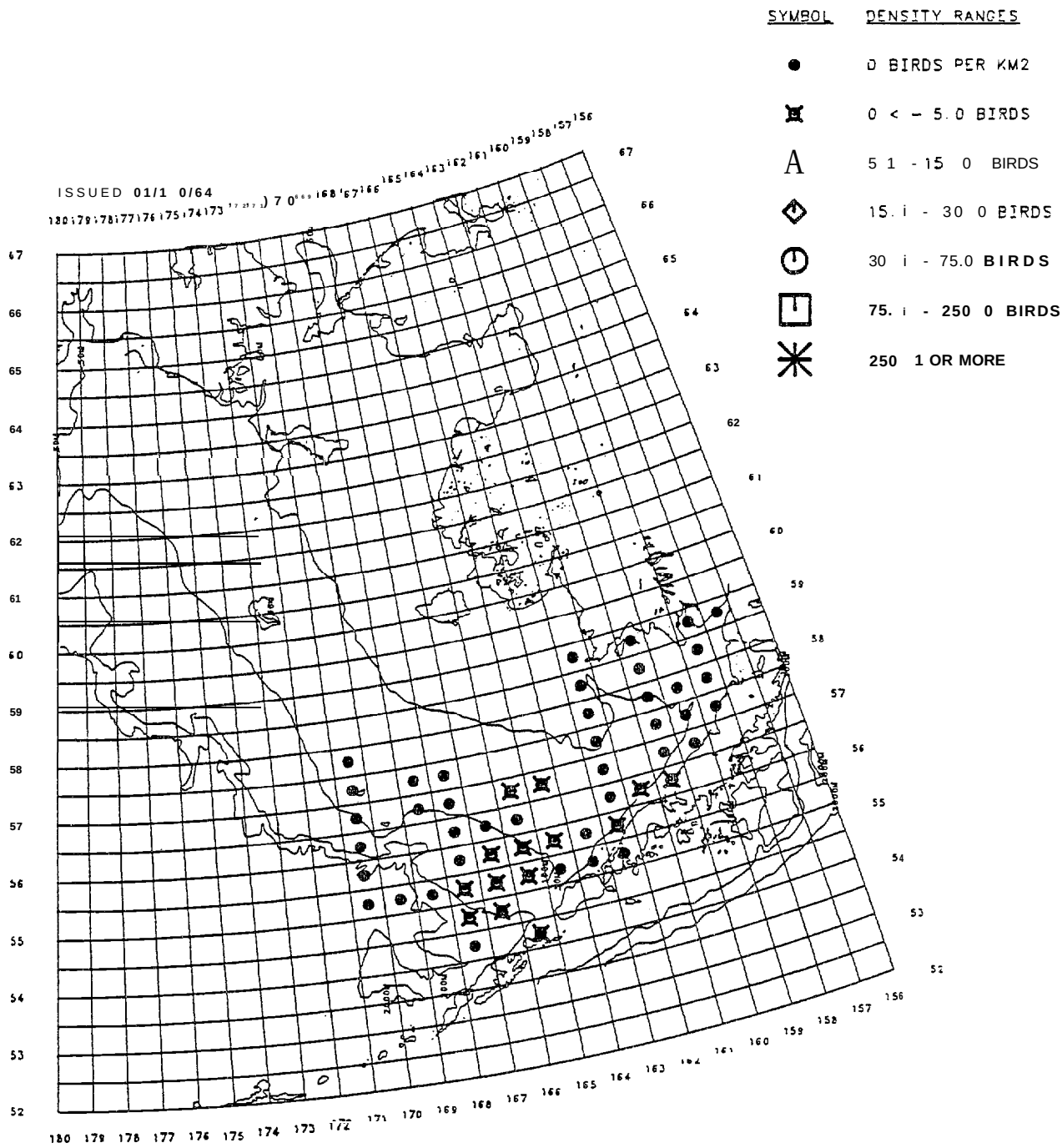


Figure 89. Mean densities, Tufted Puffins: Winter.

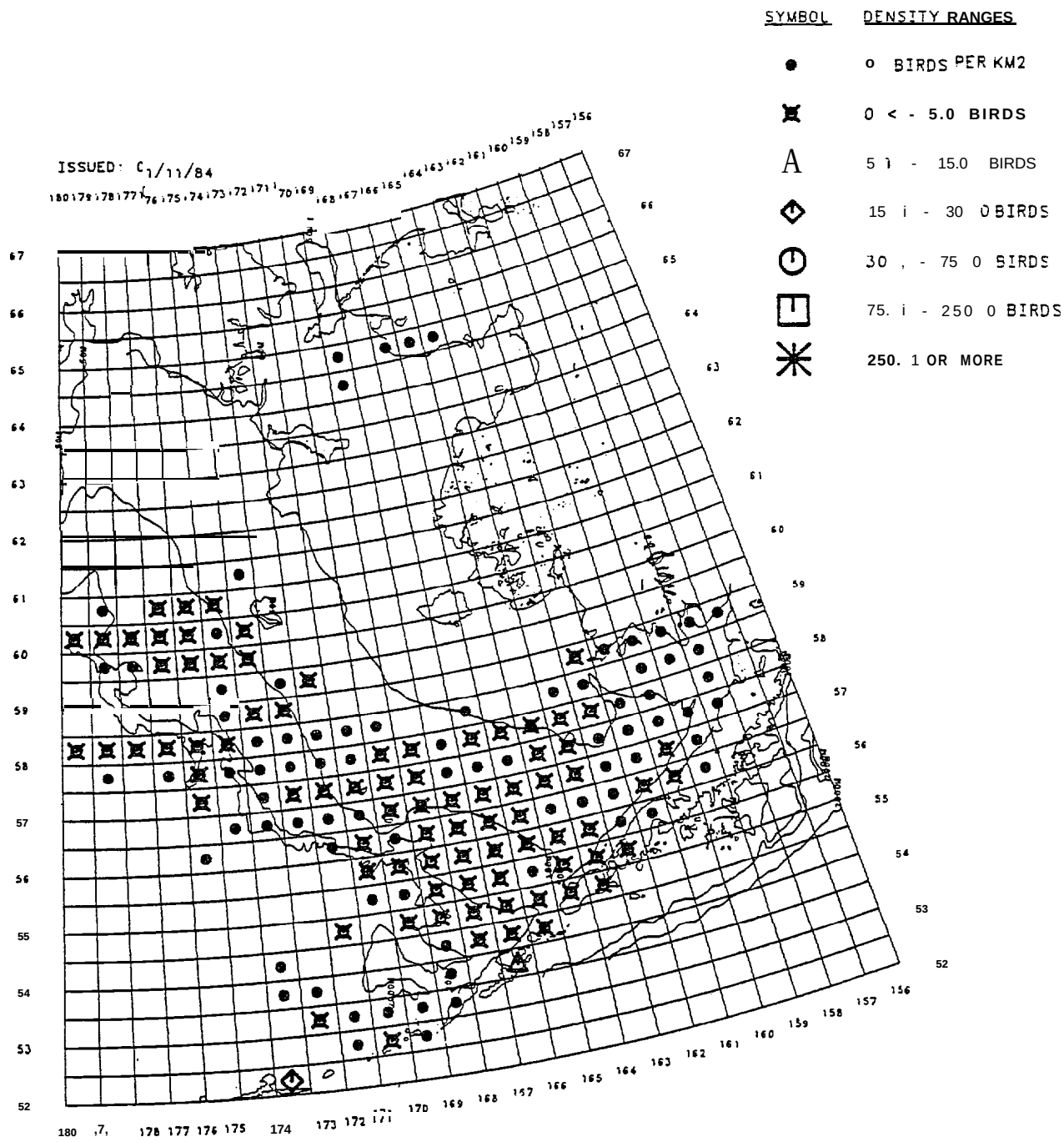


Figure 90. Mean densities, Tufted Puffins: Spring.

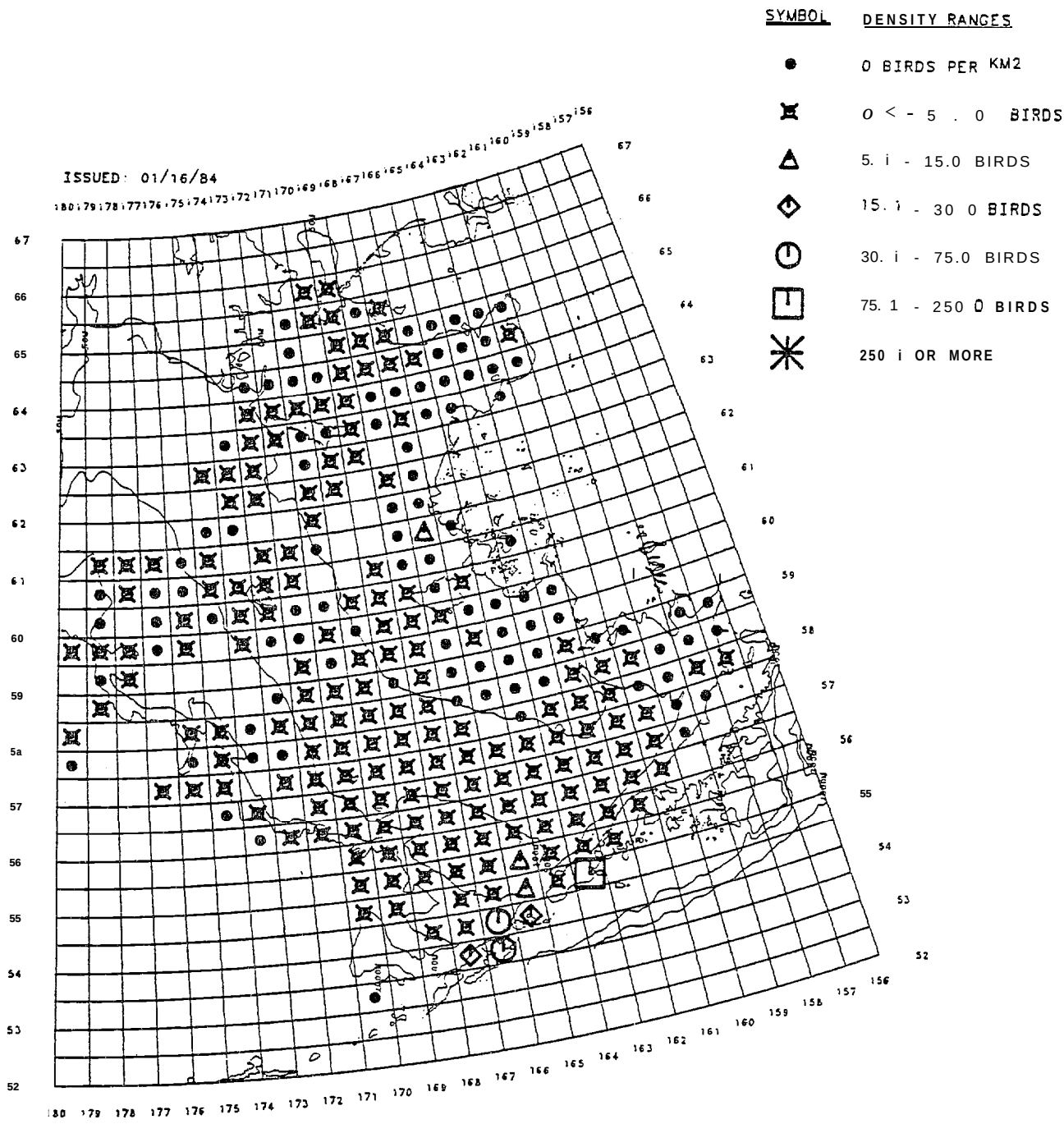


Figure 91. Mean densities, Tufted Puffins: Summer.

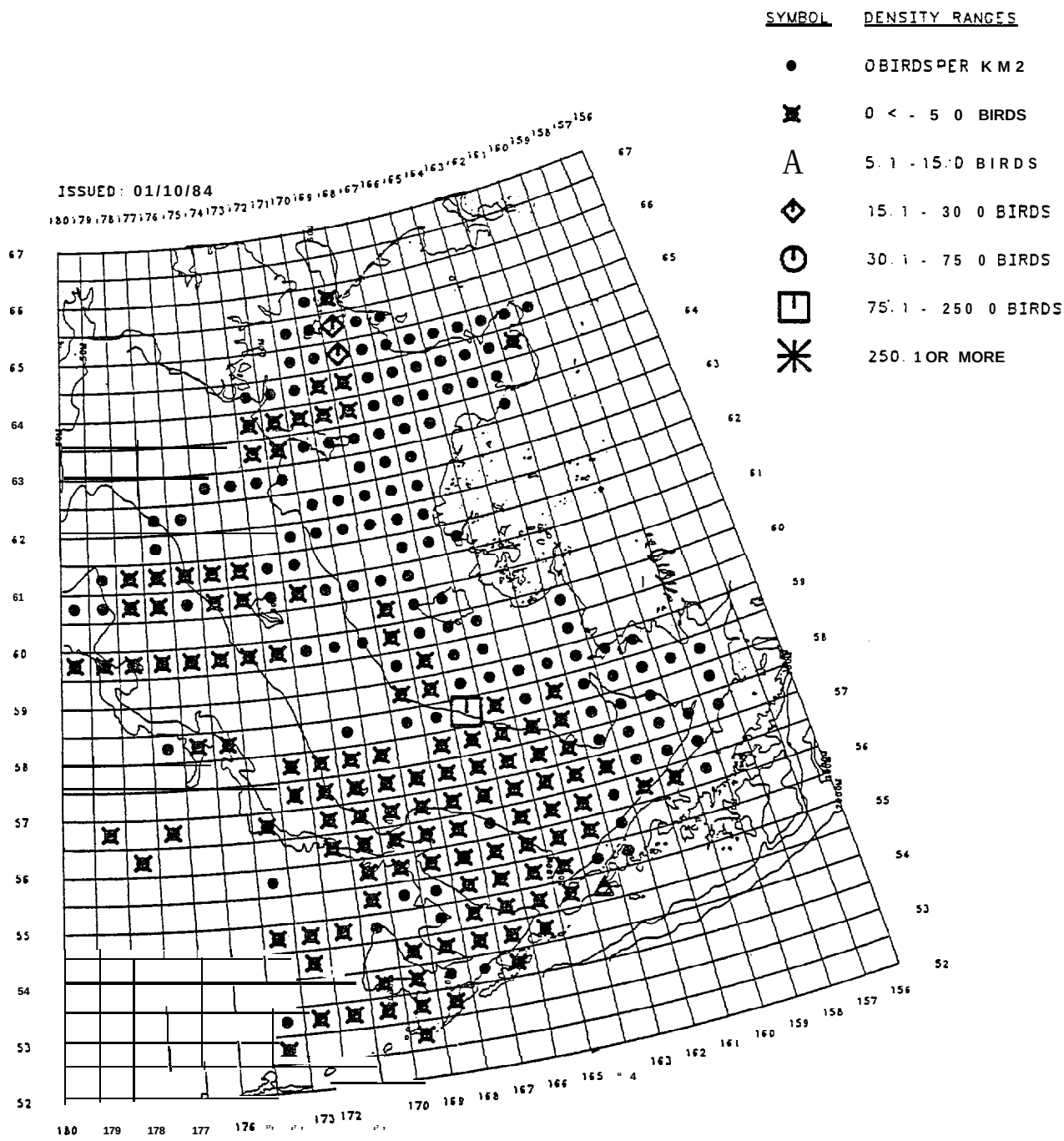
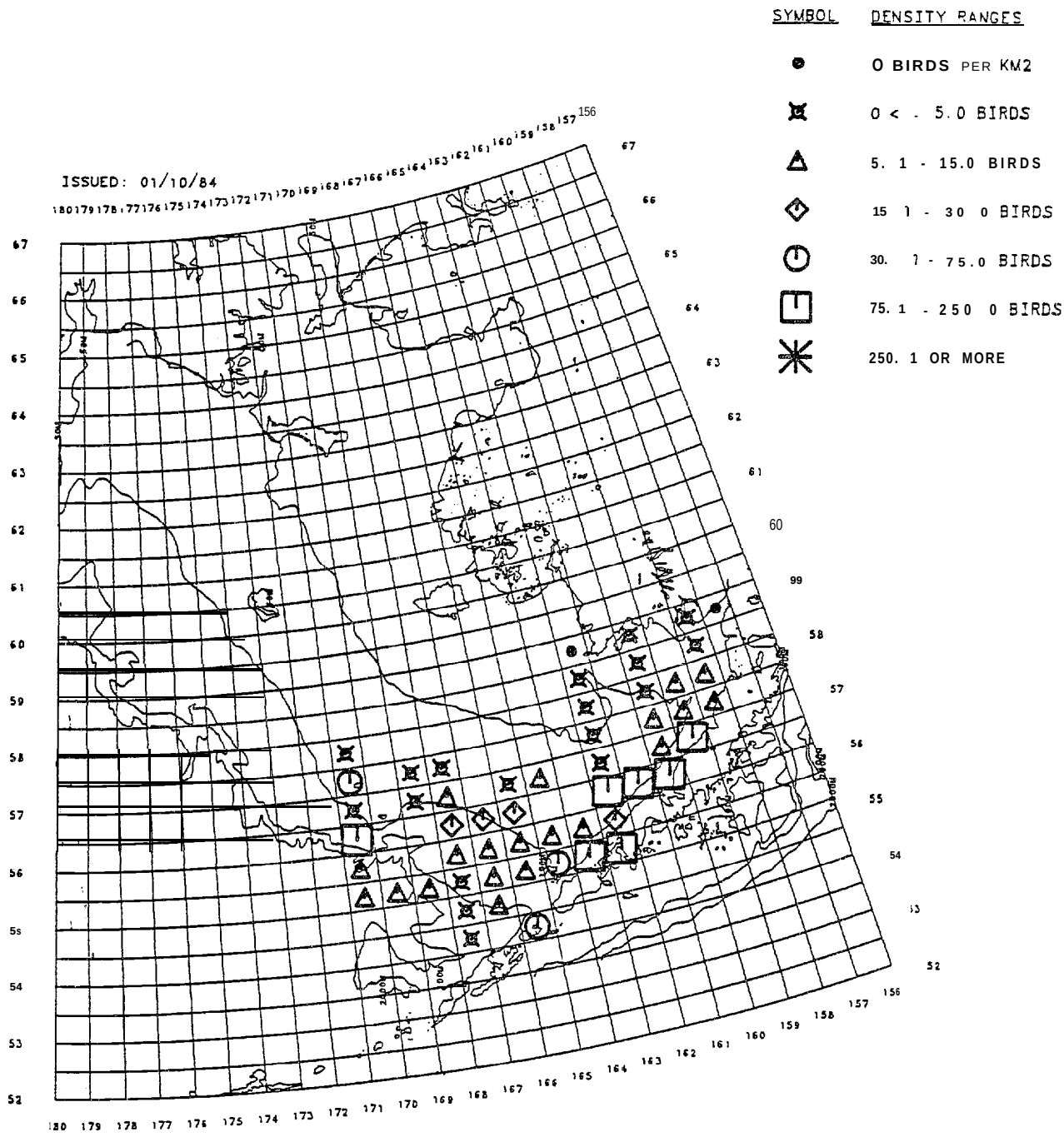


Figure 92. Mean densities, Tufted Puffins: Autumn.

APPENDIX 3

Summary plots for bird distribution in the Bering Sea



BERING SEA MEAN DENSITY PLOT
ALL BIRDS
WINTER

Figure 93. Mean densities, all birds: Winter.

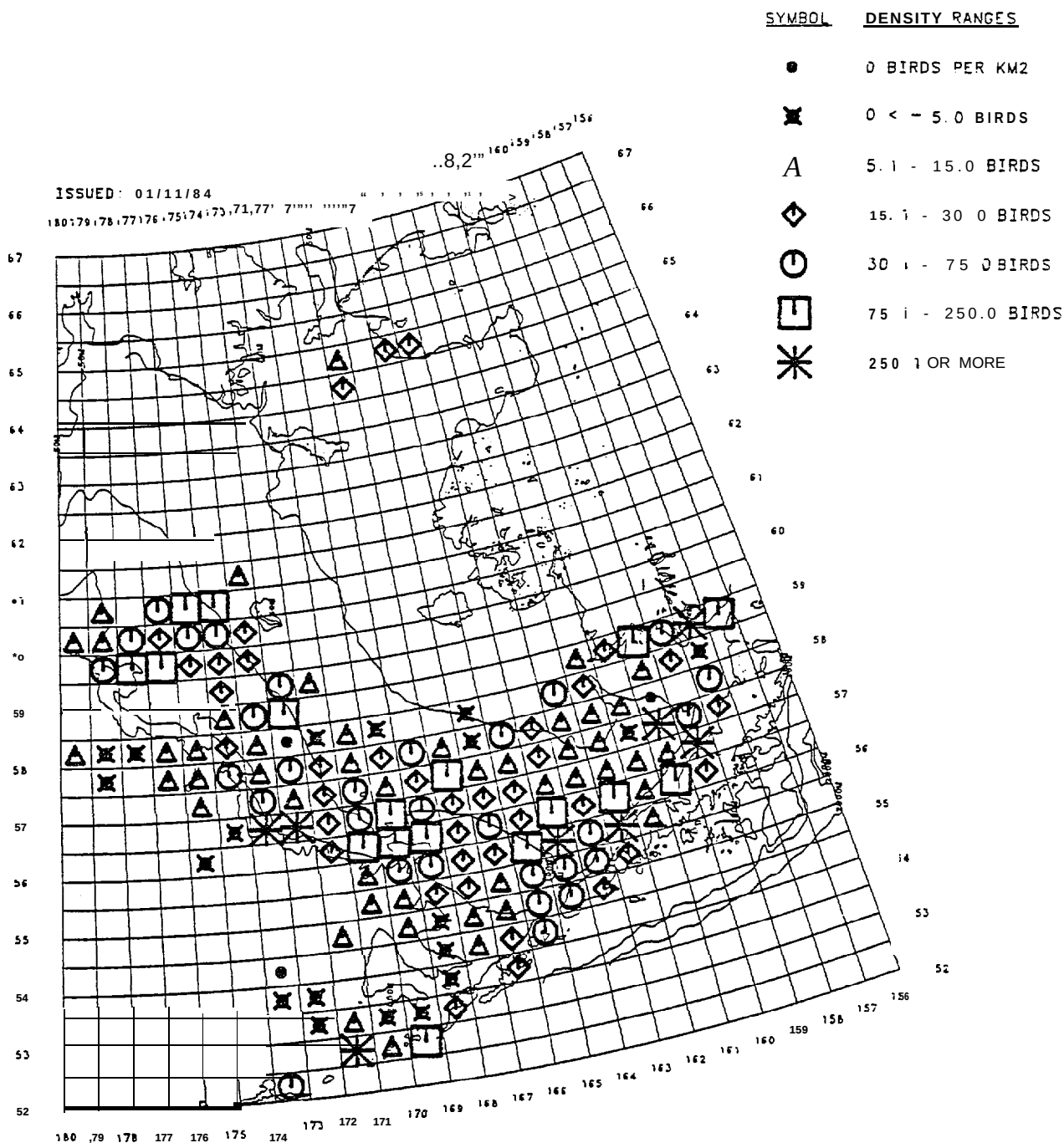
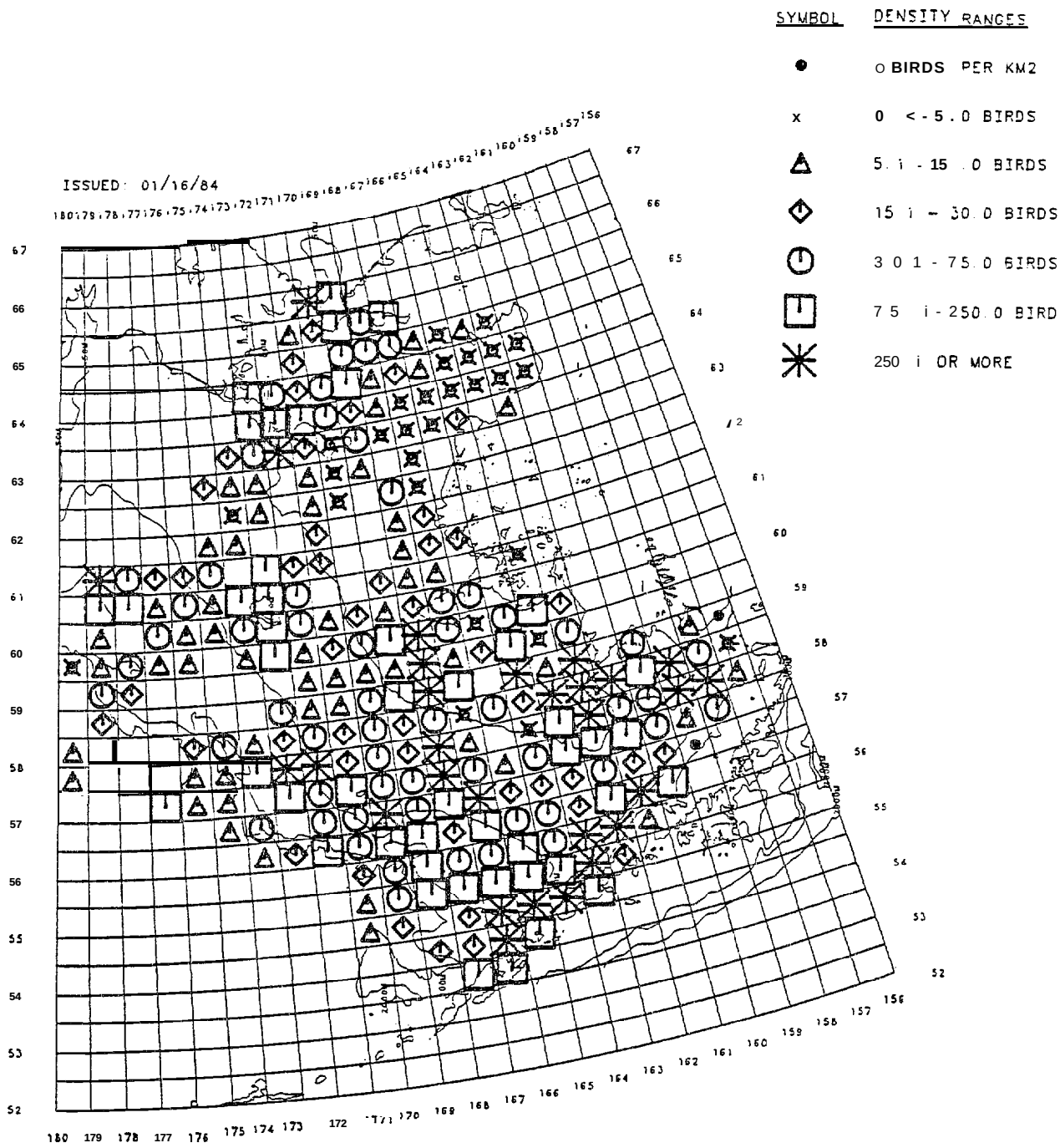
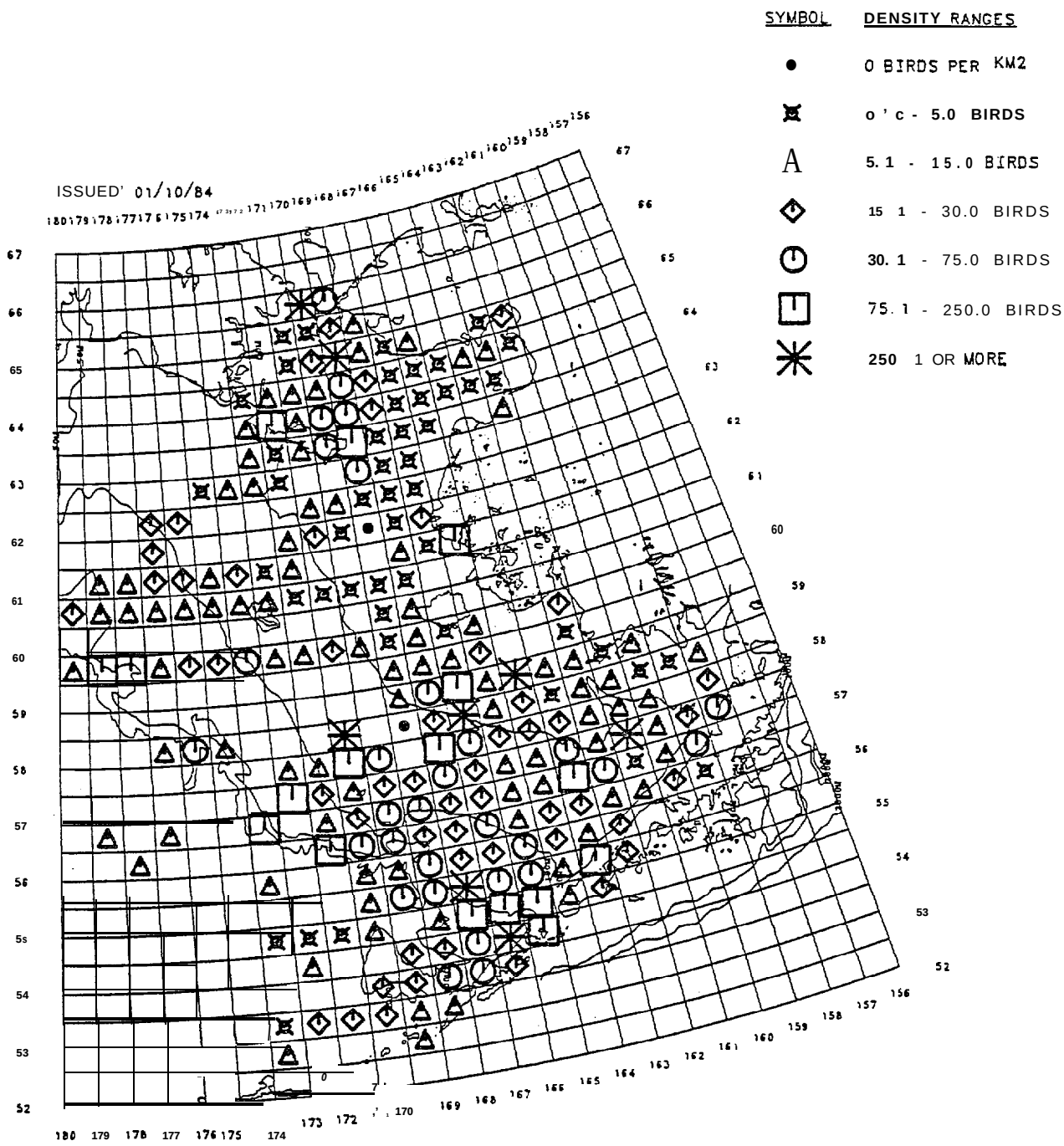


Figure 94. Mean densities, all birds: Spring.



BERING SEA MEAN DENSITY PLOT
ALL BIRDs
SUMMER

Figure 95. Mean densities, all birds: Summer.



BERING SEA MEAN DENSITY PLOT
ALL BIRDS
AUTUMN

Figure 96. Mean densities, all birds: Autumn.

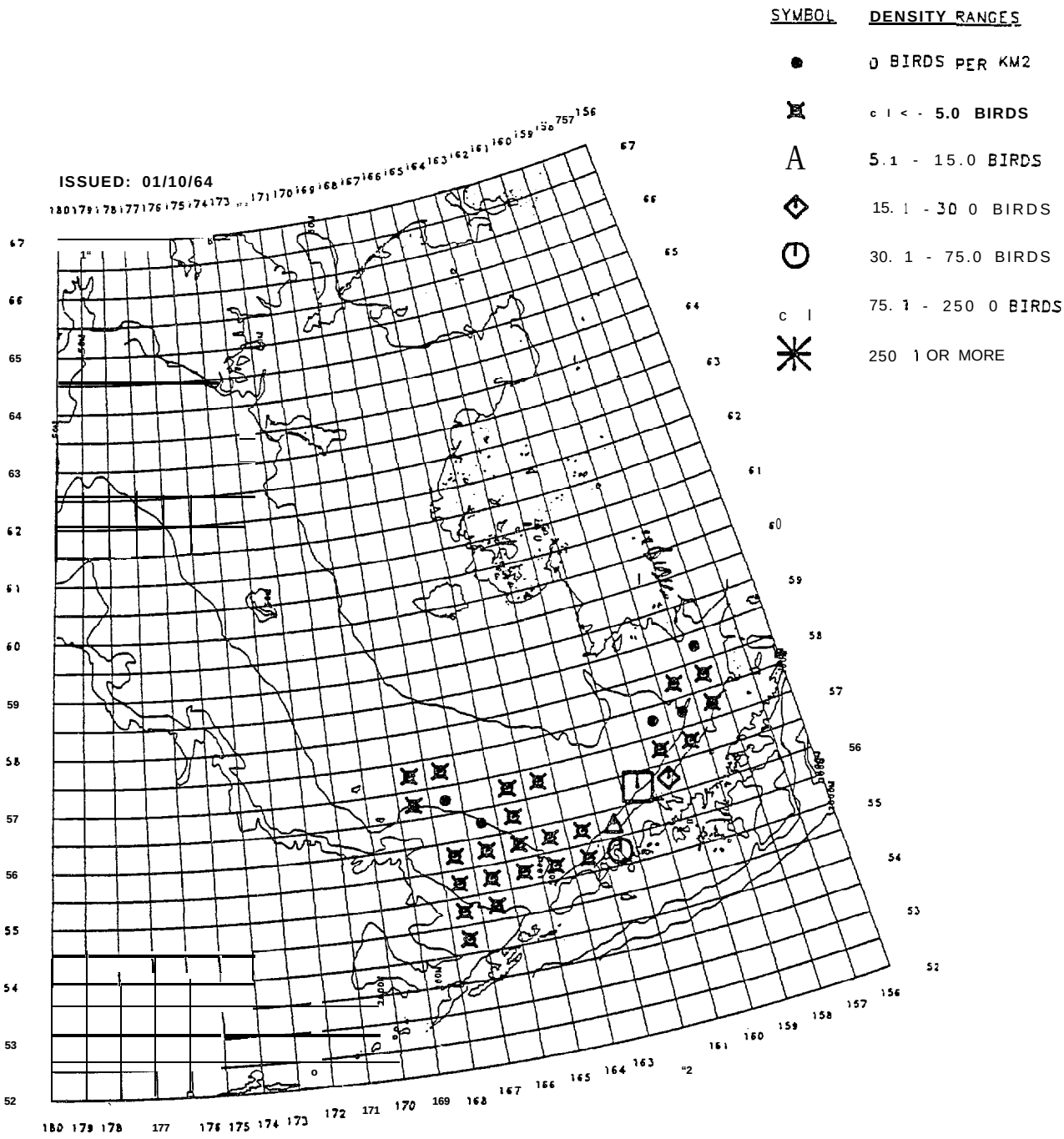
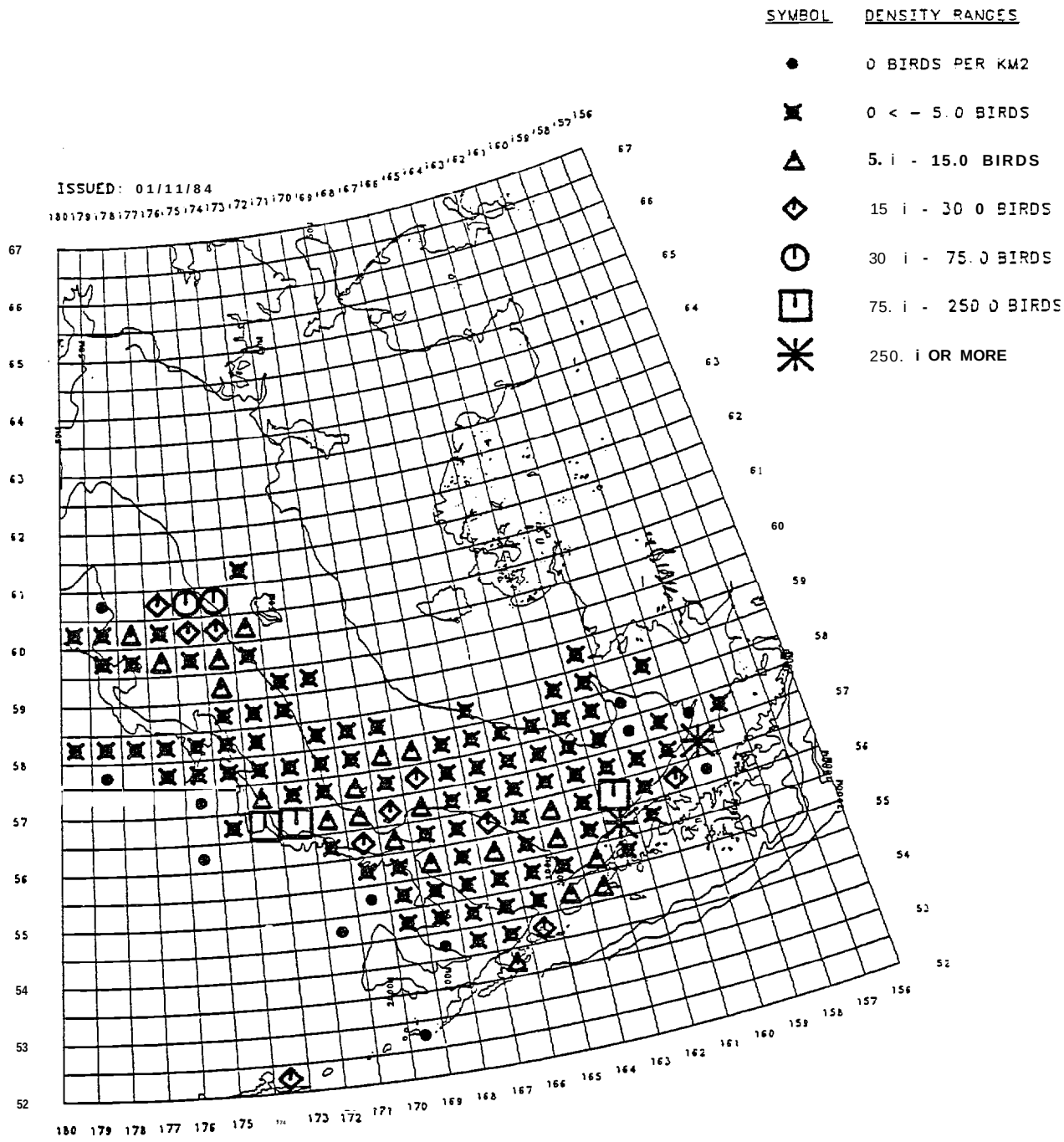


Figure 97. Mean densities, birds on the water: Winter.



BERING SEA MEAN DENSITY PLOT
ALL BIRDS ON WATER
SPRING

Figure 98. Mean densities, birds on the water: Spring.

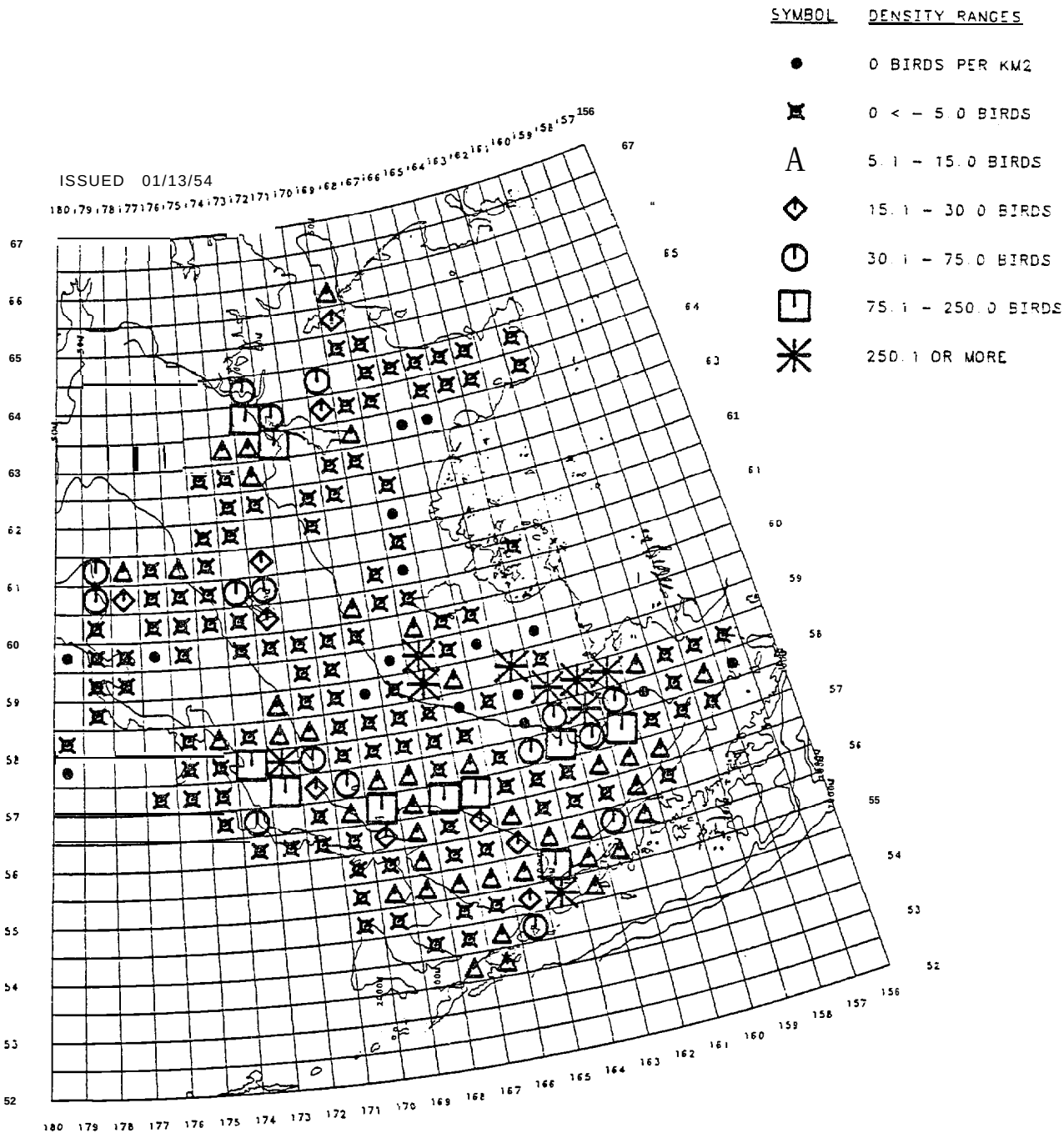


Figure 99. Mean densities, birds on the water: Summer.

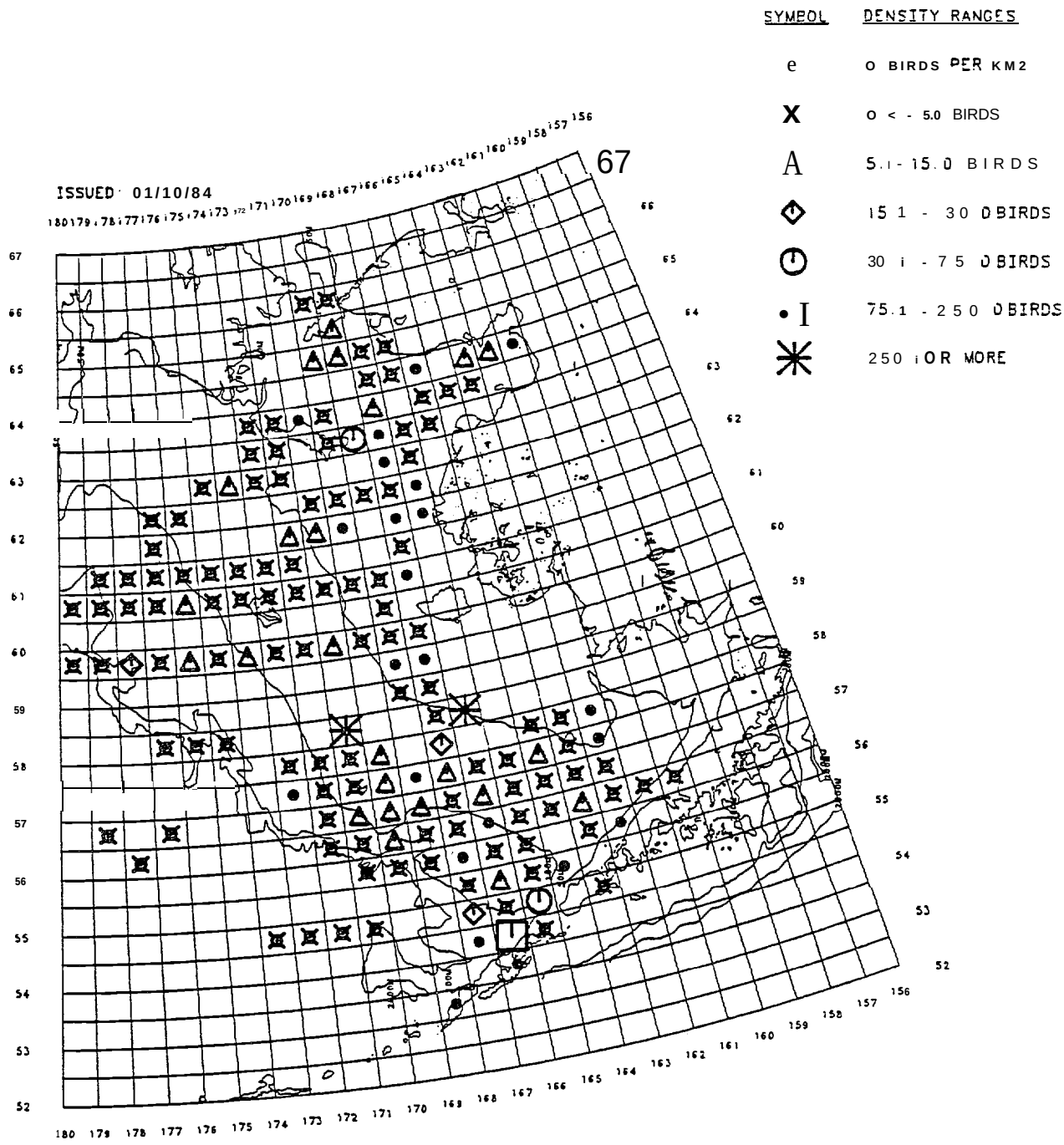


Figure 100. Mean densities, birds on the water: Autumn.

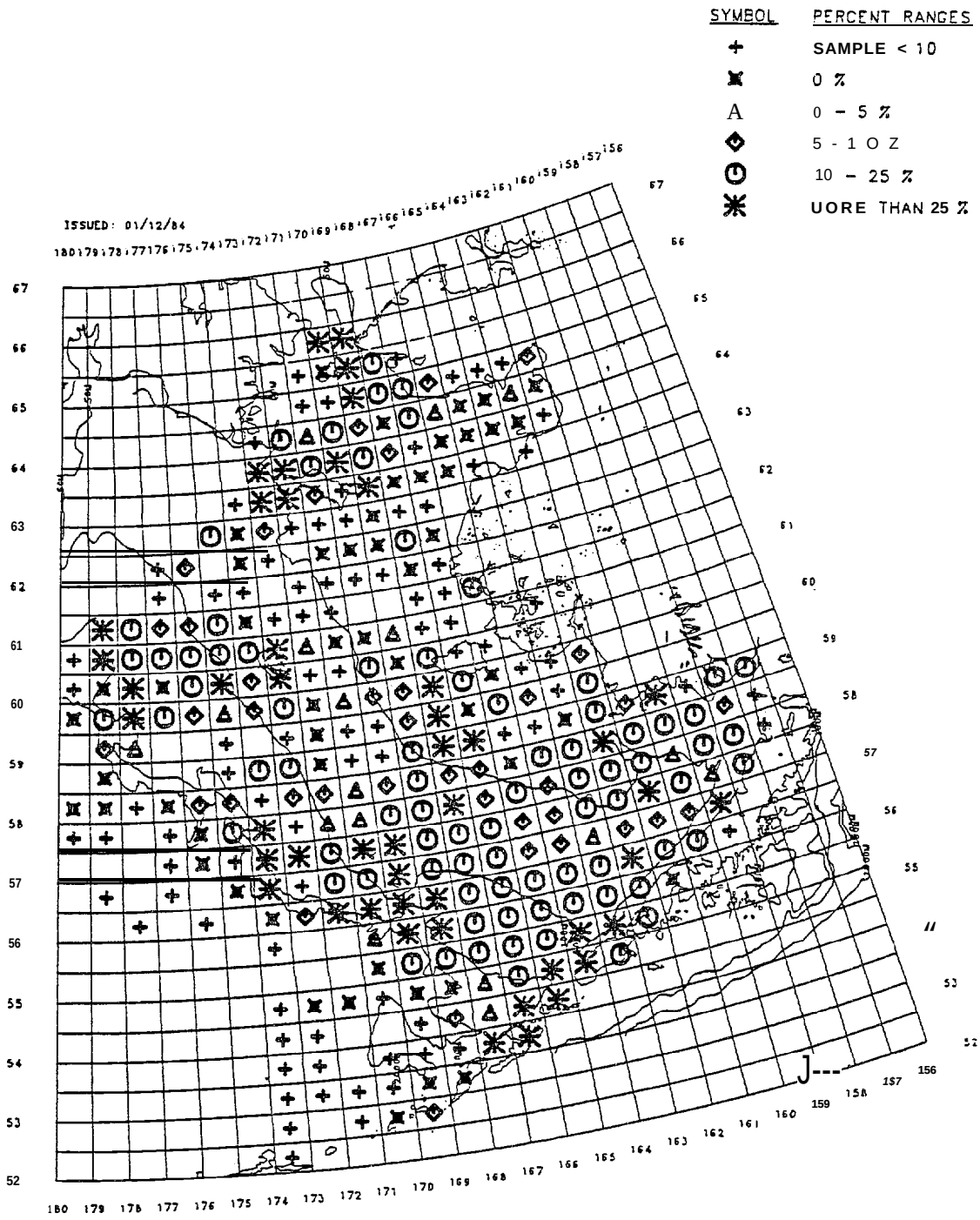


Figure 101. Frequency distribution of transects with densities ≥50 birds/km².

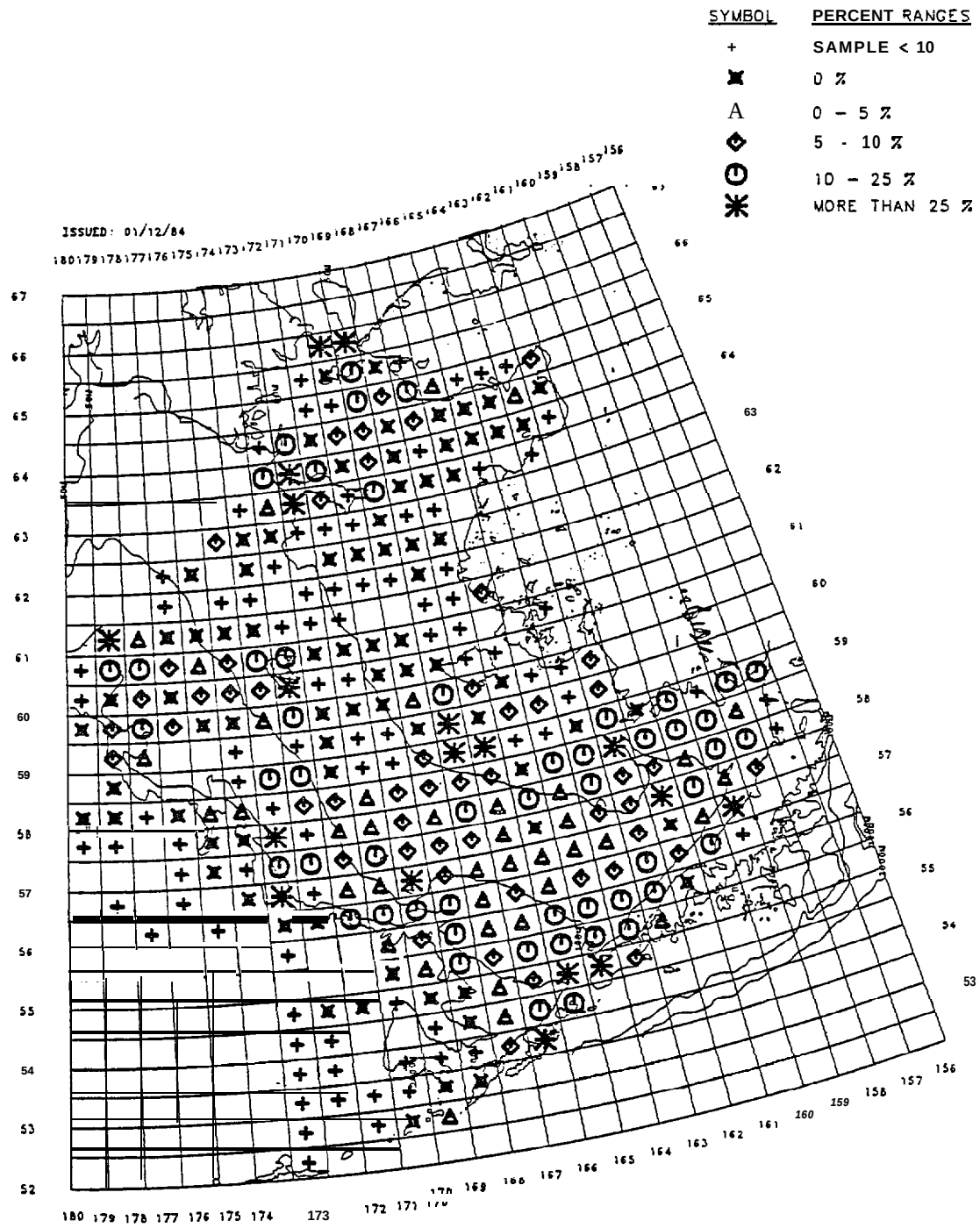
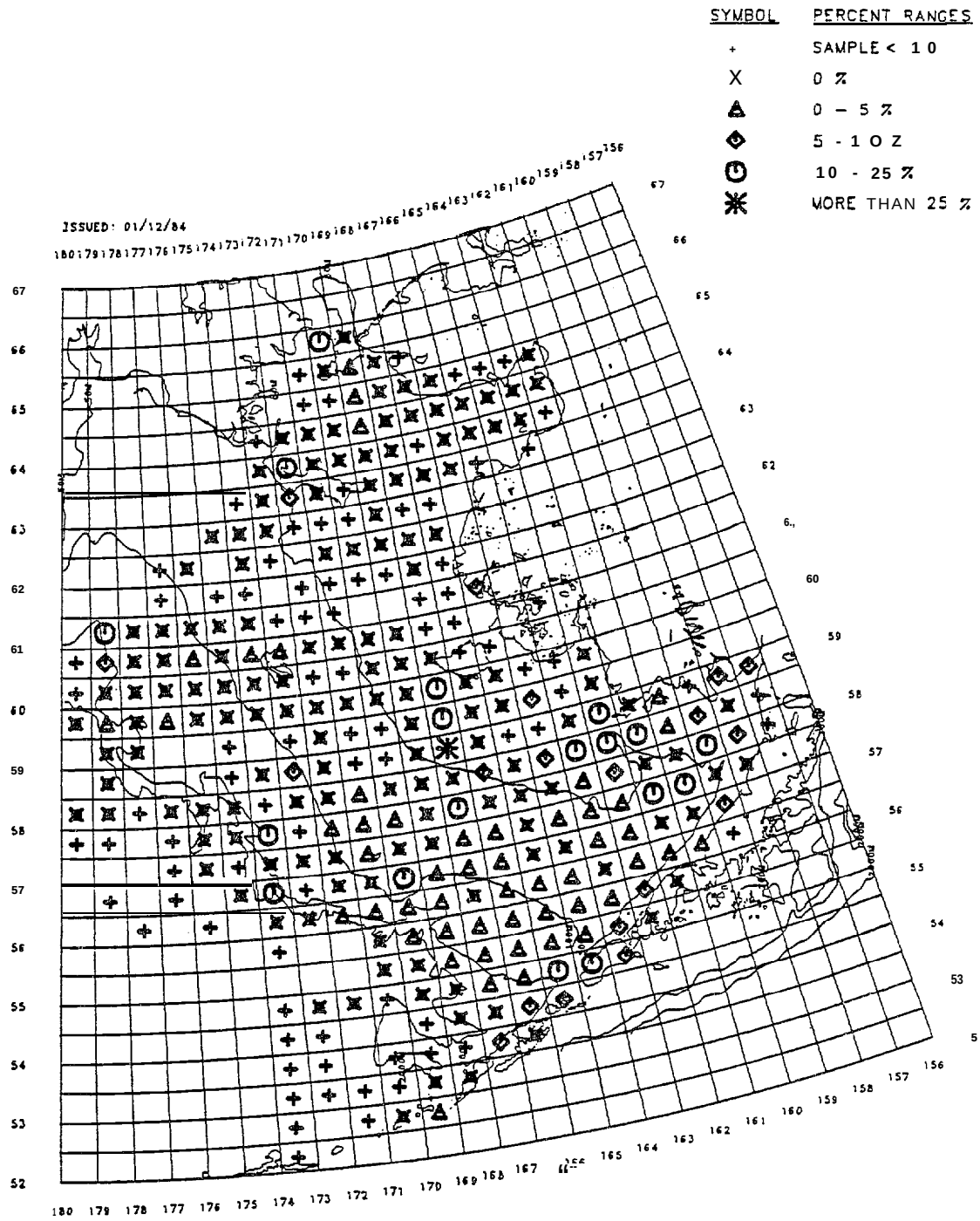


Figure 102. Frequency distribution of transects with densities ≥100 birds/km^2.



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

Figure 103. Frequency distribution of transects with densities ≥500 birds/km^2.

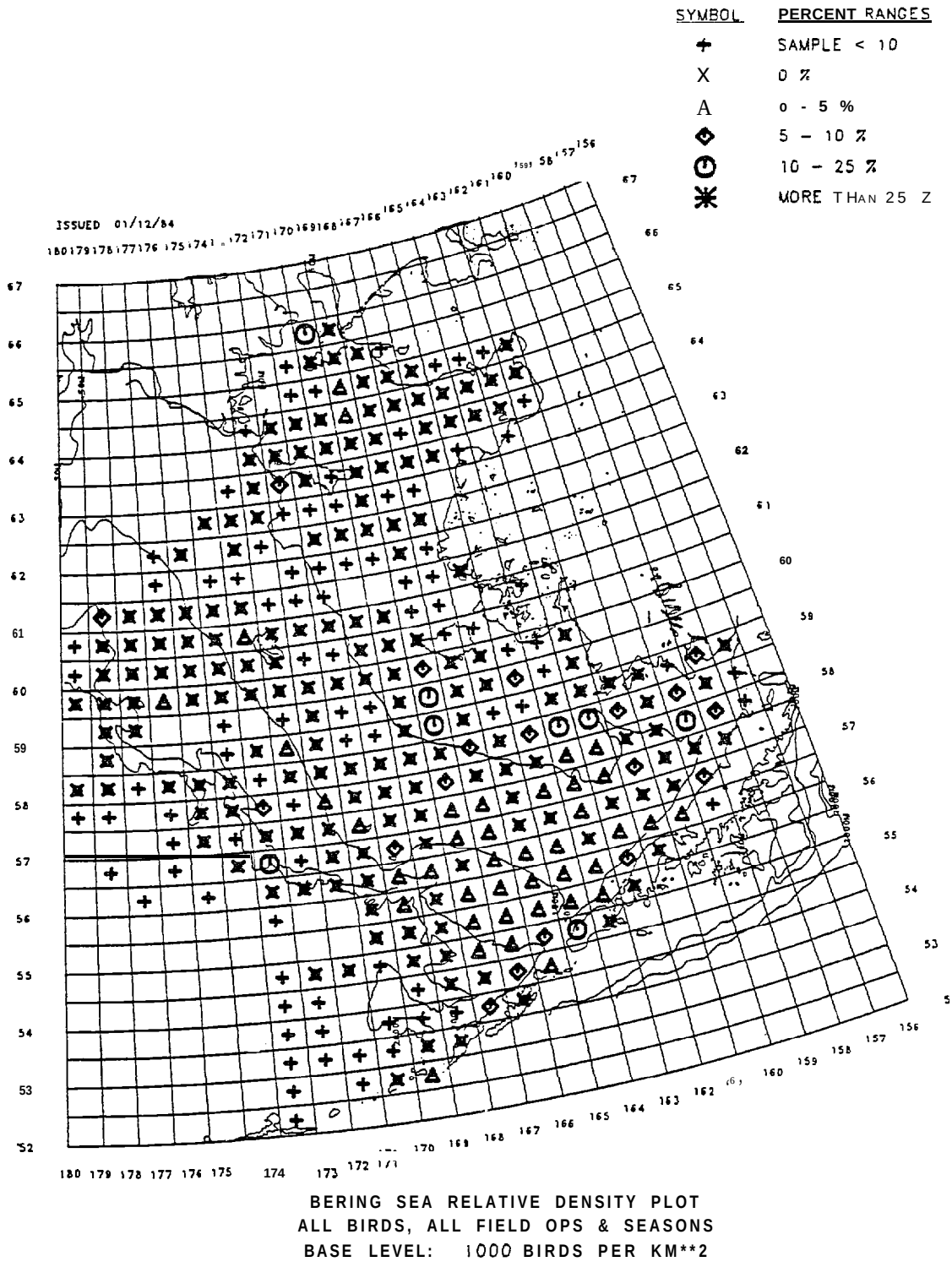


Figure 104. Frequency distribution of transects with densities ≥1,000 birds/km^2.

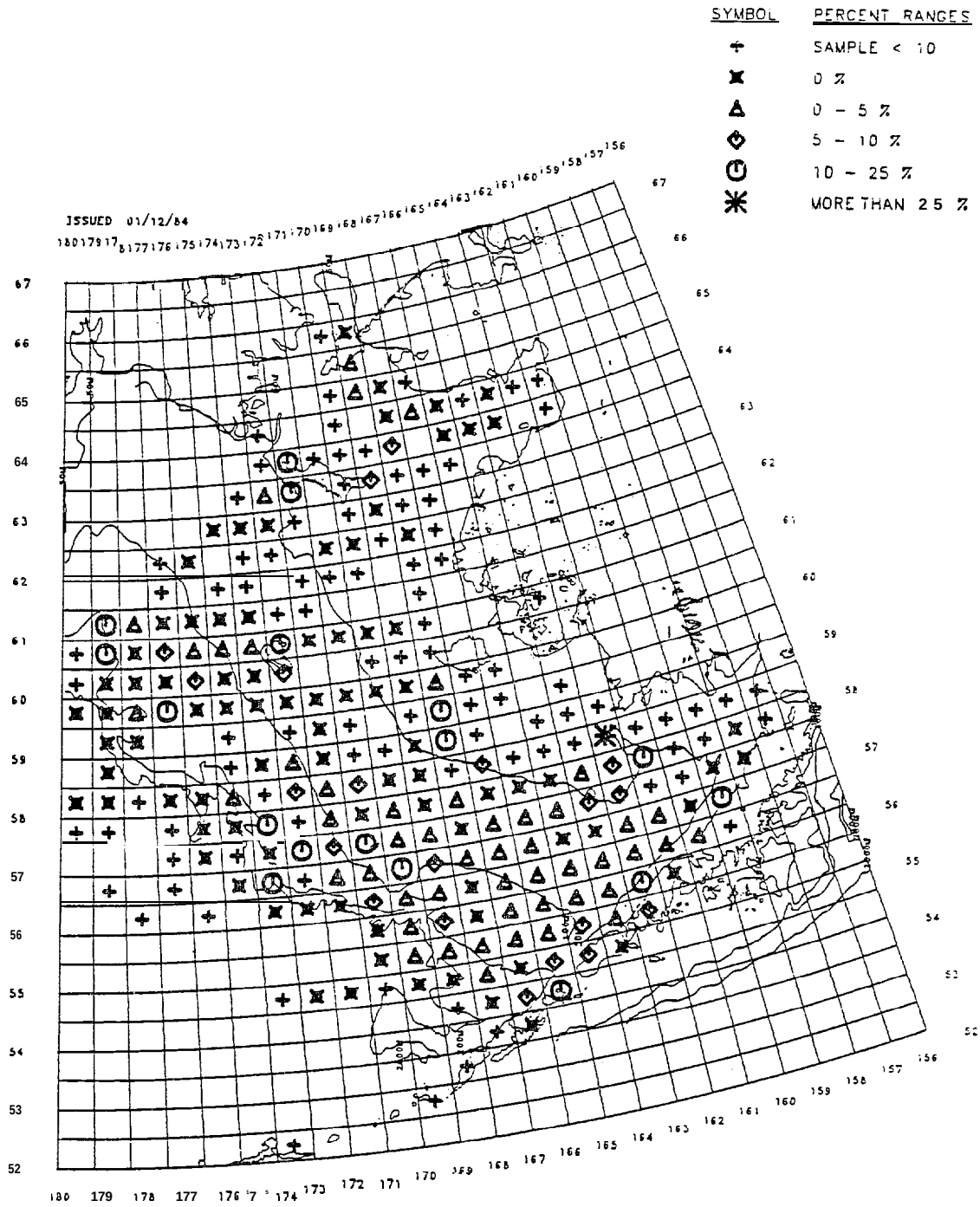


Figure 105. Frequency distribution of transects with densities ≥50 birds/km^2: Birds on the water.

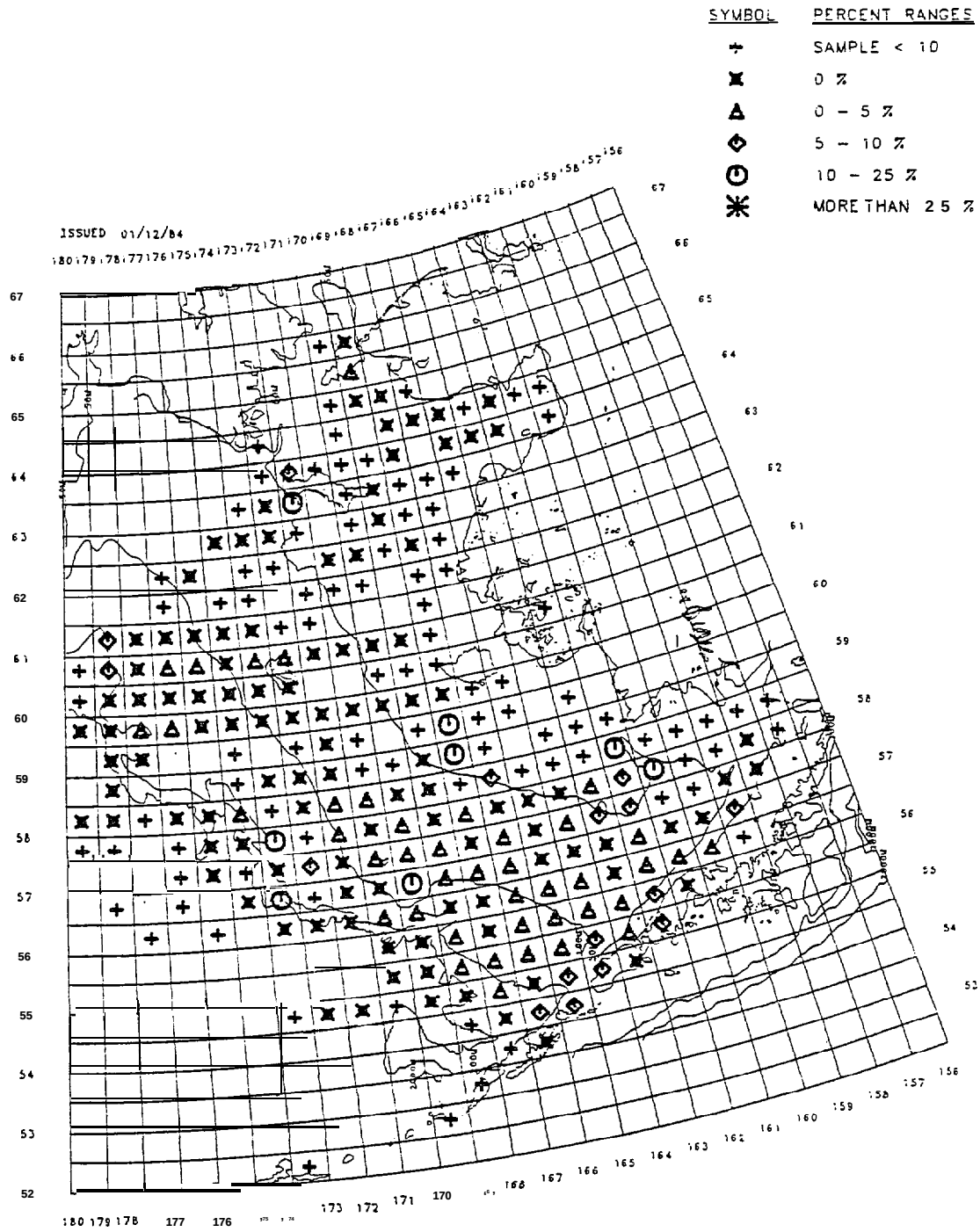
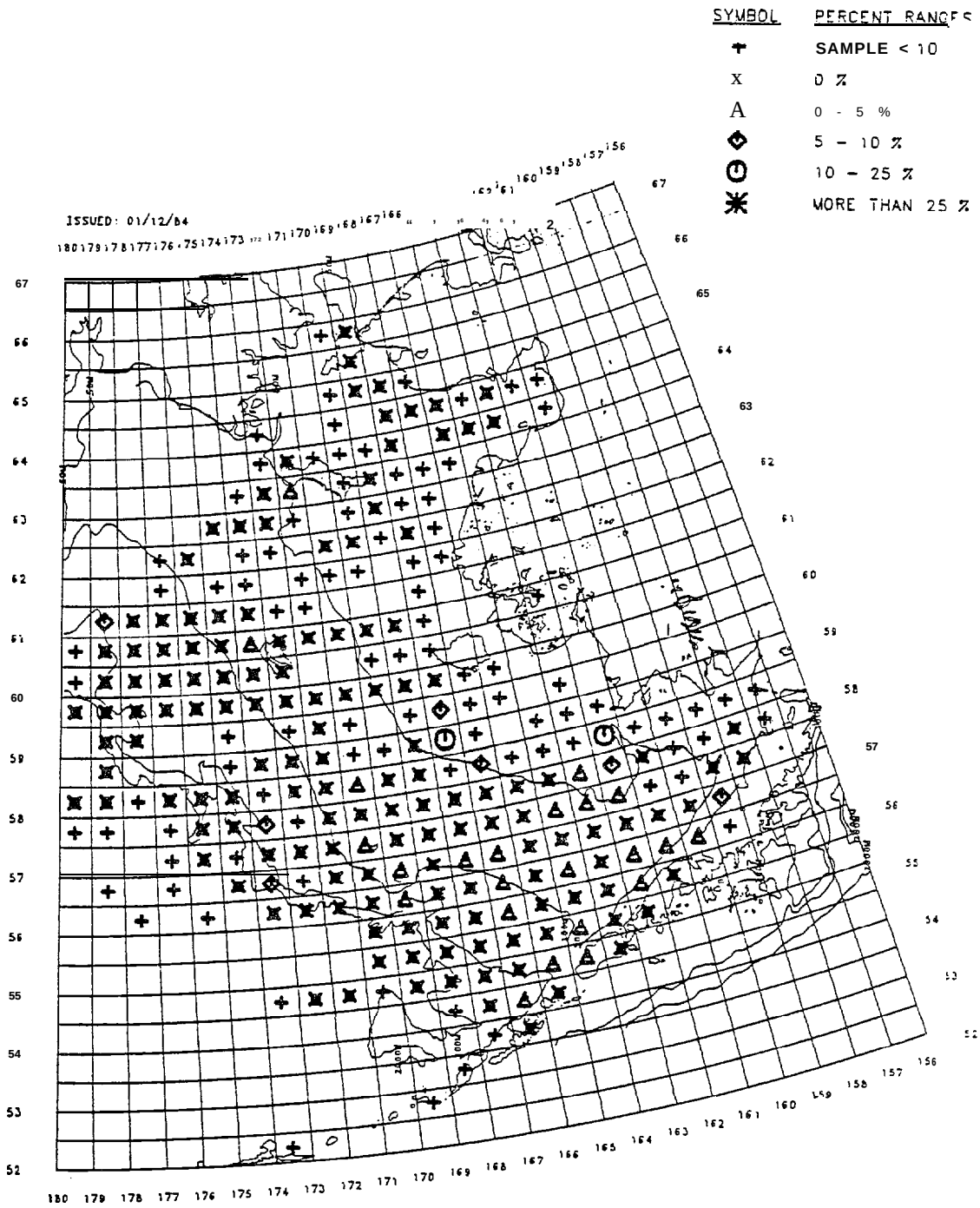


Figure 106. Frequency distribution of transects with densities ≥100 birds/km^2: Birds on the water.



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

Figure 107. Frequency distribution of transects with densities ≥500 birds/km^2: **Birds on the water.**

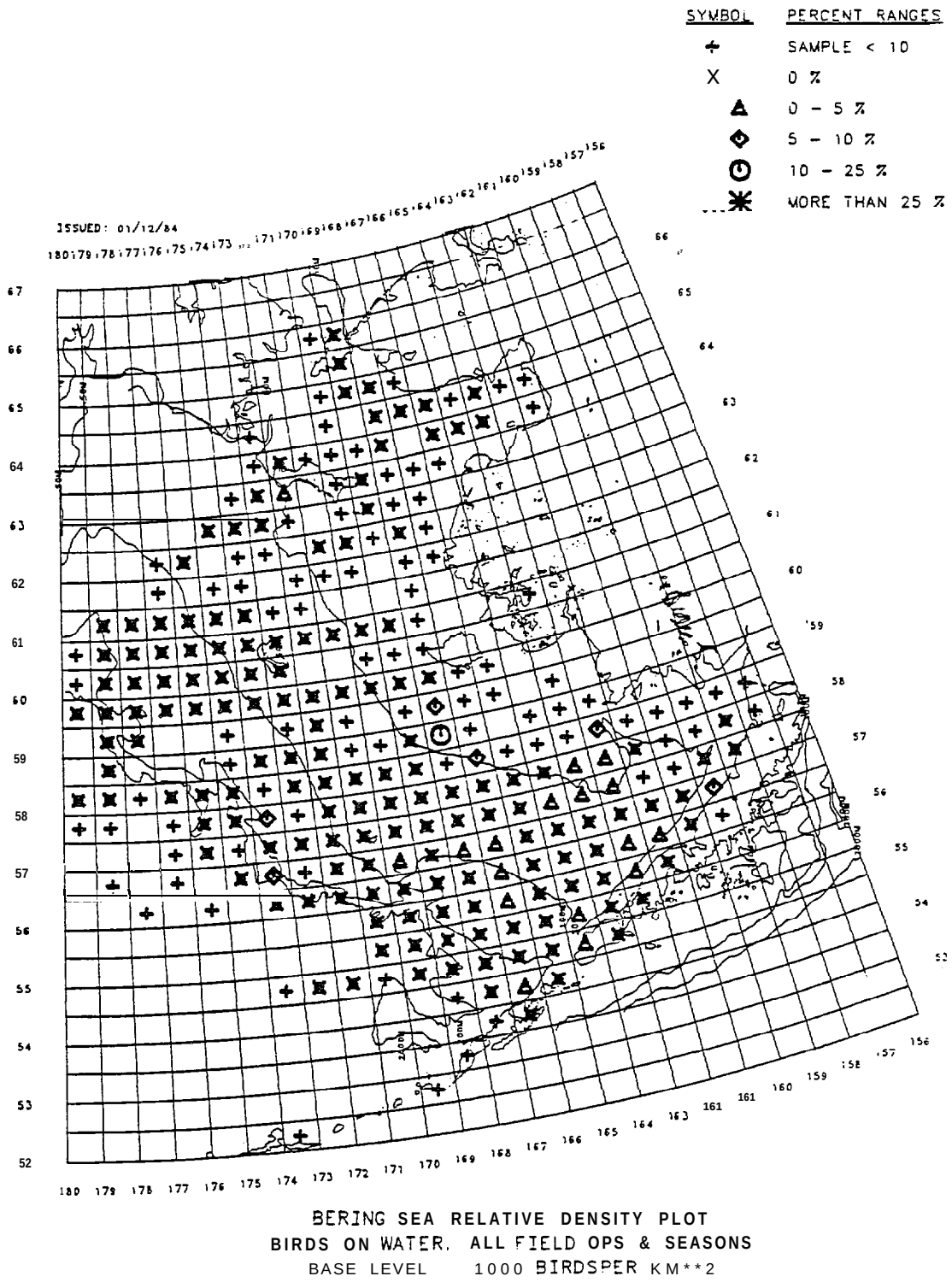


Figure 108. Frequency distribution of transects with densities ≥1,000 birds/km^2: Birds on the water.

APPENDIX 4

Cruises and species groups used in generating distribution maps and other URI products

DATA SETS FOR HUNT PRODUCTS
29 DEC 1983

FILE TYPE	RU	FILE ID	TRACK NUMBER	PROBES	REQUESTED AREA
033	083	UCI501	TR3957		*
	083	UCI601	TR3958		*
	083	UCI602	TR3959		*
	083	UCI703	TR3960		*
	083	UCI704	TR3961		*
	083	UCI801	TR4179		*
	083	UCI802	TR4180		*
	083	UCI803	TR4181		*
	083	UCI804	TR4182		*
	083	UCI805	TR4183		*
	083	UCI806	TR4184		*
	083	UCI808	TR4185		*
	083	UCI580	TR6852		*
	083	UCI480	TR6946	P	*
	083	UCI680	TR6947	P	*
	083	UCI280	TR6948	P	*
	083	UCI380	TR6949	P	*
	083	UCI180	TR6950	P	*
	083	UCI901	TR7487	P	*
	083	UCI902	TR7488	P	*
	083	UCI903	TR7489	P	*
	083	UCI281	TR7601	P	*
	083	UCI381	TR7602	P	*
	083	UCI781	TR7603	P	*
	083	UCI181	TR7654		*
	083	UCI481	TR7655		*
	083	UCI701	TR7656		*
	083	UCI702	TR7657		*
	083	UCI581	TR7897	P	*
	083	UCI681	TR7898	P	*
	083	UCI881	TR7899	P	*
	083	UCI182	TT0479		*
	083	UCI282	TT0480		*
	083	UCI382		P	*
	083	UCI482	TT0501	P	*
	083	UCI582	TT0481		*
	096	290676	TR1299		
	108	1616 1	TR0565		

DATA SETS FOR HUNT PRODUCTS
29 DEC 1983

FILE TYPE	RU	FILE ID	TRACK NUMBER	PROBES	REQUESTED AREA
033	108	0622 1	TR0566		
	108	16140	TR0580		
	108	0621 1	TR0581		*
	108	26140	TR0609		*
	108	0531 1	TR0610		
	108	0522 1	TR0611		*
	108	05220	TR3251		*
	108	0531 0	TR3252		
	108	05320	TR3253		
	108	0532 5	TR3254		
	108	1615 0	TR3255		
	108	3607 0	TR3256		
	108	3607 4	TR3257		
	108	3607 6	TR3258		
	108	0622 3	TR3479		
	196	1DI577			
	196	1SR377			
	196	1SR477			
	196	1SR578			
	196	1SR678			
	196	3A1A76	TR2339		
	196	3A2A76	TR2340		
	196	2A2776	TR2341		
	196	3A1676	TR2342		
	196	3A2676	TR2343		
	196	3A3676	TR2344		
	196	3A2776	TR2345		
	196	3A3776	TR2346		
	196	3A4776	TR2347		
	196	3A5776	TR2348		
	196	3A6776	TR2349		
	196	3A1876	TR2350		
	196	3A2876	TR2351		
	196	3A1976	TR2352		
	196	3A2976	TR2353		
	196	3A3976	TR2354		
	196	2A1576	TR2355		
	196	2A2576	TR2356		

DATA SETS FOR HUNT PRODUCTS
29 DEC 1983

FILE TYPE	RU	FILE ID	TRACK NUMBER	PROBES	REQUESTED AREA
033	196	2A1676	TR2357		
	196	2A2676	TR2358		
	196	2A1776	TR2359		
	196	2A3676	TR2360		
	196	2A5676	TR2361		
	196	2A6676	TR2362		
	196	2A7676	TR2363		
	196	2A3776	TR2364		
	196	2A4776	TR2365		
	196	2A1876	TR2366		
	196	2A2876	TR2367		
	196	2A1976	TR2368		
	196	2A2976	TR2369		
	196	2A3976	TR2370		
	196	2A4976	TR2371		
	196	2A1A76	TR2372		
	196	2A1B76	TR2373		
	196	2PD976	TR2738		
	196	2WR976	TR2739		
	196	30K676	TR2740		
	196	2PD676	TR2741		
	196	2IC676	TR2742		
	196	2CL676	TR2744		
	196	2WR676	TR2745		
	196	3PP776	TR2746		
	196	2CB776	TR2747		
	196	3CR776	TR2748		
	196	3BR776	TR2749		
	196	3OK776	TR2750		
	196	2BW776	TR2751		
	196	3BB776	TR2752		
	196	2UP776	TR2753		
	196	2WR776	TR2754		
	196	2PD776	TR2755		
	196	2IC876	TR2756		
	196	2CL876	TR2757		
	196	3PP876	TR2758		
	196	30K976	TR2760		

DATA SETS FOR HUNT PRODUCTS
29 DEC 1983

FILE TYPE	RU	FILE ID	TRACK NUMBER	PROBES	REQUESTED AREA
033	196	2IC976	TR2761		
	196	2BW576	TR2762		
	196	2KL676	TR2763		
	196	3BL676	TR2764		
	196	2KL776	TR2765		
	196	3PI776	TR2766		
	196	3PB876	TR2767		
	196	2BW076	TR2769		
	196	2CL976	TR2789		
	196	1SR376	TR2838		
	196	1SR476	TR2839		
	196	2GLA76	TR2840		
	196	2GL976	TR2841		
	196	2DI976	TR2842		
	196	2GL876	TR2843		
	196	2BI776	TR2844		
	196	2GL875	TR2845		
	196	3AL876	TR2846		
	196	3C0776	TR2916		
	196	3C0676	TR2917		
	196	3C0876	TR2918		
	196	UCI478	TR4796	P	
	196	3AL878	TR6114		
	196	3AL877	TR7395		
	196	3GL877	TR7396		
	196	GL3976	TR7434		
	196	C03976	TR7436		
	196	NW3878	TR7437		
	237	WD5WFS	TR1689		
	237	WD6OSI	TR1690		
	237	WD6SUI	TR1691		
	237	WD6WFS	TR1692		
	237	WD77BS	TR5392		
	237	A6D8BS	TR5393		
	237	WD78BS	TR5393		
	237	WD78CS	TR5394		
	239	01UC75	TR3106		
	239	02UC75	TR3107		

DATA SETS FOR HUNT PRODUCTS
29 DEC 1983

FILE TYPE	RU	FILE ID	TRACK NUMBER	PROBES	REQUESTED AREA
033	239	03UC75	TR3108		*
	239	01UC76	TR3109		
	239	02UC76	TR3110		
	239	03UC76	TR3111		*
	239	04UC76	TR3112		
	239	05UC76	TR3113		*
	337	FW5007			
	337	FW5028			
	337	FW6069			
	337	FW6096			
	337	FW6100			
	337	FW6200			
	337	FW6300			
	337	FW7047			
	337	FW7050			
	337	FW7051			
	337	FW7052			
	337	FW7053			
	337	FW7054			
	337	FW8006			
	337	FW8007			
	337	FW8008			
	337	FW8012			
	337	FW8014			
	337	FW8015			
	337	FW8016			
	337	FW8017			
	337	FW8018			
	337	FW8025			
	337	FW8027			
	337	FW8028			
	337	FW8100			
	337	FW9001			
	337	FW7032	TR2377		
	337	FW7033	TR2378		
	337	FW7028	TR2847		
	337	FW7031	TR2848		
	337	FW7034	TR2849		

DATA SETS FOR HUNT PRODUCTS
29 DEC 1983

FILE TYPE	RU	FILE ID	TRACK NUMBER	PROBES	REQUESTED AREA
033	337	FW7035	TR2850		
	337	FW7036	TR2851		
	337	FW7042	TR2852		*
	337	FW7045	TR2853		
	337	FW7046	TR2854		
	337	FW5008	TR3481		*
	337	FW5009	TR3482		
	337	FW5014	TR3483		*
	337	FW5027	TR3484		
	337	FW5030	TR3485		
	337	FW5032	TR3486		*
	337	FW6001	TR3487		
	337	FW6015	TR3488		
	337	FW5004	TR3571		
	337	FW5018	TR3572		*
	337	FW5034	TR3573		
	337	FW6025	TR3574		
	337	FW6026	TR3575		
	337	FW6028	TR3576		
	337	FW6029	TR3577		
	337	FW6093	TR3578		*
	337	FW7026	TR3579		
	337	FW7027	TR3580		
	337	FW7029	TR3581		*
	337	FW5010	TR3584		
	337	FW5021	TR3585		*
	337	FW6085	TR3586		*
	337	FW6086	TR3587		*
	337	FW6186	TR3588		*
	337	FW6088	TR3589		*
	337	FW5013	TR3590		*
	337	FW5023	TR3591		*
	337	FW5024	TR3592		
	337	FW6066	TR3593		*
	337	FW5011	TR3634		*
	337	FW5012	TR3635		*
	337	FW5015	TR3636		*
	337	FW5016	TR3637		*

DATA SETS FOR HUNT PRODUCTS
29 DEC 1983

FILE TYPE	RU	FILE ID	TRACK NUMBER	PROBES	REQUESTED AREA
033	337	FW5020	TR3638		*
	337	FW5022	TR3639		*
	337	FW5026	TR3640		*
	337	FW5033	TR3641		*
	337	FW5035	TR3642		*
	337	FW5036	TR3643		*
	337	FW5037	TR3644		*
	337	FW5038	TR3645		*
	337	FW6006	TR3804		*
	337	FW6009	TR3805		*
	337	FW6012	TR3806		*
	337	FW6021	TR3807		*
	337	FW6057	TR3808		*
	337	FW6067	TR3809		*
	337	FW6068	TR3810		*
	337	FW6070	TR3811		*
	337	FW6074	TR3812		*
	337	FW6082	TR3813		*
	337	FW6084	TR3814		*
	337	FW6087	TR3815		
	337	FW6089	TR3816		*
	337	FW5003	TR3842		
	337	FW5006	TR3843		*
	337	FW5025	TR3844		
	337	FW5029	TR3845		
	337	FW5031	TR3846		
	337	FW6002	TR3847		
	337	FW6004	TR3848		
	337	FW6005	TR3849		
	337	FW6010	TR3850		
	337	FW6007	TR3851		
	337	FW6008	TR3852		
	337	FW6011	TR3853		
	337	FW6013	TR3854		
	337	FW6014	TR3855		
	337	FW6016	TR3856		
	337	FW6018	TR3857		
	337	FW6019	TR3858		

DATA SETS FOR HUNT PRODUCTS
29 DEC 1983

FILE TYPE	RU	FILE ID	TRACK NUMBER	PROBES	REQUESTED AREA
033	337	FW6027	TR3859		*
	337	FW6050	TR3860		
	337	FW6051	TR3861		
	337	FW6052	TR3862		
	337	FW6064	TR3863		
	337	FW6077	TR3864		
	337	FW6078	TR3865		
	337	FW6083	TR3866		
	337	FW6092	TR3867		
	337	FW6094	TR3868		
	337	FW6095	TR3869		
	337	FW4001	TR6497		
	337	FW9002	TR6498		
	337	FW6400	TR7397		
	337	FW8019	TR7398		
	337	FW8023	TR7399		
	337	FW8024	TR7400		
	337	FW8026	TR7401		
	337	FW8029	TR7402		
	337	FW8032	TR7403		
	460	EC1978	TR7914		
	467	AERSR1	TR4318		
	467	AERSR2	TR4319		
	467	AERSR3	TR4320		
	467	AERSR4	TR4321		
	467	AERSR5	TR4322		
	467	AERSR6	TR4323		
	467	AERSR7	TR4324		
	467	AER801	TR5395		
	467	AER802	TR5396		
	467	AER803	TR5397		
	467	AER804	TR5398		
	467	AER805	TR5399		
	467	AER806	TR5400		
	467	AER807	TR5401		
	467	AER808	TR5402		
	467	AER809	TR5403		
	467	AER810	TR5404		

SPECIES LIST FOR HUNT PRODUCTS

Bering Sea

FT033, Marine Bird Sightings, Ship/Aircraft

Small and Unidentified Alcids

881010000000
881010060000-881010119999
912901000000
912901060000-912901119999

Crested Auklets

881010110100-881010110199
912901110100-912901110199

Least Auklets

881010110200-881010110299
912901110200-912901110299

Parakeet Auklets

881010100100-881010100199
912901100100-912901100199

Cormorants

880404000000-880404999999
911004000000-911004999999

Eiders

880601170000-880601179999
911201170000-911201179999

Northern Fulmars

880302020100-880302020199
910902020100-910902020199

Gulls except Kittiwakes

881008000000-881008029999
881008040000-881008059999
912802000000-912802029999
912802040000-912802059999

Black-legged Kittiwakes

881008030000-881008030199
912802030000-912802030199

Red-legged Kittiwakes

881008030200-881008030299
912802030200-912802030299

Common Murres

881010030100-881010030199
912901030100-912901030199

Murres

881010030000-881010039999
912901030000-912901039999

Thick-billed Murres

881010030200-881010030299
912901030200-912901030299

Storm Petrels: Unidentified Storm Petrels and Fork-tailed Storm Petrels

880303000000-880303020199
910903000000-910903020199

Phalaropes

881006000000-881006999999
912707000000-912707999999

Horned Puffins

881010130200-881010130299
912901130200-912901130299

Tufted Puffins

881010140100-881010140199
912901140100-912901140199

Shearwaters: Unidentified Shearwaters, Sooty Shearwaters, and Short-tailed Shearwaters

880302040000
880302040700-880302040899
910902040000
910902040700-910902040899

Waterfowl

880600000000-880699999999
911200000000-911299999999

APPENDIX 5

Mean, standard deviation and frequency of densities for selected species in the central Bering Sea shelf by zone

Platform type code: 1

Number of tapes: 1
Tape number 1 assigned to unit: 16 Files skipped before reading: 0 Number of files searched: 6

Number of cruises accepted: 6
Cruises accepted: UC'11s2 UC I282 UCI382 UCI482 UCI582 UCI999

Number of tax code sets: 12
Number of tax codes for each set: 1 1 1 1 2 1 1 1 1 1 1 4
Species mnemonics and codes:

ALL	All birds	91000CI00C10 8	
NOFU	Northern Fulmar	7109020201 0	
SHER	shearwaters	9109020400 2	
STPE	storm-petrels	9109030000 4	
BLKI	w -legged kittiwake	912S020300 0	912.3020301 0
'HAL	phalaropes	9127070000 4	
LEAU	least Auklet	9129011102 0	
MURR	murres	9129010300 2	
CRAU	Crested Auklet	9129011101 0	
COMU	- -	9 1 2 9 0 1 0 3 0 1 0	
TBMU	Thick-billed Murre	9125'010302 0	
SMAL	small alcids	9129010000 0	9129011001 0 9129011101 0 9129011102 0

Number of seasons: 3
Season mnemonics and months:

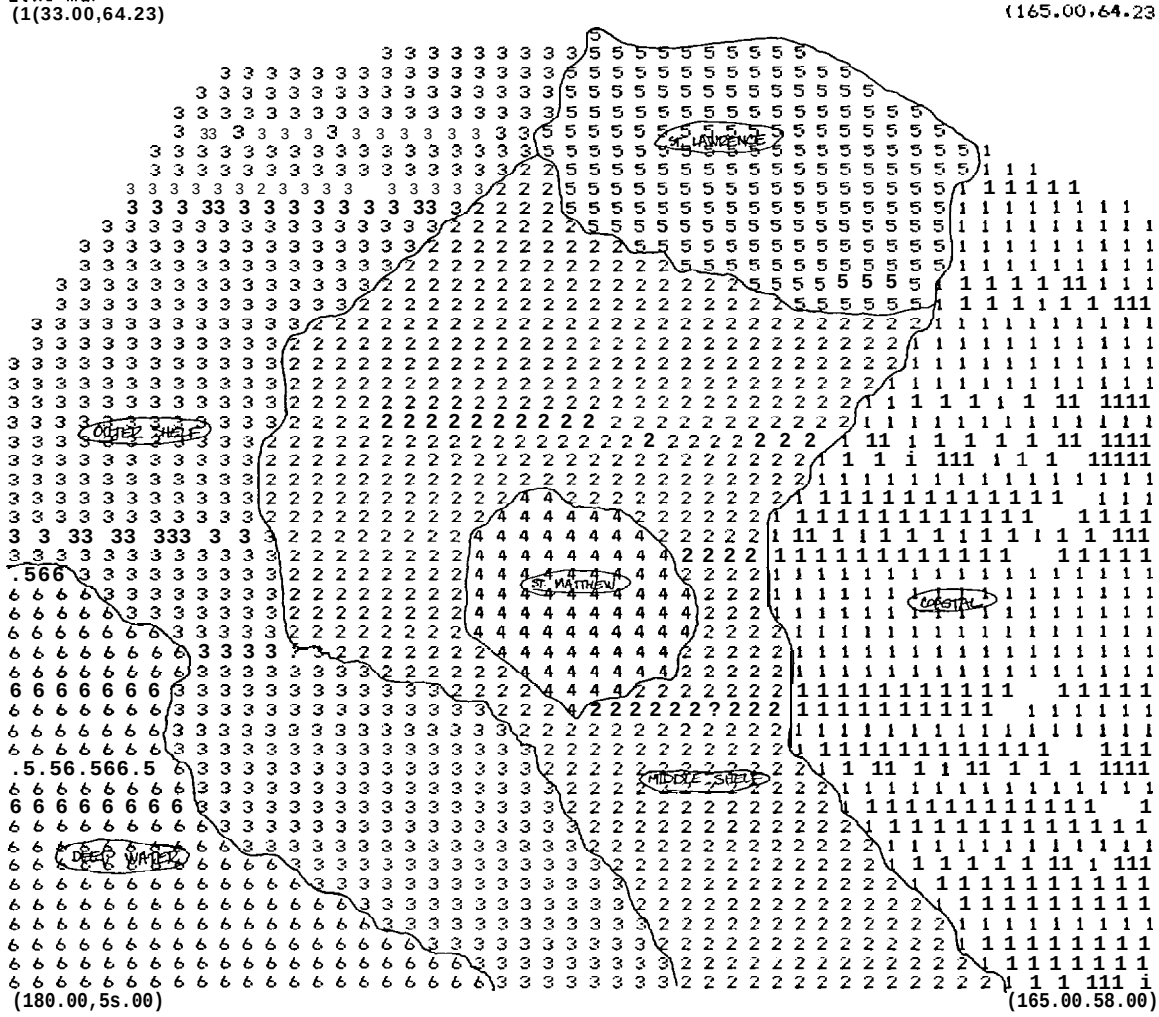
"SPRING	3	4	5
SUMMER	6	7	8
AUTUMN	9	10	11

Zone files accepted:

NBSCO.ZON	63.	63.	58.	58.	59.	60.	62.							
Coastal	32.	o.	0.	0.	27.	57.	22.							
	167.	165.	165.	167.	169.	170.	168.							
	38.	0.	0.	20.	53.	27.	10.							
NBSMI.ZON	60.	59.	58.	58.	59.	60.	61.	62.	63.	62.				
Middle Shelf	57.	27.	0.	0.	42.	1%.	22.	12.	32.	22.				
	170.	169.	167.	171.	173.	176.	177.	176.	173.	168.				
	27.	53.	20.	30.	43.	45.	2.	42.	4.	10.				
NBSSL.ZON	58.	5s.	59.	59.	60.	60.	62.	64.	64.	63.	62.	61.	60.	59.
Outer Shelf	0.	0.	0.	39.	10.	47.	10.	0.	14.	32.	12.	22.	18.	42.
	171.	174.	177.	17s.	177.	180.	180.	177.	172.	173.	176.	177.	176.	173.
	30.	".	43.	25.	57.	o.	0.	30.	28.	4.	42.	2.	45.	43.
STM60K.ZON	61.	61.	60.	60.	59.	59.	60.	60.	61.					
St. Matthew	12.	2.	52.	25.	59.	46.	1.5.	49.	9.					
	173.	172.	171.	171.	171.	172.	174.	174.	173.					
	5.	12.	44.	9.	48.	45.	6.	10.	39.					
STL60K.ZON	63.	62.	62.	.52.	62..,	63.	63.	64.	64.					
St. Lawrence	32.	22.	23.	40.	46.	6.	32.	14.	12.					
	167.	168.	169.	170.	171.	172.	173.	172.	169.					
	38.	10.	28.	48	47.	49.	4.	28.	56.					
NBSDP.ZON	60.	60.	59.	59.	53.	53.								
Deep Water	47.	10.	39.	0.	0.	0.								
	180.	177.	178.	177.	174.	180.								
	0.	57.	25.	43.	0.	o.								

Zone map
(1(33.00,64.23)

(165.00,64.23)



(180.00,5s.00)

(165.00.58.00)

Cruise UCI182 reading

Rejection list Width: 0 Platform: 0 Length: 10 Latitude: 0 Longitude: 0 Zone: 82 Month: 0

Records written on file 0

Cruise UCI282 reading

Rejection list Width: 0 Platform: 0 Length: 21 Latitude: 0 Longitude: 0 Zone: 30 Month: 0

Records written on file 0

Cruise UCI382 reading

Rejection list Width: 0 Platform: 0 Length: 4 Latitude: 0 Longitude: 0 Zone: 171 Month: 0

Records written on file 0

Cruise UCI482 reading

Rejection list Width: 0 Platform: 0 Length: 21 Latitude: 0 Longitude: 0 Zone: 1 Month: 0

Records written on file 0

Cruise UCI582 reading

Rejection list Width: 0 Platform: 0 Length: 10 Latitude: 0 Longitude: 0 Zone: 275 Month: 0

Records written on file 0

Cruise UCI999 reading

Rejection list Width: 0 Platform: 0 Length: 13 Latitude: 0 Longitude: 0 Zone: 108 Month: 0

Records written on file 0

NBSCO.ZON	ALL	NOFU	SHER	STPE	BLKI	PHAL	LEAU	MURR	CRAU	COMU	TBMU	SMAL
SPRING												
XB all	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
SD all	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
XB water	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
SD water	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
N	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
Empty	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.003	0.000	0.000	0.000	0.000
0-5	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
5-15	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
15-30	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
30-75	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
75-250	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
250-	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
SUMMER												
XB all	75.18	0.68	0.16	0.00	14.48	0.00	0.00	39.86	10.35	2.38	1.48	10.58
SD all	.48.90	1.54	0.94	0.00	16.64	0.00	0.00	48.98	28.86	5.50	3.18	28.78
XB water	16.32	0.07	0.00	0.00	5.42	0.00	0.00	7.71	1.62	1.35	0.73	1.78
SD water	22.4.5	0.45	0.00	0.00	1S.52	0.00	0.00	9.50	7.72	3.30	2.24	7.72
N	36.	36.	36.	3.5.	36.	34.	36.	34.	36.	36.	34.	36.
Empty	0.028	0.806	0.972	1.000	0.194	1.000	1.000	0.083	0.722	0.694	0.750	0.639
0-5	0.000	0.139	0.000	0.000	0.083	0.000	0.000	0.056	0.056	0.167	0.111	0.139
5-15	0.083	0.056	0.028	0.000	0.389	0.000	0.000	0.27S	0.083	0.0%3	0.139	0.083
15-30	0.167	0.000	0.000	0.000	0.167	0.000	0.000	0.139	0.028	0.056	0.000	0.028
30-75	0.417	0.000	0.000	0.000	0.167	0.000	0.000	0.306	0.056	0.000	0.000	0.056
75-250	0.278	0.000	0.000	0.000	0.000	0.000	0.000	0.139	0.056	0.000	0.000	0.05.4
250-	0.028	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
AUTUMN												
X9 all	3.34	0.0.5	0.01	0.12	0.74	0.33	0.02	0.06	0.35	0.00	0.00	0.85
SD all	5.99	0.22	0.11	0.68	1.56	1.3%	0.18	0.24	1.07	0.00	0.00	1.71
XB water	0.85	0.00	0.00	0.00	0.14	0.05	0.00	0.0.5	0.30	0.00	0.00	0.48
SD water	2.17	0.00	0.00	0.00	1.13	0.34	0.00	0.24	0.93	0.00	0.00	1.07
N	76.	7.5.	76.	76.	76.	76.	76.	76..	74.	76.	7.5.	76.
Empty	0.224	0.934	0.987	0.947	0.618	0.908	0.987	0.934	0.855	1.000	1.000	0.684
0-5	0.632	0.066	0.013	0.039	0.368	0.079	0.013	0.066	0.132	0.000	0.000	0.276
5-15	0.118	0.000	0.000	0.013	0.013	0.013	0.000	0.000	0.013	0.000	0.000	0.039
15-30	0.013	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
'3(3-7.5	0.013	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
75-250	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
250-	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000

COASTAL ZONE

MIDDLE SHELF ZONE

NBSMI.ZON	ALL	NOFU	SHER	STPE	BLKI	PHAL	LEAU	MURR	CRAU	COMU	TBMU	SMAL
SPRING												
XB all	43.55	2.10	0.01	0.21	3.14	0.33	22.11	13.57	0.1s	0.64	7.97	22.58
SD all	61.16	3.15	0.08	1.57	6.63	1.'26	56.02	24.2.5	0.69	1.52	13.82	56.12
XB water	19.62	0.27	0.00	0.00	0.74	0.13	11.37	6.32	0.00	0.24	4.54	11.50
SD water	44.82	1.27	0.00	0.00	4.14	0.57	43.91	10.13	0.00	1.20	9.57	43.89
N	113.	113.	113.	113.	113.	113.	113.	113.	113.	113.	113.	113.
Empty	0.000	0.345	0.991	0.965	0.345	0.894	0.354	0.044	0.938	0.690	0.221	C). 327
0-5	0.053	0.558	0.009	0.027	0.522	0.088	0.159	0.372	0.062	0.292	0. 478	0.159
5-15	0.283	0.080	0.000	0.000	0.097	0.013	c). 204	0.319	0.000	0.018	0. 159	0.230
15-30	0.212	0.01s	0.000	0.009	0.027	0.000	0.053	0.142	0.000	0. 000	0. 044	0.053
30-7s	0.319	0.000	0.000	0.000	0.009	0. 000	0. 159	0. 115	0. 000	0. 000	0.0'97	0. 159
75-250	0.124	0.000	0.000	0.000	0.000	0.000	0.062	0.009	0. 000	0. 000	0.000	0. 062
250-	0.009	0.000	0. 000	0.000	0. 000	0. 000	0.009	0.000	0.000	0.000	0.000	0. 009
SUMMER												
XB all	18.93	1.69	0.30	0.50	0.7s	0.14	1.34	11.00	0.94	1.05	1.32	3.81
Shall	30.62	5.16	1.35	3.28	2. 16	1.53	7.(>2	24.80	8.65	5.47	2.90	15.56
XB water	3.39	0.16	0.00	0.05	0.00	0.02	0.25	2.40	0.28	0.23	0.29	0.64
SD water	5.51	1.18	0.06	0.68	0.07	0.32	1.91	3.81	1.96	0 .90	1.05	3.71
N	291.	291.	291.	291.	291.	291.	291.	291.	291.	2'91.	291.	291.
Empty	0.024	0.694	0. 897	0.935	0.732	0.986	0.866	0.110	0.918	0.790	0. 684	0.722
0-5	0.2S4	0.227	0.093	0.045	0.234	0.003	0.065	0.368	0.055	0. 165	0.213	0.141
5-15	0.347	0.048	0.010	0.003	0.031	0.007	0.048	0.313	0.017	0.038	0.096	0.082
15-30	0.220	0.024	0.000	0.014	0.003	0.003	0.014	0.155	0.003	0.000	0.007	0.034
30-75	0.124	0.007	0.000	0.003	0.000	0.000	0.003	0.041	0.003	0.003	0.000	0.010
75-250	0.027	0.000	0.000	0.000	0.000	0.000	0.003	0.010	0.003	0.003	0.000	0.010
250-	0.003	0.000	0.000	0.000	0.000	0.000	0.000	0.003	0.000	0.000	0.000	0.000
AUTUMN												
XB all	12.00	0.47	0.13	0.20	0.77	0.94	0.91	3.94	1.43	0.03	0. 09	4.01
SD all	14.83	0.96	0.44	0.73	2.03	9.13	2.51	6.52	6.10	0.28	0. 44	7.79
XB water	3.s3	0.05	0.00	0.04	0.09	0.29	0.37	1.45	0.65	0.03	0.09	1.60
SD water	6.03	0.37	0.00	0.40	0.76	2.80	1.06	3.29	1.59	0.28	0.44	2.67
N	223.	223.	223.	223.	223.	223.	223.	223.	223.	223	223.	223
Empty	0.013	0.740	0.906	0.888	0.677	0.946	0.713	0.345	0.726	0. 982	0.946	0.291
0-5	0.314	0.260	0.094	0.103	0.287	0.013	0.242	0.417	0.211	0.018	0.054	0.475
5-15	0.430	0.000	0.000	0.009	0.031	0.031	0.040	0.188	0.045	0.000	0.000	0.184
15-30	0.175	0.000	0.000	0.000	0.004	0.004	0.004	0.031	0. 009	0.000	0.000	0.0.31
30-75	0.058	0.000	0.000	0.000	0.000	0.000	0.000	0.01s	0.004	0. 000	0.000	0.013
75-250	0.009	0.000	0.000	0.000	0.000	0.004	0.000	0.000	0.004	0.000	0.000	0.004
250-	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000

OUTER SHELF ZONE

NBSSL.ZON	ALL	NOFU	SHER	STPE	BLKI	PHAL	LEAU	MURR	CRAU	COMU	TRMI	SMAI
SPRING												
XB all	38.33	2.68	1.71	6.57	1.66	1.16	18.52	4.81	0.03	0.15	3.20	18.76
SD all	126.13	4.26	17.18	32.85	4.82	6.85	121.75	6.30	0.16	0.52	4.42	121.77
XB water	5.82	0.28	0.00	0.02	0.30	0.07	3.31	1.56	0.01	0.06	1.01	3.38
SD water	15.97	1.38	0.00	0.13	2.74	0.61	15.69	2.72	0.07	0.33	2.05	15.69
N	168.	168.	168.	168.	168.	168.	168.	168.	168.	168.	168.	168.
Empty	0.006	0.304	0.923	0.780	0.500	0.821	0.583	0.155	0.970	0.905	0.315	0.518
0-5	0.119	0.554	0.036	0.107	0.440	0.137	0.149	0.524	0.030	0.095	0.446	0.196
5-15	0.363	0.119	0.030	0.012	0.048	0.030	0.161	0.274	0.000	0.000	0.208	0.179
15-30	0.286	0.018	0.006	0.042	0.000	0.000	0.048	0.036	0.000	0.000	0.030	0.048
30-75	0.155	0.006	0.000	0.042	0.012	0.006	0.024	0.012	0.000	0.000	0.000	0.024
75-250	0.054	0.000	0.006	0.012	0.000	0.006	0.024	0.000	0.000	0.000	0.000	0.024
250-	0.018	0.000	0.000	0.006	0.000	0.000	0.012	0.000	0.000	0.000	0.000	0.012
SUMMER												
XB all	76.95	6.85	8.80	43.33	0.62	28.26	0.62	6.84	0.05	0.10	3.89	0.90
SD all	213.63	18.91	76.37	136.07	2.22	119.40	2.31	9.49	0.41	0.64	7.21	3.14
XB water	22.33	2.35	0.01	5.87	0.09	10.65	0.27	2.89	0.03	0.00	1.76	0.35
SD water	79.49	16.37	0.13	27.02	0.86	71.25	1.33	5.32	0.36	0.06	4.97	1.59
N	223.	223.	223.	223.	223.	223.	223.	223.	223.	223.	223.	223.
Empty	0.027	0.363	0.713	0.242	0.785	0.789	0.857	0.265	0.973	0.964	0.561	0.816
0-5	0.139	0.314	0.202	0.305	0.184	0.013	0.108	0.350	0.022	0.027	0.202	0.130
5-15	0.247	0.188	0.058	0.242	0.022	0.040	0.031	0.247	0.004	0.009	0.148	0.045
15-30	0.184	0.103	0.009	0.054	0.009	0.027	0.004	0.094	0.000	0.000	0.076	0.009
30-75	0.188	0.022	0.004	0.049	0.000	0.036	0.000	0.045	0.000	0.000	0.013	0.000
75-250	0.112	0.004	0.000	0.054	0.000	0.063	0.000	0.000	0.000	0.000	0.000	0.000
250-	0.103	0.004	0.013	0.054	0.000	0.031	0.000	0.000	0.000	0.000	0.000	0.000
AUTUMN												
XB all	20.76	0.96	4.65	0.22	0.20	0.14	4.07	2.53	0.11	0.01	0.10	8.11
SD all	43.75	1.44	27.73	0.64	0.65	0.92	9.70	4.07	0.54	0.08	0.55	20.30
XB water	4.95	0.05	0.48	0.03	0.03	0.00	1.46	1.27	0.03	0.01	0.09	2.46
SD water	11.89	0.25	5.47	0.22	0.20	0.00	3.74	2.58	0.23	0.08	0.52	5.95
N	137.	137.	137.	137.	137.	137.	137.	137.	137.	137.	137.	137.
Empty	0.022	0.562	0.737	0.861	0.861	0.971	0.562	0.358	0.942	0.993	0.956	0.343
0-5	0.234	0.409	0.219	0.139	0.139	0.015	0.226	0.489	0.051	0.007	0.044	0.321
5-15	0.467	0.029	0.007	0.000	0.000	0.015	0.139	0.139	0.007	0.000	0.000	0.212
15-30	0.182	0.000	0.015	0.000	0.000	0.000	0.036	0.015	0.000	0.000	0.000	0.073
30-75	0.051	0.000	0.000	0.000	0.000	0.000	0.036	0.000	0.000	0.000	0.000	0.044
75-250	0.029	0.000	0.022	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.007
250-	0.015	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000

NBSDP.ZON	ALL	NOFU	SHER	STPE	ELKI		LEPU	MURR	CRAU	COMU		SMAL
DEEP WATER ZONE												
SPRING												
XB all	5.80	1.33	0.18	0.17	1.04	0.16	0.46	1.09	0.34	0.01	0.68	0.96
SD all	5.38	2.01	0.94	0.84	2.19	0.60	1.16	2.06	2.07	0.08	1.52	2.62
XB water	0.91	0.06	0.00	0.01	0.18	0.03	0.15	0.13	0.00	0.00	0.11	0.19
SD water	2.45	0.36	0.00	0.07	0.99	0.26	0.58	0.44	0.00	0.00	0.41	0.64
N	146.	146.	146.	146.	146.	146.	146.	146.	146.	146.	146.	146.
Empty	0.068	0.438	0.952	0.918	0.589	0.904	0.801	0.575	0.938	0.993	0.685	0.747
0-5	0.473	0.500	0.034	0.075	0.384	0.096	0.185	0.316	0.048	0.007	0.281	0.212
5-15	0.390	0.062	0.014	0.007	0.021	0.000	0.014	0.028	0.000	0.000	0.034	0.027
15-30	0.068	0.000	0.000	0.000	0.007	0.000	0.000	0.000	0.014	0.000	0.000	0.014
30-75	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
75-250	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
250-	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
SUMMER												
XB all	23.51	4.48	1.40	15.29	0.47	0.03	0.29	0.27	0.03	0.00	0.05	1.00
SD all	57.83	10.30	3.24	51.14	1.48	0.25	1.13	0.97	0.32	0.00	0.35	4.43
XB water	1.26	0.54	0.12	0.14	0.00	0.00	0.14	0.05	0.00	0.00	0.02	0.22
SD water	2.32	1.21	0.85	0.55	0.00	0.00	0.58	0.21	0.00	0.00	0.14	0.89
N	140.	140.	140.	140.	140.	140.	140.	140.	140.	140.	140.	140.
Empty	0.157	0.564	0.621	0.450	0.850	0.986	0.907	0.957	0.993	1.000	0.971	0.871
0-5	0.414	0.214	0.307	0.293	0.114	0.014	0.071	0.036	0.007	0.000	0.029	0.071
5-15	0.143	0.107	0.050	0.029	0.036	0.000	0.021	0.007	0.000	0.000	0.000	0.043
15-30	0.064	0.093	0.021	0.064	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.007
30-75	0.150	0.014	0.000	0.136	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.007
75-250	0.057	0.007	0.000	0.021	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
250-	0.014	0.000	0.000	0.007	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
AUTUMN												
XB all	22.04	2.63	15.36	0.25	0.44	0.36	0.34	0.46	0.25	0.00	0.05	0.91
SD all	57.89	4.78	55.83	1.57	0.78	1.77	1.17	0.85	1.91	0.00	0.28	2.79
XB water	0.99	0.18	0.03	0.00	0.00	0.00	0.02	0.14	0.00	0.00	0.05	0.07
SD water	1.21	0.66	0.26	0.00	0.00	0.00	0.14	0.44	0.00	0.00	0.28	0.24
N	57.	57.	57.	57.	57.	57.	57.	57.	57.	57.	57.	57.
Empty	0.035	0.526	0.439	0.930	0.984	0.047	0.895	0.684	0.082	0.000	0.965	0.754
0-5	0.281	0.298	0.333	0.053	0.016	0.018	0.088	0.316	0.000	0.000	0.035	0.193
5-15	0.491	0.123	0.105	0.018	0.030	0.035	0.018	0.000	0.018	0.000	0.000	0.035
15-30	0.088	0.053	0.035	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.018
30-75	0.070	0.000	0.053	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
75-250	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
250-	0.035	0.000	0.035	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000

ST. MATTHEW ISLAND ZONE

STM60K.ZON	ALL	NOFU	SHER	STPE	BLKI	PHAL	LEAU	MURR	CRAU	COMU	TBMU	SMAL
SPRING												
XB all	5.66	2.25	0.00	0.09	1.49	0.00	0.00	7.54	2.24	1.78	1.49	2.24
SD all	9.47	1.42	0.00	0.29	2.27	0.00	0.00	7.43	5.58	1.81	2.29	5.58
XB water	5.69	0.09	0.00	0.00	0.00	0.00	0.00	5.2[illegible]	0.00	1.30	0.91	0.00
SD water	7.06	0.28	0.00	0.00	0.00	0.00	0.00	7.2[illegible]	0.00	1.71	1.96	0.00
N	10.	10.	10.	10.	10.	10.	10.	10.	10.	10.	10.	10.
Empty	0.000	0.0[illegible]	1.000	0.900	0.500	1.000	1.000	0.000	0.800	0.300	0.400	0.800
0-5	0.100	0.9[illegible]	0.000	0.100	0.400	0.000	0.000	0.500	0.100	0.600	0.500	0.100
5-15	0.400	0.1[illegible]	0.000	0.000	0.100	0.000	0.000	0.400	0.000	0.100	0.100	0.000
15-30	0.400	0.0[illegible]	0.000	0.000	0.000	0.000	0.000	0.100	0.100	0.000	0.000	0.100
30-75	0.100	0.0[illegible]	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
75-250	0.000	0.0[illegible]	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
250-	0.000	0.0[illegible]	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
SUMMER												
XB all	193.32	9.30	1.03	0.04	2.51	0.13	17.93	144.33	1.18	1.02	4.65	31.44
SD all	448.56	37.80	2.53	0.35	3.85	1.0[illegible]	58.41	401.18	6.89	2.15	10.11	97.17
XB water	72.35	0.37	0.04	0.00	0.19	0.0[illegible]	4.55	62.76	0.67	0.30	2.62	7.53
SD water	345.45	1.02	0.23	0.00	1.11	0.0[illegible]	16.58	342.74	5.31	1.19	6.46	21.72
N	67.	67.	67.	67.	67.	67.	67.	67.	67.	67.	67.	67.
Empty	0.000	0.373	0.776	0.985	0.358	0.985	0.537	0.000	0.925	0.672	0.537	0.343
0-5	0.000	0.343	0.149	0.015	0.493	0.000	0.239	0.030	0.045	0.239	0.224	0.179
5-15	0.030	0.164	0.075	0.000	0.134	0.015	0.119	0.194	0.000	0.090	0.149	0.224
15-30	0.149	0.075	0.000	0.000	0.015	0.000	0.015	0.149	0.015	0.000	0.060	0.134
30-75	0.269	0.030	0.000	0.000	0.000	0.000	0.015	0.284	0.015	0.000	0.030	0.030
75-250	0.328	0.000	0.000	0.000	0.000	0.000	0.045	0.179	0.000	0.000	0.000	0.045
250-	0.224	0.015	0.000	0.000	0.000	0.000	0.030	0.164	0.000	0.000	0.000	0.045
AUTUMN												
XB all	6.56	0.69	0.20	0.02	1.7[illegible]	0.04	0.66	0.84	0.11	0.01	0.00	1.43
SD all	7.01	1.16	0.68	0.21	3.1[illegible]	0.33	3.44	1.54	0.50	0.11	0.00	3.96
XB water	1.36	0.04	0.00	0.00	0.2[illegible]	0.00	0.07	0.39	0.10	0.01	0.00	0.39
SD water	2.17	0.18	0.00	0.00	1.1[illegible]	0.00	0.33	1.02	0.49	0.11	0.00	1.06
N	74.	74.	74.	74.	74.	74.	74.	74.	74.	74.	74.	74.
Empty	0.108	0.608	0.905	0.986	0.527	0.986	0.892	0.689	0.932	0.986	0.000	0.622
0-5	0.459	0.378	0.095	0.014	0.351	0.014	0.068	0.284	0.068	0.014	0.000	0.311
5-15	0.338	0.014	0.000	0.000	0.108	0.000	0.027	0.027	0.000	0.000	0.000	0.054
15-30	0.068	0.000	0.000	0.000	0.014	0.000	0.014	0.000	0.000	0.000	0.000	0.014
30-75	0.027	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
75-250	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
250-	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000

ST. LAWRENCE ISLAND ZONE

	ALL	NOEU	SHER	STPE	BLKT	PHAI	LEAU	MURR	CRAU	COMU	TBMU	SMAL
XB all	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
SD all	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
XB water	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
SD water	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
N	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
Empty	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
0-5	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
5-15	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
15-30	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
30-75	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
75-250	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
250-	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
SUMMER												
XB all	343.04	1.27	0.01	0.00	8.84	0.03	145.78	56.09	100.37	2.17	2.10	253.87
SD all	942.32	2.67	0.09	0.00	47.18	0.28	521.72	99.01	579.68	8.17	6.12	856.48
XB water	96.03	0.03	0.00	0.00	2.79	0.03	73.72	9.00	1.79	0.94	0.37	82.63
SD water	442.94	0.30	0.00	0.00	29.39	0.28	429.21	25.26	5.05	5.38	1.58	437.80
N	113.	113.	113.	113.	113.	113.	113.	113.	113.	113.	113.	113.
Empty	0.035	0.717	0.991	1.000	0.451	0.991	0.354	0.097	0.345	0.805	0.788	0.150
0-5	0.106	0.274	0.009	0.000	0.363	0.009	0.018	0.159	0.142	0.071	0.080	0.106
5-15	0.080	0.011	0.000	0.000	0.150	0.000	0.133	0.221	0.097	0.088	0.088	0.088
15-30	0.080	0.009	0.000	0.000	0.018	0.000	0.097	0.221	0.097	0.027	0.027	0.071
30-75	0.159	0.000	0.000	0.000	0.000	0.000	0.133	0.088	0.080	0.000	0.018	0.159
75-250	0.274	0.000	0.000	0.000	0.000	0.000	0.142	0.150	0.204	0.009	0.000	0.248
250-	0.265	0.000	0.000	0.000	0.018	0.000	0.124	0.062	0.035	0.000	0.000	0.177
AUTUMN												
XB all	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
SD all	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
XB water	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
SD water	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
N	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
Empty	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
0-5	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
5-15	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
15-30	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
30-75	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
75-250	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
250-	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000

APPENDIX 6

Prey taken by birds at St. Matthew Island

We made two collections of birds at St. Matthew Island to compare diets of species between the colonies at St. Matthew Island and the Pribilof Islands. We collected 25 birds in October 1982 and another 41 birds in July 1983 (Table 15). We are only able to compare the July collection with the Pribilof data because of seasonal shifts in diet and because our Pribilof collections were limited to the summer. This comparison must be considered preliminary due to the small sample size for St. Matthew Island.

Food samples were treated as *given* in Hunt et al. (1981a), with the exception that we are now able to detect jellyfish both through microscopic detection of nematocysts and by visual identification of the dehydrated gelatinous tissue (Harrison, in press).

During the summer, dietary diversity for birds at St. Matthew Island was either equal (COMU, TBMU, LEAU) to that shown by the same species at the Pribilof Islands, or was greater (NOFU, BLKI, PAAU). While Common Murres and Least Auklets used the same major prey (gadids and Calanus, respectively) at both St. Matthew and the Pribilof Islands, the other species we collected used different prey at the two locations. At the Pribilof Islands, fish (primarily gadids) were the major prey for Northern Fulmars, Black-1egged Kittiwakes, Thick-billed Murres and Parakeet Auklets. At St. Matthew Island the major prey found in Northern Fulmars was squid, in Black-1egged Kittiwakes and Parakeet Auklets the major prey was jellyfish and hyperiid amphipods (mostly Hyperia), and in Thick-billed Murres the major prey was the amphipod Parathemisto pacifica. Although gadids do not appear to be the major prey for many species at St. Matthew Island, when fish appeared in our collections they were mostly gadids. In the summer, the prey which appeared most frequently in our collection from St. Matthew Island were jellyfish and hyperiids (occurring together) and gadids. In the fall collection, squid, gadids and crustaceans appeared most frequently. In the fall, dietary diversity of birds at St. Matthew appeared to be less than during the summer.

Table 13. Prey (% occurrence) taken by seabirds at St. Matthew Island, based on collections in October 1982 (25 birds) and July 1983 (41 birds). NOFU=Northern Fulmar, BLKI=Black-legged Kittiwake, TBMU=Thick-billed Murre, LEAU=Least Auklet, CRAU=Crested Auklet, PIGU=Pigeon Guillemot, HOPU=Horned Puffin, GLGU=Glaucous Gull, COMU=Common Murre, PAAU=Parakeet Auklet

	N OFU	BLKI	TBMU	LEAU	CRAU	PIGU	HOPU
N (OCTOBER)	11	4	1	3	2	1	3
Jellyfish	9%				50%		
Nereid	9%						
Squid	82%						
Unid. Copepod		25%		66%			
Parathemisto pacifica	9%			33%			
Unid. Hyperiid				33%			
Unid. Amphipod							33%
Thysanoessa raschii				33%			
Spirontocaris tridens					50%	100%	
Unid. Crustacean	27%						33%
Theragra	9%	25%			100%		
Unid. Gadid			100%				33%
Osmeridae		50%					33%
Unid. Fish	27%	25%				100%	33%

	NOFU	BLKI	TBMU	LEAU	GLGU	COMU	PAAU
N (JULY)	8	8	5	3	1	8	8
Jellyfish	37%	75%	20%		100%	25%	50%
Nereid	12%	25%					25%
Pteropod		12%					25%
Squid	87%						
Unid. Copepod	12%			66%			12%
Parathemisto pacifica		25%	60%	33%			25%
Unid. Hyperiid	50%	87%	20%		100%	12%	50%
Unid. Gammarid	37%	37%					
Unid. Amphipod	12%						
Unid. Euphausiid	12%		20%				
Unid. Decapod		12%					
Unid. Crustacean	25%	12%	20%		100%		12%
Unid. Gadid		37%	40%	33%		87%	
Unid. Myctophid		12%				12%	12%
Unid. Fish	12%	12%	40%			12%	12%
Fork-tailed Storm-petrel	12%						