# OBSERVATION OF SEABIRDS IN THE SOUTHERN OCEAN IN 1988/89

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Abstract

This paper examines the numerical and species distribution of birds in the sub-Antarctic area of the Southern Ocean to the south of 60°S. Thirty minute observations were made daily during daylight hours at 8:00; 12:00, 16:00 and 20:00 ship-time, while sailing between Antarctic stations and while en route to ports of call. Maps summarize the distribution of 14 bird species as well as of the individual species: Antarctic, snow, and cape petrels and the southern fulmar. Ice distribution patterns prevailing over the study period are discussed as is the wide variability of numerical and species distribution in each oceanic sector of Antarctica.

Résumé

Cette communication examine la répartition numérique et spécifique des oiseaux dans la zone subantarctique de l'océan Austral au sud de 60° S. Tous les jours, des observations d'une durée de trente minutes ont été effectuées, à la lumière du jour, à 8h00, 12h00, 16h00 et 20h00, heure du bord, en naviguant entre les stations antarctiques et en route pour les ports d'escale. Des cartes récapitulent la répartition de 14 espèces d'oiseaux ainsi que celle des espèces particulières : pétrel antarctique, pétrel des neiges, pétrel du Cap et fulmar antarctique. Les tendances dominantes de la répartition de la glace au cours de l'étude sont discutées de même que la grande variabilité de la répartition numérique et spécifique dans chaque secteur océanique de l'Antarctique.

Резюме

В данной работе рассматривается количественное распределение и видовое распространение птиц в приантарктической (к югу от 60° ю.ш.) области Южного океана. Наблюдения, по 30 мин. каждое, выполнялись ежедневно в светлое время суток 8, 12, 16, 20 часов по судовому времени, во время переходов судна между антарктическими станциями и при следовании в порты захода. Приводятся карты общего распределения 14обнаруженных видов птиц, а также распределения отдельных видов - антарктического, снежного, серебристо-серого буревестников и глупыша. Рассмотрены особенности распространения льдов в исследуемый период. Показана значительная неравномерность количественного распределения и видового распространения птиц в каждом секторе Антарктики.

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Resumen

Este documento examina la distribución numérica y de las especies de aves en el área subantártica del océano Austral al sur de los 60°S. Se realizaron observaciones diarias de treinta minutos de duración a las 8:00, 12:00, 16:00 y 20:00 horas (hora del barco), mientras se navegaba entre las estaciones antárticas y puertos escalas. Los mapas resumen la distribución de 14 especies, además de la distribución de las especies individuales de: petreles antárticos, dameros, nevados y plateados. Se debaten los patrones de distribución del hielo predominantes durante el período de estudio y también la gran variabilidad de la distribución numérica y de las especies en cada zona oceánica de la Antártida.

## 1. INTRODUCTION

The CCAMLR Ecosystem Monitoring Program (CEMP) includes the observation of sea-bird numbers and species composition. So far a great deal of information has been gathered together on bird behaviour, distribution and nesting sites. Unfortunately, the marine stage of these birds' life cycle remains a virtual mystery. As a result it is impossible to learn their migration routes, distribution patterns, the makeup of their diet and feeding behaviour at sea. It was therefore considered appropriate to investigate the numerical distribution and species composition of seabirds to the south of 60°S during the second Antarctic cruise of the RV *Akademik Fedorov*.

## 2. METHOD OF OBSERVATION

Observations were made while the vessel was in transit between the following stations:

- Bellingshausen and Druzhnaya (11 to 28 December 1988);
- Druzhnaya and Molodezhnaya (28 December 1988 to 3 January 1989);
- Molodezhnaya and Bunger Hills (10 January to 2 February 1989);
- Russkaya and Leningradskaya (26 February to 12 March 1989);
- Bunger Hills and Molodezhnaya (9 to 20 April 1989)

as well as en route to ports of call. The survey route is shown in Figure 1.

Observations lasting 30 minutes each were carried out during the daylight hours at 8:00, 12:00, 16:00 and 20:00 ship-time. As the periods of daylight became shorter (March/April), the number of observations was reduced to three or even two. The average speed was about 15 knots and the distance between two sequential observations was approximately 60 miles. When it was necessary to negotiate large ice massifs, the speed of the vessel decreased and there was less distance between observation points. A total of 175 half-hour observations were made during the voyage.

The observer was positioned in the stern section on the second deck of the superstructure (about 12 m above the sea surface) facing the wake of the vessel and had a 180° range of vision. Each observation was preceded by the recording of coordinates, course and speed of the vessel as well as environmental conditions such as visibility, type of precipitation and ice cover, which have a direct impact on bird behaviour. At the end of the observation the maximum number of birds of each species sighted at one time during a particular shift was recorded. The appearance of large flocks or new species between

observation shifts was also noted. Observations were carried out regularly and interrupted only in cases of extremely poor visibility, heavy fog, snow or blizzard. Binoculars with a magnification of 7x50 were used for species identification of birds a long way from the vessel.

Considering that of all environmental factors the sea ice cover has the greatest impact on bird behaviour and migration, this paper shall deal only with ice distribution patterns over the observation period. According to the data obtained, ice conditions in the Southern Ocean during the 1988/89 season were reckoned to be close to average.

## 3. RESULTS OF OBSERVATIONS

During the cruise of RV *Akademik Fedorov* to the south of 60°S in the Southern Ocean, 14 species of birds were identified:

- wandering albatross (*Diomedea exulans*)
- black-browed albatross (*Diomedea melanophris*)
- sooty albatross (*Phoebetria palpebrata*)
- giant petrel (*Macronectes giganteus*)
- southern fulmar (*Fulmarus glacialoides*)
- Antarctic petrel (*Thalassoica antarctica*)
- cape petrel (*Daption capensis*)
- snow petrel (*Pagodroma nivea*)
- blue petrel (*Halobaena caerulea*)
- Wilson's petrel (*Oceanites oceanicus*)
- Dominican gull (*Larus dominicus*)
- Antarctic tern (*Sterna vittata*)
- southern polar skua (*Stercorarius skua maccormicki*)
- white-chinned petrel (*Procellaria aeguinoctialis*)

Observation results showed a distinct variability in the numerical and species distribution of birds. The most obvious feature was the absence of some species over vast areas. In the Atlantic sector, for example, the white-chinned petrel was not encountered, while in the Indian Ocean sector, the Dominican gull and in the Pacific Ocean sector the Antarctic tern, the Dominican gull and the white-chinned petrel were absent. Moreover, significant fluctuations in species composition were noted within the confines of a single sector. In general this was observed when the vessel was sailing from ice-free areas or areas close to the ice-edge to regions of vast ice massifs. In the western part of the Atlantic sector, for example, between 10 and 12 bird species were regularly observed near the ice-edge. In the region of the ice massif in the Weddell Sea the number of species fell to between four and five. Although this paper will not explore in depth the reasons for such significant variability in the distribution of species composition, it is worth noting that the absence of a particular species in one or another area may be due to the season in which observations were carried out or ecological factors which govern the migration patterns of that particular species of bird.

The numerical distribution of sea birds was even more uneven. An interesting fact here was that the fluctuation in species composition (an increase or decrease in the number of species) was not connected with fluctuations in the abundance of birds in a particular area.

The most prolific flocks, which consisted of several thousand birds, were observed in the Indian Ocean sector. Large flocks of birds were also typical here in autumn.

The number of birds in the Atlantic sector during the period of observations was in the order of a few hundred individuals, while in the Pacific Ocean sector it never exceeded a few dozen per observation shift.

Earlier studies also frequently mentioned the wide spatial fluctuations in the numerical distribution of birds in Antarctica (FIBEX Seabird Data Interpretation Workshop, Cape Town, South Africa, 10 to 18 April, 1985. BIOMASS Report Series 44). Despite the long duration of the observation period, these past results create a basis for assuming that the numerical distribution patterns which emerged in our study are close to the real situation.

Significant variations in quantitative distribution of seabirds occurred in each sector of Antarctica. The greatest abundance of birds in the Atlantic sector was witnessed near the ice-edge in the South Orkney, South Shetland and South Sandwich Islands area (Figure 2), where their numbers reached more than 100 during a single observation shift. Abundance was less to the east of the South Sandwich Islands and did not exceed 50 birds during a shift. The number of birds at the ice massif generally did not exceed 10 individuals (between 60°S, 11°W and the Antarctic continent) despite such favourable feeding conditions as broken ice and numerous patches of ice-free water. Bird numbers increased again only in very close proximity to the Antarctic continent where ice density was between 9 and 10 points and where small polynyas had formed. Separate observations put their numbers at 50 specimens.

A more even distribution of birds was typical for the area between Druzhnaya and Molodezhnaya Stations (Figure 3). Birds were observed here at every shift though their numbers never exceeded 10. Only once, on 30 December 1988, when the vessel was sailing across an area of virtually ice-free water where only strips of finely broken ice occurred, were large flocks consisting of more than 100 individuals of different species observed. The main species in these flocks were the Antarctic and cape petrels. Bird behaviour here was interesting: they did not fly above the ship's wake in the usual manner, but rather along the sides and in front.

Larger flocks were observed between Molodezhnaya and Bunger Hills Stations (Figure 4). A huge mass of birds consisting of more than 3 000 individuals was observed on 14 January 1989 in the Sodruzhestva Sea (67°S, 73°45'W). Flocks contained between 100 and 300 birds and were almost evenly distributed along the survey route of the vessel. The Antarctic petrel (about 70%) and southern fulmar (about 30%) were the most common species here although the giant, Wilson's and snow petrels were also present. As the vessel neared birds sitting in the water and on ice-floes, they flew away to the side or another 100 to 200 m ahead of the ship. Ice cover density in this area was from one to three points; the ice was almost entirely broken up and consisted of snowy chunks. Ice-floes measuring 2x3 m or 3x5 m were sighted only occasionally. Large flocks, consisting mainly of white-chinned petrels which had been encountered only in the Indian Ocean sector, were witnessed in the area of Bunger Hills Station near the ice-edge. During repeat observations (9 to 20 January 1989) very large flocks were encountered again, this time their numbers exceeded 1 000 specimens (Figure 5). Antarctic and snow petrels were the most common species in this mass of birds and in many instances their percentage ratio was equal. It was only in the Sodruzhestva Sea (63°45'S, 72°14'W) that the predominance of the Antarctic petrel re-emerged. Its abundance was more than 1 000 in mixed flocks while the numbers of snow petrel did not exceed 200 individuals. It ought be noted that for the most part the vessel was sailing in an area of new pan-ice from 10 to 15 cm thick; ice density was from 8 to 10 points.

The smallest number of birds observed over the period was in the Pacific Ocean sector (Figure 6). Undoubtedly, this could have been due to the season (late summer/early autumn) as well as severe ice conditions. In this region even the number of birds in ice-free water was not more than a handful. As a rule, snow, Antarctic and giant petrels were observed at the same time. No birds were encountered while the vessel sailed in the area of the Pacific Ocean ice massif (ice density - 9 to 10 points). It was only while the ship was at anchor near the Russkaya Station that several Antarctic petrels and skuas were observed near a polynya which had formed there. Birds were typically absent as the vessel sailed from the Russkaya Station to the eastern part of the Ross Sea along the Antarctic coast. It should be noted that thin new ice with an ice density of 10 points covered the entire route of the vessel. Flocks of more than 100 birds which were comprised of snow and Antarctic petrels were only sighted in the area

bounded by the coordinates 77°16'S and 175°32'W; single skuas were also observed. An iceberg measuring 100x30 km was located in this area. Near the iceberg a small polynya played host to between fifteen and twenty whales and some seals.

## 4. SPECIES DISTRIBUTION PATTERNS

The wandering albatross (*Diomedea exulans*) was observed in the Atlantic and Indian Ocean sectors in areas to the north of 60°S. Individual specimens were sighted at 66°S in the Pacific Ocean sector (65°50'S, 153°50'W, 25 February 1989). The number of birds per observation generally did not exceed one or two. A slight increase of wandering albatrosses to the north was observed in the autumn; in April 1989 the species was not encountered further south than 56°S in the Indian Ocean sector.

The black-browed albatross (*Diomedea melanophris)* was also observed in small numbers in the Atlantic and Indian Ocean sectors to the north of 60°S. In the Pacific Ocean sector individual specimens were sighted at 63°S.

The sooty albatross (*Phoebetria palpebrata*) was generally encountered further south than the the wandering and black-browed albatross. It was observed at 65°S in the Indian sector and at 73°30'S in the Pacific sector. Most often single birds were observed and it was rare for two to be seen together.

The giant petrel (*Macronectes giganteus*) was practically always encountered, with one or two birds sighted per shift, in all of the study areas. It was only absent from the vast ice massif in the Pacific Ocean sector. However, to the west of 176°W in the Ross Sea this species formed small flocks of four or five birds.

The blue petrel (*Halobaena caerulea*) was mainly observed in ice-free areas. The greatest number of birds (eleven) in the Atlantic sector occurred to the south of the South Sandwich Islands. In the Indian Ocean sector the blue petrel only was observed to the east of 75°W. The largest congregations of this species (approximately 300 specimens) occurred in the northern part of the Mawson Sea (61°S, 108°W). In the Pacific sector only small numbers (one or two) of birds were encountered. In autumn the blue petrel was observed in the Indian Ocean sector to the north of 65° to 63°S and its numbers on occasion reached 15 to 17 specimens. A flock of between 100 and 150 birds was noted on 24 April 1989 at 63°S and 31°W in the Atlantic sector.

Wilson's petrel (*Oceanites oceanicus*) generally occurred in small numbers of between one and three birds in the Atlantic sector. The number of birds was only as high as twenty in the South Orkney and South Shetland Island areas of the Scotia Sea. It is noteworthy that this species, like many others, was absent from the Weddell Sea ice massif, although it was observed near the Risser-Larsen glacier where there were many small polynyas. Two or three specimens would follow in the ship's wake which enabled them to feed on cryoplankton which was constantly abundant in sub-surface drift-ice. One to three specimens of Wilson's petrel were almost always present in the Indian Ocean sector, while in the Pacific sector they appeared only occasionally. Single birds were encountered only twice; on 24 February 1989 (62°S, 166°W) and 11 March 1989 (72°34'S, 173°W). A repeated survey of the Indian Ocean sector in autumn revealed that one or two birds were only present to the north of 61°S on the way to Bunger Hills Station. Wilson's petrel was not encountered in the other survey areas of the Indian or Atlantic Ocean sectors.

The southern polar skua (*Stercorarius skua maccormiki*) was observed primarily near the Antarctic continent and islands (one or two birds). The greatest number of birds recorded at one observation shift was 17 near Molodezhnaya Station. Four to five specimens were regularly observed near Russkaya Station in the Pacific sector. This species was absent from the survey areas in the Indian and Atlantic Ocean sectors in the autumn.

The Antarctic tern (*Sterna vittata*) was observed periodically and in small numbers only in the Atlantic and Indian Ocean sectors. A small flock, comprising twelve of these birds, was seen only once, in the western part of the Indian Ocean sector on 31 December 1988 (63°26'S, 29°08'W). This particular flock was migrating south towards the Antarctic continent. The Antarctic tern was absent from the Pacific sector and during repeat surveys of the Indian and Atlantic sectors in the autumn.

The Dominican gull (*Larus dominicus*) was observed only as individual birds in the Atlantic sector between Bellingshausen Station and 32°W. The greatest number of birds, 28, was recorded in the South Shetland Islands area, although this species was sighted at 71°S, 11°W near the Antarctic continent (five birds).

The white-chinned petrel (*Procellaria aeguinoctialis*) was encountered only in the Indian Ocean sector. Large flocks of up to 20 birds were common in summer to the east of 74°W. The number observed at one shift exceeded 200 only in the Mawson Sea at 64°S, 100°W. In the autumn the highest number of birds (100 at one observation shift) was recorded in the Mawson Sea. It should be noted that between two and seven specimens per shift were sighted near the Molodezhnaya Station where they were absent in summer. The presence of a large number of this species over a prolonged period (three to four months) in one area, the Mawson Sea, indicated that this may be its permanent feeding ground and possibly, breeding area.

The snow petrel (*Pagodroma nivea*) was sighted almost everywhere in the ice massifs and in ice-free water near the ice-edge. This species generally formed small flocks of between 3 or 4 and 10 birds. Individual specimens of the snow petrel were observed in the Scotia Sea near the South Shetland Islands (Figure 7). This species was regularly sighted to the east of 20°W, near the ice-edge and in the ice massif of the Weddell Sea. Moreover, on some days the snow petrel was the only species of flying bird present. The number and frequency of encounters with the snow petrel between Druzhnaya and Molodezhnaya Stations decreased as the vessel got further away from the Antarctic continent (Figure 8). During some observations near Molodezhnaya Station this species again predominated in mixed flocks. In the Indian Ocean sector single specimens of the snow petrel were only sighted in the Sodruzhestva Sea (Prydz Bay) and the Davis Sea on the way to Mirny Station. It is possible that these birds were sighted so infrequently because of considerably low ice density (one to three points). Another reason may be the changed biological condition of the birds who were at that time breeding on the Antarctic continent. Moreover, it is significant that the snow petrel was again one of the most abundant species in the area near Bunger Hills Station. Repeated surveys of the area between Bunger Hills and Molodezhnaya Station in the autumn revealed an increase in the number of snow petrels (Figure 10); in some cases more than 200 specimens were observed (in the western part of Prydz Bay). Such a large concentration of birds may be explained in two ways. Firstly, a considerable compaction of the ice took place in April and ice density was 9 to 10 points over a large part of the Indian Ocean sector. The ice-edge shifted north to 64°S, and in some places, to 63°S. These severe ice conditions made it impossible for the snow petrel to remain within the ice massif near the Antarctic continent. This necessitated the concentration of birds near the ice-edge. A second reason may be the departure of young birds from the nest which released older and parent birds from their duties (Brown, 1966). The snow petrel was sighted occasionally in the vicinity of the Pacific Ocean ice massif near Russkaya Station where there was a large polynya in the western part of the Ross Sea during the research period. Between 5 and 10 birds were recorded per observation shift. The number of snow petrels per shift reached 50 only in the eastern part of the Ross Sea as the vessel departed a zone of high ice density (8 to 10 points) near an enormous iceberg where there were patches of ice-free water. Food availability in the area seems to have been the main reason for the formation of such a large flock. This is supported by the fact that petrels were absent from the area near the Antarctic coast between Russkaya Station and 172°W where ice density was 10 points over the entire area.

The Antarctic petrel (*Thalassoica antarctica*) was one of the most common species observed near the Antarctic continent during the cruise of RV *Akademik Fedorov*. Birds tended

to form flocks consisting of 15 to 20 birds and were sighted in ice massifs near Antarctic stations and in areas of ice-free water. Individual specimens were observed in the Atlantic sector to the east of 20°W (Figure 7). An interesting fact is that the Antarctic petrel was not encountered in the Scotia Sea in December 1988 when the vessel's survey route passed by the Antarctic continent and numerous islands. The Antarctic petrel was constantly observed between Druzhnaya and Molodezhnaya Stations and its numbers decreased only to the east of 15°W. In the Kosmonavtov Sea the species was sighted periodically (Figure 8), although in the Indian Ocean sector it was more abundant. Flocks of Antarctic petrels consisting of hundreds of birds were observed here practically daily (Figure 9). The greatest number of birds (over 3 000) was recorded on 14 January 1989 in Prydz Bay at 67°18'S, 74°W. Surface water temperature in this area was minus 2°C. Birds congregated together so closely on ice-floes and in the water that it was almost impossible to see some of the smaller ice-floes. As the vessel neared them, some of the birds flew away and settled 200 to 300 m ahead of the ship. Abundant flocks of Antarctic petrels were also observed in the Sodruzhestva Sea during surveys in the Indian Ocean sector in the autumn (Figure 10). Swarms of hundreds of birds were sighted here each day. In the Pacific Ocean sector the Antarctic petrel was only encountered near the ice-edge and no more than a few dozen were observed at a time (Figure 11).

The cape petrel (*Daption capensis*) was most widely distributed in the Atlantic sector (Figure 7) and the most abundant flocks were observed near the Antarctic peninsula, the South Orkney and South Sandwich Islands. More than 100 birds were recorded at separate observations in these areas. One of the features of the numerical distribution of this bird is the significant decrease in abundance or even complete absence from areas of ice massifs. Individual specimens of the cape petrel were encountered only now and again in the ice massif of the Weddell Sea (Figures 7 and 8). Ice density in this area varied widely - from ice-free water to 10 points. This species was observed regularly only to the east of 30°W (Figure 9) where 10 to 15 birds were recorded per observation shift. The high abundance of the cape petrel in Prydz Bay is apparently caused by low ice density (one to three points) and a rich food supply in the shape of krill. This species formed smaller flocks of between 5 and 10 birds in the Pacific sector near the edge of the ice massif and in the area of Leningradskaya Station and the Balleny Islands (Figure 11). In autumn larger flocks of cape petrel in the Indian Ocean sector were recorded to the north of 62° to 63°S (Figure 10). Its abundance dropped sharply closer to the ice-edge and only individual birds were sighted.

The southern fulmar (*Fulmarus glacialoides*) was observed mainly in small numbers of two to three, although in some cases groups of five or six were encountered. The greatest number of this species was recorded in the Balleny Islands area on 21 March 1989. As a rule the southern fulmar was sighted in localized areas over a one or two-day period. This species was first observed in the South Shetland and South Sandwich Islands areas (Figure 7). In the Kosmonavtov Sea the southern fulmar was only observed on the way to Molodezhnaya Station (Figure 8) after which it was sporadically sighted in Prydz Bay and in the area of Mirny Station (Figure 9). This species was observed in the Pacific sector in open ocean (60° to 61°S, 158° to 160°W) and in the Balleny Islands area. The distribution pattern of the southern fulmar remained virtually unchanged in the Indian Ocean sector during the autumn. It was encountered infrequently and in small numbers (Figure 10).

## 5. CONCLUSIONS

Our study demonstrates the significant variability in the distribution of birds in Antarctica by numbers and species. The most abundant flocks were recorded in the Indian Ocean sector of the Southern Ocean where flocks of more than 3 000 birds were sighted. The second most prolific sector was the Atlantic Ocean sector and the third was the Pacific Ocean sector.

One reason for the existence of such large numbers of birds in the Indian Ocean sector is probably the close proximity of nesting areas and the presence of a plentiful and readily accessible food supply.

Many bird species did not form large flocks and tended to gather in small groups of between one and five specimens. Only the Antarctic, snow, white-chinned and cape petrels flocked together in their hundreds and even thousands.

The cape petrel was the dominant bird species over the greater part of the Atlantic Ocean sector over the observation period. In the Indian Ocean sector it was the Antarctic petrel and in the Pacific Ocean sector, the snow and Antarctic petrels.

The number of birds in the areas of the Weddell and Ross Sea ice massifs was much lower compared to areas free of ice and near the ice-edge.

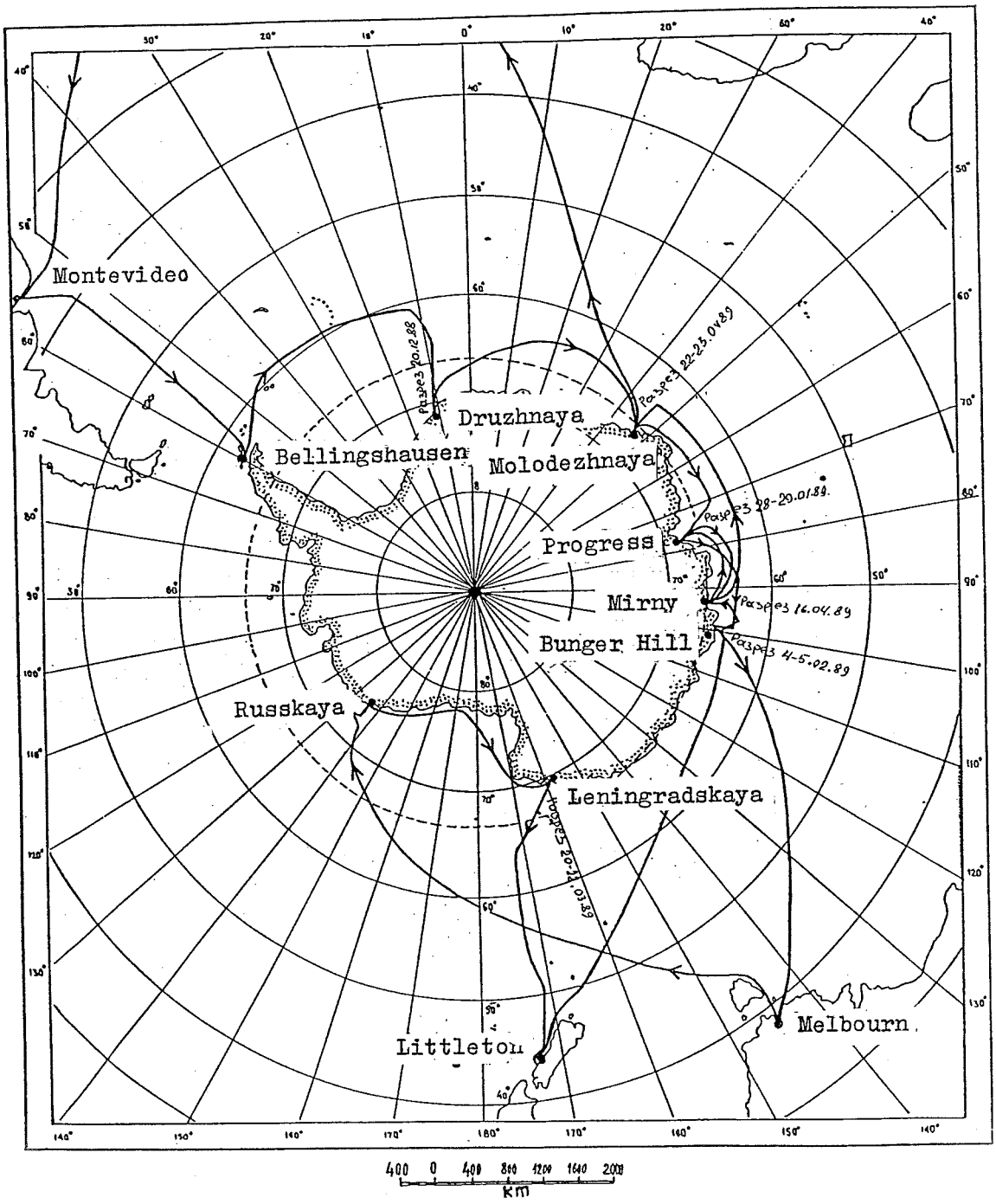


Figure 1: Cruise track of the RV *Akademik Fedorov* (1 November 1988 to 29 May 1989).

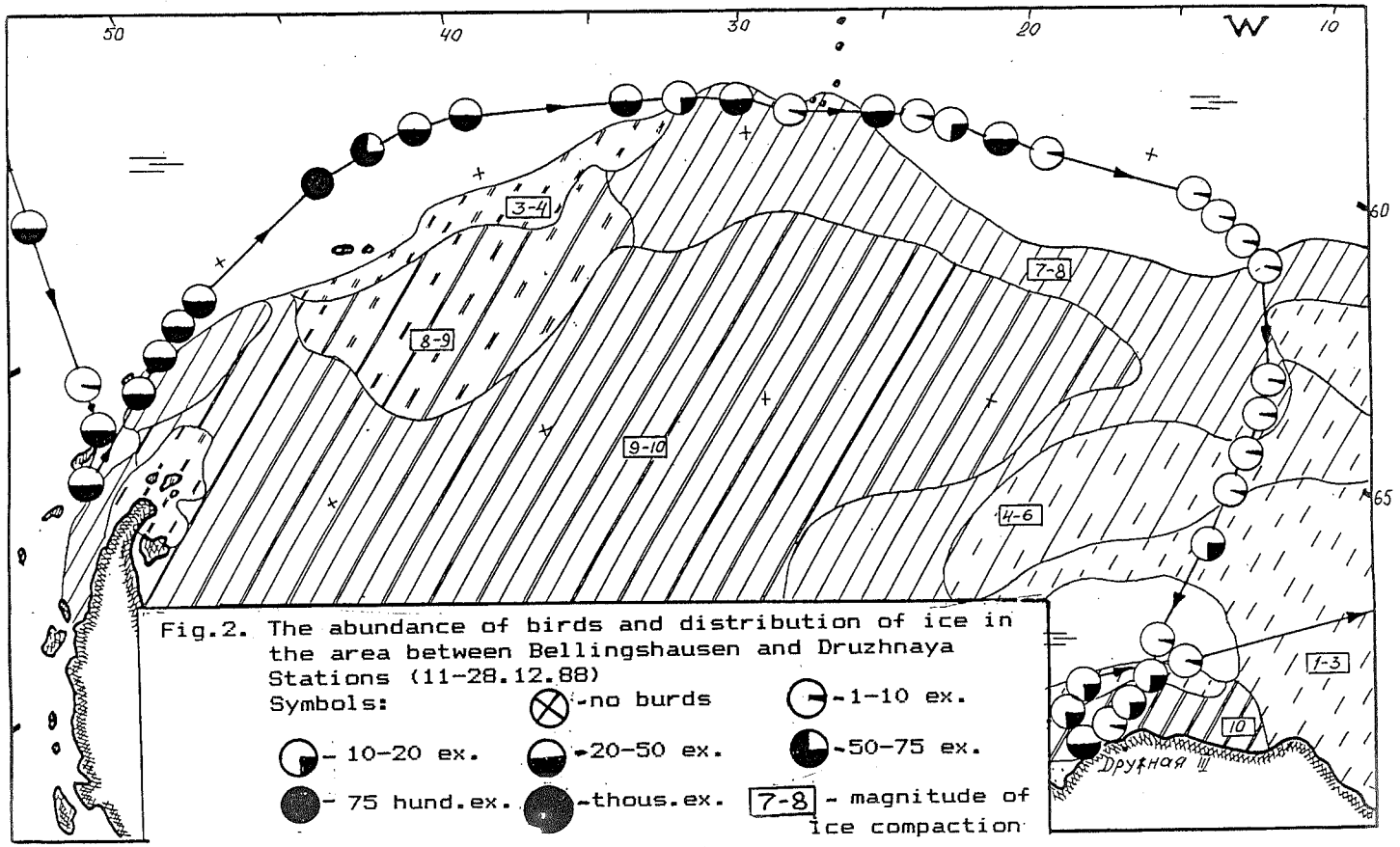


Figure 2: Bird abundance and ice distribution between Bellingshausen and Druzhnaya Stations (11 to 28 December 1988). Key: (1) no birds present; (2) 1 to 10 specimens; (3) 10 to 20 specimens; (4) 20 to 50 specimens; (5) 50 to 75 specimens; (6) 75 to hundreds of specimens; (7) thousands of specimens; (8) degree of areal ice density.

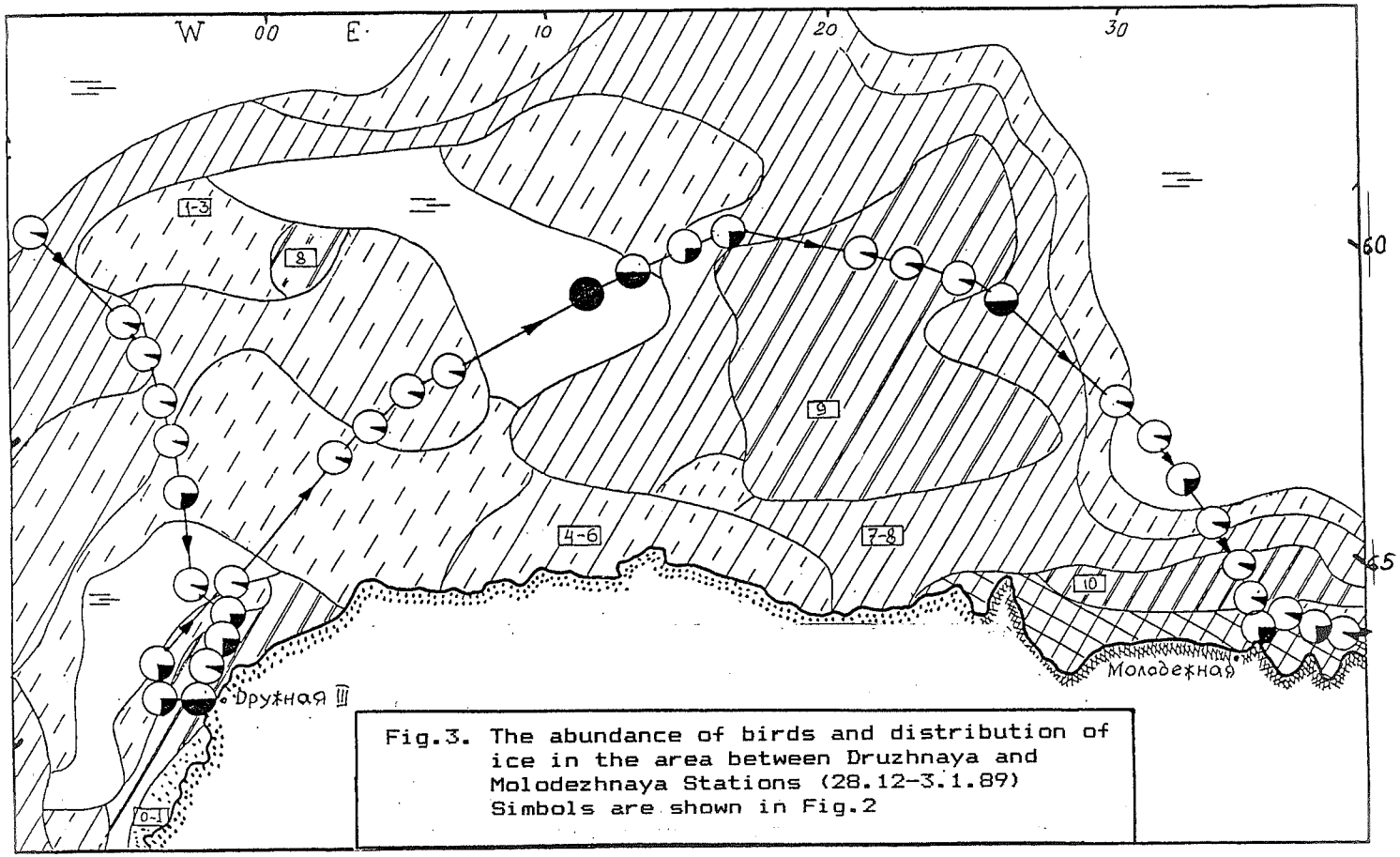


Figure 3: Bird abundance and ice distribution between Druzhnaya and Molodezhnaya Stations (28 December 1988 to 3 January 1989). (See Figure 2 for key).

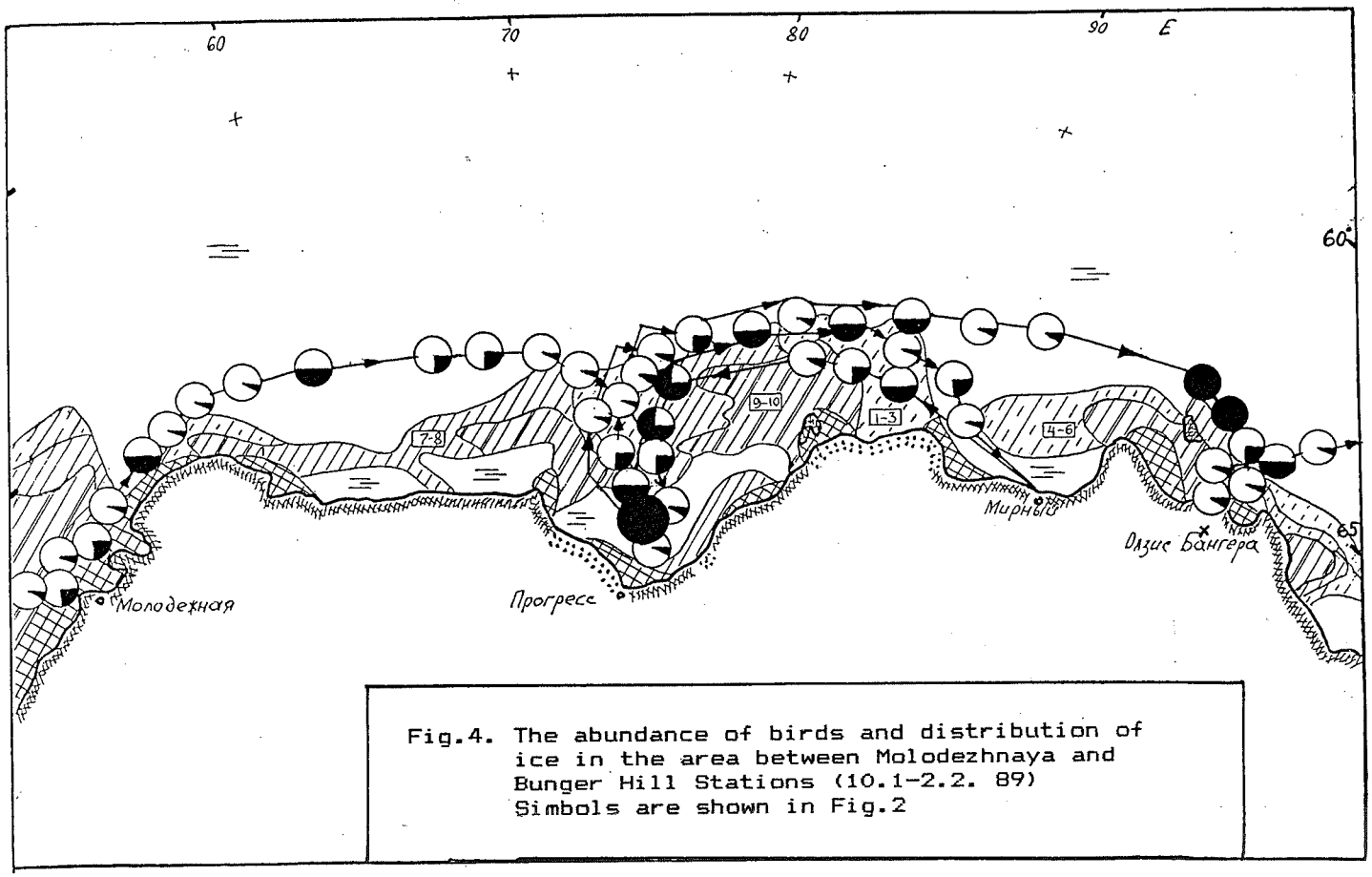


Figure 4: Bird abundance and ice distribution between Molodezhnaya and Bunger Hills Stations (10 January to 2 February 1989). (See Figure 2 for key).

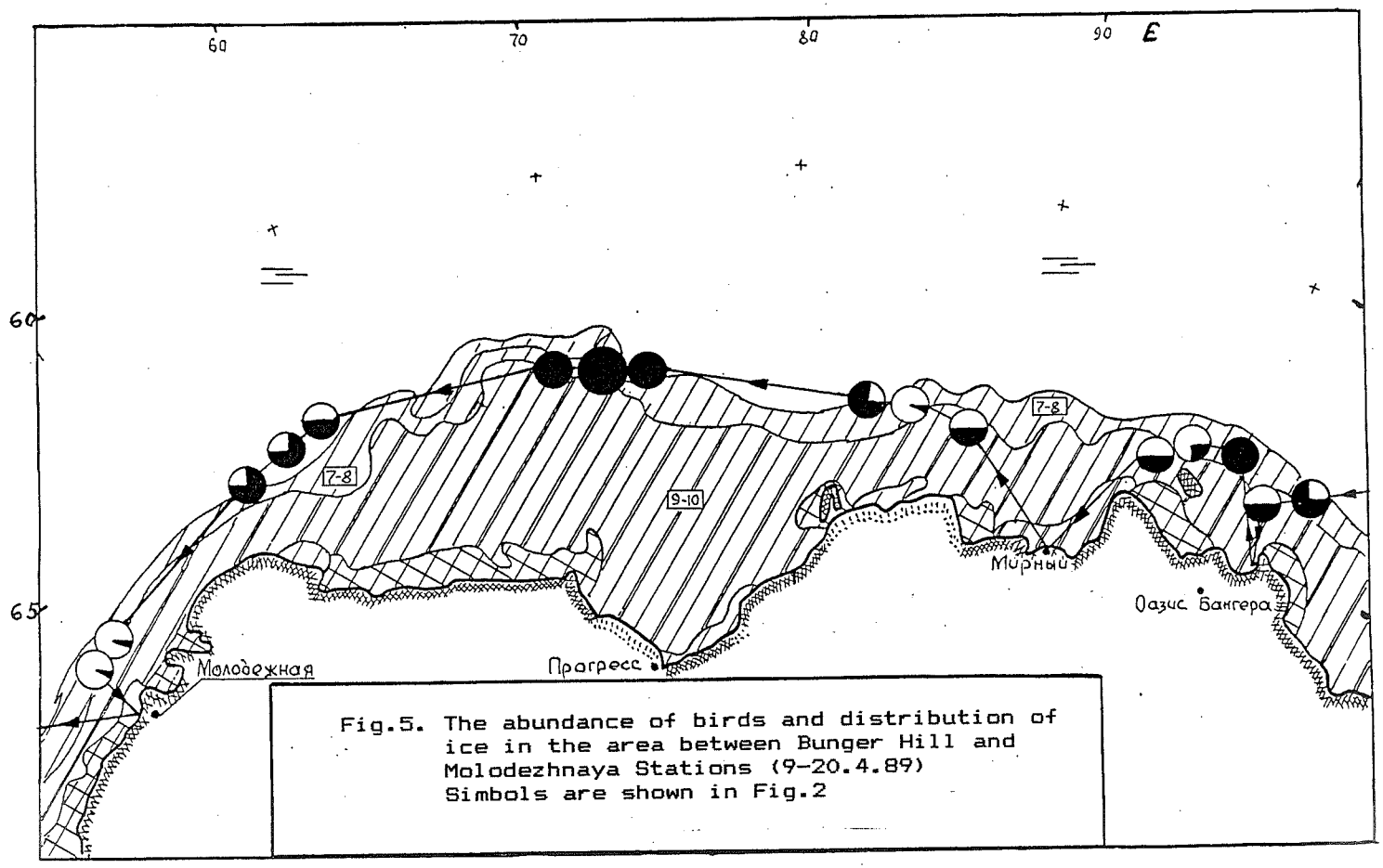


Fig.5. The abundance of birds and distribution of ice in the area between Bunger Hill and Molodezhnaya Stations (9-20.4.89) Simbols are shown in Fig.2

Figure 5: Bird abundance and ice distribution between Bunger Hills and Molodezhnaya Stations (9 to 20 April 1989). (See Figure 2 for key).

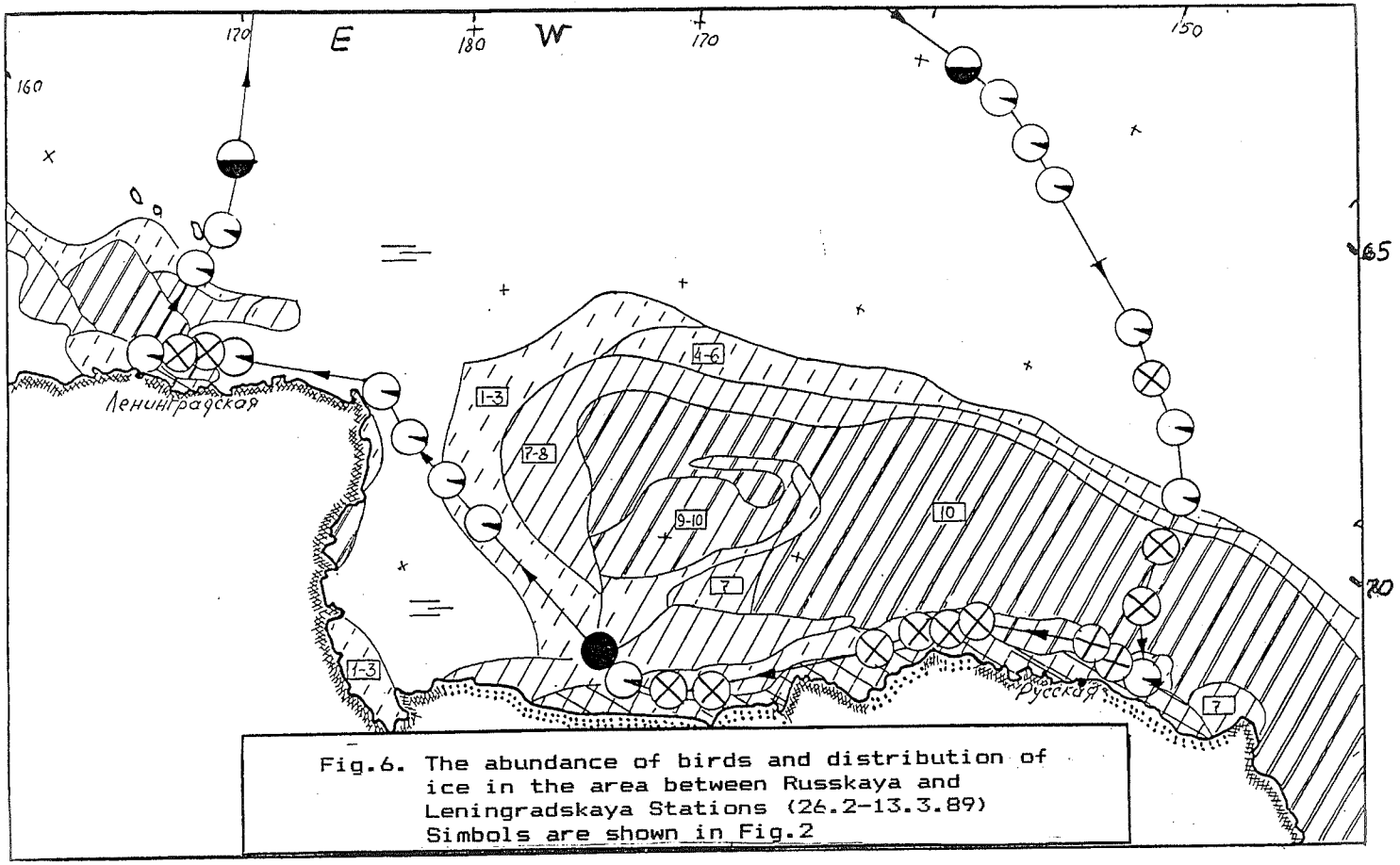


Figure 6: Bird abundance and ice distribution between Russkaya and Leningradskaya Stations (26 February to 12 March 1989). (See Figure 2 for key).

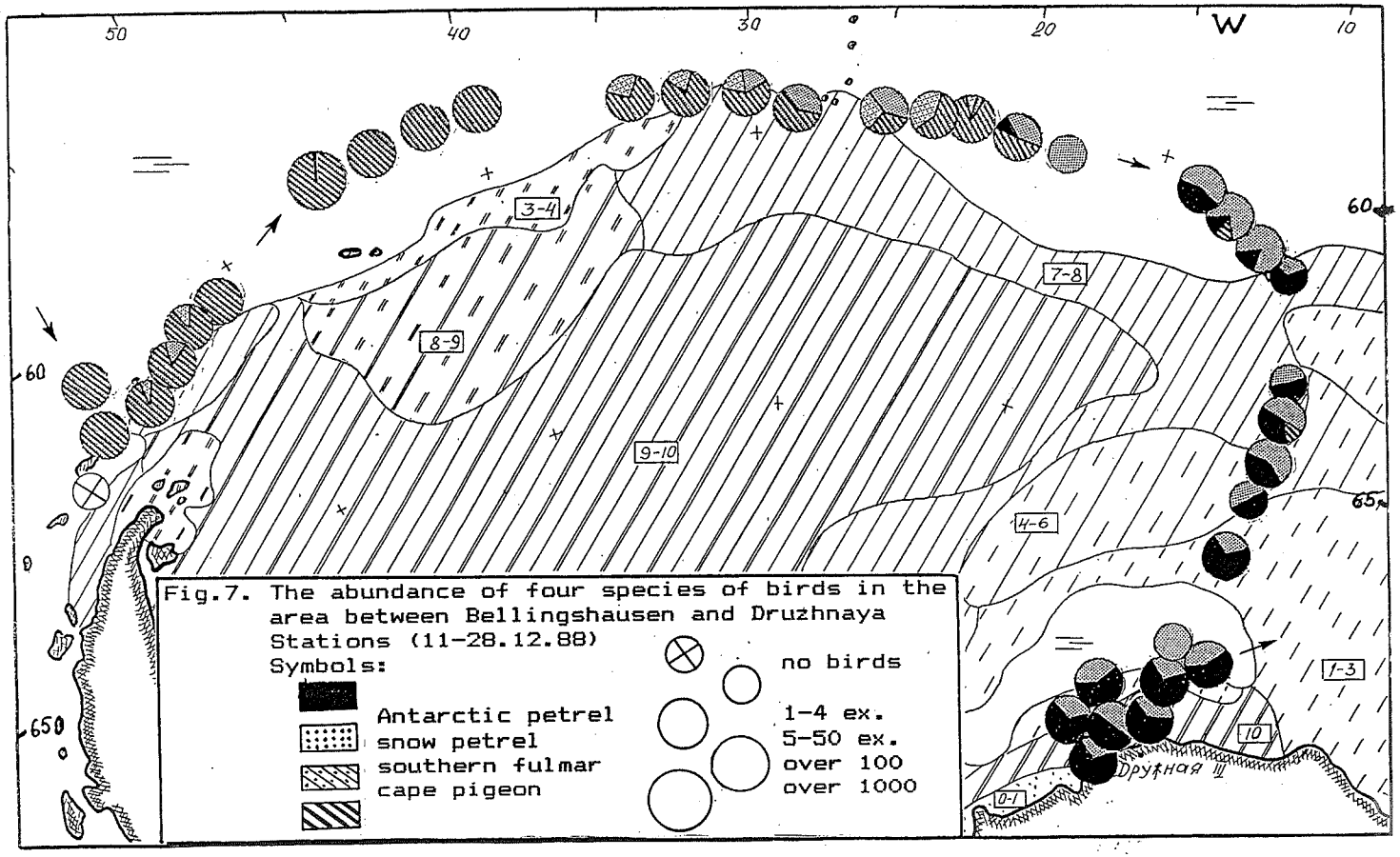


Figure 7: Ratio of abundance among four species of birds between Bellingshausen and Druzhnaya Stations (11 to 28 December 1988). Key: (1) Antarctic petrel; (2) snow petrel; (3) southern fulmar; (4) cape petrel; (5) no birds present; (6) 1 to 4 specimens; (7) 5 to 50 specimens; (8) over 100 specimens; (9) over 1 000 specimens.

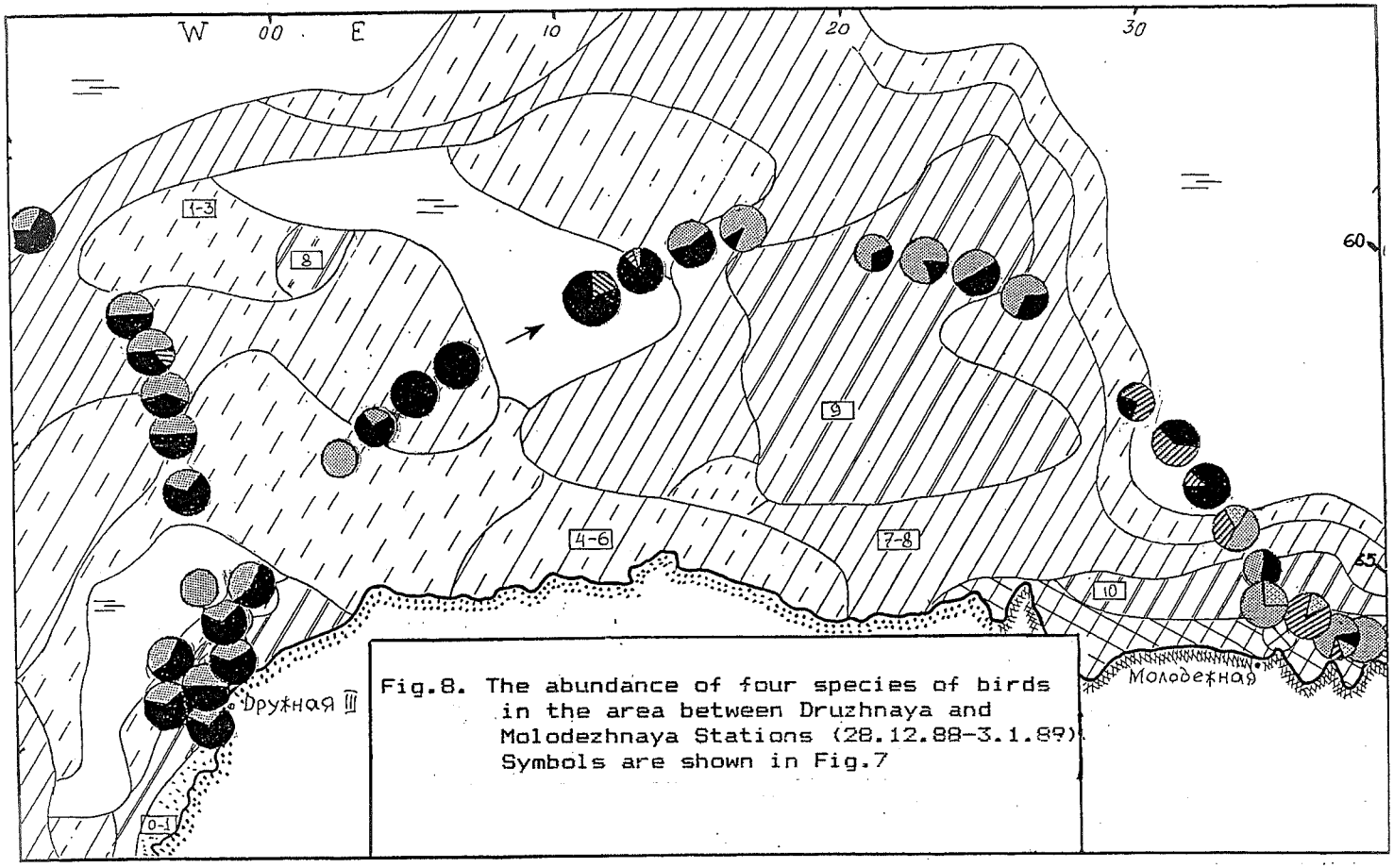


Figure 8: Ratio of abundance among four species of birds between Druzhnaya and Molodezhnaya Stations (28 December 1988 to 3 January 1989). (See Figure 7 for key).

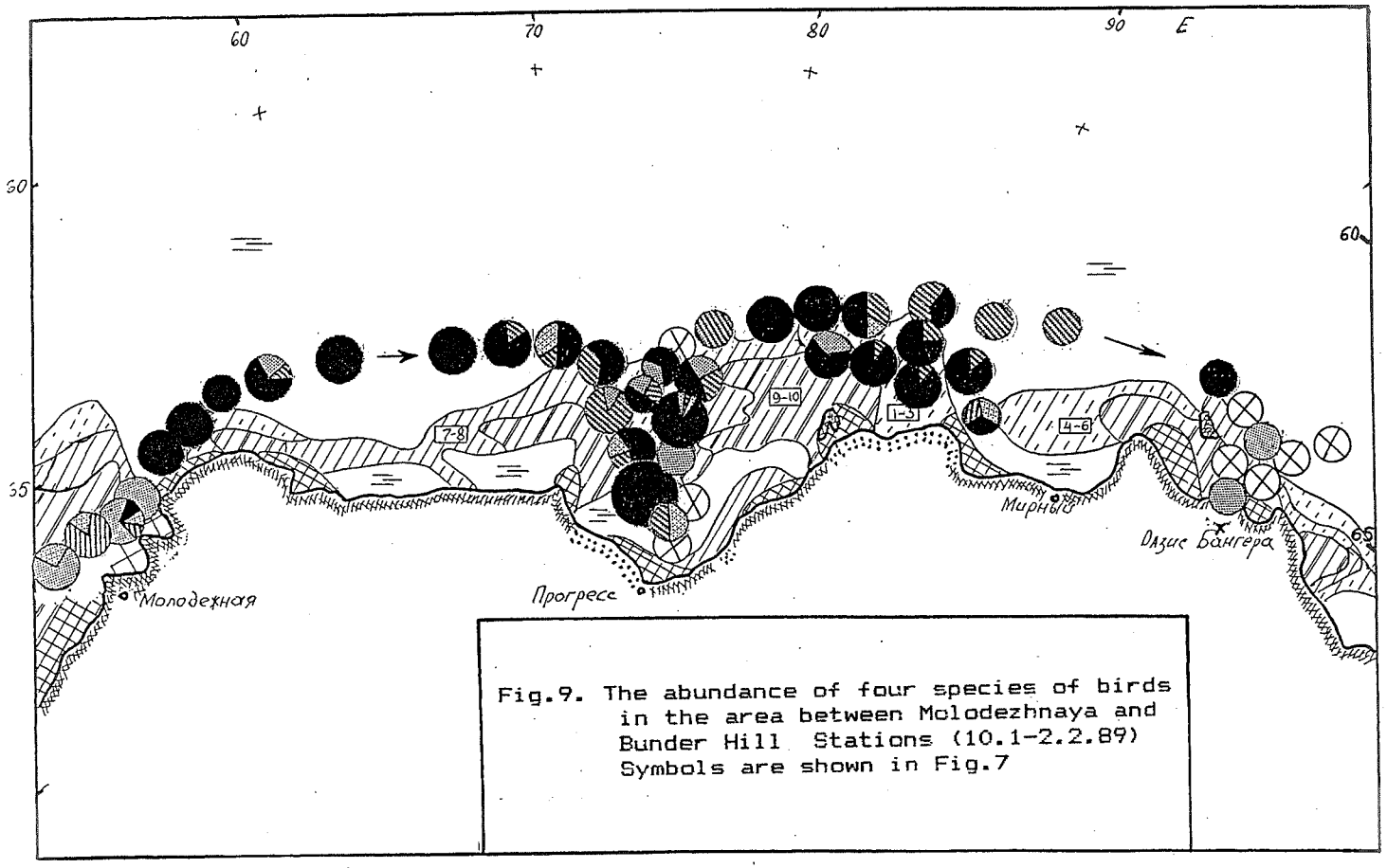


Figure 9: Ratio of abundance among four species of birds between Molodezhnaya and Bunger Hills Stations (10 January to 2 February 1989). (See Figure 7 for key).

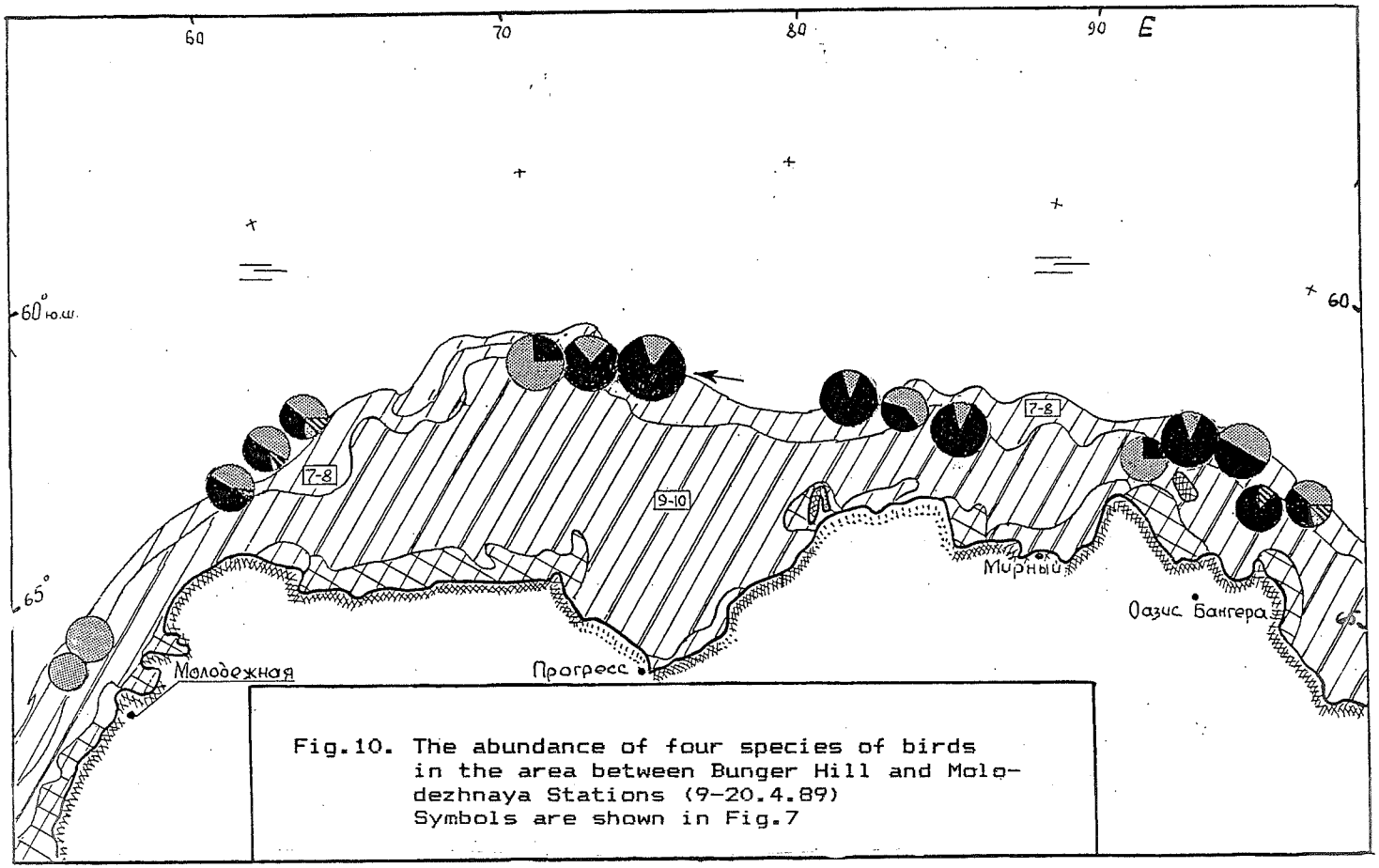


Figure 10: Ratio of abundance among four species of birds between Bunger Hills and Molodezhnaya Stations (9 to 20 April 1989). (See Figure 7 for key).

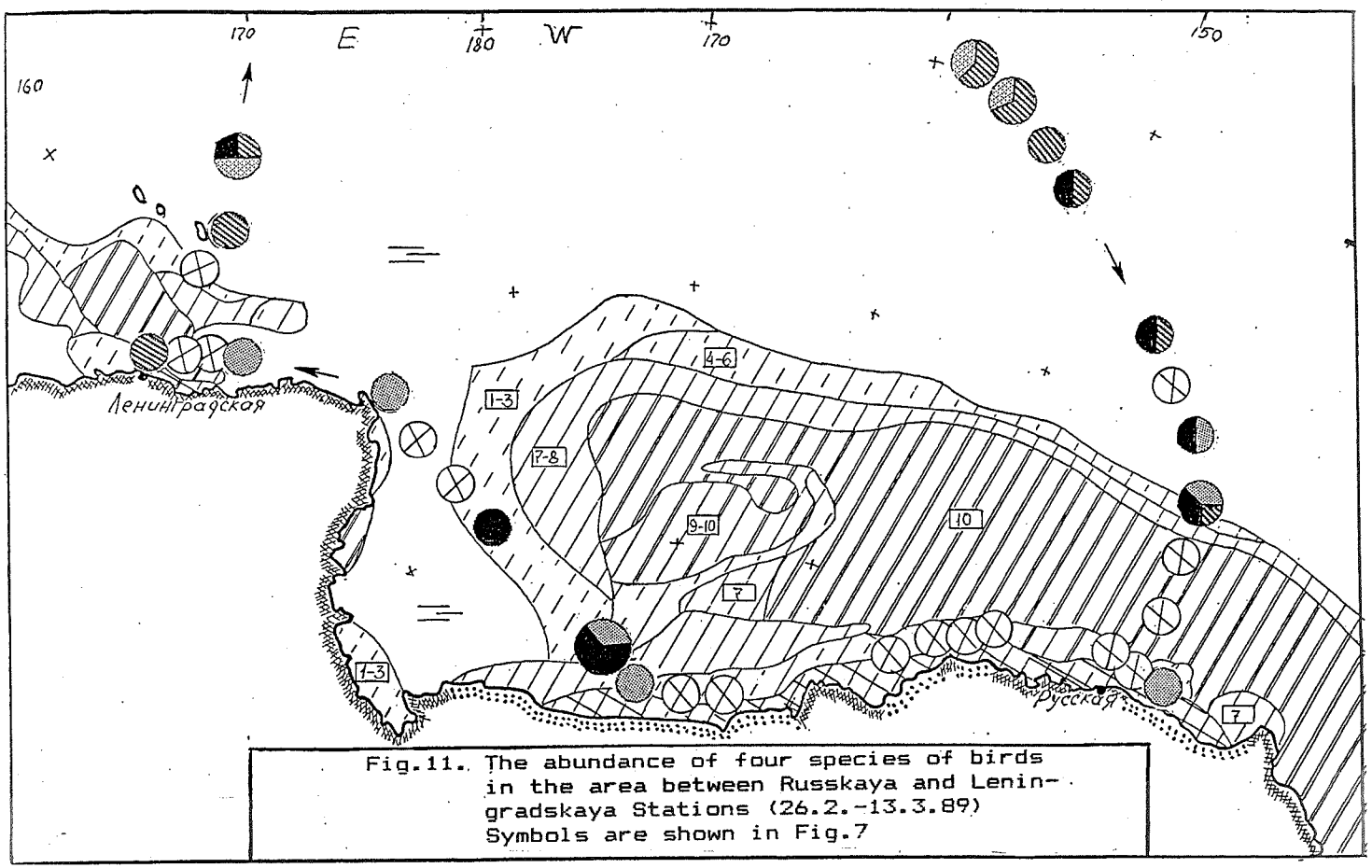


Fig.11. The abundance of four species of birds in the area between Russkaya and Leningradskaya Stations (26.2.-13.3.89) Symbols are shown in Fig.7



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