

2. SOME DATA ON THE DISTRIBUTION AND MIGRATIONS OF POLAR COD IN THE SEAS OF THE SOVIET ARCTIC

By

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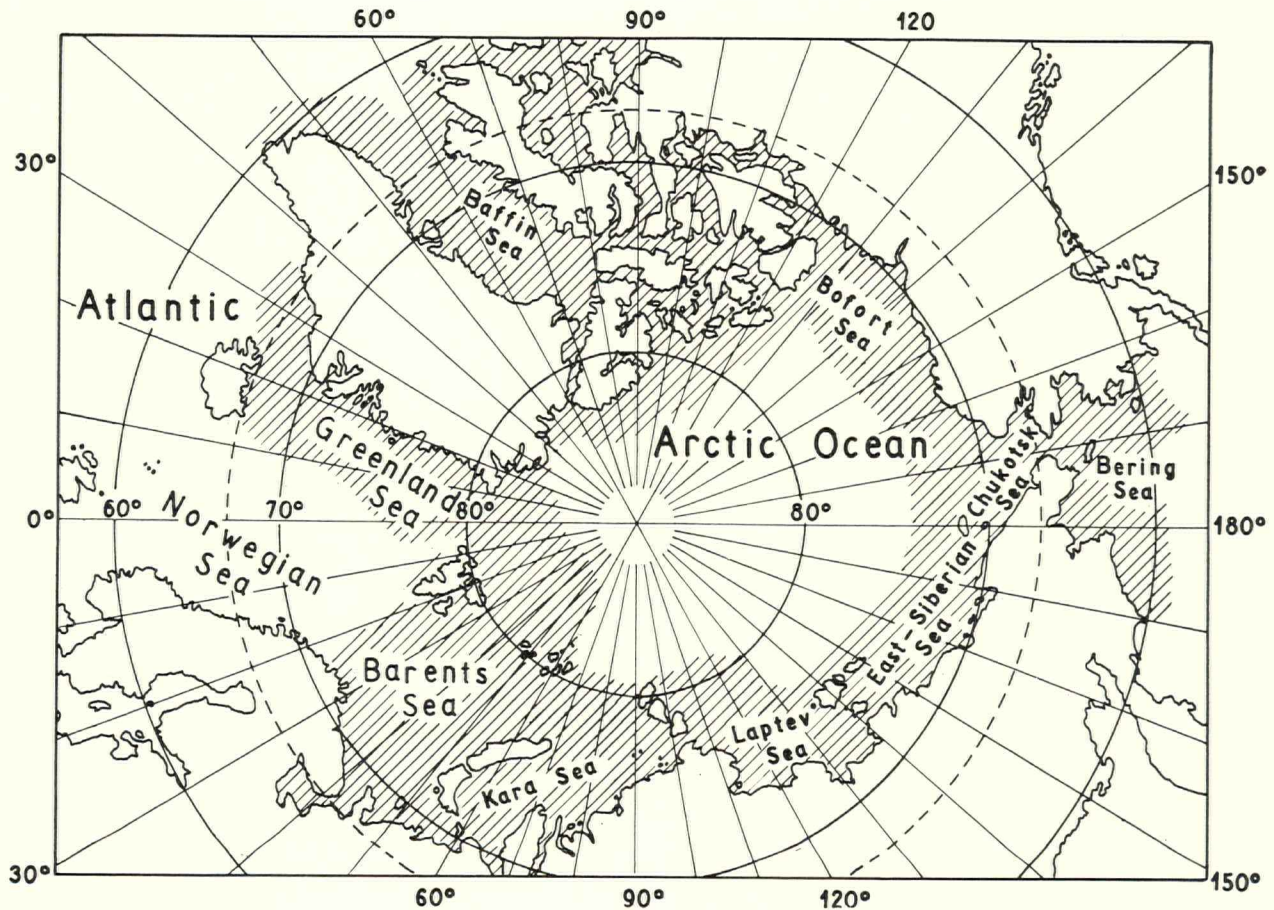


Figure 7:7. Distribution of Polar cod in the Arctic Seas (hatched sectors are given according to HOFSTEN, 1920, with the author's supplements).

Polar cod *Boreogadus saida* (Lepechin) is abundant in the seas of the Soviet Arctic. The first scientists to study its ecology were the Soviet investigators S. S. KLUMOV, B. P. MANTEUFEL and T. S. RASS. Observations by KLUMOV (1937) indicated Polar cod to be of great importance in the food chains of the Arctic Seas.

The first information on the reproduction is found in papers by RASS (1934, 1945). MANTEUFEL (1943) presented the most complete data on the ecology in

the Barents and White Seas. In recent years a number of papers on Polar cod have been published (BUTORIN, 1965; MOSKALENKO, 1964; YUDANOV, 1964), but still very little is known of this species which is so abundant in Arctic Seas. The author studied it for a number of years (PONOMARENKO, 1962, 1963, 1964, 1965 a, b, c; PONOMARENKO, NATENSON and NAUMOV, 1962) and has been in correspondence with scientists of the Polar stations in the White, Barents, Kara, East-Siberian, Chukotsk and Laptev Seas. The present paper is

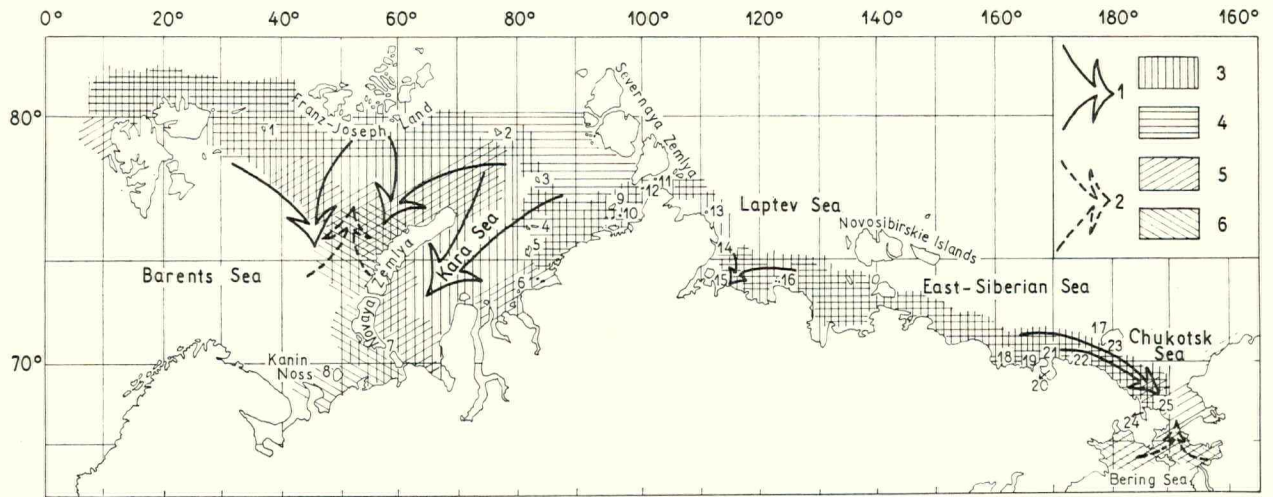


Figure 7:8.* Diagram of Polar cod migrations in the seas of the Soviet Arctic. 1. wintering and spawning migration; 2. feeding migrations; places of mass occurrence of Polar cod: 3. June to July; 4. August to September; 5. October; 6. from November-December to January-February.

1. Victorian Island
2. Vize Island
3. Lonely Island
4. Izvestiya TSIK Island
5. Islands of the Arctic Institute
6. Dickson Island
7. Kara Gate
8. Kolguev Island
9. Russkij Island
10. Sterlegon Island
11. Solnechnyi Island
12. Heiberg Island
13. Andrei Island

14. Harbour of Mariya Pronchishceva
15. Anarbay Bay
16. Dunai Island
17. Wrangel Island
18. Ambarchik
19. Rau-Chua
20. Chaun Inlet
21. Pevek
22. Valkarkai
23. Somnitelnaya Harbour
24. Kolyuchin Inlet
25. Nettan.

based on the reports received from these people and on the observations carried out by the Polar Institute in the Barents Sea and part of the Kara Sea.

More than 150 reports were received from the Polar stations in the Soviet Arctic from 1959 to 1961. In the Barents Sea material was collected by the author and other scientists from the Polar Institute mainly in the autumn-winter months (September-March) from 1956 to 1959, from 1962 to 1965, and all the year round in 1960 and 1961.

Polar cod are usually found near the ice-edge in the upper layers of the Arctic Seas and descend to greater depths only during spawning and when the ice breaks and melts. The migration paths and areas of concentration depend mainly on the distribution of ice. Polar cod can drift passively with ice over great distances. In autumn large concentrations move into those sections of the Barents Sea where ice is observed later. It spawns in the near-bottom layers in areas near the ice-edge. Near the ice-edge the mass development of

* Additional data have shown that there is also a feeding migration from the Kolguev area to the strait between Novaya Zemlya and the Vaigach Islands.

phyto- and zooplankton occurs and here Polar cod are the only mass plankton-eaters. As a result, Polar cod lives in the zone rich in food from its earliest stages of development. Such an adaptability to the peculiar conditions of life among ice-floes is responsible for its very great abundance in Arctic Seas.

The Polar cod is circumpolar (Figure 7:7) and forms several separate stocks. Within the Soviet Arctic it is found almost as far as the North Pole, from the White and Barents Seas in the west to the Bering Sea in the east. Two, three and probably more stocks differing in feeding areas, migration routes and spawning places inhabit that area. One stock lives in the Kara, Barents and White Seas, and another in the Chukotsk and Bering Seas. Local stocks probably inhabit the Laptev and East-Siberian Seas (Figure 7:8). All these stocks mix in the boundary areas.

In the Kara, Barents and White Seas is found probably the most abundant stock not only in the Soviet Arctic but in the whole Arctic area. In autumn-winter Polar cod form huge concentrations in the Kara and eastern Barents Seas. They are washed ashore in very great quantities by the gales. In the islands and

on the coast of the Kara Sea, along the water edge, one may see heaps of dead Polar cod, 50–100 cm wide and 30–50 cm high, extending over tens of kilometres.

Great concentrations of Polar cod are observed in summer near the ice-edge in the northern Kara Sea (east of Franz Josef Land). Polar cod occur every year in the eastern areas of the Kara Sea off Geiberg and Solnechnyi Islands. In some years they are very abundant there, in others only isolated schools are observed. When Polar cod are plentiful, their mass arrivals inshore occur in July–August. They usually appear in the cracks of ice in June. In September–October they disappear from the surface layers and probably either descend to greater depths with the beginning of timber-rafting or migrate into other areas.

Polar cod are found in great numbers off Ruskii and Sterlegov Islands by the end of July and in early August. In some years they move farther east, in others they stay here till October. Sometimes they approach the waters-edge where many fish perish during the ebb-tides.

In the Dickson Island area Polar cod are sometimes found under the ice and in the Polynia* at the edge of shore-ice throughout the winter. They appear in greatest numbers in June–July. On some days and sometimes for several days running Polar cod are so numerous that one can observe the water being rippled and dark-coloured by the hoards of fish.

With the water temperature rising (in August and September in the surface to 10° and even more in some years), Polar cod descend to great depths or migrate to the north along the coast of the Taimyr Peninsula. Off Dickson Island Polar cod remain at the surface feeding on shrimps and smaller organisms as well as algae. Sometimes larger fish eat small fish of the same species. No fishery for Polar cod exists in the Dickson Island area, but sportsmen catch them in small numbers as bait for Polar foxes. Small Polar cod are also used in hook fishing for larger Polar cod.

In summer the number of Polar cod in the northern Barents Sea is evidently less than in the Kara Sea except in the area between the northern island of Novaya Zemlya and the Franz Josef Land archipelago.

In the autumn–winter period the Polar cod which inhabit the Kara and northern Barents Seas in summer form pre-spawning and then spawning concentrations in the Novaya Zemlya area (PONOMARENKO, 1963, 1964). Pre-spawning and spawning concentrations are found almost every year in the north-eastern areas of the Barents Sea from September–October to the end of February (in some years even till April) (Figure 7:9).

The data given enable us to represent schematically the summer distribution and migrations in the Barents

and Kara Seas. In March–April, Polar cod start migrating north and east from the areas of Novaya Zemlya and the south-eastern Barents Sea. In June–July they reach the areas of Dickson, Arctic Institute, Izvestiya TSIK, Uedinenie and Vize Islands. In some years they stay in these areas of the Kara Sea till September–October. In other years they migrate even farther east in August–September and sometimes enter the Laptev Sea through the Vilkitzky and other straits. In the second half of September or the beginning of October the first migrations to the west occur.

In addition to Polar cod migrating from the Kara Sea, there is in the Laptev Sea a local stock which feeds in the open parts of the sea and spends the winter, probably spawning, in the coastal zone. This is evident from the small number always found among the broken ice in the open part of the Laptev Sea. MOSKALENKO (1960) discovered wintering areas for Polar cod in the Anabarskyi Gulf. In early spring Polar cod are also seen off the shores of the Mariya Pronchishcheva Harbour, Andrei Island and Taimyr Peninsula. When shore ice breaks in the latter half of June, Polar cod appear off Dunai Island (the northern part of the Lena River estuary) where they remain till autumn.

There is probably a local stock of Polar cod in the East-Siberian Sea because RASS (1945) found fry of Polar cod in a sample from that sea. However, fry alone do not provide sufficient evidence for proving the existence of spawning areas in the East Siberian Sea. It is possible that the fry were carried into the East-Siberian Sea from the Bering Sea where there are well-known spawning areas for Polar cod. Great schools move past the Ambarchik Bight (near the estuary of the Kolyma River) and the shores of Rauchua and Pevek (in the mouth of the Chaunskaya Inlet) into the Bering Sea.

Migrating schools are also observed in the Chukotsk Sea 6 km east of Pevek off the Netti settlement and in Somnitelnaya Harbour in Wrangel Island. In the southern Chukotsk Sea and in cold waters of the Bering Sea the abundance increases in winter and decreases in summer. Migrations and areas of distribution in the Soviet Arctic Sea throughout the year are shown schematically in Figure 7:8.

SUMMARY

Polar cod are usually found near the ice-edge. Their adaptation to life near the ice-edge has resulted in their great abundance in Arctic Seas. At present there are no food competitors for Polar cod with the same abundance. The existence of separate stocks of *Boreogadus saida* is responsible for the circumpolar distribution in Arctic Seas. Thus, at least two or three

* "Polynia" are unfrozen patches of water in the midst of ice.

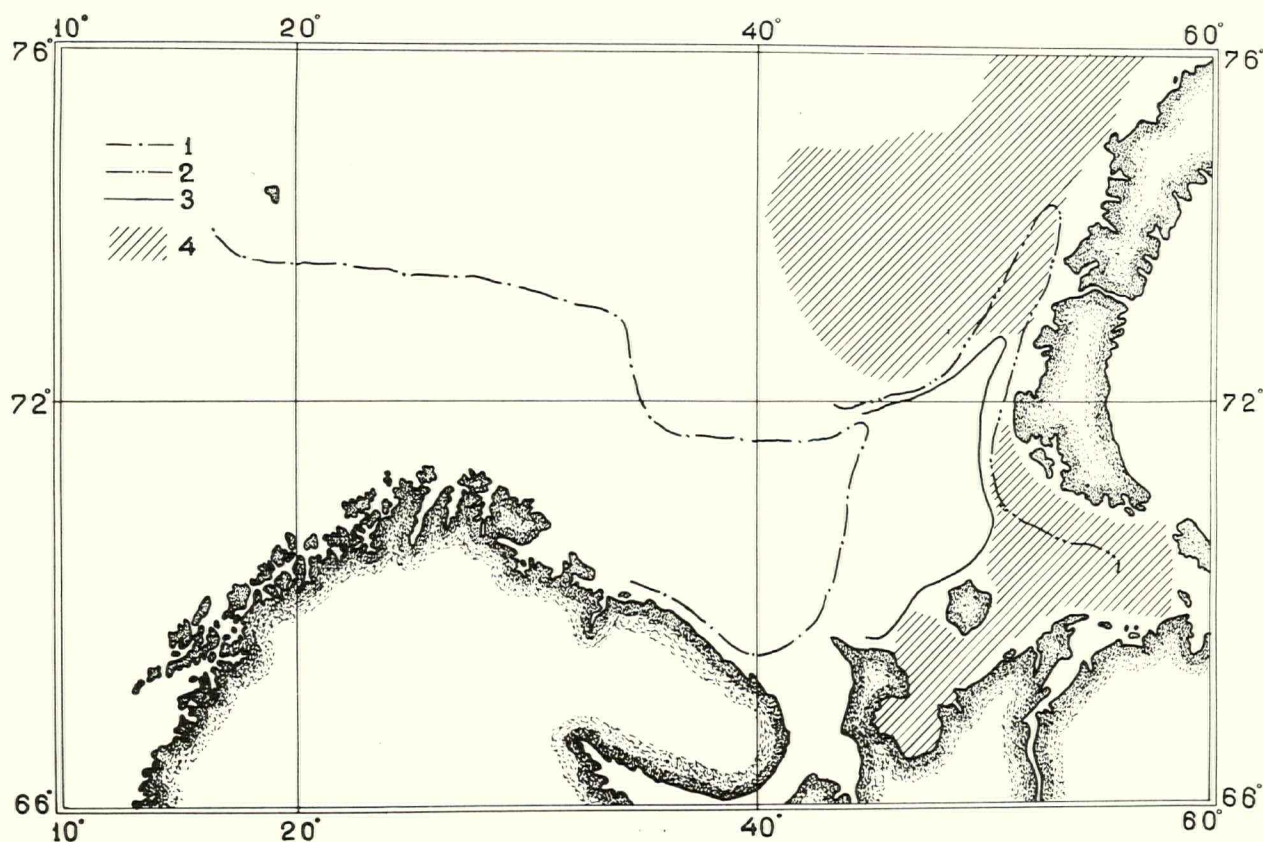


Figure 7:9. Limits of distribution and places of occurrence of the most dense concentrations of Polar cod during their autumn-winter arrival in the Barents Sea.

1 – in cold years. 2 – in warm years. 3 – in moderate years (more often). 4 – places of the most dense concentrations of prespawning and spawning Polar cod in the open sea.

and probably more stocks with different feeding and spawning areas and migration routes inhabit the Soviet Arctic.

In the Kara, Barents and White Seas lives a stock which is probably the most abundant not only in the Soviet Arctic but in the whole Arctic area.

Seasonal distribution and migration in the Barents and Kara Seas are well known and are presented schematically. In March-April Polar cod which spawn off Novaya Zemlya in the south-eastern Barents Sea and, in some years, in the White Sea, migrate north and east. In June-July they reach the areas of Dickson, Arctic Institute, Izvestiya TSIK, Uedinenie, Vize and other Islands. In some years they remain in these sections of the Kara Sea till September-October, in others they move farther east and enter the Laptev Sea in August-September. In the latter half of September or at the beginning of October they start migrating to the west.

In the Laptev Sea there is, in addition to the Polar cod migrating from the Kara Sea, a local stock which

feeds in the open parts of the sea and spends the winter, and probably spawns, in the coastal zone. A local stock of Polar cod can probably be found in the East-Siberian Sea, as RASS found fry of Polar cod in a sample from that sea. However, we know of the mass arrivals of Polar cod into the East-Siberian Sea from the Chukotsk Sea. Polar cod from this stock winter in the southern Chukotsk Sea and in the cold waters of the Bering Sea.

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3. SPAWNING AND DEVELOPMENT OF POLAR COD

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Three genera of gadoid fishes — *Eleginus*, *Arctogadus* and *Boreogadus* — are represented in the cold seas of the Arctic Ocean. Their species are marine fish but their life is connected with brackish waters, as rightly indicated by ZENKEVITCH in 1933. *Eleginus navaga*, the navaga, approaches the shores and enters the lower part of the rivers before spawning, which takes place in the sea; *Arctogadus borisovi* permanently inhabits brackish waters near the shores and enters estuaries of the Siberian rivers. *Boreogadus saida*, the Polar cod, usually abounds in the brackish surface layer of the Arctic seas just below the ice, sometimes approaching the shores and entering the rivers (ANDRIYASHEV, 1954). In contrast to *Eleginus* and *Arctogadus* which are confined to coastal waters, the Polar cod is widely distributed over the whole Arctic Ocean including its central part. The Polar cod is extremely numerous and occurs now and then in large shoals. It is of great importance as food for the sea mammals and birds of the Arctic. Because of the great quantity, the Polar cod is of interest for commercial fisheries in spite of its low market qualities.

Spawning of Polar cod takes place from the end of December to the end of March, mostly in January-February and mainly under the ice-cover. Its larval and post-larval stages were first described by SCHMIDT in his classical monograph on gadoid larvae (1905); the eggs were described by PERTSEVA (1936) and KAZANOVA (1949). The development of the eggs takes

place in the surface layers, beginning under the ice-cover and ending under the open sea-surface free of the thawed ice. Floating eggs were collected in water of $< 0^{\circ}$ to 1.8° C. In February-March eggs were widely spread in the eastern part of the Barents Sea from the Kanin and Kolguev areas in the south, northwards to the northern island of Novaya Zemlya. From January to June eggs were also found in the south-eastern part of the Barents Sea, in the coastal waters of the so-called Petchora Sea (RASS, 1936; KAZANOVA, 1949; KASHKINA, 1962; PONOMARENKO, 1964 a, b).

Polar cod eggs are among the largest gadoid eggs, being 1.53-1.90 mm in size. The egg membrane is very thin and easily damaged; pigmentation on the body of the embryo appears late and is very scarce. The egg structure evidently shows some adaptations to development under specific Arctic conditions, viz. 1) large size of egg corresponds to the low water temperature, which as shown by special studies (RASS, 1935, 1941, 1948) is the general rule for fish eggs; 2) a thin, flimsy membrane corresponds to the absence of waves under the ice-cover; 3) late development and scarcity of pigmentation are in agreement with the idea that the ice-cover provides sufficient protection from direct sunlight.

Hatching of Polar cod larvae has not been observed; the smallest prolarvae known are about 5.5 mm; yolk resorption must probably be over when the prolarvae reach a length of 6.5 mm. Prolarvae of Polar cod are