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A.G. Slizkin

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Distribution of snow crabs of the genus *Chionoecetes* and their habitat in the northern part of the Pacific Ocean

by A.G. Slizkin

Snow crabs belong to the group of underutilized commercial products of the Far Eastern seas. They are widely distributed in the shelf zone and on the continental slope in the northern part of the Pacific Ocean, and are represented by the species *Chionoecetes opilio*, *Ch. bairdi*, *Ch. tanneri*, *Ch. angulatus* and *Ch. japonicus*. Information on the distribution of snow crabs can be found in compendiums on the fauna of the Far Eastern seas and western coast of North America (Rathbun, 1925; Kobyakova, 1937, 1958; Sakai, 1939; Garth, 1958; Ushakov, 1959; Pereira, 1967).

The regular trawl surveys undertaken by TINRO over the past decades have altered our view on the distribution of certain species, and allowed us to examine many of the biological questions pertaining to the snow crabs and their individual populations (Novikov, Gavrilov, 1970; Slizkin, 1974, 1974a, 1977, 1978; Rodin, Slizkin, 1977; Slizkin, Myasoyedov, 1979).

Nevertheless, the majority of published papers either only mention the occurrence of this or that species of snow crabs, or give a description of some population or a part of it. Being in possession of fairly extensive material on snow crabs from the Sea of Japan, Sea of Okhotsk and the Bering Sea, we shall be taking a first comparative-ecological look at the distribution and environmental relationships of various age groups of this group of animals, i.e. adult crabs, juveniles and larvae. In order to examine the entire range of snow crabs in the N Pacific, we borrowed the missing data on the southern part of the Sea of Japan and Pacific coast of North America from published sources.

The study was based on material collected by the author in the period from 1968 to 1974 during eight expeditions to the Bering Sea, Sea of Okhotsk and the Sea of Japan, and by scientists of the TINRO Commercial Invertebrates Laboratory in 1974-1978. In all, 20 research expeditions were carried out, including 4000 trawlings with a 27.1 m otter trawl. Six hundred and seventy trawlings were carried out with a Sigsbee trawl in order to study the distribution of juveniles, and 286 plankton stations to study the distribution of the pelagic larvae.

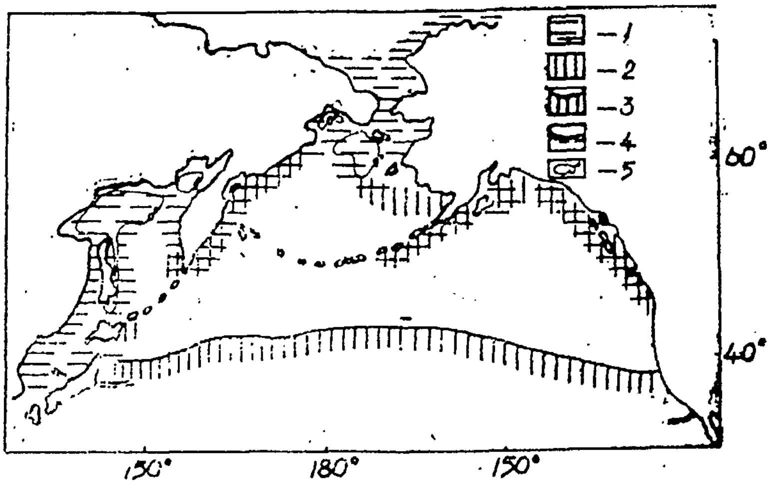

Fig. 1. Distribution of snow crabs in the North Pacific: 1 - *Ch. opilio*; 2 - *Ch. bairdi*; 3 - boundary of the boreal water structure (M.A. Radzikhovskaya, 1965); 4 - southern boundary of the boreal region (Ye.F. Guryanova, 1972); 5 - zero isotherm of bottom waters in summer (K.V. Moroshkin, 1966; V.S. Arsenyev, 1967)

Of all the species of snow crabs, *Ch. opilio* (Fig. 1) has the most extensive range. This species is encountered off the American coast of the Pacific Ocean from British Columbia to Point Barrow (43°-70°30' N, Rathbun, 1925). Here it inhabits the Gulf of Alaska, the Bering Sea, and the southern part of the Chukchi Sea from Wrangel Is. to the mouth of the Mackenzie R. (MacGinitie, 1955). Along the Asian coast, it is found in the Chukchi and Bering seas, and in the Sea of Okhotsk. It is found up to Korea Strait (33° N) in the Sea of Japan, and up to Honshu (38° N) along the Pacific coast of the Japanese islands. In the areas where the shelf is narrow (the Aleutian and Kurile island arcs), *Ch. opilio* is scarce, and our investigations have shown that it is not encountered at all in the areas of the central Kuriles. This species forms large populations in the vicinity of the Pribilof Islands and Bristol Bay in the Bering Sea (Slizkin, 1974), and also in the Sea of Okhotsk and Sea of Japan (Tokago, 1965; Novikov, Gavrilov, 1970; Ogata, 1973; Slizkin, Myasoyedov, 1979).

Ch. opilio is encountered everywhere in the zone where the water temperature at the bottom fluctuates from -1.8 to +7.0°C (see table). Only in the southernmost parts of the range, where the water in summer warms through to a considerable depth, is this species encountered in shallow waters at a temperature of 10°C. At the same time, this species, as no other, tolerates low temperatures, which makes it possible for it to inhabit the southern part of the Arctic (Chukchi Sea). The optimal water temperature in all of its habitats is lower than in all the other species of snow crabs, and for juveniles the optimal temperatures are below zero even in summer (see table). These conditions correspond to the zone in which the cold intermediate layer of water comes in contact with the bottom.

It was established earlier (Slizkin, 1974; Slizkin, Myasoyedov, 1979) that large stocks of young *Ch. opilio* are concentrated in the zones where the cold intermediate layer comes in contact with the bottom, which are confined to stationary gyrals. In the Bering Sea, for example, young snow crabs predominate northwest of the Pribilof Islands and in the central part of Anadyr Gulf, while in the Sea of Okhotsk they predominate in the central part of the W Kamchatka shelf and off the coast of E Sakhalin. In the Sea of Japan, where *Ch. opilio* inhabits the deepest layers in comparison with other areas (see table), it is confined to the cold bottom layer of water which is homologous to the cold intermediate layer in the northern seas (Radzikhovskaya, 1961). This confinement of *Ch. opilio* permits us to assign it to the Pacific glacial species (using the terminology of Ya.A. Birstein and L.G. Vinogradov, 1953). The occurrence of *Ch. opilio* in the southern part of the Chukchi Sea gives grounds for characterizing it as a low-arctic Pacific glacial species.

In papers published earlier (Vinogradov, 1950; Birstein, Vinogradov, 1953), it is indicated that another shelf species, *Ch. bairdi*, is encountered in the northeastern part of the Pacific Ocean and in the Bering Sea up to the Olyutorski cape. We have established that it is widely distributed off the Asian coast of the N Pacific, and can be found up to the southern Kuriles (see Fig. 1).

Water temperature range, summer optimal temperatures (in brackets) and the depths of occurrence (m) of snow crabs in the northern part of the Pacific Ocean

Species of crabs and areas	Adults	Juveniles	Larvae and hatching period
Chionoecetes opilio			
Bering Sea, southeastern part, northwestern part	-1.8+4.9 (1.9) 25-412 (96) -1.8+7.2 (0.9) 20-530 (115)	-1.5+5.2 (0.8) 21-152 (69) -1.8+6.3 (-0.4) 12-300 (71)	0.0+3.0 IV-V -0.5+2.5 V-VI
Sea of Okhotsk, western Kamchatka, eastern Sakhalin	-1.8+4.3 (0.5) 36-530 (136) -1.8+7.0 (0.5) 18-460 (166)	-1.8+3.2 (-0.1) 28-500 (80) -1.8+7.2 (-0.6) 20-510 (124)	+0.5+0.6 V-VI -1.0+10.0 VI
Sea of Japan, northwestern part, southern part*	-1.8+3.0 (1.3) 26-630 (170) 1.0+5.0 225-400 (300)	-1.8+2.5 (1.3) 20-190 (188) 0.5+3.0 250-400 (250)	0.0+3.6 III-V +9.0+12.0 III-IV
Chionoecetes bairdi			
Bering Sea, southeastern part, northwestern part	-1.6+6.2 (2.4) 20-348 (101) -1.7+5.1 (1.4) 15-510 (89)	-1.1+5.5 (2.8) 22-415 (124) -1.1+5.0 (1.9) 10-355 (92)	+0.2+4.0 IV-V -0.1+3.0 IV
Chionoecetes tanneri			
British Columbia**	+2.0+8.4 (5-6) 457-1900 (600)	+1.8+8.4 (2-6) 900-1100	+7.0+12.0 II-III
Chionoecetes angulatus			
Kurile-Kamchatka area	+0.4+3.9 (3.2) 107-1150 (635)	+0.6+3.0 (2.0) 400-1928 (780)	undetermined
Chionoecetes japonicus			
Sea of Japan, southern part***	+0.1+0.7 200-2700 (600)	+0.1+0.7 (600-1000)	+7.0+12.0 II-III

*with the addition of Ogata's (1973) and T. Kon's (1969) data on larvae.
**according to Pereira's data (1966, 1967).
***according to Fukataki's (1968) and Yamahara's (1969) data.

On the whole, *Ch. bairdi* occurs in the NE Pacific, from the coast of the state of Oregon (43°34' N; Hosie, Gaumer, 1974) to the Bering Sea in the north and the Kurile Islands in the east. Its maximum abundance is observed in the Gulf of Alaska and Bristol Bay (Slipp, 1952; Garth, 1958; Hosie, Gaumer, 1974; Slizkin, 1974; Rodin, Slizkin 1977). In the western part of its range, *Ch. bairdi* abounds in Olyutorski Gulf, off the coast of eastern Kamchatka and around the northern Kuriles, i.e. in the areas where the cold intermediate layer is not clearly defined and transforms quickly in spring (Arsenyev, 1967). In the indicated areas, *Ch. bairdi* is confined to the lower part of the cold intermediate layer, and because of this, it is encountered at a higher water temperature and at greater depths than *Ch. opilio* (see table).

The northern boundary of the range of *Ch. bairdi* extends only up to Cape Navarin (62° N). The absence of *Ch. bairdi* north of the Anadyr faunistic barrier (Andriyashev, 1939), a unique boundary of distribution of arctic species southward and boreal Far Eastern species northward, points to its boreal nature. This species is not found in the Sea of Okhotsk, except in the southern and northern Kuriles, and in the southern part of W Kamchatka (Slizkin, 1974; Slizkin, Myasoyedov, 1979). The environmental conditions in the northern part of the Sea of Okhotsk and off the eastern coast of Sakhalin are unsuitable for *Ch. bairdi*, as the water temperature in the layer of residual winter cooling in the zone of contact with the bottom stays below zero throughout the year (Moroshkin, 1966).

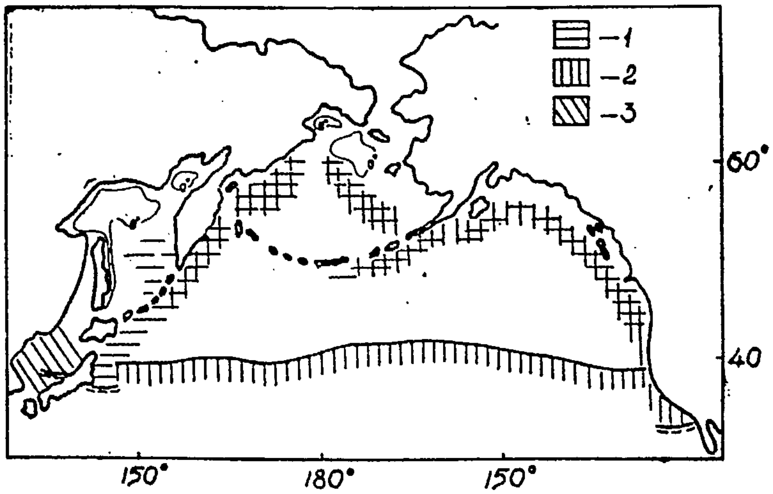

Fig. 2. Distribution of snow crabs in the northern part of the Pacific Ocean: 1 - *Ch. angulatus*, 2 - *Ch. tanneri*, 3 - *Ch. japonicus*. Other markings as in Fig. 1.

Other species of the genus *Chionoecetes* (*Ch. angulatus* and *Ch. tanneri*), like the two preceding species, are also encountered along the N Pacific coast on the continental slope. *Ch. angulatus* (Fig. 2) occurs mainly in the western part. Its maximum abundance is noted in the central region of the Sea of Okhotsk and in the western region of the Bering Sea (Zgurovsky, 1981; Slizkin, 1978). It can be found up to the coast of Oregon (43° N) in the southeastern part of its range (Rathbun, 1925), up to the southern Kuriles and Hokkaido (40° N) in the southwest (Deryugin, Ivanov, 1937; Sokolova, 1960), and up to 61°45' N in the Bering Sea.

Ch. tanneri (Fig. 2) is confined mainly to the eastern part of N Pacific (Pereira, 1967) where it is encountered around San Diego (from 32°17' N), in the Gulf of Alaska and the Bering Sea, and up to eastern Kamchatka (Deryugin, Ivanov, 1937; Slizkin, 1974). *Ch. tanneri*, which occurs off the northern Oregon coast at a depth of 500-1900 m, is encountered at a water temperature ranging from 2.3 to 5.8°C (Pereira, 1967), while *Ch. angulatus*, which occurs on the Pacific and Sea of Okhotsk sides of the northern Kuriles at a depth of 107-1900 m, is encountered predominantly at lower temperatures ranging from 0.4 to 3.9°C (see table).

Ch. japonicus occurs at the drop-off to the depths [continental slope?] in the Sea of Japan. In the southern part of the sea, it is encountered predominantly at depths of 600-1000 m, but the general range of depths is 200-2700 m (Yamahara, 1969). The water temperature in this layer, which is homologous to the cold intermediate layer of the northern Far Easterm seas, varies from 0.1 to 0.7°C (Radzikhovskaya, 1961), i.e. the water temperature in the zone of *Ch. japonicus* is lower than in the zone of *Ch. angulatus*.

Proceeding from the above information, we can say that the southern boundary of snow crab distribution in the western and eastern parts of the North Pacific is located at 33° and 40° N respectively, i.e. it almost coincides with the southern subarctic water structure boundary (Radzikhovskaya, 1965), or the boundary of the Pacific temperate region (Guryanova, 1972). The more southern occurrence of the widely distributed *Ch. opilio* and *Ch. angulatus* in the western part of their ranges (33° and 40° N) as compared with the eastern part (43° N) corresponds to the southern position of the subarctic water structure boundary in the northwestern part of the Pacific Ocean.

Though *Ch. tanneri* does occur as far south as 32° N in the upper part of the subtropical region, it is nevertheless encountered at a maximum bottom temperature of 8.4°C and optimal temperature of 2-6°C (see table), which corresponds to the boreal water structure. Therefore, the deepwater snow crabs should be assigned to the boreal-bathyal species.

The nature of the distribution of snow crabs in the North Pacific points to the fact that the latitudinal boundaries of distribution are determined mainly by the temperature factor, while the formation of large populations in a particular area is determined by a set of factors, the primary ones being the direction of the currents that transport the larvae, the type of bottom substrates, sufficient space and a supply of food for foraging adults. The distribution of snow crabs, as representatives of the migratory benthos, is greatly affected by the structure of the waters or, rather, the zone in which certain water masses which determine the patchy distribution of the crabs come in contact with the bottom.

As a rule, snow crabs can be found from the layer of summer warm-up (approximately from 50 m) to a depth of about 100 m, below which they are rarely encountered (see table). At the same time, snow crabs inhabit waters with temperatures not higher than 7°C. Only in the southernmost parts of their ranges, where the water in summer warms up to a considerable depth, are the shelf species (*Ch. opilio* and *Ch. bairdi*) encountered at a higher water temperature. Therefore, all the species of snow crabs inhabit the zone in which the cold and warm intermediate water masses come in contact with the bottom.

Like the majority of other bottom-dwelling animals, the snow crabs have a heterotopic cycle of development, and that is why the pelagic larvae, slow juveniles and migrating adults are encountered in different environmental conditions.

The reproductive biology of all the species of snow crabs is generally the same. All of them have a planktotrophic larva, including the bathyal species (Pereira, 1967; Takeuti, 1972). The table shows that the hatching of snow crab larvae in the British Columbia area and southern part of the Sea of Japan takes place in February–March; in the more northern areas, in Bristol Bay and in the southern part of the W Kamchatka coastal region, it takes place in April–beginning of May, and off Cape Navarin at the end of May–beginning of June (Kanarskaya, Slizkin, 1975). The temperature of the surface waters in which snow crab larvae undergo metamorphosis varies from 0 to 12°C (see table). In northern areas, such temperatures are observed during the period of maximum summer warm-up of the waters, while in southern areas they are noted in winter and early spring. The pelagic development of snow crab larvae lasts about two months and coincides with the mass blooming of phytoplankton, the most favourable period for the larvae. In the given case, the spawning characteristics of snow crabs are governed by Orton's rule (S.A. Mileykovsky, 1970).

The geographic and vertical distribution of *Chionoecetes* species leads us to the conclusion that the individuation of species and their migration to considerable depths could not have taken place in the distant past. Evidence of this is the similarity in the type of metamorphosis, the subarctic-boreal confinement of all the species, and the slight morphological differences between them. Furthermore, the phenomenon of hybridization is noted among snow crabs (Karinen, 1972). The planktotrophic pelagic larva, which is also characteristic of bathyal species, contributed to their extensive dispersal along the continental slope throughout the northern part of the Pacific Ocean. Only in the Sea of Japan, which is isolated enough from the Pacific Ocean, did the bathyal species *Ch. japonicus* form due to gradual adaptation of the shelf species *Ch. opilio* to life in the deep. It appears that the formation of *Ch. angulatus* also occurred due to the adaptation of *Ch. opilio* to life on the continental slope. The fact that these species are tolerant of comparatively low temperatures and have a predominantly Asian range points to this. The predominantly American distribution of *Ch. bairdi* and *Ch. tanneri*, and their confinement to a higher temperature than in *Ch. opilio* and *Ch. angulatus* gives us reason to assume that an area of speciation of these species exists off the American coast.

References

1. Andriyashev A.P. An Outline of the Zoogeography and Origin of the Ichthyofauna of the Bering Sea and Adjacent Waters. Leningrad: Leningrad State University Publishing House, 1939, 185 p.

2. Arsenyev V.S. Currents and Waters Masses of the Bering Sea. Moscow: Nauka Publishers, 1967, 132 p.

3. Birstein Ya.A., Vinogradov L.G. New data on the Decapoda of the Bering Sea. Zool. zhurnal [Zoological Journal], 1953, v. 32, No. 2, p. 215-228.

4. Vinogradov L.G. Determination table of shrimp, crayfish and crabs of the Far East. Izv. TINRO, 1950, v. 33, p. 179-358.

5. Guryanova Ye.F. Zoogeographic zonation of the sea. In: The Fauna of the Gulf of Tonkin. Moscow: Nauka Publishers, 1972, p. 8-12.

6. Deryugin K., Ivanov A. A preliminary summary research on the benthos of the Bering and Chukchi seas. In: USSR Marine Research, Leningrad: GTI Publishers, 1937, No. 5, p. 246-259.

7. Zgurovsky K.A. Distribution and abundance of the deepwater snow crab in the vicinity of the northern Kuriles. In: Biological Resources of the Shelf and Their Rational Utilization and Conservation. Vladivostok: Far Eastern Scientific Centre of the USSR Academy of Sciences, 1981, p. 51.

8. Kanarskaya O.A., Slizkin A.G. Spawning periods and distribution of crab larvae in the Bering Sea. In: Biological Resources of the Far Eastern Seas. (Summaries of reports), Vladivostok: TINRO, 1975, p. 65-66.

9. Kobyakova Z.I. Decapoda of the Sea of Okhotsk and Sea of Japan. Uch. zap. LGU, 1937, No. 15, p. 93-154.

10. Kobyakova Z.. Decapoda from the locality of the southern Kuriles. In: Research on the Far Eastern Seas. Moscow: USSR Academy of Sciences Publishing House, 1958, No. 5, p. 249-260.

11. Kon T. Fishery biology of *Chionoecetes opilio*. III. Density of distribution and shell width variation with depth. Bull. Jap: Soc. Sci. Fish., 1969, v. 35, No. 7, p. 624-628 (transl. from Japanese).

12. Mileykovsky S.A. Dependence of the reproduction and spawning of shelf bottom-dwelling invertebrates on water temperature. Tr. IO AN SSSR, 1970, v. 88, p. 113-149.

13. Moroshkin K.V. Water Masses of the Sea of Okhotsk. Moscow: Nauka Publishers, 1966, 68 p.

14. Novikov N.P., Gavrilov G.M. Distribution and abundance of snow crabs off the eastern coast of Sakhalin. Rybn. khoz-vo, 1970, No. 2, p. 8-9

15. Radzikhovskaya M.A. Water masses of the Sea of Japan. In: Main Geological and Hydrological Features of the Sea of Japan. Moscow: USSR Academy of Sciences Publishing House, 1961, p. 108-122.

16. Radzikhovskaya M.A. Main structural features of the waters in the northern part of the Pacific Ocean. In: Oceanological Research. Moscow: Nauka Publishers, 1965, No. 13, p. 41-46.

17. Rodin V.Ye., Slizkin A.G. Variation of the distribution and abundance of commercial crabs (Lithodidae et Majidae) in Bristol Bay. Biol. morya [Marine Biology], 1977, No. 5, p. 84-89.

18. Slizkin A.G. Peculiarities of the distribution of crabs (Crustacea, Decapoda, Lithodidae et Majidae) in the Bering Sea. Tr. VNIRO, 1974, v. 99, p. 29-37.

19. Slizkin A.G. Areas of distribution of some species of crabs in the Bering Sea. In: Hydrobiology and Biogeography of Shelves in Cold and Temperate Waters of the World Ocean. Leningrad: Nauka Publishers, 1974a, p. 61-62.

20. Slizkin A.G. Distribution and comparative ecology of crabs (Lithodidae et Majidae) in the northwestern part of the Pacific Ocean. Summaries of reports presented at the 1st Conference of Soviet Oceanologists. Moscow: Nauka Publishers, 1977, No. 2, p. 28-29.

21. Slizkin A.G. Some ecological peculiarities of *Chionoecetes opilio* in the Far Eastern seas. Summaries of reports presented at the Second All-Union Conference on Shelf Biology, part 2, Kiev: Naukova Dumka Publishers, 1978, p. 104-105.

22. Slizkin A.G., Myasoyedov V.I. Some questions regarding the biology and ecology of *Chionoecetes opilio* from the W Kamchatka population. In: Research on Fish Biology and Commercial Oceanography. Vladivostok: TINRO, 1979, No. 10, p. 44-51.

23. Sokolova M.N. Distribution of biocoenoses of benthic fauna in deepwater depressions of NW Pacific. Tr. IO AN SSSR, 1960, v. 34, p. 21-59.

24. Tokado T. 1964 research on the snow crab. Hokusuishi geppo, 1965, v. 22, No. 4, p. 219-234 (transl. from Japanese).

25 Ushakov P.V. Fauna of the Sea of Okhotsk and the Conditions of Its Existence. Moscow: USSR Acad. Sci. Publishing House, 1959, 459 p.

26. Fukataki H.O. Snow Crabs. Nihon Kaiku Suisanshiki Kenkyujo Renraku Nyuusu, 1968, p. 192-202 (transl. from Japanese).

27. Yamahara M. Study of the resources of bottom fish (snow crabs). 1968 Data of the Yamagata Experimental Station for the Study of Fishery Products, 1969, No. 2, p. 1-18 (transl. from Japanese).

[English references follow in the original]