

The Hydromedusae and its distribution in Chukchi Sea and adjacent southern edge waters of Canada Basin, Arctic Ocean

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Abstract The present paper is based on materials collected in Chukchi Sea and adjacent southern edge waters of Canada Basin, Arctic Ocean during the period from July to August 1999 on the icebreaker, the R/V "Xuelong", by the Chinese First Arctic Scientific Expedition. Totally, 8 species of pelagic Hydromedusae were identified, of which 4 species belonged to Anthomedusae, 2 species to Leptomedusae, 1 species to Trachymedusae and 1 species to Narcomedusae, the *Neoturris brevicornis* is recorded for the first time in Chukchi Sea. Their principal morphological characteristics are described and illustrated. The 8 species of Hydromedusae occurring in the Chukchi Sea were all cold water species, of which 6 species belong to neritic species and 2 species to ocean species. According to the geographic distribution of species, they may be divided into three groups: Arctic species, Arctic-boreal species and Boreal-temperate species. From the view-point of zoogeography, species from these waters belong to the Arctic fauna. The abundance of Hydromedusae in Chukchi Sea was generally low, with a mean value of $108 \text{ ind.} \cdot 10^{-2} \cdot \text{m}^{-3}$. *Rathkea octopunctata* and *Aglantha digitale* were dominant species. From the view-point of vertical distribution *Aglantha digitale* is inhabiting in the depth of 0 - 300 m and with the maximum in the depth of 50 m to 100 m.

Key words Chukchi Sea, Canada Basin, Arctic Ocean, Hydromedusae, distribution.

1 Introduction

In the Arctic and its surrounding waters zooplanktons are rather low in species, but most of them are rich in number. They are important both as food for economic fishes and as sea grazers on phytoplankton. Thus they are important secondary producers in the sea as key links in marine food chains (or web) and as a subgroup in the marine ecosystem. As result, many scientists have studied them with an aim at the marine ecological dynamics. The zooplankton in the Arctic area is mostly cold water species, the distribution of which is taken as indicator for the movement of cold water mass. Among them the drifting or non-swimming Hydromedusae are characterised by carrying a great amount of water in its body, which can be regarded as the best indicator for cold water mass.

The zooplanktonic investigation in Arctic began in period from 1893 to 1896 led by Nansen from Norway with results published in the early 1900's. Later there were the expeditions in Kara Sea, Norwegian Sea and New Siberian Archipelago organised by Russian from 1900 to 1908 and in Arctic by Canadian from 1913 to 1918.

However, it was only after 30's that a larger scale of investigation started (Grainger 1965; Vinogradov and Merinikov 1980). Since then many publications were published mainly from Russia, UK, Norway, Canada, Japan etc.. Among them, much detailed study was conducted on the horizontal and vertical distribution of copepods (Johnson 1956). In recent years, many countries have still taken the zooplankton monitoring as an important step in their Arctic program (Wing 1972; Kosobokova *et al.* 1998).

There were 42 Hydromedusae species recorded in Arctic seas, including those in Norwegian Sea and Greenland Sea (Kramp 1961, 1968; Kosobokova *et al.* 1998). Among them, a total of 12 species were recorded but little information is known about their abundance distribution in Chukchi Sea (Naumov 1960; Wing 1972).

China started to investigate Arctic in the summer of 1999 and there were studies on the zooplankton in Chukchi Sea and Bering Sea. This paper reports the Hydromedusae species and their abundance distribution in Chukchi Sea and adjacent southern edge waters of Canada Basin, Arctic Ocean with aims at contributing biodiversity data to the Arctic study and for ecological purpose.

2 Materials and methods

The samples for this study were taken by Lin Jinghong who was from the Third Institute of Oceanography, SOA and jointed the Arctic expedition on R/V "Xuelong", a research icebreaker from China, at 26 horizontal and one vertical layered stations in range from 66°00'00"N to 75°25'26"N and from 153°37'17"W to 174°59'02"W (Fig. 1) in the period of 14 July to 25 August 1999. The samples were collected with a zooplankton net of length 280 cm, opening diameter 80 cm and mesh size 0.505 cm. At the horizontal station an integrated vertical trawl was pulled from the seabed or from the depth 200 m to the surface where water depth was greater than 200 m. At the vertical trawl station the collection was done at layers from 50 m to 0 m, 100 m to 50 m, 200 m to 100 m, 300 m to 200 m, 500 m to 300 m, 800 m to 500 m. The samples were immersed in site with 5% formalin and were examined under LM, counted and transferred to the unite of individuals per 100 m³.

3 Description of species

As a result, 8 species of Hydromedusa have been identified from the collected samples, among them, *Neoturris brevicornis* is recorded for the first time in the Chukchi Sea. Their morphological characters are described as follows.

3.1 *Euphysa flammea* (Linko 1905) (Fig. 2)

Body radially symmetrical, umbrella 5 - 7 mm high, 3.5 - 5.0 mm wide; walls moderately thick; apex rounded, without apical projection and apical chamber. Manubrium broad, spindle-shaped, about 2/3 of the bell cavity in length. Gonads encircling manubrium, with many eggs covering the surface of manubrium in female adult. Four radial canals. 4 marginal tentacles at basal bulb, broad club-shaped in front view, no ocelli. The line between the basal bulb and jelly of bell distinct in lateral view, groups of nematocysts scattered at proximal part in the shape of half

ring and forming more complete rings toward distal part of tentacle.

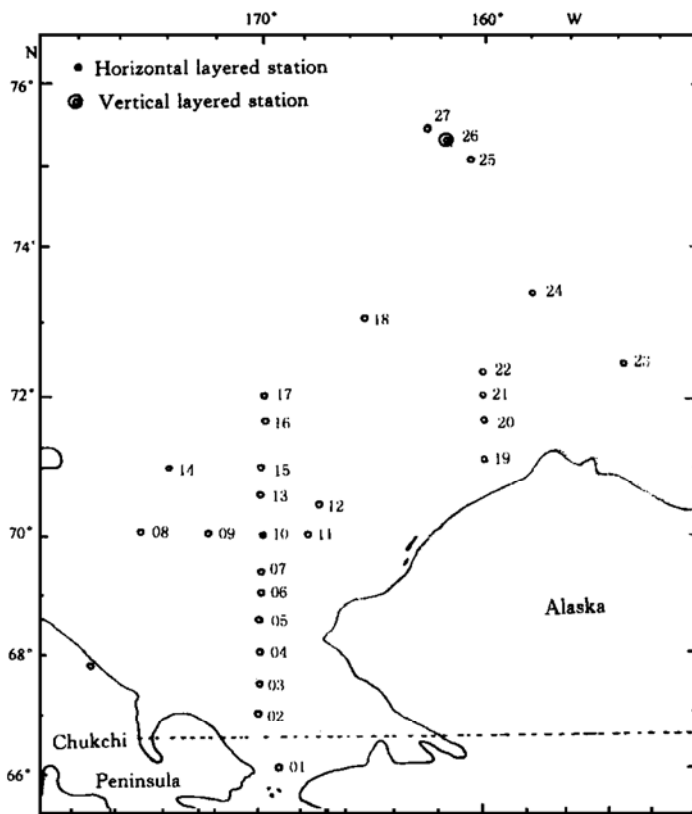


Fig. 1. Sampling station for zooplankton.

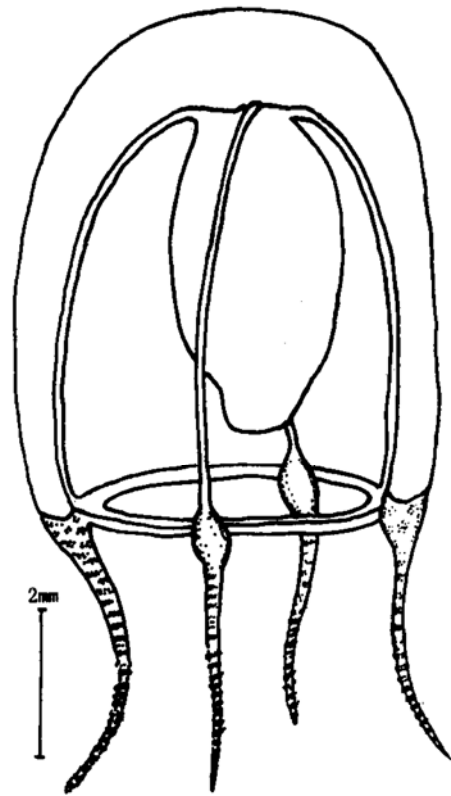


Fig. 2. Lateral view of *Euphysa flammea*(Linko).

This species belongs to Euphysidae of order Anthomedusae. It was named after its fiery-red or orange color at the manubrium and tentacle bulbs in living organisms.

Locality and date: 28 specimens were collected from six stations (02, 03, 05, 07, 11, 14) in 67 – 71°N, 168 – 174°W, from July 14, 1998 to August 3, 1999.

Distribution: *Euphysa flammea* was considered as circumpolar species (Kramp 1926). It occurs in the coastal waters during the summer months and in Chukchi Sea, East Siberian Sea, Laptev Sea, Kara Sea, Barents Sea, White Sea, Norwegian Sea, W. Greenland, Beaufort Sea and Newfoundland waters of Canada, the northern coast of Alaska and north-west waters of America (Mayer 1910; Kramp 1961; Grainger 1965) and in Bering Sea and Sea of Okhotsk in the north Pacific Ocean (Naumov 1960).

3.2 *Plotocnide borealis* (Wanger 1885) (Fig. 3)

Body nearly globular to bell shaped; 1.2 – 3.0 mm high and 1.0 – 2.5 mm wide; jelly thick; apex rather thick, rounded. Manubrium broad, globular, without a peduncle, with a dome-shaped apical chamber. Apical chamber larger for young medusa (Fig. 3B). Manubrium exceeds 2/3 of bell cavity in length. Mouth round in shape. Gonad surrounding manubrium. Four narrow radial canals. Four long and thin solid marginal tentacles; tentacle bulbs well developed at the basal. Tentacles bearing an oval terminal swelling studded with nematocysts.

This species belongs to Tubulariidae of order Anthomedusae.

Locality and date: Two specimens were collected from station 18 in August 5, 1999; Two specimens, from station 22 in August 9, 1999.

Distribution: It is widespread in Arctic and subarctic waters, including Chukchi Sea, East Siberian Sea, Laptev Sea, Kara Sea, White Sea, western Barents Sea, Davis Strait and Norwegian Sea (Naumov 1960; Kramp 1961); and nearshore waters of Vancouver in the British Columbia, Canada (Arai and Brinckmann-Voss 1980).

3.3 *Rathkea octopunctata* (M. Sars 1835) (Fig. 4)

Umbrella 1.8 mm high, 1.5 mm wide, somewhat globular and thick, apex contracted and thicker. Manubrium enlarged on well developed peduncle. Whole manubrium 1/2 to 2/3 of bell cavity in length. Mouth surrounded by four oral arms, each branch of oral arm is bifurcated with a terminal nematocyst knob, some specimens with one pair of lateral nematocyst clusters proximal to the bifurcation. Gonad completely surrounding stomach, asexual reproduction by budding from stomach wall. Four radial canals beginning from four sides of peduncle to ring canal of umbrella margin. Eight marginal tentacle bulbs, four perradial positions with five tentacles each, four interradial positions usually with three tentacles each. Color of marginal bulbs yellow, no ocelli.

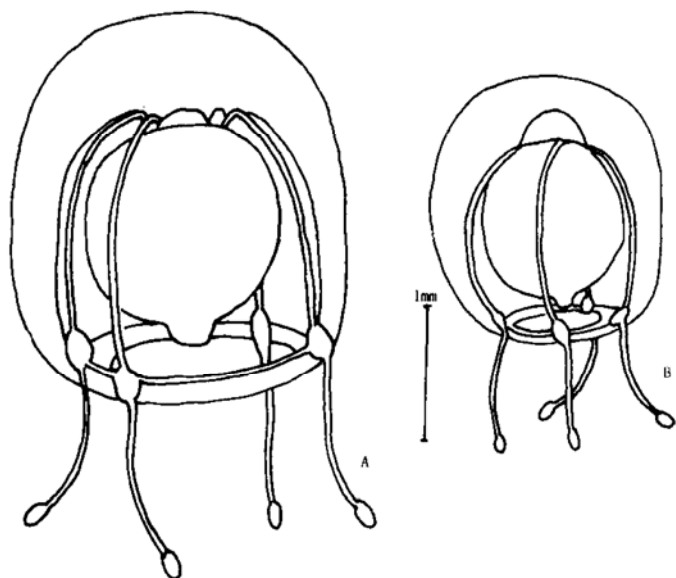


Fig. 3. Lateral view of *Plotocnide borealis* Wagner. A. mature adult, B. Young.

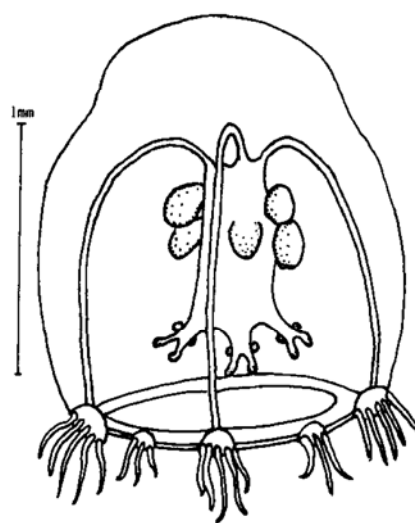


Fig. 4. Lateral view of *Rathkea octopunctata* (M. Sars)

This species belongs to Rathkeidae of order Anthomedusae. When it was recorded as a new species it was placed in the genus *Cytaeis*. This genus bears many simple oral tentacles with no oral arm. However medusa with oral arm and without simple oral tentacle should be placed in to genus *Rathkea*.

Locality and date: Total 164 specimens were collected from Chukchi Sea in July and August, the appearing rate reached 58%.

Distribution: It is widespread in Arctic, frigid zone and temperate zone of North

Pacific and North Atlantic (in winter it may occur in the cold water current flowing to the subtropical zone), in Chukchi Sea, Laptev Sea, Kara Sea, Barents Sea, North Sea, Iceland, the west Greenland, the northwestern coast of Europe, the Black Sea, the Mediterranean Sea, the North America and Alaska coast, Bering Sea, Sea of Okhotsk, Japan waters (Naumov 1960), Bohai Sea, Yellow Sea, East China Sea and Taiwan Straits in winter (Chow and Huang 1958; Zhang 1982).

3.4 *Neoturris breviconis* (Murbach and Shearer 1902) (Fig. 5)

Umbrella dome-shaped, 20 mm high and 20 mm wide, jelly thin and apex thick, with a rather low apical projection. Manubrium large and broad, skirt-shaped, 1/3 to 1/2 of bell cavity in length; mouth margin folded. Gonads at four radial positions folded on oblique adradial, with interstitial pit in the interradial position. Four radial canals, broad, ribbon-shaped, jagged on both sides. Ring canal smooth but narrower than radial canal. Velum developed. About 100 marginal tentacles densely crowded, marginal tentacle bulbs without ocelli.

This species belongs to Pandeidae of order Anthomedusae. By reason of its mesenteries, it was once placed in the genus *Leuckartia*. As its manubrium has isolated pits in interradial position, many marginal tentacles are ranged densely, and the tentacle bulbs show lack of a true spur and ocelli. It should be placed in genus *Neoturris*.

Locality and date: Three adult specimens were collected from station 6 in July 18 and station 12 in August 3, 1999, respectively.

Distribution: Bering Sea, Sea of Okhotsk, eastern Kamchatka Peninsula and southern Alaska, nearshore waters of Norway and Greenland, southern Iceland, the northern Japan waters (Kramp 1959; Naumov 1960), northern Canada (Arai and Brinckmann-Voss 1980).

This species is a new record for Chukchi Sea.

3.5 *Obelia longissima* (Pallas 1766) (Fig. 6)

Umbrella flat, jelly thin, 2.8 - 3.0 mm in diameter. Stomach short, with quadrangular base. Mouth with four short, simple lips. Four slender radial canals. Four globular gonads outside the radial canals near bell margin. Around 100 solid marginal tentacles, slightly stiff and tidy, each with small basal bulb and a short projection of endodermic plugging into the mesogloea of bell margin. Eight adradial lithocysts, each situated on underside of basal bulb of marginal tentacle, with one concretion each. Velum reduced.

This species belongs to Campanularidae of order Leptomedusae. The life history of genus *Obelia* is dominated by hydroid generation, and it is short in the stage of medusa of a simple structure. It is difficult to tell the difference between these two stages. Thus the majority of taxonomists take this genus as medusa *Obelia* spp. We took it as *Obelia* medusa of China Seas following the same nomination. According to reports, genus *Obelia* had two species in Arctic waters, They were *Obelia longissima* and *O. geniculata* (Naumov 1960). These two species of medusa are bigger and identified to have hydroid generation. However the gonads in latter species is near the stomach in small body (1 mm) and bigger body gonads are in

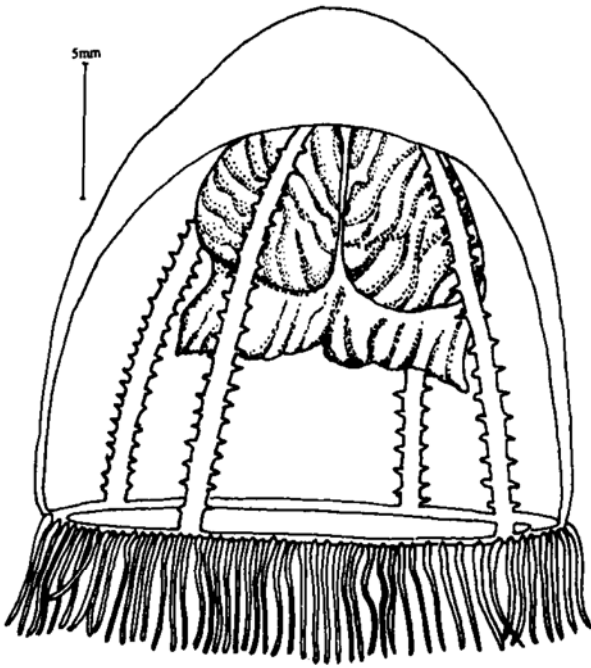


Fig. 5. Lateral view of *Neoturris brevicornis* (M. and Sh.)

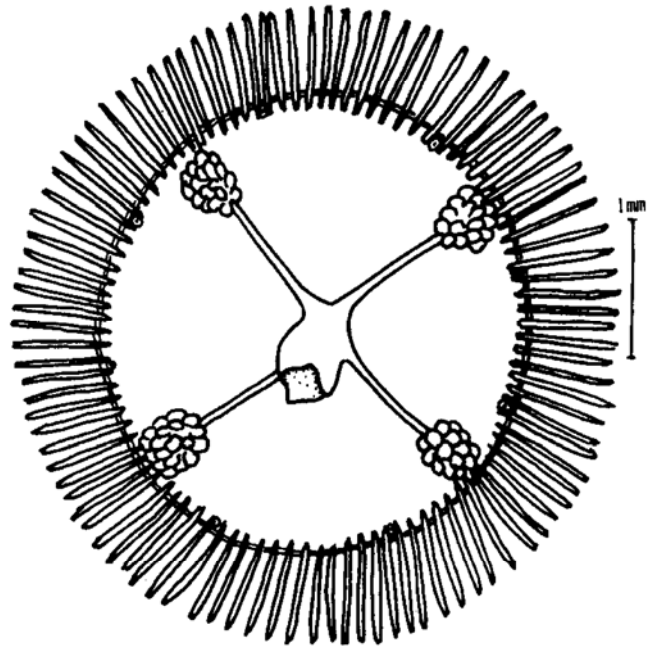


Fig. 6. Oral view of *Obelia longissima* (Pallas).

middle of radial canal. Since the present species has gonads near the bell margin, it has been placed into *O. longissima*.

Locality and date: 15 specimens were collected from station 04, 06 and 10 on August 9, 1999; 2 specimens were collected from station 22 on August 9, 1999.

Distribution: Arctic and frigid zone waters, including northern Russian Seas and the Far East Seas, the Black Sea, Chile, the Straits of Magellen (Naumov 1960); Alaska, Iceland, northwestern Europe and the Atlantic coastal seas of North America (Mayer 1910).

3.6 *Tiaropsis multicirrata* (M. Sars 1945) (Fig. 7)

Umbrella flatted, hemispherical, jelly thin, 5.6 – 6.5 mm in diameter. Mouth broad, quadrangular, with four fairly long and broad lips. Mouth margin folded. Stomach flat, with fairly short peduncle. Four radial canals. Gonads pod-shaped, $1/3 - 2/3$ of the radial canals in length. About 160 marginal tentacles, with swollen bulbs. Eight open marginal lithocysts, each with many concretions. The black ocelli at the base of lithocysts is very distinct in the species.

This species belongs to Mitrocomidae in order Leptomedusae. According to Arai and Brinckmann-Voss report (1980), when umbrella reached 18.3 mm in diameter, the gonads are long-sinuuous, occupying nearly whole length of radial canals in adult specimens. The gonads in our specimen are pod-shaped and only at the center of radial canal, it may be considered to be an approximately mature medusa but not a large and completely mature one.

Locality and date: Specimens were collected at station 3 on July 14, 1999, one at station 10 on August 3, 1999; two at station 16 on August 4, 1999.

Distribution: Chukchi Sea, White Sea, Iceland, Greenland, Barents Sea to

English Channel, including Seas of Norway, Denmark *et al.* of Northwest Europe, Newfoundland of North America to Woods Hole, U. S. A; N. W. Pacific: Bering Sea, Sea of Okhotsk (Russell 1953; Naumov 1960; Kramp 1968). Some juvenile specimens, 2.0 - 2.2 mm wide, were found in Yantai (the Yellow Sea), China, in February to March (Chow and Huang 1958).

3.7 *Aglantha digitale* (O. F. Muller 1766) (Fig. 8)

Umbrella 8 - 16 mm high and 6 - 9 mm wide, almost cylinder shaped, mesogloea underdeveloped, lateral walls thin, conical apical projection slightly thick. Gastric peduncle long and slender, exceeding half height of bell cavity. Stomach very small, with four lips. Eight radial canals, beginning from stomach base along gastric peduncle equidistantly and extend upward to the subumbrella apex, and along subumbrella to ring canal. Eight pendant gonads on radial canals near the gastric peduncle base, gonad broad finger-shaped in juvenile stage; gonad sausage-shaped in adult stage, colour of living specimen bright and pinkish red; gonads yellowish, bright and beautiful.

This species belongs to Rhopalonematidae of order Trachymedusae, *Aglantha digitale* resembles *A. intermedia*, but differs from the latter in a longer stomach, 4 pairs radial canals S-shaped on gastric peduncle.

Locality and date: 470 specimens were collected from 13 stations on August 3 to August 25, 1999. It was dominant species in the surveyed waters.

Distribution: widespread in Arctic Seas, including northern Russian Seas,

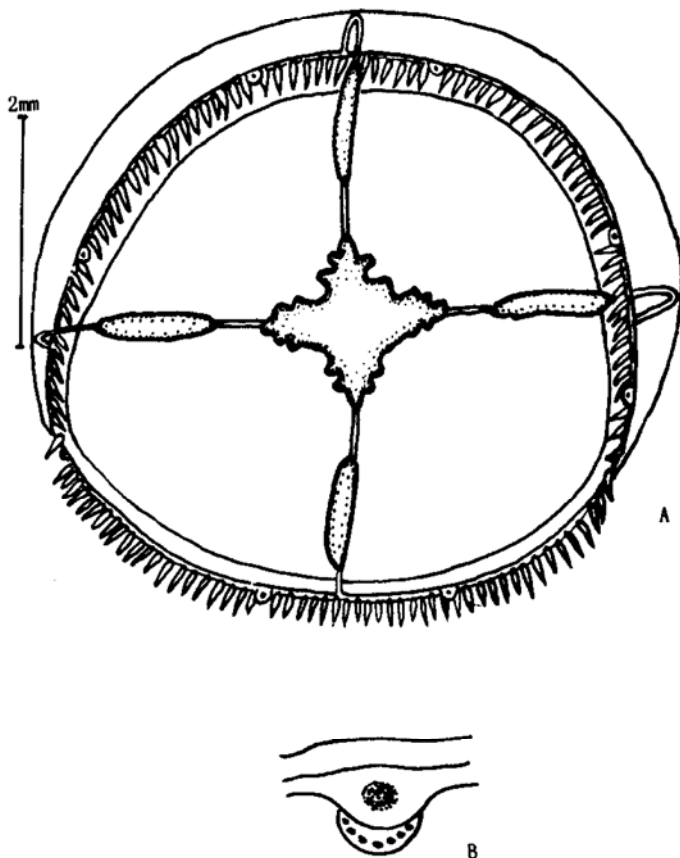


Fig. 7 *Tiaropsis multicurrata* (M. Sars). A. oral view, B. lithocyst.

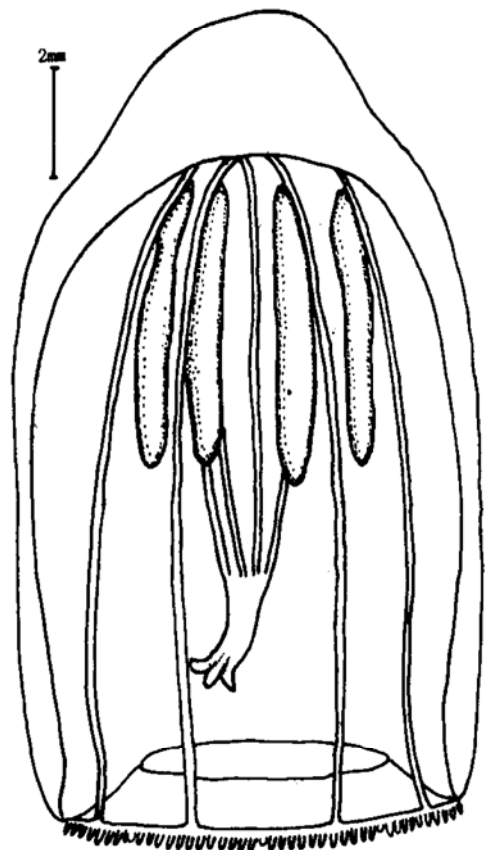


Fig. 8 Lateral view of *Aglantha digitale* (O. F. Muller).

Iceland and Greenland, North Pacific, the north seas of northern Japan and western coast of U.S.A; Atlantic: the north seas of east coast of U.S.A., the north seas of Gibraltar Str. and Azores Is. (Naumov 1960; Arai and Brinckmann-voss 1980).

3.8 *Aeginopsis laurenti* Brandt 1835 (Fig. 9).

Umbrella 12 mm wide, hemispherical, apex jelly thick, lateral wall very thin. Stomach broad lenticular, with 16 square stomach pouches, jagged edges at the stomach pouches at four perradial and four interradial positions, with peronia in a deep gap and adradial position in a half gap. Four perradial tentacles at the middle and upper parts of exumbrella. 2 - 3 statocysts on each octant bell margin.

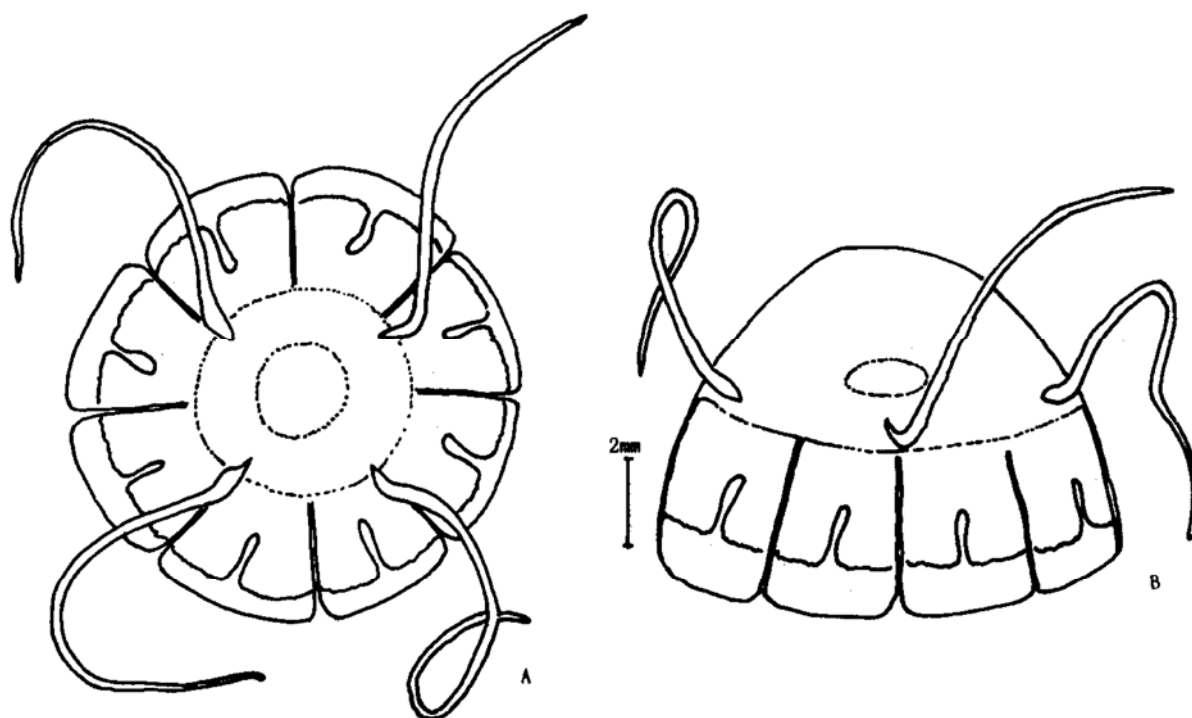


Fig. 9 *Aeginopsis laurenti* Brandt. A. dorsal view, B. lateral view.

This species is similar to *Aegina citrea* in its four tentacles, but differs from the latter, which bears only eight stomach pouches and four perradial peronias. This species resembles genus *Aeginura* in having 16 stomach pouches and 8 peronias, and the latter differs from the former in 8 tentacles and secondary tentacles on the umbrella margin.

Locality and date: a specimen was collected each from the eastern part of surveyed eastern waters (Station 21, 22 and 23) in August 8 to 11, 1999, respectively.

Distribution: The whole Arctic Seas including northern Russian Seas, Iceland, Greenland and Alaska waters, U.S.A.; N.W. Pacific: Japan Sea, Sea of Okhotsk and Bering Sea; the north seas of northern California from west coast and New England from east coast, U.S.A (Mayer 1910; Naumov 1960; Alvarino 1999).

4 Species composition and fauna characters

A total of 8 species was found in samples of Chukchi Sea by the cruise. Inclusive, up to the present 13 species have been recorded in here. The species richness is quite low as compared with those in Bering Sea (19 species) in the south of Arctic cycle and in Japan Sea (> 70 species) (Naumov 1960; Kramp 1968). It is far less than the species richness found in the East China Sea (> 140 species).

Hydromedusae is a group of zooplankton growing mainly in neritic waters. Due to their reproducing style, Order Anthomedusae, Leptomedusae and Limnomedusae are mostly neritic water species, which account for 80% of total Hydromedusae species, while Trachymedusae and Narcomedusae are all oceanic species, which account for 20% of the total. Thus the ratio (N/O) of neritic species to oceanic species reaches 4:1 in Chukchi Sea. In 8 species found in this expedition, there were 4 Anthomedusae, 2 Leptomedusae, 1 Trachymedusae and 1 Narcomedusae, i. e. 6 neritic and 2 oceanic species that made up 3 in N/O ratio. Compared with the global N/O mean ratio 4, the species in the waters investigated is considered to be the neritic group showing a certain influence from the ocean water due to the environmental conditions of the area. In addition to 4 stations at depth exceeding 2000 m, which are located in the Northeast of the waters investigated, which is the part of southern Canada Basin, Arctic Ocean, other stations are mostly at depth of around 50 m in addition to a few stations at depth of 30 m. It suggests that the surveyed area was located in the neritic sea. The species appeared at 4 stations at depth of over 2000 m are exclusive oceanic species (Fig. 10), of which, 2 had also been found at the neritic stations. In station 01, at depth of 49 m, near the Bering Strait oceanic species were rich in number, which probably resulted from the invasion of stronger offshore currents from Bering Sea during the survey period.

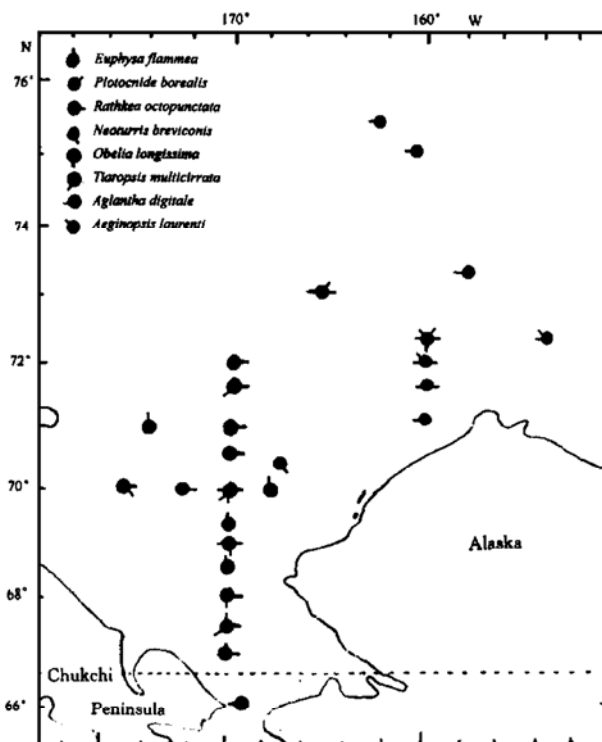


Fig. 10 The species distribution of Hydromedusae.

In aspect of temperature adaptation, 8 species of Hydromedusae appearing in

Chukchi Sea are all cold water species due to the dominance of Arctic water in this region, where the upper layer water temperature is low (-5°C in general) even in the southern Chukchi Sea near the Bering Strait in summer (Spoel and Heyman 1983). The geographic distribution varied with the species that adapted to different water temperatures. They can be divided into 3 groups, the Arctic species which occur in Arctic Zone and in the nearby boreal cold waters, such as *Plotocnida borealis*, the Arctic-boreal species, such as *Euphysa flammea*, *Aeginopsis laurenti*, *Aglantha digitale*, *Neoturris brevicornis* and *Obelia longissima*, which are distributed extensively in Arctic and boreal cold waters, and the boreal-temperate species, such as *Tiaropsis nultcirrata* and *Rathkea octopunctata*, are wide-spread in the Arctic and boreal cold-temperate waters.

Among the 8 species of Hydromedusae from Chukchi Sea which were also found in north of Canadian sea waters, only 6 species were found in the east of Siberia sea, Laptev Sea and Kara Sea. It suggested that the fauna of Hydromedusae in Chukchi Sea is much similar to that of the eastern waters probably due to the existence of clockwise cyclone in Chukchi Sea, Beaufort Sea and the southern part of Arctic Ocean (Johnson 1956). Of the Hydromedusae, 7, 7, 5, 2, and 1 species occurred in Bering Sea, Sea of Okhotsk, Japan Sea, the Yellow Sea and the East China Sea, respectively. It demonstrates that the Hydromedusae fauna in Chukchi Sea is closer to that in Bering Sea and Sea of Okhotsk Sea and quite different from that in China Seas. Based on the geographic distribution, we agree with the opinion that geographically the zooplankton fauna is found in the Arctic waters belongs to the Arctic province (Spoel and Heyman 1983). However, it needs to be detailedly, studied as there is slight difference in the species composition between the Pacific part and the Atlantic part of Arctic sea.

5 Abundance distribution for Hydromedusae

5.1 Horizontal distribution

5.1.1 Horizontal distribution for total abundance

According to the data analyses on 26 stations, the occurrence rate of Hydromedusae reaches 100%, with average $108 \text{ ind.} \cdot 10^{-2} \cdot \text{m}^{-3}$, in this region. In comparison with the other seas the abundance is low in Chukchi Sea. For example, with the same type of net and method, the total number of Hydromedusae in the west Taiwan Strait reached a mean $231 \text{ ind.} \cdot 10^{-2} \cdot \text{m}^{-3}$ (Lin and Zhang 1991). The abundance was even higher in nearshore waters, for example, it was $780 \text{ ind.} \cdot 10^{-2} \cdot \text{m}^{-3}$ in the coastal waters of Jiangsu, China (Zhang 1983). An ecological survey on the north coastal of Alaska, eastern part of Chukchi Sea by U.S. showed that there were 4 species of Hydromedusae (with no abundance data available except for copepods). The USSR and Canada surveyed the Arctic several times, but they only reported the occurrence of Hydromedusae species. Thus the data from this expedition can be taken for future comparison.

5.1.2 Horizontal distribution for dominant species

Determined with the species dominance (> 0.1), the species *Rathkea octopunctata* and *Aglantha digitale* were considered as the dominant species during this survey.

Rathkea octopunctata — It is the most common and dominant Hydromedusae species, with occurrence rate 58% and species dominance 0.21, in this region and it averaged $27 \text{ ind.} \cdot 10^{-2} \cdot \text{m}^{-3}$. The highest abundance appeared at station 06 with abundance $352 \text{ ind.} \cdot 10^{-2} \cdot \text{m}^{-3}$ and the next was at station 04 with abundance $117 \text{ ind.} \cdot 10^{-2} \cdot \text{m}^{-3}$. It is noted that this species was not found at 5 deep-water stations in the northeast of the region surveyed (Fig. 11). This species can be taken as the wide-spread representative species in the neritic cool waters.

Aglantha digitale — The species mostly appeared in the east of the surveyed waters except for most stations in the west part. The highest abundance was found at station 01 in the north of Bering Strait ($200 \text{ ind.} \cdot 10^{-2} \cdot \text{m}^{-3}$). With average $32 \text{ ind.} \cdot 10^{-2} \cdot \text{m}^{-3}$ over the surveyed areas it is the species of highest abundance, but in comparison with *Rathkea octopumctata* this species shows the lower occurrence rate (only 42%). This is the oceanic cold-water species in Arctic region.

5.2 Vertical distribution

At station 26 the result shows that there were only 2 species by a vertical trawl through 6 layers from the depth 800 m to the surface. The species *Aglantha digitale* was found from the layer 300 – 0 m (Fig. 12) and it was the most abundant at layer 100 – 50 m ($76 \text{ ind.} \cdot 10^{-2} \cdot \text{m}^{-3}$), and the next at layer 50 – 0 m. In contrast to layer 500 – 300 m and 800 – 500 m a species of Trachymedusae (unidentified larvae due to broken specimen) was found with minor abundance, no such species was found again in layers from 300 – 0 m.

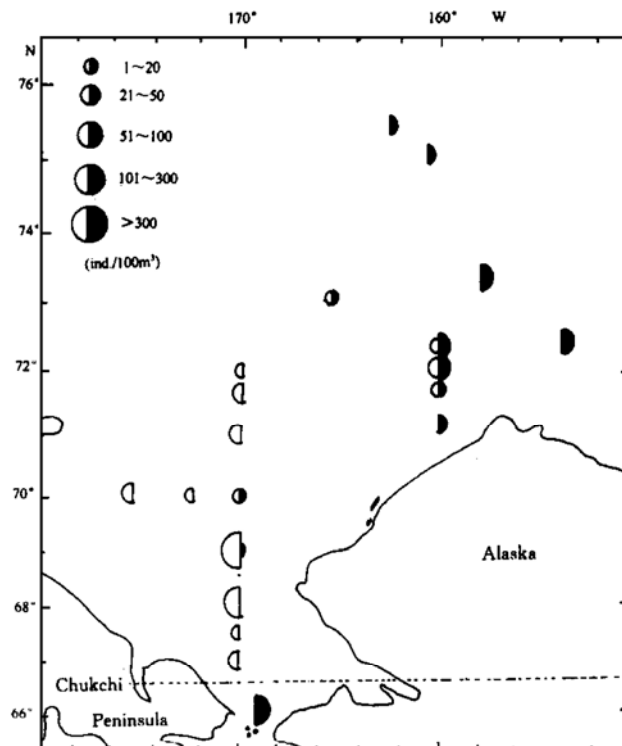


Fig. 11. The horizontal distribution of *Rathkea octopunctata* (○) and *Aglantha digitale* (●) based on the number of individual.

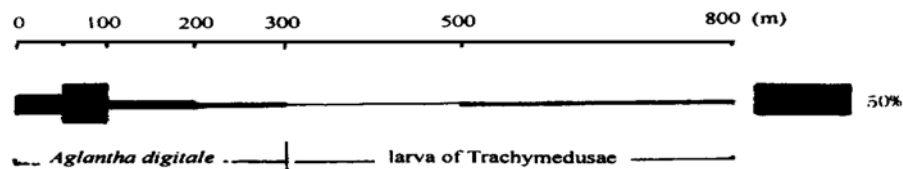


Fig. 12. The vertical distribution of Hydromedusae in station 26.

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