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Deep-water Hydrozoa (Cnidaria: Medusozoa) in the Sea of Japan, collected during the 51st Cruise of R/V *Akademik M.A. Lavrentyev*, with description *Opercularella angelikae*, sp. nov.

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ABSTRACT

A report is given about Hydrozoa collected at depths between 455 and 3666 m in the Sea of Japan during the Russian-German expedition on R/V *Akademik M.A. Lavrentyev*. Ten species were found, with four of them being typical bathyal–abyssal and abyssal zones. A new species, *Opercularella angelikae*, is described, and it was the dominant hydroid in samples from 970 to 3660 m. Four eurybathic species characteristics of the Sea of Japan were sampled between 455 and 582 m. Abyssal (pseudoabyssal after Andriashev, 1979) hydroid fauna in the Sea of Japan is reported. The hypothesis that an exclusively deep-water fauna is lacking in abyssal regions of the Sea of Japan is disputed. The author's personal opinion considered concerning the borders of 1000 m between shallow and deep hydrozoan species in the Sea of Japan.

1. Introduction

Maximum depths in the Sea of Japan reach about 3700 m. In 2010, a deep-sea expedition was undertaken on board R/V *Akademik M.A. Lavrentyev* to investigate the deep-sea benthos of the Sea of Japan from lower bathyal to abyssal depth (Malyutina and Brandt, this issue). Hydrozoans were collected at depths between 455 and 3666 m, offering an opportunity to compare the hydrozoan fauna of the shelf to that of the bathyal and abyssal area in the Sea of Japan.

Knowledge of Hydrozoa of the northwestern part of the Sea of Japan was summarized by Naumov (1960, 1969) who recorded 99 species. Additional information on the fauna of the region and the entire Sea of Japan was added in reports by Zelickman (1976), Arai and Brinckmann-Voss (1980), Chapligina (1980, 1992, 1993), Antsulevitch (1983a,b, 1987), Stepanjants, 1994, Stepanjants (1988, 1998), Stepanjants et al. (1993), Sheiko and Stepanjants (1997), Anokhin (2001), Lindsay and Hunt (2005), Chapligina and Dautova (2005), Jung Hee (2002, 2006, 2007, 2008, 2009), Jung Hee Park and Hye Jung Won (2005), and Petrova et al. (2011).

At present, many more species of Medusozoa (Sheiko and Stepanjants, 1997) including several species of Siphonophora, Scyphozoa and Staurozoa are known from the entire Sea of Japan.

This is nearly double the number of species of Hydrozoa reported earlier from the northwestern Sea of Japan (Naumov, 1960, 1969). Notably, most species from the northwestern and the entire Sea of Japan comprise Medusozoa of the shelf zone. Of 12 species included amongst the deep-water hydrozoan fauna by Naumov (1960: p. 124, 1969), none has been reported in the Sea of Japan. However, this likely reflects the sampling bias (lack of study) and scarcity of knowledge of the deep-sea fauna in this area rather than absence of species at bathyal and abyssal depths.

It was common sense that deep-sea regions of the Sea of Japan are inhabited by eurybathic hydroid species and that a "specific abyssal fauna" is completely absent there (Naumov, 1960, 1969). The same accepted concerning other invertebrate groups (Derjugin, 1915, 1933; Vinogradov, 1968; Andriashev, 1974, 1979). Vinogradov (1968) following Derjugin (1933) and foreshadowing the ideas of Andriashev (1979) called the Sea of Japan an "aberrant region" of the ocean. Of pelagic siphonophora cnidarian *Dimophyes arctica* (Chun, 1897) is known from bathyal depth of the Sea of Japan below 1000 m (Vinogradov, 1968).

Material collected during the Russian-German expedition on board of R/V *Akademik M.A. Lavrentyev* demonstrates the vertical distribution of hydroids in the Sea of Japan which are presented here. An interpretation of the vertical distribution of hydroids in that basin different from our former knowledge is presented here on the basis of the newly collected material.

2. Material and methods

Material from the expedition with R/V *Akademik M.A. Lavrentyev* in August 2010 to the Sea of Japan was examined using a MSP-2 (LOMO) stereomicroscope. Photographs of colonies and constituent

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Table 1
Species list of Hydrozoa found during the expedition on R/V *Akademik M.A. Lavrentyev.*

Taxon	Total vertical distribution in m	Station number, depth in m
Subclass Hydroidolina Ord. Anthoathecata Fam. Pandeidae 1. *Garveia arborea* (Browne, 1907)	Abys; 420–3100 (Schuchert, 2007)	B2–5, 1699
Fam. Corymorphidae 2. *Euphysora* (*bigelowi*?) (Maas, 1905). actinulae	Eurybat. from littoral to abyssal (Schuchert, 2010)	A7–9; 3340–3347
Ord. Leptothecata Fam. Phialellidae 3. *Opercularella angelikae* sp. nov.	Abys; 970–3666; data of this expedition	B6–6; 970–994
Opercularella angelikae sp. nov.	Abys; 970–3666; data of this expedition	A6–8; 2545–2555
Opercularella angelikae sp. nov.	Abys; 970–3666; data of this expedition	D2–8; 2653–2683
Opercularella angelikae sp. nov.	Abys; 970–3666; data of this expedition	C1–8; 2670–2681
Opercularella angelikae sp. nov.	Abys; 970–3666; data of this expedition	B4–7; 3298–3353
Opercularella angelikae sp. nov.	Abys; 970–3666; data of this expedition	A7–9; 3340–3347
Opercularella angelikae sp. nov.	Abys; 970–3666; data of this expedition	C3–4; 3427–3431
Opercularella angelikae sp. nov.	Abys; 970–3666; data of this expedition	B1–7; 3665–3666
Fam. Tiarannidae 4. *Stegolaria geniculata* (Allman, 1888)	Bath–abys; 576–1727 m (Vervoort, 1985)	B6–6; 970–994; B7–6; 517–521; A2–8; 582
Fam. Zygophylacidae 5. *Zygophylax convallaria* (Allman, 1877)?	Eurybat; 70–994 m (Hirohito, 1995)	A2–10; 455–465; B6–6; 970–994; A2–8; 582
Fam. Sertulariidae 6. *Abietinaria abietina* (L.,1758)	Eurybat about 5–2481 m (Naumov, 1960, 1969; Antsulevitch, 1987)	A6–6; 2481
7. *Thuiaria articulata* (Pallas, 1766)	Eurybat about 11–582 m (Naumov, 1960, 1969; Cornelius, 1995; Schuchert, 2001)	A2–8; 582
Fam. Aglaophenidae 8. *Cladocarpus formosus* Allman, 1874	about 60–1400 m (Naumov, 1960, 1969; Cornelius, 1995; Schuchert, 2001)	A2–8; 582
Fam. Campanulariidae 9. Obelia dichotoma?	Eurybat (Cornelius, 1995; Stepanjants, 1988, 1998)	?
Subclass Trachylina Ord. Narcomedusae 10 Fam. Solmarisidae?	Abyss?	A6–8; 2545–2555; A7–9; 3340–3347

parts were prepared with an MSP-2 device (LOMO) and a digital camera IK 5100. For SEM (Zeiss EVO 40), fragment of colony was dehydrated through a series of acetone, then dried in a critical point dryer, before being mounted on a stub and coated with platinum–palladium alloy.

Ten species of Hydrozoa were found in the samples (Table 1). As many specimens were poorly preserved (only skeletal remains, or they were much contracted) identification was not always possible. Thus, some material could only be identified with a question mark, or to genus level only (Table 1).

The type material is deposited in the Museum of A.V. Zhirmunsky Institute Marine Biology FEB RAS, Vladivostok (MIMB), Zoological Institute RAS, St. Petersburg (ZIN), Russia and the Zoological Museum of Hamburg (ZMH), Germany.

3. Systematics

Class Hydrozoa Owen, 1843
Subclass Hydroidolina Collins, 2000
Order Leptothecata Cornelius, 1992
Suborder Conica Broch, 1910
Family Phialellidae Russell, 1953
Genus *Opercularella* Hincks, 1868

Diagnosis according to Hincks (1868): Stem simple or branching, rooted by a thread-like stolon; hydrothecae ovate-conic, with a cleft border; the segments of which converge to form of operculum; polypites long, cylindrical, and with a conical proboscis; reproduction by means of furred sporosacs, which (in the female) become extracapsular before the escape of the planules.

New diagnosis: Colonies stolonal (with erect hydranths) or upright and slightly branched, arising from a creeping hydrorhiza. Hydrothecae cylindrical, arising from long or short pedicels; perisarc of pedicels mostly smooth but some annulation apparent; operculum cone-shaped, not distinctly demarcated from hydrothecal wall; diaphragm present at hydrothecal base. Nematophores absent. Gonothecae, when present, oval.

Representatives of this genus differ from those of close genera by the absence of nematophores (present in colonies of representatives of the genera *Lovenella* Hincks, 1868 *Egmundella* Stechow,1921, *Oplorhiza* Allman,1877), presence of diaphragm at the base of hydrotheca (absent in *Calicella* Hincks, 1861) by the absence of a distinct boundary between the wall of the hydrotheca and the region of operculum (the boundary is present in representatives of *Calicella*, *Lovenella*) and by the structure of the operculum: in hydrotheca of representatives of *Opercularella* the typical valves are absent, and the operculum is formed as a result of closing of the costate edge of hydrotheca wall that can be clefted, which appears as valves (the typical triangular valves are present in operculums of *Lovenella*, *Calicella*, *Oplorhiza*).

For three species of the genus *Opercularella* a new genus *Racemoramus* Calder, 2012 was described (Calder, 2012). It is very difficult to find distinct morphological differences of colonies of representatives of this genus: *R. panicula* (G.O. Sars, 1874), *R. denticulata* (Clarke, 1907), *R. indivisa* (Fraser, 1948) from those of typical *Opercularella*. The grape-like cluster arrangement of a number of hydrotheca on hydrocaulus at regular distances from each other and frequently in different planes can be regarded as the major difference. However, because such an arrangement of hydrotheca does not always occur, it is very difficult to identify the genus. The second difference, in the opinion of Calder (2012), is the presence of free medusae, their morphology remaining unknown until now. Gonothecae oval-elongated, on articulated short pedicel.

Opercularella angelikae, sp. nov. (Figs. 1–5).

Material examined

Holotype: MIMB 27401 St. D2–8, 1.09.2010; 42°06.6051–42°06.455N; 131°21.0149–131°20.9308E, depth 2653–2683 m. Entire colony (Fig. 1).

Schizoholotype: ZIN 1/11225 St. D2–8, 1.09.2010; 42°06.6051–42°06.455N; 131°21.0149–131°20.9308E, depth 2653–2683 m. Fragment of colony.

Paratype 1: ZMH C12152 St. A6–8, 16.08.2010; 44°18.6270–44°18.4712N; 137°24.3985–137°24.3985E; depth 2545–2555 m.

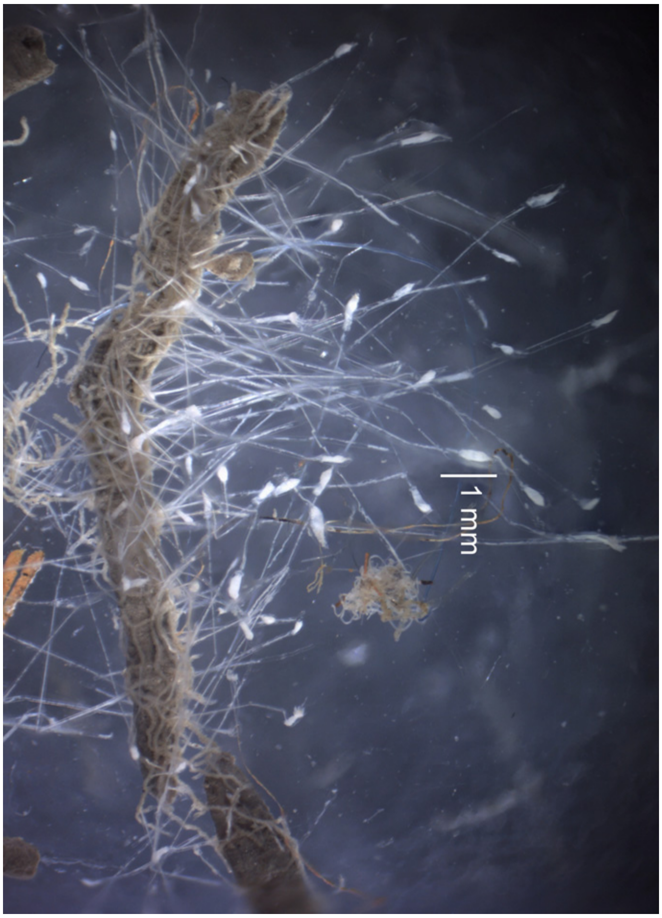

Fig. 1. *Opercularella angelikae* sp. nov. Holotype. Whole colony.

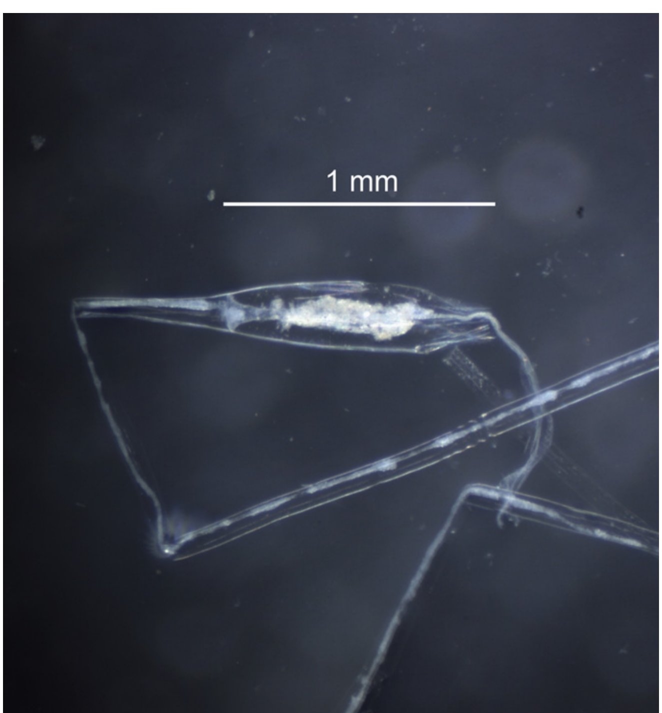

Fig. 2. *Opercularella angelikae* sp. nov. Paratype 2 Fragment of colony – hydrotheca.

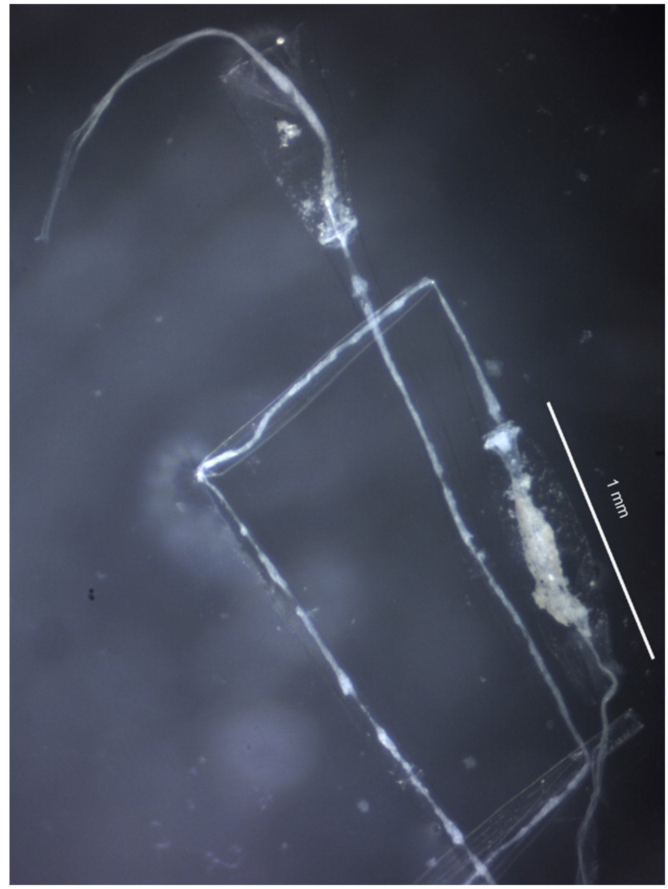

Fig. 3. *Opercularella angelikae* sp. nov. Fragment of colony with two hydrothecae.

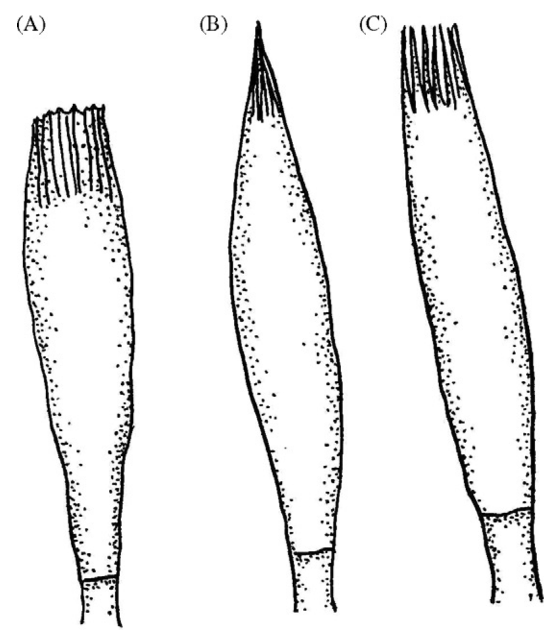

Fig. 4. Scheme of hydrotheca structure of /Opercularella angelikae /sp. nov: (A) opened orifice; (B) closed orifice and (C) with a cleft border.

Colony fragments in the form of clew of hydrotheca pedicels (Fig. 2).

Paratype 2: MIMB 27402. St. A6–8, 16.08.2010. 44°18.6270–44°18.4712N. 137°24.3985–137°24.3985E; depth 2545–2555 m. Colony fragments in the form of clew of hydrotheca pedicels.

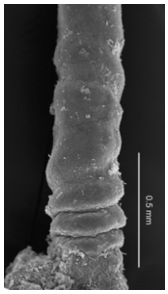

Fig. 5. Base of hydrotheca pedicel of *Opercularella angelikae* sp. nov. structure.

Paratype 3: ZIN3/11227 St. B1–7.19.08.2010. 42°15.5533–42°15.7357N; 136°43.2772–136°43.3044E; depth 3665–3666 m. Separate hydranths, entangled by their pedicels in a clot, and sometimes two hydranths arising from the hydrorhiza.

Description of holotype: The colony occurs on wood. Hydrorhiza, a dense network extending over substrate, giving rise to unbranched pedicels approximately 10–15 times longer than hydrotheca, each pedicel with a terminal hydranth encased in a hydrotheca having thin, transparent perisarc. Apical part of hydrothecal wall costate. Tip of hydrotheca cone-shaped when closed. Frequently aperture of hydrotheca is open, and in this case the costate pattern in the region of the apical part of hydrotheca wall is distinct. Hydrotheca walls along these ribs often diverge forming plates of the operculum, with protruding hydranth (Fig. 3). Distinct boundary between operculum and thecal wall lacking. Diaphragm present at hydrothecal base. Hydrotheca narrow, its diameter noticeable larger than that of pedicel. Tracks of regeneration sometimes clearly visible on pedicels (up to 4 tracks), and these occasionally bent in form of "knees" (Fig. 4). Perisarc of pedicels mostly smooth, but annulated patterns observed at base of pedicel and sometimes several times along its entire length (up to 6 rings) (Fig. 5). Gonophores not found.

Measurements (for all material in mm): Length of hydrotheca 0.76–1.02; diameter of hydrotheca 0.20–0.31; length of pedicel 10.00–17.00; pedicel diameter 0.07–0.10.

Colonies usually growing over the wood or alga substrates. May be found over other hydroid or bryozoan colonies.

Differential diagnosis

New species is placed in the genus *Opercularella* Hincks, 1868 based on the number of morphological characters, such as the arrangement of the opercular apparatus in the form of slits in the apical part of the hydrotheca wall, but not in the form of triangular valves; lack of nematophores; lack of distinct boundary between the operculum and wall of hydrotheca; and presence of diaphragm in basal part of hydrotheca.

O. angelikae can be compared with two other deep water species that primary have been assigned to the same genus, *O. denticulata* (Clarke, 1907) and *O. producta* (G.O. Sars, 1874). Gonothecae of the former are also unknown. Unlike our colonies, they are branching, on hydrocaulus grape-like clusters of hydrothecae are formed and their hydrothecae and pedicels are much shorter (about 0.7 mm). *O. denticulata*, assigned to the new genus *Racemoramus* by Calder (2012) (see the genus description), occurs in the East Pacific within a larger range of depths than *O. angelikae* (488–5849 m) (Vervoort, 1972). Colonies of *O. producta* have non-branching pedicels, their length as a rule being 1–5 mm and length of hydrotheca 0.4–0.9 mm. This species is eurybathic, and most records of it have been from the North Atlantic (Vervoort, 1985; Calder, 2012, as *Lovenella producta*).

A specimen described as *Opercularella* sp. from depths of approximately 3000 m from waters of the western North Atlantic (Calder, 1996; Calder and Vervoort, 1998) may in fact be referable to *O. angelikae*. To judge by the structure of hydrotheca and hydrothecal pedicel of *Opercularella* sp. such a possibility is not inconceivable although sizes of these parts of skeleton of *Opercularella* sp. are much smaller.

Etymology: The species is named after Dr. Angelika Brandt, the leader of the German scientific party of the Russian-German expedition on R/V *Akademik M.A. Lavrentyev*.

Larvae

In samples from maximum depths studied by this expedition (2545–2555 m and 3340–3347 m) larvae of representatives of some Hydrozoa taxa have been found. Because of minute sizes of larvae and their poor preservation it is impossible to clarify morphology of these organisms; however, an approximate identification to a family or a genus is attempted.

Subclass Hydroidolina Collins, 2000
Order Anthoathecata Cornelius, 1992
Suborder Capitata Kühn, 1913
Family Corymorphidae Allman,1872
Euphysora (*bigelowi*?) (Maas, 1905)? Larvae (Figs. 6, 7)
Sampled between 3340 and 3347 m depth

Larvae in the form of slightly developed young polyps (1 mm height) with two whorls of tentacles. Oral tentacles are arranged on a relatively long hypostome in several random rows (Figs. 6 and 7). Between the whorls of tentacles of one actinula there are undeveloped buds of gonophores the structure of which is impossible to understand. Tentacles of the oral whorl bear weak traits of capitate structure. Tentacles of the basal whorl are filiform. The rounded base of the polyp has the small nodule, which might become an elongated and produced pedicel of a polyp with rhizoids. External skeleton is absent.

In only one species of the genus *Euphysora* (*bigelowi?*) polyp is known. At present the majority of authors are inclined to reduce *Euphysora* in a synonym of the genus *Corymorpha* (Sassamann and Rees, 1978; Schuchert, 2010). However, the polyps have characters permitting to regard *Euphysora* valid genus: oral tentacles of polyp are capitate (in *Corymorpha* they are filiform); arrangement of oral tentacles in several random whorls (in polyps *Corymorpha* oral tentacles are arranged in an ordered whorl). Based on the above characters the actinulae found here are placed in the genus *Euphysora*, presumably in species *E. bigelowi* (Maas, 1905).

Subclass Trachylina Collins, 2000?
Order Narcomedusae Haeckel, 1879
Family Solmarisidae? Haeckel, 1879 (Figs. 8 and 9).

Caught at depth of 2545–2555 m and 3340–3347 m two minute larvae, approximately 1 mm in diameter of the primordial bell. No characteristic features of morphology have been established except for the presence of 21–22 marginal tentacles arranged not at the very edge of the bell, but slightly higher than that from the side of the exumbrella (Fig. 8), which is characteristic of Narcomedusae. It can be seen that the presence of marginal lobes of the bell (Fig. 9) is also regarded as a character of Narcomedusae.

4. Discussion

Hydrozoan fauna from bathyal and abyssal depth of the Sea of Japan has not been studied until recently. The references to discoveries of separate hydroid species in general articles or publication of non-hydrozoan invertebrates dealing with faunal studies need verification.[1]

[1] For example, report that the deep-sea nudibranch mollusk *Doridunculus unicus* from the Sea of Japan (3000–3620 m) feeds on hydroids *Egmundella* sp. (=*Oplorhyza* sp.) (Martynov and Roginskaya, 2005). According to S. Stepanjants

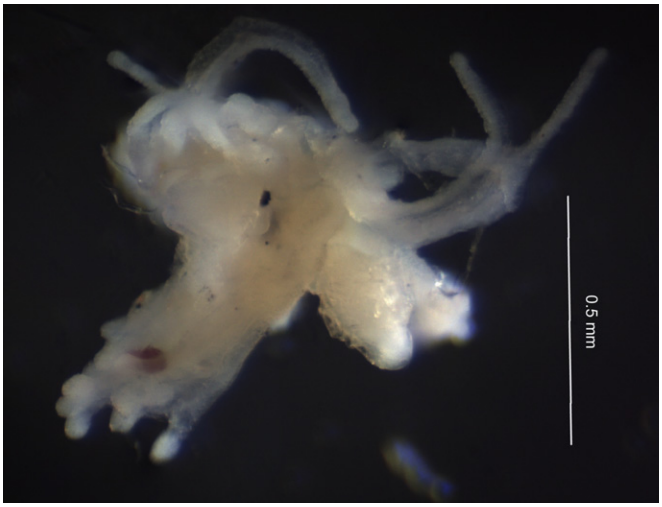

Fig. 6. *Euphysora* (*bigelowi*?) (Maas, 1905) Photograph of total specimen.

Fig. 8. Narcomedusa? Solmarisidae? juv. View from above.

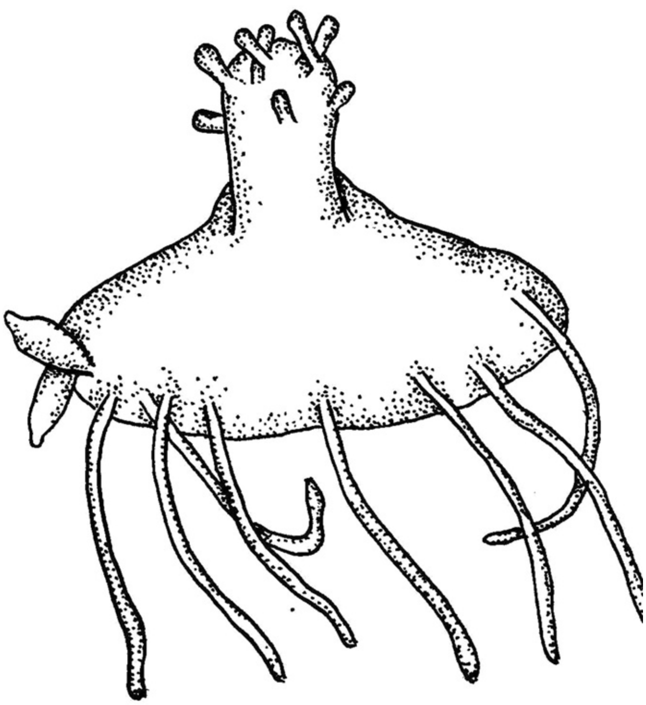

Fig. 7. *Euphysora* (*bigelowi*?) (Maas, 1905) Scheme of outward appearance.

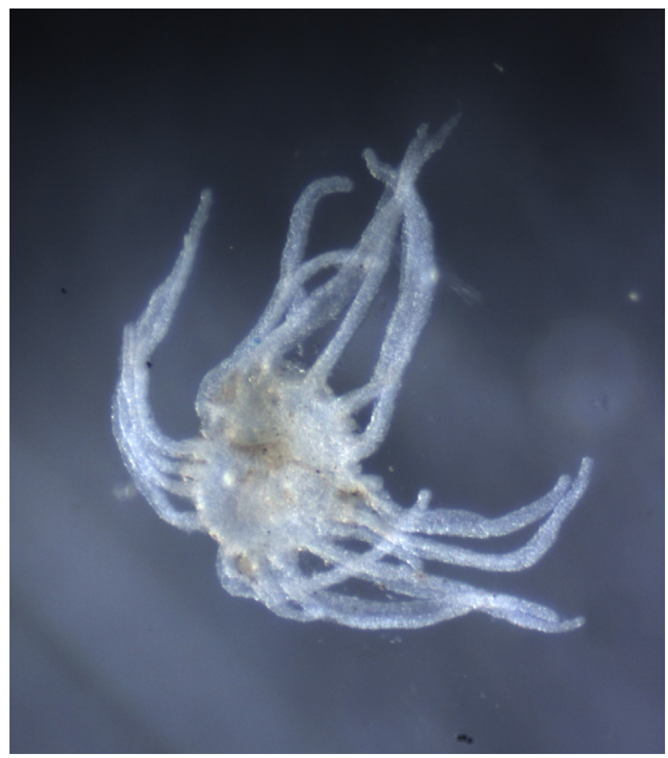

Fig. 9. Narcomedusa Solmarisidae? juv side-view. The same magnification as Fig. 8.

As mentioned above, of the 12 deep-water hydroid species mentioned by Naumov (1960, 1969) none have been reported for the Sea of Japan. From collections of the expedition on board the R/V *Akademik M.A. Lavrentyev* between 455 and 3666 m 10 hydrozoa species have been found in the Sea of Japan, however, their vertical distribution can be regarded as specific. In terms of overall frequency in the samples, *O. angelikae*, sp. nov., was considered dominant. It was particularly well-represented by dense colonies at depths greater than 2500 m. Five other species were found at depth of more than 900–1000 m (Table 1). Five of these (*Euphysora* sp. (*bigelowi*?) juv, *Garveia arborea* (Browne, 1907), *Stegolaria geniculata* (Allman, 1988), *Zygophylax convallaria* (Allman, 1877), and the narcomedusa of the family Solmarisidae juv. are previously unknown both in the Sea of Japan and in the adjacent Russian seas. The distribution of hydrozoan species at deep ocean depth in the Sea of Japan is documented in Table 1. From 455 m to approximately 1000 m, four eurybathic species known from upper sublittoral to bathyal zones occur. Between 1000 and 3666 m, three typical abyssal (''pseudoabyssal'' on Andriashev's terminology conformably to the Sea of Japan) species unknown for the shelf were found. The 1000 m isobath is therefore considered to be a

(*footnote continued*)
who supposendly identified this material (p. 144) has never been these samples. In Fig. C and F displays most likely a ctenostomate bryozoan, probably *Bowerbankia* (Dr. A.Ostrovsky, personal communication). here did not contain colonies of the genera *Egmundella* or *Oplorhyza*.

boundary between shallow and deep hydrozoan species in the Sea of Japan.

This conforms with the earlier conclusions that at the depth of the ocean there "archibenthal transit" (446–940 m) and "upper abyssal" (940–2635 m) zones (Menzies et al., 1973 – after Vinogradova, 1977). The boundary between them passes at a depth of approximately 1000 m. This conforms to the earlier assertion of Vinogradova (1977) that the presence of such abyssal forms allows one to speak about specificity of deep water fauna of different areas of the World Ocean.

Another hypothesis regarding geographic distribution of deep-water fauna is that abyssal species inhabit only one ocean (Vinogradova, 1979). Data obtained from study of deep-sea species in the Sea of Japan refute this belief. *S. geniculata* Allman, 1888, discovered at a depth of 1699 m in the Sea of Japan, is known to occur at bathial—upper abyssal depths (about 1000–1300 m) of the eastern North Atlantic.

The discovery of larval stages of some hydrozoan species (see above) in the depth of the Sea of Japan. Actinulae of the family Corymorphidae, most probably *E. bigelowi*, belonging to a shelf genus have been found in the abyssal. This conforms to the theory of Mileykovsky (1973, 1977) that pseudopopulations of shelf species might inhabit in bathyal and abyssal. In the opinion of Mileykovsky (1977) pseudopopulations allow the benthic species to use dietary resources of the entire area occupy new biotopes and expand their area reproduction.

5. Conclusions

The following conclusions are drawn after examination of Hydrozoa obtained from bathyal and abyssal depths in the Sea of Japan:

1. The current opinion that deep regions of the Sea of Japan are inhabited by eurybathic species, and that a true deep-sea fauna is absent there, is refuted bathyal and abyssal species were found during this study. Examples include *S. geniculata* Allman, 1888.
2. The theory that species of deep-sea macrobenthos are limited to a particular ocean (Vinogradova, 1979) is not supported by our data on Hydrozoa.
3. At depths between 900 m to 3660 m, hydrozoan species are rare and few in number and typical bathyal or abyssal in their vertical distributions. This accords previous studies on vertical zonation of hydrozoans from near-surface waters to the abyssal zone (Calder, 1996, 1998).
4. Actinula larvae of the family Corymorphidae found at abyssal depths of the Sea of Japan probably belong to shelf species *E. bigelowi*, which confirms the hypothesis of Mileykovsky (1977) of species distribution over wide bathymetric ranges due to larval transport.

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