Taxonomic revision of deep-sea Ostracoda from the Arctic Ocean

Moriaki Yasuhara[1], Anna Stepanova[2], Hisayo Okahashi[1], Thomas M. Cronin[3] and Elisabeth M. Brouwers[4]

[1]*School of Biological Sciences, Swire Institute of Marine Science, and Department of Earth Sciences, The University of Hong Kong, Kadoorie Biological Sciences Building, Pokfulam Road, Hong Kong SAR, China*

[2]*Texas A&M University, Department of Oceanography, College Station, Texas 77843, USA*

[3]*MS 926A U.S. Geological Survey, National Center, Reston, Virginia 20192, USA*

[4]*MS 406 U.S. Geological Survey, Denver Federal Center, Denver, CO 80225, USA*

email: moriakiyasuhara@gmail.com or yasuhara@hku.hk

ABSTRACT: Taxonomic revision of deep-sea Ostracoda from the Arctic Ocean was conducted to reduce taxonomic uncertainty that will improve our understanding of species' ecology, biogeography and relationship to faunas from other deep-sea regions. Fifteen genera and 40 species were examined and (re-)illustrated with high-resolution scanning electron microscopy images, covering most of known deep-sea species in the central Arctic Ocean. Seven new species are described: *Bythoceratina lomonosovensis* n. sp., *Cytheropteron parahamatum* n. sp., *Cytheropteron lanceae* n. sp., *Cytheropteron irizukii* n. sp., *Pedicythere arctica* n. sp., *Cluthia whatleyi* n. sp., *Krithe hunti* n. sp. This study provides a robust taxonomic baseline for application to paleoceanographical reconstruction and biodiversity analyses in this climatically sensitive region.

INTRODUCTION

The taxonomy of deep-sea Ostracoda (Crustacea) from the Arctic Ocean, mainly the western Arctic Canada Basin, was first established by Joy and Clark (1977) using sediment material from bottom samples taken from drifting ice islands. Since then, numerous deep-sea ostracod studies have been conducted in the Arctic Ocean and adjacent Nordic Seas mainly focusing on application of Ostracoda as a proxy for Quaternary paleoclimate and paleoceanography (Cronin et al. 1994, 1995, 2010a, 2013; Jones et al. 1998, 1999; Poirier et al. 2012). However, the scanning electron microscopy (SEM) images of ostracods shown in Joy and Clark (1977) appear to be deformed and do not correspond to modern standards in SEM imaging, and subsequent Arctic deep-sea ostracod studies rarely illustrate the species (Cronin 1996). Notable exceptions are the studies of Greenland Sea ostracods by Whatley and colleagues (Whatley et al. 1996, 1998; Whatley and Eynon 1996): They showed clear SEM images of many species including many that also inhabit the Arctic Ocean proper. Russian researchers have published several important papers on Arctic deep-sea ostracod taxonomy often with high-quality sketches or light microscope images (Schneider 1962; Sirenko 2001). However, such papers are written in Russian language, published in Russian journals or books that foreign researchers find difficulty to access, and so they are often overlooked or incorrectly cited.

Modern Arctic Ostracode Database (MAOD), originally developed by Cronin et al. (1991) and recently expanded by Cronin et al. (2010b), is a comprehensive database compiling ostracod census data from hundreds of sites covering most areas of Arctic Ocean and adjacent Nordic Seas, and has been playing important role both in paleoceanography and biodiversity research in this climatically sensitive, near-pristine region (Cronin et al. 1994, 1995, 2010a; Yasuhara et al. 2012). The MAOD was constructed by several ostracod specialists (including some of co-authors of the present paper, T.M.C., E.M.B., and A.S.) with revised robust taxonomy. Unfortunately, however, the MAOD does not include images of ostracods to help identification. So, it is important to clearly depict Arctic deep-sea ostracod species and to link them to the MAOD taxonomy list. Here we re-illustrate most of deep-sea ostracod species from the Arctic Ocean and adjacent Nordic Seas using high-resolution SEM images and conduct taxonomic revision.

SYSTEMATIC PALEONTOLOGY

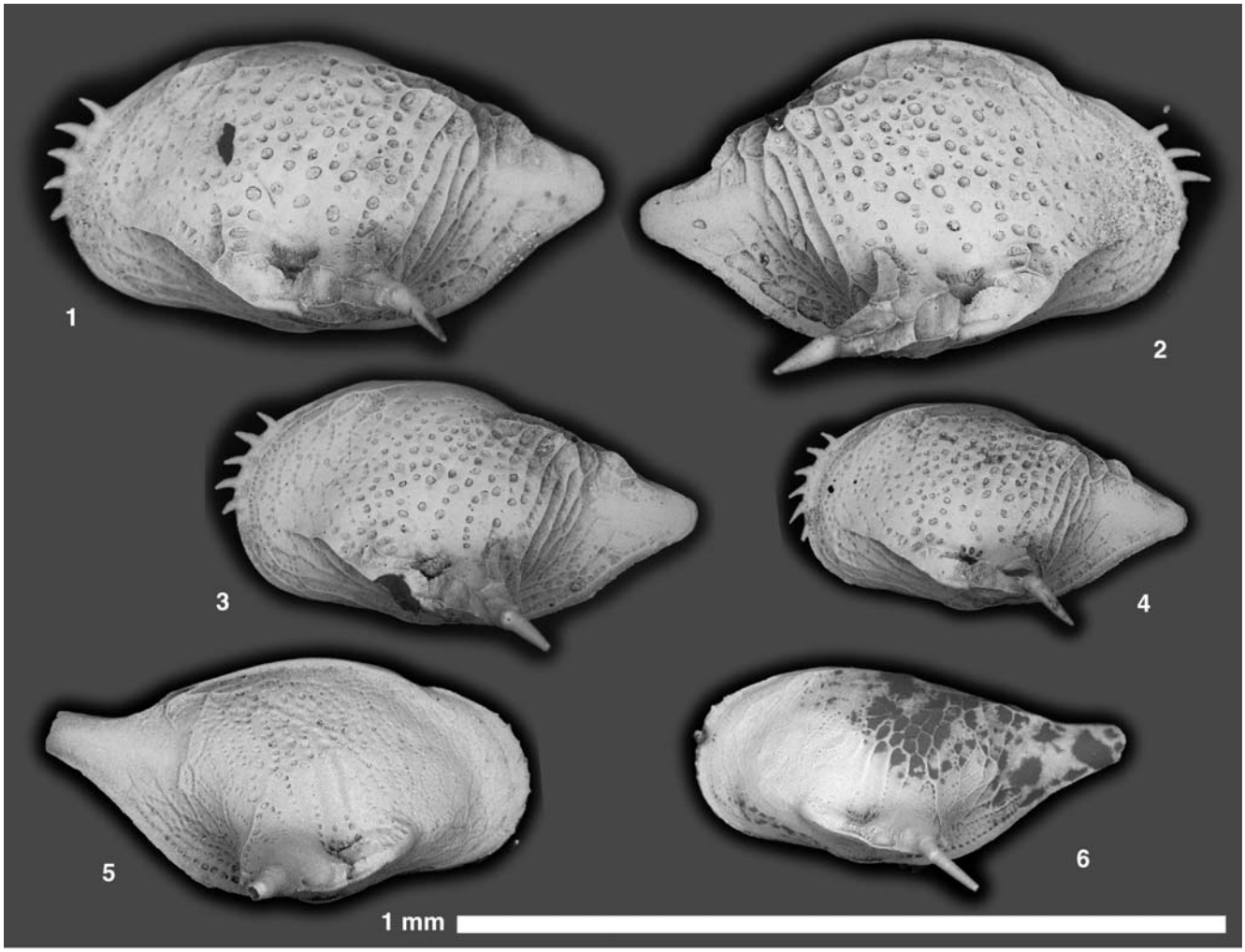
Most of the ostracod specimens used for the present study were selected from the Arctic ostracod collection of T.M.C. Additional specimens came from the samples from the core AF07-31 obtained during an expedition onboard R/V "Akademic Fyodorov" in 2007. Localities of specimens used for the present study are shown in Text-figure 1 and Table 1. The full information for the specimens is available in Appendix 1. The majority of the specimens are the Modern specimens that come from the upper few centimeters of sediments, which is consistent with the Joy and Clark work. Uncoated specimens were digitally imaged with Philips XL-30 environmental SEM (for the specimens shown in Plates 1–16) and Hitachi Tabletop SEM TM3000 (for the specimens shown in Text-figure 2), and were deposited in the National Museum of Natural History (Washington DC, catalog numbers USNM 594082–USNM 594256). High-resolution plates and text-figure of ostracod SEM images are available at

TEXT-FIGURE 1
Map showing the location of samples included in the present study.

Dryad (http://datadryad.org/; http://dx.doi.org/10.5061/dryad.r2170). We follow the higher classification scheme of the World Ostracoda Database (Brandão et al. 2014) with certain modifications. In the following section, synonymies are abbreviated to conserve space, but usually one of the references given contains a comprehensive synonymy. Abbreviations: LV, left valve; RV, right valve; A-1, last juvenile instar (adult minus one); L, length (mm); H, height (mm).

Class OSTRACODA Latreille 1802
Subclass MYODOCOPA Sars 1866
Order HALOCYPRIDA Dana 1853
Suborder CLADOCOPINA Sars 1866
Superfamily POLYCOPOIDEA Sars 1866
Family POLYCOPIDAE Sars 1866

Genus ***Polycope*** Sars 1866
Type species: Polycope orbicularis Sars 1866



TEXT-FIGURE 2
The SEM images of *Cytheropteron sedovi* Schneider, 1962 and *Cytheropteron lanceae* n. sp. 1–4, *Cytheropteron sedovi*. 1, USNM 594251, AF07-31, 37–41cm; LV, lateral view. 2, USNM 594252, AF07-31, 150–154cm; RV, lateral view. 3, USNM 594253, AF07-31, 7–11cm; LV, lateral view. 4, USNM 594254, AF07-31, 0–4cm; LV, lateral view. 5–6, *Cytheropteron lanceae*. 5, USNM 594255, AF07-31, 330–333cm; RV, lateral view. 6, USNM 594256, AF07-31, 37–41cm; LV, lateral view. Scale bar represents 1mm.

Remarks. We use genus name *Polycope* in broad sense following MAOD's taxonomy, but note that recent zoological studies, for example Karanovic and Brandão (2012), divide the genus into several separate genera based on soft parts, which are not preserved in the Arctic. Due to the variable abundance and preservation of *Polycope* species in surface and downcore sediments, all species of this genus are lumped into the generic level category *Polycope* spp. in the MAOD database and paleoceanographic studies (Poirier et al. 2012). Further study may reveal important ecological differences among Arctic *Polycope* species.

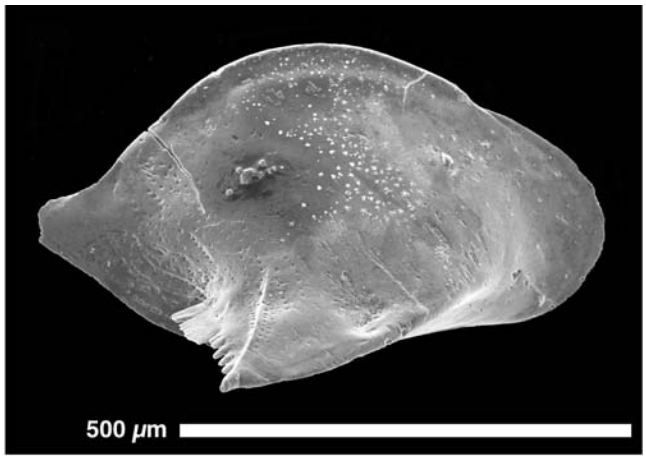
Polycope arcys Joy and Clark 1977
Plate 1, figures 1–3

Polycope? arcys JOY and CLARK 1977, p. 144, pl. 2, figs. 18–21.
non *Polycope* sp. cf. *P. arcys* Joy and Clark. – DIDIÉ and BAUCH 2001, pl. 1, fig. 28 (as erratum for Didié and Bauch 2000).
non *Polycope arcys* Joy and Clark. – YASUHARA et al. 2009, p. 881, pl. 1, figs. 6.

Dimensions: See Table 2.

Remarks: The SEM image of external view of the holotype specimen in Joy and Clark (1977, pl. 2, fig. 18) seems to be deformed. *Polycope arcys* Joy and Clark 1977 is very similar to *Polycope martinezi* (Karanovic and Brandão 2012) reported from equatorial Atlantic, but the former has coarser punctation and better developed lateral spines. The specimens reported as *Polycope arcys* and *Polycope* sp. cf. *P. arcys* from the North Atlantic Ocean (Didié and Bauch 2001; Yasuhara et al. 2009) are *Polycope martinezi*. *Polycope arcys* is known only from the Arctic Ocean, while *Polycope martinezi* is distributed only in the Atlantic Ocean. Although differences are subtle, we tentatively consider both of *Polycope arcys* and *Polycope martinezi* as separate species because of clear difference in the geographical distribution.

MAOD taxonomic category: Polycope spp.



TEXT-FIGURE 3
The SEM image of topotype specimen (RV) of *Cytheropteron vespertilio* (Reuss 1850) from the former clay pit of Baden-Sooss in Lower Austria (stratotype of the Badenian), Vienna Basin, Miocene, Lower Badenian, Upper Lagenidae Zone (Rögl et al. 2008). Courtesy of Dr. Irene Zorn. Scale bar represents 0.5mm.

Polycope bireticulata Joy and Clark 1977
Plate 2, figures 1–2

Polycope bireticulata JOY and CLARK 1977, p. 144, pl. 1, fig. 22 (non? fig. 21). – non? WHATLEY et al. 1996, pl. 4, fig. 12. – non? STEPANOVA et al. 2003, pl. 4, figs. 14, 15. – non? STEPANOVA 2006, p. S190, pl. 6, figs. 16–17.
non *Polycope* cf. *bireticulata* Joy and Clark. – YASUHARA et al. 2009, p. 881, pl. 1, figs. 3–4.
non? *Polycope* sp. – HARTMANN 1993, pl. 1, figs. 1a, 1b.

Dimensions: See Table 2.

Remarks: Although the SEM images of external views of the holotype and paratype specimens in Joy and Clark (1977, pl. 1, figs. 21–22) seem to be deformed, our specimens are otherwise conspecific with the holotype specimen. The holotype specimen (Joy and Clark 1977, pl. 1, fig. 22) has well-developed secondary reticulation and lacks any marginal spines. In contrast, the paratype specimen (Joy and Clark 1977, pl. 1, fig. 21) lacks secondary reticulation and has two distinct marginal spines. Although we didn't encounter the specimens with marginal spines, the paratype specimen may belong to a separate, perhaps new species. *Polycope* sp. of Whatley et al. (1996) is identical to the paratype specimen (Joy and Clark 1977, pl. 1, fig. 21).

Polycope cf. *bireticulata* reported from the North Atlantic (Yasuhara et al. 2009) is similar to *Polycope bireticulata* Joy and Clark 1977, but the former is smaller and has different outline and muri alignment. The specimens reported as *Polycope bireticulata* from shallow marine–upper bathyal areas of the Arctic Ocean and Greenland Sea (Whatley et al. 1996; Stepanova et al. 2003; Stepanova 2006) may not be conspecific with *Polycope bireticulata,* because they have different muri alignment and comparatively weakly developed reticulation. *Polycope* sp. of Hartmann (1993) is very similar to *Polycope bireticulata*, but has weaker developed reticulation.

MAOD taxonomic category: Polycope spp.

Polycope inornata Joy and Clark 1977
Plate 3, figures 2–5, 8

Polycope inornata JOY and CLARK 1977, p. 143, pl. 3, figs. 1–4.

Dimensions: See Table 2.

Remarks: The SEM image of external view of the holotype specimen in Joy and Clark (1977, pl. 3, fig. 1) seems to be deformed. Here we show clear SEM images of both left and right valves. Most of our specimens lack long anterior marginal spine. Presence or absence of this spine may be intraspecific variation, though further research is needed. Although Joy and Clark (1997) considered that lateral surface of this species lacks ornamentation, based on our high-resolution SEM images, that lateral surface is ornamented with thin, long carina and primary reticulation along anteroventral margin and with partially distributed and weakly developed punctation. In the largest specimen (pl. 3, fig. 8), weak punctation is distributed throughout the lateral surface. Thus the largest specimen is very similar to *Polycope punctata* Sars 1869, but distinguished from it by having distinct long carina and primary reticulation along anteroventral margin. *Polycope inornata* Joy and Clark 1977 is also very similar to *Polycope vasfiensis* Sissingh 1972, but the entire ventral margin of the latter is ornamented with long carina and primary reticulation.

MAOD taxonomic category: Polycope spp.

Polycope punctata Sars 1869 sensu Joy and Clark (1977)
Plate 3, figure 1

? *Polycope punctata* SARS 1869, p. 171. – ? SARS 1922, p. 32, pl. 15, fig. 2. – JOY and CLARK 1977, p.143, pl. 3, figs. 14–16.

Dimensions: See Table 2.

Remarks: Comprehensive synonymy of *Polycope punctata* Sars 1869 is found in Joy and Clark (1977) and Stepanova (2006), but we are not completely sure if the Arctic specimens are conspecific with the Norwegian (i.e., type locality) specimens, because there is no published SEM image of Norwegian specimens and the sketch of a Norwegian specimen shown in Sars (1922) lacks anterior marginal spine that is clearly evident in our specimen. The holotype and lectotype have not been designated, and the location of the original material of Sars (1869) is unknown (Stepanova 2006). *Polycope* sp. cf. *P. punctata* of Didié and Bauch (2000, 2001) is similar to our Arctic specimens, but distinguished by having evenly rounded dorsal margin.

MAOD taxonomic category: Polycope spp.

Polycope bispinosa Joy and Clark 1977
Plate 1, figures 4–9

Polycope bispinosa JOY and CLARK 1977, p. 143, pl. 3, figs. 11–13.
Polycope frigida NEALE 1981, p. 55, text-figs. 8.59, 8.61, pls. 8.56, 8.58, 8.60, 8.62.

Dimensions: See Table 2.

Remarks: Most of our specimens lack long anterior marginal spine. Presence or absence of this spine may be due to intraspecific variation such that further research is needed. Because differences between *Polycope bispinosa* Joy and Clark 1977 and *Polycope frigida* Neale 1981 is very subtle, we con-

TABLE 1
Sample list. Lat: latitude. Long: longitude. WD: water depth (m).

Locality code	Region	Long (º)	Lat (º)	WD
10/2 Polarstern GKG	Norwegian - Greenland Seas	?	?	?
Geomar 23243-1	Greenland Sea/off Iceland	6.535	69.372	2710
Meteor 23453-1	Mohns Ridge/S. Iceland	8.7333	76.4765	2016
Meteor 23454-2	Greenland Sea/off Iceland	11.7500	76.7497	2126
Meteor 23455-2	Mohns Ridge/S. Iceland	8.4050	76.8673	2362
Meteor 23456-6	Mohns Ridge/S. Iceland	6.3630	77.0667	2200
Meteor 23457-3	Mohns Ridge/S. Iceland	6.4050	76.6367	2259
NP-19/10	Lomonosov Ridge	-61.8600	87.1000	1200
NP-19/18	Morris Jesup Ridge	-32.1300	84.6133	845
NP-19/19	Morris Jesup Ridge	-24.9100	84.1883	590
NP-19/20	Morris Jesup Ridge	-16.2900	83.1450	1010
NP-19/9	Lomonosov Ridge	-58.2900	87.2483	1192
NP-26/32	Mendeleyev Ridge	-178.0800	79.4000	1610
AF07-31	Mendeleyev Ridge	-171.9478	78.6303	2280
NP26 sta 5	Mendeleyev Ridge	-178.15	78.98	1435
Pl-91-AR-BC02	Nansen Basin	33.3800	83.7065	4004
PS1698-2	Greenland Sea	-14.5800	74.1800	850
PS1704-3	Greenland Sea	1.0800	78.3900	1195
PS1707-1	Icelandic Ridge	-13.8300	72.6167	2118
PS1893-1	Greenland Sea	-10.1100	74.8677	3245
PS1905-1	Greenland Sea	-3.3800	76.9188	1761
PS1913-5	Greenland Sea/Mohns Ridge	5.4072	74.4845	2857
PS2163-2	Gakkel Ridge	59.0778	86.2417	3047
PS2164-4	Gakkel Ridge	59.0889	86.3350	2030
PS2177-1	Lomonosov Ridge	134.3061	88.0367	1388
PS2179	Lomonosov Ridge	138.0094	87.7467	1230
PS2179-3	Lomonosov Ridge	138.0100	87.7500	1230
PS2184-3	Lomonosov Ridge	148.05	87.63	1640
PS2185-4 MUC	Lomonosov Ridge	144.13	87.53	1051
PS2186-5	Lomonosov Ridge	140.1633	88.5150	2036
PS2189-1	Lomonosov Ridge	144.1833	88.7817	1018
PS2195-4	Amundsen Basin	9.1978	86.2283	3873
PS2200-5	Morris Jesup Rise	-14.0000	85.3267	1074
PS2202-2	Morris Jesup Rise	-14.1261	85.1067	1083
PS2212-6 MUC	Yermak Plateau	15.717	82.063	2439

TABLE 2
Size of selected ostracod specimens. USNM: catalog number. T: type (P: paratype. H: holotype). V: valve (L: left. R: right). A: adult. F: female. M: male. L: Length (mm). H: Height (mm).

USNM	Species	T	V	Instar	Sex	Plate	Fig	L	H
594082	*Polycope arcys*		R	?	?	1	1	0.525	0.475
594083	*Polycope arcys*		L	?	?	1	2	0.380	0.351
594085	*Polycope bispinosa*		R	?	?	1	4	0.545	0.471
594088	*Polycope bispinosa*		L	?	?	1	7	0.680	0.599
594089	*Polycope bispinosa*		L	?	?	1	8	0.620	0.544
594091	*Polycope bireticulata*		R	?	?	2	1	0.365	0.325
594093	*Polycope reticulata*		R	?	?	2	3	0.398	0.363
594095	*Polycope semipunctata*		R	?	?	2	5	0.261	0.249
594096	*Polycope moenia*		L	?	?	2	6	0.315	0.270
594098	*Polycope moenia*		R	?	?	2	8	0.312	0.258
594100	*Polycope punctata*		L	?	?	3	1	0.843	0.694
594101	*Polycope inornata*		R	?	?	3	2	0.621	0.532
594104	*Polycope inornata*		L	?	?	3	5	0.561	0.497
594105	*Polycope* sp. 1		R	?	?	3	6	0.495	0.415
594107	*Polycope inornata*		L	?	?	3	8	0.930	0.796
594108	*Polycope horrida*		R	?	?	3	9	0.535	0.441
594115	*Argilloecia* cf. *robinwhatleyi*		L	A	?	4	6	0.515	0.222
594116	*Argilloecia* cf. *robinwhatleyi*		R	A	?	4	7	0.517	0.231
594117	*Argilloecia* cf. *conoidea*		L	A	?	4	8	0.614	0.266
594118	*Argilloecia* cf. *conoidea*		R	A	?	4	9	0.604	0.269
594119	*Australoecia posteroacuta*		L	A	?	4	10	0.497	0.196
594120	*Argilloecia* sp. 1		R	A	?	4	11	0.608	0.231
594121	*Bythoceratina lomonosovensis*	H	L	A	?	5	1	1.172	0.624
594122	*Bythoceratina lomonosovensis*	P	R	A	?	5	2	1.142	0.615
594123	*Bythoceratina scaberrima*		L	A	?	5	3	0.803	0.519
594124	*Bythoceratina scaberrima*		R	A	?	5	4	0.853	0.522
594125	*Cytheropteron parahamatum*	P	L	A	?	5	5	0.531	0.315
594127	*Cytheropteron parahamatum*	H	R	A	?	5	7	0.523	0.307
594128	*Cytheropteron carolinae*		L	A	?	5	8	0.462	0.258
594129	*Cytheropteron carolinae*		R	A	?	5	9	0.504	0.291
594130	*Pseudocythere caudata*		L	A	M?	6	1	0.585	0.264
594131	*Pseudocythere caudata*		R	A	M?	6	2	0.578	0.278
594133	*Pseudocythere caudata*		L	A	F?	6	4	0.690	0.367
594136	*Pseudocythere caudata*		L	A	M?	6	7	0.592	0.291
594140	*Pseudocythere caudata*		L	A	F?	6	11	0.612	0.333
594141	*Pseudocythere caudata*		R	A	F?	6	12	0.606	0.322
594142	*Cytheropteron higashikawai*		L	A	?	7	1	0.759	0.501
594143	*Cytheropteron higashikawai*		R	A	?	7	2	0.782	0.511
594145	*Cytheropteron sedovi*		R	A	?	7	4	0.848	0.466
594146	*Cytheropteron sedovi*		L	A	?	7	5	0.875	0.466
594147	*Cytheropteron sedovi*		R	A	?	7	6	0.713	0.444
594148	*Cytheropteron sedovi*		L	A	?	7	7	0.736	0.415
594149	*Cytheropteron lanceae*	H	R	A	?	7	8	0.637	0.376
594150	*Cytheropteron perlaria*		L	A	F?	8	1	0.502	0.285
594151	*Cytheropteron perlaria*		R	A	F?	8	2	0.487	0.285
594154	*Cytheropteron perlaria*		L	A	M?	8	5	0.458	0.239
594155	*Cytheropteron perlaria*		R	A	M?	8	6	0.468	0.252
594158	*Cytheropteron groenlandicum*		R	A	?	9	1	0.571	0.366
594160	*Cytheropteron groenlandicum*		L	A	?	9	3	0.534	0.326

TABLE 2
continued.

USNM	Species	T	V	Instar	Sex	Plate	Fig	L	H
594162	*Cytheropteron irizukii*	P	L	A	?	9	5	0.500	0.332
594163	*Cytheropteron irizukii*	H	R	A	?	9	6	0.476	0.278
594164	*Cytheropteron scoresbyi*		L	A	?	9	7	0.498	0.255
594165	*Cytheropteron scoresbyi*		R	A	?	9	8	0.451	0.260
594166	*Cytheropteron scoresbyi*		L	A	?	9	9	0.428	0.230
594167	*Cytheropteron aielloi*		L	A	?	10	1	0.498	0.280
594168	*Cytheropteron scoresbyi*		R	A	?	10	2	0.493	0.267
594169	*Cytheropteron aielloi*		R	A	?	10	3	0.471	0.273
594170	*Cytheropteron carolinae*		L	A	?	10	4	0.570	0.325
594171	*Cytheropteron carolinae*		R	A	?	10	5	0.517	0.307
594172	*Cytheropteron pseudoinflatum*		L	A	?	10	6	0.570	0.336
594174	*Cytheropteron pseudoinflatum*		R	A	?	10	8	0.552	0.337
594176	*Cytheropteron pseudoinflatum*		L	A	?	11	1	0.531	0.322
594180	*Eucytherura delineata*		L	A	?	11	5	0.439	0.248
594181	*Eucytherura delineata*		R	A	?	11	6	0.449	0.259
594183	*Pedicythere neofluitans*		L	A	?	11	8	0.410	0.241
594185	*Pedicythere neofluitans*		R	A	?	11	10	0.413	0.217
594186	*Pedicythere arctica*	H	R	A	?	12	1	0.474	0.325
594187	*Pedicythere arctica*	P	L	A	?	12	2	0.469	0.283
594188	*Eucythere argus*		L	A	?	12	3	0.630	0.372
594189	*Cluthia whatley*	H	L	A	F?	12	4	0.361	0.207
594190	*Cluthia whatley*	P	R	A	F?	12	5	0.348	0.195
594191	*Cluthia whatley*	P	R	A	M?	12	6	0.425	0.222
594194	*Krithe hunti*	H	L	A	M	13	1	0.919	0.424
594195	*Krithe hunti*	P	R	A	M	13	2	0.920	0.412
594196	*Krithe hunti*	P	L	A	F	13	3	0.835	0.453
594197	*Krithe hunti*	P	R	A	F	13	4	0.847	0.465
594198	*Krithe hunti*	P	L	A	F	13	5	0.775	0.441
594200	*Krithe hunti*	P	L	A	M	13	7	0.807	0.391
594204	*Krithe hunti*	P	R	A	F	13	11	0.663	0.350
594221	*Krithe minima*		L	A	F	14	17	0.617	0.301
594222	*Krithe minima*		R	A	F	14	18	0.579	0.291
594225	*Krithe minima*		L	A	M	14	21	0.621	0.283
594226	*Krithe minima*		R	A	M	14	22	0.590	0.255
594230	*Acetabulastoma arcticum*		L	?	?	15	1	0.809	0.383
594232	*Acetabulastoma arcticum*		L	?	?	15	3	0.932	0.458
594233	Paradoxostomatid sp. 1		R	?	?	15	4	0.698	0.314
594234	*Paracytherois chukchiensis*		R	A	?	15	5	0.572	0.210
594235	*Paracytherois chukchiensis*		L	A	?	15	6	0.545	0.202
594237	*Microcythere medistriata*		L	A	?	15	8	0.354	0.161
594238	*Microcythere medistriata*		R	A	?	15	9	0.371	0.188
594239	*Microcythere medistriata*		L	A	?	15	10	0.355	0.168
594240	*Henryhowella asperrima*		L	A	M	16	3	1.026	0.549
594244	*Henryhowella asperrima*		R	A	M	16	4	0.987	0.517
594245	*Henryhowella asperrima*		L	A	M	16	5	0.987	0.520
594247	*Henryhowella asperrima*		L	A	F	16	7	0.898	0.549
594248	*Henryhowella asperrima*		R	A	F	16	8	0.919	0.534
594249	*Henryhowella asperrima*		L	A	F	16	9	0.870	0.544

sider *Polycope frigida* as a junior synonym of *Polycope bispinosa*.

MAOD taxonomic category: Polycope spp.

Polycope horrida Joy and Clark 1977
Plate 3, figures 9–10

Polycope horrida JOY and CLARK 1977, p. 145, pl. 3, figs. 5–8.

Dimensions: See Table 2.

Remarks: Polycope sp. cf. *P. horrida* of Didié and Bauch (2000, 2001) is similar to *Polycope horrida* Joy and Clark 1977, but distinguished by having more densely spinose carapace.

MAOD taxonomic category: *Polycope* spp.

Polycope moenia Joy and Clark 1977
Plate 2, figures 6–9

Polycope moenia JOY and CLARK 1977, p. 145, pl. 3, figs. 17–19. – JONES and WHATLEY 1995, p. 104, pls. 22.105, 22.107.

Dimensions: See Table 2.

Remarks: The SEM image of external view of the paratype specimen in Joy and Clark (1977, pl. 3, fig. 17) seems to be deformed.

MAOD taxonomic category: Polycope spp.

Polycope semipunctata Joy and Clark 1977
Plate 2, figures 4–5

Polycope semipunctata JOY and CLARK 1977, p. 145, pl. 3, figs. 9–10.

Dimensions: See Table 2.

Remarks: The SEM image of external view of the holotype specimen in Joy and Clark (1977, pl. 3, fig. 9) seems to be deformed.

MAOD taxonomic category: Polycope spp.

Polycope reticulata Müller 1894
Plate 2, figure 3

Polycope reticulata MÜLLER 1894, p. 235, pl. 7, figs. 44, 49–50; pl. 8, fig. 20. – CABRAL and LOUREIRO 2013, p. 137, pl. 1, fig. 1.

Dimensions: See Table 2.

Remarks: Polycope reticulata Müller, 1894 is similar to *Polycope bireticulata* Joy and Clark 1977, but distinguished by lacking secondary reticulation. *Polycope reticulata* is very similar to *Polycope* sp. of Whatley et al. (1996) (=the paratype specimen of *Polycope bireticulata*, Joy and Clark, 1977, pl. 1, fig. 21), but the former lacks marginal spines. Further research is needed to confirm whether this difference in marginal spines is intraspecific variation.

MAOD taxonomic category: Polycope spp.

***Polycope* sp. 1**
Plate 3, figures 6–7

Dimensions: See Table 2.

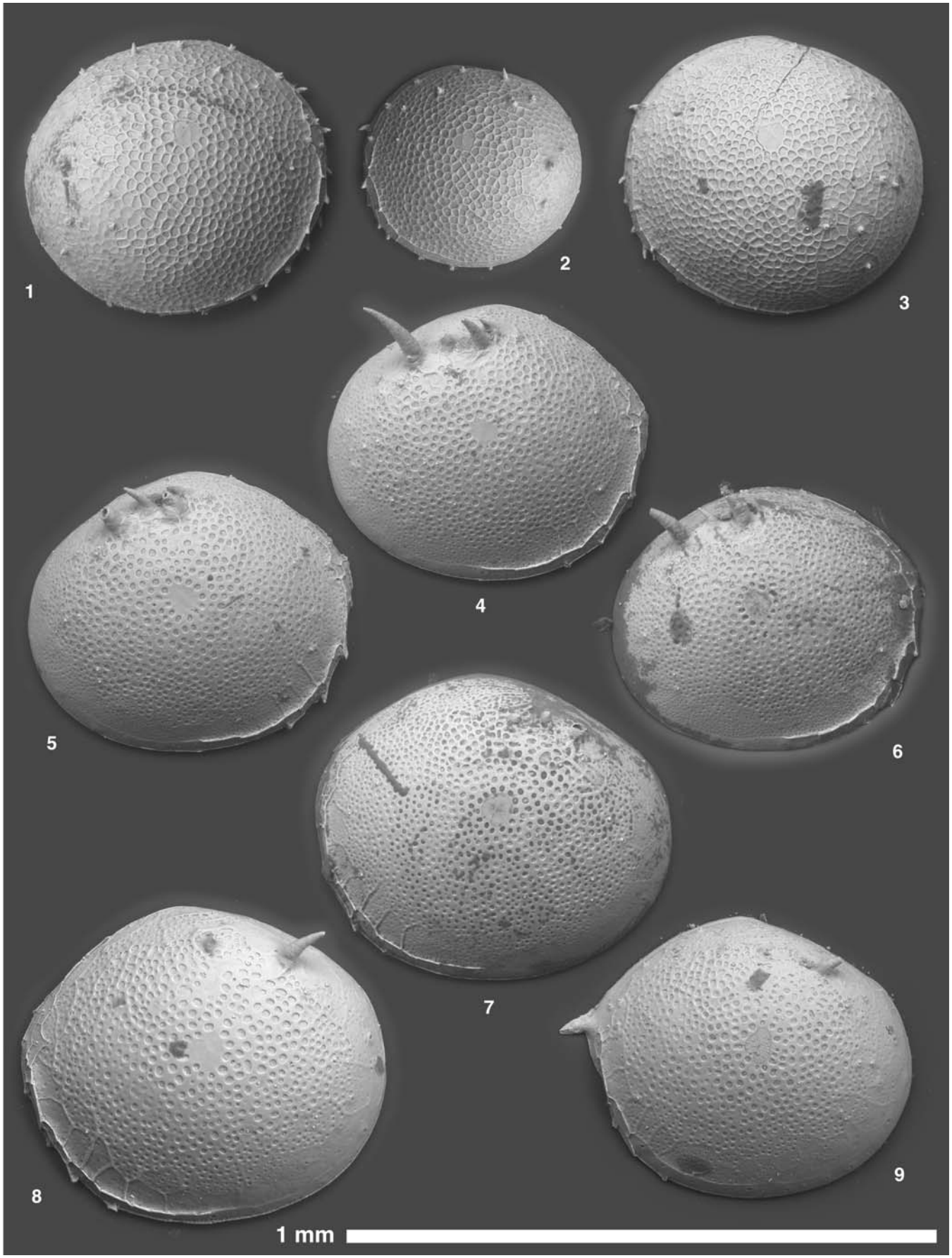
Remarks: Polycope sp. 1 is similar to *Polycope orbicularis* s.l. sensu Yasuhara et al. (2009), but distinguished by having punctation in the central part of valve.

MAOD taxonomic category: Polycope spp.

PLATE 1
All SEM images. Scale bar represents 1mm.

1–3 *Polycope arcys* Joy and Clark 1977.
- 1 USNM 594082, PS2179, 9–10cm; RV, lateral view.
- 2 USNM 594083, PS2186-5, 10–11cm; LV, lateral view.
- 3 USNM 594084, PS2202-2, 0–1cm; LV, lateral view.

4–9 *Polycope bispinosa* Joy and Clark 1977.
- 4 USNM 594085, PS2186-5, 10–11cm; RV, lateral view.
- 5 USNM 594086, PS2186-5, 10–11cm; RV, lateral view.
- 6 USNM 594087, PS2179, 9–10cm; RV, lateral view.
- 7 USNM 594088, PS2164-4, 0–1cm; LV, lateral view.
- 8 USNM 594089, Geomar 23243-1, 90–91cm; LV, lateral view.
- 9 USNM 594090, Geomar 23243-1, 180–181cm; LV, lateral view.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Subclass PODOCOPA Müller 1894
Order PODOCOPIDA Sars 1866
Suborder CYPRIDOCOPINA Jones 1901
Superfamily PONTOCYPRIDOIDEA Müller 1894
Family PONTOCYPRIDIDAE Müller 1894

Genus ***Argilloecia*** Sars 1866
Type species: Argilloecia cylindrica Sars 1866

Argilloecia* cf. *conoidea Sars 1923
Plate 4, figure 8–9

non *Argilloecia conoidea* SARS 1923, p. 56, pl. 25. – ? NEALE and HOWE 1975, pl. 3, fig. 2. – ? LORD 1980, pl. 3, fig. 14. – CRONIN 1996, fig. 4b. – WHATLEY et al. 1996, pl. 1, figs. 3–4 (non 1–2). – WHATLEY et al. 1998, pl. 1, fig. 1. – non STEPANOVA 2006, p. S186, pl. 6, fig. 6.

Dimensions: See Table 2.

Remarks: Our specimens are conspecific with those illustrated by Whatley et al. (1996 in part, pl. 1, figs. 3–4, non 1–2; 1998, pl. 1, fig. 1). Compared to the original sketches of Sars (1923), our specimens have less upturned posterior margin. There is no published SEM image of the Norwegian (i.e., type locality) specimen [except an internal view of a fossil specimen shown in Lord 1980]. The holotype and lectotype have not been designated, and the location of the original material of Sars (1923) is unknown (Stepanova 2006).

MAOD taxonomic category: Argilloecia spp.

***Argilloecia* sp. 1**
Plate 4, figure 11

Argilloecia conoidea Sars. – WHATLEY et al. 1996, pl. 1, figs. 1–2 (non 3–4). – STEPANOVA 2006, p. S186, pl. 6, fig. 6.

Dimensions: See Table 2.

Remarks: Whatley et al. (1996) considered this species as male specimens of *Argilloecia conoidea* Sars 1923. However, we consider this to be a separate species since the specimens illustrated in Whatley et al. (1996) and attributed to as male and female of *Argilloecia conoidea* are morphologically very different, exceeding the level of sexual dimorphism in our opinion. Stepanova (2006, pl. 6, fig. 6) also reported this species as *Argilloecia conoidea*.

MAOD taxonomic category: Argilloecia spp.

Argilloecia* cf. *robinwhatleyi Yasuhara, Okahashi and Cronin 2009
Plate 4, figures 1–7

Argilloecia cylindrica Sars. – WHATLEY et al. 1996, pl. 1, figs. 5–6. – WHATLEY et al. 1998, pl. 1, figs. 2–3. – STEPANOVA et al. 2003, pl. 4, fig. 8. – STEPANOVA 2006, p. S187, pl. 6, fig. 7.
non *Argilloecia robinwhatleyi* YASUHARA et al. 2009, p. 888, Pl. 3, figs. 15, 18–20.

Dimensions: See Table 2.

Remarks: This species is very similar to *Argilloecia robinwhatleyi* Yasuhara, Okahashi and Cronin 2009, but the former has angular anterodorsal corner especially in internal view and broader posterior inner lamella. Although rather subtle, we think that these differences may indicate two different species. Thus, we prefer to call this species *Argilloecia* cf. *robinwhatleyi* Yasuhara, Okahashi and Cronin 2009. This species is also similar to *Argilloecia cylindrica* Sars 1866 (see Sars 1923; Moore 1961), but the latter has much more straight dorsal margin and less acuminate posterior margin. *Argilloecia* cf. *robinwhatleyi* is conspecific with the species identified as *Argilloecia cylindrica*

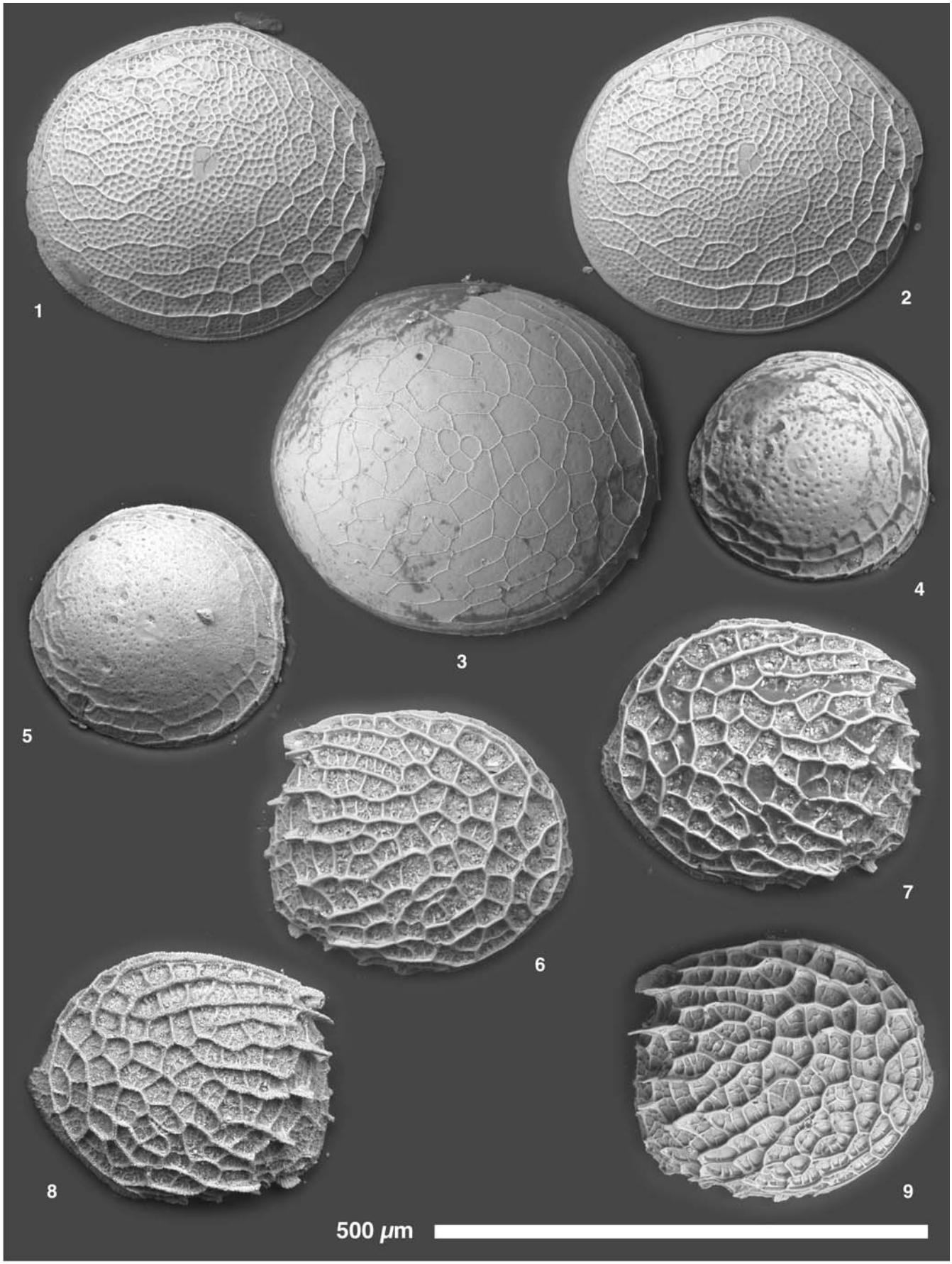
PLATE 2
All SEM images. Scale bar represents 500μm.

1–2 *Polycope bireticulata* Joy and Clark 1977.
1 USNM 594091, PS2177-1, 0–1cm; RV, lateral view.
2 USNM 594092, PS2177-1, 0–1cm; RV, lateral view.

3 *Polycope reticulata* Müller 1894, USNM 594093, PS2179, 9–10cm; RV, lateral view.

4–5 *Polycope semipunctata* Joy and Clark 1977.
4 USNM 594094, PS2186-5, 10–11cm; RV, lateral view.
5 USNM 594095, PS2200-5, 183cm; RV, lateral view.

6–9 *Polycope moenia* Joy and Clark 1977.
6 USNM 594096, PS2202-2, 0–1cm; LV, lateral view.
7 USNM 594097, PS2202-2, 0–1cm; RV, lateral view.
8 USNM 594098, PS2200-5, 123cm; RV, lateral view.
9 USNM 594099, PS2177-1, 0–1cm; LV, lateral view.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500 μm

by Whatley et al. (1996, 1998), Stepanova et al. (2003), and Stepanova (2006).

MAOD taxonomic category: Argilloecia spp.

Genus *Australoecia* Mckenzie 1967
Type species: Australoecia victoriensis McKenzie 1967

Australoecia posteroacuta Coles and Whatley 1989
Plate 4, figure 10

Australoecia posteroacuta COLES and WHATLEY 1989, p. 108, pl. 6, figs 5–8. – YASUHARA et al. 2009, p. 890, pl. 3, figs. 3, 6, 9, 12.
Argilloecia sp. WHATLEY et al. 1996, pl. 1, fig. 7.

Dimensions: See Table 2.

Remarks: This is the first verified record of this species with SEM images from the Arctic Ocean.

MAOD taxonomic category: Other

Suborder CYTHEROCOPINA Gründel 1967
Superfamily CYTHEROIDEA Baird 1850
Family BYTHOCYTHERIDAE Sars 1866

Genus ***Bythoceratina*** Hornibrook 1952
Type species: Bythoceratina mestayerae Hornibrook 1952

Bythoceratina scaberrima (Brady 1886)
Plate 5, figures 3–4

Cytherura scaberrima BRADY 1886, p. 198, pl. 14, figs. 10–11.
Cythere scaberrima (Brady). – BRADY and NORMAN 1889, p. 245, fig. (unnumbered).
Bythoceratina scaberrima (Brady). – BENSON and SYLVESTER-BRADLEY 1971, p. 76, pl. 1, figs. 2, 7. – SYLVESTER-BRADLEY and BENSON 1971, fig. 18. – BENSON 1973, p. 23, pls. 1-3-24, 1-3-26, 1-3-28, 1-3-30. – WHATLEY et al. 1998, pl. 1, figs. 6–7. – DIDIÉ and BAUCH 2001, pl. 1, fig. 29 (as erratum for Didié and Bauch 2000). – CRONIN and DWYER 2003, pl. 1, fig. i. – CRONIN et al. 2002, fig. 2B.
Retibythere scaberrima (Brady) – GUERNET 2005, p. 109.
Bythoceratina scaberrima mediterranea COLALONGO and PASINI 1980, p. 72, pl. 1, fig. 9, pl. 4, figs. 9–10.

Dimensions: See Table 2.

Remarks: Comprehensive synonymy is found in Guernet (2005) and this paper. There is certain degree of variation in the development of spines and primary reticulation in this species, i.e., some are more densely spinose and deeply reticulate than others but otherwise identical. Forms with sparse spines and shallow reticulation, that includes the original sketch of Brady (1886), are known from the Arctic Ocean (Cronin et al. 2002; this paper), North Atlantic Ocean (Brady 1886; Didié and Bauch 2000, 2001), Greenland Sea (Whatley et al. 1998), and Mediterranean Sea (Benson and Sylvester-Bradley 1971, pl. 1, fig. 7; Colalongo and Pasini 1980). Densely spinose, deeply reticulate forms are known from the Indian Ocean (Benson and Sylvester-Bradley 1971, pl. 1, fig. 2; Sylvester-Bradley and Benson 1971; Benson 1973). We tentatively consider this difference as intraspecific variation. This taxon has not been revised and holotype and lectotype have not been designated (Benson 1973).

MAOD taxonomic category: Bythoceratina scaberrima (Brady 1887)

Bythoceratina lomonosovensis Yasuhara, Stepanova, Okahashi, Cronin and Brouwers, **n. sp.**
Plate 5, figures 1–2

Etymology: For the type locality, Lomonosov Ridge.

Holotype: Adult LV, USNM 594121 (Pl. 5, fig. 1).

Paratype: USNM 594122.

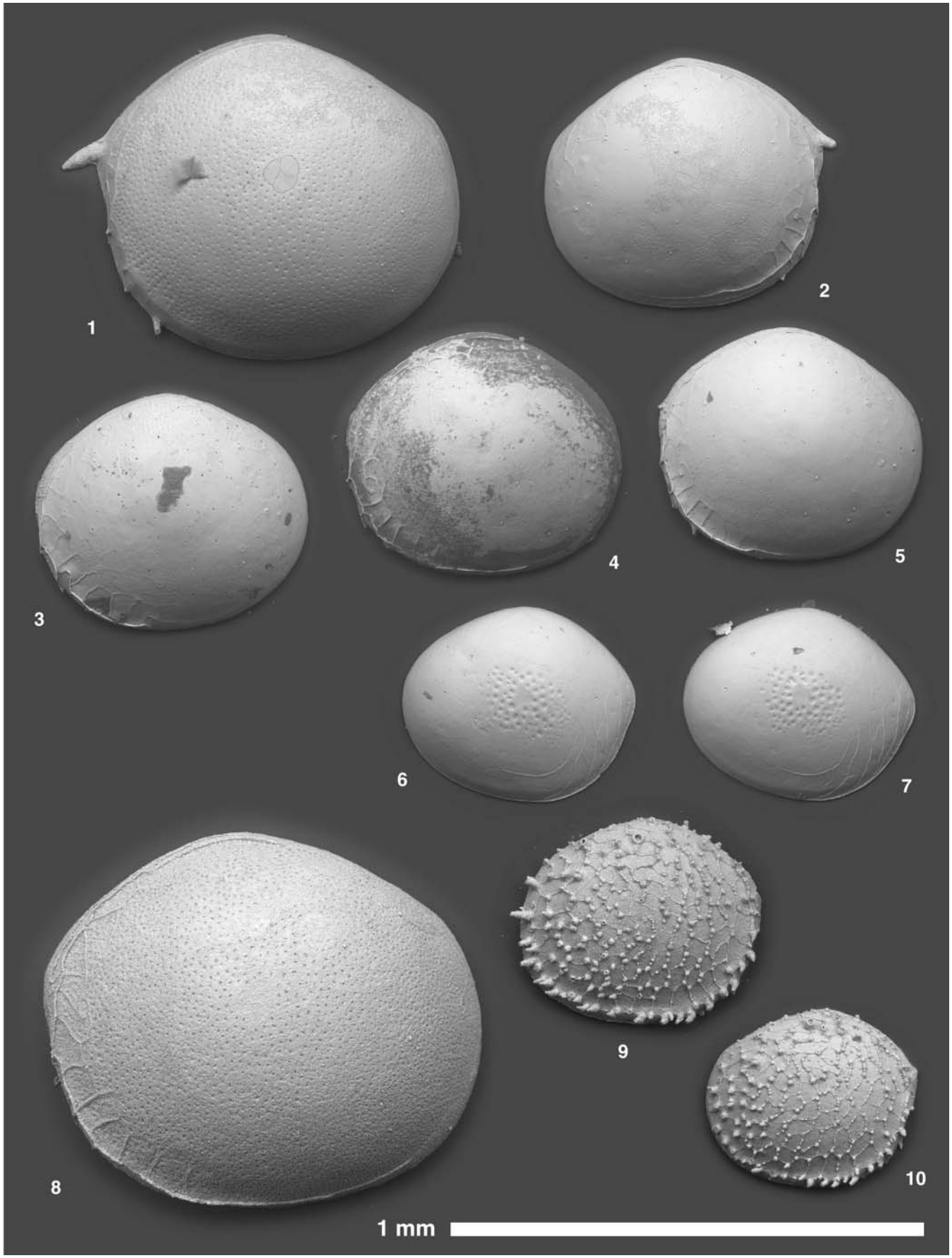
PLATE 3
All SEM images. Scale bar represents 1mm.

1 *Polycope punctata* Sars 1869 sensu Joy and Clark (1977), USNM 594100, PS2177-1, 0–1cm; LV, lateral view.

2–5, 8 *Polycope inornata* Joy and Clark 1977.
- 2 USNM 594101, PS2177-1, 0–1cm; RV, lateral view.
- 3 USNM 594102, PS2164-4, 0–1cm; LV, lateral view.
- 4 USNM 594103, PS2177-1, 0–1cm; LV, lateral view.
- 5 USNM 594104, PS2177-1, 0–1cm; LV, lateral view.
- 8 USNM 594107, PS2179-3, 17–18cm; LV, lateral view.

6–7 *Polycope* sp. 1.
- 6 USNM 594105, Geomar 23243-1, 55cm; RV, lateral view.
- 7 USNM 594106, Geomar 23243-1, 60–61cm; RV, lateral view.

9–10 *Polycope horrida* Joy and Clark 1977.
- 9 USNM 594108, NP26 sta 5, 80–82cm; RV, lateral view.
- 10 USNM 594109, NP26 sta 5, 77.5–79cm; RV, lateral view.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1 mm

Type locality and Horizon: PS2179-3, 11–12cm (87.75ºN, 138.01ºE, 1230m water depth, Quaternary).

Dimensions: See Table 2.

Diagnosis: A very large *Bythoceratina* species with almost smooth carapace.

Description: Carapace moderately calcified, very large. Outline subrectangular in lateral view; anterior margin rounded, smooth; caudal process upturned; dorsal margin almost straight; ventral margin slightly convex. Lateral surface almost smooth. A ventrolateral ridge well developed, smoothly continuous, slightly curved, bearing a well developed spine at the posterior end; three parallel carinae running on the ridge. A median sulcus very shallow and unclear. Internal features as for genus.

Remarks: This species is distinguished from any other *Bythoceratina* species by its very large size, smooth carapace, and well developed and smoothly continuous ventrolateral ridge with a spine and three carinae.

MAOD taxonomic category: Uncertain

Genus ***Pseudocythere*** Sars 1866
Type species: Pseudocythere caudata Sars 1866

Pseudocythere caudata Sars 1866
Plate 6, figures 1–12

Pseudocythere caudata SARS 1866, p. 88. – SARS 1926, p. 239, pl. 109, figs. 2a–k. – MOORE 1961, p. Q268, fig. 195.5. NEALE 1967, figs. 5e–i, pl. 1, figs. e–f. – BONADUCE et al. 1975, p. 119, pl. 14, figs. 9–10. – JOY and CLARK 1977, p. 137, pl. 1, figs. 1–3. – HORNE 1986, p. 119, figs. 1m, 2c. ATHERSUCH et al. 1989, p. 255, fig. 108. – WHATLEY et al. 1996, pl. 1, figs. 10, 12. FREIWALD and MOSTAFAWI 1998, pl. 60, fig. 5. – WHATLEY et al. 1998, pl. 1, figs. 8–9. – DIDIÉ and BAUCH 2001, pl. 1, fig. 20 (as erratum for Didié and Bauch 2000). – STEPANOVA et al. 2003, pl. 1, fig. 4. – ALVAREZ ZARIKIAN 2009, p. 3, pl. P2, fig. 4. – YASUHARA et al. 2009, p. 892, pl. 4, figs. 7–12.

Pseudocythere cf. *P. caudata* Sars. – NEALE 1967, p. 14, figs. 5a–d, pl. 1, figs. a–b.

Pseudocythere caudata mediterranea BONADUCE, MASOLI, PUGLIESE and MCKENZIE 1980, p. 136, pl. 1, fig. 1, pl. 2, figs. 1–2, 6.

Pseudocythere cf. *caudata* Sars. – MALZ and JELLINEK 1994, figs. 3–4, 6.

Pseudocythere gr. *caudata* Sars. – COLES et al. 1996, p. 150, pl. 2, figs. 3–4.

Pseudocythere (*Dopseucythere*) *caudata* Sars. – GUERNET 2005, p. 108.

Dimensions: See Table 2.

Remarks: There is certain degree of morphological variation in this species. For example, North Atlantic deep-sea specimens have more inflated posteroventral area and less prominent caudal process (Yasuhara et al. 2009) compared to our Arctic specimens. Furthermore, some specimens have a small spine in anterodorsal corner (Pl. 6, figs 2 and 5). We consider that all specimens listed in the synonymy and figured here fall within intraspecific variation, at least until further investigation. We agree with Guernet (2005) and consider that *Pseudocythere caudata mediterranea* Bonaduce et al. 1980 is merely *Pseudocythere caudata* and subspecies division is not needed. The holotype and lectotype have not been designated, and the location of the original material of Sars (1866) is unknown (Stepanova 2006).

MAOD taxonomic category: Pseudocythere caudata Sars 1866

Family CYTHERURIDAE Müller 1894

Genus *Cytheropteron* Sars 1866
Type species: Cytheropteron latissimum (Norman 1865) (=*Cythere latissima* Norman 1865) (designated by Brady and Norman 1889; see Horne and Whittaker 1988 for details and lectotype)

Cytheropteron alatum Sars 1866
Cytheropteron alatum SARS 1866, p. 81. – SARS 1926, p. 225, pl. 104, fig. 1. – PENNEY 1993, figs. 4n–4o. – FREIWALD and

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PLATE 4
All SEM images and adult specimens. Scale bar represents 1mm.

1–7 *Argilloecia* cf. *robinwhatleyi* Yasuhara, Okahashi and Cronin 2009.

1 USNM 594110, PS2200-5, 178cm; LV, lateral view.

2 USNM 594111, PS2200-5, 178cm; RV, lateral view.

3 USNM 594112, PS2200-5, 183cm; RV, lateral view.

4 USNM 594113, PS1913-5, 0–2cm; LV, internal view.

5 USNM 594114, PS1913-5, 0–2cm; RV, internal view.

6 USNM 594115, 10/2, 24–26cm; LV, lateral view.

7 USNM 594116, 10/2, 24–26cm; RV, lateral view.

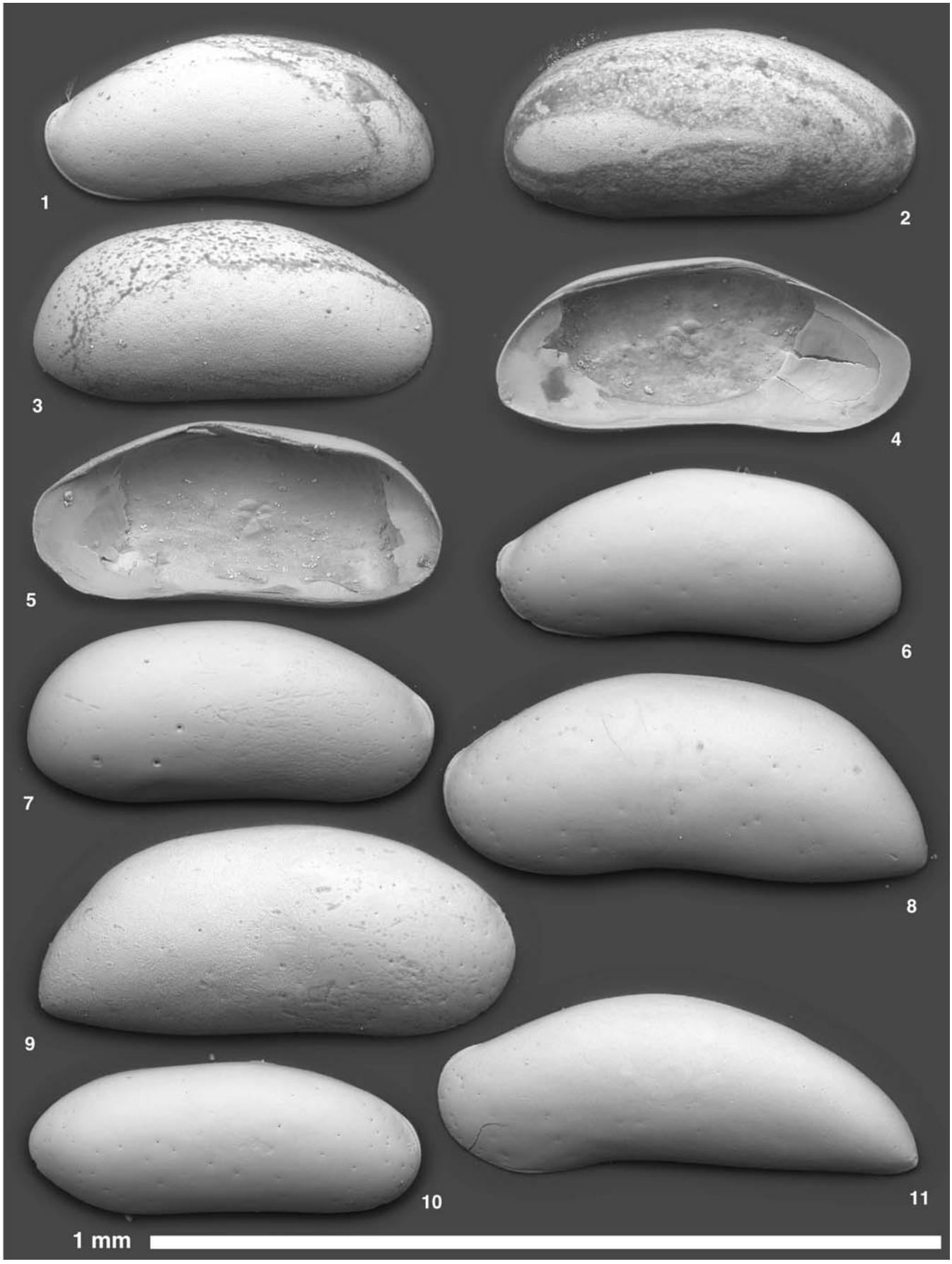
8–9 *Argilloecia* cf. *conoidea* Sars 1923.

8 USNM 594117, 10/2, 24–26cm; LV, lateral view.

9 USNM 594118, 10/2, 24–26cm; RV, lateral view.

10 *Australoecia posteroacuta* Coles and Whatley 1989, USNM 594119, 10/2, 24–26cm; RV, lateral view.

11 *Argilloecia* sp. 1, USNM 594120, 10/2, 24–26cm; LV, lateral view.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MOSTAFAWI 1998, pl. 59, fig. 7. – DIDIÉ and BAUCH 2000, pl. 2, fig. 6.
Cytheropteron vespertilio (Reuss). – COLES et al. 1996, pl. 3, fig. 9.

Dimensions: See Table 2.

Remarks: Several published SEM images of Norwegian (i.e., type locality) specimens (Penney 1993; Freiwald and Mostafawi 1998) are identical to the sketches of Sars (1926). Although original description (Sars 1866) lacks any illustrations and the holotype and lectotype have not been designated, we consider that only these figured specimens (Sars 1926; Penney 1993; Freiwald and Mostafawi 1998) as reliable records of *Cytheropteron alatum* Sars 1886. *Cytheropteron alatum* sensu Whatley and Masson (1979) are not identical to *Cytheropteron alatum* in our opinion. Joy and Clark (1977), Whatley and Masson (1979), and Guernet (2005) showed the comprehensive synonymy, but these lists should be treated with caution. There are no reliable records of this species from Arctic Ocean.

Cytheropteron vespertilio (Reuss 1850)
Text-figure 3

Cypridina vespertilio REUSS 1850, p. 81, pl. 11, figs. 13a–c.
Cytheropteron vespertilio (Reuss). – non BONADUCE et al. 1976, p. 101, pl. 52, figs. 7–12. – non COLES et al. 1996, pl. 3, fig. 9. – non WHATLEY et al. 1996, pl. 3, figs. 5–6. – non WHATLEY et al. 1998, pl. 2, figs. 16–17. ?GUERNET 2005, p. 99. – ?AIELLO and BARRA 2010, p. 412. – non CABRAL and LOUREIRO 2013, p. 140, pl. 2, fig. 4.
?*Cytheropteron volantium* WHATLEY and MASSON 1979, p. 255, pl. 4, figs. 1–5, 7. – non? CABRAL and LOUREIRO 2013, p. 140, pl. 2, fig. 5.

Remarks: *Cytheropteron vespertilio* (Reuss 1850) has been confused with *Cytheropteron alatum* Sars 1866 and *Cytheropteron higashikawai* Ishizaki 1981, because no SEM image of any type or topotype specimen has been published. Dr. Irene Zorn kindly provided us a SEM image of topotype specimen of *Cytheropteron vespertilio* shown here (Text-figure 3). This topotype specimen comes from the former clay pit of Baden-Sooss in Lower Austria (stratotype of the Badenian), Vienna Basin, Miocene, Lower Badenian, Upper Lagenidae Zone (Rögl et al. 2008). Based on this topotype specimen, *Cytheropteron vespertilio* is easily distinguishable from *Cytheropteron alatum* and *Cytheropteron higashikawai*, because *Cytheropteron vespertilio* has much less downward and developed ala and partially punctate lateral surface and lacks posterodorsal carina. In our opinion, there is no reliable record of *Cytheropteron vespertilio* from the post-Pliocene Mediterranean region or the Atlantic Ocean. One possible exception is *Cytheropteron volantium* Whatley and Masson 1979, which may be a junior synonym of *Cytheropteron vespertilio*.

Cytheropteron higashikawai Ishizaki 1981
Plate 7, figures 1–3

Cytheropteron alatum Sars. – JOY and CLARK 1977, p. 139, pl. 2, figs. 4–6. – CRONIN 1996, fig. 5a.
Cytheropteron? higashikawai ISHIZAKI 1981, p. 56, pl. 12, figs. 6–9, pl. 13, fig. 16, pl. 14, figs. 2a–b, 13.
Lobosocytheropteron pectinata GOU and HUANG 1983 (in Gou et al. 1983), p. 47, pl. 10, figs. 38, 40–44.
Lobosocytheropteron higashikawai (Ishizaki). – RUAN and HAO 1988, p. 286, pl. 48, figs. 12–16. – HOU and GOU 2007, p. 308. pl. 124, figs. 1–3, pl. 125, fig. 16.
Cytheropteron higashikawai Ishizaki. – WANG et al. 1988, p. 267, pl. 54, figs. 2–3. – CAI 1991, p. 104, pl. 4, fig. 6. – MOSTAFAWI 1992, p. 154, pl. 6, fig. 123. – AYRESS et al. 1996, figs. 3f, 5c, pl. 9, figs. 8, 10–12, pl. 10, figs. 1–2. – ZHAO et al. 2000, p. 262, pl. 1, fig. 1. –TANAKA et al. 2012, p. 10, pl. 1, fig. 16.
Cytheropteron vespertilio (Reuss). – WHATLEY et al. 1996, pl. 3, figs. 5–6. – WHATLEY et al. 1998, pl. 2, figs. 16–17.

Dimensions: See Table 2.

Remarks: *Cytheropteron higashikawai* Ishizaki 1981 is very similar to *Cytheropteron alatum* Sars 1866, but distinguished by having sinuous dorsal margin especially in LV, less upturned caudal process, better developed median sulcus, a distinct carina along the posterodorsal margin, and only one long and broad spine at the posterior end of posterior edge of the ala (*Cytheropteron alatum* has two long and broad spines at the posterior end of posterior edge of the ala: Sars 1926; Penney

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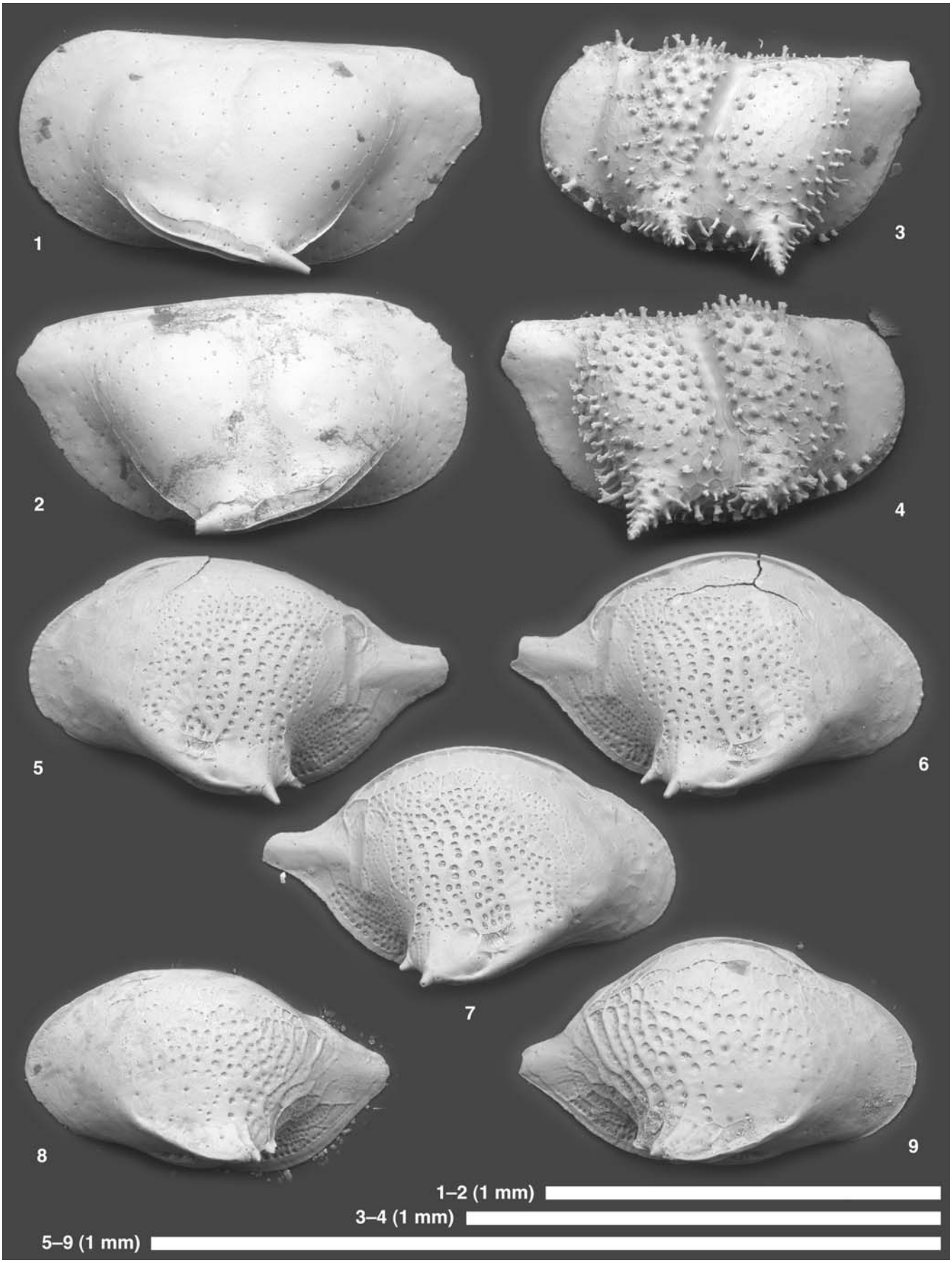
PLATE 5
All SEM images and adult specimens. Scale bars represent 1mm.

1–2 *Bythoceratina lomonosovensis* n. sp.
1 USNM 594121, PS2179-3, 11–12cm; LV, lateral view.
2 USNM 594122, PS2179-3, 15–16cm; RV, lateral view.

3–4 *Bythoceratina scaberrima* (Brady 1886).
3 USNM 594123, PS2202-2, 0–1cm; LV, lateral view.
4 USNM 594124, PS2185-4, 12–13cm; RV, lateral view.

5–7 *Cytheropteron parahamatum* n. sp.
5 USNM 594125, Meteor 23454-2; LV, lateral view.
6 USNM 594126, Meteor 23454-2; RV, lateral view.
7 USNM 594127, PS1913-5, 0–2cm; RV, lateral view.

8–9 *Cytheropteron carolinae* Whatley and Coles 1987.
8 USNM 594128, PS1704-3; LV, lateral view.
9 USNM 594129, PS1698-2; RV, lateral view.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1–2 (1 mm)
3–4 (1 mm)
5–9 (1 mm)

1993; Freiwald and Mostafawi 1998). In addition, *Cytheropteron alatum* has thin carina along posterior edge of ala (*Cytheropteron higashikawai* lacks this carina). *Cytheropteron higashikawai* is easily distinguished from *Cytheropteron vespertilio* (Reuss 1850) as discussed in Remarks of the *Cytheropteron vespertilio* section above. *Cytheropteron higashikawai* is widely distributed in the Nordic seas, Arctic, and northwestern and southwestern Pacific, but is not known from the North Atlantic proper.

MAOD taxonomic category: Cytheropteron alatum Sars 1866 (may be in part)

Cytheropteron sedovi Schneider, 1962
Plate 7, figures 4–7; Text-figures 2.1–2.4

Cytheropteron sedovi SCHNEIDER 1962, p. 104, pl. 12, fig. 1.
Cytheropteron bronwynae JOY and CLARK 1977, p. 140, pl. 2, figs. 1–3. – JONES and WHATLEY 1995, p. 41, pls. 22-42, 22-44. – CRONIN 1996, fig. 5b.

Dimensions: See Table 2.

Remarks: Schornikov [in Sirenko (2001)] indicated that (1) *Cytheropteron bronwynae* Joy and Clark 1977 is a junior synonym of *Cytheropteron sedovi* Schneider 1962; (2) *Cytheropteron sedovi* Schneider 1962 is not conspecific with *Cytheropteron ?sedovi* Schneider sensu Whatley and Masson (1979); (3) *Cytheropteron ?sedovi* Schneider sensu Whatley and Masson (1979) is conspecific with *Cytheropteron sedovi* Schneider sensu Lev (1962) [note of the authors of the present paper: because such paper does not exist, this is most likely misprint of Lev (1972)] and *Cytheropteron* ex gr. *sedovi* Schneider sensu Lev (1983) [note of the authors of the present paper: but illustrations given in Lev (1972, 1983) do not allow for a detailed comparison]; and (4) *Cytheropteron ?sedovi* Schneider sensu Whatley and Masson (1979) is not conspecific with *Cytheropteron sedovi* Schneider 1969 [sic.] sensu Whatley et al. (1996). We agree with Schornikov's opinions. Stepanova et al. (2004) described *Cytheropteron ?sedovi* Schneider sensu Whatley and Masson (1979) as *Cytheropteron laptevensis* Stepanova 2004. *Cytheropteron sedovi* Schneider 1969 [sic.] sensu Whatley et al. (1996) is conspecific with *Cytheropteron aielloi* Yasuhara, Okahashi and Cronin 2009 in our opinion (See *Cytheropteron aielloi* section below). In sum, our restudy of these species shows that (1) the species of *Cytheropteron bronwynae* is junior synonym of *Cytheropteron sedovi*, (2) there were three independent species under the name of *Cytheropteron sedovi*, and (3) these are now formally described as *Cytheropteron sedovi*, *Cytheropteron laptevensis*, and *Cytheropteron aielloi*. As seen in Plate 7 and Text-figure 2, there is certain intraspecific variation in *Cytheropteron sedovi*. For example, the Mendeleyev Ridge specimens shown in Text-figure 2 have better developed, much longer spine on apex of ala compared to the other specimens.

MAOD taxonomic category: Cytheropteron bronwynae Joy and Clark 1977

Cytheropteron groenlandicum Whatley and Eynon 1996
Plate 9, figures 1–4

Cytheropteron groenlandicum WHATLEY and EYNON 1996, p. 195, pl. 1, figs. 1–5. – WHATLEY et al. 1996, pl. 1, fig. 15. – WHATLEY et al. 1998, pl. 1, figs. 15–16.

Dimensions: See Table 2.

Remarks: This is the first certain record of this species with SEM images from the central Arctic. We confirmed this species both from Greenland Sea and Arctic Ocean (Morris Jesup Ridge).

MAOD taxonomic category: Cytheropteron spp.?

Cytheropteron hamatum Sars 1869
Cytheropteron hamatum SARS 1869, p. 172. – SARS 1926, p. 226, pl. 106, fig. 2. – PENNEY 1993, fig. 4p.

Dimensions: See Table 2.

PLATE 6
All SEM images and adult specimens. Scale bar represents 1mm.

1–12 *Pseudocythere caudata* Sars 1866.

1 USNM 594130, PS2186-5, 10–11cm; LV, lateral view.

2 USNM 594131, PS2189-1, 0–1cm; RV, lateral view.

3 USNM 594132, PS2189-1, 0–1cm; LV, lateral view.

4 USNM 594133, 10/2, 4–6cm; LV, lateral view.

5 USNM 594134, PS2189-1, 0–1cm; RV, lateral view.

6 USNM 594135, PS2186-5, 10–11cm; LV, lateral view.

7 USNM 594136, Geomar 23243-1, 100–101cm; LV, lateral view.

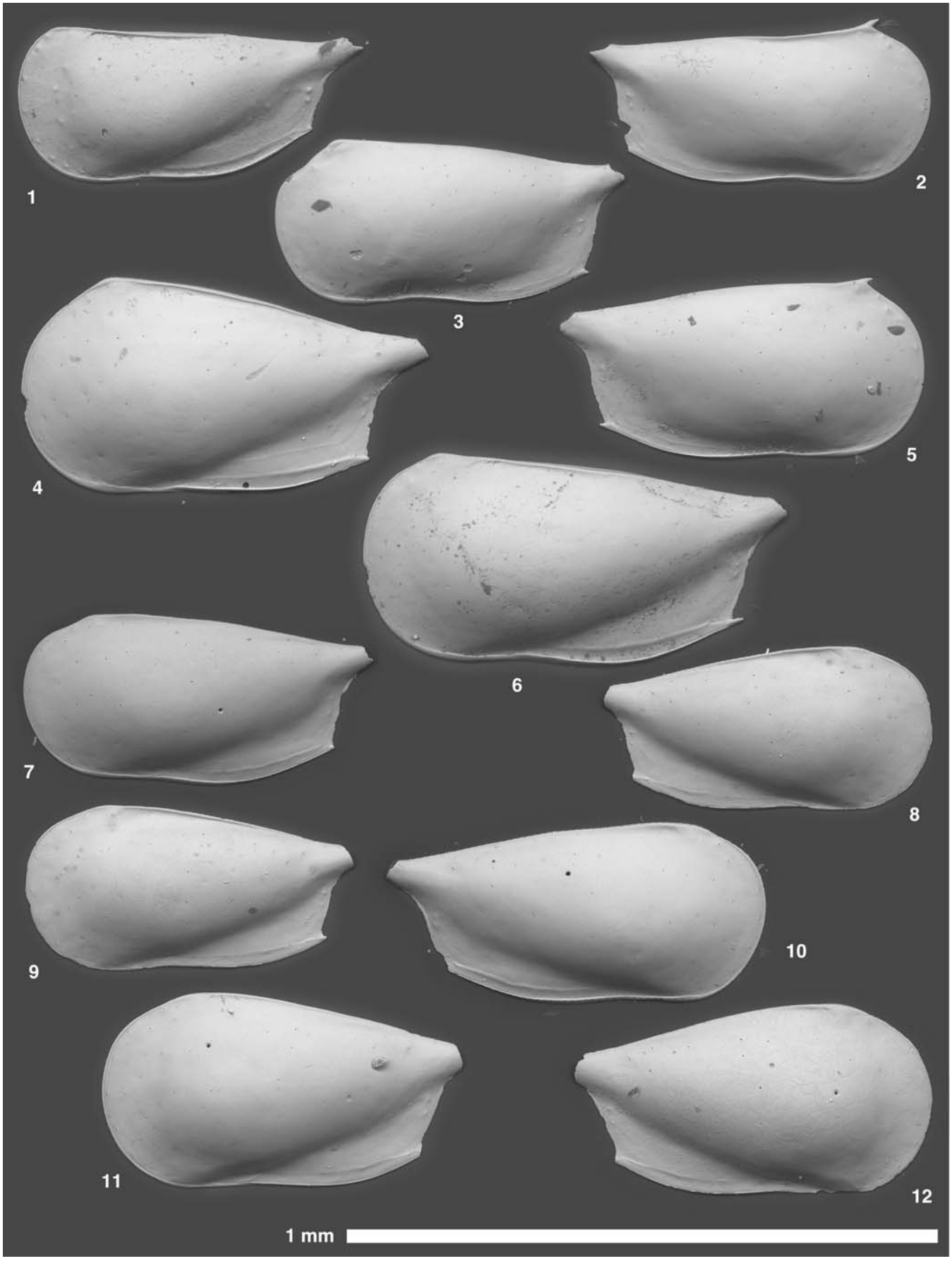
8 USNM 594137, 10/2, 4–6cm; RV, lateral view.

9 USNM 594138, 10/2, 4–6cm; LV, lateral view.

10 USNM 594139, Geomar 23243-1, 100–101cm; RV, lateral view.

11 USNM 594140, 10/2, 4–6cm; LV, lateral view.

12 USNM 594141, 10/2, 4–6cm; RV, lateral view.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Remarks: Cytheropteron hamatum Sars 1869 is not conspecific with *Cytheropteron hamatum* Sars sensu Whatley and Masson (1979) or Whatley et al. (1996, 1998) and is distinguished by having only one spine on ala [*Cytheropteron hamatum* Sars sensu Whatley and Masson (1979) and Whatley et al. (1996, 1998) has two spines on the ala]. Penney (1993) showed a clear SEM image of *Cytheropteron hamatum* from topotypic region. We did not find *Cytheropteron hamatum* Sars 1869 in the present study.

Cytheropteron parahamatum Yasuhara, Stepanova, Okahashi, Cronin and Brouwers, **n. sp.**
Plate 5, figures 5–7

Cytheropteron hamatum Sars. – non? WHATLEY and MASSON 1979, p. 236, pl. 3, figs. 4, 8, 11–13. – WHATLEY et al. 1996, pl. 1, figs. 17–19. – WHATLEY et al. 1998, pl. 1, figs. 17–19. – CRONIN 1996, fig. 6b. – ? DIDIÉ and BAUCH 2000, pl. 2, fig. 22.

Etymology: With reference to similarity to *Cytheropteron hamatum*.

Holotype: Adult RV, USNM 594127 (Pl. 5, fig. 7).

Paratypes: USNM 594125, USNM 594126.

Type locality and Horizon: PS1913-5, 0–2cm (74.4845ºN, 5.4072ºE, 2857m water depth, Recent).

Dimensions: See Table 2.

Diagnosis: Large *Cytheropteron* species with well developed two spines on ala.

Description: Carapace moderately calcified, highest at middle. Outline subrhomboidal in lateral view; anterior margin rounded, slightly frill-like; caudal process prominent, elongated, pointed at mid-height; dorsal margin rounded; ala well developed, extending below ventral margin, having two well-developed spines at its apex. Anterodorsal and posterodorsal margins without cardinal angles. Lateral surface partially punctate. Thin carina running along dorsal margin of RV. Internal features as for genus.

Remarks: This species is conspecific with *Cytheropteron hamatum* Sars 1869 sensu MAOD and Whatley et al. (1996, 1998).

MAOD taxonomic category: Cytheropteron hamatum Sars 1869

Cytheropteron carolinae Whatley and Coles 1987
Plate 5, figures 8–9; plate 10, figures 4–5

Cytheropteron carolinae WHATLEY and COLES 1987, p. 60, pl. 2, figs. 6, 7, 9. – WHATLEY et al. 1996, pl. 1, figs. 13–14. – WHATLEY et al. 1998, pl. 1, figs. 13–14. – non CRONIN 1996, fig. 6a. – non ALVAREZ ZARIKIAN 2009, p. 4, pl. P4, fig. 7.
non *Cytheropteron* sp. cf. *C. carolinae* Whatley and Coles. – DIDIÉ and BAUCH 2000, pl. 2, fig. 23.

Dimensions: See Table 2.

Remarks: Our specimens are identical to *Cytheropteron carolinae* Whatley and Coles 1987 sensu Whatley et al. (1996, 1998). *Cytheropteron carolinae* Whatley and Coles 1987 sensu Whatley et al. (1996, 1998) is very similar to *Cytheropteron carolinae* Whatley and Coles 1987, but the former has less punctate carapace, more reticulate posterior half, more sinuous dorsal margin, and only one weakly developed spine on posterior edge of ala (the latter has well-developed two or more spines there) (Whatley and Coles 1987; Yasuhara et al. 2009). We tentatively consider these differences as intraspecific variation. *Cytheropteron carolinae* sensu Alvarez Zarikian (2009) and *Cytheropteron* sp. cf. *C. carolinae* of Didié and Bauch (2000) are not conspecific with *Cytheropteron carolinae* or *Cytheropteron carolinae* sensu Whatley et al. (1996, 1998). *Cytheropteron carolinae* sensu Cronin (1996) is *Cytheropteron scoresbyi* Whatley and Eynon 1996.

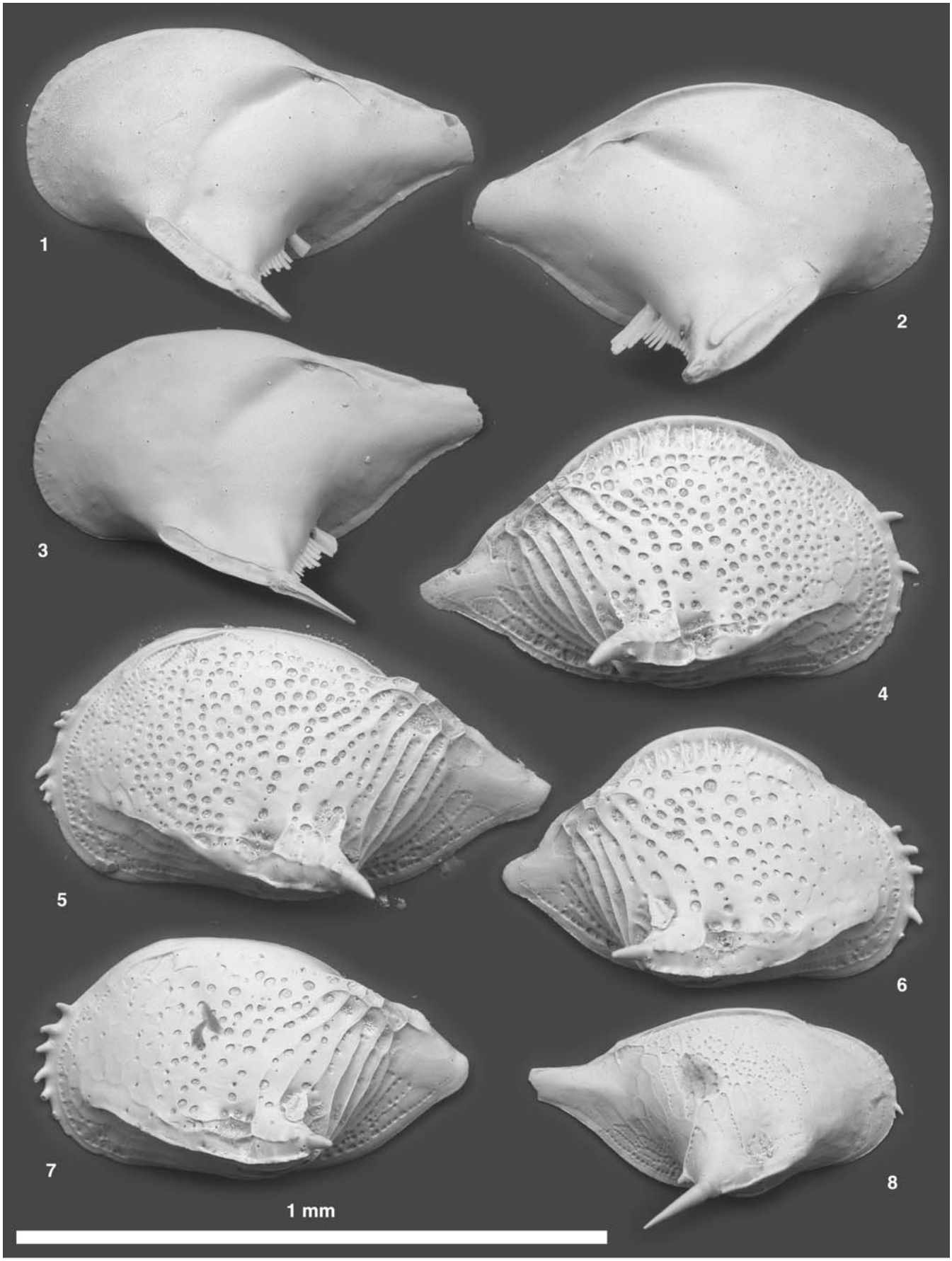
MAOD taxonomic category: Cytheropteron carolinae Whatley and Coles 1987

PLATE 7
All SEM images and adult specimens. Scale bar represents 1mm.

1–3 *Cytheropteron higashikawai* Ishizaki 1981.
- 1 USNM 594142, PS1893-1; LV, lateral view.
- 2 USNM 594143, PS1893-1; RV, lateral view.
- 3 USNM 594144, Geomar 23243-1, 64cm; LV, lateral view.

4–7 *Cytheropteron sedovi* Schneider, 1962.
- 4 USNM 594145, PS2195-4, 0–1cm; RV, lateral view.
- 5 USNM 594146, Pl-91-AR-BC02; LV, lateral view.
- 6 USNM 594147, PS2179-3, 9–10cm; RV, lateral view.
- 7 USNM 594148, PS2179-3, 9–10cm; LV, lateral view.

8 *Cytheropteron lanceae* n. sp., USNM 594149, NP-26/32, 2.5–5.0cm; RV, lateral view.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Cytheropteron perlaria Hao 1988 (in Ruan and Hao 1988)
Plate 8, figures 1–8

Cytheropteron testudo Sars. – WHATLEY and COLES 1987, pl. 3, fig. 1. – COLES et al. 1996, pl. 3, figs. 10–11. – WHATLEY et al. 1996, pl. 3, figs. 2–3. – WHATLEY et al. 1998, pl. 2, figs. 14–15. – DIDIÉ and BAUCH 2000, pl. 2, fig. 12. – ZHAO et al. 2000, p. 266, pl. 1, figs. 23–24. – CRONIN et al. 2002, fig. 2I. – HOU and GOU, p. 290, pl. 120, figs. 9–10.
Cytheropteron perlaria HAO 1988 (in Ruan and Hao 1988), p. 280, pl. 47, figs. 4–9. – SWANSON and AYRESS 1999, p. 155, pl. 1, figs. 7–13, pl. 2, figs. 1–3. – ? AYRESS et al. 2004, p. 29, pl. 3, figs. 7–8. – STEPANOVA 2006, p. S163, pl. 3. – BERGUE et al. 2006, fig. 7I. – BERGUE and COIMBRA 2008, p. 130, pl. 6, fig. 15. – ALVAREZ ZARIKIAN 2009, p. 4, pl. P3, figs. 1–2. – YASUHARA et al. 2009, p. 904, pl. 7, figs. 12–13.

Dimensions: See Table 2.

Remarks: Comprehensive synonymy of *Cytheropteron perlaria* Hao 1988 is found in Swanson and Ayress (1999), Stepanova (2006), and Yasuhara et al. (2009) and supplemented here. This species is distinguished from *Cytheropteron testudo* Sars 1869, by having much more elongate and triangular lateral outline (see Swanson and Ayress 1999 for detail). There are no reliable records of *Cytheropteron testudo* from the Arctic Ocean. *Cytheropteron perlaria* has global distribution as seen in the synonym list.

MAOD taxonomic category: Cytheropteron testudo Sars 1869

Cytheropteron pseudoinflatum Whatley and Eynon 1996
Plate 10, figures 6–9; plate 11, figures 1–2

Cytheropteron pseudoinflatum WHATLEY and EYNON 1996, p. 196, pl. 1, figs. 6–11. – WHATLEY et al. 1996, pl. 2, figs. 8, 10, 11. – WHATLEY et al. 1998, pl. 2, figs. 7–8.

Dimensions: See Table 2.

Remarks: Our specimens have better developed reticulation especially on the ala and, in several specimens, on anterior half compared to the type and other specimens of *Cytheropteron pseudoinflatum* Whatley and Eynon 1996 reported from the Greenland Sea (Whatley et al. 1996, 1998; Whatley and Eynon 1996), but otherwise identical. We consider this difference as intraspecific variation.

MAOD taxonomic category: Cytheropteron pseudoinflatum Whatley and Eynon 1996

Cytheropteron scoresbyi Whatley and Eynon 1996
Plate 9, figures 7–9; plate 10, figure 2

Cytheropteron scoresbyi WHATLEY and EYNON 1996, p. 196, pl. 2, figs. 1–6. – WHATLEY et al. 1996, pl. 3, fig. 1. – WHATLEY et al. 1998, pl. 2, figs. 6, 10.

Dimensions: See Table 2.

Remarks: Cytheropteron laptevensis Stepanova 2004 is distinguished from *Cytheropteron scoresbyi* Whatley and Eynon 1996, by having more subquadrate outline, coarser reticulation, and different shape of ala. *Cytheropteron sedovi* Schneider, 1962 is easily distinguished from *Cytheropteron scoresbyi*, by having much larger size, large spine on apex of ala, anterior marginal spines, well developed carinae in dorsal margin and posterior one third.

MAOD taxonomic category: Cytheropteron carolinae Whatley and Coles 1987

Cytheropteron aielloi Yasuhara, Okahashi and Cronin 2009
Plate 10, figures 1, 3

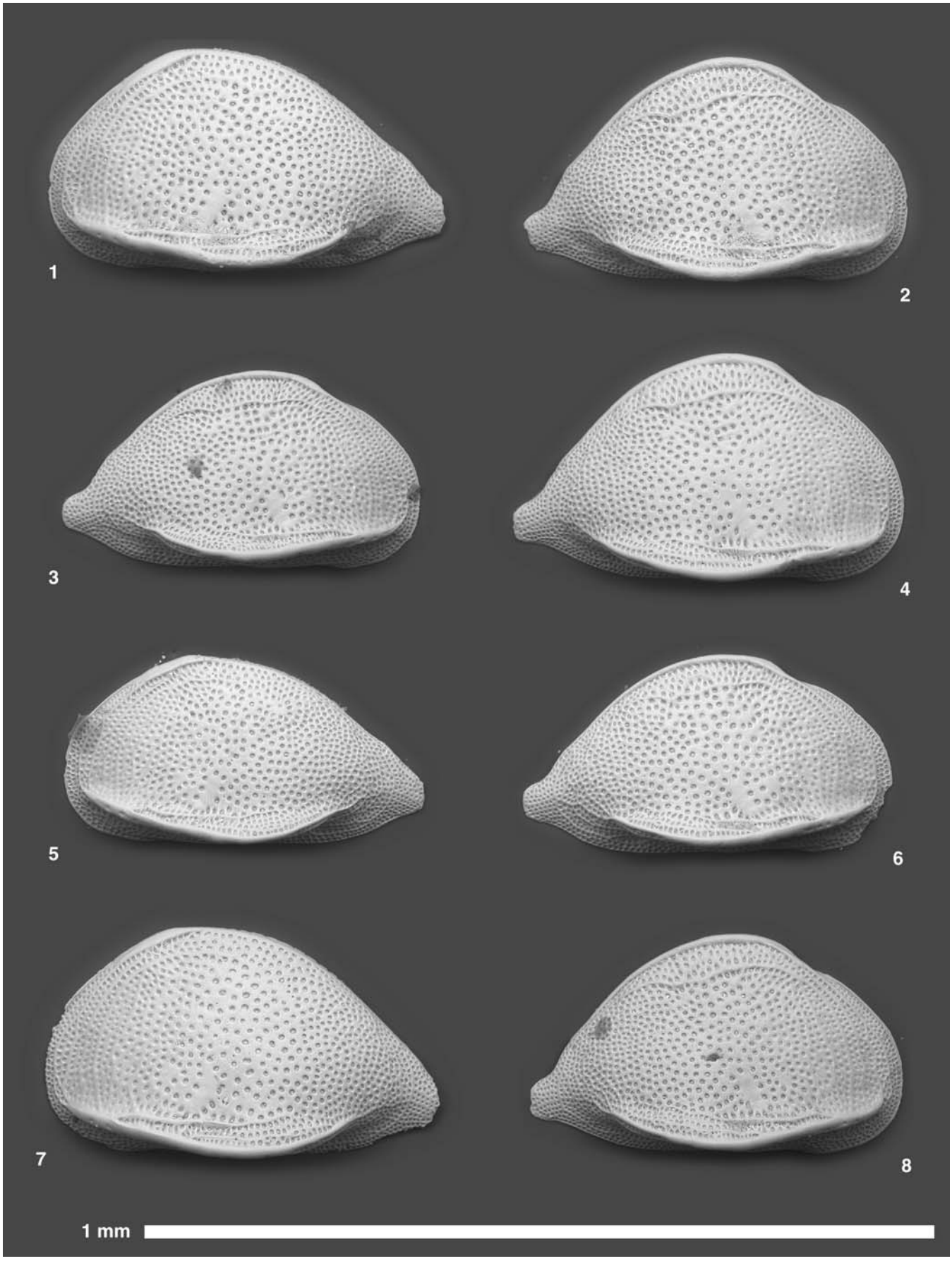
Cytheropteron aielloi YASUHARA, OKAHASHI and CRONIN 2009, p. 898, pl. 10, figs. 3–6.
Cytheropteron sedovi Schneider 1969 [sic. correctly 1962]. – WHATLEY et al. 1996, pl. 2, fig. 15–17. – WHATLEY et al. 1998, pl. 2, figs. 11–12.

Dimensions: See Table 2.

Remarks: Cytheropteron aielloi Yasuhara, Okahashi and Cronin 2009 is very similar to *Cytheropteron scoresbyi* Whatley and Eynon 1996, but distinguished by having less slender outline, less prominent caudal process, much less developed of secondary reticulation especially in dorsal margin and anterior half, and less downturned ala. *Cytheropteron sedovi* Schneider 1969 sensu Whatley et al. (1996, 1998) is identical to this species. Although morphological differences between *Cytheropteron aielloi* and *Cytheropteron scoresbyi* are rather subtle, we prefer to consider them as separate species, waiting further research.

PLATE 8
All SEM images and adult specimens. Scale bar represents 1mm.

1–8 *Cytheropteron perlaria* Hao 1988.
1 USNM 594150, PS1905-1; LV, lateral view.
2 USNM 594151, PS1698-2; RV, lateral view.
3 USNM 594152, NP-19/18; RV, lateral view.
4 USNM 594153, NP-19/18; RV, lateral view.
5 USNM 594154, NP-19/19; LV, lateral view.
6 USNM 594155, NP-19/19; RV, lateral view.
7 USNM 594156, NP-19/19; LV, lateral view.
8 USNM 594157, NP-19/19; RV, lateral view.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MAOD taxonomic category: Cytheropteron carolinae Whatley and Coles 1987

Cytheropteron lanceae Yasuhara, Stepanova, Okahashi, Cronin and Brouwers, **n. sp.**
Plate 7, figure 8; Text-figures 2.5–2.6

Etymology: From Latin lanceae (genitive noun) = lance, with reference to a very long spine on apex of ala of this species.

Holotype: Adult RV, USNM 594149 (Pl. 7, fig. 8).

Paratypes: USNM 594255, USNM 594256.

Type locality and Horizon: NP-26/32, 2.5–5.0cm (79.4000ºN, 178.0800ºW, 1610m water depth, Quaternary).

Dimensions: See Table 2.

Diagnosis: Moderate-sized *Cytheropteron* species with a very long spine on apex of ala and weak surface reticulation.

Description: Carapace moderately calcified, relatively small, highest at middle. Outline subrhomboidal in lateral view; anterior margin rounded; caudal process prominent, upturned; dorsal margin slightly arched; ala well developed downward, extending below ventral margin, having a very long spine at its apex. Anterodorsal and posterodorsal margins without cardinal angles. Lateral surface partially ornamented with shallow primary and secondary reticulation especially in the central part in lateral view. Internal features as for genus.

Remarks: Cytheropteron lanceae n. sp. is distinguished from *Cytheropteron parahamatum* n. sp., and *Cytheropteron irizukii* n. sp. by having much more slender outline and a very long spine on apex of the ala. *Cytheropteron lanceae* n. sp. is distinguished from *Cytheropteron sedovi* Schneider, 1962, by having much more slender outline, comparatively weakly calcified valve, very long spine on apex of ala, and much weaker surface ornamentation.

MAOD taxonomic category: Cytheropteron carolinae Whatley and Coles 1987?

Cytheropteron irizukii Yasuhara, Stepanova, Okahashi, Cronin and Brouwers, **n. sp.**
Plate 9, figures 5–6

Etymology: In honor of Toshiaki Irizuki, Shimane University, for his work on circumpolar ostracods.

Holotype: Adult RV, USNM 594163 (Pl. 9, fig. 6).

Paratype: USNM 594162.

Type locality and Horizon: PS2189-1, 0–1cm (88.7817ºN, 144.1833ºE, 1018m water depth, Recent).

Dimensions: See Table 2.

Diagnosis: Moderate-sized *Cytheropteron* species with punctate carapace and acuminate and downward pointing ala with a sharp spine at its apex.

Description: Carapace moderately calcified, relatively small, highest at middle. Outline subrhomboidal in lateral view; anterior margin rounded; caudal process prominent, upturned; dorsal margin arched, slightly sinuous; ala acuminate, well developed downward, extending below ventral margin, having a sharp, long spine at its apex. Anterodorsal and posterodorsal margins without cardinal angles. Lateral surface punctate in the central part; weak carinae developed in posterior third; primary and secondary reticulation developed in posterodorsal area. Internal features as for genus.

Remarks: *Cytheropteron irizukii* n. sp. is similar to *Cytheropteron porterae* Whatley and Coles 1987 sensu Whatley et al. 1996, but the former's ala is acuminate, is well developed downward, extends below ventral margin, and has a sharp and long spine at its apex.

MAOD taxonomic category: Cytheropteron porterae Whatley and Coles 1987

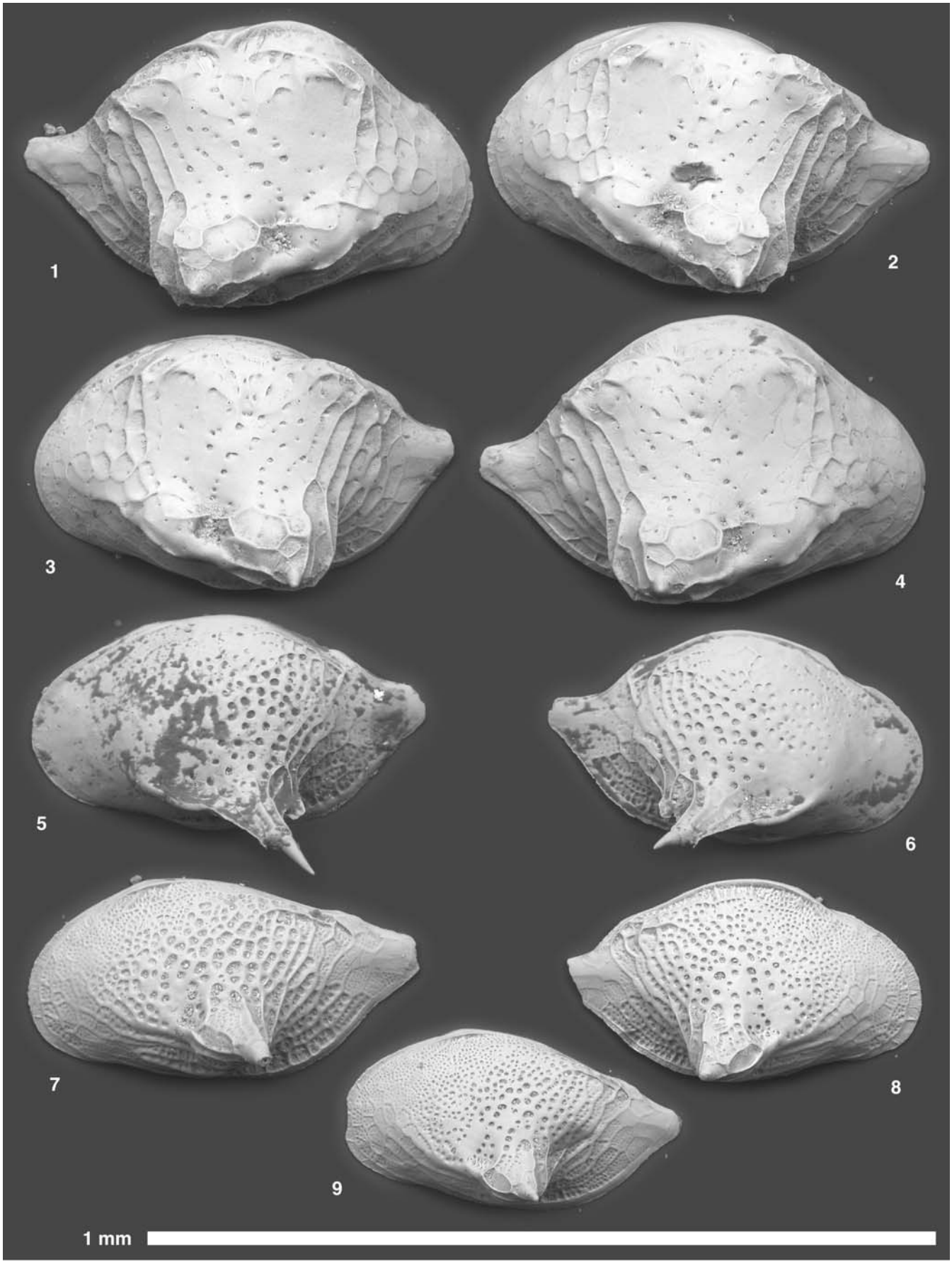
Genus ***Eucytherura*** Müller 1894
Type species: Eucytherura complexa (Brady 1867) (=*Cythere complexa* Brady 1867) (designated by Alexander 1936)

PLATE 9
All SEM images and adult specimens. Scale bar represents 1mm.

1–4 *Cytheropteron groenlandicum* Whatley and Eynon 1996.
- 1 USNM 594158, PS1905-1; RV, lateral view.
- 2 USNM 594159, PS1698-2; LV, lateral view.
- 3 USNM 594160, NP-19/19; LV, lateral view.
- 4 USNM 594161, NP-19/19; RV, lateral view.

5–6 *Cytheropteron irizukii* n. sp.
- 5 USNM 594162, PS2189-1, 0–1cm; LV, lateral view.
- 6 USNM 594163, PS2189-1, 0–1cm; RV, lateral view.

7–9 *Cytheropteron scoresbyi* Whatley and Eynon 1996.
- 7 USNM 594164, Pl-91-AR-BC02; LV, lateral view.
- 8 USNM 594165, Meteor 23454-2; RV, lateral view.
- 9 USNM 594166, Meteor 23454-2; LV, lateral view.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Eucytherura delineata Whatley and Eynon 1996
Plate 11, figures 3–6

Eucytherura delineata WHATLEY and EYNON 1996, p. 198, pl. 2, figs. 7–11. – WHATLEY et al. 1996, pl. 3, figs. 7–8. – WHATLEY et al. 1998, pl. 2, figs. 20–21.

Dimensions: See Table 2.

Remarks: This is the first certain record of this species with SEM images from the central Arctic.

MAOD taxonomic category: Eucytherura delineata Whatley and Eynon 1996.

Genus ***Pedicythere*** Eagar 1965
Type species: Pedicythere tessae Eagar 1965

Pedicythere neofluitans Joy and Clark 1977
Plate 11, figures 7–10

Pedicythere neofluitans JOY and CLARK 1977, p. 138, pl. 1, figs. 18–20. – SCHORNIKOV 2005, p. 212, fig. 8n.

Dimensions: See Table 2.

MAOD taxonomic category: Pedicythere neofluitans Joy and Clark 1977

Pedicythere arctica Yasuhara, Stepanova, Okahashi, Cronin and Brouwers, **n. sp.**
Plate 12, figures 1–2

Etymology: For the type locality.

Holotype: Adult RV, USNM 594186 (Pl. 12, fig. 1).

Paratype: USNM 594187.

Type locality and Horizon: PS2202-2, 0–1cm (85.1067ºN, 14.1261ºW, 1083m water depth, Recent).

Dimensions: See Table 2.

Diagnosis: *Pedicythere* species with very large, thick, continuous dorsomarginal frill and a row of pits along dorsal margin.

Description: Carapace thin, small, highest at anterior cardinal angle. Outline subtriangular in lateral view; anterior margin rounded, bearing five short feather-like spines and a ventral frill; caudal process prominent and upturned, bearing a long, feather-like caudal spur; dorsal margin slightly concave, bearing very large, thick, continuous frill. Ala extending below ventral margin, its anterior edge bearing a blade-like carina; its apex bearing a long spine; posteroproximal edge of ala bearing three feather-like processes; two fine carinae running along ala. Anterodorsal margin angular; posterodorsal margin straight. Lateral surface almost smooth; bearing a row of pits along dorsal margin; a thin carina running along posterior margin. Internal features as for genus.

Remarks: This species is distinguished from other species by having very large, thick, continuous dorsomarginal frill, a row of pits along dorsal margin, and three feather-like processes at posteroproximal edge of ala (e.g., see Schornikov 2005). See Schornikov (2005) for terminology for this genus.

MAOD taxonomic category: Pedicythere neofluitans Joy and Clark 1977?

Family EUCYTHERIDAE Puri 1954

Genus ***Eucythere*** Brady 1868
Type species: Eucythere declivis (Norman 1865) (=*Cythere declivis* Norman 1865) (designated by Brady and Norman 1889; see Horne and Whittaker 1985 for details and lectotype)

Eucythere argus (Sars 1866)
Plate 12, figure 3

Cytheropsis argus SARS 1866, p. 58.
Eucythere argus (Sars). – SARS 1925, p. 162, pl. 75, fig. 1. – CRONIN 1981, p. 396, pl. 4, figs. 3–4, 6. – HORNE and ROSENFELD 1986, p. 71, pls. 13-72, 13-74, text-fig. 1. – ATHERSUCH et al. 1989, p. 90, text-fig. 31, pl. 2, fig. 9. – BROUWERS 1990, p. 34, pl. 10, figs. 16, 17, pl. 11, fig. 7, pl. 12, figs. 1–6. – WHATLEY et al. 1998, pl. 2, fig. 22. – STEPANOVA 2006, p. S183, pl. 5, figs. 15–16. – FRENZEL et al. 2010, pl. OS1-2, fig. M (in Supporting Information online).

Dimensions: See Table 2.

Remarks: Our specimen is very similar to *Eucythere argus* (Sars 1866), but is higher in proportion to its length, even compared

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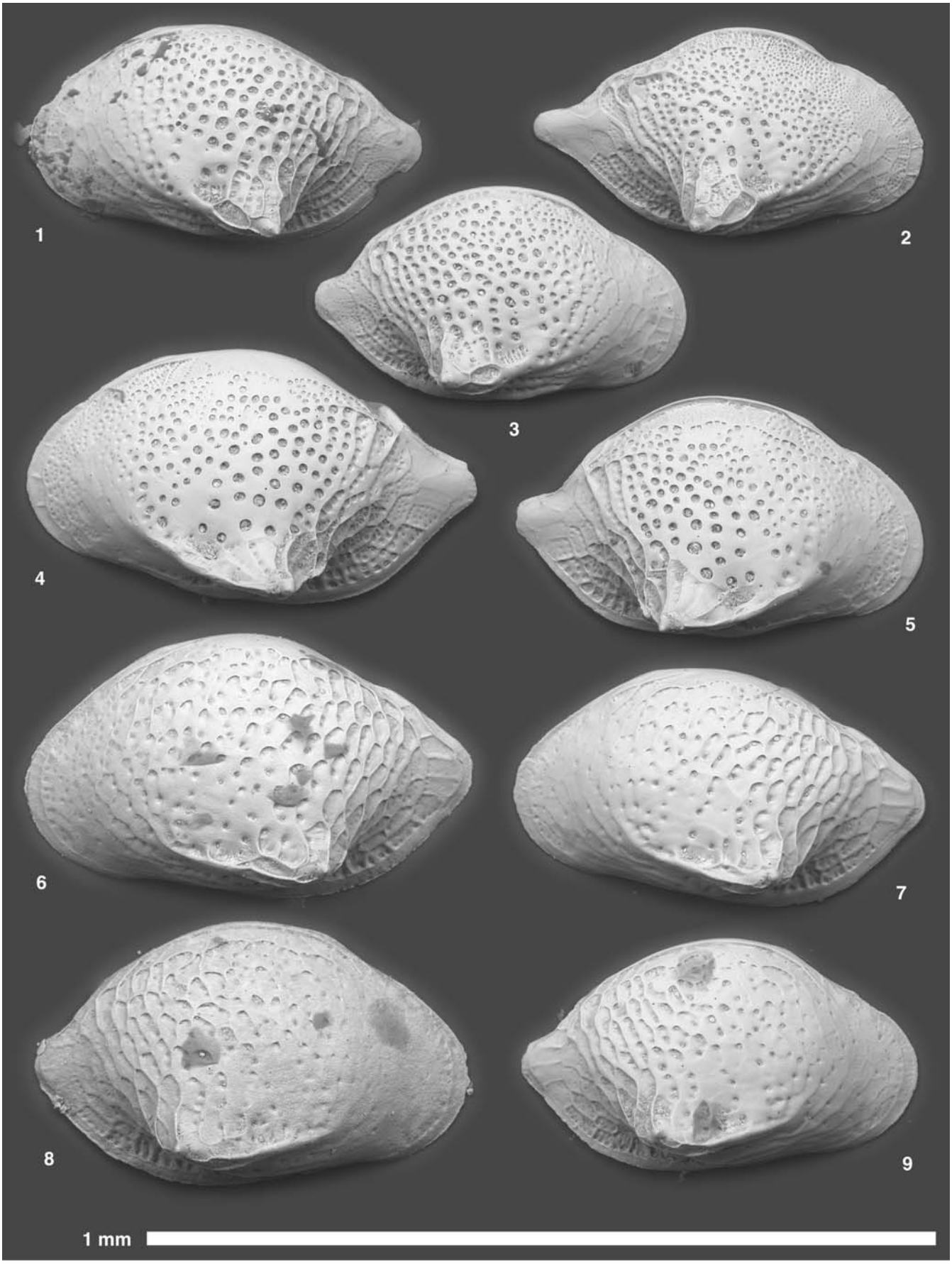
PLATE 10
All SEM images and adult specimens. Scale bar represents 1mm.

1, 3 *Cytheropteron aielloi* Yasuhara, Okahashi and Cronin 2009.
1 USNM 594167, PS2189-1, 0–1cm; LV, lateral view.
3 USNM 594169, PS1913-5, 0–2cm; RV, lateral view.

2 *Cytheropteron scoresbyi* Whatley and Eynon 1996, USNM 594168, Meteor 23453-1; RV, lateral view.

4–5 *Cytheropteron carolinae* Whatley and Coles 1987.
4 USNM 594170, Meteor 23453-1; LV, lateral view.
5 USNM 594171, Meteor 23453-1; RV, lateral view.

6–9 *Cytheropteron pseudoinflatum* Whatley and Eynon 1996.
6 USNM 594172, PS2200-5, 123cm; LV, lateral view.
7 USNM 594173, Meteor 23453-1; LV, lateral view.
8 USNM 594174, PS2200-5, 123cm; RV, lateral view.
9 USNM 594175, Meteor 23453-1; RV, lateral view.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to female *Eucythere argus*. The specimen also lacks large sieve-type pores, although it may be preservation artifact. However, Brouwers (1990) pointed out large intraspecific variation of this species. Furthermore, we found only one specimen in the present study. Thus we tentatively consider that our specimen falls within intraspecific variation of this species. Comprehensive synonymy of this species is found in Stepanova (2006) and Horne and Rosenfeld (1986).

MAOD taxonomic category: Eucythere argus (Sars 1866)

Family KRITHIDAE Mandelstam 1958 (*in* Bubikyan 1958)

Genus ***Krithe*** Brady, Crosskey and Robertson 1874
Type species: Krithe praetexta (Sars 1866) (=*Ilyobates praetexta* Sars 1866)

Krithe hunti Yasuhara, Stepanova, Okahashi, Cronin and Brouwers, **n. sp.**
Plate 13, figures 1–11; plate 14, figures 1–11

non *Krithe glacialis* BRADY et al. 1874. – non ROBINSON 1978, pl. 6, fig. 8. – non BROUWERS 1994, figs. 11.7–1.8. – non WHATLEY et al. 1996, pl. 3, figs. 13–16. – non WHATLEY et al. 1998, pl. 3, figs. 5–6, text-figs. 7.1–7.4. – in part STEPANOVA 2006, p. S185, pl. 6, figs. 2–3 (non pl. 5, fig. 21, pl. 6, figs. 1, 4–5).
Krithe sp. A WHATLEY et al. 1998, figs. 7.7–7.8.
Krithe sp. B WHATLEY et al. 1998, figs. 8.1–8.4.
? *Krithe* sp. C WHATLEY et al. 1998, figs. 8.5–8.6.
? *Krithe* sp. D WHATLEY et al. 1998, fig. 8.7.
? *Krithe* sp. E WHATLEY et al. 1998, fig. 8.8.
Krithe cf. *pernoides* (Bornemann). – CRONIN 1996, p. 279, fig. 7b.
Krithe "bartonensis" (Jones). – JOY and CLARK 1977, p. 139, pl. 1, figs. 4–7.

Etymology: In honor of Gene Hunt, Smithsonian Institution, for his work on deep-sea ostracods.

Holotype: Adult male LV, USNM 594194 (Pl. 13, fig. 1).

Paratypes: USNM 594195, USNM 594196, USNM 594197, USNM 594198, USNM 594199, USNM 594200, USNM 594201, USNM 594202, USNM 594203, USNM 594204, USNM 594205, USNM 594206, USNM 594207, USNM 594208, USNM 594209, USNM 594210, USNM 594211, USNM 594212, USNM 594213, USNM 594214, USNM 594215.

Type locality and Horizon: Meteor 23454-2 (76.7497ºN, 11.75ºW, 2126m water depth, Recent).

Dimensions: See Table 2.

Diagnosis: *Krithe* species with relatively weakly calcified carapace, slightly sinuous anterodorsal margin in RV, and gradually tapering and then truncated posterior margin.

Description: Carapace weakly calcified, large. Outline elongate and subrectangular in lateral view; anterior margin evenly rounded; posterior margin gradually tapering and then truncated; dorsal and ventral margins straight in LV; anterodorsal margin slightly sinuous in RV; ventral margin straight in RV. Anterodorsal and posterodorsal corners slightly angular. Lateral surface smooth.

Remarks: This species is identical to *Krithe* sp. A and *Krithe* sp. B of Whatley et al. (1998), and most likely also to *Krithe* sp. C, *Krithe* sp. D, and *Krithe* sp. E of Whatley et al. (1998). *Krithe* cf. *pernoides* of Cronin (1996) is also identical to this species. *Krithe "bartonensis"* (Jones) of Joy and Clark (1977) is a juvenile of this species.

This species is widely reported from deep Arctic without image as *Krithe* cf. *pernoides* (Cronin et al. 1995) or as *Krithe glacialis* Brady, Crosskey and Robertson, 1874 (MAOD; Briggs 1997). True *Krithe glacialis* is distinguished from this species, by having less sinuous anterodorsal margin in RV, much smaller size and comparatively blunt posterior margin. Our comparison is based on Brady et al. (1874), Robinson (1978), and Whatley et al. (1996, 1998), which we consider as reliable records of *Krithe glacialis*.

Internal features of this species were shown by line drawings of *Krithe* sp. A and *Krithe* sp. B in Whatley et al. (1998, figs. 7–8). According to these figures, anterior inner lamella well developed, with a long anterodorsal marginal pore; vestibule mush-

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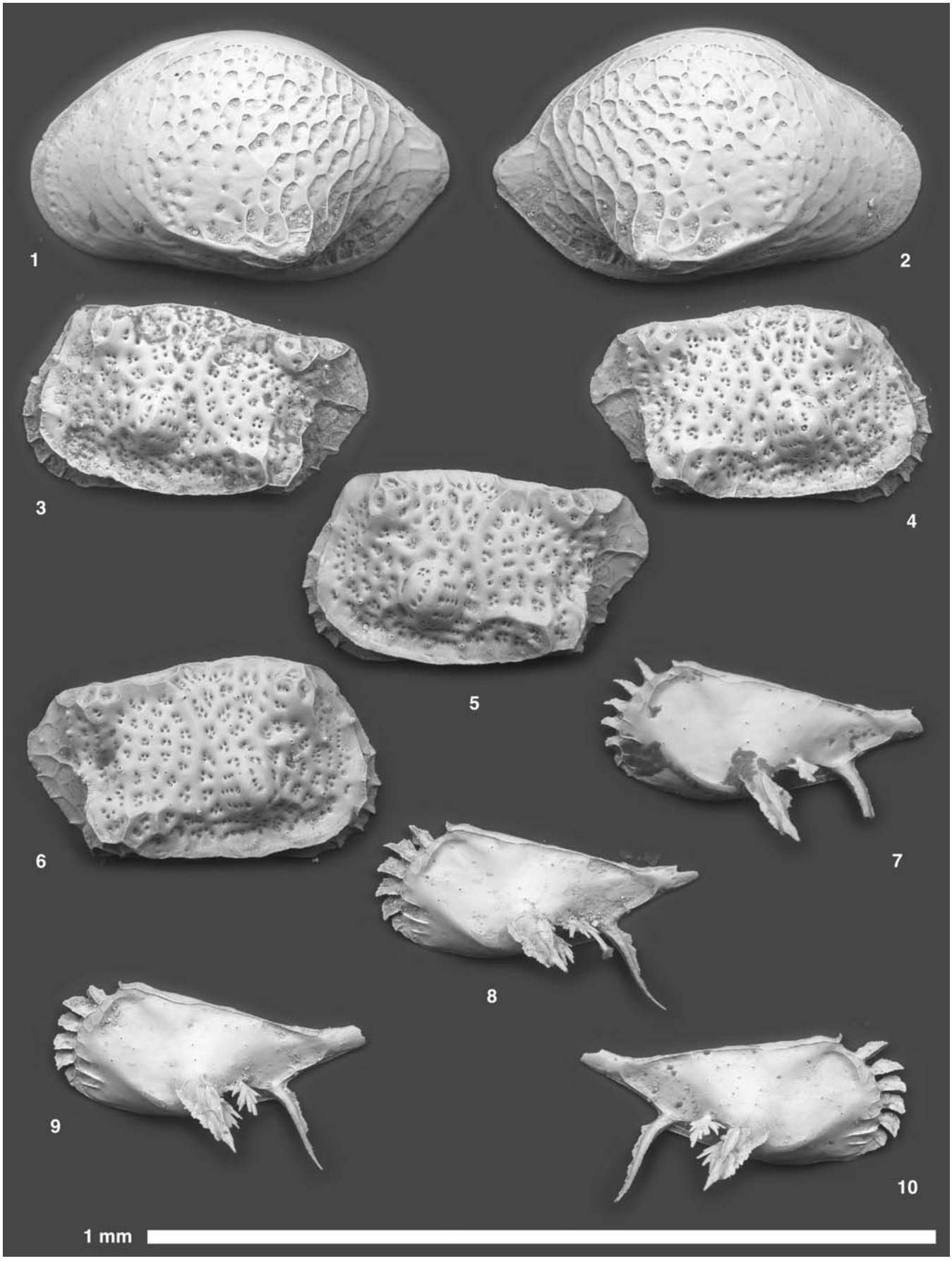
PLATE 11
All SEM images and adult specimens. Scale bar represents 1mm.

1–2 *Cytheropteron pseudoinflatum* Whatley and Eynon 1996.
1 USNM 594176, Meteor 23455-2; LV, lateral view.
2 USNM 594177, Meteor 23455-2; RV, lateral view.

3–6 *Eucytherura delineata*, Whatley and Eynon 1996.
3 USNM 594178, PS2202-2, 0–1cm; LV, lateral view.
4 USNM 594179, PS2202-2, 0–1cm; RV, lateral view.
5 USNM 594180, NP-19/20; LV, lateral view.
6 USNM 594181, NP-19/20; RV, lateral view.

7–10 *Pedicythere neofluitans*, Joy and Clark 1977.
7 USNM 594182, PS2186-5, 0–1cm; LV, lateral view.
8 USNM 594183, PS2189-1, 0–1cm; LV, lateral view.
9 USNM 594184, PS2189-1, 0–1cm; LV, lateral view.
10 USNM 594185, PS2202-2, 0–1cm; RV, lateral view.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1 mm

room shaped. Posterior inner lamella well developed in its ventral half. Hingement adont. Subcentral muscle scars consist of a trilobate frontal scar and vertical row of four adductor scars. Adult female and male specimens along with A-5–A-1 juvenile specimens are shown here.

MAOD taxonomic category: Krithe glacialis Brady, Crosskey and Robertson 1874 (most likely in part)

Krithe minima Coles, Whatley and Moguilevsky 1994
Plate 14, figures 12–25

Krithe minima COLES, WHATLEY and MOGUILEVSKY 1994, p. 88, pl. 2, figs. 16–18, pl. 3, figs. 1–5, text-figs. 3EE–3JJ. – CRONIN 1996, p. 279, fig. 8a. – WHATLEY et al. 1998, fig. 7.5–7.6. – ? AYRESS et al. 1999, p. 8, figs. 2C, 3K–3L, 8I–8J.

Dimensions: See Table 2.

Remarks: Adult female and male specimens along with juvenile A-3–A-1 specimens are shown. *Krithe minima* Coles, Whatley and Moguilevsky 1994 is easily distinguished from *Krithe hunti* n. sp., by having much more slender outline and smaller size.

MAOD taxonomic category: Krithe minima Coles, Whatley and Moguilevsky 1994

Family LEPTOCYTHERIDAE Hanai 1957

Genus ***Cluthia*** Neale 1973
Type species: Cluthia cluthae (Brady, Crosskey and Robertson 1874) (=*Cythere cluthae* Brady, Crosskey and Robertson 1874)

Cluthia whatleyi Yasuhara, Stepanova, Okahashi, Cronin and Brouwers, **n. sp.**
Plate 12, figures 4–8

Nannocythere sp. WHATLEY et al. 1998, pl. 3, figs. 9–10.
? *Nannocythere* sp. DIDIÉ and BAUCH 2000, pl. 4, fig. 25.
Nannocythere delicata [nomen nudum]. – CRONIN et al. 1995, p. 265. – SIRENKO 2001, p. 101.

Etymology: In honor of, Robin C. Whatley, University of Wales, Aberystwyth, who first recognized this species.

Holotype: Adult LV, USNM 594189 (Pl. 12, fig. 4).

Paratypes: USNM 594190, USNM 594191, USNM 594192, USNM 594193.

Type locality and Horizon: NP-19/20 (83.145ºN, 16.29ºW, 1010m water depth, Recent).

Dimensions: See Table 2.

Diagnosis: *Cluthia* species with regular punctation and without nodes and ventrolateral ridge.

Description: Carapace moderately calcified, small, highest at anterior cardinal angle. Outline subtriangular in lateral view; anterior margin evenly rounded, smooth; posterior margin truncated; dorsal margin almost straight; ventral margin slightly sinuous. Anterodorsal and posterodorsal corners obtuse-angular. Lateral surface punctate.

Inner lamella broad. Hingement holomerodont; anterior and posterior terminal teeth in RV crenate; median hinge bar in RV may be crenate; ventral ridge of median hinge socket in LV crenate especially in anterior half. Frontal scar J-shaped; adductor muscle scars consisting of vertical row of four scars, median two scars elongate. Internal snap-knob structure present at mid-length ventrally.

Remarks: This species has been assigned to *Nannocythere* Schäfer 1953 (type species *Bythocythere pavo* Malcomson 1886 = *Nannocythere remanei* Schäfer 1953), but *Nannocythere* has gongylodont hinge (Athersuch and Horne 1983). This species is distinguished from *Cluthia cluthae* (Brady, Crosskey and Robertson 1874), by having regular punctation and lacking nodes and ventrolateral ridge. Internal details of this species are very similar to those of *Cluthia cluthae* (the type species of this genus), including J-shaped frontal scar, holomerodont hinge with crenate ventral ridge of median hinge socket in LV, and snap-knob structure (Neale 1973), which strongly support that this species belongs to *Cluthia*.

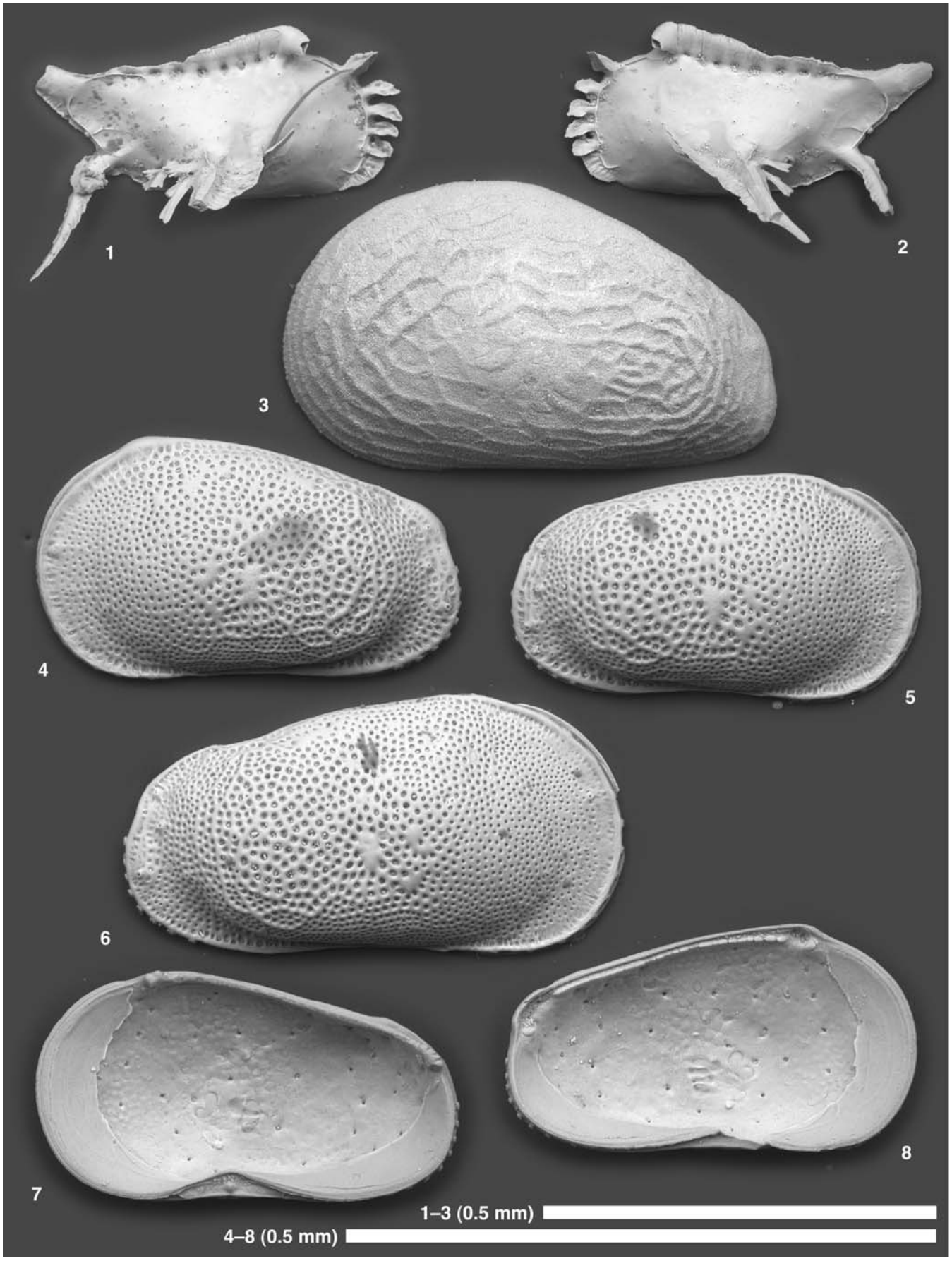
MAOD taxonomic category: Nannocythere sp.

PLATE 12
All SEM images and adult specimens. Scale bars represent 0.5mm.

1–2 *Pedicythere arctica* n. sp.
1 USNM 594186, PS2202-2, 0–1cm; RV, lateral view.
2 USNM 594187, NP-19/19; LV, lateral view.

3 *Eucythere argus* (Sars 1866), USNM 594188, NP26 sta 5, 78–80cm; LV, lateral view.

4–8 *Cluthia whatleyi* n. sp.
4 USNM 594189, NP-19/20; LV, lateral view.
5 USNM 594190, NP-19/20; RV, lateral view.
6 USNM 594191, PS2202-2, 0–1cm; RV, lateral view.
7 USNM 594192, NP-19/10; RV, internal view.
8 USNM 594193, NP-19/10; LV, internal view.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1–3 (0.5 mm)
4–8 (0.5 mm)

Family PARADOXOSTOMATIDAE Brady and Norman 1889

Genus ***Acetabulastoma*** Schornikov 1970
Type species: Acetabulastoma littorale Schornikov 1970

Acetabulastoma arcticum Schornikov 1970
Plate 15, figures 1–3

Acetabulastoma arcticum SCHORNIKOV 1970, p. 1135, text-fig. 3. CRONIN 1996, p. 273, fig. 4a. – DIDIÉ and BAUCH 2001, pl. 1, figs. 13–15 (as erratum for Didié and Bauch 2000). – CRONIN et al. 2010, fig. 2.

Dimensions: See Table 2.

Remarks: This species is known as ectoparasite of sea-ice associate amphipods and thus as an important paleo-sea-ice proxy (Cronin et al. 2010a; Cronin et al. 2013 in press).

MAOD taxonomic category: Acetabulastoma arcticum Schornikov 1970

Genus ***Paracytherois*** Müller 1894
Type species: Paracytherois striata Müller 1894 (Designated by Howe 1955)

Paracytherois chukchiensis Joy and Clark 1977
Plate 15, figures 5–6

Paracytherois chukchiensis JOY and CLARK 1977, p. 141, pl. 1, figs. 12–14.

Dimensions: See Table 2.

Remarks: The SEM images of *Paracytherois chukchiensis* in Joy and Clark (1977) are not very good in quality and seem to be deformed. *Paracytherois bondi* Yasuhara et al. 2009 is very similar to *Paracytherois chukchiensis* by having lateral surface covered with very fine, horizontal striations, but distinguished by having down-turned anterior margin and more acuminate posterior margin.

MAOD taxonomic category: Paracytherois chukchiensis Joy and Clark 1977

Genus Uncertain

Paradoxostomatid sp. 1
Plate 15, figure 4

Dimensions: See Table 2.

MAOD taxonomic category: Paradoxostoma spp. ?

Family MICROCYTHERIDAE Klie 1938

Genus *Microcythere* Müller 1894
Type species: Microcythere inflexa Müller 1894 (designated by van den Bold 1946)

Microcythere medistriata (Joy and Clark 1977)
Plate 15, figures 7–11; plate 16, figures 1–2

Cytheropteron? medistriatum JOY and CLARK 1977, p. 140, p. 2, figs. 10–13.
Microcythere medistriatum (Joy and Clark). – non ALVAREZ ZARIKIAN 2009, pl. P8, figs. 7–8.

Dimensions: See Table 2.

Remarks: This species has been widely reported as *Cytheropteron? medistriatum*, *Microcythere medistriatum* [gender incorrect], or *Microcythere medistriata* from the deep Arctic Ocean, but usually without images (Cronin et al. 1994, 1995; Briggs 1997; Jones et al. 1999). The SEM images of this species in Joy and Clark (1977) seem to be deformed.

MAOD taxonomic category: Microcythere medistriata (Joy and Clark 1977)

PLATE 13
All SEM images and adult specimens. Scale bar represents 1mm.

1–11 *Krithe hunti* n. sp.

1 USNM 594194, Meteor 23454-2; LV, lateral view.

2 USNM 594195, Meteor 23454-2; RV, lateral view.

3 USNM 594196, PS1698-2; LV, lateral view.

4 USNM 594197, PS1707-1; RV, lateral view.

5 USNM 594198, NP-26/32, 2.5–5.0cm; LV, lateral view.

6 USNM 594199, Meteor 23454-2; RV, lateral view.

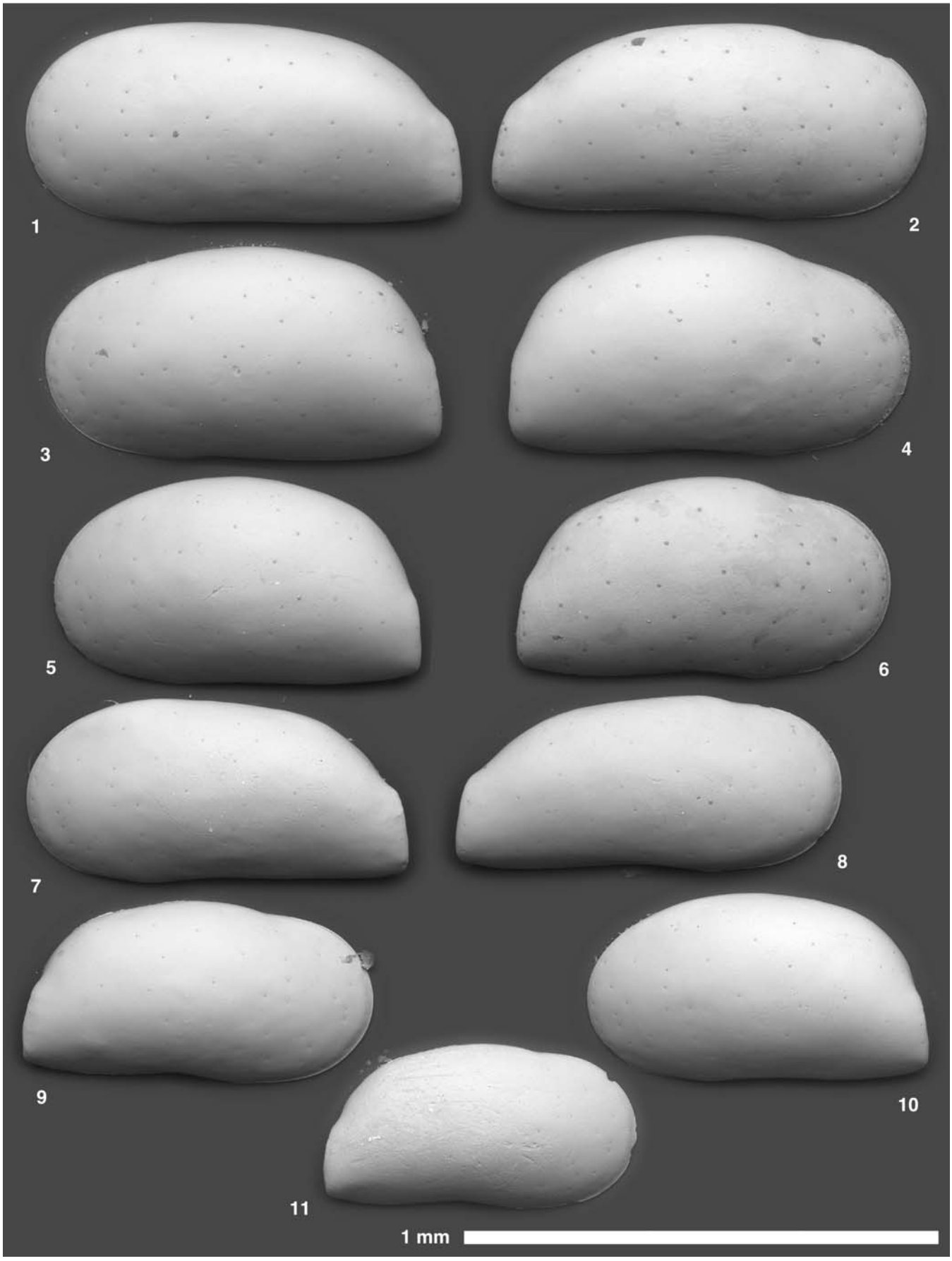
7 USNM 594200, NP-26/32, 2.5–5.0cm; LV, lateral view.

8 USNM 594201, NP-26/32, 8.5–9.5cm; RV, lateral view.

9 USNM 594202, Geomar 23243-1, 63cm; RV, lateral view.

10 USNM 594203, NP-26/32, 2.5–5.0cm; LV, lateral view.

11 USNM 594204, NP-26/32, 78–80cm; RV, lateral view.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Family TRACHYLEBERIDIDAE Sylvester-Bradley 1948

Genus ***Henryhowella*** Puri 1957
Type species: Henryhowella evax (Ulrich and Bassler 1904) (=*Cythere evax* Ulrich and Bassler 1904) (lectotype designated by Forester 1980)

Henryhowella asperrima (Reuss 1850)
Plate 16, figures 3–10

Cypridina asperrima REUSS 1850, p. 74, pl. 10, figs. 5a–5b.
Henryhowella asperrima (Reuss). – MALZ and JELLINEK 1984, pl. 5, figs. 38–39. – KEMPF and NINK 1993, p. 95, figs. 1–30. – CRONIN 1996, p. 273, fig. 7a. – WHATLEY et al. 1998, pl. 3, figs. 20–21. – AIELLO and SZCZECHURA 2004, p. 26, pl. 4, figs. 12–14. – PIRKENSEER and BERGER 2011, p. 54, pl. 7, figs. 6a–6c, 7a–7c, pl. 8, figs. 1a–1c, 2a–2c, 3a–3c.
Henryhowella cf. *asperrima* (Reuss). – YASUHARA et al. 2009, p. 926, pl. 20, fig. 7; pl. 21, figs. 1–4.
Henryhowella asperrima s.l. (Reuss). – UFFENORDE 1981, p. 148, pl. 2, figs. 14–15, 17–19.
Echinocythereis dasyderma (Brady). – JOY and CLARK 1977, p. 142, pl. 2, figs. 14–17.
Henryhowella sp. cf. *H. dasyderma* (Brady). – DIDIÉ and BAUCH 2001 (as erratum for Didié and Bauch 2000), pl. 1, figs. 1–2.

Dimensions: See Table 2.

Remarks: We consider that our specimens fall within intraspecific variation of *Henryhowella asperrima* (Reuss 1850). This species has considerable intraspecific variation in our opinion. Full synonym list and detailed discussion will be available in separate paper. The SEM images of this species in Joy and Clark (1977) seem to be deformed.

MAOD taxonomic category: Henryhowella asperrima (Reuss 1850)

PLATE 14
All SEM images. Scale bar represents 1mm.

1–11 *Krithe hunti* n. sp.
1 USNM 594205, PS2163-2, 0–1cm; LV, adult, lateral view.
2 USNM 594206, NP-26/32, 2.5–5.0cm; LV, A-1, lateral view.
3 USNM 594207, NP-26/32, 2.5–5.0cm; RV, A-1, lateral view.
4 USNM 594208, NP-26/32, 2.5–5.0cm; LV, A-2, lateral view.
5 USNM 594209, NP-26/32, 2.5–5.0cm; RV, A-2, lateral view.
6 USNM 594210, NP-26/32, 2.5–5.0cm; LV, A-3, lateral view.
7 USNM 594211, NP-26/32, 2.5–5.0cm; RV, A-3, lateral view.
8 USNM 594212, NP-26/32, 2.5–5.0cm; LV, A-4, lateral view.
9 USNM 594213, NP-26/32, 2.5–5.0cm; RV, A-4, lateral view.
10 USNM 594214, NP-26/32, 2.5–5.0cm; LV, A-5, lateral view.
11 USNM 594215, NP-26/32, 2.5–5.0cm; RV, A-5, lateral view.

12–25 *Krithe minima* Coles, Whatley and Moguilevsky 1994.
12 USNM 594216, PS1913-5, 0–2cm; RV, A-3, lateral view.
13 USNM 594217, PS1913-5, 0–2cm; LV, A-2, lateral view.
14 USNM 594218, PS1913-5, 0–2cm; RV, A-2, lateral view.
15 USNM 594219, PS1913-5, 0–2cm; LV, A-1, lateral view.
16 USNM 594220, PS1913-5, 0–2cm; RV, A-1, lateral view.
17 USNM 594221, PS1913-5, 0–2cm; LV, adult, lateral view.
18 USNM 594222, Meteor 23455-2; RV, adult, lateral view.
19 USNM 594223, PS2212-6, 6–7cm; LV, adult, lateral view.
20 USNM 594224, PS2179-3, 9–10cm; RV, adult, lateral view.
21 USNM 594225, Geomar 23243-1, 100–101cm; LV, adult, lateral view.
22 USNM 594226, Meteor 23455-2; RV, adult, lateral view.
23 USNM 594227, Geomar 23243-1, 180–181cm; LV, adult, lateral view.
24 USNM 594228, PS2212-6, 6–7cm; LV, adult, lateral view.
25 USNM 594229, PS2179-3, 9–10cm; RV, adult, lateral view.

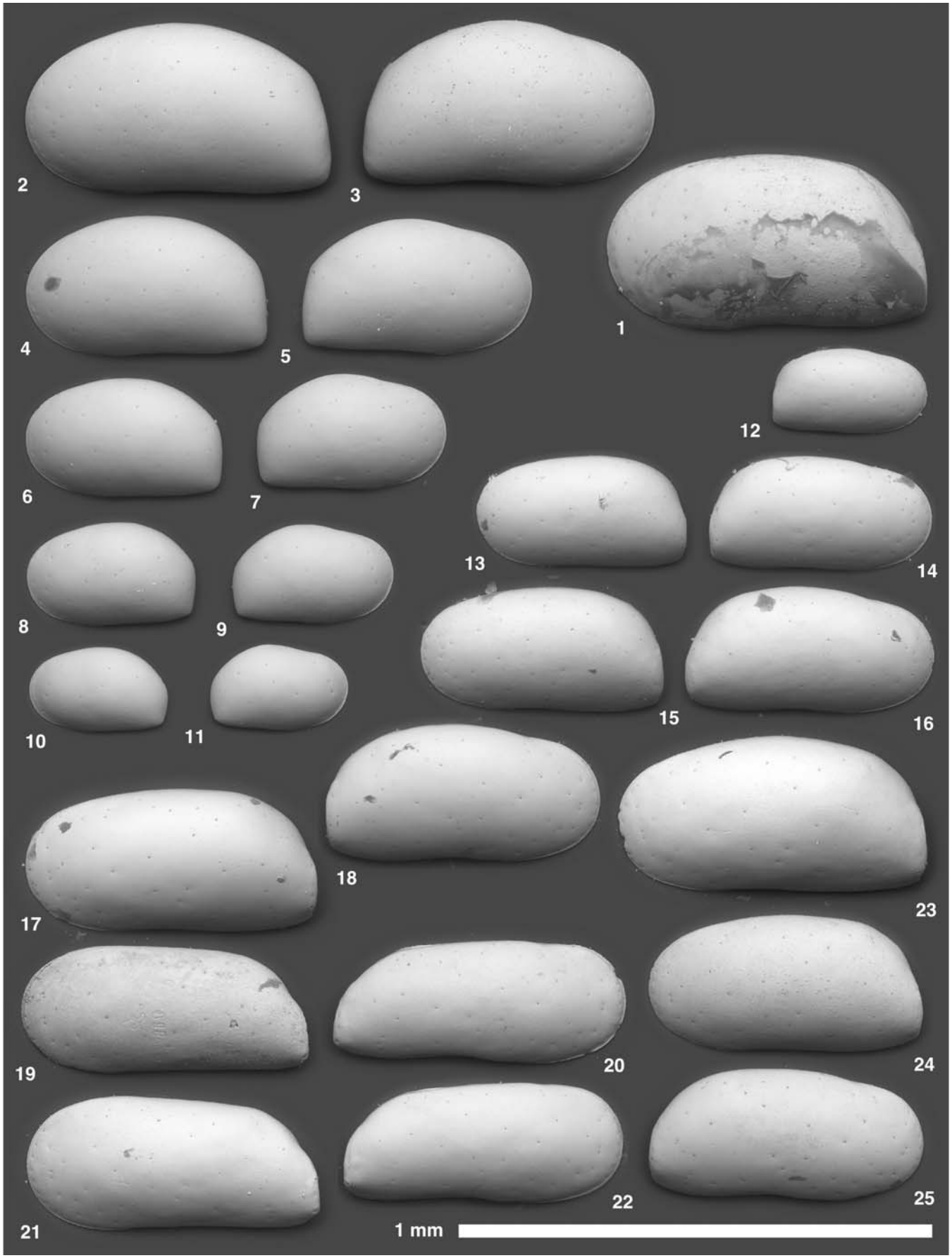
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PLATE 15

All SEM images. Scale bars represent 0.5mm (except scale bar for 5b that represents 50μm).

1–3 *Acetabulastoma arcticum* Schornikov 1970.

1 USNM 594230, PS2189-1, 0–1cm; LV, lateral view.

2 USNM 594231, PS2164-4, 0–1cm; RV, lateral view.

3 USNM 594232, PS2200-5, 183cm; LV, lateral view.

4 Paradoxostomatid sp. 1, USNM 594233, 10/2, 24–26cm; RV, lateral view.

5–6 *Paracytherois chukchiensis* Joy and Clark 1977.

5a–b USNM 594234, PS2200-5, 178cm; RV, adult, lateral view (5a, whole view; 5b, closeup view).

6 USNM 594235, PS2200-5, 178cm; LV, adult, lateral view.

7–11 *Microcythere medistriata* (Joy and Clark 1977).

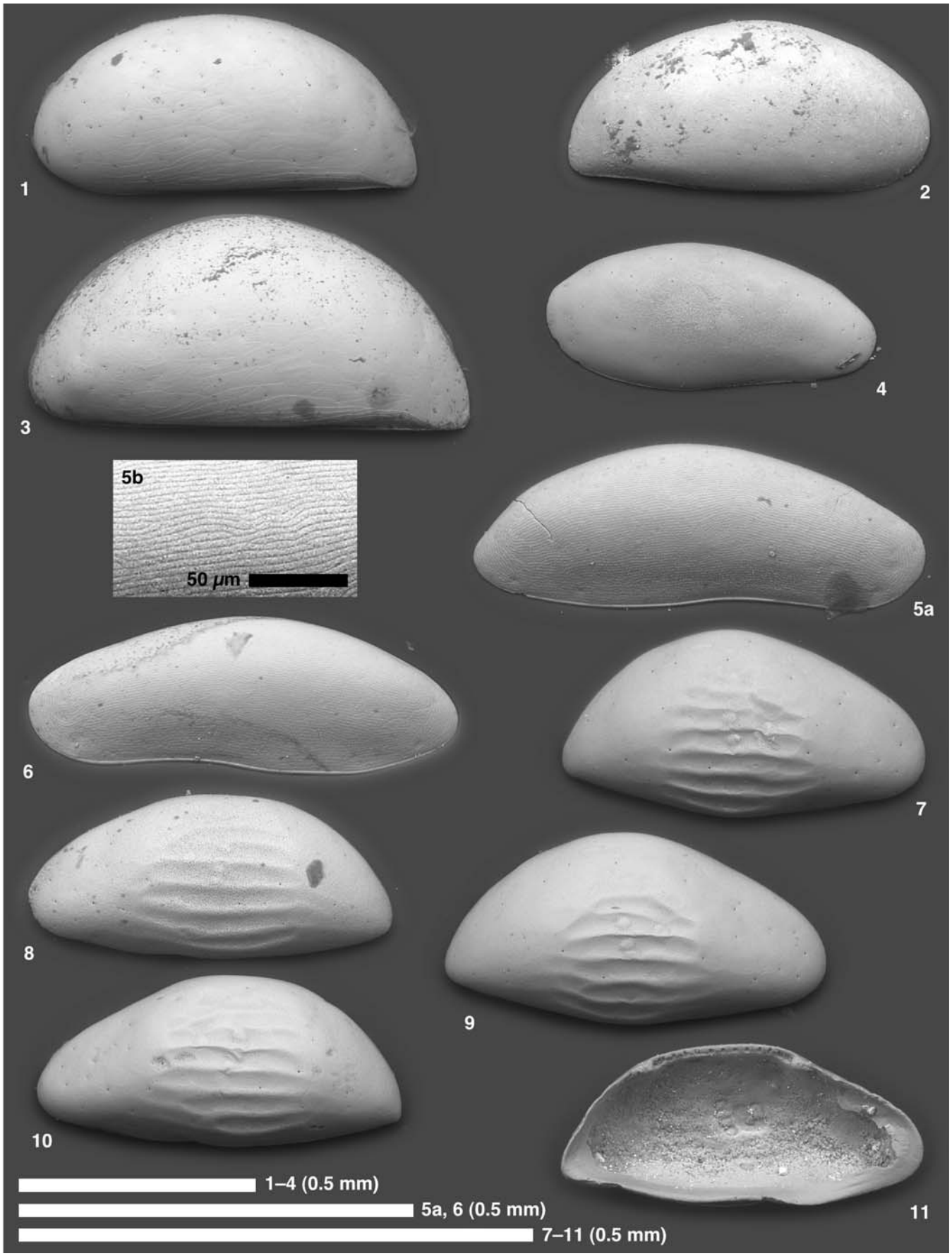
7 USNM 594236, PS2179, 9–10cm; RV, adult, lateral view.

8 USNM 594237, PS2200-5, 183cm; LV, adult, lateral view.

9 USNM 594238, NP-19/9; RV, adult, lateral view.

10 USNM 594239, NP-19/10; LV, adult, lateral view.

11 USNM 594240, NP-19/10; LV, adult, internal view.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7–11 (0.5 mm)

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PLATE 16

All SEM images and adult specimens. Scale bars represent 0.5mm.

1–2 *Microcythere medistriata* (Joy and Clark 1977).

1 USNM 594241, NP-19/10; RV, internal view.

2 USNM 594242, NP-19/18; LV, internal view.

3–10 *Henryhowella asperrima* (Reuss 1850).

3 USNM 594243, Meteor 23456-6; LV, lateral view.

4 USNM 594244, Meteor 23456-6; RV, lateral view.

5 USNM 594245, PS2184-3, 1–2cm; LV, lateral view.

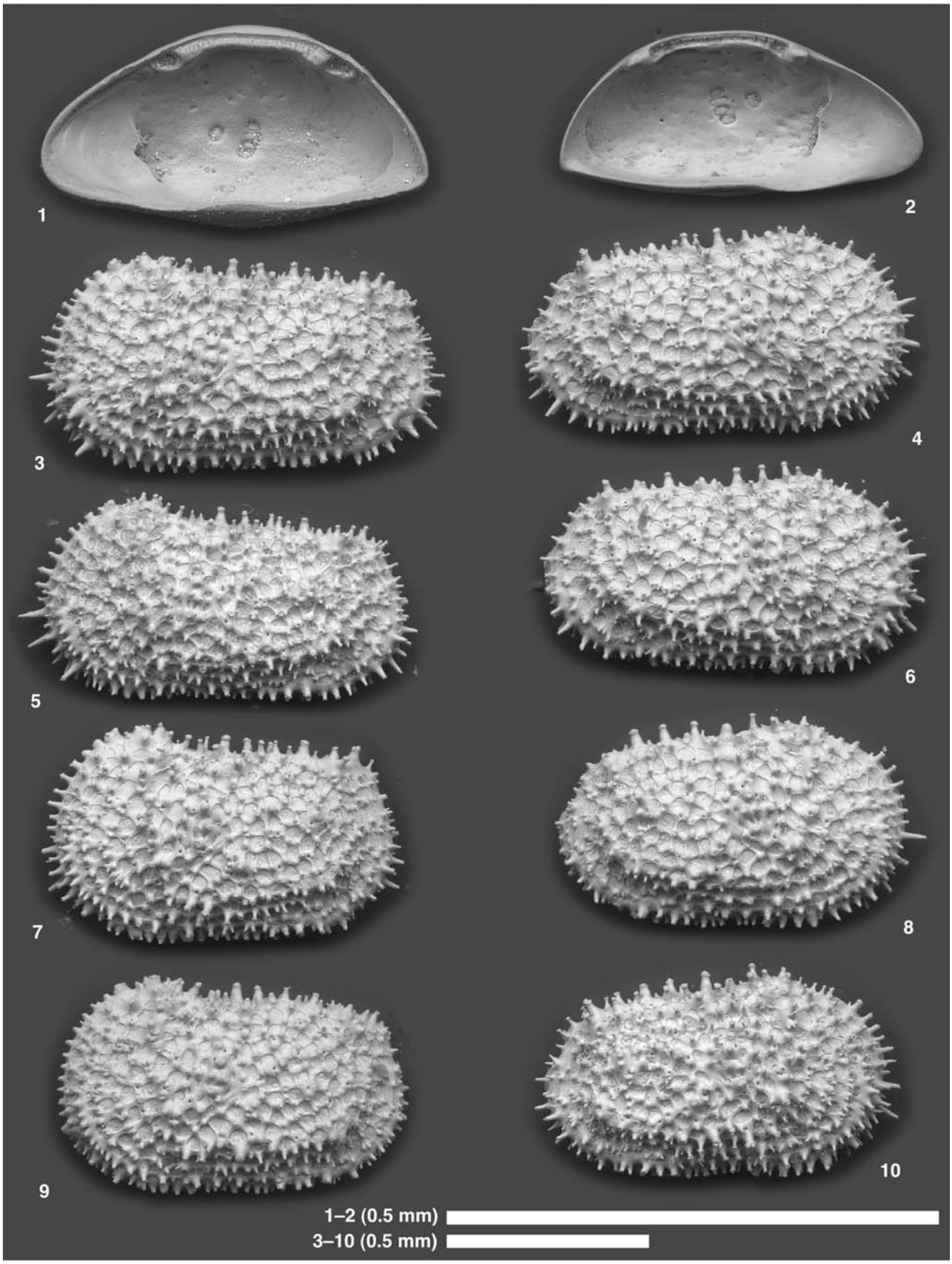
6 USNM 594246, Meteor 23457-3; RV, lateral view.

7 USNM 594247, Geomar 23243-1, 48cm; LV, lateral view.

8 USNM 594248, Meteor 23457-3; RV, lateral view.

9 USNM 594249, Geomar 23243-1, 210–211cm; LV, lateral view.

10 USNM 594250, Geomar 23243-1, 100–101cm; RV, lateral view.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1–2 (0.5 mm)
3–10 (0.5 mm)

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APPENDIX 1

Detailed information of the specimens used for the present study. USNM: catalog number. T: type (P: paratype. H: holotype). V: valve (L: left. R: right). A: adult. A-1: last juvenile instar (adult minus one). F: female. M: male.

USNM	Species	T	V	Instar	Sex	Locality code	Section	Age	Plate
594082	*Polycope arcys*		R	?	?	PS2179	9–10 cm	Quaternary	1
594083	*Polycope arcys*		L	?	?	PS2186-5	10–11 cm	Quaternary	1
594084	*Polycope arcys*		L	?	?	PS2202-2	0–1 cm	Modern	1
594085	*Polycope bispinosa*		R	?	?	PS2186-5	10–11 cm	Quaternary	1
594086	*Polycope bispinosa*		R	?	?	PS2186-5	10–11 cm	Quaternary	1
594087	*Polycope bispinosa*		R	?	?	PS2179	9–10 cm	Quaternary	1
594088	*Polycope bispinosa*		L	?	?	PS2164-4	0–1 cm	Modern	1
594089	*Polycope bispinosa*		L	?	?	Geomar 23243-1	90–91 cm	Quaternary	1
594090	*Polycope bispinosa*		L	?	?	Geomar 23243-1	180–181 cm	Quaternary	1
594091	*Polycope bireticulata*		R	?	?	PS2177-1	0–1 cm	Modern	2
594092	*Polycope bireticulata*		R	?	?	PS2177-1	0–1 cm	Modern	2
594093	*Polycope reticulata*		R	?	?	PS2179	9–10 cm	Quaternary	2
594094	*Polycope semipunctata*		R	?	?	PS2186-5	10–11 cm	Quaternary	2
594095	*Polycope semipunctata*		R	?	?	PS2200-5	183 cm	Quaternary	2
594096	*Polycope moenia*		L	?	?	PS2202-2	0–1 cm	Modern	2
594097	*Polycope moenia*		R	?	?	PS2202-2	0–1 cm	Modern	2
594098	*Polycope moenia*		R	?	?	PS2200-5	123 cm	Quaternary	2
594099	*Polycope moenia*		L	?	?	PS2177-1	0–1 cm	Modern	2
594100	*Polycope punctata*		L	?	?	PS2177-1	0–1 cm	Modern	3
594101	*Polycope inornata*		R	?	?	PS2177-1	0–1 cm	Modern	3
594102	*Polycope inornata*		L	?	?	PS2164-4	0–1 cm	Modern	3
594103	*Polycope inornata*		L	?	?	PS2177-1	0–1 cm	Modern	3
594104	*Polycope inornata*		L	?	?	PS2177-1	0–1 cm	Modern	3
594105	*Polycope* sp. 1		R	?	?	Geomar 23243-1	55 cm	Quaternary	3
594106	*Polycope* sp. 1		R	?	?	Geomar 23243-1	60–61 cm	Quaternary	3
594107	*Polycope inornata*		L	?	?	PS2179-3	17–18 cm	Quaternary	3
594108	*Polycope horrida*		R	?	?	NP26 sta 5	80–82 cm	Quaternary	3
594109	*Polycope horrida*		R	?	?	NP26 sta 5	77.5–79 cm	Quaternary	3
594110	*Argilloecia* cf. *robinwhatleyi*		L	A	?	PS2200-5	178 cm	Quaternary	4
594111	*Argilloecia* cf. *robinwhatleyi*		R	A	?	PS2200-5	178 cm	Quaternary	4
594112	*Argilloecia* cf. *robinwhatleyi*		R	A	?	PS2200-5	183 cm	Quaternary	4
594113	*Argilloecia* cf. *robinwhatleyi*		L	A	?	PS1913-5	0–2 cm	Modern	4
594114	*Argilloecia* cf. *robinwhatleyi*		R	A	?	PS1913-5	0–2 cm	Modern	4
594115	*Argilloecia* cf. *robinwhatleyi*		L	A	?	10/2 Polarstern GKG	24–26 cm	Quaternary	4
594116	*Argilloecia* cf. *robinwhatleyi*		R	A	?	10/2 Polarstern GKG	24–26 cm	Quaternary	4
594117	*Argilloecia* cf. *conoidea*		L	A	?	10/2 Polarstern GKG	24–26 cm	Quaternary	4
594118	*Argilloecia* cf. *conoidea*		R	A	?	10/2 Polarstern GKG	24–26 cm	Quaternary	4
594119	*Australoecia posteroacuta*		L	A	?	10/2 Polarstern GKG	24–26 cm	Quaternary	4
594120	*Argilloecia* sp. 1		R	A	?	10/2 Polarstern GKG	24–26 cm	Quaternary	4
594121	*Bythoceratina lomonosovensis*	H	L	A	?	PS2179-3	11–12 cm	Quaternary	5
594122	*Bythoceratina lomonosovensis*	P	R	A	?	PS2179-3	15–16 cm	Quaternary	5
594123	*Bythoceratina scaberrima*		L	A	?	PS2202-2	0–1 cm	Modern	5

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594124	*Bythoceratina scaberrima*		R	A	?	PS2185-4 MUC	12–13 cm	Quaternary	5
594125	*Cytheropteron parahamatum*	P	L	A	?	Meteor 23454-2		Modern	5
594126	*Cytheropteron parahamatum*	P	R	A	?	Meteor 23454-2		Modern	5
594127	*Cytheropteron parahamatum*	H	R	A	?	PS1913-5	0–2 cm	Modern	5
594128	*Cytheropteron carolinae*		L	A	?	PS1704-3		Modern	5
594129	*Cytheropteron carolinae*		R	A	?	PS1698-2		Modern	5
594130	*Pseudocythere caudata*		L	A	M?	PS2186-5	10–11 cm	Quaternary	6
594131	*Pseudocythere caudata*		R	A	M?	PS2189-1	0–1 cm	Modern	6
594132	*Pseudocythere caudata*		L	A	F?	PS2189-1	0–1 cm	Modern	6
594133	*Pseudocythere caudata*		L	A	F?	10/2 Polarstern GKG	4–6 cm	Quaternary	6
594134	*Pseudocythere caudata*		R	A	F?	PS2189-1	0–1 cm	Modern	6
594135	*Pseudocythere caudata*		L	A	F?	PS2186-5	10–11 cm	Quaternary	6
594136	*Pseudocythere caudata*		L	A	M?	Geomar 23243-1	100–101 cm	Quaternary	6
594137	*Pseudocythere caudata*		R	A	M?	10/2 Polarstern GKG	4–6 cm	Quaternary	6
594138	*Pseudocythere caudata*		L	A	M?	10/2 Polarstern GKG	4–6 cm	Quaternary	6
594139	*Pseudocythere caudata*		R	A	M?	Geomar 23243-1	100–101 cm	Quaternary	6
594140	*Pseudocythere caudata*		L	A	F?	10/2 Polarstern GKG	4–6 cm	Quaternary	6
594141	*Pseudocythere caudata*		R	A	F?	10/2 Polarstern GKG	4–6 cm	Quaternary	6
594142	*Cytheropteron higashikawai*		L	A	?	PS1893-1		Modern	7
594143	*Cytheropteron higashikawai*		R	A	?	PS1893-1		Modern	7
594144	*Cytheropteron higashikawai*		L	A	?	Geomar 23243-1	64 cm	Quaternary	7
594145	*Cytheropteron sedovi*		R	A	?	PS2195-4	0–1 cm	Modern	7
594146	*Cytheropteron sedovi*		L	A	?	Pl-91-AR-BC02		Modern	7
594147	*Cytheropteron sedovi*		R	A	?	PS2179-3	9–10 cm	Quaternary	7
594148	*Cytheropteron sedovi*		L	A	?	PS2179-3	9–10 cm	Quaternary	7
594149	*Cytheropteron lanceae*	H	R	A	?	NP-26/32	2.5–5.0 cm	Quaternary	7
594150	*Cytheropteron perlaria*		L	A	F?	PS1905-1		Modern	8
594151	*Cytheropteron perlaria*		R	A	F?	PS1698-2		Modern	8
594152	*Cytheropteron perlaria*		R	A	M?	NP-19/18		Modern	8
594153	*Cytheropteron perlaria*		R	A	F?	NP-19/18		Modern	8
594154	*Cytheropteron perlaria*		L	A	M?	NP-19/19		Modern	8
594155	*Cytheropteron perlaria*		R	A	M?	NP-19/19		Modern	8
594156	*Cytheropteron perlaria*		L	A	F?	NP-19/19		Modern	8
594157	*Cytheropteron perlaria*		R	A	F?	NP-19/19		Modern	8
594158	*Cytheropteron groenlandicum*		R	A	?	PS1905-1		Modern	9
594159	*Cytheropteron groenlandicum*		L	A	?	PS1698-2		Modern	9
594160	*Cytheropteron groenlandicum*		L	A	?	NP-19/19		Modern	9
594161	*Cytheropteron groenlandicum*		R	A	?	NP-19/19		Modern	9
594162	*Cytheropteron irizukii*	P	L	A	?	PS2189-1	0–1 cm	Modern	9
594163	*Cytheropteron irizukii*	H	R	A	?	PS2189-1	0–1 cm	Modern	9
594164	*Cytheropteron scoresbyi*		L	A	?	Pl-91-AR-BC02		Modern	9
594165	*Cytheropteron scoresbyi*		R	A	?	Meteor 23454-2		Modern	9
594166	*Cytheropteron scoresbyi*		L	A	?	Meteor 23454-2		Modern	9
594167	*Cytheropteron aielloi*		L	A	?	PS2189-1	0–1 cm	Modern	10
594168	*Cytheropteron scoresbyi*		R	A	?	Meteor 23453-1		Modern	10

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USNM	Species	T	V	Instar	Sex	Locality code	Section	Age	Plate
594169	*Cytheropteron aielloi*		R	A	?	PS1913-5	0–2 cm	Modern	10
594170	*Cytheropteron carolinae*		L	A	?	Meteor 23453-1		Modern	10
594171	*Cytheropteron carolinae*		R	A	?	Meteor 23453-1		Modern	10
594172	*Cytheropteron pseudoinflatum*		L	A	?	PS2200-5	123 cm	Quaternary	10
594173	*Cytheropteron pseudoinflatum*		L	A	?	Meteor 23453-1		Modern	10
594174	*Cytheropteron pseudoinflatum*		R	A	?	PS2200-5	123 cm	Quaternary	10
594175	*Cytheropteron pseudoinflatum*		R	A	?	Meteor 23453-1		Modern	10
594176	*Cytheropteron pseudoinflatum*		L	A	?	Meteor 23455-2		Modern	11
594177	*Cytheropteron pseudoinflatum*		R	A	?	Meteor 23455-2		Modern	11
594178	*Eucytherura delineata*		L	A	?	PS2202-2	0–1 cm	Modern	11
594179	*Eucytherura delineata*		R	A	?	PS2202-2	0–1 cm	Modern	11
594180	*Eucytherura delineata*		L	A	?	NP-19/20		Modern	11
594181	*Eucytherura delineata*		R	A	?	NP-19/20		Modern	11
594182	*Pedicythere neofluitans*		L	A	?	PS2186-5	0–1 cm	Modern	11
594183	*Pedicythere neofluitans*		L	A	?	PS2189-1	0–1 cm	Modern	11
594184	*Pedicythere neofluitans*		L	A	?	PS2189-1	0–1 cm	Modern	11
594185	*Pedicythere neofluitans*		R	A	?	PS2202-2	0–1 cm	Modern	11
594186	*Pedicythere arctica*	H	R	A	?	PS2202-2	0–1 cm	Modern	12
594187	*Pedicythere arctica*	P	L	A	?	NP-19/19		Modern	12
594188	*Eucythere argus*		L	A	?	NP26 sta 5	78–80 cm	Quaternary	12
594189	*Cluthia whatleyi*	H	L	A	F?	NP-19/20		Modern	12
594190	*Cluthia whatleyi*	P	R	A	F?	NP-19/20		Modern	12
594191	*Cluthia whatleyi*	P	R	A	M?	PS2202-2	0–1 cm	Modern	12
594192	*Cluthia whatleyi*	P	R	A	F?	NP-19/10		Modern	12
594193	*Cluthia whatleyi*	P	L	A	F?	NP-19/10		Modern	12
594194	*Krithe hunti*	H	L	A	M	Meteor 23454-2		Modern	13
594195	*Krithe hunti*	P	R	A	M	Meteor 23454-2		Modern	13
594196	*Krithe hunti*	P	L	A	F	PS1698-2		Modern	13
594197	*Krithe hunti*	P	R	A	F	PS1707-1		Modern	13
594198	*Krithe hunti*	P	L	A	F	NP-26/32	2.5–5.0 cm	Quaternary	13
594199	*Krithe hunti*	P	R	A	F	Meteor 23454-2		Modern	13
594200	*Krithe hunti*	P	L	A	M	NP-26/32	2.5–5.0 cm	Quaternary	13
594201	*Krithe hunti*	P	R	A	M	NP-26/32	8.5–9.5 cm	Quaternary	13
594202	*Krithe hunti*	P	R	A	F	Geomar 23243-1	63 cm	Quaternary	13
594203	*Krithe hunti*	P	L	A	F	NP-26/32	2.5–5.0 cm	Quaternary	13
594204	*Krithe hunti*	P	R	A	F	NP-26/32	78–80 cm	Quaternary	13
594205	*Krithe hunti*	P	L	A	F	PS2163-2	0–1 cm	Modern	14
594206	*Krithe hunti*	P	L	A-1	?	NP-26/32	2.5–5.0 cm	Quaternary	14
594207	*Krithe hunti*	P	R	A-1	?	NP-26/32	2.5–5.0 cm	Quaternary	14
594208	*Krithe hunti*	P	L	A-2	?	NP-26/32	2.5–5.0 cm	Quaternary	14
594209	*Krithe hunti*	P	R	A-2	?	NP-26/32	2.5–5.0 cm	Quaternary	14
594210	*Krithe hunti*	P	L	A-3	?	NP-26/32	2.5–5.0 cm	Quaternary	14
594211	*Krithe hunti*	P	R	A-3	?	NP-26/32	2.5–5.0 cm	Quaternary	14

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USNM	Species	T	V	Instar	Sex	Locality code	Section	Age	Plate
594212	*Krithe hunti*	P	L	A-4	?	NP-26/32	2.5–5.0 cm	Quaternary	14
594213	*Krithe hunti*	P	R	A-4	?	NP-26/32	2.5–5.0 cm	Quaternary	14
594214	*Krithe hunti*	P	L	A-5	?	NP-26/32	2.5–5.0 cm	Quaternary	14
594215	*Krithe hunti*	P	R	A-5	?	NP-26/32	2.5–5.0 cm	Quaternary	14
594216	*Krithe minima*		R	A-3	?	PS1913-5	0–2 cm	Modern	14
594217	*Krithe minima*		L	A-2	?	PS1913-5	0–2 cm	Modern	14
594218	*Krithe minima*		R	A-2	?	PS1913-5	0–2 cm	Modern	14
594219	*Krithe minima*		L	A-1	?	PS1913-5	0–2 cm	Modern	14
594220	*Krithe minima*		R	A-1	?	PS1913-5	0–2 cm	Modern	14
594221	*Krithe minima*		L	A	F	PS1913-5	0–2 cm	Modern	14
594222	*Krithe minima*		R	A	F	Meteor 23455-2		Modern	14
594223	*Krithe minima*		L	A	M	PS2212-6 MUC	6–7 cm	Quaternary	14
594224	*Krithe minima*		R	A	M	PS2179-3	9–10 cm	Quaternary	14
594225	*Krithe minima*		L	A	M	Geomar 23243-1	100–101 cm	Quaternary	14
594226	*Krithe minima*		R	A	M	Meteor 23455-2		Modern	14
594227	*Krithe minima*		L	A	F	Geomar 23243-1	180–181 cm	Quaternary	14
594228	*Krithe minima*		L	A	F	PS2212-6 MUC	6–7 cm	Quaternary	14
594229	*Krithe minima*		R	A	F	PS2179-3	9–10 cm	Quaternary	14
594230	*Acetabulastoma arcticum*		L	?	?	PS2189-1	0–1 cm	Modern	15
594231	*Acetabulastoma arcticum*		R	?	?	PS2164-4	0–1 cm	Modern	15
594232	*Acetabulastoma arcticum*		L	?	?	PS2200-5	183 cm	Quaternary	15
594233	Paradoxostomatid sp. 1		R	?	?	10/2 Polarstern GKG	24–26 cm	Quaternary	15
594234	*Paracytherois chukchiensis*		R	A	?	PS2200-5	178 cm	Quaternary	15
594235	*Paracytherois chukchiensis*		L	A	?	PS2200-5	178 cm	Quaternary	15
594236	*Microcythere medistriata*		R	A	?	PS2179	9–10 cm	Quaternary	15
594237	*Microcythere medistriata*		L	A	?	PS2200-5	183 cm	Quaternary	15
594238	*Microcythere medistriata*		R	A	?	NP-19/9		Modern	15
594239	*Microcythere medistriata*		L	A	?	NP-19/10		Modern	15
594240	*Microcythere medistriata*		L	A	?	NP-19/10		Modern	15
594241	*Microcythere medistriata*		R	A	?	NP-19/10		Modern	16
594242	*Microcythere medistriata*		L	A	?	NP-19/18		Modern	16
594243	*Henryhowella asperrima*		L	A	M	Meteor 23456-6		Modern	16
594244	*Henryhowella asperrima*		R	A	M	Meteor 23456-6		Modern	16
594245	*Henryhowella asperrima*		L	A	M	PS2184-3	1–2 cm	Quaternary	16
594246	*Henryhowella asperrima*		R	A	M	Meteor 23457-3		Modern	16
594247	*Henryhowella asperrima*		L	A	F	Geomar 23243-1	48 cm	Quaternary	16
594248	*Henryhowella asperrima*		R	A	F	Meteor 23457-3		Modern	16
594249	*Henryhowella asperrima*		L	A	F	Geomar 23243-1	210–211 cm	Quaternary	16
594250	*Henryhowella asperrima*		R	A	F	Geomar 23243-1	100–101 cm	Quaternary	16
594251	*Cytheropteron sedovi*		L	A	?	AF07-31	37–41 cm	Quaternary	T-fig. 2
594252	*Cytheropteron sedovi*		R	A	?	AF07-31	150–154 cm	Quaternary	T-fig. 2
594253	*Cytheropteron sedovi*		L	A-1?	?	AF07-31	7–11 cm	Quaternary	T-fig. 2
594254	*Cytheropteron sedovi*		L	A-2?	?	AF07-31	0–4 cm	Modern	T-fig. 2
594255	*Cytheropteron lanceae*	P	R	A	?	AF07-31	330–333 cm	Quaternary	T-fig. 2
594256	*Cytheropteron lanceae*	P	L	A-1?	?	AF07-31	37–41 cm	Quaternary	T-fig. 2