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Insular Shelf, Slope and Bathyal Bivalve and Scaphopod Fauna in the Southwestern Sector of the Sea of Japan Based on the Collection by the T/V *Tanshu-maru* during 2009 Summer

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Abstract: From the bottom trawl catches in 2009 summer from depths of 132 m to 1898 m in the southwestern sector of the Sea of Japan, 29 species of bivalves and 7 scaphopods were sorted out. The bivalve fauna of this area and depth contains apparent subarctic cold-water elements, such as *Delectopecten randolphi*, *Parvamussium alaskense*, *Cardiomya behringensis* among others mixed with probable endemic species, such as *Portlandia toyamaensis*, *Nuculana robai*, *Cuspidaria trosaetes* and so on. Most of other species are common to intermediate-water in temperate Japan, namely, *Acila divaricata*, *Limopsis obliqua*, *Poromya castanea*, *Cardiomya sagamiana* and others.

Key words: Bathyal, insular shelf, slope, bivalves, scaphopods, Sea of Japan.

Introduction

The shelf to bathyal zones in the southwestern sector of the Sea of Japan is one of the most productive fishing areas for bottom fishes, snow crabs (*Chionoecetes opilio* and *C. japonica*) and buccinid whelks (*Buccinum* spp. and *Neptunea* spp.).

The reports on offshore bivalve fauna in this sea area (western sector of the Sea of Japan) are rather scarce except Ito (1967, 1979), Tsuchida and Hayashi (1994) and Tsuchida and Hori (1996), in contrast to richer information on those in mid-sector of the Sea of Japan, such as around Noto Peninsula and Toyama Bay (Kuroda and Kikuchi, 1933; Habe, 1952, 1973; Ito, 1954, 1990; Ito *et al.*, 1986), and Sado Island – Niigata area (Kuroda, 1957; Ito, 1978, 1979, 1981, 1985, 1989). Those of the northern coastal waters, such as along the coast of Primorye to the Korean Peninsula are recently thoroughly compiled by Lutaenko and Norseworthy (2012) emphasizing the rich diversity of bivalve mollusks in the Sea of Japan. Kamenev (2012) reported 26 bathyal and abyssal bivalves from the northern and central Sea of Japan.

This paper reports results of identification of bivalves and scaphopods sorted out from the trawl catches for test investigation on *Chionoecetes* resources conducted by Kasumi High School of Hyogo Prefecture on board the Training Ship *Tanshu-maru* in 2009 summer. The surveyed area was restricted to the southwestern sector of the Sea of Japan, such as west of Oki Islands and off Shimane Prefecture. The trawling depths ranged from 150 m down to 1898 m.

Table 1. Data relevant to trawl sampling by the T/V *Tanshu-maru*, in 2009. Abbreviations for sampling gears: OT, otter trawl; ZY, beam trawl.

Stn. no.	Date	Gear	Position in	Position out	Depth (m)	Locality
TS09-T047	1 June 2009	OT	36°08.90′N, 133°46.83′E	36°07.75′N, 133°47.49′E	207–207	E of Oki Is.
TS09-T088	3 June 2009	OT	35°49.20′N, 134°51.89′E	35°49.25′N, 134°52.56′E	200–200	Off Kinosaki
TS09-T102	30 May 2009	OT	35°53.27′N, 135°48.27′E	35°53.02′N, 135°47.72′E	242–242	Wakasa Bay
TS09-T104	30 May 2009	OT	35°55.25′N, 135°46.77′E	35°55.22′N, 135°46.45′E	261–262	Wakasa Bay
TS09-T107	30 May 2009	OT	36°09.30′N, 135°54.87′E	36°08.43′N, 135°54.91′E	202–201	off Echizen-misaki
TS09-T116	7 June 2009	OT	36°43.36′N, 135°54.23′E	36°42.03′N, 135°53.38′E	441–442	E of Kanazawa
TS09-BZ200	29 June 2009	ZY	35°10.31′N, 132°20.85′E	35°10.44′N, 132°21.06′E	200–200	W of Hino-misaki
TS09-BZ250	26 June 2009	ZY	35°44.53′N, 132°16.58′E	35°44.43′N, 132°16.25′E	250–251	W of Oki Is.
TS09-BZ300-1	29 June 2009	ZY	35°48.31′N, 132°15.79′E	35°48.03′N, 132°16.45′E	311–301	W of Oki Is.
TS09-BZ300-2	25 June 2009	ZY	35°47.95′N, 132°16.35′E	35°47.90′N, 132°16.14′E	302–302	W of Oki Is.
TS09-BZ350	26 June 2009	ZY	35°49.82′N, 132°15.69′E	35°49.76′N, 132°15.30′E	349–350	W of Oki Is.
TS09-BZ400	29 June 2009	ZY	35°50.88′N, 132°12.86′E	35°51.01′N, 132°13.27′E	400–402	W of Oki Is.
TS09-BZ500	29 June 2009	ZY	35°52.93′N, 132°13.32′E	35°53.29′N, 132°13.99′E	493–506	W of Oki Is.
TS09-BZ600	26 June 2009	ZY	35°54.43′N, 132°12.70′E	35°54.36′N, 132°12.30′E	612–605	W of Oki Is.
TS09-BZ650	26 June 2009	ZY	35°54.66′N, 132°10.95′E	35°54.61′N, 132°10.37′E	644–648	W of Oki Is.
TS09-BZ700	26 June 2009	ZY	35°55.09′N, 132°10.50′E	35°55.06′N, 132°09.80′E	697–710	W of Oki Is.
TS09-C160	30 June 2009	ZY	35°42.10′N, 132°36.85′E	35°42.53′N, 132°37.21′E	160–160	W of Oki Is.
TS09-C170	30 June 2009	ZY	35°44.42′N, 132°35.35′E	35°44.63′N, 132°35.57′E	171–171	W of Oki Is.
TS09-C180	30 June 2009	ZY	35°46.23′N, 132°33.64′E	35°46.55′N, 132°33.92′E	180–180	W of Oki Is.
TS09-C190	30 June 2009	ZY	35°20.84′N, 132°34.25′E	35°51.32′N, 132°34.56′E	191–191	W of Oki Is.
TS09-C210	1 July 2009	ZY	35°53.85′N, 132°32.84′E	35°53.36′N, 132°32.58′E	210–210	W of Oki Is.
TS09-C220	28 June 2009	ZY	35°50.62′N, 132°25.55′E	35°50.83′N, 132°25.71′E	251–251	W of Oki Is.
TS09-C300	28 June 2009	ZY	35°51.89′N, 132°23.02′E	35°52.06′N, 132°23.28′E	301–300	W of Oki Is.
TS09-C350	28 June 2009	ZY	35°52.76′N, 132°21.04′E	35°52.97′N, 132°21.30′E	350–350	W of Oki Is.
TS09-C400	28 June 2009	ZY	35°53.55′N, 132°20.01′E	35°53.96′N, 132°20.17′E	402–401	W of Oki Is.
TS09-C420	28 June 2009	ZY	35°54.87′N, 132°19.76′E	35°55.15′N, 132°20.05′E	455–455	W of Oki Is.
TS09-C600	4 July 2009	ZY	35°56.00′N, 132°17.77′E	35°56.40′N, 132°18.30′E	598–593	W of Oki Is.
TS09-C650	4 July 2009	ZY	35°56.18′N, 132°16.84′E	35°56.32′N, 132°17.07′E	648–651	W of Oki Is.
TS09-C700	4 July 2009	ZY	35°57.20′N, 132°17.12′E	35°57.41′N, 132°17.36′E	701–702	W of Oki Is.
TS09-H1	3 July 2009	ZY	35°55.74′N, 132°36.54′E	35°56.22′N, 132°36.92′E	196–196	W of Oki Is.
TS09-HC150	30 June 2009	ZY	35°41.99′N, 132°39.08′E	35°42.37′N, 132°39.53′E	151–150	W of Oki Is.
TS09-HC170	30 June 2009	ZY	35°51.12′N, 132°23.96′E	35°51.58′N, 132°24.35′E	280–280	W of Oki Is.
TS09-HN230	2 July 2009	ZY	35°53.40′N, 132°30.18′E	35°53.94′N, 132°30.47′E	230–230	W of Oki Is.
TS09-N180	3 July 2009	ZY	35°51.08′N, 132°37.66′E	35°51.55′N, 132°38.10′E	180–180	W of Oki Is.
TS09-N190	3 July 2009	ZY	35°54.06′N, 132°36.80′E	35°54.53′N, 132°37.09′E	190–190	W of Oki Is.
TS09-N220	1 July 2009	ZY	35°55.18′N, 132°32.18′E	35°54.71′N, 132°31.90′E	220–220	W of Oki Is.
TS09-N300	1 July 2009	ZY	35°57.93′N, 132°27.65′E	35°28.40′N, 132°28.05′E	300–300	W of Oki Is.
TS09-N220	1 July 2009	ZY	35°55.18′N, 132°32.18′E	35°54.71′N, 132°31.90′E	220–220	W of Oki Is.
TS09-N300	1 July 2009	ZY	35°57.93′N, 132°27.65′E	35°28.40′N, 132°28.05′E	300–300	W of Oki Is.
TS09-N400	1 July 2009	ZY	36°00.43′N, 132°25.93′E	36°00.30′N, 132°25.79′E	398–398	W of Oki Is.
TS09-N450	4 July 2009	ZY	35°59.40′N, 132°23.59′E	35°56.68′N, 132°23.61′E	452–447	W of Oki Is.
TS09-ZY10-1	25 June 2009	ZY	35°46.22′N, 132°05.03′E	35°46.24′N, 132°04.89′E	284–284	W of Oki Is.
TS09-ZY10-2	2 July 2009	ZY	35°46.15′N, 132°04.99′E	35°46.25′N, 132°04.29′E	281–281	W of Oki Is.
TS09-ZY12-1	25 June 2009	ZY	35°43.47′N, 132°07.28′E	35°43.68′N, 132°07.88′E	253–255	W of Oki Is.
TS09-ZY12-2	2 July 2009	ZY	35°43.34′N, 132°07.11′E	35°43.36′N, 132°06.42′E	251–250	W of Oki Is.
TS09-ZY14-1	4 July 2009	ZY	36°00.10′N, 132°32.53′E	36°00.59′N, 132°33.26′E	251–250	W of Oki Is.
TS09-ZY10-1	25 June 2009	ZY	35°46.22′N, 132°05.03′E	35°46.24′N, 132°04.89′E	284–284	W of Oki Is.
TS09-ZY16-1	25 June 2009	ZY	35°46.15′N, 132°13.90′E	35°46.13′N, 132°13.79′E	281–280	W of Oki Is.
TS09-ZY10-1	25 June 2009	ZY	35°46.22′N, 132°05.03′E	35°46.24′N, 132°04.89′E	284–284	W of Oki Is.
TS09-ZY16-2	25 June 2009	ZY	35°46.79′N, 132°16.64′E	35°46.77′N, 132°16.58′E	281–281	W of Oki Is.
TS09-ZY10-1	25 June 2009	ZY	35°46.22′N, 132°05.03′E	35°46.24′N, 132°04.89′E	284–284	W of Oki Is.
TS09-ZY16-3	2 July 2009	ZY	35°46.09′N, 132°13.31′E	35°46.19′N, 132°14.16′E	280–280	W of Oki Is.
TS09-ZY17	29 June 2009	ZY	35°40.16′N, 132°17.38′E	35°40.49′N, 132°18.03′E	210–210	W of Oki Is.
TS09-ZY18	29 June 2009	ZY	35°43.23′N, 132°16.32′E	35°43.10′N, 132°16.49′E	237–235	W of Oki Is.
TS09-ZY20	29 June 2009	ZY	35°43.33′N, 132°21.91′E	35°43.75′N, 132°22.46′E	215–215	W of Oki Is.
TS09-ZY23	2 July 2009	ZY	35°50.19′N, 132°23.83′E	35°50.66′N, 132°24.23′E	269–270	W of Oki Is.
TS09-ZY25	30 June 2009	ZY	35°49.80′N, 132°26.95′E	35°50.26′N, 132°27.41′E	230–230	W of Oki Is.
TS09-ZY27	1 July 2009	ZY	35°56.78′N, 132°28.05′E	35°56.35′N, 132°27.64′E	280–280	W of Oki Is.
TS09-ZY29-1	25 June 2009	ZY	35°48.05′N, 132°10.11′E	35°47.83′N, 132°09.66′E	322–318	W of Oki Is.
TS09-ZY29-2	2 July 2009	ZY	35°48.03′N, 132°09.43′E	35°48.03′N, 132°10.12′E	320–320	W of Oki Is.

Table 1. (continued)

Stn. no.	Date	Gear	Position in	Position out	Depth (m)	Locality
TS09-ZY31	1 July 2009	ZY	35°59.27′N, 132°27.77′E	35°58.79′N, 132°27.36′E	319–320	W of Oki Is.
TS09-ZY33	29 June 2009	ZY	35°51.96′N, 132°09.33′E	35°52.25′N, 132°10.03′E	445–460	W of Oki Is.
TS09-ZY34	19 August 2009	ZY	35°57.17′N, 132°34.18′E	35°57.45′N, 132°34.33′E	211–211	W of Oki Is.
TS09-OW01	19 August 2009	ZY	35°39.77′N, 132°19.75′E	35°39.89′N, 132°20.03′E	199–199	W of Oki Is.
TS09-OW02	19 August 2009	ZY	35°48.19′N, 132°17.08′E	35°48.24′N, 132°17.31′E	301–301	W of Oki Is
TS09-OW03	19 August 2009	ZY	35°50.89′N, 132°12.97′E	35°50.93′N, 132°13.22′E	400–400	W of Oki Is
TS09-OW04	19 August 2009	ZY	35°53.37′N, 132°14.99′E	35°53.31′N, 132°14.73′E	500–499	W of Oki Is
TS09-OW05	19 August 2009	ZY	35°54.66′N, 132°14.63′E	35°54.58′N, 132°14.42′E	604–602	W of Oki Is
TS09-OW06	19 August 2009	ZY	35°55.30′N, 132°13.15′E	35°55.12′N, 132°12.66′E	701–696	W of Oki Is
TS09-OW07	24 August 2009	ZY	35°56.07′N, 132°10.83′E	35°55.97′N, 132°11.37′E	800–801	W of Oki Is
TS09-OW08	24 August 2009	ZY	35°57.96′N, 132°13.05′E	35°58.17′N, 132°13.53′E	897–908	W of Oki Is
TS09-OW09	24 August 2009	ZY	35°58.93′N, 132°12.28′E	35°59.06′N, 132°12.83′E	997–1001	W of Oki Is
TS09-OW10	24 August 2009	ZY	36°01.24′N, 132°12.43′E	36°01.21′N, 132°13.03′E	1100–1101	W of Oki Is
TS09-OW11	24 August 2009	ZY	36°05.30′N, 132°13.78′E	36°05.48′N, 132°14.31′E	1204–1204	W of Oki Is
TS09-OW12	23 August 2009	ZY	36°09.88′N, 132°11.48′E	36°10.12′N, 132°11.98′E	1299–1298	W of Oki Is
TS09-OW13	23 August 2009	ZY	36°13.06′N, 132°08.71′E	36°13.34′N, 132°09.21′E	1408–1396	W of Oki Is
TS09-OW14	23 August 2009	ZY	36°13.48′N, 132°03.53′E	36°13.93′N, 132°03.71′E	1496–1499	W of Oki Is
TS09-OW15	23 August 2009	ZY	36°16.14′N, 131°58.77′E	36°16.57′N, 131°59.01′E	1600–1597	W of Oki Is
TS09-OW17	20 August 2009	ZY	36°31.52′N, 131°50.35′E	36°31.18′N, 131°50.10′E	1797–1797	W of Oki Is
TS09-OW18	20 August 2009	ZY	36°37.88′N, 131°40.95′E	36°37.60′N, 131°40.65′E	1895–1895	W of Oki Is
TS09-OW21	21 August 2009	ZY	36°26.06′N, 131°45.23′E	36°26.42′N, 131°45.58′E	1797–1797	W of Oki Is.
TS09-OW22	21 August 2009	ZY	36°32.00′N, 131°37.26′E	36°32.33′N, 131°37.61′E	1898–1897	W of Oki Is.
TS09-OW24	22 August 2009	ZY	36°33.64′N, 132°03.57′E	36°33.89′N, 132°03.98′E	1700–1697	W of Oki Is.
TS09-OW25	22 August 2009	ZY	36°35.03′N, 131°55.07′E	36°35.38′N, 131°55.38′E	1790–1795	W of Oki Is.
TS09-OW26	22 August 2009	ZY	36°40.54′N, 131°45.09′E	36°40.54′N, 131°45.09′E	1895–1895	W of Oki Is.
TS09-OW27	22 August 2009	ZY	36°50.37′N, 131°47.51′E	36°50.53′N, 131°47.95′E	1995–1994	W of Oki Is.
TS09-OW28	26 August 2009	ZY	36°12.95′N, 132°34.97′E	36°12.16′N, 132°34.89′E	601–598	W of Oki Is.
TS09-OW29	26 August 2009	ZY	36°12.48′N, 132°33.60′E	36°12.05′N, 132°33.52′E	697–702	W of Oki Is.
TS09-OW30	26 August 2009	ZY	36°08.72′N, 132°33.77′E	36°08.48′N, 132°33.44′E	796–796	W of Oki Is.
TS09-OW31	26 August 2009	ZY	36°07.19′N, 132°29.53′E	36°07.00′N, 132°29.06′E	888–900	W of Oki Is.
TS09-OW32	25 August 2009	ZY	36°10.65′N, 132°28.19′E	36°10.22′N, 132°28.02′E	1008–1007	W of Oki Is.
TS09-OW33	25 August 2009	ZY	36°13.58′N, 132°26.30′E	36°13.19′N, 132°26.53′E	1090–1082	W of Oki Is.
TS09-OW34	25 August 2009	ZY	36°08.64′N, 132°19.53′E	36°08.85′N, 132°20.01′E	1200–1190	W of Oki Is.
TS09-OW36	25 August 2009	ZY	36°16.24′N, 132°11.40′E	36°16.48′N, 132°11.91′E	1400–1396	W of Oki Is.
TS09-OW37	25 August 2009	ZY	36°22.52′N, 132°11.64′E	36°22.97′N, 132°11.79′E	1500–1497	W of Oki Is.
TS09-OW38	26 August 2009	ZY	36°16.25′N, 132°36.27′E	36°15.76′N, 132°36.12′E	600–604	W of Oki Is.
TS09-OW39	26 August 2009	ZY	36°16.45′N, 132°35.15′E	36°16.08′N, 132°35.02′E	702–704	W of Oki Is.
TS09-OW40	28 August 2009	ZY	36°14.04′N, 132°32.72′E	36°13.70′N, 132°32.44′E	795–800	W of Oki Is.
TS09-OW41	28 August 2009	ZY	36°13.40′N, 132°30.78′E	36°13.66′N, 132°31.25′E	885–870	W of Oki Is.
TS09-OW42	28 August 2009	ZY	36°16.76′N, 132°28.36′E	36°16.65′N, 132°27.86′E	1000–1015	W of Oki Is.
TS09-OW43	27 August 2009	ZY	36°18.10′N, 132°26.43′E	36°17.72′N, 132°26.15′E	1097–1090	W of Oki Is.
TS09-OW44	27 August 2009	ZY	36°17.34′N, 132°23.04′E	36°12.11′N, 132°22.70′E	1200–1197	W of Oki Is.
TS09-OW45	27 August 2009	ZY	36°22.09′N, 132°21.22′E	36°22.44′N, 132°21.61′E	1295–1288	W of Oki Is.
TS09-OW46	27 August 2009	ZY	36°20.51′N, 132°16.54′E	36°20.93′N, 132°16.81′E	1397–1397	W of Oki Is.
TS09-OW47	27 August 2009	ZY	36°27.23′N, 132°14.29′E	36°27.71′N, 132°14.61′E	1504–1497	W of Oki Is.

Materials and Methods

Collecting gears. The specimens were collected by two types of trawl nets operated by T/S *Tanshu-maru*: an otter trawl and a beam trawl. The sizes of the otter trawl was 53.9 m in length, 7.8 m in width and 6 m in height at the mouth, with a span of 18 m between the tips of the side net. The stretched mesh size of the main part of the net was 50 mm, that of the cod end is 20 mm. The beam trawl has 8.2 m mouth span, and composed of a pair of steel skids with 0.7 m wide and 2 m length, two beams, and 27.2 m collecting net. The stretched mesh size of the main part of the net was 25 mm, that of the cod end is 20 mm.

Small bivalves and scaphopods under this paper are non-commercial species, thus all specimens were brought home for study.

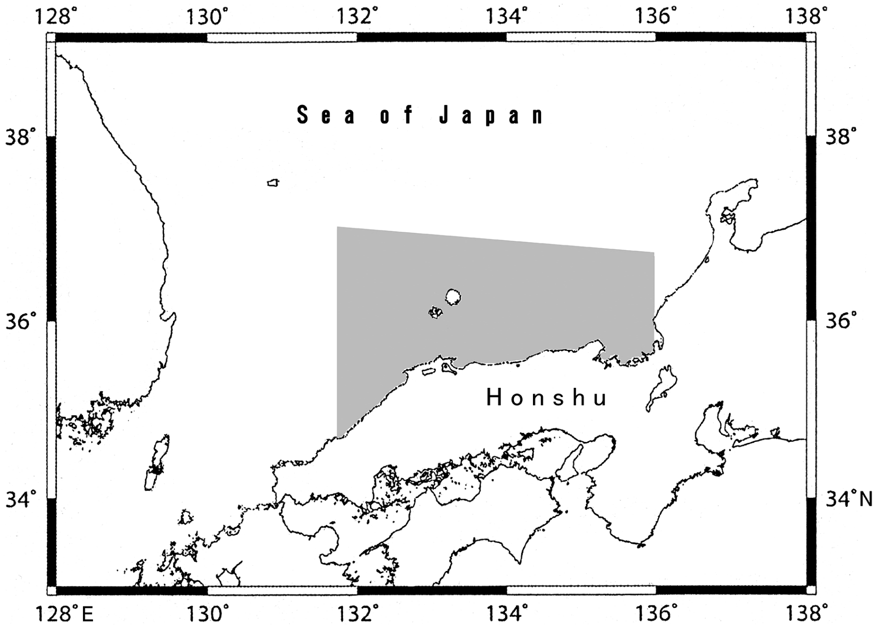

Fig. 1. Sampling area (shaded) that contains trawl stations in Table 1.

The position, date, and depth of the positive stations for the present material are shown in Table 1, and the area that includes all positive stations is depicted in Fig. 1.

Format. Under the entry of "Material examined" forerun by the scientific name and Japanese name (Jn), station number prefixed by TS09- and number of specimens with range of shell length (both in parenthesis) are recorded only for live-taken specimens. Dead, empty shells or detached valves are not into consideration. If any, some observations on specimens and taxonomic comments on the specimens are all given under "Remarks", in which previous distribution records are also occasionally referred.

The systematic arrangement of taxa primarily follows Bieler and Mikkelsen (2006).

Taxonomy

CLASS BIVALVIA
Subclass Protobranchia
Order Nuculoida
Family Nuculidae

Acila divaricata (Hinds, 1843) [Jn: Ōkiraragai] (Fig. 2A)

Material examined. TS09-T047 (5: 17.8–24.5); TS09-T088 (5: 17.9–27.4); TS09-T102 (75: 8.5–25.8); TS09-T104 (1: 28.9); TS09-T107 (1: 14.5); TS09-BZ200 (99: 10.3–29.2); TS09-BZ250 (2: 14.0, 27.1); TS09-C170 (10: 10.0–28.4); TS09-C180 (10: 8.0–19.3); TS09-C190 (17: 14.7–25.0); TS09-C210 (27: 20.5–28.0); TS09-C220 (37: 8.4–31.7); TS09-C250 (8: 12.9–28.2); TS09-H1 (43: 16.3–27.4); TS09-HN230 (4: 25.7–29.4); TS09-N190 (1: 8.1); TS09-ZY12-2 (1: 22.4); TS09-ZY16-1 (1: 25.4); TS09-ZY17 (5: 21.7–25.4); TS09-ZY18 (5: 16.0–29.3); TS09-ZY20 (6: 15.3–26.4); TS09-ZY25 (16: 16.0–31.3); TS09-ZY34 (23: 8.3–25.8); TS09-ZY141 (1:

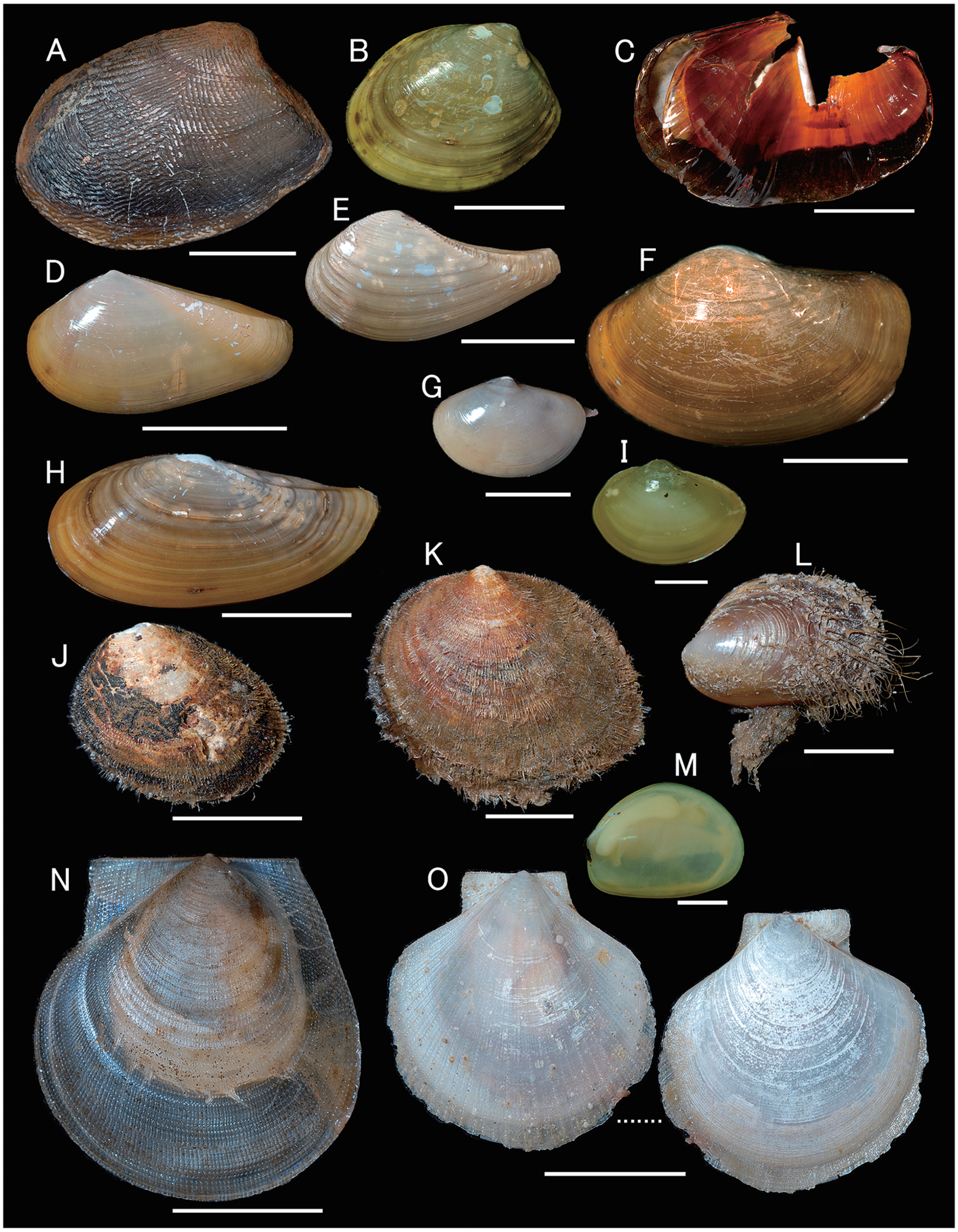

Fig. 2. Protobranchia and Pteriomorphia. A. *Nucula divaricata*, HN230; B. *Leionucula tenuis*, BZ250; C. *Petrasma pervernicosa,* HN230; D. *Nuculana* (*Robaia*) *robai*, C400; E. *Nuculana* (*Thestyleda*) *arai*, C180; F. *Portlandia toyamaensis*, C300, G. Ditto. juvenile, BZ250; H. *Yoldia similis*, C170; I. *Yoldiella philippiana.* OW31; J. *Limopsis obliqua*, C170; K. *Limopsis tajimae*, HC150; L. *Modiolus margaritaceus*, HC150; M. *Dacrydium vitreum*, OW31; N. *Delectopecten randolphi*, OW32; O. *Parvamussium alaskense*, OW02. Scales: 10 mm for A, C, D, F, H, J, K, N, O; 5 mm for B, E, G, L; 1 mm for I, M.

243); TS09-OW01 (64: 15.2–28.2); TS09-OW02 (1: 20.3).

Remarks. The present specimens are safely identified to be *A. divaricata.* The present representatives from the Sea of Japan have less inflated shell with less prominent flexure and finer sculpture than the population of the Pacific coast. The phenotypic variability is thus suggested.

Leionucula tenuis (Montagu, 1808) [Jn: Kogurumigai] (Fig. 2B)

Material examined. TS09-C160 (2: 3.5, 6.2); TS09-ZY18 (3: 1.0–2.5); TS09-BZ250 (2: 3.8, 9.7).

Remarks. The bathymetrical range of this species in the Sea of Japan given in Kamenev (2012) is 10–1075 m. The present collection (160–250 m) falls within that range.

Order Solemyoida

Family Solemyidae

Petrasma pervernicosa (Kuroda, 1948) [Jn: Abura-kinutarégai] (Fig. 2C)

Material examined. TS09-OW10 (1: badly fractured, 42.9); TS09-OW43 (1: fractured).

Remarks. The occurrence of this species from the Sea of Japan is unusual. This species has been known from bathyal depths from off Hokkaido and southward to middle Honshu on the Pacific side, 100–500 m depth (Kuroda, 1948b; Higo *et al.*, 1999). Another unusual occurrence in the past was from the sea bottom under whale carcasses laid on the sea-bottom at around 200 m depth. This suggests that the present species prefers such reducing environment (Fujiwara *et al.*, 2009).

Order Nuculanoida

Family Nuculanidae

Nuculana* (*Robaia*) *robai (Kuroda, 1929) [Jn: Rōbai = Chirirōbai] (Fig. 2D)

Material examined. TS09-BZ300 (1: 18.2); TS09-BZ350 (3: 10.6–18.3); TS09-BZ400 (1; 16.2); TS09-BZ700 (3: 16.6–19.6); TS-C160 (2: 4.9, 8.4); TS09-C170 (8: 12.0–13.9); TS09-C180 (3: 14.6–15.3); TS09-C250 (3: 13.0–15.1); TS09-C300 (80: 10.0–18.4); TS09-C330 (1: 17.9); TS09-C350 (11: 5.7–18.7); TS09-C400 (9: 8.4–18.4); TS09-C550 (1: 19.3); TS09-C600 (3: 10.0–20.0); TS09-C650 (7: 8.2–20.9); TS09-C700 (1: 18.6); TS09-HC150 (2: 19.5, 20.1); TS09-HC280 (1: 16.0); TS09-N400 (10: 14.7–18.6); TS09-N450 (42: 12.0–19.1); TS09-ZY16-1 (2: 9.3, 12.0); TS09-ZY29-1 (9: 16.1–19.8); TS09-ZY29-2 (4: 17.3–18.4); TS09-ZY33 (3: 17.9–18.3); TS09-ZY141 (1: 13.1); TS09-OW02 (5: 16.1–18.5); TS09-OW03 (23: 8.7–18.8); TS09-OW04 (19: 15.1–20.7); TS09-OW05 (6: 7.9–17.6); TS09-OW06 (2: 17.8,19.6); TS09-OW07 (9: 16.8–21.5); TS09-OW08 (21: 16.7–20.8); TS09-OW09 (4: 4.3–18.5); TS09-OW11 (5: 15.6–18.7); TS09-OW12 (18: 15.2–18.9); TS09-OW14 (17: 14.0–17.0); TS09-OW15 (138: 4.1–15.6); TS09-OW21 (2: 2.5, 3.5); TS09-OW28 (3: 3.0–4.2); TS09-OW29 (4: 15.6–18.8); TS09-OW30 (3: 16.3–19.7); TS09-OW31 (5: 14.1–18.0); TS09-OW32 (1: 16.4); TS09-OW33 (25: 2.8–20.2); TS09-OW34 (1: 15.8); TS09-OW36 (1: 16.2); TS09-OW37 (2: 15.2, 16.2); TS09-OW39 (7: 2.0–18.5); TS09-OW40 (6: 16.4–18.3); TS09-OW43 (9: 13.9–17.8); TS09-OW44 (5: 15.5–19.2); TS09-OW45 (19: 15.0–17.6); TS09-OW47 (1: 13.9).

Remarks. Small (immature) specimens (such as those from St. TS09-OW21) are characterized in having prominent beak, iridescent yellow sheen, strong growth lamellae, heaved escutcheon and sharply pointed posterior end, demonstrating that this species undergoes some morphological transformation with growth. Kamenev (2012) considered that *Robaia habei* Scarlato, 1981 is conspecific with this species.

Nuculana* (*Thestyleda*) *arai Habe, 1958 [Jn: Oni-arabori-rōbai] (Fig. 2E)

Material examined. TS09-C180 (1: 11.0).

Remarks. Habe (1958) originally described this taxon from the S.S. *Sōyō-maru* stations 324, 371, 468 and 484 as a subspecies of *N. yokoyamai* (Kuroda, 1934) that "separable from the real *N. yokoyamai* in having the decidedly coarser concentric ribs on the surface. Therefore, the writer gives a new subspecific term, *arai* for this form . . . ." But, according to Habe's records, both typical *N. yokoyamai* and this taxon are sympatric, thus this is herein treated a species rank, but not subspecies.

Family Yoldiidae

Portlandia toyamaensis (Kuroda, 1929) [Jn: Toyama-sodegai] (Figs. 2F, G)

Material examined. TS09-T088 (1: 21.3); TS09-T102 (1: 21.1); TS09-T116 (1: 23.7); TS09-BZ200 (6; 12.6–16.9); TS09-BZ250 (26: 6.9–19.3); TS09-BZ300 (9: 19.1–25.7); TS09-BZ350 (2: 7.7, 17.9); TS09-BZ400(2: 17.8, 20.1); TS09-BZ500 (5: 20.7–25.7); TS09-BZ600 (11: 23.5–26.3); TS09-BZ650 (5: 21.3–25.5); TS09-BZ700 (26: 18.1–29.0); TS09-C220 (10.7–18.7); TS09-C250 (56: 7.2–23.3); TS09-C300 (70: 12.8–28.7); TS90-C330 (5: 12.2–20.2); TS09-C350 (6: 8.8–25.3); TS09-C400 (4: 16.2–20.5); TS09-C450 (1: 17.2); TS09-C600 (6: 21.9–15.3); TS09-C650 (25: 21.9–28.4); TS09-C700 (28: 20.7–29.4); TS09-H4 (1: 16.8) TS09-HC280 (6: 18.9–22.6); TS09-N220 (2: 16.3, 17.9); TS09-N300 (1: 19.6); TS09-N400 (19: 13.9–25.4); TS09-N450 (14: 12.3–26.5); TS09-ZY10-1 (11: 11.9–24.5); TS09-ZY10-2 (1: 13.6); TS09-ZY12 (2: 15.7, 17.2); TS09-ZY16-1 (21: 10.6–27.0); TS09-ZY16-2 (34: 11.1–24.7); TS09-ZY16-3 (8: 14.1–20.9); TS09-ZY18 (38: 8.6–22.5); TS09-ZY23 (10: 17.9–25.3); TS09-ZY25 (1: 10.5); TS09-ZY27 (1: 18.8); TS09-ZY29-1 (50: 11.3–26.8); TS09-ZY29-2 (13: 13.4–24.6); TS09-ZY33 (2: 15.6, 21.3); TS09-ZY34 (1: 12.7); TS09-OW02 (15: 14.5–25.5); TS09-OW03 (17: 16.2–24.7); TS09-OW04 (27: 17.4–24.3); TS09-OW05 (37: 16.6–29.0); TS09-OW06 (42: 12.9–27.7); TS09-OW07 (38: 20.3–28.1); TS09-OW08 (22: 16.3–25.6); TS09-OW28 (41: 11.9–28.1); TS09-OW29 (55: 16.2–26.5); TS09-OW30 (69: 11.7–29.7); TS09-OW31 (7: 19.9–29.3); TS09-OW33 (1: 2.8); TS09-OW34 (7: 14.5–17.7); TS09-OW38 (74: 18.7–31.4); TS09-OW39 (75: 21.3–29.7); TS09-OW40 (67: 19.9–30.9); TS09-OW41 (2: 24.0, 25.9); TS09-O45 (5: 13.3–20.29).

Remarks. Since the name of this taxon was listed by Kuroda (1929) with the remarks for the illustrations (figs 14, 15 in appendix p. 6) that "Type specimen, Toyama Bay, 13 mm (Kikuchi)", no description by himself has been given since. Habe (1961) subsequently described in Japanese that "Shell well inflated, umbo situated near center, ventral margin gently round. Toyama Bay to off southern Kyushu, 200–600 m depth" and also in English (Habe, 1964) that "This is similar to *P.* (*P.*) *japonica* (Adams et Reeve), but has a more inflated shell which is covered with a shiny greenish grey periostracum. Uncommon at 200–600 m deep, from Toyama Bay in Japan Sea to southern Kyushu"

This species is closer in profile to *P. lischkei* (E. A. Smith, 1885) from bathyal depths in Sagami Bay and the Sea of Enshu-Nada. However, this species is easily separable from that congener in having more inflated shell (Fig. 3). The full description of conchological characters may be as below:

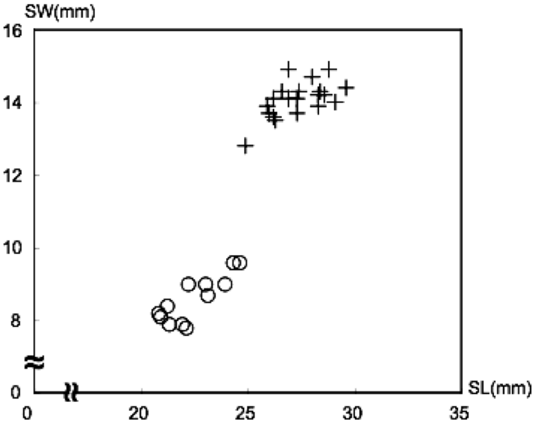

Fig. 3. Comparison of shell width (SW)/shell length (SL) between *P. lischkei* (open circle) and *P. toyamensis* (plus)

Shell thin but sturdy, elongate oval with upturned posterior part, equivalve, inequilateral, laterally inflated. Beaks low, situated at about 45% anteriorly, orthogyrous. Surface porcellaneous white, covered by adherent, shining olive-colored periostracum, which is usually corroded at umbonal area. Antero-dorsal margin gently descending to continue to gently convex ventral margin via round anterior margin. After postero-ventral corner, posterior margin abruptly ascending, vertically meeting weakly concave postero-dorsal margin forming nearly rectangular postero-dorsal angle. Posterior part weakly compressed laterally with somewhat auriculated appearance. No lunule, but escutcheon distinct. One to three very feeble radial ridges occasionally running from umbo towards postero-ventral corner or around midpoint of posterior margin.

Inner surface white with weak pinkish hue. Hinge plate strong, with about 14–15 strong teeth with several proximal minute ones on anterior arch, 15–16 strong teeth with several minute ones on posterior arch which is much thicker than anterior arch. Chondrophore large, hemi-circular, accommodating strong resilium. Anterior adductor scar drop-shaped, situated below anterior extremity of anterior arch of hinge plate, posterior one elliptical, situated near end of posterior arch. Pallial line apparent, pallial sinus so deep that reaching to level of umbo.

Yoldia similis Kuroda and Habe in Habe, 1958 [Jn: Naga-sodegai] (Fig. 2H)

Material examined. TS09-T088 (1: 18.30); TS09-C170 (33: 19.5–26.8).

Remarks. *Yoldia bartschi* Scarlato, 1981 may be conspecific with this species.

Yoldiella philippiana (Nyst, 1844) [Jn: Kibi-sodegai] (Fig. 2I)

Material examined. TS09-BZ200 (1: 2.3); TS09-ZY18 (11: 1.4–2.6); TS09-ZY33 (5: 1.8–2.3); TS09-OW07 (37: 1.0–3.5); TS09-OW08 (41: 0.9–3.4); TS09-OW09 (18: 0.8–2.8); TS09-OW11 (22: 1.2–3.0); TS09-OW12 (3: 1.2–2.9); TS09-OW15 (4: 2.1–2.3); TS09-OW21 (109: 0.9–1.9); TS09-OW22 (3: 2.1–2.4); TS09-OW25 (1: 2.1); TS09-OW27 (3: 2.1–2.5); TS09-OW28 (225: 0.6–2.8); TS09-OW29 (3: 1.1–2.0); TS09-OW30 (74: 0.9–3.1); TS09-OW31 (60: 1.0–2.8); TS09-OW33 (7: 1.2–3.4); TS09-OW34 (4: 1.6–2.0); TS09-OW36 (7: 1.5–2.8); TS09-OW37 (32: 0.9–2.6); TS09-OW38 (281: 0.7–3.9); TS09-OW39 (256: 1.1–2.6); TS09-OW40 (26: 1.0–2.6); TS09-OW41 (22: 1.2–2.3); TS09-OW42 (1: 2.7); TS09-OW43 (31: 1.2–2.9); TS09-OW45 (13: 2.0–3.0); TS09-OW47 (13: 1.5–2.9).

Remarks. Since this taxon was listed by Kuroda (1929) with the remarks for the illustrations (figures 20, 21 in appendix p. 6) under the name of *Yoldia* (*Yoldiella*) *kibi* Kuroda that "Type specimen, Toyama Bay, 3 mm (Kikuchi)", no description by Kuroda himself has been given. Habe (1961) subsequently described in Japanese using the name *Portlandia* (*Yoldiella*) *pygmaea* (Münster) that "Shell small, ovate. The Sea of Japan (100–200 m)", and also in English (Habe, 1964) that "This shell is minute, shiny brown, ovate, in shape. The umbo is rather nearer to the posterior end than to the anterior. At 100–200 m in depth from the Sea of Japan to the Arctic Seas. The Japanese form is named *P.* (*Y.*) *p. kibi* Kuroda".

Higo *et al.* (1999) claimed that Münster's name was *nomen nudum*, consequently, *Yoldiella philippiana* (Nyst, 1844) is the correct name for this species. Kurozumi and Tsuchida (2000) used this name. Sasaki *et al.* (2006) reported this species in the stomach content of a sea-star *Ctenodiscus crispatus* in Toyama Bay. They gave a detailed description (in Japanese) of their specimens including biometrical proportions of the shell, conditions of prodissoconch, and hinge armatures in use of SEM images.

This species has been known from off Hokkaido (40–450 m) and Suruga Bay (2230 m) (Higo *et al.*, 1999). Thus, this is not endemic to the Japan Sea, although it is likely more abundant and commoner here than elsewhere. Among seven species of the genus *Yoldiella* reported by Scalrato (1981), two species, namely, *Y. derjugini* Scarlato, 1981 and *Y. orbicula* Bartsch in Scarlato, 1981 were found from bathyal depths by Kamenev (2012). The former is most likely identical with *Y. philippiana*.

Subclass Pteriomorphia (=Autolamellibranchiata)
Order Arcoida
Family Limopsidae

Limopsis obliqua A. Adams, 1863 [Jn: Nanamé-shirasunagai] (Fig. 2J)

Material examined. TS09-C160 (2: 14.3, 21.5); TS09-C170 (186: 10.6–15.6); TS09-C180 (34: 12.8–17.6); TS09-C190 (16: 14.2–17.2); TS09-H1 (3: 13.5–15.4); TS09-H2 (4: 9.6–10.0); TS09-N180 (2: 16.5, 16.6); TS09-N190 (13: 12.5–17.6); TS09-ZY34 (101: 6.5–16.9); TS09-ZY35 (3: 8.9–10.6).

Remarks. The relation between this species and *L. kurilensis* Scarlato, 1981 merits more comparative study. Habe (1953) described another oblique species, *L. crassula* from the Sea of Japan (off Tsugaru Peninsula and near Sado Island). But Habe's species has more oblique, thinner and less inflated shell with straight hinge plate. Many specimens carry *Modiolus margaritaceus* on shell surface.

Limopsis tajimae (Sowerby, 1914) [Jn: Ō-shirasunagai] (Fig. 2K)

Material examined. TS09-HC150 (123: 10.8–34.2).

Remarks. This name was thought to be a junior synonym of *L. belcheri* (A. Adams and Reeve, 1850) (*e.g.*, Habe, 1977), but we retained *L. tajimae* as valid, because the photographs of type specimens in Higo *et al.* (2001) show minor morphological differences between both species. "Tajima" is an old name of Hyogo Prefecture, which is a part of the cost of the area covered by the present survey.

Order Mytiloida
Family Mytilidae

Modiolus margaritaceus (Nomura and Hatai, 1940) [Jn: Mamé-hibarigai] (Fig. 2L)

Material examined. TS09-C160 (3: 8.0–17.4); TS09-C180 (1: 8.7); TS09-HC150 (200<: 2.0–10.6); TS09-HC170 (2: 7.2, 7.4).

Remarks. Aggregately byssate on shell surface of *Limopsis obliqua*. They seem to utilize shell surface of *Limopsis* shell for hard stratum at settlement rather than the special commensalism.

Dacrydium vitreum (Möller, 1842) [Jn: Kitano-hibarigai] (Fig. 2M)

Material examined. TS09-OW08 (1: 2.5); TS09-OW09 (1: 2.5); TS09-OW21 (1: 3.0); TS09-OW28 (3: 2.4–2.5); TS09-OW30 (4: 3.0–3.5); TS09-OW31 (10: 2.1–2.9); TS09-OW36 (1: 2.0); TS09-OW37 (8: 1.5–2.2); TS09-OW39 (2: 2.2–3.5); TS09-OW41 (3: 1.7–2.6); TS09-OW43 (3: 2.5–3.5).

Remarks. This small bathyal mytilid is identifiable to be *D. minimum* Okutani and Izumidate, 1992 described from the Yamatotai Bank, 400–1200 m depth. However, Kamenev (2012) agreed with Scarlato (1981) and Coan *et al.* (2000) that this species along with *D. nipponicum* Okutani, 1975 represent infraspecific variabilities, otherwise young growth stages of circumboreal species, *D. vitreum* (Möller, 1842).

Order Pectioida
Family Pectinidae

Delectopecten randolphi (Dall, 1897) [Jn: Ōhari-nadeshiko] (Fig. 2N)

Material examined. TS09-OW11 (3: 14.6–16.8); TS09-OW13 (2: 16.9–19.7); TS09-OW14 (1: 11.0); TS09-OW15 (1: 8.1); TS09-OW18 (142: 3.7–19.2); TS09-OW21 (5: 3.9–20.4); TS09-OW22 (2: 7.5, 15.0); TS09-OW24 (84: 5.4–27.1); TS09-OW26 (2: 14.1, 14.4); TS09-OW27 (1: 10.0); TS09-OW-29 (8: 9.2–19.7); TS09-OW30 (3: 19.7–21.3); TS09-OW31 (1: 2.9); TS09-OW32 (21: 9.7–26.5); TS09-OW37 (3: 12.6–14.0); TS09-OW44 (1: fractured); TS09-T108 (8: 7.0–12.7).

Remarks. Coan *et al.* (2000) applied the name of *D. vancouverensis* (Whiteaves, 1893) to this species.

Family Propeamussiidae

Parvamussium alaskense (Dall, 1871) [Jn: Arasuka-nishiki] (Fig. 2O)

Material examined. TS09-BZ300 (2: 8.5, 17.6); TS09-BZ350 (3: 8.7–17.8); TS09-C450 (1: 21.8); TS09-N250 (2: 17.3, 19.0); TS09-N300 (15: 14.8–22.3); TS09-ZY10-1 (3: 15.6–17.0); TS09-ZY10-2 (3: 11.3–18.1); TS09-ZY27 (11: 15.4–23.6); TS09-ZY31 (8: 14.8–20.6); TS09-ZY53 (11: 15.4–24.4); TS09-ZY141 (28: 13.5–22.7); TS09-OW02 (9: 9.6–19.0); TS09-OW03 (2: 13.1–14.1); TS09-OW05 (1: 12.3).

Subclass Heteroconchia
Order Carditoida
Family Cardiidae

Cyclocardia rjabininae (Scarlato, 1955) [Jn: Erimo-marufumigai] (Fig. 4A)

Material examined. TS09-C170 (1: 11.4)

Remarks. A single specimen is close to *C. ferruginea* (Clessin, 1888) in having about 25 radial ribs, but differs in having less pronouncedly prosogyrous beaks, and less convex ventral margin with angulated posterior margin generating sub-quadrate profile. This is thus referable to a subarctic species, *C. rjabininae* (= *C. erimoensis* Tiba, 1972 *fide* Scarlato, 1981), which is distributed from the Kamchatka, Okhotsk Sea to Hokkaido, southward to the present locality.

Family Astartidae

Tridonta polaris Dall, 1921 [Jn: Shijiminari-shiraogai] (Fig. 4B)

Material examined. TS09-C120 (103: 7.3–12.3); TS09-C170 (3: 6.7–9.6); TS-C180 (119: 7.1–12.0); TS09-N190 (2: 10.7, 11.3).

Remarks. Scarlato (1981) considered this taxon being a junior synonym of *T. borealis* Schumacher, 1817.

Order Anomalodesmata
Family Pandoridae

Pandorella otukai Habe, 1952 [Jn: Nerigai] (Fig. 4C)

Material examined. TS09-C170 (1: 11.2)

Family Periplomatidae

Periploma* (*Takashia*) *plane (Ozaki, 1958) [Jn. Ryūgū-hagaoromo] (Fig. 4D)

Material examined. TS09-ZY18 (2: 8.7–14.5).

Remarks. Scarlato and Kafanov (1988) had described a similar looking species, *Periploma subfragilis* from the Sea of Japan and southern Okhotsk Sea, 40–515 m depth, which was later considered to be conspecific with *P. aleutica* (Krause, 1885) by Coan *et al.* (2000). The present species has shorter posterior region and sharply truncated posterior end than Scarlato and Kafanov's species.

Family Poromyidae

Poromya castanea Habe, 1952 [Jn: Kuriiro-sunamégai] (Fig. 4E)

Material examined. TS09-BZ250 (2: 5.0, 8.2); TS09-BZ500 (1: 16.5); TS09-BZ650 (1: 12.9); TS09-C220 (5: 10.4–13.2); TS09-C250 (5: 7.5–15.4); TS09-C330 (1: 13.4); TS09-C350 (1: 14.4); TS09-C400 (TS09-C400(1: 15.4); TS09-C450 (1: 14.0); TS09-C650 (2: 12.7, 13.7); TS09-C700(1: 13.4); TS09-H2 1 (1: 11.6); TS09-H4 (1: 8.8); TS09-N250 (2: 10.0, 13.1); TS09-N450 (1: 16.2); TS09-ZY10–1(1: 12.7); TS09-ZY16-1 (5: 8.4–11.4); TS09-ZY16-2 (3: 10.6–13.4); TS09-ZY18 (7: 8.0–16.4); TS09-ZY25 (6: 9.9–11.9); TS09-ZY29-1 (12: 7.9–14.5); TS09-ZY29-3 (5: 11.7–14.3); TS09-ZY33 (1: 13.2); TS09-ZY34 (1: 10.1); TS09-ZY53 (1: 10.5);

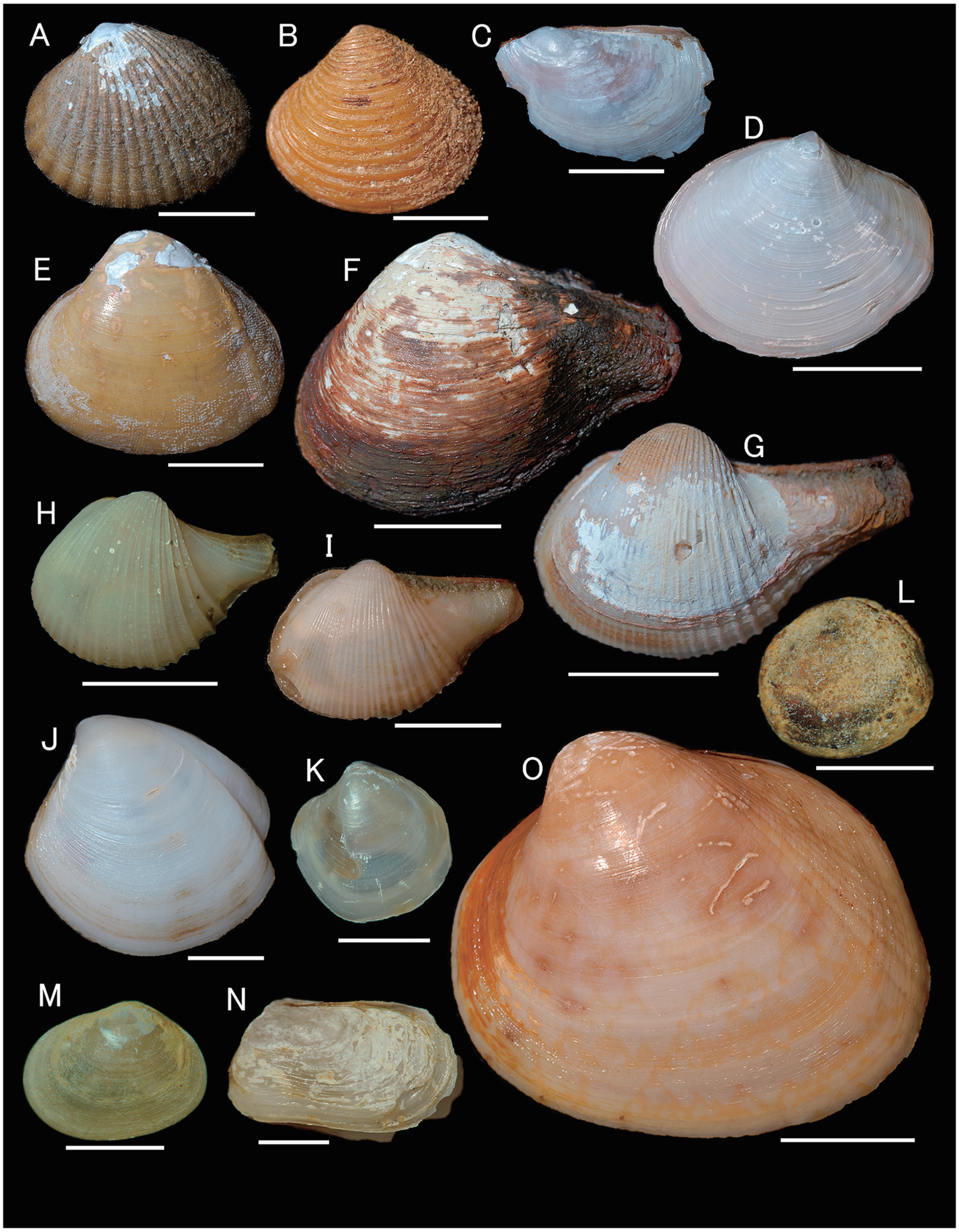

Fig. 4. Hetroconchia. A. *Cyclocardia rjabininae*, C170; B. *Tridonta prolata*, C120; C. *Pandorella otukai*, C170; D. *Periploma plane*, St.18; E. *Poromya castanea,* C700; F. *Cuspidaria trosaetes*, OW08; G. *Cardiomya behringensis*, OW30; H. *Cardiomya* cf. *gouldiana*, OW05; I. *Cardiomya sagamiana*, OW04; J. *Thyasira tokunagai*, OW44; K. *Axinulus yamatotaiensis*, OW39; L. *Mendicula ferruginosa*, OW28; M. *Montacuta* sp. OW38; N. *Hiatella orientalis* OW02; O. *Serripes groenlandica* T104. Scales: 10 mm for F, G, O; 5 mm for A-E, H-J; 2 mm for K, L, N; 1 mm for M.

TS09-OW02 (2: 6.1, 14.5); TS09-OW03 (4: 12.5–16.2); TS09-OW04 (3: 11.8–15.8); TS09-OW09 (2: 13.9, 14.4); TS09-OW28 (1: 18.9); TS09-OW32 (1: 15.5).

Family Cuspidariidae

Cuspidaria* (*Nordoneaera*) *trosaetes Dall, 1925 [Jn: Atsu-shakushi] (Fig. 4F)

Material examined. TS06-BZ700 (1: 24.1); TS09-H2 (1: 15.8); TS09-OW05 (1: 22.9); TS09-OW06 (1: 23.8); TS09-OW07 (4: 18.7–26.2); TS09-OW08 (1: 24.0); TS09-OW29 (2: 29.1); TS09-OW32 (1: 27.7); TS09-OW33 (2: 19.0, 25.5); TS09-OW41 (1: 25.2); TS09-OW47 (1: 15.7).

Remarks. Strangely enough, neither Lutaenko and Noseworthy (2012) nor Kamenev (2012) listed this species, despite it is one of representative bivalves of the Sea of Japan.

Cardiomya behringensis Leche, 1883 [Jn: Tengu-shakushi] (Fig. 4G)

Material examined. TS09-BZ250 (1: fractured); TS09-BZ400 (1: 12.7); TS09-BZ600 (3: 15.0–15.3); TS09-C100 (11: 11.8–21.1); TS09-C300 (7: 11.1–15.4); TS09-C650 (3: 13.2–17.7); TS09-N180 (1: 12.3); TS09-ZY16-1 (4: 1.7, 3 fractured); TS09-ZY16-2 (1: 13.7); TS09-ZY29-1 (2: 17.3, fractured); TS09-OW03 (2: fractured); TS09-OW04 (2: fractured); TS09-OW06 (2: 17.6); TS09-OW09 (1: 28.6); TS09-OW11 (1: 20.8); TS09-OW17 (1 : 17.6); TS09-OW18 (1: 14.1); TS09-OW21 (2: 14.5, fractured); TS09-OW25 (1: fractured); TS09-OW26 (10: 13.0–18.5); TS09-OW28 (3: 14.3–16.4); TS09-OW29 (7: 13.3–17.8); TS09-OW30 (21: 12.8–26.5): TS09-OW31 (1: 26.9); TS09-OW34 (1: 25.5); TS09-OW36 (1: 19.3); TS09-OW43 (1: 18.4); TS09-OW46 (1: fractured).

Remarks. This species represents a subarctic element. It ranges from the Bering Sea and northern North Pacific down south to the Sea of Japan and to Sagami Bay (Okutani *et al.*, 1988; Coan *et al.*, 2000; Higo *et al.*, 2001). Habe (1977) claimed that both *C. robiginosa* Okutani and Sakurai, 1964 from bathyal depths in Sagami Bay, and *C. behringensis okutanii* Scarlato, 1972 from the Sea of Japan are only phenotypes of this taxon.

Cardiomya cf. ***gouldiana*** (Hinds, 1843) [Jn: Himé-shakushi] (Fig. 4H)

Material examined. TS09-BZ500 (1: 9.1); TS09-OW05 (1: 12.3).

Remarks. The specimens under examination have higher disc than the typical ones. They merit further comparative studies using more materials from other localities.

Cardiomya sagamiana Okutani and Sakurai, 1964 [Jn: Sagami-himeshakushi] (Fig. 4I)

Material examined. TS09-C250 (1: fractured); TS09-N190 (1: 8.6); TS09-N450 (1: 10.4); TS09-OW04 (1: 11.4).

Remarks. The present specimen is separable from *C. behringensis* in having smaller shell with less number of radial ribs, which are as wide as inter-rib spaces, and more elongated rostrum. *C. gouldiana* is separable from this species in having more irregularly spaced radial ribs of which strong ones located near the base of rostrum. Habe (1977) considered that *C. sagamiana* Okutani and Sakurai, 1964 may be synonymised with *C. tosaensis* (Kuroda, 1948a). However, *C. tosaensis* has slender ribs, 18–20 in number, occasionally intercalated, and wider inter-rib spaces. *C. tosaensis* has strongly opisthogyrous beaks and upturned rostrum generating concave dorsal margin of the rostrum (Kikuchi *et al.* 1996; Higo *et al.*, 2001). Instead, *C. sagamiana* has more than 25 ribs, which are parallel-sided and as wide as or sometimes wider than inter-rib space, and less opisthogyrous beak and sub-straight rostral dorsal margin. Habe's suggestion cannot be supported.

Order Veneroida
Family Thyasiriidae

Thyasira* (*Thyasira*) *tokunagai Kuroda and Habe in Habe, 1951 [Jn: Hanashigai] (Fig. 4J)

Material examined. TS09-OW06 (1 : 13.2); TS09-OW07 (3: 12.2–15.4); TS09-OW08 (1: 13.8); TS09-OW11 (1 : 16.8); TS09-OW29 (1: 15.2); TS09-OW-30 (2: 13.9, 15.4); TS09-OW31 (9: 8.2–13.5); TS09-OW32 (1: 15.9); TS09-OW33 (1: 12.6); TS09-OW44 (2: 15.6, 18.4); TS09-OW45 (1: fractured).

Axinulus yamatotaiensis (Okutani and Izumidate, 1992) [Jn: Yamato-usu-hanashigai] (Fig. 4K)

Material examined. TS09-ZY18 (33: 1.2–2.8); TS09-OW11 (2: 2.1, 2.5) ; TS09-OW12 (1: 3.1); TS09-OW21 (5: 1.8–2.9); TS09-OW28 (11: 1.2–2.1); TS09-OW30 (10: 0.9–3.8); TS09-OW31 (11: 1.5–3.5); TS09-OW38 (29: 1.4–4.1); TS09-OW39 (4: 3.0–3.5); TS09-OW41 (2: 2.0, 2.1).

Remarks. The type locality of this species is Yamatotai Bank, central Japan Sea, 375 m depth, concurrent with the next species. Kamenev (2012) considered that this may be conspecific with *Adontorhina cyclia* Berry, 1947.

Mendicula ferruginosa (Forbes, 1844) [Jn: Sabitsuki-hanashigai] (Fig. 4L)

Material examined. TS09-ZY18 (136: 1.2–2.4); TS09-OW21 (1: 2.7); TS09-OW28 (1: 3.0); TS09-OW39 (1: 2.5).

Remarks. We have concluded that *Axinopsida rubiginosa* Okutani and Izumidate, 1992 described from the Yamatotai Bank is a synonym of a circumpolar species, *M. ferruginosa*, based on investigation on large number of the additional specimens collected by the R/V *Hakuho-maru* from the neighborhood of the Ensei Knoll (unpublished).

Family Galeommatidae

Montacuta sp. (Fig. 4M)

Material examined. TS09-OW36 (1: 2.0); TS09-OW38 (2: 1.1, 2.0).

Family Hiatellidae

Hiatella orientalis (Yokoyama, 1920) [Jn: Kinumatoigai] (Fig. 4N)

Material examined. TS09-BZ150 (1: 5.5); TS09-BZ250 (1: 8.7); TS09-OW02 (1: 6.6).

Remarks. This species byssate onto sunken timbers.

Family Cardiidae

Serripes groenlandica (Bruguière, 1789) [Jn: Uba-torigai] (Fig. 4O)

Material examined. TS09-T104 (1: 25.5)

CLASS SCAPHOPODA
Order Dentaliida
Family Dentaliidae

Striodentalium rhabdotum (Pilsbry, 1905) [Jn: Muchi-tsunogai] (Fig. 5A)

Material examined. TS09-C150 (1: 15.0); TS09-C160 (1: 9.90); TS09-C170 (41: 18.6–34.5); TS09-C190 (1: 29.4); TS09-HC150 (11: 25.3–33.7).

Striodentalium tosaensis (Habe, 1963) [Jn: Tosa-tsunogai] (Fig. 5B)

Material examined. TS09-C160 (30: 26.8–37.2)

Family Fustiariidae

Fustiaria nipponica (Yokoyama, 1922) [Jn: Saké-tsunogai] (Fig. 5C)

Material examined. TS09-OW02 (5: 31.9–36.7); TS09-OW3 (1: 29.2); TS09-OW41 (1: fractured); TS09-OW30 (2: fractured)

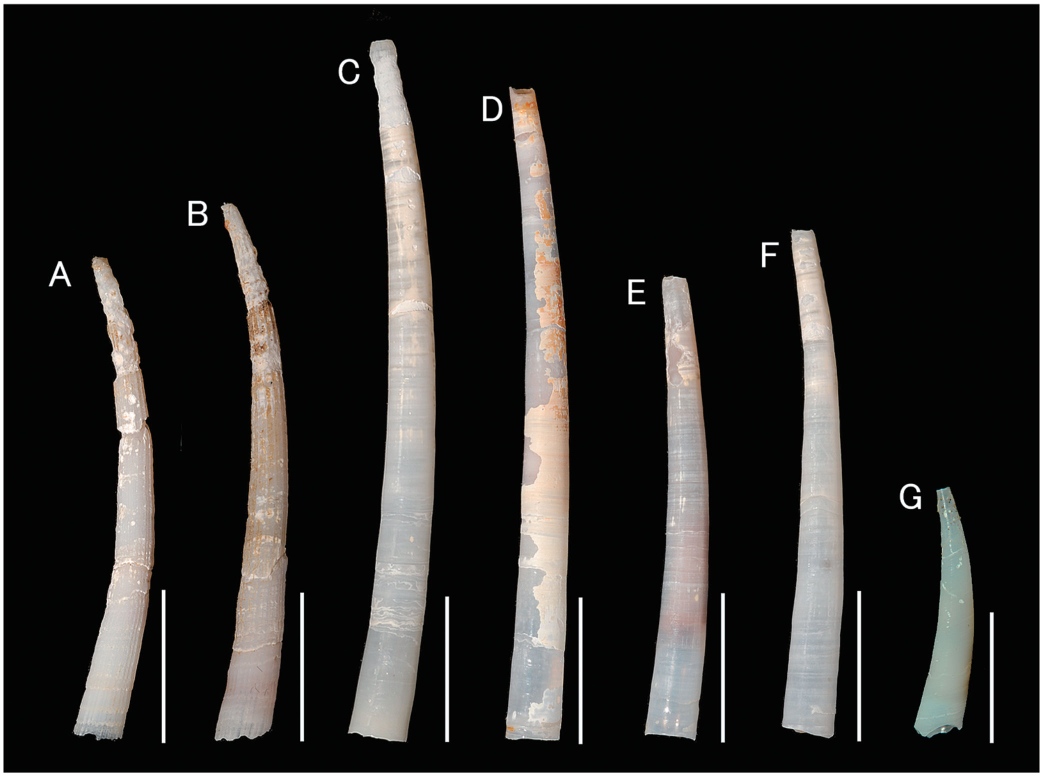

Fig. 5. Scaphopoda. A. *Striodentalium rhabdotum*, C170; B. *Striodentalium tosaensis*, C160; C. *Fustiaria nipponica*, OW02; D. *Laevidentalium toyamaense*, OW39; E. *Laevidentalium coruscum*, BZ350; F. *Laevidentalium* sp., C350; G. *Gadilina* sp. OW39. Scales: 10 mm for A-F; 5 mm for G.

Family Laevidentaliidae

Laevidentalium toyamaense (Kuroda and Kikuchi, 1933) [Jn: Toyama-tsunogai] (Fig. 5D)

Material examined. TS09-N400 (4: 34.9–56.6); TS09-OW30 (3: 34.4–48.3); TS09-OW31 (3: 30.3–43.1); TS09-OW39 (1: 44.4).

Laevidentalium coruscum (Pilsbry, 1905) [Jn: Setomono-tsunogai] (Fig. 5E)

Material examined. TS09-C420 (1: 33.2); TS09-ZY350 (2: 20.5, 46.2)

Laevidentalium sp. (Fig. 5F)

Material examined. TS09-C300 (1: 19.8); TS09-C350 (1: 17.2); TS09-C400 (2: 13.1, 29.9); TS09-N450 (1: 19.6); TS09-ZY29-1 (2: 22.2, 28.3); TS09-OW03 (fragmented shells 2: 24.5, 42.4); TS09-OW29 (1: fractured).

Order Gadilida

Family Gadilidae

Gadilia sp. (Fig. 5G)

Material examined. TS09-BZ300 (2: 5.0, 6.9); TS09-BZ350 (3: 6.3–10.2); TS09-ZY18 (3: 4.8–6.9); TS09-ZY29 (2: fractured); TS09-OW11 (1: 3.6); TS09-OW28 (6: 4.0–8.7); TS09-OW31 (5: 6.0–11.2); TS09-OW38 (12: 3.0–12.1); TS09-OW39 (1: 14); TS09-OW43 (1: 4.5); TS09-T107 (2: 24.6, 25.5).

Discussion

Twenty-nine species of bivalves and seven scaphopods (including four species identifiable only to the generic level) were discovered from the present material. The total number of specimens examined is over 5100, among which 4950 are bivalves. The constituents of the present material represent soft bottom endobiont fauna excluding a few byssate epibionts, such as *Delectopecten randolphi*, *Modiolus margaritacesus*, *Dacrydium vitreum* and *Hiatella orientalis*.

In spite of the fact that sampling of this survey was not quantitative, but numbers of individuals examined and collecting stations by species may indicate "relative abundance" and "frequency" (Tables 2 and 3).

Thus, four protobranchs, namely, *Acila divaricata*, *Nuculana robai*, *Portlandia toyamaensis*, and *Yoldiella philippiana* are most abundant and most frequent among the bivalves in the present material. It is interesting to note here that Yamashita (1978) found that *Portlandia japonica*, *Nuculana acinea* and *Acila divaricata* are among five dominant mollusks in trawl catch in the Yellow Sea. *Portlandia japonica* is close to *P. toyamaensis*, and *Nuculana acinacea* allies to *N. robai*, respectively, thus the dominancy of these species in the Yellow Sea may suggest a certain "parallel fauna" of the western sector of the Sea of Japan. Two septibranchs, *Poromya castanea* and *Cardiomya behringensis* are frequent, but less abundant than above-mentioned four protobranchs.

The major part of area covered by the present survey overlaps that reported by Ito (1967) and Tsuchida and Hayashi (1994). Ito listed 324 littoral to offshore bivalves, among which bathymetrical range for those taken by bottom-trawl were given. Depth ranges of species in Tables 4 are here compared with Ito's and Kamenev's data. Such a discrepancy may be caused by the fact that

Table 2. Ten "most abundant" bivalve species.

Species	Numbers of specimen
Yoldiella philippiana	1313
Portlandia toyamaensis	1128
Nuculana robai	570
Acila divaricata	468
Limopsis obliqua	371
Delectopecten randolphi	284
Astarte polaris	227
Modiolus margaritaceus	206
Mendicula ferruginosa	139
Axinulus yamatotaiensis	106

Table 3. Ten "most frequent" bivalve species.

Species	Numbers of positive station
Portlandia toyamaensis	60
Nuculana robai	53
Poromya castanea	31
Yoldiella philippiana	29
Cardiomya behringensis	28
Acila divaricata	26
Delectopecten randolphi	17
Parvamussium alaskense	14
Dacrydium vitreum	11
Thyasira tokunagai	11

Table 4. Comparison of depth range data (in m). Over all distribution ranges are shown in Higo *et al.* (1999)

Species	Ito (1967)	Kamenev (2012)	Presnt study	Higo *et al.* (1999)
Acila divaricata	ND	ND	191–211	50–350
Nuculana robai	*ca.* 250–400	83–2900	132–1504	100–335
Portlandia toyamaensis	*ca.* 250–400	ND	200–1295	100–600
Yodiella philippiana	*ca.* 350–450	ND	600–1898	40–2230
Poromya castanea	*ca.* 175	30–950	211–1008	30–350
Cardiomya behringensis	*ca.* 175–275	100–800	281–1985	40–500

Ito's survey was focused in shallower strata than the present investigation.

The present investigation revised vertical range for selected species in the Sea of Japan. In the most recent paper, Kamenev (2012) treated 26 deep-sea bivalves from the central and western sectors, as well as Primorye coast of the Sea of Japan. His data on bathymetrical range of distribution of every species also show a certain discrepancy form those of the present survey. This may because the geographical coverage of Kamenev's paper is more extensive than that of the present materials.

By referring to a huge number of past bibliographies, Lutaenko and Noseworthy (2012) published a catalogue of bivalves living along the cost of Primorye down south to the eastern coast of the Korean Peninsula, listing 367 species. In their catalogue, eight species in the present collection are lacking: *Petrasma pervernicosa*, *Nuculana arai*, *Yoldia similis*, *Limopsis obliqua*, *Dacrydium vitreum*, *Thyasira tokunagai*, *Periploma plane* and *Cuspidaria trosaetes*. It may because these bivalves may live more southerly than the geographical coverage by Lutaenko and Noseworthy (2012). For instance, they claimed that *Thyasira tokunagai* never occur in the Rus-

Table 5. Ratio of assumed "elements" classification of bivalves in the present material.

Assumed "elements"	Number of species	Ratio (%)
Subarctic cold-water (+circumboreal) element	8	27.6
Endemic element	4	13.8
Temperate/intermediate-water element	15	51.7
Unknown	2	6.9

sian waters.

In comparison to Lutaenko and Noseworthy's work, Kamenev treated only 26 bivalve species living in bathyal and abyssal zones in the Sea of Japan. Only 12 species are common with the present material: *Leionucula tenuis*, *Nuculana robai*, *Portlandia toyamaensis* (=*Megayoldia* sp. of Kamenev), *Yoldiella philippiana* (?=*Y. derjugini* by Kamenev), *Dacrydium vitreum*, *Parvamussium alaskense*, *Axinulus yamatotaiensis* (?=*Adontorhina cyclia* by Kamenev), *Mendicula ferruginosa*, *Cyclocardia rjabininae*, *Hiatella orientalis* (?=*H. arctica* by Kamenev), *Cardiomya behringensis*, and *Poromya castanea*. This may because the difference of intensity of sampling by area and by depth.

In faunal element analyses, Lutaenko and Noseworthy (2012) proposed six elements, namely, Tropical-subtropical, subtropical, subtropical-low boreal, low boreal, widely distributed boreal+circumboreal, and boreal-arctic, while Kamenev (2012) classified into five categories: North Pacific-Arctic, Circumboreal-Arctic, North Pacific, Sea of Japan, and Northwest Pacific.

The present material contains apparent cold-water subarctic North Pacific elements including circumboreal species. For example, *Delectopecten randolphi*, *Parvamussium alaskense,*, *Cardiomya behringensis*, *Mendicula ferruginosa* among others mixed with probable endemic species, namely, *Portlandia toyamaensis*, *Nuculana robai*, *Cuspidaria torsaetes*, and *Poromya castanea.* Most species are common to temperate intermediate-water fauna along the Pacific coast, such as off Sanriku Coast, and Sagami Bay, namely, *Acila divaricata*, *Petrasma pervernicosa,*, *Limopsis tajimae*, *Modiolus margariataceus*, *Cardiomya sagamiana* and others.

The probable ratio of each element, based on high degree of assumption in reference to the past records (*e.g.*, Habe, 1977: Scarlato 1981; Higo *et al.*, 1999; Coan *et al.*, 2000; Kamenev, 2012) and personal observations, may be like what is shown in Table 5.

Lumping Kamenev's data for comparison with this table, subarctic cold-water (arctic+ circumboreal) elements may be 30.8%, endemic elements, 19.2%, and temperate (North and Northwest Pacific) elements, 50.0%. It is interesting that both values do not show a spectacular difference between each other, in spite of the fact that sampling areas and depths are not the same.

Thus, the bivalve components represented by the present material is a mixture of cold-water elements conveyed by the Liman Current and temperate intermediate-water dwellers under the influence of the Tsushima Warm Current which is the major branch of the Kuroshio.

This general view will support Tsuchida and Hayashi's (1994) analyses of molluscan fauna below 150–200 m depth. They claimed that the said fauna occupies uppermost part of "the Japan Sea Intermediate Water" defined by Ogata (1972), and consisted by endemic species (such as *Portlandia toyamaensis*), cold currents species (such as *Parvamussium alaskense*) and those with bathyal habitat on the Pacific coast, namely, from off Sanriku Coast down south to Sagami Bay, Suruga Bay and Tosa Bay. The last-mentioned one is equivalent to "temperate/intermediate-water elements" in Table 5. They occupy more than half of the components indicating that they are the majority of bathyal bivalve fauna in the (south-) western sector of the Sea of Japan, and cold-water subarctic and endemic elements are apparent but minor ones.

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