# *Neptunea sakurai* (Ozaki, 1958) (Gastropoda: Buccinidae) from middle to upper Pleistocene deposits in the southern part of the Japan Sea

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## ABSTRACT

An extinct buccinid species, *Neptunea sakurai* (Ozaki, 1958), belonging to *N. lyrata* stock, was collected from the Middle to Upper Pleistocene deposits on the seabed at upper bathyal depths in the southern part of the Japan Sea. This is the first record of this species from the Middle to Upper Pleistocene deposits, and it indicates that this species survived the end-Early Pleistocene extinction event in the lower sublittoral to upper bathyal depth.

*Additional Keywords*: Marine, fossil, deep water, end-Early Pleistocene extinction event

## INTRODUCTION

Pliocene to Quaternary molluscan fossils have rarely been recorded from outcrops on the seabed of the Japan sea. Many shallow-water species have been illustrated from the upper Pliocene to lower Pleistocene deposits off the western Honshu (San'in region) in the southern part of the Japan Sea (Okamoto, 1978; Okamoto and Honza, 1978). These assemblages indicate a mixture of the cold-water species dominant Omma-Manganji fauna (Otuka, 1939a) and the warm-water Kakegawa fauna (Otuka, 1939b). The molluscan fossils from the southern part of the Japan Sea are important for estimating environmental change because few marine deposits crop out in the western Honshu.

Several specimens of the fossil buccinid of the genus *Neptunea* collected in upper bathyal depths of the southern part of the Japan Sea were acquired from commercial bottom trawlers. This paper discusses the identify of this species and significance of the occurrence.

## MATERIALS AND METHODS

Fossil specimens of a species of *Neptunea* were recovered from two closely situated localities in the southern part of the Japan Sea (Figure 1). Nine specimens from Loc. 1 (35°43′21″ N, 130°43′21″ E, 305m depth), and 14 specimens from Loc. 2 (35°29′30″ N, 130°44′40″ E, 201m depth), were examined for the present study.

Isotope ages were determined using two specimens from Loc. 1, and assigned to 47,565 ± 483 yrBP and 51,400 ± 680 yrBP by the Institute of Accelerator Analysis Ltd., based on $^{14}C$ methodology (Bronk Ramsey, 2009; Heaton et al., 2020). However, these ages seem to be near or slightly over the limit of this method, which is usually within the range of 50 ka to 60 ka (Trumbore, 2000). There is a possibility for the age to be older than late Pleistocene. The calcareous nannofossil assemblage attached to the present specimens may also be helpful to estimate the age; accordingly, six nannofossil species were identified from the relatively hard sediments scraped off from the inner side of apertural parts of *Neptunea* species from Loc. 1. Among them, the occurrence of a coccolithophore *Emiliania huxleyi* indicates the fossil's age to be from 265 ka (middle Pleistocene) to the present (Sato et al., 2009). From these data, the age of the fossils can be assigned to the middle to late Pleistocene.

Institutional Abbreviations: IGPS, Institute of Geology and Paleontology, Tohoku University, Sendai; NMNS PM, Paleontological molluscan collection of the National Museum of Nature and Science, Tokyo.

## SYSTEMATICS

Family Buccinidae Rafinesque, 1815

### Genus *Neptunea* Röding, 1798

Subgenus *Neptunea* Röding, 1798
**Type Species:** *Murex antiquus* Linnaeus, 1758 by subsequent designation (Sandberger, 1861).

### *Neptunea (Neptunea) sakurai* (Ozaki, 1958)

(Figures 2–13)

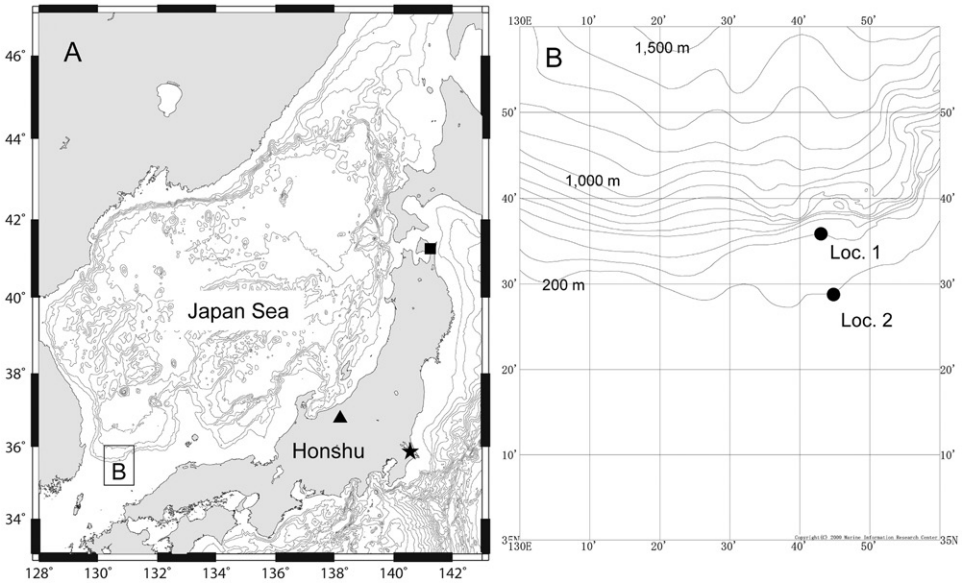



**Figure 1.** Localities of study fossils. A square area "B" shown in the map "A" (left) is enlarged in the right. Black circles indicate localities of the present material. A black star shows the type locality of *Neptunea sakurai* (Ozaki, 1958), a black square and a black triangle show additional localities, Hamada Formation in Aomori Prefecture, and Ogikubo Formation in Nagano Prefecture, respectively.

*Suavodrillia sakurai* Ozaki, 1958: p. 162, pl. 16, figs. 8, 9.
*Neptunea sakurai* (Ozaki) – Hatai et al., 1961: pl. 3, fig. 17; Masuda, 1982: pl.156, fig. 1455; Nagamori, 2014, pl. 18, figs. 8a, b.
*Neptunea* (*Neptunea*) *sakurai* (Ozaki) – Amano, 1997: figs. 3–4, 5; Shimaguchi and Nara, 2015: pl. 3, fig. 4.
not *Neptunea sakuraii* (Ozaki) – Baba, 1990: p. 164, pl. 10, fig. 19 [=? *N. lyrata* (Gmelin, 1791)].

**Type Locality:** Cliff, 500m south of Matsugishi railway Station, Choshi City, Chiba Prefecture, Pacific side of central Honshu. Lower Pleistocene Iioka Formation.

**Type Material:** Holotype, NMNS PM 4500 (Figures 5, 6).

**Original Description:** "Shell moderate in size, fusiform; although the early whorls are broken, spire apparently shorter than the apertural part, apical angle 60; each whorl sculptured by a strong, broad, rounded carina below the middle, the surface above it slightly convex, and concave below; body whorl with 11 primary cords below the carina, with secondary ones in the narrow interspaces; obsolete subsutural cord visible in front of suture. Entire surface covered with numerous distinct lines of growth, which intersect the carina and revolving cords thus giving rise to somewhat rugose appearance. Inner lip covered with narrow callus, outer lip strongly flexuous; canal moderately broad." (Ozaki, 1958, p. 162).

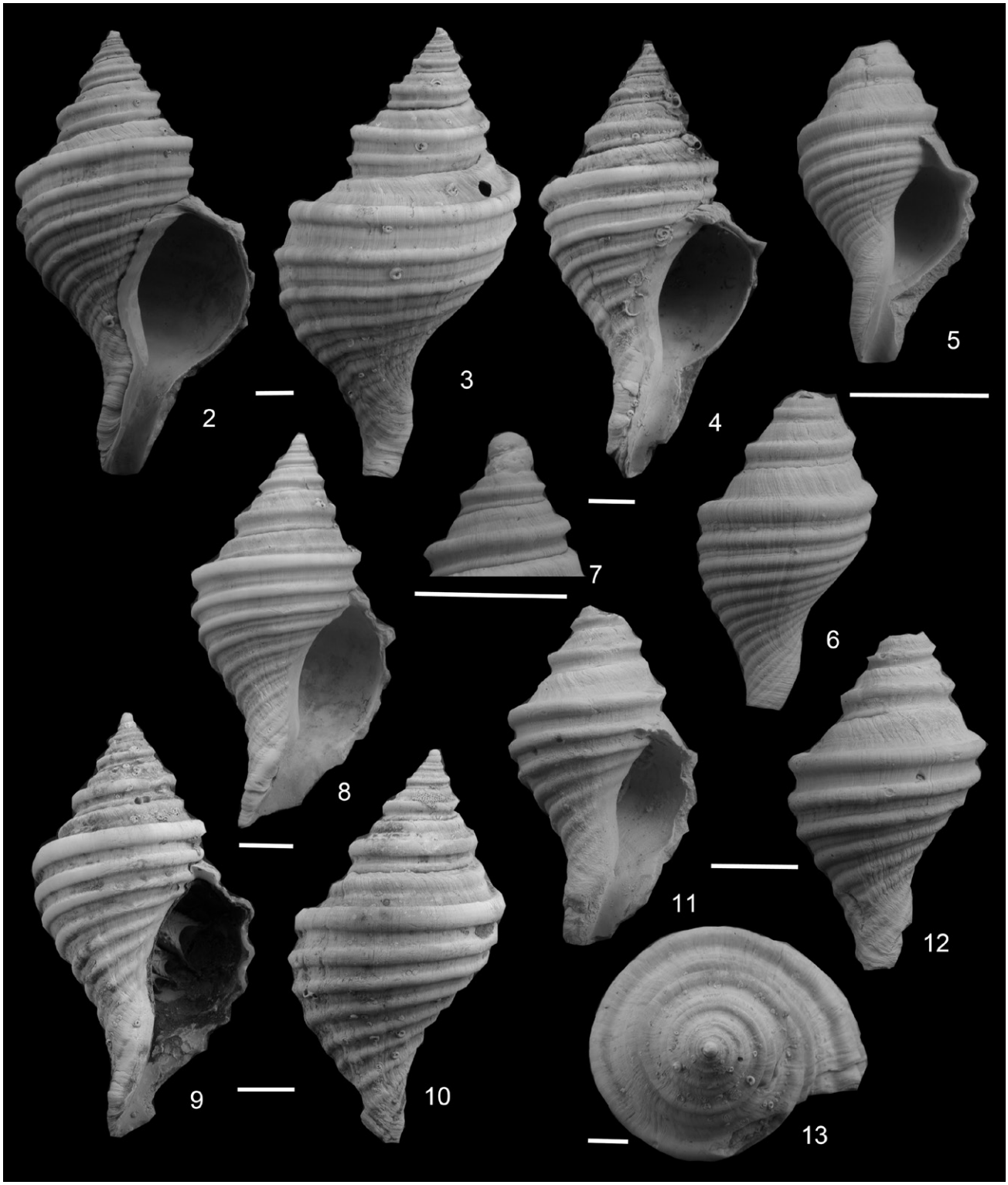
**Description of the specimens from the southern part of Japan Sea:** Shell medium in size for genus, up to 118.9 mm, moderately thick; protoconch (Figure 7) well preserved, smooth, consisting of two relatively large convex whorls (diameter = 3.0 to 3.3 mm); teleoconch of five and half whorls in largest specimens. Body whorl large, occupying about three-fourths of shell length. Suture deep. Penultimate whorl sculptured by three round-topped cords and fine growth lines; lower two cords strong, with middle one being most prominent, and uppermost cord situated below suture weakest with additional indistinct cord between middle and upper cords. Body whorl sculptured by eight to 12 round-topped cords (most frequently 10) with one interstitial weak cord and fine growth lines; strongest cord situated above periphery, producing rather convex shoulder; base ornamented with six to nine cords (most frequently eight); uppermost cord located just below deep suture. Aperture ovate; inner lip covered by thick calcareous callus; outer lip not thickened. Siphonal canal narrow, long and oblique. Fasciole narrow and relatively long.

**Material Examined:** Eight well-preserved specimens (NMNS PM 65148) from loc. 1, and 14 specimens (NMNS PM 65149) from Loc. 2 (Figure 1B).

**Measurements:** See Table 1.

**Distribution:** Pliocene; Ogikubo Formation in Nagano Prefecture (Nagamori, 2014). early Pleistocene; Iioka Formation in Chiba Prefecture (Ozaki, 1958) and Hamada Formation in Aomori Prefecture (Hatai et al., 1961; Amano, 1997; Shimaguchi and Nara, 2015). middle to late Pleistocene deposits from the western part of the Japan Sea (this study).

**Remarks:** Ozaki (1958) proposed this species in the turrid genus *Suavodrillia* Dall, 1918, based on single




**Figures 2–13.** *Neptunea sakurai.* **2, 3.** Specimen from Loc. 1, NMNS PM 65148-1. **2.** Apertural view. **3.** Dorsal view. **4.** Specimen from Loc. 2, NMNS PM 65149-3; Apertural view. **5, 6.** Holotype from the Iioka Formation, NMNS PM 4500. **5.** Apertural view; **6.** Dorsal view. **7, 8.** Specimen from Loc. 1, MNS PM 65148-4. **7.** Protoconch. **8.** Apertural view. **9, 10.** Specimen from Loc. 2, NMNS PM 65149-1. **9.** Apertural view; **10.** Dorsal view. **11, 12.** Specimen from the Hamada Formation, NMNS PM 58112; **11.** Apertural view. **12.** Dorsal view. **13.** Specimen from Loc. 1, MNS PM 65148-2, Apical view. Scale bar = 1cm.

**Table 1.** Measurements of specimens.

| No. | NTW* | Height (mm) | Diameter(mm) | PSN** | BSN*** |
|---|---|---|---|---|---|
| 64148-1 | 5.5 | 117.2+ | 59.8 | 3 | 10 |
| 64148-2 | 5.5 | 109.8 | 60.9 | 3 | 10 |
| 64148-3 | 4 | 104.4+ | 62.7 | 3 | 11 |
| 64148-4 | 5 | 79.8 | 42.0 | 3 | 11 |
| 64148-5 | 5.5 | 118.9+ | 55.7 | 3 | 10 |
| 64148-6 | 4 | 104.0+ | 49.4 | 3 | 11 |
| 64148-7 | 4 | 80.8+ | 40.9 | 3 | 9 |
| 64148-8 | 4 | 93.1+ | 47.3 | 3 | 11 |
| 65149-1 | 5 | 75.1 | 37.9 | 3 | 9 |
| 65149-2 | 5.5 | 80.6 | 43.7 | 3 | 8 |
| 65149-3 | 5 | 87.6 | 44.1 | 3 | 9 |
| 65149-4 | 5 | 55.4+ | 33.0 | 3 | 10 |
| 65149-5 | 4 | 75.8+ | 42.1 | 3 | 9 |
| 65149-6 | 4 | 74.7+ | 41.4 | 3 | 8 |
| 65149-7 | 4.5 | 72.1+ | 39.0 | 3 | 10 |
| 65149-8 | 3 | 56.0+ | 34.2 | 3 | 9 |
| 65149-9 | 4 | 76.2+ | 39.4 | 3 | 9 |
| 65149-10 | 4 | 58.1 | 31.6 | 3 | 10 |
| 65149-11 | 4 | 82.1+ | 43.7 | 3 | 12 |
| 65149-12 | 5 | 68.1+ | 37.7 | 3 | 9 |
| 65149-13 | 4 | 64.9+ | 40.6 | 3 | 9 |
| 65149-14 | 5 | 85.1+ | 42.8 | 3 | 13 |

*NTW= number of teleoconch whorls; **PSN= number of spiral cords on the penultimate whorl; ***BSN= number of spiral cords on the body whorl. NMNS PM 64148 from Loc. 1 and NMNS PM 65149 from Loc. 2.

juvenile specimen (height = 22 mm) from the lower Pleistocene Iioka Formation in Chiba Prefecture on the Pacific side of central Honshu. The holotype has only one cord on the penultimate whorl and 12 cords on the body whorl. In describing the fauna from the lower Pleistocene Hamada Formation in Aomori Prefecture, Hatai et al. (1961) recorded this species and allocated it to the genus *Neptunea* Röding, 1798. When Amano (1997) illustrated immature specimens from the Hamada Formation stored at IGPS, he included *N. sakurai* in the *N. lyrata* stock as defined by Goryachev (1978). These specimens have one or three strong cords on the penultimate whorl and eight to 10 cords on the body whorl. Although these specimens are juvenile or immature shells, Shimaguchi and Nara (2015) illustrated for the first time a fully grown specimen, attaining about 100 mm in length, from the Hamada Formation. This specimen is most similar to our specimens from the southern part of the Japan Sea in having three spiral cords on the penultimate whorl and about 10 cords with one interstitial cord. Our specimens are therefore confidently identified as *Neptunea sakurai.*

According to the original description, the species was named after Dr. K. Sakurai. Thus, Masuda and Noda (1976) pointed out that the species name must be changed to *N. sakuraii* based on the Latin grammar. However, according to ICZN article 32.5, *N. sakurai* should be used regardless of its grammatical incorrectness, as it is the original spelling of the name.

This species is closely similar to the extant species, *N. excelsior* Fraussen and Terryn, 2017 recorded in the Eastern China, Korea, Primorie to central Sakhalin in the Japan Sea, Hokkaido, the Sea of Okhotsk, and the southern Bering Sea off Kamchatka. Both species share a similar number of strong spiral cords with at least one interstitial cord, not fine threads. However, *N. excelsior* differs from *N. sakurai* in having a larger shell (up to 190 mm), flat-topped cords sometimes with secondary fine cords on top and a shorter and wider siphonal canal. *Neptunea excelsior* has thus far not been recorded from the Japanese archipelago side of the Japan Sea.

*Neptunea lyrata* (Gmelin, 1791) is another related species, but it differs from *N. sakurai* by having a larger shell (attaining 187 mm in height) with a shorter siphonal canal and sculpture of many fine threads between strong spiral cords (Golikov, 1963; Fraussen and Terryn, 2017). Baba (1990: pl. 10, fig. 19) illustrated an incomplete specimen

of a species of *Neptunea* as *N. sakuraii* (*sic*) from its type locality, the Iioka Formation. However, the illustrated species has an angulated shoulder at the strongest cord on the body whorl and numerous fine interstitial threads. These characters agree with *N. lyrata*, not with *N. sakurai*.

## DISCUSSION

In the Pliocene to Early Pleistocene, the Omma-Manganji fauna (Otuka, 1939a) flourished mainly in the Japan Sea borderland (Ogasawara, 1986; Amano, 2001, 2007).

The oldest specimen of *Neptunea sakurai* was recorded by Nagamori (2014) from the Pliocene Ogikubo Formation in Nagano Prefecture, near the Japan Sea side of central Honshu, together with some characteristic species of the Omma-Manganji fauna. Molluscan assemblages of the lower Pleistocene Hamada Formation in Aomori Prefecture include some characteristic species of the Omma-Manganji fauna, including *Neptunea sakurai* (Hatai et al., 1961; Ogasawara, 1977, 1986; Masuda and Ogasawara, 1981; Amano, 1997; Shimaguchi and Nara, 2015). In addition to the Hamada Formation, this species is also known from the lower Pleistocene Iioka Formation in Chiba Prefecture, central Honshu (Ozaki, 1958), based on the immature holotype. This species was considered to have become extinct due to end-early Pleistocene extinction events in the Japan Sea because of the environmental deterioration due to glaciation (Amano, 2004, 2007). Thus, the present finding of this species from the middle to upper Pleistocene deposits confirms its survival until a later time in the southern part of the Japan Sea. This is also the first record of this species from the seabed of the Japan Sea at upper bathyal depths (201 to 305m) at the present sea level.

Some deep-water molluscan species could successfully survive the end-early Pleistocene extinction as well as the Last Glacial Maximum (LGM) event. These include *Portlandia toyamaensis* (Kuroda, 1929), *Buccinum tsubai* Kuroda in Teramachi, 1933, and *B. striatissimum* Sowerby, 1899 (Amano, 1996, 2004, 2007). They might have survived in the depth range between 100 and 400m because the marine water with normal salinity and oxygen concentration (intermediate water) existed at this depth range during the glacial ages (Amano, 2004).

## ACKNOWLEDGMENTS

We are grateful to Geerat J. Vermeij (UC Davis) for his critical reading of the manuscript and useful suggestions. We thank Takuma Haga (NMNS) for his technical support to measure the isotope ages. We also thank Jerry Harasewych (Department of Invertebrate Zoology, Smithsonian Institution), Yuri I. Kantor (Severtsov Institute of Ecology and Evolution, RAN), and Anton Oleinik (Florida Atlantic University) for their critical reading and many useful suggestions for improving the manuscript. This work is financially supported by the integrated project "Geological, biological, and anthropological histories in relation to the Kuroshio Current" conducted by the National Museum of Nature and Science.

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