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<th>Tanaka, Yoshihiro</th>
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<tr>
<td>Citation</td>
<td>Paleontological Research, 20(2), 105-115</td>
</tr>
<tr>
<td>Issue Date</td>
<td>2016-04-01</td>
</tr>
<tr>
<td>Doc URL</td>
<td><a href="http://hdl.handle.net/2115/64951">http://hdl.handle.net/2115/64951</a></td>
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<td>Type</td>
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<td>File Information</td>
<td>PR20-2 105-115.pdf</td>
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A new and ontogenetically younger specimen of *Numataphocoena yamashitai* from the upper part of the Horokaoshirarika Formation (lower Pliocene), Numata, Hokkaido, Japan

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Received May 30, 2015; Revised manuscript accepted September 13, 2015

Abstract. A new periotic of *Numataphocoena yamashitai* from the upper part of the Horokaoshirarika Formation (lower Pliocene), Numata, Hokkaido, Japan shows younger ontogenetic features in comparison to the matured holotype (NFL 7). The referred specimen of *N. yamashitai* is smaller (approximately 90% in size) than the physically and sexually matured holotype periotic. The holotype (NFL 7) and referred specimen (NFL 2617) show several differences owing to ontogenetic changes, such as: the holotype (NFL 7) has a more strongly swollen medial part of the anterior process, blunt anterior keel, rounded anterodorsal angle, deeper and clearer anterior incisure, more rounded pars cochlearis, deeper and narrower hiatus epitympanicus rather than a flat area, longer posterior process with an extra edge posterolaterally. *N. yamashitai* differs from other fossil phocoenids in having a narrower and sharper anterior part of the internal acoustic meatus and a robust anterior process. *Haborophocoena toyoshimai* similarly has a relatively narrow internal acoustic meatus and a robust anterior process, compared with other fossil phocoenids. Between *N. yamashitai* and *H. toyoshimai*, *N. yamashitai* has a narrower internal acoustic meatus and a more robust anterior process. These similarities imply a close relationship between *Numataphocoena* and *Haborophocoena*. The new specimen provides diagnostic features and insight into ontogenetic variation of *N. yamashitai*.

Key words: fossil, ontogeny, periotic, Phocoenidae

Introduction

The holotype of *Numataphocoena yamashitai*, a primitive fossil phocoenid, was found at an outcrop of the upper part of the Horokaoshirarika Formation (upper Miocene to lowest Pliocene) at the riverbed of the Horonitachibetsu River, Numata, Hokkaido, Japan in 1985 by Shigaru Yamashita. *N. yamashitai* was later described as a new genus and species by Ichishima and Kimura (2000) and identified as a physically and sexually mature individual, based on closed and firm epiphyseal sutures of the vertebrae, ulna and radius. Referred materials of *N. yamashitai* have never been described or reported. A new periotic is here described and identified as *N. yamashitai* from the upper part of the Horokaoshirarika Formation, 1 km upstream from the type locality of *N. yamashitai* along the Horonitachibetsu River. The periotic was found with an otariid fossil pinniped, NFL 10 (Yamashita and Kimura, 1990), from the same area. The periotic shows smaller dimensions, which probably reflects the younger ontogenetic stage of the referred individual. This is the first referred specimen of this species.


Systematic paleontology

Order Cetacea Brisson, 1762
Unranked taxon Neoceti Fordyce and de Muizon, 2001
Order Odontoceti Flower, 1867
Family Phocoenidae Gray, 1825
Yoshihiro Tanaka

Genus *Numataphocoena* Ichishima and Kimura, 2000


*Numataphocoena yamashitai* Ichishima and Kimura, 2000

*Figures 2, 3*


*Remarks.*—NFL 2617 is identified as *Numataphocoena yamashitai*, because *N. yamashitai* can be distinguished from other phocoenids by having a massive and robust anterior process and a narrower and sharper anterior part of the internal acoustic meatus, and by having a flat area around the aperture for the vestibular aqueduct.

*Locality.*—NFL 2617 was dug up with a fossil pinniped, NFL 10 from the riverbed of the Horonitachibetsu Figure 1. Locality maps (A) and stratigraphic sections of the locality based on previous studies which are mentioned in the text (B). Left side of figure A is from Tanaka and Kohno (2015).
A new fossil porpoise periotic from Numata, Japan

Figure 2. Right periotic of *Numatapocoena yamashitai* Ichishima and Kimura, 2000, NFL 2617. A, lateral view; B, ventral view; C, dorsomedial view; D, dorsal view; E, medial view; F, anterior view; G, posterior view.

10 mm
Figure 3. Key features of right periotic in Figure 2, *Numataphocoena yamashitai* Ichshima and Kimura, 2000, NFL 2617. A, lateral view; B, ventral view; C, dorsomedial view; D, dorsal view; E, medial view; F, anterior view; G, posterior view.
A new fossil porpoise periotic from Numata, Japan

Horizon and age.—The Miocene–Pliocene sedimentary sequence at Numata, Hokkaido includes about 200 m and 500 m thickness of the upper and lower parts of the Horokaoshirarika Formation, respectively (Watanabe and Yoshida, 1995). A thin tuff layer separates the upper and lower parts of the Horokaoshirarika Formation (Kobayashi et al., 1969). Fission track method provided an age for the tuff of 4.5 ± 0.7 Ma (Wada et al., 1986). Above the Horokaoshirarika Formation, the Ichinosawa and Bibaushi formations lie in the lower stream of the Horonitachibetsu River. The Horoshin Formation is exposed 2 km upstream from this locality. NFL 2617 was collected in situ from the upper part of the Horokaoshirarika Formation. NFL 2617 has been cleaned and has no matrix. The original horizon of NFL 10, which is the same as that of NFL 2617, is the upper part of the Horokaoshirarika Formation (Furusawa et al., 1993).

From the upper part of the Horokaoshirarika Formation, three vertebrates, the type skeleton of *Numataphocoena yamashitai* Ichishima and Kimura, 2000. Dimensions follow Fordyce (2002), Perrin (1975) and Kasuya (1973). Measurements are rounded to the nearest 0.5 mm. For skull and mandible, distances are either horizontal or vertical.

### Table 1. Measurements in mm of right periotics (NFL 2617 and holotype NFL 7) of *Numataphocoena yamashitai* Ichishima and Kimura, 2000. Dimensions follow Fordyce (2002), Perrin (1975) and Kasuya (1973). Measurements are rounded to the nearest 0.5 mm. For skull and mandible, distances are either horizontal or vertical.

<table>
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<tr>
<th>Periotic</th>
<th>NFL 2617</th>
<th>NFL 7</th>
</tr>
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<tbody>
<tr>
<td>maximum anteroposterior length from anterior apex to apex of posterior process</td>
<td>30.5</td>
<td>33.6</td>
</tr>
<tr>
<td>maximum anteroposterior length parallel to dorsal margin</td>
<td>30.3</td>
<td>33.8</td>
</tr>
<tr>
<td>maximum dorsoventral depth anterior process perpendicular to axis of periotic</td>
<td>16.1</td>
<td>15.8</td>
</tr>
<tr>
<td>length of anterior process from anterior apex to level of posterior of malleolar fossa</td>
<td>15.6</td>
<td>15.6</td>
</tr>
<tr>
<td>length of anterior process from anterior apex of anterior process to level of anterior of pars cochlearis in notch immediately lateral to fine ridge</td>
<td>8.5</td>
<td>7.2</td>
</tr>
<tr>
<td>dorsoventral depth at fovea epitubaria</td>
<td>10.5</td>
<td>11.6</td>
</tr>
<tr>
<td>length facet on posterior process point to point</td>
<td>10.6</td>
<td>12.2</td>
</tr>
<tr>
<td>maximum width of anterior process at base</td>
<td>11.7</td>
<td>13.1</td>
</tr>
<tr>
<td>approximate anteroposterior length of pars cochlearis</td>
<td>16.6</td>
<td>18.2</td>
</tr>
<tr>
<td>approximate transverse width of pars cochlearis from internal edge to fenestra ovalis</td>
<td>8.6</td>
<td>9.3</td>
</tr>
<tr>
<td>transverse width of periotic, internal face of pars cochlearis to apex of lateral tuberosity</td>
<td>10.7</td>
<td>10.9</td>
</tr>
<tr>
<td>length of posterior process of periotic</td>
<td>10.5</td>
<td>12.6</td>
</tr>
<tr>
<td>length of posterior process parallel to posterior profile/ steeply acute to long axis of body</td>
<td>11.4</td>
<td>13.1</td>
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General description

Periotic.—Morphological terminology follows Mead and Fordyce (2009). The periotic (Figures 2, 3 and Table 1) has a short and wide anterior process, skewed medi-ally, and a globe-like pars cochlearis, which is about twice as long as the anterior process. The posterior process is short.

The anterior process is robust, with a prominent anterodorsal angle and keel. Laterally, the parabullary ridge is swollen and bears small striae. The fovea epitubaria for the accessory ossicle is deeply depressed and...
Figure 4. Right periotic of *Numataphocoena yamashitai* Ichishima and Kimura, 2000. NFL 7, holotype. A, lateral view; B, ventral view; C, dorsomedial view; D, dorsal view; E, medial view; F, anterior view; G, posterior view.
Figure 5. Key features of right periotic in Figure 4, *Numataphocoena yamashitai* Ichishima and Kimura, 2000, NFL 7, holotype. A, lateral view; B, ventral view; C, dorsomedial view; D, dorsal view; E, medial view; F, anterior view; G, posterior view.
forms an angle on the parabullary ridge in lateral view. On the anteromedial surface of the anterior process, the anterointernal sulcus runs between the fovea epitubaria and anterodorsal angle. On the holotype, NFL 7 (Figures 4, 5), there are two anterointernal sulci. There is a small rounded pit (about 1 mm in diameter) only on NFL 2617, just anterior to the anterointernal sulcus. The anterior incisure is shallow anteriorly and runs slightly posterior to the anterodorsal angle, deepening posteriorly.

The pars cochlearis is hemispherical ventrally, transversely compressed and anteroposteriorly elongate. A tiny rounded foramen for the hiatus fallopii is visible slightly medial to the anterior edge of the internal acoustic meatus, only on the holotype, NFL 7 (around 0.5 mm in diameter), but is not visible on NFL 2617 because of damage. The anteroposteriorly long triangular internal auditory meatus (maximum length = 12.0 mm, 4.1 mm wide) opens on the center dorsally. The meatus contains four structures: 1, the proximal opening of the facial canal, which is deep, anteroposteriorly long and oval (about 1 mm in diameter); 2, the foramen singulare, which is circular and smaller (about 0.1 mm in diameter); 3, the spiral cribriform tract, which is located anteromedial to the foramen singulare; 4, the area cribrosa media, which is a shallow fossa, is located at the posterior rim of the internal acoustic meatus. A thin transverse ridge separates the large and rounded proximal opening for the facial canal from the smaller foramen singulare. A transverse crest separates the opening of the facial canal and foramen singulare and the spiral cribriform tract and area cribrosa media (broken). The anterior margin of the fenestra rotunda is damaged, but it appears to have been 0.7 mm in transverse diameter. The fenestra rotunda opens posterodorsally. The aperture for the vestibular aqueduct is transversely long (2 mm in maximum diameter) and semi-crescentic. The aperture for the cochlear aqueduct shows broken margins, but is circular and much smaller than the vestibular aqueduct (0.4 mm in diameter).

On the body of the periotic, ventrally, the malleolar fossa is a shallow and anteroposteriorly long square (5 mm long and 3 mm wide). The lateral tuberosity is swollen both laterally and ventrally, and continues with the parabullary ridge. The anterolateral end of the parabullary ridge forms the anteroventral angle. The hiatus epitympanicus is narrow, bears a rounded lateral margin, and is situated posterior to the lateral tuberosity. Just between the malleolar fossa and posterior process, there are two tiny deep pits, the submalleolar fossa anteriorly and the fossa incudis posteriorly. The facial crest is thick and separates the fossa incudis and ventral opening of the facial canal. The facial canal is deep and continues to the deep facial sulcus, which widens towards the stapedial muscle fossa posteriorly. Between the facial sulcus and stapedial muscle fossa, there is no clear border. The fenestra ovalis is large (2 mm in diameter) and excavates the pars cochlearis medially. The stapes is in situ (see below).

The short posterior process has a thin anterior margin. The bullar facet is weakly depressed with multiple weak ridges. The dorsal surface of the periotic has a developed dorsal angle at the level of the aperture for the vestibular aqueduct.

**Stapes.**—The right stapes is preserved in situ. A small and deep pit on the posteromedial surface presumably represents the vestigial stapedial foramen; the ventral section is smooth (1.3 mm in diameter).

**Discussion**

**Comparison among other fossil Phocoenidae.**—The two periotics of *Numataphocoena yamashitai* show shared and diagnostic features, which are discussed here. The reported fossil Miocene and Pliocene phocoenids are listed in Table 2 and compared with *N. yamashitai*.

*Numataphocoena yamashitai* differs from other phocoenids having a narrower and sharper anterior part of the internal acoustic meatus and a robust anterior process. All other fossil phocoenids have a rounded internal acoustic meatus and also a slender anterior process, except for *Haborophocoena toyoshimai* and *Salumiphocoena stocktoni*. *S. stocktoni* shares a narrow internal acoustic meatus with *N. yamashitai*, but lacks a robust anterior process. *H. toyoshimai* similarly has a relatively narrow internal acoustic meatus and robust anterior process compared with other fossil phocoenids, but they are narrower and more robust, respectively, on *N. yamashitai*. These similarities imply close relationships between *Numataphocoena* and *Haborophocoena*. *N. yamashitai* has never been included in a phylogenetic analysis so far.

**Comparison between the referred specimen NFL 2617 and the holotype of Numataphocoena yamashitai, NFL 7.**—These two periotics share features as discussed above, but differ in size and also some morphological conditions. NFL 7, the holotype of *N. yamashitai*, which has a 10% larger periotic, was identified as a physically and sexually mature individual, based on the closed and firm epiphyseal suture of the vertebrae, ulna and radius (Ichishima and Kimura, 2000). NFL2617 is the first referred specimen of *N. yamashitai* and was recovered from the same stratigraphic unit (upper part of the Horokaoshirarika Formation) at a nearby locality, so morphological differences may simply reflect ontogenetic differences with the holotype. Ontogenetic variation among the Delphinoidae has been discussed by Kasuya (1973). The study examined one phocoenid species, *Neophocaena phocaenoides*, and found that the
length of the posterior process (relative to the length of the periotic) increased during growth.

For comparison between ontogenetically different Numataphocoena yamashitai, NFL 7 and 2617, five individuals of the modern porpoise, Phocoena phocoena were examined. It is supposed that the youngest individual among the five is NFL 2619 (2.5 mm maximum length). SMAC 1263 (2.7 mm) and SMAC 2878 (2.9 mm) are juveniles, but more developed compared with NFL 2617. Two supposed adult periotics, TK 84 (in Kasuya, 1973, pl. 12, figs. 10–18) and one in the B. T. Walter Collection (in Wilson, 1973; Fig. 6g–h) are used for comparison.

The differences listed below might be ontogenetic variations, which are seen among the modern periotics above. Compare to ontogenetically younger individuals, adults have a swollen medial surface of the anterior processes; more rounded anterodorsal angles; deeper anterior incisures: more rounded and larger pars cochlearis; longer posterior process.

These ontogenetic variations on the periotic are seen between the two N. yamashitai. The holotype (NFL 7) has a more strongly swollen medial surface of the anterior process, which shows a blunt anterior keel anteriorly. Related with the swollen structure, the anterodorsal angle is more rounded, and the anterior incisure is deeper and clearer (the angles between the anterior process and anterior surface of the pars cochlearis are 120 and 102 degrees, NFL 2617 and 7 respectively). The pars cochlearis is larger and more rounded on the holotype (NFL 7). The hiatus epitympanicus is a V-shaped notch on the holotype, but is a flat area on the referred specimen. The holotype’s posterior process is longer with an extra edge posterolaterally.

Previously, three periotic features were used to diagnose N. yamashitai. One of the three, having a swollen and rounded cochlear portion, relates to ontogeny. Another diagnostic character, having a massive and robust anterior process (length/width are 0.62 and 0.63) can be useful for identifying N. yamashitai, even if differ-
ences can be seen between the matured holotype (NFL 7) and the immature referred specimens (NFL 2617). No other phocoenid has such a robust anterior process.

**Conclusion**

The new periotic described herein is assigned to *Numataphocoena yamashitai* from the Horonitachibetsu River, the lower Pliocene (about 3.5 to 5.5 Ma, the upper part of the Horokaoshirarika Formation, Numata, Hokkaido, Japan), which shows a robust anterior process and very narrow anterior margin of the internal acoustic meatus. The specimen is 90% the size of the holotype of *N. yamashitai* (assumed to be a physically and sexually matured individual). More specimens will provide further diagnostic features and insight into ontogenetic variation of *N. yamashitai*.

**Acknowledgements**

I thank Masanobu Kato, Takayuki Tanaka and Tadashi Seto for finding and collecting the specimens in August, 1986, and Shigeru Yamashita, Masaichi Kimura, Numata Fossil Laboratory and the Numata Town Board of Education for collecting and preparing the specimens. I particularly thank the two journal peer-reviewers, Robert Boessenecker (University of Otago) and Rachel Racicot (Howard University), for their constructive comments. I also thank Gabriel Aguirre-Fernández (University of Zurich) for providing constructive comments that helped improve the manuscript. Thanks are also due to R. Ewan Fordyce (University of Otago), who gave constructive comments on this research, to Naoki Kohno (National Museum of Nature and Science) for geological discussion, and to Satoshi Shinohara (Numata Fossil Museum) for taking me to fossil localities in Numata town. I am grateful to Hitoshi Furusawa (Sapporo Museum Activity Center) for his permission to examine comparative specimens.

**References**


Fordyce, R. E., 1989: Origins and evolution of Antarctic marine mam-
A new fossil porpoise periote from Numata, Japan


Tomida, Y. and Kohno, N., 1992: Fossil marine mammals from the Koeito Formation (Middle Late Miocene to Early Pliocene) in Wakkanai City, northern Hokkaido, Japan. *Memoirs of the National Science Museum (Tokyo)*, vol. 23, p. 49–56.


