# A STUDY OF THE GENUS *BERARDIUS* DUVERNOY*

CHARLES McCANN

*8 Kiwi Street, Heretaunga, Upper Hutt, New Zealand*

## ABSTRACT

The taxonomy and distribution of the two known species of *Berardius*, *B. arnouxi* Duvernoy and *B. bairdi* Stejneger are reviewed, and some anatomical and biological aspects of the two species are considered.

## INTRODUCTION

The members of the genus *Berardius* or Porpoise Whales, in spite of their large size, are little known. Although one of its two closely allied species, *B. bairdi* Stejneger, was known to and fished for by Japanese whalers very early in historic times, it was not scientifically recognised until 1883.

The genus *Berardius* was founded by Duvernoy in 1851 on a skull from Akaroa, Banks Peninsula, New Zealand. The specimen was taken to France by M. Arnoux, who was at the time surgeon to the French corvette *Rhin* commanded by Captain Berard. These two gentlemen are commemorated in the generic and specific names of the type species, *Berardius arnouxi* Duvernoy.

Although more than a hundred years have elapsed since the original description of *B. arnouxi*, barely forty specimens have been reported in literature. By some mischance, the ' o ' was omitted from Arnoux in the original description. Since then, some cetologists have retained the original spelling, *arnuxi*, while others have amended it to *arnouxi*. As the original spelling was almost certainly a ' lapsus calami ', the amended spelling should be adopted.

Flower (1872) gave the first detailed description of the general anatomy of *Berardius* from a specimen then in the Museum of the Royal College of Surgeons. This specimen which had stranded at New Brighton, Canterbury, New Zealand, on 16th December, 1868 had been sent to London by Sir Julius von Haast. Little has since been added.

The two known species are geographically isolated: *B. arnouxi* Duvernoy occurs only in the Southern Hemisphere, in the Southern Pacific and Southern Atlantic Oceans; whilest, *B. bairdi* Stjneger is confined to the Northern Pacific Ocean, concentrating seasonally near Japan while strays are occasionally found

---

* This paper was compiled some years ago while the author was still employed as the Vertebrate Zoologist at the DOMINION MUSEUM, Wellington (now the NATIONAL MUSEUM) under the Directorship of Dr. R. A. Falla (now Sir Robert A. Falla), since retired. Dr. R. K. Dell, is the present Director of the National Museum.

The specimen registration numbers quoted in the paper are referred to by the originals with the prefix D. M. or Dom. Mus.

*Sci. Rep. Whales Res. Inst.,*
*No. 27, 1975, 111-137.*

along the western shores of North America.

Recent papers by Omura *et al.* (1955) and others have discussed the biology and whaling of *B. bairdi*, but no such information is available for *B. arnouxi*. McCann (1962), in a revision of the genus *Mesoplodon* discovered that the calves of *B. arnouxi* had until then been identified as *Mesoplodon hectori* (Gray). Hector (1870) had originally identified the type of *M. hectori* (Gray) correctly as the young of *Berardius arnouxi* Duvernoy, but Gray (1871) declared it a new species of *Berardius*. Turner (1872) cautiously transferred *B. hectori* Gray to *Mesoplodon* where it had remained ever since. McCann's discovery not only places the genus *Mesoplodon* in a more satisfactory systematic position, but indicates that the breeding grounds of *Berardius arnouxi* are in the vicinity of the New Zealand Archipelago.

## GENUS *BERARDIUS* DUVERNOY (PLATES I-II)

| | | |
|---|---|---|
| 1851. | *Berardius* | Duvernoy, Ann. Sci. Nat. (3) 15: 52. Type *Berardius arnouxi* Duvernoy. Type locality: Akaroa, New Zealand. Type in *Paris Museum.* |
| 1872. | *Mesoplodon* | Turner, Trans. Roy. Soc. Edin. 26: 778. (*Berardius hectori* (Gray)) |
| 1922. | *Paikea* | Oliver, Proc. Zool. Soc. Lond. p. 575. Type *Mesoplodon hectori* (Gray), Type *Brit. Mus.* 1677b. 76. 2. 16. 3. |

## DESCRIPTION

Large whales attaining 7.8 to 12.7 metres (26 to 42 ft) in length. Head large, buffer-like, without nuchal depression but a pronounced rostrum or beak; upper jaw subacute anteriorly; lower jaw longer than the upper, extremity rounded; two pairs of strongly compressed functional teeth near the extremity, the anterior larger than the posterior; teeth erupted in both sexes on reaching maturity; occasionally only a single (anterior) tooth present in each ramus; normally no teeth in maxillae. Eye of moderate size. Blowhole median, crescentic. A pair of diverging gular grooves forming an inverted V-shape, the anterior arms not in contact; occasionally an additional pair of shorter grooves may appear; no thoracic nor abdominal pleats. Body fusiform, laterally compressed posteriorly only. Flippers moderately broad and rounded distally; flukes large, shallowly falcate, without median notch although occasionally a shallow indentation may appear mesially. Dorsal fin nearer the caudal, triangular, slightly falcate or represented by a short obtuse elevation.*

## SIZE

*B. bairdi* is larger than *B. arnouxi;* the former reaches 12.6 metres in length (42 ft), whereas the latter has not been known to exceed 9.9 metres (33 ft). Curiously,

---

* Perhaps the result of injury or attack by shark.

although *B. bairdi* is the larger and bulkier of the two species, it has a relatively smaller head than *B. arnouxi* (True, 1910: 67).

## SEXUAL DIFFERENCES

Females of *B. bairdi* are larger than males, but in *B. arnouxi* both sexes appear to be of very similar size. As the mandibular teeth erupt in both sexes at maturity, the external sexual differences are not as well marked as other genera of the family in which the teeth erupt in the male alone.

## GESTATION

The few breeding records available, suggest that the gestation period is approximately ten months and calving takes place during the late spring or early summer.

## ANATOMICAL OBSERVATIONS

### *The skull* (Pls. III–VI)

The skull of *Berardius* differs from those of other ziphioid genera in its greater symmetry and simplicity. Its elements are less firmly interdigitated than in other genera. The *mesorostral groove* remains unossified throughout life, i.e. the *mesethmoid cartilage* does not ossify partially nor wholly as in *Ziphius* and *Mesoplodon*. The cranium is relatively more depressed in adults than in the rest of the family, being broader than deep (Pl. VI).

Flower (1872) drew attention to the imperfect closure of the suture between the basisphenoid and presphenoid bones; the suture being, at times, open 12.5 mm (1 in) or more. This is quite normal, not only in *Berardius* but also in other members of the Ziphiidae. In *Berardius*, the suture between the supraoccipital and the frontal bones is also imperfectly closed, but in the rest of the family there is a more complete fusion of these elements. The basioccipital and the basisphenoid elements fuse completely, so that, in all the genera, the line of fusion is not clearly discernible.

In dorsal view (Pl. III, fig. 2), the posterior cranial region is semilunate, the antorbital tubercles forming the ‘ horns ’ of the moon. The rostrum is somewhat lanceolate, arising from within the antorbital notches and is considerably shorter than the mandibles. In side view (Pl. III, fig. 3), the dorsal profile is almost straight; the lower profile rising gently from the pterygoids towards the end of the rostrum. The maxillae are much shorter than the premaxillae, the latter alone forming the extremity. In ventral view (Pl. III, fig. 1) a small portion of the vomer is visible between the pterygoids and palatines. For a short distance anteriorly, the approximation of the margins of the maxillae obscures the vomer, which reappears once more as a linear-lanceolate bony wedge between the maxillae and premaxillae (Pl. III, Vo), but ends considerably short of the rostrum extremity. The premaxillae approximate (but do not fuse) in front of the vomer. An open canal forms a ridge on the ventral aspect of each premaxilla. From the anterior ' segment ' of the vomer, there is a marked difference in the transverse level between the maxillae and premaxillae, the latter being nearer the midline, resulting in a certain amount of flatness in this region.

No basirostral grooves are present, but there is a blind ' pit ' beneath the maxillae just in front of the malar bones (Pl. VII, MP). The position of this pit corresponds approximately to the commencement of the basirostral groove in *Mesoplodon grayi* Haast, the species in which the basirostral grooves are best developed in the family. There is no maxillary notch or tubercle as in *Mesoplodon*, but a maxillary crest is present (PL. 7, MXC).

In *Berardous* the premaxillae are subequal posteriorly, the right being only very slightly wider than the left in the narial region. Their extremities are nodular and are not turned outward as in *Mesoplodon* nor do they overhang the narial opening in the adult. The large bulbous nasal bones overtop the ends of the premaxillae slightly and over-hang the narial opening, supported below by a wide ' bracket ' formed by the posterior wall of the vomer, (Pl. V, fig. 3, Vo). In the newly-born animal the nasals do not attain the full size and are consequently below the level of the extremities of the premaxillae. Two large ' blind pits ' (BP) on the wall of the vomer, just below the nasals (one on either side of the septum) are characteristic of *Berardius* and readily distinguish it from any other genus of Ziphiidae. These pits are clearly visible in both old and young (Pl. V, fig. 3, BP).

The mesethmoid is completely fused with the presphenoid posteriorly. Within the narial cavity the mesethmoid is sandwiched and fused between the recurved walls of the vomer; together they form the narial septum. Anteriorly the mesethmoid emerges from between the vomerine walls and enters the mesorostral groove as a free projection for a short distance, becoming thicker and roughened along its dorsal surface. It is free from the vomer.

The walls of the narial cavity are composed posteriorly and mesially (septum) largely of the vomer; the lateral faces largely of the pterygoid, the premaxillae and small wedges of the maxillae and palatines. A large foramen, situated on the internal lateral face of the nares leads by a canal, laterally, to a large foramen in the orbital region.

*Foramina* (Pl. III): In dorsal view, the skull shows several large formina, some of which are useful accessory diagnostic features. Anteriorly, there are two premaxillary foramina, one in each premaxilla (PMXF); two large maxillary foramina, one (sometimes dual or multiple) in each maxilla (MXF). Both pairs of foramina are in front of the narial cavity; in *Berardius* they are approximately on the same transverse level although slight variations in level may occur. At the posterior edge of the maxillary crest or occasionally slightly further back, there is a large foramen connected by a canal with a foramen in the orbital region. This *post-crest foramen* (PCF) (as I propose to call it) is peculiar to *Berardius* and absent in other ziphioids, even in *Hyperoodon ampullatus* which has a greatly exaggerated maxillary crest. Still further back, on the maxillary plate, there is another large foramen

(PMF) (and occasionally an additional one or two); a canal connects this foramen to another in the orbital region.

*Antorbital foramina* (Pls. VI, VIII): In ventro-lateral view, the skull of *Berardius* has three large foramina in front of the large infundibulliform optic foramen (OPF). These three large foramina are not readily seen in any of the other ziphioid genera as they are concealed within the apparently *single* ' antorbital foramen ' behind a ridge formed by the palatine bone. The anteriormost foramen (Pl. VII, fig. 1) leads by a wide canal to the maxillary foramen (MXF) on the dorsal surface. Occasionally, immediately above this foramen (1), a small foramen perforates the lachrymal bone (L) and passes under it. A short distance behind is another large foramen (Pl. VII, fig. 2) which perforates the lachrymal bone posteriorly; a large vessel leads from this foramen to the dorsal surface of the skull where it appears as the post-maxillary foramen (PMF) (or foramina). Lastly, somewhat below and a little behind the last mentioned foramen and partially below the optic foramen (OPF) is another large foramen (Pl. VII, fig. 3). From this foramen, a large canal passes to a large foramen on the lateral wall of the narial cavity (NF) and another backwards through the foramen lacerum (Pl. X, fig. 1) into the brain cavity. This is the passage of the 5th cranial nerve.

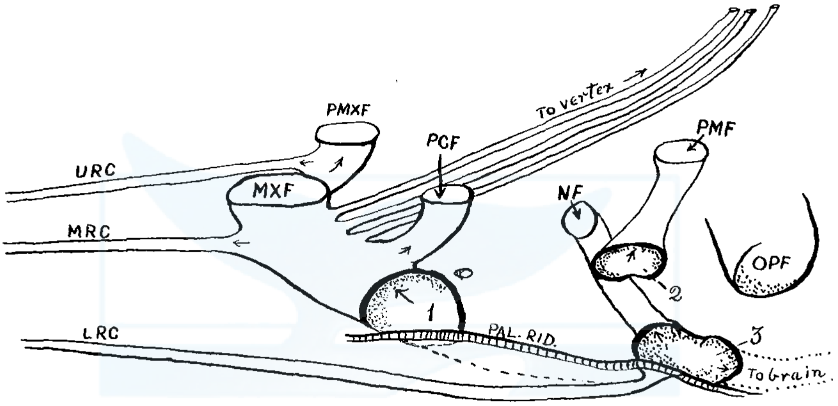


Fig. 1. Arrangement of antorbital foramina (diagramatic). Lettering as in other figures. del. C. McCann.

From within the maxillary foramen (MXF) several secondary canals diverge (text-fig. 1): one large division from the maxillary contributes to the formation of the premaxillary foramen (PMXF); anteriorly a canal passes through the matrix of the maxilla towards the extremity of the rostrum (I term this the *median* rostral canal (MRC)); posteriorly, three similar canals pass backwards under the premaxilla towards the vertex, emerging laterally under the posterior extremity of the premaxilla. Other smaller canals from within the maxillary foramen arise to appear dorsally on or near the base of the maxillary crest. Finally, a large canal from within the maxillary foramen emerges as the maxillary crest foramen (MCF) towards the rear of the crest itself.

From within the premaxillary foramen, a canal is given off anteriorly leading to the extremity of the rostrum. This canal, which I propose to call the *upper rostral canal* (URC), is sandwiched between the premaxilla and the maxilla, particularly proximally.

Attention has already been drawn to the canals leading from within the large posterior foramen to the narial cavity and the brain case. Anteriorly, a small canal passes through the maxtrix of the maxill towards the end of the rostrum; I propose to call this the *lower rostral canal* (LRC). These three rostral canals are readily seen in a cross section through the rostrum.

(In *Ziphius*, the lower rostral canal, instead of passing through the matrix of the maxilla, passes to the exterior at the anterior edge of the palatine bone and continues in a shallow groove to the end of the rostrum underside).

The optic foramen is large and canals lead from it into the cranial cavity, to the internal optic foramen, and through the foramen lacerum.

Behind the optic foramen (OPF), the external foramen ovale (FO) is situated beneath the falciform process (FP) of the squamosal surrounding the tympanic bulla. A little further to the rear, and at a slightly lower level, is the external auditory foramen. The exterior exit of the carotid artery is somewhat irregular in position and size; it is situated at the suture between the pterygoid and the alisphenoid.

*Brain case* (Pl. X, fig. 1): The brain cavity is amply described by Flower (1872).

Relatively, it appears to be larger than in other members of the family. A well-marked ridge, formed by the orbito-sphenoid and continued upwards by the frontal, is present in *Berardius*. This ridge is developed to a lesser degree in *Hyperoodon*, but absent in both *Ziphius* and *Mesoplodon*.

The base of the brain case appears to be flatter in *Berardius* than in *Ziphius*. The sella tursica and tuberculum sella are both better developed in *Ziphius* (female) than in *Berardius*, and the walls of the cerebellum fossa appear to be more rugose.

In sagittal section the internal cranial foramina are readily visible. From anterior to posterior, they are:

1) A small foramen high up on the wall of the presphenoid close to the midline, entering the nares by a canal. Flower (1872) suggests this may be the rudiments of the olfactory foramen.

2) The large optic foramen perforating the presphenoid.

3) The large sphenoidal fissure (Pl. VII, fig. 1) and the foramen rotundum slightly behind the optic foramen (Pl. VI, OPF), but obscured by the orbito-sphenoidal ridge. These transport the nerves to the orbit and the middle division of the 5th cranial nerve.

4) A small foramen for the carotid artery (Pl. IX, ca). On the floor of the basisphenoid, on a transverse level with the foramen ovale. The canal to the exterior appears as a foramen near the posterior border of the pterygoid.

5) The large foramen ovale further to the rear of the sphenoidal fissure and partially obscured by a ridge of bone. In *Berardius* the sulcus leading from the foramen ovale to the sphenoidal fissure is broad and shallow, but in *Ziphius* and *Mesoplodon* it is more canalised.

6) A foramen for the seventh nerve to the rear of the foramen ovale. This enters the funnel of the auditory meatus and exits through the auditory foramen.

7) The condylar foramen, a small foramen a short distance behind the auditory foramen. This perforates the cerebellar fossa, but has its external opening in the fissure formed by the basioccipital crest and the exoccipital.

8) The auditory foramen, clearly visible to the rear.

*Mandibles* (Pl. III, fig. 3)

The mandibles in *Berardius* are much longer than the rostrum and permanently expose the large anterior teeth. The distal half of each ramus is comparatively narrow and the upper and lower profiles in this region are almost parallel; the proximal half expands rapidly to form the posterior half. There is no defined ' gonus ' in *Berardius* as in some other ziphioids. The symphysial union is relatively short and the two halves do not anchylose even in old age as in the rest of the family. The mental foramen may be single or multiple and is somewhat erratically situated.

*Mandibular teeth* (Pl. XII)

Unlike other genera of Ziphiidae, *Berardius* erupts two pairs of functional teeth in both sexes, the anterior pair being usually larger than the posterior. They are strongly compressed laterally. In this, both *Berardius* and *Mesoplodon* agree; and differ from the rest of the family in which the teeth are circular or oval in cross-section.

Viewed laterally, both pairs are roughly triangular, the base being the shortest side, while the anterior edge is frequently slightly longer than the posterior. The lateral faces may be flat or variously undulate with numerous furrows and striae arising along the base and converging towards the apex. Along the antero-posterior edge, the axis is bent outwards slightly. The tip is an acute, enamelled point surrounded by a ' collar ' of dentine. In old animals the teeth are usually so severely abraded, that their tops are flat, almost level with the gum.

Occasionally, only a single tooth (anterior) is present in each ramus.

*Vertebrae:*

The formula of the vertebrae in the two species is as follows:

*Berardius arnouxi:* C 7 (3+4); Th 10; L 12 (13); Ca. 19=48 (49).
*Berardius bairdi:* C. 7. (3+4); Th. 11; L. 12. ca. 16+=46+.

True (1910) observed that the skeletons of both species of *Berardius* are very similar in most details, but there are some specific differences particularly in the number of thoracic vertebrae and of ribs.*

---

* Hale (1962) records a specimen of *B. arnouxi* with eleven ribs on one side.

Hector (1878) recorded thirteen lumbar vertebrae in a specimen of *B. arnouxi*, which is still in the collection of the National Museum, Wellington. Wellington (*Slet Mus.* 183) and has unmistakably thirteen lumbar vertebrae. However, *twelve* lumbar vertebrae appears to be the normal number in *B. arnouxi* as shown by other specimens in the National Museum, Wellington. True (1910) remarks that the " discrepancy here shown cannot be accounted for at present, but at all events, none of the formulae of *B. arnouxi* correspond to that of *B. bairdi*."

In the number of thoracic vertebrae, the two species differ specifically. *B. arnouxi* has ten and *B. bairdi*, eleven. The numbers of ribs correspond to the numbers of vertebrae respectively.

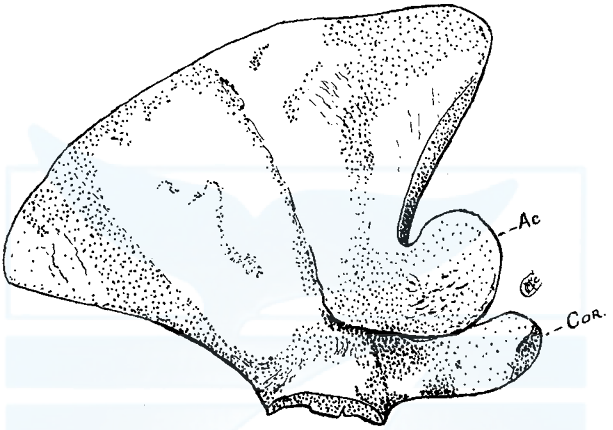


Fig. 2. *Berardius bairdi* Stejneger. Right scapular (714×525 mm.) (after True, 1910, pl. 33, fig. 2).

*Cervical vertebrae:* The three anterior cervical vertebrae are completely anchylosed in the adult to form a single mass in both species. A newly born specimen of *B. arnouxi* (*Dom. Mus.* 614) has only the first two vertebrae completely fused.

*Caudal vertebrae:* The number of vertebrae in the caudal region appears to vary slightly (eighteen to nineteen appears to be normal). The small terminal elements may easily be lost or dissolved during maeeration.

*Chevron bones:* There are normally nine chevron bones, the first usually of two irregular pieces, not united mesially. The fourth and fifth are the largest and best developed.

*Sternum:*

The sternum is like that of *Ziphius* and *Mesoplodon*, but naturally larger. It is normally composed of five elements, the fifth frequently anchylosed to the fourth and bifid posteriorly.

*Scapulae:* (Pl. XIII)

Apart from size, the shape of the scapulae is remarkably different in the two species. The acromion and coracoid processes are contrasted; there is a greater space between the two processes in *B. arnouxi* than in *B. bairdi*, and in *bairdi* the acromion almost completely overlaps the dorsal margin of the coracoid (text-fig. 2).

## SCHOOLING

Omura and his colleagues (1955) state that *Berardius bairdi* forms schools of ten or more individuals, males appearing in greater numbers than females.

There is some evidence that the breeding school could be dominated by a single master bull. Linear weals and other wounds occur on the bodies of males, particularly old bulls, indicating that there is considerable rivalry among the males —the females seldom exhibit such scarring. Adult females of *Berardius* probably add their quota of scarring on the bulls for unwanted attentions.

## MALE RIVALRY

Pike (1953) referring to scars in *Berardius bairdi* offers another explanation of scarring " Numerous white scratch marks appear on the back and flanks of both specimens (Pl. II, III). The scratch marks when found on males of other Ziphiidae and Delphinidae, have been attributed to the teeth of rival males. This explanation seems unlikely to be applicable in this species whose teeth are either buried in the gums [young animals] or are so blunt and protrude so slightly. A more plausible explanation for all species is that the scratches are caused by the sharp ' beaks ' of the squids on which they feed. Similar scratches are found on the heads of sperm whales."

This explanation overlooks the fact that the teeth are extremely sharp when first erupted and only become blunt with age, and that scarring by cephalopods would not be restricted to males, nor would it occur indiscriminately all over the body. The present author believes the scars are the result of male rivalry, a view also held by Omura, Fujino and Kimura (1955). Over several years, I have examined numerous carcases of Ziphiidae and other whales for scarring. I find that in male *Ziphius* linear scars, which are numerous on back and flanks, less common on the body, appear as single weals or exactly parallel weals, ranging from a few centimetres to one metre or more in length. They are produced by one or a pair of teeth ripping along the body, the distance between the parallel scars corresponding to the distance between the mandibular teeth at the extremity of the mandible. Females rarely exhibit linear scarring.

There are also round, oval or elliptical white scars*, particularly by the vent.

---

* Recently, my suspicions that the elliptical scars, so commonly met with on the bodies of ziphioids, particularly in the region of the vent, were probably caused by some epizoic crustation were confirmed, when I asked Dr. J. C. Yaldwyn, the Assistant Director of the National Museum to produce the largest ' copepod ' he was aware of in the museum ' collection. This he did and I immediately recognised it as the epizoan responsible for the scars. It proved to be the female of *Livoneca ravnaudi* (M. Edwards): CYMOTHOIDAE. A paper on the subject will appear shortly under our joint names.

In *Mesoplodon*, linear scars are very common on old males, but they are never exactly parallel as in *Ziphius*. As the mandibular teeth are nearer the posterior union of the symphysis in *Mesoplodon* (except in *M. mirus* True) both teeth cannot be brought into play at the same time. (*M. mirus* could produce scars similar to those in *Ziphius*). Circular, oval or elliptical scars also appear on the body as in *Ziphius*.

In *Berardius* there are three types of linear weals: (a) a single rip probably made by a single anterior tooth; (b) parallel line or scars (Pl. II, fig. 5) made by the two anterior teeth, the distance between the weals being approximately that between these teeth; and, (c) parallel linear scars, one larger and deeper than the other, but the width narrower than to the distance between the two anterior teeth. These could be produced by both teeth of one ramus making contact at the same time. All three forms of linear scars have been seen on one old male (Pl. II).

There were also the usual circular, oval and elliptical scars (Pl. II, fig. 5). The circular, oval or elliptical scars referred to probably result from the attack or attachment of suctorial animals. Pike (1951) and Nemoto (1955) discuss and illustrate scars made by cyclostomes, particularly the Sea Lamprey (*Entosphenus tridentatus*), a species confined to the Northern Pacific Ocean. In the whales I have examined the scars showed what appeared to be the impressions left by the transverse lamellae of the discs of sucker-fish. Prolonged attachment could well bring about permanent discolouration of the skin. Concentrations of scars are invariably around the vent, which suggests that the fish congregate in the area to feed on excrement. Squid have been known to scar sperm whales in much the same manner.

Parasitic crustaceans could also be responsible for some of the scarring, some scars suggesting the erstwhile presence of barnacles, e.g. *Coronula*. However, while these dermal barnacles are commonly epizoic on baleen whles, they have not, as far as I am aware, been observed on ziphioids. Circular scars could also result from 'jab' wounds caused by the tip of an opponent's rostrum.

## SYNONYMY

*BERARDIUS ARNOUXI* Duvernoy: The Southern Porpoise Whale

| | | |
|---|---|---|
| 1851. | *Berardius Arnuxii* | Duvernoy, Ann. Sc. Nat. (3) 15: 51. (Type locality: Akaroa, Banks Peninsula, New Zealand. Type in *Paris Mus.*). |
| 1866. | *Berardius Arnuxi* | Gray, Cat. Seals & Whales Brit. Mus. p. 348. |
| 1870. | *Ziphius* (*Berardius*) *Arnouxii* | Owen, Monogr, Palaeontogr. Soc. p. 31, fig. 11. |
| 1870. | *Berardius Arnouxi* | Hector, in Knox, Trans. N. Zeal. Inst. 2: 27. |
| 1870b. | *Berardius Arnouxi* | Hector, Ann. Mag. Nat. Hist. (4) 5: 222. Trans. N. Zeal. Inst. |
| 1870a. | *Berardius Arnouxi* | Haast, Trans. N. Zeal Inst 2: 190. |
| 1870b. | *Berardius Arnouxi* | Haast, Ann. Mag. Nat. Hist. (4) 6: 348. (Repeat of previous article) |

| | | |
|---|---|---|
| 1871. | ' *Ziphidae* ' | Knox & Hector, Trans. N. Zeal. Inst. 3: 125, pls. 13–17. |
| 1871. | *Berardius Hectori* | Gray, Ann. Mag. Nat. Hist, (4) 8: 115–117. (Type locality: Titahi Bay, N. Zeal., Type *Brit. Mus.* 1677b. 76. 2. 16. 3.) |
| 1872. | *Mesoplodon Hectori* | Turner, Trans. Roy. Soc. Edin. 26: 778. |
| 1872. | *Berardius Arnouxi* | Flower, Trans. Zool. Soc. Lond. 8: 203–234, pls. 27–29. |
| 1873. | *Mesoplodon Knoxi* | (part.) Hector in Knox, Trans. N. Zeal. Inst. 5: 167 (Part type, Titahi Bay specimen, *Brit. Mus.* 1677b. 76. 2. 16. 3) |
| 1873. | *Mesoplodon Hectori* | Hector, Trans. N. Zeal. Inst. 5: 170. |
| 1874. | *Mesoplodon Hectori* | Gray, Trans. N. Zeal. Inst. 6: 96–97. |
| 1876. | *Berardius arnouxi* | Buller, Trans. N. Zeal. Inst. 8: 407. |
| 1878. | *Mesoplodon hectori* | Hector, Trans. N. Zeal. Inst. 10: 338, p. 16. |
| 1878. | *Mesoplodon hectori* | Flower, Trans. Zool. Soc. Lond. 10: 416, pls. 71 and 72 fig. 4. |
| 1880. | *Berardius arnouxi* | Van Beneden & Gervais, Osteogr. Cet. pp. 377, 515, Atlas pls. 21–23. |
| 1893. | *Mesoplodon hectori* | Forbes, Proc. Zool. Soc. Lond. p. 277. |
| 1900. | *Mesoplodon hectori* | Beddard, Book of Whales, Lond. p. 220. |
| 1900. | *Berardius arnouxi* | Beddard, Book of Whales, Lond. p. 228–233. |
| 1910. | *Berardius arnouxi* | True, Bull. U.S.N.M. 73: 77. |
| 1920. | *Berardius arnuxi* | Marelli, An. Mus. Nac. Secc. Zool. Buenos Aires. 30: 411–444, pls. 1–5. |
| 1922. | *Berardius arnouxi* | Oliver, N. Zeal. Journ. Sci. Tech. 5: 135. |
| 1922. | *Paikea hectori* | Oliver, Proc. Zool. Soc. Lond. p. 575. (Type, *Brit. Mus.* 1677b. 76. 2. 16. 3). |
| 1924. | *Mesoplodon hectori* | Harmer, Proc. Zool. Soc. Lond. p. 542. |
| 1939. | *Berardius arnuxi* | Hale, Rec. S. Austr. Mus. 19 (4); 5. |
| 1950. | *Mesoplodon hectori* | Fraser, Proc. Linn. Soc. Lond. 162: 50, pls. 3, 4. |
| 1957. | *Berardius arnouxi* | Taylor, Proc. Zool. Soc. Lond. 129 (3): 325–332, pl. 3, figs. 1–4. |
| 1962a. | *Berardius arnouxi* | McCann, Tuatara 10 (1): 13–18, pls. 1, 2. |
| 1962b. | *Berardius arnouxi* | McCann, Rec. Dom. Mus. 4 (9): 83–94 pls. 1–5. |
| 1962. | *Berardius arnuxi* | Hale, Rec. S. Austr. Mus. 14 (2): 231–243, pls. 5, 6, text fig. 1. |
| 1974. | *Berardius arnouxi* | McCann, Sci. Rep. Whales Res. Inst., Japan, No. 26, 145–155, Figs. 1–23, pls. 1–8. |

## DESCRIPTION

*General external characters as in the genus*

*Teeth* (Pl. XII): The anterior mandibular teeth are normally larger than the posterior. Viewed laterally both are roughly triangular in shape, the base being the shortest side, and the anterior frequently longer than the posterior. The lateral faces may be flat or undulate with numerous furrows or striae arising along the base and converging towards the tip. Viewed antero-posteriorly, the vertrical axis is inclined slightly outwards in its upper portion. The apex is formed of an enamelled point of about 10 to 12 mm surrounded by a ' collar ' of dentine. On the inner face of the enamelled cusp there may be one or two vertical furrows. In old animals the tooth is worn down to a flat-top level with the gum.

*Size:* *Berardius arnouxi* may attain a length of 9.6 m (32 ft). The difference in size between the sexes does not appear as pronounced as in *B. bairdi.*
Measurements in the flesh, ad. male. *Dom. Mus.* 1,433 (Col. C. McCann)

Total length 8.50 m; snout to anterior edge of dorsal 6.150 m; Snout to genital 5.60 m; genital to anal 0.30 m; length of penis 0.90 m; circum. of penis at base 0.23 m; snout to eye 1.50 m; snout to flipper 1.77 m; gape 0.59 m; snout to blowhole 1.10 m; blowhole 0.13 m; Beak 0.551 m; throat groove 0.55 m; anal opening 0.23 m; Fluke across 2.444 m.

Neonatals so far recorded do not exceed 3.0 m (11 ft) but the records could be of animals prematurely born when the true neonatal length be slightly greater.

*Colour:* " The colour of the whole animal was of a deep velvety black, with the exception of the lower portion of the belly, which had a greyish colour." (Haast, 1870).

" The colour was black with a purple hue, except a narrow band along the belly which was grey. The muzzle, flippers and tail lobes were intensely black." (Hector, 1878: 338).

An old male from Pukerua Bay (Pls. I–II), although decomposing, clearly showed a dirty white dorsal surface. This colour extended from the ' crest ' of the head to shortly behind the dorsal fin. Parts of the dorsal fin and some surrounding areas were even whiter. The rest of the body was brownish black (Pl. I and II, fig. 1). As most observers describe the dorsaum is black, it is possible that in this individual the dorsum may have bleached during exposure, after death and before stranding.

## DISTRIBUTION

*Berardius arnouxi* is apparently confined to the South Pacific and South Atlantic Oceans, between 30°S and Antarctica. Odd specimens have stranded along the eastern shores of New Zealand as far north as 37°S, but these strandings have been later than the normal period when this whale visits the New Zealand area.

*Specimens:* (See text—fig. 3)

*New Zealand Waters:* Otago Peninsula, 1840 (*Otago Mus.* A14.37 mandibles); Stewart Island (*Otago Mus.* A24.69, skull), 2 teeth (*Dom. Mus.* 523); Mason Bay, Stewart Island, February, 1929 (*Dom. Mus.* 523); Mason Bay, Stewart Island, February, 1929 (*Dom. Mus.* 416, skeleton); Centre Island, Foveaux Strait (*Dom. Mus.* 528, worn tooth); Chatham Islands (*Otago Mus.* A339); Coast near Wanganui, before 1920 (*Wang. Mus.* A339); Coast near Wanganui, before 1920 (*Wang. Mus.* skeleton); Worser Bay, Wellington, January 1870 (*Dom. Mus.* 7, skull), 12th January, 1877 (*Dom. Mus.* 183, skull); 30th January, 1876 (*Dom. Mus.* 239, 2

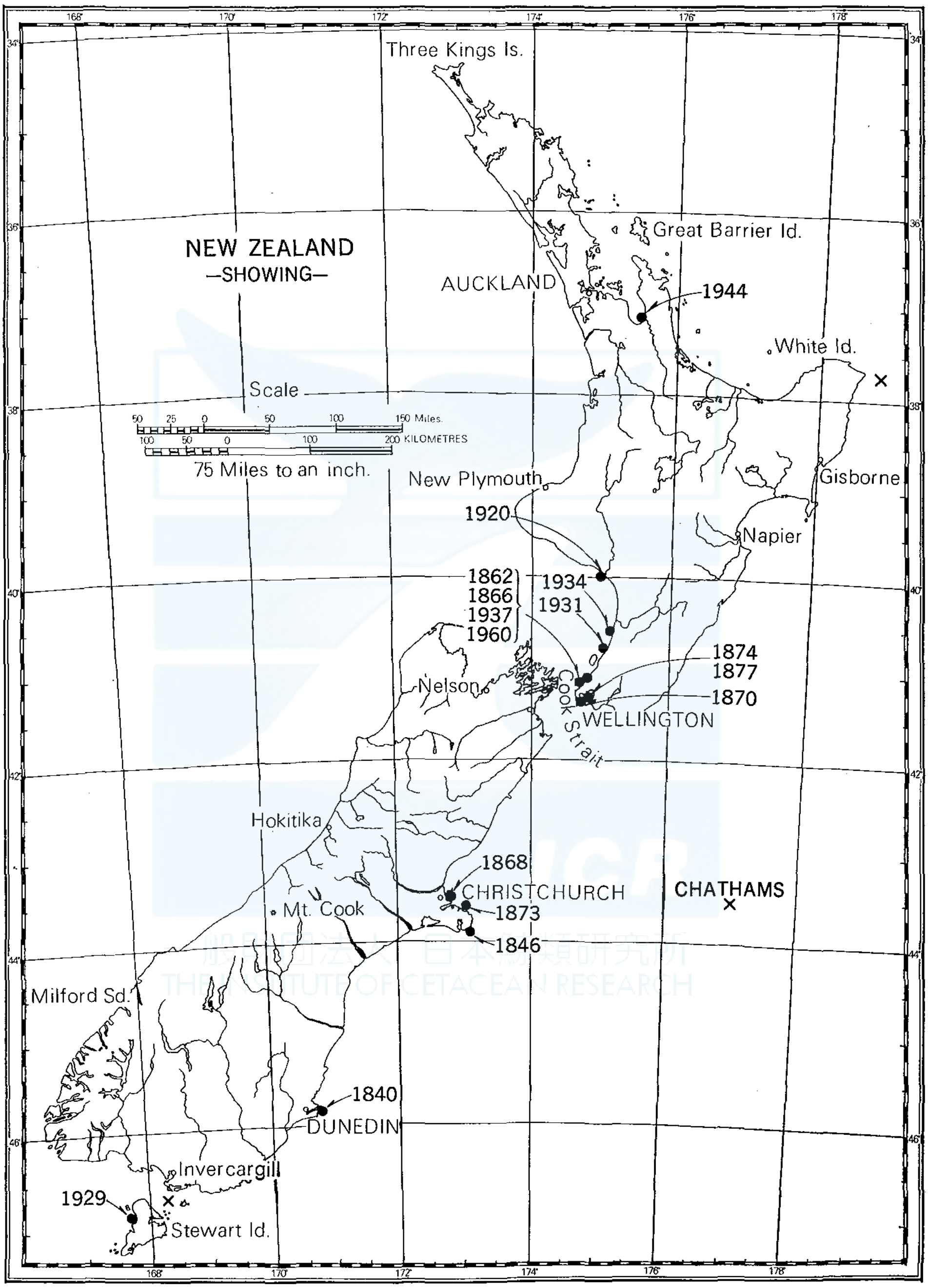


Fig. 3. Strandings of *Berardius arnouxi* Duv. in New Zealand.

teeth); Saltwater Creek, north of Banks Peninsula, 27th December, 1873 (*Dom. Mus.* 1402, skeleton); New Brighton Beach, Christchurch, 16th December, 1868 (*Roy. Coll. Surg.*, skeleton); Akaroa, Banks Peninsula, 1846 (Type, *Paris Mus.*), (*Brit. Mus.* 96.11.20.1, male); South Tapu, Thames Coast, 13th March, 1944 (*Auck. Mus.*); Te Horo Beach Wellington District, 13th January, 1931, male, 8,400 mm (28 ft); Otaki Beach, Wellington Dist, 4th January, 1934, female, 8, 100 mm (28 ft.), (*Dom. Mus.* 528, 4 teeth);* Pukerua Bay, Wellington District,18 th February 1960, old male, 8,850 mm (29– ft), (*Dom. Mus*. 1433, 2 teeth); **Pencarrow, Wellington Harbour, male 9,000 mm (30 ft, male), female 6,000 (20 ft), ft), (*Dom. Mus.* 526, 2 teeth); Lyall Bay, Wellington, 1874 (Buller); East Cape, (*Dom. Mus.* 527, 1 tooth); Titahi Bay, Wellington District, January, 1866, male 2,725 mm (9– ft), (*Britl Mus.* 1677b 76. 2. 16. 3, Type of *B. hectori* Gray); Plimmerton, Wellington District, 25th January, 1937, 3,200 mm (10 ft, 8 in.), (*Dom. Mus.* 614, skeleton); ' New Zealand ', (*Brit. Mus.*), (U.S.N.M. 21511).

*Australian waters:* Port Lorne, S. Australia, 27th December 1935, 8,700 mm (29 ft), (*S. Austr. Mus.* M. 5012)

*Antarctic waters:* Taylor, April 1955 (Photographs).

*Argentine waters:* Arroyo del Pescado, Los Talas, 29. 5. 1918, female, 7,800 mm (26 ft), (*Mus. Nac.* Buenos Aires).

*South Atlantic waters:* South Shetland Islands, female (*Brit. Mus.* 1934. 6. 15. 1); Falkland Islands (*Brit. Mus.* 1949. 8. 19. 1); La Plata, 29th May, 1918, female, (*Mus. Nac.*, Buenos Aires).

Of thirty specimens recorded from New Zealand waters, the majority stranded during the late spring or early summer (December to February–March). Two neonatals which may have been premature births are recorded as stranding in January 1866 and 1937 (as *Mesoplodon hectori* (Gray)). The presence of adults and neonatals during the same period of the year suggests that *Berardius arnouxi* visits the New Zealand area to breed. On the other hand, photographs of *Berardius arnouxi* locked in the ice in April 1955 (Taylor, 1957) show that they return to the Antarctic region to feed. These observations point to a seasonal north and south migration.

The single recorded Australian specimen, a gravid female was found in the same period in which *Berardius* visits New Zealand waters.

The number of *Berardius arnouxi* visiting New Zealand waters annually is unknown, particularly as their visits do not coincide with the whaling season (May to August), and they are not at present of commercial value. Any information we have is derived from chance strandings.

In the South Atlantic, there appears to be a similar pattern of movement presents itself, but the records are too few for definite conclusions. A single neonatal has been recorded from one of the smaller islands of the Falklands group (Fraser, 1950), but its exact time of stranding is unknown.

As with *Mesoplodon*, species of *Berardius* appear to calve near the larger archi-

---

* Porirua Harbour, Wellington District, January 1862, male, 8100 (27 ft), (*Fide* Knox, 1871: 125)

** The sex of these two specimens is in doubt as they were reported and the teeth of the adult collected by a layman. They may have been a female and calf.

pelagos of the world in both hemispheres. *B. arnouxi* in the New Zealand and South Atlantic archipelagos and *B. bairdi* around the Japanese Archipelago.

## FOOD

Haast (1870) notes that the stomach contents of one animal contained about half a bushel of the horny beaks of cephalopods (squids). Haast mentions ' Octopus ', but this is hardly likely, as the octopus is an inshore animal, whereas squids are pelagic and often occur in vast shoals.

## ANATOMICAL OBSERVATIONS

*Cranium* (Pls. III, IV): The cranium of the adult has been well described and figured by Duvernoy (1851) and Flower (1872).

The skull of *Berardius* exhibits almost perfect symmetry (Flower 1872). The same symmetry appears in the newly-born young. The large bulbous nasals are a prominent feature of the vertex in the adult, but the nasals are not so conspicuous in the newly born (Pl. IV, fig. 1). The extremities of the premaxillae rise above the nasals and are slightly curved forwards, not so recumbent as in the adult, nor do they overhang the narial cavity as in some species of *Mesoplodon*. Further, they do not twist outwards as asymmetrically as in *Mesoplodon;* they are almost equal in size, the right premaxilla being *very* slightly larger than the left.

The recurved walls of the vomer, with the mesethmoid bone sandwiched between them contribute to the formation of the narial septum, the mesethmoid bone eventually emerging anteriorly into the mesorostral groove as a free projection between the margins of the premaxillae. The ossified projection of the mesethmoid terminates as an irregular, rough or nodular projection, extending as far forwards as a transverse line drawn through the middle of the maxillary crest. In the flesh, the mesethmoid bone is continuous with the mesethmoid cartilage and fills the mesorostral groove. In *Berardius* the mesorostral groove is permanently open and is never partially nor wholly filled by bone as in some species of *Mesoplodon*. Posteriorly, the vomer forms a broad ' bracket ' beneath the large nasals with a large blind pit (BP) on either side of the septum. The shape of the ' bracket ' and the presence of the blind pits are distinctive of *Berardius*.

Anteriorly, the vomer extends about two-thirds the length of the rostrum forming a trough for the mesorostral cartilage. Ventrally, much of the anterior end of the vomer is visible, wedged between the premaxillae. This condition is also found in the newly-born young (Pl. IV, fig. 2, Vo).

In dorsal view, the rostrum is somewhat spearshaped. No distinct maxillary turbercle is present but there is a maxillary crest. In side view, its dorsal profile is straight; the lower gradually descends from its anterior extremity towards the pterygoids. In ventral view, the broad maxillary prolongations are seen embracing the premaxillary extremities with the vomer wedged between. In transverse section, the rostrum is considerably broader than deep near the middle.

The adult skull is broader than high, but in the newly-born the height is greater than the breadth.

*Foramina* (Pl. IX, fig. 1): The premaxillary and maxillary foramina are on approximately the same transverse level. The premaxillary is very much smaller than the maxillary which frequently has secondary foramina around it. The postcrest foramen and the secondary foramina are not pronounced in the neonatal skull.

*Antorbital region* (Pl. IX, fig. 2): The antorbital tubercle is exaggerated by the presence of a deep antorbital notch. In dorsal view, the tubercle is seen to be formed by the maxilla and a small portion of the malar bone, with the anterior extremity of the frontal, a short distance behind forming the orbit. In side view, the broad anterior end of the frontal is shortly behind the end of the maxilla and the anterior projection of the malar bone. At the lower corner of the frontal, a narrow portion of the lachrymal bone is visible but not on a level with the lateral margin of the frontal. Ventrally, the malar bone alone appears to form the tubercle; the lachrymal bone falls short of the lateral margin of the frontal. There is a triangular wedge between the frontal and the malar.

The antorbital notch is margined by the maxilla alone.

In the newly-born, the arrangement is somewhat different. In dorsal view, the malar borders the antorbital notch; the lachrymal is just visible in front of the anterior extremity of the frontal. The orbital portion of the frontal is not laterally expanded as in the adult, but forms a narrow margin to the maxilla behind the tubercle. In side view, the large ' cuboidal ' end of the lachrymal abuts the anterior end of the frontal and a very small portion of the malar is also visible. Ventrally, the lachrymal and malar bones predominate in the formation of the tubercle and malar bones predominate in the formation of the tubercle to the exclusion of the anterior end of the frontal and maxilla.

*Mandibles:* The extremity of the mandibles protrudes considerably beyond the rostrum, so much so that the anterior teeth are outside the mouth when it is closed. The distal half of the mandibles is comparatively narrow and the upper and lower profiles are almost parallel. The proximal half expands rapidly to form the posterior portion of the jaw. The symphysial union is comparatively short and the two halves appear never to fuse together as in some other genera. The mental foramen may be single or multiple and somewhat irregularly situated on either side, even in the same individual.

*Eyes:* The relative size of the eye ' sockets,' in relation to the length of the skull, is smaller than in either *Ziphius* or *Mesoplodon.* The jugal process is accordingly comparatively short.

*Ear Bones* (Pl. XI): The bulla and the periotic of an adult measure 73 by 48 mm and 80 by 45 mm respectively (*Dom. Mus.* 1406). In the newly-born the same bones in the same order measure 54 by —— mm, periotic not stated (*Brit. Mus.* 1677b. 76. 2. 16. 3); 51 by —— mm, periotic not stated (*Brit. Mus.* 1949. 8. 19. 1); 51.5 by 36 mm and 56 by 32 mm (*Dom. Mus.* 614).

*Scapula* (Pl. XIII): In *B. arnouxi* the vertebral border is more or less straight, not conves as in *B. bairdi;* both the anterior and posterior borders are more vertical than in *B. bairdi.* The anterior border is almost straight, whereas in *B. bairdi* it is convex dorsally, and slightly concave ventrally; the posterior border is less concave than in *B. bairdi.* The anterior spinous fossa is relatively narrower than in *B. bairdi.*

The acromion is almost level with a vertical dropped from the anterior angle; the upper and lower profiles are, at first, almost parallel but gradually diverge towards the extremity; in some specimens the extremity is decidedly wider. In *B. bairdi,* the acromion falls short of a vertical dropped from the anterior angle and the lower profile turns abruptly upwards producing an almost semicircular anterior margin, which gives the entire process a somewhat circular or spiral border.

The coracoid and acromion processes are subequal in length whereas in *B. bairdi* the former exceeds the latter. In dorsal view the two processes are divergent, but in *B. bairdi* there is very little space between the two. The coracoid is narrow with both upper and lower profiles slightly concave; in *B. bairdi* the process is broad and slightly curved upwards with the upper profile concave, the lower convex.

## SYNONYMY

*BERARDIUS BAIRDI* Stejneger: Japanese Porpoise Whale

| | | |
|---|---|---|
| 1883. | *Berardius bairdi* | Stejneger, Proc. U.S.N.M. 6: 75–77. (Type locality: Bering Island; type *U.S.N.M.* 20992). |
| 1883. | *Berardius vegae* | Malm, Bihang K. Svenska Akad. Handl. 8 (4): 109. |
| 1886. | *Berardius bairdi* | Stejneger, Journ. Amer. Geogr. Soc. N.Y. 18: 317–328. |
| 1900. | *Berardius bairdi* | Beddard, Book of Whales, Lond. p. 233. |
| 1910. | *Berardius bairdi* | True, Bull. U.S.N.M. 73: 60, pls. 26–33. 34, fig. 7, 35, fig. 7; 36, fig. 7; 39; 42. |
| 1931. | *Berardius bairdi* | Kellogg, Journ. Mamm. 12: 73–77. |
| 1942. | *Berardius bairdi* | Matsuura, Zool. Mag. Zool. Inst. Fac. Sci. Jap. Univ. 54: 466–473. |
| 1943. | *Berardius bairdi* | Matsuura Marine Mamm. (Kaiju). 298 pp. |
| 1948. | *Berardius bairdi* | Scheffer & Slipp, Amer. Midl. Nat. 39 (2): 266. |
| 1949. | *Berardius bairdi* | Scheffer, Pacific Sci. 3: 353, fig. 1. |
| 1953. | *Berardius bairdi* | Pike, Journ. Mamm. 34: 98–104, pl. 1. |
| 1953. | *Berardius bairdi* | Slipp & Wilke, Journ. Mamm. 34: 105–113, pls. 1, 2. |
| 1953. | *Berardius bairdi* | Omura, Fujino & Kimura, Sci. Rep. Whales Res. Inst. Jap. 10: 89–132 (*per errorum baildi*) |
| 1958. | *Berardius bairdi* | Omura, Sci. Rep. Whales Res. Inst. Jap. 13: 213–214, figs. 1, 2. |

## DESCRIPTION (PL. XIV FIG. 1)

General external characters as in the genus. There is no marked difference in the size and shape of the mandibular teeth in either sex; (they are erupted in both sexes alike on reaching maturity (Omura, 1955). Pike (1953) examined an 8.7 m (29 ft) females which he regarded as both physically and sexually immature, and found the teeth were " completely buried." His observations support those of Omura (1955).

The largest teeth on record are: (anterior) vertical height 89; antero-posterior width 103 mm; lateral diameter ——; (posterior) vertical height 60 mm; antero-posterior width 37 mm; lateral width ? for a male of 9.9 m (33 ft); (interior) vertical height 93 mm; antero-posterior width 72 mm; lateral diameter ?; (posterior) vertical height 55 mm; antero-posterior width 33; lateral width ?; for a 8.7 m (29 ft) female (Pike, 1953).

*Size:* *B. bairdi* is up to 3.0 m (10 ft) longer than *B. arnouxi*. The largest known female measured 12. 6 m (42 ft). Males are about 2.0 m (approx. 7 ft) smaller than females.

*Colour:* Pike (1953) describes a male and female as follows: " In these specimens the body is black on the head, back, flukes and flippers. The undersurface is of a slightly lighter shade, with white patches at the umbilicus and some white and grey markings. The male has a conspicuous diamond-shaped white patch at the umbilicus and some white around the genital opening. The female is lighter in colour and the skin was covered by abrasions caused while the whale was being towed into the station. Numerous white scratch marks appear on the back and flanks of both specimens (Pls. I, II, V)."

Omura *et al.* (1955) state: "According to our observations, however, color of whole body is pure black or somewhat lighter, even on the under surface of the body is pure black or somewhat lighter, even on the under surface of the body. It is not certain, but most whalers say that there are two groups of *Berardius*, one being black and another slatish. As there are many white scratch marks (Pls. I–II) on the skin of *Berardius*, especially in old bull, the colour looks more lighter than it is in such whales. There are white patches in three regions of the ventral side of the body, i.e. on the throat, between the flippers and at the umbilicus (Pls. II–IV, Pl. III, fig. 2). Every *Berardius* seems to have the white patch on the throat or between the flippers, there are considerably individual differences."

## DISTRIBUTION

*Berardius bairdi* is restricted to the Northern Pacific Ocean; concentrating in Japanese waters during the breeding season in spring and summer. Occasional stray individuals or small schools are found off the North American coast.

*Specimens:* Bering Island (Type, *U.S.N.M.* 20992); St. George Island, ad. female (*U.S.N.M.* 49726); Centerville, California, ad. male (?), (*U.S.N.M.* 49725); St. George Island, young male, (*U.S.N.M.* 49727); Bering Island (?), (Grebnitzki?) (*U.S.N.M.*); about 10 miles off Kains Island, Quatsino Sound, 5th July, 1950, ad. male, 9.9 m (33 ft), (Pike, 1953); 20 miles E.S.E. of Cape St. James, 9th August, 1951, imm. female, 8.7 m (29 ft), (Pike, 1953); one mile south of Ocean City, Washington, July 1950, 16.5 m (35 ft), (Slipp and Wilke, 1953); Japan, *Nat. Sci. Mus.*, 10.8 m (36 ft); Santa Cruz, California, June, 1925 (*Mus. Calif. Acad. Sci.* skull);

## COMMERCIAL WHALING

In summer and autumn, *B. bairdi* concentrates in Japanese waters north of the 30°N parallel. The Japanese whaling season is from April to November (Omura *et al*, 1955: 93), reaching its peak in the summer months of July and August. Omura and colleagues found the main concentration in the southern part of the range off the east coast of Japan proper, the whales moving in northwards, according to the whalers, as the season advances. After breeding, they apparently leave for feeding grounds in more northern latitudes.

Whaling commences in the northernmost area in the Okhotsk Sea earlier than elsewhere and has a second peak in autumn but it is supposed that there is a different population or community in the Okhotsk Sea from elsewhere.

The small numbers taken along the western shores of Japan may be due to few schools passing west through the Soya and Tsugaru Straits.

The American season is from April to September or October, but as *Berardius* is a sporadic visitor it is less important than in Japan (Scheffer and Slipp, 1948: 256).

## BREEDING

Omura *et al* (1955, fig. 28) extrapolate length records to arrive at the following " the pairing of *Berardius* takes place in February and the parturition in December in most individuals, length of gestation being about 10 months." Omura (1958) however, records an anomalous 12 mm long embryo taken in August, and True (1910) records a newly-born calf discovered in June.

The neonatal length, in most cetaceans, is approximately one-third the length of the parent. Accordingly, in *Berardius bairdi* which can grow to about 12.6 m (42 ft), the newly-born calf should approximate 4.2 m (14 ft). Omura *et al* (1955) estimated the neonatal length as 4.5 m (15 ft). The largest foetus they record was in September and measured 4.2 m (14 ft). Stejneger (True, 1910: 64) records a newly-born calf of 4.8 m (16 ft) washed up on Bering Island on June 5, 1883, with the remains of the umbilicus still adhering.

## FOOD

Pike (1953) records the stomach contents of a young female as: " about two gallons of small rockfish and squid remains."

## PARASITES

Omura *et al.* (1955) record *Conchoderma* sp. attached to the teeth (Pl. XIV, 2). This barnacle has been recorded on the teeth of *Hyperoodon ampullatus* and *Physeter catodon* (Wolff, 1960), and I have found it on a tooth of *Mesoplodon grayi*. A species of *Conchoderma* is also found commonly on *Megaptera nodosa*, never on the animal itself but attached to the barnacle *Coronula*, so commonly found on the Humpback. Unlike *Coronula*, *Conchoderma* must have a hard substrate to attach itself to.

Pike (1953) recorded nematodes in the stomach of a specimen of *B. bairdi*.

## ACKNOWLEDGMENTS

The author wishes to thank Dr. R. A. Falla, Director, Dominion Museum, Wellington, for the opportunity of undertaking the work; Dr. R. R. Forster, Director, Otago Museum, Dunedin, for the loan of material; Dr. R. K. Dell and Mr. B. Hamlin for valuable comments and suggestions on the manuscript; Mr. P. M. Hedgland, Photographer, Dominion Museum, for the excellent anatomical photographs; Dr. H. Omura, Whales Research Institute, Japan, for permission to reproduce the photographs of *Berardius bairdi;* and Miss M. Hall, Librarian, Dominion Museum at the time, for help in obtaining literature.

## REFERENCES

BEDDARD, F. E., 1900. *A book of whales.* London, 320 pp. 40 illustrations: 228–233.

BENEDEN, P. J. VAN, and F.L.P. GERVAIS, 1868–1880. *Osteogr. cet. osteographie des cetaces vivants et fossiles.* Paris, pp. 377, 515, Atlas, pls. XXI-XXIII.

BULLER, W. L., 1876. Presidential address 7th August, 1875; *Trans. N. Zeal. Inst.*, 8: 407.

CARCELLES, A., 1948. Los cetaceos en las aquas argentinas. *Mus. Arg. cien. Nat.* (Pub. Extra), 238: 6.

DUVERNOY, G. L., 1851. Memoire sur les caracteres osteologiques des genus nouveaux ou des especes nouvelles de oetaces vivant ou fossiles. *Ann. Sci. Nat.*, 3(15): 1–71.

FLOWER, W. H., 1872. On the recent ziphioid whales, with a description of the skeleton of *Berardius arnouxi. Trans. Zool. Soc. Lond.*, 8(3): 203–234, pls. XXVII-XXIX.

FLOWER, W. H., 1878. A further contribution to the knowledge of the existing ziphioid whales: genus *Mesoplodon. Ibid.*, 10(11): 416, pls. LXXI-LXXII fig. 4 (*M. hectori*).

FORBES, H. O., 1893. Observations on the development of the rostrum in the cetacean genus *Mesoplodon*, with remarks on some of the species. *Proc. Zool. Soc. Lond.*, 216–236, pls. XII-XV. (*M. hectori*).

FRASER, F. C., 1950. Note on a skull of Hector's beaked whale, *Mesoplodon hectori* (Gray) from the Falkland Islands. *Proc. Linn. Soc. Lond.*, 162: 50–52, pls. III-IV, figs. 1–5.

GRAY, J. E., 1866. *Cat. Seals, Whales and dolphins in the British Museum,* 384 pp.

GRAY, J. E., 1871. Notes on the *Berardius* of New Zealand. *Ann. Mag. Nat. Hist.*, (4)8: 115–117.

GRAY, J. E., 1874. List of seals, whales and dolphins of New Zealand. *Trans. N. Zeal. Inst.*, 6: 96–97.

Haast, J. von, 1870. Preliminary notice of a ziphid whale, probably *Berardius arnuxi*, stranded on the 16th December, 1868 on the beach near New Brighton, Canterbury. *Ibid.*, 2: 190–192.

Haast, J. von, 1870. Ditto. *Ann. Mag. Nat. Hist.*, (4)6: 348 (Repeat of previous article).

Hale, H. M., 1939. Rare whales in South Australia. *S. Austr. Nat.*, 19(4): 5–6, photo.

Hale, H. M., 1962. Occurrence of the whale *Berardius arnuxi* in Southern Australia. *Rec. S. Austr. Mus.*, 14(2): 231–243, pls. V-VI, fig. 1.

Harmer, S. F., 1924. On *Mesoplodon* and other beaked whales. *Proc. Zool. Soc. Lond.*, 541–587.

Hector, J., 1870. List of the bones of Seals and whales in the Colonial Museum, Wellington, New Zealand. *Ann. Mag. Nat. Hist.*, (4)5: 220–224.

Hector, J., 1872. On the whales and dolphins of New Zealand seas. *Trans. N. Zeal. Inst.*, 5: 155–170, pls. I-VI.

Hector, J., 1878. Notes on the whales of New Zealand Seas. *Ibid.*, 10: 331–343, pls. XVI-XVII.

Kellogg, R., 1931. Whaling statistics for the Pacific Coast of North America. *Journ, Mamm.*, 12: 73–77.

Knox, F. J., and J. Hector, 1871. Observations on the Ziphiidae, a family of cetacea. *Trans. N. Zeal. Inst.*, 3: 125–129.

Malm, A. W., 1883. Skelettdelar af hval, insamlade under expeditionear med Vega 1878–1880. *Bihang. K. Svenska Akad. Handl.*, 8(4): 109.

Matsuura, Y., 1942. On the northern Porpoise whale, *Berardius bairdi* Stejneger, in waters near Boshu. *Zool. Mag., Zool. Inst., Fac. Sci. Tokyo Imp. Univ.*, 54: 466–473.

Matsuura, Y., 1943. *Berardius bairdi* Stejneger ranges the Sea of Okhotsk. *Ibid*, 55: 237.

Matsuura, Y., 1943. *Marine mammals (Kaiju)*. Tokyo, 298 pp.

Marelli, C. A., 1920. Revision osteologica de *Berardius arnouxii* Duv. *An. Mus. Univ. Nac. Buenos Aires.*, 30: 411–444, pls. I-V.

McCann, C., 1962. The taxonomic status of the beaked whale, *Mesoplodon hectori* (Gray)—Cetacea. *Rec. Dom. Mus.*, 4(0).

Nemoto, T., 1955. White scars on Whales. (I) Lamprey Marks. *Sci. Rep. Whales Res. Inst.*, 10: 69–77, figs. 1–10.

Nishimura, S., and M. Nishiwaki, 1964. (*Berardius bairdi* Stejn.). *Publ. Seto Mar. Biol. Lab.*, Art. 25, pl. XXI, fig. 1 (only).

Nishiwaki, M., and N. Oguro, 1971. Baird's beaked whales caught on the coast of Japan in recent 10 years. *Sci. Rep. Whales Res. Inst.*, 23: 111–122. pls. I-II.

Ohsumi, S., 1964. Comparison of maturity and accumulation rate of corpora albicantia between left and right ovaries in cetacea. *Ibid.*, 18: 123–147, pl. I.

Oliver, W.R.B., 1922a. The whales and dolphins of New Zealand. *N. Zeal. Journ. of Sci. & Tech.*, 5(3): 129–141.

Oliver, W.R.B., 1922b. A review of the cetacea of New Zealand seas. *Proc. Zool. Soc. Lond.*, 557–585, pls. I-IV.

Omura, H. K. Fujino, and S., Kimura, 1955. Beaked whale *Berardius bairdi* of Japan, with notes on *Ziphius cavirostris*. *Sci. Rep. Whales Res. Inst. Japan.*, 10: 89–132, pls. I-X, figs. 1–30.

Omura, H., 1958. Note on embryo of Baird's beaked whale. *Ibid.*, 13: 213–214, figs. 1–2.

Owen, R., 1870. Monograph on the British fossil cetacea from the Red Crag. *Monogr. Palaeontogr. Soc.*, 1–40, pl. I-V.

Pike, G. C., 1953. Two records of *Berardius bairdi* from the coast of British Columbia. *Journ. Mamm.*, 34: 98–104, pl. I.

Slipp, J. W., and F. Wilke, 1953. The Beaked Whale *Berardius* on the Washington Coast. *Ibid.*, 34: 105–113, pls. I-II.

Scheffer, V. B., and J. W. Slipp, 1948. The whales and dolphins of Washington State with a key to the cetaceans of the West Coast of North America. *Amer. Midl. Nat.*, 39(2): 257–337.

Scheffer, V. B., 1949. Notes on three whales from the Aleutian Islands. *Pacific Sci.*, 3: 353, fig. 1.

Stejneger, L., 1883. Notes on the natural history of the Commander Islands including descriptions of new cetaceans. *Proc. U.S.N.M.*, 6: 75–77.

Stejneger, L., 1886. On the extermination of the great Northern Sea-cow (*Rytina*) a Reply to Professor

A. E. Nordenskioeld. *Journ, Amer. Geog. Soc. N.Y.*, 18: 317–328.

TAYLOR, R.H.F., 1957. An unusual record of three species of whales being restricted to pools in Antarctic sea-ice. *Proc. Zool. Soc. Lond.*, 129(3): 325–332, pls. I-VII.

TRUE, F. W., 1910. An account of the beaked whales of the family ziphiidae in the collection of the United States National Museum, with remarks on some specimens in other American Museums. *Bull. U.S. N.M.*, 73: 1–89. pls. I-ILI.

TURNER, W., 1872. On the Occurrence of *Ziphius cavirostris* in the South Shetland Seas, and a comparison of its skull with that of Sowerby's whale (*Mesoplodon Sowerbyi*). *Trans. Roy. Soc. Edin.*, 26: 759–778, Append. 779–780.

WOLFF, T., year. Rankefodderne *Conchoderma* og *Coronula* pa hvaler. Saertryk af '*Flora og Fauna*', 66(1): 1–8, 6 photos.

## APPENDIX I. MEASUREMENTS OF SKULLS

| | A | B | C | D | E | F | G | H | I | J |
|---|---|---|---|---|---|---|---|---|---|---|
| 1 | 1392 | — | 1420 | 1240 | 1193 | 1262 | 1220 | 1200 | 1270 | 1174 |
| 2 | 894 | — | 870+ | 820+ | 780 | 800+ | 780+ | 785 | 865 | 800 |
| 3 | 1080 | — | 1040 | 970+ | 918 | 1000+ | 900+ | 910 | 1040 | — |
| 4 | 494! | — | 560 | 555 | 455 | 570 | 518 | 475 | 530 | 493 |
| 5 | 684 | — | 720 | 623 | 615 | 710 | 660 | 620 | 625 | 577 |
| 6 | 748 | — | 700 | 675 | 610 | 710 | 640 | 620 | 660 | 584 |
| 7 | — | — | 445 | 380 | 405 | 430 | 410 | 395 | — | 378 |
| 8 | 150 | — | 169 | 166 | 158 | 184 | 172 | 160 | 155 | 149 |
| 9 | — | — | — | 108 | 90 | 95 | 92 | 95 | 80 | — |
| 10 | — | — | 211 | 205 | 201 | 208 | 192 | 180 | — | — |
| 11 | 210 | — | 219 | 199 | 195 | 221 | 183 | 195 | — | 189 |
| 12 | 102 | — | 92 | 87 | 75 | 82 | 90 | 90 | 91 | 80 |
| 13 | — | — | 240 | 235 | 210 | 215 | 200 | 202 | 180 | — |
| 14 | — | — | 390 | 350 | 370 | 415 | 340 | 350 | 380 | — |
| 15 | — | — | 71 | 78 | 65 | 73 | 65 | 82 | 63 | 72 |
| 16 | 213 | — | 218 | 215 | 194 | 194 | 186 | 192 | — | 186 |
| 17 | — | — | 168 | 156 | 137 | 166 | 133 | 128 | — | — |
| 18 | 1236 | 1245 | 1240 | — | 1065 | 1158 | 1055 | 1050 | 1011 | — |
| 19 | 294 | 350 | 327 | — | 262 | 287 | 250 | 280 | 245 | — |
| 20 | 222 | 230 | 210 | — | 202 | 212 | 213 | 193 | — | — |

## APPENDIX II. MEASUREMENTS OF

| | A | B | C | D | E | F | G | H | I |
|---|---|---|---|---|---|---|---|---|---|
| 1 | 1378 | 1524 | 1423 | 1062(?) | 1474 | 1440 | 1343 | 1438 | 1421 |
| 2 | 880 | 960 | 925 | 578% | 1025 | 908 | 870 | 923 | — |
| 3 | — | 1185 | 1130 | 720+ | 1187 | 1146 | 865 | 1122 | 1170 |
| 4 | — | 563 | 544 | — | 575 | 569 | 525 | 582 | 571 |
| 5 | 666 | 766 | 682 | 530 | 716 | 693 | 657 | 757 | 686 |
| 6 | — | 750 | 675 | 520 | 740 | 732 | 660 | 748 | — |
| 7 | — | — | — | — | — | 447 | 397 | 445 | — |
| 8 | 188 | 207 | 197 | — | 223 | 208 | 194 | 206 | 201 |
| 9 | — | — | — | — | — | — | — | — | — |
| 10 | 181 | 215 | 195 | 165 | 197 | 204 | 203 | 215 | 194 |
| 11 | 238 | 235 | 217 | 187 | 239 | 238 | 239 | 246 | 230 |
| 12 | 96 | 110 | 98 | 83 | 100 | 98 | 94 | 102 | 98 |
| 13 | — | — | — | — | — | — | — | — | — |
| 14 | — | — | — | — | — | — | — | — | — |
| 15 | 84 | 85 | 82 | 83 | 71 | 86 | 72 | 78 | — |
| 16 | 240 | 261 | 228 | 195 | 235 | 246 | 216 | 221 | 238 |
| 17 | 168 | 193 | 171 | 142 | 178 | 180 | 173 | 170 | 163 |
| 18 | 1282 | 1334 | 1289 | 883+ | 1360 | 1334 | 1190 | — | 1300 |
| 19 | 145+ | 292 | 295 | 145+ | 310 | — | — | — | 276 |
| 20 | 223 | 271 | 230 | 175 | 245 | 241 | 212 | 222 | 234 |

OF *BERARDIUS ARNOUXI* (MILLIMETERS)

| K | L | M | N | O | P |
|---|---|---|---|---|---|
| 1350 | 1372 | 587 E | 505+ | 601 | 1260 |
| 903 | 919 | 343 | 280+ | 358 | 765 |
| 1078 | 1097 | 443 E | 383+ | 469 | 648(?) |
| 525 | 533 | 235 | 252 | 240 | — |
| — | 625 | 228 | 207 | 228 | — |
| 662 | 671 | 258 | 238 | 242 | 700 |
| — | — | — | 140 | — | 435 |
| 150 | 152 | 37 | 46 | 35 | 168 |
| — | — | — | 37 | — | — |
| — | — | — | 82 | — | 200 |
| 203 | 208 | — | 116 | — | 218 |
| 69 | 74 | 49 | 49 | 50 | 98 |
| — | — | — | 84 | — | — |
| — | — | — | 197 | — | — |
| 62 | 61 | — | 38 | — | — |
| 188 | 191 | 90 | 93 | 91 | 220 |
| — | — | — | 59 | — | 154 |
| 1225 | 1245+ | 481 | 440 | 498 | 1155 |
| 303 | 310 | 155 | 125 | 161 | 290 |
| 204 | 211 | 83 | 92 | 91 | 230 |

A. Type *Paris Mus.*
B. *Otago Mus.* A14.31
C. *Otago Mus.* A24.69
D. *Otago Mus.*
E. *Dom. Mus.* 7
F. *Eom. Mus.* 416
G. *Dom. Mus.* 143
H. *Dom. Mus.* 1402
I. *Mus. Nac.* Bs. Aires
J. *S.R.N.M.* 21511
K. Flower 1868 R.C. 3
L. True
M. *Brit. Mus.* 1677G, 76.2.16.3
N. *Dom. Mus.* 614
O. *Brit. Mus.* 1949-8.A.1
P. *S. Aust. Mus.* M.5012

*BERARDIUS BAIRDI* (MILLIMETERS)

A. Type *U.S.N.M.* 30992
B. *U.S.N.M.* 49736
C. ? *U.S.N.M.* 49725
D. *U.S.N.M.* 49727
E. Bering Isl. *U.S.N.M.*
F. 33 ft. (Pike, 1953)
G. 29 ft. (Pike, 1953)
H. ? 34 ft. 5 in. (Slipp & Wilke, 1953)
I. 36 ft. (Omura, Fujino, & Kimura, 1955)

Key to the numbers, *1* to *20*, in the appendix tables of measurements.

*1.* Total length of skull; *2.* Length of rostrum; *3.* Tip of rostrum to posterior median margin of pterygoids; *4.* Height of vertex to pterygoids, vertical; *5.* Breadth between centre of orbits; *6.* Breadth between zygomatic processes; *7.* Breadth at maxillary notches; *8.* Breadth of rostrum at middle; *10.* Greatest breadth of premaxillaries, proximally; *11.* Greatest breadth of premaxillaries in front of anterior nares; *12.* Greatest breadth of anterior nares; *13.* Length of temporal fossa; *14.* Breadth between temporal fossae; *15.* Breadth of foramen magnum; *16.* Width of occipital condyles; *17.* Height of occipital condyle; *18.* Length of mandible; *19.* Length of symphysis; *20.* Greatest depth of mandible.

## EXPLANATION OF PLATES

### PLATE I

*Berardins arnouxi* Duvernoy stranded in Pukerua Bay, New Zealand.
Photos E. Pain.

### PLATE II

Old male of *Berardius arnouxi* Duvernoy.
Fig. 1. Stranded animal; Fig. 2. Head showing frontal bos, beak and gular grooves; Fig. 3 Blowhole and scarring; Fig. 4. genital and anal area; Fig. 5. Dorsal fin, new and old scars and wounds; note the parallel scars and possible shark teeth marks (left lower corner).
Photos McCann.

### PLATE III

Skull of adult *Berardius arnouxi* Duvernoy.
(See index to lettering, page 137).
*Courtesy National Museum.*
Photos P. M. Hedgland.

### PLATE IV

Skull of neonatal *Berardius arnouxi* Duvernoy.
(See index to lettering, page 137).
*Courtesy National Museum*
Photos P. M. Hedgland.

### PLATE V

Sagittal section of adult *Berardius arnouxi* Duvernoy.
Figs. 1. and 2. general aspect. Fig. 3. Narial region; note ' blind pit' (BP) in vomer.
(See index to lettering, page 137)
*Courtesy National Museum*
Photos P. M. Hedgland.

### PLATE VI

Posterior aspect of Skulls of *Berardius arnouxi* Duvernoy.
Fig. 1. neonatal; Fig. 2. adult.
(See index to lettering, page 137)
*Courtesy National Museum*
Photos C. Hale Fig. 1. & P. M. Hedgland Fig. 2.

### PLATE VII

Antorbital region of adult *Berardius arnouxi* Duvernoy.
(See index to lettering, page 137)
*Courtesy National Museum*
Photos P. M. Hedgland.

### PLATE VIII

Antorbital and aural region of neonatal *Berardius arnouxi* Duvernoy.
Fig. 1. Antorbital foramina and optic foramen; note only foramen No. 2 is visible at this stage. Fig. 2. aural area.
(See index to lettering, page 137).
*Courtesy National Museum*
Photos P. M. Hedgland.

### PLATE IX

Formation of Antorbital tubercle and associated bones in *Berardius arnouxi* Duvernoy (adult).
Fig. 1. Dorsal aspect; Fig. 2. ventral aspect; Fig. 3. orbital region.

(See index to lettering, page 122).
*Courtesy National Museum* Photos P. M. Hedgland.

## PLATE X

Adult *Berardius arnouxi* Duvernoy.
Fig. 1. Brain cavity; Fig. 2. Aural region.
(See index to lettering, page 122).
*Courtesy National Museum* Photos P. M. Hedgland

## PLATE XI

Adult and neonatal tympanic bones contrasted.
A—adult; B—neonatal.
(See index to lettering, page 122).
*Courtesy National Museum* Photos P. M. Hedgland

## PLATE XII

Teeth of *Berardius arnouxi* Duvernoy.
Upper set, inner faces; centre, outer faces of same set; lower, antero-posterior faces.
*Courtesy National Museum* Photos P. M. Hedgland

## PLATE XIII

Scapulae of *Berardius arnouxi* Duvernoy.
Fig. 1. Dorsal aspect of adult and neonatal.
Fig. 2. Ventral aspect of same pair.
*Courtesy National Museum* Photos P. M. Hedgland.

## PLATE XIV

*Berardius bairdi* Stejneger.
Fig. 1. Adult animal; Fig. 2. Extremity of rostrum; note *Conchoderena* attached to teeth; Fig. 3. Teeth of adult and of a 2,700 mm foetus; top row, anterior, bottom row, posterior.

Photos
Courtesy Dr. H. Omura.

## PLATE XV

Adult skull of *Berardius bairdi* Stejneger.
(See index to lettering, page 122).

Photos
Courtesy Dr. H. Omura.

## KEY TO LETTERING AND FIGURES ON PLATES

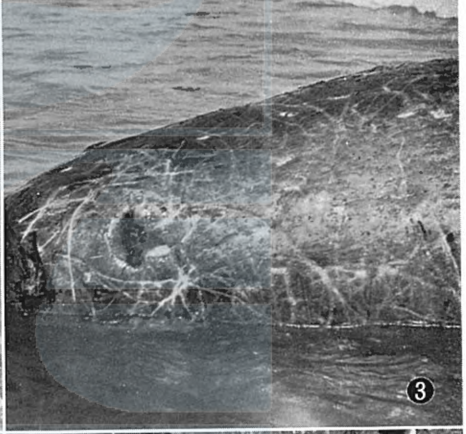
Ac—Acromion.
ALS(AS)—Alisphenoid bone.
AN—Antorbital notch.
AOF—Antorbital foramen.
AT—Antorbital tubercle.
AU(auf)—Auditory foramen.
B(ty)—Tympanic bulla.
BOC—Basioccipital crest.
BP—' Blind pit ' in posterior wall of vomer (nares).
BS—Basisphenoid bone.
Ca—Carotid foramen.
CE—Condylar foramen.
Cor—Coracoid.
EO—Exoccipital bone.
ET(e)—Eustacian tube.
F—Frontal bone.
FC—Falx cerebri.
FM—Foramen magnum.
FO(fo)—Foramen ovale.
FP—Falciform process.
FS(fl)—Sphenoidal fissure.
J—Jugal process.
L—Lachrymal bone.
LRC—Lower rostral canal.
M—Malar bone (jugal).
MAS—Mastoid process.
MCF—Post maxillary crest foramen.
MD—Mandible.
ME(MES)—Mesethmoid bone.
MF—Mandibular foramen.
MP—Maxillary pit.
MRC—Median Rostral canal.
MRG—Mesorostral groove.
MX—Maxilla.
MXC—Maxillary crest.
MXF—Maxillary foramen.
N—Nasal bone.
NF—Narial foramen.
OBS—Orbito-sphenoid bone.
OC—Occipital condyle.
OF(OPF)—Optic foramen.
OS—Orbitosphenoid.
Pa—Parietal.
Pal.-Rid.—Palatine ridge.
PCF—Post crest foramen.
PE(per)—Periotic bone.
PL(Pl)—Palatine bone.
PMF—Post maxillary foramen.
PMX—Premaxillary.
PMXF—Premaxillary foramen.
PS—Presphenoid.
PT—Pterygoid bone.
S—Nasal septum.
SO—Supraoccipital bone.
SQ—Squamosal bone.
Ty(B)—Tympanic bulla.
Vo.—Vomer.
URC—Upper rostral canal.

*Ear bones:*
a—Posterior articular surface between bones.
a′—Anterior articular surface between bones.
af—Aquaduct of Fallopius.
al—Anterior lobe of periotic bone.
e—Eustacean tube.
eam—External auditory meatus.
epl—Exterior posterior lobe of tympanic.
fo—Fenestra ovalis.
fr.—Fenestra rotunda.
ipl—Internal posterior lobe of tympanic.
m—Mastoid process.
per—periotic bone.
pl—Posterior lobe of periotic.
ty—Tympanic bulla.

*Numbers:* Nos. 1, 2 and 3 refer to foramina in the antorbital region.

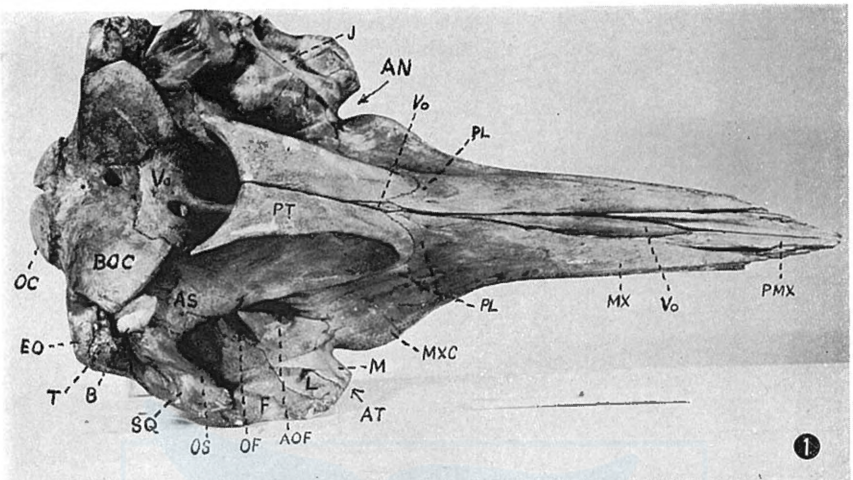

①


②

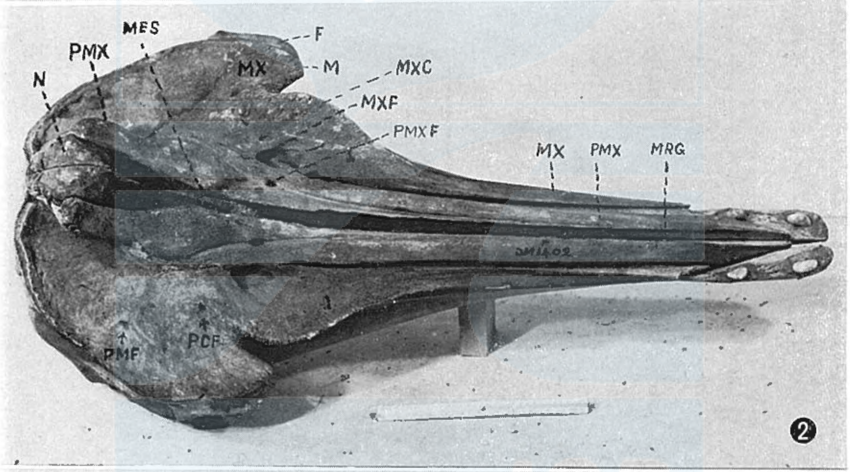

③


④

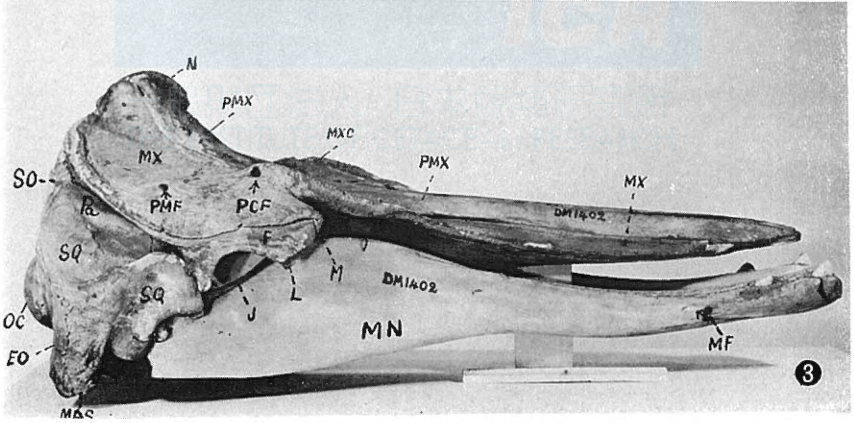

⑤


J
AN
Vo
PL
Vo
PT
OC
BOC
AS
PL
MX
Vo
PMX
EO
MXC
M
T
B
L
AT
SQ
F
OS
OF
AOF

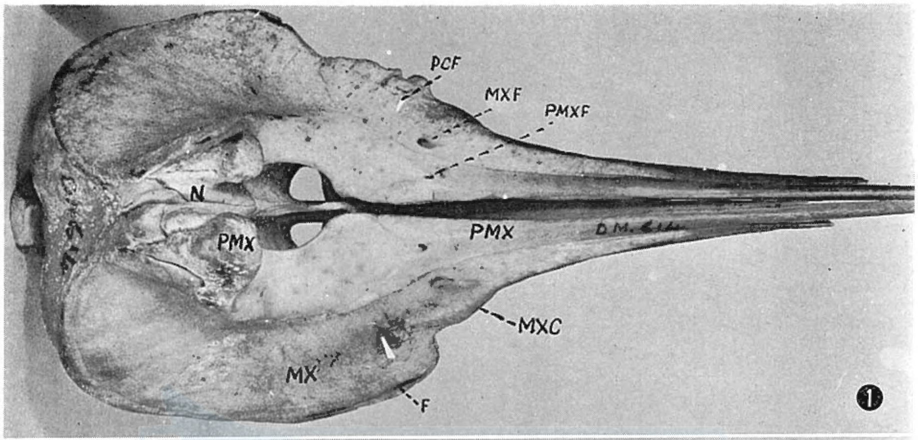
①


MES
F
PMX
MX
M
N
MXC
MXF
PMXF
MX
PMX
MRG
DM1402
PMF
PCF

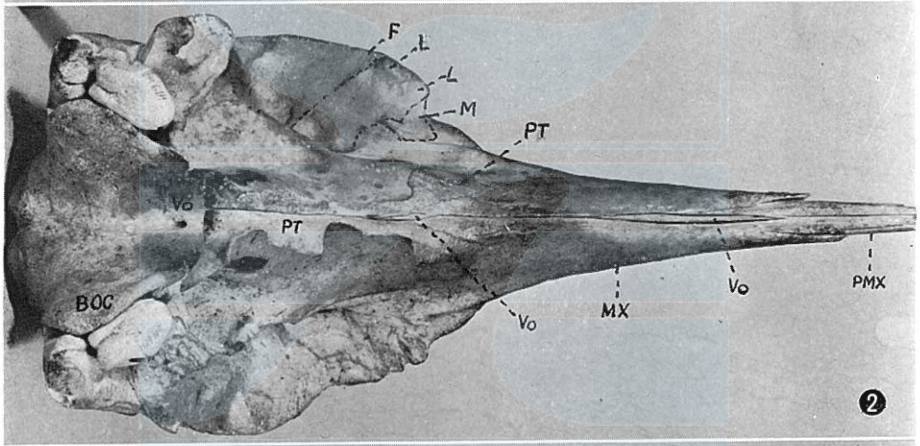
②


N
PMX
MXC
MX
PMX
SO
PMF
PCF
Pa
MX
DM1402
SQ
F
M
DM1402
L
SQ
J
OC
MN
MF
EO
MAS

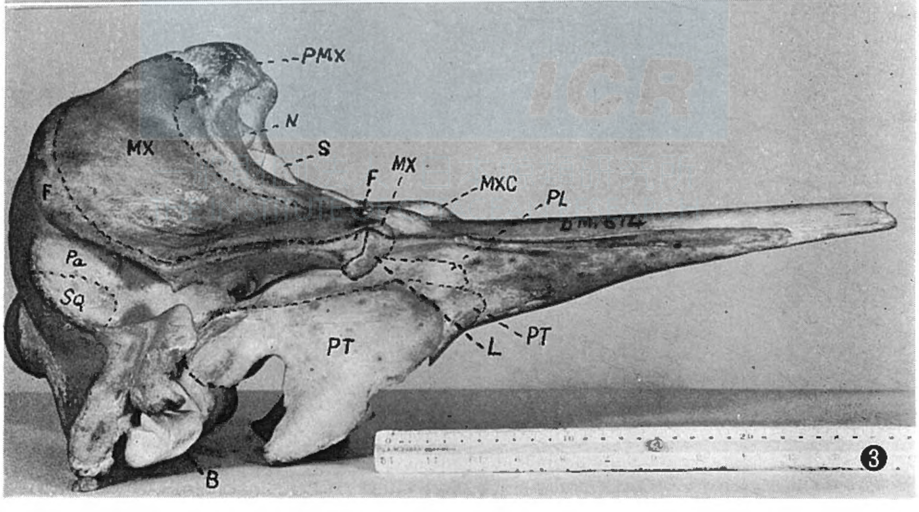
③


PCF
MXF
PMXF
N
PMX
PMX
MXC
MX
F

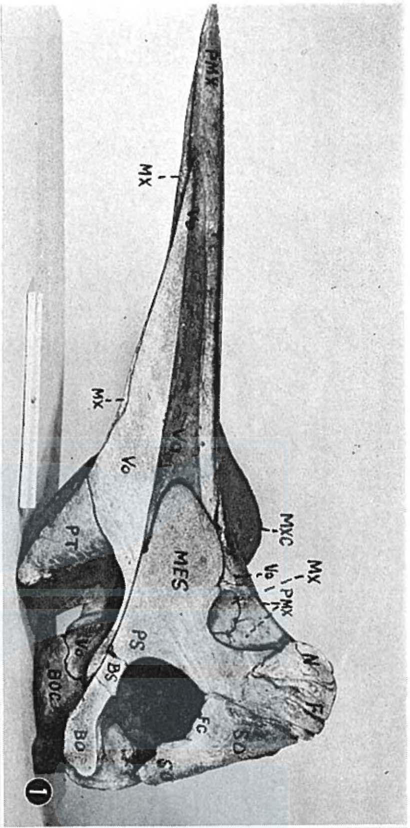
❶

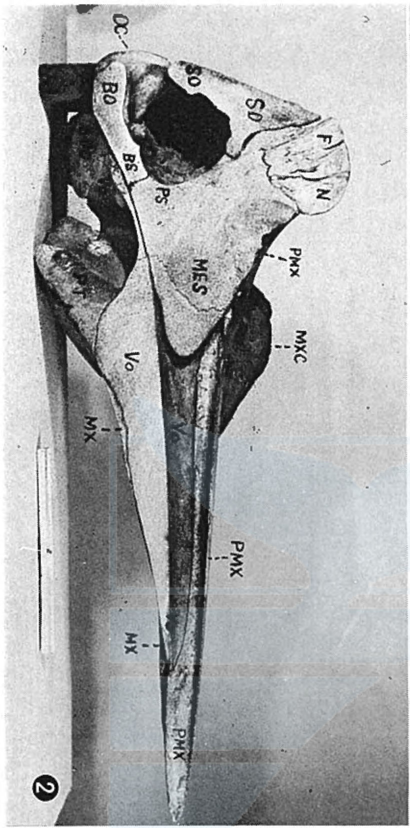

F
L
L
M
PT
Vo
PT
BOC
Vo
MX
Vo
PMX

❷

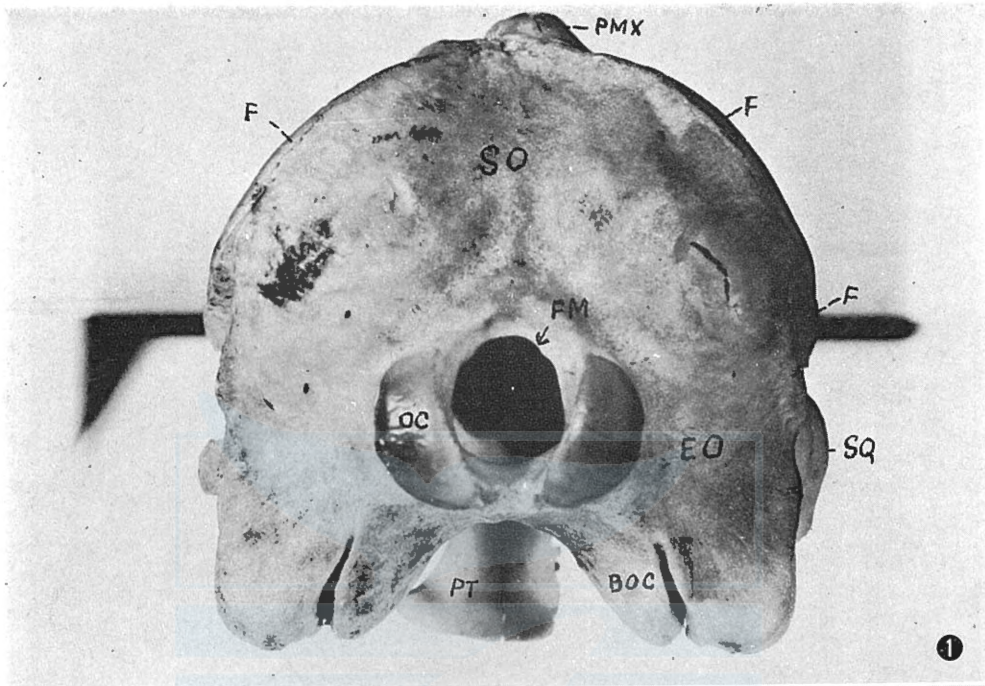

PMX
N
MX
S
MX
F
MXC
F
PL
Pa
SQ
PT
L
PT
B

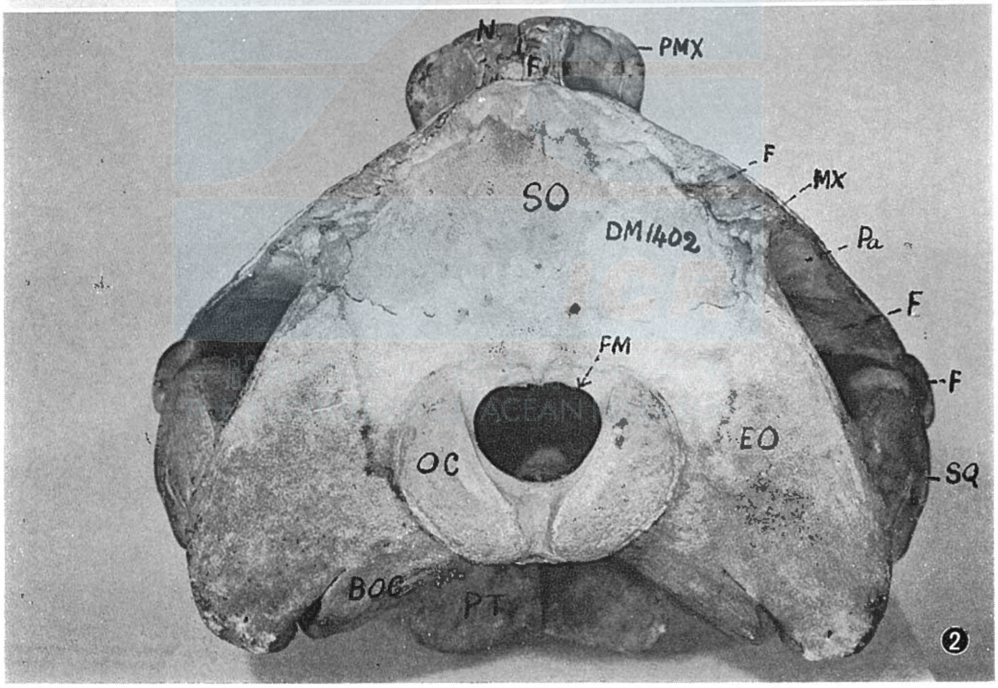
❸

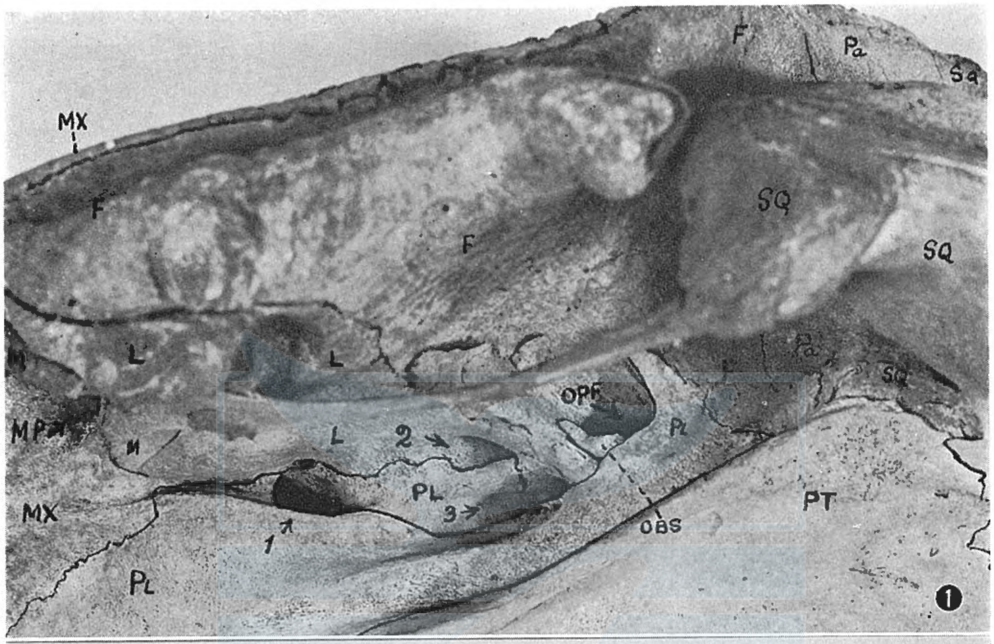

①
PMX
MX
Vo
MX
Vo
Vo
MXC
MX
Vo
PMX
MES
PT
PS
Vo
BOC
BS
BO
FC
SO
N
F
SO


②
OC
SO
BO
SO
F
N
BS
PS
PMX
MES
PT
MXC
Vo
MX
Vo
PMX
MX
PMX

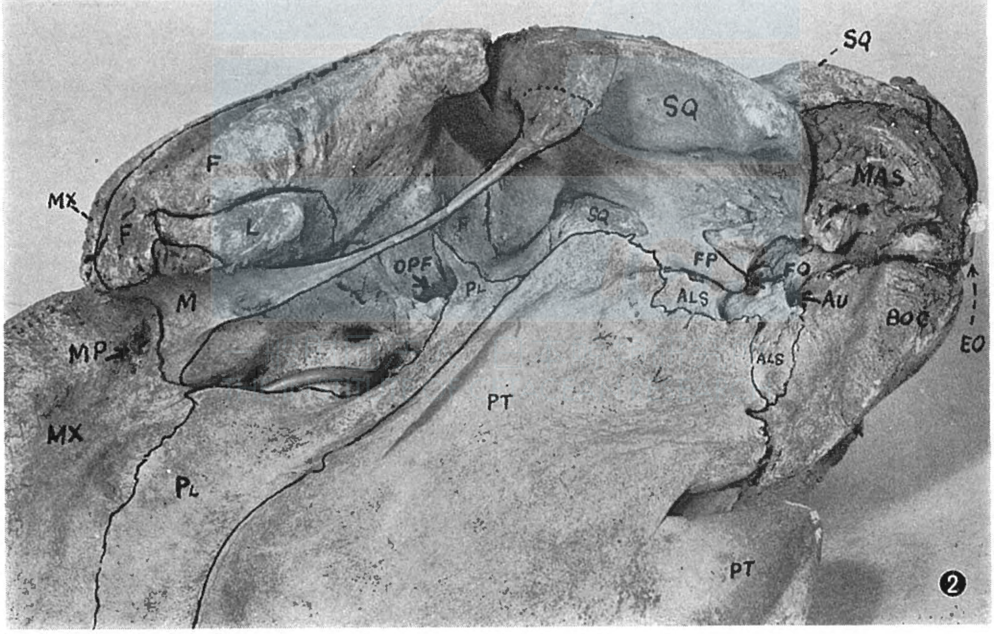

③
Vo
Vo
MES
PMX
PL
PMX
MX
BPT
Vo
PS
S
Vo
BS
FS
BO
FC
SO
N
F


PMX
F
F
SO
F
FM
OC
EO
SQ
PT
BOC
1

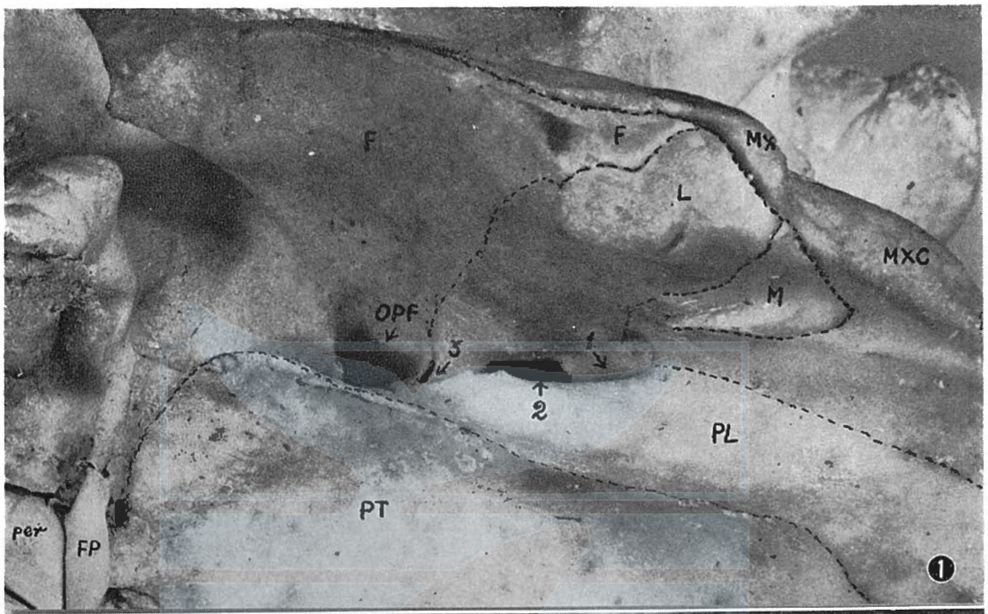

N
F
PMX
F
MX
SO
DM1402
Pa
F
FM
F
OC
EO
SQ
BOC
PT
2


F
Pa
Sa
MX
F
SQ
F
SQ
M
L
L
Pa
SQ
OPF
MP
M
L
2
PL
PL
3
MX
1
OBS
PT
PL

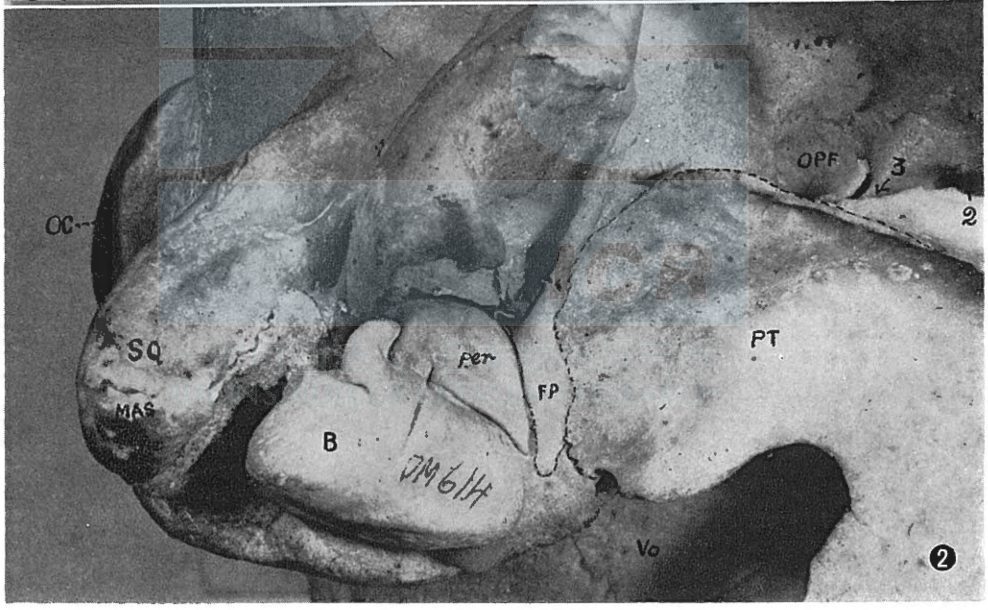
①


SQ
SQ
MAS
F
MX
F
L
F
SQ
OPF
PL
FP
FO
AU
ALS
BOC
M
ALS
EO
MP
MX
PT
PL
PT

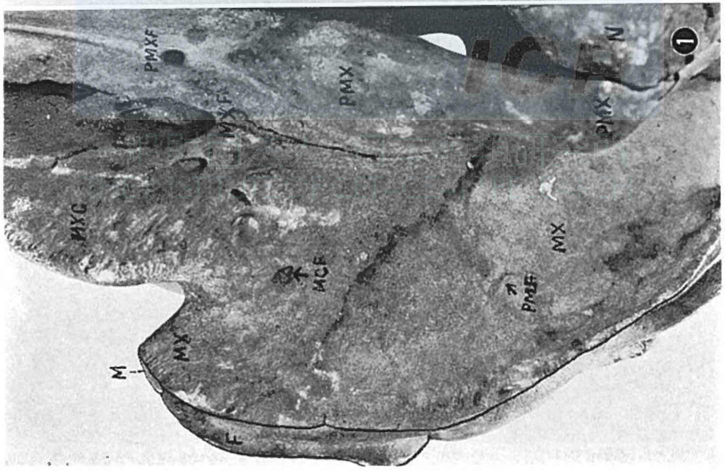
②

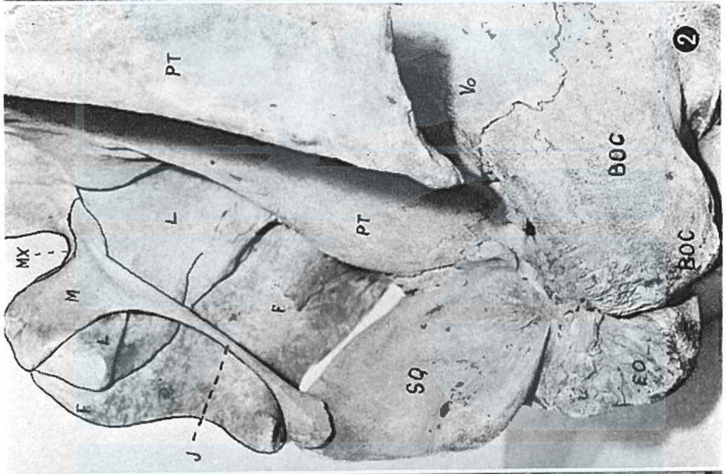

F
F
MX
L
MXC
M
OPF
3
1
2
PL
PT
per
FP

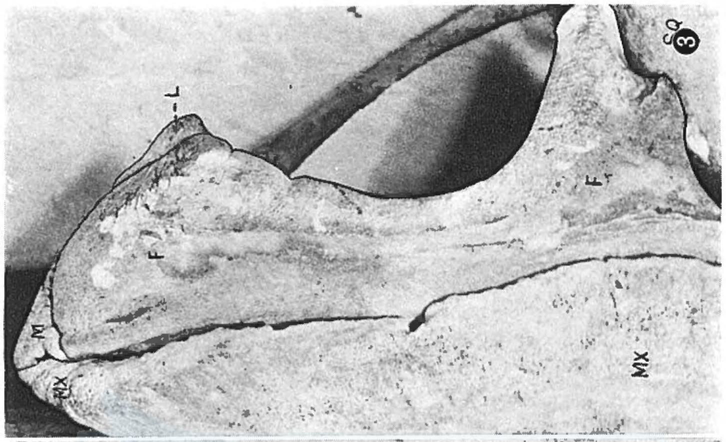
①

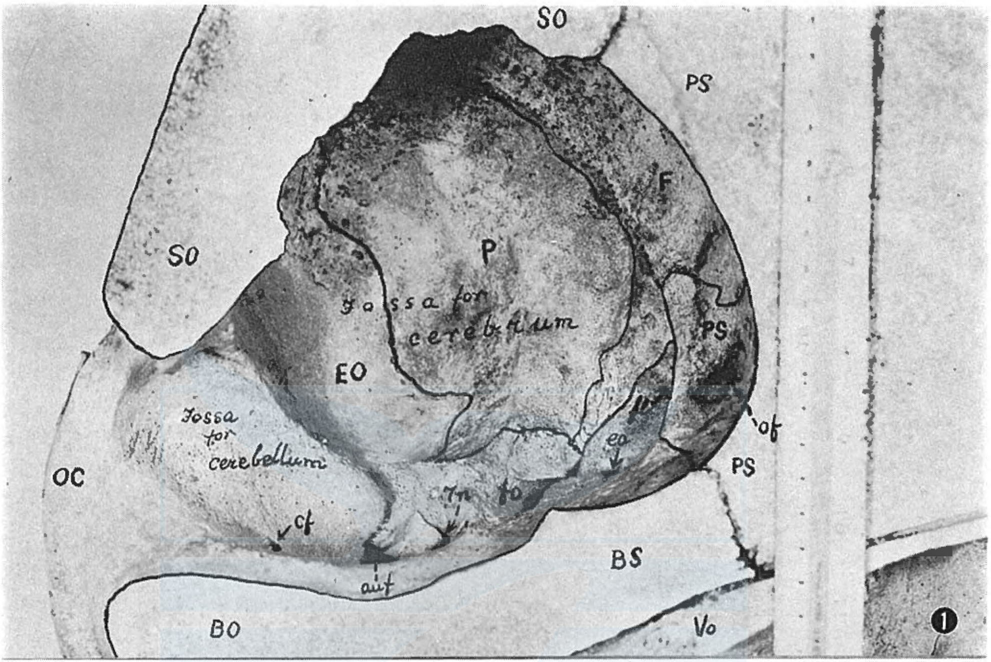

OC
OPF
3
2
SQ
MAS
per
FP
PT
B
419WC
Vo

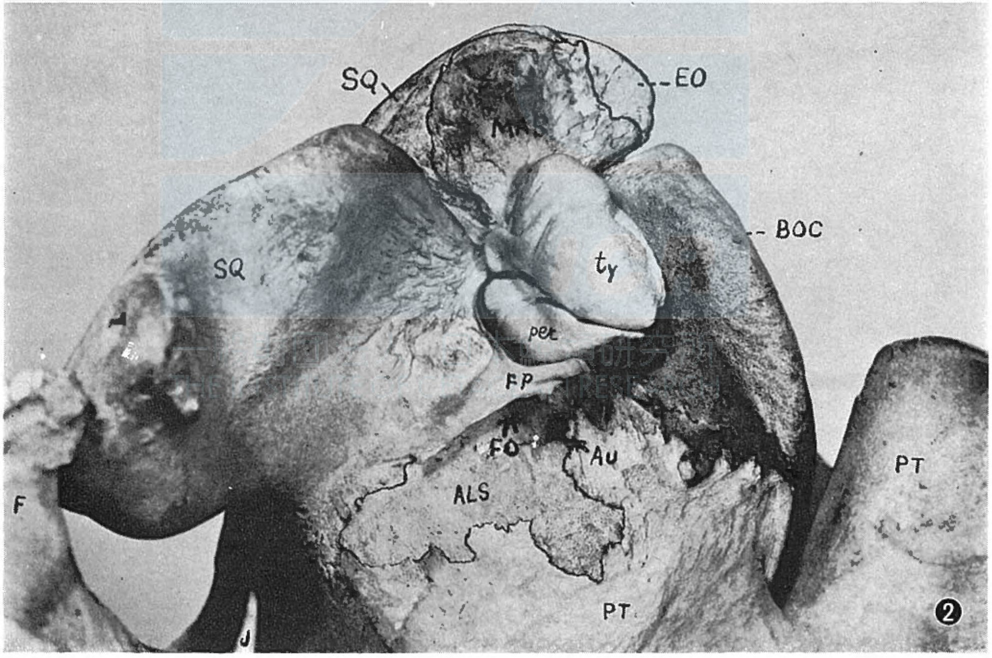
②

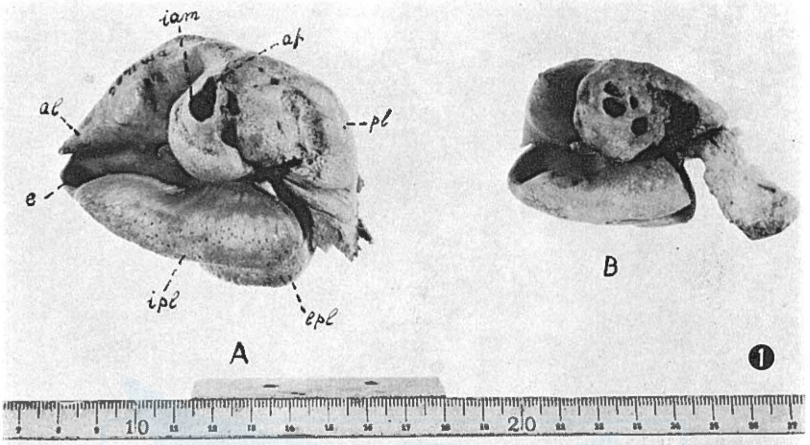

1
PMXF
PMX
MXF
MXC
N
PMX
MCF
MX
PMF
M
MX
F


2
PT
Vo
BOC
BOC
MX
M
L
PT
L
F
F
J
SQ
EO

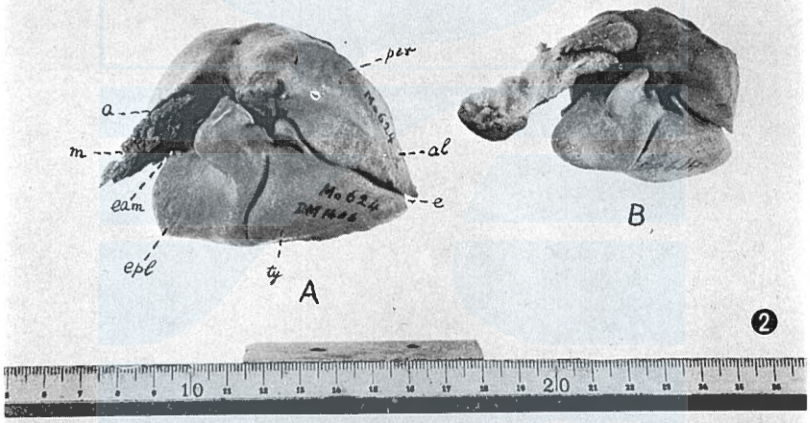

3
SQ
L
F
F
M
MX
MX


SO
PS
F
SO
P
Fossa for cerebrum
PS
EO
of
Fossa for cerebellum
eo
OC
PS
cf
7n
fo
BS
aif
BO
Vo
❶

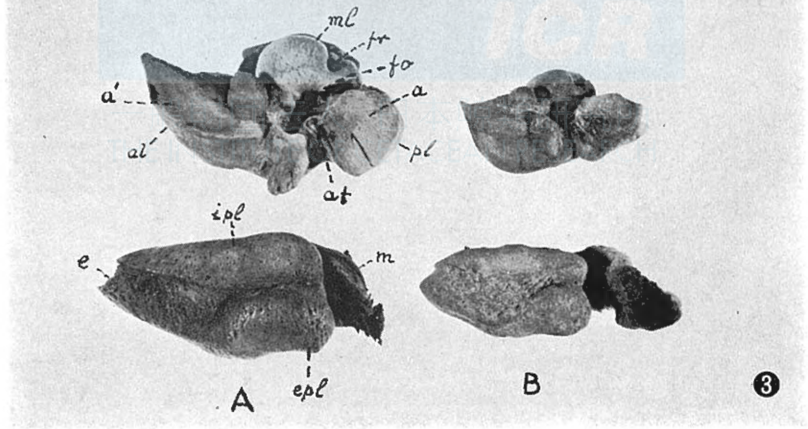

SQ
EO
MAS
BOC
ty
SQ
pet
FP
FO
AU
ALS
F
PT
PT
J
❷


iam
af
al
pl
e
ipl
epl
A
B
10
20

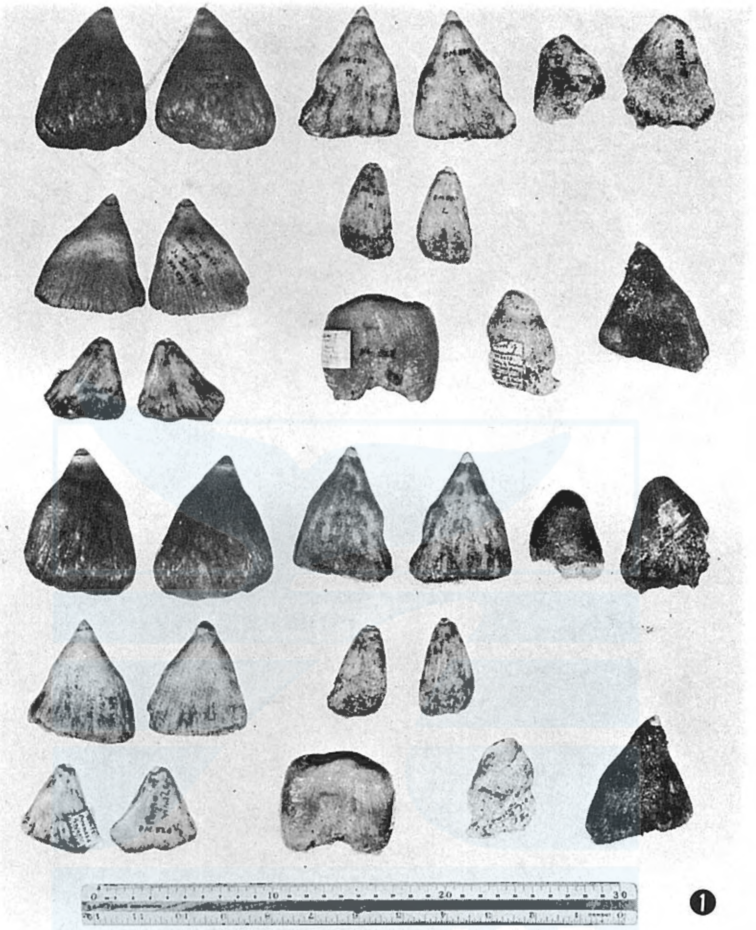
1


per
a
m
al
eam
e
epl
ty
Mo 624
A
B
10
20

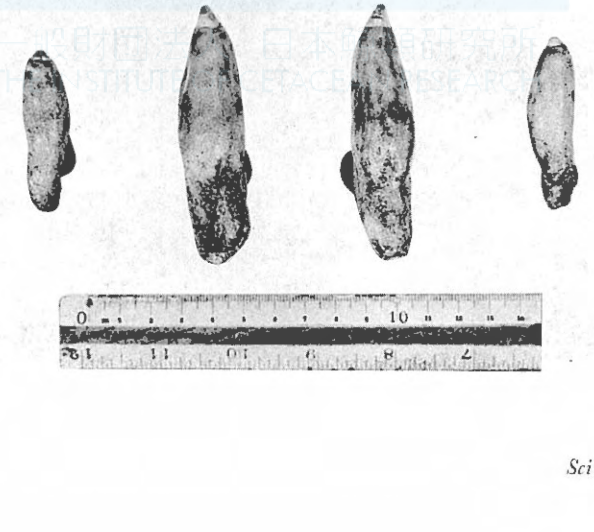
2


ml
fr
fo
a'
a
al
pl
at
ipl
e
m
epl
A
B

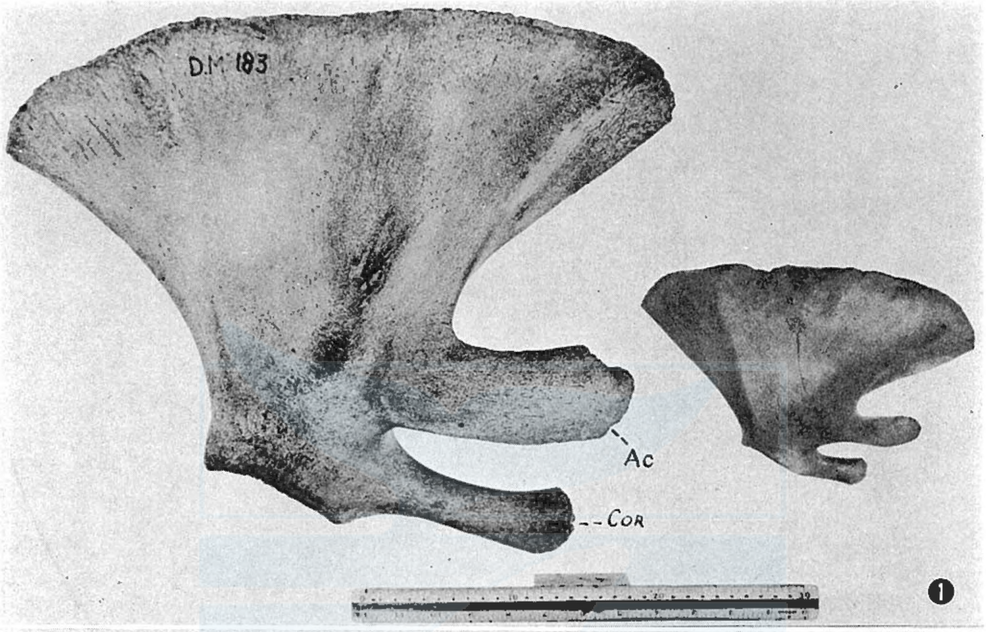
3



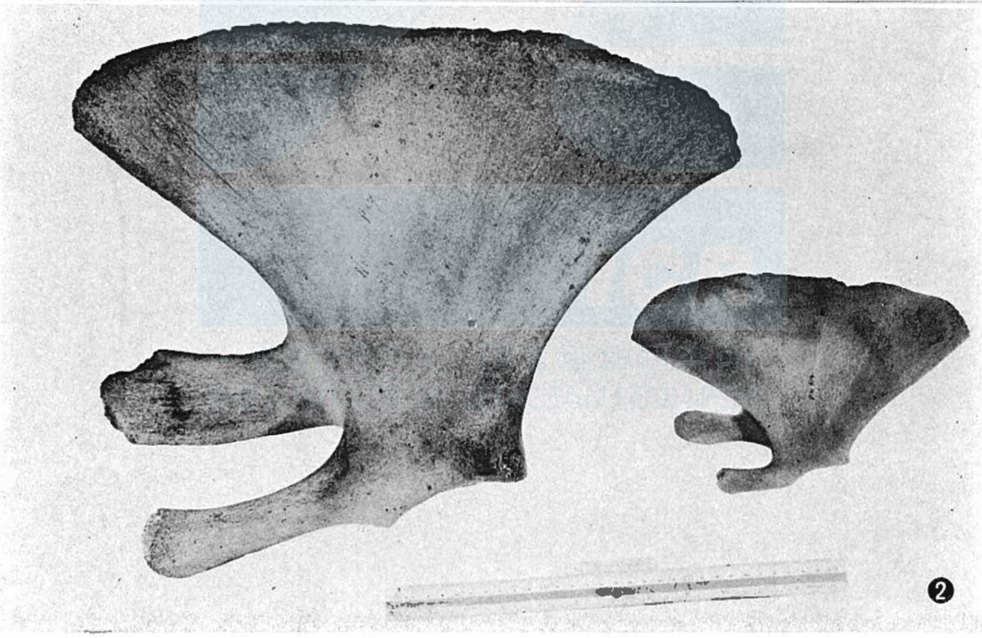
❶



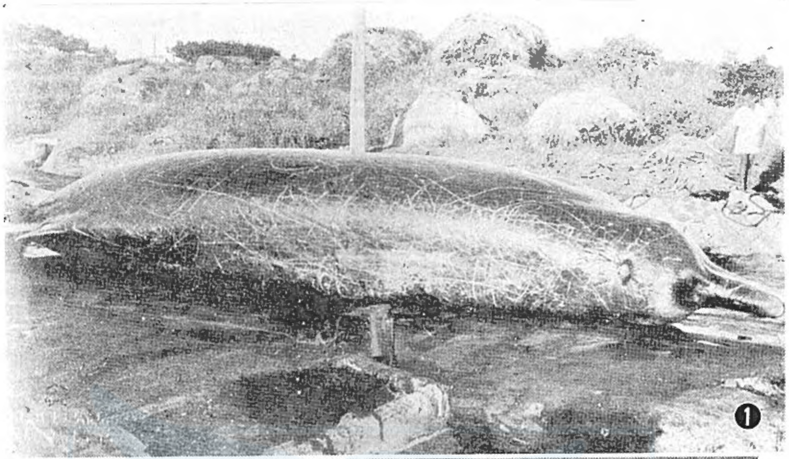
❷

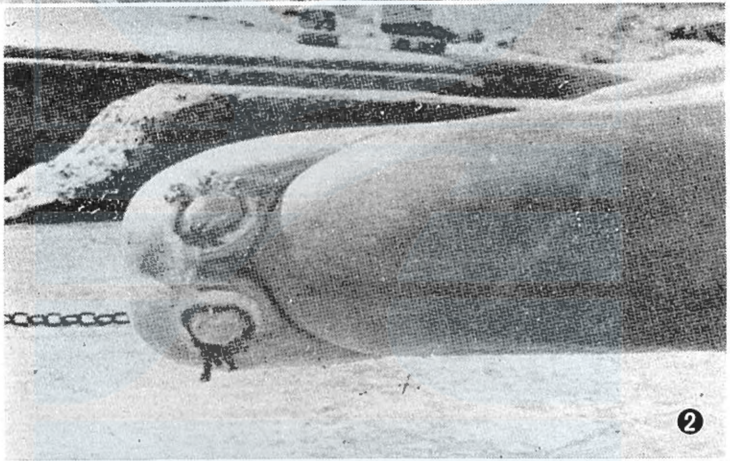


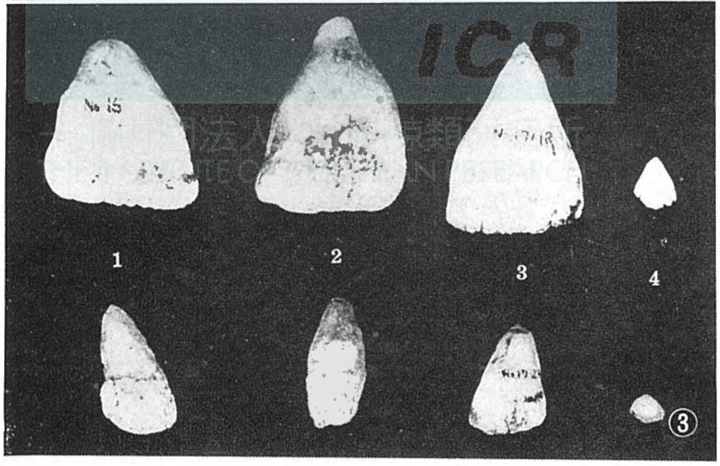
❶



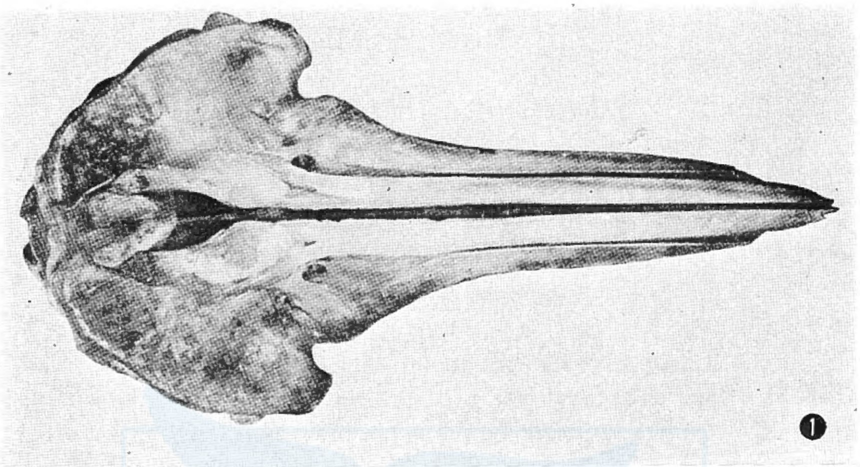
❷


❶

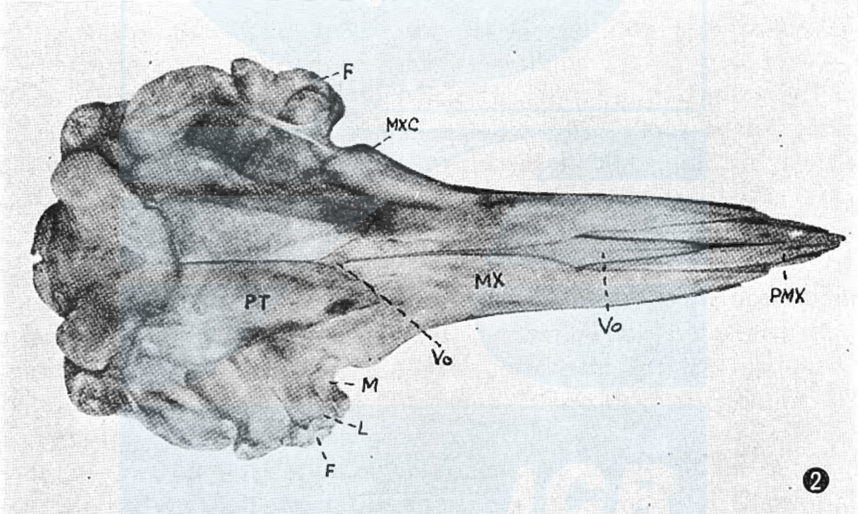

❷



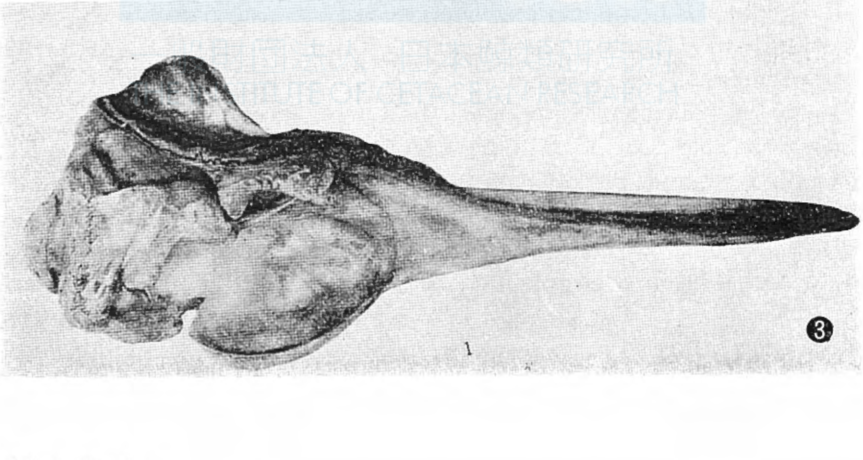
③



1



2



3