

## Supplementary Information to:

# A new balaenopterid whale from the late Miocene of the Southern North Sea Basin and the evolution of balaenopterid diversity (Cetacea, Mysticeti)

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**Table S1**

Stratigraphic and geographic data for the taxa used in the analyses

Taxon name	FO (1)	LO (1)	Areas of occurrence	References
<i>Protocetus atavus</i>	48.6	40	Mediterranean	Paleobiology Database
<i>Georgiacetus vogtlensis</i>	40.4	37.2	North Atlantic	Paleobiology Database
<i>Gaviacetus razai</i>	48.6	40.4	Indian	Paleobiology Database
<i>Maiacetus inuus</i>	48.6	40.4	Indian	Paleobiology Database
<i>Basilosaurus cetoides</i>	37.2	33.9	Mediterranean North Atlantic	Paleobiology Database
<i>Cynthiacetus peruvianus</i>	37.2	33.9	South Pacific	Paleobiology Database
<i>Dorudon atrox</i>	37.2	33.9	Mediterranean, North Atlantic	Paleobiology Database
<i>Zygorhiza kochii</i>	37.2	33.9	North Atlantic	Paleobiology Database
<i>Mammalodon colliveri</i>	28.4	23.03	South Pacific	Paleobiology Database
<i>Janjucetus hunderi</i>	23.9	27	South Pacific	Fitzgerald (2006)
<i>Fucaia buelli</i>	33.9	31	North Pacific	Marx et al. (2015)
<i>Aetiocetus weltoni</i>	28.4	23.3	North Pacific	Paleobiology Database
<i>Waharoa ruwhenua</i>	27.3	20.43	South Pacific	Boessenecker & Fordyce (2015)
<i>Yamatocetus canaliculatus</i>	28.4	23.3	North Pacific	Paleobiology Database
<i>Eomysticetus whitmorei</i>	28.4	23.3	North Atlantic	Paleobiology Database
<i>Micromysticetus rothauseni</i>	33.9	28.4	North Atlantic	Paleobiology Database
<i>Horopeta umarere</i>	27.3	25.2	South Pacific	Tsai & Fordyce (2015)
<i>Sitsqwayk cornishorum</i>	28.4	23.03	North Pacific	Peredo & Uhen (2016)
<i>Morenocetus parvus</i>	20.03	15.97	South Atlantic	Buono et al. (2018)
<i>Miocaperea pulchra</i>	11.608	7.246	South Pacific	Bisconti (2012)
<i>Caperea marginata</i>	0.012	0.0	South Pacific	Paleobiology Database
<i>Balaenella brachyrhynchus</i>	5.3	5.0	North Sea	Bisconti (2005)
<i>Balaena mysticetus</i>	0.012	0.0	North Atlantic, North Pacific	Paleobiology Database
<i>Eubalaena glacialis</i>	0.012	0.0	North Atlantic	Paleobiology Database
<i>Balaenula astensis</i>	3.4	3.2	Mediterranean	Bisconti (2000)
<i>Titanocetus sammarinensis</i>	15.97	13.81	Mediterranean	Bisconti (2006)
<i>Tiucetus rosae</i>	13.65	7.246	South Pacific	Paleobiology Database
<i>Metopocetus hunteri</i>	11.608	7.246	North Sea	Paleobiology Database
<i>Cophocetus oregonensis</i>	20.43	15.97	North Pacific	Paleobiology Database
<i>Aglaocetus moreni</i>	20.43	15.97	South Atlantic	Paleobiology Database
<i>Mixocetus elysius</i>	11.608	7.246	North Pacific	Paleobiology Database
<i>Uranocetus gramensis</i>	11.608	7.246	North Sea	Paleobiology Database
<i>Isanacetus laticephalus</i>	20.43	15.97	North Pacific	Kimura and Ozawa (2002)
<i>Metopocetus durinasus</i>	15.97	13.65	North Atlantic	Paleobiology Database
<i>Diorocetus hiatus</i>	15.97	13.65	North Atlantic	Paleobiology Database
<i>'Aglaocetus' patulus</i>	15.97	13.65	North Atlantic	Paleobiology Database
<i>Parietobalaena palmeri</i>	15.97	13.65	North Atlantic	Paleobiology Database
<i>Pelocetus calvertensis</i>	15.97	13.65	North Atlantic	Paleobiology Database
<i>Joumocetus shimizui</i>	11.608	7.246	North Pacific	Kimura and Hasegawa (2010)
<i>Parietobalaena campiniana</i>	15.0	13.2	North Sea	Bisconti et al. (2013)
USNM 187416	17.0	15.0	North Atlantic	Gottfried et al. (1994)
<i>Piscobalaena nana</i>	11.608	4.0	South Pacific	Paleobiology Database
<i>Herpetocetus morrowi</i>	3.6	2.6	North Pacific	Paleobiology Database
<i>Cetotherium riabinini</i>	11.6	7.246	Paratethys	Paleobiology Database
<i>Cetotherium rathkei</i>	13.65	7.246	Mediterranean (Paratethys)	Paleobiology Database
<i>Thinocetus arthritus</i>	13.65	11.608	North Atlantic	Paleobiology Database
<i>Halicetus ignotus</i>	13.65	11.608	North Atlantic	Paleobiology Database
<i>Herentalia nigra</i>	11.608	7.246	North Sea	Paleobiology Database
<i>Archaeoschrichtius ruggieroi</i>	11.0	7.5	Mediterranean	Bisconti & Varola (2006)
<i>Eschrichtioides gastaldii</i>	5.0	3.0	Mediterranean	Bisconti (2008)

<i>Eschrichtius robustus</i>	0.1	0.0	North Sea, North Atlantic, North Pacific	Paleobiology Database
<i>'Balaenoptera' ryani</i>	11.608	7.246	North Pacific	Paleobiology Database
RBINS M. 2231	5.0	5.0	North Sea	Bisconti & Bosselaers in prep. a
MPTAM 207.13307	3.6	3.2	Mediterranean	Bisconti et al. in prep.
<i>Archaeobalaenoptera castriarquati</i>	3.8	2.558	Mediterranean	Bisconti (2007a); Freschi & Cau (2016)
<i>Protororqualus cuvieri</i>	3.1	3.0	Mediterranean	Bisconti (2007b); Freschi & Cau (2016)
<i>'Balaenoptera' cortesii</i> var. <i>portisi</i>	3.6	2.588	Mediterranean, North Atlantic, North Pacific	Deméré et al. (2005)
SAM PQL-55001	5.3	5.0	South Atlantic	Govender et al. (2016)
<i>Plesiobalaenoptera quarantellii</i>	11.608	7.246	Mediterranean	Bisconti (2010)
<i>'Balaenoptera' bertae</i>	3.35	2.5	North Pacific	Boessenecker (2013)
<i>Parabalaenoptea baulinensis</i>	7.246	5.332	North Pacific	Zeigler et al. (1997)
<i>Fragilicetus velponi</i>	5.332	5.0	North Sea	Bisconti and Bosselaers (2016)
<i>'Megaptera' hubachi</i>	5.332	3.6	South Pacific	Bisconti (2011)
<i>Diunatans luctoretemergo</i>	5.3	2.558	North Sea	Bosselaers & Post (2010)
<i>'Balaenoptera' siberi</i>	7.246	5.332	South Pacific	Paleobiology Database
MHNL 1610	8.0	7.0	South Pacific	Bisconti et al. (in prep. a)
MHNL 1613	7.5	7.3	South Pacific	Bisconti et al. (in prep. b)
UT PU13842/5	3.4	3.2	Mediterranean	Caretto (1970)
MAB002286	8.2	7.5	North Sea	Bisconti et al. (in prep. c)
RBINS 2315	3.71	2.74	North Sea	Bisconti & Bosselaers (in prep. b)
NMR 7096	3.7	2.7	North Sea	Bisconti & Bosselaers (in prep. c)
<i>Incakujira anillodefuego</i>	7.5	7.3	South Pacific	Marx & Kohno (2016)
<i>Megaptera novaeangliae</i>	0.781	0.0	North Atlantic, North Pacific, South Atlantic, South Pacific, Indian Ocean	Paleobiology Database;
<i>'Balaenoptera' bertae</i>	5.332	2.558	North Pacific	Boessenecker (2013)
<i>Miobalaenoptera numataensis</i>	6.8	6.5	North Pacific	Tanaka & Watanabe (2019)
<i>'Megaptera' miocaena</i>	11.608	7.246	North Pacific	Paleobiology Database
Maesawa-Cho	5.3	5.0	North Pacific	Oishi et al. (1985)
Shimajirikujira	9.0	8.0	North Pacific	Kimura et al. (2015)
<i>Balaenoptera borealis</i>	2.6	0.0	North Atlantic, North Pacific, South Atlantic, South Pacific, Indian Ocean	Paleobiology Database
<i>Balaenoptera edeni</i>	0.012	0.0	North Atlantic, North Pacific, South Atlantic, South Pacific, Indian Ocean	Paleobiology Database
<i>Balaenoptera musculus</i>	1.806	0.0	North Atlantic, North Pacific, South Atlantic, South Pacific, Indian Ocean	Paleobiology Database
<i>Balaenoptera omurai</i>	0.012	0.0	North Pacific	Paleobiology Database
<i>Balaenoptera brydei</i>	0.012	0.0	North Pacific	Wada et al. (2007)
<i>Balaenoptera physalus</i>	1.3	0.0	North Atlantic, North Pacific, South Atlantic, South Pacific, Indian Ocean, Mediterranean	Paleobiology Database
<i>Balaenoptera acutorostrata</i>	3.6	0.0	North Atlantic, North Pacific, Mediterranean, Indian Ocean	Paleobiology Database
<i>Balaenoptera bonaerensis</i>	0.012	0.0	South Atlantic, South Pacific	Paleobiology Database

FO, first occurrence; LO, last occurrence. Data in Ma.

## Institutional abbreviations

AMNH, American Museum of Natural History, New York, USA;  
ChM, The Charleston Museum, Charleston, USA;  
RBINS, Royal Belgian Institute of Natural Sciences, Brussels, Belgium;  
MAB, Oertijdmuseum Boxtel, Bosscheweg 80, 5283 WB Boxtel, The Netherlands;  
MAUL, Museo dell'Ambiente, Università di Lecce, Lecce, Italy;  
MGB, Museo Geopalaeontologico 'G. Capellini', Bologna, Italy;  
MCA, Museo Geopalaeontologico 'G. Cortesi', Castell'Arquato, Italy;  
MHNL, Museo de Historia Natural, Lima, Peru;  
MPTAM, Ente Gestione Aree Protette Artigiane, Asti, Italy and Museo Paleontologico Territoriale dell'Astigiano e del Monferrato, Asti, Italy;  
MRSN, Museo Regionale di Scienze Naturali, Torino, Italy;  
MSNT, Museo di Storia Naturale del Territorio, Calci, Italy;  
MPST, Museo Palaeontologico, Salsomaggiore Terme, Italy;  
NBC, Naturalis Biodiversity Center, Leiden, Holland.  
NHG, Natuurlijke Historie Genootschap, Zeeuws Museum, Middelburg, The Netherlands;  
NMB, NatuurMuseum Brabant, Tilburg, Holland;  
NMR, Natuurhistorisch Museum, Rotterdam, Holland;  
RBINS, Royal Belgian Institute of Natural Sciences, Brussels, Belgium;  
SMSN, Staatliches Museum für Naturkunde, Stuttgart, Germany;  
USNM, United States National Museum of Natural History, Smithsonian Institution, Washington, DC, USA;  
ZMA, Instituut voor Systematiek en Populatiebiologie/Zoölogisch Museum, Amsterdam, Holland (the zoological and paleontological collections of ZMA recently moved to NBC).

## Specimens used in the comparative analysis

The specimens listed below were examined by one or all the authors. In some cases, it was not possible to directly examine the specimens; in those cases, the relevant literature is provided in the list below. The list includes 8 undescribed taxa that are included in a phylogenetic analysis for the first time in this paper. These taxa are from Italy (MPTAM 207.13307 and UT PU13842/5), Belgium (RBINS M. 2231, M. 2315, NMR 7096, MAB002286) and Peru (MHNL 1610 and 1613). All these new taxa are baleenopterids and their publications are in progress. Relative ages of the species listed below are from the Cetacea section of the Paleobiology Database mostly compiled by Mark Uhen and, for undescribed taxa, from the cited literature.

### 1. *Protocetidae*

We compiled the matrix by using the following taxa:

- (i) *Protocetus atavus*: SMNS 11084 (holotype); middle Eocene.
- (ii) *Georgiacetus vogtlensis*: Hulbert *et al.* (1996), Hulbert (1998); middle Eocene.
- (iii) *Maiacetus inuus*: Gingerich *et al.* (2009); middle Eocene.
- (iv) *Gaviacetus razai*: Luo & Gingerich (1998); middle Eocene.

### 2. *Basilosaurus cetoides*

Kellogg (1936); Uhen (1998); late Eocene.

### 3. *Cynthiacetus peruvianus*

Martinez-Caceres & Muizon (2017); late Eocene-to-early Oligocene.

### 4. *Dorudon atrox*

Uhen (2004); late Eocene.

### 5. *Zygorhiza kochii*

USNM 4748, 16638, 449538; Kellogg (1936), Uhen (1998); late Eocene.

### 6. *Aetiocetus weltoni*

Barnes *et al.* (1994), Deméré & Berta (2008); late Oligocene.

### 7. *Mammalodontidae*

We compiled the matrix by using the following taxa:

- (i) *Mammalodon colliveri*: Fitzgerald (2010); late Oligocene.
- (ii) *Janjucetus hunderi*: Fitzgerald (2006); late Oligocene.

### 8. *Fucaia buelli*

Marx *et al.* (2015); early Oligocene.

### 9. *Waharowa ruwhenua*

Boessenecker & Fordyce (2015); late Oligocene.

### 10. *Yamatocetus canaliculatus*

Okazaki (2012); late Oligocene.

### 11. *Micromysticetus rothauseni*

Sanders & Barnes (2002a); late Oligocene.

### 12. *Eomysticetus whitmorei*

ChM PV4253 (holotype), Sanders & Barnes (2002b); late Oligocene.

### 13. *Horopeta umarere*

Tsai & Fordyce (2015); late Oligocene.

### 14. *Sitsqwayk cornishorum*

Peredo & Uhen (2016); late Oligocene

### 15. *Morenocetus parvus*

Buono *et al.* (2018); early Miocene.

### 16. *Caperea marginata*

AMNH AMO 36692; RBINS 1536; Baker (1985), Beddard (1901); Recent.

### 17. *Miocaperea pulchra*

Bisconti (2012); late Miocene.

18. *Balaena mysticetus*  
USNM 257513; ZML 1680, 3997, 2563, 2001; Bisconti (2003), Burns *et al.* (1993), Reeves & Leatherwood (1985); Recent.
19. *Balaenula astensis*  
MSNT MC CF 35 (holotype); Bisconti (2000); early Pliocene.
20. *Balaenella brachyrhynchus*  
Natuurmuseum Brabant (Tilburg), specimen 42001 (holotype); Bisconti (2005); early Pliocene.
21. *Eubalaena glacialis*  
AMNH 42752, 256803, 90241; MSNT 264; USNM 267612, 3339990, 23077, 301637; Bisconti (2003), Cummings (1985a), True (1904); Recent.
22. *Tiucetus rosae*  
Marx *et al.* (2017); middle-to-late Miocene.
23. *Pelocetus calvertensis*  
USNM 11976 (holotype); Kellogg (1965); middle Miocene.
24. *'Aglaoctetus' patulus*  
USNM 13472; Kellogg (1968c); middle Miocene.
25. *Uranocetus gramensis*  
Steeman (2009); middle-to-late Miocene.
26. *Isanacetus laticephalus*  
Kimura & Ozawa (2002); early Miocene.
27. *Joumocetus shimizui*  
Kimura & Hasegawa (2010); late Miocene.
28. *Parietobalaena palmeri*  
AMNH 128885; USNM 10677, 16570, 24883, 10909; Kellogg (1968d); middle Miocene.
29. *Parietobalaena campiniana*  
RBINS M.399-R.4018 (holotype); Bisconti *et al.* (2013); middle Miocene.
30. *Diorocetus hiatus*  
USNM 16783 (holotype), 205990; Kellogg (1968b); middle Miocene.
31. USNM 187416; middle Miocene.
32. *Herpetocetus morrowi*  
El Adli *et al.* (2014); late Pliocene.
33. *Piscobalaena nana*  
Bouetel & De Muizon (2006); late Miocene-to-early Pliocene.
34. *Cetotherium rathkei*  
Pilleri (1986); middle Miocene.
35. *Cetotherium riabinini*  
Gol'Din *et al.* (2014); late Miocene.
36. *Mixocetus elysius*  
Kellogg (1934b); late Miocene.
37. *Metopocetus hunteri*  
Marx *et al.* (2015); late Miocene.
38. *Metopocetus durinasus*  
USNM 60460 (holotype); Kellogg (1968a); late Miocene.
39. *Herentalia nigra*  
Bisconti (2015); late Miocene.
40. *Cophocetus oregonensis*  
Packard & Kellogg (1934); early Miocene.
41. *Aglaoctetus moreni*  
Kellogg (1934a); early Miocene.

42. *Thinocetus arthritus*  
Kellogg (1969a); late Miocene.
43. *Halicetus ignotus*  
Kellogg (1969b); late Miocene.
44. *Eschrichtius robustus*  
AMNH 181374, 34260, 1750 (*'Eschrichtius cephalum'*), A; NMB 42001; USNM 364969, 364580, 571931, 364969, 364977, 364970, 364973, 504305; ZML St20350, St13130, 630. Andrews (1914).
45. *Eschrichtioides gastaldii*  
MGPT 13802 (holotype); Bisconti (2008); early Pliocene.
45. *Archaeoschrichtius ruggieroi*  
MAUL 230/1; Bisconti & Varola (2006); late Miocene.
46. *Titanocetus sammarinensis*  
MGB 9073 1CMC172 (1-6) (holotype); Bisconti (2006); middle Miocene.
47. *'Balaenoptera' ryani*  
Hannah & McLellan (1924); late Miocene.
48. *Archaeobalaenoptera castriarquati*  
holotype (inventory of the Soprintendenza per i Beni Archeologici dell'Emilia Romagna item No. 240536; MCA); Bisconti (2007a); late Pliocene.
49. *Protororqualus cuvieri*  
Bisconti (2007b); late Pliocene.
50. *'Balaenoptera' cortesi var. portisi*  
Sacco (1890); Portis (1884); early Pliocene.
51. *Plesiobalaenoptera quarantellii*  
holotype (inventory of the Soprintendenza per i Beni Archeologici dell'Emilia Romagna item No. 240505; MPST); Bisconti (2010); late Miocene.
52. *Parabalaenoptera baulinensis*  
Zeigler *et al.* (1997); late Miocene.
53. *Fragilicetus velponi*  
Bisconti & Bosselaers (2016); early Pliocene.
54. **UT PU13842/5**  
Caretto (1970); early Pliocene.
55. *Miobalaenoptera numataensis*  
Tanaka & Watanabe (2019); late Miocene.
56. **Shimajiri-kujira**  
Kimura *et al.* (2015); late Miocene.
57. **Maesawa-cho**  
Oishi (1984); early Pliocene.
58. *'Megaptera' hubachi*  
Dathe (1983); Bisconti (2011); middle Pliocene.
59. *Megaptera novaeangliae*  
AMNH 24679; MSNT 263; USNM 269982, 486175 (1-2), 13656/16252, 21492; ZMA 14964, 14953 (1-2), 14952 (1-2), 14965, 14966, 14967; Winn & Reichley (1985); Recent.
60. *Diunatans luctoretemergo*  
NHG 22279 holotype; Bosselaers & Post (2010); early Pliocene.
61. *'Balaenoptera' siberi*  
Pilleri (1989); late Miocene.
62. *'Balaenoptera' bertae*  
Boessenecker (2013); early-to-late Pliocene.

- 63. *'Megaptera' miocaena***  
Kellogg (1925); Late Miocene.
- 64. *Balaenoptera omurai***  
Wada et al. (2003); Yamada et al. (2008); Recent.
- 65. *Balaenoptera acutorostrata***  
AMNH 181411, 35680; RBINS 1537; MSNT 260, 261; ZMA 12873; Stewart & Leatherwood (1985), True (1904); Recent.
- 66. *Balaenoptera bonaerensis***  
Omura (1975); Recent.
- 67. *Balaenoptera physalus***  
AMNH 35026, 256796; MSNT 251, 252, 253, 258, 255, 257; ZMA 14950 (1-2), 14927 (1-2), 14935 (1-2), 23353, 14947; Gambell (1985a); Recent.
- 68. *Balaenoptera musculus***  
AMNH 234949, 256797, 256798; MSNT 250; ZMA 23356, 23354, 23355, 14946, 14942, 14961; Yochem & Leatherwood (1985), True (1904); Recent.
- 69. *Balaenoptera edeni***  
USNM 504692, 236680 (1-3); Cummings (1985b); Recent.
- 70. *Balaenoptera brydei***  
NBC Reg. 4003; NBC RGM 17712; Yamada et al. (2008); Recent.
- 71. *Balaenoptera borealis***  
USNM 504699, 504698, 504701, 504244, 486174; Gambell (1985b); Recent.
- 72. *Nehalaennia devossi***  
NMR 14035; this work; late Miocene.
- 73. MPTAM 207.13307**  
Bisconti et al. (in prep. a); early Pliocene.
- 74. NMR 7096**  
Bisconti & Bosselaers (in prep. a); late Pliocene.
- 75. RBINS M. 2231**  
Bisconti & Bosselaers (in prep. b); early Pliocene.
- 76. RBINS M. 2315**  
Bisconti & Bosselaers (in prep. c); early Pliocene.
- 77. MAB002286**  
Bisconti et al. (in prep b); Late Miocene.
- 78. SAM55001**  
Govender et al. (2017); late Miocene.
- 79. *Incakujira anillodefuego***  
Marx & Kohno (2016); late Miocene.
- 80. MHNL 1610**  
Bisconti et al. (in prep. c); late Miocene.
- 81. MHNL 1613**  
Bisconti et al. (in prep. d); early Pliocene.



## Outline of undescribed specimens

### **MPTAM 207-13307**

This specimen represents a new genus and species of Balaenopteridae whose description is now complete. It includes an incomplete skull with periotic still in articulation and part of the postcrania. The estimated age is earliest Piacenzian.

### **NMR 999100007096**

This specimen includes skull, periotic and part of the postcrania. Its morphology suggests a close relationship to 'Balaenoptera' portisi. In the remainder of the paper and in the illustrations it is called NMR 7096. The estimated age is early Piacenzian.

### **RBINS M. 2231**

This specimen includes skull, periotics, dentaries and part of the postcrania. It is closely related to '*Balaenoptera*' siboldina of which it represents the first reasonably complete skeleton. The specimen is briefly presented in Bisconti & Bosselaers (2014) and a full description is currently in progress. The specimen is currently held by RBINS. The estimated age is Early Pliocene.

### **RBINS M. 2315**

The specimen includes partial skull and postcrania of a Pliocene individual very close to *Protororqualus cuvieri*. The description of this specimen is currently in progress.

### **MHNL 1613**

The specimen includes a large skull with periotics still in articulation. It represents a new balaenopterid genus characterized by wide exposure of parietal at the cranial vertex. A description is currently close to be finished. The estimated age is Late Miocene.

### **MHNL 1610**

The specimen includes a partially prepared skull with fragments of dentary. Its morphology suggests close relationships with *Archaeobalaenoptera castriarquati* of which it could be an additional species. A description is currently in progress. The estimated age is Late Miocene.

## Character list

The following character list is developed from the morphological dataset of Bisconti & Bosselaers (2016). In the present dataset, character states were redefined and re-formulated in order to warrant clear understanding. In defining character states, we made use of personal observations on specimens listed above and of literature. In particular, we need to cite the following papers that we used for character definitions and codings: Boessenecker & Fordyce (2015); Fordyce & Marx (2012); Steeman (2009); Geisler & Sanders (2003); Kimura & Ozawa (2001); Kellogg (1923); Miller (1925).

### **ROSTRUM: PREMAXILLA, MAXILLA, NASAL**

- 1) Rostrum length:**
  - (0) Rostrum length shorter or equal to neurocranium length;
  - (1) Rostrum length longer than neurocranium length.
- 2) Rostrum width:**
  - (0) Rostrum narrow;
  - (1) Rostrum wide.
- 3) Rostrum straight:**
  - (0) Yes;
  - (1) No, rostrum highly arched.
- 4) Rostrum arc:**
  - (0) Continuous;
  - (1) Discontinuous.
- 5) Mesorostral groove:**
  - (0) Absent;
  - (1) Present.
- 6) Ventral keel along rostrum:**
  - (0) Absent;
  - (1) Present.
- 7) Premaxilla widens at anterior end:**
  - (0) No;
  - (1) Yes.
- 8) Premaxillary foramen:**
  - (0) Present;
  - (1) Absent.
- 9) Posterior end of premaxilla:**
  - (0) More anterior than frontonasal suture;
  - (1) At posterior end of nasal;
  - (2) Anterior to nasal.
- 10) Sutural contact between rostrum and frontal limited to ascending process of the maxilla:**
  - (0) No;
  - (1) Yes.
- 11) Premaxilla and frontal articulation:**
  - (0) Sutured;
  - (1) Not sutured.
- 12) External surface of maxilla:**
  - (0) Sub-vertical;
  - (1) Sub-horizontal.

- 13) Medial border of maxilla anterior to narial fossa:**
- (0) Straight;
  - (1) Sinuous.
- 14) Lateral border of maxilla:**
- (0) Uniformly concave;
  - (1) Straight;
  - (2) Uniformly convex;
  - (3) Sinuous
- 15) Thickness of lateral border of maxilla:**
- (0) Thin;
  - (1) Thick.
- 16) Lateral process of maxilla:**
- (0) Absent;
  - (1) Present.
- 17) Length of lateral process of maxilla:**
- (0) Short;
  - (1) Long.
  - (2) Very long.
- 18) Position of external apex of lateral process of maxilla:**
- (0) Anterior to antorbital corner of orbit;
  - (1) Anterior and medial to orbit.
- 19) Infraorbital process of maxilla:**
- (0) Absent;
  - (1) Present.
- 20) Ascending process of maxilla:**
- (0) Absent;
  - (1) Present.
- 21) Width of ascending process of maxilla relative to its length:**
- (0) Narrow;
  - (1) Wide.
- 22) Length of ascending process of maxilla:**
- (0) Short;
  - (1) Long;
- 23) Lateral border of ascending process of maxilla:**
- (0) Forms an evident corner with posterior border of maxilla;
  - (1) Forms a wide curve with posterior border of maxilla.
- 24) Position of posterior ends of ascending processes of maxillae:**
- (0) Posterior ends do not meet along midline;
  - (1) Posterior ends meet along midline.
- 25) Meeting of ascending processes of the maxillae along the longitudinal axis of the skull:**
- (0) Contact limited to posterior corners;
  - (1) Contact extended to most of medial borders of the ascending processes of the maxillae.
- 26) Shape of posterior end of ascending process of maxilla at adulthood:**
- (0) Triangular;
  - (1) Squared;
  - (2) Rounded.
- 27) Shape of posterior end of ascending process of maxilla during late ontogeny:**
- (0) Triangular;
  - (1) Squared;
  - (2) Rounded.

- 28) Lateral and medial borders of ascending process of maxilla:**
- (0) Anteriorly diverging;
  - (1) Parallel;
  - (2) Anteriorly converging.
- 29) Position of posterior end of maxilla:**
- (0) Anterior to nasal;
  - (1) At level of posterior end of nasal;
  - (2) Posterior to nasal.
- 30) Position of posterior ends of maxillae:**
- (0) Transversely far;
  - (1) Transversely close;
  - (2) Transversely very close.
- 31) Numerous dorsal infraorbital foramina:**
- (0) Absent (only one foramen is present);
  - (1) Present.
- 32) Location of dorsal infraorbital foramina:**
- (0) Scattered along dorsal surface of maxilla;
  - (1) Mostly located close to the medial border of maxilla.
- 33) Medial border of maxilla:**
- (0) not relieved;
  - (1) relieved and forming a crest.
- 34) Antorbital notch:**
- (0) Absent;
  - (1) Present.
- 35) Shape of antorbital notch:**
- (0) Concavity in anterior edge of lateral process of maxilla without medial-projecting groove;
  - (1) Developed along medial-projecting groove.
- 36) Articulation between maxilla and frontal:**
- (0) Tight;
  - (1) Loose.
- 37) Maxillary pocket:**
- (0) Absent;
  - (1) Present.
- 38) Infraorbital plate visible in dorsal view:**
- (0) No;
  - (1) Yes.
- 39) Teeth at adulthood in maxilla and premaxilla:**
- (0) Present;
  - (1) Absent.
- 40) Grooves for vasculature of baleen epithelium:**
- (0) Absent;
  - (1) Present.
- 41) Fissure located along posterior border of maxilla in ventral view:**
- (0) Absent;
  - (1) Present.
- 42) Elongation of fissure:**
- (0) Fissure short;
  - (1) Fissure long.

- 43) Nasal length:**
- (0) Nasal reaching the anterior 20% of rostrum;
  - (1) Nasal reaching approximately rostrum midlength;
  - (2) Nasal reaching the posterior 20% of rostrum;
  - (3) Nasal reaching a point close to the anterior border of the supraorbital process of frontal.
  - (4) Nasal reaching a point located within the interorbital region of the frontal.
- 44) Anterior border of nasal:**
- (0) Concave;
  - (1) Straight;
  - (2) Convex.
- 45) Median keel in nasal:**
- (0) Absent;
  - (1) Present.
- 46) Position of anterolateral corner of nasal:**
- (0) Anterior to anteromedial corner;
  - (1) Lateral to anteromedial corner;
  - (2) Posterior to anteromedial corner.
- 47) Position of frontonasal suture:**
- (0) At anterior border of interorbital region of frontal;
  - (1) Well within interorbital region of frontal.
- 48) Nasal borders:**
- (0) With a concavity at midlength
  - (1) Converging anteriorly;
  - (2) Parallel-to-subparallel;
  - (3) Diverging anteriorly.
- 49) Nasal width:**
- (0) Nasal transversely wide;
  - (1) Nasal with strong transverse compression along its entire length.

## **FRONTAL**

- 50) Shape of supraorbital process of frontal:**
- (0) Flat and forming a dorsal shield;
  - (1) descending from interorbital region of frontal;
- 51) Diversity of depressions:**
- (0) No depression;
  - (1) Gentle depression from interorbital region of frontal;
  - (2) Abrupt depression from interorbital region of frontal;
- 52) Cross-sections of depressions:**
- (0) No depression;
  - (1) Triangular;
  - (2) Laterally concave;
  - (3) Squared;
  - (4) Half-circle.
- 53) Anteroposterior length of supraorbital process of frontal;**
- (0) Short;
  - (1) Long;
  - (2) Very long.
- 54) Transverse diameter of supraorbital process of frontal:**
- (0) Short;
  - (1) Long;
  - (2) Very long.

- 55) Anterior border of supraorbital process of frontal:**
- (0) Directed posteriorly;
  - (1) Directed transversely;
  - (2) Directed anteriorly.
- 56) Anterior border of supraorbital process of frontal:**
- (0) Straight;
  - (1) Convex;
  - (2) Concave.
- 57) Backing of central and distal portions of the anterior border of the supraorbital process of frontal from its anteromedial corner:**
- (0) Absent;
  - (1) Present.
- 58) Posterior border of supraorbital process of frontal:**
- (0) Uniformly concave;
  - (1) Medial concavity;
  - (2) Straight.
- 59) Posterior border of supraorbital process of frontal:**
- (0) Directed posteriorly;
  - (1) Directed transversely;
  - (2) Directed anteriorly.
- 60) Supraorbital foramina:**
- (0) Present;
  - (1) Absent.
- 61) Orbitotemporal crest:**
- (0) Along posterodorsal edge of supraorbital process of frontal;
  - (1) From postorbital corner to anteromedial end of supraorbital process of frontal;
  - (2) Forming a curve from postorbital corner onto dorsal surface of supraorbital process of frontal;
  - (3) Forming a curve along anterior edge of supraorbital process of frontal.
- 62) Orbitotemporal crest:**
- (0) Well developed and sharp;
  - (1) Well developed and rounded;
  - (2) Highly reduced to a line.
- 63) Superimposition of parietal on interorbital region of frontal:**
- (0) Absent;
  - (1) Present.
- 64) Long superimposition of posteromedial elements of rostrum on interorbital region of frontal:**
- (0) Absent;
  - (1) Present.
- 65) Posterior border of interorbital region of frontal:**
- (0) In contact with parietal;
  - (1) In contact with supraoccipital.
- 66) Shape of coronal (frontal-parietal) suture:**
- (0) Straight;
  - (1) Anteriorly convex;
  - (2) Anteriorly concave.
- 67) Coronal suture in dorsal view:**
- (0) Visible;
  - (1) Not visible because superimposed by the supraoccipital.

- 68) Frontal encircles ascending process of maxilla:**  
 (0) No;  
 (1) Yes.
- 69) Postorbital process and zygomatic process of squamosal:**  
 (0) Far;  
 (1) Close;  
 (2) Superimposed and articulated by dedicate facet.
- 70) Location of optic canal in ventral surface of supraorbital process of frontal:**  
 (0) Along anterior three-fourth;  
 (1) Along posterior one-fourth.
- 71) Length of intertemporal constriction:**  
 (0) Very long;  
 (1) Long;  
 (2) Short;  
 (3) Very short.
- 72) Transverse diameter of intertemporal constriction:**  
 (0) Wide;  
 (1) Moderately constricted;  
 (2) Highly constricted.
- 73) Presence of narial process:**  
 (0) Present;  
 (1) Absent.
- 74) Length of narial process relative to nasal length:**  
 (0) Short;  
 (1) Long.
- 75) Shape of narial process:**  
 (0) The narial processes form a triangle in dorsal view;  
 (1) The narial processes form a bilobated protrusion in dorsal view.

## **PARIETAL**

- 76) Location of frontal border of parietal:**  
 (0) Posterior to posterior apex of ascending process of maxilla;  
 (1) Anterior to posterior apex of ascending process of maxilla.
- 77) Anterolateral corner of parietal (for Balaenidae only):**  
 (0) Sharp;  
 (1) Broad.
- 78) Anterior portion of external surface:**  
 (0) Visible in dorsal view;  
 (1) Not visible in dorsal view because overhanged by temporal crest.
- 79) Posterior portion of external surface:**  
 (0) Visible in dorsal view;  
 (1) Not visible in dorsal view because overhanged by temporal crest.
- 80) Post-parietal foramen:**  
 (0) Present;  
 (1) Absent.
- 81) Parietal spreading onto emergence of supraorbital process of frontal:**  
 (0) Absent;  
 (1) Present.
- 82) Parietal exposed at cranial vertex:**  
 (0) Yes;  
 (1) No.

- 83) Length of parietal exposure at vertex:**  
 (0) Long;  
 (1) Moderate;  
 (2) Short;  
 (3) Very short.
- 84) Sagittal crest at cranial vertex:**  
 (0) Present;  
 (1) Absent.
- 85) Attach for temporalis muscle at intertemporal constriction:**  
 (0) Very narrow;  
 (1) Slightly widened;  
 (2) Moderately widened;  
 (3) Wide.
- 86) Shape of sagittal crest:**  
 (0) Sharply-edged;  
 (1) Forming two opposite concavities.
- 87) Tubercle at lambdoid suture:**  
 (0) Absent;  
 (1) Present.
- 88) Parietal-squamosal suture:**  
 (0) Sinuous;  
 (1) Straight.

#### **SQUAMOSAL**

- 89) Dorsoventral height of squamosal:**  
 (0) Low dorsoventral height;  
 (1) High dorsoventral height.
- 90) Anteroposterior length of zygomatic process of squamosal:**  
 (0) Very long;  
 (1) Long;  
 (2) Short.  
 (3) Very short.
- 91) Height of zygomatic process of squamosal:**  
 (0) Zygomatic process higher than postglenoid process;  
 (1) Zygomatic process at the same level of postglenoid process;  
 (2) Zygomatic process much higher than postglenoid process.
- 92) Projection of anterior portion of zygomatic process of squamosal in dorsal view:**  
 (0) Projecting anteromedially;  
 (1) Projecting anterolaterally;  
 (2) Projecting anteriorly.
- 93) Projection of posterior portion of zygomatic process of squamosal in dorsal view:**  
 (0) Projecting anteromedially;  
 (1) Projecting anterolaterally  
 (2) Projecting anteriorly.
- 94) Zygomatic process of squamosal in dorsal view:**  
 (0) Anteriorly straight;  
 (1) Anteriorly twisted.
- 95) Distinctive articular facet for postorbital process of frontal on zygomatic process of squamosal:**  
 (0) Absent;  
 (1) Present.



- 96) Projection of apex of zygomatic process in lateral view:**  
 (0) Anterior;  
 (1) Ventral.
- 97) Postglenoid process of squamosal:**  
 (0) Projecting ventrally;  
 (1) Projecting posteroventrally.
- 98) Twisted postglenoid process of squamosal:**  
 (0) No;  
 (1) Yes.
- 99) Lateral surface of squamosal:**  
 (0) Smooth;  
 (1) With single fossa for sternomastoid muscle;  
 (2) With double fossa for sternomastoid muscle.
- 100) Anteroposterior concavity along dorsolateral edge of glenoid fossa of squamosal:**  
 (0) Absent;  
 (1) Present.
- 101) Glenoid fossa of squamosal:**  
 (0) Forming a right angle in lateral view;  
 (1) Slightly concave;  
 (2) Highly concave (half-moon shaped);  
 (3) Straight.
- 102) Location of glenoid fossa of squamosal:**  
 (0) posterior to orbit;  
 (1) immediately posteroventral to orbit.
- 103) Height of squamosal at nuchal crest:**  
 (0) Low;  
 (1) High.
- 104) Supramastoid crest:**  
 (0) Present;  
 (1) Absent.
- 105) Orientation of supramastoid crest:**  
 (0) Dorsal;  
 (1) Anterior.
- 106) Nuchal crest in dorsal view:**  
 (0) Wide;  
 (1) Narrow;  
 (2) Very narrow.
- 107) Nuchal crest in dorsal view:**  
 (0) Circular;  
 (1) Triangular.
- 108) Nuchal crest in dorsal view:**  
 (0) Reaching a point anterior to occipital condyle;  
 (1) Reaching a point posterior to occipital condyle;  
 (2) Reaching a point at the same level as occipital condyle.
- 109) Squamosal bulging into temporal fossa:**  
 (0) No;  
 (1) Yes.
- 110) Extension of temporal fossa:**  
 (0) Very wide;  
 (1) Wide;  
 (2) Reduced.

- 111) Extension of temporal fossa:**  
 (0) Longer than wide;  
 (1) Wider than long.
- 112) Shape of temporal fossa in dorsal view:**  
 (0) Oval;  
 (1) Almond-shaped;  
 (2) Triangular.
- 113) Surface of temporal fossa anterior to nuchal crest:**  
 (0) More horizontal than ventral-most portion;  
 (1) Developed dorsoventrally.
- 114) Squamosal cleft:**  
 (0) Absent;  
 (1) Present.
- 115) Shape of squamosal cleft:**  
 (0) Straight;  
 (1) Triangular.
- 116) Length of squamosal cleft:**  
 (0) Short;  
 (1) Long;  
 (2) Very long.
- 117) Origin of squamosal cleft at adulthood:**  
 (0) From parietal-squamosal suture;  
 (1) From parietal-squamosal-alisphenoid suture;  
 (2) From squamosal-alisphenoid suture;  
 (3) From squamosal-ptyergoid suture.
- 118) Origin of squamosal cleft during late ontogeny:**  
 (0) From parietal-squamosal suture;  
 (1) From parietal-squamosal-alisphenoid suture;  
 (2) From squamosal-alisphenoid suture;  
 (3) From squamosal-ptyergoid suture.
- 119) Infundibulum of Foramen ovale:**  
 (0) Absent;  
 (1) Present.
- 120) Foramen ovale:**  
 (0) Infundibulum complete;  
 (1) Infundibulum incomplete.
- 121) Foramen ovale:**  
 (0) Located within squamosal;  
 (1) Located between squamosal and pterygoid.  
 (2) Located within pterygoid.
- 122) Suture present in foramen ovale:**  
 (0) No;  
 (1) Yes.
- 123) Squamosal crease:**  
 (0) Absent;  
 (1) Present.
- 124) Secondary squamosal crest:**  
 (0) Absent;  
 (1) Present.

**125) Secondary squamosal fossa:**

- (0) Absent;
- (1) Present.

**126) Basicranial foramina:**

- (0) Separate foramina in posterolateral portion of skull;
- (1) Foramina confluent into a single and large posterior lacerate foramen.

**SUPRAOCCIPITAL**

**127) Supraoccipital in dorsal view:**

- (0) Not visible because main development is dorsoventral;
- (1) Visible because it superimposes on parietal.

**128) Anteroposterior supraoccipital elongation:**

- (0) No anteroposterior elongation;
- (1) Short: supraoccipital superimposed on posterior portion of parietal;
- (2) Long: supraoccipital superimposed on most of parietal;
- (3) Very long: supraoccipital superimposed on whole parietal and part of interorbital region of frontal.

**129) Anteroposterior supraoccipital elongation with respect to zygomatic process of squamosal:**

- (0) Anterior border of supraoccipital reaching a point located more posteriorly than the anterior apex of the zygomatic process of squamosal;
- (1) Anterior border of supraoccipital reaching a point located more anteriorly than the anterior apex of the zygomatic process of squamosal.

**130) Shape of anterior border of supraoccipital:**

- (0) Round;
- (1) Triangular;
- (2) Squared;
- (3) Ogival.

**131) Distinctive articular facets for ascending process of the maxilla in anterior border of supraoccipital:**

- (0) Absent;
- (1) Present.

**132) Size of anterior border of supraoccipital:**

- (0) Wide;
- (1) Pointed;
- (2) Narrow.

**133) Elevation of anterior border of supraoccipital in lateral view:**

- (0) High elevation formed by dorsal protrusion of parietals lateral and in front of the anterior border of supraoccipital;
- (1) Low elevation without contribution by the parietal;
- (2) No elevation at all.

**134) Distinctive depression in front to supraoccipital in lateral view:**

- (0) Present;
- (1) Absent.

**135) Dorsal surface of supraoccipital:**

- (0) Concave;
- (1) Flat-to convex.

**136) Attach sites for neck muscle attachments:**

- (0) Not evident;
- (1) Well developed.

**137) Attach sites for neck muscle attachments:**

- (0) Shaped as triangular relieves with flat surface;
- (1) Shaped as tubercles.

**138) External occipital crest:**

- (0) Absent;
- (1) Present.

**139) Lateral borders of supraoccipital in dorsal view:**

- (0) Not visible;
- (1) Uniformly convex;
- (2) uniformly straight;
- (3) uniformly concave;
- (4) sinuous because of the presence of a transverse constriction.

**140) Position of transverse constriction of supraoccipital:**

- (0) In anterior-most portion;
- (1) At mid-length;
- (2) In posterior half.

**141) Degree of transverse constriction:**

- (0) Scarce;
- (1) Moderate;
- (2) Strong.

**142) Lateral borders of supraoccipital anterior to the transverse constriction:**

- (0) Concave;
- (1) Straight-to-convex.

**143) Length of external occipital protuberance:**

- (0) Long;
- (1) Moderate;
- (2) Short.

**144) Anterolateral corner of supraoccipital:**

- (0) Not distinguishable;
- (1) Collapsed into a single anterior point;
- (2) Rounded;
- (3) Squared.

**145) Supraoccipital bent at midlength:**

- (0) No;
- (1) Yes.

**INTERPARIETAL**

**146) Interparietal:**

- (0) Absent;
- (1) Present.

**147) Shape of interparietal:**

- (0) Short;
- (1) Long.

**148) Shape of interparietal:**

- (0) Wide;
- (1) Narrow.

**JUGAL**

**149) Jugal elongation:**

- (0) Jugal elongated and mostly straight;
- (1) Jugal short and rounded.

## **LACRIMAL**

### **150) Lacrimal exposed in dorsal view:**

- (0) No;
- (1) Yes.

### **151) Sutured lacrimal:**

- (0) Yes;
- (1) No.

## **EXOCCIPITAL**

### **152) Exoccipital in posterior view:**

- (0) Anterolateral border forming a right angle with lateral edge of supraoccipital;
- (1) Anterolateral border continuous with lateral edge of supraoccipital.

### **153) Exoccipital development in posterior view:**

- (0) Exoccipital transversely elongated;
- (1) Transverse elongation of exoccipital reduced.

### **154) Protrusion of posterolateral corner of exoccipital:**

- (0) At level of postglenoid process;
- (1) Medial to postglenoid process.

### **155) Protrusion of posterolateral corner of exoccipital:**

- (0) Reaching a point more anterior than occipital condyles;
- (1) Reaching a point more posterior than occipital condyles.

### **156) Protrusion of posterolateral corner of exoccipital:**

- (0) More posterior than postglenoid process of squamosal.
- (1) More anterior than postglenoid process of squamosal;

### **157) Occipital condyle:**

- (0) Convex articular face;
- (1) Flat-to-slightly convex articular face.

### **158) Neck of occipital condyle:**

- (0) Well developed;
- (1) Indistinct.

### **159) Condylloid foramen:**

- (0) Present;
- (1) Absent.

### **160) Foramen in jugular notch:**

- (0) Present;
- (1) Absent.

## **BASIOCCIPITAL**

### **161) Basioccipital crest:**

- (0) Absent;
- (1) Present.

### **162) Fusion of medial crest of basioccipital crest and falcate process of basioccipital:**

- (0) Absent;
- (1) Present.

## **ALISPHENOID**

### **163) Alisphenoid exposure in temporal fossa:**

- (0) Present;
- (1) Absent.

**164) Size of alisphenoid exposure in temporal fossa:**

- (0) Large;
- (1) Small;
- (2) Very small.

**165) Alisphenoid borders:**

- (0) Between frontal, parietal, squamosal and pterygoid;
- (1) Between parietal, squamosal and pterygoid;
- (2) Between parietal and squamosal;
- (3) Between parietal and pterygoid.

**PALATINE**

**166) Palatine reaching a point located close to posterior border of skull:**

- (0) No;
- (1) Yes.

**PTERYGOID**

**167) Pterygoid fossa:**

- (0) Absent;
- (1) Present.

**168) Pterygoid hamulus:**

- (0) Short;
- (1) Well developed.

**169) Ventral lamina of pterygoid:**

- (0) Absent;
- (1) Present.

**170) Pterygoid exposure in temporal fossa:**

- (0) Absent;
- (1) Present.

**PERIOTIC**

**171) Posterior process exposure in lateral wall of skull:**

- (0) Absent;
- (1) Present.

**172) Posterior process length:**

- (0) Short;
- (1) Moderate;
- (2) Long.

**173) Posterior process size and shape:**

- (0) Prismatic and robust;
- (1) Transversely compressed and flattened.

**174) Facial sulcus along posterior process:**

- (0) Absent;
- (1) Present.

**175) Facial sulcus along posterior process:**

- (0) Short;
- (1) Long.

**176) Position of facial sulcus on posterior process:**

- (0) Along medial border and hidden in ventral view;
- (1) Ventromedial;
- (2) Completely ventral.

- 177) Borders of facial sulcus:**  
 (0) Sulcus bordered by crests;  
 (1) Sulcus widened and bordered by narrow relieves.
- 178) Facial sulcus completely included in a tube-like structure:**  
 (0) No;  
 (1) Yes.
- 179) Shape of posterior border of posterior process:**  
 (0) Clavate;  
 (1) Squared;  
 (2) Pointed.
- 180) Stylomastoid fossa:**  
 (0) Not distinguishable;  
 (1) Elongated and shallow;  
 (2) Elongated and covered by a relieved dorsal edge in the posterior process;  
 (3) Short and included within posterior process as a notch.
- 181) Anterior process:**  
 (0) Absent;  
 (1) Present.
- 182) Anterior process length:**  
 (0) Short;  
 (1) Long.
- 183) Anterior process thickness:**  
 (0) Thick;  
 (1) Thin;  
 (2) Blade-like.
- 184) Origin of anterior process:**  
 (0) Abruptly depressed from dorsal surface of periotic;  
 (1) Anterior process continuous with dorsal surface of periotic.
- 185) Anterior process in dorsal (or ventral) view:**  
 (0) Squared;  
 (1) Irregular shape;  
 (2) Triangular;  
 (3) Elliptical.
- 186) If triangular, medial edge of anterior process:**  
 (0) Convex or straight;  
 (1) Concave.
- 187) If triangular, lateral edge of anterior process:**  
 (0) Convex or straight;  
 (1) Concave.
- 188) If triangular, apex of anterior process:**  
 (0) Round;  
 (1) Pointed.
- 189) Lateral tuberosity:**  
 (0) Absent;  
 (1) Present.
- 190) Size of lateral tuberosity:**  
 (0) Small;  
 (1) Large.
- 191) Shape of lateral tuberosity:**  
 (0) Protruding and squared or rounded;  
 (1) Protruding and triangular.

- 192) Lateral process of anterior process:**  
 (0) Absent;  
 (1) Present.
- 193) Length of lateral process of anterior process:**  
 (0) Long;  
 (1) Short.
- 194) Shape of lateral process of anterior process:**  
 (0) Broadly triangular;  
 (1) Sharply triangular.
- 195) Medial emergence of anterior process:**  
 (0) Absent;  
 (1) Present.
- 196) Tensor tympani groove:**  
 (0) Present;  
 (1) Absent.
- 197) Dorsal surface of periotic:**  
 (0) Highly relieved;  
 (1) Low.
- 198) Highly relieved dorsal surface of periotic:**  
 (0) Squared;  
 (1) Dome-shaped.
- 199) Dorsal surface of periotic and anterior process forming a straight line in medial view:**  
 (0) No;  
 (1) Yes.
- 200) Suprameatal area:**  
 (0) Concave;  
 (1) Gently descending;  
 (2) Convex and protruding.
- 201) Superior process:**  
 (0) Present;  
 (1) Absent.
- 202) Size of superior process:**  
 (0) Convex dorsal profile in medial view;  
 (1) Reduced to a low ridge;  
 (2) Absent.
- 203) During late ontogeny, internal acoustic meatus including:**  
 (0) Tractus spiralis foraminosus, foramen singulare and endocranial opening of facial canal;  
 (1) Tractus spiralis foraminosus and foramen singulare.
- 204) At adulthood, internal acoustic meatus including:**  
 (0) Tractus spiralis foraminosus, foramen singulare and endocranial opening of facial canal;  
 (1) Tractus spiralis foraminosus and foramen singulare.
- 205) Crista transversa during ontogeny:**  
 (0) Septum-like;  
 (1) Thick.
- 206) Crista transversa during adulthood:**  
 (0) Septum-like;  
 (1) Thick.
- 207) Position of crista transversa at adulthood:**  
 (0) Does not reach medial rim of internal acoustic meatus;  
 (1) Reaches medial rim of internal acoustic meatus.



- 208) Fissure in endocranial opening of facial canal during ontogeny:**  
 (0) Absent;  
 (1) Present.
- 209) Fissure in endocranial opening of facial canal at adulthood:**  
 (0) Absent;  
 (1) Present.
- 210) Vascular groove:**  
 (0) Evident;  
 (1) Reduced;  
 (2) Absent.
- 211) Transverse elongation of pars cochlearis:**  
 (0) Short;  
 (1) Elongated.
- 212) Anteroposterior elongation of pars cochlearis:**  
 (0) Short;  
 (1) Elongated.
- 213) Inflation of pars cochlearis:**  
 (0) Absent;  
 (1) Present.
- 214) Anterior crest along pars cochlearis:**  
 (0) Absent;  
 (1) Present.
- 215) Cochlear window (round window) and aperture for cochlear aqueduct (endolymphatic foramen) confluent during late ontogeny:**  
 (0) No;  
 (1) Yes.
- 216) Cochlear window (round window) and aperture for cochlear aqueduct (endolymphatic foramen) confluent at adulthood:**  
 (0) No;  
 (1) Yes.
- 217) Cochlear window (round window) and aperture for cochlear aqueduct (endolymphatic foramen) opening in a tube-like channel:**  
 (0) No;  
 (1) Yes.
- 218) Promontorial groove:**  
 (0) Absent;  
 (1) Present.
- 219) Size of promontorial groove:**  
 (0) Small;  
 (1) Large.
- 220) Endocranial opening of facial canal connected to internal acoustic meatus by a groove:**  
 (0) No;  
 (1) Yes.
- 221) Pyramidal process:**  
 (0) Present;  
 (1) Absent.

#### **TYMPANIC BULLA**

- 222) Shape of posterior border:**  
 (0) Bilobated;  
 (1) Transversely straight;

- (2) Convex;
- (3) Keeled.
- 223) Elongation of portion posterior to conical process:**
  - (0) Present;
  - (1) Absent.
- 224) Posterior border fissurated:**
  - (0) Yes;
  - (1) No.
- 225) Elliptical foramen:**
  - (0) present;
  - (1) absent.
- 226) Ventral keel:**
  - (0) Absent;
  - (1) Present.
- 227) Ventral concavity:**
  - (0) Present;
  - (1) Absent.
- 228) involucral protrusion in dorsal view:**
  - (0) Absent;
  - (1) Present.
- 229) Dorsal border of involucrum in medial view:**
  - (0) Gently descending;
  - (1) Not descending.
- 230) Position of Eustachian opening relative to overall height of tympanic bulla:**
  - (0) Low;
  - (1) High.
- 231) Eustachian opening bordered anteriorly:**
  - (0) no;
  - (1) yes.
- 232) Flat posterior dorsomedial face:**
  - (0) No;
  - (1) Yes.
- 233) Anterolateral expansion:**
  - (0) Absent;
  - (1) Present.
- 234) Extension of anterolateral expansion:**
  - (0) Short;
  - (1) Long.
- 235) Shape of anterolateral expansion in dorsal view:**
  - (0) Round;
  - (1) Pointed.
- 236) Tympanic cavity:**
  - (0) High;
  - (1) Low.
- 237) Height of tympanic bulla:**
  - (0) High;
  - (1) Low.
- 238) Anterior border:**
  - (0) Anteriorly convex;
  - (1) Anteriorly straight-to-concave.

- 239) Sigmoid process:**  
 (0) Anteroposteriorly elongated;  
 (1) Transversely elongated.
- 240) Conical process:**  
 (0) High;  
 (1) Very reduced.
- 241) Proportional size of tympanoperiotic complex with respect of head size:**  
 (0) Large;  
 (1) Small.
- 242) Outer lip and dorsal border of involucrum:**  
 (0) Descending parallel toward anterior end;  
 (1) Posteriorly diverging as the outer lip is more inclined than involucrum.

## **DENTARY**

- 243) Cranio-mandibular joint:**  
 (0) Tight;  
 (1) Loose.
- 244) Teeth on dentary at adulthood:**  
 (0) Present;  
 (1) Absent.
- 245) Mental symphysis:**  
 (0) Present;  
 (1) Absent.
- 246) Groove for mental ligament:**  
 (0) Absent;  
 (1) Present.
- 247) Anterior torsion:**  
 (0) Absent;  
 (1) Present.
- 248) Massive elongation of dentary ramus:**  
 (0) Absent;  
 (1) Present.
- 249) Coronoid process height:**  
 (0) High;  
 (1) Moderately high;  
 (2) Low;  
 (3) Very low-to-absent.
- 250) Postcoronoid crest:**  
 (0) Absent;  
 (1) Present.
- 251) Postcoronoid fossa:**  
 (0) Absent;  
 (1) Present.
- 252) Size of postcoronoid fossa:**  
 (0) Wide;  
 (1) Small.
- 253) Satellite process:**  
 (0) Absent;  
 (1) Present.

- 254) Size of satellite process:**  
 (0) Large;  
 (1) Small.
- 255) Orientation of articular surface of mandibular condyle:**  
 (0) Posterodorsal;  
 (1) Dorsal;  
 (2) Posterior.
- 256) Posterodorsal corner of dentary:**  
 (0) Round;  
 (1) Sharp.
- 257) Angular process:**  
 (0) High;  
 (1) Moderately high;  
 (2) low;  
 (3) Very low.
- 258) Angular process in lateral view:**  
 (0) Located more anteriorly than articular surface of condyle;  
 (1) Rounded and not protruded.  
 (2) Projecting ventrally;  
 (3) Projecting posteriorly.  
 (4) Squared and not protruding.
- 259) Mandibular foramen:**  
 (0) Wide;  
 (1) Small.
- 260) Shape of mandibular foramen:**  
 (0) Posteriorly concave;  
 (1) Triangular;  
 (2) Fissurated.
- 261) Gingival foramina:**  
 (0) Absent;  
 (1) Present.
- 262) Mental foramina:**  
 (0) Only one per dentary;  
 (1) Several mental foramina present per dentary.
- 263) Dentary curvature in dorsal view:**  
 (0) Dentary with lateral concavity in dorsal view;  
 (1) Dentary straight;  
 (2) Dentary moderately bowed;  
 (3) Dentary strongly bowed.
- 264) External curvature in dorsal view:**  
 (0) Absent;  
 (1) Continuous;  
 (2) Discontinuous.
- 265) Presence of dorsoventral curvature in dentary in lateral view:**  
 (0) Absent;  
 (1) Present.
- 266) Types of dorsoventral curvature in dentary in lateral view:**  
 (0) Absent;  
 (1) Continuous;  
 (2) Discontinuous.

**267) Mylohyoidal groove:**

- (0) Absent;
- (1) Present.

**268) Crest along the ventral border of the dentary with a parallel groove:**

- (0) Absent;
- (1) Present.

**269) Medial face of dentary ramus:**

- (0) Flat;
- (1) Convex.
- (2) Concave.

**VERTEBRAE**

**270) Cervical vertebrae:**

- (0) Free;
- (1) Fused.

**271) Cervical vertebrae:**

- (0) Elongated;
- (1) Shortened.

**272) Neural processes of cervical vertebrae:**

- (0) Free;
- (1) Fused.

**273) Dorsal process of C3:**

- (0) Present;
- (1) Absent.

**274) Dorsal process of C4:**

- (0) Present;
- (1) Absent.

**275) Dorsal process of C5:**

- (0) Present;
- (1) Absent.

**276) Dorsal process of C6:**

- (0) Present;
- (1) Absent.

**277) Dorsal process of C7:**

- (0) Present;
- (1) Absent.

**278) Ventral process of C3:**

- (0) Present;
- (1) Absent.

**279) Ventral process of C4:**

- (0) Present;
- (1) Absent.

**280) Ventral process of C5:**

- (0) Present;
- (1) Absent.

**281) Ventral process of C6:**

- (0) Present;
- (1) Absent.

**282) Ventral process of C7:**

- (0) Present;
- (1) Absent;

- (2) Reduced to a tubercle.
- 283) Foramen transversarium in C3:**
  - (0) Complete;
  - (1) Incomplete.
- 284) Foramen transversarium in C4:**
  - (0) Complete;
  - (1) Incomplete.
- 285) Foramen transversarium in C5:**
  - (0) Complete;
  - (1) Incomplete.
- 286) Foramen transversarium in C6:**
  - (0) Complete;
  - (1) Incomplete.
- 287) Foramen transversarium in C7:**
  - (0) Complete;
  - (1) Incomplete.
- 288) Foramen transversarium**
  - (0) Complete in C2;
  - (1) Incomplete in C2.
- 289) Fusion of sacral vertebrae:**
  - (0) Present at least in part;
  - (1) Absent.
- 290) Number of sacral vertebrae:**
  - (0) >1;
  - (1) 1.
- 291) Sharp lateroventral projection of transverse process:**
  - (0) Present;
  - (1) Absent.
- 292) Foramen at emergence of transverse process:**
  - (0) In caudal vertebrae;
  - (1) In last lumbar and caudal vertebrae.

## **SCAPULA**

- 293) General proportions of scapula:**
  - (0) High and narrow;
  - (1) Low and wide.
- 294) Orientation of scapular spine:**
  - (0) Divergent from margo cranialis and directed dorsally;
  - (1) Parallel to margo cranialis and directed anterodorsally.
- 295) Development of teres fossa:**
  - (0) Small;
  - (1) Enlarged.
- 296) Margo cranialis:**
  - (0) Straight;
  - (1) Convex;
  - (2) Concave.
- 297) Inclination of margo cranialis with respect to horizontal axis:**
  - (0) High;
  - (1) Scarce.

**298) Margo caudalis:**

- (0) Straight-to-scarcely concave;
- (1) Highly concave.

**299) Development of supraspinous fossa:**

- (0) Wide;
- (1) Reduced;
- (2) Invisible in lateral view.

**300) Scapular spine:**

- (0) Well developed;
- (1) Reduced.

**HUMERUS**

**301) Orientation of caput humeri:**

- (0) Along longitudinal axis of humerus;
- (1) Located posteriorly to longitudinal axis.

**302) Size of tuberculum majus:**

- (0) Small;
- (1) Large.

**303) Direction of tuberculum majus:**

- (0) Anteroposterior;
- (1) Dorsal;
- (2) Ventral.

**304) Shape or margo ulnaris:**

- (0) Straight;
- (1) Concave.

**305) Shape of caput humeri:**

- (0) Flat;
- (1) Highly convex.

**306) Lateral edge of caput humeri:**

- (0) Straight;
- (1) Forming a corner.

**307) Orientation of lateral edge of caput humeri:**

- (0) Anteroposterior;
- (1) Oblique (from a posterodistal to an anteroproximal position);
- (2) Anteroposterior posterodistally and dorsoventral anteroproximally.

**308) Lateral expansion of articular surface of caput humeri:**

- (0) Scarce;
- (1) Well developed.

**309) Deltopectoral crest:**

- (0) Present;
- (1) Absent.

**310) Tuberculum deltoideus:**

- (0) Highly relieved;
- (1) Reduced;
- (2) Absent.

**311) Articulation with radius and ulna:**

- (0) Rotational;
- (1) Non-rotational.

**312) Position of ulnar epycondyle:**

- (0) High;
- (1) Low;

(2) Almost absent.

**313) Relative length of humerus:**

- (0) Longer than radius and ulna;
- (1) Humerus length nearly equals that of radius and ulna;
- (2) Much shorter than radius and ulna.

**314) Proximal surface of tuberculum deltoideus:**

- (0) Continuous with deltopectoral crest;
- (1) Concave;
- (2) Straight and projecting posteriorly.

**RADIUS**

**315) Proximal curvature:**

- (0) Massive;
- (1) Reduced-to-absent.

**316) Distal expansion:**

- (0) Absent;
- (1) Present.

**317) Proximal contact with ulna:**

- (0) Present;
- (1) Absent.

**318) Size of radius with respect to ulna:**

- (0) Anteroposterior diameter similar to that of ulna;
- (1) Anteroposterior diameter larger than that of ulna.

**ULNA**

**319) Olecranon: proximal corner:**

- (0) Directed proximally;
- (1) Directed distally.

**320) Olecranon: size:**

- (0) Well developed;
- (1) Reduced.

**321) Olecranon: dorsal and ventral borders:**

- (0) Parallel;
- (1) Diverging posteriorly;
- (2) Forming a right angle.

**322) Olecranon: ventral angle:**

- (0) Right angle-to-obtuse;
- (1) Acute.

**323) Olecranon: posterior border:**

- (0) Squared;
- (1) Round;
- (2) Straight.

**324) Proximal articular facet of ulna and upper side of olecranon:**

- (0) Forming a corner;
- (1) Straight.

**325) Distal expansion of ulna:**

- (0) Absent;
- (1) Present.



## **MANUS**

### **326) Articulation of carpals:**

- (0) Tight articulation;
- (1) Loose articulation.

### **327) Digit number:**

- (0) Five;
- (1) Four.

### **328) Hyperphalangy:**

- (0) Absent;
- (1) Present.

### **329) Proportions of manus:**

- (0) Manus wide;
- (1) Manus narrow.

### **330) Trapezium:**

- (0) Present;
- (1) Absent.

### **331) Separate cartilaginous fields for trapezoid and unciform:**

- (0) Yes;
- (1) No.

## **HINDLIMB**

### **332) Pelvis articulated with vertebral column:**

- (0) Yes;
- (1) No.

### **333) Massive reduction of pelvis size:**

- (0) No;
- (1) Yes.

### **334) Functional hindlimbs in adults:**

- (0) Yes;
- (1) No.

## **STERNUM AND RIBS**

### **335) Number of ribs articulated to sternum:**

- (0) >1;
- (1) 1.

### **336) First rib shape:**

- (0) Not expanded;
- (1) Expanded.

### **337) Sternum formed by several sternebra:**

- (0) Yes;
- (1) No, only by one manubrium.

### **338) Head of first rib:**

- (0) Bifid;
- (1) Single.

### **339) Ribs with bifid head posterior to 5<sup>th</sup>:**

- (0) Yes;
- (1) No.

### **340) Pachyosteosclerotic ribs:**

- (0) Absent;
- (1) Present.

## **DENTITION**

**341) Positions of upper premolars and molars:**

- (0) Close to each other;
- (1) Well separated by diastemata.

**342) Positions of lower premolars and molars:**

- (0) Close to each other;
- (1) Well separated by diastemata.

**343) Number of denticles on posterior upper teeth:**

- (0) >3 along anterior or posterior borders;
- (1) 3 or less along anterior or posterior borders.

**344) Dental generations:**

- (0) Polyophiodonty;
- (1) Monophiodonty.

**345) Heterodont teeth on dentary:**

- (0) Present;
- (1) Absent.

**346) Dentition reduced to a few anterior upper teeth:**

- (0) No, complete dentition is present;
- (1) Yes.

**347) Inferred or observed loss of mineralization in teeth (due to *C4orf* gene mutation):**

- (0) Absent;
- (1) Present.

## **BALEEN**

**348) Inferred or observed presence of baleen:**

- (0) Negative;
- (1) Positive.

**349) Inferred or observed length of baleen:**

- (0) Short;
- (1) Long.

**350) Direction of baleen racks:**

- (0) Limited to posterior part of rostrum;
- (1) Parallel;
- (2) Anteriorly convergent.

## Taxon x character matrix used in phylogenetic analysis

### Protocetidae

000-00000	00000000--0	0-----	-0-00-00-0	00-0000000	0000000000	0000000000
00000000-00	00000000000	00000000000	00000-0000	00000----0	-000000000	0-00000-00
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### Cynthiacetus peruvianus

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### Basilosaurus cetoides

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### Dorudon atrox

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### Zygorhiza

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### Mammalodontidae

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### Fucaia buelli

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### Aetiocetus weltoni

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### Yamatocetus canaliculatus

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*Eomysticetus whitmorei*

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*Micromysticetus rothauseni*

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*Waharowa ruwhenua*

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*Sitsqwayk cornishorum*

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*Horopeta umarere*

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*Morenocetus parvus*

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*Caperea marginata*

001011011 1110111011 10000-1111 0100111001 10-3212020 1121000020 0111011101  
 0300--0010 101-13-011 3201000000 0011000100 21210----1 0000001131 0-01011012  
 ----300--1 0111010111 1111--0101 0120112101 111011---0 --0--001-0 01210?101?  
 0100100010 0011110001 1101001111 1001111013 00-0-10211 0111011100 1111111101  
 1111111111 1111111111 1110111211 1112110101 0010101111 0111111110 1---11-011 1

*Miocaperea pulchra*

001011011 1110111011 10000-1?11 0100111001 1103212020 1121000020 0111011100  
 0300--0010 101-13-011 3221000000 0011000100 21210----1 0200001131 0-01011012  
 ----200--? 0111000111 1111--0101 0120112101 1110??---0 --0--001-0 ???????????  
 ??001?0010 0?????????? ??????????? ??????????? ??????????? ??????????? ???????????  
 ??????????? ??????????? ??????????? ??????????? ??????????? ??????????? ?-?-1?-011 1

*Balaenella brachyrhynchus*

101011011	1100111201	10000-1?11	0100111001	1??3???0?0	1110100020	0111011101
0301100010	101-13-111	3111000100	0301011100	21210----1	1100001131	0-21011002
----300--?	0111100111	1111--1101	0020112101	1110?0---0	--11101???	?????0????
?001?0010	???1110001	110100111?	?011???????	???????????	???????????	???????????
???????????	???????????	???????????	???????????	???????????	???????????	?-?-1?-011 1

*Balaena mysticetus*

101011011	1100111201	10000-1111	0100111001	1113212020	1110100020	0111011101
0301100010	101-13-111	3111000100	0301011100	21210----1	1100001131	0-21011002
----300--1	0111100111	1111--1101	0020112101	111010---0	--11101000	012000000?
0100100010	0011110001	1101001111	1011111113	00-0-10211	011311?100	1110000000
1111111111	1110000000	0110110111	1121111000	1000011010	0111111110	0---11-011 1

*Balaenula astensis*

10111??11	1100?11211	10000-1?11	0100111001	11?3001020	1110110021	0101011101
0301010110	111-13-011	3111000000	0011011100	21210----1	1100001131	0-01011001
----200--?	0111100110	1110131101	0020112101	111010---0	--10001000	012?00?00?
01001?0010	0011110001	110100111?	?011111113	00-0-10211	0111112100	?????000??
???????????	???????????	???????????	???????????	???????????	???????????	?---11-011 1

*Eubalaena spp.*

101111011	1100111211	10000-1111	0100111001	1113001020	1110110021	0101011101
0301010110	111-13-011	3111000100	0301011100	21210----1	1100001131	0-01011001
----200--1	0111100111	1110131101	0020112101	111010---0	--10001000	212000001?
0100100010	0011110001	1101001111	1011111113	00-0-10211	0113112100	1110000010
1111111111	1110000000	0110110111	1121111110	1000011010	0111111110	0---11-011 1

*'Aglaoctetus' patulus*

110-11111	1110111101	11000-0?01	1100111001	10-3101030	1111110000	0111101001
0200--0-11	0001000010	1011000100	0301000010	11100----1	0110001121	1-11000-02
----100--1	0111110111	1110130100	1010112100	311011---1	000--01010	012?0?00?0
10010?0010	0011110110	0111100001	001???????	???????????	???????????	0100?0?0?0
0?1?????1	11?????????	???????????	???????????	???????????	???????????	?---11-110 2

*Pelocetus calvertensis*

110-11111	1110211101	11000-0?01	1100101001	10-3?01031	1110121000	0111101001
0200--0-11	0001000010	1011000100	0301000010	11100----1	0110001121	1-11000-03
----100--1	0111110111	1110130100	1020112100	311???????	??0--01???	???????????
?0010??010	??21110110	0111100001	0011111012	1100-00120	?113100001	010?0?00?0
?02?1??101	11?1011110	0110011211	212?-?????	?????010??	?????11110	0---11-110 2

*Uranocetus gramensis*

110-11111	1110211101	11000-0?01	1100101001	10-3101131	1111110000	0111101001
0200--0-11	0001000010	1011000100	0301000110	11100----1	0110001121	1-11000-14
0010100--1	0111110111	11101?0100	1020112100	311??1---1	000--01010	012?0?00?0
10010?0010	0?21110110	0111100001	00111????12	1100-00120	1113000001	100000000?
?100?????01	1??0102011	0110011211	?122?10100	011100????	???????????	?---11-110 2

*Isanacetus laticephalus*

110-11111	1110211001	11000-2?01	1100111011	10-3101021	1111121000	0111101001
0200--0-11	0001????010	1011000100	1301000110	11100----1	0110001121	1-110?????
?????100--1	01111?01??	?1110-0100	1010112100	311011---1	000--01010	012?0?00?0
10010?0010	0111110110	0111100001	00111????1?	???????????	???????????	???????????
???????????	1???????????	???????????	???????????	???????????	???????????	?---11-110 2

*Joumocetus shimizui*

110-11111	1110011001	11000-0?01	1100111011	10-3101131	11111220?0	0111101001
0200--0-11	0001001010	10??????00	??01??0000	11100----1	0110001121	1-1100????4
0010100--1	01111?0111	11110-0100	1010112100	?1??1---?	000--0?????	???????????
?0010?????	??11110110	0110--0001	?01111101?	?????0013?	?112000001	???????????
???????????	1???????????	???????????	???????????	???????????	???????????	?---11-110 2

*Parietobalaena palmeri*

110-11111 1110??1001 11000-2101 11001?10?1 10-3101021 1111112000 0111101001  
0200--0-11 0001000010 1011000000 1101000100 11100----1 0110011121 1-11000-14  
0010100--1 0111110111 1110130100 1010112100 310001---1 000--01010 01211111?0  
1001000010 1111110110 0110--0001 0011111012 1100-00120 1111000001 0100000000  
0??1??????1 11????????? ??????????? ??????????? ??????????? ??????????? ?---11-110 2

*Parietobalaena campiniana*

110-11111 1110111001 ??????????? ?100111001 10-????????? 1111122020 011??????1  
02???-?-?? ?0?????010 1011000000 1101000100 11100----1 0110001121 ???????????  
??????????1 ?111100111 111???30100 1010112100 ?10001---1 000--01010 012?1?11?0  
10010?0010 1111110110 0110--0001 0011111012 1100-00120 1111000001 0100000000  
112??111?1 1?????????? ??????????? ??????????? ??????????? ??????????? ?---11-110 2

*Tiucetus rosae*

110-11??1 111??????1 110?0-0?02 2100??10?1 1??3000121 111????-?? 0?11101001  
0200--0-11 0001111010 1011000000 0101000100 11101000?1 0110011121 1-11101014  
0010100--1 0111100111 1110100100 1110112100 ?11??-1 000--01??0 ???????????  
?0010??010 ??11110110 011??00001 001????????? ??????????? ??????????? ???????????  
??????????1 1?????????? ??????????? ??????????? ??????????? ??????????? ?---11-110 2

*Diorocetus hiatus*

110-11111 1110110110 11010-0?01 2100111001 10-2001030 1111020000 0111100001  
0200--0-00 1002000010 1011000100 0101001100 11100----1 0010001121 1-12101-14  
0011000--1 0111110111 1110130100 0010102000 311013---1 000--01010 212?1?11?0  
10010?0010 1111110100 0110--0011 0011111012 1100-00131 ?111000001 01?????0??  
??2?????101 1101012010 0?????????? ??????????? ??????????? ??????????? ?---11-110 2

USNM187416

110-11?11 1110110110 10000-0?02 2100111001 10-2001020 1111010021 0111101001  
0200--0-00 1002000010 1021000100 0101001100 11100----1 00?0001121 1-12101-14  
0001000--1 0111110111 1110130100 0120112000 ??????????? ??????????? ???????????  
?????????? ?111101?? 0111010011 01????????? ??????????? ??????????? ???????????  
?????????? ??????????? ??????????? ??????????? ??????????? ??????????? ???-11-110 2

*Mixocetus elysius*

110-11111 1110110110 1111002?01 1100100001 10-3001120 1121021002 0210102001  
0210--1-00 1002111010 202100000? 0301000001 1100?----1 0010001120 0-22110-01  
----000--1 0111110111 1110110100 ??22?????? ??????????? ??????????? ???????????  
?001?????? ??????????? ??????????? ?1?1111012 ???0-00211 ?11?000000 01?0000000  
000??00?? ?1?1?1?111 1?????????? ??????????? ??????????? ??????????? ?---11-110 2

*Cetotherium rathkei*

100-1???? 111??10110 1111102?02 2????10?001 1103101130 1121021021 0210102001  
0210--0-00 1002111010 2022000001 0301000000 11000----1 00?0001120 1-12100-14  
0111000--1 0111010111 1111--0110 0?????????? ??????????? ??????????? ???????????  
?????????? ?201101?? 0111000011 01????????? ??????????? ??????????? ???????????  
?????????? ??????????? ??????????? ??????????? ??????????? ??????????? ?-?-11-110 2

*Cetotherium riabinini*

100-11?10 1110110110 1111102?02 210011?001 10-2211120 1121010001 0210102001  
0210--1-00 1002111010 2022000001 0301000000 11000----1 0110001120 1-12100-14  
0011000--1 0111110111 1110120100 0120?????0? ??????????? ??????????? ???????????  
?????????? ?201101?? ???0--00?1 01?1111012 1100-10021 2111000001 010?0001?0  
002?0001?1 1000110002 111101????? 1112-10100 011100????? ?111?????1 1---11-110 2

*Metopocetus durinasus*

?20-1???? 111??????0 111?100?02 2?????0??? ???3???130 11????????? ???010200?  
?210--1-00 1002111010 ?????000??? 0301000101 11?00----1 0??0??112? 1-12100-14  
0111000--1 ?111?10111 11101??100 ?????????? 311113---1 000--00010 012?1?11?0  
10010?0010 10????????? ??????????? ??????????? ??????????? ??????????? ???????????  
?????????? ??????????? ??????????? ??????????? ??????????? ??????????? ???????????1?? ?

*Metopocetus hunteri*

??0-1???0 111??????0 111?000?02 2????????? ???????1?0 1121?????? ????010200?  
?210--1-00 1002111010 2022000001 0301001101 11?01000?1 0000001120 1-12100-11  
----100--1 ?111110111 1110120100 011010201? ?1111????? ???????010 012?1?11??  
?0000?0010 1021110110 0110--0001 011???????? ??????????? ??????????? ???????????  
?????????? ??????????? ??????????? ??????????? ??????????? ??????????? ??????????1?? ?

*Piscobalaena nana*

100-11110 1110110110 1111110?02 2100111001 1104001130 1121021000 0210102001  
0210--1-00 1002111010 2022000101 0301000000 11000----1 0110001120 0-22100-11  
----200--1 01110101?? ?111--0100 0100102000 311113---1 000--00010 012?1?1110  
00010?0010 1101110110 0110--0001 0111111012 1100-00131 2112000001 0100000000  
0020001101 1101011100 0111011211 2111210100 0111001??? 0?11110110 0---11-110 2

*Herpetocetus morrowi*

100-11??0 111?110110 1111112?02 2100111001 10-3001130 1121022001 0210102001  
0210--0-00 0002111010 1022000001 0001002100 11000----1 0100001120 1-12100-14  
0012000--1 0111110111 1110020110 1100102010 311113---1 100--01010 012?1?1110  
10010?0010 1001110110 0110--0001 0111111012 1100-00130 1112000001 0?????????  
?????????01 110???????? ??????????? ??????????? ??????????? ??????????? ??????????? ?---11-110 2

*Herentalia nigra*

??0-1???? 111??????0 111?000?02 2????????? ???????120 1121?????? 021010200?  
?210--1-00 1002111010 ?????????? ???1?0001 11?01001?1 0000?0112? 0-02101011  
----200--1 ?111010111 1110220100 0120102000 ?1111????? 000--?1010 ??????????  
?00???????? ??????????? ??????????? ??????????? ??????????? ??????????? ???????????  
???????????? ??????????? ??????????? ??????????? ??????????? ??????????? ??????????1?? ?

*Thinocetus arthritis*

??0-1???? ??????????? ??????????? ??????????? ??????????? ??????????? ???????????  
????????-?? ??????????? ??????????? ??????????? ??????????? ???????1??? ???????????  
???????????? ??????010111 111???0100 ??20112010 31111????? 000--00100 01??1?11?0  
00010?0010 1011110100 0111000011 011???????? ??????????? ??????????? 010000?000  
0??0?????01 1101110111 0112011211 1112210100 011100???? ??????10110 ???????1?? ?

*Halicetus ignotus*

??0-1???? ??????????? ??????????? ??????????? ??????????? ??????????? ???????????  
????????-?? ??????????? ??????????? ??????????? ??????????? ???????1??? ???????????  
???????????? ??????????? ??????????? ??10112000 31101????? 100--01100 01??1?11?0  
00010?0010 1011110100 0111010011 011???????? ??????????? ??????????? 0100000000  
0110111101 110???????? ??????????? ??????????? ??????????? ??????????? ??????????? ??????????1?? ?

*Titanocetus sammarinensis*

110-11010 1110110110 11100-2?00 0100100001 10-3001100 1111120002 0100102001  
0210--0-00 1001111010 1011000001 0301000011 11100----1 0??0001120 0-02100-01  
----200--1 0111010111 1110120100 01????????? ??????????? ??????????? ???????????  
???????????? ??????????? ??????????? ?1?1111012 1100-10120 1113100000 010????????  
?????????1? ??????????? ??????????? ??????????? ??????????? ??????????? ??????????? ??????????1?? ?

*Cophocetus oregonensis*

110-11111 1110110110 11010-2?01 1100100001 10-3001120 1111121002 0210102001  
0210--0-00 1002111010 1022000100 0101000010 11110----1 0011001121 1-12100-04  
0101000--1 0111010111 1110110100 0020?????? 311013---1 000--00100 012?0?01?0  
10010?0010 0111110100 0110--0011 00111??012 1100-20120 2112100001 0100000000  
011?????01 1101111002 011?011211 2122-????? 010100???? ??????????? ?---11-110 2

*Aglaocetus moreni*

110-11110 1110110110 10000-2?01 1100110001 10-3001100 1111110001 0110102001  
0210--0-00 1002111010 1011000100 0101000010 11110---1 0011001121 1-12100-04  
0101000--1 0111010111 1110110100 0020??????? ?????????? ?????????? ??????????  
??????????? ?????????? ?????????? ???1111012 1100-0012? ?112000001 ??????????  
??????????? ?????????? ?????????? ?????????? ?????????? ?????????? ?---11-110 2

*Eschrichtius robustus*

101011011 1110211001 10000-2211 0100111001 10-4102120 1121110021 0220102101  
0211--0-00 1002121010 2122000101 0301000001 2111111?21 0101001120 2-22101114  
11103010-1 0111110111 1110100110 1020?????02 3101120001 000--111-0 01211011?0  
101111100- 1211111000 0111000010 0111111013 00-1110131 2112011000 0100000000  
0001111101 1100110001 1112011211 1111211100 0201011111 ?111111110 0---11-110 2

*Eschrichtioides gastaldii*

110-11??0 1110?????1 10000-2?11 0100??1001 10-3101120 1121110011 0220100001  
0211--0-00 1002121010 2111000101 0301000101 21011000?1 01?1001120 0-02101101  
----00???1 0111100111 111??0110 ?????????? ?????????? ?????????? ??????????  
??????????? ?10111000 0111000010 0111111013 00-1110131 2112011000 010???????  
?????????1? ?????????? ?112011211 2121-????0 020200???? ?111????? ?---11-110 2

*Archaeoschrichtius ruggieroi*

????????? ?????????? ?????????? ?????????? ?????????? ?????????? ??????????  
????????-?? ?????????? ?????????? ?????????? ?????????? ?????????? ??????????  
??????????? ?????????? ?????????? ?????????? ?????????? ?????????? ??????????  
??????????? ?????????? ?????????? ???1111012 11010????? ?112011002 ??????????  
??????????? ?????????? ?????????? ?????????? ?????????? ?????????? ?---11-11? ?

RBINS M. 2231

110-????? 111????1001 10100-??1? ??????1?1? ?????????1?0 1230020022 0320102011  
131??1-11 1003121010 ?????????01 0?01000000 21211011?1 0110001121 0002100-01  
----200--? ?111110111 111011?1?? 1020112100 1110020011 110--11010 012?0?00?0  
11111?110- 0131111100 0101100001 0011111012 1100-21331 2113100002 010????0??  
??2????11? ?11110002 1112011211 2112-10?00 01120?1??? ?????????? ?---11-110 2

'*Balaenoptera*' *ryani*

????????? ?????????? 1??0-??2 0????????? ??????????0?0 1231?0??2 011110100?  
?210--0-01 1002121010 ?????????? ???1??1100 21?11000?1 010?00112? 1012101004  
1110100--? ?11??10111 111020?110 1????????? ?111120011 000--11010 012?0?01?0  
00011?1010 01????11?0 01?110000? ?0????????? ?????????? ?????????? ??????????  
??????????? ?????????? ?????????? ?????????? ?????????? ?????????? ??????????1?? ?

*Protororqualus cuvieri*

110-11010 1110211001 10100-2?12 1100111111 10-4101120 1242101012 0320102011  
0220--1-11 1003021010 1?11000??? ?01002100 2121?????1 01?1001121 1012101014  
0201100--? 0111100111 111??0110 ?????????? ?????????? ?????????? ??????????  
??????????? ?1111110? ?10??000?1 01?1111012 1100-21241 ?111000000 0100?????0?  
?????????01 11?111?112 1112001211 1121210100 0101001??1 ?11111???? ?---11-110 2

RBINS M. 2315

??0-????? 11????????? 101?0-2?12 2??0?11??? ?????????1?? 12421????11 0??0102012  
122??1-11 1003021010 ???1?10101 0?01001000 21211110?1 010100112? 10121????4  
0201100--? ?111110111 111010?1?0 1120112100 ?111120001 100--001-1 112?0?01??  
?1110?1010 0131111100 1101100001 011????????? ?????????? ?????????? ??????????  
??????????? ?????????? ?112?11211 ?1????????? ?????????? ?????????? ??????????1?? 2

UT PU13842/5

110-11112 1111211??1 10100-1?12 1100??1111 10-4201120 1242200012 0320102012  
1211--1-11 1003021010 1121010101 0101001100 2121?????1 01?1001121 1012101014  
0201110--1 0111100111 111010?110 1?2????????? ?111120001 100--011-1 112?0?01?0  
21110?0010 0131111100 1101100001 0111111012 1100-21241 2112100000 0100000000  
0021111101 1101112112 1110010001 2122-10100 011100???? ?111111111 0---11-110 2



*'Balaenoptera' cortesi var. portisi*

100-11112 111011???? 10100-0?12 2111???1??? 1???????130 1231100011 0321102111  
122???0-11 1002121010 1011100111 0100000100 2121112230 1?00011213 1021111004  
1212100--? 0111110111 1111--0110 1120112100 ?111?20011 110--00??? ??????????  
?1110?00- ??31111110 010??0000? ?1?1111012 1100-21131 2112000000 0100000000  
000?????1? ???1112112 1112011211 11122?????1 001200???? ???? ?????? ?--11-110 2

**NMR 7096**

??0-1?112 1110?????? 10100-0?12 2101?????1 ????????130 1231?????? ????110201?  
??21--1-11 1002121010 1211100012 0100000100 211211123? 1100001121 3012110-04  
1212100--? ?111110111 11100??1?0 1020102100 11010200?1 110--00010 112?1?11??  
?1110?000- 0131111110 010110000? ?11??????? ?????????? ?????????? ??????????  
?????????? ?????????? ?????????? ?????????? ?????????? ?????????? ?-?-1?-110 2

**MPTAM 207.13307**

110-110?1 1110??10?1 10100-2?12 210????1111 1??4010130 1232100012 0320102011  
1210--1-11 1003121010 2011000001 0301001100 2121110210 1000011212 2022101004  
1210300--? ?111110111 111011?1?0 1110112100 1111120001 110--001-0 0????1?11??  
?1110?100- 01????????? ?????????? ?????????? ?????????? ?????????? 0100000000  
002111110? ?????????? ?????????? ?????????? ?????????? ?????????? ??????????1?? 2

*Plesiobalaenoptera quarantellii*

110-11111 11112110?1 10100-2?1? 1100111?11 1????????? 12?21????? ???01?????  
??1????-11 1???121??? ?????????? ?????????? ?????????? ??????????12? 2022010-04  
01030????? ??????1011? ?????????? ??21112000 1111020011 110--00010 012?1?11?0  
21110?0011 1130111100 1101100001 0011111012 1100-21341 0113100002 01000????0  
???11?????1 11????????? ?????????? ?????????? ?????????? ??????1111? ?--11-110 2

**SAM55001**

?????????? ?????????? ?????????? ?????????? ?????????? ?????????? ??????????  
????????-?? ??????????0 ?????????? ???0?????0 ??????????1 010100???? ??????????  
?????????? ?111?????? ??????????1?? ?????????? 1110200111 010--00010 012?1?11?0  
21110?0011 1030111100 1101100001 0?1???????? ?????????? ?????????? ??????????  
?????????? ?????????? ?????????? ?????????? ?????????? ?????????? ??????????1?? 2

*Parabalaenoptera baulinensis*

110-11111 1110??1001 10100-2?11 2100111?01 1??3001120 1232201022 0320102011  
??20001-11 1003121010 1021100001 0301001100 21211?2??1 01?000?121 0022101014  
1100210--? 0111??011? ?????????? ?????????? ?????????? ?????????? ??????????  
?????????? ?????????? ?????????? ???1111012 1110-21241 0113000002 0100?????0?  
??1?????01 11????????? ?????????? ?????????? ?????????? ?????????? ?--11-110 2

*Fragilicetus velponi*

??0-????? 11????????? 10100-2?11 2????????? ??????????110 12322????2 0??010201?  
1221--1-11 1003121010 10110?0000 0301000101 11201122?1 0100001121 2022101014  
1110300--? ?111110111 111111?1?0 1120112100 11111200?1 110--001-1 112?1?11?0  
11110?0010 11????????? ?????????? ?????????? ?????????? ?????????? ??????????  
?????????? ?????????? ?????????? ?????????? ?????????? ?????????? ??????????1?? 2

*'Megaptera' hubachi*

110-11010 1110111001 10100-2?11 1100111111 1??3011120 1232101021 0320102011  
1210001-11 1003121010 1021000000 0101000100 11211100?1 0100001121 2022101004  
1110300--? 0111110111 11?11101?0 1021112002 1111?2000? ??0--00??? ?????1?11?0  
21110?0011 11????????? ?????????? ???1111012 1100-21241 ?113000002 0100000000  
0021111101 1101110111 1110011211 2112110100 0111001111 0111111111 0--11-110 2

*Incakujira anillodefuego*

110-11111 1110311101 10100-2?11 1100111111 10-4011130 1242200112 0320102012  
1210001-11 1003121010 1011110111 0201001100 21211?????1 01?0001121 2022101012  
----301101 0111110111 1110210110 1121?????? ?11??20??1 100--00??? ??????????  
?1110?001? ??31111110 1101100001 0111111012 1100-2134? ?112000?0? 0100000000  
00?0?????01 1111111110 1110011211 2122110100 0111001111 01111?1?11 0--11-110 2

MHNL 1613

110-11111	1110311101	10100-2?12	1100111111	10-3011130	1242202122	0320102012
1211--1-11	1003121010	1011110112	0101000100	21211100?1	0010001121	2022101012
----30110?	0111110111	11102001?0	102????????	???????????	???????????	???????????
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*Archaeobalaenoptera castriarquati*

110-1?110	1110111101	10100-2?12	1100111111	???3000120	1242100022	0320102011
1221101-01	1013121010	11110?0102	0301001100	1121???????	???000?121	3022101014
121001100?	01111101??	???????????	?1?????????	???????????	???????????	???????????
???????????	???????????	???????????	???1111012	1100-212??	?111???????	???????????
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MHNL 1610

110-1?012	1110111101	10100-2?12	2100111111	???4010120	1242100021	0320102012
?221--1-11	1003121010	1011010102	0101001100	2121???????	???000?121	3022101014
1210011001	0111?101??	???????????	???????????	???????????	???????????	???????????
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MAB002286

?20-?????	???????????	10??0-2??2	2???????????	?????????1?0	1242???????	???010201?
1221--1-01	1003121010	???????????	???1001100	21?11003??	???000112?	3022101014
121001100?	?111110111	111020?1?0	1121102100	?11??200?1	110--10010	012?0?01??
?1110?????	???????????	???????????	???????????	???????????	???????????	???????????
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*Nehalaennia devossi*

?10-11??0	111?111001	10100-1?12	2100111111	10-3010130	1232102121	0320102011
1310001-11	1003121010	202200000?	0101001100	21211003??	???0001121	0022101012
----01100?	0111110111	1111--?1?0	1110112100	?111120001	110--001-0	???????????
?1110?0???	???????????	???????????	???????????	???????????	???????????	010???????
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'*Balaenoptera*' *bertae*

?20-?????	???????????	1???0-????	2???????????	?????????1??	1231100110	0320102011
121????1-11	1003121010	2012000101	0201001100	2121100???	???1001121	2022101004
0111300--?	?111110111	11?????1?0	1110112100	???????????	???????????	???????????
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Shimajiri-kujira

?20?????01	????????1110	1?100-????	2????111111	?????????1??	1232100122	0130122011
121????1-11	1003121000	2011000101	0201001100	2121???????	???1001121	?0?2101012
----?00--?	?111110111	11?????01??	?1?????????	?11??20001	010--00???	???????????
?1110?0010	??3101110?	???110?00?	?0?????????	???????????	???????????	???????????
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Maesawa-cho

110-11011	1110?11101	10100-??12	1100111111	10-4102130	1232200?20	0320102012
?211--1-11	10031210?0	1211010001	0201001100	2121???????	???00?121	0022110-04
1010200--?	?11111011?	???????????	???????????	???????????	???????????	???????????
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*Miobalaenoptera numataensis*

???????????	11????1101	?????-????	?????????1?	???????????	1231100120	0320102012
121????-?1	1003121010	1011110111	0101001100	2121???????	01?0001121	00221?????2
----000--?	?111110111	11?????1?0	??201121??	?111120001	100--001-0	012?1?11?0
11111?1010	01?????????	???????????	???????????	???????????	???????????	???????????
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*Diunatans luctoretmergo*

?????????1 ??????????? 101?0-1?11 0?????????? ???4012120 1232??????? ??201201??  
130????1-01 1003121010 2022000001 0101000100 21211111??? 0100001121 2002110-04  
1110300--? ?111110111 111020?1?0 1120112100 ?111120011 110--001-1 011?1?11??  
?1111?0010 0131111111 110???0000 001???????? ??????????? ??????????? 01000???00  
??????????? ??????????? ??????????? ??????????? ??????????? ??????????? ???????????1?? 2

*Megaptera miocaena*

?10-?1???1 111??11001 10000-2??21 0100111111 10-3011120 1232110022 0320102012  
1311--1-11 1003131010 1211010001 0201001100 21211?????1 01?0001121 0002110-02  
----000--? 0111111111 1111--0110 1?2???????? ?111120011 1?0--001-0 012?0?00?0  
21111?000- 10111111100 1110001101 1?????????? ??????????? ??????????? ???????????  
??????????? ??????????? ??????????? ??????????? ??????????? ??????????? ?-?-?1?110 2

*'Balaenoptera' siberi*

110-11011 1110211101 10100-1?22 1100111111 1??41?2130 1232202121 0320112112  
?300011--1 111-131010 1?22010?01 0?01001000 2121??????1 0???001121 0002110-02  
----000--1 011111?111 11????????? ??????????? ??????????? ??????????? ???????????  
????????????? ?????????????? ?????????????? ??11111111 00-0-212?? ?111?????? ?10????????  
????????????? ?111110111 1110011211 1122010100 0111001111 11111111?? ?- --11-110 2

*Megaptera novaeangliae*

110-11011 1110211101 10100-2211 0100111111 10-4010120 1232202121 0320102012  
1300011-11 0003131010 1211010101 0201001100 2121112301 0111001121 0022100-14  
1010310--1 0111101111 1111--0110 1021112102 3110120011 110--101-0 012?0?00?0  
11111?000- 0130111110 1101100001 0011111013 1110-21341 2113200011 0100011111  
0001111101 1111112111 1112011211 1122011100 1112111111 1111111111 0---11-110 2

*Balaenoptera musculus*

110-11011 1110211101 10100-1222 0100111111 10-4011120 1232200020 0320112112  
1301--1-11 011-131010 1211011101 0201001100 21211123?1 0111001121 2102100-04  
1110310--1 0111101111 1110210110 1021112102 1111020011 110--10010 112?0?00?0  
11111?110- 0130111101 1101100001 0011111012 1110-21341 2113200012 0100000000  
0020001101 1111112111 1110011211 1112010100 0000001111 1111111111 0---11-110 2

*Balaenoptera physalus*

110-11011 1110111101 10100-1222 0100111111 10-4010130 1232202021 0320102012  
1301--1-11 0003131010 1221011101 0201002100 2121112321 0111001121 2102100-14  
1110310--1 0111101111 1110210110 1021112102 1110120111 100--011-1 0121010010  
111101000- 0030111101 1101100001 0011111012 1110-21341 2113200012 0100000000  
0021111101 1111112111 1110011211 1112010100 0111001111 1111111111 0---11-110 2

*Balaenoptera acutorostrata*

110-11011 1110111101 10100-1222 0100111111 10-3202130 1232200020 0320102012  
1300011-11 0003131010 1221011101 0201002100 2121112331 0111001121 0102100-14  
1110311101 0111101111 1110210110 1011112102 1110120011 000--111-0 0121010000  
111111000- 0130111101 1101100001 0011111012 1110-21341 2113200012 0100000000  
0020101101 1111112111 1112011211 1112010100 0111001111 1111111111 0---11-110 2

*Balaenoptera bonaerensis*

110-11011 1110111101 10100-1222 0100111111 10-3202130 1232200020 0320102012  
1300011-11 0003131010 1221011101 0201002100 2121112331 0111001121 0102100-14  
1110311101 0111101111 1110210110 1011112102 1110121111 000--011-0 012?0?0000  
11111?000- 0130111101 1101100001 0011111012 1110-21341 2113200012 010?000000  
0020101101 1111112111 1112011211 1112010100 0111001111 1111111111 0---11-110 2

*Balaenoptera omurai*

110-11011 1110211101 10100-1222 0100111111 10-4000130 1232200020 0320102012  
1300001-11 0003131010 1?21011101 0201002100 21211123?1 0111001121 2002100-14  
1110311101 0111101111 1110230110 1021112102 1110121011 010--111-0 012?0?00?0  
11111?000- 0030111101 1101100001 0011111012 1110-21331 2113200012 010????????  
????????????? ?????????????? ?????????????? ?????????????? ?????????????? ?????????????? ?- --11-110 2

*Balaenoptera brydei*

110-11011 1110211101 10100-1222 0100111111 10-4001120 1232200111 0320102012  
1301--0-11 0003131010 1?21011101 0201002100 21211123?1 0111001121 0002101014  
1110311001 0111101111 1110210110 1021112101 3110120111 000--111-0 212?0?00?0  
11111?000- 0030111101 1101100001 0011111012 1100-21331 2113200012 0100000000  
0021111101 1111112111 1112011211 1112010100 0111001111 1111111111 0---11-110 2

*Balaenoptera edeni*

110-11011 1110211101 10100-1212 0100111111 10-3000130 1232200111 0310102012  
1300011-11 0003131010 1221011101 0201002100 21211123?1 0111001121 2102101014  
1110311101 0111101111 1110210110 1021112101 3110120111 000--111-0 212?0?0010  
11111?000- 0030111111 1101100001 0011111012 1100-21331 2113200012 0100000000  
0020001101 1111112111 1112011211 1112010100 0111001111 1111111111 0---11-110 2

*Balaenoptera borealis*

110-11011 1110211101 10100-1222 0100111111 10-4000120 1232202110 0320102012  
1301--1-11 0003131010 1221011101 0201102100 21211123?1 0111001121 2002100-14  
1110311101 0111101111 1110210110 1021112102 1110121111 110--111-0 2121010010  
111111100- 0130111101 1101100001 0011111012 1100-21301 2113200012 0100000000  
0021111101 1111112111 1112011211 1122110100 0111001111 1111111111 0---11-110 2

**Table S2**

Results of phylogenetic analysis.

<b>Research algorithms</b>	<b>N<sup>1</sup></b>	<b>TL<sup>1</sup></b>	<b>CI<sup>1</sup></b>	<b>RI<sup>1</sup></b>
Traditional search	25	1606	0.291	0.756
Traditional search (weighted characters)	1	1638	0.285	0.749
<b>New Technology search (sectorial search set off; all algorithms)<sup>2</sup></b>	<b>2</b>	<b>1604</b>	<b>0.291</b>	<b>0.756</b>
New Technology search (sectorial search set off; all algorithms; weighted characters)	4	1605	0.291	0.749
New Technology search (sectorial search set on; Tree Fusing)	1	1605	0.291	0.756
New Technology search (sectorial search set on; Tree Fusing; weighted characters)	2	1640	0.285	0.749
New Technology search (sectorial search set on; Drift)	2	1605	0.291	0.756
New Technology search (sectorial search set on; Drift; weighted characters)	2	1640	0.285	0.749
New Technology search (sectorial search set on; Ratchet)	1	1605	0.291	0.756
New Technology search (sectorial search set on; Ratchet; weighted characters)	1	1640	0.285	0.749

<sup>1</sup> Caption: N, number of cladograms found by the corresponding algorithms; TL, Tree length; CI, Consistency Index; RI, Retention Index.

<sup>2</sup> Bold: most parsimonious solutions used in the paper representing our preferred hypothesis of phylogeny.

**Table S3**

Dataset used for analysis of evolutionary radiation hypothesis. Numbers in the left column represent time intervals; numbers in the other columns represent numbers of rami observed in the cladogram in the corresponding time intervals.

<b>Time interval (in Ma)</b>	<b>Balaenomorpha</b>	<b>Balaenomorpha without Balaenopteridae</b>	<b>Balaenopteridae</b>	<b>Balaenoidaea (from <i>Bisconti et al., 2017</i>)</b>
0-1	14	6	9	5
1-2	14	6	9	5
2-3	23	6	17	5
3-4	33	8	25	11
4-5	21	9	12	9
5-6	29	14	15	11
6-7	21	6	15	5
7-8	40	16	24	9
8-9	39	16	23	3
9-10	32	16	16	3
10-11	32	16	16	3
11-12	49	22	27	4
12-13	17	11	6	1
13-14	21	21	0	1
14-15	14	14	0	1
15-16	12	12	0	1
16-17	21	21	0	2
17-18	11	11	0	2
18-19	9	9	0	2
19-20	9	9	0	2
20-21	14	14	0	0
21-22	5	5	0	0
22-23	1	1	0	0
23-24	6	6	0	0
24-25	6	6	0	0
25-26	8	8	0	0
26-27	8	8	0	0
27-28	8	8	0	0
28-29	10	10	0	0
29-30	10	10	0	0
30-31	10	10	0	0
31-32	10	10	0	0
32-33	10	10	0	0
33-34	11	11	0	0
34-35	17	17	0	0

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