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SUPPLEMENTARY ONLINE MATERIAL FOR

New fossil remains from the Pliocene Koetoi Formation of northern Japan provide insights into growth rates and the vertebral evolution of porpoises

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SOM_1
Institutional Abbreviations

AMNH, American Museum of Natural History, New York, New York, USA.
CAS, California Academy of Sciences, San Francisco, California, USA.
CMM, Calvert Marine Museum, Solomons, Maryland, USA.
HMH, Historical Museum of Hokkaido, Sapporo, Japan.
HMNH, Haboro Museum of Natural History, Haboro, Japan.
IGF, Museo di Geologia e Paleontologia dell'Università di Firenze, Italy.
IRSNB, Institute Royal des Sciences Naturelles, Bruxelles, Belgium.
LACM, Los Angeles County Museum of Natural History, California, USA.
MGP, Museo Geopaleontologico G. Capellini, Università di Bologna, Bologna, Italy.
MGPT, Museo Geopalaeontologico, Università di Torino, Torino, Italy.
MNHN, Museúm National d'Histoire Naturelle, Paris, France.
MPST, Museo Palaeontologico di Salsomaggiore Terme; Salsomaggiore Terme, Italy.
MSNT, Museo di Storia Naturale e del Territorio, Università di Pisa, Pisa, Italy.
NMV, Nakagawa Museum of Natural History, Nakagawa, Japan.
NMNS, National Museum of Nature and Science, Tokyo, Japan.
OU, Geology Museum, University of Otago, Dunedin, New Zealand.
SDSNH, San Diego Natural History Museum, San Diego, California, USA.
SMAC, Sapporo Museum Activity Center, Sapporo, Japan.
UCMP, University of California Museum of Paleontology, Berkley, California, USA.
UCMVZ, Museum of Vertebrate Zoology, University of California, Berkley, California, USA.
UCR, University of California at Riverside, Riverside, California, USA.
USNM, United States National Museum of Natural History, Smithsonian Institution, Washington, DC, USA.

List of the Specimens

Archaeoceti

Basilosauridae †

Zygorhiza kochii †**NMNS** PV 17652 (cast of USNM V 11962), USNM V 4678, 4679, 4680, 11962, 12975, 16639

Odontoceti

Prosqualodontidae †

Prosqualodon davidis † AMNH 18601, USNM PAL 467596

Agorophiidae †

Agorophius pygmaeus † LACM 143475, USNM PAL 243980, 449561

Xenorophidae †

Archaeodelphis patrius †**NMNS** PV no catalogue number

Xenorophus sloanii † USNM V 11049

Patriocetidae †

Patriocetus kazakhstanicus † USNM PAL 510829

Physeteridae

Orycterocetus crocodilinus † USNM V 14729, 14730, 22926, 22931, 22953, USNM PAL 336585, 364222

Physeter catodon: **NMNS** M 3539, 24818, 24819, 25991, MSNTUP 266, USNM A 35315, USNM 253051

Kogiidae

Kogia breviceps AMNH 14158, 36595, **NMNS** M 24773

Waipatiidae †

Waipatia maerewhenua † OU 22095, USNM PAL 508061 (cast of OU 22095)

Platanistidae

Platanista gangetica CAS 16340, **NMNS** M 24853, 24857, 24859, 24861, 24862, 24936, USNM A 23456

Pomatodelphis inaequalis † USNM PAL 187414

Zarhachis flagellator †**NMNS** PV 17788 (cast of USNM V 10485), USNM V 10485, 10911, 16633

Squalodontidae †

Squalodon calvertensis †**NMNS** PV 17787 (cast of USNM V 10484), **NMNS** PV 15396 (cast of USNM PAL 206288), USNM V 10484, 22902, 23537, 25910, USNM PV 175382

Squalodelphinidae †

Notocetus vanbenedeni † AMNH 9485, 29060

Eurhinodelphidae †

Xiphiacetus bossi † USNM V 8842, 11867, 16581, 16890, 23086, 23216, 25670

Ziphiidae

Squaloziphius emlongi † USNM PAL 181528

Berardius bairdii **NMNS** M 3535, 25987, 25988, 26427, 30129

Mesoplodon ginkgodens **NMNS** M 8743, 24870, 24937, 35126

Tasmacetus shepherdi USNM 484878

Ziphius cavirostris AMNH 40015, 40016, **NMNS** M 3537, 24291, 26423, 26426, 31331

Lipotidae †

Lipotes vexillifer † AMNH 57333, USNM 218293

Parapontoporia sternbergi † LACM 6238, SDSNH 22633, 75060, 123658

Iniidae

Inia geoffrensis **NMNS** M 24891, USNM A 49582, USNM 239667, 395614, 395415, 395602, 396166;

Pontoporidae

Pontoporia blainvillei **NMNS** M 24982, 36353, 36355, UCMVZ 148033, USNM 482707

Brachydelphis mazeasi † MNHN PPI 121, 124, 230, PPI 233, no catalogue number

Pliopontos littoralis † MNHN SAS 193, 931, 953

Kentriodontidae †

Kentriodon pernix † IRSNB 372, USNM V 8060, 10670

Hadrodelphis calvertense † CMM-V 11, USNM V 23408, USNM PAL 182938

Atocetus iquensis †: NMNH PPI 113, 114, 115

Albireonidae †

Albireo whistleri † UCMP 314589

Odobenocetopsidae †

Odobenocetops peruvianus † MNHN SAS 1613, 1614, USNM PAL 488252, LACM no catalogue number (cast of SMNK PAL 2491), **NMNS** PV 20741 (cast of SMNK PAL 2491);

Monodontidae

Monodon monoceros AMNH 19316, LACM 72548, MSNTUP 274, 275, **NMNS** M 33766, USNM A 22973, 22983, USNM 267957, 267958, 267961

Delphinapterus leucas AMNH 10192, 180017, 212184, 212552, 34937, **NMNS** M 5630, 34189, USNM A 7382, USNM 238105, 571021, MSNTUP 276, 277, 293

Denebola brachycephala † UCR 21245

Phocoenidae

Archaeophocaena teshioensis † NMV-56

Miophocaena nishinoi † NMV-6

Phocoena phocoena **NMNS** M 24648, 24902, 24902, 24958, 24960, 27391, 27393, 28365, 28366, 28367, 29356, 29357, 29398, 29797, 29798, USNM 571592,

571709, 571883, 572783

Phocoena spinipinnis UCMVZ 145780, USNM 395729, 395738, 395739, 395743, 550782

Phocoena dioptrica LACM 86042, USNM 571484, 571485, 571486

Phocoena sinus: LACM 28259, USNM 303308, 395722, 395723, 395892, 571431

Phocoenoides dalli LACM 43473, **NMNS** M 21379, 21380, 21382, 21383, 21384, 24679, 24682, 24686, 24687, 24688, 24689, 24691, 24692, 24693, 24694, 24696, 24697, 24944, 25163, 25166, 25169, 25171, 25174, 25175, 25177, 25233, 25942, USNM 276064, 286865, 504417, 504969

Neophocaena phocaenoides **NMNS M** 24659, 24660, 24945, 24946, 24947, 24949, 24950, 24953, 24955, 24964, 27005, 27885, 28371, 28436, 30114, USNM 239990, 240001, 241503, 550473, 504910

Australithax intermedia † MNHN PPI 65

Haborophocoena toyoshimai † HMNH 110-1

Haborophocoena minutus † SMAC 1388

Lomacetus ginsburgi † MNHN PPI 104, USNM 452992

Piscolithax boreios † UCR 15975

Piscolithax tedfordi † UCR 15972

Piscolithax longirostris † MNHN SAS 933, 934, 940

Pterophocaena nishinoi † NMV-7

Salumiphocaena stocktoni † UCMP 34576

Septemtriocetus bosselaersi † IRSNB M.1928

Delphinidae

Lissodelphis borealis **NMNS** M 24743, 24782, 24783, 24828, 24829, 25182, 26628, 27724

Cephalorhynchus hectori USNM A 84588, USNM 500864, 571649, MSNTUP 292

Leucopleurus acutus USNM A 14279, 22942, USNM 504166, 504763, 550995, 571387, 571402

Feresa attenuata **NMNS** M 24591, 24593, 24594, 24595, 32546, USNM 395177, 484995, 504917, 550389

Peponocephala electra **NMNS** M 21284, 21285, 24654, 24657, USNM 504503, 504504

Globicephala macrorhynchus **NMNS** M 4511, 24603, 24604, 24802, 24810, 24609, USNM A 22571, 37261, USNM 504396

Hemisyntrachelus cortesii †; IGF 1525V, 1545V, MB 8547 1COC1, 8548 1COC2, 8550 1COC4, 8551 1COC5, 8552 1COC6, 8556 1COC10, 8566 1COC20, 8567

1COC21, 8568 1COC22, MGPT PU13874, 13875, 13880, 13882, MPST A, B

Pseudorca crassidens **NMNS** M 24616, 24772, 29345, 32743, USNM 218360, 484982

Grampus griseus **NMNS** M 21400, 24664, 25981, 29490, 29524, 29544, USNM 504328, 550308, 571602, 572474

Orcinus orca LACM 52479, 72577, **NMNS** M 4510, 21262, 32458, 33459, USNM A 22068, USNM 219326, 239537, 550857

Orcaella brevirostris USNM 199743, 486170

Delphinus delphis **NMNS** M 24646, 24647, 24698, 25180, 25263, 500134, 550750, USNM 482800

Sousa chinensis LACM 72168, USNM 258859

Stenella attenuata **NMNS** M 23624, 23625, 23626, 23655, 24666, 24667, 24668, 24700, 24703, 24924, 24925, 24926, 24927, 25109, 25110, 25115, 25121, 25122, 25123, 25119, 25130, 25135, 25136, 25139, 25140, 25141, 24142, 24145, 14148, 27415, USNM 261431, 487118

Tursiops truncatus **NMNS** M 24635, 24788, 24618, 24702, 24738, 24907, 24923, 32763, USNM 572707

Lagenodelphis hosei **NMNS** M 24920, 24921, 29574, 29575, USNM 571619

Steno bredanensis **NMNS** M 19770, 23622, 24637, 24639, 25197, 29467, USNM A 49628, 49983, USNM 572802

Sotalia fluviatilis LACM 19594, 49708, 49709, USNM 253476, 571461, 571558

Eodelphinus kabatensis† HMH 68037

SOM_2. MORPHOLOGICAL CHARACTERS USED IN THE PHYLOGENETIC ANALYSIS

Numbers between square brackets indicate the character number used in previous cladistic analyses.

Rostrum

(1) Length of rostrum as percent skull length: moderately long, 50–55% (0); long, 55–60% (1); very long, >60% (2); medium, 50–40% (3); very short, 40–35% (4) (Murakami et al. 2012a, b [1]; modified from Arnold and Heinsohn, 1996 [8]; Bianucci, 2005 [1]; Lambert, 2008 [1]).

(2) Premaxillae: inflated almost entire length of rostrum (0); flat almost entire length of the rostrum (1) (Murakami et al. 2012a, b [2]).

(3) Premaxillae: not compressed mediolaterally (0); compressed mediolaterally at anterior rostrum (1) (Murakami et al. 2012a, b [3]).

(4) Premaxillae at apex of rostrum: with lateral margins parallel or diverging (0); narrowing (1) (Murakami et al. 2012a, b [4]; modified from Bianucci, 2005 [2]).

(5) Maxilla length as percent rostrum length: short, <85%, tips of maxillae not reaching tip of rostrum, (0); long, >89%, tips of maxillae to within 10% of rostrum tip (1); same as state 1 except of rostrum lacking alveoli (2) (Murakami et al. 2012a, b [5]; modified from Lambert, 2005 [1]).

(6) Mesorostral groove: V-shaped or U-shaped opening (0); partially or completely filled in with vomer (1) (Messenger and McGuire, 1998 [1429]; Geisler and Sanders, 2003 [5]; Geisler et al., 2011 [5], 2012 [5]; Murakami et al. 2012a, b [6]; derived from Moore, 1968).

(7) Lateral margin of rostrum anterior to maxillary flange: concave (0); straight (1); convex (2) (Murakami et al. 2012a, b [7]; modified from Bianucci, 2005 [3]).

(8) Rostral constriction: absent (0); constriction anterior to antorbital notch (1); constriction anterior to maxillary flange (2) (Murakami et al. 2012a, b [8]; modified from Muizon, 1984; Barnes, 1985b; Messenger and McGuire, 1998 [1424]; Geisler and Sanders, 2003 [6]; Geisler et al., 2011 [6], 2012 [6]).

(9) Antorbital notch: absent or weakly developed (0); well developed (1) (Messenger and McGuire, 1998 [1426]; Fajardo-Mellor et al., 2006 [6]; Murakami et al. 2012a, b [9]).

(10) Width of premaxillae at mid-rostrum as percent greatest width of maxillae at level of postorbital processes: wide, >25% (0); medium, 25–15% (1); narrow, <15% (2)

(Murakami et al. 2012a, b [10]; modified from Aguirre-Fernandez et al., 2009 [4]). If the supraorbital process of the maxilla does not reach above the postorbital process, then the width is measured as a percent of the frontal width, excluding the postorbital process at the postorbital line.

(11) Width of rostrum at mid-length as percent greatest width of maxillae at level of postorbital processes: wide, >35% (0); medium, 35–30% (1); narrow, <30% (2) (Murakami et al. 2012a, b [11]; modified from Aguirre-Fernandez et al., 2009 [6]).

(12) Width of rostrum at antorbital notch as percent greatest width of maxillae at level of postorbital processes: wide, >68% (0); medium, 68–45% (1); narrow, <45% (2) (Murakami et al. 2012a, b [12]; modified from Geisler and Sanders, 2003 [7]; Geisler et al., 2011 [7], 2012 [7]).

(13) Premaxillae in dorsal view: contacting along midline for less than half length of rostrum (0); widely separated by mesorostral groove in rostrum (1); narrowly separated by mesorostral groove in rostrum (2); contacting along midline for approximately half the entire length or more than of rostrum but not fused (3); contacting along midline for approximately half the entire length or more than of rostrum and partially fused (4); converging (either contacting and separating) in mid-rostrum (5) (modified from Murakami et al. 2012a, b [13]; modified from Muizon, 1988; Fordyce, 1994 [52]; Messenger and McGuire, 1998 [1405]; Geisler and Sanders, 2003 (9); Geisler et al., 2011 [9], 2012 [9]).

(14) Suture between maxilla and premaxilla on rostrum: unfused except distal tip of rostrum (0); fused partly or along most of rostrum (1) (Murakami et al. 2012a, b [14]; modified from Fordyce, 1994 [36]; Messenger and McGuire [1418], 1998; Geisler and Sanders, 2003 [10]; Lambert, 2005 [2]; Geisler et al., 2011 [10], 2012 [10]).

(15) Posterior wall of antorbital notch: maxilla (0); lacrimal and jugal, or maxilla appeared in small area posterior to antorbital notch parallel with lacrimal and jugal (1) (Murakami et al. 2012a, b [15]; modified from Geisler and Sanders, 2003 (15); Geisler et al., 2011 [15], 2012 [15]).

(16) Vomer anterior to maxilla-palatine suture in ventral view: not exposed (0); width of vomer <10% length of vomer, (1); vomer width ratio >10% vomer length (2) (Messenger and McGuire, 1998 [1428]; Murakami et al. 2012a, b [16]; derived from Zhou, 1982).

(17) Anterior sinus fossa: absent (0); between anterior extremity of pterygoid sinus and posterior extremity of upper tooth row (1); between posterior extremity of upper tooth row and midpoint of rostrum (2); beyond midpoint of rostrum (3) (Murakami

et al. 2012a, b [17]; modified from Muizon, 1988; Barnes, 1990; Bianucci, 2005 [13]; Arnold and Heinsohn, 1996 [21]; Geisler and Sanders, 2003 [157]; Aguirre-Fernandez et al., 2009 [18]; Geisler et al., 2011 [157], 2012 [157]; derived from Fraser and Purves, 1960).

Teeth

(18) Number of double-rooted teeth in maxilla: 6–8 (0); 0 (1) (modified from Geisler and Sanders, 2003 [23]; Geisler et al., 2011 [23], 2012 [23]; Murakami et al. 2012a, b [18]).

(19) Large diastema between posterior buccal teeth: absent (0); present (1) (Geisler and Sanders, 2003 [25]; Geisler et al., 2011 [25], 2012 [25]; Murakami et al. 2012a, b [19]).

(20) Tooth enamel: reticulating striate (0); smooth (1); nodular (2); absent (3) (Murakami et al. 2012a, b [20]; modified from Messenger and McGuire, 1998 [1469]; Geisler and Sanders, 2003 [26]; Geisler et al., 2011 [26], 2012 [26]; derived from Zhou, 1982).

(21) Teeth: heterodont and some teeth with dentine (0); conical, with or without accessory cusp (1); spatulate (2); laterally compressed (3) (Murakami et al. 2012a, b [21]; modified from Heyning, 1989 [40], 1997 [72]; Arnold and Heinsohn, 1996 [25]; Messenger and McGuire, 1998 [1470]; Geisler and Sanders, 2003 [27], 2012 [27]; Lambert, 2008 [16]; Geisler et al., 2011 [27]; derived from Barnes, 1984a).

(22) Upper anterior "teeth": about same size as upper posterior teeth (0); greatly enlarged (1); clearly smaller than upper posterior teeth or absent (2) (modified from Murakami et al. 2012a, b [22]).

(23) Buccal teeth ectocingulum: present (0); absent (1) (Murakami et al. 2012a, b [23]; modified from Geisler and Sanders, 2003 [31]; Geisler et al., 2011 [31], 2012 [31]).

(24) Buccal teeth entocingulum: present (0); absent (1) (Geisler and Sanders, 2003 [32]; Geisler et al., 2011 [32], 2012 [32]; Murakami et al. 2012a, b [24]).

(25) Greatest diameter of largest functional tooth as percent of greatest width of maxillae at level of the postorbital processes: large, >5% (0); medium, 5–3% (1); small, <3% (2) (Murakami et al. 2012a, b [25]; modified from Aguirre-Fernandez et al., 2009 [15]).

Mandible

(26) Anterior mandibular teeth: deeply rooted, root >50% of tooth (0); not deeply rooted, root <50% of tooth (1) (Messenger and McGuire, 1998 [1471]; Geisler and Sanders,

2003 [28]; Geisler et al., 2011 [28], 2012 [28]; Murakami et al. 2012a, b [26]; derived from Flower, 1872; Moore, 1968).

(27) Anterior-most mandibular "tooth": about same size as posterior teeth (0); smaller than posterior teeth (1); greatly enlarged (2) forming a tusk (Murakami et al. 2012a, b [27]; modified from Muizon, 1991; Geisler and Sanders, 2003 [36]; Messenger and McGuire, 1998 [1477]; Geisler et al., 2011 [36], 2012 [36]; derived from Flower, 1872).

(28) Number of teeth in mandible: 16–11 (0); 9–8 (1); 2 (2); 1 (3); 17–23 (4); 24–27 (5); 28–39 (6); >40 (7) (Murakami et al. 2012a, b [28]; modified from Messenger and McGuire, 1998 [1468]; Geisler and Sanders, 2003 [37]; Geisler et al., 2011 [37], 2012 [37]).

(29) Length of mandibular symphysis as percent of mandible length: long, >20% (0); short, <20% (1) (Murakami et al. 2012a, b [29]; modified from Messenger and McGuire, 1998 [1465]; Arnold and Heinsohn, 1996 [7]; Bianucci, 2005 [26]).

(30) Mandibular symphysis: sutured but unfused (0); fused (1) (Fordyce, 1994 [5]; Messenger and McGuire, 1998 [1466]; Geisler and Sanders, 2003 [40]; Geisler et al., 2011 [40], 2012 [40]; Murakami et al. 2012a, b [30]; derived from Flower, 1885).

(31) Longitudinal groove on underside of mandibles: absent (0); present (1) (Geisler and Sanders, 2003 [41]; Geisler et al., 2011 [41], 2012 [41]; Murakami et al. 2012a, b [31]; derived from Miller, 1923).

(32) Mandible: bowed medially (0); straight (1); slightly bowed laterally (2) (Sanders and Barnes, 2002; Geisler and Sanders, 2003 [42]; Geisler et al., 2011 [42], 2012 [42]; Murakami et al. 2012a, b [32]; derived from Miller, 1923).

(33) Elevation of coronoid crest: very high (0); moderate (1); low (2) (Murakami et al. 2012a, b [33]; modified from Geisler and Sanders, 2003 [44]; Bianucci, 2005 [27]; Geisler et al, 2011 [44], 2012 [44]).

Orbit

(34) Antorbital process: triangular (0); robust and globose or rectilinear (1) (Bianucci, 2005 [4]; Murakami et al. 2012a, b [34]).

(35) Anterior edge of supraorbital process: oriented anteromedially (0); oriented slightly anterolaterally, at an angle <30° (±) with sagittal plane (1) (Murakami et al. 2012a, b [35]; modified from Geisler and Sanders, 2003 [49]; Geisler et al., 2011 [49], 2012 [49]).

(36) Ratio of length of antorbital process of lacrimal to length of the orbit: <0.6 (0);

≥0.6 (1) (Murakami et al. 2012a, b [36]).

(37) Lacrimal: wrapping around anterior edge of supraorbital process of frontal and slightly overlying its anterior end (0); appearing dorsally and forming most of antorbital process (1); appearing dorsally but not prominently in antorbital process (2); restricted to below the supraorbital process of maxilla (3) (Murakami et al. 2012a, b [37]; modified from Geisler and Sanders, 2003 [51]; Geisler et al., 2011 [51], 2012 [51]; derived from Kellogg, 1923; Miller, 1923).

(38) Lacrimal foramen or groove: present (0); absent (1) (Geisler and Sanders, 2003 [52]; Geisler et al., 2011 [52], 2012 [52]; Murakami et al. 2012a, b [38]).

(39) Lacrimal and jugal: separated (0); fused (1) (Heyning, 1989 [7], 1997 [39]; Geisler and Sanders, 2003 [53]; Geisler et al., 2011 [53], 2012 [53]; Murakami et al. 2012a, b [39]; derived from Flower, 1869; Schulte, 1917; Miller, 1923).

(40) Lacrimal and jugal: contacting each other externally (0); lacrimal excluded from edge of skull, jugal directly contacting anterior edge of frontal (1) (Geisler and Sanders, 2003 [54]; Geisler et al., 2011 [54], 2012 [54]; Murakami et al. 2012a, b [40]; derived from Miller, 1923).

(41) Jugal: thick and sturdy (0); thin, splint, or absent (1) (Geisler and Sanders, 2003 [56]; Lambert, 2005 [21]; Geisler et al., 2011 [56], 2012 [56]; Murakami et al. 2012a, b [41]; derived from Miller, 1923; Barnes, 1990).

(42) Combined anteroposterior length of the lacrimal and jugal exposure that is posterior to antorbital notch: with skull in ventral view, exposure is small and combined length forms <50% of anteroposterior distance from antorbital notch to postorbital ridge (0); intermediate, forms between 50 and 62% of that distance (1); large, forms between 62 and 69% that distance (2); very large, forms >69% of that distance (3) (Murakami et al. 2012a, b [42]; modified from Geisler and Sanders, 2003 [55]; Geisler et al., 2011 [55], 2012 [55]).

(43) Dorsolateral edge of internal opening of infraorbital foramen: formed by maxilla (0); formed by maxilla and lacrimal and/or jugal (l); formed by lacrimal and/or jugal (2); formed by frontal (3) (Geisler and Sanders, 2003 [57]; Geisler et al., 2011 [57], 2012 [57]; Murakami et al. 2012a, b [43]; derived from Miller, 1923).

(44) Ventromedial edge of internal opening of infraorbital foramen: formed by maxilla (0); formed by maxilla and palatine and/or pterygoid (1); formed by palatine and/or pterygoid (2) (Geisler and Sanders, 2003 [58]; Geisler et al., 2011 [58], 2012 [58]; Murakami et al. 2012a, b [44]; derived from Miller, 1923).

(45) Infraorbital plate of maxilla: *present (0); absent (1)* (Geisler and Sanders, 2003 [59]; Geisler et al., 2011 [59], 2012 [59]; Murakami et al., 2012a, b [45]; derived

from Miller, 1923). Order of states reversed from Murakami et al. (2012a, b).

(46) Direction of apex of postorbital process of frontal: projected posterolaterally and slightly ventrally (0); directed ventrally (1) (Murakami et al., 2012a, b [46]; modified from Geisler and Sanders, 2003 [61]; Geisler et al., 2011 [61], 2012 [61]).

(47) Shape of postorbital process of frontal: stick-like (0); pointed, attenuated, or acute triangular (1); triangular, trapezoidal, or an anteroposteriorly widened J-shaped (2); dorsoventrally long J-shaped (3) (Murakami et al., 2012a, b [47]). (48) Frontal-maxilla suture angled posterodorsally at an angle of 50–70° (±) from axis of rostrum, with lateral exposure of frontal thickening posteriorly: absent (0); present (1) (Geisler and Sanders, 2003 [48]; Geisler et al., 2011 [48], 2012 [48]; Murakami et al. 2012a, b [48]; derived from Miller, 1923).

Facial Region

(49) Anterior dorsal infraorbital foramina: one (0); two (1); three or more (2) (Murakami et al. 2012a, b [49]; modified from Barnes, 1984b; Geisler and Sanders, 2003 [64]; Geisler et al., 2011 [64], 2012 [64]).

(50) Rostral basin: absent or poorly defined (0); present, situated medial to antorbital notch and anterior to supraorbital process of frontal (1) (Geisler and Sanders, 2003 [65]; Geisler et al., 2011 [65], 2012 [65]; Murakami et al. 2012a, b [50]).

(51) Width of premaxillae at antorbital notches as percent width of rostrum at antorbital notch: narrow, <49% (0); moderate, 50–64% (1); wide, >65% (2) (Geisler and Sanders, 2003 [66]; Geisler et al., 2011 [66], 2012 [66]; Murakami et al. 2012a, b [51]).

(52) Premaxillary foramina: absent (0); one on right side (1); two on right side (2); three on right side (3) (Geisler and Sanders, 2003 [69]; Geisler et al., 2011 [69], 2012 [69]; Murakami et al. 2012a, b [52]; derived from Barnes, 1990).

(53) Size of premaxillary foramen: right and left subequal (0); right much larger than left (1) (Messenger and McGuire, 1998 [1415]; Murakami et al. 2012a, b [53]; modified from Geisler and Sanders, 2003 [70]; Geisler et al., 2011 [70], 2012 [70]).

(54) Position of premaxillary foramen: anterior of antorbital notch and anterior edge of supraorbital process (0); approximately medial to or posterior to antorbital notch region (1) (Geisler and Sanders, 2003 [71]; Geisler et al., 2011 [71], 2012 [71]; Murakami et al. 2012a, b [54]).

(55) *Posterolateral sulcus: deep (0); shallow or absent (1); posterior part of sulcus covered by premaxilla (2); presence of additional posterolateral sulcus or changing into longitudinal striation (3)* (modified from Murakami et al. 2012a, b [55];

Muizon, 1984, 1988; Lambert, 2008 [6]; Geisler and Sanders, 2003 [72]; Geisler et al., 2011 [72], 2012 [72]). Ontogenic stages in extant phocoenids indicate that a longitudinal striation of premaxillary eminence is homologous to the posterolateral sulcus.

(56) Premaxillae: contact both nasals (0); at least one not contacting nasals (1) (Murakami et al. 2012a, b [56]; modified from Arnold and Heinsohn, 1996 [35]).

(57) Posterior dorsal infraorbital foramina: absent (0); one (1); two or more (2) (Murakami et al. 2012a, b [57]; modified from Barnes, 1990; Geisler and Sanders, 2003 [75]; Geisler et al., 2011 [75], 2012 [75]).

(58) One of posterior dorsal infraorbital foramen placed posteromedially, near posterior extremity of premaxilla: absent (0); present (1) (Fordyce, 1994 [62]; Lambert, 2005 [13]; Murakami et al. 2012a, b [58]).

(59) Premaxillary sac fossae: absent (0); present (1) (Messenger and McGuire, 1998 [1411]; Lambert, 2005 [4]; Murakami et al. 2012a, b [59]).

(60) Ascending processes of maxillae: covering most of frontals, except vertex (0); covering most of frontals and reaching medial than lateral most part of frontals at vertex (1); covering most of frontals, except vertex and region below the vertex (2); frontals partly exposed between ascending processes of maxillae and nuchal crest (3) (Murakami et al. 2012a, b [60]; modified from Muizon, 1991, 1994; Geisler and Sanders, 2003 [129]; Geisler et al., 2011 [129], 2012 [129]).

(61) Maxillae at anterior edge of supraorbital processes: abutting anterior edge of supraorbital processes of frontals (0); covering partially or almost completely surface of supraorbital processes (1) (Murakami et al. 2012a, b [61]; modified from Fordyce, 1994 [3]; Messenger and McGuire, 1998 [1419]; Geisler and Sanders, 2003 [76]; Geisler et al., 2011 [76], 2012 [76]; derived from Miller, 1923).

(62) Lateral edge of antorbital process of maxilla: equal in thickness or thicker than posterior to antorbital process of maxilla but lower than premaxilla at rostrum (0); thicker than posterior to antorbital process of maxilla and higher than premaxilla at rostrum (1); same as state 1, but with thicker part of maxilla continuing to posterior of postorbital process (2); same as state 1, but compressed laterally and higher than premaxilla at rostrum (3) (Murakami et al. 2012a, b [62]; modified from Geisler and Sanders, 2003 [78]; Geisler et al., 2011 [78], 2012 [78]).

(63) Pneumatic maxillary crest overhanging medially: absent (0); present (1) (Zhou, 1982; Heyning, 1989 [26], 1997 [58]; Fordyce, 1994 [66]; Arnold and Heinsohn, 1996 [14]; Messenger and McGuire, 1998 [1421]; Murakami et al. 2012a, b [63]).

(64) Maxillary ridges on supraorbital process of maxilla: longitudinal ridges absent

except at lateral edge of antorbital process (0); presence of longitudinal ridge except at lateral edge of antorbital process (1); longitudinal ridge present and joined with maxillary flange (2); presence of transversely compressed high crest, except at lateral edge of antorbital process (3) (Murakami et al. 2012a, b [64]; modified from Muizon, 1984, 1987; Barnes, 1985b; Messenger and McGuire, 1998 [1420]; Geisler and Sanders, 2003 [79]; Geisler et al., 2011 [79], 2012 [79]; derived from Miller, 1923).

(65) Anterior edge of nasals: anterior to, or in line with, anterior edges of supraorbital processes of frontals (0); posterior to anterior edges of supraorbital processes of frontals (1) (Murakami et al. 2012a, b [65]; modified from Geisler and Sanders, 2003 [80]; Geisler et al., 2011 [80], 2012 [80]).

(66) Premaxillae: separated anterior to external bony nares, exposing mesethmoid (0); joined premaxillae (or maxillae) closing at least posterior part of mesorostral groove (1) (Lambert, 2005 [3]; Murakami et al. 2012a, b [66]).

(67) Bony nares: V-shaped, premaxillae gradually converging anteriorly to midline (0); U-shaped, premaxillae abruptly converging anteriorly to midline (1) (Muizon, 1988; Geisler and Sanders, 2003 [81]; Geisler et al., 2011 [81], 2012 [81]; Murakami et al. 2012a, b [67]).

(68) Fossa for inferior vestibule on maxilla lateral to external nares or lateral to premaxilla: absent (0); present (1) (Muizon, 1988; Murakami et al. 2012a, b [68]; derived from Curry, 1992).

(69) Medial maxilla-premaxilla suture or accessory occicles anterior to external nares: absent (0); present (1) (Muizon, 1984, 1988; Arnold and Heinsohn, 1996 [24]; Messenger and McGuire, 1998 [1422]; Murakami et al. 2012a, b [69]).

(70) Premaxillary crest or posterior maxillary crest adjacent to nasal: absent (0); present (1) (transverse premaxillary crest, sensu Lambert, 2005 [6]; Murakami et al. 2012a, b [70]).

(71) Premaxilla: not overhanging itself or maxilla laterally (0); overhanging itself or maxilla laterally, from anterior to midpoint of external nares (1*)* (Murakami et al. 2012a, b [71]).

(72) Premaxillary sac fossa: smooth (0); rugose (1) (Messenger and McGuire, 1998 [1551]; Murakami et al. 2012a, b [72]).

(73) Ratio of width of right premaxilla to width of left premaxilla in line with midpoint of external nares: 0.90–1.19 (0); 1.20–1.50 (1); 1.50> (2) (Murakami et al. 2012a, b [73]).

(74) Ratio of greatest width of premaxillae to greatest width of maxillae at level of

postorbital processes: ≥0.50 (0); 0.49–0.38 (1); <0.38 (2) (Murakami et al. 2012a, b [74]).

(75) Premaxillary eminence: absent (0); present but low (1); present and high (2) (Lambert, 2008 [4]; Murakami et al. 2012a, b [75]; modified from Muizon, 1984; Barnes, 1985a; Heyning, 1989 [36], 1997 [68]; Arnold and Heinsohn, 1996 [12]; Messenger and McGuire, 1998 [1410]; Geisler and Sanders, 2003; [68]; Fajardo-Mellor et al., 2006 [2]; Geisler et al., 2011 [68], 2012 [69]; derived Flower, 1867; Noble and Fraser, 1971).

(76) Posterior projections of premaxillae: both premaxillae extending posterior to anterior tip of nasals (0); both premaxillae extending posterior to nasals (1); only right premaxillae extended posterior to nasal (2); neither premaxillae extending posterior to external nares, and narrow posterior end of premaxillae adjacent to external nares (3); neither premaxillae extending beyond external nares, and premaxillae displaced laterally by medial projection of maxilla (4); only right premaxilla extending beyond or in line with anterior-most portion of nasals (5) (Murakami et al. 2012a, b [76]; modified from Muizon 1984; Barnes, 1985a; Heyning, 1989 [39, 42], 1997 [63, 71, 74]; Arnold and Heinsohn, 1996 [35]; Messenger and McGuire, 1998 [1407, 1408]; Fajardo-Mellor et al., 2006 [3]; Lambert, 2008 [5]).

(77) Right premaxilla: portion anterior to nasal opening wider than portion posterior to opening, with nasal septum angled anteriorly and to left (0); portion posterior to nasal opening wider than portion anterior to opening, with nasal septum angled anteriorly and to right (1) (Geisler and Sanders, 2003; [86]; Geisler et al., 2011 [86], 2012 [86]; Murakami et al. 2012a, b [77]).

(78) Left external bony nares: same size as right external bony nares (0); at least twice the size of right external bony nares (1) (Barnes, 1990; Geisler and Sanders, 2003 [87]; Geisler et al., 2011 [87], 2012 [87]; Murakami et al. 2012a, b [78]).

(79) Supracranial basin: absent (0); present (1) (Heyning, 1989 [8], 1997 [40]; Fordyce, 1994 [18]; Messenger and McGuire, 1998 [1400]; Geisler and Sanders, 2003 [88]; Lambert, 2005 [10]; Geisler et al., 2011 [88], 2012 [88]; Murakami et al. 2012a, b [79]).

(80) Proximal ethmoid region: not visible in dorsal view, roofed over by nasals (0); exposed dorsally (1) (Messenger and McGuire, 1998 [1455]; Geisler and Sanders, 2003 [92]; Geisler et al., 2011 [92], 2012 [92]; Murakami et al. 2012a, b [80]; derived from Miller, 1923).

(81) Mesethmoid: not expanded posterodorsally (0); extended posterodorsally but

narrow (1); expanded posterodorsally and visible in lateral view (2) (Murakami et al. 2012a, b [81]; modified from Muizon, 1984, 1988; Messenger and McGuire, 1998 [1454]; Bianucci, 2005 [9]).

Vertex and Area Adjacent to the Nares

(82) Inflections of ascending processes of premaxillae: gradual, with premaxillae in dorsal view smoothly tapering as premaxillae shift from horizontal to mostly vertical (0); abrupt, with anterior splint of maxilla emerging from posterior edge of premaxilla and splitting into posterolateral plate and posteromedial splint (1) (Geisler and Sanders, 2003 [107]; Geisler et al., 2011 [107], 2012 [107]; Murakami et al. 2012a, b [82]; derived from Fordyce, 1994).

(83) Inflections of premaxillae just anterior to, or in line with, anterior edge of supraorbital processes of frontals: absent (0); present (1) (Murakami et al. 2012a, b [83]; modified from Geisler and Sanders, 2003 [108]; Geisler et al., 2011 [108], 2012 [108]).

(84) Premaxillary cleft: absent (0); present, posterior part of ascending processes of premaxillae bearing a distinct cleft, originating at posterior edge of premaxillae and continuing anteriorly, dividing each premaxilla into two (1); present, with shallow cleft (2) (Geisler and Sanders, 2003 [109]; Geisler et al., 2011 [109], 2012 [109]; Murakami et al. 2012a, b [84]).

(85) Nasal bones: two (0); one or zero (1) (Heyning, 1989 [9], 1997 [41]; Murakami et al. 2012a, b [85]; modified from Messenger and McGuire, 1998 [1431]; Geisler and Sanders, 2003 [113]; Geisler et al., 2011 [113], 2012 [113]; derived from Küzmin, 1977).

(86) Nasals: lower than frontals (0); nearly same height as frontals (1); clearly higher than frontals (2) (Muizon, 1988; Messenger and McGuire, 1998 [1434]; Geisler and Sanders, 2003; [124]; Geisler et al., 2011 [124], 2012 [124]; Murakami et al. 2012a, b [86]).

(87) Nasal protuberance: absent (0); present (1) (Muizon, 1988; Messenger and McGuire, 1998 [1433]; Fajardo-Mellor et al., 2006 [7]; Lambert, 2008 [8]; Murakami et al. 2012a, b [87]).

(88) Both nasals: straight anterior edges in one transverse plane (0); with point on midline and gap on each side between premaxilla and nasal (1); concave posteriorly on midline and gap on each side between premaxilla and nasal (2); concave posteriorly on midline (3) (Murakami et al. 2012a, b [88]; modified from Geisler and Sanders, 2003 [116]; Geisler et al., 2011 [116], 2012 [116]; derived from

Moore, 1968).

(89) Nasals: fossae on nasals absent (0); smooth-surfaced fossa on anterior to anterolateral surface (1) (Messenger and McGuire, 1998 [1437]; Murakami et al. 2012a, b [89]).

(90) Transverse width of either of nasals as percent maximum length of nasals: very narrow, <20% (0); narrow, 21–69% (1); wide, >70% (2) (Murakami et al. 2012a, b [90]; modified from Muizon, 1988; Messenger and McGuire, 1998 [1432]; Geisler and Sanders, 2003; [119]; Geisler et al., 2011 [119], 2012 [119]).

(91) Nasals: medial portions roughly in same horizontal plane as, or higher than, lateral portions (0); medial portions depressed, forming a median trough immediately posterior to nasal openings (1) (Muizon, 1988, 1991; Geisler and Sanders, 2003; [118]; Geisler et al., 2011 [118], 2012 [118]; Murakami et al. 2012a, b [91]).

(92) Lateral edges of nasals: not overhanging or covering maxillae or premaxillae (0); overhanging or partly covering maxillae or premaxillae (1) (Murakami et al. 2012a, b [92]).

(93) Nasal-frontal suture: approximately straight transversely (0); anterior wedge between frontal posterior ends of nasals (1); W or reversed U suture line (2) (Murakami et al. 2012a, b [93]; modified from Muizon, 1988; Geisler and Sanders, 2003 [121]; Geisler et al., 2011 [121], 2012 [121]).

(94) Frontals posterior to nasals and between premaxillae: wider than maximum transverse width across nasals (0); same as transverse width of nasals (1); narrower than transverse width of nasals, maxillae expanded medially posterior to nasals (2) (Geisler and Sanders, 2003 [125]; Geisler et al., 2011 [125], 2012 [125]; Murakami et al. 2012a, b [94]; modified from Messenger and McGuire, 1998 [1457]).

(95) Frontal boss on vertex: absent (0); present (1) (Muizon, 1984, 1988; Messenger and McGuire, 1998 [1461]; Fajardo-Mellor et al., 2006 [12]; Murakami et al. 2012a, b [95]; modified from Lambert, 2008 [9]).

(96) Synvertex: absent (0); present (1); highly developed (2) (Murakami et al. 2012a, b [96]; modified from Muizon, 1991; Messenger and McGuire, 1998 [1404]; Lambert, 2005 [7]).

(97) Cranial vertex skewed asymmetrically to left side: absent (0); present (1) (Barnes, 1990; Bianucci, 2005 [7]; Aguirre-Fernandez et al., 2009 [18]; Murakami et al. 2012a, b [97]).

(98) Anterodorsal wall of braincase: formed by frontals (0); mostly formed by maxillae (1) (Geisler and Sanders, 2003 [127]; Geisler et al., 2011 [127], 2012 [127]; Murakami et al. 2012a, b [98]; derived from Schulte, 1917; Miller, 1923).

(99) Nuchal crest: higher than frontals and/or nasals (0); at same level as frontals and/or nasals (1); below frontals and/or nasals (2) (Murakami et al. 2012a, b [99]; modified from Geisler and Sanders, 2003 [128]; derived from Moore, 1968).

Temporal Fossae, Zygomatic Arch, and Occipitals

(100) Temporal fossa: not roofed over by lateral expansion of maxillae (0); roofed over by lateral expansion of maxillae (1) (Muizon, 1988; Heyning, 1989 [22], 1997 [54]; Arnold and Heinsohn, 1996 [39]; Messenger and McGuire, 1998 [1453]; Murakami et al. 2012a, b [100]).

(101) Roof of temporal fossa: frontals (0); frontals, but with large opening through maxillae and/or premaxillae exposing margins of window formed by a frontal ring (1) (Geisler and Sanders, 2003 [132]; Geisler et al., 2011 [132], 2012 [132]; Murakami et al. 2012a, b [101]).

(102) Position and orientation of origin for temporal muscle on supraorbital process of frontal: origin laying on posterior face of supraorbital process and directed roughly posteriorly (0); origin lying on posteroventral face of supraorbital process and directed roughly ventrally (1) (Fordyce, 1994 [8]; Lambert, 2005 [23]; Murakami et al. 2012a, b [102]).

(103) Parietal: not fused to any bone (0); completely fused to, and indistinguishable from, frontal or supraoccipital (1) (Murakami et al. 2012a, b [103]).

(104) Parietals in dorsal view: contacting each other on the midline or separated by interparietal (0); in skull roof but visible only as small triangular areas at edges of intertemporal constriction, with supraoccipital overlapping and obscuring median portions (1); completely absent in skull roof (2); visible only as triangular areas, dorsolateral to supraoccipital, with non-overlapping supraoccipital separated from and contacting parietals along irregular suture (3) (Geisler and Sanders, 2003 [134]; Geisler et al., 2011 [134], 2012 [134]; Murakami et al. 2012a, b [104]; derived from Whitmore and Sanders, 1977; Barnes, 1990; modified from Lambert, 2005 [15]).

(105) Interparietal: present (0); absent or fused and therefore not distinguishable from parietals and frontals (1) (Geisler and Sanders, 2003 [135]; Geisler et al., 2011 [135], 2012 [135]; Murakami et al. 2012a, b [105]).

(106) Sagittal crest for temporal muscle: present (0); absent (1) (Murakami et al. 2012a, b [106]; modified from Geisler and Sanders, 2003 [136]; Geisler et al., 2011 [136], 2012 [136]).

(107) Alisphenoid: broadly exposed laterally in temporal fossa (0); lateral surface broadly overlapped by parietal, with a narrow strip visible or invisible on ventral

edge of temporal fossa in lateral view (1) (Geisler and Sanders, 2003 [141]; Geisler et al., 2011 [141], 2012 [141]; Murakami et al. 2012a, b [107]).

(108) Zygomatic process of squamosal: directed anterolaterally (0); directed anteriorly (1) (Sanders and Barnes, 2002; Geisler and Sanders, 2003 [142]; Geisler et al., 2011 [142], 2012 [142]; Murakami et al. 2012a, b [108]).

(109) Zygomatic process of squamosal: part of dorsal face visible in lateral view, or sternomastoid fossa extending more than one quarter the length of zygomatic process of squamosal (0); entire dorsal surface of squamosal visible in lateral view, and sternomastoid fossa more than one quarter the length of zygomatic process of squamosal (1) (Murakami et al. 2012a, b [109]).

(110) Emargination of posterior edge of zygomatic process by sternomastoid muscle fossa, skull in lateral view: absent, posterior edge forming nearly right angle with dorsal edge of zygomatic process of squamosal (0); shallow emargination (1); deep emargination (2) (Geisler and Sanders, 2003 [144]; Geisler et al., 2011 [144], 2012 [144]; Murakami et al. 2012a, b [110]).

(111) Width of squamosal lateral to exoccipital as percent greatest width of exoccipitals, skull in posterior view: exposed portion of squamosal narrow, <15% (0); moderate, 16–35% (1) (Geisler and Sanders, 2003 [145]; Geisler et al., 2011 [145], 2012 [145]; Murakami et al. 2012a, b [111]).

(112) Ventral edge of zygomatic process of squamosal in lateral view: concave (0); almost straight (1); convex (2) (Geisler and Sanders, 2003; [150]; Geisler et al., 2011 [150], 2012 [150]; Murakami et al. 2012a, b [112]).

(113) Retroarticular process of squamosal: not reduced (0); greatly reduced (1) (Murakami et al. 2012a, b [113]).

(114) Retroarticular process in lateral view: tapering ventrally (0); squared off ventrally (1); same as state 1 except very wide anteroposterior diameter of process (2) (Geisler and Sanders, 2003 [151]; Lambert, 2005 [24]; Geisler et al., 2011 [151], 2012 [151]; Murakami et al. 2012a, b [114]; derived from Muizon, 1991).

(115) Relative ventral projections of retroarticular and post-tympanic processes of squamosal: retroarticular process more ventral or at same level as post-tympanic process (0); apex of retroarticular process higher than post-tympanic process (1) (Lambert, 2005 [25]; Murakami et al. 2012a, b [115]).

(116) Nuchal crest in dorsoposterior view: semicircular, pointed anteriorly (0); rectangular or weakly convex anteriorly or posteriorly (1); convex posteriorly and/or midpoint convex triangular and pointed anteriorly (2); prominently convex anteriorly (3)*; prominently convex posteriorly (4)* (Murakami et al. 2012a, b [116];

modified from Geisler and Sanders, 2003; [152]; Geisler et al., 2011 [152], 2012 [152]; derived from Barnes, 1985b). State (4) was added to the original character description of Murakami et al. (2012a, b).

(117) Occipital shield: smoothly convex or concave (0); bearing distinct sagittal crest (1) (Sanders and Barnes, 2002; Geisler and Sanders, 2003 [155]; Geisler et al., 2011 [155], 2012 [155]; Murakami et al. 2012a, b [117]).

(118) Dorsal condyloid fossa: absent (0); present, situated anterodorsal to dorsal edge of condyle (1); present and forming deep pit (2) (Geisler and Sanders, 2003 [156]; Geisler et al., 2011 [156], 2012 [156]; Murakami et al. 2012a, b [118]; derived from Sanders and Barnes, 2002).

Anterior Basicranium

(119) Palatine: thin, forming posterior part of nasal cavity (0); thick, forming part of anterior wall of nasal cavities (1); maxilla does not join anterior wall of nasal cavities (2) (Murakami et al. 2012a, b [119]; modified from Geisler and Sanders, 2003; [158]; Geisler et al., 2011 [158], 2012 [158]; derived from Miller, 1923).

(120) Palatine: exposed ventrally (0); partially covered by pterygoid, which divides it into medial and lateral exposures (1); ventral surfaces completely covered by pterygoids (2) (Muizon, 1987; Arnold and Heinsohn, 1996 [15]; Messenger and McGuire, 1998 [1440]; Geisler and Sanders, 2003 [159]; Lambert, 2005 [27]; Geisler et al., 2011 [159], 2012 [159]; Murakami et al. 2012a, b [120]; derived from Miller, 1923).

(121) Lateral lamina of palatine: absent (0); present (1) (Muizon, 1984, 1988, 1991; Arnold and Heinsohn, 1996 [16]; Messenger and McGuire, 1998 [1443]; Murakami et al. 2012a, b [121]).

(122) Lateral lamina of palatine: free from or sutured to maxilla (0); fused to maxilla (1) (Muizon, 1988; Messenger and McGuire, 1998 [1439]; Geisler and Sanders, 2003 [161]; Geisler et al., 2011 [161], 2012 [161]; Murakami et al. 2012a, b [122]).

(123) Lateral lamina of palatine: do not form bony bridge over orbit; form bony bridge over orbit (1) **(**Muizon, 1984; Messenger and McGuire, 1998 [1444]; Murakami et al. 2012a, b [123]).

(124) Pterygoids in anteroventral view: separated from each other by posteroventrally elongated palatines and/or vomer (0); contacting entire length of hamular process (1); contacting each other partially (2) (Murakami et al. 2012a, b [124]; modified from Arnold and Heinsohn, 1996 [5]; Messenger and McGuire, 1998 [1445]; Fajardo-Mellor et al., 2006 [9]; derived from Flower, 1883; Barnes, 1985a; Marsh

et al., 1989).

(125) Medial pterygoid-palatine suture in ventral view: angled anteromedially (0); nearly transverse (1); angled anterolaterally (2); angled anteroposteriorly (3) (Murakami et al. 2012a, b [125]; modified from Geisler and Sanders, 2003 [162]; Geisler et al., 2011 [162], 2012 [162]).

(126) Lateral lamina of pterygoid: absent (0); present and articulated with alisphenoid (1); partial, restricted to region lateral to hamular process (2) (Murakami et al. 2012a, b [126]; modified from Arnold and Heinsohn, 1996 [13]; Messenger and McGuire, 1998 [1446]; Geisler and Sanders, 2003 [164]; Lambert, 2005 [32]; Geisler et al., 2011 [164], 2012 [164]; derived from Miller, 1923; Kellogg, 1936; Fraser and Purves, 1960).

(127) Subtemporal crest: present (0); present but reduced, or absent (1) (Geisler and Sanders, 2003 [165]; Geisler et al., 2011 [165], 2012 [165]; Murakami et al. 2012a, b [127]).

(128) Superior lamina of pterygoid: absent from sphenoidal region but present in orbital region (0); present and covers most of ventral exposure of alisphenoid (1); partially absent from orbital region (2); completely absent from orbital region (3) (Murakami et al. 2012a, b [128]; modified from Arnold and Heinsohn, 1996 [16]; Geisler and Sanders, 2003 [167]; Geisler et al., 2011 [167], 2012 [167]; derived from Miller 1923; Fraser and Purves, 1960).

(129) Pterygoids excavated anterior to choanae by the pterygoid sinuses, with distinct anterior fossa clearly limited forwards by rounded wall: absent (0); present (1) (Lambert, 2005 [28]; Murakami et al. 2012a, b [129]).

(130) Depth of pterygoid sinus fossa in basicranium: shallow or partially excavated (0); deep, excavated dorsally to level of cranial foramen oval (1); deep, and extended dorsally into orbit (2) (modified from Fordyce, 1994 [6]; Lambert, 2005 [30]; Murakami et al. 2012a, b [130]).

(131) Anterior level of pterygoid sinus fossa: interrupted posterior to, or the level of, antorbital notch (0); extending beyond the level of the antorbital notch (1) (Lambert, 2005 [29]; Murakami et al. 2012a, b [131]).

(132) Preorbital and postorbital lobes of pterygoid sinuses: widened apices of preorbital and postorbital lobes of pterygoid sinuses, without fusion of lobes (0); widened and fused apices of preorbital and postorbital lobes of pterygoid sinuses, to insert optic nerve (1) (Murakami et al. 2012a, b [132]; modified from Muizon, 1988; Arnold and Heinsohn, 1996 [19]; Bianucci, 2005 [10]; Aguirre-Fernandez et al., 2009 [19]).

(133) Preorbital lobe of pterygoid sinus fossa in the basicranium: absent (0); present (1) (Fraser and Purves, 1960; Arnold and Heinsohn, 1996 [18]; Murakami et al. 2012a, b [133]). *Platanista* is coded 0; although the preorbital lobe of the pterygoid sinus is developed in *Platanista*, because preorbital lobe of pterygoid sinus "fossa" in the basicranium is absent in *Platanista*.

(134) Dorsal development of fossa for preorbital lobe of pterygoid sinus toward the frontal-maxilla suture: absent (0); present (1) (Muizon, 1984, 1988; Heyning, 1989 [37], 1997 [69]; Messenger and McGuire, 1998 [1460]; Arnold and Heinsohn, 1996 [20]; Lambert, 2008 [13]; Murakami et al. 2012a, b [134]; modified from Fajardo-Mellor et al., 2006 [13]; derived from Fraser and Purves, 1960).

(135) Postorbital lobe of pterygoid sinus fossa: absent (0); present (1) (Arnold and Heinsohn, 1996 [18]; Geisler and Sanders, 2003 [170]; Geisler et al., 2011 [170], 2012 [170]; Murakami et al. 2012a, b [135]; derived from Fraser and Purves, 1960).

(136) Anteroposteriorly elongated pterygoid sinus fossa, at level of orbit, bordered by mediolaterally compressed subtemporal crest of frontal: absent (0); present (1) (Murakami et al. 2012a, b [136]).

(137) Orbitosphenoid: not contacting lacrimal (0); contacting lacrimal (1) (Murakami et al. 2012a, b [137]).

(138) Ratio of length of hamular process of pterygoid to neurocranium length: <0.30 (0); 0.30–0.44 (1); 0.45–0.59 (2); >0.60 (3). The length of the hamular process of the pterygoid is measured from anterior edge of the pterygoid to posterior edge of the hamular process. The neurocranium length is measured from anterior edge of the antorbital process to posterior edge of occipital condyles (Murakami et al. 2012a, b [138]; modified from Heyning, 1989 [18], 1997 [50]; Muizon, 1991; Messenger and McGuire, 1998 [1447]; Lambert, 2005 [31]).

(139) Well-developed hamular crest: absent (0); present (1) (Muizon, 1988; Messenger and McGuire, 1998 [1449]; Bianucci, 2005 [14]; Murakami et al. 2012a, b [139]; modified from Fajardo-Mellor et al., 2006 [10]).

(140) Exposure of medial lamina of pterygoid hamuli in lateral view: complete or broad exposure due to extreme reduction of lateral lamina of pterygoid hamuli (0); no exposure due to a posterior extension of lateral lamina extending posterior to medial lamina (1); medial lamina of pterygoid hamuli exposing lateral lamina through ovoid window in lateral view (2) (Muizon, 1988; Fajardo-Mellor et al., 2006 [11]; Murakami et al. 2012a, b [140]; derived from Noble and Fraser, 1971).

Posterior Basicranium

(141) Falciform process of squamosal: plate-like with anteroposteriorly wide base (0); rod-like with narrow base (1); poorly developed or absent (2) (Geisler and Sanders, 2003 [176]; Geisler et al., 2011 [176], 2012 [176]; Murakami et al. 2012a, b [141]; modified from Lambert, 2005 [36]).

(142) Falciform process of squamosal: medial surface not sutured to lateral lamina of pterygoid (0); medial surface sutured to lateral lamina of pterygoid (1) (Murakami et al. 2012a, b [142]; modified from Geisler and Sanders, 2003 [177]; Geisler et al., 2011 [177], 2012 [177]).

(143) Tympanosquamosal recess: absent (0); present, but small rectangular fossa for sigmoid process of tympanic bulla (1); present and enlarged, forming triangular fossa medial and anteromedial to postglenoid process (2); very large, forming large fossa bordering entire medial edge of glenoid fossa (3) (Geisler and Sanders, 2003 [178]; Geisler et al., 2011 [178], 2012 [178]; Murakami et al. 2012a, b [143]; modified from Lambert, 2005 [35]; derived from Fraser and Purves, 1960).

(144) Bifurcation of tympanosquamosal recess: absent, almost undeveloped, pubic, or elliptic (0); present (1) (Murakami et al. 2012a, b [144]; modified from Muizon, 1988; Bianucci, 2005 [11]; Aguirre-Fernandez et al., 2009 [20]).

(145) Fossa for the basisphenoidal sinus: absent (0); present (1) (Fraser and Purves, 1960; Mead and Fordyce, 2009; Murakami et al. 2012a, b [145]).

(146) Position of alisphenoid-squamosal suture, with skull in ventral view: anterior to external opening of foramen oval or a homologous groove (0); courses along groove for mandibular branch of trigeminal nerve, or just posterior to it (1); just medial to anterior edge of floor of squamosal fossa, foramen oval, and/or groove situated entirely on alisphenoid (2) (Geisler and Sanders, 2003 [180]; Geisler et al., 2011 [180], 2012 [180]; Murakami et al. 2012a, b [146]).

(147) Groove for mandibular branch of trigeminal nerve: lateral end of groove wrapping laterally around posterior end of pterygoid sinus fossa and opening primarily anteriorly (0); directed laterally and located entirely posterior to pterygoid sinus fossa (1) (Murakami et al. 2012a, b [147]; modified from Geisler and Sanders, 2003 [181]; Geisler et al., 2011 [181], 2012 [181]).

(148) Periotic fossa: bowl-shaped (0); having transverse ridge, dividing periotic fossa into anterior and posterior portions (1) (Geisler and Sanders, 2003 [184]; Geisler et al., 2011 [184], 2012 [184]; Murakami et al. 2012a, b [148]).

(149) Suprameatal pit of squamosal: absent (0); present but shallow, situated dorsolateral to spiny process of squamosal (1); forming deep dorsolateral excavation into squamosal (2) (Geisler and Sanders, 2003 [185]; Geisler et al., 2011

[185], 2012 [185]; Murakami et al. 2012a, b [149]).

(150) Foramen spinosum: absent (0); present, located in anteromedial corner of anterior part of periotic fossa near or on squamosal-parietal suture (1) (Muizon, 1994; Geisler and Sanders, 2003 [186]; Geisler et al., 2011 [186], 2012 [186]; Murakami et al. 2012a, b [150]).

(151) Posterior portion of periotic fossa: fossa absent (0); fossa present but shallow (1); highly compressed fossa forming narrow slit or small blind foramen (2); posteromedial portion contains large deep fossa (3) (Geisler and Sanders, 2003 [187]; Geisler et al., 2011 [187], 2012 [187]; Murakami et al. 2012a, b [151]).

(152) Length of zygomatic process of squamosal as percent of greatest width of maxilla at postorbital process: >31% (0); ≤30% (1) (Murakami et al. 2012a, b [152]; modified from Heyning, 1989 [33, 35], [65, 67]; Geisler and Sanders, 2003 [188]; Geisler et al., 2011 [188], 2012 [188]). If the maxilla does not reach above the postorbital process, then use the frontal above the postorbital process.

(153) External auditory meatus: wide (0); narrow (1) (Fordyce, 1994 [10]; Geisler and Sanders, 2003 [189], 2012 [189]; Lambert, 2005 [26]; Geisler et al., 2011 [189]; Murakami et al. 2012a, b [153]).

(154) Vomer: posterior edge terminating on or at anterior edge of basisphenoid (0); terminating on basioccipital, covering basioccipital-basisphenoid suture ventrally (1) (Barnes, 1984b; Geisler and Sanders, 2003 [190]; Geisler et al., 2011 [190], 2012 [190]; Murakami et al. 2012a, b [154]).

(155) Rectus capitus anticus muscle fossa: absent or poorly developed (0); present with well-defined anterior edge (1) (Geisler and Sanders, 2003 [192]; Geisler et al., 2011 [192], 2012 [192]; Murakami et al. 2012a, b [155]).

(156) Posteroventral-most point of basioccipital crest: rounded over (0); forming closely appressed separate flange, with narrow crease separating it dorsally from rest of basioccipital crest (1); projecting distinct flange posteriorly (2); distinct but separated by pronounced notch, interrupting basioccipital crest (3) (Geisler and Sanders, 2003 [193]; Geisler et al., 2011 [193], 2012 [193]; Murakami et al. 2012a, b [156]).

(157) Angle formed by basioccipital crests in ventral view: parallel with no angle formed (0); ca. 15–40° (1); ca. 42–68° (2); ca. 70–90° (3); >100° (4) (Murakami et al. 2012a, b [157]; modified from Geisler and Sanders, 2003 [194]; Geisler et al., 2011 [194], 2012 [194]).

(158) Hypoglossal foramen: separated from jugular foramen, or jugular notch, by thick bone (0); separated by very thin bone or absent, in latter case hypoglossal foramen

becoming confluent with jugular foramen (1) (Geisler and Sanders, 2003 [195]; Geisler et al., 2011 [195], 2012 [195]; Murakami et al. 2012a, b [158]).

(159) Jugular notch, gap between paroccipital process and basioccipital crest: opening notch, width of opening and depth of notch about equal (0); narrow and almost slit-like, depth much greater than width of opening (1) (Geisler and Sanders, 2003 [196]; Geisler et al., 2011 [196], 2012 [196]; Murakami et al. 2012a, b [159]).

(160) Paroccipital process, skull in ventral view: posterior edge located well anterior to the posterior edge of condyle (0); posterior edge in transverse line with posterior edge of condyle (1) (Geisler and Sanders, 2003 [197]; Geisler et al., 2011 [197], 2012 [197]; Murakami et al. 2012a, b [160]).

(161) Fossa for posterior sinus of exoccipital: absent or slightly concave (0); moderately concave (1); forming deep sack-like structure (2) (Murakami et al. 2012a, b [161]; modified from Muizon, 1991; Lambert, 2005 [38]).

Malleus

(162) Tuberculum of malleus: unreduced (0); highly reduced, almost indistinguishable from articular head (1) (Muizon, 1985; Messenger and McGuire, 1998 [1499]; Geisler and Sanders, 2003 [198]; Geisler et al., 2011 [198], 2012 [198]; Murakami et al. 2012a, b [162]; modified from Lambert, 2005 [69]. derived from Doran, 1876).

(163) Processus muscularis of malleus: shorter than manubrium of malleus (0); sub-equal or longer than manubrium (1) (Murakami et al. 2012a, b [163]; modified from Muizon, 1985, 1988; Messenger and McGuire, 1998 [1550]; Geisler and Sanders, 2003 [199]; Lambert, 2005 [70]; Geisler et al., 2011 [199], 2012 [199]).

Periotic

(164) In ventral view, length of anterior process of periotic anterior to cochlear portion as percent length of cochlear portion: short, <59% (0); long, >60% (1) (Murakami et al. 2012a, b [164]; modified from Muizon, 1988; Heyning, 1989 [5]; Messenger and McGuire, 1998 [1489]; Geisler and Luo, 1996 [1]; Luo and Marsh, 1996 [24]; Geisler and Sanders, 2003 [203]; Lambert, 2005 [39]; Geisler et al., 2011 [203], 2012 [203]; derived from Kellogg, 1936; Yamada, 1953; Kasuya, 1973).

(165) Apex of anterior process of periotic in dorsal view: pointed (0); dorsal edge of anterior process showing highly rounded or oblique edge due to its reduction with or without pointed apex (1); thickened by prominent dorsal tubercle giving apex rectangular section in plane of body of periotic (2) (Murakami et al. 2012a, b [165];

modified from Fordyce, 1994 [53]; Lambert, 2005 [40]).

(166) Lateral groove or depression affecting profile of periotic as viewed dorsally: no obvious vertical groove dorsal to hiatus epitympanicus (0); groove present with overall profile of periotic becoming slightly to markedly sigmoidal in dorsal view (1) (Fordyce, 1994 [35]; Murakami et al. 2012a, b [166]).

(167) Anterior process of periotic: anteroposterior ridge undeveloped (0); anteroposterior ridge developed dorsally on anterior process and body of periotic, associated with development of depression adjacent to groove for tensor tympani (1) (Fordyce, 1994 [55]; Murakami et al. 2012a, b [167]).

(168) Articulation of anterior process of periotic to outer lip (= processus tubarius) of tympanic bulla: contact of ventral surface of anterior process of periotic with outer lip of tympanic bulla (0); contact with thickened rim of outer lip of tympanic bulla and additionally with accessory ossicle (1); contact only with accessory ossicle (2) (Luo and Marsh, 1996 [7]; Lambert, 2005 [46]; Murakami et al. 2012a, b [168]).

(169) Lateral tuberosity of periotic separated from anterior process by marked transverse groove (part of antero-external sulcus) in lateral view: presence of groove (0); absence of groove, lateral tuberosity continuous with anterior process (1) (Lambert, 2005 [47]; Murakami et al. 2012a, b [169]).

(170) Lateral tuberosity of periotic in ventral view: short, narrow, and poorly individualized lateral tuberosity (0); tuberosity thickened, well developed laterally with an exposed ventral surface distinctly larger than mallear fossa (1) (Lambert, 2005 [48]; Murakami et al. 2012a, b [170]).

(171) Parabullary ridge of periotic: thin (0); sturdy (1) (Murakami et al. 2012a, b [171]; modified from Bianucci, 2005 [15]).

(172) Articulation of anterior process with squamosal: extensive, most of lateral side contacting squamosal (0); large centrally-oriented ovoid region contacting squamosal, free around edges (1); small area of contact with squamosal (2); contact absent, articulation via ligaments (3) (Geisler and Sanders, 2003 [207]; Geisler et al., 2011 [207], 2012 [207]; Murakami et al. 2012a, b [172]; modified from Heyning, 1997 [32]; Messenger and McGuire, 1998 [1490]; derived from Heyning, 1989).

(173) Anterior bullar facet: present (0); absent (1) (Muizon, 1984, 1988, 1991; Messenger and McGuire, 1998 [1496]; Lambert, 2005 [42]; Murakami et al. 2012a, b [173]; modified from Fordyce, 1994 [4]; derived from Kellogg, 1936).

(174) Origin of tensor tympani muscle: deep, pocket-like fossa with anterior groove (0); anterior groove only (1) (Geisler and Luo, 1996 [7]; Luo and Marsh, 1996 [15]; Geisler and Sanders, 2003 [217]; Geisler et al., 2011 [217], 2012 [217]; Murakami

et al. 2012a, b [174]).

(175) Fenestra rotunda: oval (0); shaped like teardrop with fissure directed toward perilymphatic foramen (1) (Fordyce, 1994 [22]; Geisler and Sanders, 2003 [222]; Lambert, 2005 [49]; Geisler et al., 2011 [222], 2012 [222]; Murakami et al. 2012a, b [175]).

(176) Dorsal surface of periotic in lateral view: convex dorsally (0); pyramidal process convex dorsally (1); nearly flat (2) (Murakami et al. 2012a, b [176]; modified from Luo and Marsh, 1996 [18]).

(177) Posterodorsal edge of stapedial muscle fossa: ventral to, or in line with, dorsal edge of fenestra rotunda (0); well dorsal to fenestra rotunda (1) (Geisler and Sanders, 2003 [223]; Geisler et al., 2011 [223], 2012 [223]; Murakami et al. 2012a, b [177]).

(178) Stylomastoid fossa: absent or reduced (0); present (1) (Geisler and Luo, 1996 [14]; Geisler and Sanders, 2003 [217]; Geisler et al., 2011 [217], 2012 [217]; Murakami et al. 2012a, b [178]).

(179) Caudal tympanic process of periotic: low, its ventral and posterior edges drawing smooth curve (0); prominent, its ventral and posterior edges forming a right angle in medial view (1) (Geisler and Sanders, 2003 [225]; Geisler et al., 2011 [225], 2012 [225]; Murakami et al. 2012a, b [179]).

(180) Position of aperture for cochlear aqueduct: dorsomedial (0); medial (1) (Lambert, 2005 [51]; Murakami et al. 2012a, b [180]).

(181) Aperture for cochlear aqueduct: smaller than aperture for vestibular aqueduct (0); approximately same size as aperture for vestibular aqueduct (1); much larger than aperture for vestibular aqueduct, with narrow posterior edge (2) (Geisler and Sanders, 2003 [227]; Geisler et al., 2011 [227], 2012 [227]; Murakami et al. 2012a, b [181]; modified from Muizon, 1987; Fordyce, 1994; Lambert, 2005 [52]).

(182) Excavation of dorsal crest at base of anterior process: absent (0); present, with fossa on dorsolateral side of dorsal crest (1) (modified from Geisler and Sanders, 2003 [231]; Geisler et al., 2011 [231], 2012 [231]; Murakami et al., 2012a, b [182]).

(183) Fundus of internal acoustic meatus: funnel-like, smaller at blind end and wider near rim (0); tubular (1) (Luo and Marsh, 1996 [31]; Geisler and Sanders, 2003 [234]; Geisler et al., 2011 [234], 2012 [234]; Murakami et al. 2012a, b [183]).

(184) Internal acoustic meatus: pyriform (0); circular (1) (Muizon, 1984; Messenger and McGuire, 1998 [1498]; Bianucci, 2005 [21]; Murakami et al. 2012 [184]).

(185) Lateral wall of internal acoustic meatus: high, with wedge-shaped area of elevated bone occurring between dorsal edge of dorsal crest and internal acoustic meatus, the

latter extending ventrally and increasing its depth (0); low, not protruding noticeably from suprameatal fossa and surrounding bone (1) (modified from Murakami et al., 2012a, b [185]; Geisler and Sanders, 2003 [235]; Geisler et al., 2011 [235], 2012 [235]).

(186) Aperture for vestibular aqueduct, in dorsal view: at transverse level of spiral cribriform tract foraminosus (0); more lateral than tractus spiralis foraminosus (1) (Lambert, 2005 [53]; Murakami et al., 2012a, b [186]).

(187) Articular rim: absent (0); present but small, forming ridge anterolateral to articulation surface of posterior process of periotic and separated from it by sulcus; ridge fitting into corresponding cavity posterolateral and slightly dorsal to spiny process of squamosal (1); present, sigmoidal and laterally elongated with hook-like process (2) (Geisler and Sanders, 2003 [239]; Geisler et al., 2011 [239], 2012 [239]; Murakami et al. 2012a, b [187]; modified from Muizon, 1987; Messenger, 1994; Messenger and McGuire, 1998 [1494]; Fordyce, 1994 [33]; Lambert, 2005 [55]).

(188) Bony connection between posterior process of periotic and squamosal/occipital bones: present (0); absent (ligamentous) (1) (Muizon, 1984; Arnold and Heinsohn, 1996 [34]; Messenger and McGuire, 1998 [1491]; Murakami et al. 2012a, b [188]; derived from Fraser and Purves, 1960; Kasuya, 1973; Heyning, 1989).

(189) Posterior process of periotic in lateral view: ventrally bent (0); in same plane as body of periotic (1) (Bianucci, 2005 [19]; Murakami et al. 2012 [189]; modified from Arnold and Heinsohn, 1996 [28]; Lambert, 2005 [54]).

(190) Angle between posterior bullar facet of periotic and long axis of cochlear portion in ventral view: >135° (0); ≤135° (1) (Murakami et al., 2012a, b [190]; modified from Geisler and Sanders, 2003 [246]; Lambert, 2005 [54]; Geisler et al., 2011 [246], 2012 [246]; derived from Kasuya, 1973; Barnes, 1990; Luo and Marsh, 1996).

(191) Ventral surface of posterior process of periotic, along a straight path perpendicular to its long axis: flat (0); concave (1); convex (2) (Murakami et al. 2012a, b [191]; modified from Geisler and Sanders, 2003 [242]; Geisler et al., 2011 [242], 2012 [242]).

(192) Posterior bullar facet of periotic: with many long deep grooves and low ridges (0); with some shallow grooves and/or low ridges (1); without grooves or ridges (2) (Bianucci, 2005 [20]; Murakami et al. 2012a, b [192]).

(193) Length of posterior process of periotic as percent length of pars cochlearis: long, ≥85% (0); short, ≤84% (1) (Murakami et al. 2012a, b [193]; modified from Barnes, 1990; Luo and Marsh, 1996 [24]; Geisler and Sanders, 2003 [245]; Geisler et al.,

2011 [245], 2012 [245]).

(194) Mastoid exposure of posterior process of periotic on outside of skull: exposed externally (0); not exposed, enclosed by exoccipital and squamosal (1) (Geisler and Luo, 1996 [28]; Luo and Marsh, 1996 [28]; Geisler and Sanders, 2003 [249]; Geisler et al., 2011 [249], 2012 [249]; Murakami et al. 2012a, b [194]).

Tympanic Bulla

(195) Anterior spine of tympanic bulla: absent (0); present but short (1); present and long (2) (Muizon, 1987; Fordyce, 1994 [45]; Geisler and Sanders, 2003 [250]; Lambert, 2005 [62]; Geisler et al., 2011 [250], 2012 [250]; Murakami et al. 2012a, b [195]; modified from Messenger and McGuire, 1998 [1484]; derived from Kasuya, 1973).

(196) Anterolateral convexity of tympanic bulla with anterolateral notch: absent (0); present (1) (Muizon, 1987; Fordyce, 1994 [46]; Lambert, 2005 [63]; Murakami et al. 2012a, b [196]).

(197) Articulation of posterior process of tympanic bulla with squamosal: process contacting post-tympanic process of squamosal and posterior process of periotic (0); process contacting periotic only (1) (Muizon, 1984; Fordyce, 1994 [29]; Arnold and Heinsohn, 1996 [34]; Messenger and McGuire, 1998 [1481]; Lambert, 2005 [56]; Murakami et al. 2012a, b [197]; derived Kasuya, 1973).

(198) Width of tympanic bulla as percent of its length along its long axis: wide, ≥65% (0); narrow and long, ≤64% (1) (Geisler and Sanders, 2003 [251]; Bianucci, 2005 [23]; Geisler et al., 2011 [251], 2012 [251]; Murakami et al. 2012a, b [198]; derived from Kasuya, 1973).

(199) Accessory ossicle or homologous region on lip of bulla: not fused (0); fused to anterior process of periotic (1) (Barnes, 1990; Fordyce, 1994; Luo and Marsh, 1996; Geisler and Sanders, 2003 [255]; Geisler et al., 2011 [255], 2012 [255]; Murakami et al. 2012a, b [199]).

(200) Lateral furrow of tympanic bulla: shallow groove (0); absent (1); deep, well-defined groove (2) (Murakami et al. 2012a, b [200]; modified from Muizon, 1984, 1988; Arnold and Heinsohn, 1996 [31]; Messenger and McGuire, 1998 [1485]; Fajardo-Mellor et al., 2006 [17]; Lambert, 2008 [17]; derived from Kasuya, 1973).

(201) Sigmoid process: directed laterally to posterolaterally (0); directed anteriorly to anterolaterally (1) (Murakami et al. 2012a, b [201]; modified from Messenger and McGuire, 1998 [1486]; Lambert, 2005 [67]).

(202) Dorsal edge of sigmoid process: distal end expanded anteriorly to articulate with lateral tuberosity of periotic (0); not articulating with squamosal or periotic (1) (Murakami et al. 2012a, b [202]; modified from Geisler and Sanders, 2003 [260]; Geisler et al., 2011 [260], 2012 [260]; modified from Luo and Marsh, 1996 [10]).

(203) Ventral margin of tympanic bulla in lateral view: convex (0); concave (1) (Lambert, 2005 [66]; Murakami et al. 2012a, b [203]).

(204) Elliptical foramen of tympanic bulla: present (0); absent or close (1) (Geisler and Sanders, 2003 [261]; Geisler et al., 2011 [261], 2012 [261]; Murakami et al. 2012a, b [204]; derived from Kasuya, 1973).

(205) Size of posterior process of tympanic bulla: equal to or greater than tympanic bulla (0); much smaller than tympanic bulla (1) (Muizon, 1984, 1991; Heyning, 1989 [23, 29], 1997 [55, 61]; Messenger and McGuire, 1998 [1482]; Murakami et al. 2012a, b [205]; modified from Lambert, 2005 [57]; derived from Yamada, 1953; Kasuya, 1973).

(206) Surface of posterior process of tympanic bulla: spiny or irregular edges (0); cauliflower-like bony growth (1); rounded and pachyostotic (2) (Muizon, 1991; Messenger and McGuire, 1998 [1483]; Murakami et al. 2012a, b [206]; derived from Kasuya, 1973).

(207) Median furrow: short extension on ventral face of interprominental notch (0); anterolateral curvature of median groove to connect to long lateral furrow on outer lip (1); median groove reaching an anterior level beyond lateral furrow, and often slightly curved laterally (2); long and deep rectilinear median groove reaching at least to base of anterior tip of tympanic bulla (3) (Lambert, 2005 [64]; Murakami et al. 2012a, b [207]).

(208) Median furrow on posterior side of bulla: divided by a transverse ridge originating from involucrum (0); transverse ridge absent (1) (Geisler and Sanders, 2003 [267]; Geisler et al., 2011 [267], 2012 [267]; Murakami et al. 2012a, b [208]).

(209) Posterior edge of inner posterior prominence of involucrum: approximately in line with posterior edge of outer posterior prominence (0); distinctly anterior to posterior edge of outer posterior prominence (1) (Muizon, 1987; Geisler and Sanders, 2003 [269]; Geisler et al., 2011 [269], 2012 [269]; Murakami et al. 2012a, b [209]; derived from Kasuya, 1973).

(210) Involucrum of tympanic bulla: not excavated (0); excavated (1) (Muizon, 1988; Arnold and Heinsohn, 1996 [37]; Messenger and McGuire, 1998 [1487]; Murakami et al. 2012a, b [210]; modified from Lambert, 2005 [60]).

(211) Involucrum: groove absent (0); bearing prominent transverse groove on dorsal

surface, dividing involucrum into thicker posterior part and thinner anterior part (1) (Geisler and Sanders, 2003 [271]; Geisler et al., 2011 [271], 2012 [271]; Murakami et al. 2012a, b [211]).

(212) Ridge on inside of bulla: present, as transverse ridge extending laterally from involucrum and partially dividing cavum tympani into anterior and posterior portions (0); absent (1) (Geisler and Sanders, 2003 [272]; Geisler et al., 2011 [272], 2012 [272]; Murakami et al. 2012a, b [212]).

(213) Ventral keel of tympanic bulla: present along entire length (0); terminating approximately at level of lateral furrow or mid-point of the tympanic bulla (1); poorly defined along entire length (2) (Geisler and Sanders, 2003 [273]; Geisler et al., 2011 [273], 2012 [273]; Murakami et al., 2012a, b [213]; derived from Kasuya, 1973).

(214) Posterior end of ventral keel: not protruding and directed medially (0); protruding and directed medially (1) (Geisler and Sanders, 2003 [275]; Geisler et al., 2011 [275], 2012 [275]; Murakami et al., 2012a, b [214]).

Hyoids

(215) Basihyal and thyrohyals: unfused (0); fused (1) (Murakami et al. 2012a, b [215]; modified from Bianucci, 2005 [25]).

(216) Basihyal and thyrohyals: arched (0); angled (1) (Murakami et al. 2012a, b [216]; modified from Bianucci, 2005 [25]).

Vertebral

(217) Dorsal transverse process of atlas: developed dorsolaterally (0); fused with ventral transverse process, with length of process greater than width (1); absent or rudimentary obtuse angle (2) (Murakami et al. 2012a, b [217]; modified from Muizon, 1988; Barnes, 1990).

(218) Roof of neural canal of atlas: arched (0); convex (1); straight (2) (Murakami et al. 2012a, b [218]).

(219) Postzygapophysis of axis in anterior view: appearing as crest, elongated dorsolaterally (0); appearing as rudimentary crest (1); not appearing (2) (Murakami et al. 2012a, b [219]).

(220) Capitular articulation facets of posterior vertebrae: facets gradually shift downward on sequential vertebrae to fuse with tubercular facets (0); facets abruptly shift from a position on neural arch to a pedestal, originating from centrum on subsequent vertebra (1) (Geisler and Sanders, 2003 [282]; Geisler et al., 2011 [282],

2012 [282]; Murakami et al. 2012a, b [223]; derived from Flower, 1869; Miller, 1923).

(221) Transverse processes of lumbar vertebrae: oriented ventrolaterally (0); oriented laterally and horizontally (1) (Geisler and Sanders, 2003 [284]; Geisler et al., 2011 [284], 2012 [284]; Murakami et al. 2012a, b [225]; derived from Sanders and Barnes, 2002).

(222) Ratio of greatest breadth of transverse process to width of centrum at anterior face in lumbar vertebrae: some or all lumbar vertebrae >2.5 (0); no lumbar vertebrae >2.5 (1) (Murakami et al. 2012a, b [226]).

(223) Number of caudal vertebrae: 15–20 (0); 21–27 (1); 28–33 (2); 34–40 (3); >41 (4) (Murakami et al. 2012a, b [228]; modified from Geisler and Sanders, 2003 (288); Bianucci, 2005 [40]; Geisler et al., 2011 [288], 2012 [288]).

Sternum and Sternal Ribs

(224) Sternum: consists of four or five parts (0); consists of two or three parts (1); consists of single bone (2) (Murakami et al. 2012a, b [229]; modified from Geisler and Sanders, 2003 [290]; Geisler et al., 2011 [290]; derived from Yablokov, 1964; Van Valen, 1968).

(225) Ventrolateral processes on manubrium of sternum: absent (0); present but small, occur ventral to articulation surface of first costal cartilage or rib (1) (Muizon, 1988; Messenger and McGuire, 1998 [1503]; Geisler and Sanders, 2003 [289]; Geisler et al., 2011 [289], 2012 [289]; Murakami et al. 2012a, b [230]; derived from Klima et al., 1980).

(226) Sternal ribs: unossified or ossification of fewer than five pairs (0); ossification of five pairs or more (1) (Murakami et al. 2012a, b [231]; derived from Flower, 1867).

Scapula

(227) Anterodorsal part of scapula: rounded (0); rounded and anterior edge pointed (1); almost rectilinear (2) (Murakami et al. 2012a, b [232]).

(228) Ventral projection on anterior border of scapula: absent (0); present (1) (Fajardo-Mellor et al., 2006 [26]; Murakami et al. 2012a, b [233]; derived from Noble and Fraser, 1971).

(229) Anterior angle between scapula and midpoint of glenoid fossa: *weakly expanded anteriorly, >35° (0); strongly expanded anteriorly, <35°* (1) (Murakami et al. 2012a, b [234]; modified from Bianucci, 2005 [31]). Order of states reversed from Murakami et al. (2012a, b).

(230) Posterior angle between scapula and midpoint of glenoid fossa: *weakly extended posteriorly, >25° (0); strongly extended posteriorly, <25°* (1) (Murakami et al. 2012a, b [235]; modified from Bianucci, 2005 [32]). Order of states reversed from Murakami et al. (2012a, b).

(231) Crest dividing between infraspinous fossa and tears fossa: weakly developed (0); strongly developed (1) (Murakami et al. 2012a, b [236]).

(232) Coracoid process of scapula: not expanded distally (0); expanded distally (1); notably reduced or absent (2) (Murakami et al. 2012a, b [237]; modified from Muizon, 1987, 1994; Messenger and McGuire, 1998 [1504]; Geisler and Sanders, 2003 [292]; Lambert, 2005 [73]; Bianucci, 2005 [33]; Geisler et al., 2011 [292]; derived from True, 1904).

(233) Coracoid process of scapula, when glenoid fossa directed ventrally: directed horizontally (0); directed nearly anterodorsally (1); directed anteroventrally (2) (Murakami et al. 2012a, b [238]; modified Barnes, 1990).

(234) Acromion of scapula: narrow and not expanded distally (0); expanded distally (1) (Murakami et al. 2012a, b [239]; modified from Bianucci, 2005 [34]).

(235) Acromion of scapula, when glenoid fossa direct ventrally: directed horizontally (0); directed anterodorsally (1); directed anteroventrally (2) (Murakami et al. 2012a, b [240]; modified Barnes, 1990).

(236) Supraspinous fossa of scapula: present (0); absent or nearly absent (1) (Muizon, 1987, 1994; Geisler and Sanders, 2003 [293]; Lambert, 2005 [72]; Geisler et al., 2011 [293], 2012 [293]; Murakami et al. 2012a, b [241]).

Forelimb

(237) Ratio of length of humerus to length of radius: long, >1.1 (0); short, <0.8 (1) (Murakami et al. 2012a, b [242]; modified from Sanders and Barnes, 2002; Geisler and Sanders, 2003 [297]; Geisler et al., 2011 [297], 2012 [297]).

(238) Location of apex of deltopectoral tuberosity of humerus: within proximal 65% of humerus (0); within distal 35% of humerus (1) (Murakami et al. 2012a, b [243]; modified from Muizon, 1988; Messenger and McGuire, 1998 [1506]; Geisler and Sanders, 2003 [295]; Bianucci, 2005 [35]; Geisler et al., 2011 [295], 2012 [295]).

(239) Prominent deltoid crest on anterior edge of humerus: present, forms greatest anteroposterior diameter along shaft (0); forming a knob-like tuberosity (1); neither tuberosity or crest absent (2) (Geisler and Sanders, 2003 [294]; Geisler et al., 2011 [294], 2012 [294]; Murakami et al. 2012a, b [244]; derived from Sanders and Barnes, 2002).

(240) Radial and ulnar facets of humerus in lateral view: facets forming a semicircular articulation surface (0); facets forming an obtuse angle (1) (Barnes, 1990; Geisler and Sanders, 2003 [296]; Geisler et al., 2011 [296], 2012 [296]; Murakami et al. 2012a, b [245]).

(241) Olecranon process: present as a distinct process (0); present as a slightly raised proximal posterior edge (1); absent (2) (Messenger and McGuire, 1998 [1507]; Geisler and Sanders, 2003 [296]; Geisler et al., 2011 [284], 2012 [284]; Murakami et al. 2012a, b [246]; modified from Muizon, 1984; Barnes, 1990; Arnold and Heinsohn, 1996 [10]; Fajardo-Mellor et al., 2006 [28]; derived from Howell, 1927).

Soft Tissues

(242) Spermaceti organ: absent (0); present (1) (Fordyce, 1994 [17]; Messenger and McGuire, 1998 [1511]; Geisler and Sanders, 2003 [97]; Geisler et al., 2011 [97], 2012 [97]; Murakami et al. 2012a, b [247]; derived from Norris and Harvey, 1972; Cranford et al., 1996).

(243) Museau de singe: absent (0); present (1) (Messenger and McGuire, 1998 [1512]; Murakami et al. 2012a, b [248]; derived from Norris, 1964; Cranford et al., 1996).

(244) Lateral lips of nasal plug: present (0); absent (1) (Messenger and McGuire, 1998 [1523]; Murakami et al. 2012a, b [249]).

(245) Proximal sac: single frontal sac (0); sac complex, with nasofrontal sacs and vestibule (1) (Heyning, 1989 [6, 11, 17], 1997 [33, 43, 49]; Fordyce, 1994 [16]; Messenger and McGuire, 1998 [1531, 1532]; Lambert, 2005 [18]; Murakami et al. 2012a, b [250]).

(246) Posterior nasal sacs: absent (0); present (1) (Heyning, 1989 [41], 1997 [73]; Arnold and Heinsohn, 1996 [6]; Messenger and McGuire, 1998 [1534]; Murakami et al. 2012a, b [251]).

(247) Posterior nasal sacs: single (0); divided (1) (Messenger and McGuire, 1998 [1535]; Murakami et al. 2012a, b [252]).

(248) Anterior section of nasofrontal sac: absent (0); present (1) (Messenger and McGuire, 1998 [1536]; Murakami et al. 2012a, b [253]).

(249) Anterior part of nasofrontal sac: smooth (0); trabeculate (1) (Messenger and McGuire, 1998 [1537]; Fajardo-Mellor et al., 2006 [35]; Murakami et al. 2012a, b [254]; derived from Heyning, 1989).

(250) Vestibular sac: absent (0); present (1); hypertrophied (2) (Heyning, 1989 [28], 1997 [60]; Fordyce, 1994 [31]; Arnold and Heinsohn, 1996 [1, 3]; Messenger and McGuire, 1998 [1541]; Lambert, 2005 [17]; Fajardo-Mellor et al., 2006 [39];

Murakami et al. 2012a, b [255]).

(251) Floor of vestibular sac (nasal sac): not rigid (0); rigid (1) (Heyning, 1989 [38], 1997 [70]; Arnold and Heinsohn, 1996 [2]; Messenger and McGuire, 1998 [1543]; Fajardo-Mellor et al., 2006 [38]; Murakami et al. 2012a, b [256]).

(252) Vestibular sac (nasal sac): undivided (0); bilaterally divided (1) (Messenger and McGuire, 1998 [1544]; Fajardo-Mellor et al., 2006 [36]; Murakami et al. 2012a, b [257]; derived from Heyning, 1989).

(253) Right and left sides of vestibular sac: same size (0); right side larger than left (1) (Heyning, 1989 [30], 1997 [62]; Messenger and McGuire, 1998 [1545]; Murakami et al. 2012a, b [258]).

(254) Intrinsic muscle in vestibular sac (nasal sac): absent (0); present (1) (Messenger and McGuire, 1998 [1546]; Fajardo-Mellor et al., 2006 [37]; Murakami et al. 2012a, b [259]; derived from Mead, 1975).

(255) Floor of vestibular sac (nasal sac): smooth (0); wrinkled (1) (Heyning, 1997 [70]; Arnold and Heinsohn, 1996 [2]; Messenger and McGuire, 1998 [1543]; Murakami et al. 2012a, b [260]).

(256) Diagonal membrane: absent (0); present (1) (Messenger and McGuire, 1998 [1550]; Murakami et al. 2012a, b [261]; Heyning, 1989).

(257) Spiracular cavity: slit-like (0); rounded (1) (Messenger and McGuire, 1998 [1552]; Murakami et al. 2012a, b [262]).

(258) Pars posteroexternus muscle: absent (0); present (1) (Messenger and McGuire, 1998 [1553]; Murakami et al. 2012a, b [263]).

(259) Pars intermedius muscle: absent (0); present (1) (Messenger and McGuire, 1998 [1554]; Murakami et al. 2012a, b [264]).

(260) Pars posterointerus muscle: absent (0); present (1) (Messenger and McGuire, 1998 [1556]; Murakami et al. 2012a, b [265]).

(261) Pars anterointerus muscle: one insertion (0); two insertions (1) (Messenger and McGuire, 1998 [1557]; Murakami et al. 2012a, b [266]).

(262) Blowhole shape: longitudinal slit, may be slightly sigmoidal or angled (0); crescent, with apices pointed anteriorly (1); crescent, with apices pointed posteriorly, may be skewed (2); rectangular (3) (Murakami et al. 2012a, b [267]; modified from Messenger and McGuire, 1998 [1525]).

(263) Soft tissues of nasal passages distal to bony external nares: separated for most of their length but confluent just proximal to blowhole (0); confluent (1) (Heyning, 1989; Fordyce, 1994 [20]; Messenger and McGuire, 1998 [1529]; Geisler and Sanders, 2003 [95]; Lambert, 2005 [16]; Geisler et al., 2011 [95], 2012 [95];

Murakami et al. 2012a, b [268]).

(264) Distal sac: absent (0); present, situated immediately distal to museau de singe (1) (Murakami et al. 2012a, b [269]; modified from Heyning, 1989 [12], 1997[44]; Fordyce, 1994 [14]; Messenger and McGuire, 1998 [1533]; Geisler and Sanders, 2003 [99], 2012 [99]; Lambert, 2005 [19]; Geisler et al., 2011 [99]).

(265) Blowhole ligament: absent (0); present (1) (Heyning, 1989 [15], 1997 [44]; Fordyce, 1994 [13]; Messenger and McGuire, 1998 [1527]; Geisler and Sanders, 2003 [101]; Lambert, 2005 [20]; Geisler et al., 2011 [101], 2012 [101]; Murakami et al. 2012a, b [270]).

(266) Blowhole ligament: not appressed against skull (0); appressed against skull (1) (Messenger and McGuire, 1998 [1528]; Murakami et al. 2012a, b [271]).

(267) Cartilage on blowhole ligament: absent (0); present (1) (Messenger and McGuire, 1998 [1529]; Murakami et al. 2012a, b [272]).

(268) Premaxillary sac: absent (0); present (1) (Heyning, 1989 [16], 1997, [48]; Messenger and McGuire, 1998 [1538]; Geisler and Sanders, 2003 [105]; Geisler et al., 2011 [105], 2012 [105]; Murakami et al. 2012a, b [273]).

(269) Accessory sac: absent (0); present, forms small diverticulum of inferior vestibule and extends anterolaterally around the attachment of blowhole ligament to the premaxilla (1) (Messenger and McGuire, 1998 [1549]; Geisler and Sanders, 2003 [106]; Fajardo-Mellor et al., 2006 [40]; Geisler et al., 2011 [106], 2012 [106]; Murakami et al. 2012a, b [274]; derived from Schenkkan, 1971; Mead, 1975; Heyning, 1989).

(270) Esophageal forestomach: present (0); absent (1) (Geisler and Sanders, 2003 [300]; Geisler et al., 2011 [300], 2012 [300]; Murakami et al. 2012a, b [275]; derived from Mead, 1989; Rice and Wolman, 1990).

(271) External throat grooves: absent (0); one pair converged anteriorly (1); irregular in number and shape (2) (Murakami et al. 2012a, b [276]; modified from Messenger and McGuire, 1998 [1512, 1513]; Geisler and Sanders, 2003 [301]; Geisler et al., 2011 [301], 2012 [301]).

(272) Dorsal fin: present (0); dorsal hump (1); absent (2) (Murakami et al. 2012a, b [277]; modified from Messenger and McGuire, 1998 [1562]; Geisler and Sanders, 2003 [304]; Geisler and Sanders, 2003 [304], 2012 [304]; derived from Leatherwood and Reeves, 1983; Jefferson and Newcomer 1993, Reeves et al. 2002).

(273) Shape of flipper: fan shaped (0); rounded at tip (1); sharply pointed at tip (2); entire flipper rounded (3) (Murakami et al. 2012a, b [278]; modified from

Fajardo-Mellor et al., 2006 [31]; Lambert, 2008 [25]; derived from Leatherwood and Reeves 1983, Brownell et al. 1987).

Additional skeletal characters

(274) Mesorostral groove diverging anterior from posterior to antorbital notch: absent (0); present (1) (Murakami et al 2012 b [279]).

(275) Premaxillary foramen locating; medial (0); midpoint to lateral (1) (Murakami et al 2012 b [280]).

(276) Lateral margin of the right premaxilla posterior to premaxillary foramen: widen posteriorly (0); straight (1) (Murakami et al 2012 b [281]).

(277) Number of two head ribs: ≥9 (0); 8 (1); ≤7 (2) (Murakami et al 2012 b [282]).

SOM_3. CHARACTER-TAXON MATRIX USED IN THE PHYLOGENETIC ANALYSIS

original NEXUS file available at

http://app.pan.pl/SOM/app60-Murakami_etal_SOM/CladisticMatrix.nex

Abbreviations Used in the Matrix—a = 0, 1 ; b = 0, 1 or 2; c = 0 or 2; d = 0 or 3; e = 0 or 4; f= 0 or 5; g = 1 or 2; h = 1, 2, or 3; j = 1 or 3; k = 2 or 3; m = 2 or 5; n = 3 or 4; p = 3, 4, or 5; q = 4 or 5; r = 4, 5, or 6; s = 5 or 6; t = 6 or 7.

Taxon	10	20	30	40
Georgiacetus vogtlensis	?000?0-000	00?00?0000	0?000??0?0	000-0??000
Zygorhiza kochii	000000-000	0100000000	00000?0000	000-000000
Archaeodelphis patrius	????????1?	?1??1?0???	??????????	???1??0100
Xenorophus sloanii	?000?00111	0110110012	0?000?????	???0000100
Agorophius pygmaeus	?????0??1?	?0?01???0?	0???0??0?0	00?-????01
Patriocetus kazakhstanicus	2000?0011?	?1101??000	0?000?????	0?00?01?01
Orycterocetus crocodilinus	2000?00110	?010010103	1?--2?????	???11?????
Physeter catodon	2101101111	00100101-3	1-1120aq00	002a102110
Kogia breviceps	0101101111	01100101-1	1---201010	0021012111
Waipatia maerewhenua	?00?00011?	?110110?12	0?100?0?00	00100011?a
Squalodon calvertensis	2100?00112	2110110010	1?1000?0?0	00000??10a
Notocetus vanbenedeni	2000100012	211001?100	11101??00	00?001????
Prosqualodon davidis	0100100012	11100?0002	0011001?0	00?00-1?01
Squaloziphius emlongi	?????0?01?	?1?01?0???	??????????	???000110?
Zarhachis flagellator	2000100012	2140110101	1110201701	10210?????
Pomatodelphis inaequalis	2000100011	2240010101	??????07?1	10?10?1???
Platanista gangetica	2000100012	22410001?1	11??111501	10011-1???
Tasmacetus shepherdi	2001110012	2111010101	1011012501	002a003101
Berardius bairdii	2001200011	21101?01-1	3----12210	012a003100
Ziphius cavirostris	2001210012	2110a101--	1----12310	0120003100

Taxon	10	20	30	40
Mesoplodon ginkgodens	2001211011	21101101-1	3----12310	0121003100
Xiphiacetus bossi	2001200012	2141101101	1-112??701	00?000111a
Lipotes vexillifer	2000100212	2031100102	1011100601	1000002110
Parapontoporia sternbergi	2000?01212	2131110101	1?112??t?1	10?0002l?0
Inia geoffrensis	2000101012	2131100102	1011000601	0001002110
Pontoporia blainvillei	2000101012	2131101101	1011200701	1001002110
Pliopontos littoralis	?00??0?01?	?1??110?01	1???2?????	???000????
Brachydelphis mazeasi	0010100011	21101?110?	1??????40?	1?10001l?0
Kentriodon pernix	1011100011	2110100101	10101??6??	00??003110
Atocetus iquensis	2011100011	2150100101	1?1120?501	0000003110
Hadrodelphis calvertense	20001?0012	21401?1112	101?100411	000000?110
Albireo whistleri	0101??0011	2140100??1	1?111??50?	0121003110
Denebola brachycephala	3001100010	01101?0101	?2????????0	?????02??0
Delphinapterus leucas	3100100010	0120100111	1211101110	0120001110
Monodon monoceros	3100100110	0120a001--	1211-0--10	0121001110
Odobenocetops peruvianus	4--0002010	0010?201-3	1111-0-???	???1?-----
Haborophocoena toyoshimai	?????0?01?	?1?01????1	1???2?????	??210?3110
Australithax intermedia	?????0?00?	?1?01?1?0?	??????????	????0?3110
Lomacetus ginsburgi	1101101001	11101?1?0?	????????1?	??21003110
Piscolithax boreios	?101?01011	01101?1?01	????2???1?	0?21003110
Piscolithax longirostris	0100101011	0110111101	1?1120?61?	0?11003110
Piscolithax tedfordi	0000101011	01101?1?0?	??????????	???1003110
Salumiphocaena stocktoni	?101??101?	??101???01	1?1?2??61?	0??10?31??
Septemtriocetus bosselaersi	?????0?01?	?1?01?1?0?	???**?**??????	????0?????
Phocoena sinus	4100101001	0110121101	221120?410	0?21003110
Phocoena spinipinnis	4100101001	0110121101	2211201410	0121003110
Phocoena dioptrica	4100101001	1110121101	2211201410	0121003110
Phocoena phocoena	4100101001	1110121101	2211201r10	0121003110
Phocoenoides dalli	4100101001	0110121101	2211201r10	0121003110
Neophocaena phocaenoides	4100101010	0110121101	2211101e10	0121002110
Lissodelphis borealis	1101101011	11201?1101	1211201t10	0120013110
Cephalorhynchus hectori	3101101011	0120111101	1211201s10	0121003110
Leucopleurus acutus	3100102011	1110111101	12??201610	0120013110
Orcaella brevirostris	4100112010	0110111101	1???001e10	0110003110

Taxon	10	20	30	40
Orcinus orca	3101102111	0110101101	1211101010	0101003110
Feresa attenuata	3101112010	0110111101	1211101010	0121003110
Globicephala macrorhynchus	3101112010	0110101101	1211200110	0121003110
Grampus griseus	3101100010	00101011-1	1-11210210	0121003110
Hemisyntrachelus cortesii	1100102011	0150101101	1???1?0010	0111003110
Peponocephala electra	1101112010	0110101101	1211201q10	0120003110
Pseudorca crassidens	3101112010	0110101101	12??101a10	0101003110
Delphinus delphis	1001102012	2150103101	1211201710	0120012110
Lagenodelphis hosei	0101102011	0150113101	1211201t10	0120012110
Sousa chinensis	2001100211	2150111101	1211201610	011a003110
Stenella attenuata	2001101011	2150102101	1211201t10	012001k110
Tursiops truncatus	1001102011	1150102101	1211201q10	0120013110
Sotalia fluviatilis	1001101011	2150101101	1211201s10	0120003110
Steno bredanensis	1001100111	2150101100	1211101q00	002000k110
Pterophocaena nishinoi	????????1?	?1??1?1?0?	??????????	???1003?10
Eodelphinus kabatensis	??????????	?????????1	1???2?????	0?2????????
Haborophocoena minutus	????????1?	?1??1?????	??????????	???1003110
Archaeophocaena teshioensis	??????????	??????????	??????????	????0?????
Miophocaena nishinoi	????????1?	?1??1?????	??????????	???1??3?10

Taxon	50	60	70	80
Georgiacetus vogtlensis	0?0?0??-00	-0---0-?0-	0-0-000000	0???-0--00
Zygorhiza kochii	0?0?000-a0	-0---0-00-	0-0-000000	000?-0--00
Archaeodelphis patrius	?0211?00?1	????0001-	000000000?	???-?0-000
Xenorophus sloanii	?2111??021	????000010	1000001000	000?01-000
Agorophius pygmaeus	?11010?020	11001?101-	10?0000000	00??01-000
Patriocetus kazakhstanicus	?01?1000?0	0100101013	1000100000	00??01-?0?
Orycterocetus crocodilinus	?110100110	111a101001	1001101000	0020021111
Physeter catodon	0110102100	01111-0001	1200101000	0020-20111
Kogia breviceps	02101001a0	21110-?000	1200-11000	0022--0111
Waipatia maerewhenua	?010112020	2101002013	1000100011	000001-001
Squalodon calvertensis	?11?103020	1101102013	1000100001	0?0001-001
Notocetus vanbenedeni	??101100a0	2101002113	1000100001	000100-001
Prosqualodon davidis	1110102ag0	110000g010	1101100001	000001-001

Taxon	50	60	70	80
Squaloziphius emlongi	?011112020	0101001010	1001100001	000100-001
Zarhachis flagellator	??1?102020	1100001110	1310100?01	000001-001
Pomatodelphis inaequalis	?0?11120?0	2100101013	1310100?01	000001-001
Platanista gangetica	0331102120	a20100g112	131010000a	000?01-001
Tasmacetus shepherdi	1212103000	0101001010	1002111011	0011001001
Berardius bairdii	03121020b1	0101102010	1002110001	0011001001
Ziphius cavirostris	13121000a0	010110101c	1002110001	1021001001
Mesoplodon ginkgodens	?30210001?	010110a013	1102111001	0012001001
Xiphiacetus bossi	1010110020	010100g010	1002100001	010100-001
Lipotes vexillifer	1320100000	0201111010	1000110010	000100-001
Parapontoporia sternbergi	1?10?100a0	0101111010	1100110000	00??00-001
Inia geoffrensis	13101000b0	010101g012	1001111000	000020-001
Pontoporia blainvillei	101010a010	a101011010	1003111000	100020-001
Pliopontos littoralis	?1??1000a0	110101g010	1001111000	00a010-001
Brachydelphis mazeasi	?2111010g0	110100a010	1001111000	000010-001
Kentriodon pernix	1310112010	110100g010	1000110011	000100-001
Atocetus iquensis	?110102010	2101001010	1100110011	000000-001
Hadrodelphis calvertense	?320112020	010100??10	1?0?110011	0?0100-001
Albireo whistleri	1111112020	110100g010	1101111110	001020-001
Denebola brachycephala	???0?1202?	11?101?011	10001??111	?0?004-?01
Delphinapterus leucas	1211112020	110101g011	1000111111	1a2114-001
Monodon monoceros	131?112020	110101g011	1000111111	1a2114-001
Odobenocetops peruvianus	??00110020	2101?11003	100011101?	10-003-001
Haborophocoena toyoshimai	1300112010	1101111011	1000111111	102113-001
Australithax intermedia	13001???10	0101211011	1001111111	101223-001
Lomacetus ginsburgi	130?10?010	1101211011	1101111111	101223-001
Piscolithax boreios	1200112020	0101211011	1001111110	10-223-001
Piscolithax longirostris	1200112020	110121g011	1001111110	101223-001
Piscolithax tedfordi	11?0103010	010121?011	1001111111	10?223-001
Salumiphocaena stocktoni	1???1??010	?101211011	100?111111	10???3-?01
Septemtriocetus bosselaersi	???01120?0	?1012??011	1000111?0	10-213-00?
Phocoena sinus	1200100020	0g0a311012	100a111110	110223-001
Phocoena spinipinnis	1201100020	0g0a311012	1000111110	110223-001
Phocoena dioptrica	12011120g0	0g0131g012	1001111110	110223-001

Taxon	50	60	70	80
Phocoena phocoena	12011120g0	0g0131g012	1001111110	110223-001
Phocoenoides dalli	1201112020	0g0131g012	1001111110	100223-001
Neophocaena phocaenoides	12011120g0	0g0131g012	1000111110	111223-001
Lissodelphis borealis	110a112020	010a11g011	100011101a	102105-001
Cephalorhynchus hectori	1301101020	010111g012	1000111011	102105-001
Leucopleurus acutus	1001112020	1101111011	1000111011	002105-001
Orcaella brevirostris	130111202?	1101111012	1100111011	102005-001
Orcinus orca	130110202?	a101102012	1100111011	001100-001
Feresa attenuata	12a1112020	110111g012	1100111011	002105-001
Globicephala macrorhynchus	130110002?	1101111011	1100111011	102105-001
Grampus griseus	1201112020	010101g012	1100111010	10211f-001
Hemisyntrachelus cortesii	?2??11202?	1101111012	1100111011	001105-001
Peponocephala electra	130111c020	110111g011	1100111011	102105-001
Pseudorca crassidens	130110k020	110110g012	110011101a	a0210f-001
Delphinus delphis	110011k020	110111g011	1100111011	102105-001
Lagenodelphis hosei	1010113020	010011g011	1100111011	1a2105-001
Sousa chinensis	13001a0020	1101111011	110011101a	002105-001
Stenella attenuata	1101113020	110111g011	110011101a	102105-001
Tursiops truncatus	1b0011k020	1101111012	1100111011	10210f-001
Sotalia fluviatilis	13a0101020	110111g012	1100111011	a02105-001
Steno bredanensis	1100111020	110a1ag012	1100111011	a02105-001
Pterophocaena nishinoi	1110112020	1??11?101?	1000????1?	10?00???0?
Eodelphinus kabatensis	????110?20	?10?1?201?	?????1101?	10100?????
Haborophocoena minutus	?2??1120g0	0101211011	1000111111	1021?3-001
Archaeophocaena teshioensis	?????????0	120?20??1?	1???111111	102?10-001
Miophocaena nishinoi	??101??010	1101311011	1000111111	1?2115-001

Taxon	90	100	110	120
Georgiacetus vogtlensis	0000000000	000-000?00	-000?0000?	000000?000
Zygorhiza kochii	0000000000	001-000?00	-000?00100	0001000100
Archaeodelphis patrius	00100?0001	001-?000?0	-000??0100	01000???00
Xenorophus sloanii	00100?0001	0000010??	1?????????	????????00
Agorophius pygmaeus	010g010?0?	0010010010	0100110100	10000011??
Patriocetus kazakhstanicus	01010?0?02	0000010010	010011?100	1001001??0

Taxon	90	100	110	120
Orycterocetus crocodilinus	?000a00002	?01-001?00	0011110000	0010-40020
Physeter catodon	0-00100-01	001-001010	-011011000	0110-40020
Kogia breviceps	0-001-----	----000101	-011111110	0a00040021
Waipatia maerewhenua	0101010002	0001011?10	0100111101	0001100110
Squalodon calvertensis	0002000002	0001011110	0102111100	1000000011
Notocetus vanbenedeni	0000010101	??11010?ga	1102?11100	1000a10110
Prosqualodon davidis	0100010002	0011011?10	0102?11100	1001000??0
Squaloziphius emlongi	0000010001	0021020?10	0102111100	0002010111
Zarhachis flagellator	0000000002	001101001a	1102111100	1200011112
Pomatodelphis inaequalis	00000?0002	0001010?00	1?02011100	1201010??1
Platanista gangetica	0000000001	00a10010g0	0103111100	1211000012
Tasmacetus shepherdi	0100010101	0012021?21	010k011001	1002130011
Berardius bairdii	0100020101	0001021?2?	0103011001	10020n0011
Ziphius cavirostris	0000010101	0011021011	0103011001	10021n0a10
Mesoplodon ginkgodens	0?000101?1	0011021?11	0?02011002	0002130 2?0
Xiphiacetus bossi	0100000102	002002001a	a?02111000	1002110g10
Lipotes vexillifer	0000000311	0022101010	1103111101	1000011110
Parapontoporia sternbergi	0000000011	0012101021	0?02111101	0001010g10
Inia geoffrensis	0000000311	0010101020	a103011101	10010a1110
Pontoporia blainvillei	0000010011	0012000010	0103111101	1000010210
Pliopontos littoralis	0?00010011	0012001?10	1103011101	100101021?
Brachydelphis mazeasi	0000010011	0012001011	010k011101	0000?101?0
Kentriodon pernix	0000020012	0012011020	0102a11102	000100011a
Atocetus iquensis	2?00020312	1112000?21	0102011102	?a0000???1
Hadrodelphis calvertense	0?0?000012	1111000?1?	?10301????	?????00??0
Albireo whistleri	1-00000212	0021100?11	0103011001	0000000210
Denebola brachycephala	1???000311	0112101010	0???01?111	?00001??10
Delphinapterus leucas	1-00010312	0112001010	0103011111	0001011210
Monodon monoceros	2-000a0312	0112101?10	0?0211111g	0a01010110
Odobenocetops peruvianus	?-000?03??	?0--000?10	?103111?00	021211?110
Haborophocoena toyoshimai	1-0000????	???2101?11	0102011002	0000002?0
Australithax intermedia	1-00001212	0?12101?11	0103?11002	010?000210
Lomacetus ginsburgi	1-00001212	0012101?11	0?03?1????	?????00210
Piscolithax boreios	1-00001212	0112101?11	010201????	?????002?0

Taxon	90	100	110	120
Piscolithax longirostris	1-000012?2	0011101?11	0102?11002	0100000?11
Piscolithax tedfordi	1-00001212	0011101?11	0102?11002	?100000?10
Salumiphocaena stocktoni	1-000?1212	?111?0??11	0?0201??02	??0?00?2??
Septemtriocetus bosselaersi	1-0?00????	??1210??11	010201?0??	02???001??
Phocoena sinus	1-00001212	0110101?11	0103a11001	0100000110
Phocoena spinipinnis	1-00001212	0110101?1a	0?03a11001	0a00000g10
Phocoena dioptrica	1-00001212	0110101?11	010k011001	0111100g10
Phocoena phocoena	1-00001212	0110101011	0?0k011001	0111100210
Phocoenoides dalli	1-00001212	0110101011	0102111001	0a11000g10
Neophocaena phocaenoides	1-00001212	0110101?11	010ka11001	0100000110
Lissodelphis borealis	2-00010312	00a2001?11	0102a11002	0000010?0
Cephalorhynchus hectori	2-00010312	0022001011	0103011002	0000010110
Leucopleurus acutus	2-00010312	0022001?21	010k011001	0000010110
Orcaella brevirostris	2-000103?2	0022001?11	0103011102	000001??11
Orcinus orca	2-000g0312	0022001?g1	0103011102	0001040110
Feresa attenuata	2-00010012	0112001011	010201110g	00000g0110
Globicephala macrorhynchus	2-00020012	0122001?01	0102111002	01000402?1
Grampus griseus	2-00010312	0022001?01	010201100g	0a000g1?11
Hemisyntrachelus cortesii	2-000103?2	0?22001?01	0102?1100g	000101???0
Peponocephala electra	2-00020312	0022001?21	0102011002	0a01020110
Pseudorca crassidens	2-00010312	0122001011	0102011a0g	0000011010
Delphinus delphis	2-00010312	0022001?11	0102011002	0a00010g10
Lagenodelphis hosei	2-00010312	0022001021	0102a11002	0a00010210
Sousa chinensis	2-00010312	0022001?01	0103011a02	0a0001a110
Stenella attenuata	2-00010312	0022001?11	0102011002	0a000g0210
Tursiops truncatus	2-00010312	0022001011	0102011a02	000a0ga110
Sotalia fluviatilis	2-00010312	0012001?01	0103011002	0000010110
Steno bredanensis	2-00010312	0012001011	0102011002	0000010210
Pterophocaena nishinoi	??0???????	???????0?1	0102?11002	00010??210
Eodelphinus kabatensis	2?0?0?????	??????10?1	??0??1?001	00010????0
Haborophocoena minutus	1-00001112	0012101?11	?102011002	0001002?0
Archaeophocaena teshioensis	2-000?1312	00????10??	?????????2	?0??????10
Miophocaena nishinoi	?-0000????	???21010??	????0?????	?????0??10

Taxon	130	140	150	160
Georgiacetus vogtlensis	0--?00000?	0-??00??0?	0000?00???	0?0?000000
Zygorhiza kochii	0?-0000k00	0-0000000-	0?100?????	?001001010
Archaeodelphis patrius	0--?100?00	0-0000?00-	0?10011???	3?01101000
Xenorophus sloanii	0-??0?0?0?	?-??000???	??????????	??????????
Agorophius pygmaeus	??????0???	?-0?00????	??0??1?011	??0???????
Patriocetus kazakhstanicus	0?????????	?-??00????	??30??111?	300101??00
Orycterocetus crocodilinus	0--2100300	0-0000?10-	0-20021000	001012k110
Physeter catodon	0--2200300	0-000011?-	1-30011010	01100?30?0
Kogia breviceps	0--2100000	0-0000101-	2??0001000	0111013010
Waipatia maerewhenua	0--???0?10	0-00000???	00k00g1121	a000002000
Squalodon calvertensis	0-????0011	0-0000??0?	002002a101	0001002100
Notocetus vanbenedeni	00-?310k11	1-1?00????	??30??1021	3001001110
Prosqualodon davidis	10?0200k1?	0-0?00000-	00k0?21???	?001002?01
Squaloziphius emlongi	10-?000?12	0-0?00?10-	00300g1000	0011102011
Zarhachis flagellator	1??1310k11	1-0000?20-	01300?1121	3001002010
Pomatodelphis inaequalis	??-131??11	1-0000??0-	01300????1	3?01000100
Platanista gangetica	0?01310011	1-0000120-	0130010??1	300000g100
Tasmacetus shepherdi	0-12000011	1-00000311	1031001011	0111003?11
Berardius bairdii	0-?200011?	1-00001301	103100100?	0011013010
Ziphius cavirostris	0-?2000111	1-00001311	1-3101101?	0111103a10
Mesoplodon ginkgodens	0??200??1?	1-00001311	1-310?????	?111103010
Xiphiacetus bossi	0-?131001?	0??0100l?0	0?31021000	0011001010
Lipotes vexillifer	1000321312	1010100110	2031121000	1011113110
Parapontoporia sternbergi	1000??1?1?	1-00101???	g031021010	3011002000
Inia geoffrensis	110--0a312	0-10100---	2031021010	h01113ga00
Pontoporia blainvillei	1110310012	1-101011a2	2031020100	3010012a10
Pliopontos littoralis	1a00??a01?	1?1?100??-	00310????0	?011002000
Brachydelphis mazeasi	10003g1?1?	a?1?100002	00k10g???0	?111001??0
Kentriodon pernix	110???1k12	1?1010??10	0-31021000	00110a2010
Atocetus iquensis	1000321312	1?1?100110	0-21??1???	311?001010
Hadrodelphis calvertense	100???1?1?	1-10?00?0?	??????1???	??????????
Albireo whistleri	1002221?11	0-00101000	0-310?10??	3111002110
Denebola brachycephala	10????1??2	0-00100??0	0?21??????	?01???????
Delphinapterus leucas	1010210a11	0-00011000	0-310210g0	0011002010

Taxon	130	140	150	160
Monodon monoceros	1010210311	0-00011000	0-310?1???	0011002010
Odobenocetops peruvianus	1-00-11?11	0-0010-00-	20300??0??	30?11??110
Haborophocoena toyoshimai	10102?1212	0?1?100100	0?310?10??	31110?21?0
Australithax intermedia	10????1312	1?11100???	0?211?10??	31?100??10
Lomacetus ginsburgi	1010??1312	0?10100???	????1?????	3??100??10
Piscolithax boreios	101?????12	0??1100???	??????????	??????????
Piscolithax longirostris	10?0221312	0?11100110	00310?1???	311?002?10
Piscolithax tedfordi	1??02??312	0??1100???	0?311?10??	3111002?10
Salumiphocaena stocktoni	101?????1?	0???1?0??1	??31??????	????????1?
Septemtriocetus bosselaersi	??????1?12	0?1110????	??211?10??	31??002010
Phocoena sinus	1000221312	0?11100001	00211??00?	3111002100
Phocoena spinipinnis	1000221312	0?11100001	00311??0??	3111002a10
Phocoena dioptrica	1000221312	0?11100002	00211??0??	311?0021a0
Phocoena phocoena	1000221312	0-11100002	00211210a0	31110a2a10
Phocoenoides dalli	1000221312	0?11100002	00211210a0	?111002010
Neophocaena phocaenoides	1000221312	0-11100001	00311?10?0	311100210?
Lissodelphis borealis	1000221312	0?10100010	00310?10??	3111002010
Cephalorhynchus hectori	1000221312	0?10100011	0-k1021000	31110?2110
Leucopleurus acutus	1002221312	0-10100010	0-210?10??	3111102110
Orcaella brevirostris	1010221?12	0-10100010	0-310??0??	3111002000
Orcinus orca	10a0221312	0-1010001?	0-?10?1???	?111002010
Feresa attenuata	1000221312	0-10100110	0-310?1??0	3111102100
Globicephala macrorhynchus	1010221312	0-10100010	0-31021???	3111133000
Grampus griseus	1002221?12	1010100010	0-310?1??0	3111103000
Hemisyntrachelus cortesii	101?221?12	0?1?100012	0-310?????	3111102?10
Peponocephala electra	1000221312	1-10100110	0-310?10??	3111002100
Pseudorca crassidens	1010221?12	0-10100012	0-310?10??	3111002100
Delphinus delphis	1000221312	0110100110	0-310?10??	3111002a10
Lagenodelphis hosei	100c221312	a?10100110	0-310?1000	3111002110
Sousa chinensis	1000221312	0110100010	0-k1021000	3111002000
Stenella attenuata	1002221312	0?1010011c	0-3102101?	3111002a10
Tursiops truncatus	100c221k12	0110100112	0-310210a0	j1110021a0
Sotalia fluviatilis	1010221?12	001010001c	0-310?11?0	311100k100
Steno bredanensis	10a0221?12	0110100110	0-310210a?	31110021a0

Taxon	130	140	150	160
Pterophocaena nishinoi	1002221312	0?10100?00	??31121O??	3111002110
Eodelphinus kabatensis	1012221?12	???0100?10	??3102??00	?111??????
Haborophocoena minutus	10102?1?12	0?1?10????	0?310??0??	3010002110
Archaeophocaena teshioensis	10?02???1?	???01?????	??31??????	??1???????
Miophocaena nishinoi	10??????12	0??01?0???	??????????	??????????

Taxon	170	180	190	200
Georgiacetus vogtlensis	??????????	?0?00?????	????0??0?0	???000?000
Zygorhiza kochii	0000000000	0?0100??00	?00a0000?0	000000000?
Archaeodelphis patrius	0??1?00???	?0?10?0?1?	???????0??	??01??0?0?
Xenorophus sloanii	??????????	??????????	??????????	??????????
Agorophius pygmaeus	0?????????	??????????	??????????	??????????
Patriocetus kazakhstanicus	1?????????	?a????????	?????????0	0??1??????
Orycterocetus crocodilinus	0??0000210	0110110100	1000100?00	200??00012
Physeter catodon	0101000210	?311110000	1000100100	2001000011
Kogia breviceps	0101000211	?311010000	2110100110	1201000011
Waipatia maerewhenua	0??1011101	0201020100	0000111100	1101010102
Squalodon calvertensis	0??1000?00	0201010000	0010111000	0211210102
Notocetus vanbenedeni	1001011100	0201020000	2011111000	0111210000
Prosqualodon davidis	???12?0???	??11????1?	???????1?0	a101???01?
Squaloziphius emlongi	0?????????	??????????	??????????	??????????
Zarhachis flagellator	1??1211?01	00010100a0	a100112000	a?1?21?102
Pomatodelphis inaequalis	0000211?01	0?01?10000	0100012000	121?210102
Platanista gangetica	10?1011100	0001010001	0111112000	1111200012
Tasmacetus shepherdi	01?1000100	1201120101	2010000110	0211000012
Berardius bairdii	0101000100	1?01110110	1010000100	111?000012
Ziphius cavirostris	01?1000101	?101010101	2010000111	0211000012
Mesoplodon ginkgodens	0100000101	0?01110111	1010000111	0211000112
Xiphiacetus bossi	0011000?01	1k01010101	c001100?00	0111100102
Lipotes vexillifer	10?0000210	1311121110	0011110110	1011000002
Parapontoporia sternbergi	1?????????	??????????	??????????	??????????
Inia geoffrensis	1010100210	0311020000	100a010110	0211001112
Pontoporia blainvillei	1010100210	0311020000	1010110111	a211001102
Pliopontos littoralis	1??0100?10	0?11000000	10?0110?11	111?001102

Taxon	170	180	190	200
Brachydelphis mazeasi	1010100?10	0311000?0	0000110110	11110?1?0?
Kentriodon pernix	0010200?10	0311000000	1000110100	1101001102
Atocetus iquensis	0010200210	0?11000000	a0?0110110	11a?001102
Hadrodelphis calvertense	???120??10	0?1??0?0?0	00?0?1?100	?10?001?02
Albireo whistleri	0??0200211	1?11021000	0?00110l?0	11?1001000
Denebola brachycephala	0??0200210	1?11021000	1000110?10	111?00?100
Delphinapterus leucas	0010200210	1311020000	0000110010	11a1000100
Monodon monoceros	0010200210	1311010000	0000010010	110?000100
Odobenocetops peruvianus	???1200?01	1?11?1?000	00?1010010	?2??000001
Haborophocoena toyoshimai	1??0200210	1311021000	0000110101	110?001000
Australithax intermedia	1?????????	??????????	??????????	??????????
Lomacetus ginsburgi	2?????????	??????????	??????????	??????????
Piscolithax boreios	???0200?10	1?11021000	0000110101	110?001000
Piscolithax longirostris	2010200?10	1?11020000	000011010?	1???001100
Piscolithax tedfordi	??10200?10	1?11?21000	0000110101	110?001100
Salumiphocaena stocktoni	?010200?10	??1??????0	000011?1?1	111?00?00?
Septemtriocetus bosselaersi	1?????????	??????????	??????????	??????????
Phocoena sinus	1010200?10	0?11020000	0000110110	111?001100
Phocoena spinipinnis	10?0200210	0?11020000	0000110110	111?001100
Phocoena dioptrica	1??0200??0	??1??????0	1??0?1??11	?21??01?00
Phocoena phocoena	2010200210	0311020000	0000110110	a211001100
Phocoenoides dalli	2010200211	0311020000	0000110111	1g1?001100
Neophocaena phocaenoides	2?10200211	0311020000	0000110110	1111001100
Lissodelphis borealis	?010200210	0?11010000	0000110111	101?101101
Cephalorhynchus hectori	1010200210	0311021000	1000110110	1011001101
Leucopleurus acutus	101020?21?	?311020000	0000110101	1001001101
Orcaella brevirostris	1010200210	1?11011000	0000110110	100?001101
Orcinus orca	0011200210	1?11111000	b000010111	100?101101
Feresa attenuata	0010200210	1311020000	0000110111	1011001101
Globicephala macrorhynchus	0010200210	1?11000000	0000110110	101?101101
Grampus griseus	0010200210	131101a000	0000110111	1011100101
Hemisyntrachelus cortesii	0???2????0	1????2???0	0??0110?1?	?0??0011??
Peponocephala electra	0010200210	131102a000	0000100111	101?001101
Pseudorca crassidens	0010200210	1311010000	0000100111	1001000101

Taxon	170	180	190	200
Delphinus delphis	1010200210	1311121000	0000110111	1011101101
Lagenodelphis hosei	1010200210	1?11021000	0000110101	101?101101
Sousa chinensis	00?0?00?10	0?11020001	?000110111	101?001??1
Stenella attenuata	1010200210	1311121000	0000110101	1011101101
Tursiops truncatus	0010200210	1311021000	1000110111	1011001101
Sotalia fluviatilis	0010200210	1?11021000	0000110101	101?101101
Steno bredanensis	0010200210	0311021000	1000110101	101?001101
Pterophocaena nishinoi	1??0200?1?	1311021000	0000110101	11010?1100
Eodelphinus kabatensis	???020021?	1311021000	0000110101	1001001100
Haborophocoena minutus	??????????	??????????	??????????	??????????
Archaeophocaena teshioensis	??????????	??????????	??????????	??????????
Miophocaena nishinoi	???0200?11	??110?000?	?0?0?1???1	11????????

Taxon	210	220	230	240
Georgiacetus vogtlensis	???0??0?0?	???0??????	0?????????	??????????
Zygorhiza kochii	0?0?0?0000	0?00000000	00??? 0?00?	???0?0??00
Archaeodelphis patrius	??????????	??????????	??????????	??????????
Xenorophus sloanii	??????????	??????????	??????????	??????????
Agorophius pygmaeus	??????????	??????????	0???? ?????	??????????
Patriocetus kazakhstanicus	??????????	??????????	??????????	??????????
Orycterocetus crocodilinus	?00101110?	0021??????	??????????	??????????
Physeter catodon	1?01011100	00g1011221	?101000000	0011100011
Kogia breviceps	1101011100	0000001021	1101002001	0011000001
Waipatia maerewhenua	0100102100	0?20??00??	??????????	??????????
Squalodon calvertensis	0?00102100	1120??20??	1????????1	0?012100?1
Notocetus vanbenedeni	0100103100	1120??00??	?????????1	02-021????
Prosqualodon davidis	???????00?	??00??????	???20?0001	02-021???1
Squaloziphius emlongi	??????????	??????????	??????????	??????????
Zarhachis flagellator	0a00103110	0100100?0	10????????	??????????
Pomatodelphis inaequalis	0?0?102110	?000??????	??????????	??????????
Platanista gangetica	0100103110	1000000000	?011000001	02--21000a
Tasmacetus shepherdi	1000010110	10101120-1	100a0?20??	0100101011
Berardius bairdii	1000012110	000001???1	0000001001	0101101010
Ziphius cavirostris	1000012110	11100120?1	1000000001	0a0a001011

Taxon	210	220	230	240
Mesoplodon ginkgodens	100?012100	1110102O?1	?010000001	0100001010
Xiphiacetus bossi	0a00102101	1000??001?	1???0?0001	1020201001
Lipotes vexillifer	0000102111	01010?2000	1012002100	0020200111
Parapontoporia sternbergi	??????????	??????????	??????????	0?????????
Inia geoffrensis	010a100111	0100000010	1002100001	0001000-21
Pontoporia blainvillei	0100120101	0100100020	1002100001	0000000-21
Pliopontos littoralis	0?00122101	0000???21?	??????????	??????????
Brachydelphis mazeasi	??0?122??1	01?0????1?	???2??????	??????1011
Kentriodon pernix	0010120101	0100?0?000	1???1?????	????????a1
Atocetus iquensis	0?10120101	0?101?2010	?0??????01	002?001110
Hadrodelphis calvertense	0?1?120111	???????11?	????1????1	0020?00000
Albireo whistleri	0010120101	0100102121	1??2112001	0021100111
Denebola brachycephala	0011100111	0100??????	??????????	????????11
Delphinapterus leucas	0011100111	0100100210	1?12110001	012a000-21
Monodon monoceros	0011100111	010111001?	1?12110001	000a000110
Odobenocetops peruvianus	??1?1?2111	0100??02??	??????????	??????????
Haborophocoena toyoshimai	0011120101	0100??????	??????????	??????????
Australithax intermedia	??????????	??????????	??????????	??????????
Lomacetus ginsburgi	??????????	??????????	??????????	??????????
Piscolithax boreios	??11120101	0?00???0??	1?????????	??????????
Piscolithax longirostris	0?11120111	010011?01?	????1?????	??????????
Piscolithax tedfordi	0?11120111	0?00????1?	??????????	??????1111
Salumiphocaena stocktoni	??1?120111	0?00??????	1?????????	0????01010
Septemtriocetus bosselaersi	??????????	??????????	??????????	??????????
Phocoena sinus	0?11120?11	01??1122-0	1022112001	012000110?
Phocoena spinipinnis	01111201a1	01c01122-0	1022110001	0120201101
Phocoena dioptrica	????12011?	??001122-0	102211?0??	??????1100
Phocoena phocoena	0111120111	01201022-0	1022112a01	0100001101
Phocoenoides dalli	0111120111	0100102c-?	104211ca00	a10a0011a0
Neophocaena phocaenoides	0111120111	01001022-0	1022112a01	012000110a
Lissodelphis borealis	00101001a1	01111022-0	1032110111	1120001101
Cephalorhynchus hectori	0011102111	0110??22?0	1?12110001	0120101111
Leucopleurus acutus	0010100111	0101??????	??32112001	1110101111
Orcaella brevirostris	0011100111	01g01022-?	1?22110111	0020001111

Taxon	210	220	230	240
Orcinus orca	0011100111	011a1a20-?	1012112001	01?1?0111a
Feresa attenuata	0011100111	01101122-0	1032112001	0101001101
Globicephala macrorhynchus	0011100111	01001022-?	?01?110001	1a2a2011?1
Grampus griseus	0011102111	01011022-?	1?22110101	1101101101
Hemisyntrachelus cortesii	??10102111	01101120-?	1??111????	?120201111
Peponocephala electra	0010100111	01101122-?	??42112101	1101101111
Pseudorca crassidens	0010100111	0110?a22-?	1?11?11101	0a00011?1
Delphinus delphis	0010100111	01011a21-?	??221121a1	a101101101
Lagenodelphis hosei	0010100111	01011022-0	1032112101	1121101111
Sousa chinensis	0???10???1	??????20-0	101211c101	102110111a
Stenella attenuata	001a1001a1	01011022-0	1?42112101	112a101?11
Tursiops truncatus	0010100101	01111122-0	101211ca01	1101101111
Sotalia fluviatilis	0011100111	01001020-0	1022112101	10201 a1101
Steno bredanensis	0010102101	01101022-?	??22112101	112a101101
Pterophocaena nishinoi	0111120101	0120??221?	??????????	??????????
Eodelphinus kabatensis	0010102111	0110?1????	??????????	??????????
Haborophocoena minutus	??????????	??????????	??????????	??????????
Archaeophocaena teshioensis	??????????	??????????	??????????	??????????
Miophocaena nishinoi	??????????	??????????	??????????	??????????

Taxon	250	260	270	277
Georgiacetus vogtlensis	??????????	??????????	??????????	???---0
Zygorhiza kochii	0?????????	??????????	??????????	???---0
Archaeodelphis patrius	??????????	??????????	??????????	???????
Xenorophus sloanii	??????????	??????????	??????????	???0???
Agorophius pygmaeus	??????????	??????????	??????????	???000?
Patriocetus kazakhstanicus	??????????	??????????	??????????	????10?
Orycterocetus crocodilinus	??????????	??????????	??????????	???aa1?
Physeter catodon	011000?0?0	?????00000	00010??001	2111101
Kogia breviceps	011000?0?0	?????00000	02010??001	0010111
Waipatia maerewhenua	??????????	??????????	??????????	???010?
Squalodon calvertensis	1?????????	??????????	??????????	???0a01
Notocetus vanbenedeni	??????????	??????????	??????????	???000?
Prosqualodon davidis	0?????????	??????????	??????????	???010?

Taxon	250	260	270	277
Squaloziphius emlongi	??????????	??????????	??????????	???010?
Zarhachis flagellator	??????????	??????????	??????????	???0002
Pomatodelphis inaequalis	??????????	??????????	??????????	???000?
Platanista gangetica	2001111100	?????10??0	0010101101	0100102
Tasmacetus shepherdi	0000110?10	?????10001	1110111110	1010102
Berardius bairdii	0001111?10	?????10001	121011111?	c010101
Ziphius cavirostris	0000110000	?????10001	1110111110	101a102
Mesoplodon ginkgodens	0000110??0	?????10001	1310?111??	101a102
Xiphiacetus bossi	??????????	??????????	??????????	???0101
Lipotes vexillifer	2001111102	0?10010??0	0310?00100	0000101
Parapontoporia sternbergi	??????????	??????????	??????????	???110?
Inia geoffrensis	2000111?12	0?10010??0	0110?00111	011a102
Pontoporia blainvillei	2000111?12	0?10010??0	0110100110	0000102
Pliopontos littoralis	??????????	??????????	??????????	???0102
Brachydelphis mazeasi	1?????????	??????????	??????????	???a10?
Kentriodon pernix	0?????????	??????????	??????????	???1102
Atocetus iquensis	1?????????	??????????	??????????	???0101
Hadrodelphis calvertense	0?????????	??????????	??????????	???1002
Albireo whistleri	0?????????	??????????	??????????	???0100
Denebola brachycephala	1?????????	??????????	??????????	?????0?
Delphinapterus leucas	1001111101	0100011110	0110101101	02g0a0?
Monodon monoceros	1001111101	0?00011110	011010010?	02g0a01
Odobenocetops peruvianus	??????????	??????????	??????????	???111?
Haborophocoena toyoshimai	??????????	??????????	??????????	???100?
Australithax intermedia	??????????	??????????	??????????	???010?
Lomacetus ginsburgi	??????????	??????????	??????????	???010?
Piscolithax boreios	??????????	??????????	??????????	???010?
Piscolithax longirostris	??????????	??????????	??????????	???010?
Piscolithax tedfordi	0?????????	??????????	??????????	???010?
Salumiphocaena stocktoni	0?????????	??????????	??????????	???00??
Septemtriocetus bosselaersi	??????????	??????????	??????????	???00??
Phocoena sinus	0001111111	1101110011	011010011?	0020102
Phocoena spinipinnis	0001111111	11?1110011	011010011?	0020101
Phocoena dioptrica	0???????1?	11?11?????	??11??????	?0g0a00

Taxon	250	260	270	277
Phocoena phocoena	0001111111	1101110011	0110100111	00g0102
Phocoenoides dalli	0001111111	1101110011	011010011?	0010a00
Neophocaena phocaenoides	1001111111	1101110011	011010011?	02g0a0a
Lissodelphis borealis	000110?101	0000110111	011010011?	0220102
Cephalorhynchus hectori	000110?101	0000110111	011010011?	001010?
Leucopleurus acutus	000110?101	0000110111	011010011?	0021102
Orcaella brevirostris	a00110?101	0000110111	011010011?	0011101
Orcinus orca	000110?101	0000110111	011010011?	0010102
Feresa attenuata	000110?101	0000110111	011010011?	0020102
Globicephala macrorhynchus	000110?101	0000110111	011010011?	0031112
Grampus griseus	000110?101	0000110111	011010011?	0020102
Hemisyntrachelus cortesii	0??????????	??????????	??????????	???010?
Peponocephala electra	000110?101	0000110111	011010011?	0020102
Pseudorca crassidens	000110?101	0000110101	011010011?	0030112
Delphinus delphis	000110?101	0000110111	011010011?	0020102
Lagenodelphis hosei	000110?101	0000110101	011010011?	0020102
Sousa chinensis	000110?101	0000110111	011010011?	0020102
Stenella attenuata	000110?101	0000110111	011010011?	002a102
Tursiops truncatus	000110?101	0000110111	0110100111	0020102
Sotalia fluviatilis	000110?101	0000110111	011010011?	0020102
Steno bredanensis	000110?101	0000110111	011010011?	0020102
Pterophocaena nishinoi	??????????	??????????	??????????	????1??
Eodelphinus kabatensis	??????????	??????????	??????????	???101?
Haborophocoena minutus	??????????	??????????	??????????	???100?
Archaeophocaena teshioensis	??????????	??????????	??????????	???101?
Miophocaena nishinoi	??????????	??????????	??????????	???101?

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