Electronic Supplementary Material for

# Oldest record of monk seals from the North Pacific and biogeographic implications

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## 1. Supplementary Text

Herein we describe additional specimens from LACM Loc. 6902 which allow us to asses the marine mammal fauna from that locality. However, this is not meant to be a description of all single bones collected from that horizon, but only a representation of those which we are able to identify to the lowest taxonomic level possible.

**Institutional Abbreviations**—LACM, Vertebrate Paleontology Collection, Natural History Museum of Los Angeles County, Los Angeles, CA, U.S.A; UCMP, University of California Museum of Paleontology, Berkeley, CA, U.S.A.; USNM, Department of Paleobiology, National Museum of Natural History, Smithsonian Institution, Washington, D.C., USA.

SYSTEMATIC PALEONTOLOGY

CETACEA Brisson, 1762

ODONTOCETI Flower, 1865

DELPHINOIDEA Gray, 1821

*ATOCETUS* Muizon, 1988

*ATOCETUS NASALIS* (Barnes, 1985)

(Figure S1a-c; Tables 1, S2)

*Pithanodelphis* new species, Barnes et al., 1985:table 1.

*Pithanodelphis nasalis*, Barnes, 1985:p. 3.

*Atocetus nasalis*, Muizon, 1988:p. 130.

**Referred Specimens**—LACM 122670, left periotic; LACM 123872, partial skull (see Barnes [1], for additional details).

**Remarks**—These specimens were figured and described in detail by Barnes [1] as belonging to *Pithanodelphis nasalis*. Later, Muizon [2] in his description of *Atocetus iquensis* from the late Miocene Pisco Formation in Peru, reassigned *P. nasalis* to *Atocetus*. These taxa were generally considered as being part of the Kentriodontidae (e.g. [1-3]). However, recent phylogenetic analyses that included multiple purported kentriodontids have demonstrated that *Atocetus* and some other traditional kentriodontids are more closely related to other taxa within Delphinoidea [4,5].

PHOCOENIDAE Gray, 1821

*PISCOLITHAX* Muizon, 1983

*PISCOLITHAX* CF. *P. TEDFORDI* Barnes, 1985

(Figure S1d-f; Tables 1, S2)

*Piscolithax* sp., Barnes et al., 1985:table 1.

**Referred Specimens**—LACM 122673, right periotic and stapes.

**Description and Comparison**—The periotic has a sinuous outline in ventral and dorsal views, similar to the type specimen of *Piscolithax tedfordi* (UCMP 315972; [6]). The anterior process is relatively short, oriented anteromedially and has a blunt anteroventral spine, thus differing from the bifid condition observed in UCMP 315972. The anterior process also lacks the

more prominent parabullary ridge observed in *P. tedfordi*. LACM 122673 does share with *P. tedfordi* having a relatively short posterior process that is oriented posterolaterally and has a triangular outline in ventral view, differing from the larger posterior process of *P. boreios* (UCMP 315975; [6]). The articular surface of the posterior process is shallowly concave and has faint longitudinal striations. The dorsolateral surface of the body of the periotic is irregularly flat. The cochlear portion is rounded in dorsal or ventral views, with a flat anteroventral surface as in *Piscolithax tedfordi* and *P. boreios*. Dorsally, the internal auditory meatus has a low transverse septum as in the Almejas *Piscolithax* spp.; the facial canal is located anterolaterally within the internal auditory meatus, while the foramen singulare is in closer proximity to the inferior acoustic foramen than to the former. The endolymphatic foramen is within a rounded depression dorsally, near the base of the posterior process as is in *P. tedfordi* and *P. boreios*; while the perilymphatic foramen is located medial to the endolymphatic foramen and has a conical protuberance near its posterior edge which overhangs the foramen rotundum. A similar, but smaller, protuberance is also observed in UCMP 315972. The stapedial fossa is deeply concave and relatively long; medially joining the ventral opening of the facial canal. The foramen ovale is blocked by the stapes. The mallear fossa is shallowly concave and has a rounded outline.

**Remarks**—LACM 122673 closely resembles those of *Piscolithax* spp. from the Almejas Formation in Baja California [6], rather than those of other phocoenids from the Eastern Pacific region (e.g., *Salumiphocaena stocktoni*, *Semirostrum ceruttii* [7,8]). Specifically, it resembles more closely the periotic of *P. tedfordi*, sharing the presence of a conical protuberance near the posterior edge of the perilymphatic foramen, as well as the size and orientation of the posterior process. However, we only refer it to this particular species tentatively, as it does show some differences as mentioned above.

MYSTICETI Flower, 1864

CETOTHERIIDAE Brandt, 1872

HERPETOCETINAE Steeman, 2007

HERPETOCETINAE GEN. ET SP. INDET.

(Figure S2a-c; Tables 1, S3)

*Nannocetus*? sp., Barnes et al., 1985:table 1.

**Referred Specimens**—LACM 122682, nearly complete left mandible, missing the distal end and apex of coronoid process.

**Description and Comparison**—The mandible is relatively small in size (Table S2). The ramus is bowed laterally, and has seven anteriorly-oriented mental foramina spread along its dorsal surface. The opening of the mandibular canal is dorsoventrally broad, tapering anteriorly towards a U-shaped apex. The anterior edge of the mandibular canal extends beyond the posterior edge of the coronoid process as in some herpetocetines [9]. The lateral surface of the mandible posterior to the canal is ~3-4 mm thick and forms a shallowly concave, broad mandibular fossa; while its ventral edge is dorsoventrally thick, with a shallowly concave dorsal surface. The apex of the coronoid process is missing, but what remains shows that it was relatively low and recurved laterally; the coronoid process has a length of about 71 mm and is 17 mm high as preserved. The posterior slope of the coronoid process is curved medially roofing over the mandibular fossa. The mandibular condyle is oriented posterodorsally and is anteroposteriorly elongated with a lozenge outline in posterior view. The articular surface is

irregularly flat to convex; in dorsal or ventral views the condyle is offset laterally. Medially, below the condyle there is a notch forming the fossa for the internal pterygoid muscle, similar to that seen in some cetotheres (e.g. [10,11]). The angular process is small, barely projecting posteriorly beyond the mandibular condyle similar to the condition in *Diorocetus hiatus* and *Cetotherium riabinini* [11,12], and unlike the longer process of most herpetocetines [9,10,13-16]. The ramus is mediolaterally flattened, being largely oval in cross section, with a flat medial and convex lateral surfaces. Proximally, the ramus is 42 mm high at a point just anterior to the coronoid process, then increasing in dorsoventral thickness towards its anterior end (52 mm), similar to some herpetocetines [9,10,13-15]. In medial or lateral views, the ramus is gently sinuous with its anterior end being recurved dorsally, and twisted laterally. Towards the distal end, the ventral edge of the ramus becomes mediolaterally thinner, almost keel-like. Distally, on the ventromedial surface of the ramus, the symphyseal groove forms a long, shallow, horizontal sulcus located towards the ventral half of the ramus. In dorsal view the mandible is bowed laterally and has a series of mental foramina opening anterodorsally, and which continue anteriorly as a shallow sulcus almost to the point or reaching the subsequent foramen; the mental foramina range in diameter from 2-5 mm.

**Remarks**—LACM 122682 seems to represent a relatively small species of herpetocetine, as it shares with these having a long, laterally recurved coronoid process, flat medial surface of the ramus, and dorsoventrally expanded distal end of the ramus [9,10,14,15]. Comparatively, it is smaller than the mandibles of *Piscobalaena nana*, and herpetocetine mandibles known from the Santa Margarita Sandstone, Purisima and San Mateo formations of California [9,10,14,15]. It differs from most known herpetocetine mandibles except the specimens from the Santa Margarita and San Mateo by having an anteriorly extended opening of the mandibular foramen,

but differs from these in having a shorter angular process [9]. Barnes et al. [17] tentatively referred LACM 122682 to *Nannocetus*, which is a relatively small genus of herpetocetine, known by its nominal species *Nannocetus eremus*, from the nearly contemporaneous Towsley and Santa Margarita formations in California [14,18]. However, neither the type nor the referred specimen of *N. eremus* have associated mandibles, while those of the contemporaneous, and larger, *Mixocetus elysium* are not well preserved, making comparisons with LACM 122682 impossible [14,19,20].

BALAENOPTERIDAE Gray, 1864

BALAENOPTERIDAE GEN. ET SP. INDET.

(Figure S2d-f; Table 1)

Balaenopteridae, Barnes et al., 1985:table 1.

**Referred Specimens**—LACM 122684, left supraorbital process of frontal.

**Description and Comparison**—The bone is incompletely preserved, measuring a maximum of 225 mm anteroposteriorly and 376 mm mediolaterally. The anterior edge of the supraorbital process is incompletely preserved medially. The dorsal surface of the supraorbital process is flat to gently concave towards its anterolateral margin, lacking the ascending temporal crest seen in gray whales [21]. The posterior edge of the supraorbital process is straight to sigmoidal in dorsal view as in most balaenopterids [22], thus differing from the concave border seen in stem mysticetes, herpetocetines, balaenids and *Miocaperea pulchra*, or the markedly sinuous edge of *Eschrichtius robustus* [10,14,16,19,23-26]. The posterior edge of the

supraorbital process is oriented laterally, as in *Inkakujira anillodefuego*, *Megaptera novaeangliae* and some species of *Balaenoptera* (e.g. *B. siberi*), and unlike the anterolateral (e.g. *Parabalaenopteral baulinensis*, *B. musculus*) or posterolateral (e.g. *B. bertae*) orientation of other balaenopterids [15,22,23,27]. The pre- and postorbital processes have a triangular outline in lateral view, and the orbital rim is gently concave, resembling the orbit of *I. anillodefuego*; the orbit is 157 mm long. In dorsal view, the preorbital process is more medially positioned than the postorbital process as in *I. anillodefuego*, and unlike the more laterally prominent preorbital process of *Balaenoptera bertae* [15]. The postorbital process is short, resembling that of *I. anillodefuego*, *Parabalaenoptera baulinensis* and most extant balaenopterids, differing from the more posteriorly prominent process of *Megaptera miocaena* and or the ventrally longer process of *Balaenoptera siberi* [22,27-30]. The posterior edge of the postorbital process is flat, and likely contacted the zygomatic process of the squamosal as in most balaenopterids [22,28]. Ventrally the optic canal is conical, and bounded anteriorly and posteriorly by relatively thick pre- and postorbital ridges. The preorbital ridge is anteroposteriorly thinner than the postorbital ridge and becomes dorsoventrally expanded and gently recurved medially; the postorbital ridge is thick, and is continuous laterally with the postorbital process as in other balaenopterids [22].

**Remarks**—The morphology of LACM 122684 is consistent with crown balaenopterids rather than with other groups of extant and extinct mysticetes. Amongst balaenopterids, it most closely resembles *Inkakujira anillodefuego* and *Balaenoptera siberi* in both size and morphology, more than it does with coeval or slightly younger species from California such as *Megaptera miocaena*, *Parabalaenoptera baulinensis* or *Balaenoptera bertae*. Both, *I. anillodefuego* and *B. siberi* are known from the Aguada de Lomas level of the Pisco Formation in Peru, which is temporally coeval with the Monterey Fm. locality studied here [22,28,31].

LACM 122684 resembles more closely the morphology of *I. anillodefuego* as they differ from *B. siberi* by having a shorter postorbital process. However, because of the incompleteness of the Monterey specimen, we prefer to refer it to as Balaenopteridae gen. et sp. indet. until additional, more complete comparative material becomes available.

CARNIVORA Bowdich, 1821

PINNIPEDIA Illiger, 1811

OTARIIDAE Gill, 1866, *sensu* Velez-Juarbe, 2017

*PITHANOTARIA* Kellogg, 1925

*PITHANOTARIA STARRI* Kellogg, 1925

(Figs. S3a-c, Tables 1, S4)

*Pithanotaria starri*, Barnes et al., 1985:table 1.

*Pithanotaria starri*, Velez-Juarbe, 2017:page 2, fig. 6D.

**Referred Specimens**—LACM 115677, right mandible, including i3, p2 and the proximal end of the canine.

**Description and Comparison**—The horizontal ramus is slender and has a sinuous ventral border. The mandibular symphysis has a suboval outline, being longer than high and oriented anterodorsally. Anteriorly, there are six small mental foramina ventral to the alveoli for i2-3, and a slightly larger one anteriorly, below the incisor. The genial tuberosity is at the posteroventral end of the symphysis, at a level below p3. Posterior to the genial tuberosity, the ventral surface of the ramus is shallowly concave, being dorsoventrally narrowest at the level

posterior to the last postcanine tooth, but becomes more rounded, forming a low crest for the insertion of M. digastricus, as in the specimens referred to this species by Repenning and Tedford [32]. The coronoid process is relatively low and narrow, with an anteroposterior length less than 42% of the total mandibular length. The anterior edge of the coronoid slopes posterodorsally. The masseteric fossa is deepest along its anterior and ventral edges, and is long (= 41% of the total length of the mandible). The mandibular condyle has an elliptical outline and located about 15 mm above the level of the alveolar row, with its long axis perpendicular to the long axis of the skull. Medially, the mandibular canal is small (~2 mm in diameter) and opens posterodorsally. As preserved, the angular process is narrow, and does not form a medial shelf, similar to *Eotaria crypta* and *Callorhinus gilmorei* [33,34].

The dental formula in LACM 115677 consists of i2-3, c, p1-4, m1-2. The alveolus for i2 is poorly preserved. The third incisor (i3) has a suboval cross section; a small cingulum is present on its distal side and lacks accessory cusps, similar to that of *Callorhinus ursinus*. Only the base of the canine is preserved; it has an oval cross section. The postcanine teeth consist of double-rooted p2-m1, and single-rooted p1 and m2. Of the postcanine teeth, only p2 is preserved. The crown consists of a distally-curved, conical protoconid, and a faint, dorsally curved lingual cingulum; it lacks other cusps which are more typical of pan-otariids, as well as the crenations or accessory cuspules seen in other otariids like *Thalassoleon mexicanus*, *Thalassoleon inouei, Callorhinus gilmorei* and *Callorhinus ursinus* [34-38]. All the postcanine alveoli have a rounded outline except for m2 which is oval.

**Remarks**—LACM 115677 can be distinguished from most other crown otariids, except *Thalassoleon* spp., by having double rooted p2-m1 and having postcanine teeth with dorsally arched lingual cingula [32,37]. However, LACM 115677 differs from *Thalassoleon* spp. by its

smaller size as well as lack of accessory cusp or cuspules in p1-4 [32,35,37]. The lower postcanine dentition of *Pithanotaria starri* seems to be variable, with some specimens consisting of p1-4 and m1 (e.g. LACM 115153; [34]), while others, like LACM 115677, also have an m2, resembling the condition in the stem otariid *Eotaria* spp. Variation in the presence of m2 has been observed at least in some extant otariids, but this may be the first case in an extinct taxon [39]. There are additional specimens referable to *Pithanotaria starri* from LACM Loc. 6902 as well as from other localities of the Monterey Formation in Southern California, but they will be described and discussed in greater detail in a separate work.

ODOBENIDAE Allen, 1880 *sensu* Magallanes, Parham, Santos, & Velez-Juarbe, 2018

ODOBENIDAE gen. et sp. indet.

(Figs. S3d-l, Tables 1, S5-S6)

*Imagotaria downsi*, Barnes et al., 1985:table 1 (in part).

**Referred Specimens**—LACM 121015, partial right premaxilla and maxilla, including I2 and canine; LACM 58548, partial left maxilla, including canine, P1-3; LACM 73566, right p1; LACM 52601, left p3 or p4.

**Description and Comparison**—LACM 121015 consists of a partial right premaxilla and maxilla of a juvenile specimen. The premaxilla of LACM 121015 has three incisors as in most odobenids, with incisor 3 being notable larger [32,40]. The alveoli of I1-2 are transversely compressed. The crown of I2 is somewhat diamond-shaped in cross section towards its apex, which is truncated by a worn occlusal surface; distally it has a small, conical accessory cusp. The

alveolus for I3 is much larger than those of the other incisors and has an oval outline as in *Imagotaria downsi* (LACM 144453; [41]). The anterodorsal end of the premaxilla forms a low, rounded prenarial process resembling that of *Imagotaria downsi*, *Titanotaria orangensis*, *Archaeodobenus akamatsui*, and some other, undescribed odobenids from the Monterey Fm. [18,32,34,41,42]. The narial opening seems to have been oval with relatively thick margins. In lateral view, the alveolar row is slightly elevated and recurved anterodorsally. The nasal process of the premaxilla is visible in lateral view and its anterior margin is shallowly concave.

The maxilla of LACM 121015 has a bulbous lateral surface due to the enlarged canine. The canine is only partially erupted; the crown is conical, recurved and has a distal carina. The anteroposterior diameter of the canine is 16mm by 13 mm buccolingually, but was likely much larger once fully erupted, based on the diameter of the alveolus (21 mm). The palatal surface is shallowly concave, with the premaxilla forming the incisive foramen. In the palatal surface of the maxilla there is also a partially preserved palatal foramen at the level of P3, which is continuous anteriorly as a shallow groove. In the postcanine alveolar row there are at least four alveoli. The anteriormost representing P1 has a diameter of about 8mm. The second and third alveoli seem to represent single rooted P2 and P3, while the fourth partial alveolus is interpreted as that of P4. If the alveoli for P2-3 represent alveoli for single-rooted postcanine teeth, and not a double-rooted P2 as in *Archaeodobenus akamatsui*, they would be comparatively smaller than those of *Imagotaria downsi* (type and USNM 185060) and *Titanotaria orangensis* [18,32,41], but similar to those of LACM 123283.

LACM 58548 consists of a partial left maxilla of a juvenile specimen, judging by the porous surface of the bone and the unerupted dentition. The medial surface of the maxilla has grooves and ridges marking the contact with the premaxilla. The palatal surface is shallowly

concave; at the level of P3 there is a small (~2 mm) palatal foramen that opens anteriorly and continues as a shallow groove anteriorly as in LACM 121015 (see above) and in one of the referred specimens of *Imagotaria downsi* (USNM 184060; [32]). The canine is unerupted but visible laterally as the bone is broken; the crown is conical, recurved and ~24 mm high. P1 is broken at the base, but, like P2-3, the crown is bulbous, and remnants of a prominent, crenulated lingual cingulum is visible towards its distal end, similar to the P1 described below (LACM 73566) as well as those of *Pelagiarctos thomasi* [43]. P2-3 are unerupted, the crowns consist of a large, conical paracone; the distal edge of the paracone forms a sharp ridge on both teeth. As in P1, a prominent a crenulated lingual cingulum is visible in P3, reminiscent of the condition observed in *Imagotaria downsi*, *Titanotaria orangensis* and other undescribed odobenids from the Monterey Fm. [18,34,41].

LACM 73566 is a right P1 which has a conical root that is recurved posterodorsally and open distally exposing the pulp cavity; a longitudinal groove extends the full length of the root on its buccal side. The crown is bulbous, with a large, conical, distally curved paracone. The medial and distal edges of the paracone form sharp crests that extend from the apex to the level of the lingual cingulum. A nearly inconspicuous buccal cingulum is only present on the distal portion of the crown, similar to that of *Imagotaria downsi* [41]; while the lingual cingulum is more prominent and crenulated, unlike the smoother cingulum of *I. downsi*, but reminiscent of the condition observed in *Pelagiarctos thomasi* [43], and LACM 123283 (Odobenidae sp. 1 of Velez-Juarbe [34]).

The root in LACM 52601 is broken proximally but seems to have been double, judging by the midline constriction in the middle of the preserved root portion. The crown is unworn which may indicate a young age for the specimen. The crown is bulbous, with no buccal

cingulum and a prominent, crenulated lingual cingulum that has a dorsoventral thickening distal to the protoconid. Mesially there is a large paraconid, whose lingual edge descends to join the cingulum. The protoconid is the largest cusp, and has a triangular outline in buccal and lingual view, and is slightly recurved distally. The metaconid and hypoconid are similar in size, both slightly smaller than the paraconid. The metaconid is located closer to the hypoconid than to the protoconid, unlike that of *Neotherium mirum* in which is located midway between those cusps [44]. The cusp arrangement and proportions of LACM 52601 somewhat resembles the p3/4 of *Pelagiarctos thomasi* and *Pelagiarctos* sp., but differs from the former by its smaller dimensions [43,45]. It also differs from the p3 of *Imagotaria downsi* [32,41] as the metaconid in this taxon is much reduced and located between the protoconid and hypoconid; the crown of the type of *I. downsi* also has larger dimensions. It does share with *Pelagiarctos* spp., *Imagotaria downsi*, *Titanotaria orangensis* and *Archaeodobenus akamatsui* having a crenulated lingual cingulum, although the crenulations seem more prominent in the Monterey specimen [18,41,42,43,45].

**Remarks**—LACM 121015, LACM 58548 and LACM 73566 represent young individuals, based on the partially erupted canine and distally open root, respectively. In general morphology, LACM 121015 resembles *Imagotaria downsi*, *Titanotaria orangensis*, and LACM 122444 (Odobenidae sp. 2 of Velez-Juarbe [34]). However, it differs from these by the smaller size of the postcanine alveoli which is shares with LACM 123283. LACM 58548 is relatively incomplete which complicates comparisons; however, the distinctly crenulated lingual cingulum of P1 makes it distinct from *I. downsi* (see below), being instead similar to *Pelagiarctos* spp., LACM 73566 and Odobenidae sp. 1 (LACM 123283; Velez-Juarbe [34]). LACM 52601 seems to also represent an odobenid of unknown affinities distinct from *Imagotaria downsi*, *Titanotaria*

*orangensis*, *Archaeodobenus akamatsui*, and others, but sharing some similarities with *Pelagiarctos thomasi*.

Both Odobenidae sp. 1 and 2 are known from the Monterey Formation in Southern California, and are represented by multiple specimens [34]. Their morphology is distinct from other late Miocene odobenids, such as *Imagotaria downsi* and *Titanotaria orangensis*, and will be described in greater detail elsewhere, including further comparison with the material described here.

*IMAGOTARIA* Mitchell, 1968

*IMAGOTARIA* CF. *I. DOWNSI* Mitchell, 1968

(Figs. S4a-h, Tables 1, S5, S7)

*Imagotaria downsi*, Barnes et al., 1985:table 1 (in part).

**Referred Specimens**—LACM 50971, right P2 or P3; LACM 57323, partial left mandible of a juvenile individual, with p2-m2 unerupted but partly visible; LACM 117678, left P1.

**Description and Comparison**—In P1 (LACM 117678) the crown is bulbous, conical and recurved distally. The crown lacks a buccal cingulum while the lingual cingulum is smooth, lacking the cuspule present in the type of *Imagotaria downsi*, and being instead more similar to P1 of the referred specimens [32,41]. A distal carina extends from the apex of the paracone to a nearly indistinct cusp on the distalmost end of the crown. The root is conical in LACM 117678 and gently curved lingually. The root bears a buccal longitudinal groove, giving it a bilobed

cross section as in *Imagotaria downsi* [41]. The crown is similar in size to those of *Imagotaria downsi* (LACM 144453, cast of type) and referred specimen USNM 184060, only with LACM 117678 being slightly larger than the type. Other odobenids from the Monterey Fm. where P1 is preserved such as LACM 73566 and LACM 123283 (= Odobenidae sp. 1 of Velez-Juarbe [34]), have more prominent, crenulated lingual cingulum (see above).

The root of LACM 50971 is missing the apex, but it is otherwise complete; it is cylindrical, with a buccal longitudinal sulcus that gives it a bilobed cross section as in *Imagotaria downsi* and *Titanotaria orangensis*, and unlike the double-rooted P2/P3 of *Archaeodobenus akamatsui* [18,41]. The crown is bulbous with a prominent lingual cingulum that has two cusplets towards its mesial edge and a single one distally. The crown consists of a conical paracone, whose distal edge forms a sharp ridge that descends steeply to meet a small, conical metacone. The crown has wear facets on the mesial surface of the paracone and distal corner of the lingual cingulum. LACM 50971 shares a similar crown morphology with P2 and P3 of *Imagotaria downsi* (LACM 144453; [41]), although it is slightly smaller; however, it resembles more closely P2 as they share the presence of a small metacone and a smoother lingual cingulum than those of P3 or P4. The referred specimen of *I. downsi* (USNM 184060; [32]) differs by having a less prominent lingual cingulum, more discreet crenulations and a nearly indistinct metacone located halfway between the apex and base of the crown. In *Titanotaria orangensis* P2 and P3 are heavily worn, but seem to differ from LACM 50971 by having more heavily crenulated lingual cingula [18]. While it differs from *Archaeodobenus akamatsui* by having a bilobed root, and a less distolingually prominent cingulum [42].

LACM 57323 consist of the nearly complete left mandible of a very young individual. The symphysis is oriented anterodorsally at about 35º relative to the alveolar row. A pair of small

(~2 mm diameter) mental foramina are located ventral at the level of the incisors, while an additional five foramina, ranging in diameter between 1-3 mm are located on the lateral surface of the ramus between p2-3. The anterolateral surface of the symphyseal region is smooth. The genial tuberosity is located at the posteroventral end of the symphysis, at the level of p2, and extends well beyond the ventral border of the ramus as in *Imagotaria downsi*, *Titanotaria orangensis*, *Archaeodobenus akamatsui*, *Nanodobenus arandai*, *Dusignathus* spp. [41,42,46,47]. The lateral surface of the ramus is gently convex, while medially it is flat to gently concave. The ventral border of the ramus posterior to the genial tuberosity is ventrally concave, forming a sharp ridge that becomes more rugose posteroventrally, likely representing the anterior extent of the digastric insertion. Based on the preserved teeth and alveoli, the adult postcanine dentition seems to consist of p1-4, m1-2. Of the postcanine teeth, only p2, m1-2 are partially visible. A presumably deciduous incisor is broken at the base, the root has a circular cross section and is located lingually, close to the symphysis. Of the permanent incisors, only a small, conical tip is visible. Premolar 1 is represented by a rounded, conical alveolus. The second premolar is partially visible; the crown consists of a conical protoconid with sharp mesial and distal edges. An incipient metaconid is present on the distal edge of the protoconid, similar to p2 of *Imagotaria downsi* (LACM 144453; [41]). Other pairs of alveoli distal to p2 seem to represent those of deciduous teeth; through these alveoli the tips of p3-4 are visible, but not much else can be said about them because of their poor preservation. The molars are visible mainly in occlusal view. The first molar (m1) is at least twice as large as m2; the crown consists of a large protoconid, and smaller, conical hypoconid and paraconid of similar size; a lingual cingulum is present and has small crenulations on its distal end. The second molar is much smaller as in other

odobenids (e.g. *Neotherium mirum*; [43]), and has a similar cusp pattern as m1, but lack lingual or labial cingula.

**Remarks**—The upper premolars closely resemble the morphology of *Imagotaria downsi*, more so than that of other odobenids from the Monterey Formation*, Archaeodobenus akamatsui* or *Titanotaria orangensis*. The morphology of the mandible is similar to that of *Imagotaria downsi*, *Titanotaria orangensis*, *Archaeodobenus akamatsui*, sharing with these a smooth anterior symphyseal region and a prominent genial tuberosity located at the level of p2, differing from the more posteriorly located tuberosity of *Nanodobenus arandai* [18,41,42,47]. The lower molars are unknown in *Archaeodobenus akamatsui* and *Titanotaria orangensis*, whereas they are heavily worn in other Monterey odobenids (i.e. LACM 123283, LACM 122444; [18,42]). The size and morphology of m1-2 is most similar to that of *Imagotaria downsi* and is herein provisionally referred to that taxon (LACM 144453; [41]). In this regard, *Imagotaria downsi* is known from similar-age deposits elsewhere in California, sometime also in association with the otariid *Pithanotaria starri* [32,41] supporting this provisional assignment.

SIRENIA Illiger 1811 *sensu* Velez-Juarbe and Wood, 2019

DUGONGIDAE Gray, 1821 *sensu* Velez-Juarbe and Wood, 2019

HYDRODAMALINAE Palmer, 1895

*DUSISIREN* Domning, 1978

*DUSISIREN* SP.

(Figs. S4i-j, Tables 1, S8)

*Dusisiren* cf. *D. jordani*, Barnes et al., 1985:table 1.

**Referred Specimens**—LACM 37610, centrum of cervical vertebra; LACM 37611, middle caudal vertebra.

**Description and Comparison**—The cervical vertebra seems to belong to an adult individual, as the articular surfaces of the centrum are fairly smooth, and the transverse and spinous processes are broken, not unfused as in juvenile specimens [48]. Its morphology is consistent with cervicals 3-6, as it lacks the posterior demifacets usually present in cervical 7 (e.g. [49]). The centrum is anteroposteriorly thin, with a rectangular outline in anterior or posterior views. The anterior and posterior surfaces of the centrum are irregularly concave. The transverse processes seem to have been oriented slightly anterolaterally, at least proximally.

LACM 37611 is a middle caudal vertebra of a juvenile individual, judging by the very porous anterior and posterior articular surfaces of the centrum and the incomplete transverse processes [48]. The centrum has an hexagonal outline in anterior and posterior views similar to those of *Dusisiren jordani*, and unlike the more rounded centra of other dugongids (e.g. *Metaxytherium albifontanum*; [50]). As in caudals 3-20 of *Dusisiren jordani*, the ventral surface of the centrum has a two pairs of blunt projections for articulation of the chevrons [48]. The neural spine is short, and the neural canal is relatively small. Only the left prezygapophysis is preserved but is reduced to a cylindrical knob.

**Remarks**—The morphology of these specimens is consistent with that of crown Dugongidae. Barnes et al. [17] originally referred this specimen to *Dusisiren* cf. *D. jordani*, which is known from other localities of the Monterey Formation as well as others throughout California [48,51,52]. However, a second species of *Dusisiren* seems to be present in the Monterey Fm., as Domning and Furusawa [52] report the presence of *Dusisiren dewana*, a

species otherwise known from similar age deposits in Japan [53]. The size of the cervical vertebra is more similar to that of *D. dewana*, rather than with the larger *D. jordani*, and may be that it belongs to that taxon; however, we prefer a conservative approach and only refer this material to *Dusisiren* sp.

## 4. Supplementary Tables

TABLE S1. List of shared and related taxa between the upper Monterey, Almejas, and Pisco formations.

| Taxon | Formation | Age | Source |
|---|---|---|---|
| *Atocetus nasalis* | Upper Monterey Fm. | 8.5-7.1 Ma | [1,17]; this work |
| *Piscolithax* cf. *P. tedfordi* | Upper Monterey Fm. | 8.5-7.1 Ma | [17]; this work |
| Herpetocetinae gen. et sp. indet. | Upper Monterey Fm. | 8.5-7.1 Ma | [17]; this work |
| Balaenopteridae gen. et sp. indet. | Upper Monterey Fm. | 8.5-7.1 Ma | [17]; this work |
| Monachinae gen. et sp. indet. | Upper Monterey Fm. | 8.5-7.1 Ma | This work |
| *Piscolithax boreios* | Almejas Fm. | 8.0-5.5 Ma | [6,18] |
| *Piscolithax tedfordi* | Almejas Fm. | 8.0-5.5 Ma | [6,18] |
| *Atocetus iquensis* | Pisco Fm. (CLB) | >9.2 Ma | [2,54] |
| Monachinae | Pisco Fm. (CLB) | >9.2 Ma | [54]; Pers. obs. |
| *Piscolithax aenigmaticus* | Pisco Fm. (AGL) | 8.8-8.0 Ma | [55-57] |
| *Piscobalaena nana* | Pisco Fm. (AGL) | 8.8-8.0 Ma | [31,57]] |
| *Balaenoptera siberi* | Pisco Fm. (AGL) | 8.8-8.0 Ma | [28,31,57] |
| *Incakujira anillodefuego* | Pisco Fm. (AGL) | 8.8-8.0 Ma | [22,57] |
| *Acrophoca* sp. | Pisco Fm. (AGL) | 8.8-8.0 Ma | [31,57] |
| *Australophoca changorum* | Pisco Fm. (AGL) | 8.8-8.0 Ma | [57,58] |
| *Piscolithax longirostris* | Pisco Fm. (SAS) | 7.1-5.93 Ma | [2,31,57] |
| *Piscobalaena nana* | Pisco Fm. (SAS) | 7.1-5.93 Ma | [10,57] |
| *Acrophoca longirostris* | Pisco Fm. (SAS) | 7.1-5.93 Ma | [31,59] |
| *Piscophoca pacifica* | Pisco Fm. (SAS) | 7.1-5.93 Ma | [57,59] |

| | | | |
|---|---|---|---|
| *Hadrokirus martini* | Pisco Fm. (SAS) | 7.1-5.93 Ma | [57,60] |

Abbreviations: AGL, Aguada de Lomas vertebrate level; CLB, Cerro La Bruja vertebrate level; SAS, Sacaco vertebrate level.

TABLE S2. Measurements (in mm) of periotics described in this work (modified from [61]).

| | *Atocetus nasalis* (LACM 122670) | *Piscolithax* cf. *P. tedfordi* (LACM 122673) |
|---|---|---|
| Maximum length of periotic | 30.0 | 28.0 |
| Proximal thickness of anterior process | 10.4 | 8.5 |
| Maximum width of periotic | 17.2 | 18.9 |
| Least distance between fundus of internal auditory meatus and aperture for endolymphatic duct | 1.7 | 3.6 |
| Least distance between fundus of internal auditory meatus and aperture for perilymphatic duct | 1.6 | 2.9 |
| Length of articular surface of posterior process | 11.4 | 10.2 |
| Width of articular surface of posterior process | 9.7 | 9.4 |
| Diameter of cochlear portion | 15.8 | 14.6 |

TABLE S3. Measurements (in mm) of herpetocetine mandible (LACM 122682).

| | |
|---|---|
| Total length as preserved (linear) | 650+ |
| Total length as preserved (curvilinear) | 664+ |
| Length of coronoid process | 71 |
| Height of coronoid process | 17+ |
| Height at mandibular condyle | 66 |
| Width of mandibular condyle | 24 |
| Anterior margin of mandibular foramen to anterior edge of condyle | 89 |
| Least dorsoventral thickness of ramus | 42 |
| Greatest dorsoventral thickness of ramus | 52 |
| Transverse thickness anterior to mandibular foramen | 28 |
| Transverse thickness at distal end | 23 |

TABLE S4. Measurements (in mm) of *Pithanotaria starri* mandible and teeth (LACM 115677; modified from [34]).

| | | | |
|---|---|---|---|
| Total length | 126.4 | i3: anteroposterior length | 3.6 |
| Depth at p1 | 20.4 | i3: height of crown | 2.9 |
| Depth at p2 | 21.7 | i3: transverse width | 3.0 |
| Depth at p3 | 22.2 | c: anteroposterior length | 7.7 |
| Depth at p4 | 19.5 | c: transverse width | 6.0 |
| Depth at m1 | 19.4 | p1: anteroposterior length | 4.2a |
| Depth at m2 | 18.2 | p1: transverse width | 3.8a |
| Diastema between p1-2 | 1.1 | p2: anteroposterior length | 5.6 |
| Diastema between p2-3 | 2.9 | p2: height of crown | 5.8 |
| Diastema between p3-4 | 3.2 | p2: transverse width | 3.5 |
| Diastema between p4-m1 | 0.7 | p3: anteroposterior length | 6.9a |
| Diastema between m1-2 | 0.7 | p3: transverse width | 3.4a |
| Length of coronoid process at base | 45.9 | p4: anteroposterior length | 6.8a |
| Length of toothrow canine-m2 | 54.6 | p4: transverse width | 3.3a |
| Length of postcanine toothrow | 44.4 | m1: anteroposterior length | 6.6a |
| Length of masseteric fossa | 52.2 | m1: transverse width | 3.3a |
| Length of symphysis | 32.4 | m2: anteroposterior length | 4.2a |
| Height of symphysis | 14.4 | m2: transverse width | 2.4a |
| Orientation of symphysis | 45º | | |

Abbreviation: a, measurement of alveoli.

TABLE S5. Measurements (in mm) of isolated odobenid teeth.

| | Length of crown | Width of crown | Height of crown |
|---|---|---|---|
| LACM 117678 | 13.9 | 11.5 | 13.9 |
| LACM 73566 | 12.3 | 11.5 | 13.6 |
| LACM 50971 | 12.1 | 9.8 | 11.8 |
| LACM 52601 | 12.5 | 8.9 | 9.7 |

TABLE S6. Measurements (in mm) of odobenid rostra and teeth/alveoli.

| | LACM 121015 | LACM 58548 |
|---|---|---|
| Transverse width of external nares | 38e | - |
| Width of rostrum lateral to external nares | 13.5 | - |
| I1: anteroposterior length | 8.8a | - |
| I1: transverse width | 4.8a | - |
| I2: anteroposterior length | 6.0 | - |
| I2: transverse width | 4.9 | - |
| I2: height of crown | 4.4 | - |
| I3: anteroposterior length | 13.7 | - |
| I3: transverse width | 8.6 | - |
| C: anteroposterior length | 16.2 | - |
| C: transverse width | 11.9 | - |
| C: height of crown | 28.3 | 24.4 |
| P1: anteroposterior length | 6.6a | 10.2 |
| P1: transverse width | 7.1a | 8.4 |
| P2: anteroposterior length | 9.9a | 10.2a |
| P2: transverse width | 6.7a | - |
| P2: height of crown | - | 12.8 |
| P3: anteroposterior length | 8.9a | 12.4 |
| P3: transverse width | 5.8a | - |
| P3: height of crown | - | 12.7 |

Abbreviation: a, measurement of alveoli; e, estimate.

TABLE S7. Measurements (in mm) of *Imagotaria* cf. *I. downsi* mandible and teeth (LACM 57323; modified from [34]).

| | | | |
|---|---|---|---|
| Total length as preserved | 107.9 | Orientation of symphysis | 35º |
| Depth at p1 | 20.4 | p1: anteroposterior length | 6.7a |
| Depth at p2 | 21.7 | p1: transverse width | 5.0 |
| Depth at p3 | 22.2 | p2: anteroposterior length | 10.7 |
| Depth at p4 | 19.5 | p2: height of crown | 10.9 |
| Depth at m1 | 19.4 | m1: anteroposterior length | 13.1 |
| Depth at m2 | 18.2 | m1: transverse width | 8.6 |
| Depth at genial tuberosity | 37.2 | m1: height of crown | 10.4 |
| Length of postcanine toothrow | 72.5 | m2: anteroposterior length | 7.9 |
| Length of symphysis | 41.1 | m2: transverse width | 5.7 |
| Height of symphysis | 18.5 | m2: height of crown | 5.8 |

Abbreviation: a, measurement of alveoli.

TABLE S8. Measurements (in mm) of vertebrae of *Dusisiren* sp. (modified from [48]).

| | LACM 37610 | LACM 37611 |
|---|---|---|
| Total height | - | 77.7+ |
| Anterior breadth of centrum | 64.0 | 65.4 |
| Posterior breadth of centrum | 70.3 | 60.4 |
| Height of centrum in midline | 47.7 | 44.4 |
| Thickness of centrum in midline | 15.8 | 32.2 |
| Width of neural canal | - | 17.1 |
| Height of neural canal | - | 10.7 |

## 3. Supplementary Figures

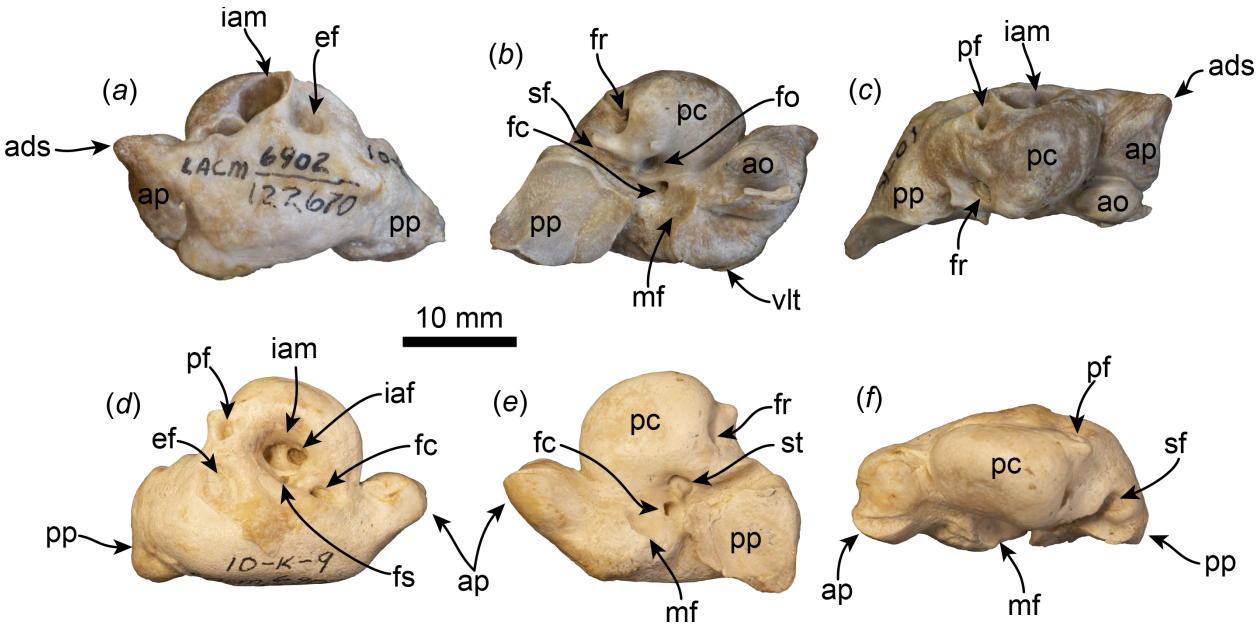


**Figure S1.** Left periotic of *Atocetus nasalis* (LACM 122670), in dorsolateral (*a*), ventral (*b*) and medial (*c*), views. Right periotic of *Piscolithax* cf. *P. tedfordi* (LACM 122673), in dorsal (*d*), ventral (*e*), and medial (*f*), views. Abbreviations: ads, anterodorsal spine; ao, accessory ossicle; ap, anterior process; ef, endolymphatic foramen; fc, facial canal; fo, foramen ovale; fr, foramen rotundum; fs, foramen singulare; iaf, internal auditory foramen; iam, internal auditory meatus; mf, mallear fossa; pc, pars cochlearis; pf, perilymphatic foramen; pp, posterior process; sf, stapedial muscle fossa; st, stapes; vlt, ventrolateral tuberosity.

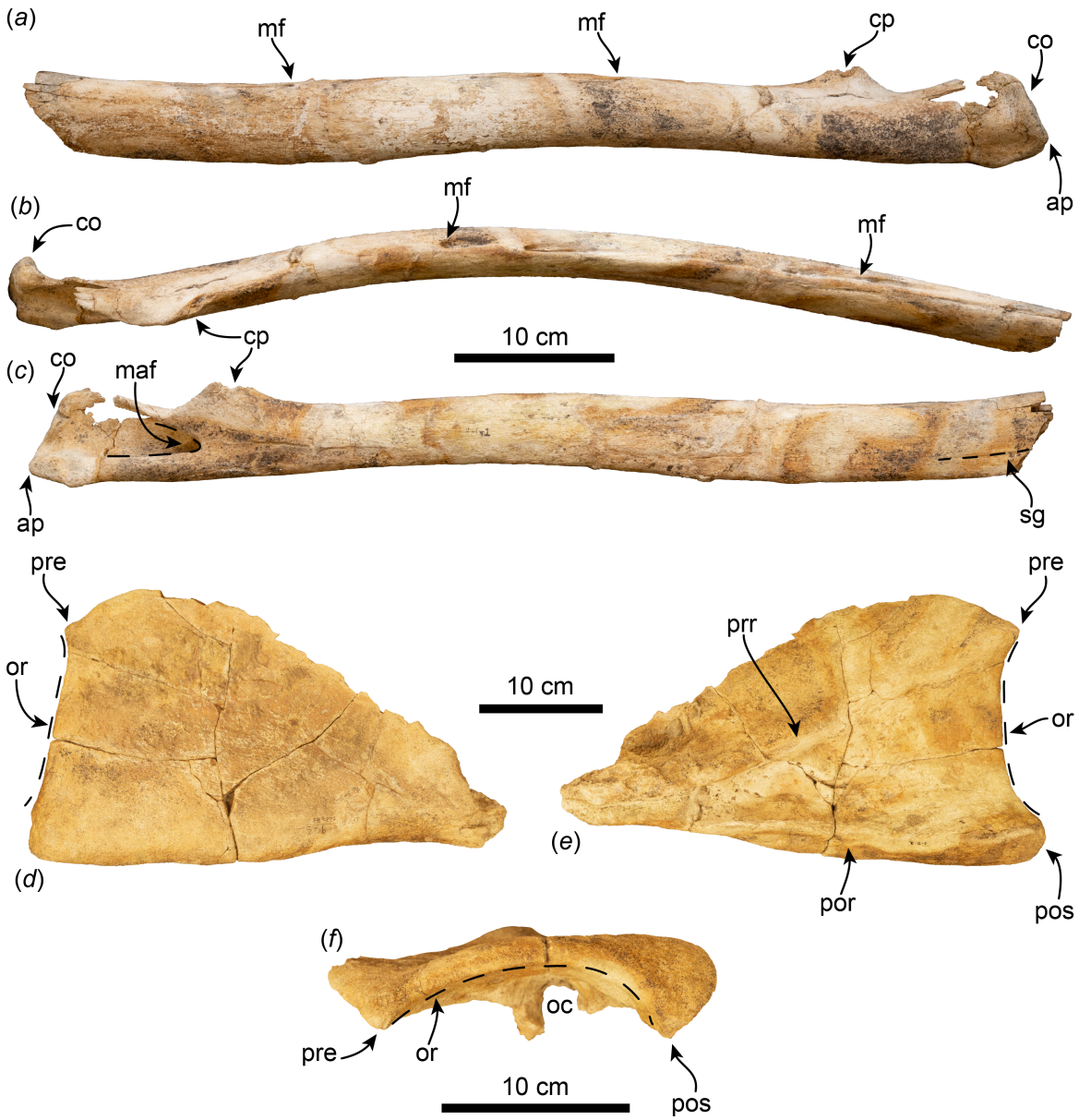


**Figure S2.** Left mandible of Herpetocetinae gen. et sp. Indet. (LACM 122682), in lateral (*a*), dorsal (*b*), and medial (*c*), views. Left supraorbital process of frontal of Balaenopteridae gen. et sp. indet. (LACM 122684), in dorsal (*d*), ventral (*e*), and lateral (*f*), views. Abbreviations: ap, angular process; co, condyle; cp, coronoid process; maf, mandibular foramen; mf, mental foramen; oc, optic canal; or, orbit; pos, postorbital process; pre, preorbital process; por, postorbital ridge; prr, preorbital ridge; sg, symphyseal groove.

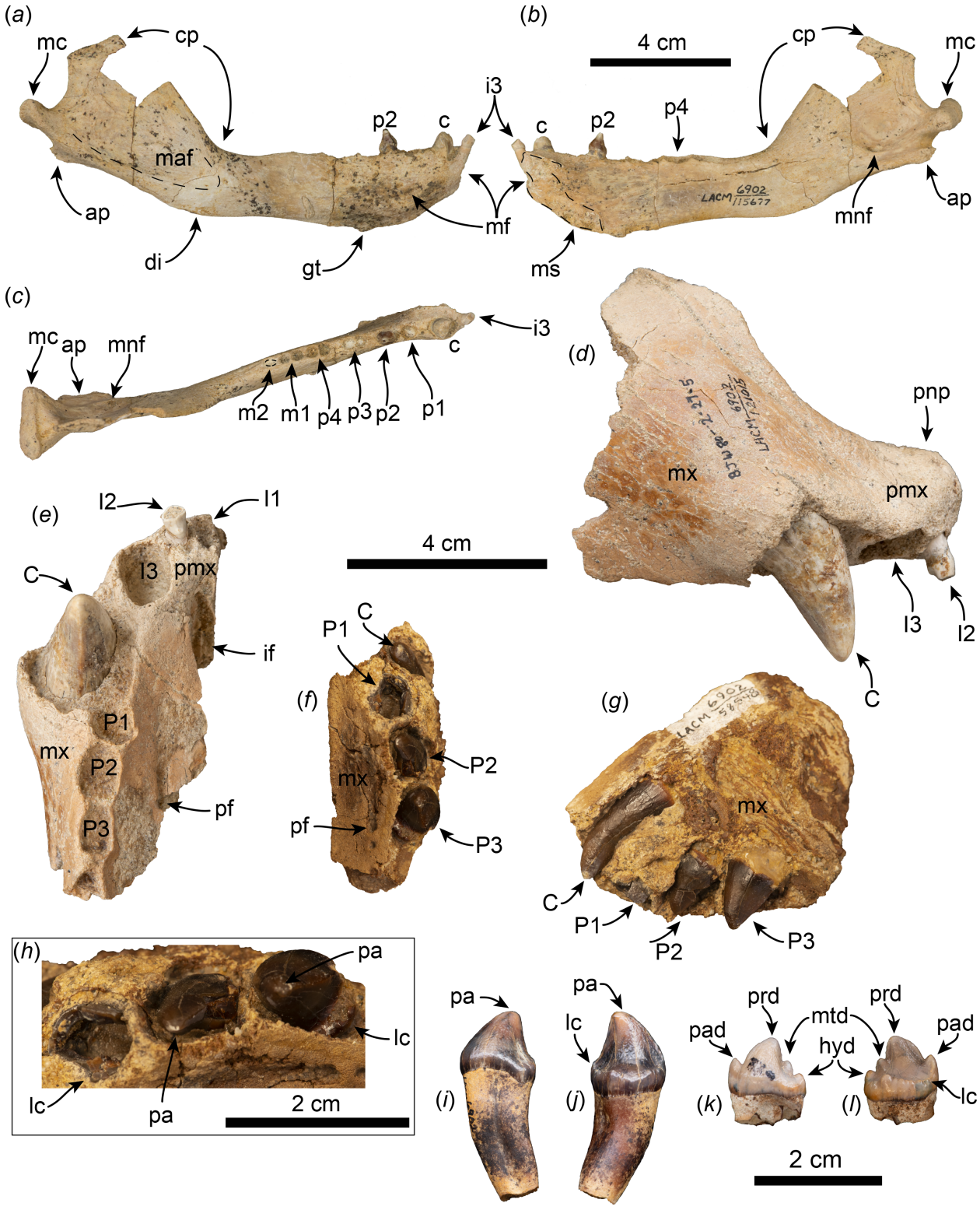


**Figure S3.** Right mandible of *Pithanotaria starri* (LACM 115677), in lateral (*a*), medial (*b*), and dorsal (*c*), views. Right premaxilla and maxilla of Odobenidae gen. et sp. indet. (LACM

121015), in lateral (*d*), and ventral (*e*), views. Left maxilla and teeth of Odobenidae gen. et sp. indet. (LACM 58548), in ventral (*f*), and lateral (*g*), views; (*h*) detail of postcanine teeth in occlusal view. Right P1 of Odobenidae gen. et sp. indet. (LACM 73566), in buccal (*i*), and lingual (*j*), views. Left p3 or p4 of Odobenidae gen. et sp. indet. (LACM 52601), in buccal (*k*), and lingual (*l*), views. Abbreviations: ap, angular process; C, upper canine; c, lower canine; cp, coronoid process; gt, genial tuberosity; hyd, hypoconid; I1-3, upper incisors 1-3; i3, third lower incisor; if, incisive foramen; lc, lingual cingulum; pf, palatine foramen; m1-2, lower molars 1-2; maf, masseteric fossa; mc, mandibular condyle; mf, mental foramina; mnf, mandibular foramen; ms, mandibular symphysis; mtd, metaconid; mx, maxilla; P1-3, upper premolars 1-3; p1-4, lower premolars 1-4; pa, paracone; pad, paraconid; pmx, premaxilla; pnp, prenarial process; prd, protoconid.

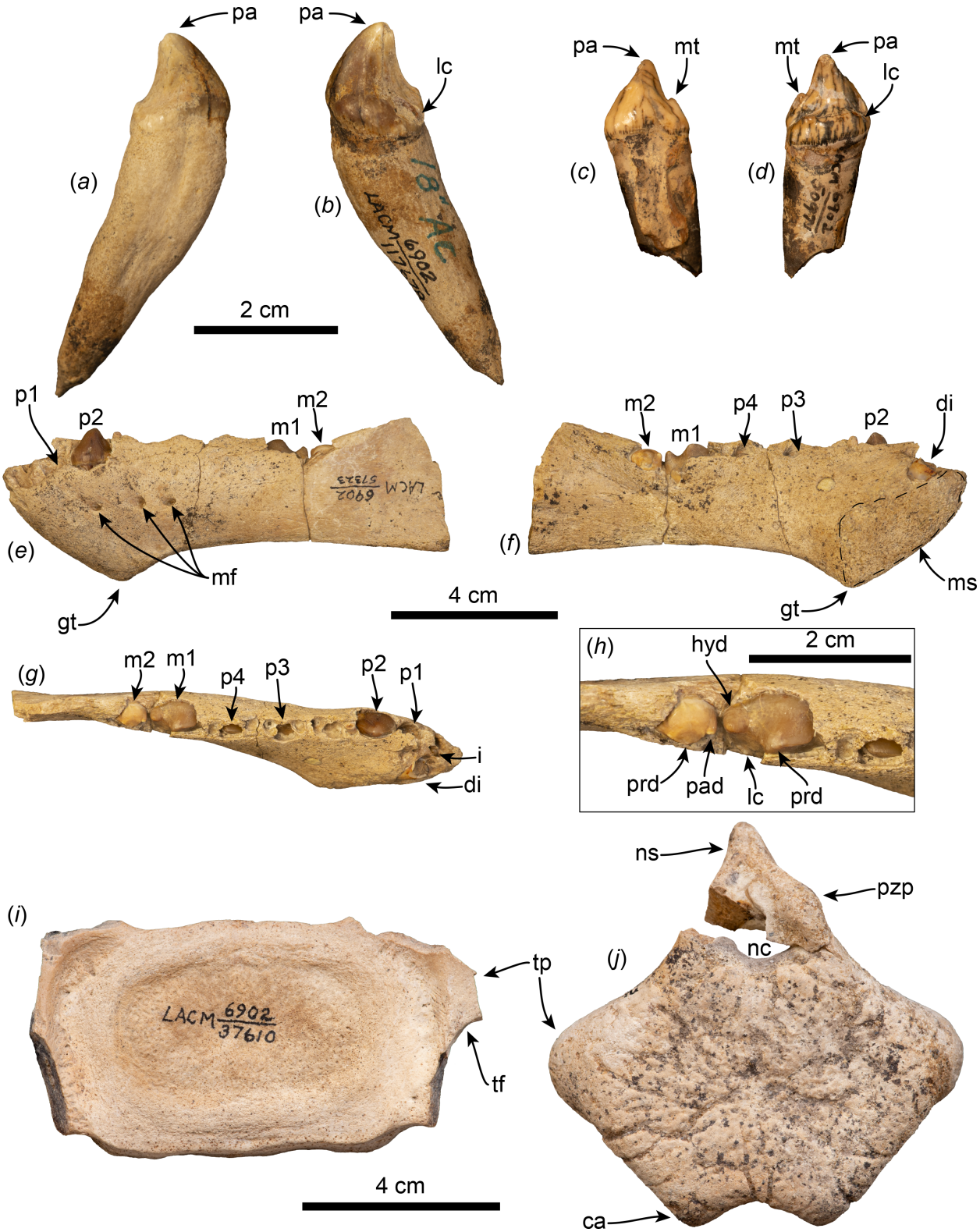


**Figure S4.** Left P1 of *Imagotaria* cf. *I. downsi* (LACM 117678), in buccal (*a*), and lingual (*b*), views. Right P2 or P3 of *Imagotaria* cf. *I. downsi* (LACM 50971), in buccal (*c*), and lingual (*d*),

views. Partial left mandible of *Imagotaria* cf. *I. downsi* (LACM 57323), in lateral (*e*), medial (*f*), and dorsal, (*g*) views; (*h*) detail of lower molars in occlusal view. Cervical vertebra of *Dusisiren* sp. (LACM 37610), in anterior (*i*) view. Middle caudal vertebra of *Dusisiren* sp. (LACM 37611), in anterior (*j*) view. Abbreviations: ca, chevron articulation; di, deciduous incisor; gt, genial tuberosity; hyd, hypoconid; i, lower incisor; lc, lingual cingulum; m1-2, lower molars 1-2; mf, mental foramina; ms, mandibular symphysis; mt, metacone; nc, neural canal; ns, neural spine; p1-4, lower premolars 1-4; pa, paracone; pad, paraconid; prd, protoconid; pzp, prezygapophysis; tf, transverse foramen; tp, transverse process.

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