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Definitive specimens of Merlucciidae (Gadiformes) from the Eocene James Ross Basin of Isla Marambio (Seymour Island), Antarctic Peninsula

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Abstract: An isolated partial right dentary (BAS D.515.2) collected by the British Antarctic Survey prompted a re-evaluation of gadiform remains from the La Meseta Formation (conventionally middle Eocene) of Isla Marambio (Seymour Island), Antarctic Peninsula. Modern gadiforms (hakes and cods) range from the Arctic to Antarctic, inhabiting deep sea benthic, shore, estuarine, and freshwater environments. Based on a fossil record primarily composed of otoliths, they are known to extend back to the Eocene and Oligocene. The new specimen was recovered from the fossil penguin locality D.515. It is characterized by a single row of sharp, ankylosed teeth set upon robust bony pedestals. The surface anterior to the mental foramen exhibits ascending and descending ridges with slightly rugose texture. The ascending ridge is fractured, but partially covers the lateral aspect of the tooth row. BAS D.515.2 is unlike the dentary of macrourid gadiforms, also recovered from the Eocene of Antarctica. BAS D.515.2 preserves several features similar to previously published accounts of the gadiform "†*Mesetaichthys*" from Isla Marambio. These specimens are probably the same taxon and their combined character suite indicates it is a member of Merluccidae. Thus, these are the only non-otolithic skeletal specimens of an Eocene hake known outside of the London Clay's †*Rhinocephalus*.

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Key words: cod, dentary, hake, Notothenioidei

Introduction

Isla Marambio, Antarctic Peninsula, is the most important locality for Palaeogene fossil fishes in Antarctica. Its taxonomically and ecologically diverse fauna stands in marked contrast to that of the Recent, which is highly endemic and taxonomically restricted. Palaeogene fishes of Antarctica are known primarily from the Eocene of the La Meseta Formation of Isla Marambio. The La Meseta comprises an array of neoselachians, chimaeroids, and teleosts (Eastman & Grande 1989, 1991, Ward & Grande 1991, Jerzmanska 1991, Long 1992, 1994, Cione & Reguero 1998, Eastman 2000, Kriwet 2005) that span almost the entire Eocene record from roughly 54.2 Ma in Telm 2 to 34.2 Ma in Telms 6 & 7 (Marenssi 2006, Ivany *et al*. 2008). Several fragmentary Eocene teleost fish specimens were identified as Gadiformes or cods (Grande & Eastman 1986, Jerzmanska & Swidnicki 1992, Kriwet & Hecht 2008) and an additional specimen is attributed to the Notothenioidei (Balushkin 1994), the dominant element of the Recent fauna. Here we describe an isolated partial right teleost dentary (BAS D.515.2) collected by W.N. Croft in 1946. The specimen was recovered from the 'Fossil Penguin' locality, D.515, described by Croft in Marples (1953) and again mentioned by Simpson (1971). However, the approximate latitude and longitude provided in those publications do not correspond to the locality description and are therefore not provided here. The approximate locality was described by Croft in Marples (1953, p.2) as roughly half a mile north-east of the eastern headland of Penguin Bay, on the '150 ft terrace-like coastal feature' that dominates the eastern side of the island (Fig. 1). Accordingly, this places the specimen in the uppermost part of

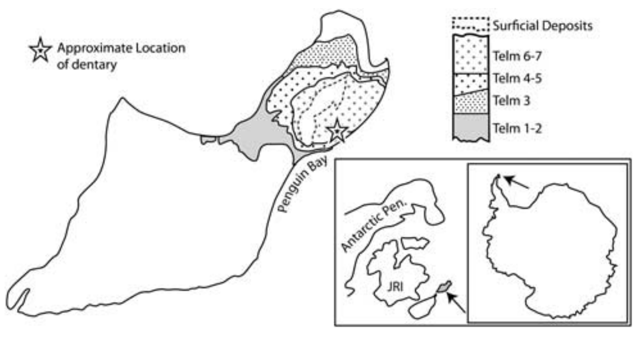

Fig. 1. Map of Antarctica with detail of Isla Marambio (Seymour Island) showing locality BAS D.515.2 (star). Telms redrawn from Sadler (1988, fig. 1).

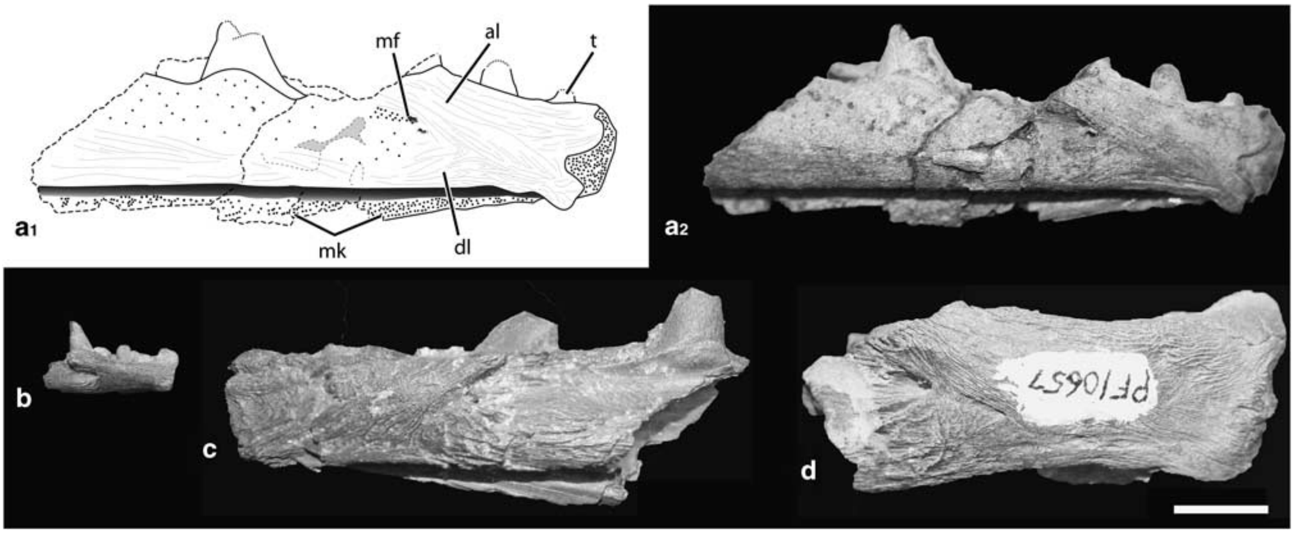

Fig. 2. Fossil dentaries from Isla Marambio in lateral view. **a_1.** line drawing, and **a_2.** photograph of BAS D.515.2 (right side). **b.** FMNH PF10656 (right side). **c.** FMNH PF 10673 (left side). **d.** FMNH PF 10657 (right side). al = ascending limb, dl = descending limb, mf = mental foramen, mk = median keel, t = teeth. Scale bar: 1 cm.

the La Meseta Formation, more probably Telm 7 than Telm 6 (Sadler 1988).

Institutional abbreviations

AMNH = American Museum of Natural History, FMNH = Field Museum of Natural History, OU = Ohio University, UF = University of Florida, Gainesville.

Comparative materials

Fossil specimens, FMNH PF10656, FMNH PF10657, FMNH PF10672, FMNH PF10673, recent specimens, Notothenioidei, *Bovichtus diacanthus* OU JTE-BDIA-2, *Chaenocephalus aceratus* OU JTE-CAC-1, *Champsocephalus gunnari* OU JTE-CGU-2, *Cottoperca trigloides* OU JTE-04-04-4, *Eleginops maclovinus* OU JTE-EMA-E, *Lepidonotothen nudifrons* OU JTE-LNU-65, *Lepidonotothen squamifrons* OU JTE-LSQ-1, *Notothenia coriiceps* OU JTE-NCO-04-04-3, *Pagothenia borchgrevinki* OU JTE-PBO-2, *Parachaenichthys charcoti* OU JTE-PCHAR-1, *Pogonophryne scotti* OU JTE-PSC-1, *Pseudochaenichthys georgianus* OU JTE-PsGEO-1, *Trematomus bernacchii* OU JTE-TBE-1, *Trematomus newnesi* OU JTE-TNE-28. Gadiformes, *Macruronus novaezelamdiae* OU OUVC-MNO-2, *Merluccius cf. albidus*

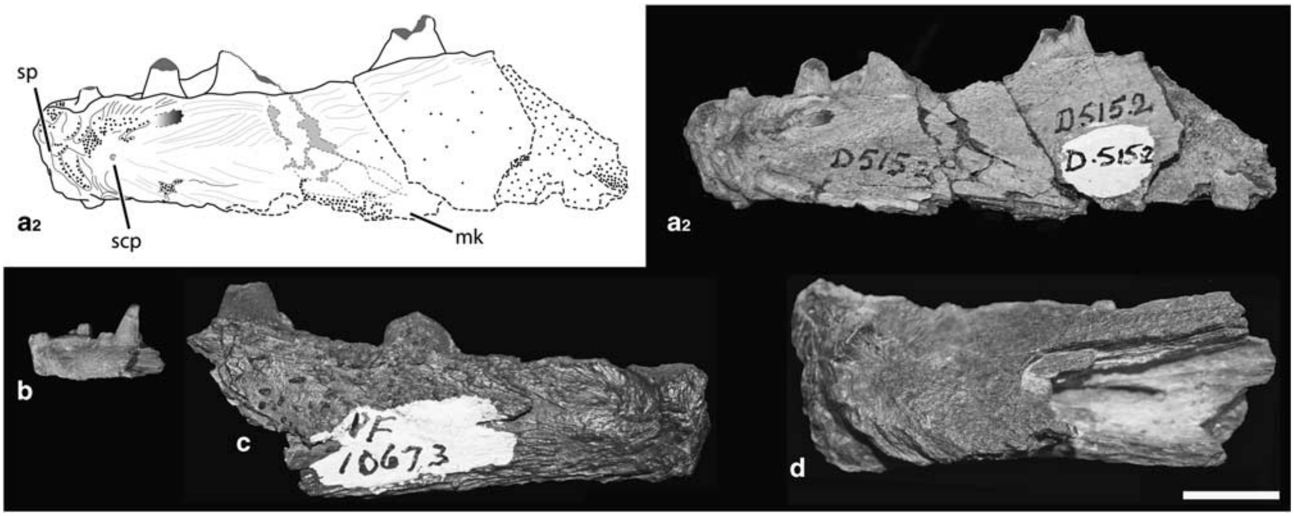

Fig. 3. Fossil dentaries from Isla Marambio in medial view. **a_1.** line drawing, and **a_2.** photograph of BAS D.515.2 (right side). **b.** FMNH PF10656 (right side). **c.** FMNH PF 10673 (left side). **d.** FMNH PF 10657 (right side). mk = median keel, scp = sensory canal pore, sp = symphyseal process. Scale bar: 1 cm.

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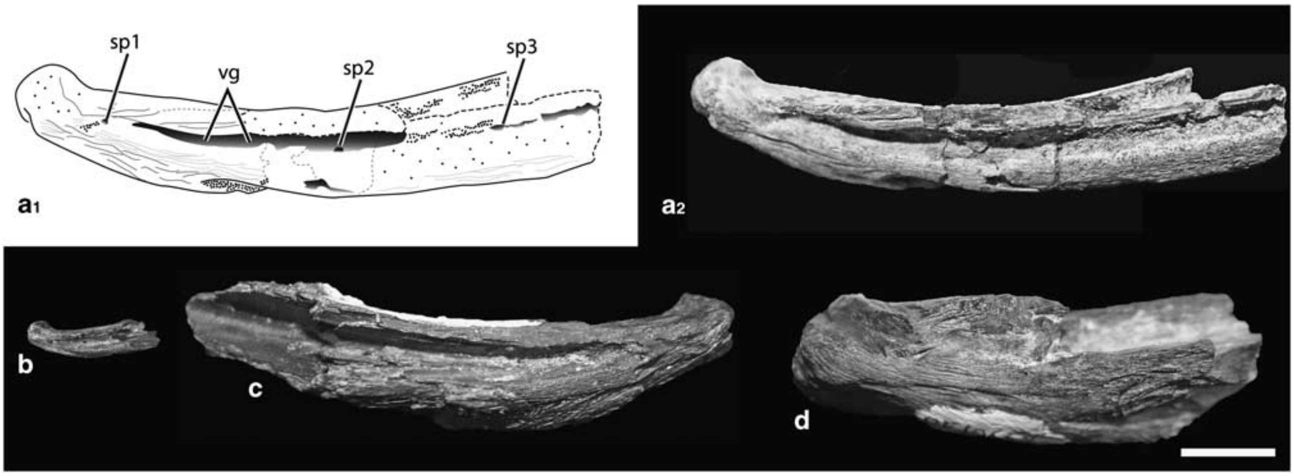

Fig. 4. Fossil dentaries from Isla Marambio in ventral view. **a₁.** line drawing, and **a₂.** photograph of BAS D.515.2 (right side). **b.** FMNH PF10656 (right side). **c.** FMNH PF 10673 (left side). **d.** FMNH PF 10657 (right side). scp1-3 = ventral sensory canal pores 1–3, vg = ventral groove. Scale bar: 1 cm.

UF20063, *Merluccius gayi* UF20483, UF26963, *Merluccius productus* AMNH 46427, AMNH 47586.

Systematic palaeontology

OSTEICHTHYES (Huxley, 1880)
ACTINOPTERYGII (Cope, 1887)
TELEOSTEI (*sensu* Patterson & Rosen, 1977)
PARACANTHOPTERYGII (*sensu* Patterson & Rosen, 1989)
ANACANTHINI (*sensu* Patterson & Rosen, 1989)
GADIFORMES (*sensu* Cohen, 1984)
GADOIDEI (*sensu* Endo, 2002)
MERLUCCIIDAE (Gill, 1884)

Referred specimen

British Antarctic Survey (BAS) D.515.2, partial right dentary.

Age and distribution

Telm 7, Late Eocene (*sensu* Sadler 1988).

Diagnosis

Specimen is determined to belong to Merluccidae based on long lower jaw, no osteological evidence of barbels, well developed sharp teeth. Additional features include a trench instead of a canal for the mandibular nerve.

Description

The dentary fragment, which forms the focus of this study, is just under 6 cm long from the symphysis to the distal fractured surface and is estimated to be roughly half the actual total length of the dentary. At its widest point the dentary is 1.05 cm. The dentary is narrowest at the symphysis. The lateral surface is convex and the medial surface is flat. There is a v-shaped sculpting on the lateral surface of the dentary beneath the first and third preserved teeth (Fig. 2a$_1$ & a$_2$). The mental foramen is posterior to the apex of the sculpting, which projects as ascending and descending limbs (thus increasing the depth of the dentary

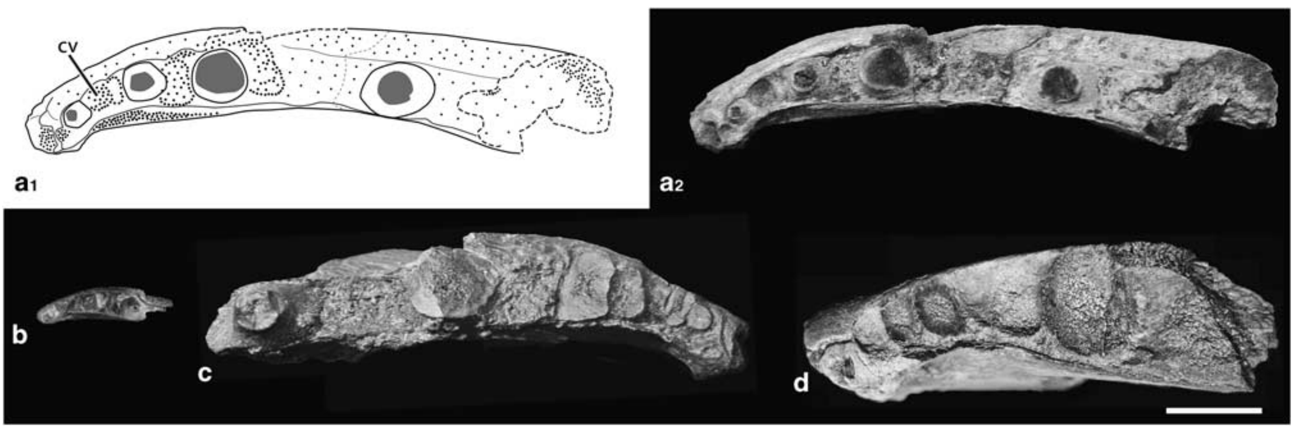

Fig. 5. Fossil dentaries from Isla Marambio in occlusal view. **a₁.** line drawing, and **a₂.** photograph of BAS D.515.2 (right side). **b.** FMNH PF10656 (right side). **c.** FMNH PF 10673 (left side). **d.** FMNH PF 10657 (right side). c = tooth cavity. Scale bar: 1 cm.

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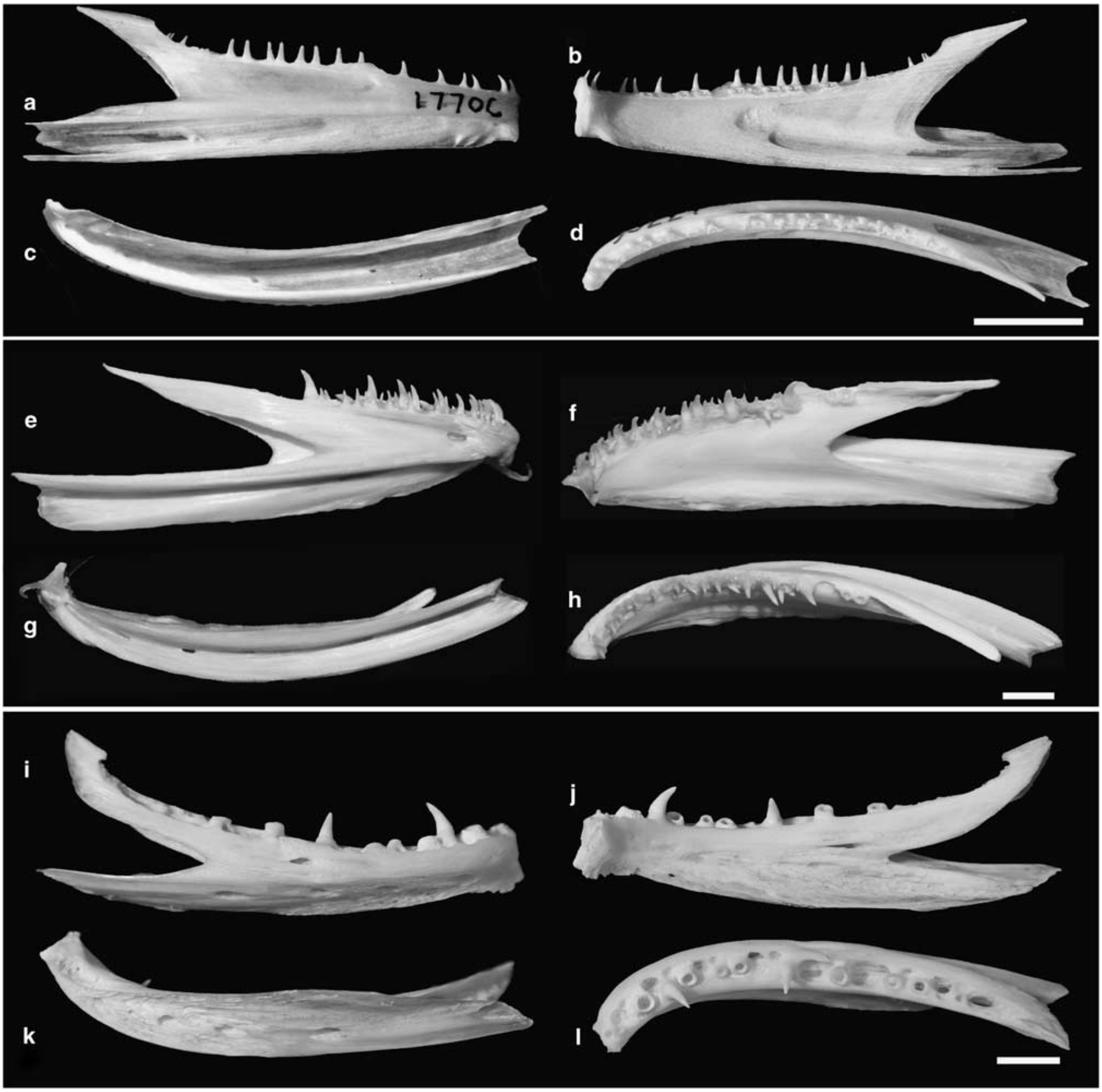

Fig. 6. Right dentaries of a merluccid, *Merluccius gayi*, specimen UF 1770C, in **a.** lateral, **b.** lingual, **c.** ventral and **d.** occlusal views. Right dentaries of a gadid, *Gadus morhua*, specimen JTE GMO 4, in **e.** lateral, **f.** lingual, **g.** ventral, and **h.** occlusal views. Right dentaries of a nototheniid, *Dissostichus eleginoides*, specimen JTE DEL 04-04-6, in **i.** lateral, **j.** lingual, **k.** ventral, and **l.** occlusal views. Scale bar: 1 cm.

from anterior to posterior). The ascending limb is fractured and partially covers the lateral aspect of the tooth row. The descending limb is short but complete. The most posterior aspect of the dentary is fractured anterior to the position of the expected lateral incision, which marks dorsal and ventral processes for the anguloarticular. In medial view (Fig. 3a_1 & a_2), the symphyseal process is smooth on the narrow articular facet and irregular lingual to the articular facet. The dorsal aspect of the medial surface ascends slightly to flank the fourth preserved tooth. There is a small sensory canal pore beneath the first preserved tooth. No distinct medial incision is present. A median keel is continuous with the medial surface, offset from the lateral surface by a deep ventral groove and is fractured ventrally. The deep ventral groove is consistent with the position of a mandibular sensory canal and there are three recognizable pores present within the groove (Fig. 4a_1 & a_2). In occlusal view (Fig. 5a_1 & a_2), the dentary possesses a single row of

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sharp, ankylosed teeth set upon robust bony pedestals. For four teeth, only bases and a portion of the crowns, preserved without their apices, are present. Teeth are largest posteriorly and longer anteroposteriorly than labiolingually. Between each tooth is a deep cavity that is marked by several small pores. The cavities of absent teeth are round, but anteriorly they are crowded and appear more oval.

Discussion

BAS D.515.2 is unlike the dentary of macrourid gadiforms, which are known in abundance from otoliths in the Eocene of Antarctica (Kriwet & Hecht 2008). BAS D.515.2 resembles the dentary fragments previously described by Grande & Eastman (1986, p. 129, fig. 5d–i; see also Figs 2–5) and together they represent a growth series of the same taxon, which is consistent with the description of "*Mesetaichthys*" (Jerzmanska & Swidnicki 1992). Given that we were able only to compare dentaries in the absence of associated skeletal material, we are unable to justify formalizing this name, but future work, including additional collection and comparison of other skeletal elements, may allow this.

"*Mesetaichthys*" grew to a massive size but the morphology of its jaw and the relative position of the largest tooth bases in those jaws was maintained during its growth. All specimens of "*Mesetaichthys*" have v-shaped sculpting (present in modern gadiforms, but not in modern notothenioids, Fig. 6) with an ascending limb that flanks the tooth row (Fig. 2). Among modern gadiforms, the v-shaped sculpting is more anterior along the dentary in gadids than in merlucciids (Fig. 6). Teeth of "*Mesetaichthys*" are tall with straight crowns, as in *Merluccius* Rafinesque, 1810 (Fig. 6a & b), not posteriorly curved crowns as in the notothenioid *Dissostichus* Smitt, 1898 (Fig. 6i & j). A median keel is observed in gadiforms such as *Gadus* and *Merluccius*, and the keel is separated from the lateral surface by a deep sensory groove marked by pores of sensory canals (Fig. 6a–c & e–g). There are more sensory pores in *Gadus* L., 1758, than in *Merluccius* and "*Mesetaichthys*". A median keel is absent in most notothenioids, except for *Cottoperca trigloides* (Foster, 1801). In all notothenioids, however, including *C. trigloides*, there is a completely walled sensory canal, not a deep groove (Fig. 6k). The occlusal view of "*Mesetaichthys*" shows a single row of large, sharp, ankylosed teeth set upon robust bony pedestals, consistent with the type-1 tooth replacement found in *Merluccius*. Type-1 tooth replacement is the primitive attachment mode for actinopterygians and it is characterized by complete ankylosis of the tooth to the attachment bone (Fink 1981). The anteriormost tooth bases are oval, crowded, and aligned in single row. Some notothenioids have a single row of teeth, but the majority of taxa have multiple rows of teeth. Several gadids also have multiple tooth rows. Merlucciids, such as *Merluccius* have a single-to-offset tooth row (Fig. 6d).

In conclusion, the suite of similarities that the dentaries of our specimen and "*Mesetaichthys*" show to the dentary of *Merluccius* comprises our rationale for assigning these specimens collectively and definitively to the Merlucciidae. Our new dentary, from a large merlucciid, supports the notion that there was a considerable biomass of bony fish in the productive, cool temperate marine palaeoenvironment then occurring at the position of Isla Marambio. This biomass supported large and diverse populations of sharks (Case 1992), an element missing from Antarctic waters today.

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