Andean Geology 42 (2): 268-283. May, 2015
doi: 10.5027/andgeoV42n2-a06

Andean Geology
www.andeangeology.cl

PALEONTOLOGICAL NOTE

New chondrichthyans from Bartonian-Priabonian levels of Río de Las Minas and Sierra Dorotea, Magallanes Basin, Chilean Patagonia

***Rodrigo A. Otero[1], Sergio Soto-Acuña[1, 2]**

[1] *Red Paleontológica Universidad de Chile, Laboratorio de Ontogenia y Filogenia, Departamento de Biología, Facultad de Ciencias, Universidad de Chile, Las Palmeras 3425, Santiago, Chile.*
otero2112@gmail.com

[2] *Área de Paleontología, Museo Nacional de Historia Natural, Casilla 787, Santiago, Chile.*
arcosaurio@gmail.com

* *Corresponding author: otero2112@gmail.com*

ABSTRACT. Here we studied new fossil chondrichthyans from two localities, Río de Las Minas, and Sierra Dorotea, both in the Magallanes Region, southernmost Chile. In Río de Las Minas, the upper section of the Priabonian Loreto Formation have yielded material referable to the taxa *Megascyliorhinus* sp., *Pristiophorus* sp., *Rhinoptera* sp., and *Callorhinchus* sp. In Sierra Dorotea, middle-to-late Eocene levels of the Río Turbio Formation have provided teeth referable to the taxa *Striatolamia macrota* (Agassiz), *Palaeohypotodus rutoti* (Winkler), *Squalus* aff. *weltoni* Long, *Carcharias* sp., *Paraorthacodus* sp., *Rhinoptera* sp., and indeterminate Myliobatids. These new records show the presence of common chondrichtyan diversity along most of the Magallanes Basin. The new record of *Paraorthacodus* sp. and *P. rutoti*, support the extension of their respective biochrons in the Magallanes Basin and likely in the southeastern Pacific.

Keywords: Cartilaginous fishes, Weddellian Province, Southernmost Chile.

RESUMEN. Nuevos condrictios de niveles Bartoniano-priabonianos de Río de Las Minas y Sierra Dorotea, Cuenca de Magallanes, Patagonia Chilena. Se estudiaron nuevos condrictios fósiles provenientes de dos localidades, Río de Las Minas y Sierra Dorotea, ambas en la Región de Magallanes, sur de Chile. En Río de Las Minas, la sección superior de la Formación Loreto (Priaboniano) ha proporcionado material referible a los taxa *Megascyliorhinus* sp., *Pristiophorus* sp., *Rhinoptera* sp., y *Callorhinchus* sp. En Sierra Dorotea, niveles del Eoceno medio a tardío de la Formación Río Turbio han proporcionado dientes atribuibles a los taxa *Striatolamia macrota* (Agassiz), *Palaeohypotodus rutoti* (Winkler), *Squalus* aff. *weltoni* Long, *Carcharias* sp., *Paraorthacodus* sp., *Rhinoptera* sp., y Myliobátidos indeterminados. Estos nuevos registros muestran la presencia de una diversidad común de condrictios a lo largo de la mayor parte de la cuenca de Magallanes. Los nuevos registros de *Paraorthacodus* sp. y *P. rutoti* apoyan la extensión de sus respectivos biocrones en la Cuenca de Magallanes y probablemente en el Pacífico suroriental.

Palabras clave: Peces cartilaginosos, Provincia Weddelliana, Extremo sur de Chile.

1. Introduction

The research of fossil vertebrates carried out in the last years along the Magallanes Region and supported by two Antarctic Ring projects (Anillos de Ciencia Antártica, Conicyt-Chile; ARTG-04 2007-2009; ACT-105 2010-2013) have recovered a diversity of chondrichthyans ranging a time span between the Maastrichtian and the late Eocene. Two main localities have yielded abundant remains of the group. The upper section of the Loreto Formation exposed at Río de Las Minas near Punta Arenas includes so far at least 13 different taxa from a single level of Priabonian age (Otero *et al*., 2012). The second and richest locality is Sierra Baguales in the northern part of the Magallanes Region, which has provided remains of five typically Maastrichtian taxa and at least eighteen Paleogene taxa (Otero *et al*., 2013a).

We present new finds of fossil sharks (Chondrichthyes, Elasmobranchi, Neoselachii) and chimaeroid fishes (Holocephali, Chimaeriformes) recovered from two localities of the Magallanes Region in southernmost Chile. The first is Río de Las Minas, west of Punta Arenas. From the upper section of the Loreto Formation the first local records of *Megascyliorhinus cooperi* Cappetta and Ward, 1977, *Pristiophorus* sp., *Callorhinchus* sp., and *Rhinoptera* sp. are here described. The second studied locality is Sierra Dorotea, northeast of Puerto Natales. In the latter, upper levels of the Río Turbio Formation (Bartonian-Priabonian) have yielded specimens referable to the taxa *Striatolamia macrota* (Agassiz), *Carcharias* '*hopei*' (Agassiz), *Palaeohypotodus rutoti* (Winkler), *Paraorthacodus* sp., *Rhinoptera* sp., as well as indeterminate miliobatoids and indeterminate callorhynchids.

2. Localities and Geologic Setting

2.1. Sierra Dorotea, Puerto Natales

The first locality studied is Sierra Dorotea (51°35"S; 72°21"W), settled 20 km NE from Puerto Natales, near the international border with Argentina (Fig. 1). In this locality, the base of the section is better exposed on the cliffs facing to Puerto Natales. The latter are part of the Dorotea Formation (Katz, 1963) originally assigned to the Maastrichtian-Danian based on biostratigraphic correlations, and later constrained to the late Maastrichtian based on U-Pb shrimp radioisotopic dates (Hervé *et al*., 2004). The eastern part of the Sierra have unequivocally Cenozoic levels, these being distinguished by the presence of *Glycimeris* cf. *ibari* (Philippi, 1887), *Panopea* cf. *clausa* (Wilckens, 1910) and *Venericardia* (*Venericor*) *carrerensis* Griffin, 1991. This fauna was recognized by Griffin (1991) in outcrops of the Río Turbio Formation (Feruglio, 1938) exposed in Argentina. The unit extends beyond the northern margin of the international border, and follows a general N-S strike as it happens with most of the sedimentary units in the studied area. It is easily observed that the levels of the Río Turbio Formation are continous over the Chilean side. Following the scheme of Hünicken (1955), the studied levels are part of the upper section originally assigned to the Paleocene-Eocene, based on stratigraphic correlations and fossil marine invertebrates. The age of this section was later constrained to the middle-late Eocene by Malumián and Caramés (1997) based on stratigraphic correlations and microfossils.

The chondrichthyan-bearing level studied here comprises brown-to-greenish sandstones with coarse-to-fine grain. Fossils are abundant and mostly represented by marine invertebrates of the genera *Cucullaea*, *Glycimeris*, *Pholadomya, Panopea*, as well as ostreids. Vertebrates include the presence of the penguin genus *Palaeeudyptes* (Sallaberry *et al*., 2010). This genus has a widespread distribution along the Weddellian Biogeographic Province, WBP hereafter (Zinsmeister, 1979), and it is regarded as typical form in the Eocene-Oligocene of Antarctica, but being particularly abundant in Priabonian levels (Reguero *et al*., 2013), thus, providing additional support for a middle-to-late Eocene age for the fossil bearing levels of Sierra Dorotea studied here.

2.2. Río de Las Minas, Punta Arenas

This is located about 10 km west of Punta Arenas (53º08'S; 71º03'W), in the Brunswick Peninsula (Fig. 1). A canyon is conformed by a well-stratified section of the Loreto Formation (Hoffstetter *et al*., 1957). This unit is about 800 m thick, composed of well-sorted sandstones and including glauconitic and concretionary horizons with frequent intercalated beds containing fossil flora and several coal seams of variable thickness. Fasola (1969) studied palynomorphs from several points along the Río de Las Minas canyon, assigning an Oligocene age for the

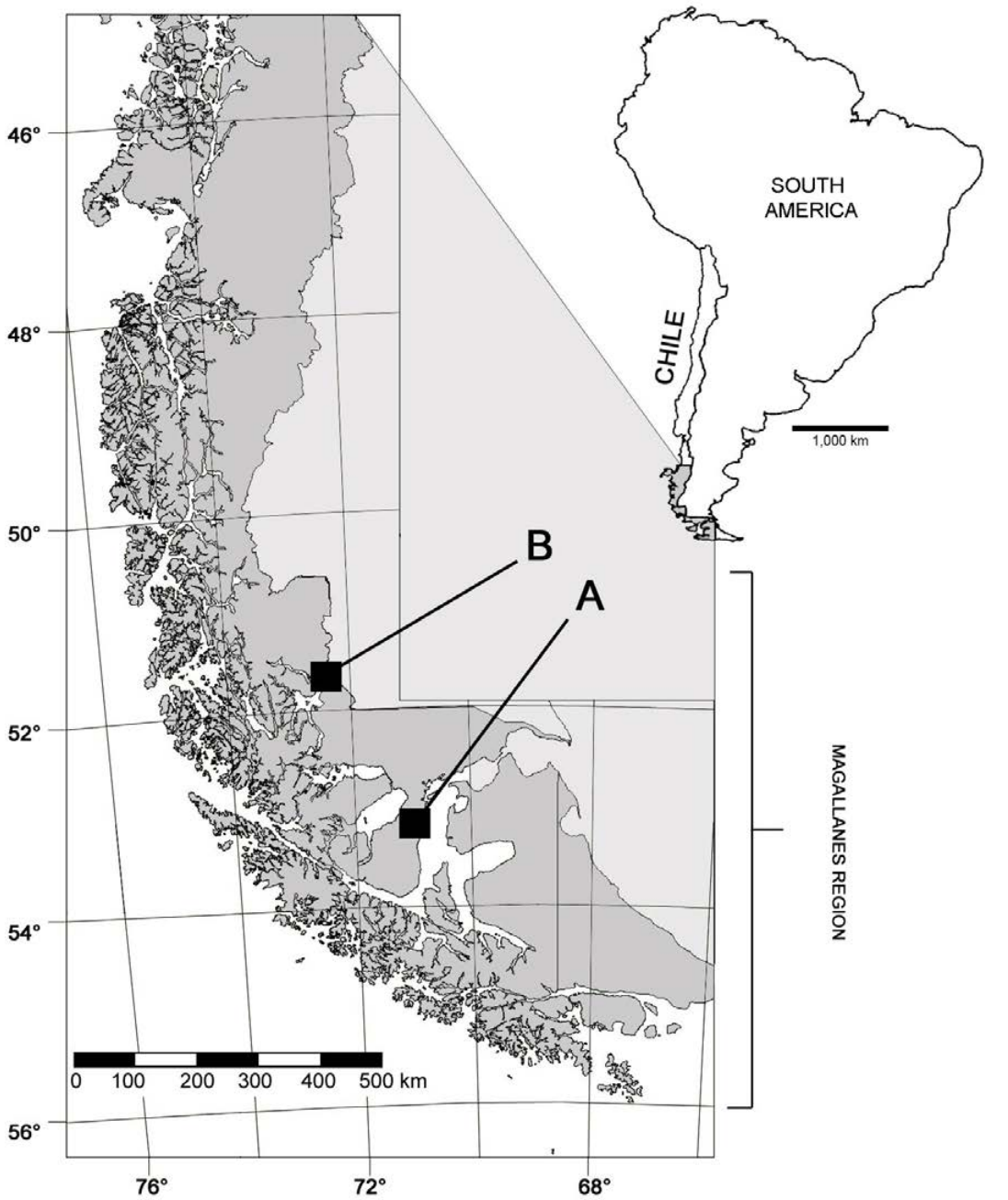

FIG. 1. Map indicating the two localities where the studied material was recovered. **A**. Río de Las Minas, Punta Arenas; **B**. Sierra Dorotea, Puerto Natales.

unit based on this record. The upper section (Otero *et al*., 2012: fig. 2) includes a single level with chondrichthyan teeth, which was dated on 36.48±0.47 Ma based on U-Pb Shrimp radioisotopic date. This age is consistent with the paleobotanic record as well as with the chondrichthyan assemblage which indicate a Priabonian age (Otero *et al*., 2012 and references therein); in consequence, most of the section of the Loreto Formation exposed at Río de Las Minas is older than the Priabonian.

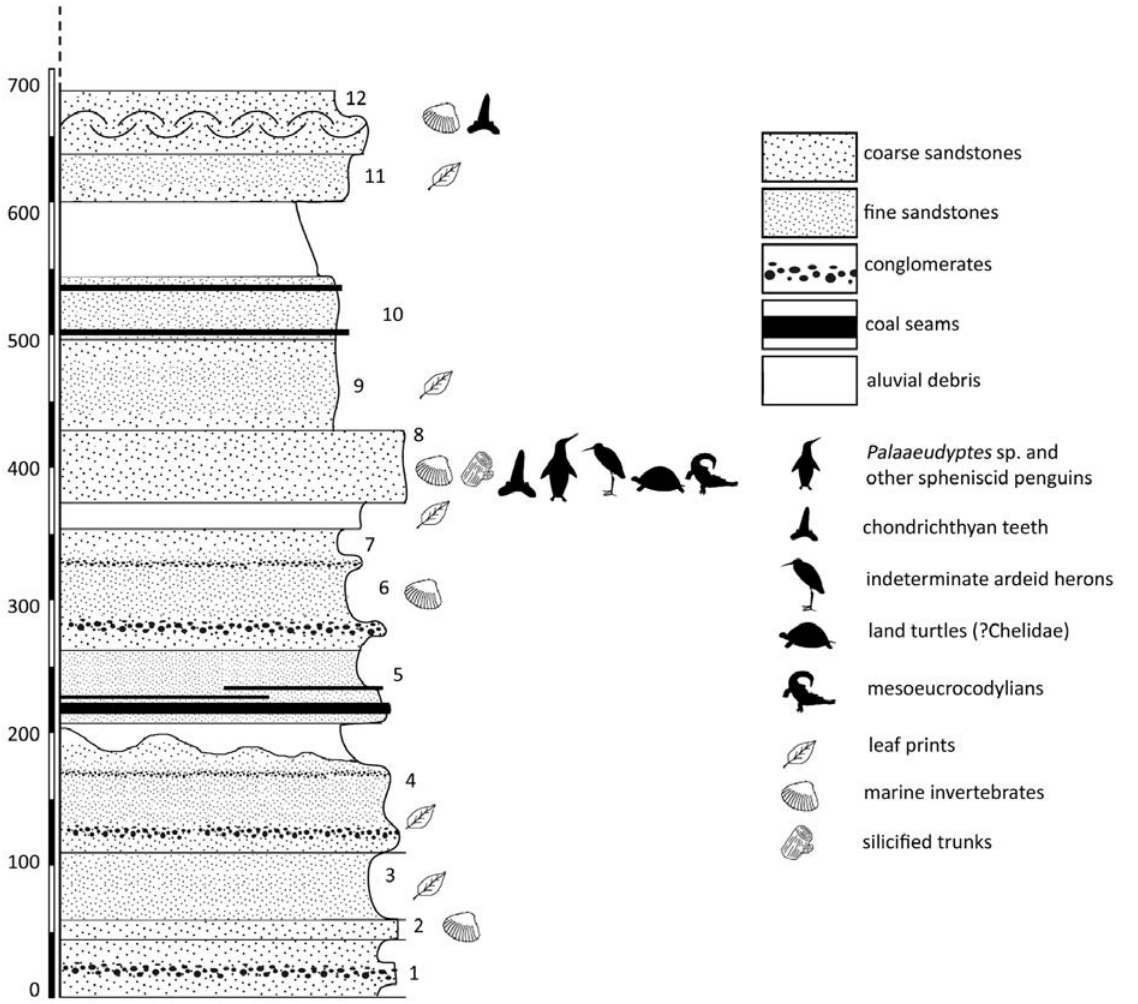

FIG. 2. Stratigraphic section of the upper part of Sierra Dorotea. Small numbers on each level follows the general description by Hunicken (1955, *in* Hoffstetter *et al*.,1957: p. 316-319), and complemented with the observations made during this current study.

3. Material and Methods

Several tens of fragmentary vertebrate remains were recovered by the authors from Río de Las Minas and Sierra Dorotea, during January, 2013 and January, 2014. Among these, the most abundant are chondrichthyan teeth, followed by less frequent bone remains. Most of the collected specimens from Sierra Dorotea were scattered on surface and obtained by sieving, while few of them were directly recovered from their respective hosting levels. The absence of any articulated specimens as well as the broken cusplets in most teeth (even in those recovered *in situ*) indicate that the vertebrate remains were reworked previous to their final deposit. Isolated teeth were recovered from the recent soil formed by weathering of the fossiliferous sandstone, while *in situ* material was still included in well-consolidated matrix, being obtained by usage of chisels and direct hammering. Largest bone fragments observed (mostly birds) did not exceed 5 cm, while teeth belonging large taxa were not found.

Morphologic criteria for identifying taxa were mostly based on Cappetta (1987, 2012). Comparisons were carried out with previous specimens collected from Sierra Baguales (Otero *et al*., 2013a).

The chronostratigraphic nomenclature and formal divisions used here follows the scheme of

the International Stratigraphic Chart of Cohen *et al*. (2013).

Institutional Abbreviation: SGO.PV: Paleontología de Vertebrados, Museo Nacional de Historia Natural, Santiago, Chile.

4. Systematic Paleontology

Class Chondrichthyes Huxley, 1880
Subclass Elasmobranchii Bonaparte, 1838
Subcohort Neoselachii Compagno, 1977
Order Lamniformes Berg, 1958
Family Mitsukurinidae Jordan, 1898
Genus *Striatolamia* Glikman, 1964

Type species: '*Otodus macrotus*' Agassiz, 1843; Eocene. Paris Basin, France.

Striatolamia macrota (Agassiz, 1843)
Fig. 3A-F

Material: SGO.PV.6549a, b: two isolated anterolateral teeth. Eastern Sierra Dorotea, Magallanes Region, southernmost Chile. Upper levels of the Río Turbio Formation, Bartonian-Priabonian.

Description: Teeth with slender and sharp crown having sigmoidal profile, with non-serrated cutting edges that fade near the base. The enameloid bear profuse striations over its lingual surface but they are absent on the labial surface. The labial enameloid overhangs the root. The root has two well-separated branches and a lingual bulk.

Remarks: Teeth of the species *Striatolamia macrota* were previously recovered in southernmost Chile, particularly in the localities of Sierra Baguales, from beds of Bartonian-Priabonian age of the Río Baguales (=Man Aike) Formation, and in the upper section of the Loreto Formation exposed at Río de Las Minas near Punta Arenas, from levels of Priabonian age (Otero *et al*., 2012, 2013a). This species is also abundant in Bartonian-Priabonian strata of the La Meseta Formation in Seymour Island, Antarctica (Reguero *et al*., 2013 and references therein).

Family Odontaspididae Müller and Henle, 1838
Genus Carcharias Rafinesque, 1810

Type species: *Carcharias taurus* Rafinesque, 1810. Recent.

Carcharias sp.
Fig. 3G

Material: SGO.PV.6548a-c: Three anterolateral teeth. Eastern Sierra Dorotea, Magallanes Region, southernmost Chile. Upper levels of the Río Turbio Formation, Bartonian-Priabonian.

Description: Anterior tooth with high and slender crown, with sigmoidal profile; crown with complete cutting edges; one sharp and medially recurved lateral cusplet on each side of the crown; root with separate branches and lingual bulk.

Remarks: The studied teeth are similar to those referred to *C.* '*hopei*' by Ward (1988) and Cappetta and Nolf (2005), although a specific determination is here precluded since the latter species has unresolved taxonomical status. Despite of this, teeth of *Carcharias* sp. are common in Bartonian-Priabonian strata along the Magallanes Basin, with previous records in Río de Las Minas and Sierra Baguales (Otero *et al*., 2012, 2013a). The genus was also recovered from Maastrichtian beds of the Dorotea Formation in Sierra Baguales (Otero *et al*., 2013a). Although teeth of *Carcharias* spp.are abundant in southernmost South America since the Upper Cretaceous and through the rest of the Cenozoic (Cione *et al*., 2007), this genus seems to be absent in higher latitudes. To date, no contemporary records are known in Antarctica, suggesting that the austral distribution of the genus could be restricted to the Magallanes Basin.

Genus *Palaeohypotodus* Glickman, 1964
Palaeohypotodus rutoti (Winkler, 1874)
Fig. 3H-I

Type species: '*Odontaspis*' (=*Palaeohypotodus*) *rutoti* Winkler, 1874. Late Paleocene of Belgium.

Material: SGO.PV.6556a: One anterior tooth. SGO. PV.6556b: one lateral tooth, both isolated. Eastern Sierra Dorotea, Magallanes Region, southernmost Chile. Upper levels of the Río Turbio Formation, Bartonian-Priabonian.

Description: Anterior tooth with high and slender crown that becomes distally broader than its base and labially convex; sigmoidal profile of the crown and soft enamel in both labial and lingual surfaces; crown with cutting edges fading near the base; roots with well-separated branches leaving a deep notch between them. Lateral teeth having two to three

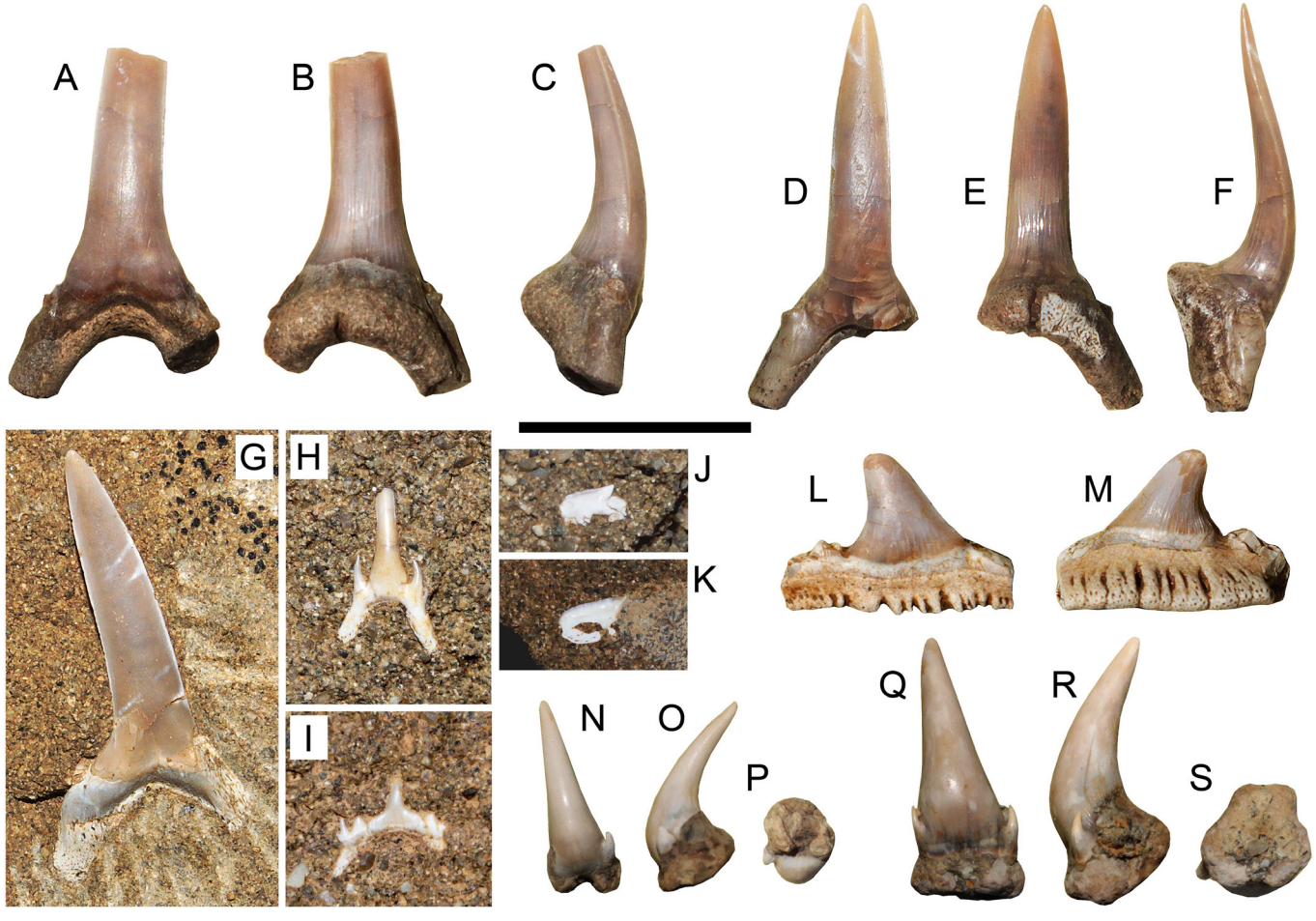

FIG. 3. St*riatolamia macrota* (Agassiz). **A.** SGO.PV.6549a, anterolateral tooth in labial view; **B.** lingual view; **C.** profile view. SGO.PV.6549b, anterolateral tooth; **D.** labial view; **E.** lingual view; **F.** profile view. *Carcharias* '*hopei*' (Agassiz); **G.** SGO.PV.6548a, anterolateral tooth in labial view. *Palaeohypotodus rutoti* Winkler; **H.** SGO.PV.6556a, anterior tooth in labial view; **I.** SGO.PV.6556b, lateral tooth in labial view. *Squalus* aff. *weltoni* Long; **J.** SGO.PV.6557a, lateral tooth in labial view; **K.** SGO.PV.6557b, lateral tooth in labial view; **L.** *Paraorthacodus* sp. SGO.PV.6547, lateral tooth in labial view; **M.** lingual view. Upper levels of the Río Turbio Formation, Middle to Late Eocene. *Megasyliorhinus* sp. SGO.PV.6553a. Lateral tooth; **N.** labial view; **O.** profile view; **P.** basal view. SGO.PV.6553b. Lateral tooth; **Q.** labial view; **R.** profile view; **S.** basal view. Río de Las Minas, Punta Arenas, southernmost Chile. Upper levels of the Loreto Formation, Late Eocene (Priabonian). Scale bar equals 10 mm.

sharp and medially recurved lateral cusplets on each side of the crown; base of the crown overhanging the root and having profuse vertical folds; root with well-separated branches and lingual bulk.
Remarks: This is the first record of the species in the Magallanes Basin. Previous austral records on the WBP are known from early Eocene (Ypresian) levels of the La Meseta Formation in Seymour Island, Antarctica (Long, 1992; Kriwet, 2005; Reguero *et al*., 2013). This age differs from the records along the Northern Hemisphere, where this species is restricted to the Paleocene (Cappetta, 1987).

Order Squaliformes Goodrich, 1909
Family Squalidae Bonaparte, 1834
Genus *Squalus* Linnaeus, 1758

***Squalus* aff. *weltoni* Long, 1992**
Fig. 3J-K

Type species: *Squalus weltoni* Long, 1992. Seymour Island, Antarctica. La Meseta Formation, late Eocene.
Material: SGO.PV.6557a-c: Three lateral teeth. Eastern Sierra Dorotea, Magallanes Region, southernmost Chile. Upper levels of the Río Turbio Formation, Bartonian-Priabonian.
Description: Teeth small, larger than high; crown triangular and distally recurved, with complete cutting edge and having serrations in the anterior margin; Labial face with an apron that extends ventrally to the root, while in the lingual face there is a projection of the crown (uvula, *sensu* Cappetta, 1987). The root has rhomboidal basal outline, being narrower than the crown and with several nutritious foramina.
Remarks: Squalid sharks have been reported in the WBP. Records from Eocene levels of the La Meseta Formation in Antarctica firstly included indeterminate squalids (Welton and Zinsmeister, 1980). These were later precised as the species *S. woodbrunei* Long, 1992 and *S. weltoni* Long, 1992. In addition, the genus *Centrophorus* was also described from the same unit. Previous records in southern South America only include the genus *Centrophoroides* found in Maastrichtian levels of the Dorotea Formation in Sierra Baguales (Otero *et al*., 2013a). The new specimens here studied confirm the persistence of squalids in the Magallanes Basin throughout the K/P boundary, while it verifies the widespread distribution of the family along the WBP.

Order Synechodontiformes Duffin and Ward, 1993
Family Palaeospinacidae Regan, 1906
Genus *Paraorthacodus* Glikman, 1958

Type species: '*Sphenodus*' *recurvus* Trautschold, 1877. Cenomanian of Russia.

***Paraorthacodus* sp.**
Fig. 3L-M

Material: SGO.PV.6547: One isolated tooth. Eastern Sierra Dorotea, Magallanes Region, southernmost Chile. Upper levels of the Río Turbio Formation, Bartonian-Priabonian.
Description: Teeth axially broader than dorsoventrally high, with short, triangular but slender crown having two or three triangular lateral cusplets; both lingual and labial surfaces of the crown bear striations extended between from tip to base; the root is distinctive, with a flat base having several parallel nutritious grooves that extend over the lingual face; presence of a lingual bulk on the root.
Remarks: The genus *Paraorthacodus* have been recorded in the Upper Cretaceous of Argentina (Ameghino, 1893), central Chile (Suárez *et al*., 2003) and Antarctica (Klug *et al*., 2008). Its provincial distribution on Paleogene units is also documented in central Chile from likely Paleocene strata (Muñoz-Ramírez *et al*., 2007; González *et al*., 2010; Groz and Palma 2013). Although its worldwide record seems to be restricted to the Paleocene (Cappetta, 1987), the genus was found in Ypresian levels of the La Meseta Formation (*Cucullaea* I Allomember) (A. Cione, personal communication *in* Reguero *et al*., 2013). Considering this, the presence of a single tooth in Sierra Dorotea suggests the re-working from older strata that could reach even Ypresian levels. This is also supported by a similar situation detected on Sierra Baguales, with a reworking that could reach to Paleocene levels based on the presence of teeth of the genera *Otodus obliquus* and *Megascyliorhinus cooperi* (Otero *et al.*, 2013a).

Order Carcharhiniformes Compagno, 1973
Family Scyliorhinidae Gill, 1862
Genus *Megascyliorhinus* Cappetta and Ward, 1977

Type species: *Megascyliorhinus cooperi* Cappetta and Ward, 1977. Ypresian of England.

Megascyliorhinus sp.
Fig. 3N-S

Material: SGO.PV.6553a, b: Two isolated teeth. Río de Las Minas, Punta Arenas, southernmost Chile. Upper levels of the Loreto Formation, Priabonian.
Description: Teeth with high, slender, and triangular crown, basally swollen and lingually recurved; one medially recurved lateral cusplet on each side; soft enameloid; root comparatively small with respect to the crown, with two short but massive branches separated by a deep groove, and a prominent lingual bulk.
Remarks: Regionally, identical teeth have been recovered from lower levels of the Man Aike (=Río Baguales) Formation in Sierra Baguales, north of Magallanes Region, being firstly referred to *M. cooperi* by Otero *et al*. (2013a) due its narrow morphologic affinities. Since this species was originally recovered from Ypresian beds of England (Cappetta and Ward, 1977) and due the evidence of re-working in lower levels of the Man Aike Formation, Otero *et al*. (2013a) considered the possibility that the studied specimens could be hosted in levels older than the Bartonian. Otherwise, the known record of the genus *Megascyliorhinus* extends from the Eocene onwards the Pleistocene. The current find in Priabonian levels of the Loreto Formation proves the occurrence of this taxon in younger beds along the Magallanes Basin. Regionally, the genus (represented by a probable different species with higher crowns) was recovered from Oligocene beds of New Zealand (Keyes, 1984) proving its widespread distribution during the Eocene-Oligocene boundary along the WBP (Zinsmeister, 1979).

Order Pristiophoriformes Berg, 1958
Family Pristiophoridae Bleeker, 1859
Genus *Pristiophorus* Müller and Henle, 1837

Type species: *Pristis cirratus* Latham, 1794. Recent.

Pristiophorus sp.
Fig. 4A-B

Material: SGO.PV.6554. One isolated rostral spine. Río de Las Minas, Punta Arenas, southernmost Chile. Upper levels of the Loreto Formation, Priabonian.
Description: Isolated crown of a rostral tooth; long and slender crown, dorso-ventrally compressed, with smooth enameloid; complete cutting edge in the anterior margin; cutting edge of the posterior margin fading near the half of the crown.
Remarks: Rostral teeth of *Pristiophorus* are known in high latitudes of the Southern Hemisphere since the Upper Cretaceous. The genus was recovered from upper Maastrichtian levels of the López de Bertodano Formation (Klb9) in Seymour Island, Antarctica (Otero *et al*., 2014), while the species *P. lanceolatus* have been described from Eocene levels of the La Meseta Formation, in the same locality. The genus was also reported in Bartonian-Priabonian levels of the Man Aike Formation exposed at Sierra Baguales (Otero *et al*., 2013a).

Superorder Batomorphii Capetta, 1980
Order Myliobatiformes Compagno, 1973
Family Rhinopteridae Jordan and Evermann, 1896
Genus *Rhinoptera* Cuvier, 1829

Type species: '*Myliobatis*' *marginata* Saint-Hilaire, 1809. Recent.

Rhinoptera sp.
Fig. 4C-F

Material: SGO.PV.6551: One lateral tooth. Río de Las Minas, Punta Arenas, southernmost Chile. Upper levels of the Loreto Formation, Priabonian. SGO.PV.6552: One complete central plate. Eastern Sierra Dorotea, Magallanes Region, southernmost Chile. Upper levels of the Río Turbio Formation, Bartonian-Priabonian.
Diagnosis: For diagnosis, see Cappetta (1987).
Description: Isolated and complete median tooth plate with flat occlusal surface of the crown, having profuse punctuations over the latter, and wrinkles around the lateral margins of the crown; holoaulacorhize vascularization of the root, with parallel nutritious grooves comparatively deeper than those of *Myliobatis* and having high and recurved septa between each basal groove.
Remarks: The materials here described are the first teeth referable to this genus found in Eocene beds of the Magallanes Basin. Teeth of *Rhinoptera* were reported from likely Paleocene strata of central Chile (Muñoz-Ramírez *et al*., 2007). The genus remains unreported yet in higher latitudes of Antarctica.

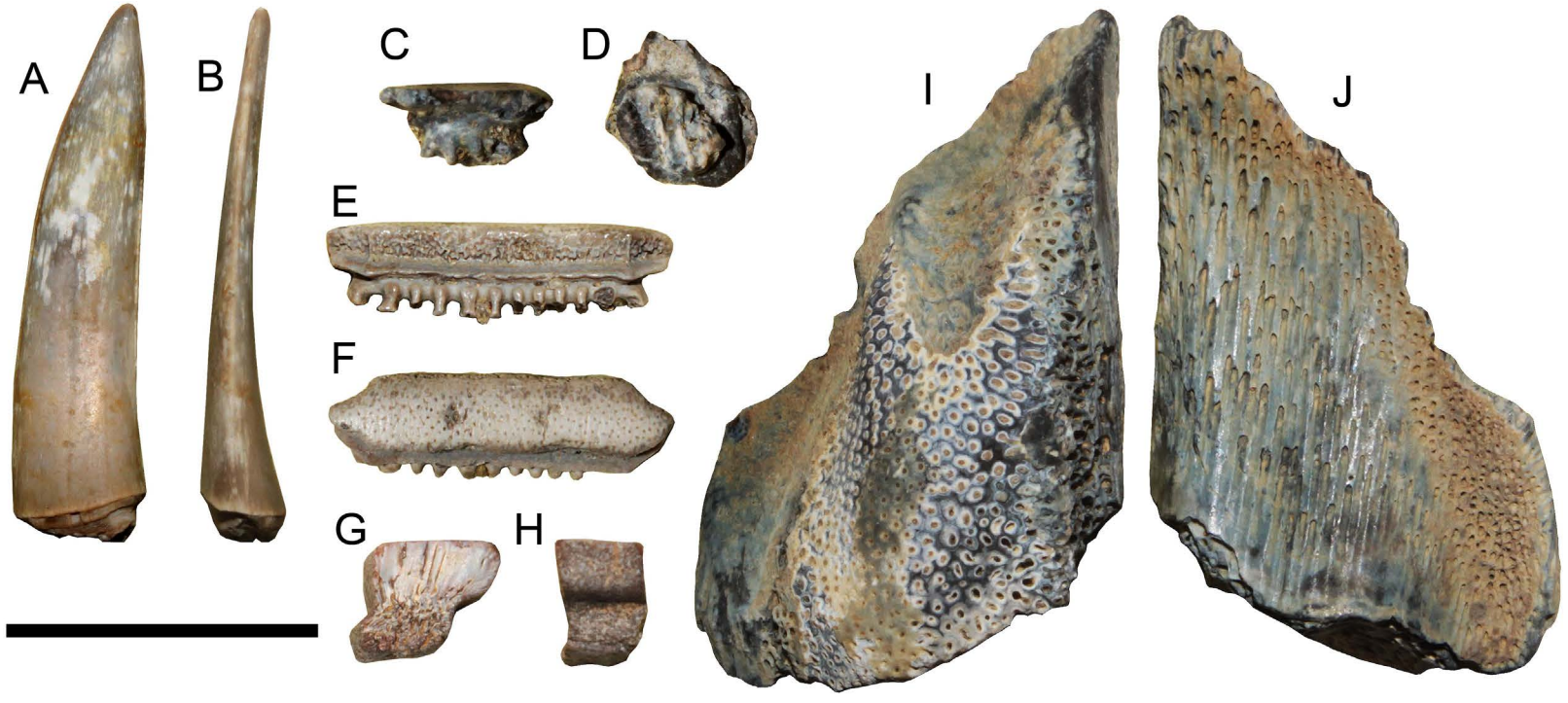

FIG. 4. P*ristiophorus* sp. SGO.PV.6554. Rostral spine. **A**. dorsal view; **B**. axial view. Río de Las Minas, Punta Arenas, southernmost Chile. Upper levels of the Loreto Formation, Late Eocene (Priabonian). *Rhinoptera* sp.; **C**. SGO.PV.6552 lateral tooth in lateral view; **D**. same in basal view. Río de Las Minas, Punta Arenas, southernmost Chile. Upper levels of the Loreto Formation, Late Eocene (Priabonian); **E**. SGO.PV. 6551, median tooth plate; **F**. Same in axial view. Myliobatidae indet; **G**. SGO.PV.6550, fragment of a median tooth plate in profile view; **H**. Same in axial view. Eastern slopes of the Sierra Dorotea, Magallanes Region, southernmost Chile. *Callorhinchus* sp. SGO.PV.6555, left mandibular; **I**. Occlusal view; **J**. Basal view. Río de Las Minas, Punta Arenas, southernmost Chile. Upper levels of the Loreto Formation, Late Eocene (Priabonian). Scale bar equals 10 mm.

Family Myliobatidae Bonaparte, 1838

Myliobatidae indet.
Fig. 4G-H

Material: SGO.PV.6550: One fragment of medial tooth. Eastern Sierra Dorotea, Magallanes Region, southernmost Chile. Upper levels of the Río Turbio Formation, Bartonian-Priabonian.
Description: small medial fragment of a median tooth plate, showing typical holoaulacorhize vascularization of the root with parallel nutritious grooves. The occlusal surface of the crown is flat and in profile view, the latter is axially shifted with respect to the root.
Remarks: Dental plates of myliobatids are frequent along Eocene units of the WBP (Kriwet, 2005; Reguero *et al*., 2013; Otero *et al*., 2012, 2013a). The new find, although fragmentary, provides evidence on the widespread distribution of *Myliobatis* along the Magallanes Basin.

Subclass Holocephali Bonaparte, 1832
Order Chimaeriformes Obruchev, 1953
Family Callorhynchidae Garman, 1901
Genus *Callorhinchus* Lacépède, 1798

Type species: *Callorhinchus callorhynchus* (Linnaeus, 1758), Recent.

***Callorhinchus* sp.**
Fig. 4I-J

Material: SGO.PV.6555. One isolated mandibular plate. Río de Las Minas, Punta Arenas, southernmost Chile. Upper levels of the Loreto Formation, Priabonian.
Diagnosis: For diagnosis of the genus *Callorhinchus*, see Kriwet and Gaździcki (2003).
Description: Mandibular tooth plate with a single central hypermineralized pad restricted to the distal part of the coronal surface, flanked by narrow tritors on the symphyseal and/or labial edges (Otero *et al*., 2013b).
Remarks: The genus *Callorhinchus* is a widespread taxon along the WBP between the Upper Cretaceous-Eocene. Its presence is documented from upper Maastrichtian levels of the López de Bertodano Formation in Seymour Island, Antarctica (Martin and Crame, 2006; Otero *et al*., 2013b) and from Eocene levels of the La Meseta Formation, in the same locality (Kriwet and Gaździcki, 2003).

5. Discussion

5.1. Condrichthyan Paleobiogeography along the Magallanes Basin and Antarctica during the Eocene

The Antarcto-Pacific Eocene diversity of chondrichthyans includes elements with global distribution, as well as others so far restricted to the Southern Hemisphere. Based on the known record, four groups can be separated based on their known paleobiogeographic distribution: **i.** taxa exclusively restricted to latitudes near 65°S on the Antarctic Peninsula. This group includes the genera *Bathyraja, Carcharhinus, Centrophorus, Cetorhinus, Stegostoma, Dalatias, Deania, Heptranchias, Lamna, Pristis, Pseudoginglymostoma, Scoliodon,* and *Chimaera* (Kriwet, 2005; Reguero *et al*., 2013). These genera are also known in the Northern Hemisphere (Cappetta, 1987 and references therein); **ii.** a second tentative group comprise those taxa restricted to the Antarctic Peninsula and southernmost South America. So far, only the genera *Anomotodon* and *Callorhinchus* fall into this condition (Kriwet, 2005; Otero *et al*., 2013b), and it is possible that this situation could be a bias of the still incomplete austral record; **iii.** a third group comprise a larger diversity with widespread taxa along Antarctica and the Magallanes Basin during the Eocene. These are represented by the genera *Carcharocles, Galeorhinus, Hexanchus, Ischyodus, Jaekelotodus, Macrorhizodus, Myliobatis, Odontaspis, Palaeohypotodus* (known in the Paleocene of the Northern Hemisphere but recovered from upper Ypresian levels of Antarctica; see Reguero *et al*., 2013), *Paraorthacodus* (recovered from latest Ypresian levels of Antarctica; see Reguero *et al*., 2013), *Pristiophorus, Squalus, Squatina* and *Striatolamia*, while the genera *Abdounia, Carcharias, Carcharoides, Megascyliorhinus, Notorhynchus,* and *Rhinoptera* are to date restricted to southern South America during this lapse; **iv.** finally, a fourth group include the genera *Otodus* and *Rhizoprionodon* which are only known in the northern part of the Magallanes Region (lat. 50°48'). The distribution of all these taxa is summarized on Table 1.

The new records described here allow complementing the distribution of *S. macrota*, *P. rutoti*,

TABLE 1. DISTRIBUTION OF KNOWN CHONDRICHTHYAN GENERA ALONG ANTARCTICA AND THE SOUTH-EASTERN PACIFIC DURING THE EOCENE.

Genus	Antarctica	Río de Las Minas	Sierra Dorotea	Sierra Baguales
Bathyraja	x	-	-	-
Carcharhinus	x	-	-	-
Centrophorus	x	-	-	-
Cetorhinus	x	-	-	-
Chimaera	x	-	-	-
Dalatias	x	-	-	-
Deania	x	-	-	-
Heptranchias	x	-	-	-
Lamna	x	-	-	-
Pristis	x	-	-	-
Pseudoginglymostoma	x	-	-	-
Scoliodon	x	-	-	-
Stegostoma	x	-	-	-
Anomotodon	x	x	-	-
Callorhinchus	x	x	-	-
Palaeohypotodus	x	-	x	-
Carcharocles	x	-	-	x
Galeorhinus	-	x	-	-
Hexanchus	x	x	-	x
Ischyodus	x	x	-	x
Jaekelotodus	-	-	-	x
Macrorhizodus	x	x	-	x
Myliobatis	x	x	x	x
Odontaspis	x	x	x	x
Paraorthacodus	x	-	x	-
Pristiophorus	x	x	-	x
Squalus	x	-	x	-
Squatina	x	x	-	x
Striatolamia	x	x	x	x
Abdounia	-	x	-	x
Carcharias	-	x	x	x
Carcharoides	-	x	-	x
Megascyliorhinus	-	x	-	x
Notorhynchus	-	x	-	x
Rhinoptera	-	x	x	-
Otodus	-	-	-	x
Rhizoprionodon	-	-	-	x

Sources of information from Kriwet (2005), Otero *et al*. (2012, 2013a, 2014), Reguero *et al*. (2013) (R), and this study.

Carcharias sp., as well as myliobatids, which now can be regarded as common faunal elements along the Magallanes Basin. Despite remaining unknown in Sierra Dorotea, the records of *Megascyliorhinus* in Río de Las Minas and Sierra Baguales also indicate a widespread distribution. In addition, *Rhinoptera* sp. is at least restricted to the southern and central part of the same basin.

5.2. Chronostratigraphic implications of the new records

The presence of *Megascyliorhinus* sp. in outcrops of the Loreto Formation at Río de Las Minas is interesting. Chondrichthyan records found in the locality were all recovered from a single level and they represent an assemblage of a well constrained age (Priabonian-Rupelian), while radioisotopic dates indicates a very well defined peak at 36.48±0.47 Ma, constraining the age of the fossil-bearing level exclusively to the Priabonian (Otero *et al*., 2012). Lower levels of the same section include coal seams representing stagnant marshes with abundant vegetation, and the large-scale cross-bedding of some sandstone units that is typical of Gilbert-type bayhead deltas or migrating barrier bars (Le Roux *et al*., 2010), consistent with an estuarine depositional environment. On the other hand, regional previous records of *Megascyliorhinus* are only known in the northern part of the Magallanes Basin, being recovered from Bartonian-Priabonian beds of Sierra Baguales (Otero *et al*., 2013a). Since the teeth from Río de Las Minas do not differ from those from Sierra Baguales, we consider them as probably belonging to the very same species (still indeterminate). Also, due the late Eocene age of the material (radioisotopically controlled in Río de Las Minas), the previous identification of *Megascyliorhinus cooperi* in Sierra Baguales should be kept only to genus level, being possible that these teeth belong to a still poorly known species typicallt distributed in the Magallanes basin during the late Eocene.

On the other hand, the presence of *Paraorthacodus* sp. in Sierra Dorotea is very interesting. The genus is well-known in the Upper Cretaceous-Paleocene with a widespread distribution (Cappetta, 1987). An exception to this happens on Ypresian levels of the La Meseta Formation (*Cucullaea* I Allomember) where the genus *Paraorthacodus* have been recovered (A. Cione, personal communication *in* Reguero *et al*., 2013). Similar is the case of *Palaeohypotodus rutoti*, species restricted to the Thanetian of the Northern Hemisphere but also recorded in the Ypresian of the *Cucullaea* I member of La Meseta Formation (Long, 1992; Reguero *et al*., 2013). This documented extension of its chronostratigraphic range makes plausible their eventual occurrence in Bartonian-Priabonian levels of the Río Turbio exposed at Sierra Dorotea by extension of biochrons. However, an eventual reworking of the material from Ypresian levels and subsequent redeposition on Bartonian-Priabonian horizons of the Río Turbio cannot be ruled, pointing out the need of radioisotopic dates for support this still partial evidence.

The geologic setting of the marine basins in Magallanes and in the southeastern Pacific shows in both cases a general absence of Paleocene beds. Upper Cretaceous (Maastrichtian) marine sediments are commonly contacted with middle-to-late Eocene beds through an erosive unconformity. Such is the case between the the Quiriquina Formation and the Concepción Group (*sensu* Charrier *et al*., 2007) in central Chile (Stinnesbeck, 1986), as well as between the Dorotea Formation and the Man Aike-Río Turbio (and likely Loreto) formations in southernmost Chile (Katz, 1963; Charrier and Lahsen, 1969). The only possible Paleocene beds in the Magallanes Basin are represented as an exception in Cerro Dorotea Formation (Hünicken, 1955), which levels conformably overlies the Cerro Cazador (=Dorotea) Formation in outcrops near to Río Turbio, Argentina. Chondrichthyan records from the Quiriquina Basin include Maastrichtian assemblages (Suárez *et al*., 2003) and more recently, Paleogene assemblages including the genera *Paraorthacodus* and *Palaeohypotodus* (Muñoz-Ramírez *et al*., 2007; González *et al*., 2010; Groz and Palma-Heldt, 2013). Considering the Pacific Maastrichtian-Eocene discordance, is likely that these records have an Eocene age. Such situation adds support to the existence of a biochron extension for several classically Paleogene taxa but recorded from Eocene levels of the WBP.

The additional specimens here referred to *Callorhinchus* sp., and *Rhinoptera* sp., respectively represents their first Eocene occurrence in the Magallanes Basin. The new record of *Pristiophorus* sp. extends its contemporary occurrence in the southern margin of the basin. The new records of *Striatolamia macrota* (Agassiz), *Carcharias* sp., *Rhinoptera* sp., and indeterminate myliobatids in Bartonian-Priabonian

beds of Sierra Dorotea allow complementing the distribution of these taxa between the previous records from Río de Las Minas and Sierra Baguales, respectively.

6. Conclusions

The studied material includes the first record of *Megascyliorhinus* sp., *Pristiophorus* sp., *Callorhinchus* sp., and *Rhinoptera* sp. in late Eocene levels of the Loreto Formation exposed at Río de Las Minas, Punta Arenas, southernmost Chile. The radioisotopic date and the relative age obtained from the previously recognized chondrichthyan assemblage confirm the Priabonian age of the fossil-bearing level, while the depositional environment and the taphonomic condition of most of the teeth preserving even their delicate cusplets, allow discarding the reworking of the material from older levels. Since *M. cooperi* have been considered as a typical Ypresian taxon, we propose an extension of its biochron along the southeastern Pacific at least until the Priabonian. The new records extend the number of chondrichthyan genera found in the upper section of the Loreto Formation from 12 to 16.

On the other hand, it is described the first occurrence of *Striatolamia macrota*, *Palaeohypotodus rutoti*, *Carcharias* sp., *Squalus* sp., *Rhinoptera* sp., *Paraorthacodus* sp. and indeterminate myliobatids in Bartonian-Priabonian levels of the Río Turbio Formation exposed at Sierra Dorotea, near Puerto Natales. Previously, the genus *Paraorthacodus* was considered as typically Paleocene, with the exception of confirmed records from Ypresian levels of La Meseta Formation in Seymour Island Antarctica, and likely Eocene records from central Chile. Considering the general absence of Paleocene marine strata along the Pacific and in the Magallanes Basin, this new record extends its biogeographical occurrence into southern South America indicating its presence in Bartonian-Priabonian levels, and suggesting an extension of its previous known Biochron (Upper Cretaceous-Ypresian), although, the re-working of the recovered specimen from older strata in Sierra Dorotea cannot be discarded. The additional taxa described from the latter locality complements their contemporary distribution along the Magallanes Basin, proving the existence of a faunal continuity along the latter, based on the austral-most records from Río de Las Minas and the northern-most records from Sierra Baguales. From the 16 genera recognized in the upper section of the Loreto Formation at Río de Las Minas, 13 of them are now recognized to be also present in Bartonian-Priabonian levels at Sierra Baguales. This faunal correlation supports that the deposition on each locality was nearly contemporary and occurred in a very similar environment. These results also indicate a noticeable degree of correlation between part of the Man Aike Formation at Sierra Baguales, the upper slopes of the Río Turbio Formation at Sierra Dorotea, and finally, the upper section of the Loreto Formation at Río de Las Minas.

Acknowledgments

The authors, fieldwork, logistics and research were supported by the Antarctic Ring Project ACT-105, Conicyt-Chile. Especial thanks to J.L. Oyarzún (Puerto Natales) for his valuable assistance on the first fieldworks and logistics. C. Underwood (Birkbeck University of London) and C. Pimiento (Florida Museum of Natural History) are especially thanked for the review and the valuable comments that helped to improve the original manuscript.

References

Agassiz, L. 1833-1844. Recherches sur les poissons fossils. Five volumes. Imprimerie de Petitpierre: 1420 p. Neuchâtel.

Ameghino, F. 1893. Sobre la presencia de vertebrados de aspecto Mesozoico, en la formación Santacruceña de la Patagonia austral. Revista del Jardín Zoológico de Buenos Aires 1: 76-84.

Berg, L.S. 1958. System der rezenten und fossilen Fischartigen und Fische. Deustch Verlag der Wissenschaften: 310 p.

Bleeker, P. 1859. Enumeratio specierum piscium hucusque in Archipelago indico observatarum. Acta Societatis Scientiarum Indo-Neerlandae 6 (i-xxxvi): 1-276.

Bonaparte, C.L. 1832-1838. Selachorum Tabula Analytica. Nuovi Annali di Scienze Naturali 1: 195-214. Bologna.

Bonaparte, C.L. 1834. Iconografia della fauna italica per le quattro classi degli animali vertebrati. Tomo III, puntata 29-58. Pesci.

Cappetta, H. 1980. Les sélaciens du Crétacé Supérieur du Liban. 2: Batoides. Palaeontographica Abteilung A (168): 149-229.

Cappetta, H. 1987. Handbook of Paleoichthyology. Volume 3b: Chondrichthyes II. Mesozoic and Cenozoic Elasmobranchii (Schultze, H.-P.; editor). Gustav Fischer Verlag: 193 p.

Cappetta, H. 2012. Chondrichthyes (Mesozoic and Cenozoic Elasmobranchii: Teeth). *In* Handbook of Paleoichthyology (Schultze, H.P.; editor), Vol. 3E. Verlag Dr. Friedrich Pfeil, München: p. 512.

Cappetta, H.; Ward, D.J. 1977. A new Eocene shark from the London Clay of Essex. Palaeontology 20: 196-202.

Cappetta, H.; Nolf, D. 2005. Révision des quelques Odontaspididae (Neoselachii: Lamniformes) du Paléocène et de l'Eocène du Bassin de la mer du Nord. Bulletin de l'Institut Royal des Sciences Naturelles de Belgique, Sciences de la Terre 75: 237-266.

Charrier, R.; Lahsen, A. 1969. Stratigraphy of Late Cretaceous. Early Eocene, Seno Skyring-Strait of Magellan area, Magallanes Province, Chile. American Association fo Petroleum Geologists, Bulletin 53: 568-590.

Charrier, R.; Pinto, L., Rodríguez, M.P. 2007. Tectono-stratigraphic evolution of the Andean Orogen in Chile. *In* The Geology of Chile (Moreno, T.; Gibbons, W.; editors). Geological Society: 21-114. London.

Cione, A.L.; Mennucci, J.A.; Santalucita, F.; Acosta, C. 2007. Local extinction of sharks of genus *Carcharias* Rafinesque, 1810 (Elasmobranchii, Odontaspididae) in the eastern Pacific Ocean. Revista Geológica de Chile 34 (1): 139-145. doi: 10.5027/andgeoV34n1-a07.

Cohen, K.M.; Finney, S.M.; Gibbard, P.L.; Fan, J.-X. 2013. The ICS (International Commission on Stratigraphy) International Chronostratigraphic Chart. Episodes 36 (3): 199-204.

Compagno, L.J.V. 1973. Interrelationships of living elasmobranchs. *In* Interrelationships of Fishes (Greenwood, P.H.; Miles, R.S.; Patterson, C.; editors). Supplement I to Zoological Journal of the Linnean Society of London 53: 15-61.

Compagno, L.J.V. 1977. Phyletic relationships of living sharks and rays. American Zoologist 17: 303-322.

Cuvier, L.C.F.D.1829. Le Règne Animal, distribué d'aprés son organisation, pour servir de base à l'histoire naturelle des animaux et díntroduction à l'anatimie comparée. Edition 2 (2): 1-406.

Duffin, C.J.; Ward, D.J. 1993. The Early Jurassic Palaeospinacid sharks of Lyme Regis, southern England. Belgian Geological Survey, Professional Paper 264: 53-102.

Fasola, A. 1969. Estudio palinológico de la Formación Loreto (Terciario Medio), Provincia de Magallanes, Chile. Ameghiniana 6: 3-49.

Feruglio, E. 1938. El Cretácico Superior del Lago San Martin (Patagonia) y de las regiones adyacentes. Physis 12: 293-342.

Garman, S. 1901. Genera and families of the Chimaeroids. Proceedings of the New England Zoological Club 2: 75-77.

Gill, T. 1862. Analytical synopsis of the Order of Squali and revision of the nomenclature of the genera. Annals of the Lyceum of Natural History of New York 7: 367-408.

Glikman, L.S. 1958. O tempakh evolyutsii lamnoidnykh akul. Doklady Akademii Nauk SSSR 123: 568-672.

Glikman, L. 1964. Akuly paleogena i ikh stratigraficheskoe znachenie. Akademii Nauk Soyuza Sovetskikh Sotsialisticheskikh Respublik: 228 p.

González, N.; Groz, C.; Palma-Heldt, S. 2010. Registro adicional de dientes de elasmobranquios en el Paleógeno de Talcahuano, Región del Biobío, Chile. *In* Simposio-Paleontología en Chile No. 2, Libro de Resúmenes: p. 59. Concepción.

Griffin, M. 1991. Eocene bivalves from the Río Turbio Formation, southwestern Patagonia (Argentina). Journal of Paleontology 65 (1): 119-146.

Groz, C.; Palma-Heldt, S. 2013. Contribution of fossil record of Elasmobranchs to the knowledge of the limit K/P in the Biobío Region, Chile. *In* Geosur, International Symposium on the Geology and Geophysics of the Southernmost Andes, the Scotia Arc and the Antarctic Peninsula. Bollettino di Geofisica teorica ed applicata, Supplement B (54): 233-234. Viña del Mar.

Goodrich, E.S. 1909. Vertebrata Craniata (First fascicle: cyclostomes and fishes). *In* A Treatise on Zoology (Lankester, R.; editor). Adam and Charles Black, , part IX: 1-518. London.

Hervé, F.; Godoy, E.; Mpodozis, C.; Fanning, M. 2004. Monitoring magmatism of the Patagonian batholith through the U-Pb SHRIMP dating of detrital zircons in sedimentary units of the Magallanes Basin. *In* Geosur, International Symposium on the Geology and Geophysics of the Southernmost Andes, the Scotia Arc and the Antarctic Peninsula (Carcione, J.; Donda, F.; Lodolo, E.; editors), Actas 4-06. *In* Bolletino di Geofisica Teorica ed Applicata 45 (2): 113-117. Buenos Aires.

Hoffstetter, R.; Fuenzalida, H.; Cecioni, G. 1957. Chile-Chili. *In* Lexique Stratigraphique International. Amérique Latine, Centre National de la Recherche Scientifique 5 (7): 444 p. París.

Hünicken, M.A. 1955. Depósitos Neocretácicos y Terciarios del extremo SSW de Santa Cruz (Cuenca Carbonífera de Río Turbio). Revista del Instituto Nacional de Investigaciones en Ciencias Naturales, Ciencias Geológicas 4: 1-161.

Huxley, T.H. 1880. On the application of the laws of evolution to the arrangement of the Vertebrata, and more particularly of the Mammalia. Proceedings of the Zoological Society of London 43: 649-661.

Jordan, D.S. 1898. Description of a species of fish (*Mitsukurina owstoni*) from Japan, the type of a distinct family of lamnoid sharks. Proceedings of the California Academy of Sciences 3: 199-204.

Jordan, D.S.; Evermann, B.W. 1896. The fishes of North and Middle America. Bulletin of the United States National Museum 47: 1-1240.

Katz, H. 1963. Revision of Cretaceous stratigraphy in Patagonian Cordillera of Última Esperanza, Magallanes province, Chile. American Association of Petroleum Geologists Bulletin 47: 506-524.

Keyes, I.W. 1984. New records of fossil elasmobranch genera *Megascyliorhinus*, *Centrophorus*, and *Dalatias* (Order Selachii) in New Zealand. New Zealand Journal of Geology and Geophysics 27: 203-216.

Klug, S.; Kriwet, J.; Lirio, J.M.; Núñez, H.J. 2008. Synechodontiform sharks (Chondrichthyes, Neoselachii) from the Upper Cretaceous of Antarctica. *In* Mesozoic Fishes 4-Homology and Phylogeny (Arratia, G.; Schultze, H.P.; Wilson, M.V.H.; editors). Verlag Dr. Friedrich Pfeil, München: 455-467. Germany.

Kriwet, J. 2005. Additions to the Eocene Selachian fauna of Antarctica with comments on Antarctic selachian diversity. Journal of Vertebrate Paleontology 25 (1): 1-7.

Kriwet, J.; Gaździcki, A. 2003. New Eocene Antarctic chimeroid fish (Holocephali, Chimaeriformes). Polish Polar Research 24: 29-51.

Lacépède, B.G.E. 1798. Histoire naturelle de poissons (vol. I) par le citoyen La Cépède, membre de l'Institut National, et professeur du Muséum d'Histoire naturelle. Tome premier: 400 p. Paris.

Latham, J. 1794. An essay on the various species of Sawfish. Transactions of the Linnean Society of London 2: 273-282.

Le Roux, J.P.; Puratich, J.; Mourgues, F.A.; Oyarzun, J.L.; Otero, R.A.; Torres, T.; Hervé, F. 2010. Estuary deposits in the Rio Baguales Formation (Chattian- Aquitanean), Magallanes Province, Chile. Andean Geology 37 (2): 329-344. doi: 10.5027/andgeoV37n2-a04.

Linnaeus, C. 1758. Systema naturae per regna tria naturae, secundum classes, ordines, genera, species, cum characteribus, differentiis, synonymis, locis. Editio decima, reformata, Tomus I. Holmiae. Laurentii Salvii 1-4: 1-824.

Long, D.J. 1992. Sharks from the La Meseta Formation (Eocene), Seymour Island, Antarctic Peninsula. Journal of Vertebrate Paleontology 12: 11-32.

Malumián, N.; Caramés, A. 1997. Upper Campanian-Paleogene from the Río Turbio coal measures in southern Argentina: micropaleontology and the Paleocene/Eocene boundary. Journal of South American Earth Sciences 10: 189-201.

Martin, J.E.; Crame, J.A. 2006. Paleobiological significance of high-latitude Late Cretaceous vertebrate fossils from the James Ross Basin, Antarctica. *In* Cretaceous-Tertiary High-Latitude Paleoenvironments, James Ross Basin, Antarctica (Francis, J.E.; Pirrie, D.; Crame, J.A.; editors). Geolological Society of London, Special Publication 258: 109-124.

Müller, J.; Henle, F. 1837. Ueber die Gattungen der Plagiostomen. Archiv für Naturgeschichte 3: 394-401.

Müller, J.; Henle, F. 1838-1841. Systematische Beschreibung der Plagiostomen. Plagiostomen: i-xxii + 1-200, 60 pls. Berlín.

Muñoz-Ramírez, C.P.; Zambrano, Z.; Montoya, G.; Moyano, H. 2007. Dientes de tiburones y rayas (Chondrichthyes, Elasmobranchii) de la Formación Quiriquina aflorante en Talcahuano, Chile Central. Boletín de la Sociedad de Biología de Concepción 78: 7-22.

Obruchev, D.V. 1953. Studies on edestids ad the works of A.P. Karpinski. U.S.S.R Academy of Sciences, Works on Palaeontological Institute, Publication 45: 1-86.

Otero, R.A.; Torres, T.; Le Roux, J.P.; Hervé, F.; Fanning, C.M.; Yury-Yáñez, R.E.; Rubilar-Rogers, D. 2012. A Late Eocene age proposal for the Loreto Formation (Brunswick Peninsula, southernmost Chile), based on fossil cartilaginous fishes, paleobotany and radiometric evidence. Andean Geology 39 (1): 180-200. doi: 10.5027/andgeoV39N1-a09.

Otero, R.A.; Oyarzún, J.L.; Soto-Acuña, S.; Yury-Yáñez, R.; Gutiérrez, N.; Le Roux, J.; Torres, T.; Hervé, F. 2013a. Neoselachians and Chimaeriformes (Chondrichthyes) from the Upper Cretaceous-Paleogene of Sierra Baguales, southernmost Chile. Chronostratigraphic, paleobiogeographic and paleoenvironmental implications. Journal of South American Earth Sciences 48: 13-30.

Otero, R.A.; Rubilar-Rogers, D.; Yury-Yáñez, R.; Vargas, A.O.; Gutstein, C.S.; Mourgues, F.A.; Robert, E. 2013b. A new species of chimaeriform (Chondrichthyes; Holocephali) from the uppermost Cretaceous of the López de Bertodano Formation, Isla Marambio (Seymour Island), Antarctica. Antarctic Science 25: 99-106.

Otero, R.A.; Gutstein, C.S.; Vargas, A.O.; Rubilar-Rogers, D.; Yury-Yáñez, R.E.; Bastías, J.; Ramírez, C. 2014. New chondrichthyans from the Late Cretaceous (Campanian-Maastrichtian) of Seymour and James Ross islands, Antarctica. Journal of Paleontology 88: 411-420.

Philippi, R.A. 1887. Los fósiles Terciarios i Cuartarios de Chile. F.A. Brockhaus, Leipzig: 256 p.

Rafinesque, C.S. 1810. Caratteri di alcuni nuovi generi e nuove specie di animali e pinate della Sicilia, con varie osservazioni sopra i medisimi: 3-69.

Regan, T. 1906. A classification of the selachian fishes. Proceedings of the Zoological Society of London 2: 722-758.

Reguero, M.A; Marenssi, S.A.; Santillana, S.N. 2013. Weddellian marine/coastal vertebrate diversity from a basal horizon (Ypresian, Eocene) of the *Cucullaea* I Allomember, La Meseta formation, Seymour (Marambio) Island, Antarctica. Revista Peruana de Biología 19 (3): 275-284.

Saint-Hilaire, G. 1809. Description de l'Égypte ou Recueil des observations et des Recherches qui ont été faites en Égypte pendant léxpédition de l'Armée Francaise, Paris, Histoire Naturelle, 10 vols.: 99-144.

Sallaberry, M.A.; Yury-Yáñez, R.E.; Otero, R.A.; Soto-Acuña, S.; Torres, T. 2010. Eocene birds from the western margin of southernmost South America. Journal of Paleontology 84: 1061-1388.

Stinnesbeck, W. 1986. Zu den faunistischen und paläokologischen Verhältnissen in der Quiriquina Formation (Maastrichtium) Zentral-Chiles. Palaeontographica 194: 99-237.

Suárez, M.E.; Quinzio, L.A.; Fritis, O.; Bonilla, R. 2003. Aportes al conocimiento de los vertebrados marinos de la Formación Quiriquina. *In* Congreso Geológico Chileno, No. 10, Sección temática Actas 3: 7 p. Concepción.

Trautschold, H. 1877. Über Kreidefossilien Russlands. Bulletin de la Societe des Naturalistes de Moscou 11: 332-349.

Ward, D. 1988. *Hypotodus verticalis* (Agassiz, 1843), *Hypotodus robustus* Leriche (1921) and *Hypotodus heinzelini* (Casier, 1967), Chondrichthyes, Lamniformes, junior synonyms of *Carcharias hopei* (Agassiz,1843). Tertiary Research 10 (1): 1-12.

Welton, B.; Zinsmeister, W. 1980. Eocene neoselachians from the La Meseta Formation, Seymour Island, Antarctic Peninsula. Natural History Museum of Los Angeles County, Contributions in Science 329: 1-10.

Wilckens, O. 1910. Die Anneliden, Bivalven, und Gastropoden der Antarktischen Kreideformation. Wissenschaftliche Ergebnisse der Schwedische Südpolar Expedition 3: 1-132.

Winkler, T.C. 1874. Mémoire sur des dents de poisson du terrain bruxellien. Archives du Musée Teyler 3: 295-304.

Zinsmeister, W.J. 1979. Biogeographic significance of the Late Mesozoic and early Tertiary molluscan faunas of Marambio Island (Antarctic Peninsula) to the final break-up of Gondwanaland. *In* Historical Biogeography, Plate Tectonics and the Changing Environment (Gray, J.; Boucot, A.J.; editors). Oregon State University Press: 349-355. Corvallis.

Manuscript received: March 13, 2014; revised/accepted: March 23, 2015; available online: March 27, 2015.