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SHARKS FROM THE LA MESETA FORMATION (EOCENE), SEYMOUR ISLAND, ANTARCTIC PENINSULA

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ABSTRACT—The marine waters of present-day Antarctica contain an exceedingly depauperate elasmobranch fauna. Recent investigations into the Eocene marine sediments of the La Meseta Formation of Seymour Island, Antarctic Peninsula yielded 13 fossil sharks new to the Antarctic region. Two, *Stegostoma* cf. *S. fasciatum* and *Pseudoginglymostoma* cf. *P. brevicaudatum*, were unknown as fossils. *Squalus woodburnei*, *S. weltoni*, and *Anomotodon multidenticulata* are new species. *Heptranchias howelli*, *Centrophorus* sp., *Deania* sp., *Dalatias licha*, *Odontaspis rutoti*, *O. winkleri*, *Lamna* cf. *L. nasus*, and *Scoliodon* sp. are reported in Antarctica for the first time. In addition, the new fossil shark material increases the representation of the four previously known fossil sharks from Seymour Island: *Squatina* sp., *Pristiophorus lanceolatus*, *Carcharias macrota*, and *Carcharocles auriculatus*.

INTRODUCTION

A diverse ichthyofauna, largely represented by isolated shark teeth, occurs in the middle to late Eocene La Meseta Formation of Seymour Island, Antarctica. This study is concerned with the identification and paleontological importance of the elasmobranch fossils. Seymour Island is one of a series of islands that lies east of the northern tip of the Antarctic Peninsula, at approximately latitude 64°15′S and longitude 56°45′W, almost directly south of Tierra Del Fuego, South America (Fig. 1). The present-day climate on Seymour Island is influenced by the adjacent Antarctic landmass, but during the austral summer little or no snow falls on the island so the outcropping rocks may be prospected for geological and paleontological materials.

Seymour Island is a fragment of an ancient landbridge that extended from Antarctica to southern South America and included portions of the Antarctic Peninsula from the Late Cretaceous through the Early Tertiary (Woodburne and Zinsmeister, 1984). This land bridge provided a terrestrial dispersal route between the two continents for marsupials, birds, and other terrestrial organisms (Case et al., 1988). The stratigraphic sequence of Seymour Island extends from the Upper Cretaceous (Lopez de Bertodano Formation) through to the lower Paleocene (Sobral Formation), the upper Paleocene (Cross Valley Formation), and to the middle to late Eocene (La Meseta Formation) (Woodburne and Zinsmeister, 1984; Sadler, 1988). Some outcrops of the La Meseta Formation are capped by Quaternary glacial deposits (Elliot and Trautman, 1982).

The late Eocene beds of the La Meseta Formation are exposed on the northern portion of Seymour Island (Fig. 1) and have yielded the fossils described herein (Fig. 2; Table 1). The La Meseta Formation consists of marine sediments of poorly consolidated sandstone, pebbly sandstone, sandy siltstone, clays, and shell beds. Preserved within these various strata are the remains of several faunas consisting of nautiloids, echinoderms, and mollusks, along with relatively abundant vertebrate remains that include both bony and cartilaginous fishes, reptiles, cetaceans, birds (primarily penguins), and marsupials. Over 900 teeth of 17 different taxa of fossil sharks have been collected by U.C. Riverside expeditions.

The La Meseta Formation is 450 m thick and is divided into seven numbered units within three sections (Sadler, 1988; Elliot and Trautman, 1982). The base of Telm 1 rests uncomforably on the Cross Valley Formation and is sparsely fossiliferous (Sadler, 1988); however, there are several fossil shark localities in Telm 2. Telm 3 and Telm 4 and 5 contain the bulk of the fossil shark localities. These units contain sequences of thick shell beds, sands, and silts (Sadler, 1988; Elliot and Trautman, 1982; Welton and Zinsmeister, 1980). The uppermost units, Telm 6 and 7 contain no fossil sharks.

The study of the fossil fishes of Seymour Island began as early as 1906 with Woodward's work on Cretaceous fish remains from the Island but it was not until 1976 that the existence of fossil sharks from the Paleogene of Seymour Island was first noted. The first identifications of fossil sharks were made by del Valle et al. (1976) who listed *Scapanorhynchus raphiodon*, *S. undulatus*, *Isurus mantelli*, *Isurus* sp., and *Carcharias* sp. from the La Meseta Formation. Welton and Zinsmeister (1980), however, left open the possibility that some specimens of *Scapanorhynchus* and possibly *Isurus* might actually be teeth of *Carcharias*. Indeed, the teeth of these taxa are similar in general form, and *Scapanorhynchus* has not been recorded by any subsequent investigations.

Cione et al. (1977) identified three taxa of sharks from the La Meseta Formation: *Carcharias macrota, Isurus novus*?, and *Carcharocles* sp. Welton and Zinsmeister (1980) re-evaluated the neoselachian fauna from the La Meseta Formation based on newly collected material and provided more precise descriptions and improved illustrations of the previously known *Carcharias macrotus* and *Carcharocles auriculatus*. They also gave descriptions of *Squatina* sp. and an indeterminate squaloid shark similar in morphology to *Centrophorus* or *Deania*. Grande and Eastman (1986) published a review of the entire Antarctic fossil ichthyofauna that included the first occurrence in Antarctica of *Pristiophorus* sp. from the La Meseta Formation.

METHODS AND MATERIALS

Abbreviations: **LACM**, Los Angeles County Museum of Natural History, Section of Fishes; **RV**, University of California, Riverside fossil vertebrate locality; **UCR**, cataloged specimen in the University of California, Riverside, vertebrate fossil collection.

The fossil vertebrates were obtained by both wet-screening and surface collecting. At RV-8200 (Fig. 2) in the lower section of Telm 4, the Seymour Island polydolopid marsupial locality, sediments were carefully screened with a fine-mesh mosquito-net bag (see Case et al., 1988). Some eight to ten tons of fossiliferous sediment were screened and picked through in the field, and over 250 pounds of concentrated matrix were carefully examined for small shark teeth under a stereomicroscope in the laboratory. The result was the recovery of a large amount of vertebrate fossils, including a diversity of shark, ray, and chimaeroid species, usually in good condition. Because the screening process was thorough, there was no collecting bias against small species or species that have small teeth, so RV-8200 has become the most representative site for Seymour Island's neoselachian assemblage. The vertebrate fossils from the remaining sites were recovered by surface-collecting alone. The faunal diversities at these other localities are low because they have not been intensely collected through screening.

The shark remains consist almost entirely of teeth, but some vertebrae and a few poorly preserved dorsal spines were also recovered. Of the vertebrae, only *Squatina* sp. could be positively identified. Because there are many squaloid teeth from the deposit, and because the few dorsal spines recovered show similarities to the dorsal spines of the extant *Squalus acan-*

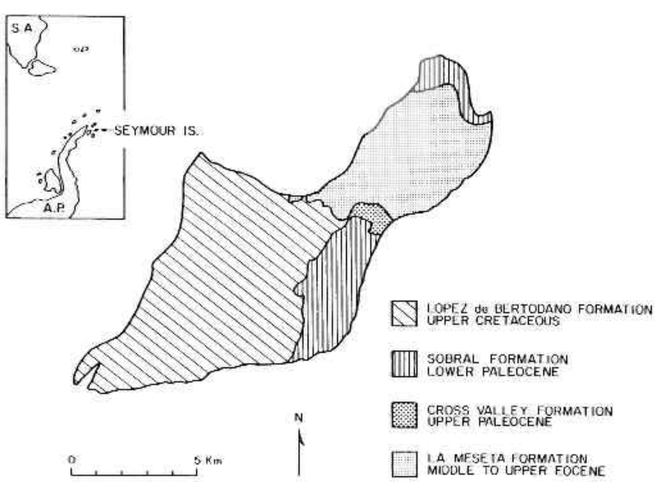

FIGURE 1. Geological map of Seymour Island showing its position in relation to South America (S.A.) and the Antarctic Peninsula (A.P.), and diagramming the different geologic formations on the island, including the La Meseta Formation.

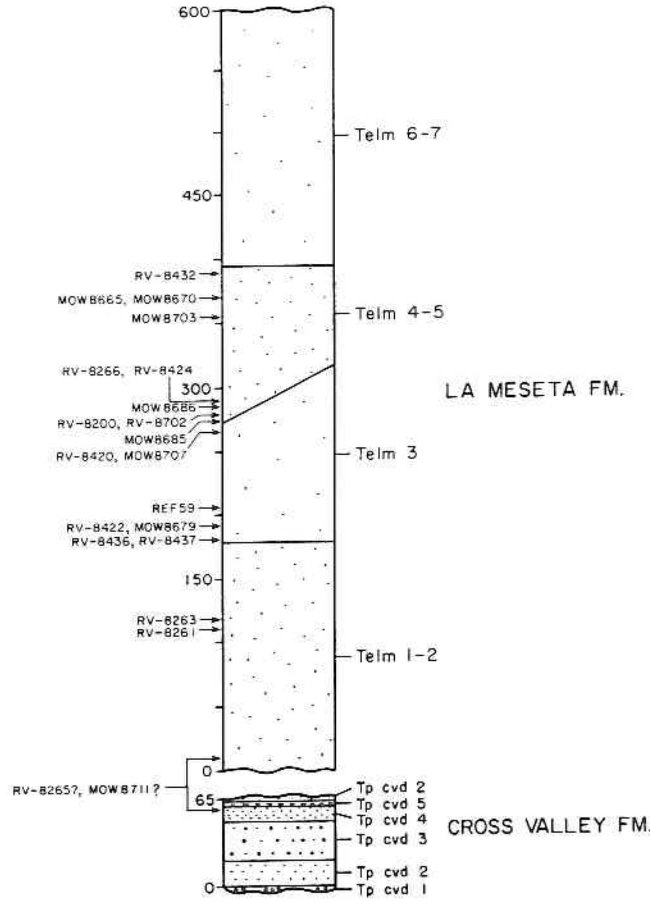

FIGURE 2. Stratigraphic sequence of the La Meseta Formation, Seymour Island, Antarctic Peninsula, showing the units and the distribution of fossil shark localities within them. The sequence is marked in fifty meter intervals. Abbreviations: Telm, Eocene La Meseta Formation; Tp cv, Paleocene Cross Valley Formation; RV, University of California, Riverside, vertebrate locality site number; MOW, Michael O. Woodburne locality field number, University of California, Riverside; REF, R. Ewan Fordyce locality field number, University of Otago, New Zealand.

TABLE 1. Distribution of shark fossils by taxa (left margin) and locality (heading) within the stratigraphic context of the middle to late Eocene La Meseta Formation (Localities are listed from lowest to highest).

TAXA	RV-8265 MOW-8711	RV-8261	RV-8263	RV-8436 RV-8437	RV-8422 MOW-8679	REF-59	RV-8420 MOW-8707	MOW-8685	RC-8200 RV-8702	MOW-8686	RV-8266	RV-8424	MOW-8703	MOW-8665 MOW-8670	RV-8432
Heptranchias howelli											2				
Hexanchidae gen. indeter.									1						
Squalus woodburnei									12						
Squalus weltoni									17			1			
Centrophorus sp. or *Deania* sp.		12	3						5						
Dalatias licha									1			3			
Squatina sp.									83			1			
Pristiophorus lanceolatus				1				2	118	1		14			
Pseudoginglymostoma cf. *P. brevicaudatum*									1						
Stegostoma cf. *S. varium*									2						
Odontaspis winkleri									7						
Odontaspis rutoti									25	15	2	1	1		
Carcharias macrota	3	20		152	7	1	11	2	133		185	49	1	6	15
Anomotodon multidenticulata											1				
Lamna cf. *L. nasus*				2					33	1		1			
Carcharocles auriculatus	1						1								
Scoliodon sp.									2						

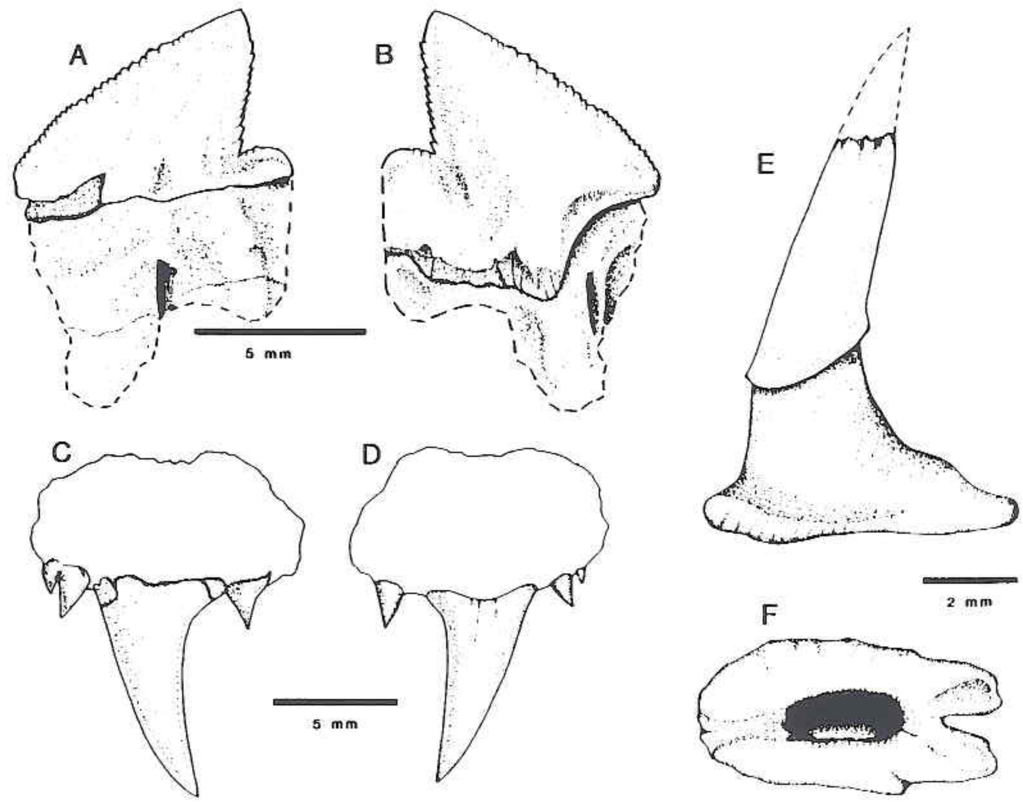

FIGURE 3. **A–B**, Labial and lingual view of lower lateral tooth of *Dalatias licha* (UCR 22085); **C–D**, labial and lingual views of an upper lateral tooth of *Heptranchias howelli* (UCR 22045); **E–F**, lateral and basal views of rostral tooth of *Pristiophorus lanceolatus* (UCR 22082).

thias, the fossil dorsal spines are probably from squaloid sharks. As the teeth in fossil sharks provide the only accurate and easily accessible diagnostic information, the identifications here are based strictly on dental material. The collection of fossil teeth from Seymour Island is extensive and shows a wide range of tooth sizes and tooth positions, which allows accurate identifications.

Because the dentitions of many shark families or genera have changed little throughout the Cenozoic, detailed comparisons of fossil teeth to those of extant members of the same taxa can provide much information to determine the identity of a fossil shark specimen. Applegate (1965) expressed the need to compare teeth of living and fossil sharks to ensure a clear understanding of the variations in shark dentition and to avoid taxonomic confusion. I follow that methodology here by comparing the Seymour Island teeth to those of similar fossil species, as well as to those of living representatives of each taxon. Fossil and recent teeth, prepared and dried jaws and tooth sets of extant species, and detailed drawings and photographs were all used in the comparisons. Tooth terminology used in this study is largely after Welton (1979), Welton and Zinsmeister (1980), Applegate (1965), Ward (1979), and Compagno (1970).

SYSTEMATIC PALEONTOLOGY

Class Chondrichthyes Huxley, 1880
Subclass Elasmobranchii Bonaparte, 1838
Cohort Euselachii Hay, 1902
Subcohort Neoselachii Compagno, 1977
Superorder Squalomorphii Compagno, 1973
Order Hexanchiformes Berg, 1940
Family Hexanchidae Gill, 1885
Genus *Heptranchias* Rafinesque, 1810

Heptranchias howelli (Reed, 1946)
Fig. 3C–D

Description—UCR 21206 and UCR 22045 are both upper lateral teeth with a single primary, distally oblique cusp that is weakly convex on the labial face and moderately convex on the lingual face. The mesial and distal cutting edges that extend from the crown apex to the crown foot are smooth and well developed. UCR 22045 has two mesial denticles and one distal denticle lateral to the primary cusp; UCR 21206 has one mesial and one distal denticle, both lateral to the primary cusp. On UCR 22045, the denticles are prominent but small. UCR 21206 has comparatively larger and longer denticles. Both specimens are embedded in a dense sandstone, obscuring the structure of the root.

Remarks—On the upper lateral teeth of *Heptranchias,* the lateral denticles mesial to the primary cusp provide excellent and accurate diagnostic characters to differentiate *Heptranchias* from the other two genera of Hexanchidae. *Hexanchus* usually lacks any denticles mesial to the primary cusp in the upper teeth. A reduced mesial denticle may be present on the upper anterior and lateral teeth of the extant *Hexanchus griseus,* usually in juveniles, but it is not nearly as prominent as the mesial lateral denticle in *Heptranchias* (Bass et al., 1975b). The upper lateral teeth of *Notorynchus cepedianus* have a reduced mesial denticle, which is not nearly as prominent as in *Heptranchias.* Also, the central cusp in *Notorynchus cepedianus* is not nearly as sinuous as in *Heptranchias* (Kemp, 1978).

UCR 21206 and 22045 are closely similar to the corresponding upper lateral teeth in the extant *Heptranchias perlo* (Bass et al., 1975b; Welton, 1974a). Despite the striking similarities, Welton (1974a, 1979) contends that *H. perlo* was preceded by *H. howelli* in the late Eocene. Cigala-Fulgosi (1977) reported *H. perlo* from the Miocene in Italy, and Antunes and Jonet (1970) recorded it from the Miocene of Portugal. Although the upper lateral teeth in both *H. perlo* and *H. howelli* closely resemble one another, the lower lateral teeth in these two species differ slightly: *H. perlo* has a more elongated primary cusp than *H. howelli.* Based on Welton's interpretations, UCR 21206 and UCR 22045 are referred to *Heptranchias howelli.* The only other hexanchiform specimen (UCR 22043) is a worn fragment of a lower lateral tooth that consists of a primary cusp and first secondary cusp. The crown apices of these cusps are missing, as are the mesial denticles, the root, and the remaining secondary cusps. UCR 22043 cannot be assigned a taxonomic status below Hexanchidae.

Fossil Occurrences—The teeth of *Heptranchias howelli* from Seymour Island represent the first records of the genus and species from the Antarctic continent. Reed (1946) described the type species from the Eocene of New Jersey, and it has since been collected in the upper Eocene of Oregon, Washington, and Vancouver Island, British Columbia (Waldman, 1970; Welton, 1974a), the Eocene of Morocco (Cappetta, 1981) and South Australia (Kemp, 1978), and the Oligocene of Japan (Applegate and Uyeno, 1968; Kemp, 1978). Cappetta (1987) suggested that the late Oligocene *Heptranchias tenuidens* (Leriche, 1938) is a synonym of *H. howelli*; however, *H. howelli* normally has three to five mesial cusplets whereas the mid-Miocene to Recent *H. perlo* usually has one. *H. tenuidens* has two mesial cusplets, indicating that its teeth are intermediate in structure between the older and younger species of *Heptranchias* and should remain as a valid species.

Order Squaliformes Compagno, 1973
Family Squalidae Blainville, 1816
Genus *Squalus* Linnaeus, 1758

Squalus woodburnei, sp. nov.
Fig. 4A–G

Etymology—This new species of Eocene *Squalus* is named in honor of Michael O. Woodburne, who organized and directed the Antarctic expeditions to Seymour Island that collected the fossils described in this paper.

Holotype—UCR 22105, a complete lateral tooth.

Paratypes—UCR 22089, UCR 22222, teeth.

Type Locality—UCR RV-8200, lowermost section of Telm unit 4, La Meseta Formation, late Eocene, Seymour Island, Antarctic Peninsula.

Diagnosis—Diagnosed by the combination of a lingually directed enameloid peg, triangular, widened crown, shallow depression on apical surface of peg; slightly widened labial flange.

Description—Both the labial and lingual faces of the cusp are smooth, with the labial crown face weakly convex and the lingual one weakly convex, flat, or slightly concave lingually in apical view. The triangular cusp is distally oblique with a pronounced but low distal blade. A well-formed mesial cutting edge extends along the crown from the apex to the crown foot. The distal cutting edge extends downward from the crown apex either vertically or with a slight mesial inclination, up on to the distal blade, and down to the crown foot. The mesial and distal cutting edges of the crown and distal blade are smooth. A prominent enameloid flange extends from the crown foot in the center of the labial face down to the root, extending down below the root face. Numerous small foramina are present both mesial and distal to the flange just below the crown foot. A prominent lingually directed enameloid peg extends from the center of the lingual crown foot; the peg is relatively broad at the base and has a depression on its apical surface. A single round foramen is situated directly below this peg with its opening on the lingual edge of the attachment surface of the root. The attachment surface, or root base, is flat to moderately concave mesiodistally.

Remarks—The thin, distally inclined cusp, distal blade, lingual peg, labial flange, apicobasally short root, and single large foramen are characteristic features of *Squalus.* The unserrated specimens of *Squalus woodburnei* from the La Meseta Formation are very similar in overall structure to the Paleocene *Squalus minor.* However, *S. minor* has a lingual peg with a depression on the mesial side of the peg that extends up on the apical surface, giving the peg the appearance of being curved mesially. In the La Meseta specimens of *Squalus woodburnei* the peg is much stouter, triangular, widened at the base, and lingually directed, and it has a depression only on the apical surface of the peg. In addition, the labial flange of the La Meseta specimens is relatively wider than in *Squalus minor.*

Squalus weltoni, sp. nov.
Fig. 5A–G

Etymology—The specific name of this taxon is in honor of Bruce J. Welton, who noted and discussed but did not formally describe this unique Paleogene squaloid shark in his 1979 dissertation.

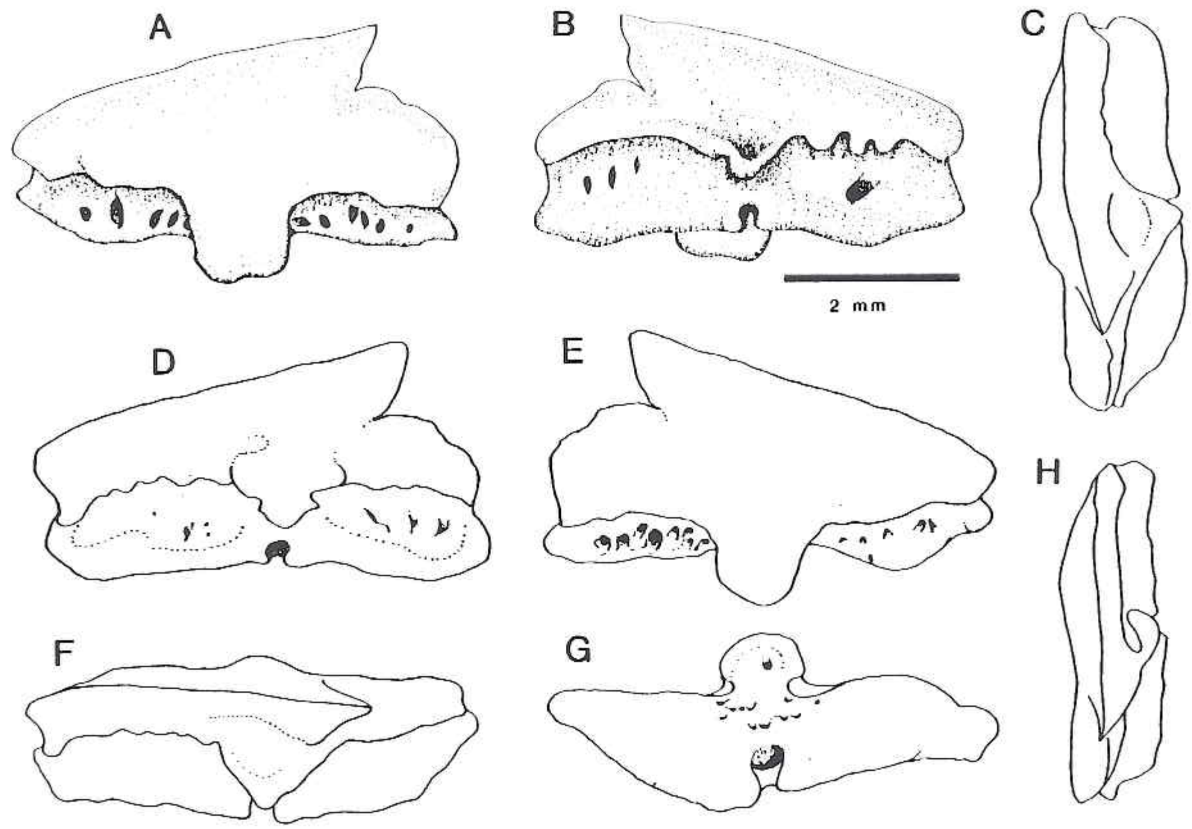

FIGURE 4. A–C, labial, lingual, and apical views of lateral tooth of *Squalus woodburnei* (UCR 22105); D–G, lingual, labial, apical, and basal views of lateral tooth of *S. woodburnei* (UCR 22089); H, apical view of lateral tooth of *Squalus minor* from the Paleocene of Orp-le-Grand, Belgium, to compare lingual peg with that of *Squalus woodburnei*.

Holotype—UCR 22088, a complete lateral tooth.

Paratypes—UCR 22084, UCR 22109, UCR 22108.

Type Locality—UCR RV-8200, lowermost section, Telm unit 4, La Meseta Formation, late Eocene, Seymour Island, Antarctic Peninsula.

Additional Paratypes and Localities—LACM 115686–115688, LACM locality 4316, Quimper Sandstone, Jefferson Co., Washington, late Eocene; LACM 11531, LACM Locality 4304, Kirker Sandstone, Contra Costa Co., California, late Eocene to early Oligocene; LACM 115313–115316, LACM Locality 4303, Pittsburg Bluff Formation, Colombia Co., Oregon, middle Oligocene (Welton, 1979).

Diagnosis—Distinguished from all other species of *Squalus* by the combination of a mesiodistally short crown, vertical to sub-vertical distal cutting edge, serrations on all mesial, distal, and distal blade cutting edges, moderately concave root base.

Description—The crown is relatively high, and the labial and lingual faces of the cusp are smooth. The cusp is generally triangular and inclined distally with the mesial cutting edge arched slightly and the distal cutting edge relatively vertical to sub-vertical. A low, arched distal blade is situated mesial to the cusp. The cusp has relatively coarse serrations on the cutting edges that extend from the base of the cusp to almost the crown apex on the mesial side, along the distal cutting blade, and down on to the cutting edge of the distal blade. A prominent enameloid flange extends from the crown foot in the center of the labial crown face slightly below the root. Numerous small foramina are present on the root mesial and distal to the flange just below the crown foot. A prominent mesiolingually directed peg extends from the center of the lingual crown foot, and a slight depression extends from the mesial side of the peg onto the apical surface. A single large, round foramen is situated directly below this peg with the opening on the basal edge of the lingual root face. The root base is slightly flat to moderately concave mesodistally.

Remarks—The serrated teeth of the Seymour Island *Squalus* differ from those of most other *Squalus* species with serrated teeth by the presence of serrations along all cutting edges of the cusps. *S. crenatidens* has a raised central portion of the mesial cutting edge that bears serrations, and has few (if any) serrations on the other cutting edges. *S. orpiensis* also lacks serrations on the distal cutting edge of the cusp, and the serrations on the distal blade are much coarser than those seen in the serrated La Meseta specimens. The only other spe-

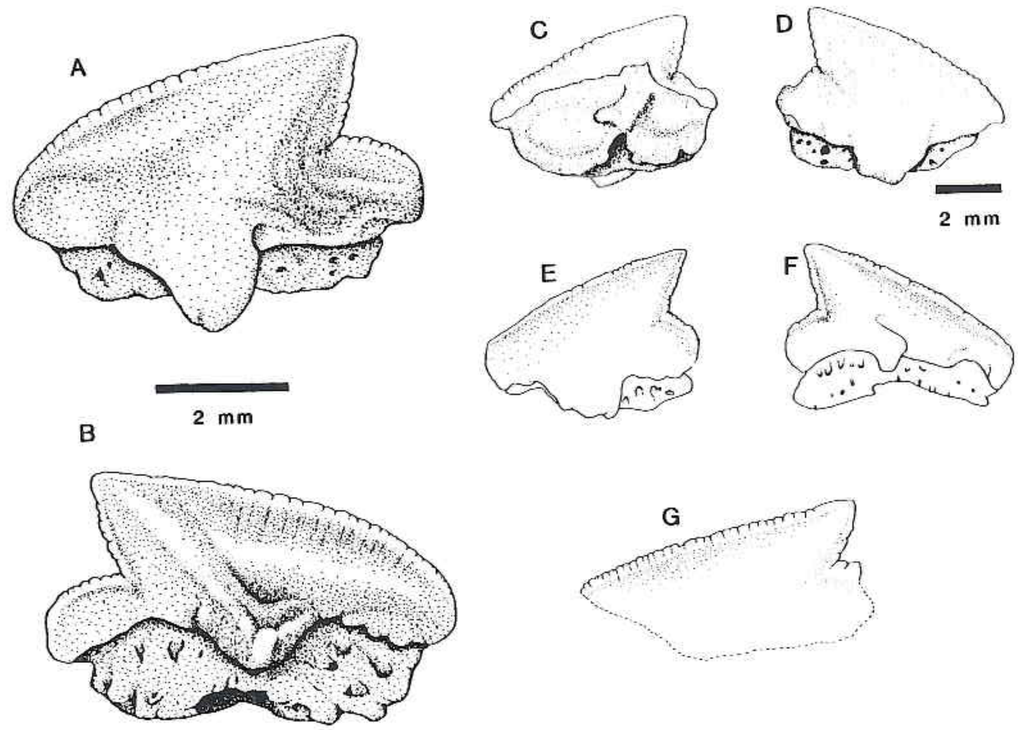

FIGURE 5. **A–B**, Labial and lingual views of tooth of *Squalus weltoni* (UCR 22088); **C–D**, lingual and labial views of *Squalus weltoni* (UCR 22108); **E–F**, labial and lingual views of *Squalus weltoni* (UCR 22084); **G**, labial views of *Squalus weltoni* (UCR 22109).

cies of *Squalus* with serrations on all the cutting edges is *S. occidentalis*: however, it has more numerous and coarser serrations, a flat root base, and is relatively longer mesodistally. With this unique suite of characters, the serrated teeth of *Squalus* from Seymour Island are placed in a new species, *S. weltoni.*

Occurrences—In his 1979 dissertation, Welton discussed this taxon from several late Eocene and early and mid-Oligocene localities from the northwest coast of the United States (listed as paratypes in this study). Apparently, *Squalus weltoni* had a wide distribution during the Paleogene in the higher latitudes of both the Northern and Southern Hemispheres. Because no additional specimens have been found in lower latitudes, it is possible that *Squalus weltoni* had a bi-temperate distribution, like that of extant species of *Squalus* (Compagno, 1984; Garrick, 1960b). In the Miocene, the morphologically similar *Squalus occidentalis* replaces *S. weltoni* in North America. *Squalus weltoni* is the first record of a serrate *Squalus* from the Southern Hemisphere.

Genus *Centrophorus* Mueller and Henle, 1837

Centrophorus sp.
Fig. 6E–G

Description—Lower lateral teeth are labiolingually compressed with a triangular central cusp that is moderately inclined distally. The labial crown face is either flat or weakly convex, and smooth; the lingual crown face is weakly to moderately convex and smooth. The mesial and distal cutting edges are straight and finely to coarsely serrated. The distal blade is low and apically arched and forms a distinct notch at the mesial junction with the central cusp. A flat enameloid flange extends from the center of the labial crown face well down onto the labial root face, terminating before the marginal end of the root base.

The root is labiolingually compressed and basally rounded, with the mesial portion of the root curving apicomesially to form a shallow depression in which the adjacent mesial tooth fits to form an interlocking tooth row. A lingual longitudinal ridge extends mesiodistally across the upper portion of the root and projects lingually. A transverse groove and central lingual foramen enter the root below the ridge. Below the crown foot on the labial face, there are several vertically oriented foramina. The lower posterior tooth (UCR 21207) is similar to the lower laterals in most respects, except that the distal portion of the tooth is elongated.

The upper teeth have triangular crowns with an erect central cusp that shows a very slight distal inclination. The labial crown face is flat to weakly convex and smooth; the lingual crown face is moderately convex and smooth. The mesial and distal cutting edges are straight and smooth. The distal blade is either poorly developed or absent. A short enameloid flange extends from the center of the lingual crown foot to just above the lingual longitudinal ridge, but a rather elongate and flat enameloid flange extends from the labial crown face well down onto the labial root face where it terminates upon contact with the transverse notch on the lower margin of the root. In some specimens, the flange bifurcates slightly at the transverse notch.

The root is mesiodistally compressed and square at the base. A slight curvature and depression are present on the distal margin of the root. A pronounced lingual longitudinal ridge extends across the upper portion of the root and projects lingually. The transverse groove and central lingual foramen do not exit once having entered below the ridge. Several small, vertically oriented foramina are present below the lingual crown foot on either side of the labial flange.

Remarks—A combination of several diagnostic characters such as a distal root depression, enameloid flange, lingual protuberance, and distal blade, separate these teeth from those of all other known sharks except *Deania* and *Centrophorus,* which have the same tooth structure as the Seymour Island specimens. Both *Deania* and *Centrophorus* are squaliform sharks that, although placed in separate genera, show a large degree of convergence in tooth structure (Garrick, 1959, 1960a, b). The wide range of dental variation within these taxa makes it difficult to separate the two genera and their species on the basis of teeth alone. Also, there is confusion about how many living and fossil species are valid (Compagno, 1984). But by using several morphological criteria, one can begin to separate the teeth of *Deania* from *Centrophorus.*

In *Centrophorus,* the transverse groove and the central lingual foramen enter below the lingual longitudinal ridge and normally do not exit (Fig. 7E–F); but when an exit is present, it is on or just below the apex of the ridge. In *Deania,* the central lingual foramen always enters below and and exits above the lingual longitudinal ridge (Fig. 7B–D); Ledoux, 1970). The cutting edges of *Deania* bear either weak serrations or (more commonly) none at all; in *Centrophorus,* the mesial cutting edge is normally coarsely or finely serrated. Therefore, those teeth that have no serrations but do have a central lingual foramen that enters below and exits above the lingual longitudinal ridge (UCR 21210, 21221, 22124, and 22125) can be referred to *Deania.* Those teeth with coarse or fine serrations but without a central lingual foramen (UCR 21197, 21207, 21213, and 22087) can be assigned to *Centrophorus.*

Occurrence—*Centrophorus* has a widespread paleogeographic distribution, although it occurs infrequently in the fossil record, possibly because of its small size and because collecting techniques may be biased toward larger teeth. *Centrophorus* is known from the Upper Cretaceous of Lithuania (Cappetta, 1987), the Paleocene of California and the Eocene of Oregon (Welton, 1972, 1974b, 1979), the Eocene to the upper Pliocene of New Zealand (Keyes, 1984), the upper Eocene and lower Oligocene of Czechoslovakia (Cappetta, 1987), the upper Oligocene and lower Miocene of California (Phillips et al., 1976), the lower Miocene of Germany (Cappetta, 1987) and the mid-Miocene of France (Ledoux, 1972), and the lower Pliocene of Italy (Cigala-Fulgosi, 1986). The La Meseta specimens represent the first record of this genus from Antarctica.

Genus *Deania* Jordan and Snyder, 1902

Deania sp.
Fig. 6A–D

Description—Lower labial teeth are labiolingually compressed with a triangular cusp that is moderately inclined distally. The labial crown face is either flat or weakly convex and smooth; the lingual crown face is weakly to moderately convex and smooth. The mesial and distal cutting edges are straight and smooth. The distal blade is low and apically arched and forms a distinct notch at the mesial junction with the central cusp. A flat enameloid flange extends from the center of the labial crown face well down onto the labial root face, terminating before the marginal end of the root base.

The root is labiolingually compressed and basally rounded, with the mesial portion of the root curving apicomesially to form a shallow depression in which the adjacent mesial tooth overlaps to form an interlocking tooth row. A longitudinal ridge extends mesiodistally across the upper portion of the root and projects lingually. A transverse groove and central lingual foramen enter the root just below the ridge and exit just above it. Below the crown foot on the labial face, there are several vertically oriented foramina.

The upper teeth have a triangular crown with an erect central cusp that shows a very slight distal inclination. The labial crown face is flat to weakly convex and smooth, and the lingual crown face is moderately convex and smooth. The mesial and distal cutting edges are smooth, and the distal blade is absent or poorly developed. A short enameloid flange extends from the center of the lingual crown foot to just above the lingual longitudinal ridge, but a rather elongate and flat enameloid flange extends from the labial crown face well down onto the labial root face where it terminates upon contact with the transverse notch on the lower margin of the root.

The root is mesodistally compressed and square at the base. A slight curvature and depression are present on the distal margin of the root. A pronounced lingual longitudinal ridge extends across the upper portion of the root and projects lingually. A transverse groove and central lingual foramen enter below the ridge and exit just above it. Several small, vertically oriented foramina are present below the lingual crown foot on either side of the labial flange.

Remarks—The teeth of *Deania* are very similar to those of *Centrophorus* but lack serrations on the cutting edges and have a transverse groove and a central lingual foramen that exits above the lingual longitudinal ridge (see above).

Occurrence—The virtual absence of *Deania* from the fossil record is probably because it is frequently misidentified as *Centrophorus.* Still, *Deania* is reported

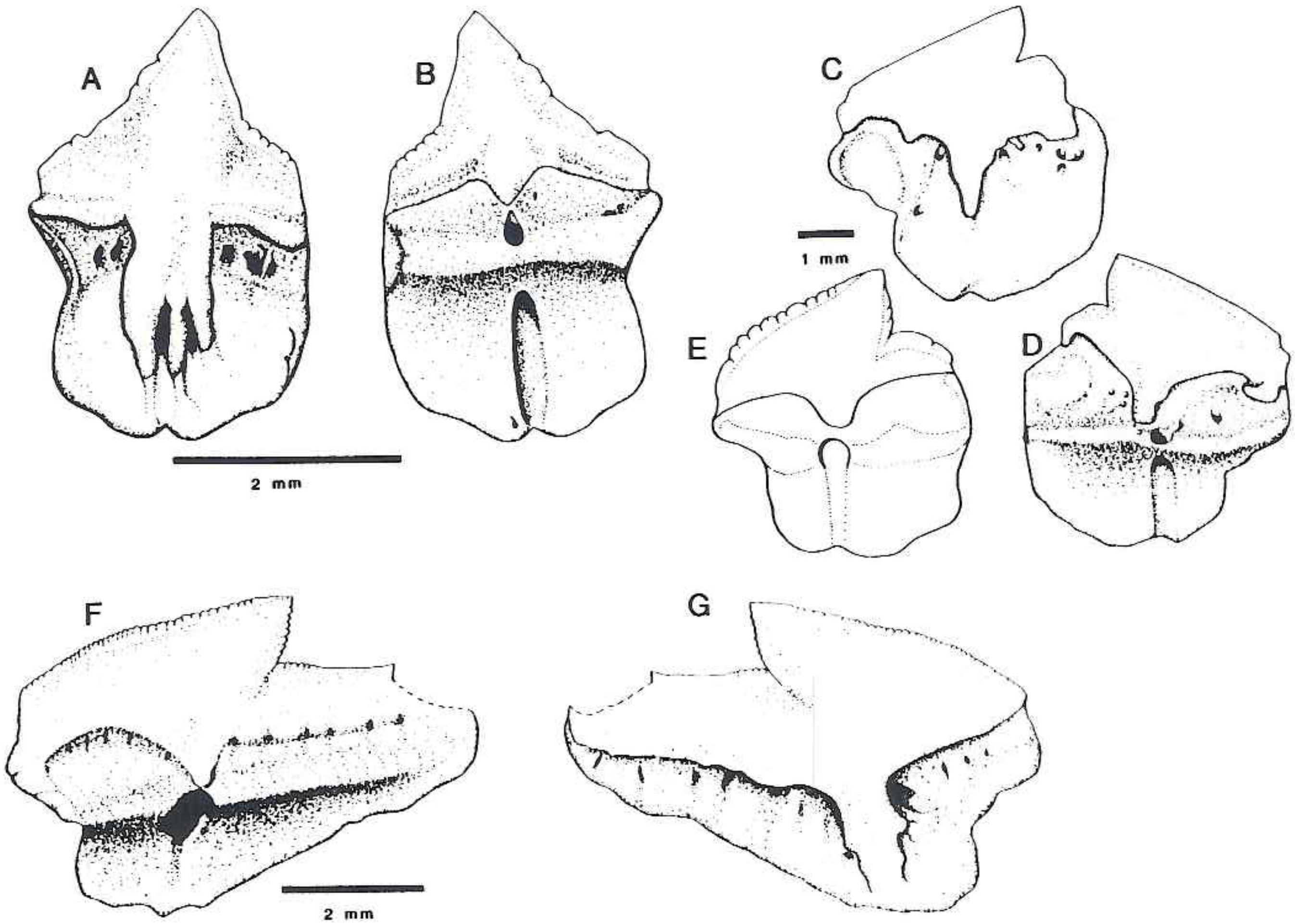

FIGURE 6. **A–B**, labial and lingual views of upper tooth of *Deania* sp. (UCR 21086); **C–D**, labial and lingual views of lower lateral tooth of *Deania* sp. (UCR 22125); **E**, lingual view of lower lateral tooth of *Centrophorus* sp. (UCR 21197); **F–G**, lingual and labial views of lower posterior tooth of *Centrophorus* sp. (UCR 21207).

from the Miocene of Portugal (Antunes and Jonet, 1970), the mid-Miocene of France (Ledoux, 1972), the Miocene of Barbados (Casier, 1966; misidentified as *Centrophorus*) and Germany (Cappetta, 1987), and from the lower Pliocene of Italy (Cigala-Fulgosi, 1986). Welton and Zinsmeister (1980) described several squaloid teeth from Seymour Island that could have been from either *Centrophorus* or *Deania* but because the specimens were incomplete, no definite generic or specific assignment was proposed. This report of both *Deania* and *Centrophorus* from Seymour Island confirms Welton's initial observation. The specimens of *Deania* from the La Meseta Formation are the oldest known and represent the first occurrence of this genus from the Southern Hemisphere.

Genus *Dalatias* Rafinesque, 1810

Dalatias licha (Bonnaterre, 1788)
Fig. 3A–B

Description—UCR 22085 has a high and erect triangular crown that is compressed labiolingually and shows a slight distal inclination; both the labial and lingual crown faces are weakly convex and smooth. Posterior to the crown, a prominent and arched distal blade forms an acute notch at the junction with the crown. Coarse, vertically oriented serrations are present on both the mesial and distal cutting edges of the crown, becoming smaller and fainter apically. Fine serrations are present on the mesial portion of the distal blade. The crown foot on the lingual side is straight, apparently from wear, but the crown foot on the labial side extends well down into the center of the root, then curves abruptly apicomesially to form a shallow depression into which the distal portion of the adjacent mesial tooth overlaps and forms an interlocking tooth row. The root, although broken and incomplete, is also labiolingually compressed. Directly below the center of the crown foot on the labial side is an upwardly directed foramen that is clearly visible.

Remarks—UCR 22085 has a highly compressed and erect triangular crown, a distal blade and a mesial depression in the root, and coarse, vertically oriented serrations. These features separate this tooth from those of all other known sharks except those of *Dalatias*. *Centroscymnus* and *Somniosus* have teeth somewhat similar to UCR 22085, but lack the highly erect, triangular crown of the latter. *Euprotomicrus, Squaliolus, Scymnodon,* and *Scymnodalatias* lack the relatively large size and the coarse vertically oriented serrations present in the Seymour Island specimen. UCR 22085 looks superficially similar to teeth of *Deania* and *Centrophorus* but is much larger and more erect than the teeth in either of these genera and lacks many characters seen in these forms such as a lingual longitudinal ridge and an elongate enameloid labial flange. Based on illustrations of fossil and Recent specimens of *Dalatias licha* by Casier (1961), Garrick (1960a), Ledoux (1970), Bass et al. (1976), Bigelow and Schroeder (1948), Uyeno and Matsushima (1975), and Keyes (1984), UCR 22085, 21221, and 22122 belong to *Dalatias licha*.

Occurrence—The first appearance of *Dalatias licha* is from the middle Eocene of New Zealand, where it ranges to the upper Pliocene (Keyes, 1984). *Dalatias licha* has also been recorded from the Miocene of France (Ledoux, 1972), Japan (Itogawa et. al., 1985), Barbados (Casier, 1966), Sardinia (Cappetta, 1987), the Miocene of Portugal and the Pliocene of Italy (Zbyszewski and d'Almeida, 1950; Cigala-Fulgosi, 1986), and the Pliocene of Japan (Uyeno and Matsushima, 1975). The occurrence of *Dalatias licha* in the La Meseta Formation of Seymour Island represents the first record of both the genus and species from Antarctica.

Order Pristiophoriformes Compagno, 1973
Family Pristiophoridae Bleeker, 1859
Genus *Pristiophorus* Mueller and Henle, 18??

Pristiophorus lanceolatus (Davis, 1888)
Fig. 3E–F

Description—The rostral teeth consist of a thin and elongated single cusp that narrows from the base to form a sharp apex. The crown is weakly convex on both the dorsal and ventral sides. The crown is smooth and lacks transverse ridges, and tends to be erect or with a slight posterior curvature. A smooth and weakly developed anterior and posterior cutting edge extends from the crown apex to the crown foot, where it is lost.

The root expands widely from the crown foot and is very wide at the base in some specimens. It is often shaped somewhat like a dorsoventrally compressed goblet (UCR 22082) whereas in other specimens the root is rather narrow and conically shaped (UCR 22083). There is usually a shallow depression on the posterior edge of the root base; and on the root base where the tooth connects to the rostral blade, there is an elongated, apicobasally oriented foramen that extends deeply into the root.

Remarks—*Pristiophorus* differs from the extant *Pliotrema* and the extinct *Ikamauius*, the two other genera of Pristiophoridae, by lacking serrations on the posterior or anterior cutting edges of the rostral teeth, which is a key diagnostic character. As all of the pristiophorid rostral teeth from Seymour Island lack any type of serration on either cutting edge, they are placed in the genus *Pristiophorus*. As yet, no oral teeth of any pristiophorid shark have been recovered from Seymour Island. The tooth morphology of these specimens matches that of the fossil *Pristiophorus lanceolatus*, which bears the morphology most similar to that of the living taxa (Slaughter and Springer, 1968).The Seymour Island teeth of *Pristiophorus* lack the longitudinal striations of *P. tumidens*, the small overall size and basal striae of *P. suevicus*, and the parallel crown margins and abrupt crown apex of *P. lineatus*.

Occurrence—*Pristiophorus lanceolatus* is widespread, both geographically and temporally, throughout the Cenozoic. Although Keyes (1982) regards this taxon as ". . . a large extinct Southern Ocean—Australasian, temperate water pristiophoroid, restricted to this region," this may not be the case. Fossils of this species occur in the upper Eocene to Pliocene in New Zealand and Australia (Keyes, 1982), but similar teeth occur in the Eocene of Oregon (Welton, 1972), the Oligocene of Argentina (Cione and Exposito, 1980), the Miocene of southern California (pers. observ.), and the lower Pliocene of Italy (Cigala-Fulgosi, 1986). *Pristiophorus* occurs in many other fossil localities worldwide. Barnes et al. (1981) recorded it from the late Pliocene of southern California, which seems to be the most recent occurrence of sawsharks in the Eastern Pacific, and Herman et al. (1974) recorded *Pristiophorus* from the late Neogene of Belgium, which is the youngest record of sawsharks in the North Atlantic. Grande and Eastman (1986) noted the first occurrence of *Pristiophorus* from Seymour Island in their review of the Antarctic fossil ichthyofauna but declined to designate a species for the specimens.

Superorder Squatinomorphii Compagno, 1973
Order Squatiniformes Bonaparte, 1838
Family Squatinidae Bonaparte, 1838
Genus *Squatina* Dumeril, 1806

Squatina sp.
Fig. 7A–C

Description—The teeth have a prominent but relatively short central cusp; both the labial and lingual surfaces of the cusp are rather strongly convex. The central cusp is weakly oblique distally and has a slight lingual recurvature. Both types of curvature can vary in degree according to placement in the jaw. Smooth and well-developed mesial and distal cutting edges extend from the crown apex down to the lateral mesial and distal blades; lateral denticles are absent. Extending down from the crown foot on the center of the labial surface, a very prominent enameloid flange pro-

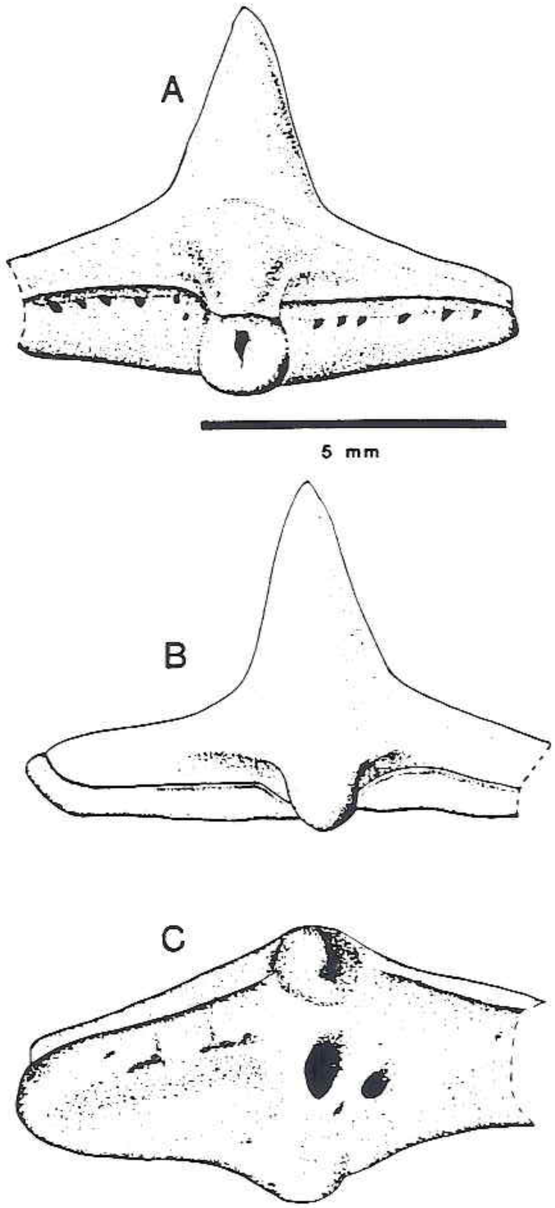

FIGURE 7. A–C, lingual, labial, and basal views of tooth of *Squatina* sp. with distal portion of root lobe missing (UCR 22185).

trudes basally. The root is mesiodistally expanded, and its base is weakly concave with a single, large foramen in the center. A rather robust lingual protuberance extends horizontally from below the lingual crown foot to the lingual edge of the root; a single foramen is situated at the lingual edge of the of this protuberance. On either the distal or mesial side of the lingual protuberance and below the lingual crown foot, there are many small, mesiodistally oriented foramina.

Remarks—The jaw and tooth structure of *Squatina* closely resembles that of *Orectolobus*, but this reflects evolutionary convergence, rather than a close phyletic relationship (Compagno, 1984). *Squatina* tends to have a relatively shorter cusp than in *Orectolobus*, and the cusp tends to be less oblique distally. The mesial and distal blades of *Squatina* are low, but the mesial and distal blades of *Orectolobus* are elevated and sometimes form low and weakly blade-like distal denticles on the lateral teeth (LACM 39426). In *Orectolobus*, the labiolingual transverse ridge extends much farther out on the root than in *Squatina*. On the root base, *Squatina* usually has a single large and deep apically oriented foramen, rather than two small and shallow foramina as in *Orectolobus*.

Based on their structure, the teeth of *Squatina* from Seymour Island are exceedingly similar to those of the extant *Squatina*. The living species of *Squatina* are characterized primarily by the shape of their nasal barbels (Bigelow and Schroeder, 1948), and show few dental differences. This makes species identification on the basis of teeth alone very difficult, and thus the specimens from Seymour Island will be listed as *Squatina* sp. indet.

Occurrences—Welton and Zinsmeister (1980) reported that *Squatina* is "well represented in most Cenozoic neoselachian assemblages." It is known from the Upper Jurassic to the Recent in Europe, from the Upper Cretaceous to the Recent in North America, from the Eocene of Africa, and the Miocene of Australia (Romer, 1966; Cappetta, 1987). Welton and Zinsmeister (1980) reported the first occurrence of *Squatina* from the La Meseta Formation.

Superorder Galeomorphii Compagno, 1973
Order Orectolobiformes Compagno, 1973
Family Orectolobidae Jordan and Fowler, 1903
Genus *Stegostoma* (Mueller and Henle, 1838)

Stegostoma cf. *S. fasciatum* (Herman, 1783)
Fig. 8A–C

Description—UCR 22183 and 22184 are small (2 mm or less apicobasal crown height) with a high central crown that has a slightly sigmoidal distal edge that gives the tooth a somewhat laterally distorted posture. The labial crown face is weakly convex and the lingual crown face is moderately convex, with a reduced enameloid extension of the basal lingual crown face on the top of the lingual root extension. A weak cutting edge extends from the crown apex down to the adjacent pair of lateral denticles. The crown foot forms a peg extending basally from the basal portion of the labial crown face, and is arched in the center of the crown foot on the basal portion of the peg. The root has a flat base with a foramen on the basal surface of the lingual root extension. On both the mesial and distal sides of the foramen, two pairs of very small openings are developed. There is also a small foramen on the lower margin of the lateral depressions of the root.

Remarks—In their possession of a partially sigmoidal central cusp, along with the single pair of lateral denticles, labial enameloid peg and lingual root exten-

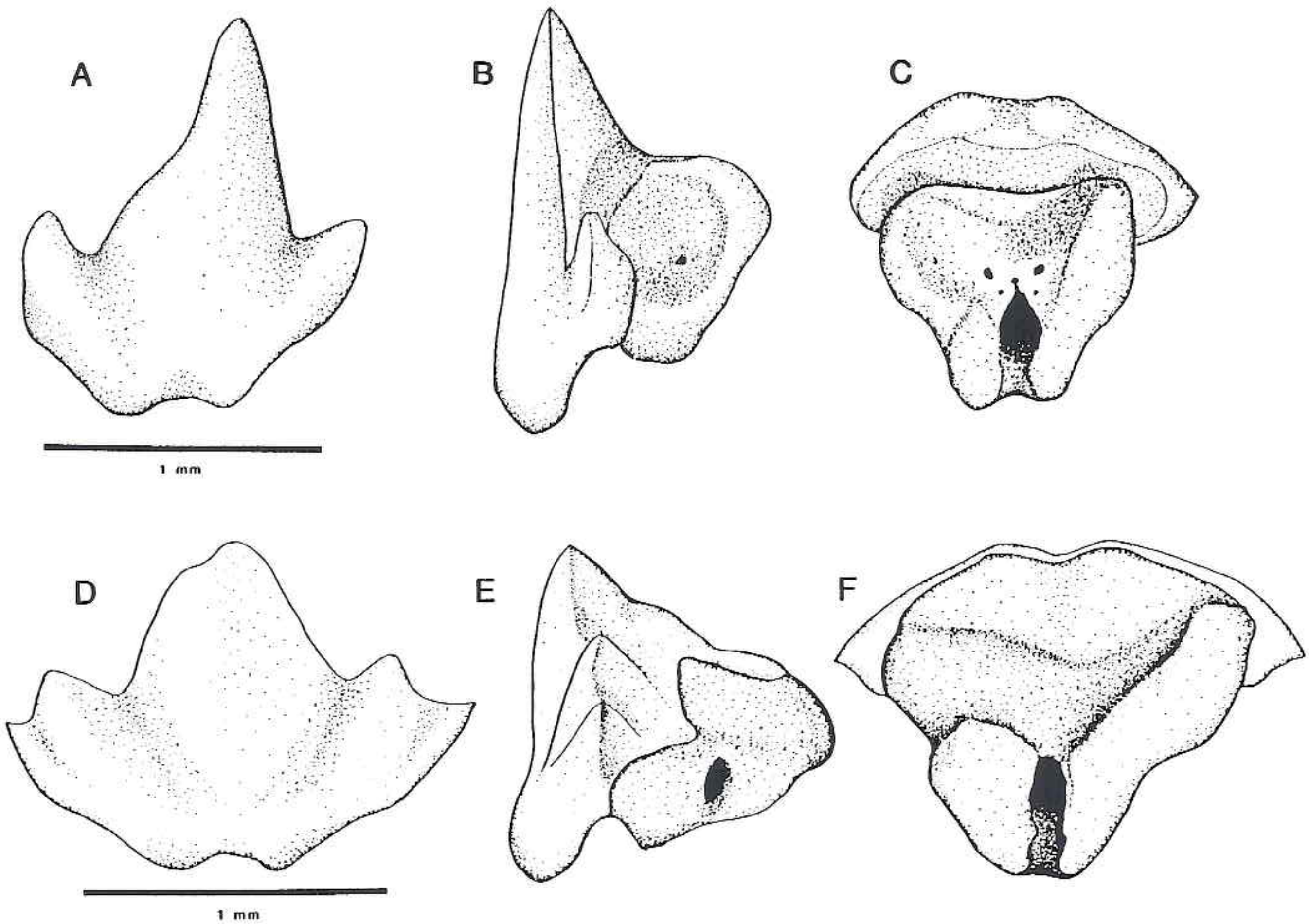

FIGURE 8. **A–C**, labial, lateral, and basal views of anterior tooth of *Stegostoma* cf. *S. fasciatum* (UCR 22183); **D–F**, labial, lateral, and basal views of tooth of *Pseudoginglymostoma* cf. *P. brevicaudatum* (UCR 22179).

sion, as well as their small size, UCR 22183 and 22184 are exceedingly similar to the extant *Stegostoma fasciatum*. Close comparisons to the teeth of the living species (Bass et al., 1975a; Herman and Crochard, 1977; Cappetta, 1980; Dingerkus, 1986) show no apparent differences in characters. The only other fossil form known that is related to *Stegostoma*, the Eocene *Eostegostoma angustum* Taverne and Nolf, 1978 is similar to *Stegostoma fasciatum* but lacks the constricted lingual protruberence of the root, the slightly sigmoidal central cusp, and the arched central portion of the labial crown foot seen in UCR 22183 and 22184 and the extant *Stegostoma fasciatum*. As only one complete specimen has been collected from the La Meseta Formation, a detailed dental comparison cannot be carried out, and the specimen will be listed as *Stegostoma* cf. *S. fasciatum*.

Occurrence—The La Meseta occurrence of *Stegostoma* cf. *S. fasciatum* is the first known for both the genus and species from the fossil record. The apparent discontinuity of the paleontological history of this taxon is probably due to the minute size of the teeth, which escape most collecting techniques. This new discovery shows that *Stegostoma* is contemporary with *Eostegostoma*, which some consider ancestral to *Stegostoma* (Taverne and Nolf, 1978). I must note, however, that Herman (1977) illustrates a tooth under the name of *Mesiteia greeni* but it is dissimilar to the type specimens described by Cappetta (1973) and very similar in morphology to the Seymour Island *Stegostoma*. Because of the poor quality of the photos and the lack of lateral or basal views of the tooth, I cannot provide an adequate discussion on the taxonomic relationships of this specimen.

Genus *Pseudoginglymostoma* Dingerkus, 1986
Pseudoginglymostoma cf. *P. brevicaudatum*
(Guenther, 1866)
Fig. 8D–F

Description—UCR 22179 is a small posterior tooth (about 1.6 mm in apicobasal height), with a broad, low

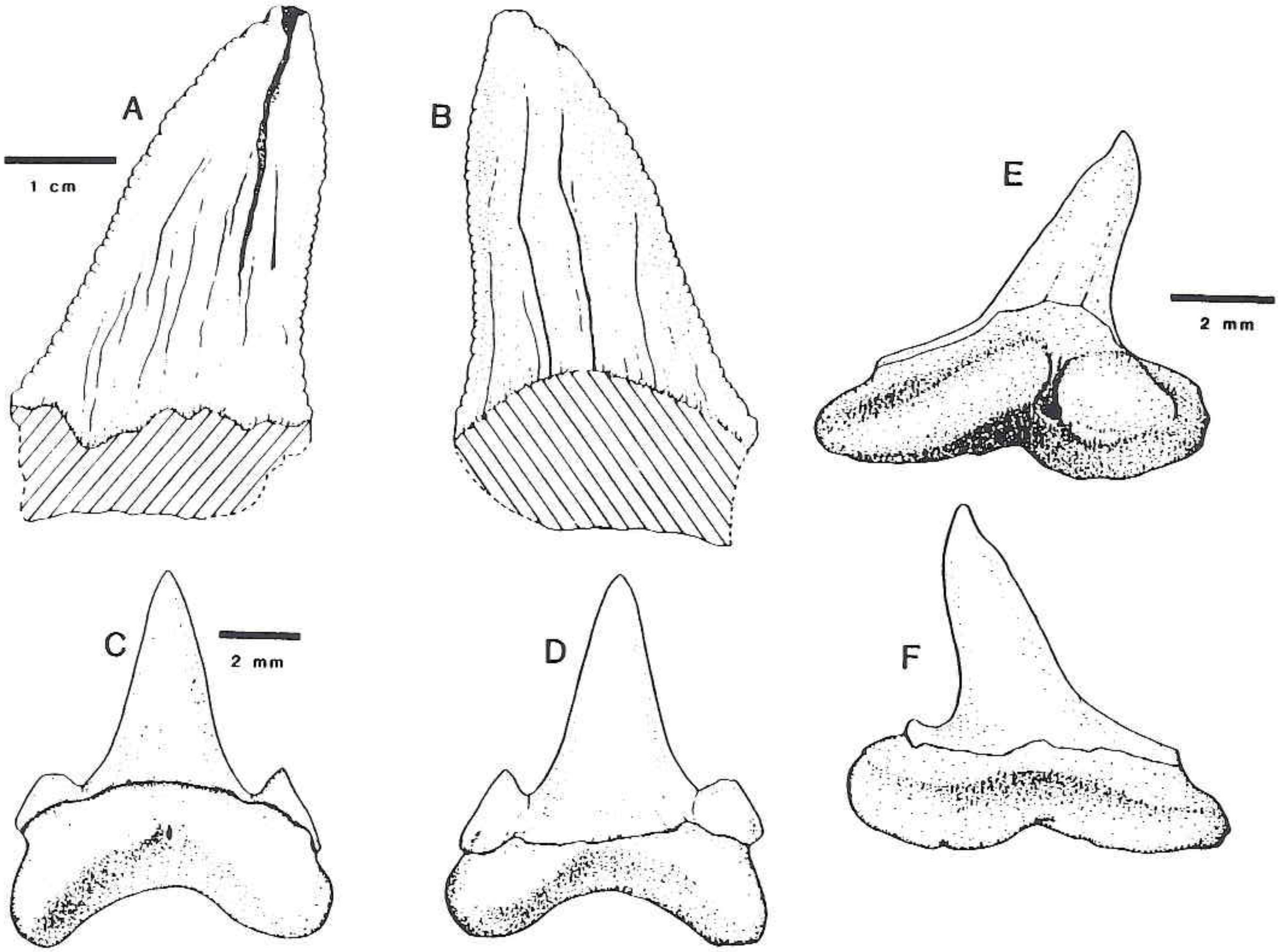

FIGURE 9. **A–B**, labial and lingual views of anterolateral tooth of *Carcharodon auriculatus* (UCR 22020); **C–D**, lingual and labial views of lateral tooth of *Lamna* cf. *L. nasus* (UCR 22075); **E–F**, lingual and labial views of posterolateral tooth of *Scoliodon* sp. (UCR 22200).

central crown and one pair of pronounced lateral denticles. The labial crown foot arches in the central basal portion of the labial crown face, and curves apically to form denticle-like projections adjacent to the pair of lateral denticles. A cutting edge extends down from the crown apex onto the lateral denticles. The labial crown face is weakly convex, and the lingual crown face is strongly convex. An enameloid extension of the lingual crown face protrudes down onto the lingual extension of the root. The labial crown foot forms a blunt enameloid peg on the basal portion of the crown. The root base is flat, with a large opening on the base of the lingual root extension.

Remarks—The very small size of this tooth, combined with features such as a labial enameloid flange, a lingual extension of the root and basal lingual crown surface, and unique denticles, separates UCR 22179 from the teeth of all other sharks except the extant genus *Pseudoginglymostoma* (Bass et al., 1975a). Nearly all other living and fossil ginglymostomids have a similar overall tooth structure but have a more denticulated crown. *Ginglymostoma africanum* (Casier, 1960), *G. subafricanum*, and *G. minutum* (Herman, 1977) also have a reduced number of denticles, but the teeth are proportionately larger, more elongate, and more vertically oriented than those of *P. brevicaudatum. P. brevicaudatum* does not have a lingual extension of the root found in *G. daimerisei* (Herman, 1972). UCR 22179 lacks the enameloid folds on the labial crown face seen in the fossil *Protoginglymostoma* (Cappetta, 1987). The La Meseta tooth is nearly identical to those of the living *Pseudoginglymostoma brevicaudatum* but because only one specimen has been collected from the La Meseta Formation an exact species identification is not advisable.

Occurrence—*P. brevicaudatum* has never before been

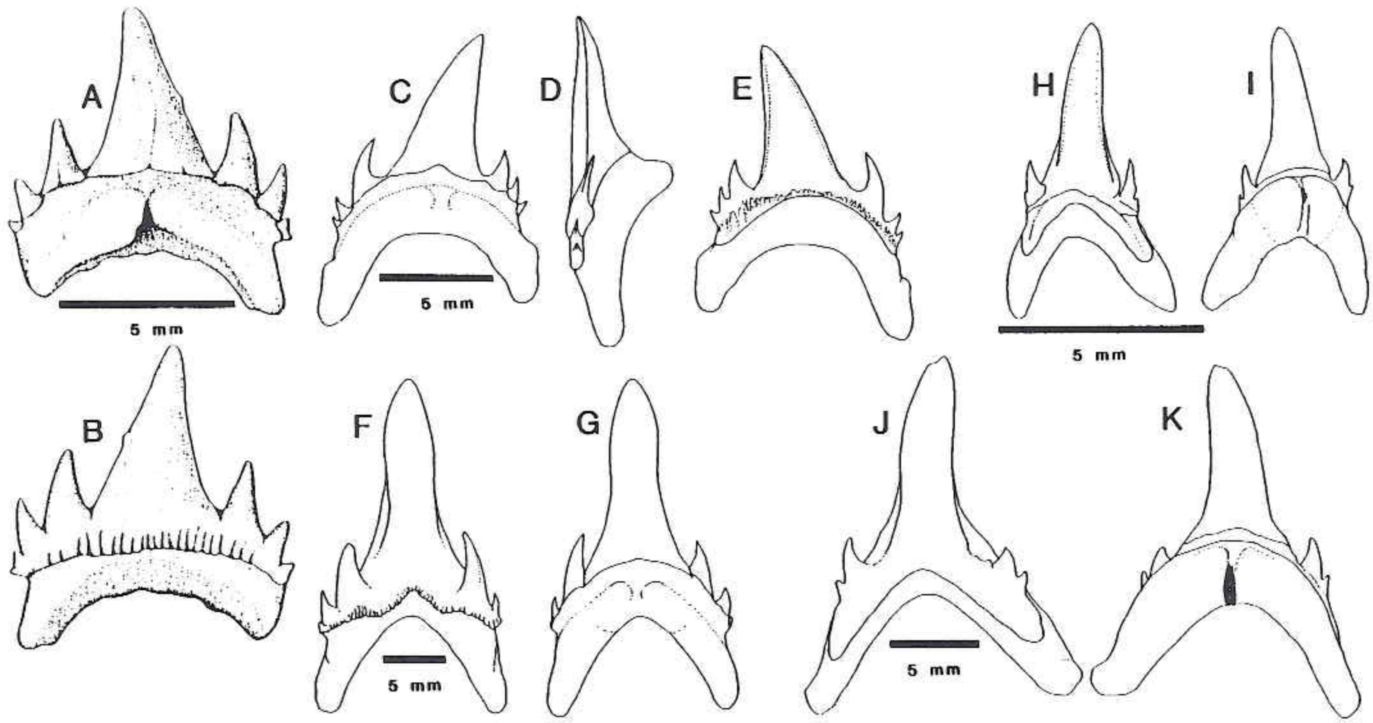

FIGURE 10. **A–B**, Lingual and labial views of posterior tooth of *Odontaspis rutoti* (UCR 21220); **C–E**, lingual, lateral, and labial views of lateral tooth of *O. rutoti* (UCR 21162); **F–G**, labial and lingual views of anterior tooth of *O. rutoti* (UCR 21015); **H–I**, labial and lingual views of anterior or symphyseal tooth of *O. winkleri* (UCR 22071); **J–K**, labial and lingual views of lateral tooth of *O. winkleri* (UCR 22072).

documented as a fossil, and UCR 22179 represents the first fossil record of the genus. The primary reason for the lack of any other specimens from any other fossiliferous deposits is that collecting techniques may be biased against such small teeth. Additionally, *P. brevicaudatum* is currently a Southern Hemisphere species, and the Eocene elasmobranch faunas of southern Africa and South America have not been studied intensively.

Family Odontaspididae Mueller and Henle, 1838
Genus *Odontaspis* Agassiz, 1838

Odontaspis winkleri (Leriche, 1905)
Fig. 10H–K

Description—The central cusp is narrow and elongate, and may be moderately sigmoidal in lateral view. The labial crown face is moderately to strongly convex and smooth, and the labial crown foot is smooth. The lingual crown face is strongly convex and smooth. The mesial and distal portions of the labial crown foot extend well down onto the root lobes. The mesial and distal cutting edges are smooth and well-developed and extend to the crown apex almost to the crown foot. The mesial and distal lateral denticles are relatively long; the denticles nearest the cusp are longer than those more distal to the cusp. There may be two or three denticles on both the mesial and distal side of the cusp, and the lateral denticles curve lingually to a greater degree than does the central cusp.

The bilobate root is wide and broadly arched with a very prominent and robust lingual protuberance; there is a deep apicobasally oriented transverse groove and a large central lingual foramen in the middle of the lingual protuberance. The root lobes are narrow; the mesial root lobe tends to be slightly longer than the distal root lobe in the lateral teeth.

Remarks—Teeth of *Odontaspis winkleri* are similar to those of extant *O. ferox*, but the lateral denticles in *O. winkleri* tend to be more robust and are parallel to or slightly angled toward the central cusp. Similar to *O. rutoti*, teeth of *O. winkleri* have a generally thinner cusp that is longer and widens rapidly at the base, lacks the strong, short folds on the labial crown foot, has a more convex labial crown face, a more inflated lingual protuberance with a deeper central lingual foramen and transverse groove, and a mesial and distal labial crown foot that extends farther down on the root lobes.

Occurrence—*Odontaspis winkleri* is found in the Paleocene and lower Eocene of England (Ward, 1980), the lower and middle Eocene of Belgium (Leriche, 1951; Casier, 1966), and the Eocene of Maryland and Virginia (Cappetta, 1987; Ward and Wiest, 1990). The Seymour Island specimens represent one of the latest occurrences of *O. winkleri,* and the first for the Southern Hemisphere. Extant *O. ferox* may first appear in the late Oligocene (Phillips et al., 1976) but certainly does range from the Pliocene to the present (Cigala-Fulgosi, 1986; Landini, 1977).

Odontaspis rutoti (Winkler, 1874)
Fig. 10A–G

Description—The central cusp is narrow and long and may show a weak or moderate sigmoidal curvature in lateral view (UCR 22070). The labial crown surface is weakly convex and smooth. Short, prominent, apicobasially oriented transverse ridges are present on the labial surface of the crown foot. The lingual crown face is strongly convex and smooth. The mesial and distal cutting edges are smooth and well developed, and extend from the crown apex to just short of the crown foot. The mesial and distal lateral denticles are relatively long; the denticles nearest the central cusp are longer and more robust than those farthest from the central cusp. There may be two or three lateral denticles on both the mesial and distal sides of the tooth. The lateral denticles are curved lingually to a greater degree than is the central cusp and are present on most of the teeth.

The bilobate root is wide and broadly arched, with a prominent and robust lingual protuberance that is seen in all of the tooth positions. An apicobasially oriented transverse groove lies on the central crest of the lingual protuberance. The root lobes are narrow; the mesial root lobe tends to be slightly longer than the distal root lobe in the lateral teeth.

Remarks—Recently regarded as a separate genus (*Palaeohypotodus* Cappetta, 1987), this taxon is now included in the genus *Odontaspis* (Ward, 1988). Although generally similar to *O. winkleri, O. rutoti* is characterized by the short and strong plications of the labial crown foot of all tooth positions. However, the Seymour Island teeth referable to *O. rutoti* are unique in that some characters are unlike the "normal" structure of the European Paleocene specimens and show some morphological similarities to *O. winkleri.* Unlike the European Paleocene specimens of *O. rutoti,* the Seymour Island teeth are generally smaller and more gracile, with thinner lateral denticles, a more sigmoidal central cusp, and a more convex labial crown face, but the plications on the lingual crown foot indicate that it is still *O. rutoti.*

Occurrence—The late Eocene Seymour Island specimens of *Odontaspis rutoti* are the geologically youngest yet known and represent the first occurrence of this species in the Southern Hemisphere. *O. rutoti* is known from the Paleocene of Belgium, England, and France (Herman, 1972; Leriche, 1951; Casier, 1967; Gurr, 1962; Ward, 1980; Cappetta, 1987), Maryland and Virginia (Ward and Wiest, 1990) and Greenland (Cappetta, 1987).

Genus *Carcharias* Rafinesque, 1810

Carcharias macrota (Agassiz, 1843)
Fig. 11A–B, D–E

Description—The lateral teeth are narrowly triangular and relatively elongate, with a weakly convex labial crown face and a moderately convex lingual crown face. A well developed mesial and distal cutting edge extends from the crown apex to near the crown foot; both edges are smooth. The lingual crown face can be smooth (UCR 21214) or can have many fine apicobasally oriented striations (UCR 22068). A single small but prominent lateral denticle may be present on both the mesial and distal sides of the crown foot, but the lateral denticles may be worn, broken, or missing on some specimens. Lateral teeth of the adult have a wider, more triangular crown, and low, wide lateral denticles.

The root is broadly arched and bilobate; the mesial root lobe tends to be slightly longer than the distal root lobe. The lingual protuberance is relatively low in the lateral teeth and a transverse groove is present on the central crest of the lingual protuberance.

The anterior teeth are similar to the laterals except for a few characteristics: the crown is much longer and normally is sigmoidally curved in lateral view; the lingual crown face is strongly convex and the anterior teeth are usually more robust mesiodistally than the lateral teeth; the lateral denticles are located farther down on the root and are detached from the central cusp, and a relatively wide gap separates them from the crown; the bilobate root is deeply forked and its lobes are elongate; the lingual protuberance on the root is prominent, with a transverse groove in the center of the crest.

The intermediate tooth is similar to the lateral teeth but it is much reduced and tends to have a larger root in relation to crown. The posterior teeth are flattened apicobasally and the cusp and root are mesodistally elongated. Lateral denticles may be reduced or absent.

Remarks—The U.C.R. collection of teeth referable to *Carcharias macrota* is extensive. All of the tooth positions (Applegate, 1965) except the symphyseals are represented by over 600 fragmentary or complete teeth. The Seymour Island material of *Carcharias macrota* can be separated from all other extinct species of *Carcharias* by the large anterior teeth that have poorly developed transverse ridges on the labial crown face, striations on the strongly convex labial crown face, a small, conical pair of lateral denticles, and a robust lingual protuberance.

Taxonomic Note—The placement of the *macrota* tooth type into the genera *Carcharias* or *Striatolamia* has been debated. I agree with Compagno (1984) that the extant *Odontaspis ferox* and *Carcharias taurus* be-

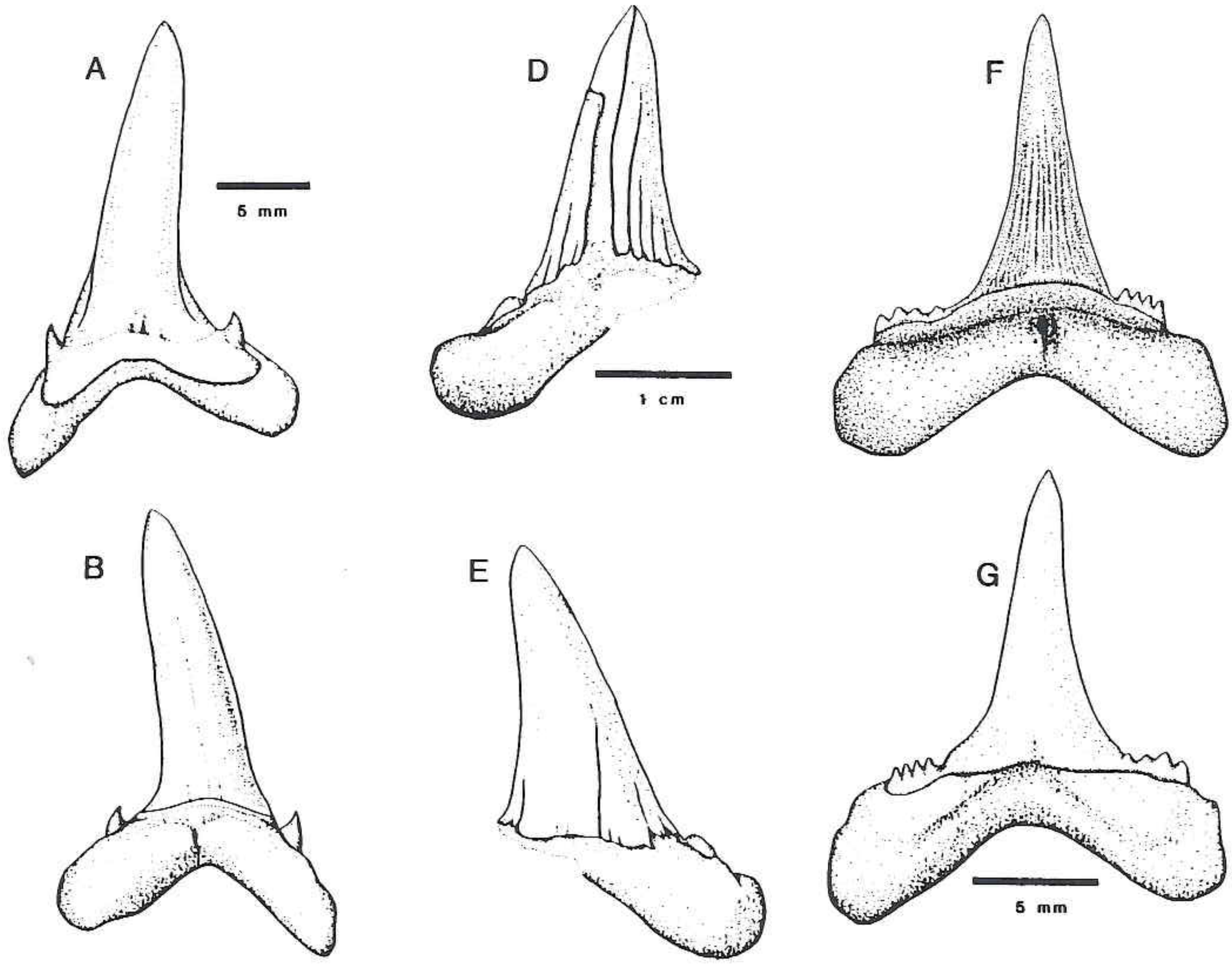

FIGURE 11. A–B, labial and lingual views of anterolateral tooth of *Carcharias macrota* (UCR 22068); D–E, lingual and labial views of a large adult lateral tooth of *Carcharias macrota* missing distal root lobe and showing low lateral denticles and a wide crown (UCR 22178); F–G, labial and lingual views of lateral tooth of *Anomotodon multidenticulata* (UCR 21167).

long to distinct genera, and that the latter species should not be assigned to the genus *Odontaspis*. Cappetta and Nolf (1981) placed the *macrota* tooth type in the genus *Striatolamia*, based on the presence of longitudinal striations on the lingual face of the cusp. Careful examination of over 900 *macrota* specimens from Seymour Island, however, shows that such striations are highly variable in this taxon and are not a reliable diagnostic feature. In size and number of denticles, shape, size, and width of the crown, variation in tooth position, size of the root, and presence of striations, the Seymour Island *macrota*-type teeth show the same suite of morphological characteristics and the same degree of variability as in the extant *Carcharias taurus* (Applegate, 1965; Sadowsky, 1970; Taniuchi, 1970; Bass et al., 1975a; pers. obs.). I therefore conclude with Ward (1980) and Welton and Zinsmeister (1980) that *Carcharias* is indeed the valid generic placement for *macrota*-type teeth and there is no reason to retain the genus name *Striatolamia*.

Occurrence—*C. macrota* seems to be a widely dispersed species restricted to the Paleogene, when it often makes up the bulk of neoselachian fossils. Case (1981), Applegate (1968), Thurmond and Jones (1981), and Ward and Wiest (1990) reported *C. macrota* from the Eocene of the eastern and southeastern United States. Welton (1972) and Applegate (1968) recorded the taxon from the Eocene of Oregon and California. Applegate (1968) also reported it from the Paleocene of Baja California, Mexico. *C. macrota* also occurs in the Eocene of North Africa (Arambourg, 1952), England (Ward, 1980), France (Cappetta and Nolf, 1981), and

Germany (Hocht, 1978). Welton and Zinsmeister (1980) mentioned *C. macrota* from the Eocene of the U.S.S.R. and Chile.

Cione et al. (1977) first recorded *Carcharias macrota* from the Eocene of Seymour Island, and further work by Welton and Zinsmeister (1980) validated this occurrence. The U.C.R. collection of *C. macrota* teeth adds two previously unrecorded tooth positions (intermediate and posterior), and its larger sample size better illustrates the range of tooth size and variability in the fossil populations.

Family Mitsukurinidae Jordan, 1898
Anomotodon Arambourg, 1952

Anomotodon multidenticulata, sp. nov
Fig. 11F–G

Etymology—*multidenticulata* pertains to the series of fine and even lateral denticles, which are unique to this species.

Holotype—UCR 21167, undamaged, probably a lower lateral tooth.

Type Locality—UCR RV-8266, in the lower unit of Telm 5 in the middle to late Eocene La Meseta Formation of Seymour Island, Antarctic Peninsula.

Diagnosis—This species has a pair of labiolingually compressed lateral denticles, each with four smaller cusplets on the apex of the lateral denticle.

Description—UCR 21167 is a lateral tooth with a mesiodistally thin and apicobasally elongate crown. The crown face is weakly convex labially, and strongly convex lingually. Well-developed mesial and distal cutting edges extend from the tip of the crown apex down to the crown foot. Fine striations extend from the crown foot up to about two-thirds of the total crown height on the lingual crown face. The lateral denticles are labiolingually compressed, with four fine cusplets on the apical surface of the denticle. On the mesial side of the crown, the cusplets on the lateral denticles are even in height and form acute apices; on the lateral side of the crown, the lateral denticles are not nearly as even and do not form such acute apices. The bilobate root is wide and has a lingual protuberance in the center of the root below the lingual crown foot. The lingual foramen enters the root just below the apex of the lingual protuberance.

Remarks—UCR 21167 is a lateral tooth because the root is wide, not arched, and it has a thin and long crown. The lateral teeth of *Carcharias, Odontaspis,* and *Scapanorhynchus* are more mesiodistally broad, labiolingually robust, or sigmoidally curved, unlike UCR 21167. The lateral teeth of these genera also have a distally oblique crown; the crown of UCR 21167 is perpendicular to the root and shows no mesial or distal inclination. All of the above characters (including fine striations on the lingual crown face and robust, mesiodistally expanded root) of UCR 21167 are found in the Cretaceous to Paleogene genus *Anomotodon.* A unique characteristic of UCR 21167 is the labiolingually compressed lateral denticles, each with four even cusplets. *Anomotodon sheppeyensis* Casier, 1966 lacks lateral denticles and has a relatively thinner root. *A. maslinensis* Pledge, 1967 has only one pair of lateral denticles, and the lingual crown face striations extend to the crown apex. Because the suite of characters seen in UCR 21167 is unique, it is placed in a new species, *Anomotodon multidenticulata.*

Occurrence—*Anomotodon* first appears in the Lower Cretaceous of France (Cappetta, 1975), and is later found in the Upper Cretaceous of Lebanon (Cappetta, 1980), North Africa (Arambourg, 1952), and Japan (Itogawa et al., 1977), the Upper Cretaceous and Paleocene of Belgium (Herman, 1977), and the Eocene of England (Ward, 1980). A questionable record of *Anomotodon* is from the Miocene of the southeastern United States (Case, 1980).

Only a single specimen of *Anomotodon multidenticulata* has been found in the La Meseta Formation. Several reasons could account for its rarity. First, the species could have been indigenous to marine habitats outside the Eocene Seymour Island area, and strayed into the area only on rare occasions. Second, the species could have been regionally endemic to the Eocene Seymour Island area but in very small numbers. Most likely, this species may have been a large deepwater species that occasionally ventured into the shallow depositional environment of the La Meseta Formation under certain circumstances; as with other deepwater squaloid sharks such as *Heptranchias howelli* and *Dalatias licha,* their teeth would be rare. Finally, *Anomotodon* became extinct by the end of the Eocene, and its rarity here may reflect declining abundance.

Order Lamniformes Campagno, 1973
Family Lamnidae Mueller and Henle, 1838
Genus *Lamna* Cuvier, 1817

Lamna cf. *L. nasus* (Bonnaterre, 1788)
Fig. 9C–D

Description—The teeth are triangular and broad at the base. The anterior teeth are erect and the lateral teeth show a very slight distally oblique posture. The lingual crown surface is weakly convex and smooth; the lingual crown surface is moderately convex and smooth. There is a well-developed smooth mesial and distal cutting edge that extends from the crown apex down to near the crown foot where it continues up onto the lateral denticles. The lateral denticles are stout and triangular with a weakly convex labial face and a moderately convex lingual face and are connected to or in close association with the central cusp. The relatively inflated bilobate root is mesiodistally broadened and has a reduced lingual protuberance with a small transverse groove and central lingual foramen in the center.

Remarks—There is much confusion among the many fossil species of *Lamna* in the current literature. Most of these are undoubtedly invalid synonyms or misidentifications of other taxa. The Seymour Island teeth are distinctive because they lack the robust central cusp, enlarged lateral denticles, and massive root of most Cretaceous and Paleogene lamnoids. In contrast to the Eocene *Isurolamna affinis* (Casier, 1966; Cappetta, 1987), the Seymour Island teeth are much more rounded on the lateral edges of the root lobes and have a more rounded lingual root face. They lack the straight transverse groove on the lingual protuberance of the root, and the distal lateral denticle is not divided. Also, the anterior teeth of *Isurolamna affinis* lack lateral denticles, but none of these teeth have so far been collected in the La Meseta Formation.

The Seymour Island teeth closely resemble those of the extant *Lamna nasus* in overall appearance. In fact, UCR 22075 (and many others) show no differences from the corresponding teeth of a recent *Lamna nasus* (LACM 39276-21 and author's collection) and illustrations in Bass et al. (1975a) and Bigelow and Schroeder (1948). The extant *Lamna ditropis* from the northern Pacific has a taller and more narrow crown, and has a thinner and more bifurcated root than either *L. nasus* or the La Meseta Formation *Lamna*. The Oligocene *Lamna rupeliensis* Leriche, 1910 has a similar tooth structure but the lingual face of the root is somewhat rugose, and the cusps are wider at the base. The Seymour Island teeth of *Lamna* are nearly identical in their structure to the teeth of the extant *Lamna nasus* and are thus designated as *Lamna* cf. *L. nasus*.

Fossil occurrences: This is the earliest occurrence of a "morphologically recent" *Lamna* but a similar and geologically younger species, *L. rupeliensis*, is known from the lower Oligocene of Belgium and Germany (Leriche, 1910; Cappetta, 1987). The extant *Lamna nasus* occurs in the Pliocene of Belgium (Herman et al., 1974), and the upper Miocene and Pleistocene of the Netherlands (van den Bosch, 1978). This new occurrence pushes the record of the genus back to at least the mid- to late Eocene.

Genus *Carcharocles* Jordan and Hannibal, 1923

Carcharocles auriculatus (Blainville, 1818)
Fig. 9A–B

Description—UCR 22020 is an incomplete specimen lacking both the mesial and distal root lobes, most of the root below the crown foot on the labial surface, and the mesial and distal portions of the crown foot and crown neck. The crown apex is worn and fragmented, and the lateral denticles are missing. This is the largest elasmobranch tooth in the U.C.R. collection, with a total apicobasal height of 48 mm. The crown is high and narrow and robust mesiodistally, with a moderately convex labial crown face and a strongly convex lingual crown face. The crown itself shows a slight distally oblique curvature, indicating that UCR 22020 could be a lateral tooth. A well-developed and coarsely serrated mesial and distal cutting edge extends from the crown apex to the crown foot, but the serrations are worn. The crown neck is wide but is only partially preserved.

Remarks—UCR 22020 is incomplete and lacks the enlarged and serrated lateral denticles characteristic of the Paleogene *Carcharocles auriculatus*. Nevertheless, the preservation of the central cusp is still sufficient to allow taxonomic assignment to this species. The triangular, mesiodistally narrow cusp of UCR 22020 is diagnostic of *C. auriculatus*, whereas *C. angustidens* (if it is not synonymous with *C. auriculatus*) has more of a mesiodistally broadened, less elongate, and slightly robust central cusp. Of the remaining species of *Carcharocles*, *C. megalodon* has more broadly triangular central cusps that bear more even and finer serrations on the cutting edges, rather than the coarse serrations of UCR 22020. In *C. megalodon*, lateral denticles are normally absent. UCR 22020 is essentially similar to *C. auriculatus*, previously described from the La Meseta Formation by Cione et al. (1977) and Welton and Zinsmeister (1980), and is referred here to this taxon.

Taxonomic Note—The systematic relationship of *Carcharocles* to other sharks is not clearly established. Welton and Zinsmeister (1980), Keyes (1972) and others contend that *Carcharocles* (equals *Carcharodon* and *Procarcharodon* in past literature) represents the same lineage as the Miocene to recent *Carcharodon carcharias*, so *Carcharodon* should be retained as the proper generic name for the extinct species *megalodon* and *auriculatus*. Muizon and DeVries (1985) and Casier (1960) present evidence that the recent *Carcharodon carcharias* evolved from the Miocene *Isurus hastalis*. Cappetta (1987) and Casier (1960) feel that that the *auriculatus* and *megalodon* tooth types are quite distinct from *Carcharodon*, and represent an extinct lineage of sharks. Tooth characters seen in *Carcharocles*, and lacking in the extant *Carcharodon carcharias*, include overall large size, robust crown and root, and a lingual neck. Therefore, Cappetta (1987) listed the *auriculatus* and *megalodon* tooth types under the genus *Carcharocles*. I feel, based partially on the above mentioned characters, that the genus *Carcharocles* should be retained for *auriculatus*, *megalodon*, and *angustidens*, but this does not exclude them from an evolutionary relationship to *Carcharodon*.

Occurrence—*Carcharocles auriculatus* is widespread and prominent, but never common, in most Eocene and early Oligocene elasmobranch assemblages. Welton and Zinsmeister (1980) listed *C. auriculatus* from the middle and upper Eocene of North America, Europe, and Africa; and from the Oligocene of Europe and South America. Keyes (1972) also reported *C. auriculatus* from the middle Eocene to the Oligocene in New Zealand. Welton and Zinsmeister (1980) suggested that many records of *C. auriculatus* occurring later than Eocene or early Oligocene may actually represent specimens of *C. angustidens* (the "descendant" species of *C. auriculatus*) that have been misidentified; additionally, the post-Eocene occurrences of *C. auriculatus* may be teeth reworked from older deposits. Cione et al. (1977) first recorded *C. auriculatus* from Antarctica. Later, a second specimen consisting of a single broken tooth was described by Welton and Zinsmeister (1980) from Seymour Island. UCR 22020 represents the third record of *C. auriculatus* from the La Meseta Formation.

Order Carcharhiniformes Compagno, 1973
Family Carcharhinidae Jordan & Evermann, 1896
Subfamily Scoliodontinae Whitley, 1934
Genus *Scoliodon* Mueller and Henle, 1837

Scoliodon sp.
Fig. 9E–F

Description—UCR 22200 has a narrow crown with a nearly flat labial crown face, a weakly to moderately convex lingual crown face, and with a slight distal inclination. The cutting edges are smooth and extend down onto the small distal blade. The distal crown face has a slight sigmoidal curvature. The root is somewhat linear and has lobes extending mesiodistally. A prominent lingual protuberance extends from the center of the root to the mesial and distal portions of the root lobes, and has an apicobasally oriented central lingual foramen in the center of the lingual protuberance. The root base is moderately concave.

Remarks—UCR 22200 and 22201 have features unique to the genera *Scoliodon, Loxodon,* and *Rhizoprionodon* of the family Carcharhinidae. *Sphryna* has a crown that is more mesiodistally robust than in UCR 22200 and 22201, and both latter specimens have a lingual protuberance that is far more prominent and developed than in *Sphryna.* In comparison to extant and fossil forms (Case, 1980, 1981; Cappetta, 1970; Springer, 1964), UCR 22200 and 22201 closely resemble teeth of *Scoliodon.* All species of *Scoliodon* have a well-developed distal blade, but the distal blades in UCR 22200 and 22201 are much less developed, perhaps reflecting wear. Alternatively, these may be posterior teeth which commonly have a reduced distal blade.

Occurrence—*Scoliodon* is an uncommon but widespread taxon in the Paleogene, but is more common in the Neogene. *Scoliodon* has been recorded in the Eocene of India (Mishra et al., 1973), Nigeria (Arambourg, 1952), France (Cappetta and Nolf, 1981), England (Ward, pers. comm.), and in the southeastern United States (Case, 1981), and now in Antarctica for the first time. It also occurs in the Oligocene of Belgium (Bor, 1980), the Miocene of India (Sahni and Mehrotra, 1981), Ecuador and Brazil (Longbottom, 1979), Portugal (Antunes and Jonet, 1970; Jonet, 1978), Spain (Antunes et al., 1981), France (Cappetta, 1970), the Netherlands (Bengevoord, 1973), Belgium (Longbottom, 1979), and from the Pliocene of Angola (Antunes, 1977, 1978).

DISCUSSION

The La Meseta Formation has a remarkable fossil elasmobranch assemblage. It contains species previously known from other parts of the world, extending the range of these taxa well into the Southern Hemisphere. Many species, such as *Heptranchias howelli, Deania* sp., *Centrophorus* sp., *Dalatias licha, Odontaspis winkleri, O. rutoti, Lamna* cf. *L. nasus,* and *Scoliodon* sp. have been found in very small numbers at various sites scattered around the globe. The new discoveries of these taxa from Seymour Island are important not only because they extend the known temporal and geographical ranges of these species, but also because they add a new source of specimens from which their evolutionary history, paleoecology, and paleobiogeography can be interpreted. The recovery of the teeth of *Pseudoginglymostoma* cf. *P. brevicaudatum* and *Stegostoma* cf. *S. fasciatum* are particularly important because they represent the first known fossil occurrences of these two extant genera. In addition, *Squalus woodburnei, S. weltoni,* and *Anomotodon multidenticulata* are newly described species.

The shark remains from the La Meseta Formation represent one of the most diverse and prolific late Eocene temperate neoselachian assemblages known from the Southern Hemisphere. Seventeen taxa of sharks alone demonstrate a wide species diversity. The diversity of the Eocene elasmobranch fauna sharply contrasts with the diminished fauna found in present-day Antarctic waters, and supports the idea that some global event at the end of the Eocene may have drastically affected the marine organisms living in the Antarctic in the Paleogene (Kennett and Barker, 1990).

Deania, Squalus with serrated teeth, *Stegostoma, Pseudoginglymostoma,* and morphologically modern *Lamna* have their earliest fossil record in the La Meseta Formation. The La Meseta assemblage also includes last occurrences of some taxa, such as *Odontaspis winkleri, O. rutoti,* and *Anomotodon.* These new discoveries make the La Meseta Formation one of the most important sources of Eocene sharks yet discovered.

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