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EOCENE STELLEROIDS (ECHINODERMATA) AT SEYMOUR ISLAND, ANTARCTIC PENINSULA

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ABSTRACT—The new asteroid species *Sclerasterias zinsmeisteri* (Asteriidae), *Paragonaster clarkae, Tesselaster clarki* (both Goniasteridae), and the new ophiuroid species *Ophiura hendleri* (Ophiuridae) are described from the late Eocene La Meseta Formation at Seymour Island, Antarctic Peninsula. The arm tip of an apparently new genus of the Oreasteridae is too incomplete to assign at the generic level. Other La Meseta asteroid species have been described elsewhere. Six of seven recognized stelleroid genera and all represented families survive, and differences between new species and existing congeneric species are subtle. Thus, the La Meseta fauna was similar to living faunas in basic composition.

Among La Meseta asteroids, *Zoroaster* aff. *Z. fulgens* and *Ctenophoraster downeyae* are known from numerous specimens; fossils of the other species are comparatively uncommon and given the uncertainties of sampling, further taxa might await discovery at Seymour Island. Although the Paxillosida is known from Jurassic rocks, fasciole-bearing, semi-infaunal genera are first known from Cretaceous deposits, and *Astropecten* and *Astropecten*-like *Ctenophoraster* are first recorded from Cenozoic rocks. *Zoroaster* and *Tesselaster* are only known from deep water settings today, although they are found in the La Meseta. *Ophiura hendleri,* the only ophiuroid recognized to date from the La Meseta, occurs singly, in small groups, and in Paleozoic-type ophiuroid-rich beds.

INTRODUCTION

THE LATE EOCENE La Meseta Formation at Seymour Island, Antarctic Peninsula, contains diverse echinoderms, including echinoids (McKinney et al., 1988; Radwanska, 1996), crinoids (Meyer and Oji, 1993; Baumiller and Gazdzicki, 1996), and stelleroids (Blake and Zinsmeister, 1979, 1988; Aronson et al., 1997). Holothuroids are as yet unrecognized. The late Eocene of the Southern Ocean area is interpreted as a temperate setting (Case, 1992; Stilwell and Zinsmeister, 1992), and many distinctive asteroid taxa found in the region today (A. M. Clark, 1962) are absent from the La Meseta Formation.

Many aspects of the geology and paleontology of Seymour Island have been treated in Feldmann and Woodburn (1988), and Vizcaino et al. (1997). The La Meseta Formation is a clastic deposit on Seymour Island, off the Antarctic Peninsula (Figure 1). Locally, it contains remarkably abundant and taxonomically diverse marine invertebrates, and it has become a setting of keen paleontologic interest (e.g., Feldmann and Woodburne, 1988; Stilwell and Zinsmeister, 1992). The La Meseta Formation has a lenticular form suggested to represent a trough or channel (Sadler, 1988). Basal unconformities crop out at the northwest extremity of the island and at the south side of Cross Valley, which marks the waist of the island. The axis of the trough is approximately central in the outcrop belt, at the plateau, and it appears to have extended in an approximately east-west direction. Within the La Meseta, facies are complex. Seven stratigraphic units have been recognized, all showing small-scale lenticularity; correlation is difficult within the regional depositional framework.

Stelleroids are widely distributed in the La Meseta, although most were collected from the middle part of the outcrop belt toward the axis of the inferred channelway. Asteroids decline in abundance near the top of the Formation, but dense ophiuroid assemblages are present in higher intervals. Many sediments closer to the northern and southern erosional bases generally contain fewer fossils but some stelleroids are present. Sediments in these areas are thinly bedded and not significantly disrupted by burrowing or storm beds.

Interpretations of the age of the La Meseta range from not older than late early Eocene in the lower portions to as late as early Oligocene in the uppermost portion. Stilwell and Zinsmeister (1992) interpreted the molluscan fauna of the upper La Meseta as late Eocene. Keller et al. (1992) related the turnover of planktonic foraminifera between the middle Eocene and the early Oligocene to onset of glaciation.

THE EOCENE STELLEROID FAUNA AT SEYMOUR ISLAND

Taphonomy.—The fossil record of stelleroids is generally poor and therefore the La Meseta occurrence is remarkable because of its comparative diversity. Fossil asteroids assignable to extant families, however, have been reported from Mesozoic rocks. Essentially complete specimens representing existing stelleroid families are known from the Hettangian, at the beginning of the Jurassic (Blake, 1984, 1990). A probable Bajocian (Middle Jurassic) occurrence from Switzerland (Hess, 1972) includes six surviving families representing four orders; all represented genera are extinct, however. Thus, diversification of living asteroid families and orders was taking place during the Jurassic; however, few Jurassic species and genera appear closely related living equivalents.

The Eocene La Meseta fauna (Figures 2–6), in contrast, has an appearance familiar to the student of living asteroids. It includes three genera of the Goniasteridae (*Paragonaster clarkae,* Figure 2.3–2.12; *Tesselaster clarki,* Figure 4.1–4.6; *Buterminaster elegans*) and one each of the Zoroasteridae (*Zoroaster* aff. *Z. fulgens,* Figure 7.5), Asteriidae (*Sclerasterias zinsmeisteri,* Figure 4.6–4.13), Oreasteridae (genus and species unknown, Figures 2.1, 2.2; 3), and Astropectinidae (*Ctenophoraster downeyae,* Figure 7.6). A single modern-appearing ophiuroid, *Ophiura hendleri* (Ophiuridae, Figures 5–7) is known as well. Familial affinities of a number of poorly preserved specimens are uncertain but they do not appear to represent undescribed taxa.

Given known asteroid diversity through time, the poor fossil record of stelleroids appears to be a taphonomic artifact. Asteroids tend to have a large coelom enclosed by small, unfused ossicles; most asteroids are epifaunal, and many are found in shallow, turbulent environments where they are readily dissasociated and ossicles rapidly dispersed after death. Many ophiuroids perhaps are sturdier but they, too, appear readily subject to destruction after death.

Only a single species of each La Meseta genus has been recognized, whereas multiple species of individual genera occur in many contemporary settings (e.g., Fisher, 1911; 1928; Walen-

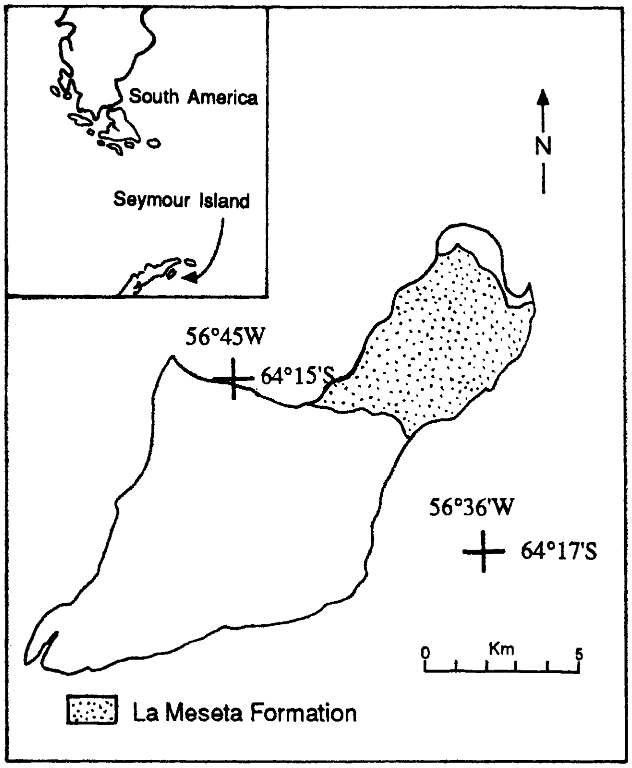

FIGURE 1—Seymour Island, Antarctic Peninsula. The outcrop pattern of the La Meseta Formation, source of all fossils discussed here, is stippled.

kamp, 1976, 1979). In modern settings, individuals of many species are rare and congeneric species commonly do not occur together; presence of a single species of each genus in the La Meseta does not appear significant.

Feeding habits and occurrences.—Many asteroids are feeding generalists and therefore feeding habits of the La Meseta representatives are difficult to determine with confidence, although a few hints are available. Specimens of both *Ctenophoraster* and *Zoroaster* have been discovered with gastropods within the disk; *Struthiolarella variablis* (Struthiolarellidae) was found in *Ctenophoraster* and an unidentified but similar gastropod in *Zoroaster.* Gastropods parasitic in asteroids are known today, but most belong to the family Eulimidae (Jangoux, 1987), which is typified by slender, smooth shells very different from those of *Struthiolarella.* Further, living zoroasterids and especially astropectinids are well-known predators of invertebrates (Jangoux, 1982). One La Meseta *Ctenophoraster* specimen was discovered in an ophiuroid assemblage (Figure 7.6), although there is no suggestion of ophiuroid material in the gut position of this poorly preserved individual.

Another suggestion of predation is the occurrence of impressions of the ventral surface of asteroids with a dense population of a very small, undescribed (W. J. Zinsmeister, personal commun., 1994) bivalve (Figure 7.5). Among La Meseta asteroids, arm shape and disk form of the trace fossils are closest to those of *Zoroaster,* although *Sclerasterias zinsmeisteri* (Figure 4.6–4.13) also has long arms and a small disk, and the diet of the Asteriidae includes diverse invertebrates (Jangoux, 1982). Blake and Zinsmeister (1988) interpreted small individuals of fossil *Zoroaster* in a budlike posture as suspension feeders, although such behavior has not been reported in living *Zoroaster.*

Although data are limited, many living goniasterid species are omnivorous (Jangoux, 1982). *Tessellaster* has been observed with coral in the stomach, whereas recorded gut contents of living *Paragonaster* is varied, but includes sediment and bivalves. A third La Meseta goniasterid, *Buterminaster elegans* (Blake and Zinsmeister, 1988), is similar in form to *Pentagonaster* and *Tosia*; all three are stoutly constructed, and individuals generally are small. *Tosia* and *Pentagonaster* feed on sponges, bryozoans, ascidians, and detritus (Jangoux, 1982), and a similar diet would appear appropriate for *Buterminaster.*

The living asteroids *Astropecten* and *Luidia* are common on unconsolidated substrates in shelf settings. The two are unusual among asteroids in that they are capable of self-burial, pushing sediment laterally from beneath their bodies and gradually sinking beneath the surface as they do so (Heddle, 1967). True burrowing, involving lateral movement into and through the substate, is unknown among asteroids. In both of these genera, the presence of deep intermarginal channels (so-called "fascioles") seems important in that it allows unobstructed water flow over the animal body surface, aiding self-burial. *Ctenophoraster,* as a fossil genus known only from Seymour Island, is very similar to *Astropecten* and it, too, probably is and was capable of self-burial.

Although the Astropectinidae is known from rocks of Jurassic age (e.g., Hess, 1972), the oldest clearly identified fasciole-bearing taxon is from the Early Cretaceous (Hauterivian and Barremian, Hess and Blake, 1995); somewhat younger Cretaceous occurrences of fasciolar paxillosidans are known from the Cenomanian (Breton, 1995), Campanian (Blake, 1988; Blake and Sprinkle, 1996) and Maastrichtian (Blake and Sturgeon, 1995). *Astropecten* and *Ctenophoraster,* however, are first known from Cenozoic rocks, and the 102 recognized living species of *Astropecten* (A. M. Clark, 1989) suggest speciation is active, perhaps indicating the value of a semi-infaunal habit. Although the fossil record of asteroids is poor, the habit of self-burial enhances opportunity for preservation, suggesting that the known stratigraphic ranges might be approximately correct and that asteroid self-burial evolved in the Cretaceous and *Astropecten*-like taxa in the Cenozoic.

The Zoroasteridae today is known only from water depths beyond 220 m in the Atlantic (A. M. Clark and Downey, 1992), yet *Zoroaster* is abundant in the shallow-water La Meseta Formation. Jablonski and Bottjer (1990) included *Zoroaster* among

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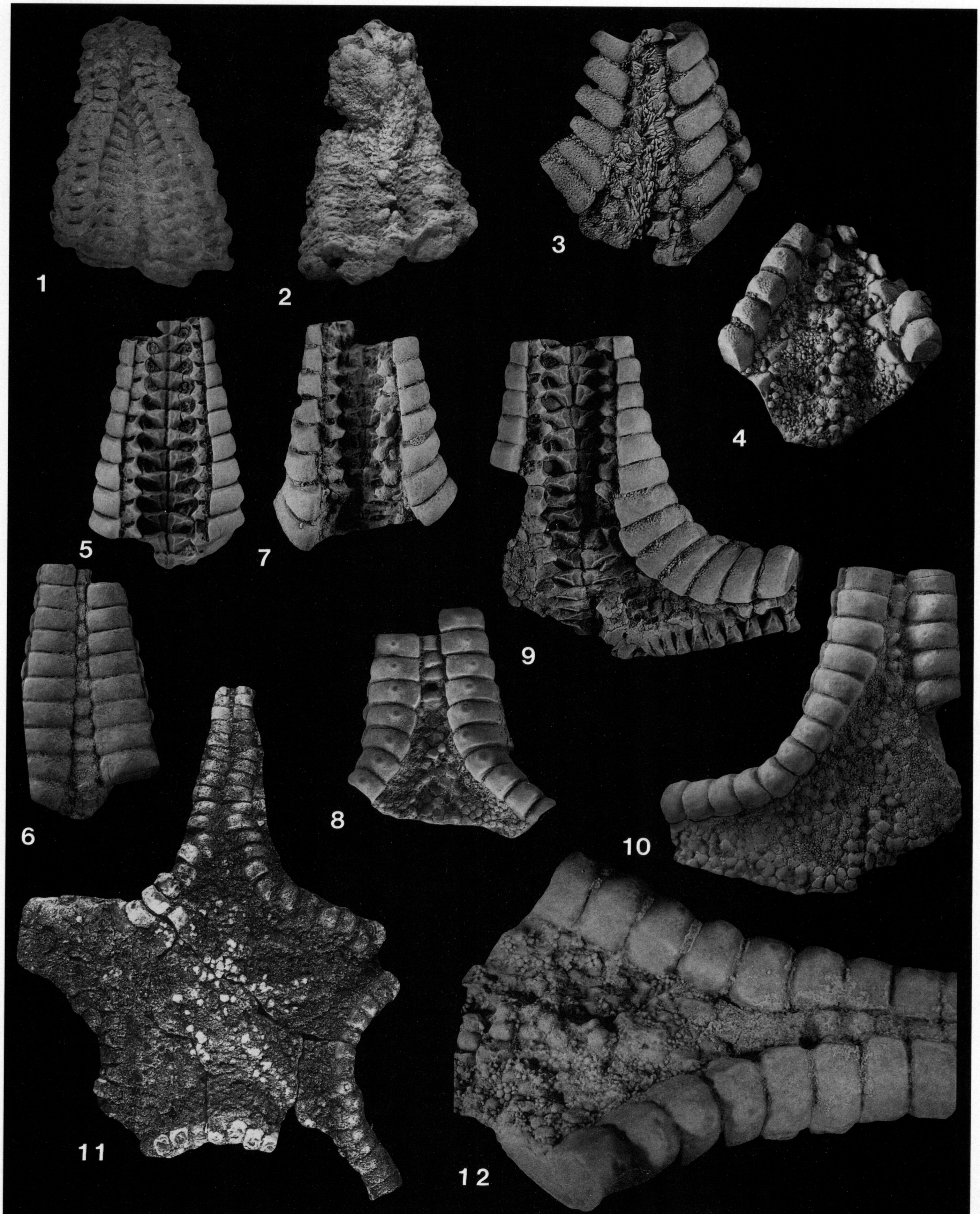
FIGURE 2—*1, 2,* Oreasterid sp., ×3, loc. 86-04, hypotype, USNM 490418; *1,* ventral view, ambulacrals and adambulacrals dominate the view, with the edges of the marginals exposed; *2,* dorsal view, marginals are to the sides and radials forming an irregular midline; an enlarged distal radial is present near the arm tip, compare with Figure *3. 3–12, Paragonaster clarkae,* new species, all loc. 94-03; *3–10,* alternate ventral and dorsal views of four fragments showing ossicular form and arrangement, ×1.5; *3,* inferomarginals separated by adambulacral columns with some spines remaining, *4,* paxillae are displaced but granules remain, paratype, USNM 490415; *5,* form of ambulacrals and adambulacrals, *6,* single series of angular radials, paratype, USNM 490421; *7, 8,* fragment from just distal to the juncture of an arm with the disk, spine bases on the superomarginals, and a single series of radials, paratype, USNM 490422; *9,* marginals, paxillae, ambulacrals; *10,* radials enlarged compared to adjacent paxillae, paratype, USNM 490422; *11,* dorsal view showing general shape, ×3, holotype, USNM 490423; *12,* dorsal view, superomarginals with spine bases, paxillae, radials, granules, ×3, paratype, USNM 490424.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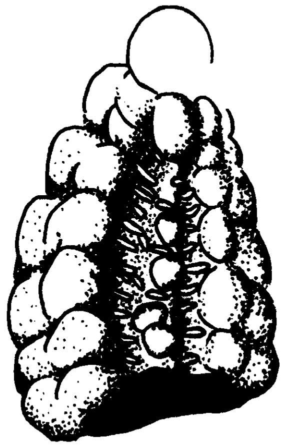


FIGURE 3—Oreasterid sp., compare Figure 1.2; the rounded, unpaired terminal is at the end of the double marginal column, and a row of enlarged radial dorsals is separated from the marginals by a row of laterals, ×3, loc. 86-04, hypotype, USNM 490418.

taxa apparently retreating to deeper habitats through time. Many deep-water asteroids (e.g., Pterasteridae, Brisingida) are of delicate construction, and the contrasting sturdy arrangement of *Zoroaster* is consistent with origins in shallow, perhaps more turbulent settings.

A particularly tantalizing La Meseta fossil is the small oreasterid arm tip (Figures 2.1, 2.2, 3). Oreasterids today are found in shallow, warm-water environments, and not in the Southern Ocean, indicating a retreat from this region as temperatures declined in the Cenozoic.

The Seymour Island ophiuroid.—Only one ophiuroid species, *Ophiura hendleri,* is now known from the La Meseta Formation, although specimens are quite common. The lack of diversity seems surprising given the richness of La Meseta invertebrate faunas in general and presence of multiple ophiuroid species in many living faunas. Low apparent diversity might result in part from taphonomic changes. The taxonomy of living ophiuroids stresses plate arrangement and spine development, but recrystallization and compaction of the sandy La Meseta sediments disrupted and obscured tiny ophiuran plates. Nevertheless, all known La Meseta specimens are either clearly *O. hendleri* or so poorly preserved as to be of uncertain affinities beyond the class or family level.

Ophiura hendleri occurs as the isolated specimen or in small groups, including beneath the protective cover of molluscan shells (Figure 7.4), but most striking are the beds of ophiuroids covering areas up to an estimated 40 m^2 and 10 cm in thickness (Figure 7.2, 7.3, 7.6). Ophiuroid beds are more common in Paleozoic rocks (Aronson, 1987, 1991), and those of the La Meseta appear to represent local and brief reversion to Paleozoic conditions (Aronson et al., 1997). Most ophiuroids employ multiple feeding mechanisms (Warner, 1982) and *Ophiura sarsii,* living in dense populations off North Carolina at depths of 450 m, is both a suspension-feeder and a deposit-feeder (RBA, observations from the *Johnson Sea-Link* submersible, 1991–1992). *Ophiura hendleri* plausibly also was capable of a range of feeding habits.

SYSTEMATIC PALEONTOLOGY

Cladistic studies of living stelleroid genera are not currently available and therefore summary diagnoses below are traditional in structure, treating both overall form and potential unique characters. *Buterminaster elegans* Blake and Zinsmeister, 1988, (Goniasteridae) is not discussed below, although it is a La Meseta taxon. Expanded locality data are provided in the appendix.

Class ASTEROIDEA de Blainville, 1830
Order VALVATIDA Perrier, 1884
Superorder VALVATACEA Blake, 1987
Family GONIASTERIDAE Forbes, 1841
Genus PARAGONASTER Sladen, 1889

Type species.—*Paragonaster ctenipes,* Sladen, 1889, by subsequent designation in Fisher (1919), see A. M. Clark (1993).

Summary diagnosis.—Five-armed genus of the Goniasteridae; interbrachial angles flattened to broadly rounded, arms attenuated, long, slender. Abactinal ossicles paxilliform, rows of abactinals declining in number more or less abruptly at base of arm, single row of abactinals extending from base of arm to terminal. Marginals numerous, rounded in both lateral and transverse profiles. Adambulacral furrow margin angular, furrow not tightly closed by ossicles; apical oral spine unpaired. Dorsal surface primary ossicles closely covered by granules, ventral surface ossicles with short spines; no enlarged spines or pedicellariae. (Modified from A. M. Clark and Downey, 1992).

PARAGONASTER CLARKAE new species
Figure 2.3–2.12

Diagnosis.—Species of *Paragonaster*; form robust, ossicles stout. Short spines on superomarginals; abactinal ossicles with closely appressed accessory spinelets.

Description.—Flattened, five-armed goniasterid; form dominated by stout marginals, broadly rounded interbrachial angles, sharply tapering arms. Radius estimated 90 mm in specimen of r approximately 30 mm, R/r approximately 3:1.

Abactinal ossicles of disk paxilliform, stout, closedly appressed, covered with approximately 15 closely spaced granules; granules similar over entire dorsal surface. Radial series becoming differentiated as marginal series converge at base of arm. Proximal radials slightly wider than long, then approximately square, then longer than wide; distal radials very narrow, elongate, so that marginals nearly meet at arm midline, but radial series not known to terminate on arm. Madreporite not recognized.

Marginal series robust, dominating arm margin; ossicles of two series paired, nearly flat-sided except for low ridge near ossicular edges; ossicles vertically elongate, lateral outlines nearly rectangular. Interbrachial superomarginals somewhat wider than long; medial, distal superomarginals distinctly so. Interbrachial inferomarginals distinctly higher than corresponding superomarginals, becoming equisized at base of arms; superomarginals distinctly larger than inferomarginals on most of arm. Superomarginals of disk, proximal portion of arm angular in cross section; proximal arm superomarginals with circular spine base; superomarginals of arm more rounded, surface covered by granules. Inferomarginals rounded, spines apparently lacking; inferomarginals granulated near dorsal-lateral edge, accessories grading to spinelets on ventral surface of ossicles.

Actinals in about three series, perhaps 10 ossicles present in row adjacent to adambulacral row, actinal row terminates on arm near disk. Actinals angular, accessory spinelets present. Adambulacrals robust, longer than wide, longitudinal muscle depressions robust, furrow margins angular, outer face flat; armature includes short spinelets. Adambulacrals of distal portion of disk and arms, robust, elongate. Ambulacral body elongate, triangular; cross-furrow articular processes vertical; four proximalmost ambulacrals foreshortened. Terminal unknown. First ambulacral body rectangular, very stout; other ossicles of oral frame unknown.

Comparisons.—*Paragonaster clarkae* can be separated from other species of *Paragonaster* based on the presence of superomarginal spines. The robust form is most like that of *P. grandis,* although it differs from this species based on the presence of closely appressed granules. Other species generally are of more delicate form, with apparently longer, more slender arms and a correlated more flattened interbrachial profile. In the other species, the lateral abactinal ossicles terminate closer to the arm base. Living *Paragonaster* is widely distributed in the world's oceans, but this is its first occurrence from the Antarctic.

Etymology.—The species is named in honor of Ailsa M. Clark.

Material.—Fragments and one nearly complete specimen from 94-3; 35 fragments were from the channel deposit at that locality, and they are poorly preserved, whereas 20 better-preserved fragments are from a thinly bedded interval at the same locality; many of the fragments probably were derived from a single specimen. Holotype, USNM 490423, paratype suite 490426, from the channel; paratypes USNM 490419–490422, 490424, paratype suite 490425 from the thinly bedded interval. Arm fragment paratype 490427, locality 86-4; four arm and disk fragments, paratype suite 490428, locality 94.3.

Genus TESSELASTER H. L. Clark, 1941

Type species.—Tesselaster notabilis H. L. Clark, 1941, by original designation.

Summary diagnosis.—Five-armed genus of the Goniasteridae; interbrachial angles broadly rounded, arms triangular, attenuated. Abactinal ossicles flattened, polygonal, covered by granules, rows of abactinals declining more or less abruptly at arm base, with single row of rectangular abactinals extending to about midarm position before terminating in at least *T. notabilis*; superomarginals abut across arm axis from that point to terminal. Marginals numerous, ossicular outlines in vertical section of both series square interbrachially becoming rectangular on arms; marginals partially bare, granules inset, clustered in groups; actinals numerous, granulate. Edge of ambulacral furrow angular, furrow not tightly closed by ossicles; apical oral spine present on each mouth angle ossicle. No enlarged spines or pedicellariae. (Modified from A. M. Clark and Downey, 1992).

TESSELASTER CLARKI new species
Figure 4.1–4.5

Diagnosis.—Species of *Tessellaster* with bulbous marginals, comparatively few marginal granules; adambulacrals foreshortened; adambulacrals, actinal ossicles both with cylindrical spines.

Description.—Flattened, five-armed goniasterid; marginals moderately large, interbrachial angles broadly rounded, arms apparently tapering sharply; arm radius unknown, disk radius approximately 15 mm in available specimens.

Abactinal area rather abruptly reduced to single radial series on arms (most of arms missing in available specimens, therefore persistence of radials uncertain); radials angular, varied in shape, closely spaced, tabulate, subcircular, domed; disk radials somewhat enlarged; abactinals generally uniform, diminishing in size toward radial interbrachial area, although some smaller ossicles present especially near midarm area; ossicles covered by granules. Madreporite small, near disk center.

Marginals robust, dominating arm margin; ossicles of two series paired, nearly flatsided, weakly cuneate on disk becoming rectangular on proximal portion of arm. Lateral ossicular outlines nearly rectangular; marginals of both series somewhat wider than long more distally on arm; outer faces domed, cross sectional profile rounded, margins bordered by granules, with few granules impressed onto otherwise bare surface; enlarged spines lacking. Actinals robust, in three or four rows, closely spaced, appearing somewhat irregular in form, bearing short, columnar spinelets.

Adambulacrals foreshortened, apparently more or less upright in furrow, closely spaced, with two? short, stout, columnar spines. Oral frame ossicles probably fairly small; mouth ambulacral ossicles smaller than immediately adjacent adambulacrals; other ossicles of oral frame unknown.

Comparisons.—Many genera of the Goniasteridae, including *Tessellaster,* share a suite of distinctive characters including overall outline with a flattened dorsal surface; tabular, closely spaced abactinal ossicles, and robust, blocklike marginal ossicles. Arms are comparatively slender in many genera of the Goniasteridae, but in most (e.g., *Pseudarchaster*), several rows of abactinals extend most of the length of the arm. Among those with abactinals extending to the tip, *Ogmaster, Stellaster* and *Anthenoides* have a more or less thickened dermal layer and reduced granules; the tissue would not be preserved in the fossil, but the presence of abactinal and intermarginal granules demonstrates the absence of these tissues in life. *Rosaster, Nymphaster, Paragonaster,* and *Tessellaster* all posess narrow arms. In both *Rosaster* and *Nymphaster,* only radials extend from the disk onto the arms; in both, granules cover the superomarginals, and abactinals are more nearly paxillate in *Nymphaster.* Abactinals other than radials also terminate at the base of the arms in *Lithosoma,* as well as in a number of other genera in which abactinals are typically quite flat. In these genera, granules surround the ossicular edges but they are not present on dorsal surfaces.

In the living *Tessellaster notabilis,* many rows of abactinals terminate near the base of the arm, and a single series of radials extends to the midarm position. The series becomes disjunct before terminating. Unfortunately, only proximal portions of the arms are known from both available fossil specimens, but the thickened, tabular abactinal form, becoming rectangular in arm radials, is an important similarity between the fossils and *T. notabilis*; in addition, abactinals in both species are covered by closely spaced granules. Marginals in both are approximately square in outline, with granules along the ossicular edges and impressed into the surface in patches.

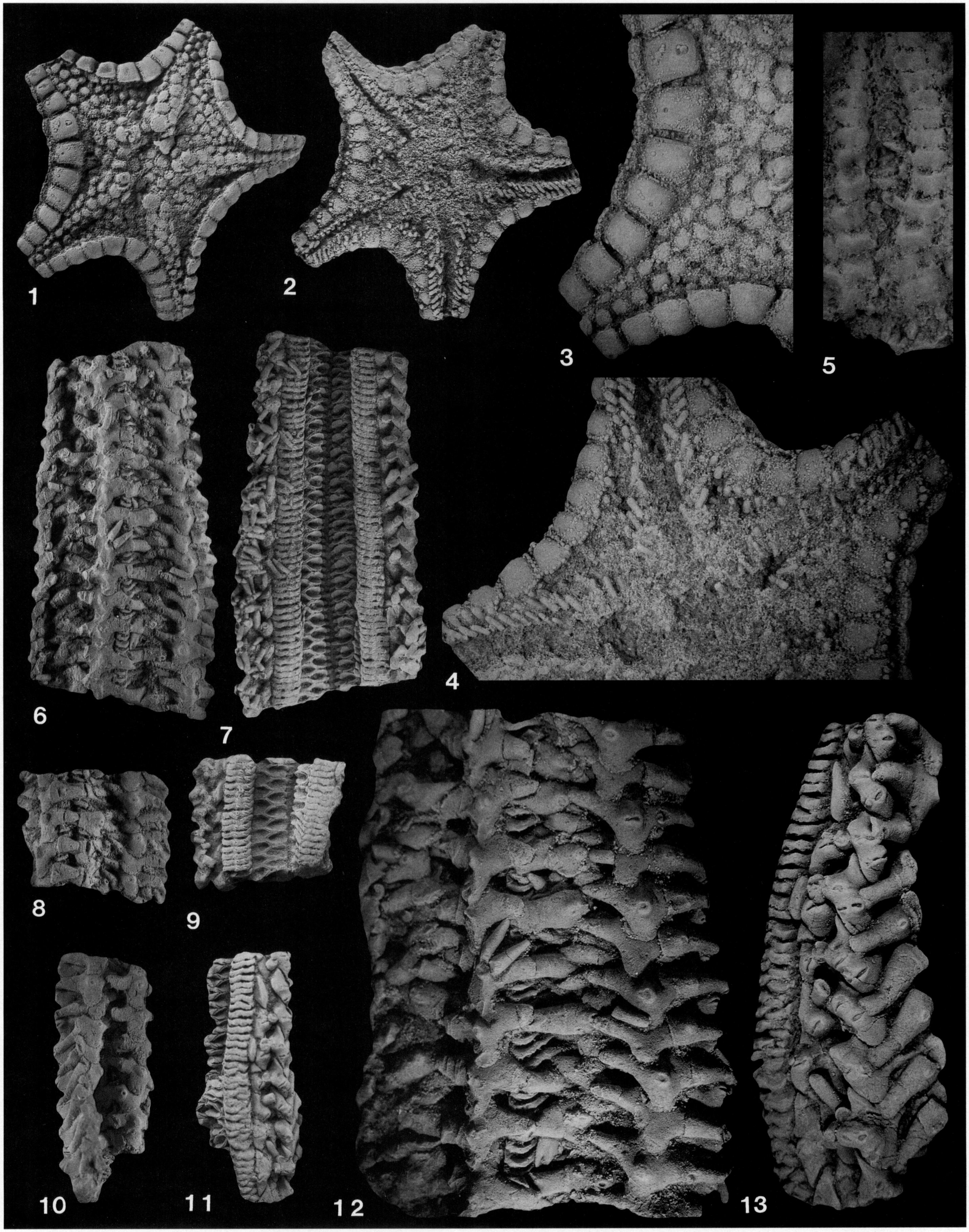
Tessellaster notabilis and *T. clarki* are readily distinguishable in that the adambulacrals are foreshortened in *T. clarki,* and they bear robust cylindrical furrow spines; similar spines are found on the actinals. In *T. notabilis,* adambulacrals are elongate, and adambulacral furrow spines are flattened and somewhat delicate. Subambulacral and actinal accessory ossicles are granules rather than true spines. Marginals are comparatively bulbous in *T. clarki,* and inferomarginal granules are more sparsely developed. In spite of these differences, the strong similarities of form, abactinal, and marginal development justifies inclusion of the new species in *Tessellaster.*

Etymology.—The species is named in honor of Hubert L. Clark.

Material.—Two incomplete specimens, both from 86-5. Holotype, USNM 490429, R approximately 13 mm; the ventral surface of the specimen is somewhat obscured by sediment. Paratype, USNM 490430, R approximately 17 mm; the specimen is largely wind-abraded, obscuring surface details but exposing ossicular arrangements and proportions.

Family OREASTERIDAE Fisher, 1911
genus and species unknown
Figures 2.1, 2.2, 3

Description.—Curled arm tip approximately 22 mm in length, 12 mm in breadth at proximal end; tip bulbous, arm bottom flattened, tip cross section approximately triangular. Dorsal surface of tip arched, abactinal radial series enlarged, ossicles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tabular, thickened, approximately polygonal; radial size gradually diminishing distally on arm until next-distalmost radial. Proximalmost four preserved radials with very short, stout spines; next two (three?) lacking spine; next-to-distalmost enlarged, forming part of stout arm tip, with medial spine base; distalmost radial comparatively very small, spine lacking. One lateral ossicular row on each side of radial series, these series terminating lateral to enlarged radial; form of laterals obscure but of smaller size than that of adjacent radials. Spines on abactinals small, cylindrical, numerous, not closely spaced; smaller spine bases domal.

Ossicles of marginal series paired, thickened, somewhat bulbous, irregular; lateral outline approximately square, ossicles of both series overlapping proximally; fascioles lacking. Superomarginals smaller than corresponding inferomarginals; inferomarginals form ambitus at ventral surface, ossicular margin somewhat angular, therefore arm tip transverse outline approximately triangular; ossicles of both series with enlarged medial spine, smaller columnar spinelets similar to spines of preserved proximal radial series; length of large inferomarginal spine approximately 1 mm.

Actinals in single series; actinals rectangular, elongate, closely abutted, each actinal abuts two adambulacrals, actinal spine arrangement probably similar to those of marginal series.

Adambulacrals stout, rectangular in ventral outline, transversely elongate, upright in arm, closely spaced; side faces probably similar so that ossicles are approximately bilateral across radial plane; with two or three larger subambulacral spines in transverse series, perhaps also smaller spinelets; furrow edge straight, probably with furrow row of smaller spinelets on notched edge, allowing closure of furrow. Ambulacrals robust, with broad radial water-canal groove; podial pores biserial. Terminal lost but articular surface small.

Remarks.—Although only an arm tip remains, the oreasterid affinities are clear. Marginal ossicles of the Goniasteridae typically are tabular, and the ossicles of the two series are similar, whereas those of the fossil are oreasterid-like in that they are globular and irregular. In many oreasterids, marginals of the two series are somewhat dissimilar, and the fossil is consistent with that pattern in that the inferomarginals are somewhat enlarged, and they protrude laterally beyond the superomarginals. Differentiated, somewhat irregular and domed radial ossicles, with an enlarged representative proximal to the tip, are oreasterid-like, as are the enlarged medial spines on both marginals and radials. The flattened adradial margin of the adambulacrals allowed the adambulacrals to be pulled together, closing the furrow and protecting the tube feet.

Although very fragmentary, the form of the marginals appears unlike that of described genera, as is the arrangement of spines. There are two groups of oreasterids, the first including genera such as *Goniodiscaster* and *Anthenea* that are goniasterid-like, with flattened dorsal surfaces and limited differentiation of abactinal ossicles, and the second including genera such as *Oreaster* that are thickened in body cross section with a more complexly differentiated, somewhat open, abactinal network. The fossil is very incomplete and distorted, but the rather simple, flat form of the dorsals suggests the former group.

Material.—One well-preserved arm tip fragment from locality 86.4; the tip is approximately 12 mm long, 7 mm in width. Proportions suggest a specimen of radius of at least 40 mm, but it could have been derived from a much larger individual. Hypotype, USNM 490418.

Order PAXILLOSIDA Perrier, 1884
Family ASTROPECTINIDAE Gray, 1840
CTENOPHORASTER DOWNEYAE
Blake and Zinsmeister, 1979
Figure 7.6

Ctenophoraster downeyae BLAKE AND ZINSMEISTER, 1979, p. 1150, pl. 1; 1988, p. 494, fig. 3.1.

Remarks.—Most available specimens of *Ctenophoraster downeyae* appear to have had comparatively short, triangular arms rather than the long, slender arms typical of living species. Great variability of arm form has been recognized in *Astropecten* (e.g., Döderlein, 1917), but taxonomists have not sought to subdivide the genus, and arm shape should not be stressed in *Ctenophoraster.*

Material.—Many largely fragmentary specimens are available, see locality index, Blake and Zinsmeister (1979, 1988).

Superorder FORCIPULATACEA Blake, 1987
Order FORCIPULATIDA Perrier, 1894
Family ZOROASTERIDAE Sladen, 1889
Genus ZOROASTER Thomson, 1873
ZOROASTER aff. Z. FULGENS Thomson, 1873

Zoroaster fulgens THOMSON, 1873, p. 153.
Zoroaster aff. *Z. fulgens* Thomson, 1873. BLAKE AND ZINSMEISTER, 1979, p. 1151, pl. 2; 1988, p. 495, figs. 3.7–3.10, 4.1–4.4.

Remarks.—Downey (1970) found the Atlantic living species of *Zoroaster* to be only weakly demarcated, and synonymized them under *Z. fulgens,* pending future studies. Blake and Zinsmeister (1979) found strong similarities between the Seymour specimens and living *Z. fulgens.* There are minor differences (Blake and Zinsmeister, 1979), and the fossils appear robust as compared to living representatives, with arms that are short and blunt. Nevertheless, Downey (1970) noted a range of shapes among living representatives, and blunt-armed individuals with robust arms likely would be taphonomically favored; recognition of a new species is not warrented at this time.

Material.—Many largely fragmentary specimens are available, see locality index and Blake and Zinsmeister (1979, 1988).

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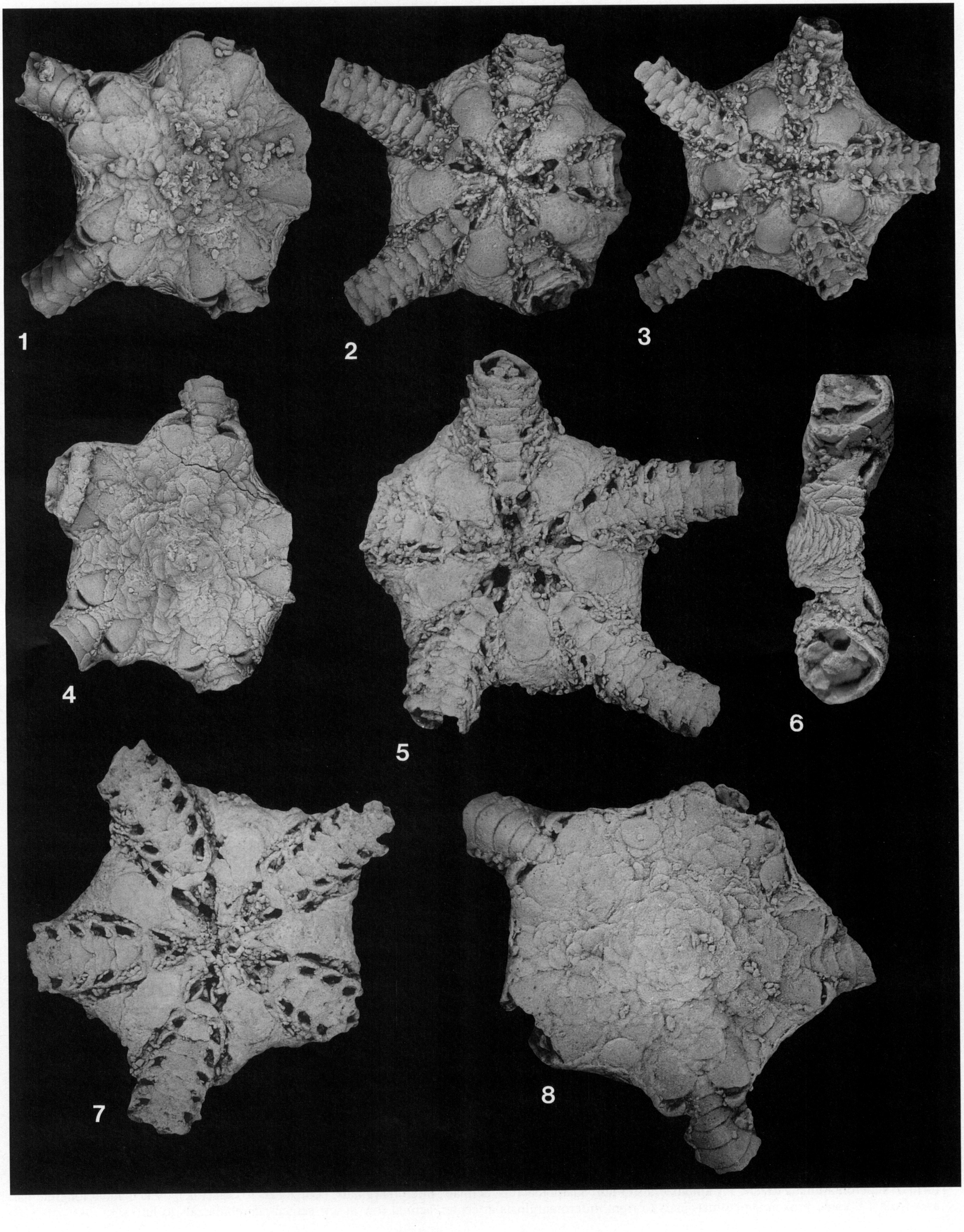
FIGURE 4—*1–5, Tesselaster clarki,* new species, both loc. 86-04; *1–4,* holotype, USNM 490429; *1, 2,* overall dorsal and ventral views, ×1.5; *3,* dorsal view shows form of superomarginals with few accessory ossicles present on superomarginals in life and enlarged granules occur along intermarginal edge of inferomarginals to left, ×3; *4,* ventral view shows form of inferomarginals with enlarged granules near lateral edge of inferomarginals and stout adambulacral spines, ×3; *5,* ventral view of wind-abraded specimen, adambulacrals are transversely elongate and closely spaced, ×3, paratype USNM 490430. *6–13, Sclerasterias zinsmeisteri,* new species, proximal and medial arm fragments with distal to top of page, all loc. 86-05; *6, 7, 12,* paratype, USNM 490431; *6, 7,* dorsal and ventral views show general arrangment and form of ossicles, ×1.5; *12,* dorsal view with superomarginals to right, arrangement of spine bases, laterals adjacent to superomarginals, radials at midline of arm, ×3; *8, 9,* paratype, USNM 490432; *8,* dorsal view with superomarginals to left and right, and intermediate ossicular rows largely squeezed together to center; *9,* ventral view showing arrangement of adambulacrals and ambulacrals, funnel-shaped podial pores, ×1.5; *10, 11, 13,* paratype USNM 490433, *10,* form of superomarginals to left, *11,* ambulacrals to left, adambulacrals, actinals, inferomarginals, both ×1.5; *13,* specimen rotated about longitudinal axis from *11,* some broken superomarginals to right, inferomarginals at center, actinal row at left center, adambulacrals to left ×3.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Family ASTERIDAE Gray, 1840
Genus SCLERASTERIAS Perrier

Discussion.—The present specimens and those described by Blake and Zinsmeister (1988) are readily assigned to the Asteriidae based on general form, the presence of compressed ambulacral column ossicles, four rows of podia, and small, cross-shaped body ossicles.

Genera and species of living asteriids are based largely on arrangement of body ossicles and the nature and arrangement of pedicellariae. Unfortunately, ossicular arrangement usually is significantly disrupted in fossil asteriids, and pedicellariae are almost always lost; the few that might remain cannot be relied upon to provide much information either on original form or distribution. Based on the generic revision of Fisher (1928), relatively poorly preserved Seymour Island specimens were assigned to *Sclerasterias* by Blake and Zinsmeister (1988); more complete material now available indicates that this assignment was reasonable, although the absence of pedicellariae makes interpretation difficult.

Assignment of the La Meseta fossils to *Sclerasterias* is based on the presence of a small disk and apparently pentagonal arms, and a dorsal skeleton consisting of regular transverse and longitudinal rows of lobate ossicles. Only one lateral ossicular series is present, and intermediate ossicles between the radial and superomarginal series are not developed. Many, but not all radials, laterals, and superomarginals bear prominent columnar spines, and a prominent lobe extends ventrally on individual ossicles of the superomarginal series. The actinal ossicles occur in a single series, although they can appear double locally, probably due to collapse in preservation. Adambulacrals are diplacanthid.

SCLERASTERIAS ZINSMEISTERI new species
Figure 4.6–4.13

Sclerasterias? sp. BLAKE AND ZINSMEISTER, 1988, p. 495, fig. 4.5–4.9.

Diagnosis.—*Sclerasterias* species with robust ossicles. Dorsally, one connecting ossicular series present, that between lateral series and superomarginal series. Radials and marginals with zero, one, or two spines and spine bases; superomarginals with medial spine base alternating with those either lacking bases, or less frequently, those with spine bases displaced laterally on descending ossicular lobe. Some superomarginals with two spine bases.

Description.—(Augmenting Blake and Zinsmeister, 1988) Central area of disk rather lightly constructed, interbrachial ossicles stout. Radial ossicular series clearly defined, ossicles gradually decreasing in size distally. Radial ossicles cruciform with lateral flanges approximately perpendicular to proximal-distal axis; length, breadth of medial ossicle about 5 mm, central region of ossicle small, medial spine bases one or two; spines stout, abruptly tapering, up to 4 mm long. Lateral ossicles present in single series on each side of radial series; laterals rectangular to weakly elliptical, transversely elongate, rather flat, with large medial spine base on at least proximal ossicles. Interossicular papular pores large. Secondary connecting series apparently linked to laterals and superomarginals near disk but absent from remainder of arm; connecting ossicles simple, rodlike. Ossicles of marginal series paired, quite strongly overlapping proximally. Superomarginals rather low, cruciform, central area large, with prominent abradial flange, strongly overlapping proximally. Zero, one, or two spine bases present on superomarginals; ossicles with medial bases alternating with those lacking base, or those with base laterally offset, or with two bases. Medial superomarginals approximately 4 mm long on larger specimens, actinal flange about 2.5 mm long, abactinal flange about two-thirds length of actinal. Inferomarginals similar in size to superomarginals but thicker, with central area more irregular. Inferomarginal medial abactinal flange length about 3 mm, other flanges probably weakly defined. Inferomarginals with one or two spine bases; spines on medial ossicles about 3 mm long, 4 mm on proximal ossicles. One or two rows of actinals present, these stout, elliptical, closely arranged, with medial spine base, small lateral flanges. Ambulacral column strongly compressed, adambulacrals diplacanthid, with stout conical spines up to 3 mm long, the spines forming strong ventral armor; ambulacrals robust, with well-defined podial openings. Pedicellariae rarely preserved lateral to radials.

Comparisons.—The skeleton of *S. zinsmeisteri* is robust as compared to living species, and only a single connecting ossicular row adjacent to the laterals is developed; most radials and superomarginals have spines, and some spines on the superomarginal series are offset.

Etymology.—The species is named for William J. Zinsmeister.

Material.—From Blake and Zinsmeister (1988), holotype designated herein, USNM 406174, paratypes designated herein, 412358 and 412359. Forty-three fragments collected from locality 86.5, paratypes 490431–490433, paratype suite 490434; and a single unillustrated paratype USNM 490435.

Class OPHIUROIDEA Gray, 1840
Order OPHIURIDA Müller and Troschel, 1840
Family OPHIURIDAE Lyman, 1865
Genus OPHIURA Lamarck, 1801

Remarks.—H. L. Clark (1911, p. 36) noted that "several very different generic types" and well over 100 species were included within *Ophiura*. In spite of the apparent need for generic revision, Mortensen (1927) and A. M. Clark and Courtman-Stock (1976) provided very useful diagnoses of *Ophiura*; the Seymour Island specimens are consistent in all essential aspects with these diagnoses. The following list of characters is based on these references; all apply to *O. hendleri* although they are not necessarily unique to *Ophiura* and presumably some might one day be deemphasized or dropped from a revised generic concept.

The dorsal surface of the fossil disks are flat and covered by many small, similar scales. The radial shields are distinct rather than contiguous. An arm comb is present distal to each radial shield; each pair is separated by a notch across the arm. The primary plates on the dorsal surface of the disk are at most weakly differentiated. The dorsal profile of the arm of many species is arched, and arms issue from a reentrant in the disk; edges of the arm are bordered by a notch that extends to the ventral surface, and the notch is bordered by small papillae. The second tentacle pore is outside the mouth edge and opens into the mouth slit. Tentacle pores are associated with each arm segment apparently throughout the length of the arm, although they are small.

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FIGURE 5—*1–8, Ophiura hendleri,* new species, showing general plate arrangements, all loc. 86-03; *1–4, 6,* ×5; *5, 7, 8,* ×6. *1, 2,* dorsal view shows large radial shields, complex arrangement of smaller dorsal plates, arched dorsal surface of arm, ventral shows shape of shields, form of ventral plates, holotype, USNM 490436; *3,* ventral view, paratype, USNM 490437; *4, 6,* dorsal and lateral views, dorsal to right, paratype, USNM 490438; *5,* ventral view, LACM 7187; *7,* ventral view, LACM 7188; *8,* dorsal view, LACM 7189.

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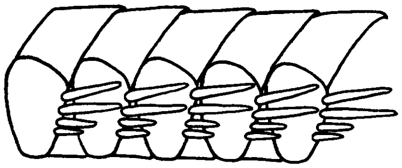

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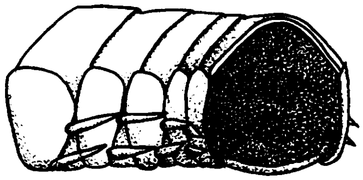

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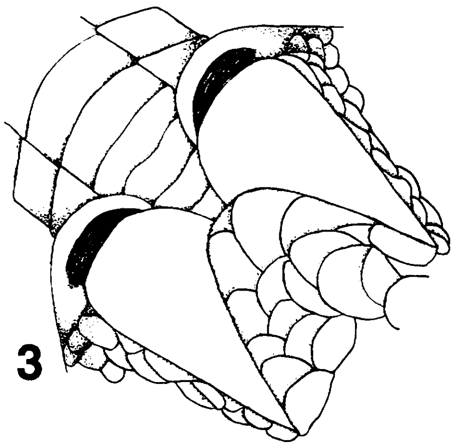

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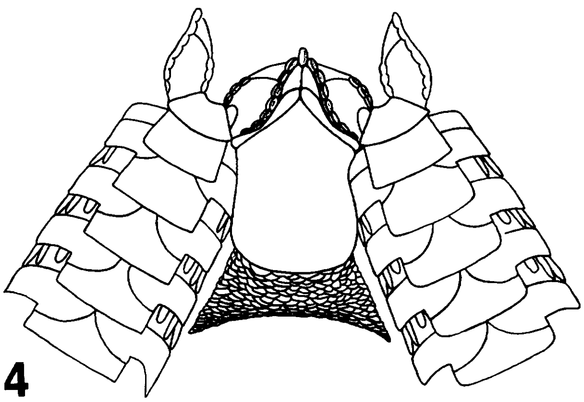

FIGURE 6—*1–4, Ophiura hendleri,* new species, generalized diagrams showing ossicular configuration with differences incorporated into drawings reflecting ranges of variation among specimens. *1, 2,* lateral views of arm showing spine distribution and ossicular form, not all spines are shown on *2*; *3,* dorsal view of portion of the disk and one arm; radial shields are largest plates; *4,* ventral view of portion of the disk and two arms; area around the mouth is somewhat obscured in available specimens; approx ×8.

Among species assigned to *Ophiura,* size, shape and definition of radial shields, the primary plates, and other scales is varied, and *O. hendleri* lies within the range of variation, although this is an unsatisfying foundation, reflecting the need for revision.

The name "*Ophiura*" has been applied to fossils as old as Cretaceous and questionably to Jurassic representatives (Spencer and Wright, 1966) as well, but no attempt was made here to reevaluate and revise earlier fossil assignments to *Ophiura.* Specimens of the species *Ophiura texana* (W. B. Clark, 1893) from the Cretaceous Washita Group of Texas were available; however, this species clearly is a congener of *O. hendleri* and therefore *O. hendleri* does not date from near the time of origin of the genus.

Ophiocten is similar to *Ophiura*; based on characters provided by Paterson et al. (1982, p. 110), *Ophiura,* including *O. hendleri,* is distinct in terms of connection of the second tentacle pores directly to the mouth slit, presence of well-developed arm combs, presence of a distinct notch at the base of the arm plates, and the shape of the arm plates, and presence of numerous tentacle scales.

OPHIURA HENDLERI new species
Figures 5.1–5.8, 6.1–6.4, 7.1–7.4, 7.6

Diagnosis.—*Ophiura* species with many similar thin, irregular?, overlapping, dorsal disk scales. Radial shields distinct, triangular, tapering sharply proximally, not contiguous. Arm dorsal surface arched, sides flat, spines 5, robust, short. Ventral arm plates robust, approximately first five ventral arm plates medially contiguous. Oral shields longer than wide; jaw plates prominent, weakly flaired; oral papillae truncate.

Description.—Disk diameter reaching at least 12 mm, arm length over 40 mm in specimen of disk diameter 10 mm; disk outline pentagonal with interbrachial outline typically slightly concave. Dorsal, ventral disk surfaces both probably fairly flat in life. In specimen of diameter 10.0 mm, arm width at base about 3.0 mm; at 10 mm, breadth nearly 2.0 mm. Arm cross section broadly rounded, dorsal midline of arm angular to sharply angular proximally becoming flatter toward the arm tip; arm flattened ventrally; arm tip attenuated. Surfaces of all ossicles covered by very fine (0.025 mm), closely arranged microgranular sculptoring.

Radial shields of pair 0.5–0.75 mm apart, triangular; in specimen of diameter 10.0 mm, exposed shield length about 2.5 mm, 1.5 mm at widest point, tapering distally to blunt terminus less that 0.5 mm distal to widest point; markedly tapering proximally to more or less acute point. Remainder of dorsal disk surface covered by small, thin, imbricate scales, sizes somewhat varied among individuals; scales at middle of disk more or less uniform, interradial scales can be enlarged; lateral, ventral interradial scales small.

Jaw plates robust, proximally-distally elongate, broadly in contact, nearly parallel-sided in some specimens to weakly flairing distally in others. Each jaw plate bearing one or two apical oral papilla, or possibly one on jaw plate pair; each side of jaw, adoral shields with a continuing series of six or seven blunt oral papillae. Distal papillae together with several adjacent ventral plates forming closing cover over second oral tentacle opening.

Oral shields pentagonal, width about three-fourths length, widest immediately proximal to distal side. Distal side broadly rounded, lateral sides weakly concave, with ossicular outline tapering very gradually proximally, proximal sides slightly concave, converging to form angular proximal margin. Adoral shields ovate or comma-shaped, broadly in contact medially, tapering laterally; proximal sides concave, distal side convex. Genital slits extend around lateral edge of disk; apparently bordered on both sides by series of small scales, more distal scales equidimensional, proximal scales elongate (but lost or obscured in most specimens).

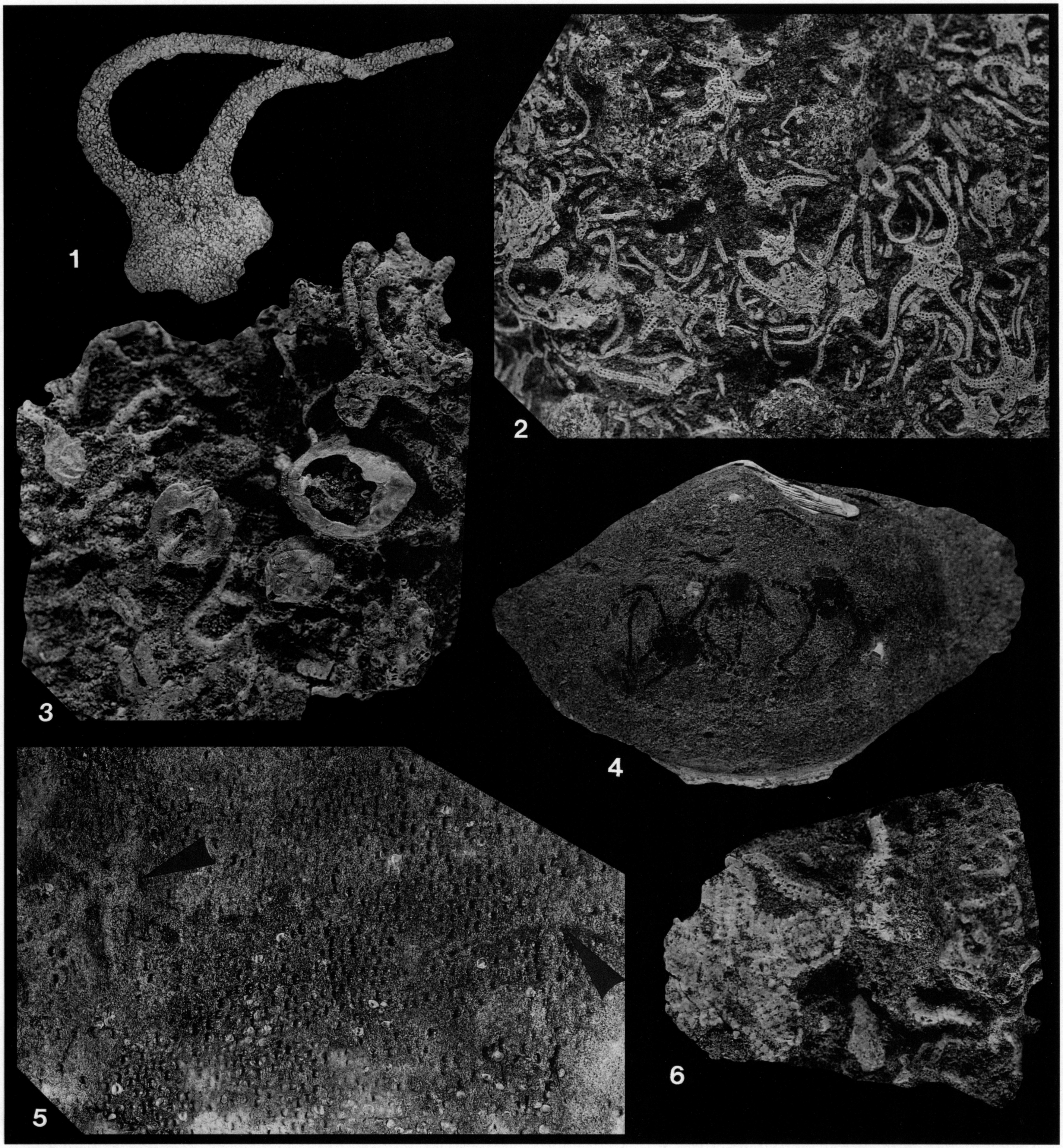

FIGURE 7—*1–6,* Stelleroid occurrence at Seymour Island; *1–4, 6, Ophiura hendleri,* new species, ×1.5; *5,*×0.2. *1,* many of the ophiuroids show such poor preservation but this specimen with two nearly complete arms illustrates arm proportions, loc. 86-03, paratype, LACM 7183; *2,* portion of an ophiuroid assemblage, many ophiuroids are abraded showing interiors of disks and arms, loc. 86-03, LACM 7184; *3,* brachiopods associated with ophiuroids, loc. 94-25, LACM 7185; *4,* ophiuroids apparently were living and buried inside a bivalve shell, float near loc. 94-08, LACM 7186; *5,* trace fossils of two ?*Zoroaster* (arrows) associated with large numbers of a very small, undescribed (W. J. Zinsmeister, personal commun., 1994) bivalve, loc. 94-16, USNM 490439, ×0.5; *6,* ophiuroids associated with *Ctenophoraster downeyae,* a probable predator to left, loc. 94-07, USNM 490435, ×1.5.

Dorsal surface of arm steeply vaulted proximally, outline becoming more rounded near midline of arm. Proximalmost three or four dorsal arm plates exposed in reentrant between radial shields; proximal dorsal arm plates four to five times wider than long, with proximal, distal edges transverse, nearly parallel. Width of 15th dorsal plate about twice its length, with proximal and distal margins still parallel but flexed distally; distally, dorsal arm plates reduced in relative size, separated longitudinaly but overlapped strongly by lateral arm plates.

Lateral arm plates not bowed but forming flat margin to arm; dorsally, reentrants bearing articulating ridge for arm spines well developed. Arm spines short, not overlapping next distal spine row; spines laterally compressed, base of spine thick, acutely narrowing to blunt tip. Four of five spines present on proximal laterals, at least to about 15th arm joint, dorsal-most quite long but second spine longest, probably extending in life to near base of spine of next-distal lateral plate; next two or three progressively shorter. Tentacle scales cover podial pores, with very small scales along distal edge of lateral arm plate on at least proximal segments.

Ventral arm plates about twice as wide as long; first four or five ventral plates (those beneath the disk) in contact but becoming disjunct distally. Shapes of proximalmost plates changing, the first shield-shaped with distal reentrant, the next quadrangular, then pentagonal, subsequent plates triangular with midarm plates about twice as wide as long, elliptical. Distally, ventral arm plates probably becoming reduced in relative size.

Remarks.—Specimens of more than fifty species assigned to *Ophiura* were studied, and others were reviewed from printed material, but adequate documentation of all named species was not available. From this survey, *Ophiura hendleri* is most similar to *O. acervata, O. sarsi, O. texturata,* and *O. luetkeni.* In *O. acervata* Lyman, the central plate and primary radials are better defined, and several lateral interradial scales are much larger, whereas dorsal radials are smaller. The oral shields of that species are shorter and more deeply indented by the genital burase. The lateral arm plates in *O. acervata* are comparatively large, and ventral arm plates are reduced to small elliptical structures beyond about the third plate. Dorsal arm plates are somewhat larger but also comparatively narrow after about the sixth plate. Arms again are distinctive in *O. sarsii* (Lutken), in which no more than the first two ventral arm plates are in contact and the lateral arm plates are comparatively broad and angular in cross section, with long spines on a well-developed spine ridge. The jaws are comparatively broad and divergent with pointed rather than blunt papillae, and the oral shield is comparatively short and wider proximally. *Ophiura hendleri* is very similar to *O. texturata* Lamarck, especially in the development of the dorsal surface; however, the ventral arm plates are disjunct in the latter, separated by a pit-like depressions; ventral and lateral interbrachial scales are comparatively large, and oral papillae pointed in *O. texturata.* In *O. luetkeni* (Lyman), ventral arm plates are again disjunct and laterals bear relatively long, delicate spines. The oral shield is distinctly shorter, comparatively small and equidimensional, and oral papillae are attenuated.

Ophiura hendleri can be distinguished from the nine living Antarctic species in overall appearance. The five arm spines serve to distinguish *O. hendleri* from *O. frigida, O. meridionalis, O. rouchi, O. serrata,* and *O. umitakamuruae,* all of which have three, and *O. mimaria,* which has seven or eight. *Ophiura crassa* and *O. flexibilis* hare four or rarely five, and broad jaws, small, short radial shields, and relatively few large scales in the ventral interbrachii. *Ophiura migrans* has five to seven arm spines, broad jaws, oral shields wider than long, and relatively few large scales in the ventral interbrachii. *Ophiura hendleri* is also similar to the Texas Cretaceous species *O. texana,* although oral shields are waisted in the latter species, and a number of small supernumerary plates occur where the arms join the disk; primary plates are more clearly differentiated in *O. texana.*

Etymology.—The species is named in honor of Gordon Hendler.

Material.—Hundreds of specimens, mostly of rather poor quality of preservation, see locality log. Holotype, USNM 490436, paratypes USNM 490437, 490438; unnumbered USNM paratypes; paratypes LACM 7183–7194.

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APPENDIX

LOCALITY DATA

Seymour Island (Figure 1) is approximately of a figure-eight shape, with the Eocene La Meseta Formation lying almost entirely on the smaller, northeastern portion of the island, and the Cretaceous and Paleocene rocks occurring to the southwest; the waist of the island is occupied by a broad lowland called "Cross Valley." The northeastern portion of the island is approximately 6 km (NE-SW) by 4 km (NW-

SE); it is an erosional remnant crowned by a comparatively small meseta that approximately parallels the long axis of that portion of the island and divides the La Meseta Formation outcrop area into "eastern" and "western" areas. Most locality descriptions below begin with either an "E" or "W" reflecting this distribution; a few begin with "CV" for the Cross Valley area and a few near Cape Wiman (Figure 1) begin with "CW." All localities containing stelleroids available to us are included below.

86-01.—W Float specimens scattered for about 20 m at the base of NW-facing slope below the drainage of 94-30 and 94-10, approx. 350 m NNE of 94-30 and between 1,000 and 1,050 m SE of the intersection of 56°40′W and 64°14′S and between 650 and 700 m SW of 56°38′ and W 64°14′S. *Ctenophoraster* in unfossiliferous silty sands; some brachiopods.

86-02.—W On the slope approx. 100 m NE of 94-32 at approx. the same elevation; scattered *Zoroaster, Ctenophoraster.*

O. hendleri. type loc. LACMIP 17106

86-03.—W Approx. 6 m below the crest of Ruby nose on line between the tip of the nose and 94-2; two ophiuroid assemblages approx. 1 m in lateral extent and 1–3 cm thick separated by 0.1 m band of indurated gray sandstone with scattered, allochthonous brachiopods and ophiuroids. Float blocks of ophiuroid assemblages occur from several points on slope but it is unclear whether these represent a single horizon. *Ctenophoraster* in the debris slope.

86-04.—CV Specimens widely distributed along approx. 300 m of surface of dissected topography on the north side of primary Cross Valley drainage, centered about 900 m NW of the intersection of 56°40′W and 64°16′S and 1,050 m SW of the intersection of 40′W and 15′S; extending SE from below a high point approx. 350–400 m due west of 56°40′W. Localized patches of abundant *Zoroaster, Ctenophoraster, Paragonaster* in buff silts; few other fragmentary fossils.

86-05.—CV Specimens distributed along approx. 30 m of weakly dissected topography, below crest of rise on north side of primary Cross Valley drainage, centered about 750 m SE of the intersection of 56°42′W and 64°15′S and 1,700 m SE of the intersection of 41′W and 15′S. Fauna diverse, *Zoroaster, Ctenophoraster, Tessellaster, Sclerasterias,* corals, mollusks, in fine buff silts.

86-06.—CW On SE-facing slope of primary ridge extending NE from northern tip of plateau, centered approx. 1,200 m NE of intersection of 56°38′W and 64°14′S and 550 m NW of 56°36′W and 64°14′S. Scattered *Ctenophoraster* and *Zoroaster* fragments, *Metacrinus* crinoids, mollusks, in gray muddy siltstones.

86-07.—E Between 100 and 150 m NW of 94-11, on north-facing slope of central branch (of three) of the second principal drainage south of Larsen Cove. *Ctenophoraster* fragments.

86-08.—CW On N-facing slope below prominent hill, approx. 1,050 m SE of intersection of 56°38′W and 64°13′S and 1,250 m SW of 56°36′W and 64°13′S; few very small *Zoroaster* fragments, *Metacrinus* crinoid.

86-09.—CW NE-facing slopes at southeast end of EW-trending valley south of Cape Wiman; approx. 400 m east of the intersection of 56°38′W and 64°13′S; on 13′, then fossils scattered in spurs to south of latitude line. *Ctenophoraster, Zoroaster* with molluscan-rich debris including oysters; both asteroids also found weathering out of relatively unfossiliferous horizons from about 10 m interval.

86-10.—W Approx. 400 m SW of intersection of 56°38′W and 64°14′S and 1,450 and 1,500 m SE of 56°40′W and 64°14′S; few very poorly preserved asteroids in sandy matrix on NNE-facing slope.

86-11.—W Approx. 300 m SW of intersection of 56°38′W and 64°14′S and approx. 1,550 m SE of 56°40′W and 64°14′S; flaggy float blocks containing abundant ophiuroids but not true assemblages, and mollusks, inarticulate brachiopods; on rubble-covered NNE-facing slope.

94-01.—W Near edge of crest of Ruby nose on the SW-facing side of a gradually sloping surface, N of north fork of principal drainage between Ruby and the next nose to the SW; approx. 900 m NE of intersection of 56°40′W and 64°15′S and 1,050 and 1,100 m SE of 56°40′W and 64°14′S. Small ophiuroid assemblage several m in diameter, specimens not abundant, associated with brachiopods.

94-02, 94-32.—W Steep, dissected NW-facing slope ESE across gully from flat surface of *94-33,* and between two larger gullies (which digitate and converge toward crest of point), and 5 to 25 m above floor of gully; 94-32 is to NE, 94-2 to SW; scattered *Ctenophoraster,* echinoids, mollusks, wood.

94-03.—W Head of an NS-trending gulch WSW of prominent, conical hill; Approx. 900 m NE of intersection of 56°41′W and 64°15′S and 850 m NW of the intersection of 40′W and 15′S; with diverse well-preserved, nearly autochthonous molluscan, coral, asteroid fauna in thin-bedded, indurated clastics to W, unconsolidated channel sands with large slump blocks, scattered, displaced asteroids and echinoids to E. *Zoroaster, Sclerasterias, Paragonaster, Ctenophoraster,* ophiuroid fragments.

94-06.—W On flats between 750 and 800 m NE of intersection of 56°40′W and 64°15′S and 1300 m NW of the intersection of 38′W and 15′S; ophiuroid associated with angular cobbles that might be Miocene in age (W. J. Zinsmeister, personal commun.).

LACMIP 17107

94-07.—W On north-facing flank of Ruby nose in about middle of drainage that passes west of conical prominence at base of meseta, between 1,000 and 1,050 m NE of intersection of 56°40′W and 64°15′S and 1,000 m SE of 56°40′W and 64°14′S; and to the west 25 m, beyond the gully. Two very localized indurated ophiuroid assemblages in a rubble slope separated vertically about 3 m, in unconsolidated sands; beds under 10 cm thick, extending about 0.33–1.0 m along outcrop; other ophiuroids scattered through sands; poorly preserved *Ctenophoraster* with ophiuroid assemblage; *Metacrinus* crinoid; echinoids; brachiopods; burrow casts. (includes loc. 94-08).

LACMIP 17118

94-09.—W Prominent NNE-WSW-trending spur approx. 500 m NE of Ruby nose elevation marker; locality is near edge of crest on SW-facing side of spur near its SE extremity between 1,300 and 1,350 m NE of intersection of 56°40′W and 64°15′S and between 1,000 and 1,050 m SE of 56°40′W and 64°14′S. Ophiuroid assemblage with abundant specimens approx. 20 cm thick exposed along approx. 4 m, on southwest to northwest side of a tiny knoll near to the crest of the knoll; *Ctenophoraster*? trace approx. 30 m to west.

94-10.—W Lag near the edge of flat nearly 100 SE of 30, between 1,200 and 1,250 m SE of intersection of 56°40′W and 64°14′S and between 850 and 900 m SW of 56°38′W and 64°14′S; crinoid, brachiopods.

94-11.—E Gradually sloping lag surface on NW-facing slope of low drainage entering most southerly of three main forks of second principal drainage south of Larson Cove between 700 and 750 m NW of the intersection of 56°36′W and 64°15′S and 1,150 and 1,200 m SW of the intersection of 36′W and 14′S, fossils collected over area approx. 50 m in length. Many *Metacrinus* crinoids, some tightly clustered, others scattered over broad, rather flat lag surface; bone fragments, ophiuroid? trace fossil, *Sclerasterias.*

94-12.—E A small saddle on the central branch (of three) of the second principal drainage south of Larsen Cove between 950 and 1,000 m NW of the intersection of 56°36′W and 64°15′S and 1350 m SW of the intersection of 36′W and 14′S. The saddle is floored by small distributary channels, and contains a diverse molluscan and brachiopod fauna; immature *Zoroaster, Ctenophoraster,* crinoids, scattered ophiuroids.

94-13.—E East-facing lag slope approx. 300 m southeast of 94-11, 550 m NW of the intersection of 56°36′W and 64°15′S and 1,450 m SW of the intersection of 36′W and 14′S. Few *Metacrinus* crinoids, few molluscan, brachiopod fragments.

94-17.—W Approx. 50 m NNW of 94-33 at the same stratigraphic horizon; abundant *Zoroaster.*

94-20.—E North-facing slope of east-west hill approx. on 64°15′S and 650 m W of the intersection with 56°36′W. *Metacrinus* crinoids on deflation surface.

94-21.—E On east-facing side of gulch approx. 900 m SW of the intersection of 56°36′W and 64°15′S and between 900 and 950 m SE of the intersection of 38′W and 15′S; approx. 150 m from the sea cliffs on a line perpendicular to the cliffs and just below and SE of a small L-shaped summit. Isolated *Ctenophoraster* in unconsolidated sands approx. 2 m above gulch floor.

94-24.—E A small knoll several m across capped by indurated fossiliferous sandstone slabs overlying unfossiliferous sands; knoll is about 2 m above the floor of a steep gulch, on the south-facing side of the gulch; locality is on the main drainage extending to the center of curvature of the meseta, between 250 and 300 m ENE of 94-26, 300 to 350 m SE of the intersection of 56°38′W and 64°15′S and 1,350 m SW of the intersection of 36′W and 15′S. Diverse mollusks, asteroids, ophiuroids, crinoid fragments, brachiopods extending along outcrop.

94-25.—E Fossiliferous float below and east of crest of spur of meseta, between 600 and 650 m NE of the intersection of 56°38′W and 64°15′S and 1,200 m NW of the intersection of 36′W and 15′S; one small *Zoroaster*, brachiopods, numerous mollusks.

94-26.—E Hummocky, low relief topography in gray silts, sands, some indurated, between 200 and 250 m SSE of the intersection of 56°38′W 64°15′S and 1,600 m NNE of the intersection of 38′W and 16′S. Most of area with few fossils, but one *Ophiura* assemblage and several horizons with abundant bivalves (*Eurhomalea* sp.).

94-30.—W Prominent NNE-WSW-trending nose 200–250 m east of that of 94-9; locality is on the east-facing slope of the major drainage extending to the west of the SW end of the airstrip, below the crest of the spur, but still on a fairly gradual slope, nearly 1,450 m NW of intersection of 56°38′W 64°15′S and approx. 900 m SW of 56°38′W and 64°14′S. Very locally derived slump blocks, exposure about 3–4 m by 1–2 m, about 1 m in thickness; dark, indurated silty shales, numerous comatulid crinoids (*Notocrinus rasmusseni*), numerous scattered ophiuroids, brachiopods, scattered mollusks.

94-31.—*Zoroaster, Ctenophoraster*; see 94-02.

94-33.—W Very steep SW-facing slope a few m west of 56°40′W nearly 800 m south of the intersection of 56°40′W and 64°14′S; a distinctive, sloping, NW-SE-trending flat surface is at the top of the slope and immediately E of 56°40′W; abundant *Zoroaster* collected from several m of evenly bedded sands, approx. 5 m above floor of gulch.

94-34.—W NW-facing slope approx. 2 m above gulch floor approx. 800 to 850 m SE of intersection of 56°41′W and 64°14′S and 600 m SW of the intersection of 40′W and 14′S; few *Zoroaster* collected from Eocene slump blocks in channel sands.

94-35.—Two float blocks, Ruby Hill; ophiuroid assemblages.

94-36.—E Near base of steep, N-facing, freshly slumping slope, immediately above main gully floor, approx. 90 m SW of 94-12. Approx. 3.5 m of sand below 0.5 m burrowed, indurated interval *Ctenophoraster*, crinoid fragments, bone fragments, brachiopods.

94-38.—E Unconsolidated, sandy, steep, northeast-facing slope approx. 2–4 m above bottom of steep secondary gulch, approx. 500 m southwest of entrance to second principal drainage south of Larsen Cove and 400 m northeast of third principal drainage, 50–100 m northwest of foot of seacliff face, between 600 and 650 m NE of 56°36′W and 64°15′S; scattered crinoids, brachiopods, fish vertebrae.

94-39.—E A sharp ridge less than 50 m east of the intersection of 56°38′W and the sea cliffs immediately N of the sea cliff face; one *Zoroaster*.

94-40.—W SW-facing slope of Ruby nose between 900 and 950 m NE of intersection of 56°40′W and 64°15′S and 950 and 1,000 m SE of 56°40′W and 64°14′S. Rubble slope with indurated coquina horizons dominated by a very small, undescribed; traces of *Zoroaster*?