

A New Species of Gorgonian Octocoral from the Mesophotic Zone off the Central Coast of California, Eastern Pacific with a Key to Related Regional Taxa (Anthozoa, Octocorallia, Alcyonacea)

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Recent offshore benthic surveys utilizing Remotely Operated Vehicles in the National Marine Sanctuaries along the California coastline under the auspices of the National Oceanic and Atmospheric Administration and the Ocean Exploration Trust, have yielded newly collected material and imagery of octocoral cnidarians from mesophotic and deep-sea habitats. As part of this effort, a new species of gorgonian coral is here described that was first observed at Cordell Bank, approximately 112 km WNW of San Francisco. The species is allocated to the gorgonian genus *Chromoplexaura* based on morphological considerations, and has since been collected or observed from four localities in central and southern California, 86–107 m in depth.

KEYWORDS: Corals, sea fans, gorgonian octocorals, Central California, Cordell Bank, mesophotic zone, taxonomic key to the genus and related taxa.

Chromoplexaura is currently regarded as a monotypic octocoral genus (Cordeiro et al. 2018c), represented by *C. marki* (Kükenthal, 1913), and is distributed from central Oregon to southern California on the west coast of North America. Bathymetric distribution of this species varies from nine to at least 90 m (Williams 2013). The new species described here represents a second species of the genus and is known from central to southern California with a depth range of 86 to 106 m.

The two species currently share several morphological similarities. Herein we describe a new species that was first observed, but not collected in 2007 by ROV imagery at Cortes Bank in southern California, near the border between California and Mexico. In 2017, colonies were observed (also not collected) by ROV in the Cordell Bank National Marine Sanctuary in central California. In 2018, four specimens were collected by ROV and one was recorded by benthic ROV imagery on board the National Oceanic and Atmospheric Administration (NOAA) ship FSV *Bell M. Shimada*, at three locations in central and southern California: Cordell Bank NMS, Monterey Bay NMS, and Channel Islands NMS.

MATERIALS AND METHODS

The type material was collected during the benthic surveys of Cordell Bank and Greater Farallones National Marine Sanctuaries on board the NOAA ship FSV *Bell M. Shimada* (Fig. 1), between 28 July and 11 August 2018. The holotype and paratypes of the new species are deposited in the marine invertebrate collections of the Department of Invertebrate Zoology and Geology at the California Academy of Sciences in San Francisco, California. Underwater video and still imagery were taken on board the ship by NOAA and MARE staff. Images of preserved material and scanning electron micrographs were taken by the first author at the California Academy of Sciences in 2018.

Abbreviations used in the text are as follows: FSV – Fisheries Survey Vessel, MARE – Marine Applied Research and Education; CASIZ – California Academy of Sciences Invertebrate Zoology; CBNMS – Cordell Bank National Marine Sanctuary; MBNMS – Monterey Bay National Marine Sanctuary; CINMS – Channel Islands National Marine Sanctuary; NMS – National Marine Sanctuary; NOAA – National Oceanic and Atmospheric Administration; ROV – Remotely Operated Vehicle.

Depths used in the text include: Shallow-water (0–40 m); Mesophotic (40–150 m); Deep-Sea (>150 m).

Material used for comparative purposes: *Chromoplexaura marki*; CASIZ 190436; NOAA Sample S-17; Gulf of the Farallones National Marine Sanctuary, Rittenburg Bank (37.88°N 123.32°W); 89.4 m depth; 08 October 2012; ROV Beagle (MARE) from R/V Fulmar (NOAA); three terminal branches, wet-preserved in 95% ethanol. *Euplexaura* sp.; CASIZ 220608; Western Pacific Ocean, Caroline Islands, Palau (7.54°N 134.47°E); 7–31 m depth; 08 December 2016; cool G.C. Williams; one partial colony, wet-preserved in 95% ethanol. *Swiftia torreyi*; CASIZ 220958; Cordell Bank National Marine Sanctuary (37.98°N 123.49°W); 948.82 m depth; 10 August 2017; ROV Hercules/Argus from E/V Nautilus; one whole colony, wet-preserved in 95% ethanol.



FIGURE 1. The National Oceanic and Atmospheric Administration (NOAA) Fisheries Survey Vessel, FSV *Bell M. Shimada*, conducts fisheries and oceanographic research throughout the Pacific coast of the United States. All type specimens of the new coral species described herein were collected by Remote Operational Vehicle (ROV) on board this ship in 2018. Photo by Gary C. Williams.

SYSTEMATIC ACCOUNT

Subclass Octocorallia Haeckel, 1866**Order Alcyonacea Lamouroux, 1812****Family Plexauridae Gray, 1859*****Chromoplexaura* Williams, 2013**

Euplexaura Kükenthal, 1913:266; 1924:93.

Chromoplexaura Williams, 2013:17.

GENERIC DIAGNOSIS.— Growth form planar and sparse, branching lateral. Retracted polyps form low rounded protuberances, mound-like to hemispherical in shape. Polyps are present on all sides of the branches, but can be arranged biserially on some narrow terminal branches. Coenenchymal sclerites are primarily robust warty spindles, somewhat ovoid in shape or approaching girdled spindles. Other sclerite types that may be present include radiates, crosses, and spindles with a median waist that approach capstans. Anthocodial sclerites are rods that are straight or curved to sinuous. Colony color red or yellow due to conspicuous color of the sclerites.

TYPE SPECIES.— *Euplexaura marki* Kükenthal, 1913.

***Chromoplexaura cordellbankensis* Williams and Breedy, sp. nov.**

Figures 2–10.

HOLOTYPE.— CASIZ 228195; NOAA Sample SH-18-09-017; Cordell Bank, Cordell Bank National Marine Sanctuary, CBNMS Transect-127; ca. 51 km W. of Point Reyes Peninsula (38°03'15.465"N 123°28'48.072"W); 100.5 m depth; 08 August 2018; ROV Beagle (MARE) from FSV *Bell M. Shimada* (NOAA); one partial specimen (missing holdfast), wet-preserved in 95% ethanol.

PARATYPES.— CASIZ 228194. NOAA Sample SH-18-09-016; Cordell Bank, Cordell Bank National Marine Sanctuary, CBNMS Transect-127; ca. 51 km W. of Point Reyes Peninsula, California, USA (38°03'15.915"N 123°28'49.874"W); 101.6 m depth; 08 August 2018; ROV Beagle (MARE) from FSV *Bell M. Shimada* (NOAA); one partial specimen (14 mm long branch fragment), wet-preserved in 95% ethanol. CASIZ 207519; La Cruz Canyon, Monterey Bay National Marine Sanctuary; California, USA (35.7694°N 121.4475°W); 106.8 m depth; 28 October 2018; coll. by ROV on board FSV *Bell M. Shimada* (NOAA); one whole specimen. CASIZ 207520; Anacapa Island, Channel Islands National Marine Sanctuary; California, USA (33.992°N 119.3722°W); 86 m depth; 31 October 2018; coll. by ROV on board FSV *Bell M. Shimada* (NOAA); one specimen in two pieces.

HABITAT AND DISTRIBUTION.— Found on rugose, rocky substrata often with conspicuous vertical relief, or on rounded boulders in boulder fields (Fig. 3). Distributed off the central and southern coasts of California, between 38.2° and 32.5°N latitude (Figs. 8–9); at mesophotic depths between 86 and 107 m. The type locality is Cordell Bank in the Cordell Bank National Marine Sanctuary, ca. 70 miles WNW of San Francisco, California, 100 m depth.

ETYMOLOGY.— The specific epithet is derived from Cordell Bank and the Latin suffix *-ensis* (belonging to); referring to the region of discovery of the new species and collection of the holotype – Cordell Bank National Marine Sanctuary.

DESCRIPTION OF THE HOLOTYPE

EXTERNAL MORPHOLOGY.— The holotype is part of a colony, 35 mm in length. The holdfast

and basal portion of the colony are missing. Branching is sparse and lateral. The main stem gives rise to two lateral side branches, about 9 mm apart and 2–2.5 mm in diameter (including polyp mounds). The longest branch is 3.4 mm in length (Fig. 2). The retracted polyps form low-rounded to hemispherical polyp mounds, each < 1 mm in length. The polyps are largely distributed biserially on the thinner distal-most portions of branches (Fig. 2B), but occur all around the stouter and more basal parts of the lateral branches and main stem (Fig. 2E). There are approximately ten mounds per cm of branch length. Finger-shaped portions of the coenenchyme-covered internal axis extend from the apical tips of some branches (Fig. 2B).

ANTHOCODIAE.—Most of the anthocodiae are preserved totally retracted into the polyp mounds, while a few are partially exerted. The walls of the anthocodiae and bases of the tentacles are relatively densely set with narrow rods that have conspicuous tuberculation (Fig. 7). Due the retracted condition of the polyps, an *en chevron* arrangement of sclerites was not observed or easily apparent. The sclerites of the anthocodiae are lighter in color than the coenenchymal sclerites, many appearing virtually colorless, thus resulting in a white coloration of the polyps.

The polyp mounds are represented by conspicuous rounded protuberances along the branches, usually expanded at the base while some are hemispherical in shape. Adjacent polyp mounds are generally separated by about 1.0–1.5 mm of bare rachis, and vary in width from 1.5–2.0 mm at the base, and are usually less than 1.0 mm in height (Fig. 2).

SCLERITES.—Coenenchymal sclerites vary from 0.06 to 0.22 mm in length (Figs. 4–6, 10A). They are predominantly wide, warty spindles with heavily warted tubercles, while some are narrower with less ornamentation (Figs. 4–5, 10A). Radiates and various immature forms are also present (Fig. 6).

Polyp sclerites are elongate rods (Fig. 7), often slightly curved or sinuous with variable tuberculation, while some are weakly club-shaped (Fig. 7, left). Small, flat rods (Fig. 7, center) are also present and could possibly be from the tentacles. Polyps sclerites vary in length from 0.08–0.24 mm in length.

COLOR.—Coenenchyme color is uniform lemon yellow throughout (Figs. 2–3), due to the conspicuous yellow coloration of the sclerites (Fig. 2F). The anthocodiae are colorless (Fig. 2E).

REMARKS

VARIATION: Although the holotype specimen exhibits only three branches including the main stem, the paratypes as well as additional colonies observed in underwater still images taken by ROV, all exhibit relatively sparse branching, but may possess as many as ten branches including the main stem. One of the paratype colonies (CASIZ 207519), branches up to four times and produces seven lateral branchlets.

DISCUSSION AND CONCLUSION

Key to species of *Chromoplexaura* and related taxa in California

- 1a. Colonies planar and sparsely branched. Coenenchymal sclerites are broad to ovoid spindles with densely set tubercles, capstans, girdled spindles, elongated radiates, and/or tuberculated crosses 2
- 1b. Colonies unbranched to copiously branched or bushy. Coenenchymal sclerites may include elongate to needlelike spindles, compact radiates, double discs, and/or disc spindles. 3
- 2a. Colonies red. Coenenchymal sclerites include ovoid spindles and girdled spindles
. *Chromoplexaura marki* (Kükenthal, 1913)

- 2b. Colonies yellow. Coenenchymal sclerites include capstans, elongated radiates, and crosses *Chromoplexaura cordellbankensis* sp. nov.
- 3a. Colonies unbranched or Y-shaped 4
- 3b. Colonies branched – copiously branched or bushy 5
- 4a. Colonies white; polyp mounds low-rounded. *Swiftia farallonesica* Williams & Breedy, 2016
- 4b. Colonies coral red to dark red. Polyp mounds prominent – conical to low cylindrical. *Swiftia simplex* (Nutting, 1909)
- 5a. Branching bushy, polyp mounds prominent – conical to cylindrical 6
- 5b. Branching sparse, polyp mounds low-rounded. Colonies coral red with white polyps *Swiftia spauldingi* (Nutting, 1909)
- 6a. Polyp mounds truncated conical; sclerites are radiates and elongate spindles with rounded tubercles *Swiftia torreyi* (Nutting, 1909)
- 6b. Polyp mounds stout, conical to cylindrical; sclerites are primarily elongate spiny spindles, often needle-like and curved *Swiftia kofoidi* (Nutting, 1909)

TAXONOMIC ASSESSMENT

The genus *Chromoplexaura* is superficially similar to several Pacific coast *Swiftia* species. The latter is currently regarded as a gorgonian genus of twenty species (Cordeiro et al. 2018b). The type species of *Swiftia* is *Swiftia exserta* (Ellis and Solander, 1786) from the western Atlantic Ocean. Several species from the Pacific coast of the Americas have been allocated to the genus *Swiftia*, and it is not clear at present whether the Atlantic vs. Pacific species represent the same genus or separate genera (Williams 2013:17). In addition, there appears to be two distinguishable groups of eastern Pacific species of *Swiftia* based on morphological characteristics. Preliminary molecular analyses (Everett and Park 2018; Everett, personal communication) have shown that the two groups (*Chromoplexaura* and *Swiftia*) have not exhibited a conspicuous differentiation, but from the morphological point of view are different (Fig. 10A, B, D). An overall detailed molecular analysis and morphological comparison are necessary to provide a cogent taxonomic assessment of the relevant taxa.

Chromoplexaura cordellbankensis sp. nov. shares superficial morphological similarities with some species of Eastern Pacific *Swiftia* regarding external morphology – such as branching pattern, low-rounded to hemispherical polyp mounds, and elongate-tubercated anthocodial sclerites. However, the coenenchymal sclerites differ markedly from those of *Swiftia*, while most closely resembling the sclerite complement of *Chromoplexaura marki* (Williams, 2013:20–21) – i.e. the presence of robust to ovoid, highly warty spindles in the coenenchyme, which are not found in species of *Swiftia* (Fig. 10A, B, D).

Chromoplexaura marki was originally placed in the Indo-Pacific genus *Euplexaura* by Kukenhal, 1913. However, the coenenchymal sclerites of *Euplexaura* species differ markedly from the two California species of *Chromoplexaura*, by the possession of tuberculate spheroids, subspheroids, double heads, and plump ovoid to irregular spindles (Fig. 10C; Fabricius and Alderslade 2001:190; Williams 2013:21, 24).

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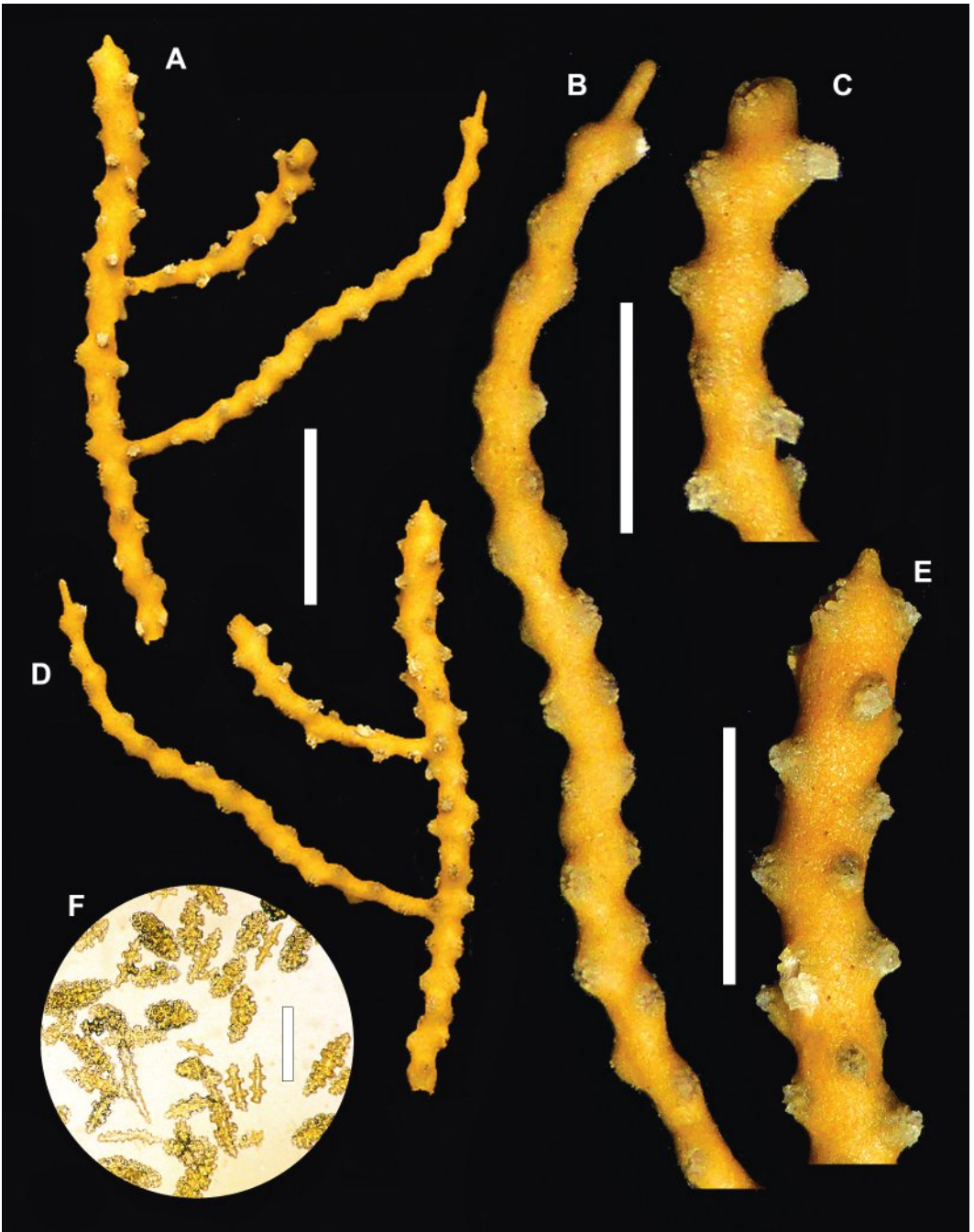


FIGURE 2. *Chromoplexaura cordellbankensis* sp. nov. Wet-preserved holotype, external morphology. A, D. Partial colony, scale bar = 10 mm. B. Detail of the proximal branch, scale bar = 5 mm. C. Distal apex region of the middle branch, scale bar = 5 mm. E. Apex region of the main stem, scale bar = 5 mm. F. Compound microscope view of sclerites at 100x magnification, showing yellow coloration, scale bar = 0.2 mm.

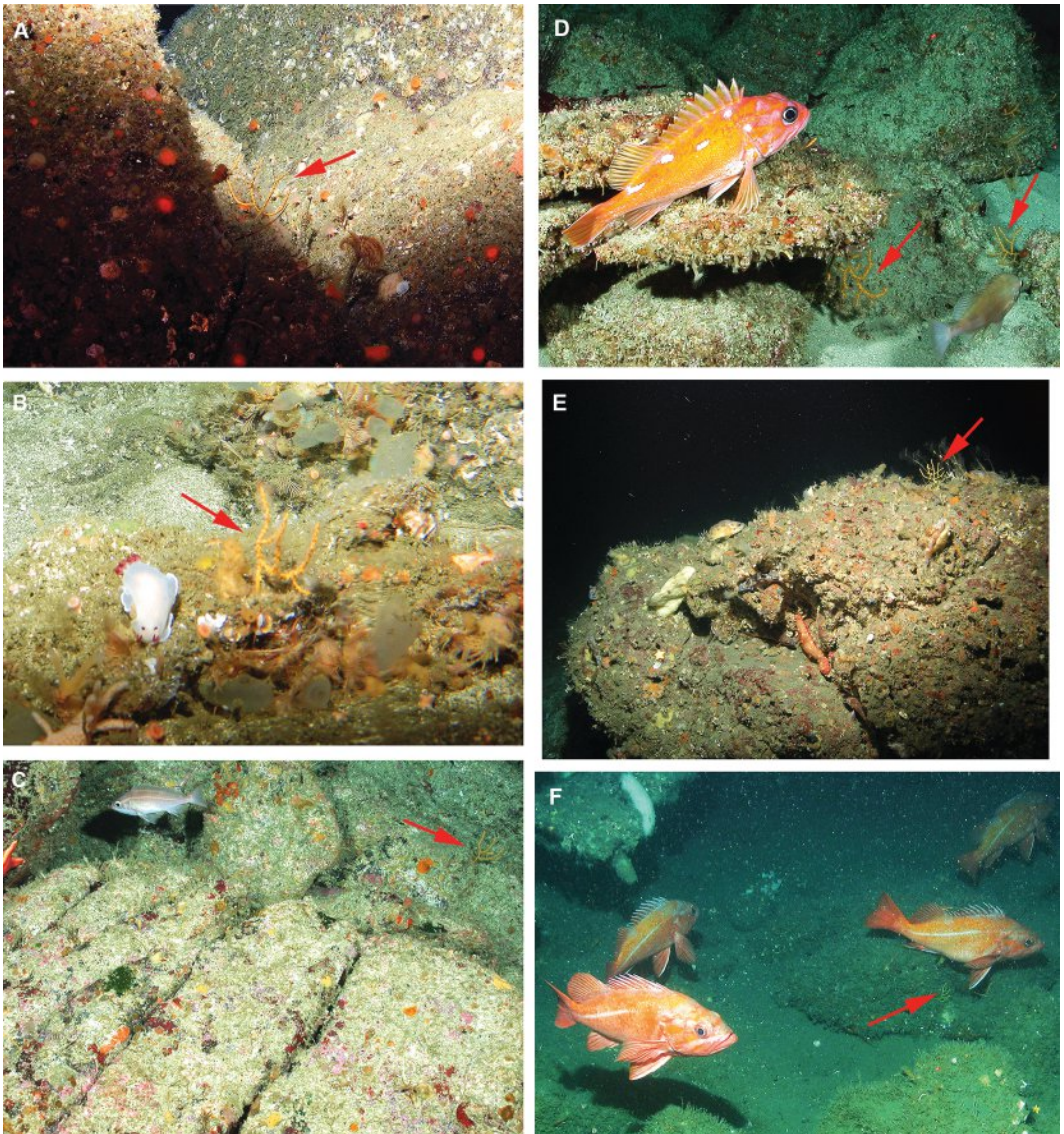


FIGURE 3. *Chromoplexaura cordellbankensis* sp. nov. Underwater photographs taken *in situ* by Remotely Operated Vehicles (ROVs), showing individual colonies of the new species (red arrows) with surrounding habitat. A. Image taken at Cordell Bank National Marine Sanctuary near the type locality, ca. 100 m depth, 8 August 2018. B. Image taken at Cordell Bank National Marine Sanctuary near the type locality, 102 m depth, 8 August 2018, with a nudibranch mollusk (*Dendrodoris azineae*) to the immediate left. C. Image taken at Cortes Bank, ca. 166 km west of Point Loma San Diego, 70 m in depth, 7 September 2007. D. Image taken at Cortes Bank, ca. 166 km west of Point Loma San Diego, 70 m depth, 8 September 2007. E. Image taken at La Cruz Canyon, Monterey Bay National Marine Sanctuary, 106.8 m depth, 28 October 2018. F. Image taken at Anacapa Island, Channel Islands National Marine Sanctuary, 86 m depth, 31 October 2018. Photographs courtesy of National Oceanic and Atmospheric Administration.

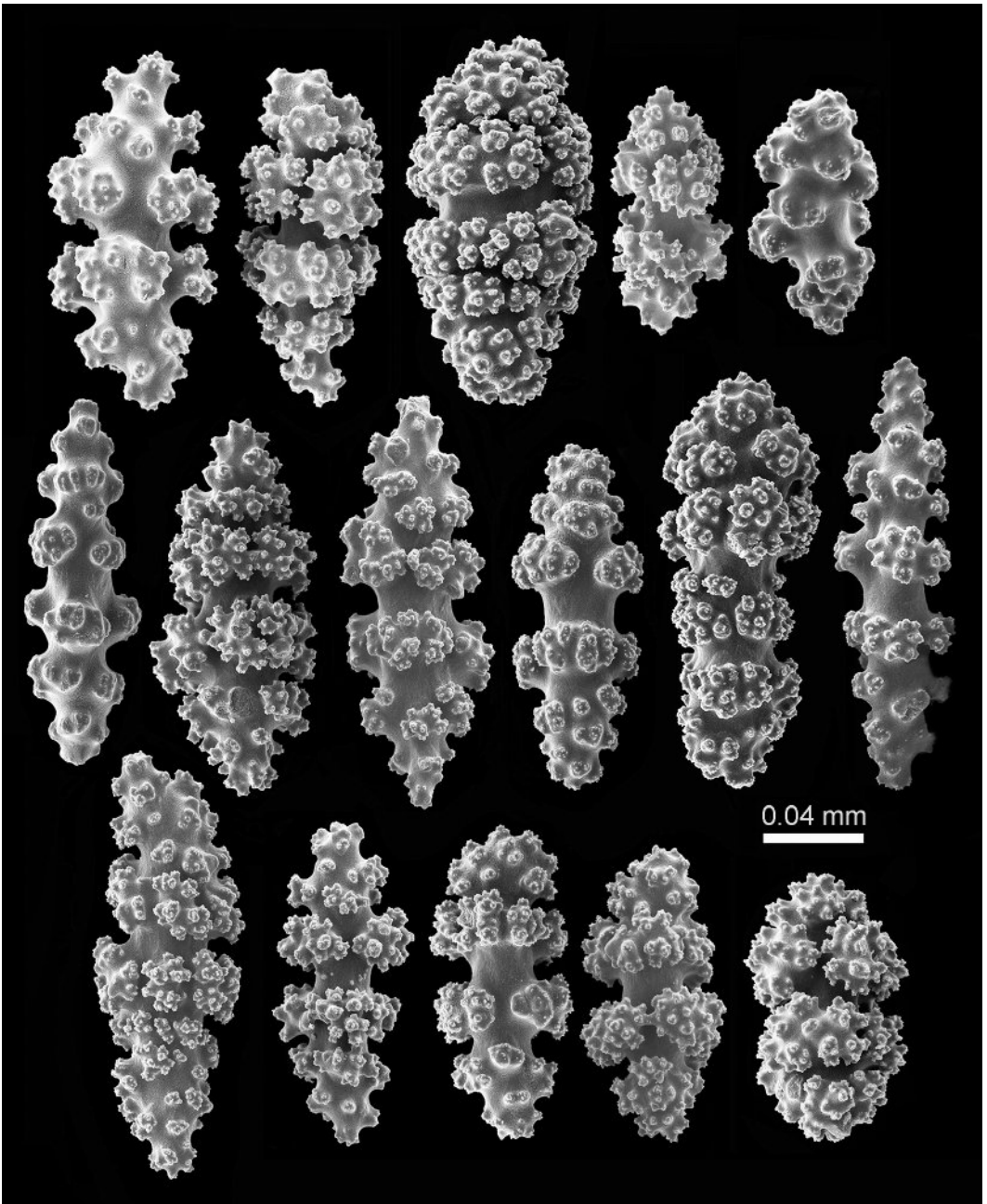


FIGURE 4. *Chromoplexaura cordellbankensis* sp. nov. Scanning electron micrographs of coenenchymal sclerites – warty spindles. Scale bar = 0.04 mm.

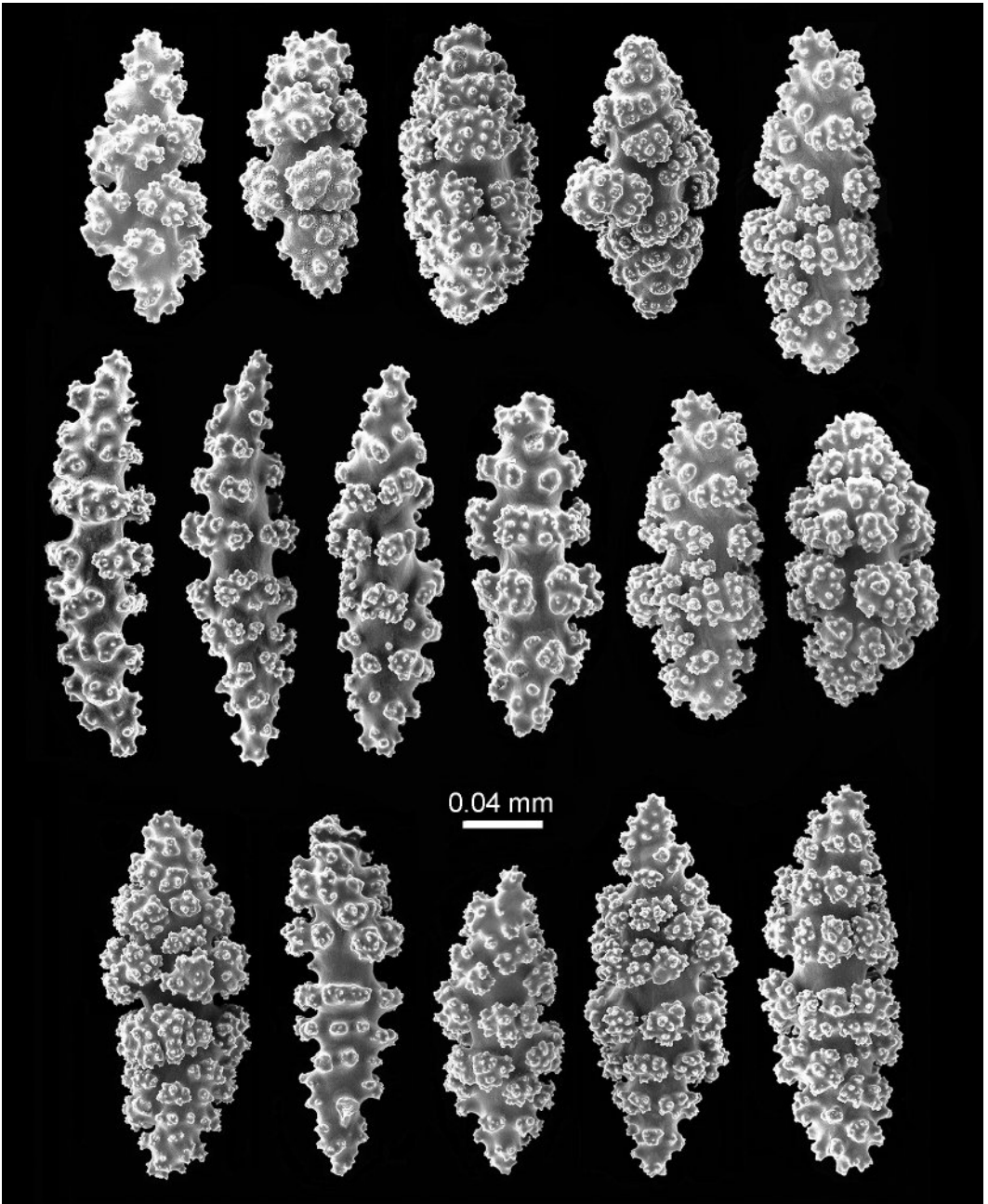


FIGURE 5. *Chromoplexaura cordellbankensis* sp. nov. Scanning electron micrographs of coenenchymal sclerites – warty spindles. Scale bar = 0.04 mm.

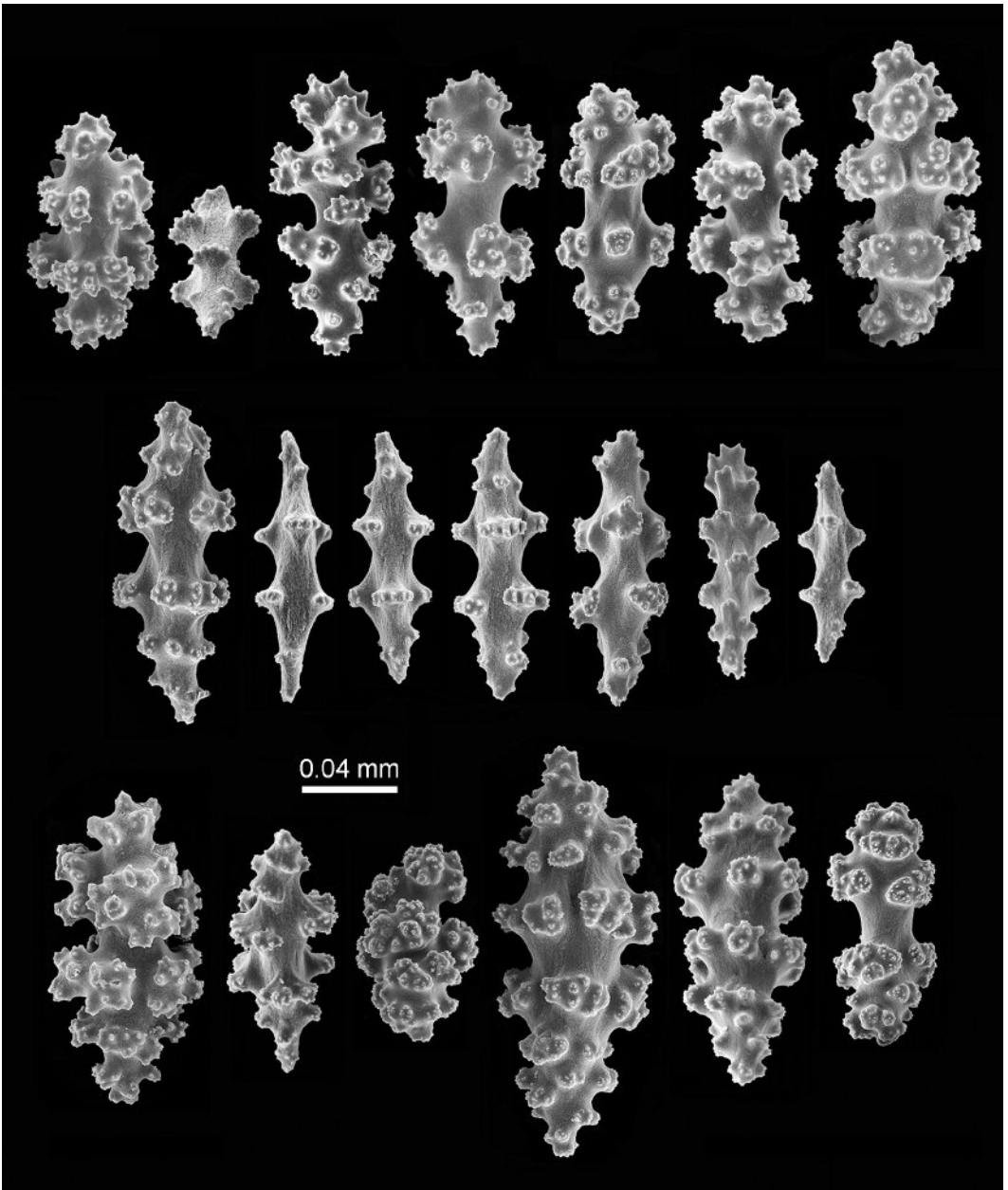


Figure 6. *Chromoplexaura cordellbankensis* sp. nov. Scanning electron micrographs of coenenchymal sclerites – radiates (top row) and various immature sclerites (middle and bottom rows). Scale bar = 0.04 mm.

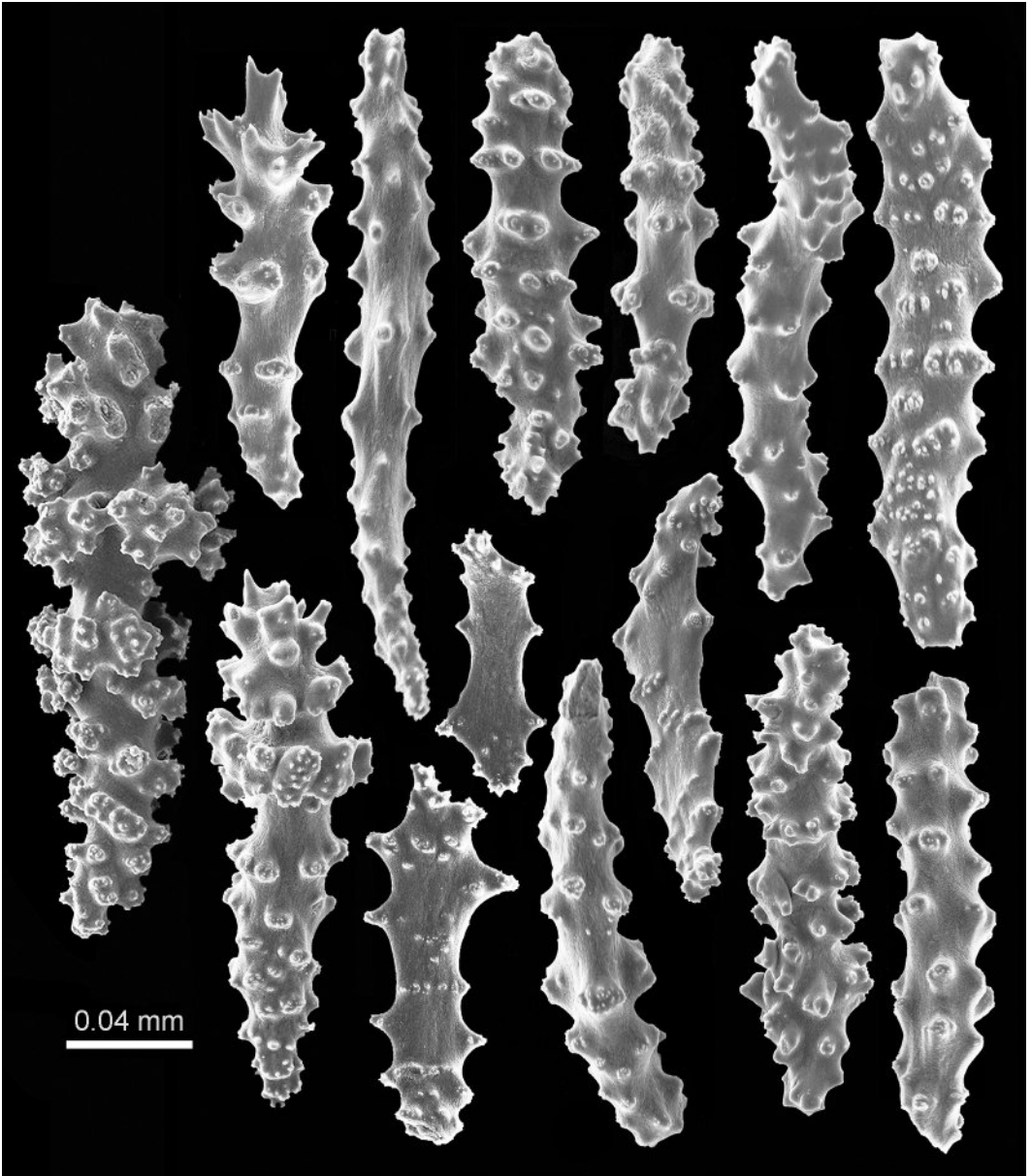


FIGURE 7. *Chromoplexaura cordellbankensis* sp. nov. Scanning electron micrographs of polyp sclerites. Scale bar = 0.04 mm.

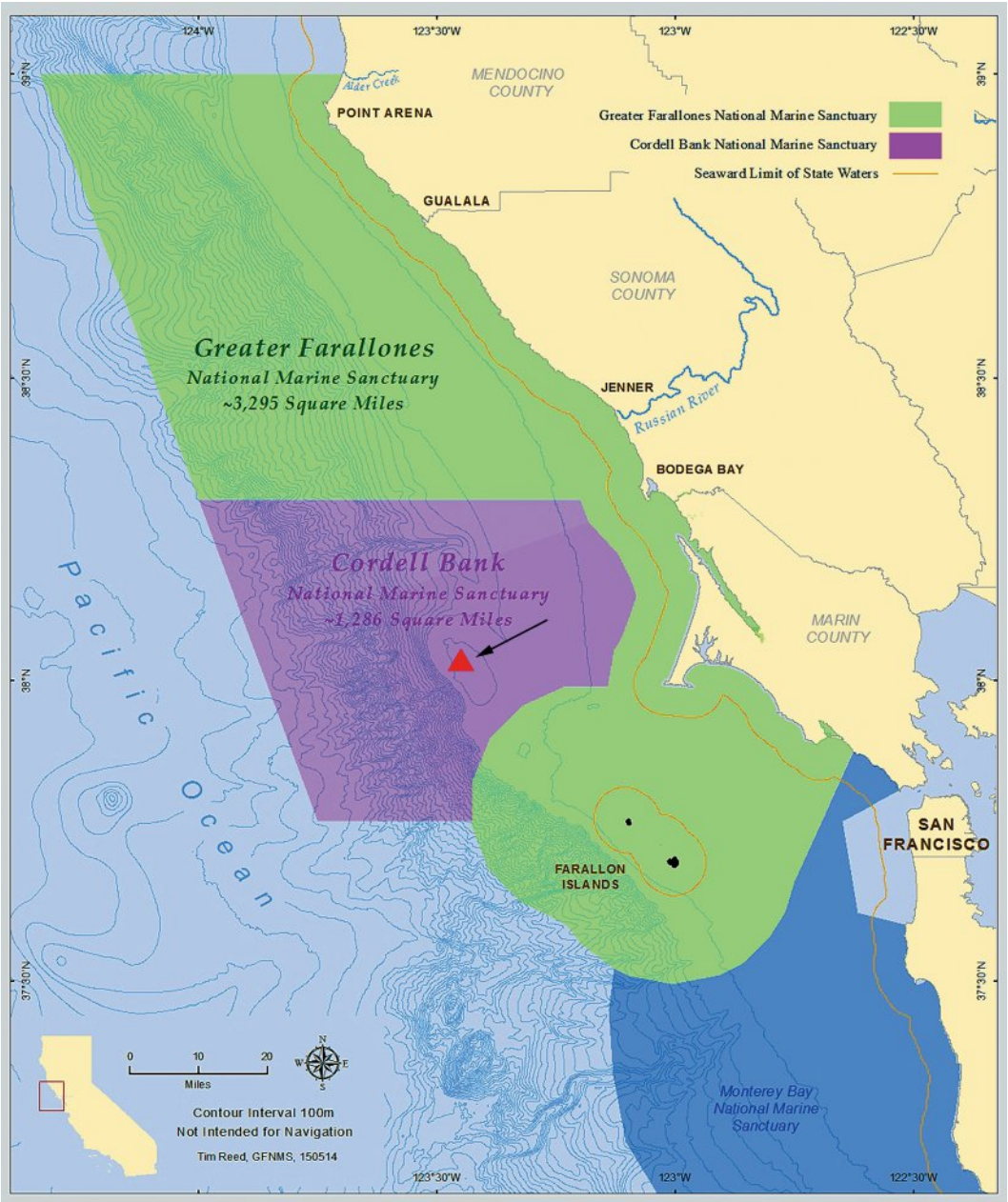


FIGURE 8. Map of Cordell Bank National Marine Sanctuary (central California); type locality of *Chromoplexaura cordellbankensis* sp. nov. (red triangle). Map adapted from National Oceanic and Atmospheric Administration (2014).



FIGURE 9. Map of the Pacific coast of the United States showing the geographical ranges of *Chromoplexaura marki* (●) and *Chromoplexaura cordellbankensis* sp. nov. (●); arrow denotes type locality.

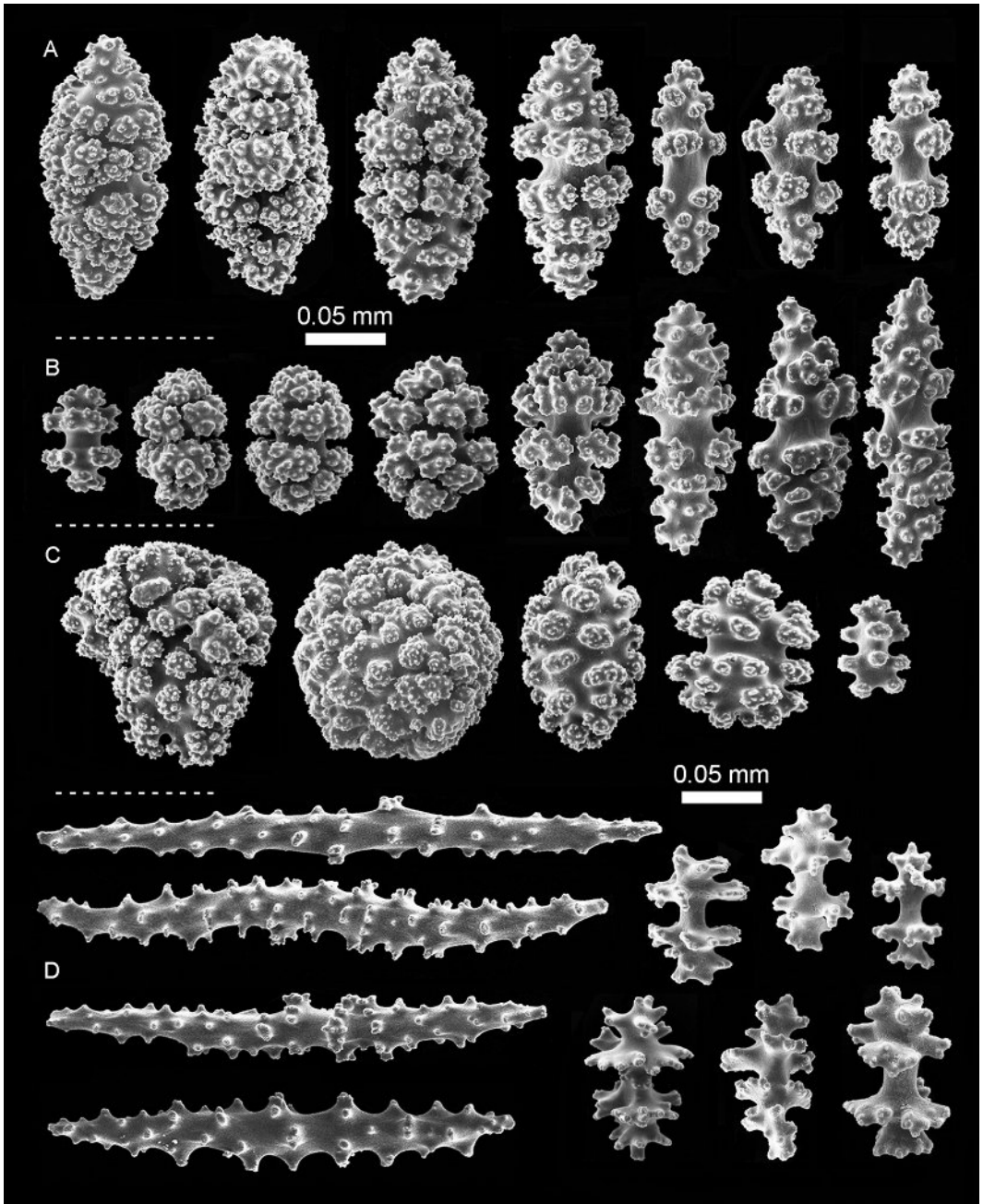


FIGURE 10. Scanning electron micrographs of coenenchymal sclerites. A. *Chromoplexaura cordellbankensis* sp. nov. (CASIZ 228194). B. *Chromoplexaura marki* (CASIZ 190436). C. *Euplexaura* sp. (CASIZ 220608). D. *Swiftia torreyi* (CASIZ 220958). Scale bars = 0.05 mm.