The nephtheid soft coral genus *Gersemia* Marenzeller, 1878, with the description of a new species from the northeast Pacific and a review of two additional species (Octocorallia: Alcyonacea)

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A new species of nephtheid soft coral inhabiting the northeast Pacific Ocean is described from samples collected using remotely operated vehicles (ROVs) and a benthic trawl. Two hundred thirty ROV video observations provide additional information about the biogeographical distribution and habitat characteristics of this new species and are used to supplement the information ascertained from collected specimens. The species described herein is found through a broad range of depths (519-2034 m), has been observed through a latitudinal range of approximately 1581 km (33.10472°N; 47° 51.412'N), and has primarily been observed living upon hard-rock substrate. In addition, we revise the generic designation of the South African nephtheid *Litophyton liltvedi* and we address the status of the Northeast Pacific nephtheid previously referred to as *Gersemia rubiformis*.

Introduction

Soft corals of the family Nephtheidae have received limited attention in recent literature. Since morphological characters of several genera have been shown to overlap, revisionary systematics of much of the family is necessary (L.P. van Ofwegen, pers. comm., and Ofwegen & Groenenberg, 2007). Three nephtheid genera have recently been described, *Pacifiphyton* Williams, 1997, *Leptophyton* Ofwegen & Schleyer, 1997, and *Chromonephthea* Ofwegen, 2005.

Species in the genus *Gersemia* are cold-temperate to polar taxa, ranging from 21 m to depths over 2000 m (present paper). The descriptions of *G. antarctica* and *G. marenzelleri* (Kükenthal 1906a and Kükenthal 1906b, respectively) are the most recent descriptions of species belonging to this genus, with the exception of the new and revised species described here. The remaining nine species were described between 1806 and 1900.

Throughout the past twenty years, the Monterey Bay Aquarium Research Institute (MBARI) has been using remotely operated vehicles (ROVs) to explore the deep in the Monterey Bay and other locations in the northeast Pacific Ocean. ROV surveys at nearby seamounts and dive sites within Monterey Canyon have yielded many new species descriptions recently, including several gorgonian corals (Cairns, 2007) and an unusual predatory sponge, *Cladorhiza pteron* (Reiswig & Lee, 2007).

The new species of *Gersemia* described in this paper was first discovered and collected at Rodriguez Seamount in 2004 and has since been observed and collected at other seamounts off the coast of California, in Monterey Canyon, and on the continental slope off northern California, central Oregon, and northern Washington (fig. 1).

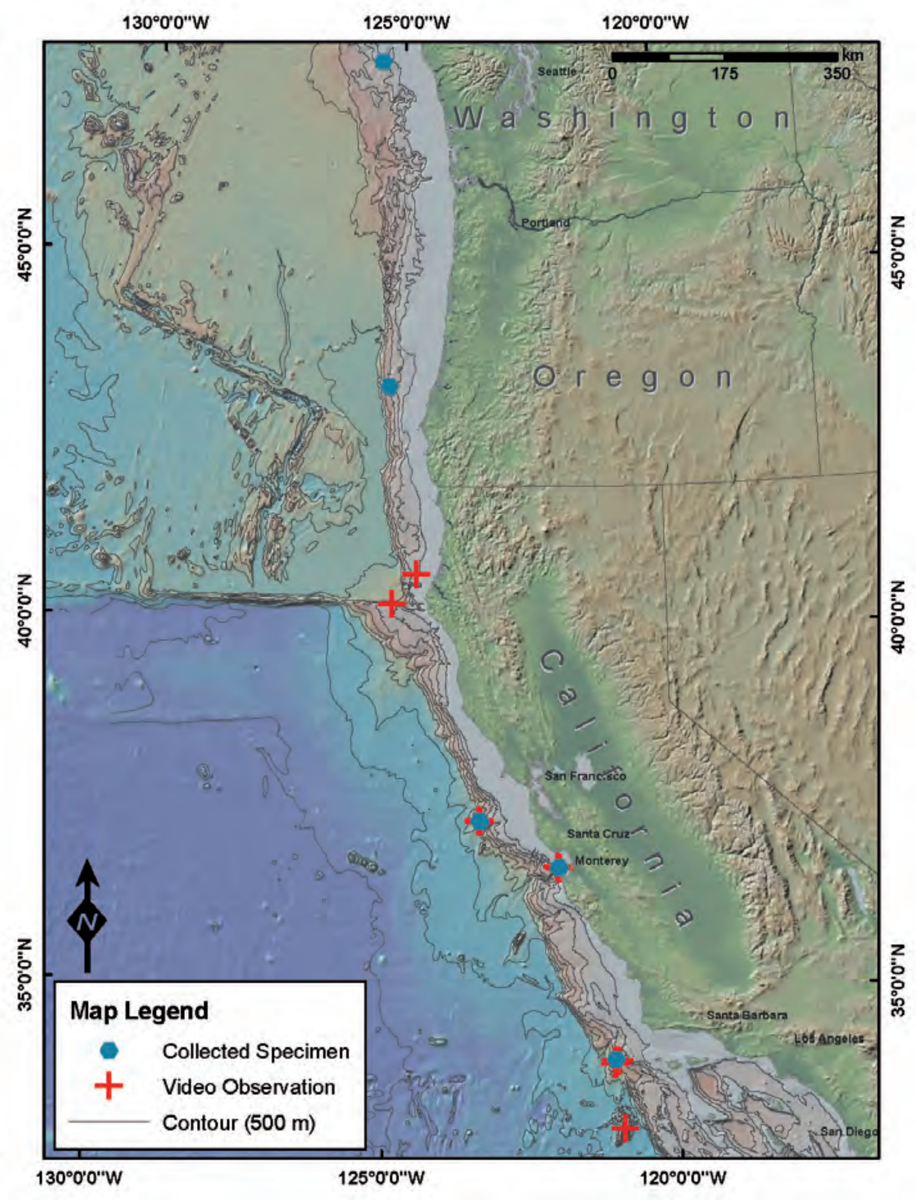


Fig. 1. Distribution of *Gersemia juliepackardae* spec. nov. Light-blue hexagon represents locations of collected specimens. Red cross represents specimens observed in ROV video only. Contours are 500 m.

Material and methods

Most of the type material was collected using ROV manipulators and is preserved in 75% ethanol. One specimen (CAS 175885) was originally fixed in 10% seawater formalin and later transferred to 75% ethanol. In addition to the specimens collected by ROVs, approximately twelve specimens representing one lot were recently found in the invertebrate zoology collection of California Academy of Sciences (CAS). These specimens were collected by benthic trawl off the Oregon coast in 1973 and were preserved in 75% ethanol. We have found this material to be conspecific with the new taxon. Microscopes used in this study include a Nikon SMZ-10 dissecting microscope, an Olympus CH-2 compound microscope, and a Leo 1400 series scanning electron microscope.

In situ observations of living colonies were made using high-resolution video (Ikegami HDL-40 and Panasonic WV-E550) and digital still (Nikon Cooplpix 990) cameras (figs. 2, 3). Over 250 hours of video recordings from San Juan, Rodriguez, Davidson and Pioneer Seamounts, Monterey Canyon, and the continental slope off northern California were reviewed using MBARI's Video Annotation Reference System, VARS (Schlining & Jacobsen Stout, 2006). Living *Gersemia* colonies and associated habitats were identified in video and added to the searchable VARS database. Within VARS, these video observations were merged with ancillary data (latitude, longitude, depth, temperature, and oxygen concentration) that were collected by the ROV at the time of deployment. The VARS query was used to export video observation data for analysis and the data were mapped using ArcGIS 9.3. In addition, six video transects were collected to estimate organism density (Monterey Canyon n=5; Pioneer Seamount n=1). Two parallel red lasers (640 nm) positioned 29 cm apart were used to estimate transect width. Transect length was calculated in ArcView® 3.2 using the Animal Movement Analysis Extension, Version 2, which was used to calculate successive distance between the start and end points of each transect (Hooge & Eichenlaub, 1997).

Systematics

Class **Anthozoa** Ehrenberg, 1831
Subclass **Octocorallia** Haeckel, 1866
Order **Alcyonacea** Lamouroux, 1812
Family **Nephtheidae** Gray, 1862
Gersemia Marenzeller, 1878

Description.— Colonies erect, arborescent from one main stalk. Polyps relatively congested at the ends of short and narrow terminal branches, an effect that is observed more readily in wet preserved specimens. Polyps non-retractile with calyces, supporting bundles of polyps, and polyp crowns absent. Polyp points present: the polyp walls and tentacle rachises usually with numerous sclerites. Points of the polyp walls sometimes arranged more-or-less *en chevron*. Stalk sclerite complement commonly includes modified or irregularly-shaped capstan-like structures. Sclerites often coloured. Species azooxanthellate. Worldwide distribution in temperate to polar regions, mostly in colder waters, up to over 1200 meters in depth.

Type species.— *Gersemia loricata* Marenzeller, 1878: 377.

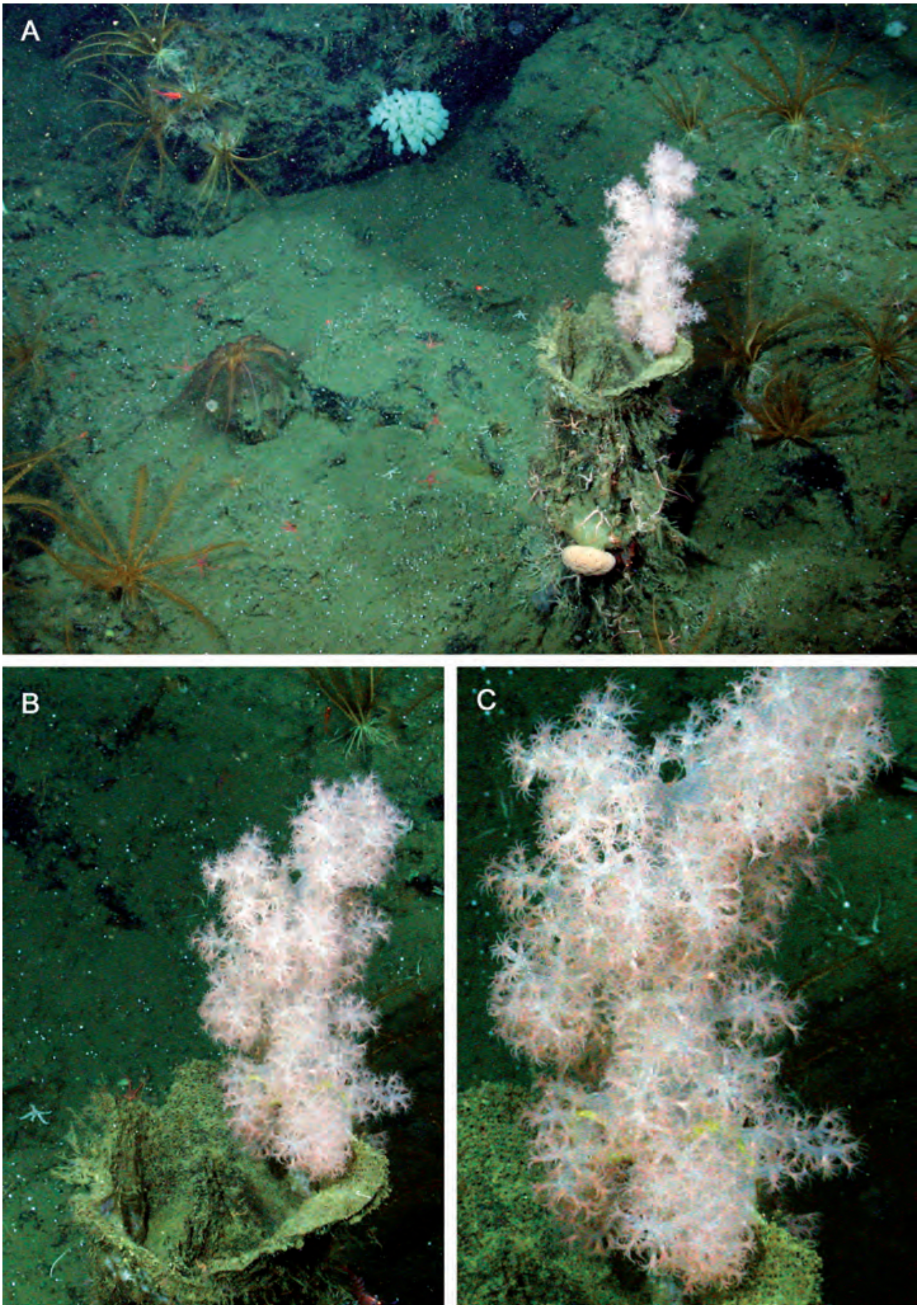


Fig. 2. *In situ* digital still images of the *Gersemia juliepackardae* spec. nov.; A. Image of the holotype growing on a dead sponge. Numerous ophiuroids are also seen living upon the sponge; other organisms visible in the image include the white sponge, *Sclerothamnopsis compressa* (left, background), the soft coral, *Anthomastus ritteri* (at base of dead sponge), and numerous crinoids, *Florometra serratissima*. B. Close-up image of the holotype. C. Detail of the holotype. Scale bar in 2A: distance between red laser points = 29 cm.

Gersemia juliepackardae spec. nov.
(figs 2, 3, 4A-B, 5, 6, 7)

Material examined.— Holotype CASIZ 175883; Sample Number T1101-A4; U.S.A., central California, Pioneer Seamount (37.37255 N 123.403252 W); 1004.9 m; 19.vi.2007; MBARI - David A. Clague; one whole specimen attached to a fragment of dead sponge. Paratype CASIZ 175884; Sample Number V3191-A1; U.S.A., central California, Monterey Canyon (36.720495° N 122.005016° W); 1186 m; 10.iv.2008; MBARI - James P. Barry; one whole specimen removed from granitic rock substratum. Paratype RMNH Coel. 39007; Sample Number T1100-A12; U.S.A., central California, Pioneer Seamount (37.368573° N 123.39311° W); 1253 m; 18.vi.2007; MBARI - David A. Clague; one fragment sampled from volcanic lava substratum.

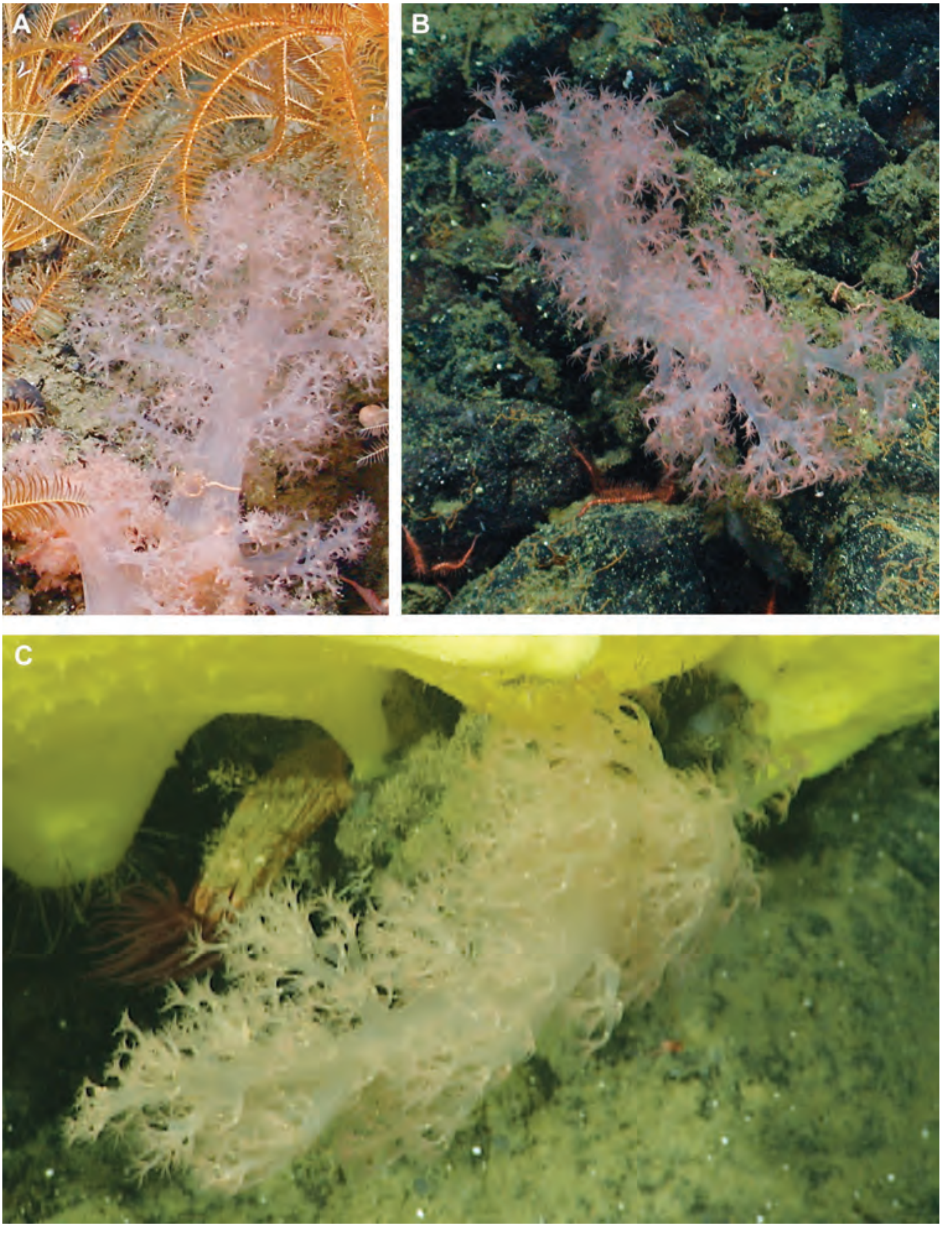
Other material: CASIZ 175885; Sample Number T661-A2; U.S.A., southern California, Rodriguez Seamount (34.055796° N 121.084348° W); 889 m; 28.iv.2004; MBARI - David A. Clague; one fragment sampled from volcanic lava substratum. CASIZ 134171; Field Number OTB-500; U.S.A., central Oregon, off shore (43.00° 21.60′ N; 125.00° 10.20′ W); 1600 m; 4.iv.1973; A. Carey Jr. on board R/V *Cayuse* via trawl; ca. 12 whole specimens. CASIZ 179446; Container Number 779; U.S.A., northern Washington, Olympic Coast National Marine Sanctuary (47° 51.412′ N 125° 28.363′ W); 879 m; 11.vii.2008; National Oceanic and Atmospheric Administration; four whole specimens attached to a rock.

Description of the holotype growth form.— The colony is attached to a fragment of dead hexactinellid sponge. The preserved and contracted holotype is 88 mm in length and 41 mm in width. Basal stalk width at proximal portion of holdfast approximately 40 mm. Lateral branching begins immediately above the holdfast into two mostly opposite rows of primary lateral branches. The primary branches each give rise to several smaller or secondary branches toward their distal ends.

Polyps.— Polyps mostly concentrated on the outer edges of ultimate branches. Some polyps occur on the primary branches in groups of two or more. Polyps are not retractile but tentacles are retractable into the body of each polyp. Polyps are tubular/cylindrical, mostly 4.5-5.5 mm long by 1.2-1.5 mm wide. Some of the smallest (presumably younger) polyps are approximately 1.5 mm in length. The distal half of polyps that contains the anthocodia are bulbous, more or less oval in shape, salmon pink in colour, and 2.3-3.0 mm long. Distal half of each polyp with eight *en chevron* points composed of salmon pink sclerites, distinct crown not developed (fig. 4A). The basal halves of polyps are white and mostly tubular. Tentacles with rods and spindles arranged *en chevron* along the longitudinal median (fig. 4B).

Sclerites.— Sclerites include spindles, club-shaped spindles, needles, branched needles; branched club-shaped spindles; and branched spindles. Polyp body wall sclerites are needles and spindles 0.09-0.51 mm (figs 5B, 6A-K). Tentacle sclerites are mostly irregularly-shaped rods and stout spindles 0.08-0.22 mm (figs 5A, 6L-N). Branched spindles of the tentacles are rare to infrequent in abundance. One end of branching sclerites are weakly bifurcate or trifurcate. Surface of the upper stalk contains eight radiates with some irregular radiates; rarely seven radiates 0.06-0.10 mm (figs 5C, 7A-H). Sclerites of the interior of the middle to upper portions of the stalk absent. Surface of the basal portion of the stalk with eight radiates 0.10-0.12 mm (figs 5D, 7I-P). Rod-like sclerites of the interior of the base of the stalk at the holdfast level extremely sparse.

Colour.— Coloration of the tentacles and the distal regions of the polyps (anthocodiae) is salmon pink; basal portion of polyps white; the holdfast and lower region of the stalk are white; the branches of the stalk and the middle to upper parts of stalk are



pale pink. The coloration is permanent and was observed *in situ* (figs. 2, 3), and in all preserved specimens as well, including those collected in 1973.

Etymology.— The new species is named in honour of Julie Packard, executive director of the Monterey Bay Aquarium, Monterey, California, for her dedication to ocean stewardship and conservation, and for elevating public awareness about the ocean environment.

◀ Fig. 3. *In situ* images of *Gersemia juliepackardae* spec. nov., non-types; A. Living colony at Pioneer Seamount on ROV *Tiburon* dive 892 (digital still image, depth = 977 m). B. Living colony from Rodriguez Seamount on *Tiburon* dive 661 (digital still image, depth = 971 m). C. Living colony at Pioneer Seamount on *Tiburon* dive 1100 (digital still image, depth = 1,253 m, specimen was collected as T1100-A12).

Distribution of collected specimens.— Rodriguez Seamount (southern California) to northern Washington (fig. 1); 888-1600 meters depth. Of the five specimens collected using ROVs, four were collected from hard rock substrata. One other specimen, the holotype, was collected from where it was attached to a dead hexactinellid sponge. The trawled material, CASIZ 134171, came from unknown habitat type on the continental shelf off central Oregon.

Distribution of material from video images presumed to be of the new species.— San Juan Seamount (southern California) to northern California (fig. 1); 520-2034 meters depth. Of the 230 individuals that were observed in video only (i.e., no specimen was collected) and identified as *Gersemia juliepackardae* by the second author, the vast majority (95%) were observed on hard-rock substrate including volcanic lavas, outcropping granite, outcropping bedded sandstone, and talus material from volcanic and granitic sources. In addition, several individuals of *G. juliepackardae* (4.4%) were observed upon either dead or living hexactinellid sponge. Only one organism was observed living upon soft sediment, but it is assumed that this organism was attached to a small rock below the sediment surface as has been observed for other deep-sea corals. Ancillary data that were collected by the ROV during video observations indicate that this species may occupy a temperature range of 1.98 – 6.13 °C (mean 3.86 ± 0.025 SE, n=235), a salinity range of 34.17 – 34.59 psu (mean 34.44 ± 0.008 SE, n=235), and oxygen concentrations of 0.21 – 1.42 mL/L (mean 0.52 ± 0.009 SE, n=235). Video transect length (mean 143.8 m ± 21.75 SE, n=6) and width (mean 0.91 m ± 0.14 SE, n=6) varied. Organism density ranged from 0.0 – 0.28 individuals m^{-2} (mean 0.09 individuals m^{-2} ± 0.05 SE, n=6).

Variability.— One Oregon specimen (CAS 134171) has numerous sclerites in the interior of the base of the stalk (the region just above the holdfast). These sclerites are rod-like with robust, thornlike, elongated tubercles.

Remarks.— Until now only three species have originally been described in the genus *Gersemia*: *Gersemia loricata* Marenzeller, 1879 (type species) from the Arctic Ocean, *G. marenzelleri* Kükenthal, 1906b, from the Sea of Japan, and *G. subtilis* Tixier-Durivault, 1961, from the tropical Atlantic Ocean. Other species that are possibly assignable to the genus *Gersemia* have been described in various genera including *Alcyonium*, *Eunephthya*, *Nephthea*, *Paraspongodes*, and *Voeringia*. *Gersemia juliepackardae* spec. nov. differs from the previously described species of *Gersemia* as follows. Polyps of the new species have eight points but no crown development (fig. 4A), whereas the polyps of *G. subtilis* have well-developed crown and points (Tixier-Durivault, 1961: 246, fig. 11f). Stalk sclerites of the new species are mostly eight radiates and 0.07-0.12 mm long, while stalk sclerites of *G. marenzelleri* are spindles and clubs 0.12-0.20 in length (Kükenthal, 1906b: 287), and those of *G. loricata* are robust spindles and rods (Marenzeller, 1878: pl. 3, fig. 3A). *Eunephthya antarctica* Kükenthal, 1906a superficially resembles *Gersemia juliepackardae* spec. nov. (Kükenthal, 1906a: pl. 3, figs. 14, 15), but the new species differs in having eight radiates in the stalk, whereas the sclerites of *E. antarctica* are mostly rods and robust spindles with pronounced tubercles (Kükenthal, 1906a: pl. 12, figs. 73, 74).

Gersemia, *Litophyton*, and *Alcyonium*
(figs 4C-D)

Gersemia liltvedi (Verseveldt & Williams, 1988), comb. nov.

Material examined.— **CASIZ 108791**; *Litophyton* sp.; Japan, Ryukyu Islands, Okinawa, Seragaki, 1.3 km ENE of Maeki-zaki (26.00° 30.40′N 127.00° 52.60′E); 58 m; 09.xi.1996; coll. R.F. Bolland, SCUBA; one whole specimen. **CASIZ 167912**; *Gersemia liltvedi*; South Africa, Cape Province, Port Elizabeth, Thunderbolt Reef, 21-24 m; 16.ii.1999; J. Starmer, SCUBA; one whole specimen.

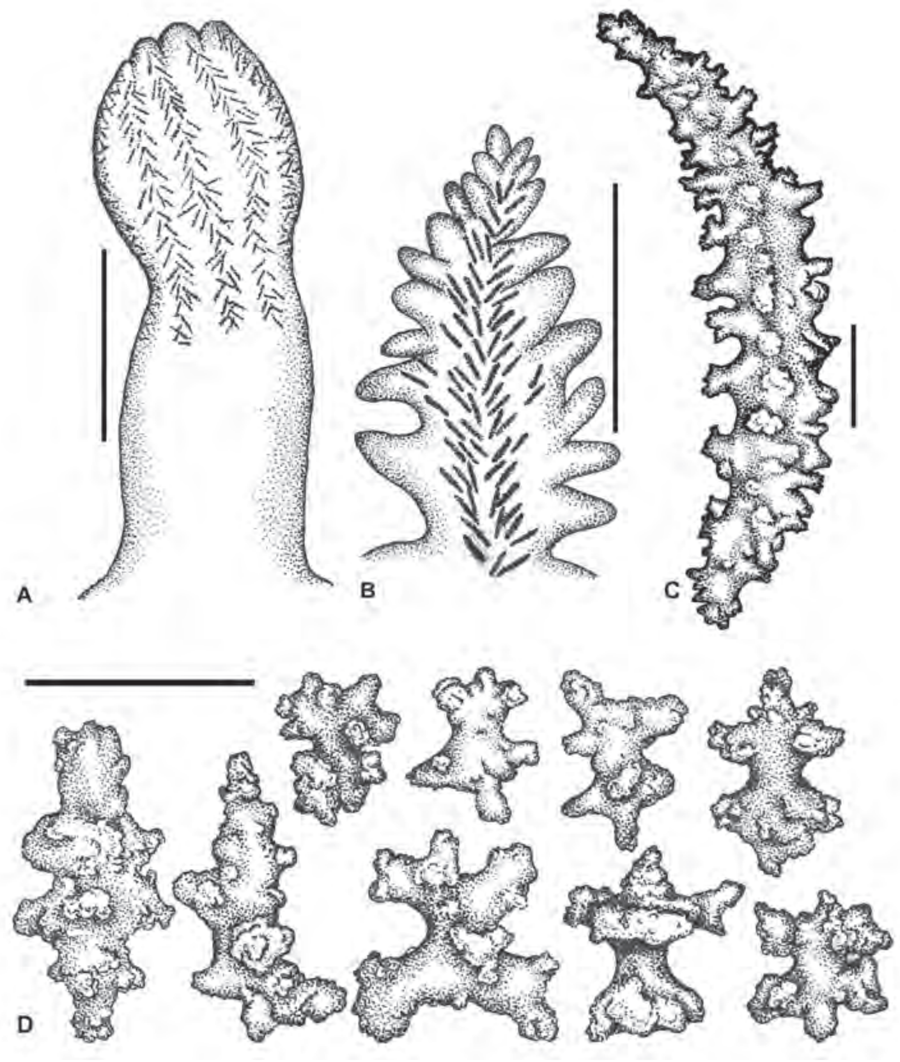


Fig. 4. A-B. *Gersemia juliepackardae* spec. nov. A. Polyp armature, paratype. Scale bar = 1.5 mm. B. Tentacle armature, paratype; Scale bar = 1.0 mm C. *Litophyton* sp. (CASIZ 108791), stalk sclerite; Scale bar = 0.1 mm D. *Gersemia liltvedi* (CASIZ 167912), stalk sclerites; Scale bar = 0.1 mm.

A soft coral from South Africa was described as *Litophyton liltvedi* by Verseveldt & Williams (1988: 321; see also Williams, 1992: 337). Subsequent investigation has shown that the proper generic designation should be *Gersemia*. Species of *Litophyton* Forskål, 1775, have some sclerites of the branches and stalk that are spindles, often with spine ornamentation more pronounced on one side (= caterpillars) (fig. 4C; see also Fabricius & Alderslade, 2001: 106). *Gersemia liltvedi* comb. nov., differs in having stalk sclerites that are modified capstans (fig. 4D). Species of both genera do not have supporting bundles or crowns in the polyps. However, they differ as follows: *Gersemia* species are

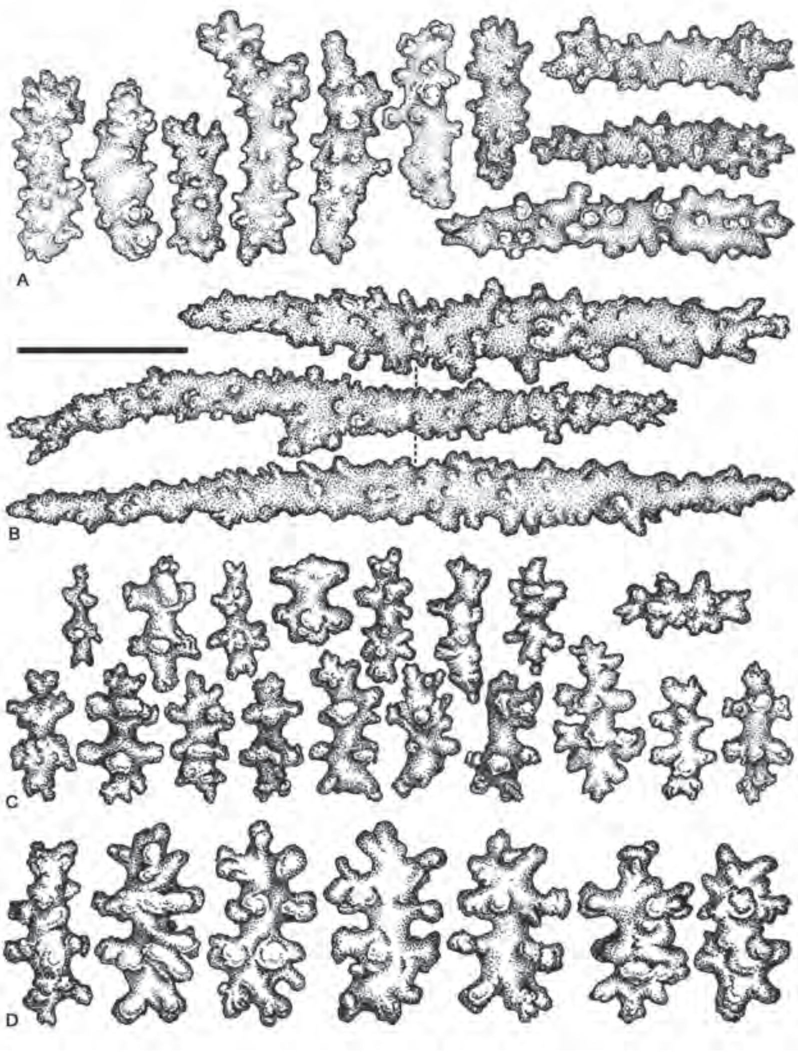


Fig. 5. *Gersemia juliepackardae* spec. nov., paratype; A. Sclerites from a tentacle rachis, 0.10-0.21 mm in length. B. Sclerites from an anthocodia, 0.36-0.46 mm in length. C. Sclerites from the upper portion of the stalk, 0.06-0.10 mm. D. Sclerites from the base of the stalk, 0.11-0.13 mm. Scale bar for A-D = 0.1 mm.

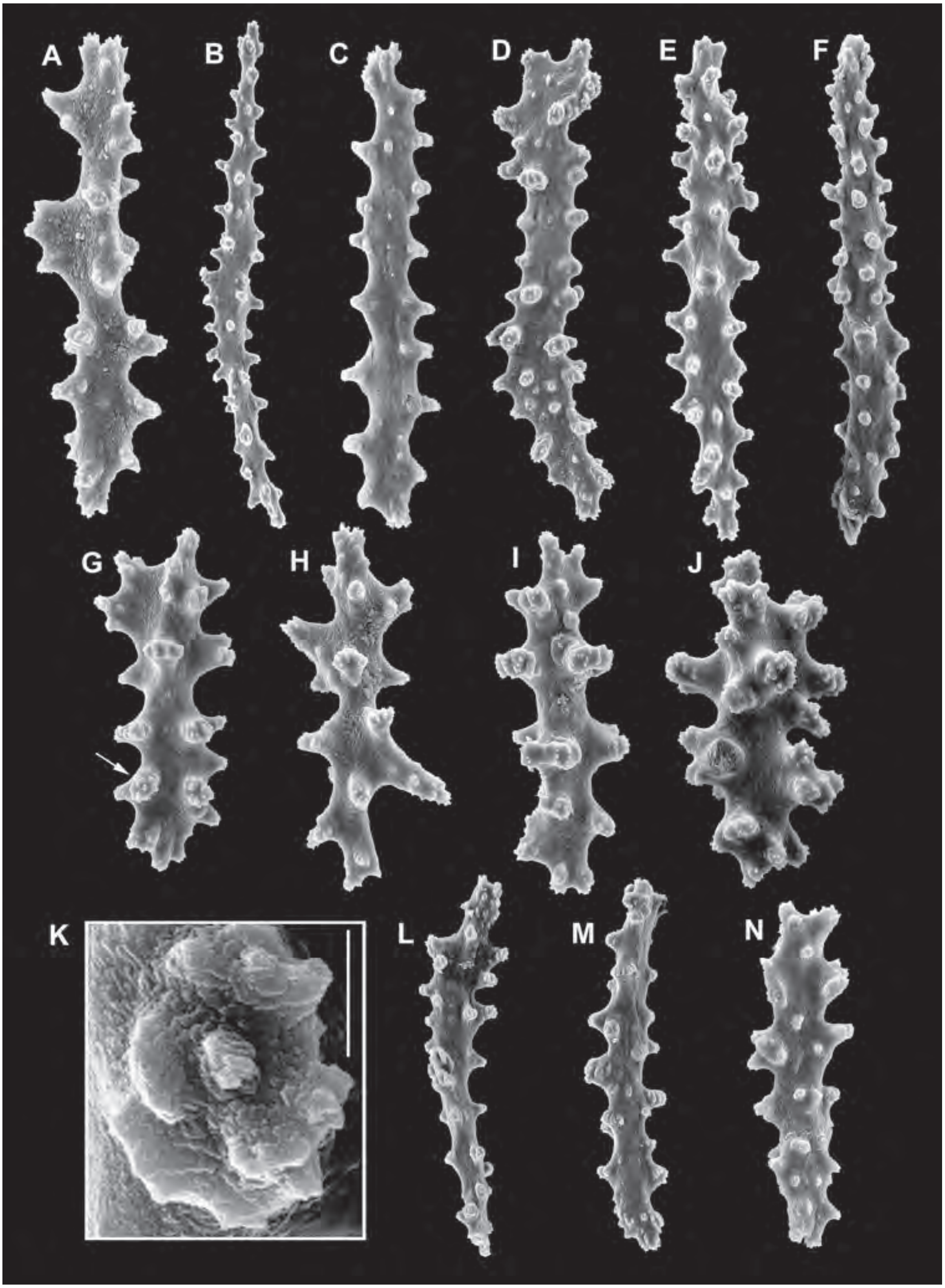


Fig. 6. *Gersemia juliepackardae* spec. nov., holotype. Scanning electron micrographs of polyp sclerites. A-K. Sclerites from the body of a polyp. A. 0.11 mm. B. 0.31 mm. C. 0.17 mm. D. 0.20 mm. E. 0.21 mm. F. 0.28 mm. G. 0.10 mm. H. 0.09 mm. I. 0.11 mm. J. 0.10 mm. K. Detail of a tubercle from the sclerite shown in G (white arrow); scale bar = 0.004 mm. L-N. Tentacle sclerites. L. 0.15 mm. M. 0.16 mm. N. 0.11 mm.

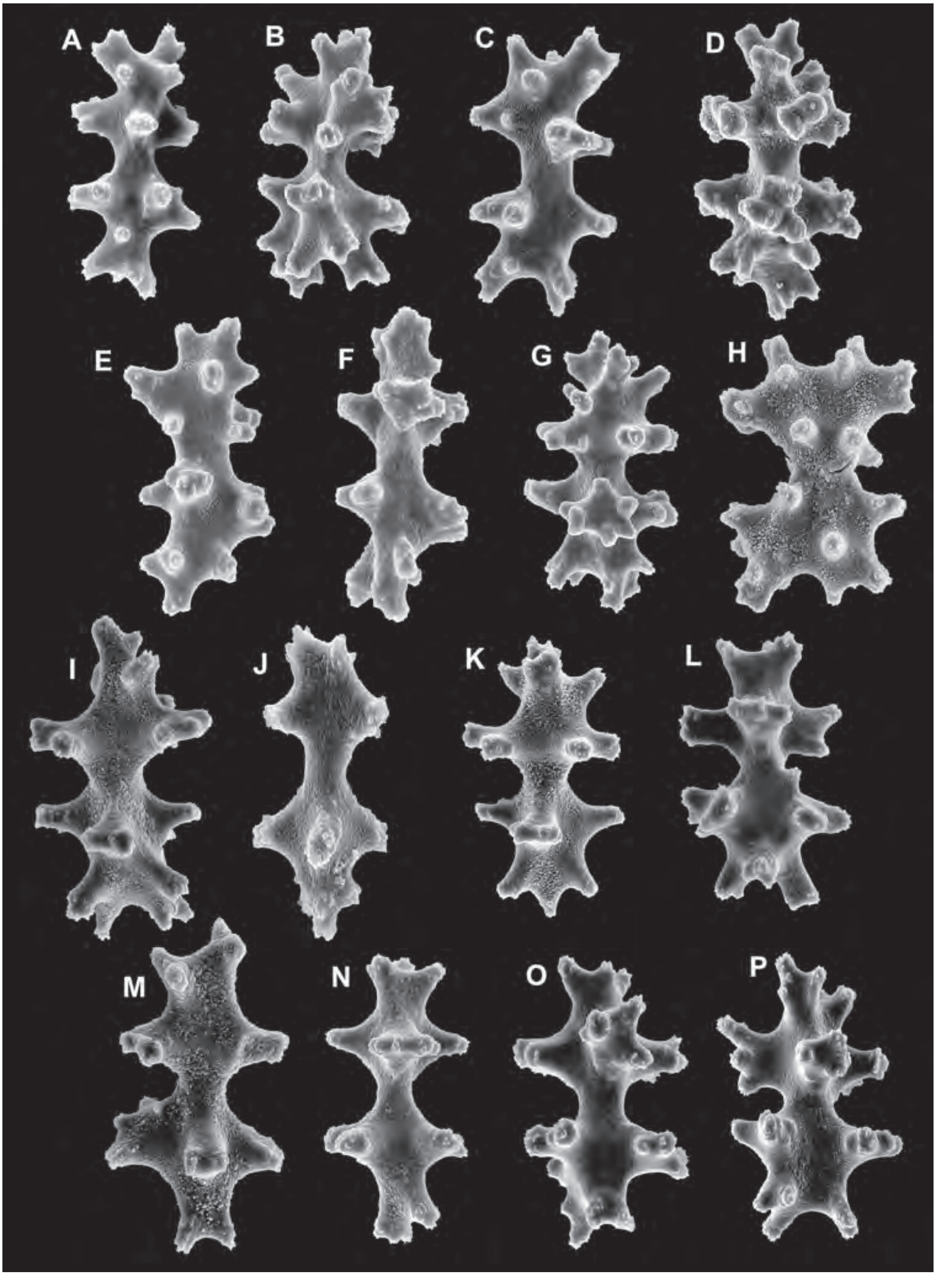


Fig. 7. *Gersemia julieparkardae* spec. nov., holotype. Scanning electron micrographs of stalk sclerites. A-H. Sclerites from upper portion of stalk. A. 0.10 mm. B. 0.09 mm. C. 0.07 mm. D. 0.09 mm. E. 0.08 mm. F. 0.07 mm. G. 0.10 mm. H. 0.08 mm. I-P. Sclerites from basal portion of stalk. I. 0.10 mm. J. 0.04 mm. K. 0.09 mm. L. 0.08 mm. M. 0.08 mm. N. 0.08 mm. O. 0.08 mm. P. 0.09 mm.

azooxanthellate, circumglobal temperate to polar, colder water taxa, that do not inhabit coral reefs; in mostly deeper water 21-1253 m (with video images depth is increased to 2034 m); sclerites are often coloured; the stalk usually has modified or irregularly-shaped capstan-like sclerites ≤ 1 mm. On the other hand, *Litophyton* species are zooxanthellate, tropical, warmer water taxa that inhabit coral reef regions of the Indo-Pacific; in shallow water < 50 m; sclerites are colourless; some stalk sclerites are spindles ≥ 0.1 mm. Taking this information into consideration, we here regard *Gersemia liltvedi* as the correct binomial designation for this taxon.

In addition, a species previously referred to by several authors as ''*Gersemia rubiformis*'' and the common name of ''Sea Strawberry'' from the Pacific northwest coast of North America (southern Alaska to northern California) is more correctly designated as an unidentified species of *Alcyonium* (Williams, 2007: 184-185, 188), and will be dealt with in a subsequent publication. The species can be aligned with other species in the genus *Alcyonium* due to its lobate growth form, the possession of crowded rounded lobules, small retractile polyps that can completely withdraw into the coenenchyme of the lobules and sclerites of densely warted spindles, radiates, and ovoid or clubbed forms similar to other species in the genus, such as *Alcyonium gruveli* Tixier-Durivault, 1955, *A. monodi* Tixier-Durivault, 1955, *A. grandis* Casas et al., 1997, *A. southgeorgiensis* Casas et al., 1997, and *A. valdiviae* Kükenthal, 1906 (Verseveldt & Ofwegen, 1992: 161-167; Casas et al., 1997: 304-310; Verseveldt & Williams, 1988: 316-321; Williams, 1992: 292-295).

Discussion

The reliance upon video and still images to supplement the ecological and biogeographical information of single species (Harbison et al., 2001; Matsumoto et al., 2003; Haddock, 2004; Cairns, 2007; Reiswig & Lee, 2007) and, also, to characterize whole faunas (Braby et al., 2007; Lundsten et al., 2009) has become more accepted recently, particularly when describing habitats such as the deep-sea. Here we have used video observations to add to our knowledge of the biogeography and ecology of this new species, with the aim of more accurately characterizing this octocoral.

The known depth and latitudinal ranges of *Gersemia juliepackardae* is large. Mean depth for collected specimens and video observations, when combined, is 1039 m (± 8.36 SE, n = 235 range 520-2034 m). Video observations also expand the latitudinal range of collected specimens by approximately 100 km to 1686 km (33.10472° N - 47.85686° N). We are confident that the combined latitudinal range of collected specimens and those observed in ROV video only are accurate, however, we suggest that the true latitudinal range may be larger than our data currently show, as this trend has been observed for other organisms found upon the continental slope and at seamounts along the west coast of the USA (Lundsten et al., 2009). Our estimate of organism density was relatively low, however, the video transects were quite long and this tends to lower the estimate for patchily distributed organisms. Localized density was often greater than our estimates indicate, as we did observe *G. juliepackardae* in densely clustered groups of four to eight individuals.

Surprisingly, the new species described here was often observed living upon dead and live sponges. The second author has observed zoanthid anemones and hydrozoan's living upon both dead and living corals and sponges, however, in a recent analysis of invertebrate community composition at three seamounts off California (Lundsten et al., 2009), no octocorals, aside from this species, were seen living upon any other organisms. This may represent the first account of a deep-sea octocoral living upon sponges. Other individuals of the new species were in this study were found living upon hard-rock substrata.

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