An unusual new gorgonian coral (Anthozoa: Octocorallia) from the Aleutian Islands, Alaska

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Key words: Gorgonian coral; *Alaskagorgia aleutiana*; molecular systematics; Octocorallia; Plexauridae; Gorgoniidae; ND2, MSH1, mtDNA.
Despite the abundance and ecological importance of octocorals in Alaskan waters, most of the species in this assemblage remain unidentified and/or undescribed. One of the largest and most abundant species from the Aleutian Islands found at depths ranging between 125 and 512 m is a new and very unusual gorgonian coral. It has stout upright colonies that are laterally branched, with thick, more or less clavate terminal branches. Its major distinguishing characteristic is its possession of tiny sclerites with stubby double heads, which occur in the outermost coenenchyme. Another significant character is its oval capstans with elaborate ornamentation. The gorgonian is described as *Alaskagorgia aleutiana* new genus and species (Cnidaria: Octocorallia: Holaxonia: Plexauridae). It is described and assigned to Plexauridae because of the affinity of DNA sequences (1337 bp mtDNA: ND2 and MSH1) of *A. aleutiana* with other plexaurid corals, even though the predominant coenenchymal sclerites are somewhat smaller and different than is usual in plexaurid genera.

Introduction

The Gulf of Alaska, particularly the Aleutian Islands, harbours one of the most productive fisheries in the world. Octocorals are among the largest sessile benthic invertebrates along Alaskan coasts, providing an excellent habitat for associated invertebrates and fish (e.g., Krieger & Wing, 2002; Risk et al., 2002; Krieger, 1993). However, of the nearly 30 species of octocorals that have been collected with fishing trawls off Alaska, only seven species (23%) have been identified and reported at the species level (Heifetz, 2002). Unfortunately, the most frequently collected octocorals fall in the list of unidentified species, which prevents one from knowing the true octocoral diversity in Alaska.

Among the rich collection of boreal octocorals obtained by the National Marine Fisheries Service during exploratory trawling in Alaskan waters over the past several years are specimens of a stout, unusual, arborescent gorgonian that calls to mind the robust gorgonians of Caribbean reefs (e.g., *Plexaurella* spp.). Nonetheless, it cannot satisfactorily be assigned to any genus and species known heretofore and is herein described as *Alaskagorgia aleutiana*, new genus, new species. In addition, we used molecular techniques (DNA sequencing) in order to obtain an independent source of characters to classify and compare *Alaskagorgia aleutiana* with other octocorals.

Methods

Specimens were examined morphologically by isolating sclerites of the coenenchyme layers by digestion of the organic matter in sodium hypochlorite, followed by preliminary observations with an optical microscope (100×). Hypochlorite was washed from the sclerites with distilled water and ethanol (70%), air-dried, mounted for the Scanning Electron Microscope (SEM) on carbon double adhesive tape, and coated. SEM scans were obtained from a Leica Stereoscan at 10 kV and the optimum magnification for each kind of sclerite. SEM stereo pairs were taken by tilting the sclerite approximately 6 degrees under the same magnification (35 tilt marks in Leica Stereoscan). *Calcigorgia spiculifera* Broch, 1935, was studied in a similar fashion to make morphological comparisons. For species comparisons, 1337 bp of partial sequences from the NADH dehydrogenase subunit 2 (ND2, mtDNA) and mutS-homolog (MSH1, mtDNA) were sequenced using primers, protocols, and analyses from Sánchez et al. (2003). Sequences from four new outgroups were also generated from a species of Ellisellidae [*Ctenocella (Ellisella) barbadensis* (Duchassaing & Michelotti, 1864)], Briareidae [*Briareum polyanthes* (Duchassaing & Michelotti, 1860)], Anthothelidae [*Erythropodium caribaeorum* (Duchassaing & Michelotti, 1860)], and Alcyoniidae (*Lobophytum* spec.), and a sequence of ND2 of the new species (deposited in Genbank Acc. Nos. MHS1 AY533649-53, ND2 AY534734-38 and Treebase S1028, M1746). A MutS-homolog (MSH1) sequence of the new species was included courtesy of S.C. France (University of Charleston). Plexaurid and gorgoniid sequences were obtained from Sánchez et al. (2003).

Systematic part
Class Octocorallia
Suborder Holaxonia
Family Plexauridae
Alaskagorgia gen. nov.

Diagnosis.— Gorgonians with a non-mineralized, proteinaceous supporting axis, having a wide, chambered central core and distinctly loculated cortex. Stout, upright colonies laterally branched, with thick, more or less clavate terminal branches (fig. 2). Small outermost coenenchymal sclerites are stubby double heads, their tubercles/warts not distinctly arranged in transverse belts; main coenenchymal sclerites larger and more distinctly rayed, with complex tubercles/warts; axial sheath sclerites are capstans, with less complex tubercles/warts. All sclerites colourless. Polyps densely armed with acute, irregularly tuberculate spindles not arranged as crown-and-points, fully retractile within a thick coenenchyme (fig. 4).

Type species.— *Alaskagorgia aleutiana* spec. nov.; by monotypy and original designation.

Etymology.— The genus is named after Alaska plus the common octocoral suffix *gorgia* (gender: feminine).

Alaskagorgia aleutiana spec. nov.
(figs 1-6)

Material.— Holotype: USNM 1007002, Alaska, Aleutian Islands, Delarof Islands, Tanaga Pass, 51º39′03″N, 178º17′45″W, 227-263 m, RV Sea Storm 130, 30.vi.2002, (ethanol). Paratypes: USNM 1010382, Alaska, Aleutian Islands, Delarof Islands, Tanaga Pass, 51º39′03″N, 178º17′45″W, 227-263 m, RV Sea Storm 130, 30.vi.2002; USNM 1007125, Alaska, Aleutian Islands, Delarof Islands, Tanaga Pass, 51º37′38″N, 178º19′12″W, 375 m, R/V Pacific Knight 94-1-121, 5.vii.1994, 2 dry colonies; USNM 1007004 and 1007006, Alaska, Aleutian Islands, Andreanof Islands, Seguam Island, 52º36′N, 172º20′W, 238 m, R/V Starlight 84-7-36, 12.vii.1984, 2 colonies in alcohol, SEM stub 2511; USNM 1007003, Alaska, Aleutian Islands, Delaof Islands, Tanaga Pass, 51º46′24″N, 178º58′00″W, 400-600 m, R/V Alaskan Leader 42, 10.vi.2000, 2 colonies in alcohol; USNM 1009948, Alaska, Aleutian Islands, Andreanof Islands, Seguam Island, 52º04′N, 172º34′04″W, 137-144 m, R/V Denominator 2000 01-71, 27.vi.1997, 7 colonies in alcohol; RMNH Coel. 32193 (ex USNM 1007147), Alaska, Aleutian Islands, Amukta Pass, 52º48.54′N, 171º31.06′W, 198 m, 4.2ºC, F/V Verstraalen, 94-1-57, 14.vi.1994, 1 dry colony; USNM 1007148, Alaska, Aleutian Islands, Amukta Pass, 52º49.13′N, 171º22.98′W, 157 m, 4.2ºC, F/V Verstraalen 94-1-56, 14.vi.1994, 1 dry colony; USNM 1007146, Alaska, Aleutian Islands, Cape Moffett, Adak Island, 51º59.25′N, 176º49.52′W, 512 m, R/V Spirit of the North, 9.iii.2000, 1 dry colony;USNM 1007127, Alaska, Aleutian Islands, south of Yanaska Island, 52º16′44″N, 170º40′48″W, 155 m, F/V Verstraalen 94-1-37, 14.vi.1994, 1 dry colony; USNM 1007126, Alaska, Aleutian Islands, SW of Semisopochnoi Island, 51º53′33″N, 179º20′09″E, 411 m, coll. J. Slear, 21.xi.2000, 1 dry colony. NOAA Auke Bay Lab, Alaska, Aleutian Islands, Cape Moffett, Adak Island, 51º57.67′N, 176º50.02′E, 150 m, Delta Dive 5620, 24.vii.2002, 1 colony in pieces in ethanol; NOAA Auke Bay Lab, Alaska, Aleutian Islands, Petrel Bank, 52º50.91′N, 179º49.85′W, 125 m, Delta Dive 5605, 17.vii.2002, 2 colonies in alcohol; USNM 1010766, Alaska, Aleutian Islands, east of Agatta I., 52º20.94′N, 174º17.9′E, 186 m, AB01-95, Kevin Renfro coll., 18.iii.2001, 1 dry branch, SEM stub 989; USNM 1010765, Alaska, Aleutian Islands, north of Agatta I., 52º55.9′N, 172º07.21′E, 219 m, AB01-97, 10.v.2001, 1 dry branch.

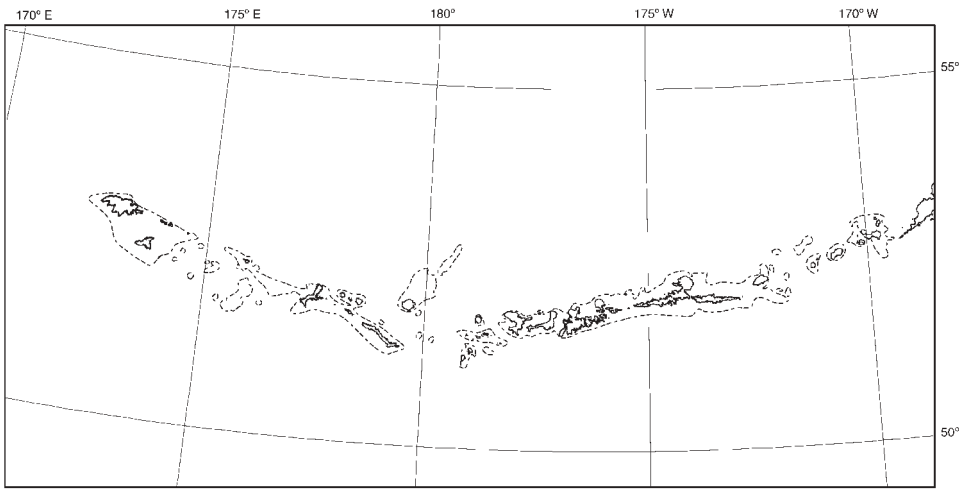

Fig. 1. Map of the Aleutian Islands showing the location of the collected specimens of *Alaskagorgia aleutiana*.

Fig. 2. Photographs of *Alaskagorgia aleutiana* holotype (USNM 1007002) with two stereopair details of branches (scale bar, left photo, 15 cm).

Description.— The colonies are arborescent, laterally branched, upright, with long, stout end-branches 12-15 mm in diameter, often with clavate tips up to 17 mm in diameter (fig. 2). Major branches may be somewhat flattened in the plane of branching, 13-16 × 12-13 mm in diameter. Colonies are very sparsely branched. The holotype has a main branch reaching 60 cm in length with only one daughter branch of about 30 cm and two terminal branches 12 and 15 cm long respectively (fig. 2). Polyps are scattered on all sides of the major branches but more or less resorbed on the main trunk and holdfast. The anthocodiae are fully retractile into the very thick cortex, but commonly are preserved more or less exsert (fig. 4). In some cases the cortex is conspicuously raised around the polyp orifices, forming short, cylindrical protuberances 4.5-5.5 mm in diameter, but in most cases these protuberances are reduced to a faintly raised rim with eight notches around the exsert polyp. The tentacular portion of the polyps is densely armed with pointed, tuberculate spindles up to 0.6 mm long (fig. 3 I-J) that may have several projecting processes (figs 5H, 6I), converging in the bases of the tentacles and extending longitudinally along the tentacle backs (fig. 6I); the introvert is devoid of sclerites. The coenenchyme is thick and divided into three layers with somewhat overlapping sclerite types. The thin surface layer contains small double heads commonly 0.04-0.07 mm in length, the largest about 0.09 mm (fig. 3A-B). Progressively inward the thick middle coenenchymal layer contains the gastric cavities of the retracted polyps and oval capstans with elaborate ornamentation, about 0.17 mm in length (figs 3D, 5A-B, 6A-B). Capstans become longer and more ornamented towards the deeper layers of the coenenchyme (figs 3C, 5D-E, 6E-F). There are occasional twinned forms producing crosses (figs 3E, 6C). Finally, the axial sheath contains less elaborate capstans of typical octoradiate form up to about 0.17 mm long, distributed in narrow rows between the longitudi-

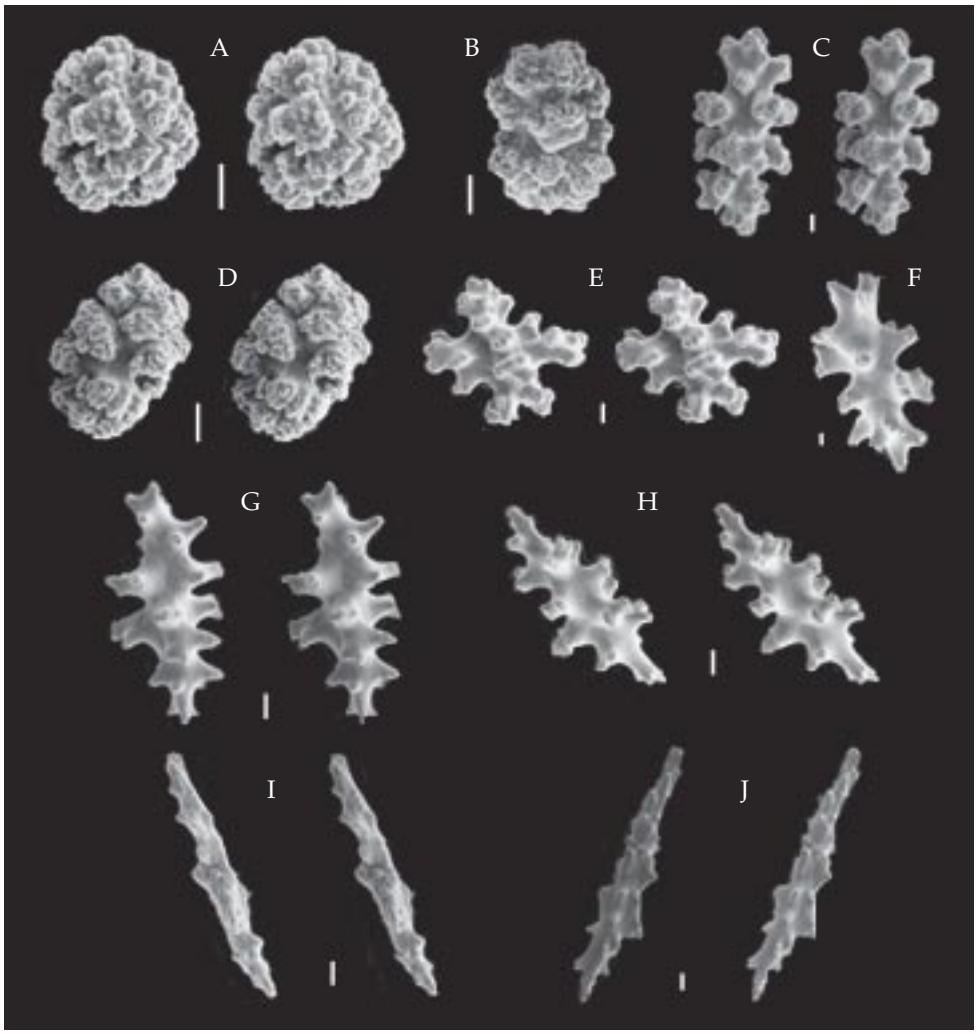

Fig. 3. SEM images and stereopairs of sclerites from holotype of *Alaskagorgia aleutiana* (USNM 1007002). A-C, Predominant sclerites from the surface coenenchyme layer (scale bar 10 :m); D-F, Predominant sclerites from the middle layer (scale bar 10 μm); G-H, Predominant sclerites from the axial layer and stem canals walls (scale bar 20 μm); I-J, Predominant sclerites from the polyp anthocodiae (scale bar 20 μm).

nal stem canals (figs 3F-H, 5C, 6H). The surface of the coenenchyme is covered with a thick layer of epidermal tissue beneath which the outermost layer of small sclerites is distributed. In some specimens this surface was stained nearly black, possibly by some other organisms such as sponges, taken during the haul (e.g., paratype USNM 1007006). All other type specimens are brown, dark in dried condition, lighter in ethanol. All sclerites are colourless.

Known distribution.— Aleutian Islands, 125-512 m (fig. 1).

Fig. 4. SEM stereopairs of four polyps and aperture from *Alaskagorgia aleutiana* paratype (USNM 1007125), showing arrangement of sclerites in the anthocodiae and aperture walls (scale bar 1 mm).

Etymology.— The species name, *aleutiana*, means: from Aleutian.

Species comparisons.— The long thick, clavate terminal branches and colony size of *Alaskagorgia aleutiana* spec. nov. resemble Caribbean plexaurid species of the genera *Plexaurella* (particularly *Plexaurella nutans* (Duchassaing & Michelotti, 1860)) and *Eunicea* (e.g., *Eunicea laciniata* (Duchassaing & Michelotti, 1860) and *E. calyculata* (Ellis & Solander, 1786)). But, despite the occasional presence of antler-like sclerites in *A. aleutiana*, which are characteristic of *Plexaurella* species, there is no recognizable homology of its sclerites compared to these Caribbean relatives. Although most Caribbean plexaurids present the overall tendency of having reduced surface sclerites these are usually club-like sclerites (Sánchez et al., 2003); the surface sclerites of *A. aleutiana* would be the smallest in the Plexauridae. Other plexaurid species such as *Swiftia exserta* (Ellis & Solander, 1786) also have small capstan-like forms in a very thin surface layer (Goldberg, 2001), also suggesting a relationship with *A. aleutiana*. However, the inner sclerites in *S. exerta* are predominantly robust, ornamented spindles whereas *A. aleutiana* exhibits octoradiate-derived capstans.

The oval capstans in the coenenchyme of the *Alaskagorgia aleutiana* are similar to those found in other Indo-Pacific plexaurids. For instance, species of *Euplexaura* have similar kinds of oval capstans, but with much more complex tubercles. Another intriguing aspect of the sclerites of *A. aleutiana* is that their girdles and warts have sub-ornamentation visibly similar to those found on the capstans of species of Acanthogorgiidae, particularly *Calcigorgia* spp. (e.g., *Calcigorgia spiculifera*, fig. 7). *A. aleutiana* shares many characteristics with the Plexauridae but the capstan ornamentation resembles species of the Acanthogorgiidae.

DNA sequences resampling analyses (66% of samples) group *Alaskagorgia aleutiana*

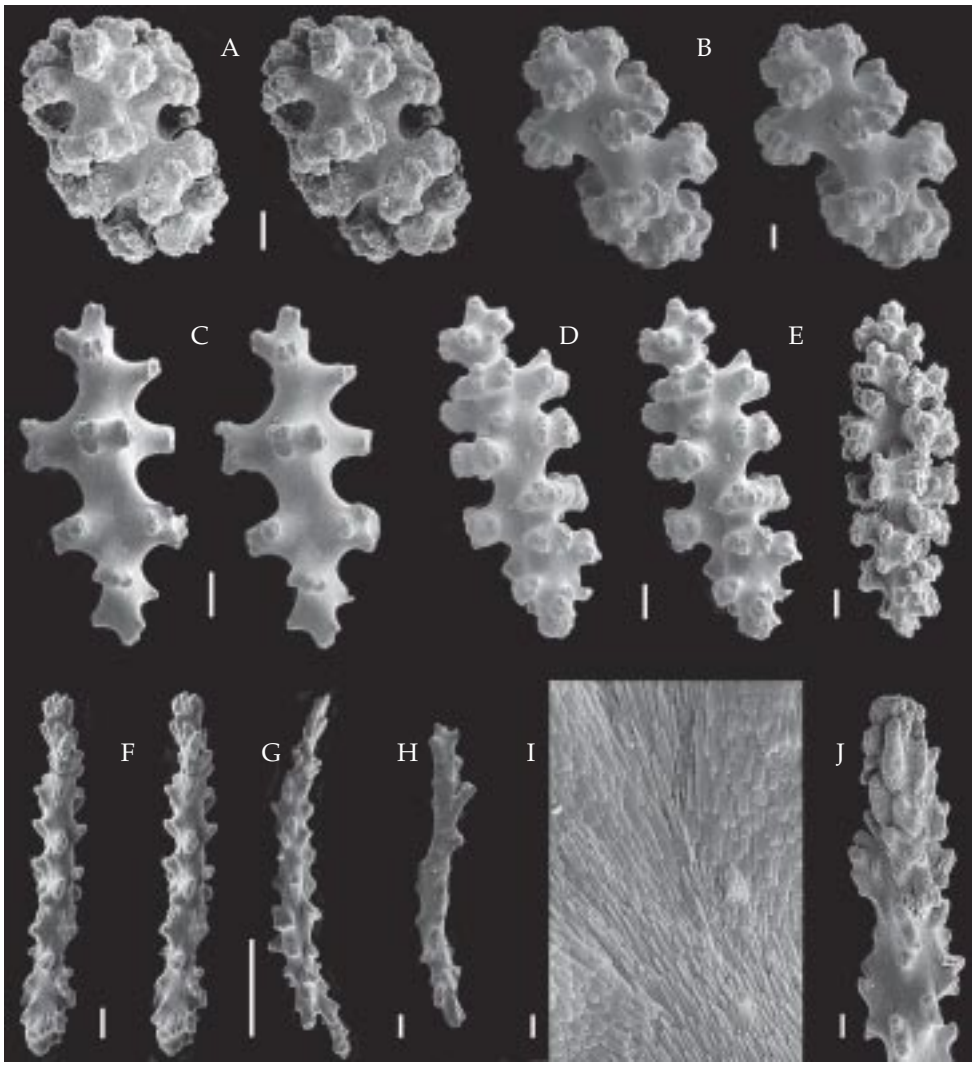

Fig. 5. SEM images and stereopairs of *Alaskagorgia aleutiana* paratype (USNM 1007125). A-B, Capstans from the surface/middle coenenchyme layer (scale bar 10 μm); C-E, Predominant sclerites from the middle and axial layers (scale bar 20 μm); F-J, Predominant sclerites from the polyp anthocodiae (scale bar 20 μm) (Fig I shows microcrystals from an anthocodial rod, scale bar 1 μm).

basal with the Plexauridae (fig. 8), using as outgroups species of the families Alcyoniidae, Anthothelidae, Gorgoniidae, Briareidae, and Ellisellidae. The same results were found using both maximum parsimony and maximum likelihood techniques using the methods from Sánchez et al. (2003). Nonetheless, it is the least supported node among the selected species (fig. 8 B). In addition, it is reiterated that Plexauridae and Gorgoniidae are not entirely monophyletic (e.g., the "plexaurids" *Plexaurella* spp. and *Muriceopsis* spp. group with the gorgoniids; see discussion in Sánchez et al., 2003 and

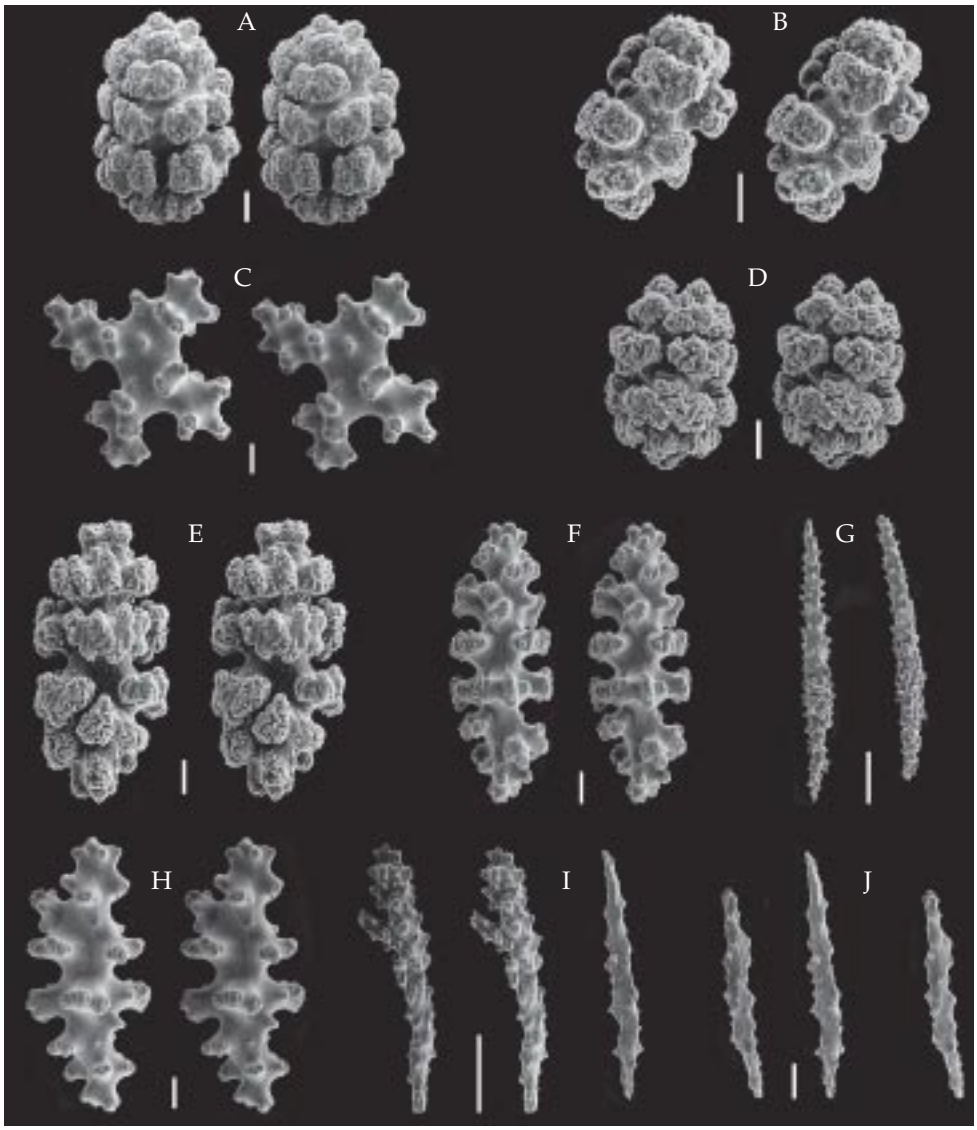

Fig. 6. SEM stereopairs of non-type specimen *Alaskagorgia aleutiana* sclerites (USNM 1010765). A-B, Predominant sclerites from the surface coenenchyme layer (scale bar 10 μm); C-F, Predominant sclerites from the middle layer (scale bars 10, 10 and 20 μm, respectively); H, Predominant sclerite from the axial layer (scale bar 20 μm); G, I-J, Predominant sclerites from the polyp anthocodiae (scale bars 20, 100 and 30 μm, respectively).

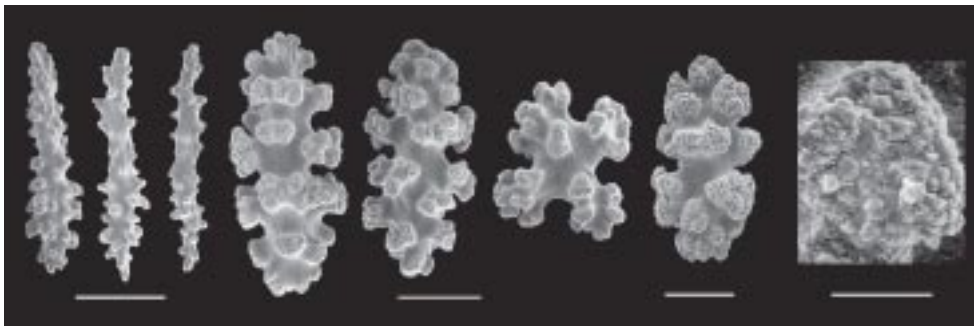

Fig. 7. SEM images of sclerites of *Calcigorgia spiculifera.* Scale bar for first three sclerites 10 mm; next three, 5 mm; seventh sclerite, 3 mm; and last enlargement of a tubercle, 1 mm.

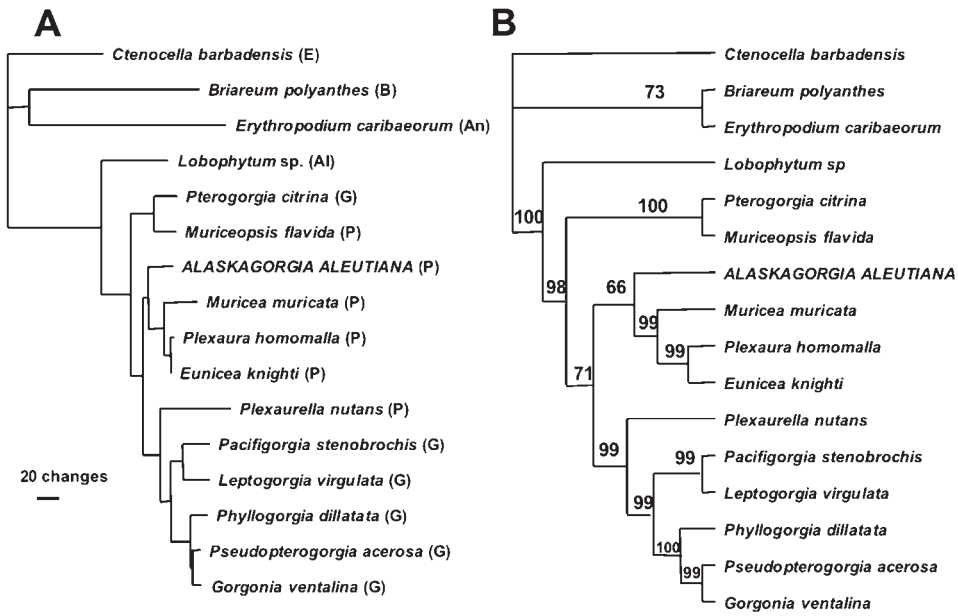

Fig. 8. A, Maximum parsimony phylogram using branch-and-bound algorithm (1337 bp, ND2 and MSH1 genes partial sequences, L = 919; Consistency Index = 0.773; Retention Index = 0.671); maximum likelihood analysis using the methods from Sanchez et al. (2003) gave the same results. Letters in parentheses indicate family names; E: Ellisellidae; B: Briareidae; An: Anthothelidae; Al: Alcyoniidae; P: Plexauridae; G: Gorgoniidae. B, Bootstrap 50% majority-rule consensus, 1000 replicates. New sequences deposited at GenBank and the alignment in www.treebase.org.

fig. 8 herein). Because of the unusual sclerites of *A. aleutiana* and the higher-level classification problems between Gorgoniidae and Plexauridae, it even may be premature to assign *Alaskagorgia* to a definitive family.

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