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The gorgonacean genus *Arthrogorgia* (Octocorallia: Primnoidae)

Frederick M. Bayer

Department of Invertebrate Zoology, National Museum of Natural History,
Smithsonian Institution, Washington, D.C. 20560, U.S.A.

Abstract.—Operations by National Marine Fisheries vessels in Alaskan waters have collected specimens of two species of the gorgonacean genus *Arthrogorgia* Kükenthal, 1908, one of them undescribed. *A. utinomii,* new species, is described and compared with *A. ijimai* (Kinoshita 1907), the type species, as well as with *A. otsukai* Bayer, 1952, and *A. kinoshitai* Bayer, 1952. All species are illustrated by scanning electron micrographs (SEM).

Family Primnoidae
Arthrogorgia Kükenthal, 1908

Arthrogorgia Kükenthal in Kükenthal & Gorzawsky, 1908:625 (type species, *Calyptrophora ijimai* Kinoshita, 1907).—Kükenthal, 1919:476; 1924:319.—Bayer, 1952:63; 1981:937 (in key).—Bayer & Stefani, 1989:455 (in key).

Remarks.—This genus is similar to *Paracalyptrophora* but has several "infrabasal" scales rather than only one pair. The flexible, pinnate colonies of *A. ijimai* Kinoshita, always with a thin, membranous coenenchymal expansion between main axis and branches harboring a polychaete commensal, are conspicuously different from the more robust dichotomous or bipectinate colonies of *Paracalyptrophora.* Two previously described species of *Arthrogorgia* (Bayer 1952) approach *Paracalyptrophora* in this respect, as does a third species described below.

It could be argued that only *A. ijimai* is generically distinct, and that the three stout, dichotomously branched species should be ranked with *Paracalyptrophora.* However, the increased number of infrabasal scales seems to be a consistent character. The new species described below is even more peculiar in the extensive development of accessory scales between the opercularis and the buccals.

Key to Species of *Arthrogorgia*

1(2). Colonies openly pinnately branched, with membranous coenenchymal expansions between the side branches and the main stem; polyps with strongly developed marginal spines on both basal and buccal pairs of body scales . . . . . *ijimai* (Kinoshita)

2(1). Colonies dichotomously branched.

3(4). Basal scale pair of polyps without projecting spines . . . . . *otsukai* Bayer

4(3). Basal scale pair of all or most polyps having marginal spines.

5(6). Free margin of buccal scales wide and developing projecting spines in some polyps but not all; when present, accessory scales below the opercularis partly or completely concealed by the margin of the buccal scales. Outer surface of scales ornamented with blunt granules . . . . . *kinoshitai* Bayer

6(2). Margin of buccal scales projecting little, not concealing the accessory scales below the opercularis, bluntly rounded or with a blunt projecting angle not a prominent spine. Outer surface of scales ornamented with radial lines of sharp prickles . . . . . *utinomii,* n. sp.

Arthrogorgia ijimai (Kinoshita, 1907)
Figs. 1, 2

Calyptrophora ijimai Kinoshita, 1907: 234.—Nutting, 1912:57, pl. 16, figs. 2, 3.
Arthogorgia membranacea Kükenthal & Gorzawski, 1908a:626; 1908b:29, pl. 2, figs. 10, 11; 1919:477; 1924:320, fig. 174.
Calyptrophora (Arthrogorgia) ijimai.—Kinoshita, 1908:59, pl. 4, fig. 28; pl. 6, fig. 54.
Not *Calyptrophora ijimai.*—Broch, 1935: 26, figs. 15, 16.

Material.—Japan. Sagami Bay: 35°09′40″N, 139°19′05″E, 1123 m, U.S.F.C. str. *Albatross* sta. 5087, 23 Oct. 1906. 5 colonies, USNM 30028 (SEM 2541). West of Izu Islands: 34°10′30″N, 138°40′E, 924 m, U.S.F.C. str. *Albatross* sta. 5080, 19 Oct. 1906. 2 colonies, USNM 30074 (SEM 94). South of Omae Zaki, Shizuoka, Honshu: 34°15′N, 138°E, 869–924 m, U.S.F.C. str. *Albatross* sta. 5079, 19 Oct. 1906. Shiono Misaki, Wakayama, Honshu: 33°23′40″N, 135°33′E, 1074 m, U.S.F.C. str. *Albatross* sta. 4969, 29 Aug. 1906. 4 colonies, USNM 49617. Shiono Misaki, Wakayama, Honshu: 33°23′40″N, 135°34′E, 1127 m, U.S.F.C. str. *Albatross* sta. 4971, 30 Aug. 1906. 6 colonies, USNM 49689.

Diagnosis.—Slender, pinnately branched *Arthrogorgia* usually with membranous coenenchymal expansion between proximal part of lateral twigs. Margin of buccal scales of polyps each with two, rarely three long, slender, fragile spines; both basal scales with a strong marginal spine (Figs. 1, 2); no infraopercular scales. Outer surface of body scales sculptured by fine, simple granules.

Description.—See Kinoshita 1908, Kükenthal & Gorzawski 1908b, Nutting 1912.

Remarks.—The species has been described adequately. The characteristic colonial form was well illustrated by Kinoshita (1908: pl. 4, fig. 28), Kükenthal & Gorzawski (1908b: pl. 2, figs. 10, 11) and Nutting (1912: pl. 16, figs. 2, 3). An isolated polyp is now illustrated by SEM (Fig. 2) for comparison with *A. otsukai* (Fig. 4), *A. utinomii* new species (Fig. 16, top) and, especially, *A. kinoshitai* (Fig. 8).

Gross evidence shown by young polyps suggests that the developmental origin of the infrabasal scales may differ among the species of *Arthrogorgia.* Young polyps of *A. ijima* about 1 mm long do not yet have infrabasals (Fig. 1, bottom), but such scales are present in young polyps of *A. otsukai* at a similar size (Fig. 4, bottom).

There can be no doubt that the "3 grosse Bruchstücke" from the Okhotsk Sea identified as *Calyptrophora ijimai* by Broch (1935) are, in fact, *A. kinoshitai* Bayer (see below).

Arthrogorgia otsukai Bayer, 1952
Figs. 3, 4

Arthrogorgia otsukai Bayer, 1952:65, pl. 2, figs. 9–12; pl. 3, figs. 13–27.

Material.—Bering Sea, between Bowers Bank and codfish banks off mouth of Aangan River, Kamchatka. U.S.F.C. str. *Albatross,* exact station data obliterated. Numerous syntypic fragments, USNM 49979.

Diagnosis.—Stout, dichotomously branched *Arthrogorgia.* Margin of buccal scales of polyps not widely extending around opercularis and without projecting spines; one or more small infraopercular scales below each opercular scale, visible beyond margin of buccal scales; margin of basal scales without a projecting spine. Outer surface of scales ornamented with widely scattered low, simple granules.

Description.—(See Bayer 1952.) As the species has not been taken since the original damaged lot, nothing can be added to the information originally provided. Incomplete whorls (Fig. 3) and individual adult and young polyps (Fig. 4) from the type are now illustrated by SEM for comparison with *A. utinomii* new species (Figs. 15–18), *A. ijimai* (Figs. 1, 2) and *A. kinoshitai* (Figs. 7–9, 12).

Arthrogorgia kinoshitai Bayer, 1952
Figs. 5–12

Calyptrophora ijimai.—Broch, 1935:26, figs. 15, 16; 1940:12, 20.

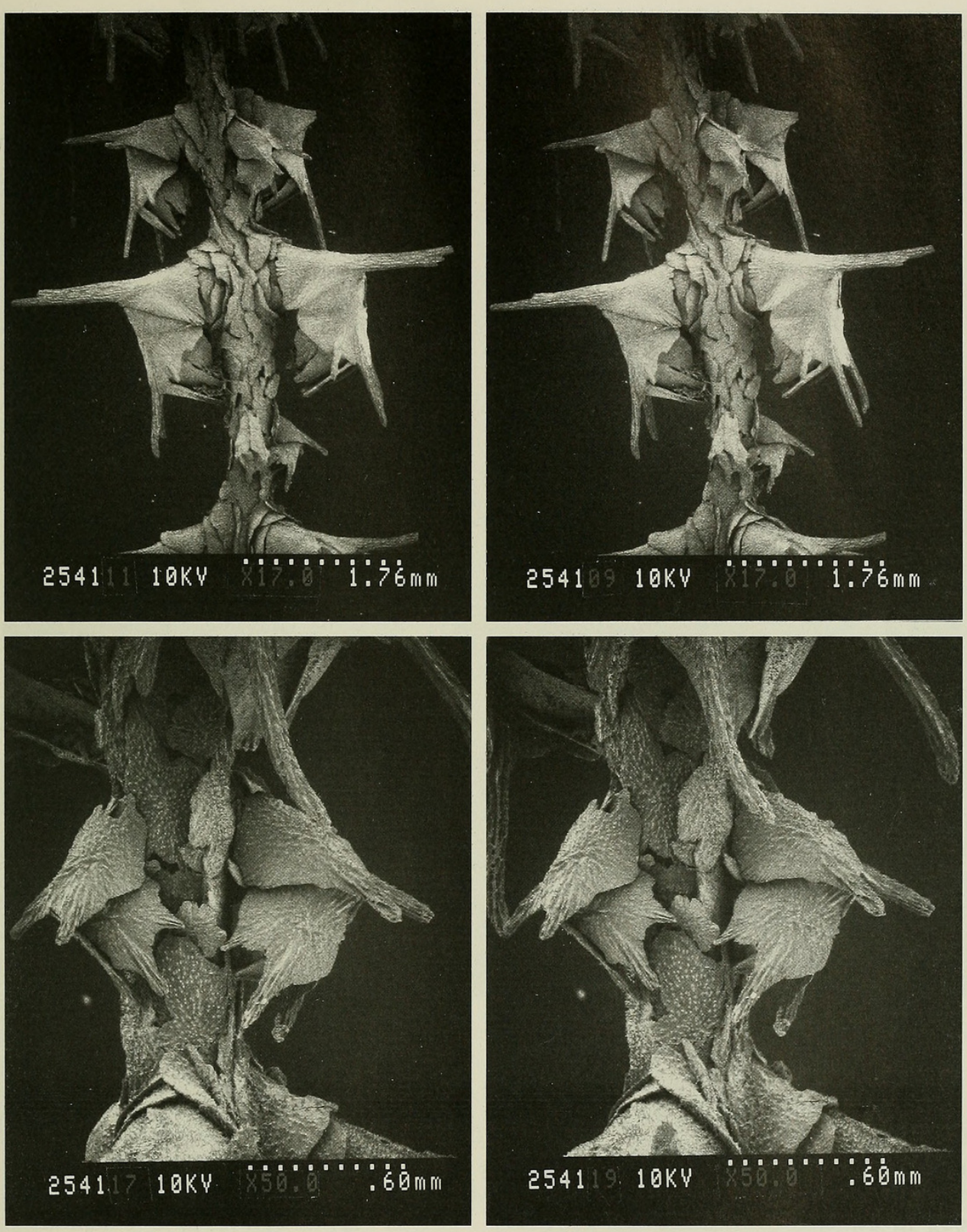


Fig. 1. *Arthrogorgia ijimai,* USNM 30028. Top, Part of lateral branchlet with whorl of fully developed polyps and two whorls of younger individuals; Bottom, Whorl of immature polyps still without infrabasal scales. SEM 2541. Stereo pairs.

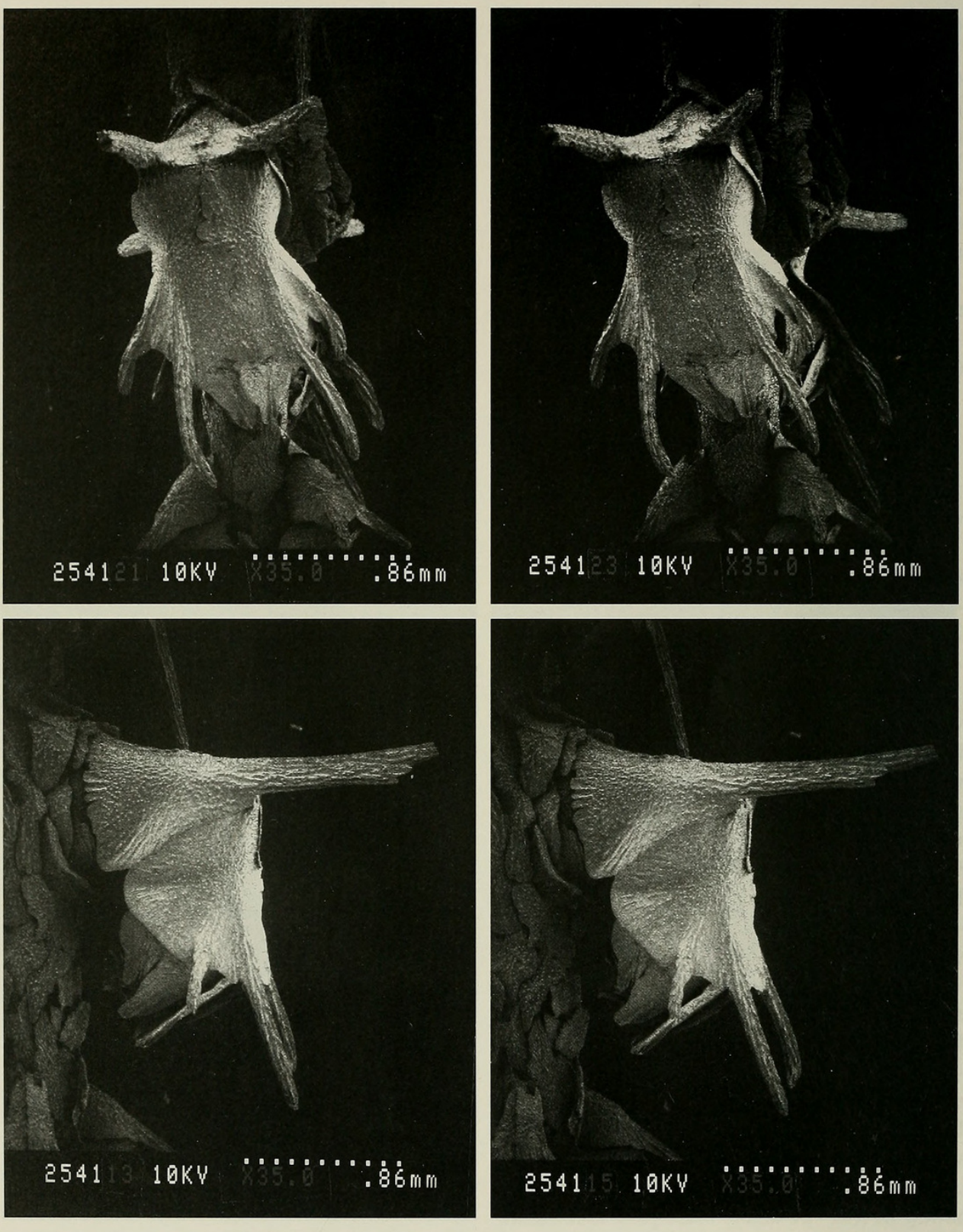


Fig. 2. *Arthrogorgia ijimai,* USNM 30028. Abaxial and lateral views of fully developed polyp. SEM 2541. Stereo pairs.

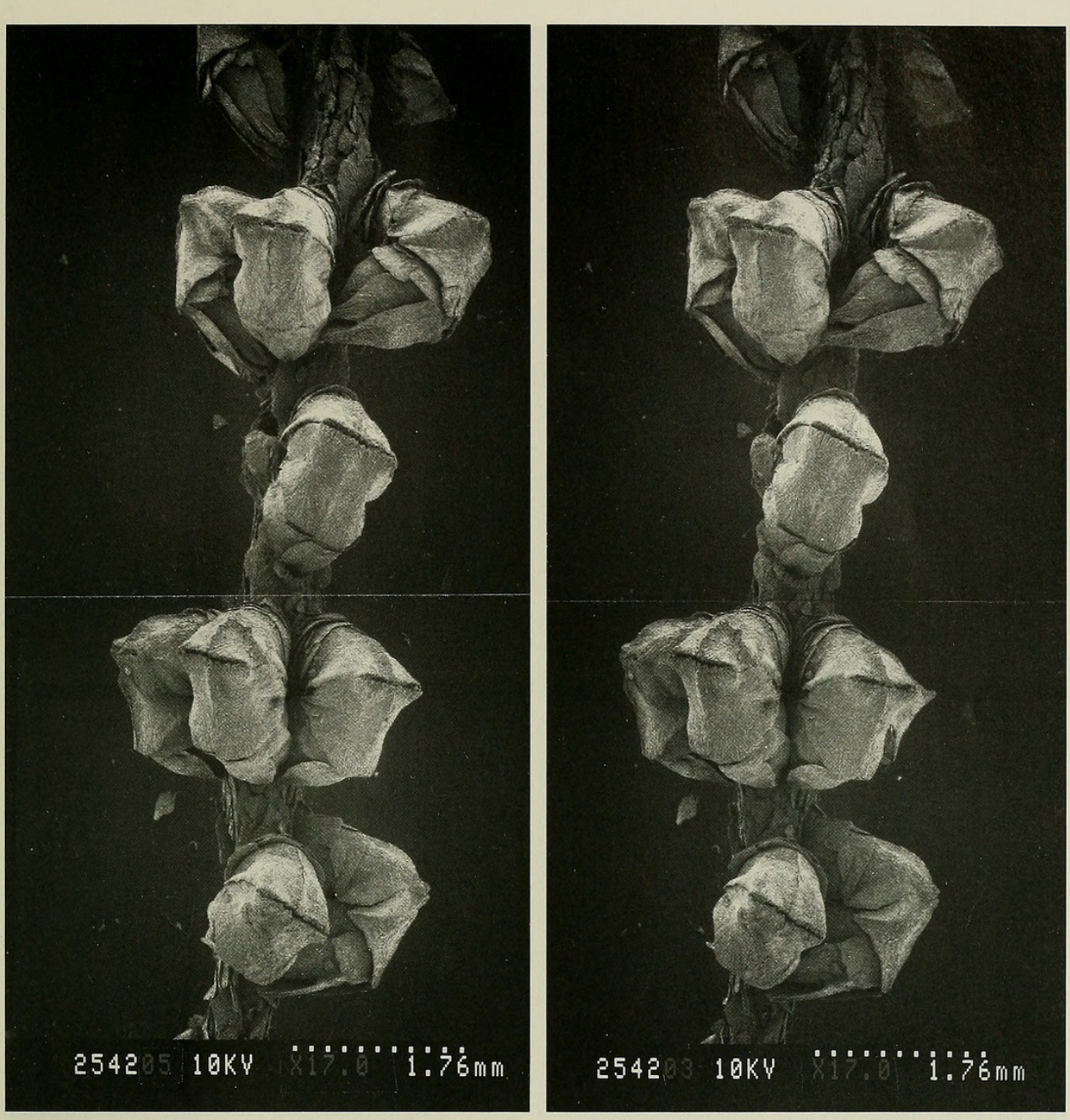


Fig. 3. *Arthrogorgia otsukai,*, USNM 49979. Part of terminal branch with four damaged whorls from syntypic fragment. SEM 2542. Stereo pair.

Not *Calyptrophora ijimai* Kinoshita, 1907: 234.

Arthrogorgia kinoshitai Bayer, 1952:64: pl. 2, figs. 1–8; pl. 3, figs. 1–12.

Material.—Alaska. Aleutian Islands SE of Agattu: 52°14′30″N, 174°13′E, 882 m, fine grey sand and pebbles, bottom temp. 38.6°F, USFC str. *Albatross* sta. 4781, 7 June 1906. One damaged colony, holotype, USNM 49978 (SEM 2499–2501, 2548). Aleutian Islands, off Near Islands: 53°05.79′N, 171°42′E, 455 m, bottom temp. 3.8°C, F/V *Pacific Knight* cruise 94-1, haul 204, 31 Jul 1994. Two colonies in good condition: colony 1, USNM uncatalogued (SEM 2510); colony 2, USNM uncatalogued (SEM 2543–2547).

Diagnosis.—Stout, dichotomously branched *Arthrogorgia* (Fig. 5) with distal margin of buccal scales widely extended as a broad, blunt lobe (Fig. 7) that in some polyps

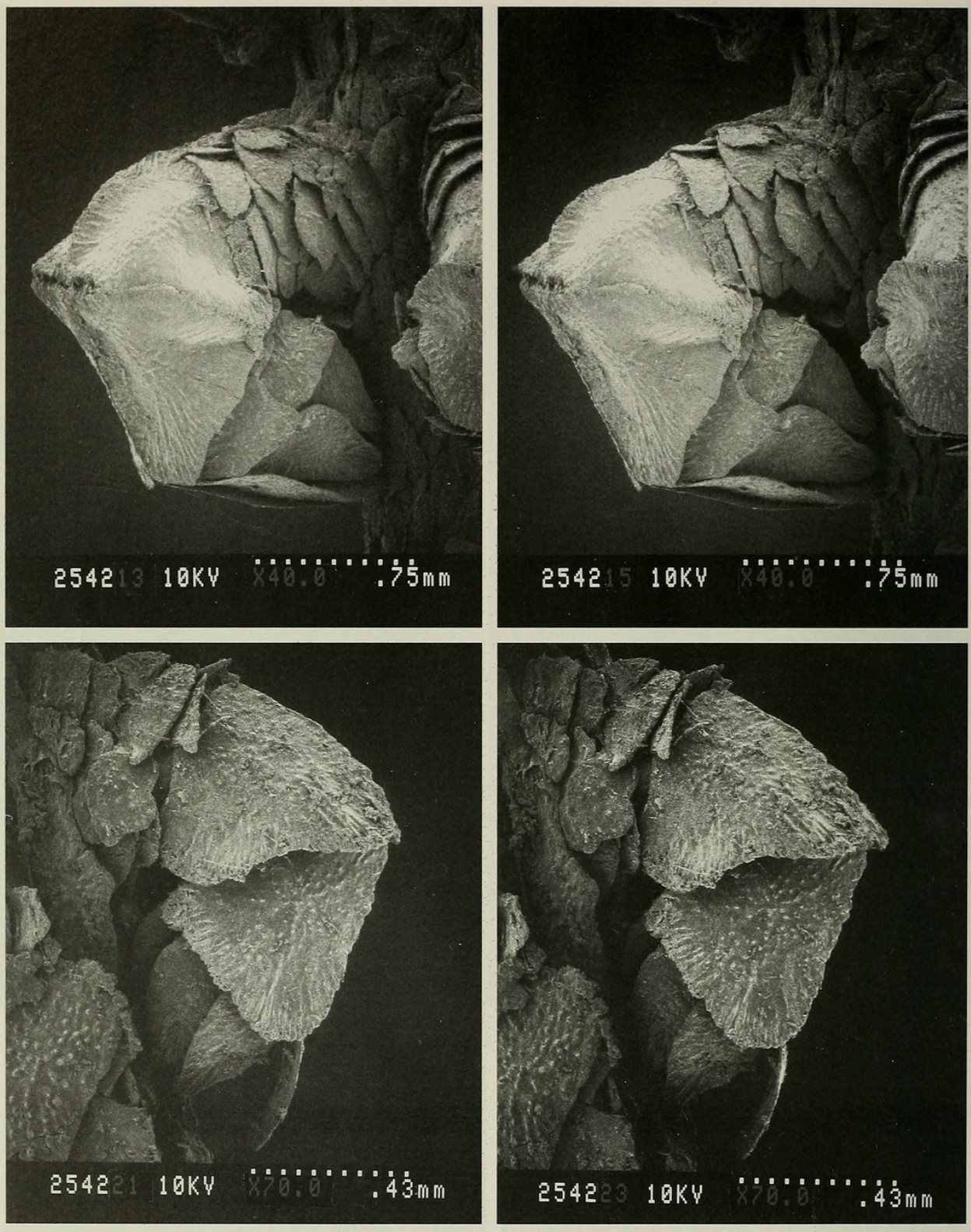


Fig. 4. *Arthrogorgia otsukai,* USNM 49979. Top, Lateral view of fully developed polyp showing multiple infrabasal scales; Bottom, Lateral view of young polyp showing multiple infrabasal scales. SEM 2542. Stereo pairs.

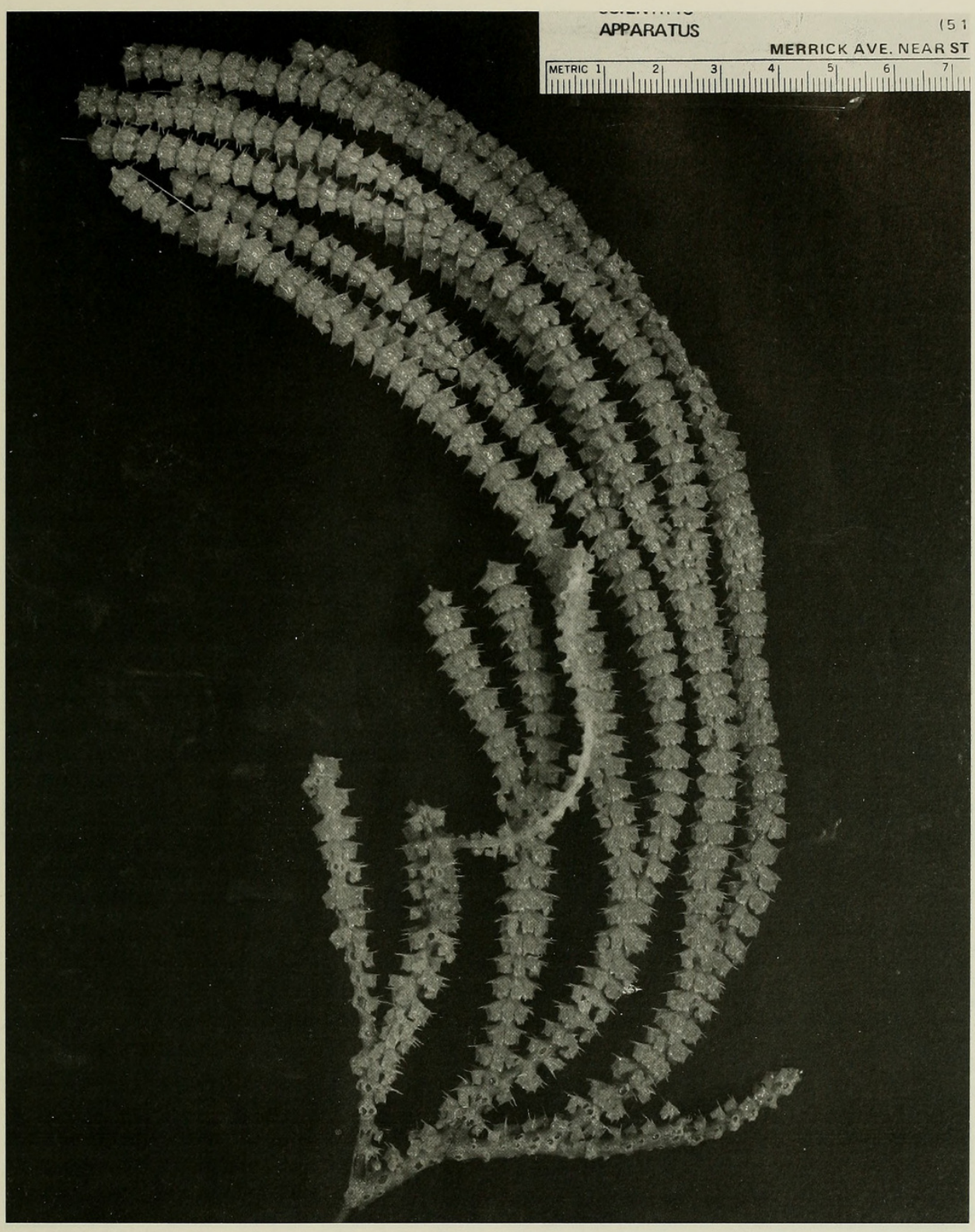


Fig. 5. *Arthrogorgia kinoshitai* from Near Islands, Aleutian Islands. Colony.

is divided into a few projecting spines (Figs. 8, 12); margin of basal scales usually with a strong marginal spine. Outer surface of scales ornamented with low, simple granules.

Description.—See Bayer 1952:64.

Remarks.—The two specimens taken by F/V *Pacific Knight* are almost intact save for the holdfast and are in very good condition. They agree with the type in all significant respects.

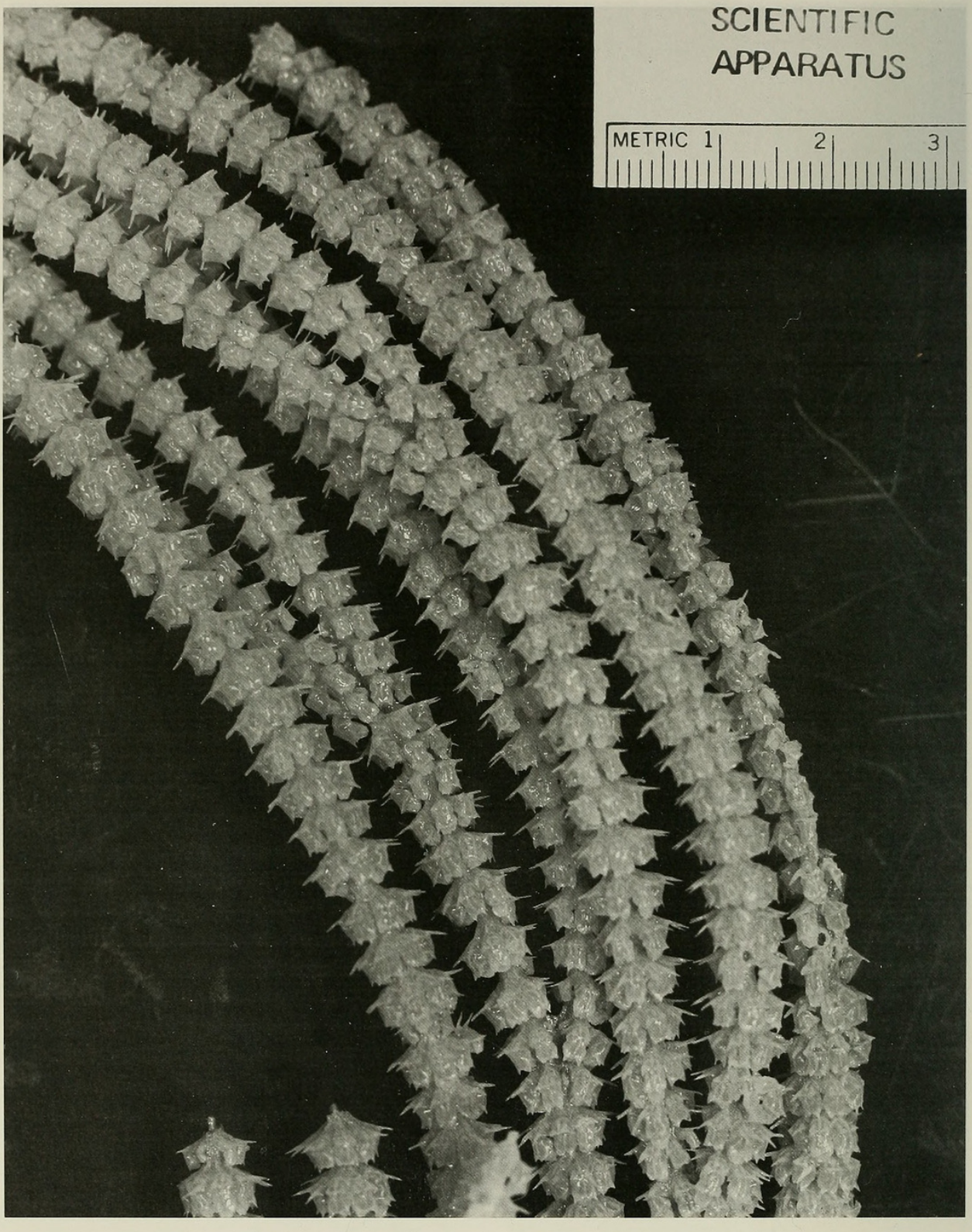


Fig. 6. *Arthrogorgia kinoshitai* from Near Islands, Aleutian Islands. Detail of branches.

The original type specimen (USNM 49978) obtained during the North Pacific cruise of USFC steamer *Albatross* in 1906 is in rather poor condition owing to inadequate curatorial maintenance. Consequently, the present material from this poorly known faunal region is a valuable addition to our National Collections.

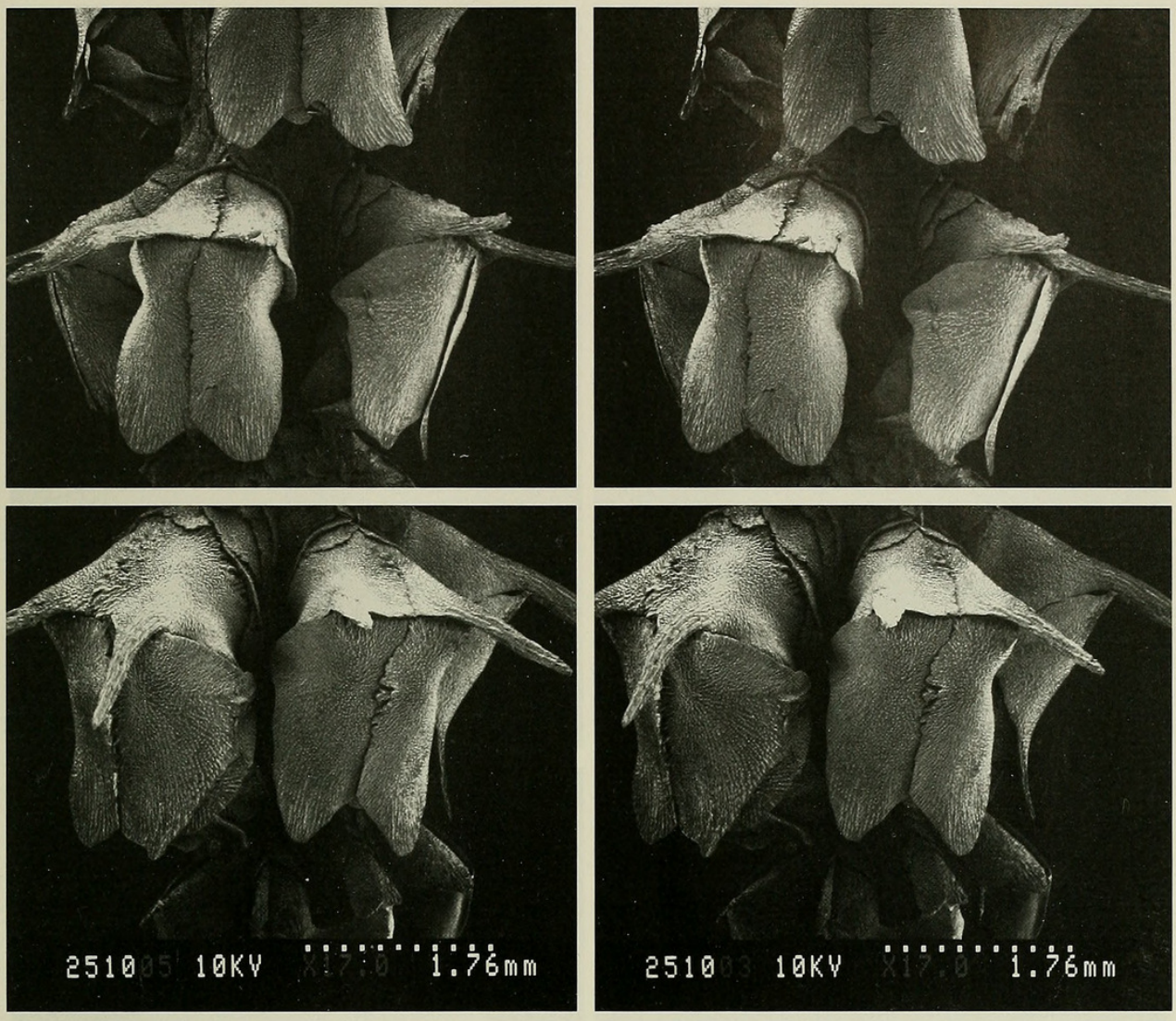


Fig. 7. *Arthrogorgia kinoshitai* from Near Islands, Aleutian Islands. Whorls of polyps. SEM 2510. Stereo view.

The large, paired plates surrounding the polyps are prone to mechanical damage incurred owing to the rigors of the environment. In one polyp isolated and examined by SEM, one of the two buccal scales appears to have been broken and the fragments subsequently repaired individually, with elaborate spinous development of the margins (Fig. 11).

Some polyps are modified for brooding (Fig. 10) and contain a single planula larva, the largest sufficiently advanced as to have clearly visible mesenteries densely packed with minute, elongate flat rodlets with scalloped margins, the longest 0.145 mm in length and 0.04 mm in overall width. In brooding polyps, the body wall between the buccal scale pair and the operculars is conspicuously enlarged to accommodate the contained larva and is packed with abundant small scales. The closed operculum projects conspicuously from the enlarged brood chamber (Fig. 10, top) and the adaxial body wall is covered by numerous small, irregular scales (Fig. 10, bottom); no evidence was found to suggest that the opercular scales are lost when the polyp expels the contained larva, as appears to be the case in *Tokoprimno maia* Bayer (Bayer 1996:514, fig. 3).

Although until now this species has not been reported since the original description, there can be no doubt that the three large fragments from the Okhotsk Sea reported by

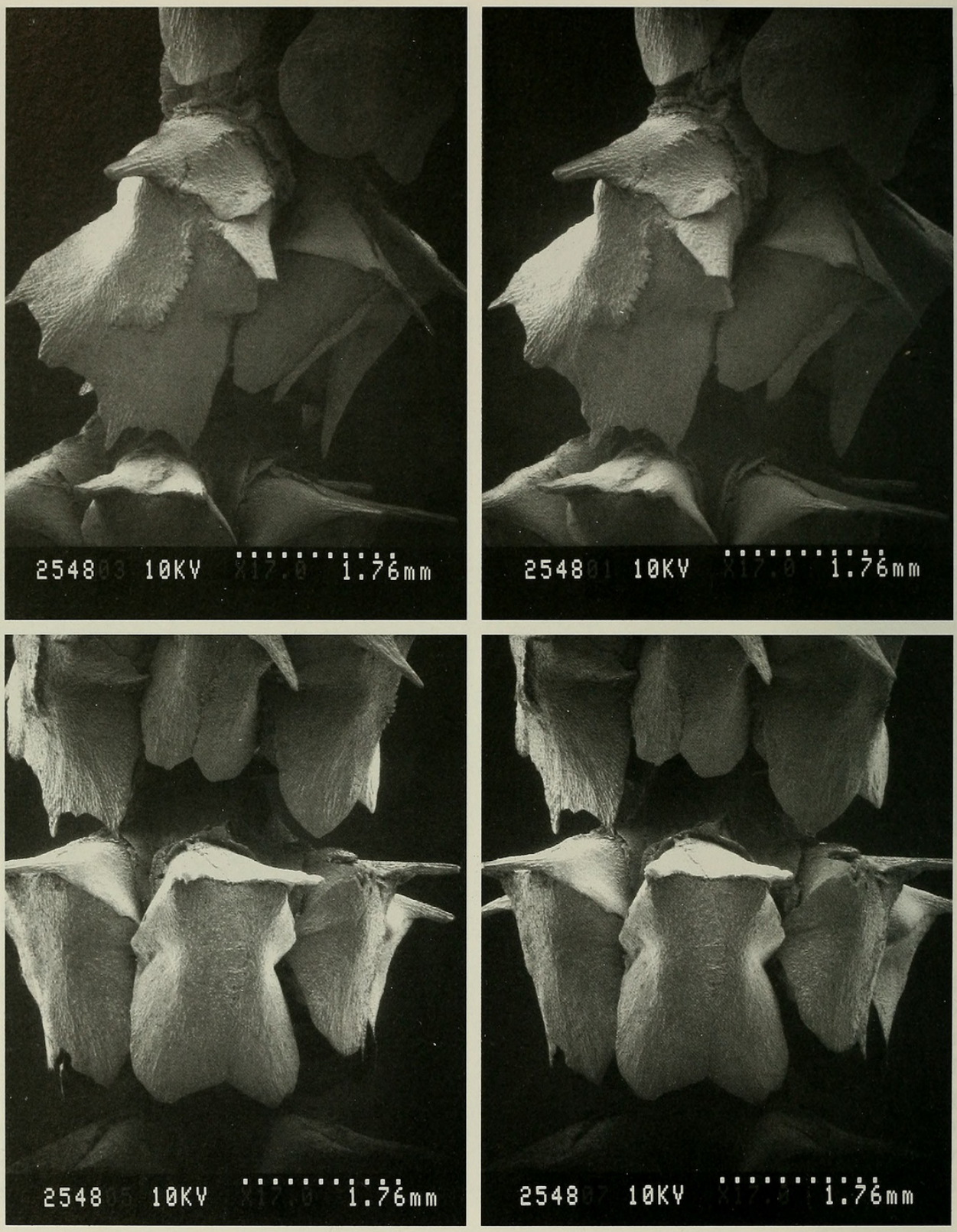


Fig. 8. *Arthrogorgia kinoshitai* USNM 49978, holotype from vicinity of Aggatu, Aleutian Islands. Whorls of polyps. SEM 2548. Stereo views.

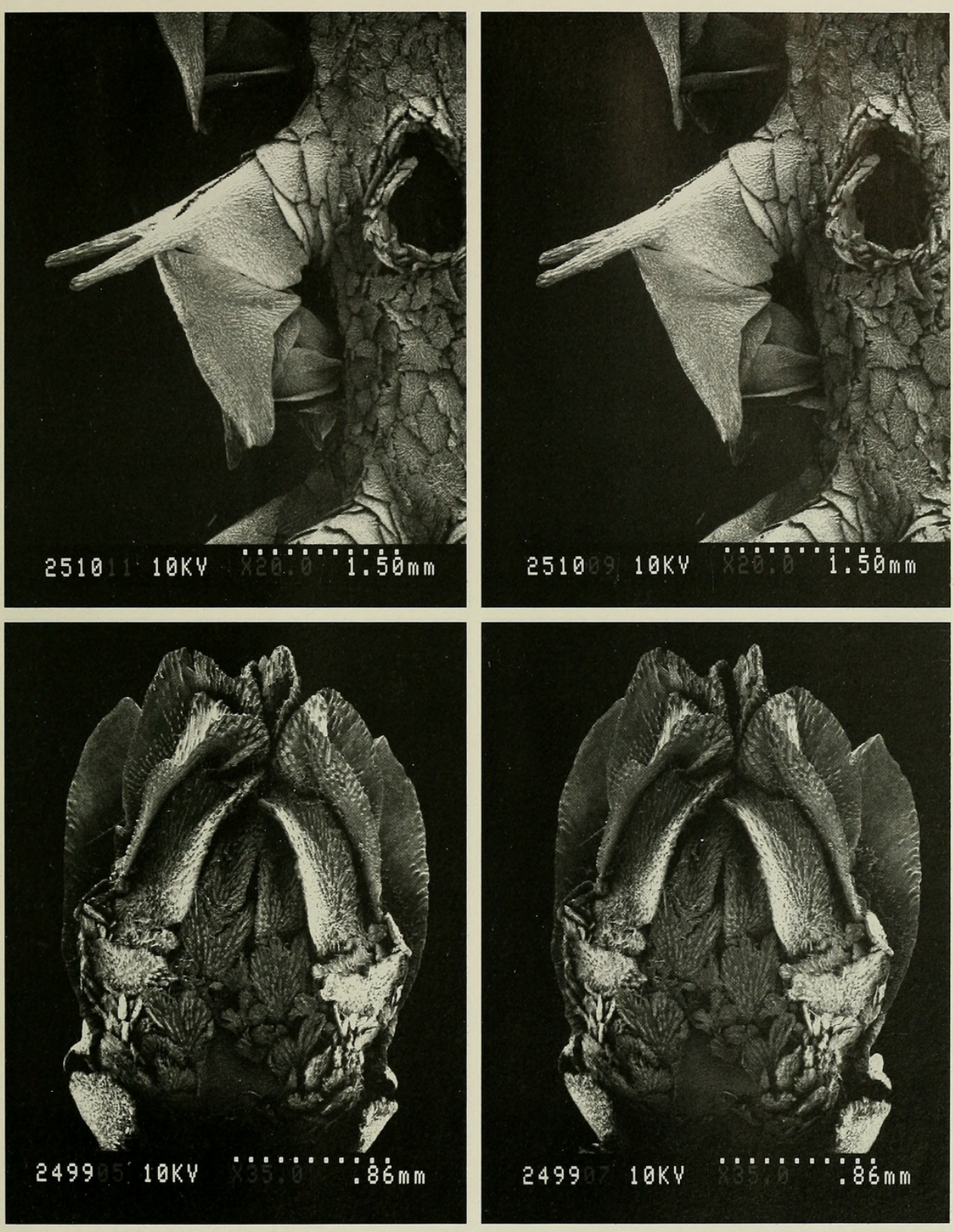


Fig. 9. *Arthrogorgia kinoshitai* from Near Islands, Aleutian Islands. Top: Lateral view of polyp *in situ,* showing multiple infrabasal scales, SEM 2510; Bottom, Opercular view of isolated polyp showing numerous small adaxial scales below the adaxial operculars, SEM 2499. Stereo pairs.

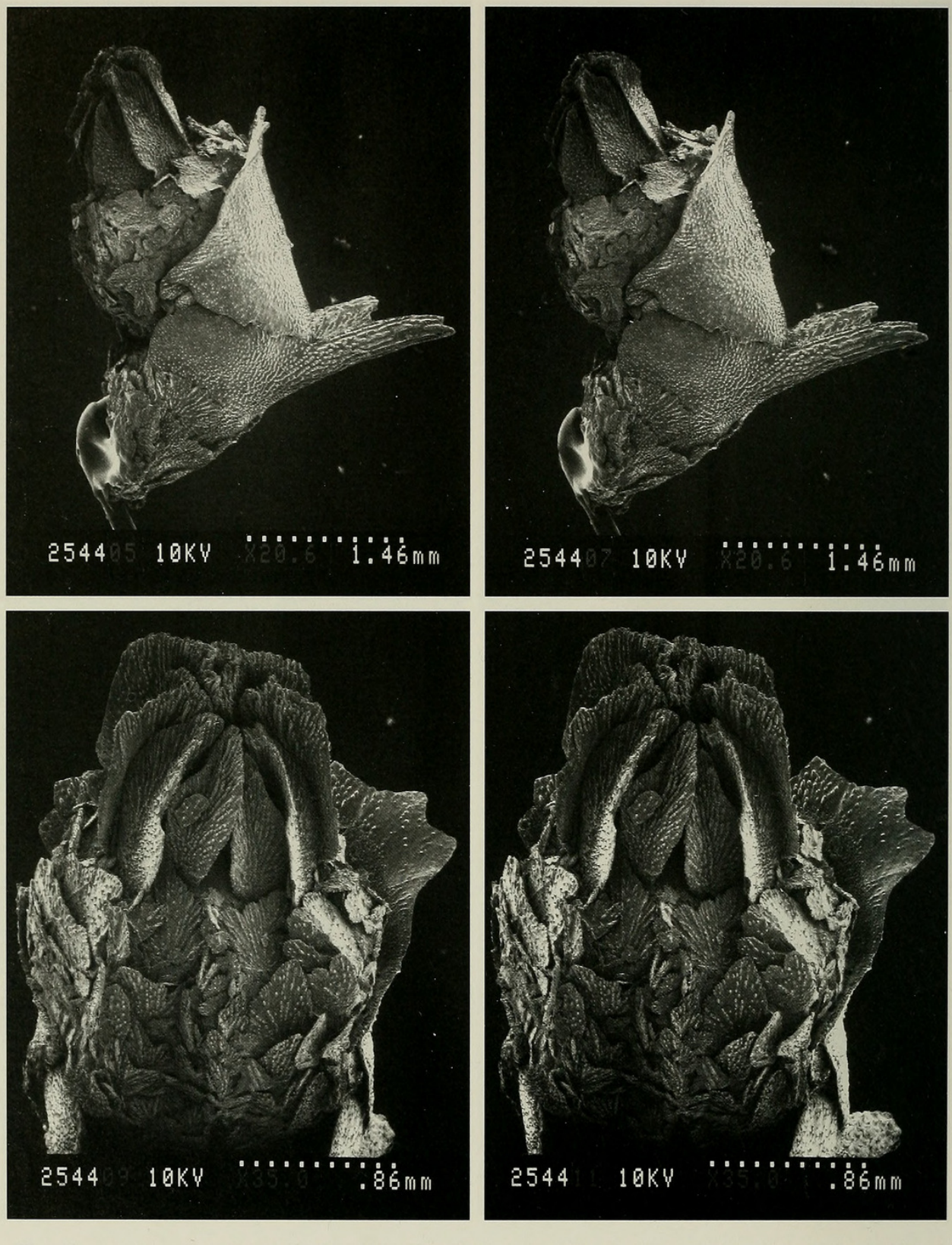


Fig. 10. *Arthrogorgia kinoshitai* from Near Islands, Aleutian Islands. Brood polyp, lateral and adaxial aspects. SEM 2544. Stereo pairs.

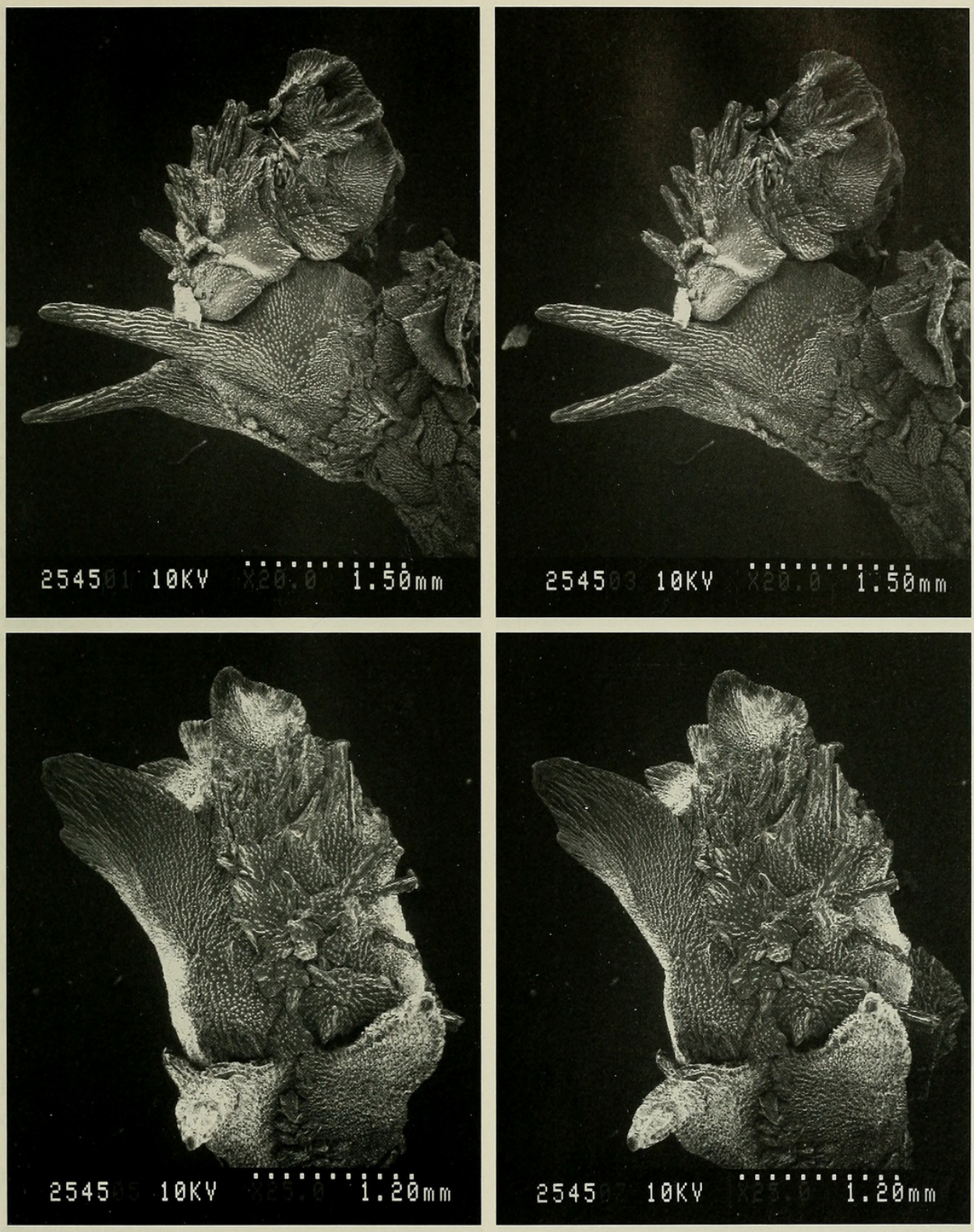


Fig. 11. *Arthrogorgia kinoshitai* from Near Islands, Aleutian Islands. Abnormal polyp with one buccal scale subdivided into several smaller, spinose scales, and the associated operculars with unusually spinose margins. SEM 2545. Stereo pairs.

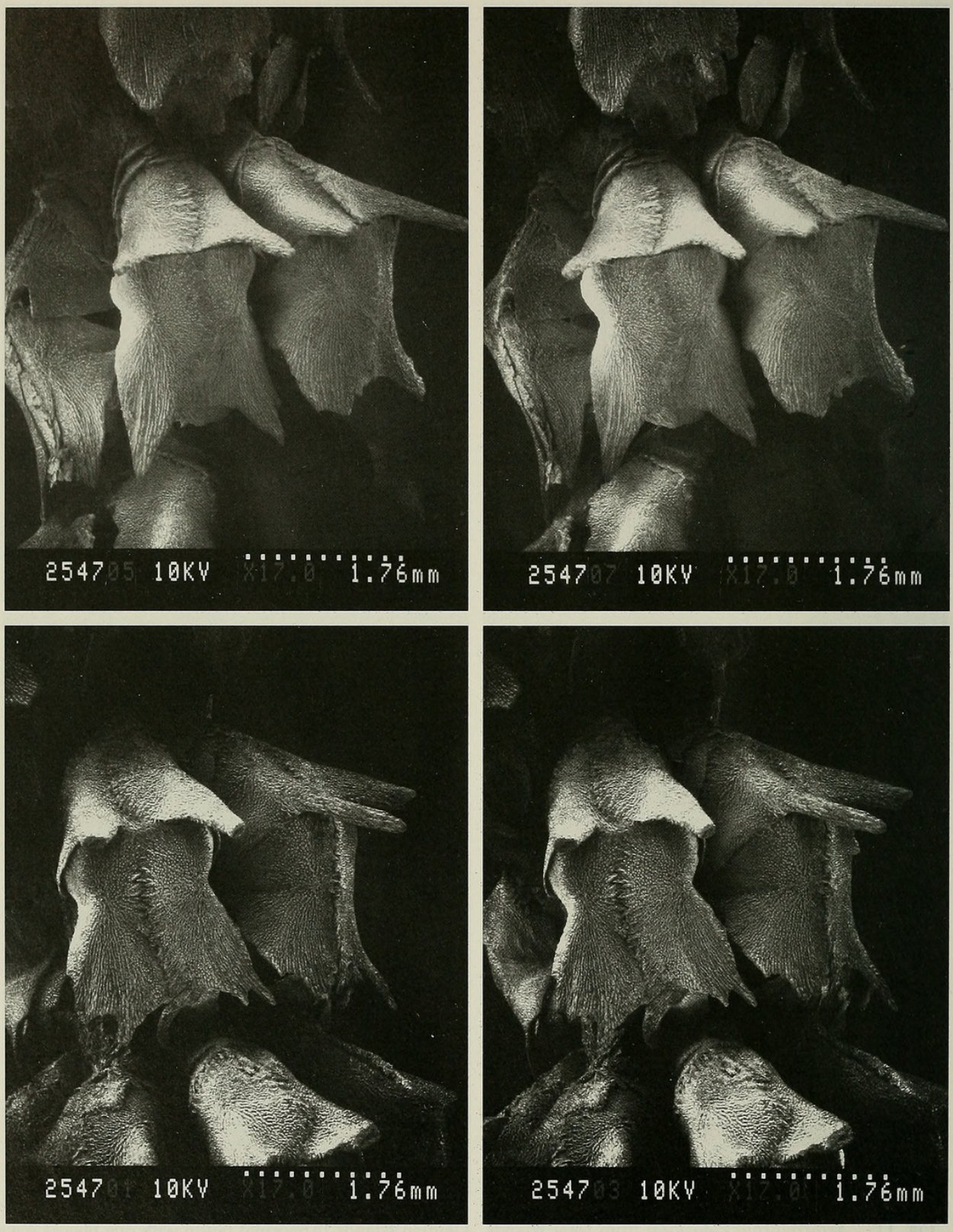


Fig. 12. *Arthrogorgia kinoshitai* from Near Islands, Aleutian Islands. Whorls of polyps showing variation of buccal margins. SEM 2547. Stereo pairs. Compare with Fig. 8.

Broch (1935:26) as *A. ijimai* (Kinoshita) are in fact *A. kinoshitai. A. ijimai* has been reported only from the vicinity of the Japanese main islands in depths of 728–1123 m, but has not been obtained in dredging and trawling stations by the then U.S. Fish Commission or subsequently by the present National Marine Fisheries Service of the U.S. Fish & Wildlife Service. Colonies of *A. ijimai* are small, pinnately branched, with very slender, flexible lateral branchlets (Nutting 1912: pl. 16, fig. 2), which is not consistent with "3 große Bruchstücke" reported by Broch, who provided no further particulars about colonial form. Moreover, his illustrations of polyps (Broch 1935:27, figs. 15a, 16) agree in general aspect with *A. kinoshitai* (Bayer 1952: pl. 2, figs. 1–3; figs. 8, 12 herewith), but not with *A. ijimai* (Kinoshita 1908b: pl. 6, fig. 54f; figs. 1, 2 herewith). The present specimens show variation in the margins of the buccal scales (SEM 2547, 2548) similar to that illustrated by Broch.

Arthrogorgia utinomii, new species
Figs. 13–20

Material.—Alaska. Aleutian Islands SSW of Attu I.: 52°28′N, 172°30′E, 234 m, R/V *Starlight* cruise 84-1, haul 36, 13 Jul 1984. One large colony lacking holdfast, otherwise in good condition, holotype, USNM (SEM 2504-2506, 2540, 2562). Aleutian Islands SE of Agattu, Aleutian Islands: 52°14′30″N, 174°13′E, 482 fathoms (=882 m), USFC steamer *Albatross* sta. D-4781, 7 June 1906. One incomplete colony lacking holdfast, USNM 58168 (SEM 1398, 2502, 2503, 2564–2566). Aleutian Islands S of Yunaska I.: 52°18.16′N, 170°41.96′W, 163 m, R/V *Harvester* cruise 802, sta. VH-80-42, 8 Aug 1980. Two branches of a large colony, USNM 80829 (SEM 1418–1422, 1428).

Diagnosis.—Stout, dichotomously branched *Arthrogorgia.* Margin of buccal scales of polyps not widely extending around operculars, with at most a blunt marginal angle not produced as a strong spine; one or more accessory infraopercular scales below abaxial, outer lateral and inner lateral opercular scales, visible beyond margin of buccal scales; margin of basal scales usually with a stout marginal spine, projecting strongly in some polyps, less so in others. Outer surface of scales with sharply prickly sculpture.

Description.—The colony (Fig. 13) is dichotomously branched, roughly in one plane, with undivided terminal branches up to 30 cm long. The bifurcations enclose rather narrow angles of 30°–35° and the branches are nearly straight and nearly parallel. The polyps are arranged in regular whorls of 7 or 8 (Fig. 14), predominantly directed downward (Fig. 15) but with a few individuals facing upward, especially just above branch dichotomies. From seven to nine whorls occur in 3 cm of branch length. The axis is brown or dark brown, with a bronze-colored metallic luster; narrow longitudinal grooves follow an irregular spiral course on the large branches, becoming essentially vertical on the narrow terminal branches.

The contracted polyps (Figs. 15–18) are 3.0–3.5 mm long measured parallel with the branch; they are protected by two pairs of large abaxial body scales, basal and buccal, and three or more pairs of infrabasals, which may be rather irregular. The basal scales have a strongly projecting marginal spike (Figs. 15, 16 top, 18 top). The free margin of the buccal scales scarcely extends beyond the base of the operculars (Figs. 16–18), sometimes forming rounded lobes (Fig. 17, bottom), sometimes a broad, projecting angle (Fig. 15, bottom). The operculum projects strongly beyond the buccal margin (Figs. 16, top; 17, top). The large buccal scales may be subdivided into several smaller, irregular scales, apparently by breakage and repair (Fig. 15 top). The operculum consists of eight tall scales, the abaxials largest, decreasing in size adaxially, the adaxial pair distinctly smaller and overlapped by the inner laterals; opercular scales with an inner longitudinal keel and corresponding external

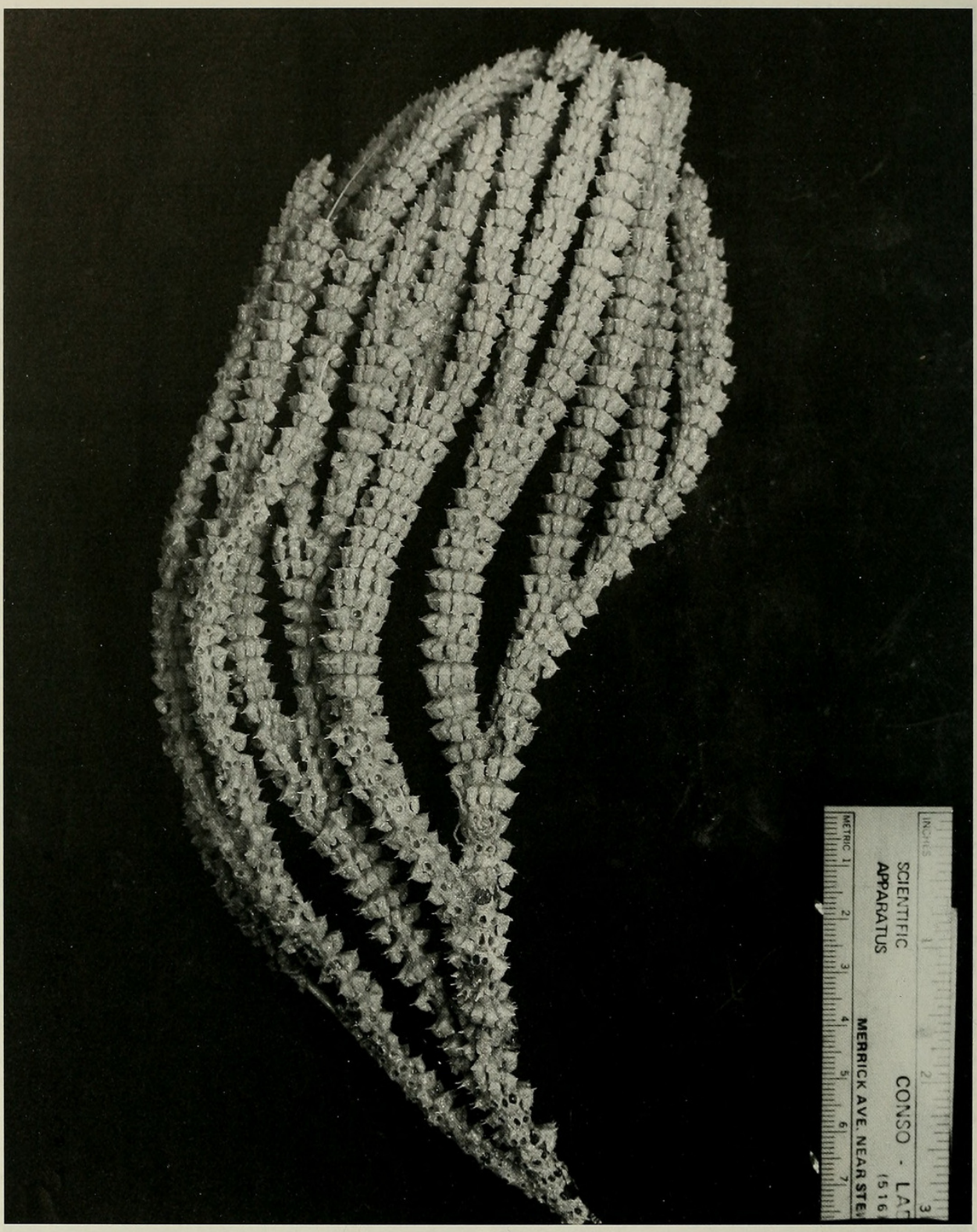


Fig. 13. *Arthrogorgia utinomii,* holotype. Nearly complete colony.

groove, most strongly developed on the abaxial and lateral scales. One or two pairs of small adaxial buccal scales (Fig. 16, bottom) lie below the adaxial operculars, followed by one or more pairs of small adaxial body scales. In fully developed polyps, accessory infraopercular scales are present below the abaxial, outer lateral and inner lateral oper-

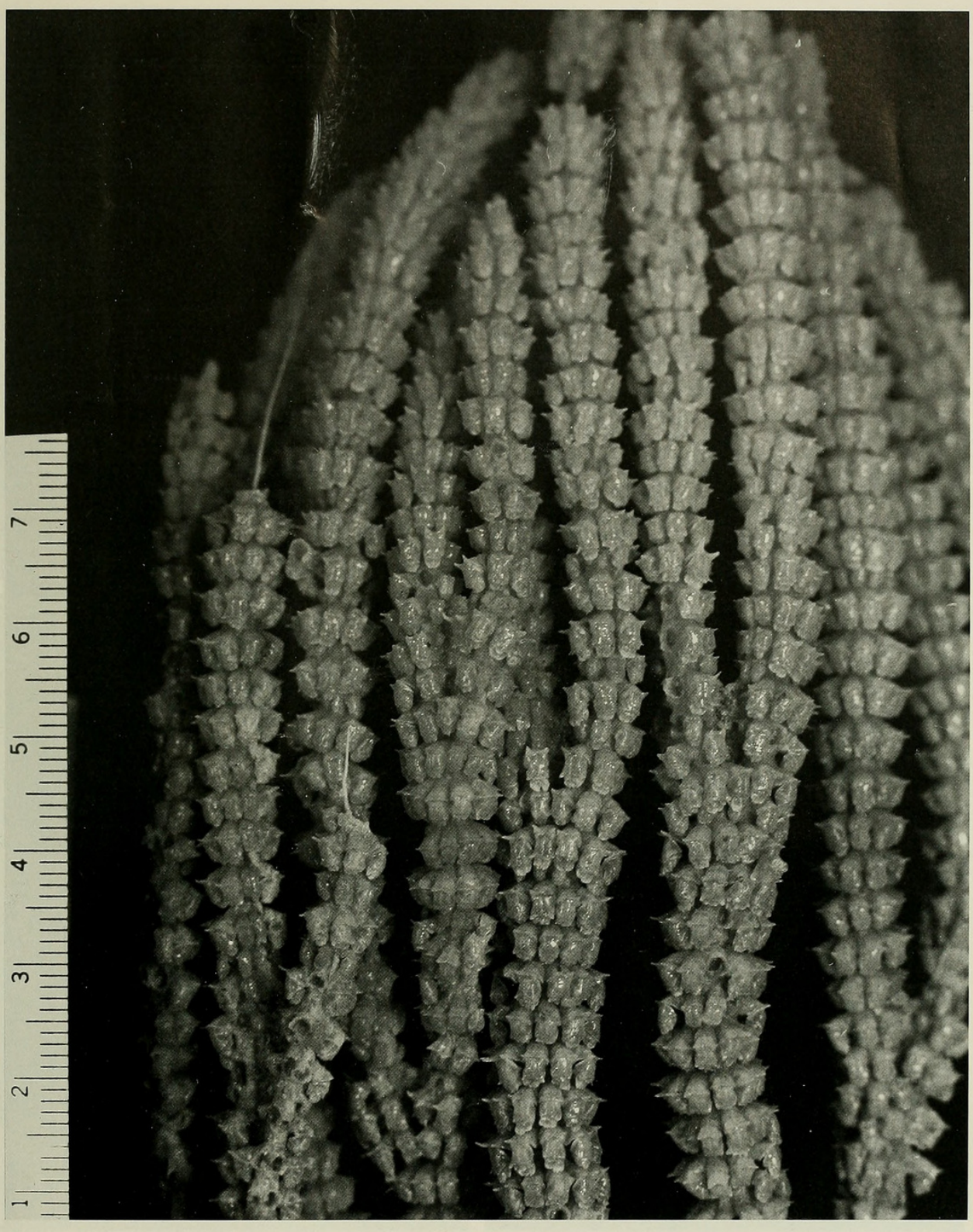


Fig. 14. *Arthrogorgia utinomii,* holotype. Detail of branches.

culars, sometimes below all. These accessory scales are visible beyond the margin of the buccal scale pair (Figs. 16, top; 17, top; 18, top) and are developed already in very young polyps (Fig. 18, bottom). These scales were called "marginal" in the case of *A. kinoshitai* and *A. otsukai* (Bayer 1952). The tentacles contain numerous small, flat, blunt

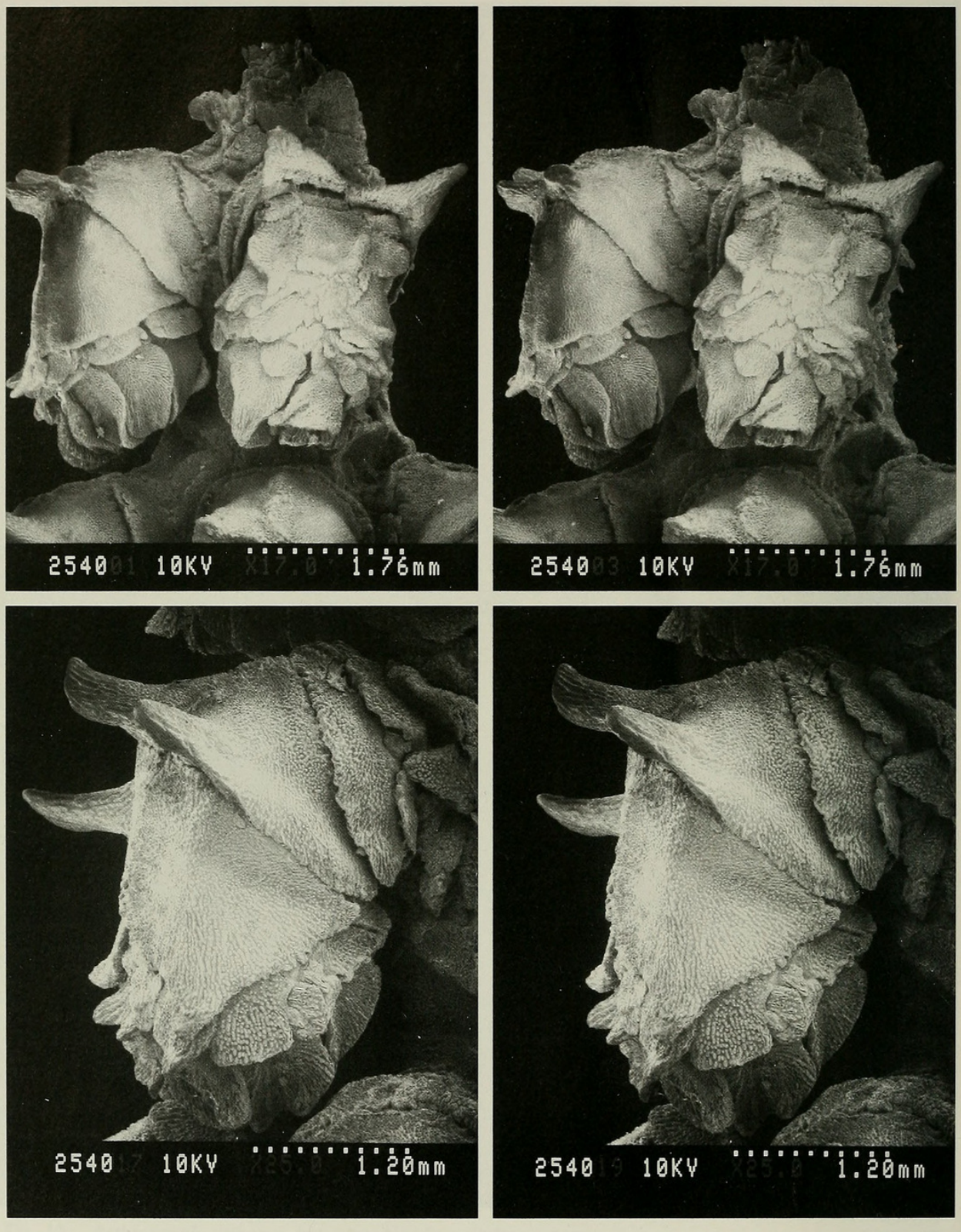


Fig. 15. *Arthrogorgia utinomii,* holotype. Top, Two polyps of distalmost whorl of terminal branch, one with medial scales subdivided by breakage and repair; Bottom, Lateral view of polyp showing infraopercular scales and angular projection of buccal margin. SEM 2540. Stereo pairs.

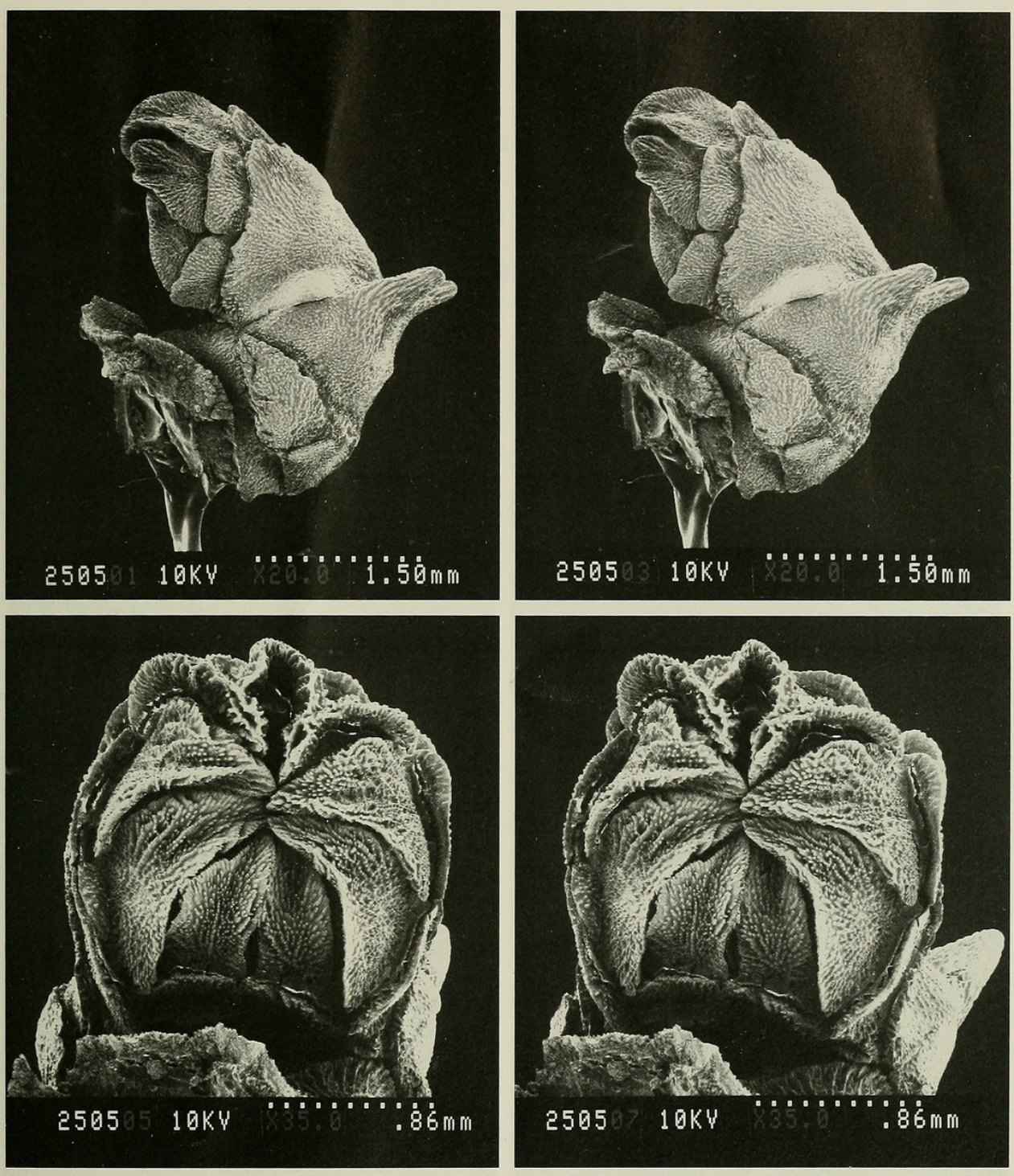


Fig. 16. *Arthrogorgia utinomii,* holotype. Lateral and opercular views of isolated polyp. SEM 2505. Stereo pairs.

rodlets with scalloped margins, about 0.085 mm long and 0.03 mm wide.

All of the body sclerites of the polyps are covered externally by sharp prickles arranged in lines radiating outward from the depositional center of the scale, ending at the margins as fine serrations; internally they are covered with complex tubercles.

The coenenchyme is filled with small, thorny or tuberculate spheroids, which become wider, flattened, and more scalelike in form where they merge with the infrabasals at the base of the polyps. In the angle of bifurcations, the coenenchyme extends as a narrow, membranous expansion possibly analogous with the coenenchymal mem-

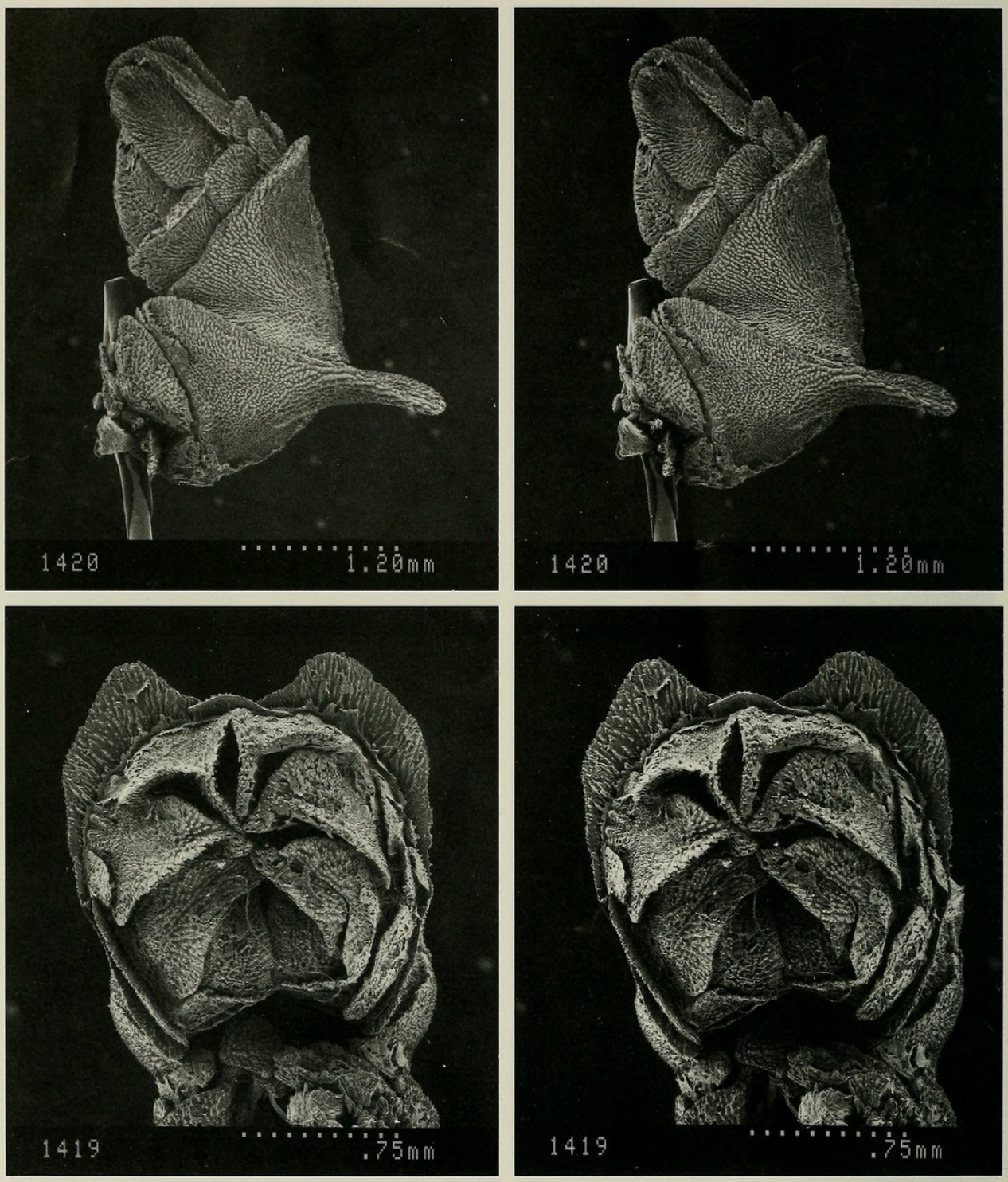


Fig. 17. *Arthrogorgia utinomii,* USNM 80829. Top, Lateral view of isolated polyp, SEM 1420; Bottom, Opercular view of isolated polyp, SEM 1419. Stereo pairs.

branes of *A. ijimai,* but not demonstrably associated with the presence of any commensal polychaete.

Most of the polyps of the colony from southeast of Attu I. (USNM 58168) have strongly developed infraopercular scales (Fig. 19, top), a condition apparently related to brooding, as several polyps dissected contain what appear to be a fully developed planula. The adaxial body wall of such individuals is protected by numerous small, irregular scales (Fig. 19, middle), small

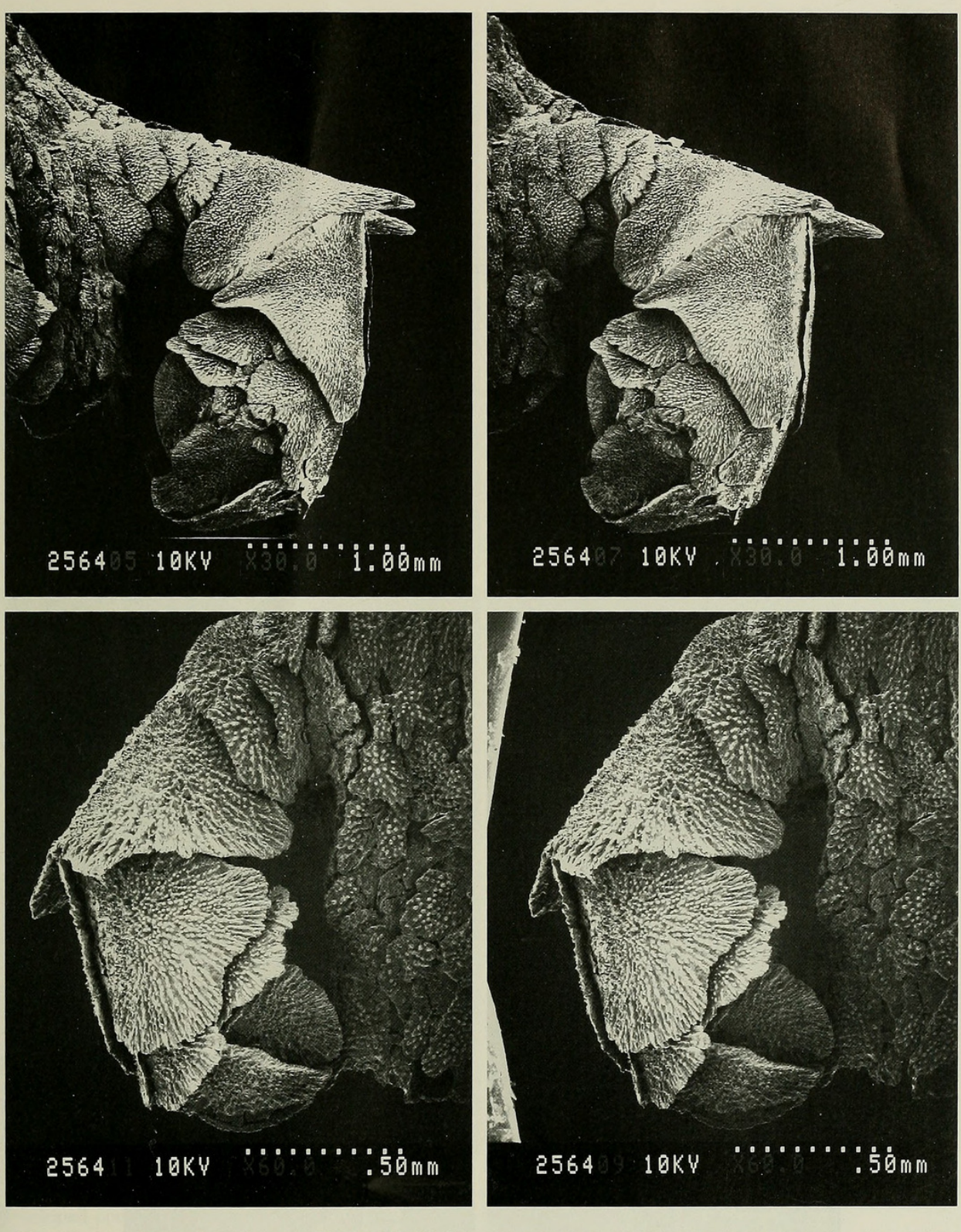
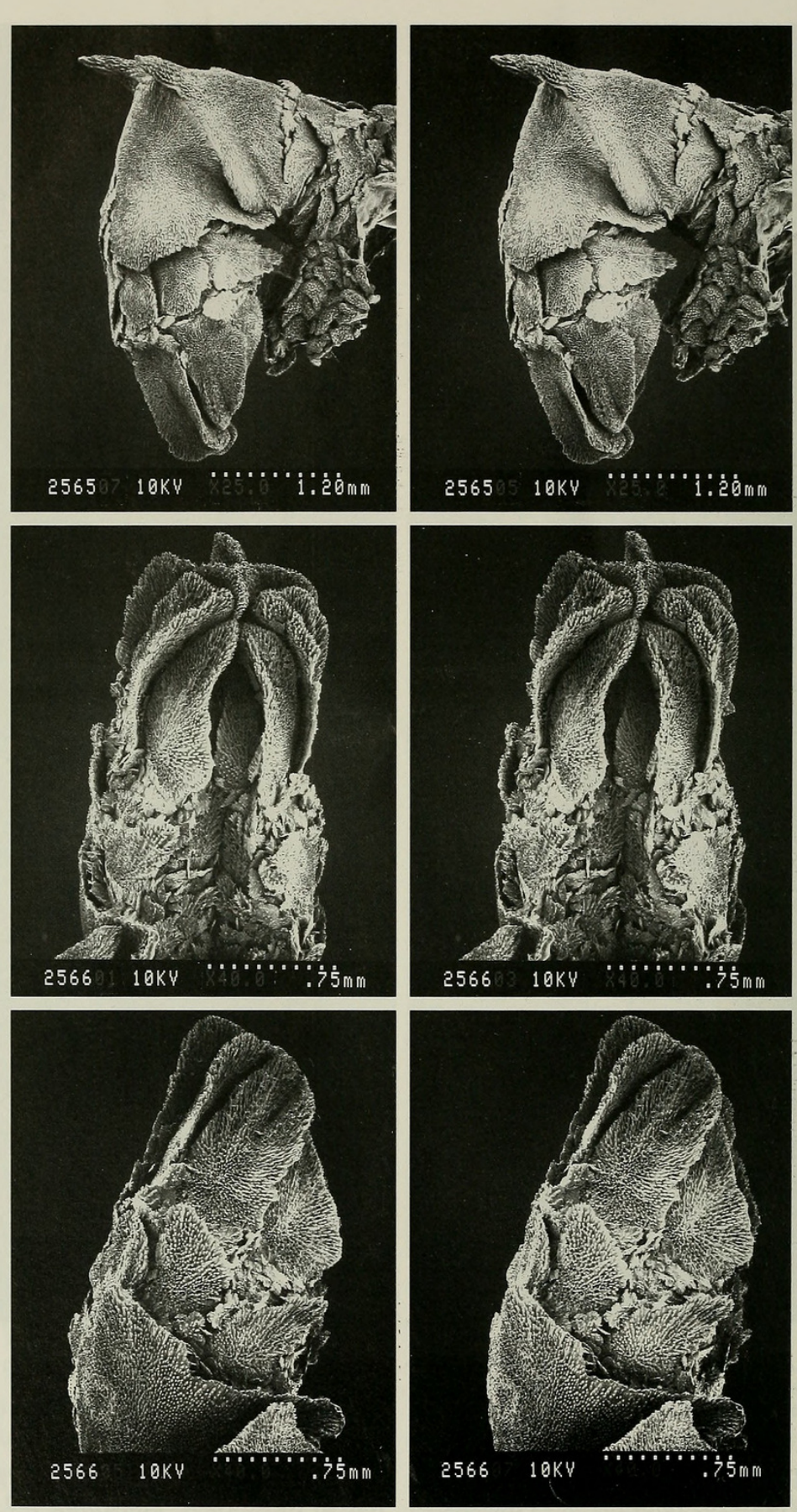


Fig. 18. *Arthrogorgia utinomii,* USNM 56168. Top, Lateral view of fully developed polyp in situ; Bottom, Lateral view of young polyp in situ. SEM 2564. Stereo pairs.

scales are present between the large infraopercular (Fig. 19, bottom), and the opercular scales protrude conspicuously beyond the buccals and infraopercular (Fig. 19, top, bottom). These brood polyps are similar to those of *A. kinoshitai* (cf. Fig. 10).

Etymology.—Named in memory of the late Dr. Huzio Utinomi, long-time friend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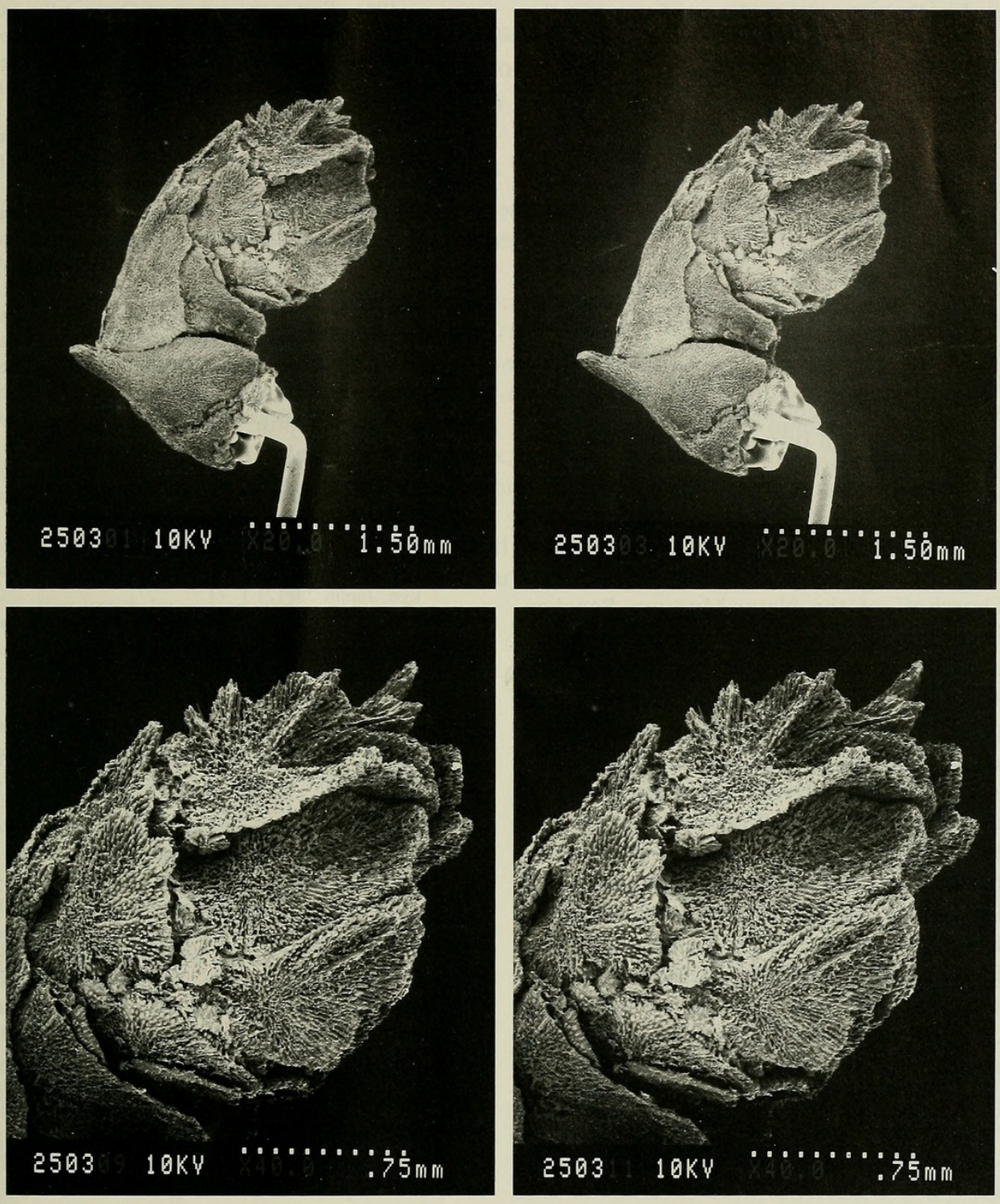

Fig. 20. *Arthrogorgia utinomii,* USNM 58168. Lateral and opercular views of polyp having elaborately developed opercular scales, SEM 2503. Stereo pairs.

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Fig. 19. *Arthrogorgia utinomii,* USNM 56168. Top, Lateral view of brooding polyp, SEM 2565; Middle, Adaxial view of operculum of brooding polyp, SEM 2566; Bottom, Lateral view of operculum of brooding polyp, SEM 2566. Stereo pairs.

and colleague whose descriptions of primnoids enhanced the scientific knowledge of the Gorgonacea of Japanese waters.

Comparisons.—Colonies of this species grossly resemble those of *A. kinoshitai* and *A. otsukai* but differ conspicuously from the delicate, pinnate colonies of *A. ijimai* (Kinoshita 1908: pl. 4, fig. 28; Nutting 1912: pl. 16, fig. 2). They differ from both in the development of accessory scales between the buccal pair and the opercularis of the polyps, from *kinoshitai* by the negligible free margin of the buccal pair, and from *otsukai* by the larger size of the polyps and the development of a strong marginal spine on the basal scales.

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