









ALCYONARIA OF THE CALIFORNIAN  
COAST

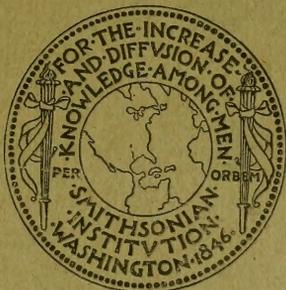
BY

CHARLES C. NUTTING

Professor of Zoology, State University of Iowa, Iowa City

No. 1658.—From the Proceedings of the United States National Museum,  
Vol. XXXV, pages 681-727, with Plates LXXXIV-XCI

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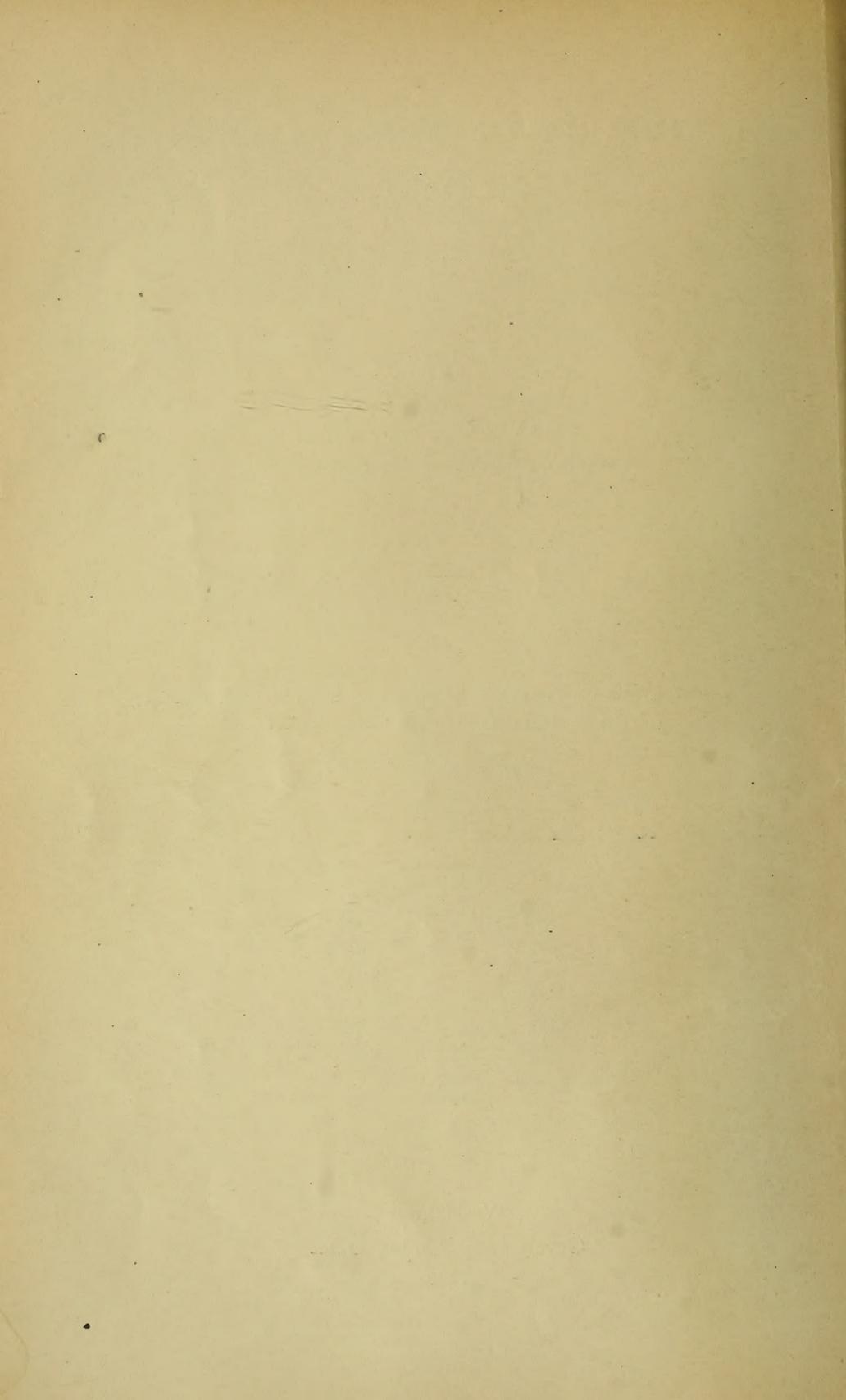
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## ALCYONARIA OF THE CALIFORNIAN COAST.

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The collections upon which this report is based were obtained for the most part by the U. S. Fisheries steamer *Albatross* while on her cruise off the Californian coast during the year 1904. The collections of the University of California also furnished much interesting material. A few species were found in the collection of the Marine Biological Association of San Diego, and others were kindly placed at my disposal by Stanford University. The writer is under great obligation to the management of the Marine Biological Laboratory at La Jolla and the Hopkins Laboratory at Pacific Grove for laboratory facilities and other valued courtesies during the time he was at work on these collections.

Almost no work had been done on the Alcyonaria of the Californian coast previous to the summer of 1905, when the writer was commissioned by the Bureau of Fisheries to investigate the alcyonarian fauna of that region.

In 1863 Prof. W. M. Gabb published descriptions of a few species in the Proceedings of the California Academy of Natural Sciences.

From 1864 to 1868 Prof. A. E. Verrill published a number of papers containing descriptions of Alcyonaria of the Pacific coast, the most important being a Review of the Corals and Polyyps of the West Coast of America.<sup>a</sup> This is an exceedingly important paper, but deals almost exclusively with forms occurring south of the region at present under consideration, and includes descriptions of less than half a dozen species from north of Mexico.

In 1902 Dr. Th. Moroff published his Studien über Octocorallien, in which he describes three new species of pennatulids<sup>b</sup> from the Californian coast.

Aside from a few scattering references, the above are all of the papers that I have been able to find dealing with the Alcyonaria of

<sup>a</sup> Trans. Connecticut Acad. Arts and Sci., I, Pt. 2.

<sup>b</sup> Zoologische Jahrbücher, Abtheilung für Systematik, Geographie, und Biologie der Thiere, XVII, 1902, p. 363.

the region under consideration. This scarcity of literature is probably due to the fact that the region is singularly barren of alcyonarian life so far as the shallow-water fauna is concerned. Quite the contrary is true of the deeper water off the Californian coast, and it remained for the Fisheries steamer *Albatross* to demonstrate this fact during the operations of that vessel in 1904, which yielded the greater part of the material upon which the present paper is based.

SYSTEMATIC LIST OF CALIFORNIAN ALCYONARIA IN THIS REPORT.

Order ALCYONACEA.

Family CORNULARIDÆ.

*Telesto rigida.*  
*Telesto ambigua.*  
*Sympodium armatum.*

Family ALCYONIDÆ.

*Anthomastus ritteri.*

Order PENNATULACEA.

Family PENNATULIDÆ.

*Pennatula aculeata.*  
*Ptilosarcus quadrangularis.*  
*Halisceptrum cystiferum.*

Family STYLATULIDÆ.

*Stylatula elongata.*  
*Acanthoptilum gracile.*  
*Acanthoptilum pourtalesii.*  
*Acanthoptilum album.*  
*Acanthoptilum scalpelliforme.*  
*Acanthoptilum annulatum.*

Family VIRGULARIDÆ.

*Balticina pacifica.*  
*Balticina finmarchica.*

Family FUNICULINIDÆ.

*Funiculina armata.*  
*Halipterus contorta.*

Family STACHYPTILIDÆ.

*Stachyptilum superbum.*  
*Stachyptilum quadridentatum.*

Family ANTHOPTILIDÆ.

*Anthoptilum grandiflorum.*

Family UMBELLULIDÆ.

*Umbellula magniflora.*  
*Umbellula huxleyi.*  
*Umbellula loma.*

Family PROTOPTILIDÆ.

*Distichoptilum verrillii.*

Family RENILLIDÆ.

*Renilla amethystina.*

Order GORGONACEA.

Suborder HOLAXONIA.

Family PRIMNOIDÆ.

*Caligorgia sertosa.*  
*Plumarella longispina.*

Family MURICEIDÆ.

*Elasmogorgia filiformis.*  
*Muricella complanata.*  
*Eumaricea pusilla.*

Family PLEXAURIDÆ.

*Psammogorgia arbuscula.*  
*Psammogorgia simplex.*  
*Psammogorgia torreyi.*  
*Psammogorgia spauldingi.*

Family GORGONIDÆ.

*Leptogorgia floræ.*  
*Leptogorgia purpurea.*  
*Leptogorgia caryi.*  
*Stenogorgia kofoidi.*

A glance at the foregoing list shows that the most striking feature of the collection is the number and variety of pennatulids, there being 20 of these beautiful forms out of a total of 38 alcyonarians.

Remembering the large number of Muricidæ and Plexauridæ described by Verrill from the west coast south of the United States, it is somewhat surprising that more numerous representatives of these groups are not included in the present list. This is probably due to the fact, before referred to, that Verrill's material was largely from shallow water, while the present collection was mostly from deep water.

The only alcyonarians that the writer saw in shallow water while working on that coast were *Stylatula gracilis* and *Renilla amethystina*, both pennatulids. So far as could be ascertained, no other alcyonarians had been collected from shallow water, either at La Jolla, where the laboratory of the Marine Biological Association of San Diego is located, or at Pacific Grove. The coast at both these places is rocky and furnishes many almost ideal habitats for alcyonarian life, and the reason for its almost entire absence is not evident, especially in view of its abundance along the Central American coast.

## Bathymetrical and geographical distribution of Californian Alcyonaria.

Name.	Depth.	Geographical distribution.						
		West coast of America.		West Pacific Ocean.	Atlantic Ocean.			
		California to Panama.	South America.		Coast of the United States.	West Indies.	Eastern Atlantic Ocean.	
	<i>Fathoms.</i>							
<i>Telesto rigida</i> .....	1,675							+
* <i>Telesto ambigua</i> .....	524							
<i>Symphodium armatum</i> .....	1,075							
* <i>Anthomastus ritteri</i> .....	231-638						+	
<i>Pennatula aculeata</i> .....	29-1,100					+		
<i>Ptilosarcus quadrangularis</i> .....	31-200?							
* <i>Halipectrum cystiferum</i> .....	394-609							
<i>Stylatula elongata</i> .....	1-52							
? <i>Acanthoptilum gracile</i> .....	20-59							
<i>Acanthoptilum pourtalesii</i> .....	44						+	
* <i>Acanthoptilum album</i> .....	40-67							
<i>Acanthoptilum scalpelliforme</i> .....	30-140							
* <i>Acanthoptilum annulatum</i> .....	31-291							
* <i>Balticina pacifica</i> .....	243-1,083							
<i>Balticina finmarchica</i> .....	60-400					+		+
<i>Funiculina armata</i> .....	135-638						+	
* <i>Halipteris contorta</i> .....	478-600							
<i>Stachyptilum superbum</i> .....	26-524	+						
* <i>Stachyptilum quadridentatum</i> .....	108-145							
<i>Anthoptilum grandiflorum</i> .....	500-734					+	+	
<i>Umbellula magniflora</i> .....	334-1,600				+			
<i>Umbellula huxleyi</i> .....	500-565				+			
* <i>Umbellula loma</i> .....	330							
<i>Distichoptilum verrillii</i> .....	995-1,573	+						
<i>Renilla amethystina</i> .....	1-6	+	+					
<i>Caligorgia seriosa</i> .....	120-1,012				+			
<i>Plumarella longispina</i> .....	191				+			
<i>Elaasmogorgia filiformis</i> .....	28-423				+			
<i>Muricella complanata</i> .....	285-345				+			
* <i>Eumuricea pusilla</i> .....	285							
<i>Psammogorgia arbuscula</i> .....	12-339	+						
* <i>Psammogorgia simplex</i> .....	447-448							
* <i>Psammogorgia torreyi</i> .....	26-197							
* <i>Psammogorgia spauldingi</i> .....	(?)							
<i>Leptogorgia flora</i> .....	(?)—80	+						
<i>Leptogorgia purpurca</i> .....	(?)—41		+			+	+	
<i>Leptogorgia caryi</i> .....	a(?)							
* <i>Stenogorgia kofoidi</i> .....	60-74							

a Shallow water.

[The asterisk (\*) indicates a new species.]

The most important fact brought out by the foregoing list is the entire absence of forms known from the American coast north of California. Aside from this purely negative showing, the most striking feature of the list is the remarkable diversity of the derivation of this fauna, its relationships being almost exactly equal in respect to the faunas of the Pacific coast south of California, the Western Pacific, the eastern coast of the United States, and the West Indies.

Another interesting feature is that the relationship with the Atlantic and Pacific faunas is almost exactly equal.

The collection is hardly extensive enough to warrant any generalizations, and even if this were not so, this singular equivalence of relationship would signify little beyond the wide distribution of the Alcyonaria in comparatively deep water.

## SYSTEMATIC DISCUSSION AND DESCRIPTION OF SPECIES.

Order *ALCYONACEA*.

Fixed colonial forms without an axis cylinder.

Family *CORNULARIDÆ*.

Polyps with solenia; or branched and bearing lateral buds.

Genus *TELESTO*.

Axial polyps, from the walls of which lateral polyps bud forth.  
 Walls containing spicules. = *Telesto californica* Kükenthal

*TELESTO RIGIDA* Wright and Studer.

*Telesto rigida* WRIGHT AND STUDER, Challenger Reports, the Alcyonaria, 1889,  
 p. 261.

Base of attachment not present; colony, in typical specimen, 33 mm. high; longest branch, 30 mm.; average diameter of main stem, 2.5 mm., widening distally.

The main stem is the elongated body of the parent body wall, from which daughter polyps branch; these also give off buds, making three generations, as it were. The stem and calyces of the daughter polyps are rather faintly corrugated, the corrugations becoming almost obsolete on distal parts of calyces. Margins with 8 lobes and almost translucent.

The spicules are warty, short spindles, with a few crosses and slender spindles.

*Color*.—Almost white in specimens preserved in formalin.

*Locality*.—Station 4422, east point of San Nicholas Island bearing S. 6° W., 2.5 miles distant. Depth, 31 fathoms.

There were also two specimens in the collection of the University of California, labeled "Sta. XXI, haul 2, June 20, 1901," off Santa Catalina Island, 43 fathoms, and "Sta. LVII-H. I., 50 fathoms, July 17, 1903," from off San Diego.

These specimens agree in essential characters with the original description.

In some places the corrugations in the calyces are well marked, while in others they are almost obsolete, showing that their presence or absence can hardly be a good specific character.

The *Challenger* secured this species at Station 71, west of the Azores, at a depth of 1,675 fathoms.

## TELESTO AMBIGUA Nutting, new species.

Plate LXXXIV, figs. 1 and 2; Plate XC, fig. 1.

Colony growing from an expanded, more or less membranous base, and forming a tangled mass in which it is difficult to distinguish individual stems; longest stem attaining a height of 19 mm. The stem, or body of the mother polyp, gives off daughter calyces without any regularity whatever. In one case an individual attains a height of about 14 mm. Calycular wall with 8 longitudinal corrugations armed with spicules placed lengthwise, and ending at the margins in 8 rounded points. The corrugations are lighter in color than the intervening spaces, and somewhat broader, giving a decidedly striated appearance to the calycular walls.

The calyces enlarge slightly and gradually toward the margins; and are often curved, when long. In some cases there are calyces of the third generation.

The polyps are all so retracted that details of their structure can not be ascertained without sectioning.

The spicules are very slender spindles, almost needle like, with their outer surfaces rather closely beset with thorn-like processes. They are most numerous in the longitudinal rugosities on the calycular walls.

*Color.*—Pale yellowish brown, growing lighter distally; the intervals between the rugosities are greenish.

*Type-specimen.*—Cat. No. 25421, U.S.N.M.

*Locality.*—Station 4514, Monterey Bay, Point Pinos light-house bearing S. 39° E., 10.7 miles distant; 524 fathoms.

## Genus SYMPODIUM.

Polyps arising from a thin, leathery membrane, retractile. Spicules small and disk-shaped.

## SYMPODIUM ARMATUM Wright and Studer.

*Symphodium armatum* WRIGHT and STUDER, Challenger Report, Alcyonaria, 1889, p. 272.

Specimens which agree well with the original description were found at the following stations:

Station 4311, Point Loma light-house bearing N. 32° E., 8.5 miles distant; 110 fathoms.

Station 4515, Monterey Bay, Point Pinos light-house bearing S. 18° E., 8.1 miles distant; 495 fathoms.

Challenger Station 56, latitude 30° 08' 45" N., longitude 64° 59' 35" W.; 1,975 fathoms.

Family *ALCYONIDÆ*.Genus *ANTHOMASTUS*.

Colony a fleshy rounded head supported by a short thick stem devoid of polyps; polyps large, scattered, and completely retractile; zooids present, scattered between the large polyps.

*ANTHOMASTUS RITTERI* Nutting, new species.

Plate LXXXIV, fig. 3; Plate XC, fig. 2.

Colony growing from a rounded, expanded, disk-shaped base; stem short and stout, devoid of polyps; head flattened, mushroom-shaped, kidney-shaped in longitudinal section. The stem is very rugose in specimens in formalin, livid whitish in color, 52 mm. long, 22 mm. in longest median diameter. The head is 72 mm. long, 57 mm. broad, and 26 mm. deep.

The large polyps are irregularly scattered over the entire head, without any well-marked bare areas, although they are rather sparsely distributed as a rule. The polyps have the body transversely and longitudinally wrinkled; 9 mm. to base of tentacles; tentacles 8 mm. long in specimens preserved in formalin. The polyps are completely retractile, but the verrucæ do not close over the retracted polyps, leaving sunken pits about 6 mm. in diameter. The younger polyps are interspersed among the older, but there seems to be no regular intergradation in size between old and young. In smaller specimens, however, this is not the case. The body cavities run down through the stem as in *Renilla*.

The zooids are distributed densely over the entire surface of the capitulum, covering it with their minute verrucæ, giving a distinctly granulated appearance to those portions not occupied by the polyps.

The spicules are of three types: 1. Needle-like forms imbedded in the surface of the capitulum. These are the most abundant. 2. Bar-like forms which are thickly crowded in the polyp walls. 3. Stars and double stars crowded on the surface of the capitulum between the siphonozooids. The zooids are surrounded by tufts of needle-like spicules.

The color of the polyps is deep crimson red, the lower part of the bodies lighter. The general surface of the capitulum is purplish pink. The stem is livid. One of the naturalists on the *Albatross* succinctly described the appearance of this species when he said that it resembled "an early rose potato stuck full of red cloves."

*Type-specimen*.—Cat. No. 25422, U.S.N.M., *Albatross* station 4415.

*Distribution*.—Station 4415, NE. point Santa Barbara Island N. 89° W. 4.7 miles, 438 fathoms; Station 4418, SW. rock, Santa Barbara Island, N. 8° E. 6.9 miles, 238 fathoms; Station 4423, E. Point San Nicholas Island S. 6° W. 2.5 miles, 216–389 fathoms;

Station 4429, Gull Island N. 21° W. 2.9 miles, 506–680 fathoms; Station 4461, Point Pinos light-house S. 3° E. 9.3 miles, 285–323 fathoms.

This striking species is named in honor of Prof. William E. Ritter, of the University of California.

### Order PENNATULACEA.

Colony free, consisting of a central stem, bearing polyps on its distal portion. Polyps either sessile, or borne on lateral leaves. A horny axis usually present. In addition to the polyps, zooids are usually found in this group.

#### Family PENNATULIDÆ.

Colony in the form of a true feather, leaves or pinnules large and evident.

#### Genus PENNATULA.

Zooids on the ventral side of the rachis only. Spicules scattered over the entire surface, not confined to the borders of the leaves.

#### PENNATULA ACULEATA Danielssen.

*Pennatula aculeata* DANIELSSEN, Forh. Vid.-Sel., Christiania, 1858, p. 25.

Numerous specimens collected by the Fisheries steamer *Albatross* seem to be of this exceedingly variable species. The following is a description of a typical colony:

Total length of colony 119 mm.; length of stem 45 mm. Stem distinctly swollen just below the rachis, the fleshy part abruptly pinching out about 7 mm. from the end, leaving bare the horny axis which expands into a terminal, transparent, greatly flattened knob or club. This is probably due to mutilation.

Leaves 23 pairs, the longest 17 mm. long by 3.5 broad, closely approximated.

There are about 10 calyces to each full grown leaf, their margins being surmounted by 8 slender acute points formed mainly by converging spicules.

Zooids densely crowded on the ventro-lateral surface, leaving a broad median band bare. Each zooid is guarded by a stockade of 5 to 10 spicules on its proximal side.

Spicules of the usual pennatulid type, the longest forming the calycular teeth and along the lower edges of the leaves, where they furnish a stiff support. They also form longitudinal bands between adjacent polyps, marking the surface of the leaf.

*Color.*—Zooids deep carmine red, pinnæ yellow, streaked closely with crimson. Stem and bare portion of rachis dull brownish yellow. The general effect is a dull crimson for the colony as a whole.

*Distribution.*—Station 4378, Point Loma light-house bearing N.  $57^{\circ}$  E. 11 miles, 458–594 fathoms; Station 4417, SW. rock, Santa Barbara Island, bearing N.  $8^{\circ}$  W. 6.3 miles, 29 fathoms; Station 4425, E. point San Marcos Island bearing S.  $7^{\circ}$  E. 218 miles, 1,100 fathoms; Station 4432, Brockway's Point, Santa Rosa Island, bearing S. 8 miles, 275–270 fathoms; Station 4433, Brockway's Point, Santa Rosa Island, bearing S.  $10^{\circ}$  E. 7.5 miles, 265–243 fathoms; Station 4436, Harris Point, San Miguel Island, S.  $7^{\circ}$  E. 9.8 miles, 271–264 fathoms.

This species is abundant and widely distributed on our North Atlantic coast, according to Verrill. It is also a common species on the eastern shores of the Atlantic and in the North Sea.

#### Genus *PTILOSARCUS*.

Calyx with two teeth. Polyps without spicules.

##### *PTILOSARCUS QUADRANGULARIS* Moroff.

Plate LXXXIV, figs. 4–10; Plate LXXXV, figs. 1–11; Plate XCI, figs. 1–2.

*Ptilosarcus quadrangularis* MOROFF, Zool. Jahrb., Abth. Syst. Geog. und Biol. Thiere, XVII, 1902, p. 385.

A rather small specimen, in alcohol, measures 200 mm. in length. Stem much swollen and longitudinally wrinkled, 93 mm. long and 37 mm. in diameter at widest part, which is about 12 mm. below the rachis. Axis 150 mm. long.

Pinnæ 52 on each side, the largest being 32 mm. dorso-ventrally, and 25 mm. in greatest width from stem to margin. Polyps in transverse rows on edges of pinnæ, there being about three rows of 50 each on a medium-sized leaf. Calyces immersed to their margins, each with a distinctly bimucronate margin.

Zooids: The ventral surface of the rachis is covered with a dense mass of zooids divided by a clearly defined median band. The zooids extend around laterally to the bases of the very short peduncles on which the pinnæ are borne.

The spicules are of the regular pennatulid type, being long spindles or needles without verrucæ. They occupy a band on the edges of the pinnæ about 2 to 3 mm. in width.

Color of the above-described specimen, a dull, brownish yellow. The color varies greatly, however, there being some specimens of a bright orange red, and others distinctly violet or even purple in color.

*Distribution.*—Station 4420, E. point San Nicholas Island S.  $77^{\circ}$  W. 5.7 miles, 33–32 fathoms; Station 4422, E. point San Nicholas Island S.  $6^{\circ}$  W. 2.5 miles, 31–32 fathoms; Station 4460, Monterey Bay, Point Pinos light S.  $12^{\circ}$  E. 10.8 miles, 52–67 fathoms.

Numerous specimens are also in the collection of the Hopkins Laboratory at Pacific Grove.

The abundance and excellent state of preservation of the material of this species in the collection of the Hopkins Laboratory at Pacific Grove, and the fact that this material was kindly placed at the disposition of the writer for study, and, so far as necessary, for dissection; together with the typical nature of this pennatulid and the apparent absence of any even fairly complete account of the anatomy of any member of the order published in English, have induced the writer to seize the opportunity to make a fairly exhaustive study of this species and a representation of its anatomy by the use of photography.

One of the first facts brought to light in the study of this material is the remarkable variation in size, color, and number of leaves, as is shown in the following table:

Number.	Length in inches.		Number of pairs of leaves.	Color.
	Stem.	Rachis.		
No. 1.....	10½	7½	50	Yellowish salmon.
No. 2.....	5½	5½	44	Purplish violet.
No. 3.....	7½	8½	57	Salmon.
No. 4.....	3.9	5.3	52	Violet wash over orange.
No. 5.....	11	7.5	48	Salmon yellow.
No. 6.....	22.5	7.5	52	Do.
No. 7.....	6.7	5	53	Do.
No. 8.....	5.7	6.4	58	Do.
No. 9.....	5.2	4.2	42	Do.
No. 10.....	5.4	5.3	39	Do.
No. 11.....	7	6.1	50	Violet wash over orange.
No. 12.....	5.8	6.5	42	Purplish violet.
No. 13.....	2.2	≈ 1.9	20	Dull yellow.
No. 14.....	.6	.7	17	Light corn yellow.

It is evident that the proportionate length of stem to rachis is exceedingly variable, one specimen having a stem 6 inches long and rachis 22.5 inches, while another (No. 7) has the rachis longer than the stem. This is doubtless due to the fact that the stem is composed largely of a tissue that is truly erectile,<sup>a</sup> so that the length of an individual stem will vary greatly at different times. The method of killing and the state of expansion at death will largely determine the length of the specimen.

The violet color seems, at first sight, to be due to sexual maturity; but there are in the collection of the University of California three specimens taken near Pacific Grove averaging only a little over 2 inches in length, which have but 16 pairs of leaves, and which I can not differentiate from this species. Their color is light-pinkish purple, the stem being a dull dark red, but yellow at the end. Two of these specimens are illustrated by fig. 9 on Plate LXXXIV.

There are two specimens showing irregularities or abnormalities.

No. 7 has a new leaf intercalated between two old ones, and a small leaf is growing directly from the upper flat surface of a fully-developed one.

<sup>a</sup> This fact is well known to the local Chinese fishermen, who secure this species on their trawl lines, and have a name for the species based on this character.

No. 11 has a number of more or less aborted leaves springing irregularly from the mass of zooids on the ventral side, as shown in Plate LXXXIV, fig. 8. The calyces on these aborted leaves appear to be quite normal. In one case there is a single calyx springing from the line of juncture of the leaf base and rachis on the ventral side. All of these abnormalities are on one side of the bare ventral space.

ANATOMICAL STUDY OF SPECIMEN NO. 1.

Stem flabby and much corrugated longitudinally, enlarging immediately below junction with rachis to a diameter of 1.9 inches and narrowing gradually to the proximal end. There is a distinct opening at the lower end.

Axis (dissected out from dorsal side), proximal end 6.7 inches from the proximal end of stem. Axis extends from this point to one 3.2 inches from distal end of feather. The axis is overlaid by a longitudinal membrane extending across the stem cavity and adherent below to the inner surface of a similar membranous sectum on the ventral side. It is therefore situated in a separate chamber running lengthwise of the feather and adherent to the dorsal and ventral walls of this chamber, which it divides into two lateral halves. This, which I will call the "axial chamber," is quite small and inconspicuous, and might readily be overlooked in certain sections. There is a similar, but larger, longitudinal chamber between the axial chamber and the dorsal wall of the stem, and another which is ventral to the axis. There are thus four chambers in all: The right axial, left axial, dorsal, and ventral.

The dorsal chamber is much the largest, the ventral next in size, and the two axials much smaller. This is the condition in a section near the distal end of the axis. Farther down, where the leaves are best developed, the four chambers change their relative size. Here the dorsal is largest, the two axials next, and the ventral smallest, as shown in the lower section illustrated in fig. 2, Plate LXXXV.

The total length of the axis is 7.9 inches and its greatest diameter 0.14 inch. It is square in section, tapering gradually at each end.

A cross section of the stem just below the rachis, but not below the proximal end of the axis, is shown in the upper left-hand figure in fig. 2, Plate LXXXV. Here the four chambers are almost equal, the axis being approximately in the center.

A similar section taken through the stem below the axis cylinder and about 3.2 inches from the proximal end of the stem is nearly round and 1.3 inches in diameter. The wall is about 0.24 inch thick and is bounded by an outer and an inner membrane, as shown in the upper right-hand section in fig. 2, Plate LXXXV. Between these membranes is a vesiculated structure, well shown in the photograph. Here the stem cavity is divided by a longitudinal membranous par-

tition into two nearly equal chambers which are roughly half-moon shaped in section. This septum is not perforated, but the walls of the chambers which constitute the inner wall of the stem are marked by rather regularly distributed linear to ovate openings, the longest diameter of which is transverse to the long axis of the stem. These openings, on account of their function, may be called stomata. (Plate LXXXV, fig. 3.)

In other sections still nearer the proximal end of the stem it is seen that the membrane dividing the stem cavity into two chambers is really double, the two layers being divaricated at the ends of the partition, the spaces thus bounded by the split ends of the partition and the portion of the inner wall of the stem between them being the much-reduced right and left axial chambers.

A section taken across the rachis above the termination of the axis shows that the chambers are all much reduced in size, the partitions between them being thickened into fleshy masses of considerable consistence.

The canals entirely disappear near the end of the rachis, which terminates in a little rounded knob covered at its extremity with a mass of needle-like spicules.

#### THE LEAVES.

There are about nine pairs of rudimentary leaves below the first pair with developed polyps. The lowest of these is extremely minute and placed on a level with the lowest of the zooids on the dorso-lateral aspect of the rachis. They are edged with a single row of rounded papillæ, which are, in fact, rudimentary calyces.

The smallest papillæ are on the inner and the largest on the outer ends of the leaves. At the outer end there is a tendency toward a zigzag arrangement of these papillæ, indicating the incipiency of the formation of two rows.

In the second pair this tendency is still more marked, there being two rather well-defined rows of papillæ extending nearly to the inner ends of the leaves, and at about the sixth pair the rows extend the entire length of the leaf border.

The third leaf has three rows of papillæ on its outer side, and these grow more and more complete in successive leaves until on the eighth leaf they extend along the entire border.

The bimucronation of the calyces appears on the outer part of the seventh leaf, while the tentacles of the polyps appear first on the outer polyps of the ninth pair of leaves. Here the polyps are rosette-shaped, when viewed from above, while on the tenth pair fully developed polyps with normal tentacles are seen.

This pair can thus be considered the first pair of functional leaves. There are about 30 polyps to the row, and the leaf is narrow and scalpelliform.

The twelfth leaf begins to show signs of the frilled border which is characteristic of the species. Beyond this, going upward, the leaves increase regularly in size and complexity of frilling, the largest being at about the middle of the rachis. (See Plate LXXXIV, figs. 7 and 8.)

A typical, full-sized leaf measures 4.2 inches around the sinuations of the polypiferous border, but is only 1.4 inches in greatest length, measured in a straight line, and has 75 polyps in the outer row, or about 275 to the entire leaf. The writer estimates that there are about 25,000 polyps to the entire colony.

Each leaf nearly meets its fellow on the dorsal side of the rachis, but not on the ventral, as shown in figs. 7 and 8, Plate LXXXIV. The leaves are very closely set and retain nearly their maximum size to near the distal end of the colony, where they diminish rapidly, forming a rosette-shaped mass at the apex of the colony, as illustrated in fig. 1, Plate LXXXV.

#### THE CALYCES.

The individual calyx is terete in form, about 3 mm. long, each coalescing with its neighbors on either side so that only the margins are exerted. The margin is ornamented with two rounded rather prominent teeth, which are opposite and situated in the upper and lower sides of the margin in the natural position of the leaf. This is well shown in fig. 5, Plate LXXXV, which is a photograph of the edge of a leaf in a vertical instead of a horizontal position, the camera being focussed on a single row of calyces, shown to the left of the figure.

Owing to the crowding of the calyces it is sometimes difficult to make out the number and position of the teeth, particularly when the polyps are expanded.

When the polyps are retracted, the teeth are more or less approximated, those from the opposite sides of the margin closing over the calycular opening. When the polyps are expanded, the teeth are widely divaricated.

A cross section of a leaf just below the calyces shows that the latter are continued downward by partitions that extend across the leaf, connecting its lower and upper surfaces. It thus comes about that these longitudinal chambers, which are continuous with the body cavities of the polyps, are uniserial, while the polyps on the border are in three and sometimes four series. This appears to be due to the crowding of the polyps which originally are in one row and are thrown into three rows by the fact that the edge of the leaf can not accommodate them in one row. A section taken across this polypiferous border at about the level of the œsophageal tubes of the polyps shows this very well as will be seen on consulting the upper section of fig. 8, Plate LXXXV. The middle and lower sections of the same figure show that the chambers which are continuations of the body cavities

are in one series, but much narrower than the body cavities shown in the upper section.

The leaf, then, below the polypiferous border, is divided into a great number of quadrangular but narrow chambers, which are parallel to each other and are separated from each other by septa which connect the upper with the lower surfaces of the leaf. The chambers extend from the body cavities of the polyps on the border of the leaf to a semicircular canal yet to be described at the base of the leaf. There is thus a chamber to each polyp, and a careful examination of the sections of the leaf which cut across these chambers will show that each of the four sides of the chamber bears the continuations of two mesenteries, each septum between chambers bearing four, or two on each side. As they approach the base of the leaf these chambers become narrower until they are almost linear, and the regularity of the arrangement of the mesenteries becomes deranged. But it is still usually possible to detect eight mesenteries to each chamber.

A section across a leaf of a sexually mature colony will reveal numerous ova or spermaries, all of which seem to be attached to the mesenteries which run down the sides of the partitions between the chambers, as is shown in fig. 9, Plate LXXXV.

The ova do not extend far below the bottoms of the œsophageal tubes, however, and a section near the basal part of a leaf will be devoid of them.

At the extreme base of each leaf these chambers open into a comparatively large canal that is inside of the leaf where it joins the rachis, and follows the curve of the line of junction of leaf and rachis for most of its length, but finally plunges into the mass of spongy tissue under the ventro-lateral aspect of the rachis and just beneath the mass of zooids. This canal terminates blindly at its other end in the basal portion of the leaf on the dorsal side of the rachis.

Fig. 6, Plate LXXXV, shows a magnified view of the side of a leaf, and the longitudinal markings made by the partitions between the chambers are plainly seen.

#### THE POLYPS.

These are of the regular alcyonarian type, with 8 fringed tentacles. They are white in color, and are expanded, in formalin specimens, about 4 mm. above the calycular walls. The polyp mouth is usually transverse to the polypiferous band of the leaf. Tentacles with about 20 papillæ on each side.

The mesenteries show plainly through the translucent walls of the polyps. Four of these bear ova and are disposed as described under the head of "Calyces."

There are no spicules, either in the tentacles or body walls of the polyps.

## THE ZOOIDS.

The two zooid bands extend the whole length of the rachis, being over 7 inches long and 0.6 broad at the widest part, narrowing gradually distally, and ending each in a somewhat curved lobe proximally. The mass is swollen and turgid to within about  $\frac{1}{2}$  inch of the proximal end, where it is suddenly contracted, the remainder being on a lower level, as seen from the ventral aspect. This proximal area on each band seems to be occupied by undeveloped zooids, as they are much smaller and less prominent than elsewhere.

The bare streak between the lateral bands of zooids is about half an inch broad at its widest part basally, and becomes almost obliterated distally. Its width and also the extent to which it is depressed between the lateral bands depends largely on the extent to which the rachis is inflated and the method of preparation of the specimen.

Both edges of the lateral bands are perfectly even, straight, and clearly defined. The bands do not reach the leaf bases laterally by about 0.16 of an inch.

The zooids are densely crowded together over the whole surface of the bands, and are greatly distorted by mutual pressure, so that their real shape is hard to ascertain, their outline being as varied as so many cobblestones in a pavement. (Fig. 10, Plate LXXXV.)

In general they present the appearance of conical or dome-shaped papillæ, inclined somewhat toward the distal end of the colony and surrounded or partly surrounded by spicules. A terminal mouth is present, but closed so tightly that nothing but a slight depression can be seen. There are no true tentacles, although a scalloped appearance around the periphery of the zooid might suggest them.

Many minute zooids are crowded between the larger ones, as if there were a succession of these structures in various stages of growth; moreover, there are many deep infoldings and convolutions of the surface which bears the zooids, so that many of the latter are carried some distance below the surface, as is shown by transverse sections of the zooid bands. Such a section, taken across the rachis, shows that the zooids are simple, sac-like bodies with an elongated oval body cavity, the upper portion of the walls being beset with numerous spicules. The lower end of the body cavity is continued broadly into a canal which passes downward and opens into one of the numerous canals that are longitudinal to the rachis and form a series the openings of which, in such a section, are regularly disposed a short distance beneath the zooids. Below this zone of longitudinal canals are seen transverse sections of numerous complicated muscle bands which, like the canals, are disposed in a regular zone or layer running lengthwise of the rachis.

These muscle bands are the most striking feature of the section, and indicate the most powerful and highly specialized muscles of the

entire colony, their disposition indicating that they serve to powerfully contract and shorten the rachis. The bands are immersed in connective tissue which is more or less vesicular, containing numerous irregular lacunæ which may be a part of the water-vascular system. (Plate XCI, fig. 1.)

Intervening between the muscle bands and the lining of the rachis cavity, is a mass of spongy tissue and a rather ill-defined layer of circular muscle bands.

To recapitulate. Passing from the surface of the rachis inward we encounter the following structures in regular order:

1. A superficial layer of zooids in longitudinal section, with the whole layer thrown into deep convolutions in places, and numerous spicules embedded in the upper parts of their walls.

2. A narrow zone of canals leading downward from the body cavities of the zooids.

3. A zone occupied by the cross sections of regularly arranged longitudinal canals, separated by partitions of connective tissue.

4. A very conspicuous zone of sections of powerful longitudinal muscles embedded in connective tissue and with numerous lacunæ.

5. A zone of loose, spongy tissue, doubtless part of the erectile tissue of the rachis.

6. An inconspicuous layer of circular muscles.

7. The lining of the cavity of the rachis.

A section taken parallel to the surface of the mass of zooids, but deep enough to include the upper part of the œsophageal tubes, shows very plainly the wall of the body cavity, the eight mesenteries in section, the endodermal lining of the œsophageal tubes and a transverse section of the conspicuous siphonoglyphs with a very unusual display of strong, lash-like cilia. For details of this interesting section see fig. 2, Plate XCI.

Below the œsophageal tubes the mesenteries are much reduced, and sometimes entirely wanting. Often one or two can be made out, but this arrangement does not seem to be constant.

#### THE CIRCULATORY SYSTEM.

The different parts of the water system have been mentioned in the above account, but not in such a manner as to show their anatomical relations as a whole.

It is possible for water to enter or leave the colony either through the opening at the distal end of the stem, the mouths of the polyps, or the mouths of the zooids. It seems likely that the extreme distension of the erectile tissue of the stem is effected by water entering the stem cavity by means of the opening at the end of the stem, and passing into the spongy erectile tissue of the stem walls by means of the "stomata" shown in fig. 3, Plate LXXXV. Probably this is the

main function of the water system in the stem. Water entering the mouths of the polyps would pass downward into the leaf chambers, which are continuous with the body cavities of the polyps, and thence into the semicircular canals at the bases of the leaves. These canals convey the water to the spongy tissue immediately under the zooid bands of the rachis. Water entering the mouths of the zooids would be conducted immediately to this spongy tissue of the rachis, which freely communicates with the spongy tissue of the stem. From here it could go into the stem chambers and out through the opening at the end of the stem.

It is quite likely that these currents may be reversed periodically, as is known to be the case in some other cœlenterates. The writer was told by one who had observed this species soon after it was taken and placed in a tank that the stem alternately expanded and contracted by inhaling and exhaling water through the opening at the end of the stem, and that the amount of expansion and contraction was very remarkable. That water is taken in through the mouths of the polyps seems very probable, from what is known of the manner of feeding of other polyps.

In most cases, however, where living polyps have been studied, water is both inhaled and exhaled through the polyp mouth.

There is doubtless some special and important function pertaining to the zooids in relation to the water system. The great size and number of the cilia in the siphonoglyphs, the regular series of longitudinal canals immediately beneath the zooid bands, together with the highly specialized longitudinal muscle bands in that region of the rachis, are highly significant of important service in the life of the colony.

The present writer has been unable to find a satisfactory explanation of these interesting structures, but hopes to renew his investigations with living material at no distant time.

It might be suggested that the contraction of the great longitudinal muscle bands would strongly compress the series of longitudinal water tubes by tending to shorten them, and that the water contained in the canals would find a direct outlet through the mouths of the zooids which would thus serve as excurrent orifices to the colony.

Jungerson, in his work on the structure and development of *Pennatula phosphorea*, gives a view of the circulatory system which ascribes an excurrent function to the zooids, but believes that the water from the polyps passes exclusively to the dorsal canal in the stem cavity.<sup>a</sup> This latter statement will certainly not apply to *Ptilosarcus quadrangularis*.

<sup>a</sup> The present writer has not seen Jungerson's work, but finds it discussed in *Traité de Zoologie concrète*, Delage and Hérouard, II, p. 345.

## Genus HALISCEPTRUM.

Pennatulidæ in which the leaves are devoid of spicules.

## HALISCEPTRUM CYSTIFERUM, new species.

Plate LXXXVI, fig. 1.

Colony attaining a height of 120 mm. Length of stem to rudimentary leaves 65 mm. The terminal bulb takes the form of a remarkable bladderlike expansion, oval to round in shape, an average one measuring 9 mm. by 6 mm. The bladder is translucent, with fine annular markings produced by muscle bands in its walls. Above this bladderlike structure is another swelling of the stem, such as usually found in this group, about 30 mm. long.

The axis cylinder terminates at about the middle of this swelling, and protrudes considerably above the distal pinnæ in all of the 13 specimens secured.

The ventral side of the stem has a distinct groove, and the bladder has an internal, longitudinal membranous septum which divides the stem cavity into two chambers, at least in its lower portion.

The pinnæ are very short, and so closely set that the polyps appear at first sight to be attached to the stem direct. There are about 32 pairs, counting the rudimentary ones. The fully developed pinnæ are nearly crescent-shaped, the concavity embracing the stem.

The polyps are 4 or 5 to each well-developed pinna, large in proportion to size of pinnæ, apparently not completely retractile, ovate in vertical section.

The margins are somewhat inflected and ornamented with 8 lobes. Some of the calyces are much longer than others.

Zooids do not seem to be present in this species.

Spicules are also apparently absent, or they are so small and scattered as to escape observation.

*Color.*—In alcohol, light buffy brown.

*Type-specimen.*—Cat. No. 25423, U.S.N.M., *Albatross* station 4541.

*Distribution.*—Station 4514, Point Pinos light-house S. 39° E. 10.7 miles, 394–524 fathoms; Station 4541, Point Pinos light-house S. 41° E. 9.3 miles, 609 fathoms.

The distinction between pinnæ and sessile polyps here seems difficult. The pinnæ might be regarded as groups of adherent, sessile polyps. In this case the species would have to go into another family, probably the Virgularidæ, which illustrates the distance which has yet to be traveled before we have a really natural classification of the pennatulids.

## Family STYLATULIDÆ.

Colony long and slender, with small pinnules which are supported beneath by a calcareous plate composed of fused radiating spicules.

Genus *STYLATULA* Verrill.

The plate of radiating spicules very large and conspicuous, the ends of the spicules often projecting beyond the borders of the leaves or pinnules.

*STYLATULA ELONGATA* (Gabb).

Plate LXXXVI, fig. 2.

*Virgularia elongata* GABB, Proc. California Acad. Nat. Sci., II, 1863, p. 167.

Complete colony measuring about 30 cm. in length, terminating basally in a round or oval translucent bulb.

All but a small median ventral strip of the rachis is concealed by the modified leaves with their calyces. The whole colony is almost exactly round in cross section. The axis is central, hard and stony, about 2.5 mm. in diameter.

The modified leaves closely embrace the rachis to which they are extensively adherent by their inner edges, fitting around it like a collar, and overlapping somewhat on the dorsal side. There are 12–16 stiff calcareous raylike stays projecting directly outward from each leaf, and extending inward nearly to the axis. They lie on the lower surface of the leaves which they support, are transparent and thorn-like, and about 3 mm. in length.

There are about 10 pairs of leaves to the inch, and owing to their unusual position the polyps appear to be arranged in whorls around the rachis.

The polyps are naked, vertical in position, standing on the upper edges of the leaves. They are very closely crowded, so much so that they sometimes appear to be in two ranks. They are really in a single row, however, and there are from 20–24 in each row. The individual polyps are small, tapering considerably at distal end, greatly flattened below by mutual pressure, and about 2 mm. long.

The zooids are very numerous and papilliform, closely packed over the whole surface of the rachis between the unattached portions of the leaves and the rachis, but not visible without dissection, as they are covered by the closely crowded leaves.

The median ventral strip of the rachis is naked and distinctly grooved.

There are no spicules, unless the thorny stays of the leaves may be called highly modified spicules, which is doubtless the case.

*Color.*—In life, light grayish brown, the soft swelling above the end bulb salmon color, the polyps white. In alcohol the entire colony is a very light brown, almost white.

*Distribution.*—Station 4448, Point Pinos light-house S. 26° W. 3 miles, 46 fathoms; Station 4451, Point Pinos light-house S. 23° W. 3.2 miles, 52–54 fathoms; Station 4491, Santa Cruz light-house N. 51°

W. 5.8 miles, 20 fathoms; Station 4520, Point Pinos light-house S. 28° W. 11.2 miles, 44 fathoms; Station 4562, Santa Cruz light-house N. 72° W. 8.1 miles, 10 fathoms. All of these stations are in Monterey Bay.

Numerous specimens were found by collectors from the San Diego Marine Biological Association laboratory in Whalers Bight, San Diego Bay. They were growing deeply immersed in the mud. Verrill's specimens were from Panama and Cape St. Lucas.

Other specimens are from Sausalito, California.

Verrill regards this species of Gabb's as identical with his own *Stylatula elongata*; the priority, however, belongs to the species named by Gabb.

For the somewhat confusing synonymy of this species, see Verrill.<sup>a</sup>

#### Genus ACANTHOPTILUM Kölliker.

Colony very slender, with small, closely crowded leaves. Stem with an end bulb, and usually another swelling above this. A comparatively small plate of spicules under the base of each leaf. Spicules in calycular walls, with points projecting above the margin of calyces. Stem without radial canals.

#### ?ACANTHOPTILUM GRACILE (Gabb).

Plate LXXXVI, figs. 3 and 4.

*Virgularia gracilis* GABB, Proc. California Acad. Nat. Sci., II, 1863, p. 167.

Colony excessively slender, total length 67 cm. Stem to beginning of rudimentary pinnæ 10 cm. Bulb not much swollen, passing almost insensibly into the swelling above, which is about 10 cm. long. A ventral median groove is often found passing along the whole rachis but this feature is not constant.

Pinnæ excessively numerous and closely approximated, short, the full-grown ones being 8 mm. long by 2½ mm. broad.

Calyces short, 8 or 9 to each fully-developed pinna, each surrounded by a border of 8 rather blunt points, oval in section, greater diameter transverse to the pinna owing to the crowding of the polyps.

The polyps are retractile, although most of them are partially expanded in alcoholic specimens.

Zooids in groups of 6 to 12 on lateral sides of rachis between adjacent pinnæ. They are more prominent than usual, showing plainly the central depression surrounded by an elevated ring.

Spicules of the ordinary pennatulid type. They are mostly needle-like, practically colorless in alcoholic specimens, having but a slight yellowish tinge. There is a patch of comparatively large spicules supporting the base of each pinna on the under side. The spicules are very sparsely distributed or absent on the stem and rachis. There are 8 longitudinal bands of spicules in calycular walls.

<sup>a</sup>Trans. Connecticut Acad. Arts and Sci., I, Pt. 2, pp. 382-384.

*Color.*—In alcohol, a light tan brown. The swelling above the end bulb is dull purplish brown.

*Distribution.*—All in Bay of Monterey. Station 4464, Point Pinos light-house S. 29° W. 7.6 miles, 31–32 fathoms; Station 4492, Santa Cruz light-house N. 54° W. 7 miles, 26 fathoms; Station 4550, Point Pinos light-house S. 6° E. 4.6 miles, 50–57 fathoms; Station 4556, Point Pinos light-house S. 7° E. 3.7 miles, 56–59 fathoms; Station 4557, Point Pinos light-house S. 25° W. 3.1 miles, 53–54 fathoms; Station 4558, Point Pinos light-house S. 79° W. 2 miles, 28–40 fathoms.

The original specimens were from the Bay of Monterey, 20 fathoms.

In his discussion of this species, which he ascribes to the genus *Stylatula*, Verrill expresses a doubt as to its belonging to this genus at all.<sup>a</sup> The specimens collected by the Fisheries steamer *Albatross* agree quite well with the original description of *Virgularia gracilis* Gabb, and this, together with the fact that the locality is the same and the species evidently abundant at moderate depths in the Bay of Monterey, makes it quite likely that the species is correctly identified as *Virgularia gracilis* Gabb, which now goes into the genus *Acanthoptilum*.

? *ACANTHOPTILUM POURTALESII* Kölliker.

*Acanthoptilum pourtalesii* KÖLLIKER, Anat. Syst. Bes. Alcyonarien, Pt. 1, Die Pennatuliden, 1872, p. 231.

A specimen, without label, agrees closely with Kölliker's description, except that the spicules of the stem are not "biscuit-shaped" but of the usual rod-like type.

A very young specimen, apparently of this species, from the collection of the University of California from San Diego Bay, shallow water, has the leaves much more widely separated than the other.

The original specimens described by Kölliker were secured off the Florida reefs at depths of from 12 to 44 fathoms.

*ACANTHOPTILUM ALBUM*, new species.

Plate LXXXVI, figs. 5–8.

Colony very slender, attaining a height of about 225 mm. Stem to rudimentary leaves about 87 mm. Terminal bulb not well marked, and about an inch above it is a slight swelling.

Pinnæ, including the rudimentary ones, about 75 pairs, 4 mm. long, regularly curving, without any twist.

Polyps apparently nonretractile, the lobular fringed tentacles being quite well expanded in alcoholic specimens, 4 or 5 to each pinna. The calyces are much reduced in size and quite soft, with an 8-lobed

<sup>a</sup>Trans. Connecticut Acad. Arts and Sci., I, Pt. 2, p. 383.

margin that is not usually well defined. The distal calyx on each leaf is produced into a point extending beyond the expanded polyp.

Zooids apparently wanting on both dorsal and ventral surfaces of the rachis, and reduced to short rows of three each between adjacent pinnæ. They are quite inconspicuous, and might readily be overlooked, being indicated in superficial view by nothing save the small groups of colorless spicules by which they are surrounded.

The spicules are colorless, of the ordinary pennatulid type, very sparsely distributed in calycular walls. There is a group of larger, spindle-shaped spicules beneath the origin of each pinna. Smaller, rod-like forms are distributed over the surface of the rachis and stem.

*Color.*—White, in preserved specimens, with the exception of a purple spot about 10 mm. long on the swelling above the terminal bulb.

*Type-specimen.*—Cat. No. 25424, U.S.N.M., Albatross Station 4473 (See below).

*Distribution.*—Station 4439, Point Pinos light-house S.  $38^{\circ}$  E. 6 miles, 42–40 fathoms; Station 4445, Point Pinos light-house S.  $13^{\circ}$  E. 6 miles, 66–60 fathoms; Station 4446, Point Pinos light-house S.  $2^{\circ}$  W. 5 miles, 59–52 fathoms; Station 4453, Point Pinos light-house S.  $17^{\circ}$  W. 2.3 miles, 49–51 fathoms; Station 4454, Point Pinos light-house S.  $13^{\circ}$  E. 8.3 miles, 71–65 fathoms; Station 4457, Point Pinos light-house S.  $21^{\circ}$  W. 6.1 miles, 46–40 fathoms; Station 4460, Point Pinos light-house S.  $12^{\circ}$  E. 10.8 miles, 55–67 fathoms; Station 4473, Point Pinos light-house S.  $15^{\circ}$  E. 2.8 miles, 59–65 fathoms; Station 4482, Santa Cruz light-house N.  $39^{\circ}$  W. 8.7 miles, 43–44 fathoms.

**ACANTHOPTILUM SCALPELLIFORME Moroff.**

Plate LXXXVI, figs. 9 and 10.

*Acanthoptilum scalpelliformis* MOROFF, Zool. Jahrb., Abth. Syst. Geog. und Biol. Thiere, XVII, 1902, p. 394.

An exceedingly attenuate form with true pinnæ. Length 97.5 cm., length of stem to first rudimentary pinnæ 262 mm. Pinnæ very numerous, short, well separated, 3.5 mm. long by 1.5 mm. broad at the base.

Polyps 7 or 8 to each fully developed pinna, uniserial, the last or distal one on each pinna being widely separated from the next.

In the stem the bulb passes insensibly into the swelling, the two together being 135 mm. long.

The zooids are in lateral rows joining the bases of the pinnæ, about 8 in a row. Sometimes the rows are partially double. The zooids are indicated by round white dots more or less completely surrounded by spicules.

The spicules are purplish pink in color, of two types: 1. Needle-shaped forms situated on the upper parts of the calycular walls on the side toward which the pinnæ are directed. 2. Long, bar-shaped spicules on the lower calycular walls, sides of pinnæ and on the rachis. They are often aggregated in lines on the pinnæ, making radiating streaks. They also form patches on the under surfaces of the pinnæ bases.

*Color.*—In fresh specimens the pinnæ are purplish; stem, upper part of bulb whitish; swelling pinkish shading to deep purple in the middle part. Ventral part of rachis nearly white.

*Locality.*—University of California Station 956, 30–140 fathoms, off La Jolla, California.

*ACANTHOPTILUM ANNULATUM*, new species.

Plate LXXXVI, figs. 11–13.

Colony very slender. Length about 156 mm.; stem 68 mm. There are about 170 pairs of pinnæ, counting the rudimentary ones. Full grown pinnæ 5 mm. long by 1.5 mm.

Polyps usually with 6 calyces to each well-developed pinna. Each calycular margin is armed with 8 moderately acute points, composed of cœnenchyma reenforced by a few spicules. The longest (distal) polyps are about 2 mm. long to margin of calyx.

The zooids are in groups of 3 to 8, laterally placed, between adjacent pinnæ. They are sometimes in a single row and sometimes in a double row.

The spicules are carmine pink in color, short rods with rounded ends, quite small. They are arranged in 8 longitudinal lines in the calycular walls, the lines ending in the points around the margin. These lines also extend downward between the extensions of the body cavities of the polyps, or on the lines which indicate the partitions between the latter, so as to constitute superficial markings on the surfaces of the leaves, these markings radiating from the base to the border of each leaf. The under part of each leaf is marked at its base by a distinct patch of densely aggregated spicules, bright carmine in color. These series of brightly colored spots, one on each side of the rachis, give an annulated appearance to the colony in side view and suggested the specific name "*annulatum*."

The spicules are generally distributed over the stem and rachis, but are less conspicuous on the former on account of the thickness of the ectodermal covering.

*Color.*—The general color of the colony is pink, owing to the combination of carmine spinules and white cœnosarc. The middle part of the stem is purplish, the basal part being light pink, and the bulb whitish.

*Type-specimen.*—Cat. No. 25425, U.S.N.M.

*Distribution.*—Station 4420, E. point San Nicholas Island S.  $77^{\circ}$  W. 5.7 miles, 33–32 fathoms (type-locality); Station 4421, E. point San Nicholas Island N.  $26^{\circ}$  W. 3.8 miles, 291–229 fathoms; Station 4422, E. point San Nicholas Island S.  $6^{\circ}$  W. 2.5 miles, 31–32 fathoms.

### Family VIRGULARIDÆ.

Colony long and slender; leaves short, sometimes reduced to a mere band of polyps, and without a plate of modified or aggregated spicules supporting their bases.

### Genus BALTICINA.

Stem short and thick, rachis proportionately very long, pinnæ reduced to band-like rows of calyces. There are spicules in the tentacles of the polyps.

#### BALTICINA PACIFICA, new species.

Plate LXXXVII, figs. 1 and 2.

A typical specimen measures 97.5 cm. in total length; the stem to the first rudimentary polyps 93 mm.; bulb 25 mm. long; swelling above bulb 75 mm. long.

The axis cylinder is very strong and hard, reaching to the end bulb. There are 114 rows of polyps, with 2 to 5 in each row, the polyps being closely appressed to each other. The rows are 5 to 8 mm. apart, measured on the dorso-lateral side.

The calyces decrease in size regularly from the first (ventral) to the last in each row. Each calyx has two broad conspicuous thorny spines on its lower margin, the outer spine being the larger. The first and largest calyx is 4 mm. high to tip of spine, and 2.5 mm. wide near the base.

The polyps appear to be nonretractile, and are of the usual alcyonarian type. The tentacles are long, and their outer surface is covered with spicules. There are also a few spicules on the body walls.

The zooids are in groups of 15 to 20 between the rows of polyps. These groups show a tendency in places to an arrangement in two or three rows. The zooids are unprotected by spicules, and appear as simple rounded granules. There are a few scattered zooids on the dorsal surface, usually continuous with the rows spoken of above.

The spicules are bar-shaped, and apparently confined to the calyces and polyps. They are most conspicuous in the calyces, where they converge to form the marginal spines. There are a few transverse rows on the polyp walls. They are diagonally arranged on tentacular bases and longitudinally disposed on the rest of the outer surfaces of the tentacles. The spicules are much more abundant on the sides of the polyps that are nearest the calycular spines.

The color of the polyps and calyces is chocolate brown, the swelling yellowish brown, and the end bulb dark reddish brown.

*Type-specimen.*—Cat. No. 25426, U.S.N.M.

*Distribution.*—Station 4326, Soledad Hill, Point La Jolla, S. 59° E. 5.6 miles, 280–243 fathoms; Station 4333, Point Loma light-house N. 27° E. 12.2 miles, 301 fathoms; Station 4433, Brockway Point, Santa Rosa Island, S. 10° E. 7.5 miles, 265–243 fathoms; Station 4513, Point Pinos light-house S. 31° E. 9.3 miles, 456–389 fathoms; Station 4516, Point Pinos light-house S. 49° E. 12.5 miles, 756 fathoms; Station 4537, Point Pinos light-house S. 74° E. 7.4 miles, 1,062 fathoms; Station 4538, Point Pinos light-house S. 85° E. 6.5 miles, 871–795 fathoms; Station 4547, Point Pinos light-house S. 82° E. 10.5 miles, 1,083 fathoms (type-locality).

Having examined a large number of specimens of this species from the Californian coast, and having found them constant in having not more than 5 polyps to each leaf (instead of from 8 to 15 as described by Kölliker),<sup>a</sup> I have concluded that the species is clearly distinct and given it the name *Balticina pacifica*.

*Pavonaria californica* Moroff<sup>b</sup> is described as having polyps without spicules, while *P. dofleini* Moroff has 11–14 polyps to the leaf, with no spicules in the tentacles.

#### BALTICINA FINMARCHICA (Sars).

*Virgularia finmarchica* Sars, Fauna Lit. Norvegiæ, II, 1856, p. 68.

In the collection at Stanford University there are a series of six specimens which were originally taken near Pacific Grove, California, by Chinese fishermen, who secured them on their trawls in deep water. These specimens apparently belong to this species. They are much macerated and their characters are difficult to make out with certainty. They differ from the preceding species, *Balticina pacifica*, in having 12–15 calyces to a row and in less prominent calycular teeth.

The upper part of the rachis has anemones attached, each with a ring-like stolon clasping the rachis, exactly as described by Verrill.<sup>c</sup>

Two other specimens in the same collection which are labeled "*Verrillia blakei*, Barracuda Inlet, British Columbia," do not seem to be fairly separable from this species. They are very large, one of them being 50 inches long; the stem to rudimentary leaves 12 inches long; terminal bulb 5 inches long. The calyces are in rows of 7 to 10. They are long, terete; margins with two low and incon-

<sup>a</sup> Anatomisch-Systematische Beschreibung der Alcyonarien. Pt. 1. Die Pennatuliden, 1872, p. 239.

<sup>b</sup> Zool. Jahrb., Abth. Syst. Geog. und Biol. Thiere, XVII, 1902, p. 393.

<sup>c</sup> Bull. Mus. Comp. Zool., XI, No. 1, p. 5.

spicuous teeth. The zooids are in rows, usually of 3, on each side of the bare middle space on the dorsal side of the rachis. On the ventral side there are two lateral rows of zooids which are somewhat broken and irregular, there being a tendency toward the formation of double rows extending down the whole length of the rachis and stem to the end bulb.

These specimens are preserved in glycerin, and the spicules seem to have largely been dissolved.

The name *Verrillia* was proposed by Stearns as a subgeneric designation based on the species named originally *Pavonaria blakei* by the same author.<sup>a</sup> Later Verrill republished Stearns's original description, a very complete one, by the way, and adds, in a footnote: "A recent examination of a specimen convinces me that this species is most nearly allied to the *Halipteris christi*, and probably ought to be referred to this genus."<sup>b</sup>

The present writer having compared the careful description of Stearns with his own description of the specimens at Stanford University finds that the two agree quite closely. These specimens, however, can not be placed in K lliker's genus *Halipteris* because the polyps are placed on rudimentary band-like pinn , instead of being seated directly on the rachis as in the original description of the genus. They can be placed, however, in K lliker's genus *Pavonaria*, which Verrill has shown to be a synonym of the genus *Balticina* Gray.<sup>c</sup> If the species under consideration is a valid one it should be called *Balticina blakei* (Stearns).

As indicated above, however, I am of the opinion that the Stanford specimens belong to the well-known species *Balticina finmarchica* (Sars).

#### Family FUNICULINIDÆ.

Polyyps sessile, free, arranged in rows on sides of rachis and provided with calyces.

#### Genus FUNICULINA.

Calyces with 8 teeth and spicules in 8 vertical bands. Zooids dorsal.

#### FUNICULINA ARMATA Verrill.

*Funiculina armata* VERRILL, Amer. Journ. Sci. and Arts, XVII, 1879, p. 240.

Largest colony about 45 cm. long. The axis is distinctly quadrangular in section, and the end bulb is scarcely distinguished from the rest of the stem, the termination being curved and pointed.

<sup>a</sup> Proc. Cal. Acad. Sci., V, 1873, p. 147. •

<sup>b</sup> Amer. Journ. Sci. and Arts, VII, 1874, p. 68.

<sup>c</sup> Bull. Mus. Comp. Zool., XI, no. 1, p. 4.

The calyces are as described by Verrill, irregularly distributed on the rachis, the rows or ranks being scarcely differentiated. The calyces are usually more expanded at the top than is indicated by Verrill's figure, but some of them have the same outline. The amount of expansion seems to depend on the stage of retraction of the polyp.

The zooids are relatively the most prominent that I have seen. They extend down on the dorsal side of the stem some distance below the rachis and within about 75 mm. of the end.

The spicules are long slender needles, forming 8 longitudinal ribs on the calycular walls and projecting decidedly from the marginal teeth. They are also thickly distributed lengthwise on the rachis, although they are sparse or wanting on the stem, where the spicules, when present, are more rod-like.

*Color.*—The polyps are dark brown, the stem and rachis being lighter.

*Distribution.*—Station 4400, 30° 50' 20'' N., 118° 03' 30'' W., 500 fathoms; Station 4407, SE. point Santa Catalina Island N. 19° 30' E., 3.2 miles, 334–478 fathoms; Station 4415, NE. point Santa Catalina Island N. 89° W. 8.6 miles, 638 fathoms.

Also U. S. Fish Commission Stations 880 and 881, 262–325 fathoms; off Sable Island, Nova Scotia, 300–400 fathoms; *Blake* stations, off Santa Cruz, 135–500 fathoms; off Guadeloupe, 163 and 769 fathoms.

#### Genus HALIPTERIS.

Calyces with 2 to 4 teeth; zooids lateral.

##### HALIPTERIS CONTORTA, new species.

Plate LXXXVI, figs. 3 and 4.

Colony much distorted, about 75 mm. long; stem 12.5 mm., round. Bulb not distinct.

Polyps arranged in rows of 5 or 6, passing obliquely from ventral to dorsal surface on both sides, forming crescentic rows. The calyces decrease in size from lateral to dorsal, the mid-dorsal being the smallest and measuring but 1.5 mm. in height. The rows are closely crowded together, leaving no lateral or dorsal surface of rachis free, except where the calyces are disturbed.

Calyces with margins armed with 4 rather blunt teeth, 2 of which are much larger and more pointed than the others. The smaller teeth are often so inconspicuous that they might well be overlooked and the calyces be described as having but 2 teeth. On the lower part of the rachis there is a short row of rudimentary polyps or calyces on the dorsal side of the stem.

The polyps are entirely retractile, and their tentacles are without spicules.

Zooids are seen in a few lateral groups of 4 to 6 between the calyces. There are also a few scattered zooids on the dorsal surface.

The spicules are needle-like, small, colorless, and arranged longitudinally in calycular walls. Elsewhere they are variously distributed, sparsely scattered on the stem, and apparently absent from the dorsal band of the rachis.

*Type-specimen*.—Cat. No. 25427, U.S.N.M.

*Distribution*.—Station 4409, SE. Point Santa Catalina Island SW. 2.1 miles, 88–52 fathoms.

#### Family STACHYPTILIDÆ.

Calyces present, free, zooids ventral.

#### Genus STACHYPTILUM.

Polyps in rows of four on each side of the median dorsal line; calyces with broad vertical bands of spicules; zooids dorsal, ventral, and lateral.

#### STACHYPTILUM SUPERBUM Studer.

Plate XXXVII, figs. 5 and 6.

*Stachyptilum superbum* STUDER, Bull. Mus. Comp. Zool., XXV, No. 5, 1894, p. 56.

Length of colony 175 mm.; stem 81 mm. Terminal bulb soft, slender, wrinkled. There is a slight swelling above the bulb. The ventral surface of the rachis has a deep, even, undulating groove.

Polyps almost surrounding the rachis. Calyces in 4 rows forming oblique series. They are terete in form, rather slender, 3.5 to 5 mm. long by 1.25 mm. broad.

The outer side of calycular wall is much the longer, the inner being almost obliterated, owing to its adherence to the rachis. Margin armed with a varying number of jagged slender teeth, including spicules. Sometimes there are but two very conspicuous teeth, at others four, or even eight; but four is the most common number, two larger and two smaller.

The zooids appear as well-defined brownish dots, a row on either side of the ventral groove being particularly conspicuous on distal parts of the colony. In many places this row is reenforced by a patch of several rows of lateral zooids. The zooids are also rather numerous between the calyces on the dorsal side of the rachis.

The spicules are large and needle-like, placed longitudinally on the walls of the calyces, although they are often more or less oblique. The ventral furrow is devoid of spicules, in marked contrast to the rest of the rachis. Spicules are also apparently lacking in the stem.

*Color*.—In alcohol, dull brown, the stem and lower part of the rachis being light yellowish brown.

*Distribution.*—Station 4427, Point San Pedro, Santa Cruz Island, N.  $35^{\circ}$  E. 7 miles, 447 fathoms; Station 4432, Brockway Point, Santa Rosa Island, S. 8 miles, 372 fathoms; Station 4442, Point Pinos light-house S.  $67^{\circ}$  W. 4.6 miles, 26–31 fathoms; Station 4435, Harris Point, San Miguel Island, S.  $13^{\circ}$  W. 7.7 miles, 287–274 fathoms; Station 4514, Point Pinos light-house S.  $39^{\circ}$  E. 10.7 miles, 524 fathoms.

*Type-locality.*—Station 3389, latitude  $7^{\circ} 16' 45''$  N., longitude  $79^{\circ} 56' 30''$  W., 210 fathoms.

STACHYPTILUM QUADRIDENTATUM, new species.

Plate LXXXVII, figs. 7 and 8.

Total length of colony, 200 mm.; stem, 68 mm. Bulb and swelling almost continuous, and not much expanded. The swelling is quadrangular in section.

The polyps are irregularly placed on the dorsal surface of the rachis, with a tendency to an arrangement in transverse rows of three or four. The larger ones are usually laterally placed, and include the smaller ones between their bases, the smaller ones usually being inserted at a higher level than the larger. On the lower portion of the rachis there is a tendency to an arrangement in subopposite pairs; higher up the smaller one or two polyps appear between the larger, while nearer the distal end there are frequently three larger ones in the oblique series. Here, however, the polyps are so crowded that it is difficult to discern any regularity.

The calyces are rather long, narrowing above, with the margin bearing four very strong sharp teeth or spines, two larger and two shorter, on its outer side.

Length of calyces to end of longest spines, 3 mm.

The polyps are retractile, and when fully retracted the spines converge, forming a pointed calyx.

There are a few lateral zooids scattered along the sides of the rachis between the polyps, and others between polyps on the dorsal surface. The zooids vary considerably in size, the dorsal ones often being the larger.

The spicules are needle-like, arranged longitudinally in calycular walls, stem, and rachis.

*Color.*—Almost white, in alcoholic specimens.

*Type-specimen.*—Cat. No. 25428, U.S.N.M.

*Distribution.*—Station 4360, Point Loma light-house N.  $86^{\circ} 30'$  E. 9.4 miles, 108–92 fathoms (type-locality); Station 4371, Point Loma light-house N.  $84^{\circ}$  E. 9.5 miles, 145–89 fathoms.

In the collection of the University of California are several specimens apparently of this species labeled "Juneau, Alaska, dredged 20 fathoms."

## Family ANTHOPTILIDÆ.

Polyps free, sessile and without calyces.

## Genus ANTHOPTILUM.

Polyps in numerous short rows, large. No streak of undeveloped polyps at lower end of rachis. Zooids dorsal, ventral and lateral. Spicules absent, except at end of stalk.

## ANTHOPTILUM GRANDIFLORUM (Verrill).

*Anthoptilum grandiflorum* VERRILL, Amer. Journ. Sci. and Arts, XXIII, 1882, p. 312.

Length of longest specimen 80 cm. The sickle-shaped stem is bare of polyps, longitudinally corrugated, and with the end bulb and swelling about equal.

The polyps are in oblique rows, about 8 to a row, naked, transversely corrugated and about 10 mm. long.

The zooids are very numerous, covering all of the rachis but a narrow ventral groove.

*Color.*—In alcohol the color of the polyps is chocolate brown, while the short stem and bare part of the rachis is very light brown, almost white.

*Distribution.*—*Albatross* station 4400, 32° 51' 20" N., 118° 03' 30" W., 500 fathoms; *Challenger* station 320, off Buenos Ayres, 600 fathoms; *Blake*, off the coast of North Carolina, 603–647 fathoms; off Guadeloupe, 730 fathoms.

This magnificent pennatulid was first described by Verrill, under the name *Virgularia grandiflora*.<sup>a</sup> Afterwards it was described by Kölliker in his report on the Pennatulids of the *Challenger* expedition, under the name of *Anthoptilum thompsoni*.

Later Verrill put it in the genus *Anthoptilum* of Kölliker, when it became *Anthoptilum grandiflorum* (Verrill).

## Family UMBELLULIDÆ.

Polyps very large, naked, borne in a cluster at the end of a long slender stem.

## Genus UMBELLULA.

Being the only genus, its characters are the same as those of the family.

## UMBELLULA MAGNIFLORA Kölliker.

*Umbellula magniflora* KÖLLIKER, Report Pennatulida, Challenger Exp., 1880, p. 24.

A number of specimens apparently belonging to this widely distributed and variable species were dredged by the Fisheries steamer

<sup>a</sup> Amer. Journ. Sci. and Arts, March, 1879, p. 230.

*Albatross* off the coast of California. The variation in size of colonies and length and number of polyps is very great. The longest colony is nearly 2 feet in length, while one of the shorter ones is only 11 inches. This latter is in very good state of preservation and seems quite typical, except, perhaps, in length.

The bulb is 13 mm. long; while the swelling above it is 25 mm. long. The stem is quadrangular in section.

The polyps are 11 in number. The body to base of tentacles is 23 mm. long, cylindrical and tapering very gradually above. Greatest diameter 4 mm., least diameter 2.5 mm. Tentacles, in alcohol, 18 mm. long. The body walls are transversely rugose and longitudinally marked by the mesenteries.

The swelling of the rachis below the polyps tapers gradually until it merges with the stem 23 mm. below the polyps.

The zooids cover the entire surface of the rachis below the polyps, except on small V-shaped bare spaces below the polyp bases. There is also a definite patch of zooids in the center of the disk, encircled by the polyps. The zooids are provided with single, finger-like tentacles.

The spicules are apparently wanting.

*Color*.—The polyps are umber brown, the tentacles being more reddish. The stem is light brown, often darkening at the bulb and swelling.

*Distribution*.—Station 4399, 32° 44' 50'' N., 117° 48' 45'' W., 245 fathoms; Station 4407, SE. Point Santa Catalina Island N. 19° 30' E. 3.2 miles, 334 fathoms; Station 4415, NE. Point Santa Barbara Island N. 89° W. 4.7 miles, 438 fathoms; Station 4423, E. Point San Nicholas Island S. 7.6 miles, 339–216 fathoms.

Studer considers that this species is identical with *Umbellula encrinus* (Linnæus), and if he is correct in following Grieg<sup>a</sup> in this matter<sup>b</sup> the distribution of the species should be extended to the North Atlantic, and should include Station 3410, latitude 0° 10' N., longitude 90° 34' W., 331 fathoms.

The type was secured by the *Challenger* from south of Tokyo, Japan, from a depth of 565 fathoms.

UMBELLULA HUXLEYI Kölliker.

*Umbellula huxleyi* KÖLLIKER, Report Pennatulida, Challenger Exp., 1880, p. 21.

A specimen from Station 4400 agrees very well with Kölliker's description, except that the polyps are not distinctly corrugated, and that the tentacles of the zooids are well developed.

*Distribution*.—Station 4400, 32° 50' 20'' N., 118° 03' 30'' W., 500 fathoms.

<sup>a</sup> Oversigt over Norges pennatulider, Bergens Museum Aarsberetning, 1891, No. 1. p. 18.

<sup>b</sup> Bull. Mus. Comp. Zool., XXV, No. 5, 1894, p. 57.

The type was secured by the *Challenger*, Station 147, South Sea, east of Kerguelen Island, 1,000 fathoms.

UMBELLULA LOMA, new species.

Plate LXXXVII, fig. 9.

Total length of colony 20 cm. Terminal bulb and swelling confluent. Stem quadrangular in section, in places greatly flattened; greatest diameter, 2.5 mm. to 4 mm.; least diameter below rachis, 1 mm. The axis ends in the base of the central polyp. The stem passes insensibly into the rachis, and the latter gradually broadens from proximal to distal ends, where it is somewhat flattened.

Polyps, in full-grown specimens, 10 in number, the arrangement being such that 9 surround a central one. Polyp body 10 mm. long, tentacles 13 mm. The basal part of polyps is swollen, and its walls are both longitudinally and transversely corrugated.

The zooids cover the exposed portion of the rachis and are scattered over the stem as far as the proximal portion of the swelling, but with a tendency toward leaving a few bare longitudinal lined. The V-shaped bare spaces between the polyp bases, so characteristic of *Umbellula magniflora*, are not found in this species. The zooids are usually without tentacles, but a few at the bases of the polyps have a single tentacle, while a few others have two. A small patch of 5 zooids on the dorsal surface between the polyps are entirely without tentacles, as are those on the stem. The zooids also invade the ventral walls of the polyps.

There are a few very minute, irregular spicules on the end bulb, but they appear to be lacking elsewhere.

*Color*.—Fresh specimens; polyps deep umber brown, tentacles somewhat lighter; stem much lighter brown, but with dark spots on end bulb and swelling.

A cross section of the lower part of the rachis shows the central quadrangular axis and the four longitudinal canals, one being as large as all of the others put together. The canals are divided by longitudinal partitions, and the whole system is surrounded by a membranous envelope. Outside of this are a number of radiating partitions, passing to the outer covering of the stem, and also the tubelike bodies of the zooids, which are continuous with the external portion of the zooids. The mesenteries and mesenterial filaments can be plainly seen.

*Locality*.—Near San Clemente Island. Taken at a depth of 330 fathoms, by the *Loma*, a little vessel owned by the Marine Biological Association, of San Diego. The name is given in honor of this exceedingly efficient little craft, which has since been wrecked on the point which bears the same name.

This species is nearest *U. magniflora*, from which it differs greatly in size and in the character and disposition of the zooids.

*Type-specimen*.—In Museum of University of California.

#### Family PROTOPTILIDÆ.

Polyps with calyces, arranged on both sides of the rachis in a single series or in indistinct rows.

#### Genus DISTICHOPTILUM.

Slender forms with the axis extended throughout. Polyps uniserial, those on opposite sides alternating. Calyces bilobed, appressed. Zooids normally three to each polyp. Spicules numerous.

#### DISTICHOPTILUM VERRILLII Studer.

Plate LXXXVII, fig. 10.

*Distichoptilum verrillii* STUDER, Bull. Mus. Comp. Zool., XXV, No. 5, 1894 p. 59.

Colony very slender, having a total length of 225 mm. The axis extends throughout the stem and rachis, ending below in a thin, curved, transparent bulb that resembles a maple seed in outline. Distal end of axis bare. Length of stem 50 mm. There is an enlargement about halfway up the stem.

The polyps are in opposite series, but are implanted toward the dorsal rather than the ventral side. Calyces adherent on their inner side, the outer side being straight and about 25 mm. long and passing insensibly into the rachis. The margin is without regular teeth, although the points of the spicules sometimes project, giving a jagged appearance. In places the polyps are nearly subopposite, and are well toward the dorsal aspect of the rachis. The pairs of calyces are adnate to each other by their inner surfaces, and the alternate pairs are rotated to the right and left so that the right-hand polyp of a lower pair is under the line separating the calyces of the pair immediately above.

The zooids are arranged in sets of three along the outer sides of the calyces, and one or two just above each calyx. They appear as mere openings, surrounded by a fence of spicules, and are entirely immersed.

The spicules are slender needles, covering the entire surface, excepting the central dorsal line of the rachis and small areas on the inner sides of calycular margins.

*Color*.—In alcohol very light pink, owing to the spicules. Rachis white, or nearly so. The bulb and swelling are pale yellow.

*Distribution*.—Station 4387, 32° 29' 30'' N., 118° 05' W., 1,000 fathoms.

The types were taken from Station 3431, latitude 23° 59' N., longitude 108° 40' W., 995 fathoms, and Station 3398, latitude 1° 07' N., longitude 80° 02' W., 1,573 fathoms.

## Family RENILLIDÆ.

Rachis expanded into a flattened, heart-shaped form borne on a short smooth peduncle without axis, and with but two canals. Zooids numerous.

## Genus RENILLA.

The genus, being the only one, has the character of the family.

## RENILLA AMETHYSTINA Verrill.

Plate LXXXVII, fig. 11.

*Renilla amethystina* VERRILL, Bull. Mus. Comp. Zool., 1864, p. 29.

Numerous specimens of this beautiful species were found in shallow water in the bay of San Diego, and were kept alive in the laboratory at La Jolla.

The frond of the living colony has the power of considerable muscular contraction, giving an undulatory motion to the edges. Some of the fully expanded polyps were at least half an inch long. After they are once expanded they are quite sluggish, and will withstand handling without retracting.

Specimens left over night in small dishes of sea water were alive, and expanded readily upon the application of fresh sea water in the morning.

*Distribution.*—Bay of San Diego, shallow water; Panama, Pearl Islands, and the coast of Peru (Verrill).

## Order GORGONACEA.

Colonies fixed, with a more or less distinct axis cylinder around which the cortex is disposed. In branched forms the axis extends throughout the ramifications.

## Suborder HOLAXONIA.

Axis cylinder well developed, and never consisting of fused spicules. It is composed of a horny substance more or less calcified, or of alternating horny and homogeneous calcareous matter.

## Family PRIMNOIDÆ.

Polyyps with well-developed calyces, retractile tentacles, and an 8-parted operculum composed of modified spicules attached to the calyx. Root calcareous.

## Genus CALIGORGIA.

Calyces club-shaped, calyx scales ctenate with radiating ribs. Calyces regularly in whorls of more than three.

## CALIGORGIA SERTOSA Wright and Studer.

*Caligorgia sertosa* WRIGHT and STUDER, Challenger Report, Alcyonaria, 1889, p. 77.

An incomplete colony is 260 mm. high, flabellate in form, consisting of a central geniculate stem giving off regularly alternate branches at the angles or geniculations. Some of the branches give off branchlets in the same manner.

The axis shows a distinct golden iridescence. The cœnenchyma is thin.

The calyces are arranged in whorls of three to six, by far the most common number being four. In places there are simply two opposite or subopposite calyces.

They are about 2 mm. in length, and the space between whorls is about 1 mm. In form the calyces are curved spindles, curving from the base outward, upward, and inward so that their apertures are directed toward the stem or branch. The margins are composed of ctenate scales, inside of which are the bases of the 8 opercular scales which form a pyramidal operculum. The individual opercular scales are long triangles, somewhat twisted and bent, and overlapping at the tips when the polyp is fully retracted. The upper whorl of calycular scales are ctenate, with radiating striæ, the others show these markings feebly if at all. There are six to nine whorls of scales in the calyces, the most common numbers being seven or eight.

The spicules are scale-like, flattened, sometimes oblong or fusiform on the stem and branches. They are imbricating and fan-shaped on the calycular walls.

*Color.*—In alcohol, light tan.

*Distribution.*—Station 4356, Point Loma light-house N.  $82^{\circ} 30'$  E. 5.9 miles, 120–131 fathoms; Station 4357, Point Loma light-house N.  $81^{\circ}$  E. 7.5 miles, 134 fathoms; Station 4358, Point Loma light-house N.  $82^{\circ} 30'$  E. 8.2 miles, 191 fathoms; Station 4386,  $30^{\circ} 30' 30''$  N.,  $118^{\circ} 06' 10''$  W., 1,012 fathoms; Station 4391,  $33^{\circ} 02' 15''$  N.,  $120^{\circ} 36' 30''$  W., 1,350 fathoms.

The type was secured by the *Challenger* at Station 192, off Kei Island, South Pacific, 140 fathoms.

## Genus PLUMARELLA.

Colony flabellate; calyces small, cylindrical, alternate and opposite; usually somewhat distant. Calyx spicules scale-like, thin, cycloid.

## PLUMARELLA LONGISPINA Kinoshita.

Plate LXXXVIII, figs. 1 and 2; Plate XC, fig. 3.

*Plumarella longispina* KINOSHITA, Journ. Coll. Sci., Imp. Univ. Tōkyō, 1908, p. 14.

Colony, incomplete, flabellate in form, 106 mm. high, and 106 mm. broad. The main stem is somewhat flattened, giving forth alternate main branches at irregular distances, and between the main branches the stem gives forth regularly alternate branches that do not subdivide. The main branches subdivide as does the main stem. Calyces strictly alternate to strictly opposite in different parts of the colony, in two opposite series on stem and branches, the top of one ordinarily reaching to the base of the one next above. Aperture pointed upward and a little outward. Calycular walls armed with conspicuous flattened scale-like spicules which vary greatly in size and in form in different calyces; the typical arrangement being about four whorls, the two proximal whorls being composed of broad curved scales with their distal convex edges ctenate, and the distal whorl bearing conspicuous thorn-like processes which extend beyond the end of the operculum. These spines are usually two to six in number, of which two are often distinctly longer than the others. Sometimes one or two spines are borne on the whorl of scales which lies just below the distal one.

The operculum is composed of eight irregularly shaped scale-like spicules, the points of which are often produced into spine-like processes. The side of the calycular wall next the branch is reduced to a narrow band, the antero-lateral processes from the proximal whorls of spicules being the only ones that meet to complete the whorl on the cauline side. Calyces about 1.5 mm. high to the summit of the operculum.

The spicules are of such varied forms as to defy description. They are all more or less flattened scales, however, the most characteristic being in the form of a flattened basal portion bearing on its distal edge the long thorn-like process that projects above the calycular margins. Many of the scales are ornamented with a convex ctenate margin. Surfaces of scales ornamented with evenly and closely distributed granules.

The color of the colony as a whole is light grayish brown, the surfaces of the stem and branches being more distinctly gray.

*Locality.*—Station 4359, Point Loma light-house N. 85° E. 9 miles, 191 fathoms. The type was secured from Okinoce Bank, Sagami Sea, 330 fathoms.

## Family MURICEIDÆ.

Spicules usually projecting from the surfaces of the cœnenchyma. A colleret of spindle-shaped spicules below the tentacular bases. An 8-rayed operculum formed by spicules on the tentacle bases.

## Genus ELASMOGORGIA.

Colonies with thin cœnenchyma, not profusely branched. Calyces verruciform, their margins infolded over the retracted tentacles, giving an appearance of invagination to the latter. Spicules spindle-shaped with verruciform projections.

## ELASMOGORGIA FILIFORMIS Wright and Studer.

*Elasmogorgia filiformis* WRIGHT and STUDER. Challenger Report, Alcyonaria, 1889, p. 133.

The single colony secured has a single whip-like stem with a branch arising near its base. Length 275 mm.

The calyces are very low broad domes or cones, rising but slightly above the general surface on all sides of the stem and branch, separated by about 3.5 mm., ovate in cross section, the longer diameter being parallel with the stem.

The spicules are heavy warty spindles, often one-sided and covered with very jagged verrucæ. There are also many smaller spicules, some of which are slender spindles, clubs, etc. The largest spicules seem to be on the stem between the calyces, although they often invade the walls of the latter, where they are usually of a distinctly more slender type and arranged transversely, forming annulations or oval markings around the margins when viewed from above.

The color of the colony is clear, light gray; axis dark brown.

*Distribution.*—Station 4349, Point Loma light-house NE. 6.5 miles, 75–134 fathoms.

The type was taken by the *Challenger* at Station 188, Arafura Sea, south of Papua, 28 fathoms. Another specimen in University of California collection, taken off San Pedro, California.

The specimen agrees very well with the original description.

## Genus MURICELLA.

Colony branched; cœnenchyma thin. Calyces, short truncated cones projecting at right angles from the branches. Spicules large.

## MURICELLA COMPLANATA Wright and Studer.

*Muricella complanata* WRIGHT and STUDER, Challenger Report, Alcyonaria, 1889, p. 125.

Colony imperfectly flabellate in form, 15 cm. high by 23.7 cm. broad. The main stem gives off lateral branches and undivided branchlets, the former dividing once, twice, or three times in a pinnate manner.

The polyps are distributed on all sides of the stem and branches, but with a strong tendency to a bilateral arrangement, especially on the ultimate branchlets where they are arranged as in typical species of *Leptogorgia*. Polyps with a distinct colleret.

The calyces are short truncated cones usually less than 1 mm. high and 2 mm. broad at base, about 1.5 mm. apart and directed at a right angle from the stem.

The spicules are slender, often curved, pointed spindles covered with scattered spinules and nodules. There are a few short stout forms. The spicules of the colleret are conspicuous curved spindles. At the base of each tentacle a few spicules are arranged in chevrons, and beyond these the tentacular spicules are longitudinally disposed in two or more rows. In the calycular walls the general arrangement of spicules is longitudinal, although many are transverse or oblique, as they are on stem and branches.

The color of the colony is reddish brown, the spicules having a slight reddish tinge.

*Distribution*.—Station 4461, Point Loma light-house S. 3° E. 9.3 miles, 285 fathoms.

The type was secured by the *Challenger* at Station 232, off Japan, 345 fathoms.

The specimens taken by the Fisheries steamer *Albatross* differ slightly from the type, particularly in having a well-marked colleret and in the arrangement of the calycular spicules.

#### Genus EUMURICEA.

Colony branched; calyces verruciform or tubular, showing an 8-rayed figure in retraction. Spicules in the form of sharp pointed needles.

#### EUMURICEA PUSILLA, new species.

Plate LXXXVIII, figs. 3 and 4.

Colony branching in an irregular manner, a little over 37 mm. in height. The main stem gives forth roughly alternate branches at irregular intervals, the two longest being 13 mm. apart, the whole colony being roughly flabellate.

The calyces are on opposite sides of the stem and branches, alternate, 2.5 mm. from summit to summit, forming low rounded domes or cones, 8-rayed on the summits, about 1 mm. high by 2 mm. broad.

The calycular walls are covered with very hispid spicules, which have their edges somewhat overlapping and are, in general, disposed transversely rather than otherwise.

The polyps are completely retracted in the specimen secured. Dissection shows that they have the colleret characteristic of this family. The tentacles are heavily armed with large jagged spindle-shaped

spicules, longitudinally arranged, except under the tentacular bases, where they are in chevrons.

The spicules are exceedingly various in form, but of the usual muriceid type. There are many unsymmetrical spindles with irregular jagged edges and processes. Clubs of various patterns are fairly common, as are small scales with jagged edges, stars, and double stars. The general arrangement of spicules is longitudinal on the stem and branches.

The color of the colony is very light gray or brownish gray; axis horn-color lightening distally.

*Type-specimen.*—Cat. No. 25430, U.S.N.M.

*Locality.*—Station 4361, Point Loma light-house S. 3° E. 9.9 miles, 97 fathoms.

### Family PLEXAURIDÆ.

Axis horny, or horny and calcareous, not jointed; cœnenchyma thick; calyces often included, placed on all sides of stem and branches; primary radial canals well defined.

#### Genus PSAMMOGORGIA Verrill.

Verrill's original description is as follows:

Corallum dichotomous or subpinnate, with round branches. Axis hornlike. Cœnenchyma moderately thick, the surface finely granulated with rough spicula. Cells scattered, somewhat flat, more frequently raised in the form of rounded verrucæ.

Polyps with rather large, elongated, slender, warty spindles at the bases of the tentacles. Spicula of the cœnenchyma mostly short, thick, and very rough, warty spindles, and rough, warty clubs of moderate size.<sup>a</sup>

#### ? PSAMMOGORGIA ARBUSCULA Verrill.

*Psammogorgia arbuscula* VERRILL, Amer. Journ. Sci., XIV, May, 1869, p. 414.

The largest colony measures 231 mm. long and is roughly flabellate in outline, dividing into two main branches about 37 mm. above the expanded base. These main branches again subdivide two or three times. The branches are of uniform diameter throughout.

The calyces are uniformly and thickly scattered throughout the cœnenchyma, but are seldom actually contiguous, and are in the form of low verrucæ, about 1.5 mm. in diameter.

The polyps are fairly well expanded in specimens preserved in formalin, extending about 1.5 mm. above the calycular margin. There are numerous warty spicules on the lower part of the body wall, and a few are placed transversely below and over the tentacular bases. They are found sparsely on the tentacles.

<sup>a</sup> Trans. Connecticut Acad. Arts and Sci., I, Pt. 2, 1867-1871, p. 414. Professor Verrill's description of the genus is here given entire. The genus is undoubtedly an aberrant one, and does not correspond to the family characters as given above, but the present writer is not prepared to attempt a reconstruction of the classification.

The spicules of the cœnenchyma are small warty spindles of various shapes, extremely verrucose. Many of them are double spindles characteristic of this genus.

The spicules on the tentacles and body walls of the polyps are more slender and less warty than the rest.

The color of the colony is bright coral red, probably owing to the color of the spicules. The polyps are white in alcohol or formalin, but may be yellow in life.

*Distribution.*—Station 4421, E. Point San Nicholas Island N. 20° W. 3.8 miles, 291 fathoms; Station 4423, E. Point San Nicholas Island S. 7.6 miles, 339 fathoms; Station 4441, Point Pinos light-house N. 87° W. 1.7 miles, 35 fathoms; Station 4451, Point Pinos light-house S. 23° W. 3.2 miles, 52 fathoms; Station 4543, Point Pinos light-house S. 25° E. 5.4 miles, 93 fathoms; Station 4550, Point Pinos light-house S. 6° E. 4.6 miles, 50 fathoms; Station 4555, Point Pinos light-house S. 63° E. 3.4 miles, 66 fathoms.

Professor Verrill reports this species from Panama and Pearl Islands, pools at extreme low-water mark, and from the Gulf of Nicoya, where it was taken by divers.

PSAMMOGORGIA SIMPLEX, new species.

Plate LXXXVIII, figs. 5 and 6; Plate XC, fig. 4.

Colony straggling, branched slightly or unbranched. Largest specimens 13 cm. long. Stem round, slender, of uniform thickness throughout.

Calyces uniformly distributed, not crowded, often as much as 2 mm. apart, tubular, small, about 1 mm. high, usually higher than broad.

The polyps have red spindle-shaped spicules in their walls and near and on the tentacular bases, where they are arranged more or less in chevrons. Otherwise they are longitudinally arranged. The cœnenchyma is thin for this genus.

The spicules are mainly of two sorts: 1. Small double spindles, rosettes, stars, and small clubs. These are found mostly in the superficial layer of the cœnenchyma, and are much less numerous than the second kind. 2. Larger spindles, slender, pointed, often somewhat curved, covered with regularly distributed verrucæ. The clubs are much less numerous than the other forms.

*Color.*—Coral red throughout.

*Type-specimen.*—Cat. No. 25431, U.S.N.M.

*Localities.*—Station 4416, SW. Rock, Santa Barbara Island, N. 49° W. 4.7 miles, 448 fathoms; Station 4427, Point San Pedro, Santa Cruz Island, N. 35° E. 7 miles, 447 fathoms (type-locality).

This species differs from its allies chiefly in the character of the spicules, the larger ones resembling those found in the genus *Muricea*.

*PSAMMOGORGIA TORREYI*, new species.

Plate LXXXIX, figs. 1 and 2; Plate XC, fig. 5.

Colony strictly flabelliform, the branches frequently anastomosing, 150 mm. high by 168 mm. broad. Main stem giving forth branches on opposite sides separated by about 7 mm. on the average. The whole forms a loose reticulation, almost exactly such as is found in the genus *Leptogorgia*.

The calyces are in the form of truncated cones about 1.5 mm. high, and the same in breadth at the base. They are distributed on all sides of the branches about 2.5 mm. apart. In front view they appear to have the arrangement found in the Gorgonidæ—that is, two opposite rows of calyces—but a closer examination shows the arrangement described above.

The spicules are warty spindles, those on the stem and branches being smaller than those on the calyces and polyps. The largest appear to be the ones in the polyp walls and basal parts of the tentacles, where they are large, warty, and fusiform, sometimes curved, arranged longitudinally and extend downward in meridional bands to near the base of the polyps. Occasional club-shaped spicules are seen, but nearly all are of the warty fusiform type.

*Color.*—Dark, purplish red throughout. Many of them are almost black, in alcohol.

*Type-specimen.*—Cat. No. 25433, U.S.N.M.

*Distribution.*—Station 4514, Point Pinos light-house S. 39° E. 10.7 miles, 524 fathoms; Station 4530, Point Pinos light-house S. 78° E. 6.8 miles, 26–28 fathoms (type-locality); Station 4537, Point Pinos light-house S. 74° E. 7.4 miles, 1062 fathoms; Station 4546, Point Pinos light-house S. 46° E. 8.4 miles, 849 fathoms. All of these stations are in Monterey Bay.

Named for Dr. Harry B. Torrey, University of California.

*PSAMMOGORGIA SPAULDINGI*, new species.

Plate LXXXVIII, figs. 3 and 4; Plate XC, fig. 7.

Colony flabellate in form; branches round in section. The manner of ramification is shown well in the photograph. (Plate LXXXVIII, fig. 3.)

Calyces scattered closely and evenly over the surface, in the form of very low verrucæ which are scarcely raised above the general surface of the colony.

Polyps completely retractile, with but few spicules and these tending to a longitudinal arrangement in the body walls in eight rows. These rows sometimes extend part way up the outer sides of the tentacles.

The spicules are small, short warty spindles and double spindles. They are of small size and exceedingly warty. The spicules in the body walls of the polyps are somewhat longer, more slender spindles, with more delicate points and verrucæ.

The color of the colony is bright coral red. The polyps, in preserved specimens, are pure white.

Beautifully expanded colonies of this fine species are in the collection at the Hopkins Laboratory, Pacific Grove, California. They were secured in Monterey Bay, but the depth is not indicated.

*Type-specimen*.—Hopkins Laboratory, Pacific Grove, California.

Named for Mr. M. H. Spaulding, formerly of Stanford University.

#### Family GORGONIDÆ.

Colony branched, usually flabellate. Axis horny, or horny and calcareous. Polyps completely retractile and bilaterally disposed. Impressions of the canals evident on the surface of the stem and branches, and bilaterally disposed. Cœnenchyma smooth. Spicules small spindles, arranged in one layer.

Genus LEPTOGORGIA Milne Edwards, emended by Verrill.

Colony flabellate, with often more or less anastomosis of the branches. Calyces verruciform or included, not distributed evenly over the surface, but leaving a broad band on front of stem and branches bare.

#### ? LEPTOGORGIA FLORÆ Verrill.

*Leptogorgia floræ* VERRILL, Trans. Connecticut Acad. Arts and Sci., I, Pt. 2, 1867 to 1871, p. 387.

A large dried specimen in the collection of the University of California is referred with some doubt to this species. It is very much larger than the type described by Verrill, which was about 6 inches high. The specimen before me is over 2 feet high. In detail, however, it agrees fairly well with the original description.

The locality is not stated on the label, which, however, gives the depth at 80 fathoms.

The type was secured by F. H. Bradley. The species is reported by Verrill as found at Panama and Pearl Islands.

#### LEPTOGORGIA PURPUREA (Pallas).

*Gorgonia purpurea* PALLAS, Elenchus Zoophytorum, 1767, p. 187.

Colony flabellate, 12.5 cm. high by 16.2 cm. broad. Stem irregularly sinuate, scarcely flattened, 3 mm. broad, giving off opposite branches at intervals of 3 to 13 mm. Some of the branches again divide once or twice. The terminal branchlets are somewhat flat-

tened, 14 to 25 mm. long, 1.5 mm. wide; somewhat widening at the terminations.

The calyces are arranged in two series on each side of the stem and larger branches and in one series on each side of the terminal branchlets. There are occasional calyces on the front and back of stem and branches. The calyces are in the form of low rounded verrucæ, closely crowded, about 1.5 mm. from summit to summit. Margins usually showing a tendency to a bilobed condition when the polyps are almost completely contracted. The calyces are about 2 mm. broad at base and 1 mm. or less high.

The polyps are small, with few spicules.

The spicules are of very uniform type, quite small stout double spindles with crowded verrucæ. They are often so stout as to be oval or even round in profile.

*Color.*—Uniformly purplish red.

*Distribution.*—Station 4431, Brockway Point, Santa Rosa Island, S. 43° W. 5.2 miles, 41 fathoms.

The locality given by Pallas is "Mare Americanus."

The *Challenger* took this species at Bahia, 10 to 20 fathoms, and at Station 310, Sarmiento Channel, depth 400 fathoms.

The specimens secured by the Fisheries steamer *Albatross* agree very well with the description and figures given by Wright and Studer.<sup>a</sup>

? *LEPTOGORGIA CARYI* Verrill.

*Leptogorgia caryi* VERRILL, Trans. Connecticut Acad. Arts and Sci., I, Pt. 2, 1867 to 1871, p. 404.

A fragmentary specimen in the collection of the University of California is hardly sufficient for identification, and is referred to this species with much doubt. It is a single unbranched stem about 8 inches long, with two distant stubs indicating that it was sparsely branched. The verrucæ are almost entirely included and hardly evident.

The spicules are typical of this genus, those in the polyps walls being very small and sparse.

The specimen bears the label "L-H 3." It was probably secured off San Diego, California.

The type was collected near San Francisco by T. G. Cary.

Genus *STENOGORGIA* Verrill.

Colony branched; cœnenchyma thin. Polyps scattered, disposed in two rows, retractile and bent inward when at rest. Calyces exerted. Spicules small warty spindles and granules. There are spicules in the tentacles.

<sup>a</sup> Challenger Report, Alcyonaria, p. 150, pl. xxix, fig. 1.

## STENOGORGIA KOFOIDI, new species.

Plate LXXXIX, figs. 5 and 6; Plate XC, fig. 6.

Colony flabellate, 78 mm. by 78 mm.; 15 mm. from the base the main stem divides into three main branches, a center one ascending and almost unbranched, the two lateral ones at first widely divaricating, then ascending and giving forth pinnate branches which tend to be opposite, but are quite irregular. Branchlets about 6 mm. apart, where regular, and somewhat flattened.

The calyces are quite prominent, conical, with broad base, forming an irregular row on each side of front and back of branch, but more numerous in front than behind, their summits 3.5 mm. apart. The calyces are 1.5 mm. high and 1.5 broad at base. Margins with 8 scallops.

Polyps with the outer sides of the tentacles crowded with spicules.

The color of the colony, including the polyps, is deep coral red. The axis is dark greenish brown, lightening distally.

The spicules are almost exclusively small thorny slender spindles, the larger ones often curved. There are a few small double spindles, and part of the larger ones have the verrucæ common in the genus *Eunicea*.

*Type-specimen*.—Cat. No. 25432, U.S.N.M.

*Distribution*.—Station 4546; Station 4553, Point Pinos light-house, S. 67° E. 3.7 miles; 74 fathoms (type-locality); Station 4554, Point Pinos light-house S. 76° E. 3 miles, 60 fathoms.

This species seems to be a *Leptogorgia* in general form and arrangement of calyces; but the spicules are more like those characteristic of some of the Muricidæ.

Named in honor of Prof. C. A. Kofoid, of the University of California.

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## EXPLANATION OF PLATES.

The photographs were taken by the author. The drawings of the spicules and histological details were made under the camera lucida by Mr. Otto F. Kampmeier, of the Department of Zoology, State University of Iowa.

## PLATE LXXXIV.

- Fig. 1. *Telesto ambigua*, new species. Somewhat reduced.
2. *Telesto ambigua*. Portions of colonies,  $\times 6$ .
3. *Anthomastus ritteri*, new species. Colony, somewhat reduced.
4. *Ptilosarcus quadrangularis*. A young specimen, dorsal aspect.
5. *Ptilosarcus quadrangularis*. Ventral aspect of same specimen.
6. *Ptilosarcus quadrangularis*. Part of ventral aspect of rachis of large specimen.
7. *Ptilosarcus quadrangularis*. Dorsal view of same.
8. *Ptilosarcus quadrangularis*. Ventral view of rachis, showing abnormal growth of rudimentary pinnæ on zooid band to the left.
9. *Ptilosarcus quadrangularis*. Two small specimens with expanded polyyps.
10. *Ptilosarcus quadrangularis*. The smallest colony examined. Somewhat reduced.

## PLATE LXXXV.

- Fig. 1. *Ptilosarcus quadrangularis*. View of distal end of colony, showing the appearance of whorls of polyyps caused by crowding of pinnæ.
2. *Ptilosarcus quadrangularis*. Upper left figure, cross section of stem and axis, showing septa, stem chambers, and spongy tissue. Upper right hand, section of stem taken below proximal end of axis. Lower figure, section across rachis with a pair of pinnæ attached.
3. *Ptilosarcus quadrangularis*. To the left, surface of stem. To the right, inner surface of stem cavity showing stomata; also the spongy tissue of wall of stem.
4. *Ptilosarcus quadrangularis*. Two small pinnæ, or leaves, showing polyp band.
5. *Ptilosarcus quadrangularis*. Edge of polyp band with polyyps retracted, showing bimucronate calyces.
6. *Ptilosarcus quadrangularis*. Portion of pinna, enlarged, showing expanded polyyps and the longitudinal chambers of the leaf.
7. *Ptilosarcus quadrangularis*. A few of the polyyps, magnified.
8. *Ptilosarcus quadrangularis*. Cross sections of leaf. Above, section just below polyp band, showing gullets and mesenteries of polyyps, and the arrangement of body cavities due to crowding. The middle and lower figures show sections taken below the gullets.

- Fig. 9. *Ptilosarcus quadrangularis*. Section of leaf to show ova and septa between leaf chambers.
10. *Ptilosarcus quadrangularis*. Surface view of portion of zooid band, enlarged.
11. *Ptilosarcus quadrangularis*. Cross section of rachis, showing zooids and muscle bands.

## PLATE LXXXVI.

- Fig. 1. *Halisceptrum cystiferum*, new species, somewhat reduced.
2. *Stylatula elongata*. Dorsal and ventral views of distal part of colony. Photographed from living specimens, slightly reduced.
3. *Acanthoptilum gracile*. Dorsal view of part of rachis, enlarged.
4. *Acanthoptilum gracile*. Ventral view of part of rachis, enlarged.
5. *Acanthoptilum album*, new species. Parts of colony, reduced.
6. *Acanthoptilum album*. Dorsal and ventral views of part of rachis, enlarged.
7. *Acanthoptilum album*. Lateral view of leaves.
8. *Acanthoptilum album*. Fragments, showing polyps.
9. *Acanthoptilum scalpelliforme*. Dorsal view, enlarged.
10. *Acanthoptilum scalpelliforme*. Ventral view, enlarged.
11. *Acanthoptilum annulatum*, new species. Part of colony, reduced.
12. *Acanthoptilum annulatum*. Ventral view of part of rachis, enlarged.
13. *Acanthoptilum annulatum*. Leaves, showing polyps, enlarged.

## PLATE LXXXVII.

- Fig. 1. *Balticina pacifica*, new species. Parts of colony, somewhat reduced.
2. *Balticina pacifica*. Part of rachis, showing polyps, enlarged.
3. *Halipteris contorta*, new species. Parts of colonies, slightly reduced.
4. *Halipteris contorta*. Part of colony, enlarged, showing calyces.
5. *Stachyptilum superbum*. Parts of rachis showing ventral and dorsal views, and of stem, about natural size.
6. *Stachyptilum superbum*. Ventral and dorsal views of part of rachis, enlarged.
7. *Stachyptilum quadridentatum*, new species. Part of rachis, somewhat reduced.
8. *Stachyptilum quadridentatum*. Part of rachis, ventral aspect, enlarged.
9. *Umbellula loma*, new species. Two views of rachis, and one of proximal part of stem, about natural size.
10. *Distichoptilum verrillii*. Portions of colony, somewhat reduced.
11. *Revilla amethystina*. Colony with expanded polyps, slightly reduced.

## PLATE LXXXVIII.

- Fig. 1. *Plumarella longispina*. Part of colony, somewhat reduced.
2. *Plumarella longispina*. Branches, enlarged.
3. *Eumuricea pusilla*, new species. Fragments, somewhat reduced.
4. *Eumuricea pusilla*. Parts of branches, enlarged.
5. *Psammogorgia simplex*, new species. Parts of colony, somewhat reduced.
6. *Psammogorgia simplex*. Parts of branches, enlarged.

## PLATE LXXXIX.

- Fig. 1. *Psammogorgia torreyi*, new species. Part of colony, somewhat reduced.
2. *Psammogorgia torreyi*. Ends of branchlets, enlarged.
3. *Psammogorgia spauldingi*, new species. Colony with expanded polyps, somewhat reduced.
4. *Psammogorgia spauldingi*, end of branch with expanded polyps, enlarged.
5. *Stenogorgia kofoidi*, new species. Colony, somewhat reduced.
6. *Stenogorgia kofoidi*. Portion of branch, enlarged.

PLATE XC.

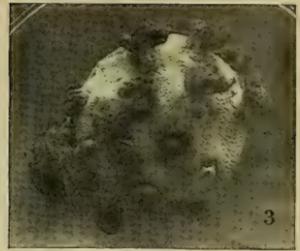
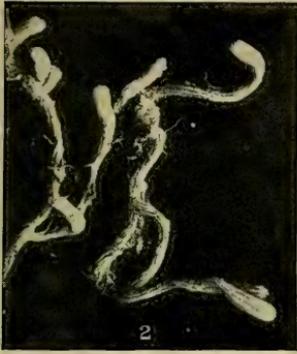
- Fig. 1. Spicules of *Telesto ambigua*, new species.  
 2. Spicules of *Anthomastus ritteri*, new species.  
 3. Spicules of *Plumarella longispina*.  
 4. Spicules of *Psammogorgia simplex*, new species.  
 5. Spicules of *Psammogorgia torreyi*, new species.  
 6. Spicules of *Stenogorgia kofoidi*, new species.  
 7. Spicules of *Psammogorgia spauldingi*, new species.

PLATE XCI.

Structural and histological details of *Ptilosarcus quadrangularis*.

- Fig. 1. Cross section of wall of rachis, through the band of zooids.  
*c*, canal from gullet of zooid to large longitudinal canal of rachis.  
*cm*, circular muscles lining cavity of rachis.  
*ect*, ectodermal lining of esophageal tube or gullet of zooid (siphonoglyph) showing long cilia.  
*end*, endodermal layer of gullet wall.  
*gul*, gullet of zooid in horizontal section taken across the siphonoglyph.  
*inv*, involution of surface of zooid band.  
*lc*, cavity of great longitudinal canals of rachis.  
*lmb*, longitudinal muscle bands, in section.  
*m*, mouth of zooid.  
*sp*, spicules, in cross section.  
*sp t*, spongy tissue below muscle bands.
2. Cross section of zooid, taken across gullet.  
*ect*, ectodermal lining of siphonoglyph.  
*end*, endodermal lining of intermesenterial chamber.  
*ic*, intermesenterial chamber.  
*m*, mesentery.  
*spgh*, cavity of siphonoglyph lined with long cilia.

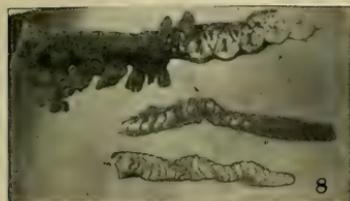
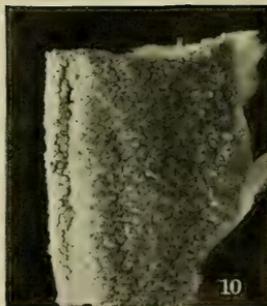
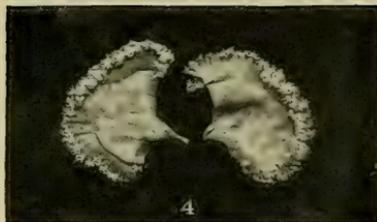
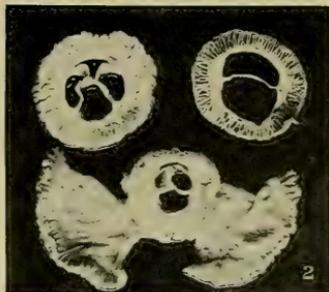
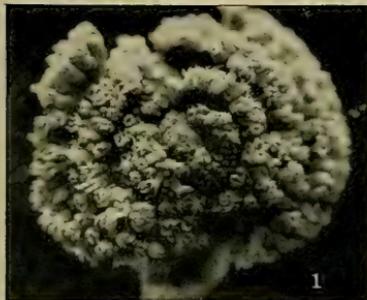




ALCYONARIA OF THE CALIFORNIA COAST.

FOR EXPLANATION OF PLATE SEE PAGE 725.

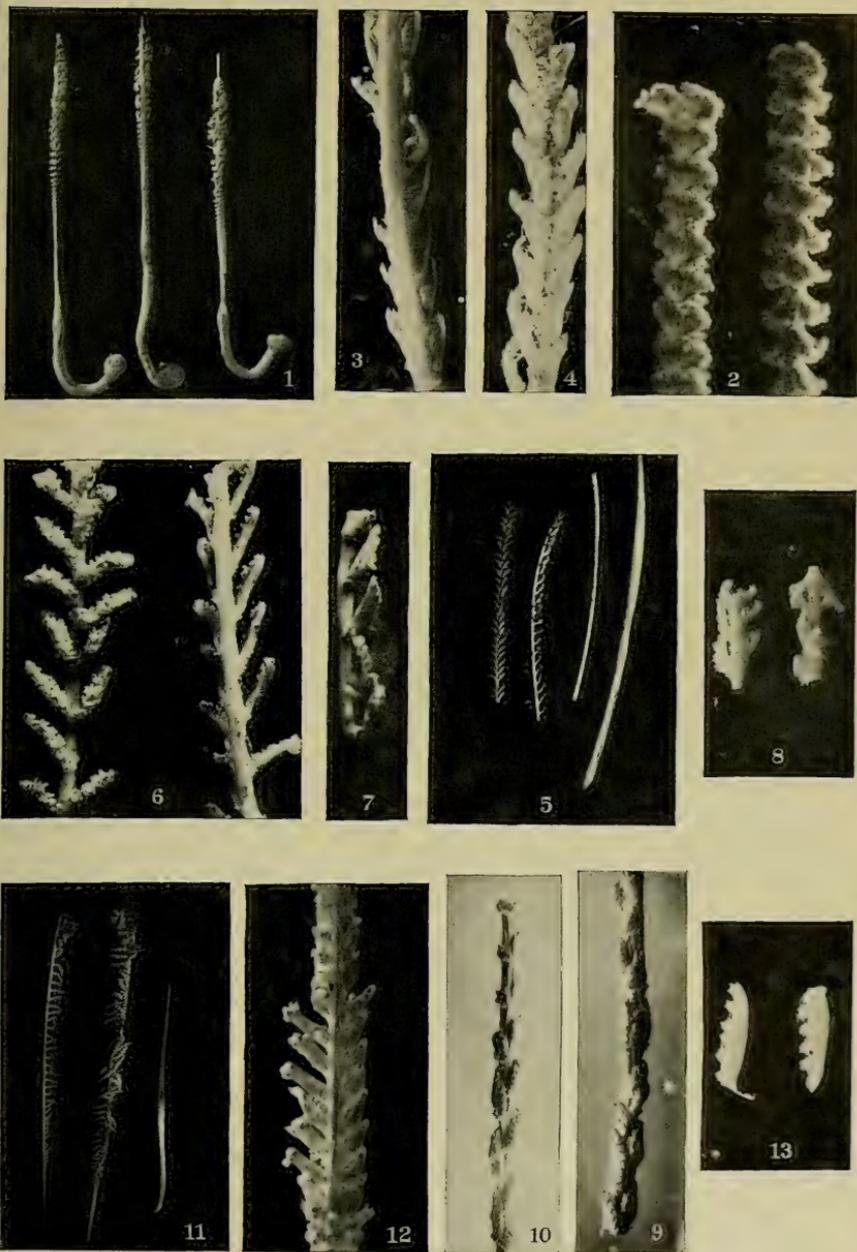




ALCYONARIA OF THE CALIFORNIA COAST.

FOR EXPLANATION OF PLATE SEE PAGES 725, 726.

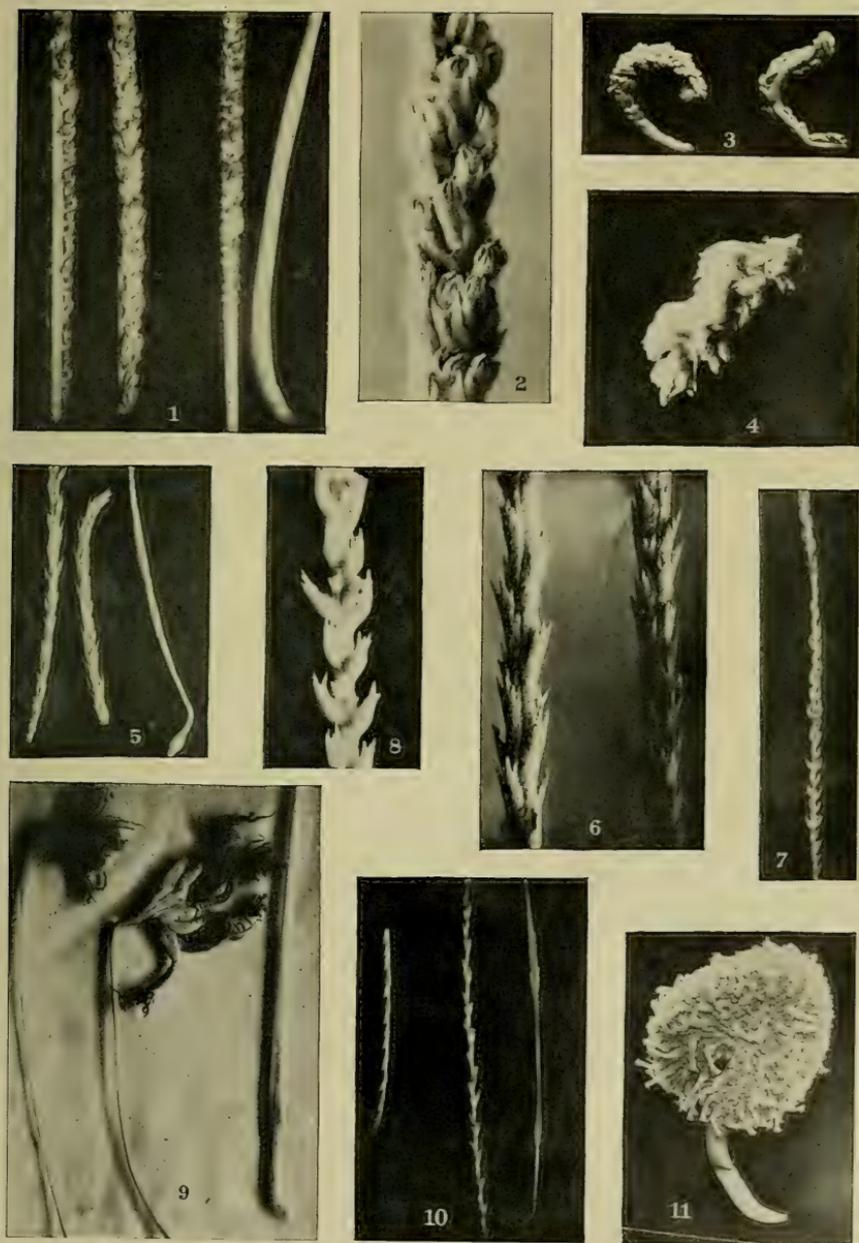




ALCYONARIA OF THE CALIFORNIA COAST.

FOR EXPLANATION OF PLATE SEE PAGE 726.

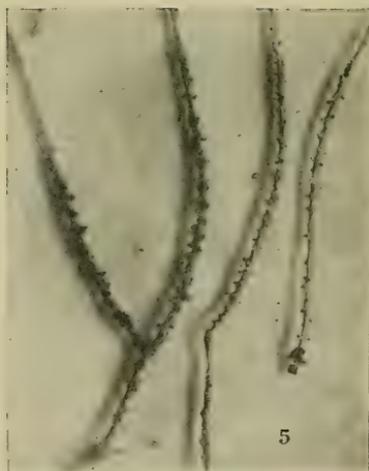
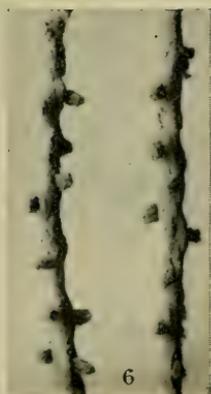




ALCYONARIA OF THE CALIFORNIA COAST.

FOR EXPLANATION OF PLATE SEE PAGE 726.

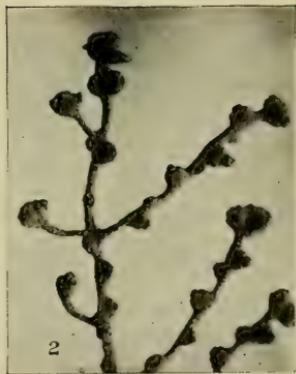
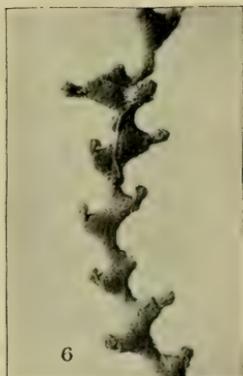




ALCYONARIA OF THE CALIFORNIA COAST.

FOR EXPLANATION OF PLATE SEE PAGE 726.

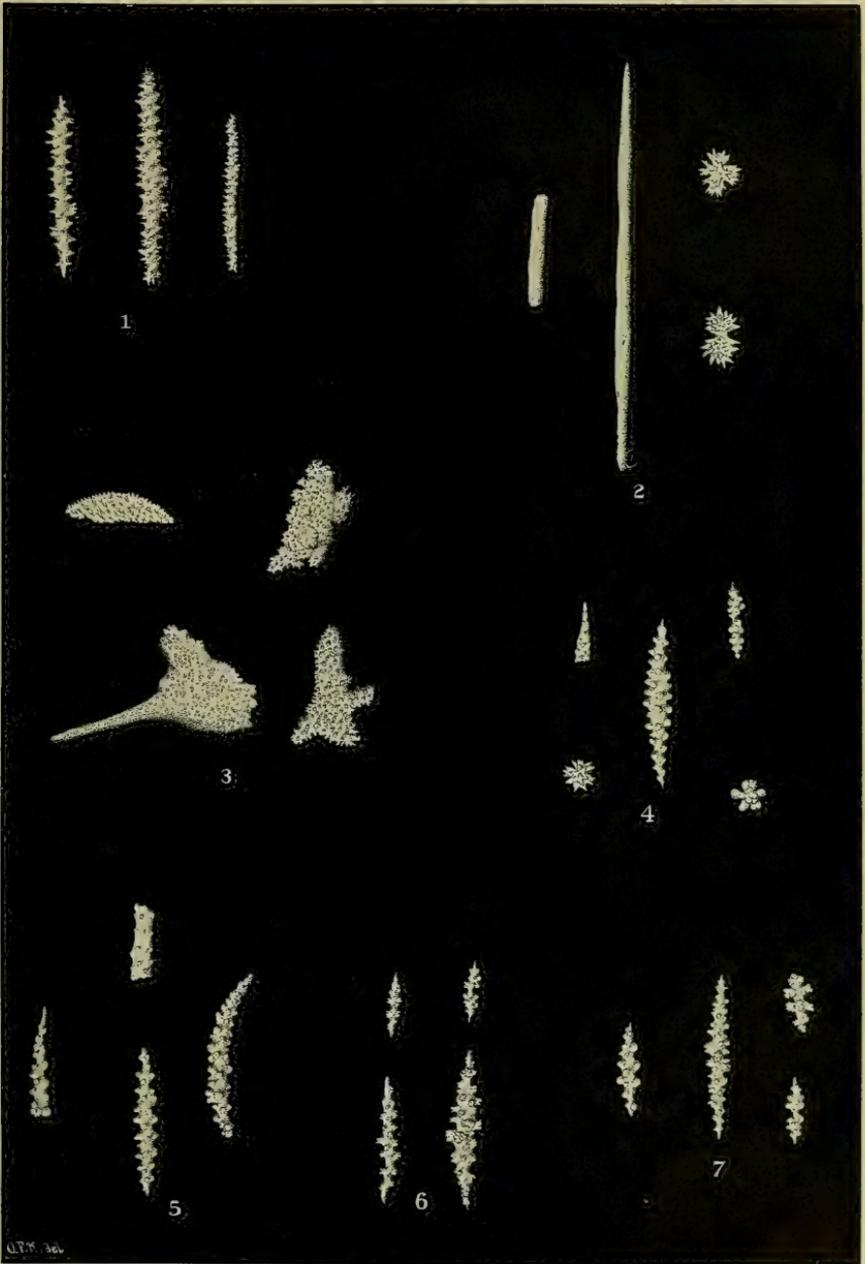




ALCYONARIA OF THE CALIFORNIA COAST.

FOR EXPLANATION OF PLATE SEE PAGE 726.

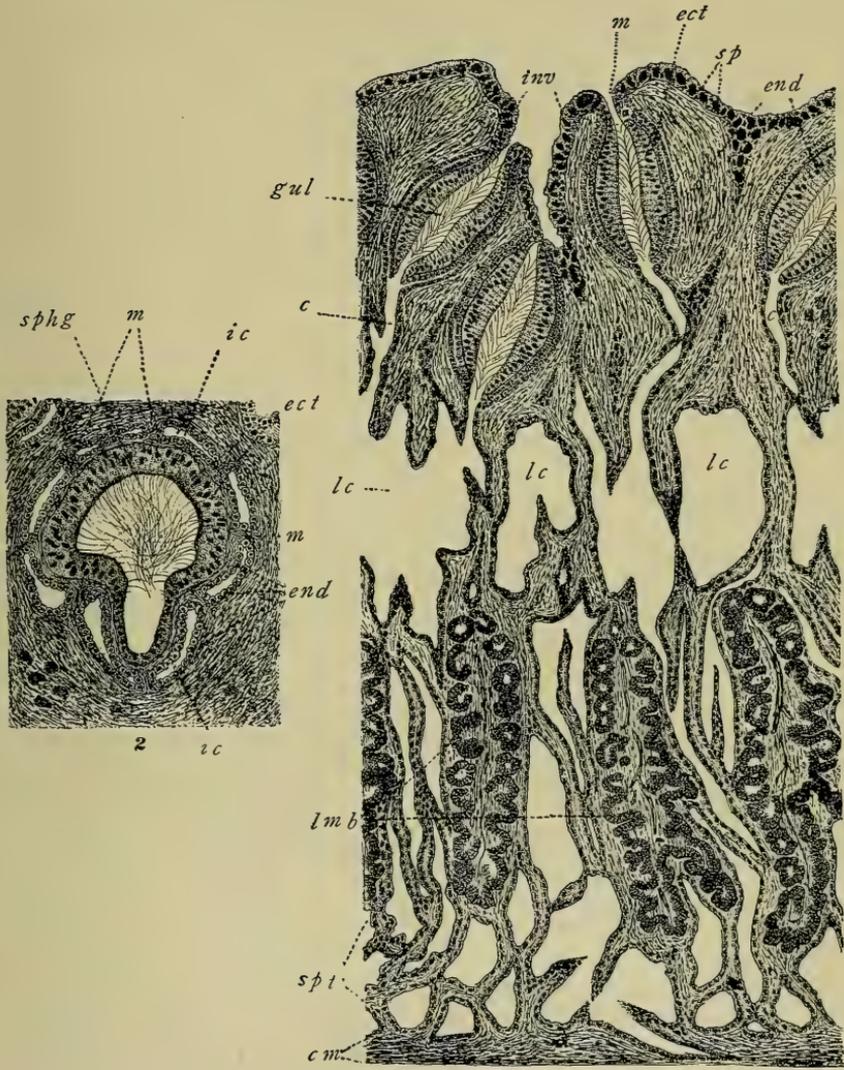




ALCYONARIA OF THE CALIFORNIA COAST.

FOR EXPLANATION OF PLATE SEE PAGE 727.





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ALCYONARIA OF THE CALIFORNIA COAST.

FOR EXPLANATION OF PLATE SEE PAGE 727.

