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BYTHOCHERES PROMINULUS, A NEW GENUS AND SPECIES (COPEPODA: SIPHONOSTOMATOIDA) FROM DEEP-WATER COLD SEEPS AT THE WEST FLORIDA ESCARPMENT

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Abstract.—A siphonostomatoid copepod, *Bythocheres prominulus,* new genus, new species, is described from a depth of 3260 m at cold seeps near the base of the West Florida Escarpment. Among its distinctive features are: the first antenna 15-segmented with an aesthete on the penultimate segment, the second antenna without an exopod, an elongate siphon, both second maxilla and maxilliped with their tips finely spinulose, legs 1–4 biramous with 3-segmented rami, and leg 5 with the free segment having 3 setae. The new copepod cannot be placed satisfactorily in any of the currently recognized families of Siphonostomatoida. Males are unknown and the family position is not designated.

Nearly 30 species of copepods, both Poecilostomatoida and Siphonostomatoida, have been described from deep-sea hydrothermal vents (Humes & Dojiri 1980, Humes 1984, Humes, 1987). However, copepods from cold seeps in the deep sea have not been reported until now. It is the object of this paper to describe a new siphonostomatoid copepod recently collected at cold seeps in deep water off the west coast of Florida.

The new copepod was found at a depth of 3260 m (a little more than 2 miles), near the base of the West Florida Escarpment, "a gigantic limestone cliff that rises some 2000 meters above the 3280-meter-deep floor of the Gulf" (Florida Escarpment Cruise Participants, C. K. Paull, Chief Scientist, 1984:32). Hypersaline water of Lower Cretaceous fresh-water origin seeps into the sea water from strata in the interior of the Florida Platform (Paull et al. 1984).

The cold seeps where the copepods were collected have very different characteristics from those of hydrothermal vents, although both environments are aphotic and under great hydrostatic pressure. At Galapagos-type hydrothermal vents, the water temperature may reach 15°C or higher (Grassle 1985), or as high as 350°C at black smoker vents at 21°N on the East Pacific Rise (Grassle 1986). However, "Despite the elevated temperatures in the immediate vicinity of the vents, most vent animals live at close to the ambient (2°C) temperature." (Grassle 1986:302–303). Sulfide of geothermal origin is present in discharged vent water at high concentrations. On soft sediments in the Guaymas Basin, Gulf of California, the flux of hydrothermal fluid may lead to growth of extensive mats of the bacterium *Beggiatoa.* In cold seeps, on the other hand, where the bottom water temperature averages 4.39°C (Paull et al. 1984), no primary sulfide discharge is found but is secondarily produced in the sediments by bacterial sulfate reduction. Consequently, at these cold seeps the mats that exist are composed primarily of inorganic materials, largely sulfur, and only to a small extent of sulfide-oxidizing bacteria (H. Jannasch, pers. comm.).

The Poecilostomatoida and Siphonostomatoida known from hydrothermal vents (Humes & Dojiri 1980, Humes 1984, Humes, 1987) belong to genera not found in other areas. Siphonostomatoida are particularly abundant both in numbers and diversity. The record of *Bythocheres* demonstrates that copepods occur in the deep sea at cold seeps as well as at hydrothermal vents.

The slurp gun, a device by means of which the copepods were collected from the base of the escarpment wall, was operated from the Deep Submergence Research Vehicle *Alvin.* It consists of a large container in the opening of which are fitted a tube whose external inlet can be directed to chosen collecting spots by *Alvin,* a filter, and a pump that draws sea water into the container (see Editor, National Geographic Magazine, 1979:684). In operation, organisms are filtered out and collect at the bottom of the container. Excess water is ejected by the pump.

The copepods were studied and measured in lactic acid, using the wooden slide technique described by Humes & Gooding (1964). The letter after the explanation of each figure refers to the scale at which the figure was drawn.

Bythocheres, new genus

Diagnosis.—Siphonostomatoida. Female: Body unmodified. Segment bearing leg 1 fused with cephalosome. Urosome 5-segmented. Caudal ramus with 6 setae.

Rostrum weakly developed. First antenna 15-segmented with aesthete on penultimate segment. Second antenna lacking exopod; endopod with second segment bearing 4 setae, 3 terminal and 1 surficial. Siphon elongate, prominent. Mandible without palp, blade long and slender. First maxilla with outer lobe having 2 setae, inner lobe bearing 3 setae and 2 small spines. Second maxilla with second segment having 2 setae on proximal part, distal part clawlike and finely spinulose. Maxilliped 5-segmented, recurved claw finely spinulose.

Legs 1–4 biramous with 3-segmented rami. Leg 1 with inner seta on basis; third segment of exopod with III,5 and that of endopod with 1,2,3. Third segment of exopod of legs 2–4 with III,I,5. Third segment of endopod of leg 2 with 1,2,3, that of leg 3 with 1,1,I,3, and that of leg 4 with 1,1,I,2.

Leg 5, carried ventrally, with first segment fused with body and bearing 1 seta. Free segment short, broad, with 3 setae.

Leg 6 represented by 1 seta and 2 very small spines.

Egg sac unknown.

Male.—Unknown.

Type species.—*Bythocheres prominulus,* new species.

Gender.—Masculine.

Etymology.—The generic name is a combination of the Greek word *bythos,* meaning the depths of the sea, and *cheres,* a combining form often used for siphonostomatoids.

Bythocheres prominulus, new species
Figs. 1–19

Type material.—10 ♀♀ in 3243 m, in slurp gun sample, 26°01'N, 84°55'W, DSRV *Alvin* dive no. 1756, 17 Oct 1986, C. Van Dover collector; 2 ♀♀, in 3266 m, in slurp gun sample from small patches of whitish mats at edge of dark or black areas of reduced sediments, West Florida Escarpment cold seeps, 26°01.8'N, 84°54.9'W, *Atlantis II/Alvin* Cruise 118-2, DSRV *Alvin* dive no. 1758, 20 Oct 1986, H. Jannasch collector.

Female.—Body (Figs. 1, 2) with moderately broad prosome slightly pointed anteriorly and forming lateral shieldlike extensions. Length (not including setae on caudal rami) 1.96 mm (1.95–2.19 mm) and greatest width 0.77 mm (0.75–0.84 mm), based on 10 specimens in lactic acid. Greatest dorsoventral thickness at level of siphon 0.50 mm, at maxillipeds 0.39 mm. Segment bearing leg 1 fused with cephalosome. Epimeral areas of segments bearing legs 1–4 rounded. Ratio of length to width of prosome 1.43:1. Ratio of length of prosome to that of urosome 1.43:1.

Segment bearing leg 5 (Fig. 3) 117 × 203 μm, in dorsal view concealing fifth pair of legs. Genital segment 265 μm long, laterally expanded in anterior half, width 234 μm, narrowed in posterior half, width 174 μm. Genital areas located dorsolaterally in posterior part of anterior half of segment. Each area (Figs. 4, 5) with small seta 34 μm and 2 minute spines 5 μm and 3 μm. Three postgenital segments from anterior to posterior 122 × 146, 91 × 135, and 185 × 169 μm, last segment much longer than either of preceding two.

Caudal ramus (Fig. 6) elongate, 187 × 78 μm, ratio 2.40:1. Outer lateral seta 40 μm and displaced a little dorsally, dorsal seta 52 μm, both smooth. Outermost terminal seta 154 μm and subterminal in position, innermost terminal seta 198 μm, and 2 median terminal setae 275 μm (outer) and 335 μm (inner); all 4 terminal setae with long setules.

Sclerotization of body weak. Body surface with refractile points (sensilla?) on dorsal surface of urosome as in Fig. 3.

Egg sac unknown.

Rostral area (Fig. 7) weakly developed. First antenna (Fig. 8) 15-segmented, 495 μm long (not including terminal setae), with aesthete on penultimate segment. Armature: 1,1,2,1,2,2,2,1,6,2,2,2,2,1 + 1 aesthete, and 11. All setae smooth. Aesthete 253 μm.

Second antenna (Fig. 9) less than half length of first antenna, 234 μm (excluding terminal setae). Longest terminal seta 78 μm. Coxa and basis unarmed. Exopod absent. Endopod 2-segmented. First and second segment with small spinules along outer surface. Second segment with 1 surficial barbed seta near midregion and 1 subterminal and 2 terminal setae.

Siphon (Fig. 7) elongate, pyriform, 380 μm in length, projecting at nearly right angle with prosome (Fig. 2) and enclosing mandibles.

Mandible (Fig. 10) lacking palp. Blade extremely long and slender, 363 μm, with several minute terminal teeth. First maxilla (Fig. 11) with slender exopod and endopod, endopod twice length of exopod. Exopod with 2 terminal long barbed setae and having few outer marginal setules. Endopod terminally with 3 long barbed setae and 2 short smooth spines. Second maxilla (Fig. 12) with long unornamented first segment; elongate second segment with proximal part having 2 small distal inner setae, subterminal seta weakly barbed, smaller terminal seta smooth, distal part forming short stout claw 80 μm (Fig. 13) with many minute spinules on concave surface. Maxilliped (Fig. 14) 5-segmented. First segment with small distal inner barbed seta. Second segment with small inner smooth seta. Third segment with small delicately barbed distal outer seta. Fourth segment with distal barbed inner seta. Fifth segment with inner terminal unilaterally barbed seta and outer recurved claw 99 μm long and densely covered with minute spinules.

Ventral area between maxillipeds and first pair of legs protuberant as in Fig. 2.

Legs 1–4 (Figs. 15, 16, 17, 18) biramous, with 3-segmented rami. Spine and setal formula as follows (Roman numerals representing spines, Arabic numerals indicating setae)

P_1	coxa 0-0	basis 1-1	exp	I-1;	I-1;	III,5
			enp	0-1;	0-2;	1,2,3
P_2	coxa 0-1	basis 1-0	exp	I-1;	I-1;	III,I,5
			enp	0-1;	0-2;	1,2,3
P_3	coxa 0-1	basis 1-0	exp	I-1;	I-1;	III,I,5
			enp	0-1;	0-2;	1,1,I,3
P_4	coxa 0-1	basis 1-0	exp	I-1;	I-1;	III,I,5
			enp	0-1;	0-2;	1,1,I,2

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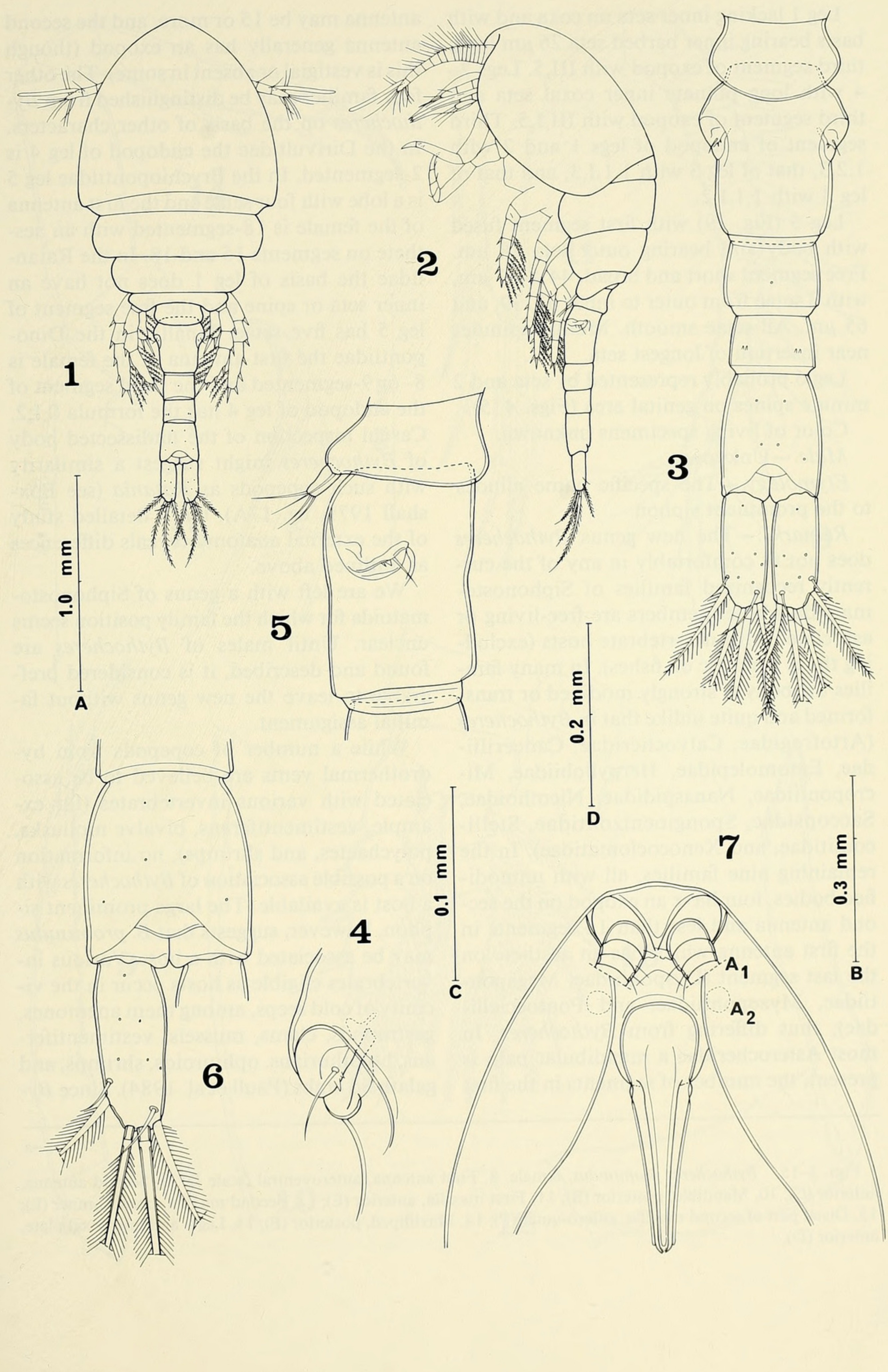
Figs. 1–7. *Bythocheres prominulus,* female. 1, Dorsal (scale A); 2, Lateral (A); 3, Urosome, dorsal (B); 4, Genital area, dorsal (C); 5, Segment bearing leg 5 and genital segment, lateral (D); 6, Anal segment and caudal ramus, dorsal (D); 7, Rostrum and siphon, ventral (B). A_1 = first antenna, A_2 = second antenna.



1
2
3
4
5
6
7
1.0 mm
A
0.1 mm
C
0.2 mm
D
0.3 mm
B
A1
A2

Leg 1 lacking inner seta on coxa and with basis bearing inner barbed seta 26 μm long; third segment of exopod with III,5. Legs 2–4 with long pinnate inner coxal seta and third segment of exopod with III,I,5. Third segment of endopod of legs 1 and 2 with 1,2,3, that of leg 3 with 1,1,I,3, and that of leg 4 with 1,1,I,2.

Leg 5 (Fig. 19) with first segment fused with body and bearing outer seta 78 μm. Free segment short and broad, 44 × 37 μm, with 3 setae from outer to inner 31, 39, and 65 μm. All setae smooth. Minute spinules near insertion of longest seta.

Leg 6 probably represented by seta and 2 minute spines on genital area (Figs. 4, 5).

Color of living specimens unknown.

Male.—Unknown.

Etymology.—The specific name alludes to the prominent siphon.

Remarks.—The new genus *Bythocheres* does not fit comfortably in any of the currently recognized families of Siphonostomatoida whose members are free-living or associated with invertebrate hosts (excluding those parasitic on fishes). In many families the body is strongly modified or transformed and quite unlike that in *Bythocheres* (Artotrogidae, Calvocheridae, Cancerillidae, Entomolepidae, Herpyllobiidae, Micropontiidae, Nanaspididae, Nicothoidae, Saccopsidae, Spongiocnizontidae, Stellicomitidae, and Xenocoelomatidae). In the remaining nine families, all with unmodified bodies, four have an exopod on the second antenna and less than 15 segments in the first antenna which has an aesthete on the last segment (Dyspontiidae, Megapontiidae, Myzopontiidae, and Pontoeciellidae), thus differing from *Bythocheres.* In most Asterocheridae a mandibular palp is present, the number of segments in the first antenna may be 15 or more, and the second antenna generally has an exopod (though this is vestigial or absent in some). The other four families may be distinguished from *Bythocheres* on the basis of other characters. In the Dirivultidae the endopod of leg 4 is 2-segmented. In the Brychiopontiidae leg 5 is a lobe with four setae and the first antenna of the female is 18-segmented with an aesthete on segments 15 and 18. In the Rataniidae the basis of leg 1 does not have an inner seta or spine and the free segment of leg 5 has five setae. Finally, in the Dinopontiidae the first antenna of the female is 8- or 9-segmented and the third segment of the endopod of leg 4 has the formula 0,I,2. Casual inspection of the undissected body of *Bythocheres* might suggest a similarity with such copepods as *Ratania* (see Boxshall 1979, fig. 17A), but a detailed study of the external anatomy reveals differences as outlined above.

We are left with a genus of Siphonostomatoida for which the family position seems unclear. Until males of *Bythocheres* are found and described, it is considered preferable to leave the new genus without familial assignment.

While a number of copepods from hydrothermal vents are believed to be associated with various invertebrates (for example, vestimentiferans, bivalve mollusks, polychaetes, and shrimps), no information on a possible association of *Bythocheres* with a host is available. The large prominent siphon, however, suggests that *B. prominulus* may be associated with a host. Various invertebrates eligible as hosts occur in the vicinity of cold seeps, among them anemones, gastropods, clams, mussels, vestimentiferans, holothurians, ophiuroids, shrimps, and galatheid crabs (Paull et al. 1984). Since *By-*

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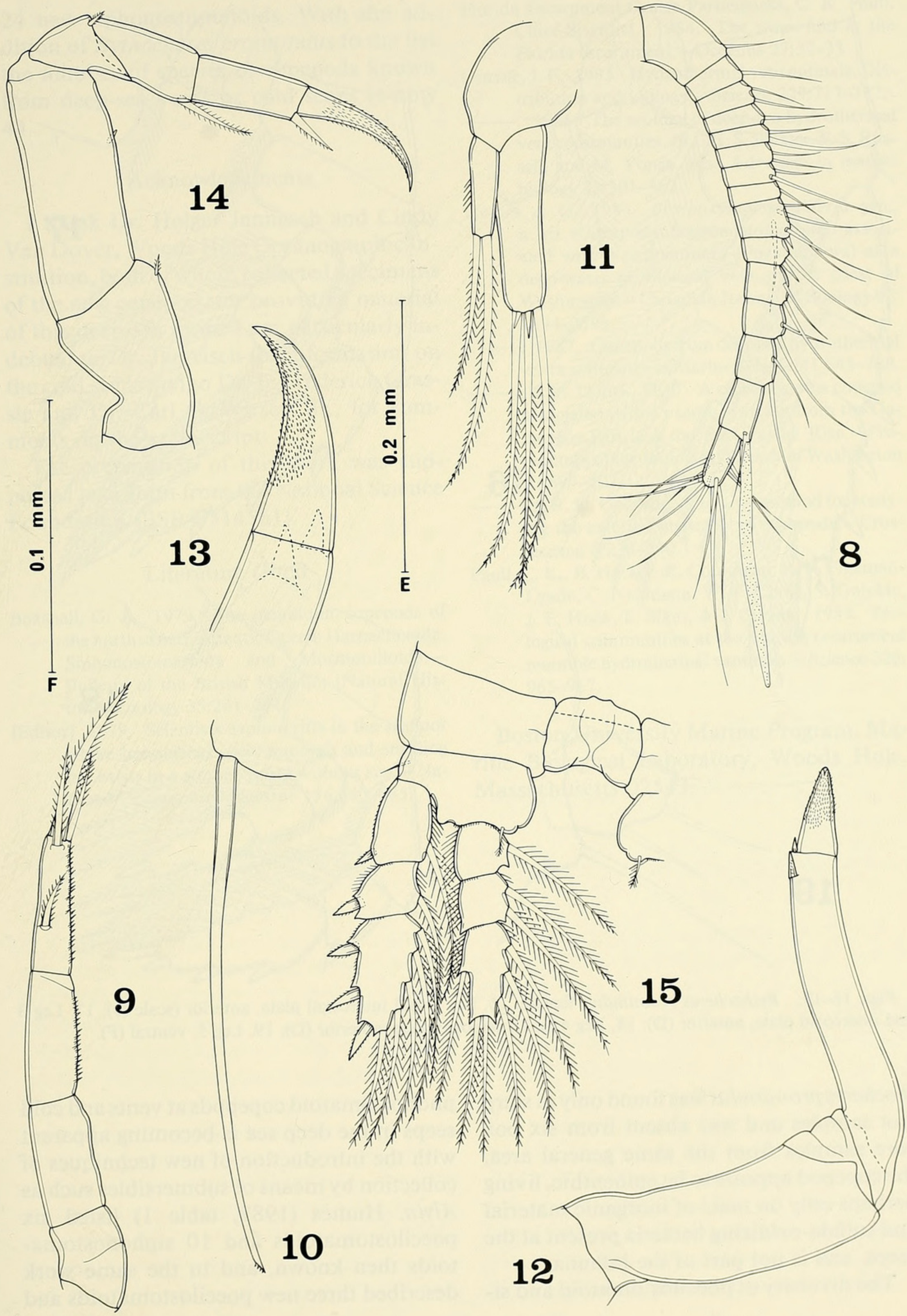
Figs. 8–15. *Bythocheres prominulus,* female. 8, First antenna, anteroventral (scale D); 9, Second antenna, anterior (C); 10, Mandible, posterior (B); 11, First maxilla, anterior (E); 12, Second maxilla, postero-inner (E); 13, Distal part of second maxilla, antero-outer (F); 14, Maxilliped, posterior (E); 15, Leg 1 and intercoxal plate, anterior (D).


14
11
8
13
0.1 mm
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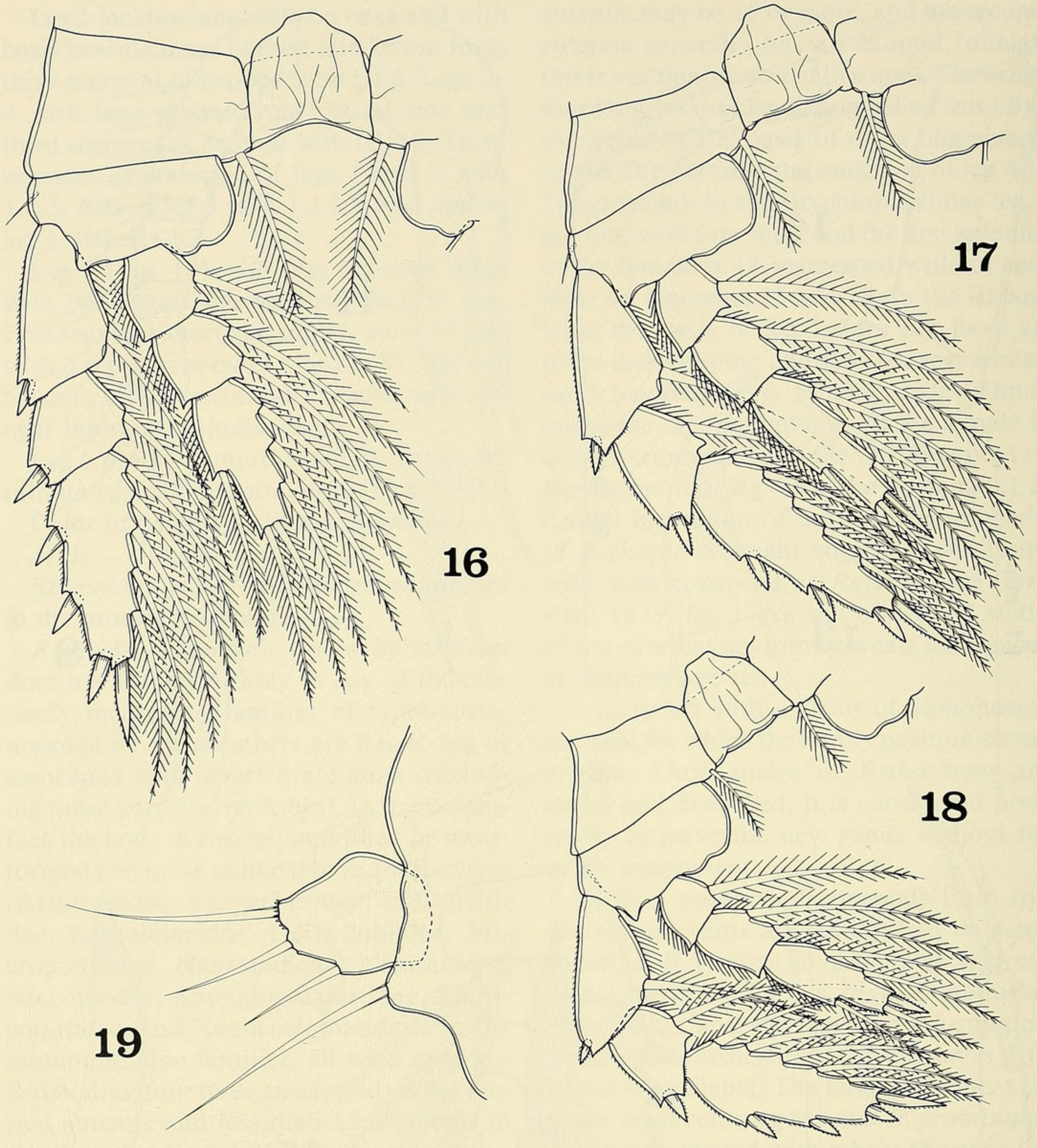

Figs. 16–19. *Bythocheres prominulus,* female. 16, Leg 2 and intercoxal plate, anterior (scale D); 17, Leg 3 and intercoxal plate, anterior (D); 18, Leg 4 and intercoxal plate, anterior (D); 19, Leg 5, ventral (F).

thocheres prominulus was found only in slurp gun samples and was absent from six box core samples from the same general area, the copepod appears to be epibenthic, living perhaps only on mats of inorganic material and sulfide-ozidizing bacteria present at the seeps, and is not part of the infauna.

The diversity of poecilostomatoid and siphonostomatoid copepods at vents and cold seeps in the deep sea is becoming apparent with the introduction of new techniques of collection by means of submersibles such as *Alvin.* Humes (1987, table 1) listed six poecilostomatoids and 10 siphonostomatoids then known, and in the same work described three new poecilostomatoids and

24 new siphonostomatoids. With the addition of *Bythocheres prominulus* to the list the number of species of copepods known from deep-sea vents or cold seeps is now 44.

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