

## Two New Species of Pogonophora from Hawaii<sup>1</sup>

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**ABSTRACT:** The first Pogonophora to be reported from the Hawaiian region have been found in collections made near Oahu and Lanai islands, dredged from depths between 275 and 595 m. New species of *Siboglinum* and *Oligobrachia* are described.

COLLECTIONS MADE BY THE Stanford Oceanographic Expedition in 1971 in the neighborhood of the Hawaiian Islands contain the first specimens of Pogonophora to be reported from the region.

Pogonophora are benthic invertebrates of somewhat uncertain affinities, largely because they have no mouth or internal digestive system and live in vertically orientated tubes in sediments, making it difficult to determine their dorsoventral orientation. Ivanov (1963) has gathered together into the English edition of his monograph most of his extensive published work on Pogonophora, including descriptions of the many species known at that date; this forms the basic identification handbook for the group. However, this monograph was written at a time when the Pogonophora were thought to be deuterostomians. Very soon afterward, the previously unknown posterior end was discovered and found to be multisegmented, with internal septa and external bristles (Ivanov 1965, Webb 1964). Knowledge of the posterior region stimulated reconsideration of the systematic position of the group (Nørrevang 1975). It is now accepted that pogonophores should be classified among the Protostomia, and discussion continues as to their probable position among the phyla; evidence is good for some relationship to Annelida (Southward 1971a, 1980).

Transference from the Deuterostomia to the Protostomia involves a reversal of the dorsoventral orientation of the body and can make comparison of new and old species descriptions rather confusing. A discussion of phylogeny and terms appropriate in the Pogonophora is to be found in George and Southward (1973). In this paper the side of the body now considered ventral [=dorsal, Ivanov (1963)] is referred to as the *neural side*, since the main nerve trunk runs along this side; here, one finds the longitudinal ciliated band or bands (Figure 1B, F, G). The side now considered to be dorsal [=ventral, Ivanov (1963)] is here termed *antineural or tentacular*; the tentacles are attached to this side, and it also bears most of the papillae.

The adult body regions were named by Ivanov on the basis of his concept of three embryonic segments giving rise to proto-soma, mesosoma, and metasoma. After the discovery of the multisegmented posterior end of the adult, the fate of the embryonic segments had to be reconsidered, and various combinations of names have since been used for the body regions. There is, however, a simple terminology, which does not imply a particular embryonic origin, and which has been used by Ivanov in parallel with his proto-, meso-, and metasoma terminology. The short, muscular anterior region of the body is called the *forepart*, the very long middle region is called the *trunk*, and the short, segmented posterior region is called the *opisthosoma*. This terminology is also used here.

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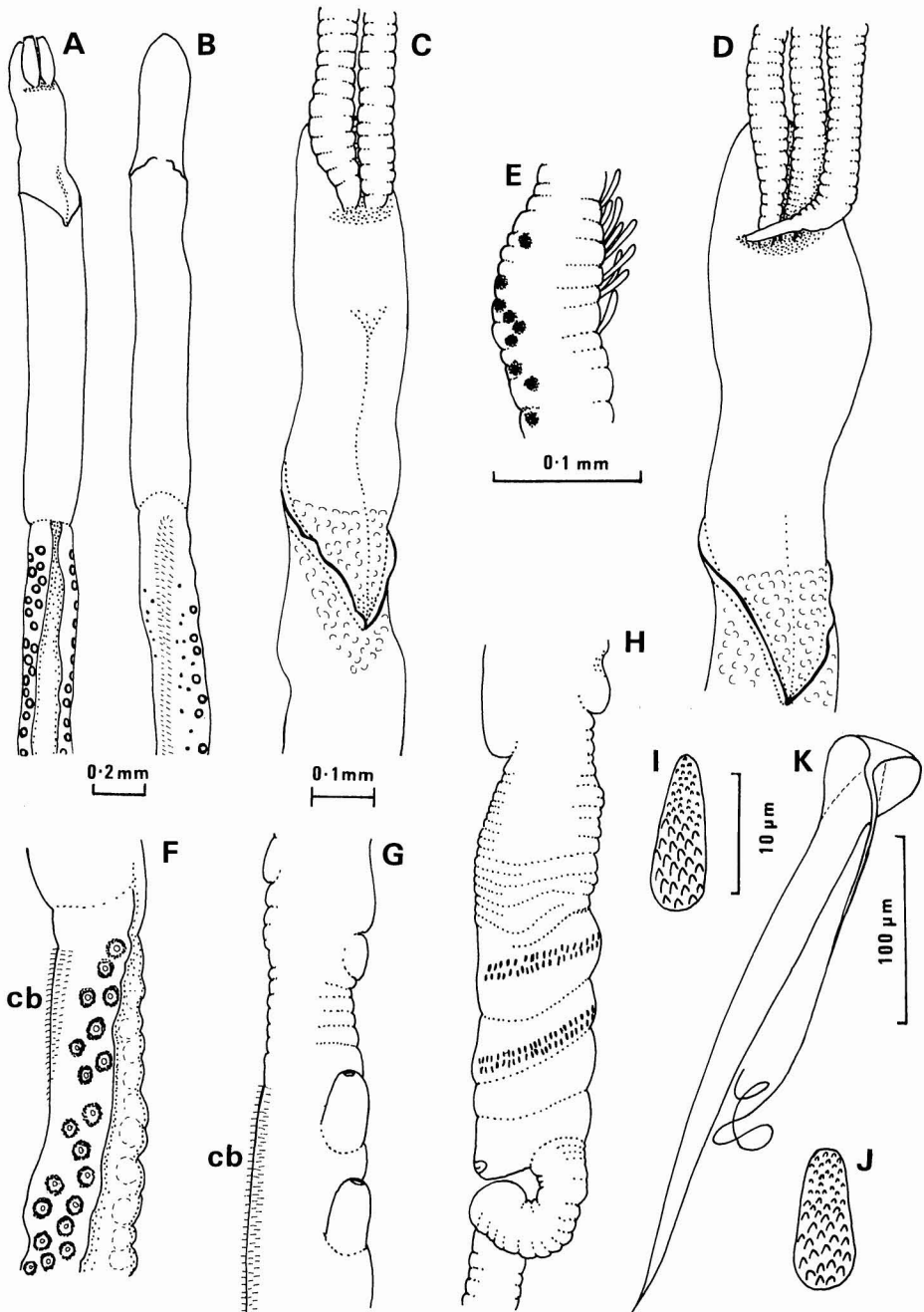


FIGURE 1. *Oligobrachia hawaiiensis* sp. nov. *A*, forepart and anterior region of trunk, tentacular (dorsal) side; *B*, forepart and anterior region of trunk, neural (ventral) side; *C*, anterior end of forepart with two tentacle bases and bridle; *D*, anterior end of forepart with three tentacle bases and bridle; *E*, part of tentacle, showing pigment spots and pinnules; *F*, junction of forepart and trunk, lateral view; *G*, anterior end of zone of enlarged papillae, lateral view; *H*, girdle region, lateral view; *I*, *J*, heads of setae; *K*, spermatophore with part of filament. cb, ciliated band.

TABLE 1  
STATION DATA

STATION NUMBER	DATE	POSITION	DEPTH (m)	SEDIMENT
89	30 August 1971	10 mi south of Honolulu Harbor 21°09.2' N, 157°56.3' W	540	Gray clay
90	3 September 1971	Southeast of Diamond Head, Oahu 21°06.7' N, 157°53.5' W	560	Fine sand
91	3 September 1971	Kaiwi Channel, 9 mi southeast of Diamond Head 21°07.6' N, 157°44.0' W	595	Clay
97	4 September 1971	1 mi west of Lanai Island 20°48.6' N, 157°01.9' W	275	Red mud/clay

NOTE: Although the cruise report indicated that Pogonophora tubes were in the dredge haul from Sta. 100 [2 mi south of Kaupo Gap, Maui, 20°34.1' N, 156°09.4' W, depth 500 fm (915 m), bottom black mud some small rocks and sand], no samples have been available.

## MATERIAL

Samples were taken by pipe dredge in depths of 275–595 m near Oahu and Lanai islands by scientific staff aboard R. V. *Proteus* (Table 1). Three species of pogonophores occur in the samples. The two to be described belong to the genera *Oligobrachia* and *Siboglinum*. The third is represented by a single empty tube from Sta. 97.

## FAMILY OLIGOBRACHIIDAE

GENUS *Oligobrachia* Ivanov*Oligobrachia hawaiiensis* sp. nov.

MATERIAL: Sta. 89, tube fragment; Sta. 90, 4 adults, 1 juvenile; Sta. 91, 2 adults, 3 juveniles; Sta. 97, tube fragments.

TYPE MATERIAL: Holotype from Sta. 90 (catalog no. T1), one paratype from Sta. 90 (catalog no. T2), and two paratypes from Sta. 91 are deposited in the Bernice P. Bishop Museum (BPBM). Three paratypes from Sta. 90 are deposited in the British Museum (Natural History) London [BM (NH) ZK 1980:1–4].

DISTRIBUTION: Living animals from 560 and 595 m depth, empty tubes from 275 and 540 m.

NAME: The specific name *hawaiiensis* records the locality where this new species has been found.

DESCRIPTION: This is a fairly small pogonophore in a black or gray-brown tube, 0.26–0.37 mm diameter, which looks like a coarse hair or fine bristle. The animal is about 0.2 mm in diameter, several centimeters long, and brownish in color. Red blood should be visible in fresh specimens. The forepart of the body is a cylindrical muscular region with a short, pointed, cephalic lobe (Figure 1A, B). The tentacles emerge from a slight groove (Figure 1C, D). There are two or three tentacles, with a line of small reddish-brown dots along one side and a row of pinnules along the other (Figure 1E). Behind the tentacle bases the forepart is fairly smooth, with a shallow median groove on the tentacular side (Figure 1C). The bridle is composed of two oblique ridges carrying dark-brown cuticular keels that fuse together in a point on the tentacular side. On the neural side, the keels are separate (Figure 1B). In some specimens there are indistinct patches of glandular epidermis in front of and behind the bridle (Figure 1C, D), but there is no white ring, such as occurs in some species of *Oligobrachia*.

The trunk is separated from the forepart by a shallow groove (Figure 1A, B, F). The anterior part of the trunk bears two wide lateral ridges separated by a median furrow. The ridges contain irregular double rows of pyriform glands with ducts that are surrounded by dark brown rings in generally opaque, brownish epidermis (Figure 1A, F).

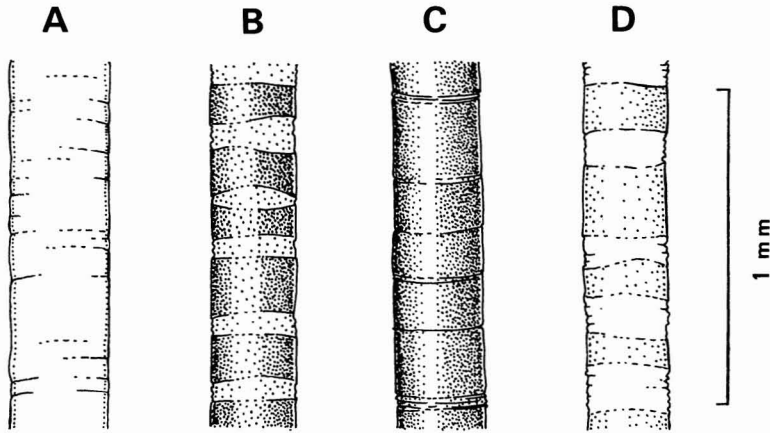


FIGURE 2. *Oligobrachia hawaiiensis* sp. nov. A, anterior region of tube; B, ringed part of tube near anterior end; C, black middle region of tube; D, pale ringed posterior part of tube.

The ciliated band on the neural side is flanked by some small reddish-brown spots (Figure 1B). The lateral ridges extend for several millimeters, forming the so-called "metameric" region. The following part of the trunk is fairly smooth, with small, irregularly arranged papillae, and ends with a zone of enlarged papillae (Figure 1G). About eight large papillae are crowded together on the antineural side and there is a ciliated band on the neural side. Shortly after this are the girdles of toothed setae (Figure 1H). There are two girdles, each containing two or three rows of setae. The heads of the setae are elongated ovals 10–14  $\mu\text{m}$  long with two groups of teeth. The posterior teeth are fairly large, but the anterior teeth are extremely small and seem to point upward rather than backward (Figure 1I, J). The postannular region is missing from most specimens, and the few fragments available are in poor condition. There seem to be single large papillae at intervals. The opisthosoma has not been found.

One animal is a mature female brooding 13 young in the anterior part of the tube. The young are 0.37 mm long and 0.15 mm in diameter. Another animal is a mature male containing spermatophores. The spermatophores are 300–340  $\mu\text{m}$  long, but not more than 18  $\mu\text{m}$  in diameter, with small folded wings on either side of the attachment of the filament (Figure 1K).

MEASUREMENTS: Forepart length 1.6–2.5 mm; forepart diameter 0.17–0.28 mm; length of anterior, "metameric" region of trunk 3–7 mm; length of preannular region of trunk at least 18 mm; total length probably at least 40 mm.

TUBE: The anterior end of the tube is colorless, limp, wrinkled, and unsegmented (Figure 2A). The first rings are brownish gray to black, separated by colorless or pale gray interspaces (Figure 2B). The middle part of the tube may be all black (Figure 2C) or have black rings and gray interspaces. It has a shiny surface. Posteriorly, the tube becomes paler, with black or gray-brown rings, and the last part is colorless, without rings. The tube wall is fairly soft, even in the middle, black region. The diameter of the tube ranges from 0.26 to 0.37 mm.

JUVENILES: The juveniles found in the same samples as the adults are smaller than the adults, have one or two tentacles, and live in colorless tubes.

COMPARISON WITH OTHER SPECIES OF *Oligobrachia*: Eight other species of *Oligobrachia* have been described (Southward 1978), five from the Atlantic and three from the Pacific. In size, tube, and general appearance *O. hawaiiensis* is closest to *O. gracilis* Southward, from the northeast Atlantic. *Oligobrachia hawaiiensis* is distinguished

from *O. gracilis* by its lack of a white ring behind the bridle, lack of black stripes on the anterior part of the trunk, smaller spermatophores, smaller teeth on the anterior ends of the setae, and softer tube wall. The three species of *Oligobrachia* already known from the Pacific are *O. dogieli* Ivanov (Ivanov 1963), *O. kernohanae* Batham (1973), and *O. mashikoi* Imajima (1973). All have larger tubes (diameter 0.5–1.0 mm) than *O. hawaiiensis*, and the tubes have brown, rather than black rings.

#### FAMILY SIBOGLINIDAE

#### GENUS *Siboglinum* CAULLERY

#### *Siboglinum ordinatum* sp. nov.

**MATERIAL:** Sta. 89, 1 animal; Sta. 90, 150 animals; Sta. 91, 12 animals; Sta. 97, 3 animals.

**TYPE MATERIAL:** Holotype and four paratypes from Sta. 90 (catalog nos. T3, T4) are deposited in the Bernice P. Bishop Museum (BPBM). Four paratypes from Sta. 90 are deposited in the British Museum (Natural History) London [BM (NH) ZX 1980:5–8].

**DISTRIBUTION:** Living animals occur from 275 to 595 m depth.

**NAME:** The specific name *ordinatum*, from the Latin, meaning “orderly,” describes the neatly arranged rings of the tube.

**DESCRIPTION:** This is a small species of *Siboglinum* with a segmented, brown-ringed tube about 0.12 mm in diameter. The animal has a cylindrical forepart, without marked grooves (Figure 3A, B). The moderately long cephalic lobe is rounded at the tip. The single, thick tentacle has two rows of pinules that are up to 90  $\mu$ m long. The base of the tentacle emerges from a shallow groove (Figure 3A). The bridle keels are colorless or pale yellow; they fuse together on the tentacular side (Figure 3A, C) and touch without fusing on the neural side of the forepart (Figure 3B, D). A slight external groove separates the forepart from the trunk. The

anterior part of the trunk has two rows of 35–38 pyriform glands, the first few in lateral ridges (Figure 3A) and the rest in separate papillae. Behind the two rows of papillae (or “metameric” region) the trunk is smooth and has only a few small papillae and glands. There is no zone of enlarged papillae. The three girdles are arranged with the first two close together and the third 0.5–1.7 mm further back (Figure 3E). The toothed setae are in single rows and have rather elongated heads carrying two groups of teeth separated by a slight “waist” (Figure 3F). The heads are 12–14  $\mu$ m long. The postannular region is usually difficult to see clearly, and the arrangement of papillae is indistinct. The opisthosoma has not been found.

Spermatophores from four males have been examined; they are spindle-shaped, slender, and pointed at both ends (Figure 3G), 120–150  $\mu$ m long, and 14–19  $\mu$ m in diameter.

**MEASUREMENTS:** Length of forepart 0.51–0.72 mm; diameter of forepart 0.07–0.095 mm; length of preannular part of trunk 5–23 mm; length of “metameric” region of trunk about 2 mm.

**TUBE:** The anterior end of the tube is colorless and segmented (Figure 3H), but after a few segments narrow yellow-brown rings appear—usually 6 or 7 per segment, but sometimes 5 or 8 (Figure 3I). The middle part of the tube is not segmented and its rings are wider and darker than in the anterior region; they are very evenly arranged (Figure 3J). Toward the posterior end, the rings appear to be double, with light-colored centers (Figure 3K). In some tubes, the rings are blotchy (as in Figure 3M), and in others, they have small light patches that look like holes (Figure 3L). The diameter of the tube ranges from 0.11 to 0.13 mm, and the length of the segments is about three times the tube diameter.

**COMPARISON WITH OTHER SPECIES:** *Siboglinum* is the largest genus of Pogonophora, with more than 60 species, but these can be grouped to some extent according to morphology and tube characters. One of the most obvious subdivisions of the genus is the

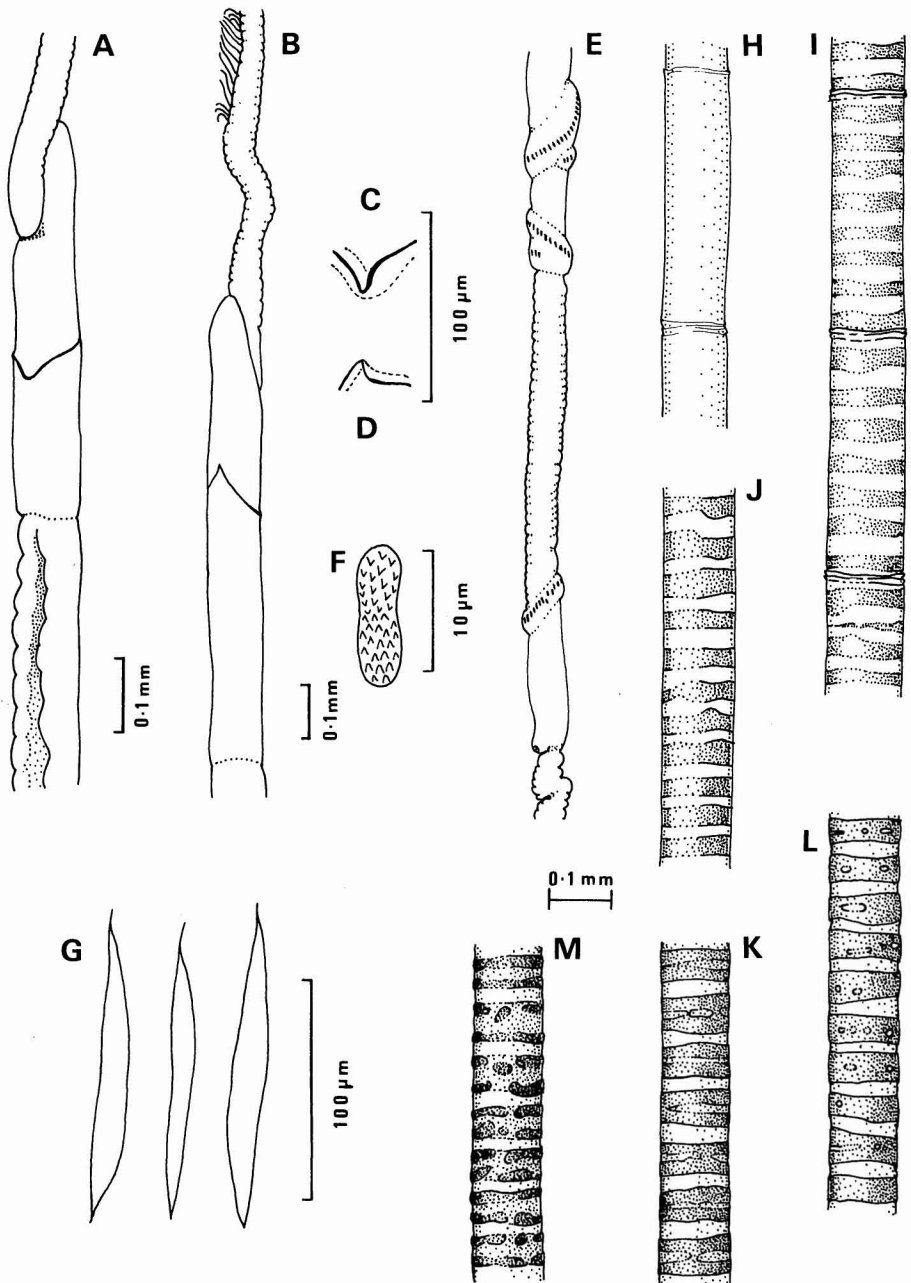


FIGURE 3. *Siboglinum ordinatum* sp. nov. *A*, forepart and anterior region of trunk, tentacular (dorsal) side; *B*, forepart and tentacle, neural (ventral) side; *C*, *D*, points of bridle, dorsal and ventral views; *E*, girdle region of young animal with girdles fairly close together; *F*, head of seta; *G*, spermatophores without filaments; *H*, anterior unringed region of tube; *I*, segmented and ringed region near anterior end of tube; *J*, simple rings from middle of tube; *K*, double rings; *L*, rings with "holes"; *M*, "blotchy" rings.

*ekmani* group of species similar to *Siboglinum ekmani* Jägersten. *Siboglinum ordinatum* belongs to this group. All the species have segmented, narrow tubes, not much more than 0.16 mm in diameter, with yellow-brown to red-brown rings. The animals have tentacles with two rows of pinules; the forepart is undistinguished; there are no cuticular plaques on the "metameric" region; and the girdles are usually three in number, the first two close together and the third some distance further back. Small differences separate the species from one another. *Siboglinum ekmani*, from the European side of the Atlantic, has about 6 or 7 rings per tube segment, like *S. ordinatum*, but its tube is a little wider (diameter 0.12–0.16 mm) and the rings are all simple rather than double. The animal is also a little larger, with the forepart 0.75–1.05 mm long; and it has darker yellow bridle keels separated on the neural side (Ivanov 1963, Jägersten 1956, Southward and Southward 1958). The slender spermatophores of *S. ekmani* are about 150  $\mu\text{m}$  long and are very similar to those of *S. ordinatum*. *Siboglinum bayeri* Southward 1971a is another Atlantic species with simple rings on the tube.

Two Indonesian species of *Siboglinum* clearly belong to the *ekmani* group: *S. sumatrense* Ivanov 1963 has shorter tube segments than *S. ordinatum*, with 7 narrow rings. The rings of the middle part of the tube are more elaborate and closer together than those of *S. ordinatum*, but they are double. The tube diameter is 0.135 mm. The forepart of the single specimen is 0.97 mm long, which is longer than in *S. ordinatum*, and the bridle keels are separate on both sides. Only two girdles are reported for *S. sumatrense*, but since only one specimen was available, a third girdle might have been overlooked. Spermatophores were not found. The second Indonesian species, *S. macrobrachium* Southward 1961, has the same tube diameter, the same number of rings per segment, and double rings similar to *S. ordinatum*. The tentacle is equally thick in both species, but the forepart of *S. macrobrachium* is somewhat longer (0.6–1.1 mm), and the bridle lies further forward. The chief dis-

tingtion between the species lies in the spermatophores, which are unusually stout in *S. macrobrachium*, being 25–30  $\mu\text{m}$  in diameter for a length of 120–190  $\mu\text{m}$ .

#### DISCUSSION

This new record of Pogonophora from Hawaii is especially interesting because there are no previous records from the mid-Pacific Ocean. The depth at which the specimens were collected is at the upper end of the usual range for pogonophores, which extend down to at least 9950 m. The upper limit of pogonophores seems to be determined by temperature, their maximum being about 12°C. Off Oahu and Lanai islands, where these specimens were collected at 275–595 m, the bottom temperature might be 12–13°C at the shallowest station and 5–6°C at the deepest station (Brock and Chamberlain 1968; Clark 1949). The same two species occur at both shallow and deep stations, showing some temperature tolerance; it would be interesting to know how much deeper they may occur, and whether other species are to be found in greater depths.

Pogonophores are most common on continental slopes and around large islands or groups of islands where there is a plentiful supply of organic matter to the sea floor. Their occurrence on the slopes of the relatively small Hawaiian Islands is thus somewhat unexpected, but terrestrial plant debris and coral reef production must together provide a sufficient food supply. Pogonophores are absent or rare on oceanic abyssal plains, and R. R. Hessler (personal communication) has noted that they do not occur in samples from the Pacific abyssal plain. This means that there is no nearby source of pogonophores and they must have reached Hawaii by way of stepping stones such as other islands. It seems more likely that the pogonophores would have reached Hawaii from the western Pacific than from the eastern Pacific, in view of the frequency of island groups on the western side and the abundance of pogonophore species in the western Pacific (Batham 1973; Ivanov 1957, 1962, 1963;



Southward 1961, 1975). Other, better-known groups of animals investigated in Hawaii are considered to be related to the fauna of the Indo-West Pacific region, perhaps via the Marshall Islands (Clark 1949, Fisher 1903, Kay 1967). The zoogeography of pogonophore distribution cannot be elucidated without more sampling, both around the Hawaiian Islands (in depths greater than 600 m) and around many other island groups.

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#### LITERATURE CITED

- BATHAM, E. J. 1973. *Oligobrachia kernohanae*, a new species of Pogonophora from New Zealand waters. *J. R. Soc. N. Z.* 3:15-22.
- BROCK, V. E., and T. C. CHAMBERLAIN. 1968. A geological and ecological reconnaissance off Western Oahu, Hawaii, principally by means of the research submarine "Asherah." *Pac. Sci.* 22:373-394.
- CLARK, A. H. 1949. Ophiuroidea of the Hawaiian Islands. *Bull. B. P. Bishop Mus.* 195:1-133.
- FISHER, W. K. 1903. The starfishes of the Hawaiian Islands. *Bull. U.S. Fish. Comm.* 23:987-1130.
- GEORGE, J. D., and E. C. SOUTHWARD. 1973. A comparative study of the setae of Pogonophora and polychaetous Annelida. *J. Mar. Biol. Assoc. U.K.* 53:403-424.
- IMAJIMA, M. 1973. A new species of the genus *Oligobrachia* (Pogonophora) collected from Tsukumo Bay, Noto Peninsula. *Ann. Rept. Noto Mar. Lab.* 13:7-12. (Japanese with English summary.)
- IVANOV, A. V. 1957. Neue Pogonophora aus dem nordwestlichen Teil des Stillen Ozeans. *Zool. Jahrb. Abt. Syst. Oekol. Geogr. Tiere* 85:430-500.
- . 1962. Pogonophora, their mode of life and distribution on New Zealand coasts. *Tuatara* 10:109-119.
- . 1963. Pogonophora. Academic Press, London.
- . 1965. Structure de la région postérieure sétigère du corps des pogonophores. *Cah. Biol. Mar.* 6:311-323.
- JÄGERSTEN, G. 1956. Investigations on *Siboglinum ekmani* nov. sp. encountered in the Skagerak, with some general remarks on the group Pogonophora. *Zool. Bidr. Uppsala* 31:211-252.
- KAY, E. A. 1967. The composition and relationships of marine molluscan fauna of the Hawaiian Islands. *Venus Jap. J. Malacol.* 25:94-104.
- NØRREVANG, A., ed. 1975. The phylogeny and systematic position of Pogonophora. Proceedings of a symposium held at the Zoological Central Institute, University of Copenhagen Nov. 1st-3rd, 1973. *Z. Zool. Syst. Evolutionforsch. Sond.* 1975:1-143.
- SOUTHWARD, E. C. 1961. Pogonophora. *Siboga-Expedition Mon.* 25(3):1-22.
- . 1971a. Pogonophora of the Northwest Atlantic: Nova Scotia to Florida. *Smithsonian Contr. Zool.* 88:1-29.
- . 1971b. Recent researches on the Pogonophora. *Oceanogr. Mar. Biol. Ann. Rev.* 9:193-220.
- . 1975. New Pogonophora from Indonesia. *Rec. Austral. Mus.* 29:441-452.
- . 1978. Description of a new species of *Oligobrachia* (Pogonophora) from the North Atlantic, with a survey of the Oligobrachiidae. *J. Mar. Biol. Assoc. U.K.* 58:357-365.
- . 1980. Regionation and metamerisation in Pogonophora. *Zool. Jahrb. Abt. Anat. Ontog. Tiere* 10:264-275.
- SOUTHWARD, E. C., and A. J. SOUTHWARD. 1958. Two new species of Pogonophora from the north-east Atlantic. *J. Mar. Biol. Assoc. U.K.* 38:439-444.
- WEBB, M. 1964. The posterior extremity of *Siboglinum fiordicum* (Pogonophora). *Sarsia* 15:33-36.