

— Review —

**Cephalopods Collected by the Submersibles and ROVs of Japan Agency
for Marine-Earth Science & Technology — Annotated Catalogue up to 2008 —**

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The crewed submersibles and ROVs of JAMSTEC have obtained many images of nektonic cephalopods, but they only rarely catch voucher specimens of such fast-moving animals. An inventory of JAMSTEC's cephalopod specimens collected by those vehicles yielded nineteen species including some noteworthy species.

Keywords: Cephalopoda, JAMSTEC, submersibles, ROVs, deep-sea species

Received 21 October 2009 ; Accepted 25 December 2009

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1. Introduction

Through the activities of crewed submersibles (*Shinkai-2000* and *Shinkai-6500*) and remotely operated vehicles (ROVs) of the Japan Agency for Marine-Earth Science and Technology (JAMSTEC), a considerable number of cephalopod images have been accumulated (see Fujikura *et al.*, 2008). However, because of the difficulty of capturing such swift-moving animals using submarine vehicles, voucher specimens for those video and still images have not always been captured and preserved in the JAMSTEC collection. Only some of the cephalopods for which interesting behaviors had been photographed or videotaped (*e.g.* Okutani & Lindsay, 2005; Okutani *et al.*, 2007) were successfully captured.

This paper lists cephalopod specimens collected by the crewed submersibles, such as *Shinkai-2000* and *Shinkai-6500*, and ROVs, such as the *Dolphin-3K*, *Hyper-Dolphin*, and some others, with taxonomic and ecological annotations according to species.

2. Materials and methods

2.1. Specimens

All of the cephalopod specimens treated here are preserved in 10% formalin or 70% ethanol and deposited in the zoological collection of JAMSTEC.

2.2. Format of catalogue

The 'material examined' in the forthcoming catalogue by species/specimen primarily follows the format as below: JAMSTEC registration number followed by accession number in parenthesis. DML (= dorsal mantle length for squids) or TL (= total length for octopuses), vessel-dive number, date of dive in parenthesis, latitude and longitude, depth of capture, general locality, name of participating scientist (or collector) in parenthesis followed by hydrographic data (if any, *e.g.* water temperature, salinity PSU, dissolved oxygen DO).

Some taxonomic or ecological comments are occasionally annotated under 'Remarks'.

3. Annotated Catalogue

3.1. Order SEPIIDA

Sepia sp. [Sepiidae]

Material examined: JAMSTEC-054312. DML 4.6 mm, *Hyper-Dolphin* Dive 254 (November 24, 2003), 31°39.7' N, 130°46.4' E, 204 m, Kagoshima Bay.

Remarks: For fear of destroying the sole specimen, the cuttlebone, which had been softened by the fixative, was not examined. Thus, the identification to species was impossible.

3.2. Order SEPIOLIDA

Sepiolo birostrata Sasaki, 1918

[Sepiolidae](Fig. 1A)

Material examined: JAMSTEC-032008 (2K1212SS5). DML 12.8 mm. *Shinkai 2000* Dive 1212 (August 16, 2000), 39°29.7' N, 138°47.3' E, 677 m, (406 m altitude above bottom), Japan Sea "Site C" (J. Hunt), 0.33°C, 34.06 PSU, DO 4.7 ml/L.

Remarks: The sole specimen is a male. This species is common in the shallow trawl catches from the western sector of the Japan Sea (Takayama & Okutani, 1992). The present specimen is a range extension of its distribution northwards off Akita Prefecture, and is the deepest record of its occurrence.

Heteroteuthis (Stephanoteuthis) hawaiiensis (Berry, 1909)

[Sepiolidae](Fig. 1B)

Material examined: JAMSTEC-053574 to 053578. DML 22.1-13.8 mm, *Hyper-Dolphin* Dive 188 (June 28, 2003), 26°41.3' N, 141°02.7' E, 912 m, Kaikata Seamount, Ogasawara (S. Tsuchida).

Remarks: Detailed field observations with some notes on these specimens were reported elsewhere by Okutani & Tsuchida (2005)

3.3. Order TEUTHIDA

Watasenia scintillans (Berry, 1911)

[Enoploteuthidae] (Fig. 1C)

Material examined: JAMSTEC-048288 (2K1334SS2a). DML 42.9 mm & 44.9 mm, *Shinkai 2000* Dive 1334 (April 2, 2002), 35°00.2' N, 139°13.6' E, 620 m, SE off Hatsushima Island, Sagami Bay, at 1200 in bottom depth (Y. Ohno).

JAMSTEC-054550 & -054551. DML 44.5 mm & 43.8 mm, *Hyper-Dolphin* Dive 277 (March 8, 2004), 35°00.2' N, 139°45.0' E, 360 m, off Hatsushima Island, Sagami Bay, at 1152 m in bottom depth (D. Lindsay).

JAMSTEC unregistered (HD521SS4b). DML 37.6 mm, *Hyper-Dolphin* Dive 521 (March 4, 2006), 34°59.4' N, 140° 15.5' E, 478 m, off Kamogawa, Boso Peninsula (D. Lindsay).

JAMSTEC unregistered: DML 39.3 mm. *Hyper-Dolphin* Dive 523 (March 6, 2006); 35°01.36' N, 139°21.72' E, sampling depth unknown, Sagami Bay, at 1460-1500 m in bottom depth (D. Lindsay).

Remarks: This species has occasionally been observed in swarms in Sagami Bay and Suruga Bay (see Okutani, 2008, fig. 26.2A) as well, at depths of around 400 m in daytime (D. Lindsay, personal observation).

***Onychoteuthis lacrima* Bolstad, 2008**

[Onychoteuthidae] (Fig. 1G)

Material examined: JAMSTEC-031983 (2K1201SS5). DML 67.9 mm, *Shinkai 2000* Dive 1201 (July 6, 2000), 35°00.1' N, 139°13.7' E, 1163 m, SE of Hatsushima Island, Sagami Bay (H. Miyake), 3.0°C, 34.43 PSU, DO 1.2 ml/L.

Remarks: The taxonomic status of the genus *Onychoteuthis* has been resolved by the recent revision by Bolstad (2008). The present specimen is characterized by having no chromatophores on the ventral surface, 22 (right) and 23 (left) tentacular hooks, and posterior visceral photophores about twice as large as anterior one. The present specimen is identifiable as *O. lacrima* among the *O. banksii*-complex in the Pacific. *O. lacrima* was originally established based on a specimen with a DML of 94 mm from central North Pacific. Bolstad (2008) stated that this species is distributed in "north-central Pacific waters (200-0 m), primarily 30°-45°N and 170°W to 170°E; also found off eastern Japan". No *in situ* image was taken.

***Onykia loennbergi* (Ishikawa & Wakiya, 1914).**

[Onychoteuthidae] (Fig. 1F)

Material examined: JAMSTEC unregistered (HD521SS4). DML 61 mm, *Hyper-Dolphin* Dive 521 (March 4, 2006), 34°59.4' N, 140°15.5' E, 494 m, off Kamogawa, Boso Peninsula (D. Lindsay), 6.6°C, 34.27 PSU, DO 1.9 ml/L.

Remarks: The living state of this specimen was photographed by the second author (DL) and shown in Okutani (2008, fig. 26.3). The ecological significance of downward gazing posture of this species is discussed elsewhere (Kubodera *et al.*, submitted)

***Gonatus pyros* Young, 1972 [Gonatidae] (Fig. 1D)**

Material examined: JAMSTEC-032010. DML 24.7 mm,

Shinkai-2000 Dive 1217 (September 14, 2000), 42°35.5' N, 143°158.0' E, 326 m, off east coast of Hokkaido (T. Hamatsu), 2.5°C, 33.62 PSU, DO 3.2 ml/L.

Remarks: This is an immature specimen. It grows to 16 cm DML (Okutani, 2005) The mantle hooks are still under development: A central large hook, a single distal small hook, and two proximal small hooks were already differentiated. The adult has a single middle-sized hook distal to the large central hook, and four small proximal hooks (Young, 1972). This species is unique within the genus with its possession of subocular photogenic tissue.

***Gonatopsis octopedatus* Sasaki, 1920 [Gonatidae] (Fig. 1E)**

Material examined: JAMSTEC-032003 (2K1207SS6 A). DML 60.9 mm, *Shinkai 2000* Dive 1207 (August 10, 2000), 37°03.5' N, 134°42.5' E, 868 m, Japan Sea site "A" off Oki Bank (J.C.Hunt), 0.23°C, 33.92 PSU.

JAMSTEC-031998 (2K1212SS6 B). DML 55.7 mm, *Shinkai 2000* Dive 1212 (August 16, 2000), 39°29.7' N, 138°47.4' E, 1029 m (70 m altitude above bottom), Japan Sea site "C" off Akita Prefecture (J.C. Hunt), 0.24°C, 34.06 PSU, DO 4.7 ml/L.

Remarks: *Gonatopsis octopedatus* was originally described by Sasaki (1920) based on a single specimen (DML 65 mm) from *Albatross* St. 332918 near Cape Patience, Sakhalin, in 440 fathoms (= 792 m). Since then, Akimushkin (1963) reported this species from the Northwest Pacific waters off Hokkaido and the Sea of Okhotsk. Subsequently, Okiyama (1970) gave a full description based on a single specimen (DML 99+ mm) from a depth of 810 m off Niigata, the Japan Sea. No essential addition is needed to bolster the descriptions by Sasaki (1920, 1929) and Okiyama (1970).

By summarizing the previous distribution data by Sasaki (1920), Akimushkin (1963), Okiyama (1970), and Nesis (1973), Nesis (1987) defined the distribution range of this species as from the "northern slope of the Bering Sea to the Sea of Okhotsk, Sea of Japan, NE Honshu, and the Gulf of Alaska. Mesopelagic, bathypelagic, and lower bathyal" probably incorporating his unpublished data. Okiyama (1970) stated that "the rather bizarre, very long, tapering and crooking distally shape of arms in the present species reminds us of a condition in octopods rather than in decapods" assuming that *G. octopedatus* may live closely associated with the ocean bottom, such as standing or crawling by using its curled arms. However, the underwater observations did not prove such a bottom-associated behavior for this squid (Hunt, personal communication; Okutani, 2008). Also, neither of the two

specimens have crooked arm tips which are very slenderly attenuated. It is not clear at present if Okiyama's specimen was a different phase or growth stage from those of the present specimens.

***Octopoteuthis cf. sicula* Rüppell, 1844**

[Octopoteuthidae] (Fig. 2A)

Material examined: JAMSTEC-02419 (2K1023SS5). DML178 mm, *Shinkai-2000* Dive 1023 (June 27, 1998), 28°26.5' N, 130°19.5' E, 1110 m, off Amami-Oshima Island, Nansei Islands (J.C.Hunt).

Remarks: The taxonomy of the genus *Octopoteuthis* has not yet been well resolved. Therefore, the identification of the present specimen is more or less tentative.

The mantle is soft, rather gelatinous, dark purplish in color and ornamented by longitudinal, discontinuous wrinkles, which are particularly apparent on the anterior ventral side. Near the posterior end of the mantle is a pair of bumps, which indicate the presence of embedded photophores. Fins reach to the posterior end of the short tail, and both lobes are united with each other with a deep V-shaped sinus in mid front. The anterior end of the fin margin does not reach to the mantle margin. According to Adam (1952), the fin length of *O. siculus* attains 90% and width 115% of DML, respectively. Compared with that data, the present specimen has smaller fins. (maybe due to shrinkage by fixation?) Left Arms I and III are mutilated at about the middle of the length, and near the base, respectively. Only the left Arm I bears a regenerated filamentous appendage at the truncated tip. Neither an aboral keel nor protective membrane are developed. All arms (except mutilated arms) are equipped with a zigzag row of hooded hooks over almost the entire length of the oral surface, and large hooks bear a pair of small spikes on the proximal margin. The extreme tips of all arms end in a black, slender fusiform photophore. Nesis (1987) emphasized that *O. siculus* has photogenic organs on the bases of the Arms III and IV, but they are not apparent in the present specimen.

The specimen was reported to be found floating dead in midwater, therefore, the depth cited above does not indicate the exact depth of habitat but rather that to which it had sunken.

Measurements: DML 178 mm, mantle width at aperture 47 mm, fin length 127 mm, fin width 120 mm, head length 55 mm, head width 47 mm, right Arm I length 55+ mm, right Arm II length 147 mm, right Arm III length 155 mm, right Arm IV length 123 mm.

***Histioteuthis hoylei* (Goodrich, 1896) [Histioteuthidae]**

Material examined: JAMSTEC-048425 (HD107SS1c). DML 80 mm, *Hyper-Dolphin* Dive 107 (May 3, 2002), 36°39.6' N, 142°06.0' E, 439 m, off Sanriku Coast (D. Lindsay), 3.1°C, 33.82 PSU, DO 2.2 ml/L.

Remarks: This is a cosmopolitan species growing up to 20 cm DML and has long been universally called *H. dofleini*. The present specimen was captured in the Japan Trench. It is considered that a large stock of this species exists in the sea off northeastern Honshu, as it is quite frequent and abundant in the diet of sperm whales (*e.g.* Okutani *et al.*, 1976).

***Chtenopteryx siculus* (Verany, 1851)**

[Chtenopterygiidae] (Fig. 1I)

Material examined: JAMSTEC unregistered (HD521SS5). DML 18.6 mm, *Hyper-Dolphin* Dive 521 (March 4, 2006), 34° 59.4' N, 140° 15.5' E, 489 m, off Kamogawa, Boso Peninsula (D. Lindsay), 6.3°C, 34.27 PSU, DO 1.8 ml/L.

Remarks: This species was collected near a swarm of *Watasenia scintillans* (D. Lindsay, personal observation). The first observation on swimming behavior of this specimen *in situ* has already been well documented (Okutani *et al.*, 2007).

***Chiroteuthis picteti* Joubin, 1894 [Chiroteuthidae] (Fig. 1H)**

Material examined: JAMSTEC-024172 (2K1139GS1). DML 62.5 mm, *Shinkai-2000* Dive 1139 (October 3, 1999), 35°00.5' N, 139°20.0' E, 1447 m, Sagami Trough (J.C. Hunt).

Remarks: The present specimen is a young stage, in which the neck is still elongated as characteristic of a *Doratopsis*-paralarva. The tentacle club of this specimen has neither sucker-less portion nor lunate flaps, thus this specimen is identifiable to be *C. picteti* (= *C. imperator*) although light organs on tentacle stem and Arm IV are still immature.

***Liocranchia reinhardti* (Steenstrup, 1856)**

[Cranchiidae] (Fig. 2D)

Material examined: JAMSTEC-018425 (2K950SS4). DML 146 mm, *Shinaki-2000* Dive 950 (June 9, 1997), 28°34.1' N, 140°38.7' E, 943 m, Suiyo Seamount (D. Lindsay), 4.2°C, 34.25 PSU, DO 1.4 ml/L.

Remarks: A brief observation on the living specimen in an onboard aquarium immediately after it had been captured was made by the junior author (DL): "The mantle of this animal was damaged with a hole in it from which one the gills sometimes was drawn out into the surrounding water when the mantle contracted. The edges of the hole had soon healed and

were slightly whitish. In the aquarium the specimen readily ate small fish that were fed to it by tying the fish to a piece of wire and prodding the beak or proximal portion of the arms. While latched on the animal was forcibly rotated and the large photophores below the eye continued to point downwards regardless of the angle of the squid's body. During such rotation the eyes reached their limit of rotatability and they rapidly rotated 360° in the opposite direction until they again pointed downwards. "

***Teuthowenia aff. megalops* (Prosch, 1847)**

[Cranchiidae] (Fig. 2B)

Material examined: JAMSTEC-031997. DML 176 mm, *Shinkai 2000* Dive 1217 (September 14, 2000), 42°35.5' N, 143°58.0' E, 326 m, Southwest off Kushiro, Hokkaido (T. Hamatsu).

JAMSTEC-048420 (HD101SS1c). DML 142 mm, *Hyper-Dolphin* Dive 101 (April 26, 2002), 40°25.9' N, 144°31.6' E, 1118 m, the Japan Trench (D. Lindsay), 2.9°C, 34.28 PSU, DO 0.6 ml/L.

Remarks: The underwater observation of the second specimen *in situ* has already been reported elsewhere (Okutani & Lindsay, 2005). The identification of the present specimen is yet inconclusive. Particularly, the configuration of photogenic tissues on the eyeball may not be identical to that of North Atlantic *T. megalops*.

***Belonella belone* (Chun, 1906)** [Cranchiidae] (Fig. 2C)

Material examined: JAMSTEC-024175 (6K468SS4). DML 116 mm, *Shinkai 6500* Dive 468 (November 16, 1998), 29°43.4' N, 59°04.0' E, 886 m, southwest Indian Ocean (D. Lindsay), 7.2°C, 34.52 PSU, DO 4.7 ml/L.

Remarks: This is a very slender animal, DML is 11 times longer than wide (10.1 mm). N. Voss (1980) synonymised *Belonella* Lane, 1957, which was a substitute name for *Toxeuma* Chun, 1906, with *Taonius* Steenstrup, 1861. However, Nesis (1972, 1982) considered that true *Taonius* contains a single species, *T. pavo* (Lesueur, 1821), and *T. pavo* auct., non Lesueur comprised two species of *Belonella*, namely, *B. belone* (Chun, 1906) in the tropical Indo-Pacific and Atlantic, and *B. borealis* Nesis, 1972 in boreal Pacific Ocean and its marginal seas. Nesis (1974) recognized one more species from the Antarctic, but never named it.

3.4. Order VAMPYROMORPHA

***Vampyroteuthis infernalis* Chun, 1903** [Vampyroteuthidae]

Material examined: JAMSTEC unregistered (HD83SS1). TL 60 mm, *Hyper-Dolphin* Dive 83 (March 9, 2002), 31°29.1' N, 140°09.3' E, 884 m, Sumisu (Smith) Caldera, Izu-Ogasawara Islands (D. Lindsay), 4.7°C, 34.32 PSU, DO 1.45 ml/L.

Remarks: The photograph in living state of this specimen in the aquarium was taken by the second author (DL) (see Okutani 2008, fig. 26.15). The body color in the living animal is brownish, and the eyes are blue under the lights of the ROV. But, the body is velvety black and eyes are red the in preserved animal as was illustrated by Chun (1915). Bioluminescence was observed in both the posterior photophores and the arm tips. Besides this specimen, two images (without voucher specimens) have been taken by JAMSTEC submersibles: *Kaiko* Dive 113 (April 20, 1999) 40°06.8' N, 144°10.2' E, 976 m, and *Hyper-Dolphin* Dive 99 (April 23, 2004) 41°00.3' N, 144°41.5' E, 1158 m (Bower *et al.*, 2006).

3.5. Order OCTOPODA

***Amphitretus pelagicus* Hoyle, 1888** [Amphitretidae] (Fig. 2E)

Material examined: JAMSTEC-048772 (HD80GS1b). TL approx. 13 cm, *Hyper-Dolphin* Dive 80 (March 5, 2002), 34°01.6' N, 138°12.0' E, 817 m, Nankai Trough (D. Lindsay).

Remarks: The living state of this specimen was photographed by the junior author (DL) in an aquarium on board the support vessel (Okutani, 2008, fig. 26.24). It turned orange in body color when agitated.

Benthoctopus sp. a [Octopodidae] (Fig. 2G)

Material examined: JAMSTEC unregistered. TL approx. 15 cm, *Shinkai-2000* Dive 418 (July 7, 1989), 27°16.0' N, 127°05.0' E, 1538 m, Izena Hole, Okinawa (M. Kimura).

Remarks: The living state of this specimen was photographed by M. Kimura and shown in Okutani (2008, fig. 26.29)

Benthoctopus sp. b [Octopodidae] (Fig. 2F)

Material examined: JAMSTEC-058309. TL 30 cm, *Shinkai-6500* Dive 418 (June 14, 2005), 33°15.8' N, 136°43.0' E, 2049 m, Nankai Trough (T. Okutani).

Remarks: The fresh state of this specimen (♀) was photographed by Y. Fujiwara and shown in Okutani (2008, fig. 26.31)

4. Additional Remarks

The crewed submersibles (*Shinkai-2000* and *Shinkai-6500*) and ROVs of JAMSTEC frequently encounter cephalopods during dives either above the ocean floor or in the midwater layers. However, such fast-moving animals, particularly nektonic squids, or large specimens have hardly ever been captured successfully.

The large cephalopods, such as *Gonatopsis* seen in Sagami Bay (Miyake *et al.*, 2005), *Magnapinna* (Vecchione *et al.*, 2001), and several cirrate octopods (*e.g.* Okutani & Fujioka, 2005) were photographed or videotaped, but they were all uncatchable objects because of their size.

Common species, such as *Todarodes pacificus*, are frequently encountered during various dives, particularly along the Sanriku Coast, but they are seldom photographed or captured because of the swift movement of the animals.

Images of thirty species of cephalopods appeared in Okutani (2008), voucher specimens of only 19 species were preserved in the JAMSTEC collection and presented here. On the contrary, no living images of seven of the species treated in this catalogue are available.

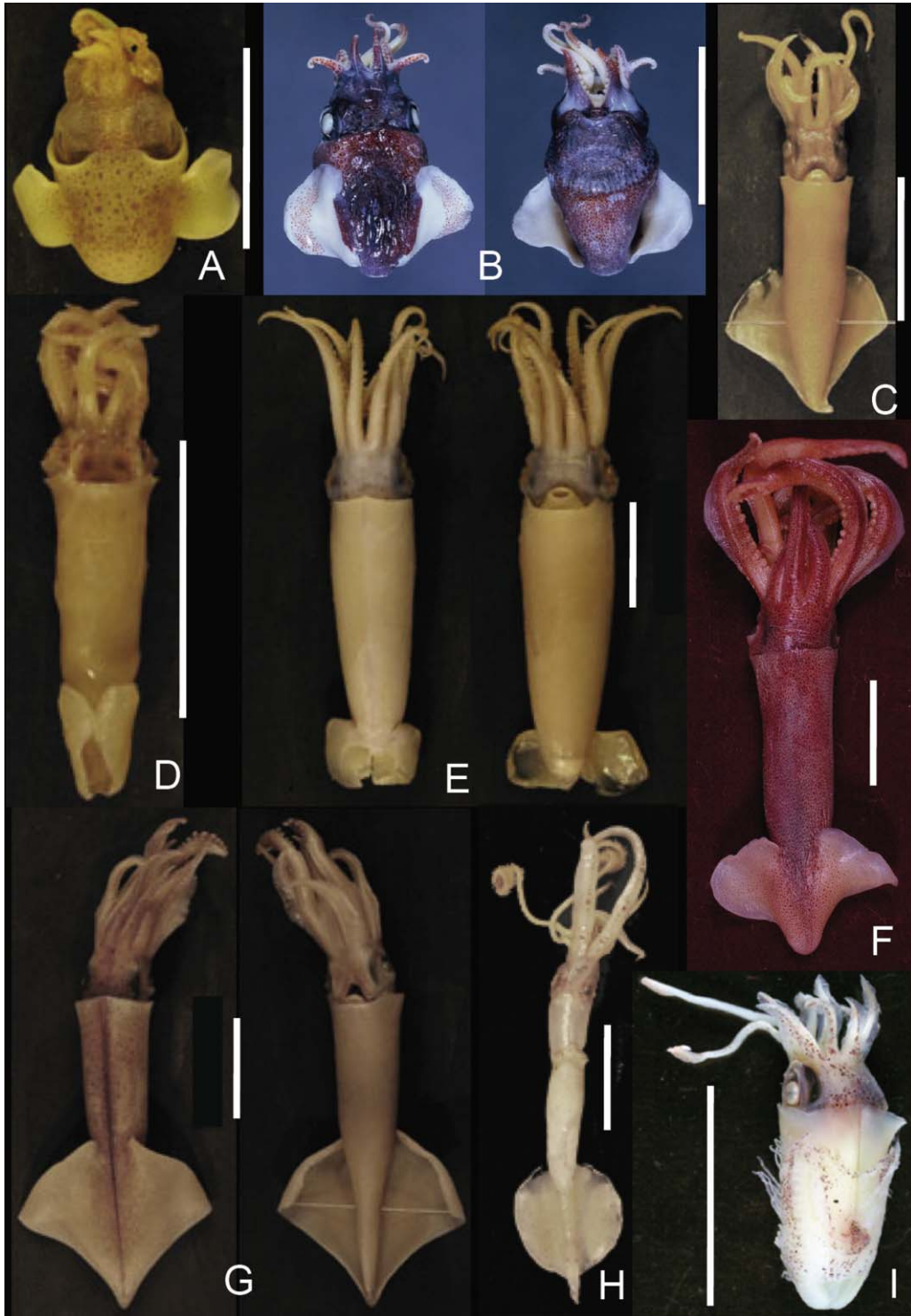


Fig. 1. Sepioida and Teuthida (Scale 20 mm; 2K = *Shinkai 2000*; HD = ROV *Hyper-Dolphin*)

- A. *Sepioida birostrata* (2K #1212: Japan Sea)
- B. *Heteroteuthis hawaiiensis* (HD #188: Kaikata Seamount) (After Okutani & Tsuchida, 2005)
- C. *Watasenia scintillans* (2K #1334: Sagami Bay)
- D. *Gonatus pyros* (2K #1217: Off Hokkaido)
- E. *Gonatopsis octopedatus* (2K #1207: Japan Sea)
- F. *Onykia loennbergi* (HD #521: Off Boso Peninsula) (After Okutani, 2008)
- G. *Onychoteuthis lacrima* (2K #1201: Sagami Bay)
- H. *Chiroteuthis picteti* (2K #1139: Sagami Bay)
- I. *Chtenopteryx siculus* (HD #521: Off Boso Peninsula) (After Okutani *et al.*, 2007)

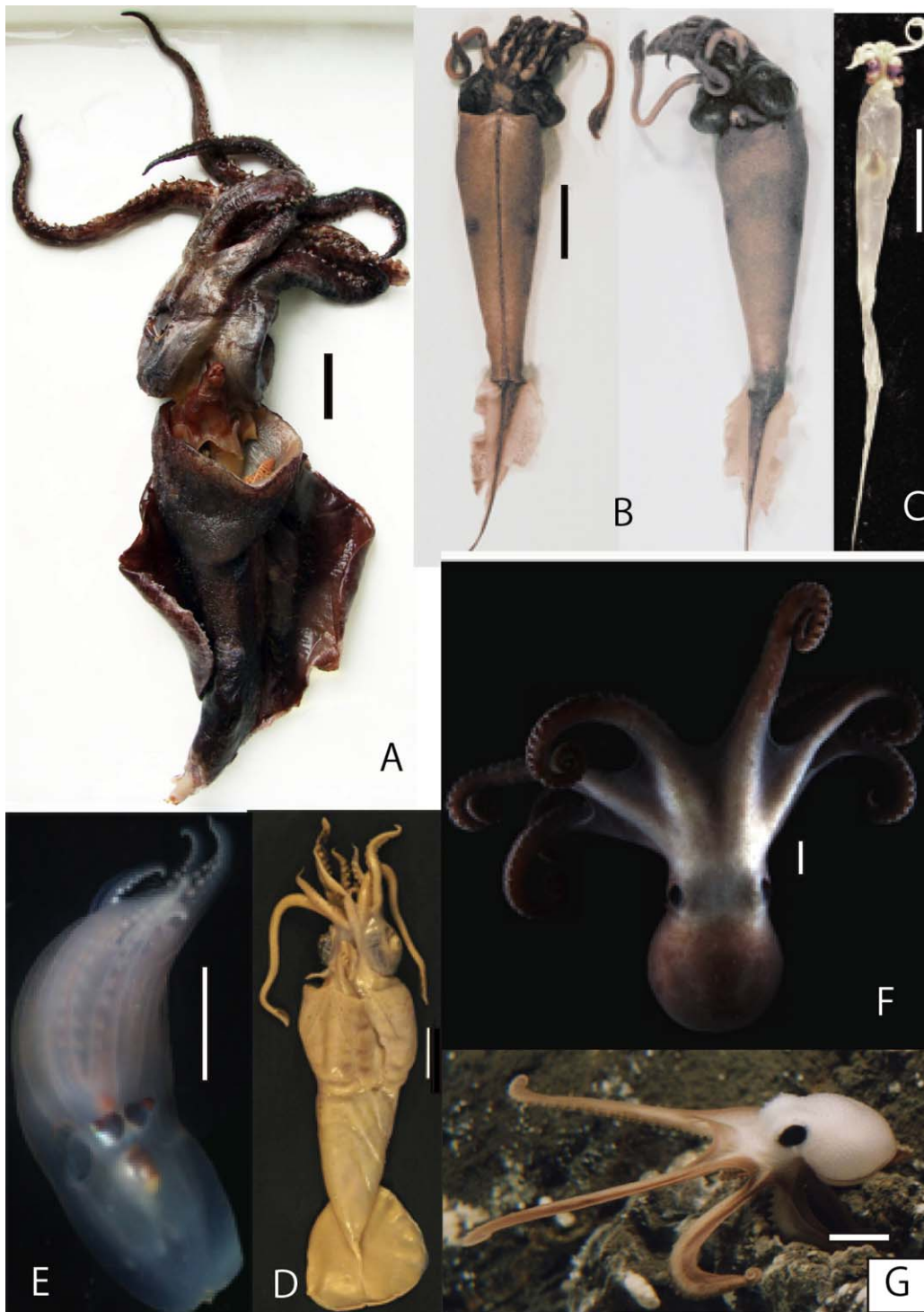


Fig. 2. Teuthida and Octopoda (Scale 20 mm; 2K = *Shinkai 2000*; 6K = *Shinkai 6500*; HD = ROV *Hyper-Dolphin*)
 A. *Octopoteuthis* cf. *sicula* (2K #1023: Off Amami-Oshima Island)
 B. *Teuthowenia* aff. *megalops* (2K #1217: Off Hokkaido).
 C. *Belonella belone* (6K #468: SW Indian Ocean).
 D. *Liocranchia reinhardi* (2K #950: Suiyo Seamount)
 E. *Amphitretus pelagicus* (HD #80: Nankai Trough)
 F. *Benthoctopus* sp. β (6K #418: Nankai Trough)
 G. *Benthoctopus* sp. α (2K #418: Izena Hole, Okinawa)

Acknowledgements

We are indebted to Dr. James C. Hunt, Dr. Hiroshi Miyake and the other past and present colleagues of JAMSTEC for their efforts in collecting mid-water and bottom-living cephalopods. Their successes were all supported by the skills and cooperation of the operations teams of *Shinkai-2000* and *Shinkai-6500*, and ROVs, and crew of the supporting vessels, R/Vs *Natsushima*, *Yokosuka* and *Kaiyo* of JAMSTEC.

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