Plankton Biol. Ecol. 46 (1): 75-87, 1999

plankton
biology & ecology

Methodology for creating an observational database of midwater fauna using submersibles: Results from Sagami Bay, Japan

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Received 1 May 1998; accepted 21 December 1998

Abstract: The meso- and benthopelagic faunas of Sagami Bay, Japan, were examined using 8 submersible dives over a one month period in May-June, 1997. An observational database containing 3041 records was created using a methodology which conservatively identified each animal observed to the most precise taxon possible. This database was used to elicit information on 75 discrete taxa. Thirteen species were new reports from Japanese waters, including 2 siphonophores, 6 medusae, 4 ctenophores, and 1 appendicularian. A review of relevant literature suggested more precise identification for some taxa. The utility of creating this kind of database was demonstrated through examples regarding trophic ecology, life history, and the effects of the type of submersible used to study pelagic species. Notes on the behavior of some specimens and a complete taxa list are presented.

Key words: midwater, submersible, Sagami Bay, methodology, gelatinous

Introduction

The study of the ecology of pelagic communities has been greatly enhanced by using submersibles. However, dive time is expensive and limited. Accordingly, many submersible studies have reported on single species (often including descriptions of new species) or taxa (see list in Hunt et al. 1997). Efforts have been made to look systematically at broader taxonomic levels using submersibles (Larson et al. 1989, 1991; Mills et al. 1996; Hunt 1996; Toyokawa et al. 1998), and at the benthopelagic subset (Childress et al. 1989; Larson et al. 1992; Lindsay et al. 1999), while a few studies have attempted to explore the entire pelagic assemblage of animals (Mackie & Mills 1983; Mackie 1985; Robison 1995). One difficulty with submersible research has been the collection of sufficient data for analyses. Steady progress has been made in methods of specimen collection (Youngbluth 1984; Robison 1993). Specimens collected in relatively healthy condition have offered insight into structural details as well as behavioral aspects such as the use of bioluminescence in the deep sea (Widder et al. 1989), trophic behavior (Larson et al. 1989), and habitat selection (Steinberg et al. 1994). Yet information about in situ ecology comes primarily from analyses of videotaped and live observations from submersibles. Given the expense and logistical difficulties associated with submersible research, effort should be made to extract the most information possible from all dives. To this end, consistent methodology needs to be developed.

The Sagami Bay, Japan, is circumscribed by the Izu Peninsula to the west and the Miura Peninsula to the east. Located south of Tokyo Bay, it is important for commercial, recreational, and ecological reasons. Little work has been published describing the midwater fauna from the bay as observed from submersibles (see Toyokawa et al. 1998; Lindsay et al. 1999). This paper presents a method of analyzing videotapes from pelagic dives in a systematic way in order to obtain as much information as possible from each submersible dive. Additionally, the results of this work provide further information on the pelagic ecology of Sagami Bay.

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Methodology

Submersible data collection

Data were collected from eight dives in Sagami Bay during May-June 1997. Seven dives were made with the remotely operated vehicle (ROV) *Dolphin 3K* while one dive was conducted using the crewed submersible *Shinkai 2000*.

Table 1. Summary of submersible dives used in the study.

Submersible	Dive No.	Date	Longitude	Latitude	Launch time (GMT+9 h)	Recovery time (GMT+9 h)	Bottom time (h : min)	Water column time (h : min)	Maximum Depth (m)
Dolphin 3K	321	27 May 1997	35°00.00'N	139°13.50'E	8:52	12:26	1:07	2:27	1195
Dolphin 3K	322	27 May 1997	35°00.00'N	139°13.50'E	13:50	16:46	0:00	2:56	630
Dolphin 3K	323	28 May 1997	35°00.00'N	139°14.00'E	8:50	16:01	0:00	7:11	1222
Dolphin 3K	324	29 May 1997	35°00.00'N	139°13.50'E	8:42	12:16	1:34	2:00	1177
Dolphin 3K	325	29 May 1997	35°00.00'N	139°14.00'E	13:29	16:16	1:00	1:47	1122
Dolphin 3K	326	30 May 1997	35°00.00'N	139°13.50'E	8:32	12:16	0:00	3:44	1211
Dolphin 3K	327	28 June 1997	34°59.50'N	139°19.50'E	8:00	13:59	0:00	5:54	1526
Shinkai 2000	945	21 May 1997	35°00.50'N	139°22.00'E	9:39	16:28	0:03	6:46	1450

Of the seven *Dolphin 3K* dives, six were conducted about 6 km southeast of Hatsushima Island, while one dive was conducted towards the center of the bay. This lone ROV dive (#327) was closer to the *Shinkai 2000* dive area than to the other *Dolphin 3K* dives (Table 1, Fig. 1). The *Shinkai 2000* was equipped with a Victor GF-S1000 HU three chip CCD camera specially modified for the vehicle. There were eight lights: five 250-W SeaLine SL-120/250 halogen lamps and three 400-W SeaArc HMI/MSR metal halide lamps. The *Dolphin 3K* was equipped with a Victor/JVC KY-F32 three chip CCD camera and six lights: three 400-W SeaArc HMI/MSR metal halide lamps and three 250-W SeaLine SL-120/250 halogen lamps (one in the rear, two in the front). Video footage was recorded simultaneously on both ST-120PRO S-VHS and BCT-D124L Digital Betacam tapes, which were reviewed in their entirety, animals being

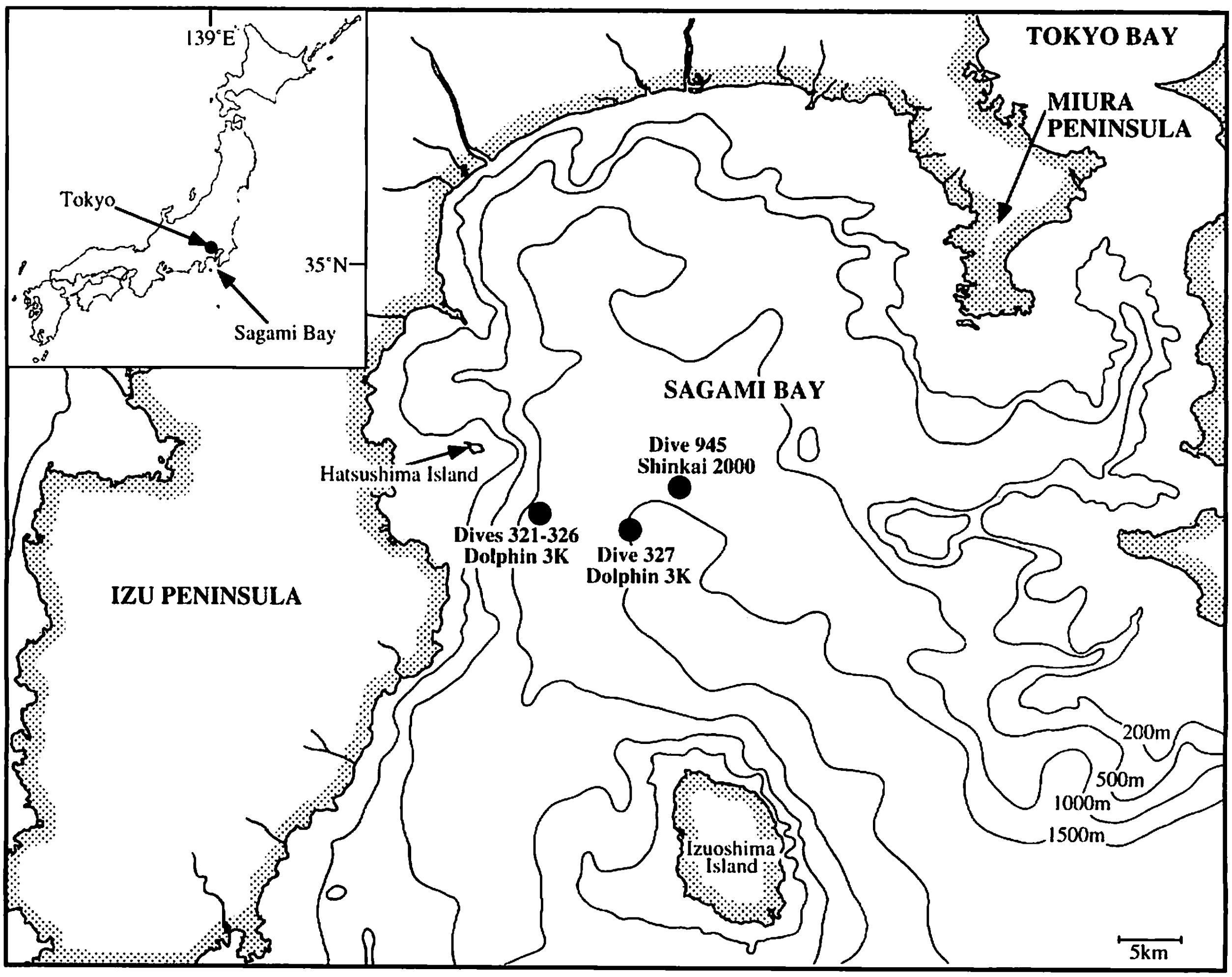

Fig. 1. Map showing the dive locations in Sagami Bay.

identified wherever possible. Specimens were collected using a single detritus sampler (Youngbluth 1984) on the *Dolphin 3K*, and by a suction sampler on the *Shinkai 2000*. A gate valve sampler, a new tool for midwater sampling inspired by Dr W. M. Hamner of UCLA and developed at the Japan Marine Science & Technology Center (JAMSTEC) was attached to this suction sampler (see Hunt et al. 1997: Fig. 1). Animals were transferred to shipboard aquaria or planktonkreisels (Hamner 1990) for behavioral observation and positive identification.

Video analysis

Video identifications of pelagic animals are necessarily subjective to some degree because one cannot collect all the animals recorded on the video. Researchers are often dissuaded from using video images they cannot fully identify to species. This study used all videotaped sequences possible by recording each animal observed to the most discriminate taxonomic level possible. Experience shows that three distinct categories of identification can be made by trained biologists. These include: 'impossible' wherein no identification is possible; 'probable' wherein an observer feels some confidence about an identification but still harbors some reserve; and 'certain' wherein an observer feels strongly confident about the identification. This final category requires an observer to believe that the identification is positive, although collection of the specimen would be necessary for true 'positive identification'. The level of confidence in an identification will of course shift depending on the taxonomic level and the quality of the video reviewed. For example, an observer may be able to make a 'certain' identification for a siphonophore at the genus level *Nanomia*, but be unable to identify the species. While another image may allow a 'probable' identification of *Nanomia* (leaving some doubt in the observer), yet allow 'certain' identification as a physonect siphonophore. In this study, we used only 'certain' identifications for analysis to reduce the chance of error. Further reduction in error was made in two ways. First, when a specimen was collected and positively identified, the video identifications were checked, and observers learned from this experience. Second, two trained observers identified animals to the same taxon, and thereby cross-checked the identifications of the other.

A complete list of all animals identified is given in the appendix. Video identifications (N=3041) were entered into a spreadsheet along with depth, time of day, and observations about each animal. Identifications were grouped by taxa, and presented in Fig. 2 for all taxa with at least three records. Individual data points may represent a single animal or multiple animals sighted at a single depth. Since the figure is not meant to show quantitative abundances (normalization of data per unit time was not possible) but rather overall patterns in depth distribution, we have shown single points at all depths where a taxon was observed. Gross differences in time spent by the submersibles at a given depth are highly unlikely however as dives were made with steady progress on both descent and ascent. Trends in depth distributions and relationships between selected taxa were examined by reordering the plots to better view specific assemblages (Fig. 3). In order to address the possible effects of dive location or submersibles used, data were sorted accordingly.

Physico-chemical data were collected using a SeaBird SBE16 CTD with an SBE13 oxygen sensor attached to the vehicles. Data series for *Dolphin 3K* dives #321–326, which were conducted over four consecutive days, were combined to give a standard profile of the bay during that time (Fig. 4). CTD and dissolved oxygen can be correlated to the presence of a given animal by matching the timecode on the CTD series to the timecode on video.

Results and Discussion

Hydrography

Water temperature decreased gradually from about 18°C at the surface to 3°C near the bottom (Fig. 4). A weak thermocline occurred at about 50 m. Salinity was 34.25 at the surface and peaked at 34.58 at 50 m. The salinity was 34.47 at the bottom, and the minimum of 34.20 occurred at 450 m. There was no local oxygen minimum in the bay at this time. Oxygen concentrations were greatest near the surface at about 5.8 ml l^{-1}, gradually reducing to 1.0 ml l^{-1} at 800 m and remaining at this low until the bottom.

Faunal records and taxonomic accounts

Animals recorded on the taxonomic list from Sagami Bay include 8 phyla representing at least 75 separate species. Thirteen of these species are new records in Japanese waters including 2 siphonophores, 6 medusae, 4 ctenophores, and 1 appendicularian. Results for depth distributions for the most common species are given in Fig. 2.

There have been few submersible studies focusing on the gelatinous midwater fauna off Japan. A summary is presented in Toyokawa et al. (1998). The only other broad study of pelagic species in this area was done by Pérès (1959). It is prudent therefore to review what has been reported and suggest connections with the present study regarding species identifications. Details below focus on gelatinous groups. It is noted here that the two dives conducted in the Pérès (1959) study were done in an area northeast of Sagami Bay where different hydrologic features prevail. The Pérès study was conducted in an area where the Kuroshio current flowing north and the Oyashio current flowing south meet, soon after heading seaward. The area therefore contains Kuroshio species and Oyashio species, as well as species found only in this transitional zone. However, although Oyashio-derived water sometimes intrudes into Sagami Bay, it was not present at the time of this study as indicated by the absence of low salinity

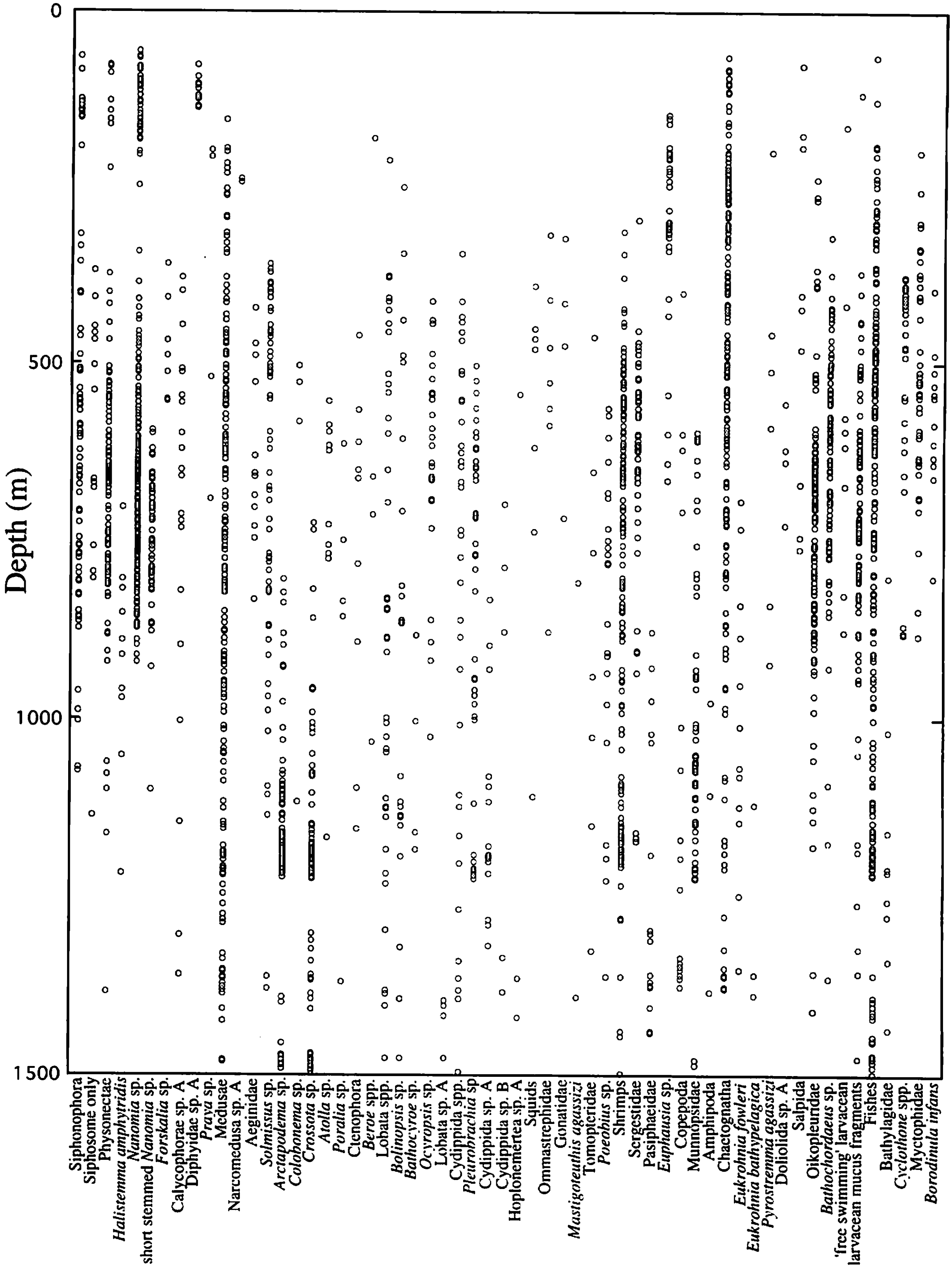

Fig. 2. Data plot of taxa with more than three observations. Taxa are sorted systematically by Phylum.

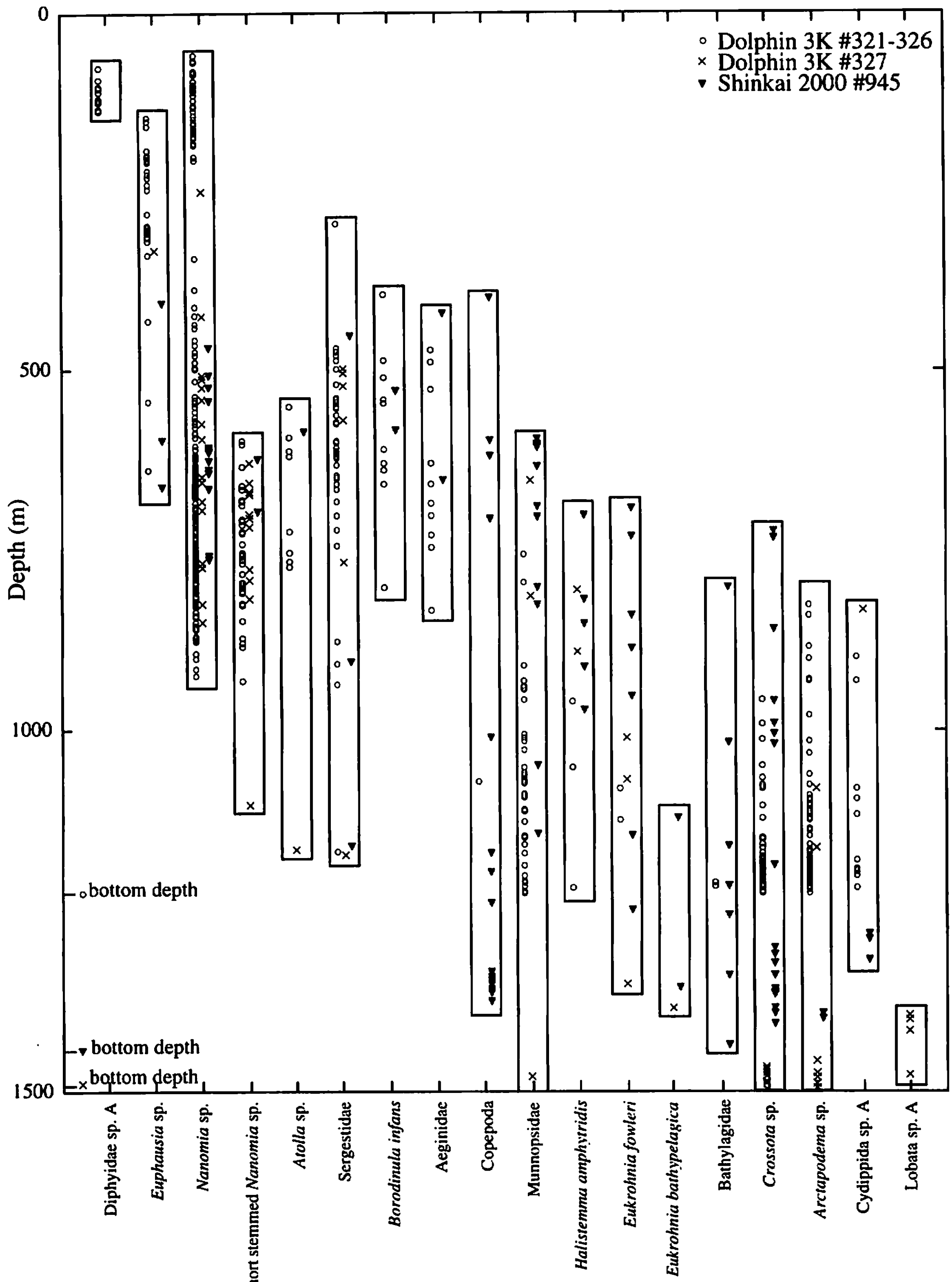

Fig. 3. Taxa segregated by vehicle used and by location. The crosses (×) represent *Dolphin 3K* dive #327, the only ROV dive conducted towards the center of the bay and in proximity to the *Shinkai 2000* dive.

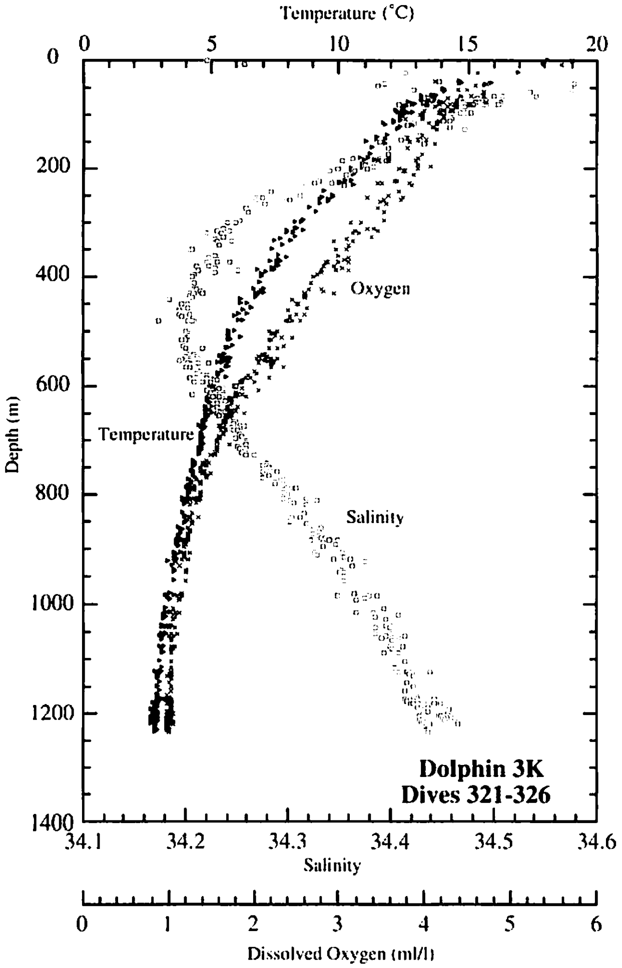

Fig. 4. CTD profile showing the temperature, salinity and dissolved oxygen profiles during *Dolphin 3K* dives #321–326 in Sagami Bay, Japan.

(<34.20) and high O_2 content (>3.5 ml l^{-1}) at mid-depths (see Senjyu et al. 1998).

Siphonophora

Nine siphonophore species were recorded in this study. Six were physonects, three were calycophorans.

***Apolemia* sp.**—Observed twice, at 527 m and 685 m. It is likely one of the apolemiid species listed in Toyokawa et al. (1998) is the same species. The only apolemiid species reported to date in Japanese waters is *Apolemia uvaria* (Kawamura 1954).

***Forskalia* sp.** (Fig. 6C).—A hitherto unknown species, description of which is forthcoming (Pagès et al., submitted).

***Nanomia* sp.** (Fig. 6B).—This is not one of the agalmatids shown previously in Toyokawa et al. (1998) which are clearly in another genus. The only species currently described from the Pacific is *N. bijuga*. Morphological and behavioral observations also suggest the species observed in Sagami Bay is *N. bijuga*.

Physonectae sp. A (see Hunt et al. 1997: Fig. 7).—Fairly large with nectosomes ranging from 10–15 cm and siphosomes over 30 cm long when extended. Nectophores were yellow or yellow-orange and numerous (>30). The pneumatophore was similarly colored. We have no record from Japanese waters for Physonectae sp. A, which was observed twice, at 703 m and 972 m .

Halistemma amphytridis (Fig. 5A).—Redescription of this species based on submersible-collected specimens is forthcoming (Pagès et al., in prep.).

Agalmatidae sp. A.—This large agalmatid is probably the same as the agalmatid observed by Toyokawa et al. (1998: Fig. 3C).

Diphyidae sp. A.—This calycophoran has a pointed anterior nectophore and rounded posterior nectophore. It was observed only at epipelagic depths (above 200 m).

Calycophorae sp. A.—Observed once at 583 m. Both nectophores were rounded and relatively large. The siphosome was over 3 m in length.

***Praya* sp.**—This species has cylindrical nectophores of equal size, with bright yellow areas equally spaced along the siphosome. Six specimens were observed between 200 m and 694 m.

Hydroidomedusae

Thirteen species of hydroidomedusae (sensu Bouillon et al. 1992) were categorized. Six species are new to Japan, including *Poralia* sp., *Aegina* sp., *Arctapodema* sp., Narcomedusae sp. A, Narcomedusae sp. B, and Hydroidomedusae sp. A. The final 3 unidentified species recorded here are different from the unidentified hydromedusa in Toyokawa et al. (1998: Fig. 4C).

Aegina citrea.—Reported in Toyokawa et al. (1998).

***Aegina* sp.**—A second *Aegina* sp. was recorded in this study. The only other report from Japanese waters is of *Aegina rosea*. However based on the morphological description given in Yamada (1997a), we believe this species to be different and therefore new to Japanese waters.

Aeginura grimaldii (Fig. 6D).—This species was identified from Sagami Bay by Dr S. Kubota (pers. comm.) and is a common cosmopolitan species.

***Solmissus* sp.**—We observed two forms, A and B, which appear to correspond to those reported by Toyokawa et al. (1998). Form A was observed 7 times, always at depths greater than 500 m. Form A had 30 or more tentacles, a thicker body than form B, and often had a purple ring around the margin (see Hunt et al. 1997: Fig 10). Form B was observed 5 times, always at depths less than 500 m. Form B had 24 or fewer tentacles, a flatter body, and no purple ring. Pérès (1959: Plate 1) and Houot (1960: Plate 1) show *Solmissus* individuals (form A) with at least 29 and exactly 32 tentacles, which they report from off Japan below 750 m and from 1190 m, respectively. Toyokawa et al. (1998) have reviewed similarities of form B to *S. marshalli*. It is difficult to determine if these different forms are developmental changes within a single species or represent two distinct species.

***Colobonema* sp.**—This is the same species reported in Toyokawa et al. (1998) as *Colobonema sericeum*.

***Crossota* sp.**—Pérès (1959) reported *Crossota rufobrunnea* at somewhat similar ranges as those reported here. During the *Shinkai 2000* dive #945, it was noted that this medusa seemed to get progressively larger and concentrated less densely as distance from the bottom increased. Within a few meters of the bottom, *Crossota* sp. were very tiny with bell diameters of about 1 cm and colored a deep red-brown. Conversely, several hundred meters off the bottom, individuals were 2–3 cm in diameter, lighter colored, and had numerous fine tentacles which extended well beyond the bell margin to lengths of 1–2 cm. Over three species of this genus have been reported from Japanese waters (Yamada 1997b).

***Arctapodema* sp.** (Fig. 6A).—This medusa is one of the most abundant forms we observed in Sagami Bay. *Arctapodema* is reported from Japanese waters for the first time and may represent a new species. One collected specimen had a diameter of 16 mm and height of 12 mm, with eight club-shaped gonads attached to the radial canals near the stomach base. The canals were completely transparent and the specimen had 136 tentacles. These characters match no species currently described. *Arctapodema* sp. was very sensitive to external movements and can escape rapidly. Escape was often accompanied by an autotomization of most or all of the tentacles, and was very similar to the escape behavior of *Colobonema*. This is undoubtedly the medusa that Pérès (1959) referred to as *Pantachogon haeckeli* and reported from 570 m to 1170 m.

Narcomedusa sp. A (Fig. 5J).—Small (1–2 cm in diameter) medusae with eight relatively long, thin tentacles. Tentacles over five times the length of the bell diameter. Observed only in shallow water (above 300 m).

Narcomedusa sp. B (Fig. 5E).—Cone-shaped medusa with six tentacles. The tentacles run along the body from the bell margin to the apex, then bend abruptly outward at 90° from the body axis.

Hydroidomedusa sp. A (Fig. 6G).—This large medusa was observed once and appeared as one red sac nested within a slightly larger transparent sac. The diameter of the bell was half that of the height, which was estimated (relative to equipment observed in the video) to be about 20 cm. The tentacles stuck to the vehicle and stretched over 1 m in length.

***Periphylla* sp.**—Observed once at 504 m. The only described species of this genus is the ubiquitous *Periphylla periphylla*.

***Atolla* sp.** (see Hunt et al. 1997: Fig. 12).—Pérès (1959) reported *Atolla bairdi* although no description was given, thus reasonable comparison is not permitted. The only other species described from Japanese waters is *A. wyvillei* into which most *A. bairdii* were synonomized by Kramp (1961).

***Poralia* sp.** (Fig. 6H).—This is a new record for Japanese waters. *Poralia rufescens* is the type species and has been found from the Indian Ocean to the eastern Pacific. At least three species of *Poralia* have been collected to date (Larson et al. 1992).

Ctenophora

Thirteen ctenophore species were recorded. Of these, 4 are new to Japanese waters.

Beroe cucumis.—*Beroe cucumis* was observed twice, at 322 m and 588 m. This species was observed twice by Pérès (1959) along with a second *Beroe* sp. which may correspond to the second reported here. *B. cucumis* is common in Japanese waters, reaching the innermost parts of Tokyo Bay (Toyokawa & Terazaki 1994).

***Beroe* sp.**—The only other species reported from Japanese waters is *Beroe forskali*.

***Bathocyroe* sp.**—*Bathocyroe fosteri* has been reported from Japanese waters by Toyokawa et al. (1998).

***Bolinopsis* sp.**—There are two representatives of this genus reported from Japanese waters, *Bolinopsis mikado* and *B. rubripunctata*. We were unable to distinguish which species occurred in our study.

***Kiyohimea* sp.**—Observed once at 834 m. The status of this genus in Japanese waters is described in Toyokawa et al. (1998).

Lobata sp. A (see Lindsay et al. 1999: Fig. 1g).—This lobate is new to Japanese waters. It was observed near the bottom in the center of Sagami Bay and was distinguished by large rounded lobes extending to over three times the length of the body.

Lobata sp. B.—This lobate is tinged red throughout. It was relatively inactive compared to other lobates we observed and may be the same as reported in Toyokawa et al. (1998: Fig. 31).

Lobata sp. C.—This lobate was observed once at 812 m. It had a deep blue body which was nearly spherical. Lobes were thin and transparent with a slight tinge of blue.

***Ocyropsis* sp.** (Fig. 5B, C).—Pérès (1959) reported a species of *Ocyropsis* occurring fairly commonly in the water column. Although there has been some doubt posed as to whether these reports are accurate (Madin & Harbison 1978) the principal distinguishing features (see Madin & Harbison 1978) of the elongate lobes used heavily for swimming and non-pigmented gut were present in Sagami Bay specimens. Only *Ocyropsis fusca* is reported from Japanese waters (Kubota 1997).

***Pleurobrachia* sp.** (Fig. 5F).—Pérès (1959) reported *Pleurobrachia pileus* from 100-m depth. None of the *Pleurobrachia* sp. observed in this study were found above 500 m.

Cydippida sp. A (Fig. 6E).—Observed in greatest abundance near the seafloor. The body is black and the tentacles are white. The body shape is flattened and wider anteriorly. This cydippid corresponds to cydippid sp. B in Toyokawa et al. (1998).

Cydippida sp. B (Fig. 5H).—This large red cydippid has been observed in several areas of the world, but is still not

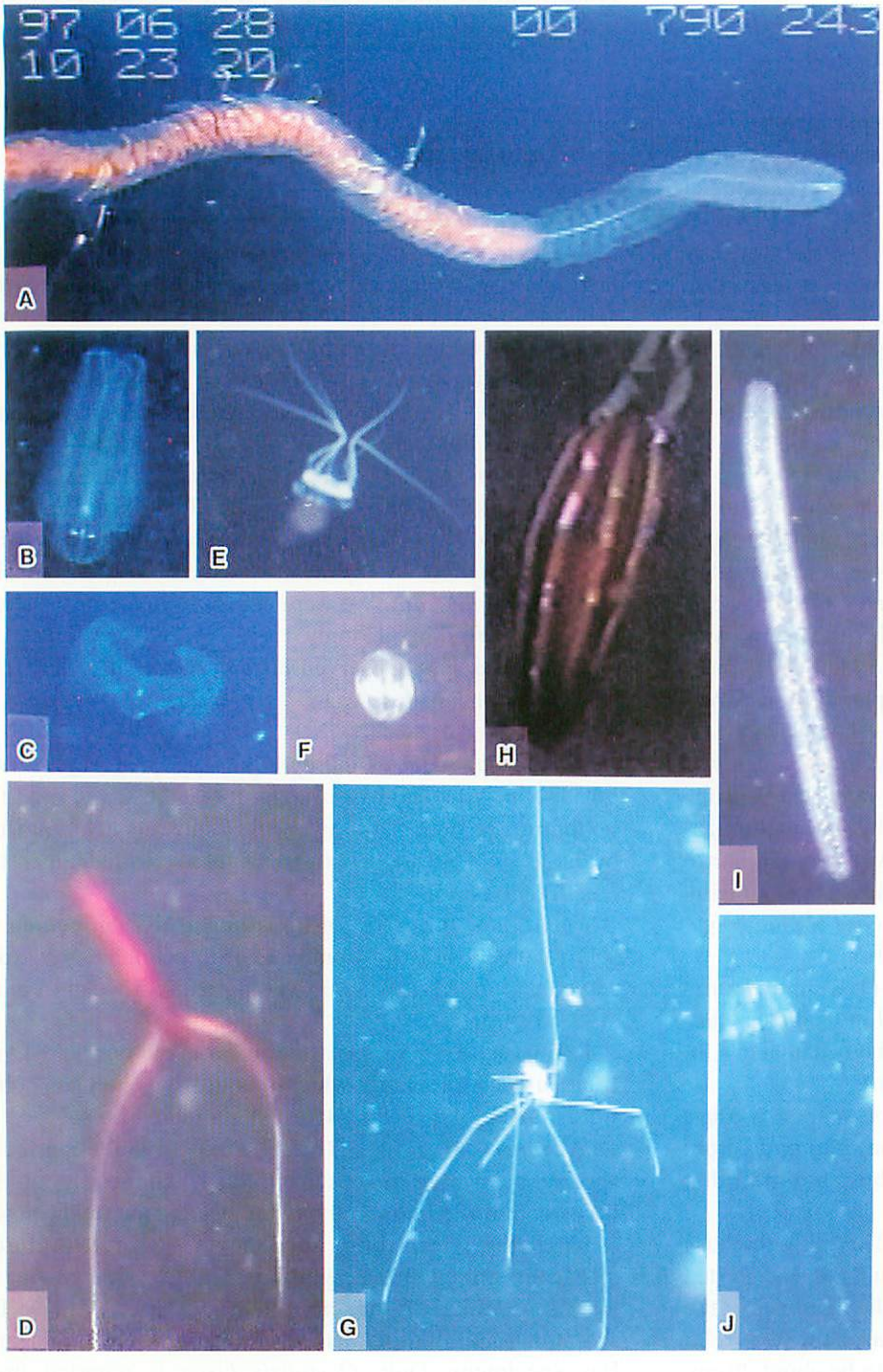

Fig. 5. Videographs of specimens from Sagami Bay. **A.** *Halistemma amphytridis*, 790 m. **B.** *Ocyropsis* sp., 868 m. **C.** *Ocyropsis* sp. swimming using its lobes, 865 m. **D.** *Mastigoteuthis agassizi* with head retracted, 1392 m. **E.** Narcomedusae sp. B, 822 m. **F.** *Pleurobrachia* sp., 545 m. **G.** *Munneurycope* sp. with head to lower right and antennae raised in direction of swimming, 1212 m. **H.** Cydippida sp. B, 1335 m. **I.** *Pyrostremma agassizi*, 931 m. **J.** Narcomedusae sp. A, 244 m.

described in the literature. It is highly active and can reach sizes greater than 20 cm in length, with tentacles which can be deployed over 1 m. The shape is oblong; the length axis is about 4 times longer than the width axis.

Cydippida sp. C.—This species was observed twice near the bottom. It was bright red in color and nearly spherical (body shape similar to *Pleurobrachia*).

Nemertea

One nemertean worm species was encountered. It was approximately 2–3 cm long, dark orange, and had a protruding proboscis. There also appeared to be faint gray streaks running along the skin in an anastomozing pattern.

Two pelagic nemerteans, both from the order Hoplonemertea, have been reported from net tows below 420 m in Sagami Bay, *Nectonemertes mirabilis* and *Pelagonemertes moseleya* (Yamaji 1984). The nemertean observed in this study resembled the former.

Mollusca

Of the 5 species of molluscs reported here, 4 were oegopsid squids including *Gonatopsis* sp., *Gonatus onyx*,

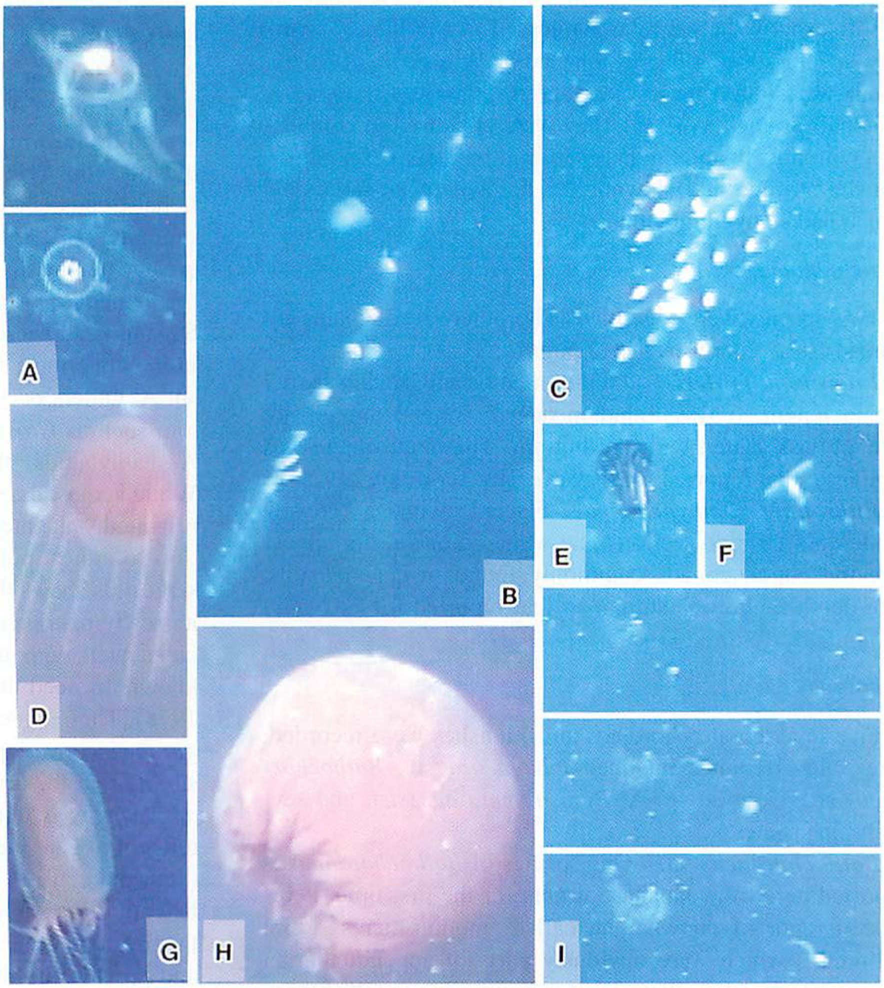

Fig. 6. Videographs of specimens from Sagami Bay. **A.** *Arctapodema* sp., side and top views, 1190 m. **B.** *Nanomia ?bijuga* swimming down in its longer stemmed form (contrast to Hunt & Lindsay 1998: Fig 1A), 616 m. **C.** *Forskalia* sp., 407 m. **D.** *Aeginura grimaldii*, 728 m. **E.** Cydippida sp. A, 1207 m. **F.** The only copepod recognizable from the ROV *Dolphin 3K*, 1012 m. **G.** Hydroidomedusae sp. A, 703 m. **H.** *Poralia* sp., 1368 m. **I.** An appendicularian escaping its house, 661 m. The white body clearly visible in the middle and bottom stills can be seen within the house in the top still. The time elapsed for this sequence was 0.5 s, demonstrating the rapid escapes previously reported by Hamner et al. (1975).

Mastigoteuthis agassizi, and *Todarodes pacificus*. The fifth was *Vampyroteuthis infernalis*. None are new to Japanese waters. *Mastigoteuthis agassizi* has characters similar to *M. flammea* in Nesis (1987). The identification here as *M. agassizi* was based on the review by Salcedo-Vargas & Okutani (1994).

Mastigoteuthis agassizi (Fig 5D) was observed only twice, but on both occasions its head was fully retracted (beyond the eyes) into the mantle, leaving only the distal half of the fourth arms and tentacles exposed. The tentacles were placed within the grooves on the fourth arms in a similar manner to *Chiroteuthis calyx* (Hunt, pers. obs.). The sole observation of *Vampyroteuthis infernalis* was fleeting but it did occur at a depth with low dissolved oxygen concentration as has been observed elsewhere (Hunt 1996).

Annelida

Only two types of polychaetes were observed during the dives analyzed for this study.

***Poeobius* sp.**—Individuals were all about 2 cm in height, with the characteristic bright yellow gut and desegmentized body. We report *Poeobius* in Sagami Bay for the first time, although the genus is considered cosmopolitan. The only species described thus far is *Poeobius meseres*.

***Tomopteris* sp.**—*Tomopteris* were 4–5 cm in length. All were completely clear with no pigment in the gut or appendages. All tomopterid species thus far recorded from Japanese waters are in the genus *Tomopteris*.

Arthropoda

Thirteen types of arthropods were observed including amphipods, calanoid copepods, *Munneurycope* sp. and at least one other munnopsid isopod, mysid shrimp, *Euphausia* sp., *Bentheogennema* sp., a pasiphaeid, at least four sergestids, and *Hymenodora* sp. There are no new records reported here for arthropods. *Bentheogennema* sp. was observed once at 1188 m. *Hymenodora* sp. was observed once at 653 m.

The 'pycnogonid' depicted in Plate 4 of Pérès (1959) was clearly a munnopsid isopod. There was no size estimation given for comparison to the species reported here, although the 700 m depth quoted by Pérès would suggest it was not the benthopelagic species found in Sagami Bay. The larger specimens observed and collected from Sagami Bay (see Fig. 5G) appear to be the same species reported as *Munneurycope* sp.II in Marshall & Diebel (1995). The gait behavior described by these authors for *Munneurycope* sp. II was exactly the same as witnessed in the large Sagami Bay species. We add only one note. While the 7th pereopods were indeed used in escape responses as reported in Marshall & Diebel (1995), they were also used in conjunction with the 5th and 6th pereopods to increase drag, adjusting the attitude and slowing the descent of an individual which had stopped moving.

Chaetognatha

Two species were identified. The other chaetognaths included one or more species of *Sagitta*.

Eukrohnia fowleri.—Orange in color and greater than 2 cm in length. It was found in deeper waters, though not strongly associated with the bottom. The depth range was similar to that reported for *E. fowleri* by Terazaki (1997).

Eukrohnia bathypelagica.—Flaccid with a creamy white-colored hind section. The white color did not appear like the coiled gonads commonly found in chaetognaths. The depth range was similar to that reported for *E. bathypelagica* by Terazaki (1997).

Chordata

Five invertebrate chordates and 11 fishes were recorded. The 5 invertebrates included *Oikopleura* sp., *Bathochordaeus* sp., Doliolid sp. A, *Pyrostremma agassizi*, and several salp species.

***Bathochordaeus* sp.**—One species of *Bathochordaeus* is reported here from Japanese waters for the first time. Pérès (1959) reported on what he called 'montgolfières' ("fire balloons") which were obviously parts of appendicularian houses (Pérès 1959: Plate 1). It is impossible to tell if these were *Bathochordaeus* sp. or not from the plate though similar shaped inner feeding filters have been observed using deep-tow cameras in the same area (Hunt, unpubl. data).

***Oikopleura* sp.**—There are 11 species of *Oikopleura* reported from Japanese waters. It is impossible at this time to identify if the Sagami Bay distribution represents more than one species, and which species are included.

Pyrostremma agassizi (Fig. 5l).—This pyrosome species has been reported from Japan and is one of the more common coastal species.

There are numerous species of salps and several doliolids described from Japan. It is not possible to say with any accuracy which species or combination were present in the distributions given here. Specimen collections will be needed in order to positively identify these animals.

The eleven fishes included two bathylagids, three gonostomiids of the genus *Cyclothone*, a hatchet fish which was probably *Sternoptyx* (based on the shape of its eyes), an idiacanthid, *Borodinula infans*, *Lampanyctus* sp., *Squalogadus modificatus* and *Melanostigma* sp. None of these is new to Japan. The idiacanthid was observed once at 812 m. *Lampanyctus* sp. was observed once at 851 m. *Melanostigma* sp. was observed twice, at 918 m and 942 m. *Squalogadus modificatus* was observed once at 1411 m.

Observational database analyses

The advantage of analyzing submersible observations as described above is to create a large enough database to begin inquiries. Figure 2 gives an overview of all taxa observed in Sagami Bay for this study. Although this method did not allow rigorous quantitative analyses, the distributional trends correlated well with published literature. For example, *Crossota* and *Arctapodema* were observed at greater depths than the aeginids, supporting the claim that trachymedusae tend to live deeper than narcomedusae in Sagami Bay. There were species which occurred principally in the uppermost 500 m such as euphausiids and Diphyidae sp. A. Others occurred principally from 1000 m to the bottom such as *Crossota* sp., *Arctapodema* sp., Cydippida sp. A, bathylagids, the *Eukrohnia* spp., and Lobata sp. A. While sergestids, aeginids, and *Borodinula infans* occurred principally at intermediate depths (Fig. 3). Closer inspection of the individual sightings within the range of sergestids shows that the majority of sightings occurred in a narrowly restricted depth range. This restricted range coincided well with the range of *Borodinula infans* which is known to feed heavily on sergestids (Nielsen & Smith 1978). The ranges of *Halistemma amphytridis* and *Eukrohnia fowleri* overlapped considerably. This suggests the possibility that the orange pigmentation within the bracts of *H. amphytridis* is obtained from eating *E. fowleri*, which are thought to gain their orange pigments from eating copepods (Terazaki et al. 1977). Of course, *H. amphytridis* might also be eating the same copepods directly, but the point here is that this database allows us to pose a new possibility to test, and provides us with a restricted depth range to target during future dives. Closer inspection of behaviors within a taxon can also yield results. For example, the overlapping ranges of *Atolla* sp. and those *Nanomia* observed with their siphosomes contracted, in conjunction with other videotaped observations, suggest that *Atolla* preys on *Nanomia* (see Hunt & Lindsay 1998).

Data in Fig. 3 were also sorted by submersible used and dive location. Comparing data collected using the manned *Shinkai 2000* and the remotely operated vehicle *Dolphin 3K* relayed information about the utility of each vehicle. The data presented in Fig. 3 include 7 dives using the *Dolphin 3K* and 1 dive using the *Shinkai 2000*. The total dive time of the ROV was 23 h 59 min vs 6 h 46 min for the manned submersible, or a ratio of 3.5 : 1 for ROV: *Shinkai* observation time. Yet a cursory review of the data presented in Fig. 3 shows that a far greater proportion of observations were made from the *Shinkai 2000* than would be expected if observations per unit dive time were equal. The reason is twofold. One, observers can see a greater volume peering through a window than when restricted to the two-dimensional image caught by the ROV video camera. Observers in a manned submersible can glance at numerous targets quickly, adjust focus, perceive size and depth, and record information much more efficiently. Second, the human eye can perceive greater detail than a camera and thus record details which cameras alone miss. For example, all observations of copepods were made from the *Shinkai 2000* except one. The exception recorded by the ROV was a large calanoid copepod which literally bounced off the camera lens enabling us to identify it (see Fig. 6F). Similarly, the smaller species of munnopsid isopod was observed with greater frequency by the *Shinkai 2000*. However, Lobata sp. A was observed only during the *Dolphin 3K* dive #327 which was the only ROV dive conducted in deeper water over the center of the bay in June, suggesting either a restricted seasonal or geographic distribution for the species.

By combining information such as the date and location of dives, vehicle used, behavior observed and depth distributions as illustrated above, it is possible to begin outlining plans for future submersible research with greater efficacy. This further assists in gaining as much insight and knowledge about pelagic ecology as possible from the limited dive time available. Submersibles are the best tools for collecting data about the biology and ecology of gelatinous forms. There are no new records presented here for species easily caught by nets, such as arthropods, squids, and fishes. However, the majority of gelatinous taxa reported here and in Toyokawa et al. (1998) are new records. Our main purpose in this paper is to present a method for establishing a useful database of submersible-collected observations. The taxonomic appendix presented with this paper is the first step towards investigating pelagic faunas using submersibles. As more specimens are collected and compared to videotaped sequences, positive identifications will replace the unknown species names listed here. However, it is instructive to delineate which species and types occur where, in order to ask the appropriate questions, form testable lines of inquiry and maximize future dive time. Rigorous annotation of video and live observations made from submersibles in a clear, consistent, and taxonomically conservative manner provides useful results which need not wait for 'positive identifications' of every specimen to be scientifically useful in the interim.

Acknowledgments

We thank Drs Bruce Robison, Shin Kubota, Francesc Pagès, George Matsumoto, Kim Reisenbichler, Jun Nishikawa, and Erik Thuesen for their assistance in helping with identifications. We thank Drs Jun Hashimoto, Katsunori Fujikura, Yoshihiro Fujiwara, and Shuhei Nishida for their field support. Special thanks to Jun Hashimoto and Bruce Robison for providing the opportunity and experience to develop the methods presented here. We sincerely thank the captain and crew of the R/V *Natsushima* and the operations team of the *Shinkai 2000* and *Dolphin 3K* for their dedicated efforts. This manuscript was improved by the comments of the editor and two anonymous reviewers to whom we are indebted.

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Appendix

List of taxa recorded in this survey using the submersibles *Shinkai 2000* and the *Dolphin 3K*. Taxa marked '*' were described positively from collected specimens. Taxa marked '†' are new records for Japanese waters.

- Phylum Cnidaria
  - Class Hydrozoa
    - Subclass Siphonophora
      - Order Physonectae
        - Physonectae sp. A†
        - *Apolemia* sp.
        - Agalmatidae sp. A
        - *Halistemma amphytridis* Lesueur & Petit, 1807*
        - *Nanomia* sp.
        - *Forskalia* sp. *†
      - Order Calycophorae
        - Calycophorae sp. A
        - Diphyidae sp. A
        - *Praya* sp.
    - Subclass Hydroidomedusae
      - Hydroidomedusae sp. A†
      - Order Narcomedusae
        - Narcomedusae sp. A†
        - Narcomedusae sp. B†
        - *Aegina* sp.†
        - *Aegina citrea* Eschscholtz, 1829
        - *Aeginura grimaldii* Maas, 1904*
        - *Solmissus* sp.
      - Order Trachymedusae
        - *Arctapodema* sp. *†
        - *Colobonema* sp.
        - *Crossota* sp.
  - Class Scyphozoa
    - Order Coronatae
      - *Periphylla periphylla* (Péron and Lesueur, 1810)
      - *Atolla* sp.
    - Order Semaeostomeae
      - *Poralia* sp.†
- Phylum Ctenophora
  - Class Nuda
    - Order Beroida
      - *Beroe* sp.
      - *Beroe cucumis* Fabricius, 1789
  - Class Tentaculata
    - Order Lobata
      - Lobata sp. A†
      - Lobata sp. B
      - Lobata sp. C†
      - *Bathocyroe* sp.
      - *Bolinopsis* sp.
      - *Kiyohimea* sp.
      - *Ocyropsis* sp.
    - Order Cydippida
      - Cydippida sp. A
      - Cydippida sp. B†
      - Cydippida sp. C†
      - *Pleurobrachia* sp.
- Phylum Nemertea
  - Class Enopla
    - Order Hoplonemertea
      - Hoplonemertea sp. A
- Phylum Mollusca
  - Class Cephalopoda
    - Order Teuthoidea
      - *Gonatus onyx* Young, 1972
      - *Gonatopsis* sp.

Appendix (continued)

Mastigoteuthis agassizi Verrill, 1881*
Todarodes pacificus Steenstrup, 1880
Order Vampyromorpha Pickford, 1936
Vampyroteuthis infernalis Chun, 1903

Phylum Annelida
Class Polychaeta
Order Phyllodocida
Tomopteris sp.
Order Poeobiida
Poeobius sp.

Phylum Arthropoda
Class Malacostraca
Order Amphipoda
Amphipoda spp.
Order Isopoda
Munnopsidae sp.
Munneurycope sp.*
Order Mysida
Mysidae sp. A
Order Euphausiacea
Euphausia spp.
Order Decapoda
Bentheogennema sp.
Sergestes similis Hansen, 1903
Sergestes spp.
Sergia prehensilis (Bate, 1881)
Sergia spp.
Pasiphaeidae sp. A
Hymenodora sp.
Class Maxillopoda
Order Calanoida
Calanoida spp.

Phylum Chaetognatha
Class Sagittoidea
Eukrohnia fowleri Ritter-Záhony, 1909
Eukrohnia bathypelagica Alvariño, 1962
Sagitta spp.

Phylum Chordata
Subphylum Urochordata
Class Thaliacea
Pyrostremma agassizi Ritter & Byxbee, 1905*
Doliolida sp. A
Salpida spp.
Class Appendiculata
Bathochordaeus sp.[†]
Oikopleura sp.
Subphylum Vertebrata
Order Anguilliformes
Borodinula infans Günther, 1878
Order Salmoniformes
Bathylagus sp.
Leuroglossus sp.
Order Stomiiformes
Cyclothone alba Brauer, 1906
Cyclothone atraria Gilbert, 1905
Cyclothone pseudopallida Mukhacheva, 1964
Sternoptychidae sp. A
Idiacanthus sp.
Order Myctophiformes
Lampanyctus sp.
Order Gadiformes
Squalogadus modificatus Gilbert & Hubbs, 1916
Order Perciformes
Melanostigma sp.