To Dr Phil Pugh
with best wishes
from Masaya Toyokawa

Plankton Biol. Ecol. 45 (1): 61-74, 1998

plankton
biology & ecology

Cnidarians and ctenophores observed from the manned submersible *Shinkai 2000* in the midwater of Sagami Bay, Pacific coast of Japan

MASAYA TOYOKAWA[1], TATSUKI TODA[2], TOMOHIKO KIKUCHI[3] & SHUHEI NISHIDA[4]

[1]*Environmental Management Division, National Research Institute of Aquaculture, Nansei, Mie 516-0193, Japan*
[2]*Faculty of Engineering, Soka University, Hachioji, Tokyo 192-0003, Japan*
[3]*Faculty of Education and Human Sciences, Yokohama National University, 79-2 Tokiwadai, Hodogaya, Yokohama 240-8501, Japan*
[4]*Ocean Research Institute, University of Tokyo, 1-15-1 Minamidai, Nakano, Tokyo 164-8639, Japan*

Received 12 November 1997; accepted 5 January 1998

Abstract: Cnidarians and ctenophores were recorded and identified from videotapes and photographs taken during two dives of the manned submersible *Shinkai 2000* in Sagami Bay, Pacific coast of central Japan, in December 1993 and 1994. At least 4 species of hydromedusae, 2 species of siphonophores, 1 species of scyphomedusa, and 7 species of ctenophores occurred. Of these, 5 ctenophores are new to the Japanese fauna. Small unidentified hydromedusae were dominant in the 750-1440 m depth layer, while siphonophores were absent below 750 m and ctenophores were scarce between 650-1440 m depth layer. Six out of 7 species of ctenophores occurred in the 399-650 m layer, while a cydippid occurred only just above the bottom. It is assumed that many more species from the meso- and bathypelagic zone of this area will be found through further studies, as has been the case in other areas of the world.

Key words: hydromedusa, mesopelagic, Sagami Bay, scyphomedusa, siphonophore

Introduction

Over the past few decades, investigations of mesopelagic gelatinous zooplankton from manned submersibles and from remotely-operated vehicles have been carried out, mostly in the North Atlantic (Larson et al. 1991), Mediterranean (Laval et al. 1989; Mills et al. 1996), and the eastern side of the North Pacific (Larson et al. 1992). A number of species have been discovered or redescribed due to results from these dives (Madin & Harbison 1978; Pugh & Youngbluth 1988; Matsumoto & Robison 1992, etc.). In particular ctenophores, which easily disintegrate by a little disturbance or in fixative and had been believed to comprise an insignificant fraction of the fauna of the open ocean, have been found to be abundant and di-

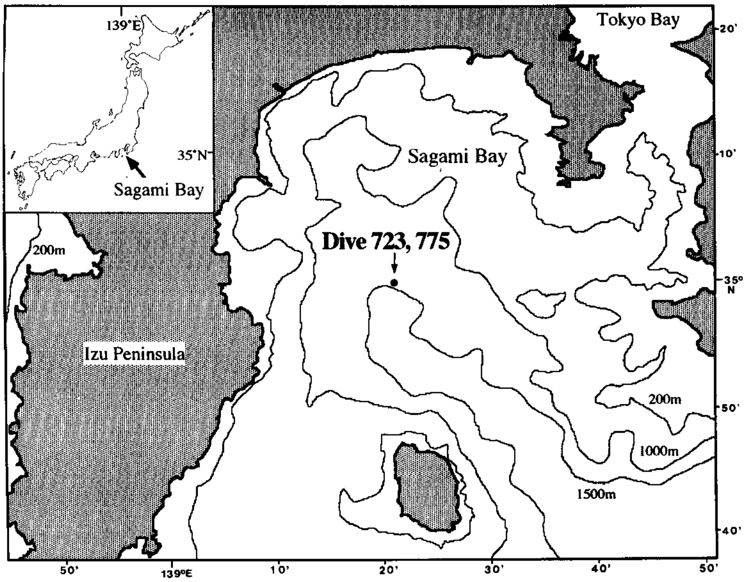

Fig. 1. Map of the station for *Shinkai 2000* dives in 1993 and 1994 in Sagami Bay.

verse at meso- and bathypelagic depths (e.g. Harbison 1986).

The midwater fauna of cnidarians and ctenophores around Japan is little known. Komai & Tokioka (1940) described a midwater ctenophore *Kiyohimea aurita* Komai & Tokioka that they collected at the surface near Shirahama Beach, Pacific coast of central Japan. Kawamura (1954) described a siphonophore, *Sagamalia hinomaru* Kawamura, collected in Sagami Bay at a depth of 450 m. In 1958, the French bathyscaphe *F.N.R.S. III* made dives off the eastern coast of Japan. Pérès (1959) reported the occurrence and vertical distributions of several species of cnidarians and ctenophores along with fishes and crustaceans from two of the dives, off Onagawa and off Cape Kinkasan. His identification of some of the medusae and ctenophores is doubtful in the light of today's much progressed knowledge of the deep water forms of these phyla. Since that expedition, 35 years ago, no investigations using submersibles on the midwater plankton in this area have been attempted.

In 1993, we started a project to investigate the meso- and bathypelagic macroplankton of Japanese waters using the research submersible *Shinkai 2000*. Here we report our observations on cnidarians and ctenophores from the first two dives.

Materials and Methods

Two dives using the *Shinkai 2000* submersible, Japan Marine Science and Technology Center (JAMSTEC), were made in December 1993 (Dive 723) and December 1994 (Dive 775) in the Sagami Trough, the central part of Sagami Bay (Fig. 1). Details of location, time, and

Table 1. Summary of two dives by *Shinkai 2000* in Sagami Bay in 1993 and 1994.

Dive No.	Latitude	Longitude	Observer	Bottom (m)	Date	Dive Time (GMT+9 hr)
723	35°01.1′N	139°21.5′E	S. Nishida	1446	2 Dec 93	0949–1621
775	35°00.5′N	139°22.0′E	T. Toda	1447	1 Dec 94	0942–1608

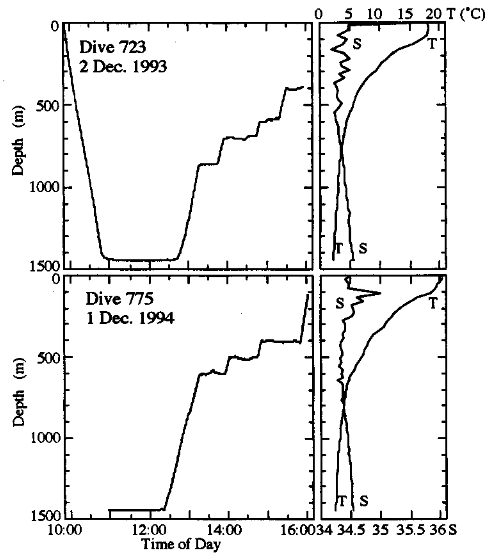

Fig. 2. Time-depth diagram of observation where video images were recorded and vertical profiles of temperature and salinity during Dives 723 and 775.

depth of observations are given in Table 1 and Fig. 2. In both dives, observations were made mainly near the bottom and on the way back to the surface. Temperature and salinity were recorded at 1-min intervals by an STD sensor equipped on the submersible. For detailed observations of macroplankton, the submersible made horizontal transects at slow speed (ca. 0.3–0.5 m s^{-1}) at several depths: 860, 700, 600, 400 m for 25, 48, 29, 20 min in Dive 723 and 1446, 600, 500, 400 m for 52, 40, 42, 60 min in Dive 775, respectively (Fig. 2). These depths were selected for investigation by the on-board researcher because these layers seemed to contain an abundance of gelatinous macroplankton observed while the submersible was making its initial descent to the bottom. Observation time was as long as the submersible's battery allowed. During the horizontal transects, when macroplankton specimens were located by the observer, the submersible followed the organism for several minutes. Macroplankton were recorded on videotape with an externally-mounted three chip CCD camera (specially designed and manufactured for *Shinkai 2000*), using 400-W metal halide search lights and fixed 250-W SeaLine lamps (model SL–120/250) for exposure. During Dive 723, video images were recorded from the surface to the bottom, and then to the end of observations at 400 m. During Dive 775, they were recorded from the bottom to 100-m depth. During Dive 775, an additional video-recording was made automatically using a Super-HARP camera (specially designed and manufactured for *Shinkai 2000*) throughout the observation and information from it was incorporated into the results. In several cases, still photographs were taken through the view port by the on-board researcher with a Nikon F4 camera.

The videos and photographs were later analyzed in the laboratory and cnidarians and ctenophores were identified as accurately as possible. Videotape was played with a Panasonic Video Cassette Recorder AG–7350 and still images were captured from the video through the video port of an Apple Macintosh 7100/80AV computer by using Video Monitor Version 1.0.1 (Apple Computer, Inc. 1993). Analyses of length and proportions of organisms were performed based on these still images on an Apple Macintosh 6100/66 computer using the public domain software NIH Image Version 1.61 (developed at the U.S. National Institutes of Health and available on the Internet at http://rsb.info.nih.gov/nih-image/). The length of each specimen was estimated by comparison with the length of one of the pieces of equipment attached to the submersible or parts of the submersible itself, which were simultaneously in focus with the target specimen. Photographs from the video were reproduced using a Hitachi VY–170 color video printer.

To test the difference in abundance of specimens among depth layers, the observed water column was divided into 399–450, 450–550, 550–650, 650–750, 750–1440, and 1440–1447 m (bottom) to include the horizontal survey (see above) at least in one of the dives. The number of the observed specimens was divided by the total number of minutes spent at the layer. Only the data from the video images taken by the CCD camera were used. In this paper, we define the abundance as the number of specimens seen per minute. For each total of hydromedusae, siphonophores or ctenophores, the null hypothesis that the abundance was not different between the two dives was tested using the Wilcoxon signed ranks test (Siegel & Castellan 1988). After the test, the null hypotheses that the abundance was not different among hydromedusae, siphonophores or ctenophores, or among depth layers were tested by using the non-parametric two-way analysis of variance (ANOVA) by ranks (Barnard et al. 1993). In both tests, we employed 5% as the probability of a Type I error.

Results

Hydrography

Water temperature was slightly higher during Dive 775 than during Dive 723. Below 400 m, it was 2.2–6.6°C during Dive 723 while it was 2.4–8.2°C during Dive 775 (Fig. 2). During both dives, water temperature was homogeneous in the upper 100 m (16.9–18.1°C for Dive 723 and 18.3–20.4°C for Dive 775). It decreased sharply to below 7°C between 100 m and 500 m, indicating a thermocline, and then decreased gradually to near 2°C at the bottom (1445 m).

The range of salinity below 400 m was almost the same in both dives: 34.2–34.6 (psu) for Dive 723 and 34.3–34.6 for Dive 775 (Fig. 2). However, the vertical profile of salinity was obviously different in the two dives. During Dive 775, salinity was around 34.5 in the 0–75 m layer and a marked salinity-maximum layer (34.5–35.0) at 100–250 m indicating the influence of the warm Kuroshio current. It then decreased to <34.5 between 250 m and 950 m reflecting the inflow of subarctic intermediate water (Iwata 1979). During Dive 723, water-column structure was not so clearly defined.

Description of cnidarians and ctenophores

A total of 90 specimens (20 specimens from Dive 723 and 69 specimens from Dive 775) with at least 4 species of hydromedusae, 2 species of siphonophores, 1 species of scyphomedusa, and 7 species of ctenophores were present (Table 2). Among these, at least 5 ctenophore species were new to our knowledge of the Japanese fauna. Most of the others have been rarely reported in this region.

Hydromedusae

Fifteen specimens occurred during Dive 723, and 30 occurred during Dive 775; of these 45 specimens, 7 specimens clearly comprised 4 species.

Colobonema sericeum *Vanhöffen (Fig. 3A)*.—A single specimen occurred at 500–508 m during Dive 775. The number of tentacles was 32. The lengths of tentacles appeared to be unequal to each other, but they were similar in structure. Linear gonads were seen along eight radial canals and were separated from the manubrium and the umbrella margin. No centripetal

Table 2. List of species observed from selected depth ranges in two dives of *Shinkai 2000*.

Depth (m)	Dive 723	Dive 775
399–450	*Kiyohimea usagi* : 1 Hydromedusa sp. : 1	*Solmissus incisa* form A : 1 *Solmissus incisa* form B : 2 Narcomedusa spp. : 2 Agalmatidae spp. : 5 Lobata spp. : 2
450–550		*Colobonema sericeum* : 1 *Solmissus incisa* form A : 1 *Bathocyroe fosteri* : 2 *Bolinopsis* sp. : 1 Cydippid sp. C : 1
550–650	?*Aegina citrea* : 1 Hydromedusa sp. A : 1 Cydippid sp. A : 1 Narcomedusa sp. : 1 Hydromedusa sp. : 1	Apolemiidae sp. : 1 *Periphylla periphylla* : 1 *Bathocyroe fosteri* : 1 Lobata sp. A : 2 Narcomedusa sp. : 1 Hydromedusa spp. : 2 Agalmatidae spp. : 4 Lobata spp. : 2
650–750	Apolemiidae sp. : 1 Hydromedusa sp. : 1 Agalmatidae spp. : 2	Hydromedusa spp. : 4 Lobata sp. : 1
750–1440	Narcomedusa sp. : 1 Hydromedusa spp. : 8	Aeginid sp. : 1 Hydromedusa spp. : 5 Narcomedusa sp. : 1 Lobata sp. : 1
1440–1447 (near bottom)		Cydippid sp. B : 15 Hydromedusa spp. : 9

canals were seen. The manubrium was narrow and without a gastric peduncle. Jelly was thin and the exumbrella smooth. The bell diameter was about 4 cm. The bell height was about 3/4 of diameter. The length of the manubrium was ×0.5 the bell diameter. The width of the velum was ×0.2 the bell diameter. When actively swimming, the frequency of pulsation was up to 2.2 Hz (pulsations per second). When gently pulsating it was about 0.7 Hz. When agitated by flow caused by the submersible, it ceased to pulsate.

Uchida (1947) reported *Colobonema typicum* (Maas) from Sagami Bay and Suruga Bay; they were corrected to *C. sericeum* by Kramp (1961).

Solmissus incisa (*Fewkes*).—Two forms occurred. Their characteristics are summarized in Table 3. Two specimens of *Solmissus incisa* form A (Fig. 4A) occurred during Dive 775, one at 513–516 m and the other at 403–405 m. Two specimens of *Solmissus incisa* form B (Fig. 3B) occurred at 403–408 m during Dive 775.

Solmissus incisa form A and *S. incisa* form B were different in the thickness of the um-

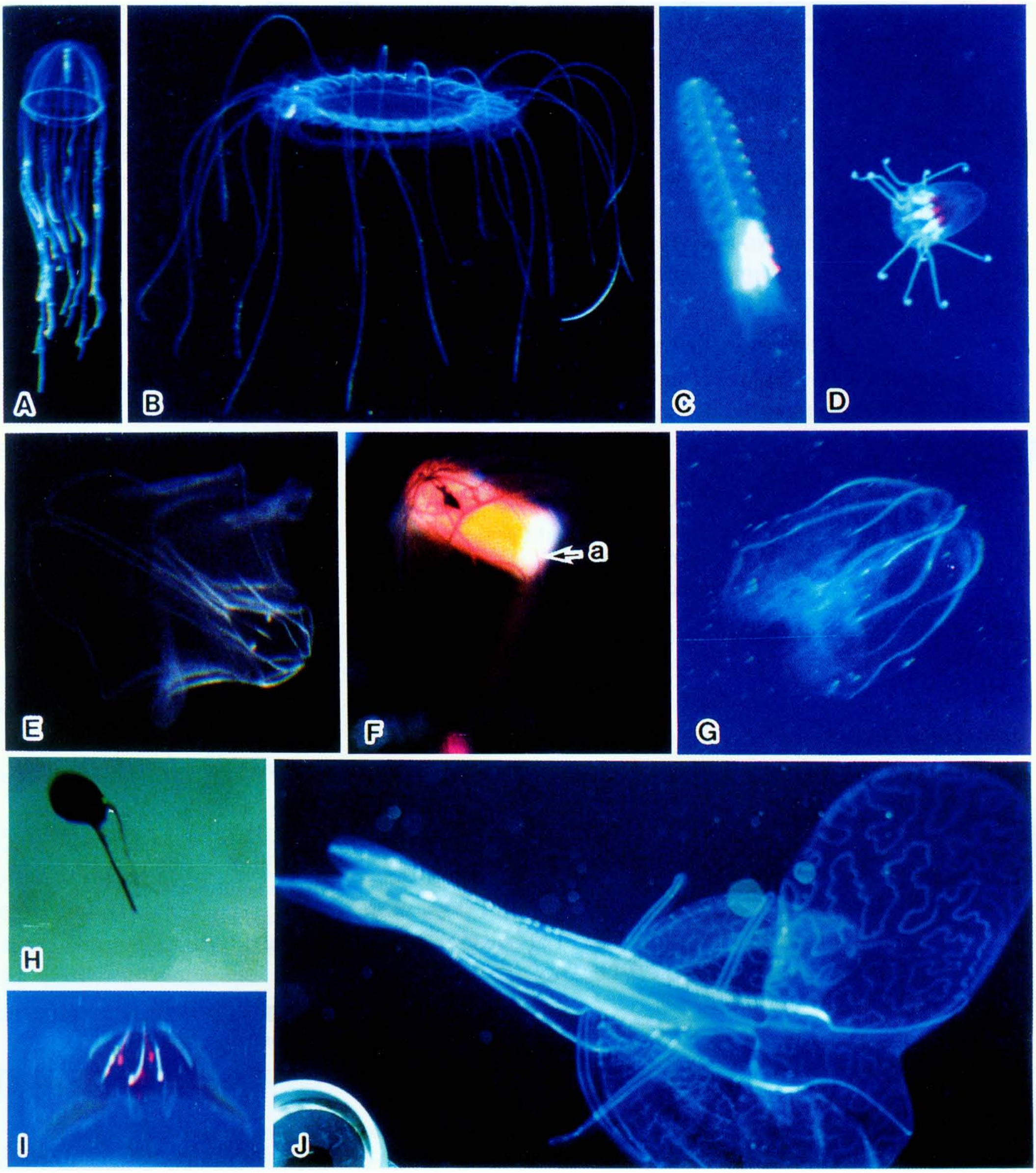

Fig. 3. In situ photographs of gelatinous zooplankton from Sagami Bay. **A.** *Colobonema sericeum*, Dive 775, 503 m, bell diameter ca. 4 cm. **B.** *Solmissus incisa* form B, Dive 775, 405 m, bell diameter 9 cm. **C.** Agalmatidae sp., Dive 775, 407 m, total length 10–11 cm. **D.** *Periphylla periphylla*, Dive 775, 594 m, bell diameter ca. 2 cm. **E.** *Bathocyroe fosteri*, Dive 775, 502 m, total length 8 cm. **F.** *Bathocyroe fosteri*, Dive 775, 496 m, showing large auricle (*a*) and pigmented stomodaeum and infundibulum; total length 9 cm. **G.** *Bolinopsis* sp., Dive 775, 507 m, length unknown. **H.** Cydippid sp. B, Dive 775, 1446 m, body length 8 cm. **I.** Lobata sp. A, Dive 775, 607 m, height of the body proper 2 cm. **J.** *Kiyohimea usagi*, Dive 723, ca. 400 m, a view in the tentacular plane; total length 28 cm.

Table 3. Comparison of characteristics between *Solmissus incisa* form A and *S. incisa* form B.

		S. incisa form A	*S. incisa* form B
Number of individuals		2	2
Depth		403–405, 513–516	403–408
Bell diameter		5 cm, 6 cm	5 cm, 10 cm
Height of umbrella/bell diameter		0.25, 0.33	0.22, 0.24
Umbrella (gelatinous disk)		Thick, flat hemisphere	Thin, slightly depressed at the top of the umbrella
Tentacles	Number	24, 24	21, 24
	Length/height	0.93, 0.98	1.03, 1.14
	Characteristics	Rigid, go directly downward when actively swimming, extend horizontally when quiescent	Thin, extend up proximally and then go straight down with obvious arching
Mouth diameter/bell diameter		0.14, 0.38 (?injured)	0.03, 0.06
Stomach pouches	Length/height	0.08	0.11, 0.12
	Width/height	0.06	0.07, 0.08
Marginal lappets		Very thin, peronial grooves unclear	Length/bell diameter: 0.13, width/bell diameter: 0.13
Velum		Undetectable	Width/bell diameter: 0.09

brella (or disk) and the characteristics of the tentacles. *S. incisa* form B closely resembled the figure and description of *S. marshalli* Agassiz & Mayer in Mills & Goy (1988) and the photograph in Robison (1995). However, the number of stomach pouches in *S. marshalli* is up to 16 and the number of tentacles is the same as the number of stomach pouches (Kramp 1968), while our 2 specimens had 21 and 24 tentacles, respectively. *S. incisa* form B looked the same as the in situ photograph of *S. incisa* in Larson et. al. (1989), too. It is difficult to assign species names to *Solmissus* spp. even for specialists (Mills et. al. 1996). *S. incisa* is found from Pacific coasts of Japan, and *S. marshalli* also has been recorded from Sagami Bay (Uchida 1927).

***?*Aegina citrea** *Eschscholtz (Fig. 4B)*.—A single specimen occurred at 600 m during Dive 723. The number of tentacles was 4. The number of pouches and peronia was not visible. The bell diameter was 2–3 cm. The bell height was about 2/3 of the diameter. Width of the 'lappet +velum' was ×0.4 the bell diameter. The length of the tentacles were ×1.5–1.7 the bell diameter. It held its 4 long tentacles apically. Bell pulsation rate was 0.7–1.0 Hz.

As the number of pouches and peronia were not determined, it is possible that the specimen was *Aeginopsis*. Pérès (1959) reported *Aeginopsis laurentii* Brandt, which was later corrected to *A. citrea* (Larson et al. 1989), from the coast of Onagawa and Kinkasan. On the other hand, *Aegina rosea* Eschscholtz is common off the southern Pacific coasts of Japan during winter (Uchida 1927); it is referred to as a junior synonym of *A. citrea* by Kramp (1961).

Hydromedusa sp. A *(Fig. 4C)*.—A single specimen of Anthomedusa or Limnomedusa occurred at 590 m during Dive 723. Jelly was thick and the umbrella was almost hemispherical. There were 16 short (×0.1–0.3 the bell diameter) tentacles. The number of radial canals was 6. The mouth was simple. Gonads which were attached to the stomach walls and extended to the proximal part of the radial canals looked yellowish under the light of the submersible. The bell diameter was about 3 cm. The height was ×0.9, and the manubrium length was ×0.4 the bell diameter.

Siphonophores

Three specimens occurred during Dive 723, and 10 occurred during Dive 775. All of the specimens were physonects. The lack of calycophoran species may be due to their small size and transparency. Very limited information is available about the shape and size of living physonect colonies and identification is usually based on the microscopic morphology of parts of the colony, especially nectophores. Consequently we were only able to distinguish Apolemiidae spp. and Agalmatidae spp.

Apolemiidae spp. (*Fig. 4D, F*).—Two specimens occurred at 745 m during Dive 723 and at 604 m during Dive 775. They were identified as Family Apolemiidae from the short series of nectophores and long siphosome crowded with numerous appendages. However, tentacles between nectophores, the most important characteristics of the genus *Apolemia* (Totton 1965), could not be seen in the video images. The stem was suspected to be bifurcate in a specimen seen during Dive 723 (Fig. 4D), the total length of which was about 25 cm, nectosome was about 4 cm, siphosome to the point of the branch was about 6 cm, longer branch was about 15 cm, and the shorter branch was about 12 cm. Total length could not be determined in the specimen from Dive 775. It had 6 nectophores which pulsated at 0.9 Hz. Siphosome length was ×20 the nectosome length.

The only member of the Apolemiidae reported in Japanese waters has been one specimen of *Apolemia uvaria* (Lesueur) collected by the *Albatross* in the Strait of Tsugaru (Kawamura 1954).

Agalmatidae spp. (*Figs 3C, 4E, H*).—Two specimens occurred at 687–699 m during Dive 723, and 9 specimens occurred at various depths between 400 and 809 m during Dive 775. Although each of them had 2 rows of nectophores and a siphosome on an elongated stem, they varied in the number of nectophores present (6–26), and the proportional ratios of nectosome and siphosome (2 : 1–1 : 4). One specimen found at 403–408 m during Dive 775 had a short siphosome and swam slowly in the direction of the siphosome or swam very fast in the direction of the pneumatophore.

Scyphomedusae

Periphylla periphylla (*Péron & Lesueur*) (*Fig. 3D*).—A single specimen occurred at 594 m during Dive 775. It had 16 tentacles, 8 stomach pouches and gonads. Stomach pouches were dark brown and the gonads were white. The exumbrella was dome-shaped and the subumbrella was conical. The diameter of the bell was about 2 cm, the height was about 3 cm, and the tentacles were about 2 cm long.

This species is known from the deep waters of the Japanese Pacific coast and from the northern portion of the Sea of Japan (Yamada 1997).

Ctenophores

Two specimens occurred during Dive 723, and 28 occurred during Dive 775. Of these 30 specimens, 24 specimens clearly comprised 7 species. The terminology used in the following descriptions is primarily that of Harbison & Madin (1982) and Harbison (1985).

Bathocyroe fosteri *Madin & Harbison* (*Figs 3E, F, 5*).—Three specimens occurred during Dive 775; 1 at 593–594 m and 2 at 497–500 m. Total length of 2 of the specimens was 8 and 9 cm. Paragastric canals ran parallel. Oral lobes were large and their length was up to ×0.8 the total length. The width of the oral lobe was 7 cm in 1 specimen. Oral lobes had a narrow cen-

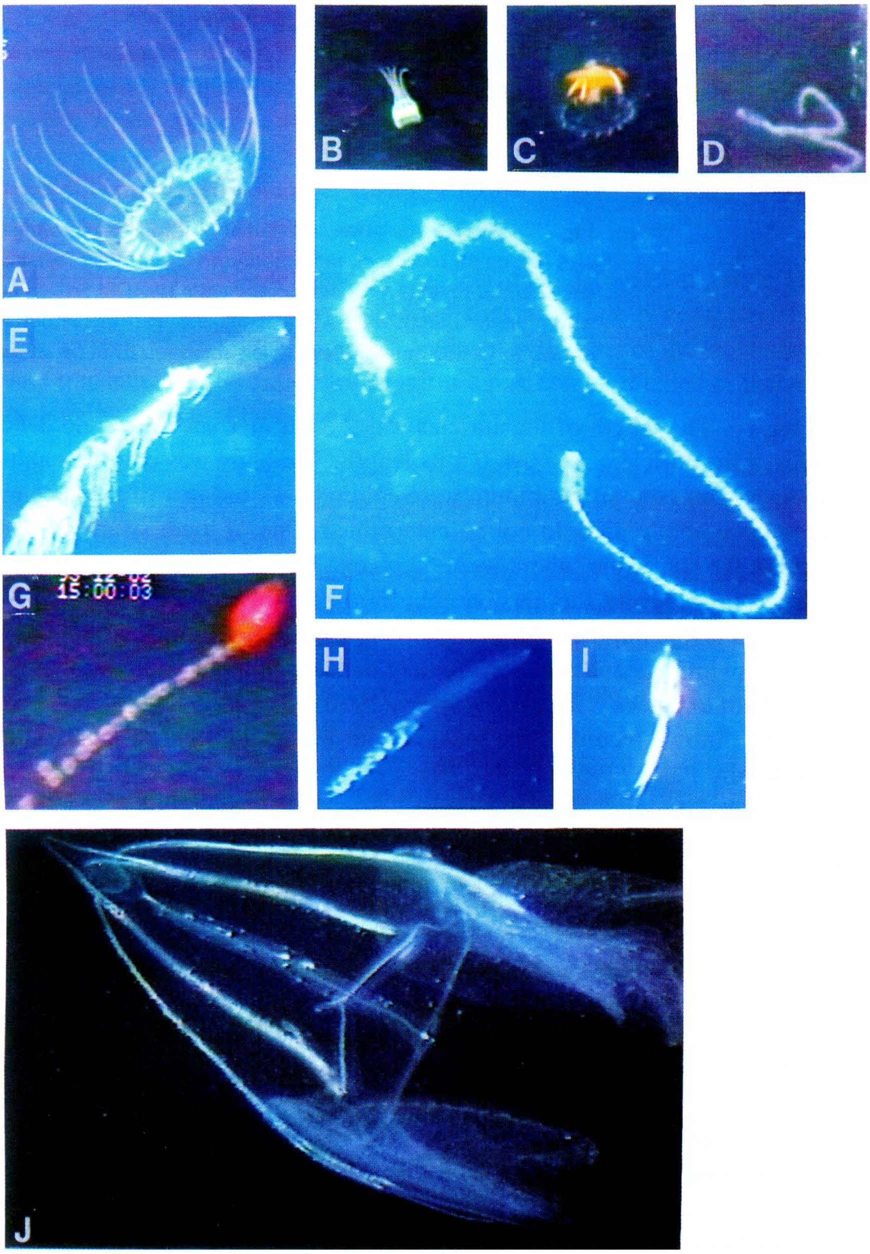

Fig. 4. Gelatinous zooplankton from Sagami Bay printed from in situ video. **A.** *Solmissus incisa* form A, Dive 775, 514 m, bell diameter 5 cm. **B.** ?*Aegina citrea*, Dive 723, 600 m, bell diameter 2–3 cm. **C.** Hydromedusa sp. A, Dive 723, 590 m, bell diameter ca 3 cm. **D.** Apolemiidae sp., the stem of which was suspected to be bifurcate, Dive 723, 745 m, total length ca 15 cm. **E.** Agalmatidae sp., Dive 775, 400 m, length unknown. **F.** Apolemiidae sp., Dive 775, 604 m, length unknown. **G.** Cydippid sp. A, Dive 723, 596 m, body length 4 cm. **H.** Agalmatidae sp., Dive 775, 585 m, length unknown. **I.** Cydippid sp. C, Dive 775, 502 m, length unknown. **J.** *Kiyohimea usagi*, a view in the stomodaeal plane of the same specimen as in Fig. 3J; the auricles originated from a position higher than the level of the mouth.

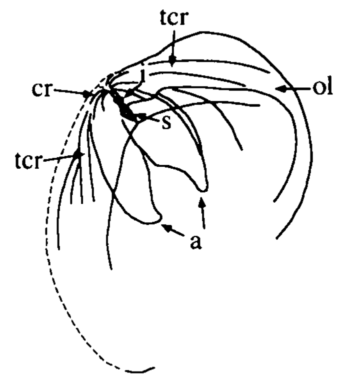

Fig. 5. *Bathocyroe fosteri*. A drawing of Fig. 3F, showing large auricles (*a*), comb rows (*cr*), infundibulum (*i*), oral lobe (*ol*) and its thickened central region (*tcr*), and stomodaeum (*s*). The broken line denotes where the outline of the body was unclear. Part of the outline was not drawn, for it was impossible to determine even from the original print.

tral thickened region. The length of the auricles was 2.3 cm in 1 specimen and 3.7 cm in another. The width of the auricle was ×0.4–0.5 its length. The body was colorless and transparent. The stomodaeum and the infundibulum were colored dark red in 1 of the specimens (Fig. 3F), while in others coloration could not be determined. One of them swam by flapping the oral lobes at about 0.6 Hz, while others were quiescent. One specimen was disturbed by the water movement caused by the submersible, but the body was robust enough to recover its usual posture within a few minutes. This is in contrast to *B. paragaster* (Ralph & Kaberry), which are inactive swimmers and are "...extremely delicate in texture, the least current being sufficient to tear them to pieces" (Ralph & Kaberry 1950).

This is the first definitive record of the species from waters adjacent to Japan, although the Ocyropsis reported by Pérès (1959) from 2 dives off Kinkasan and Onagawa is assumed to have been this species (Madin & Harbison 1978).

Kiyohimea usagi *Matsumoto & Robison (Figs 3J, 4J)*.—A single specimen occurred at 406 m during Dive 723. The outline of the body was V-shaped and the body was extremely compressed in the tentacular plane. The tentacular axis measured about 1/4 of the stomodaeal axis which was not longer than the body height. There were triangular ear-like aboral processes in the tentacular axis, one of which was 3 times longer than the other. The statocyst was sunken at the bottom of a cleft as deep as the shorter aboral process. The oral lobes were moderately large and their lengths were about ×0.8 that of the body height. The width of the oral lobes was ×0.9 that of the stomodaeal axis. The auricles were 1/4–1/3 as long as the body height. The auricles were situated at a level higher than the mouth. The length of the stomodaeum was about ×0.9 the body height. Canals on the oral lobes were complexly meandering. The presence of tentacles was unable to be determined from the video images. No pigmentation was observed. The height of the body proper (length from the aboral end of the body, except aboral processes, to the mouth) was about 19 cm and the total length (from the top of the aboral processes to the ends of the oral lobes) was about 33 cm. During the observation it was buoyant in the water column with its comb rows moving.

This is the first record of *Kiyohimea usagi* from the coastal waters of Japan, although several specimens of *K. aurita* Komai & Tokioka were collected off Shirahama and first described in 1940. Both the presence of secondary tentacles and the blind end of the oral canal in *K. usagi*, which are mentioned as the main differences between the two species (Matsumoto & Robison 1992), could not be verified from the video images. However, the V-shaped outline of the body fits better with the description of *K. usagi* than the more rounded body of *K. aurita*. Therefore, we identified the present specimen as *K. usagi*. The total length of the present specimen (ca 33 cm) was larger than both *K. aurita* (14 cm, measured from the figure in Komai & Tokioka 1940) and *K. usagi* (up to 28 cm) (Matsumoto & Robison 1992). Auricles in the present specimen occurred higher up the body than those of both *K. aurita* and *K. usagi*, which occurred at the level of the mouth, apparently because of the elongation of the body or the oral lobes. The canals on the oral lobes were more complex than those in the figures in Matsumoto & Robison (1992). This suggests that the present specimen is a more fully grown stage of Komai & Tokioka's *K. aurita* or Matsumoto & Robison's *K. usagi*. The taxonomic state of these species probably needs future review.

***Bolinopsis* sp.** (*Fig. 3G*).—A single specimen occurred at 507–515 m during Dive 775. Body shape resembled that of a cucumber, longer than wide and slightly compressed. The length of the tentacular axis was ×0.4 the total length, and was ×0.9 that of the stomodaeal axis. It was colorless and transparent. The oral lobes began at a position a little higher than the level of the mouth. The length of the oral lobes was ×0.46 the total length.

***Cydippid* sp. A** (*Fig. 4G*).—A single specimen occurred at 596 m during Dive 723. The body was bright orange-red. The body was not greatly compressed. Tentacles had side branches, which were of similar shapes and were equally spaced from the basal to the distal part of the tentacle. The length of the body was 4.0 cm, the width was 2.3 cm, and the length of the tentacles was greater than 34 cm.

There has been no previous record of this type of cydippid from coastal waters of Japan.

***Cydippid* sp. B** (*Fig. 3H*).—Fifteen specimens occurred just above the bottom (1445–1447 m) during Dive 775. The whole body was purplish black and the shape resembled an egg plant. The length of the body was 1.5–2.6 cm (n=5) and the width was 0.7–1.7 cm (n=5). Tentacle length was up to 53 cm when extended and they had filiform side branches. Parts of the comb rows seemed to be luminescent. The cydippids did not actively move by themselves but drifted with the current with their tentacles always extended downward, as if feeding on the benthos or on near-bottom plankton.

There has been no previous record of this type of cydippid from the coastal waters of Japan.

***Cydippid* sp. C** (*Fig. 4I*).—A single specimen occurred at 502 m during Dive 775. The body was not compressed and the oral end projected a little (1/7 of body length). The length of the stomodaeal axis was ×0.4 the body length. Two tentacles, which seemed to have no side branches, projected aborally. The body was slightly pigmented with pink or red.

There has been no previous record of this type of cydippid from the coastal waters of Japan.

***Lobata* sp. A** (*Fig. 3I*).—Two specimens occurred at 600 and 606 m during Dive 775. The following description is mainly of the specimen that occurred at 606 m. The body was dome-shaped and moderately compressed in the stomodaeal plane. The height of the body proper was 2 cm. The length of the stomodaeal axis was 3 cm. The length of the tentacular axis was ×0.4 that of the stomodaeal axis. The oral lobes were large and wider than long. The width of the oral lobe was ×1.4 its length, which was 2.8 cm. Eight rows of comb plates were equal in length and reached no further than the level of the mouth. The length of auricles was 1 cm. The body proper was pigmented deep red, while the oral lobes were slightly pigmented.

There has been no previous record of this type of lobate from the coastal waters of Japan.

Vertical distributions and differences between dives

There was no statistically significant differences between two dives in the abundance of hydromedusae, siphonophores nor ctenophores. Therefore, we treated the results from the two dives as two replicates in each group of 6×3 (the six depth layers and the three taxonomical categories) two-way ANOVA.

Apparently there were several tendencies to be noted; (1) small unidentified hydromedusae dominated below 750 m to above the bottom; (2) siphonophores were absent from below 750 m; (3) ctenophores were scarce between 650–1440 m where only two specimens occurred throughout the two dives. They were abundant and diverse between 399–650 m where 5 out of 6 species occurred. The exception was just above the bottom where another species,Cydippid sp. B, was abundant during Dive 775. There were no statistically significant differences in the abundance among the six depth layers (399–450, 450–550, 550–650, 650–750, 750–1440, 1440–1447 m) nor among the three taxonomic categories.

Discussion

The number of species of cnidarians and ctenophores observed and/or collected by the *Johnson-Sea-Link* from midwater in the western Atlantic (Larson et al. 1991) and in the south-western Mediterranean (Mills et al. 1996), and those was observed off the Pacific coast of Japan by the *F.N.R.S. III* (Pérès 1959) and by the *Shinkai 2000* (present study) are summarized in Table 4. Our dives and those of the *F.N.R.S. III* are much inferior compared with the dives of the *Johnson-Sea-Link* with regard to the number of dives and the inability to collect specimens . Our results and those of the *F.N.R.S. III* were all observational, while those of the *Johnson-Sea-Link* are mainly from specimens collected in situ.

Pérès (1959) reported 4 species of hydromedusae (*Solmissus* sp., *Crossota rufobrunnea* (Kramp), *Aeginopsis laurentii*, and *Pantachogon haeckeli* Maas), and three genera of ctenophores (*Ocyropsis*, *Leucothea*, and *Bolinopsis*) were dominant during his dives off northern Japan. Of these species, 4 specimens of *Solmissus* occurred during Dive 775. The photograph of *Solmissus* sp. given by Pérès (1959: Plate 1) is *Solmissus incisa* form A, according to

Table 4. Number of species of cnidarians and ctenophores observed and/or collected from the midwater (greater than 400 m) of the world's oceans by submersibles. Numbers in parentheses in western Pacific dives show the number of species identified to the specific name. In the Atlantic and Mediterranean dives all the numbers of species shown are identified species, including undescribed species.

Area	Western Atlantic	Mediterranean	Western Pacific	
Submersible	*Johnson-Sea-Link I & II*	*Johnson-Sea-Link I*	*F.N.R.S. III*	*Shinkai 2000*
No. of dives	136	26	2	2
Hydromedusae	36	8	13* (4*)	4 (2)
Siphonophores	n. d.	13	8 (1)	2 (0)
Cubomedusae	1	0	0**	0
Scyphomedusae	13	3	2 (1)	1 (1)
Ctenophores	n. d.	11	7 (1)	7 (2)
Literature	Larson et al. 1991	Mills et al. 1996	Pérès 1959	Present study

* One species from another dive of *F.N.R.S. III* in Japan is included.

** Pérès (1959) reported a specimen of Carybdeidae, but it cannot be a cubomedusa according to his description (see text).

our definition, for the 29 stiff tentacles are held upward and don't arch downwards midway. A single specimen of ?*Aegina citrea* occurred during Dive 723 and was thought to belong to the same species as Pérès's *A. laurentii* (Pérès 1959: Fig. 2), which is now thought to really have been *A. citrea* (Larson et al. 1989). We did not see *C. rufobrunnea* or *P. haeckeli*, perhaps because of their small size (20–30 mm and 15–20 mm respectively (Pérès 1959)). A single specimen of *Bolinopsis* occurred during Dive 775. Pérès's *Ocyropsis* is thought to have been *Bathocyroe fosteri* (Madin & Harbison 1978). We saw 3 specimens of *B. fosteri* during Dive 775. Though *Leucothea* is generally thought to be a warm water species, Pérès (1959) reported them as dominant below the thermocline. He didn't describe the *Leucothea* he saw, so we cannot know what he actually observed. In conclusion, it may be safe to say that *Solmissus* and *Bathocyroe* were dominant in the water column during both series of dives off Japan.

Pérès (1959) reported that macroplankters were much less abundant below 1250 m. In our dives, from 750 to 1440 m, small hydromedusae were dominant and siphonophores and ctenophores were scarce, although there were no significant differences in the abundance among the six depth layers nor among hydromedusae, siphonophores and ctenophores.

Though the statistical test showed no significant differences in the abundances of hydromedusae, siphonophores nor ctenophores between two dives, it only tells that we could not detect differences in the abundances when we combined all the different species into the three categories. There were no species that occurred during both of our two dives, while some higher categories (e.g. Hydromedusa spp., Narcomedusa sp., Agalmatidae spp. etc.) overlapped. The hydrographical data showed that the characteristics of the water masses were not similar in the two years, although the dives were carried out in the same season. It is possible that the difference in hydrographic conditions resulted in different species composition of meso- and bathypelagic gelatinous zooplankton because of their high seasonality even in the holoplanktonic species (Mills et al. 1996). However, it is also possible that the sampling scale was too small to fully describe the species diversity of the water mass, and that such a difference in species composition was observed merely by chance. Further studies in this area will greatly expand the knowledge of the deep water gelatinous fauna in this region as has been the case in other areas of the world.

Acknowledgments

We thank Drs Shin Kubota (Seto Marine Biological Laboratory, Kyoto University) and Francesc Pagès (Institut de Ciències del Mar, CSIC) for help in identification, helpful discussion and critical reading of the manuscript. We thank Drs Manabu Shiraishi and Tomoko Sakami (National Research Institute of Aquaculture), who allowed us to use the video-computer system and the color video printer. We also thank the dive team of the submersible *Shinkai 2000* and crew of the tender ship Natsushima, JAMSTEC, for their kind help with both dives. All photographs appear by the courtesy of JAMSTEC.

Literature Cited

Barnard, C. J., F. S. Gilbert, & P. K. McGregor 1993. *Asking Questions in Biology: Design, Analysis and Presentation in Practical Work. First Edition.* Longman Scientific & Technical, New York, 157 pp.

Harbison, G. R. 1985. On the classification and evolution of the Ctenophora. p. 78–100. In *Origins and Relationships of Lower Invertebrates* (eds. Morris, S. C., J. D. George, R. Gibson & H. M. Platt). Clarendon Press, Oxford.

Harbison, G. R. 1986. Toward a study of the biogeography of pelagic ctenophores. p. 112–117. In *UNESCO Technical Papers in Marine Science 49. Pelagic Biogeography*. Proceedings of an international conference. The Netherlands 29 May-5 June 1985 (eds. Pierrot-Bults, A. C., S. van der Spoel, B. J. Zahuranec, & R. K. Johnson). UNESCO, Paris.

Harbison, G. R. & L. P. Madin 1982. Ctenophora, p. 707–715. In *Synopsis and Classification of Living Organisms. Vol. 1* (ed. S. P. Parker). McGraw Hill, New York.

Iwata, S. 1979. The oceanic conditions of the Sagami Bay from the aspect of average field, p. 15–26. In *Report on the Survey of Resources and Environment in Sagami Bay–II*. Kanagawa Prefectural Fisheries Research Institute, Misaki & Sagami Bay Branch, Kanagawa Prefectural Fisheries Research Institute, Odawara. (In Japanese.)

Kawamura, T. 1954. A report on Japanese siphonophores with special references to new and rare species. *J. Shiga Pref. Junior Coll. Ser. A* **2**: 99–129, 7 pls.

Komai, T. & T. Tokioka 1940. *Kiyohimea aurita*, n. gn., n. sp., type of a new family of lobate Ctenophora. *Annot. Zool. Japon* **19**: 43–46.

Kramp, P. L. 1961. Synopsis of the medusae of the world. *J. Mar. Biol. Ass. U.K.* **40**: 1–469.

Kramp, P. L. 1968. The hydromedusae of the Pacific and Indian Oceans. Sections II and III. *Dana Rep.* **72**: 1–200.

Larson, R. J., C. E. Mills, & G. R. Harbison 1989. In situ foraging and feeding behaviour of Narcomedusae (Cnidaria: Hydrozoa). *J. Mar. Biol. Ass. U.K.* **69**: 785–794.

Larson, R. J., C. E. Mills, & G. R. Harbison 1991. Western Atlantic midwater hydrozoan and scyphozoan medusae: in situ studies using manned submersibles. *Hydrobiologia* **216/217**: 311–317.

Larson, R. J., G. I. Matsumoto, L. P. Madin, & L. M. Lewis 1992. Deep-sea benthic and benthopelagic medusae: recent observations from submersibles and a remotely operated vehicle. *Bull. Mar. Sci.* **51**: 277–286.

Laval, Ph., J.-C. Braconnot, C. Carré, J. Goy, P. Morand & C. E. Mills 1989. Small-scale distribution of macroplankton and micronekton in the Ligurian Sea (Mediterranean Sea) as observed from the manned submersible Cyana. *J. Plankton Res.* **11**: 665–685.

Madin, L. P. & G. R. Harbison 1978. *Bathocyroe fosteri* gen. nov., sp. nov.: a mesopelagic ctenophore observed and collected from a submersible. *J. Mar. Biol. Ass. U.K.* **58**: 559–564.

Matsumoto, G.I. & B.H. Robison 1992. *Kiyohimea usagi*, a new species of lobate ctenophore from the Monterey Submarine Canyon. *Bull. Mar. Sci.* **51**: 19–29.

Mills, C. E. & J. Goy 1988. In situ observation of the behavior of mesopelagic *Solmissus* narcomedusae (Cnidaria, Hydrozoa). *Bull. Mar. Sci.* **43**: 739–751.

Mills, C. E., P. R. Pugh, G. R. Harbison, & S. H. D. Haddock 1996. Medusae, siphonophores and ctenophores of the Alborán Sea, south western Mediterranean. *Sci. Mar.* **60**: 145–163.

Pérès, J.-M. 1959. Deux plongées au large du Japon avec le bathyscaphe français *F.N.R.S. III*. *Bull. de l'Institut de Océanographique* **1134**: 1–28.

Pugh, P.R. & M.J. Youngbluth 1988. A new species of *Halistemma* (Siphonophora: Physonectae: Agalmidae) collected by submersible. *J. Mar. Biol. Ass. U.K.* **68**: 1–14.

Ralph, P. M. & Kaberry, C. 1950. New Zealand coelenterates. Ctenophores from Cook Strait. *Zool. Publ. Victoria University College* **3**: 1–11.

Robison, B. H. 1995. Light in the ocean's midwaters. *Scientific American* **273**: 60–64.

Siegel, S. & N. J. Castellan, Jr. 1988. *Nonparametric Statistics for the Behavioral Sciences*. Second Edition. McGraw-Hill, New York, 399 pp.

Totton, A. K. 1965. *A Synopsis of the Siphonophora*. British Museum (Natural History), London, 230 pp, 40 pls.

Uchida, T. 1927. Studies on Japanese Hydromedusae. 2. Trachymedusae and Narcomedusae. *J. Fac. Sci., Imp. Univ. Tokyo, Sect. 4, Zool.* **1**: 145–241, pl. 10–11.

Uchida, T. 1947. Medusae in the vicinity of Shimoda. *J. Fac. Sci. Hokkaido Univ., Ser. 4, Zool.* **9**: 331–343.

Yamada, M. 1997. Class Scyphozoa, p. 541–553. In *An illustrated Guide to Marine Plankton in Japan* (eds. M. Chihara & M. Murano). Tokai University Press, Tokyo (In Japanese.)