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Article spécial n°8

Present status of the Japan Sea chemical pollution: An overview[*]

A. V. TKALIN[**]

1. Introduction

From 28 to 31 of October, 1991 in Vladivostok (formar USSR) first consultative meeting of experts and national focal points on the development of NOWPAP took place (NOWPAP-Action Plan for Protection of Marine Environment in the North-West Pacific). This meeting was organised by UNEP in cooperation with the Center for International Projects (Moscow) and Pacific Oceanological Institute (Vladivostok). 29 participants from UNEP, China, Japan, Republic of Korea and USSR worked aboard the research vessel "Akademik Korolev" of Far Eastern Regional Hydrometeorological Research Institute (FERHRI). By March, 1992 National Focal Points will prepare for UNEP National Reports including the information on the state of marine environment, national policy, measures and relevant activities on marine pollution problems in their countries. This overview had been prepared for inclusion in the Russia National Report to UNEP.

It is based on the data of FERHRI and Vladivostok Center for Environmental Pollution Control. It is necessary to intercompare these data with the results of Japanese and Korean researchers on chemical pollution of the Sea of Japan.

Investigations of the NW Pacific chemical pollution have been carried out by FERHRI specialists since 1970-s. Regular expeditions to study chemistry, biology and pollution of the open ocean and its marginal seas are fulfilled aboard FERHRI research vessels. The Sea of Japan, located between USSR, Japan and Korea, attracts maximum attention.

In the coastal zone of the Sea of Japan, in the Peter the Great Bay, chemical pollution studies have been carried out by Vladivostok Center for Environmental Pollution Control as well as by FERHRI specialists.

In 1990 about 486×10^6 m^3 of municipal and industrial waste waters were discharged in the Peter the Great Bay (23% - without any treatment). 446×10^6 m^3 were discharged from Vladivostok, 26×10^6 m^3 - from Nakhodka. With these waste waters approximately 19×10^3 tons of suspended solids, 373 tons of petroleum hydrocarbons, 51 tons of detergents, 54 tons of iron and about 10 tons of other metals were introduced in the Bay in 1990. With the river runoff 36×10^3 tons of suspended solids, 230 tons of petroleum hydrocarbons and 94 tons of detergents were discharged in 1989. Accidental oil spills were about 30 tons in 1989 and 63 tons in 1990.

2. Materials and methods

Total non-polar petroleum hydrocarbons (PHC) in sea water and bottom sediments were analysed by IR spectrophotometry (KARLBERG and SKARSTEDT, 1972; ORADOVSKY, 1977; 1979). Aromatic hydrocarbons (AHC) in sea water were measured by modified spectroflorimetric method in chrysene equivalents (IOC, 1984). Hydrocarbons were extracted from 21 or sea water by n-hexane using magnetic stirrer during 30 min. After column chromatography on Al_2O_3 fluorescence intensity was measured on JASCO FP-550 spectrofluorometer (Japan). Excitation wavelength - 310 nm, emission -

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[*] Received May 13,1992

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360 nm.

Synthetic surface-active substances (anionic detergents or surfactants) were analysed by spectrophotometric method with methylene-blue after chloroform extraction (ORADOVSKY, 1977). Chlorinated hydrocarbons were analysed by gas-liquid chromatography with electron capture detector (ORADOVSKY, 1977, 1979, 1982). Nutrients were measured by photocolorimethric methods (ORADOVSKY, 1977). Trace metals (TM) in sea water and bottom sediments were analysed by atomic absorption spectrophotometry (ORADOVSKY, 1979, 1982).

3. Total non-polar petroleum hydrocarbons

Average concentaration of petroleum hydrocarbons in the open Sea of Japan was 18 ppb in 1986-1988. In the Sea of Phillippines (to the south from 20°N) mean PHC content for the same period was 10 ppb, in the Kuroshio and Oyashio region- 12 ppb (TKALIN, 1991a). Elevated PHC concentrations in the Sea of Japan are explained, probably, by its encloseness and lower water temperature (in comparison with the Sea of Philippines), which does not promote biochemical degradation of organic pollutants. In 1989-1990 average content of petroleum hydrocarbons in the Sea of Japan was approximarely the same.

In the coastal waters of the Sea of Japan PHC concentrations are significantly higher. In 1990 average PHC content in the Golden Horn Bay (Vladivostok is situated around this Bay) exceeded 50 ppb (maximum permissable concentration for the Russia coastal marine waters). In the Amursky Bay and the Bay of Nakhodka PHC concentrations were also close to this value.

Higher concentrations of petroleum hydrocarbons in bottom sediments are observed near the main ports (Vladivostok, Nakhodka, Vrangel). In the Golden Horn Bay mean PHC content was about 10 ppt in 1990 (maximum - 40 ppt), in the Amursky Bay and the Bay of Nakhodka - 0.5-0.8 ppt (maximum - 2-3 ppt). Elevated PHC content was ovserved also near dredged material dumping sites. For example, in the Amursky Bay concentration of petroleum hydrocarbons in bottom sediments in the dumping area exceeded 4 ppt.

4. Aromatic hydrocarbons

Background level of aromatic hydrocarbons (AHC) in the North Pacific waters is about 0.04 ppb. In 1988 aromatic hydrocarbons content in the Japan Sea surface waters was 0.04-0.07 ppb (TKALIN, 1991b).

In 1989, first USSR-DPRK expedition to study chemical pollution of the Japan Sea coastal waters near the Tumangan River mouth was carrid out aboard FERHRI research vessel. Average AHC content outside the area affected by the river runoff influence was 0.06 ppb, near the river mouth concentrations of aromatic hydrocarbons reached 0.96 ppb (TKALIN and SHAPOVALOV 1991). In the same period AHC content in the Korean Strait was 0.03-0.15 ppb. Maximum concentration of aromatic hydrocarbons in surface waters of the Japan Sea in 1989 was 0.33 ppb.

In 1990 second USSR-DPRK expedition to study chemical pollution of the North Korea coastal waters was fulfilled also aboard FERHRI research vessel. In the East-Korean Gulf AHC content varied from 0.03 to 0.15 ppb (TKALIN, 1991b).

5. Synthetic surface-active substances (Anionic detergents)

In 1986-1988 average content of anionic detergents in the Sea of Japan was 25 ppb, in the Kuroshio-Oyashio region - 21 ppb, in the Sea of Philippines (to the south of 20° N)- 17 ppb (TKALIN, 1991a). As in the case of petroleum hydrocarbons, elevated concentrations of detergents in the Sea of Japan are explained by its lower water temperature and relative encloseness.

In 1989, during the first USSR-DPRK expedition near the Tumangan River mouth maximum surfactant content reached 30-40 ppb. Concentrations of detergents outside the area affected by the river runoff influence varied from 5 to 10 ppb (TKALIN and SHA-

POVALOV 1991). In 1990 average content of surfactants in the East-Korean Gulf was 10 ppb, maximum- 29 ppb (TKALIN, 1991b).

In the coastal waste of the Japan Sea, near Vladivostok and Nakhodka, concentrations of anionic detergents are significantly higher due to disharge of municipal and industruial waste waters. Though average detergent content in the Golden Horn Bay did not exceed maximum permissable concentration (100 ppb), measured concentrations occasionally reached 150-250 ppb.

6. Chlorinated hydrocarbons and nutrients

During the last years, DDT, DDD, DDE, α-HCH and γ-HCH are found in the Peter the Great Bay constatly. In 1989-1990 average concentrations of chlorinated hydrocarbons in sea water near Vladivostok and Nakhodka varied from 0.2 to 4.6 ng/l, maximum concentrations reached 100 ng/l. Organochlorines are discharged in the marine environment directly from agricultural areas as well as with river runoff.

In the bottom sediments of the Peter the Great Bay, concentrations of chlorinated compounds are also considerable. In 1990, average content of DDT and its metabolites in bottom sediments varied from 1 to 25 ng/g, α-HCH and γ-HCH - from "not detected" to 10 ng/g. Maximum concentrations of DDT, DDD and DDE reached 100-150 ng/g, HCH isomers - 50-70 ng/g.

In summer 1989 near the Tumangan River mouth, maximum concentrations of organochlorines were as follows: DDT - 1.4, DDD - 0.9, DDE - 0.6, α-HCH - 3.1, γ-HCH - 0.8 ng/l. Outside the area affected by the river runoff chlorinated compounds were not detected (TKALIN and SHAPOVALOV, 1991).

In the coastal zone of the Sea of Japan, near Vladivostok and Nakhodka, very high concentrations of nutrients were observed in surface waters. In 1990 maximum content of ammonia in the Golden Horn Bay was 273 ppb, in the Nakhodka Bay - 184 ppb, in the Amursky Bay - 132 ppb. Maximum nitrate concentrations in the same areas were 230-290 ppb, maximum phosphate content also exceeded 100 ppb.

7. Trace metals

Dissolved trace metal contents in the open Sea of Japan are less than following figures: Cu - 0.1, Pb - 0.05, Co - 0.02, Ni - 0.02 ppb (TKALIN and SHAPOVALOV, 1991). In the coastal zone, near Vladivostok and Nakhodka, dissolved TM concentrations are significantly higher. For example, in 1990 average TM concentrations in the Golden Horn Bay were as follows: Cu-4.0, Pb - 1.8, Co - 0.4, Ni - 0.6, Cd - 0.3, Hg - 0.02 ppb. Maximum content of zinc was about 200 ppb, iron - 2000 ppb.

Higher concentrations of trace metals in bottom sediments were also observed near Vladivostok and Nakhodka. In 1990 mean copper content in the Golden Horn Bay was 91 ppm, in the Amursky Bay - 19 ppm, in the open Peter the Great Bay - 3 ppm. Concentrations of lead were as follows: 124, 21 and 6 ppm, cadmium - 4.9, 1.4 and 0.5 ppm, mercury - 0.72, 0.06 and 0.02 ppm respectively. Maximum content of lead in the Golden Horn Bay was 380 ppm, cadmium - 15 ppm, mercury - about 2 ppm.

Elevated TM content in bottom sediments was observed also in the dredged material dumping sites. For example, average content of zinc in the Amursly Bay dumping site was 539 ppm, lead - 187 ppm, copper - 136 ppm, cadmium - 2 ppm.

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The environmental conditions of the tunas' maneuvering sphere in the Bay of Bengal*

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and Hisayuki ARAKAWA**

Abstract: In order to obtain information on the environmental conditions of the maneuvering sphere of tuna in the Bay of Bengal, the Indian Ocean, a series of investigations was conducted on board the T/S Shinyo-maru of the Tokyo University of Fisheries, in February 1987. Simultaneously with measurements of water temeprature, salinity, dissolved oxygen, underwater irradiance, and beam attenuation, experimental tuna-longline operations were also carried on in the same area. Regarding the water layer ranged from 38m to 69m, in which the group of tuna were caught, as their maneuvering sphere, its environmental data were obtaind through the observations, finding that those were 25.5 to 27.5 ℃ in temperature, 33.00 to 34.45 ‰ in salinity, 3.0 to 4.6 ml/l in dissolved oxygen content, 8.2 to 2.2 % in relative irradiance (i.e. total light), and 0.11 to 0.22 m^{-1} in beam attenuation coefficient, respectively. It was also understood that the maneuvering sphere of tuna was located just above the combined layer of thermocline, halocline, and oxycline or its upper part. Moreover, their sphere corresponded to slightly above or just within the high-turbidity water layer. From these results, it can be said that the tunas' living sphere of the Bay of Bengal is located in the shallowest water compared with any other tuna-fishing grounds all over the world. The reason of such a phenomenon may attribute to the location of the dissolved oxygen minimum layer locating in the subsurface layer of this oceanic water.

1. Introduction

The Bay of Bengal in the Indian Ocean is well-known as one of good fishing grounds of tuna group. The Bay has such an interesting characteristics that its surface-layer current shows, due to effects of seasonal changes of wind directions, a clockwise circulation pattern in spring while it shows a counterclockwise pattern in autumn and the salinity concentration of this layer is extraordinarily low due to enormous volume of water flown into the Bay from huge rivers. (WYRTKI, 1973)

The ecological studies on the tuna group made public in the past are mostly conducted from a viewpoint of their catch distribution in relation to their environmental conditions (UDA, 1960; KAWAI, 1969; SANDOVAL, 1971; HANAMOTO, 1975, 1986). For example, UDA (1960) informs that the range of inhabitant temperatures of tuna group is so wide as to be 11.0℃ to 32.0 ℃; HANAMOTO (1986) introduces data for inhabitant temperature, salinities, and dissolved oxygen among various ecological factors required for big-eye tuna of the Pacific Ocean indicating that the range of their inhabitant temperatures is so narrow as to be 10℃ to 15.0℃, the range of salinities of their inhabitant sphere is from 34.0‰ to 34.7‰ in the North Pacific Ocean and 34.5‰ to 35.5‰ in the South Pacific Ocean, and the minimum limit of their inhabitant dissolved oxygen is 1.0 ml/l.

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So far the studies mentioned above, the discussions are developed along a very limited number of environmental factors such as water temperatures, salinities, etc.. Accordingly, it is afraid that the results of those studies might be fairly deviated from the real state of *in situ* environmental conditions.

In this study, therefore, such optical elements as underwater irradiances and turbidities, which were measured simultaneously with longlining operations in the Bay of Bengal, are added to such conventional items as temperatures, salinities, and dissolved oxygen, so that a step advanced approach to the real state of tunas' environmental conditions can be realized.

2. Method

The surveyed area is a central part of the Bay of Bengal in the Indian Ocean. Fig. 1 shows the distribution of observation stations. At stations numbered 1 to 7, catching experiments and environment measurements were simultaneously conducted, and at Stn. 8, only the latter were carried out.

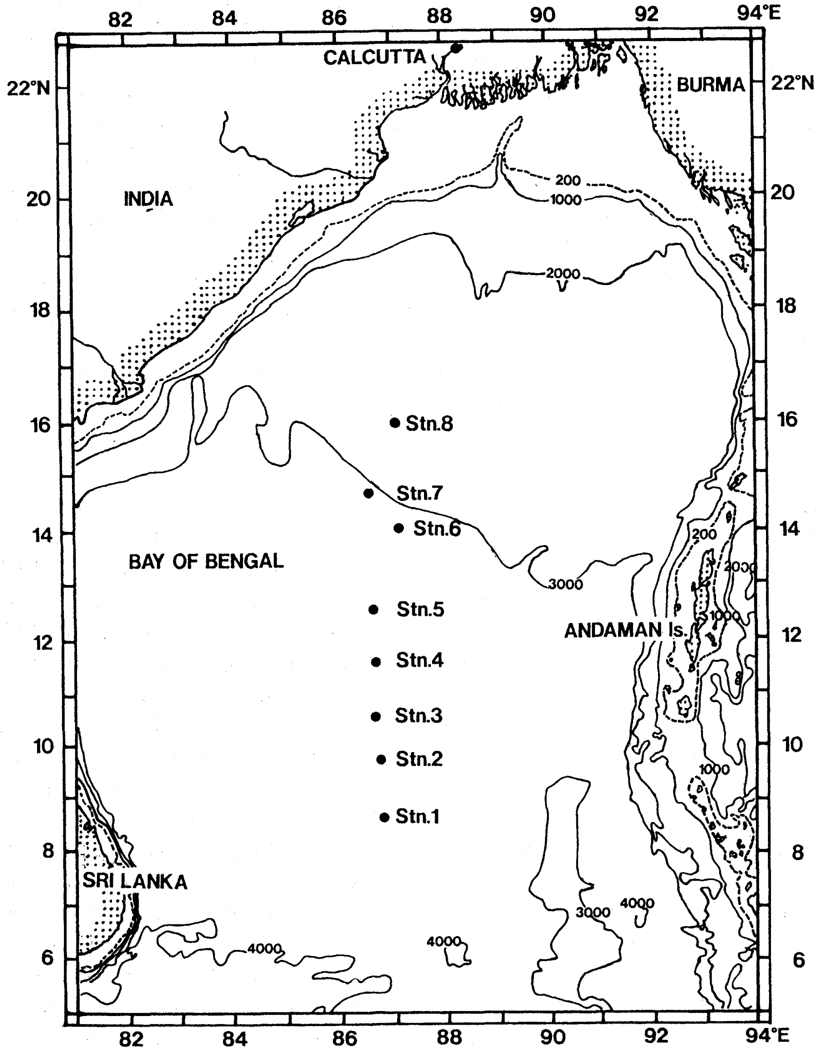

Fig. 1. Observation stations in the Bay of Bengal, Indian Ocean

The instruments for the measurement of the physical, chemical and optical environment included the CTD with DO sensor, underwater irradiance meter and *in situ* beam transmittance meter. The measuring accurancy of CTD (Mark IIIB, Neil Brown Co., LTD) was as follows; temperature, ± 0.005℃; conductivity, ± 0.005 mhos; depth, ± 0.1%. In addition, the values of dissolved oxygen were determined from the relationship between the observed and the analyzed values. (Fig. 2)

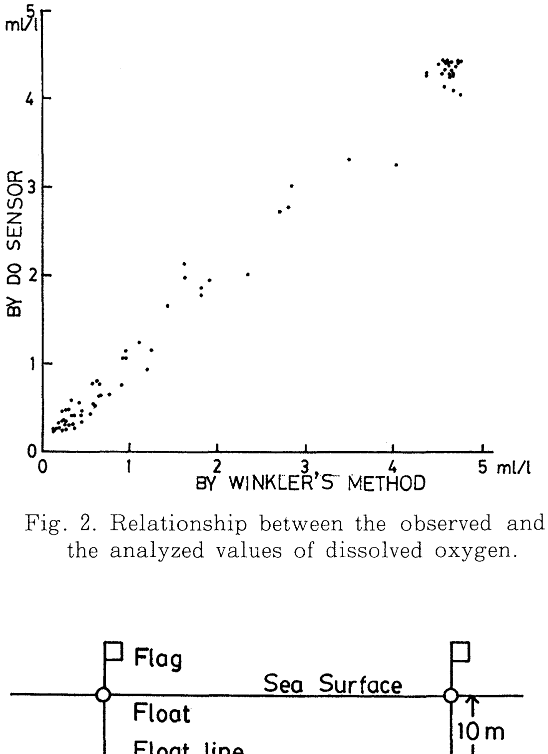

Fig. 2. Relationship between the observed and the analyzed values of dissolved oxygen.

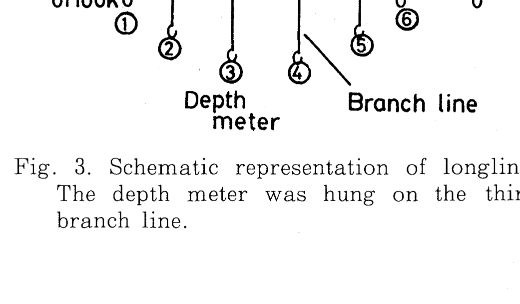

Fig. 3. Schematic representation of longline. The depth meter was hung on the third branch line.

The underwater irradiance meter (SR-8 type, Ishikawa Co., LTD) was equipped with eight interference filters with wavelengths of the maximum transmittance; 443, 481, 513, 553, 599, 663, 682 and 709 nm. A beam transmittance meter (XMS type, Martek Co., LTD) with a depth sensor was able to measure beam attenuation (centroid wavalength: 486nm) per meter.

In order to carry out observations of temperature, salinity and dissolved oxygen, a lowering of CTD was continuously made from the surface to a depth of 500 m or 1000 m. To measure irradiance, the meter was lowered at intervals of 10 m, from the surface to 50 m. Also, a beam transmittance meter was simultaneously lowered from the surface to a depth of 100 m. A beam attenuation coefficient was used as an indicator of the turbidity of water.

The tuna longline gear used in the catching experiment was the standard type with six branch lines per basket. As bait for tuna, frozen jack mackerel of which a fork length is 25 cm, was used hooking up a part of the dorsal fin. To evaluate precisely the depth of a branch line hook, the authors used self-recorded depth meter (BS-04 type, YANAGI Keiki Co., LTD). Each of the three depth meters was hung on the third branch line of the basket, which accounted for an interval of the one quarter of the total number of baskets in the line (Fig. 3). The depth (D) of each hook of a branch line was obtained by the Yoshiwara's expression (1951) as follows:

$$D = ha + hb + l\left[\,(1+\cot^2\phi)^{1/2} - \{(1-2j/n)^2+\cot^2\phi\}^{1/2}\,\right]$$

where ha is length of branch line, hb is length of float line, l is half length of main line per basket, n is number of branch line added to l, j is order of branch line, and ϕ is cross angle between x-axis and tangential line at a supporting point of main line.

The number of baskets used in one operation was 150 at stns. 1 and 2, and 200 at the others. The lines were laid down from 4:00

to 7:30 a.m., and hauled up from 0:30 to 7:00 p.m.

3. Results and Discussion

3-1. Physical and Chemical Factors.

Fig. 4 is a temperature-salinity diagram based on the data collected from stn. 1 to stn. 8. According to the water mass classification of EMERY and MEINCH (1986), Bengal Bay Water (temperature, 25.0-29.0 ℃; salinity, 28.0-35.0‰) is above 500 m in depth, and below that, there is Red Sea Persian Gulf Intermediate Water (temperature, 5.0-14.0 ℃ ; salinity, 35.5-36.8‰). The salinity of the surface sea water of the former water mass changed by the Arabian Sea Water is said to be lower, ranging from 28.0 to 35.0‰.

Figs. 5a and 5b show the vertical distribution of temperature, salinity, and dissolved oxygen at stn. 1 and stn. 8, respectively. The temperature of the surface water at stn. 1 was 28 ℃, and decreased sharply with depth between 40 m and 200 m, indicating a form of thermocline. Below the thermocline, the water temperature decreased with depth from 14 ℃ down to 6 ℃ at a depth of 1000 m. On the other hand, the surface water temperature at stn. 8 was 26 ℃, which was 2 ℃ lower than that of stn. 1. Under the surface, the vertical distribution of temperature was similar to that of stn. 1.

In terms of the salinity, surface water at stn. 1 was 33.95‰ and increased suddenly at depths from 40 m to 120 m, showing a form of halocline. The depth of halocline coincided roughly with that of the thermocline. Below the halocline, the salinity was 35.0‰ and salinity inversion appeared at a depth of 120 m to 160 m. Below that, it again increased with depth, indicating a value of 35.0 ‰ at a depth of 400 m. Meanwhile, the value of the surface water at stn. 8 was 33.3‰ less than that of stn. 1. In the vicinity of 40 m deep, halocline was present on a small scale, and below that, it had a tendency to increase with depth the same as that of stn. 1. Yet, the phenomenon of

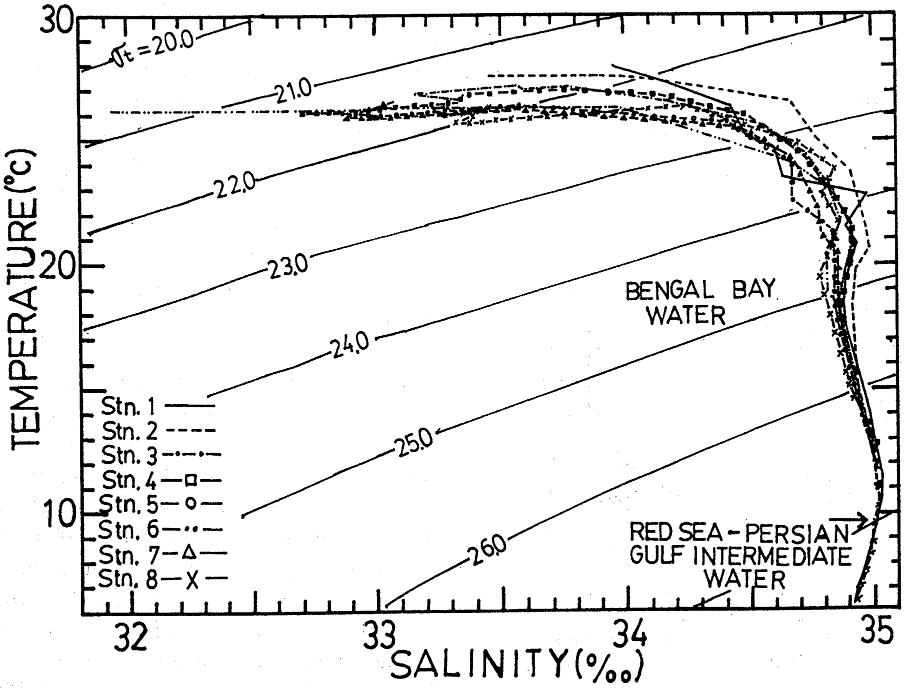

Fig. 4. Temperature-salinity diagram. Arrow in the figure means a boundary of each water mass.

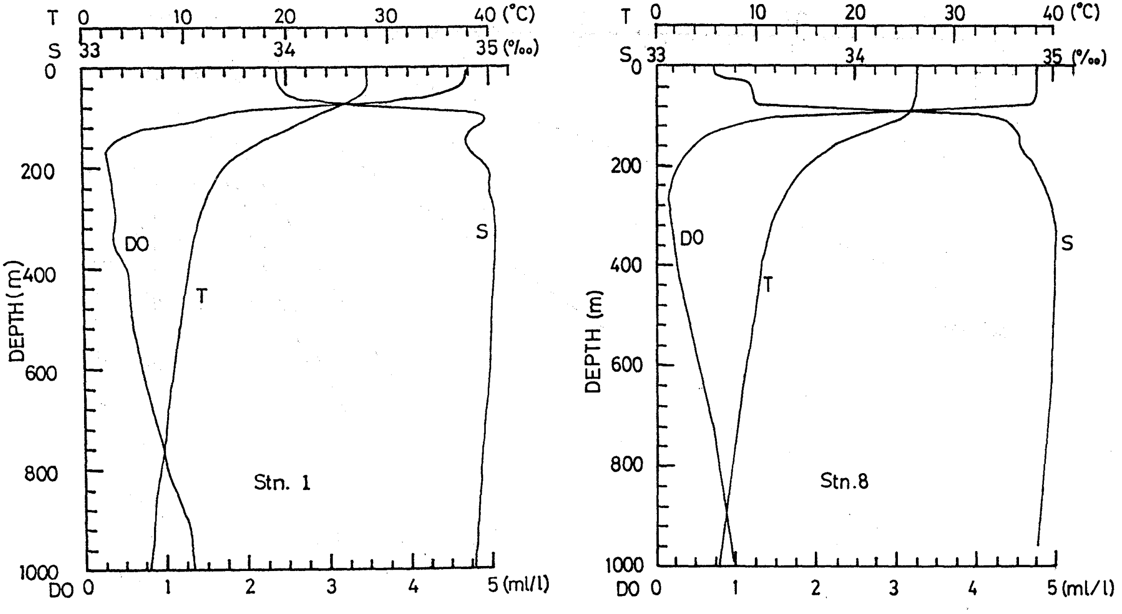

Fig. 5. Vertical distributions of temperature (T), salinity (S) and dissolved oxygen content (DO) at stn. 1and stn. 8.

inversion was present at a depth of 150 m.

The dissolved oxygen in the surface water at stn. 1 was about 4.6 ml/l, and at a depth from 40 m to 100 m, changed abruptly in the form of oxycline. At a depth of 120 m, the dissolved oxygen was 1.0 ml/l, and at a depth of 170 m, recorded the minimum value, 0.26 ml/l. Below that depth, the dissolved oxygen increased with depth, and registered 1.3 ml/l at a depth of 1000 m. Such the results of the dissolved oxygen that there are appearance of the minimum layer and an extremely wide range of dissolved oxygen concentration less than 1.0ml/l correspond to those brought forth by IIOE (International Indian Ocean Expedition). WYRTKI (1971) reports that this is one of features of dissolved oxygen distribution in the Bay of Bengal. Also, the type of depth distribution at stn. 8 was roughtly similar to that of stn. 1. However, one difference was found. It is that the minimum oxygen appeared at a depth of 260 m, which was 100 m deeper than that of stn. 1.

3-2. Optical Factors

Fig. 6 illustrates the depth profiles of downward spectral irradiance at stn. 4 as the representative of measurements. In the figure, the ratio of attenuation became larger according to the band of a short wavelength to a long one. Namely, the percentage of underwater irradiance at a depth of 30 m was 31.9 % for a blue light (481 nm), 22.3% for a green light (553 nm), and 4.03 % for a red light (599 nm), respectively. Also, the values of diffuse attenuation coefficients for downward irradiance were calculated. For instance, at a blue light it was 0.038 m^{-1}, which was about one third of 1.0m^{-1} (484 nm; HAGA and MATSUIKE, 1981) in the northern part of the North Pacific Ocean. According to the optical water mass of JERLOV (1976), this water belongs to the oceanic water type I", and is thought to be very clear.

In next, the depth distribution of water turbidity (beam attenuation coefficient; 486 nm) is shown in Fig. 7. Three stations (stns.

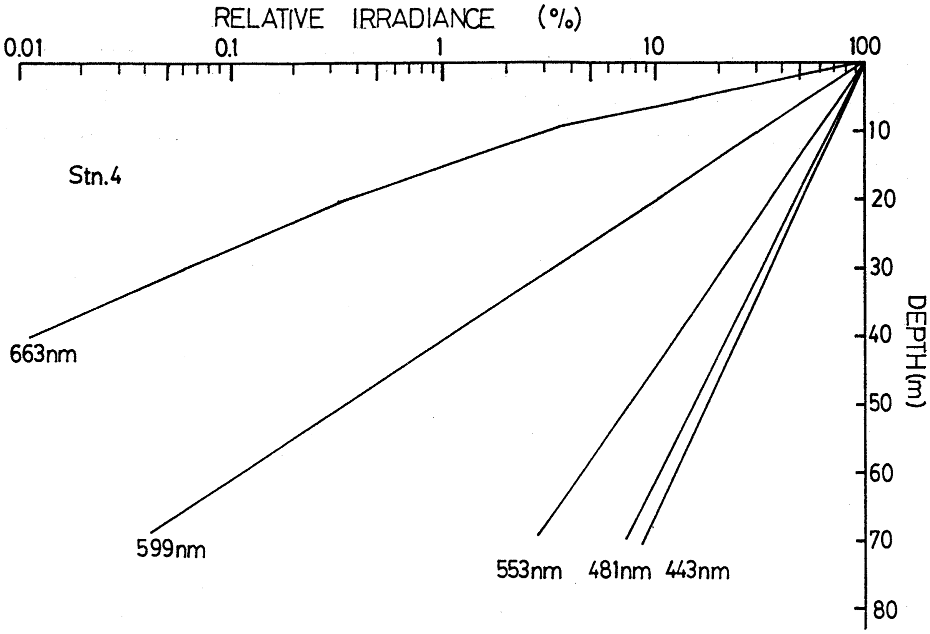

Fig. 6. Spectral distribution of underwater irradiance (relative value). Numeric on the figure is wavelength.

1, 4 and 7) were selected as the representative of measurements. The numerals in the figure increase in proportion to the degrees of turbidity of water. At stn. 1, the values of beam attenuation coefficient was nearly 0.12 m^{-1} at a depth of 0 m to 30 m, and between 40 m and 50 m, it reached the maximum value, 0.19 m^{-1}. Below that, it decreased with depth indicating a value of 0.07 m^{-1} at a depth of 100 m. At stn. 4, there was a little variance from the surface to a depth of 80 m, exhibiting ones of 0.13–0.16 m^{-1}. At stn. 7, the beam attenuation coefficient was 0.13–0.16 m^{-1} between the surface and a depth of 50 m, which was equivalent to those of stn. 1 above a depth of 40 m. At 70 m deep, it reached the maximum value, 0.18 m^{-1}, and below that, it decreased with depth, recording 0.10 m^{-1} at a depth of 90 m. As introduced above, the high-turbidity layer sometimes appears in the turbidity vertical distribution but sometimes does not according to circumstances. Furthermore it is understood that depth of water in which the high turbidity layer is configurated varies with localities.

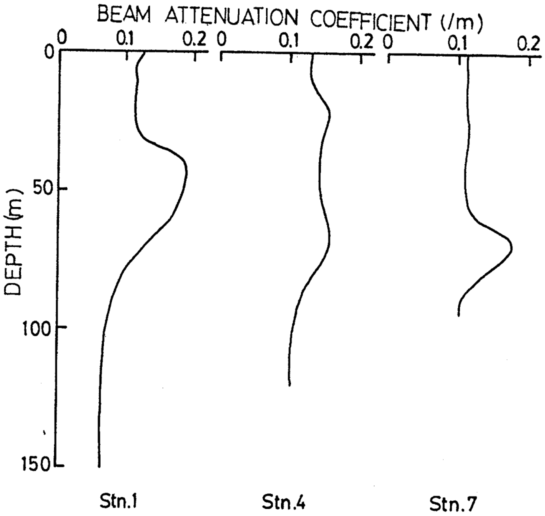

Fig. 7. Vertical distributions of water turbidity (beam attenuation coefficient) at stns. 1, 4 and 7.

3-3. *Environmental conditions of the tunas' maneuvering sphere*

Prior to discussing the characteristics of tunas' ecological conditions, it is reasonable to define their maneuveaing sphere.

In this sense, a figure of depths in which each tuna was caught by the longlining operations is provided as follows. Fig. 8 represents the catching depths of tuna and billfish by position. Symbols of solid circles, triangles and open circles indicate yellow fin, big-eye and narlin, respectively. From the figure, it can be understood that the range of catching depth is from 38.1 m to 69.0 m. In comparing the catching depth by species, marlin were caught in the shallowest water. Also, Table 1 shows characteristics of catching depth, and the thickness of the catching layer. It is found that the greatest thickness was 24.8 meters at stn. 7, and the least, 8.6 meters at stn. 4. Moreover, thickness of the catching layer changed with operation position, and averaged out to 16.5 meters.

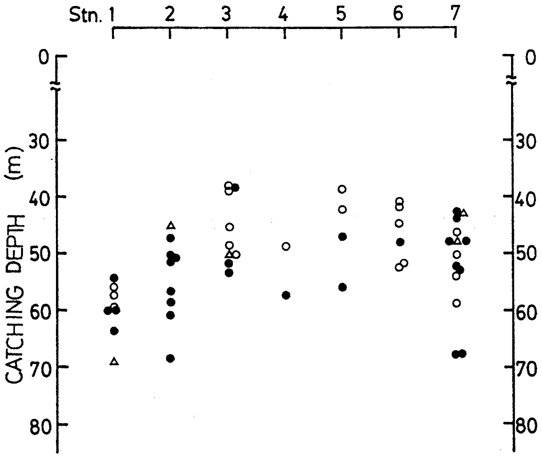

Fig. 8. Catching depth of tuna and billfish. Open circles, solid ones and triangles mean marlin, yellow fin and big-eye tuna, respectively.

Table 1. Characteristics of catching layer.

Position	Catching Layer(m)			
	Upper	Lower	Average	Thickness
Stn. 1	54.5	69.0	59.9	14.5
Stn. 2	45.2	68.5	54.5	23.3
Stn. 3	38.1	53.6	46.1	15.5
Stn. 4	48.9	57.5	53.2	8.6
Stn. 5	39.0	56.1	52.6	17.1
Stn. 6	40.9	52.5	46.6	11.6
Stn. 7	42.9	67.7	58.5	24.8

We, authors, assume that the sea layer in which tuna were caught in the Bay of Bengal is a fairly good approximation with the tunas' maneuvering sphere. Because, as explained in the preceding paragraph, the minimum oxygen layer appears in the surveyed sea regions and the layer of oxygen concentration lees than 1.0 ml/l, which is the minimum quantity required for supporting tuna's life (Hanamoto, 1986), is extended from 120 m to 800 m deep. Judging from these outcomes together with the findings of WYRTKI (1973), the said assumption can be reasonablly justified.

Figs. 9, 10 and 11 show the depth distributions of temperatures, salinuty and dissolved oxygen at each station, respectively. The dotted zones in the figures indicate the extent of the maneuvering sphere mentioned above. The temperature of the water within the maneuvering sphere ranged from 25.5 ℃ to 27.5 ℃ , and decreased toward the north.

UDA(1960) reported that the water temperature inhabitable for tuna ranged from 11 ℃ to 32 ℃. In the present paper, measurements were in the higher part of temperature range reported by UDA (1960). Moreover, the location of the maneuvering sphere was just above or the upper part of the thermocline. This finding differed from those of SUDA *et al.* (1969) and HANAMOTO (1975). They found that the catching depth of tuna was within the theromcline or below that level. Salinity within the maneuvering sphere ranged from 33.00‰ to 34.45 ‰, and decreased toward a northernly direction. These values are more smaller than 34.0-34.7‰ for big-eye tuna in the North Pacific Ocean, which HANAMOTO (1986) obtained from inhabitable water temperature, using T-S curves. Dissolved oxygen in the water of maneuvering sphere varied from 3.0 to 4.6 ml/l. Our values are about three to four times as much as that of HANAMOTO (1986). According to HANAMOTO (1986),

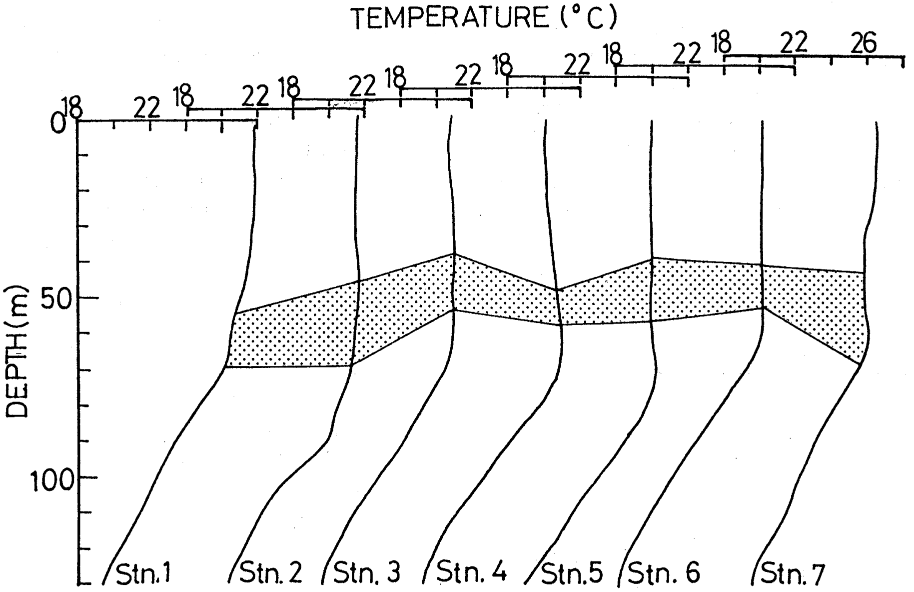

Fig. 9. Vertical distributions of temperature from 0 m to 130 m in depth. Shadow zone denotes the tunas' maneuvering sphere.

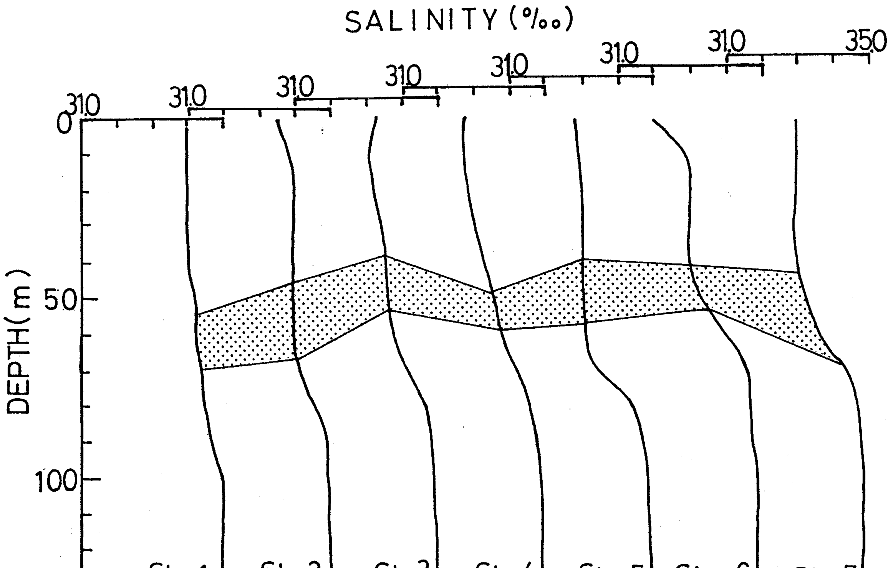

Fig. 10. Vertical distributions of salinity from 0 m to 130 m in depth. Shadow zone is shown as in Fig. 9.

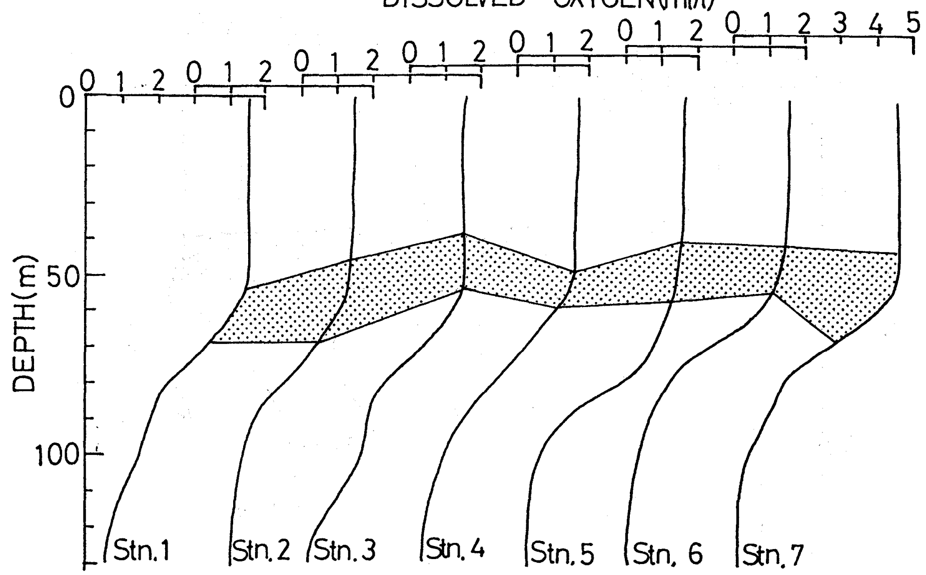

Fig. 11. Vertical distributions of dissolved oxygen content from 0 m 130 m in depth. Shadow zone is shown as in Figs. 9 and 10.

in situ measurements of dissolved oxygen inhabitable for tuna have never been conducted before. Therefore, these values are considered to be very important. Also, the maneuvering sphere was positioned just above or at the upper part of oxycline, as was observed at the thermocline and halocline.

With respect to a state of optical environment, Table 2 shows the relative values of downward irradiance by wavelength, and those of total light at the maneuvering sphere. In the table, it can be seen that the energy of the blue light was the greatest of them. On the other hand, the percentage of total light was 8.2 % at a depth of 38 m, and 2.2 % at a depth of 69 m. The ratio of attenuation on total light were almost equivalent to those of green light.

Fig. 12 illustrates the depth profiles of turbidity (beam attenuation coefficient) at each station. The dotted zone in the figure indicates the extent of the maneuvering sphere. Beam attenuation coefficients within that sphere ranged from 0.11 to 0.22m^{-1} (486nm). The highest recorded was double that of the Kuroshio area (MATSUIKE and MORINAGA, 1977). In addition, the location of the maneuvering sphere was just above or within the high turbidity layer. This might be related to migratory path for tunas' food-searching.

Table 2. Relative irradiance at the maneuvering sphere.

	Maneuvering	Sphere
Wavelength	Upper	Lower
(nm)	(38m)	(69m)
481	24 %	7.6 %
553	14	2.9
599	1.3	0.042
300–2500	8.2	2.2

Finally, let us discuss the maneuvering sphere of tuna in relation to the distribution of dissolved oxygen. YAMANAKA (1966) reported that the catching depth of tuna changed according to the location of a fishing ground. For instance, big-eye tuna in the Indian Ocean (except the Bay of Bengal) was

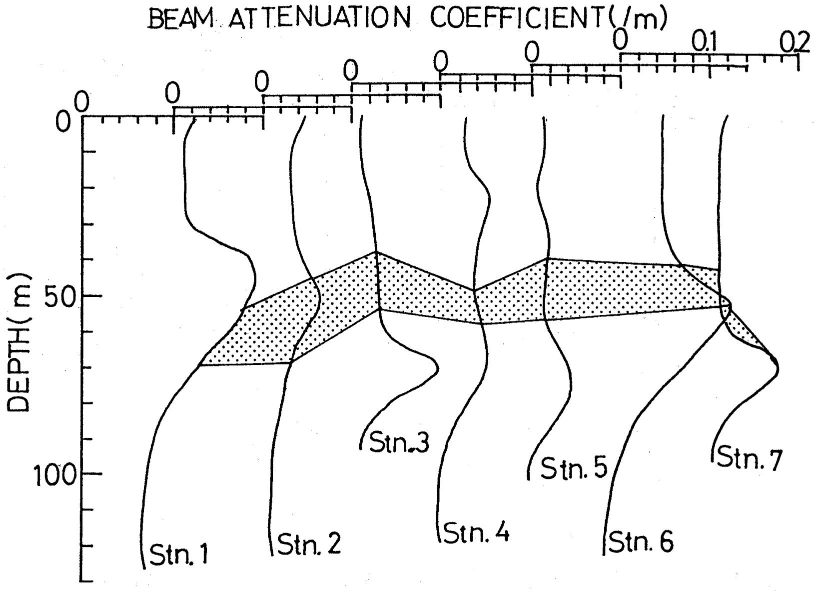

Fig. 12. Vertical distributions of water turbidity. Shadow zone is shown as in Figs. 9, 10 and 11.

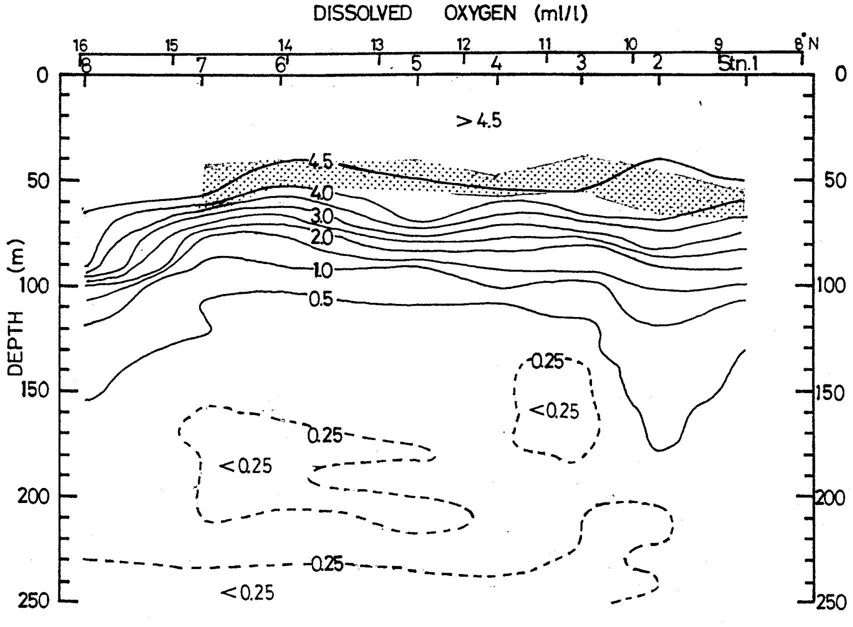

Fig. 13. Vertical profile of dissolved oxygen from 0 m to 250 m in depth. Shadow zone is shown as in Figs. 9, 10, 11 and 12.

catched at a depth of 300 m (YAMANAKA, 1966), and as for southern bluefin tuna, at a depth of 350 m (SHIBATA and NISHIMURA, 1969). Also, in the Solomon Islands in the

Pacific, the layer of yellowfin was at a depth of 40 m to 120 m (YAMANAKA and KUROHIJI, 1966), and albacore was at a depth of 90 m to 150 m in the Ogasawara Islands (YAMANAKA, 1966). Compared with the depths mentioned above, it is clear that the maneuvering sphere in the Bay of Bengal generally situated in shallower waters.

The dissolved oxygen in the water is considred to be a very important factor for survival of pelagic fish. For big-eye tuna, the dissolved oxygen minimum content must be 1.0 ml/l for survival (HANAMOTO, 1986), and for skipjack tuna, 3.5 ml/l along a migratory path (INGHAM *et al.*, 1977), and for yellowtail, 3.0 ml/l for swimming in an enclosure (YANAGI, 1986), respectively. Fig. 13 shows the vertical profile of dissolved oxygen content from the surface to a depth of 250 m in the Bay of Bengal. The dotted zone in the figure indicates the maneuvering sphere. As seen in the figure, it is understood that the minimum oxygen (content; <0.25 ml/l) appears at a depth of 150 m to 250 m. Moreover, a value of 1.0 ml/l (HANAMOTO, 1986) is observed at a depth of 100 m, and that of 3.0 ml/l (YANAGI, 1986), at depths from 60 m to 80 m. Accordingly, the vertical situation of the maneuvering sphere is said to be influenced by distribtion of dissolved oxygen content. In particular, the reason why the lower part of the layer was shallow is that the dissolved oxygen minimum layer appeared in the subsurface layer of the ocean.

Acknowledgements

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ベンガル湾におけるまぐろ•かじき類の環境条件

森永　勤・今関昭博・武田誠一・荒川久幸

要旨：インド洋・ベンガル湾のまぐろ・かじき類の環境条件を把握する目的で，1987年2月東京水産大学研究練習船神鷹丸において，従来の環境要素（水温・塩分・溶存酸素）に光学要素（水中照度・濁度）を加えた観測を延縄釣獲試験と同時に実施した。

釣獲水深（38mから69mまでの範囲）を生息領域とみなして環境条件を求めると，各値は次の通りであった；水温，25.0～27.5℃；塩分，33.00～34.45‰；溶存酸素量，3.0～4.6ml／l；相対照度（全光），8.2～2.2%；濁度（光束消散係数），0.11～0.22m^{-1}（486nm）。又，生息領域の鉛直的位置は水温・塩分・溶存酸素の場合では各躍層の直上あるいは上端部に，濁度の場合では高濁度層の直上あるいは内部にそれぞれあった。これらの結果に基づくと，ベンガル湾における生息領域では下端部の水深が世界の漁場に比較して最も浅く，酸素極小層の亜表層への出現に影響されていると考えられる。

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Société franco-japonaise d'océanographie, Tokyo

Oceanic structure in the vicinity of a seamount, the Daini Kinan Kaizan, south of Japan*

Yoshihiko SEKINE** and Tatsuya HAYASHI**

Abstract: The hydrographic observations in the vicinity of a seamount, the Daini Kinan Kaizan, south of Japan have been carried out three times in summer of 1989 and 1990. It is suggested that a pattern with week downward shift of isotherms and isohalines in the eastern side above the top of the seamount and upward shift of them just above the top of the seamount are maintained more than ten days. Vertical displacement of isotherms and isohalines at depths below the top of the seamount was always observed over the flank of the seamount. In relation to this water structure, prominent geostrophic flow with large vertical difference existed in the deep water below 1000 m. This suggests that topographic effect of the seamount is confined to depths with large vertical geostrophic shear and to greater depths. Micro-structures were observed over the seamount. In particular, a remarkable vertical temperature inversion with zonally coherent structure over the top of the seamount was observed in the first cruise made in July 1990.

1. Introduction

The interaction of ocean currents with seamounts has been of interest to oceanographers (e.g., HOGG, 1980; RODEN, 1987). As oceanic condition of seamounts may be different in localities, hydrographic observations should be made for each of seamounts. The present study is directed toward oceanic conditions in relation to circulation over the Daini Kinan Kaizan south of Japan.

The Daini Kinan Kaizan locates in a central region of the Shikoku Basin (Fig. 1) and has an elliptic shape with a longer axis form southeast to northwest. The top of this seamount is at a depth of 670 m. Up to this time, few observations have been carried out focusing on the topographic effects of the Daini Kinan Kaizan. KONAGA *et al.* (1980) observed that the detached cold eddy from the large meander of the Kuroshio,“ Harukaze” , (cf. KONAGA and NISHIYAMA, 1978) has a tendency to stay over this seamount. As the main axis of the Kuroshio passes over or near the seamount when it meanders, it is suggested that this seamount has a material topographic effect on the dynamics of large meander path of the Kuroshio.

We have observed temperature and salinity fields in the vicinity of the Daini Kinan Kaizan three times in summer (Table 1). In the following, details of the three observations and some noteworthy results are shown.

Table 1. Hydrographic observations around the Daini Kinan Kaizan.

Cruise Name	Periods of observation	Main instruments	Stations
KS-89JUL	17 Jul. 1989	CTD, ADCP	Fig. 2-a
KS-90JUL1	15 Jul. 1990	Mi-com. BT	Fig. 2-b
KS-90JUL2	24-25 Jul. 1990	CTD, ADCP	Fig. 2-b

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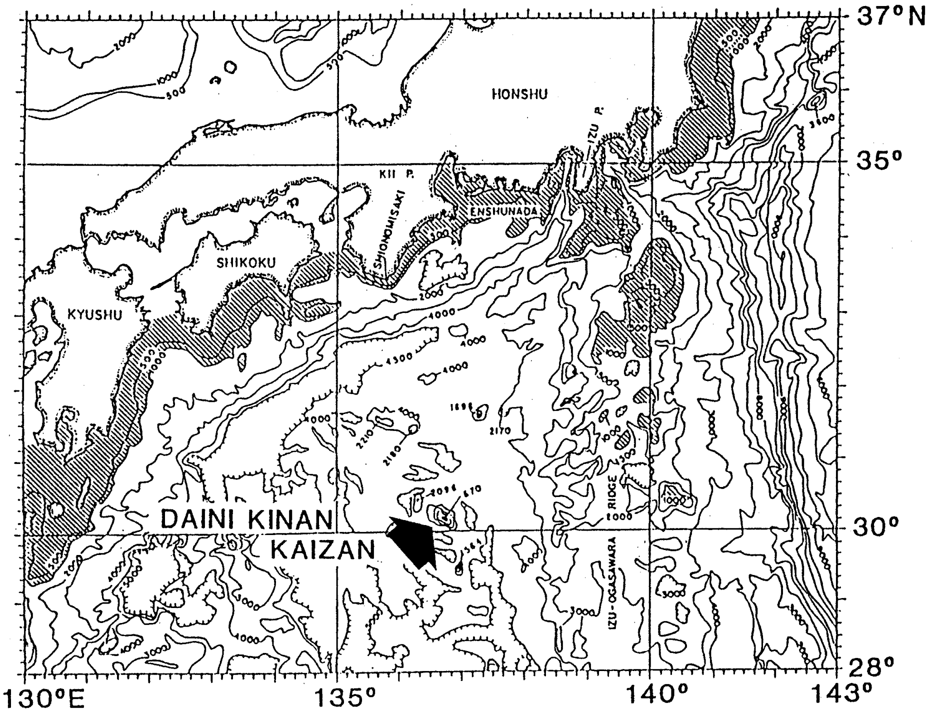

Fig. 1. Location of the seamount, the Daini Kinan Kaizan south of Japan. Isoplethes of depth (in meter) are also shown (after TAFT, 1972).

2. Observations

The hydrographic observations by CTD were carried out for three times by use of the Training Vessel Seisui-maru of Mie University (Table 1). The locations of the observational points for each cruise are shown in Fig. 2. Unfortunately, because the trouble of CTD system occurred in the second cruise, the micro-computer BT (mi-com. BT) was used for the stations 1 to 8 shown

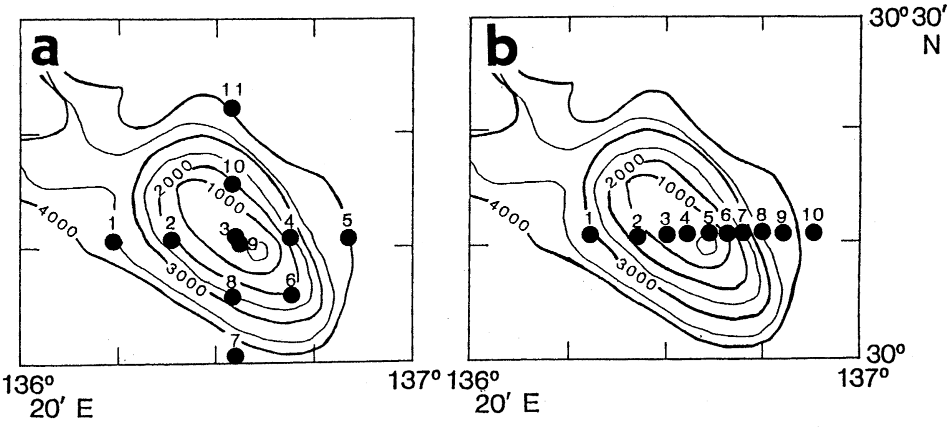

Fig. 2. Bathymetry (in meter) in the vicinity of the Daini Kinan Kaizan and observational points of CTD (closed circles). (a) Cruise KS-89JUL and (b) Cruise KS-90JUL1 (Mi-com. BT observational points from 1 to 8) and KS-90JUL2 (from 1 to 10).

in Fig. 2b. The current measurements by acoustic doppler current profiler (ADCP) were carried out for three depths, 50 m 100 m and 150 m. CTD of the upper 700 db layer at station 1 of cruise KS-89JUL1 and ADCP current data at mid-point between stations 7 and 8 of KS-90JUL2 had been lost by miss in data processing.

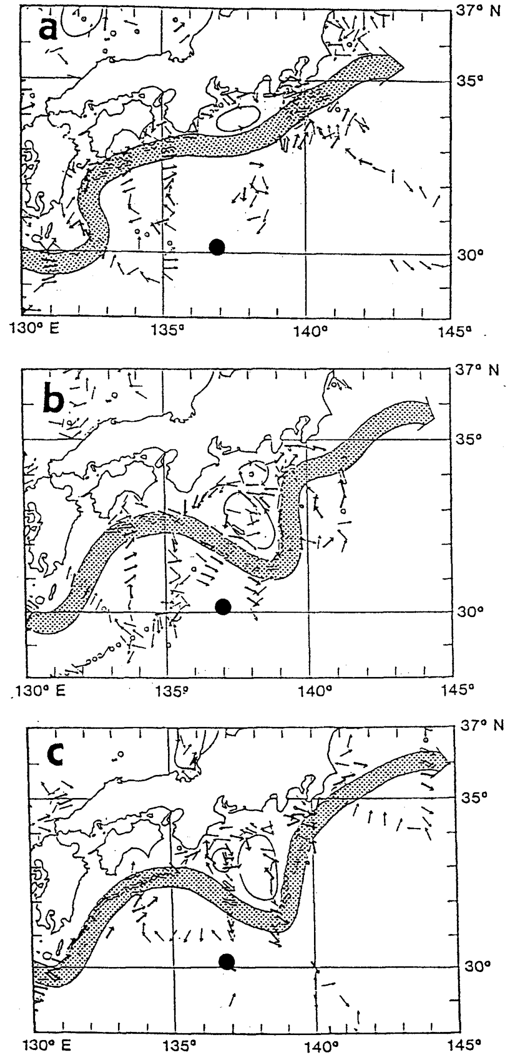

Fig. 3. Main path of the Kuroshio (stippled region) for each of the three observational periods (after, Prompt Report of Oceanic Condition compiled by Maritime Safety Agency, 1989, 1990). (a) Cruise KS-89 JUL in later half of July 1989, (b) Cruise KS-90JUL1 in early half of July 1990 and (c) Cruise KS-90JUL2 in later half of July 1990. Closed circle in each panel shows the location of the Daini Kinan Kaizan.

Here, we refer to the location of the main axis of the Kuroshio during the three cruises. Fig. 3 shows the main axis of the Kuroshio during three observational periods presented by Maritime Safety Agency. For the first cruise made in July 1989, which is hereafter referred to as KS-89JUL, no meander path was formed and the distance of this seamount from the main axis of the Kuroshio was relatively large. However, a large meander path was formed in winter of 1989 and the large meander path existed in the period of last two cruises made in July 1990, in which the main axis of the Kuroshio approached this seamount.

3. Results

The vertical distributions of temperature, salinity and density (σ_t) along two observational lines of the Cruise KS-89JUL are shown in Fig. 4. A seasonal thermocline with less saline water was formed in a surface layer shallower than 50 m. No remarkable vertical change in isotherms and isohalines are detected over the top of the seamount, of which detailed structure is unclear by the coarse distribution of observational points. However, vertical displacement of the isotherms was observed at depths below the top of the seamount. The vertical displacement has been also detected around other seamounts near the Daini Kinan Kaizan: the Tosa-bae off Shikoku (YOSHIOKA *et al.*, 1986; SEKINE and MATSUDA, 1987) and the Komahashi Daini Kaizan locating at the northern end of the Kyushu-Parau Ridge (SEKINE and SATO, 1993). The gradient changes at a depth from 1700 - 1900 db: upward (downward) shift was observed in southeastward (northwestward) in water shallower than 1700 db, while a definite upward (downward) shift existed in northwestward (southeastward) in water deeper than 1900 db.

The salinity minimum layer was observed at depths just above the top of the seamount. Because of the gradient of

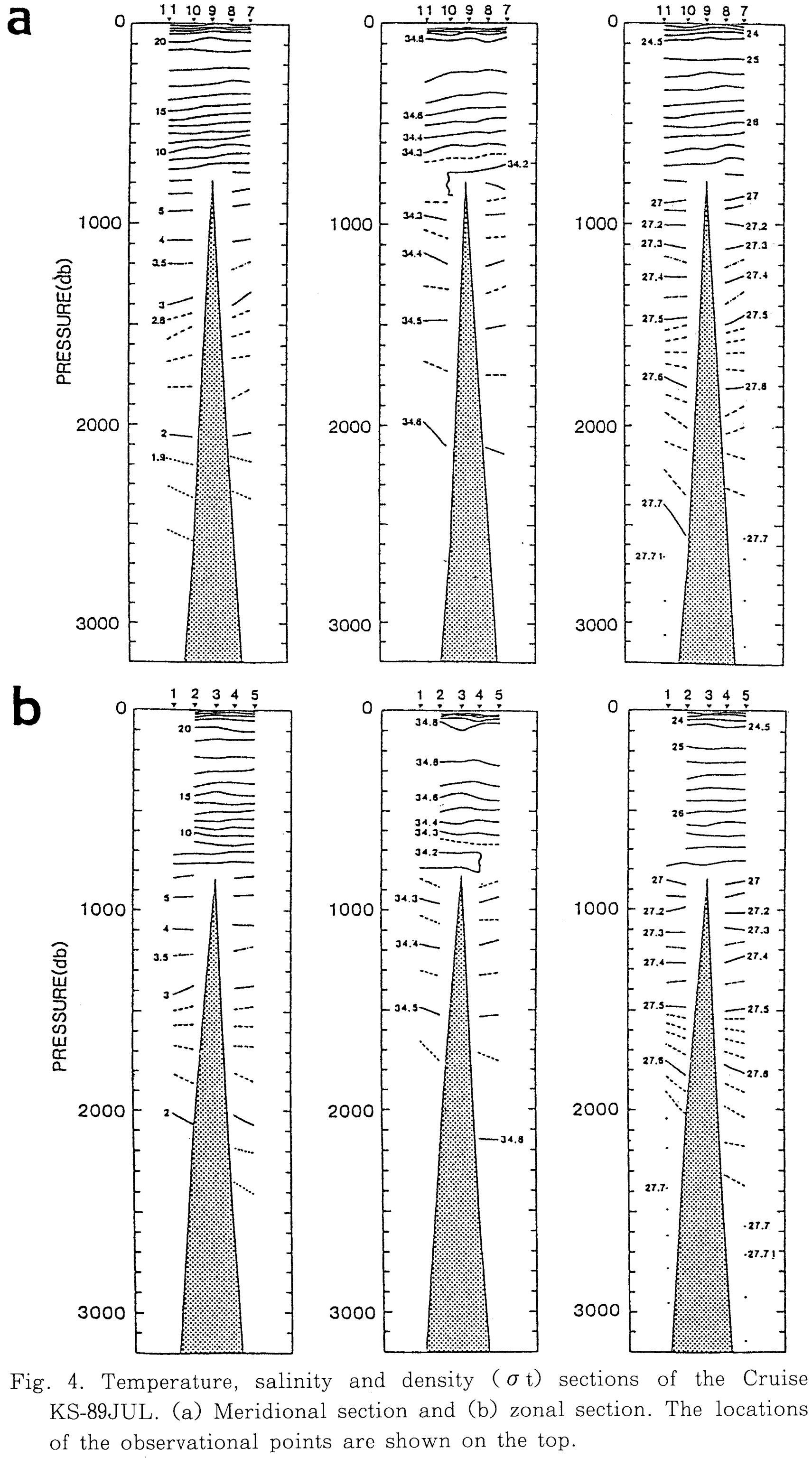

Fig. 4. Temperature, salinity and density (σt) sections of the Cruise KS-89JUL. (a) Meridional section and (b) zonal section. The locations of the observational points are shown on the top.

isohalines, less saline water than 34.5 PSU existed over the flank of the seamount at depths of 800-1500 db. Similar vertical structures to isotherms were observed also for isohalines in deeper layer than 1800 db. The vertical desplacement of isopycnal was also found in the greater depths, which suggests the existence of prominent geostrophic flow in the greater depths. Then, a geostrophic flow along the meridional section is displayed in Fig. 5. Here, owing to the difference in depth of each observational point, the reference level is assumed to be 750 db. Although absolute current velocity cannot be obtained from the present analysis, the gradient of isopycnals yields a large vertical difference in geostrophic flow more than 20 cm s^{-1} between 750 db and 1500 db in the south of the seamount. This prominent vertical change in geostrophic flow suggests that a topographic effect of this seamount

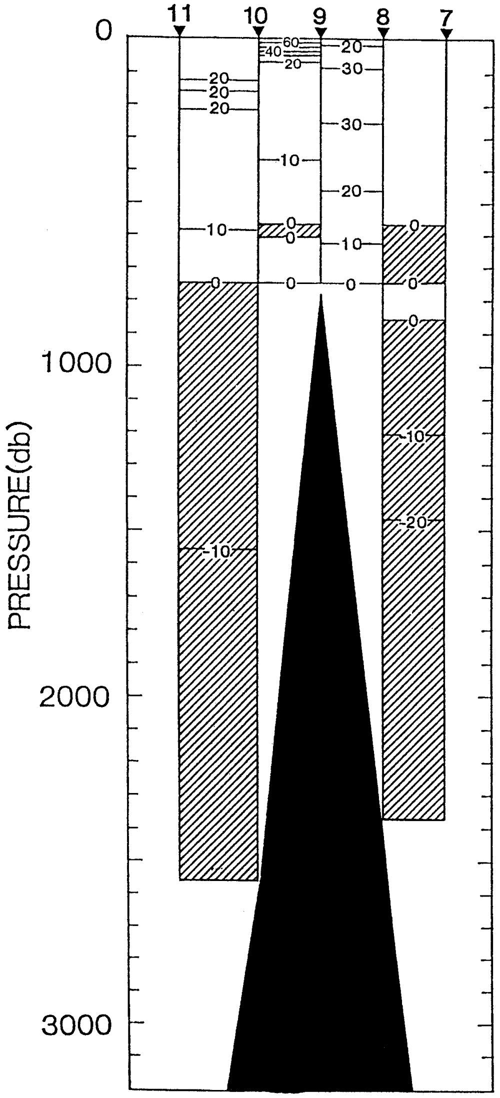

Fig. 5. Geostrophic flow (in cm s^{-1}) along the meridional section of KS-89JUL. The reference level is 750 db. Positive (negative) values show eastward (westward) flow. The regions with westward flow are shown by oblique lines.

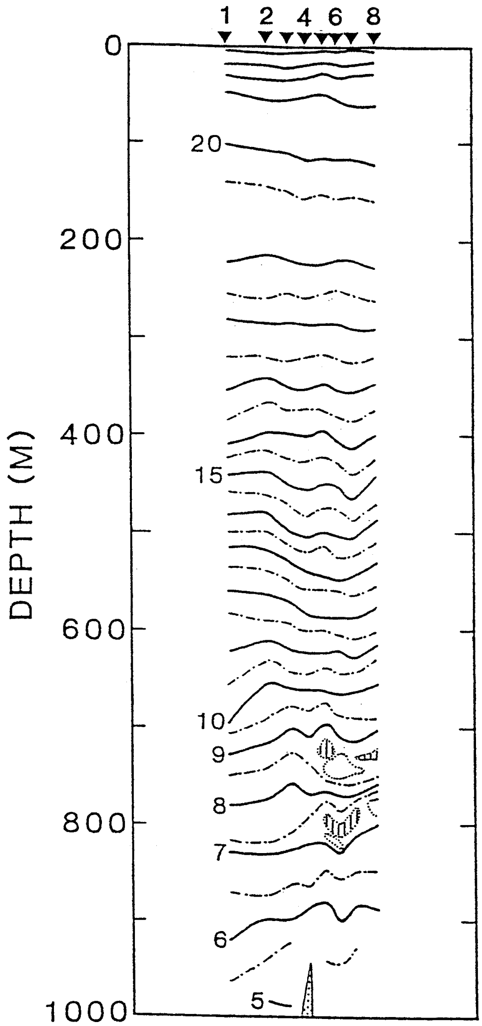

Fig. 6. Zonal temperature section of KS-90JUL1. Sectional areas with vertical inversion of temperature are shown by regions with vertical lines.

is confined to a relatively thin layer below the main thermocline.

The vertical temperature section observed in the Cruise KS-90JUL1 is shown in Fig. 6. As the observations were carried out in closer spacing than the previous one, KS-89JUL, many vertical unevenness in isotherms were detected : downward shift of the isotherms existed at depths of 450-600 m to the east of the top of the seamount and upward shift was found at depths of 650-800 m to the west. Complex upward and downward shifts were detected below 700 m. The some temperature inversions were observed at depths of 720-830 m. These temperature inversions are considered as micro-structures formed over the seamount. Upward shift of the isotherm of 6℃ is found just above the top of seamount.

To examine the temperature fields more closely, vertical profiles at eight stations are shown in Fig. 7. It is shown that noticeable temperature inversions found at depths from 710 m to 750 m have a zonally coherent structure. Below these inversions, other weak inversions are detected at depths of 790-820 m. Zonally coherent temperature inversions are considered to be due to the interleaving of warmer water.

The results of the cruise KS-90JUL2 are shown in Fig. 8. Similar vertical temperature structure to that found during the previous cruise KS-90JUL1 (Fig. 6) was observed over the seamount: deepening of isotherms are found in the east of the seamount at depths 400-650 db. This isotherm deepening, which seems to be the same as during the KS-90JUL1, must be maintained more than ten days, it is rather stable over the seamount. Upward shifts of the isotherm and isohaline just above the top of the seamount are also detected. At depth below the top of the seamount, a distinctive upward displacement of isotherms and isohalines were observed over the eastern flank of the seamount. This vertically coherent displacement may reveal

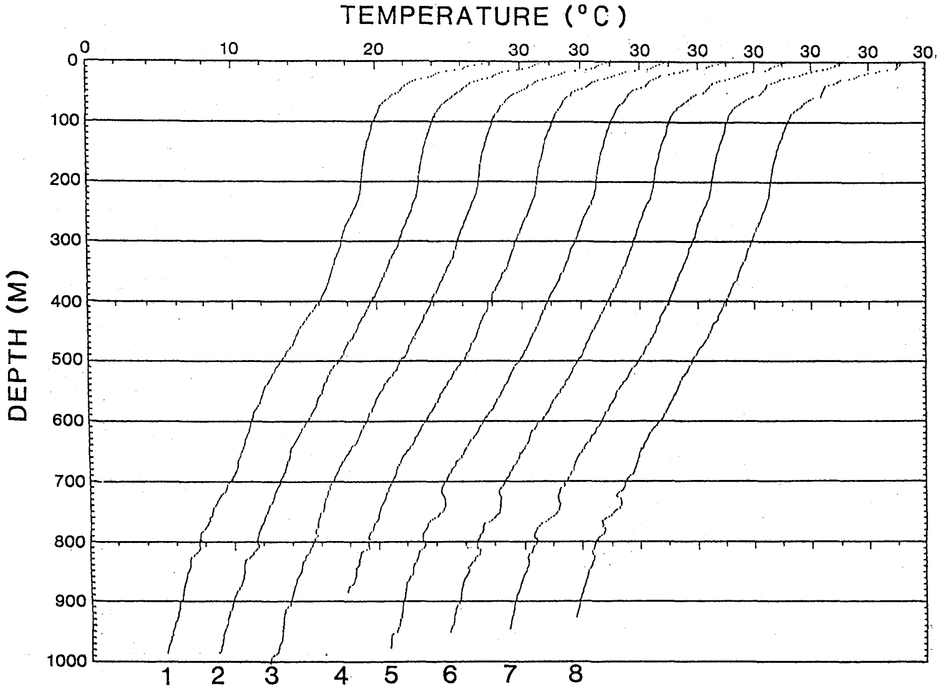

Fig. 7. Vertical change in temperature of the Cruise KS-90JUL1. Station numbers are given at the bottom.

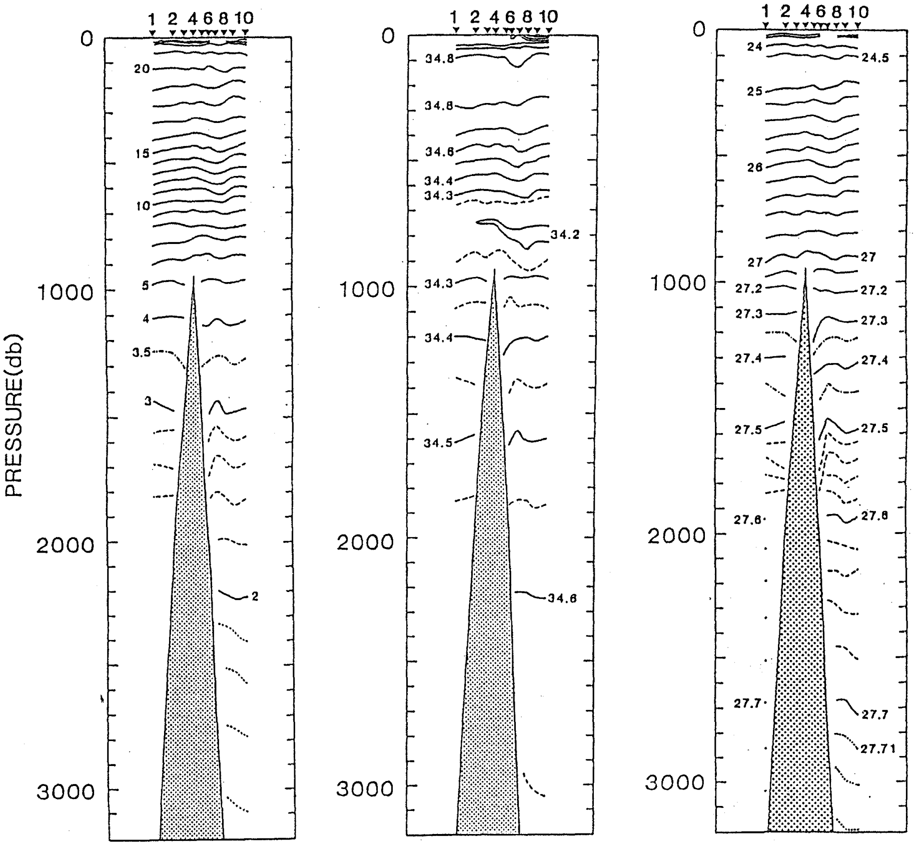

Fig. 8. Temperature (left), salinity (middle) and density (σ t) (right) sections of the Cruise KS-90JUL2.

the upwelling of deep water along the slope.

Density fields are quite similar patterns to temperature fileds. The geostrophic flow referred to 750 db is shown in Fig. 9. Because of the uplift of isopycnal, a large northward geostrophic flow with vertical velocity difference of 30 cm s^{-1} between at depths of 1000 db and 1300 db existed between two stations 5 and 6. Furthermore, southward flow between stations 6 and 7 had a vertical flow difference of 60 cm s^{-1} between at depths of 1100 db and 1800 db. This large vertical geostrophic difference in deeper water agrees with the results of the cruise KS-89JUL. It is suggested that there exists a strong current in the deep water around the seamount.

To make sure of validity of the reference level and to examine the geostrophic balance in the surface layer shallower than 150 db, in which ADCP current data were obtained, correlations between the geostrophic flow and the velocity by ADCP is shown in Fig. 10. Here, vertical differences of the northward velocities between 50 db and 100 db and those between 100 db and 150 db are compared. It is shown that no clear positive correlation is found for both the cases. A weak negative correlation (−0.41) is found for the latter case. Because of a geostrophic flow in the ADCP data, we are not able to estimate the reference level by adjusting the geostrophic velocities to those of ADCP.

4. Summary and discussion

The hydrographic observations in the

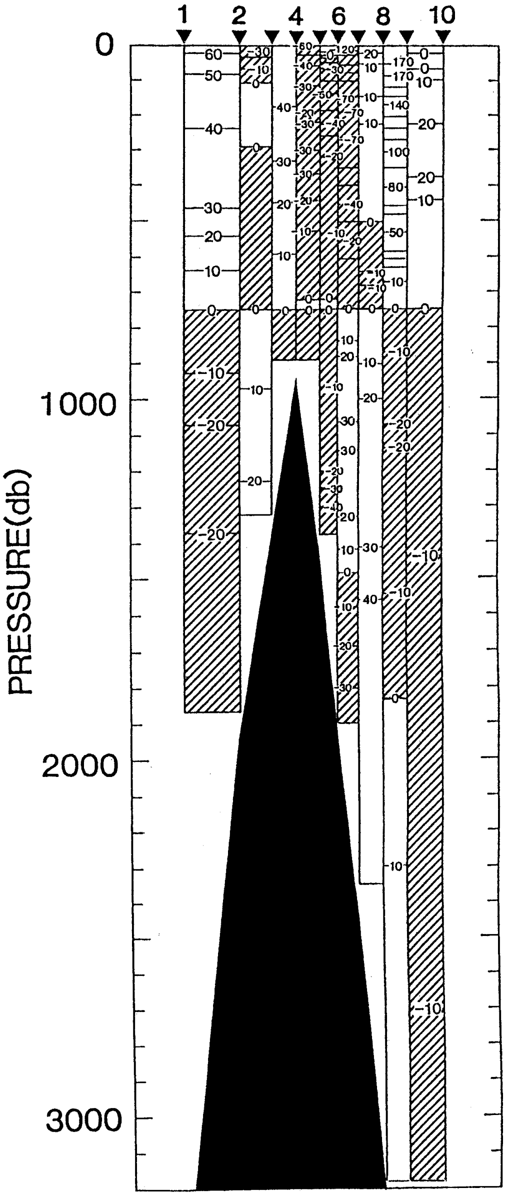

Fig. 9. Geostrophic flow on the zonal section of KS-90JUL2 referred to 750 db. Northward (southward) velocity is positive (negative).

vicinity of the Daini Kinan Kaizan south of Japan were made by the Training Vessel Seisui-maru of Mie University three times in summer of 1989 and 1990. Notable results of the observations are summarized as follows.

(1) During the first cruise (KS-89JUL), a weak undulation of isotherms and isohalines was observed in the upper 500 db layer; however, vertically coherent temperature and salinity gradients were observed over the flank of the seamount.

(2) As for the second cruise (KS-90JUL1), weak downward shift of isotherms at depths of 450–600 m in the east of the seamount, upward shift of isotherms just above of the seamount and complicated vertical temperature structure below 800 m were observed. Micro-structures of temperature with zonally coherent inversions were detected at a depth of 730 m.

(3) As for the third cruise (KS-90JUL2), similar temperature distribution to that of KS-90JUL1 was observed in depths above 1000 db. So, this temperature pattern must have continued more than 10 days; this temperature structure is considered to be stable near the seamount. Furthermore, a distinct shallowing of the isotherms and isohalines were observed in the east of the seamount.

(4) In the east of the seamount, the horizontal gradient of isopycnals suggests that a remarkable geostrophic flow with large vertical shear existed in depths greater than the top of the seamount during cruises of KS-89JUL and KS-90JUL2.

(5) The vertical difference in the geostrophic velocity shows no clear correlation with those of the ADCP in the surface water within 150 db. Since this suggests that ageostrophic flow is included in the current obtained by ADCP, the ADCP current data are not useful for estimation of the reference level of the geostrophic calculation.

The oceanic conditions around this seamount must be influenced by the seasonal variation and also by Kuroshio paths. It should be noted that no clear correlation between the geostrophic velocities and those of ADCP offers a serious problem in the current observation: ADCP data do not give the information for reference level of geostrophic caluculation. Long term direct

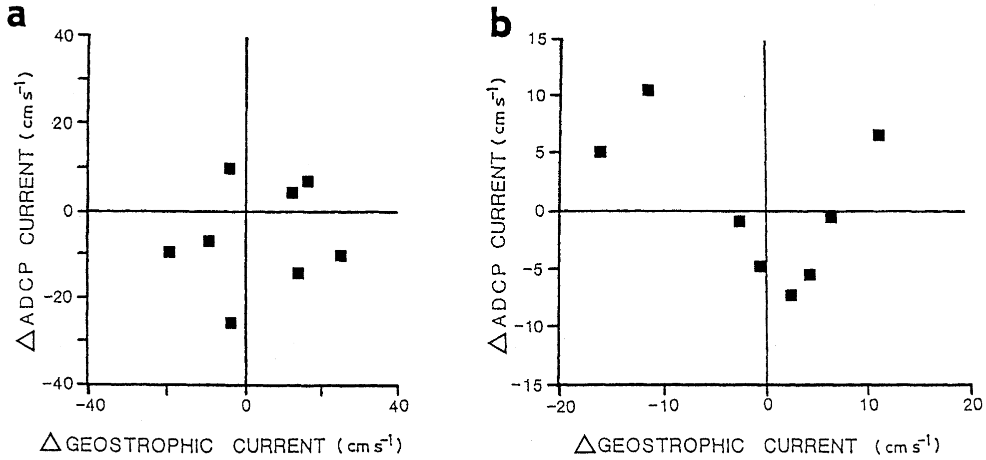

Fig. 10. Comparison between vertical differences in northward geostrophic velocity and those in velocity by ADCP along the observational line of KS-90JUL2. Velocity differences between 50 db and 100 db (a) and between 100 db and 150 db (b).

current measurements which are able to exclude ageostrophic component are needed to obtain the real velocity fields around this seamount.

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日本南岸の第二紀南海山周辺の海洋観測

関根 義彦・林 辰哉

要旨：日本南岸にある第二紀南海山周辺の海洋観測を1989年夏，1990年夏に計3回行った。その結果，海山山頂以浅では海山東に等温度線と等塩分線の下降があり，海山直上でそれらの上昇を伴うパターンが10日以上維持されることが示唆された。また海山周囲の頂上以深の斜面上では等温度線と等塩分線の鉛直変位が共通して認められた。この鉛直変位により，1000m以深の深層で地衡流が顕著な鉛直シアーを伴い，海山の地形効果はこの鉛直シアー層以深に限られる可能性が示唆された。また，海山の山頂直上では微細構造が認められた。特に水平方向に同じような構造を持つ水温の逆転が1990年7月の1回目の航海で観測された。

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Société franco-japonaise d'océanographie, Tokyo

Characteristics of ciliated protozoa inhabiting colonies of pelagic blue-green algae*

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and Ryuzo MARUMO*5

Abstract: Ciliated protozoa were isolated from the blue green alga *Trichodesmium thiebautii* which is ubiquitous and often abundant in surface seawater of the pelagic sea. Through protargol impregnation, nuclear staining and observations of the living cells, the morphological characteristics of the protist were determined and this ciliate was identified as *Holosticha diademata* (REES, 1884) KAHL, 1932. This ciliate was frequently found in the coastal seawater which suggests the wide distribution of a certain species of protozoa in the coastal and pelagic sea. This species preferentially fed on bacterial strains of *Pseudomonas* spp. when several genera of bacteria were offered as feed.

1. Introduction

In the course of our research on bacterial biomass in seawater, bacterial carbon was determined to occupy several tens of per cent of particulate organic carbon even within the euphotic zone of the seawater column (MAEDA and TAGA, 1979; MAEDA, 1982). As a result of this research, bacterial carbon is now considered to be one of the largest energy sources in the sea. WILLIAMS (1981) also mentioned the significantly large biomass of bacteria in the sea. There have been several reports describing small animals which feed on bacteria (PAFFENHÖFER and STRICKLAND, 1970; HEINLE *et al.*, 1977; KING *et al.*, 1980; MAEDA, 1989). A large portion of ciliated protozoa are also known to be bacteria feeders (WEBB, 1956; FENCHEL, 1968; TAYLOR and BERGER, 1976; ALONSO *et al.*, 1981; MAEDA and CAREY, 1985; MAEDA, 1986) and the existence of energy transfer from bacteria to animals through ciliates was conclusively established in the laboratory (SEKI, 1966; TEZUKA, 1974). Thus the role of bacteria as feed seems to be substantial and ciliates are probably one of the key animals in the process of food transfer in the marine ecosystem. From this point of view we have been interested in investigating the ecological aspects of ciliates in the marine environment.

In this report we describe the taxonomical characteristics of ciliated protozoa attached to suspended colonies of the blue green alga *Trichodesmium thiebautii* in the South China Sea. Bacterial strains which coexisted in the ciliate culture were also identified and their availability as feed for the ciliates was determined.

2. Materials and methods

Sampling

Trichodesmium colonies were collected using a plankton net with a mesh size of 330 μm in the southern area of the South China Sea during the cruise of R/V Hakuhomaru

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in November, 1981. Coastal seawater were collected with a small glass bottle at Aburatsubo Inlet, Japan. *Trichodesmium* colonies were picked up with sterilized pipettes and kept in sterilized seawater for subsequent isolation or examination of the ciliates attached to them.

Isolation of ciliated protozoa

Cililates attached to *Trichodesmium thiebautii* were isolated using a micropipette under a binocular microscope (magnification, ×45). Isolated ciliates were placed into a medium which contained the following components ($g \cdot l^{-1}$ seawater): Proteose peptone (Difco), 0.02; Tripticase (Sigma), 0.02; Bacto yeast extract (Difco), 0.02; ribonucleic acid (Sigma), 0.002; Bacto agar (Difco), 15 and extract of cerophyl leaves (Sigma), 2 ml/l (that is, 5 g of cerophyl leaves was boiled with 1 litre of distilled water for 5 min. and the supernatant after filtration with Toyo filter paper (Type 1) was used.). Ten ml of this agar medium was put into a 200 ml of flask and 10 ml of sterilized seawater was placed on top of the agar after solidification. The ciliate cultures were kept at 25 ℃.

Identification of ciliates

The species of ciliate was identified by the protargol impregnation technique (TUFFRAU, 1967) and the Feulgen nuclear reaction for examining cirri and nuclei, respectively.

Isolation and identification of bacteria

Bacteria were isolated from seawater *in situ* and from the cultivation bottle for ciliates and were cultured on the same agar medium described above. The isolated bacteria were identified according to the scheme of SHEWAN *et al.* (1960). The vibriostatic compound 0/129 (2, 4-diamino-6, 7-diisopropylpteridine) was not used to distinguish *Vibrio* from *Aeromonas*. Their discrimination was made on the basis of gas production from glucose. A few Gram-negative, oxidase-negative rods with polar flagella were assigned to *Vibrio* or *Aeromonas* but not to Enterobacteriaceae. The mode of glucose metabolism of the isolates was determined using the Hugh-Leifson's medium (HUGH and LEIFSON, 1953) made with artificial seawater instead of freshwater.

Response of ciliates to bacteria

Ten freshly cultured ciliates were washed three times in sterilized seawater for 24 hrs and placed in a small Petri dishes (27 mm diameter) with seawater. The bacterial strains used as feed for the ciliates were washed with sterilized seawater by centrifugation after cultivating for two days and were added at the concentration of 10^8 cells/ml to the Petri dishes containing the ciliate. The Petri dishes were placed in the wet chamber at 25 ℃ and ciliate numbers were determined under the binocular microscope.

3. Results

Fig. 1 shows a colony of *Trichodesmium thiebautii*. Ciliates of the order Hypotrichida were found among the *Trichodesmium* colony and these ciliates were isolated and investigated in this work.

Protargol staining shows the arrangement of cirri in the adoral, ventral and caudal zones of the ciliate cell (Fig. 2). Three frontal cirri and pairs of ventral cirri with zig-zag shape were the characteristic features

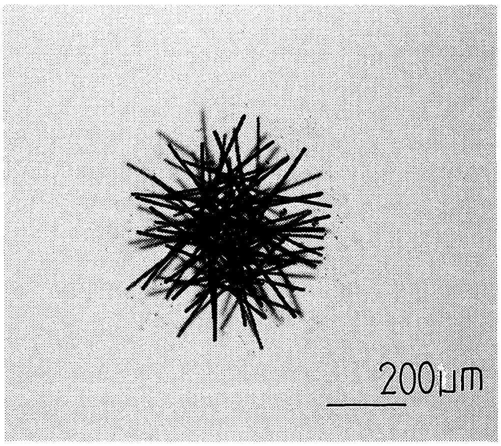

Fig. 1. A colony of the blue green algae *Trichodesmium thiebautii*.

of this ciliate. Nuclear staining revealed two macronuclei and 4 micro-nuclei (Fig. 3). Based on these observations and direct observations of the living cells, taxonomical characteristics of the ciliate are summarized diagrammatically in Fig. 4. Further characteristics of this protist are as follows. Size around 80 × 30 μm. Body flat dorsoventrally, rounded at ends. Membranelles of adoral zone (AZM) 19-26, 2 frontal cirri, about 11 left and 10 right marginal cirri. Transverse cirri around 7 and pairs of ventral cirri with zig-zag shape about 8. Bend of the anterior end of the left marginal cirrus row and a marine habitat. We identified this ciliate as *Holosticha diademata* (REES, 1884) KAHL, 1932, although the number of AZM was slightly different from that reported by BORROR (1963). The same species was also found frequently on zooplankton detritus in coastal waters of Japan, such as Aburatsubo Inlet.

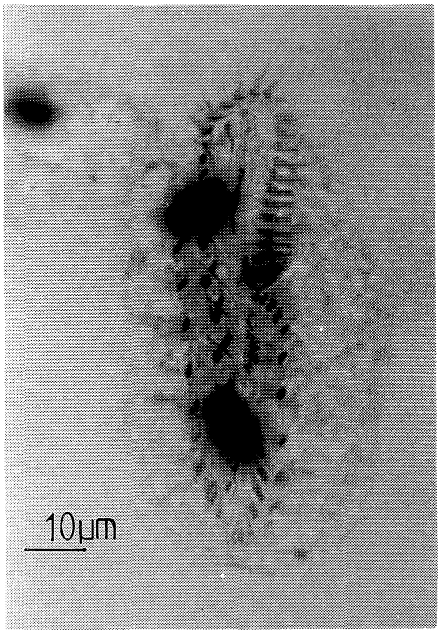

Fig. 2. Protargol impregnation of the ciliate.

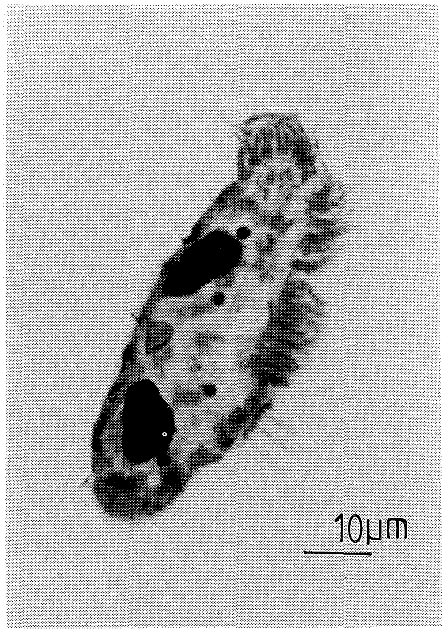

Fig. 3. Nuclear staining of the ciliate.

Bacterial strains isolated from the agar-seawater medium bottle of *Holosticha diademata* were all *Pseudomonas* spp. Among 9 bacteria isolated, *H. diademata* could be grown with 3 of these bacterial strains as feed, and amongst these strains the Strain No. 7 supported the maximum growth of ciliates during 5 days incubation (Table 1). Among the strains of *Pseudomonas, Vibrio, Acinetobacter* and *Flavobac-*

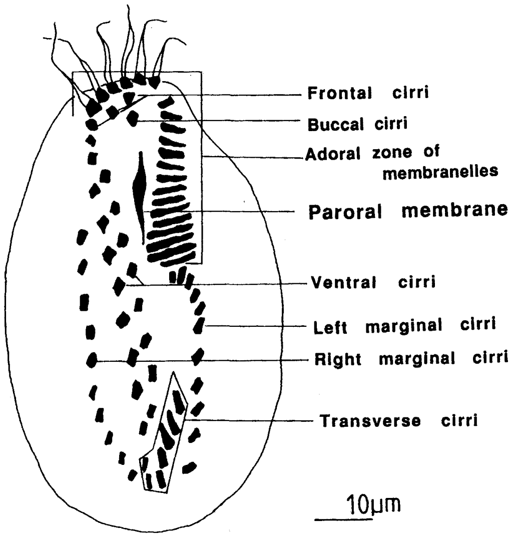

Fig. 4. Diagram summarizing the taxonomical characteristics of the ciliate, *Holosticha diademata* REES, 1884.

terium isolated from coastal seawater of Aburatsubo Inlet, *H. diademata* grew well when the animal was kept with *Pseudomonas* spp. (Table 2).

4. Discussion

The blue green alga *Trichodesmium* is ubiquitous and frequently abundant in sub-equatorial sea areas. It occurs at and/or slightly below the surface water layer and cells (size; 5-10 μm) are linked to each other in strings. The strings form coagulates resulting in colonies which are often large enough to be visible. *Trichodesmium* frequently blooms in the South China Sea and this prominent productive algae which occurs in oligotrophic environments provides a habitat for various microorganisms.

BORROR (1963) reported the distribution of *Holosticha diademata* in the sediment of a salt marsh. We found this species frequently on detritus in coastal seawater in

Table 1. Bacteria isolated from culture liquid of *Holosticha diademata* and growth of the ciliate in their presence

Strain No.	Bacterial genus	Growth of *Holosticha*
HPP 4	*Pseudomonas*	+
HPP 5	*Pseudomonas*	++
HPP 7	*Pseudomonas*	++
HPP 8	*Pseudomonas*	−
HPP 13	*Pseudomonas*	−
HPP 15	*Pseudomonas*	−
HPP 20	*Pseudomonas*	−

+ : numbers of the ciliate less than 50 cells/cm^{2*}
++ : numbers of the ciliate more than 50 cells/cm^{2*}
± : little identifiable growth of the ciliate
− : no growth of the ciliate
(*: Numbers of *H. diademata* was expressed as the unit of cells/cm^{2*} because this ciliate tended to stay on the bottom of the culture container.)

Table 2. Bacteria isolated form coastal seawater and the growth of *Holosticha diademata* in their presence

Strain No.	Bacterial genus	Growth of *Holosticha*
HPO 1	*Vibrio*	−
HPO 2	*Vibrio*	−
HPO 3	*Pseudomonas*	−
HPO 6	*Pseudomonas*	+
HPO 7	*Vibrio*	−
HPO 8	*Pseudomonas*	±
HPO 15	*Pseudomonas*	++
HPO 16	*Acinetobacter*	±
HPO 17	*Acinetobacter*	−
HPO 19	*Pseudomonas*	−
HPO 62	*Flavobacterium*	−

(Notations are same as those in Table 1.)

eutropic areas, as well as in pelagic environments. The occurrence of the same species of ciliate in both pelagic and coastal areas seems to suggest that even in oligotrophic areas the potential extent of biological productivity might be high in microbial communities. Thes high productivity of ciliates was attributed by the bloom of *Trichodesmium*.

H. diademata fed preferentially on *Pseudomonas* strains of bacteria. Although the reasons for the unsuitability of some bacteria as ciliate feed are still not clear from this study, feeding specificity may also provide a mechanism for niche partitioning among cohabiting bactivorous ciliates in the natural environment, as spatial distribution and temporal succession of ciliates can be explained by prey specificity (Noland, 1925; Coler and Gunner, 1969; Taylor and Berger, 1976).

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外洋水域の藍藻より分離した原生動物繊毛虫の特徴

前田昌調・洲浜幹雄・多賀信夫・丸茂隆三

南シナ海より採集した藍藻, *Trichodesmium thiebautii* に付着している原生動物繊毛虫を分離した。プロタルゴール染色, 核染色, および生体観察の結果, この繊毛虫は*Horosticha diademata* (REES, 1884) KAHL, 1932と同定された。この種類は沿岸域海水中にも多く, 今回の分離により, 海洋における原生動物同一種の広範な分布が示唆された。餌料として, いくつかの細菌種を投与したところ, 本繊毛虫は, *Pseudomonas* 属の細菌の存在下において, よく増殖することが明かとなった。

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Société franco-japonaise d'océanographie, Tokyo

大阪湾周辺における1985年チリ津波*

中村　重久**

The 1985 Chilean tsunami around Osaka Bay*

Shigehisa NAKAMURA**

Abstract: The 1985 Chilean tsunami is studied for getting an helpful key of preparedness to a forthcoming coastal hazard. First,a notice is givin about the specific pattern of the 1985 Chilean tsunami along the Pacific coast of the South America. Its transoceanic pattern,especially around Osaka Bay in the northwestern Pacific, is considered to discuss a possible process at establishing resonant modes in Osaka Bay and Kii Channel after the tsunami arrival.

Energetics of the 1985 tsunami helps to estimate the tsunami energy at the source area and the seismic release of the energy at the event even under a bold assumption. The 1985 event is quite similar to that of the 1960 event in the pattern around Osaka Bay. The 1985 event could be useful at establishing an advanced warning system and protection works for the forthcoming hazardous event.

1. 緒　言

北太平洋北西部における1985年チリ津波については，すでに，羽鳥がその状況を記している（羽鳥，1985）。また，中村（1991）は，南米太平洋沿岸および近畿地方沿岸の検潮記録にみられた津波について記している。

過去において，太平洋を横断して日本列島太平洋沿岸に被害をもたらした津波については，たとえば，渡辺（1985）の年表がある。なかでも，1960年チリ津波の日本列島沿岸への影響はとくに顕著であった（たとえば，高橋，1961）。このようなことから，1985年チリ津波についての検討とそこから新しくわかったことを本文で述べることとしたい。もちろん，1960年チリ津波との簡単な対比も試みてみる。これによって，大阪湾周辺で，チリ津波によって誘起された固有振動のパターンとそこに配分された津波のエネルギーの推定やそれに関連した諸問題についての知見が得られる。

2.　チリ津波の危険性

日本列島は，過去において，何回も，南米沖地震津波によって被害をうけている（たとえば，中村，1988）。その危険度は，東太平洋の津波発生確率としてとらえることも考えられる（NAKAMURA，1986）。また，地震津波の発生を，惑星地球の問題として検討した例（NAKAMURA，1990）もある。いづれにしても，南米沖，とくに，チリ沖の地震津波は南米チリ沿岸域のみでなく，太平洋北西部の沿岸域でも無視することはできない。しかし，このように危険度が高いとは言っても，現在のところ，この次の巨大チリ津波で日本を襲うものはいつかを予測することができるようになるまでには，なお，今後検討すべき問題点が多く残されていることは否定できない。

3.　南米における1985年チリ津波の特徴

これまでに，日本では，1960年チリ津波の記録や被害についての詳細な報告がなされている（高橋，1961）。近年，この1960年チリ津波の数値シミュレーションも試みられたようである。しかし，日本国内では，この

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1960年チリ津波の南米沿岸における特徴については何も語られていない。

ところで，1985年チリ津波については，チリ海軍の協力によって，南米沿岸の記録や資料が提供されている（中村，1992)。ちなみに，チリ沿岸のFig.1 に示した7検潮所における1985年チリ津波の記録はFig.2のようになっている。このFig.2 の図中の×印は震央の概位を示す。また，津波の最大波高は，Valparaiso (33.0°S, 71.6°W)で1.15 m，Talcahuano (36.5°S, 73.0°W) では3 mであった。津波伝播の岸沿いの特徴は，定性的にみて，中村（1989）が考えたケルビン波型津波としてとらえることができるかもしれない。

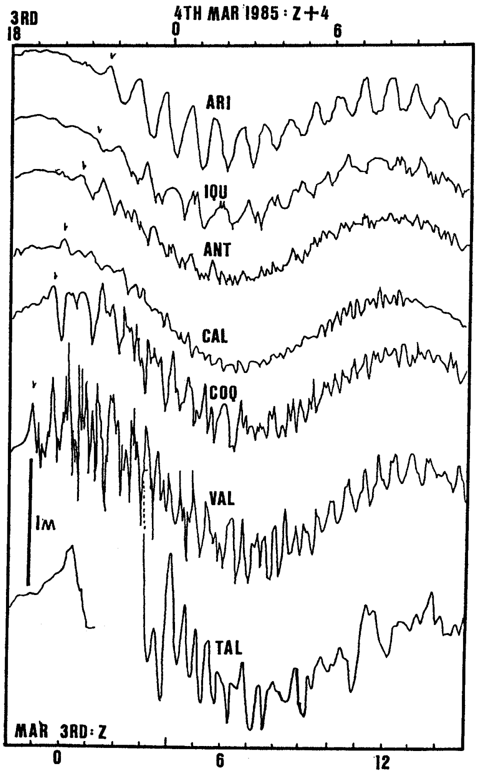

Fig.1. The 1985 Chilean tsunami along the Pacific coast of the South America.
(a) Stations: Arica as ARI, Iquique as IQU, Antofagasta as ANT, Caldera as CAL, Coquimbo as COQ, Valparaiso as VAL and Talcahuano as TAL.
(b) Vertical height scale as a stick of one metre.
(c) Local time (Z+4) at the top and Universal time Z at the bottom.
(d) Each arrow marking the first tsunami crest.

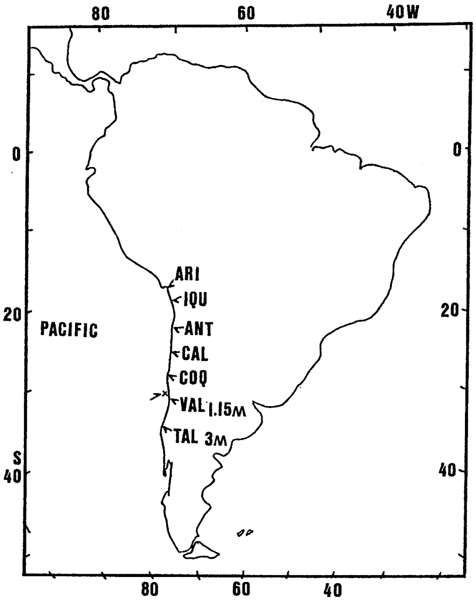

Fig.2 Location of the tide staions along the Chilean coast.

ちなみに，1960年チリ津波で，すべての記録で，津波があまりにも巨大で，スケール・アウトしたおそれも無いとは言えない。

4. 近畿地方における1985年チリ津波の特徴

近畿地方で，この1985年チリ津波はとらえられているであろうか。

1960年チリ津波（高橋，1961）の例などからみれば，チリ沖で生じた地震津波は，ハワイ諸島を経て，地震後約24時間経過した後に日本列島太平洋沿岸に到達するものとみられる。このような過去の資料や記録を参考にして，さらに，1985年チリ津波を含む検潮記録を利用して検討をすすめる。

1985年3月のチリ津波についての資料は，当時の神戸海岸気象台の周東健三によって利用可能となったが，近畿地方で津波による被害がなかったことや検潮記録からチリ津波到達の判断が容易でなかったことなどで，とくに，重要視されることなく，現在に至っている。ちなみに，Fig.3に示すような近畿地方の9検潮所における津波の記録は，Fig.4 のようになる。

ここで，簡単のために，線型波として津波をとらえ，

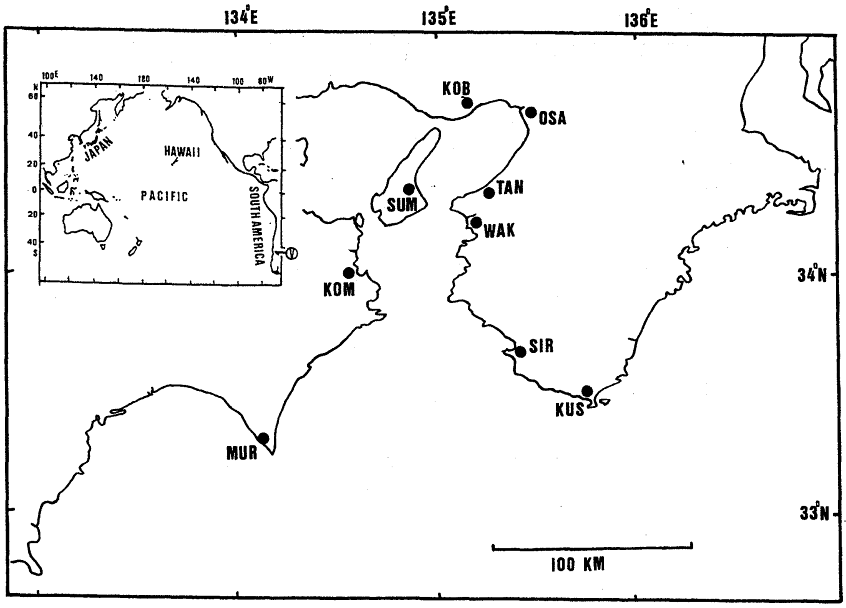

Fig.3　Location of the tide staions around Osaka Bay in the northwest Pacific.
(a) Stations: Muroto as MUR, Komatsujima as KOM, Sumoto as SUM, Kobe as KOB, Osaka as OSA, Tannowa as TAN, Wakayama as WAK, Shirahama as SIR, and Kushimoto as KUS.
(b) Scaleng bar for 100km.
(c) Inset showing the location of Japan, Hawaii and South America with a mark for Valparaiso.

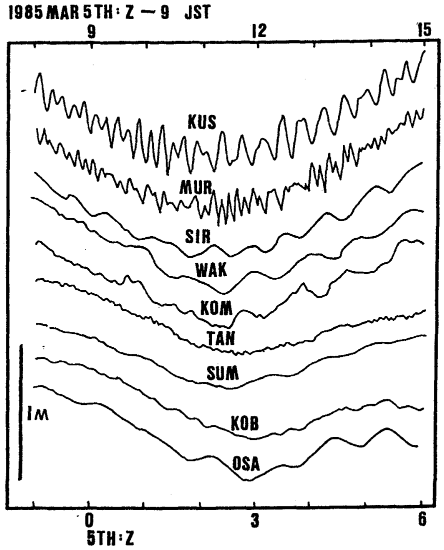

Fig.4　The 1985 Chilean tsunami recorded at the tide stations around Osaka Bay in the northwest Pacific.
(a) Vertical height scaling by a stick for one metre.
(b) Local time (Z-9) at the top and Universal time Z at the bottom,

津波のエネルギーについて考えてみることとしよう。近畿地方には，紀伊水道や大阪湾などがあり，海岸地形も海底地形も複雑である。半無限海での津波（たとえば，NAKAMURA, 1989）のモデルでは検討できない。湾水振動やそれにつながる問題（中村，1980；1981）を考えるとしても，単純化した海岸線や海底地形を想定せざるを得ない。

さて，津波を，正弦波状の波と考え，その波高をHとする。波のポテンシアル・エネルギーをE_pとし，運動学的エネルギーをE_kとする。このとき，波の運動に関与した水の単位体積あたりの全エネルギーEは，

$$E = E_p + E_k, \qquad (1)$$

ただし，

$$E = \frac{1}{8}\rho g H^2, \qquad (2)$$

ここに，ρは海水密度（約1 g／cm³），gは重力加速度（980cm／sec²）とする（たとえば，矢野，1971）。波高はcm単位，Eはerg 単位で表すものとする。

ここで，Fig.4に着目しよう。これまでに検討してきたこととあわせ考えると，津波の到達推定時刻（中村，1991）から数時間後には，大阪湾内に約50分を周

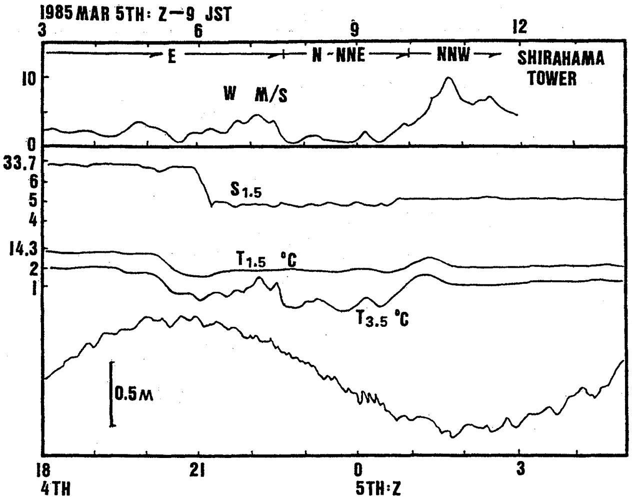

Fig.5 Oceanographical and meteorological records at the Shirahama Oceanographic Tower Station.
(a) Wind speed(m/s) and wind direction(E or N or NNE or NNW).
(b) Salinity(psu) 1.5m above the sea floor.
(c) Temperature (℃) 1.5m and 3.5m above the sea floor.
(d) Variations of the sea level with a stick for 0.5 m.
(e) Location of the station: 135°21′E,33°42′ N.

期とする振幅約10cmの水位変動が明瞭になる。水位変動の記録を，大阪（OSA)，神戸（KOB)，洲本（SUM)，淡輪（TAN）についてみると，この周期的水位変動は，大阪湾口付近を節とし，大阪湾奥を腹とする固有振動で，いわば，大阪湾の単節湾水振動である。このことから，この単節湾水振動は，チリ津波によって誘起され，振幅最大時には，大阪湾奥では，E_kはゼロであるから，概略

$$E=E_p=1.2\times10^4\text{erg} \qquad (3)$$

ということになる。大阪湾口付近では，E_pがゼロに近い値となり，

$$E=E_k \qquad (4)$$

と考えてよいだろう。

つぎに，紀伊水道に着目しよう。大阪湾について考えたときと同様にして，和歌山ではE_pは1.5×10^4esg程度，小松島では10^4 esg程度と推定される。ここで，Fig.4の水位変動のうち和歌山（WAK）と小松島（KOM）の水位変動は，約50分の周期的変動で，両者互に位相が180° ずれていることがわかる。これは，紀伊水道内には，単節横振動が生じていることを示唆している。同時に，大阪と和歌山とでは振動の位相が互に位相が180° 程度ずれていることもFig.4からわかる。

したがって，和歌山では，E_pは1.5×10^4esg程度と推定される。しかし，白浜（SIR）の水位変動をみると，これは，和歌山に対して位相が180° ずれている。白浜のE_pの値は，およそ8×10^3esgと推定される。これは，日の岬と蒲生田岬とを結ぶ線の近くを節とする紀伊水道のたて振動と解釈することもできる。

中村（1991）は，Fig.5 に示すような沖合固定点としての白浜海洋観測塔の水温・塩分の連続記録をもあわせて検討した。当時の海上風や海況から判断して，白浜に津波が到達したのは，およそ1985 3 月 5 日 8 時30分JSTと推定している。串本（KUS）および室戸岬（MUR）では，地域的な水位変動にまぎれて，津波到達の判別は難かしい。

以上のことから，チリ津波が侵入して，大阪湾および紀伊水道での固有振動が誘起され，その判別ができるようになるまでに，2－3時間を要していると考えて差支えないだろう。この2－3時間は，津波が反射して，津波のエネルギーが固有振動のエネルギーにおきかわるために要したものと考えられる。しかし，ここで考えたエネルギー変換の力学的機構が現在のところ明らかであるとは考え難い。

5. 波源域の津波エネルギーの推定

ここで，1985年チリ津波の波源域の津波エネルギー

E_tを推定してみる。簡便な方法（たとえば，矢野，1971）として，

$$E_t = \pi \rho g C R \Sigma H^2 T \qquad (5)$$

を用いる。概略の値をもとめることを目的とするため，海水密度は近似的に$\rho = 1\,\mathrm{g/cm^3}$とし，重力加速度は$g = 980\,\mathrm{cm/sec^2}$とする。水深h cmならば，津波の速さは$c = (gh)^{1/2}$とみてよい。また，Rは津波源の中心からの半径，Tは波の周期である。

チリ海軍の資料（中村，1991）によれば，1985年3月3日22時46分54秒GMT（UT）にチリ中部に強い地震があった。震央は，概略，Valparaiso沖14海里（約30km）西方であり，地震のマグニチュードは7.7（リヒターのスケール）であった。

ここで，その付近の水深hに対するcの値を200m／secとし，Rは約30kmとする。震央に最も近い海岸域での最大波高を対象として，H＝1mとし，波の周期Tは30min位とする。このとき，E_tの値は，概略，3×10^{20}ergとみてよいだろう。また，矢野（1971）の資料をもとにして，ここで，地震のエネルギーの約10^{-2}倍が津波のエネルギーになるものと考えることにすると，1985年チリ津波の最大波高をよりどころとするかぎり，地震のエネルギーE_sはおよそ3×10^{22}ergと推定されることになる。

6.　1960年チリ津波との比較

1985年チリ津波は，大阪湾内では微少なものであった。しかし，湾水振動の誘起には，1960年チリ津波の例と基本的に共通した点が認められる。すなわち，大阪湾では，湾口を節とする単節たて振動の誘起が認められる。紀伊水道では，単節横振動が誘起されていることが共通している。

1985年チリ津波と1960年チリ津波との差は，大阪湾奥の最大波高にある。1960年のときは約1.5mであったのに対し，1985年のときは約0.1mであった。波のエネルギーは波高の2乗に比例することを考えると，波源域での津波のエネルギーも同様な割合で評価できるものとみてよいであろう。

このことは，地震のマグニチュードについて，1985年ではM＝7.7（たとえば，中村，1991）とされているのに対して，1960年では主震に対してM＝8.5（東京天文台編，理科年表）であることと，相互に矛盾していない結果であると言える。

7.　1985年チリ津波の意義

すでに見たように，1985年チリ津波は，大阪湾をはじめ，近畿地方では微少であった。しかし，関連した資料を検討してみると，本文で対象とした1985年チリ津波は，1960年チリ津波の縮小版であったとも考えることができる。次の巨大チリ津波の来襲までに，その特性をとらえ，その成果を，津波警報や対策に有効に活用できればよい。その検討への鍵が1985年チリ津波であると言えるであろう。

なお，本文では，津波の指向性（たとえば，KAJIURA，1970；1974）や地震断層パラメータ（たとえば，KAJIURA，1981）についてはとくに考えることはしなかった。

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海洋観測塔で記録された遠隔台風による海上小規模渦*

中村重久**

Atmospheric eddy induced by a distant decaying typhoon observed at an offshore oceanographic tower*

Shigehisa NAKAMURA**

Abstract: At an offshore oceanographic tower station, an eddy induced by a distant decaying typhoon was observed. The tower is located in the northwestern Pacific. A part of the recorded winds at the tower suggests that the typoon 9015 must surely accompanied or induced a remote atmospheric eddy on 3rd September 1990. A conceptual model is introduced for a dynamical understanding with several assumptions in order to realize the record at the tower. Additional notice is about the suffer which was happened at almost same time just neighbour the tower.

1. 緒言

著者は沖合の海洋観測塔記録をよりどころにして，遠隔台風の衰退期に竜巻ともみられる突発的強風を検討した。このような例は，中村（1987）が論じているが，本文の例はこれとは少し視点が異る。ここでは，1990年の台風9015号の影響による地形性の海上小規模渦として，観測塔の風の記録を検討し，思考モデルによって力学的機構の概念的理解に努めた。

なお，この現象は和歌山地方気象台でも解析されており，一部既に発表された部分と重複するところがあるかもしれない。当時，気象台関係者と著者との検討を行ったことを記しておきたい。

2. 台風9015号の経路

台風9015号の経路は，台風8613号の経路によく似ている（中村，1987）。すなわち，台風9015号は，1990

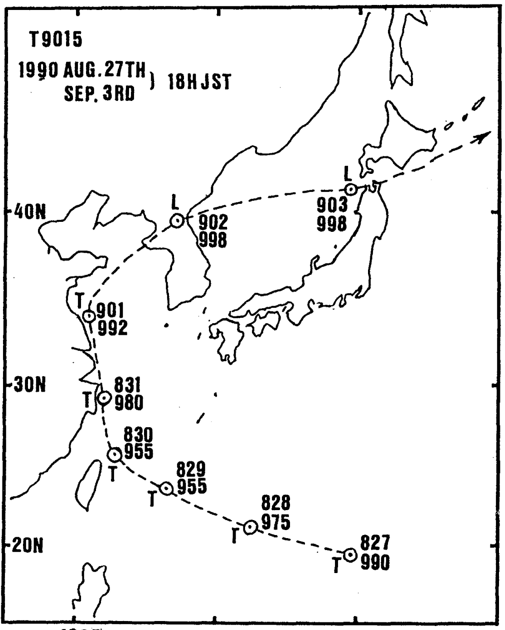

Fig.1. Track of Typhoon 9015 (27th Aug. to 3rd Sep. 1990). Marks T and L mean Typhoon and Low pressure. Encircled dot for the typhoons location at 1800JST on each day with date and pressure (mb or hPa).

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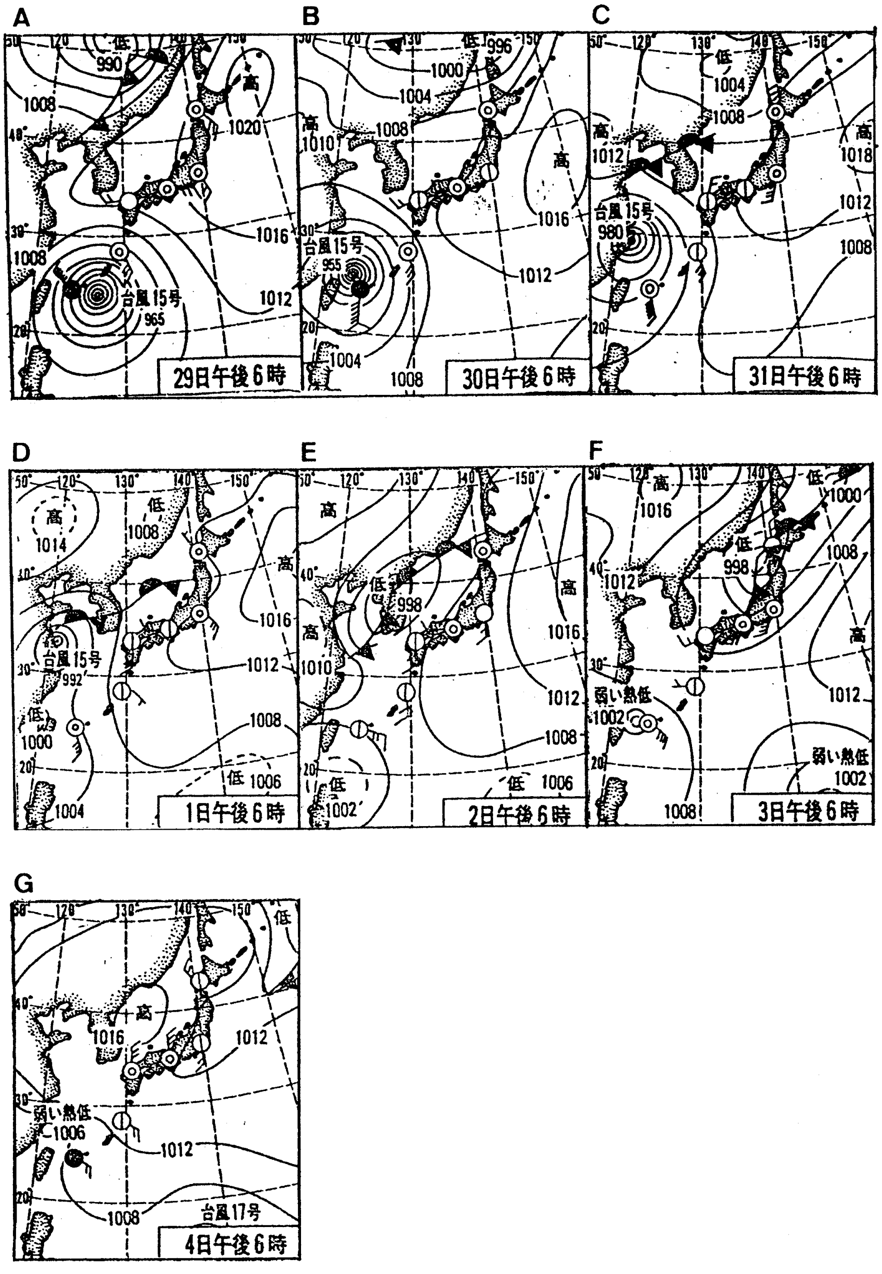

Fig. 2. A series of the surface weather map (29th to 4th Sep. 1990). A to G corresponding to the daily weather map on 29th August to 4th September 1990. Each weather map for 1800JST.

年８月27日から９月３日までFig.1に示すような経路をとった。なお図中には，各日18時（ＪＳＴ：日本標準時）について，台風中心位置と台風中心気圧（ミリバール単位：mbあるいはhPa）を示した。ちなみに，新聞天気図（たとえば毎日新聞）では，このFig.1のうち，本文に関係の深いものはFig.2のようになる。1990年８月29日18時の日本列島付近の地上天気図は，Ａのようになっていて，台風9015号が台湾東方にあることがわかる。翌30日18時には，天気図はＢのようになり，31日18時にはＣのようになる。９月１日18時の地上天気図はＤ，そして翌２日18時はＥとなる。このようにして，本文の問題とする時刻に近づいていく。図中Ｆは，９月３日18時の天気図で，この時，すでに本文の対象とした現象は収っている。翌９月４日は，日本列島は高気圧におおわれている。このように台風9015号は，朝鮮半島で強風雨洪水をもたらした後，日本海へ出て低気圧となり，津軽海峡付近を東進した。

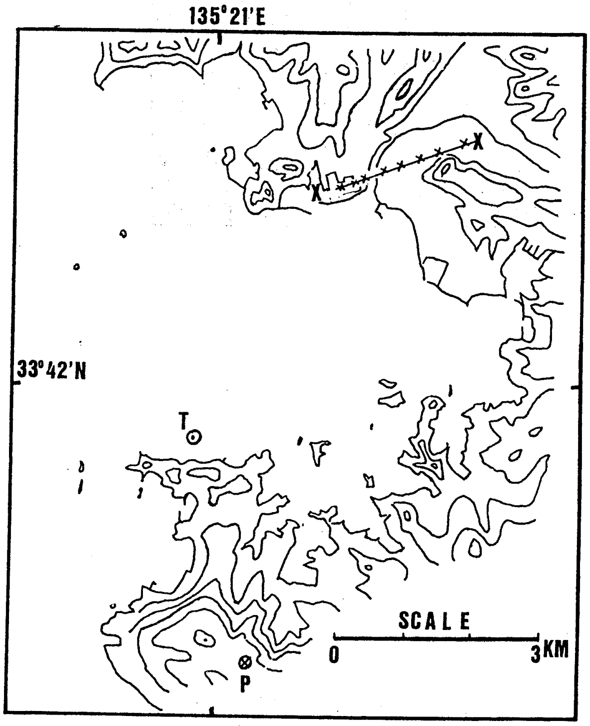

Fig. 3. Location of offshore oceanographic tower station and surrounding profile of coastal zone. Marks T and P maen Tower station and Air Port. Mark of X-X shows the sufferred belt by a sporadic gale in Tanabe City.

3. 海洋観測塔の記録

白浜海洋観測塔は，Fig.３の記号Ｔの位置にある。また，南紀白浜空港は記号Ｐの位置である。観測塔は，海岸線から沖合約0.5kmにある。また，塔周辺の陸上地形はかならずしも単純ではない。便宜的に，その地形の特徴を示す等高線をえらんで示した。

観測塔では，海象・気象の連続観測記録を１分間隔で行っている。ここでは，そのうちの平均風速W_S，平均風向W_Dおよび気温T_Aを検討の対象とする。とくに，1990年９月３日の16時30分頃，観測塔の北東方約５kmの和歌山県田辺市では，竜巻による被害の通報があった。このようなことから，観測塔の記録をみると，Fig.4のようになっていて，とくに顕著で特徴の

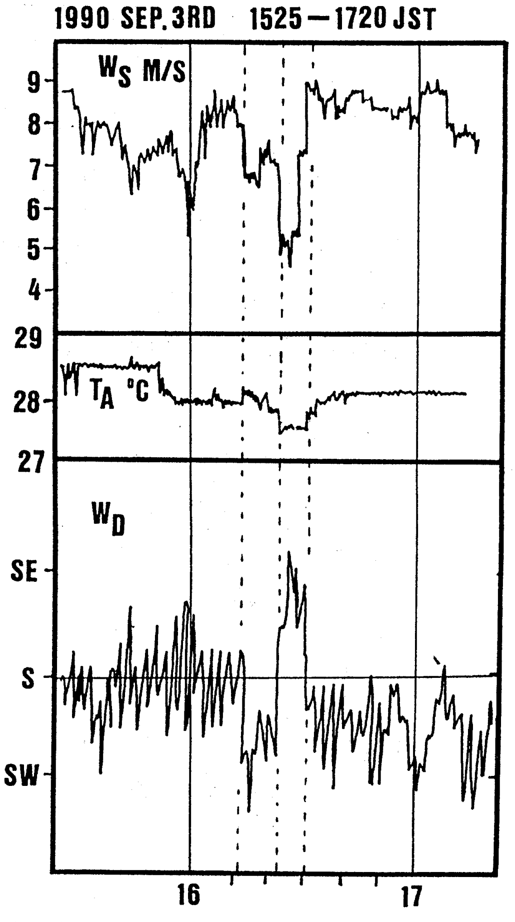

Fig. 4. Observed result at the offshore tower station. Notation W_S, W_D and T_A are for wind speed, wind direction and air temperature.

ある変動は，16時10分から30分までの間の風の変動である。なお，この9月3日の水温は，15―17時には27.1―27.2℃であった。この時の水温は気温より0.5―1.5℃低かったことになる。海面付近の大気は安定であったとみてよいだろう。

観測塔の南方，約3kmの南紀白浜空港の観測によれば，16時11分頃に風が強くなりはじめ，16時15分には，最大風速は25m／sとなっている。しかし，この空港の風の変動が，観測塔の風の変動とどのように対応しているかを，記録のみから判断することは難かしい。

一方，気象庁が1990年9月3日15時の雲の状態を日本周辺について図化しているものがあるので，これを参考にすることとし，その一部をFig.5に示した。この図では，Fig.2のような天気図よりも詳しい気象状況がわかる。紀伊半等西部に積乱雲があることが示され，低気圧となった台風9015号（記号D）は，日本海中部を20ノットの速さで東北東へ進んでいる。山陰沖（記号G）に渦動のようなものがみえるが，これは約3時間後には独立した低気圧となる。これに加えて，低気圧Dから南へのびた前線が，紀伊水道から紀伊半島へと向っている。

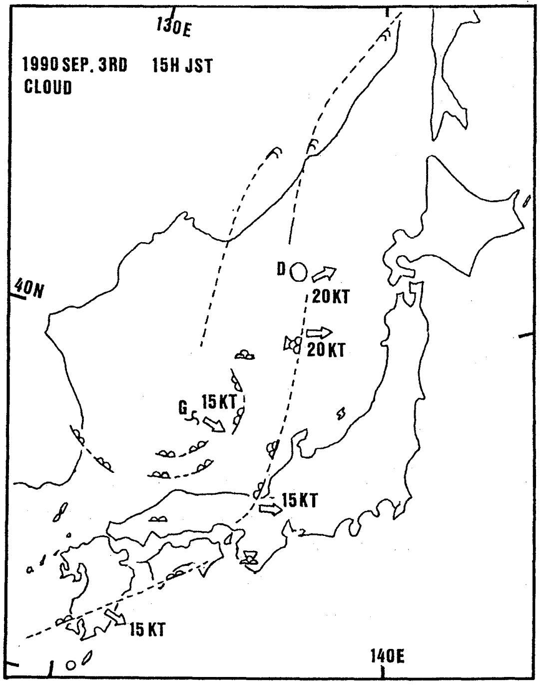

Fig. 5. Cloud map at 1500JST on 3rd September 1990. (courtesy of JMA).

このFig.5を拠りどころとするかぎり，9月3日の現象も，中田（1986）の論じた現象とよく似ているようだ。また，FUJITA（1981）の例から，トルネードに併進する小さな低気圧性渦に対応するとも解釈できそうだ。いづれにしても，この現象は和歌山地方気象台で，いろいろの気象学的情報にもとづいて検討された。ここで著者がこの現象に着目したのは，海上の小規模渦らしいものが沖合の観測塔で記録された点にある。これが従来の気象学で知られているものと同等なものか，異質なものかは不明とせざるを得ない。上層の気象データについては，和歌山地方気象台が検討しているが，現象論としてデータの対比はできても，その力学的機構をとらえる手がかりとしては満足できない。

4. 簡単な渦の思考モデル

これまでにみてきた1990年9月3日のFig.4の記録は，観測塔で得られたもので，観測船や観測ブイの記録では得ることのできないものである。

ここで，Fig.4の記録の特徴を力学的に理解する一助としてごく簡単な思考モデルを導入することを考えた。基本的には，海上にランキン渦のようなものが生じたとし，その渦が，周辺の風の場で移動するという考えに立脚する。いま，このような渦のモデルとして，Fig.6のような例を考える。図の上半分は風速の時間変化を示す。ランキン渦ならば基準線Oからの高さが相対的風速となり，風速の極大はRで，極小は－Rで認められるはずである。この渦が周辺の風の場などの影響により，風速Sで移動しているとすると，風速の時間変動は基準線をOからSへ移して考えればよい。地上からみれば，あるいは観測塔からみれば，上の渦がFig.6 の下半分に示すように北北東に移動し，その移動は渦の周辺の南風Sの場によるものとすると，Fig.4 を渦の記録として理解できるであろう。渦の移動に対して観測塔の位置が，時刻t_E・t_F・t_Gに点E・F・Gにあるとする。このとき対地風速は，点EおよびGでは，RとSとのベクトル和として表わされる。つまり，定性的には，このような簡単な渦のモデルでFig.4の16時10―30分の風の変動が，風速も風向もともにうまく理解できることになる。この考えは，1990年9月には，定性的モデルとして，著者が考えていたものである。しかし，これ以外のモデルも考えることができるかも知れない。海上の沖合の一観測塔の記録以外に，総観的資料しか得られていないので，いくつ

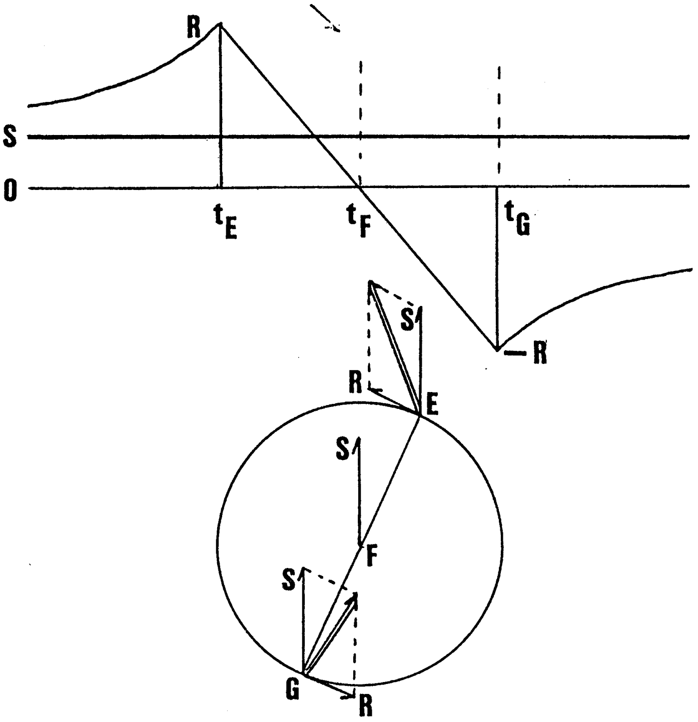

Fig. 6. A conceptual eddy model for a dynamical realizing with a primitive understanding.

もモデルを構成できるかもしれない。ただ，ここで著者が意図したのは，海上小規模渦の力学的理解である。観測塔に近い田辺市の竜巻との関連は，気象学的問題としても検討されるべきであろう。

5. 災害との関連

本文で対象とした，1990年９月３日の海上小規模渦とほとんど時を同じくして，田辺市では竜巻による被害があった。塔の記録・渦・被害との相互関係はないとは言えないが，詳細を述べるには資料が不足している。被害の状況についてみれば，その範囲はFig.3の上部のｘ－ｘの区間で，長さ約2.5km，幅約10ｍの細長い帯状地帯であった。

折から，1990年12月に，千葉県茂原市を中心にした竜巻の被害が報じられ（桂，1991），本文に述べた問題は些末なものと位置づけられたようである。ここにあえて海上小規模渦の問題を提起し，諸賢の意を問わんとするものである。

なお，本文をとりまとめるにあたり，気象庁の関係諸官，千葉県立長生高校，その他，多数の方々の御助力をいただいた。本稿は，最初の草稿から18ヶ月後，査読者の所見を得て，全面的に改稿した。

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La mer 30: 43-45, 1992
Société franco-japonaise d'océanographie, Tokyo

Faits divers

Unusual form of *Ecklonia stolonifera* OKAMURA (Laminariales, Phaeophyta)*

Masahiro NOTOYA** and Yusho ARUGA**

Three types of unusual form of *Ecklonia stolonifera* OKAMURA were found by one of the authors (M.N.) during the ecological studies of this species along the Japan Sea coast and the Tsugaru Channel coast in Aomori Prefecture, Japan.

The specimens A and B in Fig. 1 were collected on March 16, 1983 at Tanosawa, Fukaura, on the Japan Sea coast. The specimen A collected from 20 m depth is normal of this species. In *E. stolonifera* the thallus is made up of three parts; holdfast, stipe and blade. In vegetative propagation stipe and blade are produced from stoloniferous haptera. Holdfast is branched and verticillately arises. Stipe is cylindrical, about 5.2 mm in diameter and 10 cm long. Blade is linear or lanceolate with secondary serrulate bladelets.

The specimen B is unusual, having blade-like flattened stipe. It was collected from 20 m depth. Blade is about 30 cm long and 15 cm wide. The flattened stipe is about 1.2 mm thick, 10 cm long and 2 cm wide at the broadest portion, being curved with smooth surface and slightly thicker than the central part of a normal blade. Blade is issued from short stipe-like cylindrical part at the top of the flattened stipe. Blade and holfast with stoloniferous haptera and newly produced shoots are completely normal in their form. This specimen is three years old judged from holdfast system.

The specimens C and D (Fig. 1) were collected at Ohma, Shimokita Peninsula, on the Tsugaru Channel coast. The specimen C, collected on November 1, 1988 from 8.5 m depth, has two blades; one is 26.5cm long and 5.4 cm wide and the other 9.8cm long and 3.5 cm wide. It has a long stipe of 13.6 cm long with a short branched stipe of 0.7 cm long. This specimen is two years old. The blades have no zoosporangial sori.

The specimen D was collected on July 8, 1987 from a community of small thalli in shallow water of 5.2 m. It has a blade with small stipe issued vegetatively from margin of the mother blade at its serrulate portion. The mother blade is 8.6 cm long and 7.3 cm wide with stipe of 1 cm long and the daughter blade is 3.5 cm long and 3.3 cm wide with stipe of 0.5 cm long. The mother thallus is two years old and has two normal young thalli vegetatively produced from stoloniferous haptera.

There have been several reports on unusual forms in many species of Laminariales from Japan (KINOSHITA 1933, HASEGAWA and FUKUHARA 1956, TOKIDA *et al.* 1956, 1958, FUNANO 1974, YABU and HOMURA 1981, KAWABATA 1959, KAWASHIMA 1987). However, we have not known reports on unusual form of *Ecklonia stolonifera*. Similar types of unusual form have been reported in other species of Laminariales. KAWASHIMA (1987) reported two blades with branched stipe in *Alaria angusta*, *Costaria costata*, *Nereocystis luetkeana* and *Postelsia palmaeformis*. Thallus with second stipe and blade issued from the first blade was reported by FUNANO (1974) in *Laminaria 'ochotensis*. Unusual form of blade-like stipe has not been reported yet. The above-mentioned abnormal thalli were found together with normal thalli in the *E. stolonifera* population of

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* Received January 15, 1992

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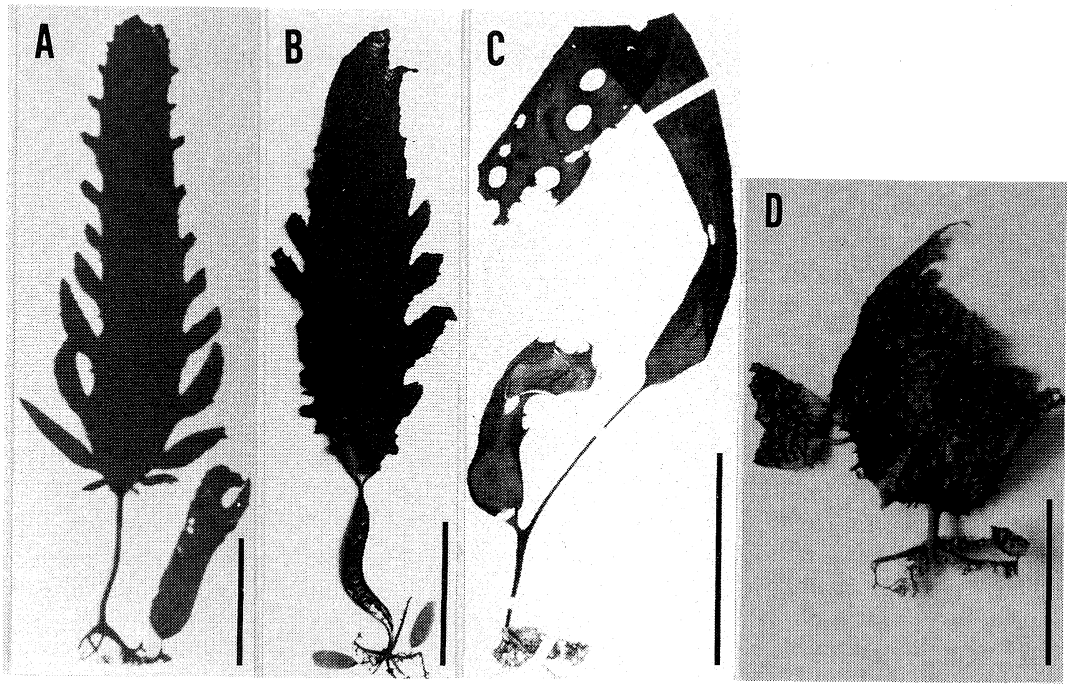

Fig. 1. *Ecklonia stolonifera* OKAMURA thalli of usual or unusual form collected from the coasts of Aomori Prefecture, Japan. (A) Thallus of usual form collected at a depth of 20 m at Tanosawa, Fukaura on the Japan Sea coast on March 16, 1983. (B) Thallus with flattened stipe collected at a depth of 20 m at Tanosawa on March 16, 1983. (C) Thallus with branched stipe and two blades collected at Ohma, Shimokita Peninsula, on the central part of the Tsugaru Channel coast on November 1, 1988. (D) Thallus with a daughter blade on stipe issued from mother blade margin, collected at Ohma on July 8, 1987. (Scale bar: 10 cm)

several years old. They had normal shoots from stoloniferous haptera. Therefore, it is inferred that the thalli of unusual form might not be under genetic control.

Recently, we have reported in the experiments of tissue culture of Laminaliales seaweeds that, in addition to callus, thalli differentiated from the blade tissue collected in the field or from a piece of the juvenile blade of Laminaliales (NOTOYA 1988, 1990, NOTOYA and ARUGA 1989, 1990). This suggests the possibility that also in nature thalli of unusual form can be produced from the wounded part of thallus tissue.

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ツルアラメの通常見られない形態

能登谷正浩・有賀　祐勝

要旨：青森県沿岸のツルアラメ群落から通常の形態とは異なる藻体3個体を採集した。すなわち，茎状部が扁平の藻体，茎状部が枝分れして2つの葉状部をもつ藻体，葉状部縁辺の鋸歯の一部から茎状部を生じ，その先に葉状部を形成した藻体である。これらの藻体は，それらから栄養繁殖によって発出した幼体ならびに同一群落内の他の藻体がいずれも通常の形態であったので，遺伝的なものではなく，体組織の分化異常によるものと推察される。

La mer 30: 46, 1992
Société franco-japonaise d'océanographie, Tokyo

学 会 記 事

1. 1991年11月22日　東京水産大学において平成4年度学会賞受賞候補者推薦委員会（第1回）が開かれ，委員長に谷口　旭氏を選出し，推薦の方法及び次回の日程を決めた。
2. 1991年12月19日　東京水産大学において学会賞受賞候補者推薦委員会（第2回）が開かれ，研究業績について審議の結果，小池勲夫氏（東大・海洋研）が最適格者との結論に達し，この結論を会長に報告することとした。
3. 1992年1月13日　平成4・5年度評議員選挙の公示を行い，投票用紙を1991年12月末日現在の全会員に発送した。2月3日までの消印で郵送された用紙を有効とする。
4. 1992年2月6日　東京水産大学において平成4・5年度評議員選挙の開票が行われた。
5. 1992年3月1日　平成4年度学会賞受賞候補者について会長より全評議員に推薦理由書を付して賛否の投票を依頼した。
6. 1992年3月22日　平成4年度学会賞受賞候補者の賛否についての評議員の投票を締め切った。開票結果は

   投票総数　44　（評議員総数53×2／3＝36　必要投票数）
   賛　44　（有効投票数44×3／4＝33　決定に必要な得票数）

   で，受賞者は小池勲夫氏（東京大学）に決定した。
7. 1992年3月24日　東京水産大学において平成4・5年度評議員選出者による平成4・5年度会長選挙の開票が行われた。

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スライド式高速曳航体 JAMSTEC TSK方式

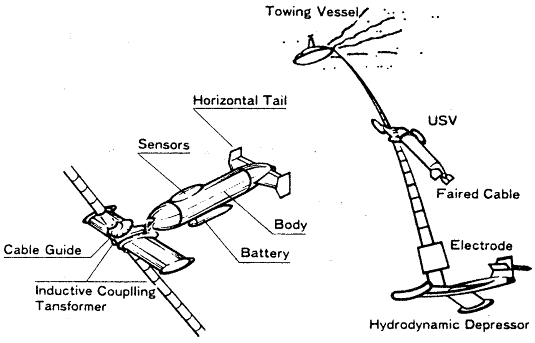
Underwater Sliding Vehicle System (USV)

○本システムは海洋科学技術センター殿の御指導によって開発されました。

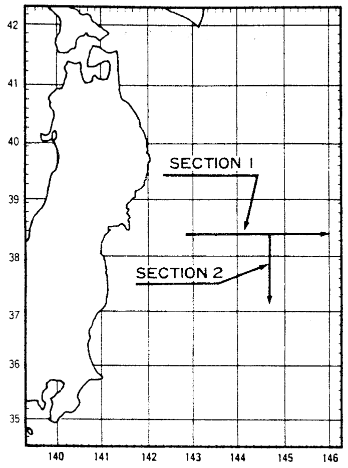
○USVは小型かつ軽量で極めて優れた水中運動性能を有しております。

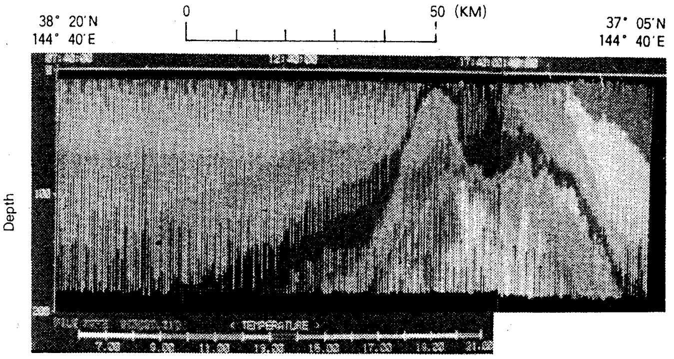
○電磁誘導伝送方式を使うことにより船上からのUSVの昇降運動制御及びリアルタイム信号モニターリングを行うことができます。

○取得データはFD及びハードディスクに記録し2次電算機処理に供します。



The USV system





T.Sスライド式高速曳航体によって得られた三陸沖の水温鉛直分布のカラー画像。

(海洋科学技術センター殿から資料を御提供頂きました。)

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Operation Dapth:Max.400m

Tow Cable :8mm hydrodynamically fared stainless steel wire rope with polyurethane coating

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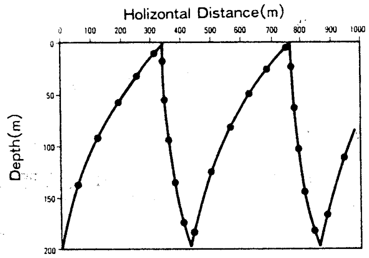
Temperatune	−2〜35℃	±0.05℃
Depth	0〜400dbar	0.5%FS

Data Transport :Inductive Coupling Data Communication System

Sempling Rate :5times per second

Sensor Battery Life :50hours



Trajectory of the USV

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