Preliminary Report
of
The Hakuhō Maru Cruise KH-76-3

July 12 - August 10, 1976
The Sea of Japan

Ocean Research Institute
University of Tokyo
1979

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By
The Scientific Members of the Expedition
Edited by
Syoiti Tanaka

Contents

Introduction

The Cruise KH-76-3 is the second cruise of the R.V. Hakuhō-Maru to Yamato-Tai area in the Sea of Japan following KH-71-4 in 1971. The principal purpose of the cruise, which is same as that of the previous one, is to investigate on conditions and mechanisms of the formation of fishing ground around a bank ("tai" in Japanese). This cruise is characterised by interdisciplinary co-operation of physical, chemical and biological oceanographers and fisheries biologists, and dense observations are concentrated to a small area around Yamato-Tai with the intention of linking physical environment, biological environment and ecology of nektons directly with one another.

The cruise consisted of two legs. In each leg, firstly rapid observations at a set of stations arranged in lattice around Yamato-Tai were conducted for the purpose of synoptic survey. Then, various observations (Station I series) were carried out at one station in the cold water area and another in the warm water area for a few days each. The same pattern of observations was repeated in each leg with the aim to examine changes of the sea in a short time period. Several more stations were set around the lattice stations to get information from a wider area. Measurements of sea current velocity (Station F series) with moored current-meters were continued through both periods. In addition, gravity measurement was continued throughout the cruise.

The R.V. Hakuhō-Maru departed Tokyo on 12th July. In the evening of next day she stopped at Otsuchi Bay, Iwate Prefecture, to deliver her No. 1 utility boat which had been transfered to Otsuchi Marine Research Center of the Ocean Research Institute. She entered into the Sea of Japan through Tsugaru Strait and came back by way of Kanmon Strait and Bugo Channel completing a round Honshu trip. She returned to Tokyo on 10th August. At about midway of the cruise, we stayed at

Sakai-Minato, Tottori Prefecture, from 24th to 29th July for supply and recreation. From evening of 18th to morning of 20th of July, Hakuhō-Maru evacuated from the area to Toyama Bay because Typhoon No. 9 came close to Japan. As a result, 3 northernmost lattice stations and 3 BT stations could not be occupied in Leg-1. However, a supplementary observation station was added in Toyama Bay. Almost all of other observations were conducted on schedule.

On behalf of all scientists aboard, I wish to express our sincere thanks to Captain I. Tadama and all the crew of the R.V. Hakuhō-Maru for their co-operation and support.

Syoiti Tanaka

Chief Scientist

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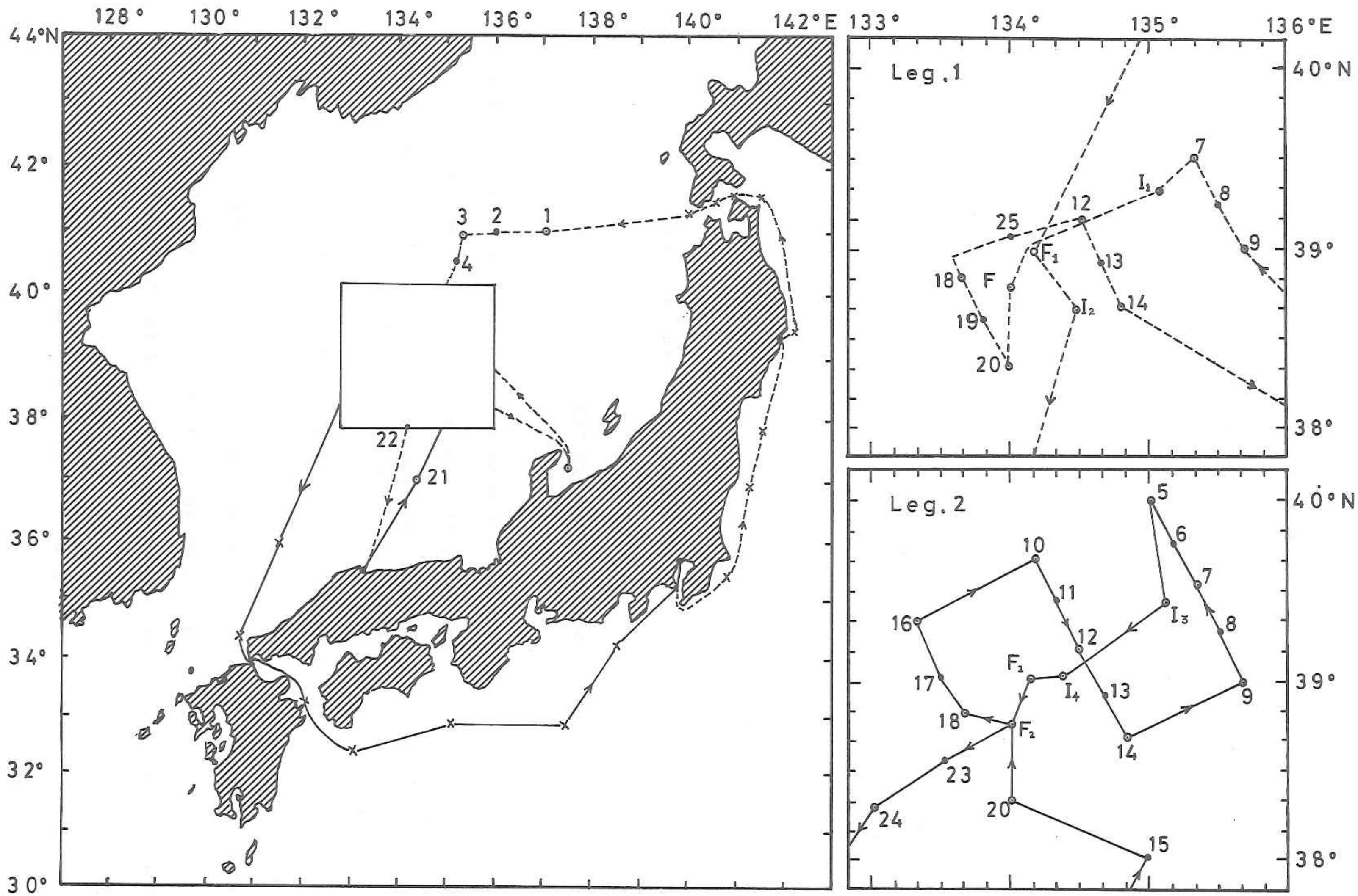

Track Chart of Cruise KH-76-3

1. PHYSICAL ENVIRONMENT OF THE YAMATO-TAI AND RELATED AREAS

1.1 Oceanographical Condition

T. Nakai, H. Hasumoto and K. Nagashima

Observations of the general oceanographic condition were conducted by S.T.D. (Bisset Berman Model 9060) and bathythermograph for the study of the physical environment. The S.T.D. observations were carried out at 27 stations and BT was lowered 44 times over vicinity of the Yamato-Tai in the Sea of Japan (see Track Chart).

Relations of temperature, salinity and depth

The vertical distributions of temperature and salinity, and T-S relations for typical stations such as Stns. 3, I-1 and I-2 are shown in Fig. 1. The water of the Sea of Japan can be divided into a cold current area and a warm current area. The boundary is marked by the Polar Front, approximately running along

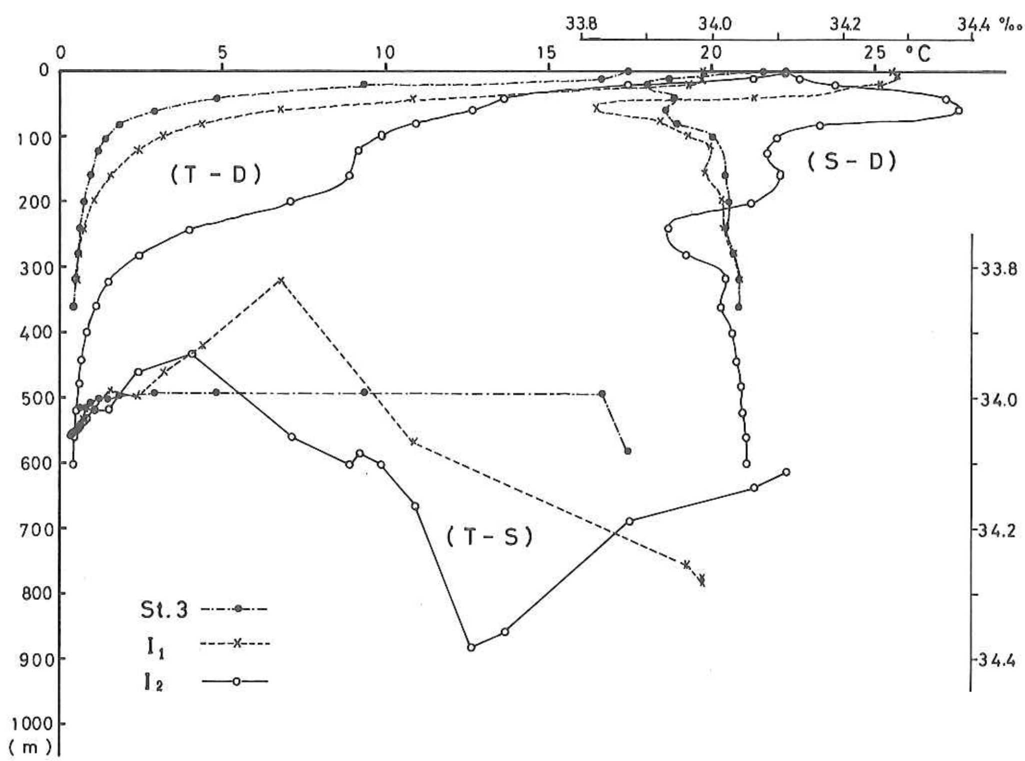

Fig. 1. Vertical distribution of water temperature, salinity and T-S diagram.

38° to 40°N, and meandering in north of the Yamato-Tai affected by the bottom configulation.

The Stn. 3 is placed in the cold current area, north side of the Polar Front. This fact is clearly evident from the diagram of T-D, S-D and T-S relation curves at this station. It shows low temperature and low salinity, but the very thin surface layer is warmed and the seasonal thermocline is most remarkably developed.

The Stn. I-2 is covered with the Tsushima Warm Current and the column of warm water is very thick, the temperature being 9°C at 150 m depth. The remarkable thermoclines are seen at two layers, upper one is the seasonal thermocline and lower one is the main thermocline. The vertical distribution of salinity at Stn. I-2 corresponds to the distribution of temperature. The high saline water, with salinity exceeding 34.3‰, lies in the upper layer, and salinity minimum water is observed at 250 m layer.

The Stn. I-1, which is very close to the Polar Front, shows the transitional

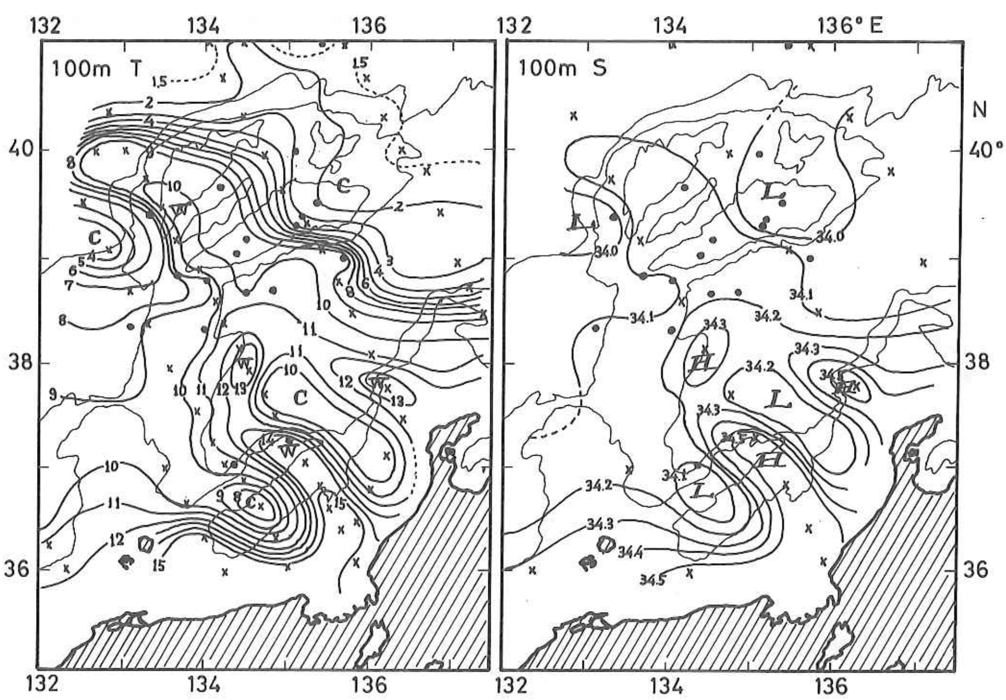

Fig. 2. Horizontal distribution of temperature (°C) and salinity (‰) at 100 m depth observed by the Hakuho-Maru and the Maizuru Marine Observatory.

state between Stn. 3 and Stn. I-2. It seems that the station is in the cold water mass, but the temperature is little higher and the surface salinity is fairly higher than that at Stn. 3.

Horizontal distributions of temperature and salinity

The horizontal distributions of temperature and salinity at 100 m layer are shown in Fig. 2. These contours are drawn based on the results of this cruise and also the data from the Maizuru Marine Observatory in the same period. The thick warm water overspreads to western part of the Yamato-Tai, and the cold water is seen to the northeastern part and to the west of the Yamato-Tai. The boundary between the warm water and northeastern cold water forms the Polar Front. Area south of the Yamato-Tai presents a complicated distribution of water masses under the influence of the course of the Tsushima Warm Current and the bottom configulation. The gross feature of the salinity distribution is similar to the

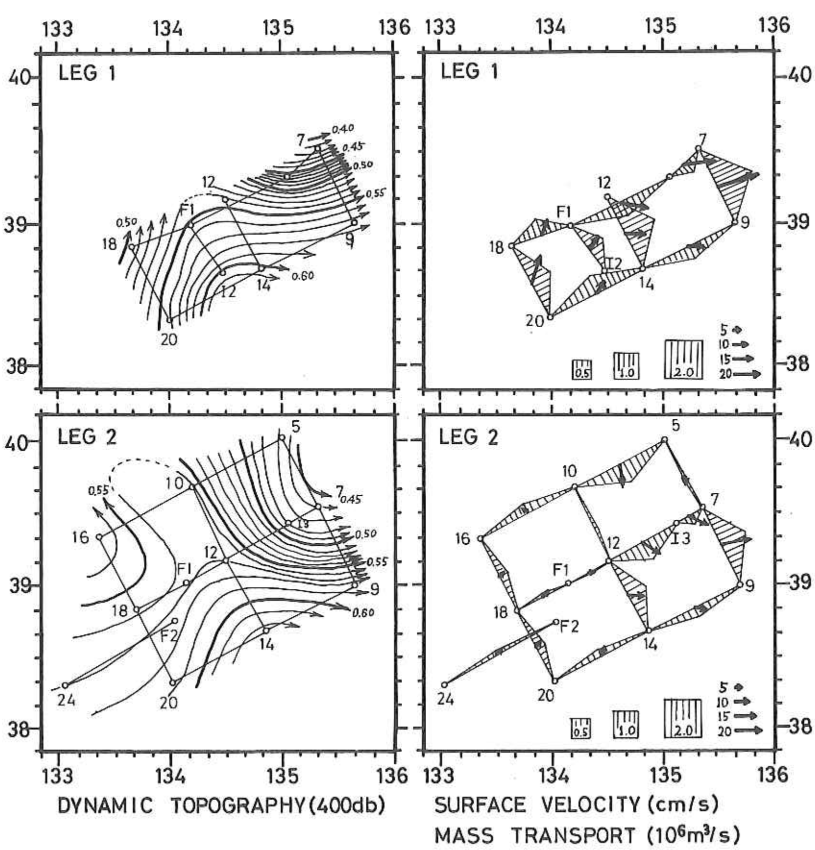

Fig. 3. Dynamic calculation.

temperature distributions. The high salinity belt corresponds with the high temperature area and the Tsushima Warm Gurrent.

Dynamic calculation

The geostrophic current in the vicinity of the Yamato-Tai is estimated with the dynamic calculation and is summarized in Fig. 3. The dynamic topography of the sea surface in dynamic meter, refered to the 400 decibar surface, is shown in this figure. Also presented in the same figure are the estimated surface velocity along the stream line as shown by the arrow marks, and the mass transport (10^6 m^3/sec) as shown by the triangular areas. It shows an example of the Tsushima Warm Current and its branch streams in this season near the Yamato-Tai.

1.2 Measurement of Water Temperature by Means of a Drifting Telemetry Buoy

W. Sakamoto and T. Inagaki

The movement of water and fluctuation of water temperature were measured simultaneously by a telemetry buoy which was allowed to drift freely. The direction of water current was estimated from tracks of buoy which were located by Rador screen every half an hour, and water temperature data were sent to the research vessel by wireless apparatus from the buoy. Both of data will be used to know the relationship between thermal stimulus to fishes and the change of their swimming circumstance.

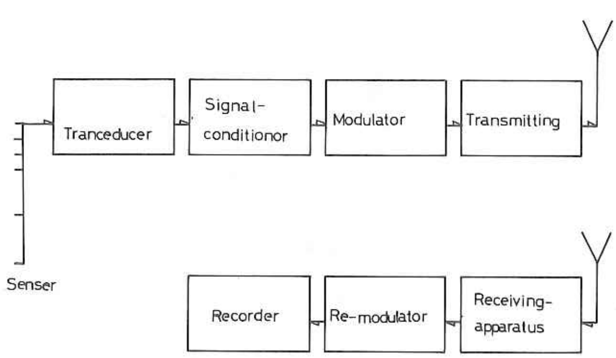

Fig. 4. Block diagram of telemetry system.

Apparatus and method

The water temperature measurement system consists of two main parts; one is the transmission part of data signals put in a drifting buoy, another is the receiving apparatus which is set in a laboratory (Fig. 4). The sensors connected with the drifting buoy measure water temperature of six layers from the sea surface to 150 m depths. The signals can be sent as far as 10 miles every one minute interval during 24 hours (Fig. 5).

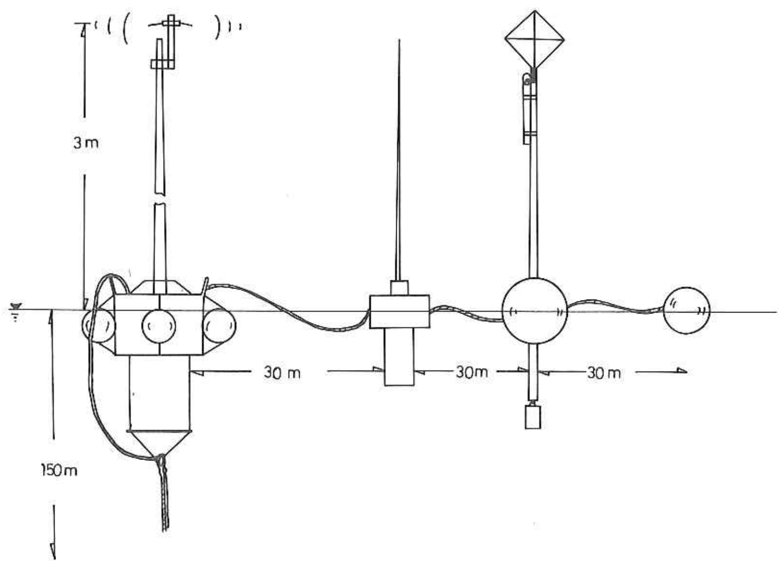

Fig. 5. Floating form of the buoy.

Measurement

The buoy tracking was carried out two times on July 21 and on August 3 1976. In either experiment, two other drifting buoys without sensors were added to form a triangle on the sea surface, since it seemed to be useful to analyse the change of water mass from its deformation. They were set one mile apart. The first observation was continued for about 24 hours at Stn. I-1. The tracks of three buoys showed that they moved to the east about 500 m/hour. The second observation was continued for about 28 hours near Stn. I-4. Data from both experiments are being analysed with the help of a computer.

1.3 Study on the Spatial Distribution of Temperature and Salinity of the Sea Surface

M. Okazaki

Purpose

The purpose of this observation is to investigate spatial distribution of temperature and salinity observed during a certain period at the surface of the adjacent seas to Japan.

Method

During the cruise (KH-76-3) of R/V Hakuhō-Maru, sea surface water was continuously pumped up into a small tank which was always overflowed. Time variation of temperature and salinity of the sea water was continuously measured by Temperature Salinity Recorder (T.S. Model ST-2), whose probe was dipped in the water tank.

Results

The measurement was started on 13th July in the Oyashio area off Sanriku, and continued in Tsugaru Strait, southern part of the Sea of Japan, Kanmon and Bungo Straits, Kuroshio area off Honshū and was finished in Tokyo Bay (9th August).

Although stabilization of the salinometer was very poor on account of many bubbles generated in the water tank, the records of measurement were somehow obtained. The maximum values of salinity fluctuation taken by the model ST-2 salinity recorder agreed fairly well with values obtained by means of Auto-Lab salinometer. It is remarkable that the measured temperature offen shows sharp discontinuities in a few miles.

The data will be analysed in consideration of data obtained in the routine marine observations.

1.4 Study on Current Velocity, Water Temperature and Salinity Fields Relevant to the Fishing Ground

M. Okazaki

Purpose

The purpose of this study is to investigate the relation between the current field near Yamato-Tai and the surrounding fishing ground. Yamato-Tai is one of the important fishing grounds in the central part of the Sea of Japan. The continuous observation of current velocity, water temperature and salinity fields was performed. Two mooring stations were settled in different configurations. One station was near the top of Yamato-Tai and other was far from the region of the top. Current measurements were carried out at the several depths including surface layer and bottom layer for 20 days from 17th July to 5th August 1976.

Method

The mooring station Stn. F-1 was set at the position near the top of Yamato-Tai ($39^{o}01.7'N$, $134^{o}08.3'E$, depth 430 m), and Stn. F-2 was at the deep sea bottom ($38^{o}46.7'N$, $134^{o}01.2'E$, depth 1490 m) about 27 km SWS-wards from Stn. F-1 (Fig. 6).

In mooring at Stn. F-1, 3 Aanderaa current-meters were installed at three depth 100 m apart (about 200 m, 320 m, and 420 m, respectively), as shown in Fig. 7. The Aanderaa current-meter (rotor type) is able to obtain data of water temperature (by thermister) and conductivity (by inductive conductivity cell) in addition to current speed and direction. The data were continuously stored in magnetic tape every four minutes.

We adopted the mooring system of subsurface buoy type for avoiding meteoro-

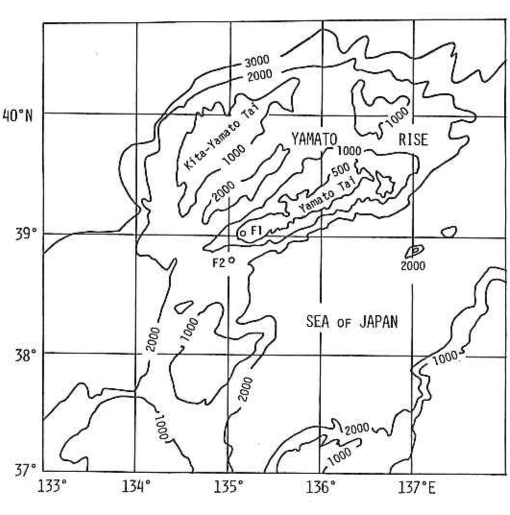

Fig. 6. The mooring stations Stns. F-1 and F-2 and bottom configurations.

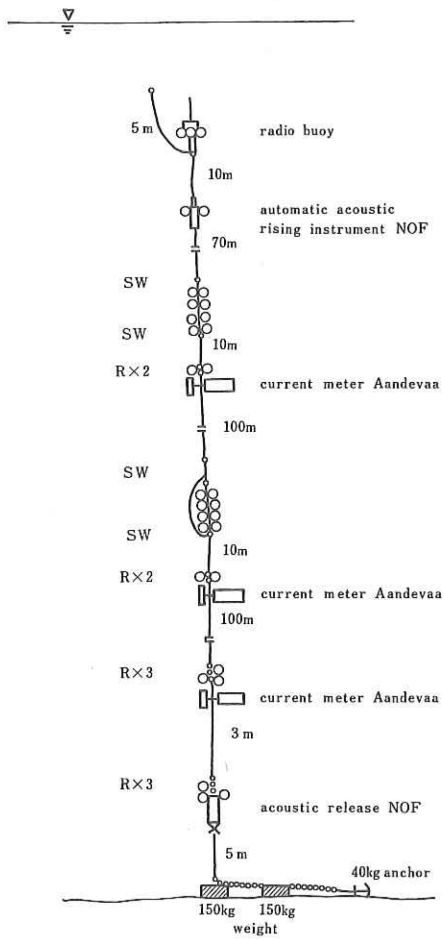

Fig. 7. Mooring line at Stn. F-1.

logical and marine disasters. The mooring system was lowered to ocean bottom by power winch with weight-first or soft-landing method. The recovery mechanics was set to start by an acoustic command from the vessel.

At the mooring station Stn. F-2, the buoy system was also moored in the subsurface. It has acoustic release recovery mechanics and Savonius-rotor type current-meter (TSCM-3) at five depths. These current-meters recorded continuously current speed and direction and water temperature, which were stored in magnetic tape every five minutes (figure is shown in the report by Nakata and Matsuo, page 16).

Results

At both stations (F-1 and F-2), the current appears to exist only in shallow layer. The details of the result at Stn. F-2 are shown in the report by Nakata and Matsuo (page 16).

At Stn. F-1, two continuous data of current were obtained in shallow layer, F1S (about 200 m depth) and middle layer, F1M (about 320 m depth). The variation of current speed and direction in both layers is shown in Figs. 8 and 9. Comparing with the records at Stn. F-2, the time variation of current at Stn. F-1 is remarkable due to the effect of complex bottom configurations.

The time variation of current at 200 m depth (F1S) shows that modified inertia oscillation is remarkable (inertia period is 19.0 hours) except in no-current intervals, and it seems peculiar to exist no-current intervals. The semi-diurnal component is dominant in the time variation of temperature only in F1S, (the observed temperature is about $4^{\circ}C$ higher than that in the record of S.T.D., but the time variation of it is stable and so, the relative values may be correct).

As shown in Fig. 9, the record of velocity at 320 m depth (F1M) is taken only in the last 8 days, in which the inertia oscillation dominates remarkably. The full records of temperature and salinity are obtained correctly. The predominant frequency in the variation of temperature is of inertia oscillation, on the other hand no dominant frequency is seen in that of salinity.

The detailed analysis of data is being carried on in consideration of the circumferential hydrographic data.

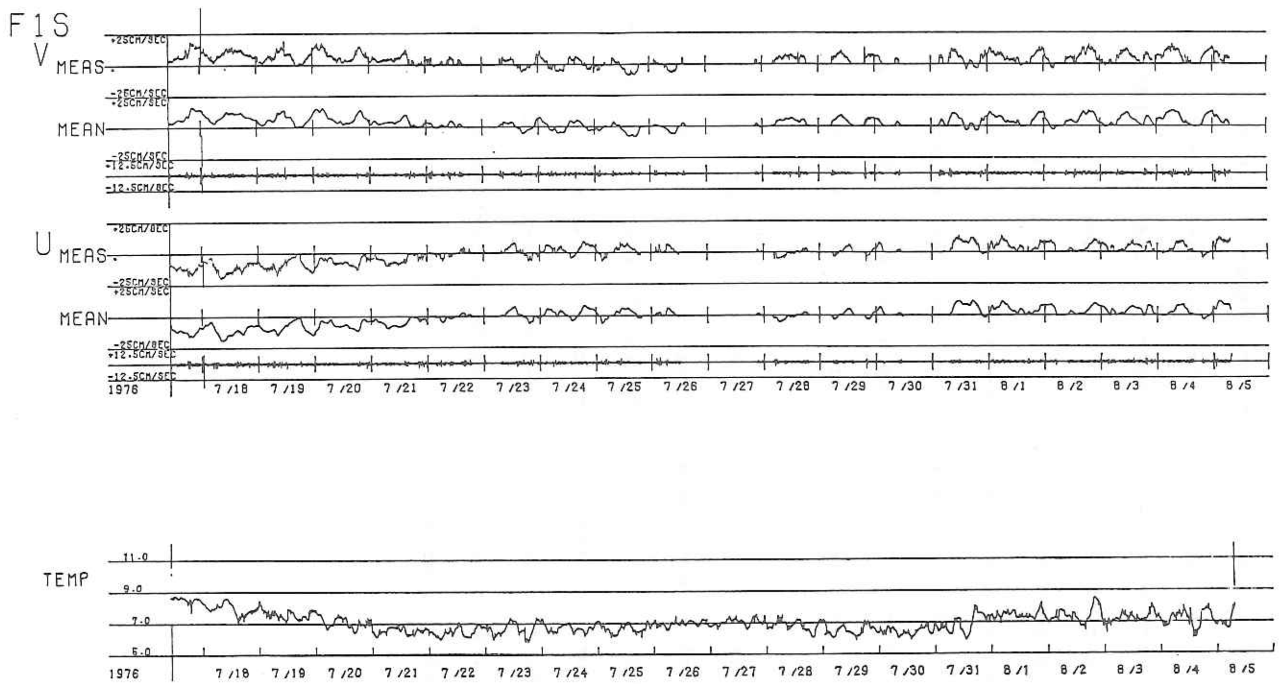

Fig. 8. The time variations of current velocities and temperature at F1S (200 m depth). above: north-south component (V, measurement, 1 hour running mean and residuals). middle: east-west component (U, same to above). bottom: temperature (°C).

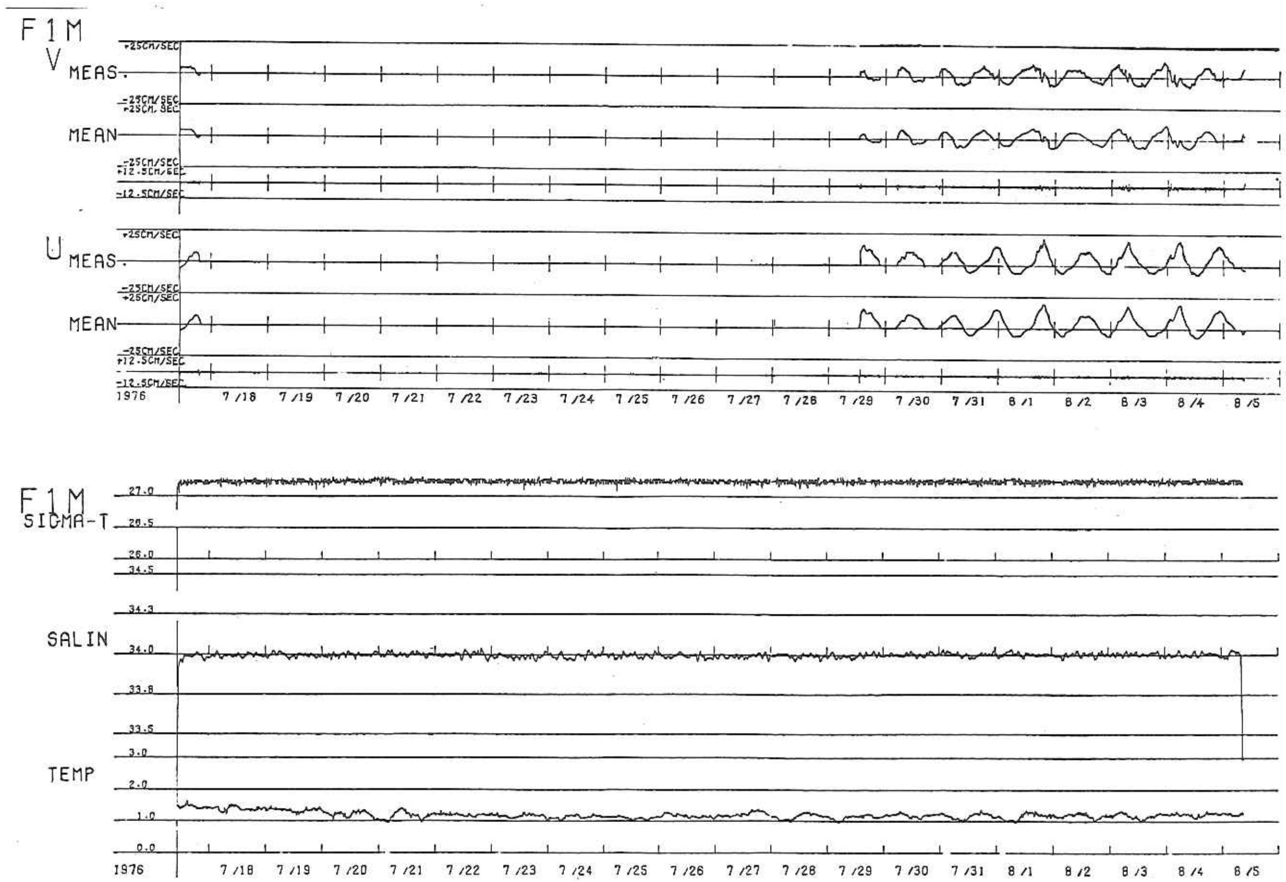

Fig. 9. The time variation of current velocities, temperature, salinity and density (σ_t) at F1M (320 m depth).
(a): north-south component (V, measurement, 1 hour running mean and residuals).
(b): east-west component (U, same to above). (c): density (σ_t).
(d): salinity ($^{o}/oo$). (e): temperature (^{o}C).

1.5 Study on the Relation between the Current Velocity Field and the Distribution of Suspended Matter

K. Nakata and S. Matsuo

Purpose

The purpose of this observation is to investigate the relation between the current velocity field and the distribution of suspended matter in the ocean. The observations of horizontal and vertical distributions of suspended matter were carried out at 13 points shown in Table 1. The depth of the observation were set at 0, 50, 100, 200, 300, 500 and 1000 m as a standard. Further at Stns. 14 and 24, the samplings were made at the depth of 10, 20, 30, 75 and 150 m.

The observations of current velocity field were made at Stn. F-2 by Eulerian

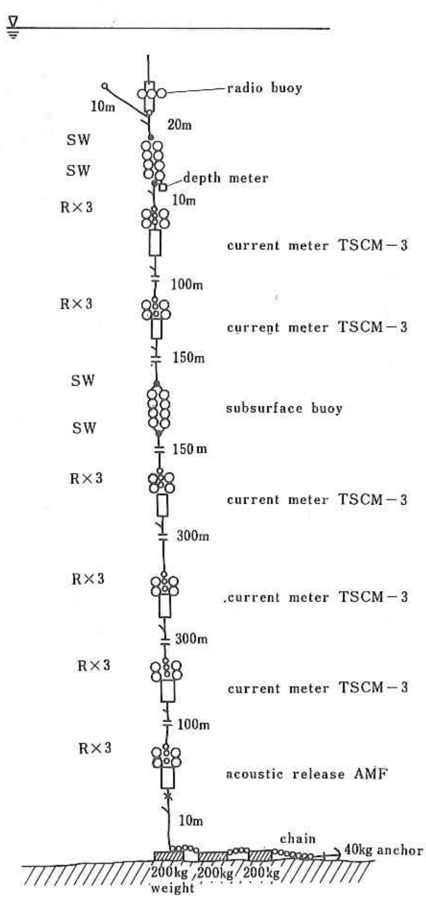

Fig. 10. The mooring configuration at Stn. F-2. SW means the swievle. R means the ring which is depicted as a small circle. The rope used is nylon 8 rope (∅=16 mm) and the lengths of the rope are also shown.

Table 1. The concentration of suspended matter (mg/l)

Stn.	Date	Time	Location Lat.	Long.	Depth	Depth (m) 0	10	20	30	50	75	100	150	200	300	500	1000	2000
	1976		N	E	m									(* 400 m,		** 250 m)		
3	7-15	1118	40-56.7	135-20.7	3480	0.47	----	----	----	0.27	----	0.16	----	0.17	0.12	0.06	0.23	0.18
5	8-02	0935	39-52.5	135-06.6	1290	0.55	----	----	----	0.33	----	0.12	----	0.11	0.12	0.14	0.12	----
7	7-20	1745	39-30.4	135-19.9	420	0.20	----	----	----	0.24	0.15	0.07	----	0.09	0.11	0.08*	----	----
9	7-20	1125	38-58.9	135-40.2	2400	0.17	----	----	----	0.16	----	0.17	----	0.12	0.16	0.21	0.12	----
10	7-31	1400	39-39.1	134-12.5	1480	0.19	----	----	----	0.24	----	0.13	----	0.23	0.15	0.11	0.22	----
12	7-18	1632	39-11.0	134-30.8	770	0.28	----	0.22	----	0.19	----	0.17	----	0.15	0.16	0.13	----	----
14	8-01	0307	38-41.2	134-50.3	3000	0.24	0.15	0.32	0.24	0.70	0.06	0.22	0.08	0.35	0.15	0.17	0.19	0.10
16	7-31	0409	39-19.6	133-21.1	1400	0.21	----	----	----	0.15	----	0.30	----	0.19	0.15	0.08	0.13	----
18	7-30	2234	38-51.1	133-42.5	1330	0.20	----	----	----	0.21	----	0.13	----	0.15	0.27	0.09	0.16	----
20	7-18	0038	38-20.0	143-00.9	1170	0.37	----	----	----	0.17	----	0.13	----	0.20	0.16	0.10	0.19	----
24	8-06	1005	38-19.5	132-59.4	2770	0.13	0.22	0.24	----	0.32	----	0.10	----	0.08	0.10	0.03	0.06	0.07
I-1	7-21	0300	39-20.0	135-05.0	340	0.20	0.07	0.09	0.14	0.19	0.08	0.05	0.09	0.02	0.08	----	----	----
I-3	8-03	0025	39-22.9	135-12.9	270	0.15	----	----	----	0.31	----	0.18	----	0.22	0.07**	----	----	----

Table 2. Salinity measured by salinometer (‰)

Stn.	Depth (m) 0	10	20	30	50	75	100	150	200	300	500	1000	2000
									(* 400 m,		** 250 m)		
3	34.078	34.070	------	34.007	33.983	34.001	34.023	34.029	34.037	34.048	34.052	34.060	34.069
5	33.776	33.784	33.780	33.946	.893	.143	33.978	.010	.022	.034	.051	.054	------
7	31.412	34.232	.862	34.238	34.071	.010	34.014	.022	.023	.045	.053*	------	------
9	33.939	33.934	34.150	.318	.373	.280	.176	.099	.032	.066	.080	34.080	34.135
10	34.200	34.165	.157	.359	.308	.238	.981	.104	.013	.032	.045	.058	------
12	.080	.061	.074	.267	.410	.303	.214	.137	.036	.041	.068	------	------
14	.193	.172	.170	.248	.500	.259	.207	.074	.099	.013	.035	34.052	34.058
16	.100	.093	.084	.259	.359	.372	.186	.012	.004	33.981	.043	.055	.054
18	.163	.162	.300	.428	.397	.278	.137	.006	.026	34.044	.061	------	------
20	.110	.135	.231	.329	.430	.311	.204	.133	.071	.031	.053	34.067	------
24	33.487	33.509	33.932	.370	.417	.335	.241	.080	.029	.629	.629	.071	34.077
I-1	34.265	34.263	34.241	.176	.184	.066	.012	.013	.027	.043	------	------	------
I-3	33.918	------	------	------	33.897	------	.016	------	.021	.031**	------	------	------

method and were also made at Stn. F-1 in order to investigate the effect of the bottom topography on the current velocity field (see also Okazaki, page 10).

Method

The sampling of sea water were carried out with 25 liter Van Dorn. The sampled water was filtered within 2 or 3 hours after sampling. The sea water were filtered through 0.8 μm pore size matched-weight pair filters (Millipore Filter AAWP0470). The samples on the filter were stored in the desiccator during cruising period. After drying under 70°C through 24 hours in the drying apparatus, the samples were cooled in the desiccator and then were weighed.

The results are shown in Tables 1 and 2, Figs. 11 and 12.

The direct observations of current velocity were conducted with 5 Savonius type current meters (TSCM-3) at Stn. F-2. The mooring configuration is shown in Fig. 10. The observation duration was about 19 days which ranged from July 17 to August 5. Recording interval was set to 5 minutes. The similar mooring type

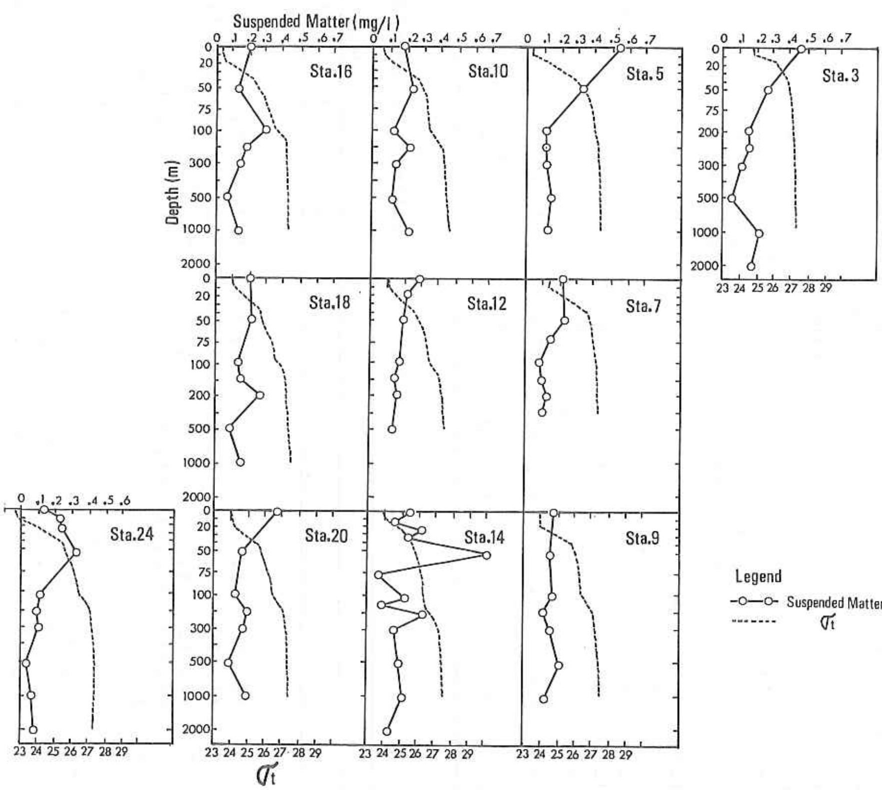

Fig. 11. Vertical distribution of suspended matter and σ_t.

was adopted at Stn. F-1 (see page 12).

Results

1) The distribution of suspended matter

The results show the tendency that the concentration of suspended matter were high values in the upper layer and low values in the lower layer in the all stations (Tables 1 and 2, Figs. 11 and 12). The concentration range was 0.03 to 0.7 mg/l. From Fig. 12, it was noticed that the concentration was high at Stns. 5 and 20, and relatively high value zone stretched between Stns. 5 and 20 like a belt in the case of surface layer.

The vertical distribution at Stn. 14 showed remarkably different tendency from other stations. At this station, the highest value layer was appeared at the depth of 50 m and the relatively high value layer, of which concentration was about 0.3 mg/l, also appeared at the depth of 200 to 300 m, where the secondary thermocline was observed. From Stn. 6 to Stn. 20, the considerably high values also appeared at those depth. These profiles agreed with σ_t profiles.

2) The results of DOC measurement

Fig. 13 shows the vertical distribution of DOC (Disolved Organic Carbon) at Stns. 3, 9 and 12. The analyses of DOC were made with the wet oxidation method by Menzel and Vaccaro (1964). The sampled water was prefiltered with Grass-Fiber

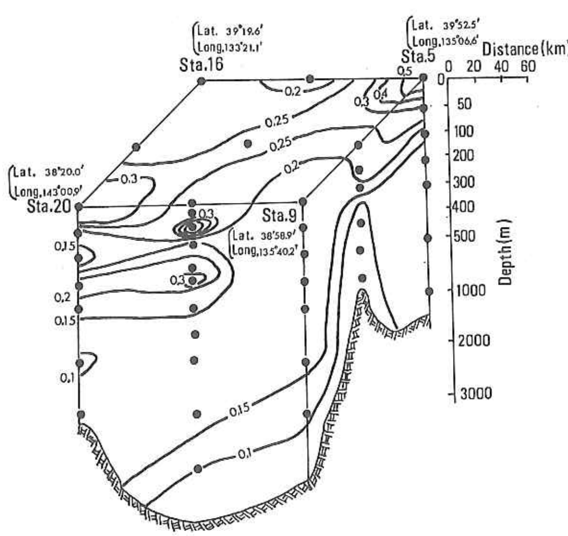

Fig. 12. The spatial distribution of suspended matter in Yamato-Tai area (mg/l).

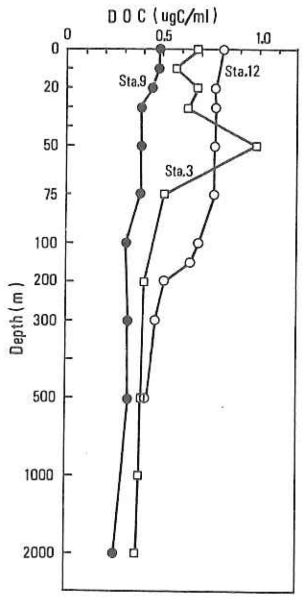

Fig. 13. Vertical distribution of disolved organic carbon.

Filter (0.8 μm). The vertical distribution of DOC concentration showed higher values in the upper layer and the lower values in the lower layer similar to the distribution of suspended matter. From the surface to 100 m layer, the DOC values were ranged from 0.4 to 1.0 μgC/ml, and the deeper layer than 300 m the DOC values were ranged from 0.25 to 0.4 μgC/ml.

3) The results of direct current velocity measurement

The current velocity data were stored in the magnetic cassette tape, and converted to the magnetic tape or card for computer through the interface in the Institute. The example of the results is shown in Fig. 14. The time variation of current velocity showed large amplitude fluctuations. The typical time scale of the fluctuations seemed to be inertial frequency (about 18 hours under this latitude). Such inertial oscillation did not appear constantly, but rather have intermittent characteristic. In the centre of the Sea of Japan, Nan-niti et al. (1966) observed the inertial oscillation. Our observation confirmed their results. The detailed analyses will be made in future.

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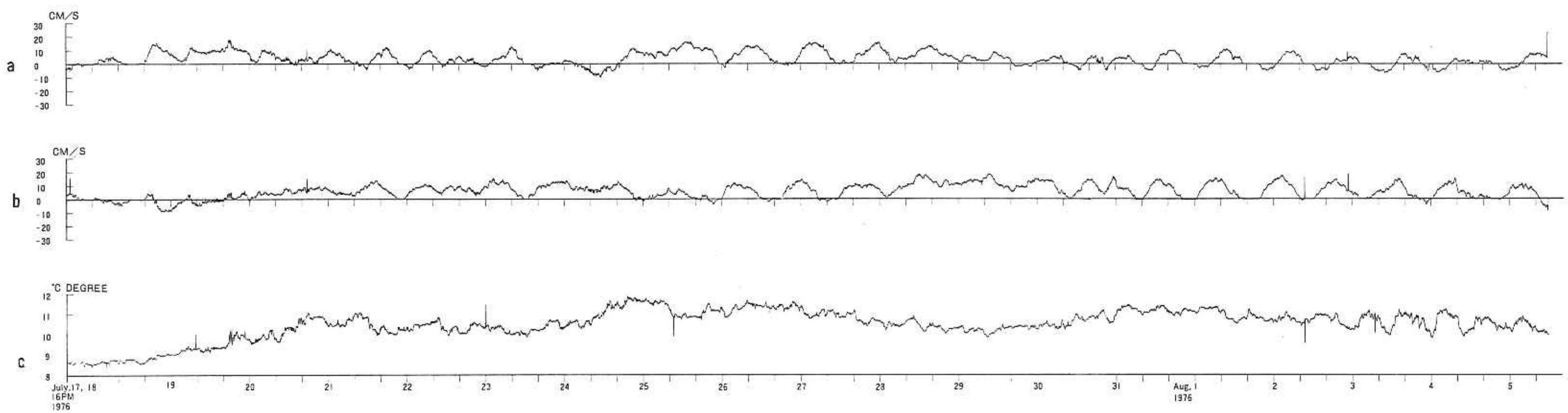

Fig. 14. The time variation of the current velocity and water temperature.

(a) east-west component. (b) north-south component.

(c) temperature.

1.6 Measurements of the Optical Properties in the Sea Water

R. Tsuda

Comparative measurements of spectral irradiance and beam transmittance were carried out during this cruise in order to investigate the optical properties in the sea water of Yamato-Tai.

Upward and downward irradiances were measured by means of a irradiance meter at the subsurface layers of Stns. 3, 5 and F-1. This meter consists of interference filters to isolate a narrow spectral band. The maximum wave-lengths of these filters are 433, 466, 505, 528, 562, 604 and 665 nm.

At each station, the vertical distribution of the beam transmittance of sea water was continuously measured down to about 120 m depth by means of in situ terbidity meter which light path was 50 cm length. A green filter was employed to limit the incident light to a narrow band centered at a wave-length about 562 nm.

2. CHEMICAL ENVIRONMENT OF THE YAMATO-TAI AND RELATED AREAS

2.1 Trace Constituents in the Sea of Japan

M. Nishimura and S. Konishi

Mercury in the seawater, maritime air, and rain

To clarify the behaviour of mercury in the earth's surface, 74 seawater samples were collected from various depths at 14 stations. Sixteen air samples were obtained by bubbling 1-2 m^3 of air through a $KMnO_4$-H_2SO_4 solution, and 9 rainwater samples were collected. The determination of mercury content is carried out in the laboratory by flameless atomic absorption spectrophotometry.

Copper in the seawater

To study the baseline of copper concentration in the Sea of Japan, 29 seawater samples were collected at 3 stations. Each sample water was taken into a 2 l polyethylene bottle and acidified with HCl aboard. The copper is determined also at the laboratory by flameless atomic absorption spectrophotometry with a carbon atomizer, after extraction.

Pb-210 and nitrogen compounds in the atomosphere over the Sea of Japan

To study the source and flux of the atomospheric Pb-210 and nitrogen compounds, the following samples were collected. The aerosols in the maritime air were collected by filtering air through a Millipore filter (pore size 1.2 μ or 0.22 μ) which was set on the bridge deck about 10 m above the sea surface. The sampling was operated for 24-72 hours with a flow rate of about 2 l/min. We obtained 9 samples for each type of the filters. The rainwater sampler having 0.6 m^2 surface area was set on the compass bridge deck and 5 samples were collected.

2.2 Studies on Some Organochlorine Compounds Residues in the Sea Water Surrounding Honshu Island

K. Tatsukawa, S. Tanabe and K. Honda

In order to make clear the transport and fate of man-made organics to the marine environment, determinations of some organochlorine compounds such as PCB, DDT, BHC and LMCH (low molecular weight chlorinated hydrocarbons) were carried out on the sea water surrounding Honshu Island. Sampling stations and results were indicated in Fig. 15 and Table 3.

Some considerations on the results are as follows: The concentrations of any organochlorine compounds showed a comparatively uniform distribution. PCB, DDT and BHC were detected in all samples, their concentrations of surface water were within the range of 0.2 to 1.1, 0.5 to 3.0 and 4.9 to 76 ng/l, respectively (with the exception of Tokyo and Sakaiminato). Higher BHC concentration was found at Stn. J which was in the vicinity of a waste dumping area. By comparison with Seto Inland Sea, PCB and BHC concentrations are in the same or lower range, but DDT concentrations in this area are considerably higher than those of Seto Inland Sea, which may reflect that the use of DDT is increasing in many tropical and developing countries. In the vertical distribution, PCB and DDT concentrations are not significantly different with depth. Because of their low solubilities, it is likely that the dispersal of PCB and DDT downward through the water column is related to the sedimentary process of various marine particles.

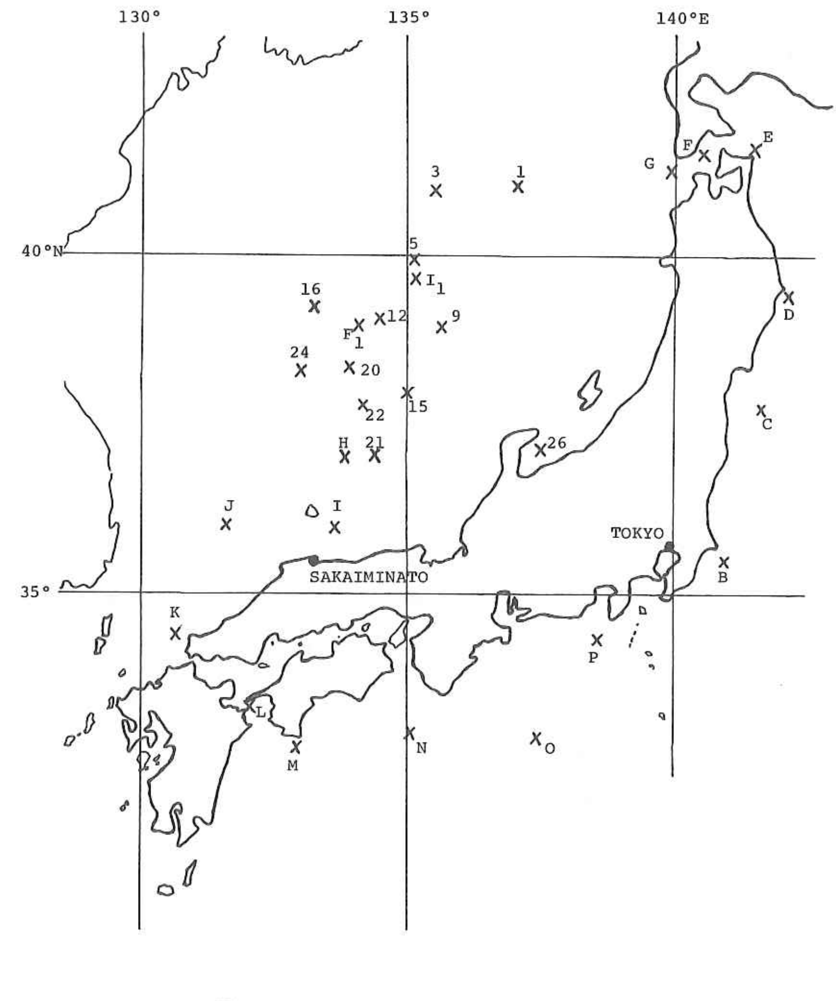

Fig. 15. Sampling stations.

Table 3. Concentration of organochlorine compounds in the sea water

Stn.	Depth	Date	Lat.	Long.	PCB	BHC Isom.	DDT Comp.	CH_2Cl_2	CCl_4	$CHCl_3$	CCl_2:CCl_2
	m	1976	N	E							
B	s	7/12	35-29.4	140-47.0	0.77	4.9	1.16	N.D	0.69	3.9	N.D
C	s	7/13	37-50.2	141-37.9	0.63	12.3	0.94	N.D	0.93	14.3	2.1
D	s	"	39-26.9	142-06.3	1.11	22.6	1.35	3.0	0.90	10.3	N.D
E	s	7/14	41-29.9	141-28.0	0.50	11.3	0.77	5.1	0.86	12.0	1.8
F	s	"	41-25.6	140-31.8	0.70	16.0	0.87	6.0	0.88	11.4	N.D
G	s	"	41-16.4	139-59.7	0.77	17.7	0.88	Tr	0.78	12.7	N.D
1	s	"	41-00.1	137-00.8	0.53	20.9	1.33	Tr	0.86	7.5	N.D
3	s	7/15	40-59.1	135-20.2	0.23	14.9	0.75	12.2	0.86	23.3	N.D
	50	"			0.43	13.8	0.58	7.8	0.88	11.7	N.D
	200	7/16			0.37	11.2	0.27	7.5	1.08	10.1	N.D
	500	"			0.41	7.2	0.29	Tr	0.59	5.6	N.D
	1000	"			0.35	3.2	0.58	9.3	0.91	17.3	N.D
	1500	7/15			0.49	1.8	0.67	8.5	0.68	18.7	Tr
F-1	s	7/16	39-00.0	134-10.4	0.58	18.0	2.13	Tr	0.91	14.1	1.7
	100	"			0.33	13.0	0.48	Tr	0.82	17.7	N.D
	150	"						Tr	0.73	9.3	1.8
	200	"			0.43	14.5	0.38	N.D	0.73	7.7	N.D
	250	"			0.50	12.1	0.29	4.8	0.89	10.9	N.D
	286	"			0.72	13.3	0.55	Tr	0.82	14.0	N.D
20	s	7/17	38-19.8	133-58.5	0.51	20.5	1.20	Tr	0.79	5.6	Tr
26	s	7/19	37-11.9	137-29.7	0.72	24.3	1.21	11.1	0.81	17.5	1.4
	50	"			0.57	8.6	0.35	12.7	0.73	23.9	1.5
	200	"			0.53	13.8	0.58	10.5	1.01	11.8	1.3
	500	"			0.47	4.8	0.41	6.0	0.54	10.6	2.3
	1000	"			0.38	1.8	0.60	10.2	0.61	12.4	1.8
9	s	7/20	38-58.7	135-40.2	0.48	24.9	2.98	10.3	0.98	29.7	N.D
I-1	s	7/22	39-20.7	135-07.6	0.38	21.6	0.51	6.9	0.67	3.4	N.D
	20	7/23			0.46	21.6	0.36	10.5	0.78	17.4	N.D
	50	7/22			0.59	17.2	0.11	Tr	0.99	6.1	N.D
	100	"			0.51	14.6	1.90	Tr	0.80	6.5	N.D
	200	"						10.1	0.75	17.0	N.D
	304	"			0.43	7.6	0.23	13.6	0.52	19.1	N.D
22	s	7/24	37-50.0	134-11.7	0.45	14.9	1.68	Tr	0.76	17.6	N.D
H	s	"	37-00.5	133-53.3	0.62	16.9	1.65	Tr	0.69	26.2	N.D
Sakai-Minato	s	7/29			1.79	18.0	1.72	21.7		19 4	0.9
I	s	"	36-00.0	133-40.7	0.36	21.9	1.13	N.D		N.D	N.D
21	s	"	37-02.6	134-20.6	0.41	23.6	2.27	N.D		N.D	N.D
15	s	7/30	38-00.0	134-59.6	0.57	18.7	1.31	5.6		4.2	N.D
16	s	7/31	39-19.6	133-21.1	0.33	21.5	0.85	10.1		6.3	N.D
12	s	"	39-08.2	134-30.0	0.32	18.8	0.72	4.8		8.2	N.D
5	s	8/2	39-52.5	135-06.6	0.34	28.6	0.73	10.2		4.4	N.D
24	s	8/5	38-19.4	133-00.7	0.33	38.9	1.01	N.D		Tr	N.D
	50	8/6			0.40	7.5	0.43	N.D		N.D	N.D
	100	"			0.42	10.7	0.38	8.0		4.9	N.D
	200	8/5			0.40	12.5	0.58	Tr		N.D	N.D
	500	"			0.34	8.3	0.39	6.7		6.3	N.D
	1000	"			0.50	10.6	0.36	N.D		N.D	N.D
	2500	"			0.47	1.5	0.30	N.D		N.D	N.D
J	s	8/7	36-00.0	131-37.1	0.31	75.9	1.04	N.D		N.D	N.D
K	s	"	34-24.3	130-42.4	0.36	32.2	0.67	6.5		3.4	N.D
L	s	"	33-17.8	132-00.0	0.38	10.6	0.75	5.2		5.5	3.1
M	s	8/8	32-39.1	133-00.0	0.29	8.6	0.52	N.D		6.2	N.D
N	s	"	32-54.9	135-04.0	0.34	8.2	0.75	Tr		5.2	N.D
O	s	"	32-48.7	137-28.0	0.32	8.0	0.99	19.7		2.1	N.D
P	s	8/9	34-15.4	138-30.0	0.33	8.3	0.78				
Tokyo	s	"			9.75	31.6	1.72	34.3		43.7	218.4
Detection limit					0.10	0.01	0.02	3.0	0.3	3.0	1.0

Tr: Trace N.D: Not detected Unit: ng/l

3. BIOLOGICAL ENVIRONMENT OF THE YAMATO-TAI AND RELATED AREAS

3.1 Distribution of Bacteria in Yamato-Tai Area

T. Yanagita

Seawater samples collected in the area of Yamato-Tai on July 29 through August 6, 1976, were subjected to the examination of (1) concentrations of chemical environmental factors, (2) numbers of two trophically different groups of bacteria — oligotrophs and eutrophs —, and (3) number of N_2-fixing bacteria and N_2-fixation activity. Samples were collected at the depths of 0, 30, 75, 150, and 300 m.

DO value was the lowest in the surface and became higher toward the depth of 300 m. At all stations examined (Stns. 21, 16, 9, 5, I-4, and 24), nutrient concentrations became increased toward the depth of 300 m. The vertical distribution pattern of nutrient concentrations, in general, was almost the same at all stations. It was characteristic that the highest value of DON was observed at Stn. I-4. The vertical distribution pattern of chlorophyll a showed two types; the one gave a peak at the depth of 75 or 150 m and the other at 30 m.

The number of bacteria showing more than 10^2 cells/ml was found in the surface water at Stns. I-4, 18, 20, 5, and 9, and the number was much less in the other stations (Stns. 16, 10, 14, 7, 9, 21, and 24). The numbers of oligotrophs and eutrophs were almost comparable in this area. Such an abundance ratio of oligotrophs and eutrophs seems to be similar to that observed in the coastal area of Toyama Bay.

The number of N_2-fixing bacteria was counted using various media containing highly diluted ones for detecting oligotrophic N_2-fixing bacteria. Although the number of N_2-fixing bacteria was relatively lower than those of oligotrophs and eutrophs mentioned above, higher number of N_2-fixing bacteria was found at those stations where the numbers of oligotrophs and eutrophs were low. N_2-fixing bacteria were most abundant in the surface at all stations examined. N_2-fixation activity of seawater samples as determined by the acetylene reduction method also showed the highest value in the surface. It gave an average value of 3.3 nmoles/liter/day.

3.2 Collection of Large Suspended Material for Scanning Electron Microscopy

S. Nishizawa

Five hundreds ml aliquots of seawater sample were made available from serial Van Dorn water samples taken at Stns. 3, 9, and 20. Each sample was put in a polyethylene bottle and kept stand still for 24 hours. The supernatant was siphoned out, and the remaining 50 ml water was filtered through a HA type Millipore filter. The filter with precipitate was washed 4 times with serially diluted filtered seawater and finally with distilled water for removing salt. The filter pad was dried in a desiccator and later freezed at -20°C. The processed samples were brought back to our laboratory for visual scrutinization of trapped particulate material under a scanning electron microscope, which is underway.

3.3 Collection of Living Specimen of Zooplankton for a Short-time Incubation to Obtain Freshly Voided Feces

S. Nishizawa and Y. Endo

Living animals were collected at night during the time when the ship was drifting at stations using a drifting net which gently filtered the sea surface water. The collected fresh animals were put in small bottles filled with filtered sea water, always one animal in each bottle. After 24 hours the entire content was fixed with formalin, and brought back to our laboratory. The samples are to be analysed for feces voided and the animal which voided them. The analyses are now underway.

3.4 Vertical Distribution of Euphausiids

Y. Endo and S. Nishizawa

Sample collections were made at Stns. 5, 7, 12, and 14 using a series of MTD nets towed horizontally at the depths of 0, 10, 30, 50, 75, 100, 150, 200, 300, 400, 500, 600, 800, and 1000 m. The deepest tow depth, however, varied from station to station. The euphausiids species occurred were Euphausia pacifica and Thysanoessa longipes both of which had been well established as dominant in the Sea of Japan. The collection at Stn. 7 was made at night and the others midday.

Preliminary examination of the samples showed that calyptopes and furciliae of both species appeared to stay throughout an entire day in the layer of 30 to 50 m depth, and a marked vertical migration was observed only for individuals in the post larval stages and adults. There was a general trend as usual that older individuals inhabited in deeper layers, and the range of migration increased in vertical extent with increasing developmental stage.

3.5 Zooplankton and Micronekton in the Sea of Japan

T. Nemoto, S. Nishida, Y. Matsuo and Y. Hirota

The studies carried out on board of Hakuhō-Maru in the cruise KH-76-3 are consisting of three main items as follows.

1. Species and abundance of micronekton.
2. Distribution of micro- and macro-zooplankton.
3. Ecology of neuston.

The plankton samples have been collected using various kind of nets including NORPAC net, ORI net, ORI neuston net and Isaacs-Kidd mid water trawl. The outline of studies and preliminary data of biomass of zooplankton and micronekton are described below.

Species and abundance of micronekton

The micronekton of the Sea of Japan was collected using 10 feet Isaacs-Kidd mid water trawl at Stns. 3, 5, 12, 20 and 21. The samples were collected by IKMT lowering to about 1,000 m depth in the sea.

The main constituents of micronekton are illustrated in Table 4 in which some macro-zooplankton also mingled. The dominant species groups are Copepoda, Amphipoda, Euphausiacea and Pisces. Each group occurs in a certain station,

Table 4. Biomass of micronekton collected by IKMT in the Sea of Japan ($g/1000m^3$)

Stations	Stn. 3 (Jul.15)	Stn. 5 (Aug. 2)	Stn.12 (Jul.18)	Stn.20 (Jul.17)	Stn.21 (Jul.21)
Chaetognatha	1.00	3.64	1.52	1.11	0.95
Copepoda	16.62	6.45	0.22	2.86	0.39
Amphipoda	0.15	0.28	0.93	26.12	6.99
Eupahusiacea	0.28	0.01	0.05	13.92	7.68
Decapoda	+	0.04	-	-	0.21
Pteropoda	-	-	-	0.06	-
Pisces	+	-	0.81	18.27	0.78

except Coelenterata, Cephalopoda.

which suggests these micronekton form the uneven distribution and heavy swarms in the sea.

The main species of each group are following.

Chaetognatha — Sagitta elegans

Copepoda — Calanus cristatus, C. plumchrus

Amphipoda — Parathemisto japonica

Euphausiacea — Euphausia pacifica and Thysanoessa longipes

Pisces — Maurolicus mulleri

Ecology of neuston

In order to investigate the neuston of the Sea of Japan, ORI-33 two-stage neuston net was towed simultaneously with MTD net. ORI-33 two-stage neuston net has two stages of rectangular mouth of 20 cm high and 60 cm wide, and upper net collects organisms in the layer between 0 and 10 cm, lower net collects the plankton in the layer between 10 and 30 cm under the surface. Its mesh size is 0.33 mm (GG54).

At Stns. 3, 21 and 24, ORI neuston net was towed simultaneously with MTD-10 horizontal closing net, and at Stn. 26, with MTD-33 horizontal closing net. At Stn. 14, ORI neuston net was also towed simultaneously with MTD-33 horizontal closing net at intervals of 4 hours from twelve o'clock on 3rd to twelve o'clock on 4th in August to examine the diurnal variations in vertical distribution of neuston. The samples were preserved in 10% solution of neutralized formalin seawater, and the sorting of species group is started. The diversity of species composition in the neuston in the space and time of the Sea of Japan is also under examination.

Distribution of zooplankton

For the study on the distribution of zooplankton, two kinds of net sampling were carried out. Vertical hauls of NORPAC twin net (mesh GG54 0.33 mm and XX13 0.1 mm, 45 cm in mouth diameter) from 150 m depth to the surface were carried out at 12 stations in Leg-1 and 13 stations in Leg-2, total 25 stations. Horizontal hauls of MTD net (mesh XX13, 56 cm in mouth diameter) in 14 layers from 1000 m depth to the surface were carried out at Stns. 3, I-1, 21 (day-night) and 24. In each sampling, the volume of water filtered was calculated by the revolution of flowmeters attached to the mouth of the net. All samples were fixed

Table 5. Settling volume of NORPAC net samples

	Mesh	GG54			XX13		
	Stn. No.	Volume of water filtered (m^3)	Settling (ml/haul)	Volume (ml/m^3)	Volume of water filtered (m^3)	Settling (ml/haul)	Volume (ml/m^3)
Leg-1	1	25.3	36.6	1.45	15.1	33.1	2.19
	3	23.3	23.6	1.01	17.9	39.0	2.18
	F-1	44.0	10.8	0.25	26.6	43.8	1.65
	F-2	32.7	12.5	0.38	24.5	49.4	2.02
	20	24.9	19.2	0.77	20.0	40.2	2.01
	18	32.4	12.6	0.39	22.7	22.8	1.00
	12	47.4	13.2	0.28	40.4	36.0	0.89
	26	26.3	3.6	0.14	20.4	8.0	0.39
	9	33.3	12.0	0.36	29.8	21.8	0.73
	7	23.6	26.8	1.14	19.4	43.6	2.25
	I-1	23.5	14.8	0.63	18.8	44.6	2.37
	I-2	25.6	7.0	0.27	22.2	46.4	2.09
Leg-2	21	21.9	10.5	0.48	18.3	25.0	1.37
	20	25.5	16.0	0.63	22.3	50.0	2.24
	18	56.5	29.4	0.52	31.7	34.0	1.07
	16	31.0	20.2	0.65	23.2	52.4	2.26
	10	23.4	10.2	0.44	20.6	26.6	1.29
	12	26.5	30.4	1.15	22.9	40.6	1.77
	14	31.5	20.0	0.63	23.1	34.8	1.51
	9	23.2	8.4	0.36	20.1	20.8	1.03
	7	30.4	43.2	1.42	24.6	51.4	2.09
	5	29.3	24.4	0.83	26.3	68.6	2.61
	I-3	36.8	55.2	1.50	31.1	113.0	3.63
	I-4	22.1	8.6	0.39	21.0	20.2	0.96
	24	25.5	10.0	0.39	22.4	40.4	1.80

Table 6. Dominant species of copepods and amphipods in NORPAC GG54 net sample

Station No. (Leg-1)	1	3	F-1	F-2	20	18	12	26	9	7	I-1	I-2
Copepoda												
Calanus cristatus	*	*	-	-	-	-	-	-	-	*	-	-
C. plumchrus	*	*	-	-	-	-	-	-	-	*	*	-
C. tenuicornis	-	-	*	*	*	*	*	-	*	*	*	*
C. sp.	-	-	*	*	*	*	*	*	*	*	*	*
Scolecithricella minor	-	-	-	*	-	-	-	-	-	*	*	*
Ctenocalanus vanus	-	-	-	-	-	*	-	-	-	-	-	-
Euchaeta marina	-	-	-	-	-	-	-	-	*	-	-	-
E. flava	-	-	-	-	-	*	-	-	-	-	-	*
Pareuchaeta elongata	*	-	-	-	-	-	-	-	-	-	-	-
Metridia pacifica	*	*	*	-	*	*	*	-	*	*	*	-
Labidocera japonica	-	-	-	-	-	-	-	-	-	-	-	-
Oithona atlantica	-	-	-	*	*	-	*	*	*	*	-	-
Amphipoda												
Parathemisto japonica	*	*	*	*	*	*	*	*	*	*	*	*
Euprimno macropa	*	*	-	-	-	-	*	-	-	*	*	-

Station No. (Leg-2)	21	20	18	16	10	12	14	9	7	5	I-3	I-4	24
Copepoda													
Calanus cristatus	-	-	-	-	-	-	-	-	*	*	-	-	-
C. plumchrus	-	-	-	*	-	-	-	-	*	*	*	-	-
C. tenuicornis	*	*	*	*	*	*	*	*	-	-	*	*	*
C. sp.	*	*	*	*	*	*	*	-	*	*	*	*	*
Scolecithricella minor	*	*	*	*	*	*	*	*	-	*	*	*	*
Ctenocalanus vanus	-	-	-	-	-	-	-	-	-	-	-	-	-
Euchaeta marina	-	-	*	-	-	-	-	-	-	-	-	-	*
E. flava	*	-	-	-	*	-	-	*	-	-	-	*	*
Pareuchaeta elongata	*	-	-	-	-	-	*	-	-	-	-	-	-
Metridia pacifica	*	-	*	*	-	*	*	*	*	*	*	*	*
Labidocera japonica	-	-	*	-	-	-	-	-	-	-	-	-	-
Oithona atlantica	-	-	*	-	*	-	-	-	-	*	-	-	-
Amphipoda													
Parathemisto japonica	*	*	*	*	*	*	*	*	*	*	*	*	*
Euprimno macropa	-	*	*	-	-	-	*	-	-	*	-	-	-

and preserved in 10% neutralized formalin seawater. After the measurement of settling volume, the NORPAC net samples were examined and the major components of zooplankton were identified.

The settling volumes (Table 5) ranged 0.14-1.5 ml/m^3 (NORPAC GG54) and 0.39-2.37 ml/m^3 (NORPAC XX13), and were generally higher at the northern stations excluding Stn. 26, where the value was extremely low. High values were recorded at Stns. 1, 3, 7 (GG54), 1, F-2, 3, 7, I-1 and I-2 (XX13) in Leg-1 and Stns. 7, I-3, 12 (GG54), 5, 7, I-3, 16 and 20 (XX13) in Leg-2.

In NORPAC GG54 samples, Copepoda, Amphipoda, Euphausiacea and Chaethognatha were predominated in all stations. The major components of Copepoda and Amphipoda were identified (Table 6). It was noted that Parathemisto japonica and Metridia pacifica predominated at almost all the stations and Calanus tenuicornis and Calanus sp. were common except northern stations, whereas Calanus cristatus and Calanus plumchrus, which are known as large species of cold water, occurred abundantly only at Stns. 1, 3, 7 and 5. At Stn. 26 (Toyama Bay) Noctiluca milialis, a red tide species, occurred abundantly.

4. NEKTON OF THE YAMATO-TAI AND RELATED AREAS

4.1 Ecological Studies of Larval Squids in the Sea of Japan

T. Kubodera and T. Tsujita

In order to investigate distribution and diurnal migration of larval squids, a series of net samplings were conducted. In addition, to make clear the change of body size of larval squids due to preservation in 5% neutral formalin, six body positions were measured.

Samples were taken by ORI-100 (160 cm in mouth diameter, 750 cm in length and 1 mm mesh aperture), IKMT 10-feet and MTD net (56 cm in mouth diameter, 200 cm in length and 0.33 mm mesh aperture). ORI-100 was towed about 20 minutes at a speed of 3 knots just under the surface mainly one hour after sunset. IKMT 10-feet was hauled obliquely for 400 m of wire run out at a speed of 1 m/sec and rolled up at same speed. During this operation ship speed was kept constant at about 3 knots. MTD nets were towed for seven layers at depths of surface, 10 m, 20 m, 30 m, 50 m, 75 m and 100 m simultaneously every 4 hours during 24 hours period from 3rd to 4th August at the same station (I-4).

Larval squids caught by above mentioned nets were measured by micrometer in 0.05 mm at mantle length, mantle width, fin length, head width, eye diameter and tentacle length. First measurement took on board before preservation in 5% neutral formalin and measurements carried out again about one week, 3 weeks, 7 weeks, 11 weeks and 15 weeks after preservation.

A total of 35 larval and juvenile squids of 4 species were caught. The dominant species is Watasenia scintillans (32 specimens). Two types of Family Gonatidae (2 specimens) and one Rhyncoteuthion stage larva were classified.

In W. scintillans, 25 specimens were caught by IKMT 10-feet towed as deep as 185 m. Among them, 21 were caught during 0-6h, 4 were caught during 6-12h and none were caught during 12-24h (Table 7). On the other hand, one was caught during 18-24h and none was caught during 24-18h by ORI-100 surface tows (Table 8). Besides them, 2 specimens were obtained from IKMT 10-feet oblique tow from 1080 m depth, and 4 specimens from ORI-100 oblique tow from 170 m depth.

Table 7. Occurrance of Watasenia scintillans collected with IKMT 10-feet towed with wire out of 400 m by sampling time of the day

Time	0-6	6-12	12-18	18-24
Number of hauls	6	3	4	2
Positive hauls	6	2	0	0
Number of specimens	21	4	0	0
Specimens per haul	3.50	1.33	0	0
Percentage occurrence	100	67	0	0

Table 8. Occurrence of Watasenia scintillans collected with ORI-100 at surface layer by sampling time of the day

Time	0-6	6-12	12-18	18-24
Number of hauls	4	0	0	13
Positive hauls	1	0	0	1
Number of specimens	1	0	0	1
Specimens per haul	0.25	0	0	0.08
Percentage occurrence	25	0	0	8

Table 9. Data on sampling by IKMT 10-feet oblique tow and wet weight per haul of zooplankton, fish larvae and Watasenia scintillans. Number in paranthesis indicates the number of individuals

Stn.	Date 1976	Position N	Position E	Zone time	Depth m	Wet weight (g) Zoopl.	Fish larvae	Watasenia scintillans
3	Jul.15	40-57	132-20	08:20-08:43	130	*	*	0
20	18	38-20	134-00	23:55-00:20	120	*	*	1.397 (4)
12	18	39-11	134-32	16:01-16:16	115	*	*	0
9	20	38-58	135-40	13:11-13:25	-	21.7	0	0
7	21	39-30	135-20	00:35-00:51	120	55.4	0.04	0.083 (1)
I-1	21	39-19	135-05	02:23-02:48	185	21.7	0.21	0.053 (1)
I-2**	23	38-37	134-31	15:10-17:36	1080	*	*	0.314 (2)
I-2	23	38-35	134-33	17:50-18:07	-	8.7	0.05	0
21***	30	37-01	134-25	03:38-03:52	120	*	*	0.100 (8)
18	31	38-51	133-43	00:12-00:29	160	46.3	0.10	0.683 (3)
16	31	39-36	133-20	08:14-08:40	135	9.1	0.06	0.117 (1)
10	31	39-39	134-14	15:23-15:44	130	1.0	0	0
5	Aug. 2	39-55	135-04	06:22-06:46	130	*	*	0.143 (3)
I-3	2	39-26	135-11	20:08-20:35	140	65.1	2.11	0
I-4	4	39-02	134-25	20:00-20:35	140	18.2	0.05	0
24	6	38-21	133-03	03:56-04:19	-	39.5	0.83	0.995 (4)

* Only W. scintillans was taken by us from the sample. Rest of the sample is being examined by other scientists.

** Not included in Table 7.

*** Gonatidae squid (Gonatopsis okutani?) was collected at this station, wet weight not measured.

These facts indicate that larval W. scintillans carries diurnal migration of being deeper than 185 m depth in daytime and moving upward to near the surface in nighttime.

One juvenile Gonatidae squid (probably Berryteuthis magister) was collected with IKMT 10-feet oblique tow from 160 m at Stn. 18 and the Gonatidae squid (probably Gonatopsis okutani) was collected with ORI-100 surface tow at Stn. 21. Rhyncoteuthion stage larva (Ommastrephidae) was caught by ORI-100 surface tow at Stn. 26.

Samples collected with each sampling gear were classified into three groups i.e. larval squid, larval fish and other plankton and wet weight of each group was measured (Tables 9 and 10).

Examination of the effects of 5% neutral formalin preservation on the length of larval squids is now in progress.

Table 10. Data on sampling by ORI-100 at surface and wet weight per haul of zooplankton, fish larvae and Watasenia scintillans. Number in parenthesis indicates the number of individuals

Stn.	Date 1976	Position N	Position E	Zone time	Wet weight (g) Zoopl.	Fish larvae	Watasenia scintillans
3	Jul.15	40-55	135-27	21:25-21:45	49.1	14.82	0
F-1	16	39-04	134-07	21:31-21:51	435.9	3.82	0
20	17	38-20	134-00	23:13-23:34	320.6	1.51	0
26*	19	37-13	137-28	21:42-22:02	186.7	0.41	0.010 (1)
7	20	39-30	135-18	21:29-21:49	89.2	5.67	0
I-1	21	39-21	135-19	21:33-21:53	467.2	13.87	0
I-1	22	39-22	135-12	20:36-20:56	176.2	22.28	0
I-2	23	38-40	134-31	19:22-19:42	55.2	0.07	0
21**	30	37-02	134-21	00:48-01:08	86.8	16.88	0
18	31	38-51	133-44	00:35-00:55	74.6	0.07	0
12	31	39-09	134-30	21:31-21:51	614.5	1.92	0
7	Aug. 1	39-33	135-22	20:32-20:52	147.7	1.92	0
5	2	39-59	135-01	01:45-02:05	90.7	0.90	0
I-3	2	39-25	135-11	20:43-21:03	153.3	0.71	0
I-4	3	39-01	134-28	21:05-21:25	-	-	-
I-4	4	39-02	134-25	20:37-21:00	545.1	0.46	0
24	6	38-21	133-04	03:20-03:40	94.5	14.99	0
14***	Aug. 1	38-44	134-55	07:52-08:18	147.8	1.92	0.143 (4)

* Rhyncoteuthion stage larva was collected at this station, wet weight is 0.064 g.
** Gonatidae squid (Berryteuthis magister?) was collected at this station, wet weight not measured.
*** Hauled obliquely from 170 m depth to surface and not included in Table 8.

4.2 Studies on Squids and Their Distribution around Yamato-Tai

Y. Matsumiya, K. Tatsukawa, S. Tanaka, K. Asano and Y. Ishida

In order to learn about the distribution of squids in the water around Yamato-Tai in relation to their biological characters and the environmental conditions in the area, quantitative samplings and biological measurements of the catch were conducted.

Method and materials

Sampling gears were made imitating a commercially used fishing tackle with many hooks, in much the same way as the previous cruise (refer to Preliminary Report of the Hakuhō Maru Cruise KH-71-4, p.47). The depth of sampling was fixed at 60 m or 30 m from the weight to the surface. The sampling period of 80

Table 11. Data for the sampling operations and the catch

Op. no.	Stn.	Date 1976	Time	Depth m	Total catch	No. of raisings	Catch per 100 raisings	No. gears used
Catch by sampling gear (standard procedure)								
J-1	3	7/15	19:47-21:07	30 or 60	5	101	5.0	2
J-2	F-1	16	20:00-21:20	"	16	102	15.7	"
J-3	20	17	21:47-23:07	"	8	124	6.5	"
J-4	26*	19	20:12-21:32	"	0	115	0.0	"
J-5	7	20	20:00-21:20	"	11	125	8.8	"
J-6	I-1	21	20:00-21:20	"	28	124	22.6	"
J-7	I-1	22	21:00-22:20	"	41	137	29.9	"
J-8	I-2	23	20:00-21:20	"	9	183	4.9	3
J-9	21	29	21:00-22:20	"	13	116	11.2	2
J-10	18	30	21:05-22:25	"	1	114	0.9	"
J-11	12	31	20:05-21:25	"	18	125	14.4	"
J-12	7	8/1	21:00-22:20	"	3	122	2.5	"
J-13	5	2	02:15-03:35	"	0	105	0.0	"
J-14	I-3	2	21:08-22:28	"	4	110	3.6	"
J-15	I-4	3	21:03-22:50	"	2	113	1.8	"
J-16	I-4	4	21:00-22:20	"	2	117	1.7	"
J-17	I-4	5	00:30-01:10	"	1	57	1.8	"
Total					162	1990	8.1	
Total excluding J-4					162	1875	8.6	
Hand-line angling catch measured						Effort (hour)	Catch per hour	
JH-1	14	7/18	20:30-22:00		6	1.5	4.0	
JH-2	18	30	23:00-24:00		2	1.0	2.0	
JH-3	14	8/1	00:00-04:00		7	4.0	1.8	
JH-4	5	2	03:00-04:00		2	1.0	2.0	
JH-5	I-4	3-4	23:00-24:00	01:30-03:30	5	3.0	1.7	
JH-6	I-4	5	22:00-24:00		2	2.0	1.0	
JH-7	24	6	02:00-03:00		3	1.0	3.0	
Total					27	13.5	2.0	

* Area of the Toyama Bay.

minutes was divided into four sections of 20 minutes (excluding operation number J-17), and 60 m or 30 m depth level was applied alternately to each section. The number of lowering and raising in 20 minutes was 12-23 times for 30 m depth level and 8-16 times for 60 m depth level. Two gears of the same type were used simultaneously (excluding J-8 using three gears), and they were assigned to keep their depth level 60 m or 30 m, respectively. The samplings were started after it got completely dark and conducted for 20-23 o'clock (excluding J-13 and J-17).

Samplings by the standard procedure mentioned above were practiced 16 times around this bank, and one time in the area of the Toyama Bay. Catch reached a total of 162 squids. Hand-line angling was used to supplement the sampling by the above mentioned gears. The number of hooks used for the hand-line angling was nine and hand-line was 60 m long. The hand-line angling catch measured amounted to 27 squids. Data for these operations are given in Table 11.

Biological measurements were made for 190 squids caught. Items of measurements were mantle length, body weight, sex, maturity and copulation. Excluding two squids, guts of 188 squids were taken out and preserved in 10% formalin for further detailed studies of maturity (weight of testis and Needhanis sac mass for male, weight of ovary and oviducts for female) and food habits.

Results

1) Catch per unit effort

In the bank area, the catch per 100 raisings of the lines in the standard operation ranges from 0-29.9 and is 8.6 squids in the average value (Table 11). This value is approximately one-third as much as the value of KH-71-4 cruise (mean: 27.4, range: 15-41). The quantitative distribution of squid in this area is uncertain for low abundance of squid and bad weather of the latter half.

Catch by depth levels is given in Table 12. The catch per 100 raisings is not always higher in the depth level of 60 m than that in 30 m. As the 60 m level covers also the layer from the surface to 30 m, the difference in the catch

Table 12. Catch per unit effort (100 raisings of lines) by depth levels

Operation number	J-2	J-5	J-6	J-7	J-9	J-11
60 m level						
No. raisings	41	48	47	55	44	49
Catch	9	2	6	22	7	11
Catch per 100 raisings	22.0	4.2	12.8	40.0	15.9	22.4
30 m level						
No. raisings	61	77	77	82	72	76
Catch	7	9	22	19	6	7
Catch per 100 raisings	11.5	11.7	28.6	23.2	8.3	9.2
Difference	10.5	-	-	16.8	7.6	13.2

per 100 raisings between 60 m and 30 m depth level may be considered to indicate the abundance of squids in the layer of 30-60 m depth. This difference of J-2, J-7, J-9 and J-11 is approximately equal to the value for the 30 m level, suggesting the uniformity on the whole swimming layer of squid. Negative values of the difference were obtained for J-5 and J-6. On these results, a large difference between this cruise and KH-71-4 cruise is recognized. No sufficient data to discuss the fluctuation of catch with time is given.

2) Maturity, size and sex

The range of ovary weight is 0-31.9 g and that of oviducts is 0-49.1 g for females. Maturity condition M (=oviducts/(ovary+oviducts)) rangeds 0-0.77. For males, the range of testis weight, Needhanis sac mass and maturity condition M (=Needhanis sac mass/(testis+Needhanis sac mass)) is 0-11.4 g, 0-12.8 g and 0-0.58, respectively. The relationships between mantle length and maturity condition M are shown in Figs. 16 and 17. This mature or immature squid is determined by colour and size of nidamental gland for female, vas deferens and

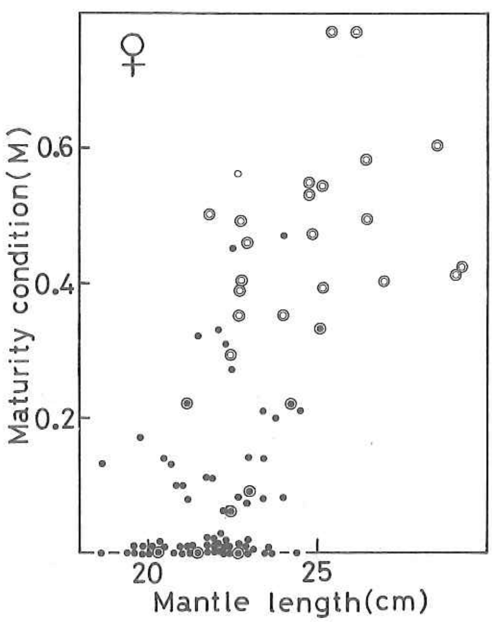

Fig. 16. Relationship between mantle length and maturity condition M for female.

Open circle: mature squid
Black circle: immature squid
Double circle: copulation squid

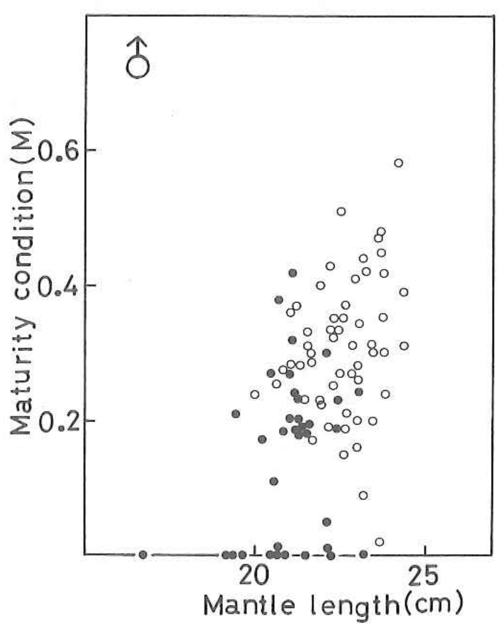

Fig. 17. Relationship between mantle length and maturity condition M for male.

Open circle: mature squid
Black circle: immature squid

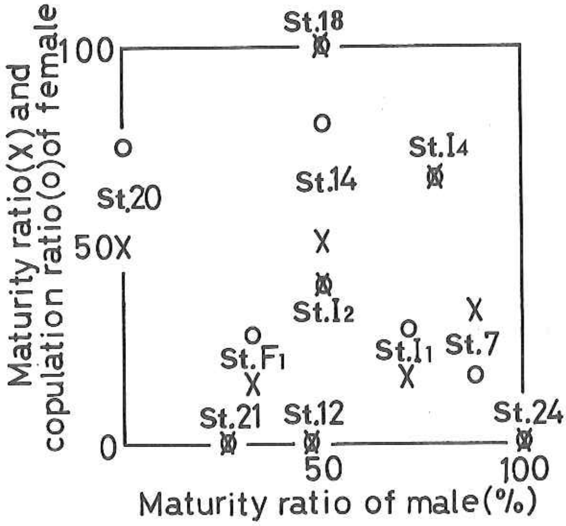

Fig. 18. Correlation between the maturity ratio of male and the maturity ratio or copulation ratio of female among sampling stations.

prostate gland for male. Commonly, the larger the mantle length the more advanced is the maturity stage. However, the mantle length range within the same stage is considerably large. The maturity ratio (ratio of mature squids to the total) varies among sampling stations and a correlation of the ratio between sexes is shown in Fig. 18. The maturity (copulation) ratio of female is considerably lower than that of male. The mantle length compositions by sampling station and sex are shown in Fig. 19. There is a clear trend that female is larger than male. Sex ratio is almost 50:50 in the entire sample (♀:♂=96:94). But few analysis can be carried out due to the smallness of the catch by station.

3) Weight and composition of stomach contents

Frequency of stomack weight (including its contents) is given in Table 13.

Table 13. Frequency of stomack weight with its contents

Weight (g)	No. squids	Weight (g)	No. squids	Weight (g)	No. squids
0.0- 0.9	1	6.0- 6.9	8*	12.0-12.9	3**
1.0- 1.9	55*	7.0- 7.9	6*		
2.0- 2.9	37*	8.0- 8.9	6**	15.0-15.9	1
3.0- 3.9	25	9.0- 9.9	4	17.0-17.9	1
4.0- 4.9	17	10.0-10.9	2	24.0-24.9	1
5.0- 5.9	19***	11.0-11.9	2	Total	188

* Contain one individual with burst stomack
** " two individuals "
*** " three individuals "

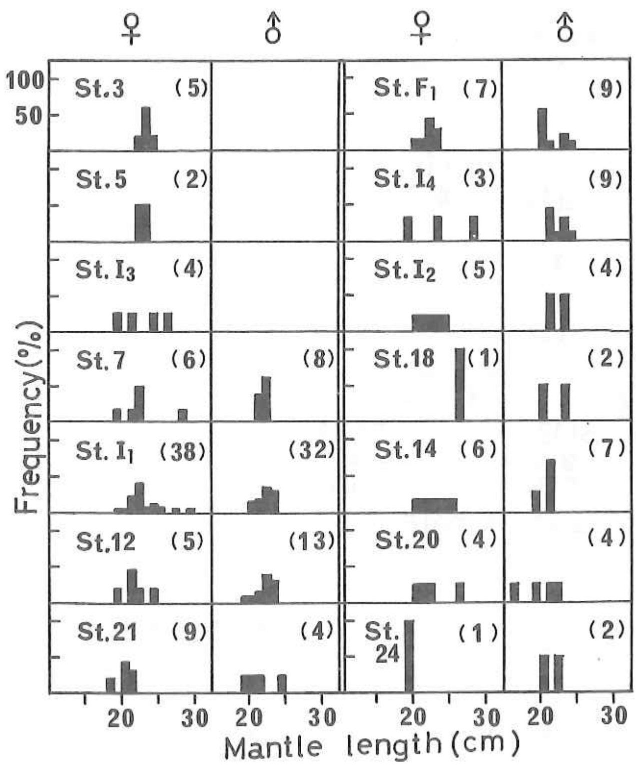

Fig. 19. Mantle length compositions by sampling station and sex. In parenthesis: the number of individuals.

Among 188 stomacks examined, 135 have stomack weight of less than 5 g. Many of stomacks are empty. The mean of stomack weights is slightly higher in this cruise (4.0 g) than that in KH-71-4 cruise (3.1 g).

The average weight of stomack contents was 1.41 g (Table 14). Clear difference of the weight was observed between cold water area and warm water area, the average being 2.35 g and 0.89 g, respectively. The highest value of the weight of stomach contents among 188 squids examined was 22.1 g for a specimen of body weight 575 g caught at the Stn. I-4 on August 3rd. The ratio of the stomach contents weight to the body weight was 0.69% on the average. The ratio in the cold water area was nearly 3 times as large as that in the warm water area. The proportion of the number of squids with empty or nearly empty stomach to the total number examined was 37.2%. The value was 14.7% in the cold water area and 60.2% in the warm water area, again showing a clear difference.

The examination of 118 stomach contents revealed that food items of squids

Table 14. The mean weight of stomach contents of common squid and the frequency of squids with the empty or nearly empty (the contents weighing less than 0.1 g) stomach

Stn.	No. squids exam. (TN)	Mean body wt. (BW) g	Mean stom. content wt. (SW) g	SW/BW x100	No. squids with empty stom. (EN)	EN/TN x100
I-1	67	218.4	3.71	1.64	7	10.4
I-3	9	250.0	3.18	1.52	2	40.0
3	6	248.3	2.72	1.08	0	0.0
5	2	242.5	0.0	0.0	2	100.0
7	15	226.3	2.13	1.03	3	20.0
Cold water	95	237.1	2.35	1.05	14	14.7
I-2	9	223.9	0.99	0.40	5	55.6
I-4	12	254.2	2.80	0.85	9	75.0
F-1	16	206.6	0.12	0.07	10	62.5
12	18	211.1	1.38	0.57	9	50.0
14	11	214.5	0.47	0.19	8	72.5
18	2	357.5	0.0	0.0	2	100.0
20	8	202.5	0.65	0.34	3	37.5
21	14	170.0	1.20	0.70	8	57.1
24	3	206.7	0.43	0.16	2	66.7
Warm water	93	227.4	0.89	0.36	56	60.2
Total	188	230.9	1.41	0.69	70	37.2

Table 15. Stomach contents of the common squid

Stn.	No. squids exam.	Volumetric percentages of food items			
		Crustaceans	Squids	Fishes	Unident. subst.
I-1	60	62.6	12.9	6.6	17.9
I-3	3	60.0	6.7	33.3	0.0
3	6	66.7	13.3	3.3	16.7
7	12	59.2	24.2	8.3	8.3
Cold water	81	62.1	14.3	12.9	10.7
I-2	4	30.0	20.0	25.0	25.0
I-4	3	0.0	0.0	100.0	0.0
12	9	29.5	11.1	41.7	17.7
14	3	33.3	6.7	60.0	0.0
20	5	20.0	0.0	0.0	80.0
21	6	0.0	50.0	0.0	50.0
24	1	0.0	100.0	0.0	0.0
Warm water	37	26.6	23.5	28.3	21.6
Total	118	38.4	20.4	23.2	18.0

included followings; Crustaceans (Amphipoda e.g. Parathemisto japonica, Euphausiids e.g. Euphausia pacifica and Thysanoessa longipes, Copepoda, etc.), Cephalopoda, Pisces and others. In stomachs of 3 squids, many spermatophore were observed. The average of the volumetric percentages of Crustaceans fed by squids was 62.1% in the cold water area (Table 15). However, in the warm water area the percentage was reduced to half, 26.6%, while that of Cephalopoda or Pisces was doubled.

If the diurnal feeding rhythm of squid was same between cold and warm water areas, the differences in the weight and composition of stomach contents would indicate the difference between these two areas in biomasses of various food species.

4) Spatial distribution of squids in relation to water masses

Sampling stations in the bank area are presented in Fig. 20 with water temperature of 100 m layer. A similarity in both maturity (copulation) and size is noticed among adjacent sampling stations (Figs. 18 and 19). Group I (Stns. 7 and I-1) in cold water mass is characterized by low maturity of female compared with male. Group II (Stns. F-1, I-4, I-2, 18, 14 and 20) in warm water mass is characterized by the same level maturity between sexes and high maturity of female compared with male. It is worth noticing that different groups of squid were observed even in a small area near the bank.

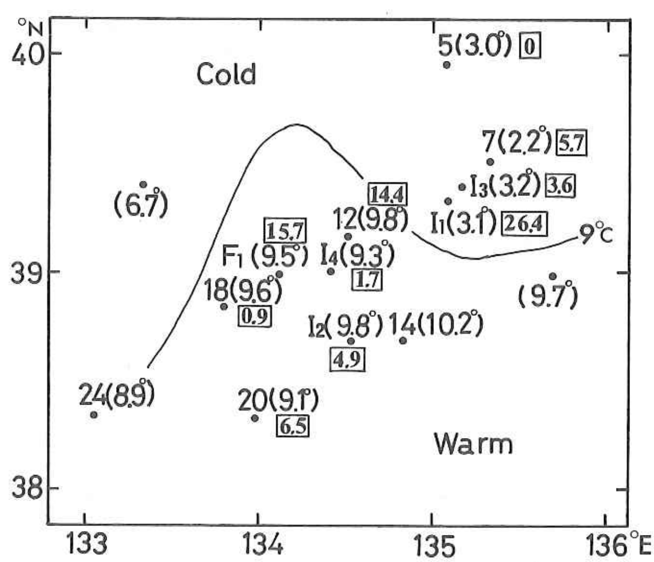

Fig. 20. Sampling stations in the bank area. In parenthesis: water temperature of 100 m depth (°C). In square: catch per 100 raisings of the lines in the standard operation.

4.3 Food Habits of Fishes around Yamato-Tai

K. Tatsukawa, S. Tanaka, K. Asano and Y. Ishida

Stomach contents of fishes caught by angling were examined to obtain the basic data for the discussion of the quantitative connection between fish and its foods in the water around Yamato-Tai.

During this cruise, 4 species were caught by anglers as follws: Theragra chalcogramma, Sebastes owstoni, Sardinops melanosticta and Scomber japonicus. For 17 fish among them, their fork length and their body weight were measured (Table 16).

The number of T. chalcogramma measured was 11 individuals. The range of fork length (FL) and of body weight (BW) was 36.6-62.4 cm and 300-1640 g, respectively. The average weight of stomach contents (CW) was 13.43 g. The CW/BW ratio was 1.30% on the average. Most of the stomach contents was Amphipoda. Squid was second to it and then Euphausiacea. The difference with the body

Table 16. Stomach contents of fishes caught by angling in the water around Yamato-Tai

Date	Stn.	Species*	(FL)	(BW)	(CW)	CW/BW	Food items (volume ratio %)**				
			cm	g	g	%	Amp.	Eup.	Cep.	Sag.	Und.
Jul. 16	F-1	TC	36.6	300	1.1	0.37	90	5	5		
	"	"	40.7	408	-	-					
	"	"	53.5	890	1.0	0.11	100				
	"	"	55.0	1000	6.6	0.66	70		30		
	"	"	58.6	1350	20.7	1.53			100		
	"	"	62.4	1640	1.8	0.11					100
	"	SO	24.8	218	trace	-	100				
Jul. 21	I-1	TC	41.0	360	7.1	1.97	100				
	"	"	41.4	500	12.9	2.58	100				
	"	"	62.0	1250	10.7	0.86	100				
Jul. 29	21	SM	18.0	65	0.3	0.46				100	
	"	"	20.3	110	-	-					
	"	"	21.6	120	-	-					
	"	SJ	24.3	150	0.6	0.40	100				
	"	"	29.8	330	1.8	0.55	100				
Aug. 2	5	TC	49.2	750	2.9	0.39		100			
	"	"	61.5	1560	69.5	4.46	1		99		

* TC: T. chalcogramma, SO: S. owstoni, SM: S. melanosticta, SJ: S. japonicus

** Amp.: Amphipoda, Eup.: Euphausiacea, Cep.: Cephalopoda (Decapoda), Sag.: Sagittidea, Und.: undistinguishable matters length, habitat, time of angling and so on was not able to be examined, because of the small size of samples.

The food of both S. owstoni and S. japonicus was Amphipoda. Saggita was fed by one of S. melanosticta. Any conclusions on food habits could not be drawn as the number of fish examined was so small.

4.4 Experimental Fishing of Nekton by Trap-Net on the Yamato-Tai

Y. Yamaguchi and H. Kobayashi

The experimental fishings were attempted to collect the data on nekton in the water around Yamato-Tai in relation to their biological characters and the environmental conditions in the area.

The trap-net used, which is illustrated in Fig. 21, was formed from four pieces of iron bar with a length of 120 cm and two iron rings with a diameter of 90 cm, and covered by nylon net of a mesh size of 1.5 cm. The iron bar has a diameter of 0.9 cm. The total weight of the net was 29 kg in sea water.

On one side of the net, a nonreturn entrance (funnel-shaped net) was fitted up for ushering fish in. The same trap-nets were connected by nylon braided rope with a diameter of 1 cm at intervals of 50 m. Two types of arrangement were tested. One of them was "I-type" as shown in Fig. 22 and the other was "L-type" as shown in Fig. 23. "I-type" was set at Stns. F-1 and 24, and "L-type" was set at Stns. I-1, I-3, and I-4. From the end of the net, the long-line having 20-25 branch lines with a length of 50 cm was extended. Fifteen nets were used on one experiment. From the starn of the ship, fishing gears were thrown overboard. The end of the rope was suspended by 6 buoys. After 12 hours, these gears were haulded by the capstan. Collected materials are shown in Table 17. The analysis of the data obtained is left for future studies.

Table 17. Collected Material

Operation number	1	2	3	4	5	Total
Station	F-1	I-1	I-3	I-4	24	
Lat. N	38-59.0	39-19.6	39-23.1	39-03.0	38-20.6	
Lon. E	134-10.0	135-05.4	135-12.9	134-24.5	133-04.5	
Quality of the bottom		Sand	Sand	Rock		
Depth m	540	340	325	320	2760	
Date 1976	Jul.16-17	Jul.22-23	Aug. 2-3	Aug. 4-5	Aug. 5-6	
Time	16:06 06:03	16:40 06:16	16:10 06:26	15:20 06:19	19:25 06:21	
Type of arrangement	I_1	L_1	L_2	L_2	I_2	
Trap-net						
(Species)						
Chionoecetes opilio	0	27	155	104	0	286
Hyas coarctatus alutaceus	0	1	1	4	0	6
Pandalus borealis	0	20	37	57	0	114
Natantia	0	2	36	81	0	119
Stegocephalus inflatus	0	22	14	3	0	39
Meterythrops microphthalma	0	0	0	0	3	3
Buccinum striatissimum	0	1	0	0	0	1
Gorgonocephalus caryi	0	4	0	1	0	5
Asteroidea	0	1	1	0	0	2
Theragra chalcogramma	0	2	2	3	0	7
Bryostemma otohime	0	2	1	0	0	3
Long-line						
(species)						
Theragra chalcogramma		3	2	3	0	8
Pleuronichthys cornutus		1	0	0	0	1
Bryostemma otohime		0	2	0	0	2
Gorgonocephalus caryi		0	0	1	0	1
Ophiuroidea		1	0	0	0	1
Holothuroidea		0	3	0	0	3

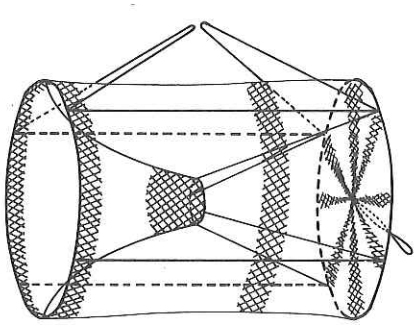

Fig. 21 Construction of the trap-net.

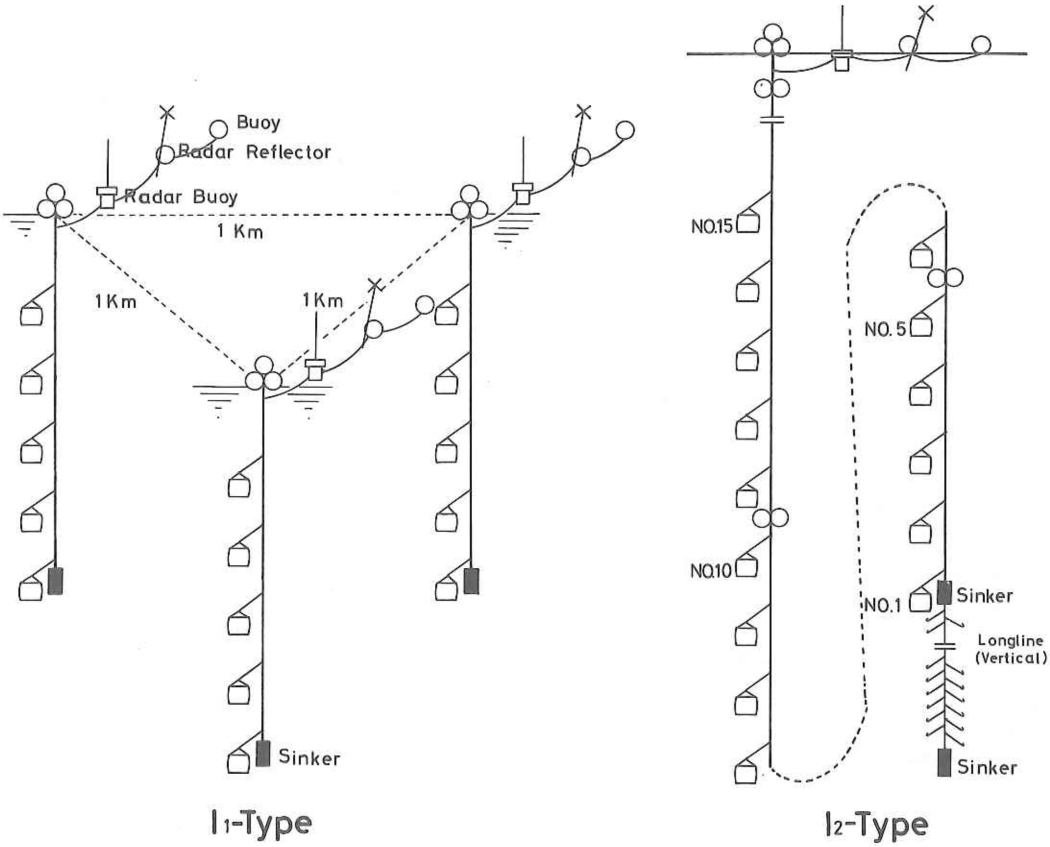

Fig. 22. Sketch showing the arrangement of the trap-nets in "I-type".

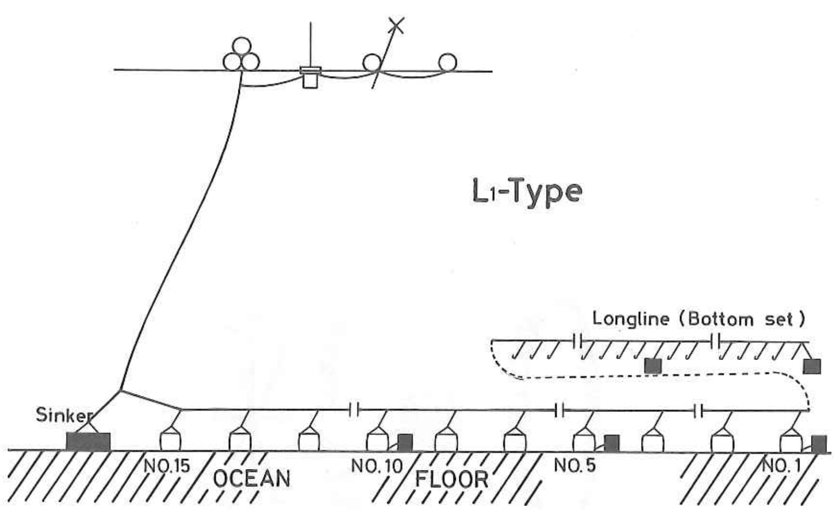

Fig. 23a. Sketch showing the arrangement of the trap-net in "L_1-type".

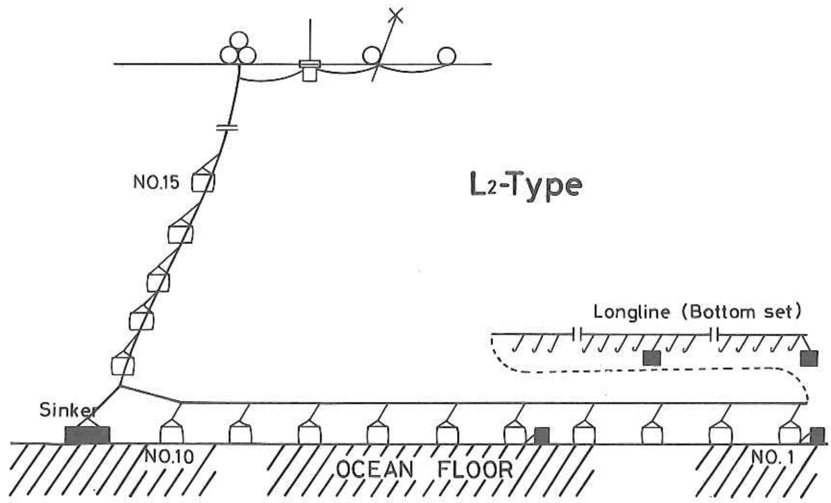

Fig. 23b. Sketch showing the arrangement of the trap-net in "L_2-type".

5. GRAVITY MEASUREMENT AT SEA

Y. Tomoda and K. Koizumi

Cruise No.: KH-76-3

Track of the ship: See track chart on page 4

Observer: K. Koizumi

Observed period: Jul. 12～Aug. 10 (1976)

Gravity meter system: T.S.S.G.

Gravity meter: Model Z-68-7-14 (string type)

Vertical Gyro: Model 72-A (a pair of single freedom Gyros)

Data processing system: Model 72-A (0.05 sec. sampling rate)

Gravity meter calibration points

Harumi (Tokyo), Sakaiminato, Harumi (Tokyo)

Trouble with gravity meter:

Out of order time of the gravity meter

Jul. 20 01:27. Jul. 23 14:10. Aug. 5 14:05.

Position fixing: Loran A, C

x Dead reckoned navigation

x NNSS

Out of order time of NNSS: None

Out of order time of PDR: None

Appendix Table I. Temperature and salinity data from S.T.D. observations.

Stn.	Stn. 3		Stn. F-1		Stn. F-2		Stn. 20		Stn. 18		Stn. 12		Stn. 14	
Date, 1976	Jul. 15		Jul. 17		Jul. 17		Jul. 17		Jul. 18		Jul. 18		Jul. 18	
Time	09:00		07:00		15:37		19:50		05:08		12:10		20:55	
Lat. N	40-56.8		38-59.0		38-47.2		38-19.7		38-50.5		39-10.0		38-41.2	
Lon. E	135-20.4		134-10.0		133-59.4		133-59.8		133-38.7		134-30.1		134-48.1	
Depth m	T °C	S °/oo	T °C	S °/oo	T °C	S °/oo	T °C	S °/oo	T °C	S °/oo	T °C	S °/oo	T °C	S °/oo
0	17.49	34.081	20.30	34.031	20.19	34.070	20.61	34.174	20.75	34.213	20.22	34.080	20.41	33.916
10	16.67	33.936	20.26	.061	20.20	.077	20.44	.186	20.68	.216	20.21	.091	20.32	34.103
20	9.53	.901	17.92	.128	19.59	.116	19.92	.272	19.02	.273	19.37	.356	16.47	.208
40	4.82	.947	12.89	.277	13.69	.000	14.67	.399	14.54	.476	14.58	.297	14.14	.377
60	2.90	.933	11.11	.148	10.40	33.977	12.14	.195	12.45	.237	11.62	.226	11.57	.198
80	1.85	.949	10.30	.185	9.09	34.074	9.81	.178	8.99	.167	10.07	.167	11.05	.253
100	1.45	34.003	9.53	.130	8.30	.086	9.05	.133	7.51	.106	9.24	.164	10.17	.183
120	1.21	.000	8.97	.120	6.98	.036	8.92	.136	5.53	.047	8.56	.102	9.65	.147
160	0.98	.020	6.79	.049	4.51	.028	6.69	.057	3.04	.014	4.49	33.955	8.99	.121
200	0.79	.028	4.03	33.981	2.84	33.973	3.58	33.993	1.79	.006	2.85	.923	7.69	.080
240	0.63	.021	2.06	34.007	1.91	.986	2.11	34.008	1.21	.011	1.74	.985	5.15	.030
320	0.48	.039	--	--	1.08	34.014	0.98	.030	0.70	.035	0.83	34.019	1.88	.006
400	0.37	.044	--	--	0.58	.034	0.60	.040	0.50	.045	0.57	.039	0.87	.037
600	0.26	.054	--	--	0.20	.060	0.32	.059	0.29	.058	0.28	.060	0.35	.058
680	0.23	.057	--	--	0.20	.065	0.25	.063	0.24	.061	0.23	.062	0.28	.061
800	0.20	.062	--	--	0.18	.066	0.20	.068	0.20	.067	--	--	0.22	.068
1000	0.16	.068	--	--	0.16	.073	0.16	.075	0.16	.076	--	--	0.16	.077

Stn.	Stn. 26		Stn. 9		Stn. 7		Stn. I-1		Stn. I-2		Stn. 21		Stn. 20	
Date, 1976	Jul. 19		Jul. 20		Jul. 20		Jul. 21		Jul. 23		Jul. 29		Jul. 30	
Time	12:14		09:39		16:48		06:29		13:21		22:07		13:38	
Lat. N	37-12.4		38-59.2		39-30.4		39-19.6		38-40.3		37-01.9		38-20.6	
Lon. E	137-29.1		135-40.3		135-20.0		135-05.4		134-30.3		134-20.6		134-00.5	
Depth m	T °C	S °/oo	T °C	S °/oo	T °C	S °/oo	T °C	S °/oo	T °C	S °/oo	T °C	S °/oo	T °C	S °/oo
0	22.05	33.323	20.62	34.057	19.19	34.254	19.70	34.275	22.24	34.111	24.91	33.808	23.00	34.244
10	21.16	.906	20.59	.063	19.55	.223	19.69	.284	21.24	.134	22.64	.782	22.97	.252
20	20.06	34.079	20.52	.053	15.01	33.777	19.30	.256	17.46	.188	20.76	34.044	21.05	.214
40	17.69	.252	13.60	.346	7.41	.953	10.83	.066	13.61	.359	15.48	.276	16.10	.497
60	16.04	.416	11.05	.210	4.27	.991	6.76	33.818	12.57	.382	13.24	.373	13.58	.407
80	14.23	.457	10.24	.187	2.79	.985	4.35	.919	10.93	.166	10.65	.139	11.76	.320
100	13.76	.464	9.37	.091	2.06	.961	3.13	.961	9.80	.100	8.64	.096	10.21	.230
120	11.08	.148	9.02	.119	1.64	34.011	2.31	.997	9.11	.084	6.40	.042	9.16	.142
160	8.38	.009	7.70	33.992	1.15	.021	1.51	.988	8.80	.102	2.54	.023	6.77	.091
200	5.16	.027	4.06	.994	0.82	.014	1.02	34.015	7.07	.060	1.37	.010	3.39	33.998
240	1.92	.032	2.63	.986	0.63	.031	0.71	.018	3.99	33.931	0.87	.015	2.09	.992
320	0.87	.039	1.02	34.022	0.51	.041	0.51	.040	1.46	34.018	0.51	.027	0.88	34.026
400	0.59	.044	0.66	.042	0.47	.052	--	--	0.76	.033	0.38	.043	0.54	.034
600	0.30	.057	0.31	.057	--	--	--	--	0.34	.054	0.23	.052	0.29	.052
800	0.19	.067	0.19	.067	--	--	--	--	0.22	.062	0.17	.063	0.19	.058
1000	0.16	.076	0.16	.074	--	--	--	--	0.17	.070	0.14	.068	0.15	.067

Appendix Table I. (Continued)

Stn.	Stn. 18		Stn. 16		Stn. 10		Stn. 12		Stn. 14		Stn. 9		Stn. 7	
Date, 1976	Jul. 30		Jul. 31		Jul. 31		Jul. 31		Aug. 1		Aug. 1		Aug. 1	
Time	19:23		06:26		12:11		18:41		01:19		11:21		17:40	
Lat. N	38-50.2		39-24.0		39-40.0		39-09.9		38-41.0		38-59.2		39-31.2	
Lon. E	133-40.4		133-20.2		134-11.1		134-29.9		134-50.2		135-41.7		135-19.5	
Depth m	T °C	S °/oo	T °C	S °/oo	T °C	S °/oo	T °C	S °/oo	T °C	S °/oo	T °C	S °/oo	T °C	S °/oo
0	22.92	34.195	22.16	34.144	22.23	34.174	22.11	34.255	22.54	34.192	22.50	34.210	22.55	34.033
10	22.15	.171	22.16	.104	21.95	.150	22.11	.260	22.54	.198	22.49	.216	22.54	.034
20	20.27	.256	21.19	.094	19.20	.073	21.89	.160	22.26	.062	19.32	33.689	20.31	33.804
40	15.09	.353	15.24	.174	14.22	.432	15.15	.297	14.63	.256	13.80	34.322	9.28	.795
60	13.05	.335	12.82	.417	11.21	.238	12.65	.350	12.39	.303	11.93	.230	5.71	.925
80	11.02	.233	9.42	33.961	10.37	.216	10.97	.235	11.16	.143	10.66	.207	3.50	.890
100	9.55	.144	6.69	.924	9.34	.112	9.84	.155	10.29	.193	9.94	.146	2.27	.978
120	8.43	.097	4.88	.972	8.91	.133	8.94	.142	9.65	.015	9.15	.094	1.80	.994
160	4.09	33.926	2.36	.989	6.39	.050	5.32	.029	8.61	.093	8.04	.096	1.36	34.007
200	1.97	.945	1.44	34.009	3.49	33.994	2.65	33.996	6.03	.047	4.46	.038	0.93	.016
240	1.19	.999	1.00	.021	2.01	.994	1.61	34.003	3.45	.007	2.26	.004	0.69	.016
280	0.93	34.007	0.80	.028	1.19	.984	1.11	.020	2.10	.022	1.36	.018	0.50	.029
320	0.68	.031	0.67	.032	0.90	34.010	0.79	.018	1.35	.016	0.91	.023	--	--
360	0.58	.036	0.56	.032	0.65	.022	0.56	.036	0.89	.032	0.69	.032	--	--
400	0.51	.033	0.45	.038	0.55	.029	--	--	0.66	.041	0.59	.036	--	--
600	0.28	.054	0.27	.054	0.31	.050	--	--	0.32	.052	0.31	.048	--	--
800	0.20	.062	0.21	.061	0.22	.062	--	--	0.22	.058	0.21	.059	--	--
1000	0.16	.075	0.18	.069	0.18	.067	--	--	0.17	.068	0.17	.067	--	--

Stn.	Stn. 5		Stn. I-3		Stn. I-4		Stn. F-1		Stn. F-2		Stn. 24	
Date, 1976	Aug. 2		Aug. 2		Aug. 3		Aug. 4		Aug. 5		Aug. 6	
Time	05:00		22:38		13:11		17:30		13:11		01:17	
Lat. N	39-57.0		39-23.1		39-03.0		39-01.6		38-46.8		38-20.6	
Lon. E	135-04.0		135-12.9		134-24.5		134-09.2		134-01.2		133-04.5	
Depth m	T °C	S °/oo	T °C	S °/oo	T °C	S °/oo	T °C	S °/oo	T °C	S °/oo	T °C	S °/oo
0	22.26	33.805	22.18	33.940	22.71	34.121	23.32	34.178	23.15	34.058	23.44	33.409
10	22.27	.814	22.18	.952	22.63	.122	22.78	.179	23.02	.134	23.16	.530
20	18.14	.805	22.04	.966	21.13	.087	21.54	.140	21.13	.256	20.93	34.280
40	12.46	34.245	14.01	34.242	15.39	.322	14.86	.334	15.68	.416	15.41	.310
60	7.56	.102	7.90	33.954	12.43	.279	13.02	.416	13.56	.444	12.71	.184
80	4.58	33.963	4.52	.987	10.55	.210	10.41	.132	11.37	.306	10.62	.191
100	2.96	.936	3.23	.972	9.28	.124	9.23	.114	9.70	.200	8.94	.115
120	2.26	.980	2.14	.998	8.79	.107	8.57	.094	8.61	.123	7.85	.045
160	1.27	.993	1.26	34.011	6.14	.052	4.94	33.984	5.18	33.916	4.06	33.884
200	1.05	34.002	0.91	.021	3.42	33.978	2.78	.996	2.64	.867	2.02	.995
240	0.83	.024	0.69	.026	1.72	34.005	1.80	34.010	1.57	.994	1.28	.995
280	0.66	.029	0.60	.032	1.21	.008	1.33	.012	1.15	34.022	0.94	34.021
320	0.54	.037	--	--	--	--	0.97	.021	0.81	.028	0.68	.024
400	0.42	.040	--	--	--	--	--	--	0.52	.032	0.50	.040
600	0.26	.054	--	--	--	--	--	--	0.26	.051	0.32	.052
800	0.20	.060	--	--	--	--	--	--	0.18	.061	0.22	.059
1000	0.17	.066	--	--	--	--	--	--	0.15	.067	0.18	.065

Appendix Table II. Data from BT observations.

Stn.	Date	Time	Lat.	Lon.	Temperature (°C) at depths (m) 0	10	20	30	50	75	100	150	200	250	Max. depth D(m)	T(°C)
	1976		N	E												
1	Jul.14	2337	41-00.2	137-00.9	16.4	16.1	11.1	6.6	2.7	2.2	2.2	2.0	1.8	1.7	252	1.7
2	" 15	0405	41-00.4	136-01.1	16.5	16.5	14.5	5.5	2.8	2.0	1.8	1.7	1.5	-	233	1.5
4	" 16	0425	40-30.1	135-10.0	18.4	17.3	14.5	7.0	4.2	3.3	1.8	1.8	1.7	-	230	1.6
19	" 18	0345	38-35.8	133-48.6	20.9	20.9	18.2	15.9	14.2	12.0	9.6	5.0	2.7	2.0	259	1.9
25	" 18	0952	39-04.2	134-00.8	20.4	20.3	20.3	14.8	11.6	10.4	9.6	8.3	4.6	2.6	270	2.0
13	" 18	1903	38-55.7	134-39.9	20.1	20.1	18.2	15.5	12.0	10.7	9.5	9.0	7.6	3.9	269	3.1
14	" 18	2035	38-40.4	134-49.7	20.6	20.6	20.0	16.7	13.4	10.9	10.3	9.1	7.9	4.7	262	4.0
26	" 19	1204	37-11.9	137-29.7	22.5	21.5	20.6	19.0	16.8	14.5	13.7	9.1	5.7	2.4	260	2.3
8	" 20	1513	39-15.5	135-30.2	21.0	20.8	19.5	17.5	12.8	8.3	5.6	2.8	2.1	-	242	1.7
I-1	" 21	1907	39-20.7	135-17.8	19.7	19.6	18.3	14.0	8.9	4.8	3.2	1.9	-	-	175	1.6
Δ-1	" 22	1212	39-23.7	135-27.2	20.9	19.4	19.2	14.3	8.2	4.9	3.3	1.9	1.5	1.3	260	1.3
Δ-2	" 22	1259	-	-	21.2	20.2	17.2	11.9	6.3	3.8	2.9	1.7	-	-	175	1.6
Δ-3	" 22	1320	-	-	21.1	20.1	18.0	11.8	6.2	4.0	2.7	1.7	1.6	-	242	1.3
22	" 24	0145	37-50.0	134-11.7	23.0	22.2	20.9	18.0	14.1	11.1	9.6	8.4	4.1	2.1	252	2.0
21	" 29	2201	37-01.9	134-20.6	25.4	24.3	22.3	18.7	14.5	11.3	9.2	3.8	2.1	1.6	265	1.6
15	" 30	0910	38-00.0	134-59.6	24.9	24.2	21.6	19.5	14.5	11.8	10.0	6.1	2.8	-	248	2.0
20	" 30	1320	38-20.4	134-00.2	24.8	24.8	22.0	17.0	15.1	12.3	10.3	8.0	4.2	-	238	2.8
F-2	" 30	1718	39-01.7	134-08.3	23.2	23.2	22.3	18.3	15.3	12.6	10.4	6.9	3.1	-	237	2.4
18	" 30	1905	38-50.3	133-40.1	23.3	23.2	21.9	17.4	14.1	11.3	9.3	6.4	2.6	1.7	253	1.7
17	" 31	0235	39-06.0	133-29.8	23.7	23.6	23.5	22.1	14.6	11.8	9.0	4.3	-	-	175	3.1
16	" 31	0605	39-23.2	133-19.9	22.2	22.1	20.5	17.7	14.0	10.2	7.0	3.0	2.0	-	245	1.7
10	" 31	1200	39-40.4	134-11.1	22.3	22.3	22.2	16.7	12.8	10.3	9.4	7.5	3.8	-	230	2.8
11	" 31	1705	39.25.2	134-20.0	22.4	23.4	22.9	19.9	13.5	10.8	9.4	6.3	3.0	-	247	1.9
12	" 31	1917	39-09.7	134-30.1	22.3	22.2	22.2	16.6	15.1	11.3	9.9	6.9	3.3	2.0	260	1.9
13	" 31	2325	38-55.5	134-40.0	22.7	22.7	22.7	17.2	14.2	11.0	9.7	8.9	5.9	4.3	270	2.1
14	Aug. 1	0107	38-40.2	134-50.1	22.8	22.7	22.7	18.0	13.9	11.5	10.3	8.8	6.5	3.5	250	3.5
9	" 1	1106	38-59.2	135-40.6	22.4	22.4	22.3	15.4	12.9	10.7	9.8	8.5	5.0	2.4	252	2.3
8	" 1	1600	39-15.5	135-25.7	23.0	22.9	22.6	20.4	10.3	5.2	3.6	2.0	1.5	1.4	252	1.4
7	" 1	1808	39-31.4	135-20.1	22.8	22.7	22.5	14.0	7.1	4.5	2.5	1.6	1.5	1.1	260	1.1
6	" 2	0005	39-45.5	135-10.3	23.1	23.1	23.1	14.2	11.8	7.5	3.8	2.3	1.6	1.1	250	1.1
5	" 2	0208	39-59.0	135-00.8	22.5	22.4	22.4	14.5	9.5	5.0	3.5	1.9	1.3	1.0	258	1.0
I-4																
Δ-1	" 3	1006	39-03.0	134-22.2	22.8	22.7	22.6	18.0	13.3	10.9	8.8	8.0	3.8	1.9	260	1.8
Δ-2	" 3	1027	39-02.7	134-21.6	22.6	22.6	22.6	18.0	13.7	10.6	9.6	7.7	3.8	1.8	260	1.6
Δ-3	" 3	1043	39-03.7	134-21.6	22.7	22.7	22.7	18.1	13.6	11.4	9.6	8.0	3.8	1.9	255	1.9
I-4	" 3	1400	39-03.0	134-24.7	22.9	22.7	22.5	17.0	13.7	11.2	9.5	7.2	3.6	2.1	255	2.1
Δ-1	" 4	1325	39-04.1	134-30.3	22.8	22.8	22.7	16.0	14.5	11.0	9.5	7.0	3.5	2.0	260	1.9
Δ-2	" 4	1349	39-04.5	134-30.0	23.0	22.8	22.5	16.5	14.0	11.3	9.5	7.0	3.3	2.1	260	1.9
Δ-3	" 4	1410	39-03.3	134-29.7	23.1	23.0	22.0	17.0	14.0	11.0	9.8	8.7	3.4	2.1	260	2.0
I-4	" 4	1550	39-03.1	134-22.6	23.9	23.0	22.8	18.2	13.5	11.0	9.7	8.0	3.4	1.9	252	1.8
F-1	" 4	1805	39-01.6	134-09.8	23.9	23.7	23.3	22.0	14.3	11.5	9.4	7.2	3.3	2.7	263	2.3
F-2	" 5	1257	38-46.7	134-01.1	23.3	23.2	22.9	18.0	14.5	11.9	9.7	6.2	3.1	2.0	262	1.8
23	" 5	1655	38-32.5	133-31.0	23.8	23.7	21.1	16.5	13.2	11.0	9.7	6.6	3.5	2.2	250	2.2
24	" 5	1949	38-19.4	133-00.7	23.9	23.9	22.7	17.5	13.8	10.5	9.7	4.7	2.3	1.7	253	1.6
24	" 6	0101	38-20.5	133-04.4	23.8	23.8	21.2	17.5	14.0	11.2	9.8	5.5	2.5	1.6	256	1.5