# Preliminary Report
of
# The Hakuhō Maru Cruise KH-70-4
(IBP Cruise)

July 29—September 1, 1970

The Japan Sea

Ocean Research Institute
University of Tokyo
1972

# ERRATA

"Depth" in Fig. 6 (P. 43) should be corrected as follows: 800 (700), 1000 (800) 1500 (1000), 2000 (1500), 2500 (2000), 3000 (2500) and 3500 (3000). The figure in brackets is error.

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By

The Scientific Members of the Expedition

Edited by

Ryuzo Marumo

# Introduction

It has been known that there exists a characteristic meso- and bathypelagic community composed of limited number of species in the Japan Sea, mainly because the Japan Sea is bordered by shallow channels with depths less than 200 m such as Mamiya, Soya, Tsugaru and Tsushima Straits from the Pacific Ocean and a closed system is formed in the hydrography of deeper layers. The present report entitled "Studies of the Ecosystem in the Japan Sea" aims to investigate pelagic flora and fauna, biomass and biogeography, especially in deeper layers in connection with environmental conditions, and to compare the ecosystem in the Japan Sea with that on the Pacific side.

A "Symposium on the Ecosystem of the Japan Sea" was held on March 27, 1970 sponsored by the Ocean Research Institute, and reviews were presented on the existing knowledge of phytoplankton, zooplankton, benthos, living resources, hydrography and geography in the Japan Sea, for effectively designing the plans of the programme of the present study.

Research works in our present cruise have constituted a part of the International Biological Programme (IBP).

Scientists aboard would like to express their hearty thanks to the crew members of Hakuhō Maru for their helpful cooperations.

Ryuzo Marumo

Chief Scientist

Contents

Cruise itinerary

| | Arrival | Departure |
|---|---|---|
| Tokyo | | July 29, 1970 |
| Fushiki | August 10 | August 13 |
| Nagasaki | August 25 | August 28 |
| Tokyo | September 1 | |

Scientists aboard

| | | |
|---|---|---|
| Marumo, Ryuzo<br>Chief Scientist | Ocean Res. Inst., Univ. of Tokyo | Zooplankton |
| Tanaka, Shoichi | Ocean Res. Inst., Univ. of Tokyo | Population dynamics |
| Maruyama, Yoshiharu | Ocean Res. Inst., Univ. of Tokyo | Bacteria |
| Nemoto, Takahisa | Ocean Res. Inst., Univ. of Tokyo | Zooplankton |
| Ishii, Takeo | Ocean Res. Inst., Univ. of Tokyo | Population dynamics |
| Omori, Makoto | Ocean Res. Inst., Univ. of Tokyo | Zooplankton |
| Kawaguchi, Kouichi | Ocean Res. Inst., Univ. of Tokyo | Zooplankton |
| Tatsukawa, Kenichi | Ocean Res. Inst., Univ. of Tokyo | Population dynamics |
| Nakai, Toshisuke | Ocean Res. Inst., Univ. of Tokyo | Physical oceanography |
| Hasumoto, Hiroshi | Ocean Res. Inst., Univ. of Tokyo | Zooplankton |
| Sawa, Shuji | Ocean Res. Inst., Univ. of Tokyo | Population dynamics |
| Aizawa, Yasushi | Ocean Res. Inst., Univ. of Tokyo | Zooplankton |
| Terazaki, Makoto | Ocean Res. Inst., Univ. of Tokyo | Zooplankton |
| Matsuda, Osamu | Ocean Res. Inst., Univ. of Tokyo | Bacteria |
| Araki, Masakuni | Ocean Res. Inst., Univ. of Tokyo | Zooplankton |
| Maeda, Masachika | Ocean Res. Inst., Univ. of Tokyo | Bacteria |
| Igarashi, Takao | Ocean Res. Inst., Univ. of Tokyo | Gravity |
| Liu, Chen-long | Ocean Res. Inst., Univ. of Tokyo | Fish |
| Okutani, Koichi | Fac. of Agriculture, Kagawa Univ. | Bacteria |
| Honda, Teruo | Fac. of Agriculture, Kyushu Univ. | Fish larvae |
| Kawada, Izumi | Dep. of Fisheries, Kyoto Univ. | Bacteria |
| Morioka, Yasuhiro | Fukui Prefectural Fisheries<br>Experimental Station | Zooplankton |
| Minoda, Takashi | Fac. of Fisheries, Hokkaido Univ. | Zooplankton |
| Uno, Shiro | Fac. of Fisheries, Hokkaido Univ. | Seston |
| Shiga, Naonobu | Fac. of Fisheries, Hokkaido Univ. | Zooplankton |
| Komaki, Yuzo | Dep. of Fisheries, Univ. of Tokyo | Zooplankton |
| Nishizawa, Satoshi | Fac. of Fisheries, Hokkaido Univ. | Seston |
| Nakajima, Kohki | Fac. of Fisheries, Hokkaido Univ. | Seston |
| Nozaki, Yoshiyuki | Fac. of Fisheries, Hokkaido Univ. | Seston |

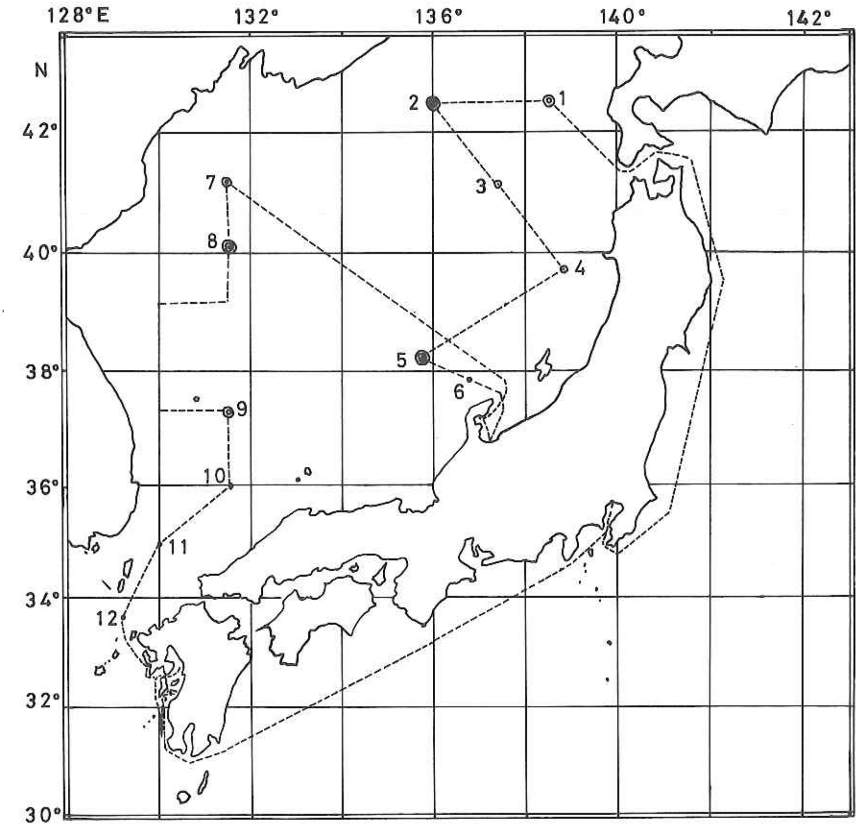


Fig. 1 Track chart of Cruise KH-70-4

## Outline of the research

The research programmes in this cruise were as follows:

1. Ecological studies on plankton and micronekton
2. Studies on particulate organic matters
3. Ecological studies on bacteria and decomposition of organic matters
4. Counting of the echo patterns of individual fish by pattern analysis method
5. Measurement of gravity
6. Hydrographic observations

Fifteen stations were to be occupied in the Japan Sea in the original plan, but they were obliged to be reduced to 12 stations (Fig. 1) owing to the successive coming of Typhoons 7009, 7010 and 7011 (refer to general weather conditions on page 10 ). Samplings and observations were carried out concerning 15 items shown in Table 1.

Table 1. Item of observations (KH-70-4).

| Station | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | Tokyo -Fushiki | Fushiki -Nagasaki | Nagasaki -Tokyo |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Nansen-ORIT cast | o | o | o | o | o | | o | o | o | o* | o* | | | | |
| Sampling by Van Dorn bottles (25 l x 2) | | o | | | o | | o | o | o | | | | | | |
| Sampling by 200-l sampler | | o | | | o | | | o | o | | | | | | |
| Sampling by Niskin sampler | | o | | | o | | | o | | | | | | | |
| BT observation | o | o | o | o | o | o | o | o | o | o | o | | | | |
| GEK observation | o | o | o | o | o | | o | o | o | o | | | | | |
| Vertical haul by Norpac double net | o | o | o | o | o | o | o | o | o | o | o | | | | |
| Oblique haul by ORI net | o | o | o | o | o | o | o | o | o | o | o | o | | | |
| Horizontal tow by ORI net | | o | | | o | | | o | | | | | | | |
| Surface tow by larva net | o | o | o | o | | | | o | | o | o | | | | |
| Horizontal tow by MTD net | o | o | | | o | | o | o | o | | | | | | |
| Oblique haul by IKMT | o | o | | o | o | o | o | o | o | | | | | | |
| Sampling by piston core sampler | | | | | o | | | o | | | | | | | |
| Observation by fish detector | | o | o | | o | | | o | o | | | | o | o | o |
| Measurement of gravity | | | | | | | | | | | | | | o | o |

* ORIT only

## 1. Oceanographic conditions

by

T. Nakai, H. Hasumoto and R. Marumo

1. Water temperature (Figs. 2 and 3)

The temperature in the deep water of the Japan Sea was remarkably even, being between 0° and 1°C in the entire depths lower than 300 m at all stations except somewhat higher temperature at St. 5. The minimum of temperature, although not so distinct, occurred at about 1500 m.

The vertical stratification of temperature in the upper 300 m can be divided into three types as follows:

(1) 1st type (Sts. 1, 2, 3, 7 and 8): The surface thin layer was warmed by heating of the radiation from the sun, but the temperature decreased conspicuously to less than 3°C at 50 m, above which layer the seasonal thermocline was most remarkably developed.

(2) 2nd type (Sts. 4 and 9): In spite of the long distance between Sts. 4 and 9, there was the similarity in their vertical distributional pattern of temperature except the surface temperatures of 22°C at St. 4 and of 25°C at St. 19. The vertical mixing is considered to be fairly developed at these stations compared with 1st-type stations. The surface water at St. 9 seems to be influenced by flowing of the Tsushima Warm Current.

(3) 3rd type (St. 5): St. 5 is strongly covered by the Tsushima Current and the column of warmer water is very thick, the temperature being 25°C at 300 m.

2. Salinity (Figs. 3, 4 and 5)

The evenness of water masses below 300-m depth in the Japan Sea was also obviously indicated by the uniform salinity value of 34.04 — 34.09 ‰.

Surface salinity was slightly lower at northern stations 1, 2 and 3 than at western stations 7 and 8. This is considered to be caused by melting of ice originated from the Siberian water from early summer to autumn at the former stations.

The influence of the Tsushima warm water was clearly-indicated by higher salinity at St. 9 (34.34 — 34.38 ‰ in 30 — 50 m), St. 4 (34.39 — 34.42 ‰ in 30 — 50 m) and St. 5 (the highest salinity of 34.44 — 34.62 ‰ in 30 — 100 m).

3. Dissolved oxygen (Fig. 6)

Oxygen content in deeper layers was remakably high compared with that on the Pacific side, preserving the value of more than 5 ml/l even below the 1000-m depth.

The vertical distribution was somewhat fluctuated in the upper 1500-m depth station by station, probably because of the complicated influence of biological and biochemical activities, but oxygen was slowly increased below this depth down to the bottom, showing 5.2 ml/l at 1500 m and 5.4 ml/l at 3000 m.

In conclusion, the water deeper than 300 m of the Japan Sea is occupied by a body of the uniform water mass with $0^{o}$ — $1^{o}$C in temperature, 34.04 — 34.09 ‰ in salinity and 5.0 — 6.8 ml/l in oxygen content. On the contrary, the upper water is generally formed by two opposite water systems of the Liman Cold Current and the Tsushima Warm Current. The former contains Sts. 1, 2, 3, 7 and 8 characterized by thin layer of warm water, conspicuous seasonal thermocline and lower salinity. The latter is represented by St. 5 with thick layer of warm water and high salinity and it extends also to Sts. 4 and 9.

## 2. General weather conditions

by

T. Nakai

The general view of weather and sea conditions in this cruise is shown in Fig. 7. Atmospheric pressure, air temperature and sea surface temperature are drawn in fine solid line, thick dotted line and thick solid line, respectively. Values of wind velocity are shown in a bar graph. Weather symbols in Japanese type, times of sunrise and sunset, and approximate time in observational stations are also shown.

Weather and sea conditions of the Japan Sea in summer season are generally calm. As a whole, the weather condition in this cruise was as calm as in an ordinary year, except the successive coming of three typhoons 7009, 7010 and 7011 in the latter half of the period of this cruise. The wind velocity rarely exceeded 10 m/sec, except the cases of these typhoons. The maximum wind velocity was 21 m/sec in Typhoon 7009 on Aug. 15, 11 m/sec in 7010 on Aug. 22, and 23 m/sec in 7011 on Aug. 29. The relation between atmospheric pressure and wind velocity is seen in Fig. 7.

Air temperature fluctuated according to sea surface temperature and wind direction. A remarkable inversion between air temperature and sea surface temperature occurred in the morning of Aug. 1. After this time, the wind direction changed suddenly from south to north and fog cleared up, and the air temperature descended considerably. Prominent daily variations of air temperature were shown at ports and harvors and in coastal sea areas, for example, from St. 5 on Aug. 7 to Nanao Bay on Aug. 15 and from the Tsushima Straits on Aug. 24 to Tokyo on Sep. 1.

The sea surface temperature had a tendency to descend gradually with wide fluctuations, on the route from the east of Boso Peninsula to the north of Tsugaru Straits. Around the Tsugaru Straits, the sea surface temperature showed one of the maximum values in this cruise, about 24.5°C on July 31, owing to the influence of the Tsugaru Warm Current. The sea surface temperature were about 20°C or less at Sts. 1 and 2 in the north-eastern part of the Japan Sea, 25°C at Sts. 5 and 6 in the offing of Noto Peninsula, 23°C at Sts. 7 and 8 in the western part, and 25°C at St. 9. The value in the Tsushima Straits area, 28°C, was the highest in the Japan Sea. On the route from Kyushu to Tokyo, it was so high, owing to the Kuroshio Current. In the open sea area, the temperature difference between air and sea was generally small.

## 3. Distribution of particulate materials

by

S. Nishizawa, K. Nakajima, Y. Nozaki and S. Uno

### 1. Introduction

The Japan Sea is morphometrically so unique that the entire water body is a practically closed system which opens to outer waters only through the narrow four waterways with depths less than 200 m. Intensive winter cooling, that occurs in most parts of this sea area except a narrow coastal band of the Tsushima Current along the Japanese Islands, induces a vigorous convective mixing, which in the cold northern sector produces the surface sources of the deep and bottom waters of the Japan Sea Basin, while in the southern sector the winter convection is confined only to the upper 200-m layer. Thus, the period of general turnover of water is considered to be very short in the Japan Sea, compared with the cases of great oceans such as the Pacific. The extremely high level of dissolved oxygen concentration more than 4 ml/l through the entire water column of the Japan Sea is a direct evidence of this.

The present study is concerned with the problem of characterization of suspended particulate organic matters in the Japan Sea in comparison with the open water of the Pacific studied previously. First, it was aimed to establish the patterns of vertical distribution of particulate carbon and nitrogen as well as phytoplankton pigments, and if any speciality in the distribution is detected, it would probably be interpreted in terms of the relative shortness of the time of turnover as is above-mentioned. Secondly, biological availability of deep-sea water particles of the Japan Sea would probably be higher than in open waters of the Pacific because, again, of the rapid turnover of deep-sea water. A special concentrator was constructed and used in this cruise to collect deep-sea water particles which were subjected to a decomposition experiment on shipboard for the test of the hypothesis.

An additional plan of chemical analysis of Pb-210 and Po-210 incorporated in suspended particles as well as in sea water was included. The interest of this work was also closely related to determination of the "age" of particles which was supposed to be anomalously young in the Japan Sea in comparison with other open oceans.

### 2. Methods

(1) Particulate organic materials: At each of 6 stations (Sts. 1, 2, 5, 7, 8 and 9), 10 litres of sea water were taken by serial casts of Van Dorn bottle from ca. 20 depths in the range from surface to bottom. Each sample was filtered immediately after sampling

through a Whatman GF/C filter and stored frozen at -20°C. In the shore laboratory, the filter together with particulate matters was combusted at 750°C, and the evolved gases of carbon dioxide and nitrogen were determined chromatographically using a Hitachi CHN analyzer.

(2) Phytoplankton pigments: At 10 stations (Sts. 1, 2, 3, 4, 5, 7, 8, 9, 10 and 11), various quantities of 500 — 1000 ml of sea water were taken by the routine Nansen casts. Each sample was filtered through a Whatman GF/C filter and the filter together with particles was ground with a tissue homogenizer by addition of fixed amounts of acetone and magnesium carbonate. The macerated sample was centrifuged, and chlorophyll a and phaeopigments in the supernatant were determined fluorometrically using a Hitachi Fluorometer. All the work was done on board.

(3) Nutrient salts and dissolved organic material: Half a litre of water was taken by the routine Nansen casts at each of the 10 stations indicated above, and the water samples were used to determine nutrient salts, i.e. phosphate, silicate, nitrate, nitrite and ammonia, and dissolved organic material, i.e. carbon, nitrogen, and phosphorus. The methods adopted for inorganic salts are those described by Strickland and Parsons (1968) except for ammonia. The latter was determined by the method of Solórzano (1969). Dissolved nitrogen and phosphorus were determined by the differences from totals that were obtained by the ultraviolet irradiation of the sample filtrate followed by nitrate and phosphate determinations, respectively. Water samples for dissolved organic carbon were stored after oxidation in sealed hard-glass ampoules, to be processed later by the method of Menzel and Vaccaro (1964). All the work was done on board.

(4) Non-ionic silica in sea water: 137 samples were obtained from 4 stations for determination of total silica. The water samples of various quantities from 2 to 20 litres were filtered through a Millipore filter (HA) to determine particulate silica. The determination is under processing and involves a colorimetric treatment after the fusion of dried sample.

(5) Pb-210 and Po-210 in sea water and in particulate matters: 22 samples of surface water from 11 stations and 57 subsurface samples from 3 stations were collected. To ca. 50 litres of seawater sample, 25 mg each of Pb and Bi were added as carriers. Pb and Po were coprecipitated with $CaCO_3$ by the addition of $(NH_4)_2CO_3$ and $Na_2CO_3$. The precipitates of carbonate were collected and stored on board. In the shore laboratory, Pb-210 and Po-210 are analysed by the radiochemical method of Tsunogai and Nozaki (1969). Pb-210 and Po-210

in particulate matters are also determined for the materials filtered off on board through a Millipore filter (HA) by the same method after the filter had been dissolved in a mixture of $HClO_4$ and $HNO_3$. The determination is under processing.

(6) A floating concentrator (Fig. 8): The apparatus constructed and used in this cruise is diagramatically shown in Fig. 8. The whole assembly was made of PVC and the float system at the top had a buoyancy that was just enough to keep the entire assembly floating with its float situating always at the water surface, when put in water, irrespective of the water level inside the concentrator. The filter used was a Millipore filter (AA) of 30-cm diameter. The apparatus was kept afloat in a 100-l water tank that was filled with the water sampled from the depth by making use of a large volume sampling bottle (200 l). The pressure head that is effected at the filter from below is constant at ca. 20 cm during the most of the filtration time if the rate of siphoning out of the filtrated water is high enough. This rate is easily controllable either by simply changing the diameter of the siphon tube or by any adjustment of the pressure head of the siphon system. For surface water samples, the water of 100 l is usually concentrated into one l in one hour or so, and for deepwater samples it is in half an hour.

Four concentrators, one for each bucket, were used simultaneously. Water samples of various quantities ranging from 200 to 400 litres were taken from 50-, 500-, 1000- and 2000-m depths at four stations (Sts. 2, 5, 8 and 9), and were concentrated into ca. one litre. The precipitates on the filter were gently washed off using a soft policeman. The concentrates were further concentrated into 50 — 250 ml by another method that is in principle the same with the former but smaller in dimension.

The final concentrates were incubated in a BOD bottle for ca. 24 hrs. in the dark at a temperature ranging from near zero to 7°C depending on the situation. The difference of the dissolved oxygen concentration in the concentrate before and after the incubation was measured by the Winkler method.

At St. 9, 200-l water samples were taken from 500- and 1500-m depths, respectively, concentrated into 5 litres, and halved. Each of these concentrated samples of 2.5 litres was filtered and stored as above for particulate carbon and nitrogen determinations. One of the pair of filters is now under a decomposition process which involves the innoculation of a small volume of raw surface seawater and the subsequent long-term (150 days) decomposition in a wet atmosphere at room temperature. The difference, if it is detected, between the pair of filtraters will give a measure of "biologically oxidizable" fraction of these particulate materials.

3. Results (Fig. 9)

Some of the data are still under processing, and any discussion of the whole results has to be made later. In Fig. 9 a series of observations obtained at St. 1 are shown. General trends of variations with depth of particulate carbon and nitrogen are strikingly similar to those previously obtained in various areas of the Pacific. However, there are several features that deserve special considerations. First, in an extremely sharp thermocline at 50-m depth there occurs a very high concentration of chlorophyll that is nearly by one order of magnitude larger than the surface concentration. This peak of chlorophyll is located near the bottom of the euphotic layer, but in the layers above the peak no measurable amounts of nitrogen source except for ammonia are observed. Perhaps, most of the summer phytoplankton production of the area may occur in this thin layer within the thermocline where the illumination is dim but nutrients are ample. Secondly, this remarkably high concentration of chlorophyll is not very clearly reflected in the profile of particulate organic material. The maximum of carbon is at 30-m depth and that of nitrogen at 40 m. The maxima are not very clearcut, being only by 20-odd % higher than the surface concentrations. The situation evidences that the phytoplankton carbon would be a minor fraction of total particulate carbon and the carbon/chlorophyll ratio of the phytoplankton population in the thermocline would be very low due to the low intensity of illumination there. There is a reason to suspect that the chlorophyll peak at 50 m is neither the peak of phytoplankton carbon nor the peak of cell number. Thirdly, the decrease of particulate organic material as well as chlorophyll just below the thermocline is really phenomenal; the decrease is very rapid and a marked minimum occurs in the 100 — 200-m layer. Below the 200 — 300-m layer, particulate material is practically constant within a narrow range of 5 — 15 μgC/l, irrespective of the occurrence of a marked discontinuity in oxygen content as well as inorganic salts at about 1000-m depth.

Although most of these features are more or less common to other open sea areas and seem to be universal, some of them are characteristically notable in the Japan Sea. Marked stratifications of various elements in and near the thermocline are particularly noteworthy and necessitate more detailed studies. As for the situation in the deepwater, a single set of observations on plankton (ultraplankton) concentrates obtained at St. 5 showed a range of respiration rate of 0.08 — 0.09 mg atoms $O/m^3$ for 500 — 2000-m depths, in contrast to the by one order higher value of 0.8 mg atoms $O/m^3$ obtained at 50-m depth.

These are not much different from values obtained by Pomeroy and Johannes (1968) for the surface and deep waters of the Sargasso Sea.

Apparent failure in finding specific features in distribution and nature of particulate organic matter in this area, however, would probably mean that decomposition of organic matter proceeds rapidly in a limited period of time that is much shorter than the general turnover of water body, and the fate of the organic material after this limited period is just an extremely slow degradation which proceeds with a negligibly low time rate.

## 4. Distribution of zooplankton collected with Norpac net, ORI net and IKMT

by

R. Marumo, T. Nemoto, M. Omori, Y. Aizawa, M. Terazaki, M. Araki,

K. Kawaguchi, Y. Komaki and T. Honda

### 1. Method

(1) Norpac double net

A 45-cm Norpac double net (the inner net made of 0.33-mm mesh cloth and the outer one made of 0.09-mm mesh cloth) was used for 13 standard vertical hauls (0 — 150 m) at 11 stations. One series of Norpac net hauls were made for six different depths in the upper 600-m layer at St. 2. The water filtered was calibrated by the revolution of a flow-meter mounted at the mouth of the net.

(2) ORI net

One of the main projects in this cruise is to determine the biomass and distribution of mesopelagic and bathypelatic plankton and micronekton in the Japan Sea. For this, big and high speed nets are required not only for the deeper waters where the number of animals are rather scarce but also for the upper layers.

A 160-cm ORI net, made of 1.0-mm mesh filtering cloth, was towed obliquely through the layer of 0 — 1000 meters at 7 stations (Sts. 2, 3, 4, 5, 7, 8 and 9). Other series of horizontal tows were made for the depths of 300, 500, 1000, 1500, and 3000 m, measured with the wire cable paid out at three stations (Sts. 2, 5 and 8). Repeated oblique hauls for the depths of 60, 100, 150 and 200 m were done according to the depth condition of the thermocline in the surface layers at these stations. All nets were equipped with a TSK depth-distance meter and a RGS flow meter at the mouth part. The opening and closing mechanism by a double release system was used for the operation of horizontal tows for the fixed depth. The ship speed was kept at 2 knots when the net was operating, and some minor modifications were done according to the sea conditions such as current and wind.

The number of samples thus obtained by ORI-net tow amounted to 70 in total. Some of samples were subjected to on-board experiments. The samples were preserved in a 10 % formalin-sea water solution, and are sorted into about 20 groups, including copepods, amphipods, euphausiids, mysids, decapods, ostracods, chaetognaths, fishes etc.

(3) Isaacs-Kidd's mid-water trawl (IKMT)

An IKMT was used for the collection of micronektonic shrimps and fishes mostly at night for 11 stations.

Six-feet IKMT installed with a depth meter was towed obliquely by paying out the wire cable as long as 800 m usually at a speed of 6 knots in paying of the wire and 4 knots in recovering. The samples were placed for further examination, but a few micronektonic shrimps and fishes were taken by this method in this cruise (refer to 2 - (3)). Two samples among them were placed for on-board experiments.

2. Results

(1) Distribution of zooplankton biomass (ORI net) (Figs. 10 and 11)

The total biomass of oblique tow samples (ORI) was large, between 70 and 100 g per 1000 $m^3$, at northern 4 stations (Sts. 2, 3, 7 and 8), while it was small, about 40 $g/1000^3$, at southern 3 stations (Sts. 4, 5 and 9) (Fig. 10). These values are much higher than those (3 to 10 g/1000 $m^3$) obtained in the Kuroshio water around Japan. The biomass at the northern stations is almost similar to that obtained in the Oyashio water of the northern North Pacific. The zooplankton community was very monotonous in taxonomic groups and species. Copepods were generally most abundant, and euphausiids, chaetognaths, amphipods and mysids followed thereafter. All of these five groups generally accounted for over 99 % of total biomass. Meso- and bathypelagic shrimps and fishes, which are distributed universally in the North Pacific, were not found in our collections. Dominant species in the Japan Sea were as follows:

Copepods

*Calanus cristatus*

*C. plumchrus*

Euphausiids

*Euphausia pacifica*

*Thysanoessa longipes*

Amphipods

*Parathemisto japonica*

*Primno macropa*

*Cyphocaris challengeri*

Mysids

*Meterythrops microphthalma*

Chaetognaths

*Sagitta elegans*

These species are apparently cold water affinities. However, at St. 5 a warm water species of chaetognath, Sagitta nagae, was abundant. This result shows that the surface water at this station was much influenced by the Tsushima Current.

Results of horizontal tow samplings are shown in Fig. 11. Day catches were always less than night catches in the upper 100-m layer at Sts. 2 and 8. This seemed to be caused by the net avoidance of larger zooplankton. However, the distributional pattern was almost similar between daytime and night. It shows that the diurnal vertical migration was not so remarkable in the Japan Sea. The similarity of vertical distributions at Sts. 2 and 8 corresponds well with that in hydrographical conditions. Usually, the largest biomass was found between surface and 100-m depth, where there existed the conspicuous thermocline. To this maximum biomass in the upper 100-m layer, all the dominant zooplankton groups mentioned above but mysids were responsible. The biomass decreased greatly at about 200-m depth. Below the depth it slightly increased and then decreased gradually with increasing depth. At St. 5, biomass distribution is even without any distinct maximum. The upper layer is occupied by warm water of the Tsushima Current system. The large population of Sagitta nagae inhabited here.

In conclusion, zooplankton biomass was small below the 200-m depth all over the Japan Sea. However, in the upper 200-m layer there was a distinct tendency that it was comparatively small in the water of the Tsushima Current, but remarkably large in the northern water of that. (R. Marumo, T. Nemoto, M. Omori, Y. Aizawa, M. Terazaki and M. Araki)

(2) Microdistribution of macrozooplankton

In order to study the patchiness of macroplanktonic crustaceans, an ORI-100 net was towed repeatedly with time and space intervals as narrow as possible at two stations.

At St. 8, 12 oblique hauls were carried out southbound with a maximum of 200-m wire paid out within a distance of approximately 6 miles, and turning northbound the haul was also repeated 12 times in the same manner. At St. 9, 11 horizontal towings, with a 200-m long wire and an opening-closing device, were performed for ten minutes each. While the sampling was going on, a 200-kc echo-sounder was operated to obtain reference records of sonic scattering layers.

The main constituents of samples at St. 8 were; Calanus cristatus, C. plumchrus, Pareuchaeta elongata, Euphausia pacifica, Thysanoessa longipes, Themisto pacificus, and Sagitta elegans. At St. 9, Themisto pacificus occurred with higher percentage, and abundant jelly-fish and thaliacean were also obtained. The samples are presently in the sorting and analyzing process, and the results will be presented in future. (Y. Komaki)

(3) Mesopelagic micronektonic fishes

Most of the Pacific mesopelagic fishes are not considered to enter into the Japan Sea, which is bounded by the region shallower than about 200 m from the Pacific side. However, three species, Maurolicus muelleri, Diaphus coeruleus, and Notoscopelus japonicus (?) are so far reported from the Japan Sea. The entrance of these species from the Pacific through the shallow strait seems possible, from considering that the distributions of these species in the Pacific are restricted to the vicinities of the margin of the continental shelf.

In this cruise, intensive collection was made at 12 stations to make up for the lack of data on the Japan Sea ichthyofauna.

As the result, only one species, Maurolicus muelleri was collected. Compared with the Pacific ichthyofauna, the Japan Sea ichthyofauna is characterized by the scarcity of mesopelagic micronektonic fishes.

Micronektonic fishes play an important role as the zooplankton feeders in the mesopelagic zone of the Pacific. On the contrary, it is of great interest to know what animals in the Japan Sea will correspond to the micronektonic fishes in the Pacific as zooplankton feeder. Amphipods will be so, because of the remarkable predominance. (K. Kawaguchi)

(4) Distribution of fish eggs and larvae

Using 160-cm larva-net of 0.33 mm in mesh size, surface tow and additional tows above and below the thermocline were made at a speed of 2 knots for 20 minutes at 11 stations. Fish larvae and eggs were found at all stations, and they were abundant in the coastal area. Larvae of anchovy, saury and flying fish were found. Saury larvae were distributed in the western stations, Sts. 2, 7, 8 and 9, though the biomass was rather small. (T. Honda)

(5) Distribution of chaetoganths

The biomass of chaetoganths in the Japan Sea was about 3.3 — 18.8 g/1000 $m^3$ in the upper 1000-m layer. In general, Sagitta elegans was widely and dominantly distributed in most stations except Sts. 11 and 12, in Tsushima Channel where Sagitta enflata was abundant. S. elegans was collected from the entire column of 0 — 3850 m, and two peaks occurred at 50 m and 500 — 600 m, respectively. (M. Terazaki)

(6) Distribution of euphausiids

Four genera and 6 species of euphausiids were collected with ORI net as follows:

Thysanoessa longipes Brandt

T. inermis (Krøer) Hansen

Euphausia pacifica Hansen

E. nana Brinton

Stylocheiron affine Hansen

Pseudeuphausia latifrons (G. O. Sars) Hansen

T. longipes and E. pacifica were most dominant.

T. longipes was distributed in the area influenced by cold water, mostly in the Liman Current area, and it inhabited down to 1700-m depth in daytime. Its larvae (furcilia and postlarval stages) were found in the layer upper than that where E. pacifica larvae were. The patchiness of T. longipes was observed at night. E. pacifica was widely distributed in the Japan Sea, abundantly in the polar front area.

E. nana, S. affine and P. latifrons are good indicators for the Tsushima Current. (M. Araki)

(7) Ontogenetic vertical migration of Calanus cristatus

A copepod Calanus cristatus is known to play an important role in the economy of the northern North Pacific. Ontogenetic vertical migration of the species after copepodite IV stage was observed at two stations (Sts. 2 and 5) in relation to their feeding behavior.

Methods: Discrete sampling with ORI-100 net was carried out at Sts. 2 and 5. Using an opening and closing mechanism, the net was towed horizontally at a speed of 1 m per sec. at 7 layers from surface to 3850-m depth (St. 2) and to 2400-m depth (St. 5). Immediately after each sampling, a sub-sample was isolated from the mixed plankton by forceps. Ten specimens of each developmental stage and sex (only for adults) were sorted, and their gut conditions were examined briefly under the microscope. Then, they were dried in an oven for 24 hours at 60°C and stored in a freezing box at -20°C for analysis of the chemical composition. Other specimens were all preserved in a 5 % formalin-seawater solution neutralized with hexamine, and brought back to the laboratory.

Results: In both sampling stations, copepodite IV stage were generally found between 65 and 300 m. Copepodite V were distributed widely from 65 to 1100 m. A characteristic feature of the distribution of the V stage was the formation of a two-maxima structure. The shallower maximum was within 100 to 150 m, and the deeper was around 800 to 1100 m.

Usually the latter was more pronounced. The distribution range of adults was restricted within 870 to 2400 m. The samples from 2000 to 3850 m were mainly composed of the carcasses (dead body) of adult females. Guts of the adults degenerated to filament-like thin glands and none of food was seen. Most of guts of the IV- and V-stage copepods collected above 200-m depth were filled with greenish materials, chiefly composed of diatoms. However, the amount of gut contents decreased with increasing depth. The body length and weight of the V stage specimens increased gradually with increasing depth. The specimens obtained at depths of 570 m or more were usually very fatty, and their guts were mostly empty. Although any analysis of their chemical composition is not yet done, the present study seems to support the idea of one of the present authors (Marumo's lecture at the JIBP-PM symposium in 1968) that C. cristatus has the following characteristics in its life.

a) The copepodite IV and V feed on phytoplankton in the shallow layers. There, the V-stage copepodites store a great reserve of fat until their nutrient condition attains a certain level which is enough for survival and reproduction.

b) Then, they quickly descend to the 600- to 1000-m depths and stay until molting. This phenomenon often causes the existence of a two-maxima structure of distribution.

c) Molting takes place at depths of around 600 to 1000 m, and the adults descend slowly without taking food.

d) They die after spawning. Their carcasses may have a significant role in deep-sea food chains. (M. Omori)

(8) If any species of genus Sergestes is distributed in the Japan Sea?

Sergestid shrimps often form one of the main constituents of micronekton community in the open ocean. Sergestes is comprised with meso- and bathypelagic forms, and so far its distribution has not been reported from the Japan Sea. Observations and samplings were carried out to define if Sergestes species is really not found there. The present study was believed to contribute to the knowledge of zoogeography of the Japan Sea.

Methods: Night samplings with a 6-feet Isaacs Kidd's mid-water trawl (IKMT) were carried out at 7 stations in the Japan Sea. The trawl was towed obliquely from the surface to a depth of about 150 m with a wire 800 m long. The ship's speed was set at 3 m per sec. during the lowering of the trawl, and it was reduced at 2 m per sec. while recovery. In addition to it, samplings with an ORI-100 net were made at 8 stations. The net was towed obliquely from the surface to about 1000 m with a wire 2000 m long. The ship's speed was set at 1 m per sec.

Results: None of Sergestes species was found from all of the sampling stations scattered in the Japan Sea. Other meso- and bathypelagic shrimps belonging such genera as Gennadas, Acanthephyra, and Hymenodora, which are abundantly distributed in the northwestern Pacific Ocean, also entirely disappeared from the studied area. Unfortunately, the sampling in Toyama Bay, which is known to have rich deep-water fauna, could not be done due to bad weather condition. The present findings, however, seemed to prove that any migration from the Pacific Ocean to the Japan Sea by Sergestes and other similar pelagic shrimps have not occurred through the Tsushima Strait or the Tsugaru Strait in the recent and postglacial periods. (M. Omori)

## 5. Distribution of zooplankton collected with MTD net

by

T. Minoda, Y. Morioka and N. Shiga

The present study deals with the detailed observations of the vertical distribution of zooplankton in the Japan Sea.

Several casts of simultaneously horizontal tows were carried out with 10 MTD 56-cm horizontal nets (Pylen #60, 0.35-mm x 0.35-mm mesh openings) at 20-m intervals between the surface and 370-m depth measured by wire length (Sts. 1, 2, 5, 7, 8 and 9), at 40-m intervals between the depths of 370 and 730 m measured by wire length (Sts. 1, 2, 5 and 8), and additionally, at 150-m intervals between the depths of 720 and 2070 m measured by wire length (Sts. 5 and 8). Horizontal tows were carried out at night and in the daytime at each of stations except in the daytime at St. 5.

Wet weight of total zooplankton was measured on board. Total biomass was represented as the wet weight per 1000 $m^3$ of water estimated from the revolution of a flow meters mounted at the mouth of ring (Fig. 12). The abundance of zooplankton biomass was usually observed in the upper 60 meters both in the daytime and at night. The component of zooplankton was quite different between the depths of 0 - 20 m and the depths more than 20 m.

Major zooplankters of the constituent such as euphausiids, amphipods, mysids, pteropods, chaetognaths, Calanus cristatus, C. plumchrus and Pareuchaeta spp. were sorted to estimate each biomass. Exact analysis of the vertical distribution in each zooplankter is under processing in the laboratory.

The vertical distribution of appendicularian group is also studied.

## 6. Experimental works on zooplankton

by

T. Nemoto

Macrozooplankton samples were collected by the 0 — 500-meter oblique tow of ORI-net for the on-board laboratory experiments.

(1) Chlorophyll pigments in stomach contents of euphausiids: The quantity of chlorophyll-a and phaeopigments in the stomach contents of euphausiids was measured by fluorometric method.

(2) Excretion of inorganic nitrogen and phosphate from zooplankton: Fresh and healthy euphausiids were incubated in the sterilized sea water, and after a certain incubation time the sea water was recovered to determine the rates of excretion of nitrogen and phosphate from several species of euphausiids.

7. Distribution of nitrogen-fixing and heterotrophic bacteria

by

Y. Maruyama

The occurrence and abundance of nitrogen-fixing bacteria in the Japan Sea were examined by the selective cultural method using two non-nitrogenous media (N and A). Distribution of heterotrophic bacteria growing on Medium PPES (P) was also investigated. The vertical sea water samples were collected at ten different stations by using the sterilized ORIT-type samplers.

The sea water samples were filtered through sterilized 47-mm HA Millipore filters. The inoculated filters were placed on agar (P, N) and silica gel (A) plates of Medium P, N and A in Petri dishes and were incubated at $18^{o}$ — $5^{o}C$ for three weeks before colonies on filters were counted. Samples of bottom deposits were also obtained by using a gravity core sampler at Sts. 5 and 8. The plating method was used for enumeration of bacteria in the sediment samples.

The results showed that the distribution of these bacteria in sea water column was remarkably influenced by the currents of the Japan Sea. A larger bacterial population in sea water column ($10^4$ — $10^2$ P, N cells in 100 ml of sea water) was found in warm current areas such as Sts. 5, 4 and 9. On the contrary, a small density of bacterial biomass ($10^2$ — $10^0$ cells in 100 ml of sea water) was found at Sts. 1, 2 and 7 in cold current areas.

In most cases, the number of bacteria grown on Medium P was the largest and that of bacteria grown on Medium A was the smallest.

Bacterial populations in the sediment samples of the Japan Sea was relatively small ($10^3$ per 1 g wet weight of sediments) and no bacterial growth on Medium A was found in any of these samples.

About $10^3$ — $10^2$ of N-bacteria were attached to plankton samples in 100 ml of sea water.

## 8. Ecological aspects of bacterial flora attached to plankton

by

O. Matsuda

Plankton samples were collected at Sts. 2, 5 and 8 with Norpac double nets, Van Dorn samplers and ORIT-type samplers to investigate the microbial flora attached to plankton. It was found that the population of attached bacteria on plankton was, in general, considerably large in comparison with that of freely suspended bacteria in the sea water column from the surface to the depth of 200 m.

Suspended materials in sea water were filtered through different types of Millipore filter having the pore sizes of 0.22, 0.45, 1.2, 3.0 and 5.0 microns to examine the relationship between particle size of suspended materials and bacterial populations on it.

The attached bacterial population was examined on board for each species of macrozooplankton taken by oblique tow with ORI net.

Further examinations are now continued in the laboratory with special reference to the direct microscopy of suspended matter and taxonomical properties of the isolated bacteria in this investigation.

## 9. Distribution of DNA-hydrolyzing bacteria

by

M. Maeda

In order to clarify the mode of existence and degradation of DNA in marine environment, the distribution of particulate DNA and the occurrence to DNA-hydrolyzing bacteria were investigated in the waters of the Japan Sea.

Water samples for the determination of particulate DNA were collected from various depths at 3 stations with Van Dorn sampler. Ten liters of each sample were filtered through bolting cloth GG-54 and Millipore filter (HA-type, 47 mm), respectively and the DNA content of particulate material on the filter was determined by the fluorometric procedure (Holm Hansen et al., 1968). Viable counts of heterotrophic bacteria and DNA-hydrolyzing bacteria were examined for the vertical seawater samples at 10 stations and for the sediment samples at 2 stations. DNase activity of each bacterial isolate was assayed with the DNase test medium (Jeffries et al., 1957).

Dense population of DNA-hydrolyzing bacteria was found usually in the surface layer and their density decreased rapidly at the depths lower than 50 meters. Such a vertical tendency of bacterial population was considerably related to the amount of particulate DNA in sea water.

About 30% bacterial strains, isolated from the heterotrophic bacterial community in the samples of surface sea water, seemed to possess the DNA-hydrolyzing ability in general. On the other hand, viable count of bacteria, which could grow on the medium only containing DNA as nitrogen and carbon source, was approximately some number in the order of less than $10^2$ per gram of wet bottom sediments at two stations.

## 10. Breakdown of chitin in aquatic environments

by

K. Okutani

Large quantities of chitin are produced in the aquatic areas of the world. It seems that the decomposition of chitin is largely due to microbial action. Bacteria are probably responsible for the decomposition of chitin in marine and fresh water environments, because many kinds of the chitin-decomposing bacteria have been isolated from the said environments.

The present experiments have been directed to investigations of chintin- and N-acetylglucosamine(NGA)-decomposing systems by bacteria in the Japan Sea.

Dense populations of chitin-decomposing bacteria were found only in the upper layer of the sea (0 — 50 m), whereas NGA-decomposing bacteria were found even in the deep layer (0 — 1000 m).

Extracellular chitinase from pure culture of the bacteria obtained in the sea was partially purified. The enzyme preparation purified with ammonium sulfate and acetone formed NGA and oligo-NGA from chitin. Further breakdown of NGA did not occur in this reaction mixture.

## 11. Distribution of chromogenic bacteria

by

I. Kawada

The relation between the distribution of chromogenic bacteria and environmental factors in water columns at various stations in the Japan Sea was examined. Samplings and countings were performed by the method which was essentially the same as described by Kawada (1969).

It was found that chromogenic bacteria examined were generally small in number as compared with aerobic heterotrophic bacteria, and that most of the chromogenic bacteria were distributed in the surface layers of the water columns. In the deeper water, few chromogenic bacteria were found.

Detailed analysis of the relation between the distribution of chromogenic bacteria and environmental factors in the sea, taxonomy of the chromogenic bacteria and examination as to the effect of ultra violet light on them are now in progress.

## 12. Acoustic observation with fish detector

by

S. Tanaka, T. Ishii, K. Tatsukawa and S. Sawa

The records of a fish detector (Sanken Elec. Co. TU - 32, SU - 32) were collected to evaluate the vertical change of the acoustic scattering layer, the swimming layer of fishes and the density of the individuals of large-sized fish. The echo signals were recorded under various conditions such as 3 frequencies (28, 75 and 200 kHz), 2 pulse lengths and the different ranges of recording ranges.

In the latter half of this cruise, acoustic records were taken at definite times (10 - 11 a.m. and 8 - 9 p.m.) and in definite depth ranges (0 - 100, 50 - 150, 100 - 200, 150 - 250, 200 - 300 and 250 - 350 m) except a few bad weather days.

From these records, a remarkable difference in the acoustic pattern was found between the northern and southern areas. In the northern area, there were many echo traces which seemed to come from large-sized fish individuals in layers deeper than 100 m (lower than 2°C) at St. 2 (42°N, 135°E), and these traces could hardly be found in the southern area. In another example, numerous echo patterns of small-sized individuals were recorded in the layer of 50-m depth (14°C) at St. 5 (38°N, 135°E).

In the southern area, e.g. at St. 9 (37°N, 131°E), the scattering layer was found in the range between the surface and the 50-m depth, and many traces of small individuals in depth larger than 50 m.

Detailed analysis of the records obtained is left for the future work.

## 13. Counting of the echo trace by the pattern analysis method

by

T. Ishii, S. Tanaka, K. Tatsukawa, S. Sawa and T. Igarashi

Fish detector survey (F) was carried out at 16 stations, Sts. F-1 — F-16, and the echo signals were recorded on the magnetic tape by the data recorder (TEAC Co. R-351F). BT observation was conducted at each station. These records were obtained for 30 minutes at the ship speed of 2 or 6 knots at each station. Out of 16 stations, 9 stations were on the route from Tokyo to Toyama, 6 stations on the route from Toyama to Nagasaki and 1 station on the route from Nagasaki to Tokyo.

A new attachment device, FFP- AD- III manufactured by Kokusai Elec. Corp., was tested, being inserted between FFP- AD- I and the computer. Though FFP- AD- II, which was already in operation, can transmit only the time of arrival of acceptable signal to the computer, the new type, FFP- AD- III, is able to transmit both that time and the level of amplitude of acceptable signal.

From the test of that device and the check of memorized data, the performance of this new device is generally in a high level except a few points.

In addition to the computer programs and systems already completed during the previous cruise (KH-69-4), new programs were completed for that project in this cruise. All of these programs were written by FASP.

New programs were as follows;

Program 7: For FFP- AD- III, in each transmission both the time from transmission until receiving of echo pulse and the amplitude of that pulse are stored on the core memory (real time process, Level-8).

Program 8: The print-out of the results of analysis, which were obtained by Program 5, was done by the RTC typewriter after arrangement in each depth range at each time interval.

The analysis of echo pattern recorded in this cruise is now in progress.

## 14. Gravity measurement

by

Y. Tomoda and T. Igarashi

Gravity measurement at sea was carried out mostly in the Japan Sea. The ship's track, along which the gravity was measured, is shown in Fig. 13. Free air, Bouguer gravity anomalies and the bottom topography profiles are shown in Figs. 14, 15 and 16.

(1) Profile from Toyama to St. 7: This profile is nearly the same as the track in the KH-69-3 cruise. Free air gravity anomaly is about 50 — 70 mgals to the north of Noto Peninsula, nearly zero at Mogami Trough, and about 80 mgals at Yamato Bank. In the basin of the Japan Sea it is nearly zero. The local anomaly reflects the bottom topography, while the regional one does not, and the average value is 10 to 20 mgals positive. As is seen from the Bouguer gravity anomaly value at the central basin of the Japan Sea, the basin is not really of oceanic structure compared with the Pacific Basin.

(2) Profile from St. 7 to Nagasaki: In this profile the ship approached the coast of North Korea at 39°05'N and 130°E, where the water depth is about 700 m. The free air gravity anomaly is about 80 mgals at the position indexed 70 Aug. 21-20. From this point the ship cruised along the coast of Korea from north to south, crossing a bank on which the minimum water depth is about 660 m. Free air gravity at this bank is about 80 mgals, which is comparable to the value at Yamato Bank. At a basin south of Takeshima Island, free air anomaly is nearly zero as is the case at other basins in the Japan Sea. In the east part of the Korea Straits free air anomaly is larger and is about 20 — 40 mgals at the channel where the water depth is shallower than 200 m. As seen from the Bouguer anomalies and the bottom topography, the region from the west basin of the Japan Sea to the Korea Straits is isostatic as a whole.

The profile from Nagasaki to Tokyo is on the same route as already measured, and the data will be used to make a more detailed gravimetric map of the southwest of Japan which will be described elsewhere.

## Explanation of data

Data from Nansen casts (Tables 2 — 9)

Latitude, Longitude: mean position of the beginning and the end of observation

Depth: reading of PDR without correction

Current: measured by GEK

Wind, Sea, Swell, Weather: observed simultaneously with Nansen cast

*: value doubtful

( ): interpolated or extrapolated

D (ob): depth observed

S: measured with Auto Lab Model 601 MK III inductive salinometer

$O_2$: measured by the method described in Manual of Oceanographic Observations (Oceanographical Society of Japan, 1963)

D (S): standard depth interpolated

Data from BT observations (Table 10)

T at Max. depth: reading at the deepest point on BT trace

Table 2. Data from Nansen casts at St. 1

| Station | Latitude | Longitude | Date | Ship time |
|---|---|---|---|---|
| 1 (H132) | 42-29 N | 138-29E | July 31, '70 | 18:05~22:10 |
| Depth 3560 m | Current 225°, 0.1 kt | Transp. 21 m | Air temp. 21.3°C | |
| Wind SSW-6 m/s | Sea SSW-3 | Swell 2 | Weather cloudy | |

| D (ob) (m) | T (°C) | S (‰) | $\sigma_t$ | $O_2$ (ml/l) | $O_2$Sat (%) | D (S) (m) | T (°C) | S (‰) | $O_2$ (ml/l) |
|---|---|---|---|---|---|---|---|---|---|
| 0 | 20.2 | 33.696 | 23.74 | 5.16 | 96 | 0 | 20.2 | 33.696 | 5.16 |
| 10 | 19.88 | 702 | 83 | 5.38 | 99 | 10 | 19.88 | 702 | 5.38 |
| 20 | 15.02 | 958 | 25.18 | 6.26 | 107 | 20 | 15.02 | 958 | 6.26 |
| 30 | 10.70 | 972 | 26.04 | 7.15 | 112 | 30 | 10.70 | 972 | 7.15 |
| 50 | 2.40 | 34.057 | 27.20 | 7.21 | 95 | 50 | 2.40 | 34.057 | 7.21 |
| 75 | 1.41 | 055 | 28 | 6.44 | 82 | 75 | 1.41 | 055 | 6.44 |
| 100 | 1.13 | 053 | 28 | 6.28 | 80 | 100 | 1.13 | 053 | 6.28 |
| 125 | 0.88 | 054 | 31 | 6.19 | 78 | 125 | 0.88 | 054 | 6.19 |
| 150 | 0.75 | 063 | 33 | 6.26 | 78 | 150 | 0.75 | 063 | 6.26 |
| 200 | 0.66 | 066 | 34 | 6.62 | 83 | 200 | 0.66 | 066 | 6.62 |
| 250 | 0.54 | 064 | 35 | 6.56 | 82 | 250 | 0.54 | 064 | 6.56 |
| 300 | 0.44 | 062 | 36 | 6.56 | 82 | 300 | 0.44 | 062 | 6.56 |
| 422 | 0.40 | 071 | 36 | 6.76 | 84 | 400 | 0.40 | 069 | 6.75 |
| 500 | 0.39 | 068 | 37 | 6.63 | 83 | 500 | 0.39 | 068 | 6.63 |
| 619 | 0.37 | 073 | 37 | 6.66 | 83 | 600 | 0.36 | 072 | 6.66 |
| 816 | 0.35 | 072 | 37 | 6.71 | 84 | 800 | 0.34 | 072 | 6.72 |
| 1010 | 0.24 | 064 | 37 | 5.36 | 67 | 1000 | 0.26 | 065 | 5.45 |
| 1204 | 0.17 | 068 | 38 | 5.03 | 62 | 1200 | 0.18 | 068 | 5.03 |
| 1490 | 0.15 | 073 | 38 | 5.10 | 63 | 1500 | 0.15 | 072 | 5.11 |
| 1973 | 0.16 | 070 | 38 | 5.27 | 65 | 2000 | 0.16 | 070 | 5.28 |
| 2461 | 0.18 | 068 | 38 | 5.36 | 67 | 2500 | 0.18 | 069 | 5.36 |
| 2960 | 0.22 | 072 | 37 | 5.39 | 67 | 3000 | 0.23 | 073 | 5.38 |
| 3459 | 0.27 | 079 | 37 | 5.33 | 66 | 3500 | 0.28 | 080 | 5.32 |

Table 3. Data from Nansen casts at St. 2

| Station | Latitude | Longitude | Date | Ship time |
|---|---|---|---|---|
| 2 (H133) | 42-28 N | 135-57E | Aug. 2, '70 | 01:20~05:30 |

| Depth 3640 m | Current 200° 0.3 kt | Transp. 18 m | Air temp. 16.6°C |
|---|---|---|---|
| Wind NE-3.5 m/s | Sea NE-3 | Swell 3 | Weather cloudy |

| D (ob) (m) | T (°C) | S (‰) | $\sigma_t$ | $O_2$ (ml/l) | $O_2$Sat (%) | D (S) (m) | T (°C) | S (‰) | $O_2$ (ml/l) |
|---|---|---|---|---|---|---|---|---|---|
| 0 | 19.2 | 33.475 | 23.82 | 5.50 | 100 | 0 | 19.2 | 33.475 | 5.50 |
| 10 | 18.80 | 853 | 24.23 | 6.01 | 109 | 10 | 18.80 | 853 | 6.01 |
| 20 | 7.84 | 34.018 | 26.55 | 8.11 | 120 | 20 | 7.84 | 34.018 | 8.11 |
| 30 | 4.87 | 049 | 26.97 | 7.27 | 101 | 30 | 4.87 | 049 | 7.27 |
| 50 | 3.28 | 057 | 27.14 | 6.52 | 87 | 50 | 3.28 | 057 | 6.52 |
| 74 | 2.54 | 062 | 19 | 6.52 | 87 | 75 | 2.54 | 062 | 6.52 |
| 99 | 1.95 | 063 | 27 | 6.59 | 85 | 100 | 1.93 | 063 | 6.58 |
| 124 | 1.40 | 057 | 28 | 6.21 | 79 | 125 | 1.39 | 056 | 6.22 |
| 149 | 1.14 | 052 | 29 | 6.36 | 81 | 150 | 1.14 | 053 | 6.36 |
| 199 | 0.80 | 059 | 30 | 6.20 | 78 | 200 | 0.79 | 059 | 6.20 |
| 249 | 0.67 | 061 | 33 | 6.21 | 78 | 250 | 0.66 | 061 | 6.21 |
| 298 | 0.56 | 065 | 34 | 6.10 | 76 | 300 | 0.55 | 065 | 6.10 |
| 397 | 0.46 | 065 | 35 | 6.17 | 77 | 400 | 0.46 | 065 | 6.18 |
| 489 | 0.44 | 066 | 36 | 6.22 | 78 | 500 | 0.43 | 066 | 6.20 |
| 587 | 0.39 | 066 | 36 | 6.04 | 75 | 600 | 0.38 | 066 | 6.02 |
| 782 | 0.26 | 066 | 37 | 5.44 | 68 | 800 | 0.22 | 066 | 5.40 |
| 977 | 0.19 | 068 | 37 | 5.04 | 62 | 1000 | 0.18 | 068 | 5.04 |
| 1172 | 0.16 | 067 | 37 | 5.10 | 63 | 1200 | 0.15 | 067 | 5.08 |
| 1464 | 0.14 | 069 | 37 | 5.15 | 64 | 1500 | 0.13 | 069 | 5.16 |
| 1952 | 0.16 | 070 | 38 | 5.27 | 65 | 2000 | 0.15 | 070 | 5.28 |
| 2439 | 0.18 | 075 | 38 | 5.34 | 66 | 2500 | 0.17 | 074 | 5.35 |
| 2929 | 0.19 | 071 | 38 | 5.33 | 66 | 3000 | 0.18 | 071 | 5.34 |
| 3426 | 0.27 | 071 | 38 | 6.35 | 79 | 3500 | (0.27) | (071) | (6.60) |

Table 4. Data from Nansen casts at St. 3

| Station | Latitude | Longitude | Date | Ship time |
|---|---|---|---|---|
| 3 (H134) | 41-08 N | 137-21 E | Aug. 5, '70 | 09:00~12:25 |

| Depth 3590 m | Current 128° 0.4 kt | Transp. 20 m | Air temp. 21.2°C |
|---|---|---|---|
| Wind calm | Sea 2 | Swell 2 | Weather fine |

| D (ob) (m) | T (°C) | S (‰) | $\sigma_t$ | $O_2$ (ml/l) | $O_2$Sat (%) | D (S) (m) | T (°C) | S (‰) | $O_2$ (ml/l) |
|---|---|---|---|---|---|---|---|---|---|
| 0 | 20.9 | 33.619 | 23.50 | 4.87 | 92 | 0 | 20.9 | 33.619 | 4.87 |
| 10 | 20.61 | 611 | 56 | 5.22 | 98 | 10 | 20.61 | 611 | 5.22 |
| 20 | 15.05 | 926 | 25.06 | 6.25 | 106 | 20 | 15.05 | 926 | 6.25 |
| 30 | 6.28 | 992 | 26.75 | 8.52 | 122 | 30 | 6.28 | 992 | 8.52 |
| 50 | 1.88 | 34.041 | 27.24 | 7.40 | 96 | 50 | 1.88 | 34.041 | 7.40 |
| 74 | 1.09 | 038 | 29 | 6.39 | 81 | 75 | 1.09 | 038 | 6.37 |
| 99 | 0.84 | 042 | 30 | 6.46 | 81 | 100 | 0.80 | 044 | 6.45 |
| 124 | 0.68 | 066 | 34 | 6.38 | 80 | 125 | 0.64 | 066 | 6.38 |
| 149 | 0.59 | 068 | 35 | 6.37 | 80 | 150 | 0.56 | 068 | 6.37 |
| 198 | 0.42 | 081 | 37 | 6.04 | 75 | 200 | 0.43 | 080 | 6.04 |
| 248 | 0.45 | 078 | 37 | 6.44 | 80 | 250 | 0.44 | 078 | 6.44 |
| 297 | 0.41 | 073 | 37 | 6.34 | 79 | 300 | 0.40 | 077 | 6.34 |
| 397 | 0.32 | 075 | 37 | 6.48 | 81 | 400 | 0.32 | 076 | 6.48 |
| 496 | 0.37 | 086 | 37 | 6.48 | 81 | 500 | 0.37 | 084 | 6.48 |
| 588 | 0.32 | 070 | 37 | 6.36 | 79 | 600 | 0.30 | 080 | 6.32 |
| 780 | 0.23 | 086 | 37 | 5.77 | 72 | 800 | 0.21 | 084 | 5.74 |
| 973 | 0.18 | 069 | 37 | 5.50 | 68 | 1000 | 0.18 | 069 | 5.45 |
| 1166 | 0.16 | 068 | 38 | 5.12 | 63 | 1200 | 0.16 | 069 | 5.12 |
| 1456 | 0.14 | 096* | 39* | 5.14 | 64 | 1500 | 0.14 | 095 | 5.15 |
| 1942 | 0.16 | 076 | 38 | 5.26 | 65 | 2000 | 0.16 | 075 | 5.26 |
| 2432 | 0.18 | 086 | 39 | 5.30 | 66 | 2500 | 0.18 | 085 | 5.30 |
| 2925 | 0.21 | 085 | 39 | 5.32 | 66 | 3000 | 0.22 | 086 | 5.32 |
| 3422 | 0.25 | 086 | 39 | 5.34 | 66 | 3500 | 0.25 | 086 | 5.34 |

Table 5. Data from Nansen casts at St. 4

| Station | Latitude | Longitude | Date | Ship time |
|---|---|---|---|---|
| 4 (H135) | 39-42 N | 138-48 E | Aug. 6, '70 | 03:25~06:00 |
| Depth 1700 m<br>Wind NE-5 m/s | | Current 131° 1.1 kt<br>Sea NE-2 | Transp.<br>Swell 1 | Air temp. 21.0°C<br>Weather rainy |

| D (ob) (m) | T (°C) | S (‰) | $\sigma_t$ | $O_2$ (ml/l) | $O_2$Sat (%) | D (S) (m) | T (°C) | S (‰) | $O_2$ (ml/l) |
|---|---|---|---|---|---|---|---|---|---|
| 0 | 22.4 | 33.789 | 23.21 | 5.14 | 99 | 0 | 22.4 | 33.789 | 5.14 |
| 10 | 22.40 | 994 | 37 | 5.32 | 103 | 10 | 22.40 | 994 | 5.32 |
| 20 | 20.96 | 34.072 | 82 | 5.28 | 100 | 20 | 20.96 | 34.072 | 5.28 |
| 29 | (18.85) | 421 | 24.64 | 6.58 | 120 | 30 | 18.80 | 420 | 6.53 |
| 49 | 13.85 | 388 | 25.78 | 6.28 | 105 | 50 | 13.55 | 364 | 6.27 |
| 73 | 8.00 | 223 | 26.68 | 6.14 | 92 | 75 | 7.75 | 213 | 6.13 |
| 98 | 5.64 | 099 | 91 | 6.17 | 87 | 100 | 5.44 | 094 | 6.18 |
| 122 | 4.21 | 077 | 27.05 | 6.35 | 87 | 125 | 4.00 | 072 | 6.16 |
| 146 | 3.06 | 063 | 16 | 6.36 | 85 | 150 | 2.99 | 061 | 6.36 |
| 195 | 1.91 | 056 | 24 | 6.27 | 81 | 200 | 1.82 | 054 | 6.26 |
| 244 | 1.23 | 049 | 29 | 6.15 | 78 | 250 | 1.21 | 049 | 6.13 |
| 293 | 0.93 | 047 | 30 | 5.93 | 75 | 300 | 0.84 | 047 | 5.88 |
| 390 | 0.53 | 047 | 33 | 5.19 | 65 | 400 | 0.51 | 048 | 5.18 |
| 487 | 0.40 | 049 | 34 | 5.13 | 64 | 500 | 0.38 | 050 | 5.13 |
| 564 | 0.34 | 055 | 35 | 5.13 | 64 | 600 | 0.32 | 060 | 5.07 |
| 749 | 0.20 | 067 | 37 | 4.75 | 59 | 800 | 0.19 | 064 | 4.76 |
| 936 | 0.17 | 062 | 37 | 4.85 | 60 | 1000 | 0.17 | 063 | 4.86 |
| 1125 | 0.14 | 063 | 37 | 4.89 | 61 | 1200 | 0.14 | 064 | 4.87 |
| 1412 | 0.13 | 068 | 37 | 4.95 | 61 | | | | |

Table 6. Data from Nansen casts at St. 5

| Station | Latitude | Longitude | Date | Ship time |
|---|---|---|---|---|
| 5 (H136) | 38-13 N | 135-44 E | Aug. 7, '70 | 00:50~04:50 |
| Depth 2800 m | Current 345° 1.2 kt | | Transp. 32 m | Air temp. 22.6°C |
| Wind NE-3 m/s | Sea NE-1 | | Swell 1 | Weather rainy |

| D (ob) (m) | T (°C) | S (‰) | $\sigma_t$ | $O_2$ (ml/l) | $O_2$Sat (%) | D (S) (m) | T (°C) | S (‰) | $O_2$ (ml/l) |
|---|---|---|---|---|---|---|---|---|---|
| 0 | 24.1 | 33.989 | 22.87 | 4.97 | 98 | 0 | 24.1 | 33.989 | 4.97 |
| 10 | 24.02 | 34.013 | 90 | | | 10 | 24.02 | 34.013 | |
| 19 | 18.00 | 340 | 24.78 | | | 20 | 17.55 | 059 | |
| 29 | 15.48 | 438 | 25.46 | 6.30 | 109 | 30 | 15.43 | 460 | 6.29 |
| 48 | 13.80 | 623 | 95 | 5.61 | 94 | 50 | 13.68 | 623 | 5.61 |
| 72 | 11.98 | 574 | 26.28 | 5.74 | 93 | 75 | 11.75 | 568 | 5.75 |
| 97 | 10.24 | 435 | 49 | 5.77 | 90 | 100 | 10.20 | 418 | |
| 121 | 9.48 | 355 | 56 | | | 125 | 9.35 | 340 | |
| 141 | 8.83 | 297 | 62 | | | 150 | 8.59 | 283 | |
| 193 | 7.45 | 211 | 75 | 6.08 | 90 | 200 | 6.78 | 194 | 6.10 |
| 241 | 4.39 | 092 | 27.02 | 6.23 | 86 | 250 | 3.93 | 085 | 6.26 |
| 290 | 2.59 | 065 | 19 | 6.36 | 84 | 300 | 2.36 | 061 | 6.36 |
| 387 | 1.19 | 050 | 29 | 6.05 | 77 | 400 | 1.09 | 052 | 5.96 |
| 485 | 0.58 | 057 | 33 | 5.37 | 67 | 500 | 0.54 | 058 | 5.35 |
| 584 | 0.42 | 058 | 34 | 5.41 | 67 | 600 | 0.43 | 060 | 5.39 |
| 776 | 0.26 | 062 | 36 | 5.05 | 68 | 800 | 0.24 | 067 | 5.04 |
| 968 | 0.18 | 070 | 37 | 5.02 | 62 | 1000 | 0.17 | 072 | 5.02 |
| 1160 | 0.16 | 074 | 37 | 5.04 | 62 | 1200 | 0.15 | 074 | 5.04 |
| 1448 | 0.14 | 071 | 37 | 5.12 | 63 | 1500 | 0.14 | 071 | 5.14 |
| 1933 | 0.17 | 070 | 37 | 5.30 | 66 | 2000 | 0.16 | 070 | 5.30 |
| 2434 | 0.18 | 069 | 37 | 5.27 | 65 | 2500 | 0.18 | 069 | 5.26 |

Table 7. Data from Nansen casts at St. 7

| Station | Latitude | Longitude | Date | Ship time |
|---|---|---|---|---|
| 7 (H138) | 41-10 N | 131-28 E | Aug. 17, '70 | 11:11~14:12 |
| Depth 3300 m | Current 317° 0.2 kt | Transp. 26.5 m (3°) | Air temp. 23.3°C | |
| Wind NNE-1 m/s | Sea NNE-2 | Swell 3 | Weather fine | |

| D (ob) (m) | T (°C) | S (‰) | $\sigma_t$ | $O_2$ (ml/l) | $O_2$Sat (%) | D (S) (m) | T (°C) | S (‰) | $O_2$ (ml/l) |
|---|---|---|---|---|---|---|---|---|---|
| 0 | 23.2 | 33.985 | 23.13 | 4.51 | 88 | 0 | 23.2 | 33.985 | 4.51 |
| 10 | 22.45 | 931 | 31 | 5.00 | 97 | 10 | 22.45 | 931 | 5.00 |
| 20 | 13.33 | 34.027 | 25.60 | 6.93 | 115 | 20 | 13.33 | 34.027 | 6.93 |
| 30 | 5.14 | 083 | 26.96 | 8.25 | 115 | 30 | 5.14 | 083 | 8.25 |
| 50 | 2.62 | 008 | 27.15 | 7.81 | 103 | 50 | 2.62 | 008 | 7.81 |
| 75 | 1.32 | 33.982 | 25 | 7.28 | 93 | 75 | 1.32 | 33.982 | 7.28 |
| 98 | 0.57 | 980 | 28 | 6.97 | 86 | 100 | 0.51 | 980 | 6.97 |
| 124 | 0.39 | 988 | 29 | 7.13 | 89 | 125 | 0.39 | 980 | 7.11 |
| 149 | 0.30 | 34.001 | 30 | 6.71 | 84 | 150 | 0.31 | 990 | 6.70 |
| 199 | 0.42 | 035 | 33 | 6.30 | 79 | 200 | 0.42 | 34.038 | 6.28 |
| 249 | 0.38 | 052 | 35 | 5.98 | 75 | 250 | 0.38 | 053 | 5.98 |
| 298 | 0.32 | 054 | 35 | 5.91 | 74 | 300 | 0.31 | 054 | 5.91 |
| 396 | 0.22 | 064 | 36 | 5.96 | 74 | 400 | 0.22 | 064 | 5.96 |
| 494 | 0.25 | 068 | 37 | 6.03 | 75 | 500 | 0.25 | 068 | 6.03 |
| 584 | 0.24 | 068 | 37 | 6.06 | 75 | 600 | 0.23 | 067 | 6.06 |
| 777 | 0.20 | 065 | 37 | 5.96 | 74 | 800 | 0.20 | 065 | 5.93 |
| 969 | 0.17 | 066 | 37 | 5.69 | 71 | 1000 | 0.17 | 068 | 5.64 |
| 1159 | 0.15 | 071 | 37 | 5.45 | 68 | 1200 | 0.15 | 071 | 5.39 |
| 1452 | 0.14 | 070 | 37 | 5.23 | 65 | 1500 | 0.14 | 070 | 5.22 |
| 1937 | 0.16 | 061 | 37 | 5.27 | 65 | 2000 | 0.17 | 065 | 5.28 |
| 2424 | 0.18 | 075 | 37 | 5.36 | 66 | 2500 | 0.18 | 075 | 5.38 |
| 2918 | 0.20 | 076 | 37 | 5.43 | 67 | 3000 | 0.20 | 076 | 5.38 |
| 3116 | 0.23 | 076 | 37 | 5.25 | 65 | | | | |

Table 8. Data from Nansen casts at St. 8

| Station | Latitude | Longitude | Date | Ship time |
|---|---|---|---|---|
| 8 (H139) | 40-06 N | 131-31 N | Aug. 18, '70 | 17:00~20:32 |
| Depth 3250 m | Current 263° 0.4 kt | Transp. – | Air temp. 22.1°C | |
| Wind NNE-8 m/s | Sea NNE-3 | Swell 3 | Weather cloudy | |

| D (ob) (m) | T (°C) | S (‰) | $\sigma_t$ | $O_2$ (ml/l) | $O_2$Sat (%) | D (S) (m) | T (°C) | S (‰) | $O_2$ (ml/l) |
|---|---|---|---|---|---|---|---|---|---|
| 0 | 22.7 | 33.904 | 23.02 | 5.13 | 100 | 0 | 22.7 | 33.904 | 5.13 |
| 10 | 19.36 | 962 | 24.15 | 5.95 | 109 | 10 | 19.36 | 962 | 5.95 |
| 19 | 14.98 | 34.077 | 25.29 | 6.94 | 118 | 20 | 14.75 | 34.074 | 7.50 |
| 29 | 5.95 | 047 | 26.84 | 8.73 | 123 | 30 | 5.75 | 041 | 8.73 |
| 48 | 2.96 | 020 | 27.12 | 7.94 | 105 | 50 | 2.82 | 017 | 7.80 |
| 72 | 1.84 | 007 | 20 | 7.10 | 92 | 75 | 1.79 | 008 | 7.14 |
| 96 | 1.26 | 017 | 27 | 7.73 | 98 | 100 | 1.20 | 014 | 7.72 |
| 119 | 0.60 | 33.983 | 23 | 7.02 | 88 | 125 | 0.50 | 33.981 | 6.93 |
| 143 | 0.36 | 995 | 29 | 6.81 | 85 | 150 | 0.35 | 34.002 | 6.74 |
| 191 | 0.39 | 34.044 | 33 | 6.50 | 81 | 200 | 0.32 | 043 | 6.46 |
| 238 | 0.33 | 039 | 33 | 6.35 | 79 | 250 | 0.32 | 041 | 6.32 |
| 286 | 0.32 | 053 | 34 | 6.25 | 78 | 300 | 0.30 | 052 | 6.22 |
| 382 | 0.29 | 059 | 35 | 6.17 | 77 | 400 | 0.28 | 059 | 6.19 |
| 479 | 0.26 | 060 | 36 | 6.34 | 79 | 500 | 0.25 | 060 | 6.35 |
| 574 | 0.24 | 063 | 37 | 6.34 | 79 | 600 | 0.22 | 062 | 6.33 |
| 763 | 0.20 | 061 | 38 | 6.06 | 75 | 800 | 0.20 | 062 | 5.94 |
| 950 | 0.16 | 063 | 38 | 5.51 | 68 | 1000 | 0.15 | 063 | 5.45 |
| 1140 | 0.14 | 068 | 38 | 5.33 | 66 | 1200 | 0.14 | 068 | 5.29 |
| 1422 | 0.14 | 068 | 38 | 5.23 | 65 | 1500 | 0.15 | 068 | 5.23 |
| 1898 | 0.16 | 068 | 38 | 5.34 | 66 | 2000 | 0.16 | 068 | 5.36 |
| 2381 | 0.18 | 068 | 38 | 5.39 | 67 | 2500 | 0.19 | 068 | 5.40 |
| 2873 | 0.20 | 067 | 38 | 5.40 | 67 | 3000 | 0.20 | 067 | 5.40 |
| 3071 | 0.21 | 066 | 38 | 5.40 | 67 | | | | |

Table 9. Data from Nansen casts at St. 9

| Station | Latitude | Longitude | Date | Ship time |
|---|---|---|---|---|
| 9 (H140) | 37-18 N | 131-30 E | Aug. 22, '70 | 09:20~11:50 |

| | | | |
|---|---|---|---|
| Depth 2325 m | Current 203° 0.9 kt | Transp. 18 m | Air temp. 24.8°C |
| Wind SSW-5 m/s | Sea SSW-3 | Swell 4 | Weather clear |

| D (ob) (m) | T (°C) | S (‰) | $\sigma_t$ | $O_2$ (ml/l) | $O_2$Sat (%) | D (S) (m) | T (°C) | S (‰) | $O_2$ (ml/l) |
|---|---|---|---|---|---|---|---|---|---|
| 0 | 25.1 | 33.017 | 21.87 | 4.76 | 96 | 0 | 25.1 | 33.017 | 4.76 |
| 10 | 24.96 | 016 | 90 | 4.81 | 97 | 10 | 24.96 | 016 | 4.81 |
| 20 | 22.03 | 965 | 23.11 | 5.46 | 105 | 20 | 22.03 | 965 | 5.46 |
| 30 | 15.32 | 34.381 | 25.46 | 6.76 | 116 | 30 | 15.32 | 34.381 | 6.76 |
| 50 | 9.64 | 341 | 26.53 | 6.26 | 97 | 50 | 9.64 | 341 | 6.26 |
| 74 | 7.26 | 203 | 78 | 6.30 | 92 | 75 | 7.05 | 198 | 6.29 |
| 99 | 5.27 | 083 | 95 | 6.26 | 88 | 100 | 5.27 | 082 | 6.26 |
| 123 | 4.30 | 090 | 27.05 | 6.41 | 88 | 125 | 4.24 | 089 | 6.42 |
| 148 | 3.47 | 086 | 14 | 6.04 | 81 | 150 | 3.41 | 081 | 6.03 |
| 197 | 1.44 | 053 | 28 | 6.11 | 78 | 200 | 1.37 | 052 | 6.11 |
| 245 | 0.87 | 054 | 30 | 5.89 | 74 | 250 | 0.76 | 054 | 5.86 |
| 294 | 0.61 | 058 | 33 | 5.71 | 72 | 300 | 0.58 | 059 | 5.77 |
| 391 | 0.43 | 065 | 35 | 5.62 | 70 | 400 | 0.42 | 063 | 5.61 |
| 488 | 0.36 | 067 | 37 | 5.50 | 68 | 500 | 0.32 | 069 | 5.49 |
| 574 | 0.29 | 070 | 37 | 5.38 | 67 | 600 | 0.25 | 071 | 5.34 |
| 764 | 0.22 | 074 | 37 | 4.99 | 62 | 800 | 0.18 | 071 | 4.98 |
| 954 | 0.17 | 072 | 38 | 4.98 | 62 | 1000 | 0.17 | 080 | 4.87 |
| 1144 | 0.14 | 092 | 39 | 5.24 | 65 | 1200 | 0.14 | 092 | 4.19 |
| 1430 | 0.14 | 077 | 38 | 5.06 | 63 | 1500 | 0.14 | 075 | 4.05 |
| 1916 | 0.17 | 084 | 39 | 5.12 | 63 | 2000 | (0.17) | (090) | (4.15) |

Table 10. Data from BT observations

| Station | Latitude | Longitude | Date | Ship time | Temp. (°C) | | | | | | | | | | Max. depth | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | 0 | 10 | 20 | 30 | 50 | 75 | 100 | 150 | 200 | 250 | D (m) | T (°C) |
| 1 | 42-29.0 N | 138-28.3 E | July 31, 1970 | 18:11 | 20.1 | 19.9 | 16.6 | 10.6 | 2.4 | 1.3 | 1.1 | 0.7 | 0.6 | 0.5 | 255 | 0.5 |
| 2 | 42-28.7 | 135-58.9 | Aug. 2 | 01:23 | 19.2 | 19.2 | 8.6 | 4.9 | 3.2 | 2.3 | 1.7 | 1.0 | 0.7 | 0.6 | 270 | 0.6 |
| 3 | 41-08.9 | 137-21.6 | 5 | 09:55 | 20.9 | 20.5 | 15.7 | 7.5 | 1.9 | 0.8 | 0.6 | 0.4 | 0.4 | 0.4 | 266 | 0.4 |
| 4 | 39-41.2 | 138-47.0 | 6 | 05:56 | 22.2 | 22.0 | 21.8 | 17.7 | 10.7 | 8.7 | 6.0 | 3.2 | 1.7 | 1.1 | 280 | 0.9 |
| 5 | 38-13.3 | 135-44.7 | 7 | 01:12 | 24.0 | 24.0 | 18.6 | 15.7 | 13.6 | 12.0 | 10.1 | 8.3 | 6.6 | 3.8 | 266 | 3.1 |
| 6 | 37-50.7 | 136-41.6 | 9 | 19:07 | 25.7 | 25.7 | 22.4 | 20.0 | 17.2 | 15.1 | 14.0 | - | - | - | 100 | 14.0 |
| 7 | 41-10.2 | 131-28.1 | 17 | 11:20 | 22.7 | 22.1 | 13.4 | 5.0 | 2.4 | 1.3 | 0.4 | 0.4 | 0.4 | 0.4 | 265 | 0.4 |
| 8 | 40-00.6 | 131-29.5 | 18 | 17:00 | 22.6 | 22.4 | 15.6 | 5.4 | 2.6 | 1.7 | 1.0 | 0.3 | 0.4 | 0.4 | 260 | 0.4 |
| 9 | 37-18.0 | 131-30.3 | 22 | 09:42 | 25.0 | 24.8 | 22.1 | 15.2 | 9.6 | 7.0 | 5.2 | 3.4 | 1.3 | 0.8 | 258 | 0.7 |
| 10 | 35-59.4 | 131-32.1 | 23 | 17:48 | 24.3 | 24.2 | 19.8 | 15.3 | 12.5 | 8.6 | 5.8 | 1.4 | 0.8 | 0.7 | 260 | 0.7 |
| 11 | 35-00.2 | 130-01.6 | 24 | 05:50 | 26.9 | 26.9 | 25.3 | 23.8 | 16.7 | 16.0 | 14.4 | - | - | - | 100 | 14.4 |

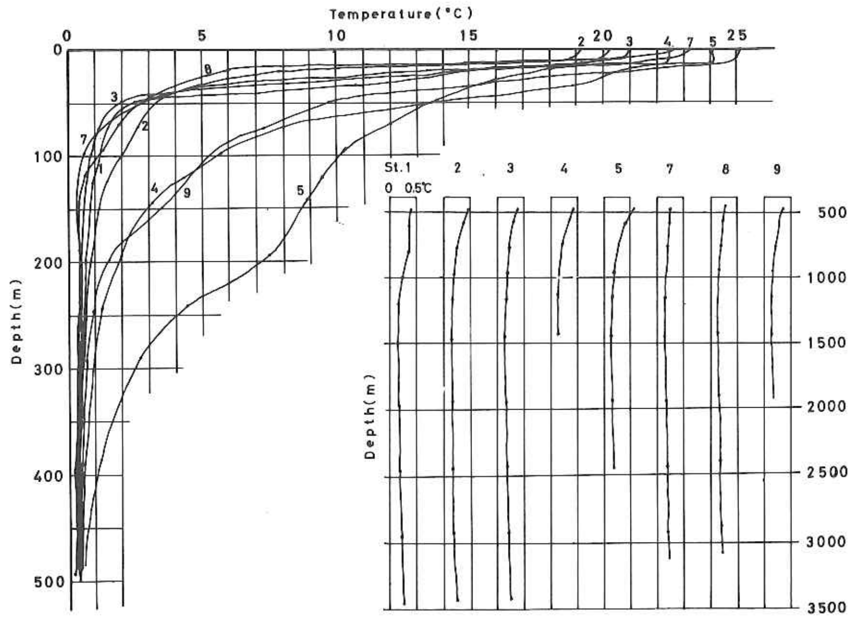


Fig. 2 Vertical distribution of water temperature

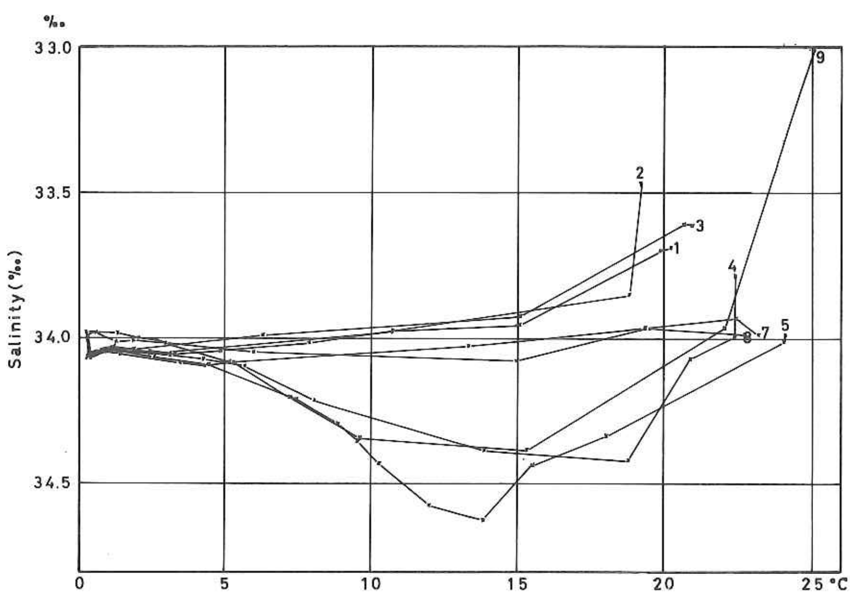


Fig. 3 Temperature-salinity diagrams

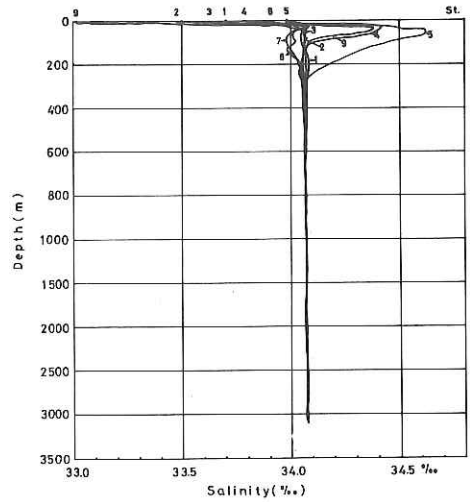


Fig. 4 Vertical distribution of salinity

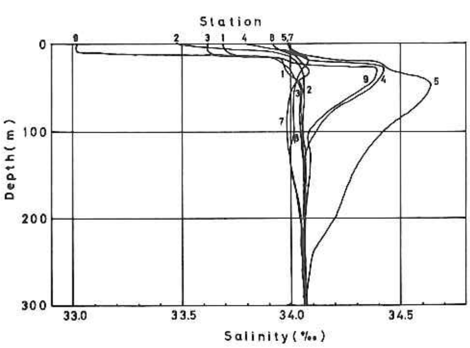


Fig. 5 Vertical distribution of salinity in upper layers

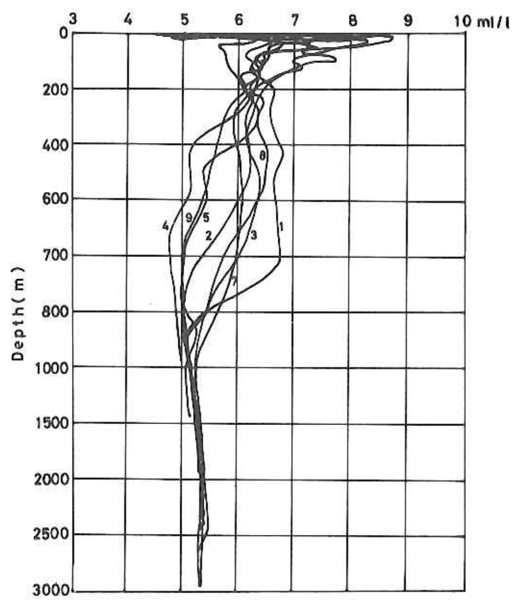


Fig. 6 Vertical distribution of dissolved oxygen

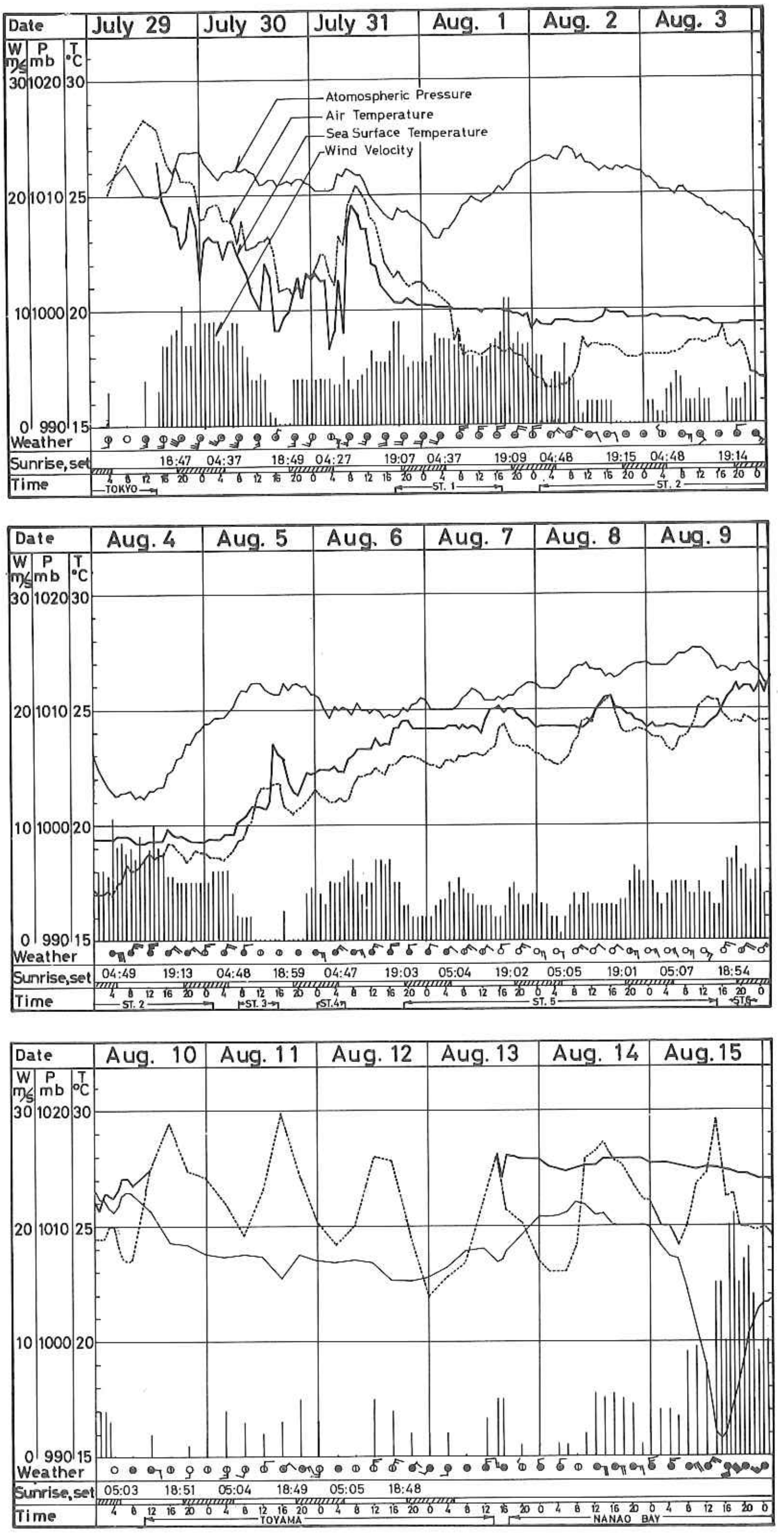


Fig. 7 General weather conditions

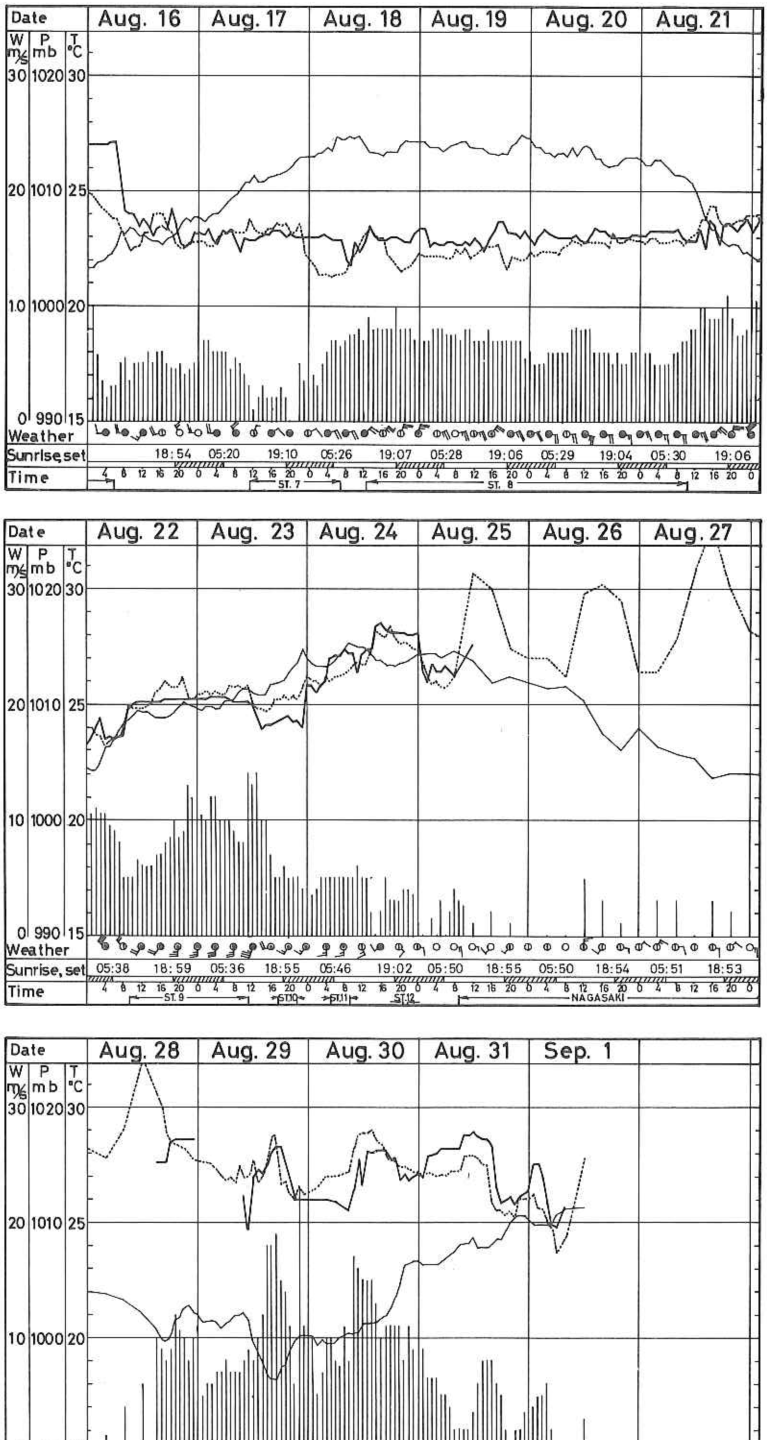


Fig. 7 General weather conditions

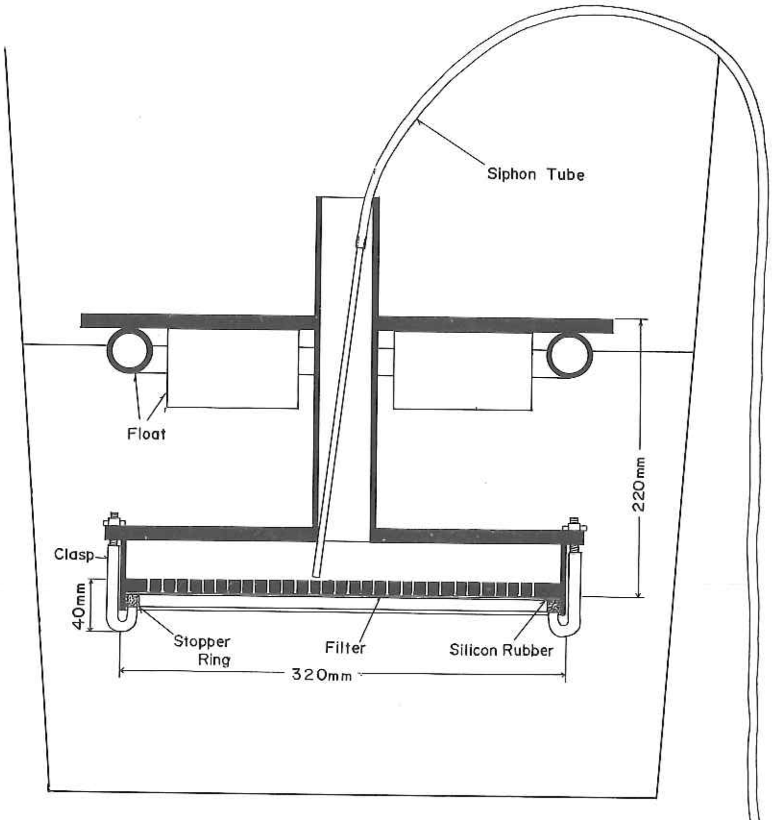


Fig. 8 Floating concentrator

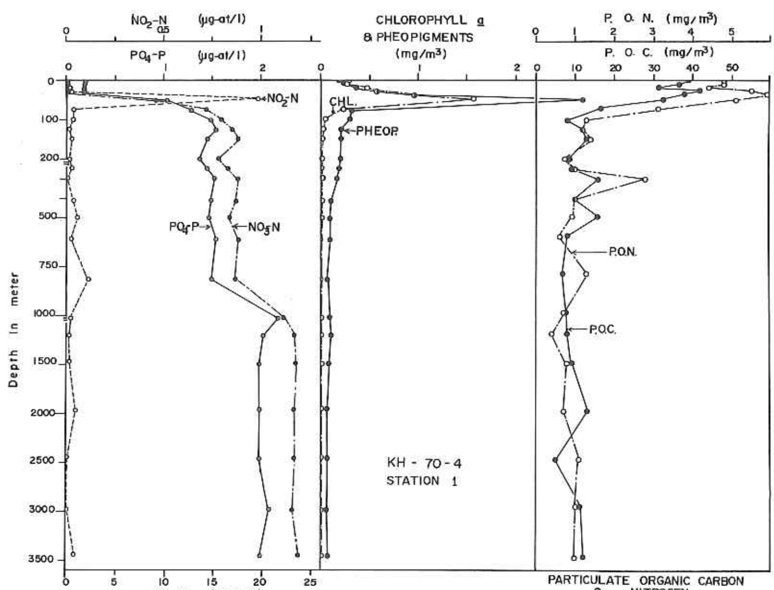


Fig. 9 Vertical distribution of $NO_2$-N, pigments and POC

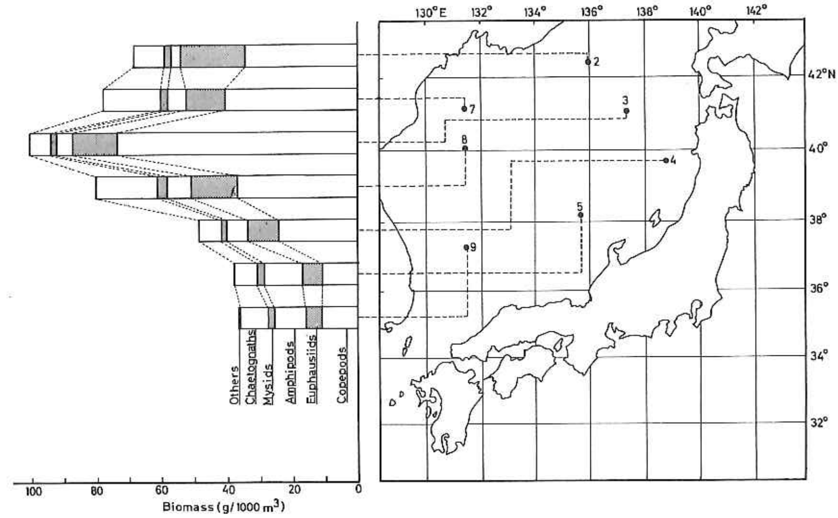


Fig. 10 Zooplankton community in the upper 1000 m (ORI-100)

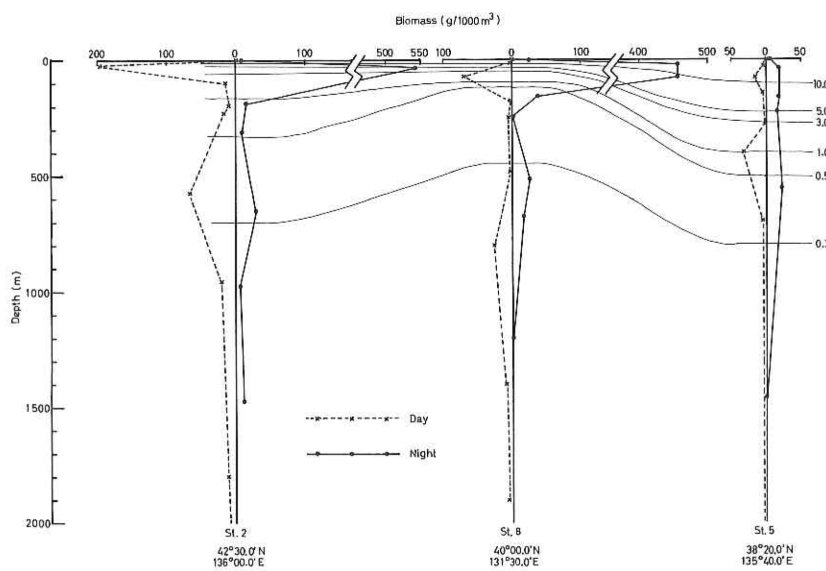


Fig. 11 Vertical distribution of zooplankton biomass (ORI-100)

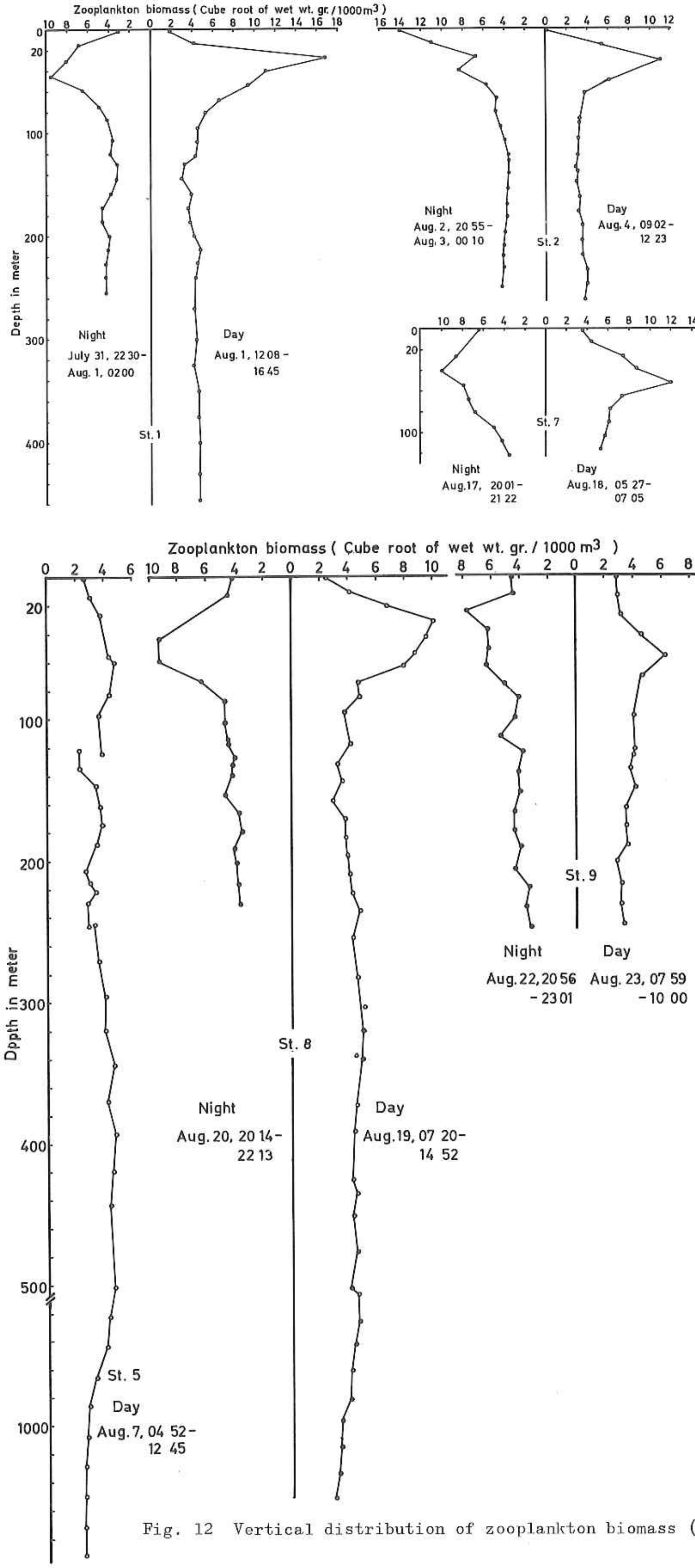


Fig. 12 Vertical distribution of zooplankton biomass (MTD)

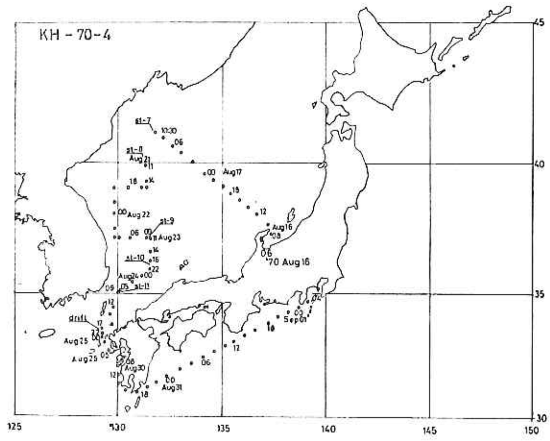


Fig. 13 Ship track for gravity measurement

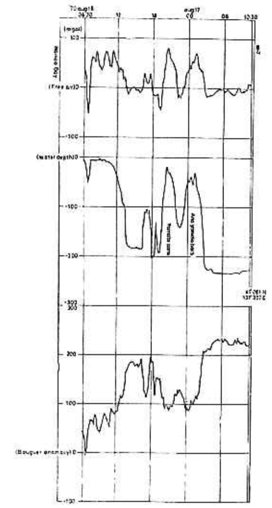

Fig. 14

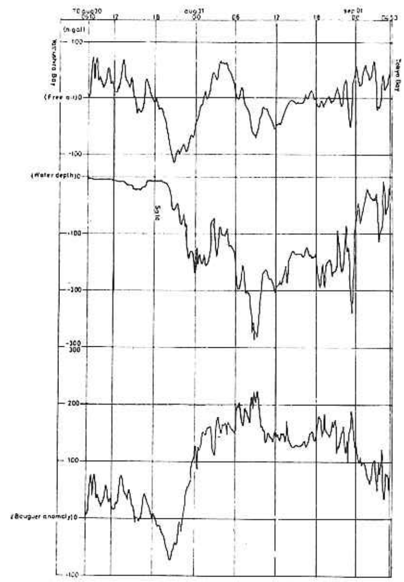

Fig. 15

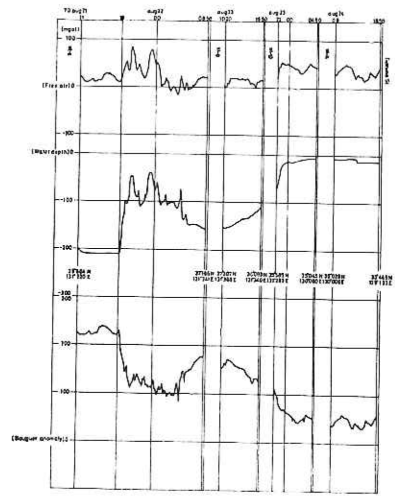

Fig. 16

Figs. 14-16 Results on gravity measurements