Preliminary Report

of

The Hakuhō Maru Cruise KH-71-2

(IBP Cruise)

May 7—June 3, 1971

The Kuroshio and East China Sea

Ocean Research Institute

University of Tokyo

1972

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By

The Scientific Members of the Expedition

Edited by

Ryuzo Marumo

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Outline of the research

The research cruise, KH 71-2, was carried out for the research entitled "Studies on the ecosystem supported by the pelagic blue-green alga Trichodesmium as a primary producer". The Hakuhō Maru (3226 tons), a research vessel of the Ocean Research Institute, University of Tokyo, left Tokyo Port on May 7, 1971 and returned on June 3, after 4 week research in the East China Sea and Kuroshio area east of Taiwan. During the cruise, she anchored on May 20 and stayed for 4 days at Naha Habour, Okinawa. The scientific team was composed of 16 persons from the Ocean Research Institute and 11 from various universities in Japan (refer to Scientists Aboard).

Trichodesmium frequently forms red tide condition in the tropical and subtropical areas as the results of remarkable propagation and physical accumulation by current or wind. Thus, most of documents have been concentrated to the Trichodesmium forming red tide. However, this alga is widely distributed throughout the year and is considered as one of main primary producers in these oceanic areas. To know the characteristics of Trichodesmium without forming red tide, our investigations were carried out in such season when Trichodesmium was not yet abundantly propagated and did not yet present any red tide phenomena.

The first survey, mainly focused on a general distributional pattern of Trichodesmium, was done at a section set from 32°N to 20°N along 125°E (Sts. 1-9 in Fig. 1) on May 10 - 18. Trichodesmium was not yet found in the East China Sea, mainly because of lower temperature for the propagation, while it was fairly abundantly distributed in the Kuroshio water east of Taiwan. At this section, observations were done concerning taxonomy, geographical and vertical distribution, activities for photosynthesis and nitrogen fixation, and chemical components of Trichodesmium, as well as environmental elements such as standing crop of plankton, water temperature, salinity, dissolved oxygen, silicate, phosphate, nitrate, nitrite and ammonia.

More detailed studies on ecology and physiology of Trichodesmium were carried out at St. 10 in the Kuroshio water for 6 days.

The present investigation was partly supported by the IBP grant of the Ministry of Education.

Finally, we would heartily thank persons in Okinawa for their kind arrangement and hospitality during the stay in Naha Harbor. Thanks are also extended to the crew members of the Hakuhō Maru for their helpful cooperation throughout this cruise.

1. General weather condition and hydrography

by

T. Nakai, H. Hasumoto and R. Marumo

(1) General weather condition (Fig. 2)

June is a rainy season in the sea southwest of Japan Islands. Fortunately, however, it was fine on most of the days of the present cruise, and easterly gently winds prevailed, because of the weak activity of the rainy front, though the wind velocity rarely exceeded 10 m/sec. Air temperature was 15°C at St. 1, while it increased to 26°C at St. 7 in the Kuroshio region.

(2) Hydrography (Figs. 3 — 6)

It is clearly shown from the sections of temperature (Fig. 5) and salinity (Fig. 6) along 125°E that the Kuroshio streamed just north of St. 4. This result coincides with former observations that the Kuroshio runs along the edge of the continental shelf in the East China Sea.

From the distributions of temperature and salinity three regions can be divided: the shallow region on the continental shelf in the East China Sea, the deep region between the continental slope and the Ryukyu Islands, and the Kuroshio open region.

In the shallow region, the upper layer is distinguished from the lower layer by the existence of a remarkable thermocline between the depths of 20 and 35 m. There exists a watermass with lower temperature and lower salinity and the salinity is less than 35 ‰ in the whole water column, the lowest salinity being less than 32 ‰ at the northernmost station, St. 1 close to the Yellow Sea.

The deep region is formed by the mixing of the Kuroshio water with the East China Sea water. The temperature increases distinctly in the 200-m depth compared with that in the northern region. The thermocline appears with values between 20°C and 10°C.

In the oceanic region, the high salinity of 34.8 ‰ is found at the depth of about 200 m and a remarkable salinity minimum exists at about 600-m depth.

2. Sampling of plankton

by

R. Marumo, M. Murano, Y. Aizawa, K. Kamada, M. Terazaki, H. Irie and T. Nakashima

(1) ORI net tow

For the sampling of macroplankton and micronekton an ORI conical net, 160 cm in mouth diameter, 750 cm in length and with filtering cloth of 1.0-mm mesh size, was used. As the standard method, surface tows at night and oblique tows of 2000-m wire out were planned at each of the stations, but at the first 3 stations oblique tows were made with the wire variously extended out in accordance with the depths of stations since these stations were located upon the continental shelf. The maximum depth which the net attained in oblique tow was measured with a TSK depth-distance meter equipped on the mouth ring, and the volume of filtered seawater was estimated with a RGS flow-meter at the center of the mouth ring. The samples were preserved in about 10 % solution of neutralized formalin seawater, and later they will be sorted into about 25 groups, i. e., amphipods, chaetognaths, copepods, fishes, macrurans, euphausiids, mollusks, mysids, ostracods and so on, and then each group is separately weighed in wet condition before being distributed to specialists.

In addition to the standard sampling, 5 oblique tows at Sts. 8, 9 and 10 were conducted for special experiments, for instance, the analysis of carotenoid in some colored chaetognaths and copepods in deep sea, and the measurement of natural ^{15}N abundance in plankton and micronekton.

(2) Norpac net tow

As a standard method in CSK (Cooperative Study of the Kuroshio and Adjacent Regions) and other projects in the Pacific Ocean, Norpac nets are widely employed. In the present cruise a Norpac double net (the inner net made of cloth of 0.3-mm mesh, the outer one made of cloth of 0.1-mm mesh) was hauled at each station on 125°E. At Sts. 4 to 7 and 9 the haulings were made upwards from an estimated depth of 150 m to the surface, but at Sts. 1 to 3 which are located upon the continental shelf, the net was hauled from the bottom upwards to the surface. The samples were fixed with neutralized formalin for the biomass and geographical surveys.

(3) MTD horizontal closing net tow

Simultaneous horizontal tows with a number of MTD horizontal closing nets, 56 cm in mouth diameter, were carried out for examining the detailed patterns of vertical

distribution of plankton. Two kinds of nets that were different in the mesh size of filtering part were employed for this purpose. One of them had a coarse mesh size of 0.3 mm and was towed for mainly zooplankton survey at the depths of 0, 5, 15, 30, 50, 100, 150, 200, 300, 400 and 500 m. The other one with a fine mesh of 0.1 mm was towed for phytoplankton survey at the depths of 0, 5, 15, 30, 50 and 100 m. At Sts. 1 to 3 which are located upon the continental shelf, however, the nets were towed from the depths of the locations.

At St. 9, more detailed samplings were conducted at 21 depths between the surface and the depth of 1500 m with coarse-mesh nets, and also at 11 depths between the surface and the depth of 100 m with fine-mesh nets. Such tows were repeated by day and by night.

The samples were preserved in about 10 % solution of neutralized formalin seawater, and later will be weighed in wet condition before the detailed examination of vertical distribution of plankton species.

(4) Water sampling for microplankton and nanoplankton survey

For the systematic and biogeographical studies of Foraminifera and Radiolaria, water samples were collected from various depths at 4 stations on 125°E with Van Dorn bottles and also from the surface on a westward leg to 125°E. The samples were preserved in 1 % solution of neutralized formalin seawater for the later identification on land.

3. Photosynthetic behaviour of *Trichodesmium* and primary productivity in ocean profiles

by

S. Ichimura, Y. Fujita, Y. Aruga, Y. Yamaguchi,

S. Shimura, M. Fujisaki and K. Taruishi

At Sts. 7, 9 and 10, photosynthetic responses of *Trichodesmium* to the light environment in water body were examined by the *in situ* method using ^{14}C technique. Phytoplankton samples were collected from the depths of 0, 5, 10, 15, 20 and 30 m with MTD 10 nets. The net catches were suspended in filtered sea water and *Trichodesmium* was isolated from a mixed population. The *Trichodesmium* suspensions were adjusted to a suitable density with filtered sea water. The algal suspensions were filled in 100-ml oxygen bottles and exposed for 3 hours in full sunshine of about midday at the depths of 0, 10, 20, 30, 50, 75, 100 and 125 m. From these, the photosynthetic behaviour of *Trichodesmium* at various depths is analyzed in relation to the environmental conditions of underwater radiation and temperature. In addition, the depth profiles of photosynthetic activity of sea water were examined by the *in stitu* method and the primary production of the column under 1 m^2 was calculated in mg $C/m^2/h$ or mg $C/m^2/day$.

4. Photoshynthetic activity of phytoplankton in shallow waters

by

Y. Yamaguchi, S. Ichimura, Y. Aruga, Y. Fujita,

S. Shimura and M. Fujisaki

The experiments were carried out at all stations to make clear the horizontal and vertical variations of the photosynthetic activity of phytoplankton in oceanic waters. The water samples from the depths of 0, 10, 20, 30, 50, 75, 100 and 125 m were collected with Van Dorn-type samplers. Light dependence of photosynthesis was examined on board the ship by the tank method using ^{14}C technique. The water samples were filled in 100-ml oxygen bottles, and 1 ml of sodium bicarbonate solution (10 μCi/ml) was added. The bottles were incubated in a temperature-constant (20°C) water tank under illumination with fluorescent light. The light intensity was regulated with neutral papers. In addition, the depth variation of photosynthetic activity per unit volume of water was examined by the in situ method at Sts. 9 and 10. The water samples were also suspended at various depths which were different from the sampling depth for examining the deviation in photosynthetic activity of each water sample expected at other depths.

5. Photosynthetic characteristics of Trichodesmium

I. Experiments under white light

by

Y. Aruga, S. Ichimura, Y. Yamaguchi, Y. Fujita,

S. Shimura, M. Fujisaki and K. Taruishi

Photosynthetic characteristics of Trichodesmium were examined with net samples from various depths at Sts. 4, 5, 6, 7, 9 and 10. Trichodesmium samples were collected by horizontal hauls with MTD 10 nets. After removing the mixed other organisms and suspended materials discernible with the naked eye, Trichodesmium samples were washed once or twice with Millipore®-filtered sea water and diluted to a suitable concentration with the filtered sea water. Photosynthesis was measured by a ^{14}C technique, or supplementarily, by an oxygen electrode technique. Samples were introduced into 100- or 50-ml oxygen bottles. After injection of ^{14}C-$NaHCO_3$ solution (10 μCi), samples were incubated in water tank of controlled temperature under illumination with the light from a bank of daylight-type fluorescence lamps. Besides photosynthetic activity at 20°C under light-saturating conditions, the activities under various light intensities or at various temperatures were also measured.

6. Photosynthetic characteristics of *Trichodesmium*

II. Experiments under monochromatic lights

by

S. Shimura, Y. Fujita, S. Ichimura, Y. Aruga,

Y. Yamaguchi, M. Fujisaki and K. Taruishi

Trichodesmium photosynthesis under monochromatic light illumination was studied with special reference to the function of photosynthetic pigments. Samples used were the same as those for experiments under white light at Sts. 9 and 10. Photosynthetic activity was measured by a ^{14}C technique. The actinic lights were monochromatic lights (half band-width, 10--20 nm), which were isolated from I_2-lamp light by a couple of secondary interference filter and sharp cut color filter. Chlorophyll *a* was excited by 677-nm light, phycocyanin by 620-nm light, phycoerythrin by 541-nm light, and carotenoids by 495-nm light, respectively. The light energy was 1.5 to 0.7 x 10^3 erg/cm^2/sec. Samples were placed in round flat flasks (10 ml, total; 1 cm, light path), which were set in a temperature-controlled water tank. After injection of ^{14}C-$NaHCO_3$ solution, samples were illuminated with various monochromatic lights for 30 minutes. Before measurement of photosynthesis, a part of each sample was filtered with a Wattman GFC filter. Samples on the filters were used for measurement of the *in vivo* absorption spectrum.

7. Analyses of photosynthetic pigments in *Trichodesmium*

I. Phycobilin chromoproteins

by

Y. Fujita, S. Shimura, K. Taruishi, S. Ichimura,

Y. Aruga, M. Fujisaki and Y. Yamaguchi

Composition of phycobilin chromoproteins in *Trichodesmium* was investigated with samples obtained at Sts. 5, 6, 7, 9 and 10. At each station, aliquots of *Trichodesmium* samples used for the photosynthesis experiments were filtered through a Wattman GFC filter with gentle suction. After removing carefully the deposits on filters other than *Trichodesmium* filaments, the *in vivo* absorption spectrum was measured with an opal glass method. At Sts. 9 and 10, *Trichodesmium* samples were collected on a large scale. Samples on GFC filters were stored at $-15^{\circ}C$ in the dark for chemical analyses in the laboratory. A part of the sample was used for the experiments on board the ship. The sample was dipped in the $10^{-2}M$ phosphate buffer (pH 6.5) in the cold for extraction of phycobilins. Solubilized pigments were fractionated with ammonium sulfate precipitation. Spectroscopic characteristics of phycocyanin were the same as those of c-phycocyanin; the main absorption maximum was located at 620 nm. However, *Trichodesmium* phycoerythrin showed quite different characteristics from those of c-phycoerythrin, having the absorption maxima at 500, 550 and 565 nm. The pattern was very similar to that of R-phycoerythrin. The peaks at 500 and 550 nm appeared also in the *in vivo* absorption spectrum. A preliminary comparison of the phycobilin content with the photosynthetic activity indicated that *Trichodesmium* having higher phycobilin content retained higher photosynthetic activity.

8. Analyses of photosynthetic pigments in *Trichodesmium*

II. Chlorophyll and carotenoid

by

M. Fujisaki, Y. Fujita, S. Ichimura, S. Shimura,

K. Taruishi, Y. Aruga and Y. Yamaguchi

Chlorophyll- and carotenoid-compositions of various *Trichodesmium* samples were investigated.

After measurement of the *in vivo* absorption spectra (cf. pigment analysis I), chlorophyll and carotenoid were extracted with 90 % acetone by grinding in a motor. Absorption spectra of clear extracts were measured with a Shimadzu D 40 R spectrophotometer. The spectra obtained were compared with the *in vivo* spectra, and relative contents of chlorophyll *a*, pheophytin *a*, β-carotene and xanthophylls were computed. A preliminary analysis of the data indicated that (1) *Trichodesmium* having higher content of pheophytin showed lower photosynthetic activity and (2) the relative content of total carotenoid was fairly constant.

Further analyses of chlorophyll and carotenoid, including identification of each pigment, are now in progress with samples obtained on a large scale at Sts. 9 and 10.

9. Inorganic nitrogen metabolism in *Trichodesmium*

by

E. Wada and T. Miyazaki

Inorganic nitrogen metabolism in *Trichodesmium* was investigated with special reference to molecular nitrogen fixation.

The samples of *Trichodesmium* were collected by horizontal tow of MTD nets. The samples were duplicated; one group was used for the measurement of $^{14}CO_2$ fixation, and the other for the following experiments.

Nitrogen fixation was measured as follows: 1 to 4 ml of dense suspension of *Trichodesmium* was placed in small glass vessels with stopcock (5 ml in volume). The vessels were evacuated (10^{-3} mm Hg) and refilled with approximately 1 : 1 mixture of nitrogen gas (50 atomic % of ^{15}N) and argon.

The assimilation of inorganic nitrogen was simultaneously measured by using the ^{15}N-labeled ammonia and nitrate in 100-ml oxygen bottles. The ammonia and nitrate were given at concentrations of more than 10 µg at.N/l to yield the maximum velocity. Experiments were conducted under the following conditions: temperature, 20°C; light intensity, 12,000 lux; incubation time, 2 hours. Control runs in the dark were included. Effects of temperatures, light intensities and the substrate concentrations were also studied.

The ^{15}N content was afterwards measured in the laboratory using a Hitachi-RMU-6 Mass Spectrometer fitted with a double collector for ratiometry.

Natural abundance of ^{15}N in *Trichodesmium* and zooplankton samples were also measured to obtain further insight into the processes of *in situ* nitrogen fixation.

10. Inorganic nitrogen metabolism in shallow waters

by

T. Miyazaki and E. Wada

A survey for the inorganic nitrogen metabolism in sea water was made along 125°E and compared with that for $^{14}CO_2$ fixation.

Samples of sea water were collected by Van Dorn bottles in the layer from the surface to the 150-m depth. The sea water samples were introduced into 500-ml glass bottles, and incubated at 20°C for 2 hours in the light (12,000 lux) or in the dark. ^{15}N-labeled ammonia, nitrite or nitrate was added at concentrations of 20, 18 or 20 μg at.N/l, respectively. The reactions were stopped by the addition of $HgCl_2$ (10^{-4}mole/l), and particulate materials were collected on a millipore® filter (HAO. 45 μ). The ^{15}N content of the samples were afterwards measured by a Hitachi RMU-6 Mass Spectrometer.

At St. 2 the both activities for ammonia oxidation and nitrate reduction to nitrite were also measured at the depths of 10, 20 and 40 m. 5 l of sea water samples were incubated in the glass bottles under natural sunlight. The temperature was controlled by placing the bottles in a tank cooled by the surface sea water. Incubation was made for six hours from 10:00 to 16:00. The concentrations of individual inorganic nitrogen compounds were the same as those used in the experiments described above. After incubation, 500-ml aliquots of the sample waters were filtered through a millipore filter for the measurement of assimilation activities. The residuals (4.5 l) were treated with sulfanilic acid and N-(1-naphthyl) ethylenediamine. The azo dye formed was concentrated about 90-fold by using a Dowex1X8 column. The variation of NO_2^- concentrations during incubation was colorimetrically measured. ^{15}N content of the sample azo dye was measured afterward in the laboratory.

11. Studies on microflagellates; their distribution and capacity for assimilation of organic matter

by

T. Tsuji

The number of viable cells of phytoplankton at Sts. 6, 7, 9 and 10 was counted. The sample of sea water (500 ml) was collected from 0- to 150-m depths and gently filtered through an HA Millipore® filter without suction. Just before the filtration was completed, the sea water remaining on the HA filter (about 1 ml) was taken up by a pipette, and transferred, after measurement of its volume, onto the counting slide glass. The number of cells was directly counted under the microscope. About 90 % or more of phytoplankton consisted of microflagellates (below 30 μ in length), and the rest, being diatoms and blue-green algae. At Sts. 5 and 10, the layer of maximum cell number coincided with that of chlorophyll maximum (about 100-m depth), but at Sts. 6 and 7 the former was located above the latter. Identification of the dominant species of microflagellates is now under way with their specimens fixed by iodine as well as the microphotographs taken on board the ship before they died.

The capacity of the assimilation of amino acids, glucose and acetate in these water samples were measured by using ^{14}C-labeled compounds. The contribution of microflagellates to this process was examined with the sample collected from the layer of chlorophyll.

12. Depth profiles of protein, chlorophylls, ribonucleic and deoxyribonucleic acids

by

S. Ichimura and Y. Yamaguchi

A total biomass of microorganisms was estimated by determination of protein, chlorophylls, ribonucleic and deoxyribonucleic acids in sea water. Water samples were taken from various depths down to near the bottom at all stations. The water samples were filtered through Gelman filters on board the ship within a few hours after sampling, and the filters were stored in a deep freezer until use. The analysis was made according to the method of Iwamura et al. (1969).

13. Spectroscopic examination of phytoplankton pigments in shallow waters

by

S. Shimura and Y. Fujita

Spectroscopic characteristics of phytoplankton pigments in water samples collected from the 0- to 150-m depth were examined along 125°E, and were compared with the photosynthetic activity. After filtration with a Wattman GFC filter, the in vivo absorption spectra of samples on filters were measured with an opal glass method. The absorption spectra of acetone extracts were also measured with the same samples. All measurements were carried out on board the ship with a Shimadzu D4OR spectrophotometer.

14. Depth profiles of photosynthetic pigments characteristic of blue-green algae

by

M. Fujisaki

Vertical distribution of photosynthetic pigments characteristic of blue-green algae was determined with water samples collected from various depths at each station. Water samples were filtered through a Wattman GFC filter on board the ship, and the filters were stored in a deep freezer until use. Pigments on the filters were afterwards fractionated in the laboratory with a thin-layer chromatography, and spectroscopically determined.

15. Enrichment experiments

by

M. Fujisaki

Nutritional requirements of phytoplankton in sea waters was studied by enrichment experiments. Water samples collected at St. 10 were enriched with addition of inorganic phosphate and/or nitrate and incubated under various conditions. Changes in chlorophyll content and photosynthetic activity were followed during the incubation.

16. Measurement of solar radiation

by

Y. Aruga

Diurnal changes of solar radiation effective for plant photosynthesis (380--710 nm) were followed with a thermopile detector (Toshiba PSZ-1) on board the ship every day throughout the cruise.

17. Measurement of underwater irradiance

by

S. Ichimura, Y. Fujita, Y. Aruga, S. Shimura,

Y. Yamaguchi, M. Fujisaki and K. Taruishi

At each station, underwater irradiance was measured from the 0- to 100-m depths with a selenium photocell. Penetrations of red, green and blue lights were also determined with the aid of color filters (Hoya R-60, G-526 and B-390).

18. Distribution and chemical properties of organic matter

by

N. Handa and K. Matsunaga

In marine environment, organic compounds exist in the form of particulate matter and in that of solute in the sea water. Both the forms of the organic materials are assumed to play an important role in the biochemical processes of inorganic and organic materials in the ocean, although they have respectively different physico-chemical states. Thus, special attention has been paid to the determination of these organic materials.

Sixty five samples of the particulate matter were collected from various depths down to 2,000 m in the eastern China Sea along 125°E from 32°N to 20°N. Carbohydrate, protein and amino acid, fatty acid and chlorophyll a were determined. Organic composition of the particulate samples from Sts. 7, 9 and 10 was determined with special attention to clarify the mechanism of the formation of the maximum layer of chlorophyll a.

In addition, the incorporation of $^{14}CO_2$ into the particulate organic constitutents by the photosynthetic reaction of phytoplankton was determined, and the turnover rates of these organic materials were calculated.

Thirty-six samples of sea water (100 ml) were collected for the analyses of dissolved organic carbon (DOC), carbohydrate, protein and amino acid and fat. Fourteen samples (10 l) were obtained for the determination of chemical properties of dissolved carbohydrate and organic acids.

19. Organic composition of Trichodesmium

by

N. Handa and K. Matsunaga

Trichodesmium was collected in a layer from the surface to the 10-m depth by simultaneous horizontal tows with a number of MTD horizontal closing nets with filtering cloth of 0.1-mm mesh.

Incorporation of $^{14}CO_2$ into the algal materials was determined by using of a part of the algal samples. The remaining samples were analysed for the study of organic constituents of the alga such as carbohydrate, protein and amino acid, fat and chlorophyll a.

Glycogen-type polyglucan was isolated from this alga and chemically characterized.

20. Distribution of inorganic elements and materials

by

O. Saito and K. Fukuda

Sixty-five samples of the particulate matter were collected at Sts. 1 to 7 in the East China Sea. The particulate matter was brought back to the laboratory in order to analyse calcium, sodium, potassium and silicon for estimation of the rates of dissolution and precipitation of calcium carbonate and silicate materials in the surface and deep waters.

^{210}Pb and ^{210}Po were separated from 30 to 50 liters of sea water by the aid of the co-precipitation with calcium carbonate. Activities of these nuclides were determined to estimate the circulation and mixing rate of the surface water.

Aerosol, air-borne dust and rain water were collected. Inorganic elements and materials and radioactive nuclides were determined to estimate the amount of the supply of these elements and materials into the sea water through the atmosphere.

21. Nitrogen fixation in marine environment

by

Y. Maruyama

For the study of nitrogen fixation in marine environment, the distributions of nitrogen-fixing bacteria, nitrogen-fixing activities and hydrogenase activities were examined in this cruise for blue-green algae, other plankton, bottom deposits and sea water samples.

The population of nitrogen fixing bacteria was estimated by selective cultural methods using non-nitrogenous media. Horizontal and vertical distributions of the bacteria in sea water were investigated at all stations. A larger bacterial population (about 10^4 cells in 100 ml of sea water samples) was found in southern areas such as Sts. 5, 6 and 7. On the contrary, a small density of bacterial biomass (less than 10^2 cells in 100 ml of sea water samples) was found at Sts. 1, 2 and 3. About 10^2--10^4 cells per 1 g wet weight of sediments were found in samples of bottom deposits obtained by using a gravity core sampler at Sts. 1, 5, 9 and 10.

The isolation of bacteria attached to blue-green algae, Trichodesmium and other plankton was performed at Sts. 1, 3, 9 and 10.

The nitrogen-fixing activity of Trichodesmium, other plankton, sediments and sea water samples was measured by the acetylene reduction method. The hydrogenase activity of those samples was examined by the tritium method. The results showed that the nitrogen-fixing activity in marine environments was generally weak, and also in this experimental condition the activity of Trichodesmium samples was not so strong as reported earlier.

Detailed analysis concerning the nitrogen fixation of these samples and physiological studies of the isolated bacteria are now being carried out in the laboratory.

22. Distribution of urea

by

Ken Sasada

In order to clarify the relationships between the distribution of urea in sea water and a few biological factors in situ, which can be considered to affect the distribution of urea in marine environments, the following investigations were carried out in this cruise.

(1) Sea water samples for the determination of urea were collected vertically by Nansen bottles at Sts. 1, 2, 3, 4, 5, 6 and 7 and were filtered through Millipore® filters (type GS). These filtered samples were stored at -20°C until the time of their determination of urea by the method of Newell et al. (1967).

(2) The relation between vertical migration of zooplankton and vertical distribution of urea was investigated at St. 10. For this purpose, sea water samples for urea determination were taken vertically in the daytime and at night, and at the same time zooplankton samples were collected from various depths by MTD-33 plankton nets.

(3) Decomposition rates of urea in sea water were examined experimentally at Sts. 1, 7 and 10. Sea water samples for this purpose were collected from various depths by Van Dorn samplers. Several 100-ml portions of each sample with additions of 2, 4, 6, 8 and 10 μg-N urea were incubated at 20°C for 1, 3, 5, 7 and 10 days. These incubated samples were stored at -20°C until the time of the determination of the amounts of urea decomposed by microbial action in sea water.

On the other hand, the isolations of urea-decomposing bacteria from vertical sea water samples were carried out at all stations to endorse the fact of microbial degradation of urea in marine environments.

23. Flying insects on the Northwest Pacific

by

S. Asahina

During a period from May 24 to June 3 an attempt was made to capture flying insects on board the research boat Hakuhō Maru in an area south of the Ryukyu Islands, northwestern Pacific.

Besides ordinary insect-nets two large air plankton-nets and four light traps were set on the upper deck of the boat. Hakuhō Maru left Naha of Okinawa on May 24, stayed adrift south of the Ryukyus at about 24°N, 126.5°E until May 30, and then sailed back to Tokyo.

While staying to the south of the Ryukyus, the weather was, unfortunately, rather calm under a high atmospheric pressure, so that the collection was extremely poor. On the return voyage a number of insects were attracted to the lights of the boat on the evening of June 1 while sailing along the Pacific coast of Japan between the peninsulas Kii and Izu. Besides, a number of insects were recognized on the boat shortly after the departure from Naha, but these insects should be excluded since they were attracted by the deck lights when the boat was at the wharf of Naha. The following observations seem worth to be noted:

(1) While staying in the south of the Ryukyus one cicada, one longicorn beetle and one Syrphid fly were collected on board the boat.

(2) While sailing along the south coast of Japan, under the presence of a front, four species of moths, four species of Diptera and one species of Aphids were captured by the light traps.

(3) For getting flying insects attention should be paid to both sides of the boat as the moving insects usually come from one side brought by the prevailing wind and remain or patrol on the other side of the boat probably due to the air current.

(4) The insects attracted by the lights of the wharf should carefully be checked and excluded. It was found, that at Haneda in Tokyo Bay some usual migratory insects were included among those attracted by the lights when the boat anchored at some distance from the shore.

24. An improvement of STD real time operation

by

T. Nakai, H. Hasumoto and T. Ishii

An experiment on STD real time operation was made in the cruise of KH-71-1 (Preliminary Report of the Hakuhō Maru Cruise KH-71-1, in print). In present cruise, the program was improved and the form of type out data was also modified.

Salinity and temperature were printed for every 10-m depth by this STD-computer system. Raw data (data for every one second) was also able to be obtained when necessary.

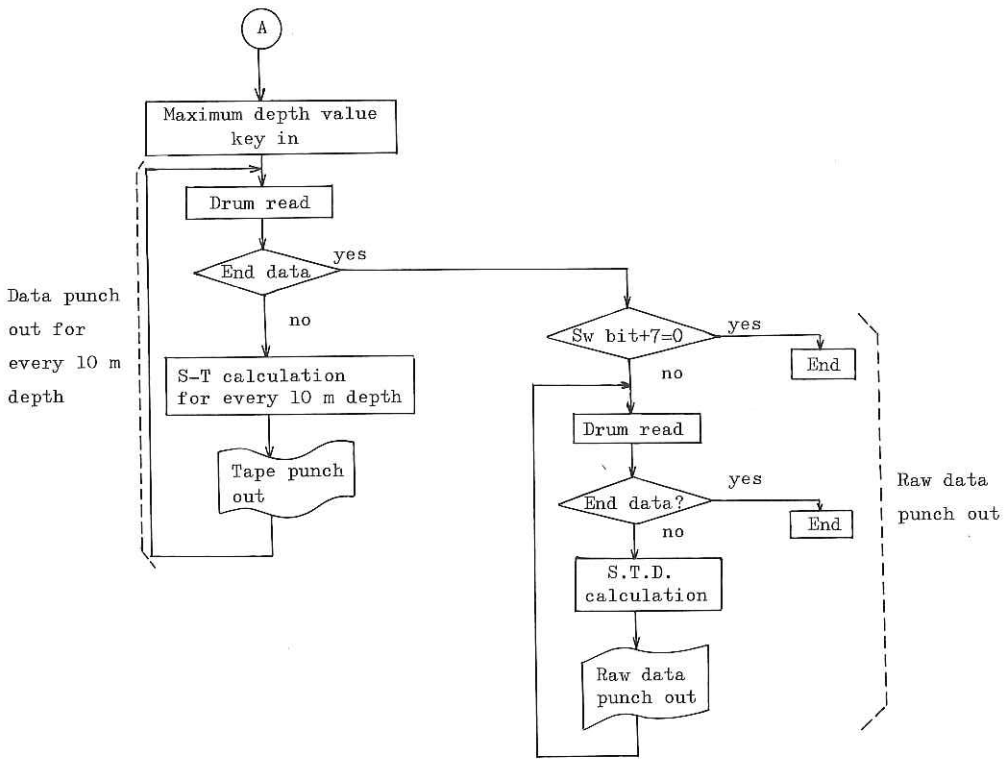
Correction can be made for depth by DSET program and for salinity and temperature by STSET program.

The test was made three times by this improved program at the following stations, and good data were resulted.

We are indebted to Mr. T. Igarashi of Ocean Research Institute, for his kind assistance for completing STD real time operation system in previous cruise.

Station	STD-1	STD-2	STD-3
Date	1971-5-25	1971-5-28	1971-5-29
Time	20:08-21:30	08:06-09:10	22:18-23:30
Lat. N	24°12.5'	24°03.7'	24°12.0'
Long. E	126°32.7'	126°33.1'	126°36.0'
Lowering depth	1200 m	800 m	600 m

The flow chart of the improved part in the present program



Explanation of data

Data from Nansen casts (Tables 1-7)

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

Depth: reading of PDR without correction

Current: measured with GEK

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

O_2: measured by the method described in Manual of Oceanographic Observations (Oceanog. Soc. Japan, 1963)

PO_4^{-3}-P: measured by the method of Murphy and Riley (Anal. Chim. Acta, 27, 31, 1962)

SiO_2-Si: measured by the method described in Manual of Oceanographic Observations (Oceanogr. Soc. Japan, 1963)

NO_3^--N: measured by the method of Bendschneider and Robinson (J. Mar. Res., 11, 87, 1952)

NH_4^+-N: measured by the method of Sagi (Ocean. Mag., 13, 43, 1966) modified by A. Hattori and E. Wada

Chl. (Chlorophyll a): measured by the fluorometric method of Yentsch and Menzel (Deep-Sea Res., 10, 221, 1963)

Data from BT observations (Table 8)

T°C at max. dep.: reading at the deepest point on BT trace

SLD (surface layer depth): thickness of surface isothermal layer

Table 1. Data from Nansen casts at Sts. 1 and 2

Station	Latitude	Longitude	Date	Ship time
1	32-01N	125-00E	May 10, 1971	10:18~10:53

Depth 50 m	Current	Transp. 12 m	Air temp. 15.4°C
Wind SSE-4	Sea SSE-2	Swell SW-1	Weather clear

D (m)	T (°C)	S (‰)	σ_t	O_2 (ml/l)	O_2Sat (%)	PO_4-P	SiO_2-Si	NO_3-N	NO_2-N	NH_4-N	Chl.a (μg/l)
						(μg atoms/l)					
0	13.4	31.806	23.39	6.37	104	0.3	8	0.15	0.00	0.37	0.54
5	13.41	800	23.39	6.38	104	0.3	10	0.57	0.04	0.37	0.24
10	12.26	817	24.11	6.75	108	0.3	9	0.76	0.02	0.15	0.31
15	11.44	852	24.26	6.84	107	0.4	9	0.68	0.11	0.26	1.68
20	10.11	922	24.56	6.59	101	0.6	9	0.97	0.50	0.44	0.87
25	10.02	947	24.58	6.59	101	0.6	9	1.6	0.57	0.38	0.59
30	10.02	955	24.58	5.20	80	0.7	11	1.8	0.53	0.30	0.74
35	10.01	952	24.58	6.50	99	0.7	10	2.5	0.50	0.52	0.70
40	10.00	951	24.60	6.64	102	0.6	13	1.9	0.53	0.32	0.82
45	10.02	954	24.60	5.40	83	1.0	13	1.7	0.75	0.19	0.93

Station	Latitude	Longitude	Date	Ship time
2	30-02N	125-00E	May 11, 1971	03:40~04:12

Depth 63 m	Current	Transp. 12 m	Air temp. 15.4°C
Wind ESE-4	Sea SSE-2	Swell SW-1	Weather cloudy

D (m)	T (°C)	S (‰)	σ_t	O_2 (ml/l)	O_2Sat (%)	PO_4-P	SiO_2-Si	NO_3-N	NO_2-N	NH_4-N	Chl.a (μg/l)
						(μg atoms/l)					
0	17.0	33.951	24.75	5.91	104	0.1	3	0.17	0.00^+	0.29	0.36
10	16.13	34.023	24.98	5.88	102	0.1	8	0.01	0.00^+	0.25	0.28
20	15.32	34.074	25.21	5.87	101	0.1	8	0.25	0.00^+	0.24	0.31
29	12.97	34.243	25.84	6.01	99	0.2	8	0.32	0.09	0.26	0.56
39	12.96	34.251	25.85	5.94	98	0.2	7	0.29	0.09	0.35	0.55
49	12.95	34.252	25.85	6.00	99	0.2	8	0.29	0.09	1.2	0.53

Table 2. Data from Nansen casts at Sts. 3 and 4

Station	Latitude	Longitude	Date	Ship time
3	28-00N	124-59E	May 11, 1971	18:38~19:10

Depth 107 m	Current	Transp. 22 m	Air temp. 21.3°C
Wind ESE-4	Sea ESE-3	Swell ESE-3	Weather cloudy

D (m)	T (°C)	S (‰)	σ_t	O_2 (ml/l)	O_2Sat (%)	PO_4-P	SiO_2-Si	NO_3-N	NO_2-N	NH_4-N	Chl.a
						(μg atoms/l)					(μg/l)
0	19.8	33.538	23.72	5.41	92	0.1	5	0.01	0.00	0.19	0.14
10	20.00	538	23.68	5.37	100	0.1	6	0.01	0.00	0.24	0.12
20	20.04	663	23.76	5.35	99	0.1	6	0.01	0.00+	0.20	0.11
30	19.58	764	23.94	5.39	99	0.1	5	0.01	0.00	0.00	0.16
50	17.58	487	24.25	5.36	95	0.2	7	0.01	0.09	0.27	0.47
75	17.36	34.365	24.97	4.11	73	0.6	15	6.78	0.07	0.16	0.12
100	17.45	431	24.99	3.91	70	0.6	15	6.89	0.06	0.25	0.15

Station	Latitude	Longitude	Date	Ship time
4	26-02N	125-04E	May 12, 1971	10:30~13:00

Depth 1690 m	Current 60° 1.9 kt	Transp. 18 m	Air temp 23.6°C
Wind ESE-5	Sea ESE-4	Swell SE-4	Weather overcast

D (m)	T (°C)	S (‰)	σ_t	O_2 (ml/l)	O_2Sat (%)	PO_4-P	SiO_2-Si	NO_3-N	NO_2-N	NH_4-N	Chl.a
						(μg atoms/l)					(μg/l)
0	24.8	34.617	23.13	4.72	95	0.1	9	0.17	0.03	0.25	0.13
9	24.85	587	10	4.77	96	0.0	16	0.20	0.00	0.97	0.13
18	24.84	586	10	4.71	95	0.0	12	0.21	0.03	0.93	0.13
27	24.86	588	09	4.74	96	0.1	19	0.17	0.02	0.29	0.11
45	24.83	586	09	4.69	95	0.1	21	0.31	0.04	0.14	0.11
59	24.58	595	19	4.66	94	0.1	17	0.38	0.05	0.91	0.15
78	23.58	625	51	4.60	86	0.4	11	0.83	0.14	0.25	0.17
98	22.87	632	72	4.44	87	0.3	11	1.7	0.27	0.25	0.11
118	22.52	676	85	4.36	85	0.3	8	4.9	0.20	1.1	0.05
138	21.96	723	24.05	4.36	84	0.3	14	2.0	0.18	0.26	0.05
158	21.09	732	31	4.20	80	0.3	15	2.3	0.09	0.60	0.05
200	18.57	705	95	4.11	75	0.5	22	5.8	0.08	0.42	0.03
244	15.84	639	25.53	3.83	67	0.6	28	8.2	0.10	0.29	0.01
259	15.19	634	69	3.82	66	0.9	25	8.7	0.00+	0.51	-
303	12.76	497	26.08	3.68	60	1.2	33	13.1	0.05	0.39	-
478	7.32	334	74	2.59	38	2.2	80	22.8	0.04	0.45	-
633	5.96	354	27.07	2.46	35	2.5	97	27.1	0.05	0.20	-
786	5.09	380	21	1.93	28	2.7	107	28.1	0.05	0.59	-
1150	4.02	427	36	1.72	24	2.8	123	27.3	0.05	0.31	-

Table 3. Data from Nansen casts at Sts. 5 and 6

Station	Latitude	Longitude	Date	Ship time
5	24-02N	124-55E	May 13, 1971	09:57~12:30

Depth 2450 m	Current 356° 0.1 kt	Transp.	Air temp. 23.8°C
Wind E-3	Sea E-3	Swell ESE-3	Weather rainy

D (m)	T (°C)	S (‰)	σ_t	O_2 (ml/l)	O_2Sat (%)	PO_4-P	SiO_2-Si	NO_3-N	NO_2-N	NH_4-N	Chl.a (μg/l)
						(μg atoms/l)					
0	23.5	34.750	23.61	4.78	94	0.1	11	0.15	0.00	0.46	0.09
10	23.62	750	62	4.96	98	0.0	10	0.20	0.00	0.28	0.10
19	23.59	755	61	4.91	97	0.0	10	0.21	0.00	0.49	0.09
29	23.54	741	61	4.86	96	0.1	10	0.15	0.01	0.15	0.09
48	23.48	747	62	4.92	97	0.0	10	0.17	0.01	0.30	0.10
72	23.30	767	70	5.20	102	0.1	14	0.20	0.04	0.39	0.13
95	22.41	748	92	4.98	97	0.0	18	0.15	0.00	0.26	0.19
119	21.79	771	24.13	4.86	93	0.1	11	0.31	0.17	0.26	0.20
143	21.28	788	29	4.62	88	0.1	14	1.03	0.14	0.30	0.09
168	20.90	813	43	4.51	84	0.3	16	1.98	0.02	0.23	0.04
192	20.39	828	87	4.48	84	0.1	8	2.49	0.01	0.13	0.06
241	18.76	853	25.01	4.41	81	0.3	10	1.77	0.03	0.11	0.02
289	17.81	833	20	4.58	82	0.4	11	1.99	0.01	0.36	-
377	15.55	687	62	4.39	76	0.7	15	7.8	0.03	0.08	-
432	13.70	534	91	-	-	1.0	18	10.1	0.03	0.28	-
525	10.56	327	26.34	4.21	66	1.5	36	14.8	0.00	0.09	-
618	7.97	316	77	3.62	54	2.2	64	21.2	0.03	0.15	-
805	5.10	372	27.19	2.71	38	2.8	103	28.2	0.02	0.09	-
993	3.86	473	40	1.86	25	3.0	122	28.2	0.02	0.10	-
1468	2.41	579	68	1.91	25	3.0	145	28.0	0.03	0.03	-
1950	1.96	636	71	2.20	29	2.9	147	24.5	0.03	0.19	-

Station	Latitude	Longitude	Date	Ship time
6	22-01N	125-00E	May 14, 1971	09:10~11:50

Depth 5900 m	Current 330° 0.7 kt	Transp. 24 m	Air temp 23.6°C
Wind ENE-3	Sea ENE-2	Swell E-3	Weather rainy

D (m)	T (°C)	S (‰)	σ_t	O_2 (ml/l)	O_2Sat (%)	PO_4-P	SiO_2-Si	NO_3-N	NO_2-N	NH_4-N	Chl.a (μg/l)
						(μg atoms/l)					
0	25.0	34.495	22.97	4.73	96	0.0	11	0.05	0.00+	0.10	0.12
10	25.05	507	97	4.67	95	0.0	13	0.04	0.01	0.14	0.11
19	25.12	607	23.01	4.69	95	0.0	8	0.11	0.01	0.11	0.11
29	24.98	691	08	4.72	97	0.0	9	0.06	0.02	0.28	0.09
48	24.02	711	44	4.75	95	0.0	12	0.07	0.01	0.13	0.13

Table 4. Data from Nansen casts at Sts. 6 and 7

Station	Latitude	Longitude	Date	Ship time
6	22-01N	125-00E	May 14, 1971	09:10~11:50

Depth 5900 m	Current 330° 0.7 kt	Transp. 24 m	Air temp. 23.6°C
Wind ENE-3	Sea ENE-2	Swell E-3	Weather rainy

D (m)	T (°C)	S (‰)	σ_t	O_2 (ml/l)	O_2Sat (%)	PO_4-P	SiO_2-Si	NO_3-N	NO_2-N	NH_4-N	Chl.a (μg/l)
						(μg atoms/l)					
72	22.56	34.779	23.92	4.71	92	0.0	10	0.05	0.02	0.20	0.14
96	21.86	834	24.15	4.54	87	0.1	8	0.17	0.13	0.40	0.15
120	21.14	844	35	4.40	84	0.2	12	1.67	0.13	0.19	0.14
144	20.79	872	49	4.27	81	0.2	8	1.94	0.06	0.44	0.11
168	20.02	892	70	4.32	82	0.2	8	2.3	0.01	0.26	0.06
192	18.99	867	96	4.21	77	0.3	12	3.0	0.01	0.24	0.02
240	17.53	826	25.02	4.41	79	0.4	13	4.2	0.03	0.25	0.03
288	16.54	770	47	3.85	68	0.4	13	4.9	0.02	0.19	0.05
384	14.21	573	83	4.21	71	0.4	12	8.0	0.02	0.10	-
480	11.25	351	26.20	3.82	61	1.2	24	13.9	0.02	0.41	-
571	8.50	195	59	3.34	50	1.8	47	20.6	0.02	0.64	-
762	5.49	219	27.02	1.87	26	2.7	88	28.3	0.02	0.18	-
952	4.23	393	29	1.56	21	2.9	117	29.8	0.01	0.31	-
1430	2.83	560	58	2.18	29	2.8	140	30.1	0.02	0.20	-
1909	2.23	614	67	2.56	34	2.8	146	29.0	0.02	0.21	-
2391	1.86	647	72	2.96	38	2.7	147	28.3	0.06	0.24	-
2879	1.64	665	75	3.30	43	2.7	149	26.9	0.04	0.24	-

Station	Latitude	Longitude	Date	Ship time
7	20-02N	124-56E	May 15, 1971	08:15~11:15

Depth 5700 m	Current 303° 1.4 kt	Transp.	Air temp. 26.4°C
Wind NE-4	Sea NE-3	Swell NE-3	Weather fine

D (m)	T (°C)	S (‰)	σ_t	O_2 (ml/l)	O_2Sat (%)	PO_4-P	SiO_2-Si	NO_3-N	NO_2-N	NH_4-N	Chl.a (μg/l)
						(μg atoms/l)					
0	27.2	34.403	22.23	4.64	98	0.1	4	0.06	0.00	0.20	0.01
9	27.20	392	23	4.70	99	0.1	4	0.06	0.00	0.28	0.06
17	27.18	388	23	4.73	99	0.1	7	0.02	0.02	0.25	0.07
26	27.16	411	24	4.62	97	0.1	5	0.06	0.00	0.21	0.09
42	25.82	565	79	4.91	100	0.1	5	0.08	0.00	0.15	0.08
63	24.91	598	23.08	4.57	93	0.1	4	0.06	0.00	0.26	0.09
83	24.81	751	24	4.85	98	0.1	5	0.08	0.00	0.19	0.13
103	24.09	874	54	4.68	93	0.1	8	0.21	0.04	0.23	0.31
123	23.57	894	71	4.92	97	0.2	4	0.85	0.04	0.60	0.23

Table 5. Data from Nansen casts at Sts. 7 and 9-1

Station	Latitude	Longitude	Date	Ship time
7	20-02N	124-56E	May 15, 1971	08:15~11:15

Depth 5700 m	Current 303° 1.4 kt	Transp.	Air temp. 26.4°C
Wind NE-4	Sea NE-3	Swell NE-3	Weather fine

D (m)	T (°C)	S (‰)	σ_t	O_2 (ml/l)	O_2Sat (%)	PO_4-P	SiO_2-Si	NO_3-N	NO_2-N	NH_4-N	Chl.a
						(μg atoms/l)					(μg/l)
141	22.82	34.884	23.92	4.67	91	0.1	5	0.83	0.04	0.26	0.14
160	22.11	821	24.08	4.56	88	0.1	9	0.66	0.13	0.21	0.10
197	20.54	904	56	4.36	82	0.4	7	2.7	0.02	0.23	-
235	18.95	862	96	4.38	80	0.4	10	3.6	0.00	0.25	-
314	I6.94	792	25.39	4.46	79	0.4	10	9.6	0.00	0.18	-
404	13.77	555	91	3.99	67	0.9	20	9.2	0.00	0.28	-
518	9.17	220	26.52	3.57	54	1.8	38	11.4	0.02	0.18	-
607	7.38	207	63	2.50	37	2.3	57	20.4	0.00	0.25	-
782	5.17	313	27.13	1.85	26	2.8	94	24.2	0.00	0.16	-
959	4.14	475	38	2.00	27	2.8	115	18.8	0.02	0.20	-
1396	2.78	571	59	2.32	27	2.8	137	25.6	0.02	0.25	-
1840	2.24	625	67	2.64	35	2.9	143	24.5	0.00	0.18	-
2304	1.85	651	73	2.92	38	2.8	147	20.7	0.04	0.30	-
2792	1.68	666	75	3.24	42	2.8	147	21.1	0.02	0.25	-

Station	Latitude	Longitude	Date	Ship time
9-1	22-05N	125-04E	May 16, 1971	17:25~18:05

Depth 5670 m	Current 342° 1.2 kt	Transp.	Air temp. 24.8°C
Wind ENE-3	Sea ENE-3	Swell NE-3	Weather fine

D (m)	T (°C)	S (‰)	σ_t	O_2 (ml/l)	O_2Sat (%)	PO_4-P	SiO_2-Si	NO_3-N	NO_2-N	NH_4-N	Chl.a
						(μg atoms/l)					(μg/l)
0	25.4	34.602	22.95	4.93	100	0.1	6	-	0.01	0.41	0.09
10	25.36	631	97	4.79	98	0.1	6	-	0.00	0.36	0.08
21	25.10	606	23.06	5.05	102	0.1	5	0.3	0.03	0.24	0.11
31	25.09	642	07	4.74	96	0.1	5	0.4	0.02	0.37	0.08
52	24.97	721	16	4.81	98	0.1	8	0.5	0.02	0.17	0.10
78	23.90	775	52	5.05	100	0.1	7	0.4	0.03	0.34	0.12
104	22.75	777	87	4.87	95	0.1	8	-	0.02	0.32	0.18
131	22.02	805	24.09	4.70	91	0.1	4	0.2	0.07	0.31	0.32
156	21.22	858	34	4.39	84	0.2	5	1.7	0.15	0.35	0.22
173	19.51	891	83	4.46	83	0.3	8	1.2	0.04	0.41	0.06
209	18.92	900	98	4.46	82	0.3	7	2.7	0.03	0.22	0.04
263	17.61	838	25.26	4.41	79	0.5	8	3.1	0.05	0.24	0.02
316	16.38	765	50	4.47	78	0.6	11	5.1	0.02	0.31	-

Table 6. Data from Nansen casts at Sts. 9-2 and 10-1

Station	Latitude	Longitude	Date	Ship time
9-2	22-01N	125-00E	May 18, 1971	06:15~07:05

Depth	Current 342° 1.2 kt	Transp. 36 m	Air temp. 25.8°C
Wind E-4	Sea E-3	Swell E-2	Weather fine

D (m)	T (°C)	S (‰)	σ_t	O_2 (ml/l)	O_2Sat (%)
0	26.7	34.519	22.47	4.24	97
9	26.54	520	54	4.25	100
19	26.56	523	54	4.23	97
47	25.22	677	23.05	4.27	96
70	24.80	674	17	4.26	96
94	23.30	792	71	4.24	94
118	22.58	797	92	4.43	93
142	21.72	808	24.17	4.43	92
166	20.82	868	45	4.23	86
190	19.96	868	71	4.14	87
238	18.34	855	25.10	4.11	75
287	17.12	807	36	4.10	72

Station	Latitude	Longitude	Date	Ship time
10-1	24-09N	126-29E	May 26, 1971	05:55~06:40

Depth 2252 m	Current 22° 1.0 kt	Transp.	Air temp. 27.0°C
Wind SE-3	Sea SE-2	Swell SSE-3	Weather cloudy

D (m)	T (°C)	S (‰)	σ_t	O_2 (ml/l)	O_2Sat (%)	PO_4-P	SiO_2-Si	NO_3-N	NO_2-N	NH_4-N	Chl.a
						(μg atoms/l)					(μg/l)
0	26.6	34.592	22.19	4.50	94	0.0	3	0.42	0.00	1.50	0.08
10	26.68	584	16	4.66	97	0.0	4	0.06	0.00^+	0.56	0.07
19	25.86	611	44	4.89	100	0.0	4	0.16	0.01	0.57	0.07
29	25.20	649	23.04	4.86	99	0.0	4	0.16	0.01	0.50	0.07
47	24.61	725	28	4.86	88	0.0	5	0.27	0.01	0.65	0.08
70	22.92	780	81	4.82	84	0.1	6	0.11	0.01	0.60	0.14
92	21.95	804	24.12	4.66	89	0.0	4	0.16	0.37	0.55	0.26
115	21.30	846	32	4.54	87	0.1	5	1.34	0.09	0.50	0.17
138	20.38	880	60	4.46	78	0.1	5	1.80	0.04	0.47	0.08
160	19.68	887	79	4.36	81	0.3	6	3.2	0.02	0.60	-
183	18.90	860	97	4.38	80	0.3	6	3.4	0.00^+	0.30	0.16
228	17.78	843	25.24	4.52	81	0.4	6	3.4	0.00	0.17	0.18
273	16.70	781	44	4.53	80	0.5	7	5.2	0.00	0.40	0.16

Table 7. Data from Nansen cast at St. 10-2

Station	Latitude	Longitude	Date	Ship time
10-2	24-11N	126-36E	May 29, 1971	07:18~07:53

Depth 3500 m	Current	Transp.	Air temp. 27.6°C
Wind SSE-3	Sea SSE-2	Swell 2	Weather clear

D (m)	T (°C)	S (‰)	σ_t	O_2 (ml/l)	O_2Sat	PO_4-P	SiO_2-Si	NO_3-N	NO_2-N
						(μg atoms/l)			
0	28.3	34.413	21.89	4.52	97	0.0	4	0.09	0.00
9	27.86	402	22.03	4.42	94	0.1	4	0.05	0.01
18	26.20	615	69	4.74	98	0.0	1	0.11	0.00+
28	25.53	669	95	4.68	96	0.0	4	0.14	0.01
46	24.67	692	23.25	4.68	95	0.0	3	0.02	0.00
69	23.70	776	59	4.58	91	0.0	6	0.04	0.00
92	22.63	869	96	4.35	85	0.1	4	1.0	0.06
116	21.49	878	24.32	4.34	83	0.2	3	1.6	0.03
141	20.80	876	48	4.60	88	0.2	4	1.9	0.04
165	20.01	882	68	4.74	88	0.2	4	1.8	0.03
190	19.50	891	84	4.34	80	0.3	5	2.8	0.01
237	17.76	846	25.23	4.54	82	0.4	9	3.5	0.01
282	16.91	800	40	4.35	77	0.4	7	4.6	0.00

Table 8. Data from BT observations

Station	Latitude	Longitude	Date	Ship time	Temp. (°C) 0	10	20	30	50	75	100	125	150	175	200	250	Max. depth D(m)	T(°C)	SLD (m)
1	32-00N	125-00E	May 10, 1971	09:56	13.4	12.5	10.4	10.0	10.0	-	-	-	-	-	-	-	51	10.0	0
2	30-00	124-59	11	01:00	17.2	16.7	15.3	13.1	12.9	-	-	-	-	-	-	-	63	12.9	6
3	28-00	125-00	11	18:14	19.9	19.9	19.8	20.0	17.6	17.4	17.6	-	-	-	-	-	110	17.6	30
4	26-00	125-01	12	10:15	24.9	24.9	24.9	24.9	24.9	24.9	23.5	22.8	22.4	21.2	18.8	15.4	260	14.6	83
5	24-02	124-54	13	09:49	23.6	23.6	23.6	23.5	23.5	23.4	22.7	22.1	21.4	20.9	20.5	18.9	260	18.2	90
6	22-01	125-00	14	09:00	25.0	25.0	25.0	25.0	24.8	23.6	22.2	21.4	20.8	20.1	19.2	17.6	261	17.0	65
7	20-01	124-58	15	08:03	27.2	27.2	27.2	27.2	26.4	25.0	24.8	24.1	23.3	22.3	21.1	18.6	259	18.1	35
9-1	22-00	125-02	16	10:52	25.1	25.1	25.0	24.9	24.8	23.5	22.8	22.0	21.4	20.4	19.7	17.9	261	17.5	55
9-2	22-00	125-00	18	06:05	26.5	26.5	26.4	26.2	25.1	24.7	23.7	23.0	21.6	20.9	19.7	18.0	250	18.0	30
10-1	24-08	126-29	26	06:46	26.6	26.6	26.0	25.2	24.8	23.3	22.3	21.3	20.3	19.5	18.5	17.3	259	16.9	19
10-2	24-17	126-37	26	22:03	26.3	26.3	26.0	25.3	24.9	23.3	22.7	21.8	20.9	20.1	19.4	18.0	262	17.2	18
10-3	24-22	126-35	27	10:00	26.1	26.1	24.9	24.5	24.0	23.2	22.4	21.6	21.2	20.4	19.6	17.6	261	17.2	22
10-4	24-10	126-36	29	07:00	28.1	28.1	26.9	25.8	25.0	24.0	23.2	22.0	20.7	20.1	19.3	17.4	260	17.1	14

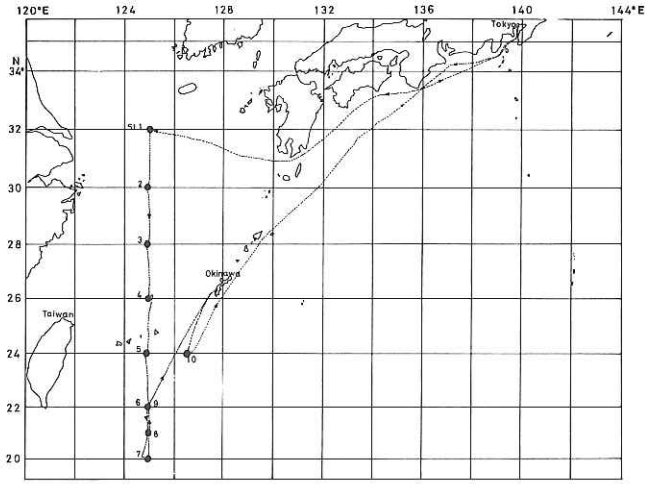


Fig. 1 Track chart of cruise KH-71-2

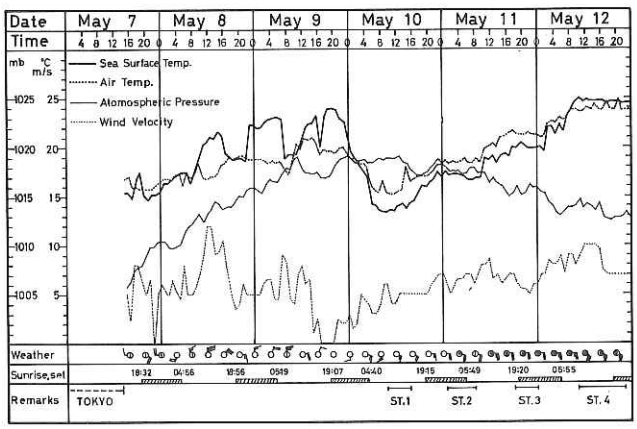


Fig. 2-1 General weather conditions

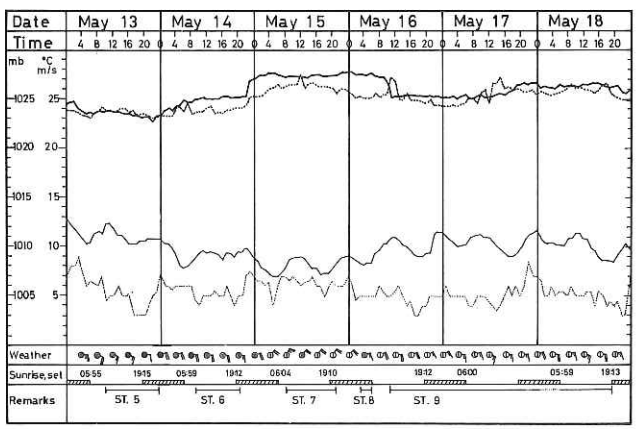


Fig. 2-2

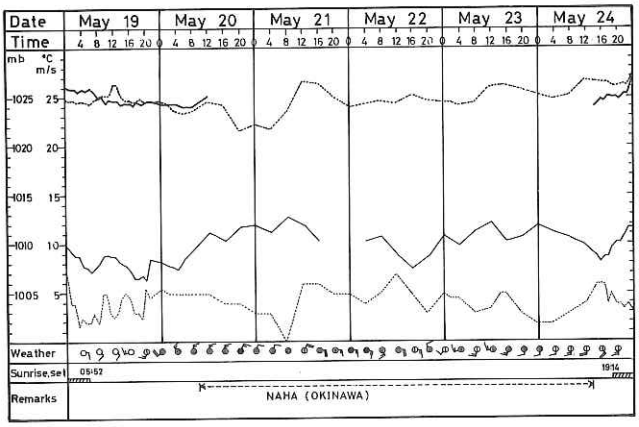


Fig. 2-3

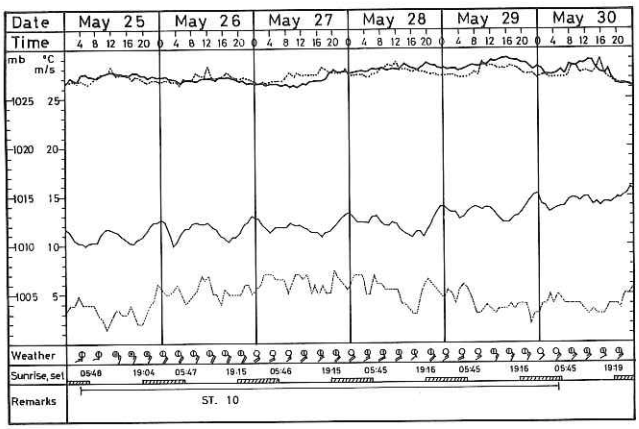


Fig. 2-4

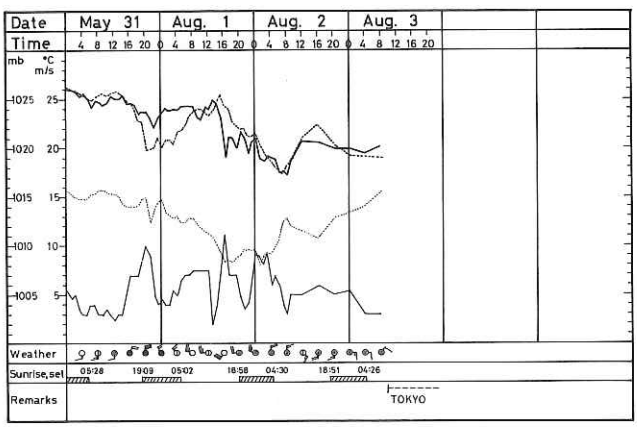


Fig. 2-5

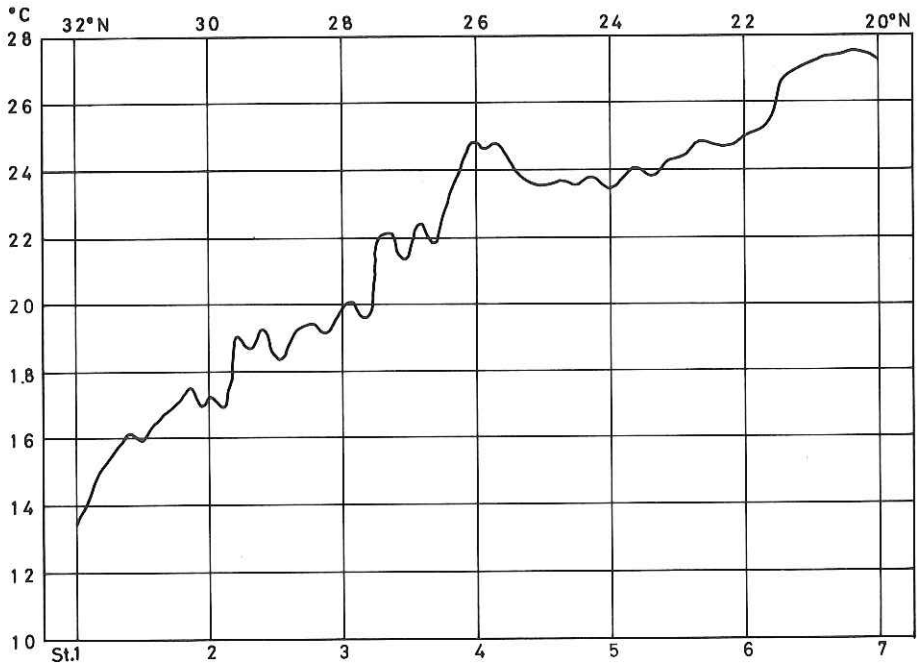


Fig. 3 Surface temperature along 125°E

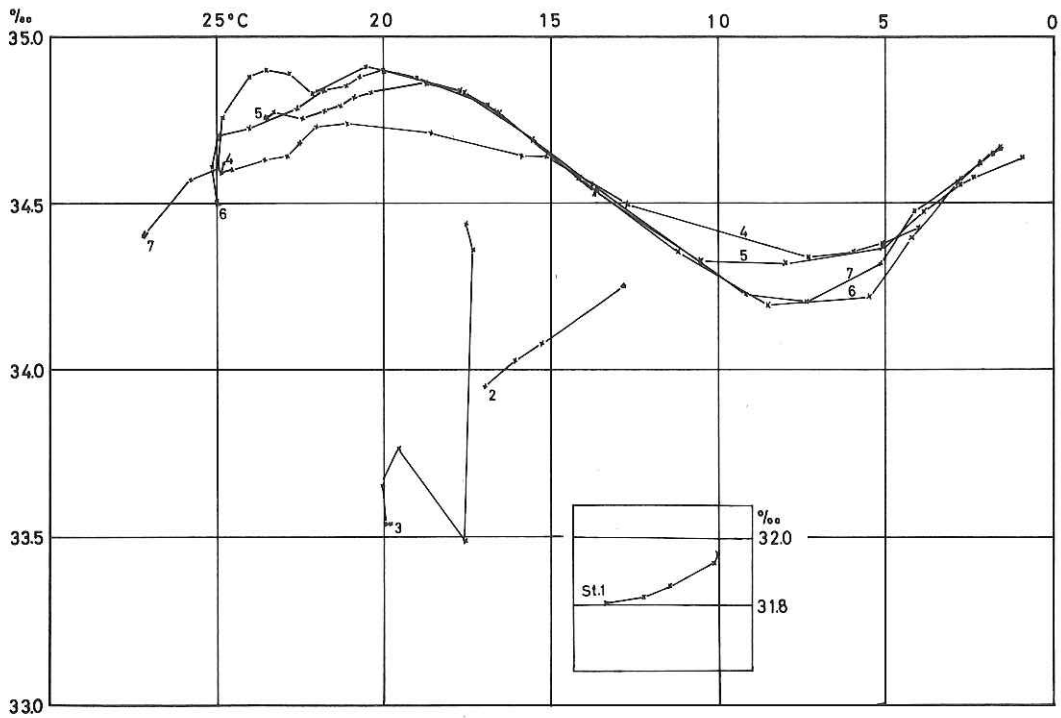


Fig. 4 T-S diagrams at Sts. 1-7

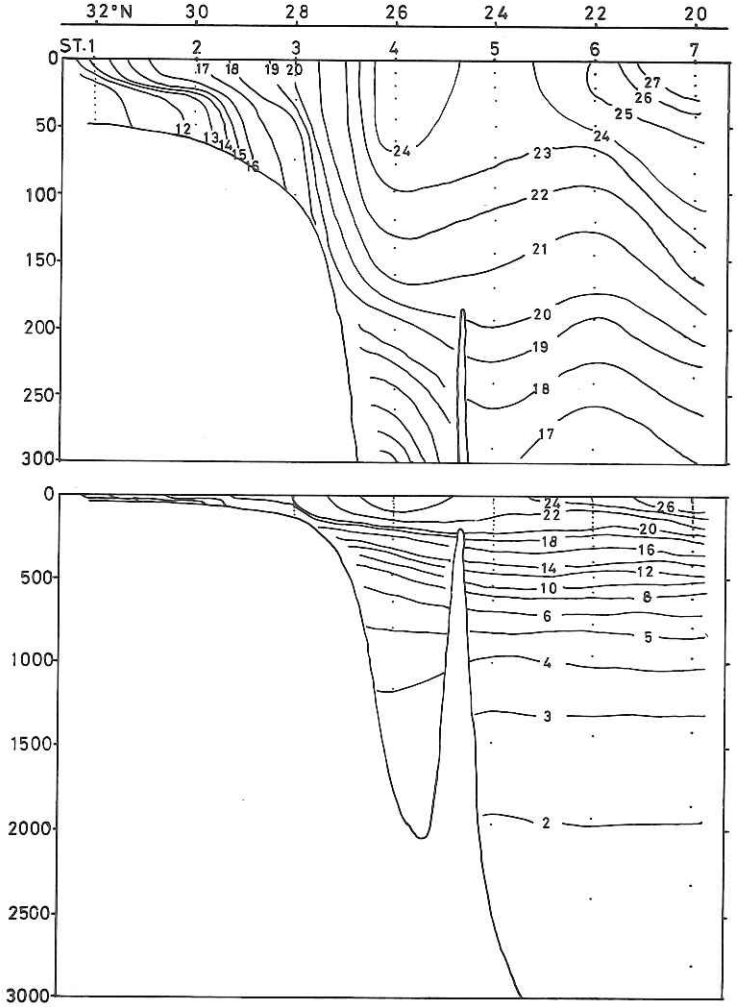


Fig. 5 Water temperature along 125°E

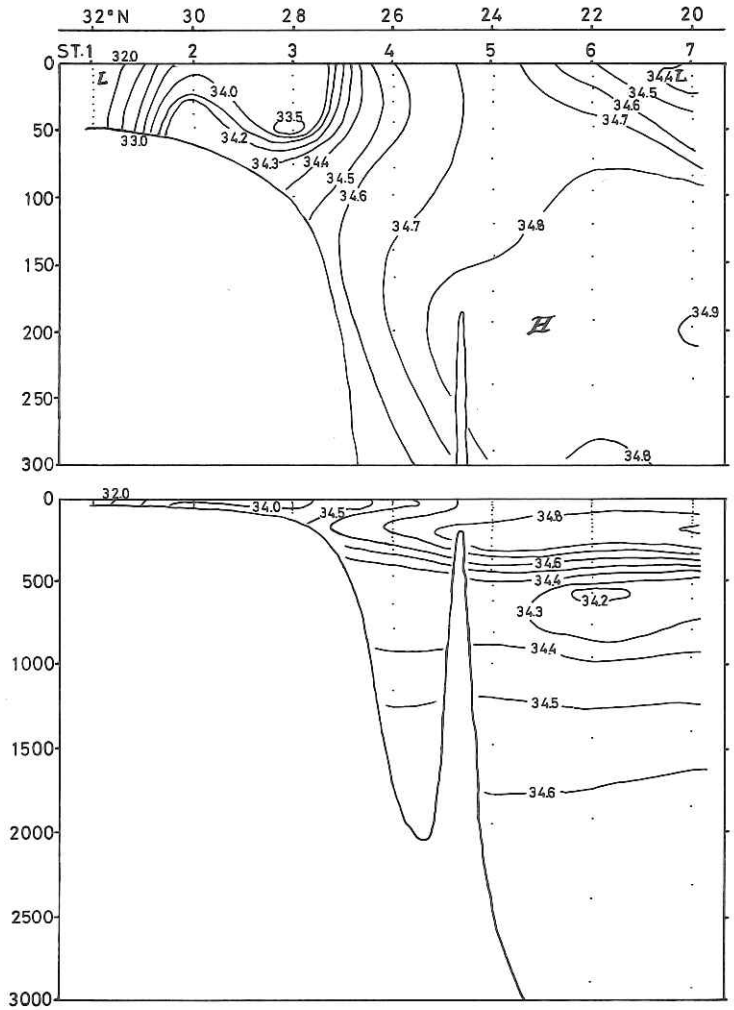


Fig. 6 Salinity (‰) along 125°E

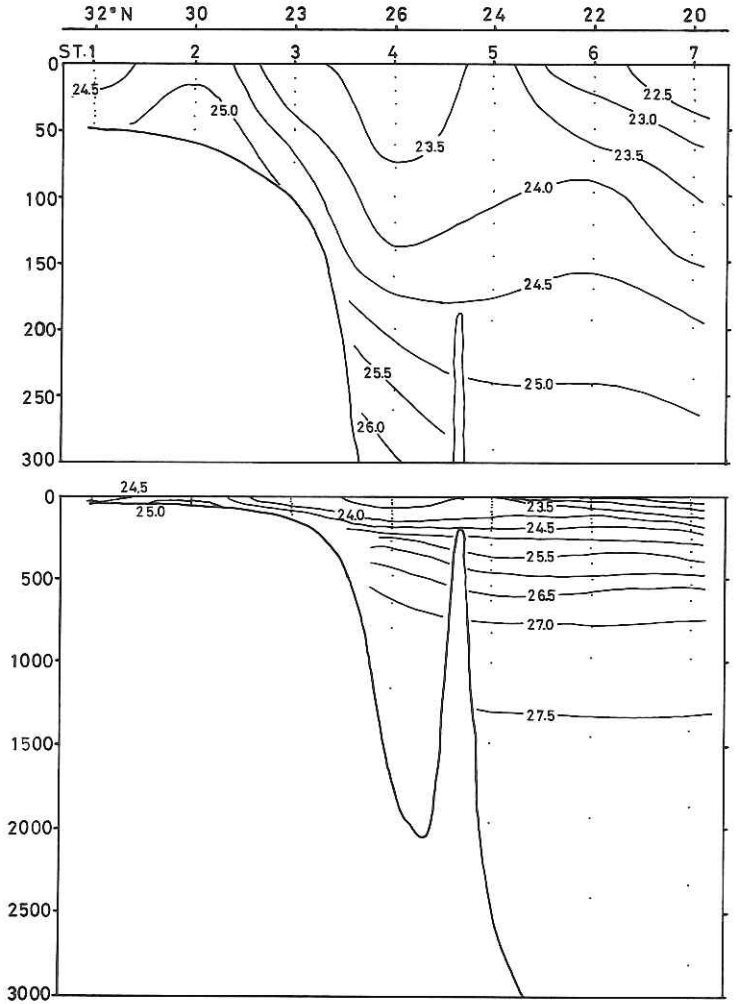


Fig. 7 σ_t along 125°E

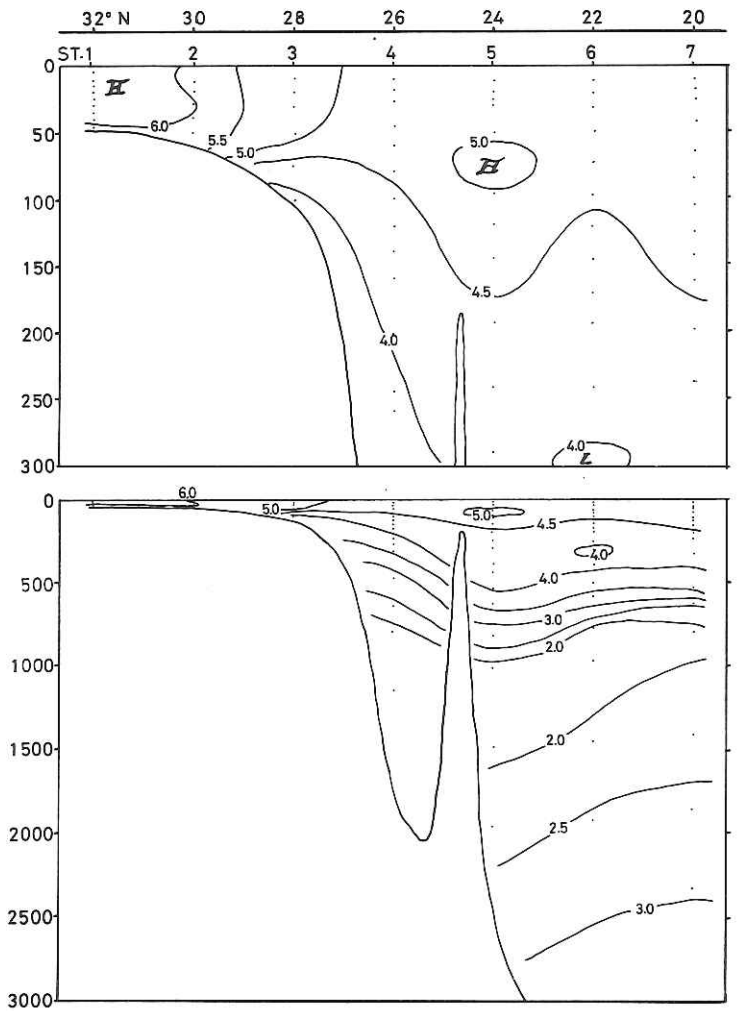


Fig. 8 Dissolved oxygen (ml/l) along 125°E

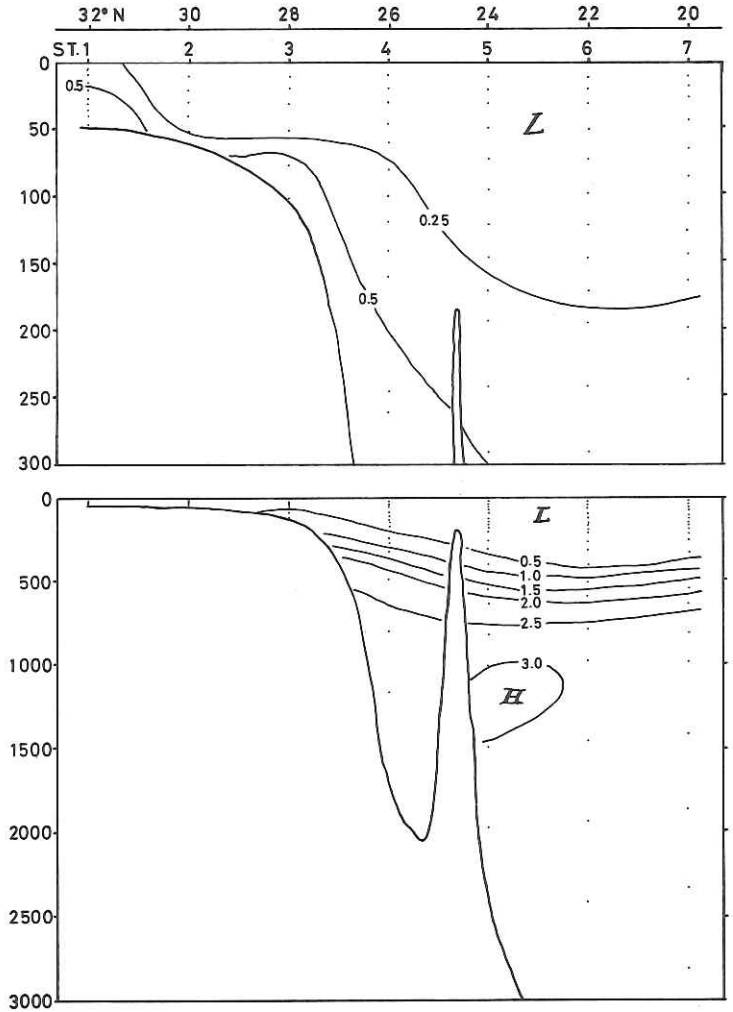


Fig. 9 Phosphate-P (μg atoms/l) along 125°E

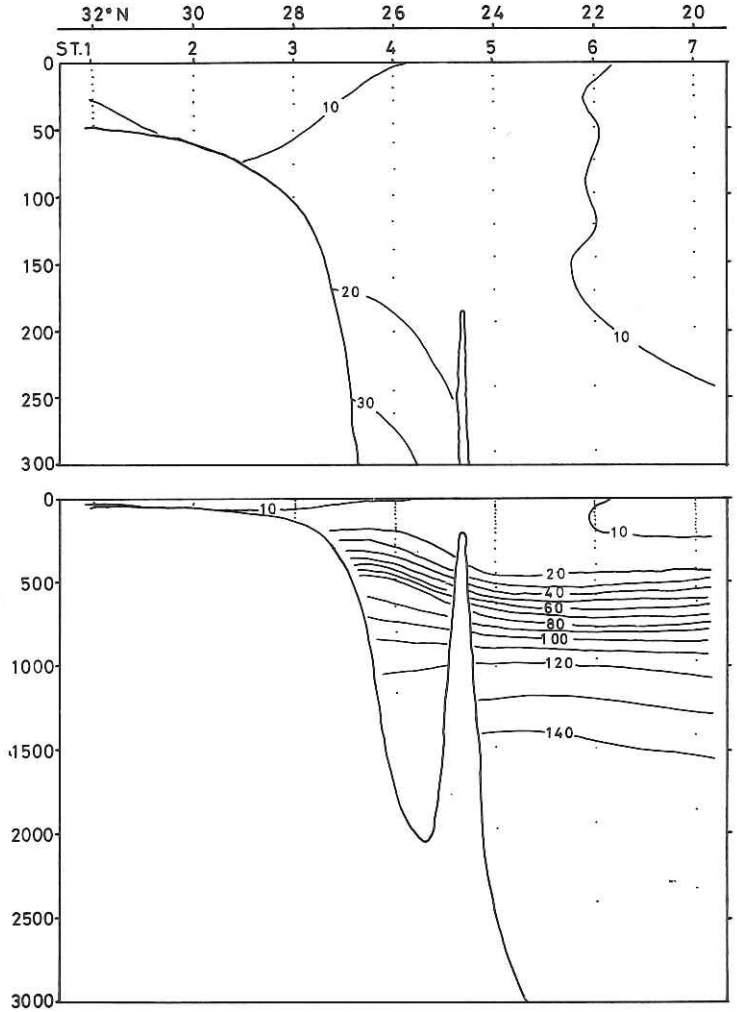


Fig. 10 Silicate-Si (μg atoms/l) along 125°E

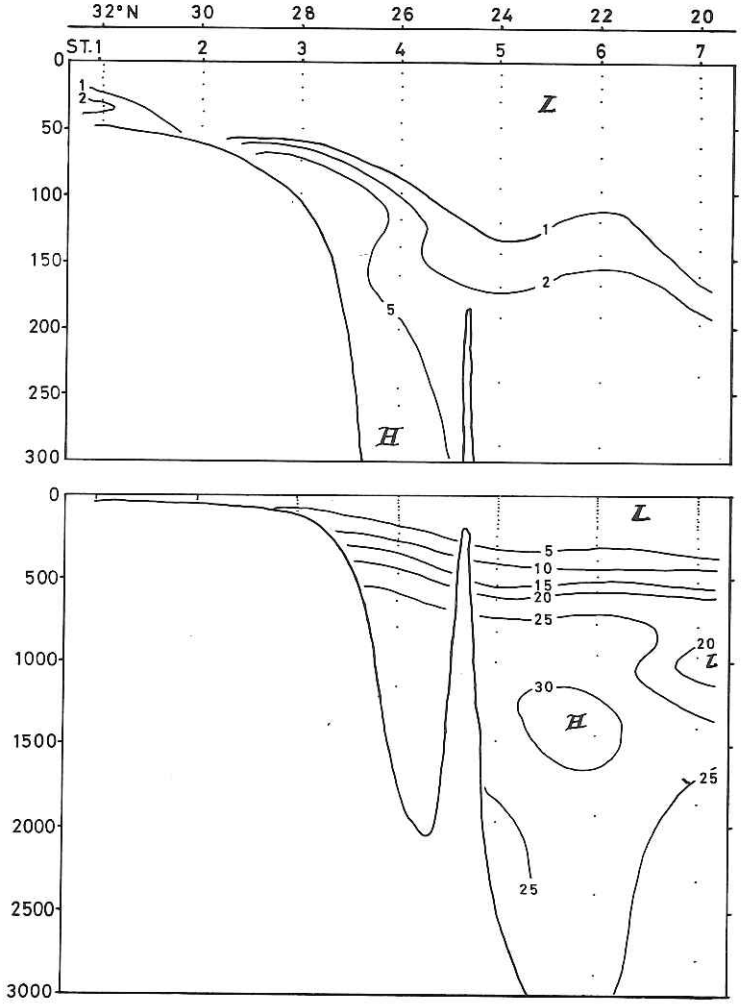


Fig. 11 NO_3-N (μg atoms/l) along 125°E

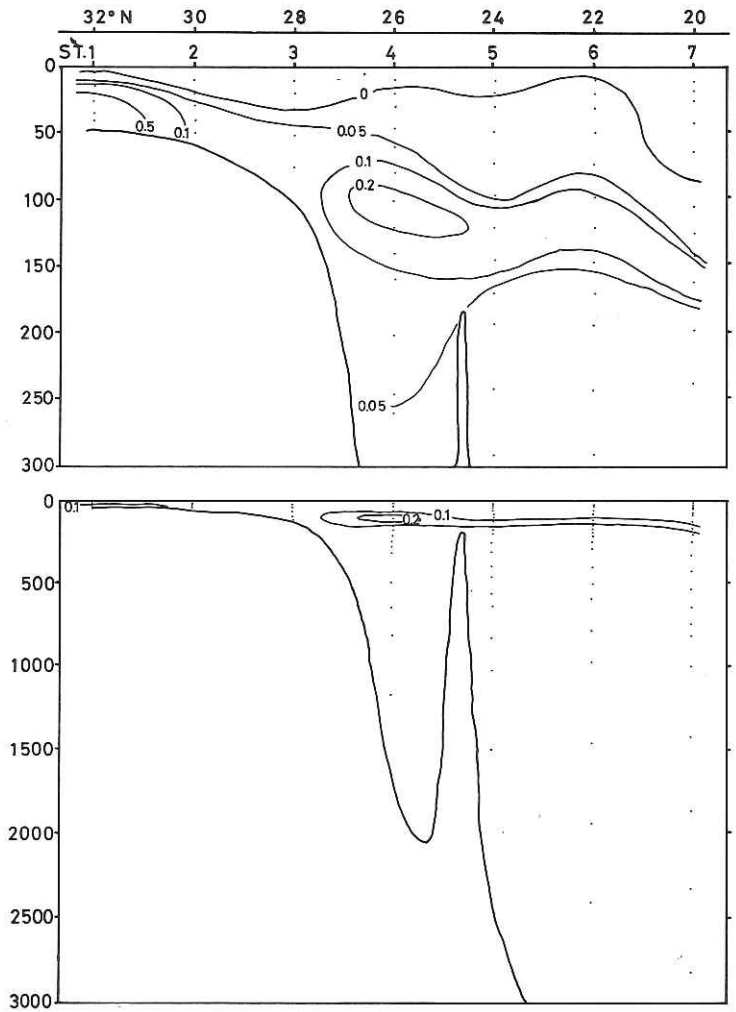


Fig. 12 NO_2-N (μg atoms/l) along 125°E

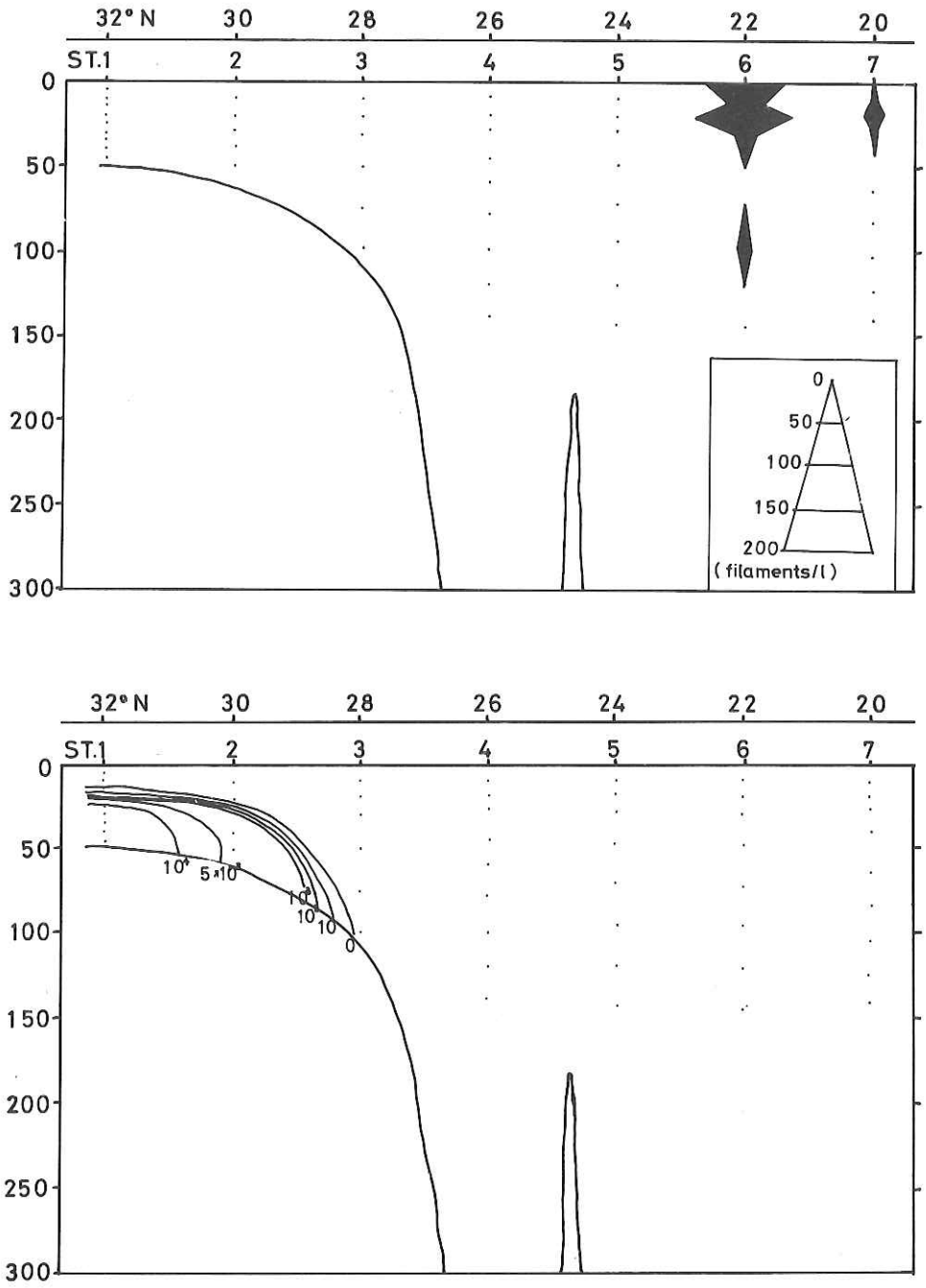


Fig. 13 Trichodesmium (filament/l) (upper) and Melosira (cell/l) (lower)