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# Environment at the Front Shore of the Institute of Algological Research of Hokkaido University\*

# By Makoto Mizuno\*\*

#### Introduction

The Institute of Algological Research of Hokkaido University is in Muroran City (42° 19' N; 141° 50' E) where is located at the northeastern part of the mouth of Uchiura-Wan (Volcano Bay), Hokkaido, Japan. Charatsunai shore, the front shore of the Institute, is mostly occupied by rocks. Many kinds of organisms including about 200 taxa of benthic algae richly grow there.

Staffs of the Institute and many visiting researchers investigate many algae growing there morphologically, physiologically and ecologically. Till now, two environmental factors in the shore, seawater temperature and specific gravity, have been recorded by the Institute. Besides those two factors, it has been expected to measure other environmental factors such as nutrients in seawater, pH of seawater, etc. for making clear the environment of this shore.

I studied autecologically a marine tube-dwelling diatom, *Berkeleya obtusa* (GREV.) GRUNOW, at Charatsunai shore in the doctor course of Hokkaido University. At that time, many environmental factors were measured at several points of the shore as the basical data for discussing the autecology of *B. obtusa*.

This paper reports some environmental factors of Charatsunai shore, and is a section of "Autecological studies on the marine tube-dwelling diatom *Berkeleya obtusa* (GREV.) GRUN."

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mental Science and Technology Center for their help with analytical technique and their encouragement.

## I Area surveyed and methods

#### 1. Area surveyed

The wide rocky flat with a size of ca.  $100 \text{ m} \times 50 \text{ m}$  juts out into the sea at the central part of Charatsunai shore. This flat is mostly 10–60 cm above the datum line, but has a large rock with a height of about 2 m at the middle portion of the flat. This flat emerges at low water. The other part of Charatsunai is the narrow, rugged shore consisting of rocks, shingles and pebbles and some rock pools are formed in this area at low water. At the east part of the shore, there is a small fall of fresh water.

The landward of the central flat and the rugged shore were decided as study areas. Temperature, pH and salinity of seawater were measured at one cleft and four pools in these areas (Figs. 1 and 2).



Fig. 1 Map of the research points of physico -chemical analyses. 1, the Cleft-1; 2, the Pool-1; 3, the Pool-2; 4, the Pool-3; 5, the Pool-4.



Fig. 2 Vertical distribution of the cleft and pools at Charatsunai. E. H. W. S., extreme high water spring; M. S. L., mean sea level; E. L. W. S., extreme low water spring. Data were obtained from tide table (Japan Meteorological Agency 1977). Cleft-1 (C-1) (Fig. 1-1) (10 cm above the datum line) was located at the north side of the central flat and many rocks emerging at low water were scattered in the cleft. The following plants grew abundantly there: *Alaria crassifolia* KJELLMAN, *Laminaria japonica* ARESCHOUG, *Sargassum confusum* C. AGARDH, *S. thunbergii* (MERTENS) O. KUNTZE, *Palmaria palmata* (LINNAEUS) STACKHOUSE, *Phyllospadix iwatensis* MAKINO, etc.

Pool-1 (P-1) (Fig. 1-2) (40 cm above the datum line) was located at the center of the landward of the central flat. *Neorhodomela aculeata* (PEREST.) MASUDA, *P. iwatensis*, etc. grew in this pool. This pool was 0.1 m deep and occupied an area of  $1 \text{ m} \times 1 \text{ m}$ .

Pool-2 (P-2) (Fig. 1-3) (60 cm above the datum line) was located at a most landward part of the central flat. This pool was 0.15 m deep and occupied an area of  $1.5 \text{ m} \times 1 \text{ m}$ . The bottom of the pool was sandy, but covered mostly with *N. aculeata*.

Pool-3 (P-3) (Fig. 1-4) (80 cm above the datum line) was a bare rock pool situated at the rugged shore. This pool was 0.1 m deep and occupied an area of  $0.6 \text{ m} \times 0.4 \text{ m}$ .

Pool-4 (P-4) (Fig. 1-5) (160 cm above the datum line) was a shallow pool on the central large rock of the central flat. This pool was 0.1 m deep and occupied an area of 2 m×1.5 m. *S. thunbergii, Corallina pilulifera* POSTELS et RUPRECHT and sea mussels grew there.

Seawater samples for nutrient analyses were collected from the following five points (Fig. 3):

Point-A was in the front of the Institute of Algological Research.

Point-B was in the central flat.



Fig. 3 Map of sampling points for the analyses of nutrients. A, the Point-A; B, the Point-B; C, the point-C; D, the Point-D; E, the Point-E; F, the Institute of Algological Research of Hokkaido University.

Point-C was near the small fall in the east part of the shore. Point-D (surface) and E (bottom, depth of 10 m) were at about 200 m off the shore.

# 2. Measurements of temperature, pH, salinity, evaporation value of water, and nutrients

Air and seawater temperatures were measured by a mercury thermometer for 2 weeks per one month from April 1977 to April 1979. These measurements were carried out 4 times a day (10:00, 13:00, 16:00 and 20:00). Air temperature was measured at the open place near the Institute of Algological Research. Seawater temperature was measured *in situ*.

Value of pH was measured at the same frequency and period with the measurement times of temperature. Water sample was carried by 100 ml polyethylene bottle to the laboratory and the pH value was recorded using pH meter (Model HM–5B, Toa Electronics Ltd.).

Salinity was measured at the time of the lower low water of spring tide from February 1978 to April 1979. The measurement of salinity was made for 10 ml seawater (filtered by glass filter) by titration with silver-nitrate using uranine-starch as an indicator (Japan Meteorological Agency 1970).

Littoral benthic algae periodically emerge at low water. At that time, the organisms will be dehydrated. The vertical distribution of these algae is partially determined by their



Fig. 4 Measuring apparatus for evaporation of water. A beaker was 6 cm of diameter and 8.5 cm in depth.

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resistivity to desiccation (BIEBL 1962, ZANEVELD 1969). The desiccation seems to be determined not only by humidity, but also by other atomospheric conditions such as temperature, wind, etc. So it is necessary to measure the evaporation value of water. In this study, the evaporation value of water was recorded from November 1977 to April 1979.

The evaporation value of water was measured by the following method: A tall beaker (6 cm diameter  $\times$  8.5 cm depth) containing 100 g of distilled water (precooled at 14°C) was weighed and then it was set at the open place. The tall beaker was covered with a glass funnel (15 cm diameter) with a bent polyethylene tube at the tip (Fig. 4). After 2 or 3 hours, the beaker was weighed again and an evaporation value of water was calculated. The evaporation value was measured twice a day, the first setting was started at 10 o'clock in the morning and the second time was done just after sunset. The evaporation value was presented as the value in grams per basal area of test beaker (28 cm<sup>2</sup>) per hour.

Ammonia–N, nitrite–N, nitrate–N, phosphate–P and silicate–Si of seawater were measured monthly from January 1976 to April 1979. The seawater samples were collected in 500 ml polyethylene bottles at 10:00. Analytical methods for subjective elements were as follows:

Ammonia-N

The indophenol-nitroprusside colorimetric method (ISHISAKA 1969) was used. Nitrite-N

The sulfanilamide-N (naphtyl) ethylenediamine colorimetric method (Japan Meteorological Agency 1970) was used.

Nitrate-N

The seawater sample was reduced by copper-cadmium (Japan Meteorological Agency 1970). Then, the same method for nitrite-N was used.

Phosphate-P

The Menzel method (Japan Meteorological Agency 1970) was used.

Silicate-Si

The molybdate-amino naphthol sulfonic acid colorimetric method (Japan Society for Analytical Chemistry, Hokkaido Branch 1971) was used.

Analyses of ammonia–N, phosphate–P and silicate–Si were completed within the day of collection. The seawater sample for analyses of nitrite–N and nitrate–N was sometimes stored at -25 °C.

All measurements for nutrient determinations were carried out in duplicate and the mean value of duplicate was present in the relevant figures.

## II Results

#### 1. Air temperature

Seasonal variation of air temperature at 13:00 (Table 1)

Among 4 measurement times a day, air temperature always reached to the highest value at 13:00. The monthly mean temperature was  $12.5^{\circ}$  in April 1977, the beginning of this investigation. Then, it gradually rose until September 1977, and was recorded the highest mean value of  $22.1^{\circ}$ . In Octeber 1977, it was  $20.3^{\circ}$  and gradually decreased until February 1978 and the lowest mean value of  $-1.4^{\circ}$  was recorded. In March 1978 it greatly rose to  $8.4^{\circ}$ .

The monthly mean temperature of April 1978 was slightly higher than that of the preceding year. The seasonal variation of the monthly mean temperatures of the second cycle (Apr. 1978-Apr. 1979) showed almost similar pattern to that of the first cycle (Apr. 1977-Mar. 1978). In 1979, however, the lowest mean temperature of  $-1.6^{\circ}$  occurred not in February but in January. Then the monthly mean temperature gradually increased from February to April in the second cycle. Furthermore, during the summer of the second cycle, it was higher than that of the first cycle.

#### Seasonal variation of air temperature at other times (Table 1)

The variation patterns of air temperature at other measurement times were just the same manner with the case of the measurement at 13:00. In these measurements, the lowest mean temperature of -5.9°C in the first cycle was recorded at 20:00 of February 1978, and in the second cycle the lowest value of -3.8°C occurred at 20:00 of January 1979.

#### 2. Seawater temperature

#### Seasonal variation of seawater temperature at the Cleft-1 at 13:00 (Tables 2 and 3)

The seawater temperature always reached the highest value at 13:00 among 4 measurement times a day. The monthly mean temperature was  $6.5^{\circ}$ C in April 1977. Then, it gradually rose until September 1977, and reached to the highest value of  $18.5^{\circ}$ C. In October 1977 it slightly decreased to  $16.8^{\circ}$ C. Then it gradually decreased until February of the next year (1978), and the lowest value of  $2.3^{\circ}$ C was recorded in Frbruary. In March 1978 the mean value slightly rose.

The monthly mean temperature of April in 1978 was the same level with that of the preceding year. The seasonal variation of the monthly mean temperature of the second cycle (Apr. 1978–Apr. 1979) showed almost similar pattern to that of the first cycle (Apr. 1977–Mar. 1978). However, the monthly mean temperatures of June and July 1978 were higher than those of the preceding year and the value of April 1979 was slightly lower than those of 1977 and 1978.

#### Seasonal variation of seawater temperature at the Cleft-1 at other times (Table 2)

The variation patterns of seawater temperature at each measurement time other than 13:00 were just the same manner with the case of 13:00. In these measurements, the lowest temperature of each year was recorded at 20:00 as 0.8°C in February 1978 and 1.5°C in March 1979.

Seawater temperature at other points (Table 3)

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At the Pools 1-4 situated at higher levels than the Cleft-1, seawaters were out of contact with the open sea at the low water, as the result, shallow pools were formed there. At that time, the water temperatures of shallow pools of these points were affected by the air temperature. At Muroran, the lower low water of spring tide occurs in the nighttime from late September to early March, but during other months it occurs in the daytime. As shown in Table 3, the seawater temperatures of the Pools 1-4 were lower than that of the Cleft-1 in the nighttime from late autumn to winter and often dropped below freezing point. But the seawater temperatures at the Pools 1-4 were higher than that of the Cleft-1 during daytime from spring to early autumn. The temperature differences of more than 10°C between Cleft -1 and Pools 1-4 were often observed during this period.

#### 3. Tidal emersion

The littoral zone is defined as the range from the extreme high water of spring tide to the extreme low water of spring tide (NISHIHIRA 1976). At Muroran, it is ranging from +172 cm to -8 cm of the datum line (Japan Meteorological Agency 1977). LEWIS (1964) showed that the occurring time of the lower low water of spring tide changes with the season. At Muroran, the lower low water of spring tide occurs in the nighttime from late September to early March, and occurs in the daytime from late March to early September.

Usually spring tide occurs twice a month. The time and duration of emersion for 5 days at each spring tide were estimated using the tide tables (Japan Meteorological Agency 1976, 1977) and monthly fluctuations of them at five different levels in height were described below.

#### Tidal emersion at the level of 10 cm above the datum line (Cleft-1) at spring tide (Tab. 4)

This level emerged for less than 4 hours in the nighttime from November to February, and submerged in the nighttime during other months. In the daytime, this level emerged for less than 3 hours from April to July and submerged from August to March.

#### Tidal emersion at the level of 40 cm above the datum line (Pool-1) at spring tide (Tab. 5)

In the nighttime, this level usually emerged for 3–6 hours from October to March, but did not emerge from April to August. In September, this level emerged again for less than 3 hours in the nighttime. This level usually emerged for 3–6 hours in the daytime from March to July. The emersions of 1–4 hours and 0–2 hours occurred in the daytime of August and September, respectively. From October to February, this level submerged in the daytime.

#### Tidal emersion at the level of 60 cm above the datum line (Pool-2) at spring tide (Tab. 6)

In the nighttime, this level usually emerged for 4–8 hours from October to February, and emerged for 0–6 hours from March to September. In the daytime, this level emerged for less than 4 hours in February and usually for 4–7 hours from March to August. This level emerged for 2–5 hours and 0–3 hours in the daytime of September and October, respectively.

From November to January, this level did not emerge in the daytime.

#### Tidal emersion at the level of 80 cm above the datum line (Pool-3) at spring tide (Tab. 7)

In the nighttime, this level emerged for 5–9 hours from September to March. In September and March, however, the emersion of less than 5 hours was also observed. The emersion of 0–5 hours occurred in the nighttime from April to August. In the daytime, this level emerged for less than 4 hours from November to January, and the frequency and duration of the emersion in February were larger than those from November to January. In March, the long time emersion of more than 6 hours also occurred in the daytime. The emersion of 5–9 hours occurred in the daytime from April to August. The emersions of 4–6 hours and 3–4 hours frequently occurred in the daytime of September and October, respectively.

#### Tidal emersion at the level of 160 cm above the datum line (Pool-4) at spring tide

This level always emerged from February to April and in September, but submerged for less than 3 hours per day during other months.

#### 4. pH of seawater (Tables 8 and 9)

The pH range of seawater at the Cleft-1 was usually 8.0-8.5 through the year. However, from October to April, the pH sometimes fell into 7.5-8.0 and from February to July it sometimes rose to 8.5-9.0. The Cleft-1 was in contact with the open sea even at the lower low water, but the seawater in the Cleft-1 became stagnant. Accordingly, as a result of photosynthesis and respiration of organisms living in the Cleft-1, the pH value fluctuated as did in a tide pool (ATKINS 1922, PYEFINCH 1943, ALEEM 1950, EDELSTEIN and MC-LACHLAN 1975).

From late September to early March, the lower low water of spring tide occurred in the nighttime, and the pH fell into less than 8.0 due to the respiration of organisms. On the other hand, from late March to early September, the lower low water of spring tide occurred in the daytime, and the pH rose to 9.0 due to the photosynthesis of plants.

This tendency was more clearly shown in the higher sampling points than the Cleft-1. Especially, at the Pool-4 the pH fell into 7.5 in the nighttime and rose to more than 9.0 in the daytime. It had a tendency that the extreme high pH was more frequently observed from late March to April, and at the Pools 1–2 it rose to more than 9.0 during this period.

It was demonstrated that pH of seawater at all sampling points usually fell off when emersion occurred in the nighttime, while, pH rose when emersion occurred in the daytime.

#### 5. Salinity of seawater at the lower low water of spring tide (Table 10)

As a result of heavy rainfall, the lowest salinity of 14.15% was recorded at the Pool-4 on July 7, 1978. On the contrary, the highest one of 41.44% occurred at the Pool-4 on the cold day, January 11, 1979.

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The Cleft-1 is usually in contact with the open sea even at the lower low water. Salinity at the Cleft-1 was in the range of 31-34‰ during measuring period except the cases of June 21, 1978 (14.24‰) and July 7, 1978 (24.12‰). The seasonal fluctuation of the salinity at the Cleft-1 was observed. In September, salinity rose to 33.46-33.67‰ and the level of 33‰ lasted into January. In February, it slightly fell to 32.43-32.99‰ and the range of 31-32‰ continued until August.

OHTANI *et al.* (1970, 1971a, 1971b) studied on the changing pattern of hydrographic conditions in Uchiura Bay and reported that the cold and low saline waters of the Oyashio Current intrude into the northeastern side (Muroran) of this bay through the upper layer from March to May, and these waters stay in the bay during summer. The warm and high saline waters of the Tsugaru Current reach the northeastern mouth of Uchiura Bay in June –July and enter the bay through the mid and lower layers from August to October and these waters stay in the bay during winter. The seawater in this study area may be influenced by the Oyashio and Tsugaru Currents.

Salinities at the Pools 1-4 were higher than those of the Cleft-1 during January and February. This phenomenon is due to the fact that low temperature in winter caused the high salinity as a result of freezing-out of salt during the formation of ice (EDELSTEIN and MCLACHLAN 1975).

#### 6. Evaporation value of water (Table 11)

#### In the daytime

Evaporation value was higher in a fine weather than in a cloudy or rainy weather, and higher value was observed in the condition of higher temperature. The highest monthly mean value of  $0.88 \text{ g}/28 \text{ cm}^2/\text{hr}$  was observed in August 1978. The lowest value of  $0.20 \text{ g}/28 \text{ cm}^2/\text{hr}$  was obtained in January 1978. This lowest value was the result of continuous decrease from the monthly mean value of  $0.37 \text{ g}/28 \text{ cm}^2/\text{hr}$  in November 1977. In February 1978, it was  $0.24 \text{ g}/28 \text{ cm}^2/\text{hr}$  and abruptly rose to  $0.54 \text{ g}/28 \text{ cm}^2/\text{hr}$  in March 1978. From April to June 1978, lower evaporation values were recorded, especially in May, as compared with that of March. It was caused by the wet weather (claudy, rainy and foggy) held for these months. The monthly mean value rose to  $0.66 \text{ g}/28 \text{ cm}^2/\text{hr}$  in July 1978, and the annual maximum value of  $0.88 \text{ g}/28 \text{ cm}^2/\text{hr}$  was recorded in August 1978. Then, it gradually fell to  $0.74 \text{ g}/28 \text{ cm}^2/\text{hr}$  in September 1978 and to  $0.51 \text{ g}/28 \text{ cm}^2/\text{hr}$  in October 1978. The fluctuation of the monthly mean values of the second cycle (Nov. 1978–Apr. 1979) was the similar pattern to that of the first cycle (Nov. 1977–Oct. 1978). However, the monthly mean value in March 1979 was slightly lower than that of the preceding year.

#### In the nighttime

The monthly mean value in the nighttime was always lower than that in the daytime. Usually, it ranged from 0.1 to  $0.2 \text{ g}/28 \text{ cm}^2/\text{hr}$ . The highest value of  $0.23 \text{ g}/28 \text{ cm}^2/\text{hr}$  was obtained in October 1978. On the other hand, the lowest value of  $0.06 \text{ g}/28 \text{ cm}^2/\text{hr}$  was

observed in June 1978. There was no seasonal fluctuation between the monthly mean values in the nighttime.

#### 7. Nutrients in seawater

#### Ammonia-N (Fig. 5)

The maximum value of ammonia-N at each point was  $8.6 \mu g$ -at/l at Point-A in January 1976, 8.6 at B in October 1978, 3.2 at C in October 1977, 1.8 at D in January 1977 and 4.3 at E in February 1977. No seasonal fluctuation was observed and a relatively high value (about  $3.6 \mu g$ -at/l) was obtained regardless of the season at Points A-C.

#### Nitrite-N

Nitrite-N was not detected in almost all water samples, and the value of more than 0.4  $\mu$ g-at/l was not taken in all analyses.

Nitrate-N (Fig. 6)







Seasonal fluctuation of nitrate-N in the seawaters of Charatsunai.
A: the Point-A (○) and the Point-B (×).
B: the Point-C (○), the Point-D (×) and the Point-E (●).

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The maximum value of nitrate-N at each point was  $9.0 \,\mu g$ -at/l at Point-A in January 1976, 7.9 at B in January 1976, 7.9 at C in January 1977, 10.5 at D in January 1977 and 9.1 at E in January 1977. The seasonal fluctuation was observed. At all points, concentration of nitrate-N became higher in November or December and reached to the annual maximum of more than  $7 \,\mu g$ -at/l during November-January. Then, nitrate-N became poorer from February or March. A low concentration of this nutrient was usually detected from spring to middle autumn.

#### Phosphate-P (Fig. 7)

The maximum value of phosphate-P at each point was  $1.1 \,\mu g$ -at/*l* at Points A and B in February 1976, 1.26 at C in February 1976 and 0.97 at D and E in December 1976. The seasonal fluctuation was observed. At all points, phosphate-P became richer in November except 1977. In the case of 1977, the increment of phosphate-P began in December. The concentration of phosphate-P reached to the annual maximum of  $1.0-1.3 \,\mu g$ -at/*l* during November-February, and it decreased from March to April. A low concentration of this nutrient was detected from spring to middle autumn.

#### Silicate-Si (Fig. 8)

The maximum value of silicate–Si at each point was  $24.7 \mu g$ -at/*l* at Point–A in January 1977, 19.4 at D in February 1976, 71 at C in November 1977, 14.9 at D in December 1976 and 14.6 at E in December 1976. The seasonal fluctuation was observed at all points except C. Silicate–Si increased in November or December and its value attained the annual maximum of  $14-25 \mu g$ -at/*l* during December–February. This nutrient abruptly decreased from March or April. A low concentration of this nutrient was detected from spring to middle autumn.

It is known that silicate-Si is more abundant in land water than in seawater, and therefore a high concentration of Si is detected in coastal shore where land water pours



Fig. 7 Seasonal fluctuation of phosphate-P in the seawaters of Charatsunai. A: the Point-A (○) and the Point-B (×). B: the point-C (○), the Point-D (×) and the Point-E (●).

(Japan Meteorological Agency 1970). Land water pours near the Points A and C. Especially, a large quantity of land water pours into these points in a rainy day or in snow -thawing season. As a result, the high concentration of silicate–Si was detected in spring or summer.

The concentration of nitrate-N, phosphate-P and silicate-Si fluctuated seasonally in the same pattern. These three nutrients were rich from late autumn to early spring, but poor during other seasons.



Fig. 8 Seasonal fluctuation of silicate-Si in the seawaters of Charatsunai. A: the point-A (O) and the Point-B (X). B: the Point-C (O), the Point-D (X) and the Point-E (•).

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Month		Measure	ment time	
WORTH	10:00	13 : 00	16:00	20:00
April 1977	10.3(10)*	12.5(11)*	10.9(9)*	
May	11.9(10)	15.5(10)	14.1(10)	
June	17.3(13)	19.6(14)	17.4(13)	
July	18.9(12)	21.0(13)	18.6(9)	—
September	20.8(9)	22.1(9)	21.4(9)	-
October	17.7(10)	20.3(11)	17.7(11)	12.9(9)*
November	9.0(11)	9.8(12)	7.0(11)	5.4(10)
December	3.0(9)	3.7(10)	0.7(10)	0.7(9)
January 1978	0.2(12)	1.2(11)	-1.0(11)	-1.8(11)
February	-2.0(12)	-1.4(11)	-4.0(7)	-5.9(9)
March	5.9(15)	8.4(15)	4.8(12)	0.3(9)
April	8.7(9)	13.4(9)	8.3(5)	4.8(6)
May	12.8(12)	13.3(14)	12.1(12)	9.9(8)
June	22.2(11)	23.0(10)	21.6(8)	16.9(5)
July	26.9(13)	29.4(12)	28.4(9)	20.9(6)
August	25.8(5)	29.3(10)	24.2(4)	21.7(2)
September	21.5(5)	24.1(9)	21.8 (5)	17.2(5)
October	15.2(9)	16.1(11)	13.9(7)	10.6(7)
November	8.6(13)	9.6(13)	8.1(9)	5.3(9)
December	4.1(9)	4.7(10)	2.6(5)	0.7(5)
January 1979	-2.0(4)	-1.6(6)	-2.3(6)	-3.8(7)
February	0.6(12)	3.0(12)	0.1(10)	-3.1(6)
March	5.3(14)	6.5(15)	4.7(8)	0.1(7)
April	7.7(10)	9.6(10)	9.1(8)	3.7(4)

Table 1Monthly mean air temperature (°C) at Charatsunai<br/>from April 1977 to April 1979.

\* Values in brackets show the number of measurements.

Table 2	Monthly mean seawater temperature (°C) at the Cleft-1 of
	Charatsunai from April 1977 to April 1979.

	aratsunai mom	11pin 1011 to 11	pm 1373.	
Month		Measure	nent time	
MOILII	10:00	13:00	16:00	20:00
April 1977	6.2(10)*	6.5(11)*	6.5(9)*	
May	9.0(10)	8.6(10)	8.1(10)	
June	12.4(13)	11.2(14)	11.9(13)	_
July	16.4(12)	16.5(13)	15.4(9)	
August	17.3**			
September	17.7(9)	18.5(9)	17.8(8)	
October	16.0(10)	16.8(11)	16.1(11)	15.4(9)*
November	11.0(11)	11.4(12)	11.1(11)	9.4(10)
December	7.9(9)	8.4(10)	8.1(10)	7.0(9)
January 1978	4.5(12)	4.8(11)	4.6(11)	4.1(11)
February	1.5(12)	2.3(11)	1.9(7)	0.8(9)
March	2.1(15)	3.1(15)	2.8(12)	0.9(9)
April	4.6(9)	6.7(9)	4.1(5)	2.7(6)
May	9.9(12)	10.6(14)	9.6(12)	8.2(8)
June	17.0(11)	16.7(10)	13.3(8)	12.4(5)
July	20.4(13)	20.6(12)	20.5(9)	18.0(6)
August	19.7(5)	20.9(5)	18.7(4)	18.1(2)
September	18.5(5)	18.8(6)	18.7(5)	17.8(5)
October	14.6(9)	14.9(10)	14.6(7)	14.0(7)
November	11.1(13)	11.5(13)	11.3(9)	10.3(9)
December	7.7(9)	8.3(10)	8.0(5)	7.6(5)
January 1979	5.1(4)	4.5(6)	4.5(6)	2.4(7)
February	2.6(12)	3.3(11)	2.9(10)	2.2(6)
March	2.4(14)	3.7(11)	2.5(8)	1.5(7)
April	4.0(10)	4.5(9)	4.0(8)	2.7(4)

\* Values in brackets show the number of measurements.

 $\ast\ast$  The datum was given by the Institute of Algological Research.

	,					
Day	Time	C-1	P-1 Sam	pling point P-9	P-3	P4
A	77	<b>v</b> 1	r . r	1 2	1 J	1 -4
April 19	10:00	0.0	10 (	10 /	10.0	10.0
4	10.00	9.0	13.4	12.4	12.0	12.2
	13.00	9.1				
-	16.00	6.4				
5	10:00	8.3	16.1	13.8	14.8	15.3
	$13 \div 00$	6.3	7.3	18.8	20.6	17.0
	16:00	7.0				
6	$10 \div 00$	9.5	12.8	14.0	14.2	13.4
	13:00	10.9	16.3	18.4	19.5	15.7
	16:00	8.1				
May 197	7					
4	10:00	16.5	16.8	18.0	17.1	17.0
	13:00	8.0	10.1	24.0	25.2	21.2
	16:00	7.7				
6	10:00	8.4	8.6	9.0	9.3	10.1
	13 : 00	7.5	6.8	13.4	15.0	15.7
	16:00	6.7				
7	10:00	6.3	6.3	7.2	7.4	8.4
	13:00	8.0	8.4	18.9	21 2	19 0
	16:00	7.6		1010		10.10
June 197	7	1.0				
14	10 · 00	11.8	12.8	10.0	19 /	17.8
11	13:00	19.7	12.0	10.0	13.4	17.0
	16:00	12.7				
15	10:00	11.0	16.2	16.0		15 0
15	10 : 00	12.0	10.5	10.5		10.0
	15.00	12.2				
16	10.00	10.7	01.0	01 0	90.4	91.9
10	10.00	17.3	21.8	21.8	20.4	21.2
	13.00	10.7				
L.I., 107	16.00	13.2				
July 197	10:00	10.1	10.0		10.0	10.0
13	10.00	16.1	16.0		18.6	19.0
	13:00	16.9				
16	10:00	24.7	27.1	26.9	26.9	28.0
	13:00	19.9	23.8	_	28.7	27.8
	16:00	19.9				
18	10:00	17.9	17.8	18.3	18.6	18.7
	13:00	17.5	17.3	19.3	19.4	19.9
	16:00	16.4				
Septemb	er 1977					
28	10:00	16.9	18.1	21.0	23.1	23.6
29	10:00	15.6	16.2	18.7	19.1	19.8
	13:00	16.5				
	16 : 00	16.6				
30	10:00	17.2			18.7	
	13 : 00	19.9				
	16:00	17.8				
October	1977					
11	10:00	15.2			17.3	16.2
-	13:00	15.5				
	16:00	15.1				
	20:00	14 5	14 1	11 9	10.7	10.2
	20.00	11.0			10.1	10.4

Table 3Seawater temperature (°C) at spring tide at Charatsunai<br/>from April 1977 to April 1979.

1	$\sim$	· -	1.
{	1.00	T1 W	non
· ·	001	~~~~	nou

Dev	Time		San	npling point		
Day	1 ime	C-1	P-1	P-2	P-3	P-4
12	10:00	15.5	15.5	18.3	17.5	18.1
	13:00	16.1				
	16:00	15.5				
	20; 00	14.9	14.5	13.2	12.8	11.6
13	10:00	15.9				
	13:00	17.0				
	16:00	16.4				
	20:00	15.9	15.6	15.0	14.7	14.2
Novemb	er 1977					
10	10:00	11.4				
	13:00	11.6				
	16:00	11.3				
	20:00	6.6	5.6	5.4	5.1	2.8
11	10:00	10.4				
	13:00	9.9				
	16:00	9.9				
	20:00	5.7	5.3	5.1	4.2	2.0
12	10:00	9.9			6.8	
	13:00	10.5				
	16:00	10.6				
	20:00	8.6	8.3	7.4	6.8	3.9
Decembe	er 1977					
22	10:00	6.4				
	13 : 00	8.3				
	16 : 00	8.0				
	20:00	4.7	2.2	1.6	1.6	-1.3
23	10:00	6.8				
	13:00	8.7				
	16:00	8.4				
	20:00	5.0	3.5	3.0	2.7	-0.5
24	10:00	7.8				
	13:00	8.7				
	16:00	8.8				
	20:00	7.9	7.5	6.3	5.7	3.9
lanuary	1978					
23	10:00	3.6				
	13 : 00	3.7				
	16:00	3.5				
	$20 \div 00$	3.4		1.7	1.2	-0.5
24	10 : 00	3.1				
	13 : 00	3.2				
	16:00	3.2				
	20:00	2.6			1.2	
25	10:00	2.5				
	13 : 00	2.5				
	16:00	2.8				
	$20 \div 00$	1.7			0.7	
Februar	y 1978					
20	10:00	1.8				
	13 : 00	1.8				
	20:00	0.8	0.7	-1.4	-0.8	
21	10:00	1.8				
	13:00	2.4				
	00 : 00	0.0	0.1	1 1	0.7	1 0

# (Continued)

			San	nnling point		
Day	Time	C-1	P-1	P-2	P-3	P-4
22	10:00	1.6				
	13 : 00	1.7				
	16:00	0.9				
	20:00	0.2	0.2	-0.6	-0.6	-1.4
March 1	.978					
25	10:00	2.2	5.4	11.0	9.7	11.6
	13:00	6.2				
27	10:00	6.6	10.3	10.2	10.8	12.6
	13:00	3.4	8.7	17.1	17.6	17.6
	10.00	5.1				
20	20.00	1.4				
29	10.00	4.1	10.0	12 C	14.9	11.2
	15 . 00	4.1	15.5	15.0	14.2	11.5
	20:00	0.0				
April 19	20.00	1.1				
25	10:00	72	10.2	97	9.0	11.6
20	13:00	6.5	11.1	17.6	18.3	18.3
27	10:00	4.3	5.0	6.6	7.4	8.3
- '	13:00	5.7	7.3	7.1	7.6	8.3
	16:00	4.7				
	20:00	3.3				
28	10:00	5.1				
	13:00	15.0	18.4	18.7	18.6	19.2
	16:00	6.4	10.4	15.8	17.7	15.9
	20:00	5.1				
May 197	78					
24	$10 \div 00$	8.4	8.5	8.6	8.6	8.7
	13:00	6.7	6.5	8.2	8.6	8.3
	16:00	6.4				
0.7	20:00	5.7			~~ ~	10 5
25	10 : 00	16.5	18.5	19.4	20.6	19.7
	13.00	19.0	24.8	26.9	25.9	23.9
	20 - 00	13.1				
26	20.00	0.0	12 0	14 5	15.9	15.9
20	16:00	0.7	10.0	14.0	13.4	10.2
	20:00	J.1 7 Q				
June 197	78	4.0				
21	10:00	15.4	15.9	15.5	15.9	16.7
	13:00	15.2			21.8	
	16:00	14.3				
22	10:00	13.8	12.3	17.2	16.9	18.4
	13:00	11.2	12.3	21.0	20.4	20.5
	16:00	9.4				
	20:00	11.6				
23	10:00	22.4	25.2	24.7	24.2	25.5
	13:00	23.3	31.2	31.4		29.1
T 1 105	16:00	13.2				
July 197	8	04.0	07.0	96.4	05.0	96.7
21	10.00	24.3	27.6	20.4	25.8	20.7
	13.00	21.2	29.4		31.0	31.4
99	10.00	19.0	22.0	99 C	20 A	<b>0</b> 2 0
22	10 • 00	41.3	44.9	22.0	66.4	40.0

1	$\sim$		,	1
1	1 02	1 tin	1100	- 1
<u> </u>	con		ncu	2

Day	Time	C-1	Sam P-1	pling point P-2	P-3	P-4
	12:00	20 5		24.9	21 5	
24	10:00	20.5	10.2	24.0	24.0	23.2
44	12:00	10.0	17.0	20.0	20.4	20.2
	13.00	19.5	20.7	31.7	51.9	30.1
	16.00	19.7				
1	20:00	15.9				
August I	978	15.0	10.0	00.0	00.0	00.0
16	10:00	15.2	16.3	23.0	22.8	23.2
	13 : 00	17.2				
	16:00	17.9				
18	10:00	19.2	29.4	29.0	26.7	28.1
	13 : 00	22.2				
	16:00	18.1				
	20:00	17.2				
19	10:00	18.6	19.7	20.6	20.8	21.1
	13:00	18.0			21.3	21.6
	16:00	18.7				
Septembe	er 1978					
14	10:00	18.3		19.8	20.2	20.1
••	13:00	18 4				
	16:00	18 2				
16	10:00	18.7				
10	13:00	10.7				
	19 - 00	10.0				
10	20.00	18.1	17 5	90.9	00.1	01 0
18	10.00	17.6	17.5	20.2	ZZ.1	21.6
	13.00	18.1				
	16:00	18.3				
~ .	20:00	18.4				
October	1978					
13	10:00	13.2				
	13:00	14.0				
	16:00	13.4				
	20:00	12.1			8.9	
14	10:00	13.7		14.1	14.8	13.1
	13:00	12.9				
16	10:00	15.2				
	13:00	15.0				
	16:00	14.6				
17	20:00	13 4	13.4	12.5	12.2	10.4
Novembe	er 1978	10.1	10.1	10.0	10.0	10.1
13	10.00	12.0			10.8	Q 1
19	12:00	12.0			10.0	3.1
	15 - 00	12.0				
	10 - 00	12.1	7.0	0.0	7.4	E 4
	20.00	10.2	7.8	8.2	7.4	5.4
14	10:00	11.1			11.2	
	13:00	12.3				
	16:00	11.9	_	_		_
	20:00	10.7	9.7	9.1	8.4	6.7
15	10:00	11.9				
	13 : 00	11.8				
	16:00	11.8				
	20:00	11.5	11.5	10.8	9.4	8.8
December	r 1978					
11	13:00	8.4				
	20:00	6.8	3.0	2.7	2.6	0.1
		5.0	~. ~			

(Continued)
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Dav	Time	C 1	San	npling point	D 0	D (
		<u>C-1</u>	P-1	P-2	P3	P-4
13	10:00	8.7				
	13:00	9.8				
	16:00	9.7				
	20:00	7.9	6.2	6.2	6.1	4.5
14	10:00	9.2				
	13:00	94				
	20:00	9.6	9.6	9.2	8 8	8
Ianuary	1979	5.0	5.0	5.6	0.0	0.0
Q Q	13 . 00	6 1				
5	16:00	57			15	1 '
	20:00	3.0	-0.4	0.0	4.0	-0.7
10	10 100	5.0	0.4	0.0	0.0	0.
10	10:00	5.4				
	15:00	5.9				
	10.00	5.9	4.0	0.0	0.0	0
11	20.00	4.4	4.0	0.0	0.6	-0.
11	10.00	4.2				
	13:00	4.5				
	16.00	4.2				0
	$20 \div 00$	0.0	2.3	-0.7	-1.5	-2.0
February	1979					
8	10:00	2.4				
	13 : 00	2.7				
	16 : 00	2.3				
	$20 \div 00$	1.1	-1.5	-0.9	-1.3	-1.1
9	10:00	2.2				
	13 : 00	3.5				
	16:00	3.5				
13	10:00	2.7	3.1	2.6	3.0	1.3
	13:00	4.3				
	16:00	3.2				
	20:00	2.3			1.9	
March 19	979					
14	10 : 00	2.7	3.3	6.4	7.5	6.3
	13:00	6.5				
	16:00	2.5				
	20:00	1.2			0.6	
15	10:00	2.9	3.7	7.2	8.0	5.
	13:00	5.7				0
	16:00	3 7				
16	13:00	4 7	3.0	77	12 0	9
10	20:00	1.1	0.0		12.0	5.0
April 197	79	1.0				
12	- 10:00	3 5	6 1	11.2	11.9	11
12	13:00	5.8	0.1	11.0	10.6	11.0
	16:00	43			10.0	
12	10:00	4.5	11 1	12 7	12.2	11
19	12.00	1.4	11.1	10.1	14.4	11.
	13 - 00	4.8	0.8	10.2	19.0	10.
	10 - 00	5.2				
10	20.00	3.6		10.0	10 5	10
16	10:00	6.1	11.5	10.9	12.5	13.
		4 4	19.9	1.1 5	14 C	15 4
	13.00	4.4	13.2	12.5	14.0	10.4

Maath		Emersi	ion in t	he day	time			Eme	rsion	in the	nightt	ime	
Month	0	0.5	1	2	3	4 hr	0	0.5		1	2	3	4 hr
Nov. 1977	(	0	0	0	0			2	2	0	4	0	
Dec.	0	0	0	0	0			0	2	2	1	3	
Jan. 1978	(	0	0	0	0			0	0	1	3	1	
Feb.	C	0	0	0	0			0	2	1	0	0	
Mar.	0	0	0	0	0			0	0	0	0	0	
Apr.	C	0	2	2	0			0	0	0	0	0	
May	1	. 2	1	4	0			0	0	0	0	0	
June	C	0	1	3	0			0	0	0	0	0	
July	C	) 1	0	0	0			0	0	0	0	0	
Aug.	C	0	0	0	0			0	0	0	0	0	
Sep.	C	0	0	0	0			0	0	0	0	0	
Oct.	0	0	0	0	0			0	0	0	0	0	

 Table 4
 Distribution of duration of tidal emersion at the level of 10 cm above the datum line at spring tide in Muroran.\*

\* Duration of emersion for 10 days at two spring tides per month was calculated from tide tables (Japan Meteorological Agency. 1976, 1977).

Table 5Distribution of duration of tidal emersion at the level of 40 cmabove the datum line at spring tide in Muroran\*.

Month		Eme	rsion	in the	dayti	me			Emer	sion i	n the	nightti	me	
wonth	0	1	2	3	4	5	6 hr	0	1	2	3	4	5	6 hr
Nov. 1977	0	0	0	0	0	0		0	0	0	1	7	2	
Dec.	0	0	0	0	0	0		0	0	0	1	4	5	
Jan. 1978	0	0	0	0	0	0		0	0	0	2	3	5	
Feb.	0	0	0	0	0	0		0	0	1	4	2	3	
Mar.	1	1	0	3	2	0		1	0	0	2	3	0	
Apr.	0	0	0	5	4	1		0	0	0	0	0	0	
May	0	0	0	2	6	2		0	0	0	0	0	0	
June	0	0	0	1	5	4		0	0	0	0	0	0	
July	0	0	1	5	4	0		0	0	0	0	0	0	
Aug.	0	1	5	4	0	0		0	0	0	0	0	0	
Sep.	1	4	0	0	0	0		1	1	3	0	0	0	
Oct.	0	0	0	0	0	0		0	0	1	9	0	0	

\* Duration of emersion for 10 days at two spring tides per month was calculated from tide tables (Japan Meteorological Agency, 1976, 1977).

Manth			Em	nersio	on ir	the	dayt	ime			Emersion in the nighttime								
Month	0	1		2	3	4	5	6	7	8 hr	0	1	2	3	4	5	6		7 8 hr
Nov. 1977	(	)	0	0	0	0	0	0	. (	)	0	0	0	0	0	- 5	;	5	0
Dec.	(	)	0	0	0	0	0	0	(	)	0	0	0	0	0	1		5	4
Jan. 1978	(	)	0	0	0	0	0	0	(	)	0	0	0	0	C	3	}	5	2
Feb.	2	2	1	0	1	0	0	0	(	)	0	0	0	0	2	3	;	5	0
Mar.	(	)	2	2	0	1	4	0	(	)	0	1	1	1	2	3	1	0	0
Apr.	(	)	0	0	0	0	8	1	1	L	2	1	1	0	0	(	)	0	0
May	(	)	0	0	0	0	7	3	(	)	0	0	0	0	0	(	)	0	0
June	(	)	0	0	0	1	0	9	(	)	0	0	0	0	C	(	)	0	0
July	(	)	0	0	0	2	4	4	(	)	0	0	0	0	C	(	)	0	0
Aug.	(	)	0	0	1	3	6	0	0	)	1	1	0	0	C	(	)	0	0
Sep.	(	)	0	1	3	3	0	0	0	)	0	1	1	2	3	(	)	0	0
Oct.	]	l	1	3	0	0	0	0	(	)	0	0	0	0	5	5	i	0	0

Table 6Distribution of duration of tidal emersion at the level of 60 cmabove the datum line at spring tide in Muroran\*.

\* Duration of emersion for 10 days at two spring tides per month was calculated from tide tables (Japan Meteorological Agency, 1976, 1977).

Table 7Distribution of duration of tidal emersion at the level of 80 cmabove the datum line at spring tide in Muroran\*.

Month			Er	ner	sion	in	the	dayt	ime					E	mei	sio	n ir	n th	ne n	ight	tin	ne	
Month	0	1	2		3	4	5	6	7	8	9 hr	0		1	2	3	4		5	6	7	8	3 9 hr
Nov. 1977	]	1	1	1	1	0	0	) (	) (	)	0		0	0	C	)	0	0	0		4	5	1
Dec.	]	1	0	0	0	0	0	) (	) (	)	0		0	0	C	)	0	0	0		1.	4	5
Jan. 1978	J	1	1	1	1	0	0	0	) (	)	0		0	0	0	)	0	0	0		3	2	5
Feb.	3	3	1	2	2	2	0	0	) (	)	0		0	0	0	)	0	0	1	4	1	5	0
Mar.	1	1	1	2	2	1	0	4	1	Ł	0		0	1	0	)	1	2	2	;	3	1	0
Apr.	(	)	0	0	0	0	0	6	5 (	3	1		0	1	2	2	4	2	0	(	)	0	0
May	(	)	0	0	0	0	0	5	5 3	3	2		2	1	4		0	0	0	(	)	0	0
June	(	)	0	0	0	0	0	1	. (	3	3		0	0	0	)	0	0	0	(	)	0	0
July	(	)	0	0	0	0	1	1	. 8	3	0		1	1	0	)	0	0	0	(	)	0	0
Aug.	(	)	0	0	0	0	4	. 4	1	2	0		1	1	3	:	1	0	0	(	)	0	0
Sep.	(	)	1	0	2	3	3	1	. (	)	0		0	0	1		1	2	5	(	)	0	0
Oct.	(	)	2	1	4	3	0	• 0	) (	)	0		0	0	0	)	0	0	2	8	3	0	0

\* Duration of emersion for 10 days at two spring tides per month was calculated from tide tables (Japan Meteorological Agency, 1976, 1977).

	ne olere i.				
Time	7.5	8.0 8.	H .5 9.0	0 9.5	Total measurements
April 1977					
10:00	0%	70%	30%	0%	10
13:00	0	73	27	0	11
16:00	Ő	56	44	Ő	9
20:00	Ŭ	00		0	-
May 1977					
10:00	٥	70	30	0	10
10:00	0	70	20	0	10
13.00	0	60	40	0	10
10,00	U	00	40	U	10
20 · 00					
June 1977					10
10:00	0	69	31	0	13
$13 \stackrel{.}{.} 00$	0	86	14	0	14
16:00	8	84	8	0	13
20 : 00					
July 1977					
10:00	0	75	25	0	12
13:00	0	92	8	0	13
16:00	0	100	0	0	8
20:00	U	200	,	,	-
Sentember 1977					
10:00	0	78	99	0	9
12:00	0	100	0	0	9
15 . 00	0	100	0	0	9
10,00	0	100	0	0	8
20.00					
October 1977	0	100	0	0	10
10:00	0	100	0	0	10
13:00	0	91	9	0	11
16:00	0	100	0	0	11
20:00	0	100	0	0	9
November 1977					
10:00	0	100	0	0	11
13:00	0	100	0	0	12
16:00	0	100	0	0	11
20:00	50	50	0	0	10
December 1977					
10:00	0	100	0	0	9
13:00	0	100	õ	0	10
16:00	0	100	0	0	10
20:00	67	100	0	0	0
20.00 Ionuoru 1079	07	33	0	0	5
January 1970	0	100	0	0	19
10.00	0	100	U	U	12
13.00	0	100	0	0	11
16:00	9	91	U	0	11
20:00	27	73	0	0	11
February 1978					
10:00	0	100	0	0	13
13:00	0	70	30	0	10
16:00	0	43	57	0	7
20:00	11	78	11	0	9
March 1978					
10:00	0	93	7	0	15
13:00	0	60	40	0	15
16:00	Ő	58	42	0	12
		50			

 Table 8
 Seasonal change of frequency distribution of pH of seawater at the Cleft-1.

· · · ·						
Time	7.5	8.0	рН 8.5	9.0	9.5	Total measurements
20:00	67	33	0	0		9
April 1978						
10:00	0	50	50	0		10
13:00	11	22	56	11		9
16:00		60	40	0		5
20:00	20	80	10	0		5
May 1978	20	00	U	U		5
10:00	0	0.9	0	0		10
10 - 00	0	92	0	0		12
13.00	0	64	29	1		14
16.00	0	83	17	0		12
20.00	12	88	0	0		8
June 1978						
10 : 00	0	36	64	0		11
$13 \div 00$	0	70	30	0		10
16:00	0	75	25	0		8
20:00	0	100	0	0		5
July 1978						
10:00	0	69	31	0		13
13:00	0	100	0	0		12
16:00	0	100	0	0		9
20:00	0	100	0	0		6
August 1978	,	100		0		v
10:00	0	100	0	0		5
13:00	Ő	100	ñ	0		5
16:00	0	100	0	0		5
20:00	0	100	0	0		4
20 · 00 Sontombor 1079	U	100	U	0		2
10:00	0	100	0	0		-
10.00	0	100	0	0		5
13.00	0	100	0	0		6
16 . 00	0	100	0	0		5
20:00	0	100	0	0		5
October 1978						
10:00	0	100	0	0		9
$13 \div 00$	0	100	0	0		10
16:00	0	100	0	0		7
20:00	14	86	0	0		7
November 1978						
10:00	0	100	0	0		14
13:00	0	100	0	0		12
16:00	0	100	0	0		9
20:00	67	33	0	0		9
December 1978						
10:00	0	100	0	0		9
13:00	ů	100	õ	Ő		10
16:00	0	100	0	0		5
20:00	40	100	0	0		5
20 · 00 Ionuory 1070	40	00	U	0		5
January 1979	0	100	0	0		,
10 - 00	0	100	0	0		4
13.00	0	100	0	0		b
16.00	0	100	U	0		6 2
20:00	57	43	0	0		7
February 1979	. –		_			
10:00	17	83	0	0		12
13:00	0	91	9	0		11
16:00	10	90	0	0		10
20:00	100	0	0	0		6

(Continued)

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Continued)						
Time	7.5	8.0	pH 8.5	9.0	9.5	Total measurements
March 1979						
10:00	14	79	7	0		14
13:00	9	64	27	0		11
16:00	25	75	0	0		8
20:00	0	100	0	0		7
April 1979						
10:00	0	78	22	0		9
13:00	0	75	25	0		8
16 : 00	0	75	25	0		8
$20 \div 00$	50	50	0	0		4

Table 9pH of seawater at spring tide at Charatsunai from<br/>April 1977 to April 1979.

	дріп	1977 to April	1979.				
	Time	C-1	P-1	Sampling point P-2	P-3	P-4	
April 1	977						
4	10:00	8 89	8 78			9.85	
•	13:00	8.60	0.10				
	16:00	8 23					
5	10:00	8 83	8 76			9 92	
5	13:00	8 /0	8 45			9.52	
	16:00	8 36	0.40			5.02	
6	10:00	8 83	8 87			9.85	
0	13:00	8 75	8 86			9.69	
	16:00	8 51	0.00			0.00	
May 10	10.00	0.01					
A	10 . 00	8 92	9 10			9 90	
4	13:00	8 50	8 50			9 50	
	16:00	8.30 8.30	0.05			5.00	
c	10:00	8.30	0 69			0 11	
0	10.00	0.00	0.04			9.44	
	13.00	8.40	0.01			9.50	
-	16.00	8.18	0 00			0 00	
1	10.00	8.18	8.22			0.00	
	13.00	8.38	8.41			9.78	
т 1/	16 . 00	8.23					
June 19	10,00	0 50	0.00			0.00	
14	10.00	8.50	8.62			9.00	
	13:00	8,34					
	16:00	8.21				0.10	
15	10:00	8.59	8.76			9.10	
	13:00	8.50					
	16:00	8.21	0.00			0.07	
16	10:00	8.79	8.82			9.07	
	13:00	8.45					
<b>.</b>	16:00	8.30					
July 19	77		o			0.51	
13	10:00	8.52	8.49			8.71	
	13:00	8.26				0.01	
16	10:00	8.85	8.70			8.91	
	13:00	8.50	8.51			8.91	
	16:00	8.33					
18	10:00	8.48	8.41			8.51	
	$13 \stackrel{.}{.} 00$	8.25	8.29			8.82	
	16:00	8.10					
Septem	ber 1977						
28	10:00	8,52	8.54			9.07	

# (Continued)

Time	<u> </u>	, S	ampling point	
	<u> </u>	P-1	P-2	<u>r-3</u> <u>r-4</u>
29 10:00	8.32	8.49		9.03
13:00	8.23			
16:00	8.21			
30 10:00	8 29			
13:00	8 40			
16:00	0.40			
10.00 October 1077	0.34			
11 10:00	0.00	0.00		0.10
11 10.00	8.29	8.30		9.19
13:00	8.29			
16:00	8.22			
20:00	8.10	8.10		7.50
12  10:00	8.39	8,39		9.08
13:00	8.32			
16:00	8.28			
20:00	8.15	8.12		7.50
13 10:00	8.38			
13:00	8 40			
16 . 00	8 32			
20:00	8 18	8 18		7 62
November 1977	0.10	0.10		1.04
10 10:00	0 20			
10 10.00	0.32			
13.00	8.19			
16 : 00	8.17			
20:00	7.74	7.71		7.51
11 10:00	8.29			
13:00	8.14			
16:00	8.15			
20:00	7.70	7.75		7.50
12 10:00	8.29			
13:00	8.29			
16:00	8.11			
20:00	7 84	7 83		7 49
December 1977		1.00		
22 10 . 00	8 13			
13:00	8 20			
16:00	0.20			
10.00	0.13	8 68	7 00	0.50
20.00	7.80	1.01	7.83	8.52
23 10.00	8.12			
13:00	8.16			
16:00	8.21			
20:00	7.81	7.64	7.89	8.29
24 10:00	8.03			
13:00	8.17			
16:00	8.17			
20:00	7.93	7.90	7.90	7.41
January 1978				
23 10:00	8,17			
13:00	8.09			
16:00	8 12			
20 : 00	7 96		7 87	7 51
20.00	1.30 Q 10		1.01	1.51
24 IV · VU 12 · 00	0.10			
13.00	0.11			
16.00	8.03			
20:00	8.01			
25  10:00	8.06			
13:00	8.13			
16:00	7.97			

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(Continu	ed)				
	Time		S	ampling point	
		<u>C-1</u>	P-1	P-2 P	<u>-3 P-4</u>
Fobruo	20:00	8.03			
20	10:00	0 25			
20	12:00	0.00			
	20 100	8 16	8 10	7 98	
21	10:00	8 23	0.10	1.50	
21	13:00	8 30			
	20:00	8.05	7 98	7 90	7.70
22	10:00	8 42	1.00	1.00	,,,,,
	13:00	8.31			
	16:00	8.13			
	20 : 00	8.00	7.89	7.89	7.58
March	1978				
25	10:00	8.46	8.74	8.77	9.10
	13:00	8.70			
27	10:00	8.92	8.75	8.70	9.08
	13:00	8.42	8.90	8.98	8.95
	16:00	8.50			
	20:00	7.92			
29	10:00	8.42			
	13:00	8.68	9.10	9.02	9.27
	16:00	8.89			
A	20:00	8.11			
April 1	978	0.00	0.00	0.00	0.10
25	10.00	8.90	9.08	8.80	9.19
97	$13 \cdot 00$ 10 · 00	8.00	0.91	0.02	9.12
21	10:00	0.00	8.00	0.09 8 71	0.23
	15.00	0.12 9.19	0.95	0.71	5.23
	20:00	0.40 9.11			
28	10:00	8 49			
20	13:00	9.39	9 20	8 92	9.20
	16:00	8 70	8 82	8 95	8.95
	20:00	8.26	0.02	0100	
May 19	978	0.20			
24	10:00	8.40	8.30	8.21	8.31
	13:00	8.12	8.10	8.37	8.30
	16:00	8.08			
	20:00	8.00			
25	10:00	8.92	8.64	8.48	9.10
	13:00	8.81	8.58	8.84	9.09
	16:00	8.39			
~ ~	20:00	8.11	0.5.	0.65	0.00
26	13:00	9.00	8.54	8.65	9.00
	16:00	8.41			
Luno 14	20.00	8.08			
June IS	10 . 00	0 61	0 40	0 20	0 00
Z1	10.00	0.01	0.49	0.39	0.00
	13.00	0.42 8 20			
22	10:00	8.68	8 43	8 21	9.13
44	13:00	8 47	8.46	8.42	9.11
	16:00	8.20	0.10	J. 10	
	20:00	8.15			
23	10:00	8.95	8.70	8.20	9.12
	13:00	8.68	8.47	8.18	9.19
	16:00	8.32			

(Continued)	
(Continuea)	

	Time	<b>.</b> .	** *	Sampling poir	it	_
	~	C-1	P-1	P-2	P-3	P-4
July 19	78					
5 GIJ 10	10 . 00	Q 70	0 60	0 22		0.99
21	10.00	8.19	0.00	0.02		9.22
	13:00	8.39	8.47			9.16
	16:00	8.21				
22	10 : 00	8.58	8.50	8.11		9.04
	13:00	8.34	8.55	8.25		9.17
24	10:00	8 32	8 33	8 29		9.20
21	12:00	8 40	8 65	Q 49		0.21
	10:00	0.40	0.00	0.42		9.21
	16.00	8.33				
	$20 \div 00$	8.10				
August	1978					
16	10:00	8.25	8.35	8.50		9.07
	13:00	8.31				
	16:00	8 29				
10	10:00	0.25	0 60	0 20		0.00
10	10.00	0.40	0.00	0.39		9.09
	13.00	8.35				
	16:00	8.25				
	$20 \div 00$	8.16				
19	10:00	8.29	8.37	8.39		8.59
	13:00	8 19				8 88
	16:00	8 10				0.00
Santam	10 · 00	0.15				
Septem	Del 1976		0.50			
14	10 : 00	8.30	8.50	8.38		9.20
	13 : 00	8.30				
	16 : 00	8.24				
16	10:00	8.28				
	13:00	8 22				
	20:00	8 10				
10	20:00	0.19	0.00	0 50		0.00
18	10.00	8.33	8.30	8.58		9.23
	13:00	8.28				
	$16 \stackrel{.}{.} 00$	8.27				
	20:00	8.20				
October	· 1978					
13	10 . 00	8 30				
10	12:00	0.00				
	13.00	0.19				
	10.00	8.13				
	$20 \div 00$	8.00			7.98	
14	10 : 00	8.29		8.40	8.40	9.30
	13 : 00	8.10				
16	10:00	8 16		e e e e e e e e e e e e e e e e e e e		
10	13 . 00	Q 12				
	10 . 00	0.10				
	10 - 00	8.12	0.07	=	0.00	
. 17	20:00	7.99	8.06	7.98	8.02	7.40
Noveml	ber 1978					
13	10:00	8.22			8.23	8.88
	13:00	8.24				
	16:00	8 22				
	20 . 00	7 60	7 20	7 70	7 00	7 47
	20.00	(.03	1.39	1.10	1.33	(.4)
14	10 . 00	8.17			8.32	
	13 : 00	8.19				
	16:00	8.19				
	20:00	7.80	7.78	7.73	8.00	7.40
15	10:00	8 08				
10	13 . 00	\$ N2				
	10.00	0.00				
	10.00	8.06	0.00		5 00	<b>F</b> 10
	$20 \div 00$	7.98	8.00	7.91	7.98	7.48

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(Continued) -

,	Гime	C-1	P-1	Sampling poi P-2	nt P-3	P-4
Decemb	er 1978					
11	13:00	8.30				
**	20:00	7 99	7 73	7 83	7.89	7.80
13	10:00	8.28		1100		
10	13:00	8.31				
	16:00	8.30				
	20:00	7.80	7.70	7.82	8.04	7.51
14	10:00	8 26	1.10	1.02	0.01	1.01
14	13:00	8 25				
	20:00	8.09	8 11	8 00	8 12	7 61
Ianuary	7 1979	0.05	0.11	0.00	0.12	1.01
gundar y Q	13:00	8 22				
5	16:00	8 13			8 34	9 51
	20:00	8 00	7 80	7 88	8 21	8 98
10	10:00	8.06	1.00	1.00	0.21	0.50
10	12:00	8.00				
	15:00	8 10				
	10 . 00	0.10 7.00	7 00	7 01	7 00	7 50
11	20.00	1.99	1.99	1.01	1.00	1.59
11	10.00	0.00				
	15.00	0.10				
	16.00	8.10	0 00	7.04	7 00	7 55
E.L.	20.00	7.96	8.00	7.84	7.80	7.55
Februar	ry 1979	0.00				
8	10.00	8.08				
	13:00	8.00				
	16:00	8.11	=		=	- 00
	20:00	7.88	7.63	7.68	7.90	7.99
9	$10 \div 00$	8.12				
	$13 \div 00$	8.34				
	16:00	8.23				
13	10:00	8.05	8.25	8.30	8.48	8.81
	13 : 00	8.30				
	16:00	8.13				
	$20 \div 00$	7.98			7.95	
March	1979					
14	10:00	8.33	8.40	8.55	8.50	9.00
	13:00	8.61				
	16:00	8.11				
	20:00	7.85			7.85	
15	10:00	8.47	8.48	8.55	8.62	8.94
	13:00	8.70				
	16:00	8.40				
16	13 : 00	8.60	8.28	8.72	8.90	9.25
	20:00	7.90				
April 1	979					
12	10:00	8.39	8.59	9.18	8.57	9.10
	13:00	8.38			8.48	
	16:00	8.24				
13	10:00	8.80	9.08	8.69	8.54	9.10
	13:00	8.38	8.54	8.90	8.79	9.00
	16:00	8.38				
	20:00	8 18				
16	10:00	8 79	9.03	8 82	8 70	9.24
10	13:00	8 50	9 11	8 86	8 87	9 12
	16:00	8 54	0.11	0.00	0.01	0.10
	20:00	8 01				
	20:00	8.01				

Time	Weather	C 1	D 1	Sampling point	D 2 D 4
		<u> </u>	P-1	P-2	P-3 P-4
February 1978					
21 $20$ : $22$	F	32.59	32.68	33.04	34.14
22 21:00	S	32.70	32.57	32.70	34.52
23 21:25	Ĉ	32 55	33 08	33 40	34 94
27 11:20	Š	32.00	20.00	29 27	32 57
27 11 . 29	5	32.43	34.37	32.37	02.01 99.64
28 12 · 12	5	32.45	32.43	32.39	32.04
March 1978					
1 - 13 : 01	C	32.26	32.21	32.23	32.01
2  14:02	F	32.39	32.39	32.64	33.26
3 16:00	С	32.41	32.48	32.57	33.29
8 20:28	F	32.26	32.37	32.25	33.04
9 21 09	F	32 26	32 37	32 28	33 73
12 11 17	ŝc	22.20	20.01	22.20	22 55
13 11:17	50	20.27	22.32	32.32	22.00
14 12.00	r	32.37	34.43	32.48	32.19
22 19.56	5	32.32	32.26	32.08	32.21
24 21:03	F	32.32	32.32	32.26	32.34
27 10:31	F	32.48	32.54	32.26	32.79
28 11:12	С	32.43	32.54	32.12	32.66
29 11:56	F	32 32	32 61	32 41	33 48
April 1978		05.05	00.01	02.11	00.10
11 10.50	F	20 E4	22 70	22 66	22 01
11 10.58	L.	32.34	32.70	32.00	35.01
12 11.27	51	32.16	32.30	30.55	28.53
13  12:09	C	32.45	32.57	32.43	32.75
25 10:14		32.28	32.34	32.34	32.39
27 11:36	С	31.78	31.98	32.12	32.36
28 12:18	F	31.96	32.03	32.14	32.34
May 1978					
8 9.21	F	32 28	32 55	22 /1	32 66
0 10:01	Ċ	32.20	22.00	22.41	20.40
9 10 01		32.14	32.23	32.34	32.43
11 11.09	r	31.38	31.38	31.42	31.58
24  10:00	C	31.45	31.51	31.58	31.47
25 10:40	F	31.80	32.30	32.25	32.43
26 11:19	Fog	31.51	31.74	31.65	31.74
June 1978					
7 9:39	F	32 45	32 92	32 61	33 01
8 10 13	я́.	32.66	33 20	32 81	33 40
0 10:13	r F	32.00	22.23	32.01	22.40
9 10 53	r	32.01	33.35	32.75	33.29
21 9.05	Fog	14.24	21.95	19.84	15.86
22 9:47	C	31.94	32.01	31.56	31.96
23 10:22	F	30.84	31.45	31.47	31.49
July 1978				14	
6 9:21	SC	31.60	31.80	31.80	31.96
7 10:00	R	24 12	27 62	17 38	14 15
8 10 26	F	31 65	31 89	31 54	32 30
20 0.20	Ċ	21 00	22.02	01.04 01.0E	22.00
20 8.34	Č	31.99	32.07	31.00	32.08
21 9.26	C	32.20	32.01	32.48	32.45
22 10:11	Fog	32.23	32.21	32.21	32.03
August 1978					-19
4 9:08	R	31.85	32.01	31.87	31.42
5 9:32	F	32.32	32.46	32.64	32.75
7 10:44	F	32.25	32.30	32.34	32.52
18 8.28	F	32 43	32 57	32.26	32.55
10 0:20	C	22.43	22 50	20 12	32.00
13 3 13 Soptomber 1079	C	04.40	32.30	52.45	34.35
September 1978	P	00.10	00.00	00.00	<u> </u>
2 8:38	F	33.46	33.60	33.69	33.84
3 9:11	C	33.53	33.60	33.66	33.76
4 9:45	F	33.67	33.71	33.85	34.51

Table 10 Salinity ( $\%_0)$  of seawater at the lower low water of spring tide.

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Time		Weather	Sampling point				
	1 mile	Weather	C-1	P-1	P-2	P-3	P-4
October	r 1978						
4	$22 \div 12$	F	33.71	33.69	33.85	33.95	33.98
5	22:53	С	33.82	33.73	33.80	33.93	34.02
17	21: $21$	F	33.71	33.82	33.76	33.93	33.95
Novem	ber 1978						
2	$21 \div 56$	F	33.60	33.69	33.71	33.76	33.95
14	20:28	F	33.49	33.75	33.64	33.71	33.80
15	21:09	С	33.76	33.67	33.71	33.33	33.98
29	20:18	R	33.44	33.40	33.13	33.33	33.19
30	21:01	F	33.42	33.40	33.31	33.46	33.48
Decemb	per 1978						
13	20:21	F	33.76	33.87	33.82	33.89	33.85
14	21:00	R	31.81	31.24	30.12	31.20	28.44
28	20:06		31.98	32.41	32,83	31.76	32.36
January	y 1979						
11	20:21	S	33.66	33.64	36.98	37.94	41.44
12	20:51	SC	33,69	35.07	36.04	36.87	39.06
26	19:55	С	33.19	32.90	33.01	32,95	32,95
Februa	rv 1979						
9	20:19	F	32.99	33.31	33.31	33.15	37.11
23	18:49	F	32.99	33.02	32.99	33.22	38.23
26	21:00	S	32.84	32.83	32.72	32.70	32.83
March	1979						
19	$12 \div 12$	F	32.57	32.72	32.72	32.75	33.01
26	19:55	С	32.55	32.50	32.66	32.61	32.63
30	10:09	R	32.39	32.26	32.16	32.10	31.98
April 1	979						
16	11 : 13	SC	32.39	32.77	32.79	32.57	32.93
18	12:40	SC	32.14	32.23	32.45	32.92	33.04

F: fine weather; SC: slightly cloudy; C: cloudy; R: rainy; S: snowy; SI: sleety.

Table 11	Monthly mean evaporation value of water (g/28cm <sup>2</sup> /hr)
	at Charatsunai from November 1977 to April 1979.

Month	In daytime	In nighttime
November 1977	0.37(7*)	0.10(6*)
December	0.28(10)	0.14(9)
January 1978	0.20(12)	0.13(11)
February	0.24(9)	0.17(9)
March	0.54(14)	0.13(8)
April	0.39(9)	0.15(6)
May	0.31(13)	0.09(7)
June	0.50(10)	0.06(5)
July	0.66(12)	
August	0.88(9)	_
September	0.74(9)	0.15(5)
October	0.51(10)	0.23(7)
November	0.38(12)	0.13(9)
December	0.28(9)	0.14(5)
January 1979	0.26(4)	0.21(7)
February	0.27(12)	0.18(7)
March	0.38(16)	0.11(7)
April	0.40(9)	0.15(4)

\* Values in brackets show the number of measurements.