ASSOCIATIONS OF PLANKTON DIATOMS AROUND JAPAN AS INVESTIGATED BY UNDERWAY SAMPLINGS ABOARD THE "OSHORO MARU" IN OCTOBER AND DECEMBER 1952 *

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I. Introduction

The training ship "Oshoro Maru" of the Faculty of Fisheries, Hokkaido University, made a round-Japan cruise from October 14 to December 15, 1952. The purpose of this cruise was not only for the regular training of cadets in navigation and seamanship, but also for a preliminary trial of undersea observations at several localities along the coasts of Japan Islands by means of the "Kuroshio", Undersea Observation Chamber (Inoue *et al.*, 1953) under supervision of Prof. N. Inoue, Faculty of Fisheries, Hokkaido University, and Dr. T. Sasaki, Scientific Research Institute, Tokyo. On this occasion Prof. Motoda who was on board the ship made collections of the surface plankton by underway samplings through the whole course of the cruise off the coasts of Honshu and Kyushu. These samples of plankton were put at the disposal of the present author. The plankton diatoms are dealt with in the present paper.

In Japanese waters in recent years a group of planktologists in Marine Observatories, Ministry of Transportation, has contributed to understanding the nature of water masses by observing the distribution of plankton diatoms.

With similar intention the present investigations were originally undertaken to observe how the diatom associations vary with the localities around the coasts of Japan within the comparatively short period of one cruise. There are such ocean currents around Japan that were traversed in the present cruise as the Tsushima Current off Japan Sea coasts, the Kuroshiwo (Japan Current) and Oyashiwo (Kurile Current) off the Pacific coasts. The particular interest may be aroused by the manner in which varying hydrographic conditions resulting from geographical and climatic effects during continuous flow of such currents, either southwards, or northwards, are reflected in the change of diatom associations. However, the track of the ship in the present cruise did not always follow a particular ocean current; the track was located very close to the coast, passing through the purely coastal waters, in certain areas, while in other areas it was shifted comparatively to the offing, touching with the prevailing ocean current. Accordingly, the findings herewith reported render possible some considerations such as above mentioned at some places, but in most descriptions are concerned with merely the findings in respect to

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characteristics in diatom associations in various localities at that time wheresoever inshore or offshore waters.

Before going further, the author wishes to express his sincere gratitude to Prof. S. Motoda under whose guidance he initiated his scientific research work. Cordial thanks are also due to from the author to Dr. T. Kawamura and Mr. M. Anraku for their many valuable advices given throughout the laboratory work. Kind help extended by Captain T. Fujii and his crew and cadets, and Prof. N. Inoue and Dr. T. Sasaki and their scientific staff aboard the ship during that cruise is gratefully appreciated.

II. Method, Location and Date of Samplings

The Handy Underway Plankton Catcher, model I, (Motoda, 1954) was employed in sampling the plankton materials. To sample the microplankton, composed mainly of phytoplankton, while underway, a narrow conical net of fine mesh bolting silk, XX 13, *i. e.*, 129 meshes per linear inch, having approximately 0.11 mm mesh opening, is inserted into the catcher. As the catcher, model I, is very narrow, 5 cm in diameter of cylindrical case, and as it has a tapering head piece, it is easy to handle at high speed tow. The instrument was towed at the end of twenty-five meters of cotton flag line at a speed of about 9 knots for 30 minutes or less; duration of tow depended upon the circumstances.

Tows were made by cadets or sailors at intervals of four hours while the ship was sailing. The net inside was often clogged with sticky materials; on such an occasion it was washed to clean it out. The instrument was not equipped with any sinking vane, but it was supported by a heavy head piece to run through the water at about a half meter or so below the sea surface. There was no equipment such as current meter to measure the volume of water filtered by the net inside or to measure the exact distance of tow, so that the samples obtained are not available for accurately quantitative studies, but may be used for rough estimation of relative abundance of population. Of all of the samples the number of cells, often composing colonies, were counted for each species so far as identified.

Approximate location of the stations where collections were made is illustrated in Fig. 1, and more exact data on the position of the stations, date and hour of collections and temperature of the surface water at that time are given in Table 1. Total sum of the sample vials amounted to sixty-six, but that from St. 57 was lost and those from St. 35 and St. 36 did not contain any organism, but only water. These are omitted from the data.

III. Results of Observations

For the sake of convenience in arrangement descriptions will be made following the track of the ship in chronological order from departure, by grouping some of the stations on

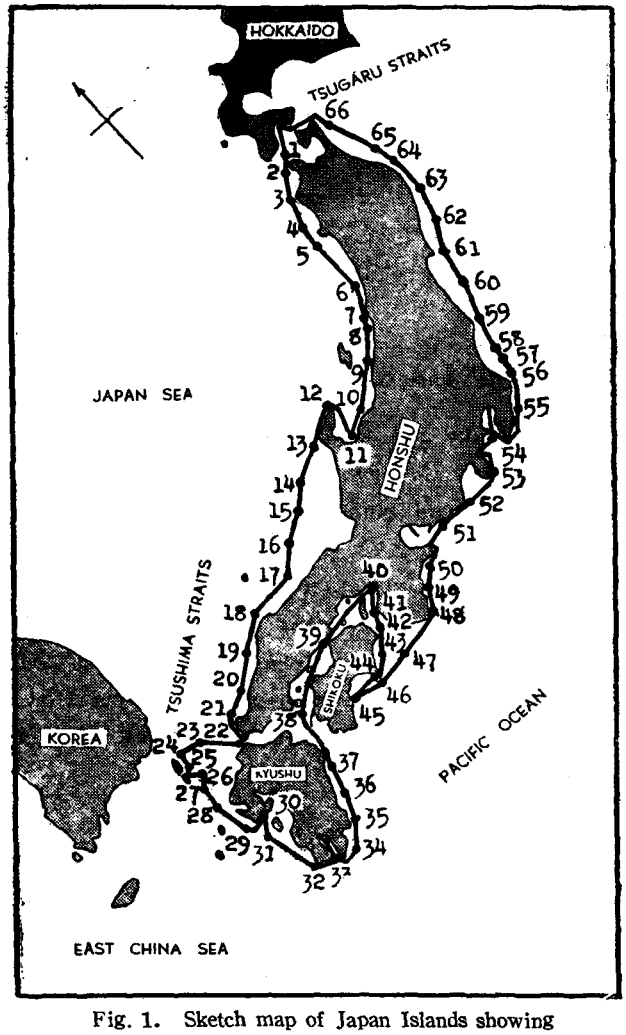

Fig. 1. Sketch map of Japan Islands showing track of the cruise and stations of sampling

the basis of neighbouring geographical situation and of apparently common associations of diatom population. Full data are given in Table 3 and summarized results in Table 2. Number of cells recorded in the text and table are only concerned with the number obtained by a tow of definite duration; all data are converted for thirty minutes' tow. It is natural that these numbers are far less than the actual number of cells which must be present in the volume of water that has been passed through the mouth opening of the instrument for such duration of tow. The filtration coefficient in such underway samplings will be much less than found in case of the use of other methods.

(1) St. 1 and 2 (Tsugaru Straits)

Cell number of total diatoms is from 3,900 (St. 1) to 25,200 (St. 2), averaging 14,550. Total species number is thirty-five. The most prevalent form is *Chaetoceros coarctatus*. This species has been known in this region as one of the representatives of tropical diatoms which appear with drift of northwards Tsushima Current from southern seas in autumn (Asamushi Marine Biological Station, 1946-49; Kokubo, 1952; Hakodate Marine Observatory, 1954). Next comes *Chaetoceros didymus* occupying about 20 % of total cells. It is a warm temperate species. The prevalence of above species indicates the inflow of a tributary current of the Tsushima Current into Tsugaru Straits in this season.

(2) St. 3-13 (Japan Sea coast of northern Honshu)

The course of the ship is located adjacent to the coast. Total cell number is counted as between 4,800 and 190,000 and 72,000 in average. Species number is eighty-four.

The leading species are *Chaetoceros coarctatus*, *Ch. decipiens*, *Ch. lorenzianus*, *Ch. didymus*, *Ch. distans*, *Climacodium biconcavum*, *C. Frauenfeldianum* and *Thalassionema nitzschioides*, though some of them are absent at some stations. *Chaetoceros coarctatus* has never occupied more than 20 % of total cells. *Hyalochaete* occupied about 50 % of total diatoms, and warm current species are found more or less commonly in the localities from Noto Peninsula to Niigata, agreeing with previous reports (Aikawa, 1936; Kawarada, 1953; Shimomura, 1954a). There are large concentrations of diatom population at St. 9 (188,400 cells) and St. 13 (179,400 cells), in which *Hyalochaete* and *Thalassionema nitzschioides* are dominant.

(3) St. 14 and 15 (Off Wakasa Bay)

These stations are located in the offing. Total cell number ranged from 7,800 (St. 14) to 32,800 (St. 15), with 20,300 in average. Number of species is twenty-one. Generally diatom population is poor both in total cell number and in species number. *Chaetoceros coarctatus* is the leading species, occupying 76 % of total diatom cells. It is followed by *Climacodium* and *Rhizosolenia*. The prevalence of tropical and subtropical oceanic species as well as the poverty in total cells indicates that the ship has passed through the water of the Tsushima Current. Shimomura (1954b) reported that the Tsushima Current off Wakasa Bay is characterized by decrease in number of plankton, particularly of phytoplankton; the more one goes to the northeast in the path of this current, the less number of plankton he finds.

(4) St. 16–21 (Japan Sea coast of southern Honshu)

Total cell number lies between 17,000 and 427,500, with 176,700 in average. Species number is sixty-seven. *Hyalochaete* occupies more than 50 % of total diatoms. *Chaetoceros lorenzianus* and *Ch. didymus* are dominant through all stations; *Ch. compressus* is dominant at St. 17–19, and *Ch. messanensis*, *Ch. distans*, and *Ch. radicans* are at St. 19–21. Aikawa (1936) reported that *Hyalochaete* occupies more than 50 % of total phytoplankton on southern Japan Sea coast of Honshu being followed by *Nitzschia seriata* and *Bacteriastrum* in autumn. There are high concentrations of diatom population at St. 16 (362,000 cells) and St. 19 (408,000 cells), in which *Hyalochaete* and *Thalassionema nitzschioides* are dominant. St. 16 is located near the coast of the oki Islands where the abundance of diatoms has been induced possibly by the upwelling of underwater near the islands, though physical proof is not obtained. According to Aikawa (1934), the vicinity of the oki Islands is a high productive area, and also to Shimomura (1954b), the phytoplankton is very abundant from the north of the oki Islands to the offing of Wakasa Bay. Shimomura suggested that the abundance of phytoplankton off Wakasa Bay in summer is due to the upwelling water in that region.

Table 1. Record of collections

No. of station	Date	Hour	Position Lat.	Position Long.	Locality	Temperature of surface water (°C)	Remarks
St. 1	October 14	17:00-17:30	41-27-00 N.	140-25-09 E.	Tsugaru Straits	18.5	
〃 2	〃 〃	20:15-20:45	41-08-00 N.	140-10-03 E.	Off Cape Gongensaki	21.5	
〃 3	〃 15	00:00-00:30	40-38-00 N.	139-48-00 E.	Off Henashi	19.0	
〃 4	〃 〃	04:00-04:30	40-15-00 N.	139-38-00 E.	Off Noshiro	21.5	
〃 5	〃 〃	08:00-08:30	39-51-30 N.	139-26-00 E.	Off Ojika Peninsula	20.5	
〃 6	〃 〃	11:50-12:20	38-47-30 N.	139-37-00 E.	Off Sakata	21.0	
〃 7	〃 〃	16:00-16:30	38-12-30 N.	139-19-00 E.	Off Senami	22.0	
〃 8	〃 〃	19:45-20:15	38-12-30 N.	139-12-30 E.	〃	22.2	
〃 9	〃 1	23:45-00:15	37-50-00 N.	138-44-00 E.	Off Niigata	27.5	
〃 10	〃 〃	07:45-08:00	37-09-05 N.	137-56-00 E.	Off Naoetsu	23.0	
〃 11	〃 〃	12:15- ?	36-54-08 N.	137-19-42 E.	Toyama Bay	22.5	
〃 12	〃 ?	?	37-36-00 N.	137-18-00 E.	Off Noto Peninsula	——	
〃 13	〃 19	19:45-20:15	37-19-00 N.	136-28-05 E.	〃	22.0	
〃 14	〃 〃	23:45-00:15	37-00-00 N.	135-30-00 E.	Off Tsuruga	19.0	
〃 15	〃 20	03:45-04:15	36-39-07 N.	135-01-05 E.	〃	20.0	
〃 16	〃 〃	07:45-08:00	36-18-01 N.	134-18-09 E.	Off Tottori	20.4	
〃 17	〃 〃	11:45-12:15	35-51-05 N.	133-51-05 E.	〃	22.4	
〃 18	〃 〃	15:45-16:15	35-35-02 N.	132-55-08 E.	Off Mastue	20.3	
〃 19	〃 〃	19:45-20:15	35-13-05 N.	132-10-00 E.	Off Hamada	22.1	
〃 20	〃 〃	23:45-00:15	34-44-00 N.	131-22-00 E.	Off Senzaki	20.4	
〃 21	〃 21	03:45-04:15	34-28-00 N.	130-52-02 E.	〃	22.2	
〃 22	〃 27	23:45-00:15	34-08-04 N.	130-38-00 E.	Off Kokura	22.0	
〃 23	〃 〃	03:45-04:15	34-30-00 N.	130-02-00 E.	Tsushima Straits	19.8	
〃 24	〃 〃	07:45-08:15	34-44-00 N.	129-31-07 E.	Northeast coast of Tsushima	22.2	
〃 25	〃 28	16:15-16:45	34-18-05 N.	129-26-05 E.	East coast of Tsushima	21.8	
〃 26	〃 29	15:30-16:00	34-04-14 N.	129-33-00 E.	Tsushima Straits	——	
〃 27	〃 〃	19:45-20:15	33-53-05 N.	129-31-00 E.	〃	21.8	
〃 28	〃 30	03:45-04:15	33-20-03 N.	129-17-08 E.	Off Hirato	23.0	
〃 29	〃 〃	15:45-16:15	32-48-06 N.	129-35-02 E.	Off Nagasaki	21.0	
〃 30	November 6	10:30-11:00	32-42-00 N.	130-01-00 E.	Tachibana Bay	20.4	
〃 31	〃 7	20:15-20:30	32-29-02 N.	129-42-02 E.	Off Cape-Nomo	17.0	
〃 32	〃 9	23:45-00:15	31-15-08 N.	130-07-01 E.	Off Makurasaki	20.4	
〃 33	〃 15	11:45-12:15	31-10-01 N.	130-42-01 E.	Kagoshima Bay	22.5	
〃 34	〃 〃	15:45-16:15	31-06-00 N.	130-58-00 E.	Ohsumi Straits	21.9	
〃 35	〃 〃	19:45-20:15	31-27-00 N.	131-26-08 E.	Off Aburatsu	23.0	Empty
〃 36	〃 16	23:45-00:15	31-59-02 N.	131-41-08 E.	Off Miyazaki	23.0	Empty
〃 37	〃 〃	03:45-04:15	32-29-01 N.	131-52-06 E.	Off Nobeoka	23.0	
〃 38	〃 〃	11:45-12:15	33-33-02 N.	132-12-00 E.	Iyo-Nada	21.0	
〃 39	〃 21	07:45-08:15	34-20-06 N.	133-43-00 E.	Bingo-Nada	19.8	
〃 40	〃 〃	16:30-17:70	34-37-00 N.	135-10-04 E.	Izumi-Nada	19.6	
〃 41	〃 25	11:45-12:15	34-13-01 N.	134-55-09 E.	Off Wakayama	19.5	
〃 42	〃 〃	19:45-20:15	34-02-01 N.	134-48-08 E.	Kii Channel	19.4	
〃 43	〃 26	23:45-00:15	33-25-05 N.	134-28-00 E.	East of Cape Muroto	21.4	
〃 44	〃 〃	03:45-04:15	33-13-06 N.	133-57-08 E.	Off Cape Muroto	22.5	
〃 45	〃 29	16:00-16:30	33-16-06 N.	133-19-00 E.	Tosa Bay	22.4	
〃 46	〃 〃	19:45-20:00	33-12-04 N.	134-00-00 E.	West of Cape Muroto	22.5	
〃 47	〃 30	23:45-00:15	33-14-02 N.	134-38-00 E.	Off Kii Channel	21.4	
〃 48	〃 〃	07:45-08:15	33-33-02 N.	135-59-06 E.	Off Cape Shionomisaki	22.1	
〃 49	〃 〃	11:45-12:15		136-17-00 E.	Off Owase	19.0	
〃 50	December ?	07:45-08:15	34-05-05 N.	136-26-01 E.	〃	21.0	
〃 51	〃 3	19:45-20:15	34-29-00 N.	137-33-02 E.	Enshu-Nada	19.8	
〃 52	〃 4	23:45-00:15	34-33-01 N.	138-24-00 E.	Off Omaezaki	19.0	
〃 53	〃 〃	03:45-08:15	34-38-02 N.	139-05-05 E.	Off Shimoda	16.6	
〃 54	〃 8	07:45-08:15	35-06-08 N.	139-36-08 E.	Sagami Bay	19.1	
〃 55	〃 13	15:45-16:15	35-13-06 N.	140-32-03 E.	Off Katsuura	20.0	
〃 56	〃 〃	19:45-20:15	35-48-05 N.	140-58-05 E.	Off Cape Inubosaki	17.5	
〃 57						——	No sampling
〃 58	〃 〃	23:45-00:15	36-26-00 N.	141-15-00 E.	Off Mito	17.1	
〃 59	〃 14	03:45-04:15	37-03-07 N.	141-12-05 E.	Off Cape Shioyasaki	15.5	
〃 60	〃 〃	07:45-08:15	37-40-05 N.	141-23-05 E.	Off Haranomachi	14.2	
〃 61	〃 〃	11:45-12:15	38-16-01 N.	141-39-03 E.	Off Kinkazan	12.5	
〃 62	〃 〃	15:45-16:15	38-52-00 N.	141-52-06 E.	Off Kesennuma	11.8	
〃 63	〃 〃	19:45-20:15	39-27-05 N.	142- E.	Off Kamaishi	12.0	
〃 64	〃 15	23:45-00:15	40-20-00 N.	142-08-02 E.	Off Kuji	12.3	
〃 65	〃 〃	03:45-04:15	40-39-02 N.	142-06-00 E.	Off Hachinohe	12.0	
〃 66	〃 〃	07:45-08:15	41-19-02 N.	141-31-07 E.	Off Cape Shiriyasaki	14.0	

(5) St. 22 (Genkai-Nada)

Total cell number is very large, amounting to 1,217,400, and species number is thirty-nine. *Chaetoceros radicans* is the most prevalent species, occupying 34 % of total cells. *Ch. lorenzianus*, *Ch. compressus*, *Ch. messanensis*, *Ch. curvisetus* and *Lauderia borealis* are also important constituents of the take.

(6) St. 23 27 (Tsushima Straits)

Total cell number is between 162,000 and 273,000 per haul in the straits, while it is between 450,000 and 1,445,000 on the coast of Tsushima Island, averaging 513,000. Species number is sixty eight. *Chaetoceros decipiens*, *Ch. lorenzianus*, *Ch. didymus*, *Ch. compressus*, *Ch. curvisetus*, *Ch. radicans* and *Ch. messanensis* are dominant, being followed by *Ch. atlanticus* v. *neapolitana*, *Ch. rostratus* and *Lauderia borealis*. *Eucampia zoodiacus* is reported to be prevalent in the straits in the fourth quarter of the year (Kokubo, 1931-40, 1937), but in the present observations this species is not found in the straits, but in the Hirato Channel.

(7) St. 28 and 29 (Hirato Channel)

Total cell number is 127,200 at St. 29 and 457,800 at St. 28, averaging 292,500. Species number is fifty-four. The leading species is *Eucampia zoodiacus*, being followed by *Chaetoceros decipiens* and *Ch. lorenzianus*.

(8) St. 30 and 31 (Amakusa-Nada)

Diatoms are abundant both in total cell number and species number. Total cell number is 792,000 at St. 30 and 5,064,000 at St. 31. The latter value is the largest one among the data obtained from all stations in the present observations. Average of cell number is 2,928,000. Species number is forty-one. *Skeletonema costatum* (21 %) and *Asterionella japoniea* (19 %) are dominant at St. 31, while *Chaetoceros pseudocruvisetus* (34 %) and *Melosira nummuloides* (19 %) are dominant at St. 30. Next to the above four species, *Ch. curvisetus* and *Eucampia zoodiacus* are important constituents. The complicated coastal currents which might be associated with the topographic contours are possibly responsible for the high production of diatoms (cf. Aikawa, 1934).

(9) St. 32 (Southwest coast cf Kyushu)

Total cell number is 2,742,000, and species number is fifty-seven. The most prevalent species is *Chaetoceros messanensis*, being followed by *Ch. compressus*, *Ch. pseudocruvisetus*, *Ch. didymus*, *Ch. radicans*, *Lauderia borealis*, *Bacteriastrum comosum* and *Rhizosolenia Stolterfothii*.

(10) St. 33 (Kagoshima Bay)

The station is located at the entrance of Kagoshima Bay. Total cell number is as large as 3,367,200, and species number is fifty-two. The components of diatoms are fairly different from those at other localities of west coast of Kyushu. *Thalassionema nitzschiodes* and *Chaetoceros pseudocruvisetus* are dominant, being followed by *Ch. compressus*, *Nitzschia seriata*, *Biddulphia sinensis*, *Hemiaulus sinensis*, *H. indica*, and *Climacodium*. *Planktoniella sol* and *Gossleriella tropica* are also found in a certain abundance. The occurrence of tropical or warm-water species is notable; the influence of the Kuroshiwo Current is apparently indicated in diatom associations at the entrance of this bay.

(11) St. 34 and 37 (Hyuga-Nada)

Diatoms are rather poor both in total cell number and in species number. Total cell number is 18,300 at St. 34 and only 2,940 at St. 37, averaging two stations 10,620 cells. Species number is twenty-nine. The leading species is *Thalassionema nitzschioides*, occupying 50 % at St. 34 and 38 % at St. 37. *Climacodium biconcavum* (18.3%) and *Melosira nummuloides* (18 %) are also important. This region is supposed to be under the influence of the Kuroshiwo Current, as is reflected in high temperature and in the prevalence of tropical diatoms as well.

(12) St. 38 (Iyo-Nada)

This station is located in the Inland Sea (Seto-Naikai). The diatom associations are distinct from those of Hyuga-Nada. Total cell number is 34,110 and species number is more than nine. *Coscinodiscus* is the most prevalent group, occupying 86 % of total cells, while *Eucampia zoodiacus* and *Hemidiscus cuneiformis* follow. Kokubo (1931-40) and Maekawa et al. (1953) reported the predominance of *Coscinodiscus* in the more western part in the Inland Sea in winter.

(13) St. 39 (Bingo-Nada)

Total cell number is 262,800 and species number is more than nineteen. *Coscinodiscus* is the most prevalent group, occupying 52 % of the total cells. In addition, the following diatoms are important constituents; *Hemidiscus cuneiformis*, *Stephanopyxis palmeriana*, *Skeletonema costatum*, *Lauderia borealis*, *Rhizosolenia Bergonii*, *Bacteriastrum hyalinum*, *B. mediterraneum*, *Ch. decipiens*, *Hemiaulus indica* and *Pleurosigma* spp. Kokubo (1934-40) reported the predominance of *Coscinodiscus* at Ohcho, Hiroshima Pref. near the present station, in early winter.

(14) St. 40 (Osaka Bay)

Total cell number is 180,000 and species number is more than twenty-four. *Thalassionema nitzschioides*, *Thalassiothrix Frauenfeldii*, and *Coscinodiscus* are dominant. The first two forms together occupy 40 %, whilst *Ch. lorenzianus*, *Ch. pseudocurvisetus*, *Eucampia zoodiacus*, *Ditylum Brightwellii* and *Rhizosolenia alata* are following.

(15) St. 41-43 (Kii Channel)

Total cell number is from 18,900 (St. 41) to 101,900 (St. 43), exceptionally rich, as large as 2,970,000 cells at St.42, and 1,017,000 in average. Species number is thirty-six. *Thalassionema nitzschioides*, *Thalassiothrix Frauenfeldii*, and *Coscinodiscus* are prevalent at St. 41 and 43; altogether the first two forms occupy above 37 %. *Chaetoceros pseudocurvisetus* is also prevalent at St. 42, occupying 67 % of the total cells. This species was reported to be a remarkable species in the inner part of Osaka Bay in December, 1952 (Ueno, 1953). The abundant diatoms at St. 42 may be associated with supply of rich nutrients from Osaka Bay which is transported to the region of St. 42 by tidal currents.

(16) St. 44 and 46 (Off Cape Muroto)

Total cell number is from 59,000 (St. 46) to 200,280 (St. 44) and 129,640 in average. Species number is forty-seven. The dominant forms are *Ch. pseudocurvisetus*, *Ch. decipiens*, *Coscinodiscus*, *Bacteriastrum*, *Thalassionema nitzschioides*, *Thalassiothrix Frauenfeldii* and *Skeletonema costatum*. The diatom associations are more or less influenced by Kuroshiwo water.

(17) St. 45 (Tosa Bay)

Total cell number is 135,240 and species number is twenty-five. *Thalassionema nitzschioides* (25 %), *Thalassiothrix Frauenfeldii* (17.5 %) and *Synedra* spp. (20 %) are dominant forms. *Chaetoceros pseudocurvisetus*, *Ch. didymus*, *Ch. atlanticus* v. *neapolitana* and *Skeletonema costatum* are also important constituents. Among these forms warm oceanic species number six and 5 % in cell number of total haul; neritic diatoms are rather prevalent, thus this sample shows neritic characters to a certain extent rather than the character of oceanic Kuroshiwo water.

(18) St. 47 (Off Kii Channel)

Diatoms are poor both in total cell number and in species number; total cell number is 8,040 and species number is nineteen. *Coscinodiscus*, *Thalassionema nitzschioides*, *Chaetoceros lorenzianus*, *Ch. decipiens*, and *Ch. coarctatus* are main constituents.

Planktoniella sol and *Gossleriella tropica* are also found. It is indicated that diatom population is fairly influenced by the Kuroshiwo Current. Characters of Kuroshiwo water as observed by diatom associations are more emphasized here than off Cape Muroto, because warm oceanic or tropical species are present to the number of 11 and occupy about 27.7 % of total cells in this station, while similar species off Cape Muroto number 12, but occupy only 5 % of total cell number.

(19) St. 48 50 (Kumano-Nada)

Diatoms are comparatively abundant in respect both to total cell number and to species number. Total cell number is between 27,500 and 333,000, averaging 224,600. Species number is fifty-one. The leading species are *Chaetoceros pseudocurvisetus* and *Skeletonema costatum*. The former species occupies above 35 % (St. 48 and 50), and the latter dces 44 % (St. 49). In addition, *Ch. decipiens*, *Ch. didymus*, *Thalassionema nitzschioides* and *Nitzschia seriata* are also important forms. Marumo (1954a) reported that diatom communities were composed of *Hyalochaete*, *Rhizosolenia* and *Nitzschia seriata* in the south of Shiono-Misaki. In the present data the diatom associations off Shiono-Misaki are mainly composed of *Hyalochaete*, but show a difference from the data of Marumo (1954a) in other constituents of less importance.

(20) St. 51-57 (From Enshu-Nada to Kashima-Nada)

Total cell number is between 69,000 and 1,276,200, excluding the datum of extremely poor haul at St. 55 (2,850 cells). Average cell number is 369,000. Species number is seventy-five. The leading species are *Chaetoceros decipiens* (St. 52,53 and 56), *Skeletonema costatum* (St. 51 and 54) and *Thalassionema nitzschioides* (St. 55). In addition, *Ch. pseudocurvisetus*, *Ch. messanensis* and *Ch. didymus* are important. According to the observations of preceding workers (Marumo, 1951; Kawarada, 1954; Asaoka, 1955), *Skeletonema costatum* is more abundant near the Miura Channel than at other localities of Sagami Bay in winter when the water of Tokyo Bay, less haline than that in Sagami Bay, flows out into the present region. A large concentration of diatoms is found at St. 52. The major constituents of this concentration are *Chaetoceros decipiens*, *Ch. lorenzianus*, *Ch. didymus*, *Ch. messanensis*, *Ch. affinis*, *Ch. compressus*, *Ch. socialis*, *Skeletonema costatum* and *Thalassionema nitzschioides*. Outflow of land drainage from the Ohi River might be suggested to be responsible for the local production of diatoms at this region. *Skeletonema costatum* is very much increased at St. 51 and 54-55, indicating the spread of coastal water to these stations, but there is an indication of some influence of Kuroshiwo water at St. 55 by the occurrence of *Climacodium biconcavum* (8.6 %). On the other hand, in the region extending from St. 52 to 53 the diatom associations are represented mainly by *Chaetoceros decipiens* together with

warm-water-preferring *Hyalochaete*, as was reported by Marumo (1955) off Sanriku District, in spite of the fact that surface temperature is lower than at other stations.

(21) St. 58-60 (Pacific coast of northern Honshu)

Diatoms are considerably poor in total cell number, except the abundant population at St. 60. Total cell number is 6,060 at St. 58, below 200 at St. 59 and 143,000 at St. 60, averaging 50,000. Species number is thirty-five. In the localities of poor diatoms, *Thalassionema nitzschioides*, *Thalassiosira* sp. and *Rhizosolenia Stolterfothii* are main constituents. At. St. 60 *Chaetoceros Eibenii* is the most prevalent species, occupying more than a half of the diatom population, being followed by *Ch. coarctatus*, *Ch. pseudocurvisetus*, *Thalassiosira* sp., *Lauderia borealis* and *Ditylum Brightwellii*. Surface temperature falls northwards from 17.1°C at St. 58 to 14.2°C at St. 60 and 15.6°C in average. This temperature is similar to that of the area of the mixing of Kuroshiwo and Oyashiwo waters as reported by Shimomura (1953) in December. From diatom associations this region is considered to be a transitional region from warm Kuroshiwo water to the mixing area at the north of Kinkazan.

(22) St. 61-66 (Pacific coast of more northern Honshu)

Diatoms are poor in total cell number which ranges between 12,500 and 33,000, averaging 20,700. Species number is forty-one. Predominant species are *Coscinodiscus granii*, *C. wailesii*, *Thalassionema nitzschioides*, and *Chaetoceros affinis*. In addition, *Biddulphia sinensis*, *Hemidiscus cuneiformis*, *Stephanopyxis palmeriana* are also important constituents. *Chaetoceros*, *Thalassionema nitzschioides* and *Coscinodiscus* spp. have been reported as important components of diatoms in the Oyashiwo water in this region (Marumo, 1954b, 1955; Shimomura, 1953). *Chaetoceros socialis* and *Ch. debilis* are also important species to which is owed the high abundance of diatoms (Shimomura, 1953). In the present observations, *Chaetoceros* occupies from 13.3 to 37 % of total cells, increasing northwards. Associated species are commonly *Chaetoceros affinis*, *Ch. decipiens* and *Ch. didymus*, and in some localities *Ch. socialis*, *Ch. debilis*, and *Ch. convolutus*. However, *Chaetoceros* species which belong either to *Phaeoceros* or *Hyalochaete*, that have been reported as characteristic indicators of the Oyashiwo Current are rare in the present data. On the contrary, *Coscinodiscus* decreases in number northwards from 42.2 to 3 %. *Thalassionema nitzschioides* is remarkably dominant at St. 66, occupying more than a half of the diatom population. It is noticed that at St. 63 *Hemidiscus cuneiformis*, *Biddulphia sineisis* and *Stephanopyxis palmeriana* occupy a considerably higher portion of the population than in other localities, and also *Corethron hystrix* (11.5 %), *Ditylum Brightwellii* and *Thalassiosira* sp. occur rather often. Tamura (1951) reported similar diatom associations to the present data from Tsugaru Straits in

January, 1951.

In the present cruise the stations are located close to the coast, so that diatom associations may have been influenced by neritic waters, and, in addition, the influence of southwards warm Tsugaru Current (a tributary of Tsushima Current) from Tsugaru Straits flowing in the comparatively inshore area and that of northwards cold Oyashiwo Current in the offing are mixed to a certain extent, exerting influence upon the associations of diatoms in the present stations.

IV. Discussion

It is still a perplexed matter to decide what plankton forms should be selected for indicating what nature of water, though accumulated works have contributed to generalize the ecological situation of the various forms in relation to the environmental characteristics, especially to the temperature of habitat, and in less completeness to the salinity.

Ocean currents may be evidently traced by the existence of most intolerant oceanic species which are transported by the current from their original propagative area. However, strictly intolerant forms, if they occur, are usually present in very small number out of their birth place; in most cases their presence or absence is only recorded, and the difficulty in accurate numerical expression is often involved. On the other hand, there is no evidenece, in phytoplanktons, that they do not reproduce in favorable circumstances wheresoever during their drift, so that even though a large concentration of such forms is found in some locality out of their original area, it does not necessarily indicate the prevalence of the current itself in this locality.

It is known that the characterization of plankton associations obtained from one place cannot be adopted for other localities; a species associating with a particular nature of water does not always do so in water of similar nature in other regions. It is natural that, for instance, some of the neritic species which widely inhabit the tropics or subtropics might be drifted with the current toward a high latitude with resistance to the changing environments; thus they would become apparent indicators of oceanic warm current in high latitude. *Chaetoceros lorenzianus* and *Ch. distans* are such forms which are considered to be indicators of the Tsushima Current in northern Japan. Such regionality of plankton characteristics forces planktologists to make more efforts in charting the characteristic associations at various localities in various seasons in as great detail as possible.

The greatest usefulness of plankton indication of water masses would be involved in the ascertainment of mixing rate of two or more water masses of different nature, *e. g.*, oceanic and neritic water, or warm and cold current, with an accuracy that physical, or even chemical, determination would not be able to manifest.

Many preceding workers have presented accounts of diatom associations on the coast and in the offing of Japan, discussing their characteristics which apparently associate with the water masses in which they are distributed. However, differences in times and

positions of samplings from the present observations, though in some cases to a very slight extent, make it difficult to make reference to the earlier reports or comparison with them. So far as possible to summarize the present data the knowledge accumulated by the many preceding authors is adopted for classifying the plankton forms into warm or cold and oceanic or neritic preference, though some should be valued as tentative decisions.

In the present observations, the track of the ship along the Japan Sea coast of Honshu was populated by such tropical or subtropical species as *Chaetoceros coarctatus*, *Climacodium Frauenfeldianum* and *C. beconcavum*. Even in the region near the coast, tropical diatoms such as *Chaetoceros diversus*, *Ch. paradoxum* and *Ch. messanensis* were prevalent. Along the track on the coast of Kyushu neritic species, viz., *Skeletonema costatum*, *Asterionella japonica* and *Eucampia zoodiacus* were most prevalent forms among the population. *Thalassionema nitzschioides* was widely distributed covering the area from Osaka Bay to Kii Channel. *Skeletonema costatum* which is known as a wide spread species and as making remarkable increase in certain neritic conditions occurred in large number on the Pacific coast from Kii Peninsula to Boso Peninsula. *Climacodium biconcavum* was found frequently in certain areas of the Pacific coast reflecting the presence of Kuroshiwo water. In such area the total cells were comparatively decreased. The area in which predominance of *Chaetoceros pseudocurvisetus* was found was also considered to be bathed with Kuroshiwo water. In the coastal region of the Pacific side occurrence of *Planktoniella sol*, *Cossleriella tropica*, *Guinardia flaccida*, *Hemiaulus indica*, *Chaetoceros coarctatus* and *Ch. atlanticus* v. *neapolitana*, though in comparatively small number, indicated that there the water was mixed with Kuroshiwo water to a certain extent. The diatom population off Cape Omae-Zaki (St. 52) was composed of *Chaetoceros decipiens* and warm-water-preferring *Hyalochaete*. This probably reflects the effects of lowering temperature. On the northern coast of Honshu on the Pacific side the track of the ship covered a region of coastal water embodying the *Chaeto*-plankton, but the flow of Oyashiwo is reflected in the occurrence of cold-water-preferring *Hyalochaete*, such as *Chaetoceros decipiens*, *Ch. debilis*, *Ch. socialis*, *Ch. convolutus* and *Corethron hystrix*. The prevalence of *Chaetoceros Eibenii* at St. 60 suggested that there is mixing of the Oyashiwo water with the Kuroshiwo water.

V. Summary

The materials of diatoms were collected by underway samplings aboard the "Oshoro Maru" during her round-Japan cruise from October 14 to December 15, 1952.

Diatom associations in neritic region along Japan Sea coast are mainly composed of *Chaeto*-plankton; warm-water *Hyalochaete*, *Rhizosolenia* and *Thalassionema nitzschioides*, while in the offings *Chaetoceros coarctatus* and *Climacodium* are prevalent, though the above mentioned neritic forms are also included.

On the northwest coast of Kyushu, *Eucampia zoodiacus* and *Hyalochaete* are predominant, and on the west coast, such neritic diatoms as *Skeletonema costatum*, *Asterionella japonica* and warm-water *Hyalochaete* are abundantly collected.

In Kagoshima Bay on the south coast of Kyushu, warm-water *Hyalochaete* and *Thalassionema* are dominant, and other forms even more preferring warm-water are found, indicating the direct influence of the Kuroshiwo Current.

Diatom associations in the Inland Sea are different from those in other localities; *Coscinodiscus* is prevalent, occupying half or more of total diatom population.

Thalassionema nitzschioides, *Thalassiothrix Frauenfeldii* and *Coscinodiscus* are dominant in the area from Osaka Bay to Kii Channel; in addition, *Chaetoceros pseudocurvisetus* is abundantly distributed off Wakayama.

From off Cape Muroto to Tosa Bay, the above forms also occurred prevalently, and in addition, several other warm-water diatoms are found together, indicating the influence of Kuroshiwo water.

Characteristic Kuroshiwo diatoms, *e. g.*, warm-water *Hyalochaete* and other several tropical forms, prevail in the offing of Kii Channel, but *Chaetoceros decipiens* is also there abundantly included.

Skeletonema costatum and *Ch. pseudocurvisetus* and other neritic diatoms are dominant on the east coast of the Kii Peninsula.

Either *Skeletonema costatum* or *Hyalochaete* and *Ch. decipiens* are leading forms in the area extending from Enshu-Nada to Kashima-Nada; the former may be the indicator species of prevalent coastal water.

On the Pacific coast of northern Honshu, *Chaetoceros Eibenii* and other *Chaetoceros* spp. are dominant to the south of Kinkazan, but in other localities, diatoms are extremely poor, represented by such forms as *Thalassionema nitzschioides*, *Rhizosolenia* and *Thalassiosira*.

On the more northern coast of Honshu, *Coscinodiscus*, *Thalassionema*, *Chaetoceros affinis*, and *Ch. decipiens* are dominant. Only a few cold species of *Hyalochaete* and *Coscinodiscus* are collected there.

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Table 2. Relative abundance of leading species occupying more than 10 percent in cell number for total population of diatoms

Station	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	37	38	39	40	41	42	43	44	45	46	47	48	49	50	51	52	53	54	55	56	58	59	60	61	62	63	64	65	66
Asterionella japonica																	10														19																																
Bacteriastrum varians																																												10																		
B. elongatum																																												24																		
B. comosum																																																														
Biddulphia sinensis																																																														
Chaetoceros Eibenii																																																														
C. coarctatus	57	33			13			12				20		94	59																																																
C. decipiens				10																									13																			14		21	23			23			14						
C. lorenzianus				9					10	20	29	9	14			17	12				10		10			13	14		12														10	18																			
C. compressus										14							22	12	11					18			13																																				
C. didymus	12	23	21		14	22	17	10	19	12	17	12	13			11																																														
C. affinis																																																												11	12	
C. distans						9	11	13																																																						
C. messanensis																			20	14					20	13						11														13					11												
C. curvisetus																								13																																							
C. pseudocurvisetus																														34										67		29																						
C. radicans																			13			34	16																								53	13	35						14									
C. socialis																																																														
Climacodium biconcavum															11																				18																												13
C. Frauenfeldianum					10																																																										
Coscinodiscus granii																																																									37	18		10	11	
C. wailesii																																																										10				
C. spp.																																				86	52	20	18		19	15		17	21																				
Corethron hystrix																																																											11			
Ditylum Brightwellii																																																														
Eucampia zoodiacus				20																								56	17																																			
Melosira nummuloides																														19					18																													
Nitzschia seriata																																																21														
Hemidiscus cuneiformis																																																										10	12			
Rhizosolenia alata																		22																																														
R. Stolterfothii																																																								25						
Skeletonema costatum																																											20				44		44			81	16									
Stephanopyxis palmeriana																															21																																	
Synedra spp.																																																												16			
Thalassionema nitzschioides						13	12	22	20			12	7												17	14							31	50	38			21			41		25		17								19			57			29		11	18	61
Thalassiosira spp.																																																							15									
Thalassiothrix Frauenfeldii																																						19	25			11	20																					
Sum of other unimporant species	31	44	79	61	63	56	60	43	51	54	54	47	66	6	30	72	56	66	56	86	90	66	74	69	63	60	73	44	58	47	60	89	69	50	26	14	48	40	57	33	40	45	35	39	46	44	22	51	56	79	66	19	65	63	45		38	63	33	50	68	46	39
Total	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100

Table 3. Abundance of diatom species in each sample (Approximate cell number for thirty minutes' tow)

Station	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21
Achnanthes longipes																					
Actinoptychus senarius																					
Arachnoidiscus ornatus																					
Asteromphalus flabellatus	30		330																		
Asterionella japonica							2010	2520		4020			1920				1500	750		210	570
Bacteriastrum varians	210			120		330				2190	510	420	14640		450	7800		3300	7200	360	2670
B. hyalinum				2850					7650								600	300			1080
B. delicatulum		840	2730				570		4500								1200	900		330	570
B. elongatum						360			600										2880		930
B. minus				5100				360									420	1050		2610	570
B. mediterraneum				600	600														2400	780	
B. comosum			630	3000	1650	810	225		10950	660			15840		300	4470	1230	7200	5100	1590	1290
Biddulphia sinensis		150	150														60				
B. mobiliensis		150	150	300			45		150	1170	150								480		60
B. longicruris						90	870	1140	3900	990	75	60	720				420	2400			75
B. pulchella																					
Coscinodiscus granii																					
C. wailesii																					
C. spp.	45		630	450	750		90														
Coscinosira polychorda					150																
Corethron hystrix			4770	600					2700	330						5460		1200	2400	120	510
Chaetoceros atlanticus																					
Ch. atlanticus v. *neapolitana*			900			2970			4650		570		480				1260				270
Ch. atlanticus v. *skeleton*																			240		
Ch. densus																					
Ch. Eibenii																					285
Ch. coarctatus	2160	8400	17650	600	6150	840	360	3090	3450	1500	240	930		7380	19200	17550	300				
Ch. tetrastichon											60										
Ch. dadayi											105										
Ch. denticulatus	75			300							210	90				1560	480	450			570
Ch. indicum											30	90	45							180	
Ch. Okamurai					90												60				
Ch. danicus																					
Ch. rostratus								210									120				
Ch. borealis									1650	2280						1950	360	450	1440	210	60
Ch. convolutus									450							14040	300				
Ch. peruvianus	210	330	1890	150	1200	1350	180	210	3600	660	1140	90	2160		150	9360	60	900	480	20	150
Ch. Castracanei																					
Ch. decipiens				9000												11700		300	11040	3180	1650
Ch. lorenzianus		510	11550	7800	2250	3120	765	660	18900	13110	6720	450	25920			61620	2040	2550	38400	5040	3750
Ch. Lauderi													180						210	90	
Ch. Weissflogii																					
Ch. compressus				4200	3000	3150	270	630	14700	9330		30	8400			41730	3780	19200	45120	4800	1950
Ch. didymus	450	5880	28650	2550	6750	9600	2430	5250	36000	7920	3960	600	22560		120	30690	480	2550	9600	2370	1230
Ch. constrictus																				900	570
Ch. Van Heurckii		120	180		120	60							60						120		
Ch. affinis	120		2850	1500	540	300	765		150	510	1830		8160			30420	120	6300	21600	3210	210
Ch. affinis v. *circularis*													270						180	180	
Ch. affinis v. *willei*																					
Ch. paradoxum						1560		420	450	1170	300					4680		900	2880		
Ch. distans		330	10800	750		3810	1590	3510	1050	1830	1875	150	4680			12090		1800	29760	3210	1650
Ch. messanensis			1260	1500						660			8400					5850	85200	6750	
Ch. diversus		420	11400	2850	1350	990	315	620	8100	1170			1680			8190		1950	6720	540	2430
Ch. curvisetus			5280		450	540		570		4200	225					2700		2100	5760		
Ch. pseudocurvisetus				450																	
Ch. debilis									2750			270						3150			
Ch. radicans																		5400		4770	1710
Ch. tortissimus																2100			56550		
Ch. socialis									1050												
Cerataulina Bergonii	60		300	150		370							1920			1560			240		150
Climacodium biconcavum		690	3300		3000	210			4050	3840	285	255		60	3600	2700		600		456	
C. Frauenfeldianum		150	3300		450	780					210	60	720								210
Dactyliosolen mediterraneum			7800		1350			75	1500	510	720	90	4800		1050	10920		900		750	
Diploneis splendida				300																	
Ditylum Brightwellii			30	1650				75	900	336		30	240	60	90	390		6150	480	210	270
D. sol			30			30															
Ethmodiscus sp.																					
Eucampia zoodiacus				18000																	
E. cornuta													720	60				150			
Fragilaria spp.		360	1740	1050	150					480			480			3900					
Gossleriella tropica																					
Guinardia flaccida			1110	750	450						60	30	960								
Grammatophora spp.																					
Hemiaulus Hauckii				750	1200	420			2550	960			10800			7410		1500	1920		
H. sinensis		150		2100			90	210												1800	
H. indica																				690	
H. membranacus	30	165			1800																
Hemidiscus cuneiformis					300																
Hyalodiscus stelliger				300																	
Isthmia nervosa																					
Lauderia borealis			300	1200									1680							1610	240
Leptocylindrus danicus				600		540	360		600							3120					
Licmophora abbreviata				150									2400						11520		
Melosira nummuloides																					
M. Borreri																					
Navicula membranacea																					270
Nitzschia seriata			510	1050		510	270	150		3690			10920				180	4650			1165
N. longissima			300				30														
N. closterium		120						90													
N. paradoxa																					
Pleurosigma spp.				150																	
Planktoniella sol																					
Pseudoeunotia doliolus				1050																	
Rhizosolenia alata	30	120	1290	750	600	2100			1800	510	225	30	1200		300	5040	360	34650	240	120	570
R. Stolterfothii		330		1950		840	180	210	900	480		45	3120		60	1560	240	1950		1020	120
R. cylindrus					450				1200							390	60				75
R. robusta		120	150					75	150	330	210				150			300	2400		
R. setigera	30		300	300	150	240	90	285	750	510	75	30	960				60	300	960	90	
R. styliformis	30	840	960	150	2850	660	30		2850	840	810	90	1200	90	2400	7020	60	2400			360
R. styliformis v. *latissima*					450			60				30			450						
R. calcar-avis		510	1590		3300	540		150	3000		1140	270	960	90	1050	5460		1050	960	210	1950
R. hebetata f. *semispina*				150						990	75	30	240			390			300	210	60
R. acuminata				150			45								450						
R. Bergonii		165		300	300							30									
R. Castracanei		330			1050									75							
R. flagillissima										150					150						
Schrödella Schröderi			5700	2400															19200	1590	1290
Skeletonema costatum	150			3930	900	300	630	570	450				7680			11550		4650		750	
Stephanopyxis palmeriana															300						
Streptotheca thamensis		2160	4440		300		210		900		2100	90		45		780					
Synedra spp.																					
Thalassionema nitzschioides	120	1500	15240	5400	1500	5580	1650	5820	37050			1170	12000		2550	29250	180	23550	35520	2280	2820
Thalassiosira spp.		150																			
Thalassiothrix Frauenfeldii		120				240										1950		900			
T. longissima			150		600	150			2100				240			1200		450			150
Triceratium favus																					
T. spp.																					
Tropidoneis spp.																					
Total	3750	25110	138180	89700	46500	43590	13980	26970	188400	67200	23400	4830	179640	7860	32820	369000	17010	154500	427500	54000	37500

Station	22	23	24	25	26	27	28	29	30	31	32	33	34	37	38	39	40	41	42	43	44
Achnanthes longipes		30																			
Actinoptychus senarius																			780	540	
Arachnoidiscus ornatus																1560					
Asteromphalus flabellatus								420			1530	800	30		210				810		
Asterionella japonica	19440		1380							950760	33000										
Bacteriastrum varians	1320	240	3120		2430					63600			1080						29580		
B. hyalinum	540	3300	8400	38940	3520			2520	49020	62460	84000			189		4200			156600	3900	6900
B. delicatulum		6600	4800		4320	1680	1170														
B. elongatum	16560		1950	15180	10440	7440				46920	33000	24000									1050
B. minus	2160	270	7800	4140	21600	6480	6000	3360		75000	13200	21600	600								750
B. mediterraneum		14196	2925				7800			89040	99000					8970		540	6960		300
B. comosum	84240	6930	26910	92460	3060	7440	3300	3360		30210	189750	12000	360								600
Biddulphia sinensis							390		2250	3180	3300	4800				1620	2440		22620		1800
B. mobiliensis				2160	720			1470		3060	3150	4440									
B. longicruris												120000	300								
B. pulchella																					
Coscinodiscus granii																					
C. wailesii																					
C. spp.			150		390				11400			7200	1260		29640	137670	36210	5070	154710	17490	29250
Coscinosira polychorda																					
Corethron hystrix	4920	270	780	11040	1080	720	2520	6840			6600	8940									450
Chaetoceros atlanticus																					
Ch. atlanticus v. *neapolitana*			6135	97380	10260	3600		420													
Ch. atlanticus v. *skeleton*			225																		
Ch. densus	240	240	90	630	540																
Ch. Eibenii			390																24390		150
Ch. coarctatus			2535			3840			5700								1200		21750		120
Ch. tetrastichon												120									
Ch. dadayi																					
Ch. denticulatus		660			1440	2640	1350	1476	45600	108180	34650	24000					1200		20010		1800
Ch. indicum	105												60								
Ch. Okamurai			360			330															
Ch. danicus																	6000				
Ch. rostratus	2880		5355	9660	360	720	600			31800		4800					1200				
Ch. borealis	2880		2340		720	480	2730				8250	7200									
Ch. convolutus			1950			1920															
Ch. peruvianus	2850	330	1200	4140		480	180	630	5700	18660	1650	9600				4860					
Ch. Castracanei																					
Ch. decipiens	4320	9240	13650	20700	8640	8640	18120	16800	11400	145680	141900	40800	600			7290		450	136890	840	10500
Ch. lorenzianus	74880	26070	19050	104880	29880	22660	19500	14880	11400	139920	100500	52800	1020				9000	810	5220		1650
Ch. Lauderi			240	390																	
Ch. Weissflogii																					
Ch. compressus	76320	23760	82260	96750	7560	20400	19210	6720		247440	199650	273600					1200				
Ch. didymus	20700	10890	23640	118680	12240	12000	6630	1260	11700	222140	150150	8400	300	135					6090		2550
Ch. constrictus		6930			1290	5520	1170			82680											
Ch. Van Heurckii																					
Ch. affinis	25200	11550	8580	13800	4680	1680	1560	6480	5700	95400	44550	96000		150					10440		120
Ch. affinis v. *circularis*		330		120	180	210					630										
Ch. affinis v. *willei*																					
Ch. paradoxum	5760	2640					1170		4500												
Ch. distans	58260	26730	7800		2280	6720	7020	2310		54060	42900		420								
Ch. messanensis	54720	12210	35295	284280	29520	12000	990	7980		273480	311950	31200	600	111							120
Ch. diversus	10080	660	1200	3330	1200	1200	5850	4620		15900		3000									
Ch. curvisetus	92520	8580	56160	13800	4440	5280	4080			302100	52890	24000									
Ch. pseudocurvisetus									269400	50700	173250	302400	1200				4800		1993470		57750
Ch. debilis	19440	8250	4680				1740			216000											
Ch. radicans	374400	44220	9000	75900	2340					37860	183750										
Ch. tortissimus			4875							216060	107250										
Ch. socialis																					
Cerataulina Bergonii	1440				360	240		420			6600	19200				810					1950
Climacodium biconcavum			2340		360	720						912000		540			600		3480		
C. Frauenfeldianum								630				74400									
Dactyliosolen mediterraneum	2880		570	6900	720					6720	13200	16800									
Diploneis splendida															90						
Ditylum Brightwellii	2880	270	390	2130	900	1440	1365	1680	2250	22260	11550	2400	60				9000	390	5190	5940	4350
D. sol																					
Ethmodiscus sp.																					
Eucampia zoodiacus		2460		2160	2700	7440	254820	22088	45750	385380	54750	24000			1560		12000	420	80040	6300	4650
E. cornuta	2160	1320	180			240					4950										
Fragilaria spp.				5520		660	1950														
Gossleriella tropica												4800									
Guinardia flaccida					540	480	4290	1470	1140			9600						240	4350	390	1350
Grammatophora spp.																					
Hemiaulus Hauckii	600	300	1170		1440	720					3300	12000									1050
H. sinensis	8640		3315		5400		5460	5700	4200	25350		177600									
H. indica												172800				8100			2610		
H. membranacus											49650										
Hemidiscus cuneiformis															2250	4150			4350	270	
Hyalodiscus stelliger								420													
Isthmia nervosa																					
Lauderia borealis	62640	9240	3900	8250	3060	3120	11310	2310	13320	15360	157400	26400				8910			52200	1110	4800
Leptocylindrus danicus	14400		180				3510	630			52800	12000	360				1200				
Licmophora abbreviata		300								18900											
Melosira nummuloides									151650		14850			540					73950		3300
M. Borreri					1800		4510														
Navicula membranacea																					2250
Nitzschia seriata	64800	9750	10725	49920	3780	3120	4460		12540	89100		72000				2430			6090	1110	630
N. longissima							150														
N. closterium							120														
N. paradoxa									3420											1230	750
Pleurosigma spp.					360				150						120	16200	540	640	600	1230	450
Planktoniella sol				4140							1650	4800									
Pseudoeunotia doliolus	360								7980					135							150
Rhizosolenia alata	9900	990		20700	3420	3300		1470		6720	6150	21600	180				4200		13950	90	1200
R. Stolterfothii	7200	1650	780	6900	3240	1920	780	2280	5700	95400	66300	192000				4860	1200				300
R. cylindrus			5070	2760	540		22050		5850	3180	4950	12000									
R. robusta		330	570			720		630	900			4800	60		120	1620			24900	60	1350
R. setigera		330	195	1350	1830		180	210	900	3120	1500	3300	60				1200	150		540	
R. styliformis	3600	3960	2145	17940	1260			420	960		1500	1200					1140		630		
R. styliformis v. *latissima*					180								120				1800				1500
R. calcar-avis	5700	1980	780	8280	2160		600			6120		32400			120	750			780		150
R. hebetata f. *semispina*	600					2640							30	30							
R. acuminata								240				2400									
R. Bergonii				1350	720	480					1530	26400				3240					
R. Castracanei		330																			
R. flagillissima		330	585	1380			1560														
Schrödella Schröderi								1890	4560		1620						3120	2670	62400	8550	3600
Skeletonema costatum	20700	300	3900	25840	1440	1680	15600	3240	40680	1068300	29700					15600				1380	6750
Stephanopyxis palmeriana							390		780			9600				29970			22500	540	3600
Streptotheca thamensis																					300
Synedra spp.																					600
Thalassionema nitzschioides	46800	11820	14340	241860	30240		15450		57000	25500	85800	1056000	9000	1110			37800	1710		37650	17700
Thalassiosira spp.	840										56750	19200	120					1170	21600	2760	
Thalassiothrix Frauenfeldii	5040		3840	1200	3060		1560			1200		64800	360				33600	4680			22050
T. longissima	1500	330	210	28800	2700						750	14400									
Triceratium favus																					
T. spp.																	2100				
Tropidoneis spp.																	7200				
Total	1217400	271680	450300	1444500	235800	162900	457800	127200	792900	5063700	2742000	3367200	18240	2940	34110	262610	179910	18840	2970000	91920	200280

Station	45	46	47	48	49	50	51	52	53	54	55	56	58	59	60	61	62	63	64	65	66
Achnanthes longipes																					
Actinoptychus senarius	480			120					90		45										
Arachnoidiscus ornatus											30										
Asteromphalus flabellatus				150					180			210	60								
Asterionella japonica					3150																
Bacteriastrum varians		5460																			750
B. hyalinum					1260	2160	5280	18900	2250			2520						390	690		570
B. delicatulum							2310		1080	2880											
B. elongatum		4080				2100	2100	16350	990			630									
B. minus								8490				1680									
B. mediterraneum								12660	720			840			2520						
B. comosum			60		600	1080	1650	29040	1170		30		720								
Biddulphia sinensis					1050	1080	1320		480		60	420	450	30		720	950	1410	1290	1050	3000
B. mobiliensis					840																
B. longicruris						5040	330					120			1680			225	150	300	
B. pulchella																					
Coscinodiscus granii												120	135		3570	6480	5610	1140	1740	1350	330
C. wailesii												90	90		1680	1020	3150	960	840	360	210
C. spp.	7200	9240	1650	2160	1260		23100	4410	600	12060	210						90		90		360
Coscinosira polychorda									180						600						
Corethron hystrix				360	420	2700	2970	6930	1620	180		1050	270		210		630	1140	120	150	60
Chaetoceros atlanticus																					
Ch. atlanticus v. *neapolitana*	3780	1680																			
Ch. atlanticus v. *skeleton*																					
Ch. densus						60	90	60		60					330						
Ch. Eibenii	1620														68550	1500	300		1020		360
Ch. coarctatus			690				2250					1050			5460						
Ch. tetrastichon																					
Ch. dadayi																					
Ch. denticulatus	540			540	1680	12150	18150	23940	2160	21600		3960	90		630				1560		
Ch. indicum																					
Ch. Okamurai																					
Ch. danicus																					
Ch. rostratus		1260						45990		1800											
Ch. borealis	2160	840							540	1260						180					
Ch. convolutus							5610											315	1170		
Ch. peruvianus	540		300		420	1890		1890	180		30					30		45			
Ch. Castracanei																					
Ch. decipiens	2700	3360	630	720	10500	46170	3960	261450	17640	540		15960	150		19530	840	420	660	1320	1050	330
Ch. lorenzianus	2700	5460	1440	330	1680	17550	14850	89460	6750			3360	120		2130			300	240	150	
Ch. Lauderi																					
Ch. Weissflogii								360													
Ch. compressus					3780			51600	540						840	480					
Ch. didymus	3240	2520			7560	25110	26730	94500	4140			5610	45		450	420		270	180		1320
Ch. constrictus									4590												
Ch. Van Heurckii																					
Ch. affinis				2340	1500	13770	33000	64260				2520					1770	660	1920	1440	2280
Ch. affinis v. *circularis*								540	360												
Ch. affinis v. *willei*								90													
Ch. paradoxum																					
Ch. distans								45990	720												
Ch. messanensis	1620		270	3600	2520	8100	25750	99540	8640	720		840									
Ch. diversus						810	2700														
Ch. curvisetus	2700				2100	2700	330	34650	210	600	30	1470			1320		1050				
Ch. pseudocurvisetus	5400	5040		14400	39900	115020	7920	97650		5220		8820	120		5550		420				
Ch. debilis					630		13110	5670		8100					4200	600		450	330	930	
Ch. radicans						2700		12600	540												
Ch. tortissimus						2550						6720									
Ch. socialis																	1035			1560	
Cerataulina Bergonii					630			1260													
Climacodium biconcavum											240	2520									
C. Frauenfeldianum																					
Dactyliosolen mediterraneum									450		60										
Diploneis splendida	540																				
Ditylum Brightwellii	2160	420	90		840	4320	960	12600	2340	180		1050	360	15	1260	180		225	210	150	60
D. sol																					
Ethmodiscus sp.											120										
Eucampia zoodiacus	1620				210	810		13230	150			1890	360		1050	180					
E. cornuta					450			2520													
Fragilaria spp.									240												
Gossleriella tropica			60																		
Guinardia flaccida			90		630	10800	990	2520	180	1260		840			270						
Grammatophora spp.					240																
Hemiaulus Hauckii																					
H. sinensis						2370			180										150		
H. indica																					
H. membranacus																					
Hemidiscus cuneiformis					2220						30	210			5250	300	3045	1350	1530	840	510
Hyalodiscus stelliger																					
Isthmia nervosa											240										
Lauderia borealis	1620			90		12150	5610	6960	6210	6120	75	1680	450		4830	600			120		
Leptocylindrus danicus		420			1050			5670													
Licmophora abbreviata																					
Melosira nummuloides																					
M. Borreri																					
Navicula membranacea																					
Nitzschia seriata	540		120		67200	720	2700	1890	630	2700	90				1080	540	210		600		
N. longissima					1050			2460													
N. closterium																					
N. paradoxa																					
Pleurosigma spp.					210																60
Planktoniella sol			120																		
Pseudoeunotia doliolus																					
Rhizosolenia alata	540		90			1080	5940	2490	300												60
R. Stolterfothii		420	120		2100		660	2520	900	900	120	3150	1200		1680				45	240	120
R. cylindrus							330														
R. robusta		2240	90		210	1620	1980	2460	450	360	30				840	60	330	45	360	390	390
R. setigera					210		330	630								30	90				120
R. styliformis								1890			30								45		
R. styliformis v. *latissima*	540					480	360								720	30					
R. calcar-avis			300		210		960		120	180					2310	240		45			30
R. hebetata f. *semispina*					150		300		60									30			
R. acuminata					120																
R. Bergonii	1080		180				300	1830	240		30	90	600								
R. Castracanei																					
R. flagillissima																					
Schrödella Schröderi	3780			540	2250	1890	3960														
Skeletonema costatum	2700		270		139230	1620	187770	60300	6840	282840	480					720					
Stephanopyxis palmeriana			120		1260	5400	1980	6300							420	1620	1050	1950	360		2010
Streptotheca thamensis																					
Synedra spp.	27000										30										
Thalassionema nitzschioides	34020	2520	1350	2760	12480	22410	16530	113400	1170	120	540	120	120	60	720	600	8940	210	1950	2190	20190
Thalassiosira spp.								60	90		30	1140	720		5880	240		420	90		
Thalassiothrix Frauenfeldii	23820					2970	3000	8190				60									
T. longissima		480									30										
Triceratium favus											180										
T. spp.																					
Tropidoneis spp.																					
Total	135240	53880	8040	27480	313800	332880	427170	1276200	76500	349680	2850	69240	6060	105	142560	17810	30990	13540	18120	12150	33120

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