2.3 System maintenance and data management of continuously monitored parameters

The monitoring system works automatically during each cruise with the exceptions of the following manual processes. Chlorine gas injection is used by the ship to prevent bio-fouling of the intake pipe. It may affect the chemical analysis and should be stopped during the chemical sampling. The inflow valve, drainage valve, and the chlorine gas injection valve are handled by the crew as well as the switches of the machines when the ship enters and leaves both harbors. The crew also checks the apparatus occasionally during the cruise.

System maintenance is done every Thursday while the ship is at anchor in Kobe Harbor. The maintenance menu includes collection of the filters, sample bottles and data floppy disk, check for drift in sensor outputs with standard solutions, calibration and washing of the sensors and general system troubleshooting.

Drift of the temperature- and salinity-sensor outputs are checked with a standard thermometer and secondary standard sea water, respectively. pH-sensor drift is checked with two kinds of buffer solutions (pH = 6.86, 9.18). Drift in the Turner Design fluorometer output is checked by three standard solutions (distilled water, 10 ppb and 30 ppb fluorescein solutions). The output of the fluorometer drifts up to 8 to 10 % due to fouling of the flow-cell. The rate of drift was found to be approximatley linear over 1 week.

The data collected from this program, just like those from satellite data programs, must be transformed from the raw electrical signals into meaningful physical, chemical and biological values. The analog signals from the sensors are converted to 12 bit digital (binary) form and recorded on a floppy disk (Level-0 data). This binary data is translated into DOS text file format called level-1 data. Level-1 data is appropriate for viewing the rough features of the temporal and spatial variation of the parameters (Fig. 3(a), (b), (c) and (d)). The Level-1 data contains some apparently inconsistent values which may be due to variations among cruises at the time pertinent longitude, sensor drift, or data measurement and processing errors.

The Level-1 data are converted into Level-2 data through the application of the time to location transformation and a sensor drift correction. The times when the ship passes certain fixed points are recorded in the log book. From this record, the latitude and longitude are linearly interpolated for each sample point (every 10 seconds). Sensor output drift is corrected assuming that the drift is linear with respect time. The results of these transformations are to be published in the next report.

2.4 Results of the monitoring, June to December, 1991

The system was manufactured in 1990 and the monitoring began at the end of June, 1991. Fig. 3(a), (b), (c) and (d) show the temporal and spatial variations of the variables through December, 1991. Temperature variability was larger in the Seto Inland Sea and particularly in the region of low salinity. Fluorescence, *i.e.* the concentration of phytoplankton biomass, was basically higher in the Seto Inland Sea (Fig. 3(d) 2/3 of the domain on the right hand side) and in the coastal seas adjacent to land than in the Tsushima Strait. The spatial distribution of fluorescence is quite heterogeneous. There was a tendency toward higher fluorescence in regions of lower salinity. This observation supports the idea that river runoff favors plankton growth through enhanced nutrient supply. However, Duce (1991) suggested that the direct input of nutrients to the sea via rainwater may be an important contributor to phytoplankton productivity. The relative importance of runoff or rainfall-derived nutrients should be investigated in the future.

Generally, the spatial variations of pH are small because of the large buffering capacity of sea water. However, there was an area where pH decreases by 0.2 of pH unit during summer relative to the other areas. Rainfall or the consequent river runoff, whose pH is usually lower than that of sea water, may also reduce the pH of surface sea water. In the present case, however, the area of low pH does not overlap with the area of low salinity. It is therefore attributed to the upwelling of benthic water, where decomposition of organic matter lowers pH.

When the monitoring was initiated, overall biomass concentration was relatively high. This time may have coincided with the early summer bloom or the terminal phase of the spring bloom. This bloom terminated in July and the biomass concentration was low during August presumably because of nutrient depletion. The gaps in the data for September were due to cruise cancelations caused by typhoons. In September and October, biomass increased. This increase may be identified as the signal of the autumn bloom. Generally cooling of the water surface and gradual weakening of stable stratification permit increased vertical mixing and consequent transport of nutrients to the euphotic layer. Here we can see that the fluorescence levels in Seto Inland Sea rose after the two typhoons, suggesting that the vertical stirring and river runoff may trigger the autumn bloom by supplying the nutrients both from below the pycnocline and from land.

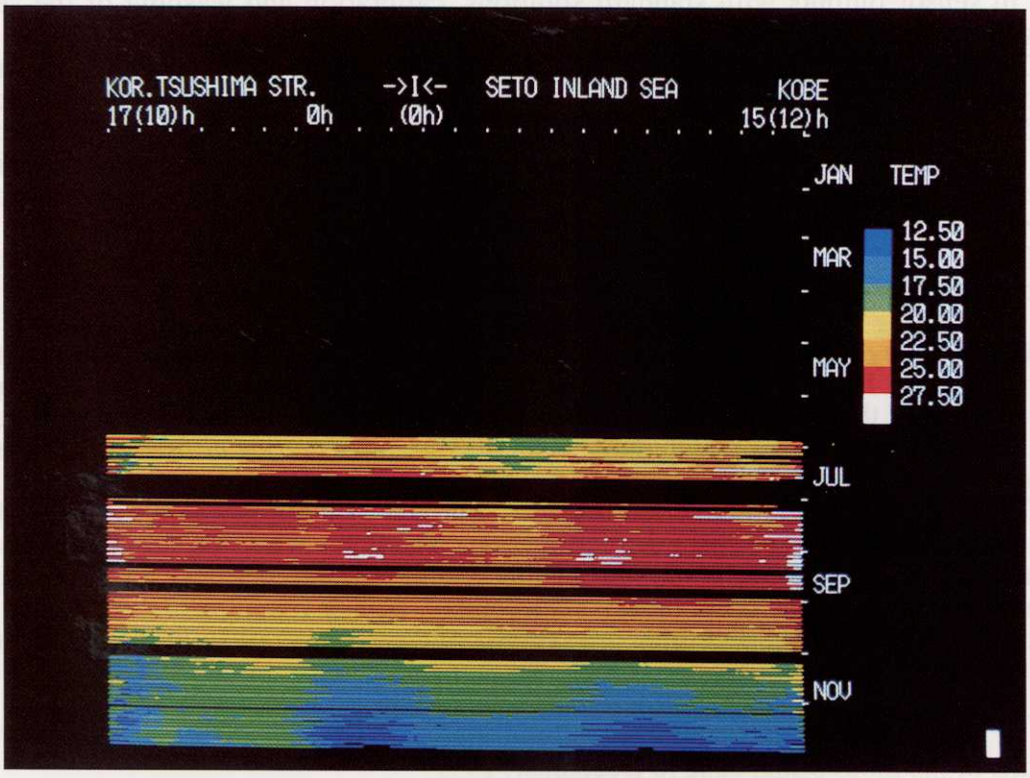

Fig. 3(a) Level-1 temperature (°C) data in 1991. The vertical axis corresponds to date. Time on the horizontal axis correspondsapproximately to the position of the ferry, *i.e.* the left end is offshore of Pusan, Korea and the right end is offshore of Kobe, Japan. The data for each cruise are color-scaled and expressed by a stripe. Each pixel represents the mean value of 18 data points, which corresponds to 3 minutes in time and approximately 1 nautical mile in length.

The concentration of nutrients was basically higher in the Seto Inland Sea than in the Tsushima Current area. Concentrations of NO_3-N and NH_3-N were low throughout our sampling (Fig. 4(a), (c)) and there is a possibility that nitrogen availability limited the growth of phytoplankton in the upper layer. Concentrations of NO_3-N and NH_3-N sometimes rose at the sampling stations near 131°E, which suggests that the intense tidal mixing in that area transports nutrients upward. From autumn to winter, concentrations of NO_2^--N and PO_4-P increased (Fig. 4 (b), (d)). These processes seem to be linked to the following spring phytoplankton bloom.

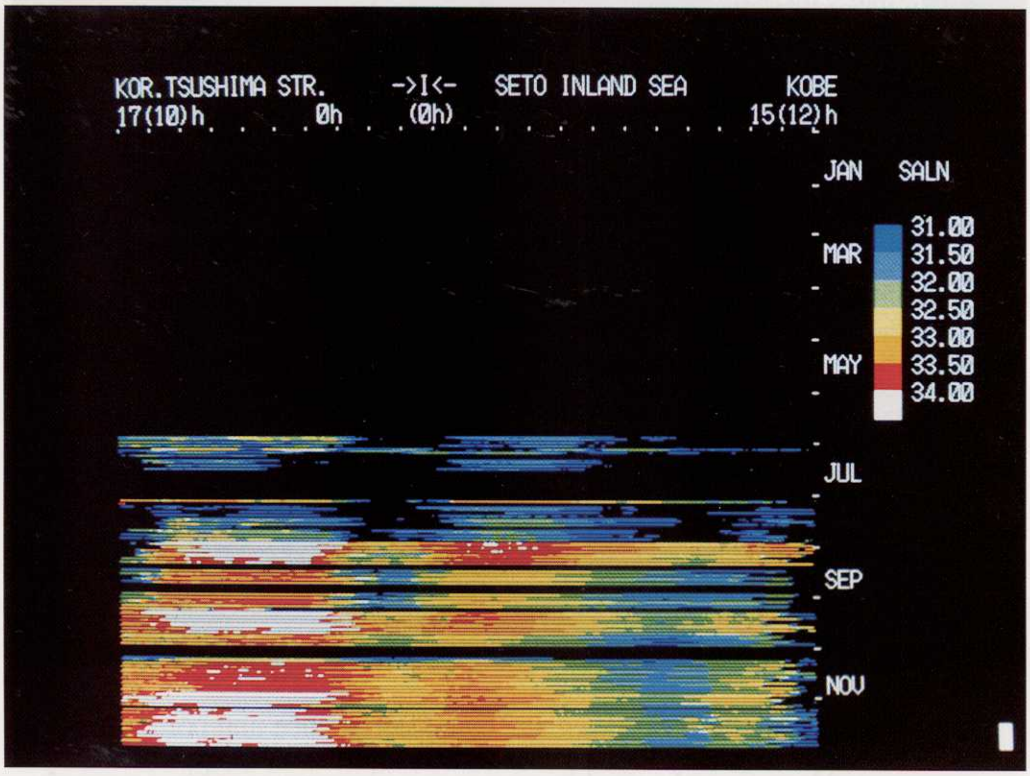

Fig. 3(b) Level-1 salinity (°/₀₀) data

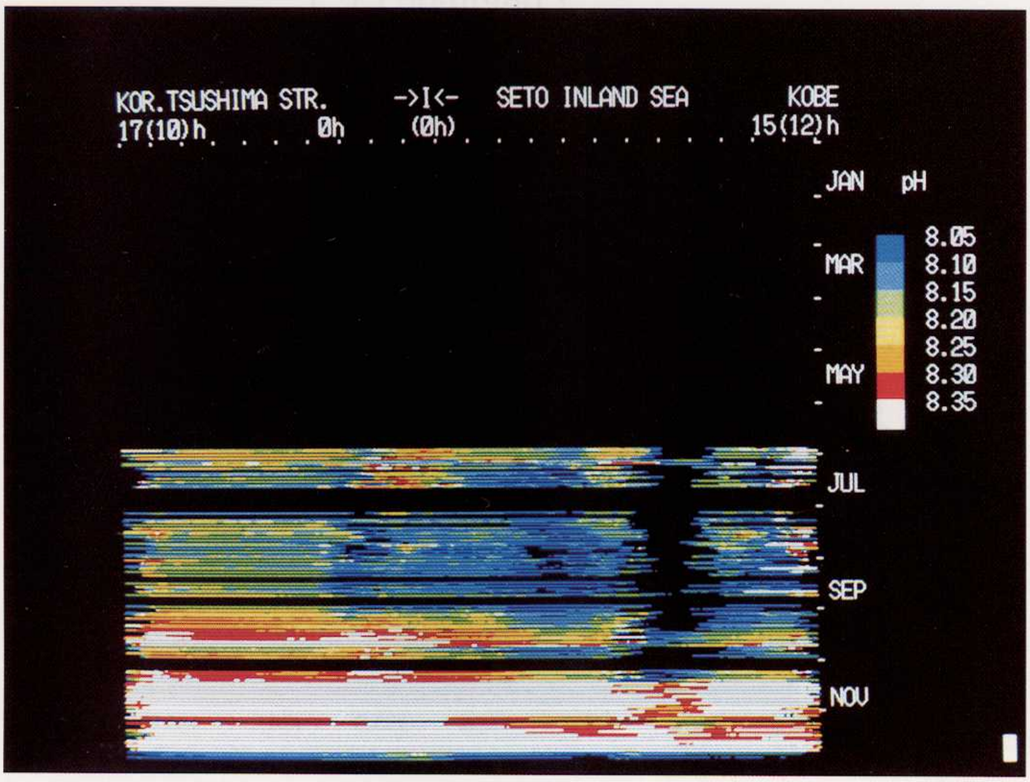

Fig. 3(c) Level-1 pH data

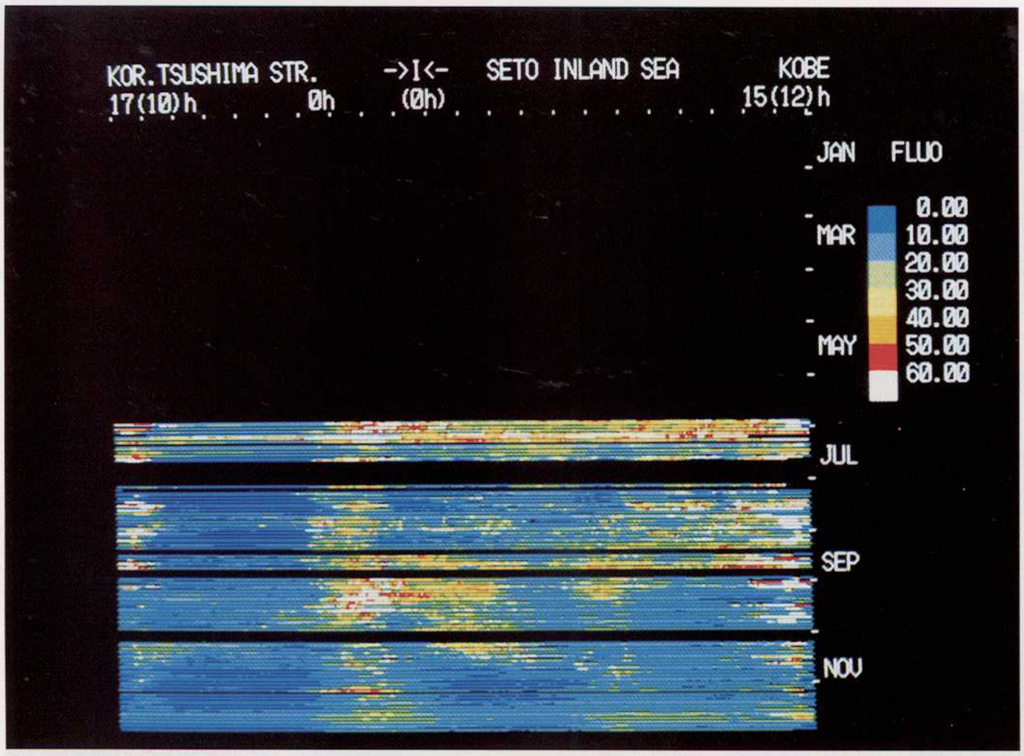

Fig. 3(d) Level-1 fluorescence data. One fluorescence unit corresponts to approximately 0.32 ppb fluorecein equivalent or approximately 0.1 μg/l chlorophyll-a.

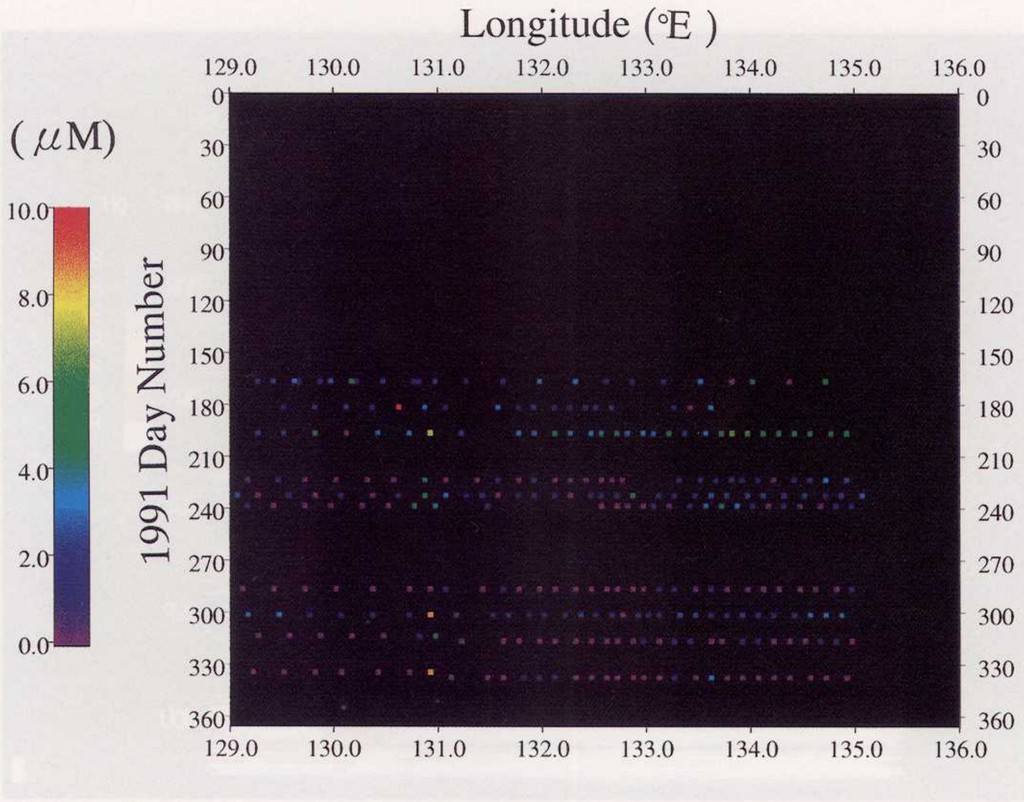

Fig. 4(a) Distribution of NO_3-N (μM) in 1991. The area east of 131°E is the Seto Inland Sea. Values more than 10 μM are shown by the maximum color.

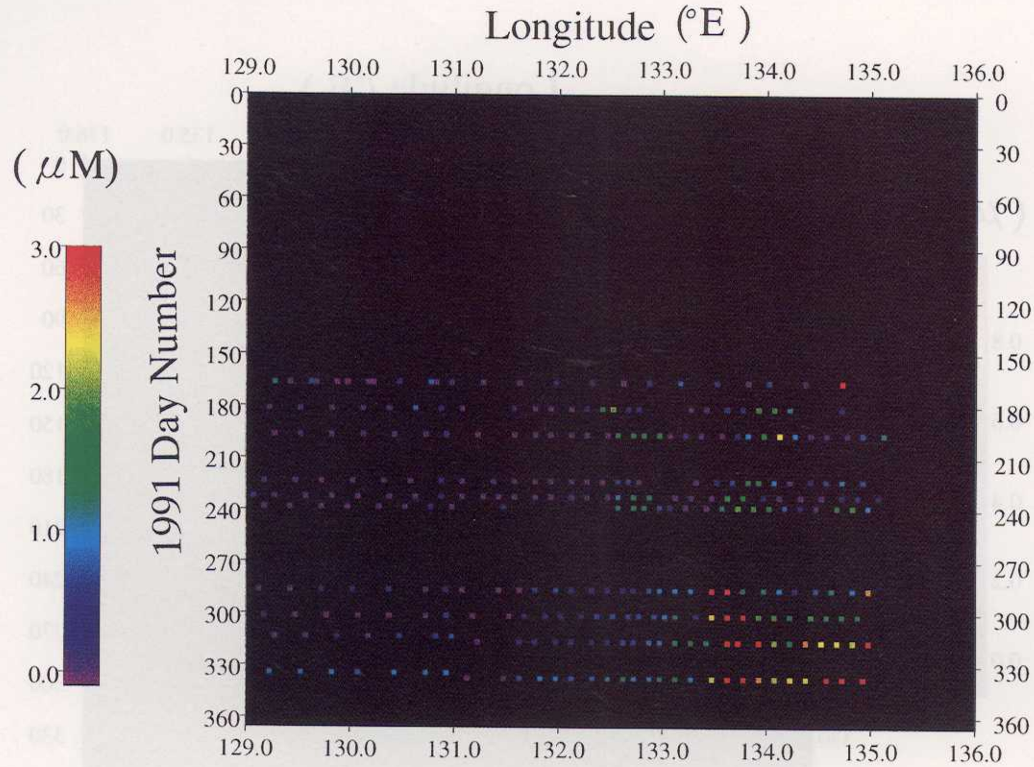

Fig. 4(b) Distribution of NO_2-N (μM). Values more than 3 μM are shown by the maximum color.

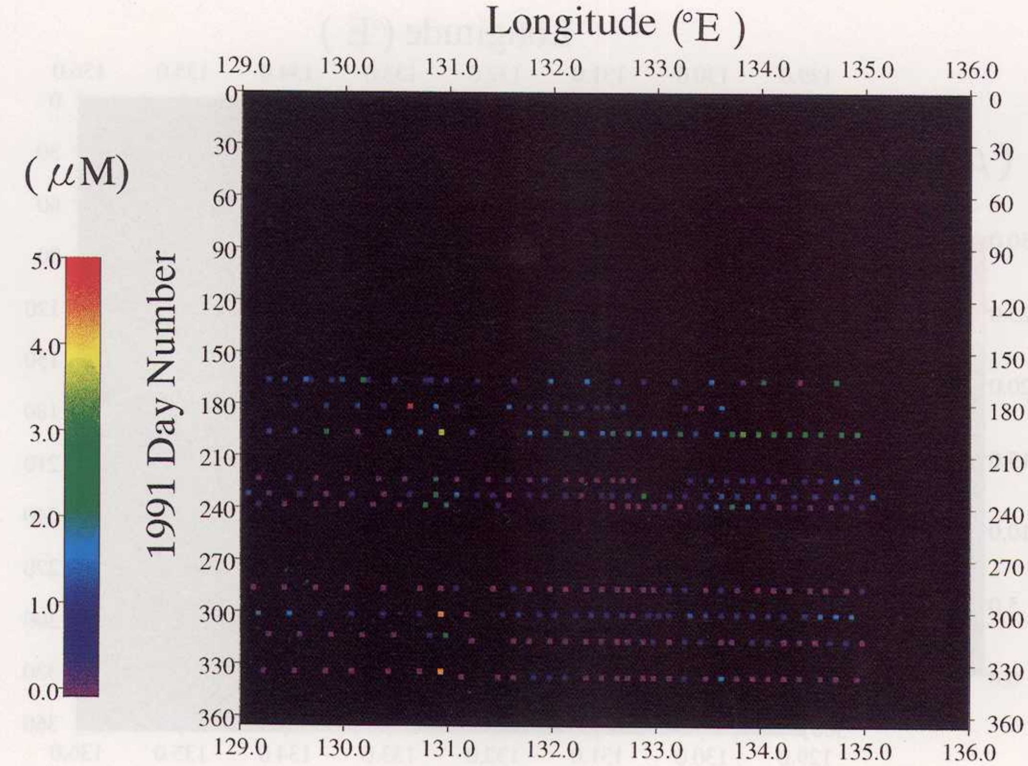

Fig. 4(c) Distribution of NH_3-N (μM). Values more than 5 μM are shown by the maximum clolor.

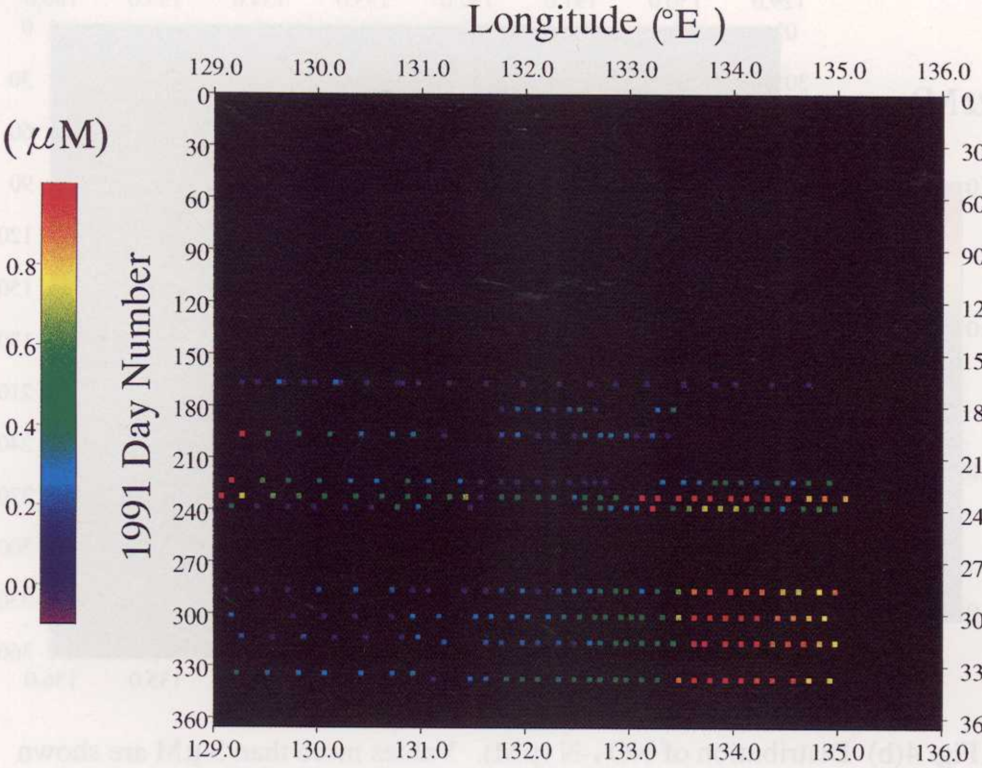

Fig. 4(d) Distribution of PO_4-P (μM). Values more than 1 μM are shown by the maximum color.

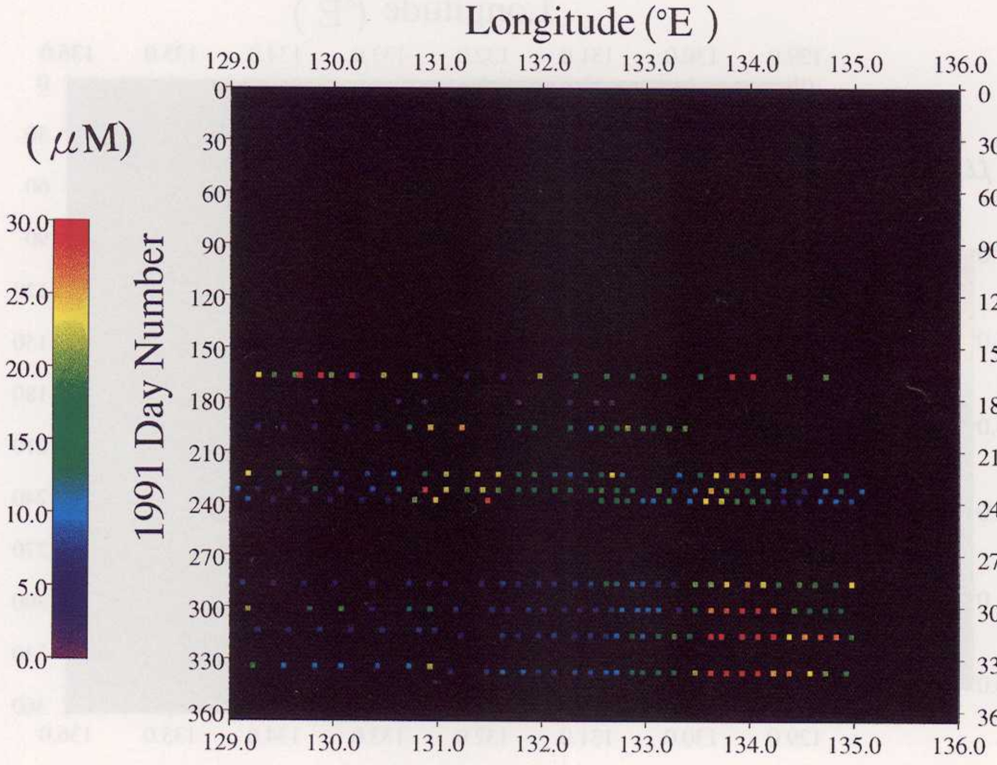

Fig. 4 (e) Distribution of dissolved Si (μM). Values more than 30 μM are shown by the maximum color.

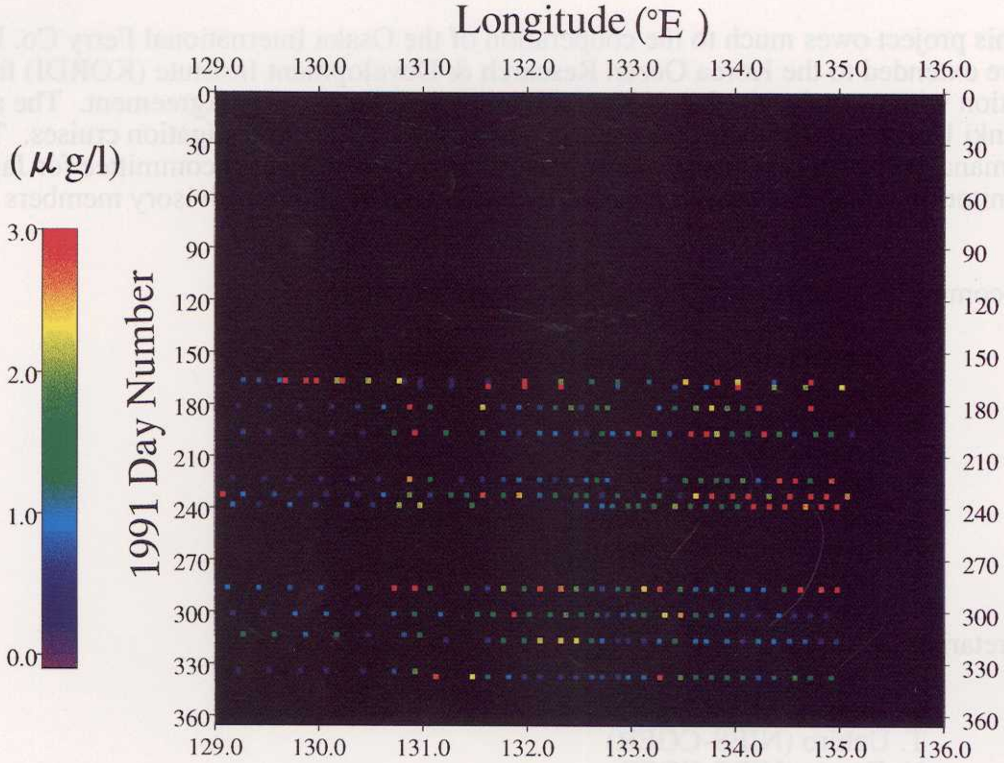

Fig. 4 (f) Distribution of chlorophyll-a (μg/l) determined with the acetone-extract method. Values more than 3.0 μg/l are shown by the maximum color.

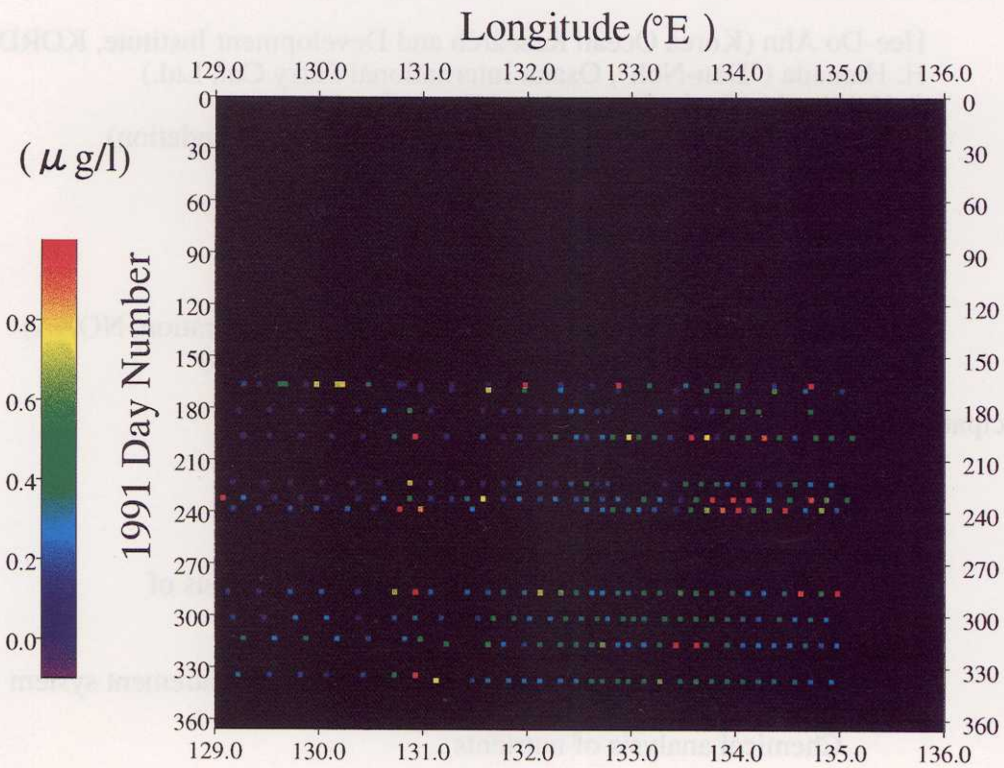

Fig. 4(g) Distribution of pheopigments (μg/l) determined with the acetone-extract method. Values more than 1.0 μg/l are shown by the maximum color.