**Chlorophyll *a* concentration measured with a continuous water monitoring system during the cruise to Syowa Station, Antarctica, JARE-27 (1985/86) to JARE-35 (1993/94).**

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## Contents

## Introduction

Since 1965, the geographical distribution of surface chlorophyll *a* over semi-global ranges has been routinely documented in every JARE (Japanese Antarctic Research Expedition) cruise, which starts from Tokyo, Japan in November, reaches Syowa Station, Antarctica, in late December or early January of the following year and returns to Tokyo in April. Since Syowa Station is located in the western part of the Indian Sector of the Antarctic Ocean, such routine work has been concentrated in the Indian Sector. Historical reviews of these long-term serial observations are given by Fukuchi (1980, 1982).

Before the cruise of JARE-25 (1983/84), a water sample was collected by bucket two to three times every day except for the days in foreign ports or at Syowa Station. Data obtained in early cruises have suggested that wide geographical variation of chlorophyll *a* standing crops in the Southern Ocean is common and particularly marked variation is closely associated with the frontal zones of the ocean. Therefore, more frequent samplings, at intervals of at least 1 or 2 hours (Plancke 1977, Fukuchi and Tamura 1982, Yamamoto 1986), are essential to depict the spatial variability on a fine scale of chlorophyll *a* distribution within a relatively narrow area around these fronts. Because the main task of JARE cruises is to transport equipment and materiel to Syowa Station Antarctica, it is not always possible to spend much ship time in such investigations stopping or sailing at slow speed over the frontal zones.

To obtain data on chlorophyll distribution on a fine scale over wider geographical ranges, a continuous measuring-recording system was first employed during the cruise of JARE 25 (1983/84) by the new icebreaker *Shirase* by Hamada et al. (1985) and Taniguchi et al. (1986). They continuously recorded *in vivo* fluorescence intensity of the flowing water, which was pumped up from an intake on the hull (8 m depth), in analog form on chart paper.

Fukuda *et al.* (1986) modified the prototype and designed a new computerized system for the cruise of JARE-26 (1984/85). A personal computer was used for real-time measurement and recording of *in vivo* fluorescence intensity and water temperature as well as for post-cruise data processing.

Furthermore, Fukuchi and Hattori (1987) designed the system not only to increase the data parameters continuously measured to as many as five, but also to acquire navigation information such as GMT, ship's position, etc. Subsequent data processing was also improved. The present technique, a surface water monitoring system, has been successfully employed since the JARE-27 cruise (1985/86). Data reports from these cruises have been published: JARE-27 in Fukuchi and Hattori 1989, JARE-28 in Kubodera and Fukuchi 1989, JARE-30 in Watanuki *et al.* 1996, JARE-31 in Konno *et al.* 1996, JARE-32 in Kuramachi *et al.* 1996, JARE-33 in Odate *et al.* 1996, JARE-34 in Ishii *et al.* 1996 and JARE-35 in Kawachi *et al.* 1996.

Published data reports are useful but processing these printed data is time consuming. Therefore, we have edited these data onto a CD-ROM. This paper describes how data from JARE-27 (1985/86) to JARE-35 (1993/94) on a CD-ROM may be accessed and manipulated easily with a personal computer.

## Surface-water monitoring system

A block diagram of the surface-water monitoring system is shown in Fig. 1 (after Fukuchi and Hattori 1987).

A one-rotor screw pump (Moineau type pump, model HNP-201S, Taiko Kikai Co. Ltd.) was installed in the shaft tunnel room. An intake was located on the hull 8 m below sea level. The pump has a capacity of 30 l / min and does not damage plankters mechanically.

Sea water pumped up to the laboratory was fed to a strainer to remove large organisms (> 5 mm in diameter) and to a bubble trap to eliminate air bubbles. The sea water, then, passed through four kinds of sensors: thermistor, conductivity sensor, dissolved oxygen (DO) sensor and fluorometer (Table 1). Navigation data (GMT, position, ship's speed, sea depth, water and air temperature) were directly transferred from the output terminal through a navigation interface to the CPU.

Table 1. Five measuring parameters of the surface water monitoring system and characteristics of sensors.

| Measuring item | Sensor |
|---|---|
| Water flow | Paddlewheel flow sensor (model MK 515, Signet Scientific, USA) |
| Temperature | Pt 100Ω sensor (Honchigo, Japan) |
| Salinity | 4 Electrode Dual Glass (Applied Microsystems, Canada) |
| DO | Polarograph (model EMCO, Danfoss, Denmark) |
| Chlorophyll *a* | Field fluorometer model 10-000R (Turner Designs, USA) |

A personal computer (YHP 9836 CS, USA) was used for real-time as well as post-cruise data processing. Data were collected every five minutes. Local mean time (LMT) was calculated from GMT and the ship's longitude. LMT is not equal to ordinary ship's time, which is not always synchronous with the actual solar rhythm.

Analog signals from the five kinds of sensors were transferred to the input/output (I / O) port. For each sampling, values averaged over 60 seconds from five sensors, as well as navigation data, were stored on a floppy disk. Twenty-eight data files were obtained from JARE-27 to JARE-35 (Table 2).

Table 2. Time (GMT) and position at the beginning and end of each data set.

| JARE | First | | | Final | | | File name |
|---|---|---|---|---|---|---|---|
| No. | GMT (YYMMDD) | Lat. (deg.) | Long. (deg.) | GMT (YYMMDD) | Lat. (deg.) | Long. (deg.) | |
| 27 | 851203 | 31.93S | 115.50E | 851212 | 63.37S | 50.28E | JARE27B |
| | 860226 | 65.06S | 37.60E | 860314 | 20.22S | 57.33E | JARE27D1 |
| 28 | 861203 | 31.96S | 115.68E | 861216 | 67.55S | 24.04E | JARE28B |
| | 870223 | 68.05S | 35.83E | 870311 | 29.08S | 54.50E | JARE28D1 |
| 29 | 871115 | 30.01N | 137.09E | 871127 | 31.89S | 115.42E | JARE29A |
| | 871203 | 32.53S | 115.05E | 871217 | 69.92S | 23.65E | JARE29B |
| | 871230 | 70.28S | 24.12E | 880213 | 67.49S | 45.70E | JARE29C |
| | 880227 | 66.30S | 49.57E | 880320 | 33.79S | 151.39E | JARE29D2 |
| 30 | 881114 | 34.70N | 139.59E | 881127 | 31.95S | 115.62E | JARE30A |
| | 881203 | 32.05S | 115.75E | 881218 | 70.22S | 23.91E | JARE30B |
| | 890304 | 68.10S | 37.64E | 890320 | 34.03S | 151.67E | JARE30D2 |
| 31 | 891114 | 31.22N | 137.95E | 891127 | 31.81S | 115.04E | JARE31A |
| | 891203 | 32.03S | 115.70E | 891216 | 66.16S | 28.13E | JARE31B |
| | 900223 | 65.91S | 48.77E | 900320 | 33.79S | 151.36E | JARE31D2 |
| 32 | 901114 | 33.97N | 139.25E | 901127 | 31.95S | 115.63E | JARE32A |
| | 901203 | 32.00S | 115.29E | 901217 | 68.23S | 40.23E | JARE32B |
| | 901217 | 68.23S | 40.23E | 910301 | 70.20S | 23.86E | JARE32C |
| | 910302 | 70.20S | 23.86E | 910319 | 34.72S | 151.93E | JARE32D2 |
| 33 | 911115 | 29.35N | 137.04E | 911127 | 32.02S | 115.68E | JARE33A |
| | 911203 | 31.92S | 115.46E | 911220 | 65.17S | 32.95E | JARE33B |
| | 911220 | 64.57S | 35.65E | 920212 | 69.01S | 39.03E | JARE33C |
| | 920216 | 68.94S | 38.81E | 920319 | 33.77S | 151.31E | JARE33D2 |
| | 920325 | 33.87S | 151.20E | 920404 | 13.23S | 146.15E | JARE33E |

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| 34 | 921114 | 31.17N | 138.03E | 921127 | 31.95S | 115.62E | JARE34A |
| | 921203 | 32.14S | 115.06E | 921216 | 67.48S | 40.18E | JARE34B |
| | 930212 | 67.82S | 38.63E | 930320 | 33.78S | 151.31E | JARE34D2 |
| 35 | 931203 | 32.43S | 114.78E | 931215 | 64.73S | 44.98E | JARE35B |
| | 940225 | 64.11S | 48.61E | 940320 | 33.77S | 151.33E | JARE35D2 |

## Post-cruise data processing

Intensities of *in vivo* fluorescence (mV) of the flowing water were calibrated into chlorophyll *a* concentrations (μg / l) with the data measured by the conventional fluorometric method of Strickland and Parsons (1968). The regression equation for each data set is listed in Table 3.

Table 3. Regression equation for each data set. *R* is fluorescence intensity (mV) of flowing water. Chl.*a* is chlorophyll *a* concentration (μg / l).

| File name | Regression equation | n | $r^2$ | Remarks |
|---|---|---|---|---|
| JARE27B | $\mathrm{Chl.}a = 0.0167 * R^{1.35}$ | 53 | 0.83 | |
| JARE27D1 | $\mathrm{Chl.}a = 0.0522 * R^{1.01}$ | 50 | 0.96 | |
| JARE28B | $\mathrm{Chl.}a = 0.0167 * R^{1.57}$ | 20 | 0.69 | |
| JARE28D1 | $\mathrm{Chl.}a = 0.0702 * R^{1.10}$ | 14 | 0.47 | |
| JARE29A | - | - | - | |
| JARE29B | - | - | - | |
| JARE29C | - | - | - | |
| JARE29D2 | - | - | - | |
| JARE30A | $\mathrm{Chl.}a = 2.75 * 10^{-6} * R^{3.92}$ | 9 | 0.69 | till 23:55, Nov.17 |
| | $\mathrm{Chl.}a = 4.47 * 10^{-5} * R^{1.69}$ | 9 | 0.65 | after 09:00, Nov.22 |
| JARE30B | $\mathrm{Chl.}a = 0.0871 * R^{0.672}$ | 22 | 0.20 | |
| JARE30D2 | $\mathrm{Chl.}a = 0.0537 * R^{0.729}$ | 18 | 0.20 | |
| JARE31A | $\mathrm{Chl.}a = 0.0363 * R^{0.883}$ | 24 | 0.19 | |
| JARE31B | $\mathrm{Chl.}a = 0.0437 * R^{0.766}$ | 24 | 0.81 | |
| JARE31D2 | $\mathrm{Chl.}a = 0.0275 * R^{0.897}$ | 45 | 0.44 | till 08:00, Mar.17 |
| | $\mathrm{Chl.}a = 0.158 * R^{0.898}$ | 5 | 0.88 | after 08:05, Mar.17 |
| JARE32A | $\mathrm{Chl.}a = 0.0120 * R^{2.41}$ | 25 | 0.46 | |
| JARE32B | $\mathrm{Chl.}a = 0.0309 * R^{0.908}$ | 36 | 0.72 | |
| JARE32C | - | - | - | |
| JARE32D2 | $\mathrm{Chl.}a = 0.00302 * R^{1.73}$ | 35 | 0.20 | |

| | | | |
|---|---|---|---|
| JARE33A | Chl.$a$ = 0.00105*$R^{3.21}$ | 33 | 0.67 |
| JARE33B | Chl.$a$ = 0.126*$R^{0.721}$ | 42 | 0.27 |
| JARE33C | - | - | - |
| JARE33D2 | - | - | - |
| JARE33E | - | - | - |
| | | | |
| JARE34A | Chl.$a$ = 0.0363*$R^{0.627}$ | 25 | 0.47 |
| JARE34B | Chl.$a$ = 0.0174*$R^{0.885}$ | 22 | 0.79 |
| JARE34D2 | Chl.$a$ = 0.117*$R^{1.20}$ | 43 | 0.78 |
| | | | |
| JARE35B | Chl.$a$ = 0.0525*$R^{0.604}$ | 18 | 0.08 |
| JARE35D2 | Chl.$a$ = 0.0646*$R^{0.811}$ | 40 | 0.21 |

Any abnormal data observed, which are probably due to mechanical trouble, were eliminated according to the following criteria:

1) Water depth less than 10 m,
2) Air temperature (navigation information) not between -30 and 50 °C,
3) Water temperature (navigation information and monitoring system) not between -3 and 40°C,
4) Ship speed not between 0 and 30 knot,
5) Salinity not between 20 and 40 psu,
6) DO not between 0 and 15 ml / l,
7) Chlorophyll *a* less than 0 µg / l,
8) Water flow passing through the monitoring system less than 1 l/min.

In addition to the above screening, all data obtained were discarded when latitude and longitude showed 0 degree.

An example of edited data is shown in Fig. 2. Twenty-eight data files observed from JARE-27 to JARE-35 are stored under the directory "\DATA" in the CD-ROM (Appendix). All are ASCII files and can be read on any type of personal computer, which can run Windows 95.

**Track charts of the JARE cruises**

Track charts of *Shirase* on JARE-27 to JARE-35 are shown in Figs. 3 - 20, which were processed from the data in the CD-ROM with the "Gp" graphics program (Konami and Edamatsu 1993). Image files (WMF files) of these figures are also stored under the directory "\IMAGE \WMF \MAP" in the CD-ROM (Appendix). Besides the WMF files, BMP and TIF files are also accessible under directories "\IMAGE \BMP \MAP" and "\IMAGE \TIF \MAP", respectively. *Shirase* sailed a similar course on every JARE cruise from Tokyo to Syowa Station. On the return to Tokyo, however, she called at Port Louis, Mauritius on JARE-27 and 28 and at Sydney, Australia on JARE-29 to JARE-35.

**Temperature, salinity and chlorophyll *a* concentration**

Temperature, salinity and chlorophyll *a* concentration in the surface layer (8 m depth) are shown along the course from Tokyo to Fremantle (Figs. 21 - 32), from Fremantle to Syowa Station (Figs. 33 - 60) and from Syowa Station to Port Louis or Sydney (Figs. 61 - 86). These figures are also stored under the directories "\IMAGE \WMF \GRAPH \LEG-A", "\IMAGE \WMF \GRAPH \LEG-B", and "\IMAGE

\WMF \GRAPH \LEG-D" in the CD-ROM, respectively (Appendix). BMP and TIF files are also accessible under "\IMAGE \BMP" and "\IMAGE \TIF".

**Data Protocol**

The data set in the attached CD-ROM may be used for publications or presentations with written permission from the National Institute of Polar Research (NIPR). Any inquires should be addressed to

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