RESEARCH SUMMARY

CRUISE FR 08/90

Departed Lae: 0800 Tuesday 02-October-1990
Arrived Townsville: 0900 Wednesday 17-October-1990

Principal Investigators

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INORGANIC AND ORGANIC CARBON CYCLES IN EQUATORIAL WATERS

ITINERARY

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CRUISE NARRATIVE

Franklin arrived in Lae on Monday October 5 at the end of cruise FR07/90. Monday afternoon was spent loading the containers and starting to set up the equipment to be used during FR08/90. After leaving Lae at 0800 on Tuesday October 2 we steamed for 36 hours to the first station, north of Manus Island (10^0 30'S, 147^0E). There was barely enough time to set up the equipment and some equipment was not operational for another day or so. Stations were then occupied at 10S and at one degree intervals along 147^0E to 5^0N. No samples were collected from 5^0N, 147^0E to 5^0N, 155^0E. On the second transect, along 155^0E, samples were collected at one degree intervals to 5^0S. After skirting around Buka Island at a distance of 12 nm, we occupied two more stations at 8^0S and 10^0S and then steamed to Townsville, occupying one further station on route through the Coral Sea.

Generally the weather was overcast with 10 - 15 knot winds and occasional gusts to 25 knots. Although we had thought that time would be at a premium, this was not the case and we completed the cruise with time to spare even though the number of hydrocasts was greater than originally planned. This was due to (i) the decision to limit most casts to 300 m, (ii) the improved turnaround time achieved by being able to leave the fluorometer mounted on the CTD for nearly all the casts, (iii) not having to charge the fluorometer power while on station, (iv) the use of a pressure system to filter large volumes of water directly from the Niskin bottles and, most importantly (v) the dedication and enthusiasm of those on watch.

No time was lost through bad weather and Franklin had no difficulty in steaming at 12 knots between stations.

SCIENTIFIC PROGRAM

Sampling Strategy

Continuous underway measurements were made of temperature, salinity, pH, in-situ fluorescence and particle size. For vertical profiles, we adopted the following sampling strategy. The CTD was fitted with a pH sensor, a light meter and a SeaTech fluorometer and power supply. The light meter was pressure rated to 300 m and since we were mainly interested in the euphotic zone, it was decided that the light meter would generally be left on the CTD and that casts would be to a depth of 300 m. At each station, there were three types of cast as listed below:

(Type 1)
Regular station
Fluorometer on
Max depth 300 m
nutrients, salinity, oxygen, copper complexing capacity (CuCC), iodine, alkalinity, particle size, Chl (a, b and c), flow cytometry (FC), bacteria (Bac and CNbac), NH4

(Type 2)
Lipid and pigment station
Fluorometer on
Max depth 300 m (approximately 25, 50, 75, 100, 125 m)
Sample depths determined from fluorometer
lipids, pigments, phytoplankton, prokaryotes

(Type 3)
Biology 'dawn station'
Light meter on
Max depth 300 m
nutrients, salinity, productivity, particle size and Chl (a, b and c), NH4

Type 3 stations were sampled approximately once a day within 3 h of sunrise. For some of the Type 1 or 2 casts, the CTD was lowered to 1000 m before sampling in the top 300 m. Trace metal (TM) samples were collected from teflon coated Niskin bottles at a few selected locations.

On the transect along 155E, additional casts were included to sample to the bottom at 5N, the equator and 5S. Trace metals were also collected to the bottom at these three stations. Prior to these casts, the zinc anodes were removed from the CTD and the zinc weights replaced by stainless steel. In order to minimise contamination from the CTD, the bottles were triggered as the CTD was being lowered at 10 m min-1. The bottles closed approximately 8 m below the nominal sampling depth. For obvious reasons, this procedure was not used for samples collected 10 m from the bottom.

RESULTS

We can only report on some of the preliminary results at this stage as many of the samples were collected for subsequent laboratory analyses. A number of new experimental techniques were tested on the cruise and a brief comment on these procedures and some of the experimental data is given below under the headings of the cruise objectives. Detailed descriptions of some of the new procedures is given in the appendix.

Cruise Objectives

1) To study the chemical and physical processes leading to increased biomass along the equator at the western boundary of the Pacific Ocean.

Samples were collected for the analyses of most category 1 and category 2 parameters as defined in the JGOFS sampling strategy. We used a new small volume technique for the determination of productivity by the uptake of 14C. The productivity was fairly low with maximum rates ranging between 0.29 and 1.01 mg C m-3 h-1. These values are in general agreement with results obtained in the Coral Sea by workers from AIMS. Samples were also collected for the determination of productivity by the uptake of 15N as ammonium (NH4) and nitrate (NO3). These samples will be analysed by colleagues from overseas. Interpretation of the data is complicated by the very low ambient levels of these nutrients.

Along the 155E transect, the maximum concentrations of cyanobacteria were generally found above the maximum concentration of phytoplankton as determined by in situ fluorescence. Samples for the determination of concentrations of bacteria and additional cyanobacteria samples will be analysed in Hobart. Some samples will be sent overseas for analysis by flow cytometry.

2) To measure vertical and horizontal profiles of pH, carbon dioxide and fluorescence in equatorial and near-equatorial waters characterised by elevated phytoplankton biomass.

The underway system for the continuous measurement of pH, T, S and in situ fluorescence performed well throughout this cruise and the preceeding cruise, FR07/90. Samples were collected regularly for the determination of chlorophyll a (to calibrate the Turner fluorometer) and alkalinity (for the calculation of pCO2 from pH). The in situ surface fluorescence was extremely low and, on some occasions, was undetectable. The alkalinity of surface waters can be estimated to within about 5%, and using a specific alkalinity of 0.1197, the values of pCO2 in the surface waters ranged from about 300 to 370 μatm. In the Bismarck

Sea, pCO2 values were about 320 to 330 μatm which agrees well with discrete measurements of pCO2 made during FR07/90. Final calculations of pCO2 will be made using interpolated values of alkalinity and values of pH that have been corrected to allow for electrode drift.

The new SeaTech fluorometer performed well and gave a good signal to noise even in shallow and deep waters containing little chlorophyll. At maximum sensitivity, the nominal output of the instrument was 3 μg/l for full scale output.

However a least squares regression of SeaTech signal against chlorophyll a, determined on samples collected during the cruise gave the result:

SeaTech (%) = 67.5 * [Chl a] + 1.9, r^2 = .881.

A multiple regression of SeaTech output against chlorophyll a, chlorophyll b and chlorophyll (c1+c2) did not lead to a significant improvement in the correlation coefficient and gave the relationship:

SeaTech (%) = 59.7 * [Chl a] + 9.6 * [Chl b] + 8.2 * [Chl c1 +c2] + 2.2, r2 = 0.884.

3) To use chemical methods, particularly lipid and pigment analyses, for the characterisation of the community structure within different water masses.

As mentioned above, some samples have already been analysed for cyanobacteria. Additional samples remain to be counted for cyanobacteria and bacteria. Samples will also be sent overseas for analysis of the abundance and fluorescence characteristics of prochlorophytes and cyanobacteria by flow cytometry. Water was also collected for identification of phytoplankton species present.

We had intended to characterise pigments by HPLC during the cruise but, as mentioned elsewhere, the equipment failed at the start of the cruise. Filters have been preserved for laboratory analyses of lipids by GC-MS and pigments by HPLC.

4) To test new sensors for the in situ determination of oxygen, pH etc.

Apart from the deployment and calibration of the SeaTech fluorometer, the only other new sensor tested during this cruise was the pH electrode mounted on the CTD. The system has an improved reproducibility and signal to noise ratio over earlier electrodes but the response seems dominated by pressure or temperature effects. Laboratory experiments in Hobart, using high pressure

equipment, should enable us to resolve the individual effects of pressure and temperature on the electrode system.

New polycarbonate sampling bottles were also tested during this cruise. There were problems with leaking and the closure systems will need modification. However the external closure mechanisms show considerable promise for the collection of clean samples. We will need to look at ways of minimising contamination from the end of the CTD cable and from the overhead hydraulic system.

PERSONNEL

Ship's Crew		Scientific Staff
Master	Neil Cheshire	Denis Mackey (Chief Scientist)
Mate	Dick Dougal	John Volkman
2nd Mate	Mike McAuley	Ed Butler
Chief Eng.	Peter Noble	Brian Griffiths
Elec. Eng.	John Davies	Harry Higgins
Bosun	Jannick Hansen	Bob Beattie
AB	Bluey Hughes	Jeanette O'Sullivan
AB	Kris Hallen	Mark Pretty
AB	Norm Marsh	Erik Madsen
Greaser	Paddy McLure	Ron Plaschke
Ch. Ste.	Ray Clarke	Dave Terhell
Ch. Cook	Gary Hall	
2nd Cook	Bob Clayton	

SUMMARY

Despite the difficulties caused by equipment failure and being one staff short (due to illness), we succeeded in achieving nearly all of our research objectives. We developed new experimental procedures and obtained valuable data on the carbon cycle in the Western Equatorial Pacific. The experience gained will greatly enhance our research capabilities on future cruises conducted as part of the JGOFS program.

APPENDIX

PARAMETERS MEASURED

Primary productivity

Primary production (14C incorporation) was measured at 12 stations with a method which uses 7 ml of seawater in a scintillation vial. This was the first time that we had used this method. A new incubator, which allowed production vs. light intensity curves at 7 light intensities from 4 depths to be measured simultaneously, was used on this cruise. In general, the sample replication was quite good. Production rates (0.29 to 1.01 mg C m-3 h-1) were similar to those found in the Coral Sea.

A technique using 15N to obtain estimates of new and regenerated production was tried on this cruise. The technique involved adding 15N as ammonia or nitrate to samples, incubating for about 6 hours, and then filtering through GF/F filters. This was done at 8 stations. Since the technique is still being developed, the results should be treated as preliminary. The major problem encountered was the violent movement of the bottles in the deck incubation due to the rolling of the ship. This can be easily fixed with some sort of bottle restraint in the incubator. The samples have been frozen, and will be sent to the Plymouth Marine Laboratories (U.K.) for analysis.

Particle size analysis

Particle size profiles were made at all of the productivity stations, and no problems were encountered except that one channel on the Division of Fisheries particle size analyzer failed. Quantitatively, the particulate organic carbon calculated from the particle size data in the equatorial region was less than at stations south of the equator. The slopes of the particle size spectra are quite different from slopes seen in the

Subtropical convergence in January 1990, suggesting different dynamics in the two regions.

Underway particle size analysis

Underway particle size logging was carried out nearly continuously throughout the cruise. On 5 October, it was noticed that the size class thresholds had been set incorrectly, and these were then corrected. There is a continuing problem of low flow through the sensor which will necessitate the sensor being recalibrated on return to Hobart before biomass results may be calculated. A peristalic pump needs to be installed in the water supply line to deliver water at the optimum velocity for underway particle size analysis.

Ammonium analyses - samples

201 samples and standards were analysed for ammonia by a manual spectrophotometric method during the cruise. Almost all of these measurements were made in triplicate.

126 seawater samples were collected from the top 6 depths of every hydro station. These were immmediately frozen for later analysis for ammonia or other nitrogen species determination in the shore-based laboratory

Iodine analyses

255 samples of seawater were collected from nearly every station and depth from which nutrient samples were taken. They were immediately filtered through an 0.45 μm filter, and refrigerated for subsequent laboratory analysis in Hobart.

Underway pH

The underway pH system was run throughout the cruise. It was monitored frequently, and the pH calibrated every two days using pH `7.3' and pH `8.8' Smith and Hood buffers, and also Hansen's Tris buffer. There were occasional problems with particles reducing the flow rate through the flow cell (solved by back-flushing), some fouling of the inner surfaces of the clear plastic tubing - observed as a yellow-green film, and the occasional inconsistency in calibration results (see elsewhere). Otherwise the system performed well.

Pigments and Lipids - sampling

Seawater samples were collected at most stations in 10 L PVC Niskin Bottles deployed on a 12 bottle Neil Brown Mark IIIB CTD. Casts were generally to 300 meters with samples collected at 125, 100, 75, 50 and 25 meters for later analysis of the pigments by HPLC. Additional samples were collected at

85, 95 and 105 meters in waters where the fluorescence maximum as shown by the SeaTech fluorometer was deeper in the water column. Fewer samples were collected for lipid analysis due to the larger volumes of water required (10 L of water for HPLC analysis of pigments, cf. 30-50 L for lipid analyses). Water was collected at the fluorescence maximum at most stations and at 50, 75, 100 and 125 meters at 5^0N, 0^0 and 5^0S along 155^0E.

A limited study of the distribution of pigments in different size fractions was also carried out. Water from the Niskin bottle was first passed through a 2 μm nuclepore filter and then through a 0.7 μm GF/F glass fibre filter. At one station, a 0.8 μm Millex filter (25 mm diameter) was used between the 2.0 μm and GF/F filters. Filters were treated as described above.

Water samples for determination of the abundance and fluorescence characteristics of prochlorophytes and cyanobacteria by flow cytometry were collected at most stations. A 4 mL portion was collected in 5 mL cryovials and immediately fixed with 20 μL of 40% glutaraldehyde. After 10 minutes, the samples were transferred to liquid nitrogen. One litre water samples were also collected for identification of the phytoplankton species present. These were collected in plastic bottles to which 5 mL of modified Lugols solution was added as a fixative. The samples were stored in a refrigerator.

Pigments and Lipids - results

An excellent range of samples for pigment and lipid analysis was collected which should provide much new data on phytoplankton populations and carbon cycles in these waters. These samples should help identify new pigment and lipid markers for the different phytoplankton groups and assess the relative importance of prokaryotic picoplankton organisms. These data will be compared with cell counts of cyanobacteria and prochlorophytes determined by flow cytometry (by Dr. Rob Olson, Woods Hole Oceanographic Institution) and of cyanobacteria determined by fluorescence microscopy (by Harry Higgins).

The patchiness in phytoplankton community structure and abundance suggested by earlier work was not observed. It seems likely that some of the earlier variation noted was due to sampling at depths above and below the chlorophyll maximum. The increase of chlorophyll a to chlorophyll b ratios with depth clearly shows that the phytoplankton species composition does vary significantly with depth.

The size fractionation experiments confirmed that much of the chlorophyll is associated with particles smaller than 2 μm. Based on previous data, this probably reflects the importance of prokaryotic biomass (cyanobacteria and prochlorophytes) in these waters. Much of the chlorophyll b is probably derived from prochlorophytes, particularly below 75 m.

Bacteria

A total of 228 samples were collected - every depth of all the type 1 hydro casts and 1 deep cast of all the intensive stations. All processing will be post-cruise in Hobart.

Cyanobacteria

A total of 194 samples were collected - every depth of all type 1 hydro stations. About half of the filters were counted on board using an epifluorescence microscope - the rest will be processed post cruise in Hobart.

The results of the samples so far counted (155E transect) indicate that the subsurface cyanobacterial maximum was generally above the microalgal / in situ fluorescence maximum.

Pigment HPLC

After an initial adjustment of the maximum pressure limiting potentiometer the fluid / mechanical component of the system functioned flawlessly. However, a problem developed with the lamp / lamp power supply of the diode-array detector. Consequently no samples were processed on board. All samples collected (type 2 casts) were thus frozen in liquid nitrogen for post cruise processing in Hobart.

If the HPLC system is to be used on future cruises, we need to improve the storage capacity for solvents. During this cruise we needed to find storage for 32 winchesters of solvent.

Sound proof box (ultra-sonic water bath)

The lead vinyl sound insulation used by the workshop was extremely efficient. It would be useful if the commercial sound reducing box bought for the ultra-sonic probe could also be lined with this material.

CTD chlorophyll

Chlorophylls were sampled from all station sites on the hydro cast at 0, 25, 50, 75, 100, 125 and 150 metres. Chlorophylls were also sampled from most Type 3 casts. A total of 192 samples were collected for the determination of chlorophylls a, b, and (c1+c2) and 157 samples were analysed whilst at sea.

Turner calibration

DELP readings were very low throughout the cruise and samples covering a wide range of chlorophyll values were hard to collect. The samples were

collected from the Turner outlet in the GP lab. The water was collected in a 5 L container and filtered through a GF/F filter using a water pump. The pressure difference was kept low. Six of the samples (out of 16) were analysed at sea.

Copper complexing capacity (CuCC) and trace metals (TM)

CuCC samples were collected from 50N to 50S along 1550E. At the intensive station at the equator, duplicate samples were collected from the TM bottles to run a check. For the other stations the samples were collected from the hydro casts (Type 1).

COMPUTING REPORT

General Data logging (TSG & pH)

Several minor changes were made to this package:

* Error messages are no longer written to the .GEN data file!

* TSGRPH can now recognise normal, non-data records. Genuine errors are now reported on the console and written to TSGRPH.LOG.

* Non-essential and debug messages were removed from the startup dialogue.

The MASTER program occasionally generates errors when it tries to read non-existent data from the TSG and pH logging programs. The cause has not been determined.

Underway Particle Size Analyzer (PSA)

This was logged for Brian Griffiths once we sorted out its RS232 interface protocol. We have data for the period 5th October - 0301/9/10 and 0000/10/10 - 1100/11/10. No data was logged after this date possibly due to a 'hangup' in either the Analyzer or the computer's RS232 interface. There needs to be some indication as to whether the PSA is being successfully logged.

ELECTRONICS REPORT

Only equipment and instruments which required attention during the cruise are reported on, all other equipment can be assumed to have performed correctly.

CTD and Rosette sampler

CTD#1 and Rosette sampler #1 were used. and apart from the occasional hiccup from the slip rings and a badly corroded altimeter cable, this worked well for the entire cruise.

After CTD station 61 the CTD was dismantled to fit the Variosens interface card and end cap connector. A separate power supply, run off the cable, should be made to supply all powered external sensors, as it appears that excessive loading of the 12 volt line in addition to inverter noise is interfering with the CTD sensor circuitry.

CTD hoist and slip rings

The CTD hoist is getting old and worn out, the chief engineer informed me that a number of teeth on the gypsy wheel are broken and the hoist needs complete overhaul, he suggested that a new hoist be purchased and the old overhauled and kept in the engine room as a spare.

The slip rings, which were overhauled last port period in Hobart have been removed and stored vertically during a later winch maintenance, contaminating the mercury and causing infrequent glitches in the data stream, a further overhaul will be scheduled for the next Hobart port period.

A sign "keep horizontal at all times" should be placed on the slip ring cover.

Variosens III

This was fitted to the CTD frame 11 October. to facilitate comparison testing with the SeaTech fluorometer. The output of the Variosens is logarithmic but, after being linearised, the 3 x 300 m. dips showed that it gave similar traces to the SeaTech fluorometer although it was noisier.

CSIRO pH probe

The pH Sensor was fitted to the CTD from start of the cruise and appeared to work well, although the data was met with some scepticism, a calibration span check was done 8/10/90 with 9.18 and 4 pH buffers, these indicated correct span, but with an offset of -0.6 pH units.

LICOR light sensor

When the light sensor was fitted, the CTD signal became extremely noisy, tests concluded that the noise was due to excessive loading of the ctd 12 volt

supply in conjunction with excessive switching noise from the inverters when both pH and light sensors were employed simultaneously, hence, for the remainder of the cruise, these sensors were employed singularly.

SeaTech fluorometer

The rosette bracket for this could not be located, so it was fitted on the variosens bracket, this unfortunately reduced the available bottle space by one. The fluorometer was, apart for a couple of deep stations, fitted for the entire cruise, after CTD station 9 the sensitivity was increased from x3 to x10
to give better surface resolution.

After CTD station 43 the fluorometer gave indications of severe sensitivity reduction, the cause of this was traced to a badly burnt pin/socket connection on the flash bulb, fortunately, these were the parts Brian Griffiths brought back from his visit to the SeaTech factory earlier this year, so the fluorometer was operational again on CTD station 46.

Intech Satnav

The Intech monitor was faulty from the previous cruise, this was repaired during layover in Lae, but after one days use the instrument failed again, the monitor was replaced with the spare Honeywell monitor, which proved that the fault was not in the monitor, but further back in the video formatting IC (IC38) of the satnav, all IC sockets on that board were cleaned and lubricated and the fault wasn't seen again.

Trimble GPS

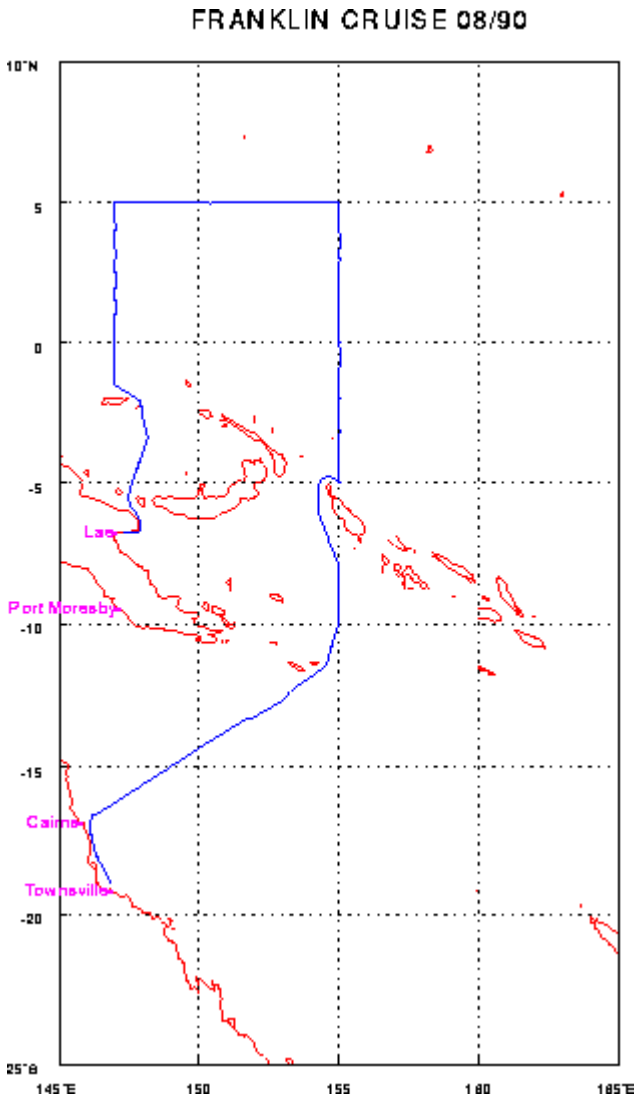
For some unknown reason, Satellite No. 21 was disabled from the start of the cruise, after enabling it, we had continuous GPS coverage for about 23 - 24 hours per day.

Meteorology station

The problem of occasional abnormal pressure data appears to be a mixture of frequent PLL unlock and micro1 loosing data blocks rather than due to errors in the scanner itself, the pressure offset during this cruise was quite constant at -8.4 HPa. Checking the buffered transducer output with a frequency counter revealed variations of about 1.5 Hz, cycling roughly with ship movement, but no change in frequency when the PLL dropped out. The DELP temperature is, according to the watch keepers, varying by up to two degrees with respect to the mercury thermometer on the monkey island. The Met soft ware had a bug removed, which caused wrong wind direction, it was discovered as all three wind instruments at one time indicated about 15 kt 3100, but the DELP display gave 12 kt 2630 whilst the ship was doing 12.5 kt 0900.

HPLC

Many hours were spent on the Waters 990 Photodiode Array Detector. It is thought that a faulty U/V lamp might be causing the problems, but with no service manuals or spares, not much could be done.


FRANKLIN CRUISE 08/90
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160
165°E
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Cairns
Townsville