# RESEARCH SUMMARY

## CRUISE FR 08/93

Sailed Townsville 2205 Friday 5 November 1993
Arrived Sydney 0735 Wednesday 1 December 1993


**Principal Investigators**

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## INORGANIC AND ORGANIC CARBON CYCLES IN EQUATORIAL WATERS - JGOFS

# CRUISE SUMMARY
# R. V. FRANKLIN
# FR 08/93

## PROJECT

**Inorganic and Organic Carbon Cycles in Equatorial Waters - JGOFS**

## SCIENTIFIC PROGRAM

## CRUISE OBJECTIVES

1) *To measure vertical and horizontal profiles of pH, carbon dioxide and fluorescence in waters of the western equatorial Pacific Ocean.*

Underway measurements were made of *in situ* fluorescence and pH. A comparison of measured $pCO_2$ and calculated (from pH and alkalinity) $pCO_2$, done on FR05/92, showed good agreement. The most significant source of error was due to drift in the pH electrodes. This effect was reduced during FR08/93 by using a new flow cell with two pH electrodes in series. The system worked well and all the data was successfully logged by the new software. Very low *in situ* fluorescence was observed and the new hardware and software resulted in a different relationship between the output from the Turner fluorometer and the DELP numbers.

Vertical profiles of pH were not measured but samples were collected for the analysis of Alkalinity and dissolved inorganic carbon (DIC) back in Hobart. Vertical profiles of *in situ* fluorescence were obtained using a SeaTech fluorometer(s) connected to the CTD. The fluorometer(s) will be calibrated from measurements of extracted Chl *a* determined by HPLC. Preliminary data, using the calibration from FR05/92, suggest that the concentration of Chl *a* is much more variable than on previous cruises with maximum values of about 0.8 $\mu g\ l^{-1}$, compared with 0.5 $\mu g\ l^{-1}$ for FR05/92. Repeated sampling at a given location showed the depth of the chlorophyll maximum moved by up to 25 m in 4 hours. This movement was due to vertical movement of isopycnals rather than to migration of the phytoplankton.

2) *To study the primary and secondary productivity of these waters.*

The photosynthetic parameters of primary production was measured using a small-bottle, $^{14}C$ incubation technique at 6 depths at 17 sites during the northward transect along 155$^0$E. In addition, 5 sites were resampled on the southward leg. A total of 240 production vs light intensity curves were recorded. At the 6 process stations primary production estimates were made on water samples taken at approximately midnight, 0800, 1200 and 1630 hrs. Only a single depth profile of primary production was made at the remaining stations. On the southward leg, 5 depths were sampled, allowing one depth to be replicated at each site. Three process stations and the island wake enrichment study were abandoned due to time restrictions caused by the change of arrival ports from Townsville to Sydney to enable the bow thruster to be fixed.

Secondary production was not measured. Zooplankton biomass estimates in the upper 100 m were made using a 0.25 $m^2$ mouth area, 200 micron mesh aperture, free-fall zooplankton net.

3) *To study the physical, chemical and biological processes that determine the vertical fluxes of carbon across the air-sea interface and within the water column.*

The vertical flux of carbon out of the euphotic zone was measured at the 6 process sites by deploying free-floating sediment traps for approximately 24 hours at each site. Modified Knauer traps were suspended at depths of 150 and 500 m, and 8 samples were collected from each depth. Samples for dissolved organic nitrogen and phosphorus estimates, were taken at each process station to 200 m, and detailed profiles to 300 m were made at $2^0$N, $1^0$N, and at the equator on the southward leg. Phytoplankton samples, and samples for flow cytometry (to determine prochlorophyte, cyanobacteria, and bacterial abundance) were taken at selected depths at selected sites.

The levels of $Pb^{210}$ and $Po^{210}$ will be determined in the dissolved and particulate phases and $Ra^{226}$ will also be determined in the dissolved phase. From these parameters, collected at $10^0$S, $5^0$S, 0, $5^0$N and $10^0$N, the sinking rates of particles from the upper water column in this region will be determined.

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

The island wake enrichment experiment was cancelled because of time restrictions. This did not allow us to assess the potential for increasing primary production downstream of the island caused by mixing and uplift of nutrients into the euphotic zone due to current flows.

Samples were collected for the analysis of wide suite of biological, chemical and physical properties. Preliminary data from this cruise have indicated that there is considerable variability over periods of ranging from hours (24 hour stations on FR08/93) to weeks (FR07/90 and FR08/90, Legs 1 and 2 on FR05/92, and repeat stations on FR08/93) to years (FR08/90, FR05/92 and FR08/93). A full analysis of the data from the three cruises, in conjunction with an analysis of data collected by other participants in the Equatorial JGOFS program should greatly improve our understanding of the carbon cycle in the western Equatorial Pacific.

5) *To use chemical methods, such as lipid and pigment analyses, for characterisation of the phytoplankton community structure within different water masses.*

No samples were collected for the analysis of lipids. Samples were collected for the analysis of chlorophylls and carotenoid pigments by HPLC. A new software package, developed at DO, will be used to assess the phytoplankton species composition from the concentrations of these pigments. We are particularly interested in obtaining information on the variations in pigment composition in a given species as a function of external parameters such as depth (light intensity).

## CRUISE NARRATIVE

This cruise was be based on two transects along $155^0$E and a number of 24-hour time series measurements that were made at $5^0$S, $3^0$S, 0, $3^0$N, $5^0$N, $8^0$N on the northbound transect and at $2^0$N, $1^0$N, 0 and $3^0$S on the southbound transect. At each of the time series stations, we deployed drifting Knauer sediment traps with eight samples collected at depths of 150 and 500 metres.

In general casts were made to 2000 m and 300 m at each location. At many locations, additional casts were made for the collection of trace metals, naturally occurring radionucleides etc.

After leaving Townsville on the evening of Friday November 5th, the laboratories were a hive of activity as we set up our equipment and started calibrating the fluorometers, underway pH sensors etc. The first stop was at $13^0$ 48'S, $151^0$ 36'E where we checked the Niskin bottles for leakage and had a test run of all our sampling procedures to ensure that we had not been too ambitious in our plans for sampling everything we could think of out of 10 litres of seawater. All went well and demonstrated that the considerable time and effort that had gone into developing our sampling was well worthwhile.

After our first official station at $10^0$S we proceeded northwards but had to move our next station from $8^0$S to $7^0$ 12'S as we did not receive permission to sample in the territorial waters of the Solomon Islands. A further submission to the Solomon Islands to sample at $8^0$S on the return transect received no reply. The station planned at $5^0$S was shifted to $4^0$ 50'S to minimise the chances of the sediment traps drifting within the exclusion zone around Buka Island.

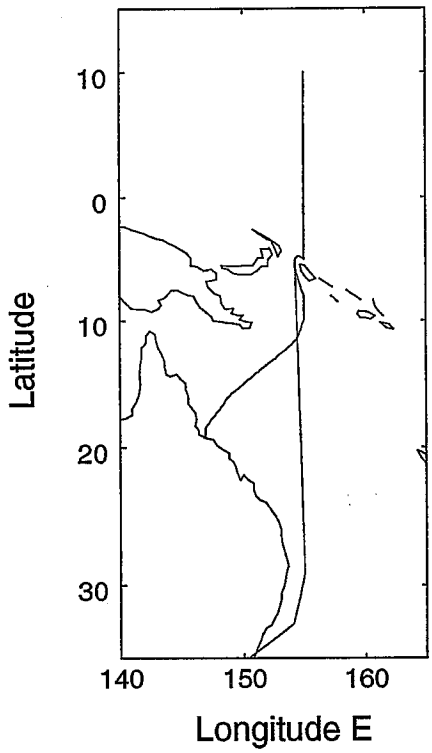
As we moved northwards, the tradewinds gradually subsided, seas were slight but the weather was dull and overcast. At $3^0$N, there was a westerly wind burst with 25 kt winds (gusting to 30 kt) over a period of about 6 hours. We passed within a few miles of Nukuoro Island and confirmed our observations from FR05/92 that (i) it is approximately 2 nm away from the position marked on Japanese charts of 1937 and, (ii) the northeast corner looks a great place to surf.

At this stage disaster struck and the bowthruster went on leave. We had the most impressive wire angle at $3^0$N that I had seen on a hydrocast since the old days on Diamantina. Fortunately, for the rest of the cruise, conditions were kind enough that the lack of a bowthruster did not compromise the program. The only effect on our routine was that the master was reluctant to recover the sediment traps at night.

From the equator to $6^0$S on the return transect, we had good conditions with mirror flat seas and winds 'gusting' to 2 knots. The sunsets were superb! As we moved southwards into the Coral Sea, conditions derteriorated markedly and from about $10^0$S to $15^0$S we were battling into rather lumpy seas.

Following numerous Faxes, it was decided that it would be necessary to go into dry dock to repair the bowthruster. At this stage we did not know where we would finish, whether we would have sufficient fuel to get there, or whether we would have to make a sharp right turn and head to Gladstone for fuel. In the final event, the cruise finished in Sydney rather than Townsville and, the research program was modified slightly so that we had sufficent fuel with the cruise being extended by only 15 hours.

## CRUISE TRACK




## PERSONNEL

| Ship's Crew | | Scientific Staff |
|---|---|---|
| Master | Neil Cheshire | Denis Mackey (DO) - Chief Scientist |
| Mate | Dick Dougal | Brian Griffiths (DF) |
| 2nd Mate | Ian Menzies | Harry Higgins (DO) |
| Chief Eng. | John Scott | Jeanette O'Sullivan (DO) |
| 2nd Eng. | Peter Harding | Ros Watson (DO) |
| Elec. Eng. | Don Roberts | Pru Bonham (DF) |
| Bosun | Jannik Hansen | Sandy Garland (DF) |
| AB | Bluey Hughes | Bob Griffiths (ORV) - Hydrology |
| AB | Kris Hallen | Les Drury (ORV) - Hydrology |
| AB | Andy Russo | Bob Beattie (ORV) - Computing |
| Greaser | Tony Bernadin | Erik Madsen (ORV) - Electronics |
| Steward | Reg Purcell | Philip Towler (U. Melb.) |
| Chief Cook | Gary Hall | |
| 2nd Cook | Bob Clayton | |

## Appendix A

### Natural Radionucleides - FR08/93 (Philip Towler)

Measurement of naturally occurring radionuclides as tracers of particle flux from the upper layers of the ocean.

Profiles were collected at $10^0$S, $5^0$S, 0, $5^0$N, and $10^0$N along the $155^0$E transect. Each profile consisted of six samples of 40 L each taken at depths down to 300 m. Each sample was filtered using a 142 mm diameter membrane filter with a pore size of 0.45 μm. The filter was held in a Sea Star filter holder. Initially the filtration was attempted using a vacuum manifold. This method was extremely slow so the filtration was done under pressure. The four Niskin bottles of each sample were pressurised and the water from all of them directed through a single filter.

Only one of the filter holders contained a filter support of plastic mesh. Using this filter support allowed the 40 L of seawater to be filtered in approximately 50 minutes. Various other materials were tried as filter supports in the second filter holder with a course cotton mesh finally being settled on. The filtration took twice as long with the cotton filter support compared to the plastic mesh.

The filters were stored for analysis in Melbourne. The radionuclides of interest were concentrated from the filtrate and the bulk of the water discarded. The "concentrates" will be analysed in Melbourne.

The levels of $Pb^{210}$ and $Po^{210}$ will be determined in the dissolved and particulate phases. In the dissolved phase $Ra^{226}$ will also be determined. From these parameters the sinking rates of particles from the upper water column in this region will be determined.

## Appendix B

### Wet Laboratory Report - FR08/93 (Harry Higgins)

At each of the stations, samples were taken from the surface to 2000 m with most of the biological sampling centred around the chlorophyll maximum (typically 85 m but spanning the range 65 - 100 m). A 5 m depth resolution typically between 55 and 100 m was chosen to adequately sample the nutracline.

In addition to the standard DO, salinity and nutrient samples the following samples were taken :

| | | |
|---|---|---|
| Pigments | 272 | 158 to be processed initially (3 of the 4 casts at the process stations to be archived) |
| Bacteria | 177 | |
| Flow cytometry | 177 | |
| Phytoplankton | 104 | Profile at 1230 cast of process stations and DCM at other stations (52 samples were air-dried and 52 were preserved with glutaraldehyde) |
| $NH_4$ | 330 | |
| DIC | 121 | At 10, 5, 3 and 1S, the equator and 1, 3, 5, 8 and 10N. |
| DOC | 97 | |
| DON/DOP | 107 | |

Apart from the DO, salinity, nutrient and some of the $NH_4$ samples (which were analysed on board) the rest of the samples will be returned to Hobart on the Franklin for processing in Hobart and thus no preliminary results are available. Isotope casts, trace metal casts and productivity results are discussed in seperate reports.

The new compressed air pressure filtration system was more efficient and safer than the previous 240 V vacuum system. The portable fan mounted in the wet lab made working conditions more pleasant in this otherwise hot and humid area.

On several occaisions Milli-Q and distilled water ran out in the chemistry and wet labs. Distilled water from the ships supply in the engine room had to be manually carried in carbouys to the header tank 2 decks up. This was an unsatisfactory arrangement, particularly in rough weather. A better pumping or distilled water supply system should be investigated urgently.

## Appendix C

### Biology - FR08/93 (Sandy Garland)

### DON/DOP Profiles

DON/DOP samples were collected at each process station on the first transect at 0, 25, 50, 60, 70, 80, 125 and 200 m. Dissolved nutrients profiles were also taken from $2^0$N, $1^0$N, 0, $2^0$S and $3^0$S. Depths sampled at these stations were 0, 25, 50, 60, 70, 80, 90, 100, 125, 150, 200, 250 and 300 m. In all 98 samples were collected and transferred frozen to Hobart laboratories by domestic flight as excess baggage. In the Hobart laboratories they will be analysed by FIA for nitrite, nitrate, phosphate, total phosphate and total nitrate.

### Size Fractionation Experiment

In addition 20 DON/DOP samples were collected for a size fractionation experiment from the second equatorial station (CTD 73) and at an additional station at $4^0$ 12'S (CTD 78). Each sample was filtered through acid washed millipore filters ranging from 0.1 to 1.2 μm. These are to be analysed by FIA for nutrients as above.

### Sediment Traps

Sediment traps consisting of 2 x 8 traps lowered to 140 and 800 m were deployed at $5^0$S, $3^0$S, 0, $3^0$N, $5^0$N and $8^0$N. The traps were filled with high density salt solution. Prior to and on retrieval of the traps, samples were taken for DON, DOP and DOC. Four of the traps from each depth were filtered through 3 pre-combusted, pre-weighed GF/F filters (2 singles and 1 double) for CHN analysis on return to the Hobart laboratories. Of the remaining traps, at each depth, sediment samples were collected for pigment analysis, SEM and $^{15}N/^{13}C$ analysis. In all 12 single and 6 double filters were collected for CHN analysis, 12 filters for SEM and 12 filters for $^{15}N/^{13}C$ analyses. All were frozen for their return to Hobart by domestic flight. The 12 pigment samples were immersed in liquid nitrogen and are to remain on the Franklin until she arrives in Hobart.

### UV Absorption Experiment

On the second transect at $2^0$N, $1^0$N, 0, $2^0$S and $3^0$S samples were collected close to the chlorophyll maximum. These are to be analysed for pigments by a UV absorption on filter technique. In addition to filtering 2 litres of each niskin through a 2.5 cm GF/F filter, normal 4.7 cm and 8 4.7 cm pigment samples were collected and remain in liquid nitrogen on board the Franklin.

### POC/PON Precision Experiment

At $4^0$ 12'S a special cast was made (CTD 78) to collect 10 niskins of sea water from the chlorophyll maximum (96 m) for a POC/PON precision experiment. Each niskin was filtered through pre-weighed, pre-combusted filters for CHN analysis in the Hobart laboratories. The 10 samples were frozen and returned to Hobart via domestic flight.