

RESEARCH SUMMARY

CRUISE FR 05/92

Depart Townsville:	2200	Monday	15-June-1992
Arrive Rabaul:	1500	Tuesday	30-June-1992
Depart Rabaul:	0600	Thursday	02-July-1992
Arrive Lae:	1200	Monday	13-July-1992

Principal Investigators

Dr. Denis Mackey
Dr. John Volkman
Dr. Bronte Tilbrook

CSIRO Division of Oceanography

Dr. John Parslow

CSIRO Division of Fisheries

INORGANIC AND ORGANIC CARBON CYCLES
IN EQUATORIAL WATERS

JOINT GLOBAL OCEAN FLUX STUDY

ITINERARY

Leg 1

Depart Townsville:	2200	Monday	15-June-1992
Arrive Rabaul:	1500	Tuesday	30-June-1992

Leg 2

Depart Rabaul:	0600	Thursday	02-July-1992
Arrive Lae:	1200	Monday	13-July-1992

CRUISE NARRATIVE

Leg 1

After spending a hectic day setting up the HPLC equipment for pigment analyses as well as the pCO₂ equilibrator, the coulometer and the alkalinity titrator, we embarked from Townsville wharf at 2200 and immediately discovered that the Gyro compass was not working. We anchored off Magnetic Island and returned to Townsville at about 0900 on Tuesday 16th.

The system was checked out by a technician from Cairns. The verdict - the compass was on its last legs but would probably last until we reached Rabaul. Since we could not get a replacement at short notice, we decided to take our chances and left Townsville at 1500.

We generally had calm seas and favourable currents which allowed us to steam at 12-13 kt and, at one stage, we managed 14 kt. We arrived at the first station (10S, 155E) at about 0600 on Friday 19th. The individual casts were completed more rapidly than planned although the sampling time between casts occasionally took longer. This pattern persisted for the whole cruise and enabled us to rapidly make up the time lost due to the faulty Gyro-compass.

Early on the morning of Monday 22nd - just before the trace metal cast - the fan belts broke on the air conditioner for the clean container. We had no spares but the engineers managed to make two out of a larger belt. The first belt broke soon after the unit was switched on, the second broke after about 1 h. Finally, a temporary fan belt was made from spliced rope and this belt, although only partly successful, remained in use for the rest of Leg 1.

Temperatures in the GP laboratory (and the photographic room in particular) were as high as 35 °C and the HPLC and coulometer were not designed to operate at such a high temperature. The air conditioning could not cope with the heat

produced by all the instruments. We took the air conditioning hose off the electronics rack in the operations room (under the PDR) and diverted it into the cable duct to the GP laboratory. This was only partly successful and, in the end, we were unable to use the coulometer and the alkalinity system during the cruise.

On Wednesday 24th, just before lunch, we moved into new territory as Franklin moved farther north than on any other cruise (the previous record was Truk). After completing the station at 100 N, 1550 E we had gained enough time to add an extra station to the 1470 E transect and so we steamed to 6N, 147E.

On Saturday 27th we checked on the Japanese buoy at 5N, 147E. We could not find it at the stated position but, as we proceeded to the next station, the buoy was located a few km away from the stated position. It was very difficult to find since it was disguised and looked like a 'floating coffin', but it seemed OK and we reported its exact location.

A few days prior to our expected arrival in Rabaul, one of the ship's officers developed shingles and, as we had continued to make good time, we arrived in Rabaul ahead of schedule so that he could seek medical attention.

Leg 2

We departed Rabaul dock at 0600, Thursday July 2nd, and after a short delay of about 3 hours in Rabaul Harbour to correct a steering problem, departed for the first time series site at 0S, 155 E. Conditions were overcast and slightly bumpy, but improved overnight. We arrived at the time series site at 1730 Friday 3rd, in calm clear conditions. Following an initial CTD cast to the bottom, the free-floating sediment trap array was deployed. Although we had not previously deployed this array, the deployment went smoothly, and the ship had no difficulty tracking the array over the next three days.

The weather remained very kind, and we completed our scheduled sampling program at Site 1 in good time. We recovered the trap array at 1600, Monday 6th, at 00 02.82' S, 155 31.56' E. Recovery was made more difficult because the main surface buoy had collapsed, and the string of small surface floats designed to facilitate recovery had submerged. The crew improvised well and managed to lasso the top float after several tries. After two further CTD stations, we departed for the second time series site at 2100 and arrived at 3S, 155E at 1230, Tuesday 7th.

We deployed the sediment trap array at 1300 and commenced the time series stations soon after. Again the weather remained calm and (mostly) clear, and we completed the time series studies in good time. This site was more interesting in that the sediment trap array initially headed SW and seemed determined to beach itself on a string of atolls at 3 18' S, 154 44' E. However, it veered

south as it approached the group, and we were able to leave it in the water for the planned three day period, recovering it at 1500, Friday 10th, at 3 18.69' S, 154 48.15' E. After completing the scheduled set of CTD casts, we departed for Lae at 0700, Saturday 11th. Wind and sea increased during this transit, and we initially made poor time against a strong current, but eventually arrived on schedule in Lae.

SCIENTIFIC PROGRAM

Sampling Strategy

Leg 1

The 24-bottle rosette was used for CTD casts from the surface to 2000 m at latitudes 10° S, 8° S, 5° S, 4° S, 3° S, 2° S, 1° S, 0°, 1° N, 2° N, 3° N, 4° N, 5° N, 8° N and 10° N along 155° E, and at latitudes 6° N, 5° N, 4° N, 3° N, 2° N, 1° N, 0°, 1° S and 1.5° S along 147° E. Additional casts to 200 m were made at about 11 stations to collect large volume samples for measurements of productivity, lipids and pigments.

For the 2000 m casts, samples were collected at depths of 0, 25, 25, 50, 50, 75, 75, 100, 100, 125, 125, 150, 150, 200, 300, 400, 600, 800, 1000, 1250, 1500, 1750 and 2000 m. For the shallow casts to 200 m, multiple bottles were tripped at 6-7 different depths including the depth of the deep chlorophyll maximum.

Samples were collected for the analysis of nutrients, salinity, oxygen, bacteria, cyanobacteria, pigments, lipids, alkalinity, DIC and, at selected stations, trace metals and copper complexing capacity. Underway measurements were made of pH and pCO₂.

Primary production was estimated at ten stations along 155° E (10°, 8°, 5°, 3° and 1° S, 0°, 1°, 3°, 5° & 8° N) and at 5 stations (5°, 4°, 2° N, 0° & 1.5° S) on 147° E. Seawater was sampled from 5 CTD depths, (generally 0, 50, 75 or the chlorophyll maximum, 100 & 125 m; however at sites with a deep chlorophyll maximum the regime was 0, 75, 110 or chlorophyll maximum, 125 & 150 m). P vs I (production versus intensity) curves were obtained by measuring ¹⁴C uptake in samples from each depth, incubating 7 ml subsamples for 1 hour at 18 light intensities, and in the dark, in a modified photosynthetron.

Results have not yet been standardized to production per unit chlorophyll, but peak production in mg C fixed per hour was found at the surface at 1.5° S, 147° E and 3° S, 155° E. At the other 13 stations production peaks were associated

with the chlorophyll maximum, which varied in depth between 60 and 115 m.

The PAR sensor was deployed at productivity stations during daylight hours, on a separate CTD cast as it is only pressure-rated to 300 m.

Water samples were filtered for nutrients (nitrate, nitrite, silicate, phosphate) at productivity depths at productivity stations only (75 samples). Filtered samples were analysed on board at the same time as the unfiltered OMS nutrients.

Particle size analysis, using a Hiac particle counter, was carried out at productivity stations at all OMS depths to 200 m. In order to determine optimum incubation time for bacterial production estimations using methyl 3H-thymidine on Leg 2, a kinetics experiment was performed at 10° N, 155° S at 50, 115 (chlorophyll maximum) and 125 m. Replicate samples were incubated to determine DNA incorporation (on board) and incorporation into other macromolecules (in Hobart). Samples were also preserved for AODC counts to determine bacterial numbers and volumes.

Zooplankton samples were collected at each productivity station by hauling a ring net (mouth area 0.25 m², mesh diameter 200 µm) from 100 m to the surface. Samples were preserved in 4% formaldehyde for subsequent determination of biomass and dominant taxa.

Along 155° E, additional casts were made to the bottom at 5° S, 0° and 5° N for the determination of trace metals. Replicate samples were collected using the teflon-coated Niskin bottles and the new Helmond-Byrne bottles. The TM bottles took about 4 h to sample mainly due to the logistics of shuffling 24 bottles. At the equator we experienced more problems with the Helmond - Byrne bottles since they did not fit on the 12-bottle rosette or the racks in the wet laboratory and we had to store the trace metal bottles (full of seawater) all over the place.

Both sets of bottles were used on the casts. The nine TM niskins were placed at 0, 100, 200, 400, 600, 800, 1000, 2000 and 3000 metres at 5° S with the fifteen HB bottles at the same depths plus 300, 500, 700, 900, 1500 and 2500 metres. At the equator, the depth was only 2500 m, therefore no samples were taken at 3000 and the bottom depth of 2500 was sampled using the TM niskin. At 5° N the sampling was the same as at 5° S except that there was no duplicate sample at 1000 metres due to the handle falling off TM niskin #80.

The protocol for sampling was:

1. Take the CTD to the burst depth then hold for 30 seconds.
2. Descend from the burst depth at 10 m/min

3. Fire off the first bottle after 30 seconds.

4. Immediately fire off the second bottle.

For 5° S, and the 2000 m depth at the equator, the duplicate bottle was raised again to the burst depth and sampled as for the 1st bottle.

A total of 69 TM and CuCC samples were taken along the 155° E transect. The TM and CuCC samples were sampled in the clean container. They were sampled under gravity and not under pressure as filtered samples were not required.

The CuCC samples were spiked with 25 æl of 0.8 µM CuSO₄ in the chemistry lab at the end of each sampling.

Due to the timing of the TM sampling, either at night or the early hours of the morning, no blank samples were taken away from the ship on the Zodiac.

Leg 2

Leg 2 was used to conduct JGOFS time series studies to complement the transect data collected on Leg 1. These studies addressed physical, chemical and biological processes and their variation on time scales of hours to days, and space scales of tens of kilometres, at each of two sites.

The transect data from Leg 1 along 155° E showed a strong surface salinity front between 2° and 3° S, and a strong subsurface salinity front between 2° and 3° N. These data also indicated a general deepening of the chlorophyll maximum from south to north, and relatively high production at 3° S. The time series sites were therefore chosen to be 0° S, 155° E and 3° S, 155° E. It would have been desirable to conduct a third station at 3° N, 155° E but this was not possible in the cruise time allocated.

The water column structure at each site on Leg 2 was established by an initial CTD cast to the bottom. A free-floating sediment trap was then deployed, and followed for about 72 hours. During this period, an intensive study was made of processes related to production and carbon flux in the top 300 m. Repeat CTD casts were made to 300 m, providing continuous profiles of T, S, DO, PAR (in daylight hours) and chlorophyll fluorescence. Water samples from 0, 25, 50, 75, 100, 125, 150, 200, 250 and 300 m were analysed for standard hydrology (salinity, DO) and inorganic nutrients (nitrate, nitrite, silicate, phosphate). The depth closest to the chlorophyll maximum (typically 75 m) was shifted to sample the chlorophyll maximum. Standard nutrient samples were unfiltered, but filtered nutrients were measured at 0, 50, 75, 100 and 125 m for comparison. Filtered samples from 4 stations at each site were collected and frozen for total dissolved nitrogen (TDN) analysis on shore.

The repeat CTD stations were divided into two categories on the basis of the primary production studies. One day was devoted to a study of diel variation in photosynthetic parameters. Stations were conducted at 0200, 0800, 1400 and 2000, and 14C incubations carried out at each of 5 depths (0, 25, 50, 75, 100 m) at each station. For each depth, P vs I curves were measured by incubating small subsamples (7 ml) for 1 hour at each of 18 light intensities (plus triplicate darks), using a modified photosynthetron.

On the other two days at each site, a reduced set of 14C incubations was carried out to investigate day-to-day and local spatial variability. Stations were conducted at 0800, 1400 and 2000, and samples from 3 depths (0, 50 and 75 m) were incubated at 9 light intensities (plus triplicate darks), chosen to give estimates of the initial slope and maximum value of the P vs I curve. One station at each site was used to compare photosynthetic parameters under blue light and white light illumination. All other incubations were carried out under blue light.

At the first site, one station at 0800 was used to conduct time series incubations in vials and in 2 l polycarbonate bottles. Samples from the surface and the chlorophyll maximum were incubated on deck under neutral density mesh screens and blue film at light intensities corresponding to 1.7, 4 and 17 % of incident solar irradiance. Subsamples were harvested and filtered at 1, 2, 4, 8, 12 and 24 hours.

Bacterial production was measured using the tritiated thymidine method. Samples were incubated from each of 3 depths (0, 50 and 75 m) at 2 productivity stations (1400 and 2000) at each site.

A prototype CCD-based spectroradiometer was used, together with a commercial 8-band radiometer, to obtain vertical profiles of downwelling spectral irradiance $E_d(\lambda)$, upwelling spectral irradiance $E_u(\lambda)$, and upwelling spectral radiance $L_u(\lambda)$, at 0900 and 1300 h each day. The profiles were conducted on the sunny side of the ship, and the HIAB crane was used to allow profiles to be made about 8 m clear of the ship's side.

Zooplankton samples were obtained at each station by hauling a 0.25 m² ring net (200 μ m mesh) from 200 m to the surface. Samples were preserved in formalin.

Large volumes of seawater (approximately 60 l at each of 4 depths) were collected and filtered for lipid analysis at 2 stations on each site.

Forty litre samples from each of 6 depths were collected and filtered, and both filtrate and filters processed and retained for D. Smith, University of Melbourne. The samples will be analysed for Pb/Th isotopes to provide alternative estimates of particle flux.

The sediment trap arrays were modelled on the Knauer design. Each array consisted of 8 individual cylindrical traps fixed to a welded aluminium cross-frame. Two arrays were deployed at 200 and 700 m depths on a single mooring attached to a surface buoy array fitted with flashing light and radio beacon. After recovery, trap contents were filtered through 47 mm precombusted GF/C filters, and frozen desiccated. One filter from each depth was analysed immediately for HPLC pigments.

The PAR sensor was deployed at productivity stations during daylight hours, on a separate CTD cast as it is only pressure-rated to 300 m.

Water samples were filtered for nutrients (nitrate, nitrite, silicate, phosphate) at productivity depths at productivity stations only (75 samples). Filtered samples were analysed on board at the same time as the unfiltered OMS nutrients.

Zooplankton samples were collected at each productivity station by hauling a ring net (mouth area 0.25 m², mesh diameter 200 µm) from 100 m to the surface. Samples were preserved in 4% formaldehyde for subsequent determination of biomass and dominant taxa.

At the Equatorial site, the sediment trap drifted slowly ESE, covering ca. 30 nautical miles in 3 days. The (uncalibrated) ADCP data indicate SE flow at ca. 0.5 m s⁻¹ above 150 m, and ENE currents at ca. 0.5 m s⁻¹ at 200 m. There was relatively little evidence of diel or day-to-day variation in the physical or chemical structure in the water column. A strong pycnocline extended from ca. 60 to 120 m, with a very pronounced subsurface chlorophyll maximum at ca. 75 m. There was considerable diel variation in photosynthetic parameters. The sediment traps at both 200 and 700 m collected a significant amount of material, as judged by colour on the filters, and shorter deployments may be possible in future.

After deployment at 3°S, the sediment trap array drifted SW, and appeared to become entrained in the circulation around an atoll group at 3° 18' S, 154° 44' E, eventually travelling south just to the east of the islands. The physical structure was characterised by a shallow mixed layer to ca. 40 m, and a series of strong stepped pycnoclines to ca. 250. The chlorophyll maximum at about 50 m was very pronounced, and production was higher than at the Equator. The amount of material collected in sediment traps was again large.

As on Leg 1, approximately 6 to 9 l of water from the top 7 depths were filtered for HPLC analysis of pigments on board. Samples were also collected from all depths for HIAC particle size analysis. Cyanobacteria samples were collected from all depths and frozen for later analysis. Phytoplankton samples were collected on filters for SEM analysis from 0, 25, 50, 75 and 100 m on one

station at each site. A detailed profile of similar samples at 10 m intervals through the subsurface chlorophyll maximum was also obtained on one station at the second site.

[PRELIMINARY RESULTS

Objectives

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

The new pH sensor from Titron did not arrive in time for the cruise and we were unable to run the underway fluorometer since the seawater supply was inadequate. The lack of underway fluorescence was not a great liability since the surface Chl a concentrations were very low and previous experience indicated that surface fluorescence was not well correlated with measurements of Chl a integrated through the water column.

Underway measurements were made of pCO₂ and pH and, although changes of about 10 - 15 æatm were commonly observed over distances of about 60 km, the surface waters were approximately in equilibrium with the atmosphere. The pCO₂ results are still being worked up but they are in general agreement with pCO₂ values calculated from pH measurements. However there are large variations in pCO₂ as can be seen from Figure 1. The data is similar to that obtained during FR08/90 although there was less variability in 1990.

The air conditioning in the GP laboratory could not cope with the heat produced by the instruments and we were unable to analyse samples for DIC and alkalinity during the cruise. Samples were collected for analysis back in Hobart.

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

Results have not yet been standardized to production per unit chlorophyll, but peak production in mg C fixed per hour was found at the surface at 1.5⁰ S, 147⁰ E and 3⁰ S, 155⁰ E. At the other 13 stations production peaks were associated with the chlorophyll maximum, which varied in depth between 60 and 115 m.

- 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 SeaTech fluorometer was invaluable to the cruise in that it enabled us to collect samples from the deep chlorophyll maximum. The fluorometer was

calibrated with Chl a measurements determined on board by HPLC. The correlation between fluorescence and Chl a was given by the equation:

$$\text{Chl a} = 0.0124 * \text{SeaTech} + 0.027 \quad (r^2 = 0.698)$$

Compared to the calibration obtained during FR08/90, the correlation coefficient was lower and the slope of the calibration was lower by about 20%. Concentrations of Chl a were generally about $0.1 \mu\text{g l}^{-1}$ rising to about $0.4 \mu\text{g l}^{-1}$ at 50 - 100 metres. The depth of the chlorophyll maximum increased from south to north along 155° E.

Samples were collected for later analysis of lipids, pigments, bacteria, cyanobacteria, trace metals, copper complexing capacity, DIC and alkalinity. The preliminary fluorescence and hydrology data were used to determine the protocols for Leg 2.

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

The data on productivity, light, salinity, temperature and nutrients will be used to study the processes controlling the biota in this region. Extended measurements were made during Leg 2. We also attempted to get information on the particulate fluxes out of the euphotic zone by deploying floating sediment traps and by collecting samples for estimating these fluxes from measurements of the disequilibrium between the naturally occurring radionuclides $^{210}\text{Pb}/^{226}\text{Ra}$ and $^{210}\text{Po}/^{210}\text{Pb}$.

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

Samples were collected and analysed on board for chlorophylls and carotenoids. The data has been processed to provide quantitative information on chlorophyll a concentrations for calibrating the SeaTech fluorometer. The pigment analyses showed high proportions of zeaxanthin and [alpha]-carotene highlighting the importance of prokaryotic organisms (cyanobacteria and prochlorophytes). Chlorophyll b from green algae was also significant at some stations. The major carotenoids were butanoylfucoxanthin and hexanoylfucoxanthin from prymneseophytes. The processing of the data for the other chlorophylls and the carotenoids will be done back in Hobart. Samples will also be analysed in Hobart for lipids.

PERSONNEL

Ship's Crew

Scientific Staff

Master	Neil Cheshire	Denis Mackey (Chief Scientist - Leg 1)
Mate	Dick Dougal	John Parslow (Chief Scientist - Leg 2)
2nd Mate	Bryce Bathe	Bob Beattie (Cruise Manager - Leg 2)
Chief Eng.	John Scott	Bronte Tilbrook (Leg 1)
2nd Eng	Peter Harding	John Volkman (Leg 2)
Elec. Eng.	John Browne	Harry Higgins
Bosun	Jannick Hansen	Val Latham
AB	Bluey Hughes	Jeanette O'Sullivan (Leg 1)
AB	Kris Hallen	Ros Watson (Leg 2)
AB	Wayne Browning	Erik Madsen (Leg 1)
Greaser	Jeff Snell	Phil Adams (Leg 2)
Steward	Dave Ramsay	Dave Terhell
Ch. Cook	Gary Hall	Danny Holdsworth (Leg 1)
2nd Cook	Bob Clayton	Don McKenzie (Leg 2)

Pru Bonham

Teresa O'Leary

Mark Pretty (Leg 1)

Brian Griffiths (Leg 2)

APPENDIX

CRUISE - FR05/92

SCIENTIFIC AND TECHNICAL REPORT

COMPUTING

CTD

The handling of the rosette firing data is deficient. On many occasions, the underwater unit reported a misfire, when in fact the bottle had fired. Only firings reported as successful are reported in the firing file and in the averaged data file. This can cause much inconvenience for people trying to use the data.

All firing data, including misfires and no responses should be recorded in the firing file. If there are inconsistencies in this file, the operator should be given the opportunity to edit it (as per the editing portion of FILHAN in the old CTD system). The edited file should be used by CTDAVE to identify the data segments to be averaged.

ADCP

The logging software performed well, but gyro errors have compromised the data quality. The Bridge gyro readout was consistently 3 - 4.50 high. However, the synchro to digital converter used by the ADCP ranged from 90 higher to 10 less than the bridge, depending on the ship's heading!!

There are a few minor ADCP problems:

1. There may be logic problems in MNUs bottom track menu:

If Manual mode is operational, one would expect this to be shown if when MNU is run. On some occasions, MNU says Auto mode is operating, but with the Manual mode parameter settings.

If Manual operation is operational and Auto is selected, or vice-versa, logging to the current file is not terminated unless the default settings are altered or re-entered.

2. A number of 'TMO errors' were observed, generally when the unit was bottom tracking or attempting to bottom track in 300 - 500 m or so of water. It is not an error, as logging is proceeding normally. The timeout interval should be made larger.

3. The RDI deck unit does not restart cleanly, after logging has been terminated, unless it is turned off and on again.

Licor light meter (MET)

I did not remove the offset of 43 for the Licor channel of the MET station until after the end-of-cruise shut down. (It is now set to 0.0.)

HYDROCHEMISTRY

New Niskin Bottles

30 new 10 litre niskins which were made by the workshop were used for the first time this cruise. The following parts were fitted to them on the cruise:

new lanyards and balls for 24 bottle rosette

stopcocks and o-rings

taps, o-rings and tap rings.

A test station was performed as station 1 and all but 1 niskin passed the salinity leak test (ie all bottles fired at salinity minimum). This bottle was replaced.

During the cruise the new niskins operated reasonably however some problems do need to be addressed.

1. After bottles were brought on deck, many end caps leaked where the handle was glued to the cap. These caps were replaced with General Oceanics caps which are moulded from one piece of PVC.
2. On all new niskins the pin which prevents the tap from being accidentally opened during deployment of CTD is too short so if tap is not closed carefully it can easily leak.
3. The stopcocks were very stiff to open and close, particularly as the niskins were being filtered which requires the stopcocks to be removed.
4. The Master made the comment that the white colour of the niskins may attract sharks. No evidence of this was experienced during the cruise.

Water Still

Upon leaving Rabaul the still began tripping the breaker a number of times. Initially it was thought that the still was faulty, so the main part of the

still which contains the anode and cathode were replaced. Problems continued with the 'new' still and as the feed water got worse it was realised that the water was so bad it was causing the still to draw too much current (at times 60 amp). As there were no 15 amp switches on board, the still burnt out 2 switches and after the breaker was modified to 20 amp instead of 10, we were able to nurse the still through the rest of the cruise. I have requested a 15 amp switch be ordered by electronics and sent to ship for installation prior to FR07/92.

Auto-analyser sampler

I experienced an unusual problem with the sampler. It started sampling when it should be washing and vice-versa. After taking it apart it was found that one of the cogs had slipped on its spindle and this had caused the phase of the sampler to be out by 180 degrees. The cog was adjusted and tightened and the sampler had no more problems.

Phosphate Analysis

We were unable to obtain a linear calibration curve, experiencing similar problems to those experienced on previous cruises. After much washing with NaOH/HCL, replacing reagents with new reagents sent from Hobart mid cruise, replacing all plastic tubing, replacing phototubes and optically peaking the colorimeter, the standard curve improved but I believe it is not satisfactory. As the phosphate line has been a problem for a while now, I believe efforts should be made to rectify all the problems with the phosphate analysis before FR07/92. The only things which have not been replaced are the heater and the mixing coils.

I also suggest that a protocol be set for all nutrients which must be met before analysis of samples is performed. This is important so that each technician works to the same quality control.

Milli-Q water

During the cruise, staff from biological oceanography commented on the quality of the Milli-Q water. As it was difficult to find out when the Milli-Q cartridges had been changed last, I changed all cartridges and the filter. If anyone changes any cartridges could they please record the date on the relevant cartridge housings.

Ammonia Analysis

About 4 days were spent collecting together equipment and reagents for the ammonia analysis. Approximately 12 hours were spent plumbing and trouble shooting the autoanalyser channel for ammonia. A further 1-2 hours were spent

preparing reagents and standards. The ammonia channel was started up and within one hour the smell of phenol was noticeable.

Dave Terhell was on shift and found the smell caused him to experience flu symptoms. This condition was alleviated when he left the contaminated area. According to the Material Safety Data Sheet phenol vapour is a nose and throat irritant. It has been recorded in the Encyclopaedia of Occupational Health and Safety that once the smell of phenol is detectable by nose in ambient air then the concentration is above TLV.

During the 12 hours in which the ammonia channel was running a series of standards were run. There was a high level of contamination by ammonia in the blanks. After the analysis was stopped and the reagent lines flushed out with Milli-Q the smell remained in the chemistry lab for 8 hours even with the porthole, window and door open for extra ventilation.

Recommendations

1. For the phenol method to be used, the whole autoanalyser and waste system would need to be operated in a laboratory fume hood. No such space is currently available on board Franklin or in the Hobart laboratory.
2. It is recommended therefore that alternative methods which do not use phenol be investigated. There is a manual method which uses salicylic acid rather than phenol which could be investigated. There is also a fluorescence method being used at Florida International University based on the conversion of NH_4 to NH_3 and the subsequent diffusion of NH_3 across a microporous hydrophobic Teflon membrane. This type of method could not be part of the autoanalyser nutrient analysis. If time is allocated to finding a new method, then sampling and storage procedures should also be researched.

Comments

Before the cruise both technicians were lead to believe that the work load on the second leg of the cruise would be minimal and we were therefore asked to have a go at analysing samples for ammonia in addition to normal analysis as well as nitrite. Unfortunately after setting up the ammonia analysis line and getting the system going it was decided that health and safety requirements could not be met due to the phenol fumes being emitted from the analysis as outlined above.

At the beginning of Leg 2 we were however rather surprised to find that, excluding the ammonia analysis, we were going to have a considerable number of samples to analyse (approximately the same rate as the first leg) and at that stage we were expecting to run the ammonias as well. In order to complete all

the analysis we had to forgo being involved in the sampling.

At a time when we had almost completed running the nutrients on the autoanalyser, John Parslow made the comment that he would have preferred that the nitrate analysis be done at a higher sensitivity for samples to 300 meters and normal sensitivity for deeper samples. As the normal sensitivity nicely covered the range of samples being analysed, and as we have not had that type of request before, the nitrates had of course been run at the normal sensitivity. Had we known of John's request at the beginning of the cruise we would have been happy to accommodate.

The point is that sometimes the hydrochem technicians are not fully advised as to what analysis is required prior to the cruise. To alleviate this problem I would like to recommend that an Analysis Request Sheet be filled out by each cruise leader prior to the cruise. If they do not know what will be required then they can say so on the sheet and we then know what to expect.

ELECTRONICS (FR05/92)

This report deals only with equipment which required maintenance or service during the cruise, all other equipment may be considered to have operated satisfactorily.

Preliminary

The following work was done both prior to the voyage and en-route to Rabaul.

1. A Licor Light Sensor #UWQ 4059 was mounted on the Hydrographic A-Frame and interfaced to MICRO6 TT2: via the new Data Taker 500.
2. The ADCP Transducer was installed in the moon pool carrier frame.
3. CTD #4 was fitted in the 24 bottle frame with 24 Bottle Rosette, Fluorometer, Battery, Titron pH Sensor #13, Licor Light Sensor #UWQ4060 and Altimeter.

To accommodate chemistry requirements, all zinc anodes were removed from the 24 bottle rosette unit, spare rosette frame and wet laboratory.

4. The Thermosalinograph Sensor assembly was inspected and cleaned.

CTD System

The 24 Bottle Rosette sampler required adjustment of the motor alignment to

alleviate multiple firings after the test cast. It then performed credibly until CTD#17 where there were 14 misfires in one cast. The problem was caused by salt water contamination in the rosette acknowledge switch, caused by a badly cut o-ring seal on the upper cam shaft.

After CTD#32 a badly corroded light I/F bulkhead socket on the CTD was replaced, the rosette acknowledge switch was cleaned the upper cam shaft o-ring was replaced. The o-ring surface was polished to remove a burr, (the cause of cut rings).

It would be handy to have access to the actual reply from the rosette u/w unit to overcome the uncertainty as to whether a 'No Fire' (NF) or 'No Acknowledge' (NA) is the cause of the not infrequent misfire indication. A (NA) reply usually would indicate that the bottle had fired, but the acknowledge was either, not sent, lost or misinterpreted.

Some way of over riding or editing the automatic Niskin Bottle count after a cast would also be of use in this respect, as the printed bottle firing record only reflects the firing record of the soft ware rather than the actual record, i.e. that of the operator.

A problem with the under-way program 'UWY', causing RTD to intermittently not except data during a CTD cast, was fixed by R. Beattie. The NEC Colour printer is having difficulty in feeding single sheets in humid conditions, perhaps tractor feed and continuous paper could be the answer, on this voyage the problem was overcome by only issuing single sheets to the printer.

Prior to the end of the cruise the CTD was removed from the 24 bottle frame and installed on the 12 bottle frame in preparation for FR06/92. The 24 bottle frame and rosette were stored in the hold.

Vertical pH profiler

At CTD stn #12, the Titron pH sensor was changed to #15 due to excessively noisy sensor #13, but after CTD stn #17 sensor #13 was re-fitted due to insensitivity of sensors #15 and #16. The sensor noise problem was prevalent for the remainder of the voyage.

The pH sensor was removed from the CTD when it became noisy and affected the fluorometer data. The spare sensors had been used on the previous leg of the cruise and reported as being unserviceable. These sensors will be returned to Hobart for repair at the end of the cruise.

EA500 Sounder

The new sounder performed faultlessly throughout the voyage. It had none of the

EK400 problems with digitising on steep slopes, and bottom depths of 6900 m were detected without problems. Bow thruster cavitation (when running 100%) still causes depth errors. A much lower power consumption, and hence less heat generation, is another advantage of this instrument.

A 7.5 volt supply was installed on the Nec 8201 (to save on batteries). It now comes on with the rack switch.

The printer port hangs when the printer runs out of paper. A hardware reset seems the only way solve this problem.

HIAC ROYCO Particle Counter

An intermittent 150 micron sensor head had its IC sockets cleaned and a new wiring loom fitted.

ADCP

Errors relating to TMO failure were frequent whilst in shallow water, but could be overcome by disabling bottom tracking. The new thermistor in the transducer was checked regularly against the TSG temperature. The difference of 0.1 - 0.2 C was fairly constant.

Liquid Scintillation Counter

Numerous power-up resets were required before this instrument came on-line. This system has been on board for seven years without refit or manufacturer service and calibration. The instrument should be serviced as soon as possible.

Ship Equipment

Gyro Compass

The S. G. Brown Gyro Compass did not work on departure from Townsville. After initial inspection and test measurements to confirm DC and AC voltage levels to the compass the master was advised to seek professional assistance from shore as we did not think it advisable to tackle the compass within sight of Port and without spares, although a comprehensive service manual is on board.

Errors were detected of approx 4 degrees between the ship's Gyro and GPS headings. Worn bearings in the gyro motor were thought to be responsible. The Gyro unit is to be replaced on arrival in Lae.

Errors were also detected between the Gyro and the logged heading. The logged heading was checked against the gyro and the results documented and presented

at the end of this report. The fault appears to be in the Gyro O/P. Another test will be done after Lae.

TRACE METAL SAMPLING

Clean Container

The clean container was found clean and tidy. The electrical lead for the alarm in the container could not be found. All other accessories were there.

The racking area in the entrance leaked considerably when it rained or when the decks were washed down. This has been a problem for some time in that a seal does not form in the roof area of the entrance. Silicone was put in the gap of the join and heavy duty tape was put on the outside. Rain still came in but it was found that the rubber seal had been dislodged. Therefore the remedy was not fully tested.

New racks made of PVC and titanium pins had been put in the entrance. The niskins would not fit in the racks as the plunger at the back hit the base of the rack. Part of the base had to be filed away to enable the niskins to be racked. The niskins were still a very tight fit for both sets of bottles i.e. TM niskins and Helmond Byrne (HB) bottles. This was due to the height of the titanium pins and the piece of PVC at the back of the rack. The piece of PVC at the back was removed and this enabled much easier racking. The PVC pieces will be sent to Hobart to be cut down as without them the bottles moved in the racks a bit. The rack on the side also would only rack three bottles instead of four as one of the pins was over the light switches. This pin or another pin will be needed when 12 bottles are to be racked in the entrance.

The trough under the niskins does not cover the new rack, but on looking at the problem I feel it is easier to just lift the new HB bottles from the rack and empty them further up.

The air conditioner in the container broke down during the voyage. The problem was located to two broken fan belts in the motor. No spares were on board and the ship did not have one the correct size. The engineers tried to make two fan belts from a larger one, but this only worked for a short time with both breaking after a couple of hours. Unfortunately the problem arose in the middle of the sampling. The second set of samples were taken in very hot conditions. A fan belt was made out of a spliced rope. This worked for a while then began to slip and couldn't keep up with the intake of warm air. It alleviated the conditions slightly for the third sampling. New fan belts (adjustable) were sent to Rabaul for the second leg.

Helmond-Byrne Trace Metal Samplers

The nylon on the bottles continued to stretch, which required adjustment to a few of the bottles for each cast. Because there were 24 TM niskins on board, the HB bottles were stored away in their storage boxes in the clean container. The adjusting of the bottles had to be done just prior to racking the bottles on the rosette which meant rushing this procedure. If the HB bottles are the only bottles used, and they can be racked in the clean container entrance, this procedure could be done without rushing.

The lanyards were the wrong length for the 24 bottle rosette. The monofilament used on the HB bottles was too thick for the swages that we had. We made up attachments with the monofilament used by the Hydrology group and covered the swages with black stretch tape. The lanyards on the TM niskins were also short and the attachments for the Hydrology bottles were used. The swages were covered with the black stretch tape.

The holes for the pins were tight on the 24 bottle rosette with bottles 95,97 and 98 also being a tight fit at the back.

The back bracket was too high for the 12 bottle rosette and the same bracket was too deep for the wet lab racks. This bracket could also have the edges in the centre smoothed.

When the bottles came up on deck there were 6 bottles which leaked and lost some sample. A total of 8 samples leaked out of 60 samples on 4 casts. The problem is mainly with the seating of the 'O' rings. A couple of lanyards caught in the lid of the next bottle. The gap size at the base did not seem to matter.

The pressure test was not very successful and seven out of the fourteen bottles tested leaked when the pressure was set at ~6 psi on the pump. The problem again seems to be the 'O' rings and some became unseated with the pressure.

The 'O' rings were recognised as a possible problem before this voyage. This will have to be addressed and the modifications to the back bracket undertaken to enable racking on all racks. The lanyard length could be solved with two sets being made with a longer set for the 24 bottle rosette using the original design. These should be easily interchangeable where necessary. We may have to look for a new 'O' ring design. Further work is needed in this area.

pH METER

The underway pH system was run by Mark Pretty and Jeanette O'Sullivan. The system was replumbed on the 19/6 1800 UTC as there was a fracture in the barrel for the electrode and temperature probe, which was causing a small leak. The barrel was replaced together with all the PVC lines including the buffer lines.

The new barrel does not have the same screw hole dimensions as the old, so only one screw is in place with tape on the other. The old barrel will be taken back to Hobart and a new one will be made.

TURNER FLUOROMETER

The underway Turner Fluorometer was not used on the voyage due to lack of water supply for the system. The CO₂ equilibrator needed the full supply of water excluding the pH line.

Although the Turner was not run, the system was checked at the end of the voyage to make sure the flow through system was working. The outlet pipe had been altered to accommodate the CO₂ equilibrator. This does not effect the Turner in any way, just the orientation of the outlet. When connecting up the system, leaks occurred in the click joined adaptors (over the sink).

SEATECH FLUOROMETER

The response of the fluorometer was checked with rhodamine B. This was done in a black bucket which was half-filled with Milli-Q, adding the vial of Rhodamine B solution and filling the bucket with Milli-Q. The bucket was placed under the fluorometer on the rosette and the top was covered with a towel. The results of the test were readings of 30% and 32%.

The final concentration of the rhodamine B should have been 25 µg/l, which should have given a reading of ~47%. The result showed a reproducible reduction in the reading. This could be due to the instrument, or the fact the rhodamine B solution was made up in the plastic vial in June 91 and, although it had been kept in darkness, it may have deteriorated. As there was no fresh Rhodamine B on board, the calibration will be repeated back at the lab using both aged and fresh rhodamine B samples.

The Fluorometer stopped working after the 6th cast of Leg 2. On opening the unit salt water was found covering the receiver optics. The unit was disassembled cleaned and reassembled. A suspect o-ring was replaced.

The unit leaked again and the leak was traced to a screw locating the receiver beam mirror. A drawing of the screw and seal is included in this report. It can be seen from the drawing that the o-ring is being used as a washer and not as an o-ring. As the o-ring compresses with time the tension on the seal is reduced and a leak is more than likely. This is a design flaw and should be rectified before the instrument is used again.

The leak was fixed by re-tensioning the screw. The case was subsequently tested

to 2500 meters without a leak. The following two casts gave problems. The first was due an oxidised internal connector, the second was due to a faulty receiver board. Both the connector and the receiver board were replaced and the unit functioned correctly. The new receiver board was installed with the time constant set to 1 second (it was previously set to 3 seconds) as significant delays were noticed between down and upcasts.

The instrument will be shipped back to Hobart after FR06/92 for some form of post calibration, servicing and removal of internal corrosion, realignment of optics and full calibration.

HPLC PIGMENTS

Samples of 6-9 I were taken from almost every shallow hydrology cast on Leg 1 and from most P vs I and P max casts on Leg 2. Samples were taken from the 0, 25, 50, 75, 100, 125 and 150 m bottles on both Leg 1 and for the P vs I casts on Leg 2. The depth of the "75" or "100" m bottles were often adjusted to the depth of the chlorophyll maximum. Usually only 3 depths, at and above the chlorophyll max, were sampled for the P max casts. In addition sediment trap samples were taken from both sites and 2 size fractionation experiments were carried out on Leg 2. Over 300 samples were taken in total.

All samples were extracted, run, and manually integrated on board except for the size fractionation filters, and about 10 samples collected towards the end of Leg 2. The data from Leg 1 and the first half of Leg 2 was backed up on to both 5.25" disks and 60 Mb tapes. The remaining data from Leg 2 was backed up on only the 60 Mb tapes.

MICROSCOPY

Samples for microscopic cyanobacterial counts were taken at 10⁰, 8⁰, 5⁰, 2⁰, and 0⁰ (N and S) on the 155⁰ E transect of Leg 1; at 5⁰, 2⁰, and 0⁰ N on the 147⁰ E transect of Leg 1 and also at two day and two night casts at the two drift stations on Leg 2. Flow cytometry samples were also taken at most stations on the 155⁰ E transect of Leg 1 and also at 8 casts during Leg 2. The samples were taken from the hydrology casts at 0, 25, 50, 75, 100, 125 and 150 metres corresponding to the HPLC pigment samples. The depth of the "75" or "100" m samples were often adjusted to the depth of the chlorophyll maximum.

All samples were filtered on board and samples from the 1550 E transect from Leg 1 were counted on Leg 2. Preliminary results indicate that the depth of maximum abundance of cyanobacteria was usually above that of the chlorophyll maximum.

Samples for bacterial counts were taken from selected casts on Leg 1 (same depths as for HPLC pigments and cyanobacterial estimates) and also on Leg 2 to complement bacterial productivity measurements. Counting will be done back in Hobart.

CARBON DIOXIDE

The major aims of the CO₂ measuring program were:

1. To measure pCO₂ distributions along the cruise track in order to determine the net flux of carbon dioxide across the air-sea interface and,
2. To obtain water column profiles of DIC and alkalinity along 155° E and 147° E that can be used to investigate carbon cycling in the ocean.

A number of difficulties occurred during the cruise which prevented a complete set of data being obtained. These difficulties were related to the location and lack of adequate air conditioning in the general purpose laboratory, and to the seawater supply on the ship. The major problems are outlined below.

The general purpose laboratory is poorly situated and too small. There is only one access to the laboratory down a steep stairwell. All of our equipment had to be carried down the stairwell and it just fitted. Some of the equipment weighed in excess of 50 kg and we were fortunate not to have injured anyone getting it down the stairs. Two groups needed to use the laboratory and, because it is so small, the benches were stacked with equipment. There was little room for supplies and these needed to be stacked on the floor, which made work difficult. If the laboratory is going to be used in the future as a general purpose lab, it needs to be enlarged and have a better access, perhaps to the scientific store through the poorly utilised dark room. Alternatively, it may be possible to relocate the laboratory.

The seawater supply lines in the general purpose lab do not deliver enough water at a high enough pressure to run pCO₂ measuring equipment and other instruments. The Turner fluorometer had to be switched off in order to make pCO₂ measurements, which prevented underway measurements of fluorescence in the surface waters being made. The seawater flow with the fluorometer switched off was at best marginally acceptable, but the preliminary pCO₂ data look reasonable. Perhaps an alternate seawater supply line could be set up for equipment that needs higher flow rates.

The drains in the general purpose laboratory also need to be improved. The sinks drain into tanks and cannot be used to drain seawater from the underway sampling equipment because they fill too quickly. The equilibrator cannot have

any pressure head where it drains and, because the general purpose laboratory is close to the water line, it is not straightforward to dump the water overboard. The ships engineers worked hard to plumb a temporary system so that the seawater coming out of the pCO₂ equilibrator could be drained overboard. Although the temporary system worked for this cruise, the water did not drain particularly well and sometimes backed up into our equilibrator. We were fortunate to have very calm conditions and helpful engineers. In rougher seas it is unlikely we would have been able to obtain data. Because the problem took time to fix, there was no chance to collect pCO₂ data during the first two days of the cruise.

The air conditioning in the general purpose laboratory was inadequate. We could not run our coulometer or alkalinity titrator during the cruise because the refrigerated water baths that we need for this equipment heated the lab up too much. The high temperatures affect the performance of the equipment and, at times, room temperatures reached 33 C. The maximum working temperature of the High Performance Liquid Chromatograph (HPLC) used by the other group sharing the lab was 30 C. Because we could not run our equipment at sea, samples had to be collected and returned to shore for analysis. Unfortunately, we only had enough bottles to collect samples at about 60% of the CTD stations. Attempts to improve the air conditioning by running a duct from the operations room located above the laboratory were not successful.

The problems outlined above contributed to us not being able to obtain a full set of data. The pCO₂ measurements began on June 18 at approximately 10⁰ S, 155⁰ E and were continued until the end of the CTD sampling at 1.50 S, 1470 E. More analysis of the data is needed onshore to establish the quality of the data because of the problems with the seawater supply and drainage. DIC and alkalinity measurements could not be made on board because of the air conditioning problems but samples were collected at about 60% of the CTD stations for analysis onshore.

BIOLOGICAL OCEANOGRAPHY

Spectroradiometer

At the start of Leg 2 a broken connector was repaired, however the unit failed subsequent testing. Six broken tracks were repaired at the back of the db25 internal connector and two components were resoldered back onto the board.

The unit operated correctly for a day then the DSIR failed to communicate. Water had entered through the cable splice into the 3 pin glenair connector on the DSIR housing, rendering it unserviceable. It was decided to remove the DSIR from the U/W housing and mount it on the deck of the ship. The 3 pin glenair

was removed from the loom and the cable reterminated. The unit operated correctly in this configuration until the second last sampling station, when water, which had ingressed from the previous leak, shorted several cable conductors together. Approx 50 meters of cable was trimmed to remove the short. It was decided not to reterminate the cable as only 50% of the cable was serviceable.

Franklin Cruise 5/92

