National Facility Research Vessel

RV FRANKLIN

VOYAGE DOCUMENTS

RV SOUTHERN SURVEYOR

CSIRO AUSTRALIA

CSIRO MARINE AND ATMOSPHERIC RESEARCH

Voyage Plans and Summaries

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Franklin Voyage Summary No. FR01/00

Title

TROPICS 2000: A continuing investigation on the supply of nutrients, organics and trace metals to the equatorial region from the Sepik River and their influence on coastal and oceanic primary production.

Itinerary

Departed Cairns 1000 hrs, Friday 14 January 2000
Arrived Rabaul 1000 hrs, Thursday 3 February 2000

Principal Investigator(s)

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Scientific Objectives

1. To investigate the supply of nutrients, organics and trace metals to the equatorial region from the Sepik River and their influence on coastal and oceanic primary production during the wet season and to contrast these results with those obtained on FR06/97 and FR07/97 (Mackey, Burns, Szymczak).

2. To identify organic biomarkers, isotopic and geochemical signatures that can be used to trace sediments, dissolved, and suspended materials from riverine to oceanic regimes (Mackey, Burns, Szymczak, Higgins).

3. To determine radiochemical and geochemical signatures for the New Guinea Coastal Undercurrent and the Equatorial Undercurrent, and use these signatures to differentiate between potential riverine and hydrothermal sources of iron and other trace elements that may be assisting primary production in the western and eastern Equatorial Pacific ocean (Mackey, Burns, Szymczak, Griffiths).

4. To assess the relative importance of nutrients (including micronutrients such as iron), and light to the biological productivity and phytoplankton biomass of the region (Griffiths, Mackey, Higgins, Parslow).

Cruise Objectives

This cruise is similar in scope to FR07/97, which was undertaken during the time of the southeast tradewinds, and at the beginning of an El Niño event. In contrast, this cruise in 2000 will be undertaken during the period of the northwest monsoons when the rainfall, and river flow, should be much greater than occurred during FR07/97. We will assess the terrestrial inputs of organic matter, macronutrients and trace elements under these two extremes of precipitation. This should help us to complete the quantitative assessment of the relative contributions of terrestrial versus marine inputs of organic matter in these coastal environments.

Comparison of data from FR07/97 and this cruise will help us to determine whether changes in precipitation over New Guinea could affect the supply of trace elements, nutrients and organic matter to the Bismarck Sea and to the Equatorial Pacific via the New Guinea Coastal Undercurrent (NGCU) and the Equatorial Undercurrent (EUC) (Lindstrom et al., Nature, 330, 533-537, 1987). Of particular importance is the supply of iron since it has recently been proposed that the productivity of the whole equatorial Pacific is ultimately driven by the supply of iron from the EUC into the overlying euphotic zone. While new production in the Equatorial Pacific is low in relation to other regions subject to upwelling, the total production is globally important since the equatorial Pacific covers such a large area (Murray et al., Science, 266, 58-65, 1994). Changes in new production in the equatorial Pacific would significantly alter the exchange of carbon dioxide between the atmosphere and the equatorial Pacific and play an important role in feedback mechanisms in the global carbon cycle.

The research plan provided here is based on the expertise and resources used during FR07/97. Two transects will be occupied: one will be out from the Sepik River across to Manus Island, and the second will be along the NGCU from about 147 degrees E to 143 degrees E. Stations will also be occupied on the Equator at about 143 degrees E and 150 degrees E in order to measure marker compounds in the Equatorial Undercurrent, and to carry out optics and primary production measurements. Sampling will be carried out over hydrothermal vents in the Bismarck Sea to allow differentiation to be made between riverine and hydrothermal sources of the radiochemical and geochemical signatures in the Equatorial Undercurrent.

Organic geochemical studies involving the use of specific organic markers and their isotopic composition have been used in the past to investigate a variety of sedimentary environments. A second issue is that organic geochemists frequently look at surface sedimentary material and make assumptions about the overlying water column. These assumptions may then be transferred to studies of ancient sediments and environments. However, it has never been fully established exactly what the sedimentary material represents as a representation of the total organic carbon input to the water column. If time permits, Kasten coring in deep water (1000-2000m) will provide additional material for these studies Again, this study in conjunction with previous data, will provide a perfect opportunity to assess this in a quantitative way.

Measurements of biological productivity and phytoplankton biomass will enable us to assess the relative importance of nutrients (including micronutrients such as iron), light and grazing in this region. Comparisons of primary production measurements made by traditional ^{14}C methods, and with two new instruments, a fast repetition-rate fluorometer and a passive solar fluorescence instrument. If a good correlation is obtained between instrument-produced primary production measurements and the ^{14}C method it may allow us to reduce the use of radioactive carbon to obtain primary production measurements. In addition, data will be collected to provide ground truth calibration/validation for SeaWIFS and MODIS ocean colour algorithms in Case 1 and Case 2 waters, and to provide support and validation of primary production algorithms. Sediment traps and *in-situ* pumps will be deployed both on the continental shelf and in the open ocean to determine the vertical fluxes of carbon and related elements. We will also measure the disequilibrium between naturally occurring actinides to provide an independent estimate of particle fluxes and to calibrate the collection efficiency of the sediment traps. Underway measurements of iron along the cruise track and vertical profiles of iron, copper and cadmium will be made and related to variations in phytoplankton biomass and productivity.

Estimates of phytoplankton class abundances will be made both by direct counts and estimates of class abundances from HPLC measurements of photosynthetic pigments using the program Chemtax (Mackey et al 1996; Mackey et al., Deep-Sea Research, - in press). While the biological pump depends on the total amount of new production in the euphotic zone, the magnitude of the pump is strongly dependent on the types and sizes of organism present for two reasons. Firstly, the rate of removal of carbon depends on the size of the organism (large, dense phytoplankton sink faster than small ones) and on how readily they are incorporated into larger particles via processes such as aggregation or incorporation into faecal pellets. Secondly, changes in the abundance of calcareous organisms will alter the alkalinity of surface waters, which alters the solubility of carbon dioxide and hence directly affects the exchange of carbon dioxide between the atmosphere and the surface waters.

Particles in the upper layer of the ocean sink to the deep ocean carrying associated organic carbon. This organic carbon may originate in surface waters of the ocean via primary production by phytoplankton, or it may originate in terrestrial plants and their decomposition products in soil and enter the ocean via rivers such as the Sepik River. The relative importance of these two sources and the rates at which the organic matter enters the deep ocean are important components of the global carbon cycle that need closer attention. Isotopic signatures of this material will be determined from in-situ pumped samples and from cores.

We will measure a suite of naturally occurring radionuclides that are attached to particles and dissolved in seawater. Calculations using the results will yield data on particle fluxes. Combined with measurement of the organic carbon content of the particles this will allow estimation of vertical organic carbon flux to the deep ocean in the region studied. The radionuclides to be measured include ^{226}Ra, ^{210}Pb, ^{210}Po and ^{7}Be. We have established techniques for concentration of these radionuclides from seawater and their measurement in the concentrates and in particles collected by filtration. The outcome will be knowledge of the flux of carbon from surface layers to the deep ocean in the region of the Bismarck sea adjacent to the Sepik River outflow and a contribution to understanding the fate of the material carried to the sea by the Sepik River.

While the TROPICS cruises are focused on the island of New Guinea, the knowledge that will be gained, and the links that will be (and have been) established with scientists from other institutions in Australia and overseas will be of great value in any future work in tropical Australia.

Cruise Track

The cruise departed from Cairns for the mouth of the Sepik River (see Figure 1). Bottle leak tests and a CTD station for George Cresswell (CSIRO) were done in the Goodenough Basin. An ADCP transect was done across Vitiaz Strait to map the New Guinea Coastal Undercurrent in the surface 300 m and a CTD cast was done through the NGCU to provide reference samples before the NGCU was influenced by the Sepik River. Surface samples were collected en route to the Sepik, in the region of the plume and from the mouth of the Sepik River itself. The latter sample enabled us to obtain fresh-water end-members for a variety of parameters. We then occupied four stations on the first transect from the river mouth to Manus Island. After steaming due west to 144ºE, we turned due south and occupied another long CTD station at the core of the NGCU at 3ºS. We then started a transect along 143ºE with long stations at the core of the NGCU (2º 30’S) and at the equator. We proceeded to 2ºN to get an ADCP section across the equator before occupying our last station on the equator at 150ºE. In addition, daily measurements of ^{14}C productivity were made and some additional surface samples were collected for measurements of iron. The cruise finished in Rabaul.

Results

Very few measurements were made on board since most of the samples collected will be returned to Hobart, Townsville and Sydney for laboratory analysis. However, a few comments about the general oceanography are pertinent to our overall aim of comparing the results from the previous cruise, collected during the SE trade wind season, and those from the current cruise during the NW monsoon season.

The plume from the Sepik was very marked and only a few meters deep and was first observed about 9 nm ESE of the mouth of the Sepik. The prevailing winds were from the NW and we had expected that the plume would have extended further from the mouth of the Sepik. However, the winds were very light at the time. As was found previously, the Sepik Canyon was characterised by many steps in salinity which became more pronounced below the salinity maximum which characterises the core of the NGCU. These salinity steps often corresponded to marked increases in the load of suspended matter as measured by increases in optical back scattering (OBS) and decreases in transmissivity (Figure 2). Repeat casts showed that there was much spatial and temporal variability in these features.

In contrast to the SE trade season, currents in the top 100 m were to the SE in the Bismarck Sea with typical velocities of 0.3 - 0.5 m/sec. The NGCU was typically found at about 200 m with velocities of 0.5 - 0.7 m/sec to the NW although velocities up to 1.5 m/sec were observed. Winds were quite variable with the NE monsoon winds of 20 - 30 kt interspersed with periods of calm or westerly wind bursts with gusts up to 45 kt. Vertical profiles of fluorescence were also rather variable and it will be interesting to look at the relationships between chlorophyll, ^{14}C productivity, wind stress and current shear.

While the Transmissometer worked well in the shallow (<300 m) waters around the Sepik, it proved useless at depths below 300 - 500 m and/or temperatures of 5 - 7 C since it had a pronounced drift which sometimes affected the response of other sensors connected to the CTD. The instrument had been purchased about 18 months previously as a replacement for an earlier model (which worked well!) but had probably not been used on deep casts prior to FR01/00. The instrument was rated to 5000 m and we were informed by the manufacturers that they are aware of the problem that we reported but they did not have an easy fix, did not want to try to repair it and even if they did repair it, it would be very expensive and they would not guarantee the result. Since the Transmissometer was the main instrument that I was relying on to look for the influence of hydrothermal plumes, I was not impressed.

Cruise Narrative

Our sampling strategy involved collecting samples from 10 locations. The first was in Vitiaz Strait to provide information on the properties of the NGCU upstream from the Sepik. The next five stations formed a transect from the Sepik to Manus Island so that we could look at the properties of the waters leaving the Bismarck Sea, including waters entering via St Georges Strait and passing to the south of Manus Island to join the NGCU. Such waters may be affected by hydrothermal vents to the south of New Britain. Two stations were selected to sample the NGCU downstram of the Sepik at 144 degrees E and 143 degrees E. Finally, two stations were occupied on the equator at 143 degrees E and 150 degrees E. The EUC at 150 degrees E carries approximately twice the volume of water that it does at 143 degrees E and so we wanted to see whether there is any difference in the concentrations of trace elements and biomarkers attributed to the Sepik River. In addition, samples were collected from the mouth of the Sepik River to provide a freshwater end member.

A station was typically occupied for about 15 hours and consisted of the following:

- Hydrology cast to 300 m;
- Hydrology cast to 2000 m;
- Productivity cast to 300 m;
- Organic biomarker cast to 300m;
- Trace metal hydrocast (Kevlar) to 300 m;
- Trace metal CTD cast to 2000 m;
- Large volume (>100 L) samples from *in situ* pumps at 200 m;
- Surface samples from the ‘rubber duck’.

The OBS and Seatech fluorometer were fitted to the CTD for most casts while the fast repetition rate fluorometer (FRRF) and Licor light sensor were fitted for the productivity casts. The transmissometer was used in the Sepik Canyon but was useless at other stations below 300 - 500 m and/or 5 - 7 C. The determination of station locations was greatly helped by the new ADCP program.

Samples were collected for the analysis of:

- Nutrients
- Salinity
- Oxygen
- ^{14}C productivity
- Chlorophyll and carotenoid pigments
- Flow cytometry
- Trace metals (Cu, Fe, Cd, Ni, Mn)
- Free copper (pCu_{free})
- Rare earth elements
- Fe^{2+}/Fe^{3+}
- Total Fe
- ^{234}Th
- Ra isotopes
- Organic biomarkers
- Lignins
- ^{13}C (organics)
- ^{15}N (organics)
- Oxygen respiration
- DOC

- POP
- PON
- TDN
- Suspended Solids
- Alkalinity
- DIC
- Humic substances

In addition, a productivity station was done every day and a floating sediment trap was deployed for 24 hours near the mouth of the Sepik River. The station at 0, 153 degrees E was occupied for 26 hours so as to get information on the diel cycle in chlorophyl and carotenoid pigments and phytoplankton abundances (by flow cytometry).

The Seatech fluorometer ‘drowned’ on the first cast but it was fortunate that there was a spare instrument on Franklin. The new Seatech fluorometer was used for all the stations described above and the output should be comparable to that of the old instrument although we will have to make allowances for the different sensitivities and time constants used on this cruise.

Unfortunately, we did not have a spare Transmissometer and this seriously compromised some of the cruise objectives

Summary

As should be clear from the above, we ended up collecting a comprehensive suite of samples for subsequent analysis and I am confident that we will be able to achieve most, if not all, of the cruise objectives as outlined earlier.

Personnel

Scientific
Denis Mackey, CMR, Chief Scientist, trace metals
Brian Griffiths, CMR, Phytoplankton production, optics
Harry Higgins, CMR, Phytoplankton pigments, ISE deployment
Jeanette O’Sullivan, CMR, Trace metal sampling
Kathy Burns, AIMS, Organics
Diane Miller, AIMS, Organics
Ron Szymczak, ANSTO, Radiochemistry
David Shuen, ANSTO, Radiochemistry
Neale Johnston, ORV, Hydrology
Val Latham, ORV, Hydrology
Phil Adams, ORV, Electronics
Bernadette Heaney, ORV, Computing

Franklin Crew
Neil Cheshire, Master
Arthur Staron, 1st Mate

Roger Pepper, 2nd Mate
John Morton, Chief Engineer
Greg Pearce, 1st Engineer
Andrew McLagen, Electrical Engineer
Dan Davies, Greaser
Mal McDougal, Bosun
Tony Hearne, AB
Terry Ganim, AB
Graham McDougal, AB
Ron Culliney, Chief Steward
Gary Hall, Chief Cook
Mark Wheeler, 2nd Cook

I would like to thank the master and the crew of the *Franklin* for their help throughout the cruise and, in particular, for installing and servicing the Biological and Clean Containers, spooling Kevlar lines onto hydro drums, fiddling with clean gear while collecting trace metal samples, taking scientists on short rides in fast boats and for providing sperm whales and killer whales for us to look at in between stations. I would also like to thank Phil Adams for his efforts in keeping all our electronic gear working and Lindsay Pender for his ADCP software which was a great help in choosing station locations.

Denis Mackey
Chief Scientist

Figure 1. Cruise Track FR01/2000

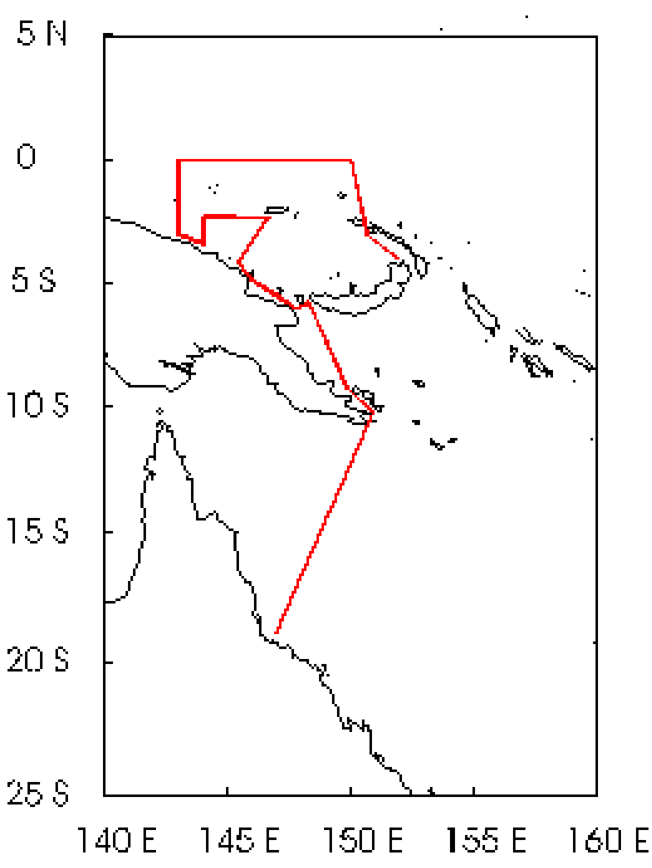
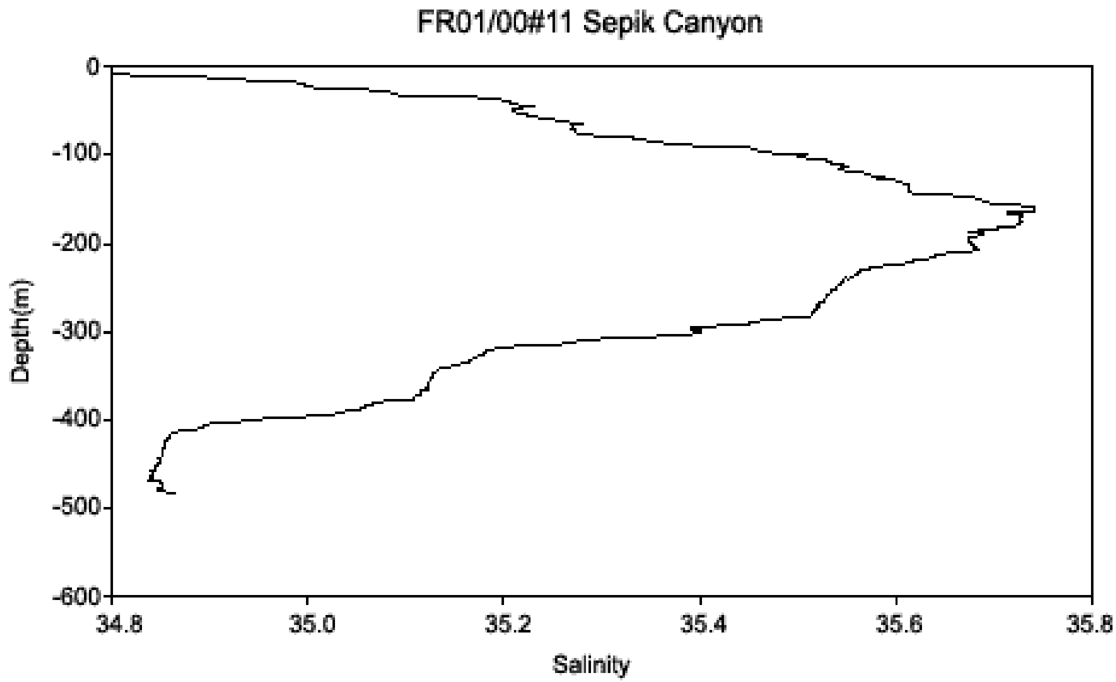
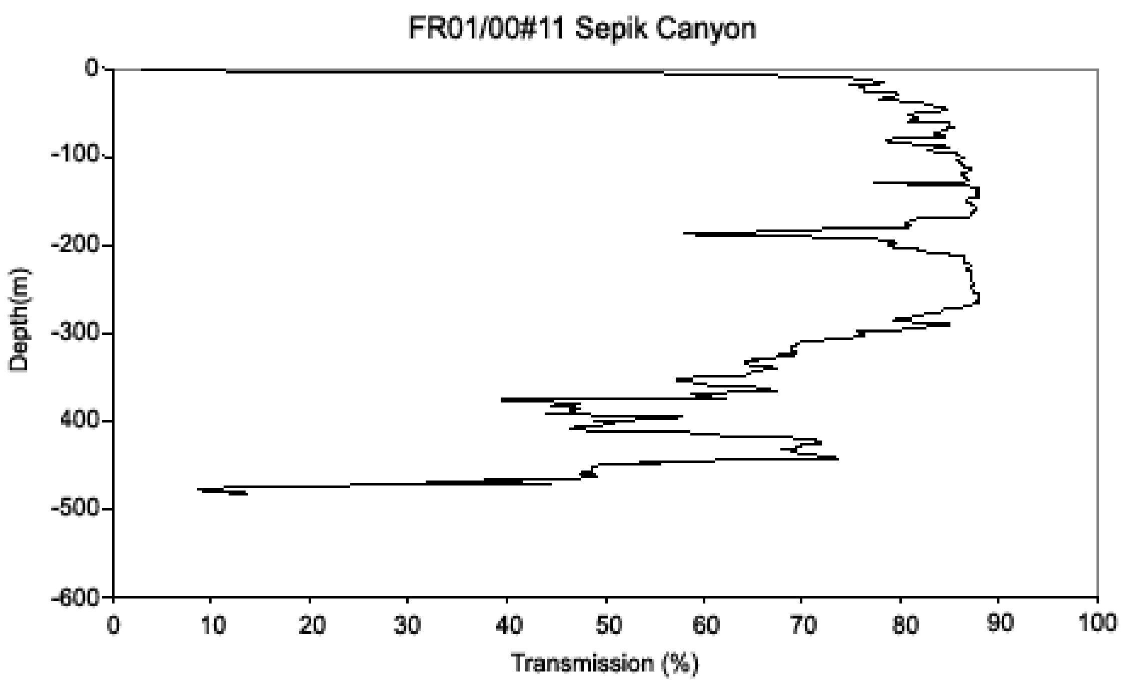
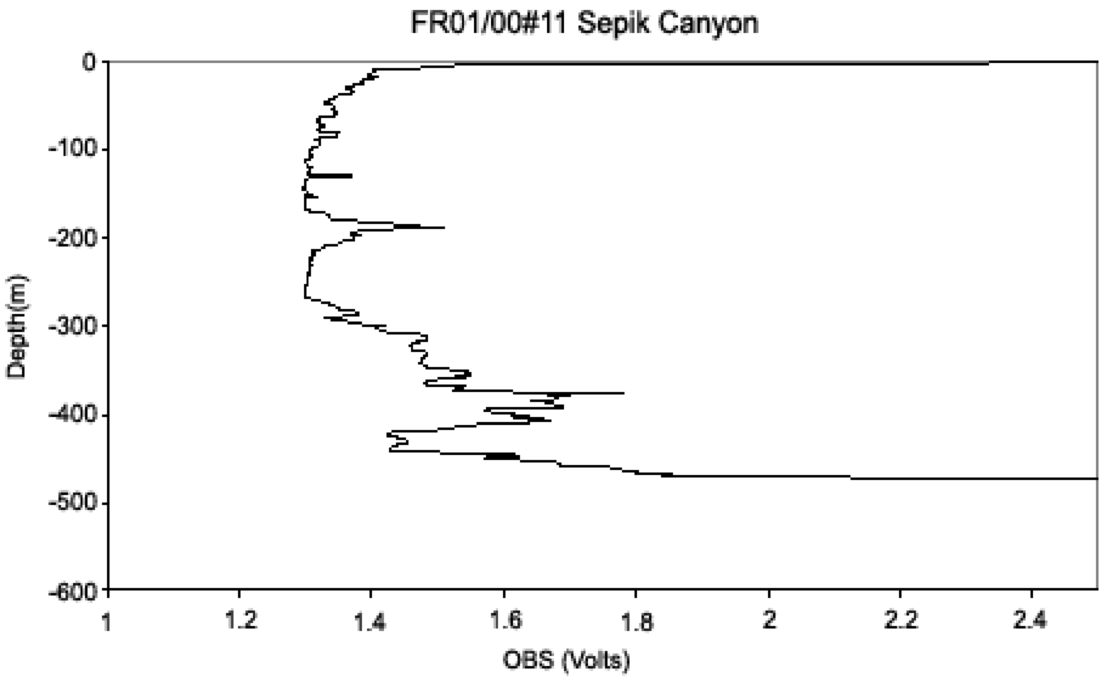


Figure 2. Vertical profiles of salinity, transmission and optical backscattering in the Sepik Canyon.







Updated: 31/01/03