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CRUISE REPORT SS 11/95

November 15 – December 7, 1995

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CSIRO AUSTRALIA

DIVISION OF **FISHERIES**

ITINERARY

DEPART: HOBART 06:00 HR WEDNESDAY, 15 NOVEMBER 1995
RETURN: HOBART 06:00 HR THURSDAY, 7 DECEMBER 1995

Note the departure date was changed from that listed on the cruise schedule to allow loading of the vessel and also to accommodate a photographic team to operate in daylight in Storm Bay during equipment trials. Due to the illness of Brian Griffiths, Bronte Tilbrook took over as Chief Scientist on 13 November.

CRUISE OBJECTIVES

BACKGROUND

One of the objectives of the INRE Climate Research Program is to identify and understand the interactions of the physical, chemical and biological processes controlling the pools and fluxes of carbon within and between the atmosphere and the ocean in the Southern Ocean in the Australian region. The sub-tropical convergence zone (STCZ), subantarctic zone, subantarctic front (SAF) and the polar zone between 40°S and 55°S are known to be important global sinks of atmospheric CO_2. The physical, chemical and biological factors responsible for drawing down CO_2 in surface waters in this zone are still a subject of international research. It seems probable that both physical factors (cooling of subtropical water advected south) and biogeochemical factors (biological production and export of organic carbon, supported by nutrients supplied by Antarctic water advected north) contribute to this draw-down. Quantifying these processes, and predicting their response to changes in ocean climate and circulation, will be carried out by the analysis of repeat sections of biogeochemical properties, and through the development of process-based models of carbon and nutrient cycling based on field observations and experiments. The repeated sections are being carried out along the SR3 line as part of the WOCE series of cruises on Aurora Australis and by 2 cruises on Southern Surveyor. This is the second of 2 process cruises on Southern Surveyor; the first was conducted in January/February 1995.

The Marine Carbon Cycles Project is carrying out this research as part of two international research programs, the Joint Global Ocean Flux Study (JGOFS) and the International Global Atmospheric Chemistry Project known as ACE-1. The JGOFS part of the cruise will provide a first look at the physical, chemical and biological environment, and carbon fluxes in the region west of Tasmania during the spring bloom period. The ACE-1 experiment will primarily address atmospheric chemistry and cloud dynamics over the Southern Ocean. It will focus especially on sulphate aerosols which are thought to form the principal cloud condensation nuclei in this region, and to derive primarily from DMS produced by phytoplankton. The DMS-aerosol-cloud link is regarded as one of the major uncertainties in feedbacks in climate models. The experiment involved a large team of US and Australian scientists, US research aircraft, and the US NOAA research vessel Discoverer. Work on the Discoverer included a series of atmospheric chemistry measurements, aerosol,

physical and optical measurements, and seawater measurements. The seawater measurements being made on Discoverer and Southern Surveyor will be particularly complementary for understanding the DMS and pCO_2 processes in this region.

This cruise will sample an area west of Tasmania where very little is known about the latitudinal and seasonal variations in nutrients, trace elements, primary production and carbon dioxide north of 50°S. This region is expected to provide an interesting contrast to areas east of Tasmania where the input of subtropical water from the East Australian Current plays a key role in summer. Results from the first of this set of 2 process cruises have shown that inputs of iron from atmospheric aerosols to surface waters are very low west of Tasmania (Sedwick et al, in press). Comparisons of properties along sections and results from biological process experiments obtained east and west of Tasmania should throw light on competing hypotheses about the role of physics and biology in CO_2 draw-down, and the effects of iron in regulating phytoplankton production. A major reason for holding this experiment west of Tasmania is the long time series of atmospheric chemistry measurements made at Cape Grim. A number of the atmospheric variables measured at Cape Grim, including oxygen, ammonia and nitrate, potentially provide information about large scale changes in ocean biology upstream of Cape Grim. The data collected in this experiment will improve understanding of the relationship between ocean biology and atmospheric composition, and potentially help to open another window on seasonal and interannual variation in the Southern Ocean.

OBJECTIVES

1. To characterise the in-situ optical properties, including spectral absorption and upwelling and down-welling spectral irradiance in different water masses west of Tasmania. (Parslow).

2. To determine how carbon fluxes, measured by primary production, direct measures of growth rates, sedimentation, and microzooplankton grazing vary in response to differences in chemical and physical forcing in different water masses west of Tasmania. (Griffiths/Parslow)

3. To determine dissolved and suspended particulate carbon concentrations with respect to vertical and mesoscale oceanic structure, and to compare these standing stocks with primary production estimates. (Trull, Antarctic CRC).

4. To determine the isotopic composition of phytoplankton carbon and nitrogen to examine the validity of using sedimentary organic matter isotopic compositions as tracers of surface-ocean paleo-CO_2 and paleo-productivity. (Trull, Antarctic CRC).

5. To continuously monitor and record the acoustic backscattering strength of organisms at 12, 38 and 120 kHz, to conduct MIDOC trawls as opportunities present to describe the distribution and movement of micronekton in the

Southern ocean and to test an acoustic data logger attached to the 12 kHz transducer on the EK500 for a short while in deep water (5000 m). (Kloser).

6. To identify source/sink regions for CO_2 west of Tasmania by measuring surface water fCO_2 along the cruise track using an underway system; collect surface and air samples about every 1° of latitude for analysis of ^{13}C and CO_2 concentrations; and to measure DIC and alkalinity in the water column at selected stations. These data are used to investigate the magnitude of the air-sea flux along the cruise track and provide information on the factors regulating the air-sea flux of carbon (Tilbrook, Division of Oceanography).

7. To estimate the rate of DMSP and DMS production in different water masses, and estimate the air-sea flux of DMS; and to correlate DMS/DMSP with water mass physics, chemistry and biology (Curran/Jones, James Cook University).

8. To quantify aerosol nutrient and trace metal concentrations; to estimate specific growth rates of individual phytoplankton species; to identify and quantify phytoplankton species abundance and to determine the physiological status and variability in photosynthetic parameters using fast repetition rate fluorescence (Green, Texas A+M University)

9. To collect pigment samples for HPLC analysis for exchange with the Japanese Marine Science and Technology Centre (JAMSTEC) as part of a collaborative research project on ocean colour remote sensing. (Parslow/Asanuma, JAMSTEC, Japan).

10. To measure the radon concentrations in air along the cruise track to estimate how long it has been since the air masses sampled have been near land. These radon measurements will allow a uniform baseline criterion to be applied to most of the ACE-1 trace-gas measurements and will complement radon and trace gas measurements being made at Cape Grim, Baring Head, Macquarie Is and on the Discoverer during ACE-1. (Whittlestone, ANSTO)

11. To examine the latitudinal distribution of larval fish and phyllosoma in surface waters. (Bruce)

AREA OF OPERATION:

West and south of Tasmania between 40°S - 53°S, and 140°E and 148°E.

RESULTS

In general, all cruise objectives were met. Southern Surveyor completed its north-south transect just before the start of the first successful Lagrangian experiment, in which "smart balloons" were released by the Discoverer and tracked by aircraft. The Southern Surveyor and Discoverer cruise tracks are shown in Figure 1. A station list (Table 1) lists what measurements were taken at each station. Underway

temperature, salinity, fluorescence and pCO_2 measurements were made continuously along the cruise track. Nitrate and silicate levels were measured continuously on transects between stations (Table 2). Good data from the Aquashuttle was obtained on 4 occasions (Table 3): stability problems and heavy weather interfered with Aquashuttle operations on other deployments. Underway, fast-repetition rate fluormetery was carried out on 9 transects (Table 4) between stations. An intercomparison station with the R.V. Discoverer was worked at 47:59.87S, 145:28.45E (our CTD stations 43) on 24 November.

Meteorological balloons were released at 12 hour intervals during the cruise, and the resulting profiles of temperature, humidity, wind speed and direction data were e-mailed to the Bureau of Meteorology, Melbourne, for inclusion into predictive meteorological models to allow planning for the aircraft missions for the ACE-1 experiment. The maximum height that a balloon reached during the period was about 25km, and the maximum distance downrange from the ship in the hour or so before the balloon burst was about 126km.

The Lagrangian experiment was started with the launch of a "smart balloon" from the Discoverer at 45°S, 141°E at 12:45 UTC 1 December, and two aircraft flights were made along the balloon's path. Contact with the balloon could not be made on the third flight, so a flight path following a calculated trajectory was followed. The Discoverer sampled along the track between 45°S, 141°E and 46°S, 148°E while Southern Surveyor sampled for 18 hours along the section from 46° 30S, 148° 00E to 47° 02S, 152° 35E, crossing the track of the second aircraft leg. During this time, meteorological balloons were released at 6 hourly intervals, and underway surface sampling salinity, temperature, fluorescence, nutrients and phytoplankton physiology using the FRRF. A surface ctd station was done at 2 hour intervals along the Lagrangian track to collect ammonia, nutrients, and DMS samples, and at the beginning and end of the Lagrangian track.

1. *Objective completed:* The in-situ optical properties of the Subtropical, Subantarctic and Polar water masses were characterised at 9 sites using both the prototype CSIRO spectral radiometer and a Biospherical Instruments PRR-600 Profiling Reflectance Radiometer. Fluorescence profiles were measured with a SeaTech fluorometer, and water samples taken at 6 depths between 0 and 100m per site were filtered, and samples stored in liquid nitrogen for measurements of the absorption spectra of particulate and dissolved constituents.

2. *Objective largely completed:* Primary production was estimated at 18 sites in the three main water masses using the small bottle, production vs. light intensity method. Profiles of particle size were done at the same sites. In-situ production rates were not done as the free-floating mooring suspending the bottles was lost at the first process station. Growth rates, and microzooplankton grazing rates were estimated at a single depth at the 7 process sites using a grazing dilution technique. Samples from the grazing dilution bottles were kept for HPLC pigment analysis and taxonomic identification. A comparison of community growth rates will be made by comparing rates from the primary production,

grazing dilution experiments, and Dr. Greene's cell cycling method (see below). Nitrogen uptake rates were measured during the day and night using ^{15}N-Ammonium and ^{15}N-nitrate at the 7 process sites. Samples for phytoplankton identification were taken at 20 stations. The free-floating sediment traps were deployed at the 7 process sites and samples recovered for estimation of the sedimentary flux past the 220m depth.

3. *Objective completed*: Dissolved organic carbon (DOC) sampling was highly successful, with ~400 samples collected. Along the major 42°S to 53°S transect at ~145°E samples were taken to 1000m depth at every degree of latitude and twice as frequently in the vicinity of the Subantarctic Front. This will be used to define the relation of DOC levels to the large scale circulation. In addition, near surface (top 200m) samples were taken every 20 nautical miles in a transect from 48°S to 46°S across a mesoscale high chlorophyll patch near 150°E to examine in detail relations with local production. Most of the samples from the 145°E transect have been analysed, the others are expected to be completed by end January 1996. Particulate organic matter sampling was also generally successful. While the submersible pump deployed to obtain large volume samples failed frequently because of thermal overloading, it was still possible to filter 100 litre volumes at 7 sites with samples taken at the surface and every 20 meters to 80 meters depth. These samples will be studied in detail to look at POM degradation at the base of the mixed layer and accompanying isotopic composition variations. Surface samples were also obtained at each CTD station along the 145°E transect.

4. *Objective not completed:* Unfortunately, because a pump in the ship clean seawater supply system failed, it was not possible to obtain surface POM samples except on station (when the pCO_2 equilibrator could be turned off). Thus the number of points of comparison of pCO_2 and POC isotopic compositions will be rather limited. This is the second Southern Surveyor cruise (SS 1/95 was the first) on which underway seawater supply problems have impeded this project.

5. *Objective completed.* Multi-frequency acoustic data was collected throughout the cruise and only approximately two days of data were lost due to poor weather. Detailed acoustic data were collected at the process stations in combination with 6 Midoc trawls. The Midoc trawls were targeted on acoustic layers between 0-300 m and the fauna predominantly pyrosoma, salps and myctophids were sized and weighed. The species composition, and size distributions of the fauna will be related to the acoustic backscattering data. The tests of the data logger for the Antarctic Division on the 12kHz transducer were carried out and the dataneed further analysis in Hobart.

6. Objective Completed: Vertical profiles of DIC and alkalinity were obtained from 25 stations, including stations at 20 n. mi intervals between 46°S-48°S along 150°E. Samples for ^{13}C analyses were taken in surface waters at 20 stations. The alkalinity and DIC samples have been analysed, but the post-analysis data calculations are to be done. The ^{13}C analyses are waiting for the new mass spectrometer to be fully commissioned. Underway fCO_2 was collected along most of the cruise track, and the data processing is waiting for calibrated thermosalinograph data to be available. Air sampling for CO_2 and ^{13}C was

carried out at 10 sites, and the samples have been sent to the CSIRO Division of Atmospheric Research for analysis.

7. *Objective completed:* DMSP (dissolved and particulate) was sampled, in duplicate, at 52 CTD stations. Dissolved DMS was sampled, in duplicate, at 32 of these stations and the air-sea flux of DMS will be estimated from these samples. A total of 10 DMS and DMSP samples, including some samples spiked after sampling, were collected during an intercalibration exercise with the Discoverer at 47°60S, 145°29E. During the Lagrangian experiment, air and water samples for DMS analysis, were taken at 2 hourly intervals, at 7 stations over a 12 hour period. Samples for DMS in air were also collected at another 13 stations throughout the cruise. DMS and DMSP were measured during one grazing dilution experiment (aT station 58).

8. *Objectives completed:* The sampling for phytoplankton growth rates, species abundance and physiological status was very successful, whilst the aerosol sampling was curtailed due to prevailing wind and weather conditions, time, and personnel constraints on board the vessel. A limited number of aerosol samples were collected during transits between sampling. These samples will be analysed at Texas A&M University to determine the composition and particle size distribution of aerosols.

   Species specific growth rates will be estimated at the 6 process sites using samples taken at approximately 3 hour intervals during the period that each station was occupied. The analysis relies on quantitative estimates of diel DNA synthesis cycles of individual species. Phytoplankton species abundance and vertical distribution will also be estimated from samples at these sites.

   The physiological status and variability in photosynthetic parameters, estimated using a fast repetition rate (FRRF) fluorometer, was measured at the five southernmost process sites, the 12 hour station at 47°20S, 150°00E, and at 11 other stations along the cruise track. In addition, surface water parameters were logged continuously by the FRRF during transits between stations as well as during the ACE-1 Lagrangian experiment (Table 4).

9. *Objective completed*: Forty-six pigment samples were taken from various depths at 8 sites along the cruise track. These will be taken to, and analysed in Japan in March. A Japanese scientist visited Hobart after the cruise to finalise intercomparison of pigment composition and chlorophyll-a concentration with the CSIRO samples.

10. *Objective achieved.* Samples were collected at 30 minute intervals between 15 November and 8 December. Data collected on some days were affected by what is thought to be vibration causing a microphonic response in the photomultiplier. In rough seas some movement of the detector may have been responsible for erratic counts. 63% of days were free from this interference. 91% of the days had bad data intervals of an hour or less, and the longest bad period was 4 hours. These bad periods occurred in conditions when the radon concentration was uniformly low. It is very unlikely that a brief burst of radon was missed in the

longest period bad data. There is no evidence that the detector was damaged by the vibrations, and the expected increase in radon concentration when the ship approached Tasmania was observed.

During the voyage, baseline conditions prevailed. High radon concentrations (>1000 mBq m-3) were observed on 15 and 17 November, moderate levels (200 to 1000 mBq m-3) on 20 to 22 and 27 November, and 7 and 8 December.

11. *Objective achieved*: A total of 14 surface net tows were made between 42°S and 53° 19S west of Tasmania giving the first latitudinal sampling covering the Subtropical, Subantarctic and Polar water masses. Both day and night tows were completed, and the samples will be sorted in Hobart. Sampling locations are given in Table 1.

SUMMARY

This was an extremely successful cruise in a very difficult part of the ocean to work in. The provision of very accurate weather forecasts from the ACE-1 Operations centre was greatly appreciated, even if most of the forecasts were for strong winds and gales! The results, when fully synthesised, will contribute greatly to our understanding of carbon and sulfur fluxes both in the water, and between the ocean and atmosphere in the Southern Ocean. They will also provide the detailed oceanographic understanding for the ACE-1 experiment, and in particular for the atmospheric sampling conducted from the National Centre for Atmospheric Research's C-130 aircraft, and assist with the interpretation of the atmospheric sampling and flux measurements on the NOAA research ship Discoverer. This was a complex experiment, involving two research vessels, one research aircraft, and sampling at ground stations located at Cape Grim, Tasmania, Baring Head, New Zealand, and on Macquarie Island, and over one hundred Principal Investigators from 12 countries around the world.

PERSONNEL:

(Note: all personnel are from the CSIRO Division of Fisheries unless indicated otherwise.)

B. Tilbrook	(Chief Scientist, CSIRO Division of Oceanography)
D. McKenzie	(Deputy Cruise Leader, Watch Leader)
P. Bonham	
K. Berry	
M. Sherlock	
R. Kloser	
A. Terauds	
M. Rayner	(OMS, Division of Oceanography)
D. Terhell	(OMS, Division of Oceanography)
T. Trull	(Antarctic CRC)
M. Curran	(James Cook University)
R. Greene	(Texas A and M University).

Ships Crew:	
Ian Taylor	Master
Pat Gibbons	Chief Engineer
John Boyes	First Mate
Richard Nicholson	Second Mate
Rick Miller	First Engineer
John Hinchcliffe	Electrical Engineer
Alan Brownlie	Bosun
Tony Hearne	I.R.
Lou Jacomos	I.R.
Mal McDougall	I.R.
Tony Hearne	I.R.
Chris Williams	I.R.
Graeme McDougall	I.R.
Phil Lee	I.R./Greaser
John Walsham	I.R.
Brenda Sherriff	Chief Steward
Charlie Veigh	Chief Cook
Don Collins	Second Cook

ACKNOWLEDGMENTS:

This cruise could not have been completed without enthusiastic support from the officers and crew of Southern Surveyor, and the Electronics and OMS staff on board. Funding for the project came through the Department of Environment, Science and Technology Climate Change Program, and appropriation funds from the CSIRO Divisions of Fisheries, and Oceanography.

B. Tilbrook
Chief Scientist

B. Hill
Acting Chief, Division of Fisheries

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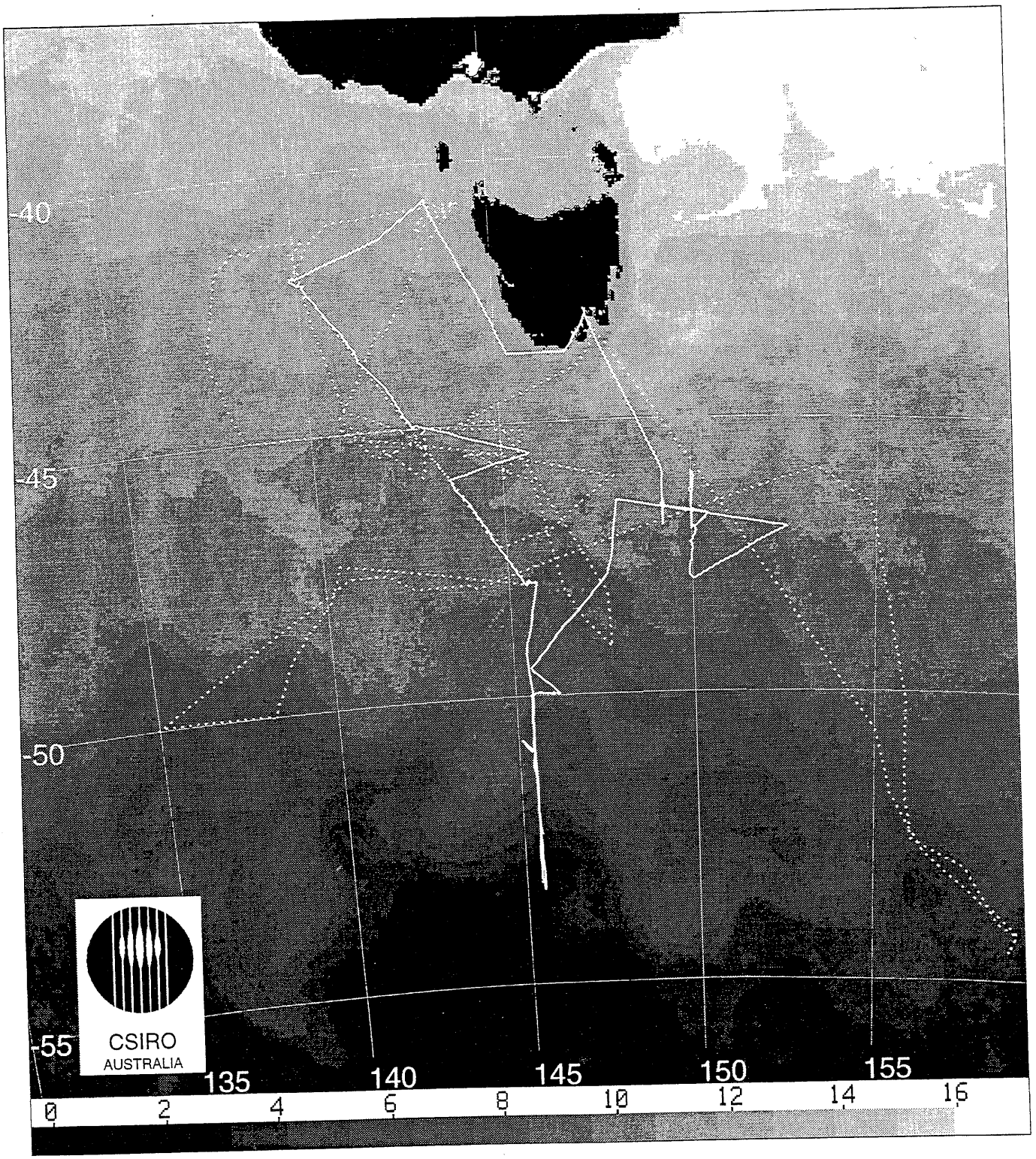
FIGURE 1. AREA OF OPERATION

Cruise tracks
Southern surveyor: solid line, discoverer: dashed line



APPENDIX 1: Station list for SS 11/95. The times are given at the start of a station. An "x" in a column indicates that samples for the parameter were taken at the station. The stations marked "no PO4" indicate that no OMS measured, phosphate analyses are available at that station due to instrumentation problems.

CTD	UTC Date	UTC Time	Latitude dd.mm.sec	Longitude ddd.mm.sec	Salinity	Oxygen	OMS Nutrients	Ammonia	TDN TDP	DMS + DMSP	DOC	POC	Alkalinity + DIC	13C	HPLC chl + pigments	Spectral Absorb.
1	16-Nov-95	14:39:10	43:42.110S	145:18.190E	x											
2	16-Nov-95	16:01:33	43:41.850S	145:17.830E	x											
3	17-Nov-95	11:40:34	40:47.010S	143:24.840E	x	x	x	x	x						x	
4	17-Nov-95	15:25:33	40:46.380S	143:25.490E	x	x	x								x	
5	17-Nov-95	18:25:34	40:44.360S	143:26.100E												
6	17-Nov-95	21:23:34	40:45.450S	143:26.350E	x	x	x		x						x	
7	18-Nov-95	1:19:35	40:45.090S	143:25.930E						x					x	x
8	18-Nov-95	3:40:32	40:45.010S	143:25.910E	x		x	x			x	x			x	
9	18-Nov-95	5:54:31	40:45.000S	143:25.930E	x		x				x					
10	18-Nov-95	9:14:30	40:44.170S	143:26.670E												
11	19-Nov-95	4:19:31	41:23.020S	142:07.590E	x	x	x				x	x	x	x	x	x
12	19-Nov-95	6:00:36	41:24.270S	142:07.610E	x	x	x			x	x					
13	19-Nov-95	16:12:39	42:00.020S	140:00.050E	x	x	x	x	x						x	
14	19-Nov-95	20:05:38	41:59.940S	139:59.380E	x	x	x		x						x	
15	19-Nov-95	23:52:42	41:59.860S	139:55.480E						x						
16	20-Nov-95	1:15:41	41:59.280S	139:56.430E	x	x	x								x	x
17	20-Nov-95	3:03:38	41:59.220S	13955.890E		x	x	x			x	x	x	x	x	
18	20-Nov-95	4:31:40	41:59.150S	139:55.140E		x	x				x		x			
19	20-Nov-95	6:32:36	41:59.020S	139:54.840E												
20	20-Nov-95	9:30:37	41:59.080S	139:54.110E												
21	20-Nov-95	12:26:38	41:58.950S	139:52.750E												
22	20-Nov-95	15:42:42	41:59.120S	139:51.290E												
23	20-Nov-95	19:23:44	41:59.490S	139:50.300E	x	x	x									
24	21-Nov-95	5:54:43	43:00.050S	140:53.850E	x	x	x			x	x	x	x	x	x	
25	21-Nov-95	15:42:43	43:59.950S	141:49.660E	x	x	x			x	x		x	x	x	
26	21-Nov-95	23:52:18	45:00.230S	142:43.550E	x	x	x		x	x					x	
27	22-Nov-95	1:52:18	4:500.180S	142:43.140E	x	x	x								x	x
28	22-Nov-95	3:21:47	44:59.820S	142:43.640E	x	x	x	x		x	x		x	x	x	
29	22-Nov-95	4:51:47	44:59.600S	142:43.680E	x	x	x									
30	22-Nov-95	5:49:42	44:59.290S	142:43.680E	x	x	x				x		x	x		
31	22-Nov-95	8:07:47	44:58.870S	142:43.740E												
32	22-Nov-95	10:30:44	44:56.840S	142:43.630E						x						
33	22-Nov-95	13:53:43	44:59.220S	142:44.020E	x	x	x	x	x						x	
34	22-Nov-95	16:49:19	44:57.770S	142:44.980E	x	x	x(no PO4)									
35	22-Nov-95	20:09:14	44:57.120S	142:46.500E	x	x	x			x					x	
36	22-Nov-95	23:40:16	44:57.020S	142:47.050E	x	x	x									

CTD	UTC Date	UTC Time	Latitude dd.mm.sec	Longitude ddd.mm.sec	Salinity	Oxygen	OMS Nutrients	Ammonia	TDN TDP	DMS + DMSP	DOC	POC	Alkalinity + DIC	13C	HPLC chl + pigments	Spectral Absorb.
37	23-Nov-95	19:39:19	45:59.890S	143:37.800E	x	x	x				x	x	x	x	x	
38	23-Nov-95	5:26:28	46:59.640S	144:32.630E	x	x	x			x	x	x	x	x	x	
39	24-Nov-95	13:44:21	48:00.070S	145:27.080E			x(no PO4)		x						x	
40	24-Nov-95	17:01:28	48:00.090S	145:27.000E												
41	24-Nov-95	19:21:30	47:59.450S	145:28.360E											x	
42	24-Nov-95	20:01:34	47:59.040S	145:29.330E	x	x	x(no PO4)									
43	24-Nov-95	21:00:31	47:59.870S	145:28.450E	x	x	x	x		x	x	x	x	x	x	
44	24-Nov-95	23:05:32	47:58.970S	145:31.890E												
45	25-Nov-95	3:30:38	47:58.650S	145:35.760E	x	x	x(no PO4)		x	x					x	x
46	25-Nov-95	6:27:31	47:58.300S	145:37.800E												
47	25-Nov-95	9:34:32	47:58.300S	145:39.790E												
48	25-Nov-95	12:39:33	47:57.920S	145:41.620E												
49	25-Nov-95	16:31:38	47:58.160S	145:43.610E											x	
50	25-Nov-95	18:40:37	47:58.710S	145:45.180E	x	x	x(no PO4)									
51	26-Nov-95	1:19:40	49:00.480S	145:26.500E	x	x	x				x	x	x	x		
52	26-Nov-95	3:04:38	49:02.320S	145:24.300E							x				x	x
53	27-Nov-95	7:07:38	53:12.060S	145:26.900E	x	x	x	x			x	x	x	x	x	
54	27-Nov-95	8:58:40	53:12.710S	145:27.870E	x	x	x				x		x			
55	27-Nov-95	10:55:39	53:12.960S	145:28.540E						x						
56	27-Nov-95	13:37:39	53:14.080S	145:29.160E	x	x	x	x	x						x	
57	27-Nov-95	17:13:37	53:15.330S	145:29.510E												
58	27-Nov-95	17:49:41	53:15.490S	145:29.770E	x	x	x			x						
59	27-Nov-95	18:59:43	53:16.170S	145:30.060E											x	
60	27-Nov-95	21:57:00	53:17.260S	145:30.370E	x	x	x		x						x	
61	28-Nov-95	1:39:43	53:18.960S	145:30.780E	x	x	x	x		x					x	x
62	28-Nov-95	2:37:38	53:19.390S	145:30.590E											x	
63	28-Nov-95	4:31:41	53:19.410S	145:31.460E												
64	28-Nov-95	7:33:38	53:23.670S	145:31.120E												
65	28-Nov-95	14:20:39	52:25.190S	145:29.260E	x	x	x			x	x	x	x	x	x	
66	28-Nov-95	22:20:12	51:24.390S	145:27.230E							x	x			x	
67	28-Nov-95	22:49:12	51:24.130S	145:27.150E	x	x	x						x	x		
68	29-Nov-95	18:02:15	51:00.070S	145:27.000E	x	x	x			x					x	
69	29-Nov-95	18:41:20	51:00.030S	145:25.960E	x	x	x				x	x	x	x		
70	30-Nov-95	0:13:18	50:29.750S	145:27.000E	x	x	x			x	x	x			x.	
71	30-Nov-95	4:43:15	49:59.600S	145:26.430E	x	x	x				x		x	x		
72	30-Nov-95	7:22:12	49:58.880S	145:30.370E	x	x	x	x			x	x	x		x	

CTD	UTC Date	UTC Time	Latitude dd.mm.sec	Longitude ddd.mm.sec	Salinity	Oxygen	OMS Nutrients	Ammonia	TDN TDP	DMS + DMSP	DOC	POC	Alkalinity + DIC	13C	HPLC chl + pigments	Spectral Absorb.
73	30-Nov-95	10:37:15	49:57.880S	145:35.850E												
74	30-Nov-95	13:37:12	49:57.700S	145:42.090E	x	x	x	x	x						x	
75	30-Nov-95	16:41:17	49:57.600S	145:45.330E	x	x	x								x	
76	30-Nov-95	19:32:18	49:57.990S	145:52.220E												
77	30-Nov-95	23:48:19	49:59.320S	146:02.030E	x	x	x		x						x	
78	1-Dec-95	2:03:19	49:58.040S	146:05.510E	x	x	x	x		x					x	x
79	1-Dec-95	5:05:00	49:58.810S	146:09.660E												
80	1-Dec-95	5:27:00	49:59.340S	146:10.360E												
81	1-Dec-95	11:44:00	49:30.050S	145:26.920E	x	x	x				x	x	x	x	x	
82	2-Dec-95	7:22:19	46:30.060S	148:00.130E	x	x	x	x		x	x	x	x	x	x	
83	2-Dec-95	9:29:18	46:33.940S	148:26.460E	x	x	x	x		x					x	
84	2-Dec-95	11:29:20	46:37.770S	148:57.940E	x	x	x	x		x					x	
85	2-Dec-95	13:32:21	46:41.510S	149:30.130E	x	x	x	x		x					x	
86	2-Dec-95	15:34:19	46:45.270S	149:59.620E	x	x	x	x		x					x	
87	2-Dec-95	17:31:21	46:48.320S	150:28.270E	x	x	x	x		x					x	
88	2-Dec-95	19:33:18	46:52.550S	151:01.360E	x	x	x	x		x					x	
89	2-Dec-95	21:30:20	46:55.380S	151:33.260E	x	x	x	x							x	
90	2-Dec-95	23:30:18	46:59.140S	152:04.620E	x	x	x	x							x	
91	3-Dec-95	1:34:20	47:02.370S	152:35.110E	x	x	x	x			x				x	
92	3-Dec-95	19:27:00	47:59.530S	150:01.550E	x	x	x			x	x		x	x	x	
93	3-Dec-95	23:35:00	47:39.600S	149:59.690E	x	x	x			x	x		x		x	
94	4-Dec-95	4:12:23	47:20.080S	150:00.300E	x	x	x	x		x	x		x		x	x
95	4-Dec-95	8:51:17	46:59.830S	150:00.190E	x	x	x	x		x	x		x	x	x	
96	4-Dec-95	12:37:19	46:39.890S	149:59.590E	x	x	x	x		x	x		x		x	
97	4-Dec-95	16:36:21	46:19.940S	150:00.090E	x	x	x	x		x	x		x		x	
98	4-Dec-95	19:53:21	46:00.100S	150:00.680E	x	x	x	x		x	x		x		x	
99	5-Dec-95	1:48:19	47:03.910S	150:00.910E												
100	5-Dec-95	14:04:21	46:38.010S	149:13.870E	x	x	x	x	x						x	
101	5-Dec-95	17:38:23	46:36.360S	149:13.950E	x	x	x		x						x	
102	5-Dec-95	22:10:22	46:34.730S	149:14.100E	x	x	x								x	
103	6-Dec-95	3:06:24	46:33.650S	149:14.060E	x	x	x	x	x		x				x	x
104	6-Dec-95	7:25:22	46:31.860S	149:13.360E						x		x				
105	6-Dec-95	8:22:22	46:31.610S	149:13.670E	x	x	x									

CTD	Pigments (JAMSTEC)	Optics	Pvsl	PSA	Grazing Dilution	15N studies	FRRF	Phytoplankton Cell-Cycling	Species (Greene)	Species (Bonham)	FF sed. traps	Zoopl. Dropnet	Larval fish	Midwater trawls
1														
2														
3					x	x		x			x			
4				x				x						
5								x						
6			x	x				x		x				
7	x							x	x					
8						x		x				x		
9								x						
10								x						
11		x							x					
12														
13					x	x		x						
14			x	x				x		x				
15														
16	x	x						x	x			x		
17						x		x						
18														
19								x						
20								x			x		x	
21								x				x		
22								x						
23			x	x						x				x
24							x		x					
25							x		x				x	
26			x	x				x		x				
27	x	x						x			x			
28					x							x		
29								x						
30														
31								x	x					
32							x	x						
33					x	x		x					x	x
34								x				x		
35			x	x				x		x			x	
36								x						

			Phytoplankton											
CTD	Pigments (JAMSTEC)	Optics	Pvsl	PSA	Grazing Dilution	15N studies	FRRF	Cell-Cycling	Species (Greene)	Species (Bonham)	FF sed. traps	Zoopl. Dropnet	Larval fish	Midwater trawls
37			x	x						x		x	x	
38													x	
39					x	x		x						
40								x						x
41											x			
42			x	x						x				
43								x						
44								x	x					
45	x	x				x		x						
46						x		x						
47								x					x	
48								x				x		
49														
50			x	x						x				
51														
52	x	x						x					x	
53								x			x			
54														
55								x	x				x	
56					x	x	x	x						x
57														
58			x	x				x		x				
59								x						
60			x	x				x		x				
61	x				x			x				x		
62		x												
63								x					x	
64														
65														
66			x	x			x			x				
67				x						x				
68			x	x			x			x				
69														
70														
71											x			
72								x	x					

								Phytoplankton						
CTD	Pigments (JAMSTEC)	Optics	Pvsl	PSA	Grazing Dilution	15N studies	FRRF	Cell-Cycling	Species (Greene)	Species (Bonham)	FF sed. traps	Zoopl. Dropnet	Larval fish	Midwater trawls
73								x	x			x	x	
74					x	x		x						x
75			x	x				x	x	x				
76								x						
77			x	x				x		x				
78	x	x				x		x				x		
79								x					x	
80														
81														
82							x							
83														
84														
85														
86														
87														
88														
89														
90														
91														
92			x	x				x		x				
93			x	x				x		x				
94								x						
95								x						
96								x						
97								x						
98			x	x				x		x				
99														
100					x	x					x	x	x	x
101			x	x						x				
102			x	x				x		x				
103	x	x				x						x		
104														
105														

APPENDIX 2: Underway nutrient transects SS11/95

Transect		Date	Time	Latitude	Longitude
ES1 to Trans-P1	Start	19.11.95	11:36	41:40.76S	141:05.99E
	End	19.11.95	15:56	41:59.79S	140:00.0E
Trans-1 to Trans-2	Start	21.11.95	7:57	43:02.33S	140:59.09E
	End	21.11.95	15:28	43:59.76S	141:48.96E
Trans-2 to Trans-P2	Start	21.11.95	17:20	43:59.89S	141:50.6E
	End	21.11.95	23:32	44:59.47S	142:43.18E
Trans-P2 to Trans-3	Start	23.11.95	2:26	45:02.85S	143:17.86E
	End	23.11.95	20:12	45:59.63S	143:37.03E
Trans-3 to Trans-4	Start	23.11.95	21:30	46:00.49S	143:36.06E
	End	24.11.95	5:06	46:59.28S	144:32.0E
Trans-4 to Trans-P3	Start	24.11.95	7:10	47:01.47S	144:34.13E
	End	24.11.95	13:24	47:59.01S	145:26.5E
Trans-P3 to Trans-5	Start	25.11.95	19:53	48:06.15S	145:43.23E
	End	26.11.95	1:05	48:59.73S	145:27.01E
Trans-5 to Trans-P5	Start	26.11.95	3:52	49:05.1S	145:23.76E
	End	27.11.95	5:30	53:08.45S	145:27.19E

APPENDIX 3: Aquashuttle transect completed on SS11/95

Transect		GMT date	GMT time	Latitude	Longitude
1	Start	21/11/95	21:30	44 40.10	142 26.33
	Finish	22/11/95	6:30	45 33.92	145 47.10
2	Start	26/11/95	5:10	49 05.69	145 23.82
	Finish	27/11/95	5:45	53 10.08	145 27.16
3	Start	3/12/95	4:10	47 09.80	152 18.59
	Finish	4/12/95	19:46	46 00.43	150 00.24
4	Start	6/12/95	13:05	47 00.25	149 13.85
	Finish	6/12/95	21:25	45 59.69	149 14.97

APPENDIX 4: Transects where the fast repetition rate flourometer was operated in flow-through made measuring Fu/Fm in surface water samples

Transect		GMT date	GMT time	Latitude	Longitude
SS Transect 1	Start	23-Nov-95	6:28	44:59.71S	143:01.54E
	Finish	23-Nov-95	8:20	45:04.95S	143:28.25E
SS Transect 2	Start	24-Nov-95	4:25	46:15.08E	143:47.31E
	Finish	24-Nov-95	18:55	47:59.91S	145:27.29E
SS Transect 3	Start	26-Nov-95	0:22	48:00.41S	145:44.69E
	Finish	27-Nov-95	10:47	53:10.7S	145:27.02E
SS Transect 4	Start	28-Nov-95	11:59	53:22.95S	145:30.97E
	Finish	29-Nov-95	3:30	51:24.33S	145:27.18E
SS Transect 5	Start	30-Nov-95	0:42	51:00.23S	145:25.14E
	Finish	30-Nov-95	9:13	50:03.46S	145:27.44E
SS Transect 6	Start	1-Dec-95	12:05	49:58.12S	146:12.28E
	Finish	2-Dec-95	12:35	46:30.22S	148:00.61E
SS Transect 7	Start	3-Dec-95	7:59	47:06.53S	152:24.41E
	Finish	4-Dec-95	0:40	47:59.58S	150:01.67E
SS Transect 8	Start	4-Dec-95	5:46	47:34.46S	149:59.99E
	Finish	5-Dec-95	1:31	46:01.39S	150:02.28E
SS Transect 9	Start	5-Dec-95	12:49	46:42.43S	149:46.72E
	Finish	7-Dec-95	23:19	42:54.41S	147:21.97E