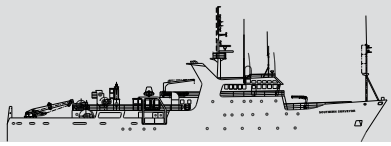

MARINE
NATIONAL FACILITY

2013
program

RV *Southern Surveyor*

CSIRO

voyage summary SS2013_v04

SS2013_v04

Voyage: Observations of remarkable eastward flows and eddies in the subtropical southeast Indian Ocean.

Voyage period
Start: 1/7/2013
End: 26/7/2013
Port of departure: Fremantle, Australia
Port of return: Broome, Australia

Responsible laboratory
IMAS, University of Tasmania
Private Bag 129, Hobart TAS 7001, Australia

Chief Scientist
Dr Eric Schulz
Bureau of Meteorology (CAWCR)
GPO Box 1289, Melbourne, Vic 3001 Australia

Scientific Objectives

Our work will include a suite of CTD, microstructure, surface drifter and float observations, and a mooring that will contribute to answering a first-order gap in our understanding of the large-scale currents in the subtropical southeast Indian Ocean. The presence of a near-surface, eastward flow across the South Indian Ocean is a remarkable aspect of the upper-ocean circulation because it flows against the westward direction from Ekman and Sverdrup theory for this region. The flow often appears as a set of distinct currents and jets. These currents have been detected in observations and simulated in some numerical models. However the underlying mechanisms driving the eastward surface currents and their eventual interaction with the Leeuwin Current and downwelling against the coast remains unclear. Furthermore, they appear to be linked to the Indonesian Throughflow and Southern Ocean water masses formed south of Australia. Our primary goal in this work is to make new observations of the physical and biogeochemical structure of the eastward flows in the region between existing observations and the Australian coast, where their fate is unknown. This region is filled with energetic eddies generated by the Leeuwin Current. Our observations will also provide insight into the nature of the interaction of these eddies with the circulation and productivity of the interior Indian Ocean. Dynamical understanding of the Indian Ocean circulation is central to the outstanding problem in ocean climate projections of correctly including surface processes to project the spatial patterns of heat uptake, steric sea-level rise, and storage of carbon dioxide.

Voyage Objectives

This voyage is the combination of a recovery and re-deployment of the RAMA mooring at 25S, 100E and an additional 10 days at sea to complete the objectives of SS2012_V04 that were compromised by the engine failure suffered by R.V. *Southern Surveyor* during that voyage. The extent to which the original objectives were achieved, and a list of the activities that were lost is summarised in the letter from Nathan Bindoff to Ron Plaschke dated 1st November 2012.

With the voyage time allowed, and to achieve as much of the original science plan for SS2012_V04 as possible, our operational objectives for SS2013_V04 are:

1) Recover and re-deploy the RAMA 25S flux reference station to continue for a second year the observations of surface atmospheric fluxes and upper-ocean density, velocity and biogeochemistry.

2) Repeat WOCE line I5 out to 105E with full depth CTDs

3) Full depth CTDs along 100E from 31S to 25S at 30nm spacing

4) Full depth CTDs along 105E from 31S to 25S at 30nm spacing

5) Full depth CTDs along 25S from 100 to 105E at 60nm spacing if time permits

6) Full depth CTDs along WOCE line I5 from 100 to 105E at 60nm spacing if time permits

7) CTD profiles to 2000m across one warm core and one cold core eddy

8) Deployments of 5 EM-APEX profilers to measure the velocity structure in eastward flows and eddies, nominal positions shown in Figure 1

9) Deployment of 7 Argo floats from CSIRO at the nominal locations marked in Figure 1, contributing to the global Argo Program **http://www.argo.ucsd.edu/**

10) Deployment of 20 surface drifters provided by NOAA, USA at the locations shown in Figure 1. This is a contribution to the global surface drifter program **http://www.aoml.noaa.gov/phod/dac/index.php** will provide information on the broad scale surface circulation in our region of interest, and will provide ground-truthing for the CSIRO/Bureau of Met. Bluelink model **http://www.bom.gov.au/bluelink/**

These operational objectives will allow us to meet our original science objectives:

1) Map the vertical and meridional extent of the South Indian Counter current, and the underlying westward flows, east of 95E (40% complete in 2012 with only one north-south line).

2) Identify the source waters of the westward flow beneath the SICC and broader eastward flow (40% complete in 2012 with only one north south line).

3) Characterise the 3-dimensional physical and biogeochemical structure of the Leeuwin Current eddies (about 85% complete).

4) Continue a moored reference station to sample surface atmospheric fluxes and upper-ocean density, velocity and biogeochemistry.

Priorities of the measurement program depend on circumstances during the voyage. Some trade off is possible between the number of CTDs and the survey of eddies in the event of equipment problems or bad weather beyond the current allowance of 1 day. The RAMA mooring has the highest priority, followed by the deployment of floats and drifters, the 105E line, the 100E line, and the survey of eddies. The lowest priority is the CTD profiles on the east west lines at 25S and 31S. The voyage aims to complete all aspects of the work satisfactorily.

A number of shipboard measurement programs and analyses of water samples will be undertaken as well as the shipboard activities listed above (see piggy-back projects and hydrographic analyses).

Results

Time available for the voyage was reduced by approximately 2.5 days due to delayed departure from Fremantle. This impacted completion of lower prioritized operational objectives.

1) Recover and re-deploy the RAMA 25S flux reference station to continue for a second year the observations of surface atmospheric fluxes and upper-ocean density, velocity and biogeochemistry.
   Completed: Successfully deployed RAMA@25S-2 on 15 July 2013, and successfully recovered RAMA@25S-1 on 20 July 2013.

2) Repeat WOCE line I5 out to 105E with full depth CTDs
   Completed. Deployed 30 full depth CTD profiles.

3) Full depth CTDs along 100E from 31S to 25S at 30nm spacing
   Mostly completed. Deployed 10 (out of a planned 13) full depth CTDs from 25S to 29.5S.

4) Full depth CTDs along 105E from 31S to 25S at 30nm spacing
   Completed. Deployed 12 full depth CTDs.

5) Full depth CTDs along 25S from 100 to 105E at 60nm spacing if time permits
   Not Completed. CTD's were not performed along this line.

6) Full depth CTDs along WOCE line I5 from 100 to 105E at 60nm spacing if time permits
   Not Completed. CTD's were not performed along this line. Ship did not transit along this line

7) CTD profiles to 2000m across one warm core and one cold core eddy
   Partially completed. Performed additional five 2000m 15Nm spacing CTDs across a cold core eddy on the 105E line. Did not encounter any warm core eddies in vicinity of ship operations.

8) Deployments of 5 EM-APEX profilers to measure the velocity structure in eastward flows and eddies
   Completed. Deployed all floats along the 105E line, including 3 in a cold core eddy.

9) Deployment of 7 Argo floats from CSIRO
   Completed. Deployed 5 (all that we were given) Argo floats along the 105E and 100E lines.

10) Deployment of 20 surface drifters provided by NOAA, USA
    Completed. All drifters were deployed in pairs along the 105E line.

Voyage Narrative

Narrative times are local.

IO5 line – shelf out to 105E

Monday 1 July 2013 was mobilisation day, and was completed by mid afternoon. The planned 1800 departure was delayed due to an oil leak in the stern tube gland which was fixed by substituting the oil with a higher viscosity, biodegradable replacement.

Thursday 4 July the vessel departed Fremantle at 1230. We tracked west to deep water off the shelf and performed a test CTD to 1000m at 1830.

5-9 July was spent sampling along the I05 line with closely spaced CTDs on the shelf and down the slope for the first day and then increased spacing at 30 Nm out to 105E. Thirty CTD deployments were performed. The CTD carried an LADCP, fluorometer, transmissometer, dissolved oxygen, PAR and Isus nitrate (on the shelf only) sensors as well as 19 Niskin bottles which were sampled for oxygen, salts, nutrients (Nitrate, Nitrite, silicate, phosphate) and chlorophyl. A Vertical microstructure profiler (VMP) deployment was performed on the outer edge of the shelf slope. The VMP is a free falling probe tethered to the ship by a rope that records mixing in the water as it descends. Each deployment consists of 3 casts and takes approximately 1 hour to complete. Light to moderate seas and weather with the occasional squall were encountered during this time.

The TSG was faulty and did not commence logging data until 7 July. The SST at intake had to be logged to the spare CTD as the TSG was not able to take that data feed directly. Salinity from the intake was not available. Light to moderate seas and weather with the occasional squall were encountered during this time.

10-14 July was spent performing 13 full depth CTDs at 30Nm spacing along the 105E line from 31S-25S. At each station the VMP was deployed from the stern A-frame (3 casts collected) and the CTD performed. At many stations combinations of paired drifters, EM-APEX profiling floats, or Argo profiling floats were deployed. A total of 20 drifters, 5 EM-APEX and 2 Argo floats were deployed along this line. During the last 3 days of this period, high-resolution sampling of a cold core eddy on the northern section of the line was conducted. This was achieved by inserting shallow (2000m) CTD casts between the deeper casts yielding 15 Nm spacing. A total of 18 CTD deployments were performed, of which 13 were full depth and 5 shallow (to 2000m).

15 July was a transit day to the RAMA site while the new buoy was prepared on the back deck. The site was reached around 1900. A VMP and full depth CTD were performed before a bathymetric survey was undertaken around the site. The original plan to perform full depth CTD and deploy Argo profilers along this line was abandoned due to the delayed departure from Fremantle.

16 July conditions were favourable for a mooring deployment (light seas and 15 kts wind). Ship set-up was 5 Nm down stream of target deployment. Surface float was deployed at 1300 and anchor released at 17:45. RAMA@25S-2 was deployed in 5513 m water depth with the surface float positioned at 24 45.06' S, 99 58.76' E. Forecast conditions for the next few days were not ideal for recovering RAMA@25S-1, but looked better by the weekend, so we decided to sample along the 100E line and return to recover the RAMA@25S-1 mooring on our transit to Broome.

17-18 July we travelled south along the 100E line, deploying 10 full depth CTD's (30 Nm spacing). Three Argo floats were deployed. The line was terminated early at 29o 30'S (1.5o and 3 CTD stations less than the original plan). Conditions were moderate (20Kts of wind) and overcast.

19 July was a transit day back north to the RAMA site under moderate conditions.

20 July we arrived back at the RAMA site around 0600. Conditions were light, but not calm enough to launch the boat (which is the preferred method for recovering the RAMA mooring). The forecast was for moderating conditions that afternoon and into the next day. The mooring recovery was deferred until after midday. By midday conditions had not changed significantly, so the boat launch was abandoned, and the alternative alongside mooring hook-up plan was adopted. Mooring recovery operations commenced at 1230 and the alongside hook-up was quickly achieved with minimal difficulty under light conditions. The mooring was recovered and all components on deck by 1700. We then commenced transit for Broom.

21-25 July was transit to broom. We performed slight deviations to the course along the transit to allow sampling of a number of eddies with underway SADCP. On 21 July we entered a warm core eddy where we deployed a bio-Argo float (24.4030S, 104.77E) and a CTD to 1000m. Underway sampling of a number of eddies continued throughout the next days with water samples collected from the flow-through pipe for chlorophyl, nutrients, salinity and nitrogen fixation analyses in addition to the shipboard ADCP and sea surface temperature.

26 July we arrived in Broom 0900 and demobilised.

Summary

The voyage was successful in achieving the scientific goals. We encountered fine weather for the most part which freed up our contingency 'weather' day to mitigate the impact of the delayed departure. Reduced at-sea time forced us to modify our plan, removing lower priority sampling along the east-west lines and into a warm core eddy, as well as shortening the 100E line. Despite this we were still able to meet our goals. The crew and science party were great and carried out their work with enthusiasm and professionalism.

Principal Investigators:

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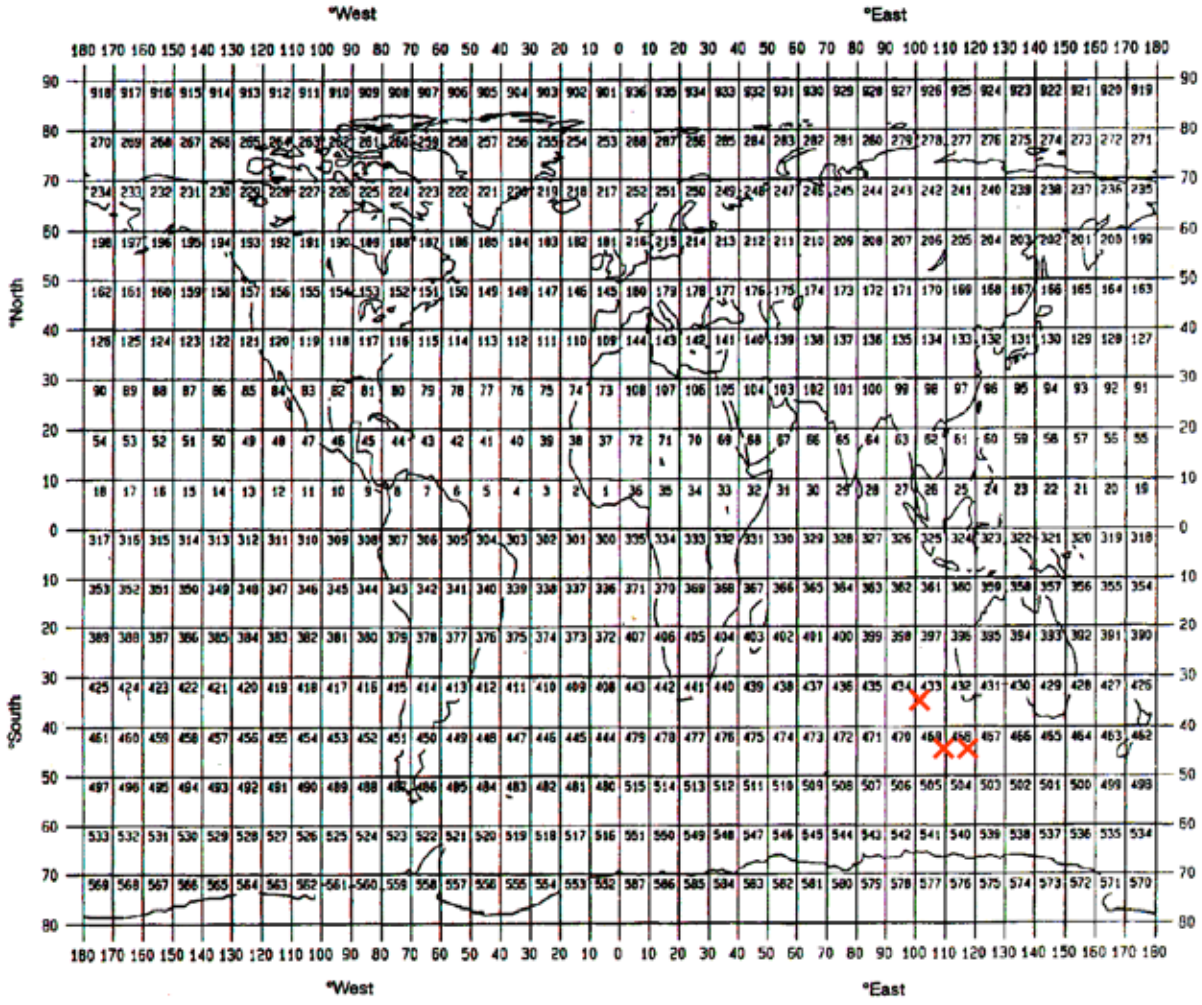
Email: eric.raes@uwa.edu.au

GEOGRAPHIC COVERAGE - INSERT 'X' IN EACH SQUARE IN WHICH DATA WERE COLLECTED



MOORINGS, BOTTOM MOUNTED GEAR AND DRIFTING SYSTEMS									
Item No.	PI	Approximate position						Data Type	DESCRIPTION
		Latitude			Logitude				
		deg	min	N/S	deg	min	E/W		
1	A	24	45.1	S	99	58.8	E	M06, H72, H17, D90, D71	RAMA flux reference station, ATLAS mooring.
2	C	31	0.5		105	0.1		D05	Surface drifter 101699
3	C	31	0.4		105	0.2		D05	Surface drifter 101656
4	C	30	0.1		104	59.9		D71	EM-APEX 6664 (Iridium comms)
5	C	30	0.4		104	59.8		D05	Surface drifter 101711
6	C	30	0.4		104	59.8		D05	Surface drifter 101662
7	C	28	59.8		105	0.0		H11 D5	Argo 6513 (Argos comms)
8	C	28	59.8		105	0.0		D71	EM-APEX 6663 (Iridium comms)
9	C	28	59.6		105	0.0		D05	Surface drifter 101703
10	C	28	59.6		105	0.0		D05	Surface drifter 101713
11	C	28	29.9		104	59.7		D05	Surface drifter 101708
12	C	28	29.9		104	59.7		D05	Surface drifter 101712
13	C	27	59.6		104	59.8		D71	EM-APEX 6218 (Iridium comms)
14	C	27	59.6		104	59.8		D05	Surface drifter 101710
15	C	27	59.6		104	59.8		D05	Surface drifter 101709
16	C	27	30.0		105	0.0		D05	Surface drifter 101657
17	C	27	30.0		105	0.0		D05	Surface drifter 101655
18	C	26	59.3		105	0.2		D71	EM-APEX 6662 (Iridium comms)
19	C	26	59.2		105	0.2		D05	Surface drifter 101706
20	C	26	59.2		105	0.2		D05	Surface drifter 101715
21	C	26	28.2		105	0.1		D05	Surface drifter 101660

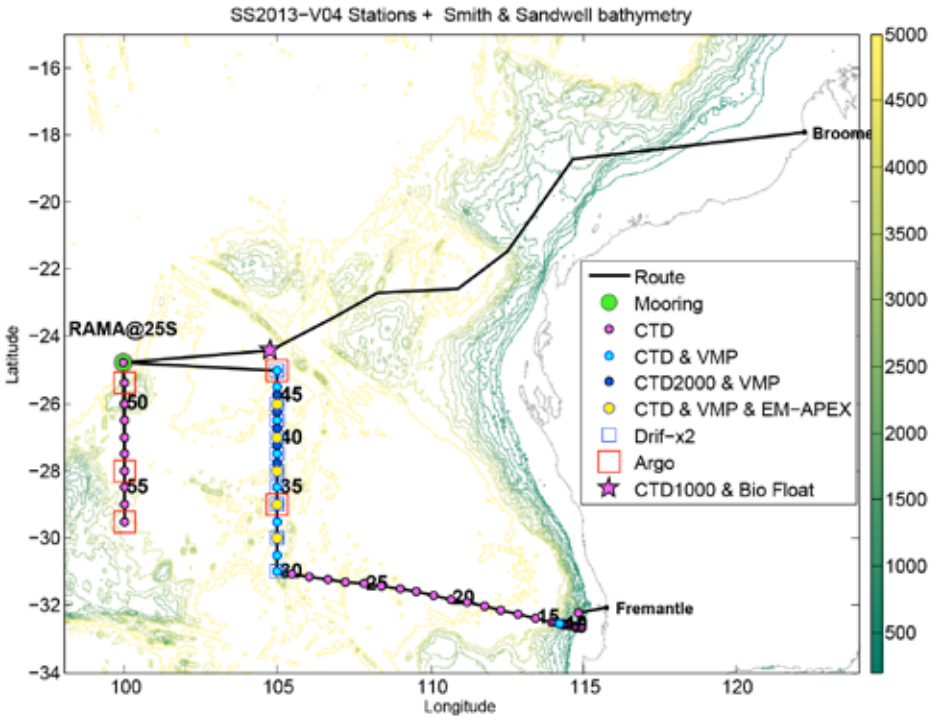
MOORINGS, BOTTOM MOUNTED GEAR AND DRIFTING SYSTEMS (continued)									
Item No.	PI	Approximate position						Data Type	DESCRIPTION
		Latitude			Logitude				
		deg	min	N/S	deg	min	E/W		
22	C	26	28.2	S	105	0.1	E	D05	Surface drifter101704
23	C	26	0.0		104	59.9		D71	EM-APEX 6217 (Iridium comms)
24	C	25	59.2		104	59.9		D05	Surface drifter 101701
25	C	25	59.2		104	59.9		D05	Surface drifter 101705
26	C	25	0.0		104	59.7		H11 D5	Argo 6225 (Argos comms)
27	C	25	0.0		104	59.7		D05	Surface drifter 101702
28	C	25	0.0		104	59.7		D05	Surface drifter 101707
29	C	25	23.4		99	59.6		H11 D5	Argo 6553 (Argos comms)
30	C	28	0.2		99	59.3		H11 D5	Argo 6555 (Argos comms)
31	C	29	29.7		100	0.1		H11 D5	Argo 6635 (Argos comms)
32	C	24	24.2		104	46.0		H11 D5	Seabird Navis Profiling float deployed for Dr Nick Hardman Mountford, CSIRO Mrine and Atmospheric Research, Floreat WA

SUMMARY OF MEASUREMENTS AND SAMPLES TAKEN					
Item No.	**PI**	**No.**	**Units**	**Data Type**	**DESCRIPTION**
33	B,C, D	58	Stations	H10, H17, H21	CTD Casts – temperature, conductivity, pressure, dissplved oxygen, fluorescence, transmissometer. See Appendix 2 for full list of Stations
34	B,C, D	15	Stations	H24	Nitrate profiles from ISUS sensor on shelf/ slope CTD stations (max depth 1000m)
35	C	58	Stations	D71	Lowered ADCP on CTD – velocity profiles
36	B,	58	Stations	H09, H21, H22, H24, H25, H26	Bottle samples – salinity, temperature, dissolved oxygen, nutrients (nitrate, nitrite, silicate, phosphate)
37	C,	58	Stations	B2	Bottle samples – chlorophyll a, 6-8 samples over the upper 200m
38	D	37	Stations	B71, B90	Bottle samples – biology at the sea surface and at the shallow chlorophyll maximum (above 200m) samples for N uptake analysis, N fixation, N uptake through 24 hour incubation, POC, PN, delO18, microarray and HPLC.
39	D	19	Stations	D90	VMP200 casts – vertical microstructure profiles (set of 3 casts to the maximum depth possible with a 400m line, usually approx. 300m)
40	D, E	37	Stations	B2, B71, 90	Surface water intake measurements– biological analyses as for CTD bottle data, item 38
41	C	3169	Nautical Miles	H71	Thermosalinograph – surface salinity and temperature – only temperature was reliable, salinity sensor not working
42	D, E	3169	Nautical Miles	H17	Underway fluorometer
43	B, C	3169	Nautical Miles	M2, M6	Standard meteorological measurements
44	D	3169	Nautical Miles	D71	Shipboard ADCP (75 kHz)

Curation Report

Item No.	DESCRIPTION
1	RAMA mooring data is processed, distributed and archived by NOAA (http://www.pmel.noaa.gov/tao/disdel/disdel-rama.html)
2, 3, 5, 6, 8-12, 14-17, 19-22, 24,25, 27, 28	Surface drifter data is processed, dristributed and archived by the Global Drifter Program (http://www.aoml.noaa.gov/phod/dac/index.php)
4, 8, 13, 18, 23	EM-APEX float data will be stored on two servers, one at University of Washington, WA, USA, and the other at the University of Tasmania, Tasmania, Australia. The collected data set, when available and quality controlled will be lodged with the Australian Oceanographic Data Network. (http://portal.aodn.org.au/webportal).
7, 26, 29-31	Argo float data is processed, distributed and archived by the Global Argo Program. Near-realtime and delayed mode data are available (http://www.nodc.noaa.gov/argo)
32	Bio-Float deployed on behalf of CSIRO, and pending instrument problems the data will presumably be lodged with the AODN (http://portal.aodn.org.au/webportal)
33	CTD profiles (CSIRO and AODN)
34	ISUS nitrate profiles (CSIRO and AODN)
35	LADCP profiles (CSIRO and AODN)
36	Bottle data – T, S, O2 (CSIRO and AODN)
37	Bottle data – chlorophyl a (UTAS and AODN)
38	Bottle data – biology (Oceans Institute, University of West Australia)
39	VMP profiles (AODN)
40	Surface intake – biology (Oceans Institute, University of West Australia)
41	Thermosalinograph (CSIRO and AODN)
42	Underway fluorometer (CSIRO and AODN)
43	Standard meteorology (CSIRO and AODN)
44	Shipboard ADCP (CSIRO and AODN)
	All of the above data will be lodged with the Australian Ocean Data Network (http://portal.aodn.org.au/webportal). No physical samples will be stored.

Voyage track chart



Ship track

General ocean area(s): Southeast Indian Ocean

Specific areas: 25° S – 32° S, 100° E – Australia

Personnel list

Scientific Participants

Name	Affiliation	Role
Eric Schulz	BOM	Chief Scientist
Nathan Bindoff	IMAS, UTAS and CSIRO	Alt Ch Sci/Science watch leader
Helen Phillips	IMAS, UTAS	Science watch leader
Viviane Vasconcellos de Menezes	IMAS, UTAS	CTD watch/ Chlorophyl analysis/ data analysis
Patrick Berk	PMEL, NOAA, USA	Mooring technician/CTD watch
Hanni Olsen	UWA	Biology
Stephanie Downes	ANU	CTD watch/voyage planning/data analysis
Nicola Maher	UNSW	CTD watch/assist with Biology/data analysis
Stefan Riha	UNSW	CTD watch/assist with Biology/data analysis
Hiski Kippo	CMAR	MNF Computing Support
Karl Forcey	CMAR	MNF Electronics Support
Mark Rayner	CMAR	MNF Hydrochemistry Support
Dave Terhell	CMAR	MNF Voyage Manager
Peter Hughes	CMAR	MNF Hydrochemistry Support
Sue Reynolds	CMAR	MNF Hydrochemistry Support

Marine Crew

Name	Role
John Barr	Master
Mike Tuck	Chief Mate
Tom Watson	2nd Mate
Fred Rostron	Chief Engineer
Seamus Elder	1st Engineer
Graeme Perkins	2nd Engineer
Darcy Chalker	Chief Steward
Warren Leary	Chief Cook
Bob Dittko	2nd Cook
Tony Hearne	CIR
Matt Streat	IR
Jonathon Lumb	IR
Michael Chalk	IR
Nathan Arahanga	IR

Acknowledgements

Thanks to the Master, Crew, MNF staff, and the onboard Science Team, the voyage was a great success.

Eric Schulz
Chief Scientist

FIGURES

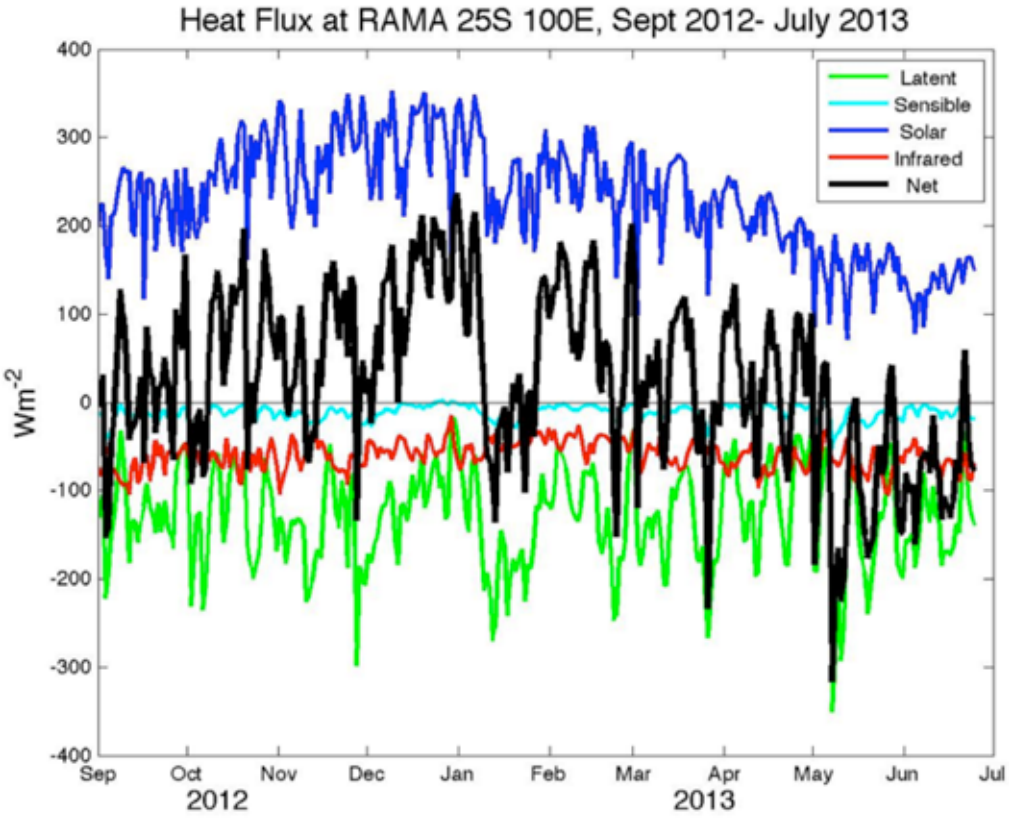


Figure1: Ocean-atmosphere heat flux components as measured by the RAMA mooring at 25S, 100E, which was recovered and redeployed during voyage SS2013_V03. Over this 10 month period the ocean heated by an average of 24 Wm^{-2}.

We have used exciting new tools and methods to make measurements of nitrogen uptake in the Indian Ocean, measure turbulent mixing in the upper ocean, and to monitor the evolution of Leeuwin Current eddies with in-situ, autonomous sampling.

We have mapped the physical and biogeochemical structure of eastward currents along 105E in a region where their character is not known.

We now have the ocean data to determine the characteristics of the eastward flows and ocean eddies (Figure 2), and the penetration of subtropical surface waters into the deep ocean. The new temperature, salinity, velocity and mixing observations of a cold core ring complement the warm core eddy sampled in 2012 and earlier measurements. Characterisation of both eastward flows and the changing ocean state in this region will be achieved in our analysis of the data collected from this voyage.

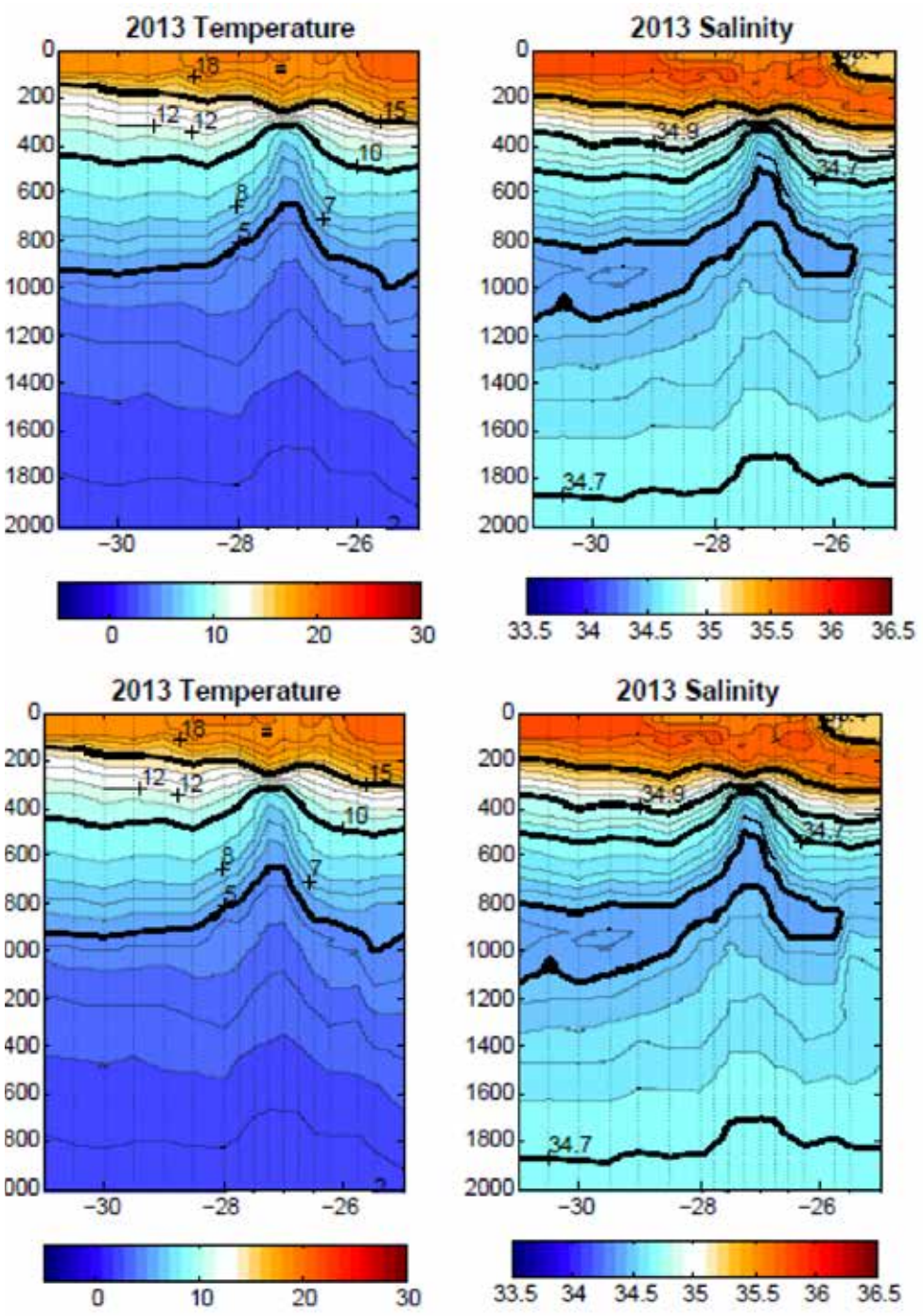


Figure 2: Temperature and salinity data along a North-South slice of the ocean at 105E, 31S to 25S. This section shows a distinctive cold core eddy, causing the upward bend of isotherms and isohalines at 27S.

APPENDICES

Appendix 1 – Station list

STATION LIST						
Deply No.	**Start time**	**End time**	**Latitude**	**Longitude**	**Depth**	**VMP200**
1	2013-07-04 10:11:32	2013-07-04 11:02:26	-32.229941	114.845530	Full	No
2	2013-07-04 16:26:58	2013-07-04 16:51:35	-32.678708	114.910820	Full	No
3	2013-07-04 17:40:00	2013-07-04 18:04:55	-32.660353	114.837006	Full	No
4	2013-07-04 19:28:18	2013-07-04 20:22:21	-32.647597	114.746340	Full	No
5	2013-07-04 21:28:43	2013-07-04 22:11:37	-32.632490	114.684241	Full	No
6	2013-07-04 23:28:37	2013-07-05 00:11:37	-32.601905	114.536451	Full	No
7	2013-07-05 01:09:58	2013-07-05 02:04:41	-32.584310	114.460915	Full	No
8	2013-07-05 02:59:20	2013-07-05 04:09:11	-32.575220	114.399673	Full	No
9	2013-07-05 05:11:10	2013-07-05 06:59:05	-32.570305	114.370150	Full	No
10	2013-07-05 07:55:43	2013-07-05 09:46:45	-32.558637	114.335329	Full	No
11	2013-07-05 10:54:55	2013-07-05 12:49:51	-32.532838	114.203379	Full	No
12	2013-07-05 15:31:36	2013-07-05 17:41:19	-32.522340	114.144279	Full	Yes
13	2013-07-05 18:54:05	2013-07-05 20:56:37	-32.504418	114.046552	Full	No
14	2013-07-05 22:37:29	2013-07-06 01:48:08	-32.438734	113.738511	Full	No
15	2013-07-06 03:26:29	2013-07-06 06:17:13	-32.374184	113.420236	Full	No
16	2013-07-06 09:04:07	2013-07-06 12:35:48	-32.261770	112.861698	Full	No
17	2013-07-06 15:22:55	2013-07-06 18:25:15	-32.150958	112.309654	Full	No
18	2013-07-06 21:18:34	2013-07-07 00:27:51	-32.039857	111.760425	Full	No
19	2013-07-07 03:30:33	2013-07-07 06:39:40	-31.927910	111.205748	Full	No
20	2013-07-07 09:43:38	2013-07-07 13:04:53	-31.816245	110.653534	Full	No
21	2013-07-07 16:05:48	2013-07-07 18:56:43	-31.705160	110.097053	Full	No
22	2013-07-07 21:50:08	2013-07-08 00:58:23	-31.594863	109.552182	Full	No
23	2013-07-08 03:48:21	2013-07-08 07:15:15	-31.499039	108.989466	Full	No
24	2013-07-08 10:45:22	2013-07-08 14:18:39	-31.430134	108.399752	Full	No
25	2013-07-08 17:38:12	2013-07-08 20:42:32	-31.360469	107.811371	Full	No
26	2013-07-08 23:57:16	2013-07-09 03:05:14	-31.293007	107.221465	Full	No
27	2013-07-09 06:11:27	2013-07-09 09:33:05	-31.223246	106.630972	Full	No
28	2013-07-09 12:43:31	2013-07-09 16:11:50	-31.156928	106.045419	Full	No
29	2013-07-09 19:33:33	2013-07-09 23:16:08	-31.087650	105.460835	Full	No

STATION LIST (continued)						
Deply No.	**Start time**	**End time**	**Latitude**	**Longitude**	**Depth**	**VMP200**
30	2013-07-10 03:04:31	2013-07-10 05:13:25	-31.002625	104.999092	Full	Yes
31	2013-07-10 09:42:46	2013-07-10 12:18:26	-30.500341	105.000320	Full	Yes
32	2013-07-10 16:46:25	2013-07-10 19:21:49	-29.999888	105.000442	Full	Yes
33	2013-07-10 23:45:43	2013-07-11 02:43:38	-29.500283	104.999714	Full	Yes
34	2013-07-11 07:03:19	2013-07-11 10:18:59	-28.999769	104.999276	Full	Yes
35	2013-07-11 14:50:30	2013-07-11 17:57:16	-28.499306	104.999685	Full	Yes
36	2013-07-11 22:10:28	2013-07-12 01:12:09	-27.999578	104.998408	Full	Yes
37	2013-07-12 04:12:21	2013-07-12 05:52:03	-27.745969	104.995007	2000m	Yes
38	2013-07-12 08:50:11	2013-07-12 12:03:51	-27.499816	104.999640	Full	Yes
39	2013-07-12 14:53:18	2013-07-12 16:21:12	-27.251027	104.999483	2000m	Yes
40	2013-07-12 19:11:19	2013-07-12 22:07:13	-26.999789	105.000234	Full	Yes
41	2013-07-13 00:50:50	2013-07-13 02:18:04	-26.749862	105.000489	2000m	Yes
42	2013-07-13 05:49:55	2013-07-13 09:03:45	-26.500259	105.000802	Full	Yes
43	2013-07-13 11:46:50	2013-07-13 13:09:30	-26.250295	105.000608	2000m	Yes
44	2013-07-13 15:40:14	2013-07-13 18:33:17	-26.000341	105.000749	Full	Yes
45	2013-07-13 21:13:56	2013-07-13 22:27:53	-25.750728	105.000308	2000m	Yes
46	2013-07-14 01:12:17	2013-07-14 03:47:51	-25.500341	105.000168	Full	Yes
47	2013-07-14 07:41:42	2013-07-14 10:47:16	-24.999617	104.999889	Full	Yes
48	2013-07-15 13:00:36	2013-07-15 16:36:08	-24.779631	99.950528	Full	No
49	2013-07-16 17:51:15	2013-07-16 20:20:36	-25.383594	100.000030	Full	No
50	2013-07-17 00:29:26	2013-07-17 01:59:21	-26.002817	99.999017	Full	No
51	2013-07-17 05:06:40	2013-07-17 08:10:57	-26.499390	100.000067	Full	No
52	2013-07-17 11:11:57	2013-07-17 14:22:20	-27.000152	100.000076	Full	No
53	2013-07-17 17:29:13	2013-07-17 20:26:04	-27.499290	99.999726	Full	No
54	2013-07-18 01:20:34	2013-07-18 04:13:31	-27.991563	99.995819	Full	No
55	2013-07-18 07:19:49	2013-07-18 10:08:12	-28.500590	99.999685	Full	No
56	2013-07-18 13:11:40	2013-07-18 15:44:21	-29.000868	100.000439	Full	No
57	2013-07-18 18:40:16	2013-07-18 21:05:16	-29.499857	99.998752	Full	No
58	2013-07-21 11:54:50	2013-07-21 12:55:29	-24.403317	104.765799	1000m	No

CSR/ROSCOP PARAMETER CODES

METEOROLOGY

M01 Upper air observations
M02 Incident radiation
M05 Occasional standard measurements
M06 Routine standard measurements
M71 Atmospheric chemistry
M90 Other meteorological measurements

PHYSICAL OCEANOGRAPHY

H71 Surface measurements underway (T,S)
H13 Bathythermograph
H09 Water bottle stations
H10 CTD stations
H11 Subsurface measurements underway (T,S)
H72 Thermistor chain
H16 Transparency (eg transmissometer)
H17 Optics (eg underwater light levels)
H73 Geochemical tracers (eg freons)
D01 Current meters
D71 Current profiler (eg ADCP)
D03 Currents measured from ship drift
D04 GEK
D05 Surface drifters/drifting buoys
D06 Neutrally buoyant floats
D09 Sea level (incl. Bottom pressure & inverted echosounder)
D72 Instrumented wave measurements
D90 Other physical oceanographic measurements

CHEMICAL OCEANOGRAPHY

H21 Oxygen
H74 Carbon dioxide
H33 Other dissolved gases
H22 Phosphate
H23 Total – P
H24 Nitrate
H25 Nitrite
H75 Total – N
H76 Ammonia
H26 Silicate
H27 Alkalinity
H28 PH
H30 Trace elements
H31 Radioactivity
H32 Isotopes
H90 Other chemical oceanographic measurements

MARINE CONTAMINANTS/POLLUTION

P01 Suspended matter
P02 Trace metals
P03 Petroleum residues
P04 Chlorinated hydrocarbons
P05 Other dissolved substances
P12 Bottom deposits
P13 Contaminants in organisms
P90 Other contaminant measurements
B01 Primary productivity
B02 Phytoplankton pigments (eg chlorophyll, fluorescence)
B71 Particulate organic matter (inc POC, PON)
B06 Dissolved organic matter (inc DOC)
B72 Biochemical measurements (eg lipids, amino acids)
B73 Sediment traps
B08 Phytoplankton
B09 Zooplankton
B03 Seston
B10 Neuston
B11 Nekton
B13 Eggs & larvae
B07 Pelagic bacteria/micro-organisms
B16 Benthic bacteria/micro-organisms
B17 Phytobenthos
B18 Zoobenthos
B25 Birds
B26 Mammals & reptiles
B14 Pelagic fish
B19 Demersal fish
B20 Molluscs
B21 Crustaceans
B28 Acoustic reflection on marine organisms
B37 Taggings
B64 Gear research
B65 Exploratory fishing
B90 Other biological/fisheries measurements

MARINE GEOLOGY/GEOPHYSICS

G01 Dredge
G02 Grab
G03 Core – rock
G04 Core – soft bottom
G08 Bottom photography
G71 In-situ seafloor measurement/sampling
G72 Geophysical measurements made at depth
G73 Single-beam echosounding
G74 Multi-beam echosounding
G24 Long/short range side scan sonar
G75 Single channel seismic reflection
G76 Multichannel seismic reflection
G26 Seismic refraction
G27 Gravity measurements
G28 Magnetic measurements
G90 Other geological/geophysical measurements