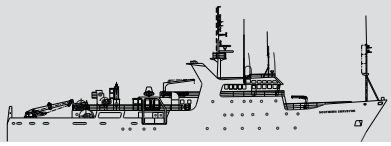


MARINE
NATIONAL FACILITY

2010 program

RV *Southern Surveyor*

CSIRO

voyage summary SS2010_V04

SS2010_V04

Assessing oceanographic delivery of nutrients to Ningaloo Reef

Voyage period

Start: 07/05/2010

End: 27/05/2010

Port of departure: Port Hedland, Australia

Port of return: Fremantle, Australia

Responsible laboratory

The Oceans Institute, M047, The University of Western Australia

Chief Scientist(s)

Prof A. M. Waite, University of Western Australia

Scientific Objectives

Ningaloo Reef is Australia's largest fringing coral reef and the basis of a major tourist industry. Though diverse and delicate, coral reefs (and the controls of their productivity) remain poorly understood. Understanding the interaction of the reef with the surrounding ocean is essential for predicting and managing the impacts of human and climate-induced changes, and therefore for the effective conservation of reefs. This proposal is part of a new initiative aimed at providing a scientific basis for determining the oceanographic distance beyond which industrial developments will not damage a reef's ecological processes. This analysis is essential for maintaining guiding sustainable development in the region. We will determine the seasonal differences in the productivity and delivery of dissolved nutrients and particles, by the Leeuwin (LC) and Ningaloo Currents (NC) on the continental shelf off Ningaloo Reef, WA, with special emphasis on identifying coastal upwelling mechanisms driving reef production. This work is part of a 3-year funded ARC project (Waite, Roughan, Pattiaratchi, Kotta) comparing reef-based uptake of nutrients from the surrounding ocean with the shelf oceanography delivering materials to the Ningaloo reef. We have applied for a second voyage in summer 2011/12 to complete the study.

Voyage Objectives

Our recent work has illuminated that Ningaloo Reef filters large volumes of ocean as it concentrates its nutrients (especially nitrogen) from the plankton (Wyatt et al., 2010). Changes in oceanic production rates offshore of Ningaloo Reef will therefore likely directly impact reef production, but the mechanisms and transport rates driven by them are unknown.

Expected Outcomes:

1. Snapshot of the physical dynamics of the Leeuwin Current (and the wind-driven countercurrent the Ningaloo Current, in two contrasting seasons – Part II)
2. 4 (four) Lagrangian drifter tracks illuminating physics of consolidation point of LC north of Northwest Cape
3. Estimation of the nutrient injections forced by mixed layer deepening and local upwelling events
4. Measurements of primary production, nutrient uptake and suspended particle concentrations along the length of Ningaloo Reef (in two seasons – Part II)
5. Estimate of local gradients in ocean acidity signature along the length of the reef and in the LC

Results

1. Successful – In general our survey covered the entire of interest – one unexpected observation was the strength and persistence of wind-driven currents during a time of year not usually known for strong winds. We also noticed a localized intensification of wind-driven processes adjacent to Cape Range. Strong winds shut down operations for ~1.5 days.

2. Successful – Our Lagrangian drifters (released at 21 S) showed unprecedented variability in lateral mixing as the LC formed, and indicated that surface currents moved directly through the clustered of oil and gas platforms on to the reefs of Ningaloo. One drifter actually grounded directly off NW cape off the Lighthouse Caravan Park.

3. Likely to be Successful – While we have not yet processed the data sufficiently to answer this question, we believe the data collected will allow us to do so including 2 X 24h experiments documenting changes in ML Depth with time.

4. Successful – Primary production, nutrient uptake and zooplankton concentrations were measured at all primary productions stations along the 7 transects – at 50 m, 200 m and 1000 m contours.

5. Successful – ocean acidity was measured on every CTD case and our measurements should yield a 3D picture of how this property varies with water mass and depth.

Voyage Narrative

During the first week at sea, our boutique team of 8 scientists deployed 4 drifters in the Leeuwin Current along the 21 S line and completed three onshore- offshore transects from Barrow Island and NW Cape, through mazes of oil and gas platforms. As we mapped the forming Leeuwin Current as it consolidates just north of NW Cape , we noted that water masses from Indonesia seem to have become very saline off the N coast of WA as they passed on their way south, and these seemed to flow, warm and salty, overtop of fresher, cooler water from the NW (Eastern Gyral Current?).

The drifters were named after our international members, Vincent (Toulouse), Judith (Kiel, Germany), Christin (Sweden) and Megan (Canada). Drifter Vincent won the race to be the first to cross the 22 S line. The three others were delayed in the last day by 30-40 knot winds from the SE which in the end forced the ship to suspend all sampling operations. While the Leeuwin Current eventually asserted its authority and sent the drifters south, there was a remarkable amount of northward coastal flow which we assume was primarily wind-driven, although this remains to be determined. We then steamed west to our 1000 m station off NW Cape, in the hopes that we can actually complete a CTD cast there. Exciting projects aboard included a first 3-D survey of ocean acidity, and a first genetic characterization of the microbes of the coastal NW. The small size of the team demanded some star performances from individuals including John Akl (CSIRO) who managed to be awake at every single CTD station, and Lynnath Beckley (Murdoch), who bounded up for every production station to do quality control on the bongo nets. Thankfully both are now at rest as we plough offshore in search of smoother swell.

We moved slowly southward along the shelf break off Cape Range against 25-30 kts, towing the instrumented Nacelle in gentle yo-yos behind us. Most of the drifters initially rallied southwards with the Leeuwin Current, but two of the drifters began to trace loops adjacent to Ningaloo Reef and another traced around an eddy east of 112 E. Thanks to David Griffin who has kept them visible to us via regular beautiful satellite images, we were able to track them against satellite images, and data from the Bureau of Meteorology (Brian Sharp) gave us regular position fixes.

Transiting en route to Fremantle, we were able to stop briefly to sample and eddy off the Abrolhos that looked promising for rock lobster phyllosoma – this was of interest for our following voyage (SS05/2010) on the MNF.

Overall this was a very intense little voyage, with most scientific crew flat tack for most days as we fiercely tackled an ambitious science plan.

Summary

We were able to execute all of our objectives successfully, and lost only a small amount of ship time due to strong SE /SW winds.

Project name

Ocean – Reef Interactions

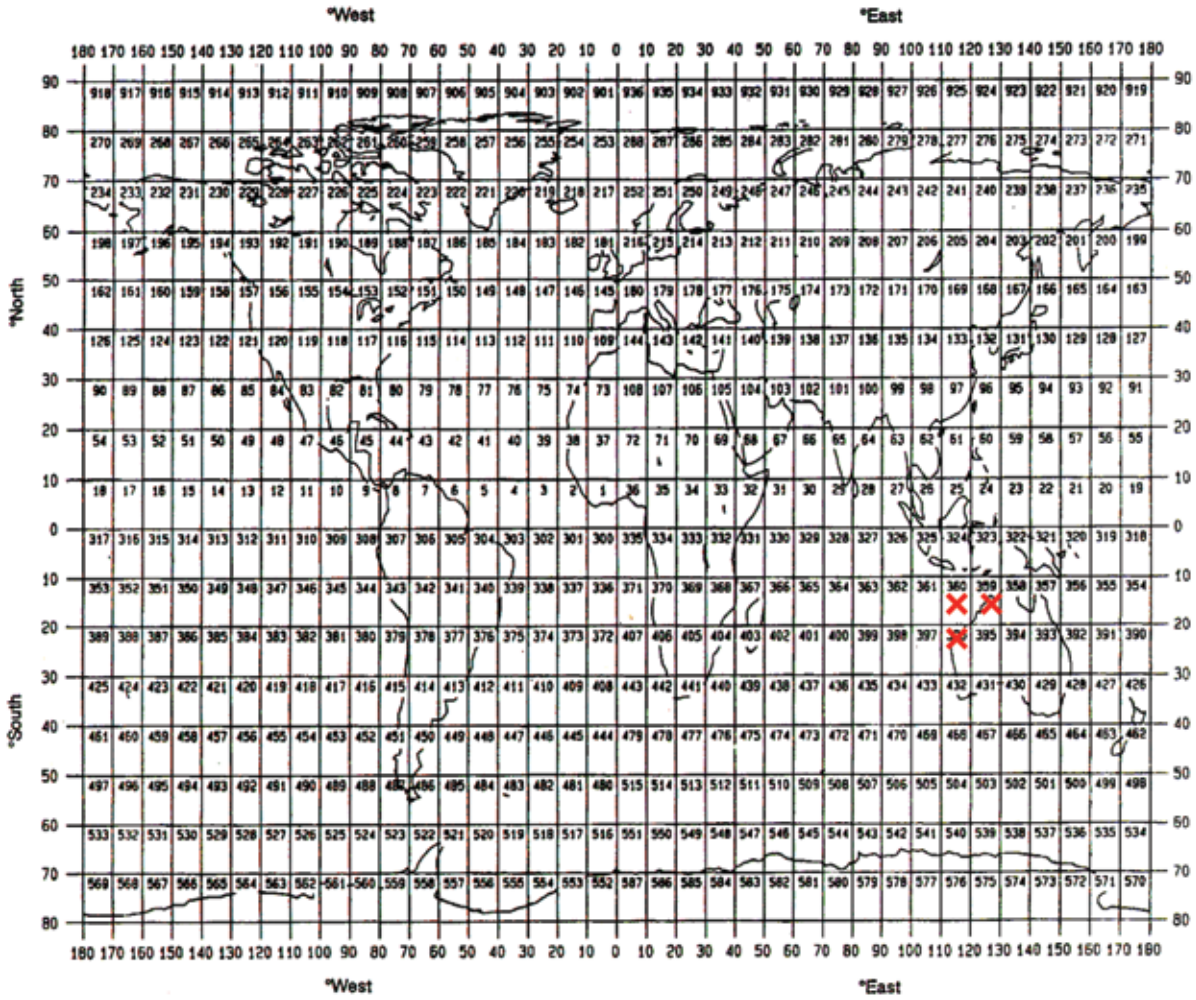
Coordinating body

Waite et al.

Principal investigators

A. Anya Waite
B. Vincent Rossi
C. Peter Thompson
D. Lynnath Beckley
E. Megan Saunders
F. Christin Säwström
G. Bronte Tilbrook / John Akl

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



MOORINGS, BOTTOM MOUNTED GEAR AND DRIFTING SYSTEMS									
Item No	**PI** See page above	**APPROXIMATE POSITION**						**DATA TYPE**	**Description**
		LATITUDE			**LONGITUDE**				
		deg	min	N/S	deg	min	E/W		
1 -	A&B	20	59.9	S	112	59.9	E	H71	Surface BOM Drifters with T, S and pressure sensors. Not recovered. #83502
2	A&B	21	005	S	113	58 14	E	H71	Surface BOM Drifters with T, S and pressure sensors. Not recovered. # 89782
3	A&B	21	0	S	114	42 49	E	H71	Surface BOM Drifters with T, S and pressure sensors. Not recovered. #83501
4	A&B	21	0	S	114	42.8	E	H71	Surface BOM Drifters with T, S and pressure sensors. Not recovered. #89783

SUMMARY OF MEASUREMENTS AND SAMPLES TAKEN					
Item No.	**PI** see page above	**NO** see above	**UNITS** see above	**DATA TYPE** Enter code(s) from list on last page	**DESCRIPTION**
1 – CTD Casts	A&B -all	109	CTD drops to 1000 m	H17 H11 H21 BO2 H16 D71 H90 – ISUS	Continuous recording of : T, S, oxygen, Chlorophyll fluorescence, transmission, ADCP, and ISUS nitrate sensor (H90)
	G – H27 Hydrochem – H21, nutrients	109 @ 3 – 10 depths		H21 H24 H25 H76 H26 H27 H10 B02	Bottle samples taken from CTD for on-board analysis of : Alkalinity (3 / cast) Salinity / Oxygen (3/ cast) Nutrients : Nitrate + nitrite, Ammonium, Silicate,Phosphate (10/ cast) Chlorophyll a (2 size fractions) (5 / Cast)
	A,(w/B,E&F)– B07, B01, B06 C-B02-HPLC	20 CTD stations	Stations	B01 B71 B06 B72 B09 B13 B14 B08 B07 B90 – Genetics	Primary Production Station Bottle Sampling : Subset of above also including : Primary Production and nutrient uptake measurements, Particulate and dissolved organic matter, Phytoplankton and bacterioplankton and viruses and bacterial genetics (4-5 depths per cast)
2- UW	A&B - TBC H71 B02 G- H27 & H90		Voyage track	H71 B02 H27 H90 – Oxygen /Ar ratio	Underway Measurements
3 - Nacelle	A? C? &B-TBC	21	Files	H71 B02 + H90 (Ecopuck)	Nacelle Tow-Yo Deployments – deployment of towed body containing T, S, and pressure sensors plus an Ecopuck with transmission at several wavelengths
4-BongoNets	D- B14/ B14/B09	?	Net Hauls	B14/B14/B09	Bongo Net Deployments

CURATION REPORT	
Item No.	**Description**
1	A / B (UWA/UNSW) :
2	A (UWA) C (CSIRO) – Bacterial / picoplankton/ virus samples and Particulate samples other than HPLC to be returned to UWA for analysis. HPLC samples to be analyzed at CMAR Hobart, CSIRO. Dissolved isotope samples to ber un by UCal Davis. Bacterial genetics samples to be run at UWA & CSIRO. G – All alkalinity samples to be returnes to Tilbrook Laboratory, CSIRO for analysis
3	A (UWA) B(UNSW) C (CSIRO)
4	D – Murdoch University – All zooplankton samples to be stored in the Beckley laboratory at Murdoch University.

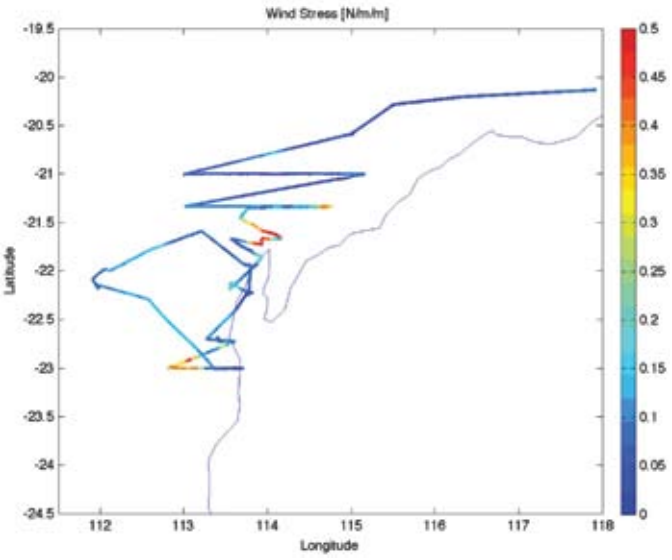


Figure 1: shows wind stress along ship track (courtesy of G. Brassington, BOM).

GENERAL OCEAN AREA: Eastern Indian Ocean

SPECIFIC AREAS: Shelf and ocean areas adjacent to, and upstream of, Ningaloo Reef

PERSONNEL LIST

Scientific Participants

Name	Affiliation	Role
Anya Waite	UWA	Chief Scientist
Lynnath Beckley	Murdoch University	Deputy Chief Scientist
Vincent Rossi	Toulouse UNSW/UWA	Physical Oceanographer
Christin Säwström	UWA	Biological Oceanographer Nutrient Uptake
Megan Saunders	UWA	Biological Oceanographer Primary Production
Judith Meyer	Uni Kiel / UWA	Research Volunteer
Filtration, microbial sampling		
John Akl	CMAR	Research Technician
Alkalinity, pCO2		
Nick Breheny	Murdoch University	Research Technician
Zooplankton, Fish Larvae		
Lisa Woodward	CMAR	MNF Voyage Manager
Pamela Brodie	CMAR	MNF Computing support
Drew Mills	CMAR	MNF Electronics Support
Peter Hughes	CMAR	MNF Hydrochemistry Support
Dave Terhell	CMAR	MNF hydrochemistry support

Marine Crew

Name	Role
Les Morrow	Master
John Boyes	1st Mate
Rob Ferries	2nd Mate
Nick Fleming	Chief Engineer
Dave Jonkers	1st Engineer
Grant Page	2nd Engineer
Tony Hearne	Chief IR
Chris Softley	IR
Matt Barrett	IR
Jonathan Lumb	IR
Grant Webberley	IR
Darcey Chalker	Chief Steward
John Fabics	Chief Cook
Scott Nichols	2nd Cook

Acknowledgements

We acknowledge funding from the Australian Research Council to A. M. Waite and co-workers, contributions and equipment from the CSIRO, and drifters generously provided by the Bureau of Meteorology. We particularly thank Lisa Woodward for generous help at sea.

Chief Scientist
Anya Waite

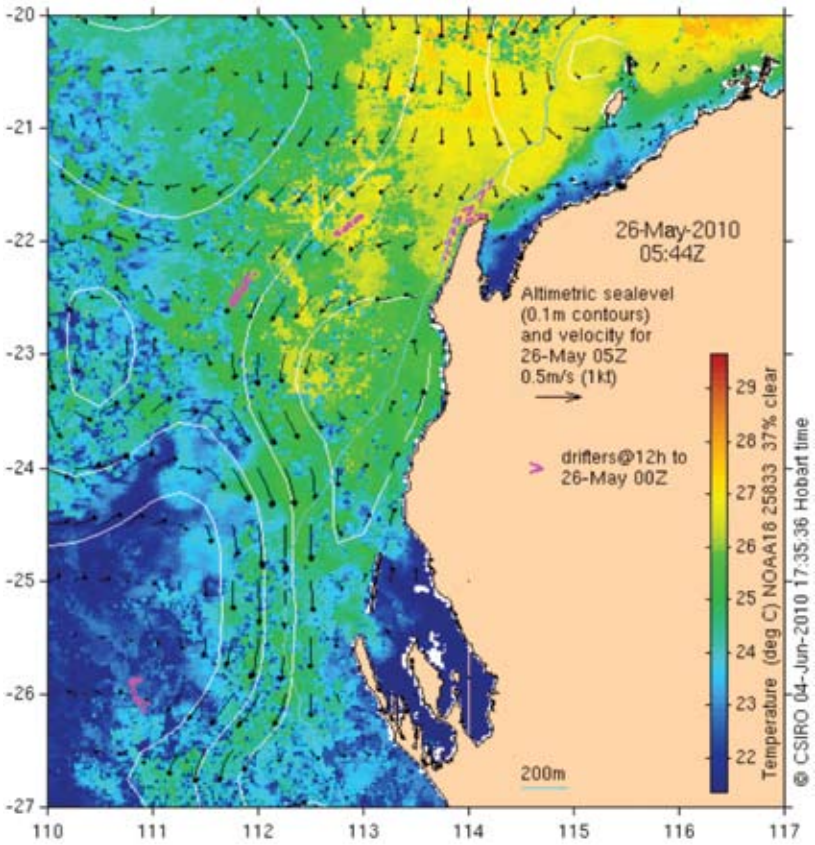


Figure 2: Geostrophic currents on 26 May 2010 in our research area showing drifters as pink arrows adjacent to Ningaloo Reef, off Northwest Cape. (Courtesy of D. Griffin, CSIRO).

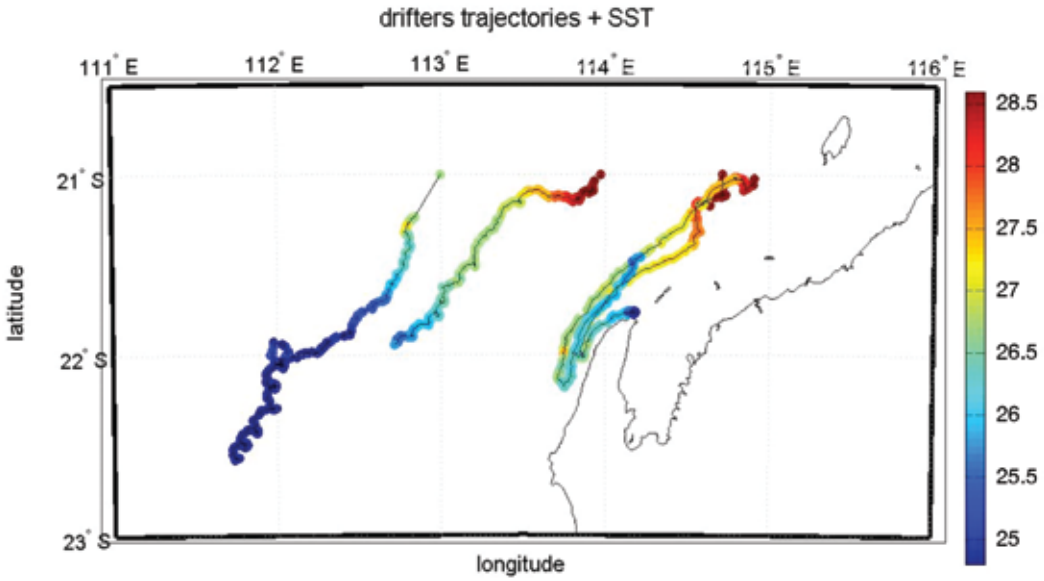


Figure 2: 4 surface drifters trajectories at the 26/05/2010 with along track recorded Sea Surface Temperature. (Courtesy of Vincent Rossi).

CSR/ROSCOP PARAMETER CODES

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