2006 RV *Southern Surveyor* program

MARINE
NATIONAL FACILITY

voyageplan

SS05/2006

Mesoscale Eddies as coastal pumps: quantifying eddy-mediated cross-shelf transport of nutrients, production and fish larvae off the WA coast.

Itinerary

Depart Fremantle 1600hrs, Tuesday 2 May 2006 after mobilising
Arrive Geraldton 0800hrs, Saturday 27 May 2006 and demobilise

Principal Investigator

Dr. Anya M. Waite (Chief Scientist)
School of Environmental Systems Engineering, University of Western Australia
Phone: (08) 6488 3082 **FAX:** (08) 6488 1015 **Email:** Anya.Waite@uwa.edu.au

Scientific Objectives

The oceanography off the coast of West Australia (WA) is dominated by the dynamics of the Leeuwin Current which transports surface waters poleward, suppressing upwelling which would otherwise supply surface nutrients for productivity in these regions. The WA coast is therefore very low in nutrients, or "ultra-oligotrophic". In such waters, production hinges on the delivery of nutrients into surface waters via upwelling, atmospheric fixation, or the presence of meso-scale cyclonic eddies that "pump" nutrients into surface waters.

CSIRO

A large mesoscale eddy field is formed seasonally by the Leeuwin Current, with its highest energy in autumn / winter between the Abrolhos Is. and Cape Leeuwin. Eddy dynamics clearly influence the biological productivity of the region, and may control the recruitment dynamics of fish and shellfish larvae, through nutrient pumping and the transport of productive coastal waters offshore.

Here we propose to investigate the potential role of these eddies in transporting productive coastal water relatively enriched in nutrients, primary production, zooplankton and fish larvae, off the shelf and into ultra-oligotrophic open ocean waters. We hypothesize that this transfer could have widespread implications for regional ecology, including enhancement of offshore production rates, and removal of finfish and shellfish larvae from the coastal zone. For short-lived larvae, such transport might represent a significant loss to recruitment; for long-lived larvae such as the rock-lobster, the transport may be a beneficial part of their life cycle. Eddy cross-shelf transport may be part of an as yet unstudied larger-scale contribution of coastal production to open ocean ecology, with the eddies acting as oceanic predators on more productive coastal ecosystems. Finally, organic rain generated from the eddies could impact deep benthic populations (including adult rock lobster) which might benefit from the export of productivity from the coast.

Our plan is to map up to two eddy features off the coast actually as they form, documenting the transport of nutrients, productivity, and fish larvae from shallow coastal waters across the 200 m isobath and into open ocean waters. We will document in detail the productivity and the biogeochemical transport within the features. We will then make an estimate the fate of the nutrients and productivity via collaboration with the biogeochemical modelling group at the CSIRO. For the purpose of this study, the term "eddy" will include eddy-like cross-shelf features such as filaments, jets and meanders, once they reach a critical size and shape.

Voyage Objectives

Overall Objective

To quantify the cross-shelf transport of nutrients, primary production and fish larvae by eddies forming off the WA coast

Hypotheses to Test

1. Warm-core and cold-core filaments / eddies forming on the coast trap water masses containing significant enrichment of nutrients, phytoplankton and fish larvae in comparison to adjacent open ocean waters

2. Once formed, both warm-core and cold-core features move enriched water masses offshore at a measurable rate

3. Cyclonic (cold-core) features, where present, act to upwell nutrients from the base of the Leeuwin Current

4. Filaments / eddies generally move water masses offshore over a time scale that is longer than coastal finfish larvae survive (~1 month), and thus act as oceanic predators on coastal larvae

6. Eddies, meanders or filaments can enhance primary production of the offshore region

Voyage Track

Area of operation: The general area of operation extends between 28-34oS and the furthermost westerly extent of the voyage would be offshore to the ~2000 m depth. Archived satellite images indicate that eddies off Central WA are recurring within these boundaries (Figure 1), especially in autumn as the Leeuwin Current intensifies. For ship track see Figures 1 and 2, attached.

Time Estimates

12.6 d per Feature = 25.2 d + ~2 d contingency

FEATURE 1
Leg 1- SeaSoar Survey – 4.6 days (See Appendix 1A)
Leg 2 – Intensive sampling – 8 days (See Appendix 1B for sampling schedule)
Sediment Trap Deployments (PP= Production station) See ship track for locations:

	Initial Deployment	Revisit @ end of Leg 1 Survey	Revisit during intensive survey	Pickup before progress to Feature 2
TRAP 1	Deploy/PP @ 1.7 d	Redeploy/PP 4.2 d	Redeploy/PP 8 d	Pickup 12 d
TRAP 2	Deploy/PP 1.9 d	Redeploy/PP 4.3 d	Redeploy/PP 9 d	Pickup 12 d
Time Gap		~2.5 d	~4 d	~3-4 d

FEATURE 2 – Repeat sampling (above) for 2nd feature; Possibly re-sample Feature 1.

RV *Southern Surveyor* Equipment

• SeaSoar • EZNet • ADCP • Scintillation Counter
• Rosette / CTD sampler with fluorometer, light meter and transmissometer
• 24*10L Niskin bottles • Flow-through fluorometer / temperature sensor
• Meteorological station (wind, temperature, light sensors) • Autoanalyzer(s)
• General Purpose Lab to be configured for C^{14} work (radiation approval required)

User Equipment

• Sediment Traps / moorings • 2 Iridium tracking buoys
• Underwater Video Profiler http://www.obs-vlfr.fr/LOV/ZooPart/Portal/
• Bongo Nets (TBA) • Neuston net (TBA) • Deck Incubators
• Microscope + Video/Screen • Filtration apparatus • PAM fluorometer
• Turner Designs Fluorometer

Personnel List

Personnel	Role at sea – Scientific Role
Anya Waite – UWA	Chief Scientist – Assist with Phytoplankton as available
Peter A. Thompson – CSIRO	Deputy Chief Scientist – Phytoplankton (HPLC / POC/PON biomarkers)
Lindsay Pender, CSIRO	Voyage Manager – Computing Support
Pru Bonham, CSIRO	Collaborating Technician - Phytoplankton
Stephane Pesant – Villefrance-sur-mer (France)	Visiting Investigator – Primary production and sediment traps
Jason Landrum – Georgia Institute of Technology (USA)	PhD student – Phytoplankton Nitrogen fixation, and NO3 and NH4 uptake experiments
Moira Llabrés – (Spain)	PhD Student – Bacteria, cell lysis / DOC /Productivity
Harriet Paterson	PhD student- Microheterotrophy / picoplankton
Marc Pichard (France)	Collaborating Scientist / Technician – Zooplankton species composition /Underwater Video Profiler / Zooscan
Lynnath Beckley	Principal Investigator – Fish and fish larvae
David Halliday	PhD student – Fish and fish larvae
Drew Mills	Electronics Support (System Support Technician)
Neal Johnston	Hydrochemistry Support(System Support Technician)
Alicia Navidad	Hydrochemistry Support

This voyage plan is in accordance with the directions of the National Facility Steering Committee for the Research Vessel *Southern Surveyor.*

Anya M. Waite
Chief Scientist

Figure 1: Ship Track Leg 1 – SeaSoar runs punctuated with Production Stations

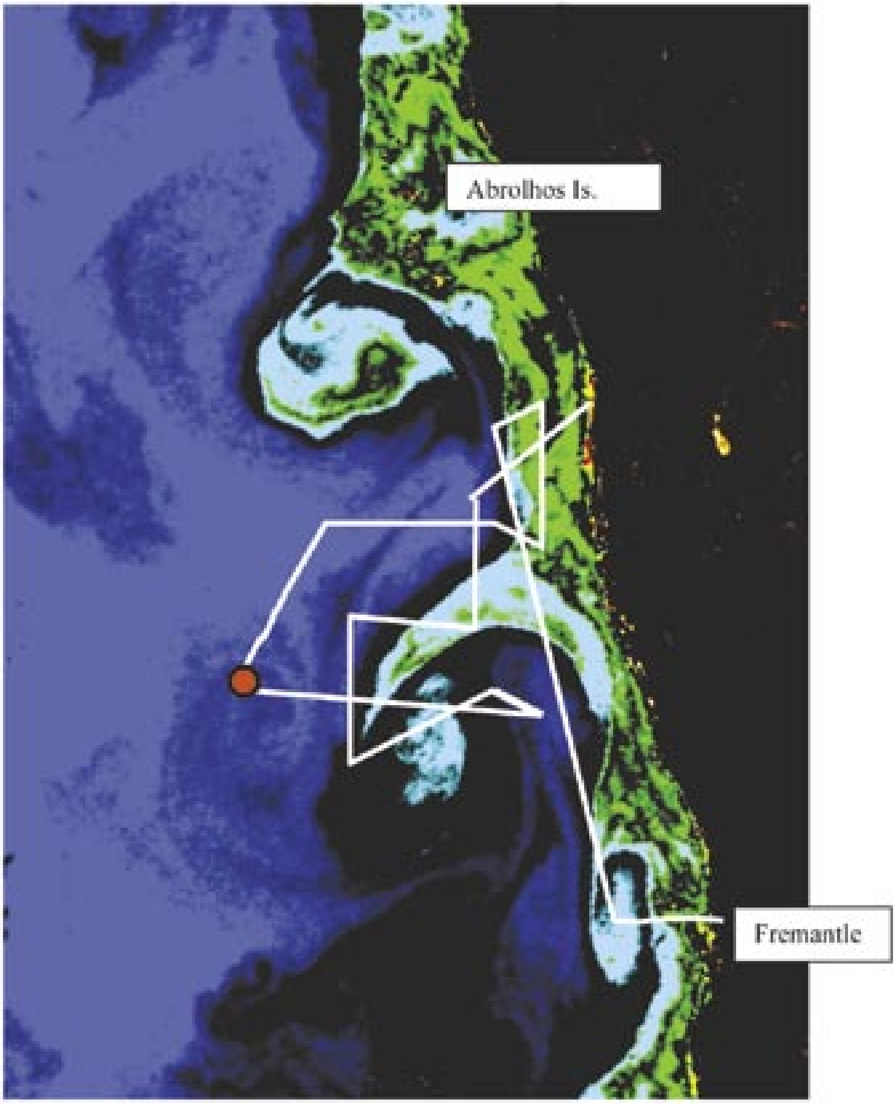
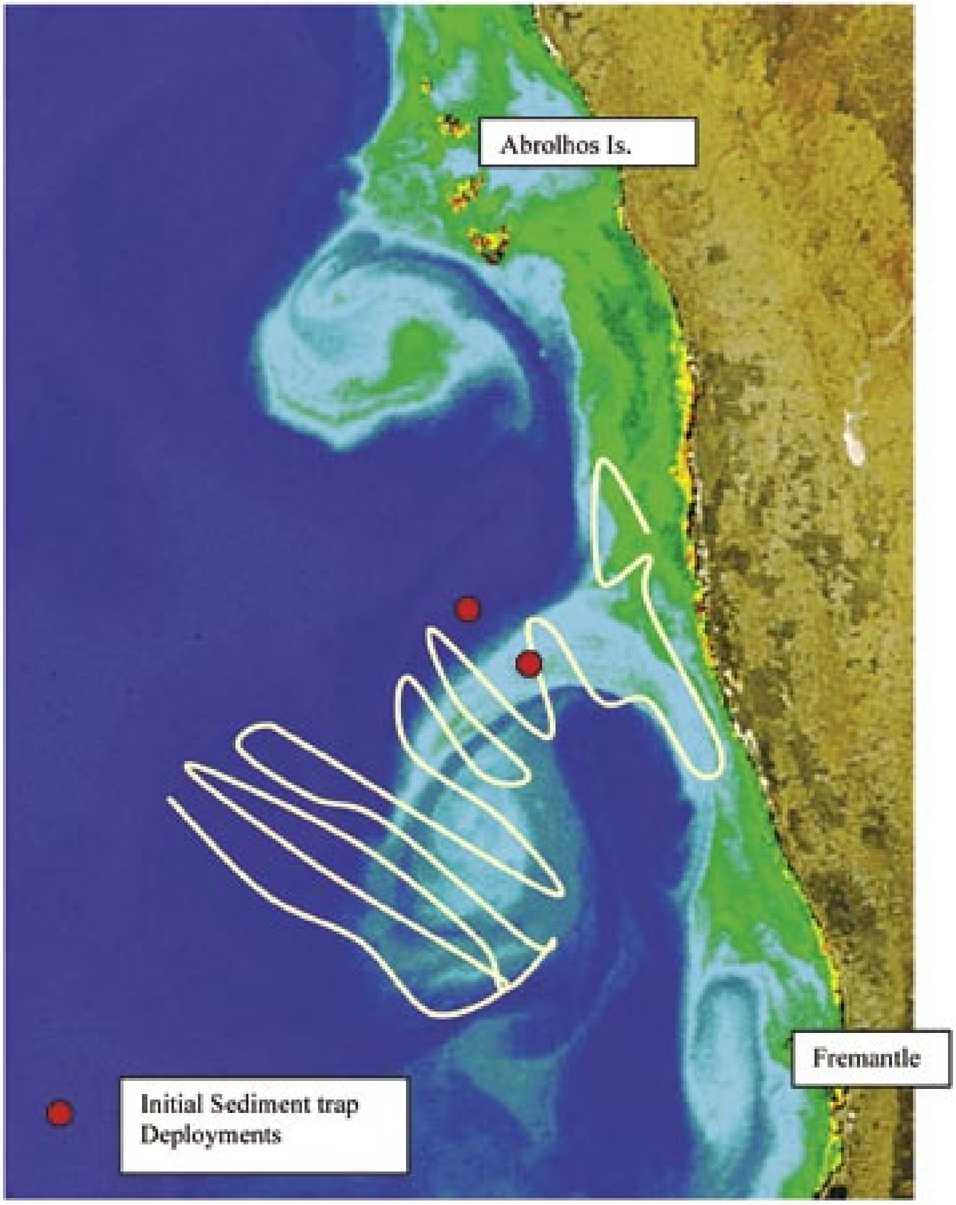


Figure 2: Ship Track Leg 2 –Intensive Survey with 6-8 CTD stations / day



APPENDIX 1: Time Estimates for SS05/2006

Leg 1: SeaSoar Survey punctuated with Productivity Stations – 4.6 Day total

LEG / Sector	Activity	Distance (km)	Distance (nm)	Speed	Time (h)	Day	Time (Local) 24 hr clock
LEG 1: Feature Survey - (Total 4.6 DAYS)							
Freo - Stn 0		60	31.91	10	3.2	0.13	
Station 0 Test	CTD				0.8		
	EZ / UVP				1.5		
	Deploy SS				0.5		
SS 1		360	191.49	8	23.9	1.24	14.88
	Retrieve SS				0.5		
end SS1 to Stn1		60	31.91	10	3.2	1.40	18.72
Station 1	CTD				0.8		
Stn 1 to Stn 2		80	42.55	10	4.3	1.61	23.76
Station 2	CTD (Productivity to run next am?)				0.8		
	Deploy Sed Traps				1.5	1.70	
Stn 2 to Stn 3		50	26.60	10	2.7	1.81	4.56
Station 3	CTD				0.8		
	Deploy Sed Traps				1.5		
	Deploy SS				0.5	1.93	
SS 2		180	95.74	8	12.0	2.43	19.44
Station 4	Retrieve SS				0.5		
	CTD				0.8		
Stn 4 to Stn 5		80	42.55	10	4.3	2.65	0.72
Station 5	CTD (Productivity)				0.8		
	Deploy SS				0.5		
SS 3		200	106.38	8	13.3	3.26	15.36
Station 6	Retrieve SS				0.5		
	CTD (Productivity to run next am?)				0.75		
	Deploy SS				0.5		
SS 4 - back to Offshore Flow		280	148.94	8	18.6	4.11	9.12
	Retrieve SS				0.5		
	CTD/Productivity Trap 2(collect to run next am)				1.0	4.17	
Trap 2 to Trap 1					2.7		
	CTD/Productivity Trap 1 (collect to run next am)				1	4.33	
Trap 1 to Source N		100	53.19	8	6.6	4.60	

Leg 2: Intensive Sampling – Schedule below is 24 hrs; this would be repeated roughly 8 times for a total of 8 days, with the exception of Sediment Trap deployments.

LEG / Sector	Activity	Distance (km)	Distance (nm)	Speed	Time (h)	Day	Time (Local)
LEG 2 : Intensive Feature Sampling – TOTAL 8 DAYS							
Station 10					110.4	4.60	23.52
(Source N)	CTD (Productivity)			1			
	EZNet				1.5	4.7	
	UVP (?)				1		
	Bongo				0.5		
Stn 10 to Stn 11		60	31.91	10	3.2	4.90	0.72
Station 11	CTD Quick Dip			1			
Trans		50	26.60	10	2.7	5.05	4.32
Station 12	CTD Quick Dip			1			
Trans		50	26.60	10	2.7	5.20	7.92
Station 13	CTD Quick Dip			1			
Trans		50	26.60	10	2.7	5.36	11.76
Station 14	CTD Quick Dip			1			
	UVP - Night			1.0			
	EZNet - Night			1.5			
Trans		50	26.60	10	2.7	5.61	17.76
Station 15	CTD Quick Dip			1			
Trans		50	26.60	10	2.7	5.77	21.6
Station 16	CTD (Productivity)			1			
(Source C)	Bongo				1.0		
	UVP - Day			1			
	EZNet - Day			1.5			