VOYAGE PLAN SS08/2003

Title
Meso-scale eddies off SW Australia: death traps or nurseries for fisheries recruitment

Itinerary
Depart Fremantle 1000 hrs, Wednesday 1 October, 2003
Arrive Fremantle 1000 hrs, Thursday 23 October, 2003

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Scientific Objectives
In the ultra-oligotrophic waters off Western Australia (WA), production hinges on the import of nutrients into surface waters through upwelling and meso-scale cyclonic eddies. Upwelling is largely suppressed by the Leeuwin Current on this coast, so cyclonic eddies are possibly of major importance for the overall productivity of the region. Satellite estimates of surface chlorophyll can show enhanced productivity associated with such eddies. They are consequently considered possible sites of enhanced growth rates ("Nurseries") for fish larvae and rock lobster phyllosoma, whose dispersal, retention and nutrition are poorly understood.

In contrast, anticyclonic eddies are areas of convergence where enhanced productivity is less likely. Whether larvae are actually being aggregated in these eddies is unknown. Such eddies are possible "Death-Traps" for larvae whose recruitment success depends on their nutrition. In "Death-Trap" eddies, larval nutrition may depend on the availability of nitrogen "fixed" from the atmosphere by specialized organisms called cyanobacteria, and the palatability of cyanobacteria to grazers.
Our key objectives are to understand the impact of cyclonic and anticyclonic eddies on the productivity of the eastern Indian Ocean, and to determine the links between the physical oceanography of these eddies, vertical nitrogen fluxes, productivity and larval fish survival.

Voyage Objectives
Here we propose to study in detail a cyclonic eddy, and an anticyclonic eddy, off the coast of WA. We will determine whether "nutrient pumping" occurs (in the cyclonic eddy) and quantify the primary and secondary production inside and outside the two eddies. Our approach is to map the eddies repeatedly in 3-D, each map (or "pass") taking ca. 36 hours, using a combination of Niskin Bottle Rosette sampling and underway measurements of currents (ADCP), T-S signature (SeaSoar CTD), primary production (in-situ PAM fluorescence), and zooplankton abundance (Multi-frequency acoustic system).

At sampling stations we will collect water for nutrient analyses, primary production (^{14}C—uptake, radioactive) and secondary production, determined from depth-stratified samples obtained with Niskin Bottles on the rosette, and E-Z plankton nets. Filtered water samples from the Niskin bottles will be analysed for particulate carbon and nitrogen, and size-fractionated nutrient isotope signatures. Nutrient uptake experiments on the same water samples will be executed to determine the uptake of N_2 gas (fixation), Ammonium and Nitrate using heavy isotopes (^{15}N; non-toxic & non-radioactive). In the centre of each eddy, we will deploy an array of floating sediment traps tethered to an IRIDIUM buoy to estimate the downward export flux of organic matter inside each eddy. The sediment traps will be collected and re-deployed each 2 - 3 days as an eddy map is completed. We will map each eddy up to 6 X during the study depending on the eddy size (see time estimates for eddy transects, below). For full details see SAMPLING STRATEGY below.

Voyage Track

The estimated latitude and longitude of the eddies to be studied will be determined in collaboration with physical oceanographers 1 month — 2 weeks before the start of the voyage. The eddies chosen will be between Cape Naturaliste and the Abrolhos Is. (Fig. 1), ideally close to the shelf break such that the eddies' impact on larval transport on and off the shelf can be estimated. We will require a brief visit to shore between the two eddies on October 12th — 13th to exchange two scientific staff (Beckley and Gaughan).

Please note: A map of all possible small boat landing sites between Cape Naturaliste and the Abrolhos can be found at the following web address (original information from Fisheries WA): www.cwr.uwa.edu.au/~waite/AWcombined.pdf . All landing sites with leading lights are indicated on this map with a star (*); however note that the passages through reefs are reasonably long in some cases. We have allowed 30 h steaming shorewards from the eddy and 3 h for the small boat manoeuvre.

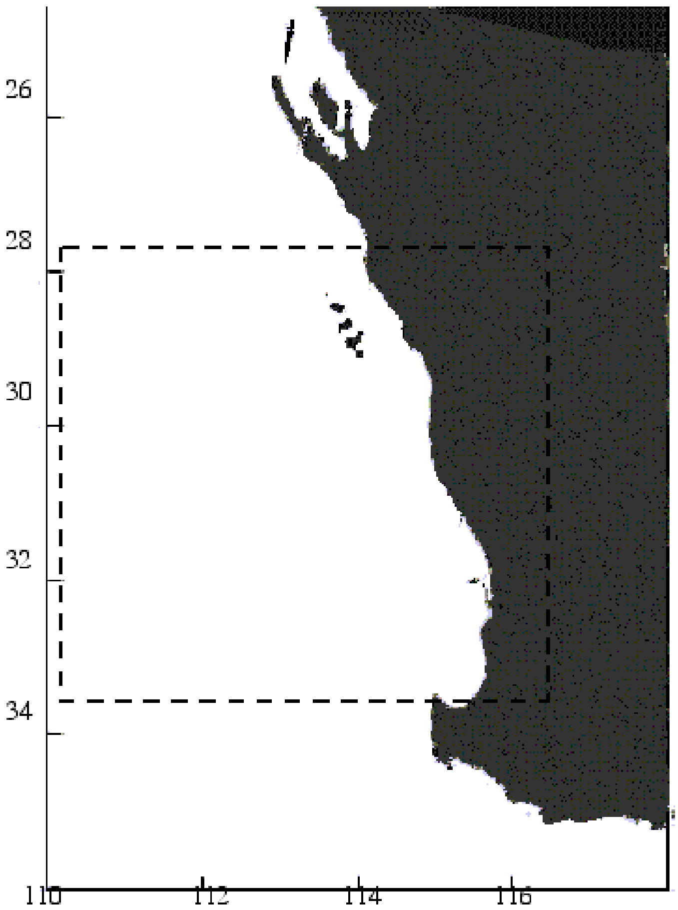


Figure 1. The general area of operation (dashed box) extends between 28-34ºS and offshore to 110ºE. The proposed start and end port is Fremantle.

Table 1. Time Estimates
Day
OPERATION
STEAMING TIME
STATION TIME
1
Fremantle to First Eddy
10-30 hrs @ 10 knots +
4 Hrs Test Station
Test station 2 hrs
2 - 11
First Eddy
Passes 1-6
Seasoar Transect: ~ 10 hrs @ 8 knots, followed by
Rosette Transects (2): Total ~26 hrs; 8 hrs @ 10 knots +
18 h station time
3x 4 hrs

12 — 13
First Eddy to Shore Pickup & Return to Second Eddy
10-30 hrs @ 10 - 11 knots +
3 hour Zodiac to shore return
14 - 22
Second Eddy
Passes 1- 6
Seasoar Transect: 10 hrs @ 8 knots, followed by
Rosette Transects (2): Total ~26 hrs; 8 hrs @ 10 knots + 18 h station time
23
Second Eddy to Fremantle
10-30 hrs @ 10-11 knots
Contingency:
TOTAL:
Conservative estimates used à ~70 h contingency
490 -556 hrs (23 days)

Piggy-back Projects

Proposed: Dr. Laurence Deydier-Stephan has applied for an EU fellowship to study the picoplankton growing within the eddies. Small (1 mL) samples for flow cytometry will be preserved in liquid nitrogen for Dr. Deydier-Stephane to analyse after the voyage. This should represent a minimal time requirement for those filtering for pigments and organic material.

Southern Surveyor Equipment / Services

- Scintillation counter
- E-Z trawl equipped with opening and closing nets (replaces the IST originally required)
- SeaSoar mounted with CSIRO CTD and CSIRO fluorometer
- Multi-frequency acoustic system
- 24-Bottle ROSETTE SAMPLER, 10L & 5L Niskins with Silicon rubbers and O-rings, Temperature, Salinity, Fluorescence, Underwater PAR to 500 m
- nutrients (Nitrate, Ammonium (?), Silicate and Phosphate) from all bottles
- salinity calibration samples from 2 depths per cast only
- UNDERWAY: ADCP, Thermosalinograph, Surface fluorescence, SeaSoar CTD, and Surface nutrients (Nitrate, Ammonium (?), Silicate and Phosphate)
- Navigation
- Meteorological data

User Equipment

- PAR and Spectral Radiation sensors
- Photosynthetron lab incubator
- Simulated in situ incubator (on deck)
- One drogue w/ sediment traps, 200 m of cable, an Iridium buoy and a strobe
- Instrumented bongo net with 300 and 500 µm mesh (Tony Koslow, CSIRO)
- Secchi Disc

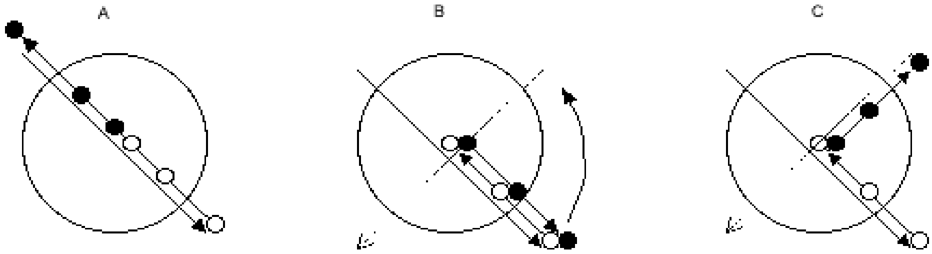
Personnel:

Scientific Staff

Dr. Anya Waite	CWR	(Chief Scientist) Phytoplankton
Dr. Stephane Pesant	CWR (Deputy Chief Scientist)	Phytoplankton
Dr. Peter A. Thompson	CSIRO Hobart	Phytoplankton
Carrie Holl	Georgia Institute of Technology	Phytoplankton
Joanna Strezlizki	CSIRO	Mesozooplankton
Barbara Mohling	Murdoch University	Fish Larvae (FL)
Harriet Patterson	CSIRO / UWA	Microzooplankton
Dr. Lynnath Beckley	Murdoch University	FL (Days 1 — 12)
Dr. Dan Gaughan	Fisheries WA	FL (Days 13 — 23)
David Terhell	CMR, Hobart	Hydrochemistry
Mark Rayner	CMR, Hobart	Hydrochemistry
Lindsay Pender	CMR, Hobart, (Voyage Manager)	Computing/SeaSoar
Mark Underwood	CMR, Hobart	Electronics

Please note: After extensive discussion with National Facility staff and our own staff, we have concluded that two hydrochemists will be essential for our voyage. Our revised plan is to do a total of up to ~1400 - 1600 nutrient samples (under consultation with the hydrochemists). This would include the possibility of some additional "quick dip" CTD stations for CTD, fluorescence and nutrients only, in between the regular stations if time permits, and / or more detailed sampling of surface waters from the in-line system on SeaSOAR transects.

SAMPLING STRATEGY
The sampling strategy is based on eddies with a diameter of 100 km. The table below shows how eddies of different diameters would change the sampling strategy.
The strategy is a combination of synoptic transects across the eddy, day-time stations and night-time stations. These sampling components are detailed below.
One "pass" at the eddy consists of one synoptic transect, 3 day-time stations and 3 night-time stations. The diagrams below show three potential voyage tracks that correspond to one "pass". It is likely that we will use option C for most passes.



- We plan to do 6 "passes" in each eddy.
- If the two eddies are adjacent, we may do three synoptic transects across both eddies, i.e. at the beginning, middle and end of the voyage.
- Sediment traps are recovered/re-deployed every second "pass", at dusk, for a total of 3 deployments/recoveries per eddy.

ADAPTING THE SAMPLING PLAN TO EDDY DIAMETERS

Eddy Diameter	Study Area Diameter	SeaSoar cross-section time @ 8 knots	Stations cross-section time @ 3hrs/stn @ 6stns*	Number of SeaSoar+Stn cross-sections per eddy
Km	Km	Hours	Hours	#
<50	50	4	20	9
100	150	10	26	6
250	300	20	34	4

* 3 Day-stations (Outside, Inside, Centre) and 3 Night-stations (Outside, Inside, Centre)

SAMPLING COMPONENTS (100 km EDDY)
SYNOPTIC TRANSECTS ACROSS THE EDDY (SEASOAR)
150 km @ 8 knots = 10 hours
Non-stop underway sampling
SeaSoar (CTD, Fluorescence)
ADCP + Acoustics

Underway Thermo-Salinograph System (T, S, fluorescence) — Nutrient and PAM analyses will be done by regular sampling of the outflow, i.e. 12 times

SYNOPTIC TRANSECTS ACROSS THE EDDY (IF SEASOAR FAILS)
150 km @ 10 knots + 9 stations @ 0.5 hours = 12 hours
9 Quick stations evenly distributed along the transect
CTD down to 300 m
NISKIN fired at 12 depths: 300, 250, 200, 150, 130, 110, 90, 70, 50, 30, 10, 1 m

DAY-TIME STATIONS
75 km @ 10 knots + 3 stations @ 3 hours = 13 hours
Stations are located Outside, Inside, and in the Centre of the eddy.

GEAR in order of deployment	TIME (hrs)	DEPTH STRATIFICATION	TEAM ON DECK
Secchi disk	0	Secchi depth	1-3 Phyto
Bucket	0	0 m	
Deck plankton pump	0	Chla max	
CTD/Rosette/PAR	1	12 depths: 500, 300, 250, 200, 150, 130, 110 m and 5 depths in the euphotic zone	
1 Oblique Bongo Tow	.5	0-200 m	2 Zoo/Fish
1 Bongo Tow	.25	0-10 m	
1 EZ Net Tow	1	0-10 m, 20 m intervals down to 100 m and 100-200 m	
TOTAL	2.75		

NIGHT-TIME STATIONS
75 km @ 10 knots + 3 stations @ 3 hours = 13 hours
Stations are located Outside, Inside, and in the Centre of the eddy.

GEAR	TIME (hrs)	DEPTH STRATIFICATION	TEAM ON DECK
Bucket	0	0 m	1 Phyto
CTD/Rosette/PAR	1	12 depths: 500, 300, 250, 200, 150, 130, 110 m and 5 depths in the euphotic zone	
1 Oblique Bongo Tow	.5	0-200 m	2 Zoo/Fish
1 EZ Net Tow	1	0-10 m, 20 m intervals down to 100 m and 100-200 m	
1 Neuston Net Tow	.5	0-10 m	
TOTAL	3		

DRIFTING SEDIMENT TRAPS (2 hours) : Deployed in the center and left to drift for 2-4 days
Recovered and redeployed in the center of the eddy

See attached document for deployment/recovery procedures (Section C SEDIMENT TRAP DEPLOYMENT)

SEDIMENT TRAP DEPLOYMENT & RECOVERY

The deployment and recovery of the sediment traps is done on the trawl deck using the A-frame or the gantry depending on the ship's design. Deployments go weight first and we add the pieces of equipment as it goes in the water. Recoveries are the reverse. The pieces of equipment are:

Weight(40kg)-20mCable-BottomTraps (200m)
TopTraps (50m)
MidWaterFloats (20m)
SurfaceFloats-10mCable-PositioningBuoy (Surface)

Deployments

Step 1. All the cable-shackles-rings is already winded on the winch.

Step 2. The weight-20mcable-BottomTraps are shackled to the end of the line and deployed with the A-frame to ensure that the traps remain relatively straight (vertical and not at angle). To do so, the A- frame is extended at the back with the traps hanging and the weight still on deck. The weight is sent overboard when the traps clear the back of the ship and can be lowered in the water.

Step 3. Unwind 150m of cable; secure the lower section of the line (sea-side) to the ship; open the line (winch-side) and insert the second piece of equipment (TopTraps). A rope (without knots) is passed through the ring below the traps to pull the weight of the line (sea-side), so that the traps remain vertical during their deployment. The rope is pulled out of the ring once the traps clear the ship and are vertically aligned with the line (sea-side). The rope shouldn't catch, but if it does it is not a big problem as it will be below the traps.

Step 4. Unwind 20m of cable; attach the MidWaterFloats; no need to open the line as the floats are simply shackled on the line.

Step 5. Unwind 30m of cable; the last 10m is composed of bungy cords; attach the SurfaceFloats-10mCable-PositioningBuoy and let go

Recovery

Steps. Exactly the reverse of the deployment.

Note 1. The important bit is to grab the line below the sediment traps (there is a ring 1m below the traps) and to pull on it manually to take the weight of the line (sea-side) so that the traps can remain vertical… otherwise they will tilt and empty on deck.

Note 2. Spilling trap's content on deck is not hazardous, as we will not use preservatives in the traps.

Note 3. As we recover the traps, the line is wound on the winch and ready for the next deployment, which in most cases will happen immediately after recovery.

Pictures

The traps were successfully deployed and recovered three times on the Aurora Australis last season. Figures 2 — 4 illustrate the gear and deployment. Fig. 2 shows a complete deployment, Fig 3 shows one frame with traps. One drifter will carry two sets of these, one at 50m and one at 200m. Fig. 4 illustrates Step 3 of the Deployment or Recovery. Danny McLaughclan has seen the gear and the deployments and would be a good contact person for questions.

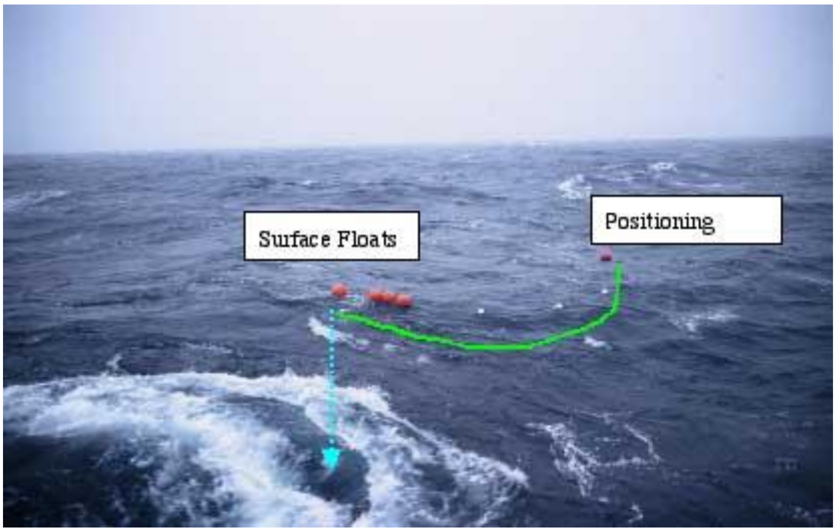


Figure 2. The array of surface floats and positioning buoy with drifter when deployed.


Figure 3. A single frame with trap


Figure 4. Step 3 of deployment / recovery.

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