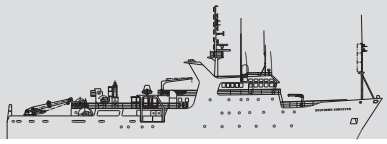

MARINE
NATIONAL FACILITY

2012 program

RV Southern Surveyor

CSIRO

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Voyage: The Biological Oceanography of Western Rock Lobster Larvae

Itinerary

Depart Fremantle, WA Australia
Sunday 25 August 2011

Arrive Geraldton, WA Australia
Tuesday 13 September 2011

Coordinating body

Waite team/UWA

Responsible Laboratory

The Oceans Institute, University of Western Australia
M047, 35 Stirling Highway, Crawley 2009

Principal Investigators

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Scientific Objectives

Lack of knowledge of Western Australia's fisheries oceanography fundamentally limits understanding of the recruitment of Western Rock Lobster, Panulirus cygnus, in a fishery worth $200-300 million/year to Australia. The life cycle of P. cygnus includes a planktonic "phyllosoma" larval stage that is transported up to 1500 km offshore via ocean currents. Development continues for approximately 9 - 11 months at sea, before juveniles ("puerulus") return over the shelf to recruit to coastal reef areas. Critical to improving the management of this fishery, which is under intensive review, is appropriate process information about the oceanographic mechanisms driving coastal recruitment. The last few years of puerulus settlement have been low, with the 2008/09 settlement the lowest in 40 years of monitoring and not explained by the environmental factors previously identified as affecting settlement. The cause of the low settlement represents a key unknown for managers assessing the sustainability of WA's coastal fisheries, and is likely to be driven by variation in food availability during the open-ocean stage of the phyllosoma larvae. Our study will test the hypothesis that the ocean productivity, particularly the nitrate-driven classic food chain supporting diatoms, copepods and other zooplankton, limits phyllosoma growth rate and survival in their oceanic phase.

We will execute this study at, or after the peak, of the autumn/winter plankton bloom in the Leeuwin Current, with the aim of quantifying oceanographic parameters crucial to modelling rock lobster larval dynamics.

Hypotheses:

1. Productivity of the offshore planktonic ecosystem drives phyllosoma nutrition and health, and is thus a critical variable driving recruitment success for the species. Specifically:
   a. The classic food web (nitrate → diatoms → copepods) is the primary source of food for rock lobster phyllosoma.

   b. Phyllosoma will be healthier (e.g., more lipid-rich) in denser patches of chlorophyll a, especially if the patches are long-lived (> 1 month) and contain developed zooplankton populations.

Late stage phyllosoma (VII – IX) should be available during the August / September period. These will be the focus of our study assessing health of late stage phyllosoma and their ability to metamorphose to puerulus.

Voyage Objectives

1. Remote Sensing: Prior to, and during, the voyage, the chlorophyll field in the study region will be examined, to identify the presence of oceanic chlorophyll a patches, as well as assessing the bloom status of the Leeuwin Current itself.

- Collection of phyllosoma for ship-board feeding experiments (Leg 1 / 6 days): We will target areas indicated by fisheries experts as collection areas for phyllosoma and use Neuston and Bongo nets to catch phyllosoma and their food. These experiments will be executed in 5 L and 20 L tanks installed on the back deck of the SS throughout the voyage. We will use Tow-yo transects as needed and the underway fluorescence to identify / confirm the presence of chlorophyll a patches as identified from satellite images. (6 Days)

2. Transects (Leg 2 / 5 Days): Survey of phyllosoma abundance across the 29 and 30 degree transects out to 112ºE. We will used the CTD at each station for nutrient uptake (3 hr per station) and sample with Surface ("Neuston") net each night from 10 pm to 2 am. Stations will be 30' longitude apart. In this phase we will make a preliminary assessment of the patchiness of both chlorophyll a and phyllosoma, as well as collecting detailed samples for biochemical analyses. We may use the Tow-yo and the underway fluorescence to identify / confirm the presence of chlorophyll a patches as identified from satellite images.

3. Targeted Patch / Front Sampling (Leg 3 / 10 Days): Patches identified as significant enough to provide enhanced food resources will be sampled in more detail to collect phyllosoma, both for more detailed biochemical analyses, and for experimental work. Areas will be indentified as enriched as chlorophyll a ("patches") and also sample areas deplete in chlorophyll a as controls. We will also specifically target the Abrolhos Front, if present, Sampling with CTD, bongo and neuston nets will be undertaken to provide experimental material.

4. We will use the Tow-yo and the underway fluorescence to identify / confirm the presence of chlorophyll a patches as identified from satellite images. During this stage of the voyage we will use the EZ net as necessary to resolve significant vertical gradients in plankton abundance.

Results and associated Voyage Narrative:

1. Remote Sensing: Prior to the voyage, the sea-surface properties including chlorophyll a indicated a stronger than usual Leeuwin Current for the late winter period, as well as the presence of a strong mesoscale eddy field between 29 S and 33 S that was likely to be a major factor structuring plankton populations. Our assessment of the presence of plankton patches therefore focused around the potential for key food-web differences to be manifested within the cold-core and warm-core eddies south of the Abrolhos Islands, some of which had been present in the region for $>$ 1 month. Important frontal areas between warm and cold sea-surface temperatures existed between 29 and 30 S and between 32 and 33 south; Argo float data suggested that in the south, the warm water of Leeuwin Current origin was up to 50 m deep. Modis chlorophyll a data was less available than we had hoped due to the variable cloud cover, but overall, we rate the success of this work as high.

2. Phyllosoma collection was highly successful, with a total collection of almost 1000 animals during the 3-week voyage. The surface net (known as the Neuston Net) was effective in collecting the animals at night, especially during the first week when night conditions were calm, and dark because of the new moon. While we initially had trouble collecting animals in good enough condition for feeding experiments, we found that towing more slowly (sometimes below 1 kt) and using shorter tows, as well as immediate immersion of the cod-end in filtered seawater upon arrival on deck, was effective in keeping the animals in good physical condition.

   However, almost immediately after the larvae were placed into our experimental tanks, we noticed that the animals refused to feed in the tanks. These were the same tanks used successfully for feeding in last year's experiments. We also noticed that there were excessive bubbles on the inside walls of the tanks. Some larvae developed white lines in their abdominal region and died. Three days of discussion and analysis led us to conclude that super-saturation of oxygen was occurring within the ship-board seawater line, which was toxic to the larvae. The problem was eventually quantified with the help of the hydrochemists Sue and Peter, who analysed the excessive oxygen content of the water (~275 μmol/L). The problem was then solved by rigging up a garden hose spraying into a large clean bin on the upper deck to de-oxygenate the water, followed by a gravity feed into our live tanks. The oxygen content was reduced to 225 μmol/L via this method, and the animals resumed normal feeding within a day. The feeding experiments confirmed our earlier discovery that chaetognaths were a preferred prey item for the phyllosoma; we also executed a number of experiments to identify preferred aspects of taste, size and texture of prey across several common prey types.

   Overall, the experiments were successful despite the early challenges. In 4 L pseudo-krysal tanks we executed prey choice / selection experiments, starvation trials, and behavioural experiments designed to test the optimal taste, texture and shape of available prey items. Because of our unprecedented success in catching live animals, we constructed an interim upwelling holding tank which we installed at the back of the fish lab. This was constructed from a net sampler, a nally bin and various screens and hoses.

3. **The patch (eddy) CTD, Bongo and Neuston net surveys** were undertaken in the first week of the voyage, when we had very calm conditions, and no major sampling challenges.

4. **The 29 S and 30 S transect surveys** were completed in the second week of the voyage, when sea conditions worsened and we experienced winds of up to 40 kts, though mostly SE 25-35 kts. This made net work challenging. However, excellent ship handling and deck support allowed us to continue to operate through the entire period. Daily bongo use at each station was hampered by impaired data streams between the bongo net unit, the internal deck unit, and software. Though the computing and electronics team did their utmost for us, these problems continued throughout the survey. We completed the final few tows as "blind" bongo hauls, without pressure sensor, but using the wire-out indicator and angle of the wire to estimate depth. We lost one CTD day due to a CTD cable failure caused by a kink in the live cable. This was repaired this immediately to minimise time losses. The "Tow yo" or Nacelle functioned well for almost two weeks, when a suspected battery fault in the Eco-puck turned out to be a significant leak in the housing. The unit took on water and failed completely. We therefore could not do a complete survey of spatial variability of the sub-surface chlorophyll a field. However we did some extra CTD casts which compensated somewhat for this. We also used the CPR whenever we had a long leg to steam, including our return to Geraldton from our last station between 32 and 33S.

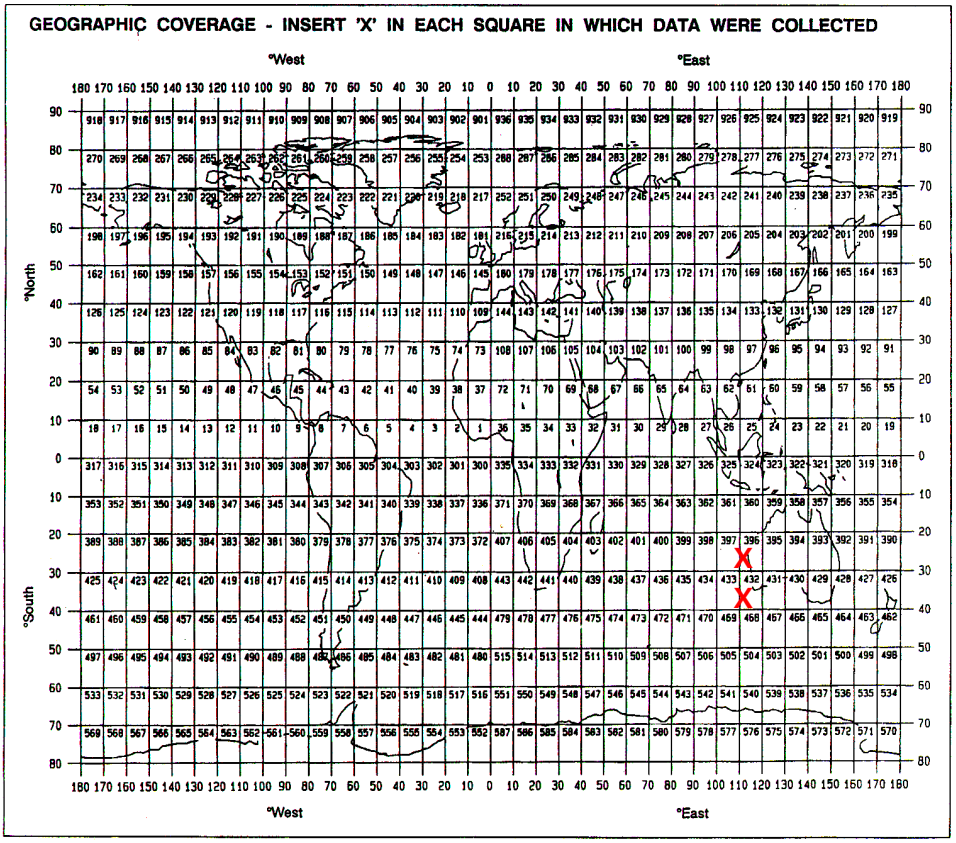
   Our colleague Peter Thompson was dropped off by small boat in Geraldton on September 9th to attend a conference in China, leaving the noon-to-midnight shift somewhat depleted but determined to continue to the end. We understand that despite a damp ride, he and his data arrived intact to the WA mainland.

Summary

Overall we had a highly successful voyage. In particular, we recognise the confident ship handling and excellent deck support from the officers and crew of the Southern Surveyor which allowed us to continue sampling through difficult conditions.

Marsden Squares

Move a red "x" into squares in which data was collected



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	1,5	38	CTD casts	H10	Vertical profiles of temperature, salinity, oxygen, fluorescence, turbidity from the ship-board rosette
2. CTD Bottle Samples	1,5 2-HPLC	228	Filtered bottle samples	H09 B01 B71 B08 H21 H24 H76 H26	At 6 CTD depths per station, samples were filtered for Chlorophyll a (2 size fractions), High Performance Liquid Chromatography (2 size fractions), Particulate Organic Matter, Lugols-preserved phytoplankton. Dissolved nutrient samples were taken at all CTD depths (10 per station).
3. Neuston Nets	1,5-POC/PN 3-,pres. 4. Genetics	64	Sets of tows	B09 B11 B10 B21 B14 B13	In a subset of tows, quantitative samples preserved in 5% formalin (« pres. ») Phyllosoma collected from surface net tows, plus prey items for phyllosoma including krill, chaetognaths and salps . Fatty acid and POC/PN isotope analyses (« POC/PN ») Genetics of phyllosoma guts and prey
4. ADCP				D71	ADCP data were recorded and stored on the ship
5. Bongo Nets	1,5-POC/PN 2-FA 3-pres	23	Individual Tows	B09 B11 B10 B21 B14 B13	Quantitative samples preserved in 5% formalin (« pres. ») Size fractionated 100 um material frozen for Fatty acid and POC/PN isotope analyses (« POC/PN »)
6. Nacelle	1,5	17	Individual Tows	H21 H11	Nacelle tow-yo from 10 m to 190 m with temperature, Salinity, oxygen, and Ecopuck (CDOM, Chl Fluorescence and backscatter)
7. Underway	1,5	700	Continuous	H11 B02	
8. Continuous Plankton Recorder	5				IMOS Equipment – plankton samples analyzed through the IMOS laboratory

Curation Report

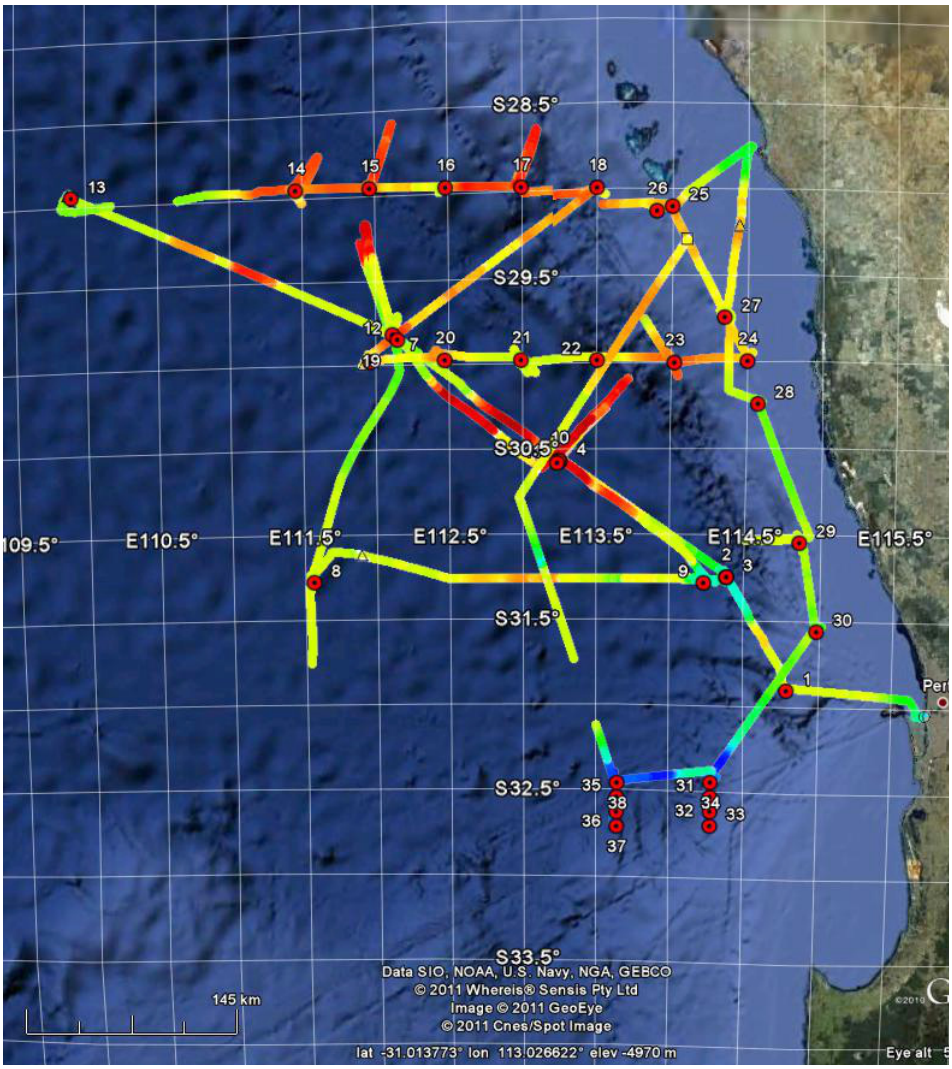
2.
- Chlorophyll a (2 size fractions)- samples analyzed on board, data UWA housed
- High Performance Liquid Chromatography (2 size fractions)- samples stored & shipped from UWA to CSIRO Hobart, processed in Hobart, and curated at CMAR and UWA
- Particulate Organic Matter – samples processed at UWA, data lodged UWA

3.
- Lugols-preserved phytoplankton.- samples stored UWA

5.
- Quantitative samples preserved in 5% formalin (« pres. ») – Samples lodged at Murdoch University
- Phyllosoma collected from surface net tows, plus prey items for phyllosoma including krill, chaetognaths and salps . Fatty acid and POC/PN isotope analyses (« POC/PN ») – Samples lodged at UWA – FA samples shipped to CMAR Hobart for analysis, POC/PN samples processed and stored UWA
- Genetics of phyllosoma guts and prey – samples stored in ethanol and sent to University of Auckland for analysis

- Quantitative samples preserved in 5% formalin (« pres. ») –Stored at Murdoch University
- Size fractionated 100 um material frozen for Fatty acid and POC/PN isotope analyses (« POC/PN ») – processed and stored as FA and POC/PN samples in 3.

Track Chart – CTD Stations indicated as red dots
– thanks to Hiski Kippo



General Ocean Area(s)

Eastern Indian Ocean

Specific Areas

Eastern Indian Ocean adjacent to southwestern Western Australia, W to 110 E north to 29 S and south to 32.5 S.

Personnel List – Science

Anya Waite	UWA	Chief Scientist
Lynnath Beckley	Murdoch University	Deputy Chief Scientist
Peter A. Thompson	CMAR	Senior Scientist
Alicia Sutton	Murdoch University	Research Assistant
Eric Raes	UWA	Research Officer
Christin Sawstrom	UWA	Scientist
Josh Dornan	WA Dept of Fisheries	Senior Technical Officer
Jonathon Saville	University of Cape Town	Student Volunteer
Andrew Jeffs	Univ of Auckland	Scientist
Richard O'Rorke	Univ of Auckland	PhD Student
Lisa Woodward	CSIRO	MNF Voyage Manager
Rod Palmer	CSIRO	MNF Electronics Support/ Deputy Voyage Manager
Hiski Kippo	CSIRO	MNF Computing Support
Peter Hughes	CSIRO	MNF Hydrochemistry support
Sue Reynolds	CSIRO	MNF Hydrochemistry support

Personnel List – Ship

Michael Watson	Master
John Boyes	1st Mate
Tom Watson	2nd Mate
Tony Hearne	Chief IR
Kel Lewis	IR
Matt Barrett	IR
Jonathon Lumb	IR
Greg Wight	IR
Upendra Kapugeekiyana	Chief Engineer
Mike Yorke-Barber	1st Engineer
Graeme Perkins	2nd Engineer
Kate Gould	Chief Steward
Stuart Mills	Chief Cook
Stephen Leslie	2nd Cook

Acknowledgements

We would like to thank the Fisheries Research Development Corporation for funding supporting this voyage.

Anya M. Waite

Chief Scientist

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

	Marine Biology/Fisheries
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