MARINE
NATIONAL FACILITY

voyageplan
ss2012_v04

2012 program

RV Southern Surveyor

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

Itinerary

Mobilise Hobart 0800hrs,
Monday 30th July, 2012
(Load mooring gear, surface drifters and profiling floats)

Mobilise Fremantle 0800hrs,
Friday 10th August, 2012

Depart Fremantle 1600hrs,
Friday 10th August, 2012

Arrive Broome 0800hrs,
Wednesday 5th September, 2012

Principal Investigators

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CSIRO

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 down welling 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

Our objectives for this voyage are:

1. Map the vertical and meridional extent of the South Indian Countercurrent, and the underlying westward flows, east of 95E (Bindoff, Phillips, Strutton and Schulz).
2. Identify the source waters of the westward flow beneath the SICC and broader eastward flow (Bindoff, Phillips, Strutton and Schulz).
3. Characterise the 3-dimensional physical and biogeochemical structure of the Leeuwin Current eddies (Bindoff, Phillips, Strutton and Schulz).
4. Establish a moored reference station to sample surface atmospheric fluxes and upper-ocean density, velocity and biogeochemistry (Bindoff, Phillips, Strutton and Schulz).

These objectives are undertaken by the following ship based activities:

1. use of the CTD, LADCP, VMP-200 microstructure profiler, and ship ADCP on the voyage track shown in the figure 1 below (Objectives 1 and 2).
2. deployment of 8 profiling floats: 2 EM _ APEX and 2 Bio _ Floats to study eddies, nominal positions shown in Figure 1 (Objective 3); and 4 Argo floats from CSIRO at the nominal locations marked in Figure 1, contributing to the global Argo Program http://www.argo.ucsd.edu/ .
3. the deployment of the RAMA mooring at 25S 100E (Objective 4)
4. 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 CSIRO’s Bluelink model http://www.bom.gov.au/bluelink/ .

Priorities of the measurement program depend on circumstances during the voyage. Some trade off is possible between the number of CTDs and the deployment of the floats in the event of equipment problems or bad weather beyond the current allowance of 1 day. The proposal is about remarkable east-west currents, and therefore the meridional lines have highest scientific priority, then the deployment of the floats, the RAMA mooring, and then the lower priority are the CTD profiles on the east west I5 line. 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).

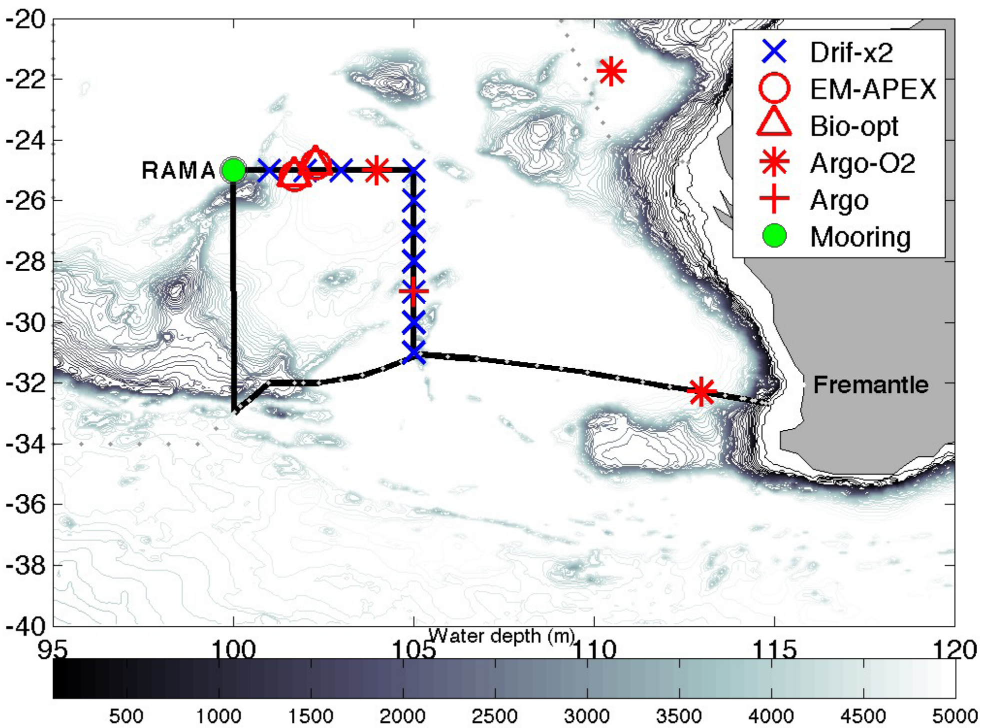


Figure 1. Proposed voyage track (black line) and nominal locations of RAMA mooring, profiling float and paired surface drifter deployments. Historical station positions from WOCE line I5 along 32°S are shown as grey dots. Contours are bathymetry from Terrainbase, contoured every 100 m depth.

Voyage Track

Time Estimates

Transit (at 11 knots)

Fremantle to CTD1 (32.67S, 114.87E) 58nm = 2.5 hours

CTD86 (31.05S, 105E) to Broome 1225nm = 51 hours

Total: 2.3 days

Research

CTD station time 86 CTDs at 3.5 hours each = 301 hours

Mooring deployment = 24 hours

Transit between CTD stations 1920 nm = 175 hours

Transit across eddies (2 perpendicular transects across 2 eddies of diameter ~150nm) 600nm = 55hours

Total: 23.1 days

Contingency

1 day

Total

26.4 days

Piggy-back Projects

Upper-ocean mixing estimates using a VMP-200 microstructure profiler

Dr Ming Feng (not participating in the voyage)
CSIRO Marine and Atmospheric Research
Underwood Avenue, Floreat WA

Dr Feng has loaned us his microstructure profiler and provided training in its use to Dr Helen Phillips. Profiles of microstructure (or turbulence) in the upper 300-400 m of the water column will contribute significantly to Objective 1, providing an estimate of ocean mixing across the interface between the near-surface eastward flows and subsurface westward flows. Across the shelf off Fremantle we will be able to obtain full-depth profiles (approx. 200m). We will aim to lower the tethered profiler at every CTD station, but we will need guidance from the operations manager as to the best way to do this. Fall rate of the profiler is about 80 cm/s so a round-trip to 400 metres will take about 16 minutes. The rope tether is streamed out so that the profiler free-falls through the water. There is a danger of cutting the rope with propellers so we would either have to have the ship's propellers stopped, or perhaps have the ship moving slowly ahead so that the rope is always behind the ship.

Nitrogen uptake in the eastward flows feeding the Leeuwin Current System

Eric Raes, Research Assistant (working with Prof Anya Waite)
Oceans Institute
M470 University of Western Australia
35 Stirling Hwy, Crawley, 6009, WA
AUSTRALIA

Involves water chemistry from rosette bottle samples. Work plan includes:

- take PON/POC samples from surface and deep Chl max (4L each)
- incubate on deck 1L bottles to get NO3, NH4, C13 uptake and N2 fixation rates (SFC and DCM)
- get some samples from the low DO, high nitrate zone off WA coast into deeper waters for a Nif gene microarray kit
- and if it would be possible, to get some extra samples to compare N2 fixation between the two eddies
- make estimates of iron concentration on the Fremantle to 100E line, and from the transit to Broome

Phytoplankton dynamics in the eastward flows feeding the Leeuwin Current System

Allison McInnes, PhD candidate
Texas A&M University
Department of Oceanography
Phytoplankton Dynamics Laboratory
College Station, Texas, 77843 USA

- I would like to test a new molecular method (mRNA FISH) that I have been working on as part of my PhD of quantifying carbon and nitrogen fixation in a sample and compare with Eric Raes and Dr. Strutton's data. I'm not exactly sure what the plan is for the amount of water we need (between what's left over for the biologists). If Eric Raes and Dr. Strutton are only collecting on some stations then I can take samples on opposite stations (ideally I'd like a small amount 1-2 L from every other station). If possible at approximately 30 stations (~1/day) it would be useful to collect a cast that Eric Raes, Dr. Strutton, and I could all collect water from (I'd like about 5L - just to be certain I get a good signal) so the data could be directly compared.
- I'm particularly interested in the eddies, as I've been collecting samples for mRNA FISH in the eddies in the Gulf of Mexico; because the temp/nutrient regimes are opposite in the eddies from the Gulf and the Indian the comparison could be rather interesting. So I'd like to collect 2-5L from every other cast on the transect through the eddies (at least surface and chl max), in addition I'd like to collect 50 mL and preserve them for identification later.

Offshore sources of high nitrate, low oxygen upper ocean waters.

Dr Peter Thompson (not participating in the voyage)
CSIRO Marine and Atmospheric Research
Hobart, TAS 7001
Australia

Aim to determine whether the thin layer of high nitrate and low DO found near 24-25S, 112E in 2007 is also found further offshore. Based on some historic DO data I have identified 2 possible routes/locations for this feature. One is further west towards Africa and the other stretching north towards the Bay of Bengal. The nutrients are important for the productivity of the west coast of Australia so it would be useful to determine their source. Some random sampling is probably required to establish a background but ideally sampling would target these features. This is most easily handled by firing a bottle in any thin layer of low (~ 30 uM or more below normal) DO in the top 250m. These are usually pretty obvious if you are watching the profile as the CTD goes down.

At the same time the thin layer of nitrate suggests some unusual nitrification activity and the molecular team would like some samples to analyse for N genes and to sequence the DNA. If filtering is already being undertaken by other science party members then the required equipment would already be available to undertake this work. Post filtering the sample would (normally) go into a dewar full of liquid nitrogen.

Southern Surveyor Equipment

Scientific Equipment

Seapath Seatex 200
Simrad EA500 (12kHz)
ADCP

Laboratory and other Facilities

General purpose laboratory (includes fume hoods, fridge, freezer)
Hydrochemistry laboratory
Wet laboratory/CTD room
-800c freezer
Walk in freezer

Winches, A-frames and Crane

CTD/Hydro winches each with 5,000m of 8mm single core conducting cable
Hydrographic A-frame
Stern A-frame (SWL 15 tonnes)
7.0 tonne knuckleboom crane
Gilson winches (15 tonne, 5 tonne)

Data Products

ADCP: standard data provided as 20 minute averages.
Underway data in netCDF format
Ship attitude – heave, pitch, roll and heading
Data from winch sensors (tension, winch speed and wire out)
Bridge log (photocopy)

Specialised Electronic Equipment

Acoustic Pinger
12kHz Acoustic Receive Transducer (low power, wide beam)
General Purpose Depth Sensor

Conductivity, Temperature and Depth Profiling (CTD)

CTD (Seabird SBE 911 plus)
CTD Rosette
10 litre Niskin bottles
Transmissometer (to 6,000m depth)
Profiling fluorometer – requires user support for calibration during voyage (6,000m depth)
Light (PAR) (to 6000m depth)
Dissolved oxygen (to 6,000m depth) – requires MNF hydrochemistry support for calibration.|Lowered ADCP (to 6,000m depth) – requires users support for data processing and interpretation.
MNF Isus Nitrate sensor (to 1,000m depth)

Chemical Analyses

Salinity – analyses as required to calibrate CTD
Oxygen – analyses as required to calibrate CTD
Nitrate + Nitrite
Nitrite
Reactive silicate
Ortho-phosphate

Other Equipment and Facilities

Underway fluorometer to measure sea surface fluorescence. User support required
Underway thermosalinograph
Meteorological data
Milli-Q water supply

User Equipment

ATLAS Mooring (Fig. 1). Itemised list of equipment will be provided by the mooring technician from PMEL. Attachment provides information about standard mooring design and deployment procedure for PMEL moorings.

8 x profiling floats (Argo-type floats) to be shipped either
- in pairs, in 2 boxes of approx. 207cm x 57cm x 42cm, weight approx 95Kg
- or individually in 4 boxes of approx. 206cm x 38cm x 43cm, weight approx 52kg

20 x surface drifters provided by NOAA, USA. Will arrive in same container as mooring gear. See http://www.aoml.noaa.gov/phod/dac/gdp _ doc.php for a picture of a drifter deployment and other details.

1 x VMP-200 microstructure profiler (in pelican rifle case – 19.6kg, 129x42x20cm) and winch with 400m-long rope. See http://www.rocklandscientific.com/Products/TurbulenceInstrumentation/VMP200/tabid/129/Default.aspx for details of instrument.

Liquid nitrogen dewar

Filtration tower (to be stored in wet lab) – 70cm(h) X 50cm(w) weight 5kgs

Chemicals to be brought on board for use on the voyage:

Acetone
Ammonium Chloride NI5
Ethanol 99.7%
Hydrochloric Acid 32%
Lugol's Iodine solution
Sodium bicarbonate 13C
Sodium Nitrate N15
Paraformaldehyde
Phosphate buffered saline

Personnel List

Nathan Bindoff	IMAS, Univ. Tas.	Chief Scientist/Science Watch Leader
Helen Phillips	IMAS, Univ. Tas.	CTD Watch/Science Watch Leader
Pete Strutton	IMAS, Univ. Tas.	CTD Watch/Water chemistry
Jessica Benthuysen	CMAR	CTD Watch
Christopher Roach	IMAS, Univ. Tas.	CTD Watch
Viviane Vasconcellos de Menezes	IMAS, Univ. Tas.	CTD Watch
Patrick Berk	PMEL, NOAA, USA	Mooring technician
Eric Raes	Univ. Western Australia	Water chemistry
Allison McInnes	Texas A&M University	Water chemistry
TBA		Student
Dave Terhell	CMAR	MNF Voyage Manager
Sue Reynolds	CMAR	MNF Hydrochemistry Support
Peter Hughes	CMAR	MNF Hydrochemistry Support
Drew Mills	CMAR	MNF Electronics Support
Hugh Barker	CMAR	MNF Computing Support

Prof Nathan Bindoff

Chief Scientist

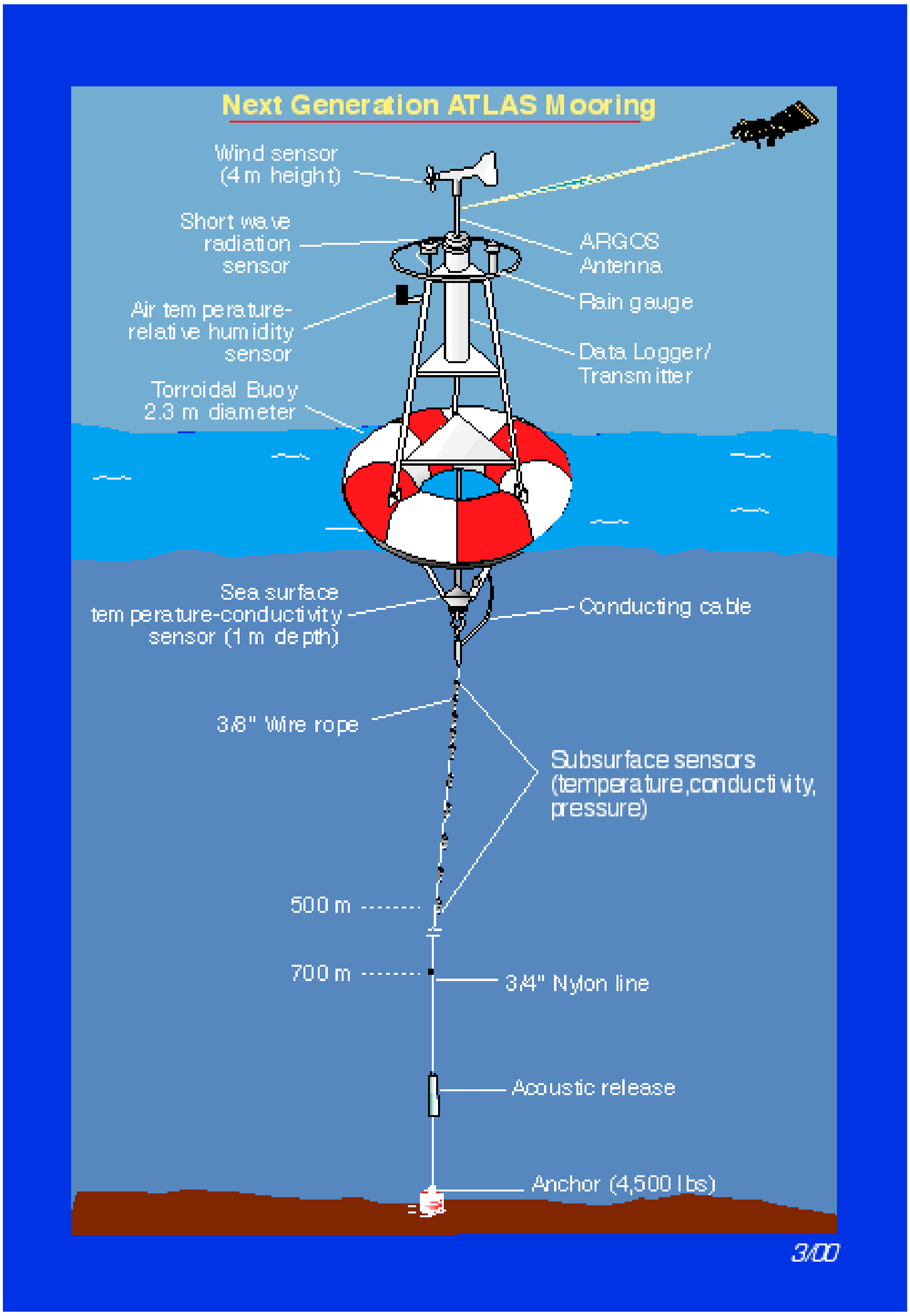


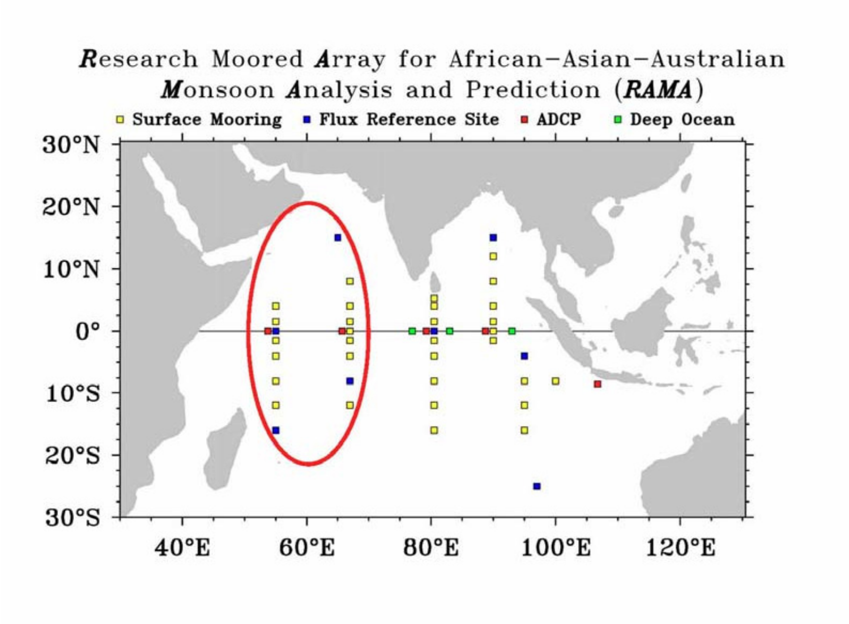
Figure 2. Design of RAMA 25 S mooring to be deployed in approx. 4000 m water depth.

Appendix 1 – Mooring design and deployment procedure (6 pages)

PMEL Mooring Equipment and Operations

NOAA's Pacific Marine Environmental Laboratory (PMEL) is investigating the possibility of deploying, recovering or repairing ATLAS moorings from vessels operating in the Indian Ocean. This work is towards the implementation of the "Research Moored Array for African-Asian-Australian Monsoon Analysis and Prediction" (RAMA). RAMA will complement the "Tropical Atmosphere Ocean/Triangle Trans-Ocean Buoy Network" (TAO/TRITON) moored array for the Pacific Ocean and the "Pilot Research Moored Array in the Tropical Atlantic" (PIRATA) for the Atlantic Ocean, providing data essential for monitoring, understanding and the prediction of regional and global climate variability. RAMA is a key component of the Indian Ocean Observing System (IndOOS), designed by the IOGOOS/CLIVAR Indian Ocean Panel (IOP).

The follow pages outline the requirements necessary to maintain these moorings. The design lifetime of the moorings is 1 year, thus an ongoing commitment of resources is needed, with cruises to each site scheduled on an approximately annual basis. The map of planned sites (Figure 1) indicates up to 20 sites which could potentially be maintained, within the limitations of time and normal working areas of the ships. Our preference would be to maintain moorings at 3 to 10 sites on cruises of up to 30 days duration though regular servicing of even an individual site is of benefit to RAMA. Initial estimates of time on station would be 24 hours per site. With time this could be shortened as scientists and ship's crew become more accustomed to operating from the ship. Nighttime operations are possible, depending on the acceptance of the Commanding Officer.



Depending on the number of sites visited and the amount of support available from the ship's personnel, PMEL would send one to three technicians to participate in the cruise. It is assumed that ship's personnel would be available to assist during deployment operations and during the transfer of equipment to and from the ship while in port. PMEL would also ask that the ship provide surface meteorology, upper ocean CTDs, and bathymetry information in the vicinity of the moorings.

Laboratory Space: Interior lab space is required for instrument testing and setup. A small amount of bench space (~2 m) is necessary for instrument checkout and a satellite-uplink monitoring station used to receive transmissions from the buoy. A cable is run from the laboratory space to an outside antenna in an area that would allow an unobstructed view of our surface mooring during deployment operations. This "line of sight" path to the buoy allows for the reception of Argos transmissions while monitoring the instrumentation.

Deck Space: The mooring hardware will require outside storage on the working deck. For three moorings about 50 m! of deck space is necessary to store the reels of rope, anchors, buoys, towers, and hardware. Space is also necessary to test our instrumentation before their deployments (Figure 2). We will need to have additional space to assemble a buoy before operations begin.

Figure 2. Surface instruments setup for system checks on the weather deck.

Communications: Email or Fax capability between the ship and PMEL is highly desirable. Communications between the lab and the ship is essential to confirm good data transmission or notification of instrumentation or hardware malfunction.

Bathymetry: A depth sounder with 6000 meter range and recording capability is required. An accurate bathymetric survey of the deployment area is necessary and an automated 2-D map generated prior to deployment is desirable. A reasonably flat target area is required, preferably at least 2 nm square. Depth variations in the drop site should be no more than 80 meters over 2 nm.

Deployment Operations: The RAMA surface moorings are deep ocean taut-line moorings with a scope (the ratio of mooring length to water depth) of 0.985. There is some flexibility in deployment methods and operations can be tailored to the characteristics of an individual vessel. A discussion with the ship's officers and scientific party will take place before operations to plan deployment procedures.

The use of a crane or A-frame, or both, is essential. The buoy will be assembled on the ship prior to deployment and is typically picked up by a crane, swung over the side of the ship, and lowered into the water using a release hook (Figure 3). The line attached to the bottom of the buoy is fair-lead around the stern of the ship and through an A-frame to a capstan. The line is slowly let out with the buoy drifting off the stern while sensors are attached to the mooring line. Figure 4 shows an alternative method of buoy deployment using an A-frame.

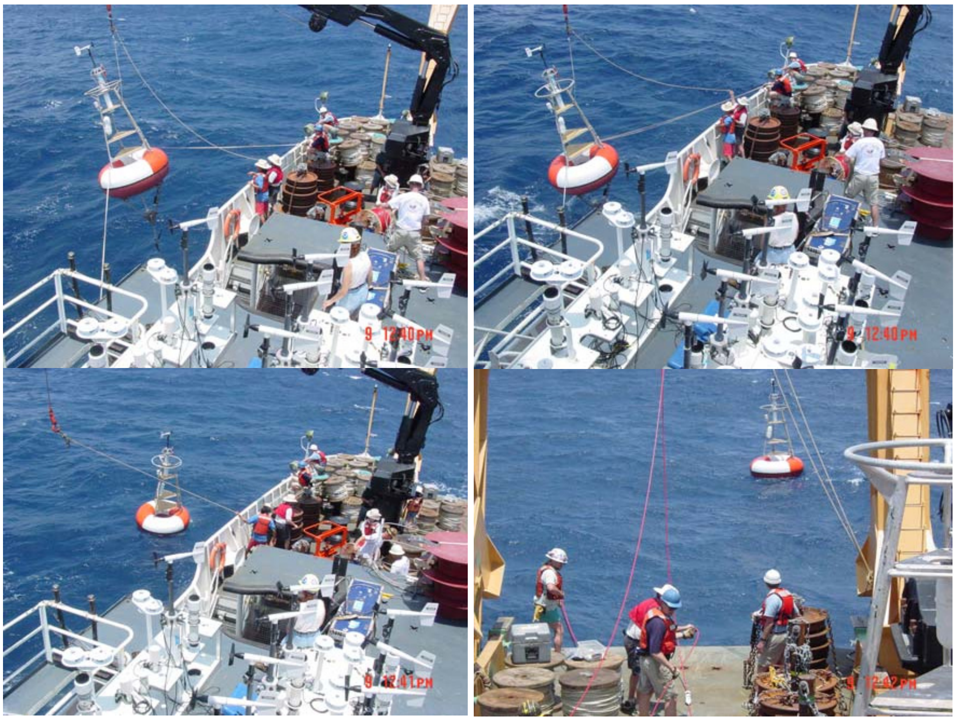


Figure 3.

Figure 4.

Ship Equipment Required:

A crane with a lifting capacity of 2950 kg and a reach that extends outboard for use in deployment of the surface buoys.

A stern A-Frame with a lifting capacity of 6300 kg, a height of 6 m with a width of at least 3 m at it's base is desirable (Figure 5).

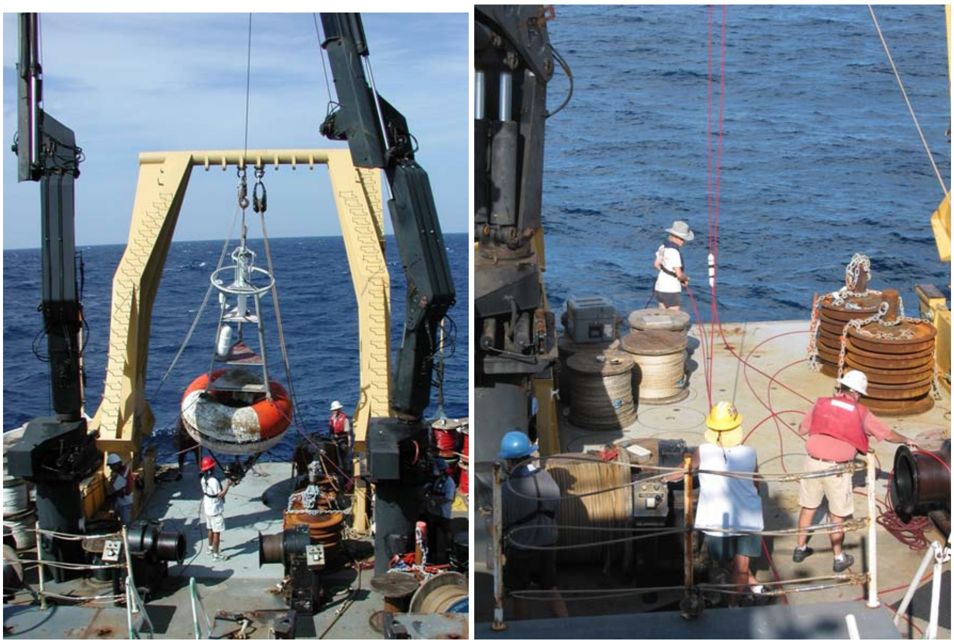


Figure 5.

Time on station: Approximately 24 hours are required for the site survey, deployment operations and data verification. More time could be needed depending on the extent of the bathymetric survey. A CTD to at least 1000 m should be performed, preferably after mooring deployment.

Acoustic Release Instrumentation: After deployment an acoustic hydrophone will be lowered into the water from the ship's deck to communicate with the acoustic release located above the mooring anchor. We use a Model 8011A EG&G Acoustic Deck Unit and a model 8242 acoustic release. PMEL will supply the Deck Unit for the cruise.

Shipment: Our shipment will be contained in one or more 40' shipping containers. The containers should be spotted on the dock next to the ship. A forklift will be necessary to unload the containers. If the ship's crane does not have the ability to lift or reach material on the dock, a dockside crane will be needed to transfer the equipment to the ship. The ship's crane must be able to move stored equipment to the working deck for deployment. Anchors should be stored near the A-frame as moving them at sea may be difficult.

Mooring Hardware: The surface buoys are a 2.4 meter toroidal buoy, constructed of fiberglass over foam. There are attachment points on the top and bottom of the buoy where metal frames (referred to as towers above the buoy and bridles below) are bolted into place. The towers are constructed of aluminum and the bridles are made of stainless steel. The 1 cm diameter, galvanized-steel mooring wire is jacketed with water tight polypropylene with a nominal outside diameter of 1.3 cm. The 8 strand plaited nylon rope has a diameter of 1.9 cm. Anchors are fabricated from scrap railroad wheels to total 2700 kg each for surface moorings. The railroad wheels are assembled on two shafts which are chained together before deployment. The working lines, blocks, reel stands and miscellaneous deck items will be provided by PMEL.

Listed below are weights, measures, and quantities of mooring hardware (including spares) that would be loaded onto the ship if 3 sites were to be maintained. **An accurate inventory suited to a particular cruise would be sent before the shipment leaves Seattle.**

Surface Mooring Hardware:

ITEM	SIZE (M)	WEIGHT (Kg)	QTY	TOTAL (Kg)
Toroid	2.3 meters diameter, 1 meter high	318	4	1272
Tower	Triangle 1.5 m base, 2.3 m high	61	4	244
Bridle	Triangle 1.5 m base, 1 m high	84	4	336
Wire Rope Reel	0.71 m diameter, 0.6 m wide	341	4	1364
Nylon Rope Reel	0.71 m diameter, 0.6 m wide (8 reels are estimated per mooring)	120	4	3840
Anchor	1.01 m diameter x 1.15 m high	1361	8	10912

	(2 per surface mooring)			
Lead Weights	0.2 m x 0.14 m x 0.15 m	150	4	600
	(3 per buoy)			
Misc. Hardware	Shipping container varies	590	2	1180

Instrumentation:

ITEM	SIZE (M)	WEIGHT (Kg)	QTY	TOTAL (Kg)
Surface Data-Logger	1.51 m x 0.56 m x 0.45 m	84	6	504
Acoustic Releases	0.81 m x 0.36 m x 0.25 m	48	6	288
Electronic monitoring box	0.91 m x 0.71 m x 0.46 m	34	1	34
Acoustic Deck Unit	0.51 m x 0.71 m x 0.36 m	32	2	64
Seacat	0.91 m x 0.25 m x 0.25 m	12	1	12
Sensor Modules	0.46 m x 0.46 m x 0.46 m	25	6	150
Misc parts box	0.91 m x 0.71 m x 0.46 m	34	1	34