

## RV Investigator Voyage Plan

<b>Voyage #:</b>	IN2016_T02		
<b>Voyage title:</b>	Transit – Hobart to Sydney		
<b>Mobilisation:</b>	Hobart, 0800 Wednesday, 24 August 2016		
<b>Depart:</b>	Hobart, 1000 Thursday, 25 August 2016		
<b>Return:</b>	Sydney, 1000 Monday, 29 August 2016		
<b>Demobilisation:</b>	Sydney, 1000 Monday, 29 August 2016		
<b>Voyage Manager:</b>	Tegan Sime	<b>Contact details:</b>	Tegan.sime@csiro.au
<b>Chief Scientist:</b>	A/Prof Andrew Bowie		
<b>Affiliation:</b>	Institute for Marine & Antarctic Studies, and Antarctic Climate and Ecosystems CRC, University of Tasmania		
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<b>Piggyback project:</b>	Australasian Seabird Group		

## Scientific objectives

### **Natural iron fertilisation of the oceans around Australia: linking terrestrial dust and bushfires to marine biogeochemistry**

Oceans play a vital role in Earth's climate through the control of atmospheric CO<sub>2</sub>. An important component of this system is the iron cycle, in which iron-rich aerosols are transported from land via atmosphere to ocean. Iron is a key micronutrient for marine phytoplankton, the scarcity of which controls essential biogeochemical processes. This project will facilitate an integrated ship-based atmospheric observational program for trace elements in oceans around Australia. During the voyages, we will sample and conduct experiments on atmospheric particles containing terrestrial dust, bushfire smoke and anthropogenic emissions that are transported from Australia to its surrounding oceans. This will provide the critical information on atmospheric iron supply for ocean fertility and health, providing the science for predicting a key factor in the future impact of the oceans on climate. The project supports the training and research of two postgraduate PhD students from IMAS-UTAS.

## Voyage objectives

### **Transit Objective**

The main objective of this transit voyage is to move the vessel from Hobart to Sydney prior to IN2016\_V04. The objectives listed below are complementary with the transit.

### **Natural iron fertilisation of the oceans around Australia: linking terrestrial dust and bushfires to marine biogeochemistry**

We will install an atmospheric sampling system for the clean collection of particles in the ship's aerosol lab. This system consists of vacuum pumps (Thomas Sheboygan 2107CD18), flow meters (DiTGM ML-2500) and filtration systems (Savillex PFA). The manifold is connected to air intake lines fed from the sampling nozzle located ~10 m above sea level on the foremast at the bow of the vessel. Samples will be collected on filters housed in 47 mm filtration holders located within a laminar flow hood (AirClean Systems) to avoid contamination. The system is controlled by automated sector control switch (pump controller) to ensure the system only samples 'clean' air from the forward sector (nominally between 270° port and 90° starboard), avoiding air impacted by the ship's exhaust. The system is capable of running up to 4 flow lines in parallel, to enable replicate sampling or to sample for different parameters using different filters on different lines. A newer more sophisticated version of this aerosol sampling system (including PM<sub>1</sub>, PM<sub>2.5</sub>, and TSP size selective inlets) is being developed at CSIRO and should be ready for installation on RV Investigator in the latter part of 2016.

Samples will be collected on a range of different filter types (polycarbonate, Whatman-41, cellulose, Teflon) suitable for different analytical needs. Filters will be changed approximately daily, depending on the aerosol loading, flow rates and amount of time the air inlet is in a suitable 'clean' air sector and sampling takes place. The sector sampling switch records the date/times and waypoints when the wind is 'in sector'. A range of procedural and field exposure blanks will be collected at sea, as well as preliminary leaching and dissolution experiments. Sampled filters will be stored frozen and returned to the shore-based laboratory for further experiments and analyses.

We will also opportunistically collect event-based clean rainwater samples using either a polyethylene funnel and collection bottle (when conditions allow) or a Dual Chimney Precipitation Sampler (N-Con Systems model 00-127; currently on order), to quantify the trace metal deposition in the 'bulk' and 'precipitate-only' fractions. Ideally samples would be collected on upper and forward decks, either above the bridge or at the bow when heading into the wind.

The project also requests access to the RV *Investigator* trace metal clean underway supply system (preferably the outlet in the clean wet lab which has been designed for clean filtration and sampling in the laminar flow hood). This will enable us to correlate the atmospheric flux of trace elements with the surface in-water concentrations. Surface seawater will also be used for leaching and dissolution experiments on the collected atmospheric particles.

Our sampled aerosols will include terrestrial dust, processed soils, particles generated through biomass burning and industrial processes, and marine aerosols. Analyses and lab-based experiments will provide observations on 'bulk' measurements of micronutrient trace elements (including iron), their solubility in fresh and saline waters (Buck et al., 2006; Mackie et al., 2006; Baker and Jickells, 2006), their processing during long-range transport and cycling (Sedwick et al., 2008), and their bioavailability to marine phytoplankton. Isotopic tracers (radon-222,  $\delta^{56}\text{Fe}$ ) and back-trajectories will be used to differentiate the source, fetch and air type.

#### **Australian Hydrographic Office**

A 24 hour hydrographic survey east of Flinders Island of an area around an unconfirmed sounding named "Minnie Carmichael rock" will be conducted for the Australian Hydrographic Service.

## **Operational Risk Management**

No potentially high risk operations have been identified.

## **Overall activity plan including details for first 24 hours of voyage**

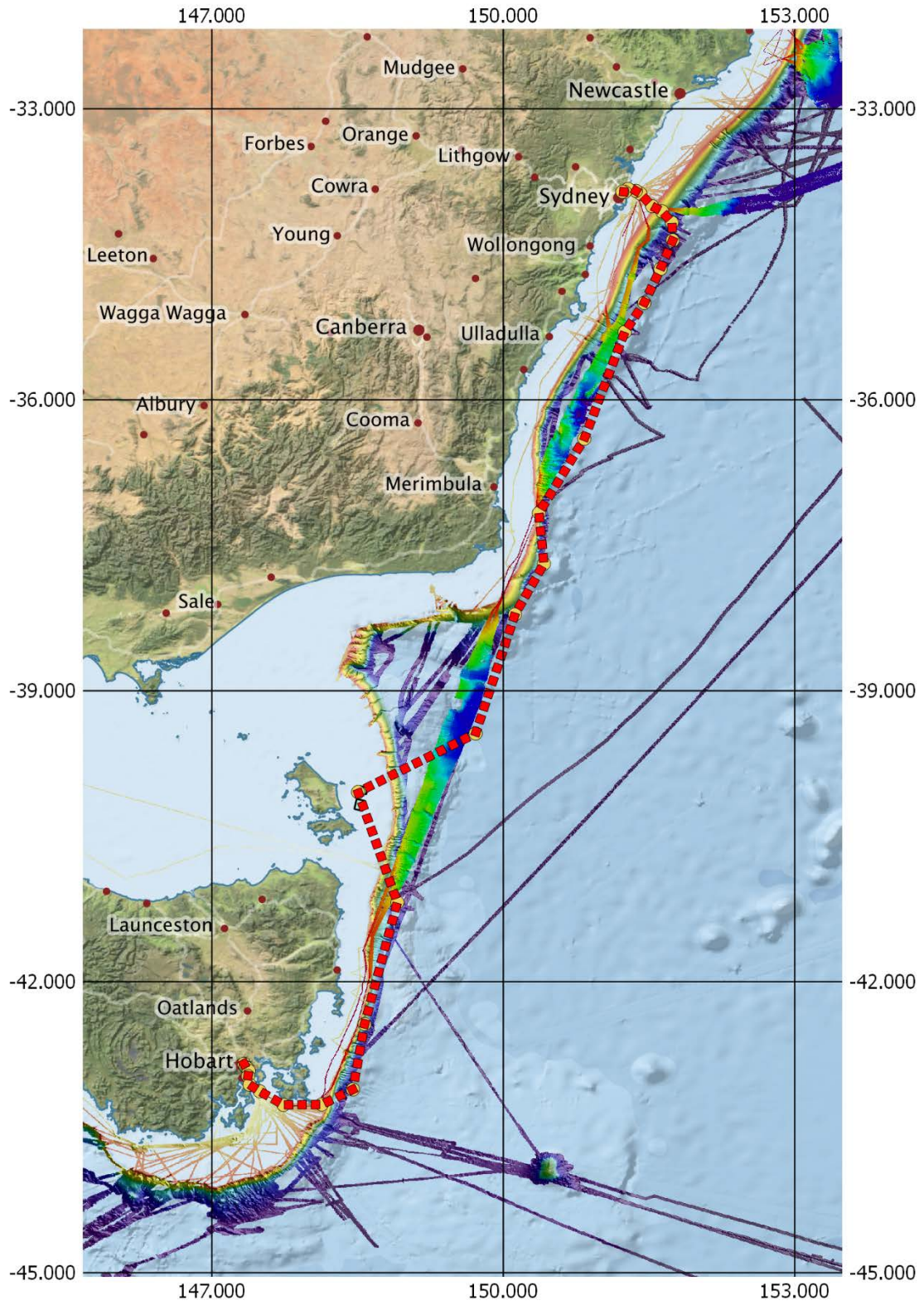
Deploy the CPR at White Rock

The aerosol sampling system will be started soon after leaving port in Hobart, and will run continuously until arrival in Sydney.

Rain sampling opportunistically if conditions are suitable.

Start trace metal clean underway supply in open waters

### Voyage track example



## Waypoints and stations

No.	Name	Lat	Lon	Crs	Dist	TDist
1	PW4	42° 53.170'S	147° 20.321'E	38.2	0 NM	0 NM
2	Sullivans Cove	42° 53.100'S	147° 20.396'E	88.8	0.2 NM	0 NM
3	Battery Pt	42° 53.096'S	147° 20.661'E	134.3	2 NM	0.2 NM
4	John Garrow Bcn	42° 54.757'S	147° 22.976'E	180.1	1 NM	2.2 NM
5	HBA PBG	42° 55.411'S	147° 22.974'E	186.3	3.2 NM	3.2 NM
6	White Rock	42° 58.583'S	147° 22.499'E	172.2	4.8 NM	6.4 NM
7	Iron Pot	43° 03.697'S	147° 23.455'E	132.6	20.3 NM	11.2 NM
8	Cape Raoul	43° 17.500'S	147° 44.000'E	90	17.5 NM	31.6 NM
9	Tasman Island	43° 17.500'S	148° 08.000'E	51.9	17.6 NM	49.1 NM
10	Hippolyte Rocks	43° 6.576'S	148° 27.057'E	7.5	16.8 NM	65.9 NM
11	Schouten Island	42° 26.113'S	148° 34.291'E	11.4	40.8 NM	106.7 NM
12	Eddystone Point	41° 10.827'S	148° 54.523'E	21.4	76.8 NM	183.6 NM
13	Site	40° 2.644'S	148° 30.254'E		70.7 NM	254.3 NM
14	South Bass	39° 26.359'S	149° 42.833'E	14.5	66.6 NM	320.9 NM
15	North Bass	38° 12.789'S	150° 7.111'E	24.3	76.0 NM	396.9 NM
16	Gabo Island	37° 41.4'S	150° 25.013'E	0	34.4 NM	431.3 NM
17	Green Cape	37° 10.000'S	150° 22.000'E	23.6	31.5 NM	462.8 NM
18	Montague Island	36° 24.000'S	150° 50.000'E	17.1	51.2 NM	514.0 NM
19	Jervis Bay	35° 18.000'S	151° 15.000'E	28.7	69.1 NM	583.1 NM
20	Shoalhaven	35° 0.000'S	151° 27.000'E	21.4	20.5 NM	603.6 NM
21	Kiama	34° 39.000'S	151° 37.000'E	19.5	22.6 NM	626.2 NM
22	Stanwell Park	34° 21.368'S	151° 44.545'E	357.9	18.7 NM	644.9 NM
23	Hacking	34° 10.333'S	151° 44.054'E	323.6	11.0 NM	656.0 NM
24	Botany Bay	34° 03.405'S	151° 37.923'E	314.6	18.7 NM	674.7 NM
25	Sydney PBG	33° 50.000'S	151° 21.600'E	269.9	2.4 NM	677.1 NM
26	North Head	33° 50.005'S	151° 18.939'E	287.7	1.9 NM	679.0 NM
27	Middle Head	33° 49.412'S	151° 16.718'E	218.7	1.6 NM	680.6 NM
28	Chowder Bay	33° 50.564'S	151° 15.613'E	216.9	0.9 NM	681.5 NM
29	Bradleys Head	33° 51.346'S	151° 14.910'E	276.8	1.2 NM	682.7 NM
30	Fort Denison	33° 51.192'S	151° 13.359'E	162.8	0.4 NM	683.1 NM
31	Mrs Macquaries Ch	33° 51.610'S	151° 13.513'E	196.3	0.4 NM	683.5 NM
32	Woolloomooloo	33° 51.930'S	151° 13.401'E			683.9 NM



## Time estimates

The following time estimates are based on a steaming speed of 11 knots.

Date	Time	Activity
25/08/2016	1000	Depart Princes Wharf for Sydney
25/08/2016	1200	Deploy CPR
28/08/2016	0830	Pick up Rob Beaman's supplementary Offshore NSW transect
29/08/2016	0030	Turn off transect towards Sydney completing 163 nmi of transect
29/08/2016	0700	Sydney PBG
29/08/2016	10:00	Arrive Garden Island

## Piggy-back projects

### Spatial and temporal variability in the distribution and abundance of seabirds

Seabirds are distributed patchily over the ocean both in space and in time. While the deployment of remote tracking devices on breeding birds has provided a window into their at-sea movements, they do not report on non-breeding or juvenile birds. It is often the survival of these stages that can have dramatic impacts on population dynamics. The long term monitoring of at-sea distribution of seabirds in the oceans around Australia can facilitate a better understanding of the dynamics of these species in an often unpredictable environment. The proposed study using at-sea observations collected along-side oceanographic data will improve our understanding of seabirds and the way in which they relate to our changing ocean environments.

Seabird at sea data will be collected according to the method described by the BIOMASS Working Party on Bird Ecology (1985). Seabird observations will be made continuously while the vessel is underway during daylight hours from the specifically designed monkey-bridge on board *RV Investigator*.

## Investigator equipment (MNF)

1. Air Sampling Pump Controller -- Sector control switch used to switch vacuum pumps on/off and enable sampling of air only when the ship is in a 'clean' sector (i.e., prevents contamination of samples by sampling air impacted by the ship's exhaust); requires Ethernet data feed of ship's met data
2. Advanced aerosol sampling system -- Under-development. To be requested after September 2016. Consists of three single 47mm filter holders with size selective inlets (PM1, PM2.5, TSP), flow control and volume recording system, pumps and housing.
3. Access to the trace metal clean underway supply system (in laminar flow hood outlet in clean wet lab)
4. Access to Milli-q system (in GP dry lab (clean))
5. Access to aerosol sampling lab, GP wet lab (clean), blast freezer and controlled temperature lab
6. Access to data from underway systems (Thermosalinograph, Atmospheric Underway Sensors, Biological Oceanography Underway Sensors)

## User Equipment

1. Continuous Plankton Recorder (CPR)
2. Aerosol sampling system (UTAS/CSIRO), includes pumps, flow meters, tubing and filtration holders
3. Laminar flow hood (UTAS), for clean sampling and sample handling
4. Sampling bottles (UTAS), to collect seawater from ship's trace metal clean underway supply
5. Precipitation (Rain) Sampler (UTAS)

## Special Requests

ASP – please provide advance notice of incineration events and a final record of incineration events for the voyage to the atmospheric team.

## Personnel List

List all scientific participants, their affiliation and role on the voyage

1.	Tegan Sime	Voyage Manager	CSIRO MNF
2.	Stephen Thomas	SIT Support	CSIRO MNF
3.	Rod Palmer	SIT Support	CSIRO MNF
4.	Matt Boyd	GSM Support	CSIRO MNF
5.	Amy Nau	GSM Support	CSIRO MNF
6.	Steve Van Graas	DAP Support	CSIRO MNF
7.	Francis Chui	DAP Support	CSIRO MNF
8.	Peter Shanks	DAP Support	CSIRO MNF
9.	Andrew Bowie	Chief Scientist	IMAS-UTAS/ACECRC
10.	Morgane Perron	Aerosols (natural iron fertilisation)	IMAS-UTAS/ACECRC
11.	Michal Strzelec	Aerosols (natural iron fertilisation)	IMAS-UTAS/ACECRC
12.	Nicholas Carlile	Bird Survey	Environment NSW
13.	Mick Roderick	Bird Survey	Environment NSW
14.	Matt Marrison	Communications	CSIRO MNF
15.	Ann Jones	Reporter	ABC
16.	Marian Wiltshire	Communications	IMOS
17.	Warrick Glynn	Communications	IMOS
18.	Ben Arthur	Education and Outreach	CSIRO
19.	Chris Krishna-Pillay	Education and Outreach	CSIRO
20.	Ron Plaschke	Observer	MNF Director
21.	Ben Rae	Observer	MNF Policy Officer
22.	Owen Craig	Communications	CSIRO
23.	Martin Ostrowski	Principal Investigator	Macquarie University
24.	Leonardo Laiolo	PhD student	UTS
25.	Kim-Arne Groneng	Rapp Hydema Tech	Rapp Hydema
26.	Bard-Morten Pederson	Rapp Hydema Tech	Rapp Hydema