RV *Investigator* Scientific Highlights

Voyage #:	**IN2017_T01**		
Voyage title:	Natural iron fertilisation of oceans around Australia: linking terrestrial dust and bushfires to marine biogeochemistry		
Mobilisation:	N/A		
Depart:	Sydney, 2000 Sunday, 24 September 2017		
Return:	Broome, 1300 Sunday, 08 October 2017		
Demobilisation:	N/A		
Voyage Manager:	Hugh Barker	**Contact details:**	Hugh.barker@csiro.au
Chief Scientist:	Andrew Bowie		
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Principal Investigator:	Katherine Walters		
Project name:	Exploring different science communication strategies for engaging the public in marine science		
Affiliation:	Griffith University	**Contact details:**	katie.walters@griffithuni.edu.au
Principal Investigator:	Ryan Beemer		
Project name:	Interdisciplinary characterisation of the macro-mechanical behaviour of offshore sediments from Northern Australia		
Affiliation:	UWA	**Contact details:**	ryan.beemer@uwa.edu.au
Principal Investigator:	Vicki Stavropoulos & Ben Arthur		
Project name:	CSIRO Educator on Board		
Affiliation:	CSIRO	**Contact details:**	vicki.stavropoulos@csiro.au
Principal Investigator:	David Steinberg		
Project name:	Macumba Wreck		
Affiliation:	Department of Tourism and Culture, Northern Territory	**Contact details:**	david.steinberg@nt.gov.au
Principal Investigator:	Eric Woehler		
Project name:	Spatial and Temporal Variability in the Distribution and Abundance of Seabirds		
Affiliation:	BirdLife Australia UTAS	Contact details:	Eric.Woehler@utas.edu.au

The Chief Scientist

Associate Professor Andrew Bowie is a Chemical Oceanographer. His research investigates the biogeochemistry of trace elements in the ocean, with projects addressing key research questions related to atmospheric dust deposition and solubilities, ocean iron fertilisation, physico-chemical speciation of trace elements and their isotopes, and the role of ocean dynamics on chemical and biological marine processes. His research outcomes are focused on assessment of trace element control of ocean productivity, ocean carbon sequestration and expanding our knowledge of marine geochemical processes. His research is supported by the Antarctic Climate and Ecosystems CRC (ACE CRC), the Australian Research Council (ARC), and several national and international collaborative grants. Andrew has provided leadership of international chemical oceanography research expeditions, is a co-chair of the Scientific Steering Committee of the 'GEOTRACES' program (an international study of the global marine biogeochemical cycles of trace elements and their isotopes).

1. Natural iron fertilisation of oceans around Australia: linking terrestrial dust and bushfires to marine biogeochemistry

Purpose

The voyage consisted of six main projects:

1. Natural iron fertilisation of oceans around Australia: linking terrestrial dust and bushfires to marine biogeochemistry (Primary Project)
2. Exploring different science communication strategies for engaging the public in marine science
3. Interdisciplinary characterisation of the macro-mechanical behaviour of offshore sediments from Northern Australia
4. CSIRO Educator on Board
5. Search for the WWII historic shipwreck *Macumba*
6. Spatial and Temporal Variability in the Distribution and Abundance of Seabirds

The Primary Project supported research to quantify the importance of iron-rich aerosols from Australia for marine biogeochemistry and ocean ecosystem health. The project sampled and conducted experiments on atmospheric particles containing terrestrial dust and bushfire smoke that were transported from Australia to its surrounding oceans. The outcomes will provide a scientific basis for managing the complex role of iron in sustaining marine ecosystem biodiversity and for informing government policy on ocean fertilisation as a carbon mitigation strategy. The Primary Project had the following three objectives:

1. To sample and conduct experiments on atmospheric particles containing terrestrial dust and bushfire smoke that are transported from Australia to its surrounding oceans.

2. To contribute to larger integrated ship- and land-based atmospheric observational program for trace elements and nutrients in oceans around Australia that aims to determination of the geochemical nature, solubility and biological availability of atmospherically delivered trace elements, and how these factors vary with long-range transport and cycling.
3. To support the training and research of postgraduate students from the Institute for Marine and Antarctic Studies at the University of Tasmania.

Contribution to the nation

Oceans play a vital role in Earth's climate through the control of atmospheric CO2. An important component of this system is the iron cycle, in which iron-rich aerosols are transported from land via atmosphere to ocean. The Primary Project supports research to quantify the importance of trace elements and nutrients in aerosols from Australia for marine biogeochemistry and ocean ecosystem health. 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.

As a result of this voyage

1. We have a better understanding of the delivery of trace elements and nutrients from atmospheric aerosols into the oceans to the southeast of Australia
2. We have found RV Investigator is an excellent platform to undertake these studies and in the future hope to run continuous measurements on voyages of opportunity.
3. We have mapped the dry and wet atmospheric deposition of key chemical constituents to the oceans southeast of Australia on a transit from Sydney to Broome in early austral spring.
4. We have continued a program of research investigating the role of atmospheric transport for providing vital mineral and nutrients for marine ecosystem health and fertility in all the ocean basins surrounding Australia.

2. Exploring marine scientists' views on the role of science in society, public perception of marine science, and the communication of marine science - Principle Investigator, Katie Walters

Katie Walters is a marine social scientist undertaking a PhD at Griffith University, Queensland. She also serves on the board of The Society of Conservation Biology Marine Section as Communications Officer.

Purpose

Part of understanding the success (or failure) of public engagement with science is exploring the full spectrum of communication as an *exchange between parties*. This involves the interrogation of both sides of the exchange.

On voyage IN2017-T01, I interviewed a number of scientists, from primary investigators to those who facilitate data collection for others. These interviews contribute to a broader data pool which will analyse how marine scientists in Australia view their role in society, what makes a good marine scientist, and what they wish the public understood about them and their work.

Contribution to the nation

There's a great deal of recent research (particularly regarding climate change) to suggest that merely telling people about science is not enough to change people's attitudes, or behaviours that might be environmentally damaging. These outcomes hinge on ideology rather than education, and addressing them requires a different set of tools than those used by the traditional "science communicator."

Developing the perception of marine science and the marine scientist is not simply a "public relations" exercise. Rather, it is an attempt to build a complete picture of what meaningful, beneficial, connection between marine science and the public might look like (in a world where the oceans face critical threats to their current state), and build strategies for developing this connection.

As a result of this voyage

1. We have contributed to a clearer understanding of scientists' sense of public understanding of their work.
2. We have added to our understanding of the genesis of individuals' attraction to marine STEM.
3. We have a clearer understanding of the spectrum of marine scientific endeavours, and how they differ in their capacity and willingness to relate to the public.
4. We have contributed to our understanding of "good" science communication as described by scientists themselves. When linked with what the public believes is good science communication, we can build a communicative space that scientists and the public agree is to their mutual benefit.

3. Interdisciplinary characterisation of the macro-mechanical behaviour of offshore sediments from Northern Australia - Principle Investigator, Dr Ryan Beemer

Purpose

To study the geobiology and mechanical properties of calcareous sediments from various locations offshore of Northern Australia

Contribution to the nation

This research has the opportunity to increase geotechnical and geological engineers understanding of the behaviour of troublesome offshore calcareous soils by examining the biology of the soil grains themselves. These sediments can be make entirely from the skeletal of the remains of marine organisms such as plankton and coral. This research could allow for more efficient design offshore systems, including renewable energy generators, and could provide insights into the formation of large submarine landslides that have been known to occur calcareous sediments and have the potential to cause large tsunamis

As a result of this voyage

The findings of this research will not be known until samples have been tested, we will be using the calcareous sediments to study how their geobiology impacts their mechanical behaviour.

4. CSIRO Educator on Board - Principle Investigator, Dr Ben Arthur

Ben Arthur works with the Marine National Facility. One of his main aims is to deliver professional development of STEM teachers and support the development of curriculum resources based on the voyage science.

Purpose

The Educator on Board program has a number of national benefits. These include; updating the STEM content knowledge of participating teachers with contemporary research, facilitating the demonstration of real-world STEM in Australian classrooms, an experience to draw on to inspire and inform students about career options in the marine sector, and the delivery of STEM education resources that are available to all Australian teachers.

Contribution to the nation

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As a result of this voyage

We have provided a unique professional development program to two Australian STEM teachers who are currently producing curriculum resources based on the voyage research (sea bird distributions, and the link between physical and biological scales in the ocean, respectively), which will be shared with all Australian teachers.

5. Search for the WWII historic shipwreck *Macumba* - Principle Investigator, Dr David Steinberg

David Steinberg is the maritime archaeologist and a senior heritage officer for the Heritage Branch of the Northern Territory Government. The Heritage Branch runs an active maritime heritage and research program and David has been researching and investigating the Northern Territory's underwater cultural heritage for close to 20 years.

David is also the President of the Australasian Institute for Maritime Archaeology (AIMA). AIMA is an incorporated, not-for-profit organisation, dedicated to the preservation of underwater cultural heritage. Based in Australia, it has sponsored work throughout Australia, Asia and the Indian and Pacific Ocean regions. AIMA works closely with State, Territory and Australian Federal Governments on policy issues, and has an active publications program and an annual conference.

Purpose

The *Macumba*, was a 2,500-ton merchant ship sunk in Northern Territory waters in a Japanese air attack on the 6 August 1943. There were three casualties. Despite early detection soon after its sinking, the wreck site had not successfully been located since WWII.

The Macumba is considered a significant historic shipwreck. It is a monument to our wartime past, and is the grave of one crew member (two others dying of their injuries after rescue). The site has considerable archaeological research potential, and has likely evolved into a rich marine habitat.

A search area was developed based on historic information and past searches. The voyage consisted of a methodical search of the sea floor using remote sensing tools. Once detected the team switched to site recording using remote sensing tools and a drop camera.

Contribution to the nation

The Macumba is a part of northern Australia's wartime history and its story reminds us that northern Australia was once the frontline in a major conflict. It is the grave of one crewman and there is a responsibility to locate these losses and provide closure to families and loved ones. An archaeological study of the Macumba will provide further insight into Australia's maritime history and heritage. As an untouched and sizeable artificial reef the Macumba may constitute a site of considerable natural significance. The Macumba may also constitute a shipping hazard, and so it was important to locate the site and determine its depth.

As a result of this voyage

We have finally located one of the most significant wartime wrecks of the Northern Territory. It ends a five year search for this significant historic shipwreck. With its discovery we can turn to mapping, research, conservation and site management. The voyage also resulted in the first recording of the site, providing invaluable information about the nature of the wreck, its layout, level of integrity and also crucial site environment information such as depth.

6. Spatial and Temporal Variability in the Distribution and Abundance of Seabirds - Principle Investigator, Dr Eric Woehler

Purpose

The project seeks to quantify the distribution and abundance of seabirds at sea around Australia using standardised seabird survey protocols. One or two dedicated observers will collect real-time data on seabirds observed within 300m transect during daylight hours while the vessel is underway. Incidental observations will be collected while the vessel is stationary (e.g. CTD stations) or while the vessel is deploying/recovering moorings. The data collected will be compatible with previous seabird at sea surveys conducted around Australia and farther south, allowing for analyses and assessments to be extended by the current surveys. The distribution of seabirds at sea is strongly linked with oceanographic features such as convergences that concentrate prey at densities that allow for efficient foraging by seabirds. Our surveys on the voyage will link with oceanographic investigations to identify the types and strengths of oceanographic features at which we observe different species of seabirds that utilise different methods of feeding (surface seizing, diving etc.). No dedicated ship time is required for the seabird surveys. Surveys are conducted by observers while the vessel is underway during daylight hours.

Contribution to the nation

The project seeks to quantify the distribution and abundance of seabirds at sea using standardised seabird survey protocols. One dedicated observer collected real-time data on seabirds observed within 300m transect during daylight hours (sunrise to sunset) while the vessel was underway. Incidental observations were collected while the vessel was underway.

More than 6000 seabirds of 20 species were recorded. In addition, observations of four species of marine mammals were also recorded.

Highlights of the seabird program comprise:

1. Tensive new spatial records for Flesh-footed Shearwaters from the Arafura Sea and northeast Timor Sea, some 15° farther north than previously recorded, with other species' distributions also extended,
2. More than 40 records of predatory fish/seabird feeding interactions, not previously published for these species in Australia, with a manuscript and data analyses started during voyage, and
3. Probable sightings of two pods of Australian Snubfin Dolphins.

As a result of this voyage

1. A record of birds, marine mammal and, cetaceans and marine debris has been made and will feed national and worldwide database
2. Exclusive observations have been made on bird/fish joint feeding behaviour