RV *Investigator* Voyage Scientific Highlights

Voyage #:	**IN2018_V02**		
Voyage title:	SOTS: Southern Ocean Time Series automated moorings for climate and carbon cycle studies southwest of Tasmania; Subantarctic Biogeochemistry of Carbon and Iron, Southern Ocean Time Series site		
Mobilisation:	Hobart, Thurs, 1-2 March 2018		
Depart:	Hobart, Friday 3 March 08:00 for equipment tests in Storm Bay and then transit to SOTS site		
Return:	Hobart, Wednesday, 21 March 2018, 0900		
Demobilisation:	Hobart, Wednesday, 21 March 2018		
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Chief Scientist:	Thomas W. Trull		
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Principal Investigators:	Philip Boyd		
Project name:	Subantarctic Biogeochemistry of Carbon and Iron, Southern Ocean Time Series site		
Affiliation:	UTAS	Contact details:	Philip.Boyd@utas.edu.au

Scientific Highlights

The Chief Scientist

Professor Trull's expertise is in chemical oceanography and marine biogeochemistry, in particular the use of chemical, isotopic, and sensor measurements to trace material flows through microbial foodwebs.

He obtained a PhD from the Massachussetts Institute of Technology – Woods Hole Oceanographic Institution Joint Program in Oceanography in 1989, and after postdoctoral work at the University of Paris joined the Antarctic CRC in 1993, and CSIRO in 2013.

Key achievements include:

1. demonstration that artificial and natural iron fertilization can enhance particulate carbon flux to the ocean interior, but that this capacity is limited and the risks insufficiently understood to merit largescale fertilization. This work contributed to the establishment of the International Maritime Organization moratorium on marine geo-engineering, for activities other than research.

2. contributions to understanding the status and progress of ocean acidification in Antarctic shelf waters.

3. establishment of the Southern Ocean Time Series examining air-sea exchanges of heat and carbon dioxide.

Title

SOTS: Southern Ocean Time Series automated moorings for climate and carbon cycle studies southwest of Tasmania

Purpose

The voyage consisted of three projects with the following objectives:

1. SOTS: The Southern Ocean is an important part of the global climate system, soaking up carbon dioxide and heat to moderate the earth's atmosphere. The Southern Ocean Time Series observatory uses a set of automated moorings to measure these processes under extreme conditions, where they are most intense and least studied. The processes occur on many timescales, from the day-night cycle up to ocean basin decadal oscillations and thus high frequency observations sustained over many years are required.

2. Trace elements: Measure profiles of trace element dissolved and particulate concentrations, and to examine the processes that produce and recycle them. The work during IN2018_v02 will in combination with those efforts deliver observations from 3 successive years and thus contribute to defining the stability versus interannual variability in trace element levels.

3. Acoustic Zooplankton and Fish Distributions: Sample the top 1000m of the water column for zooplankton and fish at the SOTS site using the profiling lagrangian acoustic optical system (PLAOS) and RMT 8 net. Commonly nets, optic and acoustic samplers are used to determine the taxonomy, size, biomass, trophic linkage and energetics of zooplankton and micronekton. Development of this methodology and technology will significantly advance our knowledge of micronekton biomass and distribution and provide the necessary structure and function understanding for the development of carbon and ecosystem models of the open ocean.

Contribution to the nation

The SOTS research improves understanding of the global climate system by focussing on a key region –the Southern Ocean. Careful sustained observations over the last decade and into the next increases our knowledge of how the ocean interacts with the atmosphere. Improved understanding is essential to enhance advice to the nation on climate variability affecting us now, develop future scenarios and impact assessments, and to make optimal decisions that will affect the nation's future. The work also directly addresses the issue of how ocean biogeochemistry and productivity respond to ocean dynamics, which is an important input to projecting future biogeochemical and ecosystem states. In addition, enhanced understanding of process occurring in the region related to clouds, ocean mixing, waves and rain will also lead to improved forecasts and warnings issued to the public.

As a result of this voyage

As a result of this voyage, we have deployed moored platforms that assemble an integrated view of the seasonality of the processes that control the productivity of the Subantarctic microbial foodweb. This analysis extends from the physics of ocean mixing and insolation, to the chemistry of ocean nutrients and the biological responses of phytoplankton, zooplankton and fish.

We examined a 5-month spring period of observations at the Southern Ocean Time Series site focusing on a rapid deepening of the mixed layer depth occurring over a week (figure 1, panel b) which shows the depth determined by changes in water temperature and the accumulation of heat energy in the ocean due to heating and cooling at the surface. We wanted to determine if the deepening was caused by cooling at the surface (causing the water to become more dense and sink down – mixing as it went), or the horizontal movement of different water past the site. To do this we used a one-dimensional model that accounts for changes in the water due to the heating and cooling and mixing, but not the horizontal movement of water. When we run the model with the observed ocean temperatures (figure 2, left panel, red line) for two weeks with surface heating and cooling we could only simulate mixing down to 100m depth as shown by the modelled temperature (left panel, black line). This was because there was only a modest amount of cooling and a general spring-time warming. We could achieve the observed ocean mixed layer depth in the simulation (figure 2, right panel) by applying a severe winter cooling event when cold and dry winds arrive from further south. Because this severe cooling event did not occur in the observations we conclude that the rapid deepening of the mixed layer depth was caused by the movement of water past the site.

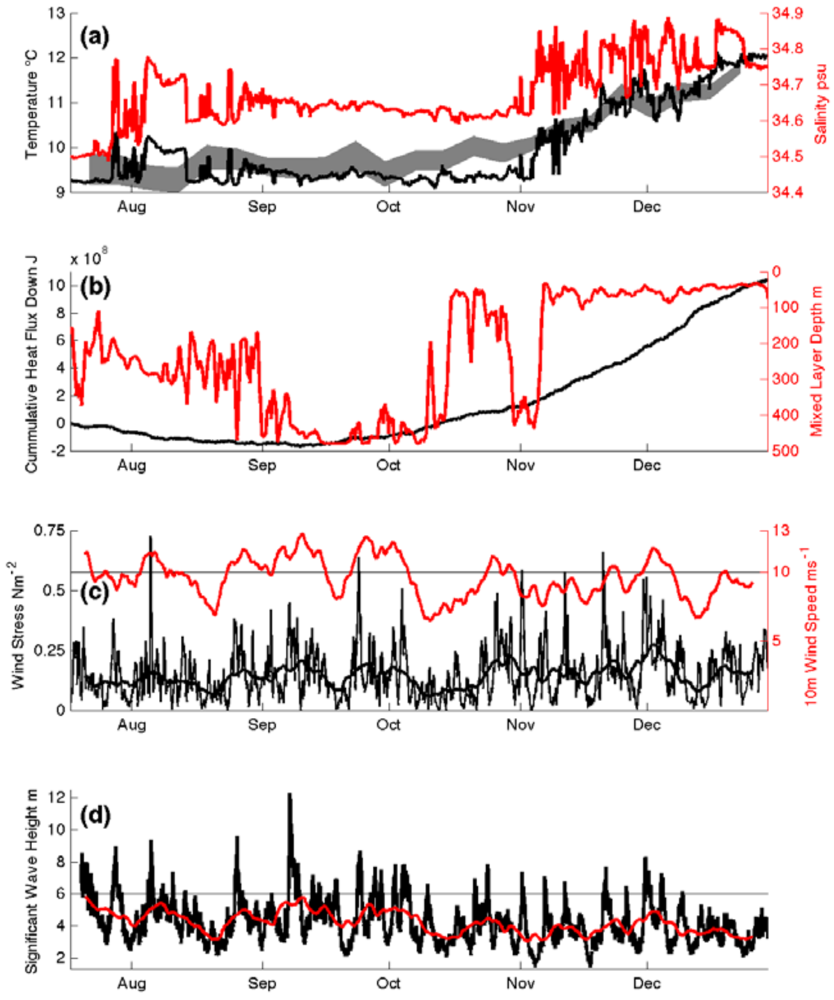

Figure 1. 5-month spring period of observations at the Southern Ocean Time Series site. Panel b shows the depth determined by changes in water temperature and the accumulation of heat energy in the ocean due to heating and cooling at the surface.

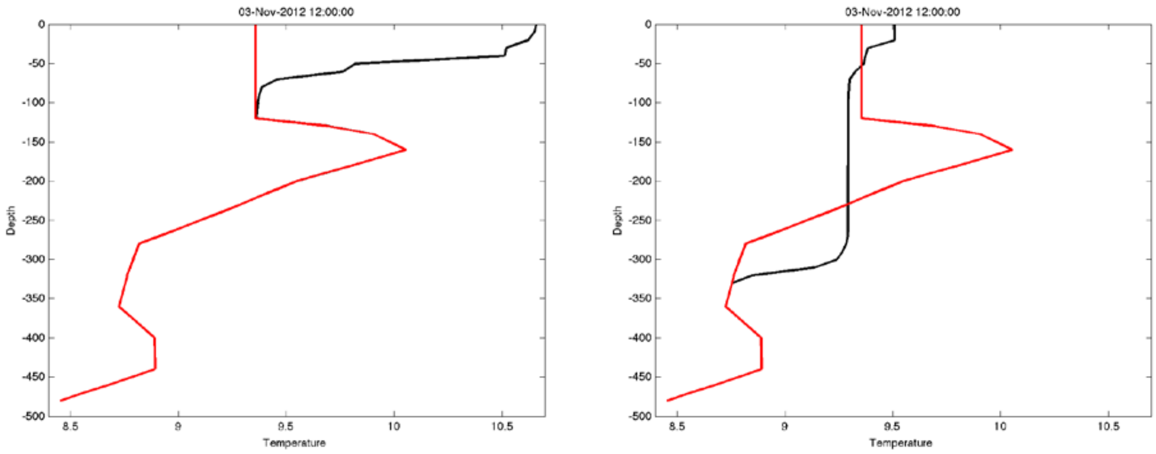

Figure 2. 1-dimensional modelled water temperature. The initial observed temperature (red) and modelled temperature 2 weeks later, using the observed surface heating and cooling (left panel) and a simulated severe winter cooling event (right panel).

A suite of projects examining carbon and iron biogeochemistry processed at the Southern Ocean Time Series site were executed.

We used a sinking camera and sonar device to determine the fish and smaller creatures inhabiting the ocean to a depth of 600m. Sonar systems are operated routinely on research ships, the measurements need to be “ground truthed” with observations of the type and number of fish in the area. We also trawled a large net behind the ship to collect samples of fish and smaller creatures in the upper 600m of the ocean. Fishes, crustaceans, squids and jellies were caught. Figure 3 show a photograph of a Medusa jellyfish from the sinking camera.

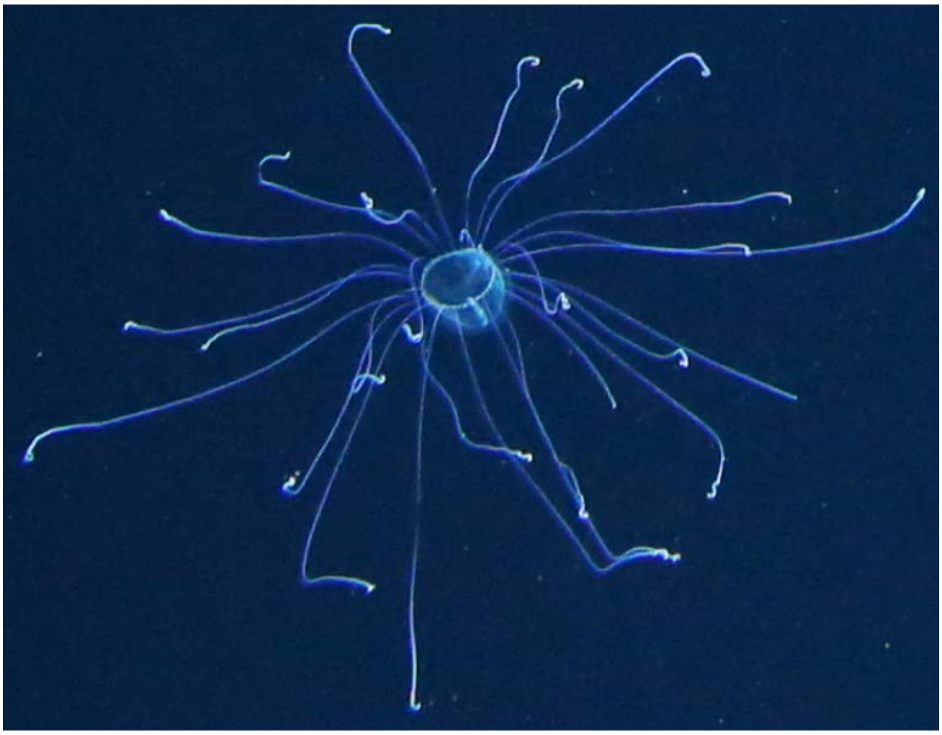

Figure 3. The sinking camera captured this Medusa jellyfish at 740m depth.