Winter 2015 Cruise Report
SA Agulhas II, 22 July – 15 August

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Research projects

The scientific research undertaken on the Winter 2015 cruise can be dividedhiya into seven primary project areas that are listed below. Although some of the projects are more independent than others, the majority are interconnected and the research and data collected within one project area strongly supports that of another. For ease of reporting, the individual projects have been kept separate however attempts have been made to refer to their interconnectivity wherever appropriate. This report contains the rationale, objectives, sampling procedures and initial results for each of the following disciplines:

1. The third Southern Ocean Seasonal Cycle Experiment (SOSCEx III) led by the CSIR with Dr Pedro Monteiro as the Principal Investigator (PI)
2. The South Atlantic Meridional Overturning Circulation South Africa (SAMOC-SA) led by UCT with Prof Isabelle Ansorge as PI
3. The Southern Ocean Trace Metal and BioGeochemistry research led by Stellenbosch University under Dr Susanne Fietz as organising PI,
4. The Continuous Plankton Recorder (CPR) for basin-scale mapping of plankton led by DEA under Dr Sir Hans Verheye as PI,
5. The importance of marine 'dark matter' in the sequestration of atmospheric CO_2, led by university of Pretoria under Prof Don Cowan
6. Acoustic data collection during the winter cruise to study Antarctic krill
7. Birdlife SA – at sea observations of top predators.

The projects funding the research listed above list are as follows:

- South Atlantic Meridional Overturning Circulation SA (SAMOC-SA) – **SNA14071275358**
- Scale Sensitivities of CO_2 Fluxes in the Southern Ocean - **SNA14072378878**

- Surface ocean physical dynamics of the Southern Ocean –**SNA14071475720**
- Understanding the biogeochemical response to physical drivers in the Southern Ocean using bio-optics - **SNA14073184298**
- Bioactive trace elements in Southern Ocean – **SNA2011110100001**
- Southern Ocean Phytoplankton Adaption to mimicked future changes in light and iron availability - Molecular bases and modelling (SOPA) – **SANCOOP 234229**
- Establishing the use of a new lipid paleo-biomarker in the Southern Ocean - **SNA14072378763**

Cruise Highlights

- The inaugural cruise of SOSCEx III, the first high resolution experiment to span a full seasonal cycle in the Southern Ocean using a combination of ships (the SA Agulhas II), robotics platforms (buoyancy gliders, wave gliders and bio-optics floats), high-resolution models and satellite observations.
- An ambitious array of moorings was deployed west and south of south of south Africa in 2013 and 2014, each of these moorings was successfully retrieved, data downloaded and redeployed. This marks a major step in our understanding of the role of the Agulhas current has on the meridional overturning circulation.
- The first high-resolution measurements in winter that reveal the characteristics of phytoplankton primary productivity and carbon draw down.
- Isotopic measurements that investigate the role of the Southern Ocean in driving past glacial and interglacial climate cycles
- Bio-optical characterization of the winter phytoplankton community towards new and improved remote sensing ocean colour algorithms
- Measurements that fill the gaps in the ocean atmosphere CO2 flux record.
- Successful collections of trace metal Fe concentrations to resolve the seasonal supply and demand mechanism of the phytoplankton community in winter
- Basin scale mapping of the abundance, distribution and diversity of plankton communities in the Atlantic and Indian sectors of the Southern Ocean
- Acoustic determination of the distribution and biomass of krill, an important food source for whales, seabirds, seals, fish and squid
- The second ever winter survey of density and distribution of southern ocean pelagic bird species.

Cruise Track

The winter 2015 cruise can be divided into two primary tracks, the GoodHope line between Cape Town and the ice edge along the Greenwich Meridian and the SAMBA line between Cape Town and the Greenwich Meridian at 34.5 degrees South longitude (see Figure 1).

The GoodHope line

The GoodHope Programme is a long term investment with repeated historical occupation crossing the entire extent of the Antarctic Circumpolar Current since 2004.

This has been achieved through a multinational collaboration between the UK, USA, France, Netherlands and Russia with South Africa having completed 15 of the 20 GoodHope crossings. The initial heat flux focus of XBT observations has been extended to include CO_2 observations and is in both counts now the strongest demonstration of South Africa's stewardship activity in the Southern Ocean. The aim of the GoodHope programme is to establish an intensive monitoring platform that provides detailed information on the physical structure and volume flux of waters south of South Africa, where inter basin exchanges occur. Sustained observations such as repeat transects provide the only means to monitor the vertical structure and to investigate the variability of the fronts in this region. The GoodHope programme investigates year-to-year and longer period variability in the fluxes, such as those related to the Antarctic Circumpolar Wave. The objectives of the GoodHope line are to continue the repeat high density physical and biogeochemical data collection along the GoodHope cruise track.

A total of 12 stations occupied the GoodHope line with multidisciplinary deployments that included Geotraces and Niskin CTD's, glider and zooplankton net tows. For more details on deployments per station please refer to Table 1 which provides a summary of all deployments with their success rates or reasons for failure or cancellation.

The following coordinates depict the waypoints for the GoodHope line:

1. Cape Town harbour
2. 14.64°E; 34.02°S
3. 0.00°E, 51.43°S
4. 0.00°E, ice edge°S

The SAMBA line

The SAMBA line is a trans-basin mooring line along 34.5°S aimed at monitoring the South Atlantic MOC and is referred to as the South Atlantic MOC Basin-wide Array (SAMBA). The array extends from South Africa down the steep continental shelf and across the deep abyssal plain to 0°E. A total of 12 stations occupied the SAMBA line, which primarily consisted of CPIES retrievals and redeployments and one deep niskin CTD deployment per station (see Table 1 highlightd in dark blue for details).

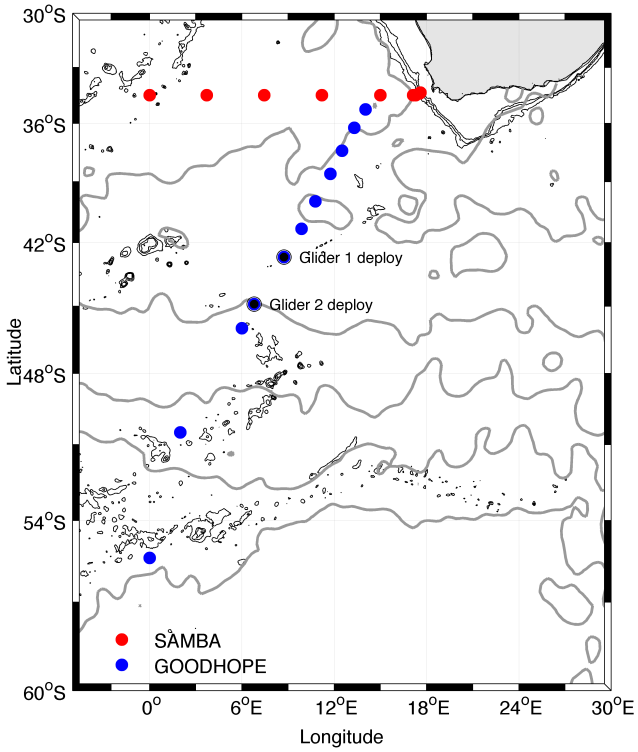

Figure 1. CTD stations depicting the GoodHope line in blue and the SAMBA line in red.

Cruise Participants

SOSCEx III

1. Dr Sandy Thomalla (Senior scientist - CSIR)
2. Dr Warren Joubert (Senior researcher - CSIR)
3. Dr Thomas Ryan-Keogh (Post Doc – CSIR / UCT)
4. Mutshutshu Tsanwani (pCO2 - DEA)
5. Marcel du Plessis (PhD student – CSIR / UCT)
6. Emma Bone (PhD student – CSIR/ UCT)
7. Charles Caulet (PhD student – University of Brittany)
8. Joshua Pein (Hons student – UCT)
9. Manare Sejeng (Hons student – UCT)
10. Alice McGrath (Hons student – UCT)
11. William Middleton (Hons student – UCT)
12. Andre Hoek (Senior Technician - STS)
13. Sinekhaya Bilana (Junior technician - CPUT / STS)
14. Hendrik Janse van Rensburg (CPUT / STS)
15. Hazel Little (Masters student - UCT)
16. Baxolele Wiseman Mdokwana (CO2 technician – DEA)
17. Mhlangabezi Mdutyana (Masters student - UCT)
18: Raymond Roman (nutrient technician – UCT)
19. Peliwe Jubase (intern – DEA)

SAMOC - SA
1. PI SAMOC-SA: Prof Isabelle Ansorge (Physical Oceanography)
2. Mr Olivier Peden (CPIES – IFREMER/LPO)
3. Mr Thierry Terre (CPIES – IFREMER/LPO)
4. Mr Marcel van den Berg (CPIES/ADCP/CTD – DEA OCEANS AND COASTS)
5. Mr Marc de Vos (UCT MSc student – CTD/XBT/Sampling/Data analysis)
6. Mr Tharone Rapeti (UCT MSc student – CTD/XBT/Sampling/Data analysis)
7. Miss Tania Williams (UCT MSc student – CTD/XBT/Sampling/Data analysis)
8. Miss Khusbhoo Jhugroo (UCT MSc student – CTD/XBT/Sampling/Data analysis)
9. Mr Ramontsheng Rapolaki (UCT MSc student – CTD/XBT/Sampling/Data analysis)
10. Katherine Moffet - CPUT student
11. Michael Funke – XBT technician Scripps
12. Remi Laxenaire – PhD student (Laboratoire de Météorologie Dynamique)

Trace Metal and Biogeochemistry
1. Dr Thato Mtshali (CSIR)
2. Dr Raissa Philibert (SU)
3. PhD candidate Sandi Smart (SU)
4. PhD candidate Alice Mühlroth (NTNU Norway, SU)
5. Ethan Campbell A (Princeton, SU)
6. Preston Coslett Kemeny (Princeton, SU)

Phyto- and zooplankton mapping
1. Janine Van Der Poel (CPR – DEA Oceans and Coasts)

Marine 'dark matter' in the sequestration of atmospheric CO_2
1. Sandra Phoma (PhD student)
2. Helen Mubanga Kabwe (MSc student)

Sea bird research
1. Taryn Morris
2. Jess Berndt
3. Martin Berg
4. Tim Carr

Acoustics
1. Fannie Shabangu (PhD student – acoustics)

Additional cruise berths for SAIAB students
1. Tshoanelo Moloi
2. Asandiswa Nonyukela
3. Ayabulela Mrubatha
4. Lusanda Gxalo

General Overview

Rationale

Oceanographic observations in the Southern Ocean and around Antarctica are sparse due to its remote location. This is further accentuated during the winter months when sea ice and hostile weather conditions present additional logistic challenges. The state of seasonal observations and modelling of the Southern Ocean is not as developed as it is in other regions of the ocean and atmosphere. While major achievements have been made in the last eighteen years during the WOCE/JGOFs era and more recently since the start of the GoodHope monitoring line in 2004 (Ansorge et al., 2004) we are only now beginning to understand the mean state and variability of the Southern Ocean (Swart et al., 2008, 2009); its coupling with the atmosphere and cryosphere, and of the zonal and meridional fluxes – but for summer months only. In addition, the Southern Ocean Seasonal Cycle Experiment (SOSCEx), a combined observational and modeling programme run parallel to GoodHope, aims to predict the response of the carbon cycle to climate change through an improved sensitivity to seasonal, subseasonal and mesoscale forcing scales. This combined high-resolution approach to both observations and modelling experiments will address key questions relating to the physical nature of the Southern Ocean and its carbon cycle. Furthermore, the Southern Ocean upper water column processes, which are important to seasonal productivity and carbon fluxes, undergo an annual "reset" during winter months when net heat losses, elevated wind stress and sea ice formation lead to an increase in the mixed layer depth (MLD). This winter "reset" is a critical process in the seasonal cycle, ensuring the regeneration in iron and nitrate concentrations during summer months when the MLD shallows.

Current logistic constraints have restricted our observations to December-January and as a consequence our ocean and climate numerical models are unable to accurately simulate seasonal ventilation processes, nor can they address what impacts changes in the biogeochemical pump through seasonal shifts in the MLD will have on the annual carbon flux. A knock on effect to the absence of any in-situ winter data is the inability for the SANAP marine community to provide a complete picture of the Southern Ocean's impact on productivity and climate.

The Winter 2015 research cruise can be divided into two dominant research programmes, the third Southern Ocean Seasonal Cycle Experiment (SOSCEx III) and the monitoring of the greater Agulhas Current system SAMOC – SA. Each of these research programmes is outlined below:

SOSCEx III Overview

Rationale

The Southern Ocean is a key component of the earth system through its regulation of atmospheric CO_2 (50% of ocean CO_2 uptake; 30% of carbon export flux) and the global heat balance through the closure of the global meridional ocean circulation and its seasonal sea ice dynamics (Schlitzer et al., 2002; Marinov et al., 2006; Marinov et al., 2008; Sallée et al., 2010; Marshall and Speer, 2012; Gille, 2014; Waugh, 2014). It also plays a pivotal ecosystem role through both ocean primary production as well as in regulating the supply of nutrients, to the lower latitudes which supports 85% of ocean production (Marinov et al., 2008; Sarmiento et al., 2004). Changes to the Southern

Ocean carbon cycle and its impact on 21st century atmospheric CO_2 depend critically on the climate sensitivity of these large-scale characteristics (Watson et al., 2014; Le Queré et al., 2007, 2013; Roy et al., 2011; Raupach et al., 2014). Based on recent preliminary findings we propose that the seasonal cycle is a key mode to both diagnose these sensitivities and evaluate earth systems models.

The mean decadal global anthropogenic carbon budget and ocean uptake (1.8 – 2.2$PgCy^{-1}$) are now well established, with the Southern Ocean accounting for about 40 - 50% of the total ocean uptake (Takahashi et al., 2009; LeQueré et al., 2014). The ocean mediation of atmospheric CO_2 has two components: the uptake of anthropogenic CO_2 and variability in the exchange of natural CO_2 (McNeil, and Matear, 2013; Bernadello et al., 2014). While the magnitude of the steady state ocean CO_2 uptake, linked to the increasing CO_2 emissions, is now robustly constrained (Le Queré et al., 2013) the major challenge to the ocean carbon community is to understand the drivers, magnitudes and trends of the non-steady state driven changes in the ocean carbon fluxes (Monteiro et al., 2010; Lenton et al., 2013; Wanninkhof et al., 2013; McNeil and Matear, 2013).

The challenge lies in both resolving the interannual variability and trends as well as understanding the dynamics that play a critical role in seasonal and intraseasonal dynamics. These may make a significant contribution to reducing the uncertainty and improving our understanding of the climate sensitivities of ocean carbon cycle models. While the former challenge will be addressed mainly using observations and empirical models, the latter will be achieved by using ocean and earth systems models and large scale seasonal cycle experiments (Swart et al., 2012; 2014; Majkut et al., 2014). The Southern Ocean mediates both the magnitude of the ocean uptake of anthropogenic CO_2 as well as the variability of the larger net exchange of natural CO_2 (Majkut et al., 2014; LeQueré et al., 2013). In this way it plays a critical role in both the uncertainties of global ocean – atmosphere CO_2 fluxes as well as the modeled climate sensitivities of the carbon cycle. Although there is increasingly strong evidence for large scale changes in the atmospheric forcing and Southern Ocean to global warming (Hall and Visbeck, 2001; LeQueré et al., 2007; Bönning et al., 2008; Gille, 2014), there is also evidence that while global biogeochemical ocean models are able to get close agreement on the mean annual flux of CO_2, they are not able to reflect the seasonal and intra-seasonal modes correctly (Lenton et al., 2013). This points to an important gap in reflecting changes in the forcing that will impact the coupled carbon – climate systems which determine the non-steady state part of the ocean atmosphere CO_2 exchange in the 21st century. Recent work has strengthened the need for such an approach by highlighting the role of sub-seasonal modes in modulating the seasonal characteristics of ocean physics and primary production responses in the Sub-Antarctic Zone south of Africa (Thomalla et al., 2011; Swart et al., 2012; Swart et al., 2014; Joubert et al., 2014).

We hypothesize that an important part of the climate sensitivity of these processes which regulate the carbon, heat and productivity fluxes are linked to fine-scale ocean dynamics, which are not adequately understood and reflected in coupled climate and earth systems models (see figure 4.1.1). SOSCEx III aims to explore the nature of this scale sensitivity with a particular focus on the seasonal cycle mode (Monteiro at al., 2011) as a test for the climate sensitivity of earth systems models in respect of the evolution of both atmospheric CO_2 and ocean ecosystems in the 21st Century.

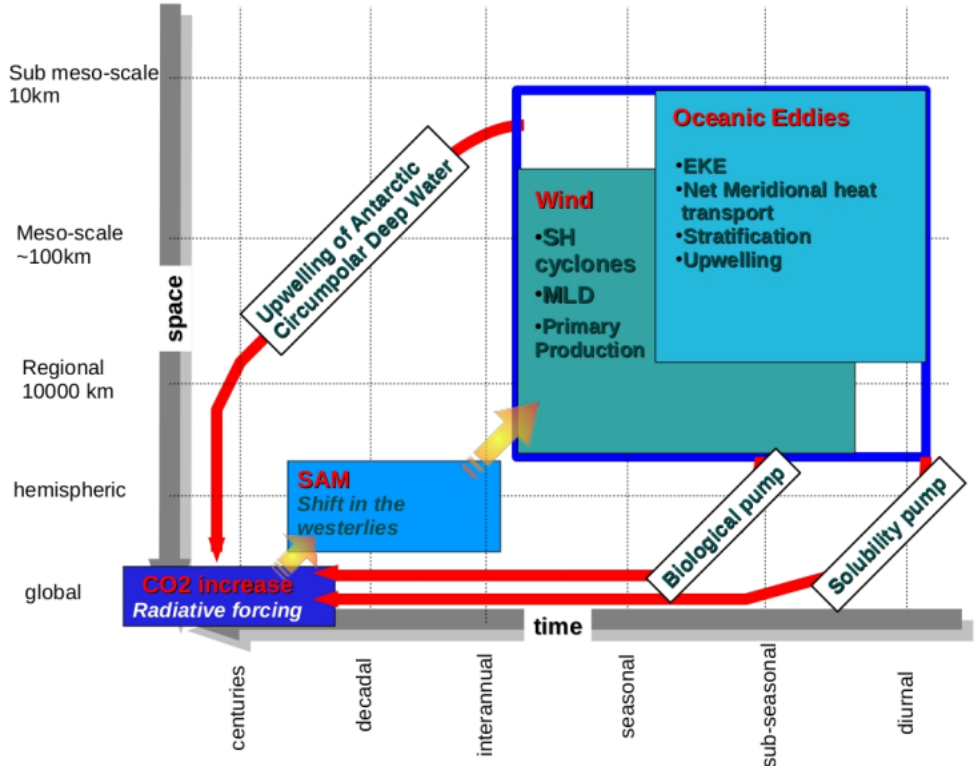

Figure 2 *A space – time plot that summarizes the core scale sensitivity hypothesis of the SOCCO programme: that meso & sub-mesoscale ocean dynamics interact with seasonal and sub-seasonal modes of forcing to mediate the role of the Southern Ocean on the non-steady state behaviour of atmospheric CO_2, which in turn drives trends in large scale atmospheric systems such as the Southern Annual Mode (SAM).*

There have been extensive advances on the role of meso and sub-mesoscale ocean dynamics in explaining the spatial variability and phasing of biogeochemical properties (Lévy et al., 2012). We build on this knowledge to understand how seasonal and sub-seasonal dynamics interact with meso and sub-meso scales to modulate the seasonality of carbon fluxes and primary production (Swart et al., 2014). In this way we aim to investigate the role of fine scale dynamics on long-term carbon-climate sensitivities. This approach is summarized in Fig. 4.1.1: whereby the role of the Southern Ocean in the long term evolution of the radiative forcing effect of atmospheric CO_2 (lower left portion of figure), which drives large scale atmospheric systems such as the Southern Annular Mode (SAM), depends on the sensitivity of the carbon flux drivers (upwelling of Circumpolar Deep Water (CDW), biological and solubility pumps) to fine scale surface boundary layer dynamics.

A closer examination of the seasonal and intra-seasonal modes of variability may not only help to diagnose critical dynamics, which explain inter-annual variability, but also climate sensitivities which may improve century scale climate predictions as well as explain large scale paleo-climate- biogeochemical adjustments in the ocean and atmosphere (Martinez-Garcia et al., 2014; Sigman et al., 2000; 2010). The importance of seasonal cycle dynamics in understanding the climate sensitivity of ocean carbon fluxes has been highlighted by Rogers, 2008; Monteiro et al., 2010; Monteiro et al., 2011; Lenton et al., 2013). However, Seasonal Cycle experiments have been hard to undertake because of platform limitations, until recently limited to ships and moorings and their space – time scale limitations (Fig. 2).

The proposed high-resolution seasonal cycle approach extends its contribution to advancing the understanding of climate sensitivities beyond carbon to ecosystem dynamics (Smetacek et al., 2004). One of the key drivers of the carbon flux in the Southern Ocean is the biological pump mediated by primary productivity in the upper ocean boundary layer (Marinov et al., 2008; Arrigo et al., 2008; Cassar et al., 2011). Primary productivity which accounts for an estimate annual carbon export flux of 3PgCy-1 (Schlitzer et al., 2002) also supports energy supply into the austral polar and sub-polar ecosystems (Smetacek et al., Sarmiento et al., 2004). Core to our thinking is that the Seasonal Cycle is the mode of variability that couples the physical mechanisms of climate forcing to ecosystem response in production, diversity and carbon export. This is highlighted in the spatial variability of contrasting seasonal modes, which contribute to elevated regions of primary productivity in the Southern Ocean (Boyd et al., 2002; Thomalla et al., 2011). More recently, a link has been made between the seasonal iron supply driven by convective winter entrainment and the phasing and magnitude of the spring bloom in the austral polar and sub-polar regions (Tagliabue et al., 2014). However, notwithstanding the key role of winter mixing, recent data obtained using ocean robotics indicate that storm driven entrainment during the summer may play a critical role in extending the duration of seasonal primary production (Swart et al., 2014) through their impact on Iron fluxes (Joubert et al., 2014). Collectively these studies indicate that there are important gaps in our understanding of the role of fine scale dynamics, which may advance the understanding of climate sensitivities not yet fully reflected in climate models.

On this basis we propose a year long high resolution (space and time) seasonal cycle experiment as an interdisciplinary platform to address the required understanding of the role of fine scale dynamics in driving large scale responses of the coupled ocean – atmosphere systems in the Southern Ocean.

Objectives

The challenge in predicting long term trends in the Southern Ocean carbon cycle lies in our ability to resolve interannual variability and the link between seasonal and intraseasonal dynamics in physical drivers and biogeochemical responses. Despite their importance, surface ocean processes at these scales are poorly understood and quantified due to operational limitations of ships and moorings. This has necessitated the use of autonomous, remotely sensed and modeling platforms that are able to address the temporal and spatial scale gaps in our knowledge of a hitherto under sampled ocean.

The primary aims of SOSCEx III are:

1/ To understand through seasonal scale observations, the role of fine scale upper ocean physical dynamics on CO_2 fluxes and primary production in the Southern Ocean and its impact on large-scale carbon-climate sensitivities.
2/ To make a significant contribution to improving the way global climate models reflect CO_2 and primary productivity climate sensitivities in the Southern Ocean.

The more specific aims of the Winter 2015 research cruise are:

1/ To deploy the robotics platforms (buoyancy and wave gliders) at the two process stations to initiate the high-resolution sampling of a full seasonal cycle in the SAZ.
2/ To provide profiles of dissolved Fe concentrations with high-resolution sampling of the upper winter mixed layer defining the ferricline and providing the winter reset values in support of summer time production
3/ To collect high resolution underway bio-optics measurements that characterise the phytoplankton community and contribute towards improved ocean colour algorithm development specific to the Southern Ocean
4/ To improve our understanding of winter versus summer phytoplankton productivity and physiology through a combination of primary production and P vs I incubation experiments and photo physiology estimates of photosynthetic efficiency
5/ To characterise the CO2 flux in winter

SAMOC- SA Overview

Introduction

The current Global and Southern Ocean Observing programme, in which South Africa is a member, and the new DST 2014 Antarctic Strategy Plan (*Skelton et al., 2014*) call for sustainable inter-seasonal observations. Repeat hydrographic transects have quantified the evolving ocean inventory of heat and carbon, demonstrated that changes are occurring throughout the full depth of the Southern Ocean and neighbouring basins, and have also provided a platform for a wide suite of interdisciplinary observations. Satellites continue provide circumpolar, year-round coverage of physical and biological variables. Moorings provide time series information on velocities and water properties in critical regions. The development of autonomous profiling floats and gliders allows broad-scale, year-round measurements to be made. Furthermore, our ability to accurately model and simulate Greater Agulhas Current processes is becoming an increasingly integral element of ocean observing system. Currently we have an incomplete picture of the mean state and variability of this sector and surrounds, its coupling with the atmosphere and of the exchange between the zonal and meridional fluxes across neighbouring basins. Our observations are limited in space and time and our models do not confidently simulate these processes. To identify the importance of the Agulhas Current system as a potential driver of climate change emphasis must now be placed on the quantification, physical understanding and long-term monitoring of the Agulhas Current system and its connection with both the Indian and Atlantic Ocean basins. To achieve these aims, the necessity of developing full basin-wide arrays, repeat monitoring lines and an improvement on seasonal measurements are crucial if uncertainties in model projections of global warming south of Africa are to be reduced.

SAMOC-SA

Argo floats, sea gliders and satellite remote sensing continue to revolutionize our ability to measure the upper layers of the ocean. They provide information about different aspects of ocean dynamics and insights into the Greater Agulhas Current system and its link with the meso- and large-scale circulation on varying temporal scales. Despite these advances, there is growing recognition of the intimate link between ocean basins and the critical need to study the full ocean water column. The aim of the SANAP/DST funded SAMOC-SA is to improve and deepen this knowledge through the development of an array of monitoring lines that span the greater Agulhas Current region (Figure 2 – SAMBA and GoodHope). Only when these lines are sustained over years-to-decades, can the scientific community begin to accurately predict the role the Greater Agulhas Current system may have in mitigating the effects of global climate change.

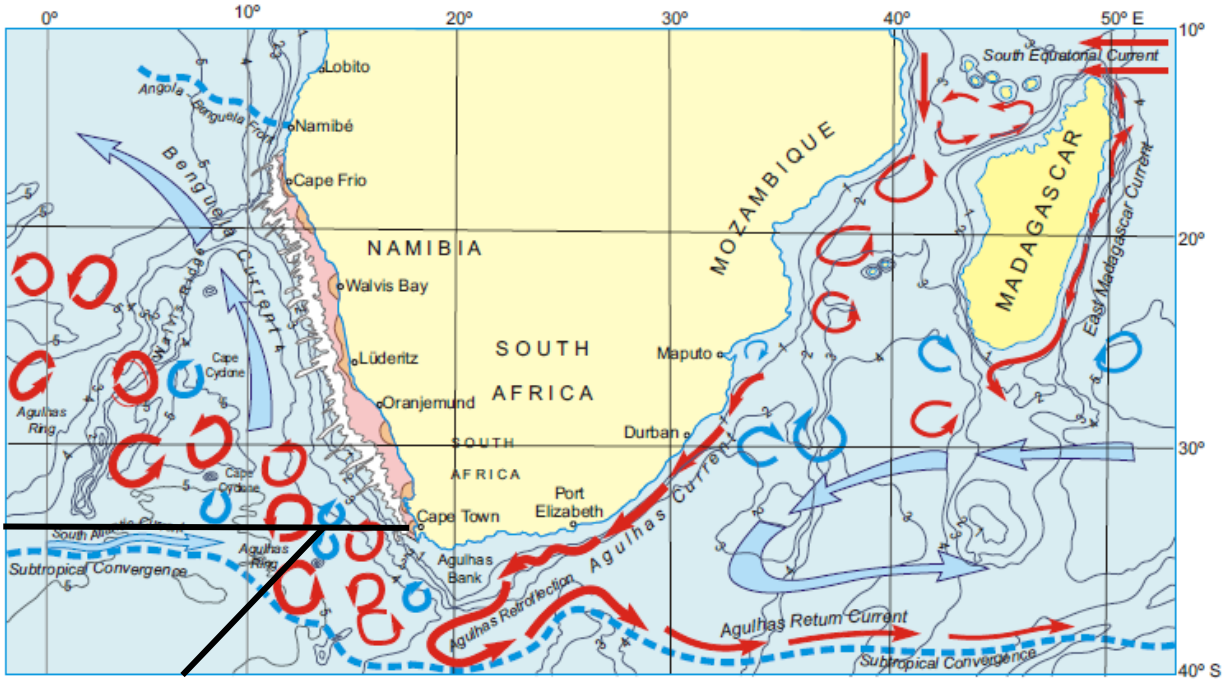

Figure 2: A schematic of the circulation of the Greater Agulhas System. The location of SAMBA along 34.5S and the northern component of the GoodHope line are shown as black solid lines.

SAMBA

1. Investigating the Agulhas Leakage and its influence on the MOC.

The large meridional gap separating the African and Antarctic continents provides a significant crossroad for water mass exchange between the subtropical Indian and South Atlantic gyres. Recent modeling studies (Biastoch et al., 2010) suggest that the Agulhas leakage is of critical influence; not only is the region a gateway for the upper limb of the Meridional Overturning Circulation (MOC) northward flow, but the shedding of Agulhas rings provides one of the major sources of salinity to the South Atlantic. Other modeling investigations suggest that variability in this leakage may correlate to changes in strength of the MOC (Biastoch and Böning 2013) and North Atlantic Sea Surface Temperature (Lee et al., 2011). Schiermeier (2013) identified the South

Atlantic near 34.5°S as a crucial location to observe and understand the mechanisms that control the meridional heat and fresh-water (or salt) transport in the South Atlantic. This initiative consists of a trans-basin mooring line along 34.5°S aimed at monitoring the South Atlantic MOC and is referred to as the South Atlantic MOC Basin-wide Array (SAMBA). Recent studies on the Agulhas Current system (Backeberg et al., 2012) have shown that its mesoscale variability has intensified due to an increase in the transport of the South Equatorial Current. A knock-on effect of this intensification is the accelerated propagation of Agulhas rings into the Atlantic. The need to monitor this leakage is critical.

In September 2013 a network of eight bottom-moored CPIES moorings were deployed along the eastern side of the SAMBA array. CPIES are able to record vertical acoustic travel time and near-bottom pressure and velocity – from these measurements temperature, salinity and north-south velocity throughout the water column can be inferred. The array extends from South Africa down the steep continental shelf and across the deep abyssal plain to 0°E (Ansorge et al., 2014). A further ten moorings are planned for deployment on the eastern flank in mid 2014. This eastern line complements the seven CPIES array extending from the South American continental shelf to 44°W, deployed by United States, Brazilian and Argentine scientists in December 2012. Repeat oceanographic surveys are planned between the African continental shelf and 0°E during each SANAP logistic voyage to Gough Island and annual or semi-annual surveys are planned for the western end of the SAMBA line up until 2016. These deployments have not only brought the SAMBA transect closer to completion but will provide high quality observations associated with the Agulhas Leakage and its long-term contribution to the MOC (Ansorge et al., 2014). However, while the SAMBA array captures the northward flow associated with the Agulhas leakage (Figure 1), a recent investigation by Dencausse et al. (2010) has shown that additional pathways for Agulhas Rings exist. These pathways are influenced by the surrounding topographical features and divide the Agulhas Leakage into northern, central and southern routes. While the SAMBA array aims to capture the majority of leakage associated with the northern and central paths, Dencausse et al (2010) study confirms that approximately 23% of Agulhas Rings advect along the southern corridor across the Subtropical Front into the Subantarctic Zone (SAZ). These rings undergo substantial hydrological modifications within the SAZ through increased mixing at their edges and high air-sea fluxes due to the cooler and fresher surrounding conditions (Gladyshev et al. 2008; Swart and Speich, 2010). A core objective of the GoodHope line was therefore to establish the importance of the southernmost route as a conduit for subtropical waters masses associated with Agulhas rings entering the SAZ (Ansorge et al., 2005). To achieve this aim the GoodHope monitoring line needed to extend further south of Africa across the Subtropical, Subantarctic and Antarctic domains.

GoodHope

2. Monitoring the Agulhas Leakage and its influence on the region south of Africa

The Goodhope field program which enters its 12th year is an established intensive monitoring line south of Africa and extends from the subtropical to Antarctic domains. The advantages of the GoodHope programme are threefold: it follows the TOPEX/POSEIDON – JASON 1 and more recently JASON 2 altimeter tracks and thus

continues to ground-truth altimetry-derived sea height anomaly data; the southern fraction of this line (south of 50˚S) continues to be monitored by a mooring array aimed at investigating the formation of deep and bottom water in the Weddell Sea, the northern section of the GoodHope line overlapped (ref and date) the USA-ASTTEX programme, enabling observations in the Southern Ocean to be linked with data collected within the Benguela region and the west coast of Southern Africa. Since early 2004, over 30 high-resolution repeat XBT transects (two per year), six full-depth hydrological transects (five Russian, one French-IPY Bonus Goodhope) and two winter occupations (South African) (Speich et al., 2013). With the increase in numbers of full-depth hydrographic cruises and underway XBT/UCTD transects, the regular deployment of Argo and more recently Bio-Argo profiling floats into the Southern Ocean, as well as the inclusion of satellite altimetry and numerical model outputs into many observation studies scientists are beginning to improve their knowledge on the regional meridional and zonal meso-scale dynamics, the ventilation of intermediate water masses and the heat and saltwater exchange south of Africa (Legeais et al. 2005; Swart et al. 2008; 2010 and Swart and Speich 2010; Speich et al., 2013). In addition, scientists have redefined the route undertaken by Indian waters into the South Atlantic (Speich et al. 2006; 2007; Speich and Arhan 2007; Doglioli et al. 2006; 2007; Dencausse et al. 2010 a, b and c). To extend beyond the current capability of observations and to begin to link GoodHope to the SAMBA transect; a comparable array comprising of ADCP and CPIES/PIES were deployed from the SA Agulhas II in December 2014. This cruise provided an opportunity to refurbish several of these moorings (see report T.Terre).

Frontal Locations

The Southern Ocean is characterised by the strong zonal nature of its main frontal bands, and its spatial structure is strongly determined by the position and flow regime of a number of frontal system separating different ACC zones (Belkin and Gordon, 1996). Extensive measurements have been made in the South Atlantic and South Indian sectors of the Southern Ocean over the past 3 decades (Ansorge et al., 2004). Full depth CTD measurements have been made during AJAX SR2 WOCE and on an opportunistic basis enroute to the ice edge. Unlike other regions of the Southern Ocean, where frontal systems display high bands of variability with enhanced eddy activity such as at the Drake Passage and South Georgia, at the South-West Indian Ridge (Ansorge and Lutjeharms, 2003) and south of Australia (Sokolov and Rintoul, 2002), the frontal characteristics in the region of the Greenwich Meridian line are less intense and variable, as can be inferred from altimetry and from historic hydrographic data. In addition, investigations by Billany et al., (2010) into the seasonality of these frontal locations at the Greenwich Meridian have shown that the STF has the most pronounced annual cycle, whereas the SAF, and particularly the APF, show smaller seasonal shifts (Figure 3). A rapid change in the STF position occurs from May to August when this front moves northwards.

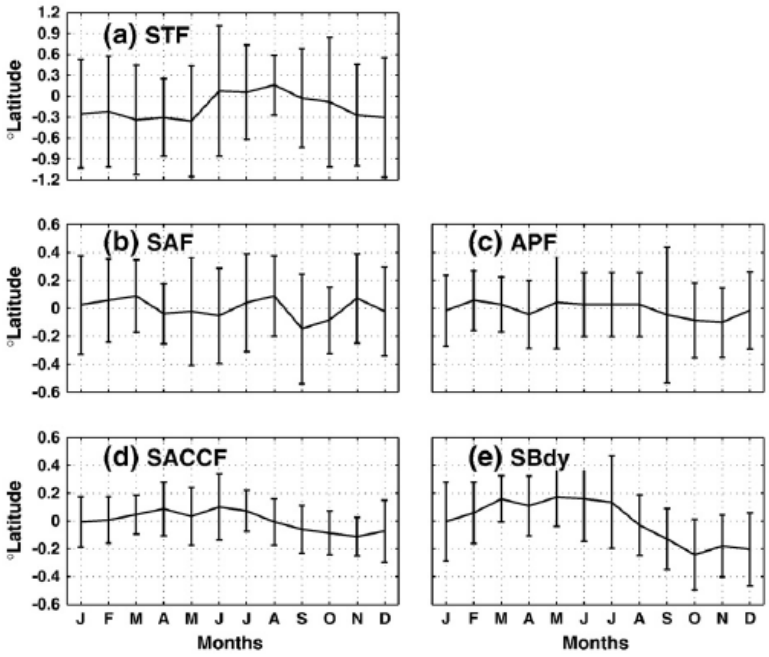

Figure 3: Mean seasonal meridional shifts (° latitude) in the frontal positions in the ACC at the Greenwich Meridian from a 15-year continuous time-series. The error bars represent the standard deviation for each month within the seasonal mean. (a) STF, (b) SAF, (c) APF, (d) SACCF, (e) SBdy. Courtesy of Billany et al., 2010.

Identification of the main ACC fronts is essential in order to trace the upper level circulation associated with the baroclinic shear. Definitions for both surface and subsurface ranges are given above in Table 1, however, in order to unambiguously place the fronts before describing the frontal features observed along the GoodHope winter transect, each front will be defined using their representative subsurface axial values at 200m, where generally each front is marked best.

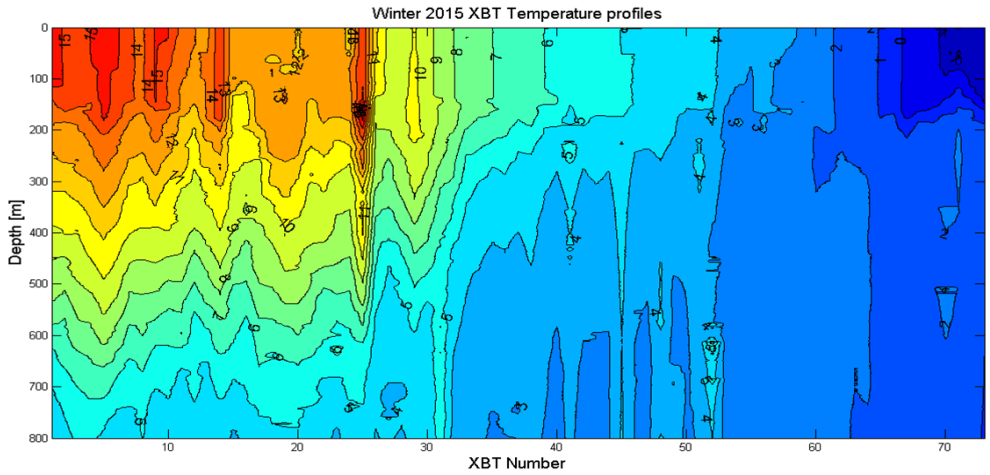

Figure 4: Hydrographic temperature data for the 2015 GoodHope transect. The position of the subsurface expressions of the STC (10˚C), SAF (6˚C) and APF (2˚C) is shown. The lack of a distinct subsurface temperature minimum layer (typical of Winter Water) south of the

APF (common on all summer GoodHope transects) due to increased wind and wave activity during the winter months is noticeable.

Table 1: Definition of the fronts bordering the Antarctic Circumpolar Current adapted from Belkin and Gordon (1996).

FRONT	SURFACE RANGE	SUBSURFACE (200 m) RANGE
STF	10.6 – 17.9˚C: 34.3 – 35.5	8.0 – 11.3˚C: 34.42 – 35.18 Axial value: 10˚C, 34.8
SAF	6.8 – 10.3˚C: 33.88 – 34.36	4.8 – 8.4˚C: 34.11 – 34.47 Axial value: 6˚C, 34.3
APF	2.5 – 4.1˚C	Axial value: 2˚C

Subtropical Front

The Subtropical Front (STF) marks the boundary between warm, salty subtropical surface water and cooler, fresher Subantarctic Surface Water to the south. It is the most northerly front associated with the ACC and the most prominent surface thermal front. XBT data collected from over 70 crossings of the STF have shown that in the South Atlantic the STFs mean position lies at 41˚40'S (Lutjeharms and Valentine, 1984). The surface expression during the winter 2015 GoodHope cruise of the STC was found between 39˚39' – 40˚54'S and the subsurface core, identified by the 10˚C isotherm at 200m, at 40˚42'S (XBT 15 – Table 2) (Figure 4). Previous studies in the South-east Atlantic sector of the Southern Ocean (Smythe-Wright et al., 1998) have identified two separate fronts associated with the Northern (NSTF) and Southern boundaries (SSTF) of the STF. These observations have been made from over 10 datasets extending across the South Atlantic from the Brazil Current at 42˚W to the Agulhas - Benguela region at 11˚E. Surface temperature and salinity definitions given by Belkin and Gordon (1996) cover the range 14.0 –16.9˚C, 34.87 – 35.58 for the NSTF and 10.3 – 15.1˚C, 34.30 – 35.18 for the SSTF. The changes in temperature and salinity are nearly density-compensating, so that the density gradient across the STF is weak.

Subantarctic Front

In contrast to the STF, the vertical shear associated with the main fronts of the ACC - the Subantarctic Front (SAF) and Antarctic Polar Front (APF) - typically extends throughout the water column. The Subantarctic Front (SAF) marks the northern boundary of the Polar Frontal Zone (PFZ), which is a transitional zone between SASW and AASW. In comparison to the STF, which is clearly characterised by a sharp and consistent gradient in both surface and subsurface expressions, making identification extremely easy (Whitworth and Nowlin, 1987), the SAF is less clear in its surface expression. The exact boundaries of the PFZ can therefore be difficult to identify due to the weak nature of this front. North of the SAF the salinity minimum of the AAIW is pronounced; south of the SAF the salinity minimum is weak or absent. The SAF is predominantly a subsurface front and can be defined by the most vertically orientated isotherm within a

temperature gradient lying between 3˚C and 5˚C, while its surface expression extends between 8˚C and 4˚C. Lutjeharms and Valentine (1984) have identified the SAF as having a mean position of 46˚23'S south of Africa. Using the criteria described by Belkin and Gordon (1996) in which the subsurface temperature range between 4.8 - 8.4°C and 34.11 - 34.47 at 200m, with axial values of 6°C, we observed the subsurface axis of the SAF at 43˚49'S (XBT 37) (Figure 4) during the winter 2015 GoodHope transect. This appears to be considerably wider than in other studies in this region of the Southern Ocean (Belkin and Gordon 1996). However, recent investigations (Swart et al., 2008) have shown that in the South Atlantic, the SAF is often found as a broad frontal band extending over 250km (43˚38'S - 47˚17'S) and with a number of narrow reversals. This observation is in agreement with Holliday and Read (1998) who have identified a number of surface steps related to both temperature and salinity inversions. The exact cause of these inversions is not known, however Lutjeharms and Valentine (1984) and Wexler (1959) have ascribed these inversions to either wind-induced upwelling or the poleward shedding of eddies.

Antarctic Polar Front

The APF marks the northern limit of the Antarctic zone and the subsurface expression of the APF is historically identified by the northern limit of the 2˚C temperature minimum at a depth of 200m (Belkin and Gordon, 1996). In some instances this is not coincident with the surface expression of the APF (Lutjeharms and Valentine, 1984) and instead the surface expression can be identified by the maximum temperature gradient between 6˚C and 2˚C. The APF is characterised by a shallow temperature minimum associated with the remnants of Winter Water, which lies at depths between 50 – 150m. It is seasonally variable; in winter it is nearly homogenous extending to 250m, while in summer the mixed layer extends only to between 50 - 100m creating a distinct subsurface T_{min}. Temperatures for this water mass range from -1.8 – 6°C at the APF, and salinity from 33.4 - 34.2. During the winter GoodHope transect the subsurface expression of the APF was found to lie at 50˚36'S (XBT 63) (Figure 4).

Southern Antarctic Circumpolar Front (SAACF)

Orsi et al. (1995) have identified an additional ACC front, which they have termed the Southern ACC Front (SACCF) and described as a circumpolar, deep reaching front lying south of the APF. The position of this front corresponds to the position of the atmospheric low-pressure belt Antarctic trough, which separates the easterly and westerly wind belts at ~65˚S. In contrast to the other fronts associated with the ACC, the SACCF does not separate distinct surface water masses, instead it is defined by the temperature and salinity characteristics of the Upper Circumpolar Deep Water (UCDW). Two branches of the SACCF, marked by a high salinity gradient 33.80 – 33.63 at 63.4ºS and 33.78 - 33.09 at 64.7˚S between 0.9 –0.7˚C, were observed by Holliday and Read (1997) in the SE Atlantic from their RRS Discovery dataset. South of Australia the SACCF has been identified by the location of the 0ºC isotherm along the T_{min}, which places the front at a mean position of 63˚48'S. Increase in air temperatures between December – February results in the warming of the surface mixed layer and the northern extent of the TML cooler than 0˚C forming a reliable indicator of the position of the SACCF. Using this definition, places the SACCF during the GoodHope transect close to the southern most station 55˚44'S (XBT 76) (Figure 4).

Summary of Sampling stations

The table below provides an overall summary of all deployments on the cruise with and indication of their success rates or reasons for failure or cancellation.

Southbound

Station Type	Latitude	Longitude	Progress
ADCP 1 retrieve only	34° 22.0118 S	17° 40.3123 E	Recovered
ADCP 2 retreieve only	34° 23.5399 S	17° 35.5217 E	Recovered
CPIES 1 retrieve only	34° 24.3887 S	17° 33.4938 E	In release mode but no detection @ surf.
CPIES 2 retrieve only	34° 29.8130 S	17° 18.036 E	Recovered
CPIES 3 retrieve only	34° 29.9640 S	17° 08.312 E	damaged on retrieval and sank
CPIES 4 retrieve only	34° 30.0000 S	15° 00.161 E	recovery delayed for return leg - rough weather
CPIES 1 + Niskin deep CTD	35° 15.6358 S	14° 02.6372 E	revovered / successful
Geotraces soak CTD			successful
Zooplankton bucket/ net haul			successful
CPIES 2	36° 13.2180 S	13° 18.1010 E	Retrieval cancelled, CPIE to stay in place
Niskin Deep - CPIES / Bio marker / dark matter			successful
Zooplankton bucket/ net haul			successful
CPIES 3	37° 24.4860 S	12° 31.0990 E	Recovered and redeployed
Geotraces			successful
Niskin Deep - CPIES / Bio marker / dark matter			successful
Zooplankton bucket/ net haul			successful
CPIES 4	38° 36.0990 S	11° 45.7650 E	Retrieval cancelled, CPIE to stay in place
Niskin Deep - CPIES / Bio marker / dark matter			successful
Zooplankton bucket/ net haul			successful
CPIES 5	39° 58.5673 S	10° 47.6676 E	Retrieval cancelled, CPIE to stay in place
Niskin Deep - CPIES / Bio marker / dark matter			cancelled
Zooplankton bucket/ net haul			cancelled
CPIES 6	41° 20.4750 S	09° 53.2060 E	Recovered
Niskin Deep - CPIES / Bio marker / dark matter			successful
Zooplankton bucket/ net haul			successful
Net			successful
CPIES 7 release	42° 41.4787 S	08° 44.1504 E	Recovrered
Geotraces shallow			successful
C-OPS			cancelled rough weather
Wave glider			successful
Geotraces bioassay			successful
Niskin Deep - CPIES / Bio marker / dark matter			successful
Buoyancy Glider			successful
Niskin shallow - biology			successful
Geotraces shallow			successful
Zooplankton bucket/ net haul			successful
Zooplankton Net Tow			successful
Zooplankton Net Tow	~44° S	good hope	cancelled rough weather
Geotraces shallow	45°S on SAF	good hope	successful
C-OPS			cancelled rough weather
Wave glider			successful
Niskin Deep - Bio marker / dark matter			cancelled rough weather
Buoyancy Glider			successful
Niskin shallow - biology			successful
Geotraces shallow			cancelled rough weather
Zooplankton Net Tow			successful
Zooplankton bucket/ net haul			successful
Geotraces Deep	46° S	08° E	successful
Niskin Deep - Bio marker / dark matter			successful
Niskin shallow - biology			successful
Geotraces bioassay			successful
Zooplankton bucket/ net haul			successful
Geotraces Shallow	50° 27S	02° E	successful
Niskin shallow - biology			successful
Niskin Deep - Bio marker / dark matter			successful
Zooplankton Net Tow			successful
Zooplankton bucket/ net haul			successful
Geotraces Deep	55° 40'S ice edge	0° E	successful
Niskin Deep - Bio marker / dark matter			successful
Niskin biology			successful
Geotraces bioassay			successful
Zooplankton bucket/ net haul			successful
CPR - deploy			successful

Northbound

Station Type	Latitude	Longitude	Progress
Retrieve CPR	54° S (on way back)	0° E	successful
Geotraces Deep			successful
Niskin Deep - Bio marker / dark matter			successful
Niskin shallow - biology			successful
Geotraces bioassay			cancelled not enough time to process
Zooplankton bucket/ net haul			successful
Zooplankton Net Tow			successful
CPR - re deploy			successful
Zooplankton Net Tow	~45° S	00° 00.0000 E	successful
CPIES 8 + CTD	34° 30.0590 S	00° 00.0000 E	successful
Bio marker / dark matter / other			successful
Zooplankton bucket/ net haul			successful
CPIES 7 + CTD	34° 29.9240 S	03° 43.146 E	successful
Bio marker / dark matter / other			successful
Zooplankton bucket/ net haul			successful
CPIES 6 + CTD	34° 30.4220 S	07° 27.032 E	successful
Bio marker / dark matter / other			successful
Zooplankton bucket/ net haul			successful
CPIES 5 + CTD	34° 29.9990 S	11° 12.185 E	successful
Bio marker / dark matter / other			successful
Zooplankton bucket/ net haul			successful
CPIES 4 + CTD Deployment only	34° 30.0000 S	15° 00.161 E	successful
Bio marker / dark matter / other			successful
Zooplankton bucket/ net haul			successful
CPIES 3 + CTD Deployment only	34° 29.9640 S	17° 08.312 E	successful
Bio marker / dark matter / other			successful
Zooplankton bucket/ net haul			successful
CPIES 2 + CTD Deployment only	34° 29.8130 S	17° 18.036 E	cancelled since due to unsuccessfull retrieval
Bio marker / dark matter / other			successful
Zooplankton bucket/ net haul			successful
CPIES 1 + CTD Deployment only	34° 24.3887 S	17° 33.4938 E	successful
Bio marker / dark matter / other			successful
Zooplankton bucket/ net haul			successful
ADCP 2 + CTD Deployment only	34° 23.5399 S	17° 35.5217 E	successful
Bio marker / dark matter / other			successful
Zooplankton bucket/ net haul			successful
ADCP 1 + CTD Deployment only	34° 22.0118 S	17° 40.3123 E	successful
Bio marker / dark matter / other			successful

Scientific Reporting

1. Physical Oceanography

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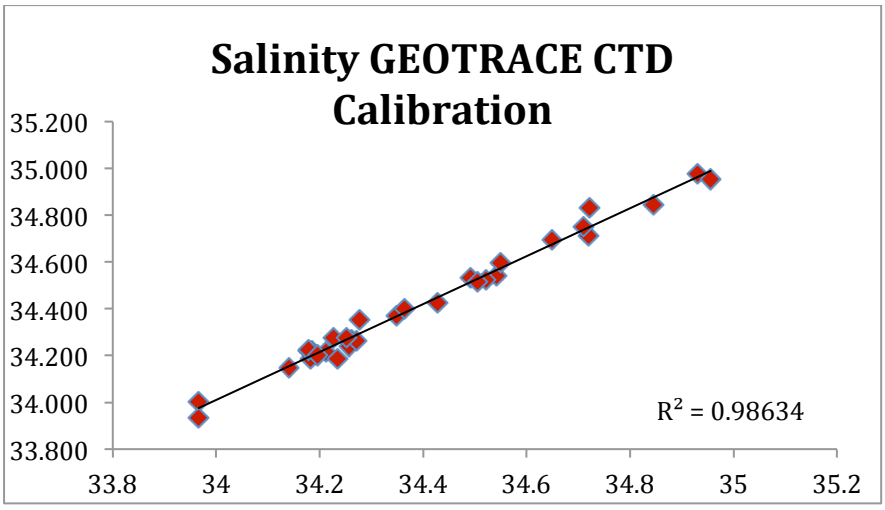
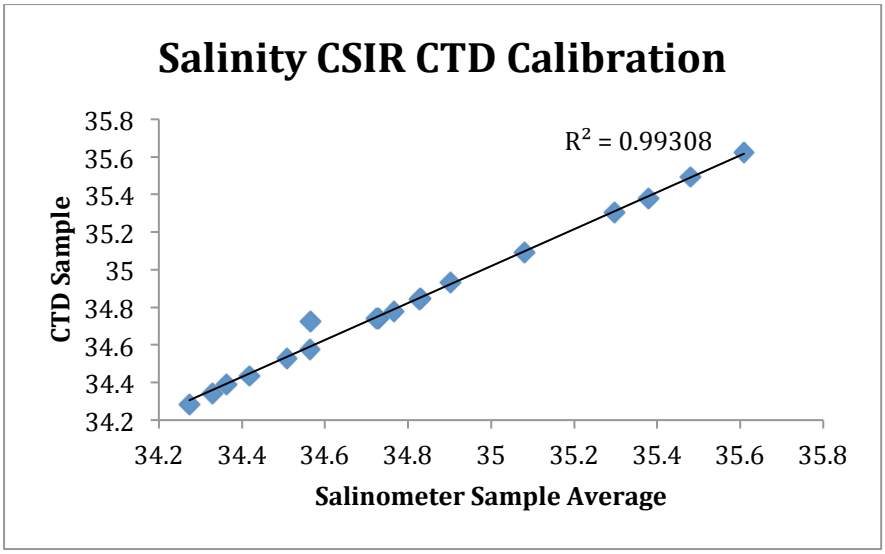
The state-of–the-art research ship SA Agulhas II represents a significant investment of R1.3 billion in polar infrastructure, which will further strengthen South Africa's scientific presence in the Southern Ocean.

GoodHope - The southbound GoodHope transect was conducted onboard the SA Agulhas II as Leg 1 of the dedicated DST winter cruise between the 16th July to 3rd August 2015. A total of 75 Sippican Deep Blue XBTs were deployed between 34˚35'S, 14˚54'E and 55˚42'S, 00˚00'E enroute to the ice edge at 56˚S. A total of 7 calibration full-depth CTD stations were deployed as part of the PIES calibration programme (Table 2). Water masses were identified and calibration data downloaded and processed via the SEASave/Soft programme into 1 m average bins. The pitch and rolling of the vessel, excess noise, change in cast velocity and sensor calibrations (salinity) were incorporated into each processing step. The list of PIES retrieved and redeployed is shown in Table 2.

SAMBA – The west-east transect associated in the SAMBA array was conducted between 8th-13th August 2015. A total of 11 CTD stations and 29 XBTs were deployed along this transect. The list of CPIES is shown in Table 2.

Salinity samples were collected at 4 depths at each CTD station occupied (bottom, 2000m, Oxygen minimum and 50 m) and were processed with a Guidline model 8410A portasal according to the manual in order to confirm the recent calibration of the salinity sensor on the Geotrace CTD system.





Graph1: Calibration comparisons between CTD and samples for both CTD rosettes.

Underway - ADCP data was collected enroute between CTD stations. The ADCP onboard is a 75 kHz Teledyne RD Instruments Ocean Surveyor capable of reaching depths of up to 700 m. Surface temperature and salinity data were recorded continuously by the shipboard thermosalinograph. This dataset was averaged into 20 minute intervals in order to reduce noise levels but to retain adequate information to identify the main frontal characteristics.

Table 2: Highlighting the positions and operations at each SAMBA/GoodHope station

CPIES-SAMBA (PINK SHADING) PIES-GOODHOPE (BLUE SHADING)

Station	**Position**	**Depth** (T =triangle.)	**On board recovery time**	**Acoustic link quality**	**Comments**
ADCP1	S34°22.802 E17°38.00	879 m T	23/07 06:00 Recovered	Receive both releases clear and loud	was trawled in 09/2013 and redeployed to a deeper position in 11/2013
ADCP2	S34°23.490 E17°35.485	1117 m T	23/07 07:43 Recovered	Receive both releases clear and loud	
CPIES1	S34°24.348 E17°33.456	1266 T	23/07 08:10 In release mode but not detected at surface	Received replies to CLR and REL commands Receive REL mode (4s)	Probably trapped on the bottom; Second attempt during the return trip; data telemetereised over an 8 hour period; CPIES 1 floated to the survey and was recovered between 9 and 11pm GMT!
CPIES2	S34°29.813 E17°18.036	2129 T	23/07 14:50 Recovered	Received replies to CLR and REL commands Receive REL mode (4s)	
CPIES3	S34°29.964 E17°08.312	2850 T	23/07 17:21 Crashed and lost on the edge to be put on board	No reply at all	
CPIES4	S34°30.250 E15°00.161	4482 T	24/07 Recovery delayed on the way back	No reply at all	Weather and sea state conditions not appropriate
PIES1	S35°15.636 E14°02.637	4562	24/07 20:58 Recovered	No reply at all	
PIES2	S36°13.213 E13°18.101	4832 T	25/07 06:40 Stay in place	No reply at all	
PIES3	S37°24.486 E12°31.099	5040 T	25/07 17:21 Recovered	No reply at all	
PIES4	S38°36.099 E11°45.765	5120 T	26/07 09:15 Stay in place	No reply at all	
PIES5	S39°58.567 E10°47.668	4775	26/07 19:00 Stay in place	No try	Weather and sea state conditions not appropriate
PIES6	S41°20.4750 E09°53.2060	4679 T	27/07 08:05 Recovered	No reply at all	
PIES7	S42°41.479 E08°44.150	4969	28/07 18:09 Recovered	Receive measurement pings, release acknowledgement and 4s mode	
CPIES8	S34°30.059 E00°00.017	4608 T	08/08 15:20 Recovered	Receive release 4s mode	Wind and sea state quite strong
CPIES7 + SYREDOMY	S34° 29.924 E03° 43.146	5030	10/08 08:18 Recovered	No reply at all	Recovered with boat
CPIES6	S34° 30.422 E07° 27.032	5185 T	10/08 23:34 Recovered	No reply at all Spares replies acquired with matlab	
CPIES5	S34° 29.999 E11° 12.185	4969 T	11/08 18:05 Recovered	No reply at all Some echoes acquired with matlab	Recovered with net
CPIES4	S34° 30.250 E15° 00.161	4482 T	12/08 16:36 Recovered	No reply at all even with matlab	Fair weather;

CPIES1	S34°29.813 E17°18.036	2129 T	13/08 23:02 Recovered	After telemetry	

Table 3: Position of all CTD and XBT stations occupied during the GoodHope and SAMBA transects.

Station	Sequence	Lat	Lon	Date	GMT	Comments	Voy #
GOODHOPE south							
XBT1		-34.535	14.973	2015-07-24	08:31:00		
XBT2		-34.679	14.875	2015-07-24	09:57:00		
XBT3		-34.887	14.735	2015-07-24	11:59:00		
XBT4		-35.090	14.596	2015-07-24	13:59:00		
CTD1	1	-35.260	14.044	2015-07-24	15:44:23	Niskin Deep	VOY016-701
XBT5		-35.907	14.034	2015-07-24	21:59:00		
XBT6		-36.109	13.892	2015-07-24	23:58:00		
XBT7		-36.309	13.752	2015-07-25	01:55:00		
CTD2	2	-36.220	13.302	2015-07-25	03:58:02	Niskin Deep	VOY016-702
XBT8		-36.930	13.311	2015-07-25	08:01:00		
XBT9		-36.606	13.017	2015-07-25	10:00:00		
XBT10		-36.878	12.653	2015-07-25	11:59:00		
XBT11		-37.269	12.611	2015-07-25	13:59:00		
CTD3	3	-37.408	12.518	2015-07-25	17:18:47	Niskin Deep	VOY016-703
XBT12		-38.650	11.668	2015-07-25	22:31:00		
XBT13		-39.037	11.397	2015-07-26	00:54:00		
XBT14		-39.366	11.165	2015-07-26	02:56:00		
CTD4	4	-38.602	11.763	2015-07-26	04:31:03	Geotrace Soak	VOY016-704
CTD5	5	-38.602	11.763	2015-07-26	05:45:04	Niskin Deep	VOY016-704
XBT15		-40.669	10.221	2015-07-26	10:59:00		
XBT16		-40.995	9.979	2015-07-26	13:00:00		
XBT17		-41.158	9.856	2015-07-26	14:00:00		
XBT18		-41.319	9.735	2015-07-26	15:00:00		
XBT19		-41.481	9.613	2015-07-26	16:00:00		
XBT20		-41.644	9.489	2015-07-26	17:00:00		
CTD6	6	-39.977	10.794	2015-07-26	18:13:01	Niskin Deep CANCELLED	VOY016-705
XBT21		-41.900	9.293	2015-07-26	19:35:00		
XBT22		-42.291	8.991	2015-07-26	21:00:00		
XBT23		-42.611	8.740	2015-07-26	22:59:00		
XBT24		-40.777	10.263	2015-07-27	00:58:00		
XBT25		-41.019	10.102	2015-07-27	03:01:00		
XBT26		-41.270	9.937	2015-07-27	04:59:00		
CTD7	7	-41.341	9.887	2015-07-27	08:25:28	Niskin Deep	VOY016-706
XBT27		-41.498	9.751	2015-07-27	14:55:00		
XBT28		-41.750	9.543	2015-07-27	17:03:00		
XBT29		-41.944	9.375	2015-07-27	18:57:00		
XBT30		-42.142	9.206	2015-07-27	20:58:00		
XBT31		-42.307	9.038	2015-07-27	22:58:00		
XBT32		-42.497	8.877	2015-07-28	00:59:00		
XBT33		-42.682	8.743	2015-07-28	02:53:00		
CTD8	8	-42.692	8.737	2015-07-28	05:20:17	Geotrace	VOY016-707
CTD9	9	-42.692	8.737	2015-07-28	06:21:00	Niskin Deep	VOY016-707

CTD10	10	-42.692	8.737	2015-07-28	10:22:43	Niskin Biology	VOY016-707
CTD11	11	-42.689	8.739	2015-07-28	13:39:41	Geotrace	VOY016-707
CTD12	12	-42.692	8.747	2015-07-28	16:15:06	Calibration Glider	VOY016-707
CTD13	13	-42.694	8.737	2015-07-28	21:29:42	Geotrace	VOY016-707
XBT34		-42.958	8.495	2015-07-29	00:59:00		
XBT35		-43.235	8.231	2015-07-29	02:56:00		
XBT36		-43.523	7.961	2015-07-29	04:55:00		
XBT37		-43.832	7.672	2015-07-29	07:05:00		
XBT38		-44.121	7.398	2015-07-29	09:01:00		
XBT39		-44.454	7.084	2015-07-29	11:00:00		
XBT40		-44.745	6.808	2015-07-29	12:58:00		
XBT41		-45.001	6.563	2015-07-29	14:58:00		
GEOTRACE ONLY							
CTD14	14	-45.002	6.563	2015-07-29	15:10:07	Geotrace	VOY016-708
CTD15	15	-45.002	6.563	2015-07-29	17:19:05	Calibration Glider	VOY016-708
CTD16	16	-45.001	6.561	2015-07-29	18:50:14	Niskin Biology	VOY016-708
CTD17	17	-45.001	6.561	2015-07-29	N/A	Geotrace CANCELLED	VOY016-708
XBT42		-45.341	6.391	2015-07-30	02:54:00		
XBT43		-45.462	6.187	2015-07-30	05:04:00		
XBT44		-45.641	5.979	2015-07-30	06:59:00		
XBT45		-45.857	5.740	2015-07-30	08:56:00		
CTD18	18	-45.999	5.597	2015-07-30	10:27:11	Geotrace	VOY016-709
CTD19	19	-45.999	5.592	2015-07-30	13:20:17	Niskin Biology	VOY016-709
CTD20	20	-45.999	5.592	2015-07-30	14:33:25	Niskin Deep	VOY016-709
CTD21	21	-45.999	5.592	2015-07-30	18:43:48	Geotrace Deep	VOY016-709
XBT46		-46.183	5.416	2015-07-30	23:00:00		
XBT47		-46.322	5.278	2015-07-31	00:01:00		
XBT48		-46.600	5.004	2015-07-31	01:59:00		
XBT49		-46.889	4.719	2015-07-31	03:56:00		
XBT50		-47.192	4.413	2015-07-31	05:57:00		
XBT51		-47.478	4.134	2015-07-31	08:01:00		
XBT52		-47.724	3.883	2015-07-31	10:03:00		
XBT53		-47.944	3.663	2015-07-31	12:00:00		
XBT54		-48.140	3.461	2015-07-31	13:59:00		
XBT55		-48.332	3.267	2015-07-31	15:58:00		
XBT56		-48.527	3.067	2015-07-31	17:59:00		
XBT57		-48.783	2.803	2015-07-31	20:06:00		
XBT58		-49.034	2.542	2015-07-31	21:59:00		
XBT59		-49.317	2.249	2015-08-01	00:01:00		
XBT60		-49.592	1.961	2015-08-01	01:55:00		
XBT61		-49.881	1.662	2015-08-01	03:53:00		
XBT62		-50.197	1.324	2015-08-01	06:00:00		
CTD22	22	-50.450	1.056	2015-08-01	08:14:35	Niskin Deep	VOY016-710

CTD23	23	-50.450	1.058	2015-08-01	13:18:33	Niskin Biology Deep	VOY016-710
CTD22 (note duplicate numbering)	24	-50.452	1.059	2015-08-01	14:49:01	Geotrace Shallow	VOY016-710
XBT63		-50.664	0.827	2015-08-01	17:59:00		
XBT64		-50.962	0.507	2015-08-01	19:59:00		
XBT65		-51.280	0.162	2015-08-01	21:58:00		
XBT66		-51.650	0.000	2015-08-01	23:55:00		
XBT67		-52.055	0.000	2015-08-02	01:54:00		
XBT68		-52.475	0.000	2015-08-02	03:57:00		
XBT69		-52.896	0.000	2015-08-02	05:55:00		
XBT70		-53.348	0.005	2015-08-02	07:56:00		
XBT71		-53.787	0.003	2015-08-02	09:59:00		
XBT72		-54.208	0.001	2015-08-02	11:59:00		
XBT73		-54.602	0.005	2015-08-02	13:55:00		
XBT74		-55.009	0.003	2015-08-02	15:58:00		
XBT75		-55.409	0.001	2015-08-02	17:57:00		
XBT76		-55.725	0.003	2015-08-02	20:01:00		
CTD23	25	-55.709	0.000	2015-08-02	20:22:00	Geotrace Shallow	VOY016-711
CTD24	26	-55.710	0.004	2015-08-02	23:31:00	Niskin Deep	VOY016-711
CTD25	27	-55.710	0.002	2015-08-03	03:10:52	Niskin Biology	VOY016-711
CTD26	28	-55.710	0.002	2015-08-03	04:43:17	Geotrace Bioassay	VOY016-711
CTD27	29	-54.000	0.000	2015-08-03	23:13:51	Geotrace Deep	VOY016-712
CTD28	30	-54.000	0.000	2015-08-04	03:24:02	Niskin Deep	VOY016-712
CTD29	31	-54.000	0.000	2015-08-04	06:03:40	Niskin Shallow	VOY016-712
SAMBA Leg 2							
CTD30	32	-34.502	0.001W	2015-08-08	16:21:00	Niskin Deep	VOY016-802
XBT77		-34.498	0.002	2015-08-08	13:52:00		
XBT78		-34.502	0.500	2015-08-08	22:19:00		
XBT79		-34.501	1.000	2015-08-09	02:06:00		
XBT80		-34.501	1.499	2015-08-09	05:07:00		
XBT81		-34.501	2.014	2015-08-09	07:35:00		
XBT82		-34.500	2.502	2015-08-09	09:44:00		
XBT83		-34.507	3.001	2015-08-09	11:57:00		
XBT84		-34.501	3.506	2015-08-09	14:05:00		
CTD31	33	-34.499	3.720	2015-08-09	15:28:51	Niskin Deep	VOY016-803
XBT85		-34.500	4.040	2015-08-10	09:33:00		
XBT86		-34.501	4.502	2015-08-10	11:13:00		
XBT87		-34.501	5.001	2015-08-10	13:00:00		
XBT88		-34.500	5.500	2015-08-10	14:46:00		
XBT89		-34.504	6.000	2015-08-10	16:30:00		
XBT90		-34.512	6.500	2015-08-10	18:14:00		
XBT91		-34.511	7.069	2015-08-10	20:14:00		
XBT92		-34.508	7.501	2015-08-11	03:20:00		

CTD32	34	-34.501	7.448	2015-08-10	11:40:00	Niskin Deep	VOY016-804
XBT93		-34.508	8.034	2015-08-11	05:11:00		
XBT94		-34.506	8.501	2015-08-11	06:46:00		
XBT95		-34.504	9.025	2015-08-11	08:30:00		
XBT96		-34.505	9.501	2015-08-11	10:09:00		
XBT97		-34.504	10.000	2015-08-11	11:53:00		
XBT98		-34.502	10.519	2015-08-11	13:47:00		
XBT99		-34.498	11.000	2015-08-11	15:29:00		
CTD33	35	-34.499	11.203	2015-08-11	18:19:00	Niskin Deep	VOY016-805
XBT100		-34.500	11.500	2015-08-11	22:48:00		
XBT101		-34.501	12.000	2015-08-12	00:35:00		
XBT102		-34.500	12.500	2015-08-12	02:24:00		
XBT103		-34.499	13.000	2015-08-12	04:13:00		
XBT104		-34.501	13.500	2015-08-12	06:01:00		
XBT105		-34.500	14.000	2015-08-12	07:46:00		
XBT106		-34.499	14.532	2015-08-12	09:41:00		
CTD34	36	-34.497	14.639	2015-08-12	10.08.00	Niskin Deep - JUNCTION	VOY016-806
CTD35	37	-34.501	15.002	2015-08-12	16:42:00	Niskin Deep	VOY016-807
CTD36	38	-34.499	17.013	2015-08-13	03:43:11	Niskin Deep	VOY016-808
CTD37	39	-34.499	17.301	2015-08-13	06:47:00	Niskin Deep	VOY016-809
CTD38	40	-34.391	17.590	2015-08-13	10:39:00	Niskin Deep	VOY016-810
CTD39	41	-34.378	17.631	2015-08-13	12:01:03	Niskin Deep	VOY016-811
CTD40	42	-34.409	17.549	2015-08-13	13:25:00	Niskin Deep	VOY016-812

2. PIES/CPIES/M-ADCP operations along both SAMBA and GoodHope transects

T. Terre, O. Peden, I. Ansorge, R. Laxenaire

Objectives

Instruments have been deployed during the September 2013 Gough cruise and December 2014 SANAE logistic cruises. During Gough 2013, 2 ADCP frames, 6 CPIES (Current Pressure Inverted Echo Sounder) and 2 more CPIES each equipped with data pods system named SYREDOMY have been deployed. The deployments were made along the SAMBA line, which stretches along 34°30'S between 17°E and 0°. As these instruments are in the water since September 2013 and on the edge of their battery life-span, it was critical that a key focus of the cruise was to recover each one of them, download the data, renew the batteries and redeployed each one.

During the second cruise along the GoodHope section in December 2014, a total of 7 PIES (i.e. not equipped with current meters) were deployed. As the deployment is only 6-months ago, the objective is to recover them, download the data, redeployed them.

Below is a summary of all the operations during the cruise. Notice that all hours are in GMT.

Summary of recovery operations

The core objective of the survey was to recover the entire SAMBA array – to ensure that sufficient time was available – it was decided that only a few of the GoodHope PIES would be retrieved and redeployed. A key concern of the voyage was the additional time needed as the decision to "rotate" each COIES was impossible due to the failed recovery of CPIES1 and the destruction of CPIES 3 – thus only CPIES 2 was available to redeploy prior to arrival at SAMBA. On this line, servicing the instrument is more demanding due to the fact that station CPIES1 has not climbed to the surface and need to be telemetered and also the SYREDOMY system on CPIES7 requires more to be re-prepare.

Station	**S/N**	**Position/**	**Depth** (T =triang.)	**On board recovery time**	**Acoustic link quality**	**Comments**
ADCP1	150 kHz WH11794 Argos 27482 SBE6556	S34°22.802 E17°38.00	879 m T	23/07 06:00 Recovered	Receive both releases clear and loud	was trawled in 09/2013 and redeployed to a deeper position in 11/2013
ADCP2	75 kHz WH5692 Argos 11262 SB6555	S34°23.490 E17°35.485	1117 m T	23/07 07:43 Recovered	Receive both releases clear and loud	
CPIES1	195 + Syredomy	S34°24.348 E17°33.456	1266 T	23/07 08:10 In release mode but not detected at surface	Received replies to CLR and REL commands Receive REL mode (4s)	Probably trapped on the bottom; Second attempt during the return trip; data telemetereised over an 8 hour period; CPIES 1 floated to the survey and was recovered between 9 and 11pm GMT!
CPIES2	310	S34°29.813 E17°18.036	2129 T	23/07 14:50 Recovered	Received replies to CLR and REL commands Receive REL mode (4s)	
CPIES3	311	S34°29.964 E17°08.312	2850 T	23/07 17:21 Crashed and lost on the edge to be put on board	No reply at all	
CPIES4	312	S34°30.250 E15°00.161	4482 T	24/07 Recovery delayed on the way back	No reply at all	Weather and sea state conditions not appropriate
PIES1	48	S35°15.636 E14°02.637	4562	24/07 20:58 Recovered	No reply at all	
PIES2	49	S36°13.213 E13°18.101	4832 T	25/07 06:40 Stay in place	No reply at all	
PIES3	50	S37°24.486 E12°31.099	5040 T	25/07 17:21 Recovered	No reply at all	
PIES4	51	S38°36.099 E11°45.765	5120 T	26/07 09:15 Stay in place	No reply at all	
PIES5	52	S39°58.567	4775	26/07 19:00	No try	Weather and sea

		E10°47.668		Stay in place		state conditions not appropriate
PIES6	54	S41°20.4750 E09°53.2060	4679 T	27/07 08:05 Recovered	No reply at all	
PIES7	55	S42°41.479 E08°44.150	4969	28/07 18:09 Recovered	Receive measurement pings, release acknowledgement and 4s mode	
CPIES8	315	S34°30.059 E00°00.017	4608 T	08/08 15:20 Recovered	Receive release 4s mode	Wind and sea state quite strong
CPIES7 + SYREDOMY	196	S34° 29.924 E03° 43.146	5030	10/08 08:18 Recovered	No reply at all	Recovered with boat
CPIES6	314	S34° 30.422 E07° 27.032	5185 T	10/08 23:34 Recovered	No reply at all Spares replies acquired with matlab	
CPIES5	313	S34° 29.999 E11° 12.185	4969 T	11/08 18:05 Recovered	No reply at all Some echoes acquired with matlab	Recovered with net
CPIES4	312	S34° 30.250 E15° 00.161	4482 T	12/08 16:36 Recovered	No reply at all even with matlab	Fair weather;
CPIES1	195	S34°29.813 E17°18.036	2129 T	13/08 23:02 Recovered	After telemetry	

Climbing Speed

Having an estimate of the time of arrival at surface once an instrument is released helps the ship personnel plan their activities during the recovery process. All the estimations were made initially on the basis of 0.5 m/s for the ADCP frames and CPIES equipped with data pods. For CPIES, the arrival time was estimated on the basis of 1 m/s and 0.6 m/s for the PIES. Later on, the estimates were adjusted but barely proved to be correct. Below is the observed climbing speed. This includes the time required to burn the wire release for the CPIES/PIES (15-20 mn according to the maker).

Station	**S/N**	**Depth (m)**	**Released**	**Detected**	**Mean**	**Time (mn)**	**Speed (m/s) (m/mn)**	**Estimate (m/s) (m/mn)**
ADCP1	150 kHz WH11794 Argos 27482 SBE6556	879	23/07 05:30	23/07 05:54	Visual Argos	24	0.6 37	0.5 30
ADCP2	75 kHz WH5692 Argos 11262 SB6555	1117	23/07 06:40	23/07 07:07	Argos Visual	27	0.7 41	0.5 30
CPIES1	195 Syredomy	1266	23/07 08:12	N.A.	N.A.	N.A.	N.A.	0.5 30
CPIES2	310	2129	23/07 13:55	23/07 14:35	Visual Radio	40	0.9 53	0.6 36
CPIES3	311	2850	23/07 16:18	23/07 17:05	Flash Radio	47	1 60	0.6 36
PIES1	048	4560	24/07 18:44	24/07 20:37	Flash Radio	113	0.7 40	0.6 36
PIES3	050	5040	25/07 15:13	25/07 17:05	Flash Radio	112	0.75 45	0.6 36
PIES6	054	4680	27/07 05:57	27/07 07:39	Radio Visual (15 mn)	102	0,75 46	0.6 36
PIES7	055	4970	28/07 16:05	28/07 17:54	Radio Visual	109	0,75 46	0.6 36
CPIES8	315	4608	08/08 13:50	08/08 14:48	Visual	58	1.3 79	0.9 53

CPIES7	196	5030	10/08 05:37	10/08 07:40	Visual Radio	123	0.7 41	0.5 30
CPIES6	314	5185	10/08 21:59	10/08 23:10	Radio Visual	80	1.1 65	1.0 60
CPIES5	313	4969	11/08 16:28	11/08 17:30	Radio Visual	62	1.3 80	1.0 60
CPIES4	312	4482	12/08 15:30	12/08 16:25	Visual Radio	55	1.4 81	1.1 65
CPIES1	195	1266	13/08 -	13/08 -	Visual C77	-	-	-

Summary of redeployment

As a consequence of the lost of CPIES #313, it was decided together and including Sabrina Speich and Chris Meinen to not reoccupy station CPIES7 and to move station PIES1 on the SAMBA line at the crossing with GOODHOPE line. This new position will replace CPIES4 on the SAMBA line as well.

In the same manner, the position of CPIES1 has been moved by half a nautical mile from the one occupied currently by CPIES #195, which has not surfaced.

Station	**S/N**	**Déploiement**	**Position**	**Triangulation**	**Prog. depth Meas. Period**
PIES3	48	25/07 20:17	S37°24.4582 E12°31.1230 5070 m (CTD)	No	5100 10 mn
PIES6	50	27/07 11:22	S41°20.8977 E09°53.2754 4680 m (CTD)	No	4800 10 mn
PIES7	54	28/07 18:19	S42° 41.647 E08° 44.241 4970 m (CTD)	No	4900 10 mn
CPIES8	310	08/08 18:42	S34° 10.140 E00° 00.035 4600	No	4500 20 mn
CPIES7	-	-	-	-	-
CPIES6	315	10/08 23:19	S34° 30.575 E07° 26.900	No	5150 20 mn
CPIES5	314	11/08 17:43	S34° 30.229 E11° 11.953	No	4900 20mn
CPIES4/PIES1 New position	55	12/08 13:38	S34° 29.933 E14° 38.351	No	4500 10 mn
CPIES3	313	13/08 05:50	S34° 29.990 E17° 08.346	No	2800 20 mn
CPIES2	196	13/08 08:23	S34° 29.820 E17° 18.068	No	2000 10 mn
CPIES1 New position	312	13/08 13:26	S34° 22.710 E17° 37.985	No	1200 20 mn
ADCP2	75 kHz WH5692 Argos 11262 SBE6555	13/08 11:31	S34° 23.436 E17° 35.543	No	1120 5 mm
ADCP1	150 kHz WH11794 Argos 27482 SBE6556	13/08 12:44	S34° 22.710 E17° 37.985	No	880 1mn12s

Data Example

The data were extracted from the recovered instruments and saved on 5 different supports to insure a redundancy in storage. A quick view on the data was performed to verify the instruments functioning during their deployment period. Below are a selection of plots of raw data which show a good data return (close to 100 % at first glance).

Line SAMBA Station CPIES2 / CPIES #310

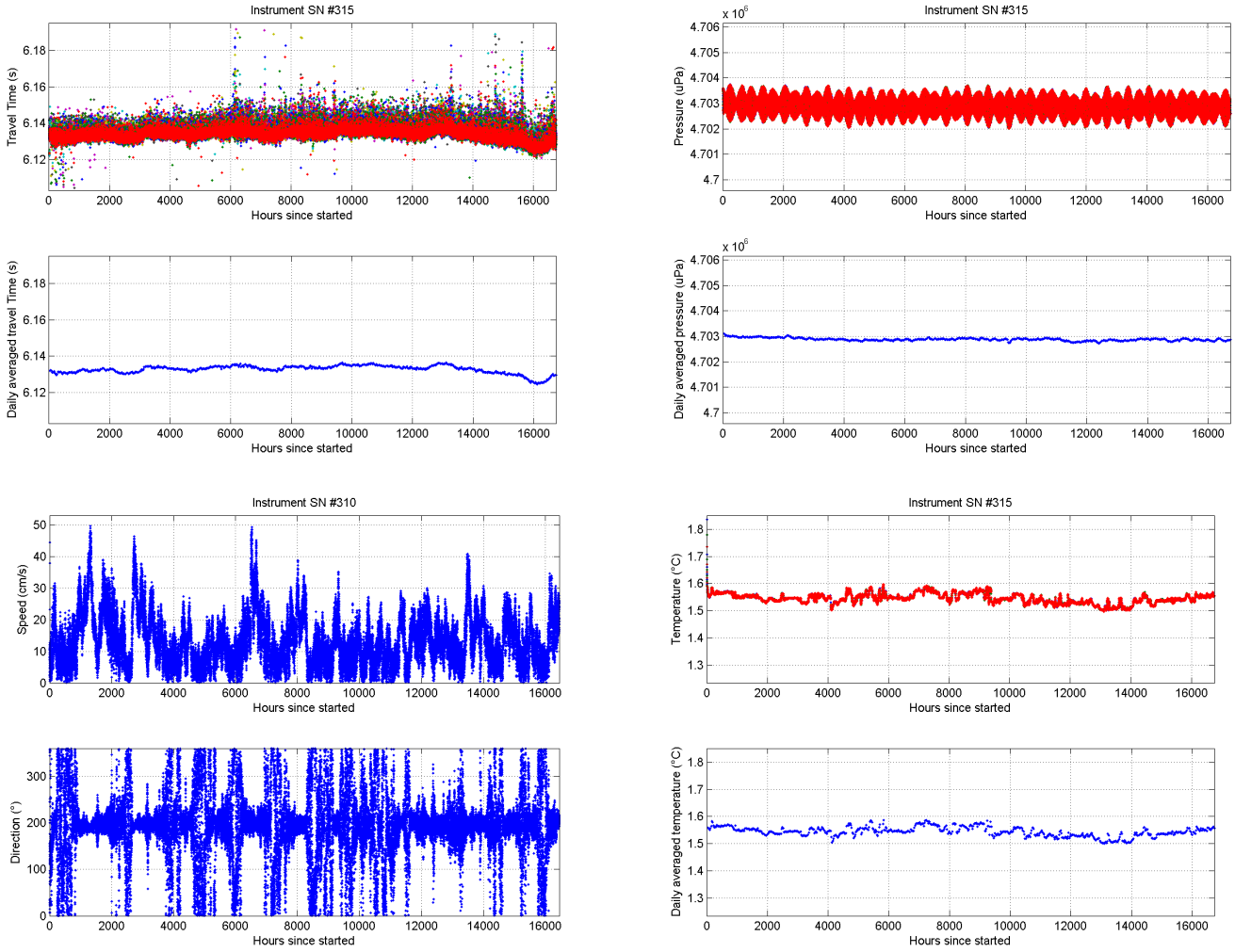


Figure: From top to bottom. Raw travel times, Daily average of travel times; Pressure, daily averaged pressure; Current speed and direction; Temperature, daily average temperature.

In summary

CPIES SN311/station CPIES3 loss results from wind and sea state conditions. While the ship manoeuvrings were well performed, recovery of such an instrument along the side board is made delicate due to the 50-m cable between the CPIES and the current meter and its associate float.

On 23/07, the C/PIES SN195 at station CPIES1 was considered to be released at the command was acknowledged (reception of 6 pings) and executed (reception of pings at 4s interval) but it never popped up at the surface- remaining in position. We had confirmation while we checked it acoustically on the way back on 13/08. A plan to recover a subset of the full data set was undertaken with the telemetry mode. A main problem was the increase in noise due to a number of factors: the CPIES1 position being close to a shipping lane, the need to stay in full DP mode, strong surface currents, full thrusters in operation. This combination proved to be a real challenge in retrieving the data. Nevertheless, we uploaded a partial subset (27 kb) at a speed of ~5.5 kb/h before

we had to stop to leave the position. The quality of the uploaded data will probably be not optimal considering the noisy environment.

Fortunately enough, the CPIES1 was seen on surface at around 20:35 (GMT) while still unexpected. The recovery did not go smoothly as the current meter and the floatation attached to it were lost, but the really essential part was safe on board with the data which will contribute to extend the observations made at this spot since 2008. Looking at the recorded data, it appears that CPIES1 did not receive the release command on 23/07. What appears to now be likely is that the CPIES went into a beacon mode after receiving a XPOND command. This has been observed in previous trials, when we already observed such behavior while testing in air the instrument. The repetitive pings sparsely received were erroneous interpreted as acknowledgement of the release mode. On 13/08, at the end of the telemetry mode, the CPIES acknowledged a release command which was executed as written in the log file.

Sea states and wind conditions coupled with the impossibility to stop the propellers during acoustics interrogations made hydrophone operations extremely difficult and even impossible to receive an acoustic signal from the C/PIES. Most of the releases have been done without knowing if the release command was accepted and executed. The CPIES1 case is a good example of the misinterpreation what could come out of this. To overcome this, a hull mounted hydrophone would definitively be better than the one deployed over the board. An alternate way could be envisioned with a trawl fish in which the hydrophone would be mounted. On SA Agulhas II, the moonpool proved to be efficient during the telemetry mode – although it must be noted that that the CPIES depth was only 1200 m.

CPIES acoustic mode during the climbing phase, we note that there is no way to know the distance between the ship and C/PIES and consequently the ascent speed. We do not know if it is climbing or not. Moreover, the repetition rate of 4s do not allow to deal with a possible auxiliary acoustic unit as in the SYREDOMY case. This is a serious handicap and solutions should be studied together with the maker.

3. Gliders

Marcel du Plessis, Andre Hoek, Hendrik van Rensburg, Sinekhaya Bilana

Introduction

Seaglider is an unmanned autonomous underwater vehicle designed for use in oceanographic missions lasting up to 6 months and covering up to 6000km at depths ranging from 50 to 1000m. Seaglider travels underwater in a sawtooth pattern. The vertical velocity component of the sawtooth pattern comes from the onboard buoyancy engine changing Seaglider's density while the horizontal velocity component comes from the lift provided by Seaglider's wings and, to a much lesser extent, Seaglider's body.

The Wave Glider models are composed of a surface "Float" and a submarine "Glider" connected by a flexible "Umbilical." The float rides on the surface of the water. The Wave Glider provides propulsion by harnessing power from wave action. Steering is provided by an electronically controlled rudder on the glider. The Glider is connected to the Float by a flexible, high-strength Umbilical that also provides power and communications connections between the Float and the Glider.

Both of these gliders are used in SOSCEx III as a part of sampling the full seasonal scale characteristics of the physical-biogeochemical coupling in the Southern Ocean. The experiment comprises of two Wave Gliders deployed in mooring mode sampling the surface CO_2 flux and weather in a 25km octagon resolving the meso- to submesoscale scale, while a buoyancy glider is deployed and twinned with each Wave Glider. The buoyancy glider profiles between the surface and 1000m depth four times a day sampling physical and biogeochemical variables (temp, salinity, fluorescence, dissolved oxygen, PAR and backscattering x2λ).

Deployment

The gliders were successfully deployed at two separate process stations. Seaglider 543 and Wave Glider CSIR1 were deployed within the SAZ (42.69 °S, 8.74 °E) while Seaglider 573 and Wave Glider CSIR2 were deliberately deployed on the location of the SAF (45 °S, 6.57 °E). See Figure 1 for graphical locations. Andre Hoek and Hendrik Janse van Rensburg undertook deployments of the gliders. Please contact Andre Hoek for a detailed technical report of the glider deployment techniques: andre@seatechnology.co.za

At each deployment station, a geotraces CTD with Niskin bottles were deployed to 1200 m to calibrate the Seaglider sensors (oxygen, salinity, chlorophyll). The CTD provides sensor measurements as well as bottle samples for calibration. Analysis of the bottle samples is considered most accurate, and all sensors are calibrated accordingly. These CTD stations also provided the basis of the biological sampling for macro-nutrients, community structure (microscopy, HPLC, absorption, particle size, PIC/PIC etc), primary production (^{15}N, PvsE, O2/Ar) and TCO2. Wave Glider calibrations are still ongoing at the time of writing.

Process Station calibration CTD 1:
Latitude = 42 41.49 °S
Longitude = 008 44.80 °E
Date = July 28 2015 16:14:57 GMT

Process station calibration CTD 2:
Latitude = 45 00.11 °S
Longitude = 006 33.76 °E
Date = July 29 2015 17:19:05 GMT

Glider Calibration CTDs

Overview

CTD casts are performed to a depth of 1200m in the same location as Seagliders 543 and 573 deployments to test the accuracy of the various sensors on board the gliders. The parameters to be tested are temperature, salinity, dissolved oxygen and fluorescence, where a conversion factor of fluorescence to chlorophyll is determined. Bottle samples of salinity, dissolved oxygen, DIC and chlorophyll are sampled in high frequency to best resolve the 1000m profile. The gases are sampled first.

DIC

Select ten depths of interest. Rinse the DIC bottles with sample water 3X and allow the volume of the bottle to overflow 2-3X. Spike with 200ul Hg_2Cl_2 (if using 500ml sample bottles) before placing the glass stopper in the bottle. (Hg_2Cl_2 is prepared as a saturated solution, at least 7.5g per 100ml milliq. 100ul is added to 250ml sample to give a final concentration of 0.04%)

Dissolved Oxygen

Select ten depths that best resolve the oxygen profile (including the oxycline). Fill the DO bottles with sample water, initially allowing the volume of the bottle to overflow 2-3X. Spike the sample immediately with 1ml $MnCl_2$ and 1ml NaOH/IOH (order is important). Place the glass stopper in the bottles and invert thoroughly before allowing to settle in the dark at room temperature. Add 1ml 50% H_2SO_4 just before analysis and invert sufficiently to dissolve all the precipitant (solution should now be a tea colour). Perform the analysis on the Metrohm 848 Titrino Plus unit. This protocol is based on the Winkler titration method.

The integrity of the reagents is tested every 24h by performing a standardised titration on the Titrino. This calibrates the instrument to the current state of the reagents. The order of the reagents in the standardisation solution is crucial and as follows:

50ml MilliQ
1ml H_2SO_4
1ml NaOH/IOH
1ml $MnCl_2$
10ml potassium iodate standard solution

It should take approximately 5ml of sodium thiosulphate to titrate this solution.

Dissolved oxygen calibration cast of Seaglider 543

Dissolved oxygen concentrations for bottle samples are considered the gold standard and are hence used to calibrated against the CTD oxygen, SBE 43 sensor as well as the Seaglider oxygen, SBE 43 sensor.

However, the dissolved oxygen bottle samples for the calibration CTD cast of Seaglider 543 were contaminated and therefore the bottle samples cannot be used for calibration. To work around this, a linear regression from all CTD oxygen, SBE 43 to Bottle Samples linear regression is obtained (Figure 1). From this way it is possible to determine a

consistent offset between the bottle samples of dissolved oxygen and the CTD oxygen, SBE 43. Using the calibrated CTD oxygen from the Seaglider calibration cast, the Seaglider 543 is then calibrated (Figure 2). Note that further calibration of the glider to the CTD calibration cast is required as there is an offset between the two. Therefore, further calibration by the analysing scientist must take place.

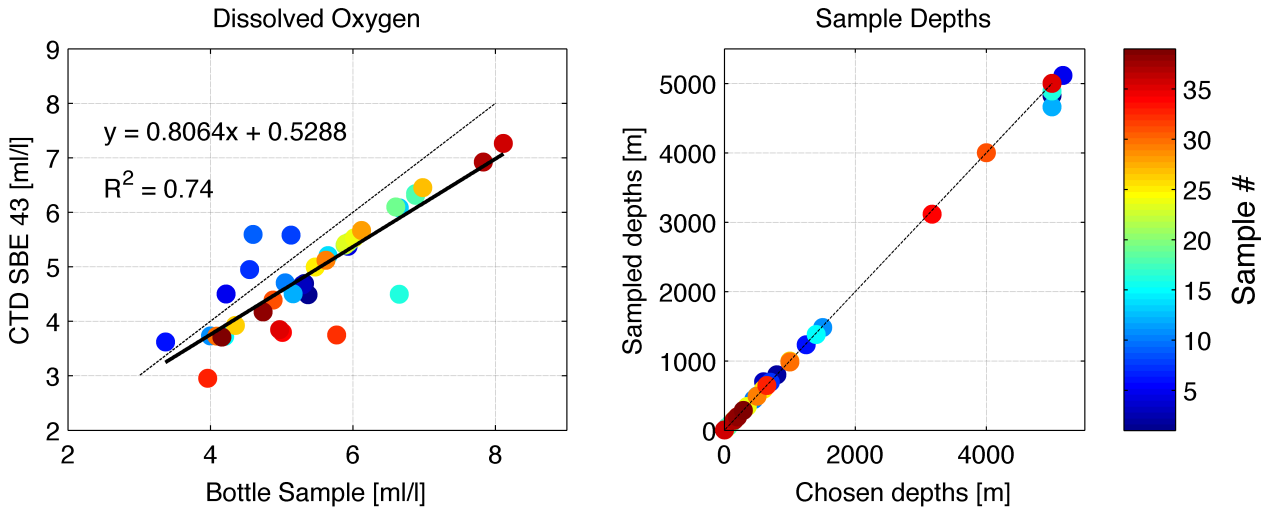


Figure 1. Dissolved oxygen measurements taken from all accurately measured CTD bottle samples are compared against the oxygen measurements given by the CTD sensor, SeaBird Electronics 43. The same sensor is found on Seaglider 543. A linear regression (solid black line in the left panel) is performed to identify the calibration equation that is applied to the oxygen data from the sensors.

NOTE: Need to convert the same units as the Seaglider [micromoles/kg], the CTD Oxygen, SBE 43 [ml/l] and bottle samples [ml/l] are changed under the following conversions:

1 ml/l = 10^3/22.391 = 44.661 micromol/l
g/l = g/kg * 1.025

e.g. ctd.diss_oxy = (ctd.o2*44.661)/1.025;

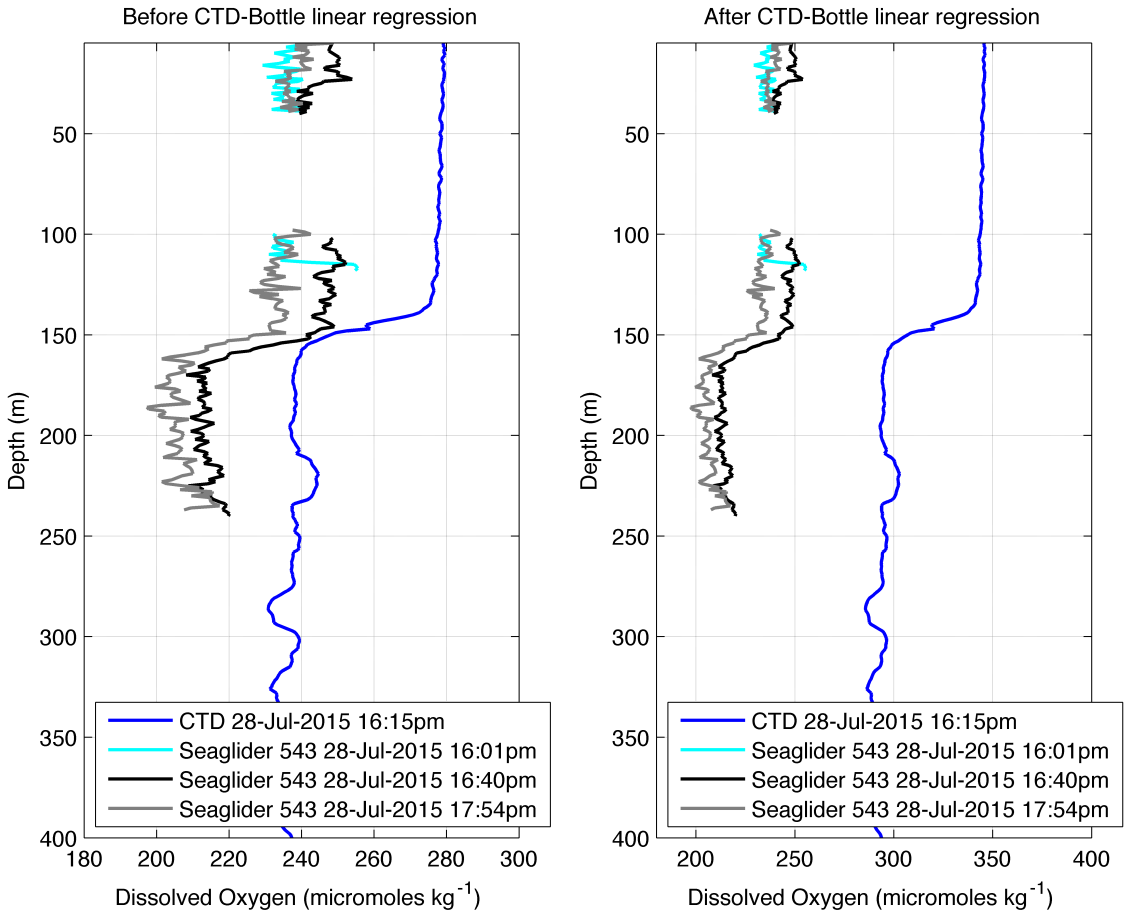


Figure 2. Left panel indicated the CTD cast (blue) and Seaglider dives (cyan, grey and black) as measured by the respective sensors. Right panel is the same for the Seaglider, with the CTD cast having the correction y = 0.8064x + 0.5288 applied to it.

The dissolved oxygen profiles of the Seaglider are then shifted to meet the calibrated CTD cast.

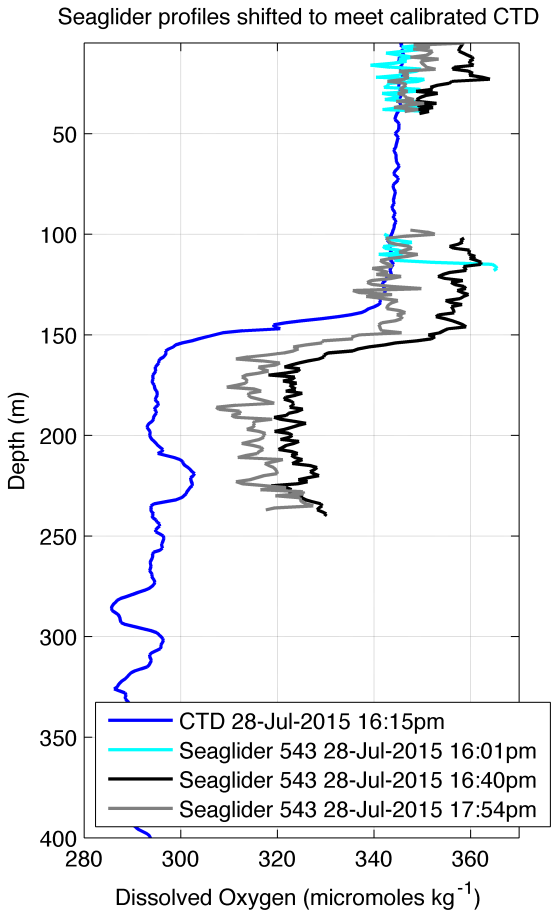


Figure 3. Glider profiles are shifted so that the closest Seaglider profile to the calibration CTD cast is met. An offset between the Seaglider and CTD dissolved oxygen exists at the base of the mixed layer oxygen maximum. Further investigation is required to determine the cause of this.

Dissolved oxygen calibration cast of Seaglider 573

For the calibration CTD cast of Seaglider 573, the bottle samples of dissolved oxygen were correctly sampled. Figure 4 indicates the Seaglider, calibration CTD and bottle samples as measured (left panel) as well as the shifted Seaglider and CTD cast to meet the accurate bottle samples. Similarly to Seaglider 543, there is a shift in the dissolved oxygen concentrations at the base of the oxygen mixed layer. This requires further investigation.

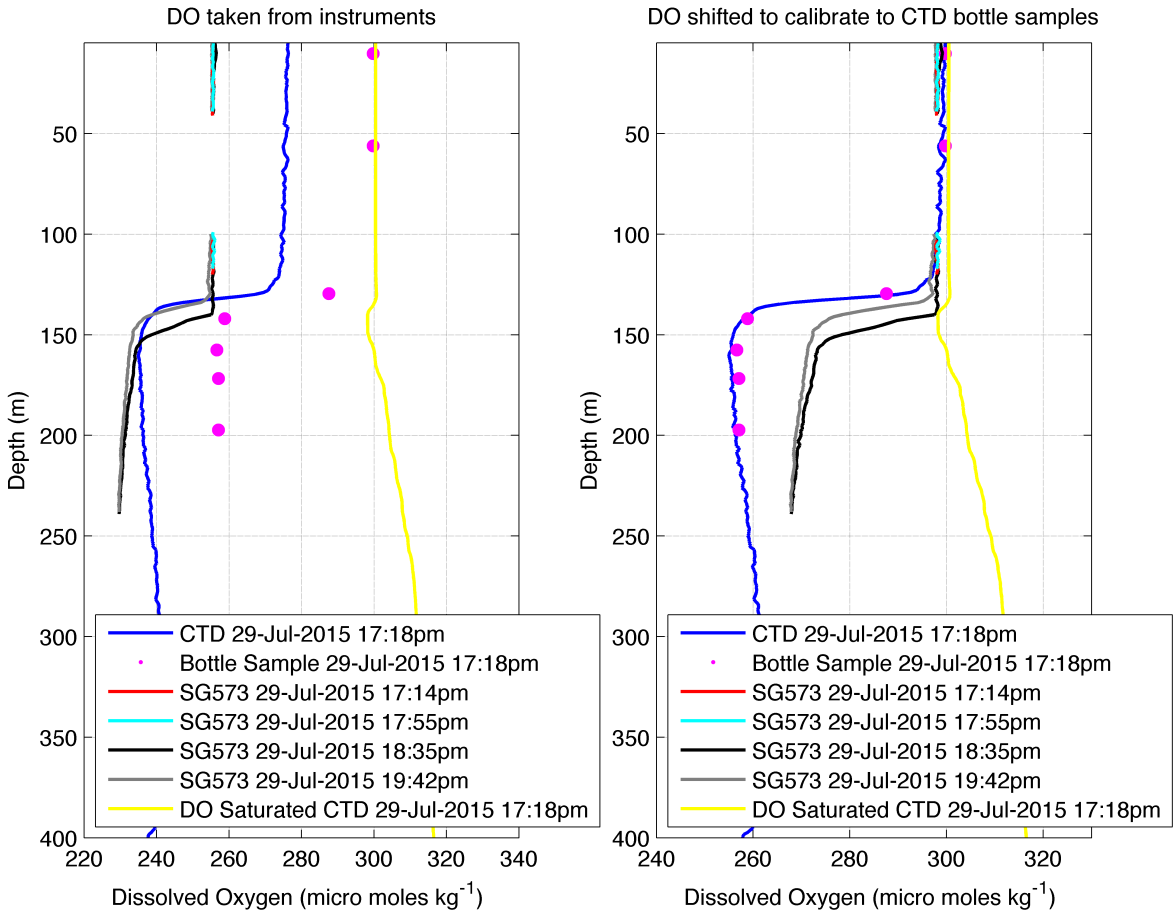


Figure 4. Converted (micromoles/kg) calibration cast dissolved oxygen concentrations for the CTD (blue line), Seaglider 573 (red, cyan, black and grey lines) and the bottle samples (magenta dots). The yellow line represents the saturated dissolved oxygen concentration of the CTD calibration cast. The left panel shows the unshifted profiles while the right panel shows the profiles shifted to meet the bottle samples.

Salinity

Select ten depths that best resolve the salinity profile (including the halocline). Rinse salinity bottles 3X with sample water before allowing the volume of the bottle to overflow 2-3X. Seal the lid with parafilm and store at room temp in the dark (salinity box is perfect).

Salinity calibration cast for Seaglider 543

The salinity values from the Seaglider, calibration CTD and bottle samples are shown to agree well with a slight offset in the salinity as well as a deviation in the bottle samples near the surface (left panel of Figure 5). The Seaglider and calibration CTD temperatures agree well and no futher calibration is required (right panel Figure 5).

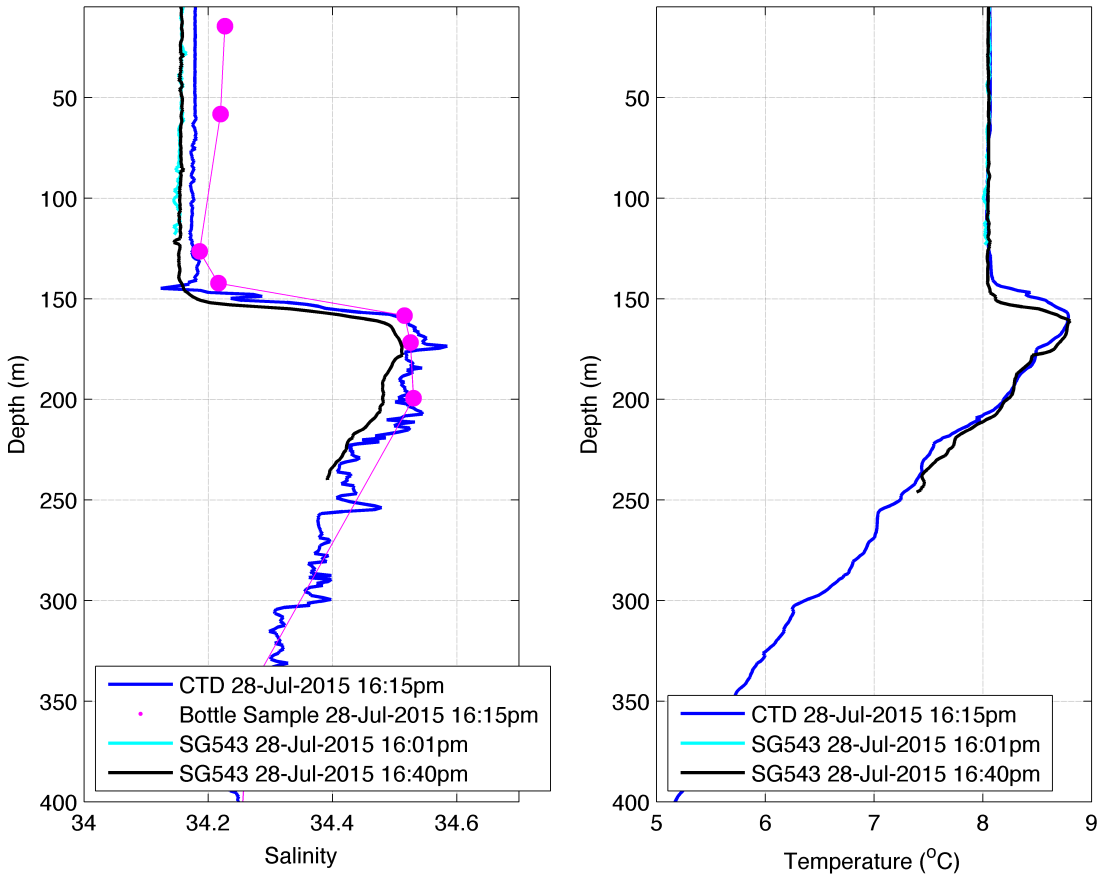


Figure 5. Left panel indicates depth profiles of salinity from the CTD (blue line), bottle samples (magenta dots) and Seaglider 543 (cyan and black lines). Right panel indicates depth profiles of temperature from the CTD (blue line) and Seaglider 543 (cyan and black lines).

Salinity calibration cast for Seaglider 573

The same technique for Seaglider 543 is applied to Seaglider 573. Here, the salinity measures from the calibration bottles do not follow the salinity profiles of the Seaglider and calibration CTD. Further investigation is required into the sampling of the bottle samples, as a salinity gradient exists within the mixed layer (left panel of Figure 6). The temperature calibration shows the Seaglider to be slightly offset from the CTD by 0.2 °C (right panel, Figure 6).

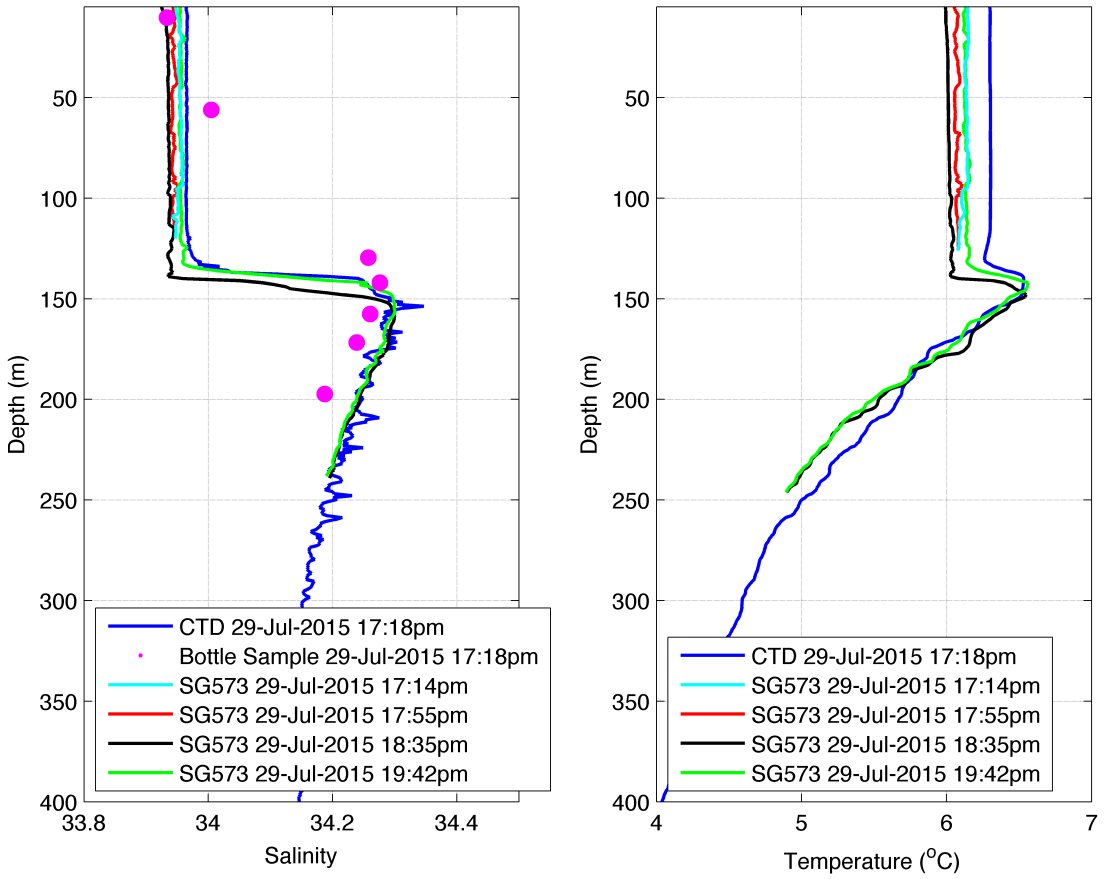


Figure 6. Left panel indicates depth profiles of salinity from the CTD (blue line), bottle samples (magenta dots) and Seaglider 573 (cyan, red, black and green lines). Right panel indicates depth profiles of temperature from the CTD (blue line) and Seaglider 573 (cyan, red black lines).

Chlorophyll-a

Select ten depths that best resolve the chlorophyll profile (including the f-max). Rinse 1L Nalgene bottles with sample water 3X before filling. Rinse the measuring cylinder with sample water 3X before measuring out 400ml to be filtered. Filter samples through 25mm GF/F filters, and immediately place in 8ml 90% acetone and store at -20°C for 12-24h.

Remove samples from the freezer 30min before analysis to prevent the cuvette from misting during the measurement. Place the CHL-NA (non-acidification) module in the Turner fluorometer and select the CHL-NA program before measuring the raw fluorescence units. Read a blank of 90% acetone before each analysis.

Seaglider calibration

To determine the Seaglider fluorescence to chlorophyll ratio, the filtered bottle samples of chlorophyll from all the CTDs is compared to the CTD fluorescence measurements

(no dark correction necessary) at the respective depths (Figure 7). This is done to increase the sampling points of comparison between the Seaglider fluorescence and chlorophyll measurements. For Figure 7, finding the maximum fluorescence value in each profile's mixed layer and applying that value to the quenched fluorescence solved the issue of quenching.

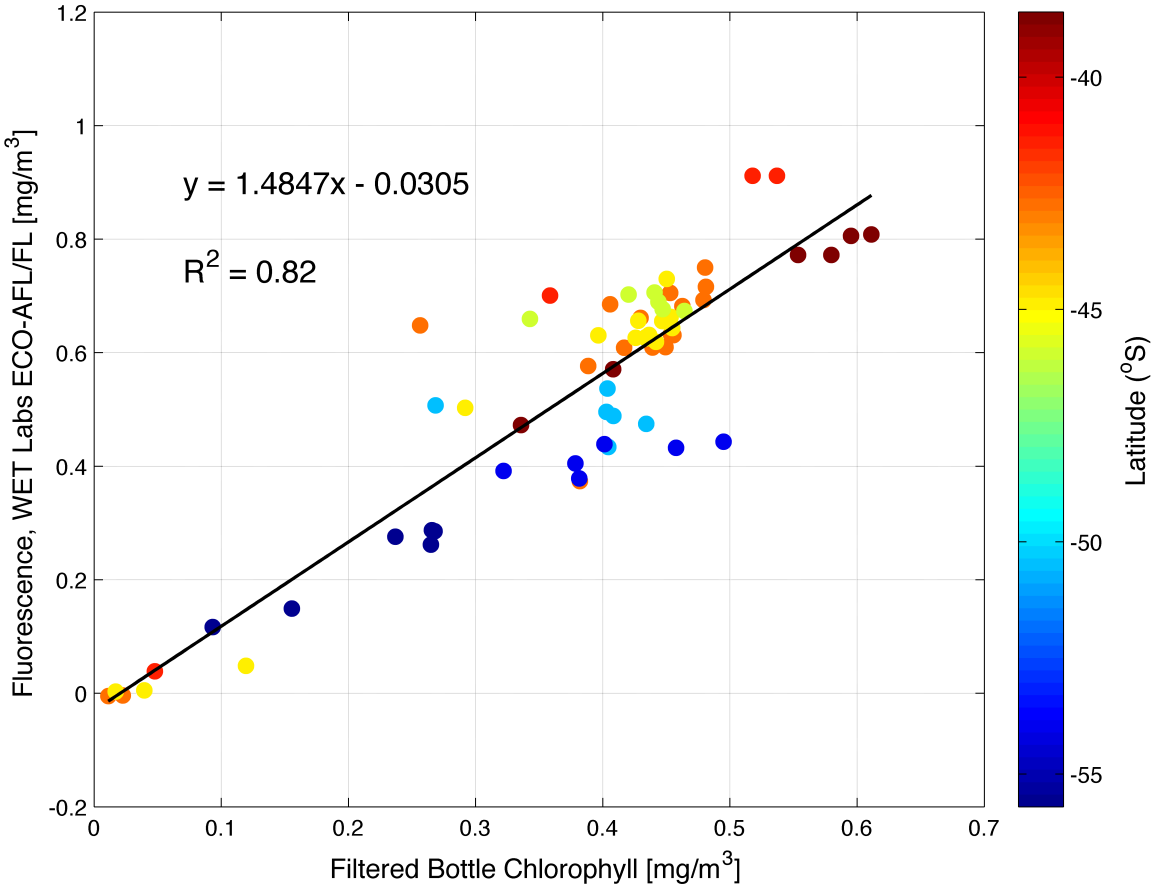


Figure 7. Chlorophyll measurements taken from all accurately measured CTD bottle samples are compared against the Fluorescence, WET Labs ECO-AFL/FL [mg/m^3] measurements given by the CTD sensor. Latitude of CTD cast given in colour. A linear regression is performed to identify the calibration equation for the CTD WET Labs ECO-AFL/FL. All measurements that were taken with latitudes south of 38 degrees are excluded.

The linear regression of from the bottle samples of chlorophyll and CTD fluorescence (Figure 7) is then applied to the CTD fluorescence to obtain CTD chlorophyll. CTD chlorophyll is used to calibrate the Seaglider fluorometer (Figure 8).

Chlorophyll calibration for Seaglider 543

Firstly, a dark count correction is applied to the Seaglider fluorescence. To determine the dark count correction, a dark mean between 170m and 240m was taken. A value of 54.6151 was obtained. This is slightly above the dark count of 48 provided by WET Labs. Once corrected, a linear regression between the CTD converted chlorophyll and

Seaglider fluorescence for the calibration cast is obtained (Figure 8).

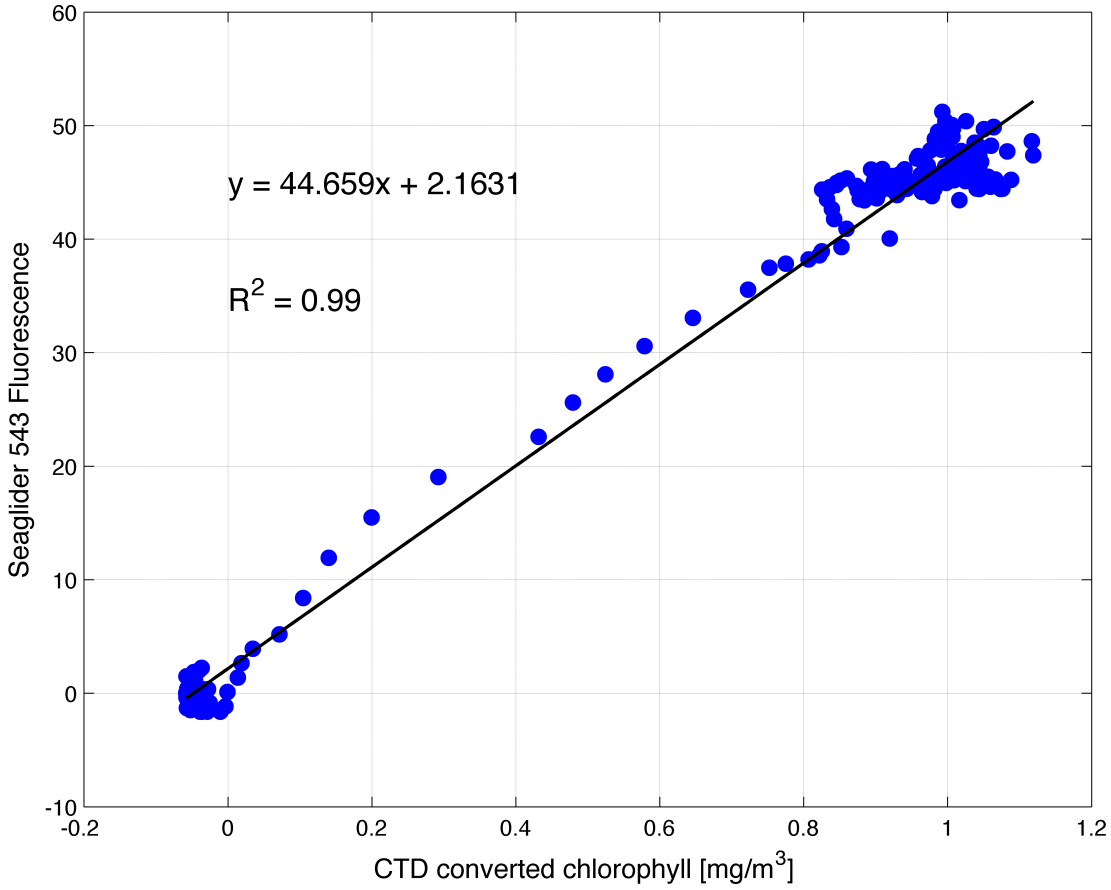


Figure 8. CTD converted chlorophyll for the calibration cast of Seaglider 543 is compared to the fluorescence measurements of Seaglider 543 (blue dots). Note the depth of the Seaglider fluorescence has been shifted upwards by 6m to allow the mixed layer gradients of both variables to match up. This allows a more accurate quantitative analysis of the slope of the mixed layer chlorophyll gradient.

The Seaglider converted chlorophyll from the linear regression in Figure 8 shown in Figure 9.

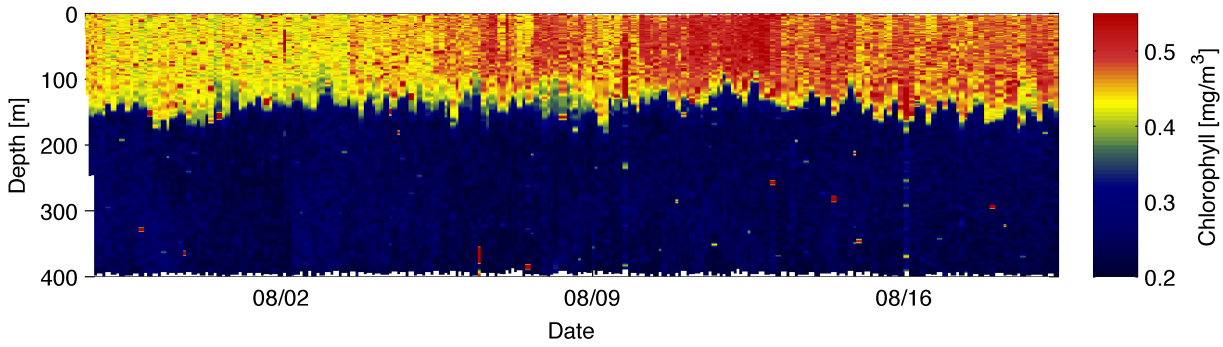


Figure 9. Seaglider 543 converted chlorophyll [mg/m^3] using the linear regression produced by comparing CTD converted chlorophyll [mg/m^3] to the Seaglider fluorescence measurements.

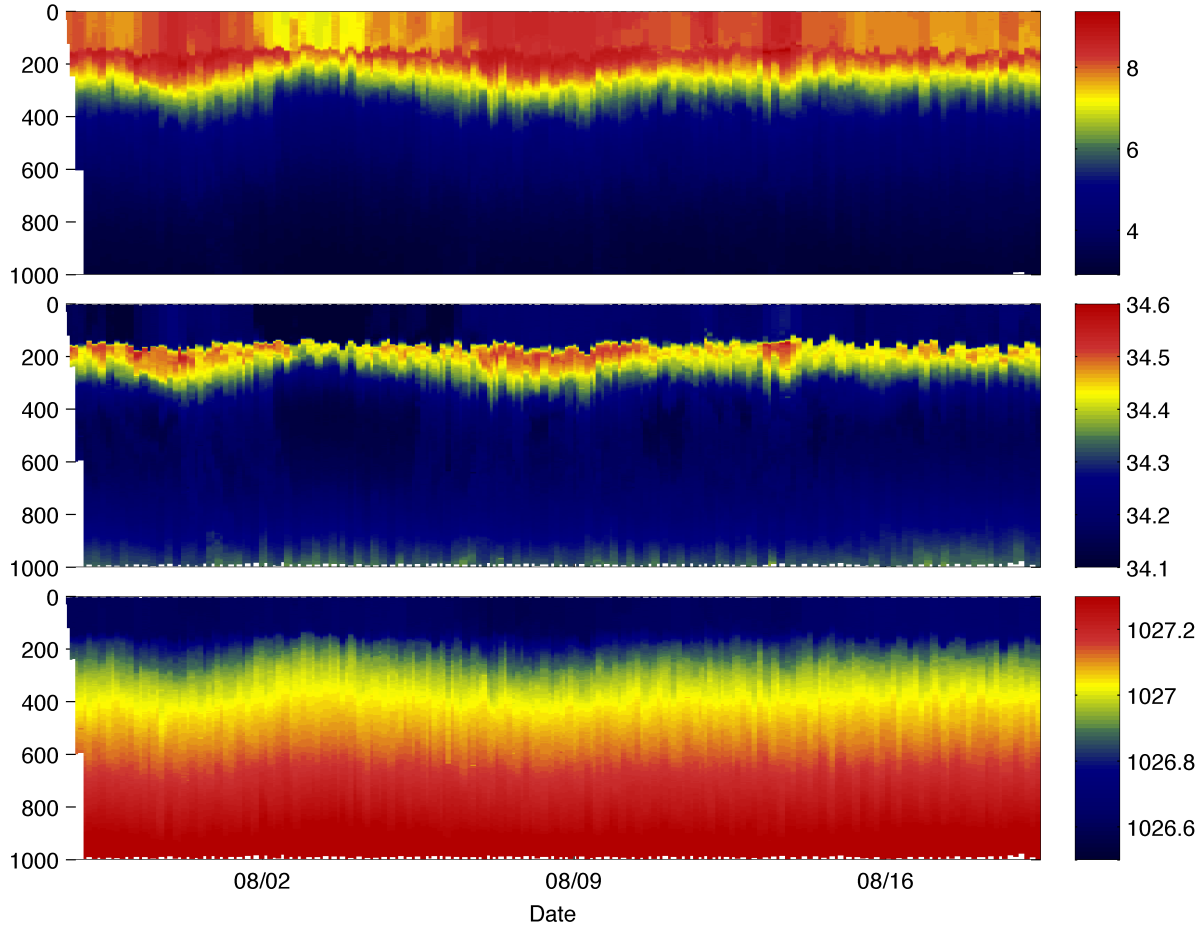


Figure 10. Hydrographic sections of Seaglider 543 for temperature [°C] (top panel), salinity (middle panel) and density [kg/m^3] (bottom panel).

Chlorophyll calibration for Seaglider 573

An engineering complication with the WET Labs Fluorometer on Seaglider 573 has prevented a calibration from being done.

Hydrographic sections from Seagldier 573 are shown in Figure 11.

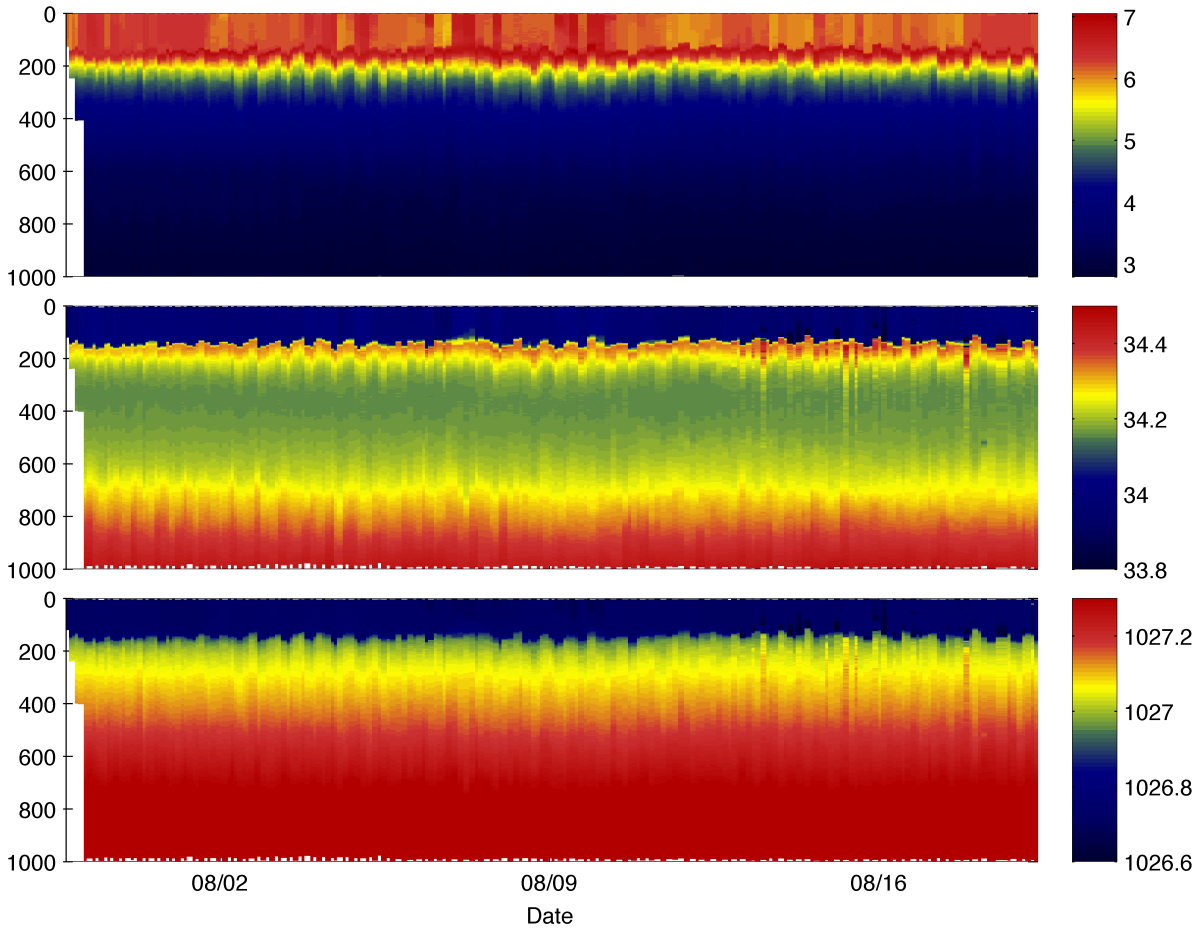


Figure 11. Hydrographic sections of Seaglider 573 for temperature [°C] (top panel), salinity (middle panel) and density [kg/m^3] (bottom panel).

4. CO_2 Observations

Team: W.R Joubert, M. Tsanwani, P. Jubasi, B. Mdokwana, A. Mrubata.

Underway observations of continuous surface pCO_2, and individual bottle samples of surface Dissolved Inorganic Carbon (DIC) and Total Alkalinity (AT) were collected from the ships underway seawater supply during the voyage. The following description provides details of the measurements and preliminary results obtained during the voyage. Figure 1 shows the temperature and salinity collected during the voyage.

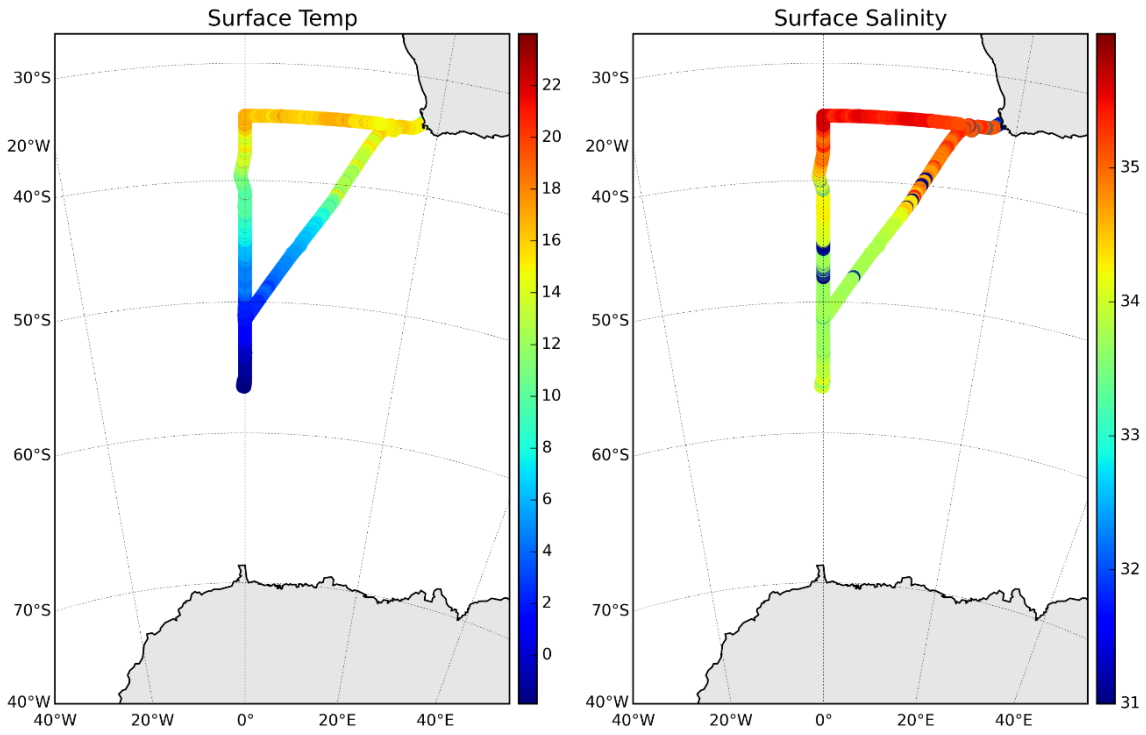


Fig. 1. Temperature and Salinity from the underway TSG along the transect.

Continuous pCO_2

The gradient between the atmosphere and ocean represents the thermodynamic potential for gas exchange of CO_2 across the air-sea interface. When the concentration is higher in the ocean, gas would tend to reach equilibrium by efflux to the atmosphere and *vice versa*.

Partial pressure of CO2 in the atmosphere and ocean were measured using an infrared gas analyser (manufactured by General Oceanics), as described in Pierrot et al., 2009. The instrument was calibrated using 4 reference gases, certified against reference standards traceable to NOAA internal standards (check the reference here). The instrument was sequenced to change between reference standards, atmospheric air, and seawater roughly every 4 hours. Data was logged through a computer interfaced through LABVIEW which also controlled the operation of the instrumentation.

On the first two days of the cruise, fluctuations in the equilibrator pressure were observed associated to fluctuation in the water volume (water level) in the equilibrator. After troubleshooting, the tubing of the peristaltic pumps that drains the condenser appeared to be blocked. This was replaced, along with the naphion drying tubes in the wet box to ensure no further restriction of gas flow. No further problems in water level were observed for the remainder of the cruise.

Another observation during the first 2 days of the voyage was that the atmospheric xCO_2 were high (~ 420 uatm), which was only slightly below the highest standard (~ 427 uatm). It was suspected that it potentially resulted from residual highest standard standard remaining in the pipes. An attempt was made to clear the residual gas prior to analysing the atmospheric readings on the licor to ensure only atmospheric air is being

measured. The pre-flush time for atmospheric air was increased to 3 minutes prior to measurement, which marginally improved the CO_2atm to ~410uatm.

The instrument was monitored roughly every 2 hours to ensure water flow, gas flow and equilibrator levels (and pressure) were in an appropriate range. Figure 2 shows the atmospheric pressure and raw xCO2 measured along the transect. It shows a distinct increase from undersaturated xCO_2 ~ 370uatm the Subtropical Region in the north (north of the STF) to supersaturated xCO_2 (> 440uatm) in the Antarctic Zone southward of the Polar Front. These are only raw output and still has to be calibrated using the reference gases, as well as the correction for atmospheric pressure and the non-ideal gas behaviour of CO_2. Furthermore, the measurements will be compared to the two wavegliders deployed in the SAZ during the voyage.

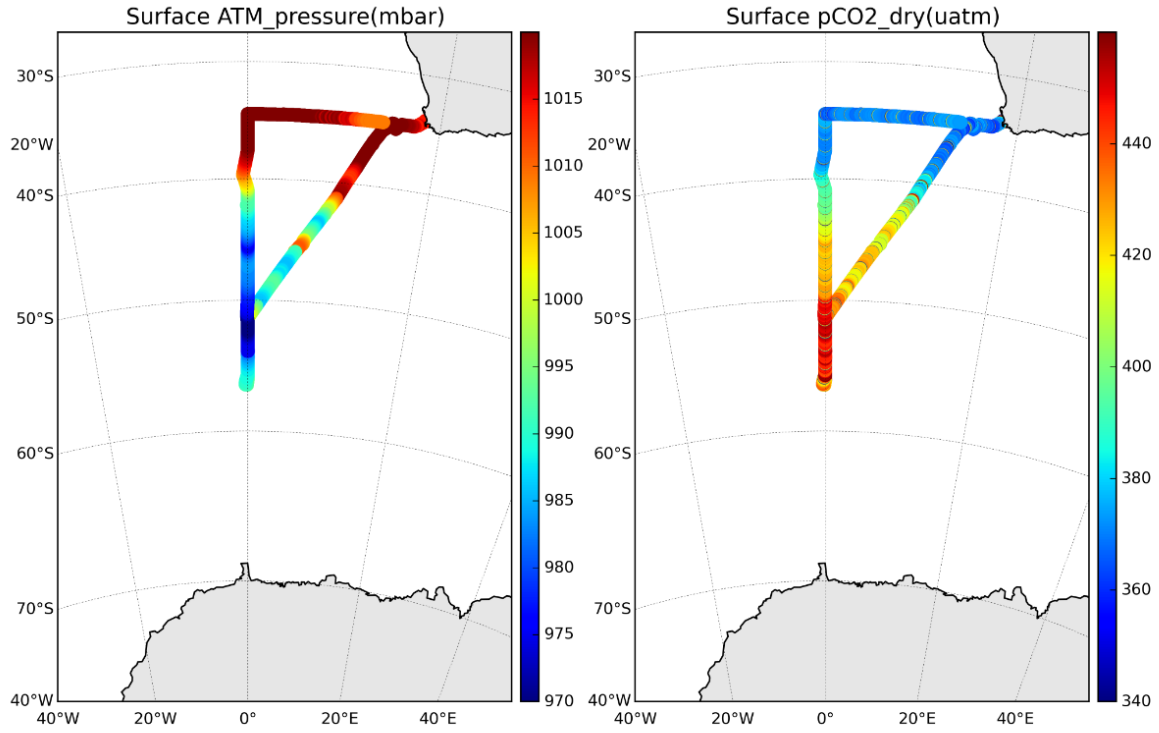


Figure 2. Raw xCO_2 (uatm) measured continuously along the transect and atmospheric pressure from the ships weather data.

Dissolved Inorganic Carbon and Total Alkalinity

Total dissolved inorganic carbon and total alkalinity samples were collected from the wet biology lab, from the same underway water supply where the TSG water is sampled. Intake temperature, salinity and atmospheric pressure were recorded at each point underway samples were collected. CTD samples were collected from nine depths with increased resolution in shallower depths. Samples collected for ship based analysis were stored in 500mL bottles (identical to CRM bottles as supplied by A Dickson) with 200µL of concentrated HgCl (Mercuric Chloride). The 500mL samples were analyzed on board using Marianda's VINDTA 3C (Versatile Instrument for the Determination of Titration Alkalinity). The VINDTA determines total alkalinity by potentiometric titration and also colometrically measures CO_2 from the same sample. Accuracy of the VINDTA

was determined by running a Dickson's CRM's before and after each batch. Consistency in reproducibility of CRM's was often difficult to achieve for entire batches, in particular for DIC which showed an increase between CRMs at the beginning and end of each batch of roughly 20 samples.

The precision of the analysis was tested by replicating 10 samples for DIC and TA collected from the same CTD. The precision for DIC and AT was 2.07 umol/kg and 1.86 umol/kg respectively, prior to adjustment for the correct acid concentration and pipette volumes. This is expected to improve after these corrections are applied to the data.

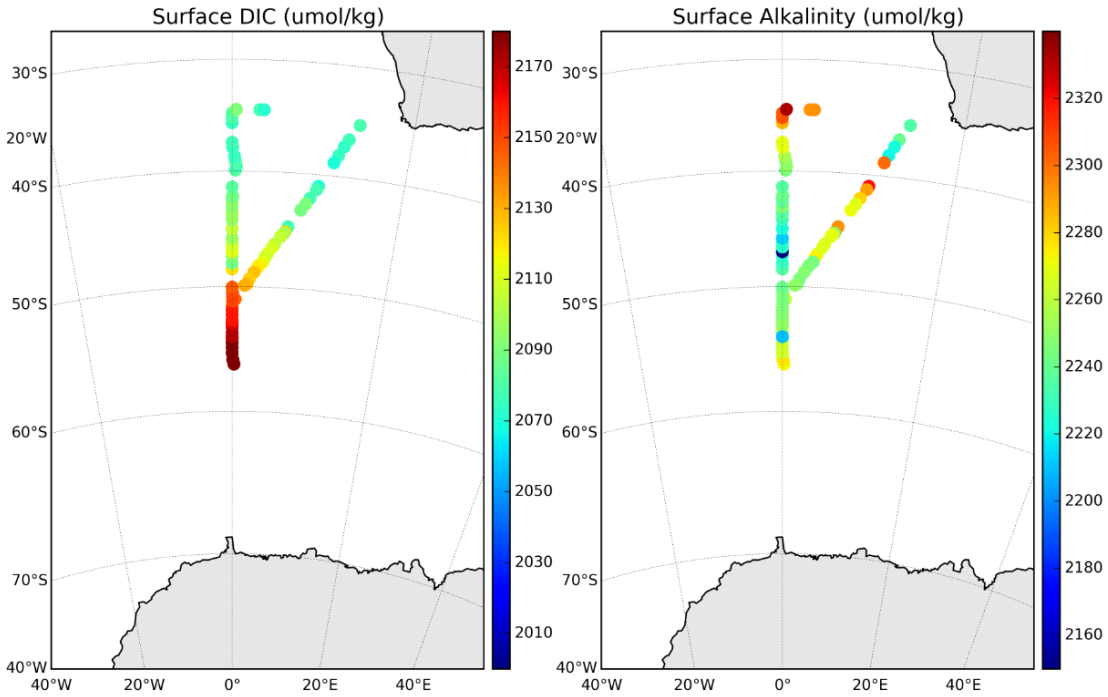


Figure 3. Shows the raw Dissolved Inorganic Carbon (umol/kg) and Total Alkalinity (umol/kg) along the transect. A correction has to be applied for the certified reference materials, nutrient concentrations and pipette volumes. Surface DIC showed a similar north to south increase from ~ 2060 umol/kg to greater than 2170 umol/kg southward of the Polar Front. TA showed variability in the surface.

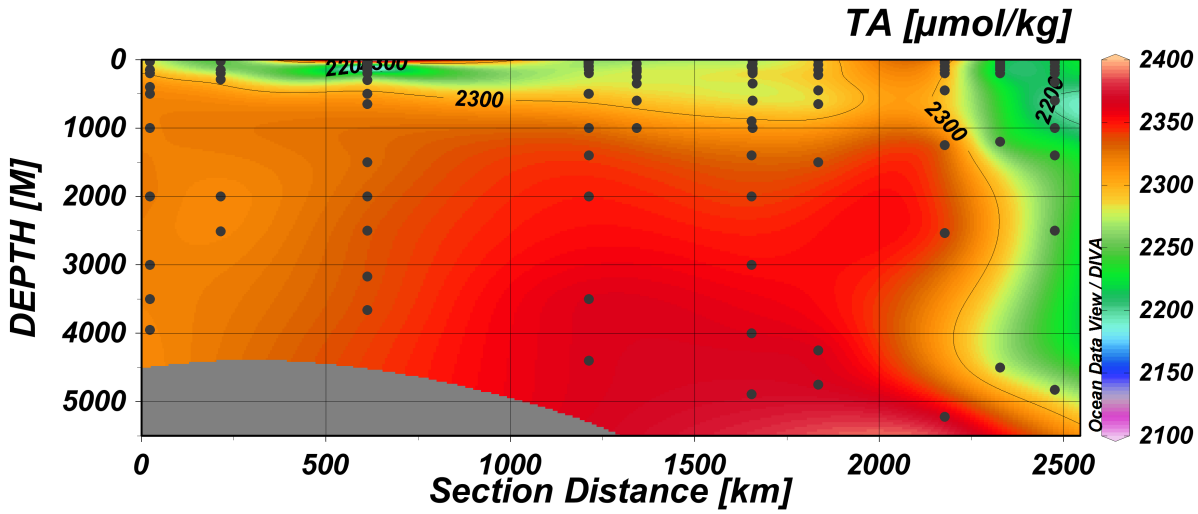


Figure 4. Raw unprocessed Total Alkalinity (umol/kg) along the transect from 10 CTD stations along the transect. Zero Distance indicates the Southern extent of the transect (~56°S)

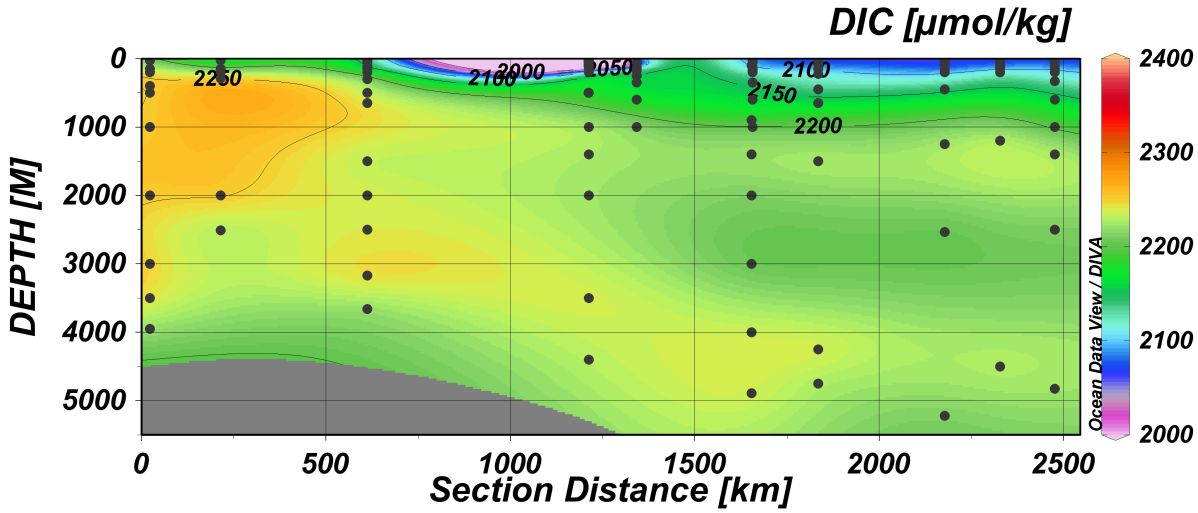


Figure 5. Raw unprocessed Dissolved Inorganic Carbon (umol/kg) along the transect from 10 CTD stations along the transect. Zero Distance indicates the Southern extent of the transect (~56°S).

DIC in the northern section of the transect shows depletion of DIC in the surface, potentially related to biological drawdown of DIC, a more homogenous DIC profile is observed in the southern portion potentially related to upwelling south of the PF. This data, after the necessary calibrations, will be further interpreted in conjunction with the nutrient and hydrographic data collected during the cruise.

5. Nutrient Analysis

Raymond Roman

Introduction

One of the unique properties of water masses is their micronutrient concentrations. As with their temperature and salinity signal nutrient concentrations can be used to trace

water mass movements from their origin and their mixing ratios. This is very evident when comparing low nutrient North Atlantic Deep Water with the nutrient rich Antarctic Intermediate Water (Millero, 1996).

Micronutrients also form an important part of the food web. In most oceanic regions they are the inhibiting factor to phytoplankton growth which is at the base of the oceanic food chain. Phytoplankton blooms also result carbon uptake making them an important component in the carbon cycle than influence our climate. In today's climate science micronutrients are important as both a tracer and regulator (Millero, 1996).

Methods

During the winter cruise 4 nutrients (nitrate, nitrite, silicate and phosphate) was analysed for all water samples (every 2 hours for underway and each CTD sample depth) taken. In total 591 samples were collected of which 580 were analysed within 24 hours of collection. Collected samples were kept in a fridge at 4° Celsius. In most cases duplicate samples were taken and frozen (-20° Celsius) for analysis at the University of Cape Town as a further quality control check. Nitrate and silicate was measured using a Lachat Flow Injection Analyser using methods 31-107-04-1-E, 31-107-04-1-C and 31-144-27-2-A whilst nitrite and phosphate were determined manually by colorimetric method as specified by Grasshoff et al. (1983). The quality of the measurements was routinely checked against reference samples that were obtained from a recent inter-calibration experiment.

Comments

The Lachat FIA presented a challenge with two of the three valves malfunctioning. This resulted in continuous line switching which meant that the analysis took considerably longer. Fault finding exercises also resulted in the waste of reagents which meant that the analysis of the last station could not be completed. The system is in need of maintenance.

References

K. Grasshoff, M. Ehrhardt and K. Kremling. Methods of seawater analysis, Verlag Chemie, Weinheim, Germany, 1983.
F. J. Millero, Chemical Oceanography, CRC Press, Boca Raton, Florida

6. Biological sampling

Persons Responsible: Sandy Thomalla, Thomas Ryan-Keogh, Emma Bone, Charles Caulet, Hazel Little, Joshua Pein, Manare Sejeng, Alice McGrath, William Middleton.

Biogeochemical measurements were collected from the underway scientific seawater supply every 2 hours in the case of nutrients and every four hours for phytoplankton community structure characterisation.

6.1 Dissolved Oxygen

Dissolved oxygen (DO) samples were collected in two different ways. Continual sampling every 4 hours from the underway lab supply as well as samples from CTD casts (generally 4) whose depths were preselected. In addition to providing stand-alone biological data, the DO samples from CTD casts were used to calibrate the buoyancy glider as well as the oxygen sensor on the CTD.

Procedure

Sample Collection

- Confirm that the sample bottle and the stopper pair match.
- The tube-tip extending from the Niskin/underway tap was placed at the base of the sample bottle.
- Rinsed the sample bottle by allowing water to overflow 3X the volume of the bottle, so as to remove any traces of reagents from previous analysis.
- Filling of the sample bottles were conducted smoothly and slowly by rotating the bottle, minimizing turbulence and avoiding aeration.
- If the sample is taken from the underway system, the sampling temperature was noted by recording the temperature of the water being sampled while the sample is overflowing the flask.
- Following collection, the individual samples were spiked immediately with 1ml of $MgCl_2$, followed by 1ml of $AlKI_2$. The dispenser tips were submerged at least 1cm below the neck of the sample bottles before dispensing. Tips should be discarded immediately afterwards.
- The stopper was inserted into the bottle, displacing excess seawater while ensuring that no bubbles were trapped. The bottles were inverted repeatedly in a vigorous fashion, set aside for two hours in a dark environment, allowing successful formation of a precipitate while reaching ambient temperature.

Titration

- The stopper was removed from the sample
- The samples were subsequently spiked with 1ml of 50% H_2SO_4 to dissolve the precipitant.
- The sample was poured into a glass beaker, previously rinsed with deionized water.
- A magnetic stirrer was added to the solution, the bottle volume recorded on the Titration unit.
- The sample was and titrated using a Metrohm 848 Titrino Plus unit.

Standardization

- The Metrohm was standardized every 24 hours using the following reagents in order: 50ml MilliQ, 1ml H2SO4, 1ml NaOH/IOH, 1ml MnCl2, 10ml potassium iodate standard solution

Comments

The procedure in which DO samples were collected might have differed between those taking the samples, with confusion as to whether pipette tips should be reused, submerged in the sample, or the stopper be placed within the sample. Rarely if ever was

the stopper placed into the DO bottles. On all CTD samples new pipette tips were used for each niskin bottle. Initially the DO was processed during the underway station allowing the precipitate to form for 45min rather than 2 hours. For future cruises the use of an auto dispenser is highly recommended as contamination led to excessive discarding of reagents.

Preliminary results

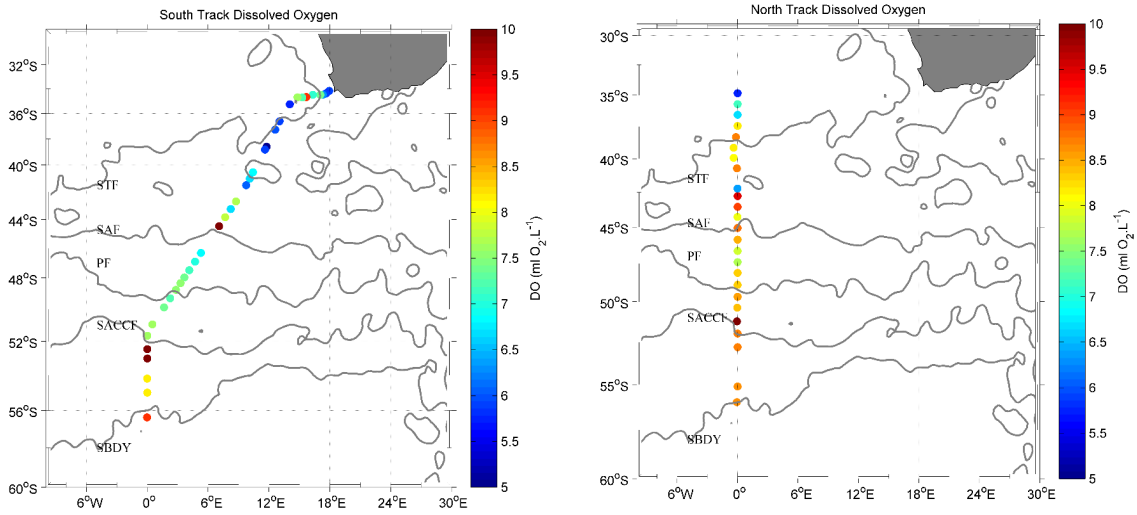


Figure 0-1.1 - Spatial plot of a) the south track of dissolved oxygen measurements and b) he north track of surface dissolved oxygen

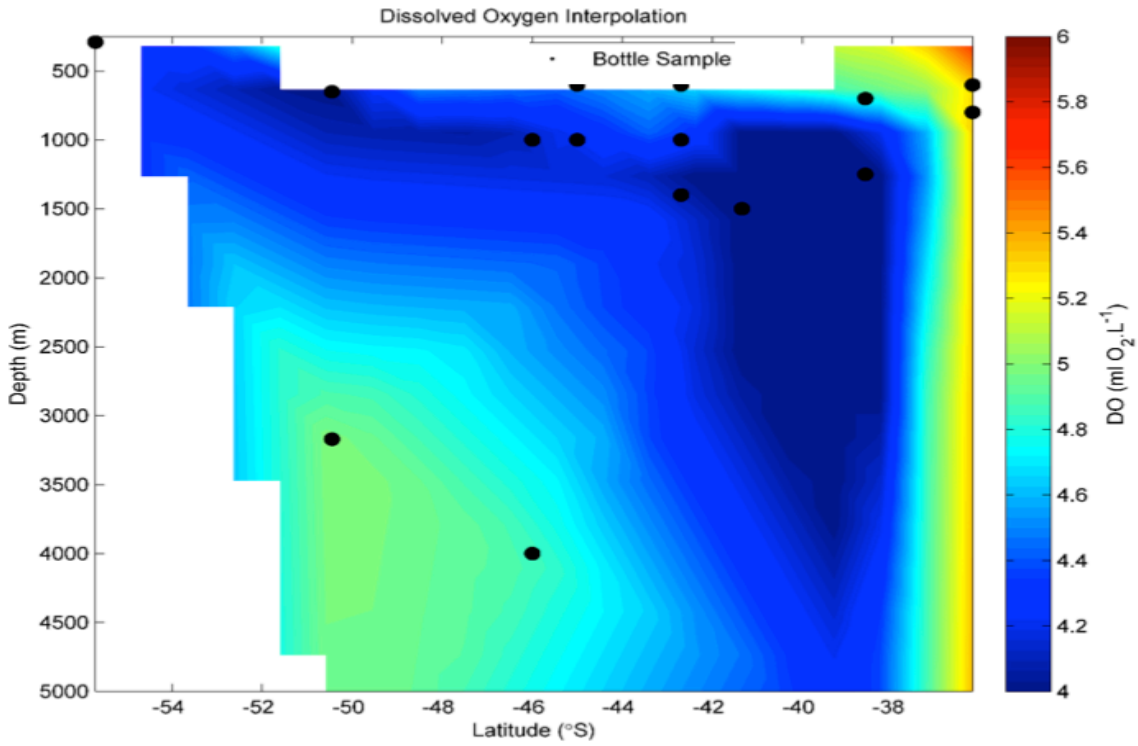


Figure 1.2. Dissolved oxygen interpolation of CTD Niskin samples

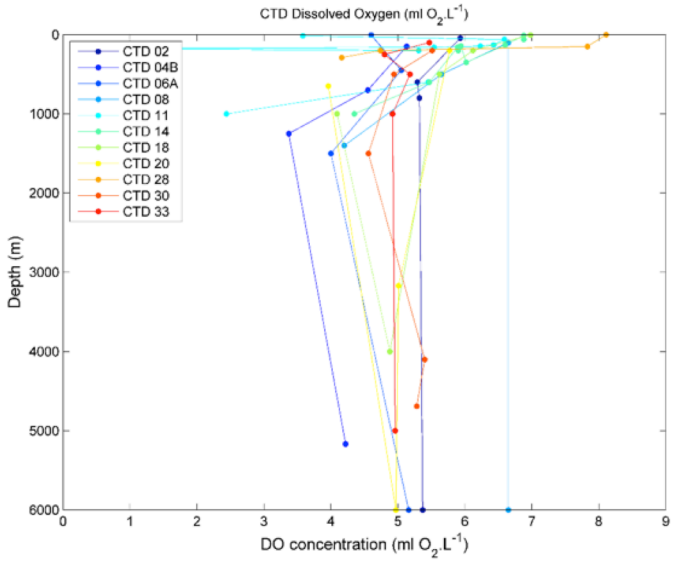


Figure 1.3. Individual profiles from CTD casts of Dissolved Oxygen. Note: depth values recorded as 'bottom' were assigned a depth of 6000 m

6.2 Chlorophyll-a

Chlorophyll-a samples were collected by filtering 500 ml of seawater from the scientific seawater supply every 4 hours and from certain depths during CTD casts (generally 6). Water samples were filtered through 25 mm Whatmann GF/F filters, placed in glass

vials with 8 ml of 90% acetone and kept in a -20 °C freezer for 24 hours. After 24 hours the samples were removed from the freezer, and stored in the dark for 10-15min to equilibrate to room temperature. Samples were inverted three times before being placed in a glass cuvette in a Turner bench-top flourometer to measure raw fluorescence. Raw fluorescence units were recorded and converted to chlorophyll concentration using a standard calibration curve created on 14 July 2015 using raw chlorophyll standard (Sigma C6144 *Anacystis nidulans*). Chlorophyll samples will be used to calibrate the underway fluorometer, the flourometer sensors on both the Geotraces and general CTD's as well as the fluorescence sensors on both buoyancy gliders.

Preliminary results

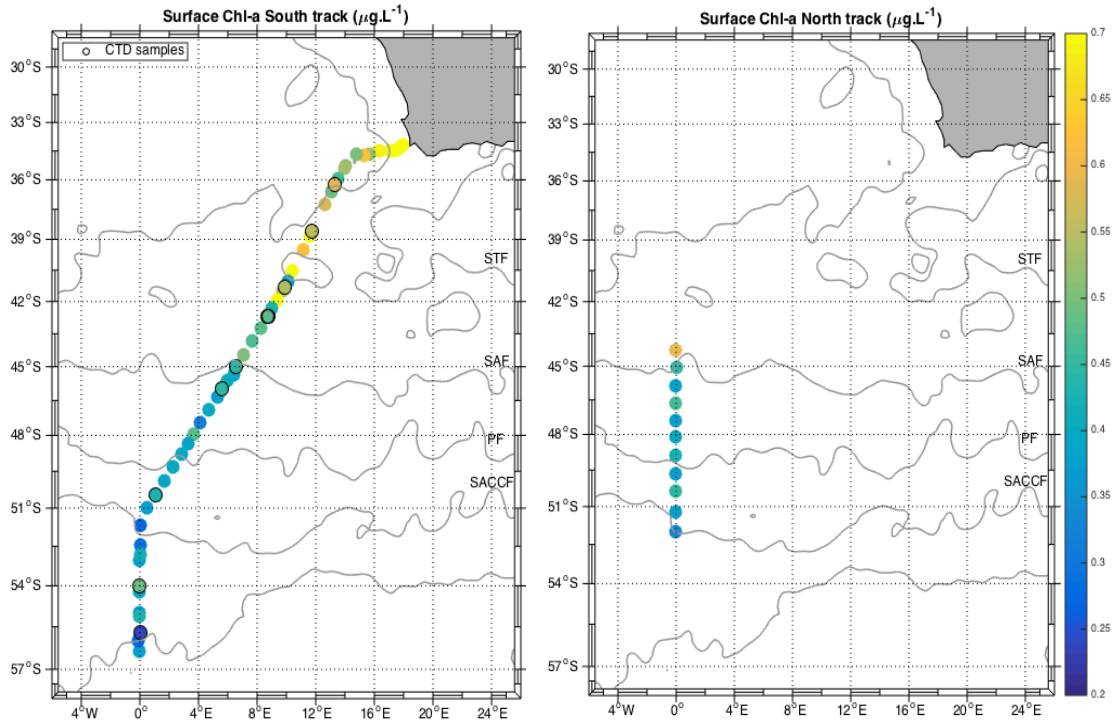


Figure 0-2.4: Surface Chl-a concentrations (ug.L-1) from underway and CTD samples. Black circles indicate the CTD sample sites. Right hand plot shows the southward leg, left hand plot shows the northward leg. Samples are from 23/07/15 to 08/08/15. STF = Sub Tropical front, SAF = Sub Antarctic front, PF = Polar front, SACCF = Sub Antarctic Circumpolar front

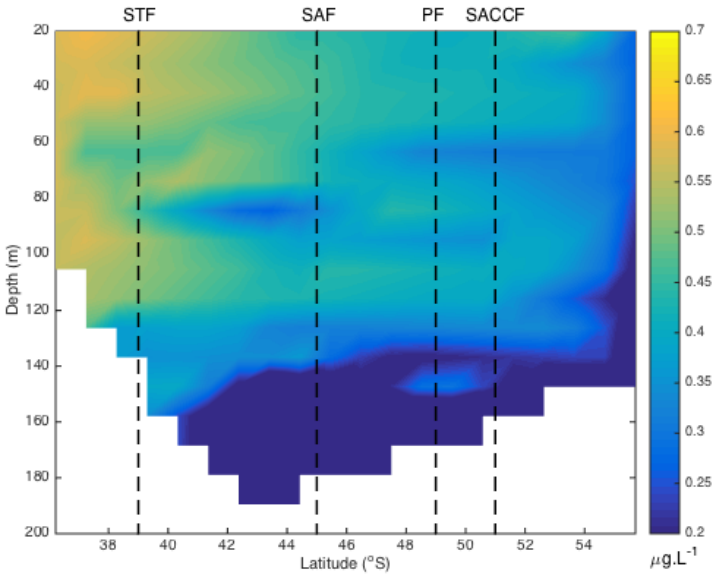


Figure 1.5: Chlorophyll concentration (ug.L^{-1}) section from Cape Town 36°S to 56 °S . Black dashed lines indicate the location of fronts. STF = Sub Tropical front, SAF = Sub Antarctic front, PF = Polar front, SACCF = Sub Antarctic Circumpolar front.

6.3 Particulate Organic Carbon (POC)

Measurements of Particular Organic Carbon (POC) provide an indicator of phytoplankton biomass. Samples for the assessment of POC were collected every 4 hours whilst underway from the scientific sea water supply and from CTD Niskin biology casts (generally 3 depths; surface, MLD and midway between surface and MLD). Two liters of seawater was filtered onto 25 mm ashed (pre-combusted) Glass Fiber Filters (GFF). Ashed filters were combusted overnight (5pm – 8am) in a muffle furnace at 400 degrees prior to the cruise. When the filtration was complete, the filter was placed in a petri dish and dried in an oven at 60^{o}C for 24 hours. Following drying the filters were acid fumed for 24 hours to remove particulate inorganic carbon by placing the filters in a desiccation chamber with a beaker of concentrated HCl in the fume hood. Filters that had undergone this cycle were then punched using a size 13 punch, before being folded into foil cups in a labeled 96-well plate. A blank ashed GF/F, in a foil cup, was placed intermittently in each row in the 96-well plate. Further processing will continue on the CHN analyser in the Archeometry department at the University of Cape Town.

6.4 High Performance Liquid Chromatography (HPLC)

HPLC is a method used for separating different pigments present in phytoplankton. This involves the chromatographic separation, identification and quantification of components in a given solution allowing for identification of the dominant phytoplankton species present in the water column in terms of their taxonomic identification and photo-physiological characterisation. Sampling took place as part of the discrete underway samples occurring at 4 hourly intervals as well as at selected depths during certain CTD casts (generally 6 depths). 2000 ml of sea water were

collected for each HPLC measurement either from the underway system or from selected Niskin bottles after CTD deployments. The 2000 ml were filtered through 25mm Whatman GF/Fs. Filters and folded into labeled cryovials and stored at -80°C.

6.5 Microscopy

Amber bottles where used to collect approximately 200ml of scientific sea water from the scientific seawater supply when underway and from selected CTD depths from Niskin – biology casts (generally 3). The sample was preserved with 4ml of alkaline lugols and stored at room temperature. The recipe for alkaline lugols is as follows: 100g Iodine, 100g sodium acetate, 200g potassium Iodatemade up to 2000ml with MilliQ.

6.6 Size Distribution (Coulter Counter)

Sandy Thomalla, Emma Bone

Suspended particles are a ubiquitous component of natural waters, and play an important role in the biogeochemical cycling of elements and in the structure and functioning of marine ecosystems. Examining light scattering and absorption within the ocean, and attempts to partition optical contributions among different constituents of seawater reply implicitly on some parameterisation of the particle size distribution. An instrument, such as the Beckman Coulter-Multisizer, is used to analyse particle size distribution and has sufficient resolution in size to resolve distinct populations within mixed assemblages of particles (Reynolds, R.A. *et al.* 2010). In brief, the Coulter counter has a microchannel that separates two chambers containing electrolyte solution (0.2µm filtered seawater). As seawater containing particles is drawn through the microchannel each particle cause a brief change to the electrical resistance of the seawater. The counter detects these changes in electrical resistance and infers particle size.

- The instrument was set up as per standard protocol
- Electrolyte was generated by first filtering seawater through a 25mm Whatman GF/F (0.7µm) and subsequently through a 0.2µm isopore polycarbonate filter.
- The 100µm aperture tube was inserted and calibrated using 14 drops of 20µm beads
- A specific SOP was created for the SOSCEx III cruise, which standardly made use of the 100µm aperture, sampling 20 runs at 2ml per run.
- Underway samples were collected from the ships uncontaminated seawater supply every 4h and certain CTDs were sampled at three designated biology depths (typically surface, chl max and bottom of the mixed layer).
- In between stations the sample beaker was filled with clean electrolyte and the system was drained and filled. All samples were sufficiently inverted before being analysed and the system was flushed once prior to every sample.

Note: Blanks (0.2µm filtered sea water) were initially run once every 24h. However, filter size was not noted and during the final third of the cruise this mistake was realised. Filtered seawater (0.2µm) was measured at every subsequent station to be used as a blank.

References
Reynolds, R.A., Stramski, D., Wright, V.M. and Wozniak, S.B. (2010) Measurements and characterization of particle size distributions in coastal waters. *J. Geophys. Res.,* 115 (C08024): 1-19

6.7 Absorbance (total/ de-pigmented particulate and Gelbstoff)

Emma Bone, Sandy Thomalla

The particulate biogenous matter that dominates open ocean optics includes living pigmented phytoplankton and weakly pigmented or unpigmented particles mainly derived from phytoplankton and other living heterotrophs. These comprise the algal and non-algal components respectively. The absorption coefficients of intact, living cells must be known to interpret the inherent (absorption) and apparent (diffuse attenuation coefficient, colour) optical properties of the ocean and to better understand photosynthetic capacity, growth rates and primary production (Bricaud, A. and Stramski, D. 1990). The quantitative filter technique is useful for determining the dissolved and particulate components of the total absorption coefficient.

Another optically measureable component of seawater is chromophoric dissolved organic matter (CDOM) or *Gelbstoff.* These organic compounds originate from numerous sources including terrigenous inputs, photochemical redox reactions and various biological processes such as cell lysis, degradation, exudation and grazing. *Gelbstoff* absorption is often extremely low in the Southern Ocean and demonstrates a weak but significant correlation with [Chl] (Reynolds, R.A. *et al.* 2001).

Particulate absorbance (PA), de-pigmented particulate absorbance (DP) and *Gelbstoff* (GB) analysis was performed on a Shimadzu UV-2501 spectrophotometer. Underway samples were collected from the ships uncontaminated seawater supply every 4h and certain CTDs were sampled at three designated biology depths (typically surface, chl max and bottom of the mixed layer). Two litres of seawater was filter through 25mm GF/Fs.

Particulate Absorbance (PA)

- The filters were processed as soon as the filtering was finished (stored in petri dishes);
- A few drops of MilliQ were added to the filter pads (PA) to ensure the moisture levels remained constant for all samples (a dry filter has a higher absorption)
- The spec was turned on and allowed 10min to warm up
- The UVPC software was started and the spec was connected to the computer through COM1
- The spec ran through its utilities check list and the following settings were adjusted:
    - Lamp change: 340nm
    - Measuring mode: ABS
    - Wavelength range (nm): Start: 800, End: 350

    - Scan speed: slow
    - Slit width (nm): 5
    - Sampling interval (nm): 1
- A baseline scan was run to ensure the background noise was between -0.005 and 0.005. Sometimes there was a lot of noise, adjusting the connection between the integrating chamber and the spec could sometimes improve this value.
- A blank was run daily, consisting of 1L MilliQ filtered through a 25mm GF/F
- The scale was set between 0-1.5, to optimally view the resultant spectrum.
- Once complete, the file and data channel saved and ASCII file exported, the filter was placed back in the petri dish and soaked in methanol until later DP analysis.

De-pigmented Particulate Absorbance (DP)

- The filters were stored in methanol, in the dark, (following PA analysis) for 24h or more, and checked regularly to ensure the methanol did not evaporate.
- Filters were placed on a designated filter set-up (funnel, clamp and receiver flask) and ~4ml methanol was poured over the membrane, followed by a similar amount of MilliQ (to remove the methanol).
- The petri dishes were rinsed thoroughly with MilliQ before their respective filters were placed back inside.
- The filter was read on the spec with the same settings used for PA.

Gelbstoff (GB)

- The filtrate from the PA/ DP sample was collected for GB measurements
- Samples were stored in clean amber bottles, in the dark. Samples were typically run every 48h.
- The spec was turned on and allowed 10min to warm up
- Cuvettes were cleaned thoroughly with ethanol before being carefully rinsed with MilliQ
- The spec ran through its utilities check list and the following settings were adjusted:
    - Lamp change: 380nm
    - Measuring mode: ABS
    - Wavelength range (nm): Start: 800, End: 250
    - Scan speed: very slow
    - Slit width (nm): 5
    - Sampling interval (nm): 1
- A baseline scan was run to ensure the background noise was between -0.005 and 0.005
- The scale was set between 0 and 0.2 when analyzing samples
- A blank was run every time GB samples were analysed. Blanks comprised of MilliQ in both the 'reference' and 'sample' cuvette.
- The 'reference' cuvette remained unchanged (containing the same MilliQ as in the blank measurement), whilst the 'sample' cuvette was rinsed between samples, three times with MilliQ and twice with each subsequent sample.
- Files and data channels were saved and ASCII files exported before the cuvettes were cleaned thoroughly and stored safely.

Consideration:
The underway water plumbing was contaminated with an as yet undetermined substance. The SOSCEx I cruise on the SA Agulhas I (February 2013) also had a contaminated underway system. Following that cruise a theoretical de-pigmented absorbance value was generated base on a paper by Bricaud, A. and Stramski, D. (1990). This technique is very rudimentary and needs to be optimised (Figure 1).

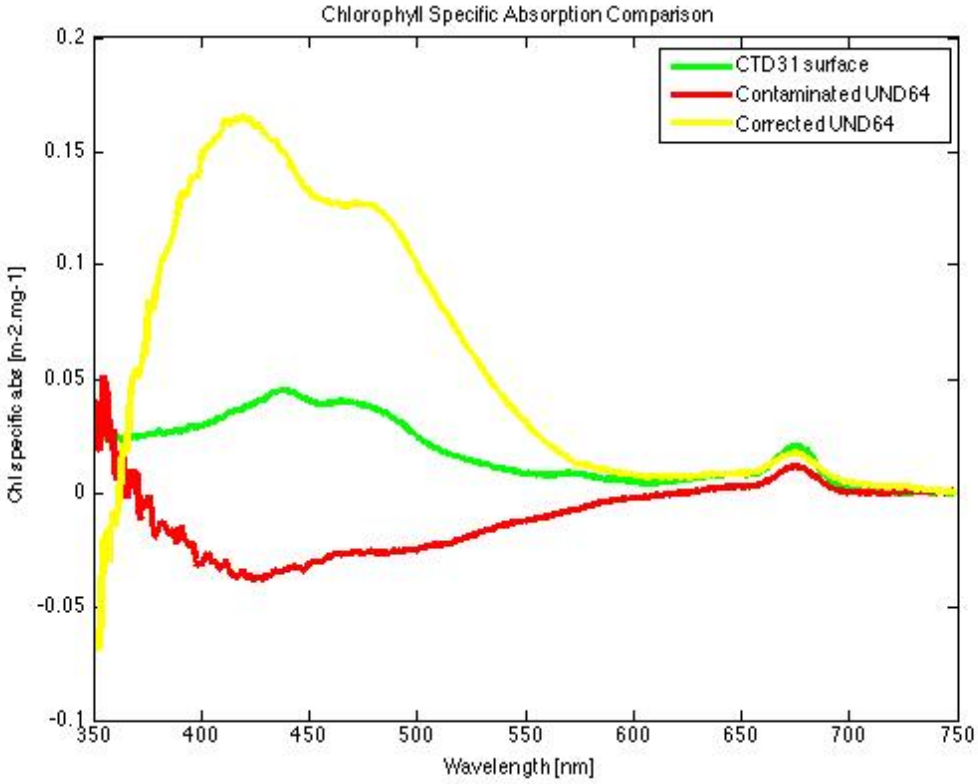


Figure 1: Chlorophyll specific absorption for an uncontaminated CTD surface sample (green), a contaminated underway surface sample (red) and a theoretically corrected underway surface sample (yellow).

Figure 1 Illustrates the vast difference between the uncontaminated CTD sample (green) and the contaminated underway sample (red). The contamination influences a large part of the visible spectrum (~360-600nm). The theoretical DP value corrects the chlorophyll specific absorption shape slightly (yellow), but the magnitude and overall shape need a great deal of attention. This will be fully assessed and hopefully resolved at a later stage.

References
Bricaud, A. and Stramski, D. (1990) Spectral absorption coefficients of living phytoplankton and nonalgal biogenous matter: A comparison between the Peru upwelling area and the Sargasso Sea. *Limnol. Oceanogr.,* 35(3): 562-582

Reynolds, R.A., Stramski, D. and Mitchell, B.G. (2001) A chlorophyll-dependent semianalytical reflectance model derived from field measurements of absorption and backscattering coefficients within the Southern Ocean. *J. Geophys. Res.,* 106 (C4): 7125-7138

7. Key metabolic proteins in marine microbial communities

Persons Responsible: T. Ryan-Keogh, E. Bone, H. Little

The diversity of marine microbial communities is poorly understood, however, microbial processes catalyse biochemical cycles on global scales. Despite this diversity the protein catalysts that perform the chemistry of these reactions are highly conserved. Iron (Fe) is a fundamental requirement for high rates of production due to the abundance of Fe-containing protein catalysts in the photosynthetic apparatus of photosynthetic cells (Shi et al. 2007). Thus Fe availability has the potential to limit the abundance of these proteins and set a limit on metabolic activity and hence primary production within the ocean. Primary production in the ocean is usually quantified through basic methods in oceanography (e.g. chlorophyll content, photosynthetic efficiency (F_v/F_m), remote sensing). Using this novel quantitative technique I will investigate the photosynthetic process at a molecular level in order to better understand the role of Fe availability on photosynthetic activity. Samples were collected for metabolic protein analysis across the STZ, SAZ and PFZ (Figure 1).

Methods - Sampling for proteins

Water samples were collected from the CTD and the ships non-toxic supply (Table 1) and from nutrient addition experiments. From the CTD, samples were collected from the surface (10-15m). Samples were collected in polyethylene carboys and volumes ranging from 1.3L to 2.0L (depending on biomass in seawater) were filtered for 1-2 hours onto 4 × GF/F filters (0.7 µm, 25mm, Whatman). The filters were then flash-frozen in liquid nitrogen and stored at -80^{o}C. Filters will be used for protein extractions to target key photosynthetic proteins including components of photosystem I & II and Rubisco.

Problems encountered:

1. Post-cruise processing requires the maximum amount of biomass possible, but due to problems with the vacuum pump the maximum volume achieved was 2.5L
2. A 2 hour time limit must be set for filtering otherwise the proteins may drastically alter and degrade during the filtering process – a few stations had to be cancelled as the time limit had been reached

References

Shi T., Sun Y., Falkowski P.G. (2007) Effects of iron limitation on the expression of metabolic genes in the marine cyanobacterium Trichodesmium erythraeum IMS101. Environmental Microbiology 9: 2945-2956

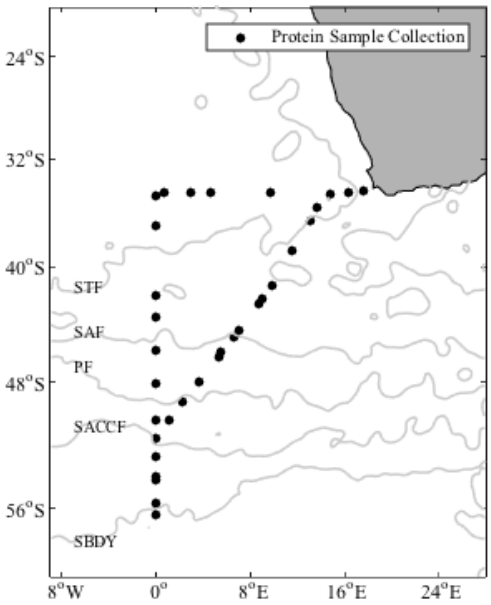


Figure 2.1 Location of protein samples collected with boundaries of the fronts (Sub-tropical, Sub-Antarctic, Polar, Sub-Antarctic Circumpolar, Southern Boundary).

Table 2 Locations and volumes filtered for protein samples collected on the Winter 2015 cruise.

Sample ID	CTD Station (if applicable)	Date	Time (GMT)	Latitude	Longitude	vial 1 (vol)	vial 2 (vol)	vial 3 (vol)	vial 4 (vol)
U06		23/07/15	10:04	-34.41	17.56	2L	2L	2L	2L
U12		23/07/15	22:01	-34.50	16.32	2L	2L	2L	2L
U18		24/07/15	10:05	-34.70	14.81	2L	2L	2L	2L
U23		25/07/15	00:01	-35.68	13.72	2L	2L	2L	2L
U26		25/07/15	10:01	-36.62	13.04	2L	2L	2L	2L
U32		26/07/15	10:56	-38.83	11.60	2L	2L	2L	2L
	CTD06A	27/07/15	08:26	-41.34	9.89	2.18L	2.5L	2.5L	2.5L
U43		27/07/15	01:14	-42.31	9.04	2.25L	2.27L	2.5L	2.5L
	CTD09	28/07/15	10:25	-42.69	8.74	2L	2L	2L	2L
U51		29/07/15	11:01	-44.46	7.08	2L	2L	2L	2L
	CTD15	29/07/15	06:50	-45.00	6.56	2L	2L	2L	2L
	CTD17	30/07/15	13:21	-45.98	5.55	2L	2L	2L	2L
U58		30/07/15	23:59	-46.32	5.28	2L	2L	2L	2L
U64		31/07/15	12:05	-47.96	3.65	2L	2L	2L	2L
U70		31/07/15	23:59	-49.31	2.25	2L	2L	2L	2L
	CTD21	01/08/15	13:20	-50.45	1.06	2L	2L	2L	2L
U76		01/08/15	23:59	-51.66	0.00	2L	2L	2L	2L
U82		02/08/15	12:00	-54.20	0.00	2L	2L	2L	2L
	CTD25	03/08/15	03:14	-55.71	0.00	2L	2L	2L	2L
U86		03/08/15	09:56	-56.38	-0.03	2L	2L	2L	2L
	CTD29	04/08/15	06:03	-54.00	0.00	2L	2L	2L	2L
U93		04/08/15	12:00	-52.81	0.00	2L	2L	2L	2L
U99		04/08/15	23:59	-50.47	-0.05	2L	1.3L	2L	2L
U105		05/08/15	12:00	-48.12	0.00	2L	2L	2L	2L

U111		06/08/15	00:02	-45.87	0.00	2L	2L	2L	2L
U117		06/08/15	23:55	-43.56	0.00	2L	2L	2L	2L
U123		07/08/15	12:02	-42.11	0.00	2L	1.87L	1.74L	2L
U135		08/08/15	00:00	-37.03	0.00	1.35L	1.66L	1.63L	2L
U141		08/08/15	12:00	-34.85	0.00	2L	2L	2L	2L
U143		09/08/15	00:00	-34.50	0.72	2L	2L	2L	2L
U149		09/08/15	11:57	-34.51	3.00	2L	2L	2L	2L
U152		10/08/15	11:58	-34.50	4.70	2L	2L	2L	2L
U160		11/08/15	12:00	-34.50	9.75	2L	2L	2L	2L

8. Productivity vs Irradiance Experiments

Persons Responsible: H. Little, T. Ryan-Keogh

In the Southern Ocean iron and light limitation are the most important biochemical factors affecting phytoplankton growth. The depth of light penetration defines the euphotic zone, (1% or 0.1% of surface light) where light is sufficient to support phytoplankton growth and reproduction by photosynthesis. Phytoplankton in the Southern Ocean have been known to show high degrees of photoadaptation to low ambient underwater irradiance. The objective of this study is to investigate photosynthesis as a function of light intensity in winter, in order to compare it to phytoplankton light responses in summer. The photosynthesis verse irradiance (P-E) experiment was used to examine photoacclimation of phytoplankton in surface water samples after the incorporation and subsequent uptake of ^{13}C by phytoplankton, as well as by light controls on nitrogen assimilation using ^{15}N stable isotopes.

Fourteen one litre water samples were collected from surface (~10m) CTD Niskin bottles, in transparent polycarbonate bottles. Each bottle was inoculated with ^{15}N (1 µmol $K^{15}NO_3$ / 100 µl) and ^{13}C (4.2507 g sodium bicarbonate / 100 ml Milli-Q water) spikes to achieve ^{15}N-NO_3 and ^{13}C enrichments of ~10 and 5% respectively. The bottles were incubated in a linear box incubator with an artificial light source at one end to recreate water-column light attenuation. A 2000-W tungsten-halogen lamp was used as the light sources: photon flux (I) ranged from 0 to 300 µE m^{-2} s^{-1} and irradiance levels in the photosynthetron were measured using a Biospherical Instruments probe (QSP200). The bottles were placed alongside one another in the incubation boxes to create a diminishing light gradient away from the light source, with the last bottle blacked out. Surface sea water was continuously circulated through the incubator box to maintain near ambient temperatures in all sample bottles, while heat protective glass was used to absorb the majority of the heat generated from the lamps. The bottles were incubated for 4 hours, after which the samples were filtered onto 25 mm ashed GF/F filters, before being dried in an oven at 60˚C for 24 hours. The samples were acid fumed with HCl in a dessicator for 24 hours, punched with a number 12 punch and finally pelleted into tin foil cups. Samples were stored with silica granules before future analysis on a mass spectrometer back at the University of Cape Town. The experiment was repeated six times along the Goodhope line, from Cape Town to the ice edge in the Southern Ocean.

Table 3.1. Photosynthesis vs. irradiance experiments

Station ID	Latitude	Longitude	^{15}N-NO_3 enrichment (%)	^{15}N Spike (µl)	^{13}C Spike (µl)	Temp start (°C)	Temp end (°C)
1	-34 24.478	12 21.009	10	400	200		
2	-42 41.502	08 44.243	10	500	400		
3	-45 00.089	06 33.687	10	1500	200	8.0	8.0
4	-45 59.926	05 35.528	10	1500	200	7.5	8.0
5	-50 26.972	01 03.375	10	2000	200	5.0	5.6
6	-55 42.596	00 00.123	5	1000	200	2.1	1.0

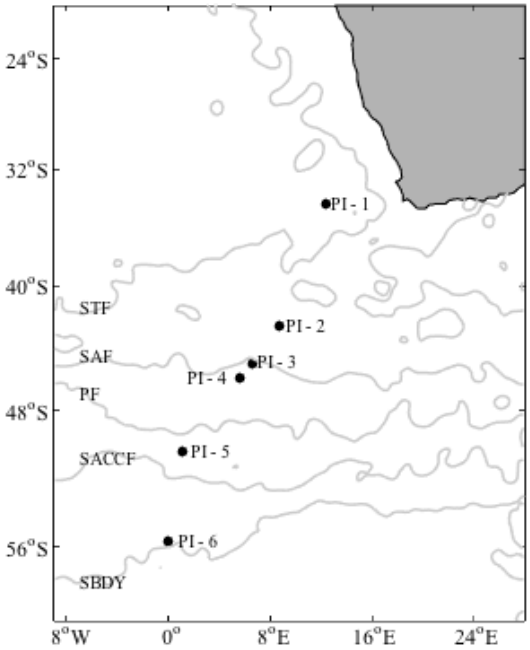


Figure 3.1 Photosynthesis vs. irradiance experimental set up locations.

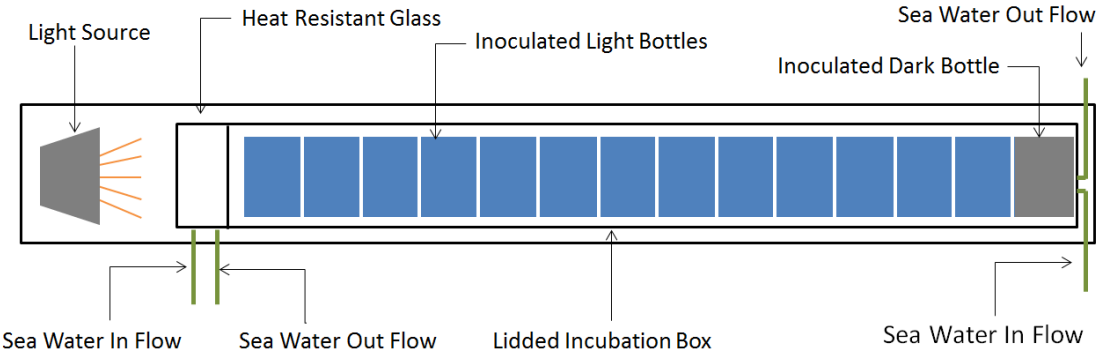


Figure 3.2. Photosynthesis vs. irradiance incubation box

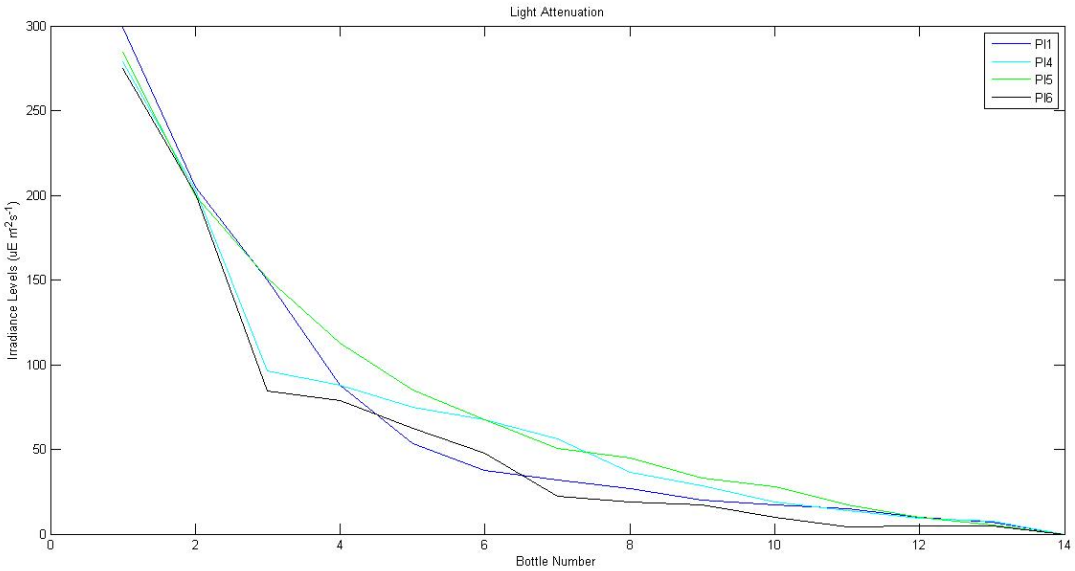


Figure 3.3. Light attenuation of bottles inside the incubation box

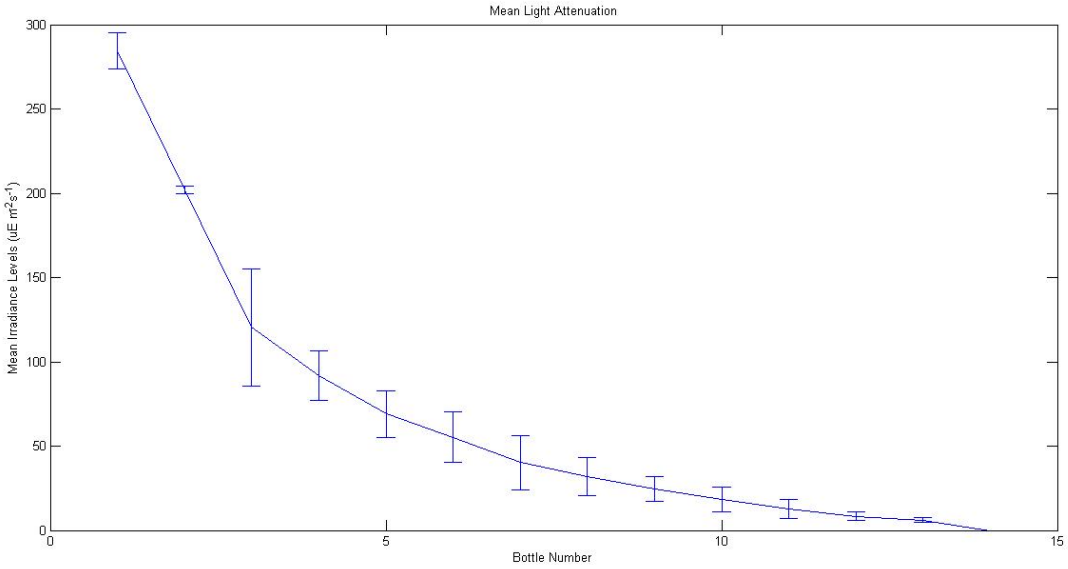


Figure 3.4. Mean light attenuation of the bottles inside the incubation box

9. ^{15}N Primary Production and Nitrification

Mhlangabezi Mdutyana and Raissa Philibert

Project Rationale

The world's oceans take up about 30% of anthropogenic atmospheric CO_2. As such they are called carbon sinks, and this CO_2 is stored as dissolved inorganic carbon (DIC). The process of photosynthesis enables phytoplankton to incorporate carbon into their tissues and promotes carbon dioxide sinking and sequestration. Particulate organic carbon (POC) in the form of marine snow sinks to the ocean depths transporting carbon.

Our understanding between the ocean interactions with carbon dioxide is vital because carbon dioxide is a greenhouse gas and the ocean is a carbon dioxide sink. The Southern Ocean is known as the largest ocean carbon sink and is therefore even important.
There are two types of primary production 1) new and 2) regenerated production. New production is primary production based on nitrate, as this form of nitrogen is new to the euphotic zone i.e. it has been upwelled into the surface waters. Regenerated production is primary production based on non-nitrate nitrogen sources i.e. forms of nitrogen excreted or re-cycled within the euphotic layer.

The f-ratio is a proxy that is commonly used as a measure of the efficiency of biological pump. It is the fraction of primary production fuelled by nitrate (NO_3) over total primary production. It is based on the assumption that the source of nitrate is found outside the euphotic zone while ammonium (and urea) is regenerated within the euphotic zone. As a result, the primary production can be divided as "new production" and "regenerated production", based on nitrate and ammonium (and other regenerated nutrients) respectively.

However, recent evidence has shown that nitrification, the biological oxidation of ammonium to nitrate, can be quite significant within the euphotic zone. As a result, production from nitrate cannot be simply classified as new production. This undermines the usefulness of the f-ratio as a proxy for carbon export. However, despite the persistent debate about the biological pump in the Southern Ocean, there have been very few measurements of euphotic nitrification in the Southern Ocean.

This winter cruise represents an opportunity to enhance the understanding of the nitrogen cycle in the Southern Ocean and its links to the carbon cycle. For this reason, a complete set of nitrogen uptake and regeneration measurements is needed especially during winter as there is very little data for this season. Nitrate and ammonium uptake are measures of primary productivity. On the other hand, the regeneration measurements allow for corrections to the isotopic dilution of the 15-N tracers as well as better constraints to carbon export models.

Aims:

- To determine nitrogen (NO_3, NO_2 and NH_4) uptake and regeneration rates
- To determine carbon uptake rates.

Methods

Primary production and nitrogen cycling experiments were conducted at 5 stations during the winter cruise.

Table 4.1: Primary production and nitrogen cycling stations during the winter cruise

Station	Date	Latitude	Longitude
CPIES 4 CTD03b	26-07-2015	38°36.099 S	11°45.765 E
SOSCEX PS1 CTD09	28-07-2015	42°41.478 S	08°44.154 E
SOSCEX PS2 CTD15	29-07-2015	45°00.116 °S	56°33.765 E

TM1 CTD21	01-08-2015	50°.275 °S	02°E
DTM1 CTD25	03-08-2015	55°42.011 °S	00°00.157 E

Nitrogen uptake and regeneration

Water from various depths was sampled using the stainless steel CTD from six light depths. The selected depths were 55%, 30%, 10%, 1% of surface irradiance, 1 depth between the 1% light and the MLD, and one depth in 200 meters. Water was sampled at these depths, filtered to remove zooplankton and placed in 1.0 L and 2.0 L polycarbonate Nalgene bottles.

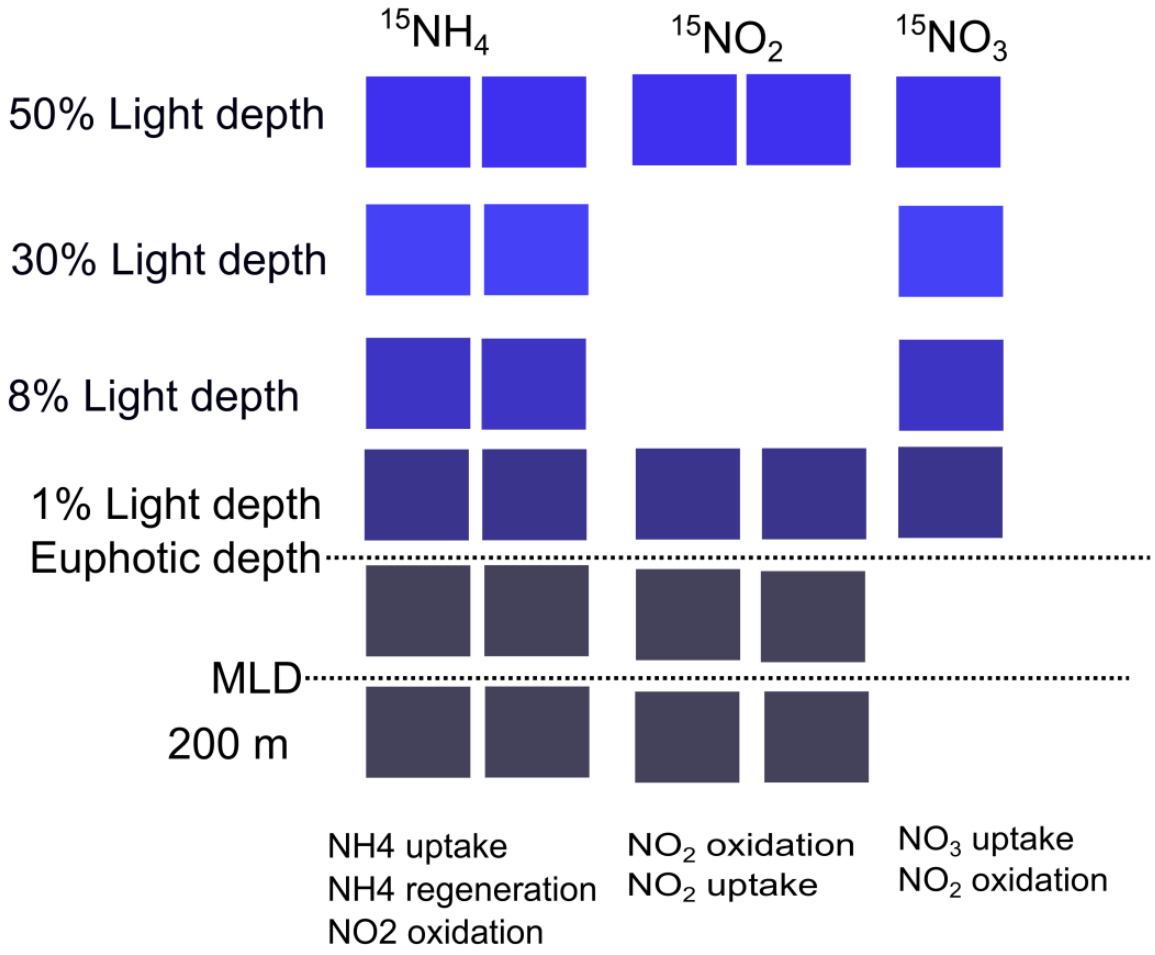


Figure 4.1. Sampling depths for primary production and nitrogen cycling experiments. Each square represents a replicate. The 15N tracer added is shown in the top row and the processes measured for each bottles is shown at the bottom.

Two 2L water sample from four light depths (55%, 30%, 10% and 1%) was spiked with ^{15}N (1 µmol $^{15}NO_3$ / 1 ml) to analyse the uptake of nitrate. Spikes were adjusted to achieve ^{15}N-NO3 ambient enrichments of ~10%. Two 2L (A and B) water sample from four light depths (55%, 30%, 10% and 1%) and two 1L (A and B) water samples one depth between the 1% and MLD and 200m depths was spiked with $^{15}NH4$ (0.05 µmol $^{15}NH_4Cl$ / 100 µl) to achieve 50 nmol/L as ammonium concentrations were often below the detection limit. These bottles were also spiked with $^{14}NO2$ (200 nmol/L above ambient concentration) as a carrier.

Two 1L water sample from four light depths (55%, 1%, MLD and 200m) was spiked with $^{15}NO_2$ () to achieve a concentration of 20 nmol/L. Prior incubation two 50ml inoculated water sample from each 2L and 1L NH_4 bottles was taken for both oxidation and regeneration, and stored in -20°C fridge to be analysed ashore. A 50ml inoculated water sample from 2L NO_3 bottles was taken before incubation and stored in -20°C fridge to be analysed ashore. A 50ml inoculated water sample from each 1L NO_2 was taken before incubation and stored in -20°C fridge to be analysed ashore.

The inoculated samples from each light depth were incubated in tubes covered in neutral density filters that simulated the various light depths. Incubators were cooled with a constant flow of water coming from the fire system. The samples were incubated for 24 hours, following which the samples were filtered through pre-combusted 25mm Whatmann GF/F filters and placed into a petri dish sealed with parafilm were stored in -20°C fridge to be analysed ashore. Before filtration after incubation 50ml was taken from all three (NH_4, NO_3 and NO_2) sealed with parafilm and stored in -20°C fridge to be analysed ashore.

Primary production profiles

In addition to the 15N tracer, 13C tracer (in the form of the sodium bicarbonate salt) was added to all the bottles in order to measure carbon uptake at the same time as nitrogen uptake.

Nutrient concentrations

- NO3, NO2, PO4, Si(OH)4 at each sampled depth were measured on board using the FIA .

NH4

For all five station ammonium concentrations were determined for each of the sampled depths. This was done using the fluorometric method for ammonium concentrations. Most ammonium concentrations were found to be below the detection limit (0.07umol/L) and as such will need to be re-run from back-up samples on land.

Experiment issues and suggestions

1. The water used for the incubators from the fire system was at times warmer than the in-situ temperature. Access underway water for the incubators on the heli-deck is essential.
2. Nitrate spike was too weak. It needs to be made at a higher concentration.

3. Nitrate uptake measurements were not repeated due to a lack of incubator space as well as time constraints. In the summer, replicate nitrate uptake measurements are recommended. This would require an additional incubator.

10. Phytoplankton Photophysiology

Persons Responsible: T.Ryan-Keogh, S. Thomalla, E. Bone

10.1 Underway Measurements

A Satlantic FIRe (Fast Induction Relaxation fluorometer) was connected to the ship's non-toxic underway water supply within the wet biology laboratory in order to assess and monitor the photophysiology of the Photosystem II within the surface phytoplankton population. The FIRe had the following parameters:

STF: 100
STRP: 60
STRI: 60
MTF: 600
MTRP: 60
MTRI: 100
Sample Delay: 1500 ms
No. of Samples: 10

Due to the low biomass the gain was set at 2400 for cruise.
Blank samples were collected from the GF/F filtrate of underway samples at 12:00 and 00:00 each day to perform blank correction. At the same time a discrete sample was collected in a dark bottle from the non-toxic water supply and a measurement was performed using the same settings as above. A total of 25 acquisitions were recorded for both blank and discrete samples.

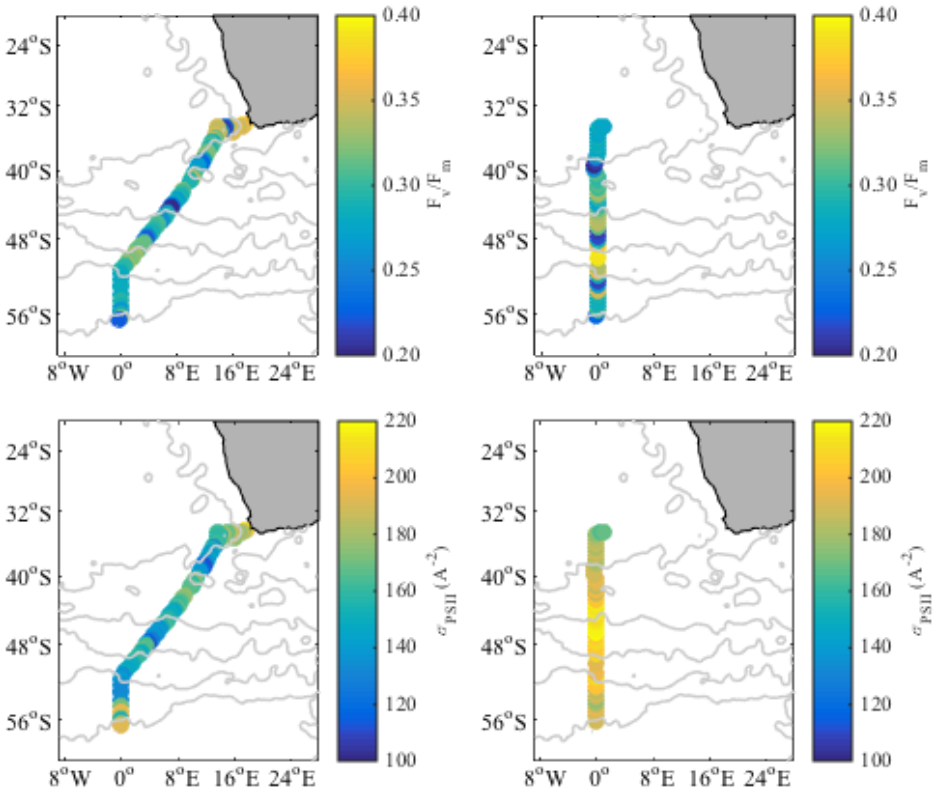


Figure 5.1 Underway F_v/F_m and Sigma ($Å^{-2}$) from continuous measurements of the non-toxic water supply using a Satlantic FIRe.

10.2 CTD Sampling

Water samples for fast repetition rate fluorometry were collected from the CTD rosette at 6 depths in the mixed layer in dark bottles before dark acclimation for 30-40 minutes. Measurements were performed using a Chelsea Technology FastOcean™ and FastAct system™. The following protocol was used:

Sat Flashlets: 100
Pitch (µs): 2
Rel Flashlets: 25
Pitch (µs): 84
Sequence interval (ms): 100
Sequence Reps: 32

The PMT was set at a constant value of 650V, with modifications made to the LED settings in order to achieve a measurement within a range of $R\sigma_{PSII}$ of ~0.04, as prescribed by the manufacturer. Initial measurements were made using all 3 LEDs in a variety of settings as described below. However, concerns were raised at the viability of measurements when trying optimise the settings to achieve a $R\sigma_{PSII}$ value of ~0.04 across all protocols. A single protocol was determined to be used from then on that only utilised the 450nm LED as this allows the data to be comparable with previous measurements performed using a Chelsea Technology FastTracka™ II system.

Protocol	450 nm LED	530 nm LED	624 nm LED
A	✓	×	×
B	✓	✓	×
C	✓	×	✓
D	✓	✓	✓

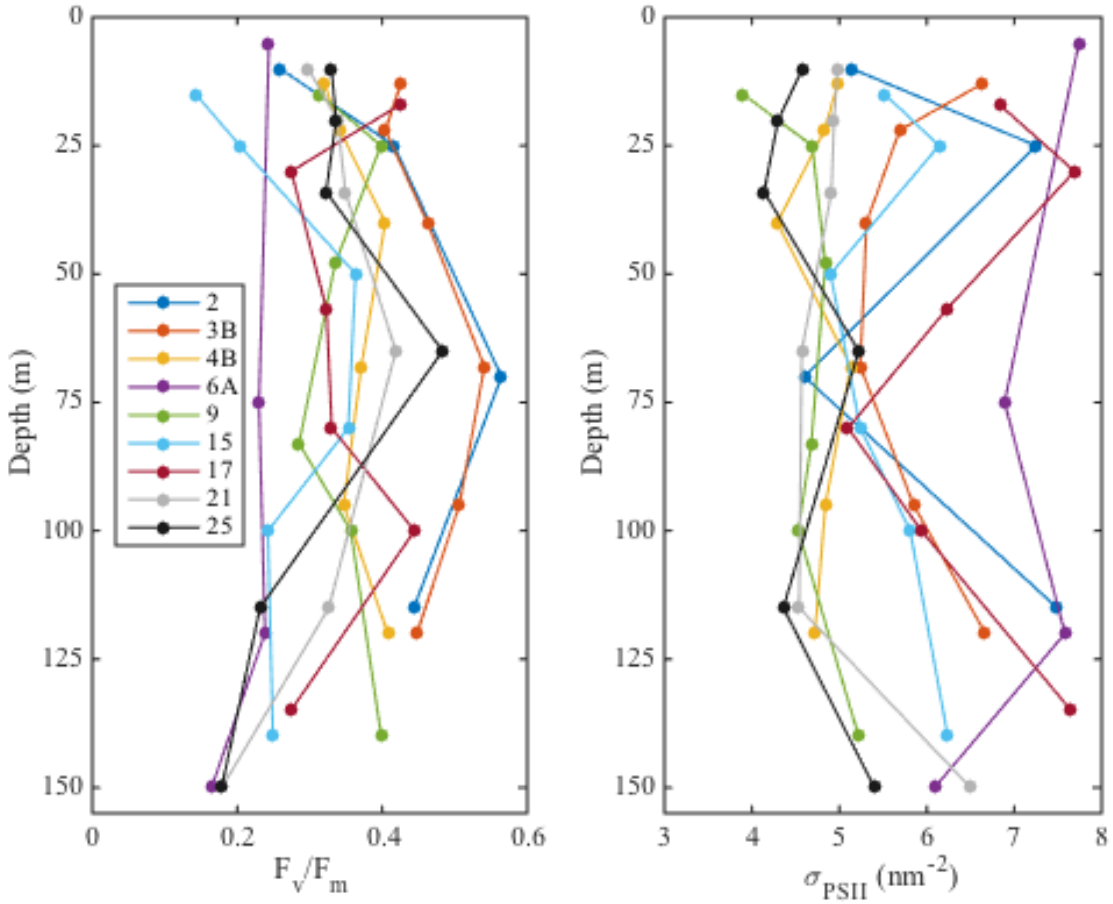


Figure 5.2 Bottle samples of F_v/F_m and σ_{PSII} (nm^{-2}) sampled from CTD rosette system.

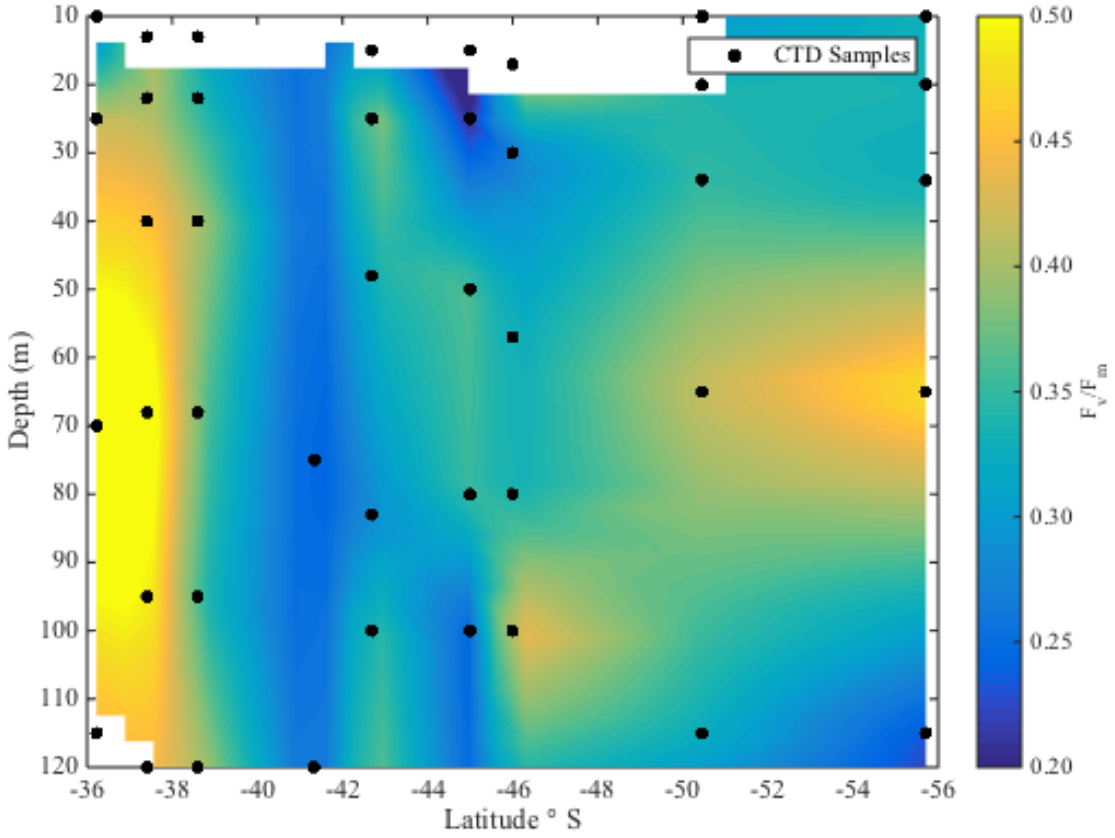


Figure 5.3 Latitudinal transect with depth of F_v/F_m from Cape Town to the ice edge.

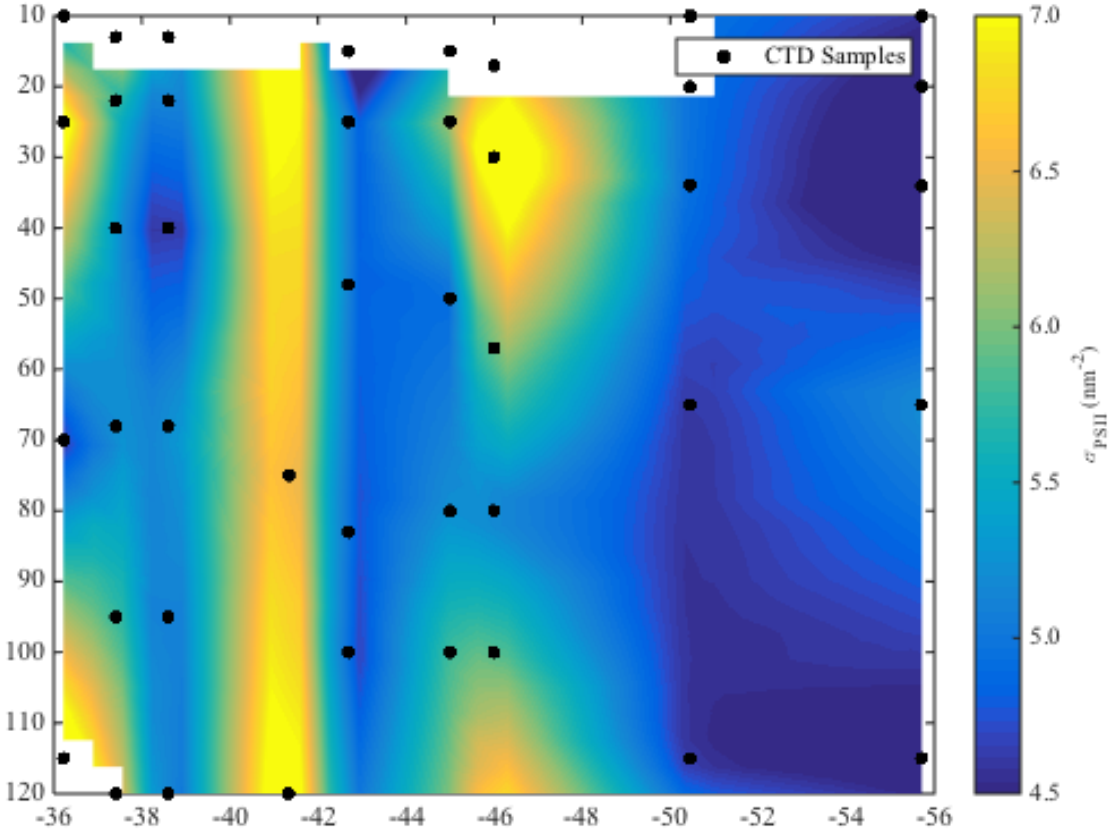


Figure 5.4 Latitudinal transect with depth of σ_{PSII} (nm^{-2}) from Cape Town to the ice edge.

10.3 Fluorescence Light Curves

Samples for fluorescence light curve measurements were collected every 4 hours while underway and from the surface bottle of CTDs. Measurements were performed using a Chelsea Technology FastOcean™ and FastAct system™. The following protocol was used in combination with Protocol A above:

PAR (μmol photons m^{-2} s^{-1})	No. of reps
0	12
10	24
30	12
51	12
72	12
92	12
113	12
134	12
154	12
175	12
216	12
335	12
446	12
650	12
839	12
900	12
1049	12
1260	12
1500	12
1865	12

Light Delay (s): 1
Light loop pitch (s): 10
Dark Delay (s): 1
Dark loop pitch (s): 10
Water jacket pump: On – level 1

As recommended by the manufacturer the number of replicate measurements at the first light step was doubled to allow the sample to acclimatize appropriately to ensure a successful a fluorescence light curve. The total time for the light curve was 42:31.

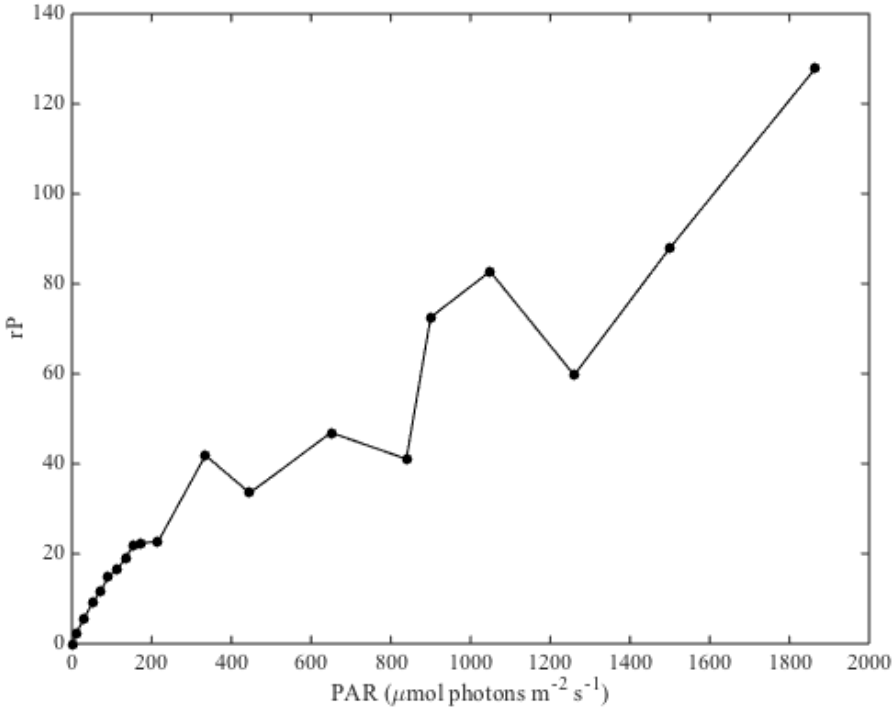


Figure 5.5 Example data collected from a fluorescence light curve.

Problems encountered

1. Due to the low biomass the noise to signal ratio is quite high – evident from blank signals representing between 10 – 50% of the signal
2. Maintaining the water jacket temperature to the in situ temperature of collected samples – milli-q froze in the tubes creating back pressure that almost broke the sample cuvette
3. Optimising protocols to obtain $R\sigma_{PSII}$ values of ~0.04 very time consuming and possibly detrimental to sample viability

11. Bio-optical sampling

Rationale

The Southern Ocean is a well-established carbon dioxide sink and plays an essential role in the global carbon cycle. The *in situ* examination of the influence of seasonal cycles and physical drivers on biological production is often spatially and temporally limited. Remote sensing has allowed for regional characterisation by providing routine, synoptic and cost-effective observations at a high frequency and over decadal time scales. Most often remotely sensed data are the only systematic observations available for chronically under-sampled marine environments (e.g. the polar oceans), and there is thus a need to maximise the value of these observations by developing ecosystem-appropriate, well-characterised products.

The capacity of the Southern Ocean to act as a long term carbon dioxide sink will only be revealed upon a better understanding of the impacts of various forcing mechanisms on phytoplankton physiology and community structure. By examining a large variety of *in situ* bio-optical and physiological parameters we hope to develop and validate appropriate regional ocean colour algorithms. Our bio-optics suite includes instruments to measure the inherent optical properties (IOPs- scattering, attenuation and absorption), as well as the fluorescence signal, used to illustrate the photosynthetic efficiency of phytoplankton populations. These data are complemented with a range of biogeochemical measurements, linking the optical properties to carbon content, size distribution and taxonomic composition of algal communities.

The above listed bio-optical, biogeochemical and photo-physiological data will be used to parameterise the particle field (dominated by the phytoplankton community) through empirical relationships between IOPs and size, pigment and carbon content. This information in conjunction with radiative transfer models and reflectance inversion algorithms will allow us to use satellite derived ocean colour data to investigate biological responses (through changes in biomass, community structure and physiology) to event, seasonal and inter-annual variability in ecosystem physical drivers at the required spatial and temporal scales.

11.1 AC-S

Underway sampling

The WETLabs Spectral Absorption and Attenuation Meter (ac-s) performs concurrent measurements of the water's absorption (a) and attenuation (c) characteristics through incorporation of a dual path optical configuration in a single instrument. The spectral range is between 400-730nm. The ac-s was set up to measure continuously flow-through chamber, receiving seawater from the ship's scientific seawater supply. The set-up ensured a continuous stream of seawater flowed into the bottom of the 'a' tube and out the top, leading into the bottom of the 'c' tube, before flowing out of the top of the 'c' tube and into the custom perspex container that housed the ac-s. The ac-s was constantly kept seawater temperature due to the continuous overflow. To start up the instrument, the 'valve', 'ac-s' and 'flow' python scripts were selected, to switch between filtered/unfiltered modes and to save the data respectively. The flow python script was only written half way through the research cruise and as such data for the flow rate is only available for the return leg of the cruise. The ac-s measures unfiltered seawater to determine the total absorbance and attenuation, and filtered seawater to measure the absorbance and attenuation of Gelbstoff and other small debris/ detritus. The difference between the two measurements provides the absorption and attenuation spectra of the particle field which in the Southern Ocean is dominated by the phytoplankton community.

CTD sampling

At all Niskin shallow biology CTD's (see Table 1) 3 x 25 Litre water samples (2 x Niskin bottles) were collected, one from the surface, one from the base of the mixed layer and one from the middle of the mixed layer for bio-optical analysis. The sample was pumped under positive pressure through the ac-s to measure total absorption and beam attenuation. Following which the sample was pumped through a series of filters on the

IOP flow board (using the python script to adjust the valves to filtered sampling) to measure dissolved absorption and beam attenuation using the compass software.

Calibration

At the beginning of the cruise an air calibration was carried out as per the instructions in the manual whereby the ac-s was dismantled, including all O-rings, and washed thoroughly in warm soapy water. The individual parts of the 'a' and 'c' tube were dried thoroughly in the drying cupboard for a few hours. Ethanol was used to clean the optical windows on the instrument, as well as the inner surfaces of the 'a' and 'c' tubes. The instrument was re-assembled, and an air calibration was performed. The cleaning and air calibration steps were performed four times.

λ = 500nm, internal temp = 26.4, external temp = 23.2

Air cal 1: a = 0.06, c= 0.75

Air cal 2: a = 0.045, c = 0.285

Air cal 3: a = 0.045, c = 0.34

Air cal 4: a = 0.05, c = 0.225

It is unclear why the c calibration values are so high and is of concern that needs to be addressed with the manufacturers.

Following the air calibration, a clean water calibration was performed whereby milli-q water was poured steadily and carefully into the a and c tubes using a tube and funnel. This step was repeated 5 times.

λ = 500nm, internal temp = 24, external temp = 23

Clean cal 3: a = 0.75, c= 3.75

Clean cal 4: a = 0.25 – 0,5, c = 3.25 -3.35

Clean cal 5: a = 0.1, c = 0. 4

Large drift observed in a and c that is assumed to be temperature related. Instrument was warm due to being run on the bench for a long time and milli-q water flowing through the tubes was cooler than ambient temperature thus affecting the readings with time as the instrument cooled with flow through.

Midway through the cruise after leaving the ice, a dirty water calibration was performed where milli-q water was passed through the ac-s and data recorded. Following dirty calibration the instrument was dismantled and cleaned with warm soapy water and ethanol soaked lens cleaners for optical windows and flow tubes. Important to note is the orange deposits were removed from both the lens windows of the instrument and the sides of both flow tubes which is very likely to negatively influence the data being collected. Following cleaning, the instrument was re assembled and milli-q run through the system several times in an attempt to get get a good clean calibration data file. At the end of the cruise a dirty calibration, clean calibration and air calibration were repeated as above.

11.2 MFL

Phytoplankton populations are easily identified by their signature accessory pigments. Chlorophyll-a is the primary light harvesting pigment, however additional accessory pigments serve to capture light at wavelengths that chlorophyll-a may not be able to effectively absorb. This umbrella effect is designed to optimise the light capturing potential of phytoplankton. These secondary pigments influence the excitation spectrum of phytoplankton in a species-specific manner, a property that has been

exploited by the JFE Advantech Multi-Excitation fluorometer (MFL), which serves to discriminate between phytoplankton species based on their accessory pigment composition. It is equipped with a high-sensitivity chlorophyll fluorescence detector and 9 excitation LEDs (375nm, 395nm, 420nm, 435nm, 470nm, 490nm, 535nm, 570nm and 590nm), measuring phytoplankton biomass and estimating species composition.

The MFL was run in continuous mode for the duration of Leg 3, sampling seawater from the ship's scientific underway supply. The optical windows of the MFL were cleaned on 04/08/2015. At all Niskin shallow biology CTD's (see Table 1) water was collected from the surface, the base of the mixed layer and the middle of the mixed layer and pumped under positive pressure to fill the MFL sampling chamber. The software was then initiated to record several minutes of data for each sample.

11.3 BB9

The WETLabs Scattering Meter (ECO BB9) contains three BB3 instruments, each providing a backscatter measurement for 3 different wavelengths (collectively 412nm, 440nm, 488nm, 510nm, 532nm, 595nm, 650nm, 676nm and 715nm), as well as one data multiplexer, which functions to power the BB3 instruments, to start each data sample, to read all data and to re-format and output the data from all BB3s in a synchronized manner. Scattering and back-scattering are very useful IOPs in terms of describing particle size and composition in ocean environments.

The BB9 was set up in a continuous flow-through chamber, receiving seawater from the scientific underway ship's supply. When the instrument is started, profiles are checked using ECOView120 software, however the data is saved through the python file 'bb9'. At each of the Niskin shallow biology CTD's three samples from within the mixed layer were analysed for their bio-optical characterization. The BB9 was drained and filled up from the bottom by pumping the sample into the BB9 using positive pressure. Once full the pump was switched off and the Ecoview software was used to record several minutes of data for each sample. On 06/08/2015 the BB9 was drained and cleaned with warm soapy water and ethanol soaked lens cleaners wiped the optical windows.

11.4 OSCAR

The TriOS OSCAR has been designed to measure the particulate light absorption in natural waters in the range of 360-750nm. The generally low concentration of particles (including phytoplankton, detritus etc.) in sea water makes it necessary for most commonly used techniques to concentrate the particles before their absorption can be measured. Once such well-established method is to concentrate particles on Whatman glass-fibre filters (GF/Fs) and measure the absorbance using a spectrophotometer (known as the quantitative filter technique, see section 3.2). The OSCAR is able to measure the original sample inside an integrating sphere, minimising scattering problems and sample handling whilst improving sensitivity.

The OSCAR was the last instrument to be turned on to measure dissolved absorption continuously. At some point more or less midway through the cruise the .dat data file got too big and we cold no longer save the data. An Email to the manufacturers for advice on how to rectify the probem resulted in them sending us many more empty .dat files and we resumed data collection after a few days of the instrument having to be

shut down. The OSCAR still needs to be calibrated by measuring the transmission by two solutions with known absorption coefficients; i.e. nigrosine and pure water as recommended by the manual. (Also temperature and salinity correction). Further, the instruction manual specifies an operational temperature of 5-40°C. As ocean temperatures plummet to as low as -1.8°C in the Antarctic zone this point should be considered if readings appear out of range.

12. Trace metal and Biogeochemistry

Cruise Participants: *Alice Mühlroth [4], Thomas Ryan-Keogh[2,3], Preson Cosslet-Kemeny, Ethan Campbell, Sandi Smart[1], Mhlanga Mdutyana[3],*
Cruise PI: *Raissa Philibert$_1$*, Dr Thato Mtshali$_2$, Dr Sandy Thomalla*

Land based Principal Investigators: *Dr Susanne Fietz[1], Prof Alakendra Roychoudhury[1],Dr Sarah Fawcett, Dr Pedro Monteiro[2]*

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12.1 Bioassay and dust experiments

Responsible persons: Raissa Philibert, *Alice Mühlroth* , Thomas Ryan-Keogh, Thato Mtshali

Introduction
This project focuses on better constraining iron and light as key agents on Southern Ocean biogeochemistry, the distribution of trace metals in soluble, dissolved and particulate form and macronutrient availability. The role of dust as a broadband natural fertiliser was tested with specific emphasis on consequent N and Si uptake. The

assessment of phytoplankton's impact on the Southern Ocean biogeochemistry will be further complemented investigating the genetic adaptation to iron starvation/enrichment and looking into cellular strategies for survival in Southern Ocean winter conditions.

Protocol

3 bioassay and dust experiments were conducted at Process station I (Bioassay 1), DTM 2 (Bioassay 2) and DTM 1 (Bioassay 3).

Table 7.1 shows the positions of each station.

Bioassay	Station	Latitude	Longitude
1	Process station I	42°41.478 S	08°44.154 E
2	DTM 2		
3	DTM 1	55°42.011 S	00°00.157 E

At each of these stations, all Go-Flo bottles were triggered at ~50 m. In the trace metal clean container, GoFlo bottles were mixed before sampling to ensure homogenous sample. The seawater was filtered through a 200 um pore size mesh to remove zooplankton and collected in trace-metal clean acid washed carboys to create a composite seawater sample. A second composite sample was taken in non-trace metal clean carboys to filter for the genetic analyses to be used to determine both the eukaryotes and prokaryotes communities.

36 2.4 L acid-washed polycarbonate bottles were filled to approx. 2/3 (i.e. approx. 1.8 L) from the composite carboy ensuring enough head space for gas exchange. 8 1-L acid washed bottles were filled to about 900 ml for the dust experiments.

Bioassay samples were adapted to 4 conditions; 2 light levels (low light, high light) for both iron enriched and no iron added. 9 bottles were incubated for each treatment in order to have sufficient volumes for the analyses. However, only 3 bottles were sampled throughout the course of the incubation. The other 6 bottles were only opened for the final termination. For the dust incubation experiments, three types of dusts were added to duplicate samples. The dusts, which are the same as the ones used during the SANAE54 cruise, were collected in Namibia. For bioassay 2 and 3, only one of the two duplicates was opened for sampling during the course of the incubation. The second was left untouched until the end.

Iron, light and temperature conditions

Iron enriched samples were spiked with Fe^{3+} under a laminar flow hood inside a clean class-100 container. Sample adaptations were prepared under the following conditions;

1) +Fe samples were prepared by adding acidic 1.0 nM Fe^{3+} (21.2 µL) from a 0.0895mM stock solution (Iron Atomic Spectroscopy Standard Conc. 02679-1EA; Sigma Aldrich) for Bioassay 1 and 2. For bioassay 3, 2.0 nM Fe^{3+} was added as Fv/Fm measurements from the two other bioassays did not show differences between treatments with and without iron and in most previous studies, 2.0 nM Fe^{3+} were added to the +Fe samples.
2) no Fe samples were left unchanged at in situ Fe levels,
3) Low light: 15 and High light: 65 $\mu E \cdot m^{-2} \cdot s^{-1}$ PAR. All the bottles from the dust incubations were exposed to the low light.
4) Temperature was set/adjusted to mimic the in situ temperature of the sampling depth.

Incubator set-up

Three incubators (Minus40 Specialised Refrigeration) were placed in the scientific storage area for conducting of the bioassay experiments. The incubators are equipped with adjustable LED strips light at the top of each shelf to provide adjustable PAR levels, and a cooling fan for temperature control. Temperature was set using temperature control unit on incubator. PAR was measured/set using a hand-held PAR sensor with a spherical receiver (4π) (Biosphere QSL 2100; Biospherical Instruments Inc). The bottles were rotated and shaken approximately every 4-6 hours to ensure all sample were expose to similar light conditions, cells are suspended and incubations are not macro-nutrient and/or gas limited due to poor diffusion to the cells.

Terminations

Bioassay

At the start point (T_0), the following variables were measured: DFe and macronutrients concentrations, Size fractionated chlorophyll, HPLC and POC. The FRRF was used to measure Fv/Fm, SigmaPSII and to create a fluorescence-light curve (FLC). Samples were taken to determine the initial prokaryotic and eukaryotic communities.

Initially, it was planned to take samples for the FRRF measurements every day and to have a single termination at Tf. However, as stations were very close to each other, this was very difficult. Furthermore, the Fv/Fm data was relatively noisy (potentially due to low biomass). Due to concerns about potential contamination of the samples from opening the incubation bottles every day, the sampling strategy was altered. FLC were planned on alternate days for the low-light and high-light treatments. This also proved too time consuming after bioassay 1. For the other two bioassay, FLC was done at T_o and at T_f.

All bioassays were terminated after 7 days. On day 6, Fv/Fm and total chlorophyll were measured. The particle size distribution was also measured using a coulter counter. At T_f, Fv/Fm (50 ml) and size fractionated chl (400 ml) was measured from the bottles which had been opened during the incubation. Fv/Fm, Total Chl (400 ml), POC (900 ml), HPLC (1000 ml), nutrients (50 ml) and prokaryotes (1 L) samples were taken from the

bottles which were kept untouched throughout. At T_f, the particle size distribution was measured from one sample for each treatment.

Table 7.2: Variables measured on each day for the three bioassays. The variables in blue were measured on the bottle which was opened during the incubation.

Bioassay	Day 1	Day 2	Day 3	Day 4	Day 5	Day 6	Day 7
BA 1 (PS I)	Fv/Fm	Fv/Fm	Fv/Fm	Fv/Fm			
BA 2 (DTM 2)	Fv/Fm	Fv/Fm	Fv/Fm			Fv/Fm	Fv/Fm Size fractionated chl Total Chl POC HPLC Nutrients Prokaryotes Particle size
BA 3 (DTM 1)	Fv/Fm Total Chl					Total [Chl-a] Particle size	

Dust experiments

For the dust incubations, there was only one termination at T_f. The T_o Fv/Fm and SigmaPSII were measured at the same frequency as for the respective bioassay. At T_f, the FRRF data was measured alongside chlorophyll and nutrients concentrations.

Protocols for subsampling from bioassays and dust incubations

For subsampling, the 2 L polycarbonate bottles were taken out of the incubators and carried in black plastic bags to the class-100 container. The bottles were kept constantly in darkness and the time outside the incubators was tried to be minimized to avoid biological reaction to the subsampling procedure (alteration of growth and the light-harvesting systems).

FRRF: A 50 ml subsample was collected at different time points over duration of the experiments (see table 1., T_0, T_1, T_2..T_f). The subsample was collected quickly in dark, 50 ml falcon tube under low light conditions (shut down all possible light sources in the container). Before measurements the samples were kept in darkness at in situ temperature of the sampling depth.

The samples were dark adapted for 30-40 minutes. Measurements were performed using a Chelsea Technology FastOcean™ and FastAct system™. The following protocol was used:

Sat Flashlets: 100
Pitch (µs): 2
Rel Flashlets: 25
Pitch (µs): 84
Sequence interval (ms): 100
Sequence Reps: 32

The PMT was set at a constant value of 650V, with modifications made to the LED settings in order to achieve a measurement within a range of $R\sigma_{PSII}$ of ~0.04, as prescribed by the manufacturer. Initial measurements were made using all 3 LEDs in a variety of settings as described below. However, concerns were raised at the viability of measurements when trying optimise the settings to achieve a $R\sigma_{PSII}$ value of ~0.04 across all protocols. A single protocol was determined to be used from then on that only utilised the 450nm LED as this allows the data to be comparable with previous measurements performed using a Chelsea Technology FastTracka™ II system.

Protocol	450 nm LED	530 nm LED	624 nm LED
A	✓	×	×
B	✓	✓	×
C	✓	×	✓
D	✓	✓	✓

Dissolved Iron (DFe) uptake: A 125 ml subsample was collected for T_0 seawater as well as from each T_f bottle into acid washed LDPE bottles under a laminar flow hood. Each 125 ml subsample was acidified to pH 1.7 (250 µl ultrapure HCl), double zip-lock bagged, filtered through 0.2 µm pore size Anatop sterile syringe filters, and stored in class-100 container for further analysis using Flow Injection Analyser (FIA) back in the trace metal laboratory at SUN/CSIR.

For the dust experiments, the samples had to be filtered before being acidified in order to remove the dust particles. The samples were filtered through 0.2 µm pore size sterile syringe (acid washed) filters. The syringes used were individually wrapped but were nevertheless rinsed with 0.5 M Suprapure acid and Milli-Q prior to filtering.

Chlorophyll a: Size-fractionated Chlorophyll a samples were collected by filtering 400 ml of seawater sample through 47 mm Nucleopore PC filters, pore size 5, 2 and 0.2 µm. Each sample will filtered 3 times consecutively starting with largest pore size to smallest. **Total chlorophyll** samples were filtered onto 25 mm GFF filters. Filters containing particulate sample were placed in 8 ml 90% acetone and chlorophyll was extracted at -20°C for 24 h. Samples are shaken gently before extract being poured into a glass cuvette and measured on a Turner bench-top fluorometer. 90% acetone. Blanks are measured for each analysis.

Dissolved N, P & Si uptake: Nutrients samples were taken from the filtrate resulting from the size-fractionated chlorophyll measurements. The receiving flask was rinsed 3 times with Milli-Q in between samples. After filtering through the 0.2 µm pore size, 50 ml of the filtrate was collected in a falcon tube. Nutrients for the dust samples were filtered using a 0.2 µm syringe filter.

HPLC: HPLC samples were collected by filtering 1000 ml of seawater sample through non-ashed 47 mm Ø Whatman GFF filters, nominal pore size 0.7 µm. It is essential do

filter under dim light. Pigment conversion is a very fast process in phytoplankton cells. The filter papers were folded (if necessary) and placed in Eppendorf 1.5 ml or 2 ml cryovials which are then stored in a -80°C freezer until time of further analysis on land at SUN.

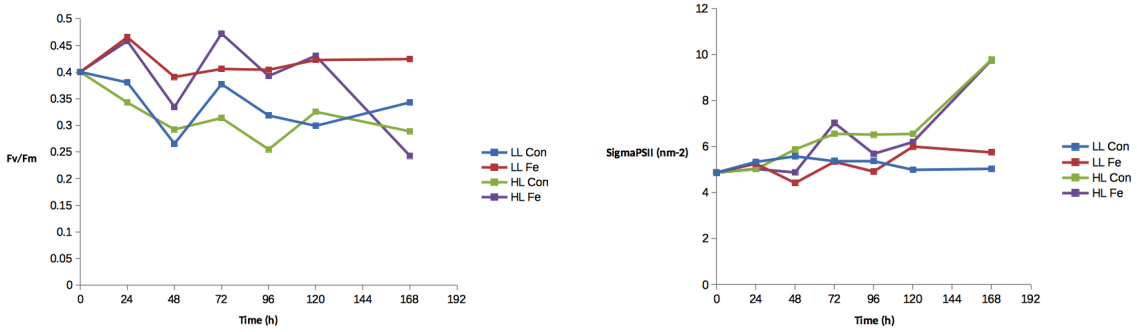
Filtering for POC: Ashed 25 mm Whatman GF/F filters, pore size 0.7 µm (ashed for 24 hours in a furnace at 450°C) was used for the filtering for POC analysis. Filter paper were stored in clean petri dishes and stored frozen before further analysis on land.

Genetics phytoplankton and microbes (prokaryotes): For the determination of eukaryotic metagenomics at T_0, 18-25 L of seawater was filtered using the peristaltic pump (speed 45). The seawater was filtered through three concomitant 47 mm Nucleopore PC filters with the pore size 5, 2 and 0.2 µm to size-fractionated the sample. Filters were stored in a 5 ml blue screw cap vial at -80°C. The filters must not be folded and were kept attached to the vial wall so that cells point inwards to the vial. For prokaryotic metagenomics samples were taken at T_0 and T_f the peristaltic pump was set up with two concomitant filters a 5 µm 47 mm Nucleopore PC filters and a Pall membrane filters (Supor® polyethersulfone membrane, diam. 47 mm, pore size 0.2 µm). 10 L for T_0 and 1 L for T_f of samples were filtered (pump speed 35) over a duration of 4 h. Filters were placed in a 2-5 ml screw cap vial and flash freezed in liquid nitrogen and stored immediately at -80°C.

At CTD stations of the Samba line, test samples were taken from various depth for finding an optimized strategy of isolation the DNA for the eukaryotic metagenomics.

Preliminary results

Preliminary results for the bioassay and dust experiments are as follows:



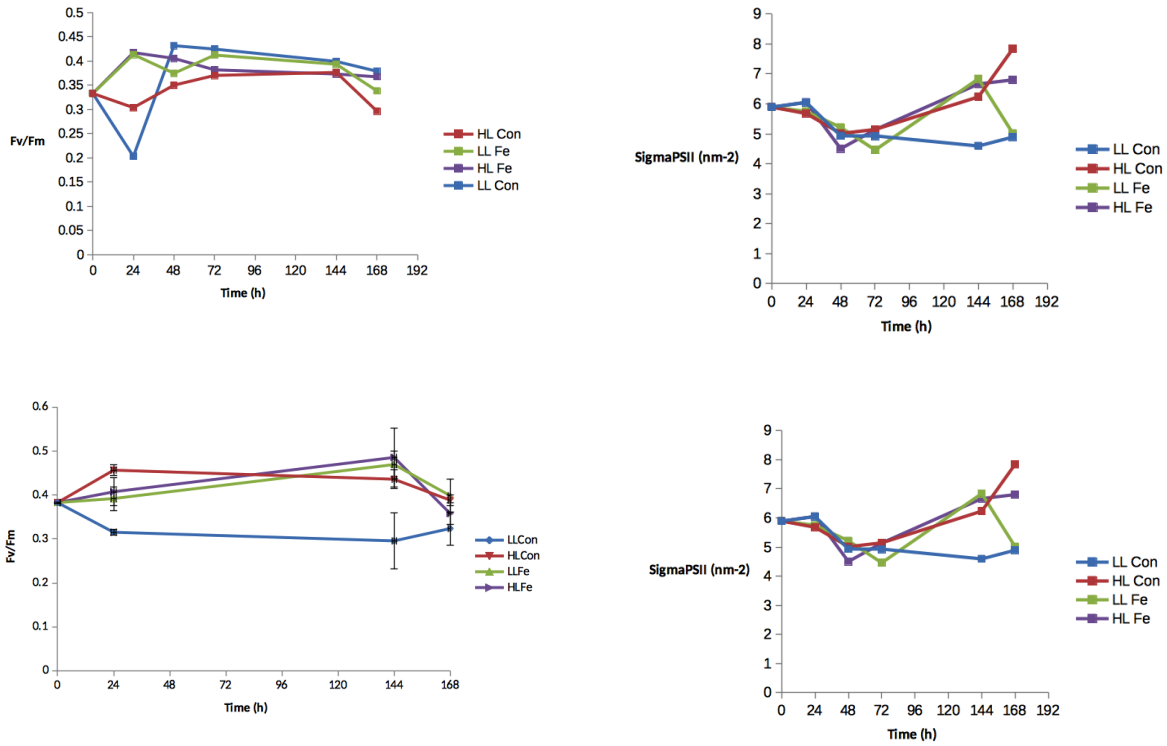
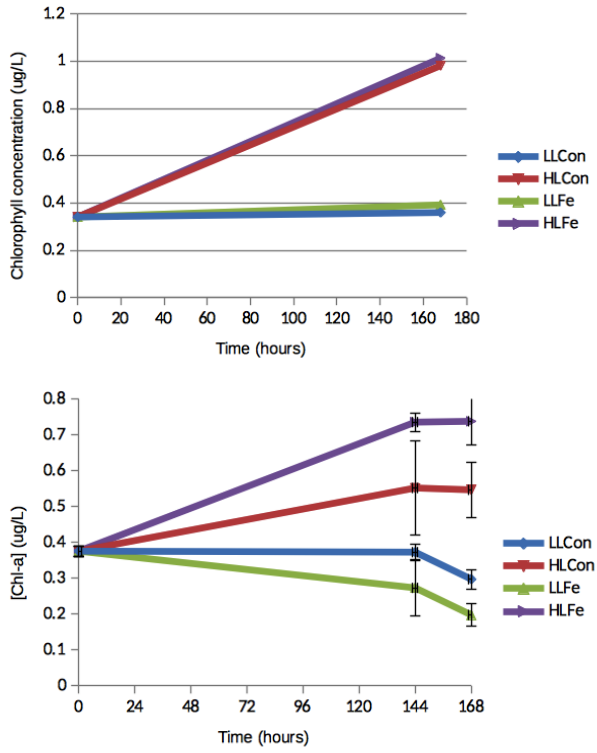


Figure 7.1: Changes in Fv/Fm for bioassay 1(DTM 1), Bioassay 2 (DTM 2) and Bioassay 3, (3 figures on right hand panel respectively). Changes in SigmaPSII for Bioassay 1, Bioassay 2 and Bioassay 3 (3 figures on left hand panel respectively).



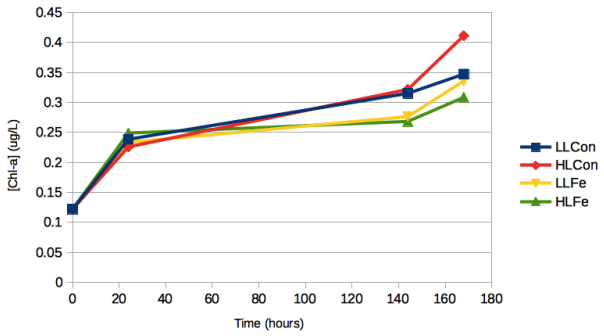


Figure 7.2: Changes in total chlorophyll concentration for bioassay 1, bioassay 2 and bioassay 3 respectively

Dust experiments

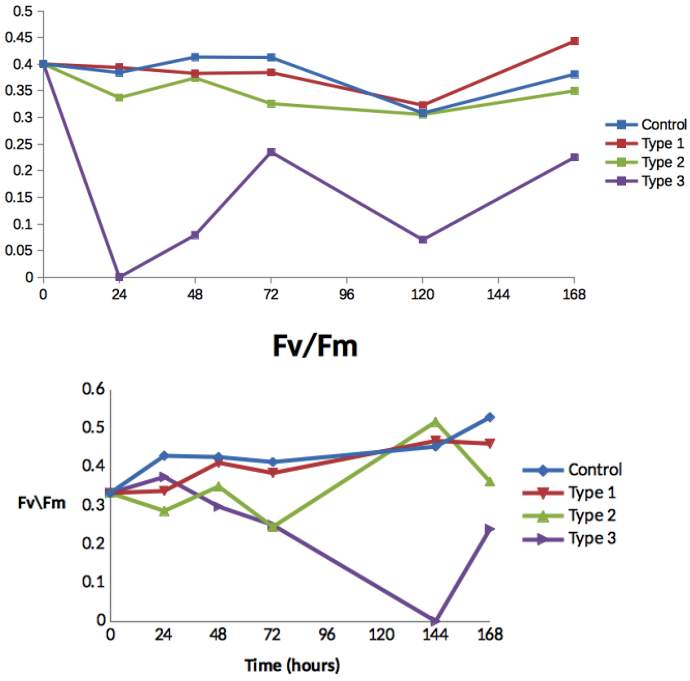


Figure 7.3 Changes in Fv/Fm for Dust experiment 1 (Bioassay 1) and for Dust experiment 2

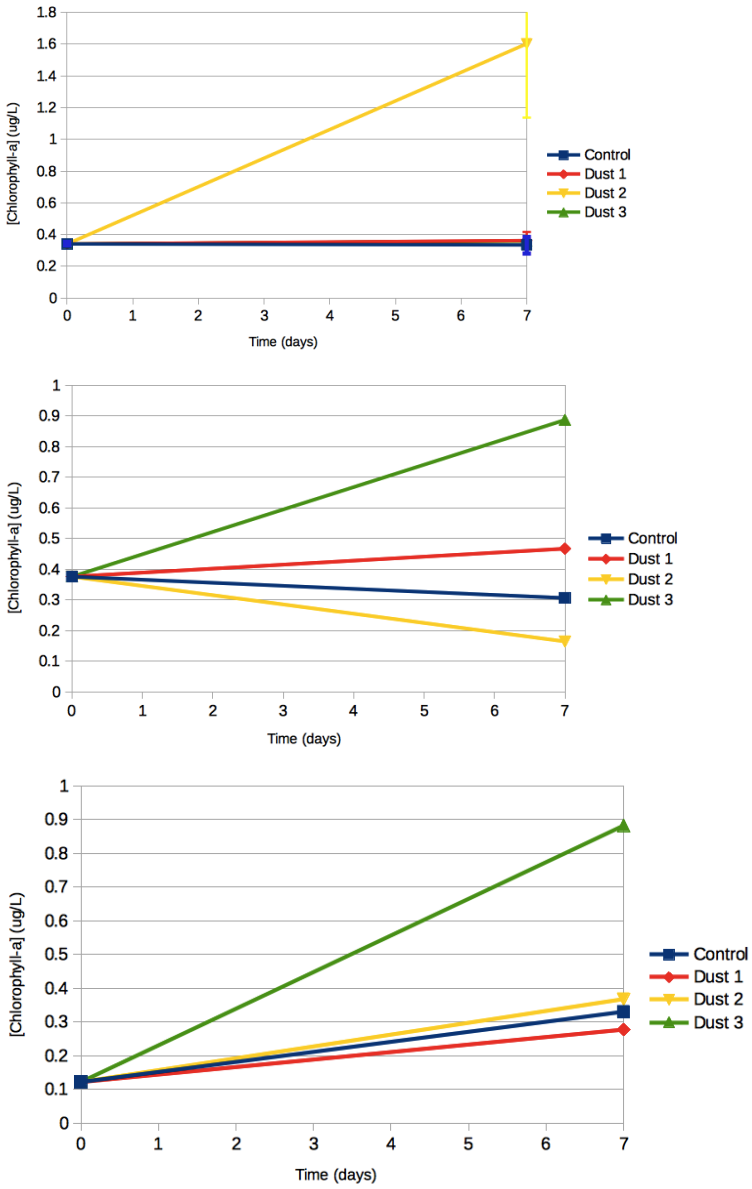


Figure 7.4: Changes in total Chl for dust experiment 1, dust experiment 2 and dust experiment 3

Issues and suggestions

Given that stations were extremely close together, it was not possible to sample every day for Fv/Fm. This was especially difficult with parallel experiments running.

Fv/Fm measurements were noisy and at first glance, do not appear to be giving good result. This could be due to the low biomass and the possible sampling time point. Based on the Fv/Fm curve of a phytoplankton cell-cycle stable Fv/Fm values can be obtained in pre-dawn state or in late light adaptation. A consistent time must be chosen. For bioassay 1 and 2, post-dawn samples were taken in an attempt to capture the peak Fv/Fm, which occurs shortly after exposure to light. This is difficult to achieve as it is easy to miss that peak. It is therefore better to take a sample at a time where Fv/Fm readings are stable I.e either noon or pre-dawn. For bioassay 3, pre-dawn samples were

taken because the incubation was set-up pre-dawn. Consequently, the To samples were taken pre-dawn.

Given that there were three experiments running in parallel, all three incubators had to be used. As a result, there was too many bottles each incubator shelves. This was more problematic on the low light shelves as these included both the bioassay and dust experiment.

It was difficult to ensure that the bottles were shaken at regular intervals. While the night-shift team did help, there was some confusion when the team changed. Furthermore, shaking the bottles manually leads exposure to increased light and high temperatures from the scientific store where the incubators are set up. An automated shaking system would be ideal.

Similarly, turning the lights on and off on the incubators should be automated. While it is not a difficult task, an automated system would ensure better reliability. According to the engineers from Sea Technologies, it is possible to retrofit such a system to our current incubators.

A set of incubation bottles is required for each planned experiment. The termination for bioassay 1 took about 9 hours as all the samples were taken in the clean container in an attempt to keep the bottles as contamination-free as possible. This was done because a potential fourth bioassay was planned. The latter was cancelled because there would have been limited time to clean the bottles between terminating the first bioassay and starting the fourth.

Bioassay and dust incubations nutrients samples were not analysed on board as there was not enough reagents to do so. In future, if nutrient analyses facilities are available on board, bioassay nutrients need to be included in the planned analyses.

One of the key questions from this bioassay was to determine how the gene expressions change when iron and light stress are relieved. However, such analyses require large volumes of water. To see the effect of light and iron on the adaptation of phytoplankton, larger incubation volumes (>10L) are required. It is worth creating a new incubation set-up (for example, an incubation container) where such volumes can be incubated.

A filtration rig that can hold three 1-L vacuum flask would be useful for the size-fractionated chlorophyll. The flasks are very unstable on the rocking ship and a rig could make it easier to use. Such a rig should allow for easy removal of the flasks for cleaning in between samples.

12.2 High resolution surface and deep dFe profiles

Responsible person Dr. Thato N Mtshali

Introduction and Scientific Objectives

The Southern Ocean plays a vital role in Earth's climate through control of atmospheric carbon dioxide concentrations. One important component of this system is the Fe cycle. Iron is a key micronutrient for marine plankton productivity, the scarcity of which limits essential biogeochemical processes and thus ocean fertility. Previous studies have shown that the trace element Fe can be supplied to the ocean *via* internal and external sources (Boyd et al., 2010). Recently, a link has been made between the seasonal Iron supply driven by convective winter mixing (or entrainment) and the phasing and magnitude of the spring bloom in the austral polar and sub-polar region (Tagliabue et al., 2014). However, notwithstanding the key role of winter mixing, recent high resolution glider datasets revealed that storm driven entrainment during summer may play a critical role in extending the duration of seasonal primary production through their impact on Iron supply to the surface mixed layer (Joubert et al., 2014; Swart et al., 2014). Collectively these studies indicated that there are important gaps in our understanding of the role of fine scale dynamics, which may advance the understanding of climate sensitivity not yet fully reflected in climate models. This project undertook an integrated oceanographic 'process study' to understand the fine scale and seasonal cycle of Fe in winter as part of the SOSCEx III winter cruise.

Our innovative measurement and analysis strategy will identify processes and quantify sources that control the distributions of dFe in winter. This project will provide maximum scientific reward for evaluating future climate change, and has strong international collaborative activity (inter-calibration station at 54.0°S; 0.00°) under the auspices of the international GEOTRACES (www.geotraces.org) program through affiliation/participation *via* Stellenbosch University.

Specific aims of the project are:

1. Conduct high-depth and time resolution shallow dFe profiles (2000m) in the Sub-Antarctic Zone (SAZ) and Sub-Antarctic Front (SAF)) as part of the SOSCEx III cruise, in order to characterize the winter 'ferricline' and to understand how this dFe reservoir is used to relief Fe limitation for the onset of the spring bloom.
2. For the first time, to conduct high-depth resolution deep dFe profiles along the BGH line at similar station positions to SANAE 54 summer cruise as part of the SAFe-pool project to compare winter vs. summer distribution of dFe through the water column.
3. Conduct on-board Fe/light Bioassay incubation experiments in order to understand the biological response to physical drivers (mixed layer) which alters the nutrient Fe and light supply to phytoplankton community.

Voyage objectives

This voyage undertook a 'process' and 'transect' studies along the BGHL. Three types of stations were used to achieve our aims: (i) high-depth and time resolution surface dFe profiles (up to 2000m) were conducted at each SOSCEx III process stations (42.7°S; 6.0°E and 45.0°S; ……°E, (ii) high-depth resolution Deep Trace Metal station (DTM) to sea floor and Shallow Trace Metal station (TM) up to 2000m (every 5°) as part of the South Atlantic Fe-pool (SAFe-pool) in collaboration with Stellenbosch University (SUN). The type of sampling and order of deployment at two process station, DTM and TM

stations are outlined below and in the SANAP 3 voyage plan.

Voyage activities:
The following activities were conducted on-board the RV SA Agulhas II to meet our scientific objectives:

1. 3 x GCTD profile down to 2000 m at process stations (2 casts at PSI and 1 cast at PSII) and full water column high-depth and time resolution to collect samples for trace metal Fe-pool (dissolved Fe (dFe), total dissolvable Fe (TdFe) and soluble Fe (SFe)). In addition, water was sampled for macronutrients analysis (Nitrate, Phosphate and Silicate).
2. 1 x TM station down to 2000m along the BGH transect with high-depth resolution to collect samples for dFe, TdFe and macronutrients.
3. 3 x DTM stations down to the sea floor (>2000m) to collect samples for Fe-pool and macronutrients.

125ml LDPE Nalgene bottles were used to collect Fe-pool samples in triplicates, while macronutrients were collected using 50ml sterilized vails. All the samples were collected using a GEOTRACES CTD rosette and all 24 GoFlo bottles were used for sampling. Samples were manipulated (acidified to pH 1.8) under laminar flow inside a clean trace metal van/container laboratory et-up on board.

The procedure associated with the deployment of trace metal clean GEOTRACES rosette is outlined in Appendix 1. All the procedures to avoid/minimise contamination were discussed with the participants/scientists at sea prior to deployment and this was required for the success of this project. Most shipboard crew had experience in deploying the rosette and has been successfully undertaken during the SANAE 53 and 54 cruises.

Results
Deployment of GEOTRACES CTD rosette and sampling for Fe-pool at all stations was successful. A total of 1280 Fe-pool samples were collected and acidified to pH 1.8 using 30% Ultrapur HCl acid. Unfortunately, we were unable to analyse dFe samples on board to check the integrity of our sampling procedure/protocol, due to the Flow Injection Analyser not working properly. A good calibration curve could not be measured due to high base-line from the reagents. However, these samples were preserved at room temperature and will be analysed at home (SUN trace metal laboratory) after the cruise, while samples for TdFe will be analysed after 6 months. Macronutrients were analysed on board following a La-Chart method of analysis using a Flow Injection Autoanalyser. One dFe cast at the PSII could not be conducted due to bad weather that created high swells. A decision was taken not to deploy the GCTD after assessing the swells height with the Chief Scientist and the Captain.

Problems
1. Broken GoFo bottles (handle and sampling spigot valve
2. Running short of GoFlo bottles sleeves
3. Rosette frame cracks

4. FIA not working
5. Laminar flow hood to sucking fumes strong enough
6. MilliQ-water foot switch

Recommendations

1. New and hearvier rosette frame
2. Buying more plastic rolls for GoFlo bottles
3. Buying a two trolleys that can be used to carry bottles to and from the container
4. Build a new and simplified FIA system
5. Bought a spare foot switch
6. Fix the fume hood (Labscheme)

Protocol for deploying and retrieving GEOTRACES CTD rosette

1. *Preparation of the GoFlo bottles*

The GoFlo bottles are prepare inside the trace metal clean van by covering the top and bottom with shower caps. The sampling spigot is covered with a zip-lock bag and the whole bottle is covered with a PVC lining.

2. *Transportation of GoFlo bottles to the rosette frame*

Bottles are transported one by one. One person inside the clean room to unhook the bottles from its rag and passes the bottle to the other person in the change room. The door lady opens the outside door and the bottle is passed to the carriers. The carriers transport the bottles to the Rosette that is situated on the poop-deck. The PVC lining is removed first before attaching the bottles onto the rosette frame.

3. *GoFlo bottles preparation prior to deployment*

Once all the bottles are attached to the rosette (with the shower caps and zip-lock bags on), they are cocked by turning the top and bottom side balls and the lanyards is attached to the CTD trigger. A thin Kevlar rope is used to tie the bottles around as a safety model.

4. *Deployment for the rosette*

Just prior to rosette deployment, the shower caps and zip-lock bags are removed. The rosette is first controlled by boson to the surface (10 to 20m) in order to activate the CTD sensors. After that, the CTD controller (siting in the ops room) takes over to drive the rosette to a specified depth. The rosette is driven very slow (0.6 – 0.8m/s) during the downward cast until 50m below the required bottom depth. The bottles are closed as the rosette move upward at a speed of 1.0m/s.

5. *Retrieval of the rosette*

Once the rosette is on-board, the sampling spigot is covered with a ziplock bag (to avoid contamination from the particles falling from the ship's roof). This is the crucial part for sampling. Then, the top and bottom balls of the bottles are covered with shower caps. In a reverse way, bottles are transported from the rosette (covered with PVC lining) into the clean van.

6. *Container re-equilibration for air circulation*

After loading the bottles in the container, it is very important to allow air circulation to equilibrate for 30min.

7. *Pre-sampling procedure*

Bottom shower caps are removed and the bottles are rinsed with Mill-Q water to remove particles and seawater salts. The nitrogen gas is used to pressurize (200 –

400bars) the GoFlo to increase the flow rate. A 0.2um pore size Acropak filter was used to collect samples for dFe. About 1L seawater was flushed through the filter before collecting the sample.

12.3 Biomarkers

Alice Mühlroth and Raissa Philibert

Introduction

We are probing the spatial distribution of a novel geolipid (hydroxyl-GDGTs) used for the paleo-reconstruction of sea surface temperature (SST) and ice conditions through glacial-interglacial cycles, which is thought to be linked to primary productivity and the N-cycle. We are studying the index-SST relationship and constrain the main ocean depth reflected by the index. The proxy data are furthermore linked to the microbial community composition and producer (Thaumarchaeota) abundance and functional genes (e.g., ammonia oxidising genes (amoA)). Primary production and nitrogen regeneration rates will also be used to establish the activity of the microbial community involved in the nitrogen cycle and the production of biomarker lipids.

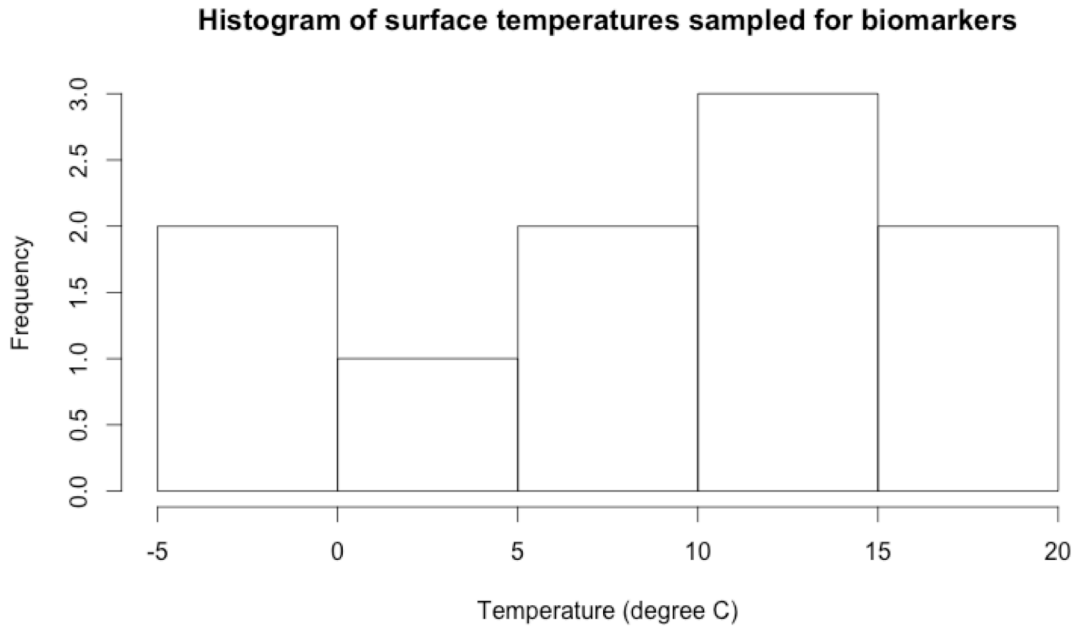
Methods

Biomarkers were sampled both from the underway system as well as several CTD stations. The sampling locations are shown in table 2 while the range of surface temperature sampled is shown in figure 16. Underway samples were taken once a day or either prior or just after each CTD station (depending on logistical constraints).
At each underway station, surface water from the underway system was filtered onto ashed 47mm GFF filters. The sample collection was ended when either the filter was clogged or a temperature change of 1ºC was observed. Biomarker underway samples coincided with underway stations where chlorophyll and nutrients were measured. At each station, samples for HPLC (2-L) and POC (1-L) were also taken. The HPLC samples were filtered onto 47 mm GFF. The samples were kept in a dark amber bottle and the filtering tower covered with a black bag in order to minimize the samples exposure to light. POC samples were filtered on ashed 25 mm filters and frozen. They will be freeze-dried back at Stellenbosch University to avoid loss of organic matter. Finally between 2 and 5 L were filtered to determine the microbial community structure. At CTD 6 and 18 and underway station 52, bucket surface samples were taken due to a contamination issue in the underway system.

Table 3: Biomarker stations with associated depths and temperatures.

Ship station	Sample number	Depth	date	time (GMT)	latitude	longitude	temp (°C)
U8	1A	5	23/07/2015	14:11	34°29.683	17°18.426	15.01
U8	1B	5	23/07/2015	14:11	34°29.683	17°18.426	15.01
U19	2A	5	24/07/2015	10:14	34°43.087	14°47.6806	14.8
U19	2B	5	24/07/2015	10:14	34°43.087	14°47.6806	14.8
U27	3A	5	25/07/2015	12:00	37°58.5035	12°09.720	13.07
U27	3B	5	25/07/2015	12:00	37°58.5035	12°09.720	13.07
CTD3B	4	4500	25/07/2015	20:24	37°24.478	12°31.099	

CTD3B	5	1300	25/07/2015	20:24	37°24.478	12°31.099	
CTD3B	6	200	25/07/2015	20:24	37°24.478	12°31.099	
CTD6A	7	surface bucket	27/07/2015	09:55	41°20.696	09°53.239	
CTD6A	8	1500	27/07/2015	13:40	41°20.696	09°53.239	
CTD6A	9	4250	27/07/2015	13:40	41°20.696	09°53.239	
U52/U53	10	surface bucket	29/07/2015	18:27	45°00.116	06°33.765	6.42
CTD18	11	surface CTD18	30/07/2015	11:00	45°59.933	05°35.514	5.69
CTD20	12	200	2015/01/08	11:15	50°26.971	01°03.379	2.1
CTD20	13	650	2015/01/08	11:15	50°26.971	01°03.379	2.4
CTD20	14	3170	2015/01/08	11:15	50°26.971	01°03.379	0.6
U83	15A	5	2015/02/08	14:00	54°32.457	00°00.062	-0.86
U83	15B	5	2015/02/08	14:00	54°32.457	00°00.062	-0.86
CTD28	16	2000	2015/04/08	06:00	54°00.019	00°00.058	
CTD28	17	290	2015/04/08	06:00	54°00.019	00°00.058	
CTD28	18	200	2015/04/08	06:00	54°00.019	00°00.058	
U91	19A	5	2015/04/08	07:52	53°42.454	00°00.198	-0.41
U91	19B	5	2015/04/08	07:52	53°42.454	00°00.198	-0.41
U107	20A	5	2015/05/08	16:12	47°23.850	00°00.009	4.83
U107	20B	5	2015/05/08	16:12	47°23.850	00°00.009	4.83
U127	21A	5	2015/06/08	16:03	42°47.035	00°00.222	9.06
U127	21B	5	2015/06/08	16:03	42°47.035	00°00.222	9.06
U131	22A	5	2015/07/08	16:12	39°06.978	00°22.788	11.55
U131	22B	5	2015/07/08	16:12	39°06.978	00°22.788	11.55
U141	23A	5	2015/08/08	12:11	34°48.1795	00°00.171	16.75
U141	23B	5	2015/08/08	12:11	34°48.1795	00°00.171	16.75
CTD30	24	200	2015/08/08	18:15			12
	25	1500	2015/08/08	18:15			2
	26	4100	2015/08/08	18:15			1



At each CTD station, three depths were sampled (200 m, oxygen minimum and 500 m from the bottom depth) for biomarkers, microbial community and POC. For each depth, 50-L were collected from the Niskin bottles into acid-washed carboys. One carboy was brought in the lab for filtering with the peristaltic pump (connection hose were washed with ethanol and MQ-water, speed 85) and the other kept cold either in the 4ºC fridge or outside (if the outside air temperature was closer to the water temperature). After 1.6 hours, the second carboy was replaced. Filtering was stopped after 4 hours.

At CTD stations CPIES 3 (CTD 3 on the GoodHope line), Process station II (CTD 6) and TM 1, nitrogen cycle measurements were taken on a separate CTD cast. It was, unfortunately, not possible to combine all 5 nitrogen cycling experiments with biomarker sampling due to time constraints.

Problems and suggestions

After a few days on the cruise, the filtered samples from the underway system started looking suspiciously orange. Based on the absorbance spectra of the seawater and observations of the filters under the microscope, it was determined that the system was contaminated. The underway system was flushed with citric acid, bleach and 10% hydrochloric acid in order to clear out the contamination. This did not fully resolve the problem. All underway sampling was suspended for a couple of days while the system was flushed. It was later resumed even though, at times, it appeared that the contamination had not been completely removed.

During the CTD sampling procedure, temperature of the sample and filtrate increased around 4-6 ºC in 1.5h effecting the results negatively. Also the carboys couldn't be stored at in situ temperature because the cold room doesn't allow adjustment under 4ºC. It would be optimal to have storage space allowing to keep the samples at water in

situ temperature and even to filter at that temperature (maybe the peristaltic pump could be isolated in something).
Extra tubing is needed. While there was a large amount of tubing, very few of the tubes actually fitted the Niskin. New tubing is needed for the peristaltic pump as well.

13. $\delta^{15}N$: Natural Abundance Nitrogen Isotope Ratios

Sampling by Sandi Smart (SUN/Princeton), Preston Cosslett Kemeny (Princeton) and Ethan Chen Campbell (Princeton)
Advised by Sarah Fawcett (Princeton/UCT) and Daniel Sigman (Princeton)

Introduction

The natural ratios of stable nitrogen isotopes ($^{15}N/^{14}N$) act as tracers of physical, chemical and biological processes in the marine environment. Uncovering the natural distributions of $^{15}N/^{14}N$ of various nitrogen pools could provide valuable information about the processes underlying these patterns in the Atlantic Sector of the Southern Ocean, where very little data of this kind currently exists.

Aim

On the 2015 winter voyage, the aim was to collect dissolved nitrate (NO_3^-), particulate nitrogen (PN), and zooplankton samples along the Good Hope Line and SAMBA line for stable isotope analysis.

The nitrate isotope data (NO_3^--$\delta^{15}N$ and NO_3^--$\delta^{18}O$) will be used to investigate seasonal processes in the marine nitrogen cycle. The relationship of isotope ratio, both throughout the water column and across the ocean, will elucidate the dynamics of wintertime nitrate uptake, nitrification, and ocean circulation. These phenomena are important because they control the supply of nitrate to the surface ocean, which in turn modifies summertime productivity and the air-sea exchange of carbon. Sampling on this cruise focused primarily on the mixed layer and upper thermocline, which are the regions most likely to recharge the surface ocean with nutrients for the summer. Studying wintertime nitrate isotope data also provides a seasonal context in which to interpret paleoceanographic isotope data and better understand nutrient utilization in different zones of the Southern Ocean throughout Earth history, with strong applications to Pleistocene glaciations.

Two kinds of PN collections were made, with the goal of measuring both the bulk N isotope ratio of surface particles and the N isotope ratios of specific fractions of the bulk PN pool (via flow cytometry) .This research will allow for better understanding of nitrogen cycling within the surface of the Southern Ocean, with direct applications to models of Antarctic biogeochemistry.

The zooplankton tows were undertaken to collect living foraminifera from the Subantarctic ocean for N isotope analysis as part of an effort to ground-truth the foram-bound N isotope proxy – a proxy for past biological nitrate consumption based on the organic N in fossil foraminifera shells buried in deep ocean sediments. The foraminifer targeted for our net tows is *Globigerina bulloides*, the species that is present throughout

most sediment cores from the region. This data will be complemented by associated nitrate and PN collections made at/near the tow locations.

Analysis of samples will be conducted at University of Cape Town, Stellenbosch University, and Princeton University.

Methods

Samples were collected in July-August 2015 on the Good Hope Line between Cape Town and the winter sea-ice edge (~56°S) as well as on the northward return leg along 0°E and subsequently the SAMBA line (along 34°S) back to Cape Town.

Underway sampling

Three different kinds of particulate (and their associated filtrate) collections were made from the underway seawater supply in the following 3-phase sequence: a 1-2 hour collection using 0.4 µm polycarbonate filters (for later flow cytometry), a 1-2 hour collection using 0.3 µm GF/F filters (for later isotope analysis of bulk N), and an 8-12 hour collection using nitex mesh filters to capture zooplankton or diatoms, depending on the region. Below we provide a more detailed protocol:

Phase 1:

- Label 3 x 60 mL bottles & lids (PC/GFF/mesh), 4 cryovials and 4 ziplock bags + prep log sheet for the next underway station
- you will find the previous nitex mesh filtration still going…
- Before ending mesh filtration, record end flow rate (e.g., how long to fill a 250 mL beaker)
- Close taps
- Record end time, lat, lon...
- If water remaining in filter holder does not flow through on its own, attach to vacuum flask / pump (but don't let them be totally sucked dry)
- Set aside for now (keeping vertical!) while start next PC filtration…

- attach parallel (Y-split) tubing with 2 in-line filter holders to underway tap
- Flush system through with "recent" underway water into the sink for a minute or so

*vinyl gloves

*wipe forceps with ethanol

- Place a 47mm, 0.4µm polycarbonate (sterlitech) filter into each in-line filter holder & put inflow-tubes into receiving carboys
- Open taps
- Remove bubbles from inline filter holders using air valves (carefully!)
- Record start time, lat, lon...
- After a short while, rinse the "PC" 60mL sample bottle &lid x3 with a few mL's of filtrate directly from tubes before filling (to just below shoulder to leave head-space for freezing!)
- Allow to flow until clogged or until 10L or 1hr 45min (replacing receiving carboys before overflow!)

In the meantime…

Store the nitex filters:

- Roll up each nitex filter using forceps and place in cryovials [wiping forceps between diff filters]
- add ~4mL low-nitrate sea water to cryovials using squirt bottle

* NITRILE gloves

- IF FORAMS (STZ/SAZ): add ~200µL of 10% buffered formalin using pipette + a new pipette tip in fume hood
- seal and shake gently/roll to re-suspend particles
- Place each one in a ziplock bag (labelled inside[PENCIL] & out)
- Put in cooler room/fridge and store with the 1L bulk tow collections
- IF DIATOMS (AZ): treat as a PC cryovial (add 70 uL formaldehyde → fridge → -80C freezer)

…
- Close taps
- Record end time, lat, lon...
- Record total volume filtered through each filter from graduations on carbuoys

*vinyl gloves
- If water remaining in filter holder does not flow through on its own, attach to vacuum flask / pump (but don't let them be totally sucked dry)
- Roll up each filter paper using forceps (not too tightly – fold in half, then half again, lengthwise), and place in cryovials [wiping forceps between touching diff filters]
- add ~4mL low-nitrate sea water to cryovials using squirt bottle and set aside for now…

Phase 2:

- Reattach in-line filter holders and flush whole system with underway water into the sink
- Empty the collection carboys (once volume recorded!!)

Start GFF collection…
*vinyl gloves
- Place a new precombusted 47mm, 0.3 um GFF into each in-line filter holder of the parallel filtering setup (using ethanol wiped forceps) & put inflow-tubes back in receiving (25L) carboys
- Open taps
- Remove bubbles from inline filter holders using air valves (carefully!)
- Record start time, lat, lon...
- Rinse "GFF" 60mL sample bottle (& lid) 3x with a few mL's of filtrate before filling (leave some head-space for freezing!)
- Allow to flow until starting to clog or until 1hr45min (replacing receiving carboys before they overflow!)

In the meantime….

Process the PC cryovials
* NITRILE gloves
- add 70µL of formaldehyde fixative (37% solution) using pipette + a new pipette tip in fume hood
- seal and shake gently/roll to re-suspend particles
- Place each one in a ziplock bag (labelled inside[PENCIL] & out)
- Put in cooler room (0-4˚C) for 1-8 hours; then transfer to freezer (-80˚C) [set alarm for ~1-8hrs later]

…
*vinyl gloves
- Before stopping the GFF filtration, rinse the "mesh" 60mL nitrate bottle (&lid) with filtrate 3x before filling to just below the shoulder
- Close taps
- Record end time, lat, lon...
- record total volume filtered through each filter from graduations on carbuoys
- If water remaining in filter holder does not flow through on its own, attach to vacuum flask / pump (but don't let them be totally sucked dry)
- set aside for now (keeping upright)…

Phase 3:

- detach the parallel filtration tubing
- attach the tubing with 2 in-line filter holders in series and flush through into sink
*vinyl gloves
- Place a 47mm, 200 um (top) and 35 um (bottom) nitex mesh filter (when in STZ/SAZ) OR 100 um (top) and 20 um (bottom) nitex mesh filter (when in AZ) into the in-line filter holders using ethanol-wiped forceps and leave outflow-tubes to flow into the sink
- Open taps
- Remove bubbles from inline filter holders using air valves (carefully!)

- Record start time, lat, lon...
- Record start flow rate (e.g., how long to fill a 250 mL beaker or 1L bottle?)
- Allow to flow until next underway PC collection (~7hrs 45mins… but can go up to 10-12hrs or even more if needed)

In the meantime…

1) Store GFF filters:
- fold GFF in half using forceps and wrap in a square of (precombusted) tinfoil [spraying forceps with ethanol between touching diff filters]
- place in a ziplock bag (labelled inside[PENCIL] & out)
- then put these directly into freezer at -80˚C (don't need to cool first)

2) Take all 3 nitrate (60mL bottle) samples to the -20C freezer
3) Move the PC cryovials from fridge to -80C freezer
4) Empty carboys (once volume recorded!!) from GFF filtration

Hydrocast / CTD sampling

From every CTD station sampled (see table of stations under "Station Data"), a single 60 mL nitrate sample was collected from every depth available (collecting first from surface bottles to minimise the risk of contamination, when possible). Sampling took place in the environmental hangar when using Niskin bottles (standard CTD cast) and in a trace metal clean laboratory container when using GoFlo bottles (GEOTRACES CTD cast).

The procedure for a typical CTD collection is as follows:

- Label 60 mL bottles & lids with cruise information, station name, and depths
- Stick a piece of lab-tape over each 60 mL bottle lid
- Find which Niskin or GoFlo bottles correspond to which depths and write on log sheet
- Write Niskin or GoFlo bottle number on the lid of each of the 60 mL sample bottles
- Record time, lat, lon, date etc. of CTD station on log sheet
- Put on vinyl gloves
- Rinse 60 mL bottle (and lid) with seawater from the Niskin or GoFlo, shake, and empty into the inside of cap. Repeat 3 times. Don't touch inside of lid /bottle top or let bottle touch the tap.
- Fill sample bottle (to just below the shoulder).

- Syringe filter each sample (rinsing the syringe and filter with both DIW and small amounts of sample seawater, then fill syringe with sample and filter back into its original 60 mL bottle).
- Transfer to the –20°C freezer.
- If it is not possible to filter all the samples at the time, freeze immediately after collection, then defrost later and syringe-filter in batches.

Note: For most samples along the Good Hope Line, the 60 mL vials were frozen after collection. These samples were later defrosted for 2.5 hours prior to filtering, and then transferred back into the –20°C freezer. For most samples along the SAMBA line, samples were filtered immediately after collection. When possible, samples were collected from the GEOTRACES GoFlo bottles instead of the Niskin bottles sampled by other projects. This was done in order to achieve a higher resolution in the lower mixed

layer and upper thermocline, and to take advantage of the opportunity to sample in a cleaner environment. At two stations (DTM2 and TM1) both the Niskin bottles and the GoFlo bottles were sampled.

Zooplankton net tows

Net tows were undertaken using a 200 μm mesh-size double-bongo net, towed at 1-1.5 knots for 1.5 hours at 7 different locations during the cruise: 5 in the Subantarctic Zone (SAZ), 1 in the Polar Frontal Zone (PFZ) and one in the Antarctic Zone (AZ). The target depth was chosen based on the depth of the florescence maximum (Fmax; obtained from the latest CTD profile) and taking into account the time of day (i.e., night tows were shallower than day tows due to the diurnal migration patterns of zooplankton).
Below is a detailed description of the protocol:
Preparing for net tow:
Check latest CTD for Fmax depth (if no recent CTD, see previous winter)
Check net condition
Attach cod-ends and firmly wrap the connections with electrical tape (making sure to cover the metal buckles but not the mesh-lined holes)
Initialise and check if we have comms

Net deployment & retrieval:
Put on waterproof gear, boots, hard hat etc.
Bring the following to the rear A-frame:

- assembled net with flowmeter and data-logger attached
- weight line/rope
- shackles
- handful of large zip ties

Attach a (two- or a three-block?) weight to the wire using the weight line.
Use a large shackle and the three rings of the towing bridle to fasten the net to the wire.
Loop a few large zip-ties through as well.
Info to give winch operator and captain:

- Ship speed: 1-1.5 knots
- Amount of wire to let out / target depth

Things to record:

- Tow#
- Initial flowmeter readings
- Target depth (m)
- Tow start time
- Start lat & lon
- Ship speed (SOG) (knots)
- Wind speed (knots)
- Wire angle
- Wire out (m)

At the same time as the tow, collect 0.3 um GF/Fs and a filtered nitrate sample from the underway water supply using the same protocol outlined above.

After 1.5 hours, ask the bosun to bring the net back up at 1 m/s.
Put on safety gear and meet the crew at rear.

Lift the net back on board, keeping the cod-ends upright (grab net above cod ends)!

Hang up net, keeping cod end upright at all times
Using a seawater hose, from the outside of the net, wash down the sides (from ~1 m above the cod end)
Unsnap the cod end bucket, and remove from the net.
Empty cod end into a bucket and rinse out with underway seawater (squirt bottle/hose) and move inside (to CTD hanger)
Swirl the bucket to resuspend particles and decant ~90% into 1L storage bottle(s) (fill up to ~900mL), using a funnel if necessary. Rinse funnel back into bucket (not 1L bottle!).
In the fume hood, wearing nitrile gloves, slowly pour 10% buffered formalin (~1/20th the volume of sample e.g., ~50 mL) into the sample bottle. Re-cap bottle(s), wrap top tightly with Parafilm to seal. Swirl and invert the bottle gently to mix.
Label sample bottle(s) with: date, tow #, approx. depth, "contains ~5% formalin by volume"
Double- or triple-bag the sample bottle in gallon Ziploc bags
Store bagged samples in a safe place – in the walk in fridge… DO NOT FREEZE!!!

Swirl bucket and pour the remaining 10% of the collection through the 5000 um sieve into a second bucket, rinsing out the first bucket and 5000 um sieve with seawater.
Pour the contents of the second bucket through the remaining (5) sieves (stacked from largest to smallest) into a clean bucket. Transfer the sieves and bottom bucket to the lab for filtering.
Wearing vinyl gloves, place 1 ashed 0.7um GF/F onto each glass frit of the filtration rig using ethanol-wiped forceps.
Pour the contents of each sieve (and the bottom bucket) into the corresponding filtration tower, rinsing out with seawater squirt bottle (doesn't need to be low nitrate).
Attach to vacuum pump (with vacugaurd and collection flask) and turn on pump, rinsing down inner side walls, and closing taps before sucked too dry.
May need to collect 2 GFFs if too much material – if so, use separate petri dishes.
Remove each GFF with ethanol-wiped forceps and place into an ethanol-wiped, labelled petri dish. Parafilm each petri dish, double ziplock bag and tape the whole stack together. Place these directly into the -20C freezer
Clean the filtration rig for next time with DIW (only acid wash frits if clog)

Things to record:
- Tow end time
- End flowmeter reading
- End lat & lon
- Actual depth (average and range)
- Filename of the data

When completely done, rinse the buckets with s/w hose in deep sink in the hanger (or with tap water, followed by MilliQ, if no s/w hose available indoors).
Rinse the cod end and net well with seawater.

At the end of the cruise, spread the net out in an approved area to fully dry before packing away

Place the net in the large plastic bag for storage

Station Data

Underway particulate samples:

			-- START --				-- END --			
Station name	**Filter type (pore size in µm)**	**Filter #**	**Date**	**Time (GMT)**	**Latitude (°S)***	**Longitude (°E)***	**Date**	**Time (GMT)**	**Latitude (°S)***	**Longitude (°E)***
U10	35 mesh	M1	23-Jul	19:00	34° 29.977'	16° 52.780'	24-Jul	6:11	34° 40.244'	15° 15.527'
	200 mesh	M2								
U16	PC	P1	24-Jul	6:36	34° 35.622'	15° 12.321'	24-Jul	7:53	34° 30.082'	15° 00.183'
	PC	P2								
U17	GFF	G1	24-Jul	8:30	34° 32.005'	14° 58.414'	24-Jul	10:16	34° 43.346'	14° 47.402'
	GFF	G2								
U18	35 mesh	M3	24-Jul	10:40	34° 45.991'	14° 44.359'	24-Jul	15:19	35° 15.616'	14° 02.620'
	200 mesh	M4								
U21	PC	P3	24-Jul	18:04	35° 15.624'	14° 02.624'	24-Jul	18:55	35° 15.624'	14° 02.625'
	PC	P4								
	GFF	G3	24-Jul	19:26	35° 15.623'	14° 02.626'	24-Jul	20:19	35° 15.623'	14° 02.625'
	GFF	G4								
	35 mesh	M5	24-Jul	20:50	35° 15.133'	14° 01.964'	25-Jul	11:27	36° 51.566'	12° 52.705'
	200 mesh	M6								
U26	PC	P5	25-Jul	11:41	36° 53.904'	12° 15.357'	25-Jul	12:43	37° 04.094'	12° 44.692'
	PC	P6								
	GFF	G5	25-Jul	13:09	37° 08.465'	12° 41.837'	25-Jul	14:04	37° 17.364'	12° 35.662'
	GFF	G6								
	35 mesh	M7	25-Jul	14:21	37° 20.323'	12° 33.869'	26-Jul	2:30	38° 25.158'	11° 52.741'
	200 mesh	M8								
CPIES 4	35 mesh	M9	26-Jul	4:08	38° 36.093'	11° 45.767'	26-Jul	12:15	39° 02.292'	11° 27.277'
	200 mesh	M10								
	PC	P7	26-Jul	12:30	39° 04.647'	11° 25.720'	26-Jul	13:28	39° 13.975'	11° 19.189'
	PC	P8								
	GFF	G7	26-Jul	14:09	39° 20.666'	11° 14.448'	26-Jul	14:54	39° 28.647'	11° 08.992'
	GFF	G8								
U50	PC	P9	29-Jul	8:51	44° 05.727'	07° 25.400'	29-Jul	9:41	44° 14.081'	07° 17.560'
	PC	P10								
	GFF	G9	29-Jul	10:03	44° 17.631'	07° 14.108'	29-Jul	11:37	44° 33.306'	06° 59.180'
	GFF	G10								
	35 mesh	M11	29-Jul	11:50	44° 35.499'	06° 56.897'	29-Jul	14:54	44° 59.801'	06° 33.900'
	200 mesh	M12								
U56	35 mesh	M13	30-Jul	7:00	45° 38.699'	05° 58.410'	30-Jul	10:54	45° 59.958'	05° 35.790'
	200 mesh	M14								
Tow 3	GFF	G11	30-Jul	11:29	45° 59.954'	05° 35.555'	30-Jul	12:39	45° 59.077'	05° 32.706'
	GFF	G12								
U57 at DTM2	35 mesh	M15	30-Jul	19:05	45° 59.930'	05° 35.513'	31-Jul	8:24	47° 31.582'	04° 04.880'
	200 mesh	M16								
U62	PC	P11	31-Jul	8:33	47° 32.836'	04° 03.538'	31-Jul	9:41	47° 40.995'	03° 55.410'
	PC	P12								
	GFF	G13	31-Jul	10:00	47° 43.180'	03° 53.237'	31-Jul	11:39	47° 54.371'	03° 41.868'
	GFF	G14								
	35 mesh	M17	31-Jul	11:50	47° 56.276'	03° 40.115'	31-Jul	not recorded	48° 31.732'	03° 03.896'
	200 mesh	M18								
U67	PC	P13	31-Jul	18:22	48° 34.249'	03° 01.321'	31-Jul	20:10	48° 47.794'	02° 47.200'
	PC	P14								

	GFF	G15	31-Jul	20:50	48° 52.875'	02° 41.915'	31-Jul	22:10	49° 03.606'	02° 30.977'
	GFF	G16								
	35 mesh	M18	31-Jul	22:29	49° 06.336'	02° 28.123'	1-Aug	9:30	50° 26.972'	01° 03.379'
	200 mesh	M19								
TM1/Tow 4	GFF	G17	1-Aug	11:27	50° 27.082'	01° 02.522'	1-Aug	13:24	50° 27.028'	01° 03.478'
	GFF	G18								
Started as leaving TM1	35 mesh	M20	1-Aug	16:54	50° 30.925'	00° 59.844'	2-Aug	8:40	53° 30.516'	00° 00.028'
	200 mesh	M21								
U80	PC	P15	2-Aug	8:50	53° 33.178'	00° 00.020'	2-Aug	10:06	53° 48.854'	00° 00.010'
	PC	P16								
	GFF	G19	2-Aug	10:31	53° 54.055'	00° 00.019'	2-Aug	11:29	54° 06.118'	00° 00.023'
	GFF	G20								
	20 mesh	M22	2-Aug	11:45	54° 09.362'	00° 00.005'	2-Aug	20:01	55° 43.372'	00° 00.198'
	100 mesh	M23								
DTM1	PC	P17	2-Aug	20:09	55° 42.541'	00° 00.026'	2-Aug	21:26	55° 42.602'	00° 00.118'
	PC	P18								
	GFF	G21	2-Aug	21:40	55° 42.601'	00° 00.119'	2-Aug	22:35	55° 42.601'	00° 00.119'
	GFF	G22								
	20 mesh	M24	2-Aug	22:44	55° 42.602'	00° 00.119'	3-Aug	12:11	56° 25.900'	00° 16.139'
	100 mesh	M25								
U87	20 mesh	M26	3-Aug	12:31	56° 20.180'	00° 15.103'	3-Aug	3:43	54° 00.020'	00° 00.059'
	100 mesh	M27								
DTM3 (straight after Tow 5)	GFF	G23	4-Aug	3:52	54° 00.020'	00° 00.059'	4-Aug	5:44	54° 00.019'	00° 00.058'
	GFF	G24								
U92/leaving DTM 3	20 mesh	M28	4-Aug	7:11	53° 51.878'	00° 00.289'	4-Aug	18:01	51° 35.236'	00° 01.585'
	100 mesh	M29								
U96	PC	P19	4-Aug	18:22	51° 31.257'	00° 02.419'	4-Aug	19:26	51° 19.703'	00° 03.654'
	PC	P20								
	GFF	G25	4-Aug	19:57	51° 14.266'	00° 03.908'	4-Aug	21:28	50° 58.490'	00° 04.613'
	GFF	G26								
	20 mesh	M30	4-Aug	21:50	50° 53.995'	00° 03.966'	5-Aug	8:33	48° 47.697'	00° 00.164'
	100 mesh	M31								
U103	PC	P21	5-Aug	8:43	48° 45.655'	00° 00.045'	5-Aug	9:46	48° 34.427'	00° 00.052'
	PC	P22								
	GFF	G27	5-Aug	10:08	48° 30.239'	00° 00.012'	5-Aug	11:06	48° 19.466'	00° 00.060'
	GFF	G28								
	35 mesh	M32	5-Aug	11:18	48° 17.051'	00° 00.060'	5-Aug	19:33	46° 44.500'	00° 00.204'
	200 mesh	M33								
U109	PC	P23	5-Aug	19:46	46° 42.102'	00° 00.200'	5-Aug	20:46	46° 30.493'	00° 00.000'
	PC	P24								
	GFF	G29	5-Aug	21:03	46° 27.063'	00° 00.067'	5-Aug	22:15	46° 13.185'	00° 00.080'
	GFF	G30								
	35 mesh	M34	5-Aug	22:26	46° 11.074'	00° 00.068'	5-Aug	12:54	43° 22.649'	00° 00.016'
	200 mesh	M35								
U117	PC	P25	6-Aug	13:08	43° 20.090'	00° 00.012'	6-Aug	14:16	43° 06.891'	00° 00.106'
	PC	P26								
	GFF	G31	6-Aug	14:36	43° 03.013'	00° 00.412'	6-Aug	15:38	42° 51.631'	00° 00.067'
	GFF	G32								
	35 mesh	M36	6-Aug	15:47	42° 49.896'	00° 00.023'	7-Aug	8:17	40° 39.584'	00° 05.499'
	200 mesh	M37								
Tow 6	GFF	G33	6-Aug	19:36	42° 13.739'	00° 00.545'	6-Aug	20:52	42° 13.460'	00° 02.615'
	GFF	G34								
U127	PC	P27	7-Aug	8:36	40° 35.964'	00° 06.911'	7-Aug	11:33	40° 02.064'	00° 20.258'
	PC	P28								
	GFF	G35	7-Aug	11:50	39° 59.060'	00° 21.890'	7-Aug	13:13	39° 44.080'	00° 29.554'
	GFF	G36								

	35 mesh	M38	7-Aug	13:22	39° 42.420'	00° 30.354'	8-Aug	11:10	35° 01.516'	00° 00.033'
	200 mesh	M39								
U141	PC	P29	8-Aug	11:22	34° 58.946'	00° 00.021'	8-Aug	12:45	34° 41.020'	00° 00.122'
	PC	P30								
SAMBA CPIES 8	PC	P31	8-Aug	16:30	34° 30.129'	00° 00.021'	8-Aug	17:35	34° 30.127'	00° 00.020'
	PC	P32								
	GFF	G37	8-Aug	17:50	34° 30.128'	00° 00.200'	8-Aug	19:41	34° 30.130'	00° 07.854'
	GFF	G38								
	35 mesh	M40	8-Aug	19:53	34° 30.021'	00° 09.361'	8-Aug	not recorded	34° 29.908'	03° 43.184'
	200 mesh	M41								
SAMBA CPIES 7	PC	P33	9-Aug	18:04	34° 29.909'	03° 43.184'	9-Aug	19:19	34° 29.102'	03° 43.031'
	PC	P34								
	GFF	G39	9-Aug	19:38	34° 28.345'	03° 42.332'	9-Aug	20:42	34° 29.970'	03° 43.115'
	GFF	G40								
U152	PC	P35	10-Aug	13:13	34°	05°03.797	10-Aug	14:26	34°	05°
	PC	P36								
	GFF	G41	10-Aug	14:42	34°	05°	10-Aug	16:02	34°	05°
	GFF	G42								
	35 mesh	M44	10-Aug	16:09	34°	05°	10-Aug	22:15	34°	07°
	200	M45								
SAMBA CPIES 6	PC	P37	10-Aug	22:36	34° 30.439'	07° 27.026'	10-Aug	23:51	34° 30.546'	07° 26.902'
	PC	P38								
	GFF	G43	11-Aug	00:07	34°	07°	11-Aug	01:10	34°	07°
	GFF	G44								
	35 mesh	M46	11-Aug	01:19	34°	07°	11-Aug	18:46	34°	11°
	200	M47								
SAMBA CPIES 5	PC	P39	11-Aug	18:56	34° 29.770'	11° 12.025'	11-Aug	19:59	34° 29.330'	11° 11.676'
	PC	P40								
	GFF	G45	11-Aug	20:13	34°	11°	11-Aug	21:19	34°	11°
	GFF	G46								
	35 mesh	M48	11-Aug	21:31	34°	11°	12-Aug	11:04	34°	14°
	200	M49								
SAMBA CPIES	PC	P41	12-Aug	11:11	34° 29.944'	14° 38.378'	12-Aug	13:08	34° 29.945'	14° 38.378'
	PC	P42								
	GFF	G47	12-Aug	12:18	34°	14°	12-Aug	14:29	34°	14°
	GFF	G48								
	35 mesh	M50	12-Aug	14:38	34°	14°	13-Aug	04:06	34°	17°
	200	M51								
SAMBA CPIES	PC	P43	12-Aug	17:15	34° 30.424'	15° 00.321'	12-Aug	18:13	34° 30.424'	15° 00.320'
	PC	P44								
	GFF	G49	12-Aug	18:28	34°	15°	12-Aug	19:53	34°	15° 05.135
	GFF	G50								
SAMBA CPIES 3	PC	P45	13-Aug	04:17	34° 29.985'	17° 08.310'	13-Aug	05:18	34° 29.984'	17° 08.309'
	PC	P46								
	GFF	G51	13-Aug	15:29	34°	17°	13-Aug	06:25	34°	17°
	GFF	G52								

CTD nitrate bottle samples:

Station name	Station number	CTD number	CTD type / sequence	Date	Downcast time from CTD file [GMT/UTC]
CPIES 2	VOY016-702	2	deep Niskin	25-Jul	3:58:02
CPIES 3	VOY016-703	3	deep Niskin	25-Jul	17:18:47

CPIES 4	VOY016-704	4	deep Niskin	26-Jul	5:45:04
CPIES 6	VOY016-706	7	deep Niskin	27-Jul	8:25:28
PS1/CPIES 7	VOY016-707	9	deep Niskin #1	28-Jul	6:21:00
PS1/CPIES 7	VOY016-707	10	shallow Niskin	28-Jul	10:22:43
PS1/CPIES 7	VOY016-707	12	shallow Niskin	28-Jul	16:15:06
PS2	VOY016-708	15	calibration Niskin	29-Jul	17:19:05
DTM2	VOY016-709	20	deep Niskin	30-Jul	14:33:25
DTM2	VOY016-709	21	deep Geotraces/GoFlo	30-Jul	18:43:48
TM1	VOY016-710	22	deep Niskin	1-Aug	8:14:35
TM1	VOY016-710	24	shallow Geotraces/GoFlo	1-Aug	14:49:01
DTM1	VOY016-711	25 (originally 23)	deep Geotraces/GoFlo	2-Aug	20:23:18
DTM3	VOY016-712	29 (originally 27)	deep Geotraces/GoFlo	3-Aug	23:14:19
SAMBA CPIES 8	VOY016-802	32 (originally 30)	deep Niskin	08-Aug	15:24:40
SAMBA CPIES 7	VOY016-803	33 (originally 31)	deep Niskin	09-Aug	15:28:56
SAMBA CPIES 6	VOY016-804	34 (originally 32)	deep Niskin	10-Aug	23:37:57
SAMBA CPIES 5	VOY016-805	35 (originally 33)	deep Niskin	11-Aug	18:17:41
SAMBA CPIES 4A (JUNCTION)	VOY016-806	36 (originally 34)	deep Niskin	12-Aug	10:23:31
SAMBA CPIES 4B (OLD POSITION)	VOY016-807	37 (originally 35)	deep Niskin	12-Aug	16:45:52

Zooplankton net tows:

		-- START --				-- END --			
Tow #	**Target depth (m)**	**Date**	**Time (GMT)**	**Latitude (°S)**	**Longitude (°E)**	**Date**	**Time (GMT)**	**Latitude (°S)**	**Longitude (°E)**
1	60	2015/07/27	12:00	41.35	9.89	2015/07/27	13:30	41.35	9.88
2	40	2015/07/28	11:49	42.69	8.74	2015/07/28	13:19	42.70	8.74
3	80	2015/07/30	11:20	46.00	5.59	2015/07/30	12:50	45.98	5.54
4	90	2015/08/01	11:13	50.45	1.05	2015/08/01	12:43	50.46	1.00
5	30	2015/08/04	01:20	54.00	0.00	2015/08/04	02:50	53.99	0.05
6	30	2015/08/06	19:21	42.23	0.00	2015/08/06	20:51	42.22	0.04
7	30	2015/08/06	21:16	42.23	0.05	2015/08/06	22:46	42.22	0.09

Preliminary Results

Most of the nitrate, PN and zooplankton samples collected on this cruise will be analysed by the participants at Princeton University, USA, for isotopic composition. The flow cytometry work will be undertaken by Dr Sarah Fawcett at the University of Cape Town.

Problems/Issues

- Contamination of the underway seawater supply (by rust or organic matter growing in the pipes) may compromise some of the particulate samples
- The temperature and salinity sensors on the bongo net had not been calibrated so this data could not be used
- Three (single) nets of the 7 double-net tows were lost due to bad weather and/or impacts during retrieval
- We achieved a higher resolution in sampling NO_3 isotopes than expected, and as a result began to run low on 0.22 µm syringe filters. Thus we chose to use filters twice. When this occurred, we rinsed the filter with MilliQ water between uses and only used the same filter on samples from similar depths and casts.
- Widespread lack of communication regarding parties responsible for operating the CTD. No clear procedure to handle misfired bottles, select bottle depths, or maintain a clear sampling order once the rosette was on deck.

Recommendations

- Find a long-term solution for keeping the underway water supply system clean
- Calibrate the temperature and salinity sensors on the bongo net for future use
- Perhaps lengthen the cable from which the net's depressor is suspended so that it cannot strike the bar connecting the two cod-ends (the broken bar seems to have been the reason for at least some of the net losses, as the two nets are then able to spin freely and tear)
- Establish, if possible, before the cruise, or at least before the station is reached, the purpose of each CTD cast, the general distribution of depths, and the party responsible for managing the cast and the order of collection of water when the CTD is back on deck.

14. The importance of marine 'dark matter' in the sequestration of atmospheric CO_2

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Participants at sea*:* ***Sandra Phoma (PhD candidate at the Centre for Microbial Ecology and Genomics, University of Pretoria) and Mubanga Helen Kabwe (MSc. Qualification from the University of Pretoria)***

Rationale, aim(s), objective(s)

Fossil fuel combustion, cement production and other anthropogenic carbon emissions continue to increase carbon dioxide (CO_2) concentrations in the atmosphere. As a greenhouse gas, the accumulation of atmospheric CO_2 results in a global radiative imbalance. The predicted build-up of atmospheric CO_2 is predicted to significantly increase the temperature of the Earth's surface, resulting in the rise of global temperature and climate change. The shift in climate will also affect the ocean ecosystem by increasing sea surface temperatures and reducing primary productivity.

As a result, the ocean carbon cycle plays a vital role in understanding and predicting atmospheric CO_2 concentrations. The biological sequestration of atmospheric CO_2 by all oceans is thought to be majorly carried out by marine plankton (both eukaryotic and cyanobacterial photoautotrophs) in the oceanic photic zone (the upper 50 – 100 m). However, the impact of heterotrophic and chemoautotrophic picoplankton which occupy the deep ocean water (loosely characterised as 'microbial dark matter') remain unknown for CO_2 capturing capability and processing.

Climate models, which are widely used as predictors of future climate impacts, rely heavily on estimates of oceanic CO_2 sequestration (both biotic and abiotic). The failure to include the CO_2 capture capacity of oceanic microbial dark matter suggests that these models may underestimate the capacity of the world's oceans to respond to further rises in atmospheric CO_2.

In this project we aim to address this knowledge gap by employing a variety modern molecular approaches (single cell genomics (SCG), stable isotope probing (SIP) etc.) with the ultimate goal being the generation of a food web model that will incorporate the contributions of marine 'dark matter' in the carbon cycle. To do this, we will implement a 'proof of concept and methodological validation' approach using samples recovered from the Southern Ocean. This is an appropriate strategy because (a) the Southern Ocean is one of the most productive oceanic systems and (b) through collaboration with other research teams; we have an opportunity to take part in Southern Ocean research cruises on board the S.A. Agulhas II.

Methodology used to collect samples

Ocean water samples were taken during the SANAP Winter cruise (20th of July to the 14th of August 2015), which will be used for Stage 2 of this research project. Samples were previously taken during the SANAP Marion Island relief cruise (15th of April to the 9th of May 2015) by Dr E Gunnigle.

Water samples were taken from two monitoring lines: Good Hope and SAMBA (Table 1). Once a CTD rosette fitted with 24 × 12 L Niskin bottles from a sampling station was brought back on deck, 5 L seawater samples were collected from CTD Niskin bottles (representing ×3 biological replicates) at pre-determined depths: (1) *deep*: ~10 m above the seafloor, (2) *middle*: oxygen minimum (O_2 min) and (3) *surface*: fluorescence maximum (Fmax), into 5L high-density polyethylene (HDPE) bottles which were rinsed twice with ~50 ml of sample water.

Each 5 L seawater sample was thereafter pre-filtered through a 0.45 µm Polyethersulfone (PES) membrane filter (Pall Life Sciences, USA). The filtrate was collected and filtered again through a 0.2 µm 47mm Supor® Polyethersulfone (PES) membrane disk filter (Pall Life Sciences, USA). This was achieved by using a dual filtration system that incorporated ×2 300 ml catchment glass cylinders (Glassco, UK) and ×2 6 L glass bottles (Glassco, UK) (Figure 1). The filtration units were attached to a single filtration ME1C pump (Vaccubrand, USA). Each filter was folded and wrapped in foil before storing in a 15 ml tube at -20°C. Each collection bottle was washed with 50ml of 70% ethanol and rinsed twice with Milli-Q water (Millipore, USA) before reaching a new sampling station.

Table 4. Water samples collected at the GoodHope and Samba monitoring lines

CTD ID	Date	Latitude	Longitude	Deep (m)	O_2 min (m)	Fmax (m)
GOODHOPE LINE						
CTD 2	25/07/2015	36°13.214 'S	13°18.106 'E	4829 m	1400 m	45 m
CTD 4	26/07/2015	38°36.099 'S	11°45.765 'E	5129 m	1520 m	150 m
CTD 7	27/07/2015	41°20.472 'S	9°53.203 'E	4750 m	1500 m	75 m
CTD 8	28/07/2015	42°41.496 'S	8°44.245 'E	4900 m	1400 m	100 m
CTD 10	30/07/2015	45°59.962 'S	5°35.528 'E	4000 m	1400 m	20 m
CTD 20	01/08/2015	50°26.974 'S	1°03.379 'E	3670 m	650 m	30 m
CTD 24	02/08/2015	55°42.596 'S	0°00.123 'E	3654 m	400 m	
CTD 28	04/08/2015	54°00.013 'S	0°00.018 'W	2509 m	290 m	25 m
SAMBA LINE						
CTD 30	08/08/2015	34°30.128 'S	0°00.200 'W	4676 m	1500 m	100 m
CTD31	09/08/2015	34°29.909 'S	3°43.184 'E	5024 m	1500 m	30 m
CTD 32	10/08/2015	34°30.545 'S	7°26.902 'E	5189 m	1375 m	40 m
CTD 34	12/08/2015	34°29.816 'S	14°38.348 'E	4515 m	1300 m	58 m

Figure 0-1. Vacuum filtration system used for sampling ocean water

Preliminary results

At the conclusion of the winter research cruise we had filtered 1080 litres of seawater, with 216 filtered biomass samples recovered for both size fraction (0.45 and 0.2 micron). These filtered biomass samples will be transported to the Centre for Microbial Ecology and Genomics (CMEG) at the University of Pretoria and will be used for molecular analysis in the near future. Oceanographic data is still yet to be received and processed.

Brief discussion and/or Future work required

The main aim of this project is to ascertain whether deep-water heterotrophic and chemoautotrophic picoplankton are important contributors to the capture of CO_2 in the Southern Ocean. In order to elucidate their function, several molecular techniques has to be carried out. We would like to carry out a phylogenetic study of the microbial groups found in the deep water column and their corresponding abundance. This will be done by using microbial biomass samples obtained from each depth as a basis to improve resolution of any findings recorded for the deep ocean water biomass samples.

After isolating total DNA using an extraction kit, high-throughput microbial community analysis will be done on an Illumina MiSeq platform using the marker gene 16S rRNA for bacteria and archaea. This will provide taxonomic data and relative abundance data in the form of read counts for each sample. We will apply Single Cell Genomics (SCG), and Stable Isotope Probing (SIP) analysis in order to elucidate metabolic pathways in chemolithotrophs, which may be crucial in CO_2 sequestration in the oceans. Ultimately, the project will provide, for the first time, a food web model that incorporates the contributions of marine 'dark matter' in the carbon cycle.

Challenges encountered, and proposed solutions

As this was the second oceanic sampling cruise/research cruise that CMEG has been a part of, there were a few technical and logistical requirements that have now been noted for future research cruises. Above all, we did not have an efficient water filtration unit, which affected the amount of we would have appreciated a larger (1L) funnel catchment. A suggestion for future research cruises would be to incorporate a third filtration unit to allow us to filter all water samples for each depth at the same time. Also, as we had to filter each 5L water sample through two membrane filters (0.45 and 0.2 micron), this task took far longer than expected; roughly 6 hours per transect point. This has an important bearing on how many samples one can process and requires prior planning and calculation before starting each monitoring transect line.

Highlights

As previously mentioned, this was the second time that CMEG has taken part in an oceanographic sampling excursion. Although challenging in terms of laboratory activities, this was a thoroughly enjoyable experience. Under the assistance and guidance of Chief Scientist Dr. Sandy Thomalla, Prof. Isabelle Ansorge and the biological oceanography team, we were able to complete our sampling regime successfully. It was a pleasure to have Mubanga to help during sampling and filtration. The staff, crew and fellow scientists were superb and very friendly, which made our stay at sea quite enjoyable and pleasant. It was a privilege to do our sampling on-board the well-equipped S.A. Aghulas II scientific vessel.

15. Acoustic data collection during the winter cruise to study Antarctic krill

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Introduction

Antarctic krill (*Euphausia superba*, hereafter krill) is an ecological key species in the Southern Ocean ecosystem as it is an important food source for whales, seabirds, seals, fish and squid (Nicol and de la Mare, 1993; Mori and Butterworth, 2006). These shrimp-like crustaceans inhabit the pelagic waters of the Southern Ocean, they can grow to a maximum lengths of 60 mm and can live up to a maximum identifiable age of 6 years. They form closely spaced mono-specific aggregations that vary in length, and they mainly feed on sea-ice algae, phytoplankton and zooplankton (Nicol and de la Mare, 1993; Shabangu *et al.*, 2014). Krill is used by humans for pharmaceuticals and nutraceuticals, and also for producing fish meals (Nicol and de la Mare, 1993; Kawaguchi and Nicol, 2007). It is envisaged and proposed that South Africa participate in the krill fishery for socio-economic benefits, thus this kind of research will equip the fishing industry with the necessary and useful information about krill.
South African scientists have conducted krill research since the 1970s and continuation of this research is essential for enhancing our understanding of the comprehensive

Southern Ocean ecosystem (Shabangu *et al.*, 2014). Despite numerous research efforts to study the biology of krill, the biology of krill is still not well understood to accurately estimate their response to environmental change and exploitation pressures (Kagawuchi and Nicol, 2007). The current krill study is important in advancing our knowledge about the food availability status in the Southern Ocean for migratory South African whale and seabird species.

The objectives of this work are as follows:

- To determine the distribution and biomass of krill (*Euphausia superba)* using acoustic data collected from the three scientific echo sounders installed aboard the RV *SA Agulhas II*;
- To verify target discriminating algorithms in different ecosystems for future automated plankton species identification procedure;
- To establish predator-prey relationships between marine mammals and zooplankton;
- To develop ecosystem models through the combination of data from acoustic (euphausiids), oceanographic, bathymetry and predator (whales): interdisciplinary approach; and
- To complement the krill abundance and distribution estimates from the two previous South African National Antarctic Expedition and earlier South African Antarctic cruises.

Survey Methods

Acoustic data were continuously logged from the 38, 120 and 200 kHz scientific transducers mounted on the drop keel of RV *SA Agulhas II* (LOA: 134 m). The ER60 software was used for applying the user define settings. The parameters and settings of each transducer are provided in Table 1. Transducers were set to transmit to a maximum depth of 250 m since this is the deepest known depth to be inhabited by krill. Due to the low memory size of the hard drive on the acoustic logging computer, all acoustic data from this cruise were directly logged onto a 1 TB external hard drive. Daily, random system checks were conducted to ensure that the system was working accordingly. Data backup was performed once a week, intensively and detailed post-processing of the data will be conducted in the future.
Zooplankton net and bucket samples for species identification and biologicals were conducted at various stations by researchers from the Department of Environmental Affairs and University of Cape Town. In instances where relatively big krill samples were obtained, length measurements were made using a ruler and recorded for acoustic target density estimations.

Table 11.1. Parameters and settings of the three Simrad transducers aboard the RV SA Agulhas II.

Transducer Type	ES38B	ES120-7C	ES200-7C
Pulse duration (μs)	1024	1024	1024
Bandwidth (kHz)	2.43	3.03	3.09
Max transmit power (W)	2000	500	300
2-way beam angle (dB)	-20.6	-21.0	-20.7
Sample Interval (m)	0.191	0.185	0.191

Absorption coefficient (dB/km)	9.8	24.4	52.7
Sound speed (m/s)	1445	1445	1494
TS transducer gain (dB)	26.5	27.0	27.0
S_A Correction Factor (dB)	0.0	-0.34	0.0
Angle sensitivity alongship	21.9	23.0	23.0
Angle sensitivity athwartship	21.9	23.0	23.0
3 dB beam angle alongship (dB)	7.1	6.51	7.0
3 dB beam angle athwartship (dB)	7.1	6.47	7.0
Alongship offset (deg)	0.0	0.0	0.0
Athwarthship offset (deg)	0.0	0.0	0.0

Preliminary results and discussion

All transducers seemed to be working well except for a few errors that notified of the loss of communication with the 38 kHz general purpose transceiver. Good quality acoustic data were collected during this cruise and these data collection did not interfere with any scientific instruments or processes on board. No transducer calibration was conducted before, during or at the end of the cruise because this survey was an opportunistic data collection; thus no planning and allowance was given to conduct the calibration experiment. Transducers on board the ship were last calibrated in December 2013, therefore it is critical that these transducers are calibrated in the near future to obtain reliable scientific results.

Large swarms of krill were observed during different times of the day and surface migration of krill was evident at night (Figure 1). Noise spikes from the acoustic Doppler current profiler (ADCP) and noises from the hull of the ship breaking through ice were observed (Figure 2); however, algorithms exist to filter out the noise. The deployment and retrieval of the zooplankton nets produced few substantial krill samples for species identification and length measurements. The length measurement results (Figure 3) show that the krill sampled from this cruise were recruits and the age class could be between 0 and 1. Seabirds were visually observed feeding on the sea surface in few occasions, which also confirm the presence of krill in the Antarctic pelagic waters. More net samples are recommended for future studies to obtain more accurate krill abundance and distribution estimation outputs.

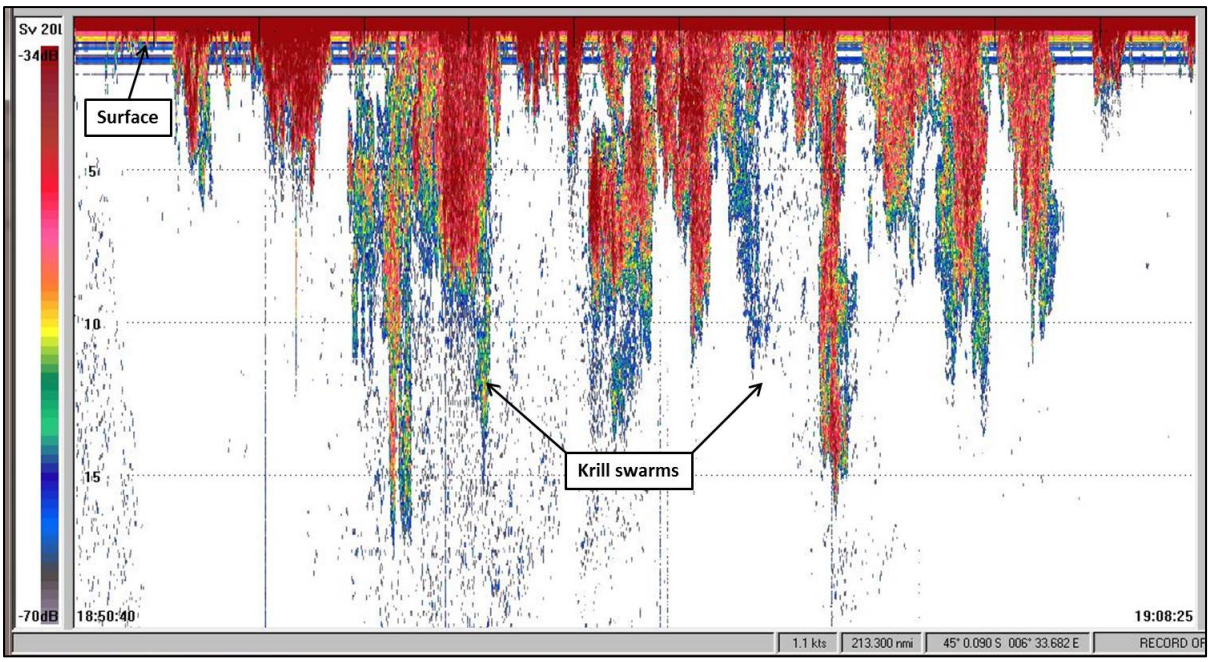

Figure 11.1. Echogram showing surface swarms of krill encountered at night.

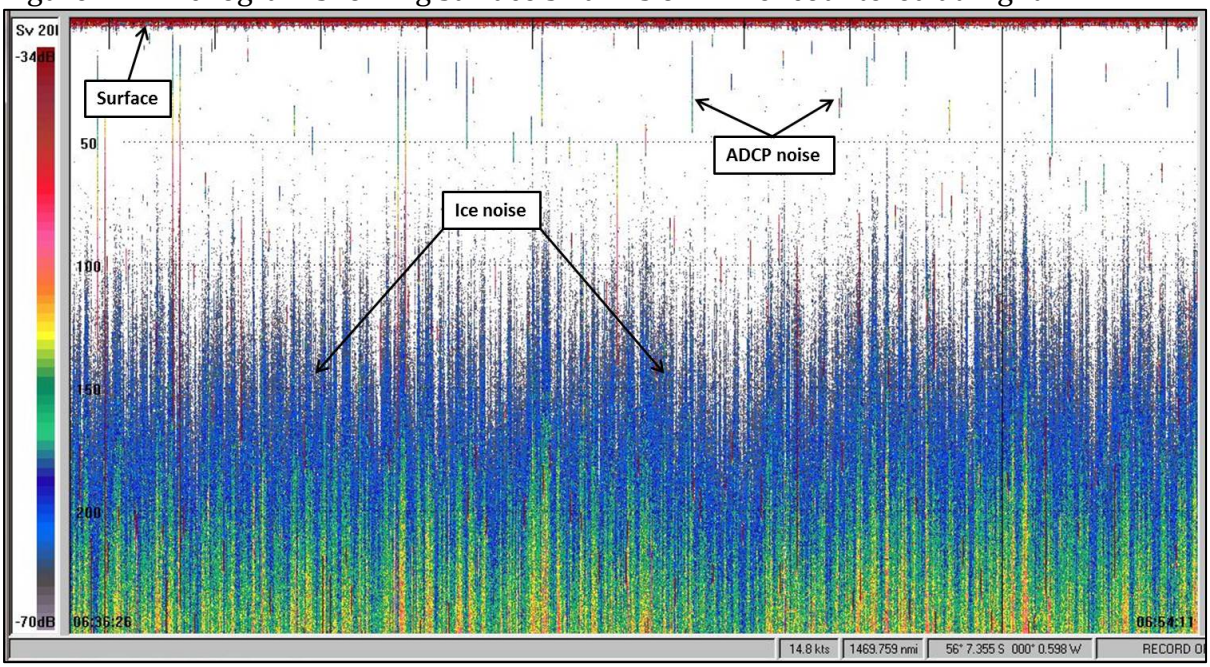

Figure 11.2. Echogram demonstrating the noises created when the ship's hull interacted with ice and by the ADCP. The ice noise is more prominent below the 100 m depths.

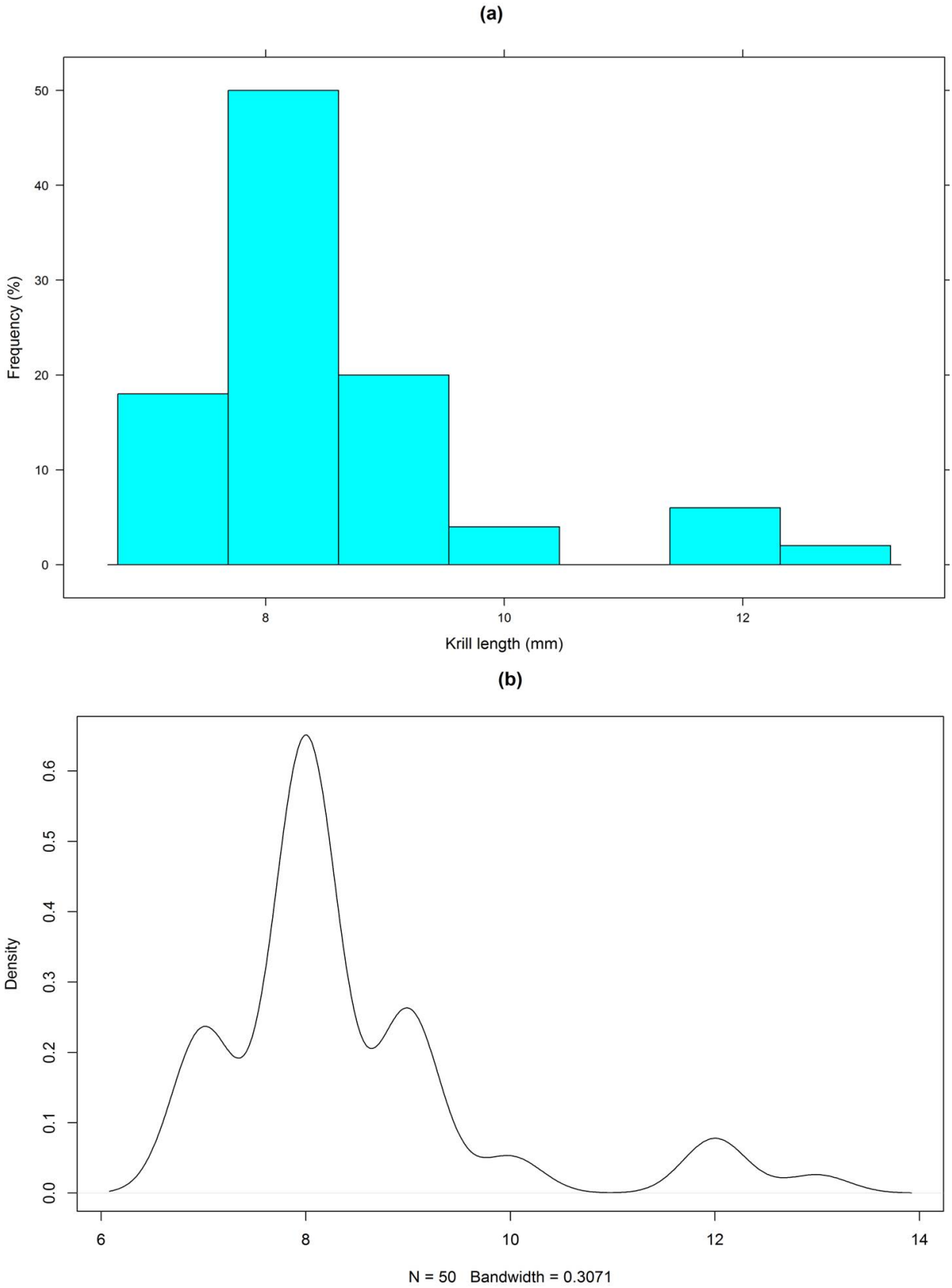

Figure 11.3. Length-frequency distribution (a) and the probability density estimate (b) of krill from this survey.

Recommendations

The upgrade of the hard drive memory size of the acoustic data logging computer from 9 GB to at least 250 GB is recommended for future easy data storage at sea. It is recommended that special time be allocated in the future for calibrating the acoustic transducers, this process usually takes 4-6 hours depending on environmental conditions. The purchase and installation of the ship's calibration gear will ensure calibration experiments in the future.

Acknowledgements
The Department of Agriculture, Forestry and Fisheries and the Department of Environmental Affairs are acknowledged for approving and funding this data collection.

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16. Continuous Plankton Recorder for basin-scale mapping of plankton

The CPR is a mechanical device towed behind ships-of-opportunity at a constant depth of about 10 m that allows the continuous and simultaneous collection of both phyto- and zooplankton material over large spatial scales. As the CPR is towed, water enters the CPR through an aperture at the front, and plankton present in the water is trapped onto a 270-µm silk mesh (the filtering mesh) inside the internal Plankton Sampling Mechanism (PSM), while another 270-µm silk mesh (the covering mesh) then sandwiches the plankton. Both silks are spooled together into a formalin-preservation tank and the 'plankton sandwich' is preserved until subsequent analysis in the laboratory. CPRs have been used since 1931 to map changes in plankton abundance and diversity and have been towed in most of the World's Oceans, including the Southern Ocean.

Changes in the abundance, distribution and diversity of plankton communities in the Atlantic and Indian sectors of the Southern Ocean, to the south of Africa have, however, generally not been studied in much detail. There are only a few "historical" CPR tows from the German RV *Polarstern* in March, April and May 2004 and in December 2007 and January 2008. The recent acquisition by DEA of CPRs allows South African scientists to regularly and more frequently tow CPRs from research and supply vessels, whenever these ships undertake annual relief voyages to research bases on Antarctica and Southern Ocean islands.

To date, these voyages have included a cruise-of-opportunity during summer 2011/12 on the RV *Polarstern* (December 2011-January 2012), followed by a number of cruises on the *SA Agulhas II* since her commissioning in May 2012, one of which during winter as part of her "Shakedown" cruise (July-August 2012), and the others during annual relief voyages to Gough and Marion islands and SANAE. Collectively, our South African CPR tows have covered a total distance of >15,000 n. miles and as such form an important contribution to the international Southern Ocean Continuous Plankton Recorder (SO-CPR) Survey.

This cruise will provide the second opportunity to map basin-scale spatial patterns of phyto- and zooplankton using the Continuous Plankton Recorder between the ice edge and Cape Town during winter, further contributing toward a more detailed description and understanding of spatial as well as seasonal, interannual and multi-decadal changes in community structure, abundance and distribution of plankton in the Southern Ocean. This CPR work forms part of South Africa's commitment and contribution to, and complements on-going work done by, the Scientific Committee on Antarctic Research/Australian Antarctic Division (SCAR/AAD)'s SO-CPR Survey, of which South Africa – through the DEA – became an active member in 2011. The SO-CPR Survey was established in 1991 as a monitoring programme to map spatio-temporal patterns of plankton, including krill, in the Southern Ocean and to use the sensitivity of plankton species to environmental variability and Climate Change as indicators of the health of the Southern Ocean.

17. Atlas of seabirds at sea (AS@S) survey

Figure 12.1 Adelie penguins © Martin Berg

Team: Taryn Morris (tarynleemorris@gmail.com), Martin Berg (martin.berg20@gmail.com), Tim Carr (reflection@mweb.co.za), Jess Berndt (jessie.a.berndt@gmail.com)

Summary

In this survey we collected data of the distribution and abundance of seabirds and other marine megafauna for the Seabird Atlas @ Sea (SA@S) project. This project is collaborative between the South African National Biodiversity Institute (SANBI), the Animal Demography Unit (ADU) at the University of Cape Town and BirdLife South Africa.

Data from the SA@S project will ultimately be used to assist institutions in defining 'ocean hotspots', where visible marine life (such as seabirds or cetaceans) congregate in relative abundance and with some degree of consistency. It also aims to identify important areas for highly threatened species. These areas might become marine Important Bird Areas for BirdLife International, or contribute to the designation of Marine Protected Areas, special nature reserves on the high seas, no-take zones to protect sensitive species from commercial fishing, etc.

In addition Martin Berg, Taryn Morris and collaborators aim to use data collected on this voyage to determine how seabird at-sea occurrence is linked to oceanic fronts. It is well established that oceanic fronts have a major impact on the density and distribution of seabirds in the Southern Ocean. However, few studies have investigated the seabird community structure in the context of both oceanographic features and prey availability. The underlying mechanisms of how frontal structures drive the occurrence patterns of seabirds therefor remains poorly understood. In one of few multi-disciplinary at-sea investigations, we analyse data collected between South Africa and the ice edge Antarctica, to determine seabird species assemblages and their quantitative relationships to oceanic fronts in a context of prey availability and oceanographic properties. We will use clustering analyses to determine influence of prey availabilities and oceanographic variables on seabird community structure as well as
generalized additive models to relate seabird abundance to ocean productivity, sea surface temperature, bathymetry, and prey availability. In this way we hope to understand how bottom-up factors influence prey availability and hence seabird presence around frontal structures in the southeastern Atlantic Ocean. We predict; (a) seabird community structure to be driven by seasonal biophysical oceanographic dynamics and (b) species-specific foraging strategies to be important factors determining the at-sea distribution of seabirds.

The objectives of this study were:

1. Collect data for SA@S to identify possible ocean hotspots, which might qualify as future marine protected areas, as well as analyse long-term seabird population trends.
2. Characterize spatial and temporal patterns of seabird composition and along return transects between South Africa and Antarctica during both summer and winter.

3. Determine whether seabird density and species composition is defined by distinct biological (e.g. chlorophyll-a, productivity, zooplankton distribution) and physical (e.g. bathymetry, sea surface temperature) properties and if the importance of these properties is specific to certain foraging strategies.
4. Analyse if the relative influence of frontal structures on seabird at-sea varies during summer and winter.

Methodology

Flying and sitting birds were identified within 10 minute-length transects from the monkey-island, only while the vessel was in motion (>10 knots). Date, time, weather conditions and beginning and end GPS points were recorded. The count area was determined using the angles of observation (either 90° or 180°) and distance from the ship (between 50-300m) for each transect. Each bird encountered, excluding "ship-followers" or birds that appeared attracted to the vessel, was identified and counted.

Preliminary results

A total of 5323 birds of 30 different species were observed in 450 10-minute survey transects within the first 14 days of the voyage (Table 1). The average number of birds observed per 10-minute transect per day ranged from 0.4 to 39. The ice shelf was reached on 3/8/2015 at which point the return journey commenced

Table 12.1. Preliminary seabird species abundances sampled within 10-minute survey bins from 24/7/2015 to 7/8/2015.

	24/7	**25/7**	**26/7**	**27/7**	**29/7**	**30/7**	**31/7**	**1/8**	**2/8**	**3/8**	**4/8**	**5/8**	**6/8**	**7/8**
Start latitude	-34.636	-36.247	-38.634	-41546	-43.866	-45.697	-47.383	-50.397	-53.451	-56.407	-53.620	-52.132	-44.190	-40.694
Start longitude	15.235	13.286	11.741	9.712	7.641	5.917	4.226	1.112	0.000	-0.056	-0.002	-0.001	0.005	0.078
End latitude	-35.259	-37.406	-39.590	-41.665	-45.002	-45.990	-48.333	-50.449	-55.015	-55.624	-52.173	-47.434	-42.675	-39.058
End longitude	14.045	12.523	11.074	9.616	6.563	5.608	3.266	1.058	0.000	0.002	0.000	0.000	0.002	0,366
Antarctic Petrel					1	26	35			4	4	5		
Atlantic Petrel				5									18	6
Atlantic Yellow-nosed Albatross	1													
Black-browed Albatross	15	8	9	2	1								8	4
Blue Petrel	1		1		85	14	39		8		26	3	25	1
Great-winged Petrel	7	34	6	2	1	0	1	1				1	5	2
Grey Petrel			4	4									17	
Grey-backed Storm-Petrel														2
Grey-headed Albatross	1	6	4	5	8	3	5					6	3	3
Indian Yellow-nosed Albatross			1											
Kerguelen Petrel					34		4		6	2	11	5	11	
Light-mantled Albatross				1	3		1							1
Little Shearwater		14	9	1	1			1			1		11	2
Northern Giant-Petrel		2												
Northern Royal Albatross			1										1	
Penguin UnID										2	100			
Pintado (Cape) Petrel	17	3	10	2	1	7	3		1			2	2	
Prions (UnID)	759	371	1597	112	37	1	11					6	41	1330
Seabirds (UnID)				1	2		1					1	4	
Shy Albatross				1									1	
Snow Petrel										18				
Soft-plumaged Petrel	19	7										1	8	17
Sooty Albatross	1	5	7				1							
Southern Fulmar					37	10	31				17	5	1	
Southern Giant-Petrel					4	1			1	7		1	2	1
Southern Royal Albatross						2							1	1
Subantarctic Skua														2
Wandering Albatross		1	1			1								
White-headed Petrel		4	37	9	1								19	6
Total birds	821	455	1687	145	216	65	132	2	16	33	159	36	178	1378
Number of transects	41	39	43	11	35	14	49	3	39	24	31	33	44	44
Average birds / transect (10 mins)	20	12	39	13	6	5	3	1	0.4	1	5	1	4	31

Future suggestions:

1) We would like to suggest basic windscreen wipers for the observation box. Continuous rain and snow made observation conditions very difficult likely leading to errors and bias. While every effort was made to keep windows clear through manual wiping, effects were short-lived (a few seconds) leading to losses in valuable sampling time and regions. While in some conditions it was possible to observe from outside, in conditions with prevailing winds hitting the ship front-on, snow, frozen rain and rain drops in the eyes made observations impossible.
2) There are several leaks in the observation box, which drip on the desks. It would be great if this could be made a dry area so that equipment, notes and computers remain dry during observations.
3) Please make passengers aware of the noise and foot activity impacts on the bridge at the beginning of the cruise so this can be minimised.
4) If at all possible, integrating updated station details (ie order of samplings, depths, estimated times on station etc.) on a simple screen on the information system so that this can be accessed from screens across the ship. At times this information was difficult to source often with differing information from different people.

Reference: Wanless, R. 2014. Protocol for data collection for density and distribution data using all platforms of opportunity (http://seabirds.saeon.ac.za/docs/sabap2_pelagic_protocol_final.pdf)

18. South African weather Service

Scope

The purpose of this report is to supply feedback on the voyage undertook and to familiarise the reader with the functions of the South African Weather Service on board the SA Agulhas II.

Personnel

SAWS Representative: Miss Robin-Lee Burger, Senior Meteorological Technician, Cape Town Weather Office.

Voyage Schedule

The voyage was scheduled to commence on Monday, 20 July 2015, but due to unforeseen circumstance we only left the harbour on Wednesday, 22 July, just after midnight. As per plan we used the GoodHope line from Cape Town and will bereturning on the Samba line back to Cape Town. We arrived at the final outbound stop at +/-55°

South on 3 August before turning back. The arrival date is still according to schedule and we are set to dock on Friday, 14 August 2015. Very very good news to some ☺

Pre Departure Preparations and Training

I had recently done the SANAE Takeover voyage from December 2014- February of this year, thus there was no need for training on how to perform the sea state observations- which is our core function when doing voyages. The cloud and weather observations is of second nature to me as this is what I do on a daily basis, however it is quite difficult to determine cloud base and horizontal visibility (if poor) due to no parameters or landmarks at sea but we do our best- also the coding allows for a broad range to work with w.r.t cloud height and how far one can actually see.

Voyage details

Surface Synoptic Observations

I was the only person on this voyage thus I was only able to do the day observations: from 06Z to 18Z- All main and intermediate Synoptic hours (every 3hours). I did the 00:00Z Synop on nights when I did the Upper Air.

What is meant by weather Observations?

On board the ship is a weather station that records Temperature, Humidity, Air Pressure, Wind Speed and Wind Direction on a 24/7 basis from automated instruments. Our instruments are supplied and maintained by an independent provider, InterMet International, and uses Vaisala instrumentation (more information on these instruments can be found on www.vaisala.com).

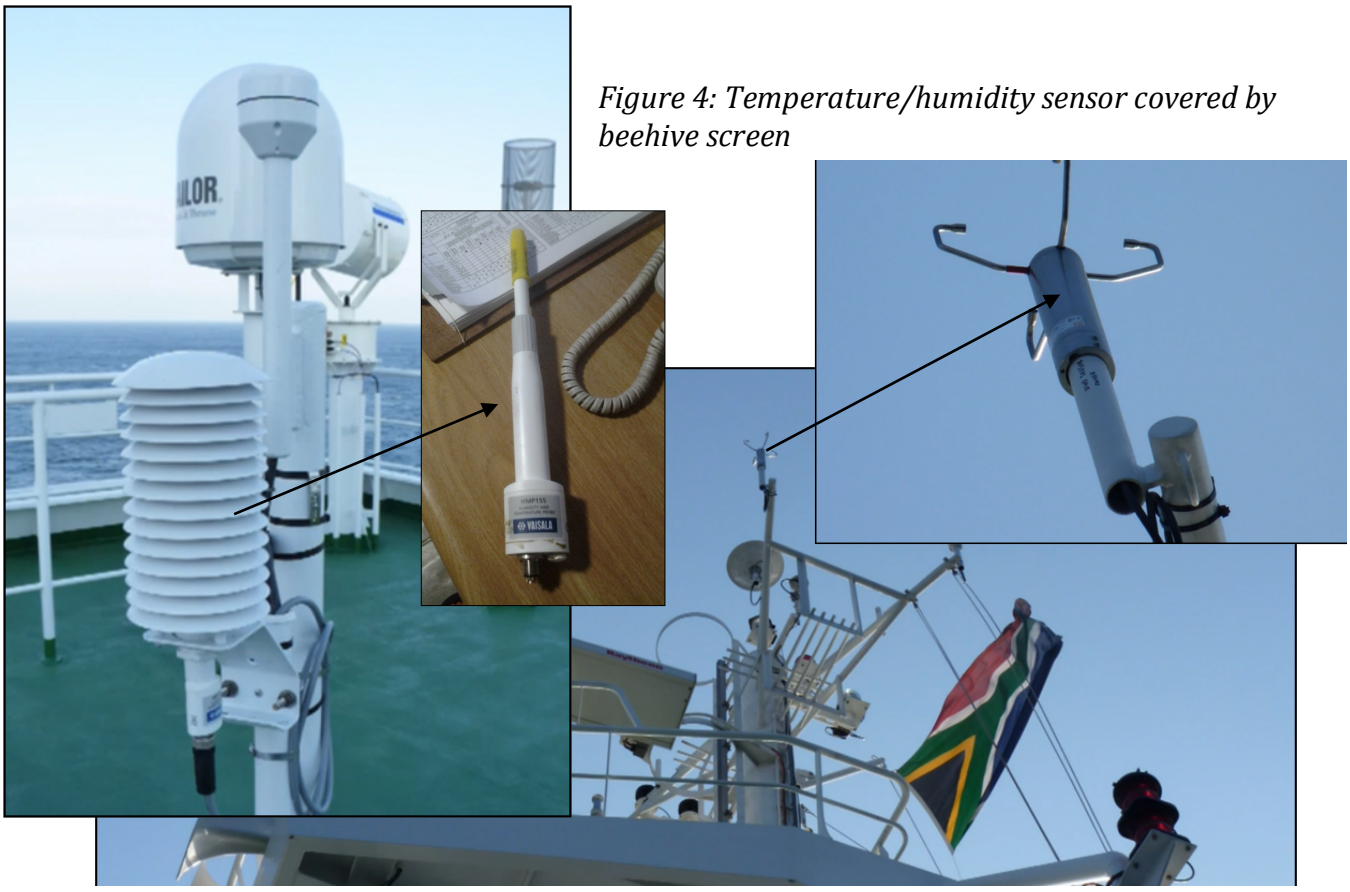


Figure 4: Temperature/humidity sensor covered by beehive screen

The observation part is where the human component comes in to do the actual physical observations of the sky and sea state. This information is coupled with the automated data and generated by a special programme written for the ship to generate the SYNOP code. The SYNOP code contains the information of the current weather of the position of the ship:

SMVA01 FZSC 030000
BBXX
ZSNO 03004 99557 30000 41997 81503 11035 21049 40007 51013 7<u>7</u>6<u>7</u>7 8000<u>7</u>
22200 01011=

Above we have a coded Synoptic report which contains:

- The date and time of the report: 00:00Z on 3 August.
- It states that the report comes from a sea station and the Vessel name/ call sign: ZSNO
- The current latitude and longitude the ship is on, also which quadrant of the world the ship is in.
- Wind information: Speed and Direction.
- Temperature data: Air and sea surface temperature.
- Horisontal visibility and what weather phenomena has reduced it, if applicable.
- The current weather, whether significant or not- There is 100 different weather codes.
- The weather history for the previous hour up to the past 6hours.
- Cloud height, cloud amount & cloud type- There is 27 different cloud types of importance.
- The pressure reduced to sea level and the amount in hectopascal the pressure has risen or dropped in the past 3hours.
- Lastly sea swell and windwave height, period and direction.

A very rare weather phenomena occured on this night. It is called ***diamond dust*** and listed as weather code "76" in International Meteorological terms. It literally looks like floating glitter in the air and mostly occurs in the Arctic and Antarctic regions where the air temperature must be well below 0°C (the air temperature on this night was -3.5°C) and falls from either clear skies (due to mixing of the cold polar air near the surface and the warm air above the ground) or the Cirrus cloud type known for its halo around the moon or sun: Code/type" 7" high cloud named CirroStratus (as reported)- A thin, fibrous veil or sheet of cloud which is characterized by the halo phenomena around the moon or sun-which was the case on this night.

The first 2weeks of the cruise I had several students from different Universities who came to shadow me for a day to see what we do on the ship. Below is a picture of me with some of the guys who came to pop in while I explain Weather and SYNOP coding to

them:

Figure 6: Students Lusanda & Asanda (Rhodes University), CSIR Technician: Sinekhaya

Upper Air Soundings

"The weather balloon" is what in Meteorology terms means "Upper Air" because it measures the weather data in the upper levels of the atmosphere, the balloon is filled with helium gas to a certain weight (in order to lift the instrument). The instrument we attach to the balloon is called a Radiosonde- which measures Temperature, Humidity, Pressure and Wind Speed & direction in the upper levels up to a height of 25-30km and ascents for up to 90mins until the balloon eventually bursts and drops in the ocean. It records the above mentioned real time data every minute at an average height of 330m per minute. We do not retrieve these instruments.

Upper Air data is used for input in computer models that assist in Weather Forecasting.

We had 2 Helium gas bottles for this voyage and I could do 8 ascents with it. I did the first 3 on the outbound leg and the next 5 during the inbound leg. I experienced no trouble with software and/or data retrieval and also no failed ascents and no faulty radiosondes. I submitted the raw data manually via Comms in instances where it was not available.

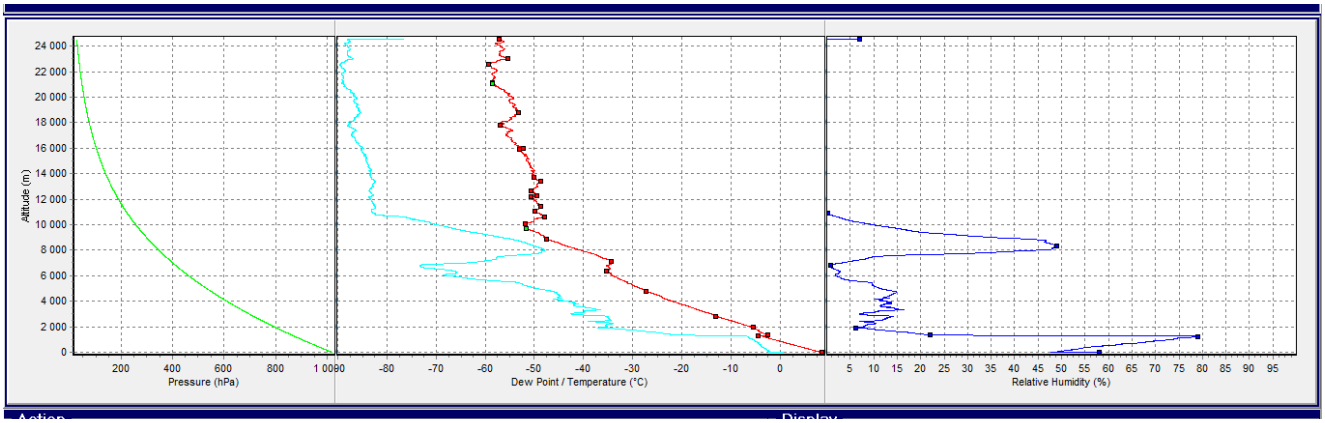
Find below an example of raw data followed by sample graphs of what the actual data looks like:

File Edit Format View Help

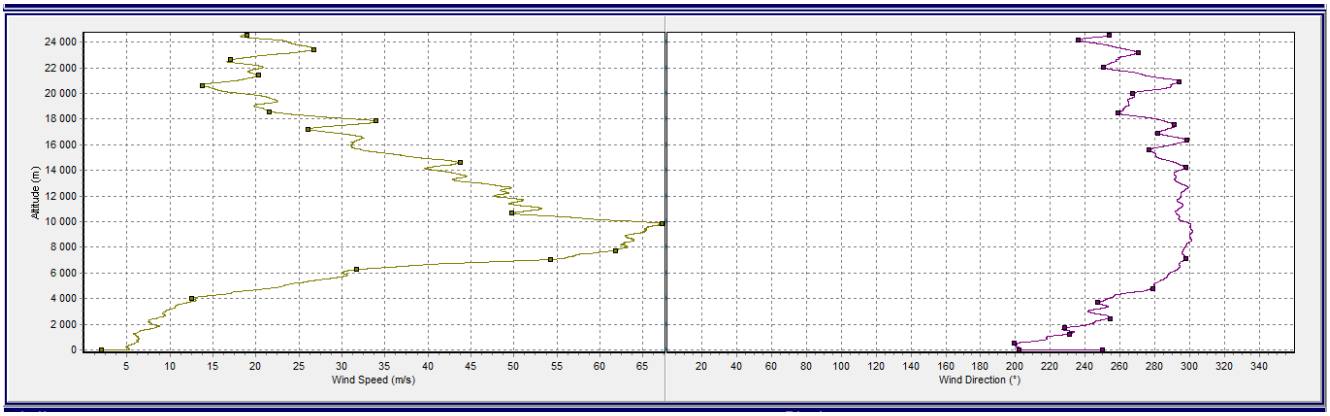
SIGNIFICANT TEMPERATURE AND HUMIDITY LEVELS

Press hPa	Temp °C	RelHum %	GPM_AGL m	WSpeed m/s	WDirn °	Time s
1020.1	+8.5	58.0	0	2.0	250	0.0
873.9	-3.6	79.1	1249	5.8	231	226.0
870.6	-4.6	66.6	1279	5.9	232	231.0
862.4	-2.5	22.7	1354	6.3	233	244.0
861.8	-2.6	22.0	1359	6.3	233	245.0
803.2	-5.4	6.2	1914	8.5	239	345.0
800.2	-5.5	6.7	1943	8.2	240	350.0
714.2	-13.2	13.9	2822	9.2	246	514.0
548.3	-27.2	14.6	4778	21.3	278	862.0
439.0	-35.4	2.7	6351	33.5	293	1150.0
408.6	-34.8	0.9	6852	47.0	295	1240.0
391.2	-34.3	5.5	7157	55.9	298	1295.0
330.4	-43.5	49.0	8316	62.7	299	1522.0
305.0	-47.5	43.7	8851	63.1	300	1631.0
267.2	-51.7	14.9	9718	66.6	301	1813.0
251.6	-51.9	8.1	10108	61.3	295	1895.0
231.9	-48.0	2.1	10640	49.8	292	2014.0
223.5	-49.0	0.1	10883	52.3	293	2064.0
217.3	-49.9	0.1	11066	53.2	295	2101.0
206.2	-48.7	0.1	11411	49.5	295	2177.0
183.9	-50.7	0.1	12159	48.8	295	2336.0
180.2	-49.4	0.1	12291	49.3	295	2365.0
170.0	-50.6	0.1	12673	49.5	299	2452.0
152.1	-48.6	0.1	13402	43.6	292	2615.0
145.3	-50.2	0.1	13699	43.6	291	2676.0
103.8	-53.0	0.1	15883	31.1	285	3116.0
101.8	-52.2	0.1	16014	31.2	290	3143.0
77.0	-57.0	0.1	17799	34.0	286	3485.0
66.2	-53.1	0.1	18760	21.0	262	3663.0
45.9	-58.5	0.1	21097	18.5	290	4088.0
36.4	-59.2	0.1	22549	16.8	258	4342.0
33.9	-55.4	0.1	23008	21.5	266	4427.0
26.6	-57.2	7.0	24543	19.0	254	4689.0

Figure 0-4 Raw weather data from balloon ascent



Graph 1: Pressure, Temperature & Humidity profile



Graph 2: Wind speed and direction profile

Communication or technical errors

We had our fair share of internet trouble again but the SYNOPS were submitted to Comms as soon as we came online again. On Tuesday evening, 11 August, the wind sensors started to malfunction. It was displaying calm winds when physically it was not the case (also in comparison to the ships wind data). I reported it to Peter Roux (Senior Data Technologist) and will monitor it till we dock. Where necessary I will make use of the ship's wind data for the SYNOPS.

Buoy Deployment

Drifting weather buoys are instruments which collect weather and ocean data within the world's oceans, it measures parameters such as air temperature above the ocean surface, wind speed and direction and barometric pressure. Since they drift in oceans, they also measure sea surface temperature, wave height, and wave period. Raw data is processed and can be logged on board the buoy and then transmitted via satellite communications.
This data can be used for weather forecasting as well as research and climate studies.

Drifting buoys measures +/- 30cm in diameter. They are made of plastic or fiberglass, and tend to be either bi-colored, with white on one half and mostly blue or black on the other half of the float. It has a temperature sensor on its base, with the barometer measuring pressure in a tube on its top. An underwater drogue is located 15 metres below the ocean surface connected with the buoy by a long, thin tether.

Figure 0-6: The drifting weather buoy

We had 5 drifting weather buoys for deployment on this voyage. Positions for deployment supplied by the Senior Scientist, Mr. TK Rashelomi, was aligned more or less with the other scientific stops/positions for CTD's and other instrumentation that was deployed/retrieved during the cruise (see buoy deployment table on page 9).

A special note of thank you to the crew who helped with most of the deployment.

Figure 0-7: Deployment of the first weather buoy

Buoy ID	127358	Buoy ID	132586	Buoy ID	127353
Date	24-07-2015	**Date**	25-07-2015	**Date**	27-07-2015
Time (GMT)	14:30Z	**Time (GMT)**	14:15Z	**Time (GMT)**	13:55Z
Latitude (DD°mm.mm')	35°10'34" S	**Latitude (DD°mm.mm')**	37°20'57" S	**Latitude (DD°mm.mm')**	41°22'83" S
Longitude (DD°mm.mm')	14°09'29" E	**Longitude (DD°mm.mm')**	12°33'73" E	**Longitude (DD°mm.mm')**	09°51'19" E
Air Temp	13.6	**Air Temp**	10.8	**Air Temp**	7.9
Sea Temp	15.1	**Sea Temp**	13.8	**Sea Temp**	12.1
QNH	1031.5	**QNH**	1032.3	**QNH**	1016.9

Buoy ID	127352	**Buoy ID**	132631	**Buoy ID**	
Date	08-08-2015	**Date**	30-07-2015	**Date**	
Time (GMT)	18:50Z	**Time (GMT)**	21:45Z	**Time (GMT)**	
Latitude		**Latitude**		**Latitude**	

(DD°mm.mm')	34°30'00" S	**(DD°mm.mm')**	46°48'10" S	**(DD°mm.mm')**
Longitude (DD°mm.mm')	00°00'00"	**Longitude (DD°mm.mm')**	05°34'77" E	**Longitude (DD°mm.mm')**
Air Temp	11.9	**Air Temp**	6.7	**Air Temp**
Sea Temp	17.0	**Sea Temp**	5.6	**Sea Temp**
QNH	1025.7	**QNH**	998.6	**QNH**

Table 1: Buoy Information

Conclusion

I think it is safe to say that yet another successful voyage made its way to the record books. Once again, I would like to thank all parties involved for making this a definite experience of note and really a memory to treasure forever.

19. ACEP phuhlisa/SAIAB team

Senior member: Dr Tshoanelo Miya
Students: Miss Asandiswa Nonyukela, Miss Lusanda Gxalo and Mr Ayabolela Mrubatha

Objectives for joining the cruise:

1. To collect fish larvae in the waters of the Southern Ocean.
2. For the students to get exposed to different researches conducted in the Southern Ocean.

19.1. Collection of fish larvae

The life history of several notothenioid fishes that are widely distributed around the Southern Ocean is not well studied. Previous studies have concentrated on the life history of notothenioids that a found in the Antarctic region, south of the Antarctic Polar Front (APF) (Kellermann & Kock 1984; Ruzicka 1996; La Mesa & Ashford 2008; Matshiner et al. 2009). There is little or no information for the notothenioids that are found in the sub-Antarctic region, north of the APF, especially species that are also found in the Antarctic region. Therefore, we aimed to collect larval stage of these fishes during the cruise, in an attempting to provide more information and understanding. Since the cruise provides opportunity to collect from both sub-Antarctic and Antarctic regions, the data might provide a better understanding regarding the distribution of notothenioid species on both side of the APF.

Collecting method: Since the larval stage of most notothenioid species is planktonic (di Prisco et al. 2007), it was arranged that I will go through the 200 um double bongo net and drift net aimed to collect zooplankton and ichthyoplankton, respectively. The bongo net collected samples between 50 and 150 m depth and drift net at approximately 5 m.

Water samples were also collected from the Niskin CTD at different depths (200 and 120 m), to check if they contain any larvae. Samples were collected in different stations along GoodHope and SAMBA lines (Table 1). Collected samples were examined under dissecting microscope to identify whether they are fish larvae or something else, and were stored in -20^{O}C freezer.

Collected samples*:* No fish larvae were collected in the Southern Ocean region (Table 1). The first fish larvae samples were collected at the SAMBA line station_Voy016-807 (34^{O} 29.8130'S; 15^{O} 00.116'E) near Cape Town. At the previous station_Voy016-805 (34^{O} 29.9990'S; 11^{O} 12.185'E), two juvenile myctophid fishes (Figure 1) were collected, and the fish larvae might belong to the same species as these two specimens. On the other hand, number of krill specimens and few krill larvae were collected at several stations along GoodHope and SAMBA lines. At the stations where collection was done at night or early hours of the morning, high numbers of krill were observed. This is consisted with the fact that at night krill accommodate waters near or at the surface. All these samples were collected by net haul and nothing was collected from the bongo net and CTD.

Table 1. Station numbers and number of specimens collected

Date	Ship's Station no.	Latitude	Longitude	Collection method	No. of specimens	Species/Specimen name
24.07.15	Voy016-701	35^{O} 15.6358'S	14^{O} 02.6372'E	Net haul	1	Larva (not fish)
25.07.15	Voy016-702	36^{O} 13.214'S	13^{O} 18.106'E	Net haul and CTD	Nothing	-
25.07.15	Voy016-703	37^{O} 24.4860'S	12^{O} 31.0990'E	Net haul and CTD	1 in the net and nothing from CTD	Larva (eel)
26.07.15	Voy016-704	38^{O} 36.0990'S	11^{O} 45.7650'E	Net haul	±10	Krill and larva (not fish)
27.07.15	Voy016-706	41^{O} 20.475'S	09^{O} 53.2060'E	Net haul	±30	Krill
28.07.15	Voy016-707	42^{O} 41.4787'S	08^{O} 44.1504'E	Net haul	±30	Krill
29.07.15	Voy016-708	45^{O} 00.115'S	06^{O} 33.773'E	Net haul	1	Larva (not fish)
30.07.15	Voy016-709	46^{O}S	06^{O}S	Net haul	Nothing	
01.08.15	Voy016-710	50^{O} 26.991'S	01^{O} 03.390'E	Net haul	Nothing	
02.08.15	Voy016-	56^{O}S	0^{O}E	Net haul	1	Larva (not fish)

04.08.15	Voy016-AM00429	54^{O}S	0^{O}E	Net haul	±10	Krill and larva (not fish)
08.08.15	Voy016-802	34^{O} 30.129'S	00^{O} 00.021'E	Net haul	±10	Krill
09.08.15	Voy016-803	34^{O} 29.9240'S	03^{O} 43.146'E	Net haul	Nothing	
10.08.15	Voy016-804	34^{O} 30.4220'S	07^{O} 27.032'E	Net haul	±10	Krill
11.08.15	Voy016-805	34^{O} 29.9990'S	11^{O} 12.185'E	Net haul	±20	Krill and fish
12.08.15	Voy016-806	34^{O} 29.945'S	14^{O} 38.378'E	Net haul	Nothing	
12.08.15	Voy016-807	34^{O} 29.8130'S	15^{O} 00.116'E	Net haul	±5	Fish larvae ☺

Fig 1. Juvenile myctophid fishes collected at ship's station number Voy016-805

***Challenges*:** There are two main possible reasons for being unable to collect fish larvae; 1) the collecting methods used might not be effective for collection of fish larvae. For example, the standard double bongo mesh size used for collection fish larvae is 500 um, while in the cruise only 200 um mesh size was available or used. Also, the CTD tap was too thin such that there is a possibility that the larvae were sieved when the water comes out. 2) Since most notothenioid species inhabit shallow waters, it is therefore possible that their larvae are not present in the open sea waters.

19.2. Student experience

Three ACEP phuhlisa honours students from Fort Hare University were given an opportunity to be part of this winter 2015 cruise. This cruise exposed them to different research activities that are taking place in the GoodHope and SAMBA lines. Programme was drafted for them (and I was included) to get opportunity to be involved or observed what different scientists are doing (Table 2). After they have been to all stations,

students choose one station of their interest to work or assist for the duration of the cruise. Below is students' report and experiences.

Students report

Boarding the ship on Monday morning, we didn't know what to expect. All we knew and sure of was that the SA Agulhas II was a beauty and ten times bigger than what we expected. We were eager to leave on Monday but were delayed, when the ship finally left the harbour, the sea sickness came rushing. We were all sick for a couple of days; it took a while for us to settle into the ship and its unpredictability. Soon after this our rotations started, where we got to visit some of the scientists' stations to see what they were working on and to assist them were possible.

Table 2. Programme for SAIAB students

Date	Warren	Sandy T	Thato	Mtshutshu	Mike	Isabelle	Robyn-Lee	Sandy S
26-July-15	Tshoanelo	Asandiswa	Ayabulela	Lusanda				
27-July-15		Tshoanelo	Asandiswa	Ayabulela	Lusanda			
28-July-15			Tshoanelo	Asandiswa	Ayabulela	Lusanda		
29-July-15				Tshoanelo	Asandiswa	Ayabulela	Lusanda	
30-July-15					Tshoanelo	Asandiswa	Ayabulela	Lusanda
31-July-15	Lusanda					Tshoanelo	Asandiswa	Ayabulela
01-Aug-15	Ayabulela	Lusanda					Tshoanelo	Asandiswa
02-Aug-15	Asandiswa	Ayabulela	Lusanda					Tshoanelo

Stations

We visited Ms Robyn-lee, who works for the SA Weather Service, at the weather station. On our visit, we went to the ship's bridge where she recorded the wind direction and estimated the wave length. We then went outside to identify and record the type of clouds as well as the other weather condition present. All these parameters were computed as part of a report of a day's weather conditions, which was presented in a number sequence that could be universally translated by other weather services. This process was repeated every three hour and the collected data contributed to forecast data. Robyn also periodically released the weather balloon into the atmosphere where it also measured parameters which would assist the weather services in constructing models for weather forecasts.

We understand that high concentrations of organic nutrients alone do not lead to high productivity. In high nutrient and low chlorophyll water, Iron is a limiting factor of

ocean productivity and chlorophyll need a large amount of iron for photosynthesis. This was learnt at Dr Thato Mtshali's station. At this station water samples from the Geo Tracer CTD were collected and passed through a Luminol solution and the iron concentrations were analysed. The iron concentrations were then related to the productivity on that particular station to conclude whether or not the iron was a limiting factor in the productivity.

At the wet biology lab we met Ms Sandi Smart who explained that Nitrogen (N) isotopes could be used as a tool to study changes in the oceanic budget and cycling of fixed N. For her PhD she would use foramnifera shells, species of zooplankton, from which nitrogen isotopes would be extracted and analysed. We were able to help her collect some of the underway samples which were filtered for zooplankton. After filtering, some of the filters containing zooplanktons were placed in vials and low nitrate water were added and fixed in 10% formaldehyde and then frozen for preservation. Other filters were wrapped in a foil and were also frozen. None of the underway samples were analysed during this cruise. We also observed the collection of zooplankton by the net tows. Collected samples were run through the sieve meshes with different sizes (5000, 2000, 1000, 500, 250, 150 um) to measure the size fractioning.

We also got to work with Dr Sandy Thomalla who taught us about the tiny little plants of the ocean (phytoplankton). Sandy and her team conduct a number of different experiments that are aimed at studying the different kinds of phytoplankton that exist (by looking at the different pigments) in the Southern Ocean, their productivity and their ability to absorb light. They further compare their data with that of the satellite. We also worked in one of the coolest labs ever, "The red room", here we helped filter sea water, which may sound easy but it wasn't because we constantly had to cross fingers for the sea water not to run out before we could collect all the samples. Each filter was then place in a freezer to be checked later for the presence of phytoplankton and the calculation of absorption.

We worked with Prof Isabelle Ansorge who explained to us a little bit about oceanography. We assisted with collecting water samples from the niskin CTD, which collects water samples from the sea at different depths as one of her students explained. The students further explained that as the CTD goes down to a specified depth (1500 to 4000 m), it measures temperature, salinity and density of the water at different depths. These data will then be compared to the one collected during last year's summer cruise to observe if there are any differences or similarities between these two seasons. Water samples collected by the CTD are also used other scientist on board for their different researches such as calculation of the amount of oxygen, pCO2, dark matter (bacteria), nitrogen and its various isotopes etc.

Dr Warren Joubert and Mr Mutshutshu Tsanwani gave us some insight on CO_2 accumulation in the atmosphere and its effects on ocean acidification and climate change. Their stations focused mainly on determining CO_2 concentration and sea water alkalinity in the Southern Ocean. Through this experience we learnt how to measure DIC concentrations and total alkalinity of the water using a VINDTA.

After our rotations Asandiswa chose to work with Ms Sandi Smart at the zooplankton station, Ayabulela chose the CO_2 and nutrient station with Mr Mutshutshu Tsanwani, and Lusanda chose to work with Dr Sandy Thomalla.

Individual stations

Asandiswa (Asa): Meeting Sandi Smart was a great experience. I learnt the importance of the Nitrogen cycle in the ocean and learnt the basis of her PhD project and its importance. After the literature review and introductions, it was time to dive into the work. At this station I learnt the importance of zooplankton identification and learnt the different methods of collection. To maximize collection, in addition to the net tow samples, underway samples were done, where the water was filtered with different sizes and kinds of filters and these filters were fixed and frozen for analysis later. Water samples were also collected to get an idea of the water profile and nutrient availability at that particular underway station. Having experience in freshwater and estuarine zooplankton sampling' I got to learn how different the sampling method was in Open Ocean. I had many questions for Sandi, which she gladly answered and made me thoroughly understand her project. I remember asking how come she did not do net tows in the middle of the night, she answered sadly that there were safety regulations that were to be followed and sampling at night was against the ships rules. I got the opportunity to behands on at my station and learnt different sampling techniques. While in the wet lab I met Preston and Ethan (both from USA), who were also collecting water samples from the CTD niskins for Prestons project.

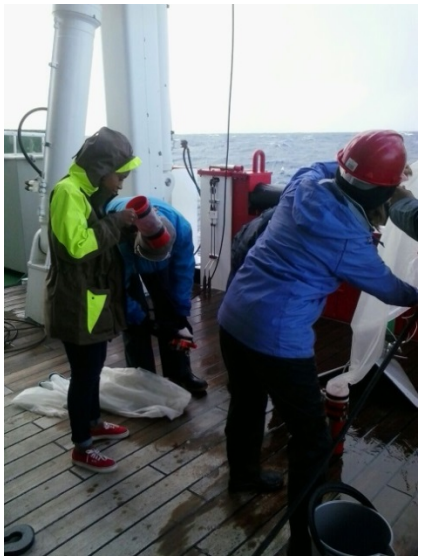


Fig 2. Asa collection samples from the bongo net

***Lusanda*:** I chose to work with Sandy because I did botany during my undergrad and therefore I understood a lot about phytoplankton of which she was working on. I learnt few more interesting stuff as I got to help her; which included: (1) we can distinguish the different kinds of phytoplankton not by looking at them under a microscope but by looking at the different kinds of pigments they absorb e.g chlorophyll, carotenoids and phycobilins. I got to help Sandy calculate absorption from the samples she had using a machine that also formed a graph that shows which pigment has been absorbed by the phytoplankton in each sample using their wavelengths and in turn this information can be used to determine which kind of phytoplankton are mostly dominate in the South Ocean. (2) When I was working with sandy the samples were already prepared, fortunately I worked with Joshua who is part of Sandy's team and helped him collect sea

water from a CTD during nishkin 7 and filtered the water for samples. It might sound quite easy but it was a nail biting experience because we needed to used 200ml of sea water for each sample (total of 8samples), we also needed to use the same water to clean the bottles three times before and after every use to prevent cross contamination, which meant there is possibility of running out of water before finishing the sample collection. Samples were then placed in a freezer at -80^{o}C for preservation of plankton samples for subsequent shore-based stable isotope analysis, which I also briefly got to help another student who was part of Sandy's team perform. Why bother studying phytoplankton in the ocean though? I asked myself, and from what I've learnt throughout this cruise is that global warming is not just that thing we learn about at school, it is real and yes "the earth cools and warms up all the time it is nothing new" as some would say but never at this rate, we have increased the process and now we need to find ways to decrease it and this is where phytoplankton fit it. Phytoplankton absorb CO_2 in the water during photosynthesis which in turn decreases the amount on CO_2 that will eventually go back to the atmosphere and therefore it is important to make sure the phytoplankton are always "happy" as Sandy would say. Some of the things that would affect them would be the presence of suspended particles in the water, which affects the amount of light that reaches into the water which therefore decreases photosynthesis. I unfortunately did not get the chance to work with Sandy as often as I would have liked to. I am extremely grateful for the experience though and happy about all the knowledge I have gained, before this cruise I had no idea what an XBT, CPIE or CTD was but now I do.

Fig 3. Lusanda assisting with cleaning the tubes for collection of samples.

***Ayabolela (Ace)*:** Based on literature, CO_2 accumulation in the atmosphere is one of the major environmental concerns. The rapid accumulation of CO_2 in the atmosphere is mostly due to various human activities which include fossil fuel combustion, industrial emissions, forest clearing, etc. These emit about 1 billion tons of carbon in the form of CO2 into the atmosphere annually and about half of this is absorbed by the global ocean. This was all learnt at the VINDTA station, the aim of their study was to determine CO_2 concentration and sea water alkalinity in the Southern Ocean. The VINDTA was used to

measure DIC concentrations and total alkalinity of the water samples obtained from a Good hope line and the SAMBA transect in the Southern Ocean. The samples were obtained from different oceanic depths and were used to determine the amount of CO_2 present and to also assess the pH of the water at these depths. The samples are obtained using niskin bottles attached to a CTD rosette. We were able to learn how to run samples on the VINDTA and help with the collection of the water samples.

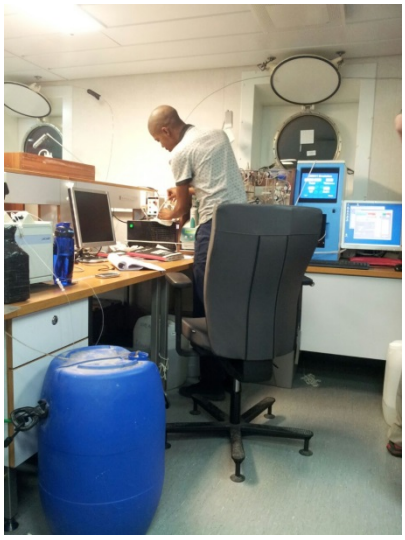


Fig 4. Ace run samples on the VINDTA

Highlights

Some of the highlights of the cruise include collecting samples from the CTD's and mid collection someone opens a niskin bottle and the water splashes everywhere, those were some good times. Watching the release of the weather balloons was always an event to look forward and wondering what will eventually happen to the balloon. The XBT firing was also an awesome moment for us, each of us having a different story to tell about the day.

Challenges

The biggest challenges for us were the oceanography terms that were regularly used. During the first presentations, they mentioned CTD's, CPIES, and XBT's, all abbreviations we had never heard before and sounded very technical. The other challenge was the sea sickness for two days, which was not a nice feeling and it limits one to their cabin.

References

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20. Winter 2015 Wash up meeting

Friday 21 August, SA Agulhas II

Present: Captain Gavin Syndercombe, Sandy Thomalla, Isabelle Ansorge, Marcel Van den Berg, Andre Hoek, Hendrik van Rensburg, Susanne Fietz, Raissa Philibert, Thato Mtshali, Warren Joubert

1. Actions emanating from the Marion 2015 Relief voyage

1.1. Follow Up On Moonpool Camera, Lights

This Action Is Sitting With Nish And Bigboy To Finalise.

1.2. Action On Rubber Skirting Under The Chemistry Lab Door

Done

1.3. Follow Up On Rapp And Upgrade Of The Winch Console Software

Got software / hardrive, action is being carried out

1.4. Monitors To Be Installed Over The Winch Array

Still to be done waiting for action on quote Due To The Cost ~R30k. Efforts are being made to reduce costs.

1.5. Investigate Adjusting The Environmental Hangar Door And Plankton Winch To Allow The Multinet Through The Hangar Door.

This has been looked at and appears promising. Weather was not especially conducive to testing proof of concept on Winter Cruise and issue will be addressed further on Gough trip. Following Gough a definitive call can be expected on whether it is a viable option or not.

1.6. To Locate Suitable Cupboard Hooks

Done

1.7. To Redirect Piping To The Pco_2 System In The Underway Lab

Action for Warren Joubert that still needs to be done.

2. CTD systems

- No obvious issues with CTD sensors
- O2 sensor on geotraces CTD a little off but was calibrated just before Marion
- Action point for Sandy to send Isabelle Dissolved Oxygen data to allow calibration of yellowCTD.
- Action point for Isabelle to calibrate DO sensor on yellow CTD
- Action point Sandy responsible for fluorometer calibrations on both CTD's
- All niskins good
- All go flos good
- Altimetre only kicked in at 25 m other times at 50m with miss daisy?
- Action point for Andre to test sensitivity of sensor and perhaps edit calibration settings.
- Geotraces frame is cracked.
- Action Point Thato: Frame needs reinforcement with another ring and/or additional sides. Frame needs to be re-welded and recoated soon to be in time for summer cruise.
- 3m of cable was cut off the Kevlar line at station CPIES 5.
- Winch consol: pressing numbers does not respond adequately. If emergency can get stuck. Solution: There is a sensitivity setting for the screen.
  Action point: Reset wire length calculation and sensitivity settings of panel.
  Suggestion: Hand over from bosan should be at 21m
- When changing winches operators need to be aware of winch that is engaged on the consol.
  Suggestions: 1/ list for operators where first step is to check which winch is engaged on the console and adjust if necessary
  2/Ask users of secondary winch to always switch back to primary winch after use.

3. Underway systems (SDS, ADCP, TSG)

- SDS: the map is excellent, data issues are all sorted,
  Action point: Andre - To create a link on STS website to the cruise data 1 and 10 min averaging.
  Action point: Marcel – to arrange a meeting with SDS map users to summarise user requirements for upgrade.
  Action point: Andre to check whether there is a network point in underway lab – done yes there is one but it was obscured behind the flow board.
- Suggestion: To Investigate opportunity to open up network bridge on router to allow SDS access in cabins.
- ADCP: all working fine
- PCO2: Suggestion that pCO2 is read into SDS data stream?
- TSG: all good

4. Scientific Sea water supply (contamination, pressure, ice, bubbles)

- Issue: contamination of scientific sea water supply
  Actions been taken: Opened up manifold, salty manifold deposit, elecrolisis

(ambient electrical field) Acid wash,
Action point: When in port to replace salt water with fresh water in pipes from pump to labs.
Action point: To get samples filtered on Gough trip to check contamination issue
Action Point: Sandy is getting filter analysed at Electron Microscope Unit at UCT

5. XBT

- Automatic XBT implemented and ran fine. Problems occurred with wind and waves. Location mount options are from heli deck and just outside the geolab lab even better (wind could blow wire onto poop deck). System will be up and running on SANAE. Heli desk wind could blow wire onto poopdeck. When conditions bad XBT will be run on manual which wil require at least 2 students on to still be on board for future cruises

6. CPIES (retrieval and deployment)

- Went very well. Given weather conditions. Challenging but fantastic support from offices and crew. One mishap on retrieval at station CPIES 3.

7. Gliders (deployment)

- Could have gone better. Release was too high and guide ropes released from either side of wave glider at separate times. We need Better protocol.
  Suggestion: Videos of what works and what doesn't work to come with a best practices deployment protocol document.
  Action Point – Andre: to put together deployment and retrieval protocol document with videos of good and bad deployments / retrievals

8. Zooplankton net

- Winch perspective all good. Please switch to CTD winch after use
- Temperature calibration needs to be look into

9. Milli-Q system (service, spares, additional system)

- Milli-Q system needs a service – Action Point Marcel
- Milli-Q needs a full setoff spares including all filters and UV light – Action point Marcel
- Milli-Q needs optimum level re-calibration for when it is full. – Action point Marcel
- Milli-Q system is not big enough to provide sufficient water for number of users:
  Suggestion: Move the larger milli-Q system from the container into the underway lab and relocate the current smaller Milli-Q system into the geo lab.

10. Points to note from correspondence:

Birders:

- Request for clearer visibility through glass and note of leaks in observational box

Response from Captain: leaks can and will be addressed. Fresh water supply possibility of hose on monkey deck to rinse windows. Current modifications to increase water pressure to get water up there. These two points will move someway to address issues.

- Integrating updated station details (ie order of samplings, depths, estimated times on station etc.) on a simple screen on the information system so that this can be accessed from screens across the ship. At times this information was difficult to source often with differing information from different people.
  Response: Plugging into SDS system with new map will help resolve this issue

Thato Mtshali:

- PAR sensor limitation to 2000m
  Response: It is hat it is, sensor has pressure limitation and needs to be removed for deep CTD's and added for shallow ones. If necessary separate shallow casts can be conducted if PAR profile is required.
- Acid waist
  HCL can be diluted and flushed.

Specific points or suggestions from my side:

- Calibration of TSG,
  Action point Isabelle - 18 underway salts need to be sent to Warren
  Action Point Warren – Generate a calibration curve for salinity sensor and send to Andre
  Action point Andre – When uploading SDS data to htp site on website need to include calibration slopes for salinity etc.
- De virus computers
  Action point - Marcel
- New ink in cartridges
  I need to ask the purser next time (not the technicians)
- Scientific sea water supply needed on heli deck for incubation experiments
  Action Point – Captain will investigate possibility of sea water supply outside of the lab.
- Suggestion: Repeat occupation of survey line recommended for increased opportunity of successful stations if weather debilitating