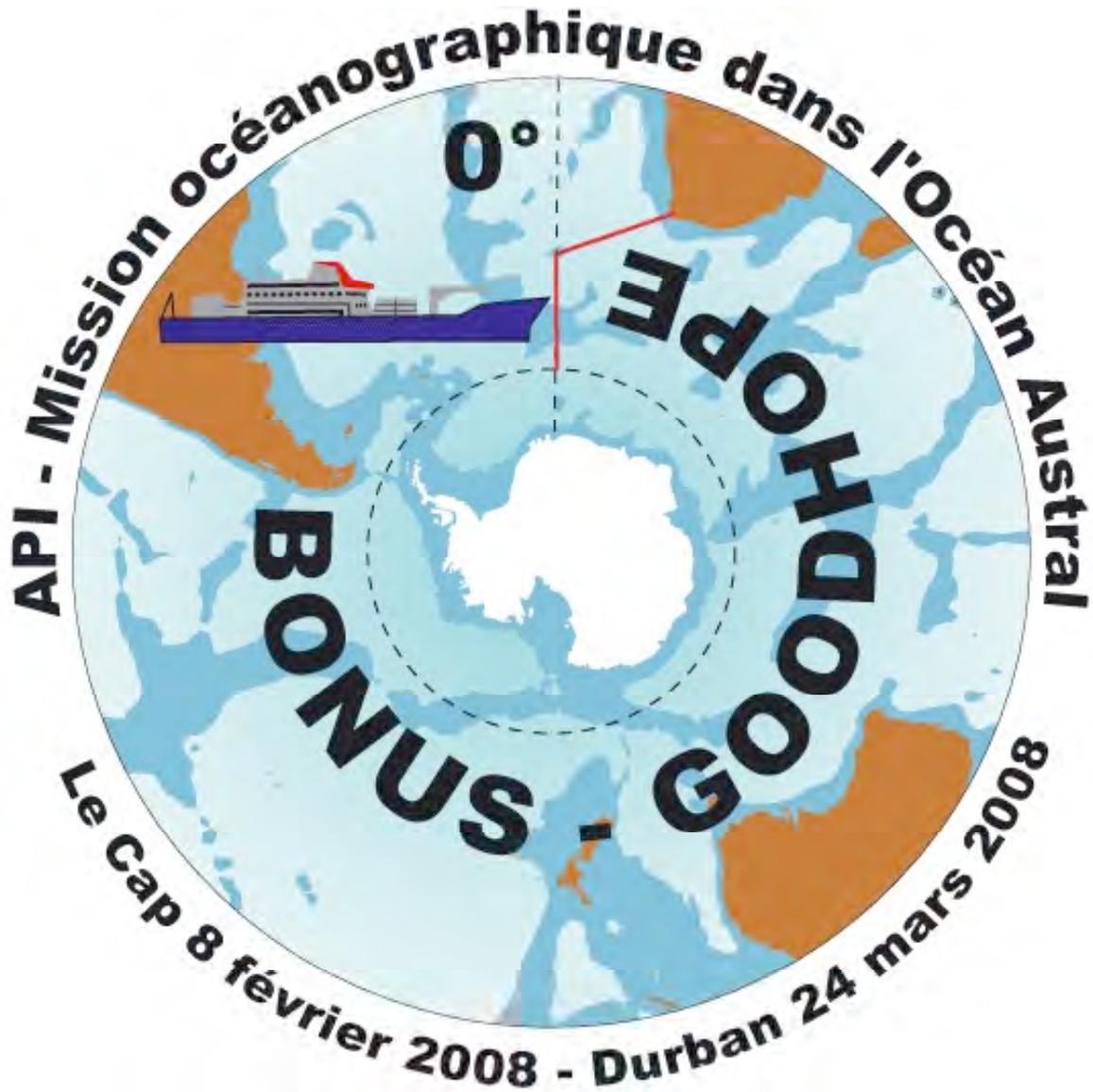


CRUISE REPORT

MD 166 BONUS-GOODHOPE



Cape Town, 7 February
57° 33'S 0°E 17 March
Durban 24 March 2008

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Chief Scientist: *Sabrina Speich*

Assisted by *Marie Boye & Frank Dehairs*

May 30, 2008

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Thanks to all scientific personnel who participated in the cruise. We wish to particularly thank Elodie Kestenare for her great help in following each observation made on board and variable measured to compile the cruise “Logbook”, very precious tool for all future BONUS-GOODHOPE data analyses.

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All the foreign teams have received support from their national programmes.

FOREWORD

This report is a compilation of the cruise narrative, observed variables, implemented equipment and preliminary results provided by the groups who participated to the cruise. Many operations were carried out and many variables were measured during the BONUS-GOODHOPE cruise. We tried to make this report as much exhaustive as possible.

1 GEOGRAPHICAL REGION OF OPERATIONS

The BONUS-GOODHOPE cruise took place on board of the French *R/V Marion Dufresne* in the South-West Atlantic and in the Atlantic sector of the Southern Ocean (the cruise track and stations are showed in the Figures 1 and 2 below). More specifically, it started on February 13 2008. Oceanographic operations have been undertaken from the shelf region just out of Cape Town harbour (at the isobath 200m), following the GOODHOPE-A21 repeated hydrographic section, and reached 57° 33'S along the Greenwich Meridian on the evening of March 15, 2008. Full water depth operations ended on March 17, at 1:45 pm (Local Time).

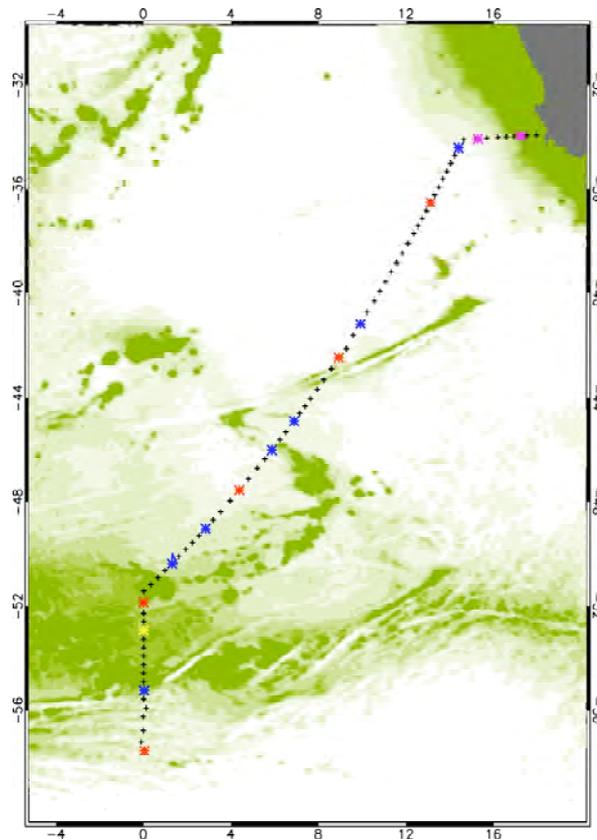


Figure 1 – Map of the BONUS-GOODHOPE transect. Each cross indicates the position of a station. Black crosses are for hydrological stations only. Blue crosses designate LARGE stations; Red crosses the SUPER stations. Pink crosses define the two C-PIES moorings deployed during the cruise. The yellow cross indicates the position of the intercalibration station.

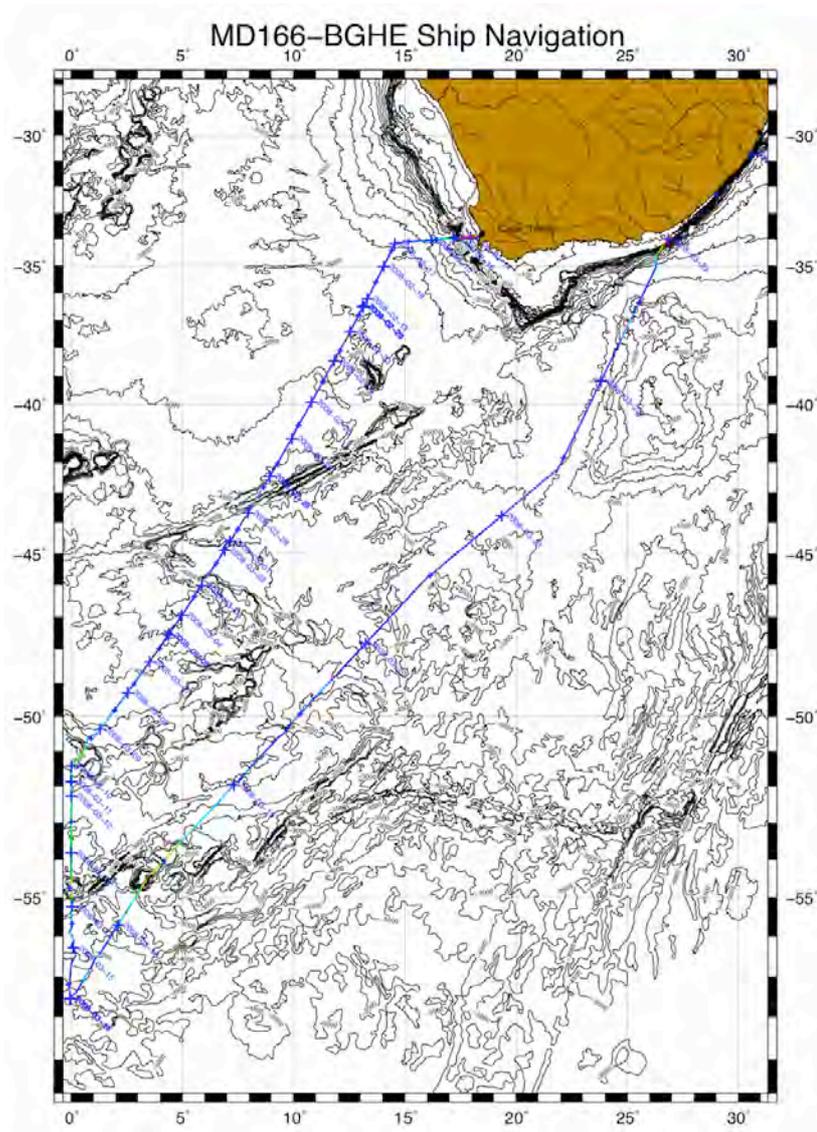


Figure 2 – Map of the BONUS-GOODHOPE transect. Dates are reported along the track.

2 CRUISE PARTICIPANTS



Picture of the BONUS-GOODHOPE cruise participants.

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3 COMPLETED RESEARCH

3.1 CRUISE OBJECTIVES REMINDER

The BONUS-GOODHOPE project in the region south of South Africa was built on two main objectives related to:

- The large scale inter-ocean exchanges,
- The characterisation of the biogeochemical processes involved in the internal cycling of trace elements and isotopes and carbon.

The BONUS-GOODHOPE project is also intimately linked to a third objective, the coastal-open ocean exchanges, which should be fulfilled in a second cruise, around and across the South African continental margin. The latter has been submitted for scientific approval and ship-time as the SACS0 project.

All three objectives are addressed using physical and biogeochemical tracer approaches, both resting on observations and models. The combination of hydrodynamical and biogeochemical objectives, as well as the cooperative approaches have been funded, essentially in France, by the CYBER and IDAO actions of the French LEFE/INSU programme, by IFREMER, IPEV and ANR. The BONUS-GOODHOPE project is part of a Southern Ocean (within the IPY) and global scale (within GEOTRACES and IMBER) international effort of ocean exploration.

Our knowledge of ocean circulation and global biogeochemical cycles has a strong basis in the GEOSECS programme, conducted in the 1970s. This international joint venture was and still is the basis for understanding the distributions and biological roles of the dissolved inorganic carbon system, the major essential nutrient elements N, P, Si, as well as a small number of relevant isotopic tracers. The ensuing development of analytical techniques now allows one to study trace elements and their isotopes (TEIs) at concentration levels and at space and time resolution that were inconceivable during the GEOSECS era. Detailed mapping can thus be obtained of far more tracers, including their isotopic composition, with the potential to provide unique insights into a wide range of oceanic processes. This opportunity was the stimulus of the recently inaugurated GEOTRACES programme. In the framework of the International Polar Year (IPY) the international geochemical community (GEOTRACES) is bringing together the best available techniques for a range of important TEIs. Within IPY, GEOTRACES therefore offers the ideal platform for a major internationally coordinated study of tracer distributions in polar waters to improve our understanding of the role of the polar oceans in the biogeochemical cycles.

The large-scale transect of BONUS-GOODHOPE (Figure 1) lies very close to WOCE cruise tracks (A12 and A21) and is similar to the one chosen in 2003 for repeat measurements by the International CLIVAR Southern Ocean GOODHOPE project. Since February 2004, this transect has been regularly sampled by high-resolution XBT lines and full depth CTDs. More than 45 ARGO profiling floats were deployed along it (www.ifremer.fr/lpo/speich/GOODHOPE/goodhope.htm). The part of BONUS-GOODHOPE devoted to the large-scale inter-ocean exchanges is therefore clearly

- **Obj.1-** Large scale monitoring and quantification of surface, mode and intermediate waters mass transport and ventilation in the southern hemisphere south of South Africa. Particular emphasis will be given to Antarctic Intermediate Water (AAIW), Subantarctic Mode Water (SAMW) and to the water properties of Agulhas rings and Cape Basin mesoscale structures.
- **Obj.2-** Determination of the distributions of selected trace elements and isotopes (TEIs), evaluation of the sources and sinks of selected TEIs, and characterisation of the biogeochemical processes involved in the internal cycling of TEIs and carbon in the study area.

3.1.1 OBJECTIVE 1: LARGE SCALE INTEROCEAN EXCHANGES

The Antarctic Circumpolar Current (ACC) is by far the largest conduit for interbasin exchanges. Recent analyses of satellite and in situ observations have uncovered that the Southern Ocean is a very turbulent region. This is particularly true for the ACC. Indeed, this current is concentrated on a number of quasi-permanent circumpolar jets that dynamically separate water masses. The positions of these jets are determined by topographic steering and by the wind stress curl. This frontal system influences the formation processes of SAMW and AAIW, and the transformation of deep waters.

South of Africa, the Southern Ocean provides the export channel for North Atlantic Deep Water (NADW) to the global ocean and the passage for heat and salt from the Indian and Pacific oceans. This region is influenced by the largest turbulence observed in the ocean. The eastward flowing ACC, the South Atlantic Current and NADW meet with the westward flow of Indian waters carried by the Agulhas Current, leading to water masses exchanges through jets, meanders, vortices, and filaments interactions. These local mesoscale interactions and the derived meridional fluxes might constitute the major link between the Southern Ocean and the Meridional Overturning Circulation (MOC). Because of these intense mesoscale activities, this region of the SO allows meridional mass, heat and fresh-water exchanges that are critical to close the MOC and the nutrient balance. SAMW and AAIW are the major waters involved in these exchanges. These waters, formed at various locations, are conveyed to the Atlantic sector by the zonal circulation, by the ACC and the Agulhas Current. Because of their different paths and origins, the water masses carried by these flows are different. When they meet south of Africa, mesoscale dynamics acts to transfer a portion of them from the SO to the South Atlantic. At the same time, mixing and air-sea interactions are responsible for significant property modifications. Considering these processes, the BONUS-GOODHOPE studies will put emphasis on ACC, AAIW and Mode Waters using physics coupled with the distributions of selected trace elements and isotopes (TEIs) in the water masses.

Finally, the SO being a very wide ocean surface circumnavigating the South Pole and extending well through the subtropics, it is submitted to a wide spectrum of climatic events and meteorological conditions. This implies very intense exchanges of properties, energy, and momentum with the overlying atmosphere. The role of such exchanges is also capital in establishing the regional dynamical and biogeochemical behaviour of both, the ocean and the atmosphere.

The main questions we have identified to approach our objectives are:

Specific objectives:

- What are the characteristics of the water masses in terms of physical and biogeochemical properties that are conveyed by the zonal circulation southwest of Africa?
- What are the origins and proportion of such water masses, and in particular of SAMW and AAIW, according to the observed physical properties and selected tracers distributions?
- What are the variations of such properties along a meridional direction crossing the high turbulence region southwest of Africa, with particular emphasis on the variation of properties of thermocline waters conveyed by Agulhas rings to the South Atlantic?
- What are the relative proportions of the different water masses (South Atlantic, South Pacific, via the ACC and Tasman and Indian via the Agulhas Current) that cross the Cape Basin and that are presumably exported as thermocline waters into the South Atlantic?
- What is the structure and impact of air-sea interactions in the observed water masses circulation, formation and transformation?

ASSESSING THE REGIONAL DYNAMICS AND AIR-SEA EXCHANGES

Since it starts, the GOODHOPE project has been a major contributor to the improvement of the data coverage of the SO in terms of number of available monthly profiles. Nevertheless, the nature of the complex exchanges of waters south of Africa makes their understanding and estimate a real challenge. Therefore, the opportunity offered by a multidisciplinary approach to deepen our understanding of such processes is unique. This is one of the reasons that pushed us to propose the BONUS-GOODHOPE project.

Moreover, while the SO is particularly poor in observations, this is even truer for the overlying atmosphere although the knowledge on the mechanisms of air-sea interactions and their evaluation is primordial in understanding the present climate and in evaluating its evolution. This is why we were particularly keen to build-up atmospheric observations and air-sea fluxes estimates during the BONUS-GOODHOPE cruise. This has been possible, observations of many variables have been undertaken and the data collected are rich. Their analysis as well as the comparisons of the obtained results with remotely sensed data will provide new insights on this climatic subsystem.

Ocean and atmosphere *in situ* observations give a snapshot view of their structure and governing dynamical processes. In order, to really be able to deepen our understanding of ocean and atmosphere dynamics and interaction, and to monitor their changes, we need to integrate the *in situ* observations in broader spatial time-series. This is possible only through numerical modelling and satellite remote sensing.

Nowadays, modelling and remote sensing provide relatively long time series of sea surface temperature, sea level height, many atmospheric variables

such as surface winds, precipitation, heat fluxes as well as chlorophyll. Models of the ocean and the atmosphere now give access to quantitative hindcasts, analyses and predictions that are intended to be used to improve our air-sea scientific understanding. Nevertheless, they all need to be validated. This was one of our new objective during BONUS-GOODHOPE. Therefore a very cooperative and successful collaboration has been set up with the *Laboratoire d’Océanographie Spatiale* of IFREMER, the US IMAGO of IRD, METEOFRENCE, MERCATOR, RSMAS and NOAA. This allowed us to receive daily regional satellite images and data, as well as models forecasts. All this data have been retrieved for further analyses to be undertaken after the cruise. In addition to the cross validation of parameters and observations, the daily maps helped us in positioning the cruise stations, radiosounding, XBTs and floats deployment as well as in understanding the real time evolution of observed surface and subsurface structures.

MONITORING THE PHYSICAL DYNAMICS BY SELECTED TRACERS:

The distribution of selected trace elements and isotopes (e.g., Obj.2) will further help us draw the picture of large-scale physical dynamics. Pa/Th disequilibrium is expected within the recently ventilated and advected water masses such as AAIW and Agulhas rings. With a residence time of 20 to 50 years ^{230}Th is more particle reactive than ^{231}Pa (residence time of about 200 years) and will trace more intense and more recent events of particle-solute interaction. Assessing the distributions of both tracers allows quantifying the “ageing” of these recently ventilated water masses. In addition, the $\epsilon_{\text{Nd}}^{(1)}$ signatures of the dissolved phase will document the origin, mixing rates and/or trajectory of the circulating water masses. Radiocarbon activity of the dissolved inorganic carbon (DIC) pool can also contribute to a better understanding of the zonal circulation of this area. Such modern ^{14}C data, when compared with data obtained earlier, during GEOSECS (1973-1978), WOCE A21 section (1990) and CIVA1 of WOCE-France (1993), will allow us to quantify recent ventilation, characterize changes in deep and bottom waters in the Agulhas current and calibrate ocean models.

Furthermore, ^{227}Ac (half-life 21.8 years) is mainly set free from deep-sea sediments through decay of its progenitor ^{231}Pa and can be used as a tracer of deep upwelling.

The two long-lived Radium isotopes ^{226}Ra and ^{228}Ra show a contrasting pattern in subpolar and subantarctic waters: ^{226}Ra (half-life 1600 years) as well as Ba are known to increase steadily in the surface waters from North to South across the ACC due to replenishment from upwelling of nutrient-rich waters. In contrast, ^{228}Ra (half-life 5.8 years) accumulates to high activities in shallow water bodies overlying continental shelf areas. It can hence be used as a tracer of shelf water input and helps to identify advection of shelf waters into the open ocean. The combined analyses of ^{227}Ac and ^{228}Ra can also be used to distinguish between

(1)

$$\epsilon_{\text{Nd}} = \left(\frac{\left(\frac{^{143}\text{Nd}}{^{141}\text{Nd}} \right)_{\text{Sample}}}{\left(\frac{^{143}\text{Nd}}{^{141}\text{Nd}} \right)_{\text{CHUR}}} - 1 \right) \times 10^4$$

where CHUR represents a present day average earth value; in the ocean, Nd is a trace element, predominantly found in the dissolved form (90 to 95%). Its residence time is around 500 to 1000 years.

vertical versus lateral movement of water masses. In the region of interest, the Agulhas Current is particularly prone to collect a distinctive shelf ^{228}Ra signal during its southward flow along the continental shelf edge of South Africa. By contrast waters protruding northward from the Antarctic Zone generally lack clear ^{228}Ra signals as they have not been in contact with shelf sediments for a relatively long time. The turbulent mixing zone south of Africa, where waters from the Atlantic, the Indian and the Southern Ocean meet, is therefore a region where identification and distinction of different water masses can be accomplished by joining physical oceanography and the TEI distributions. Careful determination of end-member activities should allow one quantifying mixing processes and assessing travel times, e.g. of Agulhas Rings and cyclonic features in the mixing zone.

Furthermore it is observed that physics (frontal systems, mixed layer depth) have a significant impact on dissolved barium (Ba) distributions, a tracer of water mass and mixing. Thus high resolution dissolved Ba profiles will provide information of water mass and mixing around frontal systems and the area of SAMW and AAIW formation. Characterisation of water-mass circulation, especially of SAMW and AAIW, will also help us to further understand the transport of trace metals and macro-nutrients to lower latitudes (Sarmiento et al., 2004).

Transient tracers provide the only means of reliably identifying the most recently formed component of a sub-surface water mass. However, it is the anthropogenic transient tracer data that show which source waters have been in closest and most recent contact with the atmosphere and hence would be most susceptible to change due to a variable climate. The inventories of transient tracers in a water mass are directly correlated with the formation rates of the water mass. The CFC inventories for the WOCE data can be compared to prior and future data sets to assess variability in formation rates. During the period 1984 to 2004 repeated sampling of hydrology and anthropogenic tracers (CFCs) has been performed along the Greenwich Meridian from Antarctica (70°S) up to 50°S . The time series have allowed an estimate of the variability in water mass properties and the ventilation rates in the eastern Weddell Sea. During the November 2004 GOODHOPE cruise, the section has been extended further north. While the continuation of the tracer time series will help assessing formation rates of bottom and deep water in the Weddell Sea with even higher precision, the northward extension of the transect, proposed here, will provide important additional information on the origins of recently ventilated thermocline waters.

3.1.2 OBJECTIVE 2: DISTRIBUTION, SOURCE, SINK OF SELECTED TEIS AND CHARACTERISATION OF THE BIOGEOCHEMICAL PROCESSES INVOLVED IN THE INTERNAL CYCLING OF TEIS AND CARBON

DISTRIBUTION AND INTERNAL CYCLE OF TRACE METALS AND MACRO-NUTRIENTS

The distribution of several GEOTRACES-key trace metals (e.g., Fe, Zn, Co, Cu, Cd, Ba) and of macro-nutrients will be determined in the water-masses

(encompassing AAIW and SAMW) at large and meso-scale. Next to physical processes (advection, mixing, ...), their distribution, source and sink strengths and internal cycling strongly depend on physical-chemical speciation, interactions with the microbial food-web, recycling and re-mineralization, and atmospheric and sedimentary inputs.

SPECIATION OF TRACE METALS AND INTERACTIONS WITH THE MICROBIAL FOOD-WEB:

The distribution of trace metals and their interaction with the microbial food-web strongly depend on their speciation in seawater, which controls their solubility, residence time in surface waters, and bio-availability. The speciation of trace metals is described by the different size-classes (particulate, dissolved, colloidal, soluble) and by the different chemical forms (organic, inorganic, oxidation state). The chemical speciation of dissolved trace metals is often dominated by complexation with organic ligands, which may increase both their residence time and bioavailability. Complexation with small organic colloids can furthermore be significant for Fe speciation and bioavailability. The origin of the organic ligands is not fully understood yet, but phytoplankton or heterotrophic bacteria can represent a significant source. The redox cycle can also be important for the speciation of at least Fe, especially in the cold waters of the Southern Ocean and at continental margin interfaces increasing both its solubility and availability. A better understanding of the speciation of these trace metals and of the processes involved in their biogeochemical cycling, including interactions with the microbial food web, is urgently needed in order to improve our understanding of the mutual dependencies between trace element occurrence and phytoplankton community composition.

Specific objectives:

- To determine the distribution and speciation of trace metals (Fe, Co, Zn, Cu, Cd, Ba) in the study area,
- To study the interactions between the speciation of Fe and the microbial food web,
- To monitor the surface gradients of trace metals and their speciation in conjunction with the microbial food web structure.

To address these objectives, the dissolved concentrations of trace metals and their speciation (e.g., the dissolved organic speciation, the redox speciation of Fe, and the colloidal/soluble Fe) will be monitored in the surface waters (here together with the taxonomy of phytoplankton) and deep waters. Incubations will be carried out on natural phytoplankton and bacterial communities, under natural and laboratory controlled conditions (temperature, light, carbon sources, inorganic nutrients Fe, Si). The phytoplankton uptake and regeneration of different Fe species (organic and inorganic) will be studied together with the phytoplankton growth. Complemented with the determination of the microbial community (phytoplankton, bacterioplankton, protozooplankton and viruses), this will help us to understand and quantify the chemical forcing of Fe on the composition and structure of the planktonic network, and on macro-nutrients (Si, N, P) as well as

the feedback of biological activity on the Fe biogeochemistry (speciation, regeneration, bioavailability).

MACRO-NUTRIENTS

Silicon plays a key role in controlling the biological carbon pump that is largely driven by diatoms. Its abundance in Southern Ocean surface waters is largely driven by Fe availability, while its transport along with subantarctic Mode Waters largely controls the thermocline nutrients and biological productivity at lower latitudes. Despite the intensive efforts deployed during the SO-JGOFS programme the Si cycle needs to be constrained further, especially aspects related with its recycling. To better assess the latter process on deck incubations will be performed to further understand the grazing pressure exerted on natural diatom assemblages (using BSi as a marker of diatom biomass) and the dissolution rates of biogenic silica (using ^{30}Si enrichment experiments). Furthermore, comparing isotopic signatures of $\text{Si}(\text{OH})_4$ and bio-silica (BSi) in seawater will provide a means to refine our understanding of $\text{Si}(\text{OH})_4$ -diatom dynamics, especially as concerns production versus accumulation. The isotopic composition of dissolved silicate tends to integrate the effect of isotope fractionation over the growth season, while isotopic composition of particles will rather reflect the instantaneous result of fractionation. The combination of d^{29}Si and d^{15}N analyses (solutes; suspended matter) will allow to further constrain our understanding of the spatial and seasonal Si:N uptake ratio variability. Investigating for the content and carbon isotopic composition of specific compounds characteristic for specific plankton groups (diatoms, dinoflagellates, coccolithophorids) will provide information on contribution of major phytoplankton groups to the suspended organic carbon pool and on possible alteration of isotopic signatures during mineralization.

Specific objectives:

- To further understand the cycle of macro-nutrients in the study area,
- To determine the Si and N isotopic signatures of surface and mesopelagic waters of the ACC and to understand how these isotopic signatures are affected by progressive nutrient depletion and formation of Mode waters.

ATMOSPHERIC INPUTS

Atmospheric transport is the dominant means by which iron is supplied to the remote ocean. This is particularly important in the SO, an area removed from the world's major deserts and where surface water iron concentrations are extremely low. Aerosol iron solubility is generally low, but it varies systematically with aerosol source. Furthermore over most of the Atlantic Ocean, soluble aerosol iron is in excess, relative to the other nutrients, in terms of phytoplankton nutrient requirements. To date the solubility of aerosol irons over the remote SO has not been determined, nor have the concentrations of the other major nutrients (N, P, Si) or micronutrient trace metals (e.g. Zn, Co, Cd) in that aerosol been determined.

Specific objectives:

- To determine the rate of supply of iron and the other major and micro-nutrients from the atmosphere in the form of wet and dry deposition,
- To evaluate the solubility of iron in aerosol over the remote South Atlantic/Southern Ocean atmosphere.

Continuous sampling for aerosols and opportunistic collection of rain water will be performed. Nutrient and trace metal concentrations will be measured. Atmospheric inputs to surface waters will be determined from these concentrations using dry deposition velocities (aerosol) or rainfall rates. Meteorological data will be required for data interpretation. Analyses of total and soluble aerosol component concentrations will be made for the determination of aerosol species solubility.

SEDIMENTARY INPUTS

Sedimentary inputs can represent the major source of trace metals in continental margin areas and in surface waters of the ACC by advection from the Antarctic Peninsula and Drake Passage. This source likely depends on benthic chemistry and dynamics such as bioturbation and organic carbon mineralization processes. It is thus proposed to estimate the biological and biogeochemical response of the sedimentary environment to quantitative and qualitative variations of particulate organic matter input and the consequences to benthic fluxes and pathways. The major issue relates to the understanding of benthic-pelagic coupling and its modifications along a large scale transect in the ACC and at the South African continental margin. Very few studies (if any) relate fate of trace metal to a complete description, both biological and biogeochemical, of the sediment-water interface functioning. Sulphate reduction is a major pathway for degradation of organic carbon in deep sea sediments. While a significant amount of work has been done regarding sulphate reduction in the Central and Northern Benguela regions, in the area of interest this information as well as information on sediment trace metal content is scarce. New data will be generated for sulphate reduction, allowing to confront the shelf area south of South Africa with the Southern Ocean basin. This has implications for benthic organic carbon recycling, trace metal speciation and epibenthic fluxing. Furthermore, practically no information is available as to what extent the southern African continental mass influences biogeochemical processes in the coastal regions by providing carbon and trace metals inputs. The study of trace metal sources and distribution in sediment is high on the agenda in South Africa. Understanding the oceans around South Africa is also of vital importance to establish if land-based sources of pollution are impacting the environment.

Specific objectives:

- To investigate the sources, distribution and deposition patterns of trace metals in the sediments,
- To quantify the exchanges through the sediment-water interface for trace metals, macro-nutrients, carbon and other chemical compounds that characterize the redox state of the sediment (oxygen, sulphide),
- To characterise the early diagenesis rates, bioturbation (meio- & macro-fauna activity) and pathways across the sediment-water interface and incubation experiments,

- To investigate of anthropogenic sources of metals and natural run off from coastal and river systems.

Sediment cores will be collected for highly resolved vertical sampling and analysis. Kinetic and exchange incubations will be carried out on board. Trace metals will be normalized to airborne or riverborne lithogenic tracers (Al, Th,...) or isotopic oceanic tracers (coll. with C. Jeandel team).

BIOGEOCHEMICAL PROCESSES INVOLVED IN THE CARBON CYCLE

ANTHROPOGENIC CO₂ PENETRATION, AIR-SEA CO₂ FLUXES

The SO acts as a sink for atmospheric CO₂ most of the time. Primary production in the SubAntarctic is one of the main contributors to this uptake of CO₂. However, the connection between carbon export to the deep ocean and air-sea CO₂ fluxes is still poorly constrained partly due to the complexity of physical and biogeochemical processes that drive CO₂ fluxes. Subduction of mode and intermediate waters represents a major pathway for anthropogenic CO₂ penetration in the ocean interior. Further south, model estimates indicate low anthropogenic CO₂ storage. However, recent studies which take into account oxygen disequilibrium under ice suggest that deep and bottom water formation in the SO is still a key process in the natural sequestration of anthropogenic CO₂ and that the inventory of anthropogenic CO₂ in the SO could be much larger than what is currently accepted. Physical processes involved in the uptake and storage of anthropogenic CO₂ will be further resolved in conjunction with Rationale 2.1. Furthermore, coupling CO₂ analysis with biological and biogeochemical observations will help to understand the biological processes involved in carbon sequestration. The questions that will be addressed are: how do air-sea CO₂ fluxes compare with carbon export (as assessed via multi-proxy approach) in the biologically active SubAntarctic zone? What is the inventory of anthropogenic CO₂ along the Zero Meridian if we carefully take into account sea ice cover effect on surface oxygen concentration further south? What is the contribution of SAMW and AAIW subduction to the overall anthropogenic CO₂ storage?

Specific objectives:

- To budget air-sea CO₂ fluxes in the ACC and compare it to C export and deep sea mineralization derived from multiproxy measurements,
- To contribute to ongoing international efforts to better assess the inventory of anthropogenic CO₂ in the S.O.

CO₂ fluxes will be calculated from underway pCO₂ measurements and meteorological data. To examine how the induced carbon export relates to air-sea CO₂ fluxes requires parallel assessment of export via the ²³⁴Th-deficit method. However, CO₂ fluxes computed from pCO₂ measurements provide a snapshot estimate that does not match the time scale of C export measurement (~one month for ²³⁴Th). It is therefore required to integrate air-sea CO₂ fluxes over the month preceding the field work by reconstructing pCO₂ fields and corresponding CO₂ fluxes using remote sensing data (wind speed, SST and Chl-a). pCO₂ – SST-SeaWIFS Chlorophyll relations will be derived taking into account the hydrological zonation determined from SST gradients. pCO₂ fields will then be

reconstructed and CO₂ fluxes calculated using QuickSCAT wind speed. Dissolved Inorganic Carbon (DIC) and Total Alkalinity (TA) will be measured and anthropogenic CO₂ inventory will be derived by applying the classical back-calculation and TrOCA (Tracer combining Oxygen, inorganic C and total Alkalinity) method on these DIC and TA data. This approach will also take into account oxygen disequilibrium under the ice which was recently proven to be crucial for the analysis of water masses south of 50°S. Results from this cruise will be integrated with data collected in the IPY framework in order to produce a synoptic inventory of anthropogenic CO₂ for the Southern Ocean. Collaboration is already set up with the others (N. Metzl, LOCEAN, Paris) involved in the budgeting of CO₂ fluxes and the assessment of anthropogenic CO₂ inventories in the SO.

FATE OF CARBON:

$\Delta^{13}\text{C}$ and $\Delta^{14}\text{C}$ signatures of the different forms of organic matter reflect the balance between production and deposition. It is therefore possible to determine the partitioning of exported carbon between dissolved and particular forms, and to understand, in conjunction with the other tracers, the factors that regulate the fate of these carbon pools. For example, recently photosynthesised organic matter is tagged with bomb-produced radiocarbon, whereas old refractory organic matter is significantly depleted in radiocarbon. Hence radiocarbon provides information on particle dynamics that is complementary to the information yielded from Th isotope geochemistry. Comparison with Th data will allow determining the degree of coupling between Th isotopes and the carbon cycle. DOC also plays an important role in the availability of limiting trace metals such as iron. Thus, determining radiocarbon in bulk DOC as well as in different organic fractions (for selected samples) will allow to better assess the DOC cycle and its interaction with to the micro-nutrients. By analysing mixed layer and subsurface suspended matter for compounds characteristic of major plankton groups (diatoms, dinoflagellates, coccolithophorids) it will be possible to assess their relative importance in sustaining carbon export. Stable carbon isotope composition of these group-specific compounds will contribute to resolving origin and reactivity of this plankton-derived organic matter.

By applying multi-tracer approach in the study of surface, mesopelagic and deep layers, the aim here is to achieve a better insight in:

Specific Objectives:

- Particle vs. solute interactions for organic carbon
- The processes in control of organic carbon export and its transformation during transit through the mesopelagic depth region.

EXPORT FLUXES, SCAVENGING RATES AND REMINERALISATION (using ^{231}Pa / ^{230}Th , ^{210}Po / ^{210}Pb , ^{234}Th , ^{210}Po and Ba)

^{231}Pa and ^{230}Th are both the decay products of soluble uranium isotopes (^{235}U and ^{238}U respectively). Pa and Th are produced at well known constant rates in the ocean, and both are sensitive to scavenging: if the production of Pa or Th is

balanced by scavenging on particles their concentration profiles must increase linearly with depth and it provides an estimate of the average settling velocity of the particles in the water column. In addition to this role of chronometer, Th isotope pairs (such as ^{230}Th - ^{232}Th or ^{230}Th - ^{234}Th) are useful tracers of the particle aggregation and dis-aggregation. Close to the coast, where particle flux is important, the Pa/Th disequilibrium measured in the dissolved and particulate fractions is used to trace the dissolved/particulate exchange and the particle settling velocity. Any difference between the linear profiles and the actual distribution of these tracers indicates that the transport of these nuclides is influenced by ocean currents and water mass mixing and hence allows tracing ocean circulation. ^{234}Th and ^{210}Po are useful in quantifying the rate of scavenging from solution onto particles and the processes governing the dynamics of particles in the ocean. These radionuclides have in common the fact that they both are daughters of a long lived parent (^{238}U) with conservative behaviour in the oceanic water column (^{210}Pb). The degree of disequilibrium and the dynamics of association to particles can be used to assess scavenging rates, export fluxes, remineralisation rates and role of types and/or composition of particles involved in these processes. The mesopelagic zone is the depth layer where most changes in sinking organic matter occur and also where SAMW and AAIW are formed. POC contents will be used to convert ^{234}Th and ^{210}Po fluxes into carbon fluxes. Hence, in conjunction with non-lithogenic particulate Ba, another tracer of carbon remineralisation in the mesopelagic waters, subsurface ^{234}Th excess (relative to equilibrium with ^{238}U) will inform on remineralization intensity of organic matter exported from the surface and help to constrain this process.

3.2 SUMMARY OF OBSERVATIONS

3.2.1 SAMPLING STRATEGY

The general measurement strategy of the transect consisted in sampling the several water masses, air-sea exchanges and atmospheric structure to provide a 2D matrix, vertical and horizontal, of water-masses characteristics, air-sea fluxes and lower atmosphere behaviour with a relative high resolution sampling. The selected vertical scales encompass the several water-masses, and, despite the tight ship-time constraints, the applied horizontal resolution tried to cover all the very important dynamical structures encountered such as all the mesoscale features, frontal systems and slope currents.

Table 1 and Figure 1 summarize the lateral station strategy and associated measurements.

3.2.2 SAMPLING METHODOLOGIES

- **Ocean physics:** We deployed 132 XBTs (1 XBT release between two full depth hydro casts and, to improve sampling around mesoscale well defined structures, the sampling was increased in frontal region), 79 hydrological stations (CTD/Niskin rosette-casts and L-ADCP), VMADCP acquisition, and deployment of 17 profiling floats. Although the planned station spacing was 20 NM, this had to be increased up to 30 NM over wide areas, due to time constraints. We managed, however, to keep the 20 NM interval across the major fronts. Moreover, all previous sampling of the southern part of the section during previous cruises (R/V Akademik Vavilov) have been relatively coarse, due to a lack of time, and limited to about 55°S by the extent of the sea ice at the period when these cruises took place (November). During BONUS_GOODHOPE we managed to keep 20 NM south of 49°S and reached the latitude 57°33', thus reaching and slightly getting over the southern limit of the ACC, for the very first time since the start of the GOODHOPE project. Two deep Current Meter Pressure Inverted Sounders have been deployed along the first part of the transect, at the continental slope (isobath 1000 m) and in the Cape Basin open ocean region (at the crossing of Jason-1 ground track 134), in order to start the international cooperative monitoring of the South Atlantic Meridional Overturning (SAMOC: Garzoli et al. 2007: see www.aoml.noaa.gov/phod/SAMOC). The onboard thermosalinograph data were collected in continuous mode and validated with a daily water sampling followed by on-board analysis
- **Atmosphere physics:** Continuous atmospheric sampling has been undertaken through a very complete set-up of instruments. Atmospheric radiosounding has been carried out on a daily basis, with higher frequency during SUPER stations to calibrate the diurnal-cycle, and when crossing pronounced mesoscale structures such as the ACC fronts.
- **CFCs : 1191 samples** (a mean of 18 samples per hydro casts) were collected from Niskin bottles. Samples were stored in glass bottles (bottles and caps are from www.sks-bottle.com. 125 ml bottles no.40000040.01S - case of 160

bottles without caps - cap size 22-400, the caps are SKS no. 6021-03 - Aluminium lined caps). The samples (about 125 ml) were taken via Viton tubes connected to glass bottles with connectors. The bottles and caps were thoroughly rinsed with the water to be sampled. The bottles were filled and capped underwater in a 1L beaker, Viton tubing was required as a fill tube between the Niskin and the sample bottle.

- **Tracers and isotopes (TEIs):** Both the dissolved and particulate phases were sampled throughout the water-column. For the *dissolved phases*: sufficient amounts of seawater (60 L for Ra/Pb, 10 L for Nd, 20 L for Pa/Th, 4-5 L for ²³⁴Th; although the Toulouse group developed a protocol allowing the recovery of all these tracers from a single volume of ca 30 L) were collected to allow the analysis of the isotopic and chemical tracers. For the *suspended particles*: major, minor and trace elements, (Ba, Si, Ca, Sr, Al, Mn, U ...) in suspended matter required filtration of 5-10 L of seawater using pressurized filtration units. The vertical distribution of these elements in the water column was assessed with appropriate resolution (15 to 20 depths on CTD casts, between 0 and 2000 m or bottom). For analyses requiring a large amount of material (e.g.: Ra, Nd, Pb isotopes), samples were collected by *in-situ* pumping using battery operated pumps, eventually fitted with manganese oxide cartridges (Ra), which allow to filter large volumes of water (100-1000 L). Assessing the C-isotopic composition of phytoplankton groups via compound specific isotope analysis (CSIA) also required large volume sampling. Multi-coring on the open-ocean (using the INSU Oktopus GmH) should have allowed to collect surface sediment and interstitial waters. All the TEIs mentioned above, together with the alkenones, were measured in solution and in the solid phase to allow an assessment on their source/sink budget,. In addition, redox-sensitive tracers (together with O₂ and pH) were measured in the interstitial waters.
- **Trace metals and speciation:** samples were collected using acid-cleaned Go-Flo bottles mounted on Kevlar line of 4000 m length. All sub-sampling and filtration were carried out in a clean container (INSU).
- **Macro-nutrients and biological parameters:** macro-nutrients (N, Si, P), Chl-a, pigments and phytoplankton taxonomy, and primary production were determined in samples collected using the Niskin-Rosette.
- **Carbon:** *Inorganic carbon:* underway pCO₂ was measured from the clean seawater system of the ship, DIC (dissolved inorganic carbon), TA (total alkalinity) and pH was sampled from the Niskin. *Organic carbon:* DOC, TOC (dissolved, total organic carbon respectively): samples for total organic carbon (TOC) were collected using Niskin-bottles fitted with Silicone tubing and Viton o-ring. DOC/TOC was sampled just after the sampling for gases, taking all necessary precautions to avoid contamination. Samples were collected in glass ampoules (8 ml) poisoned with 85%-H₃PO₄ flame sealed and stored without filtration in the dark at 4°C.
- **Atmospheric nutrients and trace metals:** High-volume (1m³ min⁻¹) samplers equipped with cascade impactors for aerosol size segregation were used (University of East Anglia). Rain samples were collected on an event basis by

deploying large (42cm diameter) plastic funnels for the duration of rainfall only (University of East Anglia).

- **Sediments:** The INSU Oktopus GmbH (Germany) multiple corer (head version MUC 8/100) equipped with 8 transparent polycarbonate cylinders has been deployed. It is one of the simplest and it is thought as the most efficient designed for successful coring and careful tubes recovery on the deck. Tubes are 61 cm in height and their inner diameter is 9.5 cm. Weight addition should have allowed the sampling of various sediments (up to 16 x 12 kg). Overlying water and up to 8 cores should have been retrieved for each station. Expected sediment height in core tubes was ranging from 25 to 45 cm. Only the top 20 cm should have been processed at first (30 sampling levels by classical slicing). Two cores should have been dedicated to pore waters extraction and solid fraction analyses, three cores to incubations (benthic fluxes and luminophores), one to microelectrodes, one to sulphate reduction rate (radiotracer ^{35}S) and one to DET incubation. The Oktopus has been deployed eight (8) times, but only the first deployment has been completely successful, very likely because of particularly calm sea conditions. A last deployment was partially successful with a very small sediment samples collected. The sediments sampling has been rather unsuccessful and difficult despite the downward speed of the oktopus being carefully controlled (1 m/s) and despite instrument depth being permanently checked both from the length of cable unwound by the record of a “pinger” dual echo (fastened on one side of the multi-tubes corer. During operation, cable tension was checked in order to track oscillating behaviour due to waves.
- **Remote sensing:** A collection of remote sensing data was established since early January by the *Laboratoire d’Océanographie Spatiale* of IFREMER, Plouzané, France. A very nice set of satellite images and data (only for ODYSSEA-SST and AVISO Real Time Absolute Dynamic Topography (ADT)) have been sent daily from France to the ship to provide a regional overview of different air and ocean variables. This operation has proven to be a very important element to optimise the position of the cruise stations and atmospheric sampling. It gave us also the possibility to follow particular structures in time and space, to understand the origins of observed mesoscale features encountered during the transect and to initiate a validation of satellite products such as SST, geostrophic velocity derived from altimetry and radiometer-derived wind speed and stresses.

3.2.3 STATIONS DESCRIPTION: PLANNED AND EFFECTIVE WORK

The BONUS-GOODHOPE cruise followed the GOODHOPE transect defined in 2003 in order to optimize repeated observations with altimetry sampling and past and present moorings deployment by University of Maine (ASTTEX project), the Alfred Wegener Institute WECCON project and NOAA-AOML repeated high resolution XBT transects. The transect starts from Cape Town harbour and joins the altimeter JASON1 133 ground track by going westward. When the 133 JASON1 ground track reaches the Greenwich Meridian (at about 51°S), the cruise track veers south. The southernmost latitude reached by any past

GOODHOPE full-depth hydrological cruise was 55°S, slightly north of the Southern boundary of the ACC. As BONUS-GOODHOPE happened during late summer, the plan was to reach 60°S as these latitudes are free from sea-ice during this time of the year. Presence of sea-ice has been the major factor that prevented to reach high latitudes during the previous GOODHOPE cruises. Because of delays that prevented operations for a few days, we were only able to reach 57°33'S. Also, initially we scheduled a sampling step of 20 NM (a total of 96 hydrological stations). Because of time constraints we had to decrease the spatial resolution (25 to 30 NM) for long sections of the transect and could only complete 79 hydrological stations, 5 SUPER and 7 LARGE. Thanks to the satellite images we were receiving on board, we adjusted stations position in a way that allowed us to sample all the water masses and most of fine dynamical structures encountered during the leg, despite the reduced sampling resolution. The final view of the BONUS-GOODHOPE stations is presented in Figure 1.

The cruise was due to leave Cape Town, South Africa, on February 9, 2008. Due to the late customs release of the French containers and the fact that a Kevlar cable and related winch for clean tracer sampling (this equipment was still at La Réunion), we only left Cape Town on February 13, at 2:00 pm Local Time (LT). During the same day, we started the hydrological casts. We had to come back to Cape Town to collect the Kevlar cable, on February 15. This made us looses a further 23 hours.

WORK PLANNED IN THE SHIP-TIME PROPOSAL

Because of constraints due to particularities of sampling protocols, ship time request and analytical resolution/performance for the different parameters to be measured, three types of stations were initially planned:

- **Hydrographical (HYDRO) stations:** one CTD/Niskin rosette-cast (0 m-bottom, 22 depths with Niskin bottles of 12L, CTD SEABIRD SBE911+). During these stations we planned to measure the full depth hydrology (T, S, pressure, O₂) and other parameters (fluorescence, Chl-a, nutrients, DIC, TA, dissolved Ba) associated to thermohaline and water column velocity observations. This latter was planned to be acquired by two 300kHz Lowered – Acoustic Doppler Current Profilers (LADCPs) mounted on the rosette carousel and occupying the space of two Niskin bottles (this is why we were sampled only 22 depths and not 24). We choose to use the SEABIRD rosette of INSU because of the large volumes of water required for biogeochemistry (the LPO rosette can accommodate only 8L bottles). In the initial proposal we planned 80 HYDRO stations (including in these 80 the first CTD cast for each other station type), for a mean station time of 4 hours each. Therefore, the total time initially evaluated for these casts amounted to 320 hours (13.3 days).
- **LARGE stations:** one CTD/ Niskin rosette cast (0 m-bottom, 24 depths, 4 h) and one Go-Flo cast (0-2000 m, 12 depths, 4 h),. Parameters to be measured: CTD parameters, biological parameters (Chl-a, chloropigments, primary production, plankton taxonomy), macro- and micro-nutrients, tracers and isotopes, DIC, TA, pH, DOC/POC. LARGE station spacing was initially planned at 80 miles, with a total of 26 stations of which 6 were SUPER stations (see below). Therefore, 20 LARGE stations in total were

planned, for a mean station time of 4 hours (this excluding the 4 hours mean time for the first CTD cast). The total time for these stations (excluding the time for each first CTD cast) was evaluated at 80 hours (3.3 days).

- **SUPER stations**: one cast for in-situ pumps (0 m-bottom, 8-12 depths, pumping time = 3 h, cast time = 3 h, total of 6 h) + two CTD/Rosette casts (0 m-bottom, 22 depths, 8 h). We initially planned to get the AWI multiple corer attached to the CTD rosette for one of the two deep CTD deployments. + two Go-Flo casts (0-2000 m and 2000 m-bottom, 12 depths each, 4 h + 8 h = total 12 h), multi-net deployment (5 depths, between 0-500 m, 1 h), large volume sampling for process studies (~40 L sampled at one sampling-depth at the Chl-a maximum using Go-Flo bottles, 1 h), Parameters: CTD parameters, biological parameters (Chl-a, pigments, taxonomy of phyto- & zoo-plankton, primary production), macro- and micro-nutrients, tracers and isotopes, sediments & core parameters, DIC, TA, pH, POC/DOC, process studies (Fe bioavailability, zooplankton feeding, Si regeneration). SUPER stations were planned at every ~ 240-320 miles, for a total number of 6 stations, about 24 hours each (always excluding the time needed for the first CTD cast and included as “HYDRO” station time). The total time for these stations (excluding the time for each first CTD cast) was evaluated to be about 144 hours (6 days).

The total amount of stations time was evaluated to 22.6 days. To this station time cost, 7 days of transit time needed to be added for a total estimate of 29.6 days of operations.

We also planned to deploy **XBT, between CTD** casts, with increased resolution across frontal regions. We were also planning the deployment of **10 to 15 ARGO profiling floats**. This additional set of observations constitutes a physical background to evaluate water mass characteristics and transport calibrated by hydrology, LADCP, and profiling floats data and extrapolated in time and space via the altimetry and satellite surface temperature observations.

Two deep Current Meter Pressure Inverted Sounders (C-PIES) were planned to be deployed in the ACC domain to complete the German and US network along the GOODHOPE line. This in the framework of a long term monitoring of the region.

WORK PLANNED BEFORE THE CRUISE (JANUARY 2008)

In January changes have been made to the initial ship-time planning, essentially because of an increased ship-time request by the biogeochemistry.

- **HYDRO stations** The HYDRO casts were slightly increased in number to cover the entire leg with a spatial resolution of 20 NM, this resolution being the minimal to resolve the mesoscale structure of the ocean dynamics. This happens to be almost insufficient in the Southern Ocean region, since the higher the latitude, the smaller the Rossby radius of deformation, and therefore the embedded dynamical scales (the first internal Rossby radius of deformation is lower than 10 km south of 50°S). Also, at the start of the project, attempts to find collaborations to cover the observation of the atmospheric physics have been unsuccessful. However, these observations

being necessary to understand the dynamics of the Southern Ocean, they were finally covered thanks to a last minute effort provided by Christophe Messenger and funding supplied by IFREMER, CNES, and INSU. Assistance was also provided by Prof. Peter Minnett at RSMAS who lent us an important set of Atmospheric instrumentations (for more details see section about the Physics of the Atmosphere). In addition, atmospheric radiosounds were provided by IFREMER, IUEM, UCT and the South African Weather Service. The opportunity uncovered by the extensive atmospheric sampling together with the need to close the ACC budgets and reach the Weddell Gyre constituted the reasons that pushed us to extend the leg southward and reach 60°S. Indeed, 60°S is the northernmost latitude of all atmosphere observations and re-analyses done in the framework of IPY. An overlapping with that latitude would have been suitable for the analysis and integration of the physical atmosphere parameters in a larger context than our cruise and would have benefited our own studies. This meant to extend the number of HYDRO stations to 96, but due to past cruises experience in the region and the mean bottom depth along the transect, we revised the mean time cost of the station to 3.5 hours. The total cost that we estimated in January for the 96 HYDRO stations was 14 days.

- **LARGE stations**: 20 in total. The total time for these stations (excluding the time for each first CTD cast) was estimated to 3.8 days.
- **SUPER stations**: 6 in total. The total time for these stations (excluding the time for each first CTD cast) was estimated to 11.8 days.
- **MARGIN stations**: 1 in total. The total time for this station (excluding the time for the first CTD cast) was estimated to 0.32 days (7.5 hours).
- **INTERCALIBRATION stations**: 1 in total. The total time for this stations was estimated to 0.5 days (12 hours).
- **LARGE VOLUME CLEAN SAMPLING**: 0.15 days (3.5 hours).

The estimated total stations time was 30.42 days with additional 8 days of transit time for a total of 38.57 days of ship operations.

The XBTs, profiling floats and C-PIES deployment plan was unchanged.

EFFECTIVE WORK DURING THE CRUISE

The true station number and type differed from the originally planned, because: (i) the initial delay in cruise departure; (ii) an interruption of operations during 12 hours (because of weather conditions); (iii) recurrent problems with the CTD winch during the first two weeks, the Oktopus sediment corer, and (iv) the larger water volumes and increased ship time requested for biogeochemistry operations. The final number and type of stations occupied were:

- **HYDRO stations**: 79 in total (included here are the first CTD cast for each LARGE and SUPER stations). The total time used for these operations was 250 hours (10.4 days). Overall the CTD/Niskin-rosette has been deployed 111 times (cast bgh000 to bgh110).

We left Cape Town harbour on February 13, at 2 pm LT after the uploading of the French containers. We started the operations with a test station (cast

bgh000) on the 2000 m isobath of the African slope along the westward transect of the BONUS-GOODHOPE line. The station work being successful, the cruise transect started properly with hydrological stations at the shelf break and continental slope just out of Cape Town harbour. During this first part of the cruise, biogeochemistry sampling was limited because of the absence of the Kevlar cable for ultra-clean GO-FLO casts. This prevented the realization of the Margin station on the African slope. Nevertheless, the biogeochemistry sampling from Niskin bottles could take place. The rosette-bottles were closed at depths to achieve appropriate resolution in the major water masses, the bottom waters and to ascertain increased resolution in the upper layers to meet requirements from the biology (most active in the mixing layer, euphotic zone and the ocean layers just beneath it).

- **LARGE stations**: 7 in total. The total time for these stations (excluding the time for each first CTD cast) has been 52.1 hours (2.2 days).
- **SUPER stations** : 5 in total. The total time for these stations (excluding the time for each first CTD cast) has been 223.2 hours (9.3 days).
- **INTERCALIBRATION station**: Most of the intercalibrations were done during other HYDRO, LARGE and SUPER stations. Therefore the only intercalibration station that was undertaken as such, was the one for the REE. The total time for this stations has been 3 hours.
- **LARGE VOLUME CLEAN SAMPLING**: This operation took only 2 hours.

The total stations time has been of 22 days.

We deployed **XBTs** in-between CTD casts and increased the resolution to about 6 NM in frontal regions. We had a 17% failing rate (fail or spiking) due essentially to rough weather conditions in the subantarctic and polar part of the transect.

We deployed **13 profiling floats** at 13 CTD casts position and four (4) additional ones on the transit to Durban. All floats, except one, were successful in transmitting data to the Coriolis data centre. The one float that failed was the one that accidentally went under the ship stern shortly after its launch.

Two C-PIES have been deployed across the South African slope and in the Cape Basin abyssal plane along the BGH line. Their position has been decided in collaboration with the German, British and US in the framework of the South Atlantic Meridional Overturning Circulation (SAMOC: www.aoml.noaa.gov/phod/SAMOC) monitoring project. The goal of this project is to monitor the variability of hydrology (heat and salt content) and water mass transport in the South Atlantic sector of the Southern Ocean.

Finally, we were also able to sample atmospheric physical variables in a very satisfactory way. The only regret is that, because of the time constraints of our cruise, it has not been possible to reach 60°S, the southernmost position for all our sampling has been 57° 33' S.

A global view of all the stations and deployments is given in Table 1. See the log-book chapter and the Annexes volume for the detailed timing of each operation.

– BONUS-GOODHOPE Cruise Report –

Table 1 – List of operations, timing and related dates during the BONUS-GOODHOPE cruise.

Station #	CTD cast #	Lat	Long	Dist (NM)	Depth (m)	OBSERVATION TYPE	True Transit T	EFFECT TIME	EFFECT HRS	EFFECT DAYS	LOCAL TIME (UT +2 hrs)
Cape Town							0	0		0	2/13/08 15:00
0	0	-33 58,72	17 13,5	60	2000	CTD Test	5.35	1.91	7.26	0.3025	2/13/08 22:15
1	1	-33 56,3	17 57,4	36.6	200	CTD _{hydro}	0	0.5	7.76	0.323333	2/13/08 22:45
2	2	-33 57,7	17 31,2	21.8	500	CTD _{hydro}	2.5	0.91	11.17	0.465417	2/14/08 2:10
3	3	-33 58,13	17 23,38	6.6	1000	CTD _{hydro} + Mouillage C-PIS	2.3	2.55	16.02	0.6675	2/14/08 7:01
4	4	-33 58,48	17 18,18	4.6	1500	CTD _{hydro}	2.5	1.65	20.17	0.840417	2/14/08 11:10
5	5	-33 59,6	16 57,1	17.6	2500	CTD _{hydro}	2.3	3.25	25.72	1.071667	2/14/08 16:43
6	6	-34 00,8	16 35,2	18.2	3000	CTD _{hydro}	2.25	3	30.97	1.290417	2/14/08 21:58
7	7	-34 02,1	16 12,0	19.3	3600	CTD _{hydro}	2.25	3.33	36.55	1.522917	2/15/08 3:33
8	8	-34 03,8	15 41,2	25.9	4050	CTD _{hydro}	2.45	3.2	42.2	1.758333	2/15/08 9:12
Back to Cape Town area to recover the kevlar cable							23.2	0	65.4	2.725	2/16/08 8:24
9	9	-34 05,5	15 09,8	26.1	4251.75	CTD _{hydro} + Mouillage C-PIS	0	5	70.4	2.933333	2/16/08 13:24
10	10	-34 07,4	14 35,0	29	4410	CTD _{hydro}	2.5	6.5	79.4	3.308333	2/16/08 22:24
011 L1	11 & 12	-34 25,5	14 24,3	21	4624	GO-FLO Test, CTD _{hydro}	2.4	12	93.8	3.908333	2/17/08 12:48
12	13	-34 43,5	14 13,6	20	4626.25	CTD _{hydro}	2.25	3.85	99.9	4.1625	2/17/08 18:54
13	14	-35 01,6	14 2,8	20	4726.75	CTD _{hydro}	3	5.25	108.15	4.50625	2/18/08 3:09
14	15	-35 19,6	13 51,9	20	4597	CTD _{hydro}	2	3.67	113.82	4.7425	2/18/08 8:49
15	16	-35 37,5	13 40,9	20	4568	CTD _{hydro}	3.5	3.5	120.82	5.034167	2/18/08 15:49
16	17	-35 55,5	13 29,8	20	4820.5	CTD _{hydro}	2.1	3.9	126.82	5.284167	2/18/08 21:49
17	18	-36 13,4	13 18,6	20	4843.5	CTD _{hydro}	4.75	7.47	139.04	5.793333	2/19/08 10:02
18	18	-36 31,4	13 10,46	5	4920.25	Octopus	2.5	6.5	148.04	6.168333	2/19/08 19:02
18	19	-36 31,4	13 07,3		4920.25	CTD _{hydro}	0.5	5	153.54	6.3975	2/20/08 0:32
18	18	-36 31,4	13 07,3	0	4920.25	GO-FLO TM 0-300	0	3.1	156.64	6.526667	2/20/08 3:38
18	20	-36 31,4	13 07,3		4920.25	CTD ML	0	3.2	159.84	6.66	2/20/08 6:50
18	18	-36 31,4	13 07,3		4920.25	PIS	0	6.4	166.24	6.926667	2/20/08 13:14
18	21	-36 31,4	13 07,3		4920.25	CTD REE 0-Bottom	0	3.8	170.04	7.085	2/20/08 17:02
18	18	-36 31,4	13 07,3		4920.25	GO-FLO 2000-3500	0	6.4	176.44	7.351667	2/20/08 23:26
18	18	-36 31,4	13 07,3		4920.25	PIS Th 0-Bottom	0	8	184.44	7.685	2/21/08 7:26
18	18	-36 31,4	13 07,3		4920.25	GO-FLO Incub Fluo Max	0	1.7	186.14	7.755833	2/21/08 9:08
18	22	-36 31,4	13 07,3		4920.25	CTD 234 Th 210 Po 0-	0	2	188.14	7.839167	2/21/08 11:08
18	18	-36 31,4	13 07,3		4920.25	GO-FLO Incub Fluo Max	0	1.5	189.64	7.901667	2/21/08 12:38
18	23	-36 31,4	13 07,3		4920.25	CTD BaSi 0-1000	0	2	191.64	7.985	2/21/08 14:38
18	18	-36 31,4	13 07,3		4920.25	GO-FLO Incub Fluo Max	0	1.5	193.14	8.0475	2/21/08 16:08
18	18	-36 31,4	13 07,3		4920.25	Plancton Net	0	0.77	193.91	8.079583	2/21/08 16:54
18	18	-36 31,4	13 07,3		4920.25	GO-FLO Cd 0-300	0	1.5	195.41	8.142083	2/21/08 18:24
18	18	-36 31,4	13 07,3		4920.25	PIS Ra	0	8.25	203.66	8.485833	2/22/08 2:39
18	18	-36 31,4	13 07,3		4920.25	GO-FLO Fe isotop	0	5	208.66	8.694167	2/22/08 7:39
19	24	-36 49,2	12 55,9		4981.25	CTD _{hydro}	2.25	5.25	216.16	9.006667	2/22/08 15:09
20	25	-37 07,1	12 44,4	20	4983.5	CTD _{hydro}	2.25	4.8	223.21	9.300417	2/22/08 22:12
21	26	-37 25,0	12 32,8	20	5071.75	CTD _{hydro}	2.25	4.2	229.66	9.569167	2/23/08 4:39
22	27	-37 42,8	12 21,1	20	5097.75	CTD _{hydro}	2.25	4.5	236.41	9.850417	2/23/08 11:24
23	28	-38 05,58	12 05,22	25	5011	CTD _{hydro}	2.3	4.7	243.41	10.14208	2/23/08 18:24
24	29	-38 27,54	11 49,86	25	4959.25	CTD _{hydro}	2.3	5	250.71	10.44625	2/24/08 1:42
25	30	-38 49,56	11 34,5	25	5154.75	CTD _{hydro}	2.3	4.5	257.51	10.72958	2/24/08 8:30
26	31	-39 11,52	11 19,2	25	5192	CTD _{hydro}	2.3	4.5	264.31	11.01292	2/24/08 15:18
27	32	-39 33,54	11 03,84	25	4991.75	CTD _{hydro}	2.3	4.5	271.11	11.29625	2/24/08 22:06
28	33	-39 55,5	10 48,48	25	4700	CTD _{hydro} PROVOR 1	2.3	3.9	277.31	11.55458	2/25/08 4:18
29	34	-40 17,52	10 33,12	25	4731.25	CTD _{hydro}	2.6	4	283.91	11.82958	2/25/08 10:54
30	35	-40 43,15	10 12,82	30	4693	CTD _{hydro}	2.7	3.5	290.11	12.08792	2/25/08 17:06
31 36, 37	36, 37	-41 10,50	09 54,98	30	4589	CTD _{hydro}	2.5	3.5	296.11	12.33792	2/25/08 23:06
31 L2	38	-41 10,50	09 54,98	0	4689.5	GO-FLO, CTD _{hydro}	0	4.6	300.71	12.52958	2/26/08 3:42
32	39	-41 36,50	09 35,06	30	4683.25	CTD _{hydro} PROVOR 2	2.5	4	302.61	12.80042	2/26/08 10:12
33	40	-42 02,22	09 16,25	30	4689.5	CTD _{hydro}	2.5	3.5	308.61	13.05042	2/26/08 16:12
34	41	-42 28,15	08 55,72	30	4526.5	CTD _{hydro}	2.5	4	307.21	13.32125	2/26/08 22:42
34 S2	42, 43, 44, 45	-42 28,15	08 55,72	0	4572.5	7xGO-FLO, CTD _{MLD} , 2xCTD ₁₀₀₀ , 3xPIS,	0	38	345.21	14.90458	2/28/08 12:42
35	46	-42 53,5	08 35,20	30	3249	CTD _{hydro}	2.5	3.5	351.21	15.15458	2/28/08 18:42
36	47	-43 19,50	08 14,11	30	2666.5	CTD _{hydro} PROVOR 3	2.5	3	356.71	15.38375	2/29/08 0:12
37	48	-43 41,10	07 55,84	30	4322.25	CTD _{hydro}	2.5	4	363.21	15.65458	2/29/08 6:42
38	49	-44 2,70	7 37,57	20	4091.25	CTD _{hydro}	2.25	3.5	368.96	15.89417	2/29/08 12:27
OCTOP				0		Oktopus	0	5.5	374.46	16.12333	2/29/08 17:57
39	50	-44 19,80	7 22,91	20	4255.25	CTD _{hydro}	2.25	3.5	380.21	16.36292	2/29/08 23:42
40	51	-44 36,84	7 8,12	20	4172.5	CTD _{hydro} , PROVOR4	2.25	4	386.46	16.62333	3/1/08 5:57
Navigation						Storm, wind 55 kt , huge swell	11	0	397.46	17.08167	3/1/08 16:57

– BONUS-GOODHOPE Cruise Report –

Station #	CTD cast #	Lat	Long	Dist (NM)	Depth (m)	OBSERVATION TYPE	True Transit T	EFFECT TIME	EFFECT HRS	EFFECT DAYS	LOCAL TIME (UT +2 hrs)
41	52	-44 53.82	6 53.18	20	4330.5	CTD GO-FLO, CTD _{MLD}	2.25	4	403.71	17.34208	3/1/08 23:12
41 L3	53, 54, 55	-44 19.80	7 22.91	0	4255.25	GO-FLO, CTD _{MLD}	0	6.5	410.21	17.61292	3/2/08 5:42
42	56	-45 19.70	6 29.91	30	3928	CTD _{hydro}	2.25	4	416.46	17.87333	3/2/08 11:57
43	57	-45 36.85	6 14.26	25	4321	CTD _{hydro}	5	3.5	424.96	18.2275	3/2/08 20:27
44	58-46 1.44	5 51.66	5 51.66	25	3467	CTD _{hydro} PROVOR5	2.5	4	431.46	18.49833	3/3/08 2:57
44 L4	59-46 1.44	5 51.66	5 51.66	0	4321	GO-FLO, CTDMLD,	0	6.5	437.96	18.76917	3/3/08 9:27
45	60	-46 21.43	5 32.77	25	3985.25	CTD _{hydro}	2.5	3.6	444.06	19.02333	3/3/08 15:33
46	61	-46 43.32	5 11.82	25	4161.5	CTD _{hydro}	2.5	3.8	450.36	19.28583	3/3/08 21:51
47	62	-47 8.34	4 47.34	30	4623.5	CTD _{hydro}	2.5	3.8	456.66	19.54833	3/4/08 4:09
48	64	-47 33.24	4 22.45	30	4488.75	CTDhydro, PROVOR6	2.5	3.6	462.76	19.8025	3/4/08 10:15
48 S3	63, 65, 66	-47 33.24	4 22.45	0	4488.75	7xGO-FLO, CTD _{MLD} , 2xCTD ₁₀₀₀ , 3xPIS,	0	46.8	509.56	21.7525	3/6/08 9:03
49	67	-47 58.02	3 57.14	30	4490.5	CTD _{hydro}	2.6	3.7	515.86	22.015	3/6/08 15:21
OCTOP		-47 58.02	3 57.14	0	4490.5	Oktopus	0	4.2	520.06	22.19	3/6/08 19:33
50	68	-48 22.68	3 31.39	30	4104.5	CTD _{hydro}	3	3.5	526.56	22.46083	3/7/08 2:03
51	69	-48 42.18	3 10.49	25	3969.75	CTD _{hydro}	2.9	3.2	532.66	22.715	3/7/08 8:09
52	70	-49 1.68	2 49.45	25	3989	CTDhydro, PROVOR7	2.5	3.5	538.66	22.965	3/7/08 14:09
52 L5	71, 72	-49 1.68	2 49.45	0	3989	GO-FLO, CTD _{MLD} , 2xCTD	0	8	546.66	23.29833	3/7/08 22:09
53	73	-49 17.94	2 31.52	20	3847	CTD _{hydro}	2.25	3.3	552.21	23.52958	3/8/08 3:42
54	74	-49 34.14	2 13.37	20	3799.5	CTD _{hydro}	2.4	3	557.61	23.75458	3/8/08 9:06
55	75	-49 50.28	1 55.01	20	3604	CTDhydro PROVOR8	2.5	3.4	563.51	24.00042	3/8/08 15:00
56	76	-50 6.36	1 36.42	20	3568	CTDhydro	4	3.2	570.71	24.30042	3/8/08 22:12
57	77	-50 22.38	1 17.61	20	3474	CTD _{hydro}	3	3	576.71	24.55042	3/9/08 4:12
57 L6	78	-50 22.38	1 17.61	0	3474	CTD GO-FLO, CTD _{MLD}	0	4.5	581.21	24.73792	3/9/08 8:42
58	79	-50 38.34	0 58.57	20	3276	CTDhydro PROVOR9	2.25	3.3	586.76	24.96917	3/9/08 14:15
59	80	-50 54.24	0 39.29	20	1992	CTD _{hydro}	2.25	2.5	591.51	25.16708	3/9/08 19:00
60	81	-51 10.08	0 19.77	20	2161	CTD _{hydro}	2.25	2.5	596.26	25.365	3/9/08 23:45
61	82	-51 25.86	0 00.0	20	2360	CTDhydro	2.25	2.5	601.01	25.56292	3/10/08 4:30
62	83	-51 56.40	0 00.0	20	2413	CTD _{hydro} PROVOR10	2.25	2.5	605.76	25.76083	3/10/08 9:15
62 S4	84 85 86 87	-51 56.40	0 00.0	0	2413	7xGO-FLO, CTD _{MLD} , 2xCTD ₁₀₀₀ , 3xPIS,	0	37	642.76	27.3025	3/11/08 22:15
63	88	-52 16.20	0 00.0	20	2637	CTD _{hydro}	2.25	3	611.01	27.52125	3/12/08 3:30
64	89	-52 36.00	0 00.0	20	2709	CTD _{hydro} PROVOR11	2.25	3	616.26	27.74	3/12/08 8:45
65	90	-52 55.80	0 00.0	20	2610	CTD _{hydro}	2.25	2	620.51	27.91708	3/12/08 13:00
65 Int	91	-52 55.80	0 00.0	0	2610	CTD _{hydro}	0	3	623.51	28.04208	3/12/08 16:00
66	92	-53 15.60	0 00.0	20	2462	CTD _{hydro}	2.25	2	627.76	28.21917	3/12/08 20:15
67	93	-53 35.4	0 00.0	20	2657	CTD _{hydro} PROVOR12	2.25	2	632.01	28.39625	3/13/08 0:30
68	94	-53 55.20	0 00.0	20	2428	CTDhydro	2.25	2.1	636.36	28.5775	3/13/08 4:51
69	95	-54 15.0	0 00.0	20	2592.75	CTD _{hydro}	2.25	2.5	641.11	28.77542	3/13/08 9:36
70	96	-54 34.8	0 00.0	20	1342	CTD _{hydro}	1.75	1.6	644.46	28.915	3/13/08 12:57
71	97	-54 54.6	0 00.0	20	1394	CTD _{hydro}	1.75	1.7	647.91	29.05875	3/13/08 16:24
72	98	-55 14.4	0 00.0	20	3023.75	CTD _{hydro}	3.75	2.5	654.16	29.31917	3/13/08 22:39
72 L7	99, 100	-55 14.4	0 00.0	20	2592.75	GO-FLO, CTDMLD, CTD1000	0	10.1	761.56	29.74	3/14/08 8:45
73	101	-55 34.2	0 00.0	20	3574.75	CTD _{hydro} PROVOR13	2	2.5	658.66	29.9275	3/14/08 13:15
74	102	-55 54.0	0 00.0	20	3952	CTD _{hydro}	2.25	3.1	664.01	30.15042	3/14/08 18:36
75	103	-56 13.8	0 00.0	20	4013.5	CTD _{hydro}	3	3.3	670.31	30.41292	3/15/08 0:54
76	104	-56 45.0	0 00.0	25	4158.5	CTD _{hydro}	6.7	3.5	680.51	30.83792	3/15/08 11:06
77	105	-57 13.2	0 00.0	25	4111	CTD _{hydro}	2.4	3.5	686.41	31.08375	3/15/08 17:00
78	106	-57 33.0	0 00.0	20	3932.75	CTD _{hydro}	1.75	3	691.16	31.28167	3/15/08 21:45
78 S5	107, 108, 109, 110	-57 33.0	0 00.0	20	4423	7xGO-FLO, CTD _{MLD} , 2xCTD ₁₀₀₀ , 3xPIS,	0	40	731.16	32.94833	3/17/08 13:45

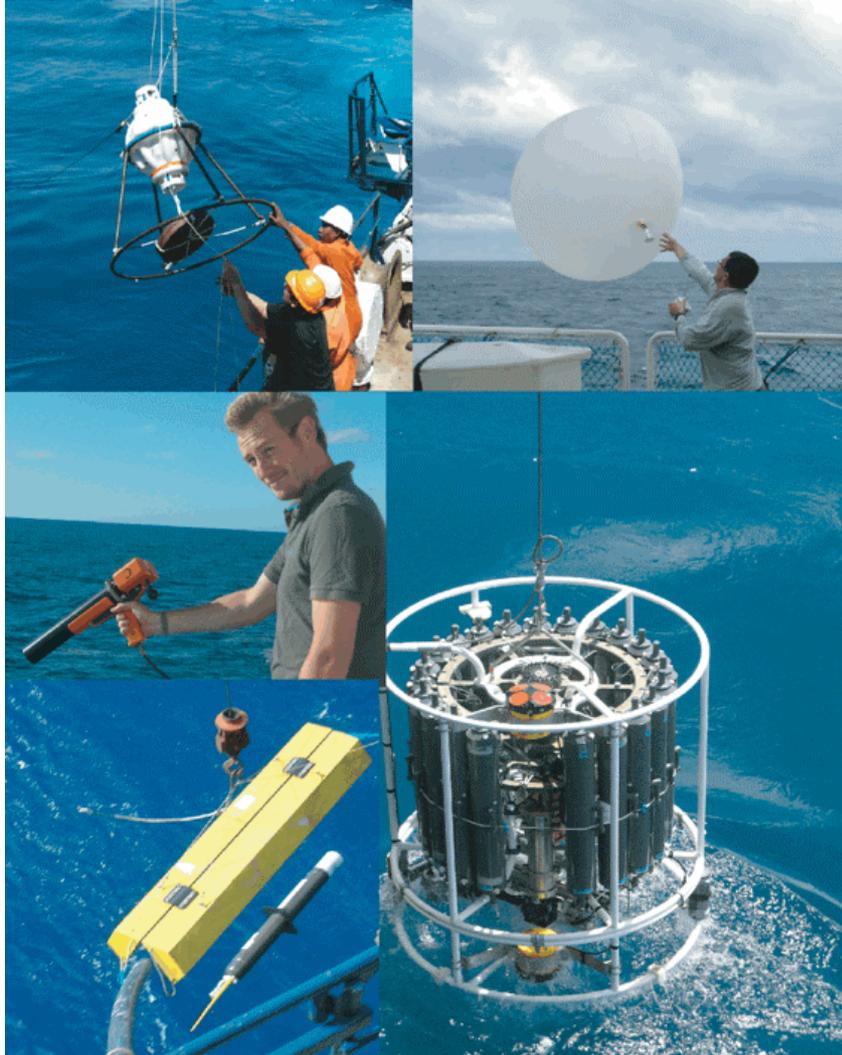
Table 1 – continued.

GENERAL IMPRESSION ON THE RESULTS QUALITY

The data quality for the data acquired directly on board (CTD captors, Thermosalinograph, O₂, PCO₂, DIC, Alkalinity, pH, Nutrients, meteorology variables, ...) has been monitored constantly and regularly. We can already state that the data quality will be very good after the usual calibration and validation processes. The data processing of ADCPs (Ship-born and Lowered) has required particular attention but the data obtained are very satisfactory and of very good quality.

4 PRELIMINARY SCIENTIFIC CONCLUSIONS

4.1 PHYSICAL OBSERVATIONS



The BONUS-GOODHOPE hydrological section has led to a very rich sampling of many water masses, surface, subsurface and deep mesoscale and frontal structures as well as a very rich and unique collection of atmospheric data. Atmospheric data collected through continuous acquisition and radiosounding, revealed already a strong interaction between ocean mesoscale and atmospheric dynamics and related air-sea exchanges and yielded a very rich set of data that will be analysed further. Satellite imagery and data we were receiving on board in real-time during the cruise were used to improve the hydrological station positioning as well as XBT, profiling floats and atmosphere radiosounding deployment strategy. This proved to be a very powerful way to optimize the ocean sampling and allowed for rapid interpretation of many ocean dynamics aspects related with observed surface and subsurface structures.

4.1.1 INVOLVED SCIENTIFIC STAFF AND TASKS DISTRIBUTION DURING THE CRUISE:

Observations coordinated by the Laboratoire de Physique des Océans,
UMR 6523 CNRS-IFREMER-IRD-UBO

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Involved scientific staff and tasks distribution during the cruise:

Sabrina Speich (UBO & IRD-LPO): team leader and chief scientist

CTD Shifts:

- 0-4 : Catherine Lagadec (IFREMER-LPO, shift responsible)
Stéphane Leizour (IFREMER-LPO)
Arnaud Leboyer (UBO-LPO)
- 4-8 : Michel Arhan (IFREMER-LPO, shift responsible)
Lionel Scouarnec (INSU)
Serguei Gladyshev (Shirshov Institute, Moscow, Russia)
- 8-12 : Catherine Kermabon (IFREMER-LPO, shift responsible)
Norbert Cortes (IFREMER-LPO)
Christophe Guillerm (INSU)

ADCPs follow-up

- Jean-Pierre Gouillou (IFREMER-LPO): installation and testing of LADCPs while in Cape Town
- Michel Hamon (IFREMER-LPO): monitoring of LADCP activity, download of LADCP data.
- Catherine Kermabon (IFREMER-LPO): data processing
- Xavier Perrot (UBO-LPO): data processing

Salinity and Oxygen analyses

- Pierre Branellec (IFREMER-LPO responsible, Oxygen analyses and TSG sampling)
- Olivier Peden (IFREMER-LPO): Oxygen analyses
- Volfrango Rupolo (ENEA-Casaccia, Italy): Salinity analyses

CFCs sampling

- Maxime Richard (UBO-LPO)
- Neil Swart (UCT, South Africa)

Profiling floats

- Norbert Cortes (IFREMER-LPO)
- Stephane Leizour (IFREMER-LPO)

C-PIES preparation and deployment

- Norbert Cortes (IFREMER-LPO)
- Stephane Leizour (IFREMER-LPO)

Expandable Bathy-Thermographs (XBTs)

- Sebastiaan Swart (UCT, South Africa)
- Issufo Halo (UCT, South Africa)

Air-sea fluxes and radiosounding

- Christophe Messenger (CNRS-LPO, responsible)
- Erica Key (sensors responsible, CETP & RSMAS)

Hélène Leau, Pierre Sangiardi, Martin Millet, Frédéric Rigaut and Yvan Reaud from Institut Polaire Français Paul-Emile Victor helped acquiring all these observations.

4.1.2 FULL DEPTH CTD ACQUISITION: PRELIMINARY VERTICAL DISTRIBUTIONS

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Full depth CTD data were acquired at 79 stations occupied in the region 33° 58' S – 57° 33' S, 17° 13' E – 0° E, from February 13, 2008 and March 17, 2008. Measurements were made at all stations from the surface to about 15 to 30 meters from the bottom. The station spacing was varied from 7-8 NM on the

continental slope, to 20 NM across frontal regions and strong topographic slopes, and, because of time delays and the tight ship-time, we lowered the resolution to 30 NM in the deep abyssal planes and away from mesoscale structures and sharp topography.

The stations were made with a SEABIRD 911+ probe mounted on a 24-bottle SEABIRD Rosette. Only 22 bottles were in operation as two bottle (bottles 22 and 23) were removed to allow the two WHS 300 kHz L-ADCPs to be fixed on the Rosette frame. Salinity, dissolved oxygen, nutrients, DIC, pH and Alkalinity were analysed on board.

Preliminary vertical distributions for the basic CTD (Temperature, Salinity, and Density) and rosette (Salinity and Oxygen) physical parameters are shown below. The measured CTD parameters were smoothed vertically with a 10 db step. The rosette parameters were linearly interpolated from the original discrete vertical sampling to provide continuous profiles.

We present here observations from the **uncalibrated** CTD data we collected during the BONUS-GOODHOPE cruise.

4.1.2.1 OCEANIC FRONTS ALONG THE BONUS-GOODHOPE TRANSECT

The oceanic region separating the African and Antarctic continents may be subdivided in three main regimes, namely, the subtropical domain north of 40°S-42°S, the ACC between 40°S-42°S and 55°S-57°S, and the eastern part of the Weddell Sea gyre to the south.

The Antarctic Circumpolar Current (ACC) is associated with several narrow jets or fronts. These frontal regions are characterised by sharp horizontal gradients in hydrological properties (such as temperature, salinity, density, oxygen and nutrients) that mark the boundaries of different water masses.

Four main fronts are continuous features of the ACC: the subantarctic front (SAF); the polar front (PF); a deep-reaching front observed persistently to the south, the southern ACC front (SACCF). The ACC is bounded at its southernmost limit, in our region, by the Southern Boundary (Sbdy). North, the ACC is separated from the Subtropical Region by the Subtropical Front (STF). From various set of data (CTD, satellite imagery and XBT) we were able to define the position of each front along the cruise track. The position of the principal branches of such fronts as derived from CTD data are given in Table 2.

Table 2 – Position of the ACC principal fronts crossed during the BONUS-GOODHOPE cruise.

FRONTS ACRONYM	POTENTIAL TEMPERATURE CRITERIA	BGH STATION NUMBER	BGH CTD NUNMBER	BGH LATITUDE
S-STF	$10^{\circ}\text{C} < \theta_{100\text{m}} < 12^{\circ}\text{C}$	33	40	42° 2' S
SAF	The northernmost region where $\theta_{400\text{m}} > 4\text{-}5^{\circ}\text{C}$	38	49	44° 2' S
PF	$\theta < 2^{\circ}\text{C}$ along the θ_{min} for depths > 200m	57	77	50° 22.4' S
SACCF	The northernmost region where $\theta > 1.8^{\circ}\text{C}$ along θ_{max} for depths > 500 m & the southernmost region where $\theta < 0^{\circ}\text{C}$ along the θ_{min} for depths > 150 m	62	87	51° 52' S
SBdy	Southern limit where $\theta_{\text{max}} > 1.5^{\circ}\text{C}$ at about 200 m of depth	74	102	55° 54.3' S

4.1.2.2 WATER MASSES FROM NORTH (THE AFRICAN CONTINENTAL SLOPE) TO SOUTH (WEDDELL GYRE).

Leaving Cape Town, on the continental shelf-break we meet at the surface a thin and narrow layer of warm and salty waters (the “Agulhas jet”); the water underneath is fresher and colder, probably northern upwelled slope waters brought southward by the “upwelling” slope undercurrent. Leaving the 200 m isobath we meet the subtropical warm and salty water of clear Indian origins. We crossed different large anticyclonic eddies (Agulhas rings). For most of them (and this appear clearly in looking at the altimetry fields), we sampled them at the periphery. Nonetheless, the signature in temperature, salinity and oxygen is classical, reaching depths of more than 1000db. The layer at about 800-1000 db is relatively saltier than classical “AAIW”. Indeed, this layer probably is made of AAIW of Indian origin that is slightly saltier than the classical variety of AAIW we will find more south along our cruise transect. During the transect, we also sampled cyclonic eddies originating from the Agulhas Bank in the northern part of the domain. Other cyclonic eddies along the northern part of the second leg of the transect (from station 10, along the altimeter ground track) seem more to be of subantarctic origin.

Underneath, along the slope, between 2300 db and 3200 db, salinity and oxygen maximum are evident, showing that we sampled the deep southward slope current of diluted NADW. When the slope reaches its deepest depths and in the Cape Basin abyssal plain, we found probably a diluted variety of Antarctic Bottom Water.

The southern STF (S-STF) is located north of the Agulhas Ridge. Just south of the S-STF, in the subantarctic region, we crossed a small cyclone (we

named as “cyclone S”). Just southward of it, well sit on the Agulhas Ridge, we sampled a very large and intense anticyclone of Indian origins (we called it anticyclone “M”). Its surface temperature is lower than the northern Agulhas anticyclones found in the subtropical domain. This is very likely due to the fact that this structure has released heat to the atmosphere, being kept in the subantarctic region for weeks if not months. Its structure shows that, this eddy has been exposed to a strong cooling, before the Summer heating. Before Summer, its mixed layer probably reached 500 to 600 db of depth. North of the eddy we found waters of southern origins. At about 600 db, just north of anticyclone “M”, we sampled a filament of what seems to be AAIW.

The principal branch of the SAF has been found just south of anticyclone “M” and the Agulhas Ridge. South of the SAF, we find surface water that gets cooler going south and shows a light seasonal thermocline. Underneath, we sampled AAIW. At deeper depths we find water that has the typical characteristic of low oxygen Upper Circumpolar Water (UCDW). South of the Agulhas Ridge, deeper waters than UCDW show more and more diluted NADW properties. Although they are characterized by more or less the same neutral density, NADW and Lower Circumpolar Water (LDCW) differ in salinity, LCDW being fresher. From our preliminary data, along our section water south of the PF seems to be “classical” LCDW having gone through the Drake Passage. Therefore, the deep water between the Agulhas Ridge and the PF are a more diluted variety of NADW compared to that found northward, in the Cape Basin. This water probably is NADW injected in the ACC in the south-western Argentine Basin, whose influence has reached the PF by the time it arrives at the Greenwich meridian. At the bottom, we found what seems to be a fresher, colder AABW variety.

The near-surface water of the Polar Frontal Zone is the least saline near-surface water in the ACC band. South of this surface fresh layer of water, we find successively the SACCF and the SBdy of the ACC. Once crossed the SBdy we reached the Weddell Gyre. There we found the water masses that classically fill the water column of the Weddell Sea. At the northern side of Weddell Gyre, along a narrow band of latitudes, surface waters are more saline than across the ACC southern fronts. This narrow band of surface waters could come from the upwelling of deep saltier water during the path of the water from the western most part of the Weddell Gyre and the prime meridian.

The fronts’ locations as well as the principal sampled water masses are superimposed on the vertical sections derived from the CTD.

4.1.2.3 PRELIMINARY BGH VERTICAL DISTRIBUTION OF TEMPERATURE AND SALINITY FROM THE CTD

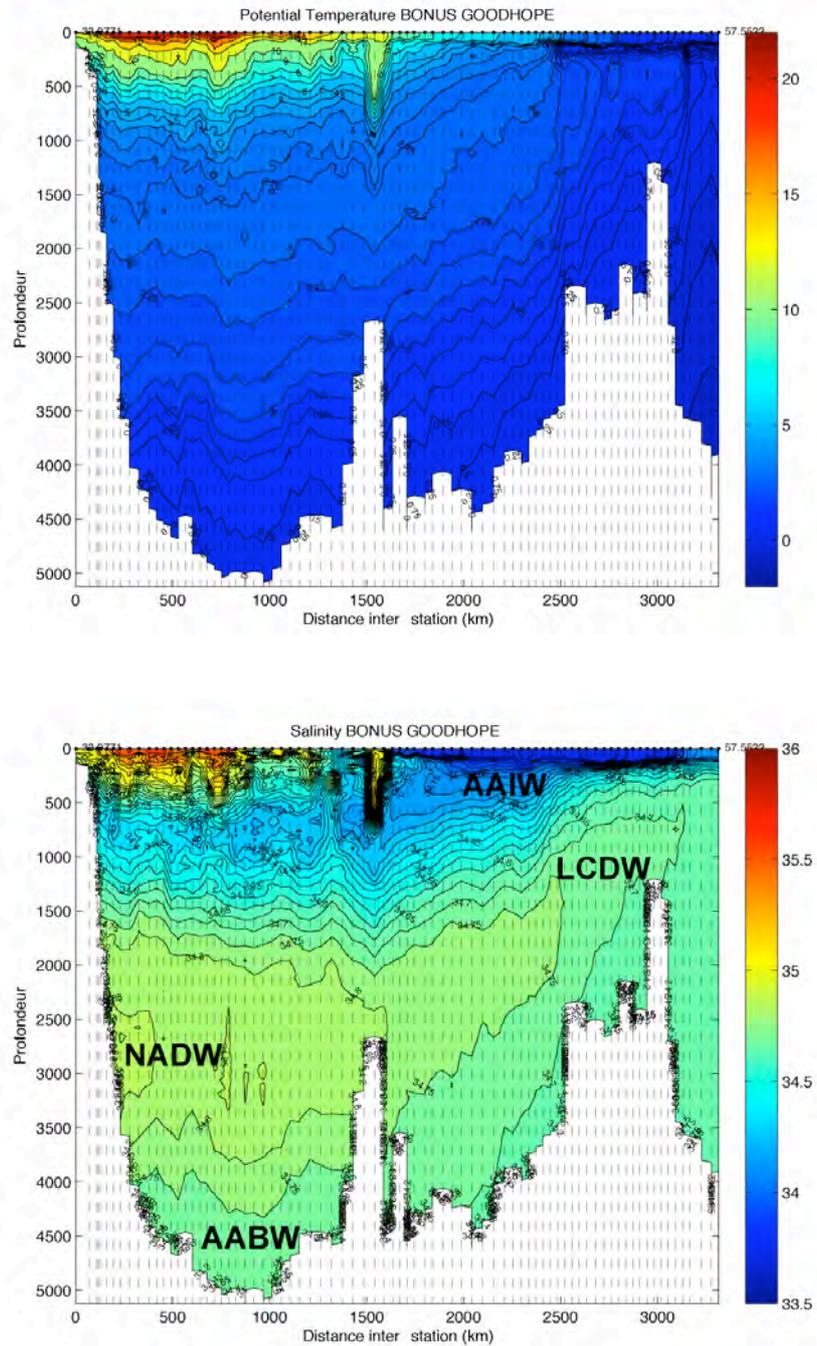


Figure 4 – Full-depth vertical sections from uncalibrated CTD observations made during BGH. Upper panel: potential Temperature (in degrees Celsius). Lower Panel: Salinity. The African Continent (i.e., the northern part of the section) is on the left.

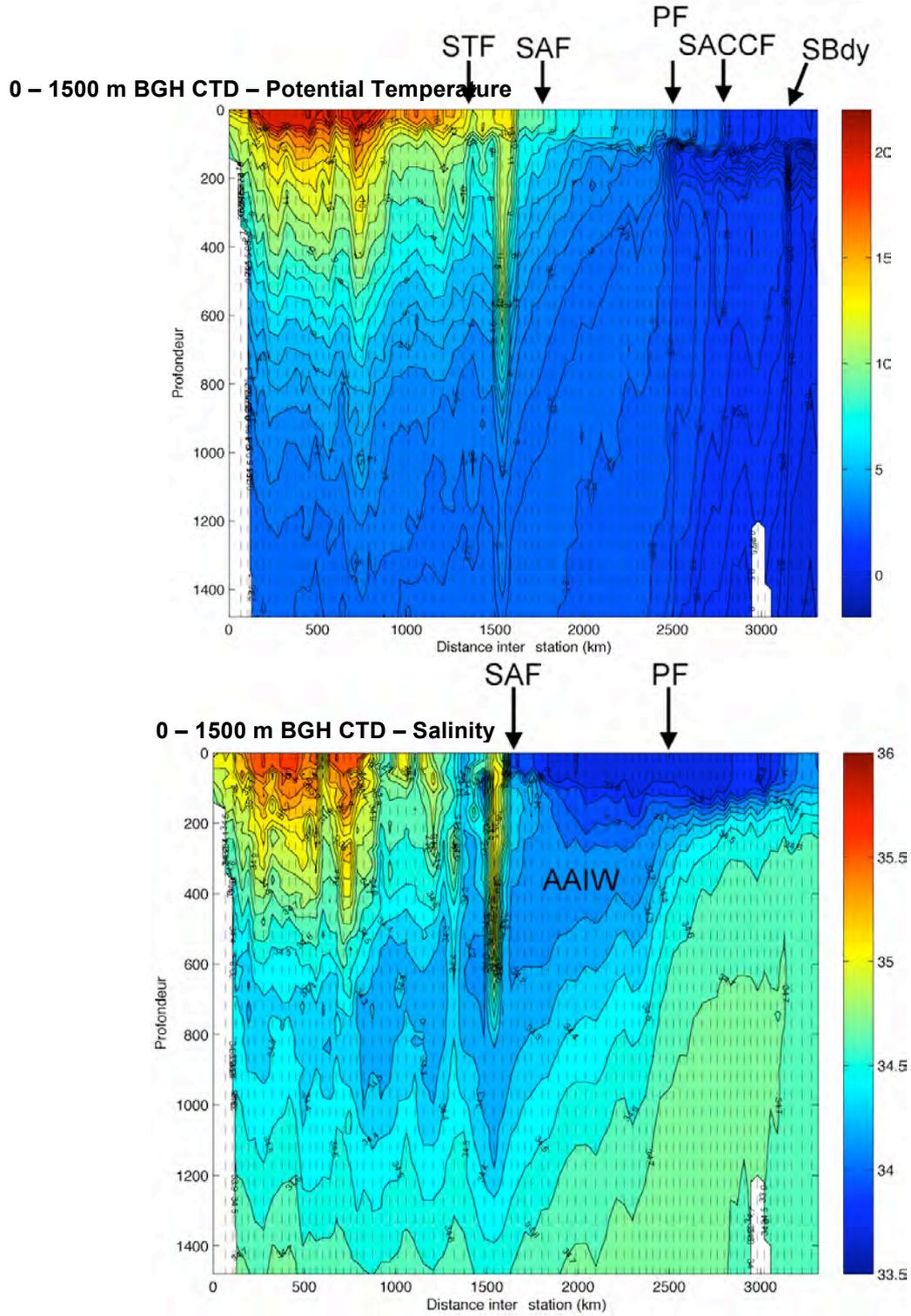


Figure 5 – Vertical sections for the upper layers from uncalibrated CTD observations made during BGH. Upper panel: potential Temperature (in degrees Celsius). Lower Panel: Salinity. The African Continent (i.e., the northern part of the section) is on the left.

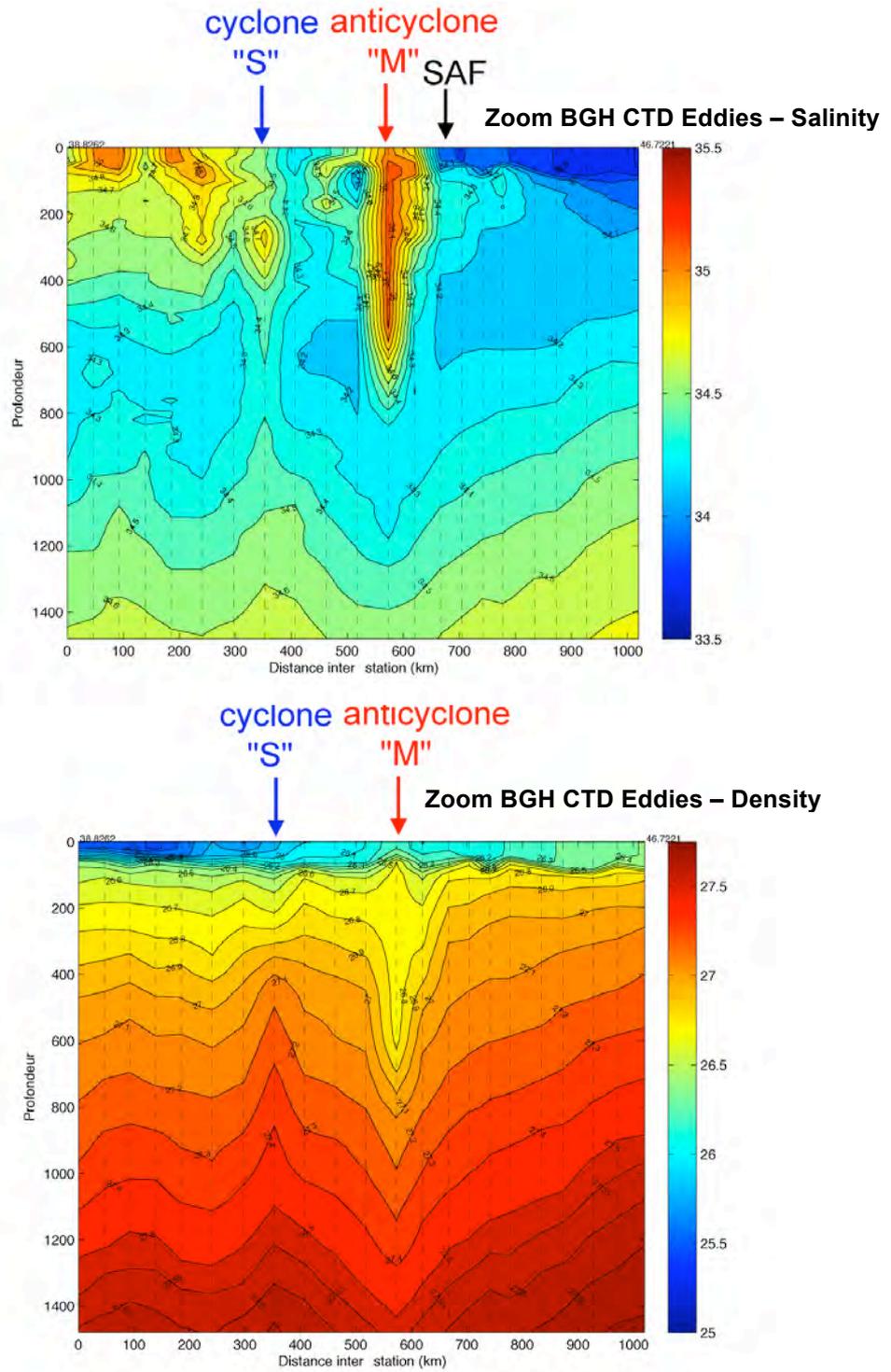


Figure 6 – Regional zoom for the SAF and eddies “S” and “Michel” (M). Upper layers vertical sections from uncalibrated CTD observations made during BGH. Upper panel: Salinity. Lower panel: potential density anomaly σ_θ (in kilograms per cubic meter). The northern part of the section is on the left.

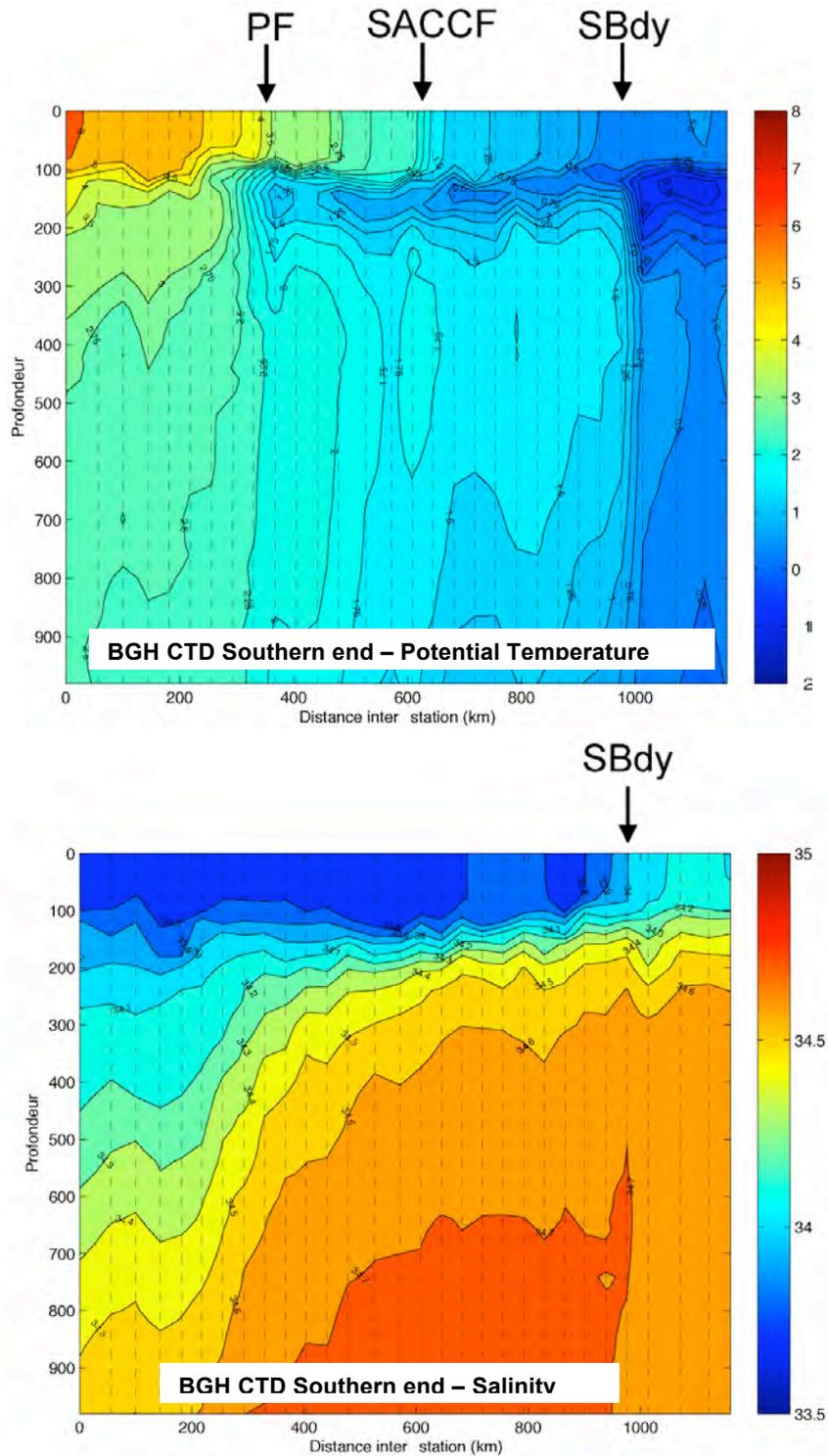
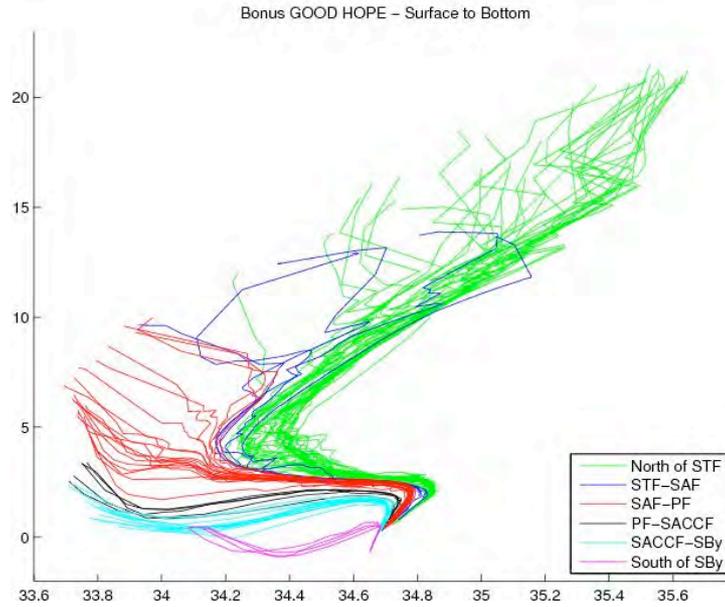


Figure 7 – Regional zoom for southern end of the BONUS-GOODHOPE transect. Upper layers vertical sections from uncalibrated CTD observations made during BGH. Upper panel: Potential Temperature (in degrees Celsius). Lower panel: Salinity. The northern part of the section is on the left.

4.1.2.4 PRELIMINARY $\theta - S$ DIAGRAMS

$\theta - S$ diagrams – full depth BGH - CTD



$\theta - S$ diagrams –BGH – CTD deep and bottom waters

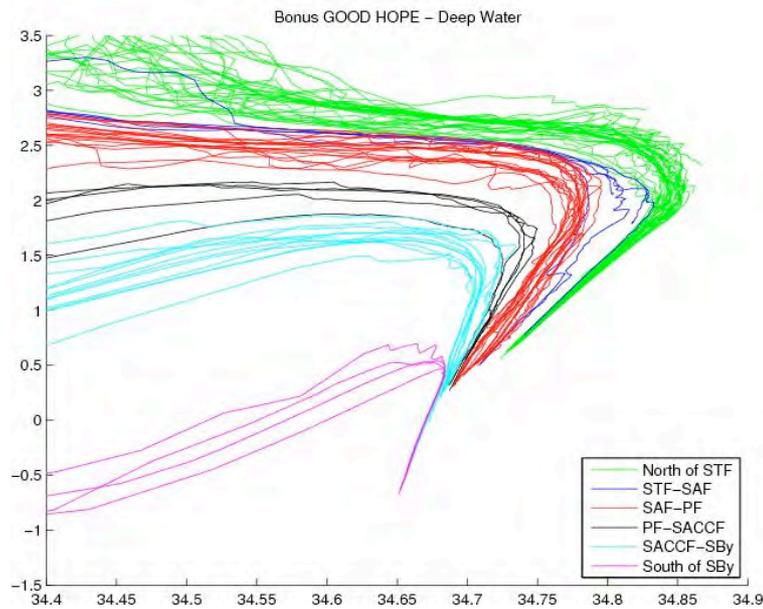


Figure 8 – Potential Temperature-Salinity relationships for the BONUS-GOODHOPE transect derived from uncalibrated CTD data. Vertical profiles are coloured from North (Green) to South (Lilac) in relation to their geographical position compared to that of the encountered fronts (S-STF, SAF, PF, SACCF, SBy). Upper panel: vertical profiles for the full depth CTD data. Lower panel: zoom on the colder domain (deep and bottom waters).

4.1.2.5 PRELIMINARY VERTICAL DISTRIBUTION OF SALINITY AND OXYGEN FROM THE 22-BOTTLE ROSETTE

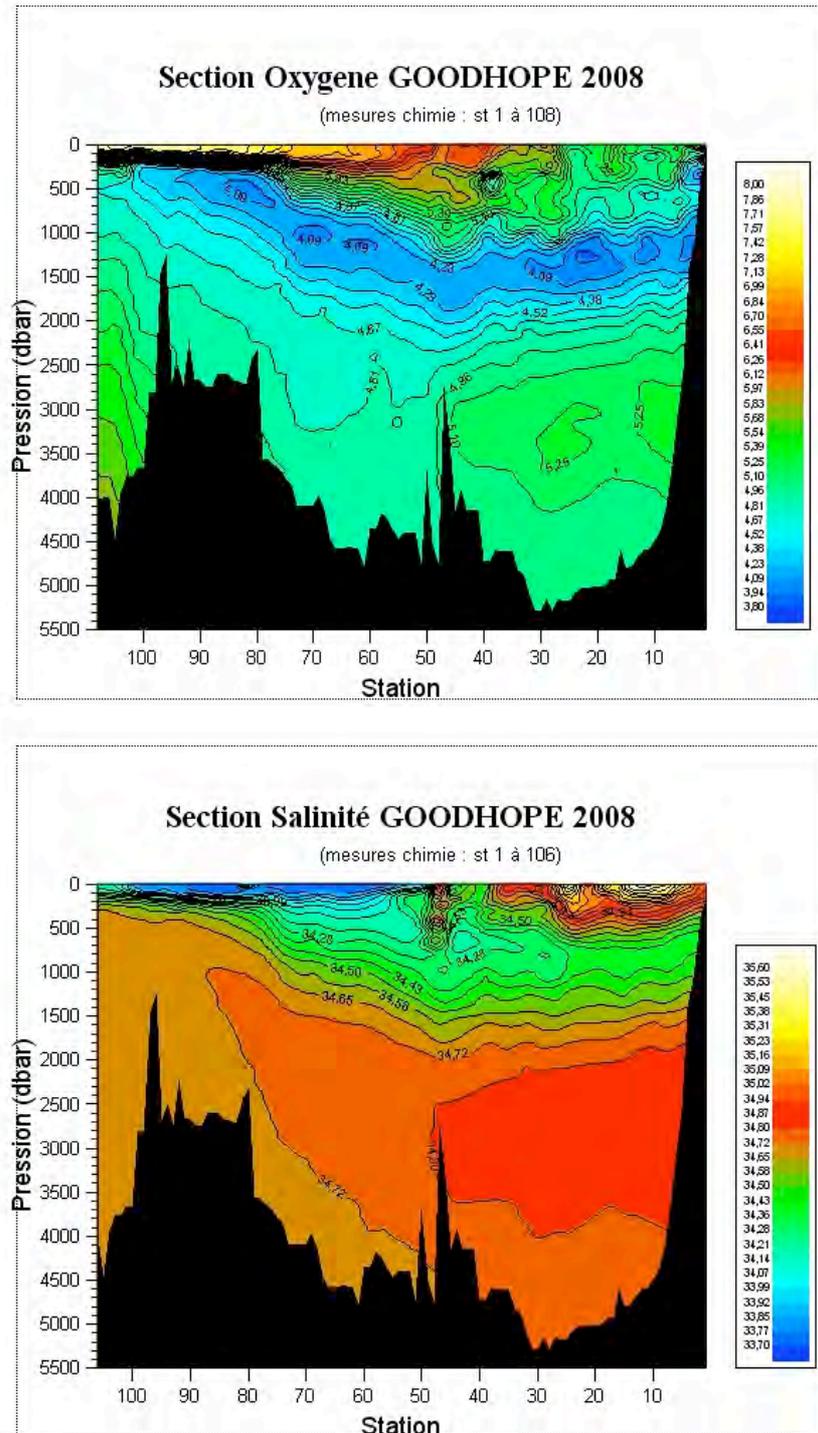


Figure 9 – Full depth vertical sections for the from uncalibrated BONUS-GOODHOPE CTD-Bottle data. Upper panel: Oxygen (in millilitres per litre). Lower Panel: Salinity. The African Continent (i.e., the northern part of the section) is on the right.

4.1.3 ACOUSTIC DOPPLER CURRENT PROFILERS (ADCPS) DATA

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4.1.3.1 VESSEL MOUNTED ACOUSTIC DOPPLER CURRENT PROFILER (VM-ADCP)

Acoustic Doppler Current Profilers (ADCP) measure Doppler frequency shift from reflected acoustic pulses. Reflections occurring mainly on passive particles, this shift can be used to resolve water current profiles. When mounted on a vessel (VM-ADCP), ocean currents are measured relative to a reference system moving along with the vessel. If the vessel's navigation parameters are known, one can compensate for this motion in software to resolve absolute current velocities. However, good quality data rely on an accurate navigation system providing position and velocity measurements relative to an Earth fixed frame as well as attitude, i.e. heading, roll and pitch, to compensate for changes of instrument orientation. Typically, VM-ADCP consists of four beams, their directions varying with the ship's orientation. If not compensated for, oscillations in roll and pitch due to vessel wave motion will be seen in the measured data.

Averaging of measurements over a period of time reduces these errors. However, precise heading, roll and pitch data available at a high rate are important for measuring ocean currents with high accuracy in rough sea conditions. Accurate heading information is essential to transform measured velocities into an Earth fixed coordinate system. The heading accuracy of a gyro compass is not sufficient for providing high quality ADCP measurements. Another important navigation

parameter is vessel velocity. This is obtained through DGPS and by measuring the vessel velocity from bottom reflections, where acoustic pulses can reach the sea floor, that is, in shallow areas.

Two RDI VM-ADCPs have been in operation on RV *Marion Dufresne*; the narrowband 150kHz VM-ADCP and a 75 kHz Phased Array instrument (Ocean Surveyor). The latter has been analyzed daily during the cruise, with the LPO-IFREMER *Cascade* software.

At the beginning of the cruise the OS 75 kHz VM-ADCP was not operational as it was giving absurd values and we did not know the angle of unalignment of the instrument. Owing with a good cooperation with Martin Mellet of IPEV, we were able to configure the VMDAS similarly to what is done on the RV *Pourquoi Pas?* (e.g., we found that the correction on the ship heading was not made. During the way to Cape Town and back to recover the Kevlar cable, it was possible to evaluate the unalignment angle to a 7.5° value).

During the first two weeks of the cruise, the weather conditions being smooth, the VM-ADCP data acquisition was very good (despite a maximum penetration of 800 m of depth). This has led to a validation of the derived velocities from the VM-ADCP with the L-ADCP data and with geostrophic velocity derived from the absolute dynamic topography (near-real time data) we were receiving on board. Because of the increasing swell as we were heading south, the depth range became shallower leading to some missing data at the end of the hydrographic transect.

VM-ADCP data have been collected also during the transit from our last hydrographic station at $57^\circ33' \text{ S } 0^\circ\text{E}$ to Durban.

VM-ADCP AVERAGED VELOCITY VECTORS FOR 50 - 350m LAYER

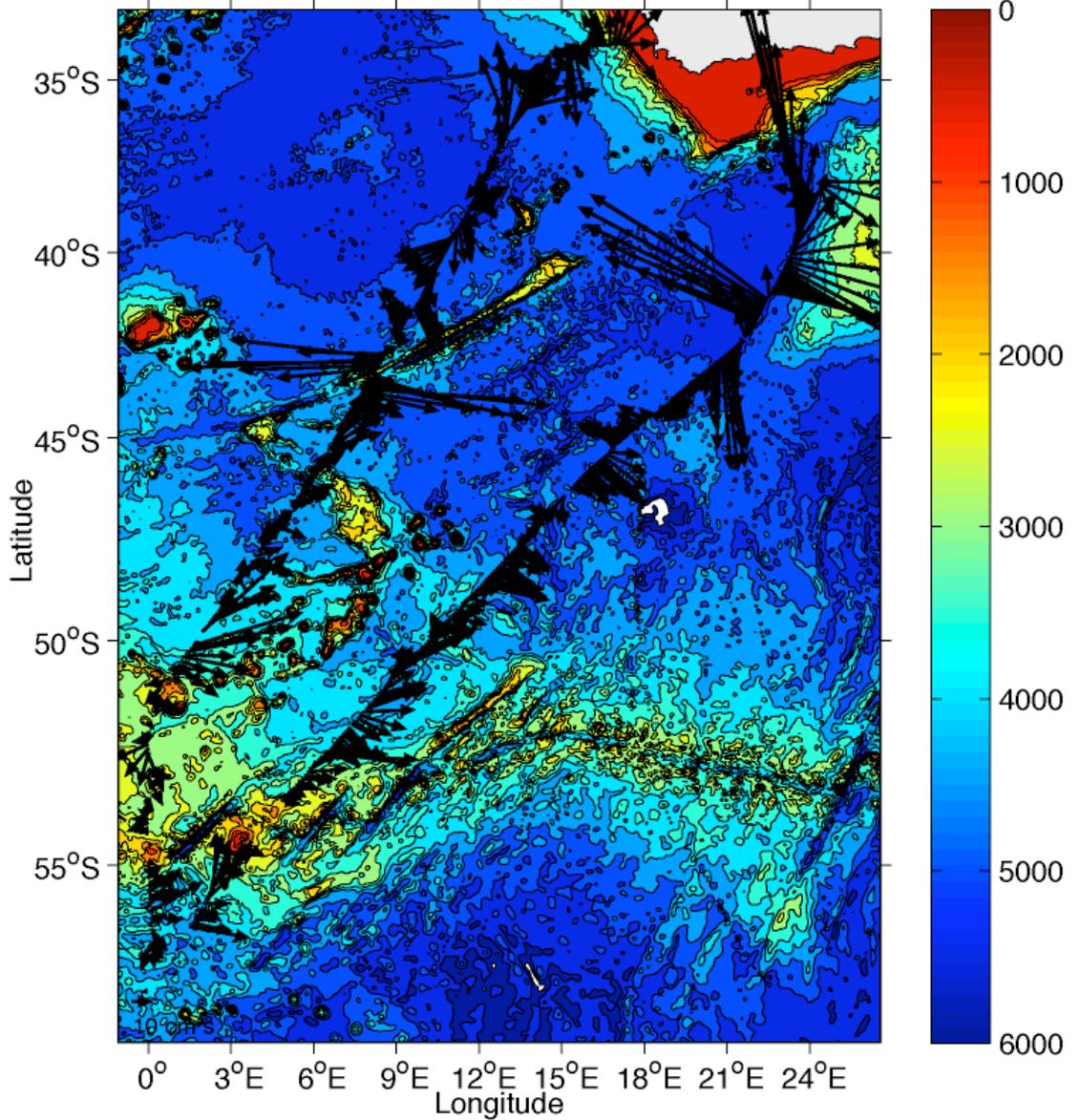


Figure 10 – VM-ADCP velocity vectors through all the BONUS-GOODHOPE transect and the return route to Durban from the last cruise station, located at 57° 33'S. The velocity values are the mean of velocities measured between 50 and 350m.

4.1.3.2 LOWERED ACOUSTIC DOPPLER CURRENT PROFILER (LADCP)

Full depth velocity profiles of ocean currents are useful for many applications in physical oceanography ranging from direct observations of the large scale ocean circulation, over investigations of individual processes that control ocean dynamics down to aspects of small scale mixing. Several methods exist to obtain deep velocity profile one of which is the lowered acoustic Doppler Current profiler (LADCP) that allows to measure full ocean depth velocity profiles during a Hydrographic station. It takes no extra ship time to obtain the measurements since the profiler is part of the CTD rosette package and requires minimal operating effort.

The LADCP-2 system we used during the BGH cruise employs 2 ADCPs (the “master” and the “slave”) of the Workhorse type (WHM300) manufactured by RD Instruments and mounted head to tail. The instruments operate at a frequency of 300 kHz. With this system, at least one of the instruments will always obtain a full range profile even when approaching the sea floor or the surface. Each acoustical transducers emits every second an acoustical pulse that is transmitted into the water and the backscattered signal along each of the four beams is analyzed. The strength of the signal allows to map changes in the backscatter environment and is also useful to monitor the instrumental performance. The Doppler frequency shift of the backscatter is transformed into a velocity estimated and the range gating allows to probe at different distances for the transducer heads. The range of useful velocity data for each single ping is about 100 m depending on backscatter conditions. A velocity profile is obtained along each of the four beams that are inclined from the vertical by 20 or 30 degrees. Using pitch, roll and a compass these profiles are then converted to earth coordinates and stored internally. Often 2--10 profiles are averaged in order to reduce the data volume during each station of 2--5 hours duration. This raw data set is then down loaded from the instrument once it is back on the research vessel. The data processing is usually done right after the cruise but we started to analyse each cast data daily. At LPO we could normally use two different L-ADCP analysis softwares, one developed by Yves Gouriou (IRD) and Catherine Kermabon (LPO) and based on a principle of vertical “integration” of velocities ; the second has been developed by Martin Visbeck (IFM-Kiel) and is based on the principle of “inversion” of ADCP data but it gives also a solution based on the vertical integration of velocities. After a quick evaluation and based on the fact that for this cruise we had a master-slave WHM300 configuration mounted on a Seabird CTD-Rosette system, we used the “Visbeck” software that was ready to be used in such a configuration and able to improve the velocity estimates by including VM-ADCP data and Seabird CTD data as well as the ship navigation system.

Besides a first LADCP (slave) needed to be changed already at station nr. 3 with no available data for this LADCP for stations 001, 002, 003, for the rest of the cruise the master LADCP and the substitute slave LADCP (borrowed from IRD) were stable and the data looked realistic.

In the following we show the derived BGH LADCP velocity vectors averaged around the bottom and for deep water (around 1500 m).

Ladcp mean velocity around bottom with shift of 300m

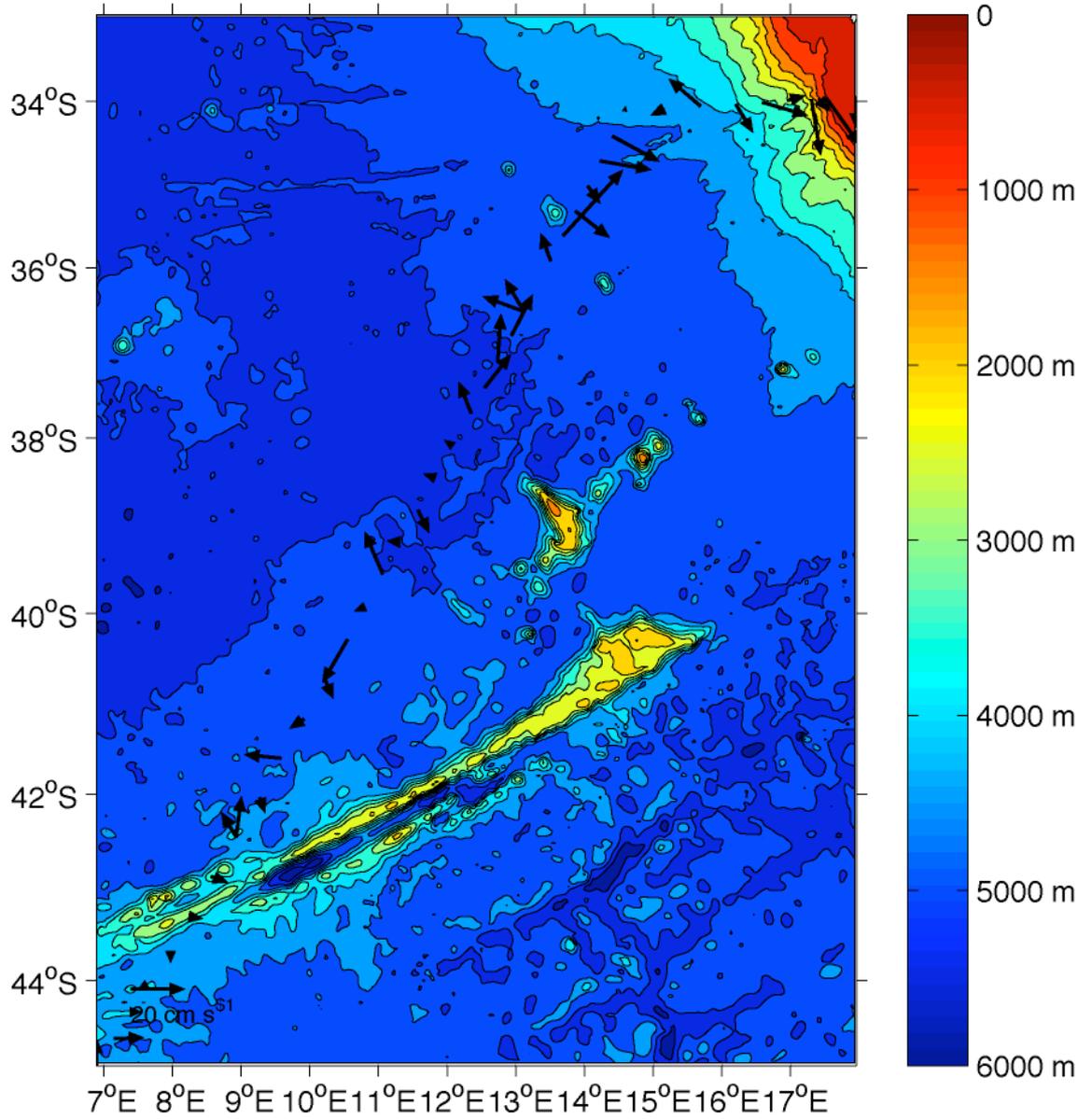


Figure 11 – Non-validated L-ADCP velocity vectors through the BONUS-GOODHOPE transect for the bottom layer with shift of 300m.

Ladcp mean velocity around 1500m with shift of 500m

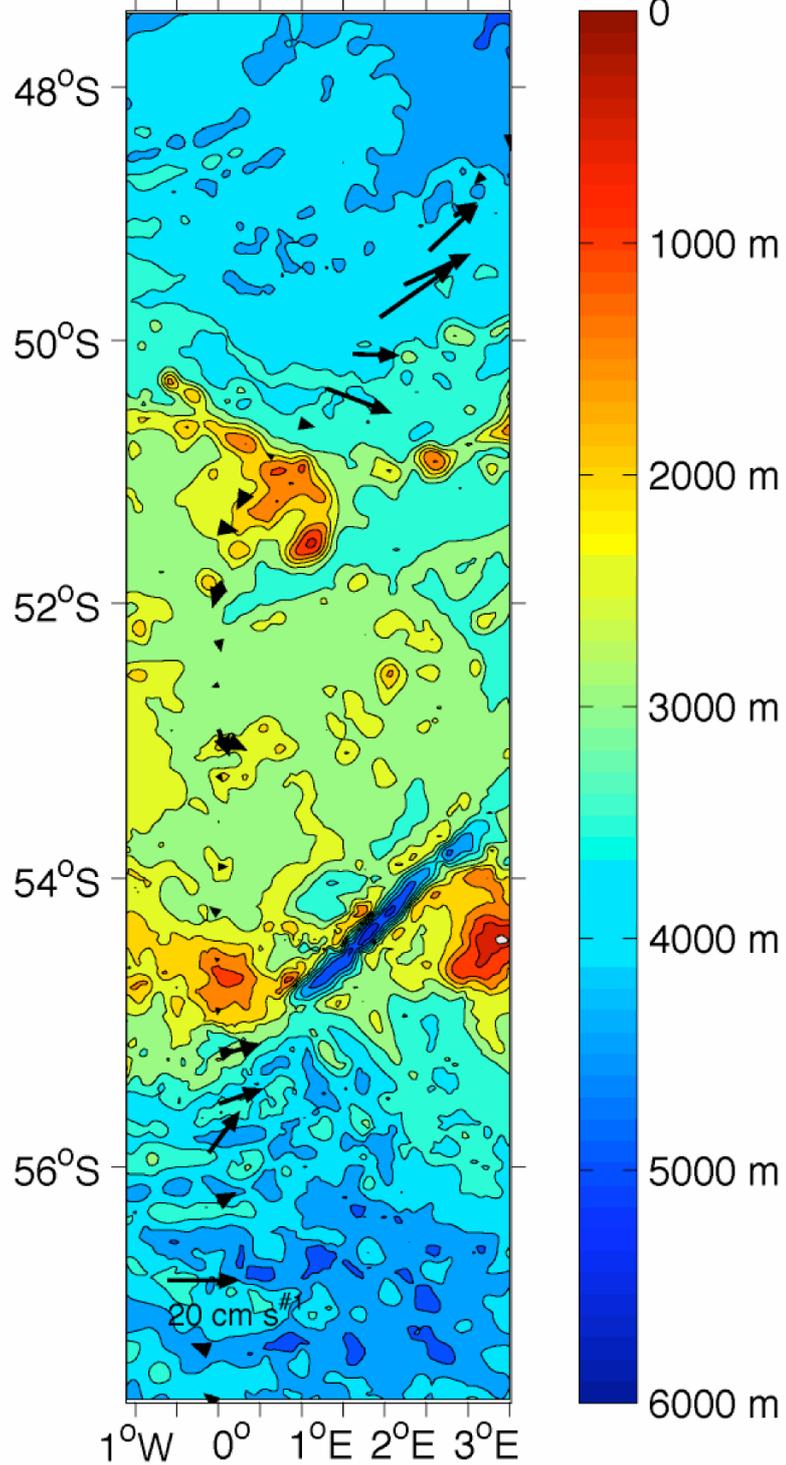


Figure 12 – Non-validated L-ADCP velocity vectors through the BONUS-GOODHOPE transect for the deep layer around 1500m of depth.

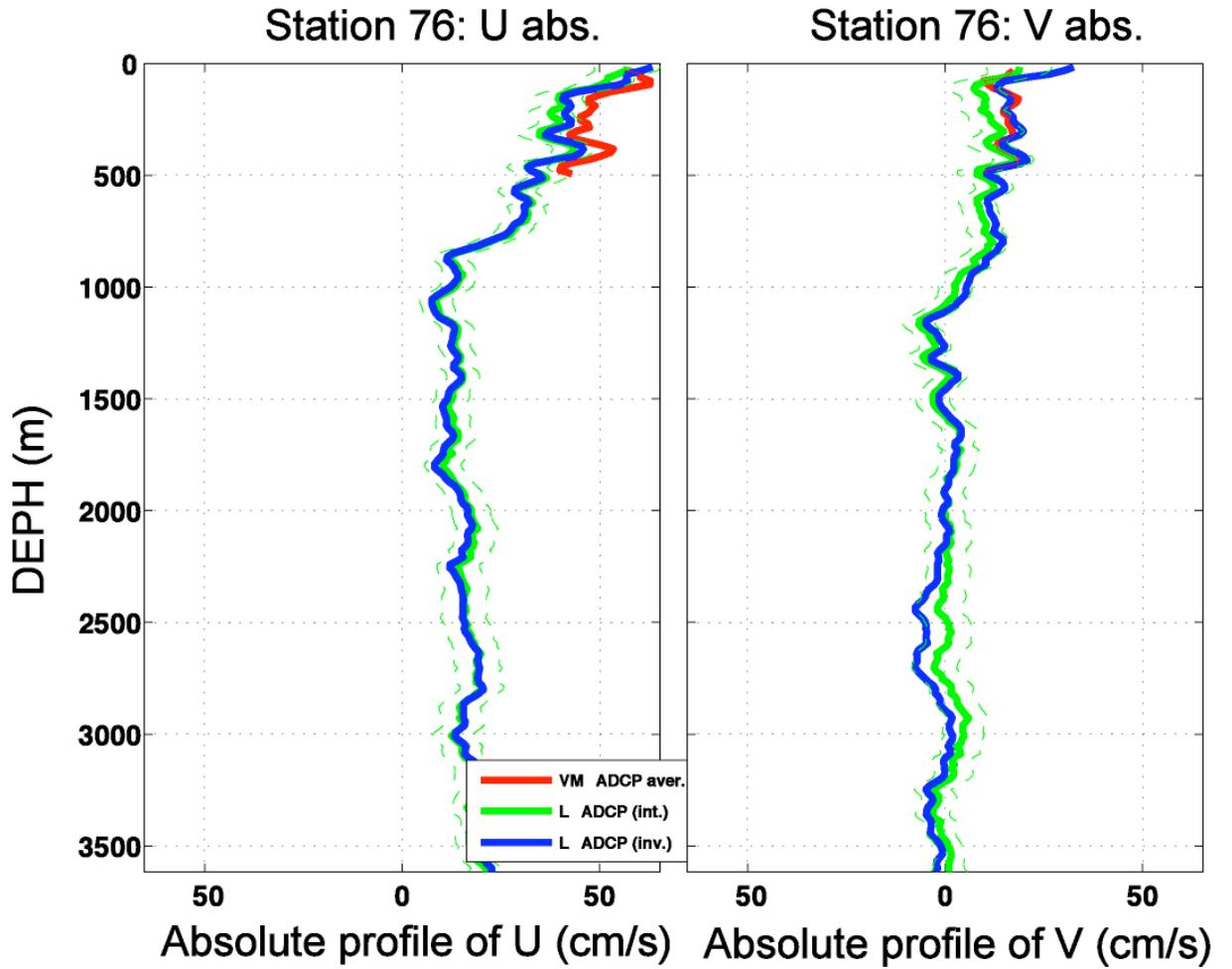


Figure 13 – Absolute vertical profiles for the U component (left panel) and V component of the VM-ADCP (in red), the L-ADCP values computed with the “integral” method (in green), and with the “inverse” method (in blue) at station 76. The three values compare well for each velocity component.

4.1.4 EXPANDABLE BATHY-THERMOGRAPH DATA

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Since the implementation of the multi-national GoodHope programme, 10 repeat high density Expandable Bathy-Thermograph (XBT) transects have taken place. These measurements are vital in determining the physical structure of the upper ocean layer between the African and Antarctic continents. Moreover, these measurements are able to provide us with valuable information on the deeper physical structure, by exploiting an array of empirical relationships. The deployment of XBTs in high density mode, during this programme, is a first for the region, allowing us to resolve the finer ocean structures and heat fluxes associated with the Antarctic Circumpolar Current (ACC) and the Indo-Atlantic exchange region. Here, we present the details and preliminary results pertaining to the eleventh repeat XBT section occupied along the GoodHope cruise track during the BONUS-GOODHOPE oceanographic survey.

For the BONUS-GOODHOPE survey, XBTs were funded by the Department of Oceanography at the University of Cape Town, South Africa. The XBTs were deployed also to fulfil the objectives of NOAA's Office of Global Programs as part of their High Density XBT project at NOAA/AOML. A total of 134 Sippican Deep Blue XBTs were deployed between 33.98° S, 18.12° E and 57.54° S, 0.03° W (Figure 14). One to two XBTs were deployed in-between each CTD station along the cruise track in order to achieve a spatial resolution of less than 10 nautical miles between each CTD and XBT deployment. The spatial resolution was increased to ~6 nm over the main frontal regions. In total, 23 XBTs (17%) failed or spiked, before the probe reached 500 m, mainly as a result of strong winds and sea swell blowing the running signal wire against the ship's hull, which resulted in the XBT wire stretching and thus creating insulation leakages. On the return transit to Durban, South Africa, an additional 9 XBTs were deployed to investigate a warm Agulhas Return Current filament/eddy that was opportunistically crossed.

The above mentioned XBT data will undergo quality control procedures at AOML/NOAA and will be available, a few months following the date of this report, at: http://www.aoml.noaa.gov/phod/hdenxibt/high_density_home.html

4.1.4.1 SURFACE AND SUBSURFACE THERMAL STRUCTURE DERIVED FROM XBTS

Identification of the main ACC fronts is essential in order to trace the upper level circulation associated with the baroclinic shear. We unambiguously position the major ACC fronts according to the criteria given by Orsi et al. (1995). The major ACC fronts were positioned as follows: northern Subtropical Front (NSTF): 37.86°S; southern Subtropical Front (SSTF): 41.47°S; Subantarctic Front (SAF): 45.04°S; Southern ACC Front (SACCF): 52.78°S; Southern Boundary (SBdy): 55.40°S. Although, classically, the STF has been found to exist as a single front, this crossing identified two distinct branches of the STF, that were separated by approximately 3.6° of latitude.

We also show the temperature anomaly of the XBT section whereby a mean temperature, from the first five GoodHope XBT sections, has been removed. This helps to highlight the mesoscale features and seasonally warmed upper layer, mentioned above. In Figure 14 we present the position of XBT stations (black dots) occupied during the BONUS-GOODHOPE survey. The station positions are overlaid onto the bathymetry (in meters) of the region. We also show XBT data collected during the BONUS-GOODHOPE survey (Figure 15). The position of the ACC fronts are as follows: northern red dashed line: NSTF; southern red dashed line: SSTF; orange dashed line: SAF; green dashed line: APF; blue dashed line: SACCF; magenta dashed line: SBdy. Last figure shows the temperature anomaly for the XBT data collected during the BONUS-GoodHope survey in comparison with the first five GOODHOPE XBTs transects. The positions of the ACC fronts are the same as in the XBT BONUS-GOODHOPE data (Figure 15).

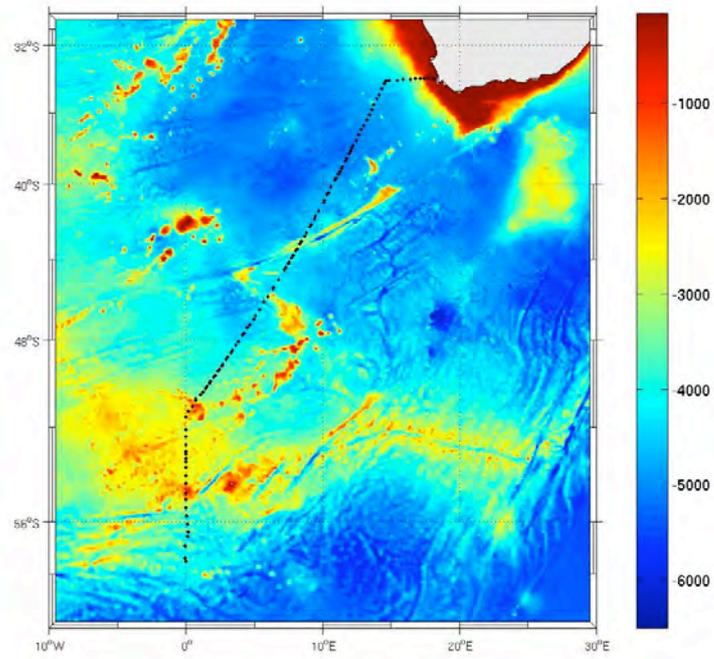


Figure 14 – Position of XBT stations (black dots) occupied during the BONUS-GOODHOPE survey. The station positions are overlaid onto the bathymetry (in meters) of the region.

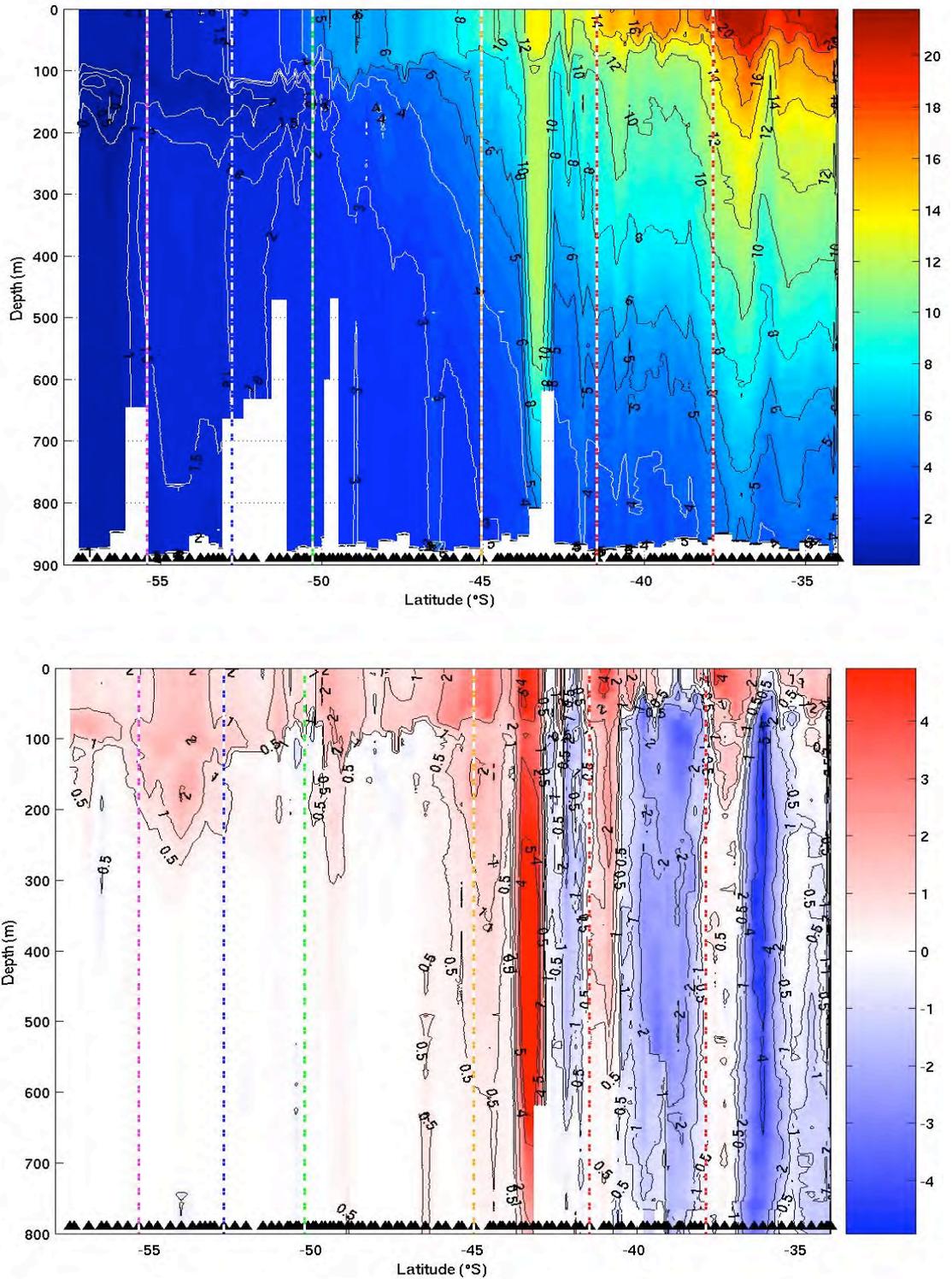
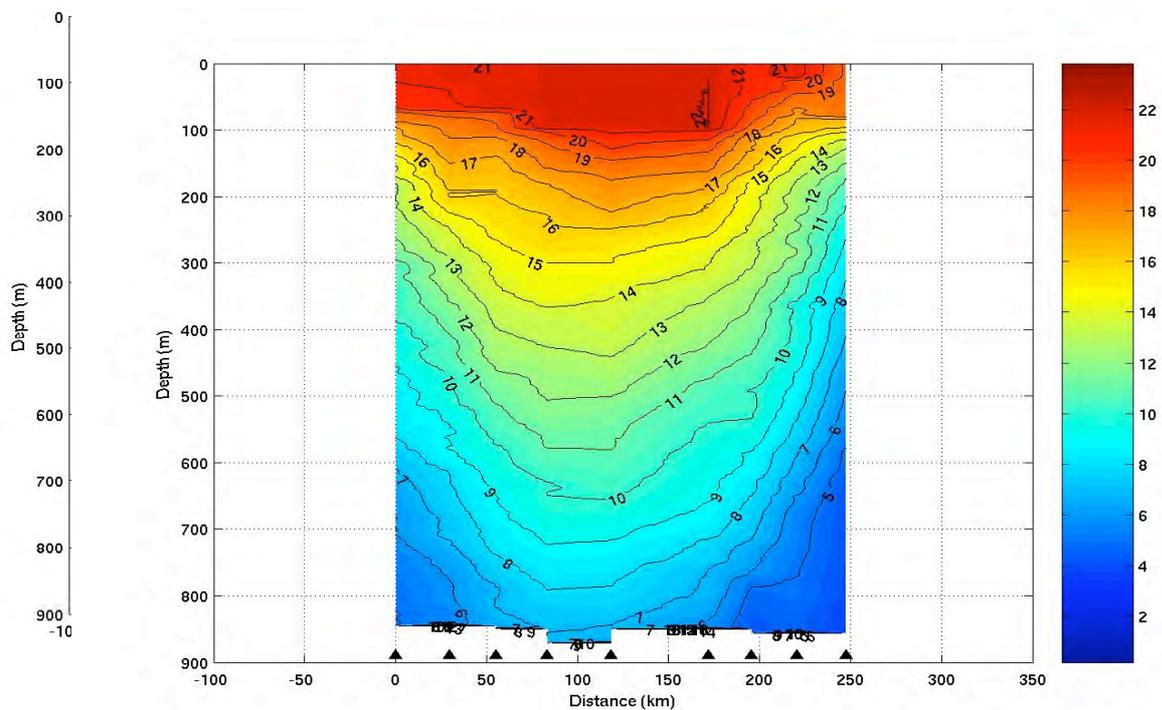


Figure 15 – Temperature section from the XBT data collected during the BONUS-GOODHOPE survey (above). Temperature anomaly section from the XBT data collected during the BONUS-GoodHope survey (below) The position of the ACC fronts are as follows: northern red dashed line: NSTF; southern red dashed line: SSTF; orange dashed line: SAF; green dashed line: APF; blue dashed line: SACCf; magenta dashed line: SBdy.

4.1.4.2 SAMPLING OF AN AGULHAS RETURN CURRENT ANTICYCLONE

During the transit from the last hydrographic station and Durban we crossed what was looking in the SST satellite data as an intense anticyclone just shed from the Agulhas Return Current. We decided to sample it with XBTs, atmosphere radiosounding and to deploy the last ARGO profiling float by slightly deviating the ship track with no cost in ship time. Figure 16 shows the temperature section obtained from the 9 XBTs deployed over this warm mesoscale feature on our return voyage to Durban, South Africa during the 21st March, 2008. The deployment of the XBTs over this feature coincided with the release of



radiosounds in order to better understand the ocean-atmospheric heat flux.

Figure 16 – Temperature section obtained from XBT data, crossing an anticyclonic, warm cored eddy, on the return leg to Durban.

4.1.4.3 DYNAMIC HEIGHT AND BAROCLINIC TRANSPORTS

The mean meridional temperature gradient in the upper 600 m, is shown in Figure 17. This data is used to determine the dynamic height at the surface, relative to 2500 dbar, by exploiting an empirical relationship between the mean upper ocean temperature and dynamic height data, from previous CTD sections (Swart et al., 2008). These representations emphasise the large declines in temperature and dynamic height over the main ACC fronts.

From the XBT dynamic height data, we are able to derive the cumulative baroclinic transport between the SBdy and the SSTF/NSTF (Figure 17) using a second empirical relationship between dynamic height and cumulative transport (relative to 2500 dbar), from previous CTD sections (Swart et al., 2008). As we expect, the largest gains in transport are located over the ACC fronts. More interestingly, further gains in transport are located away from the typical front positions and these can be attributed to additional jets that may be associated with the main ACC fronts. This is more clearly visible when we distribute the baroclinic transport in latitudinal bins, shown in Figure 18. The large reversals in transport found prior to the SAF are associated with the large anticyclonic eddy (anticyclone “M”). Less intense flow reversals are also associated with other eddies, mentioned previously.

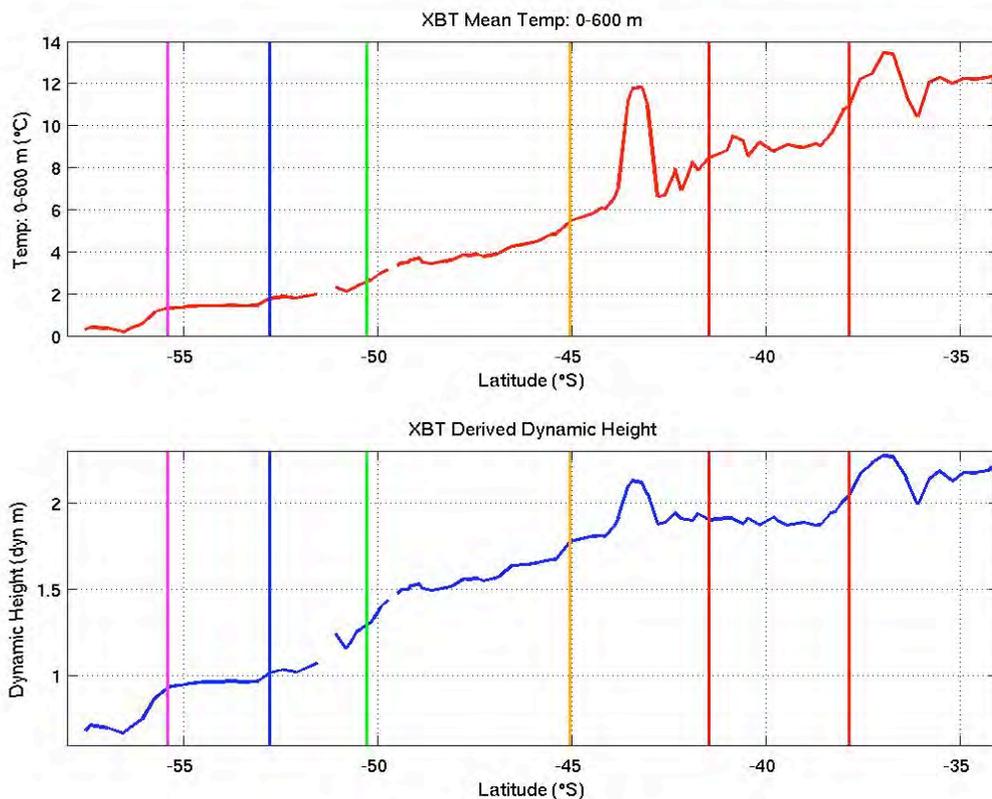


Figure 17 – Mean temperature between the surface and 600 m from XBT data (upper panel). Dynamic height data, relative to 2500 dbar, derived from XBT data (lower panel). The positions of the ACC fronts are colour-coded as for the XBT transect.

– BONUS-GOODHOPE Cruise Report –

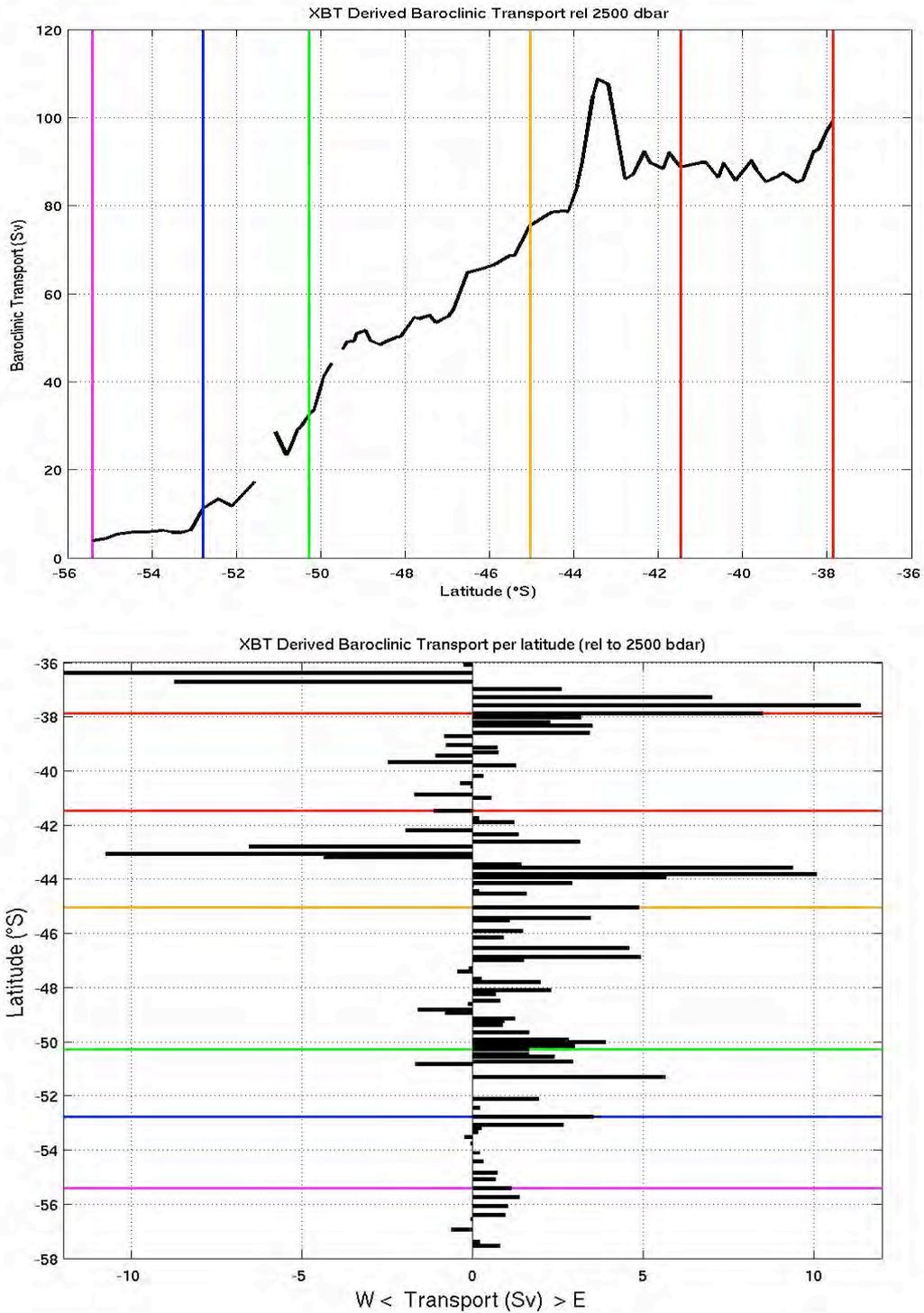


Figure 18 – The northward cumulative baroclinic transport, relative to 2500 dbar, derived from XBT data. The positions of the ACC fronts are colour-coded as in the case of Figure 16.

4.1.4.4 BONUS-GOODHOPE DERIVED GRAVEST EMPIRICAL MODES

During the BONUS-GOODHOPE survey, the Gravest Empirical Mode (GEM) was used to forecast the thermohaline structure in the upper 2500 dbar and the ACC front positions. The GEM makes use of the principle that the surface dynamic height can be used to determine the thermohaline properties, to 2500 dbar, using empirical methods.

Figure 19 illustrates the predicted fields of temperature and salinity using the altimeter derived dynamic height for the 26th of February, 2008. The GEM does an excellent job at determining the positions of the ACC fronts (e.g. the APF was located within 1 nm of the GEM predicted position). Furthermore, the GEM fields revealed most of the mesoscale eddies and features located along the surveyed section. The location of the warm Agulhas anticyclone we crossed in the Subantarctic Zone, as well as other small warm features, can be seen clearly near the position of the SAF, on the GEM fields.

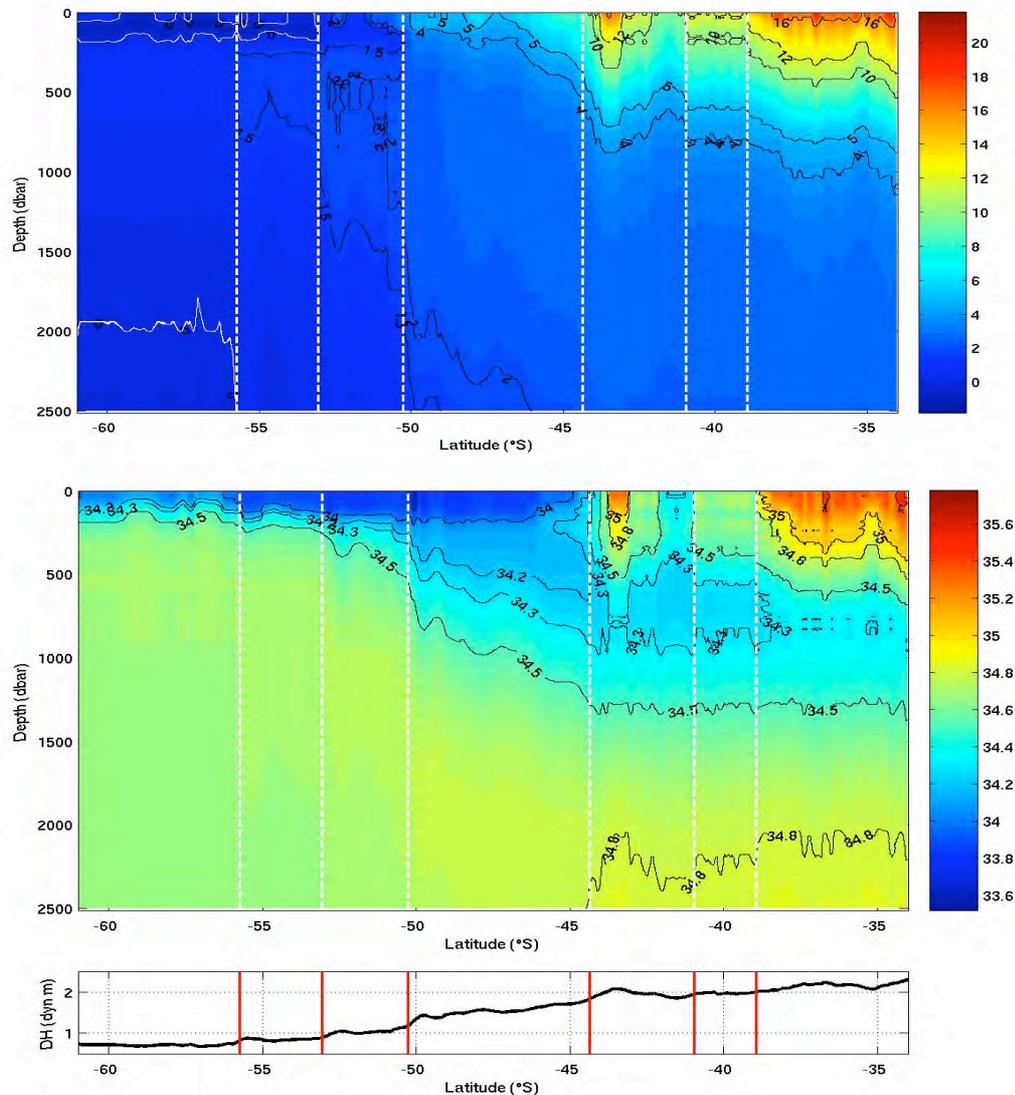


Figure 19 – A view of the temperature (upper panel) and salinity (lower panel) fields, as predicted using the GEM method. The altimeter derived dynamic height used in the GEM method to predict the thermohaline variables is depicted below each section. For each plot, the fronts are shown by the vertical lines are, from north to south, as follows: NSTF, SSTF, SAF, APF, SACCF, SBdy.

4.1.5 THERMOSALINOGRAPH DATA

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Real-time sea surface salinity (SSS) and temperature (SST) measurements were recorded from the vessel-mounted thermosalinograph (TSG). SSS (part per thousands) and SST temperature (degrees Celsius) are from SeaBird SBE21 thermo-salinometer (5m below sea level). The complete TSG data time-series are displayed on Figure 20.

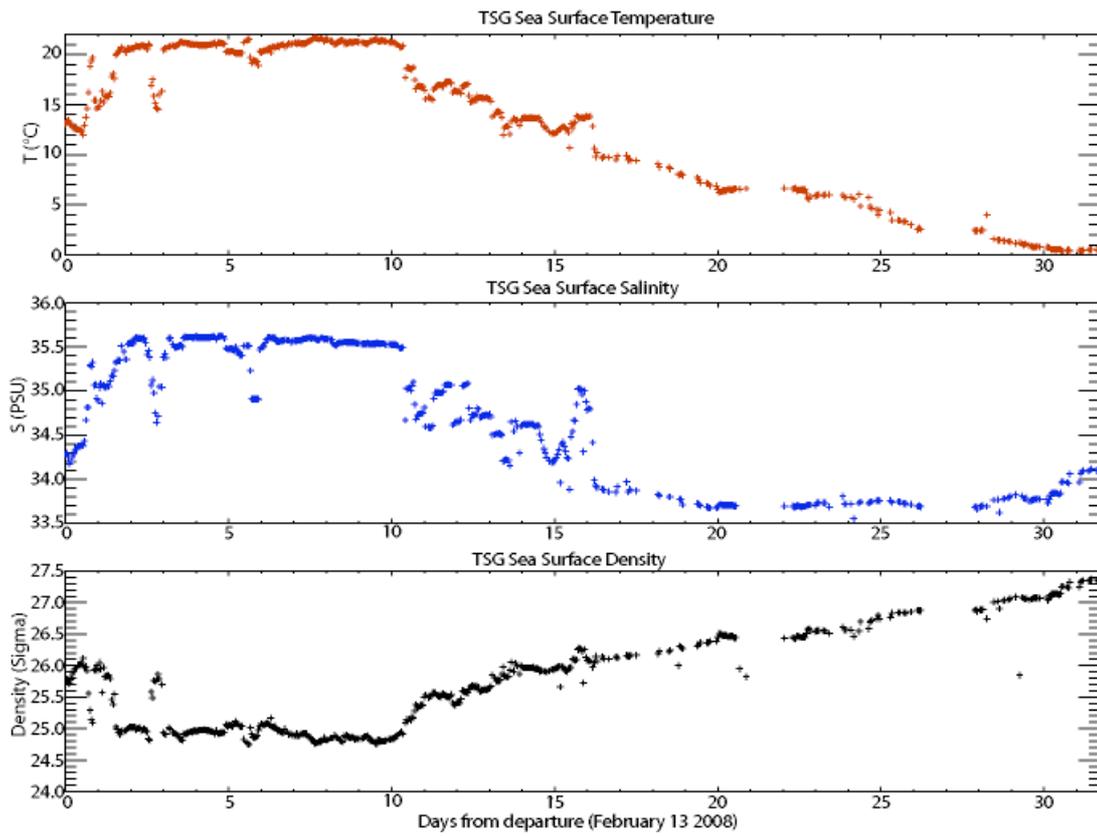


Figure 20 – Thermosalinograph data collected during the MD-166 BONUS-GOODHOPE cruise. Upper panel: Sea Surface Temperature; Middle panel: Sea Surface Salinity; Lower panel: Density anomaly.

– BONUS-GOODHOPE Cruise Report –

A quality control of TSG SSS data was undertaken daily by sampling sea-water from the two accessible direct inlet of sea-water on the ship. The one situated near the ship bow showed the most stable values. The onboard analyzed sea-water samples from the ship-bow inlet showed salinity values that compare very well with the TSG SSS values. They were very stable and showed just a slight gap. The second sea-water inlet, showed more variability. The data values used for comparison between the TSG and the sea-water samples analyses are listed in Table 3.

Table 3 – This table compares Salinity values measured by the Marion Dufresne TSG and values taken from the tap on the ship bow, near the TSG location (sal pTHS) and its deviation from the TSG salinity (delta1); values obtained from a second tap more at the rear of the ship (sal rob) and the deviation (delta2). The bow tap showed values close to those given by the TSG and a constant difference in time. While the values of salinity measured at the rear tap were much more different and variables. The validation has been done on a daily basis when weather and sea conditions permitted to reach the ship bow lowest level safely.

date	heure(TU)	latitude	longitude	temp THS	sal THS	sal pTHS	delta1	sal rob	delta2	sal inc	delta3	sal CTD	delta4
15/02/08	08:00	-34 03.79	015 41.20	20.9491	35.5973	35.6123							
16/02/08	08:35	-34 05.50	015 09.80	20.8219	35.4985	35.5102	-0.0117	35.5123	-0.0138			35.6136	-0.1151
17/02/08	12:14	-34 25.60	014 24.52	21.0204	35.6143	35.6327	-0.0184	35.5206	0.0937			35.5300	0.0843
18/02/08	08:50	-35 19.59	013 51.93	20.0606	35.4054	35.4253	-0.0199	35.5257	-0.1203	35.4438	-0.0384		
19/02/08	08:45	-36 12.93	013 19.05	20.7638	35.6051	35.6244	-0.0193	35.6227	-0.0176	35.6238	-0.2886		
20/02/08	13:00	-36 31.25	013 07.13	21.4277	35.5993	35.6200	-0.0207	35.6107	-0.0114	35.6442	-0.0449		
21/02/08	08:34	-36 29.94	013 07.07	21.1982	35.5380	35.5595	-0.0215						
22/02/08	08:50	-36 49.28	012 56.10	21.3296	35.5316	35.5563	-0.0247						
23/02/08	08:05	-37 42.96	012 21.16	20.7979	35.4949	35.5186	-0.0237						
24/02/08	09:12	-39 11.46	011 19.11	16.7831	34.9795	35.0051	-0.0256						
25/02/08	13:47	-40 43.38	010 12.87	15.3814	34.7252	34.7492	-0.0240						
26/02/08	16:04	-42 15.47	009 05.97	13.3860	34.6511	34.6365	0.0146						
27/02/08	08:40	-42 28.14	008 55.72	13.6106	34.6207	34.6411	-0.0204						
28/02/08	13:42	-42 53.68	008 34.31	13.1843	34.6718	34.7014	-0.0296						
29/02/08	08:52	-44 02.46	007 37.88			33.9258							
01/03/08		tempete											
02/03/08	08:25	-45 19.40	006 30.86			33.8371							
03/03/08	11:52	-46 21.39	005 32.65	7.3582	33.7038	33.7292	-0.0254						
04/03/08	08:00	-47 19.00	004 37.20	6.5304	33.7020	33.7302	-0.0282	33.9170	+0.2150				
05/03/08	08:44	-47 32.93	004 22.12	6.7253		33.7520		33.9457					
06/03/08	11:40	-47 58.22	003 57.46	6.5227	33.6929	33.7253	-0.0324	33.7095	-0.0166				
07/03/08	09:08	-49 01.68	002 49.93	5.9887	33.7255	33.7457	-0.0202	33.7113	+0.0142				
08/03/08		manque de temps (pb oxygene)											
09/03/08	08:52	-50 38.37	000 58.56	3.4876	33.7159	33.7551	-0.0392	33.7814	-0.0655				
10/03/08	07:33	-51 51.23	000 00.08	2.8363		33.7121		33.7110					
11/03/08	08:12	-51 52.93	000 00.19	2.8991		33.7085		33.7129					
12/03/08	08:45	-52 55.82	000 00.04	1.8461		33.7630		33.7636					
13/03/08	09:40	-54 34.79	000 00.00	1.1543	33.7724	33.8065	-0.0341	33.8316	-0.0592				
14/03/08	08:27	-55 34.23	000 00.33	0.5276	33.8325	33.8653	-0.0328	33.8634	-0.0309				
15/03/08	07:55	-56 45.76	-000 00.81	0.7209		34.1182		34.0424					
16/03/08	08:30	-57 33.12	-000 02.18	0.5237		34.0795		34.0795					
17/03/08	07:38	-57 33.08	-000 03.04	1.2862		34.0612							
18/03/08	13:38	-53 44.72	004 36.57	1.1172	33.9214	33.9481	-0.0267	34.1233	-0.2019				
19/03/08	12:00	-49 54.70	010 18.67	4.1494	33.7266	33.7569	-0.0303	34.1284	-0.4018				
20/03/08	08:44	-46 15.62	015 20.38	7.4612	33.7934	33.8231	-0.0297	34.0017	-0.2083				
21/03/08	08:21	-42 28.22	021 28.30	21.7768	35.4950	35.5241	-0.0291	33.8302	1.6648				
22/03/08	06:20	-37 40.61	024 44.38	19.3851	35.4720	35.4001	0.0719	35.4916	-0.0196				

Due to the quality of the TSG data we realized a first onboard data analysis of these data in terms of a *theta-S* diagram with coloured values that depends on time and the observed (surface) position of the crossed oceanic front. This is displayed in Figure 21.

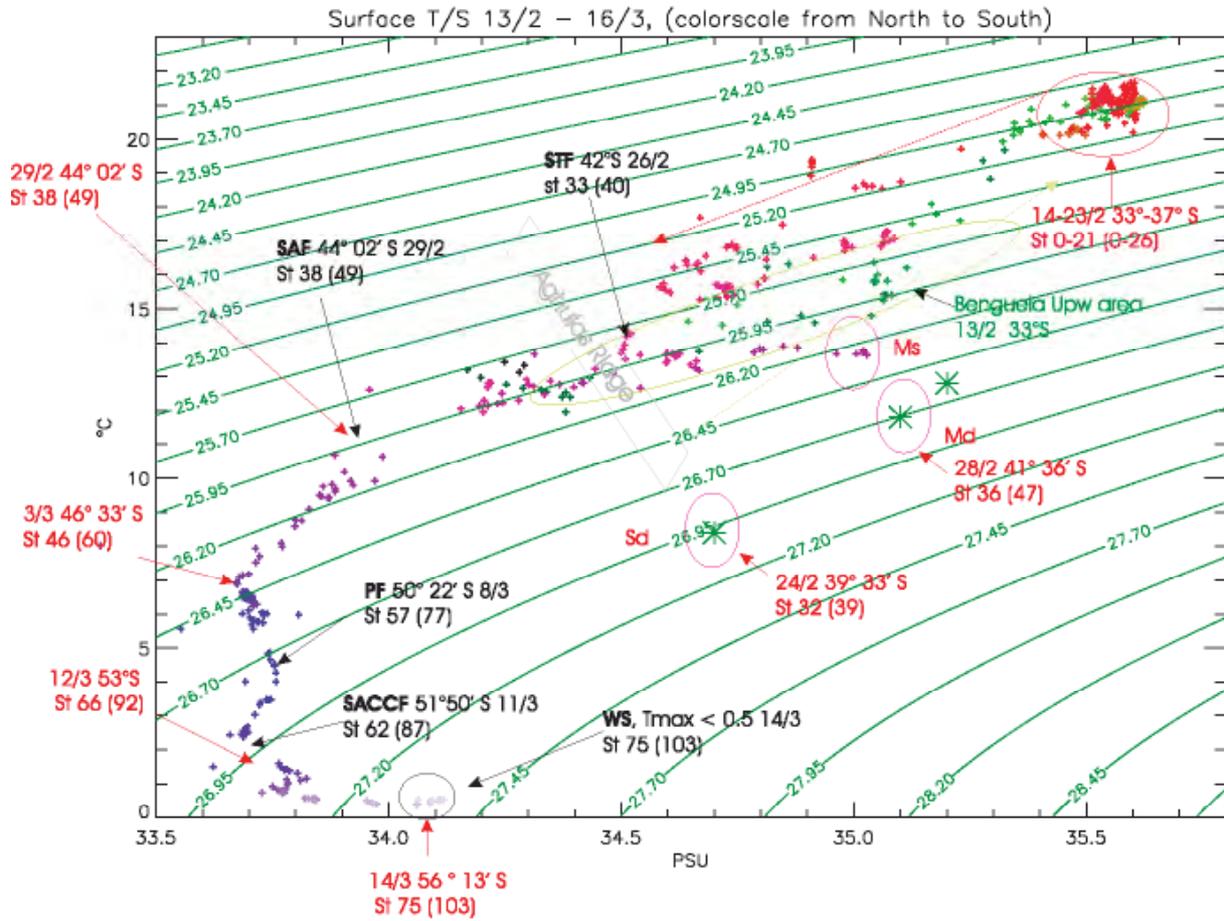


Figure 21 – Temperature-Salinity diagram for the surface value derived from TSG. Colours vary in function of time and oceanic regions crossed during the cruise. Values go from: Green (Benguela Upwelling waters); Red (Subtropical region); Lilac (between the Southern STF and SAF); Violet (between SAF and PF); Blue (between PF and SACCF); Light Violet (between the SACCF and SBdy); Lighter Violet (Northern Weddell Gyre surface waters).

4.1.6 ARGO PROFILING FLOATS (PROVORS)

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Argo is a global array by now of more than 3,000 free-drifting profiling floats that measures the temperature and salinity of the upper 2000 m of the ocean. This allows, for the first time, continuous monitoring of the temperature, salinity, and velocity of the upper ocean, with all data being relayed and made publicly available within hours after collection. For the first time, the physical state of the upper ocean is being systematically measured and the data assimilated in near real-time into computer models. Argo builds on other upper-ocean ocean observing networks, extending their coverage in space and time, their depth range and accuracy, and enhancing them through the addition of salinity and velocity measurements. Argo is not confined to major shipping routes, which can vary with season as the other upper-ocean observing networks are. Instead, the global array of 3,000 floats will be distributed roughly every 3 degrees (300km).

The development of such an observing system is of particular importance in the framework of the Southern Ocean, a region so hostile in terms of climatic conditions, so remote in location and large in extension. The deployment of such floats in the Southern Ocean only started in early 2004. Between 2004 and mid 2007, the Argo global profiling float project has collected, in the Southern Ocean, more than 66,000 temperature and salinity profiles, while the World Ocean Database shows that from 1950 to 2000, only a total of 22,809 temperature and salinity profiles to depths of at least 1,000 m were collected in the same region. We are participating to this unprecedented effort of observing the Southern Ocean since 2004 in the framework of the GOODHOPE project with ARGO float deployment from France (Coriolis), USA (NOAA), Germany (AWI) and UK (Weather Service). During the BONUS-GOODHOPE cruise we deployed 17 PROVOR Argo floats, 13 along the BONUS-GOODHOPE cruise track, and four (4) during the return transect to Durban. Of these, only 16 are transmitting data to the data centre, as one of them has been damaged during the deployment. In Table 4 are listed the position and date of deployment with all the identity numbers

associated to these floats. Below (Figure 22) also are the maps for late 2003 and the latest map of global Argo floats positions.

Table 4 – Listed are the identification numbers (Argos, WMO and serial), date and time of deployment, as well as the deployment position (latitude and longitude) for each PROVOR profiling float deployed during the BONUS-GOODHOPE cruise.

Argos	WMO	Serial number	Date & Time (UT)	Latitude	Longitude	
63730	1900628	OIN-03-S2-47	3/19/08 7:40	50° 38.98 S	09° 14.69 E	
52115	1900850	OIN-04-S2-10	3/19/08 15:54	49° 15.81 S	11° 13.74 E	
54067	1900851	OIN-04-S2-72	3/18/08 18:22	52° 56.84 S	05° 49.14 E	
54012	1900852	OIN-06-S3-01	3/13/08 22:28	53° 36.63 S	0° 00.31 W	
54056	1900853	OIN-06-S3-02	3/3/08 8:30	46° 01.45 S	05° 51.61 E	
54057	1900854	OIN-06-S3-03	3/11/08 20:41	51° 53.29 S	0° 00.07 E	
54065	1900855	OIN-06-S3-05	3/12/08 6:30	53° 36.62 S	0° 00.33 E	
63662	1900856	OIN-06-S3-06	3/7/08 19:55	47° 01.68 S	02° 49.39 E	
63663	1900857	OIN-06-S3-07	2/25/08 2:51	39° 55.579 S	10° 48.531 E	
63665	1900858	OIN-06-S3-09	3/14/08 11:15	55° 34.23 S	0° 00.12 E	
63666	1900859	OIN-06-S3-10	3/6/08 7:44	47° 33.82 S	04° 22.44 E	
63667	1900860	OIN-06-S3-11	3/9/08 10:57	50° 37.94 S	0° 58.21 E	When deployed, this float went under the ship stern for a few minutes. This float never emitted
63669	1900861	OIN-06-S3-13	3/1/08 13:46	44° 53.89 S	06° 53.09 E	
63671	1900862	OIN-06-S3-15	3/21/08 11:25	41° 56.84 S	22° 03.46 E	
63672	1900863	OIN-06-S3-16	3/8/08 13:13	49° 47.95 S	01° 58.10 E	
63673	1900864	OIN-06-S3-17	2/26/08 8:04	41° 36.22 S	09° 34.68 E	
63676	1900865	OIN-06-S3-20	2/28/08 21:13	43° 20.13 S	08° 13.38 E	

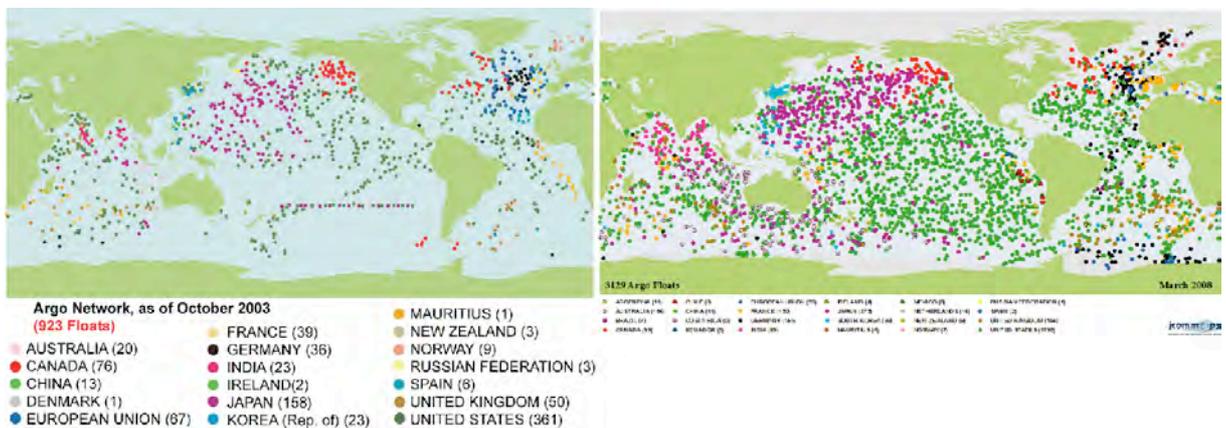


Figure 22 – Argo network floats positions as for October 2003 (left panel) and March 2008 (right panel). The BONUS-GOODHOPE/ZERO&DRAKE 2008 deployments stand out clearly.

All the BONUS-GOODHOPE floats that have been deployed are already taken into account (together with the XBT data) for weekly analyses of the global ocean status. Examples are given below in terms of temperature and salinity at 10 m and 1000 m of depth. Below are examples for before the IPY BONUS-GOODHOPE, ZERO&DRAKE, DRAKE and 30°E US cruises (October 2007) and after (March 2008). Such maps show that now we can have access to a weekly varying ocean status to at least 1800 m of depth. Before 2004, this was not

possible. This gives an unprecedented view of this capital region for the world ocean circulation and global climate. Maintaining such an effort is of primary importance to continue to build up the available time series and led to a monitoring of the upper ocean layers status, and this despite the spatial resolution is not yet optimal to resolve the fines scale ocean dynamics that composes most of the ocean circulation.

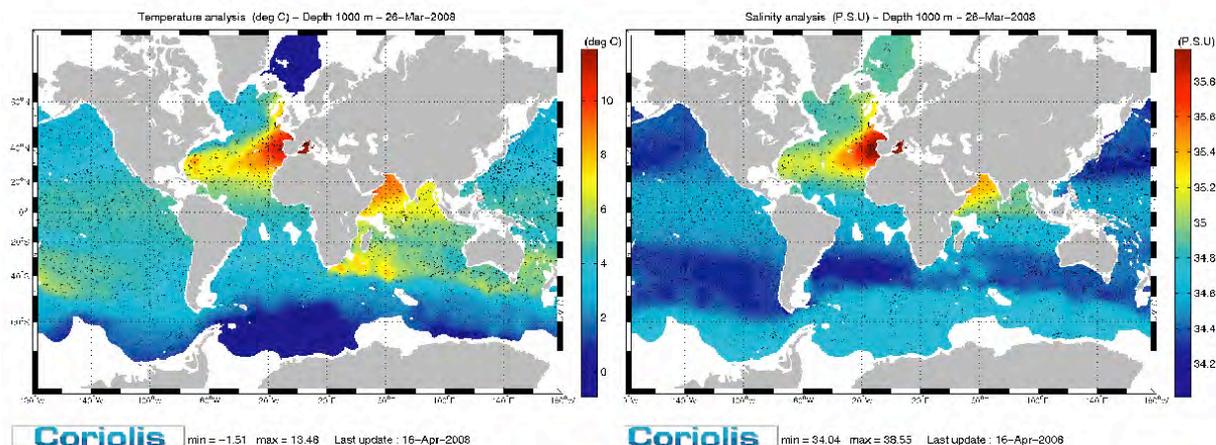


Figure 23 – Ocean status for Temperature (left panel) and Salinity (right panel) at 1000m of depth as analyzed by the Coriolis Data Centre for the week of April 16 (see <http://www.ifremer.fr/co/co0525/en/global/>).

Brief description of PROVOR profiling floats

IFREMER has developed, through industrial partnership with MARTEC company, a free-drifting hydrographic profiler based on MARVOR technology and named PROVOR. As MARVOR it doesn't need any ballasting operation and the operating pressure can be decided just before deployment if necessary:

- the profiler executes identical programmed cycles of descent, drift at depth at a given pressure for a few days, descent to the start of profile depth, raising, Argos data transmission.
- CT (Conductivity, Temperature) measurements are carried out during the descent and/or the ascent phases.
- the profiler is not located at depth. It is located only at the surface during the ARGOS data transmission phase.
- the profiler is able to synchronize the beginning of the rising profile in order to get synoptic CTD profiles from floats that are not deployed at the same time in an area.
- the number of cycles is higher than 100 and function of the number of points, which are kept for each profile and the buoyancy.
- in the case of grounding during the descent, the profiler can stay where it is stranded, waiting for the start of the ascent, or stabilise a few meters (programmable) higher, drifting for the length of the cycle at another level and trying to reach the nominal drifting depth on the next cycle.

- the CTD measurements are carried out every 10 seconds and the data are processed before transmission to reduce the amount of information and keep only some points.

Table 5 – Parameters, accuracy and resolution measured by the standard PROVOR profiling floats we deployed during BONUS-GOODHOPE.

	Pressure	Conductivity	Temperature
Range	2000 dbar	30 à 70 mS/cm	-2 à 35°C
Accuracy	3 dbar	+/- 0.03 mS/cm	+/- 0.03°C
Sensors resolution	0.1 dbar	0.001 mS/cm	0.001°C

4.1.7 CURRENTMETER PRESSURE INVERTED ECHO SOUNDER (C-PIES) MOORINGS

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The South Atlantic Ocean is unique in its role as a nexus between the deep, southward, flow of cold and salty North Atlantic Deep Water (NADW) along the eastern coast of South America and the compensating northward flow that is a mixture of warm and salty surface waters and cooler and fresher Antarctic Intermediate Waters (AAIW). This circulation pattern, in which warm waters flow towards the equator and cold water towards the pole results in an equatorward heat flux and has a strong impact also on salt flux. Although the anomalous heat flux was recognized by the middle of the last century, a true quantitative estimate has not yet been achieved as well as that of water masses exchanges and the driving processes.

The South Atlantic being at the crossroad of the MOC, has motivated several efforts to estimate the interocean exchanges, but the lack of data, the extent of the boundary region, and the variability of the flow has hindered most of these efforts (e.g., de Ruijter et al., 1999). The uncertainty about the South Atlantic interocean exchanges is particularly evidenced by the range of disparate estimates of its northward heat flux, which vary from a maximum of 0.88 PW to a minimum of -0.23 PW. In a framework of a changing climate, and the ocean being the major subsystem digesting the atmospheric heating excess, it is important to better estimate and monitor the ocean exchanges through the South Atlantic “gate”. This is why a volunteer effort has been undertaken since May 2007 to coordinate the observational effort in natural chokepoints (Drake Passage, south of Africa) and try to design a pragmatic and efficient monitoring system. This effort is summarized in the South Atlantic Meridional Overturing (SAMOC) Workshop Report (www.aoml.noaa.gov/phod/SAMOC/).

The SAMOC monitoring system rely on repeated high resolution hydrography (CTD, XBTs), deployment of Argo floats and Pressure Inverted Echo Sounder (PIES) moorings, possibly with a currentmeter added to them (the “C” in C-PIES). Figure 24 summarizes the observing system that is already almost in place by now.

South Atlantic planned and proposed observations

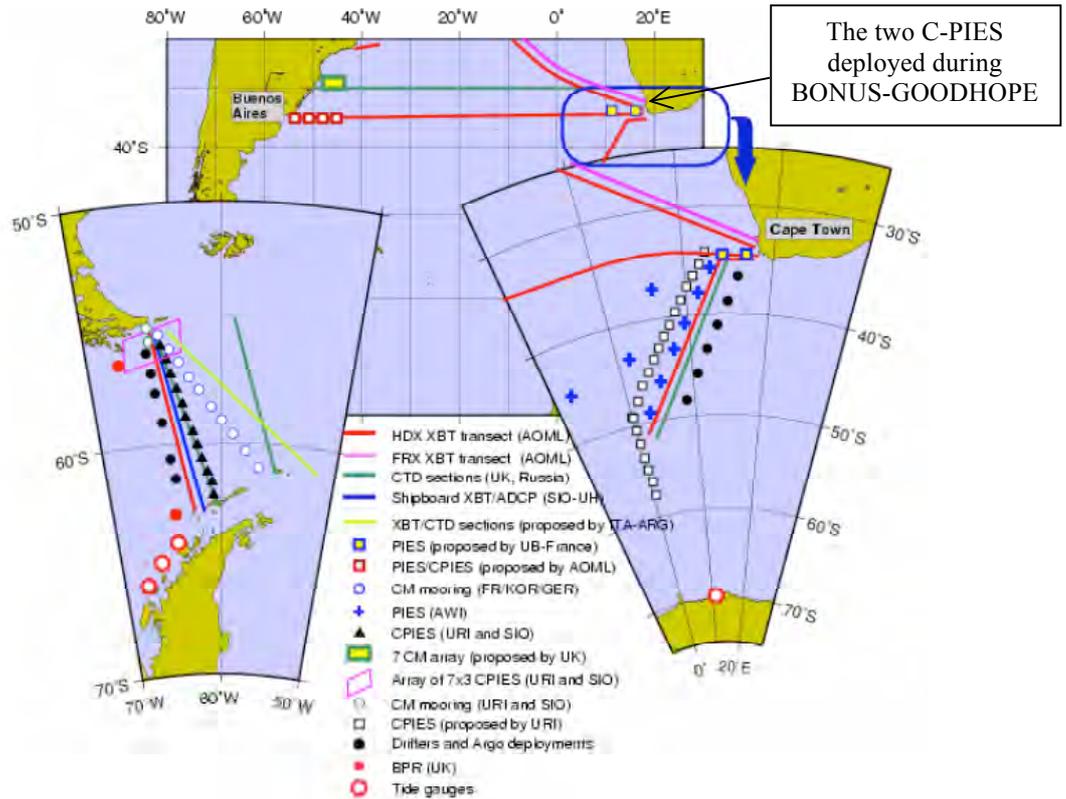


Figure 24 – Map of the South Atlantic and Southern Ocean, including the two principal choke-point regions, the Drake Passage and south of South Africa, with the current and proposed locations of instrument deployments and the institutes leading the corresponding associated projects.

In strong-current regions of the global ocean, the IES vertical acoustic echo time measurements have been used to estimate, with remarkable accuracy, entire profiles of temperature $T(p)$ and specific-volume anomaly $\delta(p)$ (or equivalently density $\rho(p)$). From hydrographic data, two-dimensional τ -parameterizations of these fields, $TG(\tau, p)$ and $\delta G(\tau, p)$, can be computed. We call each of these a "gravest empirical mode" (GEM) representation of the vertical structure. IES measurements of τ , combined with the GEM interpretation, produce estimated $T(p)$ and $\delta(p)$ time series at each site. Time-series profiles of geopotential thickness can then be estimated above each IES. Pairs of IESs give $\delta(p)$ lateral differences, which, through geostrophy, determine profiles of average baroclinic shear between the two sites (normal to the sites' separation vector). An L-shaped group of three IESs determines estimates of both velocity components. Additionally, the deep pressure and current measurements provide referencing to make the velocity profiles absolute (see : <http://www.po.gso.uri.edu/dynamics/IES/index.html>).

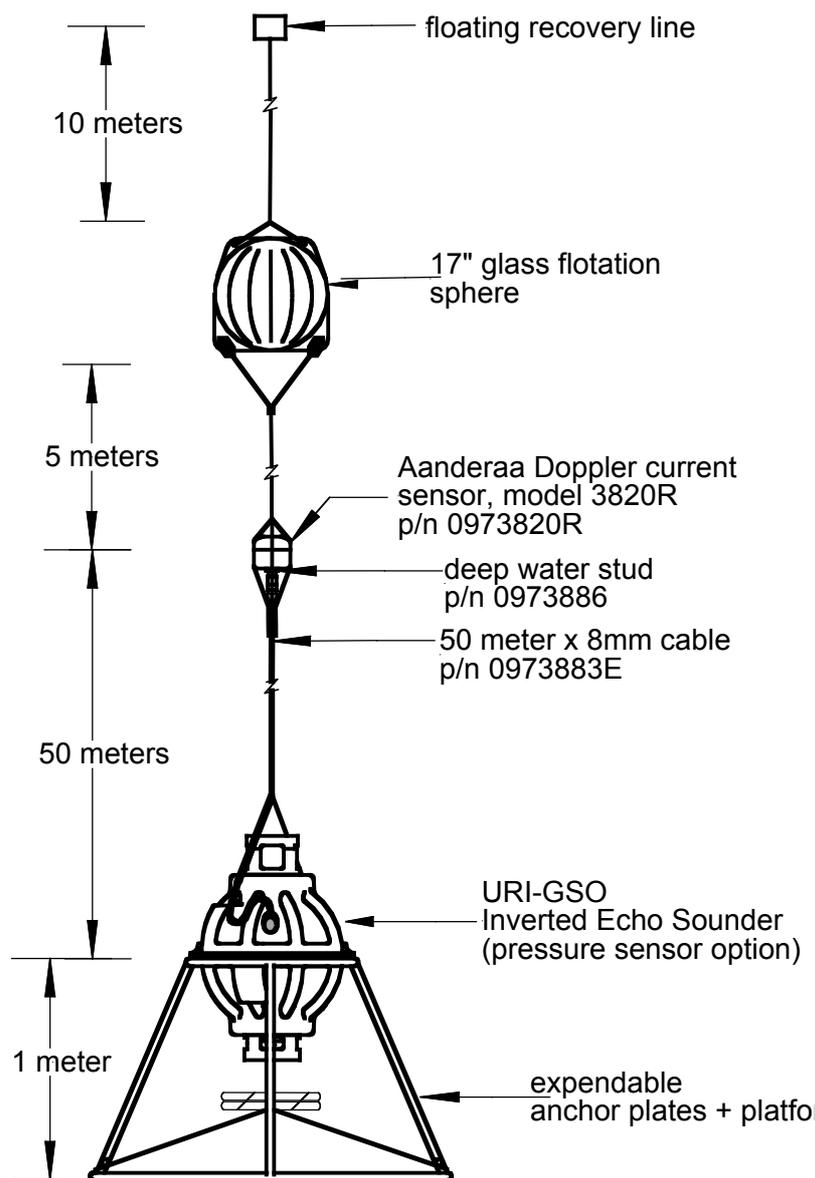


Figure 25 – IES with Doppler Current Sensor (DCS) – Deployed View

In the region south of Africa, in the ACC-GOODHOPE region the AWI has already deployed and maintains 12 PIES. In the Weddell gyre the AWI maintains since the early '90 a network of tall mooring. This is why we decided to implement with a starting set of two C-PIES the Cape Basin region just west of Cape Town, along the first part of the BONUS-GOODHOPE transect that overlaps the repeated HR A18 NOAA-AOML XBT line. At the same time four PIES will be deployed on the Argentinean side to complete the boundary currents deep monitoring through such an observing system.

The two C-PIES have been deployed successfully. The first on the southern Africa continental slope, at 1000 m depth (corresponding to the location of station 3). The second in the Abyssal plane in the Cape Basin, always along the BONUS-GOODHOPE transect. We adjusted the position of this second mooring to coincide with the Jason-1 altimeter descending ground track (station 9). This positioning results to be optimal to monitor the flow entering the South Atlantic

along the Eastern Boundary. Figure 26 shows the two C-PIES deployment positions. Both moorings sent telemetry signals once deployed and possibly landed on the sea-floor. Only for the second one we were able to download an entire flow of data and assess the mooring position with accuracy.

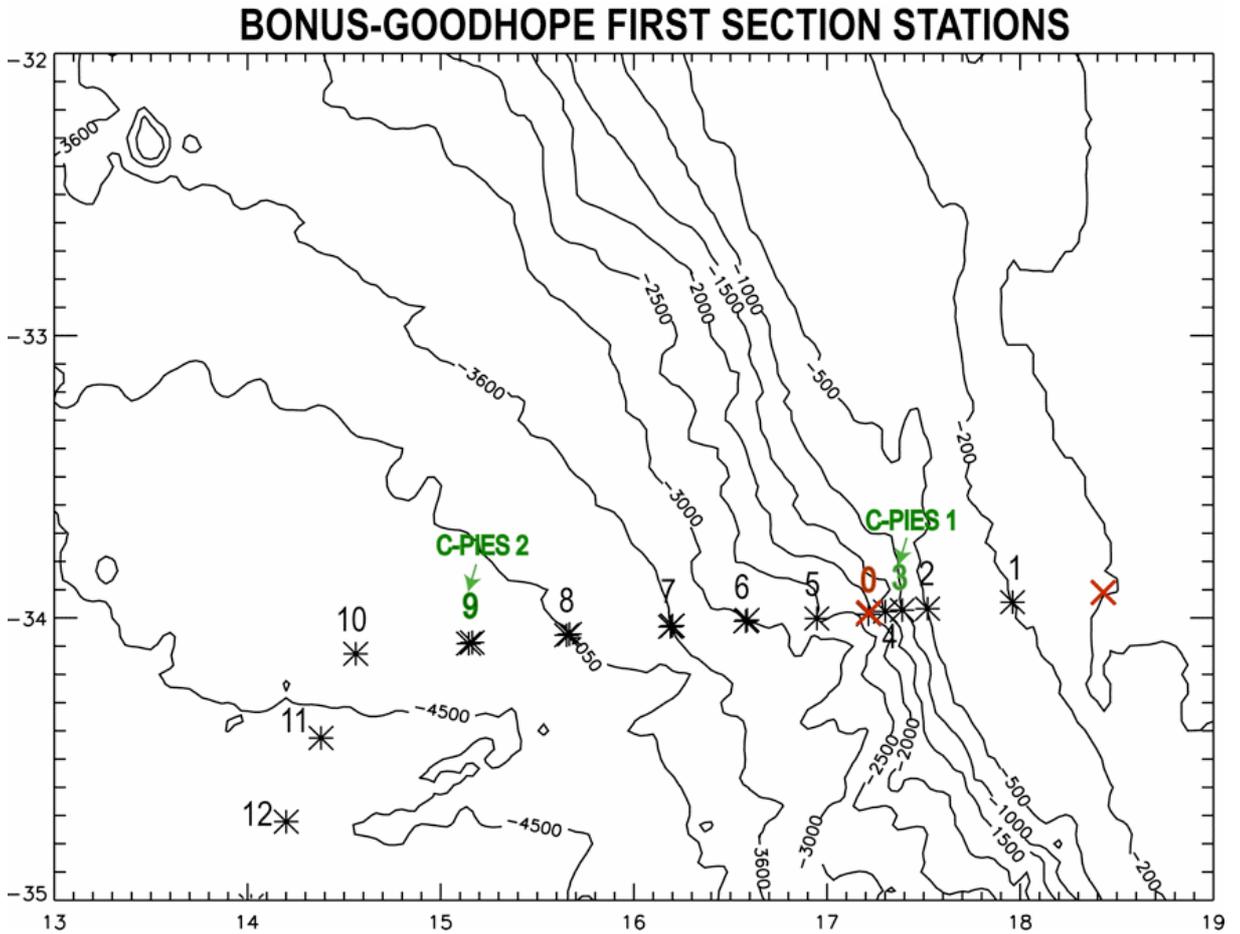


Figure 26 – Positions of the first stations of the BONUS-GOODHOPE transect. In green the two stations where the two C-PIES moorings have been deployed.

4.1.8 REMOTE SENSING AND OCEAN AND ATMOSPHERE MODELLING FORECASTS

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– BONUS-GOODHOPE Cruise Report –

A permanent, global observation of the oceans and atmospheres and their movements is vital for us to understand climate variations. Satellite remote sensing gives us the wider picture we need to achieve this for the surface and subsurface ocean as well as for the atmosphere, numerical models help to understand processes and potentially can lead to a complete 4D picture of these geophysical fluids. A large number of satellite data have been gathered by Jean-François Piolle from the *Laboratoire d’Océanographie Spatiale* of IFREMER, and sent daily to the ship. Table 6 list those data and images and include the images from the MERCATOR global ocean model 1/4° forecasting systems and Christophe Messager (LPO) original development of BONUS-GOODHOPE WRF regional atmosphere forecasts. Additional fields were sent occasionally by Dominique Dagorne from the IRD US IMAGO in Brest, France.

Table 6 – In this table are summarized all the satellite and models images and data that were sent on board daily (or weekly for MERCATOR-Ocean model outputs) by the “Laboratoire d’Océanographie Spatiale” at IFREMER, Brest.

Observed Parameter	Proposed Product	Product Producer	Number of daily images	Spatial Coverage	Resolution	Daily Volume netcdf/zip data	Daily Volume Images	Comments
SST	ODYSSSEA analysis	IFREMER	1	Whole region	0.1°	210 Ko	150 Ko	
	MSO synthesis map	FRANCE/NOAA	1 every 4 days	Whole region	0.05°	800 Ko?	280 Ko	
	METOP synthesis map	METEO-FRANCE/NOAA	1 every 4 days	Whole region	0.05°	800 Ko?	280 Ko	
Wind	MSCI fronts map	NOAA	1 every 4 days	Whole region	0.05°	800 Ko?	280 Ko	
	QuikSCAT winds	IFREMER	1	Whole region	0.5°	200 Ko	80 Ko	
Dwell	Blended winds	IFREMER	4	Whole region	0.25°	800 Ko	200 Ko	
	Swell animation	IFREMER	1	Atlantic			2.6 Mo	Animated gif only (http://www.ifremer.fr/cersat/maocs/wavetracker/movie/nrt_atl.gif)
Radiative fluxes	Surface Solar Irradiance	METEO-FRANCE (OASIS SAF)	1	65S - 60S	0.1°	350 Ko	200 Ko	http://www.os-waf.org/biba/doc/csa1_prd.htm ; 1.5.pdf
	Downward Longwave Irradiance	METEO-FRANCE (OASIS SAF)	1	65S - 60S	0.1°	285 Ko	200 Ko	http://www.os-waf.org/biba/doc/csa1_prd.htm ; 1.5.pdf
Precipitations	Accumulation via 24h infra-range+Micro- gale	US NAVY	1	65S - 60S	0.25°		700 Ko	http://www.nimr.navy.mil/ab/bniran/canTGED.html
	Rain rate SSM/I F13 & F14 morning & evening	REMSI	4	Whole region	0.25°		30 Ko	
Absolute Dynamic Topography	Absolute dynamic topographic, merged & products	REMSS	1	Whole region	0.25°		46 Ko	
	Composite MODIS images of chlorophyll-a MODIS OC2, chlorophyll-b MODIS OC4, chlorophyll-c MERIS K1, suspended matters OC3, flag-coccoliths and coccoliths (IFREMER Algoritm)	AVISO	1	Whole region	0.25°		46 Ko	
Water color		IFREMER	1	5W-20E, 60S- 130S	0.02°	400 Ko	250 Ko	Daily products derived from MODIS & MERIS (IFREMER DVNECO) Weekly SST fields of daily forecasts (seven files received once a week), the files were recovered from the ftp MERCATOR-OCEAN server: ftp://ftp.mercator-ocean.fr/pub/users/bonus_goodhope/PSY3V1R1/
MERCATOR model	SST on regular grid at 1/4° "lat"	MERCATOR	1	Limited to 60S-110°	1/8°	800 Ko	6 fichiers de 6 Mo	
WRF regional model	Atmosphere variables	LPO - IFREMER	6 files 1 file once a week	Whole region	1/8°			
WRF regional model	Atmosphere variables	LPO - IFREMER	1 file	Whole region	1/8°		6 Mo	
WRF regional model	Atmosphere profiles	LPO - IFREMER	1 file	Whole region	1/8°		1.6 Mo	

4.1.8.1 SATELLITE SEA SURFACE TEMPERATURE

We received daily on board different SST satellite products originating from different sources listed on the data listed in Table 6 and gathered essentially by the LOS-IFREMER and the US IMAGO of IRD that organized the sending of data to the ship. Of the different products, the highest spatial resolution (METOP and MSG), were interesting in terms of details of the mesoscale and submesoscale structures we crossed along the cruise transect. Nevertheless, because their space coverage is influenced by the presence of clouds, these products were very often less useful than the AMSR-E (micro-wave) and the ODYSSEA products in the subantarctic and polar regions (that is more or less south of 42°S). Nevertheless, when the cloud coverage allowed, the MSG derived visualization of oceanic fronts proved to be particular useful to assess strong SST gradient positions along the cruise transect.

Also, the availability of daily fields, such as ODYSSEA, showed to be very important because mesoscale and submesoscale observed features along the cruise were showing a very important day-to-day variability. Indeed, stations were often adjusted to get the more appropriate set of observations of these fine scales structures (eddies, frontal jets, filaments, ...). Finally, despite the increased cost in term of files size, the availability on board of the satellite data themselves (in NetCDF format) revealed to be very useful to improve the station positioning to best capture the fine thermodynamical features, to organize the atmospheric radiosounding and to follow in time the behaviour of such structures. In Figure 27 and Figure 28 are given examples in how these data were used.

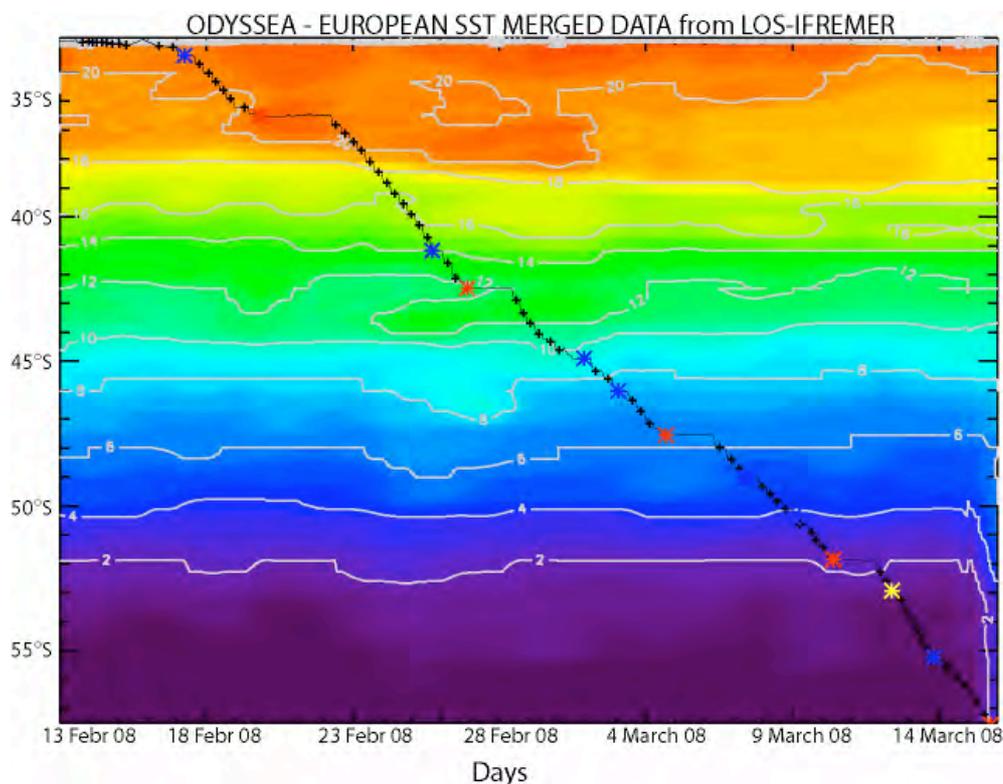


Figure 27 – The figure sketches the daily value of SST along the track as function of latitude and time. Overlapped are the day/latitude positions of the ship. Each star corresponds to a station. In black are the hydrological stations, in blue the LARGE, in red the SUPER and in yellow the intercalibration.

– BONUS-GOODHOPE Cruise Report –

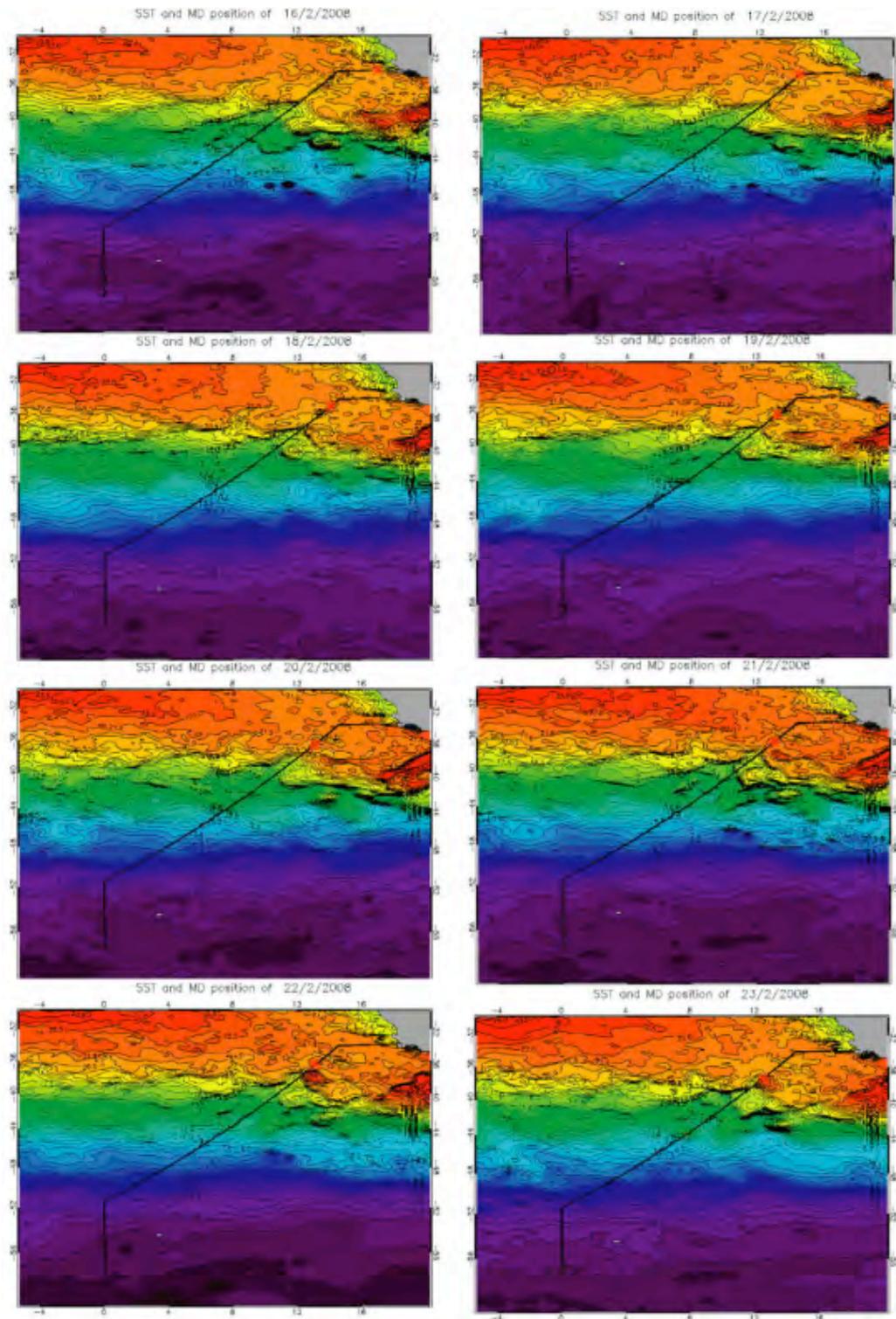


Figure 28 – Each panel shows the daily values for the SST-ODYSSEA starting from February 16 till March 16 (the day we started the last station). Temperature contours are of 0.5°C. Superimposed is the cruise transect with the red star indicating the daily position of the ship.

– BONUS-GOODHOPE Cruise Report –

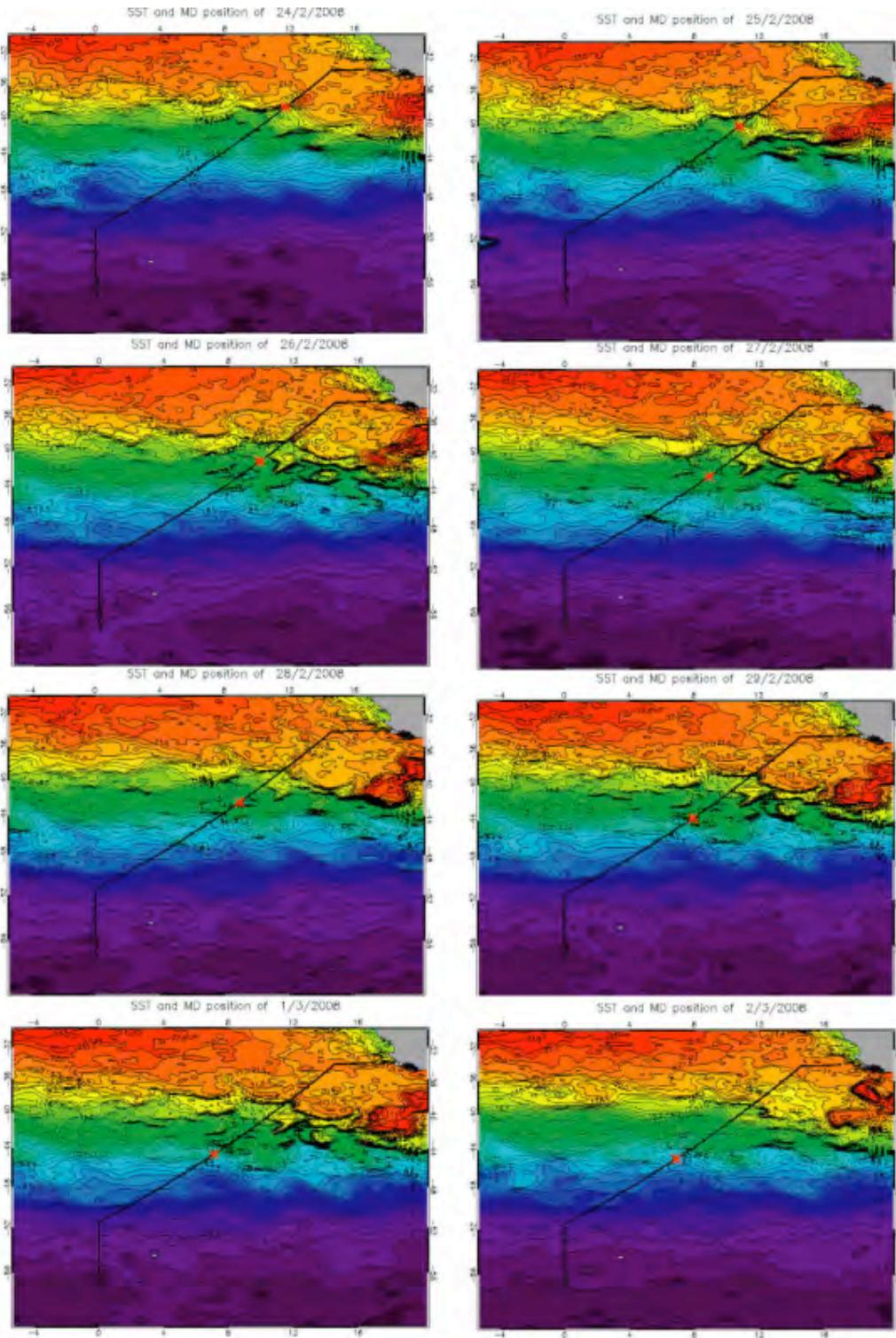


Figure 28 – Continued

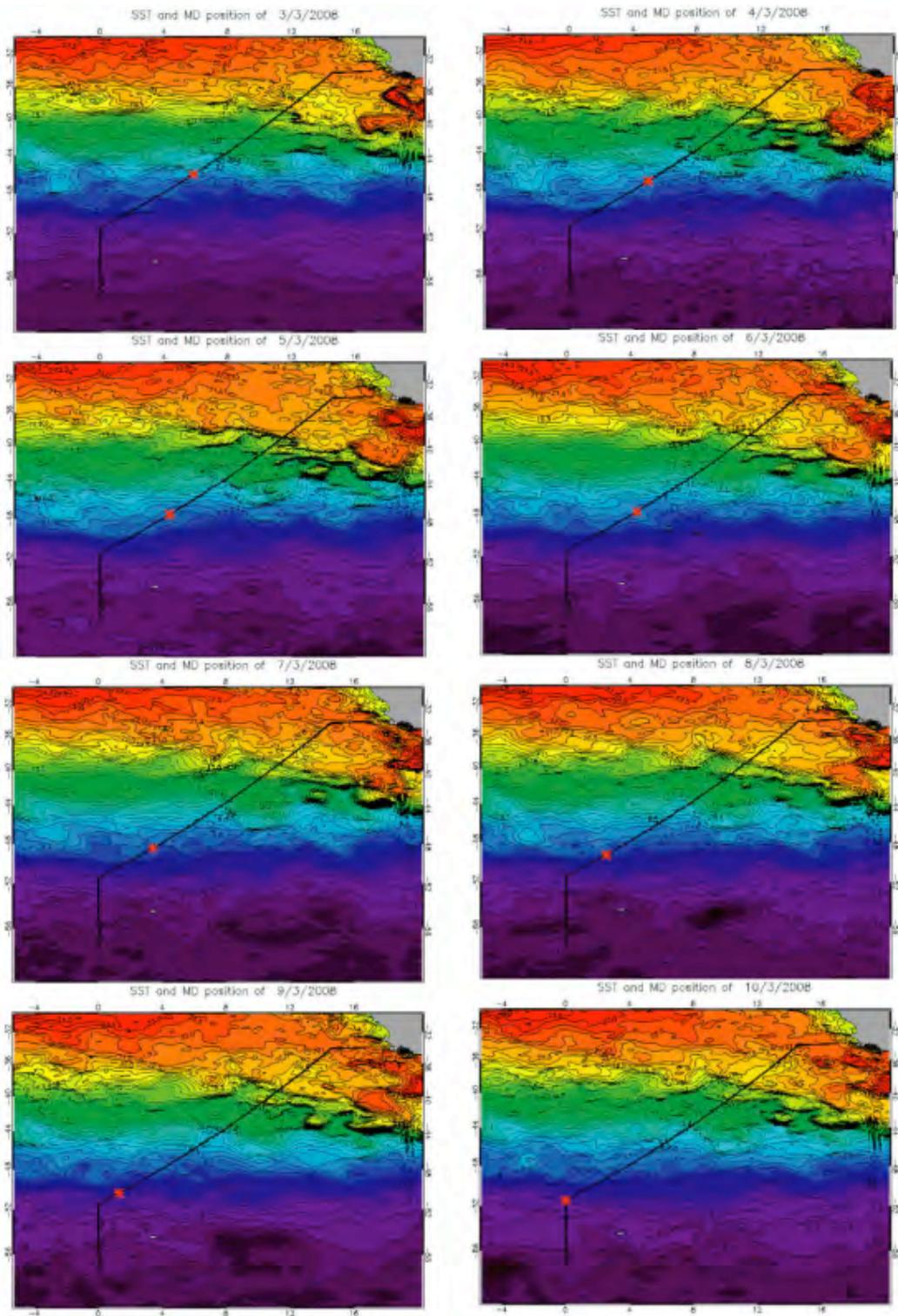


Figure 28 – Continued

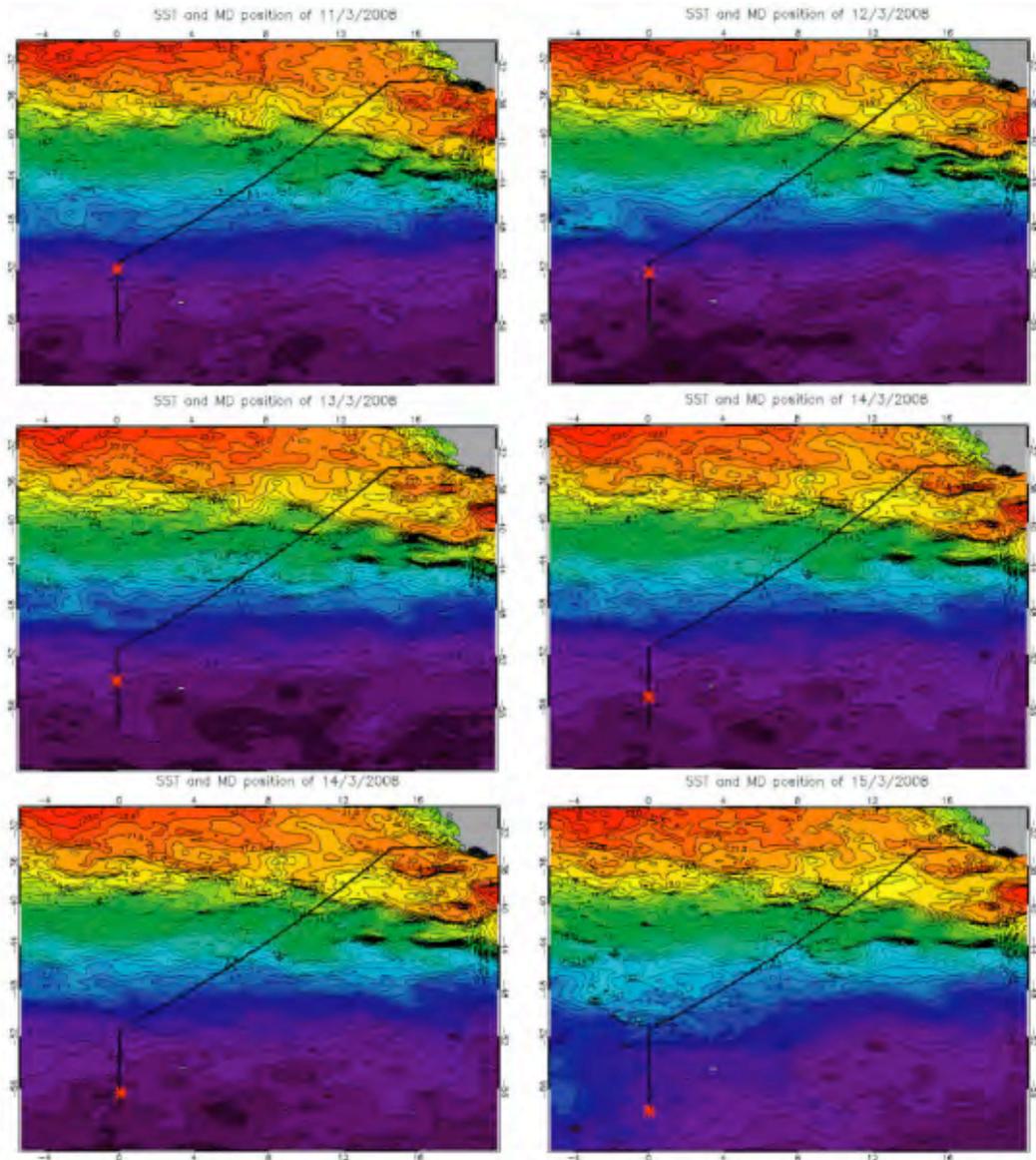


Figure 28 – Continued

SST data have been also capital in the detection and in the setting up the observation strategy of an anticyclonic eddy that detached from the Agulhas Return Current during the return transect to Durban. Thanks to the SST satellite data we were able to observe the birth of the anticyclone, to launch at *ad hoc* locations XBTs and radiosounds, and to deploy the last ARGO profiling float in the middle of the structure.

During the cruise we started to compare the satellite data to the observed SST values. This has been initiated with a comparison between the SST measured by the Marion Dufresne Thermosalinograph (TSG) and the ODYSSEA SST for which we were receiving the data in NetCDF format. This work showed a high correlation between the two fields for both, SST values and time variations. The ODYSSEA SST showed to be slightly underestimating the SST (Figure 29). This is probably due to the various parameterization and models used to recover the SST value from the different satellite sensors. Differences can also be due to the fact that the TSG SST is measured at 5 m depth while the satellite products are supposed to recover the temperature of the upper few cm of the sea water. This kind of analyses, as well as the correspondence of remote sensing observed dynamical features with those measured from the *in situ* data, need to be deepened, include the air-sea set of observations made during the cruise. This will allow better validation and calibration of the satellite products. This is of primary importance for research and operational issues (*e.g.*, satellite SST is often used for meteorological forecasts, etc).

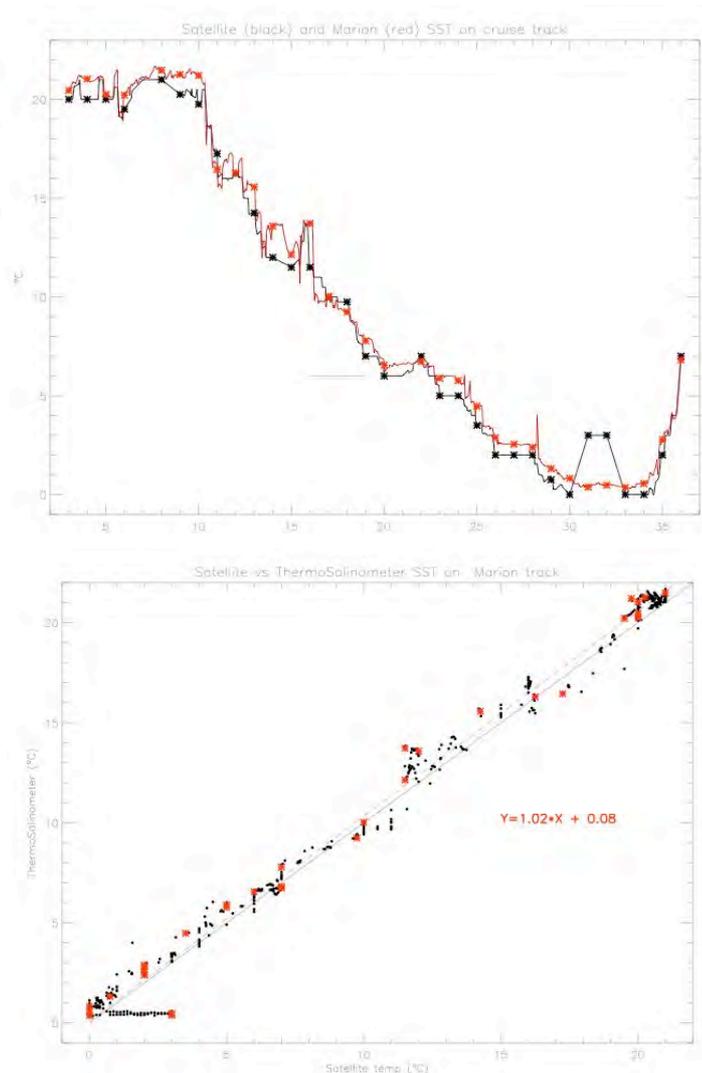


Figure 29 – Intercomparison between the satellite ODYSSEA-SST values (in black), and TSG SST values (in red). Upper panel: SST values as function of time (days); Lower panel: satellite SST values are plotted as function of TSG SST values. The points gather together along a line. This shows the high correlation between the two sensors. The regression is linear except for a two-day period at the end of the cruise.

4.1.8.2 SATELLITE DERIVED ABSOLUTE DYNAMIC TOPOGRAPHY

An altimeter measures the sea level above a reference ellipsoid η , which is the sum of the absolute dynamic topography h and the geoids height above the same ellipsoid N . In oceanography, the signal of interest is h , from which oceanographic currents can be deduced geostrophically. However, the poor knowledge of the geoid component at the very beginning of altimetry prevented the oceanographers – and it is still the case- to fully exploit the altimetry measurement. Alternatively, the repetitiveness of altimetry missions was planned so that very accurate mean sea surface profile could be computed along-track and the variable part of the dynamic topography (Sea Level Anomaly – SLA) could be deduced from the altimetry measurement at a centimetre level accuracy. The analysis of the SLA has led to numerous progresses in our knowledge of the ocean dynamics. However, 15 years after the launch of ERS-1, the inference of the absolute dynamic topography from the altimetry measurement is still a challenge. One way to do it is to add to the SLA an estimate of the Mean Dynamic Topography (MDT). Different methods have been developed to estimate the ocean MDT independently from the knowledge of the geoid's shortest scales. AVISO proposes now an absolute dynamic topography product (ADT) that adds the satellite derived SLA to what has been proven to be a robust estimate of MDT (Rio et al. 2004). This method uses a recent geoid model derived from GRACE data (EIGEN-GRACE03S) and synthetic estimates of the ocean MDT (dynamic heights and drifting buoy velocities minus concurrent altimetry height and velocity anomalies). This way we have access to 16 years of ADT time series at $1/3^\circ$ horizontal resolution in space and seven days in time. These fields are quality controlled and use different sources of altimetry data in a delayed-time mode. The use of ADT instead of SLA only in an ocean region such that around southern Africa proved to be very important, the MDT field being of the same magnitude of SLA. An example of such a field for our region is given in Figure 30. The entire region, no matter the basin (South Atlantic, Indian or Southern ocean) is characterized by eddies of different sizes and jets.

During the cruise we got access to daily images and data for the region around the BONUS_GOODHOPE transect. The data were the AVISO ADT daily fields in a “near real time” mode (released within 7 days), that is, the daily data were received for the day J-7. It must be said that the “near real time” mode the data do not benefit of the exact knowledge of the satellite orbit, therefore their precision is less accurate than that of the “delayed time” data. However, for the use of these data on the ship, such a precision was not necessary. It will be for all further work on the *in situ* and satellite data, when we will be interested in more quantitative comparisons and velocity estimates.

Despite the lag of seven days, this proved to be very important to contrast eddies and frontal jets. Indeed, even if the oceanic situation we were measuring during the cruise was one week “older” than the altimetry data we were receiving, we were able to better qualify and follow in time the different features we were crossing during the cruise than what could have been possible if we were using the SST satellite data alone. This because ADT reflects ocean processes that are not confined only at the sea surface but can go as deep as more than 1000 m. The retrieved images and data have been very important for the cruise strategy itself,

but also to understand the dynamics, origin and fate of observed *in situ* features such as the anticyclone “M” or the small cyclonic feature “S” as well as the Agulhas rings and nearby cyclones evolving in the subtropical part of the transect. An example is given in Figure 30, for ADT data the day we crossed the centre of anticyclone “M” just above the Agulhas Ridge (February 29, station 36). North the cyclonic feature “S” is still visible as well as all the Agulhas rings and cyclones in the northern part of the domain. Visible also is the SAF strong gradient just south of the anticyclone “M”.

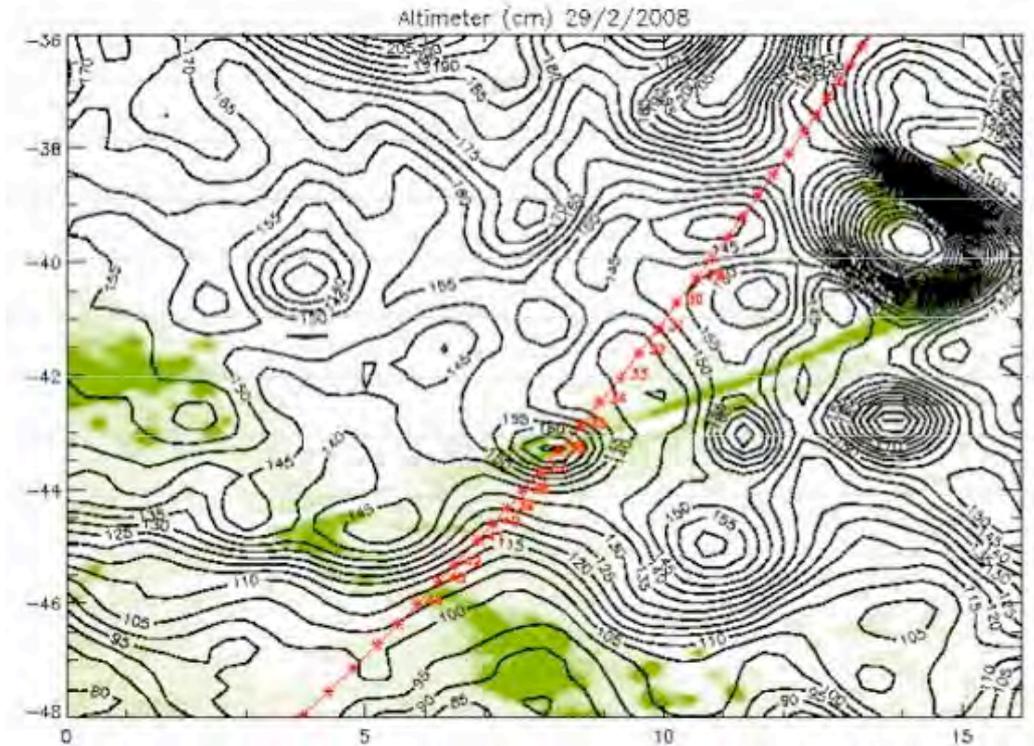


Figure 30 – Black contours show the near-real time Absolute Dynamic Topography for February 29. Contour interval is 5 cm. The bottom topography is overlapped in green and in red appears the part of the transect that crossed the region. Each star is a station. The corresponding number of station is indicated for each star.

One of the interesting features of the ADT is the possibility to retrieve the geostrophic velocity field. But the representativeness of this geostrophic field compared to the real ocean motion is still an open question. Because of the availability of the VM-ADCP data along the cruise track, one of the objectives we have is to assess what percentage of the ocean currents and to which water layer the ADT geostrophic field accounts for. On board, we started to compare qualitatively the VM-ADCP filed and the ADT derived geostrophic velocities interpolated along the cruise transect (Figure 31).

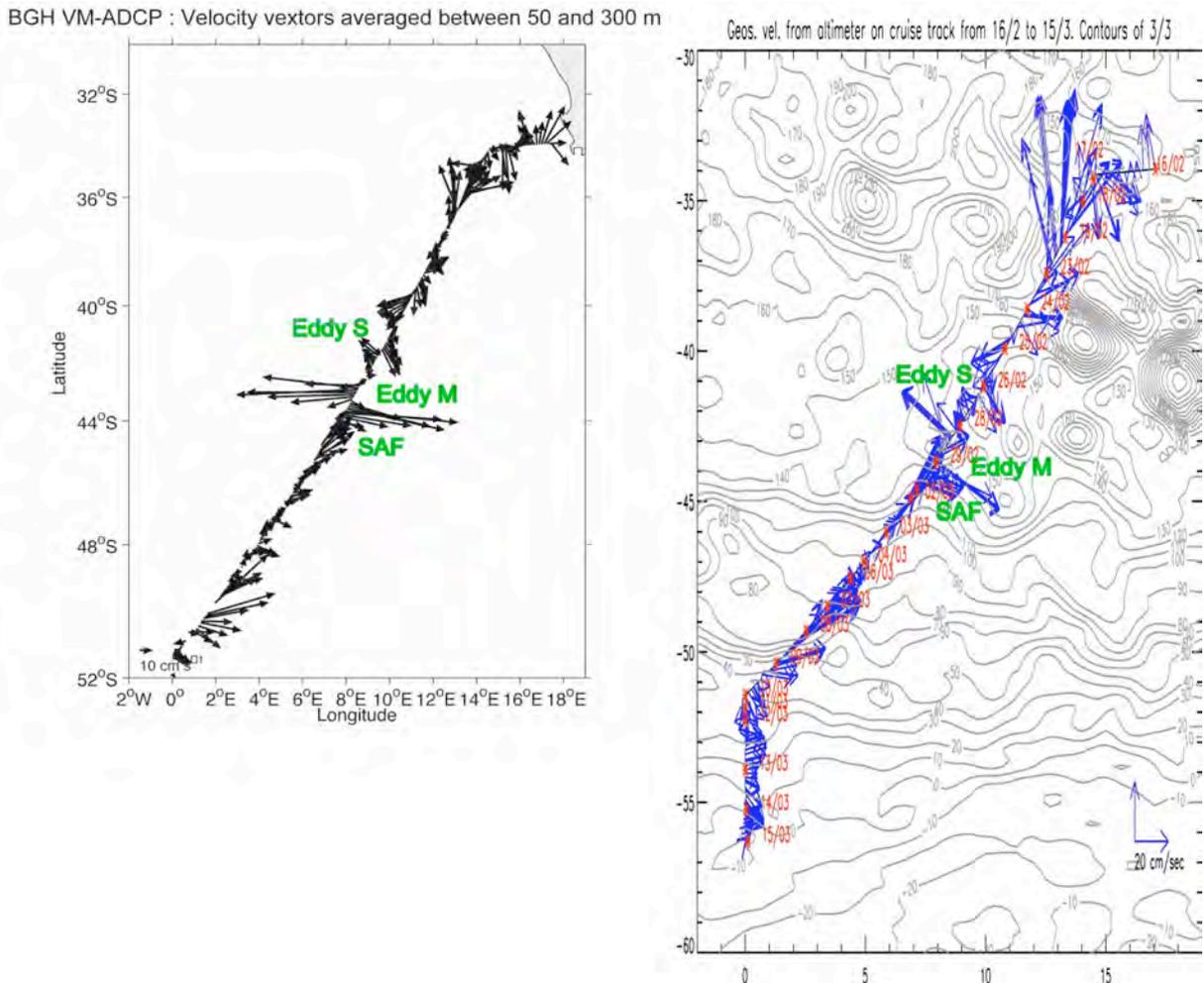


Figure 31 – Qualitative comparison between VM-ADCP velocity vectors (on the left panel) and the geostrophic velocity derived from the near-real time ADT along the BONUS-GOODHOPE transect (on the right panel, with contours of ADT for March 3 overlapped as well as the cruise transect with the date for each station). Labelled are eddies “M” and “S” as well as the SAF. The two fields behaviour compare relatively well. The comparison needs to be deepened with validated ADCP data and delayed-mode ADT (that is in general better in precision compared to the near-real time field).

4.1.8.3 OCEAN COLOUR

Ocean colour images for different ocean variables were sent on board on a daily basis. We received both MERIS and MODIS fields for chlorophyll a and suspended matter treated beforehand by the DYNCO laboratory at IFREMER and by the US IMAGO at IRD. These images were most of the time very patchy because of the satellite orbit and the presence of relatively large cloud cover. Therefore, it has been mostly impossible to follow the evolution of these fields along the cruise track. A post-cruise work on merging fields and making the mean of two or more days of data is necessary to start any comparison with the *in situ* data we collected during the cruise.

4.1.8.4 IRRADIANCE, WINDS AND PRECIPITATION DATA

Surface solar and downward longwave irradiance images, as well as winds (QuickSCAT and Blended) and precipitation daily images were compared qualitatively on board with model forecasts and observations. Because of the large set of data and the impossibility to work precisely with just images, the comparative work will start between these fields, regional and NCEP forecasts as well as *in situ* observations after the cruise. However wind fields and precipitations showed to be very helpful also in following depressions or the behaviour of high pressure regions and to validate forecasts.

4.1.8.5 REGIONAL ATMOSPHERIC FORECASTS

Regional atmospheric forecasts have been set up for the Southern Ocean sector south of Africa during the cruise period. The forecasts were made using a regional configuration of the Weather Research & Forecasting (WRF: <http://www.wrf-model.org>) Model. WRF is a next-generation mesoscale numerical weather prediction system designed to serve both operational forecasting and atmospheric research needs. It features multiple dynamical cores, a 3-dimensional variational (3DVAR) data assimilation system, and a software architecture allowing for computational parallelism and system extensibility. An operational forecast system has been set up with WRF for southern regions at several horizontal resolutions (37.5km, 12.5km) and 50 vertical levels. The run were performed using the IFREMER-Brest computer facilities.

Global forecast products from GFS-NCEP are taken as initial and lateral boundary conditions for the WRF bigger domain (with the coarser horizontal resolution - 37.5km). The child domain (12.5km) communicates with the bigger one through a two-way boundary exchange processes. The SST has been updated every 6h as well as the GFS lateral boundary conditions.

The 48H weather forecast has been produced every day at 06Z from the 00Z GFS model cycle runtime and for the forecasts product times from 00 to 48 hours. The fine and the coarse resolution forecasts (see Figure 32) were sent daily to the ship by the Inmarsat communication system.

The WRF forecast has been compared in real-time with on board atmospheric collected data. This showed that the model represented remarkably well the wind direction and intensity as well at the 10m height. Further investigations are now necessary to quantify and to provide standard forecast skills.

The forecast products have been also used to better evaluate the model ability to take into account links between ocean surface features and atmospheric boundary layers conditions (for instance the wind decrease/increase in the vicinity of ocean eddies boundaries). The WRF regional forecasts have also been used to plan the radiosounding launches, especially in relation with the air fluxes around the ship that sometimes prevented a correct and secure launch.

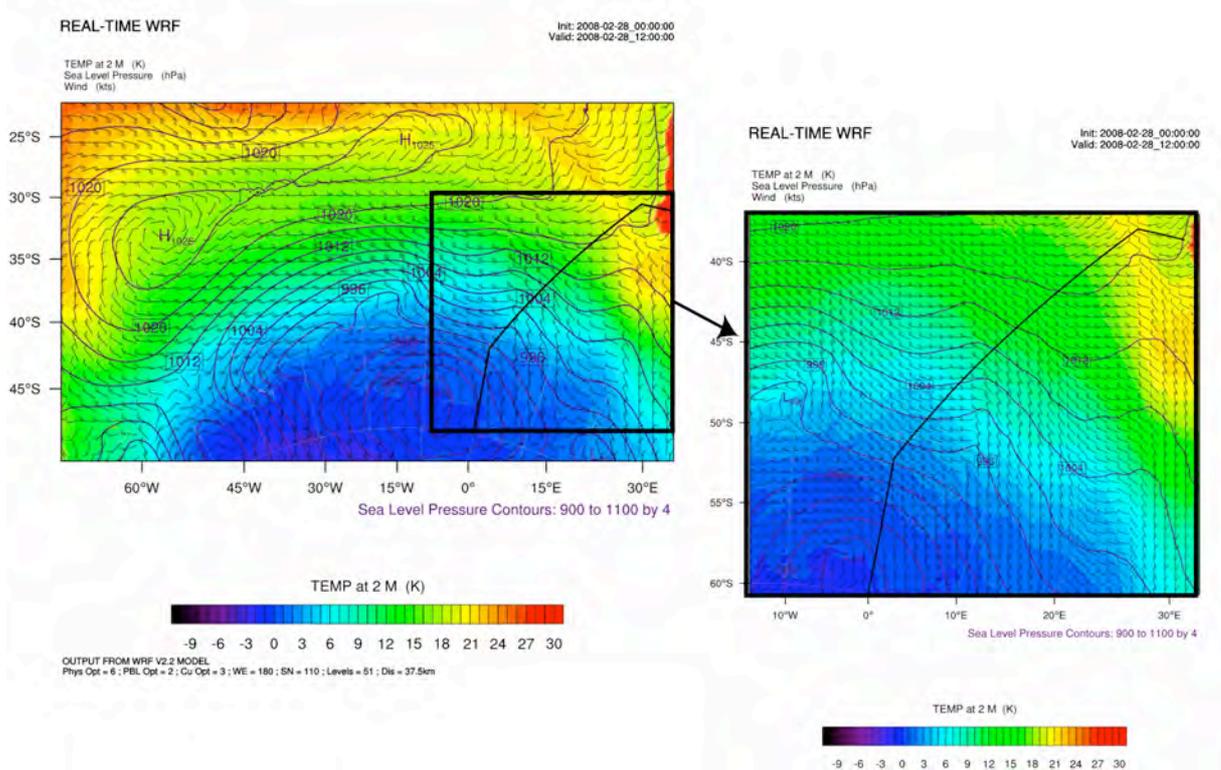


Figure 32 – Example of 12:00 forecast for February 28, 2008 for the WRF regional operational model we implemented for the basin-wide domain on the left panel (37.5 km of horizontal resolution) and for the child domain embracing tightly the cruise track (on the right) at 12.5 km of horizontal resolution. Shown variables are : 2 m height temperature (colours); Sea Level Pressure as black contours (contours spaced at 4 hPa); 10m wind vectors (m/s).

4.1.8.6 MERCATOR-OCEAN FORECASTS

The MERCATOR forecasting systems (<http://www.mercator-ocean.fr>) use a set of complex software packages. Mercator Ocean uses the full range of OPA ocean circulation models developed at LOCEAN, the oceanography and climate laboratory in Paris. The operational MERCATOR-OCEAN systems receive input from many data sources for operational requirements (real time data) but also for validation and reanalysis (delayed time data). The MERCATOR-OCEAN model assimilates satellite and in situ data via an Optimal Interpolation method. The forecast range is, in the MERCATOR system, the longest forecast range is 14 days. One new analysis and two forecasts are available every Wednesday. The forecasts are for 7 days and 14 days. The model is run on the Meteo-France VPP 5000 computer every week, during the night of Tuesday to Wednesday. Every Wednesday (day T0), the Mercator bulletin consists of: A daily analysis from T0-14 (14 days before T0) to T0. This analysis combines assimilated data and model outputs. Data are assimilated weekly, on T0-14, T0-7 and T0. A daily forecast from T0+1 to T0+14. These fields are from the numerical model only, with no data assimilation. The operational system we use is the PSY3V1 based on the global 1/4° resolution OPA ocean model. MERCATOR-OCEAN made us available every Wednesday, seven-day forecasts for the simulated SST fields for our region of the Southern Ocean. During the cruise Jean-François Piolle

at the *Laboratoire d’Océanographie Spatiale* (LOS) of IFREMER gathered the MERCATOR data. He then made them available to us via Inmarsat.

The model showed to have a mean behaviour comparable with satellite products and the *in situ* data collected during the cruise, but more quantitative comparisons are needed to precisely evaluate the skill of the MERCATOR-OCEAN PSY3V1 operational model in this region.

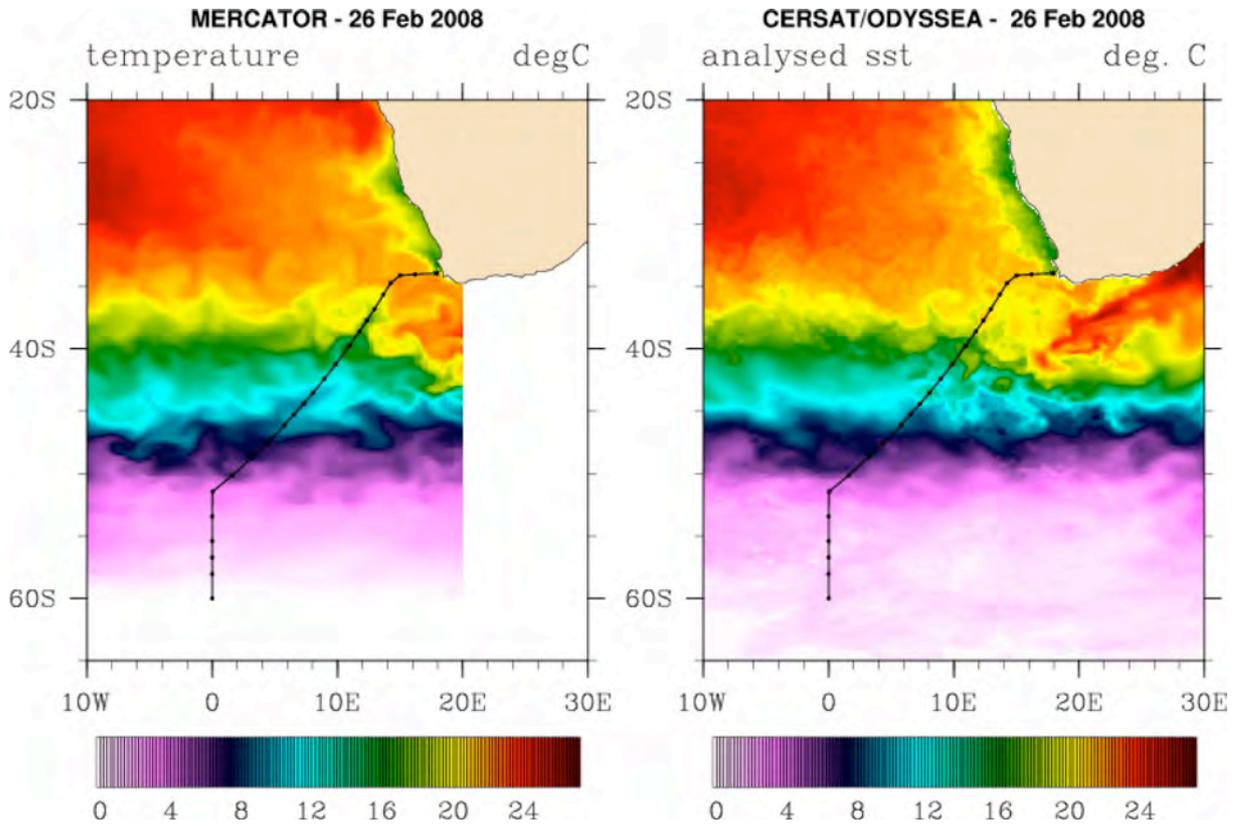


Figure 33 – SST for February 26, 2008. On the left panel the MERCATOR-OCEAN PSY3V1 forecast; On the right panel the satellite SST from ODYSSEA.

4.1.9 ATMOSPHERE AND AIR-SEA PHYSICAL ON-BOARD OBSERVATIONS

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To further the study of fluxes and better define the atmosphere-ocean interaction of fronts and eddies in the Southern Ocean and Agulhas Current region, a suite of sensors was deployed on the R/V Marion Dufresne II during Bonus-GOODHOPE. The integrated dataset would:

- a. delineate sea surface temperature features, and provide high quality measurements for validation of satellite SST products
- b. record changes in the maritime boundary layer which could be associated with heat exchange in the vicinity of fronts and eddies or forcing by large scale weather patterns (atmospheric cyclones, convective rain)
- c. mark the evolution of air-sea temperature differences both at the surface and in profile across oceanic fronts, filaments, and eddies
- d. capture changes in cloud cover, weather, and radiation over a large latitudinal range, from sub-tropical to polar atmospheric conditions

All instruments except the radiosonde receiver were installed on the bridge I, above the main bridge. Attention was paid to limit the effect of the ship on each instrument, which included profiling, imaging and hemispheric sensors, as well as those, which required adequate ventilation and clear lines-of-sight. It was also necessary to have direct access to each instrument at all times for routine cleaning and, in the case of failure or weather events that may degrade the quality of the measurements, maintenance or repair of the instrument itself.

The central instrument to this effort is the Marine-Atmospheric Emitted Radiance Interferometer (M-AERI), which measures infrared spectra between 3-18 μm . Its measurement cycle includes two blackbody calibration views, as well as views of zenith, and $\pm 55^\circ$, which combined takes approximately 10 minutes to

complete. Spectra collected from each view are used to calculate the air temperature and sea surface skin temperature (SSST) with very high accuracy. The M-AERI was sited on the starboard railing of pont I just aft of a small GPS antenna, with clear field of views of the sea surface forward of the CTD and of the sky overhead.

Just aft of the M-AERI in the starboard corner of the railing, a small table was welded onto the rail to support the all-sky camera. As it is imaging the hemispheric cloud cover and weather, it is necessary to have as few structural obstructions nearby as possible. The best that could be managed still included some obscuration of the hemispheric view by the main mast; but, this is a common problem on most research vessels and will not greatly affect classification of cloud types in the imagery.

On the port railing of pont I forward of a whip antenna the microwave radiometer was mounted for the retrieval of cloud liquid water and integrated water vapour. Part of its measurement cycle includes a tip-curve that requires a 90-degree unobstructed view of the atmosphere seaward. A reversible table with telescoping legs was constructed at the University of Miami to allow easy installation, and the instrument was oriented with cables forward so that the tip-curve would sample the atmosphere off the port side of the ship.

On the forward railing, to the starboard side of the centreline, two tabs were welded to allow for the secure deployment of the Weatherpack and radiation sensors on a T-frame. The Weatherpack, which included a Young anemometer as well as sensors to measure air temperature, relative humidity, and barometric pressure, was mounted at the top of the “T”, while an Eppley pyranometer and pyrgeometer were placed on gimbals at the end of each arm of the “T”. The plates, which house the meteorological measurements, need to be well-ventilated to ensure the best quality data. And, the Eppley domes must be maintained daily to remove traces of precipitation and soot from the ship’s smokestack, which change the radiative characteristics of the measurement dome.

All of the power and signal cables from these instruments were run into a small, wooden mobile laboratory, which was built by IPEV and craned onto the bridge near the port side railing. One laptop per instrument was allowed to capture data 24 hours a day, and the main M-AERI computer resided here as well. In times of good weather, I was able to work inside the lab and monitor all instruments in real time. During times of large seas and extreme weather events, Dr. Key was allowed to access the lab while carrying a radio and after notifying the bridge. In this way, the quality of the data and state of the instruments could be maintained.

The radiosonde receiver was installed in an engineering space above the helicopter hangar. The GPS antenna and a signal antenna built by the radio officer of the Marion Dufresne were installed on the hangar roof to provide clear reception in all directions. The signal antenna made by the radio officer was to replace a missing broomstick antenna that was not included in the shipment. Because this modified antenna did not have a preamplifier, the receiver was placed in a location that minimized the length of cable between it and the antenna. Despite the lack of preamplifier, this antenna worked well and provided reception for radiosondes to heights of 25km.

A hard hat float was also brought but not used during the cruise. The float houses a calibrated thermistor, which is spliced to marine cable and connected to a millimetre that measures resistance. The resistance is converted into temperature, providing a bulk sea surface temperature at ~ 2cm depth while the ship is hove to on station. While initially there were instrument issues that delayed the hat's use on stations, a lack of deployment location ultimately precluded its inclusion in the campaign. It was preferred to lower the hat into the sea on the same side of the ship as the M-AERI and CTD, forward but away from the bow thrusters; however, the marine cable must be run indoors to a protected area where the multimeter and laptop can log the data. The only location which fit these parameters on the "E" deck was the CTD winch cabin, and it involved threading the cable through one of the two winch cable pass-throughs. Soon the set-up came into conflict with CTD operations. So, in the end, the operation was abandoned and the thermosalinograph bulk temperature was used as the sole bulk measurement.

Table 7 provides a basic description of the parameters measured and their accuracies, as described in the manufacturer's guides.

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Table 7 Basic description of the physical atmospheric parameters measured and their accuracies, as described in the manufacturer's guides.

Manufacturer	Instrument	Height	Parameters	Units	Uncertainty	Sampling Rate	
Space Science and Engineering Center, University of Wisconsin-Madison	M-AERI	19 m	Skin temperature	K	<0.1 ¹	10 minutes	
			Air temperature	K	<0.3 ¹	10 minutes	
Coastal Environmental Svstems. Inc.	wind vane 5103	20 m	Wind speed	ms ⁻¹	0.3 ²	1 minute	
			Wind direction	°	2.0 ²	1 minute	
			Relative Humidity	%	2.0 ³	1 minute	
Eppley Laboratory	Barometer 6400 Precision infrared radiometer (PIR)	20 m	Barometric pressure	mb	0.5 ⁴	1 minute	
			19.5 m	Longwave radiation	Wm ⁻²	< 5%	1 minute
				Shortwave radiation	Wm ⁻²	1%	1 minute
SeaBird	Precision spectral pyranometer (PSP) 45	-6 m	Bulk temperature	°C	0.01°	1 minute	
			-6 m	Salinity	psu	0.0001	1 minute
Radiometrics	Microwave radiometer WVR-1100	19 m	Total integrated water vapor	cm	0.05 cm ⁵	1 minute	
		19 m	Integrated cloud liquid water	cm	0.003 cm ⁵	1 minute	
Vaisala	RS92-SGP Radiosonde	14 m -	Air temperature	°C	0.15°C ⁶	1 second ⁷	
		29 km	temperature profile				
		14 m -	Relative humidity	%	2% ⁶	1 second ⁷	
		29 km	humidity profile				
		14 m -	Wind direction	°	2° ⁶	1 second ⁷	
		29 km	profile				
University of Miami	All-sky camera	18.5 m	Wind speed	ms ⁻¹	0.15 ms ⁻¹ ⁶	1 second ⁷	
			29 km	profile			
			14 m -	Barometric pressure	hPa	0.3-0.4 hPa ⁶	1 second ⁷
			29 km	pressure profile			
			Cloud cover	okta	--	30 seconds	

¹ Minnett et al. (2001)

² Coastal Environmental Systems, Inc., Wind Monitor 5103 brochure

³ Coastal Environmental Systems, Inc., Relative Humidity Sensor S1057 brochure

⁴ Coastal Environmental Systems, Inc., Barometer 6400 brochure

⁵ ARM MWR manual for December conditions at the SGP site

⁶ All radiosonde uncertainties are based on repeatability in calibration from Vaisala.

⁷ For sonde data collected before March 4, 2008, the sampling interval for all sonde variables was 10 seconds.

Sampling Methodology

With the exception of the radiosonde launches, all instruments sampled their relevant parameters at user-defined sampling rates and operated in a port-to-port, 24-hour mode. Sampling intervals of each instrument is mentioned in Table 7. The 1-minute data provides for robust resolution of features, such as turbulence and gustiness over the top of the bridge and drops in air temperature associated with downdrafts before convective rain. However, it does not allow for resolution of the structure of turbulent features themselves, which would require the 60Hz data of more traditional flux systems, such as the Licor Open Path Gas Analyzer and a sonic anemometer reporting 3-dimensional velocities.

The daily sampling length of the all-sky cloud imager was adjusted with latitude to capture 2π hemispheric images of sky cover and weather between sunrise and sunset. The 30-second images are used to create a movie each evening, which can be analyzed later by a meteorologist. Because instantaneous classification of cloud imagery can lead to underestimation of mid- and upper-level cloud (due to the predominance of low-level cloud), the meteorologist will observe 10 minutes' worth of imagery to make each cloud determination. The movement of different cloud layers during the 10 minutes exposes upper-level clouds that would be otherwise obscured and not noted in the data record.

Radiosonde launches were made with preference towards 12Z and 18Z for satellite overpass and model integration times. When fronts or eddies were encountered, sampling would increase to four sondes per day at 0, 6, 12, and 18Z. Three diurnal cycles like this were conducted, two in conjunction with SUPER stations. On the return to Durban, a large eddy was crossed, and sampling was conducted across the eddy at 2-hour sampling resolution. Each sonde flight transmitted 1-second samples of atmospheric variables, though for sondes launched before March 4th, the temporal resolution was 10-seconds.

Storage Procedures

All data are archived to two types of media on a daily basis to prevent any losses through overwriting of files or disk crashes.

Analysis Procedures

A very preliminary quality control is applied to all data on board. These procedures are simply to remove any negative incident radiation values and rain-contaminated temperatures from the M-AERI. Further rigorous quality controls measures will be applied post-cruise to resolve a number of issues common to shipboard sampling of atmospheric and flux variables. These are discussed in Section 5.1, *Data Treatment*.

Daily time series of merged ship, Weatherpack, and M-AERI variables are plotted and displayed in the PC room. These merged maps highlight possible instrument failures, superstructure influences, sampling gaps, and rain effects, as well as encapsulating the physical variability of the air-ocean system along the ship's track. Every few days, a map of skin and air temperature, and air-skin

temperature differences are made until the end of the cruise, when a complete map of the entire cruise track is presented. Radiosonde air temperature, relative humidity, and wind profiles are plotted en masse to look at changes in atmospheric structure over the course of a day or across an eddy. Other diagnostic figures are made as necessary, to aid in cruise and radiosonde launch planning.

Preliminary Results

Shown here in Figure 34 is the cruise track, coloured by M-AERI skin temperature. The data return was quite good, despite often inclement weather. The high wind speeds often angled precipitation so that it was parallel to the ground and did not alight on the M-AERI mirror.

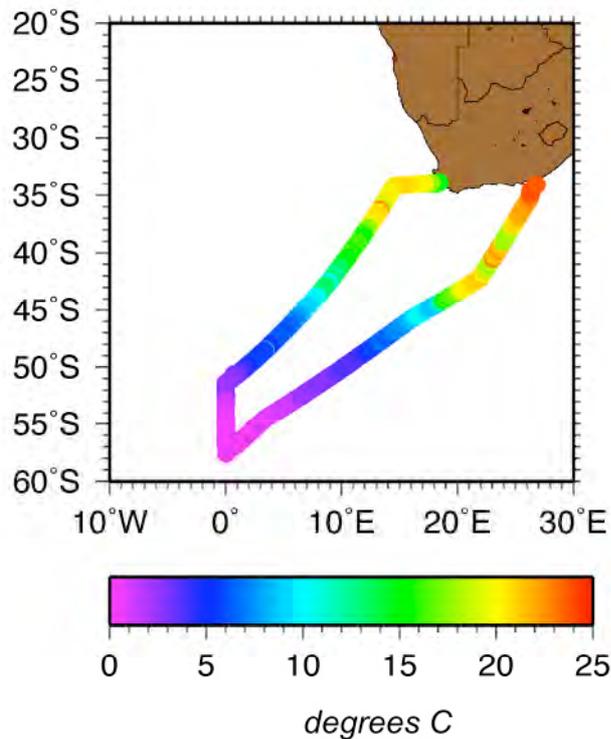


Figure 34 – Alongtrack measurements of sea surface skin temperature from the M-AERI. Strong temperature gradients at the various frontal locations are clearly seen in the data, as well as the signature of some upper ocean eddies

The ship's meteorology and thermosalinograph data is merged in this graphic (Figure 35) with the Weatherpack, M-AERI, and microwave radiometer data. As one can see, significant quality control needs to be done to remove erroneous data in the thermosalinograph and to correct for temperature and relative humidity differences between sensors.

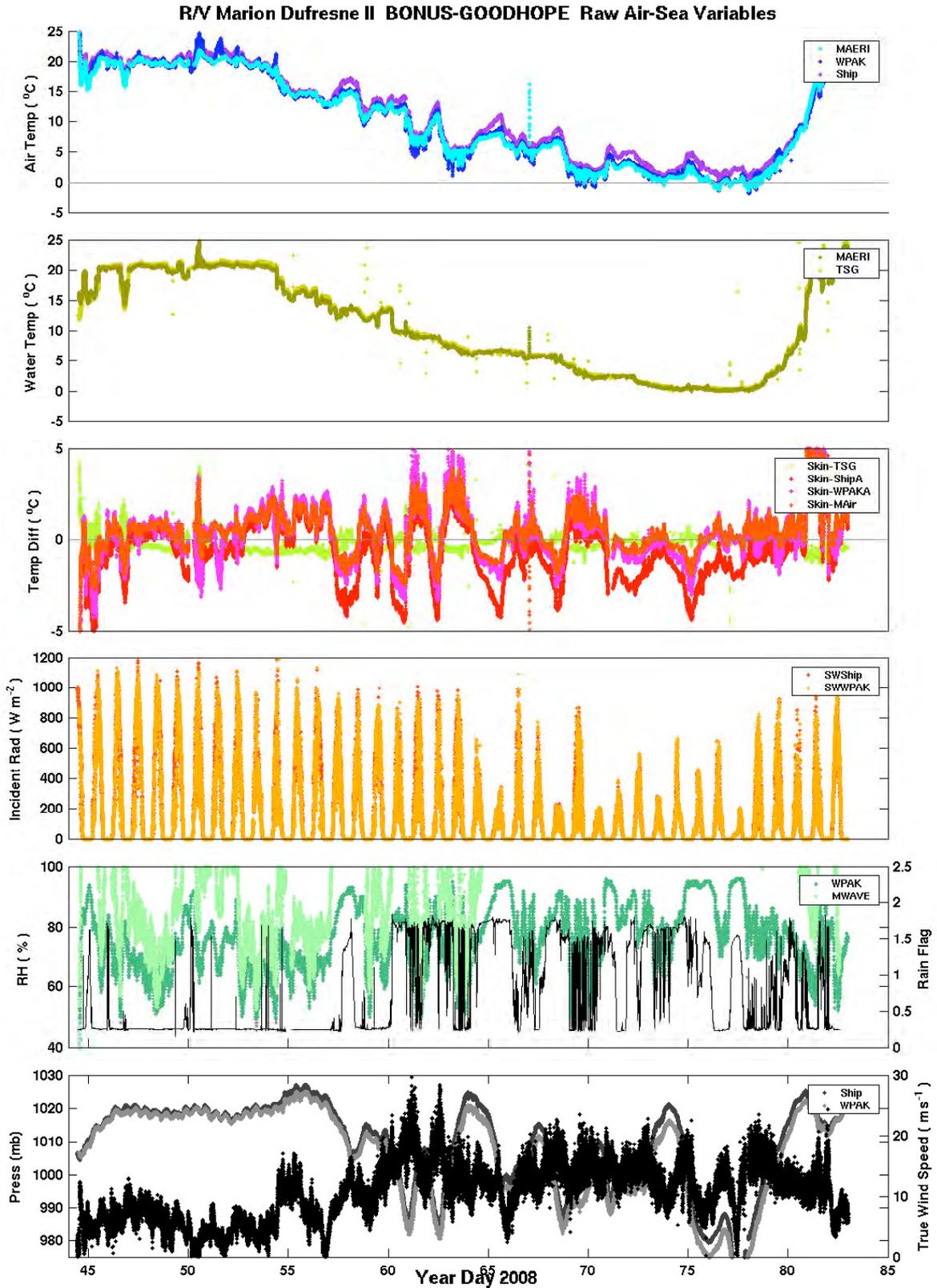


Figure 35 – Time series of the merged data sets, including meteorological, radiative, and radiometric variables.

Two sets of time series (Figure 36 and Figure 37) derived from the radiosonde data depict the varied air temperature, humidity, and wind speed along the cruise track. Wind direction was fairly constant, coming from the same quadrant for much of the cruise.

Marion Dufresne Radiosondes. 13 February - 24 March 2008.

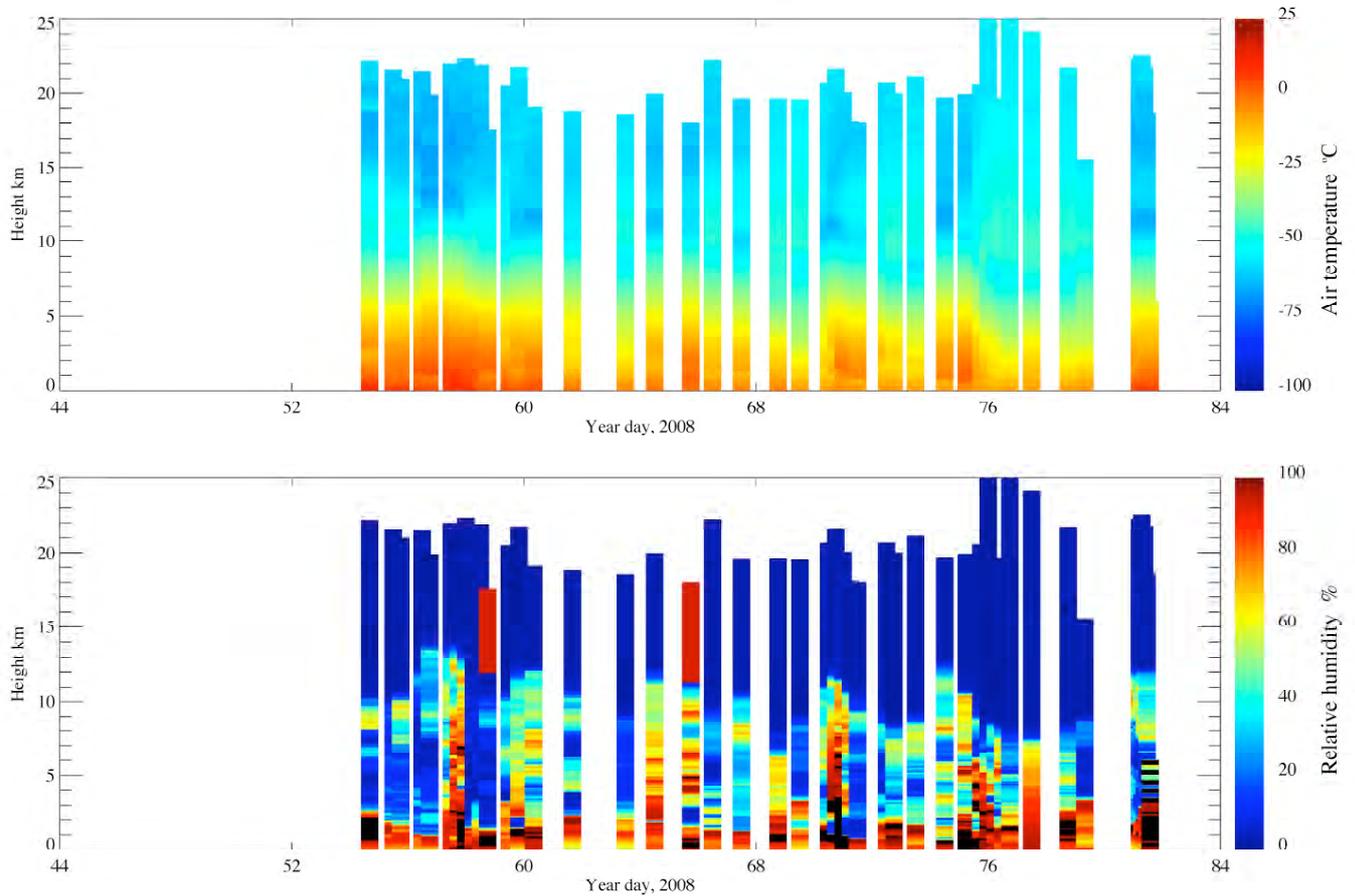


Figure 36 – Time series of air temperature and relative humidity profiles from the radiosonde data. Most radiosondes reached the tropopause, and in a few cases as high as 25km.

Marion Dufresne Radiosondes. 13 February - 24 March 2008.

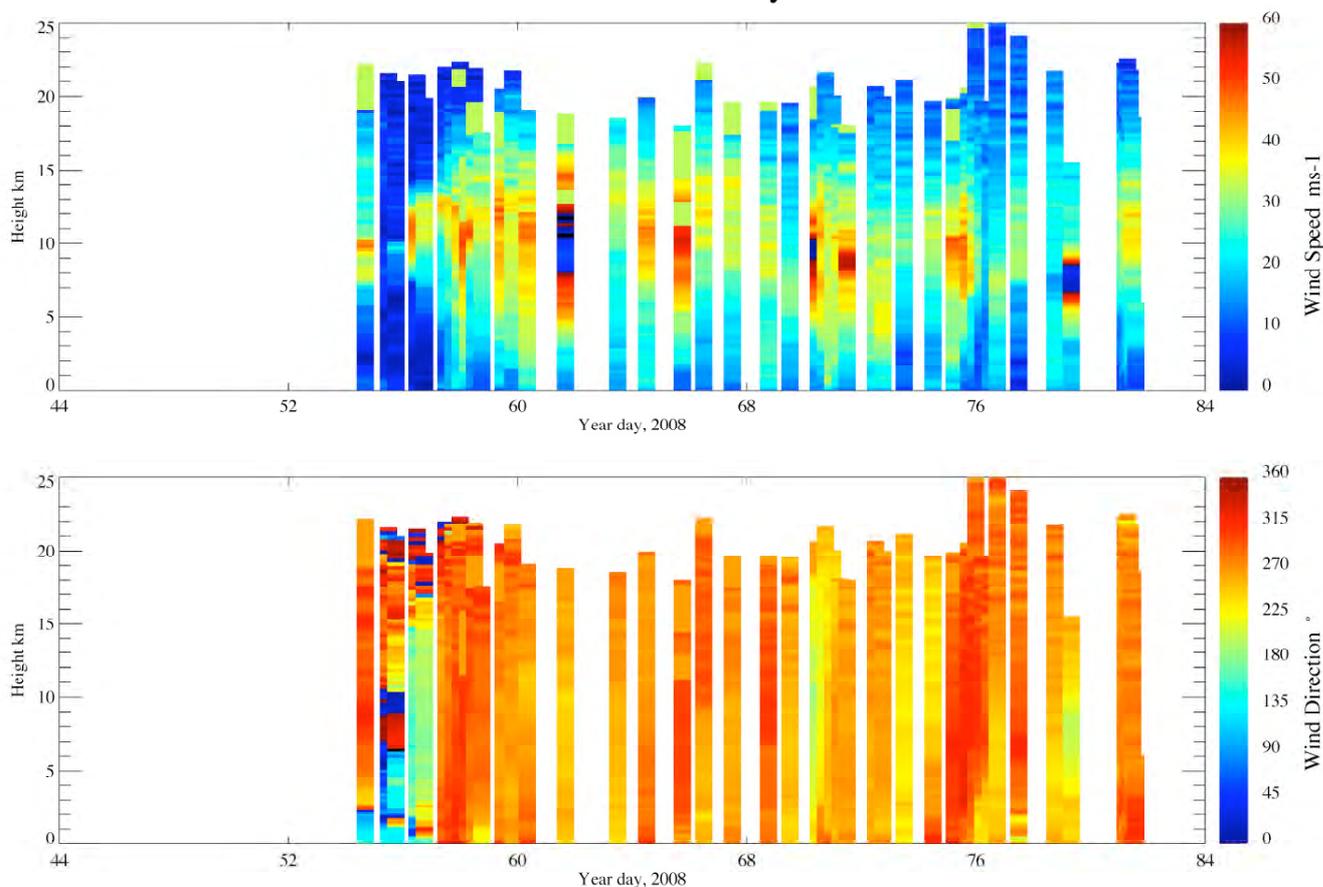


Figure 37 – Profiles of wind speed and direction as derived from GPS on each radiosonde. Not the core of high wind speeds near the tropopause and also the uniformity of the wind direction.

Data Treatment

Intercomparison of measured values, particularly noting differences between the ship's TSG bulk sea and the M-AERI sea skin temperatures and the meteorological time series from the BATOS and Weatherpack, will continue. Initial comparisons on board have shown a time offset and a bias between the BATOS and Weatherpack data streams. Since the Weatherpack air temperatures and M-AERI air temperature time series generally agree in magnitude and timing, and the M-AERI time clock is synchronized during each measurement with GPS, it is likely that the offset is in the ship's BATOS logging. The bias between the Weatherpack and BATOS will be more difficult to resolve. Superstructural heating of pont I during low wind/high insulation periods and the relative proximity of the air temperature sensor to the deck (~2m) introduces heat plumes into the Weatherpack air temperature data. Turbulent eddies and other flow distortions, such as wind acceleration over the edge of the bridge and shadowing by the ship's mast, can also influence air temperature. These rapid fluctuations are evident in both air temperature and wind time series for both sampling units.

The average difference between the Weatherpack and BATOS air temperatures is ~ 0.7°C, but this value changes as a function of wind speed and

direction, insolation, and remote forcing by eddies and downdrafts. Correlations will be performed to isolate the time lag between the BATOS and Weatherpack data, while M-AERI air temperature data will be used as “truth” to define heat plume events in the Weatherpack and bias in the BATOS air temperatures.

Bulk sea temperatures from the ship’s Seabird thermosalinograph have also undergone a level 0 intercomparison with XBT and CTD data collected at 6m depth. More detailed comparisons, assuming the start time of the profile is not that different from the sampling time at 6m depth, will allow for exact quantification of temperature differences amongst the bulk sampling devices on board. Once the validity of the thermosalinograph temperature time series has been assured, skin-bulk temperature analyses can be undertaken with the M-AERI data.

Wind data will require significant scrutiny. The Weatherpack anemometer was not located in a preferable location due to needs for accessibility during the cruise and possible interference with radio operations. It was ultimately sited to the starboard side of the centre line on pont I, blocked aft by the ship’s main mast, and measuring accelerated speeds over the bridge when winds were taken on the bow. It is undetermined at this point how much of the wind data from the Weatherpack will be usable. Winds reported on the ship’s system were collected from a Gill sonic anemometer located on the forward mast along the ship’s centerline. While the speeds may be accurate for most of the southward track when winds were taken on the bow or port side to aid in over-the-side operations, during the return to Durban, most of the winds were arriving on the stern. The level of this forward mast does not exceed that of the main mast, and is thus shadowed in a radius of more than 90 degrees to the stern. Other wind sensors on the ship, including an anemometer on top of the main mast, and another sonic anemometer on the cross-platform of the main mast, were not logged. Neither were turbulent values from the forward mast sensor provided; so, accurate determination of turbulent wind speeds and accelerations will not be possible.

Radiation measured by the gimballed Eppleys on the Weatherpack’s T-frame will be checked for shadowing post-cruise. The ship’s main mast would often shadow the insolation sensor during station operations. Ship schematics and measurements of the angles to the mast will be used with a solar model to determine the zenith angle of the sun relative to the Eppleys, so that only shadowed measurements and not cloud signatures are removed from the data. Comparison with the ship’s plate-mounted pyranometer on the second forward mast will also provide another control on the data. Since the ship’s sensor is stable relative to the ship’s plane, and thus may not be parallel to the horizon during periods of high seas, the exact value of the ship’s pyranometer will not be used; only the slope of the insolation curve over time will be used to compare with the Eppley pyranometer for removal of the shadow events. Downwelling longwave radiation measured by the Eppley on pont I will be calculated from the raw longwave and case temperature measurements collected during the cruise. This method is preferred to account for changes in the emissivity of the sensor dome due to large temperature changes along the cruise track.

Relative humidity was only reported by the Weatherpack and an ancillary sensor on the microwave radiometer. The ancillary sensor was not calibrated and suffered a failure in the middle of the cruise. Before the failure, however, the two

sensors agreed in the timing and amplitude of events, if not the exact magnitude. Another ancillary sensor, which aids in the operation and maintenance of the microwave radiometer is the rain sensor. When precipitation is detected, a blower and heater are engaged to remove any droplets or moisture from the antenna screen on the microwave radiometer. Since the rain sensor on the M-AERI was not functioning properly, all rain flags were derived from the microwave radiometer's rain sensor. This time series allows for the identification of rain-related air and sea temperature decreases, wind bursts associated with downdrafts, and possible M-AERI temperatures that should be removed from the time series due to rain/snow/hail/spray contamination of the mirror surface.

Cloud liquid water and integrated water vapour amount from the microwave radiometer will be computed by Dr. Goshka Szczodrak at the University of Miami, RSMAS using physical and statistical models.

Data Validation

Skin temperatures retrieved from the M-AERI will be compared against several satellite products to aid in the algorithm development for satellite SST. These validation efforts will be done at the University of Miami by Dr. Peter Minnett, and will focus mainly on MODIS, AVHRR, and AMSR-E. Match-up statistics for each satellite are given as a function of platform flight direction (ascending or descending), time of day (daytime or nighttime), surface wind speed, and water vapour content.

Due to the frequency of cloud cover, particularly during the southern half of the cruise track, the number of match-ups with MODIS and AVHRR will be few. AMSR-E will provide the majority of information about the position of fronts and eddies. A combined microwave-IR SST product from Chelle Gentemann at Remote Sensing Systems may also be validated with M-AERI data to determine the relative accuracy of microwave vs. merged SST products in this region.

Post-cruise Data Analysis

From the M-AERI spectra and radiosonde data, profiles of air temperature and mixing ratio can be generated for the length of the M-AERI data record. The radiosonde profile is used as a first guess and inverted into a spectra using a line-by-line radiative transfer model (LBLRTM), using code derived from that developed by Wayne Feltz at the University of Wisconsin-Madison's Space Science and Engineering Centre. The converted spectra is compared against collocated M-AERI spectra, and adjusted to fit the M-AERI. The procedure is reversed, and an atmospheric profile is derived from the adjusted spectrum. Through this intensive procedure, profiles of air temperature and mixing ratio can be derived for each M-AERI time step, ~ 10 minutes. ECMWF analysis profiles have also been used to initialize the model, when radiosonde data were not available. Since atmospheric conditions from the radiosonde data were not transmitted over the GTS to national weather prediction centres like ECMWF, forecast and analysis profiles can be used as independent "measurements" of the atmospheric state.

These time series of atmospheric profiles can be matched with XBT, CTD, and VM-ADCP upper ocean measurements to isolate frontal signatures and the transfer of heat from the ocean to the atmosphere and vice versa. Though, in > 90% of measured cases worldwide, the air-skin temperature difference is negative, indicating that the ocean is warmer than the air above it, and that the direction of heat exchange is from the ocean to the atmosphere, during Bonus-GOODHOPE, several instances of positive air-sea temperature differences were noted. Given the high temporal and spatial resolution of the hydrographic data, it may be possible to delimit the edges of atmospheric and oceanic fronts, their respective “onset” times, and the air-skin-bulk temperature gradients across the air-sea boundary. Upper ocean currents and radiosonde winds will better define the dynamical influences on the measured air-sea temperatures and aid in the determination of remote forcing by eddies and fronts upstream of the ship.

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Table 8 – BONUS-GOODHOPE radiosounds launch table.

BONUS-GOODHOPE Radiosound Launch Table																					
Filename	YYYYMMDD	Year	Day	Launch	Latitude	Longitude	Pressure at $r=0$ (mb)	Air temperature at $r=0$ (°C)	Relative humidity at $r=0$ (%)	True wind direction at $r=0$ (°)	True wind speed at $r=0$ (m/s)	Profile Finish (UTC)	Maximum Profile Height (m)	Minimum Profile Pressure (mb)	Battery Type	Filename	YYYYMMDD	Comment	Station #2	Station Comments	
D	S	Y	M	D	N	E	P	T	H	W	W	UTC	Height	Pressure	Type		Start Day (UTC)				
r5080223a	20080223	54	16	21	38.09 S	12.09 E	1020.4	16.2	76	76	203	10.0	22451	NaN	D	r5080223a	20080223	Test launch			
r5080223b	20080223	54	16	21	38.09 S	12.09 E	1016.0	20.0	76	76	203	10.0	17353	NaN	D	r5080223b	20080223	Loss of wind at 1911m, 65.5mb, 17.42			
r5080223c	20080223	55	18	05	39.58 S	11.06 E	1024.4	14.4	74	74	130	8.0	21352	46.3	D	r5080223c	20080223	Loss of wind at 1911m, 65.5mb, 17.42			
r5080223d	20080224	55	18	05	39.58 S	11.06 E	1024.4	14.4	74	74	130	8.0	21352	46.3	D	r5080223d	20080224	Loss of wind at 1911m, 65.5mb, 17.42			
r5080225a	20080225	56	11	50	40.72 S	10.21 E	1022.4	13.0	67	154	154	5.0	21766	42.6	D	r5080225a	20080225				
r5080225b	20080225	56	17	59	41.18 S	9.92 E	1020.9	13.4	62	164	164	1.5	19119	201.0	D	r5080225b	20080225				
r5080225c	20080225	57	11	55	42.04 S	9.27 E	1015.1	14.0	85	330	330	8.0	13332	22258	D	r5080225c	20080225	Data lost		Beginning of first diurnal cycle	
r5080226a	20080226	57	11	55	42.04 S	9.27 E	1015.1	14.0	85	330	330	8.0	13332	22258	D	r5080226a	20080226				
r5080226b	20080226	57	17	57	42.25 S	9.10 E	1012.6	15.0	90	325	325	9.5	19400	22074	D	r5080226b	20080226				
r5080226c	20080226	57	23	55	42.47 S	8.93 E	1008.5	14.9	92	332	332	12.5	22268	37.5	D	r5080226c	20080226				
r5080227a	20080227	58	06	12	42.47 S	8.93 E	1005.6	14.8	87	326	326	12.8	17349	16125	D	r5080227a	20080227	Intermittent loss of wind			
r5080227b	20080227	58	11	55	42.47 S	8.93 E	1005.6	14.8	87	326	326	12.8	17349	16125	D	r5080227b	20080227	Loss of wind at 11475m, 218.3 mb, 7.24			
r5080227c	20080227	58	17	59	42.47 S	8.93 E	1009.5	10.1	86	210	100	10.5	17320	79.3	D	r5080227c	20080227	Loss of RH at 19133m, 200.7mb, 18.5 ftm off starboard side of ship		On Superstation #2	
r5080228a	20080228	59	11	53	42.78 S	8.67 E	1009.0	12.1	77	304	304	10.5	13116	20795	D	r5080228a	20080228	Loss of wind at last measurement		Twine did not unravel	
r5080228b	20080228	59	19	55	43.35 S	8.24 E	1010.0	11.3	62	262	262	13.0	21996	40.5	D	r5080228b	20080228				
r5080229a	20080229	60	08	01	44.04 S	7.63 E	1013.0	12.2	83	304	304	16.0	19302	61.0	D	r5080229a	20080229				
r5080229b	20080229	60	16	04	44.90 S	6.89 E	1002.2	7.6	53	245	245	16.0	19061	62.4	D	r5080229b	20080229	Loss of wind at 16805m, 88.8mb, 17.16			
r5080301a	20080301	61	16	04	44.90 S	6.89 E	1011.0	5.1	61	241	241	13.0	18809	64.9	D	r5080301a	20080301	First sound at 15sec resolution			
r5080301b	20080301	61	16	04	44.90 S	6.89 E	1011.0	5.1	61	241	241	13.0	18809	64.9	D	r5080301b	20080301	Loss of wind at 19943m, 55.1mb, 13.17			
r5080304a	20080304	64	12	05	42.51 S	4.41 E	1017.9	7.4	78	303	303	15.0	19985	54.8	D	r5080304a	20080304	Single lost this set			
r5080305a	20080305	65	NA	NA	42.52 S	4.37 E	1009.0	8.5	93	300	300	13.0	NA	NA	D	r5080305a	20080305	Intermittent loss of wind			
r5080305b	20080305	65	11	59	42.52 S	4.37 E	1009.0	8.5	93	300	300	13.0	NA	NA	D	r5080305b	20080305	Intermittent loss of wind			
r5080306a	20080306	66	11	59	42.52 S	4.37 E	998.4	4.0	78	253	253	11.5	22346	38.3	W	r5080306a	20080306	Intermittent loss of wind			
r5080306b	20080306	66	11	59	42.52 S	4.37 E	998.4	4.0	78	253	253	11.5	22346	38.3	W	r5080306b	20080306	Intermittent loss of wind			
r5080307a	20080307	67	11	53	43.03 S	2.83 E	1011.4	5.4	71	270	270	10.0	13116	19016	W	r5080307a	20080307	Intermittent loss of wind			
r5080308a	20080308	68	NA	NA	50.00 S	1.61 E	983.9	5.7	78	270	270	16.5	NA	NA	D	r5080308a	20080308	No PFTJ signal, but good wind signal		Crossing Antarctic polar front	
r5080308b	20080308	68	18	13	50.11 S	1.61 E	983.9	5.7	78	270	270	16.0	19338	19619	D	r5080308b	20080308	Try #2 after r5080308a failed		Crossing Antarctic polar front	
r5080309a	20080309	69	NA	NA	50.04 S	0.86 E	991.3	1.7	80	236	236	13.0	NA	NA	W	r5080309a	20080309	No PFTJ signal		Loss of wind at 19065m, 62.1mb, 19.37	
r5080309b	20080309	69	12	14	50.04 S	0.86 E	991.3	1.7	80	236	236	13.0	19338	19381	D	r5080309b	20080309	Try #2 after r5080309a failed		Initially had scan issues with frequency	
r5080310a	20080310	70	11	56	51.82 S	0.00 E	1004.0	1.4	68	237	237	12.0	20077	48.2	W	r5080310a	20080310	Loss of wind at 18446m, 68.1mb, 13.0 ftm off starboard side of ship		Beginning of second diurnal cycle	
r5080310b	20080310	70	17	54	51.86 S	0.00 E	1002.5	1.9	74	285	285	12.5	21656	41.5	W	r5080310b	20080310	Loss of wind at 18446m, 68.1mb, 13.0 ftm off starboard side of ship		Beginning of second diurnal cycle	
r5080310c	20080310	70	17	55	51.86 S	0.00 E	991.0	3.7	92	285	285	13.5	20063	33.4	D	r5080310c	20080310	Reaming and windy		Light rain	
r5080311a	20080311	71	06	07	51.88 S	0.01 E	990.5	3.6	92	261	261	14.5	18106	72.8	D	r5080311a	20080311	Try #2 after r5080310a failed		Loss of wind at 17964m, 75.2mb, 7.18	
r5080311b	20080311	71	06	07	51.88 S	0.01 E	990.5	3.6	92	261	261	14.5	18106	72.8	D	r5080311b	20080311	Try #2 after r5080310a failed		Loss of wind at 17964m, 75.2mb, 7.18	
r5080311c	20080311	71	11	55	51.89 S	0.00 E	997.3	2.6	81	268	268	11.0	18026	74.3	W	r5080311c	20080311	Overcast		Whales spotted	
r5080312a	20080312	72	11	55	52.98 S	0.00 E	996.0	2.7	78	268	268	14.5	13115	20886	48.9	D	r5080312a	20080312	Overcast		
r5080312b	20080312	72	17	57	53.26 S	0.00 E	996.8	2.3	78	260	260	17.0	19155	20011	54.4	D	r5080312b	20080312	Overcast and very gusty		Overcast with some stratocumulus
r5080313a	20080313	73	11	55	54.71 S	0.07 W	1010.4	0.8	74	199	199	13.0	21155	45.2	D	r5080313a	20080313	Iceberg off of port side		Overcast	
r5080313b	20080313	73	11	55	54.71 S	0.07 W	1010.4	0.8	74	199	199	13.0	21155	45.2	D	r5080313b	20080313	Iceberg off of port side		Overcast	
r5080314a	20080314	74	NA	NA	55.67 S	0.03 E	1012.0	1.8	79	303	303	13.5	NA	NA	W	r5080314a	20080314	No PFTJ signal			
r5080314b	20080314	74	12	04	55.67 S	0.03 E	1012.0	1.8	79	303	303	13.5	19715	56.6	W	r5080314b	20080314	Try #2 after r5080314a failed			
r5080315a	20080315	75	17	58	50.48 S	0.00 E	982.3	2.6	94	320	320	10.5	17927	54.8	D	r5080315a	20080315	Intermittent loss of wind		Foggy with wind coming from stern	
r5080315b	20080315	75	17	58	50.48 S	0.00 E	982.3	2.6	94	320	320	10.5	17927	54.8	D	r5080315b	20080315	Intermittent loss of wind		Beginning of third diurnal cycle	
r5080316a	20080316	76	23	54	57.55 S	0.04 W	975.4	0.4	95	270	270	8.5	24526	24.3	D	r5080316a	20080316	Loss of wind at 24646m, 26.2mb, 0.1 ftm increment above			
r5080316b	20080316	76	05	53	57.55 S	0.04 W	976.1	0.1	92	240	240	10.7	19092	56.1	W	r5080316b	20080316	Overcast		Surrounded by icebergs	
r5080316c	20080316	76	11	55	57.55 S	0.04 W	978.5	-0.7	84	230	230	10.0	13105	18063	62.5	W	r5080316c	20080316	Partly cloudy		
r5080316d	20080316	76	17	53	57.55 S	0.04 W	982.6	0.2	78	254	254	12.5	19229	24524	23.0	D	r5080316d	20080316	Overcast		
r5080317a	20080317	77	11	56	57.55 S	0.04 W	959.4	0.3	96	315	315	3.0	13323	24153	27.8	D	r5080317a	20080317	Snowing, accumulating flurries		
r5080317b	20080317	77	11	56	57.55 S	0.04 W	959.4	0.3	96	315	315	3.0	13323	24153	27.8	D	r5080317b	20080317	Snowing, accumulating flurries		
r5080318a	20080318	78	NA	NA	54.13 S	4.01 E	986.2	1.5	71	258	258	16.0	NA	NA	NA	D	r5080318a	20080318	Single lost this set		Stunny
r5080318b	20080318	78	18	10	53.03 S	5.72 E	992.5	1.3	72	255	255	16.0	21763	40.4	D	r5080318b	20080318	Two balloons exploded before launch was successful			
r5080319a	20080319	79	07	11	50.63 S	3.24 E	1000.1	1.8	60	226	226	14.5	16844	15575	106.9	D	r5080319a	20080319	Stunny, with occasional showers		
r5080319b	20080319	79	07	11	50.63 S	3.24 E	1000.1	1.8	60	226	226	14.5	16844	15575	106.9	D	r5080319b	20080319	Stunny, with occasional showers		
r5080321a	20080321	81	06	56	42.71 S	21.00 E	1019.3	14.4	59	279	279	11.0	18831	22542	36.7	D	r5080321a	20080321	Loss of wind at 19133m, 200.7mb, 18.5 ftm off starboard side of ship		
r5080321b	20080321	81	09	07	42.37 S	21.04 E	1019.0	16.0	61	275	275	11.0	10238	21815	41.0	D	r5080321b	20080321	Loss of wind, just before end of flight		
r5080321c	20080321	81	11	14	41.98 S	22.05 E	1016.5	16.1	65	288	288	11.0	12330	18615	68.0	D	r5080321c	20080321	Loss of wind at last measurement		
r5080321d	20080321	81	13	47	41.50 S	22.36 E	1015.2	15.0	85	307	307	13.5	14108	6045	474.0	D	r5080321d	20080321	Loss of wind at last measurement		

4.2 BIOGEOCHEMICAL PROCESSES INVOLVED IN THE CARBON CYCLE



It has been often stated that the Southern Ocean plays a key role in the global carbon cycle. Understanding the exchanges of carbon between the atmosphere and ocean and the fate of carbon delivered to the deep sea is fundamental to the evaluation of ocean carbon sequestration options. The Southern Ocean supports unique food webs with strong feedbacks and linkages to biogeochemical cycles that affect carbon cycling and atmospheric CO₂ exchanges. The region is vast, remote and logistically difficult to access and thus is one of the least sampled regions on Earth. Our effort here is devoted to improve assessment on air-sea carbon exchanges and related mechanisms.

4.2.1 AIR-SEA CO₂ FLUXES AND INORGANIC CARBON VERTICAL DISTRIBUTION

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The Southern Ocean (SO) acts as a sink for atmospheric CO₂. Primary production at mid-latitude is one of the main contributors to this uptake of CO₂. However, how air-sea CO₂ fluxes relate ultimately to carbon export is still poorly constrained partly due to the complexity of physical and biogeochemical processes that drive CO₂ fluxes.

Sinking of mid-latitude mode and intermediate waters of SO is a major pathway for anthropogenic CO₂ penetration in the ocean interior. Further south, although deep water formation was initially thought as an efficient mechanism for anthropogenic CO₂ sequestration most data based on model estimates low anthropogenic CO₂ storage. However, recent studies which take into account oxygen disequilibrium under ice suggest that deep and bottom water formation in the SO is still a key process in the natural sequestration of anthropogenic CO₂ and that inventory of anthropogenic CO₂ in the SO could be much larger than what is currently believed and must be revised.

In the frame of the BONUS-GOODHOPE project we aim to address the following questions:

- How air-sea CO₂ fluxes relate to carbon export assessed from geochemical multi-proxy approach in the biologically active mid-latitude zone of the S.O.?
- What is the inventory of anthropogenic CO₂ along zero meridian if we carefully take into account sea ice cover effect on surface oxygen concentration further south? What is the contribution of mode and intermediate waters subduction to the overall anthropogenic CO₂ penetration.
- In order to address these questions, we carried out underway pCO₂ and DIC discrete measurements in order to assess the spatial distribution of the partial pressure of CO₂ (pCO₂) at the surface and the vertical distribution of dissolved inorganic carbon respectively.

4.2.2 UNDERWAY PCO₂

Underway measurement of pCO₂ concentration of surface waters was carried out throughout the cruise, from 13-02 to 23-03-08.

The complete description and performance test of the system for pCO₂ measurements was reported by Frankignoulle et al. (2001). Briefly, pCO₂ was measured continuously from the uncontaminated seawater supply of the ship. A non-dispersive infrared gas analyser (IRGA, Li-Cor® LI-6262) was used to measure pCO₂ in air equilibrated with seawater. The IRGA was calibrated daily using three gas standards of 0, 359.9 and 404.7 ppm provided by Air Liquide Belgium®. Seawater flowed into an equilibrator (3 L min⁻¹) from the top, and a closed air loop (3 L min⁻¹) ensures circulation through the equilibrator (from the bottom to the top) and the IRGA. Temperature at the outlet of the equilibrator was monitored using a pt100 temperature sensor. The pCO₂ values were corrected for the temperature difference between in situ seawater and water in the equilibrator, using the algorithm proposed by Copin-Montégut (1988; 1989).

In addition, an intercomparison with the group led by N. Metzl from the Laboratoire d'Océanographie et du Climat: Expérimentations et Approches Numériques, Institut Pierre Simon Laplace was carried out in 1998 aboard the R.V. Marion Dufresne. This will ensure a consistent potential merging of pCO₂ data from BGH cruise and OISO (Ocean Indien – Service d'Observation) survey carried out in January 2008 in adjacent waters.

Discrete dissolved inorganic carbon

All 78 "hydro" cast were sampled (all depths) for analysis of Dissolved Inorganic Carbon (DIC) analysis. More than 90% of the samples were analyzed aboard. The rest of the samples will be subsequently analyzed in Belgium.

DIC measurements were carried out with the new AIR-DIC (Analysis InfraRed – Dissolved Inorganic Carbon) system developed by MARIANDA.

The AIR-DIC, automatically acidifies and strips the CO₂ out of a known volume of sea water ranging from 500 µL up to 2000 µL integrating the infra red IR absorbance from CO₂. The AIR-DIC system consists of 4 main components: a syringe module, a sample stripping manifold, a LICOR LI-6252 non-dispersive CO₂ infra-red analyzer and a personal computer. A Kloehe syringe module equipped with a 5 port distribution valve and a thermostated 2.5 ml syringe are used to select and subsample from either water sample or a certified reference material CRM. The sample is delivered to a glass stripper. The sample is acidified in the stripper with 1.0 ml of 8.5% H₃PO₄ and the CO₂ is stripped from the sample with N₂. The gas from the stripper is dried using a series of two Pempure Nafion tubes before measurement of CO₂ concentration by the analyzer.

The mole fraction of the CO₂ is integrated to determine the total CO₂ stripped from the sample. The DIC from a seawater sample of 1500 µL was stripped during 145 s with a flow rate of N₂ of 200 ml min L⁻¹. The average of 4 replicates was considered to compute DIC concentration. The system was calibrated by carrying out measurement of 1450, 1500 and 1600 µL of Certified Reference Materials (CRM) delivered by Andrew Dickson. Water samples and CRM was kept to a constant temperature prior and during analysis.

This system is a prototype. This cruise was the first opportunity to assess the performance of the system. We carried out an intercomparison with measurements carried out by Melchor Gonzalez Davila and Magdalena Santana-

Casiano from the University of Las Palmas in Gran Canarias using the VINDTA colombimetric system, the currently most accurate and precise method for determining DIC in seawater (DOE, 1994).

Preliminary results

During the cruise, pCO₂ ranged from 325 to 415 ppmV, and exhibited significant changes across fronts and eddies than can be tracked as step changes in SST. Subtropical area appeared to be undersaturated in CO₂ compared to the atmosphere, while the subantarctic and polar frontal zones were below or near the saturation, and the polar open oceanic zone was oversaturated. The maximum of pCO₂ was observed at the southern circumpolar Antarctic front (SACCF).

Comparison with pCO₂ measurement carried out during the ISPOL cruise in spring 2004 and early summer 2004-2005 (data not shown) suggest that pCO₂ was significantly higher during the Bonus-Goodhope cruise south of the subtropical front (STF). This might suggest at first sight that we encountered a late summer regime, with conjugated warming of surface water and remineralisation of organic matters that increase pCO₂ in the subantarctic zone. South of the polar front (PF), upwelling of CO₂ rich subsurface waters (Figure 38) may contribute to the increase of CO₂ and lead to the oversaturation in CO₂ compared to the atmosphere.

Significant increase of DIC over the thousand first meters of the water column is related to mesopelagic biomineralisation. Below 1000 m, main water masses of the subtropical area and circumpolar current (e.g. North Atlantic Deep Water, Circumpolar Deep Water, intermediate Antarctic waters, among others) appears in the vertical distribution. For instance, in the subtropical area, a tongue of Antarctic Intermediate Water with DIC ranging between 2210 and 2235 $\mu\text{mol kg}^{-1}$ water is transported northward between 1000 and 1500 m. We observed an overall DIC increases southwards. Between the STF and southern boundary (SBdy), DIC increases towards the bottom, while south of the SBdy with an increase of DIC distribution exhibited an increase towards the bottom that mimics the increase of oxygen concentration (data not shown). Maximum of DIC was observed south of the SBdy in the top 1000 m.

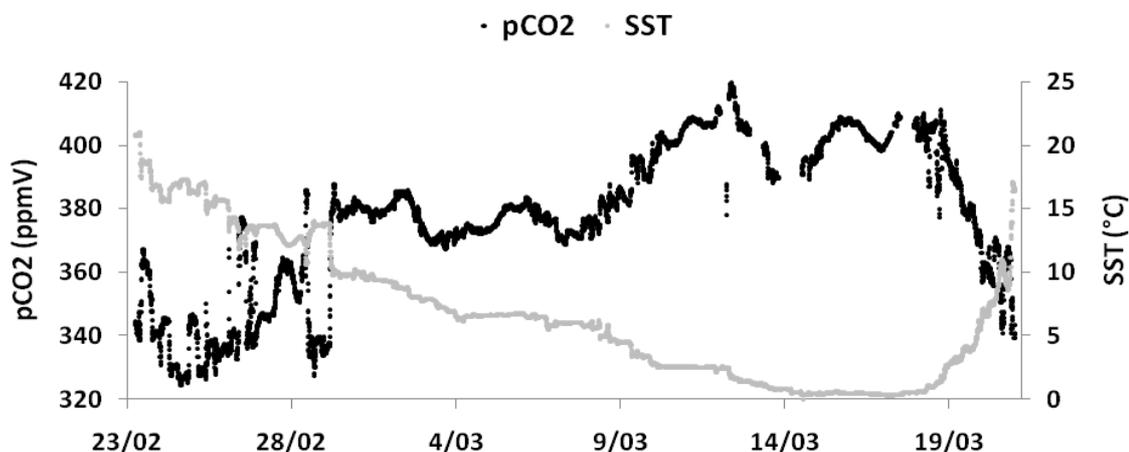


Figure 38 – Sea surface temperature (SST) and pCO₂ change along the cruise.

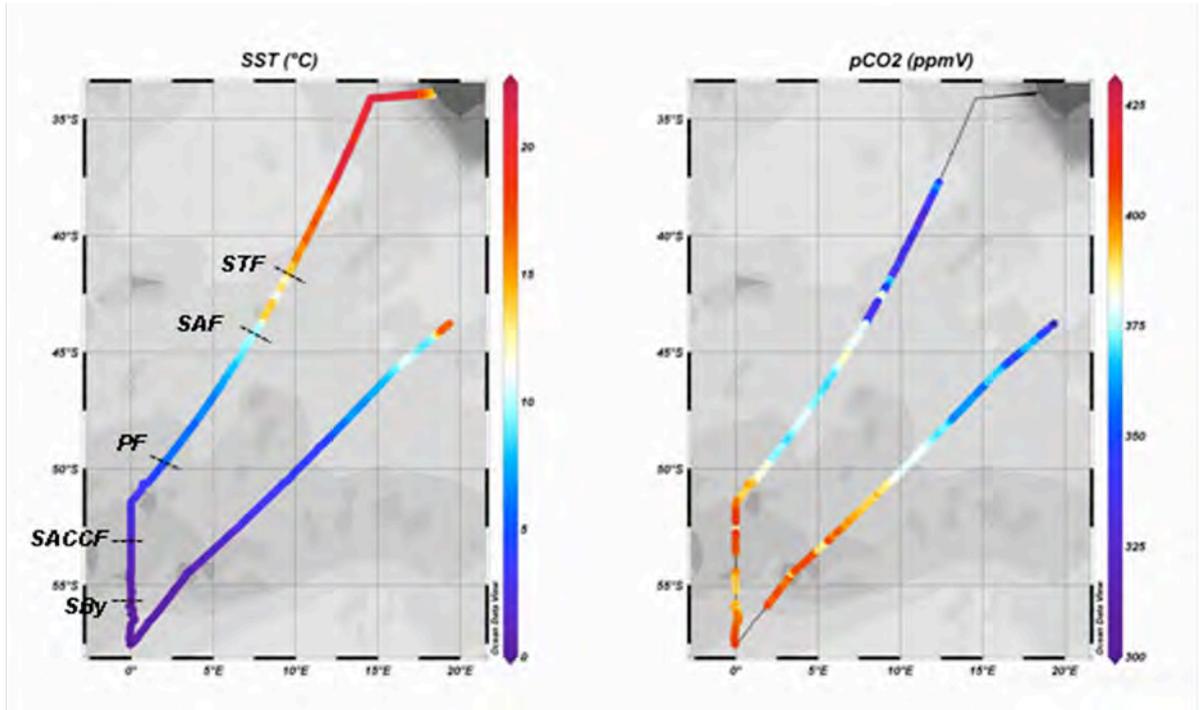


Figure 39 – Distribution of sea surface temperature (SST) and pCO₂ along the shiptrack. Approximate position of the subtropical (STF), subantarctic (SAF), polar (PF), southern antarctic circumpolar (SACCF) fronts and southern boundary (SBdy) are indicated by the black dotted lines.

Significant increase of DIC over the thousand first meters of the water column is related to mesopelagic biomineralisation. Below 1000 m, main water masses of the subtropical area and circumpolar current (e.g. NADW, AAIW, among others) appear in the vertical distribution. For instance, in the subtropical area, a tongue of antarctic intermediate water with DIC ranging between 2210 and 2235 $\mu\text{mol kg}^{-1}$ water is transported northward between 1000 and 1500 m. We observed an overall DIC increases southwards. Between the STF and southern boundary (SBdy), DIC increases towards the bottom, while south of the SBdy with an increase of DIC distribution exhibited an increase towards the bottom that mimics the increase of oxygen concentration (data not shown). Maximum of DIC was observed south of the SBdy in the top 1000 m.

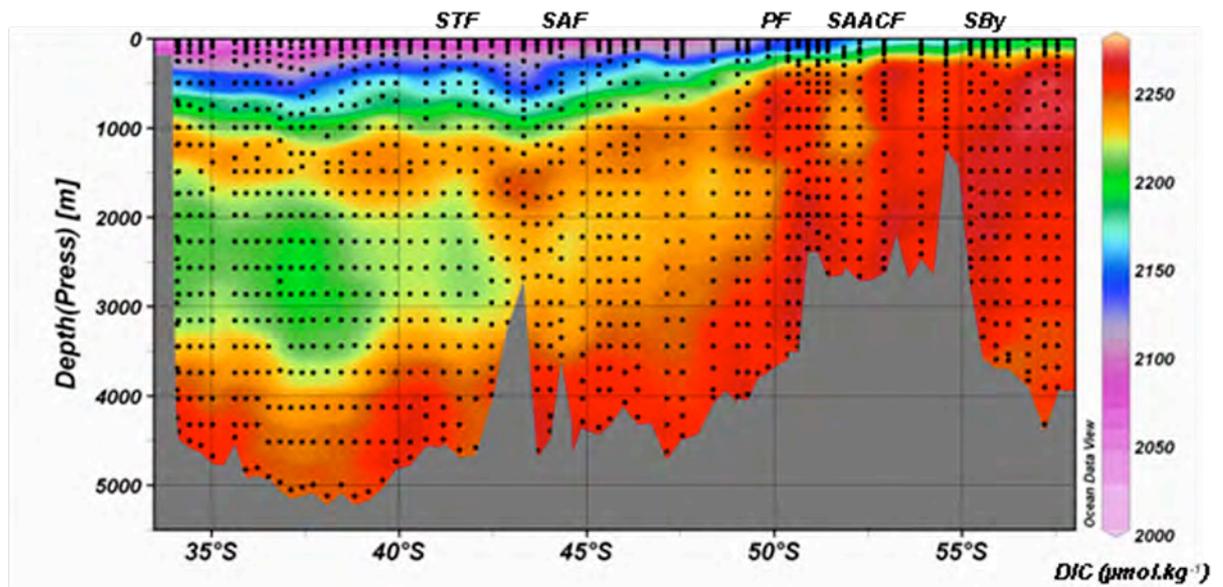


Figure 40 – Vertical distribution of dissolved inorganic carbon (DIC) along the Goodhope transect. Approximate position of the subtropical (STF), subantarctic (SAF), polar (PF), southern antarctic circumpolar (SAACF) fronts and southern boundary (SBdy) are indicated.

4.2.3 CARBONATE SYSTEM VARIABLES : PH, TOTAL ALKALINITY, DIC

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Scientific Objectives.

- Determine the carbonate system variables in the water column along the GOODHOPE section and compare them with data in previous cruises, with special emphasis on the saturation grade for calcite and aragonite.
- Determine the water mass distribution using an optimized multiparameter analysis model (OMP).
- Evaluate the anthropogenic carbon budget along the GOODHOPE section : importance of the different water masses, AABW, SAMW and AAIW. Application and comparison of different methodologies to this computation. Relationship with the evolution of other tracers as CFCs.
- Establish the inventory of C_{ANT} transported and stored during 2008. Comparison with data from 2004.

Scientific and sampling strategies.

Three variables of the carbonate system were measure on board of the Marion Dufresne in order to achieve the highest level of data quality and resolution and to account for the objectives above proposed. Initial invitation to participate in this cruise considered only the determination of two of these variables. However, the QUIMA group of ULPGC owns a coulometric determination system for total dissolved inorganic carbon that was considered by us to be an important contribution to the success of this project. 79 hydrocast Stations (78 stations plus station zero) were sampled for pH in total scale at 25°C ($pH_{T,25}$), total alkalinity (TA, in $\mu\text{mol kg}^{-1}$) and total dissolved inorganic carbon (CT, in $\mu\text{mol kg}^{-1}$). From a total of about 1639 fired bottles in hydrocast CTD stations at not repeated depths and after the corresponding analysis of the total amount of samples on board, considering in some cases a selection of depths of sampling and time for the analysis by two people, broken samples, flagged data, and other small problems, a total of valid results for pH data of 1609, for TA of 1559 and for CT of 1504 have been obtained.

Protocols: Parameter definition and methodology

pH

The pH is measured in total scale ($[H^+]_T = [H^+]_F + [HSO_4^-]$, where $[H^+]_F$ is the free proton concentration), pH_T at a constant temperature of 25°C. An automatized system based on the spectrophotometric technique of *Clayton and Byrne* [1993] with the m-cresol purple as indicator was used [*González-Dávila et al.*, 2003].

Total Alkalinity

Samples for A_T were potentiometrically titrated with standardized 0.25 M HCl (0.45M in NaCl) to the carbonic acid end point using a systems described in detail by *Mintrop et al.* [2000]. The titration of certify reference Material for Oceanic CO₂, CRMs (#85) was used to test the performance of the titration system given values that were within $\pm 1.0 \mu\text{mol kg}^{-1}$ of the certified value.

Total Dissolved Inorganic Carbon

A VINDTA 3C system [*Mintrop et al.*, 2000] (www.MARIANDA.com), with coulometer determination was used for the titration of the total dissolved inorganic carbon after phosphoric acid addition. The titration of CRMs (#85) was used to test the performance of the equipment after the preparation of each titration cell. Over 30 bottles were analysed on board with a system precision of $\pm 1.5 \mu\text{mol kg}^{-1}$.

Sampling procedure

500 ml glass bottles were used for the determination of both pH and TA. 100 ml glass bottles were used to analyse CT. The bottles were rinsed twice with seawater and over-filled with seawater. Samples were preserved from the light and analysed between stations. In shallow stations and in case the samples were not possible to be analysed for CT in less than 5 hours after sampling, poisoned with HgCl₂ (60 μl , saturated solution) was used.

Preliminary results.

Most of the effort we have carried out during transit days from the last station to Durban has been to process a first quality control to our data checking the CRMs reproducibility and accuracy.

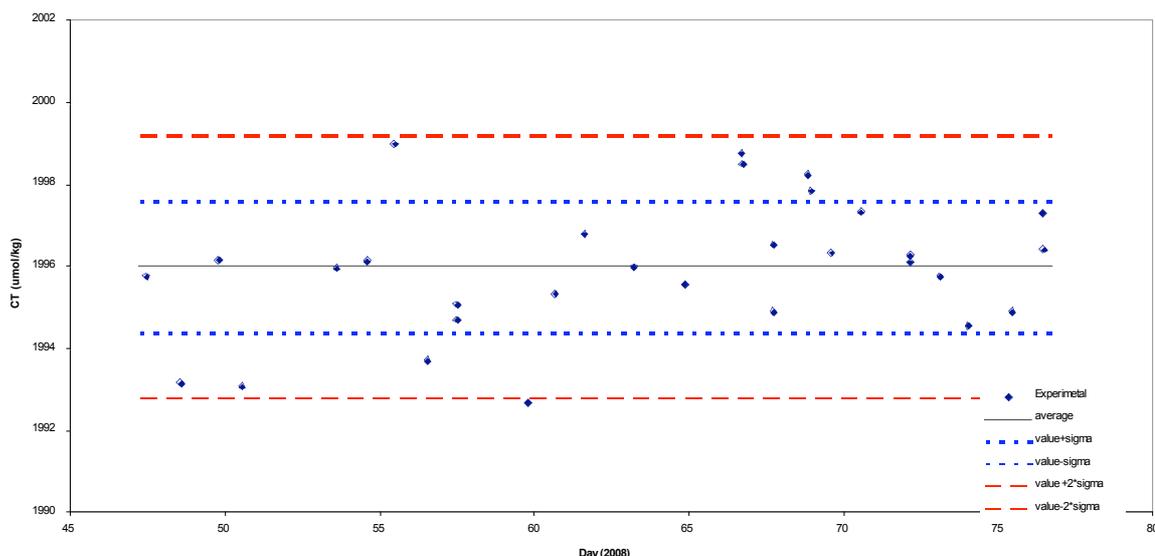


Figure 41 – Chart sheet with values of CT for the CRMs #85 determined in the cruise.

A CRM was analysed every time a new titration cell for CT determination was prepared (1 a day, except in SUPER stations) with a total of 31 data. Results give a value of $1996.0 \pm 1.6 \mu\text{mol kg}^{-1}$ for CT, while the certify value is $2000.4 \pm 0.4 \mu\text{mol kg}^{-1}$. A study done on board indicates that this difference is related to the temperature of determination of the CT that in our case was 25°C . Data has been corrected for this shift multiplying them by the factor 1.0022.

Each CRM sample was also analysed for total alkalinity determination, and the corresponding chart sheet is presented in Figure 42. The agreement between on board experimental data ($\text{NAT} = 2293.7 \pm 1.0$) and certify value ($\text{NAT} = 2293.7 \pm 0.8$) indicates accurate HCl concentration and pipette volume for the titration system.

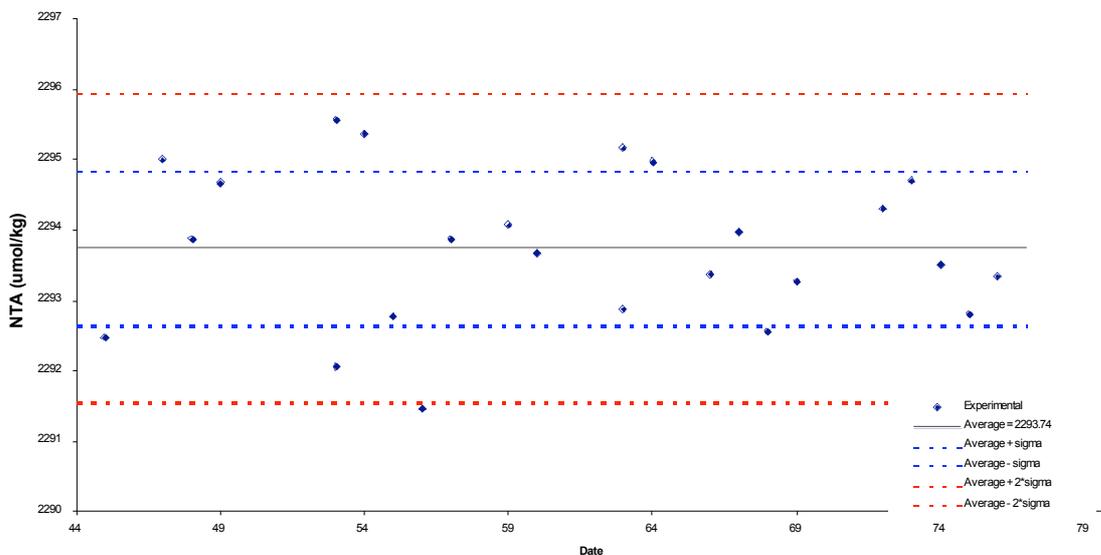


Figure 42 – Chart sheet with values of TA ($\mu\text{mol kg}^{-1}$) for CRM batch #85 analysed on board.

The inorganic carbon system determination requires salinity values for the samples analysed in order to compute the corresponding concentration both for Total alkalinity and CT. Moreover, the spectrophotometric determination of pH needs also the salinity value for the determination of the acidity constant of the dye, which is salinity dependent. The area studied along this cruise cross important frontal zones, eddies and meanders which will affect the carbonate distribution strongly correlated with water mass properties, in particular with salinity values. At this moment, we have been able to use salinity values for each bottle fired on the CTD cast, that are not validated. We expect that after real values are provided, in four weeks we can be able to provide data for each analysed parameter and an analysis of results. Same preliminary results for pH_T at 25°C are presented in Figure 43, where the stations have been selected just before and after the frontal zone STF, SAF, PF, SACCF and SBdy. Changes in the vertical profiles are related to changes in seawater properties of the different water masses and frontal zones. Station 36, shows the effect of the anticyclone “M” which affects the surface pH distribution in the first 600 meters acting as important carbon pump. Moreover, Figure 44, presents the preliminary results for the total Alkalinity along the 79 stations, closely linked to salinity variability, where the presence of the different water masses, the frontal zone and mesoscale structures are observed.

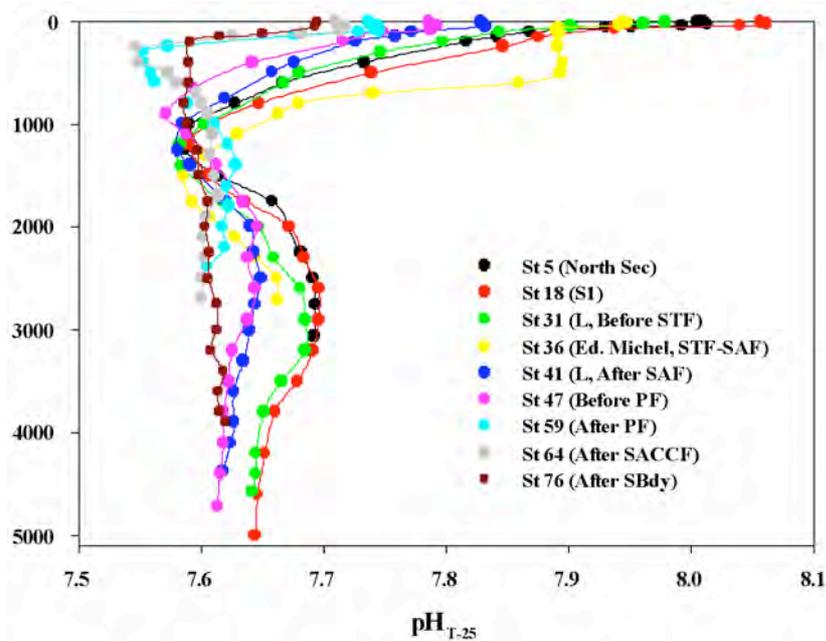


Figure 43 – Vertical profiles of pH in total scale at 25°C for selected stations representative for each area along the GOODHOPE section.

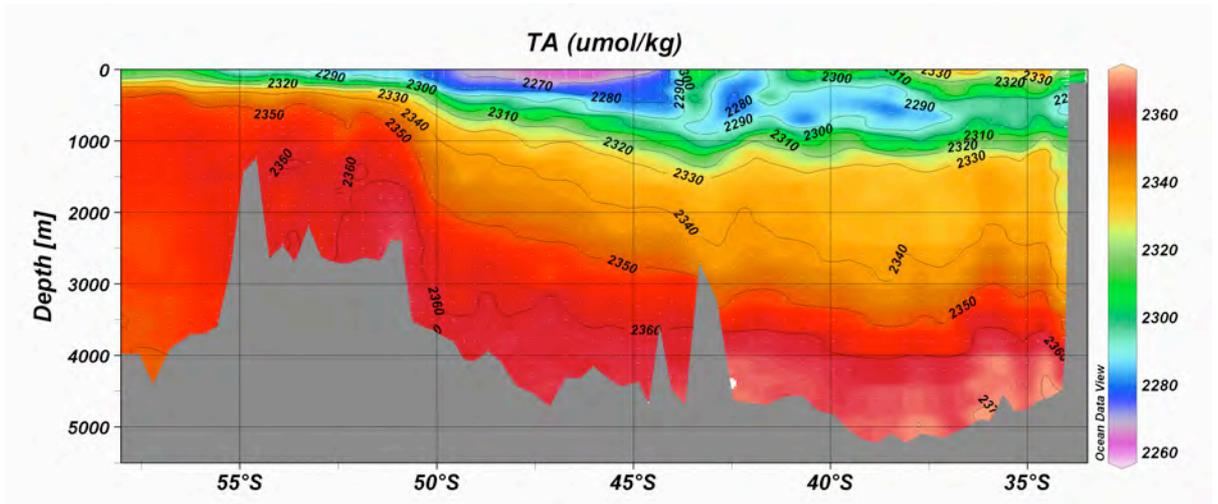


Figure 44 – Total alkalinity (in $\mu\text{mol kg}^{-1}$) distribution along the GoodHope section

4.2.4 INTERCOMPARISON OF CARBON DIOXIDE VARIABLES WITH THE GERMAN *R.V. POLARSTERN*

Written by Marie BOYE (marie.boyé@univ-brest.fr)

Onboard Marion Dufresne: Bruno Delille, Nicolas-Xavier Geilfus, Melchor González-Dávila, Magdalena Santana-Casiano

Onboard Polarstern: Steven van Heuven, Hans Slagter, Hein de Baar

For the sections from Capetown to the zero meridian, and from there along zero meridian to Antarctica, the GEOTRACES-CASO program of BONUS-GOODHOPE (MD166) aboard Marion Dufresne is complementary to the Polarstern ANT XXIV-3. Towards an overall integrated database of both expeditions, some intercomparison of carbondioxide variables between both programs was envisioned. The initial cruise tracks of Marion Dufresne and Polarstern were scheduled to be overlapping, and this, in principle, allows the positioning of stations and sampling depths at the same place. This is the strategy of choice for intercomparison of CO₂ system measurements, which are already calibrated routinely on both ships, by the shipboard use of certified reference material (CRM, supplied by Dr. A. Dickson, Scripps Institute of Oceanography).

Once at sea, Polarstern by its earlier departure was further south than Marion Dufresne. At 26 February the positions and sampling depth horizons (pressure, salinity, temperature at 22-24 depths per station) of thus far completed 21 stations with CO₂ system data aboard Polarstern (then until 59oS, 0oW) were communicated to Marion Dufresne. This allows re-occupation of selected same stations by BONUS-GOODHOPE, its overall research program and the weather permitting. 10 duplicated stations nearly matched the same occupation of both ships within 5 nautical miles maximal difference were sampled on both cruises of 22 depths each (Table 9). These common stations were located between 46°02.41'S, 5°86.48' E and 57°55.25' S, 0°03.65' E (Table 9 and Table 10).

– BONUS-GOODHOPE Cruise Report –

Table 9 – Carbondioxide variables intercomparison between Marion-Dufresne (BONUS-GOODHOPE) and Polarstern (ANT XXIV-3).

Dissolved Inorganic Carbon (DIC)		INFRARED DETECTOR SYSTEM (CT Infr), RESPONSIBLE: BRUNO DELILLE, ULg, BELGIUM, Bruno.Delille@ulg.ac.be			
Dissolved Inorganic Carbon (DIC)		COULOMBIMETRIC SYSTEM (CT Coul), RESPONSIBLE: MELCHOR GONZALEZ DAVILA, ULPGC, SPAIN, mgonzalez@dqui.ulpgc.es			
Total Alkalinity (TA)		POTENTIOMETRIC SYSTEM, RESPONSIBLE: J. MAGDALENA SANTANA-CASIANO, ULPGC, SPAIN, jmsantana@dqui.ulpgc.es			

POLARSTERN				MARION DUFRESNE				
Cruise	Station	Lat [°N]	Lon [°E]	Lat, °N	Lon, °E	Difference in nm	CTD cast	Station
PS71	101	-42,3379	8,9946					
PS71	102	-44,6604	7,0954					
PS71	103	-45,9999	5,8811					
PS71	104	-47,6635	4,2887					
PS71	106	-48,9116	2,8003	-46,024167	5,86483333	1,606051634	CTD 57	St 44
PS71	107	-50,2742	1,4531	-47,554167	4,37516667	7,434207156	CTD 63	St 48
PS71	108	-51,4983	0,0028	-48,701167	3,17818333	19,55498367	CTD 69	St 51
PS71	110	-51,9454	0,0126	-50,372667	1,30216667	8,266440325	CTD 77	St 57
PS71	112	-52,5049	-1,3844	-51,431	0,009	4,04464515	CTD 82	St 61
PS71	113	-52,9968	0,0288	-51,867	0,006	4,710340178	CTD 84	St 62
PS71	115	-53,5184	0,0043	-52,601333	0,0015	50,88978205	CTD 89	St 64
PS71	116	-54,0002	-0,0001	-52,930367	-0,0003167	4,122552811	CTD 90	St 65
PS71	118	-54,5041	0,0354	-53,591917	-0,0002667	4,414002136	CTD 93	St 67
PS71	119	-55,0009	0,0011	-53,918833	0,00166667	4,882398334	CTD 94	St 68
PS71	121	-55,4969	0,0002	-54,580467	-0,0007	4,751159707	CTD 96	St 70
PS71	122	-56,0048	0,0088	-54,912667	-0,0048333	5,297944953	CTD 97	St 71
PS71	124	-56,5057	0,0149	-55,570317	0,00456667	4,407494698	CTD 101	St 73
PS71	127	-57,4995	0,0132	-55,904267	-0,1138333	7,30440427	CTD 102	St 74
PS71	128	-58,0037	-0,0012	-56,762267	-0,0142167	15,42395604	CTD 104	St 76
PS71	130	-58,4992	0,0035	-57,5525	-0,0365	3,560319702	CTD 106	St 78
PS71	131	-59,0002	0,0064					

In black, Stations located inside 5 nm to be considered in this study

Table 10 – Additional informations on CO2 variables onboard Marion-Dufresne used for the intercomparison, including depths where data are available

	CTD Cast	Niskin	Depth(db)	T (°C)	Salinity	CT Infr	CT Coul	TA
BGH-2008	57	1	4147,9	0,817	34,69	x	x	x
BGH-2008	57	2	3802,4	0,954	34,703	x	x	x
BGH-2008	57	3	3501,9	1,155	34,716	x	x	x
BGH-2008	57	4	3252,4	1,298	34,725	x	x	x
BGH-2008	57	5	3000,9	1,468	34,737	x	x	x
BGH-2008	57	6	2749,8	1,662	34,748	x	x	x
BGH-2008	57	7	2497,4	1,902	34,763	x	x	x
BGH-2008	57	8	2248,8	2,116	34,766	x	x	x
BGH-2008	57	9	1999,4	2,374	34,771	x	x	x
BGH-2008	57	10	1749,4	2,548	34,743	x	x	x
BGH-2008	57	11	1501,9	2,571	34,685	x	x	x
BGH-2008	57	12	1298,8	2,588	34,623	x	x	x
BGH-2008	57	13	1200,3	2,592	34,58	x	x	x
BGH-2008	57	14	1001,2	2,618	34,479	x	x	x
BGH-2008	57	15	749,3	2,781	34,325	x	x	x
BGH-2008	57	16	500,7	3,136	34,173	x	x	x
BGH-2008	57	17	299,6	3,986	34,123	x	x	x
BGH-2008	57	18	151,1	4,987	34,055	x	x	x
BGH-2008	57	19	90,4	5,811	33,949	x	x	x
BGH-2008	57	20	61	7,864	33,734	x	x	x
BGH-2008	57	21	32,2	7,863	33,735	x	x	x
BGH-2008	57	24	4,7	7,861	33,734	x	x	x
BGH-2008	82	1	2666,5	0,487	34,673	x	x	x
BGH-2008	82	2	2499,9	0,543	34,676	x	x	x
BGH-2008	82	3	2250,4	0,672	34,683	x	x	x
BGH-2008	82	4	1999,9	0,853	34,693	x	x	x
BGH-2008	82	5	1798,4	1,028	34,703	x	x	x
BGH-2008	82	6	1597	1,177	34,703	x	x	x
BGH-2008	82	7	1399	1,39	34,711	x	x	x
BGH-2008	82	8	1200	1,645	34,725	x	x	x
BGH-2008	82	9	1000,2	1,818	34,719	x	x	x
BGH-2008	82	10	796,5	1,985	34,697	x	x	x
BGH-2008	82	11	795,4	1,982	34,696			
BGH-2008	82	12	794,5	1,982	34,696			
BGH-2008	82	13	597,3	2,023	34,641	x	x	x
BGH-2008	82	14	499,5	2,043	34,59	x	x	x
BGH-2008	82	15	399	2,039	34,534			
BGH-2008	82	16	247,8	1,742	34,354	x	x	x
BGH-2008	82	17	139,9	1,257	33,852	x	x	x
BGH-2008	82	18	121,2	1,851	33,773	x	x	x
BGH-2008	82	19	100,3	2,408	33,716	x	x	x
BGH-2008	82	20	69,3	2,744	33,713	x	x	x
BGH-2008	82	21	27,9	2,776	33,713	x	x	x
BGH-2008	82	24	4,6	2,78	33,713	x	x	

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	CTD Cast	Niskin	Depth(db)	T (°C)	Salinity	CT Infr	CT Coul	TA
BGH-2008	84	1	2551	0,465	34,673	x	x	x
BGH-2008	84	2	2503	0,471	34,673	x	x	x
BGH-2008	84	3	2500,2	0,47	34,673			
BGH-2008	84	4	2300,8	0,538	34,677	x	x	x
BGH-2008	84	5	2300,5	0,538	34,677			
BGH-2008	84	6	2101,2	0,657	34,682	x	x	x
BGH-2008	84	7	2102	0,657	34,682			
BGH-2008	84	8	2000,5	0,693	34,684	x	x	x
BGH-2008	84	9	1800,8	0,804	34,688	x	x	x
BGH-2008	84	10	1601,1	0,983	34,697	x	x	x
BGH-2008	84	11	1395,6	1,161	34,704	x	x	x
BGH-2008	84	12	1201,3	1,37	34,711	x	x	x
BGH-2008	84	13	1001,1	1,559	34,712	x	x	x
BGH-2008	84	14	798,1	1,734	34,699	x	x	x
BGH-2008	84	15	597,7	1,85	34,659	x	x	x
BGH-2008	84	16	401,1	1,87	34,558	x	x	x
BGH-2008	84	17	299,7	1,746	34,489	x	x	x
BGH-2008	84	18	200,4	1,188	34,26	x	x	x
BGH-2008	84	19	150,9	0,805	34,005	x	x	x
BGH-2008	84	20	99,6	2,043	33,739	x	x	x
BGH-2008	84	21	49	2,533	33,698	x	x	x
BGH-2008	84	24	4,9	2,528	33,698	x	x	x
BGH-2008	90	1	2612,1	0,415	34,669	x	x	x
BGH-2008	90	2	2499,8	0,423	34,67	x	x	x
BGH-2008	90	3	2301,4	0,454	34,672	x	x	x
BGH-2008	90	4	2098,4	0,482	34,674	x	x	x
BGH-2008	90	5	1899,4	0,528	34,675	x	x	x
BGH-2008	90	6	1747,4	0,634	34,68	x	x	x
BGH-2008	90	7	1500,3	0,872	34,694	x	x	x
BGH-2008	90	8	1298,7	1,057	34,701	x	x	x
BGH-2008	90	9	1099,9	1,236	34,707			
BGH-2008	90	10	899,3	1,423	34,705	x	x	x
BGH-2008	90	11	798,7	1,596	34,709	x	x	x
BGH-2008	90	12	699,7	1,714	34,704	x	x	x
BGH-2008	90	13	597,9	1,691	34,683	x	x	x
BGH-2008	90	14	499,5	1,765	34,66	x	x	x
BGH-2008	90	15	398,6	1,824	34,629	x	x	x
BGH-2008	90	16	249,3	1,713	34,52	x	x	x
BGH-2008	90	17	179,2	1,174	34,332	x	x	x
BGH-2008	90	18	136,9	0,592	33,997	x	x	x
BGH-2008	90	19	108,2	1,249	33,798	x	x	x
BGH-2008	90	20	67,7	1,653	33,749	x	x	x
BGH-2008	90	21	30,2	1,73	33,744	x	x	x
BGH-2008	90	24	3,9	1,749	33,742	x	x	x
BGH-2008	93	1	2664,9	0,365	34,667	to be processed	x	x
BGH-2008	93	2	2500,6	0,372	34,668	to be processed	x	x
BGH-2008	93	3	2301,8	0,393	34,669	to be processed	x	x
BGH-2008	93	4	2101,5	0,433	34,671	to be processed	x	x
BGH-2008	93	5	1899,7	0,482	34,673	to be processed	x	x
BGH-2008	93	6	1751,7	0,554	34,676	to be processed	x	x
BGH-2008	93	7	1500,3	0,707	34,681	to be processed	x	x
BGH-2008	93	8	1299,7	0,857	34,687	to be processed	x	x
BGH-2008	93	9	1100,9	1,049	34,692	to be processed	x	x
BGH-2008	93	10	902,9	1,27	34,697	to be processed	x	x
BGH-2008	93	11	800,8	1,349	34,698	to be processed	x	x
BGH-2008	93	12	701,5	1,43	34,694	to be processed	x	x
BGH-2008	93	13	601,3	1,522	34,687	to be processed	x	x
BGH-2008	93	14	499,1	1,601	34,672	to be processed	x	x
BGH-2008	93	15	400,6	1,651	34,645	to be processed	x	x
BGH-2008	93	16	251,6	1,508	34,549	to be processed	x	x
BGH-2008	93	17	169,3	0,934	34,361	to be processed	x	x
BGH-2008	93	18	141,7	0,405	34,157	to be processed	x	x
BGH-2008	93	19	121,6	0,517	33,945	to be processed	x	x
BGH-2008	93	20	79,6	1,395	33,797	to be processed	x	x
BGH-2008	93	21	39,4	1,393	33,798	to be processed	x	x
BGH-2008	93	24	4,3	1,39	33,798	to be processed	x	x
BGH-2008	94	1	2443,6	0,38	34,668	x	x	x
BGH-2008	94	2	2447,1	0,381	34,668	x	x	x
BGH-2008	94	3	2299,2	0,38	34,668	x	x	x
BGH-2008	94	4	2100,6	0,411	34,67	x	x	x
BGH-2008	94	5	1899,1	0,475	34,672	x	x	x
BGH-2008	94	6	1750,1	0,516	34,673	x	x	x
BGH-2008	94	7	1499,1	0,675	34,678	x	x	x
BGH-2008	94	8	1298,4	0,833	34,683	x	x	x
BGH-2008	94	9	1098,6	1,009	34,69	x	x	x
BGH-2008	94	10	900,5	1,253	34,696	x	x	x
BGH-2008	94	11	799,7	1,367	34,697	x	x	x
BGH-2008	94	12	699,6	1,489	34,693	x	x	x
BGH-2008	94	13	599,9	1,563	34,685	x	x	x
BGH-2008	94	14	500,3	1,636	34,67	x	x	x
BGH-2008	94	15	350	1,671	34,614	x	x	x
BGH-2008	94	16	251,8	1,622	34,561	x	x	x
BGH-2008	94	17	167,3	0,728	34,243	x	x	x
BGH-2008	94	18	149,9	0,535	34,273	x	x	x
BGH-2008	94	19	125,5	0,426	34,109	x	x	x
BGH-2008	94	20	88,7	1,194	33,821	x	x	x
BGH-2008	94	21	49,4	1,198	33,828	x	x	x
BGH-2008	94	24	3,2	1,198	33,83	x	x	x

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	CTD Cast	Niskin	Depth(db)	T (°C)	Salinity	CT Infr	CT Coul	TA
BGH-2008	96	1	1227,9	1,124	34,69	x	x	x
BGH-2008	96	2	1230,7	1,122	34,69			
BGH-2008	96	3	1100,9	1,216	34,693	x		
BGH-2008	96	4	1102	1,216	34,693			
BGH-2008	96	5	998,9	1,298	34,693	x		x
BGH-2008	96	6	901,1	1,387	34,693	x		x
BGH-2008	96	7	800,4	1,497	34,691	x		x
BGH-2008	96	8	699,2	1,567	34,689	x		x
BGH-2008	96	9	599,2	1,655	34,678	x	x	x
BGH-2008	96	10	500,5	1,733	34,657	x		x
BGH-2008	96	11	397,1	1,665	34,603	x		x
BGH-2008	96	12	298,6	1,65	34,545	x		
BGH-2008	96	13	250,4	1,576	34,489	x		
BGH-2008	96	14	179,8	0,777	34,273	x	x	x
BGH-2008	96	15	139,2	0,421	34,11	x		
BGH-2008	96	16	110	0,999	33,799	x		
BGH-2008	96	17	80,5	1,018	33,791	x		x
BGH-2008	96	18	41	1,017	33,791	x		
BGH-2008	96	19	5,3	1,016	33,791	x	x	x
BGH-2008	97	1	1408,9	0,844	34,683		x	x
BGH-2008	97	2	1299,1	0,924	34,686	x	x	x
BGH-2008	97	3	1090,5	1,109	34,692		x	x
BGH-2008	97	4	999,4	1,216	34,695		x	x
BGH-2008	97	5	1000	1,219	34,695	x	x	x
BGH-2008	97	6	898,8	1,334	34,698	x	x	x
BGH-2008	97	7	799,5	1,417	34,698	x	x	x
BGH-2008	97	8	697,3	1,501	34,693	x	x	x
BGH-2008	97	9	600,1	1,584	34,684	x	x	x
BGH-2008	97	10	500	1,675	34,67	x	x	x
BGH-2008	97	11	399,6	1,724	34,641	x	x	x
BGH-2008	97	12	330,1	1,72	34,612	x	x	x
BGH-2008	97	13	248	1,656	34,548	x	x	x
BGH-2008	97	14	179,5	1,244	34,416	x	x	x
BGH-2008	97	15	151	0,642	34,225	x	x	x
BGH-2008	97	16	110,3	0,842	33,769	x	x	x
BGH-2008	97	17	78,6	0,869	33,761	x	x	x
BGH-2008	97	18	50	0,871	33,76	x	x	x
BGH-2008	97	19	5,8	0,875	33,76	x		x
BGH-2008	101	1	3511,1	-0,157	34,646	x	x	x
BGH-2008	101	2	3511,9	-0,157	34,646			
BGH-2008	101	3	3399	-0,128	34,647	x	x	x
BGH-2008	101	4	3399,2	-0,128	34,647			
BGH-2008	101	5	3196	-0,09	34,649	x	x	x
BGH-2008	101	6	2999,9	-0,065	34,65	x	x	x
BGH-2008	101	7	2748,5	0,039	34,654	x	x	x
BGH-2008	101	8	2499,3	0,112	34,657	x	x	x
BGH-2008	101	9	2248,5	0,213	34,661	x	x	x
BGH-2008	101	10	1998,8	0,315	34,665	x	x	x
BGH-2008	101	11	1748,6	0,433	34,669	x	x	x
BGH-2008	101	12	1499,6	0,564	34,672	x	x	x
BGH-2008	101	13	1249,5	0,733	34,678	x	x	x
BGH-2008	101	14	999,5	0,994	34,689	x	x	x
BGH-2008	101	15	796,4	1,194	34,687	x	x	x
BGH-2008	101	16	599,5	1,464	34,683	x	x	x
BGH-2008	101	17	399	1,592	34,64	x	x	x
BGH-2008	101	18	198,7	1,586	34,534	x	x	x
BGH-2008	101	19	149,6	1,192	34,405	x	x	x
BGH-2008	101	20	98,6	0,269	34,098	x	x	x
BGH-2008	101	21	49,6	0,467	33,854	x	x	x
BGH-2008	101	24	5,2	0,529	33,836	x	x	x
BGH-2008	106	1	3979,1	-0,371	34,637	x	x	x
BGH-2008	106	2	3749,5	-0,38	34,638	x	x	x
BGH-2008	106	3	3498,7	-0,361	34,639	x	x	x
BGH-2008	106	4	3249,3	-0,318	34,642	x	x	x
BGH-2008	106	5	2999,5	-0,283	34,643	x	x	x
BGH-2008	106	6	2751	-0,25	34,645	x	x	x
BGH-2008	106	7	2500,1	-0,208	34,646	x	x	x
BGH-2008	106	8	2249,2	-0,15	34,649	x	x	x
BGH-2008	106	9	1999	-0,078	34,651	x	x	x
BGH-2008	106	10	1749,1	-0,001	34,654	x	x	x
BGH-2008	106	11	1499,4	0,083	34,658	x	x	x
BGH-2008	106	12	1248,3	0,195	34,662	x	x	x
BGH-2008	106	13	999,7	0,314	34,666	x	x	x
BGH-2008	106	14	800,9	0,401	34,67	x	x	x
BGH-2008	106	15	597,5	0,494	34,671	x	x	x
BGH-2008	106	16	397,5	0,54	34,661	x	x	x
BGH-2008	106	17	299,4	0,439	34,633	x	x	x
BGH-2008	106	18	198,9	-0,258	34,512	x	x	x
BGH-2008	106	19	129,1	-0,664	34,304	x	x	x
BGH-2008	106	20	80,1	0,38	34,133	x	x	x
BGH-2008	106	21	49,5	0,4	34,078	x	x	x
BGH-2008	106	24	4,4	0,402	34,064	x	x	x

4.3 TRACE ELEMENTS AND ISOTOPES (TEIs)



TEI's are a powerful tool to track the fate of carbon and nutrients such as nitrogen and silicon. For instance it is observed that physics (frontal systems, mixed layer depth) have a significant impact on ^{30}Si and dissolved Ba distributions. Besides physics, biogeochemical processes, including plankton biomass production, aggregate sinking and aggregate disintegration and remineralization, also significantly control the redistribution of carbon and other elements in the oceanic water column. The biogeochemical processes are tracked using proxies such as ^{234}Th deficit to assess particle export and particulate authigenic Ba to assess remineralization of exported organic carbon.

4.3.1 WORK AT SEA

Trace Elements and Isotopes

Trace Elements and Isotopes (TEI's) have been collected in seawater either with GO-FLO bottles suspended on a Kevlar wire on the 7 LARGE stations and 5 SUPER stations, or with In Situ Pumps (Mac Lane and Challenger) on the 5 SUPER stations, or with Niskin bottles modified with internal Teflon springs on most of the stations for some of the TEI's such Ba (see Annexes 1-3), or sporadically using the ship-intake water supply (see Reports of Verdeny *et al.*, Ezat *et al.*, Monteiro *et al.*).

In sediments TEI's have been collected with an Oktopus GmbH multiple corer (head version MUC 8/100) equipped with 8 transparent polycarbonate cylinders on the SUPER stations when efficient (see Report of Viollier *et al.*)

In the atmosphere TEI's in the aerosols were collected continuously using a high-volume ($1 \text{ m}^3 \text{ min}^{-1}$) sampler equipped with a bulk aerosol sampling head (Whatman 41 filter), while in the rain they were collected very sporadically on an event basis by deploying large (40 cm diameter) plastic funnels for the duration of rainfall only (see Report of Baker *et al.*).

A rough summary of the GEOTRACES parameters sampled during the BONUSGOODHOPE cruise is given in Table 11. The details of the sampling list are given in the Annexes, in the various reports and in the Dictionary.

Stations:	GEOTRACES PARAMETER	Device:	LARGE		SUPER		Ship		ATMOSPHERE	
			Niskin	GoFlo	Niskin	GoFlo	In situ Pump	Corer	Intake water	dust
	Trace metals concentration (Fe, Zn, Al, Cd, Co, É2tc)		70 diss. + 70 unf.			100 diss. + 100 unf.			Yes	Yes
	Trace metal organic speciation (Fe, Zn, Co, Cd, Cu)		70 dissolved			100 diss.				
	Trace metal redox speciation (Fe)		70 unfiltered			100 unf.				
	Trace metal physical speciation (Fe)		30 soluble			40 soluble				
	CdIC					50 diss.	Yes			
	FeIC					49 diss. + 49 filters	Yes			
	143Nd, 231Pa, 230Th, REE					55 diss.+ 55 filters	33 filters	Yes		
	210Po/210Pb 14,13,12C in POC		62			76	56 filters	67 filters	Yes	Yes
	234Th					07	67 filters	Yes		
	13C in specific compounds						67 filters	Yes		
	226,228Ra, 227Ac		1			7	20 cartridges		Discrete samples	Discrete samples
	Alkenones						7 filters	Yes		
	30Si in BSi		21			15	48 filters	Yes		
	30Si in dissolved-Si		76			95				
	Dissolved Ba	Few st	154			110		Yes		

Table 11– Summary of the GEOTRACES parameters sampled during the BONUS-GOODHOPE cruise

On-deck incubations

Large volumes sampled with the Niskin bottles at the Large-type B stations have been incubated with ^{13}C for deck incubations to investigate the primary production (see Report Monteiro et *al.*); with ^{15}N to study the nitrogen uptake (see Report Monteiro et *al.*), and with ^{30}Si to investigate the uptake rate of Si and dissolution rate of biogenic silicon (see Report Corvaisier, Grossteffan, Cardinal & Fripiat)

4.3.2 ORIGIN, PATHWAYS AND VENTILATION OF WATER MASSES

4.3.2.1 NEODYMIUM ISOTOPIC COMPOSITION, ^{230}Th AND ^{231}Pa CONCENTRATIONS, REE AND IRON ISOTOPIC COMPOSITION AND CONCENTRATION

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Scientific objectives.

Neodymium isotopic composition (Nd IC), ^{230}Th and ^{231}Pa concentrations, Rare Earth Element concentrations (REE) and iron isotopic composition (Fe IC) and concentration, in the dissolved (<0,4 micrometer) and particulate phase will allow to quantify and estimate, notably:

- Vertical particulate fluxes, particle settling velocities (^{230}Th and ^{231}Pa)
- Transit times of water masses involved in vertical motion (convection, subduction, upwelling... ^{230}Th and ^{231}Pa)
- Origin and mixing of water masses (Nd IC, REE)
- Matter exchange fluxes between the lithosphere and the ocean (Nd IC, REE, Fe IC)
- Dissolved particulate interactions (^{230}Th and ^{231}Pa , Nd IC, REE, Fe IC)
- Origin of the iron (Aeolian, sediment). Isotopic fractionation factors involved in Fe oceanic cycle. Fe dissolved particulate interactions. (Nd IC, Fe IC).

Scientific and sampling strategies

Sampling at the SUPER stations (5 stations).

Dissolved ^{230}Th , ^{231}Pa , Nd IC, REE : 61 samples

Particulate ^{230}Th , ^{231}Pa , Nd IC, REE (in situ pumps): 36 samples

Dissolved and particulate Fe IC: 50 samples

Protocols

Parameter definitions:

^{230}Th : concentration of ^{230}Th per seawater mass unit.

^{231}Pa : concentration of ^{231}Pa per seawater mass unit.

Nd IC: neodymium isotopic composition

REE: Rare Earth Element concentrations per seawater mass unit.

Fe IC: Iron isotopic composition

Sampling, storage and analysis procedures:

^{230}Th and ^{231}Pa , Nd IC, REE :

1. Dissolved phase: sampling with Niskin bottles, 20 L per sample, filtration at 0.4 micrometer, onboard preconcentration. Storage at pH=2 (HCl). Analyses with ICPMS, TIMS, MC-ICPMS.
2. Particulate phase : sampling with in situ pumps, 0,4 micrometer. Analyses with ICPMS, TIMS, MC-ICPMS. Storage at -20°C.

Fe IC:

Goflo sampling. 10 L per sample (20 for the two shallowest of each station). Filtration at 0.4 micrometer. Storage at pH=2 (HCl). Analyses with ICPMS, TIMS, MC-ICPMS. Filters stored at -20°C.

Preliminary results

None.

Data delivery

Within 2 to 4 years from now.

4.3.2.2 ^{226}Ra , ^{228}Ra AND ^{227}Ac SAMPLING

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Sampling of ^{226}Ra and ^{228}Ra along the water column (surface-bottom) (PI: Claudia Hanfland, Claudia.Hanfland@awi.de, Alfred Wegner Institute, AWI, Germany)

Sampling of ^{227}Ac along the water column (surface-bottom) (PI: Walter Geibert, Walter.Geibert@ed.ac.uk, University of Edinburgh, UK)

Scientific motivation

The two long-lived Radium isotopes ^{226}Ra and ^{228}Ra show a contrasting pattern in subpolar and subantarctic waters (Hanfland 2002): ^{226}Ra ($T_{1/2} = 1600$ yrs) is known to increase steadily in the surface waters from North to South across the ACC (Chung 1974; Hanfland 2002; Jacquet et al., 2004) due to replenishment from upwelling of nutrient-rich waters. In contrast, ^{228}Ra ($T_{1/2} = 5.8$ yrs) accumulates to high activities in shallow water bodies overlying continental shelf areas. It can hence be used as a tracer of shelf water input and helps to identify advection of shelf waters into the open ocean (Moore 1969, Li et al. 1980). ^{227}Ac is also a useful tracer for water mass circulation, upwelling, and mixing rates (Nozaki, 1984; Geibert et al., 2002). The combined analyses of ^{227}Ac and ^{228}Ra can also be used to distinguish between vertical versus lateral movement of water masses. In the region of interest, the Agulhas Current is particularly prone to collect a distinctive shelf ^{228}Ra signal during its southward flow along the continental shelf edge of South Africa. By contrast, waters protruding northward from the Antarctic Zone generally lack clear ^{228}Ra signals as they have not been in contact with shelf sediments for a relatively long time.

Sampling methodology and sampling treatment on board

^{226}Ra , ^{228}Ra and ^{227}Ac were collected using MnO_2 -coated filter cartridges (1 μm) via in-situ pumping filtration, using battery operated pumps that filter large volumes of water (100-1000 L). Filter cartridges were sealed wet in plastic bags to be transferred to the AWI lab for further analysis. Analysis in the home-lab will allow determining the activity ratio $^{228}\text{Ra}/^{226}\text{Ra}$ and the absolute ^{227}Ac activities. Besides, absolute activities of ^{228}Ra and ^{226}Ra can be obtained if the absolute ^{226}Ra activity is known. Therefore, parallel samples of ~ 24 L seawater, obtained from regular CTD casts using Niskin bottles, were taken specifically for ^{226}Ra . A quantitative precipitation with BaCl_2 led to the formation of $\text{Ba}(\text{Ra})\text{SO}_4$, thereby concentrating the Radium activity in a small sample volume. The precipitate was then transferred to 250 mL LDPP bottles for an easy transport to the home-lab. The procedural recovery can be calculated via the Ba content.

The Ba precipitates will be measured by gamma-spectrometry detection at home-lab (AWI, Germany). The MnO_2 -coated cartridges will be

radiochemically treated at AWI. A leaching procedure followed by iron precipitation and ion column chemistry will allow separating the different isotope fractions. ^{227}Ac will be determined by alpha-spectrometry. Analysis of the $^{228}\text{Ra}/^{226}\text{Ra}$ activity ratio will be done either by direct gamma-counting of the precipitated leachate or further processing following the so-called ^{228}Th -ingrowth method.

Sampling results

Water column profiles (surface-bottom) of 3-4 successful depths for $^{228}\text{Ra}/^{226}\text{Ra}$ and 2 depths for ^{227}Ac were collected using MnO_2 -coated cartridges with the in-situ pump deployments. An additional cartridge sample for $^{228}\text{Ra}/^{226}\text{Ra}$ was obtained by filtering 1000-1500 L of surface seawater from the ship's intake supply. An additional sample for ^{227}Ac from the surface was obtained using an alternative sampling method, which involves 100 L of seawater sample, and a MnO_2 co-precipitation. An internal yield of ^{230}Th was used to assess recovery. The precipitate was filtered through 1 μm QMA filters (124 mm diameter) using a peristaltic pump. Two QMA filters were needed for each sample, due to the easy clogging of the filters by the fine MnO_2 precipitate.

Therefore, 4-5 depths cartridge profiles for $^{228}\text{Ra}/^{226}\text{Ra}$ were collected at SUPER Stations 1, 2, 3 and 5. And 3 depths profiles for ^{227}Ac were collected at SUPER Stations 2, 3 and 5. A total of 19 cartridges will be treated back to home-lab for determining the isotopic activities. A total of 4 cartridges were deployed with unsuccessful pumping (pump did not work).

Seawater samples for ^{226}Ra , necessary to assess absolute ^{228}Ra activities, were also collected at SUPER Stations 1, 2, 3 and 5, from 3 different depths chosen to match with the in-situ pump sampling depths. An additional ^{226}Ra profile was sampled at the Inter-calibration station. A total of 18 samples were collected, including one replicate.

Table 12 – Compilation of samples collected for ^{210}Pb - ^{210}Po , ^{226}Ra , ^{228}Ra and ^{227}Ac

Station name	Type of Station	Date of sampling	Lat (S)	Lon (E)	Type of sample				
					Pb-Po ppt	Ra-226 ppt	Ra-226/228 cartridge	Ac-227 ppt	Ac-227 cartridge
18	SUPER 1	21/Feb/2008	36.29.755	13.06.997	20	3	4		
34	SUPER 2	27/Feb/2008	42.28.297	08.56.004	20	4	5	1	2
41	LARGE B1	02/Mar/2008	44.53.770	06.53.110	20	1			
48	SUPER 3	05/Mar/2008	47.33.290	04.22.540	21	3	5	1	2
52	LARGE B 2	07/Mar/2008	49.01.678	02.49.874	22				
62	SUPER 4	11/Mar/2008	51.52.158	- 00.00.109	22				
65	Intercal.	12/Mar/2008	52.58.913	00.00.020		4			
72	LARGE B 3	14/Mar/2008	55.13.948	00.02.611	20				
78	SUPER 5	16/Mar/2008	57.33.150	- 00.02.270	19	3	5	1	2
TOTAL					164	18	19	3	6

4.3.2.3 DISSOLVED BARIUM

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Dissolved Ba behaves as a bio-intermediate nutrient (*sensu* Broecker & Peng) showing slight utilization in surface waters and release in the deep waters. While Ba is clearly biogeochemically active, diss. Ba appears to have a pronounced conservative behaviour that makes it a useful tracer of water masses. This strong conservative character is due in part to the fact that concentrations of dissolved Ba (diss Ba) are two to three orders of magnitude larger than those of particulate Ba (nmol/l vs. pmol/l, respectively; see also below). Diss. Ba correlates well with silicate and alkalinity but the match is never perfect, reflecting the fact that a specific particle-solute interaction exists for this element, in which barite formation and dissolution appears to play a major role.

We sampled for dissolved Ba at all SUPER and LARGE stations, and at several Hydro stations (see Table 13 with sample list). A small volume (15 ml) of unfiltered seawater is acidified using ultrapure HCl and saved till later analysis in the home based laboratory. Samples will be diluted 30 times with ultrapure water and spiked with ^{135}Ba . The $^{135}\text{Ba}/^{138}\text{Ba}$ ratio is measured using a HR-ICP-MS and mass bias corrected by analyzing natural, unspiked Ba solutions in bracketing mode. The dissolved Ba profiles and resulting transect will be compared with those of silicate, nitrate as well as DIC, alkalinity. We will also compare results with diss. Ba results obtained earlier for the Prime Meridian section extending south of the BGH and the Weddell Basin (ANT 23; 2005; collaboration with Mario Hoppema), as well as with diss. Ba sections along 30°E (CIVA-1) and 145°E (SR3).

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Table 13 – CTD Rosette casts sampled for dissolved barium

CTD Cast #	station type	station	Date	Long	Lat	depth range
2	HYDRO	2	14/02/2008	17.43.220 E	33.56.660 S	0-bottom
4	HYDRO	4	14/02/2008	17.18.21 E	33.58.46 S	"
5	HYDRO	5	14/02/2008	16.57.13 E	33.59.68 S	"
6	HYDRO	6	14/02/2008	16.35.22 E	34.00.74 S	"
7	HYDRO	7	15/02/2008	16.12.00 E	34.01.999 S	"
8	HYDRO	8	15/02/2008	15.41.20 E	34.03.79 S	"
9	HYDRO	9	16/02/2008	15.09.80 E	34.05.50 S	"
10	HYDRO	10	16/02/2008	14.35.29 E	34.07.320 S	"
11	LARGE	11	17/02/2008	14.24.29 E	34.25.67 S	"
13	HYDRO	12	17/02/2008	14.13.570 E	34.43.425 S	"
14	HYDRO	13	17/02/2008	14.02.780 E	35.01.600 S	"
16	HYDRO	15	18/02/2008	13.41.010 E	35.37.510 S	"
17	HYDRO	16	18/02/2008	13.29.820 E	35.55.520 S	"
18	HYDRO	17	19/02/2008	13.18.590 E	36.13.400 S	"
19	SUPER 1	18	19/02/2008	13.07.320 E	36.31.370 S	"
25	HYDRO	20	22/02/2008	12.44.340 E	37.07.040 S	"
30	HYDRO	25	24/02/2008	11.34.350 E	38.49.530 S	"
34	HYDRO	29	25/02/2008	10.33.010 E	40.17.440 S	"
41	SUPER 2	34	26/02/2008	08.55.700 E	42.28.170 S	"
47	HYDRO	36	28/02/2008	08.14.230 E	43.19.460 S	"
53	LARGE 3B	41	1/03/2008	06.53.140 E	44.53.770 S	"
57	LARGE 4A	44	3/03/2008	05.51.890 E	46.01.450 S	"
63	SUPER 3	48	4/03/2008	04.22.610 E	47.33.260 S	"
69	HYDRO	51	7/03/2008	03.10.691 E	48.42.078 S	"
70	LARGE 5B	52	7/03/2008	02.49.940 E	49.01.690 S	"
77	LARGE 6A	57	8/03/2008	01.18.130 E	50.22.360 S	"
84	SUPER 4	62	10/03/2008	00.00.041 E	51.51.350 S	"
89	HYDRO	64	12/03/2008	00.00.090 E	52.36.080 S	"
94	HYDRO	68	13/03/2008	00.00.100 E	53.55.130 S	"
96	HYDRO	70	13/03/2008	00.00.042 W	54.34.828 S	"
98	LARGE 7	72	13/03/2008	00.01.380 E	55.13.847 S	"
102	HYDRO	74	14/03/2008	00.06.790 E	55.54.260 S	"
106	SUPER 5	78	15/03/2008	00.02.190 W	57.33.150 S	"

4.3.2.4 CARBON ISOTOPES (^{14}C AND ^{13}C)

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Introduction and scientific objectives

Carbon is one of the most abundant elements in the universe and is the basis for the existence of life on Earth. Knowledge of the cycling of carbon in the ocean is important not only for the understanding of the biogeochemistry of a variety of elements, but also for the global carbon cycle and thus climate changes of human concern.

Carbon-14 also called radiocarbon (^{14}C) is continually formed in nature by the interaction of neutrons with nitrogen-14 in the Earth's atmosphere. It is rapidly converted to carbon dioxide by reaction with atmospheric oxygen and mixed and uniformly distributed with the atmospheric carbon dioxide (CO_2) containing stable carbon-12 and carbon-13. Then, the CO_2 is exchanged with biosphere and ocean reservoirs. In the ocean, this distribution is governed by biological processes and carbonate chemistry. Carbon occurs in inorganic and organic pools : dissolved inorganic carbon (DIC), dissolved organic carbon (DOC), particulate organic carbon (POC), and sedimentary organic carbon (SOC). Measurements of radiocarbon and stable carbon isotopes of these different reservoirs provide some interesting insights into the oceanic carbon cycle and oceanic circulation.

The aim of this study is to investigate the variation of radiocarbon and $\delta^{13}\text{C}$ signatures of the different forms of carbon in the water column and sediment in the inter-frontal region of Southern Ocean in order to contribute to understand:

1. the zonal circulation : radiocarbon in DIC is a tracer of circulation as CFCs which allows to quantify the recent thermocline ventilation, characterize changes in deep and bottom waters in the Agulhas Current, estimate the temporal and lateral oceanic transport as $^{143}\text{Nd}/^{144}\text{Nd}$ and calibrate, evaluate ocean models
2. the fate of carbon : $\Delta^{13}\text{C}$ and $\Delta^{14}\text{C}$ signatures of the different forms of organic matter (POC, DOC and SOC) reflect the balance between production and deposition. It is therefore possible to determine the partitioning of exported carbon between dissolved and particulate forms, and to understand, in conjunction with the other tracers, the factors which regulate the fate of these carbon pools.

Methods

Three different forms of carbon samples (DIC, POC, DOC) were collected at the five SUPER stations to also investigate the variability of carbon isotopes signatures in the inter-frontal zone of the Southern Ocean. We added the LARGE station 7 for DIC samples to obtain a higher spatial resolution. Due to the Octopus problems, only one SUPER station was sampled for SOC.

Dissolved Inorganic Carbon

119 seawater samples were collected.

250 ml of seawater were collected for depth profile (19-20 depths) using Niskin bottles in the five SUPER stations and LARGE station 7. Seawater was poisoned with 1-ml of saturated HgCl₂ solution. Then, the borosilicate bottles were sealed on board.

Once back in the lab, the DIC samples will be acidified (phosphoric acid) and stripped of CO₂ by recirculated nitrogen gas (Leboucher *et al*, 1999).

Particulate Organic Carbon

Suspended POC (POC_{susp}) was collected using *in situ* pumps (Mac Lane and Challenger pumps) deployed for 2 hours. During each deployment, 150 to 1600 litres of seawater, depending of the depth and the pump characteristics, were filtered through a pre-filter (petex, 53µm) and a 1µm pore diameter, pre-combusted (550°C) quartz-fiber filters (142 mm diameter). For carbon isotope analyses, 25% of prefilter and six punches (2.5 cm diameter) of quartz filter were dried on board at 40°C.

At LSCE, quartz filters will be acidified and dried under vacuum. Then, they will be combusted in quartz tubes at 850°C. The concentration of POC (µg/l) at each depth will be determined from the pressure measurement of CO₂ gas obtained after combustion of each filter and the litres of water filtered. This will be compared with the measurements realize at VUB ANCHLAB.

A total of 43 samples will be analyzed. Prefilters will also be analyzed depending of the amount of carbon.

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<u>Super 1</u>				<u>Super 2</u>				<u>Super 3</u>			
	Depth (m)	volume (l)	cast n°		Depth (m)	volume (l)	cast n°		Depth (m)	volume (l)	cast n°
Challenger 4	50	1084	1	McLane 1	30	491	2	McLane 3	20	152	2
Challenger 3	75	693	1	INSU 4	75	1369	2	Mc Lane 1	50	207	2
Challenger 1	75	952	3	McLane 2	130	1041	2	INSU 1	80	Blk	2
Challenger 2	125	1316	1	INSU 1	175	Blk	2	Mc Lane 2	230	230	2
Challenger 1	175	1008	1	INSU 2	250	1565	2	INSU 7	1038	Blk	1
Mc Lane 3	250	603	1	McLane 3	590	1983	2	INSU 1	1048	1060	1
Mc Lane 2	500	612	1	Mc Lane 1	1450	922	1	McLane 3	2023	950	1
McLane 1	725	Blk	3	Mc Lane 2	2900	1011	1	McLane 2	4320	985	1
Mc Lane 1	750	612	1	Mc Lane 3	3940	3940	1				
McLane 2	1200	974	3								
Mc Lane 1	1250	1027	2								
McLane 3	2700	913	3								
Mc Lane 2	2750	978	2								
Mc Lane 3	4700	994	2								
<u>Super 4</u>				<u>Super 5</u>							
	Depth (m)	volume (l)	cast n°		Depth (m)	volume (l)	cast n°		Depth (m)	volume (l)	cast n°
INSU 1	30	-	2	INSU 1	20	Blk	2				
INSU 1	40	-	1	Mc Lane 1	50	658	1				
INSU 2	80	710	1	McLane 2	90	789	1				
INSU 7	100	629	2	Mc Lane 1	115	Blk	2				
INSU 2	125	765	2	McLane 2	300	991	2				
INSU 3	165	1213	1	INSU 2	500	1522	2				
Mc Lane 1	240	-	2	INSU 1	1200	Blk	1				
McLane 3	400	1156	1	Mc Lane 3	1500	1259	2				
INSU 3	749	1209	2	INSU 7	2500	-	2				
Mc Lane 2	1108	1017	1	Mc Lane 3	3884	919	2				
INSU 7	1685	Blk	1								
Mc Lane 2	1685	1012	2								
Mc Lane 1	2468	Blk	1								
McLane 3	2468	942	2								

Table 14 – Suspended particles collected using in situ pumps

Sediment Organic Carbon

9 samples of sediment were collected in SUPER station 1 using the Octopus. One of the 8 cores was sectioned in a cold room (4°C) into 0.5-1 cm thick layers. For carbon isotope analyses, 2 g of sediments were sampled in these layers and dried in an oven at 40°C.

At the lab, the sediment will be acidified to remove carbonate and dried. Then, the sample will be combusted in quartz tubes at 850°C.

Dissolved Organic Carbon

50 seawater samples were collected.

Four litres of seawater were collected using Niskin bottles for radiocarbon analyzes in the five SUPER stations. Samples were also collected for concentration of DOC at the same depths (collaboration with R. Sempéré, C. Pangiotopoulos, B. Charrière). Ten depths for each SUPER station were chosen to obtain a profile of concentration and radiocarbon DOC with a higher resolution towards the surface. The seawater samples were filtered through pre-combusted

(550°C) quartz-fiber filters (45 mm diameter). The filtrate was transferred to borosilicate bottles (2 litres), poisoned with saturated HgCl₂ solution and sealed on board.

At laboratory, the DOC samples will be acidified to remove DIC and oxidized using a system which is currently developed (Beaupré *et al*, 2007). This system combines ultraviolet oxidation and a vacuum line system to convert marine dissolved organic carbon into CO₂.

¹⁴C and ¹³C analyses

The CO₂ from DIC, POC, SOC and DOC will be converted to graphite targets and ¹⁴C will be measured by accelerator mass spectrometry (Artémis, UMS 2572). Stable carbon isotope results will be performed on splits of CO₂ when the amount of carbon allows it. The δ¹³C measurements will be made on a Finnigan Mat Delta +, IRMS.

4.3.2.5 ALKENONS

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Sea Surface Temperature (SST) is calculated by the alkenones index: alkenones are organic compounds (having 2, 3 or 4 double bonds) which are synthesized by coccolithophorids (especially *E. Huxley*), they are poorly dissolved in seawater, consequently precipitate with others organics or mineral particles forming in this way an archive within the sediment.

Our objectives in this work are to search for important advection of coccoliths. For this we sampled the following:

Sampling strategy

Seawater samples:

- maximum of fluorescence, just above and below the maximum
- in situ pumping of several litres (alkenones)
- water for taxonomy studies
- seawater in laboratory, more than 30 litres are filtered(alkenones)

Sediment samples

Sediments sampling was planned, but unfortunately our attempt was not very successful.

We collected a total of 120 samples which are brought back to the home-based laboratory for later analysis.

Sample conservation:

- samples taken for coccoliths and alkenones were oven dried (at about 50 °C).
- samples collected for taxonomy studies were kept in the dark after addition of a few ml of Lugol.
- sediment samples were wrapped in aluminium foil and preserved at – 18 °C.

Methods:

For alkenones determination, samples will be treated chemically by different organics solvents, we obtain a total organics compound which will be

separated in different fractions (hydrocarbons, fatty acids, alkenones...etc.). Finally the alkenone fractions are reconcentrated and measured via gas chromatography.

4.3.3 EXPORT FLUXES, SCAVENGING RATES AND REMINERALISATION INVOLVED IN THE CARBON CYCLE

4.3.3.1 ²¹⁰LEAD - ²¹⁰POLLONIUM DISEQUILIBRIUM IN THE 0-1000 M WATER COLUMN

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Motivation and general sampling strategy for B-GH Leg-1

The BONUS-GOODHOPE LEG-1_from Cape Town to the Southern Boundary of the ACC along the Greenwich Meridian has been chosen because it crosses the geographical region where water masses of the ACC and the Agulhas Current converge and mix before entering the South Atlantic as thermocline waters.

The general sampling strategy of LEG-1 consists of monitoring the different waters masses to provide a 2D matrix, vertical and horizontal, of water-mass characteristics to allow understanding of the physical and biogeochemical dynamics along the section with relatively high spatial resolution. The selected vertical scales various water-masses (notably AAIW and SAMW), and the applied horizontal resolution covers the main frontal systems and inter-frontal regions.

Scientific motivation for ²¹⁰Pb-²¹⁰Po sampling

²¹⁰Po ($T_{1/2} = 138.4$ d) is a useful tracer for quantifying particle export from surface waters and the processes governing the dynamics of particles in the ocean (Cochran and Masqué, 2003). ²¹⁰Po is a daughter of a long lived parent, ²¹⁰Pb ($T_{1/2} = 22.3$ y), of the ²³⁸U decay series. The degree of disequilibrium between ²¹⁰Pb and ²¹⁰Po and the dynamics of association to particles can be used to asses scavenging rates, export fluxes, remineralization rates and role of types and/or composition of particles involved in these processes. The mesopelagic zone is the depth layer where most changes in sinking organic matter occur and also where SAMW and AAIW are formed. POC contents measured in sinking particles will be used to convert ²¹⁰Po fluxes into carbon fluxes.

Sampling methodology and sampling treatment on board

²¹⁰Pb and ²¹⁰Po total activities were measured from ~ 5 L seawater samples from Niskin bottles (CTD casts), from 20 depths between 0-1000 m. The high vertical resolution sampling undertaken in this project will allow assessing the vertical distribution of these elements in great detail.

Seawater samples for ^{210}Pb and ^{210}Po were pre-treated on board in order to pre-concentrate the activities of these radionuclides. Internal yields, stable Pb and ^{209}Po , were added to assess the procedural recovery. The pre-concentration was achieved by forming an $\text{Fe}(\text{OH})_3$ precipitate that effectively scavenges Pb and Po from solution. The precipitate was then transferred to small volume HDPP bottles, for an easy transport to the home laboratory. The radiochemical analysis of these samples will be done at UAB, and the activity of the samples will be determined via high resolution alpha-spectrometry using surface barrier alpha detectors (UAB).

Sampling results

Seawater profiles of 20 depths (0-1000 m) for the ^{210}Pb - ^{210}Po work were collected from a total of 8 stations (5 SUPER Stations and 3 LARGE Stations) along the transect from 36.3°S 13.1°E to 57.33°S 0.0°E. A total of 172 samples were collected, including 6 procedural blanks (3 at the beginning of the cruise and 3 at the end), and 5 duplicate samples to ensure reproducibility.

Table 15 – Compilation of samples collected for ^{210}Pb - ^{210}Po , ^{226}Ra , ^{228}Ra and ^{227}Ac

Station name	Type of Station	Date of sampling	Lat (S)	Lon (E)	Type of sample				
					Pb-Po ppt	Ra-226 ppt	Ra-226/228 cartridge	Ac-227 ppt	Ac-227 cartridge
18	SUPER 1	21/Feb/2008	36.29.755	13.06.997	20	3	4		
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48	SUPER 3	05/Mar/2008	47.33.290	04.22.540	21	3	5	1	2
52	LARGE B 2	07/Mar/2008	49.01.678	02.49.874	22				
62	SUPER 4	11/Mar/2008	51.52.158	- 00.00.109	22				
65	Intercal.	12/Mar/2008	52.58.913	00.00.020		4			
72	LARGE B 3	14/Mar/2008	55.13.948	00.02.611	20				
78	SUPER 5	16/Mar/2008	57.33.150	- 00.02.270	19	3	5	1	2
TOTAL					164	18	19	3	6

4.3.3.2 BIOGEOCHEMICAL PROCESSES INVOLVED IN CARBON EXPORT AND REMINERALIZATION

The aim here is to achieve a better insight in: (i) particle vs solute interactions for organic carbon; (ii) the processes in control of organic carbon export and its transformation during transit through the mesopelagic depth region.

4.3.3.2.1 Export and shallow remineralization

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^{234}Th (and ^{210}Po ; see work by Elisabet Verdeny's group) is useful to quantify the scavenging from solution onto particles and the processes governing the dynamics of particles in the ocean. These radionuclides have in common the fact that they both are daughters of a long lived parent (^{238}U) present in the dissolved phase and with conservative behaviour over the oceanic water column. Profiles of total ^{234}Th inform not only on the export of particles (from the deficit of ^{234}Th vs ^{238}U) from the mixed layer but also possibly on remineralization of these sinking particles below the mixed layer (from the ^{234}Th excess relative to ^{238}U). We assessed the export of particles from the upper mixed layer using the ^{234}Th deficit method. This approach consists in recovering total ^{234}Th (i.e. dissolved and particulate) from a ^{230}Th -spiked 4L seawater sample by scavenging on $\text{Mn}(\text{OOH})$ precipitate and filtering on quartz filters. These filters are dried and counted on board for beta activity using a low beta RISØ counter. The ^{234}Th activity deficit relative to ^{238}U is integrated to yield a ^{234}Th flux associated with sinking particles. To transform this flux into a carbon flux the ^{234}Th activity exclusively associated with particles is also measured. To that purpose large volume filtrations are performed with in-situ pumps fitted with nylon screens (50 μm cut-off) and QMA quartz filters (1 μm cut-off). The material collected on the 50 μm screens is washed off and reconcentrated on a 0.4 μm silver filter. QMA filters were subsampled using a cut-out (25 mm diameter). These filters were dried and counted on board. At this stage we only have a crude idea about the magnitude of the ^{234}Th export flux along BGH. Indeed, samples need to be recounted in the home-based laboratory after about 6 months to assess background ^{234}Th activity (from

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scavenged ^{238}U) and to assess the yield of the original ^{234}Th recovery by analyzing the concentration of ^{230}Th , which is the yield monitor used. After recounting, the filters with particulate ^{234}Th will be analysed for POC content using an elemental analyzer, in order to assess $^{234}\text{Th}/\text{POC}$ ratios. Only then will it be possible to generate final numbers of POC export flux. Results will be compared with those obtained by Elisabet Verdeny on ^{210}Po and ^{210}Pb .

Table 16 – CTD rosette and in-situ pump casts for ^{234}Th activity analysis

Station type	station number	date	CAST type	CAST Number	Latitude	longitude	depth range
SUPER 1	18	20/02/08 05:06	CTD Mixed Layer	20	13.06.974 E	36.31.536 S	0-50
SUPER 1	18	20/02/08 11:30	PIS	1	13.07.139 E	36.31.255 S	0-750
SUPER 1	18	20/02/08 15:52	Super1 REE 0-bottom	21	13.07.096 E	36.31.278 S	5000
SUPER 1	18	21/02/08 05:25	PIS	2	13.08.650 E	36.28.040 S	1250-4700
SUPER 1	18	21/02/08 09:00	CTD Po-Th	22	13.06.997 E	36.29.755 S	0-1000
SUPER 1	18	22/02/08 00:30	PIS	3	13.06.311 E	36.29.105 S	75-2700
LARGE 2B	31	25/02/08 21:40	CTD HYDRO CTD Mixed	37	09.55.057 E	41.10.705 S	2600-bottom
LARGE 2B	31	26/02/08 01:37	Layer	38	09.55.313 E	41.11.390 S	0-300
SUPER 2	34	27/02/08 12:04	PIS	4	08.55.723 E	42.28.134 S	0-3940
SUPER 2	34	27/02/08 20:30	CTD Po-Th	43	08.56.004 E	42.28.297 S	0-1000
SUPER 2	34	28/02/08 00:12	BaSi	44	08.55.912 E	42.28.130 S	1500
SUPER 2	34	28/02/08 07:30	PIS	5	08.55.960 E	42.28.110 S	0-1450
LARGE 3B	41	01/03/08 15:39	CTD Mixed Layer	52	06.53.114 E	44.53.801 S	0-300
LARGE 3B	41	01/03/08 23:36	CTD HYDRO CTD Mixed	53	06.54.230 E	44.53.480 S	0-4110
LARGE 4A	44	03/03/08 08:15	Layer	58	05.52.520 E	46.01.030 S	0-200
SUPER 3	48	05/03/08 06:50	PIS	6	04.22.160 E	47.33.160 S	1038-4340
SUPER 3	48	05/03/08 17:56	CTD Po-Th	65	04.22.540 E	47.33.290 S	0-1000
SUPER 3	48	06/03/08 03:07	PIS	7	04.22.845 E	47.33.056 S	0-550
LARGE 5B	52	07/03/08 12:27	CTD HYDRO CTD Mixed	70	02.49.873 E	49.01.687 S	0-1000
LARGE 5B	52	07/03/08 14:39	Layer	71	02.49.930 E	49.01.680 S	0-150
LARGE 6A	57	09/03/08 06:16	CTD Mixed Layer	78	01.19.432 E	50.22.698 S	0-250
SUPER 4	62	10/03/08 20:30	PIS	8	00.00.00 E	51.51.330 S	0-2468
SUPER 4	62	11/03/08 02:48	CTD Po-Th	86	00.00.109 W	51.52.158 S	0-1000
SUPER 4	62	11/03/08 15:49	PIS	9	00.00.00 E	51.51.330 S	0-2468
LARGE 7A	72	14/03/08 06:47	CTD Mixed Layer	100	00.00.021 W	55.34.140 S	0-250
LARGE 7A	72	14/03/08 10:57	CTD HYDRO	101	00.00.330 E	55.34.230 S	0-1000
SUPER 5	78	to be completed	PIS	8	00.00.330 E	57.33 S	
SUPER 5	78	16/03/2008 18:44	CTD Po-Th	86	00.00.330 E	57.33 S	0-1000
SUPER 5	78	to be completed	PIS	9	00.00.330 E	57.33 S	

4.3.3.2.2 Mesopelagic remineralization

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The accumulation of particulate authigenic Ba (mainly consisting of BaSO₄, barite formed in decaying aggregates of biogenic matter) in the mesopelagic water column (100 – 1000m) has been shown to correlate with subsurface bacterial activity and to reflect the intensity of past mesopelagic remineralization of exported organic matter.

We sampled several litres of seawater (4 to 10L) using the rosette casts at LARGE B and SUPER stations and filtered the water over 0.4 µm Nuclepore membranes under pressure of filtered air. Membranes are dried and saved till later analysis in the home based laboratory. Filters will be subsampled first for δ³⁰Si of bioSi (surface water samples only) and also for the SEM-EMP study of discrete barite microparticles present on the filter. The filter part for total Ba will be subsequently digested using a tri-acid mix (HCl, HNO₃, HF). Ba (as well as Sr, Ca, Al, U, ..) will be analysed by HR-ICP-MS. Excess, non-lithogenic particulate Ba (Baxs) is calculated using Al as the crustal reference. A transfer function established earlier for the same area as BGH relating Baxs with oxygen consumption will be applied to deduce the rate of oxygen utilization and the rate of POC respired. These values will be compared with carbon export flux (obtained via the ²³⁴Th method), with new production and new community production, both assessed by the group of Pedro Monteiro.

Table 17 – CTD Rosette casts sampled for particulate barium

CTD Cast #	Station type	Station	Date	Long	Lat	depth range
23	SUPER 1	1	21/02/2008	13.06.300 E	36.28.140 S	0-1000m
44	SUPER 2	34	27/02/2008	08.55.970 E	42.28.110 S	"
54	LARGE 3B	41	2/03/2008	06.53.130 E	44.53.740 S	"
66	SUPER 3	48	6/03/2008	04.22.480 E	47.33.310 S	"
72	LARGE 5B	52	7/03/2008	02.49.930 E	49.01.690 S	"
77	LARGE 6A	57	8/03/2008	01.18.130 E	50.22.360 S	"
87	SUPER 4	62	11/03/2008	00.00.410 E	51.52.540 S	"
99	LARGE 7A	72	14/03/2008	00.02.660 E	55.13.930 S	"
110	SUPER 5	78	16/03/2008	00.02.268 W	57.33.152 S	"

4.3.3.3 USE OF CARBON ISOTOPES (^{14}C AND ^{13}C) TO TRACE MARINE CARBON CYCLE IN THE WATER COLUMN

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Scientific objectives

As explained here above in section 3.4., the aim of this study is to investigate the variation of radiocarbon and $\Delta^{13}\text{C}$ signatures of the different forms of carbon in the water column and sediment in the inter-frontal region of Southern Ocean in order to contribute to understand the fate of carbon : $\Delta^{13}\text{C}$ and $\Delta^{14}\text{C}$ signatures of the different forms of organic matter (POC, DOC and SOC) reflect the balance between production and deposition. It is therefore possible to determine the partitioning of exported carbon between dissolved and particulate forms, and to understand, in conjunction with the other tracers, the factors which regulate the fate of these carbon pools.

Methods

Cf. Sect. 4.3.2.4

4.3.3.4 DISTRIBUTION AND INTERNAL CYCLE OF SILICON

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4.3.3.4.1 Natural silicon isotopic composition

Samples were taken to compare the natural isotopic signatures of $\text{Si}(\text{OH})_4$ and bio-silica (BSi) in order to better constrain the $\text{Si}(\text{OH})_4$ -diatom dynamics (Si utilization efficiency, mixing, Si source and accumulation). The isotopic composition of dissolved silicate ($\delta^{30}\text{Si}_{\text{DSi}}$) tends to integrate the effect of isotope fractionation over the growth season, while isotopic composition of particles ($\delta^{30}\text{Si}_{\text{BSi}}$) rather reflects the instantaneous result of fractionation. To that purpose seawater sampled per rosette during LARGE and SUPER stations was filtered on $0.4 \mu\text{m}$ Nuclepore membranes. Generally 19 depths were sampled from rosette casts for the determination of $\delta^{30}\text{Si}_{\text{DSi}}$ while filters will be available only on surface for $\delta^{30}\text{Si}_{\text{BSi}}$ due to the insufficient amount of particles below. Deeper $\delta^{30}\text{Si}_{\text{BSi}}$ will however be determined from the large volume in-situ pumps samples collected with Supor filters of $0.4 \mu\text{m}$ pore size at the SUPER stations. Filtrate and filtered particles were saved for chemical processing and isotopic analysis in the home based laboratory. After a thorough purification and preconcentration process, analyses will be carried out in the home-based laboratory (MRAC) by MC-ICP-MS in dry plasma mode using Mg external doping. Before the analyses we apply a wet-alkaline digestion on biogenic silica samples (2 M NaOH leaching at 100°C for 40 min). Silicon is then purified through its quantitative reaction with Triethylamine-Molybdate following by combustion (1000°C) and a HF/HCl dissolution. For samples with $\text{Si}(\text{OH})_4$ lower than $10\mu\text{M}$ a MAGIC preconcentration step is first necessary.

Table 18 – CTD Rosette casts sampled for analysis of silicate and bioSi

Cast #	Station type	Station	Date	Long	Lat	depth range
19	SUPER 1	18	19/02/2008	13.07.320 E	36.31.370 S	1500 - bottom
23	SUPER 1	18	21/02/2008	13.06.000 E	36.25.999 S	0-1000
37	LARGE 2A	31	25/02/2008	09.55.010 E	41.10.560 S	0 - bottom
41	SUPER 2	34	26/02/2008	08.55.700 E	42.28.170 S	1400 - bottom
44	SUPER 2	34	27/02/2008	08.55.970 E	42.28.110 S	0 - 1000
53	LARGE 3B	41	1/03/2008	06.53.140 E	44.53.770 S	1250 - bottom
54	LARGE 3B	41	2/03/2008	06.53.130 E	44.53.740 S	0 - 1000
57	LARGE 4A	44	2/03/2008	05.51.890 E	46.01.450 S	0 - bottom
63	SUPER 3	48	4/03/2008	04.22.610 E	47.33.260 S	1400 - bottom
66	SUPER 3	48	6/03/2008	04.22.480 E	47.33.310 S	0 - 1000
70	LARGE 5B	52	7/03/2008	02.49.940 E	49.01.690 S	1500 - bottom
72	LARGE 5B	52	7/03/2008	02.49.930 E	49.01.690 S	0 - 1000
77	LARGE 6A	57	8/03/2008	01.18.130 E	50.22.360 S	0 - bottom
84	SUPER 4	62	10/03/2008	00.00.041 E	51.51.350 S	1200 - bottom
87	SUPER 4	62	11/03/2008	00.00.410 E	51.52.540 S	0 - 1000
98	LARGE 7A	72	13/03/2008	00.01.380 E	55.13.847 S	1500 - bottom
99	LARGE 7A	72	14/03/2008	00.02.660 E	55.13.930 S	0 - 1000
106	SUPER 5	78	15/03/2008	00.02.190 W	57.33.150 S	1250 - bottom
110	SUPER 5	78	16/03/2008	00.02.268 W	57.33.152 S	0 - 1000

4.3.3.4.2 Si isotopic dilution incubations

Isotope dilution experiments using ^{30}Si spike additions were conducted at LARGE and SUPER stations in close collaboration with the group of Rudolph Corvaisier and Philippe Pondaven (IUEM, Brest). We will assess Si-uptake rates as well as bio-silica dissolution rates to determine the Si-budget and the impact of internal recycling on the Si-availability in the surface waters. Uptake rates will be compared with N and C uptake rates assessed by the group of Pedro Monteiro. In this regard, a common sampling strategy was implemented and samples were taken from the same CTD mixed layer casts and incubated simultaneously for C, N and Si for 24h at 100%, 25% and 1% light levels. In addition some 48h incubations were performed at SUPER stations. Sample processing and analyses will be carried out in the home-based laboratory (MRAC, Tervuren) via HR-SF-ICP-MS. We also apply first an alkaline digestion on biogenic silica samples. For dissolved silicon, a preconcentration is applied, and for the samples with low $\text{Si}(\text{OH})_4$ contents, a purification step on cationic exchange resin is necessary to overcome the matrix effect.

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Table 19 – CTD Rosette casts sampled for Si uptake and bSi dissolution incubations

Cast #	Station type	Station	Date	Long	Lat	depth range
12	LARGE 1A	11	17/02/2008	14.24.520 E	34.25.600 S	0 - 250
20	SUPER 1	18	20/02/2008	13.07.120 E	36.31.310 S	0 - 300
38	LARGE 2B	31	26/02/2008	09.55.360 E	41.11.400 S	0 - 300
45	SUPER 2	34	28/02/2008	08.56.050 E	42.28.110 S	0 - 250
52	LARGE 3B	41	1/03/2008	06.53.070 E	44.53.880 S	0 - 300
58	LARGE 4A	44	3/03/2008	05.52.390 E	46.01.010 S	0 - 200
62	SUPER 3	48	4/03/2008	04.22.610 E	47.33.160 S	0 - 250
71	LARGE 5B	52	7/03/2008	02.49.920 E	49.01.680 S	0 - 250
78	LARGE 6A	57	9/03/2008	01.18.930 E	50.22.480 S	0 - 250
83	SUPER 4	62	10/03/2008	00.00.040 E	51.50.870 S	0 - 250
100	LARGE 7A	73	14/03/2008	00.00.021 W	55.34.140 S	0 - 250
108	SUPER 5	78	16/03/2008	00.02.252 W	57.33.161 S	0 - 270

4.3.3.5 NEW AND TOTAL PRODUCTION IN THE ATLANTIC SECTOR OF THE SOUTHERN OCEAN – BONUS-GOODHOPE RESEARCH CRUISE;

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Introduction:

New production fluxes south of the Sub-Tropical Front (STF), particularly in the Sub-Antarctic Zone (SAZ) between 40 – 50°S are thought to make this region one of the most important oceanic sinks of atmospheric CO₂. This sink is driven by two main mechanisms: dissolution and subduction i.e. the “solubility pump” as well as phytoplankton export fluxes, the “biological pump”. The work undertaken on the Bonus-Goodhope Cruise focused on the characteristics and variability of the “Biological Pump”.

This region is characterised by a wide range of spatial (mesoscale features and meridional gradients) and temporal scales of variability. The basis for the variability of ocean productivity in the sub-Antarctic zone remains uncertain and the lack of observations also limits the validation of indirect model estimates to quantify productivity and export production. The BONUS-GOODHOPE research cruise has provided an opportunity to investigate physical and biogeochemical processes across the major fronts in the Atlantic sector of the Southern Ocean close to, and along, the 0° meridian.

A range of nitrogen dynamics and primary productivity experiments were conducted to investigate the role of the SAZ in respect of carbon sequestration via the biological pump. Hourly (day vs night) and daily rates of new- and total production within the euphotic zone will be estimated from the uptake rates of NO₃-N, NH₄-N, urea-N and carbon using ¹⁵N- and ¹³C-labelled salts. N- and C-uptake rates were also targeted in the micro- nano- and pico-plankton size fractions using surface water samples. This suite of experiments was supplemented by a series of three, 6-day incubations. These were designed to determine the new production (and hence carbon export) response of the ambient phytoplankton assemblage to the addition of iron. Experiments were conducted in iron-replete

and –depleted oceanic environments. Net community production and gross primary production (which provides an estimate of export production, similar to the f -ratio) were determined using O_2/Ar and the triple oxygen isotope method. A high resolution underway sampling strategy was adopted using an equilibrator inlet mass spectrometer (EIMS), as well as discrete samples collected during rosette deployments.

In summary, the following work was undertaken:

- ^{15}N and ^{13}C tracer production experiments.
- New production response to iron addition.
- Natural abundance isotope variability
- Oxygen triple isotopes: Net Community Production

There should be useful synergies arising from the comparative analysis of carbon export fluxes derived from these two techniques (^{15}N uptake and O_2/Ar) and those that measure sub-seasonal (Th) and seasonal (Po) particle export fluxes.

Methods

Production Measurements:

Production measurements were undertaken using bulk water samples obtained from the 100, 50, 25, 10 and 1% light levels of the CTD Mixed Layer Depth (MLD) cast (LARGE stations, type A and B and SUPER stations). Occasionally, opportunistic sampling was undertaken at Hydrocast stations from water within the surface mixed layer (SML). These lower-volume bulk samples were used for the 50% light level, short-term incubations aimed at determining hourly day-time and night-time rates of N-uptake. In all cases, three, 2L sub-samples were pre-screened into borosilicate glass bottles (through a 200 μ m mesh to exclude grazers); for each light depth of the MLD cast as well as the single bulk sample from the SML short-term experiments. $^{15}NO_3-N$, $^{15}NH_4-N$ and $^{15}urea-N$ salts were added to the respective sub-samples from the light depths and SML sub-samples and, in addition, ^{13}C salt was added to the $^{15}NO_3-N$ bottle. ^{15}N and ^{13}C tracers were added at $\leq 10\%$ of ambient nutrient concentrations. The bottles were incubated at simulated *in situ* light levels on deck and maintained at SST by continuous sea-water flow. The period of incubation was approximately 24h for the MLD and 4h for the short-term experiments. Experiments were terminated by filtration onto pre-ashed 47mm GF/F filters, which were then dried at 75°C and retained for particulate nitrogen, carbon and ^{15}N analysis. Initial concentrations of ammonium-N and urea-N were determined manually by colourimetric method and initial nitrate-N concentrations were available from the autoanalyser results. Size-fractionated (<2 μ m, 2 – 20 μ m and 20 – 200 μ m) chlorophyll-a and phaeo-pigments were determined fluorometrically for one bulk sample in the SML.

Size fractionated production at the surface

Size fractionated nitrogen uptake and carbon fixation experiments were conducted using 20L bulk surface samples obtained using a plastic bucket. The bulk sample was pre-screened (200 μ m) and divided into three, 6L sub-samples,

contained in clear polycarbonate incubation cylinders. The sub-samples were spiked *pro rata* with $^{15}\text{NO}_3\text{-N}$, $^{15}\text{NH}_4\text{-N}$, and $^{15}\text{urea-N}$ salts. A proportional amount of ^{13}C salt was also added to the $^{15}\text{NO}_3\text{-N}$ bottle. The 3 samples were incubated at the simulated 50% light level, for 24h in each experiment. Each sample was then post-fractionated at $<20\mu\text{m}$ and $<2\mu\text{m}$ and filtered onto 47mm GF/F filters. Nitrogen uptake and carbon fixation rates will therefore be estimated for the $<2\mu\text{m}$, 2 – 20 μm and 20 – 200 μm (micro-, nano, and pico-) size fractions. Initial nutrient concentrations were obtained as previously. Size-fractionated ($<2\mu\text{m}$, 2 – 20 μm and 20 – 200 μm) chlorophyll-a and phaeo-pigments were determined fluorometrically on the initial bulk sample.

Nitrate uptake / Iron addition experiments

These experiments were conducted in waters with both low and high nitrate-N concentrations. It is assumed that the latter environment was a high nutrient, low chlorophyll (HNLC) area and hence iron-limited. Each experiment lasted for a total of 5-6 days. Broadly speaking, the experiment was designed to investigate the phytoplanktonic nitrate uptake response (new production/carbon export) to the addition of iron in a HNLC area. It was necessary to follow trace metal clean protocols during the set-up and execution of this experiment and we were fortunate to have the advice and facilities of colleagues on board (most specifically, Dr Bronwyn Wake). A mixed, bulk sample (36L) was collected in the euphotic zone using Go-Flo bottles on a Kevlar cable, sampled in a clean container and divided into thirty six, 1L sub-samples. The sub-samples were pre-screened (200 μm) and poured into acid-cleaned polycarbonate bottles. Eighteen of these bottles were spiked with $^{15}\text{NO}_3\text{-N}$ at $<10\%$ of the ambient $\text{NO}_3\text{-N}$ concentration. The remaining 18 bottles were similarly treated and, in addition, 2 nano-moles of Fe were added. The 36 bottles were then incubated at a simulated 50% light level. This made it possible to run a 6 day experiment with 3 controls ($^{15}\text{NO}_3\text{-N}$ only) and 3 iron-enriched ($^{15}\text{NO}_3\text{-N} + \text{Fe}$) sub-samples being removed each day (T1, T2, T3, T4, T5 and T6). It is hoped that this will give a time-series of nitrate uptake response. After removal from the incubator, a 100ml sub-sample was removed from one control and one iron-enriched bottle for iron-contamination tests and 1ml was removed for flow-cytometry analysis to determine the response of the phytoplankton assemblage during the 6 day experiment. Note that this was also done on To samples prior to the commencement of the experiment. Initial nitrate-N concentration was determined as described previously.

Natural Abundance Isotope Variability

The objective of this part of the programme is to characterize the variability of POC/PON, ^{13}C and ^{15}N in the surface waters across the southern ocean. 2L samples were collected from the ships intake water supply every 8 hours. The samples were frozen and retained for particulate nitrogen and ^{15}N analysis.

Oxygen isotopes NCP (EIMS)

High resolution measurement of the spatial variability of net community production using the O₂/Ar ratio and gross primary production oxygen triple isotope method was conducted underway. Anomalies of O₂/Ar relative to the long term atmospheric mean are driven by net autotrophic or heterotrophic activity. The export of carbon leaves a net positive anomaly that can be related to the net community production. The oxygen triple isotope ratios are used to derive estimates of gross primary production.

A continuous flow system that draws from the ship's scientific seawater supply was linked to a micro capillary equilibrator that separates the gas and water phases. The gas phase was analyzed on board using a Pfeiffer quadrupole mass spectrometer. The system included an Aanderraa oxygen optode and a number of thermocouples used to continuously monitor the temperature at each stage of the sampling cycle. The sampling period was < 30 seconds.

The underway system was calibrated using samples collected through the same lab seawater supply in evacuated flasks for later analysis in dual inlet mass spectrometer. The discrete lab samples were compared to *in situ* samples of surface water taken periodically from the Rosette. Small differences in the oxygen concentrations were monitored through periodic simultaneously sampling of both lab supply and surface waters for Winkler analysis.

Station information is summarized in Table 20– Table 24.

Table 20	¹⁵ N Production incubations station and sampling information for mixed layer depth casts during LARGE stations on the BONUS GOODHOPE transect.
Table 21	¹⁵ N Production incubations station and sampling information for mixed layer depth casts during SUPER stations on the BONUS GOODHOPE transect.
Table 22	Size fractionation production incubations and short term production incubation station and sampling information for surface samples on the BONUS GOODHOPE transect. O ₂ /Ar samples were also collected at all the mixed layer depth casts.
Table 23	Natural abundance isotope variability samples collected underway from the ships scientific seawater supply system.
Table 24	O ₂ /Ar samples collected underway from the ship's scientific seawater supply as well as from surface rosette samples, for comparison between these two water sources.

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Table 20 – ¹⁵N Production incubations station and sampling information for mixed layer depth casts during LARGE stations on the BONUS GOODHOPE transect.

Station	Station Label	CTD	mon/day/yr	Lat (°N)	Lon (°E)	% light	Depth [m]	Sample volume (L)
11	11 L1	12	02/17/2008	-34.43	14.41	100	1	6
11	11 L1	12	02/17/2008	-34.43	14.41	50	5	6
11	11 L1	12	02/17/2008	-34.43	14.41	25	10	6
11	11 L1	12	02/17/2008	-34.43	14.41	10	50	6
11	11 L1	12	02/17/2008	-34.43	14.41	1	80	6
31	31 L2 B	38	02/26/2008	-41.19	9.92	100	3.5	6
31	31 L2 B	38	02/26/2008	-41.19	9.92	50	3.5	6
31	31 L2 B	38	02/26/2008	-41.19	9.92	25	7	6
31	31 L2 B	38	02/26/2008	-41.19	9.92	10	15	6
31	31 L2 B	38	02/26/2008	-41.19	9.92	1	36	6
41	41L3	52	03/01/2008	-44.90	6.88	100	20	6
41	41L4	52	03/01/2008	-44.90	6.88	50	20	6
41	41L5	52	03/01/2008	-44.90	6.88	25	20	6
41	41L6	52	03/01/2008	-44.90	6.88	10	40	6
41	41L7	52	03/01/2008	-44.90	6.88	1	60	6
44	44LA	58	03/03/2008	-46.02	5.87	100	11	6
44	44LA	58	03/03/2008	-46.02	5.87	50	11	6
44	44LA	58	03/03/2008	-46.02	5.87	25	21	6
44	44LA	58	03/03/2008	-46.02	5.87	10	21	6
44	44LA	58	03/03/2008	-46.02	5.87	1	48	6
52	52 L5 B	71	03/07/2008	-49.03	2.83	100	5	6
52	52 L5 B	71	03/07/2008	-49.03	2.83	50	5	6
52	52 L5 B	71	03/07/2008	-49.03	2.83	25	10	6
52	52 L5 B	71	03/07/2008	-49.03	2.83	10	15	6
52	52 L5 B	71	03/07/2008	-49.03	2.83	1	60	6
57	57 L6 B	78	03/09/2008	-50.37	1.32	100	1	6
57	57 L6 B	78	03/09/2008	-50.37	1.32	50	1	6
57	57 L6 B	78	03/09/2008	-50.37	1.32	25	10	6
57	57 L6 B	78	03/09/2008	-50.37	1.32	10	15	6
57	57 L6 B	78	03/09/2008	-50.37	1.32	1	80	6
72	72LB	100	03/14/2008	-55.57	0.004	100	5	6
72	72LB	100	03/14/2008	-55.57	0.004	50	5	6
72	72LB	100	03/14/2008	-55.57	0.004	25	13	6
72	72LB	100	03/14/2008	-55.57	0.004	10	24	6
72	72LB	100	03/14/2008	-55.57	0.004	1	109	6

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Table 21 – ¹⁵N Production incubations station and sampling information for mixed layer depth casts during SUPER stations on the BONUS GOODHOPE transect.

Station	Station Label	CTD	mon/day/yr	Lat (°N)	Lon (°E)	% light	Depth [m]	Sample volume (L)
18	18 S1	20	02/20/2008	-36.52	13.12	100	3.4	6
18	18 S1	20	02/20/2008	-36.52	13.12	50	7.5	6
18	18 S1	20	02/20/2008	-36.52	13.12	25	14.2	6
18	18 S1	20	02/20/2008	-36.52	13.12	10	39.7	6
18	18 S1	20	02/20/2008	-36.52	13.12	1	53.7	6
18	18 S1	22	02/21/2008	-36.51	13.12	100	1	6
34	34 S2	45	02/28/2008	-42.47	8.93	100	3	6
34	34 S2	45	02/28/2008	-42.47	8.93	50	5	6
34	34 S2	45	02/28/2008	-42.47	8.93	25	10	6
34	34 S2	45	02/28/2008	-42.47	8.93	10	22	6
34	34 S2	45	02/28/2008	-42.47	8.93	1	50	6
48	S3 (MLD)	62	03/04/2008	-47.55	4.38	100	3.77	6
48	S3 (MLD)	62	03/04/2008	-47.55	4.38	50	3.77	6
48	S3 (MLD)	62	03/04/2008	-47.55	4.38	25	9	6
48	S3 (MLD)	62	03/04/2008	-47.55	4.38	10	20	6
48	S3 (MLD)	62	03/04/2008	-47.55	4.38	1	59	6
62	62 S4	83	03/10/2008	-51.85	0.00	100	5	6
62	62 S4	83	03/10/2008	-51.85	0.00	50	5	6
62	62 S4	83	03/10/2008	-51.85	0.00	25	10	6
62	62 S4	83	03/10/2008	-51.85	0.00	10	25	6
62	62 S4	83	03/10/2008	-51.85	0.00	1	125	6
80	S5	108	03/16/2008	-57.55	0.04	100	5	6
80	S5	108	03/16/2008	-57.55	0.04	50	5	6
80	S5	108	03/16/2008	-57.55	0.04	25	10	6
80	S5	108	03/16/2008	-57.55	0.04	10	30	6
80	S5	108	03/16/2008	-57.55	0.04	1	90	6

– BONUS-GOODHOPE Cruise Report –

Table 22 – Size fractionation production incubations and short term production incubation station and sampling information for surface samples on the BONUS GOODHOPE transect. O₂/Ar samples were also collected at all the mixed layer depth casts.

Station	Station Label	CTD	experiment	mon/day/yr	Lat (°N)	Lon (°E)	% light	Depth	Sample volume (L)
15	15 Hydro	16	SF	02/18/2008	-35.63	13.68	100	surface	18
18	18 S1 SF	22	SF	02/21/2008	-36.31	13.07	100	surface	18
27	27 SF	27	SF	02/23/2008	-37.55	12.35	100	surface	18
29	29 SF	34	SF	02/25/2008	-40.29	10.55	100	surface	18
42	42	55	Day	03/02/2008	-45.33	6.50	100	ML	6
47	47 SF	61	SF	03/04/2008	-47.32	4.62	100	surface	18
48	S3	66	SF	03/06/2008	-47.56	4.37	100	surface	18
62	62 S4	85	Night	03/10/2008	-51.86	0.01	100	ML	6
65	65Int	90	Day	03/12/2008	-52.93	0.00	100	ML	6
70	70SF	96	SF	03/13/2008	-54.58	0.00	100	1	18
76	76SF	104	SF	03/15/2008	-56.76	0.01	100	1	18

SF : size fractionated incubation

Day: short term daytime incubation.

Night: short term nighttime incubation.

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Table 23 – Natural abundance isotope variability samples collected underway from the ships scientific seawater supply system.

Date + UTC	Underway Natural Abundance samples			
	FilterNumber	Time	Lat	Long
16/02/2008 14:00	bgh1	14h10	34o04.76	15o04.10
16/02/2008 22:00	bgh2	21h40	34o07.329	14o34.956
17/02/2008 06:00	bgh3	06h00	34o25.560	14o24.320
17/02/2008 14:00	bgh4	14h05	34o31.931	14o20.025
17/02/2008 22:00	bgh5	22h00	34o53.746	14o07.188
18/02/2008 06:00	bgh6	05h55	35o15.031	13o54.571
18/02/2008 14:00	bgh7	16h20	35o37.514	13o41.012
18/02/2008 22:00	bgh8	21h45	35o55.316	13o31.945
19/02/2008 06:00	bgh9	08h15	35o15.5	13o29.8
19/02/2008 14:00	bgh10	16h05	36o26.531	13o10.457
19/02/2008 22:00	bgh11	22h00	36o31.248	13o07.104
20/02/2008 06:00	bgh12	06h00	36o31.257	13o07.140
20/02/2008 14:00	bgh13	16h00	36o31.252	13o07.130
20/02/2008 22:00	bgh14	21h55	36o31.820	13o07.342
21/02/2008 06:00	bgh15	06h10	36o30.712	13o07.330
21/02/2008 14:00	bgh18	16h10	36o27.534	13o06.059
21/02/2008 22:00	bgh19	21h45	36o29.781	13o06.657
22/02/2008 06:00	bgh20	06h03	36o27.547	13o07.201
22/02/2008 14:00	bgh21	13h55	36o47.343	12o56.477
22/02/2008 22:00	bgh22	22h00	37o24.889	12o32.873
23/02/2008 06:00	bgh23	06h05	37o42.949	12o21.138
23/02/2008 14:00	bgh24	15h15	38o05.511	12o05.123
23/02/2008 22:00	bgh25	21h50	38o27.516	11o49.784
24/02/2008 06:00	bgh26	06h10	38o49.561	11o34.498
24/02/2008 22:00	bgh28	21h55	39o33.54	11o03.73
25/02/2008 06:00	bgh29	06h30	40o17.457	10o33.003
25/02/2008 14:00	bgh31	14h15	40o43.939	10o12.880
25/02/2008 22:00	bgh32	21h45	41o10.693	9o54.999
26/02/2008 06:00	bgh33	06h30	41o36.548	9o35.033
26/02/2008 14:00	bgh34	14h00	42o02.245	9o16.246
27/02/2008 06:00	bgh35	05h50	42o28.144	8o55.725
27/02/2008 14:00	bgh37	14h05	42o28.134	8o55.731
27/02/2008 22:00	bgh38	06h10	42o28.12	8o55.96
28/02/2008 06:00	bgh39	08h20	42o28.11	8o56.01
28/02/2008 14:00	bgh40	14h00	42o53.619	8o33.941
28/02/2008 22:00	bgh41	22h00	43o19.78	8o13.67
29/02/2008 06:00	bgh42	06h30	44o02.4638	7o37.910
29/02/2008 14:00	bgh43	14h00	44o12.9901	7o29.1520
02/03/2008 06:00	bgh45	08h30	45o19.308	6o30.775
02/03/2008 14:00	bgh46	14h00	45o31.4105	6o19.185
02/03/2008 22:00	bgh47	20h00	45o50.260	6o00.258
03/03/2008 06:00	bgh48	06h43	46o00.9026	5o52.5160
03/03/2008 14:00	bgh49	14h00	46o21.396	5o32.66
03/03/2008 22:00	bgh50	22h00	46o50.7856	5o04.3836
04/03/2008 06:00	bgh51	08h30	47o19.064	4o37.2075

Table 23– Continued

	Underway Natural Abundance samples			
	FilterNum	Time	Lat	Long
04/03/2008 22:00	bgh52	22h00	47o33.1654	4o22.363
05/03/2008 06:00	bgh53	11h50	47o32.8733	4o22.0924
05/03/2008 22:00	bgh54	11h10	47o46.1869	4o09.4437
06/03/2008 22:00	bgh55	22h00	48o22.7728	3o31.5045
07/03/2008 22:00	bgh56	21h45	49o01.6828	2o49.93
08/03/2008 14:00	bgh57	10h00	49o49.9685	1o55.7695
08/03/2008 22:00	bgh59	20h45	50o07.8974	1o36.1175
09/03/2008 06:00	bgh60	10h30	50o38.1074	00o56.7079
09/03/2008 14:00	bgh61	20h30	51o10.2409	00o20.0162
10/03/2008 06:00	bgh62	10h15	51o52.1379	00o00.8109
10/03/2008 14:00	bgh63	22h00	51o51.4821	00o00.6702
11/03/2008 22:00	bgh64	00h50	52o16.3845	00o00.1633
13/03/2008 06:00	bgh69	06h00	54o15.012	0o00.0
13/03/2008 14:00	bgh66	11h34	54o39.9116	0o04.2234
13/03/2008 22:00	bgh67	00h10	55o14.0238	00o02.3864
14/03/2008 14:00	bgh68	16h00	55o54.2646	00o06.7938
15/03/2008 14:00	bgh85	13h30	57o12.7345	0o06.7966
16/03/2008 22:00	bgh84	22h00	57o33.1471	00o02.1885
17/03/2008 22:00	bgh83	22h00	55o52.4537	01o55.4469
18/03/2008 14:00	bgh82	14h00	53o41.073	04o42.297

Table 24 – O₂/Ar samples collected underway from the ship's scientific seawater supply as well as from surface rosette sampling sources.

Date	station #	ctd #	Station type	Lat	Lon	O ₂ /Ar (lab)	O ₂ /Ar(cast)	DO bottle #
17/02/2008	11	11	ML (LARGE)	34o25.5	14o24.3	x	1024	324
20/02/2008	18	19	S1	36o31.3	13o07.1	x	1004	321
21/02/2008	18	21	S1	36o31.3	13o07.1	x	x	451
24/02/2008	27	32	HYDRO	39o33.5	11o03.7		1062	x
25/02/2008	29	34	HYDRO	40o17.5	10o33.0	935	66	x
25/02/2008	31	37	L2	41o10.6	9o55.0	x	1021	318
27/02/2008	34	43	S2	42o28.3	8o56.1	1026	1064	114
28/02/2008	34	45	S2 (ML)	42o28.1	8o56.0	x	1040	169
28/02/2008	36	47	HYDRO	43o19.8	8o13.7	x	877	118
29/02/2008	38	49	HYDRO	44o02.5	7o37.9	x	57	161
01/03/2008	41	51	ML (LARGE)	44o53.9	6o53.1	110	x	339
02/03/2008	42	56	HYDRO	45o19.3	6o30.8	849	82	469
02/03/2008	43	56	HYDRO	45o36.5	6o12.6	x	98	x
03/03/2008	44	57	ML (LARGE)	46o00.9	5o52.6	64		325
03/03/2008	46	60	HYDRO	46o43.3	5o11.8		1077	26
04/03/2008	48	63	S3 (ML)	47o33.3	4o22.6	37	72	49
05/03/2008	48	65	S(Th-cast)	47o33.3	4o22.6	929	856	x
06/03/2008	49	67	HYDRO	47o58.2	3o57.5	1061	1201	119
07/03/2008	52	71	ML (LARGE)	49o01.7	2o49.9	39	1006	83
08/03/2008	53	73	HYDRO	49o34.1	2o14.2	840	928	109
08/03/2008	55	75	HYDRO	49o50.5	1o55.8	4	850	119
08/03/2008	57	78	ML (LARGE)	50o22.5	1o18.9	846	843	x
09/03/2008	59	80	HYDRO	50o54.2	0o039.3	93	955	169
10/03/2008	62	83	S4 (ML)	51o51.0	0o00.0	997	9	73
12/03/2008	65	90	HYDRO	52o56.3	0o00.0	899	1092	48

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Date	station #	ctd #	Station type	Lat	Lon	O2/Ar (lab)	O2/Ar(cast)	DO(lab)		DO (cast)	
								bottle #	ml/l	bottle #	ml/l
12/03/2008	66	92	HYDRO	53o15.7	00o00.1	891	949	110	7.815	46	7.815
13/03/3008	70	94	HYDRO	54o34.8	00o00.0	932	938	328		x	
13/03/2008	72	96	HYDRO	55o14.4	0o00.0	904	115	412	7.836	155	7.827
14/03/2008	73	100	ML (LARGE)	55o34.1	00o00	947	1018	122	7.745	81	7.832
14/03/2008	74	102	HYDRO	55o54.3	00o06.8	87	976	418	7.968	407	7.883
15/03/2008	76	105	HYDRO	56o46	00o00	x	1031	484	7.887	162	7.907
16/03/2008	78	108	S5 (ML)	57o33.2	00o02.3	x	x	499	7.879	459	7.768
17/03/2008			Intake	56o13.8	1o54.3	902	x	x		x	
18/03/2008			Intake	54o47.7	3o06.8	114	x	x		x	
18/03/2008			intake	53o41.1	04o42.3	1070	x	x		x	
18/03/2008			Provov	52o58	5o48	116	908	x		x	
18/03/2008			intake	52o16.8	06o51.0	107	x	X		x	
18/03/2008			Provov	50o38.9	9o14.2	1052	1062	X		x	
19/03/2008			intake	48o09.0	12o46.9	956	x	X		x	
19/03/2008			Provov	49o15.7	11o13.6	105	1076	x		x	
20/03/2008			intake	46o29.8	15o01.8	40	x	x		x	
20/03/2008			intake	44o06.2	18o48.7	832	x	x		X	
21/03/2008			intake	42o49.9	20o53.3	1089	x	x		X	
21/03/2008			Provov					x		X	

Table 24 – Continued

4.3.3.6 SPECIFIC BIOGENIC COMPOUNDS

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The content and carbon isotopic composition of specific organic compounds (total lipid extract and phospholipids derived fatty acids) characteristic for specific plankton groups (diatoms, dinoflagellates, coccolithophorids) will be assessed to yield information on (i) the contribution of major phytoplankton groups to the suspended organic carbon pool; (ii) differential changes of the lipid constituents with depth (and age) and (iii) possible alteration of $\delta^{13}\text{C}$ isotopic signatures during remineralization. Samples were taken by large volume in-situ pumps fitted with nylon screens (cut-off 50 μm) and QMA quartz filters (cut-off 1 μm). Samples were deep frozen and saved for later analysis. A modified Bligh and Dyer extraction method will be applied on samples to extract total lipids, and after silylation, samples will be analyzed on GC-MS and GC-c-IMRS to assess $\delta^{13}\text{C}$ isotopic signatures and compounds determination in the home based laboratory (VUB).

ISP Cast #	Station type	Station	Date	Long	Lat	depth range
1	SUPER 1	18	20/2/2008	13.07.14 E	36.31.25 S	50 - 750m
2	SUPER 1	18	20/2/2008	13.07.33 E	36.31.80 S	1250 - 4700m
3	SUPER 1	18	21/2/2008	13.06.70 E	36.29.60 S	75 - 2700m
4	SUPER 2	34	27/2/2008	08.55.72 E	42.28.13 S	75 - 3950m
5	SUPER 2	34	28/2/2008	08.55.96 E	42.28.11 S	30 - 1450m
6	SUPER 3	48	5/3/2008	04.22.16 E	47.33.16 S	1000 - 4400m
7	SUPER 3	48	6/3/2008	04.22.84 E	47.33.06 S	20 - 550m
8	SUPER 4	62	10/3/2008	00.00.00 E	51.51.33 S	40 - 2500m
9	SUPER 4	62	11/3/2008	00.00.00 E	51.51.33 S	30 - 2500m
10	SUPER 5	78	16/03/08	00.02.19 W	57.33.14 S	50 - 3900m
11	SUPER 5	78	17/03/08	00.03.03 W	57.33.08 S	20 - 2500m

Table 25 – In Situ Pump casts sampled for biomarkers

4.3.3.7 BORON ISOTOPES IN THE SOUTHERN OCEAN

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Introduction and scientific objectives

Increasing acidity of the surface ocean, in response to anthropogenic emission of CO₂ into the atmosphere, is a subject of preoccupation as it may have severe consequences for marine calcifying organisms, which build their external skeleton out of calcium carbonate CaCO₃ (Orr et al., 2005). During the last 200 years, roughly fifty per cent of the anthropogenic CO₂ (IPCC, 2005) contributed to the acidification of the superficial ocean by 0.1 pH-units, and sea surface pH could drop to ~ 0.4 units by the year 2100 if carbon emission increases on the present-day trend (Caldeira and Wickett, 2003). Quantifying changes of the oceanic pCO₂ over the last centuries and over thousands of years is therefore of importance to better evaluate links between oceanic and atmospheric changes of pCO₂ and their consequences on ecosystems. Past sea surface pH may be deduced from the boron isotopic composition ($\delta^{11}\text{B}$) of biogenic carbonates such as foraminifera and surface or deep-sea corals. This “ $\delta^{11}\text{B}_{\text{carbonate}} - \text{pH}_{\text{seawater}}$ ” indicator would have the potential to calculate seawater pH change of 0.02 pH-unit in the past only if different assumptions are verified. Among the assumptions, it’s commonly considered that the isotopic composition of boron (long residence time) for seawater is homogeneous in the Global Ocean about 40 ‰. Here, we suggested to precisely measuring this parameter ($\delta^{11}\text{B}_{\text{SW}}$) on MC-ICPMS in order to verify its stability, first, in different geographical locations and second in the water column, especially in the oxygen minimum zone.

Methods

141 seawater samples were collected for Boron analyses.

50 ml of seawater were collected for depth profile (14-20 depths) using Niskin bottles in the five SUPER stations and LARGE stations 1, 4, 5 and 7. Seawater was poisoned with 1 drop of saturated HgCl₂ solution.

Station	L1 - St11	S1 - St18	S2 - St34	L4 - St44	S3 - St48	L5 - St52	S4 - St62	L7 - St72	S5 - St78
hydro cast	15	14	14	14	14	15	14	15	20
tap			1		1	1	1	1	1

Once back in the lab, Boron in seawater samples will be extracted and purified on anion exchange resin Amberlite IRA 743. About 5 ml is used for this extraction. The isotopic composition of boron will be measured by using new generation of mass spectrometer MC-ICPMS with a precise bracketing approach.

4.3.4 TRACE METALS AND INTERNAL CYCLE OF TRACE METALS



The distribution of trace metals and their interaction with the microbial food-web strongly depend on their speciation in seawater which controls their solubility, residence time in surface waters, and bio-availability. The speciation of trace metals is described by the different size-classes (particulate, dissolved, colloidal, soluble) and by the different chemical forms (organic, inorganic, oxidation state). The chemical speciation of dissolved trace metals is often dominated by complexation with organic ligands, which may increase both their residence time and bioavailability. Complexation with small organic colloids can furthermore be significant for Fe speciation and bioavailability. The origin of the organic ligands is not fully understood yet, but phytoplankton or heterotrophic bacteria can represent a significant source. The redox cycle can also be important for the speciation of at least Fe, especially in the cold waters of the Southern Ocean and at continental margin interfaces increasing both its solubility and availability. A better understanding of the speciation of these trace metals and of the processes involved in their biogeochemical cycling, including interactions with the microbial food web, is urgently needed in order to improve our understanding of the mutual dependencies between trace element occurrence and phytoplankton community composition.

4.3.4.1 GO-FLO'S SAMPLES AND TRACE METALS ON DECK INCUBATIONS

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GO-FLO samples

Onboard: Johann Bown, Marie Boye, Eva Bucciarelli, Fanny Chever, Warren Joubert, Pedro Monteiro, François Lacan, Amandine Radic, Géraldine Sarthou, Sandy Thomalla, Howard Waldron, Bronwyn Wake.

Not onboard: Eric Achterberg, Peter Croot, Gideon Henderson, Rémi Losno, Sonja Ripperger, Constant van den Berg.

4.3.4.1.1.1 Trace Elements and Isotopes sampled with GO-FLO's bottles

Sampling strategy

The stations positions were selected in order to cover at most the vertical distribution of TEI's in the interfrontal regions crossed by the transect, as well as some of the frontal systems, the region of the Mode Waters formation and an anticyclonic eddy originated from the Agulhas Current retroflexion (e.g., SUPER-1 station). The sampling depths were selected to characterise the several water masses encountered in the water column, especially the Mode Waters, the Antarctic Intermediate Waters, the North Atlantic Deep Waters and the Circumpolar Deep Waters.

Ultra-clean sampling

The water samples for trace metals (Zn, Fe, Co, Al,), isotopes (Fe-IC; Cd-IC), and trace-metals on deck incubations were collected with 10 pre-cleaned 12 L GO-FLO bottles (LEMAR, FR) suspended to a Kevlar wire (NIOZ, NL). The Kevlar line was rolled up on a freshly epoxy-coated winch (IPEV) and operated with three trace-metal free pulleys (one directional for the winch, one of "return", and one counting-pulley). 10 depths were sampled at the 7 LARGE stations between surf.-2000 m and 20 depths at the 5 SUPER stations between surf.-4000 m for the trace metals by a mean of two Go-Flo casts, while only the 5 SUPER stations were sampled for the Fe and Cd-IC, and 3 to 4 SUPER stations at the maximum of fluorescence for the trace metals incubations.

Wire angle correction will be made using the "Microcat" depth sensor that was attached to the bottom of the line when maximal depth permitting (> 3500 m). Depth will further be calibrated using the nutrients analyses that were made in selected GO-FLO bottles.

The GO-FLO bottles were closed by means of Teflon messengers, and were placed in a trace-metal clean container (INSU) after retrieval.

The samples were filtered using 0.2 microm polycarbonate cartridges SARTOBAN Sartorius for dissolved trace metals and dissolved Cd-IC; using 0.4 microm polycarbonate filters mounted in a Teflon filter holder for dissolved and particulate Fe-IC; and using

prescreens (200 µm) for the incubations. All filtrations were made directly from the Teflon tape Go-Flo bottle under a free-metal nitrogen pressure of 0.1 bar.

Preliminary results of dissolved iron concentrations recorded on board indicated that the whole device and the sampling procedure were not introducing contamination for this element (see Report Chever *et al.*).

Scientific subprojects achieved with the GO-FLO sampling

The scientific topics achieved with collecting samples using the ultra-clean GO-FLO and device (Kevlar line and epoxy-coated winch) are listed here below. The objectives of each subtopic and preliminary results when available are in the several reports, except for subtopics 4, 6, 8, 9 and 10. The details of the sampling list, station positions and depths are all reported in Annexe

Subproject 1: dissolved and particulate multi-trace metals distribution in the Southern Ocean (*B. Wake, M. Boye, E. Achterberg*)

Subproject 2: particulate, dissolved and soluble iron (*F. Chever, G. Sarthou, E. Bucciarelli*)

Subproject 3: redox cycle of iron (*G. Sarthou*)

Subproject 4: organic speciation of dissolved iron and humic substances (*S. van den Berg*)
About 170 samples have been collected for dissolved iron analyses, its organic complexation, and humic substances determinations in low density polyethylene bottles (cleaned by J. Bown and M. Boye) and stored at -20°C. The samples will be analysed in Liverpool University (U.K.) in the group of S. van den Berg by the use of voltammetry and FIA-chemiluminescence methods.

Subproject 5: dissolved zinc, cobalt, cadmium distribution and organic speciation in the Southern Ocean (*J. Bown, M. Boye*)

Subproject 6: dissolved copper and/or manganese distribution and complexation (*M. Boye*)
Copper and manganese are essential micro-nutrients. Furthermore it was realized that Cu may act in reductive dissociation of Fe-organic complexes at the cell surface, hence facilitates iron uptake and phytoplankton growth. Additionally the external sources of trace metals into the oceans are either from the atmosphere (dust) or sediments, where Mn can be used as a tracer of the sedimentary iron redox cycling source. About 170 samples have been collected for dissolved copper and/or manganese analyses, the organic complexation in low density polyethylene bottles (cleaned by J. Bown and M. Boye) and stored at -20°C. The samples will be analysed at LEMAR (IUEM, FR) in the group of M. Boye by the use of voltammetry method.

Subproject 7: dissolved and particulate iron isotopic composition (*F. Lacan, A. Radic*)

Subproject 8: distribution of the dissolved cadmium isotopic composition (*G. Henderson, S. Ripperger*)
About 8 depths per SUPER station have been sampled by M. Boye for dissolved cadmium isotopic composition (e.g., about 40 samples in total) in low density polyethylene bottles of 1 to 10 L, and stored at room temperature. The samples will be analysed for their isotopic composition in cadmium by mass spectrometry in Oxford University (U.K.) in the group of G. Henderson by S. Ripperger.

Subproject 9: dissolved and particulate aluminium analytical comparison (*P. Croot, B. Wake, M. Boye*)
Aluminium can be used as an atmospheric source tracer for several trace metals, such as iron. However for this element there have been reports of contamination during storage due to release of Al from the plastic of the storage bottles. Here we have collected

duplicates samples for both particulate and dissolved Al analyses stored at pH 1.8 (nitric acid) at room temperature in low-density polyethylene bottles and in PMP bottles (cleaned by J. Bown) that will be analysed by ICPMS at NOCS (UK) by B. Wake and compared with a modified method of FIA-Chemiluminescence at IFM-GEOMAR (GR) in the group of P. Croot.

Subproject 10: dissolved trace metals analytical comparison (*M. Boye, B. Wake, J. Bown, R. Losno, F. Chever, S. van den Berg, F. Lacan, G. Henderson, S. Ripperger*) Duplicates samples for dissolved trace metals analyses stored in low-density polyethylene bottles at pH 1.8 (nitric acid) at room temperature will be analysed by ICPMS at NOCS (UK) by B. Wake, by voltammetry for Zn, Co, Cd by J. Bown at LEMAR (IUEM, FR); and compared with analyses of samples stored at pH 1.8 (HCl) in Teflon vials by ICPAES at LISA (FR) in the group of R. Losno. The dissolved iron concentrations (< 0.2 microm; expect for F. Lacan: < 0.4 microm) that will be determined by ICPMS (B. Wake; F. Lacan), FIA-Chemiluminescence (F. Chever; S. van den Berg) and ICPAES (R. Losno) will be compared in order to draw an intracomparison of the methods and procedures for dissolved iron. The dissolved cadmium concentrations (< 0.2 microm) that will be determined by ICPMS (S. Ripperger), and voltammetry (J. Bown) will be compared in order to draw an intracomparison of the methods for dissolved cadmium.

Subproject 11: co-impacts of zinc, iron, cobalt on the phytoplankton (*B. Wake, M. Boye, J. Bown*)

Subproject 12: co-impacts of iron and copper on the phytoplankton (*G. Sarthou, E. Bucciarelli, F. Chever*)

Subproject 13: impact of iron on the nitrogen uptake rate (*P. Monteiro, W. Joubert, S. Thomalla, H. Waldron, B. Wake, M. Boye*)

Subproject 14: hydrogen peroxide (*E. Bucciarelli*)

4.3.4.2 TRACE METALS (ZINC, COBALT, CADMIUM) CYCLES

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Scientific objectives

First one is to study the distributions of the micro-nutrients cobalt (Co), zinc (Zn) and cadmium (Cd) in the Southern Ocean by mean of analysis of their organic speciation and dissolved concentrations in the water column. The second objective is to further understand their biogeochemical cycles in the atlantic sector of the Southern Ocean, and their roles in the (co)limitations of the phytoplankton growth in this region, hence on the biological pump of carbon.

Protocol

The samples were collected with Go-Flo bottles attached to a Kevlar line and closed using by Teflon messengers, on every Super and Large stations with extra samples collected for the Intercalibration exercise as part of the GEOTRACES objectives. Seven LARGE stations of 10 depths (0-2000 m) and five SUPER stations of 20 depths (0-4000 m) were sampled, given about 170 samples per metal and per analysis. The samples are filtered on 0.22 µm Sartorius filter under pure N₂ pressure, and collected in LDPE clean bottles (500 ml*2 for organic speciation, 250 ml for dissolved concentrations). Organic speciation samples are stored in doubled bag and frozen at -20°C. Dissolved concentration samples are acidified with Ultrapur Acid (at pH=1.8) and stored at ambient temperature.

Method

The organic speciation and dissolved concentrations will be determined by Voltammetry at LEMAR.

References

- Ellwood *et al.* (2005). Organic complexation of cobalt across the Antarctic Polar Front in the Southern Ocean. *Marine and Freshwater Research*, 56, 1069-1075.
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- Donat, J.R. and K.W. Bruland (1998). Direct Determination of Dissolved Cobalt and Nickel in Seawater by Differential Pulse Cathodic Stripping Voltammetry Preceded by Adsorptive Collection of Cyclohexane-1,2=dione Dioxime Complexes. *Anal. Chem.*, 60, 240-244.

4.3.4.3 Fe(II) CONCENTRATIONS IN THE WATER COLUMN

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Scientific Objectives

The role of iron in limiting primary production in the oceans is now well established (Blain *et al.*, 2007; Boyd *et al.*, 2007). In oxic waters, Fe(III) is the dominant redox species, but is highly insoluble. Although Fe(II) is more soluble than Fe(III), it is rapidly oxidised by oxygen and hydrogen peroxide (Millero *et al.*, 1987). However, in the Southern Ocean, Fe(II) has been shown to exist for several hours and at elevated concentrations (~1 nM) (Croot *et al.*, 2001). The reduction of Fe(III) to Fe(II), with subsequent re-oxidation to Fe(III) is a possible mechanism by which colloidal iron is made more bioavailable to phytoplankton (Croot *et al.*, 2001).

The objectives of this work were to examine the redox state of iron along a north-south latitudinal transect in order to better understand the redox cycle of Fe(II).

Sampling and method

Depth profiles of Fe(II) were performed at the seven LARGE stations (0-2000 m) and five SUPER stations (0-bottom). Fe(II) concentrations were also measured in samples from on-board incubations (see cruise report for on-board Fe-Cu incubations). All samples were collected and processed using trace-metal clean techniques. For depth profiles, samples were collected using acid-cleaned Go-Flo bottles mounted on a 6 mm Kevlar hydrowire. The bottles were individually attached to the synthetic line and triggered at depth using Teflon messengers. Fe(II) samples were processed immediately. Sub sampling of the Go Flo bottles (60 ml) were performed in a clean container and the maximum time between sample collection and analysis was 5 min. Total (unfiltered samples) Fe(II) were collected at each station. Dissolved Fe(II) (< 0.2 µm) were also collected at Go-Flo 1 and 2.

Concentrations of Fe(II) were determined on board using a Flow Injection Method with chemiluminescence detection (Croot, Laan, 2002; Hopkison, Barbeau, 2007). The typical detection limit was 10±7 pM.

Preliminary results

Figure 45 shows depth profiles of filtered (Fe(II)_d) and total Fe(II) samples ((Fe(II))_t). Except at the shallowest and deepest depths (5.1% and 3.7%, respectively), dissolved Fe(II) represented less than 3% of total Fe(II) and were close to or lower than the detection limit.

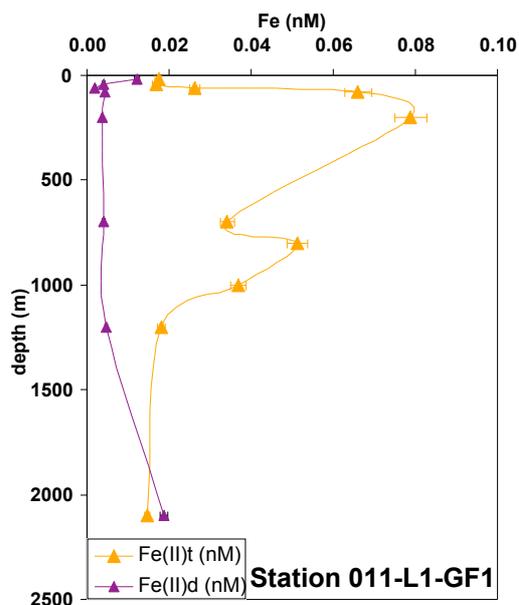


Figure 45 – Depth profiles of total and dissolved Fe(II) at station L1

On Figure 46, we reported depth profiles of Fe(II)_t and dissolved Fe (see cruise report from Chever et al.) at stations L1 and S1 (Go-Flo # 1 and 2). Fe(II)_t varied between 3 and 40% of DFe at station L1 and between 2 and 8 % of DFe at station S1.

Back in the laboratory, Fe(II) data will be processed for the other profiles and the Fe on-board incubations. Data will be delivered to the data base within the next 6 months.

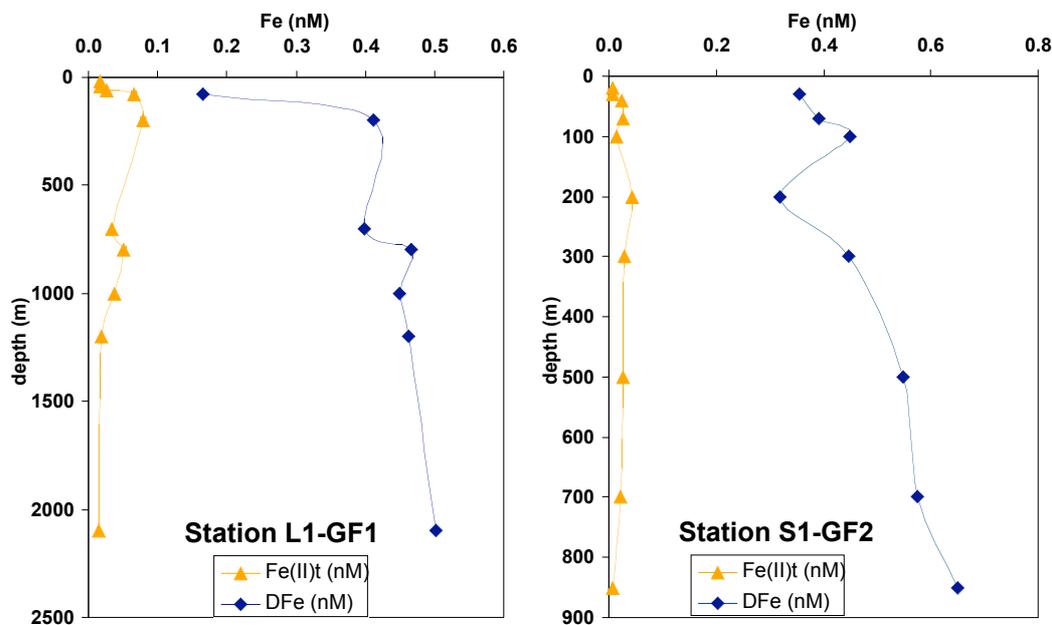


Figure 46 – Depth profiles of Fe(II)_t and DFe (see cruise report Chever et al.) at station L1 and S1.

4.3.4.4 DISSOLVED, TOTAL DISSOLVABLE AND SOLUBLE IRON CONCENTRATIONS IN THE WATER COLUMN

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Scientific objectives

The role of iron in limiting primary production and in partly controlling the structure of the planktonic community in the Southern Ocean is now well established. However, the fraction available for the phytoplankton is still unknown. The main objective is here to study the different physical (total dissolvable TDFe, dissolved DFe and soluble FeS) and redox (Fe(III) and Fe(II) (see cruise report from Sarthou et al.)) fractions of iron in seawater to better understand this topic.

Scientific and sampling strategies

Depth profiles of dissolved, total dissolvable and soluble Fe were sampled at all stations where Go-Flo casts were performed, ie the seven LARGE stations (0-2000 m) and the five SUPER stations (0-4000 m max).

Sampling and method

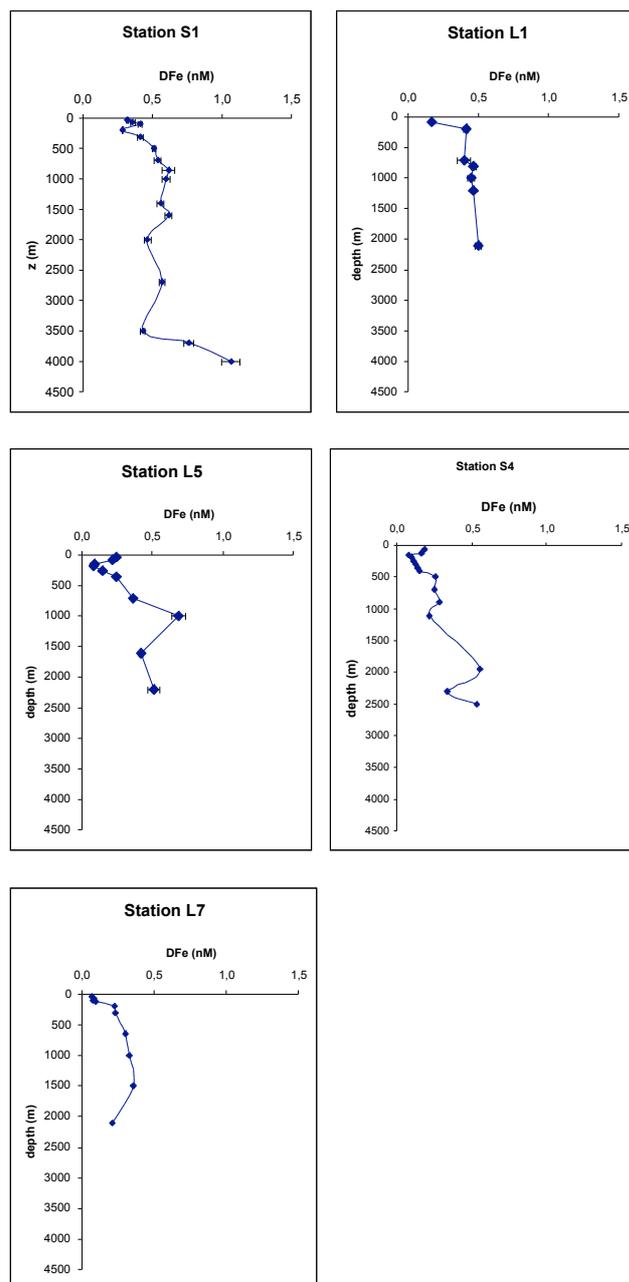
Ten Go-Flo bottles hanged on a Kevlar line were used to take samples from the surface to the bottom. Sub sampling of the Go-Flo bottles were performed in a clean container. Go-Flo bottles were gently pressured with N₂ (high purity grade) allowing on line filtration of seawater through 0.2 µm cartridges (SARTOBAN). Soluble samples were obtained by filtration of dissolved samples on 0.02 µm filters (ANOTOP 25). The samples were stored in trace metal clean 60 ml HPDE bottles and acidified by ultrapure HCl at pH 2 (as duplicates for DFe and TDFe).

The samples were stored for at least 24 h before analysis. Five profiles of DFe were determined on board using a Flow Injection Method with chemiluminescence detection, adapted from Obata *et al.* (1993). The purification of the solution of luminol through an 8-hydroxyquinoline resin column improved both the blank and detection limit of the method. The blank was determined every day. It was equal to the mean of 5 measurements of a low iron concentration sample with 0 s of preconcentration (extrapolation from the signals resulting from 10s and 120s of preconcentration). Blanks varied between 9 to 36 pM with a mean value of 23 ± 10 pM (n=8). The detection limit, equal to three times the standard deviation of the blank, ranged from 2 to 22 pM with an average value of 9 ± 6 pM (n=8). The individual contributions to the total blank of hydrochloric acid, ammonia, and ammonium acetate buffer were determined by addition of increasing amounts of these reagents in the sample and were lower than our detection limit.

Preliminary results

Erreur ! Source du renvoi introuvable. shows five profiles of DFe samples analysed on board and displays no obvious contamination. For these profiles, DFe concentrations in surface waters were lower than 0.5 nM. Concentrations increased with depth up to 1.0 nM near the bottom (station S1). These profiles are typical of the open ocean.

Figure 47 – Shown are five profiles of DFe samples analysed on board



At the laboratory, DFe profiles will be completed and duplicate samples will be analysed in order to validate our data. Total dissolvable and soluble samples will also be analysed. These data will be discussed taking into account physical and other biogeochemical parameters (water masses, nutrients, other tracers).

4.3.4.5 ON-BOARD IRON INCUBATIONS

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Scientific Objectives

The limiting role of trace metals and particularly iron (Fe) in controlling phytoplanktonic production and the structure of the planktonic community is now largely admitted in the Southern Ocean (Martin et al. 1990, Boyd et al. 2000). Fe is indeed involved in many essential cellular processes like photosynthesis, and subnanomolar concentrations of this metal are often limiting for phytoplankton growth and have a major impact on the major biogeochemical cycles (C, N, Si, S) (Watson et al. 2000, Turner et al. 2004). However, the bioavailable form of iron has still to be determined (soluble, dissolved, Fe(III), Fe(II), organic iron...). Besides, other trace metals may act as co-limiting factors. A recent study showed the role of copper (Cu) in increasing the Fe stimulation of phytoplankton growth in the Subarctic Pacific, another Fe-limited region (Cochlan et al. 2007). In this study, we aimed at better determine the effect of Fe and Fe-Cu additions on the growth parameters of the phytoplanktonic community in on-deck incubations, and the bioavailable form of Fe in these incubations.

Protocols

On-board Fe-Cu incubations were performed at SUPER stations (S1, S2, S3, and S4). Seawater for incubations was collected between 30 and 60 m, using acid-cleaned Go-Flo bottles mounted on a 6 mm Kevlar hydrowire. The bottles were individually attached to the synthetic line and triggered at depth using Teflon messengers. Seawater was gently mixed in acid-cleaned 30-l Nalgene polyethylene carboys, then immediately transferred into acid-cleaned 2.4-l Nalgene polycarbonate bottles after screening through a 200 µm mesh sieve to exclude larger organisms..

The 2.4-l experimental containers were immediately amended with iron and/or copper, macronutrients, pore waters as described below, then capped, sealed with PVC tape, and set in circulating surface seawater inside polyethylene incubators located on deck.

– BONUS-GOODHOPE Cruise Report –

Station	Position, start date	Ambient conditions	Experimental treatments
Super Station 1	36.3 S, 13.07 E 21 Feb. 2008	T = 22°C	Control (untreated) + Fe + nutrients (Si, N, P) + Fe + nutrients + Fe + Cu + nutrients + porewaters
Super Station 2	42.28 S, 08.55 E 27 Feb. 2008	T = 12°C	Control (untreated) + nutrients (Si, N, P) + nutrients + Fe + nutrients + Cu + nutrients + Fe + Cu
Super Station 3	47.33 S, 04.22 E 5 March 2008	T = 8°C	Control (untreated) + nutrients (Si, N, P) + nutrients + Fe + nutrients + Cu + nutrients + Fe + Cu
Super Station 4	51.51 S, 00.00 E 11 March 2008	T = 2°C	Control (untreated) +Cu +Fe +Fe + Cu + 2 Fe

Samples were taken for nitrate, silicate, phosphate, chlorophyll a, POC/PON, biogenic silica, cytometry, taxonomy identification, total Fe, dissolved Fe (< 0.2 µm), soluble Fe (< 0.02 µm), Fe(II), total Cu, organic Fe and Cu, and hydrogen peroxide.

Preliminary results

Most of the parameters will have to be analysed at the laboratory. Chlorophyll and nutrients were analysed on board and data have now to be processed. At first sight, it seemed that Fe additions enhanced chlorophyll levels at all stations, while Cu had different effects depending on the station.

Data delivery

Data validation and processing of nutrients and chlorophyll will take less than 6 months, allowing on time data base delivery. The analyses of the other data should be done in 12-18 months, depending on the parameter.

4.3.4.6 CO-IMPACTS OF TRACE METALS (FE, ZN, CO) ON PHYTOPLANKTON ASSEMBLAGE, GROWTH AND BIOLOGICAL PROCESSES

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Motivation

The growth of various phytoplankton species has been shown, in laboratory monoculture experiments, to be limited by various metals, these include iron, zinc and cobalt. This can be a direct limitation or a co-limitation. It has also been shown that some species are able to substitute one metal for another under deplete conditions to meet a requirement.

This work will investigate the different phytoplankton assemblages of the Southern Ocean regions and if limitation by trace metals is occurring. Field experiments (both *in situ* and bottle experiments) have shown iron addition to cause an increase in growth and cell health. Other metals have not shown as clear a response from the limited field studies done.

Method

Water was collected in the fluorescence maximum using Go-Flo bottles (trace metal clean Kevlar cable deployed). The water was processed under trace metal clean conditions. It was prescreened (200 μm) and mixed in 30 L tanks to ensure homogeneity. For incubations 1-3, 48 polycarbonate bottles (2.4 L) were used and the experiments ran for 8 days; incubation 4 was 44 polycarbonate bottles for the duration of 10 days.

Treatments for each incubation are detailed below, all metal additions were at 2 nmol l^{-1} , incubation 1 and 2 had nitrate and phosphate added to all treatments including the control.

Table 26 – Details of incubation treatments

Incubation 1	Incubation 2	Incubation 3	Incubation 4
Control	Control	Control	Control
+Zn	+Zn	+Zn	+Zn
+Co	+Co	+Co	+Co
+Fe	+Cd	+Fe	+Fe
+Zn+Co	+Zn+Co	+Zn+Co	+Zn+Co
+Zn+Fe	+Co+Cd	+Zn+Fe	+Zn+Fe

The bottles were placed in incubations, screened with neutral density screens to 50% light. The temperature in the incubations was control to ensure it remained the same as the sample collection temperature.

The number of bottles allowed for each treatment to be run in duplicate with 4 sampling points. At each of these sampling points, a bottle from each treatment was taken and completely sampled. Samples were collected for dissolved metals, nutrients (N, P and Si), flow cytometry, POC/PON/PIC and chlorophyll *a* and pigment analysis.

4.3.4.7 VERTICAL DISTRIBUTIONS OF HYDROGEN PEROXIDE

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Scientific objectives

Hydrogen peroxide (H_2O_2) is one of the most powerful oxidant in marine waters, and it is also a strong reductant ($\text{H}_2\text{O}_2 / \text{H}_2\text{O} - \text{O}_2 / \text{H}_2\text{O}_2$). Amongst reactive oxygen species (ROS), it is the most abundant (concentrations can be up to 300nM) and its life time is the longest (Asada et Takahashi., 1987, Mopper et Kieber., 2000). Because of its high reactivity, it affects the marine cycles of many organic compounds and the redox state of trace metals. It partly controls the speciation of Fe between its two redox species Fe(II) and Fe(III) (Moffett, 2001, Bagheri et al., 2000). Iron is an essential micronutrient for phytoplankton, but the chemical form available to phytoplankton is still unknown. The Southern Ocean is known to be an Fe limited area, which impairs the ability of phytoplankton to grow at its maximum. In the context of the study of the marine biogeochemical cycle of this essential micronutrient, and in parallel to the study of Fe (see Chever et al. and Sarthou et al. in this report), we investigated the distributions of H_2O_2 in order to better understand how this molecule affects the redox speciation of this trace metal.

Scientific and sampling strategy

All samplings were done at the same time as Fe samplings, ie LARGE A, LARGE B and SUPER stations.

Material and methods

Ten Go-Flo bottles hanged on a 4000m Kevlar line were used to take samples from the surface to the bottom. Seventeen casts were realised. Sub sampling of the Go Flo bottles were performed in a clean container. Go-flo bottles were gently pressured with N_2 (high purity grade) allowing on line filtration of seawater through 0.2 μm cartridges (SARTOBAN). Dissolved and total samples for H_2O_2 analyses were collected in 60 ml bottles. All samples were analysed on board in 3 hours after collection using a flow injection method with chemiluminescent detection (Yuan and Shiller, 1999).

Preliminary results

Most of the data still have to be processed. On a general basis however, it was seen that vertical distributions of H_2O_2 exhibited high concentrations in the surface layers (up to ~80 nM), decreasing rapidly with depth (generally inferior to a few nanomolar below 200 m). An interesting feature was the lower concentrations of dissolved than of total H_2O_2 observed during daylight samplings at the northernmost stations in the surface layers (Figure 48).

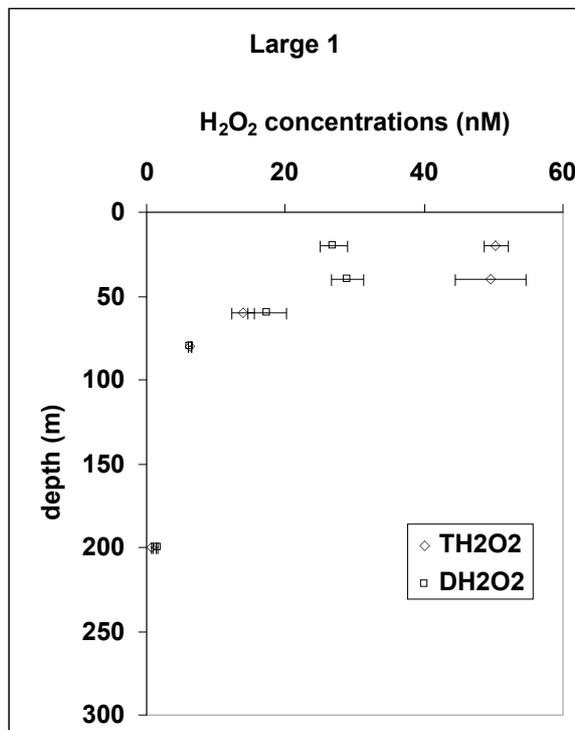


Figure 48 – Vertical distributions of total and dissolved H_2O_2 concentrations (nM) at station L1 versus depth (m).

This feature is not explained at the moment, but might involve H_2O_2 production by phytoplankton during photosynthesis.

Data delivery

Analyses were already performed onboard. Data validation and processing should take less than 6 months, allowing on time data base delivery.

4.3.4.8 INTERCOMPARISON OF GEOTRACES VARIABLES WITH THE GERMAN R. V. POLARSTERN

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Onboard Marion Dufresne: Marie Boye, Francois Lacan, Frank Dehairs, Damien Cardinal, Johann Bown, Francois Fripiat, Fanny Chever. **Not onboard:** Catherine Jeandel, Matthieu Roy-Barman, Rémi Losno

Onboard Polarstern: Hein de Baar, Ingrid Voge, Patrick Laan, Celia Venchiarutti, Elizabeth Sweet, Charles-Edouard Thuroczy, Loes Gerringa, Peter Croot. **Not onboard:** Michiel Rutgers van der Loeff, Christina de la Rocha

For the sections from Capetown to the zero meridian, and from there along zero meridian to Antarctica, the GEOTRACES-CASO program of BONUS-GOODHOPE program (MD166) aboard Marion Dufresne is complementary to the Polarstern ANT XXIV-3. Towards an overall integrated database of both expeditions, some intercomparison between both programs was envisioned.

Before departure from Capetown, where Polarstern was also in port, there has been a meeting onboard Polarstern for organizing the intercomparison. This had to be modest for following reasons:

- departure of both vessels from Capetown was delayed with many days for various reasons, at expense of scientific stations time
- adverse weather conditions in the Southern Ocean will cause more time losses
- the extensive research objectives of both expeditions are very ambitious
- the number of pre-cleaned sample bottles onboard both ships is limited

The agreed strategy was twofold. Firstly the initial cruise tracks of Marion Dufresne and Polarstern were scheduled to be overlapping, and this, in principle, allows the positioning of stations and sampling depths at the same place. This is the strategy of choice for intercomparison of CO₂ system measurements (see further report intercomparison of CO₂), and for major nutrients. Secondly for a limited number of variables, it was decided that both ships would take a small number of duplicate samples, to be exchanged after the expeditions are completed, for final analyses in the home laboratories. These variables are Barium, dissolved trace metals, Neodymium, Thorium-Isotopes, Protactinium, Rare Earth Elements, and Silicon isotopes.

Once at sea, Polarstern by its earlier departure was further south than Marion Dufresne. On February 26, 2008 the positions and sampling depths of completed Polarstern stations (then until 59°S, 0°W) were communicated by H.H.W. de Baar to M. Boye aboard Marion Dufresne, as to allow their re-occupation of selected stations, their overall research program and weather permitting.

The Bonus-GoodHope team aboard Marion Dufresne collected several replicate samples (Figure 49) for dissolved trace metals (Marie Boye & Johann Bown) at 10 depths at 47°33.16' S, 4°22.36' E (S3/GF-19 cast on March 3, 2008; Table 27), 3 replicate samples

(Francois Lacan) for Nd/Th/Pa/REE at 52°59' S, 0°E (CTD-91, March 12, 2008; Table 28); 22 duplicates (Frank Dehairs) for dissolved Ba at 46°01.45' S, 05°51.89' E (CTD-57, March 3, 2008; Table 29); and 7 duplicates (Damien Cardinal & Francois Fripiat) for Si isotopes at 55°13.93' S, 00°02.66' E (L7/CTD-99 cast, March 14, 2008; Table 30).

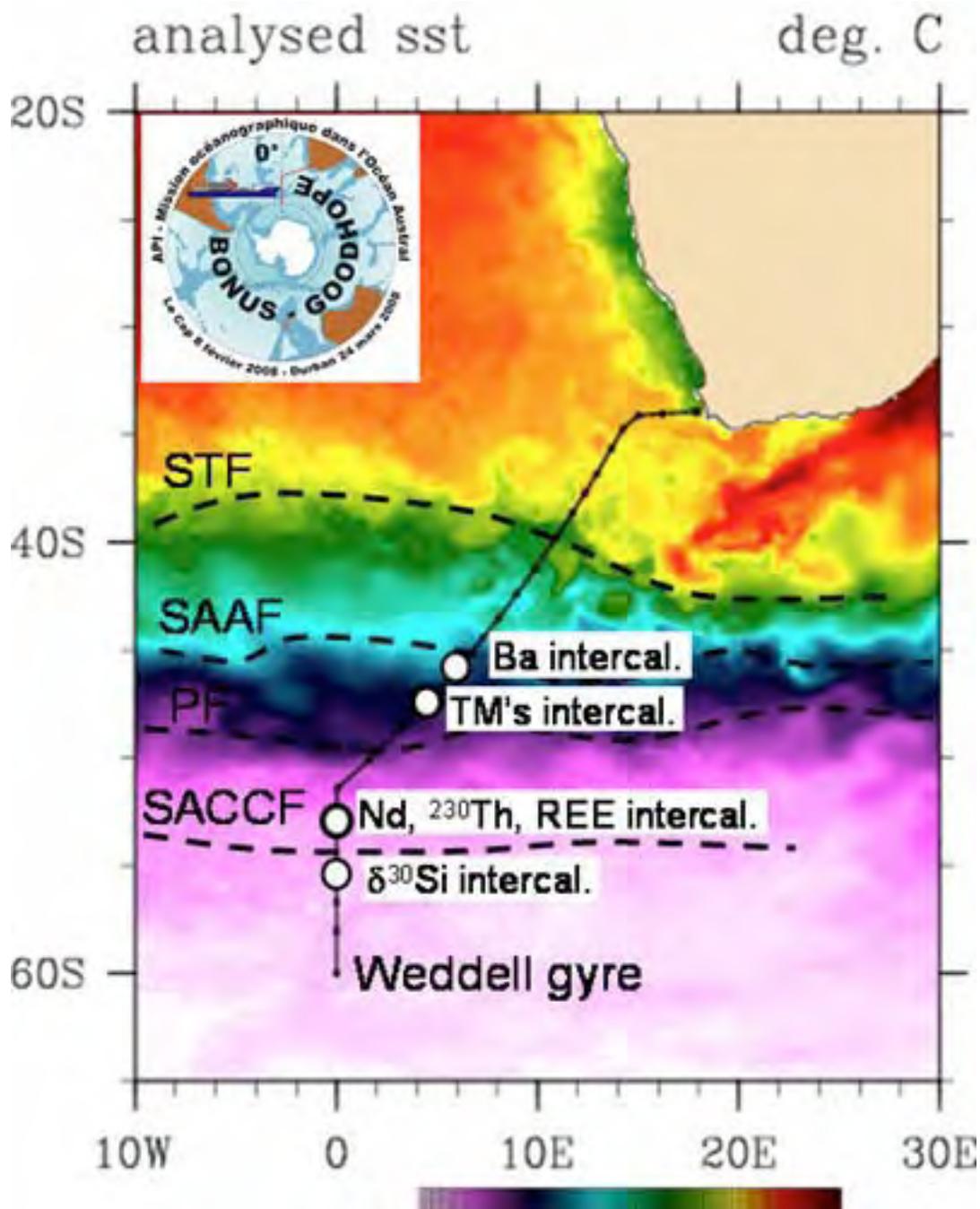


Figure 49 – Stations positions for the GEOTRACES intercomparison exercise during BONUS-GOODHOPE (SST data from Cersat/Odyseea at 08/02/26)

Similarly at Polarstern were collected 10 duplicate filtered seawater samples (Patrick Laan) for trace metals at 47°40' S, 4°17' E (PS71-104-2 February 16, 2008); 3 duplicated samples (Celia Venchiarutti) for Nd/Th/Pa and REE at 52°59.58'S 0°2.39'E (PS71/113-4 February 20, 2008); 12 duplicate samples (Ingrid Vogt) for Barium at 46°S, 5°53' E (PS71-

103-1 February 16, 2008); and 7 duplicates (Elizabeth Sweet) for Si isotopes at 53°31' S, 0°0.30'E

Table 27 – Trace metals intercomparison (GO-FLO cast)

BONUS-GOODHOPE (Marion Dufresne II)
Cast leader: Marie Boye
Sampling: Johann Bown & Marie Boye

THIRD SUPER STATION
Station number: GF19
Cast number: S3-GF19
Date start (UTC): 04/03/08 **Time start (UTC): 19H10** **Position sta**
Date end (UTC): 04/03/08 **Time end (UTC): 22H50** **Position end**
Closer CTD number: 63
Bottom depth:
with microcat

GO-FLO	Target depth (m)	Marie Boye for Patrick Laan	Marie Boye	Johann Bown	Bronwyn Wake	Fanny Chever	For Rémi Losno	For Peter Croot	For Loes Gerringa	Johann Bown	For Loes Gerringa	Annick Frederi
		Intercal. filtered	Library LEMAR filtered	Zn/Co/Cd filtered	Trace metals filtered	Fe (FIA-chem.) filtered	Trace metals (ICPAES) filtered	Al (FIA-chem) filtered	Zn/Co/Cd/Fe filtered	Zn/Co/Cd-orga filtered	Zn/Co/Cd/Fe-orga filtered	
10	50	X	X	X	X	X	X	X	X	X	X	
9	200	X	X	X	X	X	X	X	X	X	X	
8	400	X	X	X	X	X	X	X	X	X	X	
7	750	X	X	X	X	X	X	X	X	X	X	
6	1000	X	X	X	X	X	X	X	X	X	X	
5	1750	X	X	X	X	X		X	X			
4	2000	X	X	X	X	X	X	X	X	X	X	
3	2500	X	X	X	X	X	X	X	X	X	X	
2	3000	X	X	X	X	X	X	X	X	X	X	
1	3500	X	X	X	X	X	X	X	X	X	X	
Volume per depth (ml)		2500	2500	250	250	60	120	125	250	1000	1000	
Storage		HCl ultra. 30%, pH 1.8	HCl ultra. 30%, pH 1.8	HCl ultra. 30%, pH 1.8	HNO3 ultra.	HCl	HCl (seastar)	HCl ultra. 30%, pH 1.8	HCl ultra. 30%, pH 1.8	frozen	frozen	analysis

Table 28 – Nd/Th/Pa/REE intercomparison (Niskin cast)

BONUS-GOODHOPE (Marion Dufresne II)

Cast leader: François Lacan

lat	long
52°59S	0°
12 march 08	14h UTC

Jeandel-Lacan Jeandel-RoyBarman Jeandel-RoyBarman Jeandel-Lacan

Target depth (m)	dissolved Nd isotopes	dissolved ²³⁰ Th concentration	dissolved ²³¹ Pa concentration	dissolved REE concentration
380m	x	x	x	x
500m	x	x	x	x
1000m	x	x	x	x

Table 29 – Dissolved-Barium intercomparison (Niskin cast)

BONUS-GOODHOPE (Marion Dufresne II)

Sampling: Frank Dehairs

CTD 57

Date start (UTC): 03/03/08
Date end (UTC): 04/03/08
Time start (UTC): 23:47
Time end (UTC): 03:08
Position start: 46°01.45S / 05°51.89 E
Position end: 46°01.55 S / 05°52.13 E
Seafloor: 4100m

Niskin	dbar	depth	dissolved barium
1	4147	4075	X
2	3802	3735	X
3	3501	3444	X
4	3250	3198	X
5	3000	2955	X
6	2750	2708	X
7	2500	2461	X
8	2248	2217	X
9	2000	1974	X
10	1751	1729	X
11	1498	1484	X
12	1300	1285	X
13	1202	1186	X
14	1000	989	X
15	750	741	X
16	500	496	X
17	299	295	X
18	150	149	X
19	91	89	X
20	58	58	X
21	29	33	X
22			
23			
24	4	4	X

LADCP
LADCP

Table 30 – Dissolved-Silicon isotopes intercomparison (Niskin cast)

BONUS-GOODHOPE (Marion Dufresne II)
 Cast leader: Damien Cardinal
 Sampling: François Fripiat & Damien Cardinal

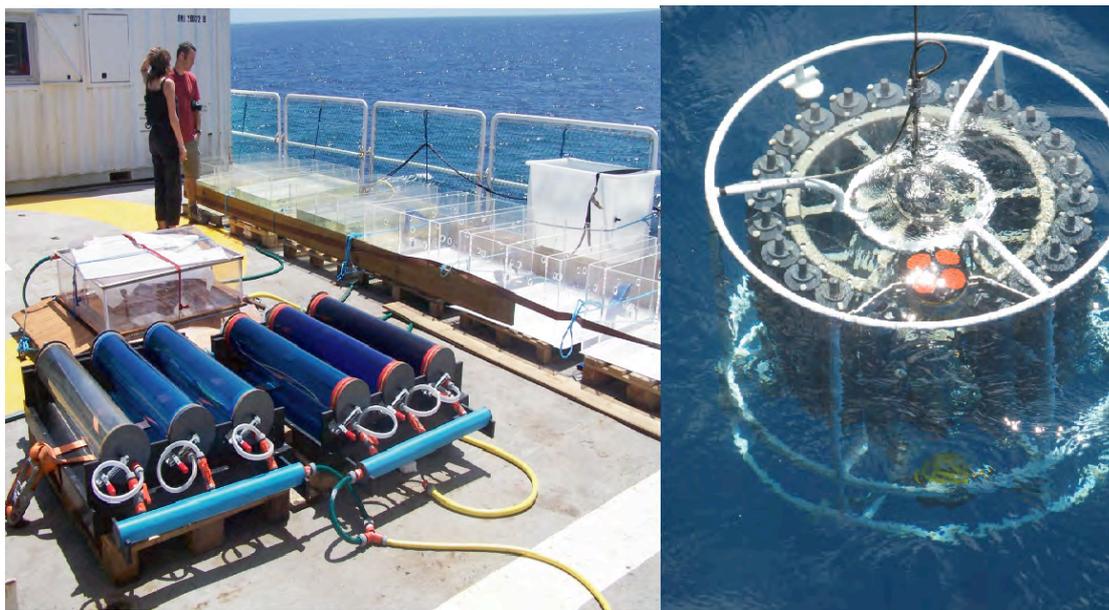
damien.cardinal@africamuseum.be
 francois.fripiat@africamuseum.be

LARGE STATION # 7
 Station number: 72
 Cast number: CTD 99 -L7
 Date start (UTC): 14/03/08 Time start (UTC): 00H10 Posi
 Date end (UTC): 14/03/08 Time end (UTC): 01H42 Posi
 Bottom depth: 2770m

Niskin	Target depth (m)	Real depth (dbar)	Volume (ml)	NO3/Si
24	surface	4.1	1000	X
20	40	39.1	1000	X
18	80	79.8	1000	X
17	100	100.3	1000	X
13	200	199	1000	X
5	600	599.5	250	X
1	1000	1001.8	250	X

Process: Filtered under pressure through 0.45µm PC membranes (Nuclepore)
Storage: PP bottles, dark, room temperature, not acidified

4.4 MACRO-NUTRIENTS AND BIOLOGICAL PARAMETERS



Silicon plays a key role in controlling the biological carbon pump that is largely driven by diatoms. Its abundance in Southern Ocean surface waters is largely driven by Fe availability, while its transport along with subantarctic Mode Waters largely controls the thermocline nutrients and biological productivity at lower latitudes. Despite the intensive efforts deployed during the SO-JGOFS programme the Si cycle needs to be constrained further, especially aspects related with its recycling. To better assess the latter process on deck incubations will be performed to further understand the grazing pressure exerted on natural diatom assemblages (using BSi as a marker of diatom biomass) and the dissolution rates of biogenic silica (using ^{30}Si enrichment experiments). Furthermore, comparing isotopic signatures of $\text{Si}(\text{OH})_4$ and bio-silica (BSi) in seawater will provide a means to refine our understanding of $\text{Si}(\text{OH})_4$ -diatom dynamics, especially as concerns production versus accumulation. The isotopic composition of dissolved silicate tends to integrate the effect of isotope fractionation over the growth season, while isotopic composition of particles will rather reflect the instantaneous result of fractionation. The combination of d^{29}Si and d^{15}N analyses (solutes; suspended matter) will allow to further constrain our understanding of the spatial and seasonal Si:N uptake ratio variability. Investigating for the content and carbon isotopic composition of specific compounds characteristic for specific plankton groups (diatoms, dinoflagellates, coccolithophorids) will provide information on contribution of major phytoplankton groups to the suspended organic carbon pool and on possible alteration of isotopic signatures during mineralization.

4.4.1 MACRO-NUTRIENTS

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Motivation and general sampling strategy for BGH

The BONUS-GOODHOPE from Cape Town to the Southern Boundary of the ACC along the Greenwich Meridian has been chosen because it crosses several oceanographic provinces, and the geographical region where water masses of the ACC and the Agulhas Current converge and mixed before entering the South Atlantic as thermocline waters.

The general sampling strategy consists of monitoring the different waters masses to provide a 2D matrix, vertical and horizontal, of water-mass characteristics to allow understanding of the physical and biogeochemical dynamics along the section with relatively high spatial resolution. The selected vertical scales various water-masses (notably AAIW and SAMW), and the applied horizontal resolution covers the main frontal systems and inter-frontal regions.

Scientific motivation

Nutrients (silicates, nitrates, phosphates) and ammonium are regular parameters in oceanography. Nutrients can be used as physical tracers as well as an indicator of biological production state. The studied area showed typical features about nutrients. Nutrients meridional gradients are expected (Cardinal *et al*, 2006). Moreover meridional nutrients transport is known. Indeed, Subantarctic Mode Waters (SAMW) have been identified as a main conduct of nutrients from the Southern Ocean to low latitudes (Sarmiento *et al*, 2004). So, the question is what are the water masses nutrients properties, how is characterized the meridional nutrient distribution in relationship with phytoplankton community structure, shifts occurring in the Atlantic sector of Southern Ocean and what are the Mode and Intermediate waters nutrients properties?

Nutrient sampling

Silicates, nitrates, phosphates and ammonium samples on each CTD are summarized in the here below spreadsheet (Table 31). Silicates, nitrates and phosphates samples from trace metals incubations were analysed, as well as silicates and nitrates on GO-FLO casts and pores waters from coring samples.

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Table 31 – Nutrients sampling on all CTD cast

Station N°	Position		CTD number	Station-type	Analysed parameters
	Longitude ° Est	Latitude ° Sud			
1	17,23	-33,98	1	0-fond	-
2	17,96	-33,94	2	0-fond	-
3	17,52	-33,96	3	0-fond	-
4	17,30	-33,98	4	0-fond	-
5	16,95	-33,99	5	0-fond	-
6	16,59	-34,01	6	0-fond	-
7	16,20	-34,03	7	0-fond	-
8	15,69	-34,06	8	0-fond	-
9	15,16	-34,09	9	0-fond	Si(OH)4, NO3-, PO4
10	14,58	-34,12	10	0-fond	Si(OH)4, NO3-, PO4
Large 1	14,41	-34,43	11	0-fond	Si(OH)4, NO3-, PO4
Large 1	14,41	-34,43	12	CM	Si(OH)4, NO3-, PO4, NH4
12	14,22	-34,72	13	0-fond	Si(OH)4, NO3-, PO4
13	14,05	-35,03	14	0-fond	Si(OH)4, NO3-, PO4
14	13,87	-35,33	15	0-fond	Si(OH)4, NO3-, PO4
15	13,68	-35,63	16	0-fond	Si(OH)4, NO3-, PO4
16	13,50	-35,92	17	0-fond	Si(OH)4, NO3-, PO4
17	13,32	-36,22	18	0-fond	Si(OH)4, NO3-, PO4
Super 1	13,12	-36,52	19	0-fond	Si(OH)4, NO3-, PO4
Super 1	13,12	-36,52	20	CM	Si(OH)4, NO3-, PO4, NH4
Super 1	13,12	-36,52	21	REE	-
Super 1	13,12	-36,52	22	PoTh	Si(OH)4, NO3-
Super 1	13,12	-36,52	23	BaSi	Si(OH)4, NO3-
19	12,93	-36,80	24	0-fond	Si(OH)4, NO3-, PO4
20	12,74	-37,12	25	0-fond	Si(OH)4, NO3-, PO4
21	12,55	-37,42	26	0-fond	Si(OH)4, NO3-, PO4
22	12,35	-37,70	27	0-fond	Si(OH)4, NO3-, PO4
23	12,08	-38,08	28	0-fond	Si(OH)4, NO3-, PO4
24	11,83	-38,46	29	0-fond	Si(OH)4, NO3-, PO4
25	11,58	-38,83	30	0-fond	Si(OH)4, NO3-, PO4
26	11,32	-39,19	31	0-fond	Si(OH)4, NO3-, PO4
27	11,05	-39,55	32	0-fond	Si(OH)4, NO3-, PO4
28	10,81	-39,93	33	0-fond	Si(OH)4, NO3-, PO4
29	10,55	-40,29	34	0-fond	Si(OH)4, NO3-, PO4
30	10,20	-40,72	35	0-fond	Si(OH)4, NO3-, PO4
Large 2	9,92	-41,19	37	0-fond	Si(OH)4, NO3-, PO4
Large 2	9,92	-41,19	38	CM	Si(OH)4, NO3-, PO4, NH4
32	9,58	-41,61	39	0-fond	Si(OH)4, NO3-, PO4
33	9,27	-42,03	40	0-fond	Si(OH)4, NO3-, PO4
Super 2	8,93	-42,47	41	0-fond	Si(OH)4, NO3-, PO4
Super 2	8,93	-42,47	42	REE	-
Super 2	8,93	-42,47	43	PoTh	Si(OH)4, NO3-
Super 2	8,93	-42,47	44	BaSi	Si(OH)4, NO3-
Super 2	8,93	-42,47	45	CM	Si(OH)4, NO3-, PO4, NH4
35	8,56	-42,89	46	0-fond	Si(OH)4, NO3-, PO4
36	8,24	-43,33	47	0-fond	Si(OH)4, NO3-, PO4
37	7,98	-43,69	48	0-fond	Si(OH)4, NO3-, PO4
38	7,63	-44,04	49	0-fond	Si(OH)4, NO3-, PO4

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39	7,38	-44,34	50	0-fond	Si(OH)4, NO3-, PO4
40	7,15	-44,61	51	0-fond	Si(OH)4, NO3-, PO4
Large 3	6,90	-44,88	52	0-fond	Si(OH)4, NO3-, PO4
Large 3	6,90	-44,88	53	CM	Si(OH)4, NO3-, PO4, NH4
Large 3	6,90	-44,88	54	PoTh	Si(OH)4, NO3-
42	6,52	-45,32	55	0-fond	Si(OH)4, NO3-, PO4
43	6,23	-45,61	56	0-fond	Si(OH)4, NO3-, PO4
Large 4	5,87	-46,03	57	0-fond	Si(OH)4, NO3-, PO4
Large 4	5,87	-46,03	58	CM	Si(OH)4, NO3-, PO4, NH4
45	5,53	-46,35	59	0-fond	Si(OH)4, NO3-, PO4
46	5,20	-46,72	60	0-fond	Si(OH)4, NO3-, PO4
47	4,79	-47,14	61	0-fond	Si(OH)4, NO3-
Super 3	4,38	-47,55	62	0-fond	Si(OH)4, NO3-, PO4
Super 3	4,38	-47,55	63	0-fond	Si(OH)4, NO3-, PO4
Super 3	4,38	-47,55	64	REE	-
Super 3	4,38	-47,55	65	PoTh	Si(OH)4, NO3-
Super 3	4,38	-47,55	66	BaSi	Si(OH)4, NO3-
49	3,96	-47,97	67	0-fond	Si(OH)4, NO3-, PO4
50	3,18	-48,70	68	0-fond	Si(OH)4, NO3-, PO4
51	3,52	-48,38	69	0-fond	Si(OH)4, NO3-, PO4
Large 4	2,83	-49,03	70	0-fond	Si(OH)4, NO3-, PO4
Large 4	2,83	-49,03	71	CM	Si(OH)4, NO3-, PO4, NH4
Large 4	2,83	-49,03	72	PoBaSi	Si(OH)4, NO3-
53	2,54	-49,30	73	0-fond	Si(OH)4, NO3-, PO4
54	2,24	-49,57	74	0-fond	Si(OH)4, NO3-, PO4
55	1,94	-49,82	75	0-fond	Si(OH)4, NO3-, PO4
56	1,62	-50,11	76	0-fond	Si(OH)4, NO3-, PO4
Large 5	1,30	-50,37	77	0-fond	Si(OH)4, NO3-, PO4
Large 5	1,30	-50,37	78	CM	Si(OH)4, NO3-, PO4, NH4
58	0,98	-50,64	79	0-fond	Si(OH)4, NO3-, PO4
59	0,66	-50,90	80	0-fond	Si(OH)4, NO3-, PO4
60	0,33	-51,17	81	0-fond	Si(OH)4, NO3-, PO4
61	0,01	-51,43	82	0-fond	Si(OH)4, NO3-, PO4
Super 4	0,00	-51,87	83	CM	Si(OH)4, NO3-, PO4, NH4
Super 4	0,00	-51,87	84	0-fond	Si(OH)4, NO3-, PO4
Super 4	0,00	-51,87	85	REE	-
Super 4	0,00	-51,87	86	PoTh	Si(OH)4, NO3-
Super 4	0,00	-51,87	87	BaSi	Si(OH)4, NO3-
63	0,00	-52,27	88	0-fond	Si(OH)4, NO3-, PO4
64	0,00	-52,60	89	0-fond	Si(OH)4, NO3-, PO4
65	0,00	-52,93	90	0-fond	Si(OH)4, NO3-, PO4
67	0,00	-53,26	92	0-fond	Si(OH)4, NO3-, PO4
68	0,00	-53,59	93	0-fond	Si(OH)4, NO3-, PO4
69	0,00	-53,92	94	0-fond	Si(OH)4, NO3-, PO4
70	0,00	-54,25	95	0-fond	Si(OH)4, NO3-, PO4
71	0,00	-54,58	96	0-fond	Si(OH)4, NO3-, PO4
72	0,00	-54,91	97	0-fond	Si(OH)4, NO3-, PO4
Large 6	0,03	-55,23	98	0-fond	Si(OH)4, NO3-, PO4
Large 6	0,03	-55,23	99	PoBaSi	Si(OH)4, NO3-
Large 6	0,03	-55,23	100	CM	Si(OH)4, NO3-, PO4, NH4
74	0,01	-55,57	101	0-fond	Si(OH)4, NO3-, PO4
75	-0,11	-55,90	102	0-fond	Si(OH)4, NO3-, PO4
76	0,00	-56,23	103	0-fond	Si(OH)4, NO3-, PO4
77	-0,01	-56,76	104	0-fond	Si(OH)4, NO3-, PO4

Table 31 – Continued

78	-0,11	-57,21	105	0-fond	Si(OH) ₄ , NO ₃ ⁻ , PO ₄
Super 5	-0,04	-57,55	106	0-fond	Si(OH) ₄ , NO ₃ ⁻ , PO ₄
Super 5	-0,04	-57,55	107	REE	-
Super 5	-0,04	-57,55	108	CM	Si(OH) ₄ , NO ₃ ⁻ , PO ₄ , NH ₄
Super 5	-0,04	-57,55	109	PoTh	Si(OH) ₄ , NO ₃ ⁻
Super 5	-0,04	-57,55	110	BaSi	Si(OH) ₄ , NO ₃ ⁻

Table 31 – Continued

Methods

Nutrients were analysed on board. Silicates and nitrates were analysed by standards methods with a Bran+Luebbe AAIII autoanalyser as described by Tréguer and Lecorre (1975). Phosphates samples were analysed using a manual spectrophotometer «Shimatzu UV 1700» as described by Murphy and Riley (1962).

Ammonium samples were analysed using a manual spectrophotometer «Shimatzu UV 1700» as described by Koroleff and Solorzano (1969).

Preliminary results

In the upper 300 meters a meridional gradient associated with interfrontal regions is detected, with nitrate concentrations increasing southward of the transect (Figure 50). This gradient may be due to changes in biological production and phytoplankton community structure (shift between coccolithoporids and diatoms for instance).

A northward meridional transport of nitrate is detected at intermediate depths. The latter is linked to the northward flowing of the Antarctic Intermediate Waters (AAIW) that form in the region of the Polar Front and SubAntarctic Mode Waters (SAMW) subducting north of the SAF, and reaching low latitudes (Sarmiento et al, 2004). Signature of eddies appears north of the SubAntarctic Front in a bowl-shaped feature, corresponding to the anticyclonic M-eddy (e.g., station 36). Depression of the isoplethes of nitrate, silicate and phosphate have all been observed in this anticyclonic eddy.

In deep waters, the influence of North Atlantic deep water (NADW) is depicted by a bulk of lower concentrations between 2000 and 4000 meters depth. A bottom signature of higher concentrations recorded at 36°S (e.g., stations 16-17 at the SUPER 1) between 5000 and 4000 meters depth remains unexplained so far, but might be due to a deep gyre of Bottom Antarctic Waters and to remineralisation from the sediments. This feature is detected in the silicates distribution as well.

The highest concentrations of ammonium (> 1.5 mg l⁻¹) were recorded in the subsurface waters centred at around 75 m at the Polar Front. The highest concentration of ammonium correlates with the lowest chl a and phaeopigments concentrations observed in the transect (see Report of Gueneugues & Boye), hence suggests that any diatom blooms generally recorded in this region was already missed in the late austral summer.

Furtur work

The nutrients distributions will be further interpreted with the biological activity, phytoplankton assemblage and water-masses circulation pathways in collaboration with

several groups of the project. The uptake rates of the nutrients on the whole productive season will be calculated using these data and compared to the uptake rates obtained in late summer for nitrogen in collaboration with the group of P. Monteiro and H. Waldron, and for silicate in collaboration with R. C

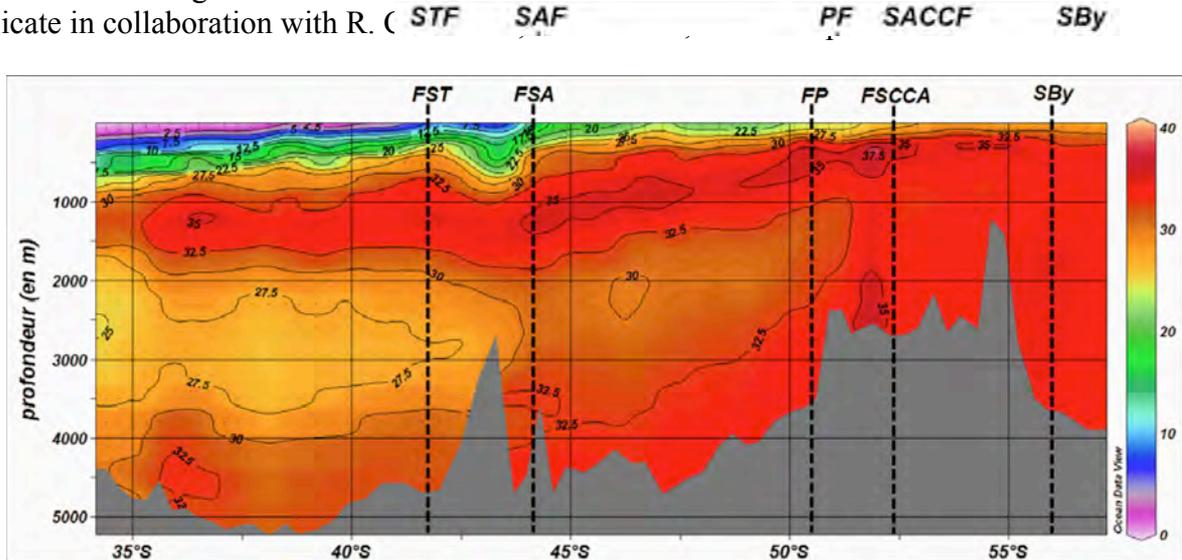


Figure 50 – Nitrates concentrations (μM) distribution during BONUS-GOODHOPE cruise. Fronts positions are given (S-STF: Southern Subtropical front. SAF: Subantarctic front. PF: Polar front. SACCF: Southern front of the Antarctic circumpolar current (ACC). Sby: Southern boundary of ACC).

Finally the Mode Waters will be further characterised by their Si^* signature (Sarmiento *et al.*, 2004) in order to process to budget calculation of the transport of Si^* by Mode Waters towards lower latitudes at the base of the ocean permanent thermocline.

The data were already presented and briefly discussed beginning of June, 2008, in the Master-2 report of F. Le Moigne (2008). Distribution des sels nutritifs dans le secteur atlantique de l'Océan Austral en fin de période estivale, Campagne BONUS-GOODHOPE, 35 pp., Master Sciences de la Mer et du Littoral, UBO, Brest, FR ; under the scientific supervision of M. Boye.

4.4.2 CHLOROPHYLLE – *a* AND PHAEOPYGMANTS

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Chlorophyll *a* sampling has been undertaken in order to see the distribution of this pigment. Also, values for phaeopigments which represents the degradation of the chlorophyll *a*, have been computed.

Samples have been taken at all CTD hydro (except CTD 0,1,4,6 and 8). During LARGE and SUPER stations, samples have been collected at the CTD cast for the Mixing Layer.

In total, 462 valid samples were collected.

Chlorophyll *a* and phaeopigments are phytoplanktonic pigments. They are present in the upper 300 meters of the water (Figure 51 and Figure 52).

All sampling depths were chosen after looking at the fluorescence profile. In general, two samples were taken at the sea surface, one at the fluorescence maximum, one at the minimum and the remaining where the fluorescence was decreasing. Globally, six samples were taken for each HYDRO CTD casts, ten at the LARGE stations and nine at the SUPER stations.

Sampling proceeded by taking one liter of sea water per niskin bottle. Filtrations were undertaken on GF-F filters with a diameter of 25 mm. After the extraction of each filter in 6 mL of acetone, the samples were kept four hours in the fridge. Thereafter, chlorophyll concentration was measured with a fluorimeter. Finally, by adding 100 μ L of HCL, 1N in the tube it was possible to obtain concentration of phaeopigments.

If time was missing, after the filtrations filters were kept in a freezer. Storage have to be protected from light and heating.

The preliminary results show that there is a gradient near the surface surface. There is an important difference of concentration south of the SAF and another decrease south of the PF.

For the phaeopigments, the values follow the chlorophyll until the PF. After, we see a decoupling between the two values. This, perhaps because of a different production or degradation of the chlorophyll.

For the chlorophyll *a*, comparison have to be made with nutrients, taxonomy and pigments to see what phytoplankton species are present. Moreover, all the data have to be calibrated with remote sensing colour.

For the phaeopigments the data have to be interpreted with pigments, bacterial activities and regenerated production.

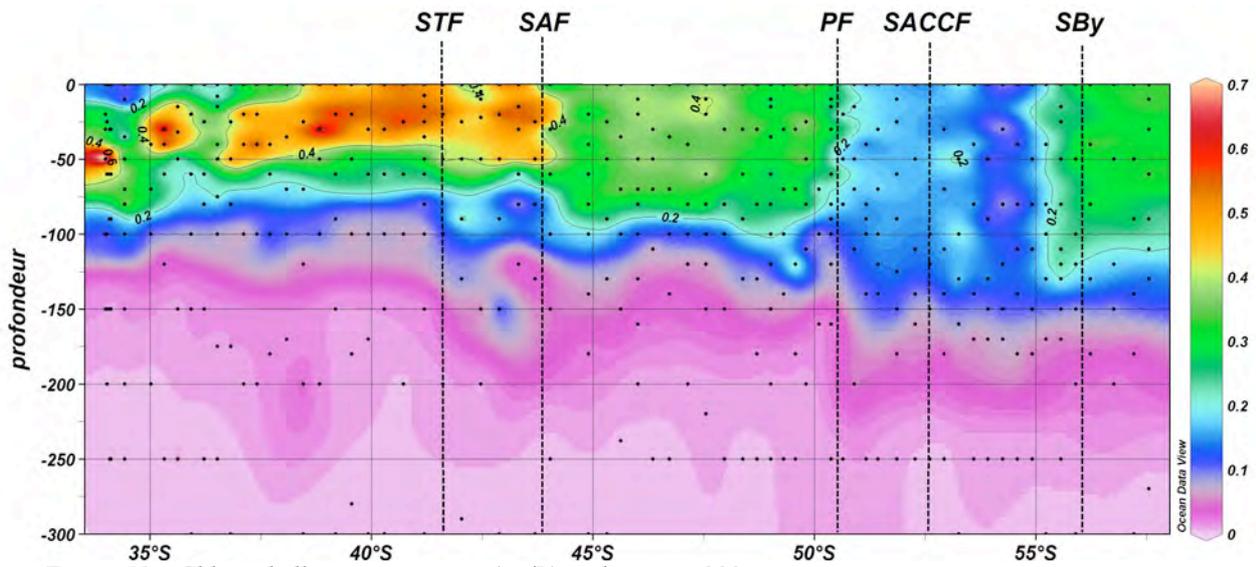


Figure 51 – Chlorophyll *a* concentration ($\mu\text{g/L}$) in the upper 300 m

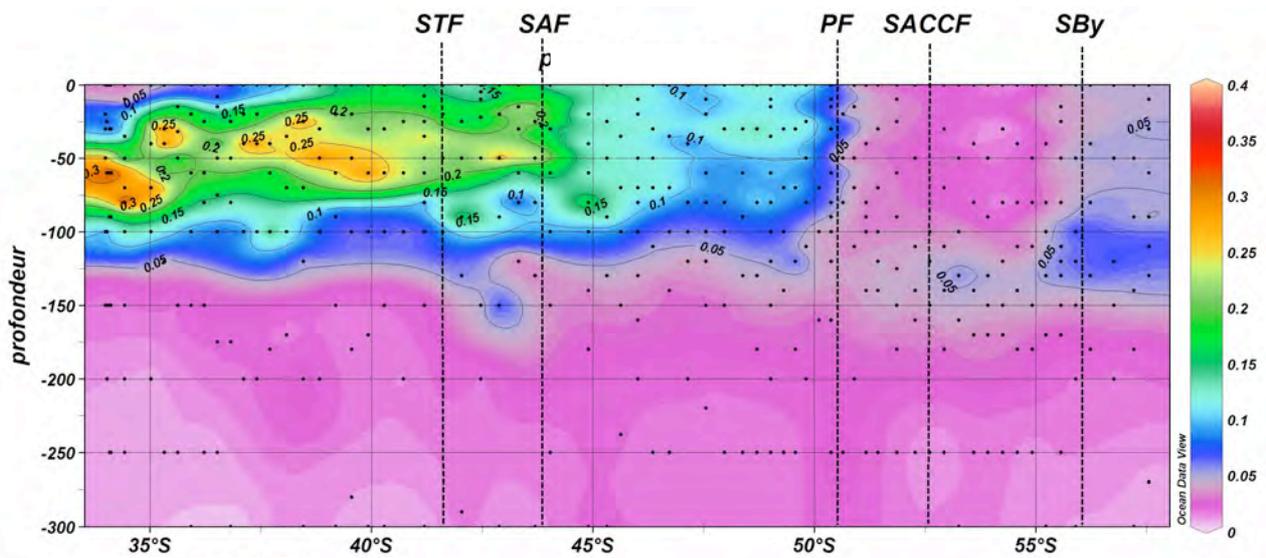


Figure 52 – Phaeopigments concentrations ($\mu\text{g/L}$) in the upper 300 m

4.4.3 PIGMENTS

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Joséphine Ras (analyses; jras@obs-vlfr.fr)

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France

The aim of this measurement is to know more about the type of phytoplankton species present in the sampled areas using pigments as proxies. Most of them can be identified by their pigments signature. Water is collected from the rosette, then filtered to collect the cells. The concentrations of major and minor pigments are measured by HPLC.

Spatial resolution of the sampling:

Pigments have been sampled on every Mixed Layer CTD (LARGE and SUPER stations) but also on some Hydro stations, in the upper Niskin bottles only (from the surface to the depth where the minimum of fluorescence is. Fluorescence is measured when the CTD gets down into the water).

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Table 32 – Summary of stations and bottles for pigment sampling

Station	n° CTD	long	lat	nbr e spl.	Niskin numbers																	
3 - HYDRO	3	17.24.59 E	33.58.06 S	6	6	7	8	10	11	12												
7 - HYDRO	7	16.12.00 E	34.01.999 S	7	15	16	17	18	19	20	21											
9 - HYDRO	9	15.09.80 E	34.05.50 S	6	17	18	19	20	21	24												
11 - LARGE 1	12	14.24.520 E	34.25.600 S	10	1	2	3	4	7	9	10	12	16	21								
14 - HYDRO	15	13.51.930 E	35.19.590 S	6	17	18	19	20	21	24												
17 - HYDRO	18	13.18.590 E	36.13.400 S	6	17	18	19	20	21	24												
18 - SUPER 1	20	13.07.120 E	36.31.310 S	9	1	2	3	4	5	11	15	17	18									
19 - HYDRO	24	12.55.980 E	36.49.540 S	6	17	18	19	20	21	24												
22 - HYDRO	27	12.21.130 E	37.42.950 S	6	17	18	19	20	21	24												
25 - HYDRO	30	11.34.350 E	38.49.530 S	6	17	18	19	20	21	24												
29 - HYDRO	34	10.33.010 E	40.17.440 S	6	17	18	19	20	21	24												
31 - LARGE 2	38	09.55.360 E	41.11.400 S	11	1	2	3	4	5	6	9	11	12	14	18							
34 - SUPER 2	45	08.56.050 E	42.28.110 S	9	1	2	3	4	9	11	15	17	18									
38 - HYDRO	49	07.37.810 E	44.02.500 S	6	17	18	19	20	21	24												
41 - LARGE 3	52	06.53.070 E	44.53.880 S	8	1	2	3	4	5	6	11	13										
43 - HYDRO	56	06.13.930 E	45.36.680 S	6	17	18	19	20	21	24												
44 - LARGE 4	58	05.52.390 E	46.01.010 S	9	1	2	3	4	5	6	9	15	24									
48 - SUPER 3	62	04.22.610 E	47.33.160 S	9	1	2	3	4	5	6	12	16	24									
49 - HYDRO	67	03.57.450 E	47.58.200 S	6	17	18	19	20	21	24												
52 - LARGE 5	71	02.49.920 E	49.01.680 S	11	1	2	3	4	5	6	7	11	13	14	21							
54 - HYDRO	74	02.13.970 E	49.34.020 S	6	17	18	19	20	21	24												
57 - LARGE 6	78	01.18.930 E	50.22.480 S	11	1	2	3	4	5	6	10	11	13	14	21							
62 - SUPER 4	83	00.00.040 E	51.50.870 S	9	1	2	3	4	9	10	12	15	18									
64 - HYDRO	89	00.00.090 E	52.36.080 S	6	17	18	19	20	21	24												
69 - HYDRO	95	00.00.030 E	54.15.000 S	7	16	17	18	19	20	21	24											
73 - LARGE 7	100	00.00.021 W	55.34.140 S	11	1	2	3	4	5	7	10	11	13	16	24							
76 - HYDRO	104	00.00.852 W	56.45.736 S	6	17	18	19	20	21	24												
78 - SUPER 5	108	00.02.252 W	57.33.161 S	8	1	3	4	8	10	12	15	24										

In total we got 213 samples on 28 stations.

Protocol:

Before the sampling, the chlorophyll concentration in the water column is estimated using the fluorescence signal of the CTD. The depths of sampling are then chosen to have the better resolution of the chlorophyll peak, making sure that the sampling goes from the surface to the depth of the minimum of fluorescence.

When the rosette is on board, the water has to be collected as fast as possible to avoid any transformation or degradation of the pigments, or sedimentation of the cells in the Niskin bottles. This has not been possible on the Hydro casts, considering that the priority has not been accorded to the pigments sampling, and that they've been sampled almost one hour after the return of the rosette.

The volume sampled is 2 litres per depth. This water has to be filtered as soon as possible, to avoid any transformation or degradation of the pigments. All the bottles are filtered at the same time on a 12 positions filter holder. Filters used are GF/F Whatman filters of 0,7µm porosity and 25mm diameter. The vacuum from the pump does not exceed 20cm Hg to avoid damaging the plankton cells.

After filtration, the filter is folded and introduced in a cryotube, quickly stored in liquid nitrogen: considering that pigments are heat-sensitive and light-sensitive, any lack of care could drive to an underestimation of their concentration.

Analysis is not done on board. Samples are flown back to France in a dry shipper approved for air transport which can maintain them frozen for at least two weeks. Samples will then be stored at -80°C and will be analysed in Villefranche-sur-Mer by HPLC.

Validated data should be available in October 2008.

4.4.4 PARTICULATE ORGANIC CARBON AND NITROGEN; PARTICULATE INORGANIC CARBON

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Motivation

The Southern Ocean (SO) acts as a sink for atmospheric CO₂. Primary production at mid-latitude is one of the main contributors to this uptake of CO₂; and its export to deep waters as particulate organic carbon (POC).

Furthermore the spatial distribution of the two major bloom-forming taxonomic classes is characterized in the Southern Ocean by massive deposits of coccoliths to the north of the Polar Front (<50°S), as opposed to vast diatom opal deposits just south of the Polar Front (Honjo, 1997). These major phytoplankton functional groups are pivotal in the oceanic carbon cycle with diatoms being major actors of the so-called biological carbon pump in the Southern Ocean, and coccolithophorids acting also as an additional source for CO₂ with the production of calcium carbonate, PIC being an analogue, (carbonate pump) that in mid-bloom operate CO₂ neutral with a "rain ratio" (CaCO₃/Corg) of 1, and at final bloom stages (CaCO₃/Corg > 1) may show a net release of CO₂ in the surface waters (Buitenhuis *et al.*, 2001). The rain ratio is pivotal in carbon cycle modelling of past, present and future oceans. The two major phytoplankton groups are also members of a "particles conspiracy", in which the heavy calcite and opal of coccolithophorids (Buitenhuis *et al.*, 2001) and diatoms respectively act as ballast (Klaas and Archer, 2002; Francois *et al.*, 2002) for biogenic debris settling into the deep sea, that drives the most pivotal conduite of the biological pump for carbon and other elements (Armstrong *et al.*, 2002).

Additionally co-limitations by micro- and macro-nutrients as well as by light and grazing pressure have shown to play an important role in controlling the rates at which macro-nutrients are consumed by phytoplankton.

These changes are reflected by differences in the nutrient ratios of the phytoplankton, such as particulate organic nitrogen (PON) over particulate organic carbon (POC).

In the frame of the Bonus-Goodhope project we aim to address the following questions:

- How POC and PIC relate to air-sea CO₂ fluxes and to carbon export assessed from geochemical multi-proxy approach in the biologically active mid-latitude zone and Polar Front of the S.O.?

- How POC and PIC relate to phytoplankton assemblage and production in the S.O.?
- How nutrient ratios relate to phytoplankton and to co-limiting factors?
- What is the contribution of mode and intermediate waters subduction to the overall rain ratio transport in late summer?

Sampling

Stations and depths:

A total number of 68 stations have been sampled (the same as sampling for chlorophyll measurements).

POC/PON/PIC have been sampled at each station to have a maximal resolution:

- At HYDRO station, on the hydro cast (6-7 depths of sampling)
- At LARGE and SUPER stations, on the mixed layer cast because of the better vertical resolution (7 to 11 depths of sampling). These changes are reflected by differences in the n

Thanks to the fluorescence signal measured during the CTD diving, surface depths of sampling were chosen in order to achieve the best resolution on the chlorophyll peak. At each station, sampling goes from the surface to the depth of the minimum of fluorescence.

PIC/POC/PON sampling:

- 1L for particulate inorganic carbon (PIC)
- 1L for particulate organic carbon and nitrogen (POC/PON)

The water for PIC/POC/PON analyses was collected around 1 hour after the return of the rosette on the deck.

Protocoles

Filtering procedure:

After sampling and chlorophyll filtering, samples for PIC/POC/PON analyses were filtered. 1L of each sampling bottle was precisely measured with a 1L graduated cylinder (“éprouvette”). All samples were progressively filtered on the 3-position filter holder (between two samples, graduated cylinder and filtering support were washed with distilled water). Filters used are GF/F Whatman filters of 0,7 μ m porosity and 25mm diameter which had been previously burned (to make sure there were no traces of carbon anymore). Once filtering done, filters are folded and stored in tubes at -20°C.

Analyse procedure:

Measurement by “elemental analysis” with CHN device directly for POC/PON, and after “decarbonatation” for PIC

Futur work

The samples will be analysed at LEMAR by A. Masson. The data will be interpreted in collaboration with groups working on carbon export, carbon dioxide fluxes, dissolved organic carbon, nitrogen uptake, and biology in order to further constraint the biological pump and the carbonate pump in the transect of BONUS-GoodHope.

4.4.5 BIOGENIC SILICA - ^{30}Si INCUBATIONS - Si DILUTION EXPERIMENTS

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Parameters

- Biogenic Silica (BSi) :
- BSi is used as a marker of diatom biomass

- ^{30}Si incubations :
- ^{30}Si incubations were conducted for the assessment of the Si Uptake Rate and BSi Dissolution rate

- Si Dilution Experiments:
- Dilution experiments to determine growth parameters and grazing rates of diatoms using BSi as a diatom proxy.

Sampling, storage and measurements:

BSi Filtrations :

- Bottom water BSi was sampled at all LARGE and SUPER stations from Hydro casts.
- Upper Mixed Layer BSi was sampled at all LARGE and SUPER stations from Hydro casts.
- Filters (PC, $0.6\mu\text{M}$) were dried and stored at ambient temperature for later analysis of BSi by spectrophotometry after alkaline digestion at the LEMAR, Plouzané.

Method: Ragueneau & al., *Continental Shelf Research* 25 (2005) 697–710.

Dilution Experiment:

- Dilution experiments were conducted at all SUPER stations using Mixed Layer water sampled with CTD rosette.
- These incubations have been done for two depths : 1%, and 100% PAR depth.
- For each depth, and for diluted and non-diluted biomass sample, three different (triplicates) 500mL PC bottles are respectively incubated for 24 and 48h.
- Filters of BSi and 50mL tubes of filtered seawater for silicate are sampled at t_0 , $t+24\text{h}$ and $t+48\text{h}$.

- Filters are dried and stored at ambient temperature, 50mL seawater tubes are stored at +4°C. Both BSi and silicates will be analysed at the LEMAR, Plouzané

Method: Pondaven & Corvaisier, *unpublished*.

³⁰Si Incubations:

- ³⁰Si incubations experiments were performed at all LARGE stations on samples taken from the mixed layer.
- These incubations have been done for 3 depths : 1%, 25% and 100% PAR depth.
- The addition of 30Si tracer is 100% in order to get a better signal for dissolution rate measurement. This experiment is coupled, on the same water, with the 10% tracer addition incubation done by Fripiat & Cardinal which is more focused on uptake rate measurements.
- For each depth 3 different (triplicates) 2000mL PC bottles are respectively incubated for 24h.
- Filters of BSi and 50mL tubes of filtered seawater for silicate measurement are sampled at t0 and t+24h. A preconcentration (MAGIC) of silicate is also performed to recover all the silicates in 20mL at the end.
- Filters are dried and stored at ambient temperature, 50mL seawater tubes and MAGIC tubes are stored at +4°C. BSi, silicates and ³⁰Si abundances will be analysed at the LEMAR, Plouzané.

Method: Corvaisier & al., *Analytica Chimica Acta 534 (2005) 149–155*, Fripiat & al. *in preparation*.

4.4.6 DISSOLVED ORGANIC CARBON DISTRIBUTION

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Introduction and scientific objectives

The aim of this study is to determine the DOC distribution in the different water masses. DOC is a key parameters for marine environment, it plays a key role in carbon cycle as it represents the largest reservoir of reactive carbon on the Earth (700 GtC comparable to atmospheric pool), moreover DOC pool plays also a key role in the food web, as it is the main source of food for bacterioplankton. DOC concentration in the ocean is mainly the result of biological activity and his distribution is driven by water masses circulation.

Methods

Dissolved organic carbon samples (DOC) were collected at the seven LARGE stations and five SUPER stations (see table). A total of 165 seawater samples were collected using Niskin bottles. In SUPER stations, samples were collected in “hydro” cast and in “MLD” cast (Mixed Layer Depth cast). In “hydro cast”, 10 samples were collected at the same depths than DOC samples for carbon isotopic analyses and were chosen to obtain a profile of concentration in the water column.

At each depth, three aliquots of 25 ml of seawater were collected in pre-combusted ampoules (450°C six hours). Samples were not filtered. They were poisoned with one drop of 85%-phosphoric acid. Then, ampoules were flame-sealed and stored at +4°C in the dark

Station	L1 - St11	S1 - St18	L2 - St31	S2 - St34	L3 - St41	L4 - St44	S3 - St48	L5 - St52	L6 - St56	S4 - St62	L7 - St72	S5 - St78
hydro cast		10		10			10			10		10
MLD cast	10	9	11	9	8	9	9	11	11	9	11	8

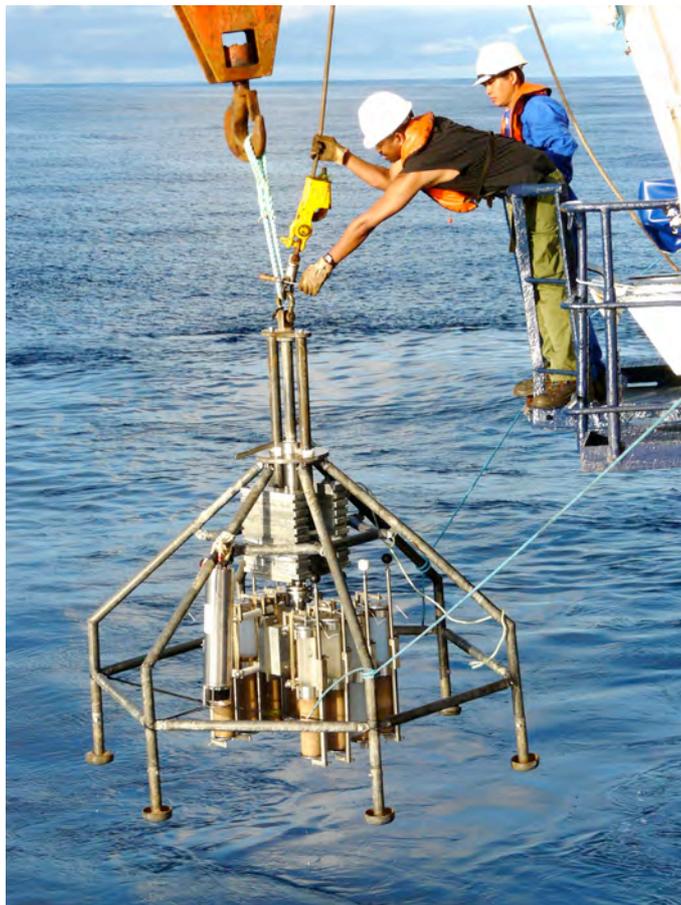
DOC measurements

DOC will be analysed by High Temperature Catalytic Oxidation using a Shimadzu TOC-5000 total carbon analyser with a quartz combustion column in the vertical position filled with 1.2% Pt on silica pillows with an approximate diameter of 2mm (Sohrin and Sempéré, 2005).. Briefly, the furnace temperature was maintained at 680 °C and the effluents passed through a mercury trap (gold wire) to remove mercury (Ogawa and Ogura, 1992). A magnesium perchlorate water trap is added to the system located before the halogen scrubber, in addition to an in-line membrane filter and the nondispersive infrared CO₂ detector. Prior to analysis, subsamples, acidified with 10 µl of 85% H₃PO₄ to pH~2 just after the sampling, are sparged for 10 min with CO₂-free pure air to remove inorganic carbon as CO₂. During the sparging procedure, we followed the recommendations of J.H. Sharp (University of Delaware), i.e., care was taken that during sparging of each sample, seawater did not overflow from the vials. This condition was possible at a gas flow rate of 40 ml min⁻¹.

One-hundred-microliter injections were repeated three to four times for each sample, the analytical precision of the procedure being within 3% on average. Prior to analyses of standards and samples, the catalyst bed was ‘conditioned’ by injecting 100 µl of acidified and sparged water from a Millipore Milli-Q PlusR system, until the lowest stable integrated area was obtained. To stabilize values for the blank, the catalyst is pre-treated by washing in 1% HCl and gently rinsed with Milli-Q water, and dried in a furnace at a temperature of about 450 °C for 10–15 min.

Sohrin, R., Sempere, R., (2005) *Seasonal variation in total organic carbon in the Northeast Atlantic in 2000-2001*. J. Geophys. Res. VOL. 110, C10S90, doi:10.1029/2004JC002731

4.5 SURFICIAL SEDIMENTS AND PORE WATERS



Sedimentary inputs can represent the major source of trace metals in continental margin areas and in surface waters of the ACC by advection from the Antarctic peninsula and Drake Passage. This source likely depends on benthic chemistry and dynamics such as bioturbation and organic carbon mineralization processes. It is thus proposed to estimate the biological and biogeochemical response of the sedimentary environment to quantitative and qualitative variations of particulate organic matter input and the consequences to benthic fluxes and pathways. The major issue relates to the understanding of benthic-pelagic coupling and its modifications along a large scale transect in the ACC and at the South African continental margin. Very few studies (if any) relate fate of trace metal to a complete description, both biological and biogeochemical, of the sediment-water interface functioning. Sulphate reduction is a major pathway for degradation of organic carbon in deep sea sediments. While a significant amount of work has been done regarding sulphate reduction in the Central and Northern Benguela regions, in the area of interest this information as well as information on sediment trace metal content is scarce. New data will be generated for sulphate reduction, allowing to confront the shelf area south of South Africa with the Southern Ocean basin. This has implications for benthic organic carbon recycling, trace metal speciation and epibenthic fluxing. Furthermore, practically no information is available as to what extent the southern African continental mass influences biogeochemical processes in the coastal regions by providing carbon and trace metals inputs. The study of trace metal sources and distribution in sediment is high on the agenda in South Africa. Understanding the oceans

around South Africa is also of vital importance to establish if land-based sources of pollution are impacting the environment.

4.5.1.1 SEDIMENT BIOGEOCHEMISTRY EVOLUTION ACROSS FRONTAL ECOSYSTEMS: SOUTHERN OCEAN BOTTOM BOUNDARY CONDITIONS AND PROXY CALIBRATION

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Scientific Objectives

Our work aims to quantify the benthic biogeochemical response to ecosystem modification across subtropical and polar fronts. Biogeochemical factors of interest include the rates and pathways of benthic organic matter degradation and carbon mineralization. In a poorly documented area of the Southern Ocean these rates and pathways are likely to change across frontal systems not only due to changes in gross primary production but also with variability in the net export of carbon to the deep ocean. Results will provide to biogeochemistry-GCM coupled models an improved estimation of benthic boundary conditions. In order to achieve this goal, a very well preserved sediment-water column interface is necessary to allow quantification of benthic fluxes. Furthermore, an integration of the benthic flux data with physical measurements of the bottom currents will allow potential resuspension rates to be estimated. This combination of benthic flux data with an understanding of the physical conditions makes the BGH campaign unique. Data on bottom and intermediate water currents will also be combined with outward benthic fluxes of macro- and micronutrients to characterize sediment feed-back to the Southern Ocean.

The sediment is also a potential source of particulate and dissolved isotopic tracers of water masses and samples will be available to define end-members at requested stations. Additionally, the quantification of the preservation of paleo-productivity/paleo-environment proxy is of primary importance to the interpretation of sediment records. We will compare the net burial rates of proxy to the quantity exported from the ocean mixed layer.

Sampling Strategy And Processing Sequences

Multitubes corer operations

During BGH cruise, we deployed an Oktopus Gmbh multiple corer (head version MUC 8/100) equipped with 8 transparent polycarbonate cylinders (Figure 53). Tubes are 61 cm height and 9.5 cm inner diameter. Initial weight is 650 kg. The thickness of sedimentary acoustic reflectors was monitored by a 3.5 kHz echosounder in order to define sampling coordinates in the course of a short survey on the ship route.



Figure 53 – Oktopus Gmbh multiple corer (head version MUC 8/100) equipped with 8 transparent polycarbonate cylinders deployed during the BONUS-GOODHOPE cruise

Basic protocol: when deployed, downward speed was 1 m/s and instrument depth was controlled both by the length of steel cable (20 mm diameter) run out and by the record of a 1s “pinger” dual echo (fastened on one side of the multi-tubes corer: Figure 53). During operation, cable tension is recorded in order to track oscillating behavior due to waves. 50 m above sediment, run out speed was slowed down to 0.3 m/s. Fast tension decrease as well as pinger echoes coincidence usually allow to determine whether the instrument reached the sediment or not. Additional cable was run out and total waiting time at depth lasted between 1 and 3 minutes. Upward operation starts directly at 1 m/s to allow quick shut off of tubes apertures. Once on the deck, the multi-tubes corer is tightly fastened after safety hook clamping. Finally, 2 out of 7 deployments allowed sediment sampling. Additional weight, breaking lines and blocking plastic tubes were also tried to increase cores recovery. Modified protocol parameters are summarized in Table 33.

Operation	Coordinates	Station	Depth (m)	Wind (knots)	Waves (m)	Extra weight (kg)	Final lowering (m/s)	Hoisting (m/s)	Cable run out (m)
Okto-01	36°26.537S 13°10.455E	18	4918	<5	0.5	0	0.3	0.2	30
Okto-02	42°15.177S 09°05.968E	34	4545	24	2	0	0.3	0.2	30
Okto-03	44°12.997S 07°29.161E	39	4285	32	4	0	0.5	0.5	15
Okto-04	47°18.971S 04°37.057E	48	4586	26	3	200	1	1	60
Okto-05	47°58.222S 03°57.466E	49	4386	28	3	200	0.3	1	20
Okto-06	51°52.952S 00°0.1290E	62	2527	29	4	200	0.5	1	20
Okto-07	57°32.7207S 0°02.5543W	78	3823	6	1.5	0	0.3	1	20

Table 33– Summary of modified protocol parameters

Core samples

Biogeochemical SUPER stations were the main targets of coring operations although slightly different positions can occur due to the sediment survey prior or after the station. SUPER station 1 was correctly sampled (undisturbed sediment-water interface) and useful information can be derived from SUPER station 5 sampling (Table 34). Sediment remains at the very bottom of the tubes were collected for SUPER stations 2 and 3. They will be used in priority to determine isotopic tracers end-members.

Table 34 – Summary of the sediment samples collected during the BONUS-GOODHOPE cruise

Operation	T bottom water (°C)	T overlying water (°C)	O ₂ (aq) bottom water (μM)	O ₂ (aq) overlying water (μM)	Number of core
Okto-01	1.1	10.1	226	224	7
Okto-07	-0.4	-0.5		259	2

Processing sequence

Slicing/Centrifugation/Filtration and Rhizon® sampling



Figure 54 – In situ filtration with Rhizon® (porous probes, 0.2 μm)

As soon as the multi-corer is safely fastened on the deck, overlying water is sampled for dissolved oxygen as well as for nutrient and trace metal analyses by immediately filtering to 0.2 μm with a PP 50 mL syringe. Overlying water temperature was also recorded (± 0.1 °C, Table 34). The appendix section presents the whole sampling strategy and targeted parameters. The high resolution (HR) core was treated within two hours after retrieval while the other cores were stored in the cool chamber until processing. *In situ* filtration with Rhizon® (porous probes, 0.2 μm) was also performed to extract clean pore waters with minimum sediment disturbance (Figure 54).

For redox sensitive compounds, slicing was done under nitrogen atmosphere in a gloves bag in a cool chamber (5 ± 1 °C). Sediment centrifugation was done at 3°C with a temperature regulated Eppendorf centrifuge in 50 mL PP tubes. Once the centrifugation is done, a PP 20 mL syringe with a “pipette tip” needle is used to collect overlying solution

from centrifuge tubes. The liquid sample is then pushed through a Nylon Nalgene[®] filtration membrane (average pore size: 0.2 μm) and delivered to PP tubes and immediately distributed acidified or frozen. Non acidified unfrozen samples were utilized in parallel for ΣCO_2 determination by FIA (Hall et Aller, 1992).

Whole core incubations

Dark core incubations were started in parallel on 2 sediment cores presenting an undisturbed interface. Sediment was first pushed upward the top of the core in order to reach an overlying optimized water volume of around 500 ml (estimated from DeWitt et al., 1997, results for abyssal sediment in the Indian sector of the Southern ocean) to allow detectable oxygen consumption. Incubations were performed in a cool chamber at 5 ± 1 °C. After cores fixation to avoid any disturbance from the ship motion, caps were placed at the top of the cores to close the system and remove any air bubbles. As soon as the system is closed and under constant weak agitation the incubation starts. (

Figure 55, left) principle of a sediment core incubation. 40 ml of prefiltered bottom water are injected with a syringe in the core (1) forcing 40 ml of overlying water to come out the core in another syringe (2). It is then possible, knowing the concentration of elements in the injected water, to calculate accumulation or consumption rates in overlying waters and then calculate benthic fluxes at the sediment/water interface. (

Figure 55, right) sediment cores incubation at SUPER station 1.

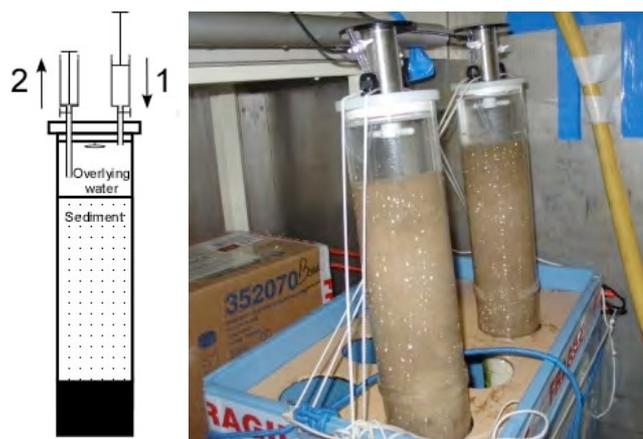


Figure 55 – Sediment core incubation.

Bottom water sampled from a CTD was filtered on a PC 0.2 μm membrane held in a 90 mm Nalgene on-line filtration support. Masterflex tubing was trace metal free. 40 mL samples were collected every 24 hours during 6 days (3 mL for tubes cleaning, 25 ml for Winkler oxygen concentration measurement, 8 ml for metal traces measurements, 4 ml for nutrients measurements). All tubing, air and skin contacts were reduced to the minimum to avoid any contamination especially for trace elements. All caps and tubes were thus washed with 5% Suprapur HCl acid and rinsed with 18 Mho milli-Q water prior all experiments.

Sulfate reduction rate incubations

At SUPER Station 1, a core with a well-preserved sediment-water interface was sliced at 1 cm resolution. Four syringes were filled with about 4 ml of sediment and injected with the radiotracer $^{35}\text{SO}_4^{2-}$. Two samples at each depth were incubated for 18 hours and two further samples were incubated for 7 days. Due to the limited sediment recovery at SUPER Station 5, only two syringe subcores were taken at 1 cm resolution. These samples were incubated for 7 days. Three controls per core were injected with the radiotracer and immediately preserved in 20% zinc acetate. 79 samples in total were incubated on board from the SUPER Station 1 core and 40 samples from SUPER Station 5. Incubations took place in the dark in the cool chamber at temperatures of 5 ± 1 °C. The Rhizon core from SUPER Station 1 was sliced into 13 slices of 2 cm depth after Rhizon sampling was complete. The samples will be used for kinetic experiments in the laboratory. The incubation samples will yield 'in situ' sulfate reduction rates as well as acid-volatile sulfide (AVS) and chromium-reducible sulfide (CRS) concentrations. The samples for further kinetic experiments were stored in the dark, in nitrogen-filled bags at 5 ± 1 °C. These samples will yield potential rates of sulfate reduction at different experimental conditions. Analyses on the incubation samples are planned to be complete within two months due to the limited half-life of ^{35}S . Blanks will be run to verify lack of contamination.

Microprofiling

Clark-type microelectrodes, a picoammeter (PA 2000 UNISENS) and a computer controlled micro-manipulator (Figure 56) were used to measure dissolved oxygen along a vertical profile across the sediment-water interface. The microelectrodes (UNISENS Ox-100) used in the analysis have 100 μm tip for minimum disturbance of vertical gradients. Resolution was between 100 and 400 μm depending on the gradient value to be characterized and ship vibration. Above 8-10 knots, ship vibrations create microscale pore water mixing/motion that produce noisy profiles. Two oxygen microprofiles were run per station down to 7 cm where oxygen asymptotic values are reached. The acquisition of high-resolution profiles allows the calculation of the diffusive flux of oxygen across the sediment-water interface. This diffusive flux integrates both aerobic and anaerobic organic matter mineralization rates (direct consumption or reoxidation of reduced by-products) in addition to the direct observation of oxygen penetration depth.



Figure 56 – Measurement of dissolved oxygen along a vertical profile across the sediment-water interface with Clark-type microelectrodes, a picoammeter (PA 2000 UNISENS) and a computer controlled micro-manipulator.

Two pH microprofiles per station were performed. Microelectrodes (UNISENS) have a 100 µm tip and were calibrated against NIST buffers (pH 6.881 and pH 9.225).

Microbiology

Sediment microbiological samples were collected from the sulfate reduction core at SUPER Station 1 (samples for bacterial counting: 12 + 1 control; samples for nucleic acid extraction: 11 + 1 control; samples for culturing: 3 + 1 control). Samples for counting were placed in 3% formaldehyde for a few hours, centrifuged and washed with phosphate-buffered saline (PBS) three times, before being stored in a 1:1 solution of PBS and ethanol at -20°C. Culturing samples were first suspended in artificial seawater, and thereafter an aliquot was placed into either a complex medium supplemented with acetate or the same medium base supplemented with lactate. Nucleic acid samples were placed in sampling vials and stored at -80°C.

Seawater microbiological samples were collected from 3 CTD Bottom casts at stations 59 (CTD 80), 71 (CTD 97) and 78 (SUPER Station 5; CTD 106); and 2 CTD Ba/Si casts at stations 62 (SUPER Station 4; CTD 87) and 78 (SUPER Station 5; CTD 110). Samples for counting were placed in 3% formaldehyde for a few hours, then centrifuged and washed with phosphate-buffered saline (PBS) three times, before being stored in a 1:1 solution of PBS and ethanol at -20°C. Culturing samples were first suspended in artificial seawater, thereafter an aliquot was placed into either a complex medium supplemented with acetate or the same medium base supplemented with lactate. Nucleic acid samples were placed in sampling vials and stored at -80°C.

Seawater microbiological samples were collected from three CTD Bottom casts at stations 59 (CTD 80), 71 (CTD 97) and 78 (SUPER Station 5; CTD 106); and two CTD Ba/Si casts at stations 62 (SUPER Station 4; CTD 87) and 78 (SUPER Station 5; CTD 110). Samples for counting (51 samples + 15 controls) were sampled directly into vials containing 2 ml formaldehyde for a final concentration of 3%, and stored at -80°C. Nucleic acid extraction samples (51 samples + 16 controls) were filtered on polycarbonate filters to 0.2 µm, and the filters stored at -80°C. Extra water samples (21 samples of 250 ml volume) were taken at the first CTD bottom and Ba/Si casts.

Due to the last-minute nature of sample planning following unsuccessful sediment coring, full protocols will be finalised after the cruise. Bacterial counts will probably be done using in situ fluorescent hybridisation (FISH). Nucleic acid extractions will follow standard methods and target major bacterial and Archaea groups to identify the bacterial/ Archaea community present. Controls collected in the field will help assess the validity of the samples. Bacterial counts and bacterial communities will be reported.

In addition, potential dark community respiration experiments were performed on 3 CTD casts with mixed layer and pycnocline samples. Incubated seawater was spiked with surface particles retained on filters. The aim of the experiment is to characterize the organic matter change (phospholipids measurement) during respiration processes within the mixed layer. This work (in collaboration with A.J. cavagna and F. Dehairs, ULB) could potentially yield information about the nature of exported material associated to shallow mineralization. The experiment was conducted as follows: 125 liters of surface seawater were filtered on precombusted QMA filters (142 mm diameter, porosity 1µm). Filters were then punched to obtain 30 culture media (25 mm punches). Whole QMA 142 filters were stored at -80°C for lipids analyses to quantify the organic matter pre-incubation. Seawater was sampled with Niskin bottles at different depths and incubated with punches in Winkler bottles. Incubation

time was 24h. Oxygen concentration was measured by Winkler titration and the remaining water was filtered on precombusted GF/F filters and stored at -80°C for lipid analyses. First values of O₂ are available on the table, lipids will be analyzed by GC-c-IRMS and GC-MS in the home based laboratory (ULB, Brussels) after total lipid extraction (modified Bligh and Dyer method) and silylation.

Preliminary Results

Chemical profiles

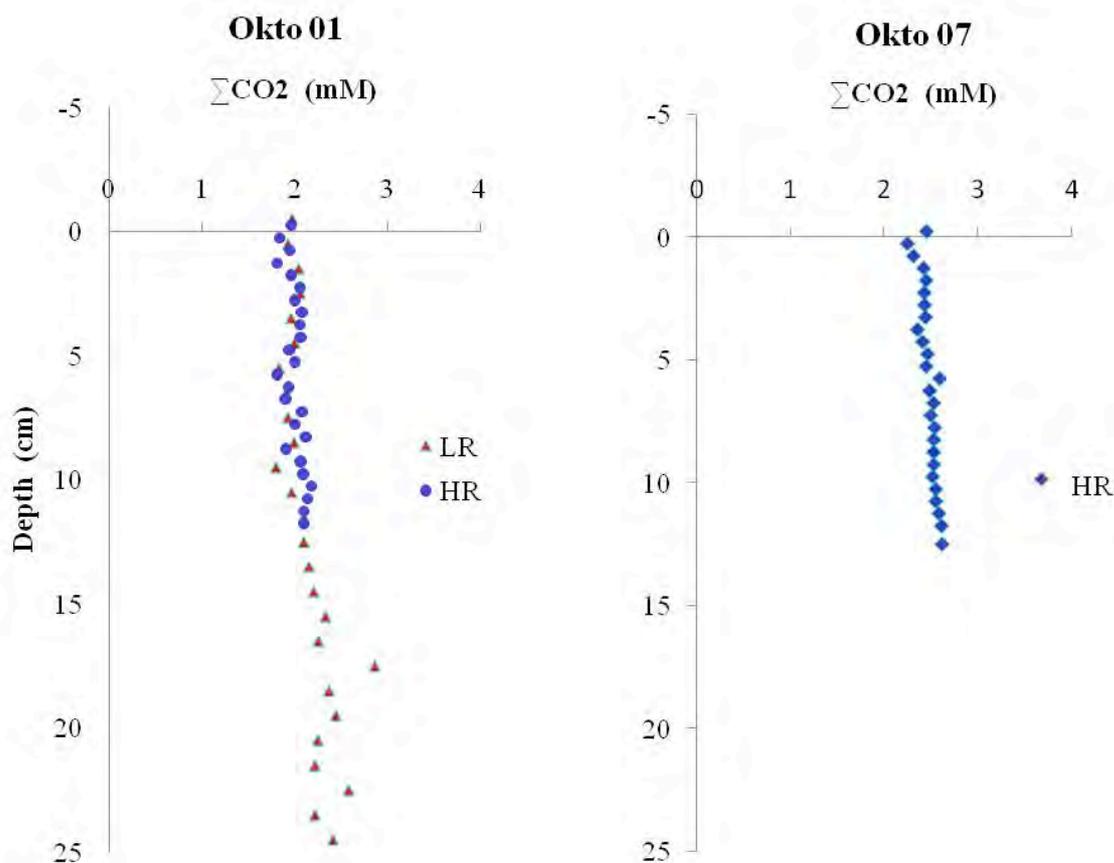


Figure 57 – Vertical profile of ΣCO_2 for SUPER stations 1 and 5.

Slight ΣCO_2 increase with depth (Figure 57) indicate a slow mineralization rate to be linked with oxygen microprofiles showing a penetration depth higher than 7 cm (Figure 58) and asymptotic values within the range of 30-50 μM .

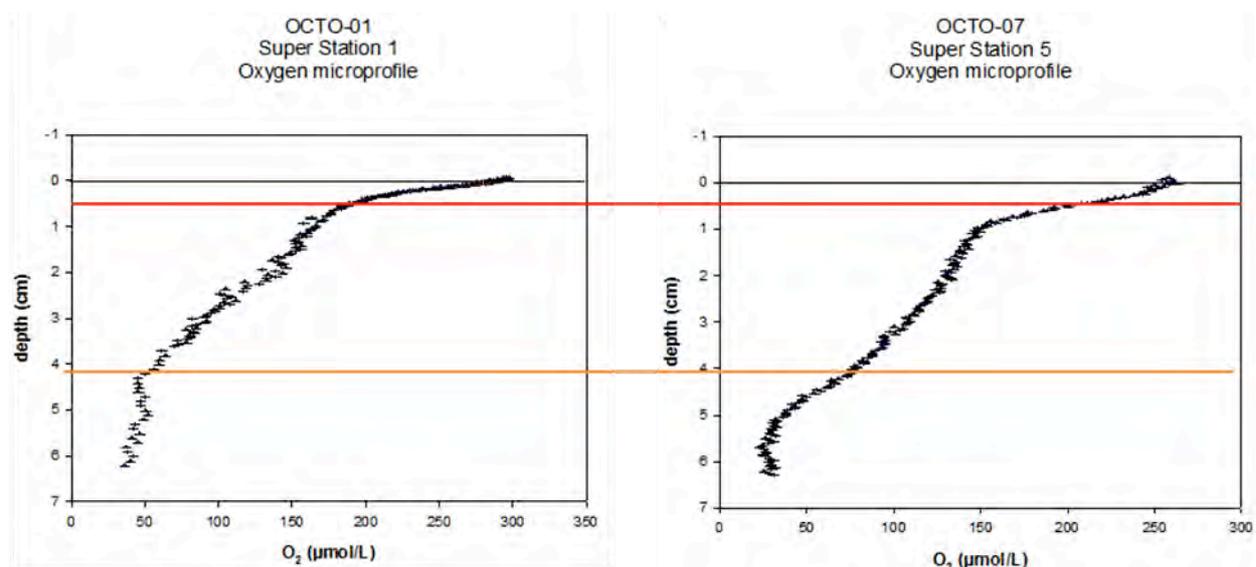


Figure 58 – Vertical oxygen microprofiles for SUPER stations 1 and 5

Whole core incubations

Figure 59 shows chosen whole core incubation results from SUPER station 1. One core was stopped after one day (corresponding to a start-end incubation) and started again so that we have 2 cores for 3 experiments. Oxygen, ΣCO_2 , silica and nitrate were measured on board by respectively winkler titration, FIA and Technicon nutrients analyser. Oxygen, ΣCO_2 and nitrate concentrations do not show any significant trend relatively the experimental protocol and analyses. Significant dissolved silica increase in concentration is however observed that defines a release in the overlying water. The average dissolved silica flux on the 3 experiments is $186 \pm 66 \text{ mmol.m}^{-2}.\text{y}^{-1}$. This value (higher than the average oceanic value) could be implemented in a water column transport model to see this source can entirely explain the possible dissolved silica anomaly observed in deep waters of Cape Basin (collaboration F. Lemoigne, LEMAR). More analyses will be done back in the laboratory (traces elements, nutrients) and will be completed within 3 months.

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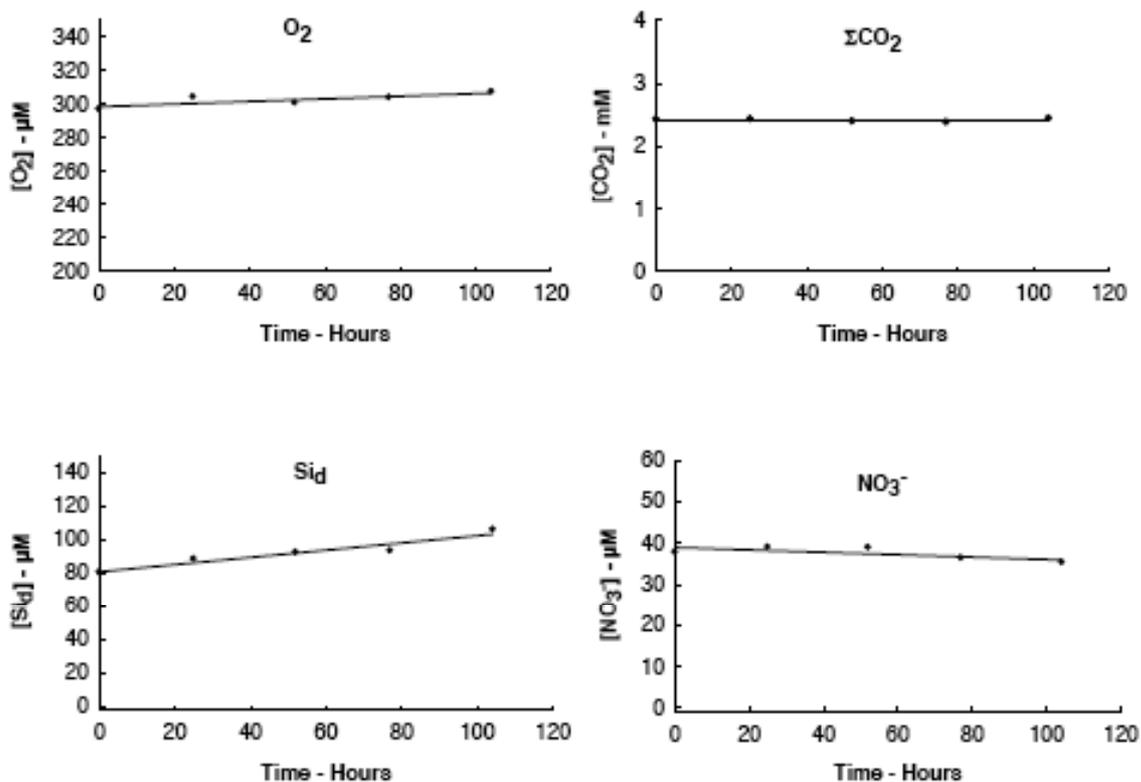


Figure 59 – Chosen whole core incubation results from SUPER station 1

Potential dark community respiration

The onboard results of the potential dark community respiration are summarized in Table 35. Significant oxygen consumption is obtained and will be discussed along with phospholipids analysed at ULB within three months.

Table 35 – Onboard results of the potential dark community

CTD	Station type	Station	Date	Long.	Lat.	Sampling depth, incubation time	Bottle volume (T0/C/TF)	Average consumption (Incubation/Control) µmol.l ⁻¹
66	Super 3	48	06/03/08 05:46	04.23.056 E	47.33.415 S	Tap water	120/120/25 ml	0.33/0.29
						40 m, 24 h	120/120/60 ml	1.85/0.05
						80 m, 24 h	120/120/60 ml	0.38/0.93
87	Super 4	62	11/03/08 03:58	00.00.109 W	51.52.158 S	40 m, 24 h	120 ml	0.49/0.02
						120 m, 24 h	120 ml	0.56/-0.01
110	Super 5	78	16/03/08 23:00	00.02.268 W	57.33.152 S	50 m, 12 h	120 ml	0.45/0.29
						50 m, 24 h	120 ml	0.78/0.65
						125 m, 12 h	120 ml	0.05/-0.01
						125 m, 24 h	120 ml	0.37/-0.13

Onboard samples distribution

Table 36 presents how sediment, solid fractions and pore waters are either distributed on board or conditioned to be preserved prior to be analysed.

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Table 36 – Summary on how sediment, solid fractions and pore waters are either distributed on board or conditioned to be preserved prior to be analysed.

bulk: bulk sediment	b: bottom	_ : very little sediment
pwf: filtered pore water, frozen	es : overlying water	multi: multiple parameters
pwa: filtered pore water, acidified 1 drop HNO3 sp	cs: centrifuged sediment, frozen	
bf: bulk + 1% formaldehyde	R: remains	

Outside IPGP, EPOC & UCT

operation	responsible	institutions	core	depth	samples	Parameter
OKTO-01	F. Planchon	MRAC	HR	0-2 cm + b	bulk	234Th
OKTO-01	D. Cardinal	MRAC	I1&I2	0-25 cm	pwa	?29Si
OKTO-01	U. Ezat	LSCE	ME	0-15 cm	bulk	Alkenones
OKTO-01	N. Laborde	LSCE	ME	0-10 cm	bulk	14C, Corg, ?13C
OKTO-07	F. Planchon	MRAC	HR	0-2 cm	bulk	234Th

IPGP, EPOC & UCT

OKTO-01	E. Viollier	IPGP	HR	0-12.5 cm	pwa	multi
OKTO-01	E. Viollier	IPGP	LR	0-25 cm	pwa	multi
OKTO-01	E. Viollier	IPGP	RK	0-30 cm	pwa	multi
OKTO-01	E. Viollier	IPGP	I1&I2	es	pwa	multi
OKTO-01	E. Viollier	IPGP	HR	0-12.5 cm	pwf	nutrients
OKTO-01	E. Viollier	IPGP	LR	0-25 cm	pwf	nutrients
OKTO-01	E. Viollier	IPGP	RK	0-30 cm	pwf	nutrients
OKTO-01	E. Viollier	IPGP	I1&I2	es	pwf	nutrients
OKTO-01	E. Viollier	IPGP	HR	0-12.5 cm	cs	multi
OKTO-01	E. Viollier	IPGP	LR	0-12.5 cm	cs	multi
OKTO-01	E. Viollier	IPGP	ME	0-25 cm	bulk	porosity
OKTO-01	A. Grémare	EPOC	I1&I2	0-25 cm	cs	pigments/amino acids
OKTO-01	A. Grémare	EPOC	I1&I3	0-7 cm	bf	meiofauna
OKTO-01	K. Barnes	UCT	LR	0-25 cm	cs	multi
OKTO-01	K. Barnes	UCT	LR, HR	b	bulk	kinetics
OKTO-01	K. Barnes	UCT	SR	0-25 cm	bulk	srr, avs
OKTO-02	E. Viollier	IPGP	R	–	bulk	isotopic tracers
OKTO-04	K. Barnes	UCT	R	–	bulk	isotopic tracers
OKTO-05	K. Barnes	UCT	R	–	bulk	isotopic tracers
OKTO-05	E. Viollier	IPGP	R	–	bulk	isotopic tracers
OKTO-07	E. Viollier	IPGP	HR	0-24 cm	pwa	multi
OKTO-07	E. Viollier	IPGP	ME	0-24 cm	pwa	multi
OKTO-07	E. Viollier	IPGP	HR	0-24 cm	pwf	nutrients
OKTO-07	E. Viollier	IPGP	ME	0-24 cm	pwf	nutrients
OKTO-07	E. Viollier	IPGP	HR	0-12.5 cm	cs	multi
OKTO-07	K. Barnes	UCT	ME	0-25 cm	cs	multi
OKTO-07	K. Barnes	UCT	SR	0-25 cm	bulk	srr, avs
OKTO-07	E. Viollier	IPGP	ME	0-25 cm	bulk	porosity

Conclusion

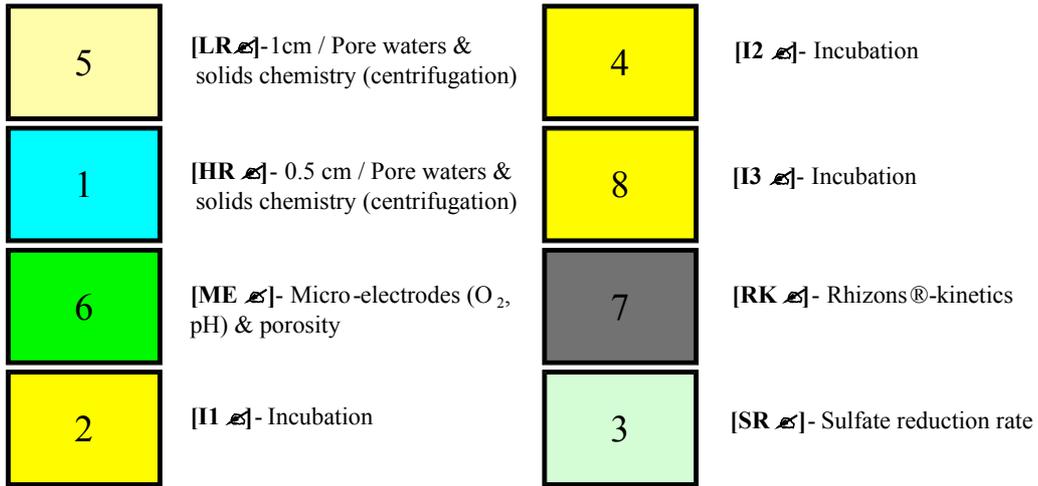
Problems encountered during multitubes corer deployment allowed 30% recovery from the 5 possible biogeochemical SUPER Stations. A discussion at the national level should be planned as soon as possible to acquire or build a reliable multitubes corer for abyssal sediments in rough seas. Nevertheless, the sediment collected at the northern- and the southernmost stations should provide interesting new insights into benthic fluxes and biogeochemical cycling in the Southern Ocean, and the sediment remains, collected after failed deployments will increase the possibility of characterizing isotopic tracers end-members.

Appendix

ex situ operations from sediment cores

Full success = 8 « perfect » cores

- (A) visually preserved sediment-water interface
- (B) Appropriate sediment height

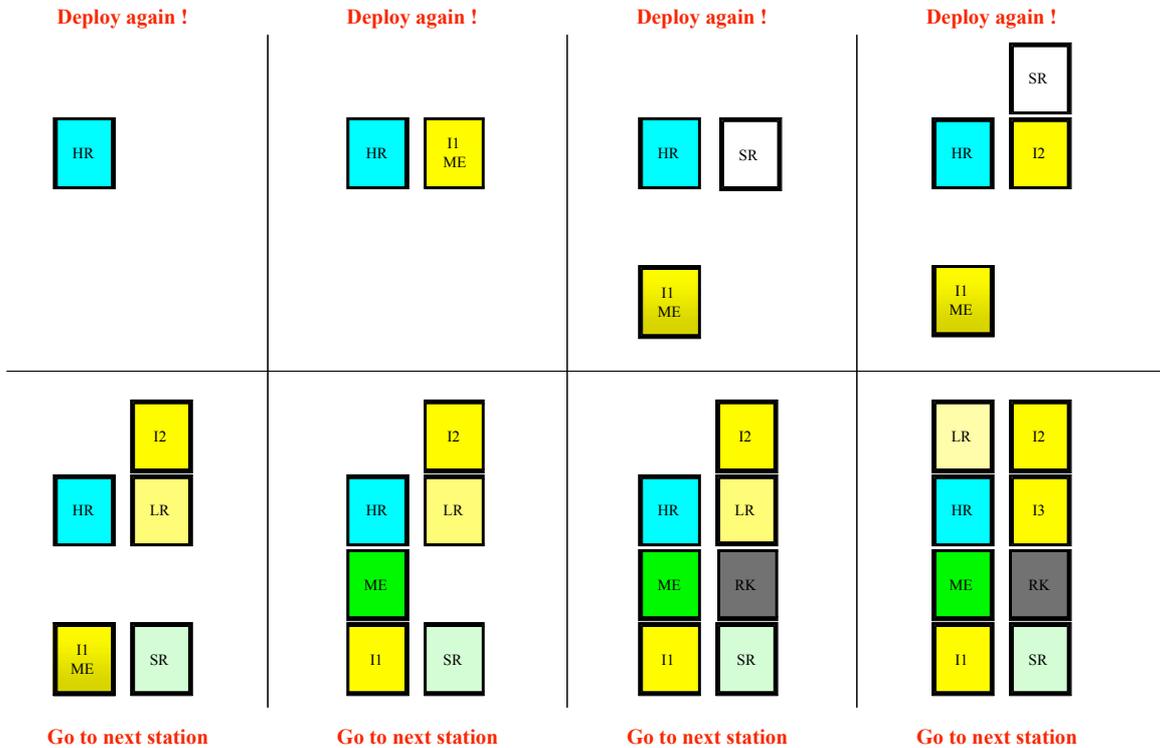


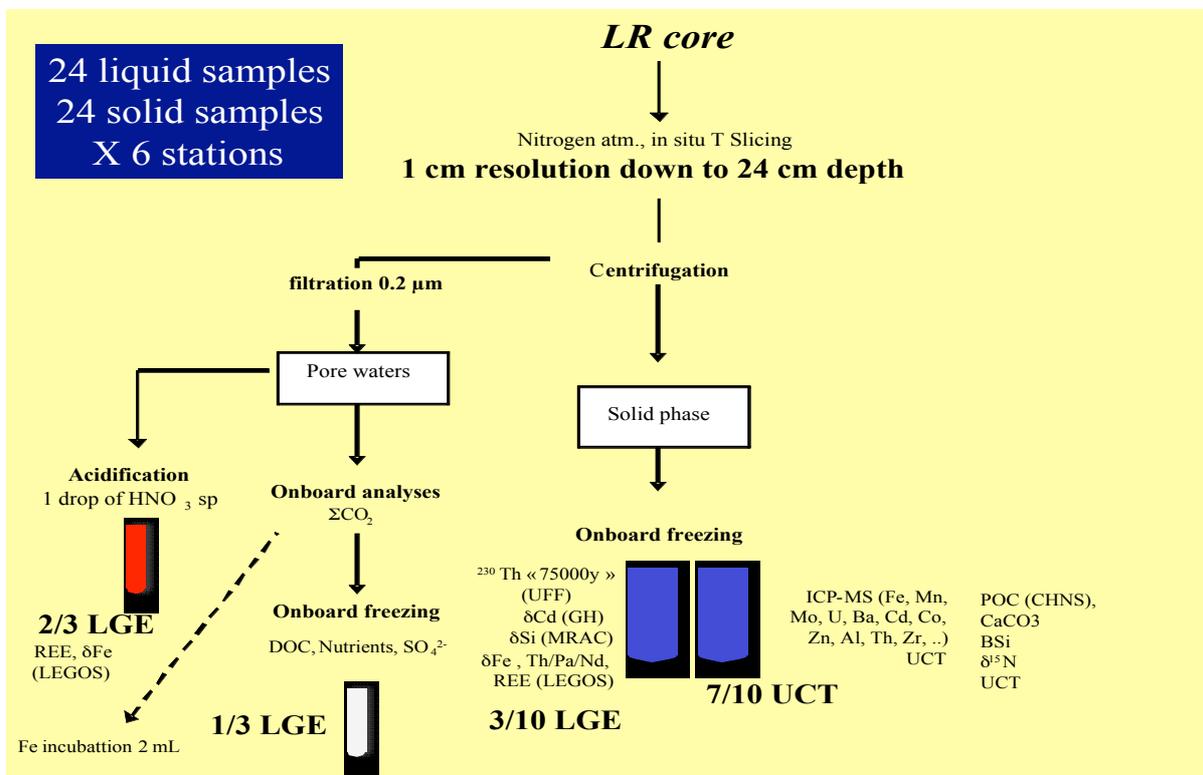
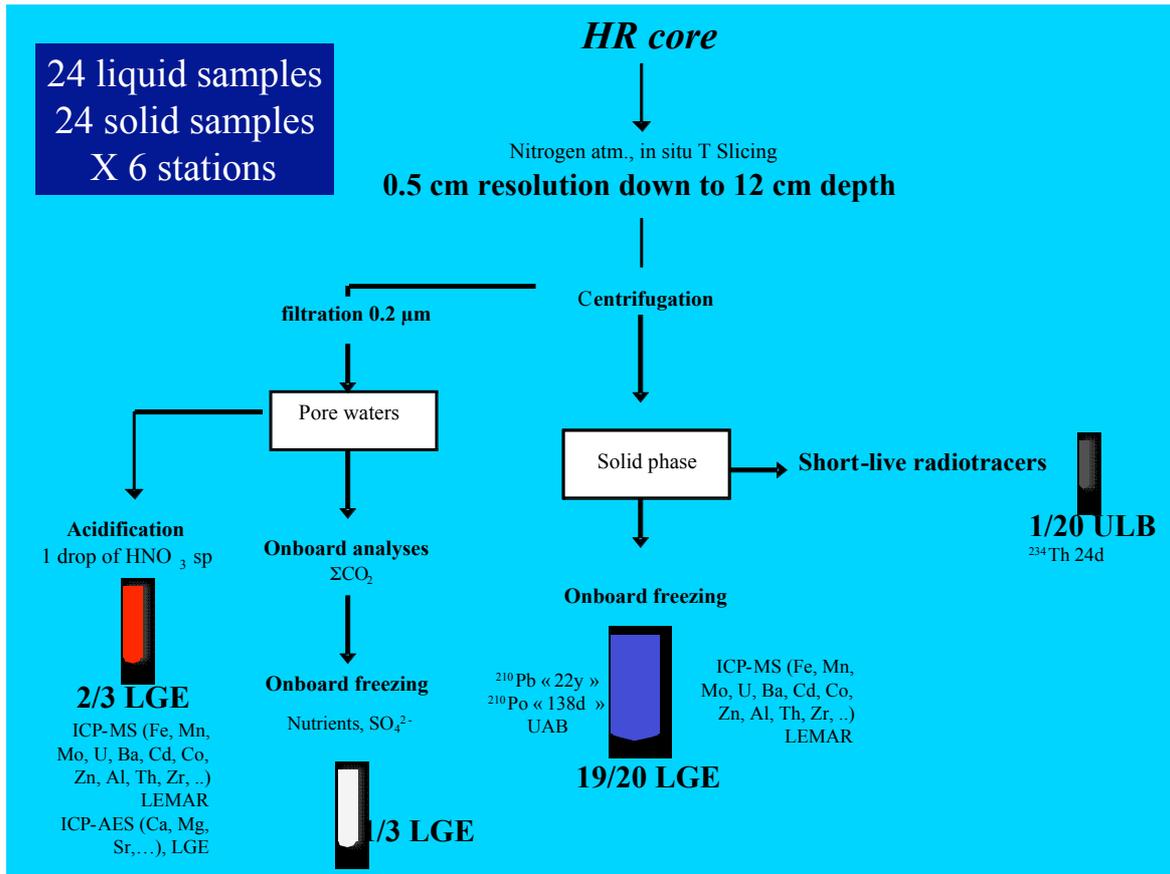
Numbers indicate priority for core distribution on deck

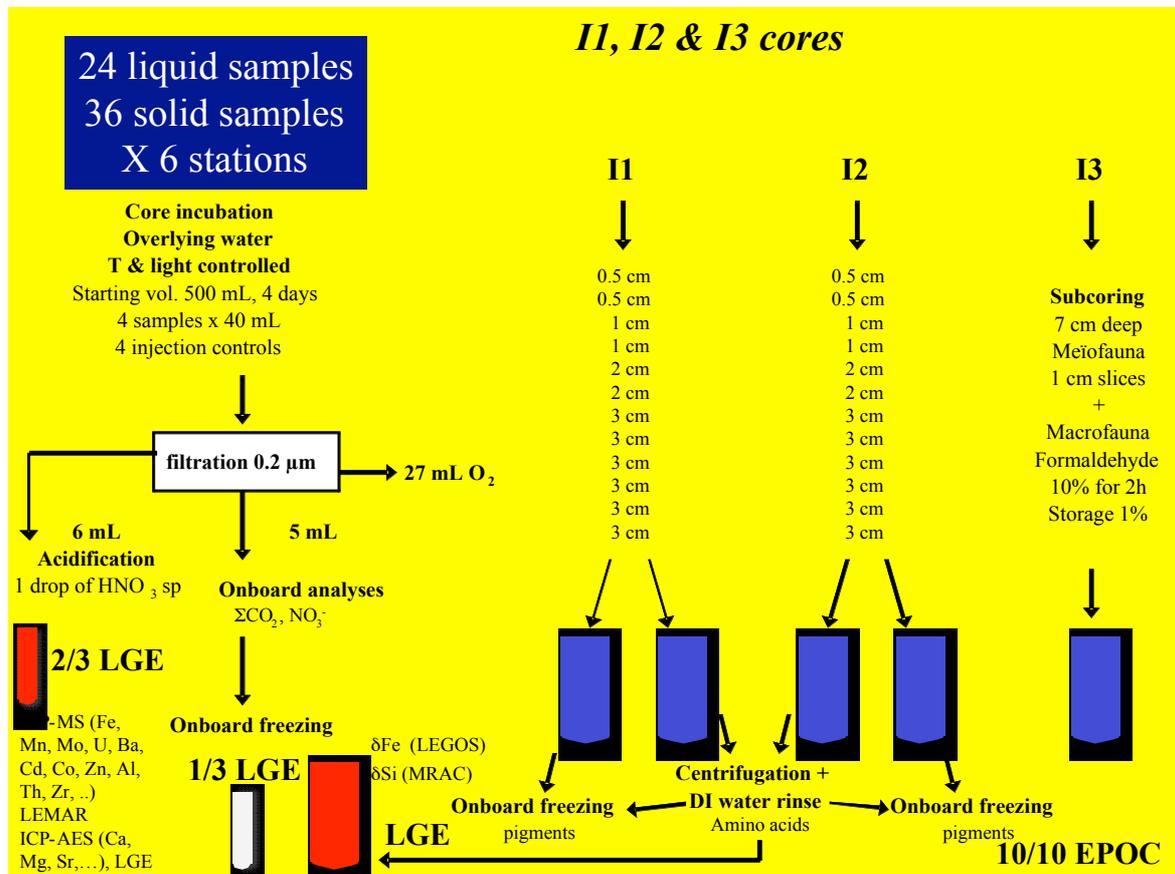
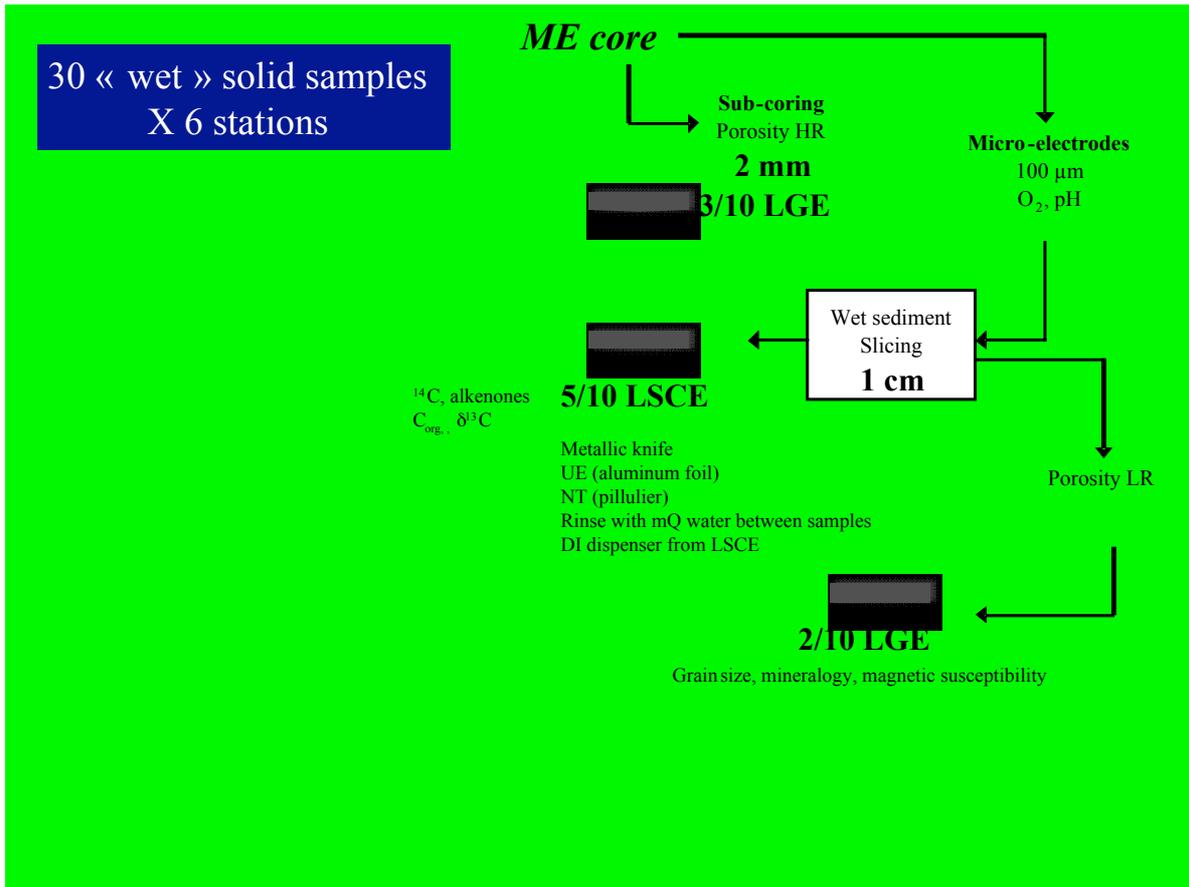
⚡caps: rubber/red

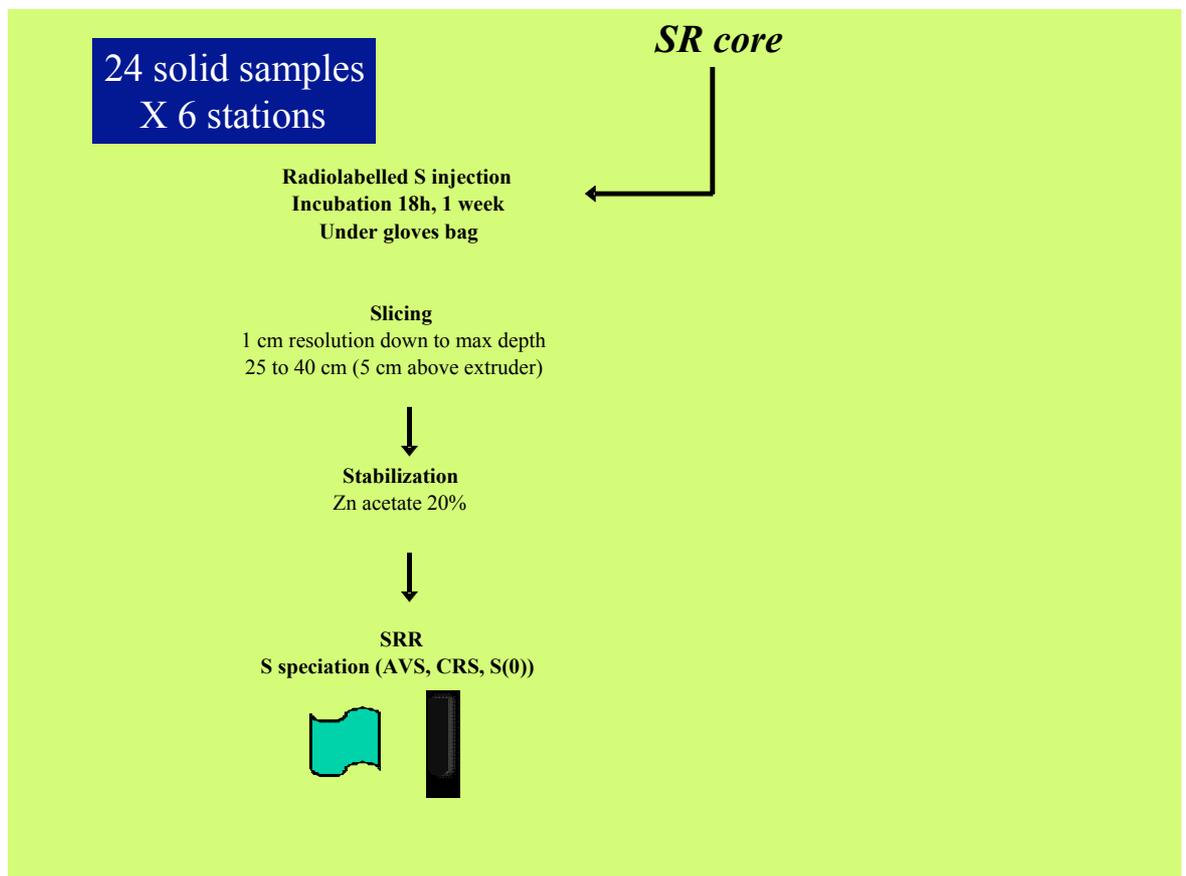
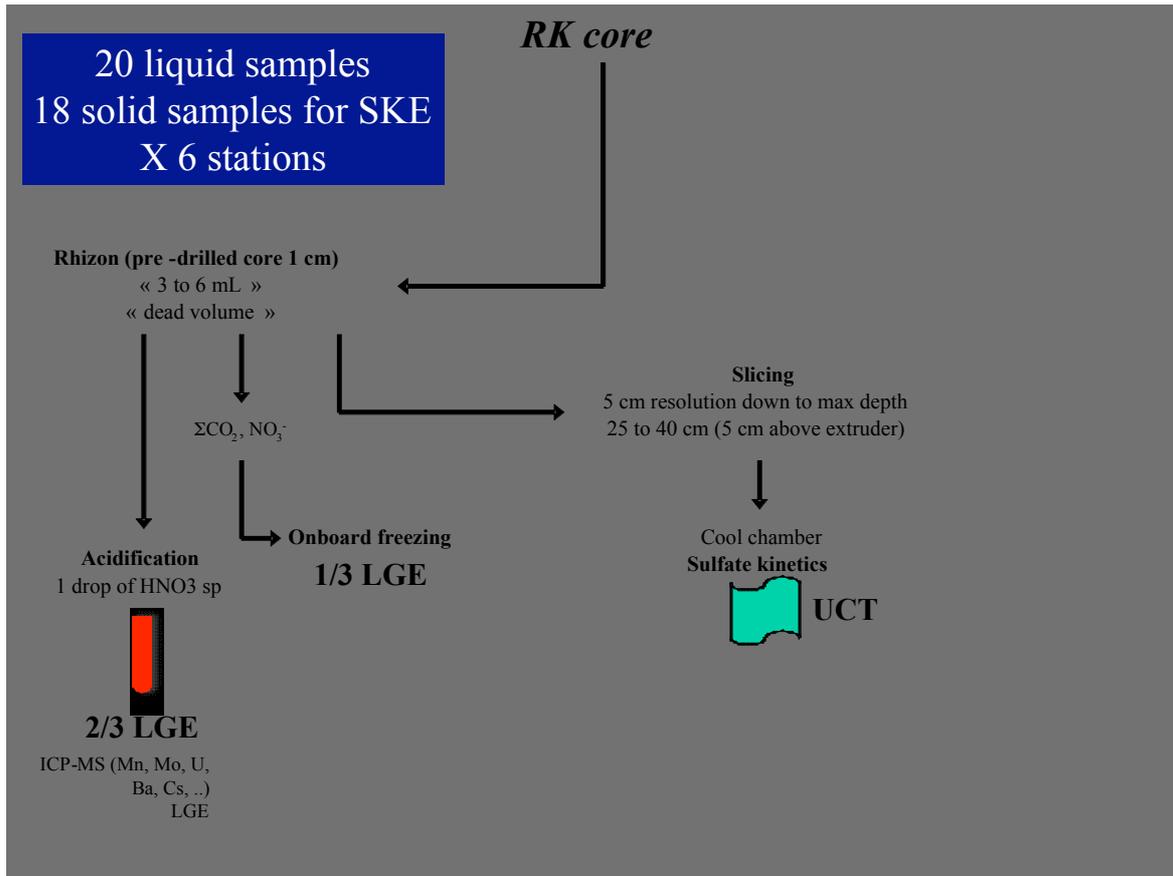
⚡caps: rubber/rubber

Deployment strategy and core use vs. Coring success









4.5.2 ATMOSPHERIC BIOGEOCHEMISTRY



Atmospheric transport is the dominant means by which iron is supplied to the remote ocean. This is particularly important in the SO, an area removed from the world's major deserts and where surface water iron concentrations are extremely low. Aerosol iron solubility is generally low, but it varies systematically with aerosol source. Furthermore over most of the Atlantic Ocean, soluble aerosol iron is in excess, relative to the other nutrients, in terms of phytoplankton nutrient requirements. To date the solubility of aerosol iron over the remote SO has not been determined, nor have the concentrations of the other major nutrients (N, P, Si) or micronutrient trace metals (e.g. Zn, Co, Cd) in that aerosol been determined.

4.5.2.1 ATMOSPHERIC NUTRIENTS AND TRACE METALS SAMPLING: AEROSOLS AND RAIN

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4.5.2.1.1 Scientific motivation

Atmospheric transport is the dominant means by which iron is supplied to the remote ocean. This is particularly important in the SO, an area removed from the world's major deserts and where surface water iron concentrations are extremely low. Aerosol iron percentage solubility is generally low at high dust loadings, but systematically increases as dust concentrations decrease (Baker & Jickells, 2006). Furthermore over most of the Atlantic Ocean, soluble aerosol iron is in excess, relative to the other nutrients, in terms of phytoplankton nutrient requirements (Baker et al., 2003). To date the solubility of aerosol iron over the remote SO has not been determined, nor have the concentrations of the other major nutrients (N, P, Si) or micronutrient trace metals (e.g. Zn, Co, Cd) in that aerosol been determined.

4.5.2.1.2 Sampling methodology

Continuous sampling for aerosols was done using a high-volume ($1 \text{ m}^3 \text{ min}^{-1}$) sampler equipped with a bulk aerosol sampling head (Whatman 41 filter). Aerosol filters had been triple-washed with HCl to reduce trace metal contamination. Rain samples were collected very sporadically on an event basis by deploying large (40 cm diameter) plastic funnels for the duration of rainfall only. These samples were collected in pairs for trace metal analysis (using equipment washed with HNO_3) and major ion analysis (using equipment washed with ultrapure water).

Samples for aerosols in filters and rain/snow in pre-cleaned bottles were stored frozen from just after collection. Samples will also be transported frozen (at -20°C) to the home lab at University of East Anglia (UEA, UK) for further analysis.

Various extraction methods will be used for aerosol analysis, followed by detection using ion chromatography, ICP-OES and other methods. Rain samples will be analysed using equivalent procedures. All analysis will be in the home laboratory (UEA, UK).

4.5.2.1.3 Sampling results

A total of 8 aerosol samples were collected, pumping between 1.5 and 3.5 days each, in a continuous sampling. Procedural blanks (cassette blank, motor blank and exposure blank) were run towards the end of the cruise during passage to South Africa.

A total of 3 rain samples were collected, for both Major Ions and Trace Metals, and a blank was run for every sample.

Table 37 – Start Locations for aerosol samples collected during BONUS-GOODHOPE cruise.

Sample	Start Time & Date	Start Location
BG08M 01	13/Feb/2008 15:30	33° 59 S, 18° 00 E
BG08M 02	14/Feb/2008 16:40	34° 00 S, 16° 52 E
BG08M 03	16/Feb/2008 13:55	34° 06 S, 15° 10 E
BG08M 04	22/Feb/2008 06:50	36° 35 S, 13° 03 E
BG08M 05	25/Feb/2008 12:30	40° 43 S, 10° 13 E
BG08M 06	29/Feb/2008 10:16	44° 02 S, 7° 38 E
BG08M 07	06/Mar/2008 20:00	48° 19 S, 3° 35.06 E
BG08M 08	12/Mar/2008 14:00	53° 00 S, 0° 0.38 W

Table 38 – Start Locations for rain samples collected during BONUS-GOODHOPE cruise.

Sample	Start Time & Date	Start Location
BG08RI 01	27/Feb/2008 06:00	42° 28 S, 8° 56 E
BG08RI 02	15/Mar/2008 21:30	57° 33 S, 0° 02 W
BG08RI 03	17/Mar/2008 11:00	57° 33 S, 0° 03 W

5 THE CRUISE LOG-BOOK

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The logbook is a crucial part of LEFE-CYBER database management process for an oceanographic cruise, and it was conceived and maintained by the BONUS-GOODHOPE “Database” committee.

This report briefly describes the logbook which was maintained during the cruise. The aims of the logbook are to record all the operations on board, to list all the sampling and measured parameters (analyzed on board or later) in order to establish a unique reference system.

The Logbook information comprises three main categories:

- Details of the operations undertaken on board;
- Inventory of the sampling carried out for each instrument;
- Characterization and inventory of all of the biogeochemical and physical parameters (both oceanic and atmospheric), in order to update and complete the data dictionary.

This work has been carried out using different tables, comprising the deployments, sampling, measurements, etc ... that were obtained in direct interaction with the scientists on board. From these specific tables, Excel files were systematically created. They constitute the logbook, a requested preliminary step for the BONUS-GOODHOPE Database.

5.1 CHRONOLOGY OF ALL THE ONBOARD OPERATIONS: THE “BRIDGE JOURNAL”

This is an inventory of the daily operations that occurred onboard, including the deployment and recovery of instruments (CTD rosette, GO-FLO bottles, In Situ Pumps, multi-corer Oktopus) and launching of devices (PROVOR profiling floats, XBTs, C-PIES moorings, sounding balloons).

5.1.1 OCEAN OPERATIONS

Date Hour UT	(Local - UT)	Longitude	Latitude	Type of station	# station	Code Instrument	Number	Action
hh:mm	hh	deg.minutes	deg.minutes					
13/02/08 14:43	2	18.07.140 E	33.58.560 S	XBT	1	XBT	1	Release
13/02/08 18:20	2	17.13.58 E	33.58.58 S	Hydro test	0	CTD	0	Deployment
13/02/08 20:15	2	17.13.58 E	33.58.58 S	Hydro test	0	CTD	0	On board
13/02/08 23:47	2	17.57.37 E	33.56.33 S	Hydro	1	CTD	1	Deployment
14/02/08 00:17	2	17.57.337 E	33.56.384 S	Hydro	1	CTD	1	On board
14/02/08 01:29	2	17.43.220 E	33.56.660 S	XBT	2	XBT	2	Release
14/02/08 02:46	2	17.31.36 E	33.57.635 S	Hydro	2	CTD	2	Deployment
14/02/08 03:40	2	17.31.278 E	33.57.737 S	Hydro	2	CTD	2	On board
14/02/08 04:08	2	17.27.120 E	33.57.950 S	XBT	3	XBT	3	Release
14/02/08 05:56	2	17.24.59 E	33.58.06 S	Hydro	3	CTD	3	Deployment
14/02/08 07:01	2	17.24.00 E	33.58.00 S	Hydro	3	CTD	3	On board
14/02/08 07:54	2	17.24.498 E	33.58.221 S	Hydro	3	CPIES	1	Release
14/02/08 09:58	2	17.18.21 E	33.58.46 S	Hydro	4	CTD	4	Deployment
14/02/08 11:37	2	17.18.21 E	33.58.56 S	Hydro	4	CTD	4	On board
14/02/08 12:34	2	17.08.47 E	33.58.92 S	XBT	4	XBT	4	Release
14/02/08 13:55	2	16.57.13 E	33.59.68 S	Hydro	5	CTD	5	Deployment
14/02/08 16:10	2	16.57.176 E	33.59.502 S	Hydro	5	CTD	5	On board
14/02/08 17:05	2	16.45.91 E	34.00.18 S	XBT	5	XBT	5	Release
14/02/08 18:09	2	16.35.22 E	34.00.74 S	Hydro	6	CTD	6	Deployment
14/02/08 21:04	2	16.35.264 E	34.00.802 S	Hydro	6	CTD	6	On board
14/02/08 22:01	2	16.24.260 E	34.01.360 S	XBT	6	XBT	6	Release
14/02/08 23:14	2	16.12.00 E	34.01.999 S	Hydro	7	CTD	7	Deployment
15/02/08 02:34	2	16.12.00 E	34.01.999 S	Hydro	7	CTD	7	On board
15/02/08 04:00	2	15.52.500 E	34.03.219 S	XBT	7	XBT	7	Release
15/02/08 04:59	2	15.41.20 E	34.03.79 S	Hydro	8	CTD	8	Deployment
15/02/08 09:07	2	15.41.759 E	34.03.682 S	Hydro	8	CTD	8	On board
16/02/08 06:52	2	15.25.720 E	34.04.55 S	XBT	8	XBT	8	Release
16/02/08 08:14	2	15.09.80 E	34.05.50 S	Hydro	9	CTD	9	Deployment

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16/02/08 11:57	2	15.09.707 E	34.05.551 S	Hydro	9	CTD	9	On board	
16/02/08 12:12	2	15.09.740 E	34.05.440 S	Hydro	9	CPIES	2	Release	
16/02/08 14:51	2	14.51.19 E	34.06.39 S	XBT	9	XBT	9	Release	
16/02/08 19:15	2	14.37.98 E	34.07.37 S	Hydro	10	CTD	10	Deployment	
16/02/08 23:24	2	14.35.282 E	34.07.336 S	Hydro	10	CTD	10	On board	
16/02/08 23:27	2	14.35.29 E	34.07.320 S	XBT	10	XBT	10	Release	
17/02/08 00:31	2	14.29.180 E	34.16.440 S	XBT	11	XBT	11	Release	
17/02/08 04:27	2	14.24.29 E	34.25.67 S	Large	11	CTD	11	Deployment	Large1A Hydro 0-bottom
17/02/08 09:03	2	14.24.344 E	34.25.592 S	Large	11	CTD	11	On board	Large1A Hydro 0-bottom
17/02/08 09:35	2	14.24.358 E	34.25.553 S	Large	11	GOFLO	1	Deployment	Large1A TM's 0-2100m
17/02/08 12:12	2	14.24.526 E	34.25.606 S	Large	11	GOFLO	1	On board	Large1A TM's 0-2100m
17/02/08 13:40	2	14.24.520 E	34.25.600 S	Large	11	CTD	12	Deployment	Large1A Mixed Layer 0-250m
17/02/08 14:24	2	14.24.550 E	34.25.638 S	Large	11	CTD	12	On board	Large1A Mixed Layer 0-250m
17/02/08 15:26	2	14.17.930 E	34.35.170 S	XBT	12	XBT	12	Release	
17/02/08 16:19	2	14.13.570 E	34.43.425 S	Hydro	12	CTD	13	Deployment	
17/02/08 20:41	2	14.13.399 E	34.43.470 S	Hydro	12	CTD	13	On board	
17/02/08 21:50	2	14.07.160 E	34.53.840 S	XBT	13	XBT	13	Release	XBT fail at 34 m – redo (see 14)
17/02/08 21:52	2	14.06.910 E	34.54.310 S	XBT	14	XBT	14	Release	
17/02/08 23:01	2	14.02.780 E	35.01.600 S	Hydro	13	CTD	14	Deployment	
18/02/08 04:35	2	14.02.982 E	35.01.640 S	Hydro	13	CTD	14	On board	
18/02/08 05:32	2	13.56.890 E	35.11.209 S	XBT	15	XBT	15	Release	
18/02/08 06:35	2	13.51.930 E	35.19.590 S	Hydro	14	CTD	15	Deployment	
18/02/08 10:15	2	13.51.931 E	35.19.596 S	Hydro	14	CTD	15	On board	
18/02/08 11:32	2	13.44.350 E	35.31.390 S	XBT	16	XBT	16	Release	
18/02/08 12:30	2	13.41.010 E	35.37.510 S	Hydro	15	CTD	16	Deployment	
18/02/08 16:01	2	13.40.972 E	35.37.532 S	Hydro	15	CTD	16	On board	
18/02/08 17:08	2	13.34.350 E	35.48.130 S	XBT	17	XBT	17	Release	
18/02/08 18:10	2	13.29.820 E	35.55.520 S	Hydro	16	CTD	17	Deployment	
18/02/08 22:05	2	13.31.195 E	35.55.354 S	Hydro	16	CTD	17	On board	
18/02/08 23:06	2	13.25.230 E	36.03.980 S	XBT	18	XBT	18	Release	XBT fail at 441 m – redo (see 19)
18/02/08 23:11	2	13.24.570 E	36.04.840 S	XBT	19	XBT	19	Release	
19/02/08 02:44	2	13.18.590 E	36.13.400 S	Hydro	17	CTD	18	Deployment	
19/02/08 10:17	2	13.19.399 E	36.12.622 S	Hydro	17	CTD	18	On board	
19/02/08 11:25	2	13.13.280 E	36.21.840 S	XBT	20	XBT	20	Release	

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19/02/08 12:00	2	13.10.455 E	36.26.537 S	Super	18	OKTOPUS	1	Deployment	
19/02/08 17:00	2	13.10.455 E	36.26.537 S	Super	18	OKTOPUS	1	On board	Super1 7 carottes sur 8
19/02/08 17:54	2	13.07.320 E	36.31.370 S	Super	18	CTD	19	Deployment	Super1 Hydro 0-bottom
19/02/08 22:09	2	13.06.767 E	36.30.822 S	Super	18	CTD	19	On board	Super1 Hydro 0-bottom
19/02/08 22:57	2	13.07.000 E	36.31.000 S	Super	18	GOFLO	2	Deployment	Super1 TM's 0-800m
20/02/08 01:26	2	13.06.000 E	36.30.000 S	Super	18	GOFLO	2	On board	Super1 TM's 0-800m
20/02/08 02:06	2	13.07.120 E	36.31.310 S	Super	18	CTD	20	Deployment	Super1 Mixed Layer 0-250m
20/02/08 05:06	2	13.06.974 E	36.31.536 S	Super	18	CTD	20	On board	Super1 Mixed Layer 0-250m
20/02/08 07:30	2	13.07.139 E	36.31.258 S	Super	18	PIS	1	Deployment	Super1 234Th,210Po,14C,Biomark 0-750m
20/02/08 11:30	2	13.07.139 E	36.31.255 S	Super	18	PIS	1	On board	Super1 234Th,210Po,14C,Biomark 0-750m
20/02/08 12:01	2	13.07.140 E	36.31.250 S	Super	18	CTD	21	Deployment	Super1 REE 0-bottom
20/02/08 15:52	2	13.07.096 E	36.31.278 S	Super	18	CTD	21	On board	Super1 REE 0-bottom
20/02/08 16:37	2	13.07.180 E	36.31.350 S	Super	18	GOFLO	3	Deployment	Super1 TM's 1000-3500m
20/02/08 21:31	2	13.05.000 E	36.28.000 S	Super	18	GOFLO	3	On board	Super1 TM's 1000-3500m
20/02/08 22:25	2	13.07.330 E	36.31.800 S	Super	18	PIS	2	Deployment	Super1 230Th,Pa,Nd,30Si,14C 0-bottom
21/02/08 05:25	2	13.08.650 E	36.28.040 S	Super	18	PIS	2	On board	Super1 230Th,Pa,Nd,30Si,14C 0-bottom
21/02/08 06:08	2	13.07.448 E	36.31.021 S	Super	18	GOFLO	4	Deployment	Super1 Incub Fluo max
21/02/08 06:53	2	13.07.133 E	36.30.403 S	Super	18	GOFLO	4	On board	Super1 Incub Fluo max
21/02/08 07:32	2	13.07.090 E	36.30.370 S	Super	18	CTD	22	Deployment	Super1 234Th,210Po,Ra 0-1000m
21/02/08 09:00	2	13.06.997 E	36.29.755 S	Super	18	CTD	22	On board	Super1 234Th,210Po,Ra 0-1000m
21/02/08 09:27	2	13.06.976 E	36.29.492 S	Super	18	GOFLO	5	Deployment	Super1 Incub Fluo max
21/02/08 10:39	2	13.06.422 E	36.28.437 S	Super	18	GOFLO	5	On board	Super1 Incub Fluo max
21/02/08 11:07	2	13.06.300 E	36.28.140 S	Super	18	CTD	23	Deployment	Super1 Ba, 30Si, Ra 0-1000m
21/02/08 12:46	2	13.06.000 E	36.25.999 S	Super	18	CTD	23	On board	Super1 Ba, 30Si, Ra 0-1000m
21/02/08 13:43	2	13.06.246 E	36.27.997 S	Super	18	GOFLO	6	Deployment	Super1 Incub Fluo max
21/02/08 14:26	2	13.06.048 E	36.27.497 S	Super	18	GOFLO	6	On board	Super1 Incub Fluo max
21/02/08 14:39	2	13.06.057 E	36.27.435 S	Super	18	Plancton Net	1	Deployment	
21/02/08 14:54	2	13.06.039 E	36.27.469 S	Super	18	Plancton Net	1	On board	
21/02/08 15:50	2	13.07.177 E	36.31.321 S	Super	18	GOFLO	7	Deployment	Super1 Cd 0-300m
21/02/08 16:29	2	13.06.000 E	36.31.000 S	Super	18	GOFLO	7	On board	Super1 Cd 0-300m
21/02/08 17:07	2	13.06.705 E	36.29.799 S	Super	18	PIS	3	Deployment	Super1 Ra, REE, 14C, Biomark 0-bottom
22/02/08 00:30	2	13.06.311 E	36.29.105 S	Super	18	PIS	3	On board	Super1 Ra, REE, 14C, Biomark 0-bottom
22/02/08 01:50	2	13.07.110 E	36.30.470 S	Super	18	GOFLO	8	Deployment	Super1 Fe isotopes 0-4000m
22/02/08 06:01	2	13.07.377 E	36.27.800 S	Super	18	GOFLO	8	On board	Super1 Fe isotopes 0-4000m

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22/02/08 07:28	2	12.59.210 E	36.42.910 S	XBT	21	XBT	21	Release	
22/02/08 08:22	2	12.55.980 E	36.49.540 S	Hydro	19	CTD	24	Deployment	
22/02/08 13:38	2	12.56.210 E	36.47.220 S	Hydro	19	CTD	24	On board	
22/02/08 14:50	2	12.49.960 E	36.58.140 S	XBT	22	XBT	22	Release	
22/02/08 16:00	2	12.44.340 E	37.07.040 S	Hydro	20	CTD	25	Deployment	
22/02/08 20:51	2	12.44.326 E	36.06.226 S	Hydro	20	CTD	25	On board	
22/02/08 21:49	2	12.38.060 E	37.16.270 S	XBT	23	XBT	23	Release	
22/02/08 23:06	2	12.32.740 E	37.25.010 S	Hydro	21	CTD	26	Deployment	
23/02/08 03:10	2	12.32.742 E	37.24.986 S	Hydro	21	CTD	26	On board	
23/02/08 04:03	2	12.26.630 E	37.34.250 S	XBT	24	XBT	24	Release	
23/02/08 05:00	2	12.21.130 E	37.42.950 S	Hydro	22	CTD	27	Deployment	
23/02/08 09:31	2	12.21.130 E	37.42.970 S	Hydro	22	CTD	27	On board	
23/02/08 10:28	2	12.14.350 E	37.51.750 S	XBT	25	XBT	25	Release	
23/02/08 11:16	2	12.07.580 E	38.01.130 S	XBT	26	XBT	26	Release	
23/02/08 12:07	2	12.05.110 E	38.05.510 S	Hydro	23	CTD	28	Deployment	
23/02/08 16:35	2	12.05.110 E	38.05.470 S	Hydro	23	CTD	28	On board	
23/02/08 17:31	2	12.00.560 E	38.12.240 S	XBT	27	XBT	27	Release	
23/02/08 18:15	2	11:55:000 E	38.20.160 S	XBT	28	XBT	28	Release	
23/02/08 19:14	2	11.49.780 E	38.27.490 S	Hydro	24	CTD	29	Deployment	
23/02/08 23:40	2	11.49.802 E	38.27.548 S	Hydro	24	CTD	29	On board	
24/02/08 00:40	2	11.44.240 E	38.35.360 S	XBT	29	XBT	29	Release	
24/02/08 01:20	2	11.39.340 E	38.42.580 S	XBT	30	XBT	30	Release	
24/02/08 02:14	2	11.34.350 E	38.49.530 S	Hydro	25	CTD	30	Deployment	
24/02/08 06:25	2	11.34.524 E	38.49.592 S	Hydro	25	CTD	30	On board	
24/02/08 07:48	2	11.25.610 E	39.02.290 S	XBT	31	XBT	31	Release	
24/02/08 08:20	2	11.21.390 E	39.08.370 S	XBT	32	XBT	32	Release	
24/02/08 09:00	2	11.19.110 E	39.11.460 S	Hydro	26	CTD	31	Deployment	
24/02/08 13:29	2	11.19.450 E	39.11.490 S	Hydro	26	CTD	31	On board	
24/02/08 14:16	2	11.13.930 E	39.19.170 S	XBT	33	XBT	33	Release	
24/02/08 14:51	2	11.08.850 E	39.26.300 S	XBT	34	XBT	34	Release	
24/02/08 15:46	2	11.03.730 E	39.33.540 S	Hydro	27	CTD	32	Deployment	
24/02/08 20:10	2	11.03.740 E	39.33.540 S	Hydro	27	CTD	32	On board	
24/02/08 20:57	2	10.58.720 E	39.40.730 S	XBT	35	XBT	35	Release	
24/02/08 21:29	2	10.54.150 E	39.47.380 S	XBT	36	XBT	36	Release	

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24/02/08 22:37	2	10.48.320 E	39.55.520 S	Hydro	28	CTD	33	Deployment	
25/02/08 02:32	2	10.48.370 E	39.55.537 S	Hydro	28	CTD	33	On board	
25/02/08 02:51	2	10.48.531 E	39.55.579 S	PROVOR	1	PROVOR	1	Release	PV 607 (2000m)
25/02/08 04:08	2	10.37.520 E	40.10.280 S	XBT	37	XBT	37	Release	
25/02/08 04:55	2	10.33.010 E	40.17.440 S	Hydro	29	CTD	34	Deployment	
25/02/08 08:50	2	10.33.430 E	40.17.473 S	Hydro	29	CTD	34	On board	
25/02/08 09:52	2	10.25.570 E	40.27.250 S	XBT	38	XBT	38	Release	
25/02/08 10:30	2	10.19.620 E	40.34.680 S	XBT	39	XBT	39	Release	
25/02/08 11:36	2	10.12.870 E	40.43.390 S	Hydro	30	CTD	35	Deployment	
25/02/08 15:06	2	10.12.870 E	40.43.390 S	Hydro	30	CTD	35	On board	
25/02/08 15:56	2	10.07.240 E	40.51.660 S	XBT	40	XBT	40	Release	
25/02/08 16:35	2	10.01.870 E	41.00.110 S	XBT	41	XBT	41	Release	
25/02/08 17:30	2	09.55.040 E	41.10.520 S	Large	31	CTD	36	Deployment	Large 2B PAR
25/02/08 18:05	2	09.55.048 E	41.10.610 S	Large	31	CTD	36	On board	Large 2B PAR
25/02/08 18:10	2	09.55.010 E	41.10.560 S	Large	31	CTD	37	Deployment	Large2B Hydro 0-bottom
25/02/08 21:40	2	09.55.057 E	41.10.705 S	Large	31	CTD	37	On board	Large2B Hydro 0-bottom
25/02/08 22:06	2	09.55.010 E	41.10.710 S	Large	31	GOFLO	9	Deployment	Large2B TM's 0-2100m
26/02/08 00:26	2	09.55.280 E	41.11.280 S	Large	31	GOFLO	9	On board	Large2B TM's 0-2100m
26/02/08 00:45	2	09.55.360 E	41.11.400 S	Large	31	CTD	38	Deployment	Large2B Mixed Layer 0-300m
26/02/08 01:37	2	09.55.313 E	41.11.390 S	Large	31	CTD	38	On board	Large2B Mixed Layer
26/02/08 03:10	2	09.41.240 E	41.28.310 S	XBT	43	XBT	43	Release	Pas de #42: probleme increment
26/02/08 04:03	2	09.35.009 E	41.36.520 S	Hydro	32	CTD	39	Deployment	
26/02/08 07:52	2	09.35.006 E	41.36.521 S	Hydro	32	CTD	39	On board	
26/02/08 08:04	2	09.34.680 E	41.36.220 S	PROVOR	2	PROVOR	2	Release	PV 617 (2000m)
26/02/08 08:52	2	09.28.960 E	41.44.840 S	XBT	44	XBT	44	Release	
26/02/08 09:33	2	09.22.750 E	41.53.320 S	XBT	45	XBT	45	Release	
26/02/08 10:28	2	09.16.270 E	42.07.240 S	Hydro	33	CTD	40	Deployment	
26/02/08 14:00	2	09.16.260 E	42.02.290 S	Hydro	33	CTD	40	On board	
26/02/08 15:11	2	09.09.620 E	42.10.590 S	XBT	46	XBT	46	Release	
26/02/08 16:00	2	09.05.940 E	42.15.150 S	Super	34	OKTOPUS	2	Deployment	
26/02/08 19:00	2	09.05.940 E	42.15.150 S	Super	34	OKTOPUS	2	On board	Super2 Environ 5cm sur une carotte
26/02/08 19:24	2	09.02.160 E	42.19.890 S	XBT	47	XBT	47	Release	
26/02/08 20:31	2	08.55.700 E	42.28.170 S	Super	34	CTD	41	Deployment	Super2 Hydro 0-bottom
26/02/08 23:47	2	08.55.696 E	42.28.163 S	Super	34	CTD	41	On board	Super2 Hydro 0-bottom

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27/02/08 00:23	2	08.55.718 E	42.28.190 S	Super	34	GOFLO	10	Deployment	Super2 TM's 1500-4000m
27/02/08 04:10	2	08.55.731 E	42.28.191 S	Super	34	GOFLO	10	On board	Super2 TM's 1500-4000m
27/02/08 05:00	2	08.55.726 E	42.28.146 S	Super	34	PIS	4	Deployment	Super2 Tracers 0-4000m
27/02/08 12:04	2	08.55.723 E	42.28.134 S	Super	34	PIS	4	On board	Super2 Tracers 0-4000m
27/02/08 12:34	2	08.55.726 E	42.28.135 S	Super	34	GOFLO	11	Deployment	Super2 TM's 200-1500m
27/02/08 14:20	2	08.55.730 E	42.28.127 S	Super	34	GOFLO	11	On board	Super2 TM's 200-1500m
27/02/08 14:45	2	08.55.850 E	42.28.200 S	Super	34	CTD	42	Deployment	Super2 REE 0-bottom
27/02/08 17:50	2	08.55.840 E	42.28.200 S	Super	34	CTD	42	On board	Super2 REE 0-bottom
27/02/08 18:07	2	08.55.854 E	42.28.210 S	Super	34	GOFLO	12	Deployment	Super2 TM's 0-200m
27/02/08 18:50	2	08.56.149 E	42.28.354 S	Super	34	GOFLO	12	On board	Super2 TM's 0-200m
27/02/08 19:24	2	08.56.050 E	42.28.270 S	Super	34	CTD	43	Deployment	Super2 234Th,210Po,Ra 0-1000m
27/02/08 20:30	2	08.56.004 E	42.28.297 S	Super	34	CTD	43	On board	Super2 234Th,210Po,Ra 0-1000m
27/02/08 21:12	2	08.55.850 E	42.28.133 S	Super	34	GOFLO	13	Deployment	Super2 Incub Fluo Max
27/02/08 22:11	2	08.55.975 E	42.28.111 S	Super	34	GOFLO	13	On board	Super2 Incub Fluo Max
27/02/08 22:26	2	08.55.970 E	42.28.110 S	Super	34	CTD	44	Deployment	Super2 Ba, 30Si, Ra 0-1000m
28/02/08 00:12	2	08.55.912 E	42.28.130 S	Super	34	CTD	44	On board	Super2 Ba, 30Si, Ra 0-1000m
28/02/08 00:38	2	08.55.970 E	42.28.112 S	Super	34	PIS	5	Deployment	Super2 Tracers 0-4000m
28/02/08 07:30	2	08.55.960 E	42.28.110 S	Super	34	PIS	5	On board	Super2 Tracers 0-4000m
28/02/08 07:50	2	08.55.970 E	42.28.120 S	Super	34	GOFLO	14	Deployment	Super2 Incub Fluo Max
28/02/08 08:26	2	08.56.000 E	42.28.120 S	Super	34	GOFLO	14	On board	Super2 Incub Fluo Max
28/02/08 08:45	2	08.56.050 E	42.28.110 S	Super	34	CTD	45	Deployment	Super2 Mixed Layer 0-250m
28/02/08 09:08	2	08.56.023 E	42.28.118 S	Super	34	CTD	45	On board	Super2 Mixed Layer 0-250m
28/02/08 09:30	2	08.56.050 E	42.28.110 S	Super	34	GOFLO	15	Deployment	Super2 Incub + TM's Fluo Max
28/02/08 09:50	2	08.56.050 E	42.28.110 S	Super	34	GOFLO	15	On board	Super2 Incub + TM's Fluo Max
28/02/08 10:53	2	08.48.920 E	42.36.480 S	XBT	48	XBT	48	Release	
28/02/08 11:48	2	08.40.560 E	42.46.810 S	XBT	49	XBT	49	Release	
28/02/08 12:50	2	08.34.970 E	42.53.580 S	Hydro	35	CTD	46	Deployment	
28/02/08 15:40	2	08.32.354 E	42.53.497 S	Hydro	35	CTD	46	On board	
28/02/08 16:36	2	08.28.610 E	43.01.630 S	XBT	50	XBT	50	Release	Spike at 434m: redo
28/02/08 16:43	2	08.27.660 E	43.02.780 S	XBT	51	XBT	51	Release	Spike at 614m
28/02/08 17:34	2	08.20.820 E	43.11.070 S	XBT	52	XBT	52	Release	
28/02/08 18:45	2	08.14.230 E	43.19.460 S	Hydro	36	CTD	47	Deployment	
28/02/08 21:00	2	08.14.179 E	43.19.477 S	Hydro	36	CTD	47	On board	
28/02/08 21:13	2	08.13.380 E	43.20.130 S	PROVOR	3	PROVOR	3	Release	PV 620 (2000m)

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28/02/08 21:58	2	08.08.660 E	43.26.350 S	XBT	53	XBT	53	Release	
28/02/08 22:42	2	08.02.370 E	43.33.590 S	XBT	54	XBT	54	Release	
28/02/08 23:56	2	07.56.140 E	43.40.950 S	Hydro	37	CTD	48	Deployment	
29/02/08 03:50	2	08.00.661 E	43.41.940 S	Hydro	37	CTD	48	On board	
29/02/08 04:54	2	07.51.820 E	43.48.060 S	XBT	55	XBT	55	Release	
29/02/08 05:47	2	07.43.660 E	43.55.420 S	XBT	56	XBT	56	Release	
29/02/08 06:55	2	07.37.810 E	44.02.500 S	Hydro	38	CTD	49	Deployment	
29/02/08 10:32	2	07.37.840 E	44.02.443 S	Hydro	38	CTD	49	On board	
29/02/08 11:22	2	07.32.630 E	44.08.470 S	XBT	57	XBT	57	Release	
29/02/08 12:29	2	07.29.900 E	44.12.900 S	N/A	N/A	OKTOPUS	3	Deployment	Vide
29/02/08 15:17	2	07.29.900 E	44.12.900 S	N/A	N/A	OKTOPUS	3	On board	
29/02/08 15:30	2	07.28.110 E	44.13.980 S	XBT	58	XBT	58	Release	
29/02/08 16:30	2	07.23.170 E	44.19.810 S	Hydro	39	CTD	50	Deployment	
29/02/08 19:36	2	07.22.793 E	44.20.269 S	Hydro	39	CTD	50	On board	
29/02/08 21:35	2	07.18.000 E	44.25.420 S	XBT	59	XBT	59	Release	
29/02/08 22:20	2	07.12.450 E	44.31.820 S	XBT	60	XBT	60	Release	XBT fail at 103 m – redo
29/02/08 22:25	2	07.11.900 E	44.32.470 S	XBT	61	XBT	61	Release	
29/02/08 23:20	2	07.08.090 E	44.36.720 S	Hydro	40	CTD	51	Deployment	
01/03/08 03:40	2	07.09.316 E	44.36.860 S	Hydro	40	CTD	51	On board	
01/03/08 07:45	2	06.57.760 E	44.42.330 S	XBT	62	XBT	62	Release	Spike at 290m: redo
01/03/08 07:49	2	06.57.520 E	44.42.710 S	XBT	63	XBT	63	Release	Spike: no data (wind)
01/03/08 09:43	2	06.54.100 E	44.46.660 S	XBT	64	XBT	64	Release	Suspicious at 270m, spike at 675m
01/03/08 13:50	2	06.53.090 E	44.53.890 S	PROVOR	4	PROVOR	4	Release	PV 613 (2000m)
01/03/08 14:59	2	06.53.070 E	44.53.880 S	Large	41	CTD	52	Deployment	Large3B Mixed Layer 0-300m
01/03/08 15:39	2	06.53.114 E	44.53.801 S	Large	41	CTD	52	On board	Large3B Mixed Layer 0-300m
01/03/08 16:22	2	06.53.030 E	44.53.900 S	Large	41	GOFLO	16	Deployment	Large3B TM's 0-2100m
01/03/08 19:17	2	06.54.204 E	44.53.205 S	Large	41	GOFLO	16	On board	Large3B TM's 0-2100m
01/03/08 19:56	2	06.53.140 E	44.53.770 S	Large	41	CTD	53	Deployment	Large3B Hydro 0-bottom
01/03/08 23:36	2	06.54.230 E	44.53.480 S	Large	41	CTD	53	On board	Large3B Hydro 0-bottom
02/03/08 00:56	2	06.53.130 E	44.53.740 S	Large	41	CTD	54	Deployment	Large3B PoTh 0-1000m
02/03/08 02:33	2	06.53.110 E	44.53.770 S	Large	41	CTD	54	On board	Large3B PoTh 0-1000m
02/03/08 03:34	2	06.45.380 E	45.02.470 S	XBT	65	XBT	65	Release	
02/03/08 04:28	2	06.38.170 E	45.11.100 S	XBT	66	XBT	66	Release	Spike at 270m, no data thereafter: redo
02/03/08 04:32	2	06.37.540 E	45.11.770 S	XBT	67	XBT	67	Release	Spike at 200m, no data thereafter

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02/03/08 05:38	2	06.30.090 E	45.19.770 S	Hydro	42	CTD	55	Deployment	
02/03/08 10:18	2	06.31.750 E	45.18.750 S	Hydro	42	CTD	55	On board	
02/03/08 12:59	2	06.24.920 E	45.25.170 S	XBT	68	XBT	68	Release	
02/03/08 13:52	2	06.19.900 E	45.30.680 S	XBT	69	XBT	69	Release	Spike at 150m: redo
02/03/08 14:00	2	06.19.130 E	45.31.460 S	XBT	70	XBT	70	Release	
02/03/08 15:25	2	06.13.930 E	45.36.680 S	Hydro	43	CTD	56	Deployment	
02/03/08 18:54	2	06.14.716 E	45.37.309 S	Hydro	43	CTD	56	On board	
02/03/08 21:23	2	06.04.480 E	45.44.970 S	XBT	71	XBT	71	Release	Spike at 590m
02/03/08 22:21	2	05.57.630 E	45.53.770 S	XBT	72	XBT	72	Release	
02/03/08 23:47	2	05.51.890 E	46.01.450 S	Large	44	CTD	57	Deployment	Large4A 0-bottom
03/03/08 03:08	2	06.52.126 E	46.01.550 S	Large	44	CTD	57	On board	Large4A 0-bottom
03/03/08 04:08	2	05.51.639 E	46.01.378 S	Large	44	GOFLO	17	Deployment	Large4A TM's 0-2050m
03/03/08 07:10	2	05.52.650 E	46.00.850 S	Large	44	GOFLO	17	On board	Large4A TM's 0-2050m
03/03/08 07:38	2	05.52.390 E	46.01.010 S	Large	44	CTD	58	Deployment	Large4A Mixed Layer 0-200m
03/03/08 08:15	2	05.52.520 E	46.01.030 S	Large	44	CTD	58	On board	Large4A Mixed Layer 0-200m
03/03/08 08:30	2	05.51.610 E	46.01.450 S	PROVOR	5	PROVOR	5	Release	PV 602 (2000m)
03/03/08 10:00	2	05.42.310 E	46.09.100 S	XBT	73	XBT	73	Release	
03/03/08 11:39	2	05.32.650 E	46.21.390 S	Hydro	45	CTD	59	Deployment	
03/03/08 15:11	2	06.32.680 E	46.21.420 S	Hydro	45	CTD	59	On board	
03/03/08 16:08	2	05.27.040 E	46.27.450 S	XBT	74	XBT	74	Release	Spike beyond 180m: redo
03/03/08 16:11	2	05.26.670 E	46.27.820 S	XBT	75	XBT	75	Release	Spike at 200m
03/03/08 16:42	2	05.23.690 E	46.30.990 S	XBT	76	XBT	76	Release	Spike at 260m: redo
03/03/08 16:47	2	05.23.130 E	46.31.540 S	XBT	77	XBT	77	Release	Very suspicious data > 100m
03/03/08 16:57	2	05.22.040 E	46.32.640 S	XBT	78	XBT	78	Release	Mini spikes at 402, 489 and 628m
03/03/08 18:34	2	05.11.830 E	46.43.310 S	Hydro	46	CTD	60	Deployment	
03/03/08 22:11	2	05.11.994 E	46.43.334 S	Hydro	46	CTD	60	On board	
03/03/08 23:18	2	05.04.140 E	46.51.080 S	XBT	79	XBT	79	Release	
04/03/08 00:13	2	04.56.200 E	46.59.230 S	XBT	80	XBT	80	Release	
04/03/08 01:28	2	04.47.490 E	47.08.320 S	Hydro	47	CTD	61	Deployment	
04/03/08 05:13	2	04.47.440 E	47.08.320 S	Hydro	47	CTD	61	On board	
04/03/08 06:09	2	04.39.330 E	47.16.360 S	XBT	81	XBT	81	Release	
04/03/08 06:51	2	04.37.206 E	47.19.064 S	Super	48	OKTOPUS	4	Deployment	
04/03/08 09:57	2	04.37.204 E	47.19.062 S	Super	48	OKTOPUS	4	On board	Super3 Moins de 5cm sur une carotte
04/03/08 11:17	2	04.30.820 E	47.25.070 S	XBT	82	XBT	82	Release	

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04/03/08 12:35	2	04.22.610 E	47.33.160 S	Super	48	CTD	62	Deployment	Super3 Mixed Layer 0-250m
04/03/08 13:24	2	04.22.572 E	47.33.248 S	Super	48	CTD	62	On board	Super3 Mixed Layer 0-250m
04/03/08 13:59	2	04.22.621 E	47.33.267 S	Super	48	GOFLO	18	Deployment	Super3 Cd 0-200m
04/03/08 14:44	2	04.22.622 E	47.33.264 S	Super	48	GOFLO	18	On board	Super3 Cd 0-200m
04/03/08 15:00	2	04.22.610 E	47.33.260 S	Super	48	CTD	63	Deployment	Super3 Hydro 0-bottom
04/03/08 18:37	2	04.22.464 E	47.33.224 S	Super	48	CTD	63	On board	Super3 Hydro 0-bottom
04/03/08 19:00	2	04.22.362 E	47.33.166 S	Super	48	GOFLO	19	Deployment	Super3 Intercalibration Polarstern 0-3500m
04/03/08 22:50	2	04.22.370 E	47.33.160 S	Super	48	GOFLO	19	On board	Super3 Intercalibration Polarstern 0-3500m
04/03/08 23:30	2	04.22.330 E	47.33.151 S	Super	48	PIS	6	Deployment	Super3 Tracers 0-bottom
05/03/08 06:50	2	04.22.160 E	47.33.160 S	Super	48	PIS	6	On board	Super3 Tracers 0-bottom
05/03/08 07:07	2	04.22.332 E	47.33.156 S	Super	48	GOFLO	20	Deployment	Super3 TM's 1500-4000m
05/03/08 10:50	2	04.22.330 E	47.33.150 S	Super	48	GOFLO	20	On board	Super3 TM's 1500-4000m
05/03/08 11:08	2	04.22.100 E	47.32.720 S	Super	48	CTD	64	Deployment	Super3 REE 0-bottom
05/03/08 14:26	2	04.22.080 E	47.32.750 S	Super	48	CTD	64	On board	Super3 REE 0-bottom
05/03/08 14:40	2	04.22.226 E	47.33.065 S	Super	48	GOFLO	21	Deployment	Super3 TM's 0-1400m
05/03/08 16:01	2	04.22.388 E	47.33.181 S	Super	48	GOFLO	21	On board	Super3 TM's 0-1400m
05/03/08 16:36	2	04.22.450 E	47.33.230 S	Super	48	CTD	65	Deployment	Super3 234Th,210Po 0-1000m
05/03/08 17:56	2	04.22.540 E	47.33.290 S	Super	48	CTD	65	On board	Super3 234Th,210Po 0-1000m
05/03/08 18:07	2	04.22.543 E	47.33.293 S	Super	48	GOFLO	22	Deployment	Super3 Incub Fluo Max
05/03/08 19:01	2	04.22.141 E	47.33.261 S	Super	48	GOFLO	22	On board	Super3 Incub Fluo Max
05/03/08 19:30	2	04.22.961 E	47.33.047 S	Super	48	PIS	7	Deployment	Super3 Tracers 0-bottom
06/03/08 03:07	2	04.22.845 E	47.33.056 S	Super	48	PIS	7	On board	Super3 Tracers 0-bottom
06/03/08 03:45	2	04.22.600 E	47.33.360 S	Super	48	GOFLO	23	Deployment	Super3 Incub Fluo Max
06/03/08 04:15	2	04.22.604 E	47.33.368 S	Super	48	GOFLO	23	On board	Super3 Incub Fluo Max
06/03/08 04:26	2	04.22.480 E	47.33.310 S	Super	48	CTD	66	Deployment	Super3 Ba, 30Si, Ra 0-1000m
06/03/08 05:46	2	04.23.056 E	47.33.415 S	Super	48	CTD	66	On board	Super3 Ba, 30Si, Ra 0-1000m
06/03/08 06:00	2	04.22.960 E	47.33.320 S	Super	48	GOFLO	24	Deployment	Super3 Incub + TM Fluo Max
06/03/08 07:27	2	04.23.140 E	47.33.210 S	Super	48	GOFLO	24	On board	Super3 Incub + TM Fluo Max
06/03/08 07:44	2	04.22.440 E	47.33.820 S	PROVOR	6	PROVOR	6	Release	PV 610 (2000m)
06/03/08 08:30	2	04.15.840 E	47.40.140 S	XBT	83	XBT	83	Release	
06/03/08 09:14	2	04.08.490 E	47.47.100 S	XBT	84	XBT	84	Release	
06/03/08 10:38	2	03.57.450 E	47.58.200 S	Hydro	49	CTD	67	Deployment	
06/03/08 14:20	2	03.57.410 E	47.58.235 S	Hydro	49	CTD	67	On board	
06/03/08 14:40	2	03.57.470 E	47.58.225 S	Hydro	49	OKTOPUS	5	Deployment	

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06/03/08 17:20	2	03.57.472 E	47.58.228 S	Hydro	49	OKTOPUS	5	On board	Super3 Zero carotte
06/03/08 18:28	2	03.48.840 E	48.06.120 S	XBT	85	XBT	85	Release	
06/03/08 19:19	2	03.40.520 E	48.14.150 S	XBT	86	XBT	86	Release	
06/03/08 20:35	2	03.31.500 E	48.22.730 S	Hydro	50	CTD	68	Deployment	
06/03/08 23:59	2	03.31.457 E	48.22.733 S	Hydro	50	CTD	68	On board	
07/03/08 00:55	2	03.24.950 E	48.28.610 S	XBT	87	XBT	87	Release	
07/03/08 01:51	2	03.16.650 E	48.36.470 S	XBT	88	XBT	88	Release	
07/03/08 02:55	2	03.10.691 E	48.42.078 S	Hydro	51	CTD	69	Deployment	
07/03/08 06:03	2	03.10.858 E	48.42.190 S	Hydro	51	CTD	69	On board	
07/03/08 06:58	2	03.03.690 E	48.48.520 S	XBT	89	XBT	89	Release	XBT fail: redo
07/03/08 07:05	2	03.02.560 E	48.49.470 S	XBT	90	XBT	90	Release	
07/03/08 07:47	2	02.56.360 E	48.55.360 S	XBT	91	XBT	91	Release	
07/03/08 08:59	2	02.49.940 E	49.01.690 S	Large	52	CTD	70	Deployment	Large5B 0-bottom
07/03/08 12:27	2	02.49.873 E	49.01.687 S	Large	52	CTD	70	On board	Large5B 0-bottom
07/03/08 13:59	2	02.49.920 E	49.01.680 S	Large	52	CTD	71	Deployment	Large5B Mixed Layer 0-250m
07/03/08 14:39	2	02.49.930 E	49.01.680 S	Large	52	CTD	71	On board	Large5B Mixed Layer 0-250m
07/03/08 14:53	2	02.49.926 E	49.01.690 S	Large	52	GOFLO	25	Deployment	Large5B TM's 0-2200m
07/03/08 17:55	2	02.49.928 E	49.01.694 S	Large	52	GOFLO	25	On board	Large5B TM's 0-2200m
07/03/08 18:28	2	02.49.930 E	49.01.690 S	Large	52	CTD	72	Deployment	Large5B Po,Ba,Si 0-1000m
07/03/08 19:44	2	02.49.874 E	49.01.678 S	Large	52	CTD	72	On board	Large5B Po,Ba,Si 0-1000m
07/03/08 19:55	2	02.49.390 E	49.01.680 S	PROVOR	7	PROVOR	7	Release	PV 606 (2000m)
07/03/08 20:54	2	02.41.500 E	49.09.130 S	XBT	92	XBT	92	Release	
07/03/08 21:25	2	02.36.480 E	49.13.700 S	XBT	93	XBT	93	Release	
07/03/08 22:15	2	02.31.870 E	49.17.970 S	Hydro	53	CTD	73	Deployment	
08/03/08 01:39	2	02.32.006 E	49.18.062 S	Hydro	53	CTD	73	On board	
08/03/08 02:28	2	02.26.550 E	49.23.030 S	XBT	94	XBT	94	Release	
08/03/08 03:16	2	02.19.330 E	49.28.910 S	XBT	95	XBT	95	Release	
08/03/08 04:04	2	02.13.970 E	49.34.020 S	Hydro	54	CTD	74	Deployment	
08/03/08 07:06	2	02.14.192 E	49.34.100 S	Hydro	54	CTD	74	On board	
08/03/08 08:04	2	02.07.540 E	49.39.410 S	XBT	96	XBT	96	Release	Spiking at 460m
08/03/08 08:41	2	02.01.730 E	49.44.560 S	XBT	97	XBT	97	Release	Spiking at 600m
08/03/08 09:48	2	01.55.370 E	49.50.180 S	Hydro	55	CTD	75	Deployment	
08/03/08 13:02	2	01.57.890 E	49.48.360 S	Hydro	55	CTD	75	On board	
08/03/08 13:13	2	01.58.100 E	49.47.950 S	PROVOR	8	PROVOR	8	Release	PV 616 (1550m)

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08/03/08 16:08	2	01.48.410 E	49.55.940 S	XBT	98	XBT	98	Release	
08/03/08 16:41	2	01.43.370 E	50.00.510 S	XBT	99	XBT	99	Release	
08/03/08 17:34	2	01.36.590 E	50.06.320 S	Hydro	56	CTD	76	Deployment	
08/03/08 20:20	2	01.37.968 E	50.06.412 S	Hydro	56	CTD	76	On board	
08/03/08 21:07	2	01.32.530 E	50.10.600 S	XBT	100	XBT	100	Release	
08/03/08 21:59	2	01.24.450 E	50.16.580 S	XBT	101	XBT	101	Release	
08/03/08 23:12	2	01.18.130 E	50.22.360 S	Large	57	CTD	77	Deployment	Large6A 0-bottom
09/03/08 02:19	2	01.18.072 E	50.22.378 S	Large	57	CTD	77	On board	Large6A 0-bottom
09/03/08 02:50	2	01.19.535 E	50.22.551 S	Large	57	GOFLO	26	Deployment	Large6A TM's 0-2100m
09/03/08 05:12	2	01.19.971 E	50.22.611 S	Large	57	GOFLO	26	On board	Large6A TM's 0-2100m
09/03/08 05:34	2	01.18.930 E	50.22.480 S	Large	57	CTD	78	Deployment	Large6A Mixed Layer 0-250m
09/03/08 06:16	2	01.19.432 E	50.22.698 S	Large	57	CTD	78	On board	Large6A Mixed Layer 0-250m
09/03/08 06:58	2	01.13.420 E	50.27.070 S	XBT	102	XBT	102	Release	
09/03/08 07:41	2	01.06.040 E	50.32.670 S	XBT	103	XBT	103	Release	
09/03/08 08:38	2	00.58.540 E	50.38.350 S	Hydro	58	CTD	79	Deployment	
09/03/08 11:20	2	00.58.621 E	50.38.489 S	Hydro	58	CTD	79	On board	
09/03/08 11:32	2	00.58.210 E	50.37.940 S	PROVOR	9	PROVOR	9	Release	PV 611 (1550m)
09/03/08 13:05	2	00.42.540 E	50.43.460 S	XBT	104	XBT	104	Release	
09/03/08 13:48	2	00.41.170 E	50.48.580 S	XBT	105	XBT	105	Release	
09/03/08 14:25	2	00.39.400 E	50.54.210 S	Hydro	59	CTD	80	Deployment	
09/03/08 16:22	2	00.39.350 E	50.54.242 S	Hydro	59	CTD	80	On board	
09/03/08 17:39	2	00.29.000 E	51.02.420 S	XBT	106	XBT	106	Release	Spikes from 200m: redo
09/03/08 17:47	2	00.27.770 E	51.03.440 S	XBT	107	XBT	107	Release	Spikes from 300m: redo
09/03/08 17:52	2	00.27.080 E	51.04.030 S	XBT	108	XBT	108	Release	
09/03/08 18:56	2	00.19.870 E	51.10.080 S	Hydro	60	CTD	81	Deployment	
09/03/08 20:44	2	00.19.945 E	51.10.286 S	Hydro	60	CTD	81	On board	
09/03/08 21:59	2	00.11.340 E	51.16.980 S	XBT	109	XBT	109	Release	Spikes from 280m: redo
09/03/08 22:06	2	00.10.460 E	51.17.650 S	XBT	110	XBT	110	Release	Miniature spike at 472m
09/03/08 23:57	2	00.00.620 E	51.25.820 S	Hydro	61	CTD	82	Deployment	
10/03/08 02:25	2	00.00.493 E	51.25.817 S	Hydro	61	CTD	82	On board	
10/03/08 03:36	2	00.00.290 E	51.33.870 S	XBT	111	XBT	111	Release	
10/03/08 04:47	2	00.00.360 E	51.42.640 S	XBT	112	XBT	112	Release	Spikes from 350m
10/03/08 05:50	2	00.00.040 E	51.50.870 S	Super	62	CTD	83	Deployment	Super4 Mixed Layer 0-250m
10/03/08 06:29	2	00.00.040 E	51.50.870 S	Super	62	CTD	83	On board	Super4 Mixed Layer 0-250m

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10/03/08 07:03	2	00.00.087 E	51.51.236 S	Super	62	GOFLO	27	Deployment	Super4 Cd + Incubation (Pedro) 0-200m
10/03/08 08:10	2	00.00.378 E	51.51.297 S	Super	62	GOFLO	27	On board	Super4 Cd + Incubation (Pedro) 0-200m
10/03/08 08:34	2	00.00.041 E	51.51.350 S	Super	62	CTD	84	Deployment	Super4 Hydro 0-bottom
10/03/08 10:44	2	00.01.030 E	51.52.420 S	Super	62	CTD	84	On board	Super4 Hydro 0-bottom
10/03/08 11:15	2	00.00.307 E	51.51.082 S	Super	62	GOFLO	28	Deployment	Super4 TM's during day 0-1000m
10/03/08 13:06	2	00.00.478 E	51.51.241 S	Super	62	GOFLO	28	On board	Super4 TM's during day 0-1000m
10/03/08 13:40	2	00.00.00 E	51.51.330 S	Super	62	PIS	8	Deployment	Super4 Tracers 0-bottom
10/03/08 20:30	2	00.00.00 E	51.51.330 S	Super	62	PIS	8	On board	Super4 Tracers 0-bottom
10/03/08 20:42	2	00.00.043 E	51.51.400 S	Super	62	CTD	85	Deployment	Super4 REE 0-bottom
10/03/08 22:38	2	00.00.724W	51.51.467 S	Super	62	CTD	85	On board	Super4 REE 0-bottom
11/03/08 00:05	2	00.00.140 E	51.51.890 S	Super	62	GOFLO	29	Deployment	Super4 Incubation (Geraldine) Fluo max
11/03/08 01:15	2	00.00.095 E	51.51.899 S	Super	62	GOFLO	29	On board	Super4 Incubation (Geraldine) Fluo max
11/03/08 01:30	2	00.00.137 W	51.51.900 S	Super	62	CTD	86	Deployment	Super4 234Th,210Po,Ra 0-1000m
11/03/08 02:48	2	00.00.109 W	51.52.158 S	Super	62	CTD	86	On board	Super4 234Th,210Po,Ra 0-1000m
11/03/08 03:15	2	00.00.260 E	51.52.190 S	Super	62	GOFLO	30	Deployment	Super4 Incubation (Bron) Fluo max
11/03/08 04:18	2	00.00.480 E	51.52.440 S	Super	62	GOFLO	30	On board	Super4 Incubation (Bron) Fluo max
11/03/08 04:27	2	00.00.410 E	51.52.540 S	Super	62	CTD	87	Deployment	Super4 Ba, 30Si 0-1000m
11/03/08 05:58	2	00.00.328 E	51.52.864 S	Super	62	CTD	87	On board	Super4 Ba, 30Si 0-1000m
11/03/08 06:20	2	00.00.320 E	51.52.700 S	Super	62	GOFLO	31	Deployment	Super4 TM's deep 1000-2400m
11/03/08 09:04	2	00.00.230 E	51.52.911 S	Super	62	GOFLO	31	On board	Super4 TM's deep 1000-2400m
11/03/08 09:28	2	00.00.00 E	51.51.330 S	Super	62	PIS	9	Deployment	Super4 Tracers 0-bottom
11/03/08 15:49	2	00.00.00 E	51.51.330 S	Super	62	PIS	9	On board	Super4 Tracers 0-bottom
11/03/08 16:20	2	00.00.300 E	51.53.280 S	Super	62	GOFLO	32	Deployment	Super4 Fe isotopes Fluo max
11/03/08 18:00	2	00.00.220 E	51.53.120 S	Super	62	GOFLO	32	On board	Super4 Fe isotopes Fluo max
11/03/08 18:35	2	00.00.130 E	51.52.960 S	Super	62	OKTOPUS	6	Deployment	
11/03/08 20:21	2	00.00.132 E	51.52.940 S	Super	62	OKTOPUS	6	On board	Super4 Zero carotte
11/03/08 20:41	2	00.00.070 E	51.59.290 S	PROVOR	10	PROVOR	10	Release	PV 603 (1550m)
11/03/08 21:45	2	00.00.040 E	52.06.280 S	XBT	113	XBT	113	Release	Miniatures spikes at 635m
11/03/08 22:50	2	00.00.106 E	52.16.379 S	Hydro	63	CTD	88	Deployment	
12/03/08 01:22	2	00.00.090 E	52.16.382 S	Hydro	63	CTD	88	On board	
12/03/08 02:24	2	00.00.310 E	52.25.810 S	XBT	114	XBT	114	Release	Miniatures spikes at 767m
12/03/08 03:57	2	00.00.090 E	52.36.080 S	Hydro	64	CTD	89	Deployment	
12/03/08 06:18	2	00.00.012 E	52.36.144 S	Hydro	64	CTD	89	On board	
12/03/08 06:30	2	00.00.330 E	52.36.620 S	PROVOR	11	PROVOR	11	Release	PV 605 (1550m)

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12/03/08 07:27	2	00.00.300 W	52.46.680 S	XBT	115	XBT	115	Release	Spike at 660m
12/03/08 08:39	2	00.00.019 E	52.55.822 S	Hydro	65	CTD	90	Deployment	
12/03/08 10:56	2	00.00.013 E	52.55.798 S	Hydro	65	CTD	90	On board	
12/03/08 12:24	2	00.00.031 E	52.58.906 S	Hydro	65	CTD	91	Deployment	Intercalibration Polarstern REE
12/03/08 13:35	2	00.00.020 E	52.58.913 S	Hydro	65	CTD	91	On board	Intercalibration Polarstern REE
12/03/08 14:28	2	00.01.830 W	53.04.480 S	XBT	116	XBT	116	Release	
12/03/08 15:02	2	00.00.760 E	53.11.300 S	XBT	117	XBT	117	Release	
12/03/08 15:48	2	00.00.140 E	53.15.620 S	Hydro	66	CTD	92	Deployment	
12/03/08 17:39	2	00.00.040 E	53.15.650 S	Hydro	66	CTD	92	On board	
12/03/08 18:19	2	00.00.030 E	53.20.760 S	XBT	118	XBT	118	Release	
12/03/08 19:11	2	00.00.000 E	53.30.720 S	XBT	119	XBT	119	Release	
12/03/08 19:53	2	00.00.160 E	53.35.515 S	Hydro	67	CTD	93	Deployment	
12/03/08 22:08	2	00.00.310 W	53.35.630 S	PROVOR	12	PROVOR	12	Release	PV 601 (1550m)
12/03/08 22:13	2	00.00.040 W	53.35.520 S	Hydro	67	CTD	93	On board	
12/03/08 23:36	2	00.00.050 W	53.44.830 S	XBT	120	XBT	120	Release	
13/03/08 00:46	2	00.00.100 E	53.55.130 S	Hydro	68	CTD	94	Deployment	
13/03/08 02:53	2	00.00.035 E	53.55.150 S	Hydro	68	CTD	94	On board	
13/03/08 04:28	2	00.00.010 E	54.05.470 S	XBT	121	XBT	121	Release	Spiking at 140m: redo
13/03/08 04:34	2	00.00.020 E	54.06.210 S	XBT	122	XBT	122	Release	
13/03/08 05:25	2	00.00.030 E	54.15.000 S	Hydro	69	CTD	95	Deployment	
13/03/08 07:34	2	00.00.037 W	54.15.043 S	Hydro	69	CTD	95	On board	
13/03/08 08:38	2	00.00.200 W	54.25.900 S	XBT	123	XBT	123	Release	
13/03/08 09:36	2	00.00.042 W	54.34.828 S	Hydro	70	CTD	96	Deployment	
13/03/08 10:54	2	00.00.030 W	54.34.829 S	Hydro	70	CTD	96	On board	
13/03/08 12:21	2	00.01.730 W	54.50.070 S	XBT	124	XBT	124	Release	
13/03/08 13:00	2	00.00.029 E	54.54.760 S	Hydro	71	CTD	97	Deployment	
13/03/08 14:25	2	00.00.241 E	54.54.787 S	Hydro	71	CTD	97	On board	
13/03/08 15:24	2	00.00.010 E	55.04.780 S	XBT	125	XBT	125	Release	
13/03/08 18:42	2	00.01.380 E	55.13.847 S	Large	72	CTD	98	Deployment	Large7A 0-bottom
13/03/08 20:40	2	00.01.655 E	55.13.703 S	Large	72	CTD	98	On board	Large7A 0-bottom
13/03/08 21:08	2	00.02.214 E	55.14.071 S	Large	72	GOFLO	33	Deployment	Large7A TM's 0-2100m
13/03/08 23:50	2	00.02.662 E	55.13.940 S	Large	72	GOFLO	33	On board	Large7A TM's 0-2100m
14/03/08 00:10	2	00.02.660 E	55.13.930 S	Large	72	CTD	99	Deployment	Large7A Ba, 30Si, Po 0-1000m
14/03/08 01:42	2	00.02.611 E	55.13.948 S	Large	72	CTD	99	On board	Large7A Ba, 30Si, Po 0-1000m

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14/03/08 04:24	2	00.00.920 E	55.24.090 S	XBT	126	XBT	126	Release	
14/03/08 06:09	2	00.00.021 W	55.34.140 S	Large	73	CTD	100	Deployment	Large7A Mixed Layer 0-250m
14/03/08 06:47	2	00.00.021 W	55.34.140 S	Large	73	CTD	100	On board	Large7A Mixed Layer 0-250m
14/03/08 08:14	2	00.00.274 E	55.34.219 S	Hydro	73	CTD	101	Deployment	
14/03/08 10:57	2	00.00.330 E	55.34.230 S	Hydro	73	CTD	101	On board	
14/03/08 11:15	2	00.00.120 E	53.34.240 S	PROVOR	13	PROVOR	13	Release	PV 609 (1550m)
14/03/08 12:25	2	00.01.690 E	55.44.750 S	XBT	127	XBT	127	Release	Spike at 645m
14/03/08 13:51	2	00.06.790 E	55.54.260 S	Hydro	74	CTD	102	Deployment	
14/03/08 16:32	2	00.06.877 E	55.54.331 S	Hydro	74	CTD	102	On board	
14/03/08 17:53	2	00.06.120 E	56.04.310 S	XBT	128	XBT	128	Release	
14/03/08 19:42	2	00.00.850 E	56.13.975 S	Hydro	75	CTD	103	Deployment	
14/03/08 22:48	2	00.00.469 E	56.13.926 S	Hydro	75	CTD	103	On board	
15/03/08 01:20	2	00.10.750 E	56.23.970 S	XBT	129	XBT	129	Release	
15/03/08 03:29	2	00.07.330 E	56.33.490 S	XBT	130	XBT	130	Release	
15/03/08 06:20	2	00.00.852 W	56.45.736 S	Hydro	76	CTD	104	Deployment	
15/03/08 09:07	2	00.00.854 W	56.45.739 S	Hydro	76	CTD	104	On board	
15/03/08 10:11	2	00.02.390 W	56.56.970 S	XBT	131	XBT	131	Release	
15/03/08 11:45	2	00.06.800 W	57.12.740 S	Hydro	77	CTD	105	Deployment	
15/03/08 15:02	2	00.06.865 W	57.12.703 S	Hydro	77	CTD	105	On board	
15/03/08 16:02	2	00.03.840 W	57.23.840 S	XBT	132	XBT	132	Release	
15/03/08 16:52	2	00.02.190 W	57.33.150 S	Super	78	CTD	106	Deployment	Super5 Hydro 0-bottom
15/03/08 19:42	2	00.02.256 W	57.33.138 S	Super	78	CTD	106	On board	Super5 Hydro 0-bottom
15/03/08 20:30	2	00.02.190 W	57.33.150 S	Super	78	GOFLO	34	Deployment	Super5 TM's deep 1000-bottom
15/03/08 23:20	2	00.02.190 W	57.33.150 S	Super	78	GOFLO	34	On board	Super5 TM's deep 1000-bottom
15/03/08 23:57	2	00.02.190 W	57.33.150 S	Super	78	CTD	107	Deployment	Super5 REE 0-bottom
16/03/08 02:54	2	00.02.180 W	57.33.140 S	Super	78	CTD	107	On board	Super5 REE 0-bottom
16/03/08 03:40	2	00.02.190 W	57.33.139 S	Super	78	GOFLO	35	Deployment	Super5 Cd + Incubation (Pedro) 0-200m
16/03/08 04:30	2	00.02.190 W	57.33.139 S	Super	78	GOFLO	35	On board	Super5 Cd + Incubation (Pedro) 0-200m
16/03/08 07:27	2	00.02.252 W	57.33.161 S	Super	78	CTD	108	Deployment	Super5 Mixed Layer 0-270m
16/03/08 07:58	2	00.02.251 W	57.33.156 S	Super	78	CTD	108	On board	Super5 Mixed Layer 0-270m
16/03/08 08:05	2	00.02.192 W	57.33.137 S	Super	78	PIS	10	Deployment	Super5 Tracers 0-bottom
16/03/08 15:20	2	00.02.193 W	57.33.139 S	Super	78	PIS	10	On board	Super5 Tracers 0-bottom
16/03/08 15:43	2	00.02.191 W	57.33.140 S	Super	78	GOFLO	36	Deployment	Super5 TM's during day 0-1000m
16/03/08 17:20	2	00.02.193 W	57.33.154 S	Super	78	GOFLO	36	On board	Super5 TM's during day 0-1000m

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16/03/08 17:30	2	00.02.190 W	57.33.150 S	Super	78	CTD	109	Deployment	Super5 234Th,210Po,Ra 0-1000m
16/03/08 18:44	2	00.02.270 W	57.33.150 S	Super	78	CTD	109	On board	Super5 234Th,210Po,Ra 0-1000m
16/03/08 19:20	2	00.02.193 W	57.33.143 S	Super	78	GOFLO	37	Deployment	Super5 Fe isotopes 0-1000m
16/03/08 21:34	2	00.02.190 W	57.33.140 S	Super	78	GOFLO	37	On board	Super5 Fe isotopes 0-1000m
16/03/08 21:57	2	00.02.268 W	57.33.152 S	Super	78	CTD	110	Deployment	Super5 Ba, 30Si 0-1000m
16/03/08 23:00	2	00.02.264 W	57.33.140 S	Super	78	CTD	110	On board	Super5 Ba, 30Si 0-1000m
17/03/08 00:15	2	00.03.021 W	57.33.084 S	Super	78	PIS	11	Deployment	Super5 Tracers 0-bottom
17/03/08 07:55	2	00.03.049 W	57.33.080 S	Super	78	PIS	11	On board	Super5 Tracers 0-bottom
17/03/08 08:02	2	00.03.048 W	57.33.040 S	Super	78	GOFLO	38	Deployment	Super5 Large Volume clean water Surface
17/03/08 08:50	2	00.03.049 W	57.33.040 S	Super	78	GOFLO	38	On board	Super5 Large Volume clean water Surface
17/03/08 09:07	2	00.02.571 W	57.32.726 S	Super	78	OKTOPUS	7	Deployment	
17/03/08 11:42	2	00.02.525 W	57.32.715 S	Super	78	OKTOPUS	7	On board	Super5: 2 carottes (sur 8)
17/03/08 12:11	2	00.01.830 W	57.32.100 S	XBT	133	XBT	133	Release	Sebaastian's Birthday!
18/03/08 18:22	2	05.49.140 E	52.56.840 S	PROVOR	14	PROVOR	14	Release	PV S2 472 (2000m)
19/03/08 07:40	2	09.14.690 E	50.38.980 S	PROVOR	15	PROVOR	15	Release	PV S2 347 (2000m)
19/03/08 15:54	2	11.13.740 E	49.15.810 S	PROVOR	16	PROVOR	16	Release	PV S2 410 (2000m)
20/03/08 11:25	2	22.03.460 E	41.56.840 S	PROVOR	17	PROVOR	17	Release	PV S3 615 (2000m)
21/03/08 04:59	2	20.38.170 E	42.59.520 S	XBT	134	XBT	134	Release	
21/03/08 06:05	2	20.54.610 E	42.49.100 S	XBT	135	XBT	135	Release	
21/03/08 07:03	2	21.09.120 E	42.40.150 S	XBT	136	XBT	136	Release	
21/03/08 08:07	2	21.24.850 E	42.30.350 S	XBT	137	XBT	137	Release	
21/03/08 09:26	2	21.44.470 E	42.18.160 S	XBT	138	XBT	138	Release	
21/03/08 11:43	2	22.05.460 E	41.53.870 S	XBT	139	XBT	139	Release	
21/03/08 12:38	2	22.13.440 E	41.42.590 S	XBT	140	XBT	140	Release	
21/03/08 13:37	2	22.21.250 E	41.30.510 S	XBT	141	XBT	141	Release	
21/03/08 14:40	2	22.29.730 E	41.17.400 S	XBT	142	XBT	142	Release	

5.1.2 ATMOSPHERIC PHYSICS OPERATIONS - RADIOSONDE LAUNCHES

See Chapter in cruise report : “Atmospheric and Air Sea physical on board observations”.

5.2 INVENTORY OF THE SAMPLES COLLECTED FOR EACH INSTRUMENT

At each station all the types of sampled parameters, the associated sampled depths and the associated sampled volumes have been accurately recorded.

Some of the documents are in the appendix of this report and all of them will be available soon on the BGH database website (CYBER) with restricted access in the “basic files” category.

CTD rosette (in Appendix 1: CTD casts)

- Rosette log:
See “CTD Casts – CTD bottles values- (filename: bgh000-110_rosette_btl.xls)
- Bottle log (with the bottle depths):
See “CTD Casts – bottle depths-” (filename: bgh000-110_depths_btl.xls)
- Water sampling data sheets for the 79 geographical stations (111 CTDs):
See “CTD Casts – samplings- (filenames: Prelevement_*casttype*_CTD*number*.xls)

In appendixes you will find main references for In Situ Pumps and GoFlo

- ISP log (appendix 2)
- GoFlo log (appendix 3)

For information on the other instruments and parameters, please refer to the individual reports and appendixes provided by each scientist.

5.3 THE DATABASE DICTIONARY

The purpose of this dictionary is to describe all the parameters acquired during the cruise, as well as the several types of instruments, for which measurements and sampling were carried out on station and underway.

Below a simplified version of the dictionary (a complete version can be found in the corresponding appendix)

Niskin-frame sampling

Rosette Cast	Parameter sampled	Scientific responsible(s) & Email(s)	Analyses responsible
Hydro	Sal	Sabrina.Speich@univ-brest.fr	Sabrina.Speich@univ-
	O2	Sabrina.Speich@univ-brest.fr	Sabrina.Speich@univ-
	O2/Ar	Michael Bender bender@Princeton.EDU, Nicolas Cassar ncassar@Princeton.EDU	Pedro Monteiro, pmon
	CFC	Sabrina.Speich@univ-brest.fr	Rana Fine, rfine@rsm
	DIC Licor	Bruno Delille, Bruno.Delille@ulg.ac.be	Bruno Delille & Nicolas Bruno.Delille@ulg.ac.t nxgeilfus@ulg.ac.be
	Alk & pH	Melchor Gonzales mgonzalez@dqui.ulpgc.es, Magda. Santana jmsantana@dqui.ulpgc.es	Melchor Gonzales mgonzalez@dqui.ulpg Santana jmsantana@c
	DIC colori	Melchor Gonzales mgonzalez@dqui.ulpgc.es, Magda. Santana jmsantana@dqui.ulpgc.es	Melchor Gonzales mgonzalez@dqui.ulpg Santana jmsantana@c
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	NH4	M. Boye, marie.boyé@univ-brest.fr	F. Le Moigne, fred.le.moigne@wana Annick.Masson@univ-
	Chloro	M. Boye, marie.boyé@univ-brest.fr	A. Gueneugues, Audrey.Gueneugues@

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	DIC colori	Melchor Gonzales mgonzalez@dqui.ulpgc.es, Magda. Santana jmsantana@dqui.ulpgc.es	Melchor Gonzales mgonzalez@dqui.ulpgc.es, Magda. Santana jmsantana@dqui.ulpgc.es	mgonzalez@dqui.ulpgc.es

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	Pigm	Hervé Claustre, herve.claustre@obs-vlfr.fr	Joséphine Ras, jras@obs-vlfr.fr	jras@obs-vlfr.fr
	Chloro	M. Boye, marie.boy@univ-brest.fr	A. Gueneugues, Audrey.Gueneugues@univ-brest.fr	marie.boy@univ-brest.fr

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	Inc 15N & 13C	Pedro Monteiro pmonteir@csir.co.za, Howard Waldron howard.waldron@uct.ac.za	Howard Waldron howard.waldron@uct.ac.za, Sandy Thomalla sandy_thomalla@yahoo.com, Warren Joubert wjoubert@csir.co.za	pmonteir@csir.co.za
	NO3 & Si	M. Boye, marie.boy@univ-brest.fr	F. Le Moigne, fred.le.moigne@wanadoo.fr/A. Masson, Annick.Masson@univ-brest.fr	Marie.boy@univ-brest.fr
	PO4	M. Boye, marie.boy@univ-brest.fr	F. Le Moigne, fred.le.moigne@wanadoo.fr/A. Masson, Annick.Masson@univ-brest.fr	marie.boy@univ-brest.fr
	NH4	M. Boye, marie.boy@univ-brest.fr	F. Le Moigne, fred.le.moigne@wanadoo.fr/A. Masson, Annick.Masson@univ-brest.fr	marie.boy@univ-brest.fr
	Taxo	M. Boye, marie.boy@univ-brest.fr	B. Beker, beatriz.beker@univ-brest.fr	beatriz.beker@univ-brest.fr
	Cocco	L. Beaufort, beaufort@cerege.fr		beaufort@cerege.fr
	POC/PIC/PON	M. Boye, marie.boy@univ-brest.fr	A. Masson, annick.masson@univ-brest.fr	annick.masson@univ-brest.fr
	inc Si D+R	R. Corvaisier, rudolph.corvaisier@univ-brest.fr/P. Pondaven, philippe.pondaven@univ-brest.fr D. Cardinal dcardinal@africamuseum.be F. Fripiat ffripiat@africamuseum.be	R. Corvaisier, rudolph.corvaisier@univ-brest.fr/E. Grossteffan, emilie.grossteffan@univ-brest.fr F. Fripiat ffripiat@africamuseum.be	rudolph.corvaisier@univ-brest.fr, ffripiat@africamuseum.be
	inc Si D	D. Cardinal dcardinal@africamuseum.be F. Fripiat ffripiat@africamuseum.be R. Corvaisier, rudolph.corvaisier@univ-brest.fr	F. Fripiat ffripiat@africamuseum.be R. Corvaisier, rudolph.corvaisier@univ-brest.fr/E. Grossteffan, emilie.grossteffan@univ-brest.fr	ffripiat@africamuseum.be rudolph.corvaisier@univ-brest.fr,
PoTh Large & Super	Sal	Sabrina.Speich@univ-brest.fr	Sabrina.Speich@univ-brest.fr	Sabrina.Speich@univ-brest.fr
	NO3 & Si	M. Boye, marie.boy@univ-brest.fr	F. Le Moigne, fred.le.moigne@wanadoo.fr/A. Masson, Annick.Masson@univ-brest.fr	Marie.boy@univ-brest.fr

– BONUS-GOODHOPE Cruise Report –

	210Po	P. Masqu� Pere.Masque@uab.es	E. Verdeny Elisabet.Verdeny@uab.cat , N. Escuberta Nuria.casacuberta@uab.cat	Elisabet.Verdeny@uab.c at
	234Th	F. Planchon frederic.planchon@africamuseum.be; F. Dehairs fdehairs@vub.ac.be	F. Planchon frederic.planchon@africamuseum.be; F. Dehairs fdehairs@vub.ac.be	fdehairs@vub.ac.be
	226Ra	C. Hanfland, chanfland@awi-bremerhaven.de		chanfland@awi- bremerhaven.de
	Ba	F. Dehairs fdehairs@vub.ac.be, D. Cardinal dcardinal@africamuseum.be	D. Cardinal dcardinal@africamuseum.be	fdehairs@vub.ac.be, dcardinal@africamuseum .be
	Bacterio	K. Barnes brnkir001@uct.ac.za/ kirstb007@gmail.com	K. Barnes brnkir001@uct.ac.za/ kirstb007@gmail.com	brnkir001@uct.ac.za/ kirstb007@gmail.com
BaSi Large & Super	Sal	Sabrina.Speich@univ-brest.fr	Sabrina.Speich@univ-brest.fr	Sabrina.Speich@univ- brest.fr
	NO3 & Si	M. Boye, marie.boy@univ-brest.fr	F. Le Moigne, fred.le.moigne@wanadoo.fr/A. Masson, Annick.Masson@univ-brest.fr	marie.boy@univ-brest.fr
	O2	Sabrina.Speich@univ-brest.fr	Sabrina.Speich@univ-brest.fr	Sabrina.Speich@univ- brest.fr
	dBa	F. Dehairs fdehairs@vub.ac.be	F. Dehairs fdehairs@vub.ac.be	fdehairs@vub.ac.be
	Ba	F. Dehairs fdehairs@vub.ac.be, D. Cardinal dcardinal@africamuseum.be	D. Cardinal dcardinal@africamuseum.be	fdehairs@vub.ac.be, dcardinal@africamuseum .be
	d30Si	D. Cardinal damien.cardinal@africamuseum.be F. Fripiat ffripiat@africamuseum.be	F. Fripiat ffripiat@africamuseum.be D. Cardinal damien.cardinal@africamuseum.be	damien.cardinal@africam useum.be ffripiat@africamuseum.be
	d30BSi	D. Cardinal damien.cardinal@africamuseum.be F. Fripiat ffripiat@africamuseum.be	F. Fripiat ffripiat@africamuseum.be D. Cardinal damien.cardinal@africamuseum.be	damien.cardinal@africam useum.be ffripiat@africamuseum.be
	234Th	F. Planchon frederic.planchon@africamuseum.be; F. Dehairs fdehairs@vub.ac.be	F. Planchon frederic.planchon@africamuseum.be; F. Dehairs fdehairs@vub.ac.be	fdehairs@vub.ac.be
	226Ra	C. Hanfland, chanfland@awi-bremerhaven.de		chanfland@awi- bremerhaven.de

– BONUS-GOODHOPE Cruise Report –

	Inc 15N & 13C	Pedro Monteiro pmonteir@csir.co.za, Howard Waldron howard.waldron@uct.ac.za	Howard Waldron howard.waldron@uct.ac.za, Sandy Thomalla sandy_thomalla@yahoo.com, Warren Joubert wjoubert@csir.co.za	pmonteir@csir.co.za
REE Super	O2	Sabrina.Speich@univ-brest.fr	Sabrina.Speich@univ-brest.fr	Sabrina.Speich@univ-brest.fr
	REE	Catherine Jeandel Catherine.jeandel@notos.cst.cnes.fr, M. Roy-Barman Matthieu.Roy-Barman@lsce.cnrs-gif.fr		Catherine.jeandel@notos.cst.cnes.fr
	Pa	Catherine Jeandel Catherine.jeandel@notos.cst.cnes.fr, M. Roy-Barman Matthieu.Roy-Barman@lsce.cnrs-gif.fr		Catherine.jeandel@notos.cst.cnes.fr
	Nd, 230Th	Catherine Jeandel Catherine.jeandel@notos.cst.cnes.fr, François Lacan lacan@legos.obs-mip.fr, M. Roy-Barman Matthieu.Roy-Barman@lsce.cnrs-gif.fr		Catherine.jeandel@notos.cst.cnes.fr
	234Th	F. Planchon frederic.planchon@africamuseum.be; F. Dehairs fdehairs@vub.ac.be		fdehairs@vub.ac.be
GEOTRACES dBa intercalibration	see special sheet	Frank Dehairs		fdehairs@vub.ac.be
GEOTRACES d30Si intercalibration	see special sheet	Damien Cardinal	François Fripiat/Damien Cardinal	damien.cardinal@africamuseum.be
GEOTRACES Nd intercalibration	see special sheet	Catherine Jeandel Catherine.jeandel@notos.cst.cnes.fr, François Lacan lacan@legos.obs-mip.fr,		Catherine.jeandel@notos.cst.cnes.fr
GEOTRACES 230Th/231Pa intercalibration	see special sheet	Catherine Jeandel Catherine.jeandel@notos.cst.cnes.fr, M. Roy-Barman Matthieu.Roy-Barman@lsce.cnrs-gif.fr		Catherine.jeandel@notos.cst.cnes.fr

– BONUS-GOODHOPE Cruise Report –

GEOTRACES 230Th/231Pa intercalibration	see special sheet	Catherine Jeandel Catherine.jeandel@notos.cst.cnes.fr, François Lacan lacan@legos.obs-mip.fr,		Catherine.jeandel@notos .cst.cnes.fr
CO2 MD/Polarstern	see special sheet	Melchor Gonzales mgonzalez@dqui.ulpgc.es, Magda. Santana jmsantana@dqui.ulpgc.es	Melchor Gonzales mgonzalez@dqui.ulpgc.es, Magda. Santana jmsantana@dqui.ulpgc.es	mgonzalez@dqui.ulpgc.e s
CO2 MD/Polarstern	see special sheet	Bruno Delille, Bruno.Delille@ulg.ac.be	Bruno Delille & Nicolas-Xavier Geilfus, Bruno.Delille@ulg.ac.be & nxgeilfus@ulg.ac.be	Bruno.Delille@ulg.ac.be

Continuous Shipboard Sea Water Sampling (UNDERWAY)

Operation	Parameter sampled	Scientific responsible(s) & Email(s)	Analyses responsible(s) & Email(s)	Email contact(s) for the data-base
Shipboard continuous water supply	pCO2	Bruno Delille, Bruno.Delille@ulg.ac.be	Bruno Delille & Nicolas-Xavier Geilfus, Bruno.Delille@ulg.ac.be & nxgeilfus@ulg.ac.be	Bruno.Delille@ulg.ac.be
	O2-isot/Ar	Michael Bender bender@Princeton.EDU, Nicolas Cassar ncassar@Princeton.EDU	Pedro Monteiro, pmonteir@csir.co.za	ncassar@Princeton.EDU
	thermosalinometer	IPEV		IPEV

Discrete Shipboard Sea Water Sampling (ship INTAKE water)

Operation	Parameter sampled	Scientific responsible(s) & Email(s)	Analyses responsible(s) & Email(s)	Email contact(s) for the data-base
Shipboard water supply	Ac-227	W. Geibert	Walter Geibert	W. Geibert
	Ra-226	C. Hanfland, chanfland@awi-bremerhaven.de	C. Hanfland, chanfland@awi-bremerhaven.de	chanfland@awi-bremerhaven.de
	POC	??		
	Alkenones	MA Sicre, marie-alexandrine.sicre@lsce.cnrs-gif.fr	Ullah Ezat, ullah.ezat@lsce.ipsl.fr	marie-alexandrine.sicre@lsce.cnrs-gif.fr
	O2-isot/Ar	Michael Bender bender@Princeton.EDU, Nicolas Cassar ncassar@Princeton.EDU	Pedro Monteiro, pmonteir@csir.co.za	ncassar@Princeton.EDU
	Bacterio	K. Barnes brnkir001@uct.ac.za/ kirstb007@gmail.com	K. Barnes brnkir001@uct.ac.za/ kirstb007@gmail.com	brnkir001@uct.ac.za/ kirstb007@gmail.com

Large volume In Situ Pumps

Filter type	Parameter sampled	Scientific responsible(s) & Email(s)	Analyses responsible(s) & Email(s)	Email contact(s) for the data-base
Petex screen (>50µm)	234Th	F. Planchon frederic.planchon@africamuseum.be; F. Dehairs fdehairs@vub.ac.be	F. Planchon frederic.planchon@africamuseum.be; F. Dehairs fdehairs@vub.ac.be	fdehairs@vub.ac.be
	210Po	P. Masquè Pere.Masque@uab.es	E. Verdeny Elisabet.Verdeny@uab.cat , N. Escuberta Nuria.casacuberta@uab.cat	Elisabet.Verdeny@uab.cat
	14C POC	Nadine Tisnerat-Laborde, Nadine.Tisnerat@lsce.cnrs-gif.fr	Nadine Tisnerat-Laborde, Nadine.Tisnerat@lsce.cnrs-gif.fr	Nadine.Tisnerat@lsce.cnrs-gif.fr

– BONUS-GOODHOPE Cruise Report –

	Biomarkers	A.-J. Cavagna acavagna@vub.ac.be; F. Dehairs fdehairs@vub.ac.be	A.-J. Cavagna acavagna@vub.ac.be; F. Dehairs fdehairs@vub.ac.be	fdehairs@vub.ac.be
Quartz filter QMA	234Th	F. Planchon frederic.planchon@africamuseum.be; F. Dehairs fdehairs@vub.ac.be	F. Planchon frederic.planchon@africamuseum.be; F. Dehairs fdehairs@vub.ac.be	fdehairs@vub.ac.be
	210Po	P. Masquè Pere.Masque@uab.es	E. Verdeny Elisabet.Verdeny@uab.cat , N. Escuberta Nuria.casacuberta@uab.cat	Elisabet.Verdeny@uab.cat
	14C POC	Nadine Tisnerat-Laborde, Nadine.Tisnerat@lsce.cnrs-gif.fr	Nadine Tisnerat-Laborde, Nadine.Tisnerat@lsce.cnrs-gif.fr	Nadine.Tisnerat@lsce.cnrs-gif.fr
	Biomarkers	A.-J. Cavagna acavagna@vub.ac.be; F. Dehairs fdehairs@vub.ac.be	A.-J. Cavagna acavagna@vub.ac.be; F. Dehairs fdehairs@vub.ac.be	fdehairs@vub.ac.be
	Alkenones	MA Sicre, marie-alexandrine.sicre@lsce.cnrs-gif.fr	Ullah Ezat, ullah.ezat@lsce.ipsl.fr	Marie - Alexandrine Sicre
Supor filter (0.4 µm)	Nd, Pa, Th, REE	Catherine Jeandel Catherine.jeandel@notos.cst.cnes.fr, François Lacan lacan@legos.obs-mip.fr, M. Roy-Barman Matthieu.Roy-Barman@lsce.cnrs-gif.fr		Catherine.jeande
	d30BSi	D. Cardinal damien.cardinal@africamuseum.be F. Fripiat ffripiat@africamuseum.be	F. Fripiat ffripiat@africamuseum.be D. Cardinal damien.cardinal@africamuseum.be	damien.cardinal ffripiat@africamuseum.be
Cartridges	227Ac	W. Geibert	Walter Geibert	W. Geibert
	Ra	C. Hanfland, chanfland@awi-bremerhaven.de		chanfland@awi-bremerhaven.de

GoFLO bottle sampling via Kevlar cable

GoFlo Cast	Parameter sampled	Scientific responsible(s) & Email(s)	Analyses responsible(s) & Email(s)	Email contact(s) for the data-base
LARGE (0-2000 m)	DMe	Marie Boye, marie.boye@univ-brest.fr	Bronwyn Wake, bronwyn.wake@gmail.com	Bronwyn Wake,
	TMe	Marie Boye, marie.boye@univ-brest.fr	Bronwyn Wake, bronwyn.wake@gmail.com	Bronwyn Wake,
	DCo, DZn, DCd	Marie Boye, marie.boye@univ-brest.fr	Johann Bown, johann.bown@univ-brest.fr	Johann Bown
	DFe	Géraldine Sarthou, Eva Bucciarelli	Fanny Chever	fanny.chever@univ-brest.fr
	TDFe	Géraldine Sarthou, Eva Bucciarelli	Fanny Chever	fanny.chever@univ-brest.fr
	Orga-Co, Orga-Zn, Orga-Cd	Marie Boye, marie.boye@univ-brest.fr	Johann Bown, johann.bown@univ-brest.fr	johann.bown@univ-brest.fr
	Orga-Fe	Stan van den Berg, vandenberg@liv.ac.uk		vandenberg@liverpool.ac.uk
	Orga-Mn/Cu	Marie Boye, marie.boye@univ-brest.fr		marie.boye@univ-brest.fr
	DMn, DCu	Marie Boye, marie.boye@univ-brest.fr		marie.boye@univ-brest.fr
	Sol-Fe	Géraldine Sarthou, Eva Bucciarelli	Fanny Chever	fanny.chever@univ-brest.fr
	TFe(II)	Géraldine Sarthou	Géraldine Sarthou	geraldine.sarthou@univ-brest.fr
	TH2O2	Eva Bucciarelli	Eva Bucciarelli	eva.bucciarelli@univ-brest.fr
	DH2O2	Eva Bucciarelli	Eva Bucciarelli	eva.bucciarelli@univ-brest.fr
	NO3	Marie Boye, marie.boye@univ-brest.fr	Annick Masson, Fred Le Moigne	marie.boye@univ-brest.fr
	S	Pierre Branellec, pierre.branellec@ifremer.fr	V. Rupolo	pierre.branellec@ifremer.fr
	Microcat	Michel Arhan, Michel.Arhan@ifremer.fr		michel.arhan@ifremer.fr
SUPER-TM's surface (0-1000 m) and	DMe	Marie Boye, marie.boye@univ-brest.fr	Bronwyn Wake, bronwyn.wake@gmail.com	bronwyn.wake@gmail.com

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TM's deep (1000-4000 m)	TMe	Marie Boye, marie.boy@univ-brest.fr	Bronwyn Wake, bronwyn.wake@gmail.com	bronwyn.wake@gmail.com
	DCo,DZn, DCd	Marie Boye, marie.boy@univ-brest.fr	Johann Bown, johann.bown@univ-brest.fr	johann.bown@univ-brest.fr
	DFe	Géraldine Sarthou, Eva Bucciarelli	Fanny Chever	fanny.chever@univ-brest.fr
	TDFe	Géraldine Sarthou, Eva Bucciarelli	Fanny Chever	fanny.chever@univ-brest.fr
	Orga-Co,Orga-Zn, Orga-Cd	Marie Boye, marie.boy@univ-brest.fr	Johann Bown, johann.bown@univ-brest.fr	johann.bown@univ-brest.fr
	Orga-Fe	Stan van den Berg, vandenbergliv.ac.uk		vandenbergliv.ac.uk
	Orga-Mn/Cu	Marie Boye, marie.boy@univ-brest.fr		marie.boy@univ-brest.fr
	DMn, DCu	Marie Boye, marie.boy@univ-brest.fr		marie.boy@univ-brest.fr
	Sol-Fe	Géraldine Sarthou, Eva Bucciarelli	Fanny Chever	fanny.chever@univ-brest.fr
	TFe(II)	Géraldine Sarthou	Géraldine Sarthou	geraldine.sarthou@univ-brest.fr
	TH2O2	Eva Bucciarelli	Eva Bucciarelli	eva.bucciarelli@univ-brest.fr
	DH2O2	Eva Bucciarelli	Eva Bucciarelli	eva.bucciarelli@univ-brest.fr
	DFe isotopes	François Lacan lacan@legos.obs-mip.fr	Amandine Radic radic@legos.obs-mip.fr	radic@legos.obs-mip.fr
	PFe isotopes	François Lacan lacan@legos.obs-mip.fr	Amandine Radic radic@legos.obs-mip.fr	radic@legos.obs-mip.fr
	DAI	M. Boye & Peter Croot, pcroot@ifm-geomar.de		pcroot@ifm-geomar.de
	TAI	M. Boye & Peter Croot, pcroot@ifm-geomar.de		pcroot@ifm-geomar.de
	DCd isotopes	Gideon Henderson, Gideon.Henderson@earth.ox.ac.uk	sonja.ripperger@erdw.ethz.ch	gideon.henderson@earth.ox.ac.uk
	NO3	Marie Boye, marie.boy@univ-brest.fr	Annick Masson, Fred Le Moigne	marie.boy@univ-brest.fr
	S	Pierre Branellec, pierre.branellec@ifremer.fr	V. Rupolo	pierre.branellec@ifremer.fr
	Microcat (surface casts)	Michel Arhan, Michel.Arhan@ifremer.fr		michel.arhan@ifremer.fr
	Pinger (deep casts)	IPEV		IPEV
SUPER- Cd + incub. Bron	DCd isotopes	Gideon Henderson, Gideon.Henderson@earth.ox.ac.uk	sonja.ripperger@erdw.ethz.ch	gideon.henderson@earth.ox.ac.uk

– BONUS-GOODHOPE Cruise Report –

	incub. Bron	Marie Boye, marie.boy@univ-brest.fr	Bronwyn Wake, bronwyn.wake@gmail.com	bronwyn.wake@gmail.com
	incub. Pedro	Pedro Monteiro	Sandy Thomalla	pmonteir@csir.co.za
	NO3	Marie Boye, marie.boy@univ-brest.fr	Annick Masson, Fred Le Moigne	marie.boy@univ-brest.fr
	S	Pierre Brannelec, pierre.branellec@ifremer.fr	V. Rupolo	pierre.branellec@ifremer.fr
	Microcat	Michel Arhan, Michel.Arhan@ifremer.fr		michel.arhan@ifremer.fr
SUPER-Fe isotopes	DFe isotopes	François Lacan lacan@legos.obs-mip.fr	Amandine Radic radic@legos.obs-mip.fr	radic@legos.obs-mip.fr
	PFe isotopes	François Lacan lacan@legos.obs-mip.fr	Amandine Radic radic@legos.obs-mip.fr	radic@legos.obs-mip.fr
	NO3	Marie Boye, marie.boy@univ-brest.fr	Annick Masson, Fred Le Moigne	marie.boy@univ-brest.fr
	S	Pierre Brannelec, pierre.branellec@ifremer.fr	V. Rupolo	pierre.branellec@ifremer.fr
	Microcat	Michel Arhan, Michel.Arhan@ifremer.fr		michel.arhan@ifremer.fr
SUPER-incub. Bron	incub. Bron	Marie Boye, marie.boy@univ-brest.fr	Bronwyn Wake, bronwyn.wake@gmail.com	bronwyn.wake@gmail.com
	Microcat	Michel Arhan, Michel.Arhan@ifremer.fr		michel.arhan@ifremer.fr
SUPER-incub. Gérald.	incub. Géraldine/Eva	Géraldine Sarthou, Eva Bucciarelli		Eva.Bucciarelli@univ-brest.fr, Geraldine.Sarthou@univ-brest.fr
	Microcat	Michel Arhan, Michel.Arhan@ifremer.fr		michel.arhan@ifremer.fr
GEOTRACES TM's intercalibration	see special sheet	Marie Boye, marie.boy@univ-brest.fr		marie.boy@univ-brest.fr

Oktopus sediment core sampling

Core profiles	Parameter	Scientific responsible(s) & Email(s)	Analyses responsible(s) & Email(s)	Email contact(s) for the data-base
	O2	E.Viollier viollier@ipgp.jussieu.fr	E.Viollier viollier@ipgp.jussieu.fr	viollier@ipgp.jussieu.fr
	pH	E.Viollier viollier@ipgp.jussieu.fr	E.Viollier viollier@ipgp.jussieu.fr	viollier@ipgp.jussieu.fr
	TCO2	E.Viollier viollier@ipgp.jussieu.fr	E.Viollier viollier@ipgp.jussieu.fr	viollier@ipgp.jussieu.fr
	NO2- + NO3-	E.Viollier viollier@ipgp.jussieu.fr	E.Viollier viollier@ipgp.jussieu.fr	viollier@ipgp.jussieu.fr
	H4SiO4	E.Viollier viollier@ipgp.jussieu.fr	E.Viollier viollier@ipgp.jussieu.fr	viollier@ipgp.jussieu.fr
	NH4+	E.Viollier viollier@ipgp.jussieu.fr	E.Viollier viollier@ipgp.jussieu.fr	viollier@ipgp.jussieu.fr
	TPO4	E.Viollier viollier@ipgp.jussieu.fr	E.Viollier viollier@ipgp.jussieu.fr	viollier@ipgp.jussieu.fr
	SO42-	E.Viollier viollier@ipgp.jussieu.fr	E.Viollier viollier@ipgp.jussieu.fr	viollier@ipgp.jussieu.fr
	Fe	E.Viollier viollier@ipgp.jussieu.fr	E.Viollier viollier@ipgp.jussieu.fr	viollier@ipgp.jussieu.fr
	Mn	E.Viollier viollier@ipgp.jussieu.fr	E.Viollier viollier@ipgp.jussieu.fr	viollier@ipgp.jussieu.fr
	DOC	E.Viollier viollier@ipgp.jussieu.fr	E.Viollier viollier@ipgp.jussieu.fr	viollier@ipgp.jussieu.fr
	Ba, U, Mo	E.Viollier viollier@ipgp.jussieu.fr	E.Viollier viollier@ipgp.jussieu.fr	viollier@ipgp.jussieu.fr
	TTM	Marie Boye, marie.boy@univ-brest.fr	B. Wake bronwyn.wake@gmail.com, J. Bown johann.bown@univ-brest.fr	johann.bown@univ-brest.fr, bronwyn.wake@gmail.com
	δSi	D. Cardinal damien.cardinal@africamuseum.be F. Fripiat ffripiat@africamuseum.be	F. Fripiat ffripiat@africamuseum.be D. Cardinal damien.cardinal@africamuseum.be	damien.cardinal@africamuseum.be ffripiat@africamuseum.be
	δFe	F.Lacan lacan@legos.obs-mip.fr	F.Lacan lacan@legos.obs-mip.fr	lacan@legos.obs-mip.fr
	δCd	M. Boye, G. Henderson Gideon.Henderson@earth.ox.ac.uk	sonja.ripperger@erdw.ethz.ch	sonja.ripperger@erdw.ethz.ch
	bulk porosity	E.Viollier viollier@ipgp.jussieu.fr	E.Viollier viollier@ipgp.jussieu.fr	viollier@ipgp.jussieu.fr
	%detrital	A. Roychoudhury alakendra.roychoudhury@uct.ac.za	K. Barnes brnkir001@uct.ac.za/ kirstb007@gmail.com	A. Roychoudhury alakendra.roychoudhury@uct.ac.za
	%CaCO3	A. Roychoudhury alakendra.roychoudhury@uct.ac.za	K. Barnes brnkir001@uct.ac.za/ kirstb007@gmail.com	A. Roychoudhury alakendra.roychoudhury@uct.ac.za
	%BSi	A. Roychoudhury alakendra.roychoudhury@uct.ac.za	K. Barnes brnkir001@uct.ac.za/ kirstb007@gmail.com	A. Roychoudhury alakendra.roychoudhury@uct.ac.za

– BONUS-GOODHOPE Cruise Report –

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	210Pb	P. Masqu� Pere.Masque@uab.es	Elisabet Verdeny Elisabet.Verdeny@uab.cat	Elisabet Verdeny Elisabet.Verdeny@uab.cat
	210Po	P. Masqu� Pere.Masque@uab.es	Elisabet Verdeny Elisabet.Verdeny@uab.cat	Elisabet Verdeny Elisabet.Verdeny@uab.cat
	230 Th	F.Lacan lacan@legos.obs-mip.fr	F.Lacan lacan@legos.obs-mip.fr	lacan@legos.obs-mip.fr
	�13C	N. Laborde Nadine.Tisnerat@lsce.cnrs-gif.fr	N. Laborde Nadine.Tisnerat@lsce.cnrs-gif.fr	Nadine.Tisnerat@lsce.cnrs-gif.fr
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	234Th	F.Planchon frederic.planchon@marion.ipev.fr	F.Planchon frederic.planchon@marion.ipev.fr	frederic.planchon@marion.ipev.fr
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	Pigments	A.Gr�mare a.gremare@epoc.u- bordeaux1.fr	A.Gr�mare a.gremare@epoc.u- bordeaux1.fr	a.gremare@epoc.u-bordeaux1.fr
	Meiofauna	A.Gr�mare a.gremare@epoc.u- bordeaux1.fr	A.Gr�mare a.gremare@epoc.u- bordeaux1.fr	a.gremare@epoc.u-bordeaux1.fr
	Corg	A.Gr�mare a.gremare@epoc.u- bordeaux1.fr	A.Gr�mare a.gremare@epoc.u- bordeaux1.fr	a.gremare@epoc.u-bordeaux1.fr
	AVS	A. Roychoudhury alakendra.roychoudhury@uct.ac.za	K. Barnes brnkir001@uct.ac.za/ kirstb007@gmail.com	A. Roychoudhury alakendra.roychoudhury@uct.ac.za
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– BONUS-GOODHOPE Cruise Report –

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Whole core incubations				
	FO2	E.Viollier viollier@ipgp.jussieu.fr	E.Viollier viollier@ipgp.jussieu.fr	viollier@ipgp.jussieu.fr
	FNO3	E.Viollier viollier@ipgp.jussieu.fr	E.Viollier viollier@ipgp.jussieu.fr	viollier@ipgp.jussieu.fr
	FNH4+	E.Viollier viollier@ipgp.jussieu.fr	E.Viollier viollier@ipgp.jussieu.fr	viollier@ipgp.jussieu.fr
	FH4SiO4	E.Viollier viollier@ipgp.jussieu.fr	E.Viollier viollier@ipgp.jussieu.fr	viollier@ipgp.jussieu.fr
	FPO4	E.Viollier viollier@ipgp.jussieu.fr	E.Viollier viollier@ipgp.jussieu.fr	viollier@ipgp.jussieu.fr
	FBa, FMo, FU	E.Viollier viollier@ipgp.jussieu.fr	E.Viollier viollier@ipgp.jussieu.fr	viollier@ipgp.jussieu.fr
	FTTM	Marie Boye, marie.boy@univ-brest.fr	B. Wake bronwyn.wake@gmail.com, J. Bown johann.bown@univ-brest.fr	johann.bown@univ-brest.fr, bronwyn.wake@gmail.com
	FDOC	E.Viollier viollier@ipgp.jussieu.fr	E.Viollier viollier@ipgp.jussieu.fr	viollier@ipgp.jussieu.fr

CTD sensors

Rosette Cast	Parameter sampled	Scientific responsible(s) & Email(s)	Analyses responsible(s) & Email(s)	Email contact(s) for the data-base
	Temperature1	Sabrina.Speich@univ-brest.fr	Sabrina.Speich	
	Temperature2	Sabrina.Speich@univ-brest.fr	Sabrina.Speich	
	Conductivity1	Sabrina.Speich@univ-brest.fr	Sabrina.Speich	
	Conductivity2	Sabrina.Speich@univ-brest.fr	Sabrina.Speich	
	O2	Sabrina.Speich@univ-brest.fr	Sabrina.Speich	
	LADCP (up and down; 300 kHz each)	Sabrina.Speich@univ-brest.fr	Sabrina.Speich	
	Fluo	Herve.Claustre@obs-vlfr.fr	Herve.Claustre	
	Transmissiometer			
	PAR			
	Pinger			

Satellite data (remote sensing)

Data resource	Parameter sampled	Scientific responsible(s) & Email(s)	Analyses responsible(s) & Email(s)	Email contact(s) for the database
ODYSSEA/IFREMER	SST (sea surface temp.)	Sabrina Speich	Jean-François Piolle, Jean.Francois.Piolle@ifremer.fr	
MODIS	SST (sea surface temp.)	Sabrina.Speich	Jean-François Piolle, Jean.Francois.Piolle@ifremer.fr	
MSG Synthesis	SST (sea surface temp.)	Richard.Legeckis@noaa.gov, pierre.leborgne@meteo.fr	Richard.Legeckis@noaa.gov, pierre.leborgne@meteo.fr	
MSG Fronts	SST derived fronts	Richard.Legeckis@noaa.gov, pierre.leborgne@meteo.fr	Richard.Legeckis@noaa.gov, pierre.leborgne@meteo.fr	
METOP Synthesis	SST (sea surface temp.)	pierre.leborgne@meteo.fr, Richard.Legeckis@noaa.gov	pierre.leborgne@meteo.fr, Richard.Legeckis@noaa.gov	
AVISO	Altimetry	Sabrina Speich		
SeaWIFs	Ocean data color	Bertrand Saulqui, bsaulqui@ifremer.fr		
SeaWIFs	"white signals"	Marie Boye		
IFREMER	wind direction & speed	Christophe Messenger	Abderrhaim.Bentamy@ifremer.fr	
REMSS	Precipitation	Christophe Messenger	Jean-François Piolle, Jean.Francois.Piolle@ifremer.fr	
METEO-FRANCE	irradiance	Christophe Messenger	Jean-François Piolle, Jean.Francois.Piolle@ifremer.fr	
IFREMER	Swell	Christophe Messenger	Jean-François Piolle, Jean.Francois.Piolle@ifremer.fr	

Atmospheric sensors

Operation	Parameter sampled	Scientific responsible(s) & Email(s)	Analyses responsible(s) & Email(s)	Email contact(s) for the data-base
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See E. Key (Erica.Key@cetp.ipsl.fr, ericalkey@gmail.com)
and C. Messenger (Christophe.Messenger@ifremer.fr) report in the cruise report

Aerosols/dust and rain

Operation	Parameter sampled	Scientific responsible(s) & Email(s)	Analyses responsible(s) & Email(s)	Email contact(s) for the data-base
aerosols collector	dust	Alexander Baker, Alex.Baker@uea.ac.uk	Alexander Baker, Alex.Baker@uea.ac.uk	Alex.Baker@uea.ac.uk
rain collector	rain	Alexander Baker, Alex.Baker@uea.ac.uk	Alexander Baker, Alex.Baker@uea.ac.uk	Alex.Baker@uea.ac.uk

Physics captors deployments

Operation	Parameter sampled	Scientific responsible(s) & Email(s)	Analyses responsible(s) & Email(s)	Email contact(s) for the data-base
XBTs	Temperature, Depth		Sebastian Swart	sebastiaan.swart@uct.ac.za
PROVOR	Temperature, Salinity, Depth		Sabrina Speich	speich@univ-brest.fr
CPIES	Current Speed, Acoustical Time, Bottom Pressure		Sabrina Speich	speich@univ-brest.fr

Ship captors and data

Operation	Parameter sampled	Scientific responsible(s) & Email(s)	Analyses responsible(s) & Email(s)	Email contact(s) for the data-base
SADCP (150 kHz)		Sabrina.Speich@univ-brest.fr		
SADCP (75 kHz)		Sabrina.Speich@univ-brest.fr		
Thermosalinometer		Sabrina.Speich@univ-brest.fr		
Navigation		Sabrina.Speich@univ-brest.fr		
Meteo		Christophe.Messenger@ifremer.fr		

5.3.1 CONCLUSION

Keeping the logbook up-to-date required a regular exchange with the scientists, a permanent monitoring of the operations on the deck and during the water sampling, and a contribution to the cruise organization, in order to have an overview of the daily operations.

As a database coordinator, this work consists in ensuring a correct transfer and daily distribution of information between scientists (distribution of the “bridge” and the participating “rosette” logs, for instance).

This logbook is the initial step to provide the essential references which are needed to identify of the different tasks and samples. The whole scientific community can thus have a global view of all of the activities undertaken during the cruise.

All the referencements will be added to the shared database in the LEFE-CYBER program, under the responsibility of Marie-Paule Torre:

<http://www.obs-vlfr.fr/proof/bonusgh>

6 IMPLEMENTED EQUIPMENT

6.1 THE VESSEL

<i>Name :</i>	MARION DUFRESNE
<i>Owner :</i>	GIE MD2 C/o CMA-CGM 4 quai d'Arenc 13002 MARSEILLE – France
<i>Operator :</i>	CMA-CGM 4 quai d'Arenc 13002 MARSEILLE – France
<i>Charterer :</i>	IPEV Technopôle Brest Iroise BP 75 29280 PLOUZANE – France
<i>Port of registry :</i>	Marseille (France)
<i>Registration nbr :</i>	RI 829498 D
<i>IMO number :</i>	9050814
<i>Length overall :</i>	120,50 m
<i>Moulded breadth :</i>	20,61 m
<i>Main engines :</i>	2 x 3000 kW
<i>Prospeller shafts :</i>	2
<i>Steering gear :</i>	2 safrans Becker (2 flap rudders)
<i>Box thruster:</i>	1 x 740 kW
<i>Generators :</i>	2 x 2880 kW and 1 x 2100 kW
<i>Cruise speed :</i>	15 knots
<i>Maximum speed :</i>	16 knots
<i>Lifting gear :</i>	2 x 25 t SWL
<i>Personnel Capacity :</i>	
<i>Number of crew :</i>	10 officers + 19 crew + 20 embarked stevedores
<i>Maximum capacity :</i>	160 persons

6.2 RADIOCOMMUNICATION AND RADIONAVIGATION

	Nbr	Equipment	Type & Model	Frequency	Emitting power
Satellite Coms	1	Inmarsat-B	NERA Saturn B	1,6 GHz	33 dBW
	1	Inmarsat Fleet77	NERA F77	1,6 GHz	
	1	Inmarsat-C	SKANTI ScanSat-CG	1,6 GHz	140W
Distress Search & Rescue	1	EPIRB Sarsat-Cospas	KANNAD 406 WH	406Mhz + 121,5Mhz	5W
	2	SART	SERPE Rescuer	9GHz	0,5W
	1	Automatic Identification System	SKANTI AIS2100	162 MHz	12W
HF & VHF Coms	1	Primary Marine USB Transceiver	SKANTI TRP8400	bande 1,6 - 4 MHz	400W
				bande 4 - 27,5 Mhz	400W
	1	Secondary Marine USB Transceiver	SKANTI TRP8750	bande 1,6 - 4 MHz	750W
				bande 4 - 27,5 Mhz	750W
	2	Marine VHF Transceivers	SKANTI VHF3000	bande 156-162 MHz	25W
Bridge	1	X-Band Radar	DECCA C.342/6	9380-9440 MHz	25kW
	1	S-Band Radar	DECCA C.343-S90	3040-3060 MHz	30kW
	1	High-Depth Echo Sounder	JRC JFE-570SD	50kHz	2 kW
	1	Small-Depth Echo Sounder	JRC JFE-570S	200KHz	2 kW

6.3 SCIENTIFIC EQUIPMENT

6.3.1 METHODS AND SCIENTIFIC EQUIPMENT USED ON BOARD

Types of samples and data	Methods used	Instruments used
Sediment cores	Coring	Multi-tubes corer
Navigation	Triangulation GPS (or DGPS)	GPS (or DGPS) receivers
Bathymetry and imagery	Multibeam	Multibeam THALES
Subbottom profiles	Subbottom profiler	3.5 kHz echo-sounder
Underway Ocean Currents Observations	VM-ADCP	OS 75 KHz and 150 KHz
Underway Sea Surface Temperature and Salinity Observations	Thermosalinometer	SBE 21
Biology Observations	Plankton net	Biologic dredge
Thermals probes	Thermicity measurements	Expandable Bathythermographs (XBT, UCT)
Mineral aerosol sampling	Air filtration	High volume pumps with cascade impactor and filter holder (UEA, UK)
Surface CO ₂ measurements	NDIR + equilibration	pCO ₂ captor (Belgium and Spain)
Surface Dissolved inorganic carbon	Potentiometric method	Equipement (Belgium and Spain)
CO ₂ Air sampling	NDIR	Equipement (Belgium and Spain)
Classical Hydrographic & biogeochemistry measurements	Seawater sampling, (Pressure, Oxygen, Salinity and Temperature measurements) & water sampling for biogeochemistry	SBE 911+ CTD (Conductivity Temperature Depth- LPO IFREMER) with a 24 bottles SBE rosette (INSU)
High frequency full-depth thermohaline structure, bottom pressure and current	Bottom moorings	2 x Currentmeter Inverted Echo Sounders (C-PIES, LPO-IFREMER)
Optics (eg underwater light levels)	Fluorometry, beam transmission	Fluorometer AQUAtracka Chelsea Instruments. and transmissiometer C-Star Wet-Labs (INSU)
Metals and their isotopes Hydrographic Measurements	Ultra-clean sampling for metals and trace isotopes	Kevlar line avec 10 Go-Flo bottles (Eq. NIOZ, NL)
Trace elements and isotopes Hydrographic Measurements	Large Volume of Water sampling for particulate measurements of trace elements and isotopes	In-situ pumps: 3 McLane, 10 Challenger (Eq. 10 INSU + 2 ULB+ 1 UAB)
Full-depth Ocean Currents Observations	L-ADCP	2 WH RDI 300 KHz LADCP (IFREMER+IRD)
Meteorological Observations	Underway measurements and full hight throposphere observations	MeteoFrance & RSMAS Equipment + Radiosounding

6.3.2 LABORATORY AND EQUIPMENT CONTAINERS

The following containers have been taken onboard of the *R/V Marion Dufresne*:

- 20 ft Chemical Laboratory container from LPO, France
- 20 ft Transport container for C-PIES and profiling floats, France
- 20 ft Transport container for the hydrography equipment, France
- 20 ft Ultra-clean Chemical Laboratory container from INSU, France
- 20 ft Transport container for In Situ Pumps, INSU, France
- 20 ft Transport container INSU/Trace metals incubation analyses,
France
- 20 ft Chemical Laboratory container from IUEM, France
- 20 ft Chemical Laboratory from VUB, Belgium

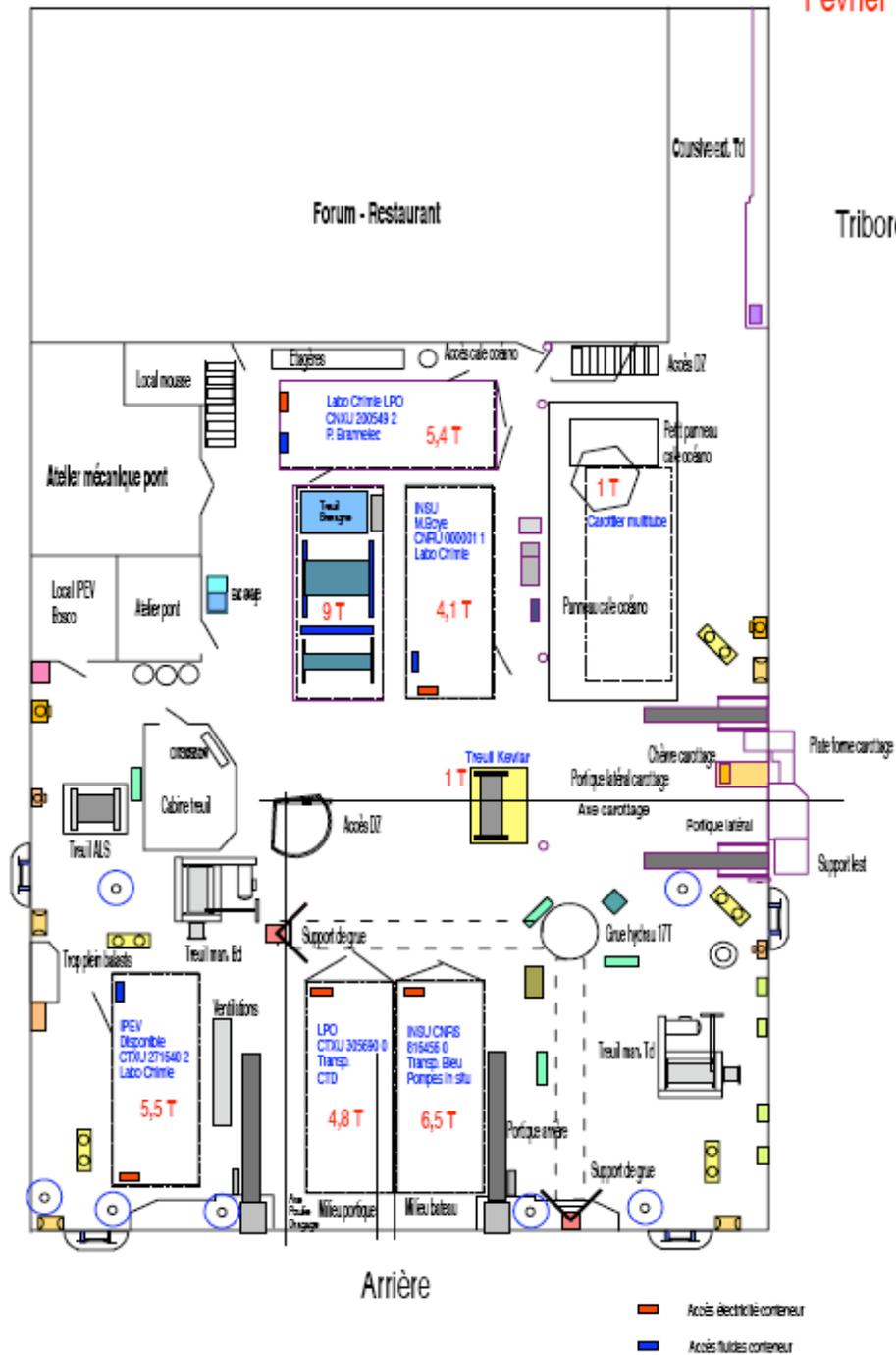
Also a little wood cabin was built by IPEV and installed on deck “E” on the fore side to store all the terminals receiving the atmospheric data.

R/V "Marion - Dufresne"

BONUS-GOODHOPE
Février - Mars 2008

Babord

Tribord

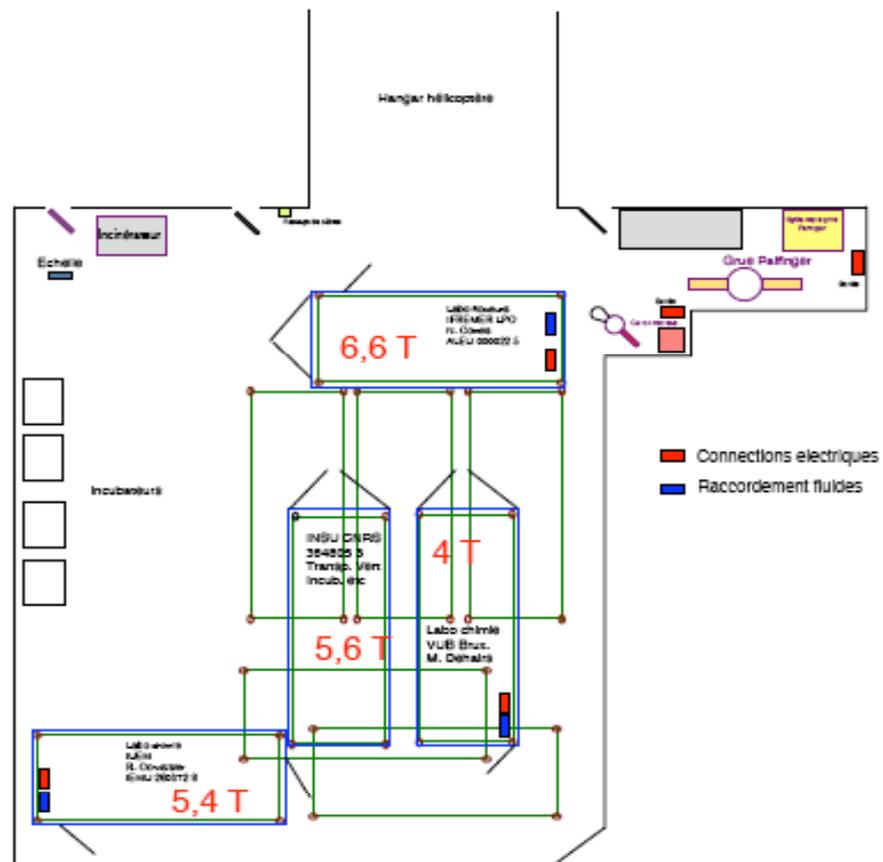


Arrière

Acés électrique conteneur
Acés fluides conteneur

Date :	07-déc-07
Projet :	Implantation Plage arr. MD2
Nom fichier :	MD-PA-01
Versión :	1
IPEV / Océanographie	
BP 76	
28280 Plouzané (France)	

Pont E Deck 3
Plage arrière



Implantation containers laboratoire
Mission Bonus- GoodHope
Plate-forme hélicoptère

Date :	11-déc-07
Projet :	Plan DZ Marion Dufresne
Nom fichier :	MD-DZ-01
Version :	1
IPEV / Océanographie	
BP 75	
29280 Plouzane (France)	

7 COMMUNICATION



Along with scientists and crew members, a student in scientific journalism, Vincent Pasquero, embarked on the *R/V Marion-Dufresne* during the Bonus-Goodhope cruise to take care of the « communication » issues with the large-public and school teachers and students. His daily work was to inform a wide public about scientists work and life on board, as well as to document the cruise with movies, interviews and pictures.

7.1 WHY COMMUNICATE ABOUT SCIENTIFIC MISSIONS ?

Scientific vulgarization has plain informational and entertaining functions. But relations between science and public became complex during the last twenty years. From the « *public understanding of science* » paradigm, we switched to the « *public engagement with science* ».

Indeed, in a constantly changing world, lead by scientific innovations, it is very important not only to understand what new stakes we are facing, but also to interact with scientists. Under the enlightenment of climate change problems, this topic become obvious. Having a journalist on board allow us to reach this double objective.

What's more, lay public may be overwhelmed by a constant flow of information. This kind of approach can help to trace back reliable knowledge to its source.

7.2 WHAT WAS SPECIFIC ABOUT BONUS-GOODHOPE CRUISE ?

Earth system sciences are at the heart of very topical problems such as, we said it, climate change. Now, Southern Ocean is a key to understand how climate regulates itself. There is so little data about this area that any new one could be of a high importance.

Furthermore, many specialists from a lot of different fields were sharing their knowledge. From a journalistic point of view, it has been a prolific experience.

In this case, it has been possible to « see under the dress of science », watching how tomorrows scientific truth is made today.

7.3 HOW TO DO IT ?

M. Pasquero organized his work on three main pillars.

- almost half of his working time has been spent on writing a diary, aiming at vulgarizing the objectives and progress of the cruise. Thus a blog has been fed every four days (www.ipev.fr/pages/bonus/AccueilBonusGoodhope).
- he documented with videos and photos the science and life onboard. This in view of :
 - feeding the blog, along with the diary
 - the use of the scientists themselves
 - to collect material for an itinenerary exhibition that will be opened during Brest 2008 for which the editing is already in progress.
- M. Pasquero answered questions sent by French scholars.

8 ASSESSMENT OF OPERATIONS AND CRUISE ISSUES

The cruise has been a very important success in terms of the number of collected data, their quality and diversity. This has been made possible thanks to the scientists on board, the IPEV personnel, as well as to the vessel captain Pierre Courtes and each member of the crew. The ship was very seaworthy, and this made possible working in rather bad weather conditions. Also, we have been very lucky in terms of meteorological conditions. We only lost 12 hours of operations..

Despite the success in collecting most of the data we originally planned, we encountered some problems of different origin and nature.

As described in section 3.2.3, the initial share of “useful ship time” between the various activities (physics and biogeochemistry) and station types (HYDRO, LARGE, SUPER) was modified in a pre-cruise meeting in January 2008. This was made necessary after a wish of the biogeochemistry party to increase the ship time allotted to the SUPER stations and to undertake intercalibrations and a special “margin” station. A very tight compromise was reached during this meeting, with a pre-cruise scientific programme amounting to 38.5 days, for 38 available days. With this reorganized programme, no extra time was left for bad weather or technical problems.

Unfortunately, the question of the available ship-time for all the operations was set as soon as the ship arrived in Cape Town (on February the 7th). We were supposed to leave the harbour and start operations on Saturday, February the 9th, in the evening. Once on board the ship, however, we were informed that the French containers that had been shipped by IPEV on December 2007 were in Cape Town, but were missing the accompanying documents needed to pass customs. This problem caused an initial delay of 3.7 days..

A second major problem was the strange missing of the ultra-clean winch, Kevlar cable, and related pulleys that were borrowed from NIOZ-Netherlands for trace metal work. This equipment was sent to La Réunion and should have been loaded on board the *R/V Marion Dufresne* early January 2008 for transport to Cape Town. The whole equipment was left in La Réunion and the missing was only discovered on late Friday evening (February the 8th). To overcome this oversight, the IPEV organized an “emergency solution” to the problem, by requesting that the Kevlar cable and pulleys be unmounted and urgently send to Cape Town via Air-Cargo transport. Because of the delay in the complete operation, we decided to leave Cape Town on February 13th. We started our operations with the HYDRO casts only, since the trace metal work planned at LARGE stations needed the use of such ultra-clean cable for GO-FLO sampling. We returned to Cape Town waters on February 15, to collect the Kevlar cable and pulleys. The time-cost incurred by the whole of this problem was 20 hours. Also, this mishap rendered impossible the sampling of the “Margin station” on the West-African continental slope.

In terms of on board equipment needed to operate the embarked instruments, we had some problems that translated essentially in additional time-delay. First of all, the rosette winch had many troubles in working properly, especially for depths deeper than 2000 m. This is probably due to the fact that both winches (indeed, the *Marion Dufresne* has two winches, located side by side, to deploy the CTD-rosette) have not been used often in the past five years. The very frequent deployment of the CTD-rosette, with its weight approaching one ton, very rapidly worn-out both winches. Because of this the diving speed of the rosette had to be significantly decreased below the usual deployment speed (1 m s^{-1} , recommended to prevent water turbulence pollution of the sampled water). Due to this problem, hydro casts often took a longer time than originally planned, with a total time loss for the 111 rosette-CTD casts

amounting to 15 hours. Moreover, the poor working order of those winches almost resulted in the loss of the CTD-rosette as at one station in the first third of the cruise control of the instrument's dive proved impossible. The emergency devices to stop the fall of the rosette were not working properly either, the instrument heavily touched the sea floor. Luckily, everything worked properly once the rosette was recovered on board.

During the last part of the transect (along the Greenwich Meridian) we encountered two additional problems. One of the two electrical engines of the ship broke down. Engine officers and crew worked very hard for almost 48 hours to solve the problem and allowing the scientific work to be completed. In addition, in this same region at the Polar Front and southward we encountered many icebergs, For security issues (presence of growlers, invisible on radar screen) the ship had to slow down between stations and during the first part of the transit to Durban,. This caused a slight additional delay in time.

We left Cape-Town with a set of 12 in-situ pumps (PIS). During deployments on average only 10 out of 12 operated properly limiting the sampling.

The Oktopus corer has been deployed eight times, but only at the first SUPER station has sediment sampling been successful. On the very last station led a further two small sediment cores samples were recovered. During the six other deployments, sea-conditions and abyssal depth (very likely), prevented a correct functioning of the instrument. Indeed, the only successful coring happened in very calm sea conditions. This problem needs to be investigated carefully for future deployments.

We deployed a total of 17 PROVOR profiling ARGO floats. 13 floats were deployed during the hydrographic transect, four during the transit to Durban. All 17 floats have been deployed in the ACC region. Because the instruments are relatively fragile (especially the transmitting Argos antenna and the CTD captors), their deployment needs to be performed with great care. Because of strong currents and wind, one of the 17 floats happened to be taken in the shear turbulence of the ship and dived under the ship stern. Although the float did surface again after a while, it never emitted a signal to the receiving stations and data centres.

We left Cape Town with three L-ADCP. Two of them were mounted on the CTD-rosette (owned by LPO), and one (owned by IRD) was kept as a spare. One of the two LPO-LADCP ceased to work at the first hydro cast. We replaced it at station 3 with the IRD-LADCP that worked well throughout the cruise and successfully measured 106 of the 110 casts!

We left Cape Town with the *R/V Marion Dufresne* RDI 75 kHz VM-ADCP not working correctly (and essentially unusable), this despite the frequent request of tests to be performed on the instrument and software since October 2007. Once we left Cape Town, we ourselves tried to work on the tests with the help of Martin Millet of IPEV. After changing the parameterization and configuration of the instrument, the quality of the collected data was very satisfactory, if not excellent (of course, with a reaching depth depending on the sea conditions). We hope that the IPEV personnel in charge of this instrument will maintain the configuration we optimised, in order for the oceanographic community to get precious upper-water velocity data wherever in the ocean the ship sails.

On the *R/V Marion Dufresne* the space dedicated to laboratory work is very significant and very comfortable. Nonetheless, the large size of the CTD-rosette frame and the cramped space of the gangway make the work around the rosette difficult. This is a point that could be improved the day this ship will be replaced by a new one.

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