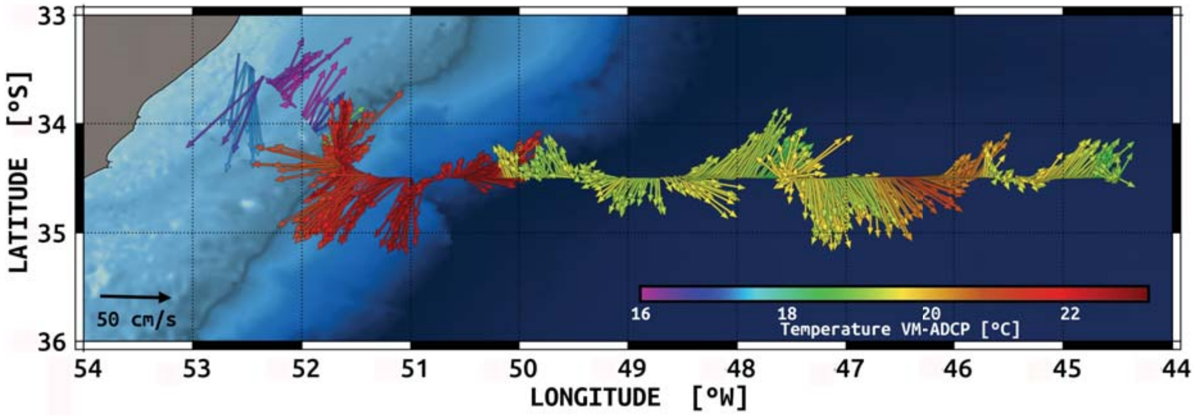
Cruise Report

SAM18/SAMBAR-A2 – *N/Oc. Alpha-Crucis*

Interannual Variability of the Meridional Transports across the



SAMOC Basin-wide Array (SAMBAR)
(FAPESP – Grant 2017/09659-6)

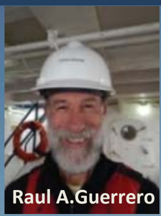
June 17th – July 2nd 2019

SAM/18 SAMBAR A2 CRUISE

western end of the SAMBA line

SAM 18/ SAMBAR_A2


Elisabete S. Braga


Raul A.Guerrero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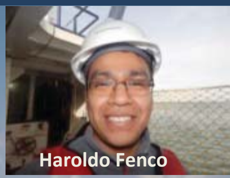
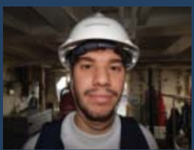

Haroldo Fenco


Marcela Charo

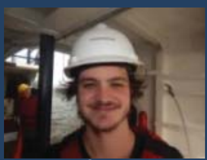

Olga T. Sato

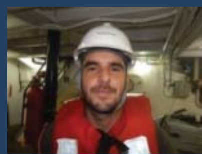

Ana Beatriz L. Cavalcante

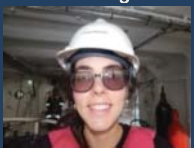

Thamyris C. Rocha

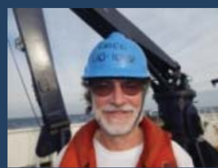

Henrique José R. Dias


Maurício M. Rocha

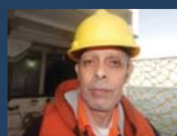

Bruno C. Pegoraro

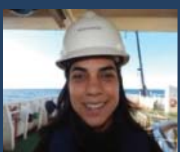

Felipe F. Pinho


Ra[za L. B. Andrade


Francisco L. Vicentini Neto


Mariah C. Borges


Wilson N. Oliveira

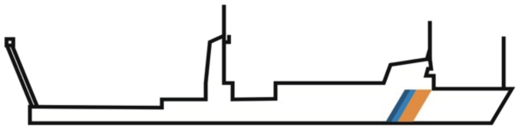

Julia F. A.   Monteiro


Henrique R. Miguel


Foto: E. S. Braga

N/Oc. Alpha Crucis-IOUSP

17th June to 1st July 2019



N/Oc. Alpha-Crucis

Technical Summary

Research Vessel: *N/Oc. Alpha-Crucis*
Ship's Captain: Helvécio de M. Rezende

Departing date: 17th June 2019 - Return to Port: 2nd July 2019

Thematic Project: Interannual Variability of the Meridional Transports across the SAMOC Basin-wide Array (SAMBAR) – FAPESP Grant No. 201709659-6

Main Research Objective: To deploy a new C-PIES, to service previously moored instruments and collect physical and biogeochemical data, to study the variability of the South Atlantic Meridional Overturning Circulation (SAMOC) and the impacts on climate from regional to global scales.

Project's Principal Investigator (PI): Prof. Dr. Edmo J. D. Campos

On board:

Chief Scientist: Prof. Dr. Elisabete S. Braga (IOUSP-Brazil)

Team Leaders: Prof Dr. Olga T. Sato (IOUSP-Brazil)
Dr. Raul Guerrero (UNMDP- Argentina)
Dr. Marcela Charo (SHN- Argentina)

Other Participants:

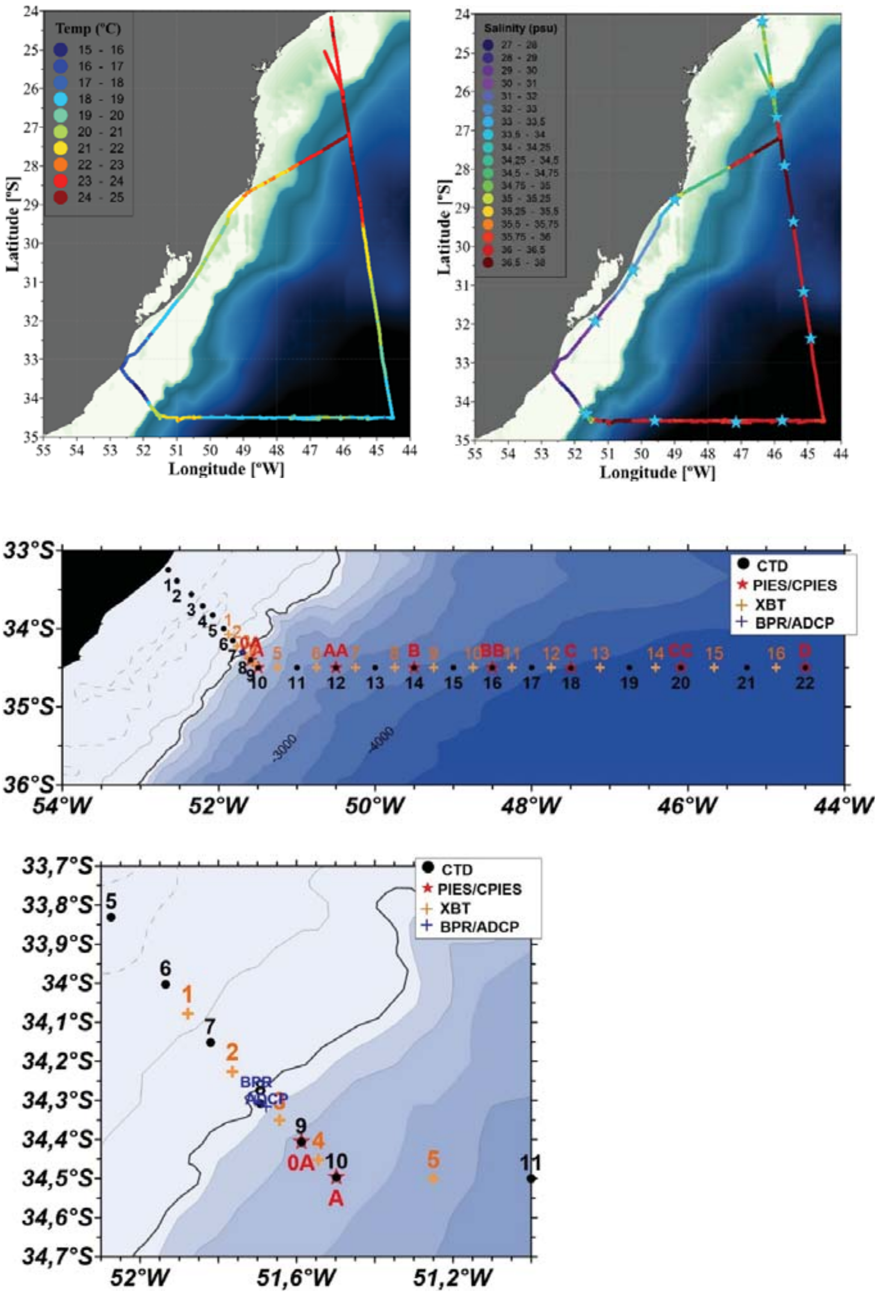
Harold Fenco	INIDP/Argentina
Thamirys Cavaton Rocha (*)	IOUSP/BR
Francisco L. Vicentini Netto	IOUSP/BR
Wilson Natal de Oliveira	IOUSP/BR
Henrique Reis Miguel	IOUSP/BR
Diego Pablo Ugaz	NOAA/USA
Ana Beatriz Leite Cavalcante (*)	IOUSP/BR
Henrique José Rodrigues Dias (**)	IOUSP/BR
Bruno Coimbra Pegoraro (**)	IOUSP/BR
Raíza Lopes Borges (*)	UFBA/BR
Júlia Figueiredo A. Monteiro (**)	UFRJ/BR
Mariah de Carvalho Borges	FURG/BR
Felipe Furtado Pinho (*)	FURG/BR
Maurício Rebouças Rocha (*)	FURG/BR.

(*) Graduate student – (**) Undergrad. student

Participants: 18 Scientists, from Brazil, Argentina and the United States, and 19 crew members (represented in part).

Cruise Track and Study Area

The cruise was carried out along the western end of the SAMOC Basin-wide Array (SAMBA), on the latitude 34.5° S, from the coast to 44.5°W. The nominal location of the of the stations in original plan is indicated in orange. The renamed stations are in black.



Cruise track from port call to study area with TSG observations (sea surface temperature and salinity) (top figures). The nominal location of the hydrographic stations (black), PIES/CPIES (red) and BPR/ADCP (blue) in original plan are indicated on middle and bottom figures.

SAM18/SAMBAR_A2 Cruise – 17th June – 2nd July 2019

Ship's Captain: José Helvécio M. de Rezende
Chief Scientist: Elisabete S. Braga

Scientific Summary

The South Atlantic Meridional Overturning Circulation (**SAMOC**) is a scientific program originated from discussions held during the SACOS Workshop, in Angra dos Reis, Brazil, in February 2003. It is a synergistic international cooperation among institutions from Brazil, Argentina, South Africa, the USA, France, the UK, Germany and other European countries. SAMOC was officially created in 2007, during the SAMOC-1 Workshop in Buenos Aires, Argentina and is currently endorsed by **CLIVAR**. The field activities started in 2009, on board the Brazilian Navy Ship Cruzeiro do Sul. That cruise was part of Project **SAM**, led by the U.S. National Oceanic and Atmospheric Administration (NOAA), in cooperation with institutions in Argentina and Brazil. Since then, the Brazilian contribution, a component of the GOOS-Brazil Program, has been enhanced with the support of the São Paulo State funding foundation (FAPESP) through Projects **SAMOC-BR (grant 2011/50552-4)** and **SAMBAR (grant 2017/09659-6)**. Additional support in Brazil are provided by the Brazilian Council for Scientific Research (CNPq), the Brazilian Navy and the Secretary of the Inter-ministerial Commission for Ocean Resources. Additional information on SAMOC are available in the site: www.aoml.noaa.gov/phod/SAMOC_international.

Project SAMBAR aims at a better understanding of the interannual variability of the heat content and meridional transports across the SAMOC Basin-wide Array (SAMBA) and the impacts on the South Atlantic Circulation, on the Regional Climate and on the MOC stability. SAMBAR will maintain and enhance the existing observing array with the deployment of new instruments and the conduction of oceanographic cruises. This document describes the activities carried out onboard the University of São Paulo's oceanographic ship *N/Oc. Alpha Crucis*, as the 18th cruise of the SAM Project and the **second SAMBAR type A** cruises.

The oceanographic campaign in the South Atlantic Ocean covered a transect extending along the latitude 34.5° S from near the South American coast to the longitude 44° 30' W, a section usually referred as the western end of the SAMOC Basin-wide Array (SAMBA). During the cruise, from June 17th to July 2nd, full-depth, GO-Ship quality CTD stations were occupied, with the sampling of physical and biogeochemical properties in the entire water column. It was also conducted the telemetry of data from inverted eco-sounders and the recovery, reconditioning and redeployment of instruments moored on the sea floor. Additionally, a number of expendable bathy-thermograph (XBT) probes were launched along the 34.5° S transect.

Eighteen scientists participated in the cruise: nine from the Oceanographic Institute of the University of São Paulo (USP, Brazil), one from Servício Hidrografia Naval (SHN, Argentina), one from the Instituto de Investigación y Desarrollo Pesquero (INIDEP, Argentina), one from the Universidad Nacional de Mar del Plata (UNMDP, Argentina); one from NOAA's Atlantic Oceanographic and Meteorological Laboratory (AOML, USA); three from the Federal University of Rio Grande (FURG, Brazil); one from the Universidade Estadual do Rio de Janeiro (UERJ, Brazil); one Universidade Federal da Bahia (UFBA, Brazil).

Summary of the Activities During the Cruise

The cruise included the sampling of physical and biogeochemical variables. The PIES/CPIES array was complete for first time in the last three years (PIES A, B, C, and D, CPIES AA, BB, CC). A new CPIES (0A) was installed west of PIES A, at 875 m. Twenty-one full-depth CTD stations were performed. Water samples were collected in 18 rosette stations for regular biogeochemical analyses (dissolved oxygen, nutrients, pH and alkalinity-1) and, at some specific depths, for REE, alkalinity-2 and CID. Due to the proximity to a storm front source zone, the weather was constantly monitored. The cruise was performed in condition to put rosette in water, except in three stations, where only the CTD was used.

Joint CTD – telemetry operation was performed with success in some stations, using only the CTD (no rosette). was also tried it in different wind/wave conditions. This procedure could represent a good economy of time in the next cruises.

The LADCP with only 3 beams worked well. A comparison of the LADCP currents with the ADCP installed in the ship showed very similar results. The moored ADCP was recovered and after the maintenance, it was redeployed. After some efforts, moored BPR was not retrieved.

Salinity measurements with Autosal were performed on onboard and minor drifts and some uncertainties were observed. Replicate samples were transported to São Paulo for double checking.

Samples of dissolved oxygen were sampled by the same person at all the stations, to minimize the sampler error. These samples were processed by Winkler method. The measures onboard will be used to validate the OD-CTD measurements. The pH measurements performed on board presented a little problem of calibration. Concentrations of pCO2 were constantly measured along the cruise. The suspended particulate matter and the chlorophyll water samples were filtered on board, the filtered water was preserved for nutrient analyses in São Paulo. The Alkalinity was sampled by two researcher groups and the CID was preserved to posterior analyses. The water for the REE analyses was filtered on board and a big volume was reserved for posterior at UFBA.

Table I presents a summary of all stations occupied during the present SAMBAR-A2 (SAM18) cruise in a chronological order. For illustration, plots are shown with preliminary results from the data collected by the CTD (Fig. 1) and the Rosette bottles (Fig. 2).

Table I. Summary of all stations executed during the SAMBAR 2019 cruise.

Station #	Date (GMT)	Time (GMT)	Latitude (°)	Longitude (°)	Prof. (m)	References
Santos	17-Jun-19	13:30	-23.9667	-46.3000		Puerto de Santos
T0	17-Jun-19	17:04	-24.1356	-46.4064	22	CTD Film Test
T1	18-Jun-19	16:27	-27.1737	-45.8262	1991	CTD Test
1	21-Jun-19	15:26	-33.2501	-52.6477	15	CTD 1 Albardao
2	21-Jun-19	17:16	-33.3902	-52.5404	15	CTD2
3	21-Jun-19	19:27	-33.5631	-52.3484	27	CTD3
4	21-Jun-19	21:17	-33.7095	-52.2009	70	CTD4, Pozo de Fango
5	21-Jun-19	22:52	-33.8329	-52.0773	46	CTD5
6	22-Jun-19	00:55	-34.0037	-51.9335	69	CTD6
X1	22-Jun-19	02:00	-34.0817	-51.8740	90	XBT1, DB S/N 01173306, México
7	22-Jun-19	02:46	-34.1533	-51.8204	126	CTD7
X2	22-Jun-19	03:50	-34.2251	-51.7631	144	XBT2, DB S/N 01173302, México
X3	22-Jun-19	05:02	-34.3500	-51.6430	671	XBT3, DB S/N 00383864, USA
	22-Jun-19	07:17	-34.4044	-51.5901	875	Mooring CPIES 0A S/N 291
	22-Jun-19	13:12	-34.3129	-51.6743		Recovery ADCP
8	22-Jun-19	14:20	-34.3123	-51.6756	389	CTD 8 near ADCP site
	22-Jun-19	23:47	-34.5077	-51.4983		Recovery PIES A S/N 221
	23-Jun-19	00:52	-34.4962	-51.4990	1361	Mooring PIES A S/N 187
9	23-Jun-19	01:15	-34.4960	-51.5005	1357	CTD 9 at site PIES A
X4	23-Jun-19	05:22	-34.4528	-51.5425	1470	XBT4, T5 S/N 00383865, USA
10	23-Jun-19	07:24	-34.4089	-51.5860	982	CTD 10 at CPIES 0A site
	23-Jun-19	10:12	-34.3166	-51.6775	390	Mooring ADCP
X5	23-Jun-19	13:21	-34.5007	-51.2493	1918	XBT5, T5 S/N 00383861, USA
11	23-Jun-19	15:11	-34.5040	-50.9940	2558	CTD 11
X6	23-Jun-19	19:26	-34.5001	-50.7473	3474	XBT6, T5 S/N 00383869, USA
12	23-Jun-19	21:08	-34.4960	-50.4978	2992	CTD12 at CPIES AA site
	24-Jun-19	00:25	-34.5032	-50.4840	2780	Recovery CPIES AA, S/N190
	24-Jun-19	02:59	-34.4985	-50.4987	2876	Mooring CPIES AA, S/N 409
X7	24-Jun-19	06:44	-34.5001	-50.2352		XBT7, T5 S/N 00383862, USA
13	24-Jun-19	08:47	-34.4983	-49.9942		CTD 13
X8	24-Jun-19	12:36	-34.4998	-49.7522	3121	XBT8, T5 S/N 00383865, USA
14	24-Jun-19	12:58	-34.4983	-49.5033	3580	CTD 14 at PIES B site and telemetry
X9	24-Jun-19	19:26	-34.5000	-49.2492	3860	XBT9, T5, S/N 00383863
15	24-Jun-19	21:10	-34.5007	-48.9996	3980	CTD 15
X10	25-Jun-19	02:01	-34.5007	-48.7503	4065	XBT 10, T5 S/N 00383871, USA
	25-Jun-19	11:36	-34.4985	-48.4946		Recovery CPIES BB, S/N 289
	25-Jun-19	12:16	-34.4991	-48.5008	4200	Mooring CPIES BB, S/N 408
16	25-Jun-19	13:08	-34.5047	-48.4962		CTD16 at CPIES BB site. CTD communication failed at 1857 m
X11	25-Jun-19	17:12	-34.4996	-48.2403	4222	XBT11, T5, S/N 00383870, USA
X12	25-Jun-19	18:43	-34.4997	-47.9995	4185	XBT12, T5 S/N 00383866, USA, at CTD site, bad weather
X13	25-Jun-19	20:16	-34.4968	-47.7467	4219	XBT13, DB S/N 01152142, México
X14	26-Jun-19	06:12	-34.5001	-47.1246	4270	XBT14, DB S/N 01152146, México
17	26-Jun-19	11:27	-34.5076	-46.7666	4545	CTD 17 without rosette
18	26-Jun-19	21:34	-34.5067	-47.4898	4572	CTD18, at PIES C site, without rosette
	27-Jun-19	02:30	-34.4901	-47.4949		Recovery PIES C S/N 280
	27-Jun-19	03:00	-34.5036	-47.4960	4540	Mooring PIES C S/N 222
X15	27-Jun-19	14:14	-34.5002	-46.4161	4690	XBT15, DB S/N 01152150, México
	27-Jun-19	16:05	-34.5000	-46.0911	4730	Mooring CPIES CC S/N 290
19	27-Jun-19	16:19	-34.4998	-46.0899	4733	CTD19 at CPIES CC and telemetry
19_1	27-Jun-19	21:06	-34.4999	-46.0894	4732	CTD 19_1, 2nd cast (Depth=1500m)
X17	28-Jun-19	00:43	-34.5006	-45.6597	4758	XBT 17, DB S/N 01152151, 2nd launching, 1st questionable
20	28-Jun-19	03:27	-34.5004	-45.2496	4758	CTD 20
X18	28-Jun-19	09:38	-34.5012	-44.8728	4760	XBT 18,DB S/N 01152147
21	28-Jun-19	13:56	-34.5031	-44.5054		CTD 21 at PIES D site and telemetry, echosounder setting passive

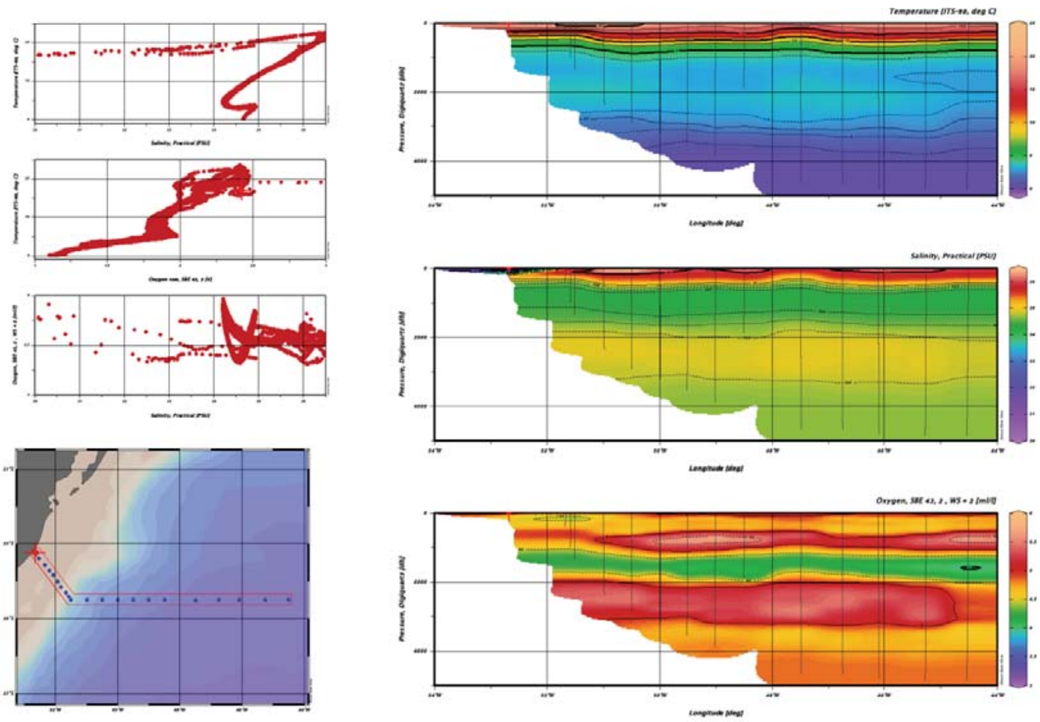


Figure 1. Vertical sections (right) of temperature (top), salinity (middle), and O_2 (bottom) and TS, TO_2, and O_2S diagrams (left) from all data measured by the CTD.

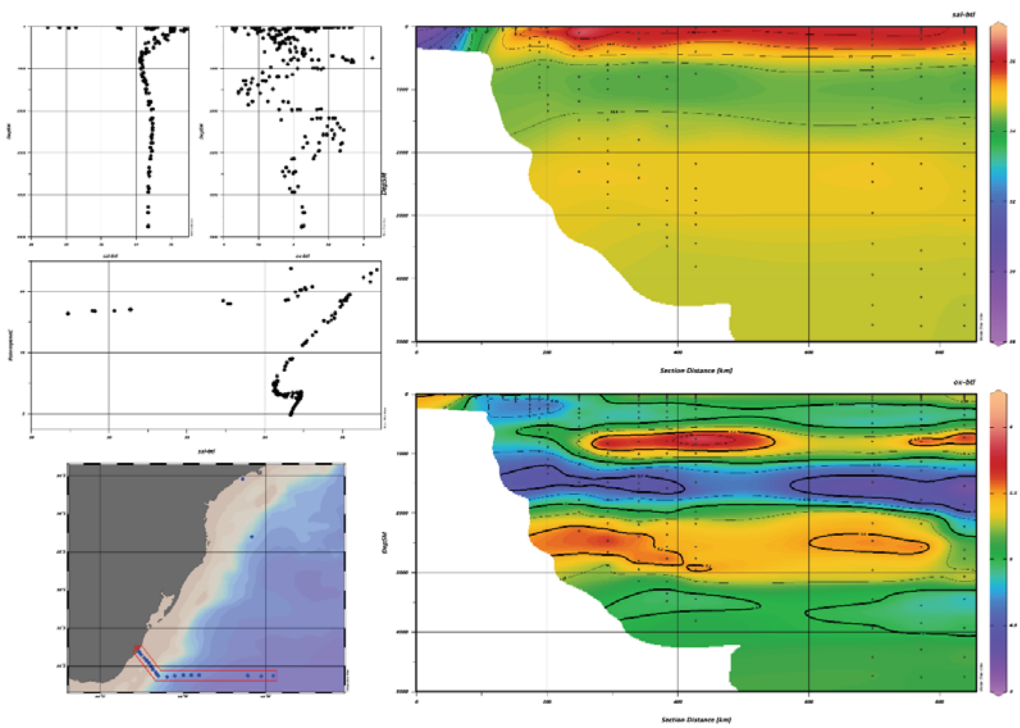


Figure 2. Vertical sections (right) of salinity (top) and O_2 (bottom) and vertical profiles of bottle salinity and bottle oxygen (top-left) and TS diagrams (left-middle) from all data measured onboard from the rosette bottles.

1. Scientific Background

The South Atlantic Ocean connects three major basins: the Pacific, the North Atlantic and the Indian Oceans. The mean meridional circulation of the South Atlantic Ocean involves a deep, southward flow of cold and salty North Atlantic Deep Water along the eastern slope of South America, and a compensating northward flow of a mixture of warm and salty surface waters, and cooler and fresher Antarctic Intermediate Waters, in the interior. Differently from other subtropical basins, this circulation pattern, in which warm waters flow towards the equator and cold water towards the pole, results in an equatorward heat flux. Although this anomalous heat flux was recognized by the middle of the 20th century, its variability and the sources for the upper return flow that makes it possible are still not well understood. Also not well known is the associated meridional net flux of freshwater (or, equivalently, salt) in the South Atlantic.

Observations indicate that a portion of the South Atlantic upper waters are produced locally, but most of the upper waters are thought to originate in the Pacific and Indian oceans. Although the relative contributions of the Pacific and Indian ocean to the South Atlantic upper ocean budget is still controversial, observations indicate that the main gateway for the entrainment of these waters into the subtropical gyre are the boundary regions located at the opposite margins of the basin, i.e., the Brazil/Malvinas Confluence (BMC) and the Agulhas Retroflection Region (ARR). In particular, the western sector of the subtropical South Atlantic presents a complex superposition of different water masses and circulation patterns (Fig. 3) that play a crucial role in the meridional fluxes of heat, salt and other physical and biogeochemical properties[1].

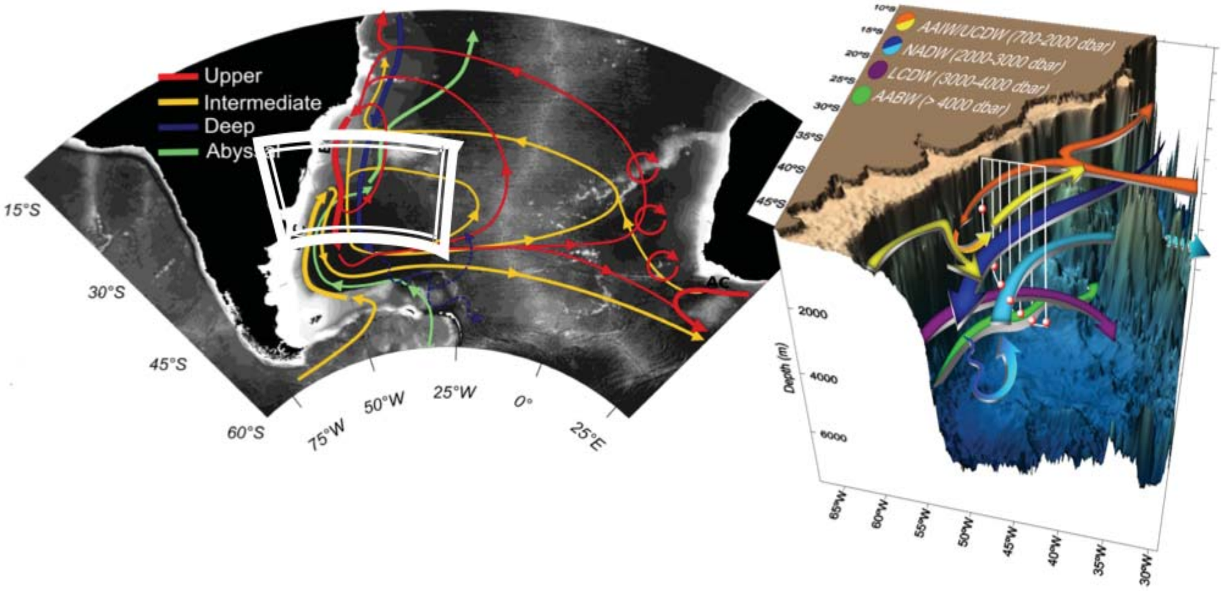


Figure 3. The region of confluence of the Brazil and Malvinas Currents presents a complex system of different water masses and circulation patterns. The better understanding of this region is an objective of SAM and SAMBAR (Valla D. *et al*., 2018).

[1] For more about the South Atlantic refer to the Report on the CLIVAR/OOPC/IAI South Atlantic Climate Observing System (SACOS), available at: http://www.clivar.org/node/355

SAMOC (South Atlantic Meridional Overturning Circulation) is an international program to investigate the meridional transports related with the global thermohaline conveyor belt in the South Atlantic. The western end of the SAMOC Basin-wide Array (SAMBA), along 34.5ºS, started in March 2009, with the deployment of four PIES (Pressure enabled Inverted Eco-Sounders). In December 2012, during the joint SAM08 and the first cruise of the SAMOC-BR Project (FAPESP grant 2011/50552-4), three new PIES equipped with currentmeter (C-PIES) were deployed. In the following years, two other instruments were also installed by the project SAMOC-BR: a bottom-mounted ADCP (Acoustic Doppler Current Profiler) and a pressure gauge, also mounted on the sea floor. At present, the instruments on the western end of SAMBA are shown in Fig. 4, together with the location of the new instruments deployed during the SAM17/SAMBAR-B1 cruise at sites **E** and **F** – C-PIES **0B** was deployed during this cruise.

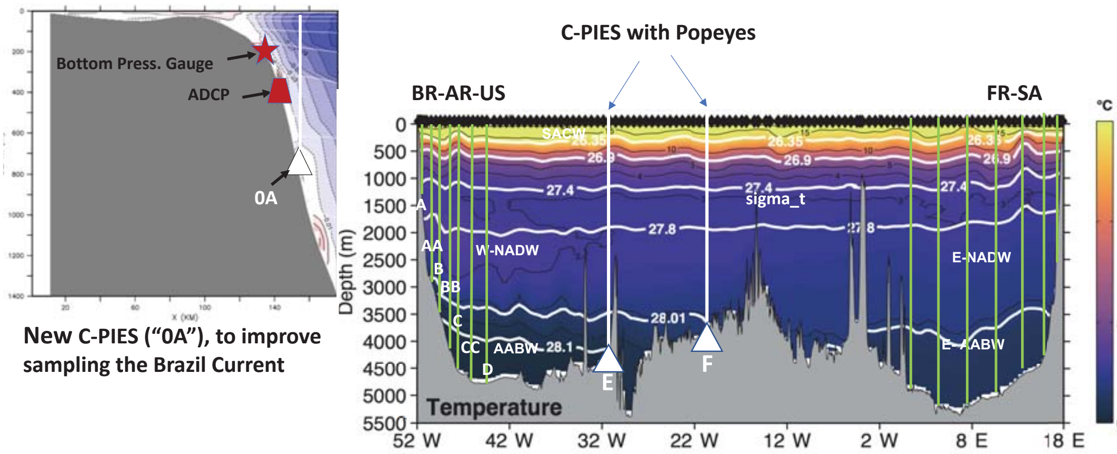


Figure 4. Vertical temperature section along SAMBA (Data from the SAM8/SAMOC-BR1 cruise and the SAMBA/Go-SHIP Cruise on board the *RF Maria Merian*, in January 2017). The location of the bottom mounted SAMBA-west instruments are indicated: a bottom pressure gauge and an ADCP (Brazil) on the shelf-break; the PIES **A, B, C** and **D** (USA) and the C-PIES (Brazil) **0A, AA**, **BB**, **CC, E** and **F**. The C-PIES **OA** was moored during the present cruise.

2. Cruise Preparation

The expedition was designed to revisit the hydrographical stations, to launch XBTs, to install the C-PIES **OA** and to recuperate and redeploy instruments and/or to do telemetry of data. Instruments that would present sign of possible malfunction during the telemetry would be recovered, serviced and redeployed. For the necessary services, several components were brought onboard, such as upgrade kits for the C-PIES; lithium batteries; spare sensors; standard IAPSO water; and several small parts and electronic components. Due to the loss of the LABMON's CTD-Rosette system during a previous cruise, a concentrated effort was carried out to purchase the required replacement. This was accomplished with additional funds provided by FAPESP and the logistical support of the Astronomical, Geophysical and Atmospheric Science Institute (IAG).

2.1 – Actions prior to the Ship's Departure

As usual, during the weeks prior to the cruise's starting date, a series of urgent and mandatory services and the acquisition of consumables, food supplies, and permanent materials for the *N/Oc. Alpha-Crucis* was required. In order to have the ship able and safe to navigate, the maintenance of one lateral motor had to be performed. The cost of this service was entirely covered with funds from the SAMBAR project's Technical Reserve.

As indicated in the project's proposal, the fuel was entirely provided by the Secretariat for the Inter-ministerial Commission for Sea Resources (SeCIRM), in the total of 100.000 liters of diesel oil, with a nominal price of R$3.99 per liter, or the equivalent to R$ 399.000,00. All the needed services, equipment and consumables, listed in Table II, were also paid directly with funds from SAMBAR's budget tagged as "ship-days cost" (Third Part Services), "Consumables" or "Technical Reserve".

All the expenses covered with funds provided by the SAMBAR budget are listed in Table.

On June 16th, everything was ready, with all the equipment and scientific personnel onboard. The ship departed from the Port of Santos on June 16th, at 11 am (GMT-3)[2].

2.2 – A major problem detected still on land

Since the Alpha Crucis lacks a more efficient system of communication, the FBB radio system (used in amateur radio communication) was restored to continue working with satellite link, with the use of pre-paid units of credit. This is crucial to assure reliable communication with land, beyond emergency calls. The costs of the radio refurbishing and a total R$ 6.000,00 in credits were paid with SAMBAR's funds. That number of credits would be enough only for very limited communication during the 15 days of the cruise (Table I). For this reason, additional credits were bought for an Iridium Satellite telephone, that was previously purchased by the SAMBAR project and is being of invaluable help while USP does not solve this problem for good, with the installation of an appropriate telecommunication system.

Table I. Discrimination of the expenses related to the cruise. The nominal value of the fuel is included to show the effective total cost. FAPESP granted the value of R$ 8,000.00 per "ship day". The amount of R$120,000.00 from these funds were used to pay part of the cruise's overall expenses. The difference to support the research was covered with funds from other items of the project's budget: "Technical Reserve", "Third Person Services" and "Consumables".

Table II: Cruise's Expenses

Total cost of the Cruise		
Description	**Budget item**	**R$**
Air and bus tickets for Brazilian participants from other states/abroad	Tech. Reserve	14,374.39
Perdiem for Braz. participants from other states or exterior	Tech. Reserve	7,148.60
Repair of the ship's lateral motor (Alpha Crucis)	3rd Part Services	59,270.00
Consumables and small parts / Oceanographic Instrument. Lab (LIO)	Consumables	6,960.07
Service winch (Alpha Crucis)	Tech. Reserve	9,979.00
Expenses with transport mat. chemistry (FURG/UERG/UFBA)	3rd Part Service	5,047.91
Repair of IOUSP's truck (transport of mat. From/to Santos)	3rd P. Services	1,900.00
Expenses with calendaring required for mooring of instruments	3rd P. Services	5,590.00
Expenses with inpection of Alpha Crucis Lifeboat	3rd P. Services	9,500.00
Expenses with material for Nutrient/Chemical Analysis	3rd P. Services	11,970.00

[2] Here and throughout the document, the time is GMT minus 3.

(LABNUT)		
Lubricant oil (SAKAMOTO)	3rd Part Services	9,688.19
Food Supplies	3rd P. Services	19,709.98
Payment Specialist services during cruise (R. Guerrero)	3rd P. Services	3,500.00
Total paid with funds granted by FAPESP		**164,638.14**
100,000 liters of diesel provided by SeCIRM – R$ 3.99 liter		**399,000.00**
Total Cost (including fuel)		**563,6389.14**

2.3 – Setting up the oceanographic equipment

On June, Sunday 16 at 17h00 pm, the scientific team arrived on board Alpha Crucis at the port of Santos. The CTD package needed to be assembled. The CTD frame had only the carrousel pylon. The CTD fish (in its box) was assembled with dual TC sensors (primary and secondary) in a horizontal setting. Oxygen sensors were also installed in the plumbing line. There were 24 brand OTE (Ocean Test Equipment) bottles in their original boxes to be installed in the rosette frame. These bottles arrived without the nylon lines that hold the caps and connect to the triggering system on the pylon. These bottles came equipped with outer metal springs for cap closing and maintain tension for water collection. This design diminishes the contamination on the water collected when compared with those bottles with internal rubber or coated spring. The installation of these bottles was a difficult task as they were wider at the spring holder and made it extremely tied fitting on the carrousel. Bottle # 24 was not installed, as the tininess took all the clearance. Right after coming on board, the nylon lines to fit our carrousel were prepared. This task took few hours and many hands (Fig. 5). The assemblage and electrical connection of the package followed: CTD, pylon and altimeter, weights, LADCP, bottles, electro-mechanical (EM) cable and security cable. The EM cable was mechanically and electrically terminated.

On June 17th, with all the equipment and scientific personnel onboard, the ship departed from the Port of Santos, as scheduled, at 10h30 (GMT-3)[3].

[3] Here and throughout the document, the time is GMT minus 3.

Figure 5. OTE Niskin bottles with outer spring (top and middle). Assembling of nylon lines for all 24 bottles (top-Left). Clearance taken by the nylon guides (middle-middle). Notch made on the guide to maintain the upper cap line from tangle between bottles, when cooked (middle-right). 23 bottles installed in the Rosette (bottom-right).

3. The Cruise Plan, the Effective Track, Participants and Equipment

According to the project's proposal approved by FAPESP, this **2[st] cruise of "Type A"** (SAMBAR_A2) was designed to carry out, on the waypoints indicated in Fig. 6, the following activities:

- To retrieve, recondition and re-launch some of the already in place PIES/C-PIES, one acoustic Doppler current profiler (ADCP) and a bottom mounted pressure recorder (BPR);
- To perform acoustic telemetry to retrieve data from some of the PIES/C-PIES
- To carry out a GO-Ship-quality hydrographic section with a rosette equipped with twenty-three 5-liters Niskin bottles and a CTD with double sensors for Conductivity, Temperature, Pressure and Oxygen, one sensor for Fluorescence, and the launching of XBT probes in between the CTD stations.
- To conduct a vertical section of velocity with a lowered ADCP mounted on the rosette;
- To sample and analyze biogeochemical properties of the water column, such as Dissolved Oxygen concentration, nutrients, dissolved CO_2, pH, alkalinity , REE (Rare Earth Elements), nutrients (Nitrate, Nitrite, Phosphate, Silicate and N-ammonium), Chlorophlyll-a and Suspended Particulate Material, using the information and material collected by the sensors and the Niskin bottles;
- To collect continuously, with instruments mounted in the ship, the near surface velocity, air and sea-surface temperature, wind speed and direction, and the concentration of O_2 in the atmospheric boundary layer.

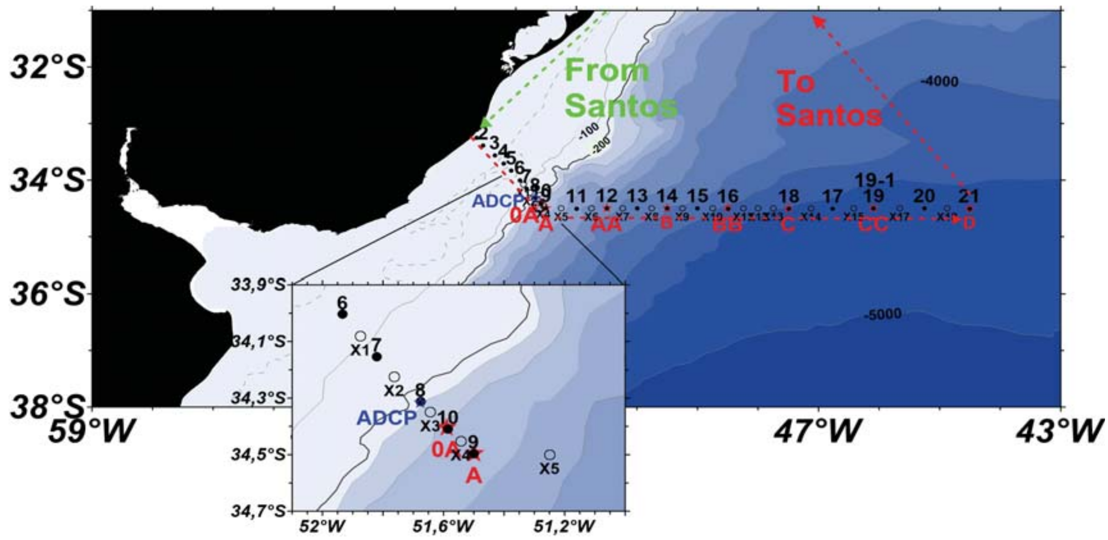


Figure 6. Map of the stations realized during the cruise, indicating the actual tracks followed by the ship. Solid black dots indicate CTD positions. Red start indicates positions of C-PIES and PIES. 18 XBT probes were launched at points in between pairs of adjacent CTD stations (open circles). Positions of the ADCP and PIES moorings at the shelf break are shown in the inset.

3.1 Cruise track

In the original plan, the ship would go directly to the easternmost station (site "D"). However, due to the foreseen weather conditions, a decision was made to first go to the westernmost point, the one nearest to the continent, as indicated in Fig. 6, from where the stations started to be carried out.

3.2 Participants

There were 18 scientists onboard, from Brazil, Argentina, and the United States of America, as listed in Table III. All of the participants were either project's Associate Researchers or students and/or technicians representing them. Travel expenses for the participants from other states or countries were covered funds from SAMBAR. This included air-travel, expenses with ground transportation, meals and eventual accommodation when not onboard, for all participants from outside São Paulo. It is important to highlight that all these expenses are insignificant when compared with the quality and the amount of work carried out by the scientists, technician and students on board. The groups were divided in two shifts of 12 hours each during the realization of the onboard activities.

Table III – Participants in the SAMBAR_A2 Cruise, June-July-2019.

No.	Name	Institution/Country	Activity on board
1	Elisabete S. Braga	IOUSP/BR	Chief Scientist/Biogeochemistry
2	Olga Tiemi Sato	IOUSP/ BR	CTD/LADCP/XBT
3	Raul Alfredo Guerrero	UMDP/Argentina	CTD/LADCP/autosal/LADCP
4	Marcela Charo	SHN/Argentina	CTD/l/XBT/LADCP
5	Harold Fenco	INEDP/Argentina	CTD/LADCP/XBT
6	Thamirys Cavaton Rocha (*)	IOUSP/BR	CTD/LADCP/XBT
7	Francisco L. Vicentini Netto	IOUSP/BR	C-PIES/ADCP/BPR
8	Wilson Natal de Oliveira	IOUSP/BR	C-PIES/ADCP/BPR
9	Henrique Reis Miguel	IOUSP/BR	C-PIES/ADCP/BPR
10	Diego Pablo Ugaz	NOAA/USA	Acoustic telemetry
11	Ana Beatriz Leite Cavalcante (*)	IOUSP/BR	Chemistry/Nutrients/O2
12	Henrique José Rodrigues Dias (**)	IOUSP/BR	Chemistry/Nutrients/O2
13	Bruno Coimbra Pegoraro (**)	IOUSP/BR	Chemistry/Nutrients/O2
14	Raíza Lopes Borges (*)	UFBA/BR	Chemistry/REE
15	Júlia Figueiredo A. Monteiro (**)	UFRJ/BR	Chemistry/Alkanility/CO2
16	Mariah de Carvalho Borges	FURG/BR	Chemistry/Alkaliniy
17	Felipe Furtado Pinho (*)	FURG/BR	CTD/LADCP/Autosal
18	Maurício Rebouças Rocha (*)	FURG/BR.	CTD/LADCP/Autosal

(*) Graduate student – (**) Undergrad. student

3.3 Description of the Equipment

A list of the main instrumental and equipment used to carry out the different activities is given in Table IV. Table V presents technical information and Figures 7 and 8 show visual details of some of the core instruments.

Table IV. Equipment used in the SAMBAR_A2 – NOc. Alpha Crucis – June 2019.

Equipment	Owner	Purpose
Rosette equipped with CTD Sea-Bird 911Plus, with dual sensors for Conductivity, Temperature, Depth, O2 and Fluorescence, and 23 Niskin bottles of 5 liters. Equipment improved due to an natural storm in the last Cruise type A	IOUSP	Continuous sampling of C, T, D, O2 and Fluorescence (an indicator for chlorophyll) in the water column and sampling of water for biogeochemical analyses.
Salinometer Autosal Guildline 8400-B	IOUSP	Onboard analyses of salinity of the water samples for evaluating the CTD accuracy
4 (four) inverted eco-sounders with Pressure gauge (PIES).	NOAA	Two of the PIES will be used to replace units that showed sign of malfunctioning during the previous SAMOC cruise. Two other to be kept as spare.
Lowered ADCP or LADCP (installed with the CTD in the Rosette)	IOUSP (Dr I.Silveira)	Used to carry out a continuous vertical profile of velocity, using an acoustic Doppler current profiler
Benthos acoustic system's deck units and hydrophones	IOUSP	Telemetry of data stored in the moored PIES/C-PIES and for acoustic release of units that to be replaced.
Vacuum pump GAST	IOUSP	Removal of air from the interior of the PIES/C-PIES, after recovery, service and battery replacement.
XBT launcher & probes	IOUSP	Deployment of XBTs
Titrand Metrohm model 907	IOUSP	Oxygen analyzer
Glass filtration system with vacuum pump Millipore	IOUSP	Used to determine chlorophyll and suspended particulate material.
Ultrafreezer and freezers	IOUSP Ship	To preserve samples for analyses (-80ºC/-20ºC)
pH-meter	UERJ	Analysis of the water samples pH
pCO2 analyzer	UERJ	Analysis of the CO2 content
Minor equipment and support material	IOUSP	Tools and supplies to support the different operations

Table V. Technical details of the core instruments.

System	Sensor	Model	SN	Maker
CTD	Pressure		1291	Seabird
	Temperature1	SBE3 plus	03-6133	Seabird
	Condutivity1	SBE 4C	04-4615	Seabird
	Oxygen1	SBE 43	43-3431	Seabird
	Pump 1	SBE 5T		Seabird
	Temperature 2	SBE3 plus	05-8858	Seabird
	Condutivity 2	SBE 4C	03-6411	Seabird
	Oxygen 2	SBE 43	04-4883	Seabird
	Pump 2	SBE 5G		Seabird
	Altimeter	PSA 916D	05-9607	Benthos
TERMOSAL	Temperature	SBE 38	57419	Seabird
	Condutivity/temp	SBE 45	64306	Seabird
ADCP	75 KHz	Surveyor	0369	RDI/Teledyne
ADCP	150 KHz	Surveyor	1867	RDI/Teledyne
LADCP	300 KHz	WorkHorse	13985	RDI/Teledyne
Salinometer		Autosal	71012	Guildline
C-PIES 0A		URI 6.2C	291	Univ. R. Island
C-PIES AA		URI 6.2C	289	Univ. R. Island
C-PIES BB		URI 6.2C	290	Univ. R. Island
C-PIES CC		URI 6.2C	291	Univ. R. Island
XBT probes	Temperature / Depth	Deep Blue		Lockheed Martin
XBT probes	Temperature / Depth	T5		Lockheed Martin
Automatic Titrator	Dissolved Oxygen	Titrand 907		Methrom
Vacuum pump	Water filtration	xxx		Millipore
Peristaltic pump	To Pumping water	Carbinet-style	07533-40	Masterflex L/S 12-VDC
pHmeter	pH measures	Prolab 300		Prolab
Ultra freezer	Preserve the samples	Legaci		REVCO
Freezer	Preserve de samples			Metalfrio
Hot house	Sterilizer material	Sx300		Sterilifer
IRGA	To measure pCO2	EGM4		PP systems

Figure 7. Ilustration of some of the instruments used during the cruise. More details in Tables VI and V .

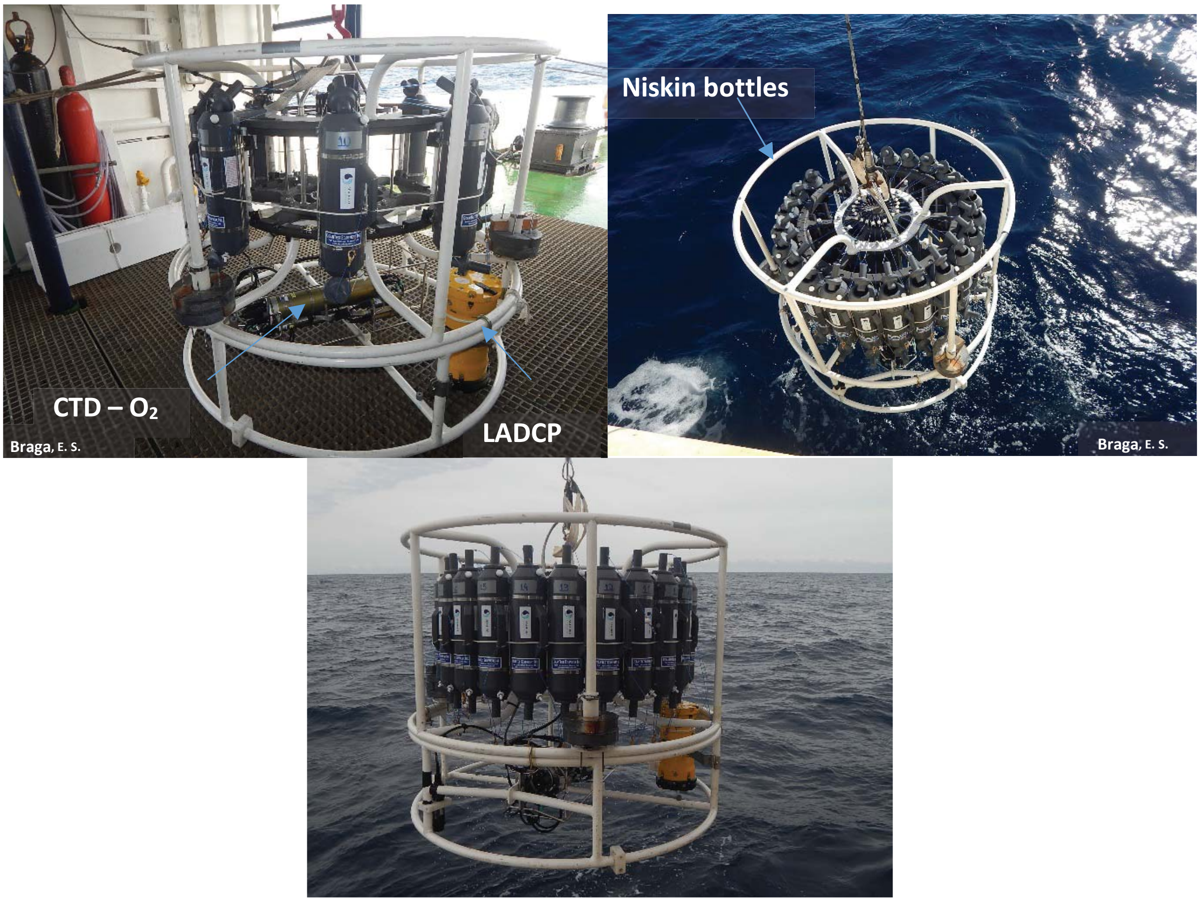


Figure 8. Details of the Rosette system, with mounted CTD & LADCP and 23 five-liter Niskin bottles.

4. Short description of the Daily Activities

Here follows a brief description of our daily activities related to the development of the mission. Just for this report, the time adopted is the local time which during the whole cruise was the Brasília time. As a standard, in all other forms and log sheets, it was adopted the UTC time.

4.1 – June 17: First Test Station and the Filming Scientists and Crew

After boarding, the team received safety and salvage training offered by the commander and crew (Fig.9).

Figure 9. Instructions in salvage and safety offered by captain and crew.

The ship departed from Santos at 10h30, on June17th towards the first waypoint (Shallow Test Point) which was reached after one hour of navigation. During this first day of the cruise, a filming team of four members plus the coordinator (Richard Dantas) were onboard shooting a documentary, which will picture the scientific activities developed at IOUSP (Fig. 10). A series of thirteen short films will be broadcast countrywide by TV Cultura. Project SAMBAR will be the first episode of the TV series. The filming team conducted a series of interviews and snapshots of various members of our scientific group, including the Chief Scientist, the Physical Oceanography Coordinator, the ship's Commanding Officer and the Second in Command Officer. The young undergraduate and graduate student activities and interests have also been one of their focus.

Figure 10. The filming team and the transport to Alpha Delphini at the guests back to land.

To fulfill the filming needs, a shallow depth test station was done to show a real station in action. For this test station the Rosette, fully equipped with Niskin bottles, CTD, LADCP, and the altimeter was deployed. The bottles were closed at 20 m, the local depth. The science group had their first opportunity to experience the routine of data acquisition and water sampling on an actual station. The biogeochemical group took the water samples for the measure of Dissolved Oxygen, to set the accuracy of the method. Soon after the test, all members of the filming team left the ship on board the B/P Alpha Delphini, which had come specifically to take the guests back to land.

The test-station was very convenient. The bottle tripping showed some problems as all nylon lines were installed in the new bottles the day before. Bottles 5 and 18 returned opened, bottle 22 with the lower cap not sited and nylon line loosed. When preparing the bottles for this station, it was observed that the line that hold the lower cap tend to go in between the bottles and get stocked with the springs. The required fixups were made. To maintain these lines free for a proper release of the lower cap a notch or indentation was made on the top spring guide. The rosette supported only 23 bottles at the place of 24, maybe the new bottles have a little difference in the diameter.

Figure 11. Preparing the rosette and CTD-LADCP to the first test.

4.1.1 – Transit to the SAMBA Line

After the departure of the filming crew, the journey started with the ship sailing towards the SAMBA line. During the transit period, the working teams were defined, each composed by experts and trainees to operate and analyze the data collected by the different instruments onboard. Table VI lists the components of the two groups, which took turns from 12:00 to 24:00 and from 00:00 to 12:00. The Chief Scientist did not follow a defined schedule and the group in charge of the biogeochemical components, in function of the high volume of work and the limited number of personnel was not divided in specific turns. This group was also coordinated by the Chief Scientist. They decided to carry out their tasks in a more dynamical fashion. Also, the specialist from NOAA (Diego Ugaz) and one member from IOUSP (Francisco Vicentini) were available whenever there was an activity related to the PIES/C-PIES.

Table VI. SAM15/SAMBAR_A2 Work Teams.

Scientific Responsible: Elisabete S. Braga	
Team Alpha: 12h00 – 24h00	Team Bravo: 0h00 – 12h00
Olga T. Sato -(Team Leader/CTD/Rosette)	Raul A. Guerrero (Team Leader/CTD-Rosette/Autosal)
Marcela Charo -Console/Data processing)	Thamirys C. Rocha- (CTD Console/SAL/Autosal)
Maurício R. Rocha -(SAL/XBT/CTD)	Felipe F. Pinho -(ADCP/Console)
Wilson Natal Oliveira - (SAL/Autosal/CTD)	Henrique Miguel- (CTD/Rosette/XBT)
Harold Fenco- (ADCP/CTD-Rosette/XBT/TSG)	

Team Biogeochemistry: 0h00-24h00
Elisabete S. Braga- Team Leader /Biogeochemical data
Bruno C. Pegoraro - (Oxygen/Nutrients/Chlorophyll/MPS)
Henrique Dias - (Oxygen/Nutrients/Chlorophyll/MPS)
Ana Beatriz L. Cavalcante (Oxygen/Nutrients/Chlorophyll/MPS)
Mariah C. Borges -(Alkalinity/CT`)
Raíza L. B. Andrade- (REE) and Neodymium Isotope (Nd)
Julia F. A. Monteiro-(pH, alkalinity/CID/Read space)

Team –PIES –CT: in function of the arrival on point
Diego P. Ugaz (PIES)
Francisco L.Vicentini Neto (PIES/CTD/Thermosal)

4.2 - June 18 - The Second Test Station – Deep Station

Decision was made to have a second test-station. That was performed at the the position 27° 10.377 S, 045° 49.550 W, on Jun 18th, 18:54h, with depth of 1960m. This station was used to test the equipment and to train the team for the sequence of data sampling operation in a deeper-water situation. In this test, all bottles arrived at surface closed. The cruise was supposed to sample many biogeochemical variables (dissolved oxygen, nutrients, chlorophyll, Suspended particulate material (SPM), pH, alkalinity and REE). For that, a large volume of water had to be sampled with the 5-liter Niskin bottles. Therefore, it was decided that the surface water should be collected in two bottles. In the test, the Niskin bottles were closed at various depths, from surface to 10 m above the seafloor. Eight bottles were closed at the depth of 1600m to collect 40 L of water for the alkalinity measurements done by FURG and 15 bottles for dissolved oxygen, alkalinity, ammonium, salinity and nutrients, Chlorophyll and SPM measurements. The test-station took 2 hours and 27 minutes to be completed.

In order to organize the water sampling for the different variables, the Physical Oceanography group used a worksheet that determinates the depths where the Niskin should be closed in the water column as a function of the sampled variables (Fig. 12). In each turn, a member of the Physical Oceanography group was responsible to control the Rosette's water sampling to make sure that the correct sequence was followed.

SAMBAR_A2 CTD sampling log CTD Number:............ Alpha Crucis CTD: ……....... Salt crate:.......

JDAY & time in water (UTC): …………………..... Bottom time:………………… Time on deck: …......……

Time sampling done: ………… Lat: ……………… Lon: ……………… Max depth (m): ……...……..

N	Prof	OD	pH	Alc DIC1	Alc DIC2	NH4	Sal	Nut/mes clo	Head	ETR	N	Notes
1											1	
2											2	
3											3	
4											4	
5											5	
6											6	
7											7	
8											8	
9											9	
10											10	
11											11	
12											12	
13											13	
14											14	
15											15	
16											16	
17											17	
18											18	
19											19	
20											20	
21											21	
22											22	
23											23	

Obs:

Figure 12. Model of the worksheet used to control the water sampling in the rosette.

After the test station, the Rosette was lowered again to fill it with water. As the Niskin bottles were brand new, there could be contamination problems with the Rare Earth Elements (REE) measurements carried out by the University Federal da Bahia (UFBA). The suggested solution was to lower the Rosette again in the water and close all bottles at one depth and leave them filled with water up to the next station to minimize the effect of contamination.

After examining the maps of wave height in the region, it was decided that the best course of action was to start the transect by the western side of the array, that is, from the coastal side. From the forecasts, it looked more probable that we could avoid the worst part of the atmospheric systems that was from the South if we started from the western side. We were hoping that the cruise could proceed normally if we arrive in the oceanic part of the transect before the next cold front could form. By examining the forecasts, there was a tendency for the systems to move quickly eastward (Fig. 13).

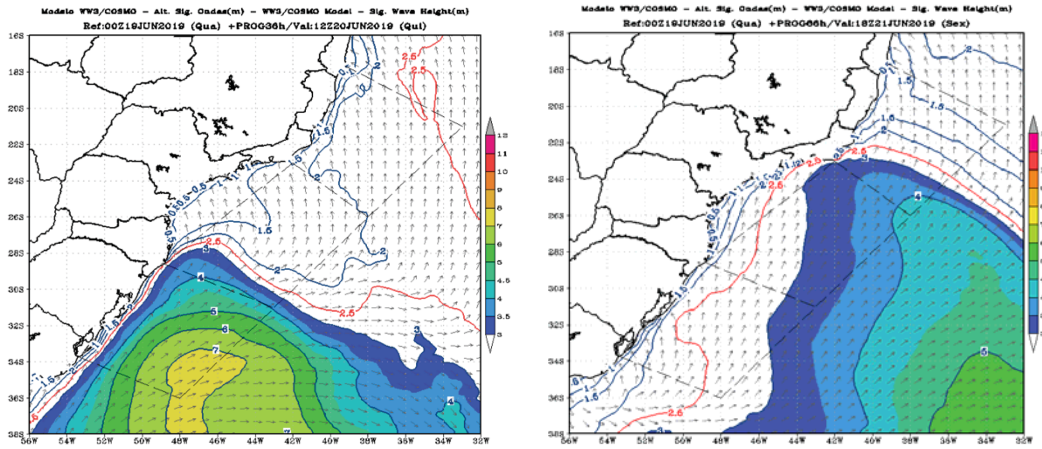


Figure 13. Forecast of wave height from the Brazilian Navy (Marinha do Brasil) processed in a model run by the Centro de Hidrografia e Navegação (CHM). The model was initialized at 00Z of June, 16th . The forecasts refers to 12h00 of June 20th and 18h00 of June 21st.

4.3 - June 21 - SAMBA - West Hydrographic Section – the shallower stations

Station 01 was reached on June 21 at 12h12. As foreseen, the ship arrived reached the first station with the good sea and weather conditions. The local depth at that point was 14 m. The Niskin bottles were closed at five depths (3 m, 5 m, 8 m, 10 m, and 12 m). The measurement of REE required 5 L of water at two depths: surface and bottom. All other chemical parameters also required samples at each one of those depth, and salinity bottles were collected at two depths only. The measurement of REE (Rare Earth Elements) required the removal of the Niskin bottles from the Rosette for the filtration to be performed inside the wet laboratory. Raiza (researcher-UFBA) had brought a peristaltic pump to accelerate the filtration process. To filter six bottles for REE, it took 1h35. Therefore, it was decided to move toward the next station while the filtration was taking place. From the other bottles, samples for chlorophyll and Suspended Material were also filtered and the measurement of dissolved oxygen were performed. The nutrients samples were preserved by the group led by Prof. Elisabete Braga (Fig. 14).

Figure 14. REE and Chlorophyll and Suspended Particulate Matter filtration.

When approaching station 02, only four bottles used for REE samples had finished the filtering process and they were reassembled in the Rosette. That is, at station 02, only 21 out of the 23 Niskin bottles were available for water sampling. That did not represent a problem because the station's depth was of only 13 m. Six different depths could be sampled at that station, with plenty of water collected by bottles that were closed at the same depths. The removal of the bottle from the Rosette's frame became the normal procedure to filter the water for REE. Normally, if the REE bottles were not finished by the next station, the Rosette would go down with missing bottles. For the shallow coastal stations, there always had enough bottles, with duplicates if it is necessary to sample the water column. The sequence of stations followed uneventfully up to Station 07. The XBT's started to be deployed at mid-points between CTD stations. The first XBT was deployed between Stations 6 and 7.

Before station 1,, an offset of -1.57 db was applied to pressure in the configuration file. This results from averaging the observed deck values of pressure in the previous 2 test stations.

The next station would involve the recovery of the bottom pressure recorder (BPR) and the moored ADCP. As the recovery of those instruments required to be at daylight, it was decided to move ahead up to Station 08 where the new CPIES 0A would be deployed.

4.4 June 22 -23 The Deployment of CPIES 0A

After reaching the nominal position of the **CPIES 0A**, the Project's Coordinator, Prof. Edmo Campos, was consulted through the satellite communication system (IRIDIUM), for deciding the best location for deployment. Following his suggestion, it was decided to choose a pont with the average depth between the ADCP (403 m) and the PIES A (1366 m), that is, where the depth reached 875 m. Using the ship's echosounder, it was determined that the CPIES 0A position should be at 34° 24.270 S, 051° 35.390 W. The CPIES was deployed at 04h13, on June 22nd (Fig. 15). The mooring team was formed by the IOUSP's technicians: Francisco Vicentini Neto, Wilson Natal de Oliveira and Henrique Rei Miguel. The telemetry was not performed at that occasion to allow the CPIES to record some data. After all, the ship would steam back to the BPR position and then return to this site to do a CTD station and the telemetry. That happened on June 23rd, with the telemetry successfully done between 03h00 and 03h34.

After the deployment of CPIES 0A, the ship moved back to the site of BPR and ADCP for their recovery.

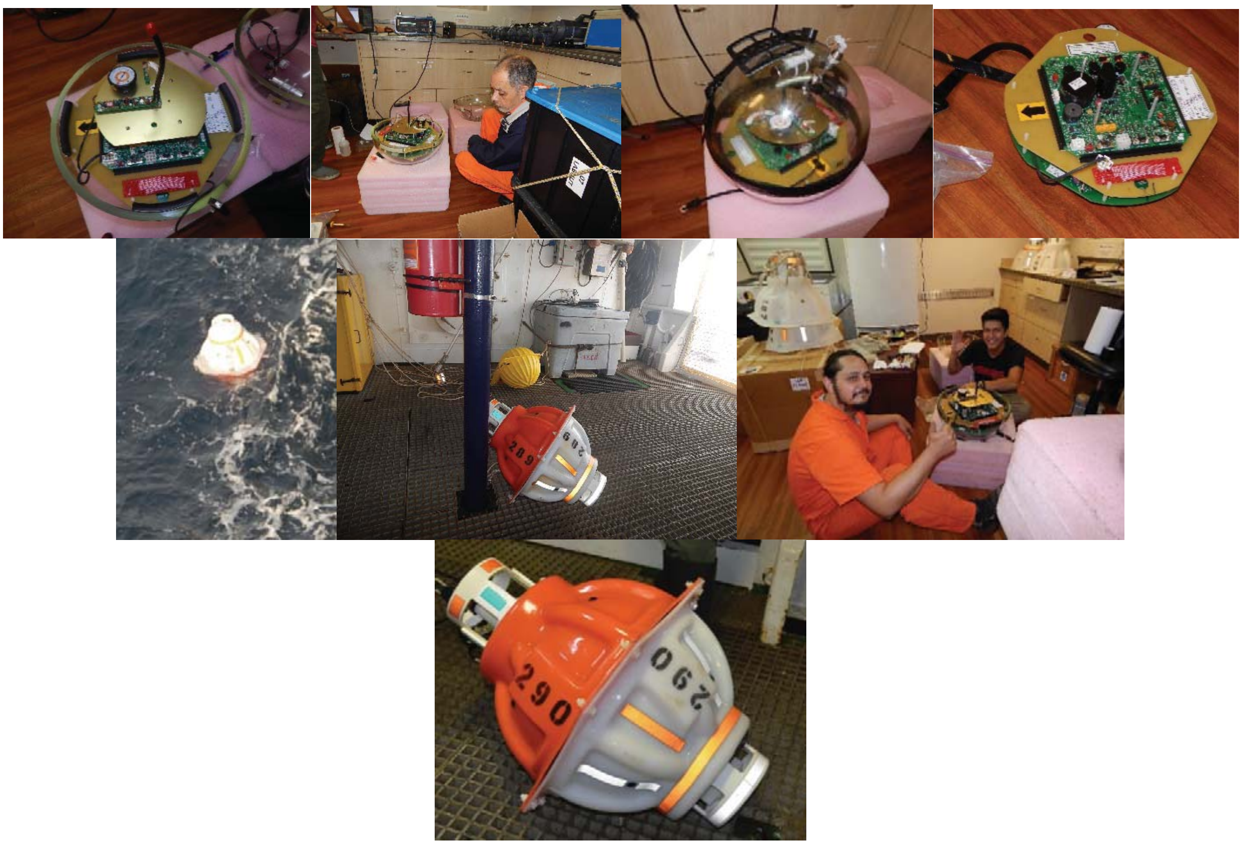


Figure 15. After retrieval, C-PIES BB (SN290) was open and a full diagnostic performed. Following instruction from URI, it was reconditioned and eventually redeployed at site AA, with nominal position 34º 30'S, 50º 30'W. The C-PIES originally deployed at Site 0A (SN289) was retrieved prior to the launching of SN290.

4.5 June 23 - The ADCP and the BPR

Summary: BPR lost and successful recovery of the ADCP

On June 23rd, the ship arrived at the location of the BPR mooring (34º 18.03'S, 51º 42.37'W) at 05h50. The ship remained drifting around 34° 17.876 S, 051° 42.107 W and 34° 18.027S, 051° 42.383W to try to communicate with BPR. The attempts to release the BPR started at 08h10 and finished at 09h15 with no success. After concluding that the recovery of that instrument would be possible, it was decided to redirect the ship toward the position of the ADCP. At 09h40 the ship arrived at 34°18.98S, 051° 40.707 W and the communication with the ADCP was started. The releasing signal was sent at 09h50, on 34° 18.933S, 051° 40.699 W. At 10h12, the ADCP was retrieved at the position 34° 18.771 S, 051° 40.458 W.

After the recovery of the ADCP, another attempt to retrieve the BPR was performed with no success again. A full-depth CTD-rosette station (08) was performed at the position that corresponded to the mid-point between the BPR and ADCP locations. As the maintenance of the ADCP onboard would take at least 6 hours, it was decided to continue with the programmed activities to install the PIES A (Fig. 16)

Figure 16. Currentmeter, ADCP and CPIES recuperation.

4.6 June 22 - Data Telemetry from PIES A

Summary: Telemetry (successful), recovery and deployment

On June 22nd, at 16h00, the ship arrived at the site of PIES A, at 34°29.814 S, 051° 29.899W. The data telemetry was done first. That was done from 16h00 to 19h15, by moving the ship relatively to the C-PIES position and letting her to drift (by uncoupling the shaft) towards that position while trying to get the telemetry done. After finishing the telemetry, the ship returned to the initial position. At 19h30 the transducer was placed in the water again to send the release command at 19h47. PIES A was taken out of the water at 20h47.

A new PIES was launched to replace the old one, at the position 34° 29.769 S, 051° 29.97W at 21h52. After the waiting period, until the PIES reached the floor, it was performed another telemetry operation to verify if everything was working as expected with PIES A. That was conducted from 23h30 pm to 01h48 (following day). Some difficulties occurred while trying to contact the PIES for several times. In the process, the ship was repositioned twice. As the PIES transmitted some information (not actual data), Diego Ugaz (Fig. 17) verified that the PIES was performing the daily data processing and was convinced that the PIES A was working properly. Following the successful redeployment of the PIES A, a full depth CTD station (St. 09) was performed at the location.

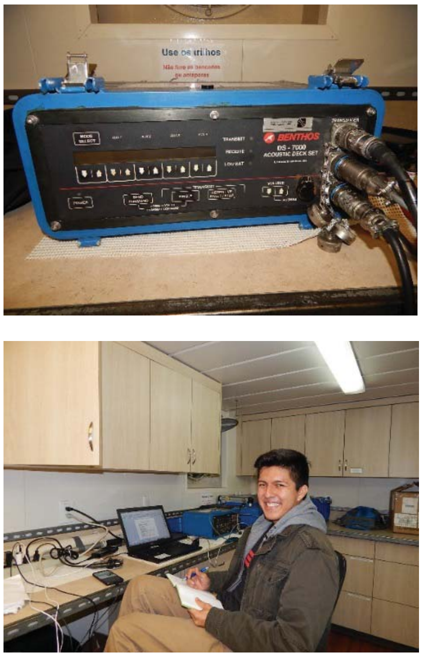


Figure 17. The telemetry of PIES A being performed by the NOAA technician D. Ugaz

On this day, the weather conditions were highly favorable for the PIES operation, including telemetry and recovery (Fig18). The weather and the ocean's state were not the cause for the bad telemetry. The sea was very calm at the moment when the PIES reached the surface and it was seen almost immediately. It is most likely that it took a long time for the second telemetry because the PIES was turned on just before the deployment and the recorded data were too short.

Figure 18. Deployment of PIES SN 187 at site A with the help of Vicentini, Miguel and Pegoraro.

Before station 9, while re-installing bottles on the rosette, bottle 9 was broken at one of the lower spring holders. It was replaced by bottle 24 (not installed previously). The damage is not significant, and the bottle can still be used if necessary.

Before station 10, line notches on bottles 9 and 22 were enlargers as in previous station the lower caps line were stocked in them.

4.7 June 23 - Redeployment of the ADCP

On June 23rd, the N/Oc. Alpha Crucis returned to site of the ADCP. Before reaching the nominal position, the ship passed over the site of CPIES 0A. Two events took place there: telemetry and the CTD 10. After that, the Alpha Crucis sailed to the position of deployment of the ADCP: 34° 18.996S, 051° 40.647W, with the depth of 390 m. The ADCP was redeployed at 07h12.

After the successful operation, the ship returned to the original plan and headed east, toward the location of XBT 5, at 34° 30.040S and 051° 14.967W, the mid-point between PIES A and CPIES AA.

4.8 June 23 - Recuperation of C-PIES SN290 and deployment of SN409 at site AA

Summary: Recovery and redeployment

At 18:09 of June 23rd, the ship arrived at the site AA (34º 29.980'S, 50º 30.019'W) where C-PIES SN290 had been moored since Apr/2018. First, a full CTD station was performed. However, this station presented some problems with the closing of the bottles (see the section on Station 12).

According the records, in April 2018 this instrument had a new chip installed but did not have a proper firmware update. It was assumed that that was the most likely reason for the failure during the attempt to carry out a telemetry in the Puerto Deseado Cruise, in October 2018. Therefore, this time the telemetry was skipped the recovery operation started immediately after finishing the CTD station. For that, the ship was repositioned back at the site AA nominal location.

Figure 19. C-PIES SN290 recovered at the site AA (left) and serviced (center). Right: The CPIES SN409 just before deployment as the new C-PIES AA..

The released signal was sent at 20h45. At 21h25 the CPIES arrived at the surface and it was brought aboard at 22h08. The currentmeter was caught under the ship and needed some work to bring aboard. This provoked a special action involving Francisco Vicentini, Henrique Miguel, the crew and collaboration of Bruno Pegoraro and Henrique Dias. Because of this little problem, the cable that connected the CPIES and the currentmeter was cut by force (Fig. 20). During the CTD statin, 6 bottles of surface waters, for unknown reason, did not close. Also, likely due to a software problem, the depths of these bottles were also not known. E. Braga suggested to use the dissolved oxygen and salinity data to determine the depth of the closed bottles.

Figure 20. The problem of C-pies and currentmeter recuperation, the rosette cable connection reconstructed.

During this night, The XBT record presented problems, as identified by the graduate student Thamirys, at 03h30. There was also a problem with the ship's echosound. Consulting the depth table initially prepared, it was found that the station 13 had about 3000m. So, for safety reason, it was decided to send CTD-rosette only to 2.800-2.900mdepth. A change in the rosette-CTD cable was performed by Raul Guerrero and Henrique Miguel (Fig. 20), verifying the humidity in the connectors. The connection was remade. Finally, the station 13 was successfuly performed.

4.9 – June 23 - Bottle problems at Station 12

We started the full-depth CTD Station 12 (34º 29.986S, 050º 29.700 W) at 6:09pm. The local depth was 2880 m. The rolling of the ship stresses the cable and generated error counts on the data strings (11 at the beginning of the cast, 22 in total by the end). During the ascension of the Rosette, the software that controls the closing-triggering of bottles presented problems, showing the following error messages: "FFF unsupported modem message" and "GG06 34 from SBE32". From there on triggering of bottle were needed to be done with the SBE deck unit: Bottles 1 to 3 triggered Ok; bottle 4 was triggered twice with one confirmation; 5 to 10 OK; bottle 11 was triggered three times, one confirmed; 12 to 14 triggered OK; 15 to 19 no confirmation. At the end, six bottles arrived at the surface unclosed. Bottle oxygen and salinity measurements will be used to reconstruct the vertical distribution of bottles according to the structure of water masses.

Error counts on the data string indicates cable problems and a new full electro-mechanical end termination was made on the cable. CTD signal was connected to the inner conducting cable and ground to the armor cable inside the block. Conducting cable shield was not used. The isolation obtained, when 1000 volts of current was applied, was: 402 Mohms between signal-conducting cable and armor cable (ground) ; and 295 Mohms between signal-conducting cable and conducting cable shield. The resistant between signal cable and ground t one end when shortened the other end was 128 ohms (this value is expected to be below 300 ohms). With the new end termination, the CTD/rosette/bottles were back in service for station 13.

4.10 – June 24th - Operation on Site B

Summary: Telemetry (success) and CTD without rosette

The ship arrived at site B on June 24th at 11h56, at the position 34° 29.9898S, 049° 30.198W. Telemetry and a full depth CTD station were programmed for this site. As the weather conditions permitted (winds around 9 knots) it was decided to perform both activities in parallel. First, the telemetry on PIES was started. Once the telemetry was underway, the CTD operation started. The telemetry lasted around 3 h using 2 sets of deck units and transducers. The transducers were lowered at the side of the ship at the depth of 10 m to 12 m. They were both at the same side as the Rosette. The transducer's and the Rosette's cables were similarly slanted during the whole operation and they never interfered with each other. Maybe in rougher weather conditions, one could have problems with them touching each other. The CTD cast took 2h30. The telemetry obtained data back to day 169 of 2018. During the whole time, the ship maintained its position using its engines and the echosounder was on passive mode. This combined operation helped to cut the time spend in the station by half. The combination of a calm weather, two deck units, transducers below 10 m, probably were the key to this successful operation.

4.11 June 25th - Telemetry, recovery and deployment of C-PIES at Site BB

Summary: Telemetry (failed), recovery, and deployment

Around 00h05 of June 25th, the ship arrived at site BB (34° 29.911S, 048° 30.173W). After the positioning of the ship, the first attempt to telemeter CPIES BB started, at 01h14. Due to the bad weather conditions, wind gusts over 30 knots, and strong currents, hardly any data could be retrieved. A second and a third attempts were tried by repositioning the ship closer to the CPIES nominal position. During those attempts, the activities had to stop due to the intense movement of the ship. Finally, by 05h38, the attempts for telemetry were aborted and the recovery was initiated. The ship arrived again at position at 07h18. The release signal was given at 07h23, and the CPIES arrived at the surface by 08h19. It was aboard the ship at 08h45.

A brand new CPIES unit (IES 408) (Fig. 21) was deployed at 09h16, position (34° 29.946S, 48° 30.055W) and a signal to start telemetry was sent at 11h10. The telemetry lasted from 12h16 to 12h22.

Figure 21. New C-PIES unit (IES 408).

4.12 – June 25th - Rosette problems with Station 16

After finishing the operations on site BB, it was planned to start the CTD Station 16. During the night, the sea state and wind conditions were too severe to perform a safe CTD cast. At 10h, the weather condition was still a little strong but under the critical limit. Therefore, it was then decided to do a CTD cast.

It is of general knowledge among CTD/rosette operators that under rolling conditions EM cable suffer strong tensions, close to its breaking limit. Kinking or actually breaking can occurs when the downward velocity of the wire (winch speed + rolling speed) exceed the free fall velocity of the CTD package, the wire then take slack and naturally twist; then the slag is suddenly taken by the rolling in the opposite direction and the wire kink or break. To avoid this condition (flying of the CTD/rosette) the package was sent down with only 8 bottles, which increases its free fall velocity.

The entrance of the equipment in the water was rough because of the ship's balance, but it proceeded uneventfully up to 1850m when suddenly contact with the CTD was lost. When the Rosette arrived at the surface, it was realized that the electro-mechanic cable was broken. The safety mechanism (Safety belt) in place avoided losing the Rosette system. After a quick investigation it was found that the stainless manila opened during operation (Fig. 22). It is likely that the stress during the rough the entrance of the instrument in the water had ripped the plastic coverage of the cable and it kept breaking down until reached the depth of failure.

Figure 22. The rosette with 8 bottles and the security belt that maintained the equipment from being lost (the action-shackle opened).

4.13 – Design of alternative plans for the bad weather

After the problems with rough sea conditions on June 25th, the ship continued to the next station. After arrival, at 15h43, waves were near to 4 – 5 m high. It was decided to launch a XBT instead of doing a CTD station. The plans for the remaining stations were as follows: continue moving toward PIES C site and, depending on the waves and wind conditions, try to do the telemetry. If conditions allowed, try the recovery and deploy of a new PIES. If the meteorological conditions remained bad, steam up to the next station, where only the CTD, no bottle sampling (Fig. 23), would be lowered to get the temperature, salinity and DO profiles. After finishing that station, the ship would come back to complete the PIES C station, including a CTD cast.

During the transit to this position the EM cable end termination was tested. It was found that the electrical connection lost continuity ½ of a meter after from the block. Consequently only the electrical connection was re-done, using a new long cable. The isolation between the signal cable and the armor cable was 11 Gohms.

CTD station 18 had the Y Air vent of secondary arrange plumbing clogged, so air purging of the tubing took longer than the soaking time. Consequently, the first 20 db of data from secondary sensors should not be considered as good data.

In transit to next station (Site CC) the CTD/Rosette package was reassembled in full. Weight from the CTD cage were taken out, plumbing lines were set for horizontal sampling, bottles installed in rosette and EM cable and safety cable secured to the frame. Weather conditions were improving and were ready for a full cast with Rosette and bottles.

Figure 23. Installation of the CTD on its frame in the vertical position. No Rosette

4.14 June 25 - Data Telemetry on Site C

Summary: Telemetry, recover, and deployment

Site C, originally Station 18, was reached at 19h00, on June 25th. The nominal position was 34° 30.21S, 047° 29.78W. At the time of arrival, the winds were over 25 knots and waves of 4-5m were observed. Maneuvering operations were attempted to get the best position for the deployment of the transducers to start the telemetry. After almost 3 hours of maneuvering, it was decided to continue to the next waypoint which was Station 19. The sea was really rough to deploy the transducers at the side of the ship.

Moving to next station, east of PIES C site, took over 6 h due to weather conditions. The ship arrived at 34° 30.457 S, 46° 45.998 W at 8h20. The Rosette frame and bottles were replaced by the CTD frame and some weights (Fig. 23). Due to the bad weather, only a CTD cast was taken at that time, with no bottle samples. After that the ship turned back to the Site C, to attempt the telemetry, recovery and deployment of a new unit.

Site C was reached, for the second time, on June 26th at 05h40. The nominal position 34° 30.212 S, 47° 29.767W. At the moment the telemetry started, winds of magnitude 18 to 21 knots were observed. The waves were high (4 m to 5 m height). The telemetry started first, and after some data had been telemetered, the CTD was lowered (only CTD without bottles). The telemetry was reasonable well succeeded and lasted almost 3 hours. After the CTD station was finished, the ship was repositioned to the initial position for the recovery procedure for the PIES. The wind was 13 knots at that time, and the PIES came to the surface and rescued in 2 hours. A new PIES unit (SN 222) was deployed at 34° 30.210 S, 47° 29.781W at 00h00 (June 27th). The second telemetry took a while (from 02h10 to 17h07), and the ship had to be repositioned twice. Diego had a hard time to get the telemetry finally done. The probable cause for that problem was the short data time series stored since its deployment. It is advisable that a new PIES be turned on some hours before its deployment. This procedure was tried at the CPIES CC site and it worked fine.

4.15 June 27 - Deployment of PIES CC

Summary: Deployment and full CTD-Rosette (successful)

The ship arrived at the site of CPIES CC on June 27th, at 11h05. The nominal position was 34° 29.997 S, 46° 5.465 W. At that time, winds of 9 knots and high swell were observed (the day was beautiful!). The CPIES at the site had been recovered by the Argentinian cruise in October 24th, 2016, due to malfunction. Since that time, no other CPIES was installed there. During this cruise the properly refurbished unit recovered from CPIES AA site was deployed. Unfortunately, as described above, the cable that attached the PIES to the currentmeter had to be broken during the recovery (see at CPIES AA description). The PIES unit (SN 290) had the lithium and clock batteries replaced, firmware updated, and the vacuum port O-ring replaced as well (Fig. 24). The fully recovered unit was then deployed at the CC site and set as a PIES because the currentmeter cables were too damaged to be used.

As usual, the operation was started with the PIES launching procedures. The PIES was launched at the nominal position 34° 29.997 S, 46° 5.465W. The nominal depth is 4730 m and it would took 1h19m for the instrument to reach the seafloor. Soon after, a full equipped Rosette station was started. During the course of the CTD station, the ship drifted away but not far enough so that the telemetry signal could not be heard. Therefore, as soon as it reached the floor, the telemetry was done successfully to show that the PIES was working as expected.

Figure 24. Relaunching the PIES SN290

Two CTD station were done at this position, as additional water from the Rosette was needed for Rear Elements sampling. The first cast was sent to the bottom and the second one (Station 19-01) was sent to 1500 db. When second cast finish we moved to the next position to occupy Station 20 (no C-Pies at this position) down to the bottom at 34º 30.022 S, 45º 14.978 W. This CTD station was actually performed at 03:23 UTC of June 28.

4.16 June 28 - Site D - The Last CTD Station

Summary: Telemetry

At 8h45 of Friday, June 28th, the ship arrived at the last waypoint, the site of PIES D (SN187). The attempts for the telemetry started at 9h05 and the response was not accurate. Due to the uncertainty, the ship was repositioned for a new attempt. While attempting to do the telemetery, the CTD station has started. During the CTD cast, the telemetry signal was very weak and a signal to stop was sent down. When CTD station was completed, the ship was repositioned again, and the telemetry signal was reconnected until finished successfully.

5. Detailed Description of the Research Activities

In this section, the research activities are described according to reports prepared by the lead-researchers of each group.

5.1 Lowered ADCP (H. Fenco & F. Furtado)

Instrument Setup and deployment

A TRDI 300kHz Workhorse (WH, S/N 13985) aluminum cased Acoustic Doppler Current Profiler (ADCP) was kindly made available by Prof. Ilson da Silveira, for use on SAM18-SAMBAR-A02 to collect full-depth horizontal velocity profiles during CTD stations. The unit was mounted in a downward looking orientation (Lowered-ADCP or LADCP) on a side of the CTD frame using a metal collar (Fig. 25), taking care not to interfere with the closing of the Niskin bottles.

Figure 25. LADCP (the yellow cylinder) mounted in the Rosette.

The WH unit was programmed to collect a profile/ensemble per second of a variable range depending on the station depth. Two separate configurations were used during SAM18: the standard 20 x 8 m bin configuration was used between the stations 8-21 (configuration file *wh300_dn.cmd*) while a 20 x 4m bin configuration was used between stations 1-7 (configuration file *wh300_dn_shallow.cmd*). The "blank after transmit" (in essence, the distance in cm between the LADCP transducer and the first bin) was set to 0 for all LADCP casts. The data was collected in beam coordinates and rotated to earth coordinates in the post-processing stage. The instrument was connected to a laptop with a Windows 10 OS using a RS-232/USB converter to set up the deployment. The software "BBTalk" developed by TRDI was used to communicate with the unit. After the cast the unit was reconnected to download the data using a 42 V power source to avoid draining the batteries. The list of commands used to deploy the unit is presented in Annex 1. Table VII summarizes the bin configuration for each LADCP cast during the cruise.

Table VII. Bin configuration during SAM18-SAMBAR-02A

Stations	bins per ensemble	bins thickness	Nominal range
1-7	20	4m	80m
8-21	20	8m	160m

LADCP calibration

A fresh new, demagnetized battery pack was installed in the ADCP before sailing. The ADCP battery is composed of 28 "D" alkaline batteries generating 42V. Before mounting the unit onto the CTD frame the internal gyro was tested (Fig. 26) to check for drifts, because the ferromagnetic material nearby the LADCP may alter the magnetic field in the vicinity of the LADCP. The testing of the ADCP gyro threw an error of 1.5º and a new drift test with CTD package was conducted with a resulting 3.0º error in the ADCP internal gyro, therefore it was not necessary to calibrate the instrument. We conclude the material surrounding the LADCP do not affect its performance and an additional calibration was not required.

The WH unit was programmed to collect a profile/ensemble per second of a variable range depending on the station depth. Two separate configurations were used during SAM18: the standard 20 x 8 m bin configuration was used between the stations 8-21 (configuration file *wh300_dn.cmd*) while a 20 x 4m bin configuration was used between stations 1-7 (configuration file *wh300_dn_shallow.cmd*). The "blank after transmit" (in essence, the distance in cm between the LADCP transducer and the first bin) was set to 0 for all LADCP casts. The data was collected in beam coordinates and rotated to earth coordinates in the post-processing stage. The instrument was connected to a laptop with a Windows 10 OS using a RS-232/USB converter to set up the deployment. The software "BBTalk" developed by TRDI was used to communicate with the unit. After the cast the unit was reconnected to download the data using a 42 V power source to avoid draining the batteries. The list of commands used to deploy the unit is presented in Annex 1. Table VIII summarizes the bin configuration for each LADCP cast during the cruise.

Figure 26: Pre-cruise LADCP gyro test. **a)** testo n deck, before mounting in the CTD frame. **b)** test after mounting.

Table VIII. Bin configuration during SAM18-SAMBAR-02A

Stations	**bins per ensemble**	**bins thickness**	**Nominal range**
1-7	20	4m	80m
8-21	20	8m	160m

Data processing

The station data were processed using the Lamont-Doherty Earth Observatory (LDEO) software package (Thurnherr, 2016), which uses an inverse method to calculate velocity profiles, optionally including LADCP bottom tracking and/or VMADCP upper ocean velocities as constraints (see Fig. 27) for an example profile). In addition to the horizontal velocity profile the IX software also provides a set of useful auxiliary information such as CTD-derived temperature, salinity and sound profiles, GPS time series used to compute the ship drift during the station or LADCP attitude and heading data. LDEO X.16 processing on board was performed using only ship navigation and bottom tracking in order to compare the results with the velocity profile collected with the vessel mounted ADCP during the cast. In order to successfully process the LADCP cast, a 1Hz binned CTD profile needs to be fed to the software. The CTD file must have at least latitude, longitude and time data (for example, Julian days or time elapsed in seconds) as well as temperature and salinity data.

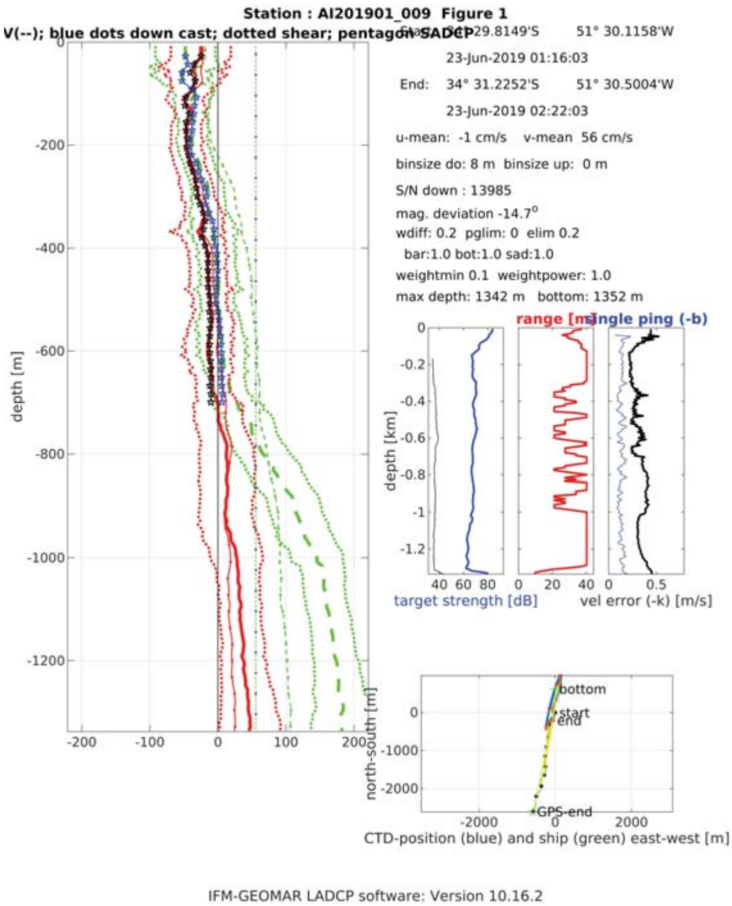


Figure 27. Averaged echo amplitude (left) y and beam correlation for LADCP station #009 computed with the X software.

Time base for the X suite.

As mentioned before, the X software requires CTD data together with a navigational data source, therefore a precise synchronization between LADCP and CTD data is required during the processing. The IX software computes the lag between the two data sets by comparing the vertical velocity of the package measured by the LADCP and the vertical velocity estimated from the CTD pressure time series. It has been previously noticed that using the NMEA *time elapsed* format (in seconds) may lead to spurious lags when calling the script *bestlag.m* (which is used to find the best lag between the two times series). Since NMEA time is recorded into the CTD file, the Year Day format is used as time base for the X processing.

Ambient Temperature Performance

Using the X software processed data, ambient temperature and CTD temperature profiles were compared in order to assess the performance of the external thermistor on the WH unit. Although ADCP thermistor has a slower response compared to the CTD temperature sensor, the two profiles matched quite well for all profiles. Figure 29 shows and example for station 009.

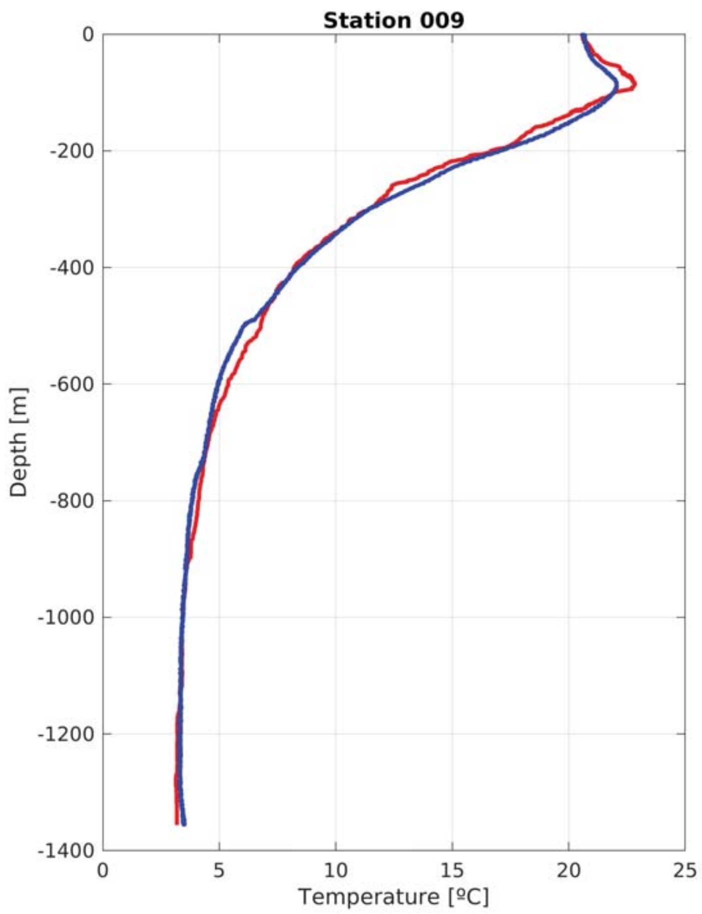


Figure 27. Temperature measurements collected by the external termistor installed in the WH unit (red blue) compared to the primary CTD temperature sensor (red line) for LADCP station 009.

After the completion of all CTD/LADCP stations, a preliminary processing of the data was carried out. Figure 28 illustrates the comparison of the zonal and meridional velocity of the LADCP and VM-ADCP (Section 5.2) of the station 009 during the cast.

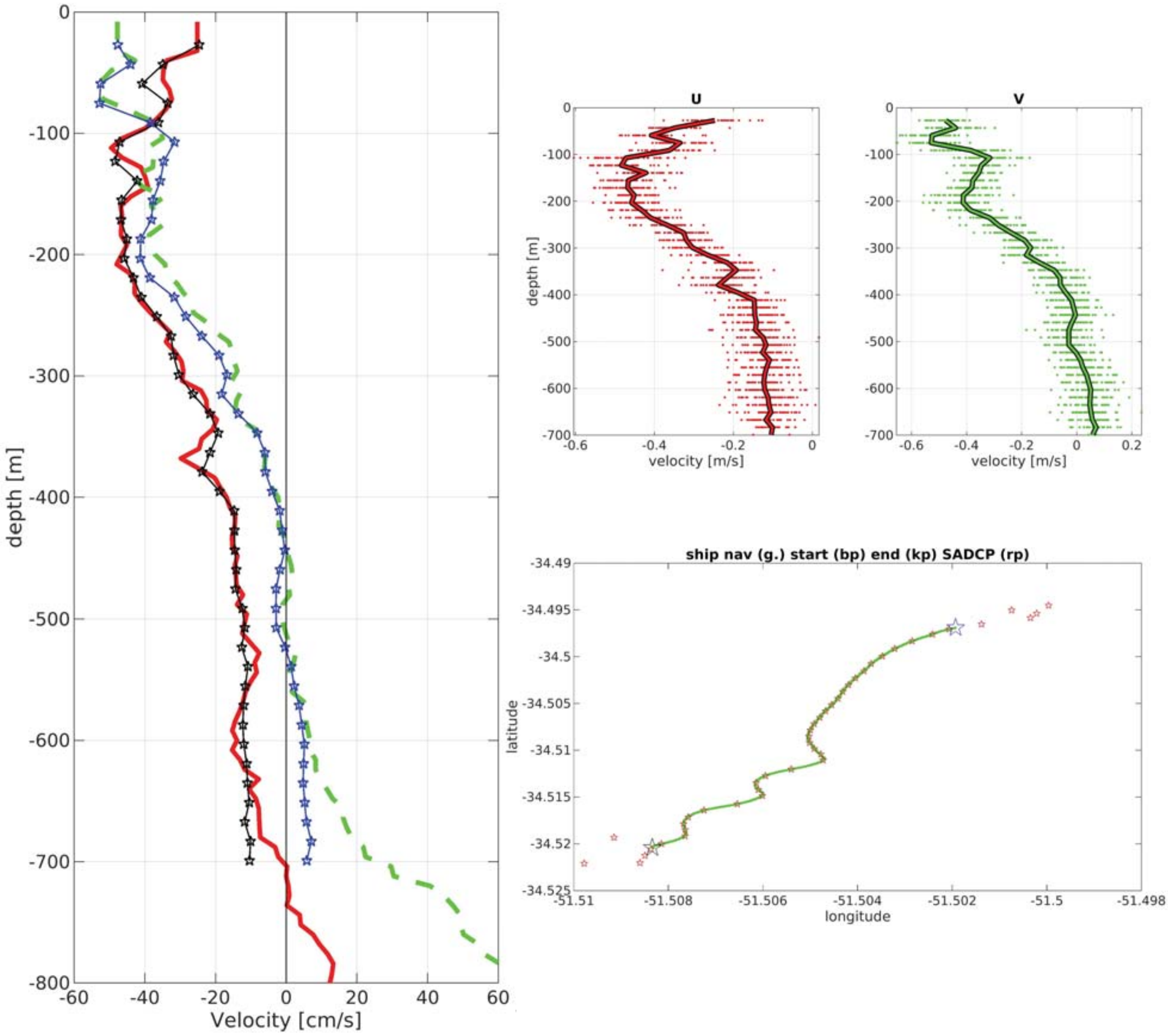


Figure 28. a) Profile station 009 of the zonal velocity (LADCP: red line and VM-ADCP: black line) and meridional velocity (LADCP: green line and VM-ADCP: blue line). b) profiles VM-ADCP and mean of the zonal velocity (red line) and meridional velocity (green line) shown in a) and c) drift of the vessel during the cast LADCP/CTD.

5.2 Vessel-Mounted ADCP (Harold Fenco, Raul Guerrero and Marcela Charo)

Data Acquisition: VmDas

Two TRDI vessel-mounted Acoustic Doppler Current Profilers (VM-ADCP) where available for use during the SAM18/SAMBAR02, an Ocean Surveyor 75 kHz (OS75, S/N 1868) and an Ocean Surveyor 150 kHz (OS150, S/N 1867). The former was run in narrowband mode while the latter was used in broadband mode, which translates into an upper and lower reference limits of 150-700 m and 75-150 m, respectively. Each VMADCP were controlled by two separate deck units located in the main lab (Fig. 29). The bin size for the OS150 was set to 8 m, the number of bins to 45 and the blanking distance 6 m. For the OS75, the bin size was set to 45 bins with a bin depth of 16 m and a blanking distance at the surface of 8 m. The time between pings was set to 2 seconds before deployment to 2 seconds.

Figure 29. Deck unit controlling each VMADCP located in the main lab.

Settings and configuration

The ADCPs were controlled via VmDas v.1.49 installed on a single PC with 1GB of RAM located in the main lab using OS Windows 7 32-bit during the track of the ship along the cruise.

The TRDI VmDas software was used to store the data collected by the VMADCPs. Next we provide some quick-look notes for setting up the software:

Open VmDas, click on File - Collect data. Then in Options - Edit data options:

- Communications tab:
  Set up such that under Current Setting the COM Port Setup is set to:

ADCP (OS75) Input: COM7, 9600, N, 8, 1

ADCP (OS150) Input: COM1, 9600, N, 8, 1

NMEA1 Input: COM4, 4800, N, 8, 1

NMEA2 Input: COM3, 4800, N, 8, 1

- ADCP Setup tab:

a) ADCP setup from file: SAM18 OS75 Narrowband NO bottom track NO sync.txt (OS75) and OS150BBDEF.txt (OS150) see Annex 5, time between ping ensembles: 2 seconds.

- Recording tab:
  Name: AI201901 (we used this name convention for all underway collected during the cruse). We added a letter at the end each time the acquisition was stopped and re-started.
  Max size: 5 (MB; when that size is reached, VmDas starts a new file with automatic numbering) no dual output directories.

- Nav tab:
  NMEA Ship Position (GGA) Source: Enable, choose NMEA1 from drop down menu disable.
  NMEA Ship Speed (VTG) Source: Enable, choose NMEA1.

- Transform tab:
  Heading Source: HDT, NMEA Port: NMEA2, Fixed Heading set to 0.
  Tilt Source: ADCP Tilt Sensor, Fixed Pitch=0, Fixed Roll=0 (don't enable tilt correction)
  Heading Sensor Magnetic/Electrical Corrections: 0 EV: Primary Heading Error, 0 EV Backup.
  ADCP Alignment Correction: 60.5 (OS75) and 46.2 (OS150) in the EA Heading alignment error. This values were taken from data collected in previous cruises on board the Alpha Crucis.

- Averaging tab:
  The STA interval was set to 120 seconds, LTA to 600 seconds
  Profile Ping Normalization Reference Layer was enabled and set to start bin = 3, end bin = 10.

Output data format

The naming convention of the output files is as follows: CRUISE_xxx_yyyyyy.END where CRUISE is the name set in the data options recording tab of VmDas (in this case, AI201901), xxx is the number set in the “recording” tab and changed before every restart of recording, and yyyyyy is a number automatically set by VmDas starting from 0 and sequentially increasing when the file size becomes larger than max size. END is the filename extension, denoting the different files that are created for each recording. The following list shows all the different file types that were created during the navigation and their content.

- ENR: binary; raw ADCP data file.
- STA: binary; average ADCP data, using the short time period specified in VmDas Data Options.
- LTA: binary; average ADCP data, using the long time period specified in VmDas Data Options.
- ENS: binary; ADCP data after screening for RSSI and correlation, either by VmDas or adjusted by user, and navigation data from .NMS file.
- ENX: binary; ADCP single-ping data and navigation data, after having been bin-mapped, transformed to Earth coordinates and screened for error velocity, vertical velocity and false targets.
- N1R: ASCII text; raw NMEA data.

- N2R: ASCII text; raw NMEA data.
- NMS: binary; navigation data after screening and pre-averaging.
- VMO: ASCII text; option setting used for collection the data.
- LOG: ASCII text; all logging output and error messages.

In addition, VM-ADCP has installed a thermistor, it measures continuously the temperature of the sea to 3 meters aprox.

Processing data in CODAS (Common Ocean Data Access System)

For the processing of the VmDas data, we used the CODAS scripts package developed by the University of Hawaii - USA and written in Python (https://currents.soest.hawaii.edu/home/index.html). In this report, we processed the *.STA data of the instruments OS150 y OS75. In the Figure 30 shows the intensity and direction of the first bin (~15m) together with the surface temperature (~3m) measured by the VM-ADCP along the ship's track.

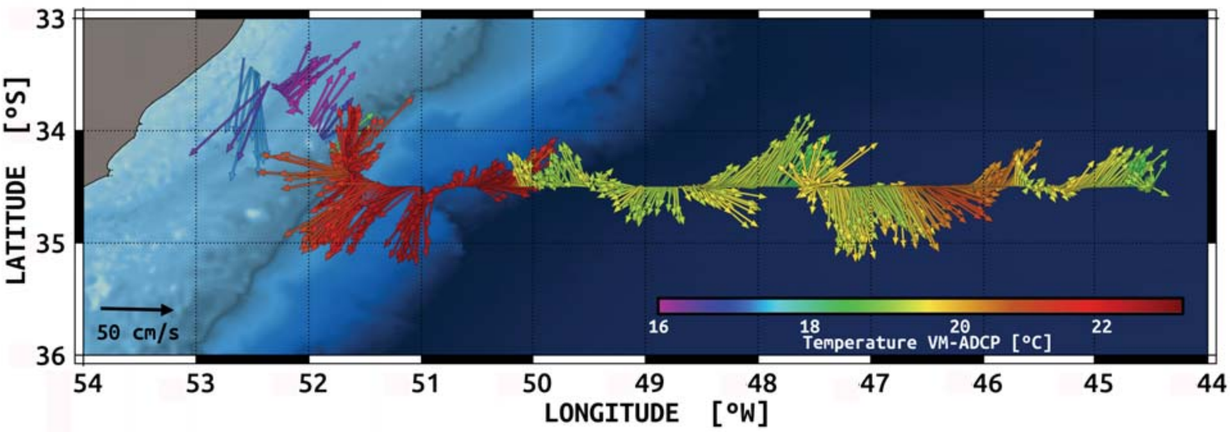


Figure 30. Surface currents derived from the VMADCP OS150 and OS75 collected during the cruise. Gray line indicates the isobath of 200.

Some coherent results with the hydrodynamics of the region are immediately observed for the shelf and the open ocean. The strongest picture is the Western intensification of the subtropical gyre along the shelf slope with the Brazil current advecting warm (> 21ºC) waters southward. Over the shelf two dominant fluxes are distinguished: A costal current moving southward and a cold mid-shelf current moving northward. The latter and more intense flux is associated to the Río de la Plata paleo-channel (70 m deep). From middle shelf to the break the current is also moving northward but showing a large contrast in temperature. The western side cooler probably in balance with local air masses and the advection of Subantartic Shelf Waters, while the eastern one, much warmer (and saltier, st. 8), could indicates submeso-scale eddies intrusions into the shelf from the Brazil Current. Finally, the ocean interior seems to reflect the characteristic meso-scale dynamics of the subtropical fronts moving eastward along the gyre.

5.3 CTD and water samples observations (R. Guerrero & M. Charo)

Table IX summarizes the CTD, LADCP and water-sampling instruments used during the cruise. Twenty-one (21) CTD stations and 18 XBT profiles were performed. Nineteen (19) stations were performed with a SBE911-CTD/SBE32-carrousel package. Stations 17 and 18 were performed with the CTD alone due to weather conditions. The SBE-32 carrousel was assembled with 23-5lts brand new Ocean Test Equipment-Niskin bottles for water sampling. The CTD was equipped with redundant TC & Ox sensors (Figure 31; left), a self-contained L-ADCP and an altimeter for approaching the bottom (Table IX). The CTD/Rosette package was assembled the day before departure (see 2.1 – Actions prior to the Ship's Departure). Primary TC & Ox sensors corresponding to the CTD fish had calibrations from 2016. Secondary TC & Ox sensors installed ad-hoc for this cruise were brand new and fresh calibrated (see Table XII). The secondary T-duct (Fig. 31) that came with this sensor from factory call our attention as its inner diameter was significantly smaller (Fig. 31; right-top) than the usual T-duct expected by us (see Fig. 31, right-botton).

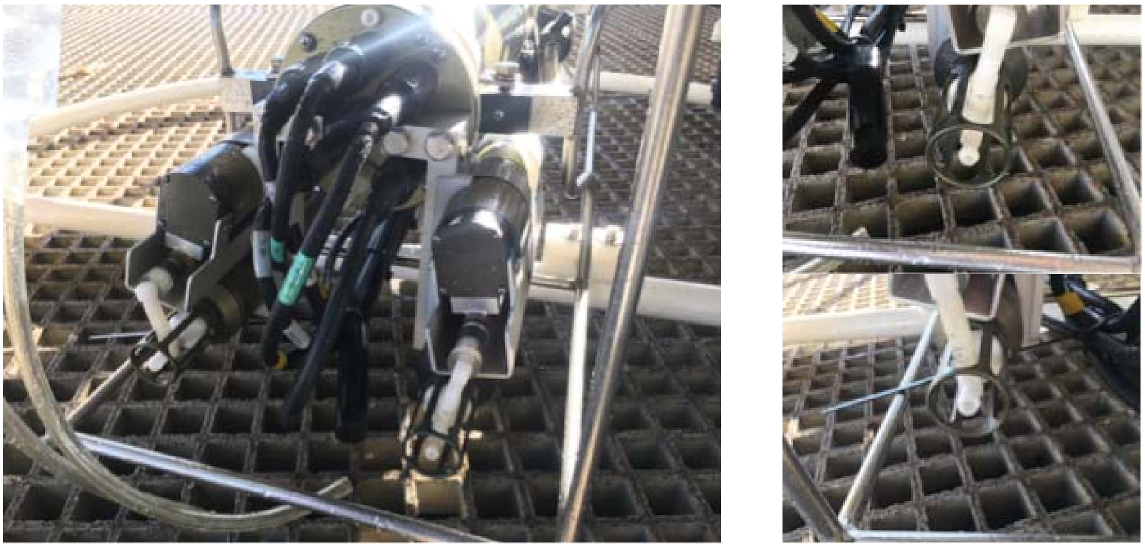


Figure 31. Redundant Temperature-Conductivity sensor (TC)(left). Secondary brand new TC sensors from SBE (left-top) assembled with a T-duct with a significant difference in section compared with primary T-duct (left-bottom).

With a smaller section, flux thru the sensor, forced by the same pump model (SBE5T), is expected to be different among them. Although no despaired response was observed among primary and secondary sensors, we'll be requesting farther information to SBE regarding these difference.

Table IX. CTD, ADCP and TSG (termosalinograph) sensors used on the cruise.

System	Sensors	Model	Serial N	Calibration date
CTD	Pressure Digiquartz w/ temp. compensation	SBE 9plus	1291	25-Oct-2016

Primary	Temperature	SBE 3 plus	0-36133	01-Oct-2016
	Conductivity	SBE 4c	04-4615	19-Oct-2016
	Oxygen	SBE 43	43-3431	01Oct-2016
	Pump 0	SBE 5T	05-8858	
Secundary	Temperature	SBE 3plus	03_6411	22-Mar-2019
	Conductivity	SBE 4C	04-4883	01-May-2019
	Oxygen	SBE 43	43-3822-	01-May-2019
	Pump	SBE 5T	05-9607	
	Altimeter	Benthos PSA 916	57419	19-Sep-2012
ADCP	RDI-Teledyne	WHS300 KHz	13985	
TSG	Temp-Conduct.	SBE 45 microTSG	0369	
	Remote Temp.	SBE 38	64306	

The CTD frame was ballasted with 360 kg of lead to balance the L-ADCP on the cage and add weight to the package to reduce kinking on the cable under heavy seas condition. Fig. 32 shows the ballast distribution around Rosette frame for future used.

Figure 32. Distribution of weight around the Rosette frame to ballast the CTD/LADCP/Rosette package.

Figure 33. OTE 5l Niskin bottle with external spring mounted in the SBE Rosette.

The Rosette bottles were brand new OTE with external stainless still spring and new nylon lines installed the day before departure (Fig. 33). The EM cable was Electro-mechanically end terminated by LIO people prior to the cruise. The end termination uses a steel block with a *wood alloy* for traction and a water tie electrical connection for communication and data telemetry. This electro-mechanical termination needed to be completely re-done after station 12 when heavy sea made fail the electrical connection to the CTD fish.

For security a *Chinese finger* was also installed above the block with a loose heavy strapped to the rosette cage. This device actually prevented the loss of the whole package on station 16.

Two test station were performed before arriving to the working area, Test 0 at 20 m, 1h from the port of Santos and Test1 once the ship reached 2000 m of bottom depth. In both cases the CTD fish overall performance was checked. All bottles from the Rosette were tripped in order to test also bottles closure, lines and release mechanism.

SAMOC section was started at its western end, over the coast in from of Albardão (Fig. 4). The first part of the section continued perpendicular to the bathymetry from the coastline thru the shelf break, shelf slope, down to a depth of 1300 m. Stations 1 to 7 were over the continental shelf (20 to 125m). Stations 8 to 10 were over the shelf break and slope between 390 and 1400m. The Bottom Pressure Recorder (BPR) was located at station 7, while the ADCP mooring site corresponded to Station 8. CPIE 0A was moored at station 10 (982 m). Last station of the cross-bathymetry line was # 9 where CPIE A was located. From this position (51° 30'W) the section become zonal along 34° 30'S until 34° 30'W with an extension of 640 km (Fig.4).

The CTD package, once in the water, was lowered immediately to 10 m for sensor soaking (in particular the oxygen ones) and pump activation. When this condition was obtained, the CTD was rised to the surface and marked the acquisition (to latter extract the surface and scan number records, and immediately after, the CTD was lowered at 30 m/min down to 100 / 150m, then 45 m/min down to 200/250m and finally 60 m/min up to 100 m off the bottom. Under rough sea (heavy waves) the package was sent deeper (over 20) and the surfacing procedure was coordinated in order to have the instrument below the surface 1 or 2 seconds (less than the wave frequency). A benthos altimeter was used to control the approach to the bottom with an alarm programed on SEASAVE to ring 10m off the bottom. Depending on winch maneuvering and sea conditions the CTD package was lowered up to a safe distance of 10 to 20 meters off the bottom on deep, shelf break and slope stations, and 2 to 5 meters on the shelf stations. From 100 m off the bottom the lowering speed was reduced to 30 m/min and to 20 m/min around 50/40 m when the altimeter start to reflect the distance to the bottom. Only few times the altimeter gave return signal at this depth, mostly it started between 30 to 20 m. The upcast was started at 45 m/min (after tripping of bottom bottles) and immediately after increased to 60m/min to near the surface. In the way up, the package was stopped at selected depth to close bottles for salinity, chemical and geochemical analysis.

A repetitive problem observed thru the cruise was random miss-closing of the bottom caps on several bottles. This occurred on bottles (station): 22 (Test0); 12, 14 y 22 (2); 13 (3); 23 (4); 6 (5); 22 (6); 6 y 10 (8); 9 (9); 2 (10); 22 (11); 2, 11, 22 (19); 2 (19-1); 6 y 10 (20). To solve this problem the length of the lower cap nylon line needed to be adjusted in order to have the handle of cap passed the horizontal position toward the bottle when cocked.

On station 12 the bottle fire control was totally lost after bottle 14 and six bottles were unclosed when the CTD was back on deck. Twenty-two error count occurred on this station. The end termination was redone, and the problem solved. For complete details see section 4.10 – June 23 (Description of the daily activities).

On station 16 we have heavy sea with large waves and significant rolling of the ship. Even though assembled with only 8 bottles to increase its free fall velocity and minimize damage on the cable, it suffers significant stress when entering into the water. At 1850m we started to have erratic

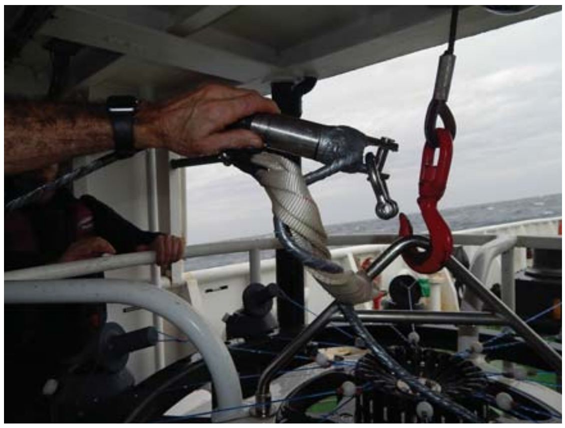


Figure 34. Recovery of the CTD/rosette package with the safety device after loosing the shackle pin when tie-wraps were cut under waving action.

connection with the CTD. Which made us suspect of electrical shortage of the cable. The package was returned to surface and the CTD Rosette comes back holding from the safe strapped line (Fig. 36). The main shackle lost its pin after cutting the safety tie-wraps. The shackle pin didn't have a cotter pin hole; so only heavy tie-wraps were installed on the pin eye to secure it. After cutting the tie-wraps, by the friction action of the shackle over the lifting bail, the stainless-steel ping went away under the continuous waving of the package (Stanley still never seize as normal steel). After this station an steel shackle with bolt, nut and cotter pin was installed.

The electrical connection was re-established after the end termination was re-done. Details of this event is described also on section 4.13 – June 23 (Description of the daily activities).

Stations 16, 17 y 18 were done without Rosette (no bottles) as the weather forecast was not favorable for full CTD/Rosette cast. To perform this station the CTD fish was disassembled from the Rosette and set both pair of sensors for vertical profiling. Four weight of lead totaling 80 kgs. Was also added to the CTD frame (SECTION 4.15).

In general, the CTD and Rosette had a normal perform, maintaining its high standard in operation and data quality (see section 5.6 Performance of the CTD).

5.4 Data acquisition and preliminary post-processing (Marcela Charo)

Data acquisition, via the SBE11 deck-unit, was done using SEASAVE V7.22 software. CTD data were preliminary post-processed according to common standards, using Seabird Data Processing V.7.26.7 software routines (Seasoft-Win32, http://www.seabird.com/software/software, SBE, 2017). The nominal calibrations were used for data acquisition.

Typical Data Processing Sequences

- Data Conversion: Convert raw.hex to engineering units, and store converted data in *.cnv file (all data) and/or *.ros file (water bottle data).
- Wild edit: Mark data value with *badflag* to eliminate wild points.
- Filter: Low-pass filter columns of data.
- Align CTD: Align data (typically conductivity, temperature, oxygen) relative to pressure. This ensures that calculations of parameters are made using measurements from same parcel of water.
- Cell Thermal Mass: Perform conductivity cell thermal mass correction if salinity accuracy of better than 0.01 PSU is desired in regions with steep gradients.
- Loop Edit: Mark scans where CTD is moving less than minimum velocity or traveling backwards due to ship roll.
- Derive: Calculate salinity, density, oxygen and other parameters.
- Bin Average: Average data into desired pressure or depth bins.
- Bottle Summary: Summarize data from water sampler *.ros file, storing results in *.btl file.

CTD Data are reported in standard Seabird Converted Data File (cnv) format. Converted files consist of a descriptive header followed by data converted to engineering units. The header contains station time and position information; the name of the raw input data file; the number of data rows and columns; a description of observed and derived variables in each column; interval between rows; scan rate or bin size and records of all processing steps.

5.5 Salinities measurement (Maurício Rocha, Thamirys Cavaton and R. Guerrero)

Figure 35. Autosal Guildline 8400B bench salinometer used for on board salinity analysis.

A total of 167 salinity samples were taken and analyzed aboard the ship during the cruise in order to monitor CTD conductivity sensor performance and bottle closure depth. Nine of those, taken in the test-stations, were used to test the equipment.

These samples were processed with a Guildline 8400B Autosal (SN71012) (Fig. 37), using IAPSO *P160* with k15: 0.99983, salinity 34.993 and expiration date at July 2019; IAPSO *P161*, k15: 0.99987, Salinity 34.995 and expiration date at May 2020. The salinometer bath temperature was set to 24˚C and the room temperature was kept between 2 and 3˚C below the setting temperature. The room temperature was measured with a digital platinum thermometer with 0.1 °C resolution, read each five samples for control.

Mauricio Rocha, Thamirys Cavaton and Raúl Guerrero processed the samples and the calibration. At the start of each measure, the standardization was performed using new IAPSO standard seawater vial. Autosal calibration was performed following the manual of the instrument, starting with a bath temperature control check, and then followed by the reference calibration as well as the zero-calibration checking. Before starting the standardization, we flushed the cell a few times to check proper operation of the circuit with the distillate water, then flushed with sea water 10 times (ideally with salinity close to 35 PSU). Then standardization began: Opening the vial and start flushing with the standard water at least 3 times, a fourth filling of the cell can be used for reading first CR. If stable, the measurement should be recorded as a reference for drifting of the calibration when compared with the previous run. Then the standardization knob should be used to match the reading of the CRx2 with the value expected for the IAPSO Standard Water value. The following reading may require fine adjustment of the cal knob. Calibration will end when three subsequent readings are stable within ± 0.0001. Then the Autosal should be considered calibrated and unknown samples could be measured afterward.

We used standards to verify if the Autosal readings were stable, however there were not enough standard for analyzing samples from all stations. As some stations were not sampled (due to bad weather conditions) and we waited to perform the analysis after sampling a few stations, the amount of standard was plenty until the end of the cruise. We also collected four seawater sub-standard samples on station 13-rosette bottle 1 (429 & 452, 453, 454, 4553) from 3150m (old and unchangeable water mass use as a reference along runs C and D). Bottle 429 was measured after the standardization on Run C (reference), bottle 452 was used to close this run, Bottles 453, 454 and 455 were used for drift control on run D. The Rc values among these sub-standards shows a mean of 0.99414 and standard deviation of 0.00005 after taking out 1 outlier (bottle #455, not considered as a reference) outside a mean ± 1 times the standard deviation in two iterations.

The salinity analyses were performed in five batches: A (tests samples and training), B (station 1-12, costal and slope), C (station 13-15, deep stations) and D (station 15-21, also deep stations). Finally, a batch E performed for the thermo-salinometer samples. The batches A, B and E followed methodology described at the previous paragraph. But on runs C and D sub-standards reading were included. It was read once on batch C and three times on D. For this last run, new standards were read three times: at the beginning for standardization, then mid and end of the run for drift control. As the sub-standards were from the same sample, they were expected to present the same values of conductivity ratio. We verified if these values changed during the run. If the values change, it would be an indication that the Autosal readings were drifting.

The Salinometer Data Logger software presented a connection problem when transferring the data from the Autosal to the computer. We were not able to solve this problem during the cruise, so the Autosal data was recorded manually in a log sheet then transferred to an excel spreadsheet for salinity calculation. Salinity was calculated according to the Practical Salinity Scale of 1978 (UNESCO 1981), obtained from the instrument manual.

In order to verify proper operation of the instrument and precision in the results, duplicates were taken on Station 14 (3537 db), Station 15 (3868 db) and Station 21 (4842 db) for later analysis at the laboratory in the IO USP. These duplicates results will also be used to verify the accuracy of the Autosal readings during the cruise. The list of duplicate salinity bottles with the respective station and rosette bottle numbers are included in the following Table X:

Table X. Salinity samples to autosal analysis.

Station	Rosette Bottle	Bottle duplicates
14	2, 5, 13	571 a 573
15	2, 7, 21	574 a 576
21	2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12, 13, 14, 15, 16, 17, 18, 19, 20, 21, 23	577 a 590 423 a 429

We observed few problems using the salinity observations during the cruise. The first problem was the sampling salinity bottles available for drawing water from the rosette and measure salinity in the Autosal. There were only 101 bottles, which are a very limited number for sampling in all the scheduled stations. In addition, some of these bottles presented a broken cap, which hindered their use. Same bottles had no seal (insert) that warranty no leakage and/or evaporation. Another situation was that solid sediments were observed in many bottles from batch/box 450 590 used for sampling several stations throughout the cruise and could cause bad readings. These sediments were incrusted in the bottom of the bottles and Hydrochloric acid solution (30%) were used to remove them and have the bottles available. After cleaning, few bottles were used to take samples and duplicates from station 21. There were also observed crystals of silicon in suspension in some bottles of these batches. This could been happen after the cleaning with hydrochloric acid, but was not possible to verified. In any case, it is recommended to discard these bottles and have all bottles for future cruises cleaned with a warm mild detergent (e.g. triton at 1% dilution) and have them thoroughly flashed with plenty of distilled water afterward.

There were also some difficulties in keeping the laboratory temperature during run C. During run C the laboratory temperature kept increasing and it could be the reason for the moderated drift observed thru station 12, 13 & 14.

IAPSO batch change from P160 to 161 between run B and C. The standardization on run C was wrongly performed to 1.99964 when the correct value was 1.99974, so to all C_R values from this run it was added 0.00010 units to correct the error. After run E the conductivity cell, right at the entrance, showed some jelly stuff, which was cleaned with 1% triton (slightly warmed) and then thoroughly flashed with distilled water.

5.6 Performance of the CTD salinity and Oxygen (Raul Guerrero & marcela Charo)

CTD Salinity

The accuracy of the salinities measured by the CTD was evaluated by comparing the salinities from the water samples with the primary and secondary salinity values coming from the CTD (DeltaS0 and DeltaS1).

A total of 154 salinity bottles were drawn from the rosette bottles. After taking out outliers outside a mean ± 2 times the standard deviation in three iterations, the number of sample used to preliminary estimate an average error and uncertainty on the CTD salinities was 128 observations for primary and 131 for secondary sensor. Figure 38 (top) shows the deltas (BTLsal – CTDsal) versus depth for both primary (red dots) and secondary (black dots) sensors without outliers. It is also shown a constant fit for secondary deltas, which has the fresher factory calibration.

Delta salinity statistics on the salinity differences, for primary and secondary sensors, are presented in Table XI. This fitting has to be considered as preliminary as more analysis has to be performed on the different runs to diminish the overall error in the fitting.

Most relevant observations on the estimated deltas that could diminish the error are:

- A shift in the deltas (for both sensor) has been observed between runs B and C. This shift could be caused by the change in the batch # of the vial. On runs A and B the Autosal was calibrated with IAPSO standard seawater batch P160 (expiration date: June 2019). While on runs C y D the Autosal was standardized with batch P161 (expiration date: 3/05/2020). A shift of +0.004 is observed in Figure 38, between station 12 and 13 (middle) and record 310 (bottom).
- Run C shows a drift during the run (stations 12, 13 & 14) (Figure 38, middle), when considering the Sub-Standards measured one (#451) immediately after the standardization and a second one (#451) at the end.
- Investigate the reason of a large number of bad deltas on station 21. First check if similar error occurred with the oxygen samples (e.g. due to miss tripping of rosette bottles o shifted in depth selection). Another reason, more difficult to prove, could be contaminated salinity samples (loosed deposit after cleaning with hydrochloric acid or even silica crystal in suspended as has been observed in some bottles (see section 5.5 Salinity measurements).

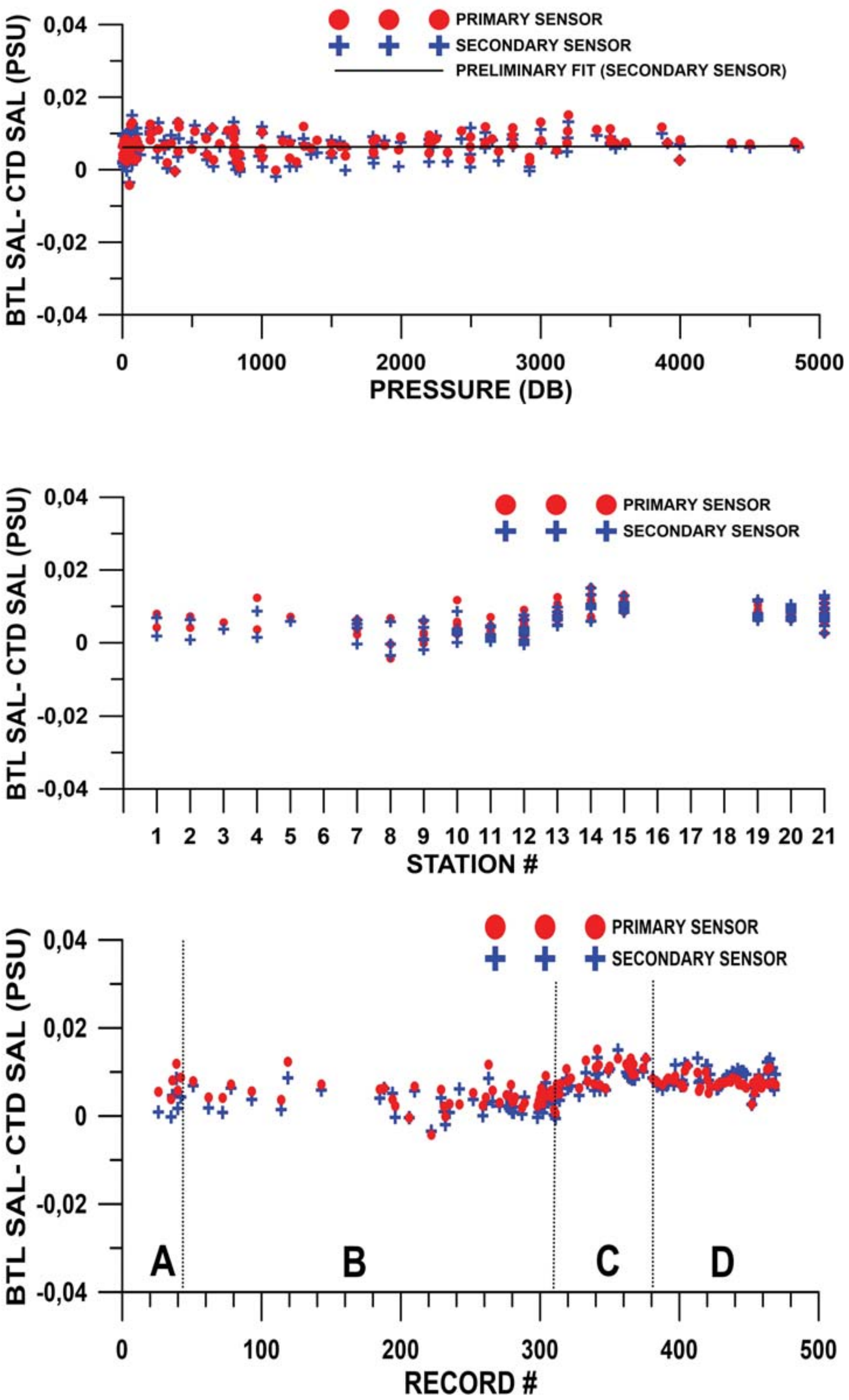


Figure 36. Differences between rosette salinities and CTD salinities (Delta: BTLsal – CTDsal) versus depth (top). Deltas versus station number (middle) and deltas versus number of record/sequence of measurement (bottom). Red (blue) dots show differences for primary (secondary) sensor. A bias fit for primary sensor is shown on top graph.

Table XI. Statistics of the differences in salinity between bottles and CTD (Deltas: BTLsal – CTDsal) for primary and secondary sensors.

Deltas	Mean	StdDev	N obsevations	% used
Primary	0.0069	0.0032	128	83
Secondary	0.0062	0.0038	131	85

CTD precision in TS diagram

The cruise evolved from the coast to the easternmost point accomplishing 21 stations within 8 days (21 to 28 June). Figure 39 present the scatter TS plots from the CTD, for primary (right) and secondary sensors (left). Tied enveloped at bottom waters (Te<0.5°C) indicates good stability in the CTD Te, Co (Sa) sensors throughout the cruise and for both sensor pairs.

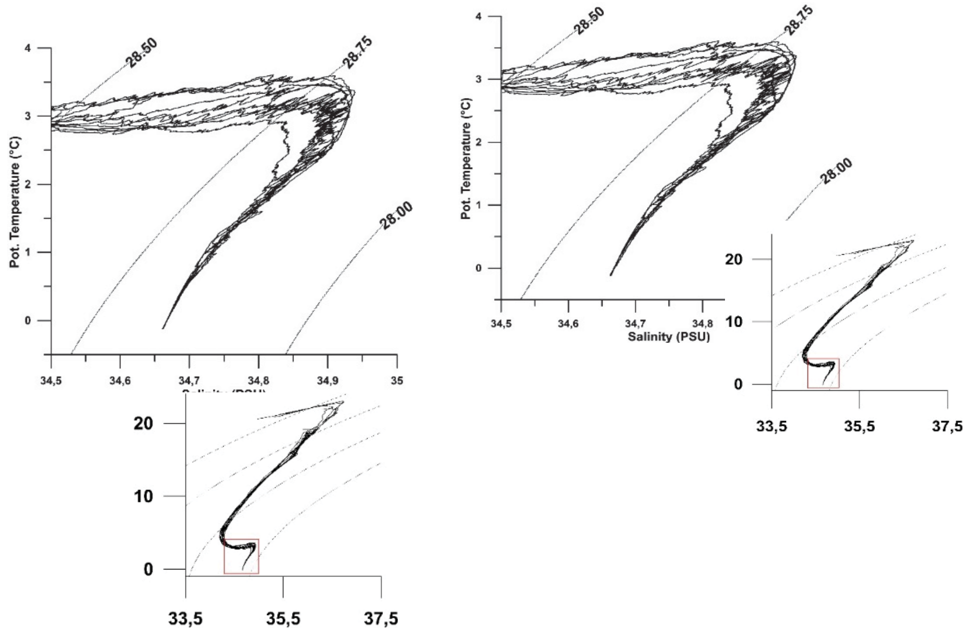


Figure 38. High resolution Scatter TS plot for deep and bottom waters, showing a tied TS envelop below 0.5 °C. This indicates good stability on the CTD salinity measurements for primary (left) and secondary (right) sensors. Inset: Reference high-resolution scatter TS plots from surface to bottom waters. for deep and bottom waters

CTD Dissolved Oxygen

Preliminary calibration of the oxygen sensors (SBE43) was performed using a statistical method estimating calibration coefficient for calculating dissolved oxygen in milliliters per liter (ml l^{-1}) from SBE 43 output voltage. The technique requires dissolved oxygen concentrations reported in ml/l determined from a range of Winkler titrated water samples and SBE 43 oxygen voltage outputs measured at the times the water samples were collected (SBE, 2012).

Mean residual for primary and secondary sensors were 0.001±0.03 (N=253) and 0.000±0.04 (N=252), respectively. Figure 40 presents the differences between SBE 43 dissolved oxygen for both sensors before and after preliminary calibration and Winkler titration dissolved oxygen.

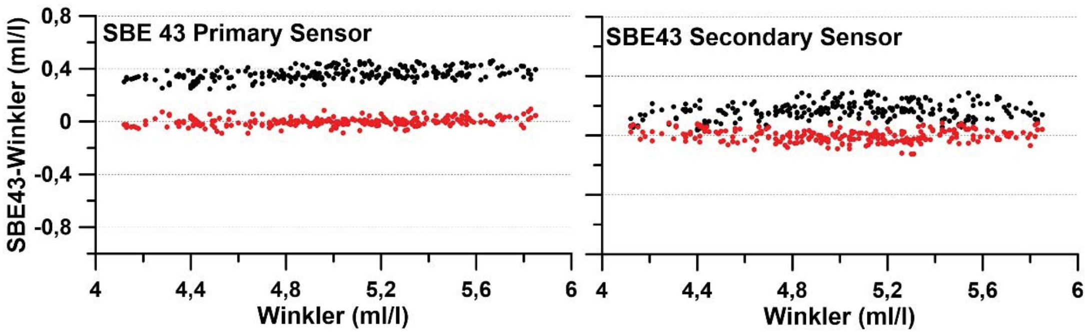


Figure 39. Distribution of dissolved oxygen residuals versus dissolved oxygen concentration (both in ml/l), before (black) and after (red) preliminary SBE43 sensors calibration.

5.7 TSG underway measurements (M. Charo, H. Fenco and R. Guerrero)

Throughout the cruise, underway quasi-continuous surface temperature and salinity observations were collected using a SBE 45 MicroTSG Thermosalinograph. The data were recorded at 10-second intervals along the track. The data from the sensors are transmitted via the SBE45 interface box, where also the NMEA GPS position is collected an string in the data record to the underway PC. On the underway PC a Data Acquisition System (DAS) gather the TSG data with meteorological and bathymetry information to generate a unique underway data logging. During this cruise Seasave V7 data acquisition software from SBE was run in parallel to collect exclusively the SBE38 and SBE34 data and treat it independently.

Temperature sensor SBE 38 is installed 3 m from the hull water intake (3m below vessel water line) on a $1^{1/4}$" pipe line. The thermosalinograph SBE 45 is located just 1 m above the SBE 38 (4 m to the intake) on a ½ " diameter pipe.

The system does not have a bubble tramp, which is highly recommended to avoid spiking on the conductivity reading and salinity calculations when bubbles enter into the system. A schematic draw for a simple bubble tramp is presented in Figure 40 that can be build and installed in the Alpha Crucis TSG circuit.

Bubble effect on conductivity (consequently on salinity calculations too) is observed under rough seas/high waves as can be observed on our cruise TSG records between stations 16 and 19 (Figure 41, e.g. Julian day 177).

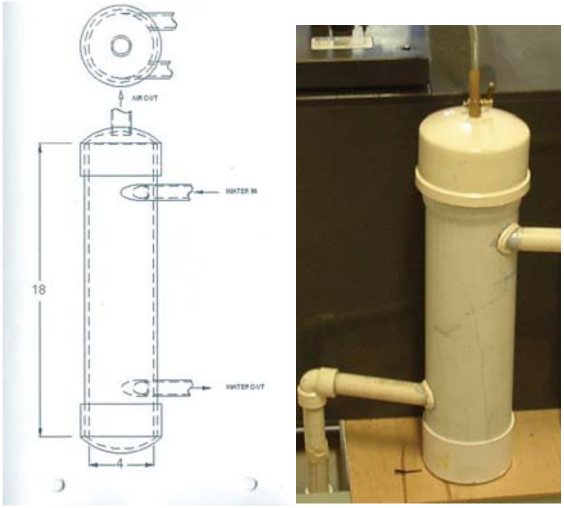


Figure 40 Simple design of a bubble tramp that can be installes in the Alpha Crucis TSG system (left). Actual bubble tramp installed in INIDEP RVs (Fisheries Research Vessels in Argentina).

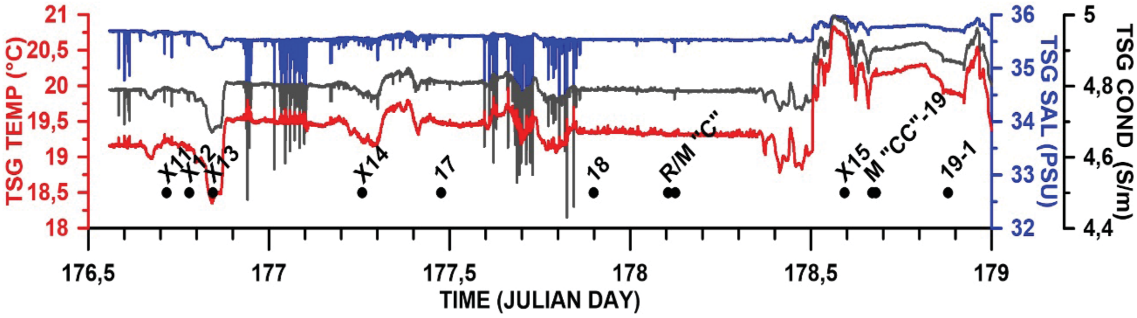


Figure 41. TSG time series throughout stations 16 to 19 showing noisy values when NOc AC was sailing under high seas and having bubble contamination in the SBE 45.

For calibration purposes, TSG temperature and salinity were compared with CTD temperature and salinity data extracted from the 3 dbar level during down and up casts at each station (Fig. 41). The comparison was done based on CTD secondary sensors only. Statistics of the differences between the CTD and thermosalinograph are shown in Table XII and Figure 42. The error observed in Salinity (>0.4 PSU) is larger that during SAMBAR-01 cruise (<0.2 PSU), which could be due to bio-fouling growth. It is suggested a cleaning procedure with warm Triton detergent al 1% dilution and distilled water. If reduction of the error does not occur, the instrument should be sent to factory to calibrate and re-platinize the Co cell.

Table XII. CTD versus Thermosalinograph and SBE38 comparison. Number of samples (N) is indicated for each sensor.

Sensors	Mean (CTD-TSG)	Std. Des.	N
SBE38 Temperature (°C)	-0.04	0.02	40
SBE45 Temperature (°C)	-036	0.03	41
SBE45 Salinity (PSU)	0.43	0.05	40

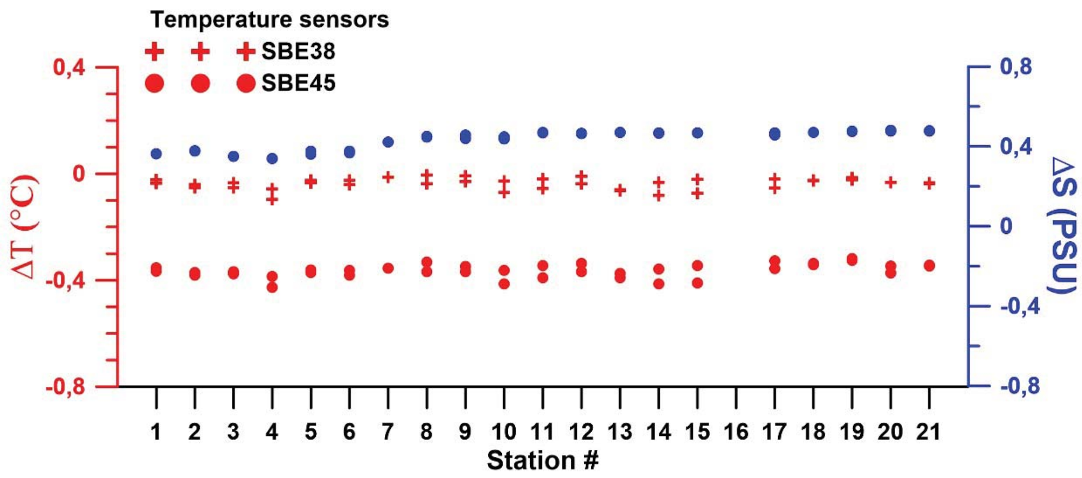


Figure 42. CTD versus TSG (SBE45 and SBE38) comparison for each sensor.

In additional, bottle salinity samples were taken from the thermosalinograph water intake to verify the thermosalinograph calibration along ship track (Fig. 43). Differences between the thermosalinograph salinities and the bottle salinities are shown in Table XIII.

Table XIII. Comparison between Thermosalinograph salinity and water sample salinity.

SAMPLE #	DATE/ TIME (UTC)	LATITUDE (°S)	LONGITUDE (°W)	TSG SAL (PSU)	BTL SAL (PSU)	ΔS(BTL-TSG) (PSU)
1	Jun 17 2019 19:34	-24.1849	-46.3719	32.8710	33.2721	0.40
2	Jun 18 2019 12:42	-26.6625	-45.9381	36.4690	36.9279	0.46
3	Jun 19 2019 18:40	-28.7939	-49.0002	35.2959	35.7424	0.45
4	Jun 20 2019	-30.6133	-50.2608	33.4616	33.885	0.42

	12:24				3	
5	Jun 21 2019 02:57	-31.9314	-51.3825	30.2814	30.6574	0.38
6	Jun 22 2019 10:19	-34.3141	-51.6796	34.7686	35.2118	0.44
7	Jun 23 2019 09:19	-34.3333	-51.6584	35.0100	35.4787	0.47
8	Jun 24 2019 13:36	-34.4977	-49.5973	35.5883	36.0626	0.47
9	Jun 26 2019 17:51	-34.5404	-47.1569	35.5914	36.0618	0.47
10	Jun 27 2019 23:57	-34.4956	-45.7721	35.6281	36.1260	0.50
11	Jun 29 2019 13:26	-32.3689	-44.9086	35.9152	36.4104	0.50
12	Jun 29 2019 23:14	-31.1691	-45.1293	35.8688	36.3648	0.50
13	Jun 30 2019 13:36	-29.3531	-45.4347	36.2314	36.7269	0.50
14	Jun 30 2019 23:49	-27.9048	-45.7055	36.3770	36.8701	0.49
15	Jul 01 2019 12:05	-26.0428	-46.0439	34.3669	34.8352	0.47

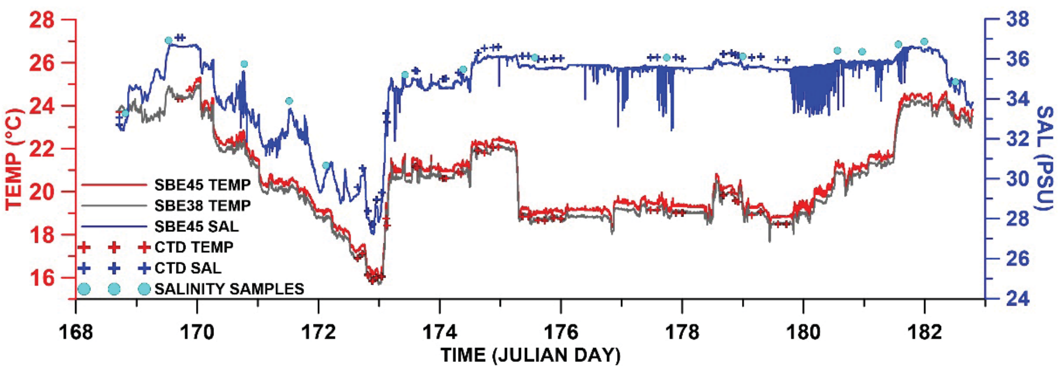


Figure 43. Time series along ship tracks of temperature and salinity: thermosalinograph (red and blue lines) and SBE38 (gray line). Also CTD temperature (red crosses) and salinity (blue cross) at 3 dbar and salinity bottle samples (light blue circle) collected from the TSG water intake are shown.

the ship track (from Santos to Santos) with the TSG temperature (left) and salinity values (right) are presented in Figure 44. On top of the track the positions of surface salinity samples taken for the TSG are also plotted.

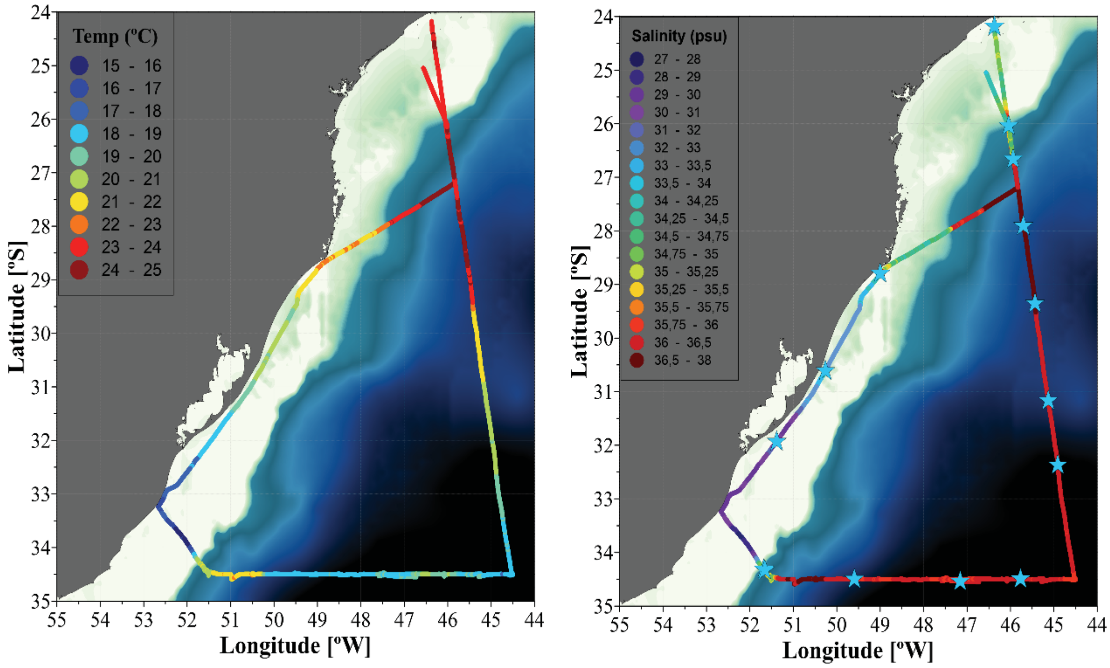


Figure 44. Sea surface temperature and salinity from TSG and location of salinity samples (light blue star) along cruise tracks. The background shading and contours indicate bottom topography in meters.

References

- UNESCO (1981). UNESCO technical papers in Marine Science # 39, Vol 3. Paris, France.

- Sea-Bird Electronics Inc.: Application Note NO.64-2. SBE 43 Dissolved Oxygen Sensor Calibration and Data Corrections, 13431 NE 20th Street Bellevue, WA 98005, USA, 2012.

5.8 Bathymetry information (F. Pinho and R. Guerrero)

The bottom depth was measured throughout the cruise with an EA600 echosounder with a frequency of 12 KHz. The ping rate was set to maximum, and a one-minute average was saved in the Data Acquisition System (DAS). The DAS depth data show a systematic positive offset of 3 m relative to the EA600 depth displayed on the screen on deep water. This offset changed to 1m at waters shallower than 50 m.

The EA600 was switched from active to passive mode every time there was a PIES/C-PIES communication. Unfortunately, from 05:55hGMT on June 24th, the echosounder stopped collecting data. The cause of this is not known. In Figure 45, it is shown the area in which the echosounder obtained information during the cruise.

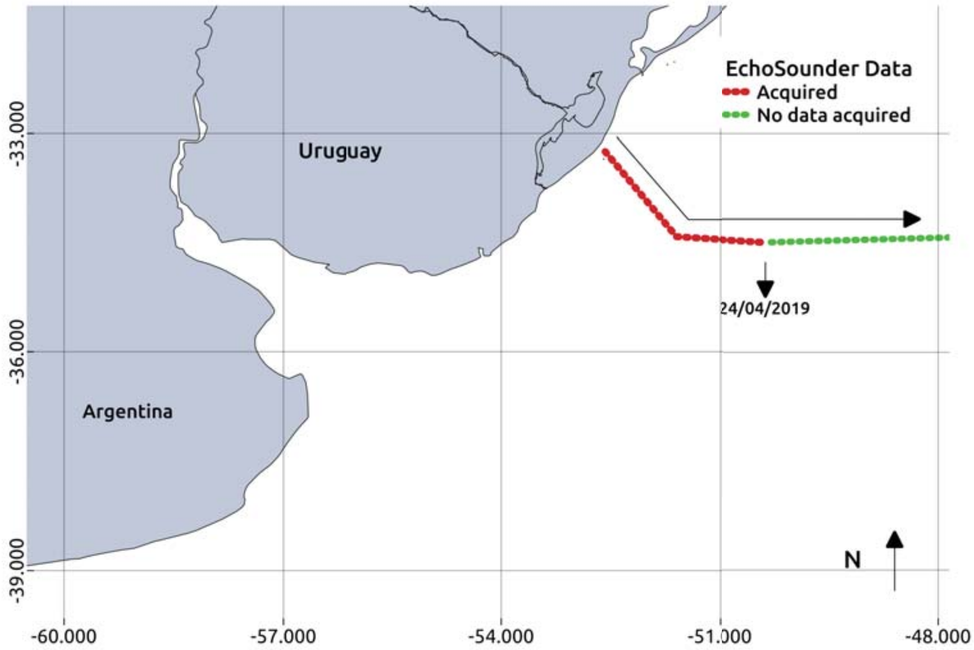


Figure 45. Track of the SAM18 cruise. Red dots mark the line where the echosounder acquired data, and Green where it did not.

Table XIV. Name of the output files from software EA600 created during the SAM18 cruise.

AI201901A1706_01	AI201901C2406_01
AI201901A1806_01	AI201901C2406_01
AI201901A1906_01	AI201901D2406_01
AI201901A2006_01	AI201901E2406_01
AI201901A2106_01	AI201901E2506_01
AI201901A2206_01	AI201901F2506_01
AI201901B2206_01	AI201901F2606_01
AI201901B2306_01	AI201901F2706_01
AI201901B2406_01	AI201901F2806_01

In Figure 46 it is displayed some of the output variables for the acquired data. It is composed of the following parameters: time, latitude, longitude, heading, among others.

1	d	m	a	h	m	s	lat	long	proa
2		GMT			GMT				°
3									
4	23	06	2019	03	50	00	-34.49588	-51.49815	291.3
5	23	06	2019	03	51	00	-34.49620	-51.49840	286.2
6	23	06	2019	03	52	00	-34.49655	-51.49867	280.1

Figure 46. Sample display of the variables displayed by the EA600 echosounder.

The software called RStudio was used for the analysis of the information. The data were preprocessed to remove any outliers related to westbound trajectories during the cruise, since we were only concerned with an eastbound transect.

After plotting the data, we observed the presence of several "plateaus" at the slope, specially in the deeper regions of the ocean, Figure 47. That flat bottom regions displayed in the data are not a representation of the actual sea floor, but a result of our data acquisition configuration in RStudio. This occurs when the acquisition of ocean depth is not adjusted accurately during the course of the cruise but the software continues to acquire information from other updated parameters. In addition to the ship's movement along the transect, the delay to adjust to the new depths develops a flat bottom in the data just because the depth remains constant until a new accurate depth value is obtained.

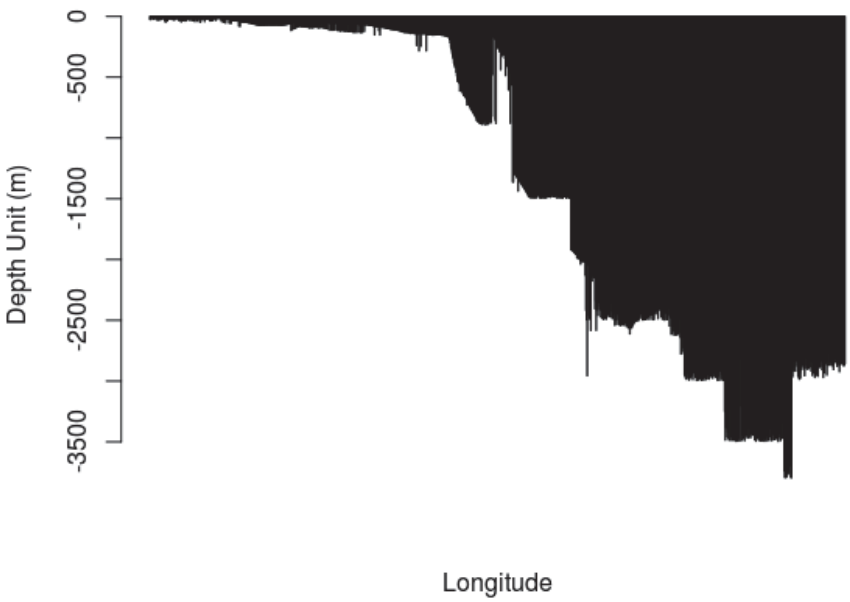


Figure 47. Ocean topography profile for the western boundary obtained by the EA600 and processed by the RStudio software.

These flat regions were neither present nor prominent in the regions including the continental shelf, as seen in the Figure 48. This could be due to the slow changes in the depth along the continental shelf. Even if the acquisition of the depth was not properly sampled, there is a low probability for a flat surface to form in the data. However, noise can still be observed along the transect, as seen in Fig. 49 depicting the actual raw data measured by the echosounder.

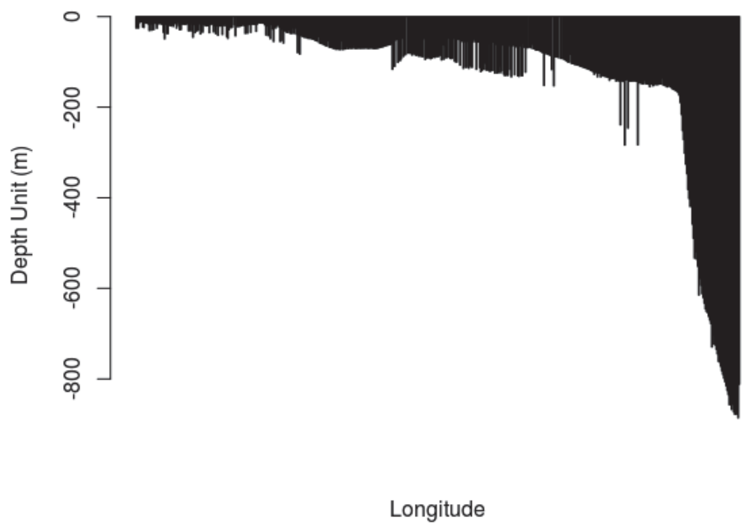


Figure 48. Similar to Figure 48, but focusing on the continental shelf region.

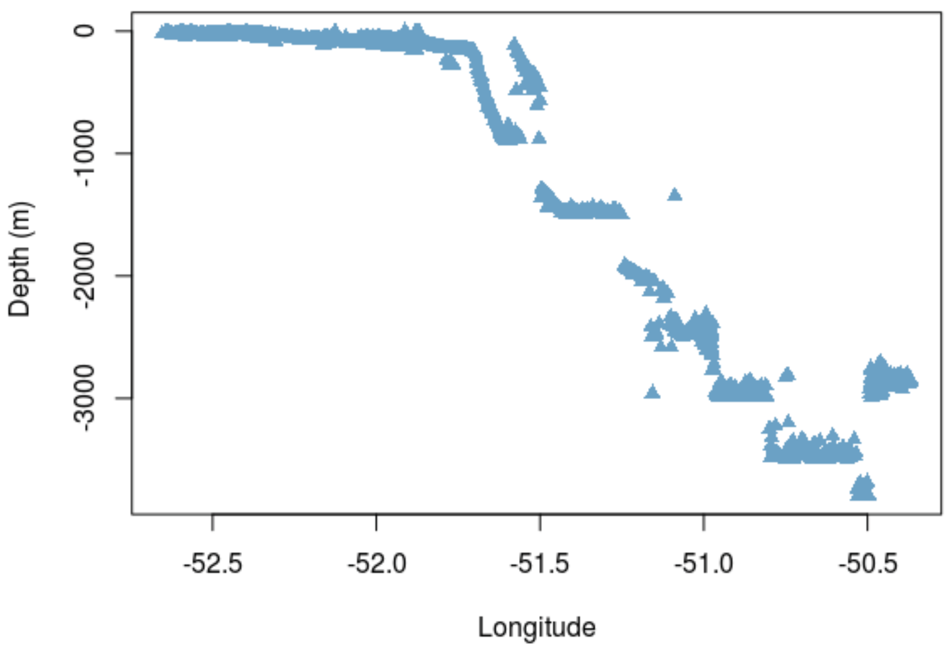


Figure 49. Raw output data from EA600 along the western boundary obtained during the cruise.

A recommendation for the next cruises to prevent the appearance of spurious data during the bottom topography acquisition is to have a person on watch continuously at the echosounder station to update the depth's range.

5.9 XBTs (Olga Sato)

The SAMBA-West XBT line

Figure 50. Deep Blue (left) XBT and T5 XBTs.

Starting after Station 6, one XBT was launched in between pairs of adjacent stations of the SAMBA line. Until site D, the total of 16 probes were deployed: 3 (four) Deep Blue model in the regions shallower than 700 meters, and 13 T-5 for the deeper regions (Fig. 50). Details of each launch are given in Table XV and Figure 51 displays the vertical temperature section produced with the data collected by the XBTs along SAMBA.

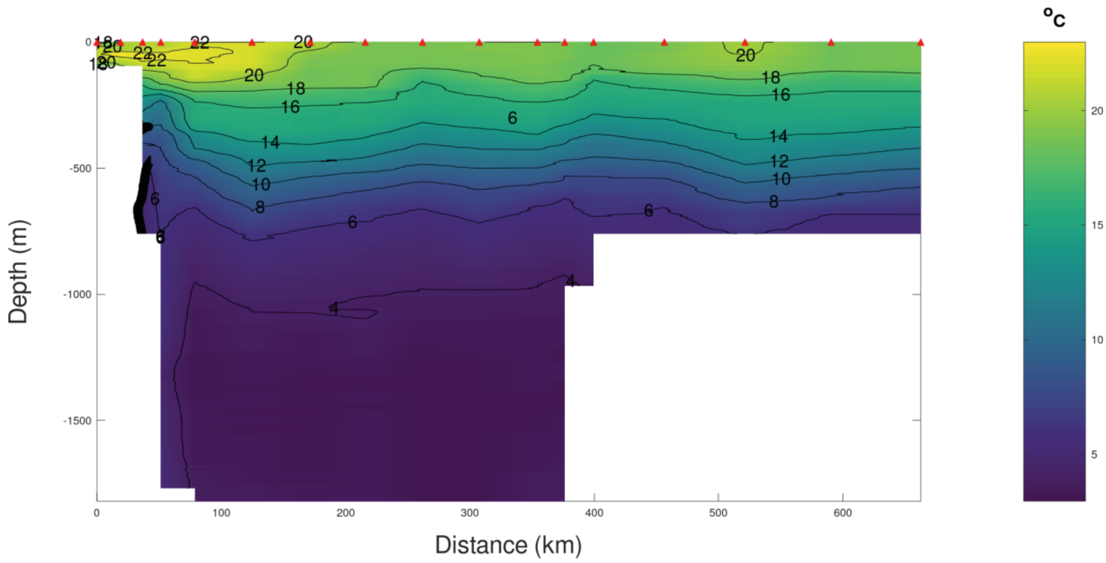


Figure 51. Vertical section of temperature from XBT along SAMBA 2019 as a function of depth and distance (km). In the second part of the cruise, only Deep Blue XBTs were available.

5.10 PIES/CPIES Operations (Diego Ugaz & Olga Sato)

Two NOAA PIES were shipped and from the US to Brazil. Two CPIES were also provided by IOUSP, as well as a third CPIES that had to be refurbished for an additional deployment. The PIES provided by NOAA were deployed at sites A and C, whereas the first two CPIES provided by IOUSP were deployed at sites AA and BB. The third CPIES upon refurbishment was deployed at the new site 0A.

Two DS7000 acoustic deck units were utilized in each telemetry session. One unit provided by IOUSP was deemed the primary unit and connected to NOAA's IES Telemetry Application on a Windows platform, whereas the second one (NOAA provided) was connected to the same application on a Linux platform. Both transducers were placed port-side approximately ten and six meters in front of the CTD package and winch cable respectively. Each transducer was also typically submerged approximately ten meters below the surface with a set of weights that were used to prevent drag depending on sea conditions.

All goals for this year's IES operations were successfully met. The following pages include a detailed summary of all PIES and CPIES operations conducted at each site, including additional details for units that underwent refurbishment and upgrades. Table XII shows the location of each instruments, considering the reallocations occurred during the cruise.

Table XV: Allocation of the instruments before and after this cruise.

	Instrument locations							
	Site 0A	Site A	Site AA	Site B	Site BB	Site C	Site CC	Site D
Before	-	PIES 221	CPIES 290	PIES 401	CPIES 289	PIES 280	-	PIES 282
Current	CPIE 291	PIES 187	CPIES 409	PIES 401	CPIES 408	PIES 222	CPIES 290	PIES 282

Detailed information on the operation performed on each of the units is given in below.

Site 0A

Operation: Deployment/Burst Telemetry PIES SN=291
Latitude: 34º 24.270 S
Longitude: 51° 35.390 W
Depth: 875 m
Deck units: Brazil (primary) and NOAA

TELEM: 67 BEACON: 75
RELEASE: 35 CLEAR: 76
XPND: 71

Date: 6/22/2019
Arrival Time at station: (07:13:00 GMT)
Telemetry: 06/23/2019, time in station: (06:00:00 to 06:34:00 GMT)

Notes:

CPIES 0A was deployed and was verified to have reached the ocean floor on 6/22 but burst telemetry was done the following day with successful results.

Site A

Operation: Telemetry/Recovery PIES SN=221
Latitude: 34° 29.90 **S**
Longitude: 51° 30.10 **W**
Depth: 1360 m
Deck units: Brazil (primary) and NOAA

Date: 06/22/2019
Time in station: 18:35:00 to 22:10:00 GMT

Operation: Deployment PIES SN=187
Latitude: -34 29.772 **S**
Longtitude: -51 29.940 **W**
Depth: 1360m
Deck Units: Brazil (primary) and NOAA

Date: 06/22/2019
Time in Station: 00:53:00 to 04:04:00 GMT

Notes:

- The ship had to be repositioned and CLEAR was not sent in between positioning.
- The instrument began sending data and abruptly stopped after the first block even though it wasn't the end of the day.
- Ranging was completed and verified before conducting a CTD station.
- Burst Telemetry was conducted after CTD station. Memory card was empty and did not have enough time to sample beforehand and could only verify sampling and functionality by observing sampling at the top of the hour on the deck units.
- Memory card for 221 was uploaded and backed up onto the SAMBAR directory. It was then wiped to prepare 221 as a backup unit for site D in case of emergency.

Site AA
Operation: Recovery CPIES SN=290
Latitude: 34° 29.974 **S**
Longitude: 50° 30.015 **W**
Depth: 2885 m
Date: 06/23/2019-06/24/2019
Time in Station: 23:47:00 to 01:09:00 GMT

TELEM: 66 BEACON: 74
RELEASE: 34 CLEAR: 76
XPND: 70

Operation: Deployment CPIES SN=409
Latitude: 34° 29.91 **S**
Longitude: 50° 29.92 **W**
Depth: 2885 m

TELEM: 65 BEACON: 73
RELEASE: 25 CLEAR: 76
XPND: 69

Date: 6/24/2019
Time in station: from 08:40pm to 10:08pm (**I have 03:00:00 to 05:17:00 GMT**)

Notes:

- This CPIES did not telemeter in October 2018, it was likely that it was not working properly, so we initiated recovery as soon as possible. Recovery was successful and data was uploaded from memory card 290.
- At this site, a brand new CPIES AA (SN 409) was deployed. After the waiting time until it reached the ocean floor, a telemetry session was done to verify if it would respond. The burst telemetry showed a good sample of data.

Site B
Operation: Telemetry PIES SN=401
Latitude: 34° 30.039' **S**
Longitude: 49° 29.999' **W**
Depth: 3535 m

TELEM: 66 CLEAR: 76

Date: 06/24/2019
Time in station: from 14:18:00 to 17:35:00 GMT

Notes:

- CTD station also conducted throughout telemetry session. The transducer that was closer to the package had a drop in quality during operations.
- There was also a miscommunication with the bridge that resulted in removing the transducers from the water before a CLEAR command could be sent to pause the telemetry session. Attempts to recover and pause the session before the end of the file were unsuccessful or could not verify 2 ping replies to either TELEM commands or CLEAR commands at the end of the session.

Site BB
Operation: Telemetry/Recovery CPIES SN=289
Latitude: 34° 29.974' **S**
Longitude: 48° 30.015' **W**
Depth: 4200 m

Date: **06/25/2019**
Time in station: 07:33:00 to 10:33:00 GMT

TELEM: 65 BEACON: 73
RELEASE: 33 CLEAR: 76
XPND: 69

Operation: Deployment CPIES SN=408
Latitude: 34° 29.945' **S**
Longitude: 48° 30.055' **W**
Depth: 4200 m
TELEM: 67 BEACON: 75
RELEASE: 24 CLEAR: 76
XPND: 71

Date: 06/25/2019
Time in Station: 12:16:00 to 14:57:00 GMT

Notes:

- No Final Yearday was requested for telemetry on 289
- No 2 ping reply was received for the CLEAR or 1st TELEM command attempt for 289

- 2nd TELEM command attempt was recognized with a 2-ping response
- Could not verify if sampling started or if sampling occurred at top of the hour
- Telemetry notes did observe current meter readings consistent with C. Meinen's notes from 10/2018
- Successful burst telemetry and deployment for 408
- <Status about 289 here and needing f/w updates?>

Site C
Operation: Telemetry/Recovery PIES SN=280
Latitude: 34° 29.593' **S**
Longitude: 47° 29.889' **W**
Depth: 4540 m
Deck units: Brazil (primary) and NOAA

TELEM: 65 BEACON: 73
RELEASE: 24 CLEAR: 76
XPND: 69

Date: 06/26/2019-06/27/2019
Time in station: from 20:50:00 to 02:32:00 GMT

Operation: Deployment PIES SN=222
Latitude: 34° 30.125' **S**
Longitude: 47° 29.758' **W**
Depth: 4540 m
Deck units: Brazil (primary) and NOAA

TELEM: 67 BEACON: 75
RELEASE: 30 CLEAR: 76
XPND: 71

Date: 06/26/2019-06/27/2019
Time in station: from 03:00:00 to 07:40:00 GMT

Notes:

- Transducer or the float above the transducer was banging a lot against the hull upon retrieval of both post-telemetry and recovery
- Telemetry session was fine and did not suffer much noise or reception loss relative to others
- Deployment of 222 had an issue where the memory card barely had time to sample before deployment which made burst telemetry difficult. Was able to verify that it had reached and remained at the bottom with XPND mode. Operator made note to leave the IES unit sampling for at least a day before deployment in the future

Site CC
Operation: Deployment CPIES SN = 290
Latitude: 34 29.997' **S**
Longitude:46 05.465' **W**
Depth: 4730 m
Deck Units: Brazil (primary) & NOAA

TELEM: 66 BEACON: 74

RELEASE: 34 CLEAR: 76
XPND: 70

Date: 06/27/2019
Time in station: 16:06:00 to 18:00:00 GMT

Notes:
- CPIES 290 was initially recovered and refurbished from Site AA
- Aside from a few reception issues, deployment, ranging and burst telemetry were deemed successful
- CTD was also in the water during ranging/burst telemetry

Site D
Operation: Recovery PIES SN=282
Latitude: 34° 30.115 **S**
Longitude: 44° 30.156 **W**
Depth: 4757 m

TELEM: 67 CLEAR: 76

Date: 06/28/2019
Time in station: from 12:00:00 to 18:44 GMT

Notes:
- CTD Operations were conducted during the first part of telemetry
- The *Alpha Crucis* drifted nearly 4km from station which affected telemetry data before the operator attempted to pause to salvage the last ~60 days in the file. Operator had to wait until CTD operations were over to get a closer repositioning and reattempt telemetry. There also wasn't a 2-ping confirmation for the CLEAR command before the repositioning, and had to be verified upon revisiting the site.
- The start of telemetry for 282 was at best rough, and it was hard to confirm it's official start time since the first clear output data was about an estimated half an hour or 60 days into the telemetry session. Quality improved despite the drift but then suffered when the drift continued further.
- Even upon being within ~100m of the site, it was very difficult to get any 2-ping response to CLEAR or TELEM commands. The EOF could not be verified during it's final reposition or telemetry attempt and a CLEAR command then was not able to receive a 2-ping response.
- SN 221 which was recovered from site A was refurbished and had its firmware upgraded as a potential backup for deployment if SN 282 was non-functioning. Fortunately, this was not the case and we now have one NOAA PIES unit assembled and ready for future deployments.

Refurbishment Notes for all relevant IES units

1. Replaced CR2032 clock battery: (YES - *all*)
2. Recovered data using CF-card reader: (YES – 221, 280*, 289,* 290)
3. Replaced vacuum port o-ring: (YES - *all*)
4. Replaced release block: (YES - *all*)
5. Replaced system/release batteries (14+10): (YES - *all*)
6. Replaced firmware (PIES62a190422.APP/CPIES62c180425): ([187, 222]/[290,291,408,409])
7. Replaced ACS chip (CPIES): (YES - 291)
8. Sealed and Pulled Vacuum: (YES - *all*)

Repairs and tests at sea

PIES 222

- The rubber stoppers were glued using a contact cement provided by the ship.
- A line was tied to the transducers penetration to hold the battery pack in place in the event the rubber stoppers came loose again.

PIES 187

- The rubber stoppers were glued using a contact cement provided by the ship.
- A line was tied to the transducers penetration to hold the battery pack in place in the event the rubber stoppers came loose again.

5.11 Moorings of ADCP & BPR: (O. Sato, F. Vicentini and W. Natal)

An important component of the cruise was the recovery and redeployment of two instruments moored on the shelf-break, off the Brazil-Uruguay border, near 34.5ºS (Table XVI). The two instruments were moored originally in December/2013, then recovered and redeployed in December/2016, and again in April/2018. Unfortunately, this time the BPR did not respond to the release signal. Its recovery was tried three times: two before the ADCP recovery, and once after (Section 4.6). The ADCP recovery happened without any problem. Data were retrieved from its internal memory and, after the installation of new batteries, the ADCP was relaunched, details are in Table XVII.

Table XVII. Details of the ADCP and BPR moorings, at the shelf-break

	Moorings	
Specs.	**BPR**	**ADCP**
Model	Sea Bird 26 plus – 600m	Teledyne WHS150-UG6
Serial Number	26P68126-1347	1841
Launching data	Not recovered	23/06/2019
Launching hour		07:12 h
Position		34° 18.996 S - 051° 40,647'W
Depth		390 m

The data stored in the ADCP were downloaded and some preliminary results are shown in Figures 52 and 53. Figure 52 illustrates the time series of velocity measured by the ADCP as a function of time and depth. Episodes of strong velocity (> 1m/s) are observed during the time series. Figure 54 shows the decomposition of the velocity in zonal and meridional components which help us to understand better from where these strong episodes are coming from. Figure 55 shows the temperature and depth measured by the ADCP. It clearly shows correlated signals in the temperature with the velocity changes.

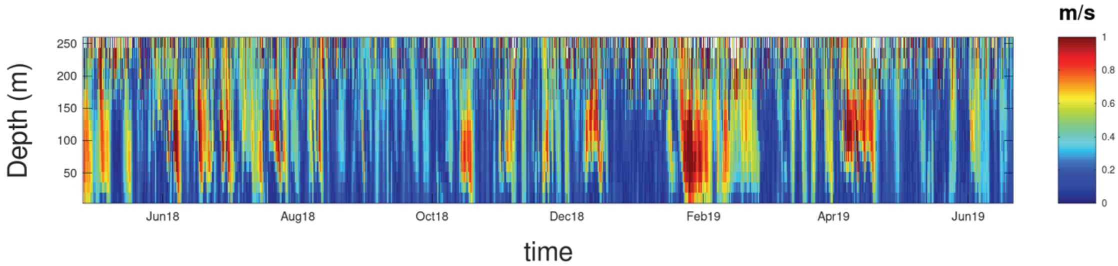


Figure 52. Time-depth diagram of the magnitude of the current measured by the moored ADCP.

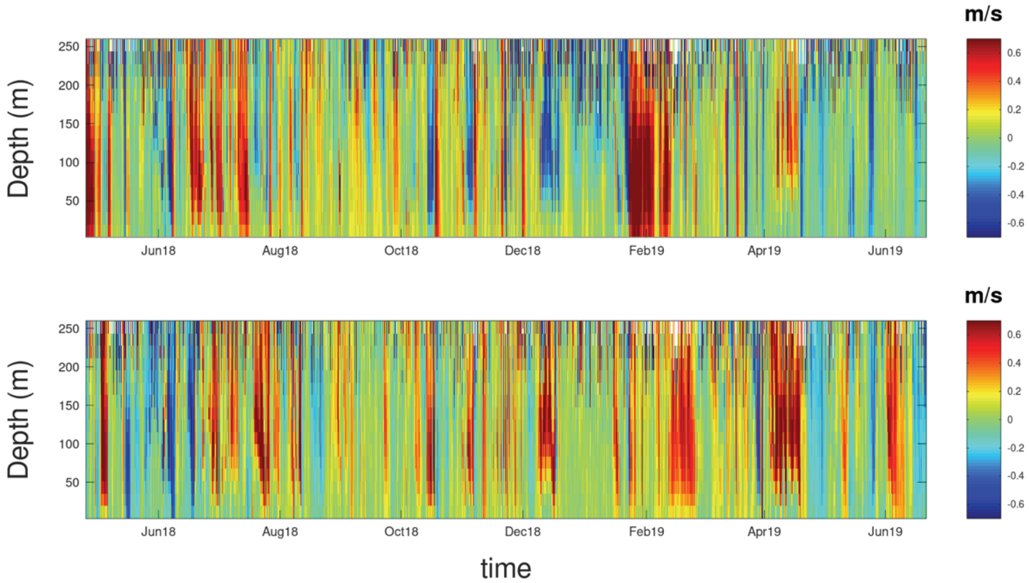


Figure 53. Time-depth diagram of the zonal (top) and the meridional (bottom) components of the current's measured by the moored ADCP.

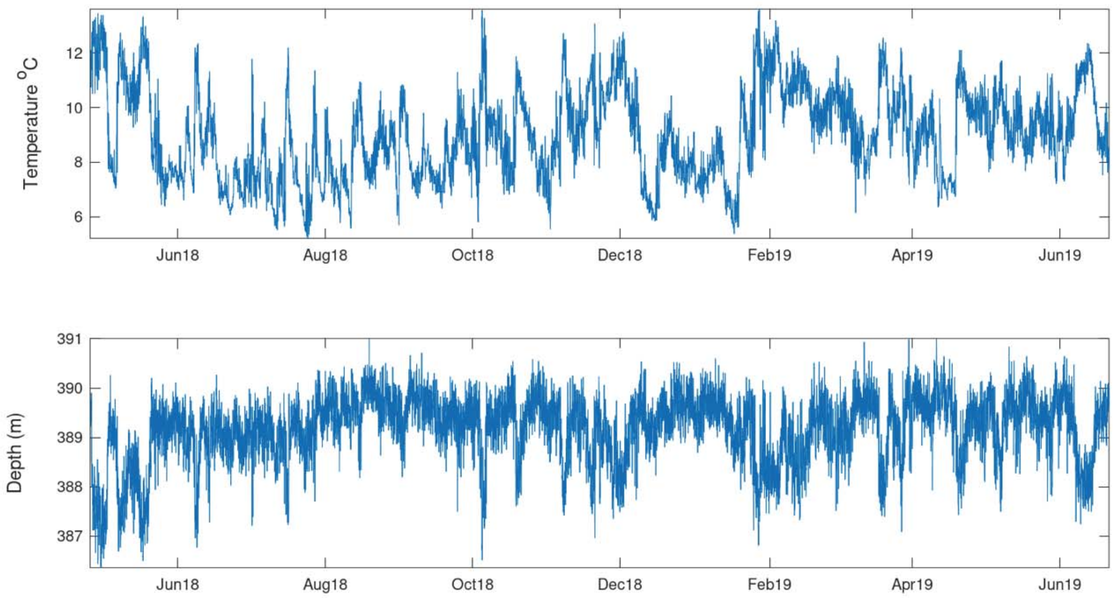


Figure 54. Temperature (ºC) and depth (m) time series measured by the ADCP.

5.12 CTD Winch and EM-cable (R. Guerrero)

What follow is the winch operation report written in 2018 (SAMBAR-01). The problem described in it is still present: "In 2013, a new 8 mm Electro Mechanical cable was installed on Alpha Crucis hydrographic winch. As the wire diameter changes from the original, the multiplication gears that drive the level wind was rebuild. With this arrangement the spooling onto the drum showed to be smooth at the first wraps (Fig. 55a). However, as the succeeding wraps come up, the spooling at both flanges become uneven with back & over of the wire. This problem then propagates inwards with consecutives wraps. It was also observed a valley to the stern flange and a hill on the bow side. Looking into the alignment of the screw groove ends with the flanges of the drums (Fig. 55b,c) it was observed a shift toward the bow (see arrows blue and red that do not align). The correction of this shift should improve the spooling on the flanges and in the interior of the drum as the wraps comes".

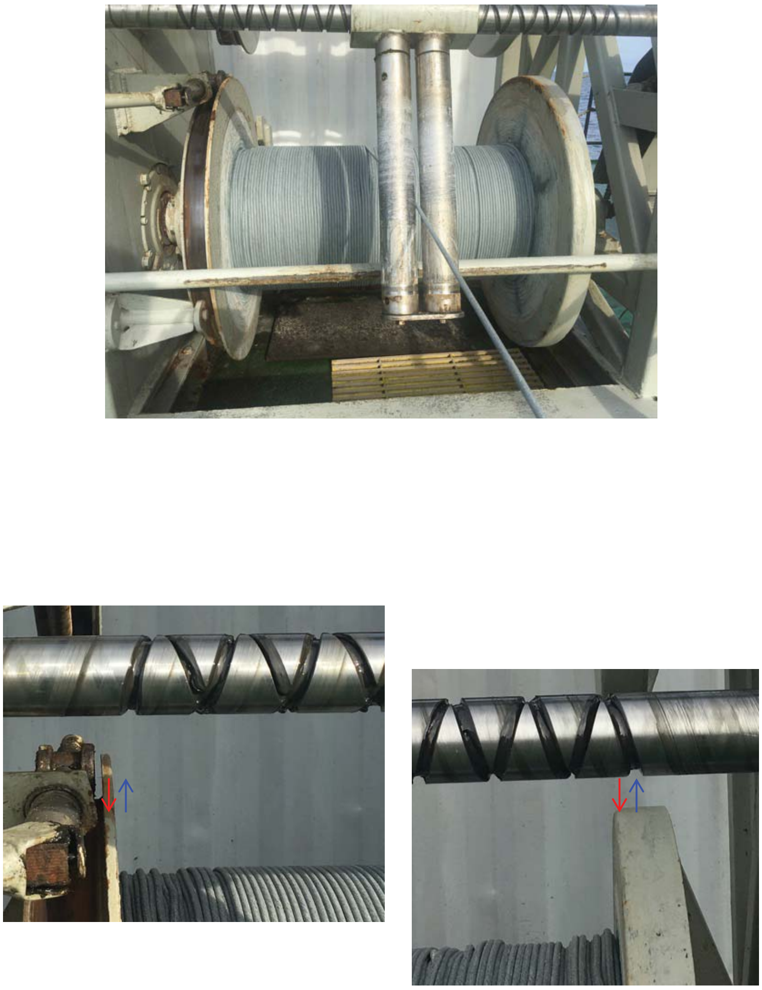


Figure 55. (Top) spooling of the drum showing a smooth of the very first wraps (around 1000 m of cable in). (lower) left and right flange misalignment of the screw groove ends.

5.13 Dissolved Oxygen bottle (E. S. Braga; A. B. L. Cavalcanti)

The water samples for chemical determination of the dissolved oxygen were taken first, avoiding bubble formation and important temperature change. The used flasks had known internal volume and diver cover. Titrations occurred in this same collection bottle at least half an hour after addition of the reagents and effective shaking of the vials. The measurements performed at the station test, with closing at the same depth, was used to verify the water leakage in the rosette bottles and also in order to determine the methodologic precision of the sampling (Table XVIII). In this cruise, exceptionally, only one researcher (Elisabete) sampled the water for all dissolved oxygen determination (this procedure was to minimize the sampling error) (Figs. 56 and 57).

Table XVII. Data of dissolved oxygen replicates, medium values and standard deviation for the test station (1).

Samples/ botte.	DO (mL L^{-1})
1	4.40
2	4.40
3	4.40
4	4.42
5	4.43
6	4.43
7	4.43
8	4.41
9	4.41
10	4.42
11	4.43
12	4.42
13	4.41
14	4.42
15	4.51
16	4.40
17	4.42
18	4.45
19	4.40
20	4.40
Average	4.42
Standard deviation	0.0256

Figure 56. Dissolved Oxygen sampling by the same person (top); OD fixation and standardization in Titrando (middle); Winkler analysis (bottom).

The dissolved oxygen measurement was performed based on the Winkler Method using a semi- automatic titration with a Titrando model Metrohm (Fig. 56, middle).

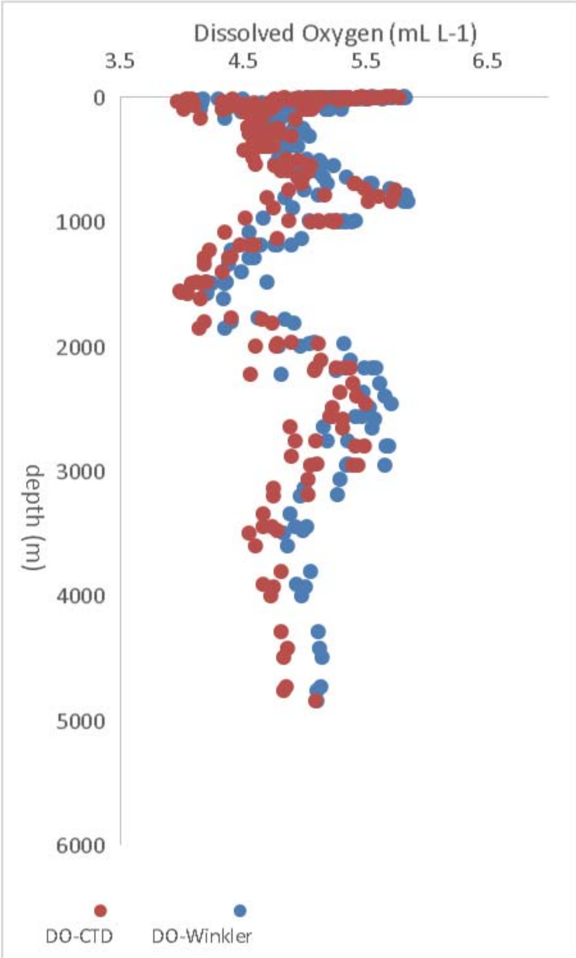


Figure 57. Vertical profile of dissolved oxygen, in blue are the Winkler at the depths of the bottles and in red are the data obtained by CTD method, SAMBAR, June 2019.

5.14 Nutrients, Chlorophyll, Suspended Particulate Material (SPM)

(E. S. Braga; B. C. Pegoraro; Dias, H. J. R.)

The samples for analyses of nutrients, chlorophyll and suspended material were collected and filtered (0.45 µm membrane GF/F Whatman on board (Fig. 58), to obtain samples for nutrient determinations (nitrate, nitrite, phosphate and silicate). This water as preserved in polyethylene flasks (-80°C) during the cruise and sent to Laboratory of nutrients, micronutrients and traces in oceans (LABNUT - IOUSP). N-ammonium was fixed (R1+R2) on board. The membranes destined to the Chlorophyll analysis were preserved in desiccator and frozen (-20°C). The same procedure was adopted for the SPM.

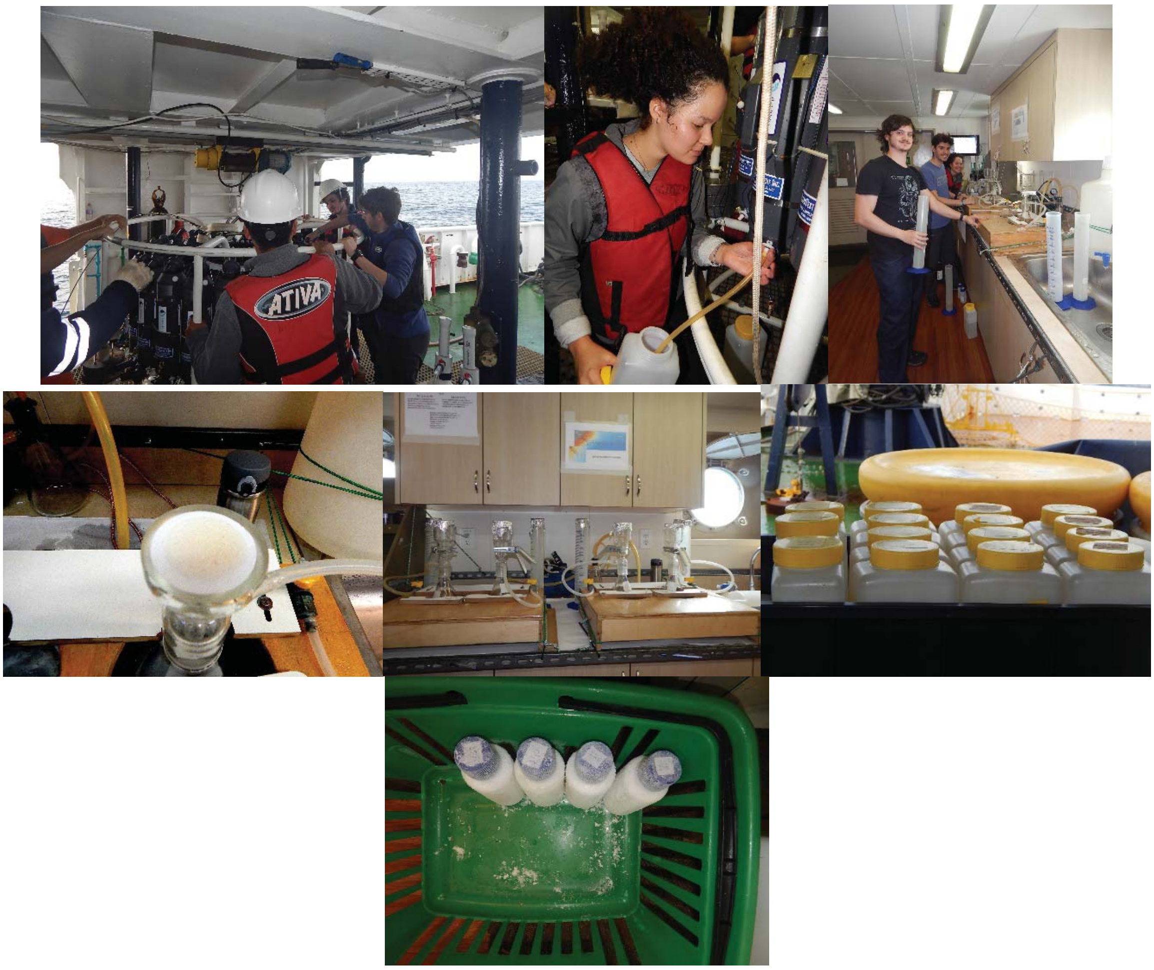


Figure 58. The water sampling for filtration and preserved the membranes for Chlorophyll and suspended particulate matter analyses and water for nutrient measurements.

The nutrients will be determined by colorimetric methods, according to Grasshoff *et al.*, 1983 for the silicate and phosphate and for nitrate and nitrite according to Le Corre & Treguer 1976 (with adaptation of Braga 1992). The chlorophyll-a will be determined by the spectrophotometric method according to Strickland & Parsons, 1968. The suspended material will be determined by the gravimetric method according to Strickland, Parsons, *op cit*. These data will be used to study the water masses characteristics and their distributions patterns.

5.15 pH and Total Alkalinity/Dissolved Inorganic Carbon (J. Figueiredo and M. Borges)

Figure 59. pH, alkalinity, DIC and pCO_2 measurements (UERJ).

A total of 19 sampling stations were performed on board of N/Oc Alpha Crucis, between June 17th and 28th of 2019. For each station, water samples were collected to analyze the following parameters: pCO_2, pH, total alkalinity (AT; UERJ) (Fig. 59), total alkalinity (AT; FURG) (Fig.60), dissolved inorganic carbon (DIC-UERJ) and dissolved inorganic carbon (DIC-FURG). AT/DIC samples were collected by two groups, UERJ and FURG, mainly focusing on an intercomparing between two different sampling and analysis methodologies.

Following the sequence of water sampling at the Rosette, the dissolved oxygen sample is the first to drawn. After that, the samples for pH were obtained, followed by samples for AT and DIC. A total of 156 AT/DIC-FURG samples were collected in 250 mL borosilicate flasks, avoiding gas exchange with the atmosphere, and immediately poisoned with 50 µL of a supersaturated mercury chloride ($HgCl_2$) solution preventing that any biological activity would interfere with the carbonate system parameters. These samples were stored in an adequate place, dark and refrigerated, until transportation to the laboratory for analysis.

The AT/DIC analysis in FURG will be directly measured by potentiometric titration in a closed cell, following the method described by Dickson et al. (2007). A solution of hydrochloric acid with a background of sodium chloride 0.1M will be used as a titrant to make sure that the seawater samples will not be diluted, and its ionic strength will not be altered. Certificated Reference Materials (CRMs obtained from A. G. Dickson on Scripps Institution of Oceanography) will be used during the analysis to access the precision of the method for AT/DIC. The results obtained from the analysis, will be processed and used to determine the other carbonate system parameters, to estimate anthropogenic carbon and to infer about ocean acidification on the region.

pH represents the concentration of H^+ and indicates the conditions of acidity, neutrality or alkalinity of the water. When associated to other parameters, as total alkalinity, the pH gives important information about the carbonate system, which regulates large scale events like ocean acidification. The samplings of water for pH analysis were taken on 60 ml glass bottles and analyzed in the ship laboratory, with the ProLab 3000 pH meter. The measurements were configured to have three decimal places and the equipment was calibrated once every day, using Metrohm buffer sets. A total of 218 samples were analysed.

Figure 60. Total alkalinity and DIC 9FURG).

DIC – Dissolved Inorganic Carbon: Headspace Method

The sampling vials for DIC were previously prepared at UERJ. The containers were washed with tap water and immersed in acid bath of HCl acid at 10% or 20% concentration for a minimum of 2 hours. The flasks were washed four times with distilled water and put in a special equipment for drying and sterilization. The vials were filled with 0,05 ml (approximately 3 drops) of phosphoric acid at 20%, which will reduce the sample's pH to approximately 2. They were closed with rubber stoppers and aluminum seals and completely filled with N2 at atmospheric pressure using a needle, (Aberg and Wallin et al., 2014).

During the cruise, before each station, the top of three flasks were punctured with a hypodermic needle to equilibrate the interior pressure with the local atmospheric pressure. At the Rosette, only after the sampling of the dissolved oxygen, pH, and the total alkalinity, the DIC could be sampled. From the Niskin bottles closed at the surface (3 m to 5 m), triplicate samples of 12 ml were collected using a system of 20 ml syringe and three-way valves. Later, using the syringe, three-way valve, and the hypodermic needle, the samples were injected into the acidified vials. They should be stored in a refrigerator and kept under cold temperatures until they will be analyzed by gas chromatography at UERJ. We have obtained 48 samples during the cruise.

Total Alkalinity (AT)

The AT for UERJ was collected in 250 ml vials from the surface Niskin bottles. In the Station 19, 20, and 21, AT was sampled at surface and at the middle of the mixed layer. A total of 19 samples were obtained. These samples were stored in a cardboard box and they will be analyzed by titration at UERJ.

pCO2

A scheme with the pCO2 sampling methodology is shown in Fig. 61. An equilibrator, a system that simulates a closed environment, is used to determine the concentration of CO2 at superficial waters of the ocean. It is used to equilibrate the amount of dissolved CO2 in the water and air within its system.

The water used in system is pumped by hydraulic pump from the thermosalinograph of Alpha Crucis. The surface ocean water is drained at the laboratory where the samples of pCO2 will be measured instantaneously. The partial pressure of CO2 is measured by a closed system coupled to an infrared gas detector (IRGA). IRGA (EGM-4 Environmental Gas Monitor for CO2, PP System's) readily determine CO2 concentrations to within a few ppm and instantaneous measurements are possible. The pCO2 was measured continuously from the second station up to 15 miles from the Porto de Santos.

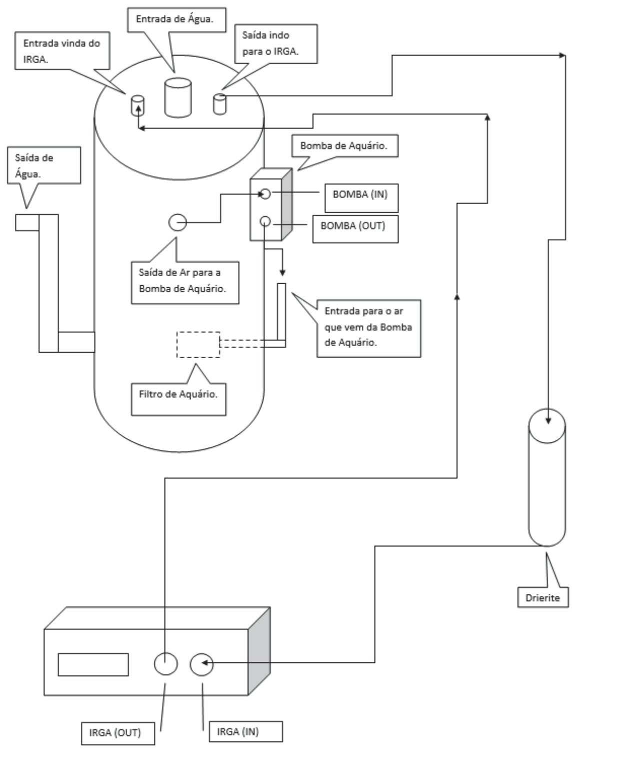


Figure 61. Scheme to represent the different stages of the pCO2 measurement.

5.16 Rare Earth Elements (REE) and Neodymium (Nd) Isotopes (Raiza Lopes Borges)

Samples for the determination of the concentration of REE and the Nd isotopic composition (εNd) in seawater were collected in 5 stations along the SAMBAR line (Table XIX). The number of depths sampled varied between 2 and 8, according to the depth of each station. For the concentration analysis, 250mL of seawater were sampled in previously decontaminated plastic bottles for each depth of each station, while the samples for the determination of εNd required around 10L of seawater for each depth and were collected in previously acid-cleaned 10L plastic bags. At some stations, due to the fact that some Niskin bottles did not close properly, a volume less than 10L was sampled for the εNd. In these cases, the volume sampled might not be enough for the εNd determination, however it was sampled anyway. Both REE and εNd samples will be processed at the laboratory and used to trace natural processes in the Atlantic Ocean, both physical (such as: water masses mixing) and biogeochemical (such as: Boundary Exchange, Redox processes).

In total, around 225L of seawater were sampled at the SAMBAR cruise and will be taken to the Laboratório de Oceanografia Química at UFBA for later processing and analysis. A few more samples were expected to be collected, however, they had to be removed from the schedule due to the weather forecast and limit of duration of the cruise.

All samples were filtered in-line (acropak 0.2 μm) during sampling, in order to reduce contamination sources (Fig. 62). The line was pressurized using a peristaltic pump in order to accelerate the filtration process. The previously decontaminated filtration system was washed with at least 2L of sample water before each sampling. Likewise, the 250mL bottles were washed 3 times with the sample before collection. Afterwards, all samples were acidified using HCl (Suprapur, Merck) for preservation and kept at room temperature until further processing in the laboratory and analysis.

Table XIX. Stations with dissolved Rare Earth Elements and Nd isotopes sampling.

Station number	1	4	8	10	19
Number of depths sampled	1	3	4	6	8

Figure 62. Water samples filtration for analyses of REE and Nd.

Summary of the biogeochemical sampling

Table XX: Number of samples collected during SAMBAR 18.

ST#	DO	ALK. (UERJ)	ALK. (FURG)	pH	DIC	SAL	NUT	NH4	CHL-*a*	SPM	REE	Nd Isotope
1	5	1	2	5	3	2	5	5	5	5	2	2
2	6	1	2	6	3	2	6	6	6	6	-	-
3	9	1	2	9	3	2	9	9	9	9	-	-
4	8	1	3	8	3	3	8	8	8	8	3	3
5	6	1	2	6	3	3	6	6	6	6	-	-
6	7	1	3	7	3	3	7	7	7	7	-	-
7	8	1	3	8	3	6	8	8	8	8	-	-
8	9	1	4	9	3	4	9	9	6	6	4	4
9	15	1	10	15	3	7	15	15	6	6	-	-
10	8	-	7	8	-	7	8	8	3	3	6	6
11	17	1	12	17	3	8	17	17	5	5	-	-
12	15	-	11	15	-	20	15	15	-	-	-	-
13	21	1	13	17	3	8	21	21	5	5	-	-
14	23	1	12	21	3	12	21	21	6	6	-	-
15	21	1	13	9	3	13	21	21	5	5	-	-
16	-	-	-	-	-	-	-	-	-	-	-	-
17	-	-	-	-	-	-	-	-	-	-	-	-
18	-	-	-	-	-	-	-	-	-	-	-	-
19	18	2	17	18	3	18	18	18	4	4	8	8
20	19	2	19	19	3	17	19	19	6	6	-	-
21	21	2	21	21	3	21	21	21	5	5	-	-
TESTE												
1	19	-	-	-	-	3	1	1	1	1	-	-
2	17	-	-	-	-	7	11	8	4	4	-	-

Appendix: Commands used for LADCP deployment

We detail next the commands used for LADCP deployment during SAM18/SAMBAR_A2:

a) wh300_dn.cmd

```
;=====================================================
;   W H M A S T E R . C M D
;   RHS: June 15, 2009
;
;   modified for use with firmware v50.36
;   data collected in beam coordinates...
;
;   WH300kHz master/downlooker deployment script
;=====================================================
; Changes from previous deployment scripts:
; (1) only commands that change defaults are included (EA,ESetc removed)
; (2) data collected in beam coordinates (allows better inspection of
;     raw data and 3-beam solutions if necessary)
; (3) staggered single-ping ensembles every 0.8/1.2 s (Andreas has seen
;     bottom-interference in WH300 data in Antarctic - seems unlikely for
;     Abaco, but does not lose us pings).
; (4) 20 8 m bins - for a range of 160 m.
;
; Ask for log file
$L
;
; Cruise header info...
;
$P                                        .
$P      AB1104 WBTS program. Abaco line: Apr-May 2011  .
$P                                        .
$P         WH MASTER 300kHz LADCP DEPLOYMENT SCRIPT    .
```

```
$P                                          .
;
;
;
$D3
;
; display ADCP system parameters
PS0
; display ADCP system options
OL
; Pause
$D2
; return to factory default settings
CR1
;
; rename recorder prefix to 'MASTR'
rnMASTR
;
; WATER MODE 15 (NO MORE 'L' COMMANDS)
WM15
;
; Flow control:
;       - automatic ensemble cycling (next ens when ready)
;       - automatic ping cycling (ping when ready)
;       - binary data output
;       - disable serial output
;       - enable data recorder
CF11101
$D2
; coordinate transformation:
;       - radial beam coordinates (2 bits)
;       - use pitch/roll (not used for beam coords?)
```

;   - no 3-beam solutions

;   - no bin mapping

EX00100

; Sensor source:

;   - manual speed of sound (EC)

;   - manual depth of transducer (ED = 0 [dm])

;   - measured heading (EH)

;   - measured pitch (EP)

;   - measured roll (ER)

;   - manual salinity (ES = 35 [psu])

;   - measured temperature (ET)

EZ0011101

;

$D2

; - configure staggered ping-cycle

; ensembles per burst

TC2

; pings per ensemble

WP1

; time per burst

TB 00:00:01.20

; time per ensemble

TE 00:00:00.80

; time between pings

TP 00:00.00

$D2

; - configure no. of bins, length, blank

; number of bins

WN020

; bin length [cm]

WS0800

; blank after transmit [cm]

```
WF0000
$D2
; ambiguity velocity [cm]
WV250
; amplitude and correlation thresholds for bottom detection
LZ30,220
$D2
; master
SM1
; send pulse before each ensemble
SA011
; wait .5500 s after sending sync pulse
SW05500
; # of ensembles to wait before sending sync pulse
SI0
$D2
; keep params as user defaults (across power failures)
CK
; echo configuration
T?
L?
$D5
; Time at start pinging
TS?
; start Pinging
CS
; End Logfile
$L
```

b) wh300_dn_shallow.cmd

```
;==================================================
```

```
;   W H M A S T E R . C M D
;   RHS: June 15, 2009
;
;   modified for use with firmware v50.36
;   data collected in beam coordinates...
;
;   WH300kHz master/downlooker deployment script
;=====================================================
; Changes from previous deployment scripts:
; (1) only commands that change defaults are included (EA,ESetc removed)
; (2) data collected in beam coordinates (allows better inspection of
;     raw data and 3-beam solutions if necessary)
; (3) staggered single-ping ensembles every 0.8/1.2 s (Andreas has seen
;     bottom-interference in WH300 data in Antarctic - seems unlikely for
;     Abaco, but does not lose us pings).
; (4) 20 8 m bins - for a range of 160 m.
;
; Ask for log file
$L
;
; Cruise header info...
;
$P                                            .
$P      AB1104 WBTS program. Abaco line: Apr-May 2011  .
$P                                            .
$P         WH MASTER 300kHz LADCP DEPLOYMENT SCRIPT    .
$P                                            .
;
;
;
$D3
;
```

```
; display ADCP system parameters
PS0
; display ADCP system options
OL
; Pause
$D2
; return to factory default settings
CR1
;
; rename recorder prefix to 'MASTR'
rnMASTR
;
; WATER MODE 15 (NO MORE 'L' COMMANDS)
WM15
;
; Flow control:
;       - automatic ensemble cycling (next ens when ready)
;       - automatic ping cycling (ping when ready)
;       - binary data output
;       - disable serial output
;       - enable data recorder
CF11101
$D2
; coordinate transformation:
;       - radial beam coordinates (2 bits)
;       - use pitch/roll (not used for beam coords?)
;       - no 3-beam solutions
;       - no bin mapping
EX00100
; Sensor source:
;       - manual speed of sound (EC)
;       - manual depth of transducer (ED = 0 [dm])
```

```
;       - measured heading (EH)
;       - measured pitch (EP)
;       - measured roll (ER)
;       - manual salinity (ES = 35 [psu])
;       - measured temperature (ET)
EZ0011101
;
$D2
;  - configure staggered ping-cycle
; ensembles per burst
TC2
; pings per ensemble
WP1
; time per burst
TB 00:00:01.20
; time per ensemble
TE 00:00:00.80
; time between pings
TP 00:00.00
$D2
; - configure no. of bins, length, blank
; number of bins
WN020
; bin length [cm]
WS0400
; blank after transmit [cm]
WF0000
$D2
; ambiguity velocity [cm]
WV250
; amplitude and correlation thresholds for bottom detection
LZ30,220
```

$D2

; master

SM1

; send pulse before each ensemble

SA011

; wait .5500 s after sending sync pulse

SW05500

; # of ensembles to wait before sending sync pulse

SI0

$D2

; keep params as user defaults (across power failures)

CK

; echo configuration

T?

L?

$D5

; Time at start pinging

TS?

; start Pinging

CS

; End Logfile

$L

References

- Thurnherr, A. M., How to Process LADCP Data With the LDEO Software (Versions IX.7 – IX.12), 2016