TEXAS A&M UNIVERSITY
DEPARTMENT OF OCEANOGRAPHY
COLLEGE STATION, TEXAS

CRUISE REPORT

ANTARCTIC **CR**OSSROAD **O**F **S**LOPE **S**TREAMS
expedition aboard B.O. PUERTO DESEADO
in the southwest Atlantic Ocean
February-March, 2009

Alejandro H. Orsi

TAMU Reference 09-01-T
May 2009

Sponsored by the National Science Foundation
and the Direccion Nacional del Antartico

Cruise Summary

Expedition: IPY-ACROSS 2009

Ship: Buque Oceanografico Puerto Deseado

Dates: 17 February 2009 – 12 March 2009

Ports of Call: Ushuaia, Argentina – Ushuaia, Argentina

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INTRODUCTION

This report presents the main science activities carried out during a cruise onboard *B.O. Puerto Deseado*, departing from and returning to Ushuaia, Argentina [17 February – 12 March, 2009]. The cruise was the first on the **A**ntarctic **CR**ossroad **O**f **S**lope **S**treams (**ACROSS**) program, an international scientific collaboration between Texas A&M University (U.S.), Earth & Space Research (U.S.), Institut Mediterrani D'Estudis Avançats (Spain) and the Instituto Antartico Argentino (Argentina). U.S. activities on this cruise were funded by the National Science Foundation. The Direccion Nacional del Antartico provided funds for this cruise's ship time and logistics, as part of their Campaña Antartica de Verano 2008/2009.

ACROSS is a U.S. contribution to the Synoptic Antarctic Shelf-Slope Interactions program, International Polar Year. The overarching goal of **ACROSS** is to better understand the causes of the observed rapid freshening and cooling of the deep water of the Antarctic Circumpolar Current as it transits the deep Scotia Sea (Figure 1). Among its objectives are to demonstrate that ventilated water from the Antarctic Slope Current of the Weddell Sea flows northward across the western section of the South Scotia Ridge east of Elephant Island, continues westward along the northern flank of the Ridge towards the Shackleton Fracture Zone, and is exported offshore and mixed with the Circumpolar Deep Water along isopycnals. This particular Antarctic cross-slope contribution to the deep ocean will be monitored with an array of three moorings using direct current and temperature-conductivity measurements from a 1-year deployment. The ultimate objective of the **ACROSS** program is to identify the optimal site and to design a cost effective long-term monitoring of the active intermediate-depth ventilation of the deep ocean by Antarctic slope waters exported at the South Scotia Ridge.

Observational programs for **ACROSS** on this cruise consist of mooring deployments; a regional survey of hydrographic measurements of temperature, salinity, dissolved oxygen, oxygen isotopes, and lowered acoustic current profiling; transects of expendable bathythermographs; and deployment of satellite-tracked surface drifters (Figure 2). Data collection and processing on this cruise were mostly done by personnel (Table 1) from the Department of Oceanography and the Geochemical and Environmental Research Group of Texas A&M University; the Institut Mediterrani D'Estudis Avançats; the Instituto Nacional de Investigacion y Desarrollo Pesquero and the Centro Nacional Patagonico. All cruise data will be presented in a separate technical report after final error inspection, quality control and adjustments are carried out at Texas A&M University. Digital forms of all hydrographic and CTD data will be contributed to the National Oceanographic Data Center.

Collateral biological activities included water sampling for microbiology and chlorophyll, benthic nets, and visual census of marine birds and mammals. These activities are not documented here.

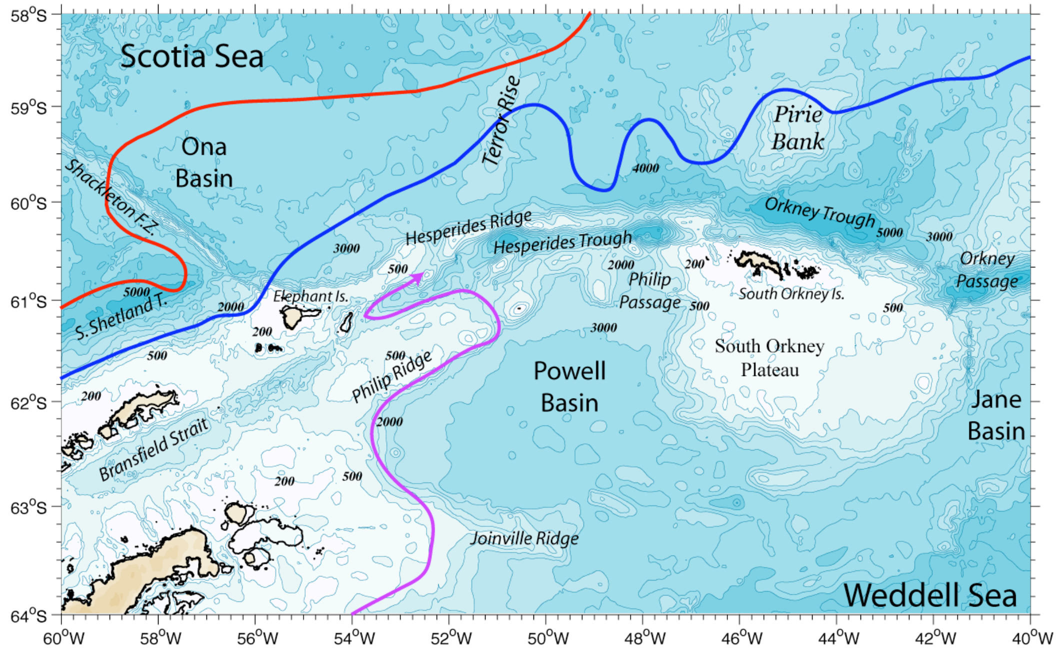

Figure 1: Schematic of the Antarctic Slope Current (purple) and southern boundary of the Antarctic Circumpolar Current (blue) paths in the southern Scotia Sea. The red line is the southern ACC front.

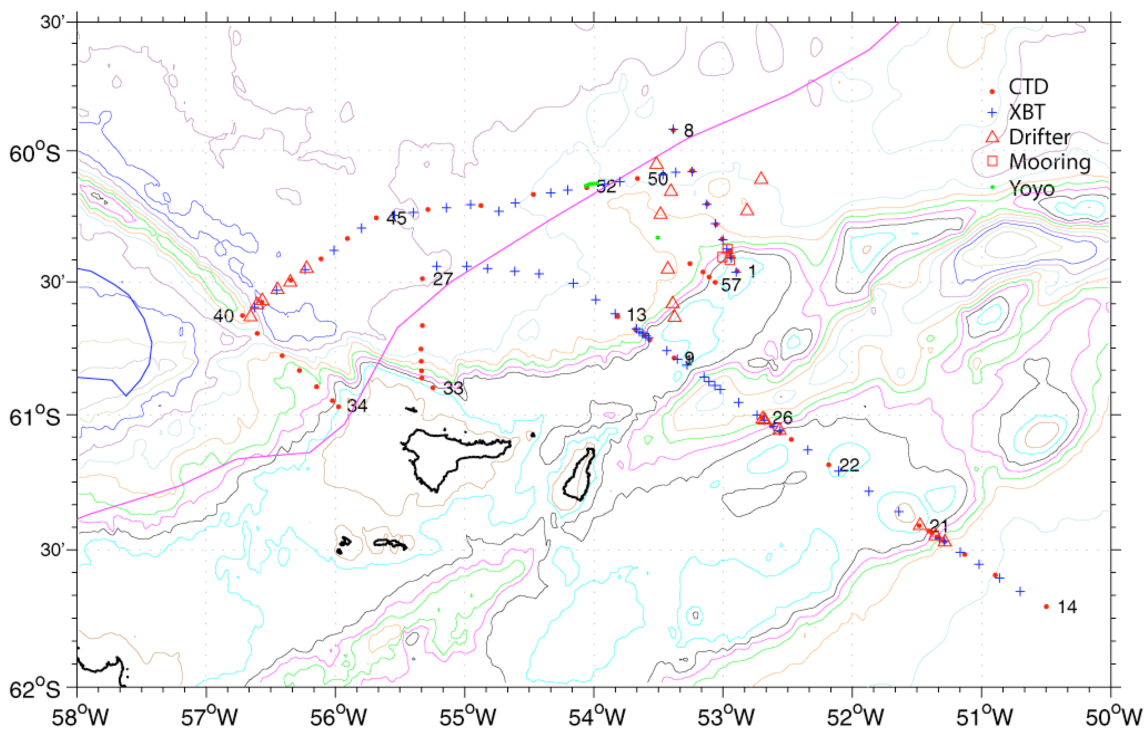

Figure 2: ACROSS 2009 study area showing the location of the main research programs whose details are provided in Tables 1-4: CTD/LADCP stations (numbered red and green dots), XBT launches (blue pluses), surface drifter deployments (red triangles) and mooring array (red squares). The thicker blue and magenta lines are the southern Front and boundary of the Antarctic Circumpolar Current.

TABLE 1: PERSONNEL

ANCILLARY SCIENCE STAFF

Cole, Kelly	TAMU [Oxygens]
Flexas, Mar	IMEDEA [CTD/Moorings]
Kim, Yongsun	TAMU [CTD/LADCP]
Kimura, Satoshi	ESR – OSU [LADCP]
Morgan, Benjamin	TAMU [Salts]
Orsi, Alejandro	TAMU [Chief Scientist]
Pisoni, Juan Pablo	CENPAT – CONICET [Salts]
Puigdefabregas, Joan	IMEDEA [Moorings/LADCP]
Reta, Raul	UNMdP – INIDEP [CTD/Salts]
Schreiner, Kathryn	TAMU [Oxygens]
Walpert, John	TAMU – GERG [CTD/LADCP/Moorings]
Wiederwohl, Christina	TAMU [CTD]

COLLATERAL SCIENCE STAFF

Chiesa, Ignacio	UBA – MACNBR [Benthos]
Gomez, Maria Ines	UBA [Microbiology/Chlorophyll]
Orgeira, Jose Luis	IAA [Birds]
Polizzi, Paula	UNMdP [Mammals]
Tolosa, Jorge	IAA [Birds]

B.O. PUERTO DESEADO STAFF [ARA]
SHIP CAPTAIN: Montero, Hernan Jorge
LIAISON OFFICERS: Adaro, Martin Pablo Cesar; del Castillo, Rafael Nicolas
PETTY OFFICERS: Arrieta, Raul; Azcurra, Marcelo; Cataldo, Jose Luis; Colman, Favio; Cornu, Matias; De Carlo, Jorge; Diaz, Juan; Galvan, Victor; Ithurrart, Jorge; Palmerola, Dario; Pardiñas, Javier; Salinas, Rafael; Soria, Nelson; Tolaba, Christian.

ARA: Armada de la Republica Argentina
CENPAT: Centro Nacional Patagonico
CONICET: Consejo Nacional de Investigaciones Cientificas y Tecnicas
ESR: Earth & Space Research
GERG: Geochemical and Environmental Research Group
IAA: Instituto Antartico Argentino
IMEDEA: Institut Mediterrani D'Estudis Avançats
INIDEP: Instituto Nacional de Investigacion y Desarrollo Pesquero
MACNBR: Museo Argentinp de Ciencias Naturales "Bernardino Rivadavia"
OSU: Oregon State University
TAMU: Texas A&M University
UBA: Universidad de Buenos Aires
UNMdP: Universidad Nacional de Mar del Plata

OBSERVATIONAL PROGRAMS

This cross-slope survey of the western South Scotia Ridge and nearby Scotia Sea consists of fifty-seven hydrographic stations with the spatial distribution shown in Figure 2. At each of these locations Conductivity/Temperature/Depth (CTD) and Lowered Acoustic Doppler Current Profiler (LADCP) profiles were taken, together with water samples collected through the full water column for physical/chemical analysis.

Seven cross-slope transects of closely-spaced stations allowed for the tracing of the Antarctic Slope Front/Current system from the northwestern Weddell Sea to Drake Passage. A zonal section was also occupied to span the farthest offshore ends of five such transects in the Scotia Sea, thus enclosing the southwestern corner of the basin.

To determine the spatial scales of interleaving structures observed at intermediate offshore layers, a continuous series of five (two) deep CTD casts was made at station fifty-two (fifty-three) while allowing the ship to drift from its original position. Station details are given in Table 2.

The horizontal resolution of the upper layer thermal structure along the longest two CTD sections was highly improved with the aid of data collected from sixty Expendable Bathythermograph (XBT) probes launched at intermediate locations. Table 3 provides more specifics of these XBT drops.

Following the occupation of the first hydrographic section near 53°W, an array of three moorings equipped with instruments distributed from subsurface to bottom levels were deployed across the northern slope of the South Scotia Ridge (Table 4).

A total of twenty surface drifting floats released in groups at key locations over the slope (Table 5) were intended to aid in the Lagrangian tracing of streamlines associated with the Antarctic Slope Current, as well as its subsequent offshore export to the Scotia Sea.

Throughout the duration of the cruise a suite of underway measurements were routinely recorded as part of the shipboard science support operations. These include high-resolution Global Positioning System (GPS) navigational data, continuous sea surface temperature and conductivity measurements, single-beam bathymetric data, and meteorological data.

Table 2. ACROSS 2009 hydrographic station details.

Sta. cast	Date m/d/y	Time h:m	Long deg W	min	Lat deg S	min	Water Depth	S	O_2	O18	Bottom Offset
1	02/20/09	13:22	52	53.497	60	27.596	425.2	10	11	10	10.6
2	02/20/09	15:26	52	56.404	60	24.436	793.2	9	10	9	10.2
3	02/20/09	18:43	52	56.879	60	23.048	1684.0	11	11	10	102.2
4	02/20/09	21:26	53	0.421	60	20.250	2251.0	10	10	9	43.0
5	02/21/09	0:40	53	3.278	60	16.934	2407.6	10	11	10	13.4
6	02/21/09	4:18	53	7.434	60	12.145	2208.0	11	11	10	120.6
7	02/21/09	8:17	53	14.170	60	4.641	3351.0	10	10	9	10.0
8	02/21/09	13:31	53	23.032	59	55.184	3303.0	11	11	10	63.0
9	02/21/09	22:31	53	22.795	60	47.192	461.7	9	10	9	15.5
10	02/22/09	6:31	53	34.056	60	43.152	658.3	10	10	9	7.6
11	02/22/09	8:21	53	36.572	60	42.163	1152.9	11	11	10	3.2
12	02/23/09	9:33	53	40.699	60	40.792	2387.8	11	11	10	13.3
13	02/23/09	14:03	53	48.806	60	37.924	2679.1	11	11	10	9.0
14	02/28/09	18:27	50	29.854	61	42.461	3219.6	12	11	10	8.6
15	02/28/09	22:37	50	53.575	61	35.530	3002.1	10	11	10	13.1
16	03/01/09	2:57	51	7.679	61	31.039	2756.6	11	11	10	8.6
17	03/01/09	6:16	51	17.204	61	28.175	2458.0	11	11	10	8.0
18	03/01/09	8:53	51	20.631	61	27.128	1748.1	11	11	10	8.1
19	03/01/09	10:59	51	24.589	61	25.840	663.1	10	7	4	9.1
20	03/01/09	12:45	51	22.904	61	26.334	1082.0	11	11	10	65.0
21	03/01/09	14:35	51	28.948	61	24.642	559.5	11	11	10	8.5
22	03/01/09	21:46	52	10.937	61	11.171	641.1	9	10	9	13.2
23	03/02/09	0:00	52	28.379	61	5.507	612.0	10	11	10	8.7
24	03/02/09	1:31	52	33.418	61	3.770	974.4	11	11	10	11.9
25	03/02/09	3:11	52	37.580	61	2.472	1585.1	11	10	10	4.4
26	03/02/09	5:25	52	41.866	61	0.616	2247.1	11	11	10	8.8
27	03/02/09	15:23	55	19.609	60	29.243	3557.2	11	11	11	8.7
28	03/02/09	20:24	55	19.654	60	39.880	3320.1	11	11	10	0.7
29	03/03/09	1:08	55	20.279	60	45.214	3233.5	11	11	10	15.5
30	03/03/09	4:50	55	20.067	60	47.992	2764.4	11	11	10	8.3
31	03/03/09	7:53	55	20.002	60	50.139	1858.1	11	11	10	6.2
32	03/03/09	9:56	55	19.865	60	51.763	1219.0	11	11	10	44.6
33	03/03/09	12:02	55	14.736	60	53.947	617.6	11	11	10	12.3
34	03/03/09	18:54	55	58.540	60	58.231	542.7	11	11	10	15.4
35	03/03/09	20:29	56	1.411	60	56.851	1080.1	11	11	10	19.0
36	03/03/09	22:43	56	8.714	60	53.683	1922.2	11	11	10	14.4
37	03/04/09	1:55	56	16.775	60	50.049	1935.5	11	11	10	16.9
38	03/04/09	5:04	56	24.740	60	46.752	2290.1	11	11	10	16.5
39	03/04/09	8:48	56	36.264	60	41.693	3384.9	11	11	10	9.9
40	03/04/09	13:28	56	43.206	60	37.655	2225.5	11	11	10	23.4
41	03/04/09	16:41	56	34.048	60	34.639	4054.0	11	11	10	24.9
42	03/04/09	21:15	56	20.806	60	29.628	3941.0	11	11	10	31.4
43	03/05/09	2:31	56	6.659	60	24.758	3882.7	11	11	10	2.3
44	03/05/09	7:46	55	54.355	60	20.101	3714.1	11	11	10	7.8
45	03/05/09	12:21	55	41.066	60	15.388	3578.0	11	11	10	6.1
46	03/05/09	17:13	55	17.030	60	13.489	3462.0	11	11	10	18.6
47	03/05/09	22:11	54	52.462	60	12.552	3309.3	10	11	9	17.1
48	03/06/09	3:33	54	28.104	60	10.025	2980.1	11	11	10	10.9
49	03/06/09	7:59	54	3.434	60	8.509	2737.1	11	11	10	10.2
50	03/06/09	11:56	53	39.761	60	6.378	3123.6	11	11	10	8.9
51	03/06/09	16:06	53	14.576	60	4.555	3341.4	11	11	10	14.0
52	03/06/09	21:32	54	3.802	60	8.050	2735.3	0	0	0	14.3
52.2	03/06/09	23:16	54	2.512	60	7.757	2792.7	0	0	0	791.6
52.3	03/07/09	0:32	54	1.513	60	7.651	2823.6	0	0	0	817.6
52.4	03/07/09	1:51	54	0.191	60	7.586	2898.6	0	0	0	885.7
52.5	03/07/09	3:10	53	58.468	60	7.469	2977.9	0	0	0	964.0
53	03/07/09	8:48	53	30.239	60	19.906	2282.8	0	0	0	10.1
53.2	03/07/09	10:11	53	30.592	60	19.950	2285.3	0	0	0	281.3
54	03/07/09	13:24	53	15.386	60	25.874	2200.8	0	0	0	45.7
55	03/07/09	16:04	53	9.380	60	27.769	1736.6	0	0	0	15.3
56	03/07/09	18:00	53	6.460	60	28.916	1233.4	0	0	0	10.8
57	03/07/09	19:40	53	3.594	60	30.086	614.0	11	11	0	12.6

Table 3. ACROSS 2009 bathythermographic survey details.

XBT	Date m/d/y	Time h:m	Long deg W	min	Lat deg S	min	Water Depth
1	02/28/09	09:02	53	21.2997	60	47.5058	437
2	02/28/09	09:43	53	6.8898	60	52.3100	1338
3	02/28/09	09:50	53	3.8585	60	53.4388	2068
4	02/28/09	09:57	53	1.2406	60	54.3182	2539
5	02/28/09	10:19	52	52.7507	60	57.2082	2172
6	02/28/09	10:43	52	44.2273	61	0.0306	2519
7	02/28/09	10:54	52	40.7185	61	1.1983	1893
8	02/28/09	11:07	52	36.5234	61	2.6080	1462
9	02/28/09	11:17	52	33.5609	61	3.5905	1046
10	02/28/09	12:15	52	20.6176	61	7.8480	924
11	02/28/09	13:15	52	6.3029	61	12.5388	551
12	02/28/09	13:55	51	52.3182	61	17.0491	579
13	02/28/09	14:35	51	38.4112	61	21.5163	544
14	02/28/09	15:26	51	19.6203	61	27.4557	2013
15	02/28/09	15:52	51	9.8950	61	30.5049	2857
16	02/28/09	16:15	51	1.2188	61	33.2013	2943
17	02/28/09	16:40	50	51.5542	61	36.1921	3080
18	02/28/09	17:05	50	42.0242	61	39.1103	3163
19	03/01/09	06:13	51	17.1873	61	28.1858	2491
20	03/02/09	08:59	53	8.7667	60	51.5167	650
21	03/02/09	09:22	53	16.7000	60	48.8167	431
22	03/02/09	09:47	53	26.0333	60	45.5833	542
23	03/02/09	10:11	53	34.4500	60	42.6833	821
24	03/02/09	10:15	53	35.8667	60	42.2000	1078
25	03/02/09	10:20	53	37.2500	60	41.7000	1888
26	03/02/09	10:24	53	38.9000	60	41.3333	2288
27	03/02/09	10:30	53	40.2000	60	40.6500	2511
28	03/02/09	10:59	53	50.0833	60	37.2500	2777
29	03/02/09	11:08	53	59.0833	60	34.0500	2875
30	03/02/09	11:54	54	9.4500	60	30.3667	3114
31	03/02/09	12:33	54	25.4167	60	28.2167	3244
32	03/02/09	12:59	54	36.7333	60	27.6167	3332
33	03/02/09	13:28	54	49.3000	60	26.9500	3442
34	03/02/09	13:50	54	59.0167	60	26.4500	3518
35	03/02/09	14:23	55	12.9333	60	26.4500	3620
36	03/04/09	15:45	56	37.5200	60	35.8300	3619
37	03/04/09	20:20	56	27.3567	60	31.9083	3878
38	03/05/09	01:14	56	14.0500	60	27.2333	3971
39	03/05/09	6:32	56	0.6700	60	22.8025	3899
40	03/05/09	11:15	55	47.8167	60	17.7333	3705
41	03/05/09	15:54	55	32.5333	60	14.7667	3556
42	03/05/09	16:21	55	23.8000	60	14.1500	3582
43	03/05/09	20:56	55	8.5000	60	13.1167	3441
44	03/05/09	21:32	54	57.2167	60	12.3333	3362
45	03/06/09	01:27	54	44.0667	60	13.8833	3247
46	03/06/09	02:16	54	36.5500	60	11.9833	3079
47	03/06/09	06:25	54	20.0333	60	9.6500	2916
48	03/06/09	07:04	54	12.1167	60	8.9833	2740
49	03/06/09	10:41	53	55.0000	60	7.6500	2947
50	03/06/09	10:56	53	47.9500	60	7.0667	2970
51	03/06/09	15:19	53	27.9833	60	5.4833	3267
52	03/06/09	15:33	53	21.9167	60	4.9500	3363
53	03/07/09	21:09	52	53.9918	60	27.7851	441
54	03/07/09	21:28	52	56.3121	60	24.5356	750
55	03/07/09	21:39	52	58.2105	60	22.4764	1746
56	03/07/09	21:50	53	0.1039	60	20.4036	2320
57	03/07/09	22:10	53	3.5161	60	16.6995	2450
58	03/07/09	22:35	53	7.5487	60	12.2954	2493
59	03/07/09	23:16	53	14.3968	60	4.7670	3395
60	03/07/09	00:08	53	23.1303	59	55.0096	3354

Table 4. ACROSS 2009 mooring deployments.

Mooring	Date m/d/y	Time h:m	Long deg W	min	Lat deg S	min	Water Depth
M1	2/22/2009	16:01	52	57.0254	60	25.0898	606
M2	2/22/2009	00:47	53	0.287	60	24.338	1169
M3	2/28/2009	15:09	52	57.774	60	22.53	1711

Table 5. ACROSS 2009 surface drifter deployments.

Drifter	ID#	WMO#	Date m/d/y	Time h:m	Long deg W	min	Lat deg S	min	Water Depth
1	70985	71572	02/27/09	18:06	52	48.8100	60	13.8000	2600
2	70990	71605	02/27/09	20:01	53	24.2000	60	9.3400	2934
3	71006	33632	02/27/09	21:55	52	42.3000	60	6.6000	3304
4	71005	71611	02/28/09	00:35	53	30.9000	60	3.1000	3307
5	71020	43502	02/28/09	03:26	53	29.0000	60	14.6000	2430
6	70984	71568	02/28/09	05:52	53	25.6000	60	27.1000	2466
7	71004	71609	02/28/09	07:21	53	23.4125	60	34.9932	1456
8	71019	71614	02/28/09	07:53	53	22.5205	60	38.0985	502
9	70988	71575	02/28/09	10:51	52	41.5030	61	0.9323	1995
10	71021	71615	02/28/09	10:56	52	40.7185	61	1.1983	1893
11	70991	71606	02/28/09	11:16	52	33.8357	61	3.4900	1081
12	71008	71613	02/28/09	15:22	51	21.3155	61	26.9207	1523
13	70993	71607	02/28/09	15:33	51	17.0194	61	28.2776	2511
14	71007	71612	03/01/09	14:19	51	28.5636	61	24.6414	576
15	70989	71616	03/04/09	15:23	56	39.4000	60	37.9500	2847
16	70987	failed	03/04/09	15:53	56	36.4000	60	35.2150	4182
17	70986	33634	03/04/09	16:17	56	33.9333	60	34.2833	4093
18	71023	33649	03/04/09	20:23	56	26.9167	60	31.7500	3980
19	70992	33647	03/04/09	22:01	56	20.9500	60	30.0833	3981
20	71022	33648	03/05/09	01:19	56	13.3333	60	26.9667	3955

MEASUREMENT COLLECTION AND TECHNIQUES

In-situ Conductivity/Temperature/Depth (CTD) *[Walpert and Wiederwohl]*

1. System Setup

Profiles of temperature, conductivity, and dissolved oxygen were measured using equipment property of Texas A&M University. The basic package consisted of a Sea-Bird Electronics SBE911+ CTD body and deck unit system, which operated at full sampling rate of 24 Hz. The CTD package was fitted with dual ducted conductivity-temperature sensors paired with pumps, and a single SBE 43 dissolved oxygen sensor. Reduced space within the rosette's lower frame constrained the mounting of the sensor suite (Figure 3) causing a vertical offset between the primary and secondary conductivity-temperature sensors of 20 cm.

A Teledyne Benthos 200 kHz sonar altimeter purchased by TAMU for this cruise was mounted on the lower frame of the rosette to guide its approach to the ocean floor. Most profiles reached to within 10 m of the bottom. Occasional interference with TAMU's rosette-mounted LADCP (300 kHz) rendered questionable data outputs from the altimeter. In such cases water depth was estimated by applying Carter's correction to the ship's Echo-Sounder readings, which uses a nominal sound speed of 1500 m/s, and the rosette was conservatively stopped between 15 m and 20 m above the corrected bottom reading. Improper up-cast spooling of the CTD cable on the winch drum delayed several stations, as the cable had to be temporarily paid out to fix the problem.

One-second navigation data derived from the vessel's GPS was fed directly into the CTD deck box unit and sampled at a rate of 1 Hz. It was merged with and recorded at every scan of the CTD data stream. The CTD time was also set to UTC using this GPS feed.

2. Acquisition

On deck CTD sensor readings were recorded on the log sheet before each deployment. The CTD was lowered to a depth of approximately 10 meters where it soaked for approximately 2-4 minutes until the pumps turned on and the oxygen sensor signal stabilized. The CTD was then returned to the surface, before the actual cast began. To best accommodate LADCP and CTD decent rates, the winch payout and hauling rate was 60 m/min for most of the entire down cast. On approaching within ~50 m off the bottom, as determined from altimeter or corrected water depth, the winch was slowed to 30 m/min.

CTD data were acquired using Sea-Bird's Seasave software, version 7.18c on a TAMU desktop computer running Windows XP Professional. Because of the lack of a computer network on the B.O. Puerto Deseado, immediately after each cast all CTD raw data outputs were copied over to thumb drives and backed up on two separate desktop computers provided by TAMU.

Appendix A provides information on particular circumstances during certain CTD casts.

3. Processing and Sensor Calibrations

Raw CTD data was processed using Sea-Bird's Data Processing software on a desktop computer running Windows XP dedicated to data processing. Processed CTD files were generally available to the science staff within an hour of each cast completion. Because the ship normally experienced considerable drift during the duration of a full hydrographic station, and in some cases finishing at a few kilometers from the starting location, data from both down and up casts were processed and saved for each CTD profile.

The dual conductivity and temperature sensors were last calibrated on 06 January and 21-24 March 2006, and had not been used prior to this cruise. 14 December 1987 is the date for the last calibration of the pressure sensor. The single dissolved oxygen sensor was calibrated on 8 August 2008 after its last use on a previous cruise.

The paired sensors agreed remarkably well throughout the cruise. Nonetheless temperature, salinity and oxygen data will be reprocessed including results from post-cruise calibrations of all the CTD sensors, which is customary and required by GERG after each cruise. Only at that time will it be determined whether the primary or secondary sensor outputs, or some combination of the two, are used for the final data set.

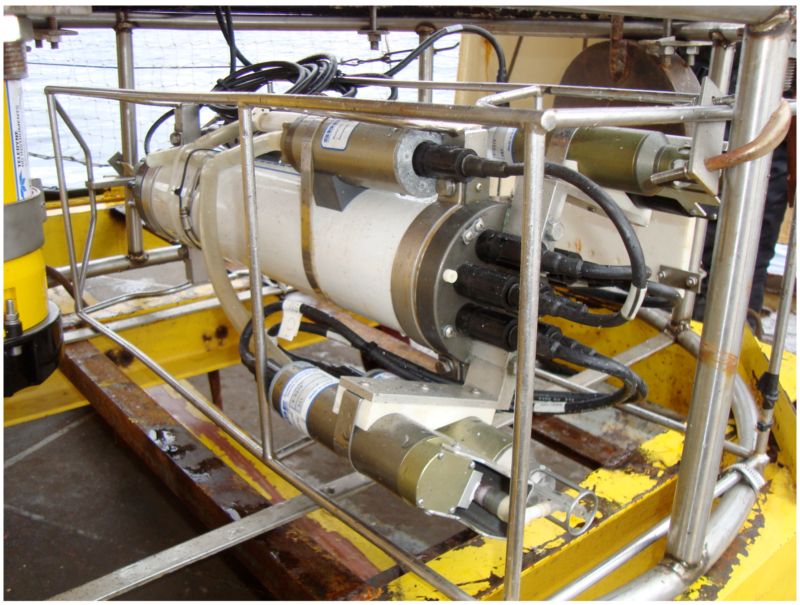

Figure 3: Mount of Sea-Bird Electronics SBE911plus CTD in the rosette frame

In-situ Lowered Acoustic Doppler Current Profiler (LADCP) *[Walpert]*

1. System Setup

The instrument used for acquisition of LADCP data in this cruise was a Teledyne RD 300 kHz Workhorse Sentinel with a single 450 W-hr internal battery-pack (Figure 4). This instrument comes with its own internal compass and tilt sensors. The compass was calibrated with the same battery pack used during the cruise to prevent changes. While on deck, the LADCP used an external AC power supply for communicating with a computer to preserve battery charge. Bottom-tracking firmware was not installed on the LADCP. The time was set to UTC using the ship's GPS and it utilized the same configuration file for each station so that its setup did not vary from cast to cast. This configuration file was uploaded to the LADCP prior to each cast.

The system's basic setup consisted of collecting LADCP data in bin-coordinates: 20 8 m bins, with one ping-ensemble per second. It was set for high power with a narrowed bandwidth to extend its data range. Because the CTD used an altimeter that operated at 200 kHz, at times interfered with the 300 kHz LADCP upon approaching the ocean floor.

2. Acquisition

The LADCP system was started approximately 2 minutes before the ship settled on station. This was sometimes difficult to judge owing to complications in positioning the ship, the slow reaction of electric engines and the inexperience of some navigators. LADCP data file were downloaded immediately after each cast using a notebook computer running Windows XP kept in the furthest aft laboratory.

3. Processing

Raw LADCP data was copied via thumb drive from the acquisition computer to the data processing computer after each station. Raw data was processed using LDEO LADCP software version IX. Processing was done in a delayed mode compared to the CTD data files, but still within a reasonable time to estimate its general quality.

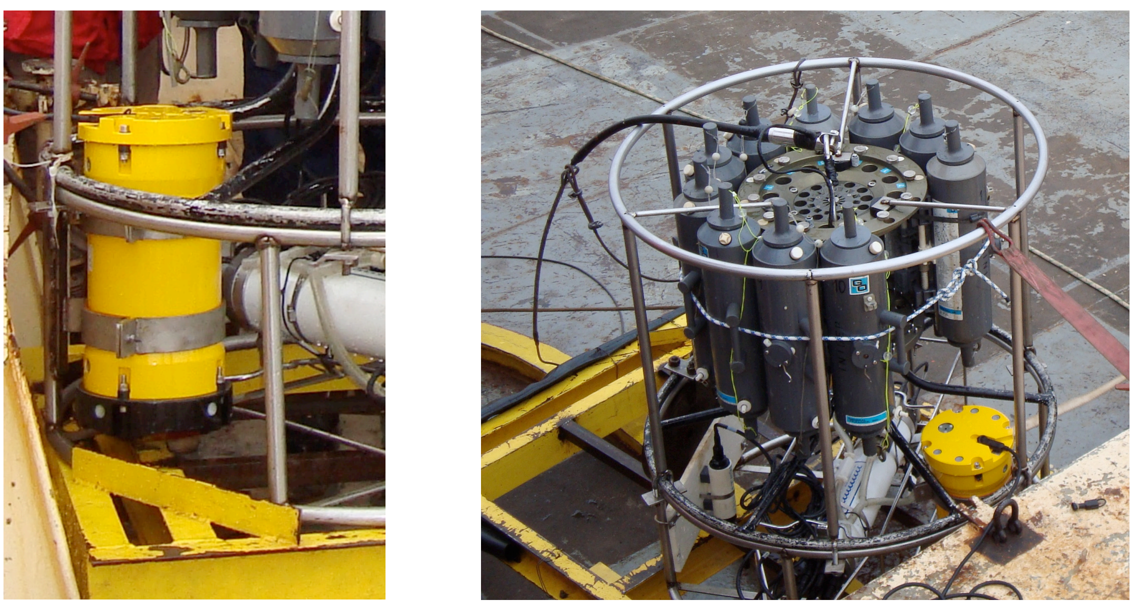

Figure 4: Teledyne RD 300 kHz Workhorse Sentinel LADCP mounted in the rosette.

Rosette Cast and Water Sample Measurements *[Walpert, Reta, Wiederwohl]*

1. System Setup

A custom built frame housing a General Oceanics Rosette with twelve 10-liter Niskin bottles was brought by TAMU, but was discovered to be too tall (1.93 m) leaving just one inch of clearance when carted out and positioned at the side A-frame for deployment (see Figure 5). This was considered too risky and problematic, in particular under the expected less than optimal sea conditions to be found in the study area. Because of this safety issue, all instruments (CTD, altimeter, LADCP) were transferred from the TAMU rosette frame to a shorter backup rosette kindly provided by the Instituto Nacional de Investigacion y Desarrollo Pesquero and handed by Raul Reta .

Water samples were taken using INIDEP's 12-position General Oceanics Rosette sampler (model 1015 -12) triggered through the Sea-bird 11 plus deck box with 5-liter water sample bottles (Figure 5). Modifications to the LADCP housing as well as the removal of two bottles from the rosette to accommodate the LADCP were required due to space constraints within the rosette.

2. Acquisition

Water was collected for onboard analysis of salinity and dissolved oxygen. Salinity and dissolved oxygen analyses are primarily to standardize CTD measurements derived from conductivity and oxygen sensors. Additional oxygen-18 samples were collected for later analysis at TAMU. Biological samples were collected at a subset of stations, and sent to Buenos Aires for analysis at the IAA and UBA.

The water sampling system was generally trouble-free. There were no major failures of the carousel system. However, we experienced a handful of leaking bottle due to end cap O-rings becoming dislodged, and consequently not sealing properly, or the occasional lack of tension on the surgical tubing used to close the bottles. In those cases the leaky bottles were noted on the sample-cop sheet and repaired before the next cast. There were also several observations of leaky spouts, but none major and in need of repair. All 10 available Niskin bottles were closed at each station, except during the series of consecutive drifting casts near the end of the cruise. Sample depths were selected during the down-cast to resolved main water column features, like extreme values in T and S, regions with homogeneous layers for salt and O2 control, and layers near the sea surface and sea floor.

Figure 5: General Oceanics Rosette 12-position 5-liter sampler Model 1015 -12.

Salinity Analysis *[Reta and Pisoni]*

1. Systems Setup

The main salinometer brought by TAMU to measure water sample salinities in this cruise is an Autosal Model 8400A. However a complete salinity analysis could not have been possible without the backup of a newer system, an Autosal Model 8400B (Figure 6), that was kindly provided by the Servicio de Hidrografia Naval through Dr. Alberto Piola. Both instruments were placed side by side and operated alternatively, or even concurrently at times, during the cruise. Unfortunately, in spite of the full usage of a dedicated wall-mounted air-conditioning/heating system in the hydro (wet) lab, the ambient temperature was difficult to stablize mainly due to the fluctuating influence from the thermic engines located directly below the lab. Another frustrating aspect of this set up was the malfunctioning display of TAMU's unit, which would suddenly dim and even fade away completely in standby mode, and other times would fail to produce complete (unambiguous) digits (unit and decimal places) in the reading mode. This pervasive behavior, which was caused by a loose internal connector, required manual tightening each time.

See Appendix B for more specific information on Autosal maintenance and malfunctions during the cruise.

2. Acquisition

A total of 511 salinity samples were collected on the 57 full water column CTD casts in the cruise. Both Autosals were calibrated using 17 IAPSO Standard Seawater ampoules with Batch P149, dated 5 October 2007, K15: 0.99984, Salinity: 34.994 provided by TAMU for this cruise.

Figure 6: Guildline Autosals: TAMU's 8400A (left) and SHI's 8400B models (right).

3. Processing

A preliminary quality control (Figures 7 and 8) was performed against data derived from the two CTD conductivity sensors, resulting in 488 bottle salinity values of unquestionable good quality.

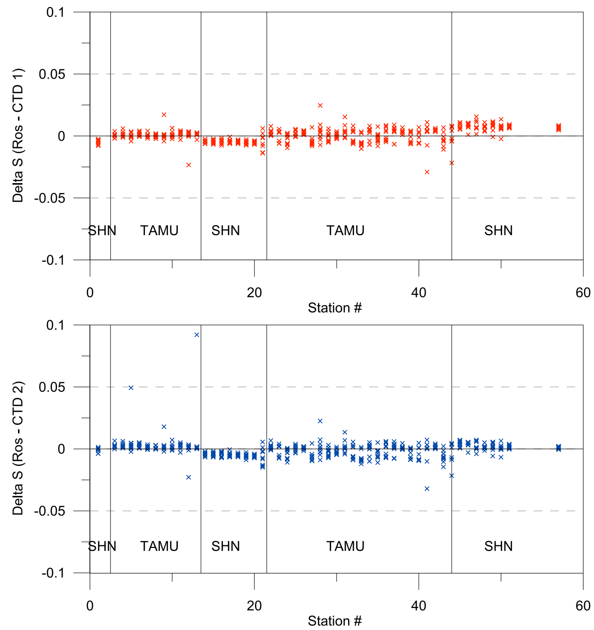

Figure 7: Salinity difference vs. station number for bottle values against primary (top panel) and secondary (bottom panel) CTD conductivity sensors.

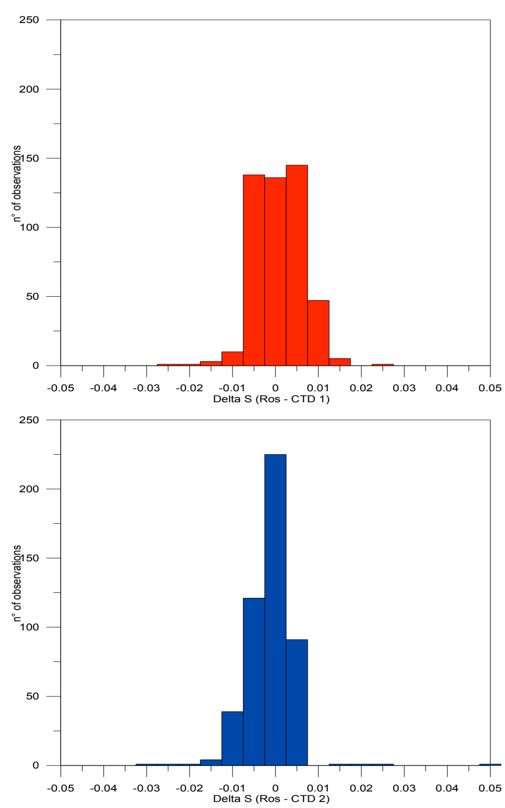

Figure 8: Histogram of salinity differences shown in Figure 7.

Oxygen Analysis *[Wiederwohl and Schreiner]*

1. Systems Setup

Dissolved oxygen analyses were performed with a Brinkmann Metrohm 665 Dosimat automatic titrator, fitted with a 5.0 mL buret to dispense thiosulfate. Photometric endpoints were detected using a Metrohm KCl millivolt probe attached to a Brinkmann Metrohm 682 Titroprocessor. Whole-bottle modified Winkler titrations were performed. The concentration of anhydrous thiosulfate used was ~8.75g/L, and the concentration of potassium iodate standard was reported as ~0.01N. Potassium iodate standards (usually 3 to 5) and DI water blanks (usually 3) were run at least every 24 hours, usually every 5-8 stations. In addition, standards and blanks were run every time reagents were changed or topped off.

Appendix C elaborates more on potentially problematic aspects noticed during titrations.

2. Acquisition

568 oxygen samples were analyzed, from a total of 53 casts. Samples were collected from the 10 Niskin bottles in the rosette directly after being brought on board. Dissolved oxygen samples were always the first parameter to be drawn from the Niskins. Using a length of Tygon tubing, samples were collected into 125 mL iodine Erlenmeyer flasks. Flasks were rinsed three times and filled to overflow at least three volumes. The draw temperature was measured using either a standard alcohol thermometer or a digital kitchen thermometer placed in the flask during collection. Draw temperatures for the first 18 stations were taken using a standard alcohol thermometer with an accuracy of 1°C and the majority, if not all, of these draw temperatures look suspect. Draw temperatures for stations 19 –57 were taken using a digital kitchen thermometer with an accuracy of 0.1°C. These draw temperatures all seem reasonable.

Immediately after collecting each sample from the Niskin bottles, they were pickled with 1 mL $MnCl_2$ reagent followed by 1 mL NaI/NaOH reagent. Samples were then stoppered, shaken, and placed out of the light. Samples were shaken a second time approximately 20 minutes after they were drawn, at which point they were capped with a water seal and again placed out of the light. Samples were analyzed within one to three hours after being shaken for the second time. Immediately prior to titration with thiosulfate, 1 mL 10 N H_2SO_4 was added to each sample. For every cast, one Niskin bottle was chosen at random to draw a duplicate sample.

3. Processing

568 out of the 583 samples drawn (53 casts, 10 bottles per cast plus one random duplicate per cast) could be analyzed. During some casts, Niskin bottles were not sampled either due to time constraints (5), because they failed to fire (7), or lab errors (3).

103 samples had dissolved oxygen values that could eventually become questionable. This is due to either Niskin problems, e.g. leaks (80 samples), lab errors (17 samples), or both (6 samples). Among the known lab errors encountered are a missing water seal after the second shake, cracked flask or stopper, auto-pipetter set to the wrong volume for H_2SO_4, water seal not removed before analysis, failure to add acid before starting the titration, and samples falling off the stir plate during titration due to the boat rocking.

Moored Current Meters and T/C/P Recorders *[Orsi, Walpert, Puigdefabregas]*

A three-mooring (M1-M3) array of current meters, temperature, conductivity, and pressure (TCP) recorders (Figure 9) were deployed along 53°W across the northern slope of the South Scotia Ridge, just west of a gap that communicates the Hesperides Trough with the Scotia Sea (Figures 1 and 2). The array is placed at the observed location of the Antarctic Slope Current/Front system as indicated by CTD data collected during the R.V. Hesperides 2008 cruise and from the first section stations made on the B.O. Puerto Deseado. Thus time series to be recorder by this moored array will provide information on the current's flow structure, variability and associated northward export of intermediate slope waters to the deep waters offshore.

Moorings were arranged at specific sites on the slope, nominally the 600-m (M1), 1200-m (M2) and 1800-m (M3) isobaths. They were instrumented with a total of 6 Nortek (Aquadopp 2000 m) and 8 Aanderaa (RCM-7, 8, 9) current meters, and 22 SeaBird (MicroCat SBE-37SM and 39) TCP recorders to provide high vertical resolution below 300 m.

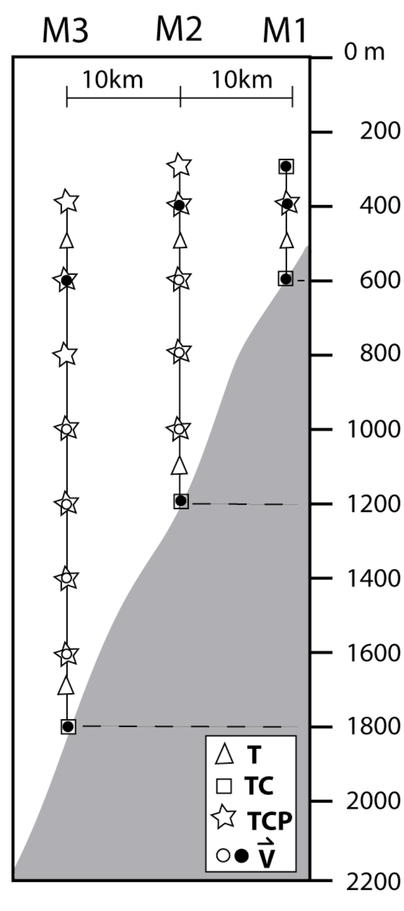

Figure 9: ACROSS array of moored temperature (T), conductivity (C), pressure (P), and current (V) recorders deployed during this cruise.

Table 6. ACROSS mooring composition.

Mooring	*Longitude*	*Latitude*	*Deployment Date*	
M1	*52° 57.025' W*	*60° 25.089' S*	*22-Feb-09*	
SBE-37	T,C	300m	0137	ESR
RCM-7	U,V	300m	6994	IMEDEA
Aquadopp	U,V	400m	3375	IMEDEA
SBE-37	T,C,P	400m	6472	IMEDEA
SBE-39	T	500m	0349	ESR
Aquadopp	U,V	600m	3275	IMEDEA
SBE-37	T,C	600m	0138	ESR
M2	*53° 0.287' W*	*60° 24.338' S*	*22-Feb-09*	
SBE-37	T,C,P	300m	3842	TAMU
Aquadopp	U,V	400m	3393	IMEDEA
SBE-37	T,C,P	400m	6469	IMEDEA
SBE-39	T	500m	0346	ESR
Aquadopp	U,V	600m	3230	IMEDEA
SBE-37	T,C,P	600m	6471	IMEDEA
RCM-7	U,V	800m	12222	IMEDEA
SBE-37	T,C,P	800m	3839	TAMU
RCM-7	U,V	1000m	12462	IMEDEA
SBE-37	T,C,P	1000m	6470	IMEDEA
SBE-39	T	1100m	0344	ESR
RCM-9	U,V	1200m	723	IMEDEA
SBE-37	T,C	1200m	0139	ESR
M3	*52° 57.774' W*	*60° 22.530' S*	*28-Feb-09*	
SBE-37	T,C,P	400m	3845	TAMU
SBE-39	T	500m	0350	ESR
SBE-37	T,C,P	600m	3846	TAMU
Aquadopp	U,V	600m	3231	TAMU
SBE-37	T,C,P	800m	3843	TAMU
SBE-37	T,C,P	1000m	3844	TAMU
RCM-8	U,V	1000m	12452	IMEDEA
SBE-37	T,C,P	1200m	3840	TAMU
RCM-7	U,V	1200m	12438	IMEDEA
SBE-37	T,C,P	1400m	3847	TAMU
RCM-8	U,V	1400m	12454	IMEDEA
SBE-37	T,C,P	1600m	3841	TAMU
RCM-7	U,V	1600m	12220	IMEDEA
SBE-39	T	1720m	0347	ESR
SBE-37	T,C	1800m	0140	ESR
Aquadopp	U,V	1800m	3280	TAMU

Instruments from TAMU, ESR and IMEDEA were distributed in all three moorings. However, the design and construction of the tallest M3 mooring was done entirely in the U.S. by the Buoy Group at GERG-TAMU; whereas M1 and M2 were done in Barcelona, Spain.

Moorings Design and Setup

M3 design (Figure 10) was modeled using two different programs: an X windows version of "WHOI Cable" by Mark Grosenbaugh and Jason Gobat at WHOI, and the Matlab program "Mooring Design and Dynamics" by Richard Dewey at University of Victoria. Both programs use a model with a typical velocity profile of 1.5 m/s in the top 100 m, 1.25 m/s between 100 m and 500 m, 1m/ s between 500 m and 1500 m, and 0.25 m/s below 1500 m to the bottom.

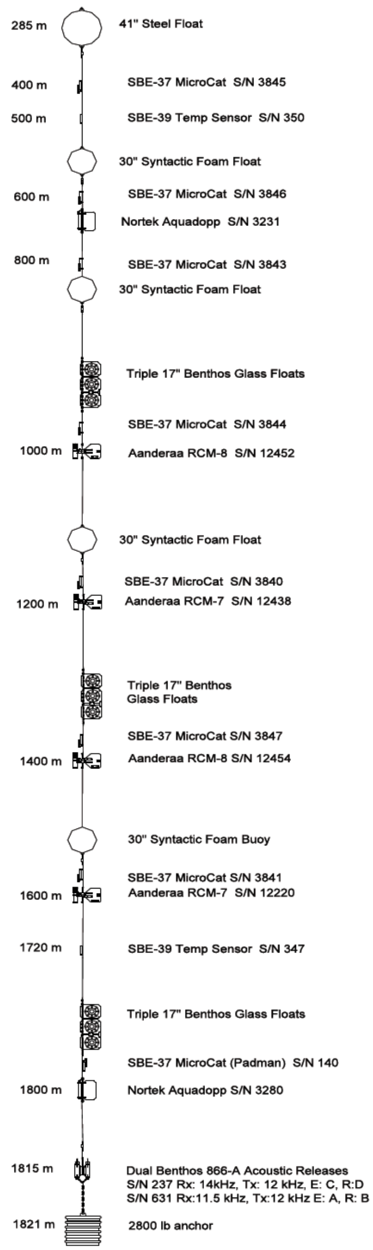

Figure 10: Mooring design for M3 (TAMU).

The M3 mooring uses 1/4" 12 strand Dyneema rope with a tensile strength of 8,400 lbs. Each M3 mooring component was pre-stretched at GERG before the cruise, and each termination was load-tested to at least 2,000 lbs, i.e. the maximum tension expected to be caused during the anchor free-fall. All M3 terminations were stitched and/or whipped after load-testing. Stainless steel oceanographic swivels were used under each buoyancy component. TAMU's Dual Benthos 866-A Continental shelf acoustic releases were used on both of the M2 and M3 moorings. The Spanish used MORS Oceano RT221 acoustic releases on M1.

All moored instruments were set to the ship's GPS time. Half-hour sampling intervals were set to record at the exact hour and half hour, and thus facilitate the later data analysis from different depths and moorings. All MicroCats recorders and Aquadopp current meters were set up identically were set with delayed-starts, enabling them to all start sampling at the exact same time (12:00:00 GMT on February 21, 2009). The Spanish group had previously setup and tested all of the Aanderaa RCMs and data storage units (DSU). Unlike the Aquadopps, the RCMs do not have the capability of remote start, thus they were all switched on manually at the exact same time (17:00:00 GMT on February 17, 2009). Their DSUs were checked following the first cycle to make sure they were all working and recording data correctly.

Deployments

After occupying eleven CTD stations along the 53°W and 54°W slope sections during the first couple of days working in the area, on 22 February 2009 we started the deployment of the mooring array. We managed to deploy the two shallowest moorings that day, ending with M2 at 10 pm (local time). We spent the following night in transit and did the last two CTD stations along the 54°W section in the morning. We arrived at the deployment location of M3 around noon (local time), and as deployment of the top floatation was about to start, a section of floatation belonging to mooring M2 was spotted floating very close to the boat. The deployment of M3 was temporarily aborted and the remainder of the day was spent the attempting to recover the apparent segments of M2; this however was unsuccessful. Winds that deteriorated up to 30-40 knots, 6 m to 8 m waves and a thick fog made this operation unsafe for the crew of a zodiac sent to fix a tagline to the drifting floats. Worse weather conditions were forecasted for the next day, Tuesday 24 February 2009, therefore the Chief Scientist requested to the Captain to remain in the area as long as possible and to attempt a recovery the next day. However, during the night the Captain ordered to head and take cover behind Elephant Island, claiming the anchor for M3 secured on the back deck represented a safety hazard to the integrity of the boat. After two days (24-25 February) anchored at the Elephant Island site, a systematic search was started again for the drifting portions of M2. A full day was dedicated to the unsuccessful combing of the area to the east of the location were the buoys were last seen. The next morning (27 February 2009) deployment of the deepest (TAMU designed and owned) mooring M3 at the 1800-m isobath began and was successfully finishing before noon. The rest of the daylight time was spent searching the area farther to the north of the last M2 sightings, but this also turned out unsuccessful.

See Appendix D for a more on difficulties encountered during mooring deployments.

Expendable Bathythermograph (XBT)

The boat's XBT system consisted of a Sippican MK21 deck unit, a PC computer and a manual launcher. It was used to drop sixty (60) 760 m reaching Deep Blue XBT probes provided by TAMU to profile the upper thermal structure between CTD stations. All launches were successful and individual data files were transferred to the main processing computers immediately after each launch.

Surface Drifters

An array of twenty (20) SVP-B satellite-tracked surface barometric drifting buoys were deployed as a contribution to NOAA-AOML Global Drifter Program. These instruments were kindly provided to this program by Dr. Rick Lumpkin and Shaun Dolk at AOML. Their trajectories and data can be tracked at AOML's the Global Drifter Center Deployment Log website (http://www.aoml.noaa.gov/phod/dac/deployed.html). 19 of these drifters successfully transmitted data shortly after deployment.

Underway Measurements

1. Navigation

Data was obtained from the onboard GPS, and merged with the high-resolution bathymetric data collected in real time using the hull-mounted mono axial echo sounder. Daily compilations were created, quality controlled and reduced by crew personnel in the seismic laboratory. All shipboard underway data were made available to science staff upon request. In addition, separate files were generated for the duration of each CTD cast, with the purpose to facilitate the processing of CTD data, LADCP data and perform complementary tidal analysis.

2. Ocean Surface Temperature and Conductivity

Temperature and conductivity measurements were collected using a SeaBird 21 instrument mounted at the water pump intake to the engine room 3 m below the sea surface. These measurements were recorded every 30 seconds, supplemented with GPS data at all times including all transit segments as well as while on station or anchored off Elephant Island. SEASAVE Win 32 Version 5.37 m software was run to acquire raw data. Two types of quality control were applied to the raw surface T-S data stream. The first by comparison to near surface (3-m) values measured during each CTD down-cast and the second method by comparison to measurements from 70 water samples collected every 6 hours and analyzed by an Autosal.

3. Winds, Air Temperature and Pressure

Hourly records of atmospheric data collected by the ship crew were provided to the Chief Scientist at the end of the cruise. These consisted of winds speed and direction, barometric pressure and air temperature.

ACKNOWLEDGEMENTS

U.S. activities on this cruise were funded by the National Science Foundation under grants ANT SGER 0818061 to Texas A&M University and ANT SGER 0830398 to Earth & Space Research.

Shiptime on the B.O. Puerto Deseado for this cruise was secured and provided by the Direccion Nacional del Antartico (DNA). ACROSS was granted Institutional Program status by the DNA as part of the planned activities during the Campaña Antarctica de Verano 2008/2009 (CAV-08/09).

A series of uncertainties surrounded this international collaborative program from the early planning stages to the final logistics around the return of equipment to the U.S. Some were expected, like adjusting to the language barrier between participants on the cruise and the communicating with military personnel operating the ship. Others were major challenges that could not have been anticipated, but they were also resolved with great deal of ingenuity and the unselfish assistance of many participants. The successful outcome of this cruise reflects the professionalism demonstrated at all times by key players. In particular, we thank Raul Reta for his careful supervision of all deck operations; Lieutenants Martin Adaro and Rafael del Castillo for their watchful attention to efficiency and safety; and the group of Oceanographer petty officers for their skillful show of teamwork throughout the cruise. We also acknowledge the assistance, to the best of their capabilities, from the rest of the crew and officers of the B.O. Puerto Deseado.

APPENDIX A: CTD CASTS SPECIFICS

Station 3: SeaSave program gave GPIB error at 666 m on the downcast. Data acquisition stopped and the cast had to be aborted. The GPIB/IEEE 488 cable was replaced and cast 2 was started and finished with no apparent errors.

Station 9: During the recovery of the CTD after completion of the cast, the package hit the side of the ship and Niskin 1 fell off the rosette and was lost. This was most likely due to the knurled knob not being screwed down properly. A spare bottle was installed at position 1 following the cast.

Stations 21-22: An oily residue was seen at the water surface and boat was repositioned before bringing CTD onboard. Up-cast data seems unaffected by this move.

Station 28: The rosette was sat on the ocean floor, due to the altimeter only starting to give believable readings ~20 m from the bottom. Depth readings from the CTD sensor stopped increasing, whereas wire-out values continued to increase. Calculations show that approximately 4 m of cable were paid out while the rosette was at the bottom. Sensors showed no degradation in signal during the up-cast, and there was no apparent damage to the CTD or sensors seen once brought on board.

Station 31: Deck unit and CTD computer lost all power during the up-cast when the CTD was almost at the surface (0.2 db). All data was saved ok, and cast did not have to be redone.

Stations 52 – 53: Yo-Yo stations with multiple casts and no bottles fired.

Station 54: Seasave real-time display was showing Niskin 1 fired at 350 m in down-cast. Similarly Niskins 2 and 3 were showing as fired at ~850 m during the up-cast, however, no bottles were armed or fired during cast. When CTD was onboard, no bottles were fired and all bottle were still open. Assumed to be a glitch in the software and computer was restarted.

APPENDIX B: AUTOSALS MAINTENANCE AND MALFUNCTIONS

When filling up the tank of the TAMU Autosal bath with distilled water and 1ml of bleach per liter, there was a spillage of water inside the instrument. The equipment was opened and it was observed that the conductivity cell was slack, permitting water to overflow. The cell was dried up with paper towels, and the rear part of the equipment was opened to dry the spilled water. The equipment was left open all night and a fan was used to remove all moisture. Contacts were cleaned up as a precautionary measure, although none of them, or any other electronic board, was wet at the time. At the beginning of some "runs" the pump did not work, which was solved by opening the front part and slightly pushing the strap.

Due to their independent malfunctioning, alternative usage (see also Figure 7) of the two Autosals was required as indicated below.

Autosal	Malfunction Type
SHN	- Drift in measurement station # 2 - Drift in measurement station # 20
TAMU	- At the end of sta. 13 the display failed and was impossible to get the digit corresponding to tens (penultimate digit) at READ mode. - During sta. 44 the display failed and was impossible to get the digits corresponding to units and tens at READ mode.

APPENDIX C: WINKLER TITRATION PROBLEMS

After set up of titration rig, several problems occurred. First an error message given on the Dosimat when the titrator was turned on was "no exch, unit!" This error message was given because the titrator was not properly attached to the top of to the exchange unit due to a missing copper connector. This connector is believed to have been broken during shipment of titration rig from College Station, TX to Ushuaia, Argentina. A piece of copper wire was loosely inserted into the location of the missing connection and the error message went away.

After the connection problems were solved, standard were successfully run and blank runs were attempted, but it was found that blank runs did not work. In order to run blanks, two consecutive titrations of 1mL KIO_3 are performed in the same flask. The Dosimat consistently overtitrates thiosulfate into samples by a small amount. The main problem we encountered was that the amount of excess thiosulfate left in the flask after the first titration was enough to completely react with the second 1 mL of KIO_3, meaning a second equivalence point could not be measured. This is likely due to one of two reasons: 1) either the probe or processor were functioning incorrectly by not stopping the titration until much past the endpoint, or 2) the KIO_3 standard solution mixed at GERG and shipped to the B.O. Puerto Deseado was mixed incorrectly.

Probe malfunction could not be ruled out while aboard the Deseado. The main probe was replaced with the spare sent with the unit, but the spare probe itself didn't work, so the first probe was put back on the unit. As a note, the spare probe box was marked "use only as a last resort" and it clearly was not tested before shipment to the boat. In order to test the original probe, solutions of thiosulfate of various dilutions were made, and very consistent increases were seen in the volume of thiosulfate used in the standard titrations with an increase in dilution amount, indicating that if the probe was to blame, it was a very consistent error. However, it is likely that the probe was functioning correctly.

The other, more likely explanation is that the KIO_3 solution was mixed too dilute, by anywhere from 4X to 10X. One mL of a too dilute solution of KIO_3 could be fully quenched by the remaining thiosulfate in the blank solution after the first titration, which would in turn not allow a second endpoint to be measured. Because all solutions were mixed at GERG prior to shipment, and no balance was available on the boat, new solutions could not be made. In order to counteract the likely too dilute KIO_3 standard solution, the thiosulfate solution was diluted by 4X for all samples for the remainder of the cruise (35g thiosulfate in 4L DI water). By diluting the thiosulfate solution, the blanks ran correctly, but the values obtained for standard runs were still about 2 or 3X less than the values usually obtained. A small sample of the KIO_3 solution and 35g thiosufate were taken back to TAMU to test the exact concentration and determine if that was in fact the problem.

APPENDIX D: MOORINGS ISSUES

A slight ridge in the nickel-bronze finish of the O-ring groove was found on an RCM-8 (S/N 12454) deployed on M3 at 1400 m. With no spares on the boat this small imperfection was feathered as much as possible, but is not likely to cause any problems. The part should be refinished after the instrument is recovered.

The RCM-9 current meter deployed on M2 had a broken conductivity cell glass bore that might affect the cell's constant, and likely will also influence the data.