LMG 14-11: Cruise Report

ChinStrAP: Changes in Stratification at the Antarctic Peninsula

Deployment cruise: November 27 - December 21, 2014
R/V Laurence M. Gould

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ASC team: Herb Baker (MPC), Cindy Dean (MLT), Mike Lewis (MT), Rich Thompson (MT), Julian Race (ET/IT) & Austin McHugh (ET)

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1 Introduction & preparation

Andy Thompson

1.1 Objectives

The goal of the ChinStrAP (Changes in Stratification at the Antarctic Peninsula) project is to assess the role of mesoscale and submesoscale variability on water mass transformation and exchange across the continental shelf and slope in southern Drake Passage. Specifically we plan to:

1. Assess the influence of flow-topography interactions on the frequency and characteristics of mesoscale eddy generation along the southern boundary of the ACC. We will be sampling a region where the strong southern ACC front (SACCF) and the ACC's southern boundary run along the continental slope before interacting with the Shackleton Fracture Zone (SFZ) and deflecting northward. This is a known region of eddy generation, as observed from remotely-sensed sea surface height (SSH), sea surface temperature (SST) and ocean color observations. We hope to obtain the *in situ* observations necessary to determine the mechanisms by which these eddies are formed and how they contribute to cross-shelf exchange.

2. Explore the interactions between surface wind and buoyancy forcing on mixed layer depth variability and its implications for ventilation of the deep ocean. Southern Drake Passage is a key location where deep isopycnals rise towards the surface across the ACC and outcrop allowing direct exchange with atmospheric temperatures and gases. This process is critical to the equilibration of dissolved gas concentrations with atmospheric values and thus influences large-scale characteristics of Earth's climate. A large number of recent studies have pointed to the strong influence of submesoscale processes, both due to surface forcing and stirring by mesoscale eddies, on rapid changes in mixed layer depth. These changes come about through dynamic instabilities related to lateral gradients in mixed layer properties. The ACC is a location where strong lateral fronts align with strong westerly winds. This situation is similar to western boundary currents, however the internal density structure is considerably different in the ACC. Our measurement strategy should allow us to capture the evolution of these dynamical processes.

3. Carry out an XBT/XCTD transect across Drake Passage on the southbound leg as a contribution to Scripps High Resolution XBT/XCTD observing line (WOCE AX22). This information will provide larger-scale context for the data collected from the three gliders.

4. Determine with high spatially- and temporally-resolved measurements the characteristic internal variability in this regional current system. This work will help to better interpret long-term observations in this same location (e.g., LTER monitoring, the AX22 high resolution XBT/XCTD line). The observations will also help validate high frequency variability in numerical models as they push towards resolving key dynamical processes at the continental shelf break.

Figure 1: Schedule for deployment cruise, LMG14-11.

To achieve these objectives, we plan to deploy two *in situ* buoyancy gliders, Seagliders, and a surface platform, a Wave Glider, to collect the physical, biological and meteorological observations to mechanistically understand the variability occurring in this region of the ocean. The total length of the deployment will be 4.5 months. This research program will also evaluate the advantage of using diverse autonomous platforms to observe a remote and harsh environment, such as the ACC and the continental shelf surrounding the Antarctic Peninsula.

1.2 Science Plan for ChinStrAP deployment cruise

The research will be carried out aboard the Laurence M. Gould between the 27th of November and the 21st of December (Figure 1). The primary purpose of the cruise is to deploy all three gliders (2 Seagliders, 1 Wave Glider) and assess their health before leaving them to sample throughout the austral summer. Recovery is planned for April 2015. In addition to the glider deployments, we hope to carry out three CTD transects that traverse the continental shelf and slope, coincident with the deployment locations of the gliders. We have planned for a total of 20 CTD stations. These are all full depth, although they span shelf (∼400 m depth) and deep ocean (∼4000 m) regions.

We are scheduled to leave Punta Arenas on the 27th of November. Ideally we will have an opportunity to open the glider crates and run self-tests/sim dives on the gliders before locking down the crates for our first Drake Passage crossing. While crossing Drake Passage, we will complete an XBT/XCTD transect (∼70 deployments). There is also time allotted for 12 hours of deep, nighttime towing before arrival at Palmer Station on 1 December. It would be helpful to carry out a shallow test CTD prior to arrival at Palmer Station.

Figure 2: Map of the ChinStrAP study site. Palmer Station is given by the blue square; yellow circles indicate CTD station and green triangles are approximate glider deployment locations. Contours are the bathymetry from the IBCSO data.

Our dedicated science time involves 10 days between 5 and 14 December. Depending on weather conditions (sea ice should not be a problem at this time of year, although we will consult satellite photos for icebergs), we will deploy the first Seaglider north of King George Island. Deployment will involve self-tests and sim dives on deck and a buoyancy test, ideally from a small boat (Figure 2). This will need to happen during daylight hours. Immediately after deployment, we will need to collect a CTD profile near the glider for calibration purposes. We will then remain in the region for approximately 12 hours, while the glider undergoes trimming. At this time we can begin to carry out the first CTD section across the continental slope and into Drake Passage.

The next deployment will be the Wave Glider, which will also be released north of King George Island. Jean-Pierre will provide information on the preparation and timing of the Wave Glider deployment. Again, a CTD will be carried out close to the deployment location of the Wave Glider and we will remain on site for 0.5 to 1 days to assess the health of the Wave Glider. We will then complete the first CTD section if there are stations remaining.

```
Planning 16-Nov-2014 14:07:08
ShipSpeed used: 10
Reference Start Time used: December 05 2014 09:00:00
Winch Speed used: 50
Using input file Station depths
```

Event#	ID	TYPE	Latitude	Longitude	DEPTH stdep	ETA	ETD	Steam toSta hrs	Time_on Station hrs	Total Time hrs
0	P	start	-64 45.600	-64 3.000	500	NA	05-Dec-2014 09:00:00	0.00	0.00	0.00
1Corner		corner	-63 0.000	-64 30.000	500	05-Dec-2014 19:37:36	05-Dec-2014 19:37:36	10.63	0.00	10.63
2KGI		glider	-61 42.000	-58 0.000	317	06-Dec-2014 15:20:04	08-Dec-2014 15:20:04	19.71	48.00	78.33
3C1_01		ctd	-61 42.000	-58 0.000	317	08-Dec-2014 15:20:04	08-Dec-2014 15:50:45	0.00	0.51	78.85
4C1_02		ctd	-61 36.000	-58 6.000	387	08-Dec-2014 16:30:36	08-Dec-2014 17:04:05	0.66	0.56	80.07
5C1_03		ctd	-61 27.960	-58 14.040	870	08-Dec-2014 17:57:31	08-Dec-2014 18:50:19	0.89	0.88	81.84
6C1_04		ctd	-61 25.020	-58 16.980	1371	08-Dec-2014 19:09:52	08-Dec-2014 20:22:43	0.33	1.21	83.38
7C1_05		ctd	-61 21.780	-58 20.220	1871	08-Dec-2014 20:44:16	08-Dec-2014 22:17:06	0.36	1.55	85.29
8C1_06		ctd	-61 18.180	-58 23.820	2376	08-Dec-2014 22:41:04	09-Dec-2014 00:34:06	0.40	1.88	87.57
9C1_07		ctd	-61 15.420	-58 26.580	2871	09-Dec-2014 00:52:29	09-Dec-2014 03:05:19	0.31	2.21	90.09
10C1_08		ctd	-61 11.760	-58 30.240	3365	09-Dec-2014 03:29:41	09-Dec-2014 06:02:17	0.41	2.54	93.04
11C1_09		ctd	-61 9.120	-58 32.880	3870	09-Dec-2014 06:19:52	09-Dec-2014 09:12:40	0.29	2.88	96.21
12C1_10		ctd	-61 7.380	-58 34.620	4367	09-Dec-2014 09:24:16	09-Dec-2014 12:36:57	0.19	3.21	99.62
13C1_11		ctd	-61 4.620	-58 37.380	4870	09-Dec-2014 12:55:20	09-Dec-2014 16:28:08	0.31	3.55	103.47
14C1_12		ctd	-60 59.880	-58 42.120	5219	09-Dec-2014 16:59:44	09-Dec-2014 20:46:30	0.53	3.78	107.78
15ElephantI		glider	-60 30.000	-52 30.000	695	10-Dec-2014 15:12:07	11-Dec-2014 15:12:07	18.43	24.00	150.20
16C2_01		ctd	-60 30.000	-52 30.000	695	11-Dec-2014 15:12:07	11-Dec-2014 15:57:55	0.00	0.76	150.97
17C2_02		ctd	-60 24.840	-52 36.480	456	11-Dec-2014 16:34:20	11-Dec-2014 17:10:34	0.61	0.60	152.18
18C2_03		ctd	-60 23.100	-52 38.640	995	11-Dec-2014 17:22:49	11-Dec-2014 18:20:37	0.20	0.96	153.34
19C2_04		ctd	-60 22.200	-52 39.720	1511	11-Dec-2014 18:26:54	11-Dec-2014 19:45:20	0.10	1.31	154.76
20C2_05		ctd	-60 21.360	-52 40.800	1992	11-Dec-2014 19:51:19	11-Dec-2014 21:28:59	0.10	1.63	156.48
21C2_06		ctd	-60 20.280	-52 42.180	2496	11-Dec-2014 21:36:39	11-Dec-2014 23:34:30	0.13	1.96	158.58
22C2_07		ctd	-60 18.000	-52 45.000	2758	11-Dec-2014 23:50:32	12-Dec-2014 01:58:52	0.27	2.14	160.98
23Saddle		corner	-60 47.760	-55 45.600	958	12-Dec-2014 11:20:47	12-Dec-2014 11:20:47	9.37	0.00	170.35
24C3_01		ctd	-60 47.760	-55 45.600	958	12-Dec-2014 11:20:47	12-Dec-2014 12:17:06	0.00	0.94	171.29
25C3_02		ctd	-60 54.600	-56 0.000	943	12-Dec-2014 13:15:53	12-Dec-2014 14:11:36	0.98	0.93	173.19
26C3_03		ctd	-60 35.400	-56 54.000	2628	12-Dec-2014 17:27:24	12-Dec-2014 19:30:31	3.26	2.05	178.51
27C3_03		ctd	-60 34.200	-56 44.400	2457	12-Dec-2014 19:59:43	12-Dec-2014 21:55:59	0.49	1.94	180.93
28Corner		corner	-63 0.000	-64 30.000	500	14-Dec-2014 00:20:11	14-Dec-2014 00:20:11	26.40	0.00	207.34
29Palmer		end	-64 45.600	-64 3.000	500	14-Dec-2014 10:57:47	NA	10.63	0.00	217.96

Figure 3: Planned timing of the ChinStrAP cruise. Note that the estimation of ship speed at 10 knots may be an overestimate, but a full 24 hours has been allotted for each glider deployment, which is an overestimate for contingency.

If we remain on schedule after the first two glider deployments, we will steam to our second deployment site east of Elephant Island. We will deploy the remaining Seaglider over the continental shelf, just to the east of the Ona Rise, where the Antarctic Slope Front (ASF) is known to exit the Weddell Sea. Similar to before, a local CTD will be carried out for calibration purposes and a CTD section across the shelf and slope will be completed. The glider should be trimmed and starting deep dives before we leave the site. With any remaining time, we will return to the saddle found along the southern edge of the SFZ and conduct a set (approximately 5) of CTD profiles on either side of the ridge. Piloting of the gliders will continue on the ship throughout the cruise.

If for any reason, the initial glider deployments take up too much time, then the deployment of the second glider will also happen over the continental shelf to the west of the SFZ. The two gliders can sample in tandem, or we could try to pilot the glider to the east of the SFZ.

We return to Palmer Station on the 16th of December and sail for Punta Arenas on the 17th. We will complete a second XBT/XCTD survey during the crossing of Drake Passage[1].

[1]When we got on the ship we learned that we were only carrying out the XBT/XCTD survey on the southbound leg.

1.3 Personnel

Below is a list of scientists participating in the deployment cruise. Next to each name is the instruments for which each person will be responsible.

Andrew Thompson, Caltech, Chief Scientist
Xiaozhou Ruan, Caltech, graduate student, **Seagliders**
Giuliana Viglione, Caltech, graduate student, **CTD & Underway data**
Andrew Delman, Scripps, graduate student, **XBT/XCTD, Salinometer**
Jean-Pierre Smit, CSIR, technician, **Wave Glider**

During CTD sampling the watch was organized on a twelve-hour-on, twelve-hour-off schedule. During the first six hours of each twelve hour shift, the watch participant would be the Point of Contact (POC), which means this person would be principally responsible for participation in the CTD sampling. During the second six hours, time was devoted to carrying out salinity analysis on the salinometer and piloting the gliders. The watches were as follows:

Xiaozhou Ruan, 12:00am to 12:00pm
JP Smit, 6:00am to 6:00pm
Giuliana Viglione, 12:00pm to 12:00am
Andrew Delman, 6:00pm to 6:00am

Our ASC crew was:

Herb Baker, Marine Project Coordinator
Cindy Dean, Marine Laboratory Technician
Mike Lewis, Marine Technician
Rich Thompson, Marine Technician
Julian Race, IT / Electronics Technician
Austin McHugh, Electronics Technician

Our ECO (Edison Chouest Offshore) was:

Ernest Stelly III, Captain
Brandon Bell, First Mate
Luke Zeller, Second Mate
Robert Depietri, Third Mate
Michael Brett, Chief Engineer
Fernando Avila, Chief Engineer

Additionally, we had an Argentinian observer on board, Diego Nicole-Dominguez.

Figure 4: The science team with SG539, Queequeg, prior to deployment. From left to right: Andrew Delman, Giuliana Viglione, Andy Thompson, Xiaozhou Ruan and JP Smit.

1.4 Location

Our study site is the continental slope and shelf at the northern tip of the Antarctic Peninsula. This is a location where the southern boundary of the ACC interacts closely with the continental margins. For this reason, this is a site of strong currents as well as strong mesoscale variability. Both deployment sites should be well away from the sea ice edge at the time of deployment, although it should be noted that the region where the ASF exits the Weddell Sea is known as Iceberg Alley and frequent monitoring of satellite images will be necessary while piloting the gliders. Icebergs are known to flow along the path of the ASF, which we will traverse constantly as our sampling strategy. Both deployment sites should be far from the sea ice edge at the time of deployment (Figure 6). However, during the survey period, sea ice will be moving northward and potentially past the tip of the Peninsula. Note that the plan is to keep SG539 and the Wave Glider west of the SFZ, which should keep us free from sea ice throughout the year. After deployment, SG566 will be piloted back to the west towards the SFZ and should arrive there well before the sea ice extends to these latitudes. Nevertheless, sea ice extents should be monitored throughout the project using the PolarView website: `www.polarview.aq/antarctic`. We also have plans to make and post daily maps of the sea ice during the course of the deployment.

This is a region where there is a strong transition between the energetic ACC (especially in the latitudes crossing the Polar Front) and the less energetic shelf regions. Altimetry data will be helpful in determining the evolving positions of the southern ACC fronts, as well as the position of coherent mesoscale eddies. This will be helpful in piloting the glider. Xiaozhou has done some preliminary work looking at the surface circulation structure in southern Drake Passage as documented in Figures 7 through 9.

Figure 5: Who's who on LMG 14-11.

Figure 6: Maps of sea ice for the months, January through May (left to right) from 2008 to 2012 (top to bottom). The black box roughly indicates our deployment site.

Figure 7: Mean surface speed in Drake Passage averaged over the period 2011 through 2013. The velocity field is derived from weekly MADT (mean absolute dynamic topography) AVISO data.

Figure 8: Mean EKE in Drake Passage as determined from the $|\nabla SSH|^2$. The scale is logarithmic, e.g. $-2 = 10^{-2}$ m^2 s^{-2}. The average is over the period 2011 through 2013.

Figure 9: SSH contours that correspond to the strongest fronts in southern Drake Passage following a Sokolov-Rintoul-type analysis. These contours are associated with large gradients in SSH. The figure shows mean absolute dynamic topography (MADT) from AVISO on April 18, 2012. The contours denote from south to north, $h = -108, -106, -104, -102, -100, -98, -96, -94$ cm. The strongest fronts are located at -98 and -92 cm.

We have downloaded and done a preliminary analysis of Laurie Padman's AntPen04.01 tide model (https://www.esr.org/polar_tide_models/Model_AntPen0401.html). Tides (the M2) are reasonably strong at the tip of the Peninsula, increasing in amplitude moving to the east towards Elephant Island. However, tidal velocities remain smaller than they are in the Weddell Sea, where two Seagliders were piloted during the GENTOO project in January 2012.

1.5 Monitoring

During the course of the cruise, it will be important to monitor the position of sea ice (most critical!), frontal position as given by SSH and the position of any icebergs in the area. To observe sea ice, we will use http://www.polarview.aq/. It may also be useful to consider the Navy's realtime assimilation of SSH, SST, etc. into a 1/12 degree HYCOM model. Fields can be found at the following website:

http://www7320.nrlssc.navy.mil/GLBhycom1-12/antarc.html.

1.6 Outreach and broader Impacts

As part of this cruise, the science team has maintained an outreach website that includes daily journals about work and life on the ship. Additionally there is a separate outreach page which has a form for sending questions to the science team while on the ship. These have been answered in batches and posted to the website. Currently schools from Rhode Island, New York, Texas and California are participating. The website can be found at:

www.gps.caltech.edu/∼andrewt/chinstrap/homepage.html

2 Cruise Narrative

Andy Thompson

Nov. 25: We arrived in Punta Arenas on a cold and windy afternoon and were picked up by DAMCO at the airport. We arrived at the hotel in early evening and met up with Giuliana, Xiaozhou, Andrew and JP and was pleased to get to a nice warm hotel room. Unfortunately I was greeted by roughly a dozen emails that had arrived since being in Miami with the realization that the Wave Glider was still in customs in Santiago. Thus began the frantic, but ultimately unsuccessful attempt to liberate the Wave Glider from Santiago customs during a strike.

Nov. 26: Another wet and windy day in Punta. We went over to the warehouse at 10.00am for our ECW fitting. We met on the Gould at 2.00pm for a safety meeting and were introduced to the ASC crew. We returned to Punta for dinner (basil pisco sours!). At 10.30pm we took both gliders out onto the back deck and ran a successful self-test on both gliders. Communications were good and batteries were fully charged (SG566 98%, SG539 95%).

Nov. 27: Happy Thanksgiving! We were planning to sail at 9.00am, but were delayed and did not leave Punta Arenas until 3:00pm in the afternoon. We spent the morning going through the self-test files generated the evening before. We completed the Excel checklist files for each glider. After leaving PA, we had a meeting in the lounge with Herb and Luke with basic information about the cruise. After dinner we had a PI science meeting with the ASC support crew as well as Captain Stelly. We went through the plans for deployment and came to an agreement to meet up with the Palmer near Livingston Island if the Wave Glider arrived in Punta Arenas successfully prior to its departure. After the science meeting, Herb and I went up to the bridge and discussed with the captain exact deployment locations for both gliders.

Nov. 28: We had a lab safety meeting with Cindy at 8.30am and had a deck safety meeting with Mike and Rosemary immediately after on the back deck. Herb alerted us to the fact that there was a problem with the starboard engine and that from late last night we had been moving at roughly 7 knots. Fernando and his crew continued to work on the problem and had it fixed by the early evening, allowing us to enter Drake Passage. Continued to look through glider self-tests. First XBT/XCTD launch estimated for 11.30pm this evening.

Nov. 29: We spent the day steaming across Drake Passage. The XBT/XCTD transect continued with the help of everyone filling out six, four-hour watches. We saw dolphins and our first iceberg.

Nov. 30: We put command, target and science files on the basestation for each glider. We finished our preparation of the ChinStrAP website and organized an order for journal contributions. The XBT/XCTD transect was completed in the early evening as we finished our crossing of Drake Passage. A net tow to catch pteropods was scheduled for 10.00pm.

The catch was extremely successful and we had good fun in the wet lab sifting through all the creatures that were pulled up. The day was rainy/snowy with low visibility throughout.

Dec. 1: We spent most of the day standing on the bow of the ship as we passed through the beautiful Gerlache Strait and the Neumeyer Channel. After this we travelled to Palmer Deep for our second fishing event. We arrived on site shortly after dinner, around 8:00pm at which point we began fishing for pteropods. This catch was not as successful as the first and as of 12.30am the nets were still going out. We plan to arrive at Palmer Station at 8.00am tomorrow morning. There were many sightings of gentoo penguins and a couple Minke whales.

Dec. 2: We arrived at Palmer Station on Tuesday, the 2nd of December. The morning was spent organizing our software for glider piloting, while some members of the science team were kindly allowed to join the station tour. We spent an hour reviewing piloting procedures and providing a piloting introduction to those less familiar with the software. Following lunch, we removed the gliders from their shipping crates, assembled their carrying cradles and moved the gliders to the dry lab. We ran bench tests on the gliders throughout the afternoon. In the evening we took both gliders out on to the back deck of the Gould and ran them through a series of self-tests and simulations dives. Communications were very good with our basestation and no serious problems were detected during the diagnostics. Gliders were returned to the dry lab around 11.00pm. That gave us an hour in the Palmer Bar during which the team of Thompson and Thompson dethroned JP and Xiaozhou at pool (2 games out of 3).

Dec. 3: Wednesday was spent combing through the simulated glider dives in preparation for deployment. One error was found in the sensor arrangement, requiring a re-installation of the oxygen and WetLabs sensors. Arrangements were made with Julian Race and Andy Archer to provide satellite images of ice concentration, SAR images and chlorophyll. The former two are primarily for iceberg avoidance while piloting the gliders. The latter images are useful for identifying Southern Ocean fronts. We tested the salinometer and and tied the gliders down to the bench in the dry lab in preparation for departure. We also used some spare time in the afternoon to climb the glacier behind Palmer Station and were treated to spectacular views and good snowball-making conditions.

Dec. 4: We departed Palmer Station at 9:00am and were treated to a stunning trip through Neumeyer Channel with sunny skies and a flat sea. In the morning we re-configured the sensors on SG539 following instructions from Kongsberg. Following lunch, we met with the ASC support team to discuss the glider deployment. In the afternoon we selected bottle depths and labelled the bottled in preparation for CTDs.

Dec. 5: We arrived at our first glider deployment site north of King George Island around 9:00am on Friday, the 5th of December. Despite a heavy fog and intermittent rain, the seas were relatively flat, perfect for glider deployment. SG566 was brought out on to the back deck and wings and antenna were assembled. We ran the glider through the pre-launch tests, but communications on the back deck were poor, likely due to satellite position and

interference with the ship structure. Communications improved after lunch and we were ready to deploy by 1:30pm. Andrew also realized that there were some problems with file permissions on the basestation. Mike Lewis, Rich Thompson, JP and Xiaozhou deployed the glider smoothly from the zodiac. The glider was well ballasted and completed its first dive 30 minutes later. We then immediately started CTDs from the glider deployment location. The rest of the evening was spent piloting the glider and improving glider flight. There were a few scary moments when we lost the ability to process the glider data, but on the whole, piloting went smoothly and by late evening we had started deep dives. On cast 4 of the CTD transect, we forgot to tighten the caps on the Niskin bottles and water samples were not collected.

Dec. 6: CTDs continued throughout the 6th of December. On the 10th CTD (4000 m), we were unable to fire any bottles when the rosette reached the bottom of the cast. We attempted to fire bottles throughout the ascent, but when the CTD returned to the ship, none of the bottles had closed. Julian Race and Austin McHugh trouble shot the problem and decided to replace the 24-bottle rosette with a spare 12-bottle rosette on the ship. The final two casts (4500 and 5000 m) were carried out without collecting water samples in order to complete the first transect.

Dec. 7: Sunday, the 7th of December was spent steaming to the Elephant Island glider deployment site. During this time, the ET's and MT's replaced the damaged pylon on the 24-bottle rosette and replaced it with the 12-bottle firing system. Every other bottle was removed on the CTD package (leaving 12 bottles). During the day we generated new CTD locations as we are well ahead of schedule. The salts for the King George transect were completed.

Dec. 8: We arrived at our second glider deployment site early on the morning of Monday, December 8. The swell had begun to increase, but again, conditions were favorable for deployment. After a safety meeting the gliders were brought out on deck at 6:00am in order to get an earlier start on the final tests and launch routine. This time we had relatively few problems with connecting to our basestation at Caltech and the glider was prepped and ready for deployment by 8:00am. Mike Lewis, Rich Thompson, Jean-Pierre Smit and Giuliana Viglione were aboard the zodiac this time and again the deployment went very smoothly. While we waited for the glider to upload its dive command, a group of chinstrap penguins congregated near the Gould—we took this as an auspicious omen. The glider commenced its first dive at 9:30am. We started our next CTD cast at 10:30am, following the glider deployment. At the start of the following CTD cast, Mike Lewis spotted a kink in the CTD wire. The CTD was brought back on deck and it was decided to cut off this piece of wire and re-terminate on the CTD package. The re-termination was accomplished on the first attempt, but the cable was accidentally melted and had to be re-terminated a second time. ET Austin McHugh completed both of these jobs. The second try was a success and we were up and doing CTD casts again by 5:00pm. We continued to pilot the gliders with minimal complications. CTD casts on the Elephant Island transect continued throughout the night, with cast 6 occurring around 1:00am. The swell was beginning to rise due to a strong low pressure system moving through Drake Passage.

Dec. 9: We awoke on the morning of the 9th to find we had not progressed beyond the 6th CTD cast. At the start of the 7th cast, a kink in the CTD wire developed in exactly the same place as earlier, suggesting a systematic problem with the CTD. The end of the wire was once again cut off and re-terminated; Austin McHugh is now a master re-terminator. This brought CTD operations to a halt as we sought feedback on potential solutions to this problem. By mid-afternoon it was decided that the move to a 12-bottle rosette had reduced the weight of the CTD package, which may have caused the kinks. Weight was added to the CTD and there have been no further problems with the wire. CTDs recommenced, but the package then developed problems firing bottles; they would fire at certain times, but not consistently. The CTD section (12 stations) was finished in the early hours of the 10th with continued problems firing bottles.

Dec. 10: On the morning of Wednesday, December 10, we steamed towards the Shackleton Transverse Ridge in southern Drake Passage, however, we were now feeling the full brunt of the storm. Winds topped out at 40 knots with 15 foot seas and predictions for this to continue building. In the afternoon, following consultation with the Herb Baker (MPC) and Ernest Stelly (Captain), we decided to seek shelter in the lee of Elephant Island, where we spent the night.

Dec. 11: We awoke on the morning of the 11th to much calmer seas, but not good news in the weather reports. With predicted wave heights exceeding 30 feet, it was decided to move into Bransfield Strait and carry out a CTD transect here, before heading towards our final transect positions in western Drake Passage, hopefully avoiding the worst of the storm. During the steam into Bransfield, Julian and Austin continued to work on the CTD but found that both the 24-bottle and 12-bottle firing mechanism were not functioning, leading to the possibility that we would continue CTDs without any water samples. The first CTD in Bransfield Strait was conducted in shallow water, close to the coast at 9:00pm, December 11. When the CTD went in the water, the bottle firing system initialized, so we attempted to collect water. On the first cast, two of the four bottles closed. On the subsequent cast, all of the bottles fired and closed and ever since, we have not had any problems with the bottles. We have no idea what happened, but are very happy with the situation! In the evening, Andy gets absolutely thrashed in a game of Hearts with Giuliana, Rich and Cindy.

Dec. 12: The Bransfield transect (10 stations) was completed early in the morning of Friday, December 12. While winds were beginning to die down in Drake Passage, seas remained high, so the decision was made to steam towards our final CTD transect location in western Drake Passage, a distance of approximately 200 miles.

Dec. 13: We arrived at the Phoenix transect at 10:00am on Saturday, December 13 and it was determined that the seas were suitable to start CTDs, which began at 11:00am. There have been no further problems with the CTD bottles.

Dec. 14: CTDs and bottle sampling continued throughout the day. At one point the CTD

was no longer relaying information about wire tension and wire payout length. This did not hamper the science, though. The final CTD came back on deck at 7:00pm and we started steaming towards Palmer Station. In the end, we completed 48 CTD stations, over twice what we had originally anticipated collecting.

Dec. 15: Awoke one hour outside of Palmer Station, which quickly became two hours and then three hours as we encountered sea ice around the station, slowing our progress to 3 knots. We arrived on the Palmer Station dock at 11.00am. Gliders continue to fly well; I prepared slides for a brief science talk the next evening. After dinner we had a team bonding exercise involving alternate dips in the Southern Ocean and the hot tub.

Dec. 16: Spent the morning cleaning out the dry lab, breaking down the cradles and re-packing the glider crates. In the afternoon, climbed up the glacier in a thick fog, which dissipated as we got over to the other side, providing nice views of the sea ice, icebergs, land spits and seals. In the evening we had a cross-town dinner at the Station; Nate and Andy gave a short science talk at 8:00pm. The rest of the evening was spent celebrating in various ways!

Dec. 17: We left Palmer Station at 9:00am and began our steam northward. Many snowballs were thrown at us upon our departure. We now have a full ship with movies running constantly. In Neumeyer Channel, the captain put out the lifeboats to complete some required drills. The evening is capped by an epic match of Phase 10 with David taking the honors.

Dec. 18: Our first day steaming through Drake Passage. Blessed with a "Drake Lake" crossing. Another long Phase 10 match with Deepak winning this time. The new XCTD software is tested with two casts taken at 59°S.

Dec. 19: Last day in Drake Passage! Giuliana and Mike raise everyone's sprits with a competitive scavenger hunt throughout the ship. Frank, Xiaozhou and Andy are triumphant!

Dec. 20: Continued steaming in calm seas up the coast of Argentina and into the Magellean Strait.

Dec. 21: Pilot comes on board around 1.00am; we dock at 9.30am . . . success!

Figure 10: Cruise track for LMG14-11.

3 Seagliders: Preparation and piloting

Xiaozhou Ruan

3.1 Seaglider deployment timeline

26th November: Arrived on ship, removed SG566 and SG539 from crates, checked contents and began self tests.

27th - 28th: Review of self tests results for both of the gliders.

29th- 1st December: Transit period.

2nd December: Arrived at Palmer Station, assembled both of the gliders, ran self tests and simulation dives and tied the glider cradles down in the dry lab.

3rd: Review self test and simulation dive results.

4th: Prepare initial target, science and cmdfiles for SG566, reviewed all the parameters in the log files.

5th: Arrived on site, LAUNCH SG566.

6th: Initial piloting, corrected flying parameters for SG566.

7th: Prepare initial target, science and cmdfiles for SG539, reviewed all the parameters in the log files.

8th: LAUNCH SG539.

3.2 Preparation

SG539 and SG566 were ballasted and checked by Kongsberg in Seattle. PAR sensors were removed and Aandera dissolved oxygen sensors were installed on both of the gliders at the same time in Seattle and they were shipped back to Caltech in August 2014. Andy set up the basestation at Caltech and tested it with Kongsberg engineers while the gliders were still in Seattle. Communication between the gliders and basestation was normal. Andy also ordered a spare set of wings, rudder and antenna. Gliders were put on a USAP ship in Port Hueneme, California and shipped to Punta Arenas. Science team members and both of the gliders arrived on board the LMG on the same day (26th November).

The phone numbers of the Caltech basestation and backup UEA basestation are as follows:

Caltech: 881600005206 (RUDICS)
UEA: 441603597331 (PSTN)

Xiaozhou did a series of self tests in the summer before the gliders were shipped. Everything worked as expected but the roll range on SG566 was from 28.64 deg (3718) to -40.45 deg (1274) which was unexpected since roll range is normally symmetric between -40 deg and 40 deg. After consulting with Kongsberg engineers, it was determined that range was related to ballasting that would allow the glider to fly well in denser polar waters. Also, both the 24V and 10V batteries on SG539 were slightly low, around 95% (98% on SG566). The decision was thus made to put SG566 in the water first.

Note that for a Mac laptop, in order to connect with the gliders and view diagnostics in a Terminal window, a USB serial connection is required. We need to first install a USB driver for Mac (used Prolific PL2303 on Xiaozhou's laptop), and sometimes may need FTDI USB serial. Then to confirm the USB serial driver is installed type

```
ls /dev/cu.*
```

To connect with the gliders type

```
screen -L /dev/tty.usbserial 9600.
```

The gliders were brought inside the dry lab after the last self tests and sim dives. We tried to interrogate the gliders with the acoustic deck box on the ship but the results were inconclusive. We did not find any readings from the deck box screen.

The interrogation and return frequencies for each glider are:

SG566 Interrogate 13.0 Respond 11.5
SG539 Interrogate 12.0 Respond 10.5

On the 4th of December we went through a complete review of the command file. The initial cmd values are given in the Appendix. We also cleaned out the sg566 and sg539 folders on the basestation using the following command:

```
/usr/local/basestation/MoveData.py-m current data location -t new location
```

Target file:

To fully survey the continental shelf in southern Drake Passage, we established targets that are both on and off the shelf. For SG566, the initial target file is as follows:

```
/ Targets holder
DRAKE lat=-6100.0 lon=-6000.0 radius=250 goto=KGIShelf
KGIShelf lat=-6143.5 lon=-5849.2 radius=250 goto=DRAKE
```

After SG566 reached the DRAKE waypoint, we put in 2 new targets on the west of KGIShelf target. These were to allow the glider to fly against the current to approach shelf perpendicular to the along-slope direction:

```
/ Targets holder
KGIShelfMid lat=-6200.0 lon=-6000.0 radius=250 goto=DRAKE
KGIShelfW lat=-6215.0 lon=-6100.0 radius=250 goto=KGIShelfE
DRAKE lat=-6100.0 lon=-6000.0 radius=250 goto=KGIShelfW
KGIShelfE lat=-6143.5 lon=-5849.2 radius=250 goto=DRAKE
```

where KGIShelfE is the original KGIShelf target.

For SG539, the original target file is:

```
/ Targets holder
SCOTIA lat=-6000.0 lon=-5300.0 radius=100 goto=HESP
HESP lat=-6030.0 lon=-5230.0 radius=100 goto=SCOTIA
```

There are two things to note for this specific mission. One is the use of a Kalman filter and the other one is the altimeter on the gliders. Because we are flying in southern Drake Passage where there are strong currents and bathymetry features change very rapidly on the shelf, we need to pay close attention to the gliders so that they do not drifter away when flying to waypoints. Also the altimeter is required to reduce the chance of hitting the bottom, which can cause unpredictable damages to the gliders.

We used the following commands on SG566 at the beginning:

$NAV_MODE,1
$HEADING,-1
$KALMAN_USE,0

This means Kalman results are used to determine the Seaglider heading when they are flying to the targets. After a few dives, we found out that SG566 would fly better without the use of Kalman filter, so it is turned off from the beginning on SG539.

We keep changing the values for

$ALTIM_BOTTOM_TURN_MARGIN
$ALTIM_PING_DEPTH
$ALTIM_PING_DELTA

when the gliders are flying over shallow waters. The altimeter did ping the bottom several times but also gave us some sporadic false hits. We increased $ALTIM_SENSITIVITY from 2 to 3 to avoid false hits. On the other hand, SG566 hit the bottom once around dive 20 and so did SG539 for several times when it was flying over shallow water after detecting the true bottom depth, so we had to increase the $ALTIM_TURN_MARGIN from 12m to 20m to give

Figure 11: Initial target position for both gliders.

it more space to turn around. According to the manual, if the altimeter is receiving false hits, the values of $ALTIM_PULSE and $ALTIM_SENSITIVITY should be increased incrementally. If the altimeter is unable to find the bottom, the values of $ALTIM_PULSE and $ALTIM_SENSITIVITY should be decreased incrementally. Tuning is often best achieved by alternately adjusting $ALTIM_PULSE and $ALTIM_SENSITIVITY by one unit until the altimeter returns realistic depth values.

Science file:

The science files for both SG539 and SG566 from the start was:

```
// Science file for ChinStrAP
/Edit for each Seaglider w/:  CT, AA oxy, WET Labs BB2FL-VMT
/depth time sample gcint
100 5 122 60
200 5 123 120
300 5 120 180
```

Then, for saving battery usage, we changed it to:

```
// Science file for ChinStrAP
/Edit for each Seaglider w/:  CT, AA oxy, WET Labs BB2FL-VMT
/depth time sample gcint
100 5 122 60
200 5 124 120
400 5 120 180
1000 5 140 180
```

We printed out log sheet for the gliders. We were each assigned 6 hours during the second half of each 12 hour shift (first 6 hours is CTD watch) so that we could make sure that both of gliders were monitored at all times. The pilot was required to check the gliders once they surface and record any errors in the log file and changes made in the cmdfiles in the spreadsheet.

3.3 Sensors

Both of the gliders were equipped with an unpumped CT sensor, an Aanderaa optode disolved oxygen sensor and a Wetlabs ECO puck. A photo of the sensor placement is shown below. Details of the sensors are listed below:

SG539:

CT sensors cal constants
calibcomm= Serial #: 0169; CAL: 10612

Figure 12: Position of the three sensors on the glider.

Aanderaa cal Constants
comm_oxy_type = AA4831
calibcomm_optode = SN: 326 CAL: 13-Feb-2014

WETLabs wlbbfl2 calibration constants.
WETLabsCalData.wlbbfl2.calinfo = SN: BBFL2VMT-762, CAL: 03-Oct-2012

SG566:

CT sensors cal constants
calibcomm = Serial #: 0204 CAL: 51714

Aanderaa cal Constants
comm_oxy_type =AA4330
calibcomm_optode = SN: 806 CAL: 52014

Wetlab Forward or Bump Out cal Constants
calibcomm_wetlabs = SN: BBFL2VMT-863, CAL: 9-Jun-2014

3.4 Self tests and simulation dives

Despite the self test that was carried out in the summer, two other self tests were completed for each glider on the cruise before they were deployed. There were generally no problems sending and receiving information between the basestation and the gliders, although signals for iridium satellite communications could be weak sometimes. We found it useful to use a hand held Iridium phone to check the signal strength at different locations before we moved the glider out on the deck.

We went through the self test files following the checklist from Kongsberg. We noticed that during the first self test on SG539, the roll control column in the eng file showed all 0's. Kongsberg engineers did not think it was a problem and this error did not repeat itself during the second self test. We agreed it was still good to go in the water.

Simulation dives were carried out at Palmer Station for both of the gliders. The cmdfiles we used for sim dives on SG566:

$SIM_W,0.1
$SIM_PITCH,-20
$D_TGT,30
$T_DIVE,10
$T_MISSION,15
$KALMAN_USE,2
$SM_CC,150
$MAX_BUOY,5

Figure 13: Glider during self-test at Palmer Station.

$USE_BATHY,0
$T_RSLEEP,1
$C_VBD,2762
$C_PITCH,2883
$C_ROLL_DIVE,2705
$C_ROLL_CLIMB,2630
$QUIT

on SG539:

$SIM_W,0.1
$SIM_PITCH,-20
$D_TGT,30
$T_DIVE,10
$T_MISSION,15
$KALMAN_USE,2
$SM_CC,150
$MAX_BUOY,5
$USE_BATHY,0
$T_RSLEEP,1
$C_VBD,2864
$C_PITCH,2573
$C_ROLL_DIVE,2100
$C_ROLL_CLIMB,2100
$QUIT

Sim dive results were also carefully checked based on the SG539 checklist provided by Andy. We had trouble plotting the sim dive results, which was solved during actual piloting (see details in the piloting section). We also found that the order of sensor values in the eng file was different from the actual sensor installation order. We switched oxygen sensor and WETlabs as instructed by Kongsberg engineer:

Scan and include these?

1. **Un-install sensors from slots in SG539.** Go to: Main menu → select Parameters and Configuration and press Enter → select Hardware configuration parameters and press Enter → select Show current hardware configuration (note the slot and port the AA and WL are assigned to) and press enter → select Configure sensor and press Enter → select the slot the Aanderaa is configured for and press Enter → select Not installed and press Enter → repeat the deletion process for the WETLabs → press Enter to go up one level → when prompted for Reinitialize hardware configuration answer Y(es); this writes the configuration change to NVRAM.

2. **Re-install sensors in the desired slots in SG539.** Go to: Hardware configuration parameters→ select Show current hardware configuration (the AA and WL should no longer be installed) and press Enter → select Configure sensor and press Enter → select the slot you want the Aanderaa configured for and press Enter → select the correct

AA model .cnf file in the list (based on self tests run at KUTI you have a 4831 on SG539) and press Enter → select the port for the AA (it should be the same port it was configured for in step 1) and press Enter → repeat the process for the WL → press Enter to go up one level → when prompted for Reinitialize hardware configuration answer Y(es); this writes the configuration change to NVRAM.

3. **Check the set-up.** Select Hardware configuration parameter; you should see the AA4831 and WL-BBFL2 listed, including slot and port assignments; are they now correct? Run a self test on the sensors; Go back up to the Hardware tests and monitoring menu → Sensors → and run a self test on both sensors

3.5 Piloting

The piloting during this mission was shared between the science team members. We prepared the first cmdfile as follows (for SG539):

```
$ALTIM_BOTTOM_TURN_MARGIN,12
$ALTIM_PING_DEPTH,350
$ALTIM_PING_DELTA,10
$D_ABORT,120
$D_TGT,45
$C_PITCH,2900
$C_VBD,2424
$T_DIVE,15
$T_MISSION,25
$MAX_BUOY,150
$SM_CC,400
$QUIT
```

Because the gliders are flying over the continental shelf, we needed to make sure the altimeter works well. Some center values are glider specific and from the trim sheet. $MAX_BUOY and $SM_CC values were first assigned the recommended values in the manual. These two values turned out to be crucial to battery consumption and they are environment dependent. MAX_BUOY is for the dive thrust and SM_CC is the full buoyancy the glider needs to expose the antenna during surface maneuver. Recommended trim values can be found in the VBD plot where CC_surf_min corresponds to the recommended value for CC_SM.

After SG566 was deployed, we found that dive plots can not be generated from the DiveData GUI script. The Matlab dialog box suggested that the data files were inconsistent and marked as "bad" by the basestation. We were first using the websites from UEA and Caltech to look at the plots and pilot. Andrew found that the actual temperature frequencies in the eng file were lower than the lower limit in the glider sg_calib_constants.m file (sbe_cond_freq_min). We decreased the values for both of the gliders and after this, the plots could thus be made from the DiveData script.

Another problem soon came up after we fixed the plot script. Raw data could not be

processed on the basestation and we did not have any nc. files for a few dives. We checked the permissions for all the files on the basestation and found that we did not have appropriate permissions for several files. After we changed the permissions, this problem was solved.

After we deployed SG539, it had 4 to 5 VBD retries in the log file for the first few dives. This situation was similar to the previous deployment two years ago when SG539 was deployed in Weddell Sea for a ten-week mission. Kongsberg engineers replied that the VBD retries are occurring when the glider is pumping to SM_CC for the surface maneuver. These are shown in the SM_CCo line in the log file. Retries at SM_CC are usually caused by cables from the science sensors or the communications cable being wrapped too close to the bladder. This does not normally prevent the glider from being able to pump to full buoyancy. If we were able to pump to full buoyancy without the glider logging an error it was safe to continue the deployment.

3.6 Recovery incidents

SG566 has gone into recovery on two separate occasions since its deployment. The first was a piloting error in the early dives. As we were sending Tashtego on deeper and deeper dives, we forgot to update $D_ABORT, so that the abort depth was reached before it was supposed to apogee. In a more serious incident, on dive 52, the glider suffered 74 roll retries and put itself into recovery. From the .cap file it looks like the glider was attempting the roll the battery pack to an extreme angle. We hypothesize that something drastic happened to the glider (it flipped?) and became disoriented. Since there were only re-tries and no errors, we allowed it to dive again with a $QUIT in and slowly increased the depth from 300 to 600 and finally back to 1000 m. We have not encountered this problem again.

4 Seagliders: Deployment method

Jean-Pierre Smit

This section provides an overview of the glider deployment method that was followed while deploying two Caltech ocean gliders aboard the Laurence M. Gould during the ChinStrAP cruise, cruise number: LGM14-11. The gliders were deployed from a zodiac as there is less of a chance of damaging the glider as compared to deploying from the aft crane of the ship.

The first deployment took place on the 5th of December, north of King George Island, coordinates: Lat -61.73 Lon -58.82. The Caltech glider Tashtego (SG566) was the first of the two gliders to be deployed. We arrived at the deployment site at about 1100 UTC. It was mostly foggy and we had light rain throughout the day. The sea was calm with a swell of about 3-4 feet. Directly upon arrival, all parties that were to be involved with the deployment were called to the bridge for a safety meeting. This was primarily to review the deployment procedure and to discuss the safety concerns involved in the operation. Thereafter, the glider was moved from the wet lab to the aft deck, and the wings and antenna were mounted to the glider. The bladder compartment was also checked to make sure that nothing was obstructing the bladder that could prevent the bladder from inflating to its maximum size. With the glider fully assembled, numerous attempts were made to establish a connection with the basestation, to conduct a self-test and sea launch test, but the connection kept dropping. An Iridium phone was later used to check the signal strength of the Iridium satellite service, and it appeared to be weak at the starboard side where the glider was standing.

After lunch, the glider was moved to the stern of the ship where the Iridium phone showed full signal strength. We attempted again to establish a connection, but the connection still kept dropping. During this time we also experienced some problems with the field laptop, which was exposed to extremely cold and wet weather for an extensive amount of time. Upon closer inspection on the basestation, it was clear that a pdoscmds.bat file was never deleted from a previous test, and was ultimately the reason for the connection dropping. Once the file was removed, the glider was able to call in. After the self-test and sea launch test were completed, the glider was put into launch, and carried onto the zodiac, which was located on the aft deck. The glider (in its cradle) was tied down on the floor of the zodiac with the antenna facing aft. The CT sail, dissolved oxygen and optics sensor covers were also removed at this time.

Four members went out on the zodiac to deploy the glider. Two marine technicians: Mike Lewis and Richard Thompson, and two glider operators: Xiaozhou Ruan and Jean-Pierre Smit.

The zodiac drove off to a safe distance from the ship, at about 700 to 1000 feet while the ship maintained a stationary position. The wind speed and direction was observed to ensure that the zodiac would not be blown towards the ship. For this particular deployment the wind came from the bow of the ship. A suitable location was found, and a retrieval line was attached to the pickup point on the glider (just below the rudder) in case the glider failed its buoyancy test and had to be retrieved. The cradle straps holding the glider in place were removed and a quick inspection was done to see if the glider has not sustained any damage along the way. Simultaneously the glider operators lifted the glider out of its cradle and onto

Figure 14: SG566 tied down on the floor of the zodiac, ready for deployment.

the pontoon of the zodiac, as seen in figure 15.

The one glider operator lifted at the front end, and the second operator lifted the glider at the back end where the rudder is located. The glider operator at the front then gently released the nose of the glider into the water while the operator at the rudder still held on to the glider until it was completely filled with water. Once filled, the operator let go of the glider and held on to the retrieval line. The glider appeared to be sitting comfortably in the water, so the retrieval line was then removed. After the piloting team on the ship was alerted that the deployment was successful, the glider received the $RESUME command, and started its first dive after a few minutes. The zodiac team returned to the ship. The deployment was completed at about 16:30 UTC.

The second deployment happened on the 8th of December, northeast of Elephant Island, coordinates: Lat -60.48 Lon -52.48. The Caltech glider called Queequeg (SG539) was to be deployed on this day. The same deployment method was followed as with SG566. We arrived on station at 0900 UTC with a swell of about 10 feet. The day was mostly cloudy, but it did not rain or snow and we had good visibility. This time, the glider tests went as planned and after only a few retries, the glider was able to establish a connection with the basestation. Again, four members went out on the zodiac: Mike Lewis and Richard Thompson, and two glider operators: Giuliana Viglione and Jean-Pierre Smit. After deployment, the glider sat comfortably in the water, and successfully went under when the $RESUME command was received.

Figure 15: SG566 deployed from the zodiac.

5 CTD

Giuliana Viglione

5.1 CTD stations

Four CTD transects were completed on this cruise, comprising 48 stations in total. The first two transects were completed immediately following the deployment of each glider, one near King George Island (12 stations, abbreviated KGI), and one near Elephant Island (12 stations, abbreviated EI). The remaining sections were carried out in the Bransfield Strait near King George Island (10 stations, abbreviated Brans) and across the Phoenix Ridge (14 stations, abbreviated Phx). The stations were selected to provide a bathymetric resolution of 500 m across each transect.

5.2 CTD operations

The initial CTD procedure was as follows. The CTD would be lowered into the water to a depth of approximately 10 meters and the rosette was held there until the CTD pump turned on, which took approximately one minute. The CTD was then raised back up to the surface before being lowered to the bottom. Over much of the depth of the ocean, the CTD was lowered at a rate of 50 m/min, although slower winch speeds were used near both the surface and the bottom. Depending on the depth of the cast, between 2 and 4 depths were chosen for collection of water samples. Duplicate bottles were fired at each depth, such that either 4, 6, or 8 samples were collected for a single cast. These were to be sampled using a Portasal machine to determine their salinity, which will be used to calibrate the CTD data. The bottles were fired only on the up-cast, and the CTD was stopped briefly at each bottle depth in order to ensure that the bottles were fired at the same depth. On each cast, bottles were fired at 10m from the bottom, except for cast 5, where due to a discrepancy between the multibeam and actual depths, the bottle was fired 50m from the bottom. The other bottle depths were decided by the chief scientist.

On cast 10, it was noticed during the up-cast that the bottles had not registered as fired. We lowered the CTD back to the bottom and attempted to re-fire the bottles, but no changes were seen. We raised the CTD as normal, firing at the prescribed depths, but when the CTD came out of the water, none of the bottles had been fired. The decision was made to continue with the transect, as we were almost in position for the next station. On casts 11 and 12, we attempted to fire the bottles as normal, but none of them worked.

During the transit from KGI to EI, the ETs worked on the rosette to try to get the bottle firing mechanism working. It was deemed to be "dead" on Julian day 340 and a 12-position carousel was placed on the frame instead. This new carousel was used for casts 13 through 48. Prior to cast 14, a kink in the cable was noticed approximately 23m from the termination. CTD operations were halted as the wire was cut and re-terminated. On cast 15, the altimeter never detected the bottom, so the sonar on board the ship was used to determine the safe depth to which the CTD could be lowered. Prior to cast 19, another kink in the cable was noticed. Once more, the wire was re-terminated. It was thought that the kinks were due to a combination of the lighter weight of the CTD with the 12-bottle

Table 1: Summary of the CTD positions completed during LMG 14-11.

Station No.	**Julian Day**	**Date**	**Bottom Time (GMT)**	**Latitude (°S)**	**Longitude (°W)**	**Max. press. (dbars)**	**Max. depth (m)**	**Dist. off bottom (m)**	**Bottles Planned (Actual)**
001 (KGI 1)	339	12/05/2014	19:02	61 43.5	58 48.9	309	305	10	6 (6)
002 (KGI 2)	339	12/05/2014	19:59	61 43.4	58 52.7	320	320	9	6 (6)
003 (KGI 3)	339	12/05/2014	21:19	61 39.9	58 55.5	517	510	10	6 (6)
004 (KGI 4)	339	12/05/2014	22:40	61 37.0	58 59.9	1079	1065	10	6 (1)
005 (KGI 5)	340	12/06/2014	00:17	61 35.3	59 02.9	1590	1550	**50**	6 (6)
006 (KGI 6)	340	12/06/2014	02:15	61 32.9	59 06.7	2024	1993	15	8 (8)
007 (KGI 7)	340	12/06/2014	04:39	61 30.9	59 08.9	2616	2574	10	8 (8)
008 (KGI 8)	340	12/06/2014	07:48	61 25.6	59 18.9	3032	2980	10	8 (8)
009 (KGI 9)	340	12/06/2014	11:05	61 22.7	59 23.9	3493	3429	?	8 (8)
010 (KGI 10)	340	12/06/2014	15:14	61 18.0	59 32.0	4131	4048	20	8 (0)
011 (KGI 11)	340	12/06/2014	20:01	61 14.3	59 38.2	4751	4652	10	8 (0)
012 (KGI 12)	341	12/07/2014	00:07	61 12.1	59 42.0	5240	5126	22	8 (0)
013 (EI 1)	342	12/08/2014	12:26	60 29.8	52 29.9	677	669	?	6 (6)
014 (EI 2)	342	12/08/2014	20:47	60 24.7	52 36.4	462	455	10	6 (6)
015 (EI 3)	342	12/08/2014	22:00	60 22.6	52 38.7	1033	1019	10	6 (6)
016 (EI 4)	342	12/08/2014	23:33	60 22.0	52 39.7	1654	1630	11	6 (6)
017 (EI 5)	343	12/09/2014	01:21	60 21.2	52 41.0	2039	2008	9	8 (8)
018 (EI 6)	343	12/09/2014	03:43	60 20.2	52 42.4	2657	2614	16	8 (8)
019 (EI 7)	343	12/09/2014	20:27	60 18.7	52 44.3	2823	2774	12	8 (8)
020 (EI 8)	343	12/09/2014	23:30	60 14.8	52 48.9	2659	2614	8	8 (6)
021 (EI 9)	344	12/10/2014	02:46	60 10.2	52 54.8	3036	2985	10	8 (6)
022 (EI 10)	344	12/10/2014	05:38	60 07.1	52 58.6	2590	2549	30	8 (8)
023 (EI 11)	344	12/10/2014	08:35	60 05.1	53 01.2	2765	2720	16	8 (2)
024 (EI 12)	344	12/10/2014	12:09	60 02.4	53 04.6	3475	3412	?	8 (2)
025 (Brans 1)	346	12/12/2014	00:32	62 10.8	58 09.6	88	87	8	4 (2)
026 (Brans 2)	346	12/12/2014	01:07	62 11.8	58 08.9	153	150	9	4 (4)
027 (Brans 3)	346	12/12/2014	01:44	62 12.4	58 08.2	369	364	10	6 (6)
028 (Brans 4)	346	12/12/2014	02:38	62 13.1	58 07.8	645	637	9	6 (6)
029 (Brans 5)	346	12/12/2014	03:49	62 13.6	58 07.4	1027	1014	14	6 (6)
030 (Brans 6)	346	12/12/2014	05:14	62 14.4	58 06.7	1310	1292	13	6 (6)
031 (Brans 7)	346	12/12/2014	06:52	62 15.5	58 05.9	1519	1499	17	6 (6)
032 (Brans 8)	346	12/12/2014	08:47	62 16.9	58 04.9	1739	1713	15	8 (8)
033 (Brans 9)	346	12/12/2014	11:10	62 19.1	58 03.5	1909	1882	?	8 (8)
034 (Brans 10)	346	12/12/2014	13:20	62 22.5	58 01.0	1935	1908	18	8 (8)
035 (Phx 1)	347	12/13/2014	14:17	62 24.1	64 27.0	2223	2188	15	6 (6)
036 (Phx 2)	347	12/13/2014	17:25	62 29.1	64 18.9	2775	2729	15	8 (8)
037 (Phx 3)	347	12/13/2014	21:11	62 36.3	64 05.9	3506	3442	15	8 (8)
038 (Phx 4)	348	12/14/2014	01:24	62 42.9	63 56.5	4522	4430	15	8 (8)
039 (Phx 5)	348	12/14/2014	05:15	62 48.1	63 48.5	3779	3707	15	8 (8)
040 (Phx 6)	348	12/14/2014	08:29	62 51.5	63 42.7	3016	2965	?	8 (8)
041 (Phx 7)	348	12/14/2014	11:26	62 53.4	63 39.9	2510	2470	15	8 (8)
042 (Phx 8)	348	12/14/2014	13:36	62 54.6	63 37.9	2030	2000	20	8 (8)
043 (Phx 9)	348	12/14/2014	15:34	62 56.2	63 35.0	1650	1626	15	6 (6)
044 (Phx 10)	348	12/14/2014	17:14	62 58.0	63 32.2	989.9	977	15	6 (6)
045 (Phx 11)	348	12/14/2014	18:23	62 59.9	63 29.2	424.5	419	10	6 (6)
046 (Phx 12)	348	12/14/2014	19:35	63 03.0	63 23.9	387.1	382	10	6 (6)
047 (Phx 13)	348	12/14/2014	20:53	63 07.3	63 17.2	472.1	466	10	4 (4)
048 (Phx 14)	348	12/14/2014	22:17	63 12.1	63 09.5	547.0	540	10	4 (4)

Figure 16: The four CTD sections with bathymetry taken from the IBCSO data set. The red markers indicate depths at which bottles were fired. Black markers indicate depths at which bottles did not fire as planned.

Table 2: List of sensors on the CTD package, provided by ETs Julian Race and Austin McHugh. This was the configuration at the start of the cruise.

Sensor	**Manufacturer/Model**	**Serial #**	**Calibration Date**
CTD Fish (pressure sensor)	Seabird SBE9Plus	0377	19 April, 2013
Temperature (primary)	Seabird SBE3	1529	20 December, 2012
Temperature (secondary)	Seabird SBE3	5025	30 April, 2013
Conductivity (primary)	Seabird SBE4	0350	11 September, 2012
Conductivity (secondary)	Seabird SBE4	2047	13 April, 2013
Fluorometer	Wet Labs ECO	FLRTD-867	19 April, 2013
Transmissometer	Wet Labs C-Star	CST-406DR	12 March, 2013
PAR Sensor	Biospherical/Licor	4561	23 April, 2014
Altimeter		54648	

rosette and the large swells present that day. Thus, it was decided to ballast the frame, and approximately 100 lbs were added to provide more tension on the wire. To further minimize the chances of the wire kinking again, from cast 19 onwards, we did not bring the CTD back up to the surface between the pump turning on and the down-cast. We also lowered the CTD at a maximum winch speed of 40 m/min, although it was still raised at 50 m/min.

After these adjustments were made, no further kinks were observed. There were several casts on which some bottles fired while some did not (casts 20 and 21). Prior to casts 21 and 22, the carousel-to-fish cable was cleaned and re-seated. On casts 23 through 25, there were problems with the communication between the carousel and the deck unit. The "bottles fired" counter reset itself during the cast, so it was unclear as to which bottles were fired at which depths. Prior to cast 23, the cable was replaced and the firing mechanism tested on deck. All bottles fired properly. The cable was cleaned once more before cast 24.

There were also two casts on which the altimeter did not see the bottom, and the sonar depth on board the ship was used to determine the depth at which the CTD should be stopped (casts 23 and 40). During cast 42, the winch speed, line out, and maximum tension displays stopped working. As the CTD depth was still reading, the cast progressed as normal. These displays did not work for cast 43 either, but were fine on cast 44 and all subsequent casts.

5.3 CTD data and processing

The CTD was equipped with a number of sensors, as listed in table 2.

The PAR Sensor was designed to withstand pressures of less than 2,000 db, so it was removed for the deep casts of the KGI and EI transects. The PAR sensor was not used for the Brans and Phx transects.

The data were processed and binned into 1 m depth bins by the ETs on board the LMG.

These files were made available on the `//triton/ctd_data/process` folder after each cast. Nine processed files were created for each cast. First, there were three files for each cast as a whole, named as LMG1411nnn.ext, where nnn is the three-digit cast number and .ext is the extension. These three files were a .cnv file, which held all of the sensor data, a .ros file, which held the information on the rosette bottles, and a .btl file, which held the readings at the depths at which the bottles were fired. In addition to these three full-cast data files, there were three files for each up- and down-cast, denoted by a 'u' or a 'd' appended to the beginning of the filename. These were a .cnv file, an .asc file, which held all of the data in an ASCII format, and a .hdr file, which held detailed information about all of the sensors.

These data were further processed using a suite of Matlab scripts, using the procedure below. Since the data were provided in a format that was already split into down- and up-casts, the scripts were run for each cast separately, rather than the combined file. Profiles were created from the down-casts only. *Note that in some cases it is necessary to tell Matlab that files generated are of .mat type by using the -mat flag.*

ctdcal2.m: This script was adapted from ctdcal.m, which takes a .cnv and a .hdr file, extracts the desired data fields and saves them to a .cal file. However, we had trouble getting Matlab to read the .cnv files, and so ctdcal2.m was created. This file instead took a .asc file and a .hdr file and extracted the pertinent information. Before passing the .asc file to the script, the first line of the file (which contained headers for the columns of data) had to be removed. The resulting data were saved as a .mat file.

spike.m: This script takes an input of a .mat file and removes large spikes in the data. It first uses the seawater equation of state to recalculate the salinities from the temperature and conductivity measurements. Then, it uses the dspike.m script to remove values of a certain size and replaces them with NaNs. The values used for the despiking process were those provided by the ADELIE cruise. The resulting file had the extension .spk. This script also plotted several properties before and after the despiking process so there could be a visual comparison of the new and old data.

interpol.m: Once the despiking had occurred, this script was applied to interpolate across the removed values. It takes a .spk file and outputs a .int file. Currently, the script is set up to interpolate across depths, as we are operating these scripts on data that have already been binned. Upon returning to Caltech, these routines will be adjusted so that the binning occurs after the despiking and interpolation processes, and the interpolation will instead be performed across scans, which occur at a frequency of 24 Hz.

newvar.m: This script takes the output of the interpolation, a .int file, and calculates a number of new variables using the seawater equation of state scripts. Newvar.m re-calculates salinity, then calculates potential temperature and several potential densities referenced to different depths. These variables are saved with the rest of the collected data in a .newvar file.

ctd2db.m: This script takes an input of a .newvar file and grids the data into 2 db bins. The resulting file is saved with the extension .2db.

section.m: This script generates sections of temperature, potential temperature, salinity, oxygen, fluorescence, transmittance, and potential density.

Since the processed data we were provided with did not include a field for the scan number, we were unable to include bottle data on these sections. Upon returning to Caltech, the raw data will be reprocessed using the SeaBird data processing software to include the scan number. The bottle data can then be included.

5.4 CTD transects

Figure 17: Preliminary King George Island CTD section: (a) Potential temperature (°C); (b) Salinity, psu; (c) Potential density (kg m^{-3}); (d) Dissolved oxygen (mL/L)

Figure 18: Preliminary Elephant Island CTD section: (a) Potential temperature (°C); (b) Salinity, psu; (c) Potential density (kg m^{-3}); (d) Dissolved oxygen (mL/L)

Figure 19: Preliminary Bransfield Strait CTD section: (a) Potential temperature (°C); (b) Salinity, psu; (c) Potential density (kg m^{-3}); (d) Dissolved oxygen (mL/L)

Figure 20: Preliminary Phoenix Ridge CTD section: (a) Potential temperature (°C); (b) Salinity, psu; (c) Potential density (kg m^{-3}); (d) Dissolved oxygen (mL/L)

Figure 21: Preliminary temperature-salinity diagram for the King George Island section. The color indicates the number of that station cast.

6 XBT/XCTD section

Andrew Delman

During the southbound transit of LMG14-11 across Drake Passage, drops of eXpendable BathyThermographs (XBTs) were carried out at 68 sites; at 12 of these sites eXpendable CTD (XCTD) drops also occurred. These XBT/XCTD measurements were collected as part of the long-term high-resolution AX22 section. At locations close to 15 of the XBT drop sites, water samples were also collected through the underway uncontamined seawater supply system. Three bottles were used for sampling at each water sample collection site, to be shipped to various PIs and tested in their home laboratories for (1) C^{13}, (2) TCO_2, and (3) nutrients. After collection, the bottles to be tested for nutrients were stored in a freezer at temperatures that were recorded daily during the remainder of the cruise and ranged between -23°C and -17°C. The samples to be tested for C^{13} and TCO_2 were stored at laboratory temperature for the remainder of the cruise. Additionally, one air sample was also collected when the ship crossed 59°S latitude (59.00°S, 63.69°W). A map of these sampling locations is given in Figure 22.

These XBT/XCTD drops and sample collections occurred between approximately 02:20 UTC on 29 Nov and 01:15 UTC on 1 Dec. The drops and sample collections were carried out by teams of three members (consisting of science team members, technicians, and volunteers on board) serving on four-hour shifts.

6.1 XBT data collection

In total, seventy-two (72) Sippican Deep Blue XBT probes were used in the course of following this transect. This includes four unsuccessful launches that were followed immediately by a second successful launch; hence usable temperature profiles at 68 different sites were obtained. The XBTs were dropped using a hand launcher, connected via an MK21 interface to a computer running Windows XP and AMVERSEAS 6.57 software. (After our section was completed, the electronic technicians on board started moving towards a new system running 64-bit Windows 7 and AMVERSEAS 9.2.) The XBT probe was loaded onto the launcher several minutes prior to the ship reaching the launching position. After the software had successfully established a connection with the probe, the team member launching the probe walked out to the port side of the ship about a minute prior to launch, and at the time of launch dropped the probe into the water. The other two team members would monitor the incoming data from the XBT during its fall; when the data became spiky or otherwise suspicious the launch was terminated by breaking the copper wire by hand.

For most launches usable data was obtained down to between 850 and 900 meters, though the XBTs were rated only to 760 meters. If a launch did not yield usable data down to 400 meters, it was immediately terminated and another probe was launched as quickly as possible, within 2-3 minutes of the first.

The XBT data from each successful launch was stored in tab-delimited text files in two formats: temperature only (.SRF) and depth/temperature (.xxx). The latter file names

Figure 22: Map of XBT and XCTD launch locations, and water/air sampling locations during the southbound transit.

Figure 23: Temperature section obtained from XBT data during the southbound transit of LMG14-11, 29 Nov-1 Dec 2014.

are in the format C141128s.xxx, with xxx the number of the XBT drop: for example XBT drop #1 would have file name C141128s.001, with drop numbers ranging from 1 to 72. Temperature data in both types of files were recorded with a scale factor of 0.001; i.e., multiply by 0.001 to get the temperature in degrees Celsius. Drop numbers 28, 33, 49, and 67 do not have usable data. The remaining drop numbers were imported from the .xxx files into Matlab using a script written for this purpose, xbt2mat.m, and plotted using another Matlab script xbt_transect_plot.m. The latter script screens for (and sets to NaN) values for temperature that are suspiciously high (>10°C) or low (<-3°C), or very different from the adjacent profiles to the north and south. The output of the plotting script is a contour plot of temperature during the southbound transit of the Laurence M. Gould (Figure 23).

6.2 XCTD data collection

Twelve Tsurumi-Seiki XCTD-1 probes were launched along the AX22 section, with serial numbers ranging from 11074118 to 11074129. The technique for launching the XCTDs was quite similar to that for the XBTs; the hand launcher was also connected via an MK21 interface to a separate computer running Windows XP and AMVERSEAS 6.57. The XCTD probes were rated down to a terminal depth of 1100 meters; however, five of the twelve probes stopped transmitting usable data at relatively shallow depths (ranging from 190 to

430 meters). The cause(s) for these probe failures at shallow depths was not conclusively established; it was suspected that the wire might be hitting the side of the ship during the XCTD probe's fall. The person launching was reminded to make sure the probe launcher is pointing away from the ship throughout the probe's fall. Additionally, for some of the later launches the person launching went to the rear corner of the ship on the port side, where it was hoped the chances of the wire hitting the ship would be greatly reduced. This probably improved the success rate of the XCTD probes, though the second-to-last probe launched (XCTD #11) still failed at 287 meters.

The XCTD data from each of these launches was stored in a binary file (.RDF), and a tab-delimited text file (.EDF). Both sets of files have names in the format C3_000xx, with xx the number of the XCTD drop—for example the .EDF file for XCTD drop #2 would have file name C3_00002.EDF, with drop numbers ranging from 2 to 13. Drop numbers 2, 5, 7, and 12 failed at shallow depths, but all drops still have at least some usable data. The .EDF files have distinct columns for depth, temperature, conductivity, salinity, sound velocity, density, and status. The status field is 8000 for data that the software determines to be valid data; other values indicate erroneous or suspect readings. These drop numbers were imported from the .EDF files into Matlab using a script written for this purpose, xctd2mat.m, and plotted using another Matlab script xctd_transect_plot.m. The latter script uses the status field to screen for (and set to NaN) suspect data points; this screening proved to be sufficient to remove suspicious values (i.e., no range screening or horizontal despiking was needed as with the XBT data). The outputs of the plotting script are contour plots of temperature (Figure 24) and salinity (Figure 25) during the southbound transit of the LMG.

Figure 24: Temperature section obtained from XCTD data during the southbound transit of LMG14-11, 29 Nov-1 Dec 2014.

Figure 25: Salinity section obtained from XCTD data during the southbound transit of LMG14-11, 29 Nov-1 Dec 2014.

7 Salinometer analysis

Andrew Delman

7.1 Water sample collection

To calibrate the conductivity/salinity measurements from the CTD, 250 mL glass bottles were filled with water samples from each Niskin bottle fired. Each glass bottle was first rinsed three times in water from the Niskin bottle to be sampled, and then filled to the shoulder with the sample, and sealed with plastic caps and stoppers. These bottles in turn were stored in open plastic crates that hold 24 water sample bottles. Each bottle was labeled with a number (representing a specific CTD cast and depth sampled) and letter (A or B, one of two bottles at each depth). When a bottle had been filled with sample, it was inverted when placed back in the crate to avoid confusion about which bottles had already been filled with samples. When all the bottles in each crate to be sampled had been filled, the crate was moved to the "Enviro" room on board where the salinometer is kept. Crates filled with sample were kept in the Enviro room for at least 12 hours before being tested with the salinometer, to allow the samples to approach the ambient temperature of the room.

7.2 The salinometer

To measure the salinity of each sample, a Guildline Instruments Ltd. PortaSal 8410A was employed (serial number 69 887). The instrument is rated for use at temperatures of 24°C ± 2 °C; the temperature in the lab was monitored during the course of sampling, and ranged between 22°-24°C. The temperature of the sample water was considered to be approximately 21°C during sampling, as the samples did not completely warm to the ambient room temperature. Before sampling began, the salinometer was calibrated with IAPSO standard seawater **(input the K-number and standard salinity for the bottle used in the calibration)**. When the salinometer was not in use for a half hour or more, a bottle of de-ionized water was placed on the sampling platform and the sampling collection tube immersed in it to prevent salt crystal formation on the tube. The salinometer was connected to a machine running the PortaSal data-logging software.

7.3 Salinometer measurement procedure

The salinometer layout is indicated in Figure 26. At the time of sampling, each bottle was unsealed and placed on the sampling platform, with the opening sealed by the rubber stopper on the salinometer and the sampling tube immersed. The conductivity cell was filled by turning the flow rate on, and flushed three times before any sample readings were taken. Then the cell was filled again, and the function knob on the PortaSal was turned from "Standby" to "Read" to take the first reading; when the reading was finished, the function knob was turned back to "Standby" and the cell was flushed. This process was repeated to take two more readings. Then the flow was turned off, and the sample bottle removed and replaced with another one.

Figure 26: Photograph showing the layout of the PortaSal 8410A salinometer.

During each reading, the PortaSal data logging software recorded conductivity ratios each second for 10 seconds. Since three readings were taken, 30 seconds of conductivity ratios were recorded by the software for each bottle, converted into salinity (in practical salinity units), and averaged. At the end of each sampling session and the end of each transect, these averages as well as all of the ratios recorded during each second of sampling were exported to Excel spreadsheets.

During the process of reading salinometer measurements, the flow rate was twice found to be too slow for effective filling and flushing of the conductivity cell. In the first instance, the tube that was feeding air into the sample bottle was found to be disconnected from the rubber stopper; reconnecting it returned the flow rate to normal levels. In the second instance, flushing the cell several times with de-ionized water returned the flow rate to normal levels.

After sampling, the complete salinometer results were stored in Excel files, one for each transect, with the naming convention LMG14-11_mmddyy_[transect abbrev.]_FINAL.xls, with the date mmddyy corresponding to the day that salinometer readings were completed for that transect. For example the file for the King George Island (KGI) transect with readings completed on December 10, 2014 is named LMG14-11_121014_KGI_FINAL.xls. A file with just the averaged salinity readings for each bottle was also created and named Salinometer_results_all_transects.xls. A tab-delimited file was also created with the averaged salinity readings for easy importing into Matlab or other data analysis software, named Salinometer_all_transects.txt.

7.4 Salinometer calibration of CTD salinities

The salinities measured from the bottle samples using the salinometer were compared with the salinities measured *in situ* by the CTD. This analysis was carried out in order to obtain an indication of the degree of accuracy of the salinities measured by the CTD, in effect serving as a calibration of the CTD salinity measurements.

Of the 289 bottle samples that were measured using the salinometer, 9 were excluded from this analysis. The reasons for exclusion included:

- The CTD salinities measured at the bottle sample depths were suspiciously low (2 bottles in the KGI transect)
- A bottle had a very different salinity measurement relative to the other bottle sampled at the same depth in the cast, as well as relative to the salinity measured by the CTD; probable error in using the salinometer or contamination of the sample (2 bottles in BRANS; 1 bottle in PHX)
- CTD salinities were not recorded at the depths that the bottle samples were recorded as collected at; this could be due to a clerical error, if the bottle depths recorded were for the bottom depth instead of the maximum depth of the CTD (2 bottles in BRANS; 2 bottles in PHX)

The salinities from the remaining 280 (out of 289) bottle samples were used in the comparison with CTD salinities, as measured on both the downward and upward portions of the cast. A Matlab script salinometer_CTD_compare.m was written and used to carry out these computations, with a Matlab function cnv2mat.m embedded in the script to read the CTD cast data contained in .cnv files. The bias (Fig. 27) and RMS difference (Fig. 28) were computed for all 280 sampling locations ("all"), as well as for the deepest depth in each CTD cast ("near bot."). The bias and RMS differences were also computed for individual transects and depth ranges, for the upward (Fig. 29) and downward (Fig. 30) CTD measurements relative to the salinometer readings. Finally, the distribution of differences between CTD and salinometer readings was considered for upward (Fig. 31) and downward (Fig. 32) CTD measurements.

Key findings from these analyses include:

1. There is a fairly consistent bias (29) where the CTD salinity measured is lower (fresher) than the readings from the salinometer. The bias is on the order of 0.002-0.007 psu.
2. The differences (Fig. 31) between the upward CTD salinities and the salinities from bottle samples collected simultaneously are mostly confined to a range between -0.012 psu and 0 psu. This means that there were very few instances in which the CTD measured a higher salinity than the salinometer reading, and very few instances in which the CTD measurement was more than 0.012 psu lower than the salinometer reading.

Figure 27: Biases of the CTD salinity measurements, relative to salinometer readings from water samples at the same location and depth. The total biases relative to all 280 bottle samples used in this analysis are shown, as well as the biases only for samples collected near the bottom bathymetry. Each of these biases are computed using data from the upward and downward portions of the CTD cast. Negative (positive) values indicate that CTD readings are on average fresher (saltier) than salinometer readings.

3. The RMS differences (28) are much larger between the salinometer readings and the downward CTD measurements (compared to the RMS diff. for the upward CTD measurements). A few near-surface measurements are responsible for the largest RMS differences in (Fig. 30b, but the differences for the downward measurements (Fig. 32) consistently span a broader range than the differences for the upward measurements (Fig. 31). The movement of water parcels of different salinities during the time period (often hours) between the downward and upward cast readings, as well as slight changes in the location of the CTD itself, likely explain the substantially larger RMS differences for the downward data.

The findings above, particularly findings 1 and 2, may be useful for estimating the statistical uncertainty of the CTD salinity measurements collected.

Figure 28: Same as Figure 27, but for the RMS difference between CTD and salinometer readings.

Figure 29: (a) Biases and (b) RMS differences of the upward CTD salinity measurements relative to salinometer readings from water samples at the same location and depth, computed individually for each transect and certain depth ranges.

Figure 30: Same as Figure 29, but for downward CTD salinity measurements.

Figure 31: The distribution of differences (offsets) of the upward CTD salinity measurements, relative to salinometer readings from water samples at the same location and depth. The differences are sorted by transect and depth range, with the same color scheme as in Fig. 29 indicating depth range.

Figure 32: Same as Figure 31, but for downward CTD salinity measurements.

8 Underway data

Giuliana Viglione

8.1 RVDAS Data

Research Vessel Data Acquisition System (RVDAS) was developed at Columbia University?s Lamont-Doherty Earth Observatory and adapted for use on the ARSV Laurence M. Gould. It consists of two categories of information: underway data (abbreviated uw) and navigation data (nav). The RVDAS data was made available every day at midnight GMT for the previous day on the `//triton/data/rvdas/` drive, with separate folders for `nav` and `uw` data. This data consisted of a series of g-zipped files for each day, each corresponding to a different sensor. The naming convention was `LMG1411xxxx.dDDD.gz`, where `xxxx` is a 4-character code that represents the system from which that data were collected and DDD is the Julian day on which the data were collected.

8.2 JGOFS Data set

Since the RVDAS data is provided at irregular intervals (ranging from 0.2 seconds to 2.5 seconds per measurement, depending on the sensor), the data was automatically calibrated, processed, and binned into 1-minute intervals by the ETs on board the LMG. This data set was also made available at midnight GMT on the `//triton/data/process/JGOF` drive, under the name `jgDDD.dat.gz`. The JGOFS data for each day consists of 22 columnar fields of both measured and calculated quantities.

Each day, the JGOFS data were retrieved from the server and processed in order to extract the quantities of interest. Since the date and time fields were separated by slashes and colons, respectively, before the data could be loaded, these markers had to be replaced with spaces in order to create columns for each field, which could then be appended to one another to create a full date/time string. The script extract.m was written to extract each desired quantity into a separate vector, then the results were saved as DDD.mat. The extracted fields were: day, month, year, hour, minutes, seconds (these six were combined into a single time field, date), PCOD latitude, PCOD longitude, sea surface temperature, sea surface salinity, sea depth (uncorrected, calculated assuming a constant speed of sound of 1500 m s^{-1}), true wind speed, and true wind direction.

8.3 Bathymetry

During the cruise, it was noticed that the depth field provided by the JGOFS data set had 9999 for every entry, indicating that the field was unused. Prior to this cruise, a new echosounder had been installed on board the ship, which provided the data in a new format. The RVDAS processing software, however, had not been updated, and so the depth data was not being processed, and instead the field was shown as null. Partway through the cruise, a patch was created for the software that would allow the new format to be processed correctly; however, we were not able to apply the patch until the data loggers were turned

Figure 33: Underway temperature and salinity data along the CTD transects.

off, when we reached 68°W. Upon returning to port, the patch was applied and the data reprocessed to give us accurate bathymetry data.

9 Shipboard Acoustic Doppler Current Profiler (ADCP)

Andy Thompson

The L. M. Gould has two RDI Doppler sonars, with frequencies of 38kHz and a 150kHz. The 38 kHz Ocean Surveyor ADCP (OS38) which can reach to 1200 m in good weather in its deep-profiling mode. In bad weather, low scattering conditions, or some speed/heading/sea state conditions that entrain bubbles under the transducer, the range is less. There is also an RDI 150 kHz narrowband instrument (NB150) that profiles at higher resolution to as deep as 350 m. Data acquisition for both sonars and the requisite ancillary navigation streams occurs via the UHDAS software, written by Eric Firing and Jules Hummon, University of Hawaii.

An Ocean Surveyor is capable of running in either broadband mode (higher resolution at the expense of penetration) or narrowband mode (slightly deeper profiling but lower resolution). It is also capable of interleaving these pings, with the tradeoff being a reduction of 50% for each type of ping. OS38 defaults are set up for bottom track ON, and 24 m bins in OS narrowband mode (os38nb). The NB 150 default setup is bottom track ON and 8 m bins. Bottom track is turned off in deep water. This profiling setup provides the deepest penetration from the OS38 (often to 1000 m) and highest resolution from the NB150 (to 350 m).

The shipboard ADCP data may be accessed via the Gould's shipboard network, which has a selection of automatically generated plots, their corresponding data files, and the directory tree in which the automated data processing is being done. This has only preliminary processing.

Fully automated data processing and plotting is done every half hour, and the data is copied to a location accessible via a web page. Data are also available via network share. On the Palmer and the Gould, the Windows shares (Samba) require

username = adcpguest
password = uhdas

The automated processing system includes corrections (from the Seapath) to the gyro heading, and as much editing as we have been able to automate. Although a final processing of the ADCP data set after the cruise will be needed, we hope that the differences between the final version and the automated version will be small. The biggest differences will likely be found under adverse conditions: shallow water, heavy seas, lack of scatterers, bad weather. Scientists are free to walk off the ship with copies of figures from the web site and the data distributed there. These come from the same processing directory the chief scientist will receive for the cruise. Please remember: these data are not fully processed. If you intend on any serious use of these data, you will have to put the finishing touches on the data.

The ADCP Linux processing pc (gentoo) belongs to the ship: currents is NOT a publically accessible computer (i.e. do not log in) and is NOT available for general use.

10 Ice conditions

Jean-Pierre Smit

10.1 Sea ice

Sea ice exposes a risk to the gliders while at sea. It can prevent the glider from surfacing by getting stuck underneath an icepack or even underneath an iceberg. The latitude at which the gliders have been deployed in is known for Iceberg activity and a possible icepack during this time of the year.

The ice conditions were monitored during the full duration of the cruise by obtaining ice images from an internet service called Polar View. This is a database that provides SAR images on a 2 to 4 day basis, and ice concentration images daily. An occasional issue we had was that the SAR images were not consistent, and some days we were unable to view the area of interest. The service is available at:

www.polarview.aq/antarctic

10.2 SAR images

The SAR plots were mainly for identifying icebergs. No big icebergs were clearly visible throughout the duration of the cruise.

The ice concentration images were for identifying the boundary of the icepack. The ice maintained a safe distance from the area where the gliders were deployed.

Figure 34: SAR images from (upper left) 11/30/2014, (upper right) 12/05/2014, (middle left) 12/08/2014, (middle right) 12/10/2014, (bottom left) 12/12/2014 and (bottom right) 12/15/2014.

Figure 35: Sea ice concentrations on the following days: December 6, 7, 8, 9, 10, 13, 14, 15, 16, 17, 18, 19.

SPAWARSYSCEN Office of Polar Programs — WEAX for ARSV Laurence M. Gould — 10-Dec-2014 1200Z

Ref A: MOVREP 4 DEC 2014 — Ref B: SITREP 8 DEC 2014

SURFACE ANALYSIS 10-Dec-2014 06Z — Seas (FT) — SURFACE FORECAST 11-Dec-2014 18Z

METSIT 06Z 10-Dec

DEEP LOW PRESSURE APPROACHES FROM THE WEST, WITH AN ASSOCIATED FRONTAL BOUNDARY OUT AHEAD OF IT THAT BRINGS SOME UNSETTLED WEATHER INTO THE REGION OVER THE NEXT 36-48 HOURS. SKIES WILL REMAIN MOSTLY CLOUDY TO CLOUDY, WITH REDUCED VISIBILITIES IN RAIN AND FOG. WINDS WILL BE SWITCHING FROM THE NORTHWEST TO THE SOUTHWEST AFTER FRONTAL PASSAGE, AND THE MAIN LOW MOVES TO THE EASTERN SIDE OF THE PENINSULA. WINDS STRENGTHEN INTO THE 20-40 KNOT RANGE, WITH POSSIBLE HIGHER GUSTS. SEAS QUICKLY BUILD IN EXCESS OF 20 FEET BY 11/0300Z, ABATING VERY SLOWLY BY END OF PERIOD. YOU MAY WANT TO TAKE SHELTER ON THE LEE SIDE OF AN ISLAND IF POSSIBLE.

FORECASTER NOTES

VALID TIME	10-Dec 12Z	10-Dec 18Z	11-Dec 00Z	11-Dec 06Z	11-Dec 12Z	11-Dec 18Z	12-Dec 00Z	12-Dec 06Z
SKY CONDITION	CLOUDY	MOSTLY CLOUDY	PARTLY CLOUDY	CLOUDY	CLOUDY	MOSTLY CLOUDY	MOSTLY CLOUDY	MOSTLY CLOUDY
WEATHER	RAIN & FOG	LIGHT RAIN	FOG	RAIN & FOG	RAIN & FOG	RAIN & FOG	NONE	NONE
VISIBILITY (NM)	3 - 5	UNRESTRICTED	4 - 6	4 - 6	2 - 4	4 - 6	UNRESTRICTED	UNRESTRICTED
SFC WINDS (DIR & KTS)	WNW 25-30 GUSTS TO 40	WNW 25-35 GUSTS TO 40	WNW 20-30 GUSTS TO 35	NW 20-30 GUSTS TO 35	WNW 20-30 OCNL GUSTS 35	WSW 20-30 OCNL GUSTS 35	SW 25-35 OCNL GUSTS 40	SW 25-35 GUSTS TO 40
SFC MAX/MIN (°C)	2/0	3/1	3/1	2/0	2/0	1/0	1/0	1/-1
SST RANGE (°C)	1/0	1/0	1/0	1/0	1/0	1/0	1/0	1/0
SEAS (DIR & FT)	W 9-12	W 10-14	W 14-18	W 18-22	W 22-26	W 22-26	W 20-24	W 18-22
ICE ACCRETION	NIL	NIL	NIL	NIL	NIL	NIL	NIL	NIL

REMOTE OPERATIONS FACILITY (ROF) COMM: 843.218.3927 IRIDIUM: 8816.763.15168 EMAIL: weather.chs@usap.gov FORECASTER: Joe Kramer

Figure 36: WEAX surface weather report for the 10th of December.

11 Weather

Andy Thompson

During the cruise, a strong low-pressure system passed through Drake Passage, which caused us to deviate from the original cruise plan. In particular we were unable to carry out our planned CTD transect across the southern edge of the Shackleton Fracture Zone. The weather maps above show the strength of the pressure system and the severity of the conditions, with wind gusts of 40 mph and predicted seas in excess of 30 feet. This necessitated our movement through Bransfield Strait.

12 Appendix: Log files

Log file from SG566 with all the parameters we used (note that some values were changed in the cmdfile)

```
version: 66.11
glider: 566
mission: 4
dive: 1
start: 12 5 114 17 14 34
data:
$ID,566
$MISSION,4
$DIVE,1
$N_DIVES,0
$D_SURF,3
$D_FLARE,3
$D_TGT,45
$D_ABORT,150
$D_NO_BLEED,29
$D_BOOST,3
$T_BOOST,0
$D_FINISH,0
$D_PITCH,0
$D_SAFE,0
$D_CALL,0
$SURFACE_URGENCY,0
$SURFACE_URGENCY_TRY,0
$SURFACE_URGENCY_FORCE,0
$T_DIVE,15
$T_MISSION,25
$T_ABORT,720
$T_TURN,500
$T_TURN_SAMPINT,5
$T_NO_W,120
$T_LOITER,0
$T_EPIRB,0
$USE_BATHY,0
$USE_ICE,0
$ICE_FREEZE_MARGIN,0.30000001
$D_OFFGRID,100
$T_WATCHDOG,10
$RELAUNCH,0
$APOGEE_PITCH,-5
```

```
$MAX_BUOY,150
$COURSE_BIAS,0
$GLIDE_SLOPE,30
$SPEED_FACTOR,1
$RHO,1.0274
$MASS,53003
$MASS_COMP,0
$NAV_MODE,1
$FERRY_MAX,45
$KALMAN_USE,0
$HD_A,0.0038360001
$HD_B,0.010078
$HD_C,9.8500004e-06
$HEADING,-1
$ESCAPE_HEADING,0
$ESCAPE_HEADING_DELTA,10
$FIX_MISSING_TIMEOUT,0
$TGT_DEFAULT_LAT,-6100
$TGT_DEFAULT_LON,-6200
$TGT_AUTO_DEFAULT,0
$SM_CC,554.85956
$N_FILEKB,4
$FILEMGR,0
$CALL_NDIVES,1
$COMM_SEQ,0
$PROTOCOL,0
$N_NOCOMM,1
$NOCOMM_ACTION,0
$N_NOSURFACE,0
$UPLOAD_DIVES_MAX,-1
$CALL_TRIES,5
$CALL_WAIT,60
$CAPUPLOAD,1
$CAPMAXSIZE,100000
$HEAPDBG,0
$T_GPS,15
$N_GPS,20
$T_GPS_ALMANAC,0
$T_GPS_CHARGE,-3359.1543
$T_RSLEEP,1
$STROBE,0
$RAFOS_PEAK_OFFSET,1.5
$RAFOS_CORR_THRESH,60
$RAFOS_HIT_WINDOW,3600
```

$PITCH_MIN,144
$PITCH_MAX,3800
$C_PITCH,2883
$PITCH_DBAND,0.1
$PITCH_CNV,0.003125763
$P_OVSHOOT,0.079999998
$PITCH_GAIN,30
$PITCH_TIMEOUT,18
$PITCH_AD_RATE,175
$PITCH_MAXERRORS,1
$PITCH_ADJ_GAIN,0
$PITCH_ADJ_DBAND,0
$ROLL_MIN,153
$ROLL_MAX,3749
$ROLL_DEG,40
$C_ROLL_DIVE,1951
$C_ROLL_CLIMB,1951
$HEAD_ERRBAND,10
$ROLL_CNV,0.028270001
$ROLL_TIMEOUT,15
$R_PORT_OVSHOOT,54
$R_STBD_OVSHOOT,49
$ROLL_AD_RATE,350
$ROLL_MAXERRORS,1
$ROLL_ADJ_GAIN,0
$ROLL_ADJ_DBAND,0
$VBD_MIN,500
$VBD_MAX,3960
$C_VBD,2762
$VBD_DBAND,2
$VBD_CNV,-0.245296
$VBD_TIMEOUT,720
$PITCH_VBD_SHIFT,0.0012300001
$VBD_PUMP_AD_RATE_SURFACE,5
$VBD_PUMP_AD_RATE_APOGEE,4
$VBD_BLEED_AD_RATE,8
$UNCOM_BLEED,60
$VBD_MAXERRORS,1
$W_ADJ_DBAND,0
$DBDW,0
$PITCH_W_GAIN,0
$PITCH_W_DBAND,0
$CF8_MAXERRORS,20
$AH0_24V,145

$AH0_10V,95
$MINV_24V,19
$MINV_10V,8.1999998
$FG_AHR_10V,0
$FG_AHR_24V,0
$PHONE_SUPPLY,2
$PRESSURE_YINT,-87.300293
$PRESSURE_SLOPE,0.0001165365
$AD7714Ch0Gain,128
$TCM_PITCH_OFFSET,0
$TCM_ROLL_OFFSET,0
$COMPASS_USE,0
$ALTIM_BOTTOM_PING_RANGE,0
$ALTIM_TOP_PING_RANGE,0
$ALTIM_BOTTOM_TURN_MARGIN,12
$ALTIM_TOP_TURN_MARGIN,0
$ALTIM_TOP_MIN_OBSTACLE,1
$ALTIM_PING_DEPTH,150
$ALTIM_PING_DELTA,10
$ALTIM_FREQUENCY,13
$ALTIM_PULSE,3
$ALTIM_SENSITIVITY,2
$XPDR_VALID,2
$XPDR_INHIBIT,90
$INT_PRESSURE_SLOPE,0.0097660003
$INT_PRESSURE_YINT,0
$DEEPGLIDER,0
$DEEPGLIDERMB,0
$MOTHERBOARD,4
$DEVICE1,2
$DEVICE2,133
$DEVICE3,147
$DEVICE4,-1
$DEVICE5,-1
$DEVICE6,-1
$LOGGERS,0
$LOGGERDEVICE1,-1
$LOGGERDEVICE2,-1
$LOGGERDEVICE3,-1
$LOGGERDEVICE4,-1
$COMPASS_DEVICE,33
$COMPASS2_DEVICE,-1
$PHONE_DEVICE,48
$GPS_DEVICE,32

```
$RAFOS_DEVICE,-1
$XPDR_DEVICE,24
$SIM_W,0
$SIM_PITCH,0
$SEABIRD_T_G,0.0042691035
$SEABIRD_T_H,0.00061758299
$SEABIRD_T_I,2.1721746e-05
$SEABIRD_T_J,2.2380325e-06
$SEABIRD_C_G,-9.88132
$SEABIRD_C_H,1.1284354
$SEABIRD_C_I,-0.00058071676
$SEABIRD_C_J,0.00013631287
$GPS1,051214,171018,-6143.524,-5848.979,28,1.8,28,10.7
$_CALLS,1
$_XMS_NAKs,0
$_XMS_TOUTs,0
$_SM_DEPTHo,1.03
$_SM_ANGLEo,-64.8
$GPS2,051214,171342,-6143.582,-5848.946,21,1.8,21,10.7
$SPEED_LIMITS,0.173,0.260
$TGT_NAME,DRAKE
$TGT_LATLONG,-6100.000,-6000.000
$TGT_RADIUS,250.000
$KALMAN_CONTROL,-0.159,0.206
$KALMAN_X,0.0,0.0,0.0,0.0,0.0
$KALMAN_Y,0.0,0.0,0.0,0.0,0.0
$MHEAD_RNG_PITCHd_Wd,311.6,102882,-18.2,-10.000,-21.02,2236
$D_GRID,45
```