JR294/295 Cruise Report

Ice Sheet Stability Programme (iSTAR)

RRS James Clark Ross

26th February – 8th March 2014

Amundsen Sea

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Norwich

With contributions from the cruise participants

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1 Cruise Narrative (Karen Heywood)

1.1 Introduction

This is the research cruise of the NERC Ice Sheet Stability programme (ISTAR). The goal is to investigate the ocean processes that are thought to enhance melting of the Pine Island Glacier in the Amundsen Sea. The cruise includes two NERC-funded ISTAR projects. The first is ISTAR A, or *Ocean2ice*, supporting a consortium led by UEA; this is cruise JR294. This project addresses processes at the continental shelf break and on the continental shelf that affect the heat delivered to the ice shelf front, together with the subsequent fate of the ice shelf meltwater. The second is ISTAR B, led by BAS, which is cruise JR295. This project addresses the processes that affect the warm water once it has entered the ice shelf cavity.

1.2 Cruise Participants

Scientific party:

UEA

Karen Heywood (hydrography; Chief Scientist)	k.heywood@uea.ac.uk
Gillian Damerell (hydrography, gliders)	G.Damerell@uea.ac.uk
Stephen Woodward (glider technician, dissolved oxygen)	Stephen.Woodward@uea.ac.uk
Bastien Queste (gliders, dissolved oxygen)	B.Queste@uea.ac.uk
Louise Biddle (gliders, hydrography, dissolved oxygen)	Louise.Biddle@uea.ac.uk
Richard Jones (meteorology)	Richard.W.Jones@uea.ac.uk

BAS

Adrian Jenkins (hydrography, Autosub)	ajen@bas.ac.uk
Pierre Dutrieux (hydrography, Autosub)	pitr1@bas.ac.uk
Povl Abrahamson (moorings)	epab@bas.ac.uk
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Mark Preston (equipment tech)	mopr@bas.ac.uk

University of Southampton

Alberto Naveira Garabato (microstructure, hydrography)	acng@soton.ac.uk
Alex Forryan (microstructure, hydrography)	a.forryan@soton.ac.uk

University of Rhode Island

Brice Loose (tracers)	brice@gso.uri.edu
Arash Bigdeli (tracers)	arash_bigdeli@my.uri.edu

SMRU, St Andrews

Mike Fedak (seal tagging)	maf3@st-andrews.ac.uk
Simon Moss (seal tagging)	sem6@st-andrews.ac.uk

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Paul Provost	pgp@noc.ac.uk
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MARS, NOC Southampton

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David Paxton	dpax@noc.ac.uk
Duncan Matthew	dlrm@noc.ac.uk

Eaton Primary School, Norwich

Barnaby Bear

Acronyms:

UEA	University of East Anglia, Norwich
BAS	British Antarctic Survey, Cambridge
SMRU	Sea Mammal Research Unit
NMFSS	National Marine Facilities, Sea Systems
MARS	Marine Autonomous and Robotic Systems
NOC	National Oceanography Centre

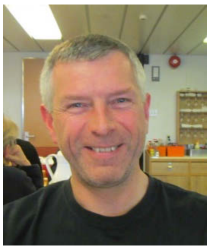
Responsibilities and watches:

	0-4	4-8	8-12	12-16	16-20	20-24
Watch Leaders	*Pierre*	*Gillian*	*Povl*	*Pierre*	*Gillian*	*Povl*
CTD & MVP	Pierre	**Gillian**	Povl	Pierre	**Gillian**	Povl
Watchkeepers		Simon	Simon		Fedak	Fedak
Microstructure and LADCP	Alex	Alex	Alberto	Alberto	Alberto	Alex
Trace gases	Arash	Arash/Brice	**Brice**	Brice	Brice/Arash	Arash
Salinometer	**Toshi**	Richard		**Toshi**	Richard	
Dissolved O2	**Louise**	Bastien	Steve	**Louise**	Bastien	Steve

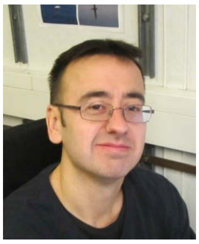
People in **bold** were responsible for the particular data set and for writing the contribution for the cruise report.

Activities outside watches

Autosub	**Adrian,** Pierre, **Steve M**
Moorings	**Povl**
Sea ice imagery	**Povl**
Seal tagging	**Fedak,** Simon
Navigation and Oceanlogger	**Richard**
Radiosondes (12.00 GMT)	**Richard**
Seagliders	Gillian, **Bastien**, **Steve W**, Louise
Bathymetry	**Louise**
Microstructure	**Alberto,** Alex
LADCP	Alberto, **Alex**
ADCP	Louise**, Pierre**
O18 bottles	**Bastien**



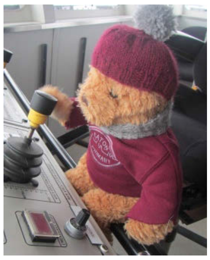
Adrian Jenkins



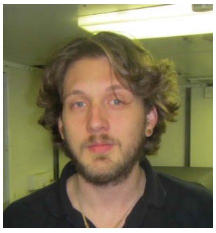
Alberto Naveira Garabato

Alex Forryan

Arash Bigdeli



Barnaby Bear



Bastien Queste

Brice Loose

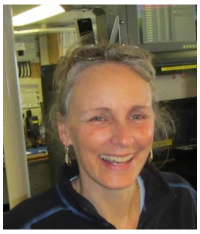
Dave Paxton

Duncan Matthew

Gillian Damerell

Jeremy Robst

John Wynar



Karen Heywood

Louise Biddle

Mark Preston

Mike Fedak

Paul Provost

Pierre Dutrieux

Povl Abrahamsen

Richard Jones

Satoshi Kimura

Simon Moss

Steve McPhail

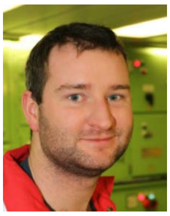
Steve Woodward

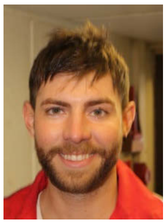
Ship's Officers and Crew:

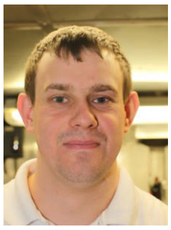
Jerry Burgan	Master
Tim Page	Chief Officer
Philippa Bowden	2nd officer
Greg Johnston	3rd Officer
Mike Gloistein	ETO Comms
Duncan Anderson	Chief Engineer
Andy Smith	2nd Engineer
Chris Mannion	3rd Engineer
Marc Laughlan	4th Engineer
Craig Thomas	Deck Engineer
Eric Jenkins	ETO
Rich Turner	Purser
Dave Peck	Bosun/Sci Ops
Martin Bowen	Bosun
George Dale	Bosun's Mate
Ian Raper	AB
Franky Hernandez	AB
Sheldon Smith	AB
Dick Robinson	AB
Alfy Velloza	AB
Gareth Wale	Motorman
Glyn Henry	Motorman
Sam Borne	Chief Cook
John Pratt	2nd Cook
Nick Greenwood	Senior Steward
Riff Raworth	Steward
Rod Morton	Steward
Daniel Colgan	Steward
Hazel Woodland	Doctor

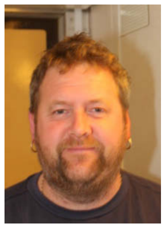

Alfy (AB)


Andy (2nd Eng)


Chris (3rd Eng)


Craig (Deck Eng)

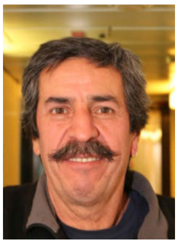

Dan (Steward)


Dave (Bosun Sci)


Dick (AB)


Duncan (Ch Eng)


Eric (ETO)


Franky (AB)


Gareth (Motorman)


George (Bosun's Mate


Glyn (Motorman)


Greg (3rd Off)


Hazel (Doctor)

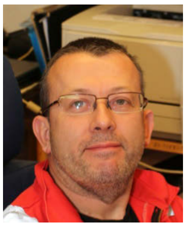

Ian (AB)

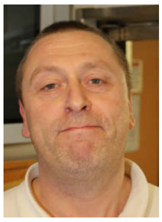

Jerry (Captain)


John (2nd Cook)


Mark (4th Eng)

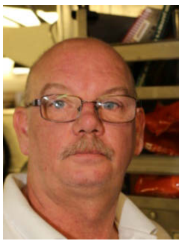

Martin (Bosun)

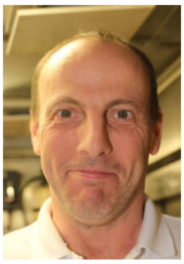

Mike (RO)

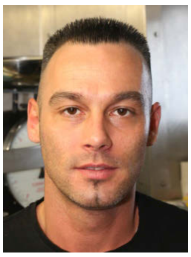

Nick (Snr Steward)


Philippa (2nd Off)


Rich (Purser)


Riff (Steward)


Rod (Steward)


Sam (Ch Cook)


Sheldon (AB)


Tim (Ch Off)

1.3 Cruise Daily Summary

Saturday 25th January, Day 25
All times in this cruise narrative are in local time for Punta Arenas, used as ship time throughout the cruise. This is GMT minus 3 hours. We were due to sail at 8 am from Punta Arenas but a problem with the cooling pipes to the engine was discovered. The engineers spent the day fixing it.

Sunday 26th January, Day 26
Departed from Punta Arenas and spent the day bunkering. Left bunkering at 17.30 and steamed west through the Straits of Magellan. The day was spent assembling and testing scientific equipment.

Monday 27th January, Day 27
Passed through the Straits in the early morning, with sightings of a few seals and whales in the distance. Turning southwest toward the Amundsen Sea, the weather and sea state soon deteriorated and the scientific party was largely laid low.

Tuesday 28th January, Day 28
Steaming southwest. Still windy, but the weather improved though the day.

Wednesday 29th January, Day 29
Steaming southwest. Both Seagliders were taken onto the aft deck and successfully run through test dives. The sea state was too high to do the planned test CTD deployment, which was postponed to Thursday.

Thursday 30th January, Day 30
Instrument and procedure tests went ahead at 8 am. Buoyancy test of the VMP5000 was successful. Test CTD done in good weather and good sea state. There were some issues with the CTD communications prior to deployment, but the cast went well until 1000 m when we were to trigger all 24 bottles. At that stage the bottles would not fire and then all communications with the CTD package was lost. The CTD was recovered, and Mark spent the rest of the day reterminating the connections; this was then load-tested on deck. After the CTD a deployment of the VMP5000 followed to 80 m loosely tethered on a rope. It successfully dropped its weights. Then the tethered VMP (VMP2000) was successfully trialled to 100 m and then 1700 m.

Friday 31st January
A rough night overnight. Watchkeeping duties began informally, including some sampling for underway salinity. The ship records its rolls on an inclinometer, and today's largest was 30 degrees to port. Lots of things ended up on the floor. We finally lost our VSAT communications so can no longer send/receive email or phone calls. We do however have 4 iridium phones on board: one for the ship which is used for work-related phone calls; one for the seal tagging team; one for the Seaglider team and one which has been bought for downloading sea ice imagery every day. The scheduled 8 am test CTD was cancelled in a confused sea with swell and wind opposed. The weather was no better at 1 pm so the test CTD was postponed again. By evening the waves and wind were abating. First icebergs were seen, though no wildlife. A meeting was held to discuss the procedures for tagging the seals, involving small boat deployment or lowering people onto the sea ice.

Saturday 1st February
We woke to calm seas and a much reduced wind. The CTD went ahead at 8 am and this time was successful, firing all the bottles at the bottom of the cast at 1000 m to provide plenty of test samples for salinity and dissolved oxygen trials of reproducibility. During the CTD our first radiosonde balloon was launched, reaching a height of 19.5 km! Following the CTD a successful trial of the free-fall VMP was conducted, including tracking its range and depth

using the VSBL. After lunch a first trial of the Moving Vessel Profiler (MVP) was undertaken, steaming at 5 knots and reaching a depth of 500 m. The weather during the afternoon was cold and snowy. Icebergs were seen more frequently, and visibility was quite poor.

Sunday 2nd February
We awoke to find ourselves in the midst of sea ice floes. It was foggy and so with poor visibility we were going slowly through the ice. The first CTD of the section (CTD3) should have taken place in the early morning but progress was delayed through the ice field; deployment was at lunchtime. Since it was the likely deepest CTD of the cruise (3500 m) we took the opportunity to bedeck the CTD frame with socks containing decorated cups. There was too much sea ice to do an untethered VMP so instead we deployed the tethered VMP. The radiosonde was delayed because of a problem with the GPS, but was successfully launched in the afternoon (without wind speed being recorded). We saw plenty of solitary crabeater seals sitting on ice floes, and a few penguins. The weather was calm, and mostly sunny with occasional fog. We are steaming slowly up the continental slope and will be working our way south across the continental shelf to the Pine Island Glacier doing CTDs and tethered VMP profiles on the way.

Monday 3rd February
A sunny day, calm in the morning but windy later on. The GPS on the radiosonde was fixed courtesy of Mark and Mike, so went ahead successfully. We were in sea ice for much of the day so steaming was relatively slow. We did CTDs and tethered profilers all day, now progressing along the continental shelf southward. We saw increasing numbers of seals, including our first Weddell seal, and some emperor and Adelie penguins.

Tuesday 4th February
A beautiful sunrise and a calm sea during the morning, doing CTDs and tethered profilers in the midst of ice floes. A short delay whilst an oil leak on the A frame was investigated. During the afternoon the ice cleared up considerably. We began CTD stations to the east of Burke Island, which could be seen as a long, low ice dome to starboard. East of Burke Island has not been mapped with swath bathymetry so extreme caution was exercised overnight as we progressed south. Orcas were seen today, fairly far away from the ship, as well as some seals and penguins. We also saw many large icebergs.

Wednesday 5th February
Overnight we passed to the southeast of Burke Island, doing CTDs and microstructure profiling. We were due at the Seaglider launch site at 8 am when the ship's day watch came on. Since we had a couple of hours free, we did a yoyo with the tethered VMP at the sill southeast of the island. Seaglider 579 “Humpback” was deployed at about 8.30 in 250 m of water. Since we are outside normal communications, the glider is being piloted by our team back at UEA so we had a number of iridium phone calls during and after deployment to check status. A CTD was undertaken at the glider launch location; the glider was then sent on a westward section. We had hoped to spend the rest of the day seal tagging, but there was a problem with the tag software. It was necessary to download new versions from St Andrews and test the tags again. Instead, a cross-section of CTDs was devised westward from the glider launch site, designed to arrive at the mooring site iStar6 at 8 am tomorrow.

Thursday 6th February
The section to the west of the mooring site was slightly curtailed in heavy sea ice and icebergs. One of the CTDs (CTD24) had a problem with the sensors being frozen; on the initial cast (CTD24a) conductivity 2 was frozen. This cast was aborted. On the proper cast (CTD24) conductivity 2 was frozen on the way down but then recovered. On arrival at the iStar6 mooring site, we did a CTD, and then the mooring was safely recovered very smoothly. A large iceberg that had calved from Pine Island Glacier last November lay between mooring sites iStar6 and iStar7, so we occupied CTD stations close to the iceberg. We arrived at iStar7 mid afternoon and soon that mooring was recovered also. Both mooring

recoveries went like clockwork in less than 2 hours. The first was in calm seas; the second in quite a strong wind with waves, with icebergs close by. The other good news of the day was that the seal tags are now fully working and tested. Unfortunately the Captain decided that we could not go to Edwards Islands where the elephant seals have been previously seen, because he and the Chief Officer are having to work 12 hour shifts because the other two officers are inexperienced. This means that no-one is available for small boat work. In addition, the islands are in an area that has not had much swath data collected (although both Polarstern and Palmer have been close by), so this is considered too risky for the junior officers to navigate. The second bad news of the day was that the glider is struggling. We received an iridium phone call from UEA during the afternoon to inform us that the Seaglider SG579 deployed yesterday had developed problems. It had an issue with the roll control so its direction was not controllable. Furthermore it seemed to have a problem with the pump. So the decision was reluctantly taken to recover the glider. Because the glider lay south of Burke Island, deemed uncharted waters, the Captain decided that he would have to be on the Bridge to take us there. Therefore some CTD stations were devised to occupy us overnight whilst waiting for him to come on watch at 6 am.

Friday 7th February

Early morning found us steaming east along the track of the CTD stations we'd occupied. The Seaglider was sending us GPS fixes every time it surfaced via the iridium phone. Once the glider was in recovery, the ship came alongside. After an anxious few minutes when the glider disappeared under the ship, it was successfully recovered. We then began investigating the possible causes of the problems. After the glider recovery, since we were so close to the Edwards Islands, the Captain agreed to go to investigate and to do the seal tagging there tomorrow. We made sure that there was no more science so that the officers and deck crew could rest. We spent the day steaming slowly eastward, and arrived at the Sturrett Islands in the early afternoon. Standing just off, we all peered through binoculars but could see no elephant seals, just penguins. Then we steamed slowly to Edwards Islands where someone on Polarstern reported seeing elephant seals in a previous year. Again we could see only penguins and the occasional crabeater seal. However there were some very promising beaches, flat and earthy without ice, which is the correct environment for elephant seals. We spent the rest of the day parked by Edwards Islands, whilst preparations were made for the small boat expeditions the next day. It was a calm, sunny but very cold day.

Saturday 8th February

Conditions were ideal for small boat work, calm and sunny. The two Humber inflatable boats were prepared, and loaded with the seal tagging equipment. However as they prepared to crane the first boat into the water, the 10 tonne deck crane stopped working. For several hours the engineers investigated. Just when we were beginning to discuss how much longer to wait, it began to work. It turns out that it doesn't like the cold temperatures, and had had a similar problem last year. The seal tagging team were scrambled and they set off, 8 people (4 scientists and 4 ship's officers/crew) and lots of equipment in the two boats. Although no elephant seals had been visible from the JCR, it turned out that there were many on the beaches of the island. It was a highly successful afternoon, with the final tally being 7 seals tagged, 3 females and 4 males. They noted that the females were much larger than expected. Although they found dozens of elephant seals on the islands' beaches, some were not at the right stage of the moult, so they had to choose carefully. The seal tagging party finally returned about 9 pm. We steamed slowly away and rested overnight.

Sunday 9th February

Morning found us parked to the northeast of the large iceberg. When the captain awoke, we set off towards the istar7 mooring site to do the VMP profile we had missed at the mooring recovery. For the rest of the day we did CTDs southeastward towards the PIG ice front. There was a successful radiosonde launch in the morning. The weather deteriorated reaching windspeeds of 40 knots and sea states of 6-7. These conditions meant that one VMP was cancelled and one CTD station cancelled altogether overnight.

Monday 10th February
The early morning CTDs 35 and 36 suffered from frozen sensors. They were deployed initially to 60 m and left there for a few minutes until they unfroze. The package was then raised to the surface for the cast. The sea was much calmer nearer the ice front, although there was still a strong wind coming off the ice shelf. It was too windy for a radiosonde launch. At 8 am we prepared for Autosub launch which went ahead smoothly. This was a 5 hour trial in open water to run through the procedures for subsequent science missions. The ship remained close by and monitored the sub's progress. Unfortunately in early afternoon, the sub lost propulsion; the propeller had stopped. The emergency weight was triggered when the sub was at 800 m, but the sub did not come to the surface as intended. For several hours it remained at 120 m and we began to hatch schemes for trawling for it. However in the evening it came to the surface and we began searching for it from the bridge with binoculars. Finally the Captain spotted it, and Autosub was safely recovered at 22.20. We then commenced CTD stations close together along the edge of the ice shelf front, as close as it was safe to go.

Tuesday 11th February
Three stations were completed overnight, with extensive sampling for tracer chemistry. The stations were close together so the limiting factor was the sampling. At about 6 am we began preparations for launch of the other Seaglider SG510 'Orca". This went ahead smoothly at about 7.20. We remained nearby until just after 10, to ensure that two dives had been completed satisfactorily. We returned to the ice shelf front to complete the CTD section. No VMP profiles are being done on this section. It was still windy and no radiosonde was launched until the afternoon when the wind abated. The CTDs continued until evening amid sunshine and a much more balmy -7°C close to the edge of the glacier. A further radiosonde was launched at the northeast corner of the section, surrounded in sea ice. The ship then steamed to open water to start the toyo section with the tethered VMP back along the ice front. At 0.75 knots, this should take about 24 hours.

Wednesday 12th February
The VMP toyo to the southwest end of the ice shelf continued overnight, but had to stop at breakfast time because the cable was going beneath the ship. It was decided that the section would be easier to operate in the opposite direction where the wind and current direction would be more favourable. Since we had to break the time series, we took the opportunity to recover the two moorings at the southern end. One was iStar9, which was recovered smoothly. We listened for the old American mooring BSR5 and ascertained that it was sitting upright; we got a clear signal on the echo sounder at 400 m depth. A plan was made to drag for it. In the mean time we went to recover the istar8 mooring. During the day the Seaglider iridium communications had got gradually worse, and its GPS fixes were increasingly erratic. We decided to recover it. Without good GPS fixes, we relied on Argos fixes obtained over the slow iridium internet connection. Extrapolating the most recent fixes, and detecting a strong Argos signal on the receiver on the ship, we searched for a couple of hours before it was spotted, lying horizontally, weighed down by ice on the antenna. After a safe recovery, we proceeded to the VMP section to work northeastward again.

Thursday 13th February
The VMP toyo section continued slowly overnight and through the day (now at 0.5 knots). A radiosonde was launched. It was a windy day, gusting 50 knots, and got quite foggy/misty in the afternoon. A radiosonde time series was conducted, but the 4th one smashed into the A frame in very strong winds.

Friday 14th February
The VMP toyo finally finished at about 6 am and we steamed for the Autosub launch position near the southwest end of the ice shelf front. Autosub was launched soon after 8. It was monitored all day. It developed a problem and returned to the surface early. Communications proved difficult and once it was located, we found that it had ice on the antenna. We spent

much of the day drifting beside the sub, devising means of removing the ice. A fire hose was tried, but to no avail. Eventually in the evening the ship was close enough to the sub to get communications with it, and the commands were sent for the sub to dive again. While it continued its test mission, we undertook a trial CTD (CTD48) to assess a problem with the wire. Unfortunately 800 m of wire needed to be removed so in the evening this was unwound along the deck and cut off. At 8 pm Autosub was sent on its mission beneath the ice shelf; it was monitored until 1 am. With CTDs impossible, a further VMP toyo was devised following the meltwater outflow.

Saturday 15th February
Autosub was recovered about 01.30 after concerns over the battery consumption. The VMP toyo commenced later than scheduled at 04.00. Batteries were changed on Autosub, and the CTD was reterminated. The VMP toyo continued up to the southwest corner of the PIG ice shelf at 11.00. The BSR5 mooring was located again and we dragged for it. This went like clockwork. The mooring and all the sensors were safely recovered. A load test was conducted on the CTD wire, and then CTD49 undertaken at the southwest corner of the PIG ice front. An MVP section along the ice front (and back) commenced about 20.00 and continued overnight, but was plagued by ice forming on the wires.

Sunday 16th February
The MVP section was aborted at 04.00 halfway back along the ice front; it had become impossible to keep the instrument ice-free and it was achieving few profiles. The temperature was -14C and with a strong wind of 35 knots everything was freezing up. A CTD was undertaken at the recovery location. A radiosonde launch was aborted when the balloon burst. A CTD at the mooring location of iStar9 (PIG_S) was undertaken followed by the mooring deployment itself (08.00-11.00). Autosub was deployed during the afternoon after some problems with the pressure switch for an Argos beacon. There were some successful radiosonde launches. After monitoring it for 5 hours, it was sent under the PIG ice shelf. It was tracked on its way until 21.00 when it was a couple of km beneath the ice shelf. We steamed west to the Thwaites Glacier to start a CTD section along the ice front there. By this time the wind had abated to 25 knots and it was clear and sunny.

Monday 17th February
Today the wind reduced and it was a bit less cold. We undertook 7 CTD and VMP stations (CTD52 to CTD58) along the ice front of Thwaites. We also steamed along the edge of an area of sea ice, scouting for suitable areas for tagging Weddell Seals. Some seals were spotted on the ice, but they were too far away to be identified as Weddell seals rather than crabeaters. The sea ice was also quite broken up and thin so probably not ideal to land people on. We left the section soon at 22.00 and steamed back to PIG.

Tuesday 18th February
We returned to the Autosub rendezvous point in the early hours and Autosub was safely recovered at 07.00 in calm seas, sunshine and very cold temperatures (-15C). The rest of the day was spent downloading and analysing its data, and replacing the batteries, aiming for a 12 hour turnaround. We moved to the iStar8 mooring location where we undertook a calibration CTD (CTD59). Mooring deployment followed surrounded by sea smoke. The anchor weight went over at 11.00. A radiosonde time series was undertaken every 3 hours through the day. The afternoon was spent doing the CTD that had been missed due to rough weather on the section into the ice shelf (formerly station 36; now station 60) and a VMP at station 35. We returned to the Autosub launch location for another launch after dinner. The sub was released at 20.00 and we monitored its progress during the test mission. A problem with the bow thrusters has resurfaced more seriously; one of the circuit breakers is broken. It was replaced but the replacement does not work either. The electrician is working on it.

Wednesday 19th February
Autosub sent beneath PIG for its second mission; this time a more complex cross-shaped mission to the grounding line and into the cavities off to the side. We monitored it until 02.00 and then headed for Thwaites. The morning was spent steaming toward the western side of the Thwaites Glacier tongue. The engineers continued to work on the wayward circuit breaker. Along the sea ice edge as we steamed south we kept a lookout for seals that might be suitable for tagging. There were plenty of emperor penguins, standing in groups or singly across the ice, but only a few solitary seals too far off to tell if they were Weddell seals. It was a calm day (wind speed below 10 knots for the first time) and sunny; relatively sheltered by the ice to the east so a sea state of only 3-4. We saw pancake ice for the first time floating past the ship. CTD stations commenced along the ice edge. The circuit breaker on the bow thruster was repaired. Stations continued overnight.

Thursday 20th February
The early morning found the sea glassy calm with sea ice forming everywhere in air temperatures of -13C during CTD68. CTD and VMP stations continued through the morning. By CTD69 we were surrounded by pancake ice forming. We left the Thwaites region soon after lunch to return to PIG to rendezvous with Autosub at midnight. The weather continued sunny with relatively low winds.

Friday 21st February
Autosub was recovered safely at about 02.00 amid pancake ice. Its flashing light proved invaluable for spotting it on the surface since it was dark and cloudy. On recovery it was immediately obvious that it had had a collision with something; the microstructure probe at the front was damaged, as was the nose of the sub and some of the communications aerials. Work began on diagnosing problems and replacing batteries while we steamed to occupy a couple of CTD stations (CTD70 and 71) to the north of Thwaites during the day. The weather turned foggy and snowy but was relatively mild, about -3C. We returned to the Thwaites ice shelf edge at 18.00, and redeployed Autosub at 20.00. It was sent on its test mission in open waters.

Saturday 22nd February
At 02.00 the decision was taken to recover Autosub since its pitch was erratic. The recovery took place in quite heavy seas, poor visibility and darkness so was difficult, but was achieved successfully at about 04.00 with only some damage to the sub's nose. We steamed to occupy the last CTD station of the Thwaites section (CTD72) and then northward to the deployment location for mooring istar6 (MID_SHELF mooring henceforth). By the afternoon the sea was glassy calm as we steamed around icebergs. The mooring was deployed at 16.00 followed by calibration CTD73. Then we steamed towards Edwards Islands, stopping en route overnight so that the 1st officer Tim could get some sleep.

Sunday 23rd February
The morning found us steaming towards Edwards, where we arrived about 8.00. The seal tagging party departed in the small boats at about 9, but after an hour or so were recalled because it was too windy and the sea was too rough. We spent the rest of the day hoping that the wind would decrease but it remained over 30 knots.

Monday 24th February
The wind abated overnight as forecast and was less than 10 knots by the morning. However at 6 am the Captain announced that he would not contemplate any further small boat work for the remainder of the cruise on safety grounds. The scientists relying on the small boats for seal tagging were understandably devastated. As an alternative, the ship steamed for the sea ice back to the west again north of the iceberg B22A. We arrived soon after lunch, and immediately saw dozens of seals. Some were crabeater seals whereas we were searching for Weddell seals to tag. We ploughed into the sea ice and soon Weddell seals were spotted. We deployed the seal tagging team onto the ice floes using the war geordie, a large

doughnut with a net wigwam above it, that three or people held onto as it was craned off the ship onto the ice. Some samples of sea ice and of the snow covering it were collected by the seal tagging team for analysis for oxygen isotopes. Three seals were tagged during the afternoon. Tagging activities ceased about 7 pm and we stayed put in the sea ice overnight.

Tuesday 25th February

We awoke to find strong winds, poor visibility, and a complete lack of seals! With a hypothesis that the seals would be more likely to haul out later in the day, we started to steam northwest along the edge of the sea ice, keeping a lookout for seals. There were plenty of penguins. Several forays into the sea ice proved fruitless. Eventually we found one that was successfully tagged; a second one nearby escaped into the water before the war geordie had been lowered onto the ice. Samples were collected for oxygen isotope analysis from a blue iceberg close to the seal tagging. After that we steamed a long way through the sea ice seeing nothing and we were beginning to despair when finally we came across several Weddell seals on a large expanse of thick pack ice. The tagging team was deployed and ran after the seals to tag them. Three seals were tagged in total over the day. There were other suitable seals nearby but frustratingly the tagging was called off by the Bridge at 6 pm because they said people were too cold and tired. We steamed to a safe location and were stationary overnight because the 1st officer and captain had been up all day. One lesson we have learnt is that for seal tagging it would have been better to have changed ship's time to the local time according to the sun, since the seals seem to haul out during local daytime.

Wednesday 26th February

At breakfast time we headed back into the pack ice to the location of yesterday's seals, but there were no seals to be seen. We therefore headed to the northwest, toward the shelf edge study area, but looked for seals as we went. It was cold (-10°C) but sunny. Our first Weddell seal was caught and darted mid-morning, but turned out to have too short hair for tagging; it was still moulting. The second however was suitable and was tagged late morning. This one was attacked by skuas while it was still dozy, and we had to scare the birds away and wait until the seal had fully woken. We steamed northwest to the shelf edge. There was thick sea ice for much of the way, including new pancake ice. This delayed our arrival at the shelf edge until about 22.00. We decided against a Seaglider deployment on account of the heavy sea ice particularly to the south (since winds were predominantly from the south). A CTD section across the trough overnight (repeating a section from JR141 in January-February 2006) commenced with CTD74.

Thursday 27th February

Good progress was made overnight with the CTD and VMP section across the trough, which is being sampled extensively for trace gases. Being so far west now, it was dark until 9 am ship's time. After breakfast we tried to recover mooring iStar2, but it did not respond to acoustic signals, nor could it be spotted on echo sounders. We continued along the CTD section and plan to return to investigate iStar2 later. We fear that the large iceberg from Thwaites that travelled over the mooring array during the last year may have caught some of the moorings. A radiosonde was launched, with a group of about a dozen minke whales around the ship. It was a sunny day but cold, with a good deal of sea ice as far as the eye could see in all directions, including newly formed pancake and grease ice. It is much more biologically productive now that we are at the shelf break, with krill swarms visible on the EK60, lots of whales and penguins (Adelie and emperor) during the day, and at one stage 97 seals were spotted at once on various ice floes around the ship. Mooring iStar3 responded acoustically but nothing surfaced when the release was triggered. Echo sounding over the site revealed however that the mooring line and instrumentation were vertical in the water. We dragged for it using the V-shaped array of anchors and wires (as used for BSR5), but nothing came up. The mooring was still in the same position afterwards so we assume that the dragging missed it. We continued with the CTD section across the trough, completing it with CTD81 in the evening at which there was a problem with the tethered VMP. The VMP deployment was aborted and investigations began into the cable and connections. CTD stations commenced northward to the continental slope.

Friday 28th February
CTDs were undertaken overnight up to CTD86, and we arrived at the site of mooring istar4 at 07.00. Whilst preparations were being made for the recovery, the gantry and a crane had a closer encounter than intended, leaving the gantry damaged. A repair was undertaken requiring the Deck Engineer to be lifted up in a gondola on the crane. Unfortunately in the couple of hours the repair took, an iceberg drifted over the mooring and we were no longer able to recover it. We steamed north to the location of mooring istar5, which was safely recovered at lunchtime. In the afternoon we returned south to istar4 and this time the iceberg had drifted sufficiently far away to trigger the release for the mooring. The mooring was recovered amid much sea ice and was onboard by mid-afternoon. We set off towards istar3 to drag for it again, but a sudden snowstorm reduced visibility and we had to stop. By the time the Captain was happy to proceed, it was too late to go to istar3, so we turned north towards the CTD section. The temperature, salinity and dissolved oxygen sensors from Autosub were swapped onto the CTD frame for cross-calibration at CTD87, in exchange for the CTD primary TC sensor and the dissolved oxygen sensor. The sensors were swapped back after CTD87. These were deep stations (2500-3000 m) with a long steam between so only 3 were occupied overnight. The wind had increased and there was quite a swell (sea state 5-6), especially as we went north out of the sea ice.

Saturday 1st March
The three deep CTD stations were completed by breakfast time, and we steamed south to istar3 to attempt dragging again. The wind and swell had died down a little but visibility was poor with occasional snowstorms and plenty of newly formed sea ice. On arrival at istar3 at lunchtime, the mooring was still clearly visible on echo sounder traces, but there was too much sea ice to drag for it. Instead we headed back along the cross-trough section to mooring istar1. Visibility was poor so we had to stop for an hour in the afternoon for the Captain to rest. At istar1 it was windy (gusting 40 knots) with poor visibility, and there was an iceberg on top of the mooring so we could not recover it. The mooring was present though and responded acoustically. We steamed north to occupy the remaining stations of the cross-slope sections. However after the first one the Captain announced that it was too windy so we remained stationary for a couple of hours. We set off again after 20.00 and occupied CTD stations across the slope front overnight.

Sunday 2nd March
Having worked stations northward, we occupied stations southward further east, until first light found us at CTD96 in 1000 m. Then we broke off the section to steam to the mooring istar1. The weather was much calmer, only 20 knots, with good visibility and the sea state was calm with a lot of sea ice. We arrived at istar1 at about 10.00 and luckily there were patches of open water amidst the sea ice and icebergs so the mooring was released and recovered. A radiosonde was launched during the mooring recovery. The istar1 mooring was redeployed (to be renamed TROUGH_W) during the afternoon followed by a CTD cast for calibration (CTD97). We returned to istar3 (listening in vain for istar2 en route) to drag for it again, but found the site covered in thick sea ice and icebergs. After some discussion, we dragged for it again, but again the mooring refused to come up; it was still visible on the echo sounders. We left the region to complete the two remaining CTD stations in the cross-trough section, CTD98 and CTD99.

Monday 3rd March
The two CTDs were completed in the early hours. The ship spent a few hours stationary overnight with the officers citing heavy sea ice. We spent the day steaming eastward through thin, newly formed ice. It was calm with murky visibility. A radiosonde was launched in the morning. The CTD section across the eastern trough started with CTD100 at 17.00. Thick sea ice was encountered between stations 100 and 101 slowing the ship.

Tuesday 4th March
We were severely delayed overnight by thick sea ice and fog, managing to complete only CTD stations up to CTD104. The final radiosonde was launched after breakfast, totalling 38 successful launches. We skipped the next intended CTD station and undertook one more CTD (105) before steaming straight for the mooring in order to be there during the crew's day shift which ends at 6 pm. The mooring was deployed in the centre of the trough at about 16.00 followed by a CTD (106). We then steamed to the west (since we had bypassed three planned stations) and occupied one on the edge of the trough (CTD107). Then we steamed east towards the final three planned CTD stations on the eastern flank of the trough. Two of these were completed in heavy sea ice in the early hours. The final station was CTD109.

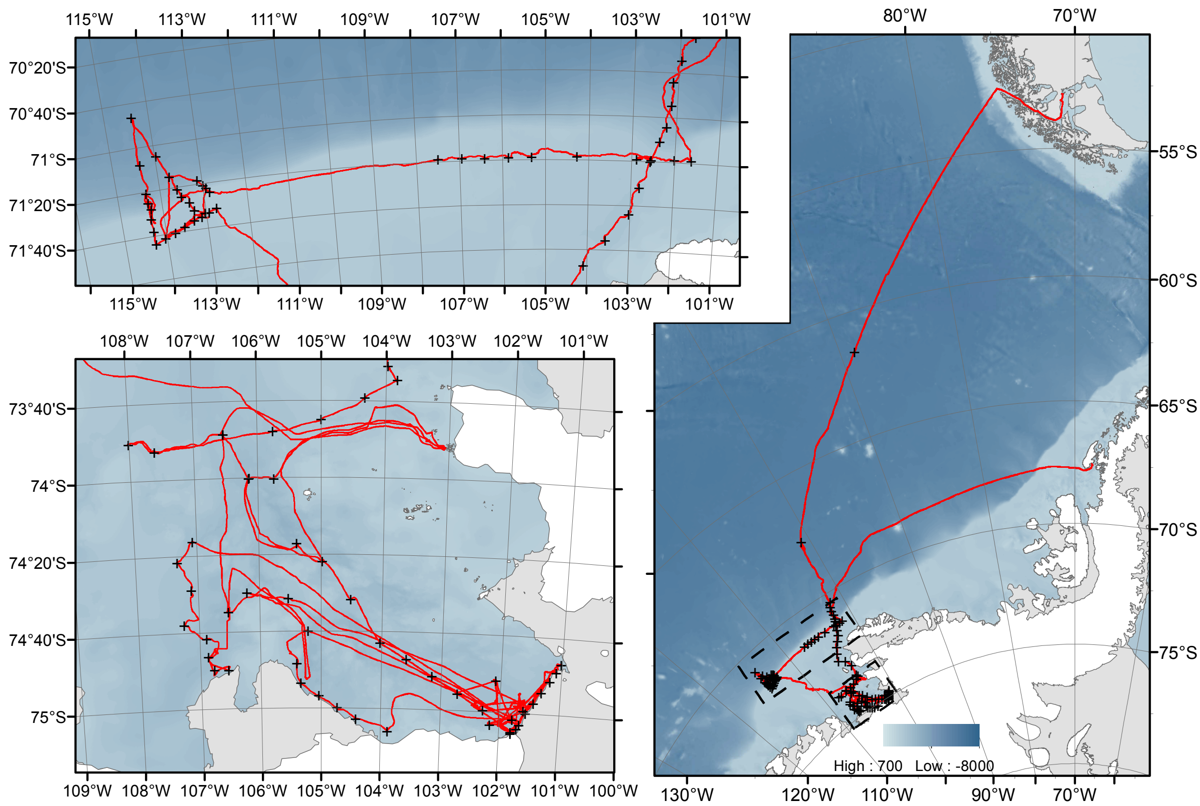
Wednesday 5th March
There was no time to complete the final planned CTD station before setting off for Rothera at the allotted time of 04.00. The sea ice was thick and progress was slow until daylight. For the rest of the day we steamed steadily northeastward.

Thursday 6th March
We steamed past Peter I Øy (or in English, Peter the First island). By this time the sea ice had gone and all that remained were some icebergs. The day was spent steaming east towards Rothera. The end of cruise buffet was held in the evening.

Friday 7th March
The day was spent steaming east towards Rothera.

Saturday 8th March
We arrived at Rothera mid-morning and the majority of the scientific party flew out on the Dash7 aircraft.

1.4 Cruise Track Plots



1.5 Project Website and Blog (Louise Biddle)

A WordPress webpage was set up approximately two weeks before the cruise with the web address ***ocean2ice.wordpress.com***. It contained an 'About' page with brief information about the background of why we're interested in Pine Island Glacier and the Amundsen Sea, as well as the main page where the blog posts appear. The blog posts were also linked into the main iSTAR website (***www.istar.ac.uk***) and Education Through Expeditions (ETE; ***www.eteteachers.org***) - when the WordPress blog was updated, the new posts would appear on these two websites as well.

As the WordPress account uses a substantial amount of bandwidth to access, blog posts were written on the ship and sent via email to Ben Webber at UEA over the BAS iridium system that was set up especially for this cruise (see section 15). The blog was updated approximately every week with posts on the environment that we're in, or on the work that had gone on that day. No photos were sent in order to ensure that the email size remained small.

The statistics on hits on the website is unknown at current, but previous to leaving the UK there were 75+ unique visitors on days when blog posts were updated. The websites that the blogs were also linked to will have a higher readership; ETE works with over 100 schools, mainly in the Devon area, but also several schools throughout the UK, Germany and the US.

Unfortunately, due to the difficult communications, we were unable to run a question and answer session with any of the schools. The video camera that was loaned to us from the iSTAR C project has been used to shoot some short films that will be distributed through ETE upon our return to the UK. These will also be used in conjunction with photos from the cruise for school visits for continued outreach after the cruise.

2 CTD Measurements

2.1 CTD Operations (Mark Preston)

Table 2.1 CTD specification

Instrument	S/N Used	Comments
CTD PC	Y	CTD PC1
Deck unit 1 SBE11plus	#-0458	
Underwater unit SBE9plus	#-0707	
Temp1 sensor SBE3plus	#03P4472	
Temp2 sensor SBE3plus	#03P2366	
Cond1 sensor SBE 4C	#04C2222	
Cond2 sensor SBE 4C	#04C2289	
Pump1 SBE5T	#4488	
Pump 2 SBE5T	#3415	
Standards Thermometer SBE35	#3527735-0024	
Transmissometer C-Star	CST-846DR	V0
Fluorometer Aquatraka Mk3	#088-216	V1
Oxygen sensor SBE43	#2290	V4
PAR sensor	#7235	V2
Altimeter PA200	#163162	V3
CTD swivel+ linkage	#196111	
Carousel + 24 Bottle Pylon	#0636	
Notes on any other part of CTD e.g.		Two broken bottle clips were replaced

faulty cables, wire drum slip ring, bottles, swivel, frame, tubing etc		along with some bottle seals.

Table 2.2 LADCP specification

Instrument	**S/N Used**	**Comments**
300KHz WH Monitor	15060	
Battery Pack	Y	
Charger	Y	
Cables	Y	'A' comms cable was notified as faulty at the start of the cruise. 'B' comms cable failed during the cruise. Both cables were then changed for new ones. No further problems were encountered.
AME Laptop (BBTalk)	Y	

Spares for the entire CTD system are carried on board and available at short notice – with the exception of the CTD frame itself. A smaller 12 bottle frame is carried as a spare for that.

Towards the end of the cruise (cast number CTD 87) The primary T and C and the dissolved Oxygen sensor were swapped out and replaced with the sensors from Autosub to allow cross calibration with that system. The instrument configuration file was copied, modified with the Autosub serial numbers and XML calibration coefficients and re saved as Autosub_JR294 InstConfig.XMLCON. The sensors were replaced after the cast and the original configuration file restored.

CTD Wire Retermination

The CTD wire was re-terminated twice during JR294.

The first re-termination was done immediately after the test CTD at the start of the cruise. I had been warned by the previous AME engineer (J Klepacki) that the electrical insulation value of the conducting wire was lower than usual, however the termination had worked satisfactorily on the previous cruise so there was no need to re make it. It failed on the first cast so was re-made and load tested at that time. The storage drum slip rings were inspected at that time also and found to be in excellent condition

The second re-termination was done after cast CTD 48 as it had been noticed that the CTD wire was starting to deteriorate badly. The outer layer of strands were starting to break up and open up. Approximately 900m of wire were flaked on deck and the wire re-terminated and load tested.

2.2 CTD Data (Gillian Damerell)

109 stations were occupied during cruise JR294. Stations 1 and 2 were test stations: station 1 had communication problems which meant no bottles were fired, no upcast data was recorded, and a retermination was required after the cast. So station 2 was a repeat (and successful) test station. Stations 3 to 36 were occupied during our steam in along the eastern trough, and stations 51 and 60 filled in locations along that line which we had missed due to lack of time and inclement weather respectively. Stations 37 to 45 were along the ice front of Pine Island Glacier. Due to concerns over the CTD wire, station 48 was done primarily for purposes of examining the wire, and after that CTD, approximately 900 m of the wire was chopped off and reterminated. Stations 49 and 50 were before/after the deployment of the MVP along the Pine Island ice front, for inter-calibration purposes. Stations 52 to 58 and 62 to 72 were along the front of Thwaites Glacier. Stations 74 to 109 were at the shelf break – 74 to 99 in the central trough and 100 to 109 in the eastern trough. Stations 25, 27, 50, 59,

73, 78, 80, 83, 85, 97 and 106 were at mooring locations – either recoveries or deployments (see mooring information in Table 10.1). For station 87 only, the primary sensors – T, C and oxygen – were taken out and replaced by Autosub sensors. This is so the Autosub data can be calibrated. Stations 31, 46, 47 and 61 were VMP only stations – no CTD. Table 2.3 lists the stations, and figure 2.1 shows their locations.

Each CTD cast acquired measurements from two Seabird CTDs and a dissolved oxygen sensor, beam transmissometer, fluorometer, PAR sensor, altimeter and 24x10 litre bottle rosette.

2.2.1 Seabird Processing

Each station was processed initially using the Seabird processing software Seasoft. The files output by Seasave have file extensions: .hex, .hdr, .bl, .XMLCON. The .XMLCON files for each cast contain the calibration coefficients for the instruments. These are updated when calibration sheets are received back from the manufacturer. The .hdr files contain the information in the header of each cast file. The .hex files are the data files from each cast and are in hexadecimal form. The .bl and .ros files contain information on bottle firings of the rosette.

For initial data processing we used Seasoft's programmes, SBE Data Processing, Version 7.22.2. We used the following options in the given order:

Data Conversion
Align CTD
Cell Thermal Mass

Data Conversion takes the .hex file with the .XMLCON file and outputs a JR294_*nnn*.cnv file and a JR294_*nnn*.ros file. Options were chosen such that the output was to a text file and both bottle and data files were created. *Align CTD* takes the .cnv file and applies temporal shifts to align the sensor readings. The offsets applied were zero for primary and secondary temperature, zero for primary and secondary conductivity, and 5 for oxygen. The output were saved in JR294_*nnn*_align.cnv files. *Cell Thermal Mass* takes the JR294_*nnn*_align.cnv files and makes corrections for the thermal mass of the cell (important in strong thermal gradients). The constants used were $\alpha = 0.03$ and $1/\beta = 7$. The output is read into JR294_*nnn*_align_ctm.cnv files. The *Loop Edit* option, which removes wakes, was not used here since *wake.m* is similar.

In all our casts the output variables were:
Scan Count
Pressure, Digiquartz
Temperature [ITS-90 deg C]
Temperature, 2 [ITS-90 deg C]
Conductivity [mS/cm]
Conductivity, 2 [mS/cm]
Oxygen, SBE 43 [µmol/kg]
Oxygen, SBE 43 [µmol/l]
Oxygen, SBE 43 [ml/l]
Oxygen, SBE 43 [Voltage]
Altimeter [m]
Fluorescence, Chelsea Aqua 3 Chl Con [µg/l]
Pump Status, on (1) or off (0)
Beam Transmission, Chelsea/Wetlab CStar [%]
PAR Irradiance [µEinsteins/m^2/s]
All files were copied to *legwork* and also to Gillian's laptop, where all subsequent processing was undertaken.

At the start of the cruise, it was unclear what procedure would be followed to calibrate the dissolved oxygen data, and also what unit dissolved oxygen should be in to use Jan Kaiser's new dissolved oxygen calibration procedure. It was therefore decided to output dissolved oxygen in all the units available through the Seabird processing.

The following protocol was followed to read the CTD data into Matlab and produce processed data files. The processing was essentially the same as carried out during JR158 (Adelie). On *legwork* under the folder /ctd, we created folders for each cast: ctd_001, ctd_002, ctd_003, etc., that we designate as ctd_*nnn*. All the CTD and bottle files at that station were kept in their own numbered directory. A README file was also maintained in each ctd_*nnn* directory and was updated manually every time any new version of the data set was created. Since we had two CTD sensors, we kept and calibrated the data from both sensors separately in all files. We did not record time as such, but used *scan*. Start time of data recording is logged as a variable that we carry through the processing as *gtime*. Latitude and longitude were also recorded from the header file, obtained from the NMEA data stream. The latitude and longitude values in the header file were carried through the processing and used as the station locations.

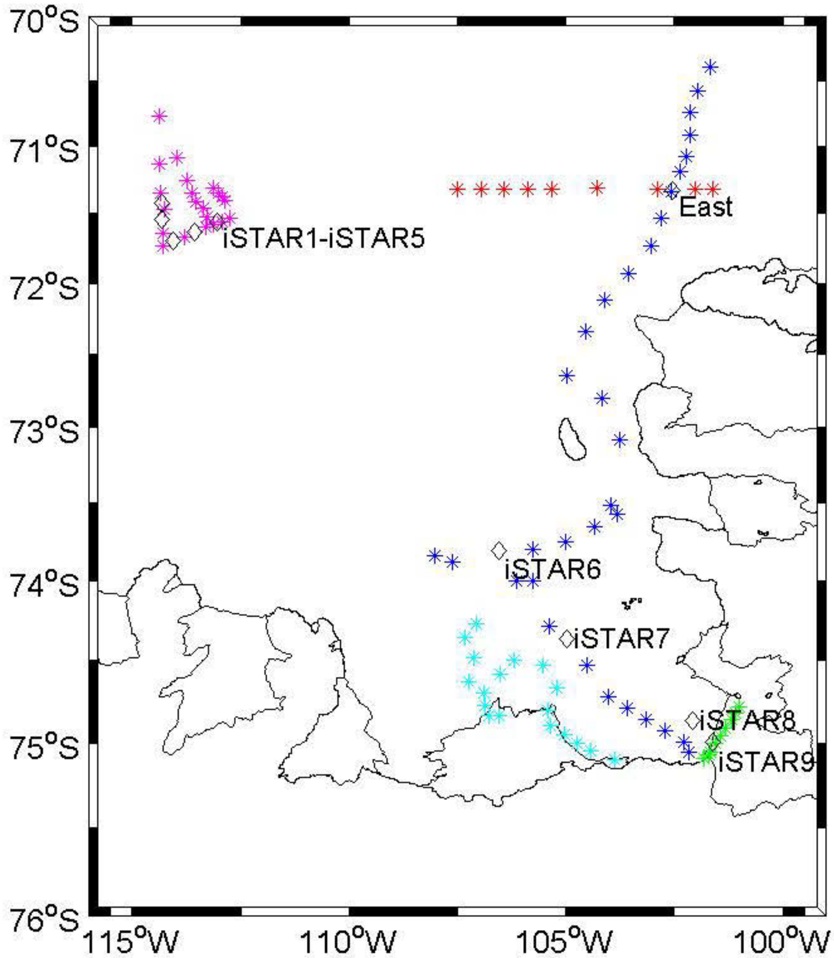


Figure 2.1: CTD stations. The blue markers are stations along the eastern trough occupied during our steam in (3 to 36, 51 and 60). The green markers are stations 37 to 45 along the ice front of Pine Island Glacier. The cyan markers are stations 52 to 58 and 62 to 72 along the front of Thwaites Glacier. The magenta markers are stations 74 to 99 in the central trough and red markers are stations 100 to 109 in the eastern trough. Stations 25, 27, 50, 59, 78, 80, 83, 85, 97 and 106 were at mooring locations and are marked as black diamonds with the names of the moorings.

Table 2.3. Station list for JR294.

Stn	Date	Julian Day	bottom time (GMT)	latitude (°S)	longitude (°W)	max pressure (db)	max depth (m)	min. distance off (m)	corrected water depth (m)
1	30-Jan-2014	30	12:18	61 35.520	88 50.350	1015	1003	>100	4686
2	1-Feb-2014	32	11:33	67 40.910	100 54.310	1014	1002	>100	4665
3	2-Feb-2014	33	16:28	70 24.100	101 40.320	3521	3457	9.35	3473
4	2-Feb-2014	33	23:07	70 34.730	101 57.290	3029	2977	9.96	2987
5	3-Feb-2014	34	05:29	70 44.520	102 7.290	2517	2477	9.79	2486
6	3-Feb-2014	34	10:56	70 54.940	102 7.840	2011	1981	9.52	1987
7	3-Feb-2014	34	15:11	71 4.700	102 13.730	1485	1465	9.3	1469
8	3-Feb-2014	34	18:50	71 11.300	102 21.920	1085	1071	9.38	1073
9	3-Feb-2014	34	22:02	71 20.310	102 34.220	634	627	9.35	633
10	4-Feb-2014	35	01:16	71 32.040	102 48.020	699	690	9.52	695
11	4-Feb-2014	35	04:47	71 43.990	103 1.540	735	726	11.11	729
12	4-Feb-2014	35	08:35	71 55.810	103 34.190	724	715	8.42	719
13	4-Feb-2014	35	12:22	72 7.200	104 5.560	575	568	9.26	571
14	4-Feb-2014	35	15:37	72 20.420	104 32.380	595	588	9.4	593
15	4-Feb-2014	35	19:14	72 38.860	104 58.490	545	539	9.21	544
16	4-Feb-2014	35	22:35	72 47.990	104 9.900	558	552	9.45	555
17	5-Feb-2014	36	01:59	73 4.990	103 46.130	566	559	9.69	633
18	5-Feb-2014	36	06:16	73 31.020	103 58.500	546	540	9.5	545
19	5-Feb-2014	36	14:13	73 34.600	103 49.660	286	283	9.4	281
20	5-Feb-2014	36	15:57	73 39.320	104 19.620	278	275	8.6	278
21	5-Feb-2014	36	18:35	73 44.990	105 0.130	592	585	9.38	593
22	5-Feb-2014	36	21:40	73 48.040	105 45.130	813	803	9.06	810
23	6-Feb-2014	37	04:43	73 52.710	107 36.590	767	757	9.47	765
24	6-Feb-2014	37	05:20	73 50.370	108 0.740	721	713	9.23	718
25	6-Feb-2014	37	09:43	73 48.580	106 32.100	973	960	8.38	968
26	6-Feb-2014	37	14:27	74 0.230	106 8.860	1233	1217	8.96	1234
27	6-Feb-2014	37	19:04	74 21.930	104 59.040	1355	1337	7.84	1342
28	6-Feb-2014	37	23:09	74 17.250	105 23.590	1129	1114	8.5	1125
29	7-Feb-2014	38	05:41	74 0.160	106 7.980	1227	1211	8.38	1222
30	7-Feb-2014	38	07:32	74 0.360	105 44.950	978	965	5.54	956
31	VMP only, no CTD								
32	9-Feb-2014	40	16:36	74 31.810	104 30.900	969	957	8.79	965
33	9-Feb-2014	40	20:33	74 43.100	104 1.640	1086	1072	8.5	1080
34	9-Feb-2014	40	00:19	74 47.250	103 35.330	1008	995	10.01	1003
35	10-Feb-2014	41	03:20	74 51.490	103 9.220	1041	1028	9.11	1034
36	10-Feb-2014	41	08:52	74 59.820	102 16.970	885	874	9.57	880
37	11-Feb-2014	42	03:43	75 5.510	101 48.200	763	754	5.59	758
38	11-Feb-2014	42	05:30	75 4.250	101 42.320	1020	1006	9.01	1010
39	11-Feb-2014	42	08:01	75 3.240	101 39.780	1061	1048	8.47	1052
40	11-Feb-2014	42	14:25	75 0.050	101 33.870	989	976	9.06	983
41	11-Feb-2014	42	16:31	74 57.420	101 26.480	956	944	9.23	995
42	11-Feb-2014	42	18:25	74 54.490	101 19.100	879	868	8.94	874
43	11-Feb-2014	42	20:03	74 51.430	101 11.360	825	815	8.6	815
44	11-Feb-2014	42	21:38	74 49.030	101 5.160	617	610	8.38	606
45	11-Feb-2014	42	23:20	74 46.840	101 0.880	645	637	8.77	647
46	VMP only, no CTD								
47	VMP only, no CTD								
48	14-Feb-2014	45	21:59	75 1.880	101 46.980	1024	1011	9.33	1054
49	15-Feb-2014	46	21:20	75 5.250	101 48.060	713	704	9.55	771
50	16-Feb-2014	47	07:44	74 59.570	101 36.290	1033	1020	9.18	1026
51	16-Feb-2014	47	10:00	75 3.420	102 9.410	742	733	8.4	739
52	17-Feb-2014	48	04:53	75 6.040	103 53.120	546	539	9.43	602
53	17-Feb-2014	48	08:20	75 2.980	104 25.080	598	591	8.03	596
54	17-Feb-2014	48	12:34	75 0.090	104 44.070	964	952	11.58	956
55	17-Feb-2014	48	14:30	74 56.980	105 2.260	752	743	3.91	748
56	17-Feb-2014	48	17:05	74 53.620	105 20.420	1287	1270	8.79	1278
57	17-Feb-2014	48	20:18	74 48.490	105 24.230	945	933	7.25	949
58	18-Feb-2014	49	00:11	74 40.000	105 12.980	1238	1222	9.06	1240
59	18-Feb-2014	49	12:11	74 51.880	102 5.020	947	935	8.99	940
60	18-Feb-2014	49	16:07	74 55.750	102 43.120	680	672	7.42	684
61	VMP only, no CTD								
62	19-Feb-2014	50	17:42	74 49.960	106 31.930	693	685	8.99	711
63	19-Feb-2014	50	20:13	74 50.010	106 46.310	952	940	9.57	944
64	19-Feb-2014	50	22:59	74 46.470	106 51.880	1167	1152	9.79	1170
65	20-Feb-2014	51	02:23	74 41.760	106 53.120	922	910	9.57	915
66	20-Feb-2014	51	05:18	74 37.990	107 14.690	703	695	9.33	707
67	20-Feb-2014	51	08:45	74 28.990	107 6.670	1037	1023	8.42	1035
68	20-Feb-2014	51	11:55	74 21.660	107 19.500	1064	1050	10.18	1052

Stn	Date	Julian Day	bottom time (GMT)	latitude (°S)	longitude (°W)	max pressure (db)	max depth (m)	min. distance off (m)	corrected water depth (m)
69	20-Feb-2014	51	14:48	74 16.410	107 4.100	1037	1024	9.11	1065
70	21-Feb-2014	52	13:41	74 31.620	105 32.120	966	954	9.62	959
71	21-Feb-2014	52	16:47	74 29.950	106 12.290	1185	1170	9.28	1178
72	22-Feb-2014	53	12:21	74 34.980	106 31.050	1225	1209	9.06	1221
73	22-Feb-2014	53	19:47	73 48.730	106 31.890	970	958	9.38	959
74	27-Feb-2014	58	01:55	71 31.890	112 44.950	423	418	7.52	425
75	27-Feb-2014	58	03:55	71 33.400	112 56.120	554	548	8.86	550
76	27-Feb-2014	58	06:15	71 34.810	113 7.180	620	612	8.84	617
77	27-Feb-2014	58	08:25	71 35.910	113 18.120	615	607	9.52	612
78	27-Feb-2014	58	10:39	71 38.160	113 32.990	609	601	8.64	606
79	27-Feb-2014	58	13:20	71 40.090	113 47.410	572	565	9.01	569
80	27-Feb-2014	58	16:11	71 41.980	114 2.480	534	527	9.5	534
81	27-Feb-2014	58	23:01	71 43.880	114 17.010	462	457	9.01	462
82	28-Feb-2014	59	00:58	71 38.310	114 17.480	481	476	9.57	479
83	28-Feb-2014	59	02:20	71 32.590	114 18.220	506	501	7.96	508
84	28-Feb-2014	59	03:40	71 28.200	114 16.190	1002	989	9.08	993
85	28-Feb-2014	59	05:24	71 25.280	114 18.840	1488	1468	8.86	1470
86	28-Feb-2014	59	07:44	71 20.990	114 20.080	1960	1931	8.21	1932
87	28-Feb-2014	59	23:15	71 7.950	114 21.970	2539	2498	14.41	2507
88	1-Mar-2014	60	04:51	70 46.580	114 23.000	3050	2997	8.94	3001
89	1-Mar-2014	60	09:48	71 5.020	113 58.210	2523	2483	8.13	2489
90	1-Mar-2014	60	20:12	71 31.550	113 16.080	616	608	8.16	611
91	2-Mar-2014	61	00:04	71 27.550	113 21.490	620	613	11.7	620
92	2-Mar-2014	61	01:50	71 24.650	113 31.470	1039	1026	9.65	1028
93	2-Mar-2014	61	03:29	71 21.140	113 36.290	1506	1485	9.21	1496
94	2-Mar-2014	61	06:00	71 15.040	113 44.430	2030	2000	7.5	2006
95	2-Mar-2014	61	08:56	71 18.480	113 7.040	1516	1495	8.3	1500
96	2-Mar-2014	61	10:45	71 21.100	113 0.030	1013	1000	8.72	1000
97	2-Mar-2014	61	17:17	71 33.430	113 1.940	594	587	8.74	591
98	3-Mar-2014	62	03:54	71 22.470	112 56.000	600	594	8.62	598
99	3-Mar-2014	62	05:13	71 24.360	112 51.450	437	432	1.12	428
100	3-Mar-2014	62	20:12	71 19.180	107 30.040	472	466	8.84	473
101	3-Mar-2014	62	22:37	71 19.120	106 56.750	505	500	6.13	499
102	4-Mar-2014	63	00:44	71 19.330	106 24.870	518	512	6.03	518
103	4-Mar-2014	63	03:09	71 19.200	105 51.750	529	523	8.55	524
104	4-Mar-2014	63	06:17	71 19.100	105 19.390	558	551	9.45	562
108	5-Mar-2014	64	02:09	71 19.220	102 0.960	619	612	7.99	612
109	5-Mar-2014	64	06:13	71 19.220	101 36.810	520	514	9.5	517

Table 2.4: Bottle bubble, toil and trouble: Number of samples taken at each station, problems with niskins and other issues/comments.

	Number of samples taken				
Stn	salinity	O18	Dissolved O_2	trace gas	Comments and leaks.
1					Bottles did not fire, and no upcast data due to comms problems. Retermination required before cast 2.
2	23	0	6 triplicates, 1 quadricate	4	Niskins 1 & 2, slow leaks. Niskin 10 was knocked as rosette brought into bottle annex. Did not sample it.
3	5	16	8 triplicates	16	
4	4	12	0	12	
5	5	0	0	0	
6	4	10	4 triplicates	10	
7	4	0	0	0	Niskin 7, significant leak, bottom end cap.
8	4	10	0	10	Niskin 7, significant leak, bottom end cap.
9	4	9	4 triplicates	8	
10	4	0	0	0	Niskin 5, top o-ring leak. Large temp diff in top 300m on upcast, check sensors.
11	4	8	4	8	Sensors seem fine now.
12	4	0	0	0	
13	4	0	0	0	
14	3	0	0	0	
15	4	4	4	0	Niskin 7, significant leak, top end cap not properly in place. Intended to be a repeat of NP09 stn 09 but actually 5 miles S.
16	4	0	0	0	Niskin 7, significant leak, bottom end cap.
17	4	0	0	0	Niskin 6, slow leak, bottom end cap. Slightly to W of planned position because an iceberg was in the way.
18	3	0	0	0	
19	4	4	4	0	
20	3	7	0	7	Niskin 7, significant leak, bottom end cap; 8, slow leak.
21	3	7	0	7	Niskin 1, not correctly cocked; 16, leaked from bottom end cap after opening valve.
22	4	9	0	9	
23	3	8	0	8	
24	9	8	0	8	cond2 was frozen when it went in - water bottle door had been left open. Went down to 400m, then up to surface and began cast again. Cond2 unfroze when nearly at the bottom of the proper cast, was fine on upcast.
25	3	8	0	8	At mooring iSTAR6 recovery.
26	3	7	0	7	NW corner of berg B31a
27	3	8	8 triplicates	0	At mooring iSTAR7 recovery.
28	4	9	0	0	SE corner of berg B31a
29	3	0	0	0	
30	2	0	0	0	
31					VMP 2000 only, no CTD. Same position as CTD 027 when we missed out the VMP.
32	3	7	4	0	Niskins 3, 4, 5, 6, all leaking!
33	4	4	4	0	
34	3	6	4	0	
35	3	5	0	0	Niskin 7, bottom end cap leak. Long delay at launch, cond1 froze. Did 'surface' soak at ~40m for 10 mins, and it unfroze.
36	4	7	0	0	cond1 frozen, soaked at ~60m, unfroze after few mins. All spigots had ice in them during sampling.
37	3 duplicates	9	0	9	Niskins 3, 4, 13, 14, 15, slow leak bottom end cap. Started doing duplicate salinities to try to address salinometry problems.
38	3 duplicates	11	0	11	Niskin 7, slow leak, spigot. Lots of gases - 11 helium and tritium as well as trace. Very fresh surface layer.
39	4 duplicates	12	0	12	Niskin 2, slow leak, spigot; 7, significant leak, bottom end cap; 13, slow leak, bottom end cap. Salinity crates left in water bottle annex starting to freeze - keep inside between stations from now on. Discovered niskin 7 has no bottom o-ring!
40	3 duplicates	10	0	10	Niskin 7 new bottom o-ring, no leak.
41	4 duplicates	10	8	10	Tritium as well as trace gases.
42	4 duplicates	9	0	9	
43	4 duplicates	9	0	9	
44	4 duplicates	8	0	8	Spring inside niskin 16 broke as we were cocking, bottle removed for this station.
45	4 duplicates	7	0	7	Niskin 16 replaced.
46					No CTD, VMP 2000 tow-yo.

	Number of samples taken				
Stn	salinity	O18	Dissolved O_2	trace gas	Comments and leaks.
47					No CTD, VMP 2000 tow-yo.
48	3	0	0	0	Test station to examine CTD wire. After this CTD, ~900m of cable was flaked out on deck and chopped off due to concerns over birdcaging. CTD reterminated before next cast.
49	4	0	0	0	Niskin 7, worse than before, from spigot when pushed in but before valve opened. CTD wire re-examined post retermination. Pre-MVP station.
50	4	0	4	0	Niskin 5, tiny drip; 7, bad, from spigot when pushed in but before valve opened. Post MVP station.
51	2	0	0	0	cond1 frozen on way down to ~80m. Down & upcast rather different. Poss meltwater signature at ~140m. At mooring iSTAR9 deployment.
52	3	1	0	0	
53	3	6	4	6	Niskin 7, slow, spigot; 12, medium, bottom end cap; 17 & 18, slow, bottom end cap. cond2 frozen when went in - did 'surface' soak at 50m & it unfroze. After this cast Mark Preston attempted to fix bottle 7's leaks.
54	4	9	0	9	Niskin 8, slow, bottom end cap. Garage door opened much too soon while ship still getting into position. Cond sensors so frozen we brought CTD back inboard and used heat gun to warm water bottle annex to thaw them out. (Heat gun directly to CTD would melt things.) Did VMP 2000 cast while CTD was defrosting. CTD cast then completed successfully.
55	4	4	4	0	
56	3	12	0	12	No SB35 data - apparently not saved and then overwritten on the instrument.
57	2	10	4	10	cond1 frozen when went in - did 'surface' soak at 50m & it unfroze.
58	2	0	0	0	
59	2	0	0	0	Niskin 3, slow, bottom end cap - not sure if really a leak or melting ice. At iSTAR8 mooring deployment.
60	2	4	0	0	Niskin 5, significant, from spigot.
61					VMP 2000 only, no CTD. Same position as CTD 035 when we missed out the VMP.
62	3	0	0	0	Niskin 5, slow, bottom end cap. Bow thrusters not working so drifted a little during the cast. SB35 data missing bottle 1.
63	2	9	0	9	Niskin 16, slow, bottom end cap.
64	3	9	8	9	Not quite correct position as too much ice.
65	1	10	0	10	
66	2	3	0	0	Approx 1 mile south of planned location due to ice.
67	3	0	0	0	Niskin 2 - couldn't leak test - spigot wouldn't move. Probably frozen. Somewhat to the west of planned location due to ice.
68	4	0	0	0	
69	4	0	0	0	
70	4	0	0	0	
71	4	0	0	0	Niskin 7, from spigot.
72	3	0	4	0	Niskins 6 & 8, bottom end cap.
73	3	0	4	0	At iSTAR6 deployment.
74	3	7	0	7	Niskin 1 did not fire. 2, 6, 21, leak from bottom end cap. At central trough.
75	2	7	0	7	Niskin 6, slow, bottom end cap.
76	2	7	0	7	
77	3	6	0	6	
78	3	7	0	7	At mooring iSTAR2.
79	3	7	0	7	Niskin 13, significant, bottom end cap. Lots of gases - 7 helium and 6 tritium as well as trace.
80	2	8	0	8	Niskins 2 & 6, slow, bottom end cap. At mooring iSTAR3.
81	4	7	7	7	
82	3	0	0	0	
83	2	0	0	0	At mooring iSTAR4.
84	4	0	0	0	
85	4	0	0	0	At mooring iSTAR5.
86	3	0	0	0	
87	3	0	12	0	Primary sensors – T, C and oxygen – were swapped out and replaced with Autosub sensors.
88	5	0	9	0	
89	3	0	0	0	Niskin 6, slow, bottom end cap.
90	3	0	0	0	Niskin 2, slow, spigot; 6, slow, bottom end cap.
91	5	0	0	0	Niskin 2, bottom end cap.
92	2	0	0	0	
93	2	0	0	0	
94	3	0	0	0	
95	3	0	0	0	

	Number of samples taken				
Stn	salinity	O18	Dissolved O_2	trace gas	Comments and leaks.
96	3	0	0	0	
97	2	0	0	0	At mooring iSTAR1.
98	2	0	0	0	
99	2	0	0	0	cond sensors frozen, did 'surface' soak at 50m and unfroze ok. Ship had to move a little during cast due to ice.
100	3	7	7	7	Niskin 5, slow, bottom end cap; niskin 13, slow, bottom end cap.
101	3	0	0	0	
102	3	7	7	7	
103	2	0	0	0	
104	2	8	8	8	
105	3	8	8	8	Niskins 2, 3, 8, 12, 17, 21, slow leak, bottom end cap. At mooring in the eastern trough.
106	3	8	8	8	6 tritium and 6 helium samples also taken.
107	3	9	9	9	Ship had to move a little during cast to avoid ice.
108	2	5	7	12	5 tritium samples taken also.
109	2	5	7	11	

2.2.2 Creation of the CTD files

All the Matlab processing routines below were altered to process the additional oxygen variables.

ctdcal.m
This reads in the JR294_*nnn*_align_ctm.cnv data file. It runs the routines *cnv2mat.m,* and *hdr2mat.m.* They read the file, rename all the variables to something comprehensible and save the data in a Matlab file jr294_*nnn*_cal.mat.

offpress.m
This reads the jr294_*nnn*_cal.mat files, plots the data near the surface, and asks the user to choose a pressure offset to apply. The aim is to have a pressure of zero at the start/end of the pressure record. During JR294 these offsets were always less than 0.4 db, and up until the central trough (stations 74 onwards), always less than 0.2db. However, for the majority of stations during JR294 the pressure offsets at the start and end of the pressure record were not the same – and always more negative at the end than at the start. We did not discover the reason for this change. Up until the stations in the central trough, this difference often showed as a small **positive** offset at the start of the pressure record (e.g., +0.1, suggesting a pressure offset correction of -0.1) and a small **negative** offset at the end of the pressure record (e.g., -0.05, suggesting a pressure offset correction of +0.05). In such a case, unless the difference in magnitude of the two pressure offsets was more than 0.1, no correction was applied. (e.g., pressure offsets of +0.04 and -0.2 at start and end of a cast respectively, correction of +0.08 applied resulting in offsets of +0.12 at the start and -0.12 at the end. But if on another cast the offsets were +0.1 at the start and -0.05 at the end, no correction was applied.) From station 74 onwards, the pressure offsets were commonly a small negative number at the start and larger negative number at the end of the pressure record. In such a case, a pressure offset correction was applied so as to make the pressure offsets of equal magnitude and opposite sign. (For example, pressure offsets of -0.08 and -0.3 at start and end of a cast respectively, correction of +0.19 applied resulting in offsets of +0.11 at the beginning and -0.11 at the end.)
offpress.m also removes any data when the *pumps* variable is zero, indicating that the Seabird pumps were not on. After applying the chosen pressure offset, the resulting data are saved as jr294_*nnn*_wat.mat.

spike_t90.m
This checks for, and sets to *NaN*, large single point spikes in conductivity, temperature, fluorescence, transmittance and oxygen. Generally there are few points that are removed in this process. It uses the despiking routine *dspike.m,* and calculates salinity using *ds_salt.m,* which calls a number of the seawater routines. During JR158 (Adelie), the seawater routines used were an older version which took T-68 as the input temperature, whereas on JR294 we

were using seawater version 3.0, which take T-90 as the input. *spike_t90.m* is a modified version of *spike.m* to use T-90. (Any scripts whose name includes _t90 have been similarly modified.) *spike.m* also performed cuts to remove fluorescence values greater than 1 and transmittance values less than 80. During JR294 we saw what seemed like real data with fluorescence >1 and transmittance < 80, so these cuts were removed. The resulting file is jr294_*nnn*_spk.mat.

wake.m
The wakes are easy to detect from plots of *press* against *scan*. The programme removes data when the same pressure level is sampled twice, and attempts to select a point which has a similar temperature to that measured at the start of the wake and accept data from that point again. It also sets to *NaN* any data when the rate of change of pressure falls below a threshold, i.e., when the package has slowed down. For JR294 this threshold was set to 0.005 db/scan instead of 0.02 db/scan as before. It has become common to lower the CTD package quite slowly in the first 50 m, gradually increasing speed, and the old threshold of 0.02 db/scan was therefore cutting out a lot of the first 50 m. *wake.m* was also modified so that the user can choose, as the input, either the _spk.mat files from *spike_t90.m,* or the _tct.mat files after a temperature calibration has been applied (see section 2.3.1). The resulting file is jr294_*nnn*_wke.mat.

interpol.m
This programme finds any data set to *NaN* in any of the temperature, conductivity, fluorescence, transmittance and oxygen variables, and interpolates across them to produce a continuous data set. The output file is jr294_*nnn*_int.mat. At this point we have 24 Hz data for the up and down casts. We then need the bottle salinity data to calibrate salinity. However, the next steps can be (and were) undertaken on the data even if salinity is uncalibrated.

makebot_t90.m
This reads in the JR294_*nnn*.bl file created by Seasoft. The .BL file contains the scan numbers to be used for extracting CTD data during bottle firings. The start and end scan numbers from this file are used to read the jr294_*nnn*_int.mat file and extract CTD data when the bottle was fired. The reason that we do not use the Seasoft values is that we have despiked the _int files already and therefore know the quality of the data going into the bottle average. Median values for each CTD variable are calculated as representative of the CTD data during the firing. The standard deviations of the temperatures and conductivities are calculated as a means of determining if the bottle was fired in a region of strong gradient. A warning is given to the user if large standard deviations are found. All standard deviations are stored alongside all the other extracted variables in the output file, jr294_*nnn*_sal.mat. Makebot also creates variables for bottle salinity, *botsal*, initally set to *NaN*, and a salinity bottleflag, *salflag*, initially set to 0.

newvar_t90.m
This calculates salinity from conductivity and temperature, and also derives potential temperature. The output is jr294_*nnn*_newvar.mat.

splitcast.m
This splits the data from jr294_*nnn*_newvar.mat into an upcast and a downcast file – jr294_*nnn*_up.mat and jr294_*nnn*_dn.mat. For JR294 this script was modified so the user can choose the input file – either jr294_*nnn*_newvar.mat or jr294_*nnn*_var.mat after a conductivity calibration has been applied (see section 2.3.2).

ctd2db.m
This does a 2 decibar binning of the CTD downcast data in jr294_*nnn*_dn.mat to produce jr294_*nnn*_2db.mat.

ctd1hz.m
This does a 1Hz binning of the CTD data in jr294_*nnn*_var.mat or (downcast and upcast) to produce jr294_*nnn*_1hz.mat.

excel_bottle_files.m
This is a new script written to output the contents of the jr294_*nnn*_sal.mat to an Excel file, as the oxygen team wished to use Excel for the oxygen calibrations. This script was run after *sb35read.m* and *sb35comp.m* (see section 2.3.1) so that it can also include the SB35 Deep Ocean thermometer temperatures. The output file is jr294_*nnn*_sal.xlsx.

Notes

The fluoresence and transmittance have only had basic despiking applied – no other data processing/clean-up/calibration. The PAR data has not been processed in any way, simply carried through. At 5/3/14, no oxygen calibration was applied to the matlab data files. See section 2.4 for post-cruise oxygen calibration.

In the final output data files jr294_*nnn*_1hz.mat and jr294_*nnn*_2db.mat, there are variables *sal1*, *sal2*, *salin* and *potemp1*, *potemp2*, *potemp*. *potemp* and *salin* are the preferred variables. *potemp=potemp2* and *salin=sal2* except for station 24 where the secondary conductivity sensor was frozen on the downcast, so *potemp=potemp1* and *salin=sal1* instead.

For station 87 only, the primary T, C and oxygen sensors were removed and replaced with the Autosub T, C and oxygen sensors. This is so the Autosub sensors can be calibrated. The calibrations discussed in section 2.3 were only applied to the secondary sensors for this station – the primary sensors (i.e., the Autosub sensors) will need to be calibrated after the cruise.

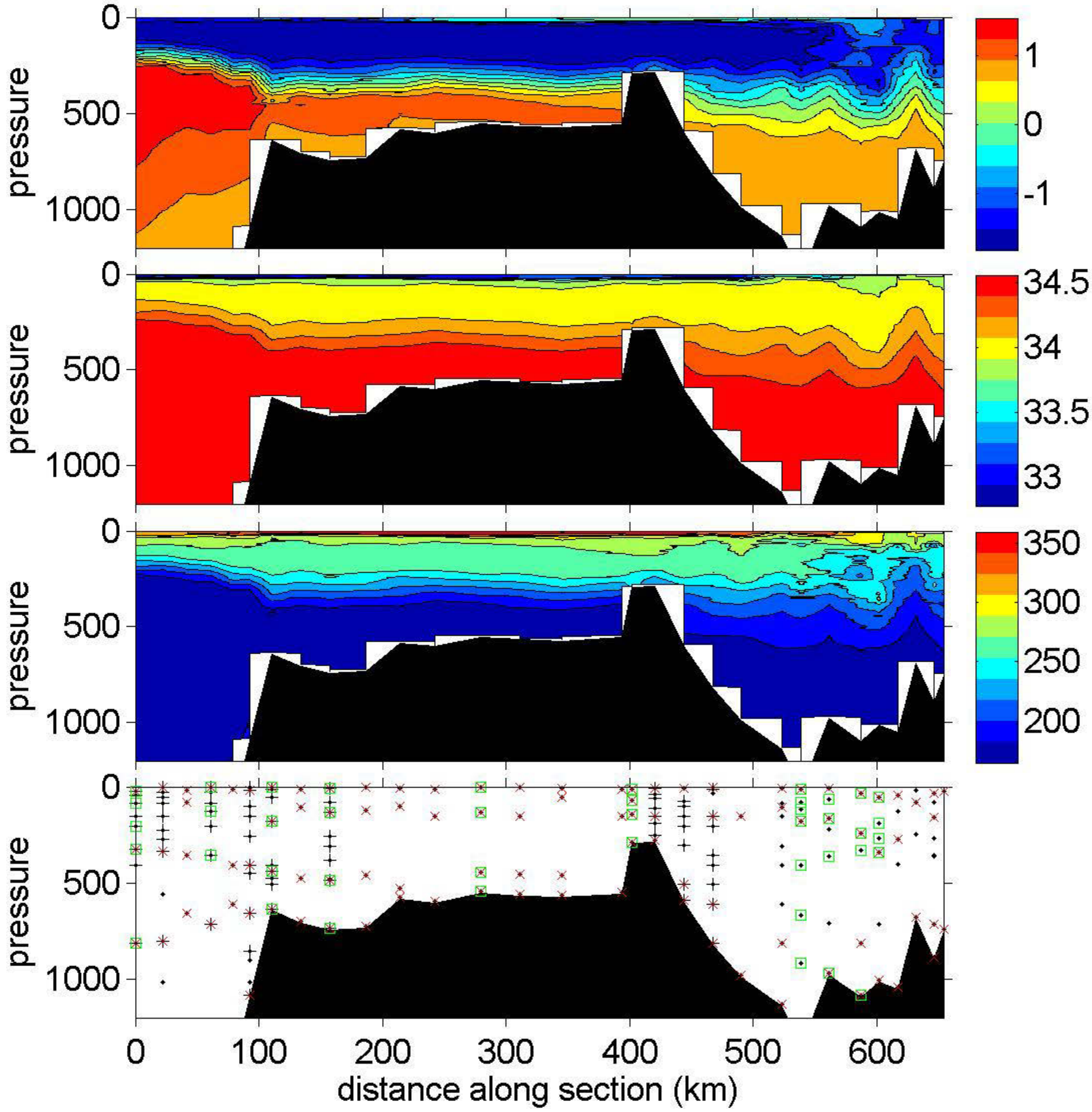


Figure 2.2: Section along the eastern trough – the stations shown as blue markers in figure 2.1. Top panel=potential temperature (°C), second panel=salinity, third panel=dissolved oxygen (µmol/kg), bottom panel=positions of bottle firings. Black dots mark depths at which bottles were fired, black plus signs + mark bottles sampled for noble gases, red crosses × mark bottles sampled for salinity, and green squares ▢ mark bottles sampled for dissolved oxygen.

Note that the bathymetry shown here is simply a linear interpolation between the water depths at each station, rather than the true bathymetry along the section.

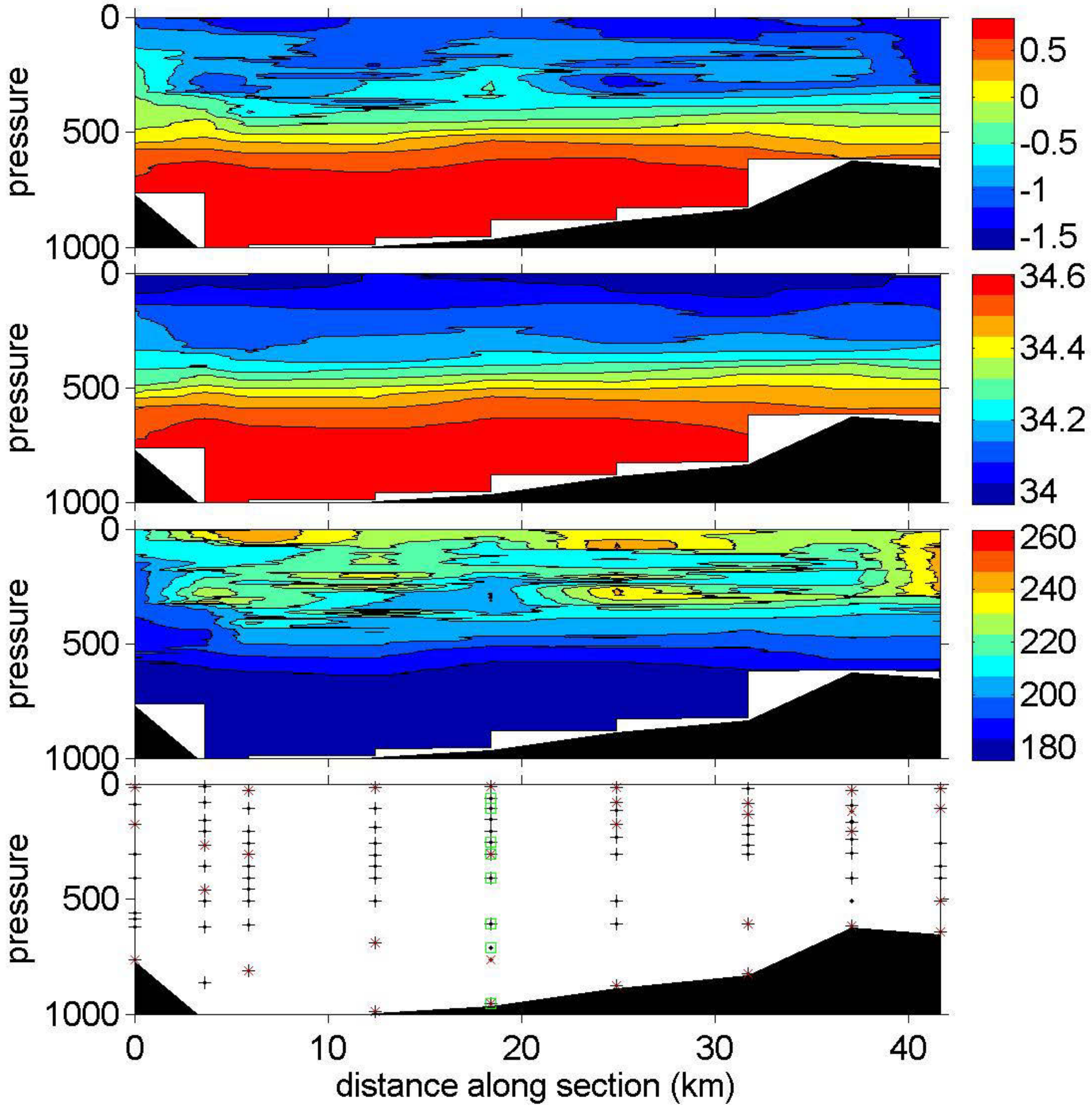


Figure 2.3: Section along the ice front of Pine Island Glacier – the stations shown as green markers in figure 2.1. Panels, markers and bathymetry as in figure 2.2.

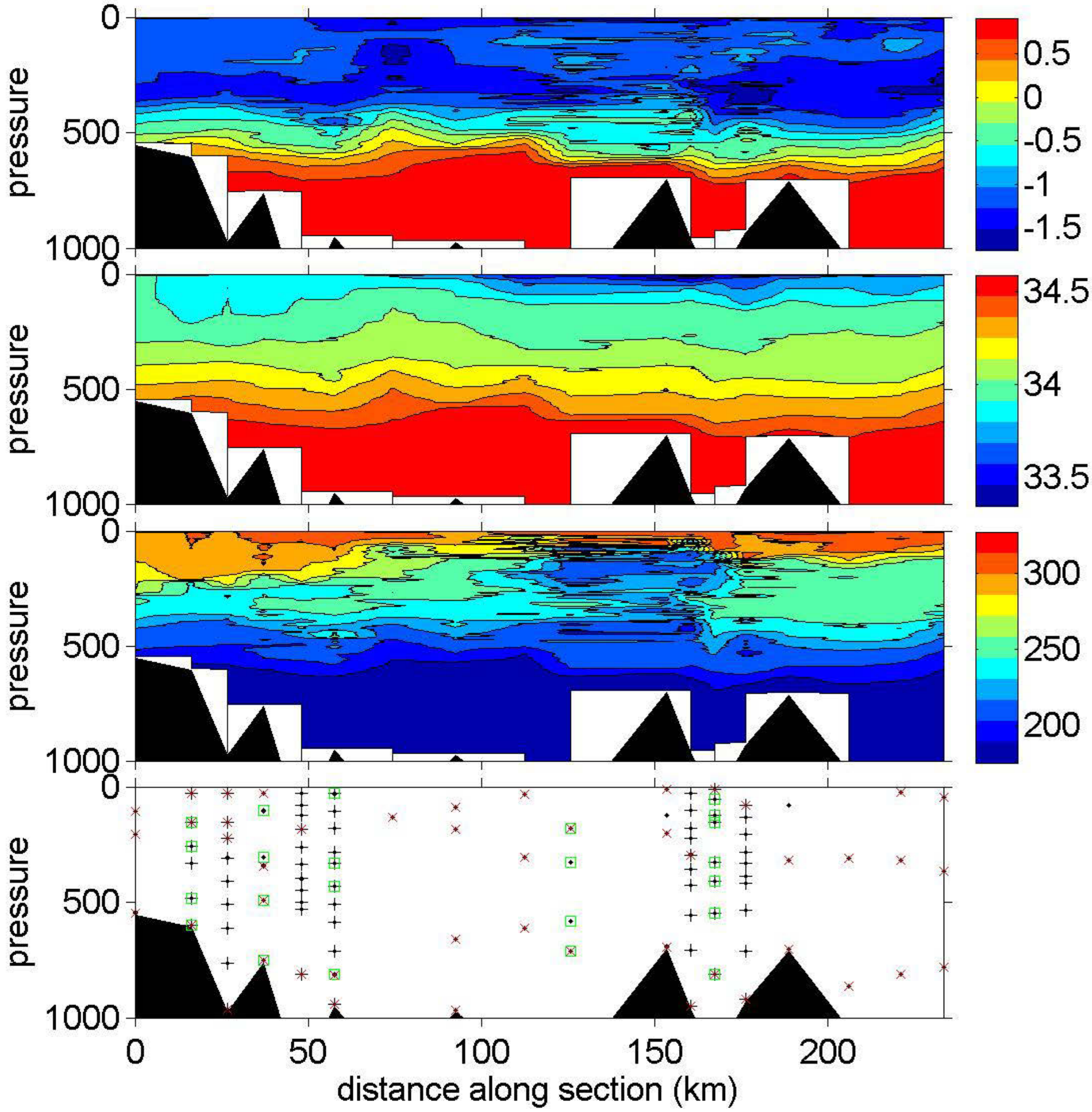


Figure 2.4: Section along the ice front of Thwaites Glacier – the stations shown as cyan markers in figure 2.1. Panels, markers and bathymetry as in figure 2.2.

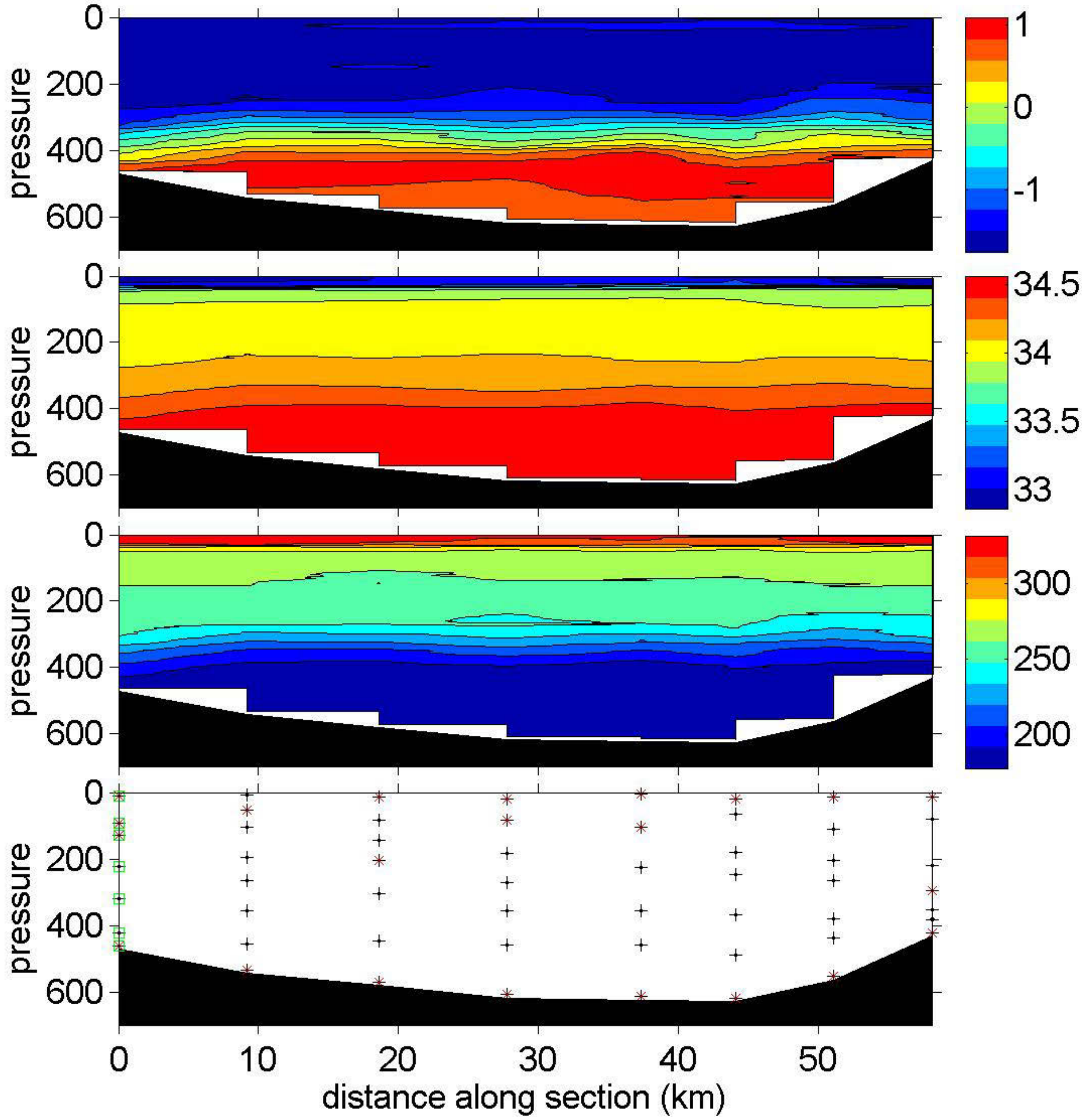


Figure 2.5: Section across trough/along shelf break at the central trough (stations 74 to 81). This is some of the stations shown as magenta markers in figure 2.1 – the base of the trident but not the prongs. Panels, markers and bathymetry as in figure 2.2.

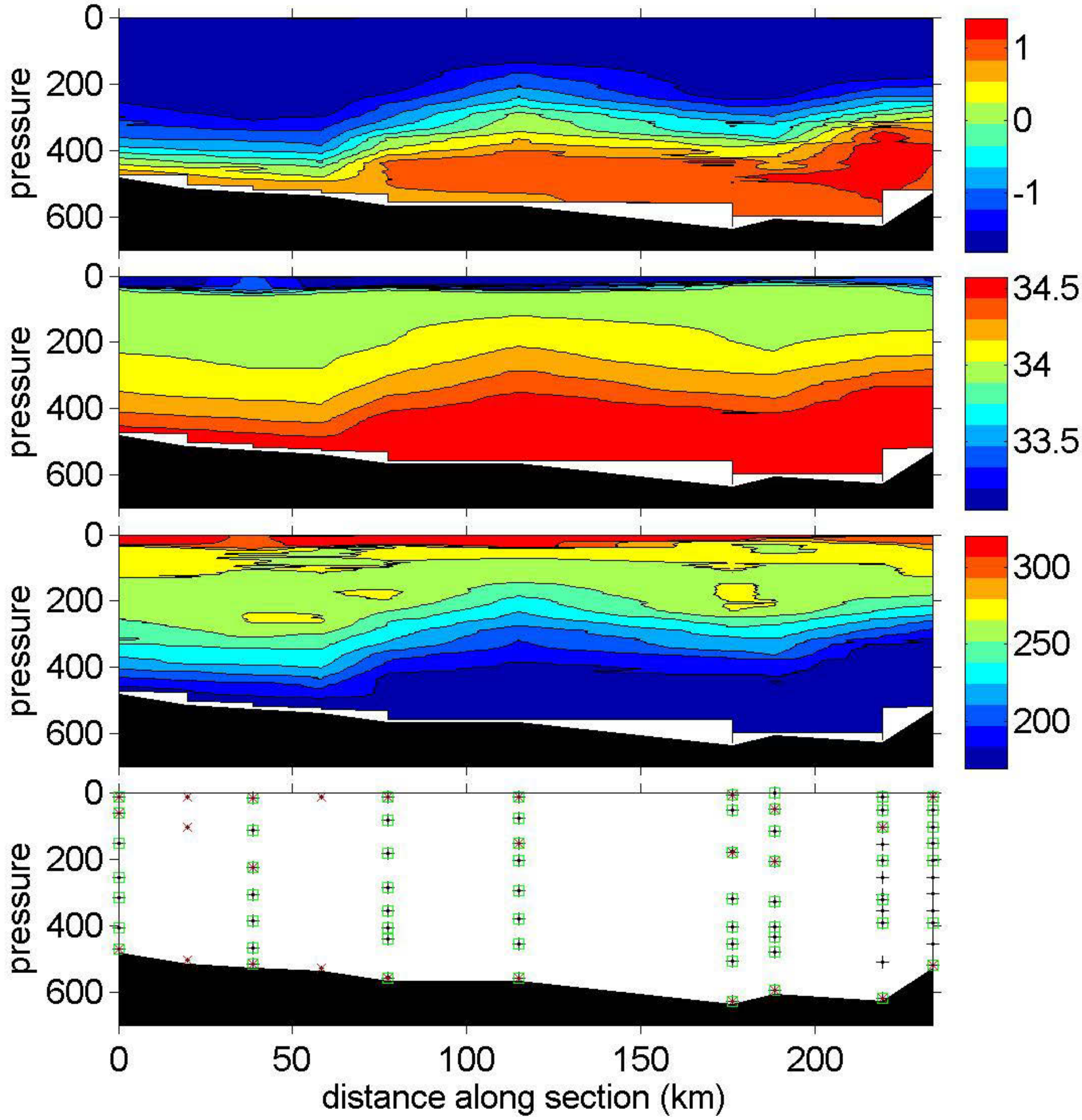


Figure 2.6: Section across the eastern trough – the stations shown as red markers in figure 2.1. Panels, markers and bathymetry as in figure 2.2.

2.3 Temperature and Salinity Calibration (Gillian Damerell)

2.3.1 SB35 Deep Ocean Standards Thermometer

The rosette was equipped with a SB35 Deep Ocean Standards thermometer to calibrate the two temperature sensors from the CTD. The thermometer measures the temperature at which the bottles were fired and the data are stored for each station in an ASCII file jr294_*nnn*_sb35.asc using Seabird's Seaterm programme.

sb35read.m
Reads the ASCII file and extracts the information about the bottle numbers, date and time at which the bottles were fired, and the temperature measured by the thermometer when the bottles were fired. The extracted information is then stored in a file named jr294_*nnn*_sb35.mat.

sb35comp.m
Calculates the difference between the SB35 temperature and the CTD temperature sensors and stores them as *sb35t1* and *sb35t2* in the jr294_*nnn*_sb35.mat file. Also plots them against pressure.

sb35diff.m
This script was extensively modified to make it more like *salanalyse.m/condanalyse.m* (see section 2.3.2). It now plots the difference between the SBE35 temperature and the CTD temperature for all the bottles of all the stations against pressure, temperature, salinity and station number, to see if there are any trends. (Station number is used as a proxy for time.) The median offsets, *medsb35t1* and *medsb35t2* are saved in the calibration file calvalues.mat.

sb35tempoffset.m
Function that goes into each station directory, loads jr294_*nnn*_spk.mat and applies the temperature offsets for both sensors:

temp1 = *temp1* + *medsb35t1* and *temp2* = *temp2* + *medsb35t2*.

All the variables in jr294_*nnn*_spk.mat are then saved in a file named jr294_*nnn*_tct.mat with the updated temperatures.

After station 72 an initial calibration was performed. After using *sb35tempoffset.m* to apply the temperature calibration offsets, *wake.m, interpol.m* and *makebot_t90.m* were re-run so that the CTD salinities in jr294_*nnn*_sal.mat were calculated using the calibrated temperatures. At this time an initial salinity calibration was also performed.

2.3.2 Salinity calibration

getsalts_t90.m
This adds bottle sample salinity, *botsal*, to the jr294_*nnn*_sal.mat file to create a jr294_*nnn*_slt.mat file. Bottle salinities are read from the file /legwork/salinometer/sal*nnn*.mat. The salinity flag, *salflag*, is set to 1 where there are data, and 0 where data are absent. Salinity and conductivity offsets are also calculated and saved to jr294_*nnn*_slt.mat. This script was modified to add *botsal*, *salflag* and all the offsets to the excel bottle file.

setsalflag.m
This checks the standard deviations of the CTD temperature and salinity data in jr294_*nnn*_slt.mat. If any of these exceeds a threshold of 0.002, *salflag* for that bottle is set to 0. The output file is jr294_*nnn*_flg.mat. The bottle salinities for stations 3 to 7 plus the first two bottles from station 8, and stations 14 to 33 had to be discarded (see section 3.1 on salinometry) so *salflag* is set to zero for all bottles at these stations. 6 other bottles are

discarded by setting *salflag* to zero because they were taken in high gradient areas. This script was modified to add the revised *salflag* to the excel bottle file.

salplot.m
This reads in the jr294_*nnn*_flg.mat file and plots the bottle salinity and CTD salinity, which is read in from the jr294_*nnn*_int.mat file. These have been plotted and printed and were used to check for dubious bottle salinities and/or high gradient areas.

salanalyse.m
Plots the salinity offsets (bottle salinity minus CTD salinity from the jr294_*nnn*_flg.mat files) for all bottle firings against pressure, temperature, salinity and station number. The variable *salflag* is used to ignore values with a high standard deviation. This is used to check whether the salinity offsets are pressure, temperature, salinity or time dependent. During JR294 an additional script, *condanalyse.m*, was written to plot the conductivity offsets against pressure, temperature, conductivity and station number. This is essentially the same as *salanalyse.m* – it is simply that since conductivity is the variable that is actually measured, it is better to do this in conductivity space than salinity space. *condanalyse.m* also calculates the median conductivity offset for each sensor, excluding points where *salflag* is set to zero, and any points which are more than two standard deviations from the mean offset. The offsets *offc1* and *offc2* are saved in the calibration file calvalues.mat.

After the initial temperature calibration performed after station 72, getsalts_t90.m, *setsalflag.m* and *condanalyse.m* were re-run. The bottle conductivities calculated in *getsalts_t90.m* were thus calculated using the calibrated temperatures and bottle salinities, and the CTD salinities were thus calculated using the calibrated temperatures and CTD conductivities.

After the initial temperature calibration performed after station 72, an initial conductivity calibration was also applied using *saloffset.m.*

saloffset.m
Reads in the jr294_*nnn*_int.mat files and then, in a manner similar to *sb35tempoffset.m,* applies the conductivity calibrations:

cond1 = *cond1* + *offc1* and *cond2* = *cond2* + *offc2*.

saloffset.m also calculates salinity from the calibrated conductivity and temperature, and derives potential temperature. The output is jr294_*nnn*_var.mat.

splitcast.m, ctd2db.m and *ctd1hz.m* were then re-run to produce output files with the calibrated temperatures, conductivities and salinities.

2.3.3 Final Temperature and Salinity Calibrations

After all CTDs were completed, a final temperature calibration was applied. The following scripts were run in the given order:

sb35comp.m
sb35diff.m
sb35tempoffset.m

The temperature calibrations applied were:

temp1 = *temp1* - 0.002174 and *temp2* = *temp2* - 0.002732

Figures 2.7 and 2.8 show the temperature offsets between the SB35 Deep Ocean Standards thermometer and the CTD temperature sensors before and after calibration. The offsets are clearly less after calibration. No dependence on pressure, temperature, salinity or time was observed.

Next, *wake.m, interpol.m*, *makebot_t90.m* and *excel_bottle_files.m* were re-run so that the jr294_*nnn*_sal.mat and jr294_*nnn*_sal.xlsx files contained the calibrated temperatures and salinities calculated using the calibrated temperatures. *getsalts_t90.m, setsalflag.m* and *condanalyse.m* were re-run after the last salinometry had been completed.

Conductivity calibrations were applied using *saloffset.m*:

cond1 = *cond1* + 0.01644 and *cond2* = *cond2* – 0.00161

then *splitcast.m, ctd2db.m* and *ctd1hz.m* were re-run to produce output files with the final calibrated temperatures, conductivities and salinities.

Figures 2.9 and 2.10 show the conductivity offsets between the bottles and the CTD conductivity sensors before and after calibration. The offsets are clearly less after calibration. No dependence on pressure, temperature, conductivity or time was observed for the secondary sensor. There are a few rather larger offsets, mainly in stations 60-90, but as can be seen in the plot of conductivity offset against pressure, these are mostly shallow bottles. We were attempting to get bottles in the surface mixed layer but were not always successful, and thus some of these bottles were in the strong gradients of the halocline. The primary conductivity sensor shows no dependence on pressure, temperature or conductivity, but it has drifted over time. No attempt was made to correct this since *cond2* is the preferred variable.

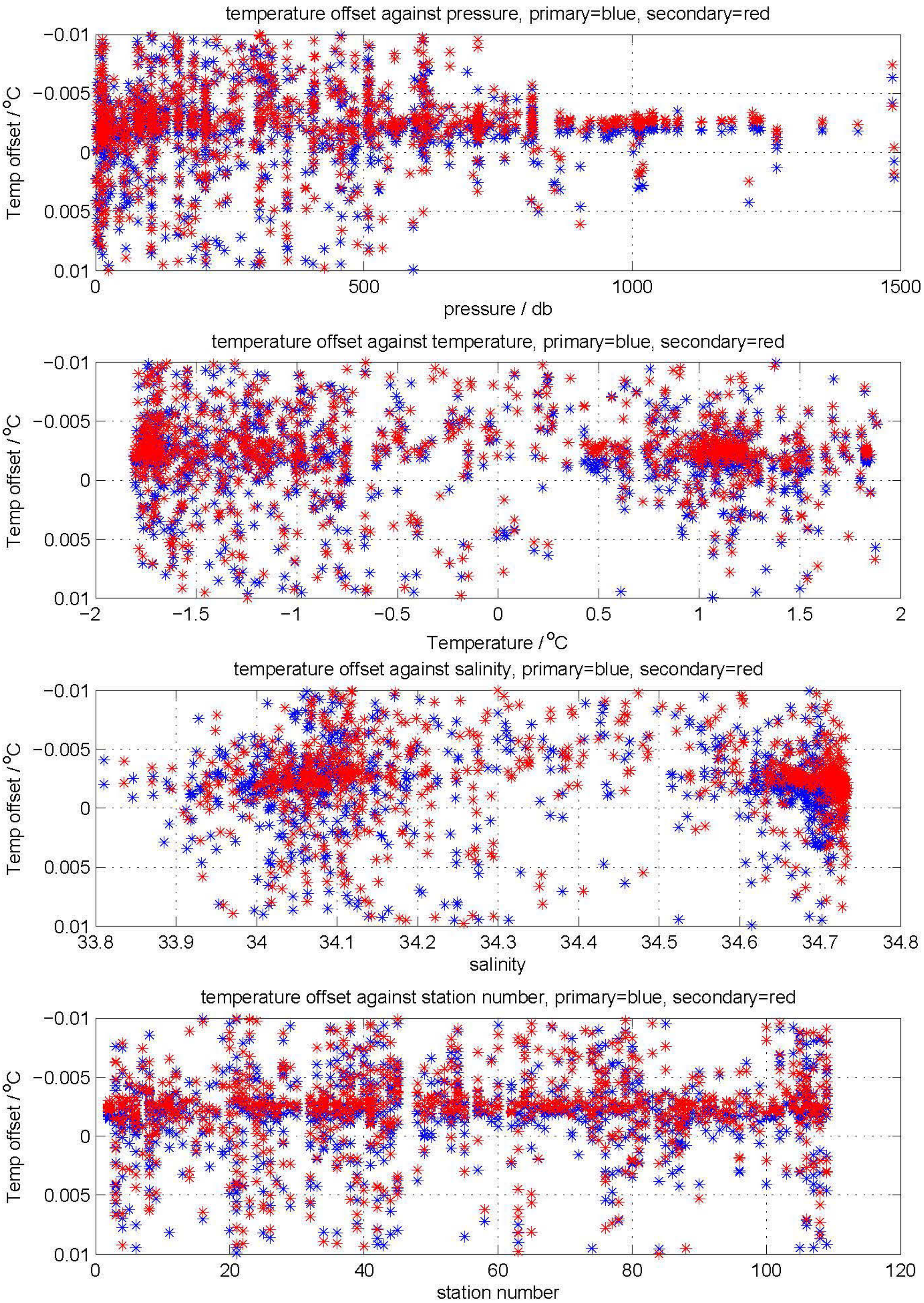


Figure 2.7: Temperature offsets between the SB35 Deep Ocean thermometer and the CTD temperature sensors before calibration.

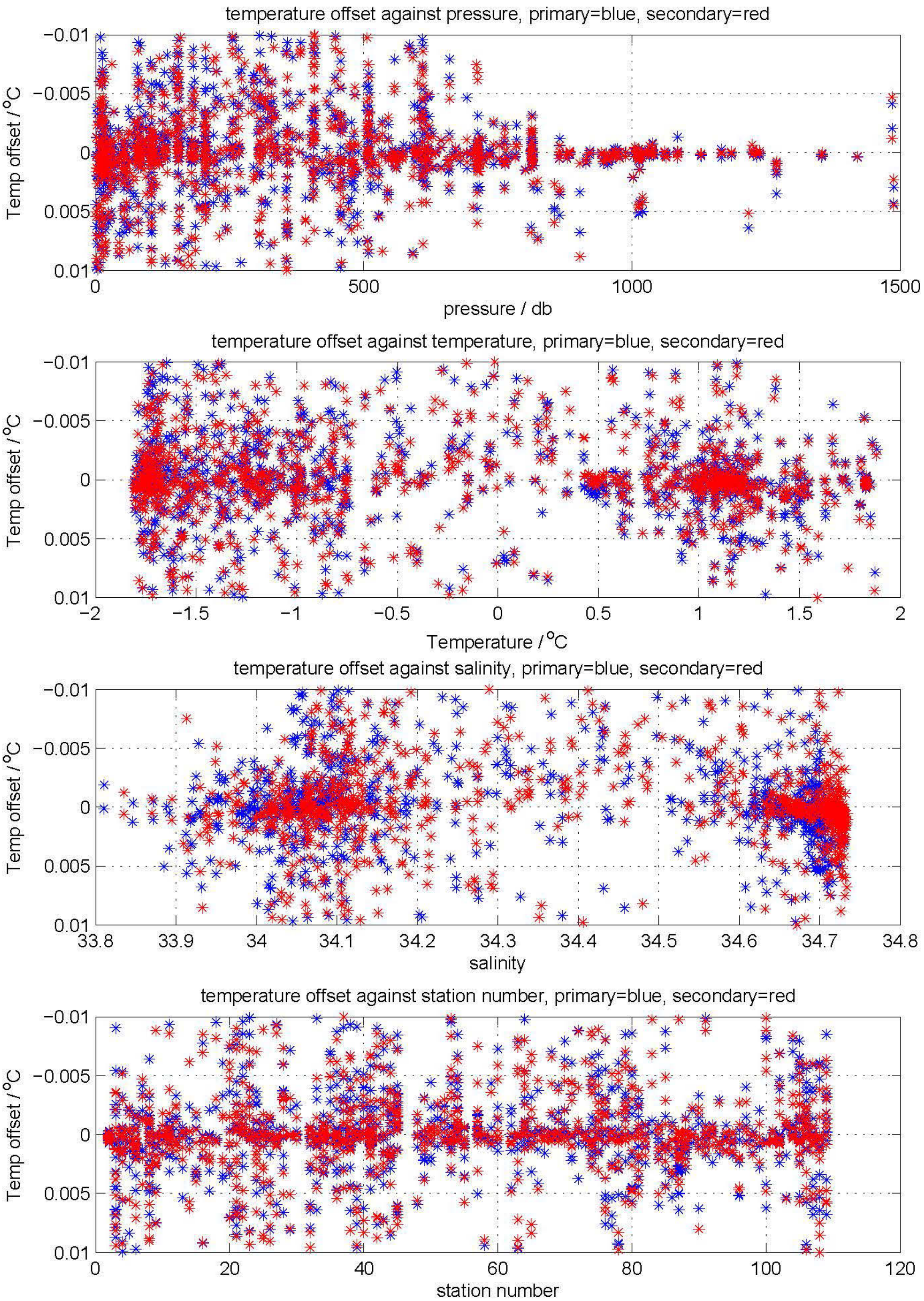


Figure 2.8: Temperature offsets between the SB35 Deep Ocean Thermometer and the CTD temperature sensors after calibration.

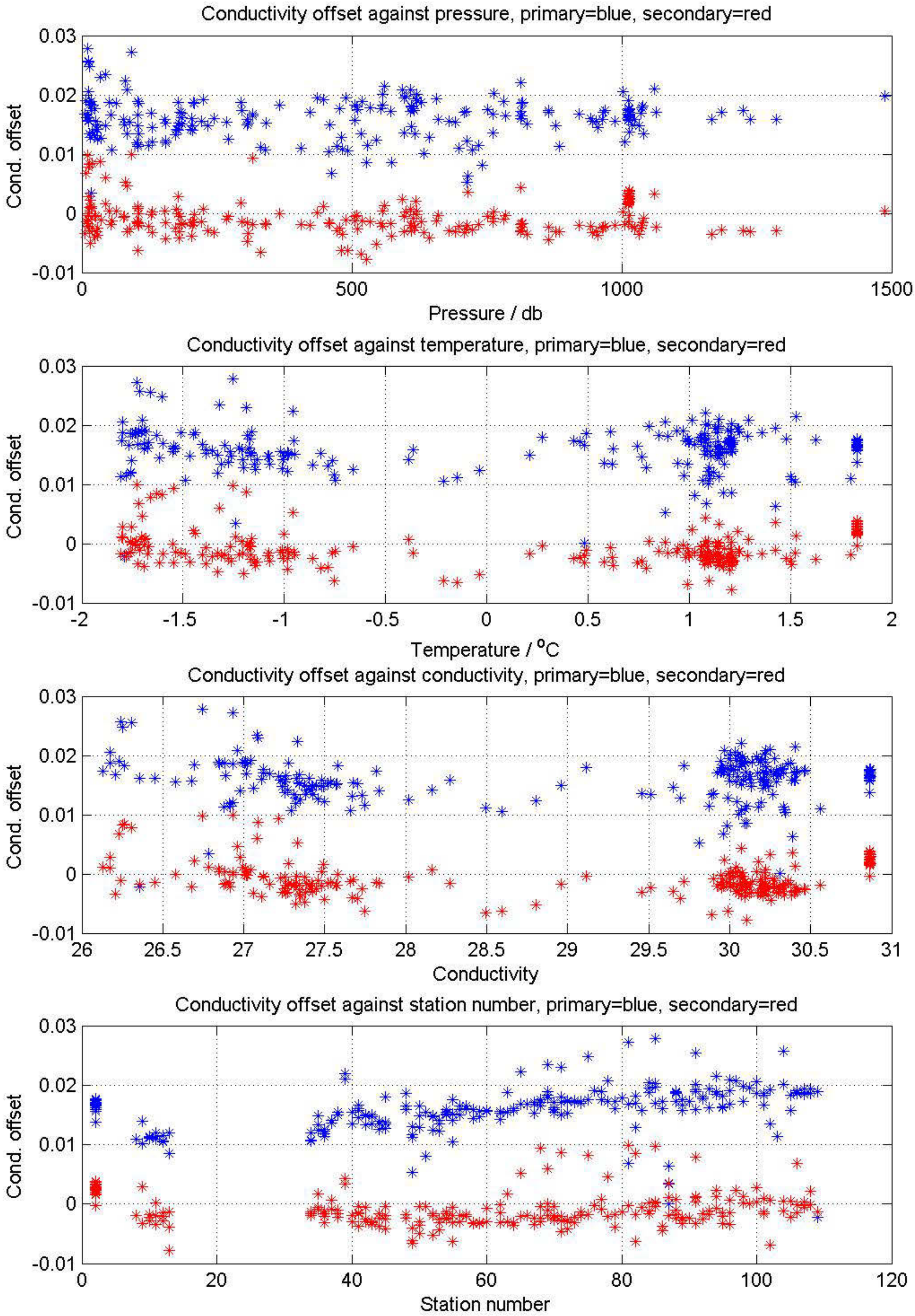


Figure 2.9: Conductivity offsets between the bottles and the CTD conductivity sensors before calibration.

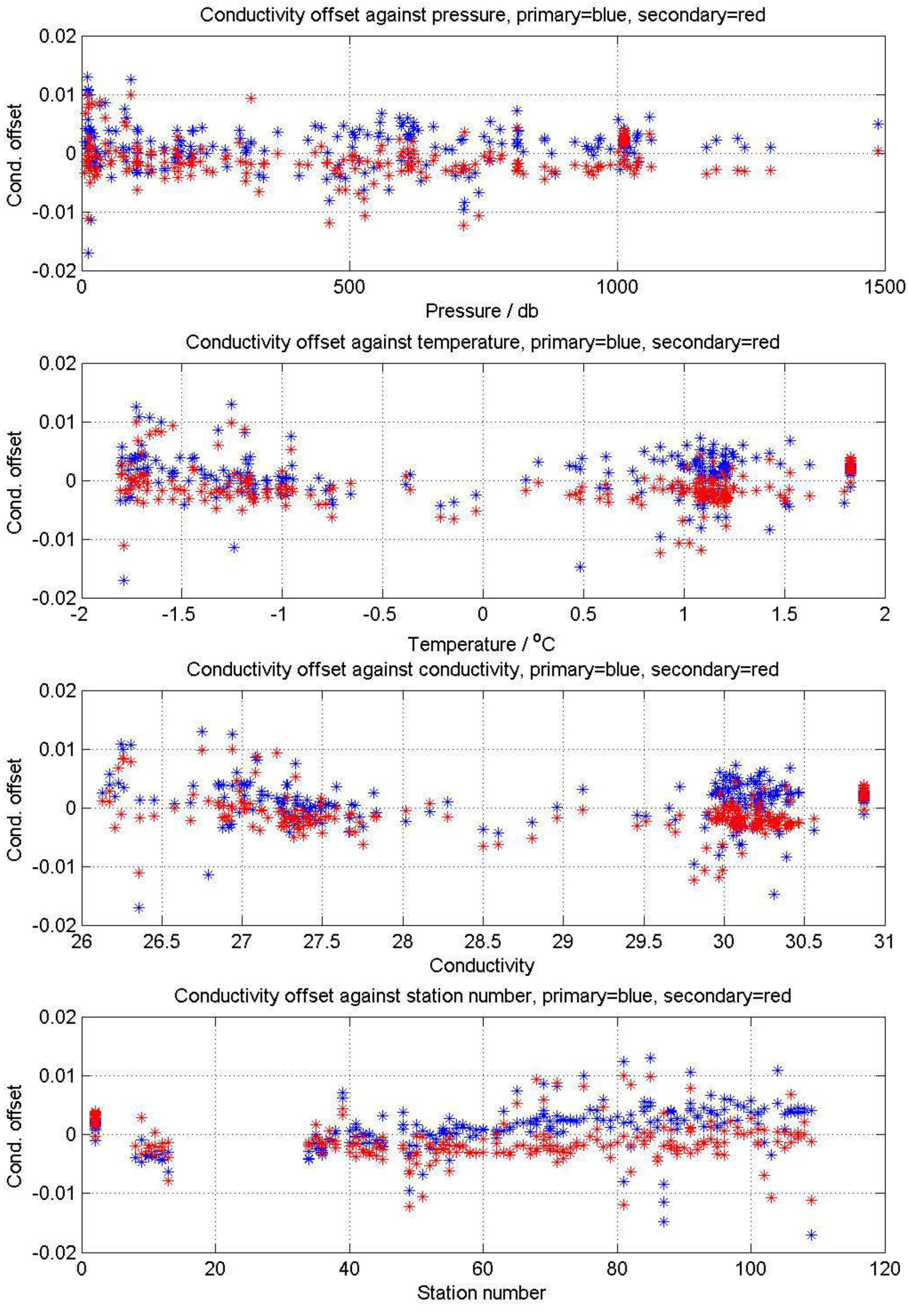


Figure 2.10: Conductivity offsets between the bottles and the CTD conductivity sensors after calibration. Note that the y-axis limits are not the same as figure 2.9.

2.4 Dissolved Oxygen Calibration (Louise Biddle and Stephen Woodward)

2.4.1 Instrumental Analysis

Analysis was carried out in the chemistry lab adjacent to the water bottle annexe, which had a variable temperature due to constant use for LADCP operation. It is not thought that this environment has affected the sampling.

Some thiosulphate was shipped dry (in 50 g aliquots, with a single pellet of sodium hydroxide in each) to make up the sodium thiosulphate on the ship. However, the older thiosulphate from cruise JC090 (bottle number JC090_SW1) was found to produce more reliable results in initial standardisation titrations. The stopper is removed from each bottle and 1ml of 5 mol dm^{-3} sulphuric acid added to the sample along with a magnetic stirring bar. Once the majority of the precipitate has dissolved, the titration is performed with 0.20 mol dm^{-3} sodium thiosulphate, using a custom-built photometric detector to determine the endpoint. Burettes were flushed before each analysis session to remove bubbles, as well as two 'junk' samples. To ensure consistency, once analysis was begun it was continued until all available samples were analysed. The temperature was recorded at the time of titration using a handheld digital temperature probe.

Before each set of analyses, a sodium thiosulphate standardisation was performed, making a total of 14 times over the length of the cruise. To do this, MilliQ water was poured into a BOD bottle with a magnetic stirring bar and reagents were added. Then reagents were added in the order of 1 cm^3 of 'standard' 23.36 mmol dm^{-3} potassium iodate solution (KIO_3; Fluka primary reference 60386, Lot number BCBD6612V, certificate number U10-0412) by Metrohm Dosimat, 1 cm^3 of H_2SO_4, 1 cm^3 of NaOH/NaI and 1 cm^3 of $MnCl_2$. Flasks were then filled to the neck with MilliQ. The resulting solution was titrated to the endpoint with $Na_2S_2O_3$ by Metrohm Dosimat and volume of titrant corresponding to the equivalence point was recorded. The temperature was recorded at the time of KIO_3 addition and titration using a handheld digital temperature probe. In oxygen concentration calculations, the average of these standardisations is used.

Determination of blank values was also performed before each set of analyses (14 times over cruise). The analysis is performed on a BOD bottle with MilliQ water that has had 0.1 cm^3 of 23.36 mmol dm^{-3} KIO_3 solution added, and then spiked in the same order as for the standards. After the initial titration, the volume of titrant that corresponds to the equivalence point is recorded, before an additional 0.1 cm^3 of KIO_3 was added to the 'blank' bottle and the titration repeated. The difference between these two titrant volumes is the blank volume. The average of the 14 blank calculations is used in the oxygen concentration calculations.

2.4.2 Results

These are not final calibrations – if you will be using the dissolved oxygen data please check what the most recent calibration is.

The oxygen concentration is calculated using an Excel spreadsheet provided by Jan Kaiser at UEA. It is output as both µmol l^{-1} and µmol kg^{-1} using temperature and salinity from the CTD bottle files.

As well as the JCR's SBE43 oxygen sensor, the opportunity was taken to calibrate the SBE43 oxygen sensor from the Autosub, on one deep cast off of the continental shelf (CTD87). This is plotted on the same plot at the JCR SBE43 calibration.

The initial calibration plot (figure 2.11) shows that there was no (or very minimal) drift over the course of the cruise. There are 3 outliers from the line, and these are coloured red and excluded from the calibration line – mainly either due to bubbles in the dispensers or being sampled on a high oxygen gradient (leading to unreliability in the results). The regression line was calculated both with and without those outliers and both are plotted; the line with outliers is barely visible on the plot, which demonstrates that they do not have a large effect on the calibration values.

A pressure effect was also found to occur in samples taken deeper than 1500 m – the SBE43 records a lower value than 'normal', and so the results lie above the line. For the calibration, these 'deep' samples have been removed from the R^2 calculation, and are coloured green on the plot. The same pressure effect was found on both the JCR SBE43 oxygen sensor and the Autosub SBE43 oxygen sensor, suggesting a common problem with this type of oxygen sensor. This pressure effect will be taken into consideration during further calibrations back in the UK.

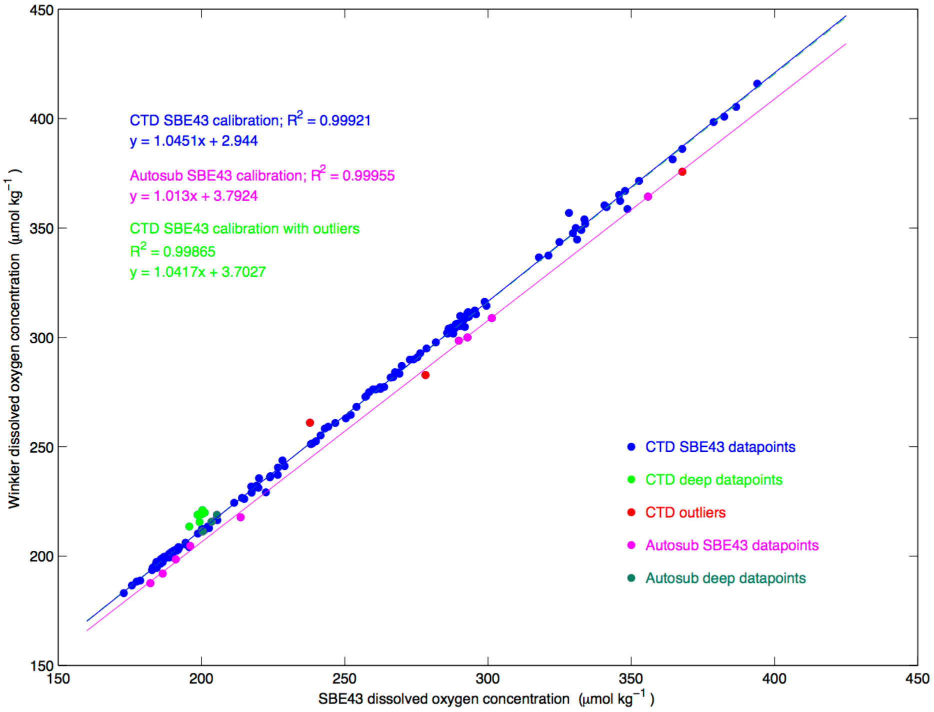


Figure 2.11; Calibration plot showing lines for all CTD datapoints (excluding deep samples), CTD datapoints excluding outliers and deep samples, and the Autosub calibration. High R-squared values can be seen for all lines, and the line of best fit plotted for the CTD calibration without outliers almost lies directly on top of the CTD calibration line with all datapoints.

3 Rosette Water Sample Analysis

3.1 Salinometry (Satoshi Kimura, Rich Jones)

Two Guildline Autosal salinometers with s/n 68959 and 63360 were available in the Bio lab on the upper deck. All the measurements were done with s/n 68959. The salinometer measures conductivity of sample in order to estimate salinity of the water. Four conductivity cells are located inside a tube, which is surrounded by a constant temperature of water. The temperature of bath needs to be set a few degrees above the room temperature. We set the bath temperature at 24 C and the room temperature fluctuated between 21 C and 23.5 C, always remained below the bath temperature.

A crate of water samples was transferred to the Bio lab more than 24 hours before the analysis, allowing the water temperature to adjust to the room temperature. At the beginning of the sample analysis, we flushed the salinometer with used IAPSO standard seawater. Then the salinometer was calibrated with a bottle of IAPSO standard seawater: batch 155, 2*k2 = 1.99962 and S=34.993. We follow the instruction sheet provided by Povl Abrahamsen and Hugh Venables, which is found in the Bio lab, which is outlined below:

At the beginning of a new crate:

Record details of standard seawater and crate (colours and number/letter):

Check that the heating lamps are flashing frequently (indicates stable temperature) and that the water bath is being stirred (look for particles in the water).

Note temperature and lab and cell.

Record readings in 'standby' and 'zero' modes.

Flush cell 2-3 times with an old (open) bottle of standard seawater before opening a new standard.

Each sample bottle was gently inverted a few times to eliminate a possible salinity gradient formed over time.

Flush the chamber of its contents, and while still holding flush, switch off the pumps and turn the flow rate down by 1 revolution

Open the bottle using a knife and clean tissue.

To run a sample:

- Turn on the pump and turn the flow rate up to maximum.
- Wipe the sample intake tube with a clean tissue.
- Place intake tube in sample bottle and put bottle in Autosal.
- Fill and flush the cell chamber 3 times.
- Allow the chamber to fill, switch off pumps, and switch the function knob to 'read' mode.
- Note the reading once the display is stabilized.
- Switch to 'standby' mode, turn on pumps, and flush the chamber.
- Repeat the above procedure for each sample 3 times.

At the end of a crate:

- Run another bottle of standard seawater after flushing with old standard.
- Note lab temperature and readings in 'zero' and 'standby' mode.
- Pump ~400 ml of MilliQ through the cell, turn suppression to zero, and perform a reading: re-flushe with MilliQ until readout is less than 0.0005.
- Leave the unit with pumps switched off, in 'standby' mode, with the chamber full of MilliQ.

3.2 Salinity Samples and Analysis (Satoshi Kimura, Rich Jones)

We took the median of 3-4 conductivity readings from the salinometer and converted to practical salinity units using sw_sals routine from the MATLAB seawater library.

Salinity values are recorded for each crate with a number given to each crate in sequence in the order that they were sampled. Excel spreadsheets Salinity_jr294_Crate*NN*to*MM*.xls were created containing the conductivity ratios. Matlab files containing salinometer results for each CTD were then created, called salNN.mat. Salinity samples were also analysed to calibrate the underway oceanlogger salinity. These are crates 6, 11, 16, and one bottle from crate 22. The subsequent files are called sal_UnderNN.mat.

The drift in the instrument (difference between the readings of IAPSO standard seawater at the start and end of analysis) was typically ~0.0002, but the Crate02 and Crate13 had an unusually high drift of 0.0005.

Crates 2, 4, 5 and 7 showed very large anomalies between the CTD salinity and the bottle (salinometer) salinity. This was found to be most likely due to operator not sufficiently agitating the sample bottles before analysis. This affects CTD station numbers 3-8, 14-33. Subsequent crates did not show this problem.

3.3 Dissolved Oxygen (Louise Biddle)

Oxygen samples were collected using Tygon R-303 tubing attached to the Niskin bottle, and followed the trace gas sampling around the rosette. BOD bottles (125ml; of known calibrated volumes) were rinsed before being inverted, rinsed again and then returned to upright and slowly filled to the brim. The bottle was then allowed to overflow three times (approximately 30 seconds), and the sample temperature was taken using a handheld digital temperature probe and recorded on the oxygen sampling logsheet. The samples were fixed using 1ml of reagents (3 mol dm^{-3} manganese chloride solution and 4 mol dm^{-3} alkali iodide) dispensed from pump bottle dispensers (Hirschmann ceramus). The bottles were then sealed with their corresponding stopper, and shaken vigorously to mix the reagents with the sample. The shaking was repeated at 20 minutes and 2 hours after the initial spiking, and then they were analysed between 12 – 36 hours after sampling.

On several occasions (8 casts out of 30) the Niskins were leaking – in the case of anything other than a minor leak, an alternative Niskin was used. Oxygen was sampled on 30 stations out of 109; five of these stations were sampled in triplicate (stations 2,3,6,9,27), whilst the rest were all single samples as the replication on the triplicates was found to be reliable (except station 3, see Section 2.4). If trace gases were being sampled, the dissolved oxygen samples were always taken from the same Niskins that the trace gases were sampled from. For further information on the calibration and analysis, see Section 2.4.

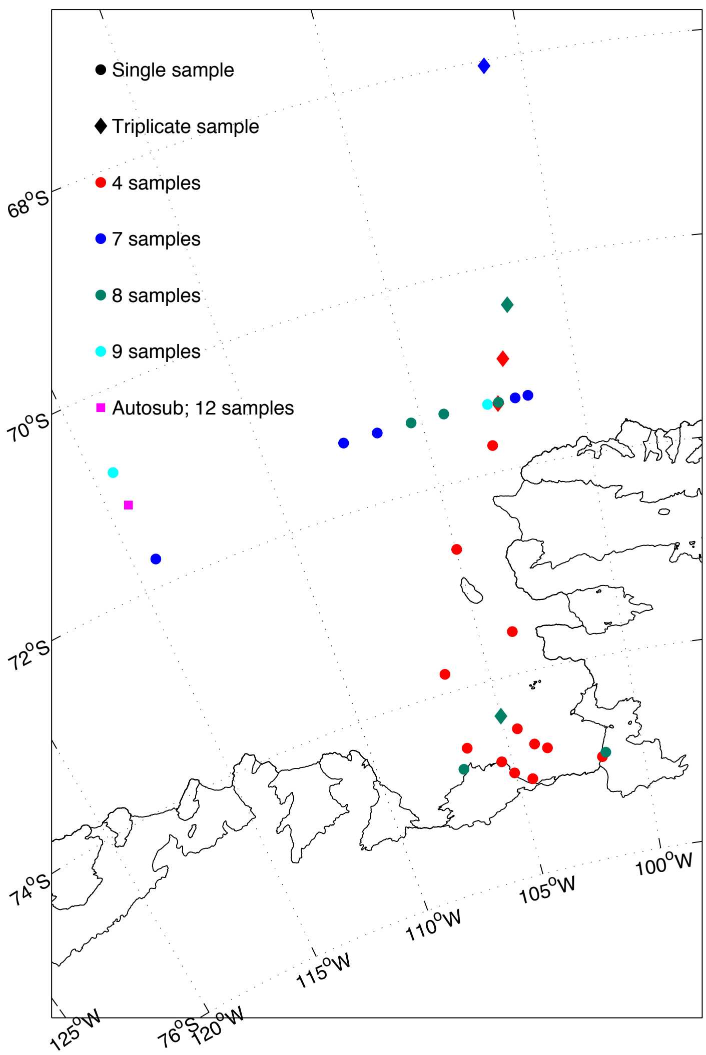


Figure 3.1 Map showing the locations of the CTDs that dissolved oxygen was sampled on.

3.4 Oxygen Isotope Sampling (Bastien Queste, Louise Biddle)

Introduction

δ18O samples were collected to serve as a proxy for meltwater fraction, to serve as an indicator for productivity when combined with Argon measurements and to supplement the trace gas sampling performed by Brice and Arash. Samples were taken whenever trace gas (Section 3.5) sampling occurred to increase the value of both samples. Additional sampling was performed with dissolved oxygen sampling and for selected station with a focus on identifying different watermasses (different T&S properties). Priority was given to high vertical resolution rather than sampling every station.

Near the end of the cruise, several samples were discarded to continue sampling alongside Brice and Arash. Stations 16, 3, 27, 60 and 4 were discarded (in order of increasing importance) for the final few CTDs. On CTDs 108 and 109, only 5 δ18O samples could be collected while 12 trace gas samples were collected for each.

Additional δ18O sampling was done independent of trace gas sampling during the transect from Edwards Island to Pine Island glacier. Furthermore, δ18O samples were collected from 4 different sources of ice to provide end points for meltwater calculation (fresh snow, compacted snow, sea ice and glacial ice). Sampling procedures for both standard nicking sampling and ice sampling are described in the following sections.

In total, 404 samples were collected from CTDs, 12 from 4 different forms of ice and two bottles were discarded because of contamination during sampling. Distribution of CTD δ18O sampling is shown below, each dot indicating an δ18O sample, coloured by dissolved oxygen concentration and overlaid on temperature. Sections for each transect as distance along track are also provided to show clearer pictures of δ18O sampling at each of the main sections of interest. CTD number is indicated for each set of δ18O samples.

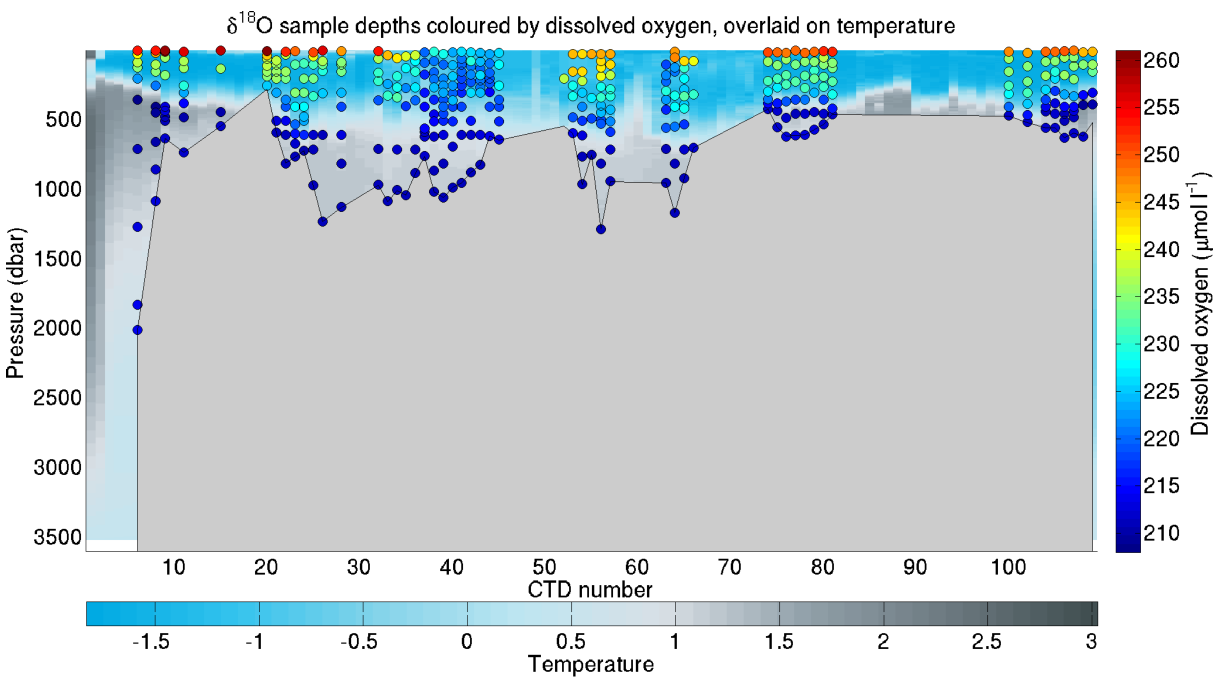


Figure 3.2. Distribution of O18 samples along the cruise track coloured by dissolved oxygen and overlaid on temperature.

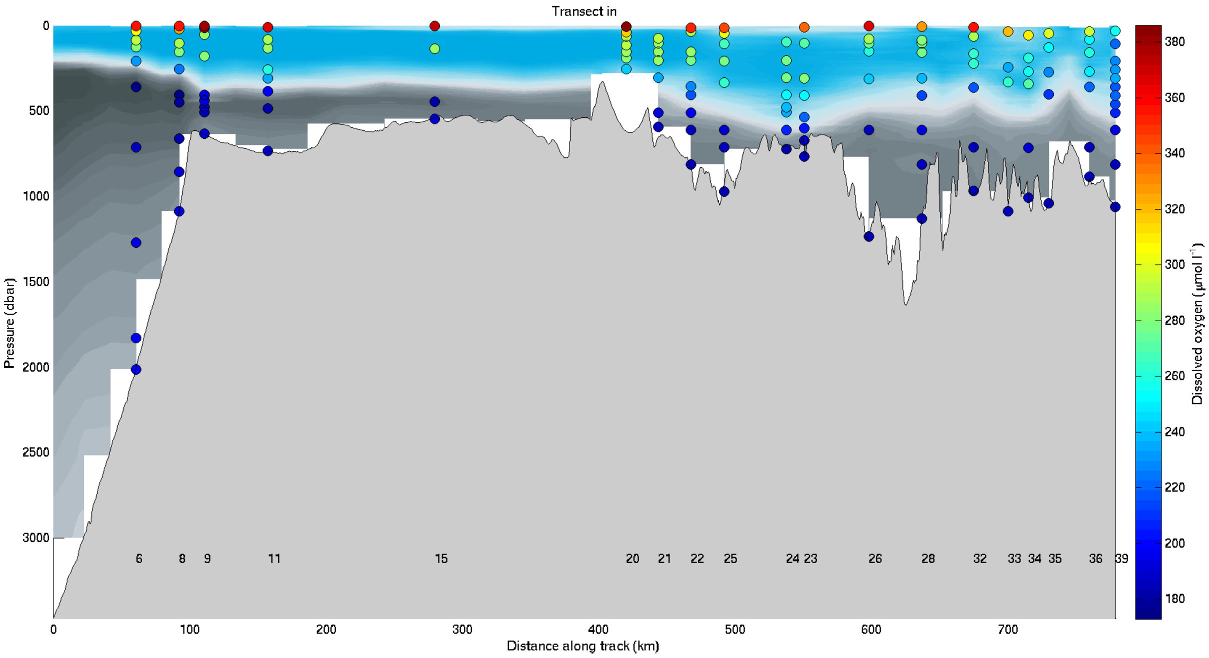


Figure 3.3 Distribution of O18 samples along the southbound transect coloured by dissolved oxygen and overlaid on temperature. Station numbers are indicated.

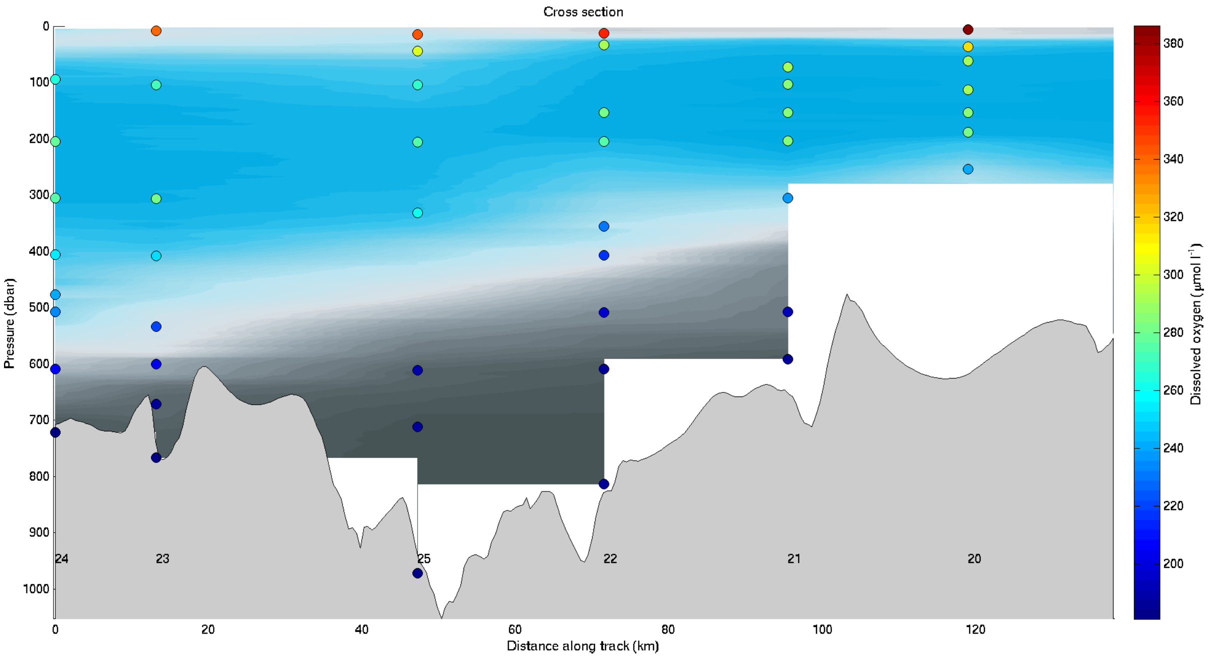


Figure 3.4 Distribution of O18 samples for the cross-section at Edwards Islands coloured by dissolved oxygen and overlaid on temperature. Station numbers are indicated.

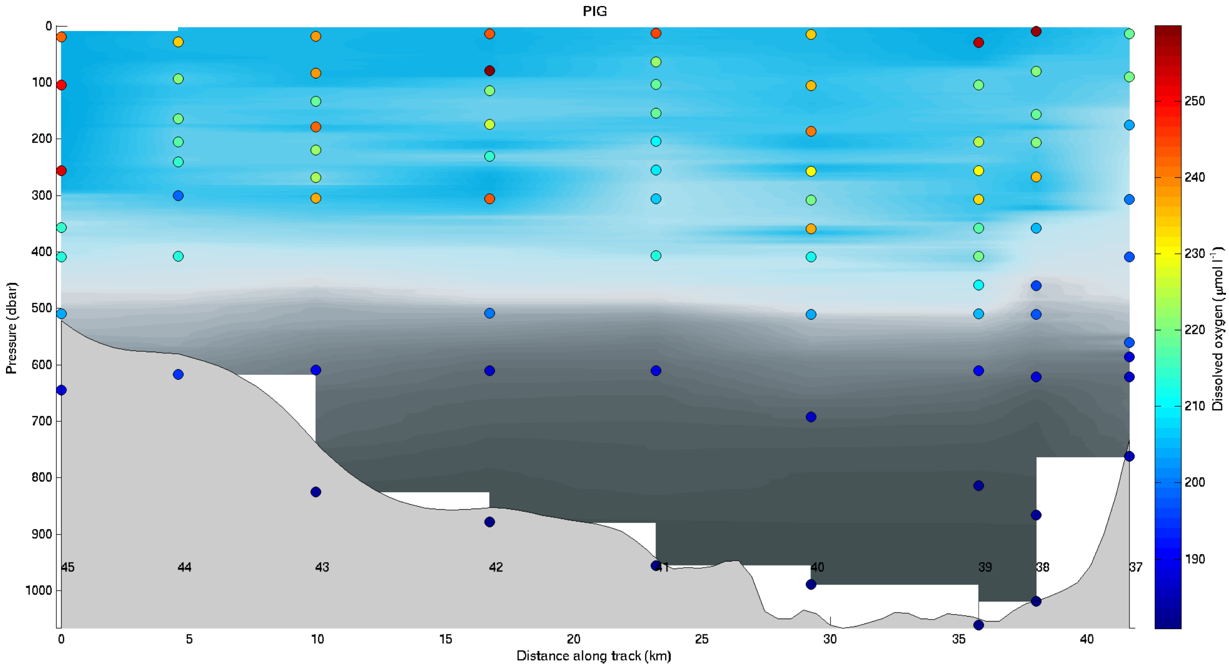


Figure 3.5 Distribution of O18 samples for the cross-section at PIG coloured by dissolved oxygen and overlaid on temperature. Station numbers are indicated.

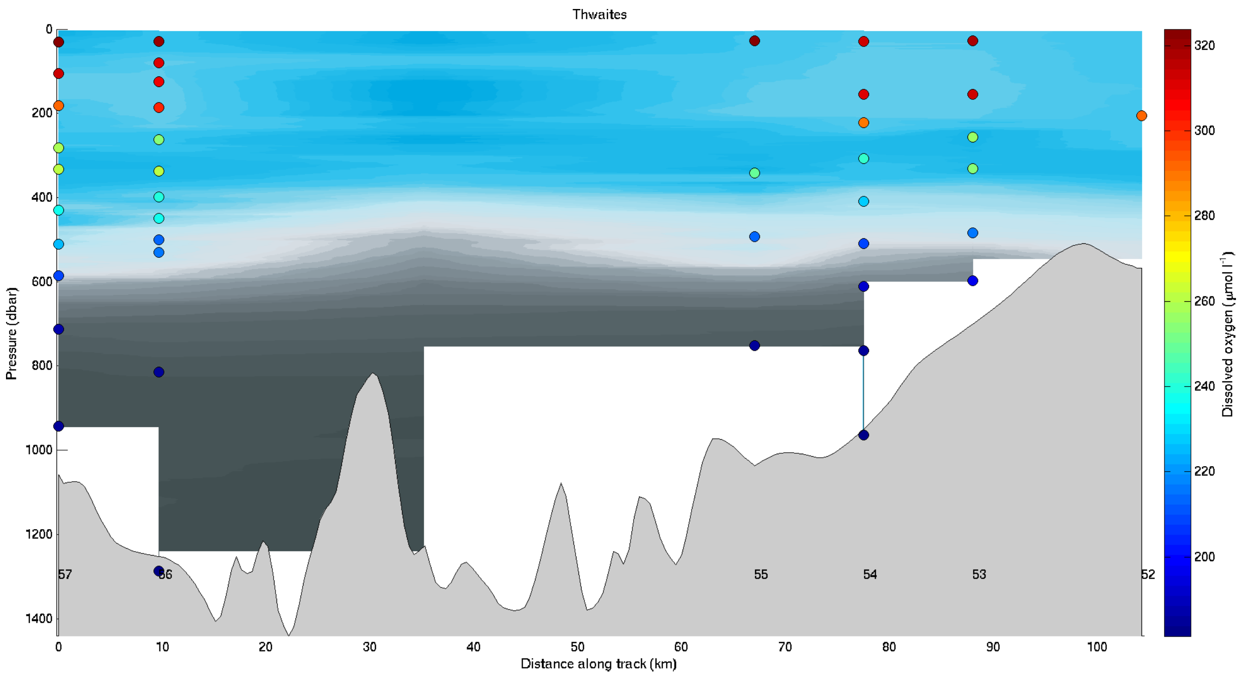


Figure 3.6 Distribution of O18 samples for the eastern cross-section at Thwaites Glacier coloured by dissolved oxygen and overlaid on temperature. Station numbers are indicated.

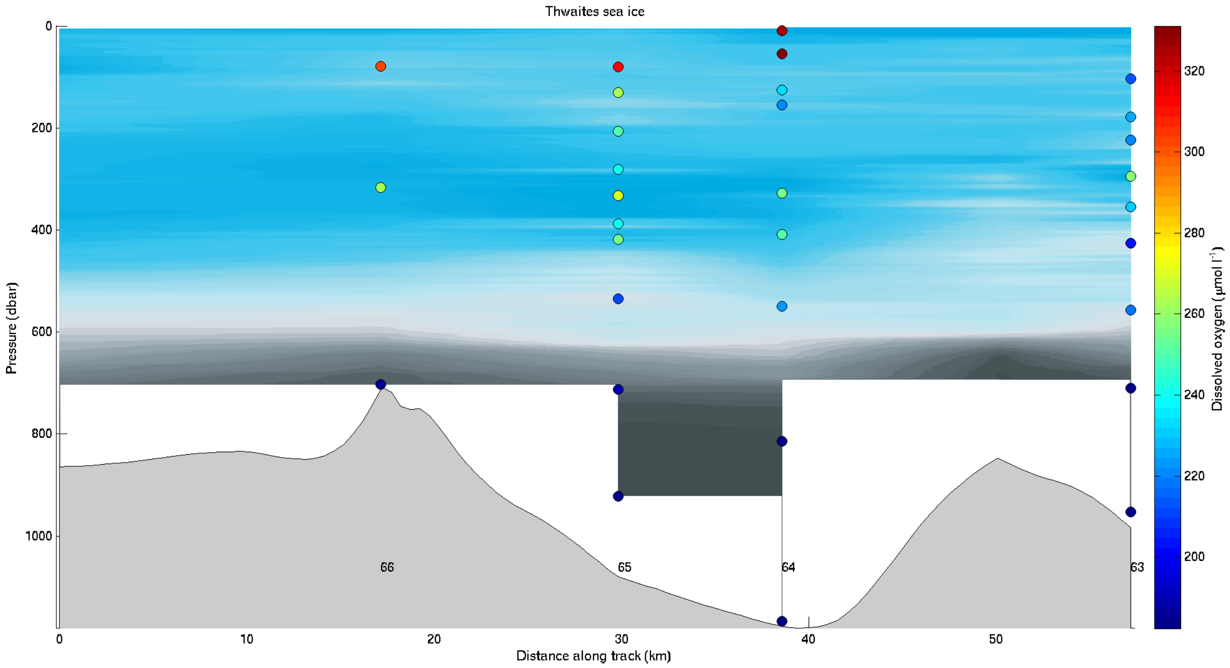


Figure 3.7 Distribution of O18 samples for the western cross-section at Thwaites Glacier coloured by dissolved oxygen and overlaid on temperature. Station numbers are indicated.

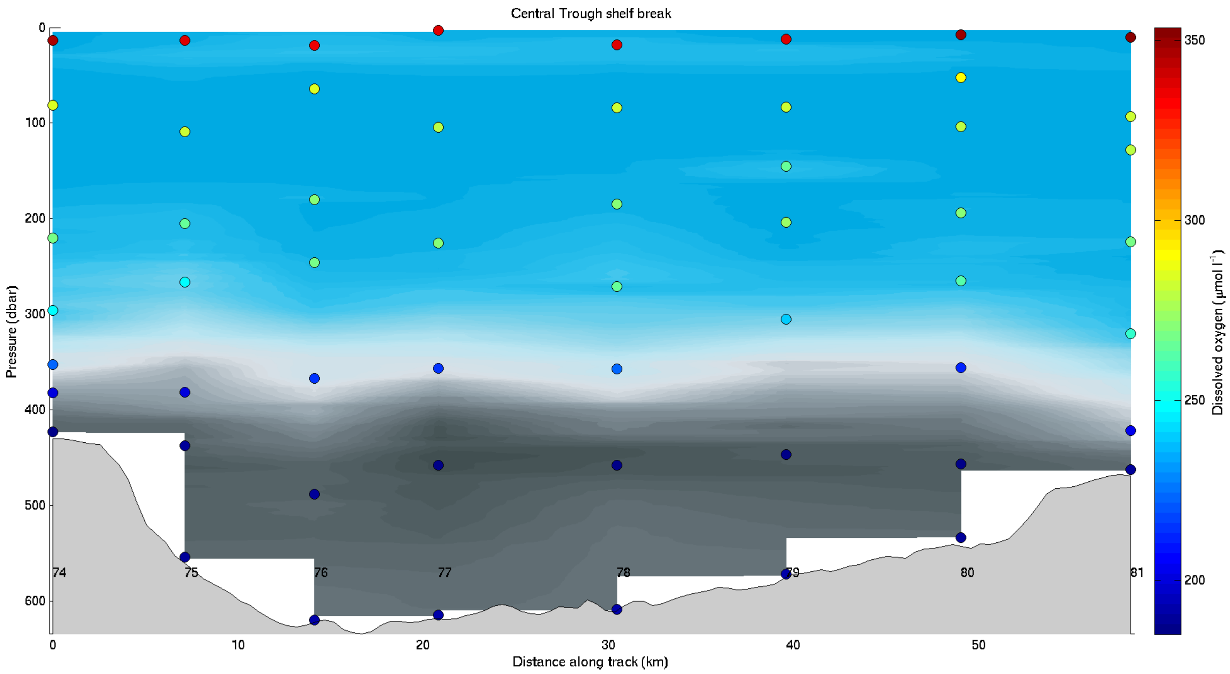


Figure 3.8 Distribution of O18 samples for the zonal central trough shelf break cross-section coloured by dissolved oxygen and overlaid on temperature. Station numbers are indicated.

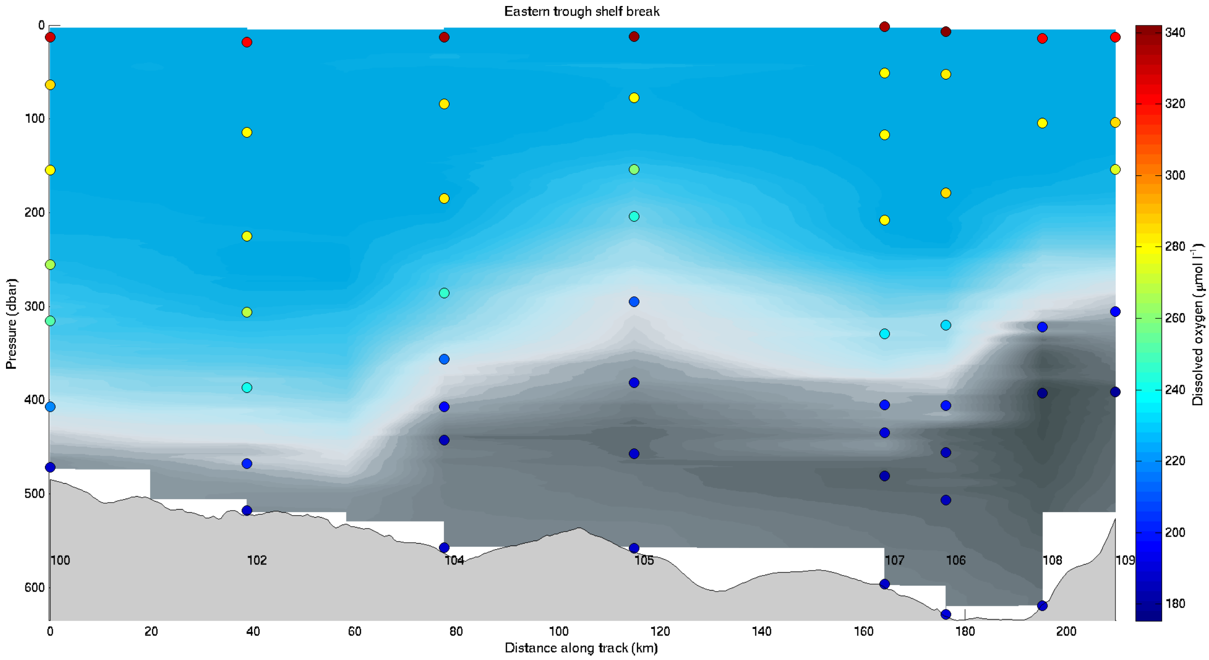


Figure 3.9 Distribution of O18 samples for the zonal eastern trough shelf break cross-section coloured by dissolved oxygen and overlaid on temperature. Station numbers are indicated.

Sampling procedure

1. Sampling should be done after all dissolved gas sampling, but before salinity sampling. Check with other people sampling they have finished with the niskins before proceeding.

2. Rinse the bottle 3 times using water straight from the niskin then fill to near the top (above the shoulder, leaving about 1cm free), leaving a small amount of headspace to allow for expansion.

3. Rinse the cap then close the bottle. Wipe the bottle down with blue roll.

4. Clearly label the samples. Add the CTD number and niskin bottle number to the $\delta^{18}O$ bottle label with a permanent marker (should be in the $\delta^{18}O$ bag next to the bottles). Write the $\delta^{18}O$ bottle number on the CTD logsheet next to the relevant depth.

5. Wrap the lid of the bottle in polywrap (also in the O18 bag) to avoid evaporation of the sample and return the sample to the oxygen bottle box.

Samples were stored at ambient temperature and then in the +4C fridge for transit.

Ice sampling

Opportunistic samples were taken of solid end-member oxygen isotope sources in order to determine their values for this region. The end-members of interest were precipitation (snow), sea ice and glacial ice. Initial attempts to collect precipitation (in the form of snow) were made on 15th February, with a 'snow sampler'; a biscuit box lined with an uncontaminated plastic sheet. This box was placed on the aft of bridge deck. The snow was collected from the box and compacted into one oxygen isotope bottle, where it was left to melt. On the same day, two more bottles were filled from snow lying on top of wooden crates on the main aft deck – if the boxes were soaked with sea-spray these samples may be contaminated.

Figure 3.10 The snow sampling box

Later on in the cruise, on the 24th and 25th February, there was the chance to collect some sea ice and glacial ice samples during seal tagging operations on the ice. On a stable ice floe, a cube of compacted surface snow was dug out, followed by another cube of what looked like sea ice. It was immediately returned to the ship, where the samples were placed in separate heavy-duty plastic bags and placed in the scientific -20°C freezer.

Figure 3.11 Collecting the compacted snow sample from sea ice

The following day, a bergy bit was positioned just to the fore of the ship whilst seal tagging operations were occurring. After the seal tagging was completed, team members were lowered in the 'Wor Geordie' over the bow of the ship, where they were able to collect a substantial amount of glacial ice. Similarly to the sea ice, this was immediately placed in heavy-duty plastic bags and put in the scientific -20°Cfreezer.

On the 26th February, the scientific -20°C freezer broke down, and so samples were removed to the -20°C freezer in Hold 2. The freezer was fixed on the 28th February, and samples were returned to the scientific -20°C freezer and sampled into oxygen isotope and salinity bottles on the 1st March.

Three different methods were used to collect oxygen isotope samples;
Chips of ice placed straight into oxygen isotope bottle (LBS1)
Ice sample melted in a vacuum packed bag (LBS2)
Ice sample melted in heavy-duty plastic bag, shut with a cable tie. (LBS3)

The outer edges of all of the samples were removed in case of contamination from sea-spray or possible sublimation in the freezer. The ice was then cut into the shape required for sampling method 2 (see below), and offcuts used to fill an oxygen isotope bottle (sampling method 1). The remaining ice was split into two; one half was placed in a plastic bag for melting (sampling method 3), whilst the other half was packaged up as airtight as possible in order to be sent back to UEA on the ship.

For sampling method 2, sterile catheter bags from the ship's hospital were used to melt the ice in. The top was cut off, ice placed in, and then resealed using a soldering iron to melt the plastic shut. A vacuum pump was then affixed to the valve at the bottom of the bag to remove any air. On occasion, the soldering did not fully close the bag, and a second attempt at sealing the bag had to be taken. After the samples were fully melted it was observed that the glacial ice sample had a small hole at the top of the bag, and so some interaction with the local atmosphere may have occurred.

After the samples from methods 2 and 3 had melted (2nd March), the meltwater was sampled into oxygen isotope and salinity bottles. For method 2, the valve on the catheter bag was used to rinse the oxygen isotope bottle (thrice for sea ice, twice for snow and once for glacial ice due to sample volumes) before filling it to the brim. Only a minimal headspace was left, as the water had melted at room temperature and so further thermal expansion is unlikely.

Sterile syringes were used to extract water samples from the bags used in method 3. The syringes were rinsed with the water from the bag and no air bubbles were permitted to enter the syringe when a sample was being taken. All oxygen isotope bottles were rinsed three times using the syringe, before being filled. This method provided enough volume of meltwater to allow salinity bottle sampling to verify the source of the ice. The results can be seen below in a table containing oxygen isotope bottle numbers. It must be considered that the standard seawater used during salinity analysis was for salinities of 34, and so there will be some uncertainty on results that are of a very low salinity. Bearing this in mind, the results support the initial judgements on the source of each ice type.

Type	**Method**	**Bottle Number**	**Salinity**
Snow (on ship)	Wooden crate 1	JR294/216	--
	Sampling box	JR294/221	
	Wooden crate 2	JR294/222	
Compacted Snow	LBS1	Y1129	**0.0211** From I-23, TSG crate 4
	LBS2	Y1151	
	LBS3	Y1127	
Sea Ice	LBS1	Y1155	**3.0743** Average of I-21, I-22, TSG crate 4
	LBS2	Y1160	
	LBS3	Y1135	
Glacial Ice	LBS1	5263	**0.1031** From I-24, TSG crate 4
	LBS2	Y1157	
	LBS3	Y1128	

The oxygen isotope bottles were all sealed with Parafilm, and will be shipped back on the JCR to the UK (expected arrival August 2014).

3.5 Noble gases and tritium as water mass tracers (Arash Bigdeli, Brice Loose)

Introduction

Noble gases, helium and tritium may be used to identify the origins of a water mass. They help elucidate mixing and dilution rates, circulation patterns, ocean ventilation and the changes that occur in water mass characteristics over time. As part of the Ocean2ice tracers team our primary role is to collect samples of helium isotopes (^{3}He and ^{4}He) and tritium (^{3}H, an isotope of hydrogen) for analysis. We are also interested in the entire suite of dissolved noble gases including isotopes of Ar, Ne, Kr, Xe and Ar/Kr/Xe ratios.

Dissolved noble gases

Noble gases may be used in the detection and quantification of the relative contributions of air-sea exchange, seasonal changes in temperature (Hamme and Severinghaus, 2007), sea-ice formation, sub-glacial melting, and sub-glacial marine ice production and in Ice Shelf Water (ISW). The melting of glacial ice produces a trace gas concentration that is unique from seawater in its saturation state and in the ratio between two individual gases. Based on the average air content of glacial ice (0.11 $cm^3\ g^{-1}$ of ice, (Hohmann et al., 2002)), pure glacial meltwater (GMW) is oversaturated in atmospheric gases as follows: He = 1050%, Ne = 781%, Ar = 175%, Kr = 85%, Xe = 41% and O_2 = 195%. At nominally 0.5% analytical precision, the noble gas signal in GMW can be detected at a concentration of 12‰ for Xe and 0.47 ‰ for He. These gas excesses surpass those of air-sea exchange processes, and thus can provide a measure of GMW, even far from the melt source. Further, the ratio of gas concentration in GMW will reflect the atmospheric concentration ratio. Atmospheric gas ratios are unique from aqueous gas ratios because of solubility (e.g. [Ne]/[Kr] (at solubility equilbrium) = 1.74 and [Ne]/[Kr] (in GMW) = 15.95).

Helium isotopes

The concentration of helium in the atmosphere is ~5 ppm. It has very low solubility in seawater (2 nmol/Kg). Helium in the atmosphere is a mixture of two stable isotopes ^{3}He and ^{4}He. The isotopic ratio of $^3He/^4He$ is 1.4×10^{-6} in air with ^{4}He being one million times more prolific than ^{3}He. Helium in the surface waters of the world ocean is in solubility equilibrium with the atmosphere. Volcanic and hydrothermal activity on the sea floor are a source of helium to intermediate depth waters in the ocean. The ratio of $^3He/^4He$ in helium that originates from mantle out gassing is between ten and thirty times greater than the atmospheric $^3He/^4He$ ratio. $^3He/^4He$ ratios are therefore a useful indicator of the circumpolar deep water (CDW) that has passed over midocean ridges before reaching the Amundsen Sea. The $^3He/^4He$ ratio can provide valuable constraint on CDW, in addition to temperature, because the sources and sinks of $^3He/^4He$ are much fewer than the sources and sinks for heat in the Amundsen Sea.

Tritium

Tritium was first detected in the environment in the late 1940s. As tritium is an isotope of hydrogen it is oxidized to HTO (tritiated water) and so is the perfect tracer for studies of the natural water cycle. The applications of bomb tritium are limited as an aging tool in waters that have been in contact with the surface oceans after the 1970s and 1980s as concentrations decreased below those which allow the age of water mass to be determined. However, if we measure tritium and its radioactive decay product – tritugenic ^{3}He – simultaneously we can calculate the tritium/^{3}He age of the water mass (the amount of time the water parcel has been isolated from the surface of the ocean) (Clarke et al., 1976).

Figure 3.12 Noble gas sampling using 5/8" ID refrigeration tubing. (Left panel) Water samples were collected from the rosette

Sampling
Noble gas samples were collected from the Niskin rosette at 46 of the 109 stations along the JR294 cruise track (Figure 3.13). In total, 399 noble gas and 30 tritium samples were collected, with an average of 10 noble gas samples per station, resulting in a vertical resolution close to 75 m.

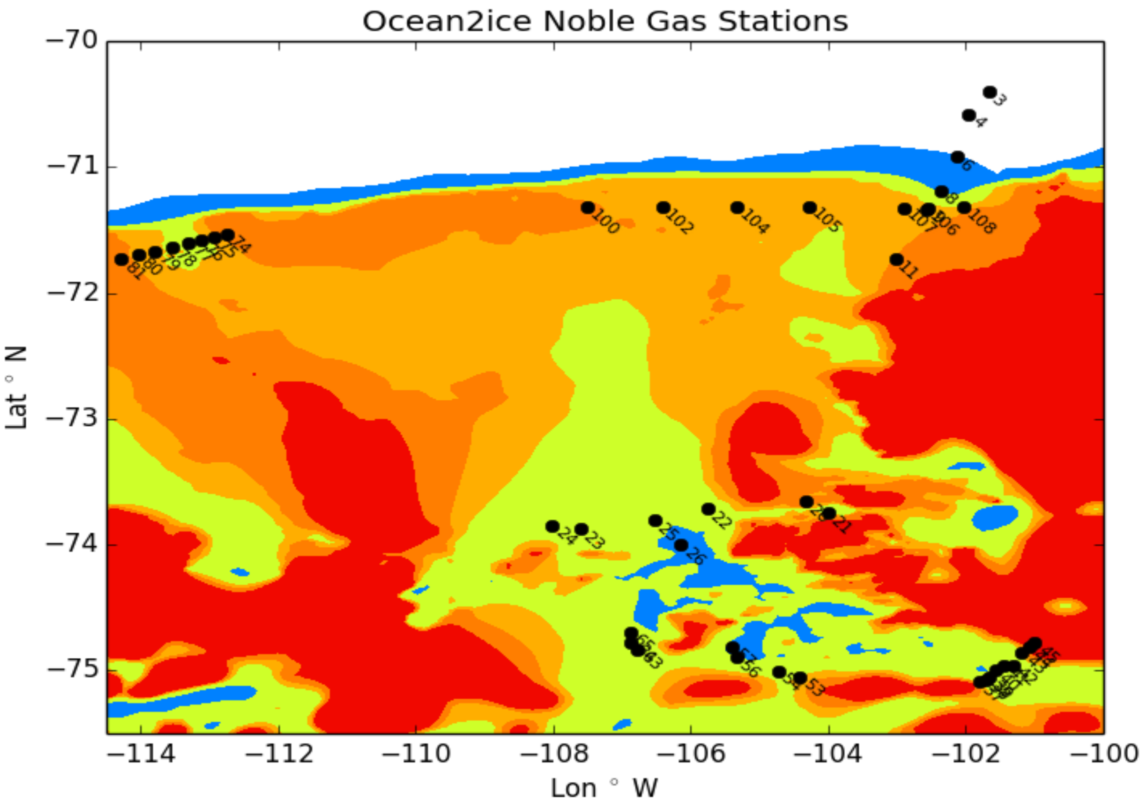


Figure 3.13 Noble gas tracer stations in the Amundsen Sea during JR294.

Noble gases are collected in copper tubes that are fitted with tygon tubing and clamps at both ends. Once the Noble gas sample has been taken it is brought into the wet lab where the tube is sealed using a crimping device that forms a cold weld at each end of the copper tube containing the sample. The nominal sample volume of a single noble gas samples is ca. 45 ml.

Tritium is collected in Argon-filled bottles to avoid contamination with the water vapor in air, and indeed tritium samples for analysis at the University of Manchester were collected in 1L amber bottles pre-filled with Ar.

Intercalibration: A total of 24 samples for He/Ne/Ar were also collected in pinch clamped copper tubes for analysis by the Environmental Tracer Group at Columbia University. These samples will allow a laboratory intercalibration between the Columbia Lab and the Isotope Geochemistry Facility at WHOI.

References:

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4 Lowered Acoustic Doppler Current Profiler (LADCP) (Alex Forryan and Alberto Naveira Garabato)

4.1 Instrument Setup

Cruise JR294 used one RDI 300kHz Workhorse LADCP unit fitted to the CTD frame in a downward-looking orientation. The LADCP was configured to have 16 x 10 m bins, one water track and one bottom track ping in a one second ensemble and a 5 m blank-to-surface. Data were collected in earth coordinates. The LADCP command configuration file is included in Appendix 4.1. Pre-deployment tests were run prior to each cast using a script supplied by BAS which is included in appendix 4.2.

4.2 LADCP Deployments

Stn.	Date	Time (GMT)	Lat. deg. N	Lon. deg. E	Pressure dbar.	Raw file	Comments
1	30/Jan/2014	12:11	-60.408	-87.1608	1160	JR294_001_m.000	Test cast to 1000 m
2	01/Feb/2014	11:33	-66.3182	-99.0948	1112	JR294_002_m.000	Test cast to 1000 m
3	02/Feb/2014	15:43	-70.4020	-101.6717	3511		No data LADCP incorrectly deployed.
4	02/Feb/2014	23:07	-69.4212	-100.0452	2976	JR294_004_m.000	
5	03/Feb/2014	05:28	-69.258	-101.8785	2472	JR294_005_m.000	
6	03/Feb/2014	10:54	-69.0843	-101.8693	1968	JR294_006_m.000	
7	03/Feb/2014	15:11	-70.9217	-101.7712	1472	JR294_007_m.000	
8	03/Feb/2014	18:49	-70.8117	-101.6347	1064	JR294_008_m.000	
9	03/Feb/2014	22:03	-70.6615	-101.4297	616	JR294_009_m.000	
10	04/Feb/2014	01:17	-70.466	-101.1997	680	JR294_010_m.000	
11	04/Feb/2014	04:48	-70.2668	-102.9743	720	JR294_011_m.000	
12	04/Feb/2014	08:36	-70.0698	-102.4302	704	JR294_012_m.000	
13	04/Feb/2014	12:22	-71.88	-103.9073	568	JR294_013_m.000	
14	04/Feb/2014	15:36	-71.6597	-103.4603	576	JR294_014_m.000	
15	04/Feb/2014	19:17	-71.3523	-103.0252	528	JR294_015_m.000	

16	04/Feb/2014	22:33	-71.2002	-103.835	544	JR294_016_m.000	
17	05/Feb/2014	01:59	-72.9168	-102.2312	552	JR294_017_m.000	
18	05/Feb/2014	06:17	-72.483	-102.025	608	JR294_018_m.000	
19	05/Feb/2014	14:14	-72.4233	-102.1723	280	JR294_019_m.000	
20	05/Feb/2014	15:59	-72.3447	-103.673	272	JR294_020_m.000	
21	05/Feb/2014	18:35	-72.2502	-104.9978	584	JR294_021_m.000	
22	05/Feb/2014	21:40	-72.1993	-104.2478	792	JR294_022_m.000	
23	06/Feb/2014	02:45	-72.1215	-106.3902	752	JR294_023_m.000	
24	06/Feb/2014	05:20	-72.1605	-107.9877	704	JR294_024_m.000	CTD double dipped (dodgy cond sensor) but ladcp not re-started.
25	06/Feb/2014	09:47	-72.1903	-105.465	952	JR294_025_m.000	
26	06/Feb/2014	14:26	-73.9962	-105.8523	1208	JR294_026_m.000	
27	06/Feb/2014	19:05	-73.6345	-103.016	1328	JR294_027_m.000	
28	06/Feb/2014	22:48	-74.2875	-105.3940	1143	JR294_028_m.000	Can't seem to get this one processed - file looks ok logfile is fine but won't run.
29	07/Feb/2014	05:42	-73.9973	-105.867	1200	JR294_029_m.000	Charge cable faulty - possibly not charging
30	07/Feb/2014	07:32	-73.994	-104.2508	968	JR294_030_m.000	Charge cable replaced post-cast
32	09/Feb/2014	16:37	-73.4698	-103.485	952	JR294_032_m.000	
33	09/Feb/2014	20:35	-73.2817	-103.9727	1064	JR294_033_m.000	
34	10/Feb/2014	00:22	-73.2125	-102.4112	992	JR294_034_m.000	
35	10/Feb/2014	03:20	-73.1418	-102.8463	1016	JR294_035_m.000	
36	10/Feb/2014	08:57	-73.003	-101.7172	864	JR294_036_m.000	
37	11/Feb/2014	03:46	-74.9082	-100.1967	744	JR294_037_m.000	
38	11/Feb/2014	05:31	-74.9292	-100.2947	1000	JR294_038_m.000	
39	11/Feb/2014	08:04	-74.946	-100.337	1040	JR294_039_m.000	
40	11/Feb/2014	14:24	-74.9992	-100.4355	968	JR294_040_m.000	
41	11/Feb/2014	16:30	-73.043	-100.5587	936	JR294_041_m.000	
42	11/Feb/2014	18:27	-73.0918	-100.6817	864	JR294_042_m.000	
43	11/Feb/2014	20:02	-73.1428	-100.8107	808	JR294_043_m.000	
44	11/Feb/2014	21:39	-73.1828	-100.914	600	JR294_044_m.000	
45	11/Feb/2014	23:21	-73.2193	-100.9853	632	JR294_045_m.000	
48	14/Feb/2014	21:57	-74.9687	-100.217	1008	JR294_048_m.000	
49	15/Feb/2014	21:19	-74.9125	-100.199	696	JR294_049_m.000	
50	16/Feb/2014	07:44	-73.0072	-100.3952	1016	JR294_050_m.000	
51	16/Feb/2014	10:00	-74.943	-101.8432	728	JR294_051_m.000	
52	17/Feb/2014	04:54	-74.8993	-102.1147	560	JR294_052_m.000	
53	17/Feb/2014	08:21	-74.9503	-103.582	584	JR294_053_m.000	
54	17/Feb/2014	12:35	-74.9985	-103.2655	944	JR294_054_m.000	
55	17/Feb/2014	14:30	-73.0503	-104.9623	736	JR294_055_m.000	
56	17/Feb/2014	17:04	-73.1063	-104.6597	1256	JR294_056_m.000	
57	17/Feb/2014	20:19	-73.1918	-104.5962	920	JR294_057_m.000	
58	18/Feb/2014	00:12	-73.3333	-104.7837	1216	JR294_058_m.000	
59	18/Feb/2014	12:09	-73.1353	-101.9163	928	JR294_059_m.000	
60	18/Feb/2014	16:06	-73.0708	-101.2813	672	JR294_060_m.000	
63	19/Feb/2014	20:12	-73.1665	-105.2282	936	JR294_063_m.000	

64	19/Feb/2014	23:02	-73.2255	-105.1353	1144	JR294_064_m.000	
65	20/Feb/2014	02:24	-73.304	-105.1147	904	JR294_065_m.000	
66	20/Feb/2014	05:18	-73.3668	-106.7552	688	JR294_066_m.000	
67	20/Feb/2014	08:45	-73.5168	-106.8888	1024	JR294_067_m.000	
68	20/Feb/2014	11:54	-73.639	-106.675	1160	JR294_068_m.000	
69	20/Feb/2014	14:49	-73.7265	-106.9317	1024	JR294_069_m.000	
70	21/Feb/2014	13:41	-73.473	-104.4647	944	JR294_070_m.000	
71	21/Feb/2014	16:45	-73.5008	-105.7952	1160	JR294_071_m.000	
72	22/Feb/2014	12:20	-73.417	-105.4825	1200	JR294_072_m.000	
73	22/Feb/2014	19:47	-72.1878	-105.4685	952	JR294_073_m.000	
74	27/Feb/2014	01:58	-70.4685	-111.2508	408	JR294_074_m.000	
75	27/Feb/2014	03:56	-70.4433	-111.0647	536	JR294_075_m.000	
76	27/Feb/2014	06:16	-70.4198	-112.8803	600	JR294_076_m.000	
77	27/Feb/2014	08:28	-70.4015	-112.698	600	JR294_077_m.000	
78	27/Feb/2014	10:41	-70.364	-112.4502	592	JR294_078_m.000	
79	27/Feb/2014	13:21	-70.3318	-112.2098	560	JR294_079_m.000	
80	27/Feb/2014	16:12	-70.3003	-113.9587	528	JR294_080_m.000	
81	27/Feb/2014	23:02	-70.2687	-113.7165	448	JR294_081_m.000	
82	28/Feb/2014	00:59	-70.3615	-113.7087	472	JR294_082_m.000	
83	28/Feb/2014	02:21	-70.4568	-113.6963	496	JR294_083_m.000	
84	28/Feb/2014	03:41	-70.53	-113.7302	984	JR294_084_m.000	
85	28/Feb/2014	05:24	-70.5787	-113.686	1464	JR294_085_m.000	
86	28/Feb/2014	07:45	-70.6502	-113.6653	1920	JR294_086_m.000	
87	28/Feb/2014	23:17	-70.8675	-113.6338	2496	JR294_087_m.000	
88	01/Mar/2014	04:50	-69.2237	-113.6167	3008	JR294_088_m.000	
89	01/Mar/2014	09:49	-70.9163	-112.0298	2480	JR294_089_m.000	
90	01/Mar/2014	20:12	-70.4742	-112.732	600	JR294_090_m.000	
91	02/Mar/2014	00:06	-70.5408	-112.6418	608	JR294_091_m.000	
92	02/Mar/2014	01:49	-70.5892	-112.4755	1024	JR294_092_m.000	
93	02/Mar/2014	03:30	-70.6477	-112.3952	1472	JR294_093_m.000	
94	02/Mar/2014	05:59	-70.7493	-112.2595	1984	JR294_094_m.000	
95	02/Mar/2014	08:56	-70.692	-112.8827	1488	JR294_095_m.000	
96	02/Mar/2014	10:46	-70.6483	-112.9995	992	JR294_096_m.000	
97	02/Mar/2014	17:16	-70.4428	-112.9677	576	JR294_097_m.000	
98	03/Mar/2014	03:55	-70.6255	-111.0667	584	JR294_098_m.000	
99	03/Mar/2014	05:16	-70.594	-111.1425	416	JR294_099_m.000	
100	03/Mar/2014	20:13	-70.6803	-106.4993	456	JR294_100_m.000	
101	03/Mar/2014	22:38	-70.6813	-105.0542	488	JR294_101_m.000	
102	04/Mar/2014	00:46	-70.6778	-105.5855	504	JR294_102_m.000	
103	04/Mar/2014	03:09	-70.68	-104.1375	512	JR294_103_m.000	
104	04/Mar/2014	06:20	-70.6817	-104.6768	544	JR294_104_m.000	
105	04/Mar/2014	13:16	-70.686	-103.727	544	JR294_105_m.000	
106	04/Mar/2014	20:08	-70.6723	-101.4503	616	JR294_106_m.000	
107	04/Mar/2014	22:19	-70.6758	-101.1113	584	JR294_107_m.000	
108	05/Mar/2014	02:12	-70.6797	-101.984	600	JR294_108_m.000	
109	05/Mar/2014	06:16	-70.6797	-100.3865	504	JR294_109_m.000	

4.3 Data Processing

RDI format binary files, recorded by the instrument, were downloaded after each cast and stored with the corresponding pre-deployment test log files. Navigation data were extracted from the SCS data stream for the ship's primary GPS positional system the Seatex Seapath 320 + (seatex-gga.ACO). All data were processed using the latest version of the Lamont-Doherty Earth Observatory (IdeoIX) software which calculates velocities using an inverse method. This package was also used to monitor the health of the beams on the instrument. Parameters changed from the IdeoIX default values were set in the *set_cast_params.m* script which is given below:

```
cruise_str = 'jcr294';
run_letter = 'wctd';
f.ladcpdo = ['./RawData/JR294_',stnstr,'_m.000'];
f.ladcpup = [''];
f.nav = './Nav/sm_ldeoIX.asc';
f.nav_header_lines = 0;
f.nav_fields_per_line = 3;
f.nav_time_field = 1;
f.nav_lat_field = 3;
f.nav_lon_field = 2;
f.res = ['./' cruise_str stnstr '/' cruise_str stnstr run_letter ];
f.ctd = ['./CTD/JR294_' stnstr '_ctm.asc'];
f.ctd_header_lines = 2500;
f.ctd_fields_per_line = 6;
f.ctd_time_field = 2;
f.ctd_pressure_field = 3;
f.ctd_temperature_field = 4;
f.ctd_salinity_field = 5;
f.checkpoints = ['./Checkpoints/' cruise_str stnstr run_letter ];
f.sadcp = [];
p.name = [cruise_str stnstr run_letter ];
p.ladcp_cast = stn;
p.cruise_id = cruise_str;
p.whoami = 'A. Forryan';
p.saveplot = [1:6];
p.ladcp_station = stn;
fname = [ 'Postimes/postime' stnstr];
postime = load(fname);
autocat = 1;
intlat = postime(4);
intlon = postime(6);
p.drot = magdev(intlat,intlon);
p.debug = 1;
p.getdepth = 2;
p.nav_error = 30;
p.navtime_av = 2/60/24;
p.btrk_mode = 3;
p.btrk_ts = 10;
p.btrk_below = 1;
p.btrk_range = [300 50];
p.btrk_wstd = 0.1;
p.btrk_wlim = 0.05;
p=setdefv(p,'bottomdist',0);
p.savemat = 1;
p.orig = 1;
p.ts_save=[1 2 3 4];
p.cm_save=[1 2 3 4];
p.pg_save=[1 2 3 4];
p.weightmin = 0.05;
ps.shear=1;
ps.std_weight = 1;
ps.smallfac = [1 0];
ps.btrk_weight_nblen = [0 0];
ps.sadcpfac = 3;
ps.shear_stdf = 2;
ps.outlier = 1;
ps.dz = 8;
```

4.4 Results

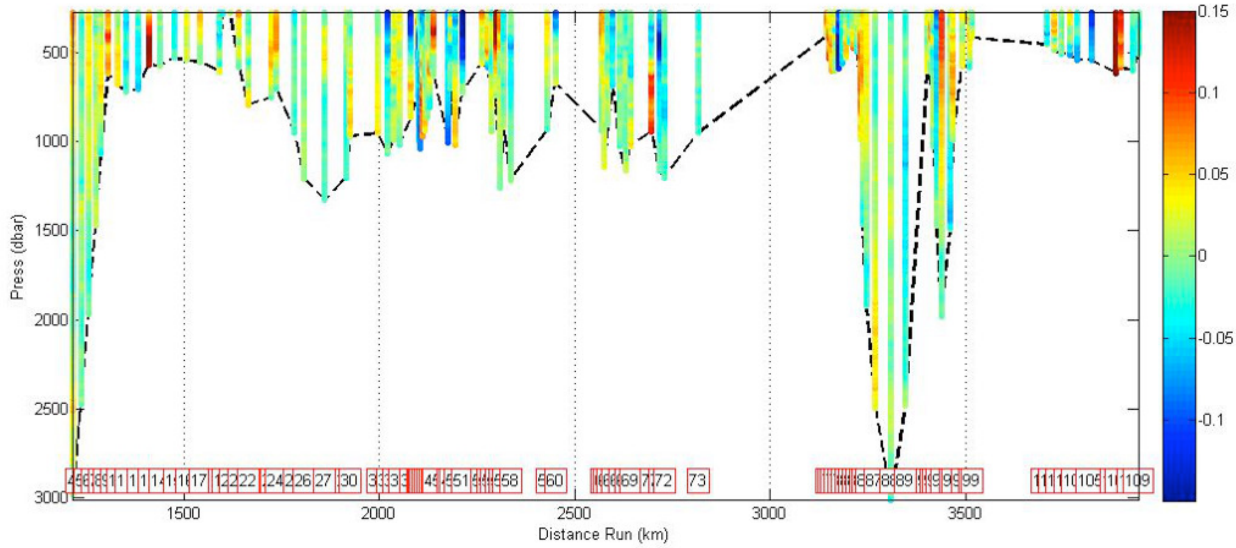


Figure 4.1 LADCP U-velocity (m s^{-1}) from stations 1 to109 for cruise JR294

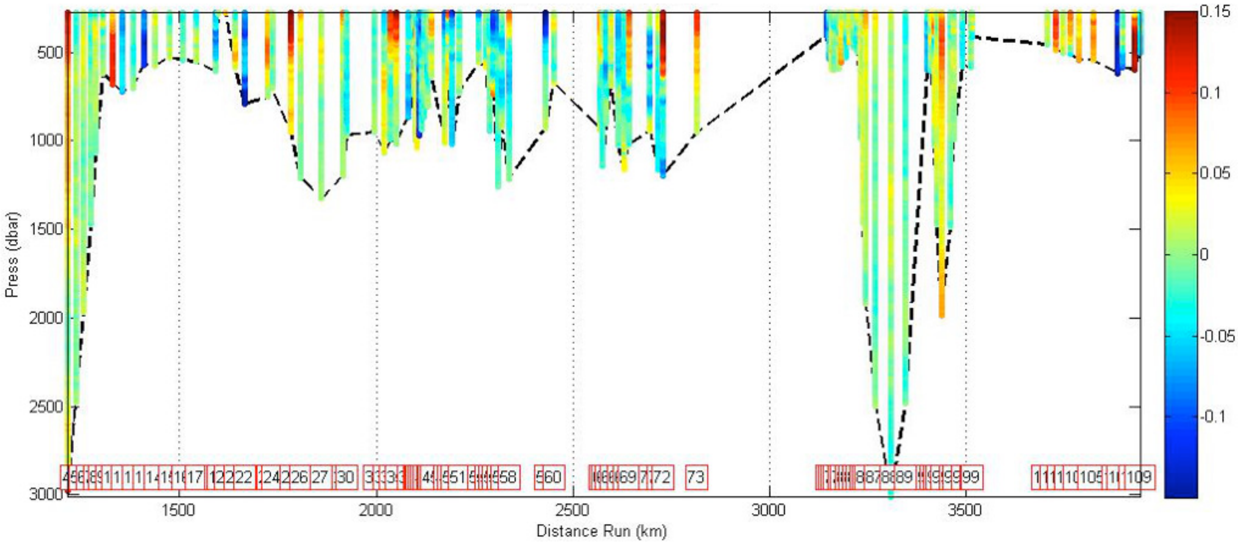


Figure 4.2 LADCP V-velocity (m s^{-1}) from stations 1 to109 for cruise JR294

Appendix 4.1 LADCP Command File

```
PS0
CR1
CF11101
EA00000
EB00000
ED00000
ES35
EX11111
EZ0011101
TE00:00:01.00
TP00:01.00
WM15
LD111100000
LF0500
LN016
LP00001
LS1000
LV250
LW1
SM1
SI0
SA001
SW05000
```

```
CK
CS
```

Appendix 4.2 LADCP Pre-deployment Tests

```
;--------------------------------------------------------------------------
;                           PRE_DEPLOY.RDS
; Script file for pre deployment RD Instruments WorkHorse
; ADCP with the BBTalk program
;--------------------------------------------------------------------------
;--------------------------------------------------------------------------
; RDI - WH ADCP pre deployment script file:
; FILE name = "pre_deploy.rds"
; Date: 11 February 2010
; Author: Julian Klepacki
; Version: 1.1
; Modified by epab on 3/4/2012: Added PS0 command for identification of ADCP
$L
$B
$W62
$P ***********************************************************************
PS0
$W62
$P ***********************************************************************
PA
$W62
$P ***********************************************************************
PT200
$W62
$P ***********************************************************************
PC2
$W62
$P ***********************************************************************
RS
$W62
$T

$W62
$P ***********************************************************************
$P Type 're ErAsE' to erase data if necessary?
$P Hit Return for Command Prompt
$P***********************************************************************
;$L
```

5 Microstructure Profilers (Alberto Naveira Garabato, Alex Forryan, John Wynar)

5.1 Overview

Two vertical microstructure profilers manufactured by Rockland Scientific International (the tethered VMP-2000 and the untethered VMP-5500) were used during the JR294 cruise. Both instruments measured profiles of temperature and velocity microstructure (i.e. on the length scales of dissipation of turbulent flows, typically a few millimetres to tens of centimetres), from which the rates of dissipation of turbulent kinetic energy (ε) and temperature variance (χ) are estimated using methodology based on Oakey (1982); and finescale temperature, salinity and pressure with a Seabird CTD mounted on each instrument. All the non-test casts in JR294 were conducted with the VMP-2000, due sometimes to the presence of sea ice and other times to the shallowness of the stations. The central goal of the microstructure element of JR294 was to investigate the small- and finescale processes influencing the flow of heat across the continental shelf and the dispersal of meltwater plumes leaving the ice shelf cavities.

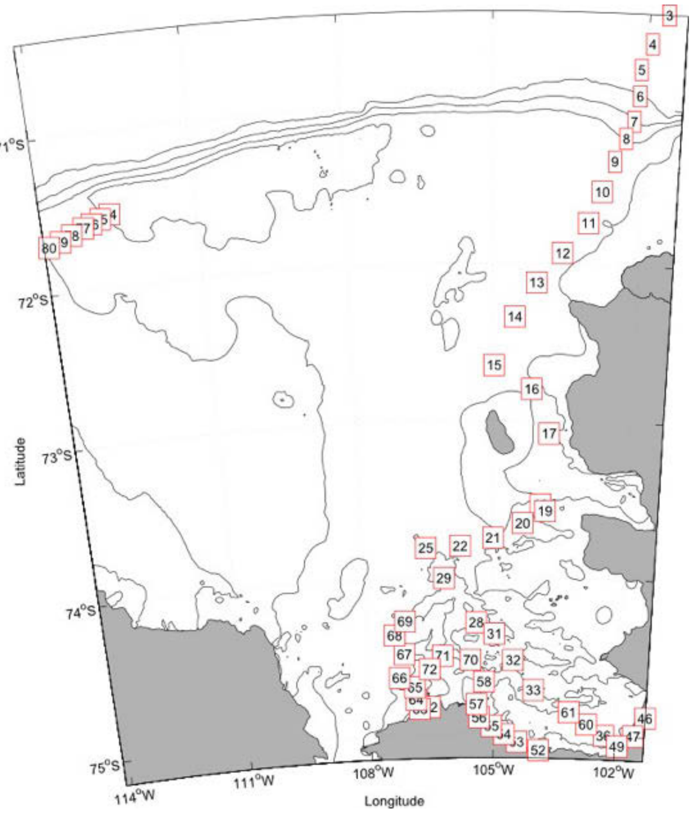


Figure 5.1: Location of microstructure casts conducted during JR294.

A total of 139 microstructure profiles were obtained during JR294, 54 of them in conjunction with standard CTD stations and 85 as part of five tow-yos (two across the sill in the eastern trough; two along different segments of the Pine Island Glacier [PIG] front; and one along the main outflow from the PIG cavity, i.e. perpendicular to the PIG front) (see Figure 5.1 and Table 5.1). The VMP-2000 proved to be a very reliable instrument, and was operated successfully in sustained conditions of extreme cold (air temperatures of -8°C to -13°C and winds of 20 kn to 30 kn were common) down to depths in excess of 1500 m. Only a few stations had to be skipped due to excessive swell. The only minor problems experienced with the instrument were related to the freezing of the CTD during transport from / to the wet lab to / from deck (this was solved by injecting warm water into the CTD tube before taking the instrument out on deck prior to deployment), and the accumulated strain on the cable due to twist that resulted from heavy usage of the instrument (this was solved by dismounting the tail end to straighten the cable a couple of times during the cruise). The VMP-2000 broke down just before its last planned profile (station 81), the symptoms of this failure being a continuous string of bad buffer readings. The cause of this breakdown was a fault in the connector between the cable and the instrument.

Table 5.1: VMP deployments during JR294.

Stn.	Latitude	Longitude	Date / time	Cast	Maximum pressure	Comments
1	61 35.658 S	88 50.276 W	30-1-2014 13:38	1	100 db	
	61 35.857 S	88 50.602 W	30-1-2014 14:07	2	1729 db	Maximum wire extension, shear2 a bit noisy. Cleaned and dried out all probes.
3	70 23.893 S	101 39.909 W	02-02-2014 18:24	1	1745 db	First station in the ice. Ship stationary. Cable snag at ~150 db, profiler halted. Ran out of cable at 1100 db. Started pulling back slowly. Stuck in ice flow on way up at 1640 db. shear2 still a bit noisy,

						cleaned and dried probe again.
4	70 34.787 S	101 57.013	03-02-2014 00:50	1	1630 db	Sea flat as glass. shear2 still noisy - replacing...
5	70 44.698 S	102 07.401 W	03-02-2014 06:39	1	1752 db	
6	70 59.918 S	102 7.5382 W	03-02-2014 10:57	1	1731 db	SBT appears to be blocked for a couple of hundred meters, ~200 db. Clears ok and upcast is fine.
7	71 04.683 S	102 13.458 W	03-02-2014 14:59	1	1416 db	Fall rate a touch slow in top 100 m. 750 db = 1080 m cable 1000 db - 1380 m cable
8	71 11.331 S	102 22.222 W	03-02-2014 18:36	1	1005 db	
9	71 20.308 S	102 34.224 W	03-02-2014 22:43	1	595 db	
10	71 32.037 S	102 48.065 W	04-02-2014 01:51	2	643 db	Cast 1 aborted due to problem with the winch.
11	71 44.075 S	102 03.168 W	04-02-2014 05:33	1	718 db	
12	71 55.809 S	103 34.224 W	04-02-2014 09:09	1	692 db	
13	71 07.189 S	194 05.566 W	04-02-2014 12:49	1	491 db	
14	72 20.401 S	104 32.333 W	04-02-2014 16:03	1	589 db	
15	72 38.906 S	104 58.620 W	04-02-2014 19:43	1	531 db	
16	72 47.990 S	104 09.903 W	04-02-2014 23:02	1	545 db	shear1 looks dodgy.
17	73 04.990 S	103 46.128 W	05-02-2014 02:27	1	548 db	shear1 again dodgy.
18	73 31.153 S	103 58.496 W	05-02-2014 06:48	1 - 8	550 - 450 db	Tow-yo.
19	73 34.461 S	103 49.628 W	05-02-2014 12:59	1 - 5	230 db	Quick time series.
20	73 39.318 S	104 19.621 W	05-02-2014 16:27	1	194 db	Start of cross-trough section
21	73 44.988 S	105 0.123 W	05-02-2014 19:12	1	583 db	
22	73 48.042 S	105 45.126 W	05-02-2014 22:18	1	772 db	
25	73 48.597 S	106 32.096 W	06-02-2014 10:30	1	922 db	
28	74 17.255 S	105 23.589 W	06-02-2014 23:57	1	998 db	
29	74 00.216 S	106 08.330 W	07-02-2014 04:01	2	1209 db	
31	74 21.703 S	104 58.034 W	09-02-2014 13:38	1	1349 db	ISTAR 7 mooring position.
32	74 31.790 S	104 30.940 W	09-02-2014 17:22	1	962 db	
33	74 43.098 S	104 01.638 W	09-02-2014 21:16	1	1015 db	SBC reading high (near air values) for most of cast. May have been blocked (frozen), clears above 800

						db on upcast and starts to read in normal range.
36	74 59.818 S	102 16.963 W	10-02-2014 10:06	1	783 db	Coldest yet...
46	74 47.991 S	101 04.130 W	12-02-2014 00:33	1-17	max ~ 1000 db	The great ice front traverse, part 1.
47	75 05.259 S	101 48.302 W	13-02-2014 00:22	1-45	max ~ 1000 db	The great ice font traverse, part 2.
49	75 03.690 S	101 56.277 W	15-02-2014 07:33	1-10	max ~ 800 db	Section running in towards glacier at southern end.
52	75 06.039 S	103 52.835 W	17-02-2014 06:16	2	578 db	Start of Thwaites stations
53	75 02.986 S	104 25.080 W	17-02-2014 09:02	1	588 db	
54	75 00.0095 S	104 44.075 W	17-02-2014 11:17	1	903 db	
55	74 56.978 S	105 02.241 W	17-02-2014 15:02	1	712 db	
56	74 53.623 S	105 20.401 W	17-02-2014 18:02	1	1233 db	
57	74 48.537 S	105 24.193 W	17-02-2014 20:59	1	778 db	
58	74 40.000 S	105 12.975 W	18-02-2014 00:55	1	1226 db	
60	74 55.701 S	102 43.102 W	18-02-2014 16:38	1	609 db	Filling in the gap on the transect.
61	74 51.301 S	103 09.236 W	18-02-2014 18:16	1	1018 db	
62	74 49.481 S	106 31.689 W	19-02-2014 18:13	1	628 db	Back at Thwaites.
63	74 50.038 S	106 46.636 W	19-02-2014 20:51	1	854 db	
64	74 46.466 S	106 51.797 W	19-02-2014 23:52	1	1121 db	
65	74 41.756 S	106 53.129 W	20-02-2014 03:08	1	900 db	Duff file recorded: header appears to be in '.000' with one data buffer followed by a header and the remaining data in '.001'.
66	74 37.993 S	107 14.687 W	20-02-2014 05:49	1	683 db	
67	74 28.989 S	107 06.656 W	20-02-2014 09:26	1	998 db	
68	74 21.664 S	107 19.449 W	20-02-2014 12:30	1	1044 db	
69	74 16.411 S	107 04.097 W	20-02-2014 15:24	1	997 db	
70	74 31.613 S	105 32.141 W	21-02-2014 14:18	1	860 db	Duff file recorded again with a '.000' and a '.001'. This time it's written a header + setupfilestr to 001 followed by a data buffer then header + data...
71	74 29.990 S	106 12.060 W	21-02-2014 17:38	1	1062 db	

72	74 34.981 S	106 31.054 W	22-02-2014 13:01	1	1218 db	
74	71 31.957 S	112 44.218 W	27-02-2014 02:34	1	385 db	Start of western trough cross section.
75	71 33.401 S	112 56.114 W	27-02-2014 04:38	1	534 db	
76	71 31.811 S	113 07.178 W	27-02-2014 06:54	1	603 db	
77	71 35.923 S	113 18.047 W	27-02-2014 09:02	1	590 db	
78	71 38.085 S	113 32.865 W	27-02-2014 11:15	1	581 db	
79	71 40.076 S	113 47.304 W	27-02-2014 13:53	1	529 db	
80	71 41.442 S	114 02.346 W	27-02-2014 16:58	1	525 db	temp1 replaced.
81	71 43.882 S	114 17.012 W	27-02-2014			Cast aborted with 'bad buffers', cable needs re-terminating.

5.2 VMP-2000 deployment, recovery and winch operation

The VMP was carried out on to deck and placed on stands. The slack wire was wound tightly back on to the winch to remove the hazard of loose wire on the deck. The VMP was attached to the crane using a quick-release mechanism and then craned over the side, in to the sea and released, the remaining slack wire again being wound on to the winch. The profiler was held at the surface until given the go-ahead by the person operating the recording computer. Once that message was received the operator veered the winch and adjusted its speed and that of the line puller to ensure that the profiler was freefalling at its terminal velocity. Veering was halted occasionally to read the length of wire-out on the cable until the pre-determined depth was reached. At this point the winch was stopped until the profiler attained its maximum depth. The profiler was then hauled back to the surface, the computer operator giving warning when it was nearing the surface so that the winch speed could be reduced for recovery. As soon as the profiler came within reach it was re-attached to the crane and hauled up on deck and laid back on its stands, all the time paying out sufficient wire to achieve this. If required, enough wire was paid out to allow the profiler to be taken into the lab.

5.3 Data processing

All processing scripts used on this cruise were adaptations of those used in previous VMP cruises by the NOCS group. All processing steps and calculations remain the same as described in previous cruise reports (Naveira Garabato, 2009; Meredith, 2011; Watson, 2011; Sallée, 2013). A summary of the processing steps is given below:

Function	**Description**
vmp_read_odas	Reads in the VMP datafile and produces two matlab files, one containing the raw un-calibrated VMP data, the other containing the extracted downcast data with all calibrations supplied in the setup.cfg file applied ('_cdc.mat').
vmp_firstlook	Produces a series of diagnostic plots for the raw un-calibrated VMP data.
vmp_process_seabird	Processes the VMP seabird data and applies

	various corrections. Output is saved as a separate matlab file ('_CTD.mat').
vmp_process_micro	Processes the VMP microstructure shear, temperature and conductivity. Microstructure temperature and conductivity are calibrated by regressing against the processed VMP seabird temperature and conductivity. Output is saved as a separate matlab file ('_Micro.mat').

A list of the sensors used during JR294 is given in Table 5.2.

Table 5.2: VMP sensors used during JR294.

She1	She2	Temp1	Temp2	SBET	SBEC	Date	Comments
M987	M989	T765	T766	03 5776	04 4169	26-1-2014	she2 noisy from cast 1; cleaned & dried twice; replaced after station 4
	M390					03-2-2014	she2 same as before she1 still consistently lower so swapped M989 back into she1 after station 5
M989						03-02-2014	
	M400					04-2-2014	Changed she2 post cast 10 - still not the same as she1
M950						05-2-2014	she1 changed following station 17 noisy
M722						15-2-2014	she1 changed following station 49 - tip damaged after cast 9
		T614	T356			17-2-2014	Swapped with VMP-6000
		T618				20-02-2014	T1 broken station 66 - no signal
		T617				27-02-2014	T1 broken following cast 80

An illustration of the data collected is given in Figures 5.2 and 5.3, which respectively display the distributions of ε and χ along a section extending along the Thwaites ice front.

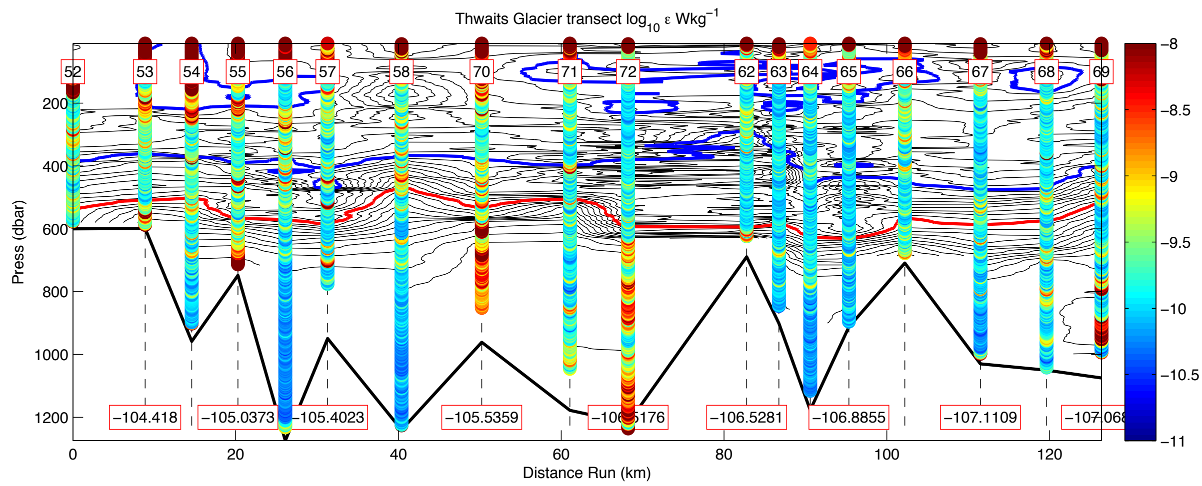


Figure 5.2: Log$_{10}$(ε) in W kg^{-1} for the section extending along the Thwaites ice front. Temperature contours are displayed in the background (red = 0°C, blue = -1°C), and longitudes and station numbers indicated.

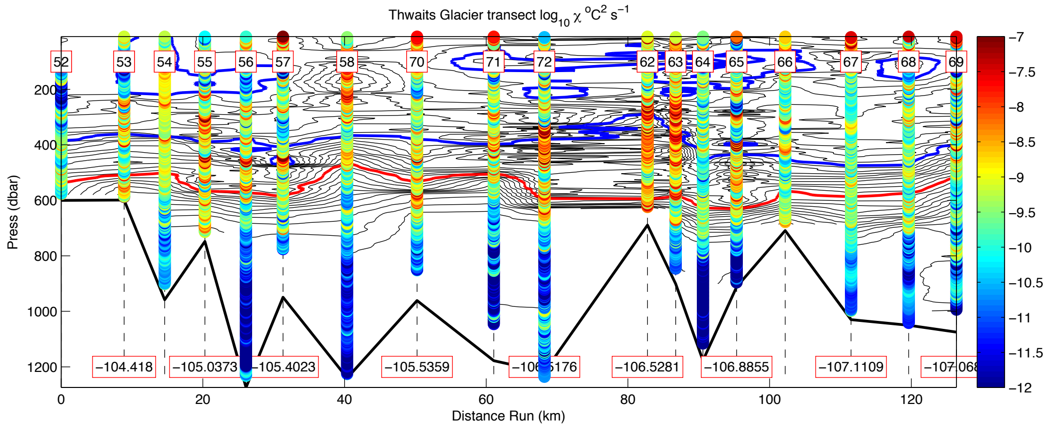


Figure 5.3: $Log_{10}(\chi)$ in $^{o}C^{2}s^{-1}$ for the section extending along the Thwaites ice front. Temperature contours are displayed in the background (red = 0°C, blue = -1°C), and longitudes and station numbers indicated.

5.4 VMP-2000 logsheet

JCR294 VMP 2000 LOG #

St. No.	Date (jday)		Latitude	Longitude	Time (GMT)	Water Depth	Max. Press.	File	Notes
		start							
		max							
		end							
		start							
		max							
		end							
		start							
		max							
		end							
		start							
		max							
		end							
		start							
		max							
		end							

5.5 BAS deployment sheet

BRITISH ANTARCTIC SURVEY

Form MS.AQ

SCIENTIFIC or CHARTERERS OVERSIDE EQUIPMENT GUIDANCE NOTES

Ship: **R.R.S. James Clark Ross**		
Sheet Number:	**Issue Status: A**	**Issue Date:** 01/02/2014

Item: VMP (Vertical Microstructure Profiler)	**Type:** 2000
Owner: Prof A Naveira Garabato	
Brief Description: Tethered Profiler	
Deployment Location: Starboard After Effer	
Weight: 60 Kg (In Air)	**Approx Dimensions:** 2m Long, Up to 0.6m∅
Winch: N/A	**Wire:** N/A
Max. Cable Veer Rate: N/A	**Max. Cable Haul Rate:** N/A
Vessel Deployment Speed: < 1knt relative to water	**Vessel Recovery Speed:** < 1knt relative to water
Persons required on deck	**Duty**
Person in charge with radio	Oversee / assist with deployment & comms to bridge.
NMF Technician	To co-ordinate/control operations and assist in deployment/recovery and operate profiler winch
One Sciencetist.	Final checks and to assist in deployment/recovery.
Two Seamen	To assist in deployment/recovery

Safety / Protective Clothing and Gear required:

- Hard Hats: Safety Footwear: Work Gloves: Warm. Foul weather gear as required.

Operation Control Room Support equipment :

- Echo Sounder to monitor bottom depth (SWATH/EA600)

Notes :

- Ensure everyone is clear which parts of the profiler that can be touched during deployment and recovery to prevent damage to sensors.

Refer to Risk Assessment Number: MRA/GEN/11/JR

Page 1 of 2 (2 Sided)

BRITISH ANTARCTIC SURVEY

Form MS.AQ (cont)

SCIENTIFIC or CHARTERERS OVERSIDE EQUIPMENT GUIDANCE NOTES

Pre Deployment Checks:

- All persons involved understand what is required.
- Working area safe and adequately lit.
- Communication between Deck / Bridge established.
- On station - Permission from the bridge to proceed.

Deployment Technique:

1. Before starting extend Effer to maximum extent to reduce time in deploying profiler and secure "sea catch" to hook to prevent its loss.
2. Attach profiler to "sea catch" via strop and fit safety pin. Attach additional steadying line to maintain orientation of profiler during deployment.
3. Confirm with bridge permission to launch
4. Take in slack wire using winch.
5. Lift profiler on crane and then remove weight safety strap.
6. Slew profiler over the side to the launch position.
7. Remove the "sea catch" safety pin.
8. Lower the profiler and clear the steadying line.
9. When ready release the profiler.

Recovery Technique:

1. Raise profiler to top of bulwark.
2. Attach crane to recovery loop on profiler.
3. Lower profiler onto deck.
4. Secure the deck and inform the bridge.

Page 2 of 2 (2 Sided)

5.6 References

Meredith, M. and N. Cunningham, 2011: Cruise report RRS James Cook JC054 (DIMES UK2). British Antarctic Survey Cruise Report, 206 pp.

Naveira Garabato, A.C., 2009: RRS James Cook Cruise 29, 01 Nov-22 Dec 2008. SOFine Cruise Report: Southern Ocean Finestructure. National Oceanography Centre Southampton Cruise Report No. 35, 216 pp.

Oakey, N. S., 1982: Determination of the rate of dissipation of turbulent energy from simultaneous temperature and velocity shear microstructure measurements. J. Phys. Oceanogr. 12, 256-271.

Sallée, J.-B., 2013: Cruise report RRS James Clark Ross JR281 (DIMES UK4). British Antarctic Survey Cruise Report.

Watson, A. J., 2011: Cruise report RRS James Clark Ross JR276 (DIMES UK2.5). Cruise Report.

6 Autosub Deployments (Adrian Jenkins, Pierre Dutrieux, Steve McPhail)

The Autosub3 deployments formed the core activity of JR295 in support of iSTAR Deliverable B work. The remainder of the work for Deliverable B comprised the ice front studies that formed the overlap with Deliverable A activities. Those are covered in other parts of this report.

6.1 Objectives of JR295 Autosub3 deployments

The overall aim of iSTAR Deliverable B was to provide an "increased understanding of the sub-ice shelf processes that lead to changes in the melt rate experienced by ice shelves" by answering the following questions:

i. How do conditions within the sub-ice shelf cavity respond to changes in oceanographic conditions at the ice front?

ii. What factors govern the spatial distribution of melt experienced by the ice shelf and how might these factors change?

To address these questions the proposed research included an observational study of ocean circulation and ice shelf melting beneath Pine Island and Thwaites glaciers. The main objectives included:

1) To extend earlier observations of seabed, ice base and water properties beneath Pine Island Glacier to obtain a more complete picture of the shape of the sub-ice cavity and the distribution of water masses within it.
2) To make observations of turbulent mixing within the cavity, and especially over the seabed ridge discovered in 2009, to determine where and how heat is transferred from the warmer water at the seabed to the colder waters at the ice shelf base.
3) To make the first direct observations of seabed depth and water properties beneath Thwaites Glacier in order to understand the main controls on ocean circulation and ice shelf melting.

The NERC Autonomous Submersible Vehicle Autosub3 was the only observational platform capable of delivering these objectives. The study of Pine Island Glacier (objectives 1 and 2) was intended to build on the successes of previous work, conducted in January 2009, while the study of Thwaites Glacier (objective 3) was more exploratory in nature and planned to follow the basic format of the earlier work with slight modification to capitalise on lessons learnt. For all Autosub3 missions the intended instrument fit will be that used during the 2009 study:

(a) Seabird CTD, with dual conductivity and temperature sensors and additional dissolved oxygen sensor and transmissometer;
(b) Simrad multi-beam echosounder, configurable as upward- or downward-looking;
(c) upward-looking RDI 300 kHz ADCP;
(d) downward-looking RDI 150 kHz ADCP);
augmented with:
(e) Edgetech 2200M sub-bottom profiler;
(f) Rockland MicroRider microstructure sensor module.

The latter two additions would enable observations of the sub-surface stratigraphy of the seafloor and turbulent mixing processes in the water column. The former was intended to provide information on the depth of the sediment cover on the seabed, critical in deciphering the record of former grounding line movement. Of particular interest was the length of time over which the grounding line remained pinned to the ridge crest prior to the current phase of retreat. The latter was intended to allow direct measurements of the vertical heat flux, critical in determining the spatial pattern of heat delivery to the ice shelf base. Of particular interest was the role of the ridge in driving enhanced mixing, and the impact this had for the overall heat flux carried over the ridge and into the inner cavity.

A total of six missions were planned: four beneath Pine Island Glacier's ice shelf and a further two beneath Thwaites Glacier Tongue. The following approximate timings for the planned missions include a period of five hours running in open water before transiting beneath the ice, a requirement of the risk assessment completed prior to the January 2009 operations:

1) A survey of the unsampled bay to the south of the main fast-flowing section of the ice shelf (approximately 30 hours). Although a glaciologically quiet area this appeared to be the deepest basin where the warmest waters within the cavity were likely to be found.
2) An exploration of the inner cavity focussing on the 2009 track to the grounding line (approximately 30 hours). We planned a fairly close approach to the seabed (<100 m) to access the warmest waters within the inner cavity.
3) A study of turbulent mixing over the crest of the ridge (approximately 40 hours). This would involve a full 24 hours travelling back and forth along a 10 km track through the front observed over the ridge in 2009.
4) A long track into the inner cavity (approximately 24 hours) aiming to cross the ridge further to the north and study the unsampled north-eastern corner of the cavity.
5) & 6) Two missions beneath Thwaites Glacier, approximately 30 hours each. Within this largely unknown cavity, Autosub would bottom- follow at different altitudes on the way in and out of the cavity. This strategy was a compromise between the need for as wide an observational coverage as possible and the necessity to minimise the risk to Autosub3. Past experience showed the major environmental hazard to be the unknown, potentially rough ice shelf base.

6.2 Mission planning

Based on the outline plans described above, final planning of mission waypoints and profiles was guided by satellite imagery acquired immediately prior to our arrival on the inner Amundsen Sea continental shelf and compilations of the most up-to-date ice thickness and seabed bathymetry data. Ice draft estimates for Pine Island Glacier were based primarily on high-resolution digital elevation models derived from SPOT stereo imagery, corrected with recent Icebridge radar soundings of ice thickness. For Thwaites glacier only radar sounding data from Icebridge and AGASEA were available. Seabed elevation for Pine Island Glacier was based on previous Autosub soundings, supplemented with estimates based on inversion of airborne gravity data and recent seismic soundings made from the ice shelf surface. A grid based on all three sources was supplied by Atsuhiro Muto from Pennsylvania State University. For Thwaites glacier there are no ground truth data, so we used a gridded bathymetry derived from airborne gravimetry and supplied by Kristy Tinto of Lamont-Doherty Earth Observatory, Columbia University.

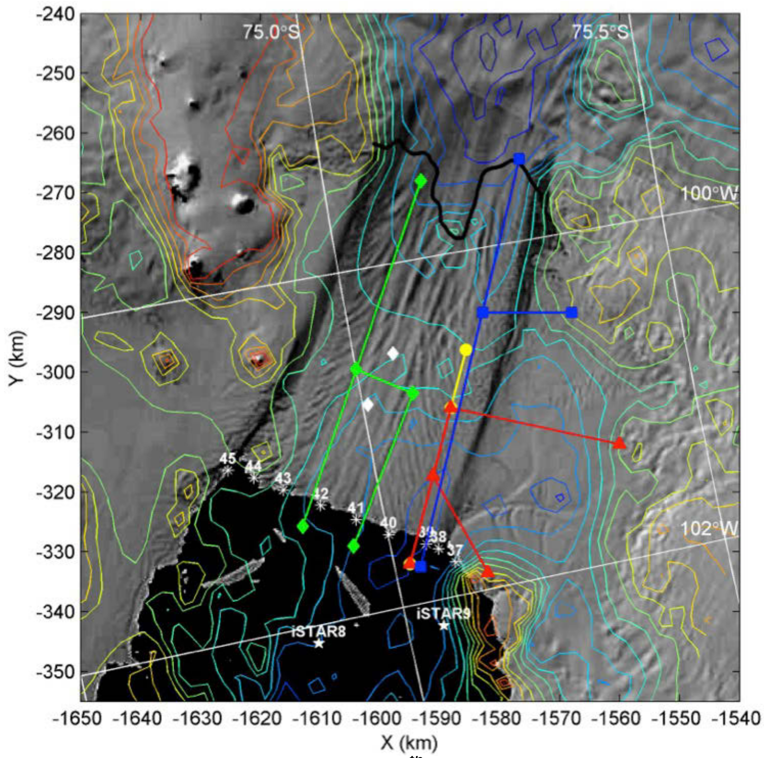


Figure 6.1: *Modis image from 27th January 2014 overlain with bathymetric contours (0 to 1400 m at 100 m intervals) and planned Autosub3 mission tracks beneath Pine Island Glacier. The bold black lines indicate the estimated position of the grounding line in 1996, while the white diamonds show the approximate locations of the US sub-ice moorings deployed in early 2013. Also shown are the positions of the iSTAR moorings and ice front CTD stations. Axes are labelled with the projection coordinates of the image. The standard parallel for this projection is 71ºS, so 1 km on the image represents about 1.0104 km on the ground.*

The four missions planned beneath Pine Island Glacier are shown in Figure 6.1. The first (yellow track, equivalent to number 3 in the earlier list) involved 24 hours of traversing back and forth through the front identified in the 2009 observations over the crest of the ridge dividing the cavity. Including time running in open water before going beneath the ice and the track to and from the ridge, this mission was expected to last around 38 hours. Although long, it was considered the least risky mission, as it was to be run entirely over ground surveyed in 2009. The second mission (red track, equivalent to number 2 in the earlier list) was also to be run entirely within the outer cavity, but included two legs into the unsampled southern embayment. Although unexplored, gravity and seismics indicated a deep basin beneath relatively thin ice, so we did not anticipate problems for Autosub3 there. Including time in open water, the mission was anticipated to last around 33 hours. The third mission (blue track, number 2 in the earlier list) was intended as a repeat of our long section into the inner cavity in 2009, with a short leg to the south to investigate the possibility of warm water access through a gap at the southern end of the ridge, and was expected to run for a total of around 37 hrs. The final mission beneath Pine Island Glacier (green track, number 4 in the earlier list) was to follow the line that we felt offered our best chance to access the inner cavity in the north. On the way back out it was to traverse between the US moorings then exit the cavity along the line of the mid-ice-front meltwater outflow. Total duration should have been around 30 hours.

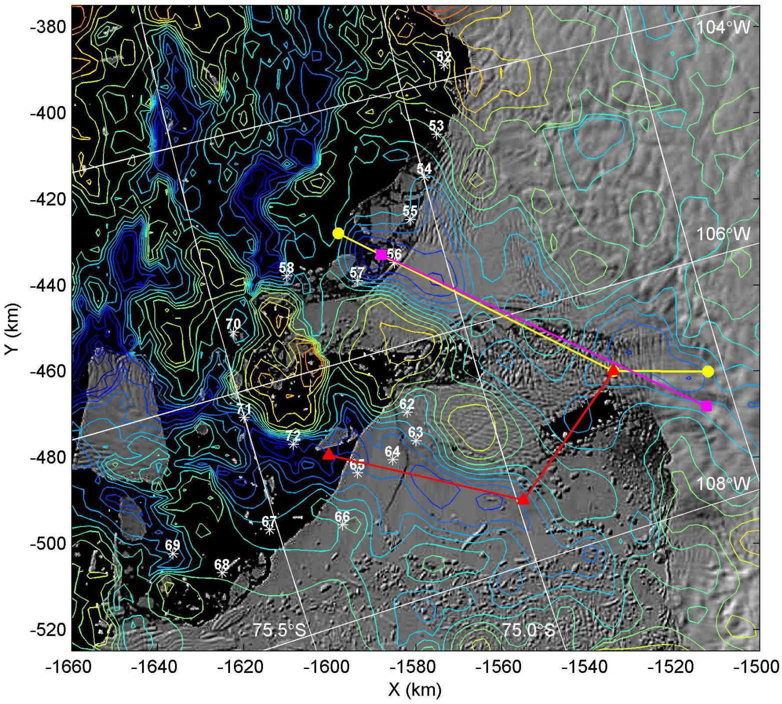


Figure 6.2: *As Figure 6.1, showing planned Autosub3 mission tracks beneath Thwaites Glacier Tongue. In this January 2014 image much of the western half of the tongue has broken out, leaving a large area of fast ice and trapped icebergs.*

The planned exploratory missions beneath Thwaites Glacier are shown in Figure 6.2. Bathymetric soundings indicated two separate troughs extending beneath the ice tongue, while inversion of airborne gravity measurements suggested that both are separated by sills from the deep channel beneath the main trunk of the glacier. The planned missions initially explored both these channels and crossed the supposed sills to the inner cavity. On the first, longer mission (yellow track) there was an extension to the south to the supposed deepest part of the grounding line. The longer mission was expected to last around 40 hours and the shorter one (red track) around 36 hours. Following delays to the Pine Island Glacier work, the plans were cut to include only one mission following the eastern trough to the grounding line (magenta track). The single mission should have lasted around 36 hours.

6.3 Work completed

A detailed summary of the missions that were run, problems encountered and data collected are given in the following sections. A brief outline is given here to describe how the plans evolved from that described above to what was actually programmed.

A test mission (M445) was run on arrival in Pine Island Bay on 10th February. The mission ended prematurely when the motor on Autosub3 stopped. Following recovery it became apparent that not only were there technical problems with the AUV, but some of the sensors were also not functioning properly. The main problem was with the multibeam echosounder, and despite the best efforts of the technical team this could not be fixed. Hence the instrument was not run on subsequent missions. The transmissometer data looked very noisy, but this was improved after removal, cleaning and deck-testing of the instrument. Underway data remained noisier than the deck-test, but good enough to detect a signal above the noise. Other sensors appeared to be performing well.

Following work to sort out the technical problems with the AUV, M446 was run on 14th to 15th February. The intention was to repeat the test mission, bring the AUV to the surface, download and check data and send it off on the first sub-ice mission if all looked good. The AUV aborted the mission during its initial dive and returned to the surface. Downloaded data showed sensors to be working fine and the reason for the abort proved to be a reaction to spurious data from the upward-pointing ADCP suggesting an obstruction above. It was decided to increase the minimum time required for positive detection of an obstacle above to avoid a repeat of the spurious abort, then send the AUV on a repeat of the intended test mission. The start of this was delayed as icing on the antenna made communication with the AUV impossible until it was close astern. The intention was to send the AUV away on its under-ice mission once the testing phase was complete without commanding it to resurface. Although the test phase was completed without problems, drainage of the batteries was seen to be faster than expected, making it clear that the planned mission could not be completed on the remaining battery power. The AUV was commanded to resurface and recovered onboard.

Following a day to change batteries and figure out the history of the battery drainage the AUV was ready for its next deployment on 16th February. The launch was delayed because of a problem with one of the Argos beacons, but M447 subsequently ran as planned over a period of 42 hours (including launch and recovery) from 16th to 18th February (Figure 6.3). For this and subsequent missions the minimum depth was set to 475 m and the minimum clearance from ice and seabed to 75 m, to allow observation slightly closer to the boundaries than we had achieved in 2009. A detailed mission plan is included in the following section, showing the planned flight profile between waypoints.

With the AUV now operating successfully beneath the ice we were planning for a 12 hour turnaround, changing batteries, processing and quality-controlling data and programming the next mission. However, even though such a rapid turnaround seemed possible, time was already too short to complete all the planned missions. We therefore decided to run one more mission beneath Pine Island Glacier, combining elements of the remaining three missions and lasting around 51 hours. The revised waypoints are plotted in Figure 6.3, and a detailed plan is given in the following section.

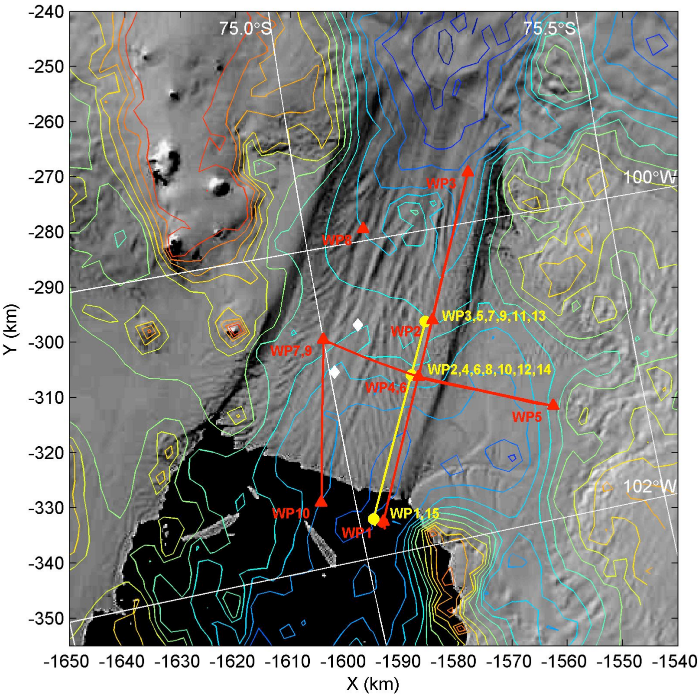


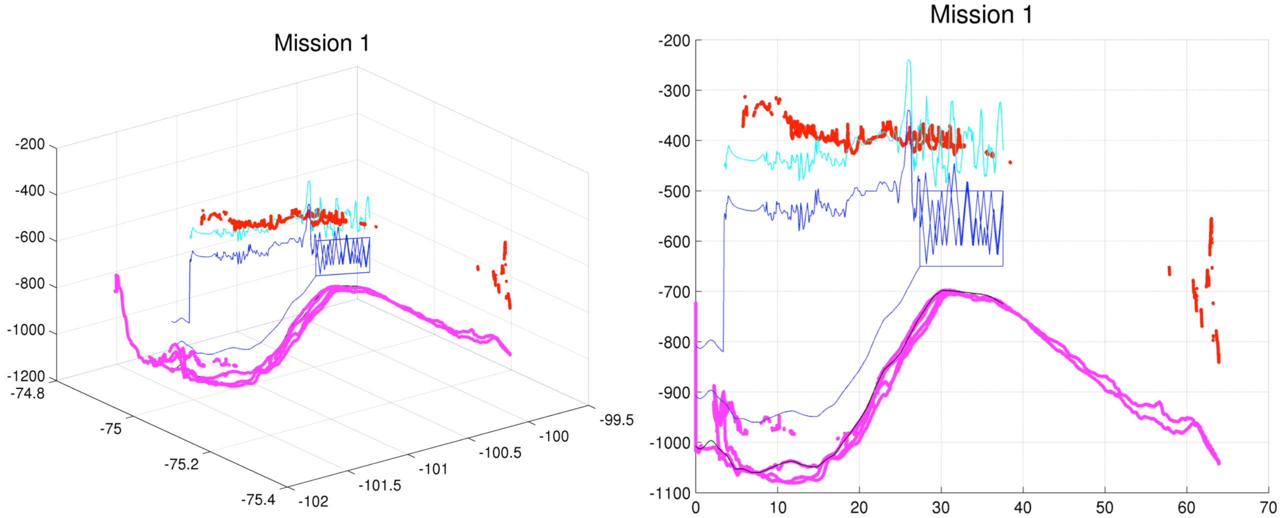
Figure 6.3: *Final waypoints and completed track for M447 (yellow) and M448 (red) beneath Pine Island Glacier. White diamonds show the approximate locations of the US sub-ice moorings deployed in early 2013.*

The AUV was ready for its next deployment on the evening of 18th February. M448 lasted a total of 57 hours (including launch and recovery), finishing in the early hours of 21st February and completing the work at Pine Island Glacier. However, on recovery it became clear that not all had gone according to plan. At some point the AUV had clearly suffered a collision, destroying the turbulence sensors and damaging the nose. On downloading the data it also became clear that one of the waypoints had been missed (Figure 6.3). The complex mission plan had begun to unravel shortly after the turn at waypoint 5. It encountered an obstacle and the avoidance procedure triggered a transition to the next leg of the mission (waypoint 6 to 7). The AUV therefore began profiling, colliding with the ice several times as it did, although apparently without damaging the turbulence sensors at this stage. Since its track to waypoint 7 was now more than twice as long as intended, the AUV timed out and transitioned to the waypoint 7 to 8 leg. However, its course changed little as it took the shortest route to the track between the waypoints. By chance, the 90° turn at waypoint 7 meant that the shortest route to the mission track took the AUV straight towards the waypoint and kept it clear of dangerous territory to the south-east. Before it had attained waypoint 7, a further collision avoidance event forced a transition to the next leg of the mission, returning from waypoint 8 to waypoint 9 (same location as 7). Once again the shortest route to the track took the AUV to the waypoint, so as soon as it reached the track is also attained waypoint 9 and transitioned onto the final leg out to waypoint 10. This leg began correctly, but the AUV collided heavily with the ice while profiling, destroying the turbulence sensors. On the final leg this event triggered a dive to safe depth and a return to the safe (final) waypoint.

Despite the damage to the AUV that needed some remedial action, another 12 hour turnaround was achieved, and we were ready to start M449 on the evening of 21st February. However, lessons learnt about the potential hazards of a complex mission in unknown territory led us to adjust our plans for the Thwaites Glacier. We had hoped to be able to sample both of the seabed channels with one long mission, adding the southern leg of the second (red) mission to the first (yellow). However, we were now wary about planning multiple legs branching from one waypoint so deep in an unknown (except for gravity inversion) cavity. Thus the plan for M449 was reduced to a simple, long, in/out leg as far into the cavity as we could get. We also abandoned plans for profiling. Although the collisions with the ice were found to be the result of a software glitch, in which ranges from the upward-pointing ADCP were not used in the depth control routines during profiling, we considered it safer not to rely on an as yet untested fix. In the end M449 was abandoned when problems emerged with the AUV's pitch control about 4 hours into the open water testing phase. The vehicle was recovered in the early hours of 22nd February in difficult conditions. Unfortunately the AUV was hit by the ship during the operation, sustaining damage to the nose. This effectively brought the Autosub3 operations of JR295 to an end.

6.4 Detailed mission plans

6.4.1) Mission 447



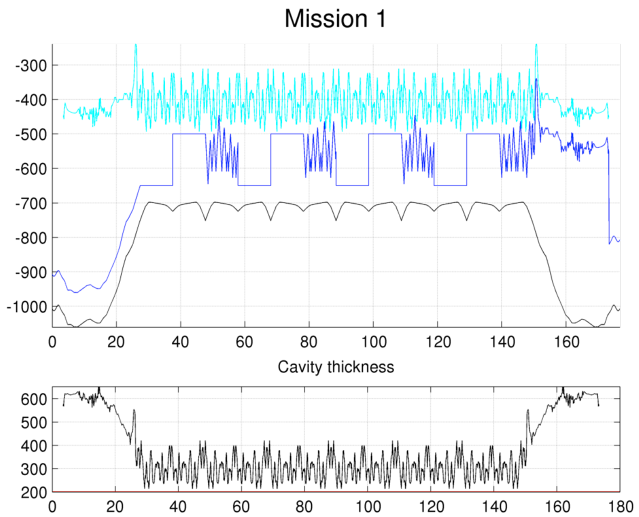


Figure 6.4: *Planned mission track with previous nearby observations and interpolated seabed and ice base elevation from gridded products. Note that the gridded ice base elevation typically overestimates channel-scale undulations. Top left: 3D view in Longitude/Latitude/Elevation space. Top right: view in distance from starting position/elevation space. Centre right: view in along-track cumulative distance/elevation space. Bottom right: along-track cavity thickness.*

Flight plan:

- max depth=1500m;
- min altitude=50m;
- min depth=475m;
- min up-altitude=100m;

Start

Waypoint 1

1. Mode: altitude 100m; Waypoint condition: turn around on limits;

Waypoint 2

2. Mode:constant depth 640m; Waypoint condition: turn around on limits;

Waypoint 3

3. Mode:constant depth 520m; Waypoint condition: turn around on limits;

Waypoint 4

4. Mode:profiling between min altitude and min up-altitude; Waypoint condition: turn around on limits;

Waypoint 5

5. Mode:constant depth 640m; Waypoint condition: turn around on limits;

Waypoint 6

6. Mode:constant depth 520m; Waypoint condition: turn around on limits;

Waypoint 7

7. Mode:profiling between min altitude and min up-altitude; Waypoint condition: turn around on limits;

Waypoint 8

8. Mode:constant depth 640m; Waypoint condition: turn around on limits;

Waypoint 9

9. Mode:constant depth 520m; Waypoint condition: turn around on limits;

Waypoint 10

10. Mode:profiling between min altitude and min up-altitude; Waypoint condition: turn around on limits;

Waypoint 11

11. Mode:constant depth 640m; Waypoint condition: turn around on limits;

Waypoint 12

12. Mode:constant depth 520m; Waypoint condition: turn around on limits;

Waypoint 13

13. Mode:profiling between min altitude and min up-altitude; Waypoint condition: turn around on limits;

Waypoint 14

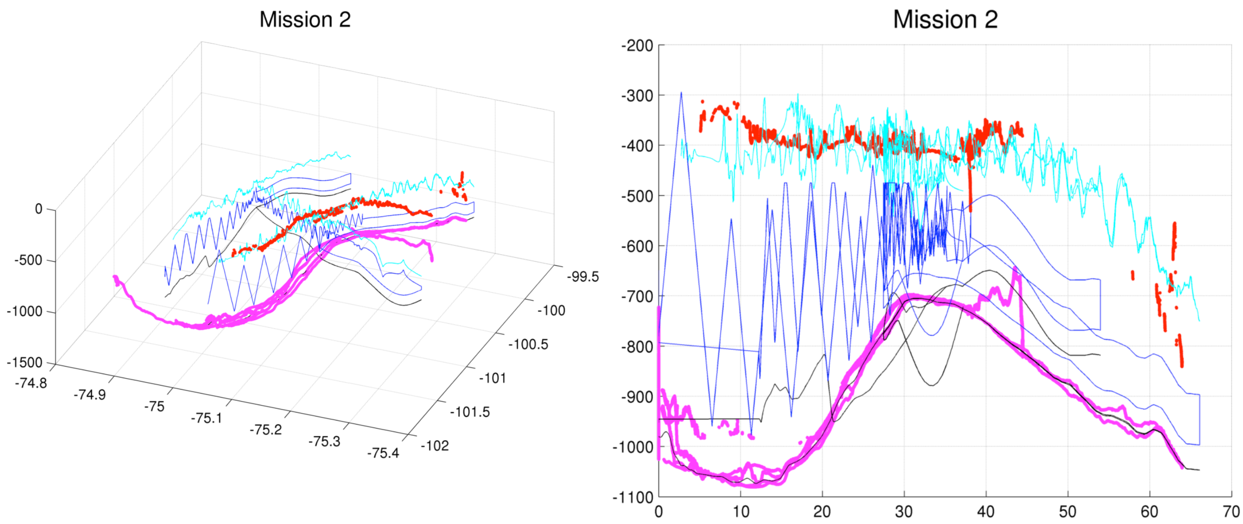
14. Mode: up-altitude 100m; Waypoint condition: always try to reach next waypoint;

Waypoint 15

End

MAIN MISSION WAYPOINTS	AND TIMEOUTS	AND DISTANCES
WP1 = S:75:1.40 W:101:45.50		
WP2 = S:75:7.84 W:100:54.15	T1 = 0:7:29:30	DIS1 = 26.970
WP3 = S:75:10.20 W:100:34.90	T2 = 0:2:47:6	DIS2 = 10.027
WP4 = S:75:7.84 W:100:54.15	T3 = 0:2:47:6	DIS3 = 10.027
WP5 = S:75:10.20 W:100:34.90	T4 = 0:2:47:6	DIS4 = 10.027
WP6 = S:75:7.84 W:100:54.15	T5 = 0:2:47:6	DIS5 = 10.027
WP7 = S:75:10.20 W:100:34.90	T6 = 0:2:47:6	DIS6 = 10.027
WP8 = S:75:7.84 W:100:54.15	T7 = 0:2:47:6	DIS7 = 10.027
WP9 = S:75:10.20 W:100:34.90	T8 = 0:2:47:6	DIS8 = 10.027
WP10 = S:75:7.84 W:100:54.15	T9 = 0:2:47:6	DIS9 = 10.027
WP11 = S:75:10.20 W:100:34.90	T10 = 0:2:47:6	DIS10 = 10.027
WP12 = S:75:7.84 W:100:54.15	T11 = 0:2:47:6	DIS11 = 10.027
WP13 = S:75:10.20 W:100:34.90	T12 = 0:2:47:6	DIS12 = 10.027
WP14 = S:75:7.84 W:100:54.15	T13 = 0:2:47:6	DIS13 = 10.027
WP15 = S:75:1.40 W:101:45.50	T14 = 0:7:29:30	DIS14 = 26.970

6.4.2) Mission 448



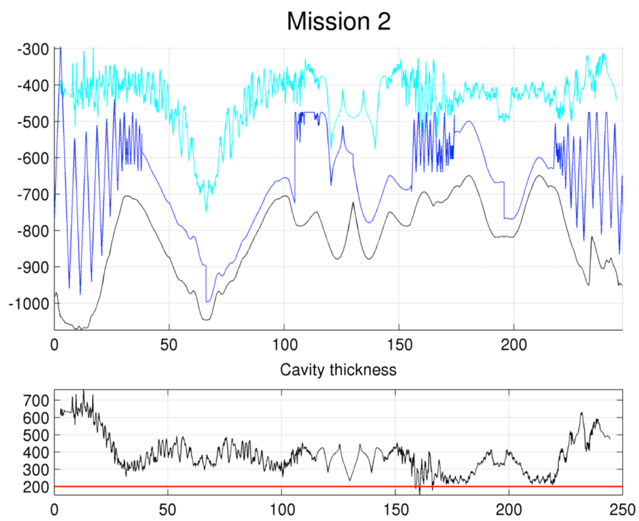


Figure 6.5: *Planned mission track with previous nearby observations and interpolated seabed and ice base elevation from gridded products. Note that the gridded ice base elevation typically overestimates channel-scale undulations. Top left: 3D view in Longitude/Latitude/Elevation space. Top right: view in distance from starting position/elevation space. Centre right: view in along-track cumulative distance/elevation space. Bottom right: along-track cavity thickness.*

Flight plan:

- max depth=1500m;
- min altitude=75m;
- min depth=475m;
- min up-altitude=75m;

Start

Waypoint 1

1. Mode: profiling between min altitude and min up-altitude; Waypoint condition: turn around on limits;

Waypoint 2

2. Mode:altitude 150m; Waypoint condition: turn around on limits;

Waypoint 3

3. Mode:altitude 75m; Waypoint condition: always try to reach next waypoint;

Waypoint 4

4. Mode:up-altitude 100m; Waypoint condition: turn around on limits;

Waypoint 5

5. Mode:altitude 75m; Waypoint condition: always try to reach next waypoint;

Waypoint 6

6. Mode:profiling between min altitude and min up-altitude; Waypoint condition: always try to reach next waypoint;

Waypoint 7

7. Mode:altitude 150m; Waypoint condition: turn around on limits;

Waypoint 8

8. Mode:altitude 75m; Waypoint condition: always try to reach next waypoint;

Waypoint 9

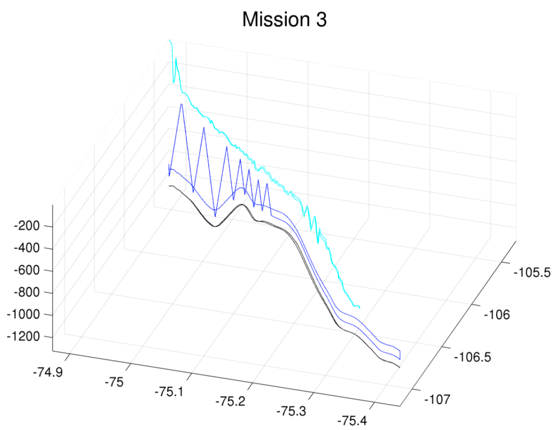
9. Mode:profiling between min altitude and min up-altitude; Waypoint condition: always try to reach next waypoint;

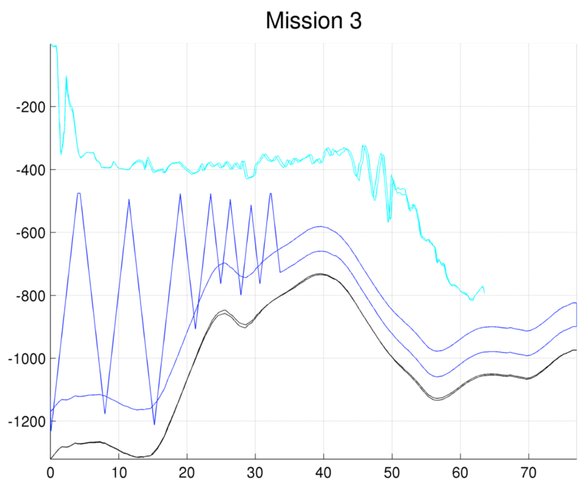
Waypoint 10

End

MAIN MISSION WAYPOINTS	AND TIMEOUTS	AND DISTANCES
WP1 = S:75:2.30 W:101:47.30		
WP2 = S:75:10.90 W:100:34.90	T1 = 0:10:26:19	DIS1 = 37.579
WP3 = S:75:16.92 W:99:40.90	T2 = 0:7:38:59	DIS2 = 27.539
WP4 = S:75:8.53 W:100:55.30	T3 = 0:10:34:16	DIS3 = 38.056
WP5 = S:75:21.04 W:101:16.50	T4 = 0:6:56:14	DIS4 = 24.975
WP6 = S:75:8.53 W:100:55.30	T5 = 0:6:56:14	DIS5 = 24.975
WP7 = S:75:0.00 W:100:34.60	T6 = 0:5:7:26	DIS6 = 18.447
WP8 = S:75:5.80 W:99:55.60	T7 = 0:5:54:57	DIS7 = 21.298
WP9 = S:75:0.00 W:100:34.60	T8 = 0:5:54:57	DIS8 = 21.298
WP10 = S:74:56.70 W:101:35.30	T9 = 0:8:11:33	DIS9 = 29.494

6.4.3) Mission 448





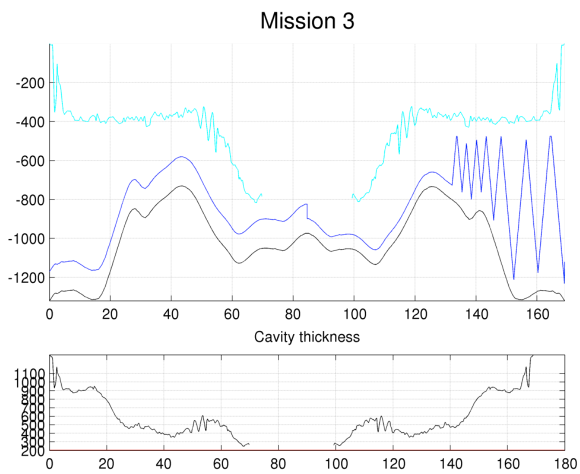


Figure 6.6: *Planned mission track with previous nearby observations and interpolated seabed (from gravimetry) and ice base elevation (from airborne radar) from gridded products. Note that the gridded ice base elevation typically overestimates channel-scale undulations. Top left: 3D view in Longitude/Latitude/Elevation space. Top right: view in distance from starting position/elevation space. Centre right: view in along-track cumulative distance/elevation space. Bottom right: along-track cavity thickness.*

Flight plan:

- max depth=1500m;
- min altitude=75m;
- min depth=475m;
- min up-altitude=75m;

Start
Waypoint 1

1. Mode: altitude 150m; Waypoint condition: turn around on limits;

Waypoint 2

2. Mode:altitude 75m; Waypoint condition: always try to reach next waypoint;

Waypoint 3

3. Mode:profiling between min altitude and min up-altitude; Waypoint condition: always try to reach next waypoint;

Waypoint 4
End

Copy of m449.msinfo:

MAIN MISSION WAYPOINTS	AND TIMEOUTS	AND DISTANCES
WP1 = S:74:52.30 W:105:15.10		
WP2 = S:75:26.50 W:107:12.00	T1 = 0:23:8:53	DIS1 = 83.333
WP3 = S:75:7.40 W:106:4.90	T2 = 0:13:2:0	DIS2 = 46.921
WP4 = S:74:52.30 W:105:15.10	T3 = 0:10:6:52	DIS3 = 36.413

6.5 CTD data

Sensor calibrations

A Seabird SBE9+ CTD system with two sets of sensors was fitted on Autosub3. The primary system on the port side comprised temperature and conductivity sensors connected via the standard Seabird TC duct, then a Seabird SBE43 dissolved oxygen sensor and Seabird submersible pump. The secondary system on the starboard side had a duplicate TC setup followed by a Wetlabs transmissometer and a second submersible pump. All the sensors, apart from the transmissometer had up-to-date pre-cruise calibrations. For the transmissometer the calibration was that undertaken during the January 2009 deployments in Pine Island Bay.

Sensor calibration coefficients that were used for onboard processing were saved in Seabird configuration file “PreJR294.con”, which is listed below:

```
Date: 02/28/2014

Instrument configuration file:
C:\Work\JR294_5\Autosub_CTD\PreJR294.con

Configuration report for SBE 911plus/917plus CTD
------------------------------------------------

Frequency channels suppressed : 0
Voltage words suppressed : 0
Computer interface : RS-232C
Deck unit : SBE11plus Firmware Version >= 5.0
Scans to average : 1
NMEA position data added : No
NMEA depth data added : No
NMEA time added : No
Surface PAR voltage added : No
Scan time added : No

1) Frequency 0, Temperature

 Serial number : 4458
 Calibrated on : 20-Sep-13
 G : 4.34327719e-003
```

H : 6.39185337e-004
I : 2.10788303e-005
J : 1.76348643e-006
F0 : 1000.000
Slope : 1.00000000
Offset : 0.0000

2) Frequency 1, Conductivity

Serial number : 2937
Calibrated on : 04-Sep-13
G : -1.06439565e+001
H : 1.47181216e+000
I : 6.08534778e-004
J : 3.88333656e-005
CTcor : 3.2500e-006
CPcor : -9.57000000e-008
Slope : 1.00000000
Offset : 0.00000

3) Frequency 2, Pressure, Digiquartz with TC

Serial number : 70775
Calibrated on : 14-Feb-08
C1 : -5.011441e+004
C2 : -1.172242e+000
C3 : 1.541650e-002
D1 : 4.151100e-002
D2 : 0.000000e+000
T1 : 2.991772e+001
T2 : -6.711437e-004
T3 : 4.378200e-006
T4 : -8.039270e-011
T5 : 0.000000e+000
Slope : 0.99870000
Offset : -0.29580
AD590M : 1.282100e-002
AD590B : -9.457690e+000

4) Frequency 3, Temperature, 2

Serial number : 4457
Calibrated on : 20-Sep-13
G : 4.32505169e-003
H : 6.30707118e-004
I : 2.00544190e-005
J : 1.72942676e-006
F0 : 1000.000
Slope : 1.00000000
Offset : 0.0000

5) Frequency 4, Conductivity, 2

Serial number : 2938
Calibrated on : 28-Aug-13
G : -1.05440111e+001
H : 1.39697528e+000
I : 4.91807213e-004
J : 4.10747888e-005
CTcor : 3.2500e-006
CPcor : -9.57000000e-008
Slope : 1.00000000
Offset : 0.00000

6) A/D voltage 0, Oxygen, SBE 43

Serial number : 1034
Calibrated on : 17-Sep-13
Equation : Sea-Bird
Soc : 5.37500e-001
Offset : -5.23400e-001
A : -2.72840e-003
B : 9.64150e-005
C : -1.24170e-006
E : 3.60000e-002
Tau20 : 1.47000e+000
D1 : 1.92634e-004
D2 : -4.64803e-002

H1 : -3.30000e-002
H2 : 5.00000e+003
H3 : 1.45000e+003

7) A/D voltage 1, Free

8) A/D voltage 2, Transmissometer, Chelsea/Seatech

Serial number : CST979DR
Calibrated on : 19-Jan-2009
M : 22.0130
B : -0.6850
Path length : 0.250

9) A/D voltage 3, Free

10) A/D voltage 4, Free

11) A/D voltage 5, Free

12) A/D voltage 6, Free

13) A/D voltage 7, Free

Scan length : 30

The primary sensors, including the dissolved oxygen sensor, were fitted to the shipboard CTD, in place of the primary sensors on that system, for CTDNN. This allowed a direct comparison of the Autosub3 primary sensors (the secondary TC sensors were lost during the recovery at the end of the curtailed M449) with the shipboard secondary TC sensors, and underway calibration data derived from the Seabird SBE35 reference temperature sensor and salinometer/Winkler titration determinations of bottle salinities and dissolved oxygen concentrations.

Data processing

The data were processed using version 7.22.2 of the Seabird "Seasoft-Win32: SBE Data Processing Software", following the procedures adopted during the January 2009 missions beneath Pine Island glacier and described in the NBP09-01 Cruise Report "Autosub3 Deployments in the Amundsen Sea".

The processing steps were as follows:

1) Data Conversion: Convert raw data from CTD (.dat file) to engineering units, storing the converted data in .cnv file. Ouput variables were:

#1	Scan count
#2	Time, Elapsed (seconds)
#3	Pressure, digiquartz (db)
#4	Temperature (ITS-90, deg C)
#5	Conductivity (S/m)
#6	Temperature, 2 (ITS-90, deg C)
#7	Conductivity, 2 (S/m)
#8	Oxygen Voltage, SBE43 (V)
#9	Beam Transmission, Chelsea/Seatech/Wetlabs Cstar (%)
#10	Beam Attenuation, Chelsea/Seatech/Wetlabs Cstar (1/m)
#11	Pump status

2) Align CTD: Align data relative to pressure (typically used for conductivity, temperature, and oxygen). Advance values (seconds) used were:

Temperature (ITS-90, deg C)	0
Conductivity (S/m)	0.073
Temperature, 2 (ITS-90, deg C)	0
Conductivity, 2 (S/m)	0.073
Oxygen Voltage, SBE43	6

3) Cell Thermal Mass: Perform conductivity thermal mass correction. Seabird recommended values were used for both conductivity sensors:

Thermal anomaly amplitude (alpha)	0.03
Thermal anomaly time constant (1/beta)	7

4) Derive: Calculate salinity, density, sound velocity, oxygen, potential temperature, dynamic height, etc. Output variables were:

#1	Salinity (PSU)
#2	Potential Temperature (ITS-90, deg C)
#3	Salinity, 2 (PSU)
#4	Potential Temperature, 2 (ITS-90, deg C)
#6	Oxygen, SBE43 (ml/l)
#7	Density (sigma-theta, kg m^{-3})
#8	Density, 2 (sigma-theta, kg m^{-3})

5) Wild Edit: Mark a data value with *badflag* to eliminate wild points. Seabird default values were used and applied to all variable:

Standard deviations for pass one	2
Standard deviations for pass two	20
Scans per block	100
Keep data within this distance of the mean	0

6) Bin Average: Average data, basing bins on pressure, depth, scan number, or time range. The following settings were used:

Bin type	Time, seconds
Bin size	2

This produced the standard two-second binned file, directly comparable to the other Autosub data files. For convenience a second version of this file was produced using the Seabird "ASCII Out" utility with all the header information apart from column headers stripped out. In this format the files can be imported straight into Matlab, producing a data array and a cell array of text strings containing the column headers.

Sensor performance

The Autosub3 CTD sensors produced good data throughout the cruise, with a couple of small caveats, apparent in Figure 6.7. Both temperature/conductivity sensor pairs gave consistent readings, and compared very well with the shipboard system. The only outlier of the four was the primary conductivity on the ship CTD. The discrepancy between the two conductivity cells on the ship was known about, and underway calibration showed the secondary to be the best. The readings from the Autosub3 dissolved oxygen appeared to be systematically low, when compared with the shipboard system. Although the data shown in Figure 6.7 do not include the final calibrations of the ship system, the values recorded in the Circumpolar Deep Water by the Autosub3 sensor do appear to be too low. The most disappointing performance was that of the Autosub3 transmissometer. The data shown in Figure 6.7 are an improvement over those recorded during the initial test mission (M445), when the noise level was around 1-2% and the offset greater. The remaining offset can be removed by recalibration using the shipboard data, while the noise level is no longer high enough to obscure the signal. Clearly the data are not as clean as those from the ship CTD, but the noise level is exaggerated near the bottom, where there were real spatial gradients in the water properties recorded by Autosub3, so the upper part of the trace gives a better reflection of the true sensor performance. Furthermore these data will not be used in quantitative analyses, but only as a qualitative indicator of water clarity.

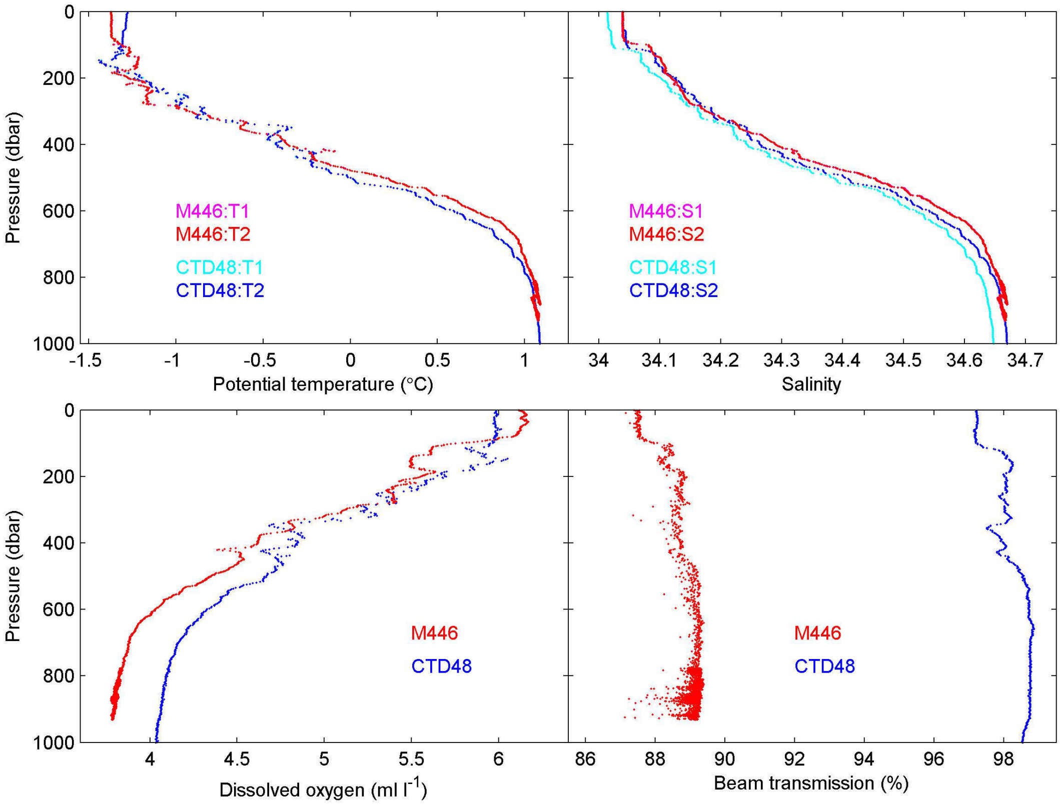


Figure 6.7: *Comparison of CTD data collected by Autosub3 during its main dive from the surface to the deepest point attained on M448 with profiles collected at CTD station number 48.*

6.6 ADCP data

Two ADCPs are fitted on Autosub3. They are used for navigation as well as for current measurements. The first one, a 150 kHz Workhorse Navigator from RDI, is directed upward and is intended to track the ice surface within a maximum range of 200 m. The second one is a 300 kHz Workhorse Navigator intended to track the seabed within a maximum range of 400 m. The configuration and ADCP settings were exact replicas of those used in 2009. The downward looking ADCP is oriented at -45 degrees in the Autosub reference frame. The upward looking ADCP is oriented at 45 degrees. Beam tilt is 60 degrees from the Autosub horizontal plane.

In general, the instruments have been found to give relatively poor results for current measurements, with short ranges and high noise levels. This is very similar to what was seen in 2009. The upward looking ADCP, which has been replaced since 2009, appeared to perform slightly better, but good velocity observations seem limited to 20 m up from Autosub.

Analysis and pre-processing of the raw data was done using a modified version of the software provided in 2009 by Povl Abrahamsen (epab@bas.ac.uk) and Kate Stansfield (ks1@soc.soton.ac.uk). It was used to assess the reliability of the measurements following each mission. More specifically, all processing steps are done using Matlab. For each mission they are summarized in the Matlab script named “processadcp.m” in the “Proc” directory inside the mission directory.

- The first step involves rewriting of the CTD data in Matlab format. It uses the function “cnv2mat_pierreasub.m”. ADCP processing is done here using pre-processed CTD data. Using fully processed CTD data is not expected to make significant differences, but remains to be done.

- The second step involves rewriting the navigation ("loadbnv_pierre.m") and ADCP ("ls3tomat_pierre.m") files, into new Matlab files suitable for the subsequent processing routines. This rewrite is necessary to make sure that numerous software evolutions and changes in Autosub Matlab outputs to not affect the processing.
- The processing is then done in three Matlab programs ("adcp_proc1.m", "adcp_proc2.m" and "adcp_proc3.m") involving operator choices. These choices are recorded in log files.
- A final editing step involves flagging bad velocity estimates. It will be done when final CTD observation are available.

Results for missions M447 and M448 where the ADCP data has been further averaged into 100-m length bins along-track are shown in Figures 6.8 and 6.9.

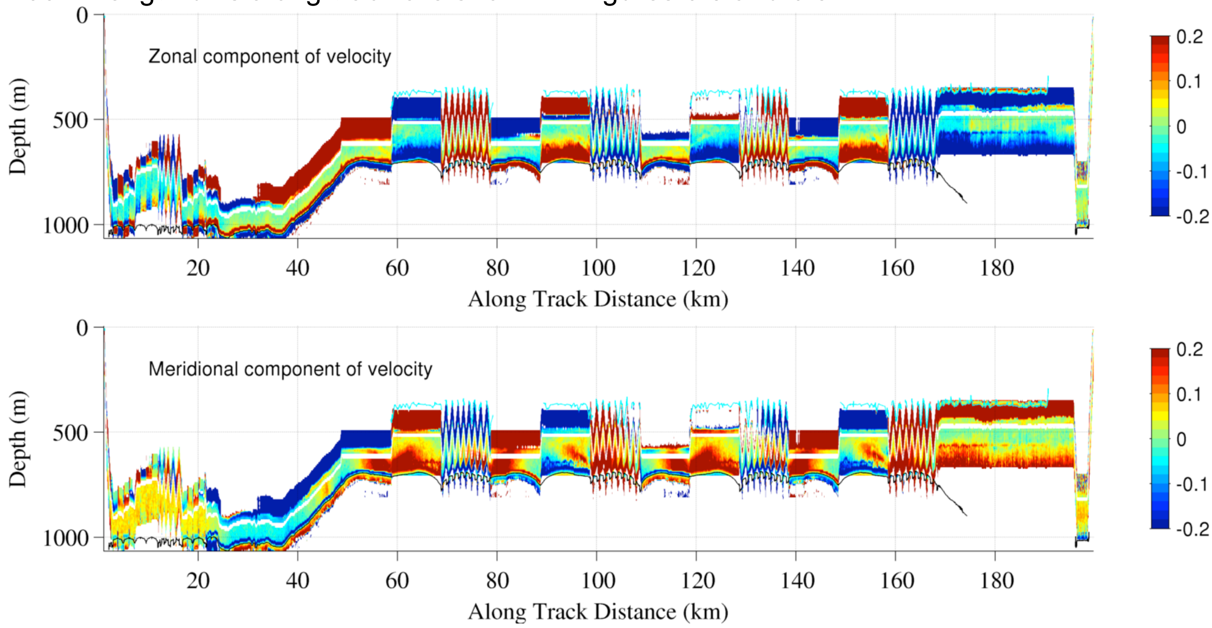


***Figure 6.8:** M447, along-track zonal and meridional components of velocity measured by Autosub 3 upward and downward-looking ADCPs.*

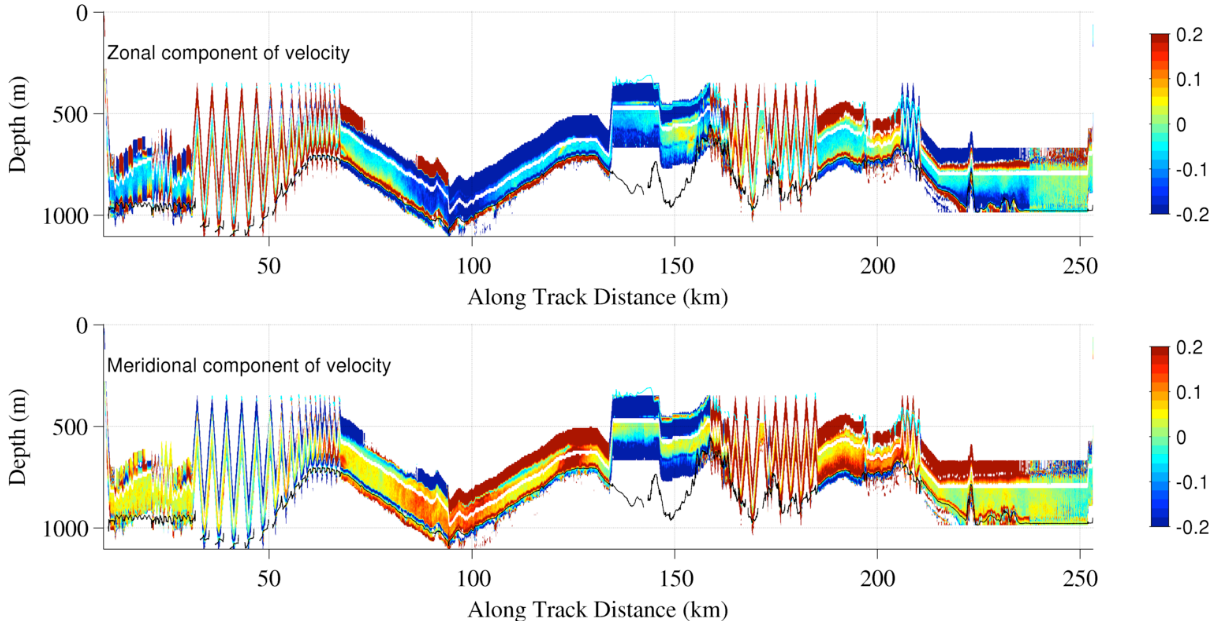


***Figure 6.9:** M448, along-track zonal and meridional components of velocity measured by Autosub 3 upward and downward-looking ADCPs.*

6.7 MicroRider data

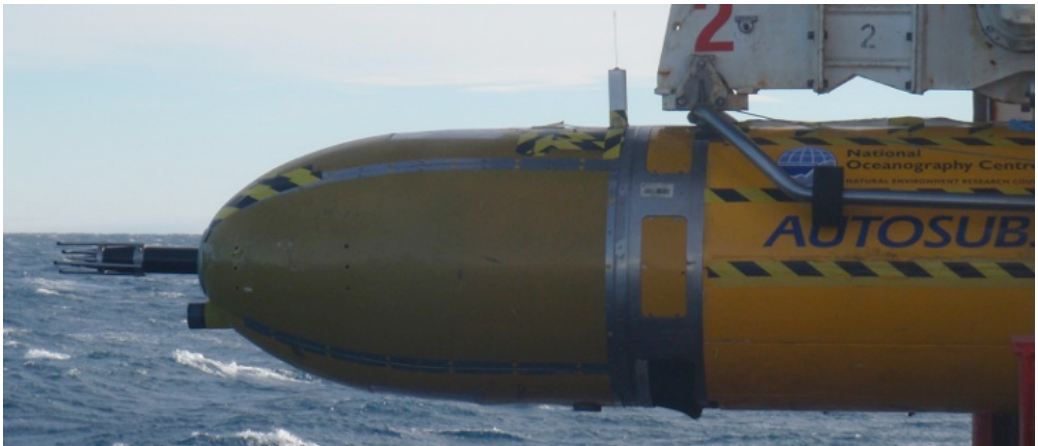
A Rockland MicroRider was mounted at the nose of Autosub 3 (Figure 6.10). It was equipped with two velocity shear probes, two fast response thermistors, one micro conductivity probe, one high-resolution pressure sensor, and high-resolution acceleration and tilt sensors.

Whenever Autosub was onboard, the probes were protected by a specially designed (home made) casing latching on the sensor guard. Given the fragility of the probes, and to limit hazardous handling, it was decided to leave the probes on the MicroRider for the entire duration of the cruise.

The probe setup and characteristics are exactly defined in the following “SETUP.CFG” script, which was installed on the MicroRider internal drive (flash card) before mission M447.

Data were downloaded after each mission using Rockland's recommended software, and basic checks of the probes performances were made to ensure they had not been damaged and remained fit for the next mission. This was done using Rockland's Matlab programs suite, and the function “p_look_HMP.m”, adapted from Rockland's “look_HMP.m”.

A first look at velocity shear and temperature spectra obtained during missions M447 and M448 is not very encouraging: the noise level is typically very elevated, so that only high levels of turbulence, if any, might be inferred from the micro-structure observations. An expected but significant amount of post-processing work will be necessary to obtain useful information from this set of observations.



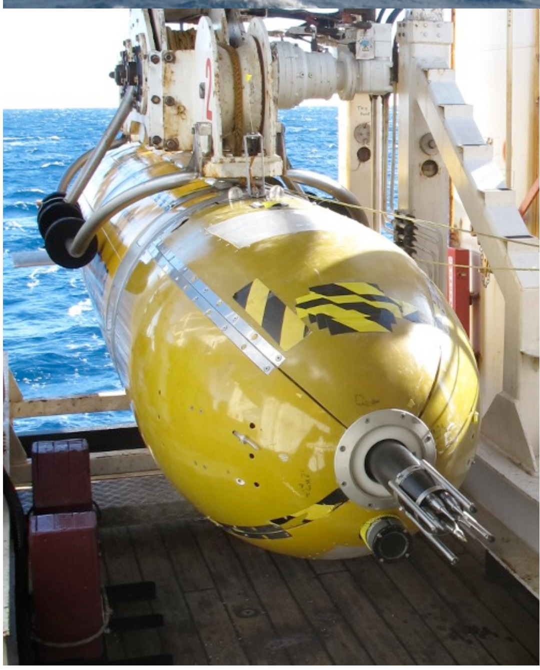


Figure 6.10: *Photo of Autosub 3 being launched for mission M447. Note the position of the MicroRider at the nose of Autosub. The probes were positioned approximately 40 cm forward of the main structure in an attempt to reduce the AUV form drag impact on the flow surrounding the probes without compromising too heavily on the added vibration induced by having a long forward extension. Also, AUV-induced mechanical vibrations were dampened by special rubber-band fixings.*

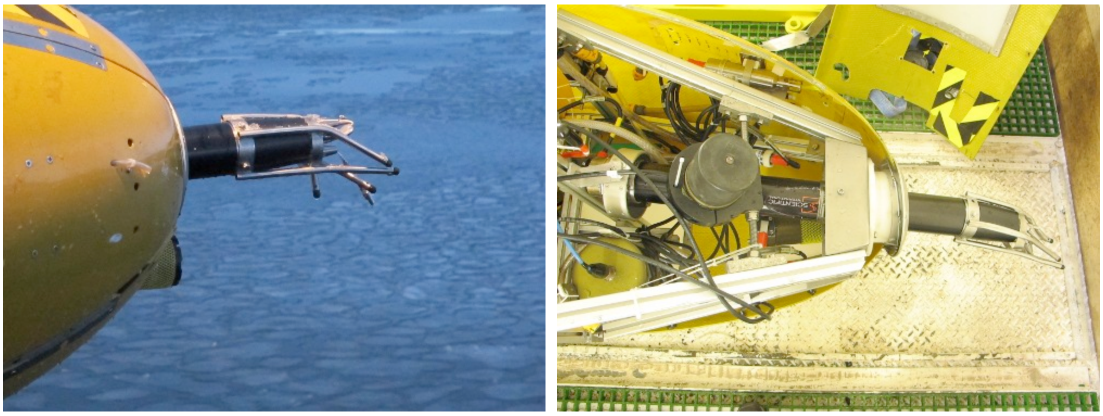


Figure 6.11: *Photo of the MicroRider state after its encounters with the ice (left) during mission M448 and after encountering the hull of the R.R.S. James Clark Ross (right).*

After a rough encounter with the Pine Island Glacier ice base during mission M448 and the loss of all the probes, the MicroRider was redeployed during mission M449. Unfortunately, it was then heavily damaged by the hull of the ship during a difficult recovery (Figure 6.11). The electronic compartment was flooded and now may be beyond repair.

SETUP.CFG

```
;-----------------------------------------------------------------------------------------
; Rolf Lueck, 2010-12-02
; File made for Adrian Jenkins MR6000-LP SN083, 2013-05-10 by DC
; Modified to account for specific probe calibration parameters / Pierre Dutrieux and Adrian Jenkins, January 2014
rate=512
prefix=dat_
disk=c:/data
recsize=1
profile=horizontal
no-fast=8
no-slow=2

[matrix]
num_rows=8
row01=  255   0    1    2    5    7    8    9    64   65
row02=  32    40   1    2    5    7    8    9    64   65
row03=  41    42   1    2    5    7    8    9    64   65
row04=  4     6    1    2    5    7    8    9    64   65
row05=  10    11   1    2    5    7    8    9    64   65
row06=  12    0    1    2    5    7    8    9    64   65
row07=  0     0    1    2    5    7    8    9    64   65
row08=  4     6    1    2    5    7    8    9    64   65
```

[channel] id=0 type=gnd name=Gnd coef0=0	[channel] id=8 type=shear name=sh1 diff_gain=0.93 SN=M996 sens=0.0784 adc_fs=4.096 adc_bits=16	[channel] id=5 type=therm name=T1_dT1 diff_gain=0.94 adc_fs=4.096 adc_bits=16 a=-8.7 b=0.99812 G=6 E_B=0.68248 SN=T758 beta=3143.55 T_0=289.15 units=[degC]

[channel] id=1 type=accel name=Ax coef0=0 coef1=1	[channel] id=9 name=sh2 type=shear diff_gain=0.95 SN=M999 sens=0.0801 adc_fs=4.096 adc_bits=16	[channel] id=6 type=therm name=T2 adc_fs=4.096 adc_bits=16 a=-9 b=0.99811 G=6 E_B=0.68242 SN=T759 beta=3143.55 T_0=289.15 units=[degC]
[channel] type=accel id=2 name=Ay coef0=0 coef1=1	[channel] id=4 type=therm name=T1 adc_fs=4.096 adc_bits=16 a=-8.7 b=0.99812 G=6 E_B=0.68248 SN=T758 beta=3143.55 T_0=289.15 units=[degC]	[channel] id=7 type=therm name=T2_dT2 diff_gain=0.94 adc_fs=4.096 adc_bits=16 a=-9 b=0.99811 G=6 E_B=0.68242 SN=T759 beta=3143.55 T_0=289.15 units=[degC]
[channel] id=32 type=voltage name=V_Bat adc_bits=16 adc_fs=4.096 G=0.1 units=[V]	[channel] id=10 type=poly name=P coef0=6.12 coef1=0.24913 coef2=1.039e-7 coef3=0 adc_fs=4.096 adc_bits=16 units=[dBar]	[channel] id=11 type=poly name=P_dP coef0=6.12 coef1=0.24913 coef2=1.039e-7 coef3=0 diff_gain=20.48 adc_fs=4.096 adc_bits=16
[channel] id=40 type=inclxy name=Incl_Y coef0=0 coef1=0.025 units=[deg]	[channel] id=41 type=inclxy name=Incl_X coef0=0 coef1=0.025 units=[deg]	[channel] id=42 type=inclt name=Incl_T coef0=624 coef1=-0.47 units=[degC]
[channel] id=12 type=poly name=PV coef0=4.096 coef1=1.25e-4 coef2=0 coef3=0 units=[V]	[channel] id=64 type=ucond name=C1 a=-0.4758 b=118.5 SN=C157 K=1.03e-3 adc_fs=4.096 adc_bits=16 units=[S cm^{-1}]	[channel] id=65 type=ucond name=C1_dC1 a=-0.4774 b=118.9 SN=C157 K=1.03e-3 diff_gain=0.402 adc_fs=4.096 adc_bits=16 units=[S cm^{-1}]

6.8 Sub-bottom profiler data

Given the lack of Autosub echo-sounder observations during this campaign, the sub-bottom profiler is the only available instrument capable of high resolution observation of the seabed.

It was mounted at the bottom of Autosub and oriented downward. Initial looks at the observations using EdgeTech's proprietary software, JSTAR, shows that the profiler performed well, and will allow us to identify both the seabed structure and, surprisingly, echo reflections from the ice base.

No navigation data were fed to the instrument during the missions, so this needs to be done in post-processing. A crude Matlab program was written during the cruise to read raw EdgeTech files. Figures 6.12 and 6.13 were made using this program. Further work is required to precisely determine the time offset between the Edgetech and Autosub navigation, and correct the sound speed (assumed for now to be 1500 m/s) to obtain accurate altitude observations.

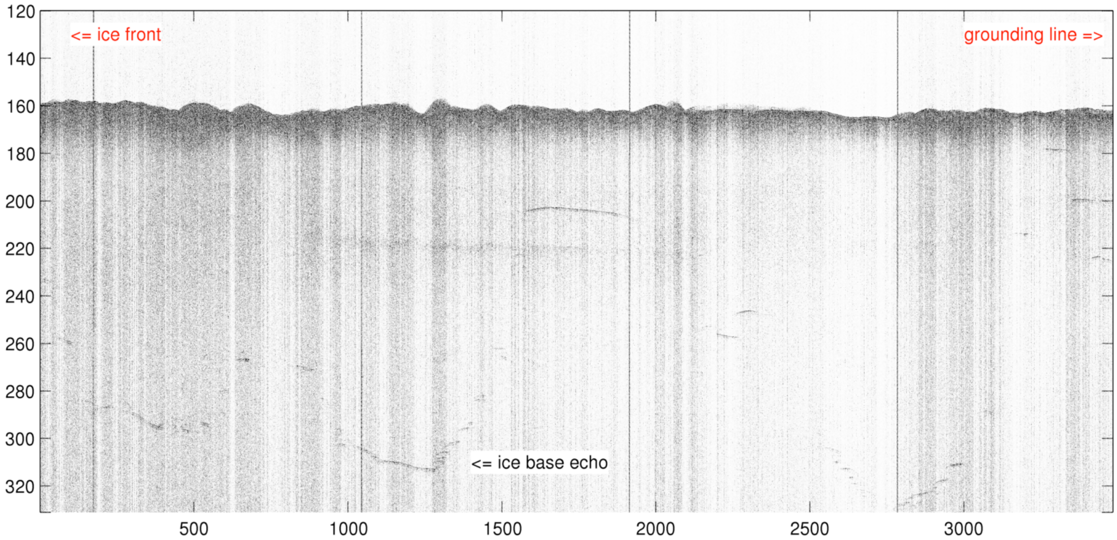


Figure 6.12: ~3500 m-long sample of sub-bottom profiler data as Autosub was passing the top of the ridge into the inner cavity, ~35 km from the ice front.

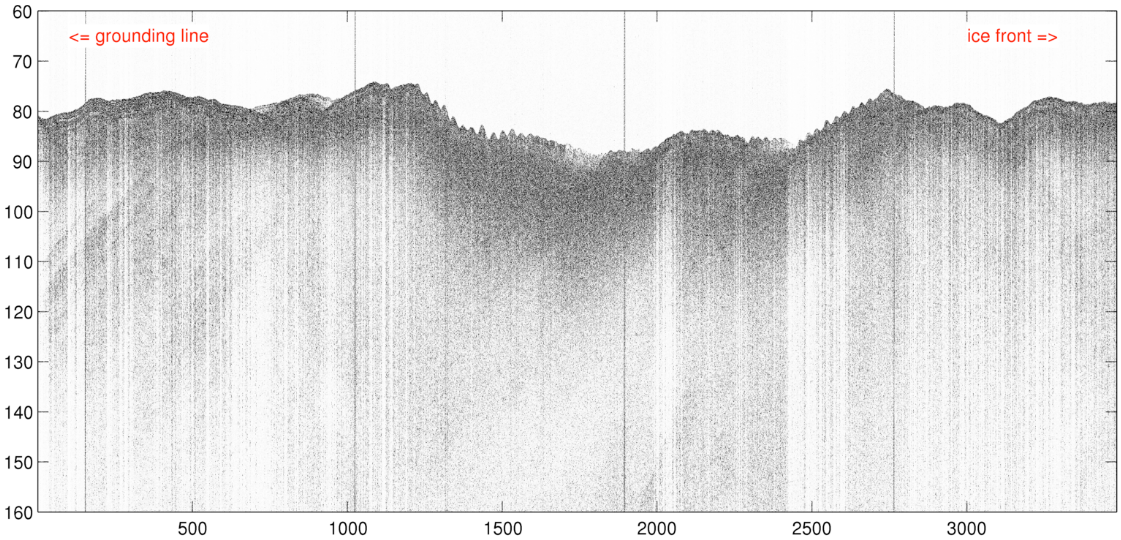


Figure 6.13: Near grounding line ~3500 m-long sample of sub-bottom profiler data as Autosub turned around ~60 km from the ice front.

6.9 Autosub3 acoustic operations

Autosub3 carries three independent acoustic communications devices, as well as the acoustic measuring devices; the upward and downward looking ADCPs, the EM2000 swath bathymetry echo sounder, the Edgetech 2-16 kHz Sub-Bottom Profiler.

(1) Emergency beacon

The emergency beacon transmits a 4.5 kHz narrow-band chirp to communicate over a long range. It was used on missions to track the sub on its outward leg under the glacier. The transducer is deployed by hand, via a sheave mounted on the ship's rail, to a depth of about 20m. (100m of cable, from the exit point of the work space).The deck unit and controlling laptop (Samsung) were housed in the starboard side of the Main Laboratory, near to a feed through port to the deck cabling. The laptop was used to run the NOC "beaconview" program.

(2) LinkQuest digital telemetry system

Autosub3 carries a LinkQuest Tracklink modem and transponder which is used to track and command the sub when underwater, and to receive a limited subset of digital data. The transponder tube is mounted in the lower part of the AUV's nose section, with the transducer on a bracket inside and at the top of the nose section. The bracket is designed to swivel on an impact from above, for example if the sub collides with the counter stern of the ship. The LinkQuest worked well at ranges up to 2-3km, although the tracking display was only available in head-up mode.

(3) ORE LXT acoustic transponder

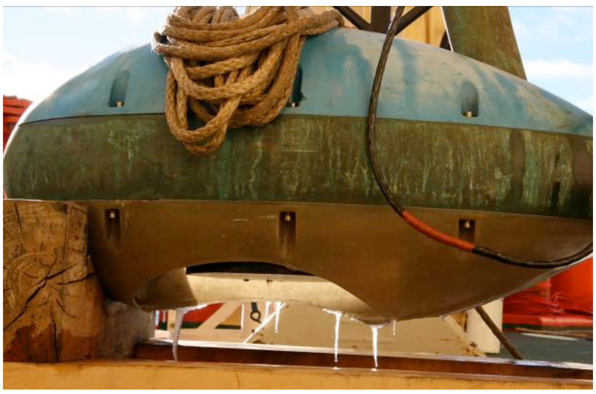
This transponder (also known as the "dumb" transponder) is used for tracking, as a backup for the LinkQuest. As yet, it is not possible to interface the LXT data to the LinkQuest or any other of our tracking displays. The AUV's transponder, which contains a battery pack sufficient for a minimum of 3 months' operations, is mounted in the aft section of the sub. The transducer is mounted forward of the tail fin, and protrudes through the upper panel.
The LXT worked well, tracking the sub to a similar range as the LinkQuest.

Acoustic Tow Fish

With the exception of the emergency beacon receiver array, all the ship born acoustic transducers are mounted on the tow fish. This is a 380kg towed body that was deployed to a depth of 12m from the aft port crane with 700 mm diameter block, and deck winch.

The fish, photos below, contains the LinkQuest surface transceiver, the large diameter receiver and the transmitter. The receiver looks down through a hole in the lower fairing, (about half the area of that fairing). The transmitter is held in a clamp on the tail bar. The LXT transducer is held in a clamp of the same design. These clamps are set up to hold the transducers out on whichever side of the fish is outboard during recovery and deployment, to minimise the risk of damage.

The systems on the fish worked without any incident, although tracking could take a number of minutes to lock in after initial AUV and fish deployments.



6.10 Time Offsets between Instruments

All the instruments onboard the AUV with the exception of the Edgetech sonar and the microstructure probe are synchronised to a common timebase (the data logger).

For reasons unknown at present it is currently not possible to set the system time of the Edgetech Sonar (or synchronise it with the logger), hence the system always starts at 1/1/2001. However, given the need to correct for the time offsets, this is of no real consequence. The pre and post mission synchronisations were achieved using an NOC written monitoring program 'TimeSync'.

For the microstructure probe, the synchronisation was done manually by opening a virtual desktop onto the Autosub logger, which itself had a serial monitor link with the probe. The accuracy of this synchronisation is estimated as +/- 1 second.

Drift rates are of order 1 second per day.

Edgetech time offset and drift source data. (from the TimeSync '.log' files).

```
M447 Start
Time at server 192.168.1.46 ;A is 16/02/2014, 17:53:05.462
Local time is: 17:52:59.921 Difference is 5.540718 seconds
Time at server 192.9.0.101 ; E is 01/01/2002, 02:43:39.406
Local time is: 17:52:59.937 Difference is -9999.000000 seconds

M447 End
Time at server 192.168.1.46 ;A is 18/02/2014, 09:29:06.725
Local time is: 9:29:01.234 Difference is 5.490747 seconds
Time at server 192.9.0.101 ; E is 02/01/2002, 18:19:42.640
Local time is: 9:29:01.249 Difference is -9999.000000 seconds

M448 Start
Time at server 192.168.1.46 ;A is 18/02/2014, 22:31:23.066
Local time is: 22:31:15.765 Difference is 7.300579 seconds
Time at server 192.9.0.101 ; E is 01/01/2002, 01:40:17.625
Local time is: 22:31:15.781 Difference is -9999.000000 seconds

M448 End
Time at server 192.168.1.46 ;A is 21/02/2014, 05:46:25.273
Local time is: 5:46:18.015 Difference is 7.476407 seconds
Time at server 192.9.0.101 ; E is 03/01/2002, 08:55:23.513
Local time is: 5:46:18.203 Difference is -9999.000000 seconds
```

Excel spreadsheet TimeOffsets.xls is provided. The results are in the table, with the last two columns as calculated output.

Mission	Ref - Logger time (sec)	Ref time	[A] Edgetech time	[B] Logger - Edgetech (sec)	[C] Drift rate (unitless)
447start	5.54	16/02/2014 17:52:59.94	01/01/2002 02:43:39.41	**382720155.0**	
447end	5.49	18/02/2014 09:29:01.25	02/01/2002 18:19:42.64	**382720153.1**	**-1.31E-05**
448start	7.30	18/02/2014 22:31:15.78	01/01/2002 01:40:17.63	**382913450.9**	
448end	7.48	21/02/2014 05:46:18.20	03/01/2002 08:55:23.51	**382913447.2**	**-1.83E-05**

Taking the logger time as the reference, then the formula to align the Edgetech time with the logger time is (A(1) is the Edgetech time at the start time, B(1) is the offset at the start time) :

Edgetech_time_corrected = A + B(1) + C(A – A(1));

Microstructure probe time offsets.
These are manually measured offsets and rates, accurate to the order of 1 second. Offset and rate information were obtained for mission 447.

	Logger Time	Microstructure Time [A]	Offset [B]	Drift Rate [C]
447start	16/02/2014 15:23:00.00	16/02/2014 15:22:49.00	**11.0**	
447end	18/02/2014 10:13:00.00	18/02/2014 10:12:47.00	13.0	**1.30E-05**

Where: Microstructure time (corrected) = A + B(1) + C(A – A(1));

6.11 Technical summary of JR295 Autosub missions

#	Dive time (GMT) Final Surface time km travelled, Max Depth Min Voltage, kWhr Dive Latitude, Longitude	Mission Objectives	Major Faults and Comments
M445	10-Feb-2014 14:24:14 10-Feb-2014 21:06:22 27.81 km , 870.4 m 101 Volts, 4.764 kWhr -74.95516, -101.62389	Test Mission to test control modes at depth, telemetry and sensors	Mission Aborted at 870 m due to a software configuration error (over depth). However the abort weight failed to release immediately and due to ballasting error the AUV was neutrally buoyant at 120 m depth. The abort weight finally released (otherwise the AUV would have been lost).
M446	14-Feb-2014 11:24:22 15-Feb-2014 05:09:20 62.87 km , 922.3 m 107 Volts, 8.835 kWhr -75.02437, -101.76569	Test Mission to be followed by 1st mission under ice. 13 kg was removed from the vehicle prior to launch.	The first dive was aborted when the AUV ran to its safe depth position due to noise on the downward ADCP triggering failed collision avoidance. The 2nd attempt at the test was successful, but the battery voltage was too low following the 5 hours monitoring time (and the previous missions usage) for the under ice mission to be attempted, particularly as there was some degree of uncertainty in regard to how long the AUV battery would last. Hence the AUV was commanded to surface. The EM2000 did not work and was disconnected for future missions in order to save 100 W of power. Ice formed on the Wifi antenna hindered recovery.
M447	16-Feb-2014 17:57:58 18-Feb-2014 06:22:48 36.4 hours 229.6 km, 968.4 m 91.42 Volts, 25.5 kWhr -75.02492, -101.76012	Test Mission with 5 hours monitoring with mission under ice with 24 hours of back and forth transects across the ridge.	Mission completed successfully as planned. Ice which formed on the Wifi antenna when the AUV surfaced hindered recovery. The ice also prevented a GPS being received at the end of the mission.
M448	18-Feb-2014 23:07:26 21-Feb-2014 03:09:36 52 hours, 280.6 km, 1008 m 87.65 Volts, 34.16 kWhr -75.03511 -101.80801	Test Mission with 5 hours monitoring with extensive mission under PIG.	The mission was successful, however there was a major problem with crashing into the underside of the ice shelf as noted below. (Pre mission) the front ARGOS beacon not transmitting. Problem, again, was the pressure switch (which had previously been replaced). The AUV crashed multiple times into the ice shelf . The AUV was not responding to the up altitude limit on the ascent phases of profiling. The cause was a software configuration error. An output from the ADCP up node (AvUpAlt) had not been bound into the corresponding input on the Depth control node. The AUV failed to respond to the forward looking collision sensor, which detected an imminent collision.
M449	22-Feb-2014 00:20:12 22-Feb-2014 05:26:22 5.1 hours 36 km , 1228 m 106.4 Volts , 3.8 kWhr	Test mission followed by linear run under Thwaites	Irregular AUV attitude during final part of test portion of mission, prior to sending it to under glacier survey mission, prompted a manual abort of the mission by acoustic command. Investigation reveals a sternplane problem. Investigating.

	-74.87276, -105.25059	glacier and back.	Starboard side nose panel and associated C&T units lost during recovery. Top nose panel severely damaged. Rockland microRider probe severely damaged resulting in water ingression to main pressure tube.

Mission Summary Sheet

Campaign : JR294 ***Mission No.*** : M445

Operating Area : Pine Island Glacier

Vehicle Configuration and sensors used

Sensors used	***Sub configuration***
1) RDI workhorse ADCP 150kHz downwards. 8 m bins 2) RDI Workhorse ADCP 300kHz upwards. 8 m bins. 3) Seabird SBE9+ CTD with dual TC sensors, SBE43 oxygen and Wetlabs transmissometer. 4) PHINS INS 5) Kongsberg EM2000 Multibeam – downward looking. Not functioning. 6) Edgetech sub-bottom profiler 7) Rockwell microrider probe	1) Rear winglets set at 5° pitched downwards. 2) 0 kg Positive buoyancy. 3) 26 battery packs

Mission Objectives & Description

- First deployment of AUV to run an "open water" test mission to exercise all sensors and control systems.
- **Start waypoint , WP1, is** S:74:55.0 W:102:22.0.
- All runs are towards a waypoint two miles to the south. Should take approx 5 hours.

Planned Mission		
AUV action	**Operator Action**	**Expected duration**
Start and Dive		3 minutes
Goto WP1 at 100 m		5 minutes
Descend to 700 m		7 minutes
Circle at 700 m	Get Telemetry Then send "Start"	40 minutes for Timeout to surface.
Depth runs: At 450 to 860 m. 5 minute out and 5 back 6 times.	Track. Deploy Emergency beacon if possible. 10 minute repetition rate.	1 hour
Circle at 700 m	Get Telemetry Then send "Start"	40 minutes for Timeout to surface
Beacon is set at 5 minutes		-
Altitude runs : 15 minutes out and back 2 times. Towards south		1 hour
Circle at 700 m	Get Telemetry Then send "Start"	40 minutes for Timeout to surface
Profile 500 to 800 m depth. 30 minutes out then back.		1 hour
Circle at 700 m	Get Telemetry Then send "Start"	40 minutes for Timeout to surface

Ascend to 60 m		12 minutes
Track sea surface at 50 m down for 10 minutes out, 10 minutes back .		20 minutes
Descend to 700		23 minutes
Circle at 700 m	Get Telemetry Then send "Start"	40 minutes for Timeout to surface
Surface and Stop.	Put Ship in safe position	12 minutes

Mission Conditions

	Start of Mission	***End of Mission***
Time [logger]	10-Feb-2014 14:24:14	10-Feb-2014 21:06:22
Position [GPS]	-74.9544 lat, -101.6187 long.	-74.9541 lat, -101.6200 long.
Sea state	2 m (sheltered by ice shelf)	
Wind speed	F7 from SW	f6
Battery Voltage	113.4 V	99.85 V

Mission Statistics

Mean motor power	NA	***Mission duration***	6.7 hours
Mean water speed	NA	***Distance travelled***	27.8 [km]
Maximum depth	870.4 [m]		

Mission Review

***Mission completed successfully* [yes/no] :** No

Motor stopped suddenly during a profile down stage.
Mission Aborted at 870 m due to a software configuration error (over depth). However the abort weight failed to release immediately and due to ballasting error the AUV was neutrally buoyant at 120 m depth. The abort weight finally released (otherwise the AUV would have been lost). The Jack in the box released during the mission.

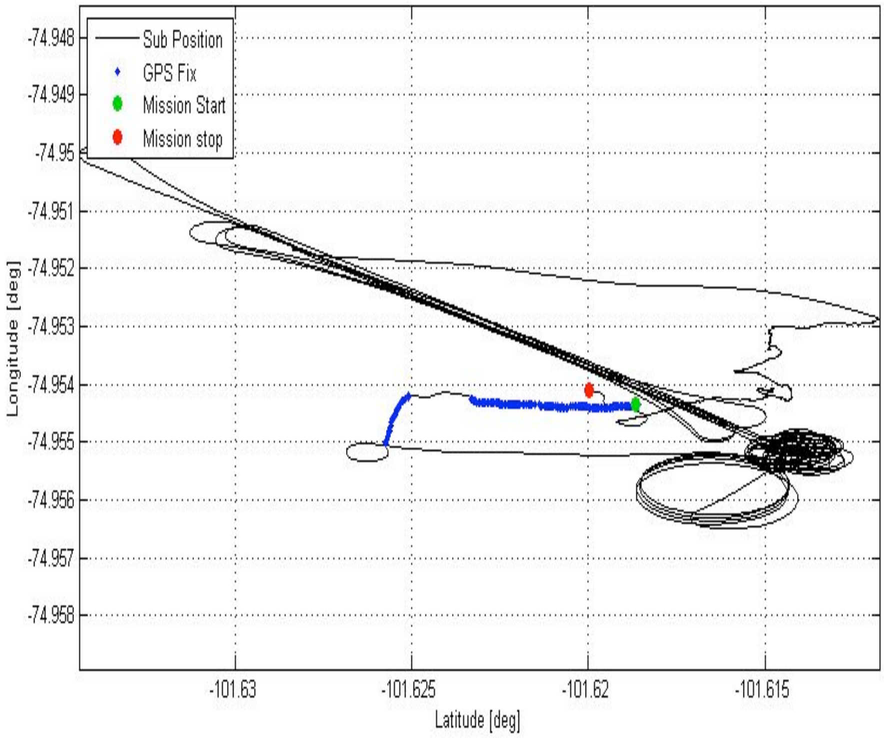
Sensor Data Quality

The multibeam gave no useful data. The transmissometer was noisy and offset. The other data looked good.

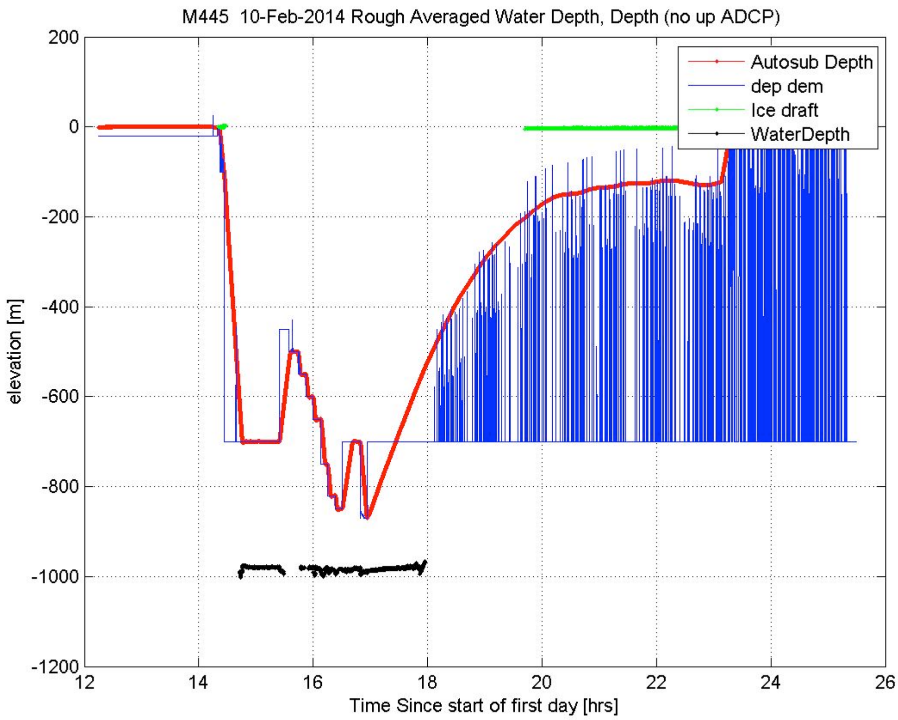
Faults arising during mission

- Motor stopped suddenly during a profile downwards.
- Abort weight did not release on command. Seemed to rattle loose when we were near resigned to having lost the AUV.
- Buoyancy was insufficient to get AUV back to surface. Ascent stopped at 120m water depth. Ballast drop was needed but did not happen.
- Only one ARGOS beacon was picked up (24263 – aft mounted) when on surface.
- WiFi not picked up from front antenna on "Monkey Island", above the bridge. Got connection with rear antenna.
- Multibeam functionality questionable as logged files were all small.
- Jack in the box released during the mission.

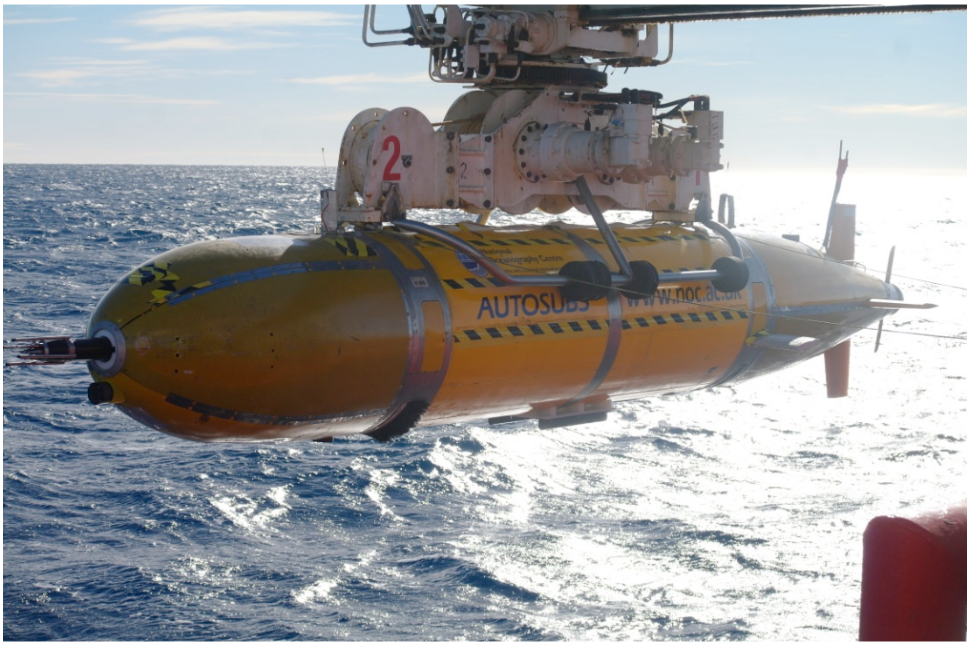
Mission Navigation Plot:



Mission Depth Plot:



Sub launch photo



Mission Summary Sheet

Campaign **:** JR294 ***Mission No.*** **:** M446

Operating Area **:** Pine Island Glacier

Vehicle Configuration and sensors used

Same as M445, Except 13 kg of lead was removed from the AUV.

Mission Objectives & Description

First under ice shelf mission for JR294
Preceded by a test mission.

Mission Conditions

	Start of Mission	***End of Mission***
Time [logger]	14-Feb-2014 11:27:22	15-Feb-2014 05:09:20
Position [GPS]	-75.02437, -101.76569	-75.0276 lat, -101.7868 long.
Sea state		
Wind speed		
Battery Voltage	107 V	94.14 V

Mission Statistics

Mean motor power	430 [W]	***Mission duration***	18.5 hours
Mean water speed	1.5 [m/s]	***Distance travelled***	62.9 [km]
Maximum depth	922.3 [m]		

Mission Review

***Mission completed successfully* [yes/no] :** No – aborted prior to under ice go command. The first dive was aborted when the AUV ran to its safe depth position due to noise on the downward ADCP triggering failed collision avoidance. The 2nd attempt at the test was successful, but the battery voltage was too low following the 5 hours monitoring time (and the previous missions usage) for the under ice mission to be attempted, particularly as there was some degree of uncertainty in regard to how long the AUV battery would last. Hence the AUV was commanded to surface. The EM2000 did not work and was disconnected for future missions in order to save 100 W of power. Ice formed on the Wifi antenna hindered recovery.

Sensor Data Quality

Wetlabs transmissometer – noisy data when in the water. Deck tests show no faults. Need to investigate: connectors, pins, cable or a different device. The EM2000 gave no data and after one more unsuccessful attempt in the lab to fix it, it was in order to save power.

Faults arising during mission

Battery voltage decline is higher than predicted or expected.
Ground fault detection. → noise on transmissometer? → Investigate.
Up ADCP giving a lot of spurious returns at between 200 and 100 m range.

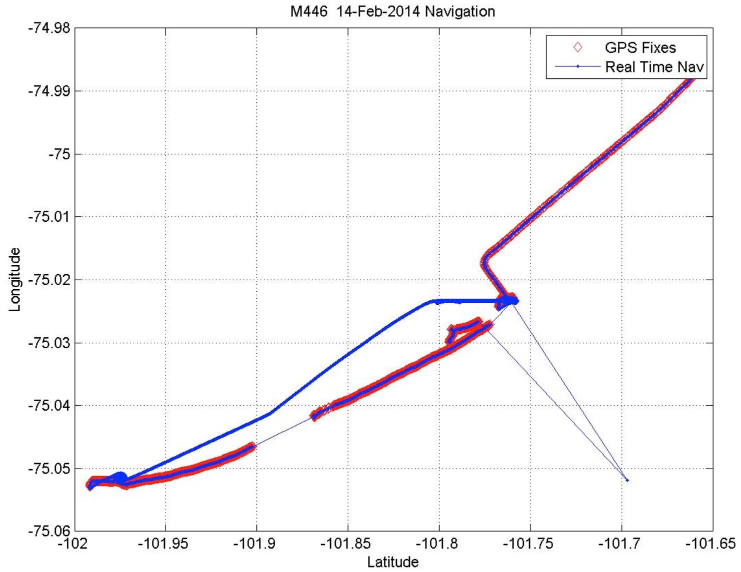
Comments

Propulsion motor showing a higher power consumption than expected → Accelerated battery decline.

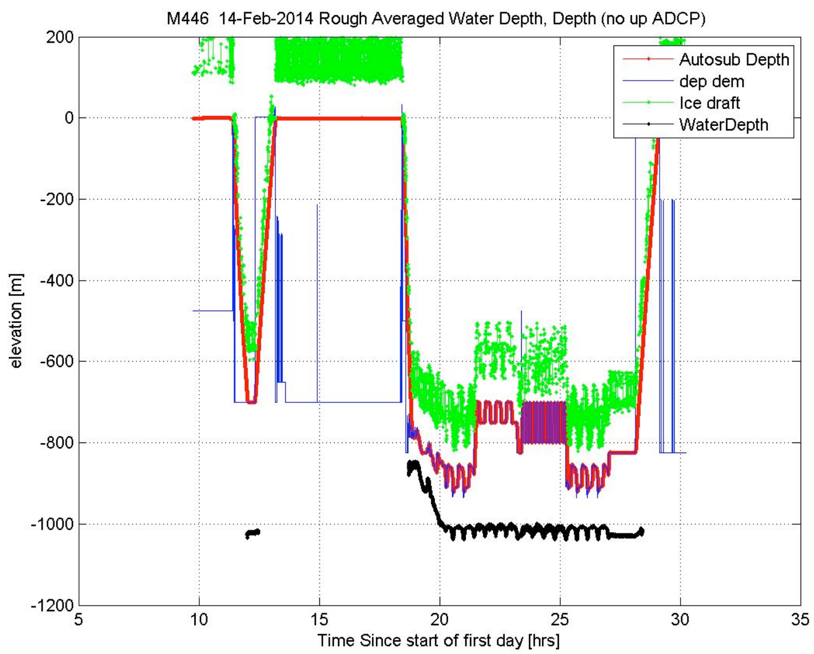
Mission Plan:

Test mission followed by 24 hour to and fro mission over ridge under the PIG.

Navigation Plot



Depth Plot



Mission Summary Sheet

Campaign : JR294 ***Mission No.*** : M447

Operating Area : Pine Island Glacier

Vehicle Configuration and sensors used

Same as M445, M446, except that the multibeam was disconnected.

Mission Objectives & Description

First under ice shelf mission for JR294
Preceded by a test mission.

Mission Conditions

	Start of Mission	***End of Mission***
Time [logger]	16-Feb-2014 17:57:58	18-Feb-2014 06:22:48
Position [GPS]	-75.02492 lat, -101.76012 long	-75.0230 lat, -101.7597 long.
Sea state		
Wind speed		
Battery Voltage	116.3 V	90.57 V

Mission Statistics

Mean motor power	430 [W]	***Mission duration***	36.4 hours
Mean water speed	1.47 [m/s]	***Distance travelled***	229.6 km [km]
Maximum depth	968.4 [m]		

Mission Review

***Mission completed successfully* [yes/no] :** Yes
Mission completed successfully as planned. Ice which formed on the WiFi antenna when the AUV surfaced hindered recovery as the ship needed to get close to the AUV for the Jack in the box to be released. The ice also prevented an GPS being received at the end of the mission.

Sensor Data Quality

All ok.

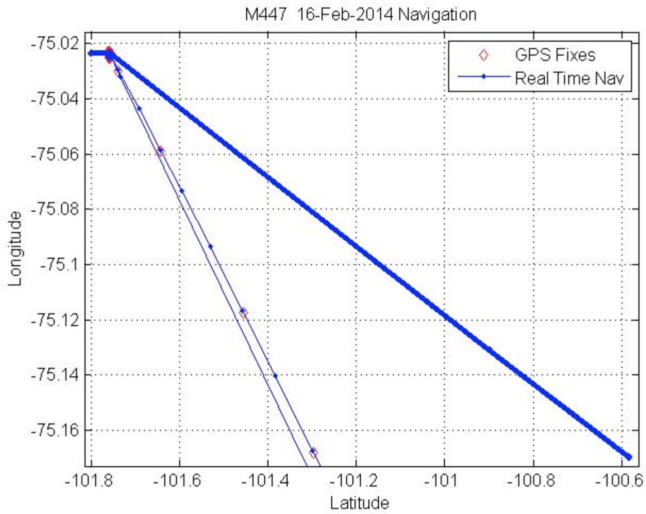
Faults arising during mission

Pre-launch – forward Argos beacon failed.
Replaced defective pressure switch (already had been replaced once – prior to M446).
Up ADCP still noisy despite changes in timing compared to previous mission.
No fix at the end of the mission due to ice build up on the antenna.

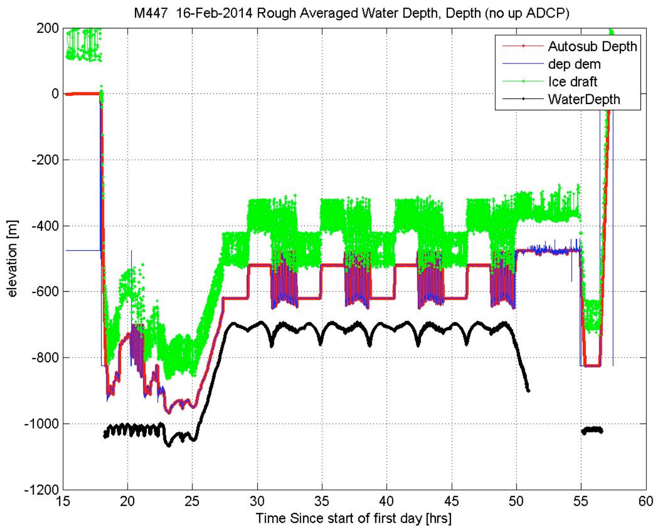
Comments

New battery packs inserted prior to this mission.

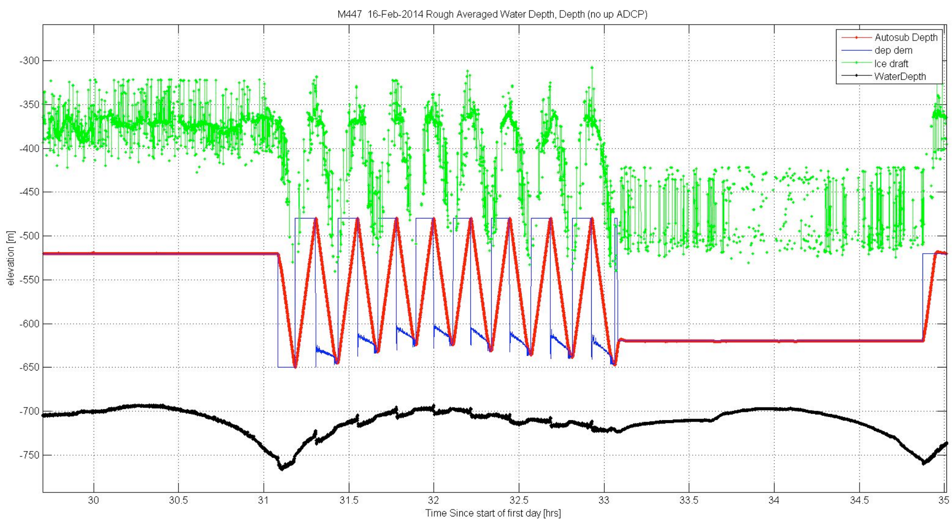
Navigation Plot



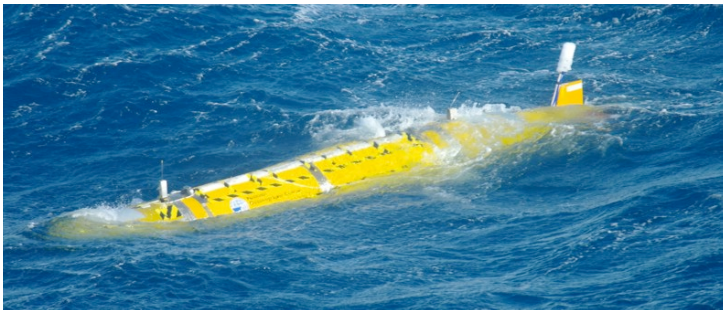
Depth Plot

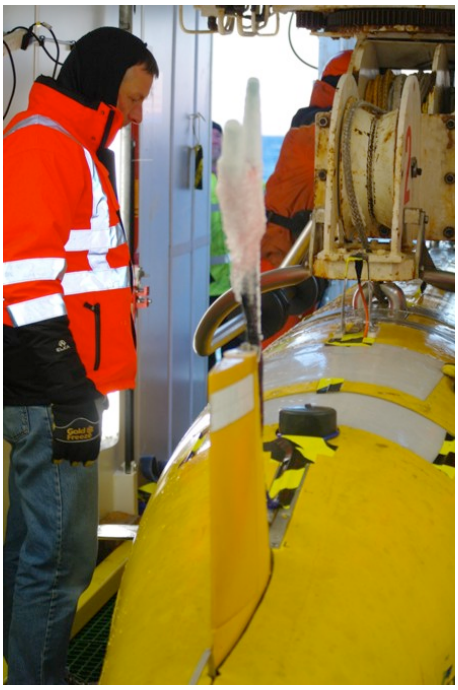


And close up of profiling. Note noisy up ranges.



Photos of Iced Antenna.





Mission Summary Sheet

Campaign : JR294 ***Mission No.*** : M448

Operating Area : Pine Island Glacier

Vehicle Configuration and sensors used

The same as M447. No multibeam.

Mission Objectives & Description

2nd run under the PIG. A plan to survey areas not covered by previous missions.

Mission Conditions

	Start of Mission	***End of Mission***
Time [logger]	18-Feb-2014 23:07:26	21-Feb-2014 03:09:36
Position [GPS]	-75.03511 lat, -101.80801 long.	-74.9546 lat, -101.6088 long.
Sea state		
Wind speed		
Battery Voltage	117 V	87.72 V

Mission Statistics

Mean motor power	430 [W]	***Mission duration***	52 hours
Mean water speed	1.47 [m/s]	***Distance travelled***	280.6 [km]
Maximum depth	1008.4 [m]		

Mission Review

***Mission completed successfully* [yes/no] :** Yes, mostly (until collisions with base of ice shelf).

Sensor Data Quality

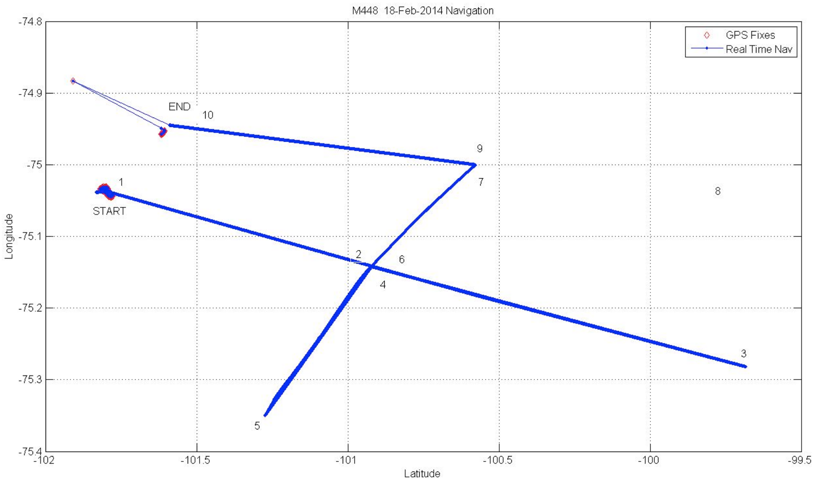
First reports are that sensors were satisfactory. The turbulence probe failed completely after the final collision.

Faults arising during mission

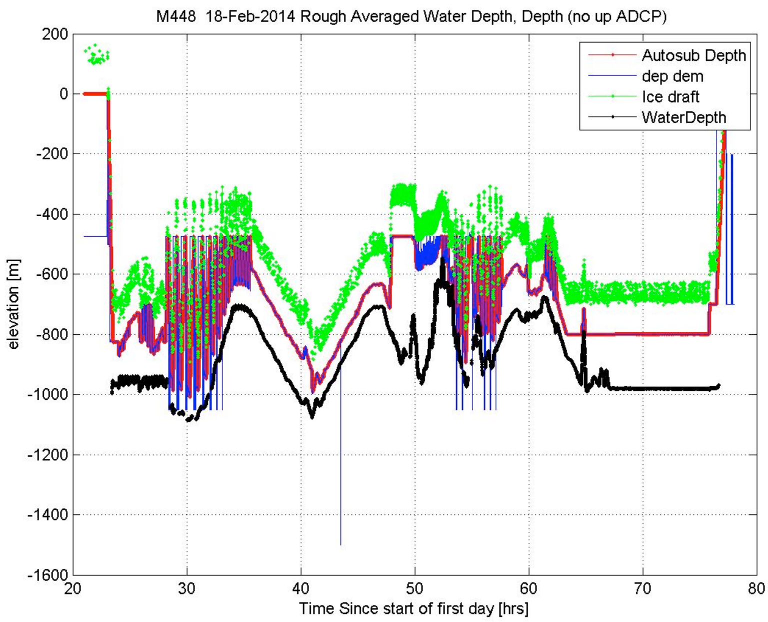
(Pre mission) front ARGOS beacon not transmitting. Problem, again, was the pressure switch (which had previously been replaced).
The AUV crashed multiple times into the ice shelf . The AUV was not responding to the up altitude limit on the ascent phases of profiling. The cause was a software configuration error. An output from the ADCP up node (AvUpAlt) had not been bound into the corresponding input on the Depth control node.
The AUV failed to respond to the forward looking collision sensor, which detected an imminent collision. The only explanation at the present is that a message transmitted over the LonTalk network by the forward sensor node to the position control node was missed. The acknowledge number of retries has been increased for this communication (from 5 to 10 retries).

Navigation Plot

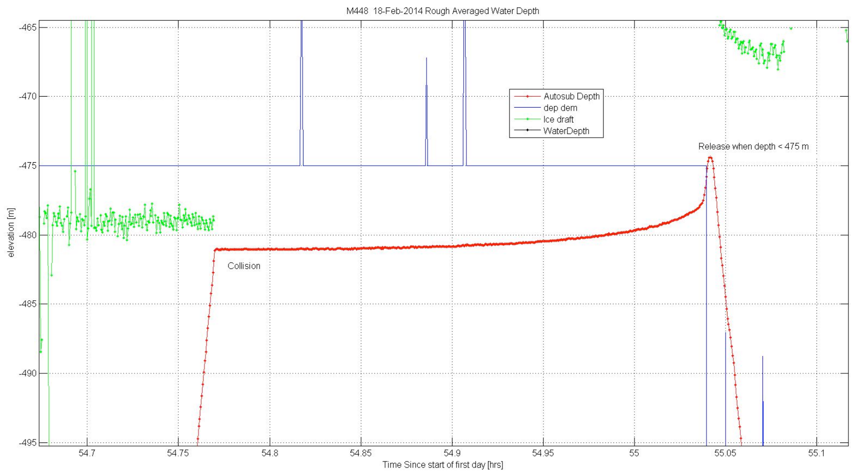
Note that WP 8 to 9 was missed out due to multiple collision imminent detected on track back from 5 to 4.



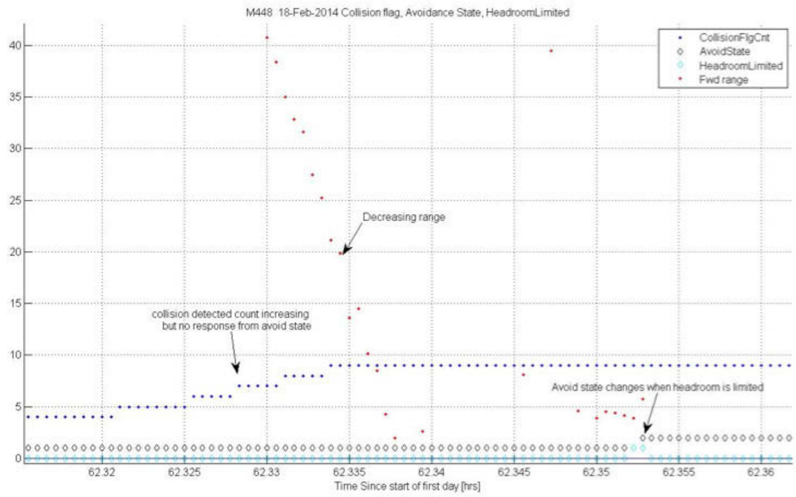
Depth Profile



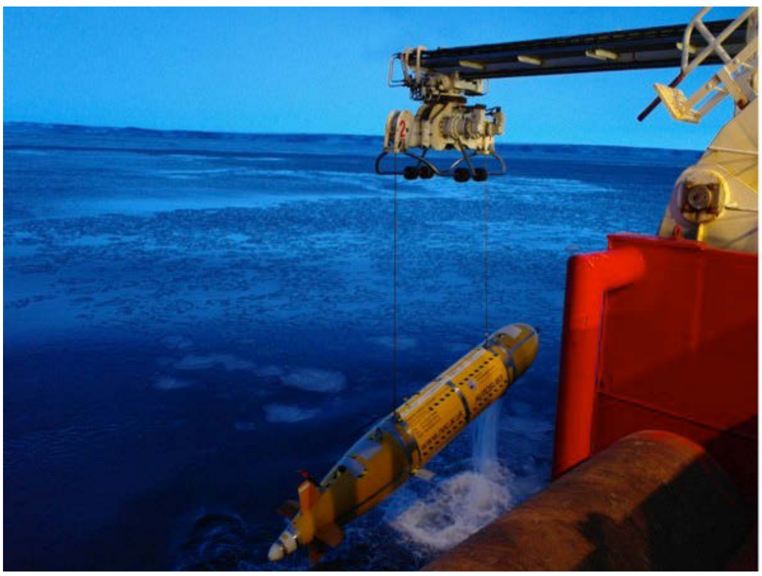
Depth Profile Close Up showing collision on profiling ascent.



Failure to respond to collision imminent detection by fwd look sensor



Recovery of M448



Mission Summary Sheet

Campaign : JR294 ***Mission No.*** : M449

Operating Area : Thwaites Glacier ice shelf

Vehicle Configuration and sensors used

As M446 . EM2000 multibeam disabled. Microstructure probe had no probes.

Mission Objectives & Description

Survey line via two way points under Thwaites Glacier ice shelf.

Mission Conditions

	Start of Mission	***End of Mission***
Time [logger]	22-Feb-2014 00:20:12	22-Feb-2014 05:26:22
Position [GPS]	-74.8726 lat, -105.2509 long	-74.8723 lat, -105.2266 long
Sea state		
Wind speed		
Battery Voltage	112.7 V	107.7 V

Mission Statistics

Mean motor power	430 [W]	***Mission duration***	5.1 hours
Mean water speed	1.25 [m/s]	***Distance travelled***	36.1 [km]
Maximum depth	1227.6 [m]		

Mission Review

***Mission completed successfully* [yes/no] :** No
Mission aborted near end of test portion due to irregular AUV attitudes.

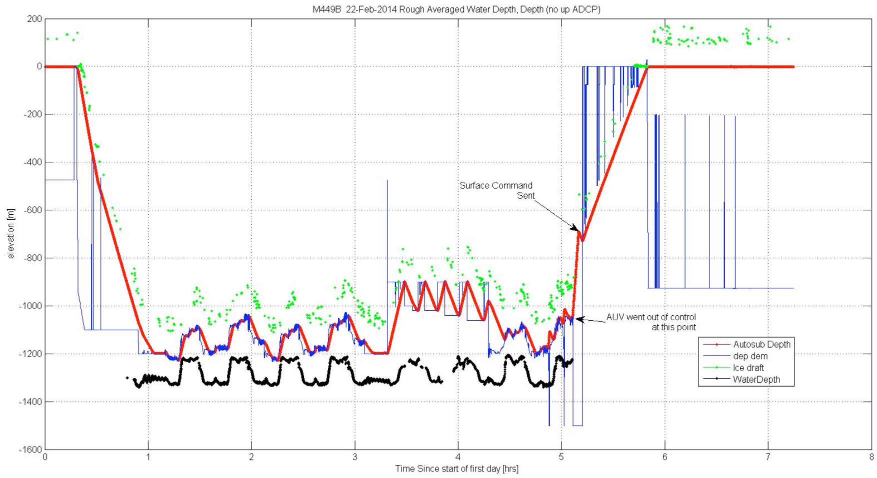
Sensor Data Quality

Pre mission:
EM2000 inoperative.
Turbulence MicroRider probe had been damaged on previous mission beneath Pine Island Glacier ice shelf.
Both kept in-situ for ballast / trim.
Data not recorded on sub-bottom profiler. We suspect an accidental, shutdown of AUV's sub-bottom profiler sonar application during the launch phase. Procedure needs reviewing and updating.

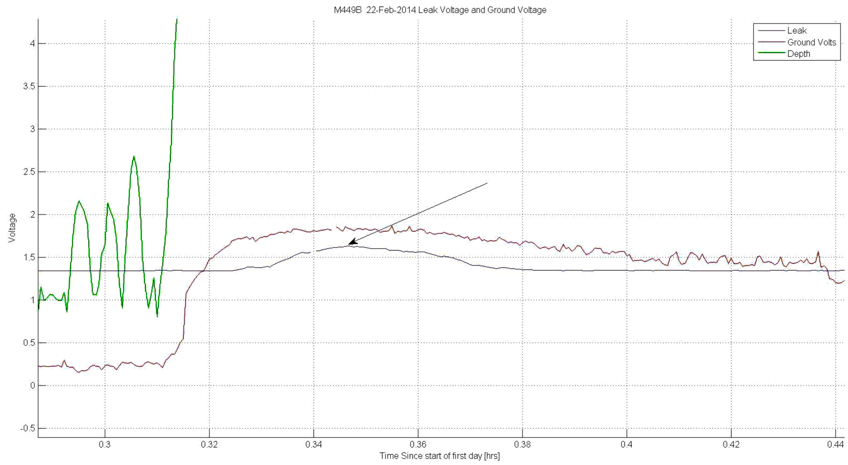
Faults arising during mission

- It was not possible to fit the abort weight pre mission. The cup would not latch into the solenoid. Cause was probably related to the previous damage to the AUV on M448, causing misalignment of the abort solenoid and drop tube. Since this mission was to be predominantly under ice, the assessment of the risk that it would be more risky that the weight dropped accidently than did not drop at all. Hence the abort weight was securely strapped in for this mission using bubble bee and gaffa tape (about 20 total layers).
- Irregular AUV attitude during final part of test portion of mission, prior to sending it to under glacier survey mission, prompted a manual abort of the mission by acoustic command. Investigation reveals a sternplane problem. Investigating.
- Starboard side nose panel and associated C&T units lost during recovery.
- Top nose panel severely damaged.
- Rockland microRider probe severely damaged resulting in water ingression to main pressure tube.

Depth Plot



Leak detected at the start of the dive



6.12 Autosub3 fault log for JR295

#	Date and Mission	Fault
1	28/01 Pre Missions	EM2000 cannot not be set to ping reliably. The ping counter as shown in the monitor program either does not increment or shows a frequency of 0.1 to 0.2 Hz (should be 0.7 Hz). Attempts were made to fault find and fix the system over a period of two weeks. The only clear resolved fault was that the wet lead (TAXI link) connecting the aft dome with the sonar receive head was faulty, open circuit on pin 6 . Ultimately we replaced this and all the cards in the EM2000 system, including the ground plane , and confirmed that the correct signals were being produced by the Lonworks modules. Using the Kongsberg SIS program we were able to find a set of cards which passed the But ultimately despite all these changes the EM2000 still refused to ping reliably. On occasions it pinged at 0.7 Hz for a period of several hours, but then reverted to 0.15 Hz or stopped completely. An inconvenience is that the Kongsberg SIS software is the only software we have for controlling and testing the system. It runs only on the Data processing laptop. This software changes the runtime and install files of the system (preventing the system working correctly) irrespective of how the software is shut down. Hence it is necessary to ensure that there is a backup of these files before doing any tests with the SIS program. Also the sound velocity files appear to be corrupted by the SIS program. The last lead of investigation was to look at the apparently very noisy 48 volt power supply (2 volt p-p , sub 1 microsecond pulses). Is there a problem with the main 48 volt power supply ?
2	29/1 Pre Missions	LXT dumb backup transponder not responding to any interrogation when tested on deck. The cause was that the manufacturer of the battery packs had manufactured them with reversed + / - polarity. Battery packs were re connected and the transponder worked (it provided invaluable when the Linkquest system took a long time to begin telemetry.
3	1/2 Pre	Forward Range Altimeter found to be faulty on test. Its internal power supply had failed, due most likely to overheating. From inspection it was clear that the internal heat sink was require

	Missions	to make thermal contact with the pressure case. This was not occurring with our re-housed system. Heatsink compound used to aid heat dissipation with the replacement unit.
4	1/2 Pre Missions	Face O-ring sealing face on the forward range altimeter sensor pressure badly pitted. (anodising chipped?). Potential for a leak. The face seal was milled flat (removing the anodising).
5	10/2 445 and all after	Scripts for Autosub CTD processing not working. Problem is related to new version of Seabird processing software installed on the processing laptop. This has extra check s and conditions which breaks our processing.
6	10/2 445	Abort of test mission due to over depth. Simple software configuration mistake. The maximum allowed depth was greater than the abort depth. This needs to be caught in the future by procedure o preferably software sensibility checking.
7	10/2 455	Abort weight did not release by when the over depth occurred. Reason is not clear (it had been tested on deck shortly before). It would appear that the problem was mechanical.
8	10/2 445	Jack in the Box prematurely released. Prior to launch It had been found to be a tight fit in its hole. Because of uncertainty that it was latched , a release command was sent. This was not cancelled or the release reset . The jack released but due to its tight fit , this was not apparent immediately It came out later post dive. The use of the releasable Jack float needs reviewing. The float often does not float in a useful configuration. Further if it failed to release for any reason we could have a serious problem. Suggest we go to a system like Autosub6000's.
9	10/2 445	Vehicle buoyancy was neutral at a depth of 120 m. This is due presumably to some measurement, arithmetic, or other mass accountancy error at NOC. It should be noted that the AUV floated Ok on launch. This is presumably due to the thermal expansion of the AUV, as it was at a temperature of ~ 20 Celsius, and immersed into water at ~ -1 Celsius. Hence a (short) line attached dip test would have been unlikely to detect this problem. 13 kg of lead removed before the next mission.
10	10/2 445	Heavy Icing of the AV Wifi antenna prevented contact with the AUV for a long time. Eventually with the ship ~ 50 m away we got Wifi telemetry.
11	10/2 445	ARGOS beacon working (24764) at the end of the mission M445 due to failed pressure switch. Switch was replaced.
12	10/2 445	Transmissometer giving noisy and low readings. This appeared to be related to ground fault on the vehicle. After an in calibration, window cleaning and after cleaning and greasing all front section connectors the ground fault and noise on the transmissometer were both much reduced.
13	10/2 445	On off switch does not effect switching AUV off . The main power switch had failed short circuit. The cause appeared to be a small electrical leakage across the reed switch, causing partial conduction of the power switch and hence failure due to over dissipation. The power switch was then deliberately by passed (short circuited), and in future the AUV was powered by insertion of the fuse pot. This seemed to work well.
14	14/2 446	After checking the battery voltage decline over telemetry, the rate of decline seemed to be greater than expected. Reasons for this was: The motor was running at lower efficiency than expected (extra drag ?) and that I was not initially aware that the type of battery used had a lower capacity than that for the discharge curve I was using. Hence I was using the wrong (optimistic) discharge curve. Contributing to the confusion were lack of any battery temperatures and uncalibrated motor current. The mission was prematurely ended, because it was thought that there was not enough energy to complete the under ice mission with enough reserve.
15	14/2 446	ADCP up giving spurious ranges 100 to 200 m. This fault continued throughout all the other missions. Tried changing the synchronisation timings with no effect. It is not the Edgetech (which is asynchronous with the other acoustic systems). Noticeably the problem was not as severe on the previous mission (445)
16	14/2 446	Mission went to safe waypoint, effectively aborting the mission. The Headroom Limited detect time was set at 10 seconds. This resulted in an the abortive test mission when the collision avoidance returned 'failed' and the AUV returned to the safe waypoint. This is not really a fault. Set the timeout value too low and false triggering is a possibility, too high and the AUV is not responsive enough to collisions. The timeout was increased to 15 seconds for subsequent missions.
17	16/2 447	The ARGOS beacon 26472 was not transmitting before start of mission. The pressure switch was faulty.
18	19/2 448	The AUV crashed multiple times into the ice shelf . The AUV was not responding to the up altitude limit on the ascent phases of profiling. The cause was a software configuration error. An output from the ADCP up node (AvUpAlt) had not been bound into the corresponding input on the Depth control node
19	19/2 448	The AUV failed to respond to the forward looking collision sensor, which detected an imminent collision. The only explanation at the present is that a message transmitted over the LonTalk network by the forward sensor node to the position control node was missed. The acknowledge number of retries has been increased for this communication (from 5 to 10 retries).

20	22/2 449	Irregular AUV attitude during final part of test portion of mission, prior to sending it to under glacier survey mission, prompted a manual abort of the mission by acoustic command. Investigation reveals a sternplane problem. Investigating
21	22/2 449	Collision off AUV with the ship during recovery. The likely mistake was to tie off the lifting lines on a cleat 25m fwd of the stern starboard quarter (responsibility accepted by McPhail for this – I should have stopped this). This is dangerous as AUV is liable to swing under the ship - as it did. We should have taken the lines to the stern, where the connection to our gantry lifting lines could be made. Starboard side nose panel and associated C&T units lost during recovery. Top nose panel severely damaged. Rockland microRider probe severely damaged resulting in water ingression to main pressure tube.

6.13 Autosub3 general data formats

Two post processed data files are produced. Both are in Matlab readable format. These are the *LS2.mat, which is 2 seconds time binned data of all the raw logger data (with the exception of the ADCP, CTD, and EM2000 data), and the *BNV.mat files, which includes navigation post processed data.

The MXXXLS2.mat format. This consists of data sorted into 2 second bins:
ADCP1 is the down looking ADCP. (150 kHz). ADCP2 is the up looking ADCP (300 kHz)

Field Name	Units	Description
'ADCP1Date'	days	ADCP 1 Date / Time. Best to ignore as is not synchronised with the logger time or GPs time.
'ADCP1Hour'	hours	
'ADCP1Minute'	minutes	
'ADCP1Month'	month	
'ADCP1Second'	second	
'ADCP1Year'	year	
'ADCP2AvAlt'	m	Averaged Altitude of all valid beams upwards looking ADCP
'ADCP2Date'	days	ADCP 2 Date / Time. Best to ignore as is not synchronised
'ADCP2Errors'	enumeration	Always zero
'ADCP2Hour'	hours	ADCP 2 Date / Time. Best to ignore as is not synchronised
'ADCP2Minute'	minutes	ADCP 2 Date / Time. Best to ignore as is not synchronised
'ADCP2Month'	month	ADCP 2 Date / Time. Best to ignore as is not synchronised
'ADCP2NodeFl'	enumeration	Always zero
'ADCP2PingH'	256 cnt	High and low bytes of the incrementing counter which triggers the ADCP 1. Used for diagnosing lost triggers.
'ADCP2PingL'	1 cnt	
'ADCP2Pitch'	radians	Pitch axis tilt of 2 ADCP. Note: it is not aligned with vehicle axis.
'ADCP2R1'	m	ADCP2 Range 1 * cos(30 degrees) (not corrected for pitch and roll)
'ADCP2R2'	m	ADCP2 Range 2 * cos(30 degrees)
'ADCP2R3'	m	ADCP2 Range 3 * cos(30 degrees)
'ADCP2R4'	m	ADCP2 Range 4 * cos(30 degrees)
'ADCP2Roll'	radians	Roll axis tilt of ADCP2. Note: it is not aligned with vehicle axis.
'ADCP2Second'	seconds	ADCP 2 Date / Time. Best to ignore as is not synchronised
'ADCP2Spare2'	-	Spare field
'ADCP2VelMod'	enumeration	Velocity mode: 0 =bottom track, 1=water track (bin 2), 3 = speed based on rpm of propeller.
'ADCP2Year'	year	ADCP 2 Date / Time. Best to ignore as is not synchronised
'ADCPAvAlt'	m	Averaged Altitude of all valid beams upwards looking ADCP
'ADCPErrors'	enumeration	Always zero
'ADCPNodeFau'	enumeration	Always zero
'ADCPPingH'	256	High and low bytes of the incrementing counter which triggers the ADCP 1. Used for diagnosing lost triggers.
'ADCPPingL'	1	
'ADCPPitch'	radians	Pitch axis tilt of ADCP1. Note: it is not aligned with vehicle axis.
'ADCPR1'	m	ADCP1 Range 1 * cos(30 degrees) (not corrected for pitch and roll)
'ADCPR2'	m	ADCP1 Range 2 * cos(30 degrees)
'ADCPR3'	m	ADCP1 Range 3 * cos(30 degrees)
'ADCPR4'	m	ADCP1 Range 4 * cos(30 degrees)
'ADCPRev'		Firmware revision ADCP1
'ADCPRev_2'		Firmware revision ADCP2
'ADCPRoll'	radians	Roll axis tilt of ADCP1. Note: it is not aligned with vehicle axis.
'ADCPSpare2'		

'ADCPTemp'	0.01 C	Temperature of ADCP head in centidegrees Celsius
'ADCPTemp_2'	0.01 C	Temperature of ADCP2 head in centidegrees Celsius
'ADCPVelMode'	enumeration	Velocity mode: 0 =bottom track, 1=water track (bin 2), 3 = speed based on rpm of propeller.
'ADCPVer_2'		Version of firmware
'ADCPVersion'		Version of firmware
'AttSpare1'		-
'AttSpare2'		-
'AttStatus'	enum	1 = alignment mode of PHINS.0 = normal.
'Attspare'		
'AvoidState'		
'BlankSize'	cm	Blanking size of ADCP down.
'BlnkSiz_2'	cm	Blanking size of ADCP up
'CellSiz_2'	cm	Profile cell size
'CellSize'	cm	Profile cell size
'CollisFlgCn'		Count of number of times forward range sensor has detected a collision
'CollisImm'		Collision imminent flag from the forward range sensor
'CorMg0'		Correlation magnitude for bottom track
'CorMg_2'		Correlation magnitude for bottom track (looking up)
'DepCtlADCPUpA'	m	ADCP up alt as used by the depth control node. 1000 m for no return.
'DepCtlADCPalt'		ADCP alt as used by the depth control node. 1000 for no return.
'DepCtlDriveFa'		Stern plane drive fault flag. Normally 0.
'DepCtldepth'	m	Depth as used by depth control node.
'DriftEast'	m	DriftEast as measured by GPS Nav node. Usually zero , as this mode of navigation is rarely used.
'DriftNorth'	m	DriftNorth as measured by GPS Nav node. Usually zero , as this mode of navigation is rarely used.
'DropOutCnt'		Number of missed messages for position control node. Is an indicator of network congestion or hardware faults.
'FixType'		0 normally.2 for GPS fix. 4 for acoustic position fix.
'GPSLatitude'	degrees	Latitude for GPS fix.
'GPSLongitude'	degrees	Longitude for GPS fix.
'GPSNodeFault'		Always zero.
'HeadAlign'	0.01 degree	Head align angle in yaw (is 4500 for down ADCP)
'HeadAlign_2'	0.01 degree	Head align angle in yaw (is -4500 for down ADCP2)
'HeadBias'		Always zero
'HeadBias_2'		Always zero
'HeadRmLimited'		0 normally . Is 1 if headroom is limited. (up an down limits cross)
'Heading'	radians	
'HomeAbsHdg'		Homing is disabled. Hence all references which begin with 'Home' are irrelevant.
'INSDepth'	m	Depth as output by INS. (Some very slight difference from raw depth due to the Kalman filtering). Generally is not used
'INSLat'	degrees	Latitude at the INS node output. (Some very slight difference from raw depth due to the Kalman filtering). Generally is not used
'INSLong'	degrees	Longitude at the INS node output. (Some very slight difference from raw depth due to the Kalman filtering). Generally is not used
'INSVEast'	ms-1	Velocity East at the INS output. Is simply slope of the longitude wrt time.
'INSVNorth'	ms-1	Velocity North at the INS output. Is simply slope of the latitude wrt time.
'INSVz'	Ms-1	Velocity Down at the INS output.
'INSspare'	-	-
'Latitude'	degrees	Latitude
'Longitude'	degrees	Longitude
'MCLastEvent'		Mission Control Last Event
'MaxDropOutC'		Maximum number of messages lost on the network
'MinAlt'	m	Altitude used by the depth control. Is normally set to the average of the ADCP beam ranges *cos(30 degrees), but uses the minimum of the two forward beams is these are significantly less than the average.
'MinAlt2'		Up Altitude used by the depth control. Is normally set to the average of the ADCP beam ranges *cos(30 degrees), but uses the minimum of the two forward beams is these are significantly less than the average.

'MinThresh'		Threshold for the ADCP down bottom detection.
'MinThrsh_2'		Threshold for the ADCP down bottom detection.
'MissedFrame'		Ignore.
'MsnCtrlStat'		Ignore
'MsnElementCnt'		Count of number of “when” clauses for the mission control.
'MtrNodeFaul'	0 or 1	Hardware fault indicator
'MtrNodeInfo'	enum	Indicates the state of the motor controller.
'MtrSpare3'		
'NumCells'		Number of ADCP bins (down)
'NumCells_2'		Number of ADCP bins (up)
'NumSat'		Number of satellites seen by the GPS node
'NumWatPings'		Number of water pings.Always 1.
'NumWtPin_2'		Number of water pings.Always 1.
'PCHeadingCt'	radians	Heading control demand generated by the position control node
'PCRudderPos'	radians	Rudder angle
'Pitch'	radians	Vehicle pitch
'PitchRate'	radians s-1	Pitch rate
'PosFault'		Position Control Node Fault
'PosHeadingI'	radians	Heading used by the position control node
'PositionGot'	0 or 1	Position go flag. Is 1 as long as the AUV is within 100 m of the destination waypoint.
'PwrBatI1'	Amperes	Current in battery tube 1.
'PwrBatI2'	Amperes	Current in battery tube 2
'PwrBatI3'	Amperes	Current in battery tube 3.
'PwrBatI4'	Amperes	Current in battery tube 4.
'PwrBatI5'		-
'PwrBatI6'		-
'PwrDCI1'	Amperes	Hotel Current 1
'PwrDCI2'	Amperes	Hotel Current 2
'PwrDCI3'	-	-
'PwrFault1'		Always 0
'PwrFault2'		Always 0
'PwrFault3'		Always 0
'PwrHPSNTmp'		Always 0
'PwrInfo1'		Always 0
'PwrInfo2'		Always 0
'PwrInfo3'		Always 0
'PwrLeak1'		Leak Voltage
'PwrLeak2'		Leak Voltage
'PwrMotorI'	Amperes	Motor Current. THIS is uncalibrated (this is a configuration error – it should be calibrated)
'PwrSpare1'		-
'PwrSpare2'		-
'PwrSpare3'		-
'PwrTemp1'		
'PwrTemp2'		-
'PwrTemp3'		-
'PwrTemp4'		-
'PwrTemp5'	Volts	Ground fault - Hotel
'PwrTemp6'	Volts	Ground Fault - Motor
'Pwr_total_I'	Amperes	Appears to be identical to the Motor Current
'Range'	m	Processed range from range sensor (overange and surface echos removed)
'RangeAux3'		-
'RangeAux4'		-
'RangeFrameC'		Number of data frames (diagnostic)
'RangeToGo'	m	Range to Go to next waypoint.
'RangeTrigCn'		Count of range sensor triggers (diagnostic)
'RateOverld'		Always zero
'RawRange'	m	Raw range. Unprocessed
'RawSeconds'		Seconds Since 00:00:00 1/1/1970
'RelA_S1Info'		Jack release info
'RelA_S2Info'		Sink weight release info
'RelB_S1Info'		Emergency Beacon release info
'RelB_S2Info'		Abort weight release info
'Roll'	radians	AUV Roll

'RollRate'	Radians s-1	
'RudderCtrlDem'	radians	Rudder demand
'Salinity'	ppt	Salinity used by the down ADCP
'Salinity_2'	ppt	Salinity used by the up ADCP
'SeapamCmd'		-
'SerNumHi'		ADCP ping cont Hi and Low
'SerNumLow'		
'SoundSpd_2'		ADCP Up sound speed
'SoundSpeed'		ADCP down sound speed
'SurfaceClea'		Surface clear as detected by the depth control node.
'TSLF'	s	Time since last GPS fix
'Vel2_east'		East velocity from Up ADCP
'Vel2_north'		North velocity from Up ADCP
'Vel_east'		East velocity from Down ADCP
'Vel_north'		North velocity from Down ADCP
'Vfilt_east'		Low Pass filtered East velocity from down ADCP
'Vfilt_east2'		Low Pass filtered East velocity from up ADCP
'Vfilt_north'		Low Pass filtered North velocity from down ADCP
'Vfilt_nrth2'		Low Pass filtered North velocity from up ADCP
'Vwater_east'		Through Water speed East
'Vwater_nort'		Through Water speed North
'Vwatr_east2'		Through Water speed East from Up ADCP
'Vwatr_north2'		Through Water speed North from Up ADCP
'YawRate'	Radians s-1	Yaw rate
'battery_V'	Volts	Battery Volts
'dep_ctrl_dem'	m	Depth control, depth demand
'mtr_I_stpnt'	Amperes	Amperes setpoint for the motor. Note that this is the winding current (proportional to torque outout), not the input electrical current.
'mtr_crnt'	Amperes	Motor Current. This is Uncall
'mtr_volts'	Volts	Motor Volts
'pitch_dem'	radians	Pitch demand
'prop_power'	W	Propeller mechanical power output
'prop_rpm'	RPM	Propeller RPM
'prop_torque'	Nm	Propeller Torque
'splane_dem'	radians	Sternplane demand
'splane_pos'	radians	Sternplane position
't'		?
'vhcl_spd'	ms-1	Speed thru water measured from propeller RPM

The MXXXBNV.mat Data format
This is also sorted into 2 seconds bins. It contains less diagnostic field than the LS2 format, and also contains some post processed navigation data.

Field	Units	Description
Date	m/d/yr	mm:dd:yy Julian Data.
Time	hr/mn/s	hh:mm:ss. UTC
Seconds	s	Seconds Since 00:00:00 1/1/1970
Elapsedtime	s	Since start of navigation file.
Pos_E	degrees	“Best estimate” Longitude. (jumps at GPS fixes removed)
Pos_N	degrees	“Best estimate” Latitude. (jumps at GPS fixes removed)
Depth	m	Depth of vehicle.
Vel_E	ms^{-1}	“Best estimate” East Velocity component.
Vel_N	ms^{-1}	“Best estimate” North Velocity component.
PosRaw_E	degrees	Raw (unprocessed) Longitude.
PosRaw_N	degrees	Raw (unprocessed) Latitude.
PosError	m	Estimate of the position error.
Posfix_E	degrees	GPS Fix: longitude
Posfix_N	degrees	GPS Fix: latitude
FixType	enumeration	GPS fix type. Obsolete. All GPs fixes are 3 D.
TSLF	s	Time since the last accepted GPS fix.
ADCPVelMode	enumeration	ADCP mode of operation: 0,1,2 0 – bottom track, 1 water track, 2 – based on propeller RPM (essentially a fault condition).
ADCPVel_E	ms^{-1}	East Velocity output by Autosub ADCP (down looking).
ADCPVel_N	ms^{-1}	North Velocity output by Autosub ADCP. (down looking).
ADCPAlt	m	Altitude measured by ADCP.

Driftrate_E	ms^{-1}	North Drift rate (or current) estimate.
Driftrate_N	ms^{-1}	East Drift rate (or current) estimate.
Travelled_km	km	Distance traveled (over ground) in km.
LPVel_E	ms^{-1}	North component Low pass filtered (smoothed) velocity.
LPVel_N	ms^{-1}	East component Low pass filtered (smoothed) velocity.
Vwater_E	ms^{-1}	North velocity through water.
Vwater_N	ms^{-1}	East velocity though water.
WaterSpeed	ms^{-1}	Speed through water.
LPGroundSpeed	ms^{-1}	Ground speed. Low pass filtered (smoothed).
LPWaterSpeed	ms^{-1}	Through water speed. Low pass filtered (smoothed).
Pitchdeg	degrees	Pitch of vehicle (degrees)
Headingdeg	degrees	Heading of vehicle (degrees)
Rolldeg	degrees	Roll of vehicle (degrees).
Splanedeg	degrees	Stern Plane degrees
Rudderdeg	degrees	Rudder degrees
Prop_rpm	Rev per minute	Propeller Radial Speed
WaterDepth	m	Depth of water. Is Depth + ADCPAlt. Is "-999" , if vehicle is out of bottom track range (400m) of seabed.
Total Power	Watts	Total electrical power usage.
battery_V	Volts	Battery Voltage.

7 Seaglider Deployments (Stephen Woodward, Bastien Queste)

7.1 Introduction/instrumentation

It was anticipated that two Seagliders would be deployed within the Amundsen Sea for the Ocean2Ice project. The gliders would be deployed on the southbound leg and recovered on the return journey to obtain as long a deployment as possible.
Three sites of interest were identified: the shelf break, a cross-trough section and a section parallel to the ice shelf. Ice conditions prevented an early deployment along the shelf break so the first deployment was planned along a transect south of Burke Island, crossing the trough from its western edge (73° 35 S; 107° 20 W) to near the Lindsey Islands (73° 35 S; 103° 45 W). The purpose of this section was to identify outflow pathways in the eastern trough and assess transport volume either side of Burke Island. The second transect was planned along the Pine Island glacier ice shelf. This second transect aimed to resolve meltwater distribution and proportion within the water column. The Seaglider was deployed near the Autosub test site (74° 55 S; 102° 22 W) and sent towards the iSTAR 8 mooring location for cross-calibration purposes (74° 51.798 S; 102° 06.250 W). The glider was recovered before it began the intended transect between a point to the north of the glacier (74° 45 S; 101° 20 W) and the location of the US BSR5 mooring to the south of the glacier (75° 03.356 S; 101° 59.024 W). The combination of these two transects would hopefully resolve the evolution of watermasses flowing in and out of Pine Island Bay through the trough and under the glacier. SG510 was selected for the PIG deployment as its batteries were already partially depleted from a previous mission and was therefore more suited to the shorter of the two deployments.

Each Seaglider was equipped with a standard sensor package (CT, DO, Wetlabs and PAR) however only one glider was equipped with an enhanced buoyancy engine (SG510).

Table 7.1 -Seaglider sensor configuration

Seaglider ID	Buoyancy engine	Sensor 1	Sensor 2	Sensor 3	Sensor 4
SG579	standard	Seabird CT sail	Aanderaa oxygen	WetLabs Ecopuck	PAR
		SBE_CT-0212	AA4330-807	WL_BBFL2VMT-836	QSP2150-50144
				532/CDOM/CHL-A	
SG510	enhanced	Seabird CT sail	Aanderaa oxygen	WetLabs Ecopuck	PAR
		SBE_CT-0135	AA4330-196	WL_BBFL2VMT-671	QSP2150-50143
				650/CDOM/CHL-A	

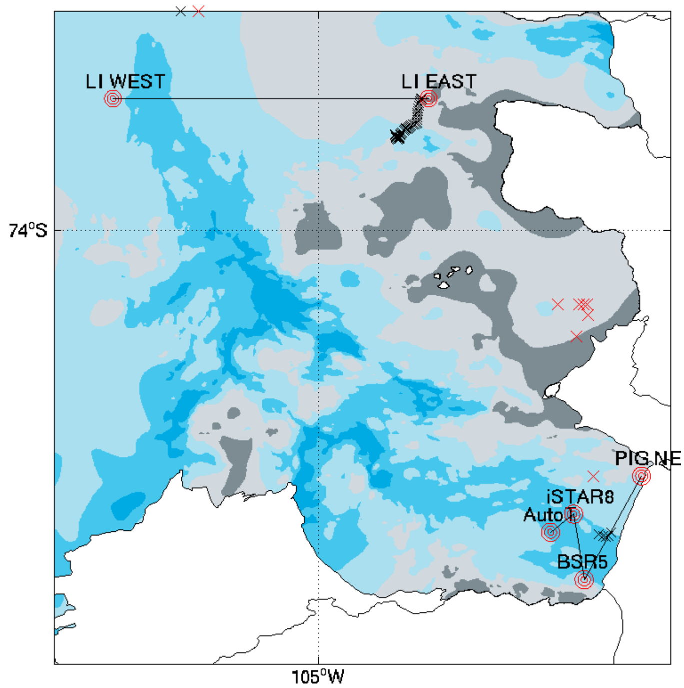


Figure 7.1 - Planned Seaglider deployments. Transects are indicated by black lines terminated by the glider waypoints. Seaglider surfacing positions are indicated by black crosses. Red crosses are indicative of incorrect GPS coordinates possibly caused by a frozen or submerged antenna (discussed further).

7.2 Pre-deployment

Pre-deployment tasks for both Seagliders were completed between 25/01/2014 and 31/01/2014. This involved setting up science, command, targets and sg_calib_constants files for each Seaglider. Self-tests and Sim dives were performed on each Seaglider, and the results checked for errors both manually and using the System Checkout 0.3.14RC9 software. Details of these files can be found in the Section 7 Appendix.

Points of note (SG510): During a previous deployment (Vigo, Spain) the parameter $PHONE_SUPPLY was changed from 2 to 1 in an attempt to draw power to Iridium comms from the 10V battery. Whilst this does not work, the on board processor does change its calculations of power consumption, meaning that SG510's 24V battery will be more depleted than indicated by the software. The value for $MASS was taken from cell C10 of the 'trim' tab of SG510's trimsheet, $VOLMAX from cell D18 of the 'ballast' tab. Pitch, roll and VBD centres used were taken from SG510's last deployment.

Points of note (both Seagliders): .eng files from self-tests on both Seagliders were checked to ensure sensor outputs were giving sensible values. To check WetLabs sensor operation it was necessary to place coloured card over the different sensor windows and check for changes in sensor output. Both sensors functioned normally. Compass readings for both Seagliders were showing errors during self-tests. To rule out errors due to declination the

Seagliders were positioned side-by-side, pointing directly aft and compass readings checked. Results from both Seagliders showed a 35-40º Eastward deviation, which matches an expected deviation of 36º due to declination at 64º S, 93ºW. We attributed the compass errors to location – metal surfaces and running engines in the vicinity.

7.3 SG579 Deployment/Recovery

Figure 7.2 Deployment of SG579 using the starboard aft crane

Final preparations for the deployment of SG579 were carried out on 04/02/2014 (IE55 and DGO connections checked, silicone grease applied to bladder, Argos tags installed and switched to standby mode). The Seaglider was placed on deck, and pre-launch routine started at 07:57 UTC on 05/02/2014. Whilst the terminal log file was checked on board, pilots at UEA checked the corresponding .prm file. The starboard aft crane was used for a buoyancy test followed by deployment. The 'rigid-rope' method was used – the rope connecting the Seaglider to the crane is passed through a 1.5m length of 22mm PVC pipe, fastened around the Seaglider lifting point (rudder notches) and returned through a second length of pipe. This arrangement prevents the rope from wrapping around and potentially breaking the antenna, which has happened in the past. For buoyancy testing, the rope is double wrapped around the Seaglider and held in place with cable ties. With enough slack in the line, the Seaglider assumes its surface position in the water. SG579 showed an excellent position in the water, so was lifted back on deck briefly to allow removal of the securing cable ties. The deployment rope was slackened off to leave a single loop around the rudder notches.

Figure 7.3 SG579 showing good surface position upon deployment

Verbal consent to deploy was given via Iridium at 11:31 UTC, and SG579 was deployed in the following conditions:

Lat:	73º35.00 S	Lon:	103º49.95 W	Time:	11:35 UTC
Wind Speed:	12 knots	Air Temp:	-4.6ºC	Sig. Wave Height:	<1m

Although there were many small icebergs in the vicinity, there was no sea ice present.
Once in the water, enough slack was given to allow the deployment rope to slip off the rudder and the antenna to pass through the loop of the rope, between the lengths of pipe. The ship then moved slowly to port, allowing observation of SG579 from a safe distance. A $RESUME command was placed in the command file, and SG579 began its first dive at 11:50 UTC. Visibility was good, and SG579 was rapidly spotted on the surface following its first dive at 73º35.45 S, 103º49.62 W, 12:11 UTC. Pilots at UEA were contacted via Iridium. Analysis of data from Dive 1 showed that buoyancy and pitch parameters were set well, but roll parameters needed significant adjustment. There were also minor software issues with the .pagers file and Matlab licence on the UEA basestation. SG579 began Dive 2 at 13:28 UTC, the JCR remained on station to continue other work.
Following contact with pilots at UEA, the decision was made to recover SG579 on 07/02/2014 due to roll issues (preventing stable flight and course correction) and a VBD problem manifested on dives to ~300m or more.
$D_TGT was reduced to 100 at 20:30 UTC on 06/02/2014, to leave SG579 doing shallow dives until the JCR was in a position to recover. A $QUIT command was placed in the command file, and visual contact was established with SG579 on 07/02/2014, 12:28 UTC at 73º41.65 S, 104º08.89W. On first approach the Seaglider was sucked beneath the ship, and contact was briefly lost. SG579 was reacquired a short time later, ~200m off the starboard bow. On second approach the Seaglider was safely recovered using the recovery loop at 13:16 UTC. The recovery loop consists of a 10m telescopic fibreglass pole with a 1m diameter loop attachment constructed from 15mm PVC pipe. Spring clips are used to fix a line to this loop. The loop is lowered over the antenna of the Seaglider and pushed beneath the surface. The line is then pulled, tightening around the rudder notches, and the line attached to the starboard aft crane for recovery. The pin from a small iron D-shackle is taped to the loop to compensate for the buoyancy of the PVC pipe.

7.4 SG510 Deployment/recovery

The same techniques were used for buoyancy testing, recovery and deployment of both SG510 and SG579. Final preparations for the deployment of SG510 were carried out on 10/02/2014. The Seaglider was placed on deck, and pre-launch routine started at 07:00 UTC on 11/02/2014. Whilst the terminal log file was checked on board, pilots at UEA checked the corresponding .prm file. Sea state and high winds made judgement of the surface position of SG510 difficult during the buoyancy test.Whilst buoyancy looked good, the Seaglider was lying more horizontal than normal. Following concerns that $SIM_W and $SIM_PITCH parameters might not have been deleted from the command file as the call was dropped before completion of file transfers in the sea launch routine, SG510 was brought back on board and connected to a laptop to check that it was still in recovery mode. A second buoyancy test was then performed. Surface position remained unchanged, but the decision was made to deploy and remain in the area for 2-3 hours in case recovery was required. Verbal consent to deploy was given via Iridium at 10:15 UTC, and SG510 was deployed in the following conditions:

Lat:	74º55.01 S	Lon:	101º40.30 W	Time:	10:20 UTC
Wind Speed:	28 knots	Air Temp:	-9.6ºC	Sig. Wave Height:	2m

There was no significant ice in the vicinity at the time of deployment.
A $RESUME command was placed in the command file, and SG510 began its first dive at 10:32 UTC. Visibility was reasonable, and SG510 was required on the surface following its first dive at 74º55.01 S, 101º40.29 W, 10:51 UTC. Pilots at UEA were contacted via Iridium. Analysis of data from Dive 1 showed that the Seaglider was diving well, and only minor trimming was required. SG510 began Dive 2 at 12:06 UTC, and the JCR moved away to continue other work at 13:15 UTC.

Following a lack of reliable GPS fixes overnight 11/02/2014 - 12/02/2014, the decision was made to attempt to locate SG510, make a visual inspection and possibly recover.
A $QUIT command was placed in the command file at 14:20 UTC on 12/02/2014. Without reliable GPS fixes, location of the Seaglider using only Argos tag fixes was difficult. Visual contact was established with SG510 at 74º58.45 S, 102º27.37 W, 22:23 UTC. Details of the performance of the Argos tags are outlined below. A large lump of ice could be seen roughly 15cm from the tip of the antenna, and the Seaglider was almost flat in the water. SG510 was safely recovered using the recovery loop at 22:38 UTC.

Figure 7.4 Recovery loop in position

Redeployment was scheduled for 26/02/2014 (74º58.45 S, 102º27.37 W), but was cancelled due to ice coverage.

7.5 Argos tag performance

Both Seagliders were deployed with a SPOT5 Argos tag mounted to the antenna. These battery powered units provide a secondary means of locating the Seaglider should normal GPS fail. The settings for the tag used on JR294 are shown below.

Table 7.2 Argos tag settings (used for both SG510 and SG579 deployments)

Report for SPOT tag 12S1205 on 26-Jan-2014 at 20:12:53 (UTC)
SPOT Time: 26-Jan-2014 at 20:08:58
Spot5Host version: 5.50.2008
SPOT5ware version: 5.02l
SPOT belongs to:
Karen Heywood
University of East Anglia
Extended Argos PTT number: 126277 or 0BA48E5F Hex. Uplink/LUT number: 11922/95transmitting with fast repetition rate of 45.00 secondsand slow repetition rate of 90.00 seconds.It checks for dry (to start transmitting) every 1/4 secondsThe transmission will start after 0 extra minute(s) of consecutive dry 1/4-sec wakeups and switches to its slow repetition rate after 10 successive dry transmissionsFast transmissions will resume after being continuously wet for 08 seconds.
The current conductivity threshold is: 50 (default)
The default conductivity threshold is: 50
Total Transmits since 08-Oct-2012 = 10161
Maximum transmissions per day = 1500
Transmit on these hours:
0 - 23
Transmit on these days:
Jan: 1 - 31
Feb: 1 - 28,
Mar: 1 - 31
Apr: 1 - 30
May: 1 - 31
Jun: 1 - 30
Jul: 1 - 31
Aug: 1 - 31
Sep: 1 - 30
Oct: 1 - 31
Nov: 1 - 30
Dec: 1 - 31
Time at temperature Histograms are not collected.
Haulout Statistics are NOT being collected

Argos tag locations are considerably less accurate than GPS, and also suffer from a delay of over 30 minutes. The following figure shows Argos tag locations for tag no 126277 on 12/02/2014, during which time SG510 was at the surface in recovery.

Table 7.3 Argos tag fixes 12/02/2014

Time	Lat	Lon
14:18	74°55.74 S	101°43.15 W
14:46	74°55.824 S	101°43.714 W
14:52	74°55.844 S	101°43.870 W
16:01	74°55.661 S	101°45.063 W
16:07	74°55.679 S	101°45.161 W
16:25	74°55.731 S	101°45.439 W
18:33	74°55.385 S	101°48.678 W
19:00	74°55.422 S	101°49.065 W

It is also possible to detect Argos transmissions on 401.677 KHz. An iCom IC-R20 receiver coupled with a Skymast 8YD3BNC directional antenna was used in an attempt to locate SG510 whilst on the surface.The directional functionality of this receiver/antenna combination is poor, but it does have a substantial range (>3nm, from previous testing in Loch Linnhe, Scotland). SG510 was located by plotting all available Argos fixes, and calculating mean direction and speed of travel. In conjunction with signals from the Argos receiver and measurements of wind direction, this data enabled the bridge officers to estimate a rough position and begin a creeping line search.

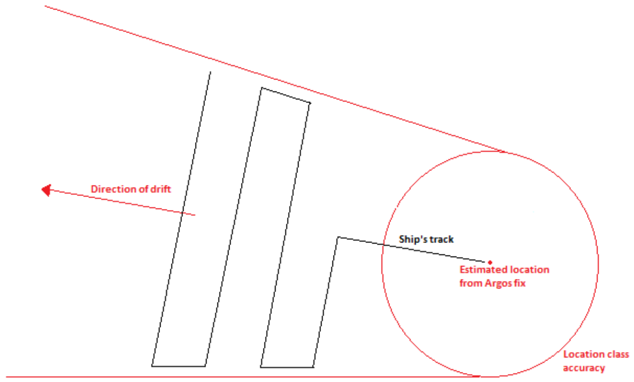


Figure 7.5 Creeping line search technique

The search for SG510 took 3½ hours, and a series of 8 Argos fixes. Towards the end of the search, aCLS goniometer belonging to NMF's Autosub team was also used to try and locate SG510. This receiver should give a directional readout of the Argos tag location, but only 2 fixes were received in 15 minutes (transmissions from Argos tag 126277 are 90 seconds apart).

7.6 Problems identified

In addition to the issues mentioned above in relation to Argos tag performance, several problems have been highlighted which require further attention:

The recovery loop technique is an improvement over previous recovery methods, and has always resulted in safe recovery of Seagliders. However, it is extremely difficult to ensure the loop is tightened correctly around the lifting point. In the case of SG579 the loop tightened around one rudder notch. The Seaglider can be recovered in this manner, but it is far from ideal. In the case of SG510, the loop slipped past the rudder completely, and tightened around the antenna below the Argos tag. It was necessary to drop a second loop of rope over the rudder by hand – a difficult procedure, and one which leaves the Seaglider vulnerable to damage for a much greater period of time than is acceptable. Testing is currently in progress in Gran Canaria of a PVC-coated steel wire loop, anchored in place by the Seaglider rudder bolts, which may prove a more reliable recovery method (if hydrodynamics are not compromised).

There is a question of whether to use a Seacatch release for rigid rope buoyancy testing and/or deployments. For buoyancy tests and deployments in extremely low sea state conditions the use of a Seacatch seems unnecessary as the Seaglider slips out of the loop relatively easily with careful crane operation. In higher sea states, however, this becomes more difficult and the risk of damaging the antenna outweighs the fact that Seacatches can be awkward to release depending on the angle of the line etc. Using a Seacatch only for the deployment and not the buoyancy test would work, but increases the time required for the full launch procedure.
Post-recovery evaluations of specific problems encountered with each of the Seagliders deployed on JR294 are outlined below.

Valve fault (SG579)

Preliminary diagnosis of the VBD fault on SG579 indicates a leaking solenoid valve. Analysis of .cap files show a reduced pumping rate at depth compared to that seen on shallow dives:

Table 7.4 Excerpt from p57900016.cap showing reduced AD/sec rate and VBD retries on 450m dive

```
3612.809,SDIVE,N,1391683838s
3617.109,SSENSOR,N,A 3616870ms 447.47m 349.3 #575
3619.084,SDIVE,N,1391683845s
3623.059,SSENSOR,N,A 3623210ms 447.63m 347.9 #576
3625.034,SDIVE,N,1391683851s
3629.309,SSENSOR,N,A 3629610ms 447.92m 346.2 #577
3631.309,SDIVE,N,1391683857s
3635.584,SSENSOR,N,A 3635623ms 448.12m 343.9 #578
3641.932,SMOTOR,N,MOTOR_DONE: ticks: 144 max 24v: 16.8mA avg 24v: 2.3mA minV 24v: 23.6V
3642.090,SMOTOR,N,GC TICKS/TIME: 18913/19089622
3642.281,HPITCH,N,Pitch completed from -0.67 cm (2736) to -0.22 cm (2880) took 0.5 sec 204mA
(278mA peak) 25.9Vmin 274 AD/sec 21 ticks
3642.681,HPITCH,N,TRACK: b: 2878/0 a: 2883/0 d: -1 o: -3
3642.877,HVBD,N,Pump completed from -317.66 cc (4095) to -0.25 cc (2801 [2979, 2623]) took
418.4 sec 1030mA (2130mA peak) 22.6Vmin 3 AD/sec 16735 ticks; 10 retries (7 w/o motion)
3643.388,HVBD,N,TRACK: b: 2979/2622 a: 2979/2622 d: -179 o: -178
3643.710,SDIVE,N,end $GC
,3643,0.52,0.00,418.38,1.030,6,0.204,0.000,2880,1297,2801,0,0,0,0,10,0
3644.012,SDIVE,N,Exiting active in GCPHASE_DONE(6) after 78 samples, ret=CONTROL_FINISHED_OK
3644.179,SDIVE,N,Leaving Apogee state due to CONTROL_FINISHED_OK
3644.321,SDIVE,N,Entering climb state
3644.500,SDIVE,N,Going up from 448.12 meters ... VBDctl=170
3644.617,SMOTOR,N,Start active
3645.673,SDIVE,N,start $GC,3645,0.62,170.4,448.1,0.0,578, ...
3645.929,SDIVE,N,1391683867s
3649.904,SSENSOR,N,A 3645915ms 448.34m 347.3 #579
3651.854,SDIVE,N,1391683873s
3656.129,SSENSOR,N,A 3651868ms 448.37m 352.6 #580
3658.104,SDIVE,N,1391683880s
3659.754,HVBD,C,no progress madeA 3658201ms 448.24m 352.8 #581
3663.929,SDIVE,N,1391683886s
3667.904,SSENSOR,N,A 3664067ms 448.17m 351.7 #582
3669.904,SDIVE,N,1391683892s
3674.204,SSENSOR,N,A 3670081ms 448.13m 351.8 #583
3676.204,SDIVE,N,1391683898s
```

Table 7.5 Excerpt from p57900001.cap showing normal pump operation on 35m dive

```
3680.179,SSENSOR,N,A 3676441ms 448.06m 351.9 #584
413.664,SDIVE,N,1391601418s
417.939,SSENSOR,N,A 414022ms 34.28m 14.3 #51
422.464,SDIVE,N,1391601427s
426.389,SSENSOR,N,A 422886ms 34.47m 19.9 #52
430.686,SMOTOR,N,MOTOR_DONE: ticks: 245 max 24v: 9.9mA avg 24v: 2.3mA minV 24v: 24.9V
430.841,SMOTOR,N,GC TICKS/TIME: 3926/3954878
431.031,HPITCH,N,Pitch completed from -0.60 cm (2771) to -0.19 cm (2903) took 0.4 sec 168mA
(288mA peak) 25.5Vmin 293 AD/sec 18 ticks
431.427,HPITCH,N,TRACK: b: 2902/0 a: 2898/0 d: 3 o: 5
431.619,HVBD,N,Pump completed from -172.69 cc (3720) to -0.25 cc (3017 [3121, 2914]) took 91.5
sec 851mA (1896mA peak) 23.8Vmin 7 AD/sec 3660 ticks
432.059,HVBD,N,TRACK: b: 3118/2915 a: 3123/2915 d: -107 o: -106
432.367,SDIVE,N,end $GC ,432,0.45,0.00,91.50,0.851,6,0.168,0.000,2903,2119,3017,0,0,0,0,0,0
432.698,SDIVE,N,Exiting active in GCPHASE_DONE(6) after 12 samples, ret=CONTROL_FINISHED_OK
432.864,SDIVE,N,Leaving Apogee state due to CONTROL_FINISHED_OK
433.004,SDIVE,N,Entering climb state
433.180,SDIVE,N,Going up from 34.47 meters ... VBDctl=170
```

```
433.293,SMOTOR,N,Start active
434.296,SDIVE,N,start $GC,434,0.53,170.4,34.5,0.0,52, ...
434.546,SDIVE,N,1391601438s
438.521,SSENSOR,N,A 434345ms 34.58m 12.0 #53
442.396,SDIVE,N,1391601446s
446.671,SSENSOR,N,A 442239ms 34.49m 7.1 #54
450.571,SDIVE,N,1391601454s
454.521,SSENSOR,N,A 450479ms 34.24m 7.9 #55
```

In the following dive plot (Figure 7.6), the black line ($MAX_BUOY) represents the amount of oil allowed to bleed into the reservoir (reducing buoyancy and causing the Seaglider to dive). This was set to 175, but it can be seen to increase to 300 at depth, indicating a leaking valve at pressure. Had SG579 dived to greater depths, it is likely that the leak may have prevented the buoyancy engine from making any progress, and the Seaglider may have failed to return to the surface. Available on-board valve testing options were performed post-recovery, but no errors were raised and all results were normal:

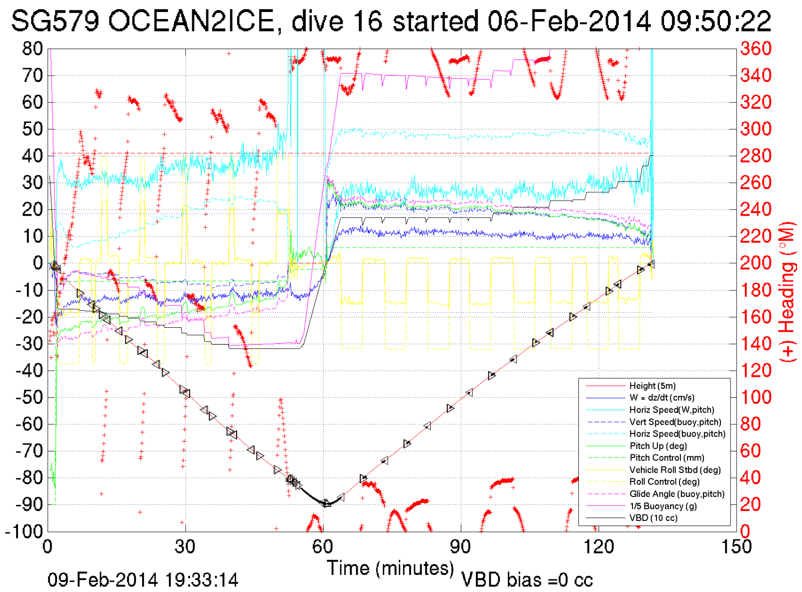


Figure 7.6 Dive 16, SG579 showing bleeding past $MAX_BUOY and heading and pitch drift on the descent

Table 7.6 Excerpt from SG579 terminal session logfile showing normal response to valve tests

```
------ VBD menu ------
 1 [read ] Current position
 2 [ad ] Move to position (AD counts)
 3 [eu ] Move to position (cc)
 4 [param ] Edit vbd parameters
 5 [timing ] Characterize valve
 6 [noise ] Valve noise test
 7 [open ] Open valve
 8 [close ] Close valve
 9 [cycle ] Cycle valve
 10 [pump ] Pump & bleed cycles (pressure chamber or AD)
 11 [soak ] Pump and hold at pressure (pressure chamber or AD)
 12 [special ] Special test #1 (motor current, amb pressure & pot)
 CR) Return to previous
Enter selection (1-12,CR): 6
Enter time in seconds to have the valve tested: [1]
Open: Raise OPN before CLS? [Y]
Close: Drop OPN before CLS? [Y]
Offset time (in ms) between valve signals: [0]
Bleed 3 counts on 1 second open and 19 counts on close.
Pump back to starting state? [Y]
237.282,HVBD,N,Pump commanded from -288.71 cc (3977) to -282.58 cc (3952)...
237.986,HVBD,D,Boost on
238.436,HVBD,N,-288.0 cc (ad: 3974 [3998, 3948])
239.261,HVBD,N,-285.8 cc (ad: 3965 [3998, 3929]) Main on
240.036,HVBD,N,
```

```
240.186,HVBD,N,-283.1 cc (ad: 3954 [3999, 3906]) MOTOR_DONE: ticks: 4 max 24v: 3.1mA avg 24v: 2.3mA minV 24v: 26.7V
240.854,SMOTOR,N,GC TICKS/TIME: 98/103306
240.943,HVBD,N,done.
241.101,HVBD,N,Pump completed from -288.71 cc (3977) to -282.34 cc (3951 [4000, 3903]) took 2.3 sec 203mA (2745mA peak)
26.0Vmin 11 AD/sec 91 ticks
241.531,HVBD,N,TRACK: b: 3999/3906 a: 3999/3906 d: -47 o: -48

------ VBD menu ------
 1 [read ] Current position
 2 [ad ] Move to position (AD counts)
 3 [eu ] Move to position (cc)
 4 [param ] Edit vbd parameters
 5 [timing ] Characterize valve
 6 [noise ] Valve noise test
 7 [open ] Open valve
 8 [close ] Close valve
 9 [cycle ] Cycle valve
 10 [pump ] Pump & bleed cycles (pressure chamber or AD)
 11 [soak ] Pump and hold at pressure (pressure chamber or AD)
 12 [special ] Special test #1 (motor current, amb pressure & pot)
 CR) Return to previous
Enter selection (1-12,CR): 5
Delay in seconds on bleeds before checking progress: [2]
VBD change assumed after how many counts? [2]
.40 Valve opened at 0 ms.
.13 .6 .2 Valve closed at 2 ms.
Pump back to starting state? [Y]
276.586,HVBD,N,Pump commanded from -303.19 cc (4036) to -282.34 cc (3951)...
277.181,HVBD,D,Boost on
277.631,HVBD,N,-302.7 cc (ad: 4034 [4045, 4022])
278.456,HVBD,N,-301.5 cc (ad: 4029 [4041, 4017]) Main on
279.206,HVBD,N,
279.381,HVBD,N,-300.2 cc (ad: 4024 [4036, 4013])
280.206,HVBD,N,-299.3 cc (ad: 4020 [4030, 4010])
281.031,HVBD,N,-298.5 cc (ad: 4017 [4026, 4008])
281.831,HVBD,N,-297.5 cc (ad: 4013 [4022, 4005])
282.656,HVBD,N,-296.6 cc (ad: 4009 [4016, 4000])
283.481,HVBD,N,-294.8 cc (ad: 4002 [4011, 3988])
284.281,HVBD,N,-292.4 cc (ad: 3992 [4007, 3975])
285.106,HVBD,N,-289.9 cc (ad: 3982 [4004, 3960])
285.906,HVBD,N,-288.0 cc (ad: 3974 [4001, 3941])
286.731,HVBD,N,-285.5 cc (ad: 3964 [4001, 3923])
287.556,HVBD,N,-283.3 cc (ad: 3955 [4001, 3904])
288.331,HVBD,N,-282.1 cc (ad: 3950 [4002, 3899]) MOTOR_DONE: ticks: 30 max 24v: 3.8mA avg 24v: 2.3mA minV 24v: 26.7V
288.996,SMOTOR,N,GC TICKS/TIME: 455/461084
289.086,HVBD,N,done.
289.243,HVBD,N,Pump completed from -303.19 cc (4036) to -282.09 cc (3950 [4002, 3899]) took 10.6 sec 571mA (2703mA peak)
26.0Vmin 8 AD/sec 422 ticks
289.682,HVBD,N,TRACK: b: 4001/3902 a: 4002/3901 d: -51 o: -52
```

A comparison of solenoid valve performance was made between SG579 and SG510 post-recovery. With the VBD set to 2000 AD counts, each bladder was wrapped in a piece of cloth, and a wooden pin used to tighten the cloth around the bladder simulating external pressure. After 1 hour the new AD reading was taken – SG510 showed a decrease of 2 AD counts (an effective increase in buoyancy) whilst SG579 showed an increase of 38 AD counts (equivalent to a leak of ~15cc oil past the solenoid valve). Although these tests should not be regarded as quantitative due to the lack of proper equipment available to perform a pressure test, they do indicate a fault on the solenoid valve of SG579.

Roll problems (SG579)

The original problem identified by the UEA piloting team relating to SG579 was very poor roll dynamics on the descent (Figure 7.6). This issue is characterised by a continuous drift in heading as the glider descends resulting in the glider adjusting its heading at every GC interval. The cause for the continuous drift in heading is as of yet unknown but may be related to the bladder leak issue. Leaking back into the main glider hull leads to a change in mass distribution which affects the glider pitch. Following the green line (pitch) on the main flight plot of dive 16 shows a gradual decrease in pitch during both casts, with the drift being more pronounced at the end of the descent where pressure is greatest and the VBD issue exacerbated. Furthermore, turn direction was unrelated to roll direction.

This likely resulted in suboptimal flight characteristics, similar to those observed at the end of the Vigo and the Tropical DISGO missions where the glider's speed was severely reduced, leading to the typical "falling leaf" pattern observed there.

Ice/temp problems

Low temperatures experienced on JR294 had two effects on the Seagliders deployed. Firstly, the Seaglider CT sensors use a small plastic insert to channel flow into the conductivity cell – in both cases this insert came loose once the Seaglider was out on deck exposed to low temperatures prior to deployment, and had to be reattached using superglue. Had this not been noticed prior to deployment, loss of the insert during the mission could have compromised conductivity data substantially. Of more concern was the fact that SG510 was recovered with such a large amount of ice on the antenna.

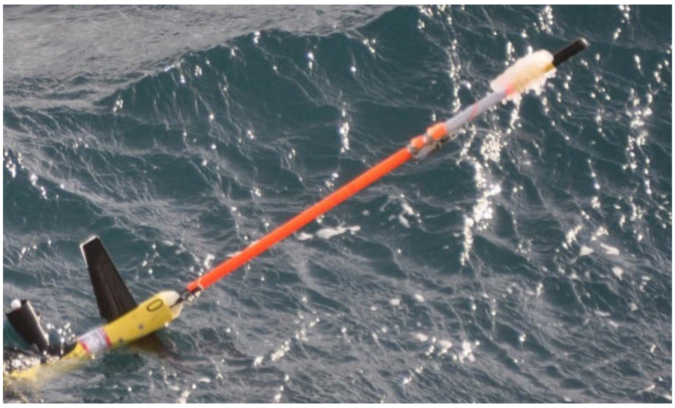


Figure 7.7 Ice on antenna and horizontal surface position of SG510 at time of recovery

A post-recovery test of GPS performance in SG510 showed good location quality (within 50metres), and this test was repeated with a lump of ice frozen around the antenna in an attempt to replicate the conditions whilst SG510 was in recovery. Our hypothesis is that the ice build-up on the antenna did not affect comms directly, but rather weighed down the antenna. This would prevent SG510 from reaching its normal surface position for comms, resulting in the spurious GPS fixes seen.

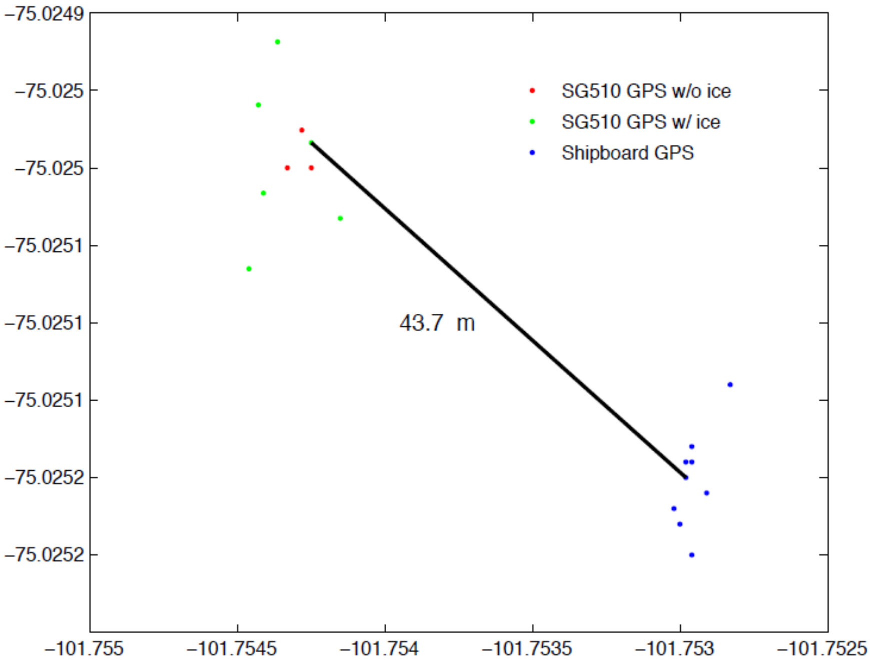


Figure 7.8 SG510 GPS location quality test

It is possible that by sending SG510 on deeper dives and reducing time at the surface the ice build-up may have been reversed, but the decision was taken that due to continuing low temperatures redeployment would not be attempted in the PIG area. Previous deployment of SG503 in the Ross Sea showed a similar drop in GPS location quality as both gliders came out from under the ice and remained in locations containing a lot of brash ice.

7.7 Data

Despite collection data for only a short period, both gliders collected interesting data showing both significant physical and biological features relevant to the project. Data from both gliders are shown below after calibration with manufacturer settings, despiking and simple cast alignment. No calibration has been performed against ship data yet.

SG510

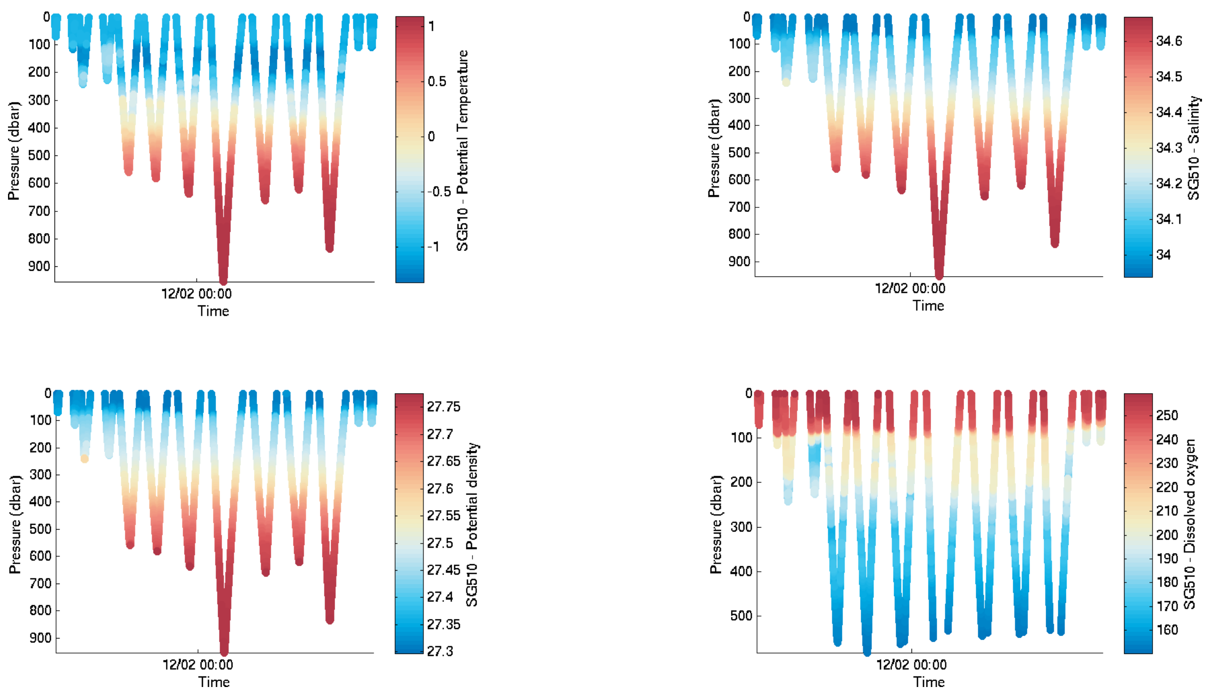


Figure 7.9: Temperature, salinity, density and dissolved oxygen concentration as observed by SG510 near PIG.

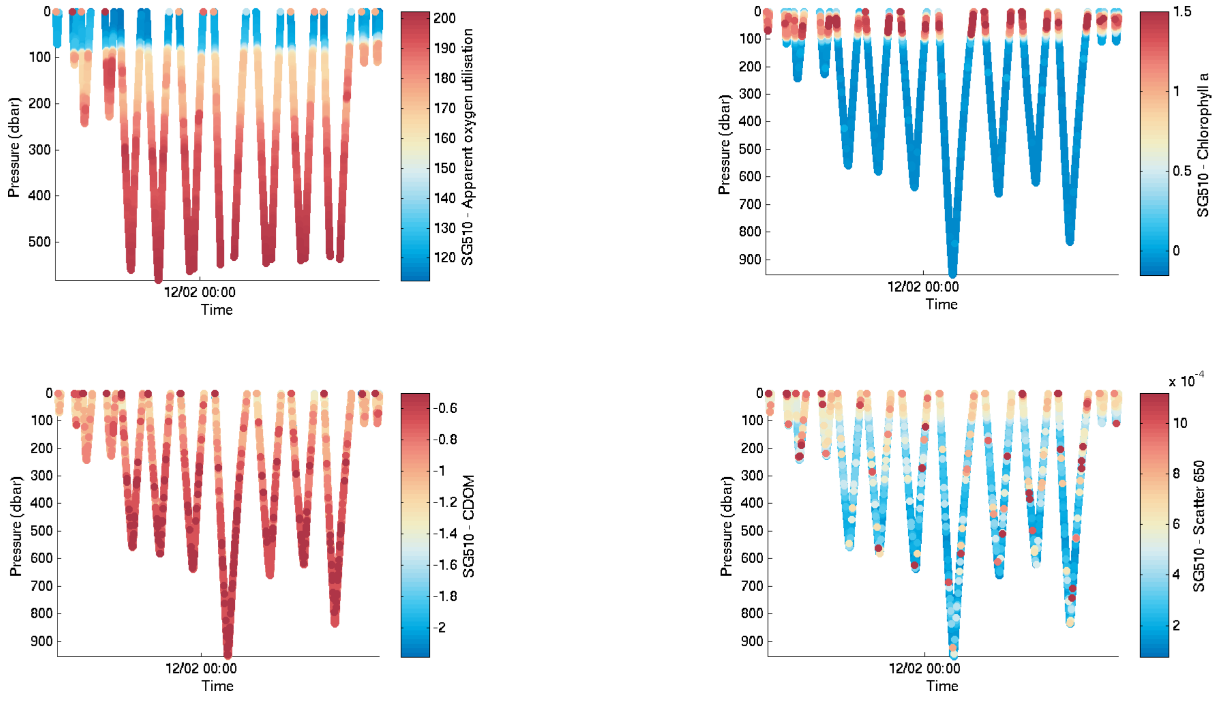


Figure 7.10 Apparent oxygen utilisation and optical properties as observed by SG510 near PIG

SG579

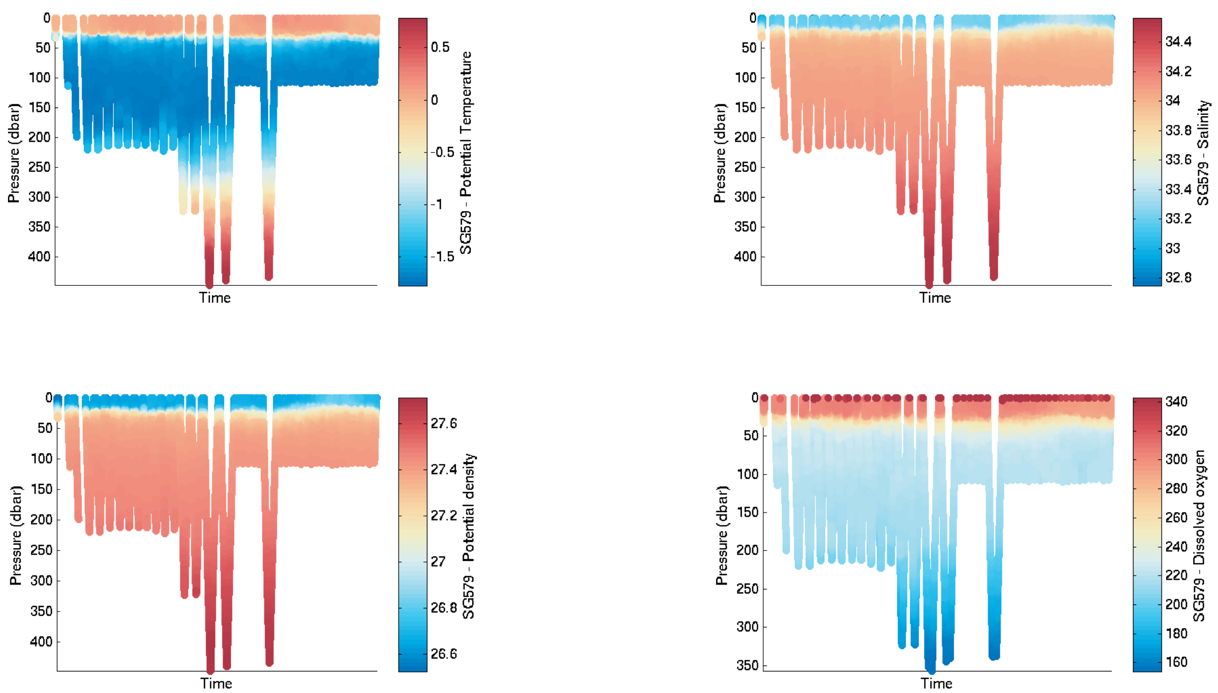


Figure 7.11 Temperature, salinity, density and dissolved oxygen concentration as observed by SG579 near Edwards Islands.

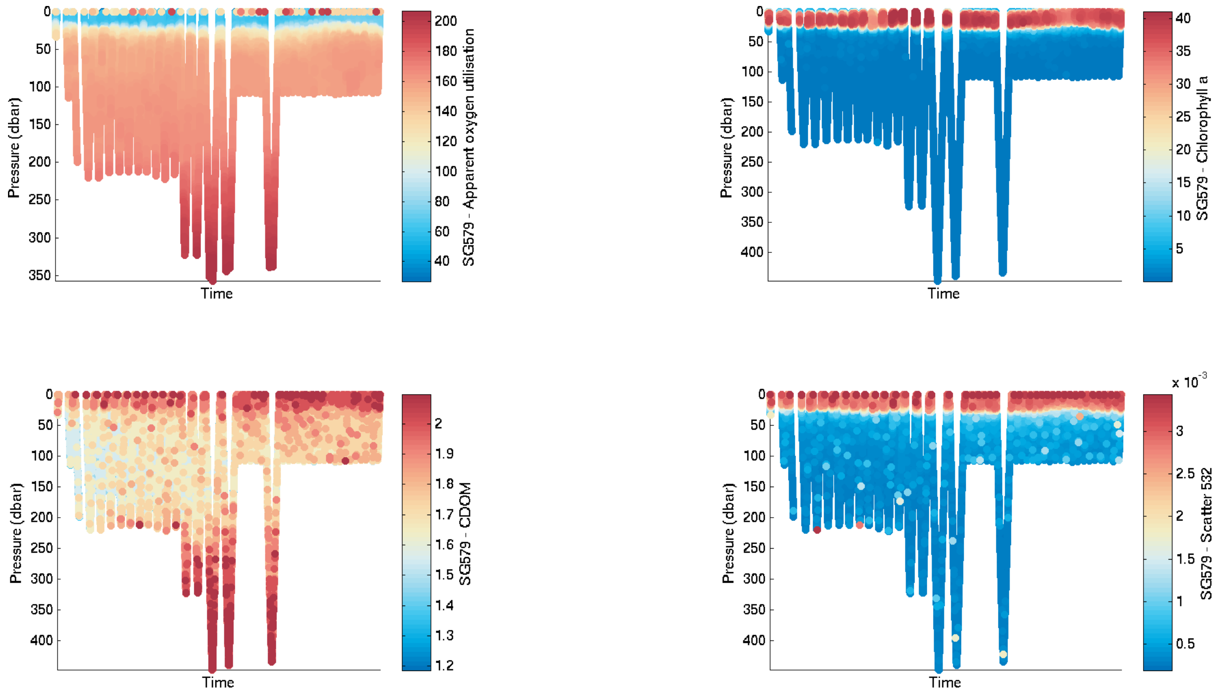


Figure 7.12 Apparent oxygen utilisation and optical properties as observed by SG579 near Edwards Islands.

7.8 Future recommendations

1 – Whilst the valve problem with SG579 may require return of the instrument for repair, the simple pressure test which confirmed the solenoid valve as the faulty part is something which can easily be done prior to shipping the Seaglider in future.
2 – Argos positioning may be aided by the use of a purpose-built receiver such as the CLS goniometer RXG134. In addition, Wildlife Computers manufacture an Argos tag (SPOT100 258D) which includes a UHF pinger with improved direction finding functionality over short ranges (<1km).
3 – Solutions to the problem of ice build-up on the antenna may be difficult, but should be investigated. Ice was concentrated on the area of yellow heat shrink which covers the base of the Iridium/GPS antenna, one possibility may be to use a smoother type of heat shrink or an additional coat of a different material. Manufacture of CT sail plugs from a different material should be more straightforward. In their current state, careful consideration should be given to the deployment of Seagliders in temperatures below freezing, especially in shallow areas where significant wind speed or sea state may lead to ice build-up.

7.9 Appendix

SG579 pre-deployment files:

targets

```
// SG579 Ocean2ICE Cruise, February 2014, BYQ 25/01/2014
SE_OUT lat=4837.80 lon=-1606.00 radius=2000 goto=CENTERa
NE_OUT lat=4844.94 lon=-1606.00 radius=2000 goto=CENTERb
```

science

```
// SG579 Ocean2ICE Cruise, February 2014, BGMW 04/02/2014
LI_VM lat=-7335.00 lon=-10345.00 radius=200 goto=LI_VM
LI_EAST lat=-7335.00 lon=-10345.00 radius=1000 goto=LI_WEST
LI_WEST lat=-7335.00 lon=-10720.00 radius=1000 goto=LI_EAST
```

cmdfile (concatenated before upload)

```
$MISSION,19
$D_TGT,50
$T_DIVE,20
$T_MISSION,30
$D_ABORT,990
$SEABIRD_T_G,0.00429755908E
$SEABIRD_T_H,0.000619018642
$SEABIRD_T_I,0.0000215417760
$SEABIRD_T_J,0.00000217238083
$SEABIRD_C_G,-9.76529694
$SEABIRD_C_H,1.13106996
$SEABIRD_C_I,-0.00224830721
```

```
$SEABIRD_C_J,0.000248196593
$MINV_24V,19
$MINV_10V,9
$D_BOOST,5
$T_BOOST,0
$EBE_ENABLE,0
$CAPUPLOAD,1
$T_RSLEEP,2
$PITCH_MIN,75
$PITCH_MAX,3902
$ROLL_MIN,167
$ROLL_MAX,3798
$VBD_MIN,481
$VBD_MAX,3961

$ALTIM_PING_DEPTH,0
$ALTIM_PING_DELTA,0
$ALTIM_FREQUENCY,13
$NAV_MODE,2
$KALMAN_USE,2
$MAX_BUOY,175
$SM_CC,400

$ESCAPE_HEADING,45
$TGT_DEFAULT_LAT,4844.9399
$TGT_DEFAULT_LON,-1606
$RHO,1.0274
$MASS,53977
$LENGTH,1.8
$C_PITCH,2805
$PITCH_GAIN,32
$C_ROLL_DIVE,2260
$C_ROLL_CLIMB,2025
$ROLL_GAIN_P,0.5
$C_VBD,3160

$QUIT
```

sg_calib_constants

```
% BYQ/SCAW/LCB 25 Jan 2014 for OCEAN2ICE
% sg_calib_constants.m

% basic glider and mission params % (NOT verified)
id_str='579';
mission_title='OCEAN2ICE';
mass=54.027;% kg
volmax=53190;% cc
rho0=1027.400;% kg/m3

% initial hydrodynamic model params % (Verified 25/01/2014)
hd_a=3.83600000E-03;
hd_b=1.00780000E-02;
hd_c=9.85000000E-06;
therm_expan=7.05000000E-05;
temp_ref=1.50000000E+01;
abs_compress=4.18000000E-06;
pitchbias=0.00000000E+00;

% software limits from cal sheet: % (Verified 25/01/2014)
pitch_min_cnts=75;
pitch_max_cnts=3902;
roll_min_cnts=167;
roll_max_cnts=3798;
vbd_min_cnts=481;
vbd_max_cnts=3961;
vbd_cnts_per_cc=-4.07671;

% pump parameters % (Verified 25/01/2014)
pump_rate_intercept=1.275;
pump_rate_slope     =-0.00015;
pump_power_intercept=17.4033;
pump_power_slope=0.017824;

% CT sensors cal constants % (Verified 25/01/2014)
calibcomm='Serial #: 0212 CAL: 28 May 2012';
t_g=4.29755908E-03;
t_h=6.19018642E-04;
t_i=2.15417760E-05;
t_j=2.17238083E-06;
c_g=-9.76529694E+00;
c_h=1.13106996E+00;
c_i=-2.24830721E-03;
c_j=2.48196593E-04;
cpcor=-9.5700E-08;
ctcor=3.2500E-06;
sbe_cond_freq_min=2.94413000E+00;
sbe_cond_freq_max=7.89908000E+00;
sbe_temp_freq_min=1; % 2.96388400E+03;
sbe_temp_freq_max=5.72292500E+03;
```

```
%Aanderaa cal Constants % (Verified 25/01/2014)
comm_oxy_type='Aa_optode';% spec Aa_optode
calibcomm_oxygen='Serial #: 807 CAL: 12/2/2008';% Serial # and cal date
% 121113 JK commented out foil coefficients to reduced baselog size
%optode_FoilCoefA1=-8.65647E-06;
%optode_FoilCoefA2=0.002206881;
%optode_FoilCoefA3=-0.2269625;
%optode_FoilCoefA4=0.000795856;
%optode_FoilCoefA5=-6.78009E-07;
%optode_FoilCoefA6=11.889709;
%optode_FoilCoefA7=-0.06533028;
%optode_FoilCoefA8=0.00012843;
%optode_FoilCoefA9=-2.89467E-07;
%optode_FoilCoefA10=-324.9648;
%optode_FoilCoefA11=2.497815;
%optode_FoilCoefA12=-0.007050041;
%optode_FoilCoefA13=-1.36382E-05;
%optode_FoilCoefB1=3832.035;
%optode_FoilCoefB2=-38.71124;
%optode_FoilCoefB3=0.1475505;
%optode_FoilCoefB4=-0.000330332;
%optode_FoilCoefB5=2.28928E-05;
%optode_FoilCoefB6=-5.0083E-07;

% Wetlab EcoPuck #836, CAL: 5/24/2011 % (Verified 25/01/2014)
% Chlorophyll
WETLabsCalData.Chlorophyll.darkCounts=47
WETLabsCalData.Chlorophyll.scaleFactor=0.0119
WETLabsCalData.Chlorophyll.maxOutput=4130
WETLabsCalData.Chlorophyll.resolution=1
WETLabsCalData.Chlorophyll.calTemperature=21.5

% CDOM % (Verified 25/01/2014)
WETLabsCalData.CDOM.maxOutput=4130
WETLabsCalData.CDOM.scaleFactor=0.0912
WETLabsCalData.CDOM.darkCounts=43
WETLabsCalData.CDOM.resolution=1.0
WETLabsCalData.CDOM.calTemperature=21.5

% Scattering at 532nm % (Verified 25/01/2014)
WETLabsCalData.Scatter_532.wavelength=532
WETLabsCalData.Scatter_532.scaleFactor=9.003E-06
WETLabsCalData.Scatter_532.darkCounts=44
WETLabsCalData.Scatter_532.resolution=1.0

% PAR Calibration Constants and Device Properties % (Verified 25/01/2014)
PAR_CalData.manufacturer='Biospherical Instruments Inc';% Manufacturer
PAR_CalData.serialNumber='50144';% Serial #
PAR_CalData.calData='04/06/12';% DD/MM/YY cal date
PAR_CalData.sensorDark=10.4;% mv
PAR_CalData.scalingFactor=6.041;% Volts/uE/cm^2sec
```

sim dive checkout

General Info
Dive 4
Dive Date 01/29/14
Dive Time: 19h 22m 49s
Reviewer gsw08kzu
Seaglider ID 579
Location OCEAN2ICE
Buoyancy Engine Standard
Software Version 66.07.14
CAP File Closed? YES

Base Station Phone Numbers
Tel Number 881600005196
Alternate Tel Number 441603506320

GPS Fix 1
Latitude 5935.7333
Longitude 8528.9368
Time 19h 09m 52s
Date 01/29/14

GPS Fix 2
Latitude 5937.3733
Longitude 8531.6038
Time 19h 22m 51s
Date 01/29/14

Bathymetry Maps
Map Filename
No maps
Deploy WARNING
Offshore WARNING
Current Location WARNING

Pitch Motor
Total Displ.(centimeters) PASS
5.00 <= Total Displ. <= 12.40 9.57
Roll Gain P MISSING
From / To (centimeters) 0.52 to -9.05
Duration (sec) PASS
5.00 <= Duration <= 16.00 8.4

Avg. Current (mA) PASS
0.00 <Avg. Current <= 300.00 52
Rate (AD/sec) PASS
Rate >= 175.00 365

Roll Motor
Total Displ.(degrees) PASS
37.50 <= Total Displ. <= 42.50 40.25
Roll Gain P 0
Roll Movement Port (degrees) PASS
-54.65 <= Port <= -39.00 -0.62
Duration (sec) PASS
2.00 <= Duration <= 4.00 2.3
Avg. Current (mA) PASS
0.00 < Avg. Current <= 100.00 34
Rate (AD/sec) PASS
Rate >= 500.00 625
Pump Maneuver
Vol. Pumped (cc) FAIL
135.00 <= Vol. Pumped<= 155.00 170.97
Duration (sec) PASS
1.00 <= Duration <= 400.00 66.9
Avg. Current (mA) FAIL
380.00 <Avg. Current <= 530.00 586
Rate (AD/sec) PASS
Rate (AD/sec) >= 7.00 10
Rate (cc/sec) PASS
Rate (cc/sec) >= 1.90 2.56

Sensor Data

AanderaaOptode PASS
0.00 <= AanderaaOptode<= 500.00 322.89..
327.81
AanderaaOptode Timeouts PASS
AanderaaOptode Timeouts <= 0 0

CT Data Sampling

Temperature PASS
-10.00 <= Temperature <= 50.00 3.29
Salinity PASS
0.00 <= Salinity <= 0.10 0
rho PASS
996.00 <= rho <= 1000.00 999.97

MicroCAT C-T Recorder
Conductivity PASS
2796.92* <= Conductivity <= 7899.08* 2943.83
..2944.04

Temperature PASS
950.00* <= Temperature <= 5722925.00* 3067.50
..3163.76
Calibration Data PASS

Glider Payload CTD WARNING: No GPCTD found!

WETLabs ECO Triplet
Backscatter (532 nm) FAIL
0.00 <= Backscatter (532 nm) <= 0.00 4130.00
..4130.00
Calibration Data FAIL

Chlorophyll FAIL
0.00 <= Chlorophyll <= 0.00 2287.00 ..2996.00
Calibration Data FAIL

CDOM FAIL
0.00 <= CDOM <= 0.00 2118.00 ..2198.00
Calibration Data FAIL

PAR
Voltage (mV) PASS
0.0000 <= PAR <= 500.0000 10.5430..11.1880

Ping Count PASS
0 <= Count < 10 5

Internal Pressure (psia) PASS
7.00 <= Internal Pressure <= 10.00 8.15

Internal Humidity PASS
Internal Humidity > 0.00 50.19

TCM Temperature (Celsius) PASS
0.00 <= TCM Temperature <= 85.00 10.7

Dew Point PASS
dewPoint<= 8.00 0.75

Fuel Gauge Data
Power Source Internal Battery
24V Battery Pack Voltage 26.06
24V Battery Pack Condition New
New Criteria > 25.50
10V Battery Pack Voltage 10.65
10V Battery Pack Condition NOT New
New Criteria > 10.70

Piloting Parameters
$ALTIM_PING_DELTA FAIL
Expected = 5 20

$ALTIM_PING_DEPTH FAIL
Expected = 80 200

$COMPASS_USE FAIL
Expected = 0 641

$CP_PROFILE WARNING
Expected = 3 NOT FOUND

$CP_RECORDABOVE WARNING
Expected = 1000 NOT FOUND

$CP_RECORDAPOGEE WARNING
Expected = 0 NOT FOUND

$CP_RECORDCONTINUOUS WARNING
Expected = 0 NOT FOUND

$CP_UPLOADMAX WARNING
Expected = 1000000 NOT FOUND

$CP_XMITPROFILE WARNING
Expected = 1 NOT FOUND

$D_ABORT FAIL
Expected = 1020 990

$ESCAPE_HEADING WARNING
Expected = 0 NOT FOUND

$ESCAPE_HEADING_DELTA WARNING
Expected = 10 NOT FOUND

$ES_PROFILE WARNING
Expected = 1 NOT FOUND

$ES_RECORDABOVE WARNING
Expected = 1000 NOT FOUND

$ES_RECORDAPOGEE WARNING
Expected = 0 NOT FOUND

$ES_RECORDCONTINUOUS WARNING
Expected = 0 NOT FOUND

$ES_UPLOADMAX WARNING
Expected = 1000000 NOT FOUND

$ES_XMITPROFILE WARNING
Expected = 3 NOT FOUND

$GC_WINDOW FAIL
Expected = 0 20

$HD_A FAIL
Expected = 3.836000e-003 0.003836

$HD_C FAIL
Expected = 9.850000e-006 0.00000985

$KALMAN_USE FAIL
Expected = 2 0

$MAX_BUOY FAIL
Expected = 5 175

$MINV_10V FAIL
Expected = 8 9

$PC_INTERVAL WARNING
Expected = 1 NOT FOUND

$PC_PROFILE WARNING
Expected = 3 NOT FOUND

$PC_RECORDABOVE WARNING
Expected = 1000 NOT FOUND

$PC_RECORDAPOGEE WARNING
Expected = 0 NOT FOUND

$PC_RECORDCONTINUOUS WARNING
Expected = 0 NOT FOUND

$PC_UPLOADMAX WARNING
Expected = 1000000 NOT FOUND

$PC_XMITPROFILE WARNING
Expected = 3 NOT FOUND

$PITCH_DBAND FAIL
Expected = 1.000000e-001 0.01

$PITCH_GAIN FAIL
Expected = 30 32

$PITCH_VBD_SHIFT FAIL
Expected = 1.230000e-003 0.00005

$RHO FAIL
Expected = 1.026000e+000 1.027

$R_PORT_OVSHOOT FAIL
Expected = 25 26

$R_STBD_OVSHOOT FAIL
Expected = 25 46

$SM_CC FAIL
Expected = 150 250

$TCM_PITCH_OFFSET FAIL
Expected = 0 0.08

$TCM_ROLL_OFFSET FAIL
Expected = 0 0.23

$TGT_DEFAULT_LAT FAIL
Expected = 4212 4844.94

$TGT_DEFAULT_LON FAIL
Expected = -7043 -1606

$T_MISSION FAIL
Expected = 15 30

$T_RSLEEP FAIL
Expected = 3 2

Communications
Target Files PASS
Cmd Files PASS
Science Files PASS
Phone numbers 881600005196
Call attempts 1
Avg. Call Attempts <= 2 PASS

Retries & Misc. Errors
CF8FileCloseErrorCount PASS
Expected <= 0 0

CF8FileCloseRetryCount PASS
Expected <= 0 0

CF8FileOpenErrorCount PASS
Expected <= 0 0

CF8FileOpenRetryCount PASS
Expected <= 0 0

CF8FileWriteErrorCount PASS
Expected <= 0 0

CF8FileWriteRetryCount PASS
Expected <= 0 0

bufferOverruns PASS
Expected <= 0 0

noGPSPPS PASS
Expected <= 0 0

noGPSdataPASS
Expected <= 1 1

pitchErrorCount PASS
Expected <= 1 0

pitchRetryCount PASS
Expected <= 2 0

rollErrorCount PASS
Expected <= 1 0

rollRetryCount PASS
Expected <= 2 0

spuriousInterrupts PASS
Expected <= 0 0

vbdErrorCount PASS
Expected <= 1 0

Expected <= 2 0

vbdRetryCount PASS

SG510 pre-deployment files:

targets

// SG510 Ocean2ICE Cruise, February 2014, LCB 10/02/2014
AutoT lat=-7455.000 lon=-10222.000 radius=500 goto=iSTAR8
iSTAR8 lat=-7451.798 lon=-10206.250 radius=500 goto=AutoT
BSR5 lat=-7503.356 lon=-10159.024 radius=500 goto=PIG_NE
PIG_NE lat=-7445.000 lon=-10120.000 radius=500 goto=BSR5

science

// SG510 Ocean2ICE Cruise, February 2014, BYQ 25/01/2014
// CT AA4330 WetLabs PAR
// Depth Interval Freq GCint
100 5 1111 60
200 5 1111 120
1000 5 1111 180

cmdfile

$MISSION,19
$D_TGT,100
$D_ABORT,990
$D_BOOST,120
$T_BOOST,5
$T_DIVE,33
$T_MISSION,40
$APOGEE_PITCH,-18
$MAX_BUOY,300
$RHO,1.027
$MASS,53235
$LENGTH,1.8
$NAV_MODE,2
$KALMAN_USE,2
$HD_A,0.0038360001
$HD_B,0.010078
$HD_C,9.8500004e-06
$ESCAPE_HEADING,45
$TGT_DEFAULT_LAT,4844.9399
$TGT_DEFAULT_LON,-1606
$SM_CC,250
$CAPUPLOAD,1
$T_RSLEEP,2
$PITCH_MIN,102
$PITCH_MAX,3868
$C_PITCH,2315
$PITCH_GAIN,37.5
$ROLL_MIN,159
$ROLL_MAX,3872
$C_ROLL_DIVE,2400
$C_ROLL_CLIMB,2080
$VBD_MIN,441
$VBD_MAX,3960
$C_VBD,2950
$MINV_24V,19
$MINV_10V,9
$ALTIM_PING_DEPTH,0
$ALTIM_PING_DELTA,0
$ALTIM_FREQUENCY,15
$SEABIRD_T_G,0.0043729311
$SEABIRD_T_H,0.00062314706
$SEABIRD_T_I,2.1936879e-05
$SEABIRD_T_J,2.1524113e-06
$SEABIRD_C_G,-10.216593
$SEABIRD_C_H,1.1959317
$SEABIRD_C_I,-0.0022304335
$SEABIRD_C_J,0.00026386941
$EBE_ENABLE,1
$QUIT

sg_calib_constants

% BYQ/SCAW/LCB 25 Jan 2014 for OCEAN2ICE
% sg_calib_constants.m

% basic glider and mission params % (NOT verified)
id_str='510';

mission_title='OCEAN2ICE';
mass=53.406;
volmax=52781;
rho0=1027.5;

% initial hydrodynamic model params % (NOT verified)
hd_a=0.003836;
hd_b=0.010078;
hd_c=9.85e-6;
therm_expan=7.05000000E-05;
temp_ref=1.50000000E+01;
abs_compress=4.18000000E-06;
pitchbias=0.00000000E+00;

% software limits from cal sheet: % (NOT verified)
pitch_min_cnts=102;
pitch_max_cnts=3868;
roll_min_cnts=159;
roll_max_cnts=3872;
vbd_min_cnts=441;
vbd_max_cnts=3960;
vbd_cnts_per_cc=-4.07671;

% pump parameters % (NOT verified)
pump_rate_intercept=1.275;
pump_rate_slope=-0.00015;
pump_power_intercept=17.4033;
pump_power_slope=0.017824;

% CT sensors cal constants % (NOT verified)
calibcomm='SN: 0135 CAL: 111810';% SN and cal date
t_g=4.37293113E-03;
t_h=6.23147082E-04;
t_i=2.19368794E-05;
t_j=2.15241121E-06;
c_g=-1.02165932E+01;
c_h=1.19593163E+00;
c_i=-2.23043349E-03;
c_j=2.63869421E-04;
cpcor=-9.5700E-08;
ctcor=3.2500E-06;
sbe_cond_freq_min=2.92803000E+00;% kHz, from cal for 0 salinity
sbe_cond_freq_max=7.69965000E+00;% kHz, est for greater than 34.9
sbe_temp_freq_min=1; % 3.35108700E+00;% kHz, from cal for 1 deg T
sbe_temp_freq_max=6.47179300E+00;% kHz, from cal for 32.5 deg T

%% AA4330 Calib % (NOT verified)

comm_oxy_type='Aa_optode';% spec Aa_optode
calibcomm_oxygen='SN: 196 CAL: 121610';% SN and cal date
%optode_FoilCoefA1=-7.1811E-06;
%optode_FoilCoefA2=0.001913061;
%optode_FoilCoefA3=-0.2050029;
%optode_FoilCoefA4=0.000719229;
%optode_FoilCoefA5=-4.44309E-07;
%optode_FoilCoefA6=11.16402;
%optode_FoilCoefA7=-0.06082851;
%optode_FoilCoefA8=9.88475E-05;
%optode_FoilCoefA9=-3.11063E-07;
%optode_FoilCoefA10=-315.8066;
%optode_FoilCoefA11=2.391703;
%optode_FoilCoefA12=-0.005931007;
%optode_FoilCoefA13=-7.26343E-06;
%optode_FoilCoefB1=3837.991;
%optode_FoilCoefB2=-37.95527;
%optode_FoilCoefB3=0.1302677;
%optode_FoilCoefB4=-0.000347757;
%optode_FoilCoefB5=2.09125E-05;
%optode_FoilCoefB6=-4.71962E-07;

% Wetlab
% Chlorophyll % (NOT verified)
%WETLabsCalData.Chlorophyll.wavelength=695;
%WETLabsCalData.Chlorophyll.darkCounts=50;
%WETLabsCalData.Chlorophyll.scaleFactor=0.0121;
%WETLabsCalData.Chlorophyll.maxOutput=4119;
%WETLabsCalData.Chlorophyll.resolution=1.9;
%WETLabsCalData.Chlorophyll.calTemperature=22.3;

% CDOM % (NOT verified)
%WETLabsCalData.CDOM.wavelength=460;
%WETLabsCalData.CDOM.scaleFactor=0.0914;
%WETLabsCalData.CDOM.darkCounts=47;
%WETLabsCalData.CDOM.resolution=1.4;
%WETLabsCalData.CDOM.maxOutput=4119;

% Scattering Sensor 650 (RED) % (NOT verified)
%WETLabsCalData.Scatter_650.wavelength=650;
%WETLabsCalData.Scatter_650.scaleFactor=3.961E-06;
%WETLabsCalData.Scatter_650.darkCounts=49;
%WETLabsCalData.Scatter_650.resolution=1.3;

sim dive checkout

General Info
Dive 3
Dive Date 01/29/14
Dive Time: 18h 54m 20s
Reviewer gsw08kzu
Seaglider ID 510
Location OCEAN2ICE
Buoyancy Engine Enhanced
Software Version 66.07.13
CAP File Closed? YES

Base Station Phone Numbers
Tel Number 881600005196
Alternate Tel Number 441603506320

GPS Fix 1
Latitude 5932.0218
Longitude 8523.3056
Time 18h 38m 58s
Date 01/29/14
GPS Fix 2
Latitude 5933.8646
Longitude 8526.0284
Time 18h 54m 22s
Date 01/29/14

Bathymetry Maps
Map Filename
No maps
Deploy WARNING
Offshore WARNING
Current Location WARNING

Pitch Motor
Total Displ.(centimeters) PASS
5.00 <= Total Displ. <= 12.40 7.64
Roll Gain P MISSING
From / To (centimeters) 0.70 to -6.94
Duration (sec) PASS
5.00 <= Duration <= 16.00 6.7
Avg. Current (mA) PASS
0.00 <Avg. Current <= 300.00 52
Rate (AD/sec) PASS
Rate >= 175.00 364

Roll Motor

Total Displ.(degrees) PASS
37.50 <= Total Displ. <= 42.50 40.09
Roll Gain P 0
Roll Movement Port (degrees) PASS
-63.35 <= Port <= -39.00 -39.86
Duration (sec) PASS
2.00 <= Duration <= 4.00 2.4
Avg. Current (mA) PASS
0.00 < Avg. Current <= 100.00 78
Rate (AD/sec) PASS
Rate >= 500.00 584
Pump Maneuver
Vol. Pumped (cc) FAIL
135.00 <= Vol. Pumped<= 155.00 322.57
Duration (sec) PASS
1.00 <= Duration <= 400.00 132.3
Avg. Current (mA) FAIL
420.00 <Avg. Current <= 620.00 161
Rate (AD/sec) PASS
Rate (AD/sec) >= 7.00 9
Rate (cc/sec) PASS
Rate (cc/sec) >= 2.30 2.44

Sensor Data

AanderaaOptode PASS
0.00 <= AanderaaOptode<= 500.00 330.64..334.73
AanderaaOptode Timeouts PASS
AanderaaOptode Timeouts <= 0 0

CT Data Sampling

Temperature PASS
-10.00 <= Temperature <= 50.00 4.05
Salinity PASS
0.00 <= Salinity <= 0.10 0
rho PASS
996.00 <= rho <= 1000.00 999.98

MicroCAT C-T Recorder
Conductivity PASS
2781.63* <= Conductivity <= 7699.65* 2927.85..2928.02

Temperature PASS
950.00* <= Temperature <= 6471.79* 3575.16..3617.98
Calibration Data PASS

Glider Payload CTD WARNING: No GPCTD found!

WETLabs ECO Triplet
Backscatter (650 nm) FAIL
0.00 <= Backscatter (650 nm) <= 0.00 4119.00..4119.00
Calibration Data FAIL

Chlorophyll FAIL
0.00 <= Chlorophyll <= 0.00 323.00 .. 364.00
Calibration Data FAIL

CDOM FAIL
0.00 <= CDOM <= 0.00 33.00 .. 41.00
Calibration Data FAIL

PAR
Voltage (mV) PASS
0.0000 <= PAR <= 500.0000 10.8770..11.6550

Ping Count FAIL
0 <= Count < 10 15

Internal Pressure (psia) PASS
7.00 <= Internal Pressure <= 10.00 8.54

Internal Humidity PASS
Internal Humidity > 0.00 34.64

TCM Temperature (Celsius) PASS
0.00 <= TCM Temperature <= 85.00 13.9

Dew Point PASS
dewPoint<= 8.00 -1.45

Fuel Gauge Data
Power Source Internal Battery
24V Battery Pack Voltage 26.07
24V Battery Pack Condition New
New Criteria > 25.50
10V Battery Pack Voltage 10.24
10V Battery Pack Condition NOT New
New Criteria > 10.70

Piloting Parameters
$AH0_10V FAIL
Expected = 95 100

$AH0_24V FAIL
Expected = 145 150

$ALTIM_BOTTOM_TURN_MARGIN FAIL
Expected = 12 0

$ALTIM_FREQUENCY FAIL
Expected = 13 15

$ALTIM_PING_DELTA FAIL
Expected = 5 20

$ALTIM_PING_DEPTH FAIL
Expected = 80 200

$ALTIM_PULSE FAIL
Expected = 3 1

$ALTIM_TOP_MIN_OBSTACLE FAIL
Expected = 1 2

$APOGEE_PITCH FAIL
Expected = -5 -18

$CF8_MAXERRORS FAIL
Expected = 20 50

$CP_PROFILE WARNING
Expected = 3 NOT FOUND

$CP_RECORDABOVE WARNING
Expected = 1000 NOT FOUND

$CP_RECORDAPOGEE WARNING
Expected = 0 NOT FOUND

$CP_RECORDCONTINUOUS WARNING
Expected = 0 NOT FOUND

$CP_UPLOADMAX WARNING
Expected = 1000000 NOT FOUND

$CP_XMITPROFILE WARNING
Expected = 1 NOT FOUND

$D_ABORT FAIL
Expected = 1020 990

$D_BOOST FAIL
Expected = 5 120

$EBE_ENABLE FAIL
Expected = 0 1

$ESCAPE_HEADING WARNING
Expected = 0 NOT FOUND

$ESCAPE_HEADING_DELTA WARNING
Expected = 10 NOT FOUND

$ES_PROFILE WARNING
Expected = 1 NOT FOUND

$ES_RECORDABOVE WARNING
Expected = 1000 NOT FOUND

$ES_RECORDAPOGEE WARNING
Expected = 0 NOT FOUND

$ES_RECORDCONTINUOUS WARNING
Expected = 0 NOT FOUND

$ES_UPLOADMAX WARNING
Expected = 1000000 NOT FOUND

$ES_XMITPROFILE WARNING
Expected = 3 NOT FOUND

$GC_WINDOW FAIL
Expected = 0 20

$HD_A FAIL
Expected = 3.836000e-003 0.003836

$HD_C FAIL
Expected = 9.850000e-006 0.00000985

$KALMAN_USE FAIL
Expected = 2 0

$LOGGERS FAIL
Expected = 7 0

$MAX_BUOY FAIL
Expected = 5 300

$MINV_10V FAIL
Expected = 8 9

$PC_INTERVAL WARNING
Expected = 1 NOT FOUND

$PC_PROFILE WARNING
Expected = 3 NOT FOUND

$PC_RECORDABOVE WARNING
Expected = 1000 NOT FOUND

$PC_RECORDAPOGEE WARNING
Expected = 0 NOT FOUND

$PC_RECORDCONTINUOUS WARNING
Expected = 0 NOT FOUND

$PC_UPLOADMAX WARNING
Expected = 1000000 NOT FOUND

$PC_XMITPROFILE WARNING
Expected = 3 NOT FOUND

$PHONE_SUPPLY FAIL
Expected = 2 1

$PITCH_DBAND FAIL
Expected = 1.000000e-001 0.05

$PITCH_GAIN FAIL
Expected = 30 37.5

$PITCH_VBD_SHIFT FAIL
Expected = 1.230000e-003 0.00123

$RELAUNCH FAIL
Expected = 0 1

$RHO FAIL
Expected = 1.026000e+000 1.027

$R_PORT_OVSHOOT FAIL
Expected = 25 21

$R_STBD_OVSHOOT FAIL
Expected = 25 20

$SM_CC FAIL
Expected = 150 615.4477

$TGT_DEFAULT_LAT FAIL
Expected = 4212 4844.94

$TGT_DEFAULT_LON FAIL
Expected = -7043 -1606

$T_ABORT FAIL
Expected = 720 1440

$T_BOOST FAIL
Expected = 0 5

$T_MISSION FAIL
Expected = 15 40

$T_RSLEEP FAIL
Expected = 3 2

$UNCOM_BLEED FAIL
Expected = 60 20

Communications
Target Files PASS
Cmd Files PASS
Science Files PASS
Phone numbers 881600005196
Call attempts 5
Avg. Call Attempts <= 2 WARNING

Retries & Misc. Errors
CF8FileCloseErrorCount PASS
Expected <= 0 0

CF8FileCloseRetryCount PASS
Expected <= 0 0

CF8FileOpenErrorCount PASS
Expected <= 0 0

CF8FileOpenRetryCount PASS
Expected <= 0 0

CF8FileWriteErrorCount		PASS
Expected <= 0	0	
CF8FileWriteRetryCount		PASS
Expected <= 0	0	
bufferOverruns	PASS	
Expected <= 0	0	
noGPSdataPASS		
Expected <= 1	0	
pitchErrorCount	PASS	
Expected <= 1	0	
pitchRetryCount	PASS	
Expected <= 2	0	
rollErrorCount	PASS	
Expected <= 1	0	
rollRetryCount	PASS	
Expected <= 2	0	
spuriousInterrupts	PASS	
Expected <= 0	0	
vbdErrorCount	PASS	
Expected <= 1	0	
vbdRetryCount	PASS	
Expected <= 2	0	

8 Ship-mounted Acoustic Doppler Current Profiler (SADCP) (Louise Biddle, Pierre Dutrieux)

Upper ocean currents are routinely measured aboard the R.R.S. James Clark Ross by a Ship-mounted Acoustic Doppler Current Profiler (SADCP). The instrument currently mounted is a 75 kHz Ocean Surveyor from RD Instruments. It was configure to measure currents from about 22 m to 814 m depth with a 8 m bin vertical resolution, although most measurements rarely reach below 600 m.

Environmental conditions were excellent for SADCP observations in the ice-free Pine Island Bay in early 2014, and the extensive work in front of the Pine Island and Thwaites Glacier resulted in a comprehensive survey of the near surface ocean currents near the ice fronts. Similarly, extensive work in the central trough at the continental shelf edge of the Amundsen sea allowed for and extensive survey of the flow conditions there. Figure 8.1 shows the measured currents, accurate to ~2 cm/s in most cases. In general, currents were slightly surface intensified, but consistent in direction over the top 500 m. In Pine Island Bay, they were dominated by a cyclonic gyre in front of the glacier. This feature is represented by a doming of the thermocline at the centre of the gyre in CTD observations, and is consistent with earlier observations.

8.1 Settings and configuration

The SADCP is mounted in the transducer well in the hull at an approximate depth of 6.3 m, with a misalignment angle of approximately 60 degrees. Both this and the exact depth of the SADCP will vary depending on the cargo load – the misalignment angle and a scaling factor are calculated in post-processing.

The SADCP can be run in narrowband or broadband, but for the entirety of JR294/5 it was run in narrowband mode, reaching an approximate depth of 800 m, with bottom tracking off. It was run independently from the SSU with an internally set ping rate of 2 seconds. The EM122 was running throughout the cruise except for CTD stations, and the SADCP was initially also switched off during moorings and Autosub trials. It was later found that the SADCP ping did not interfere with these acoustics, and so from then onwards it remained on.

The SADCP was controlled using VmDas software, which managed the data logging and preliminary screening during JR294/5. Final processing was completed on both Matlab and CODAS routines. The SADCP report from JR165 was used frequently during the cruise as a reference guide for set up and processing. It is available on legwork during the cruise, and will be available on an open-access database post-cruise, with filename *jr165_adcp_report.pdf*.

The command file used during JR294/5 is copied below. The blanking distance at the surface was set to 8 m.

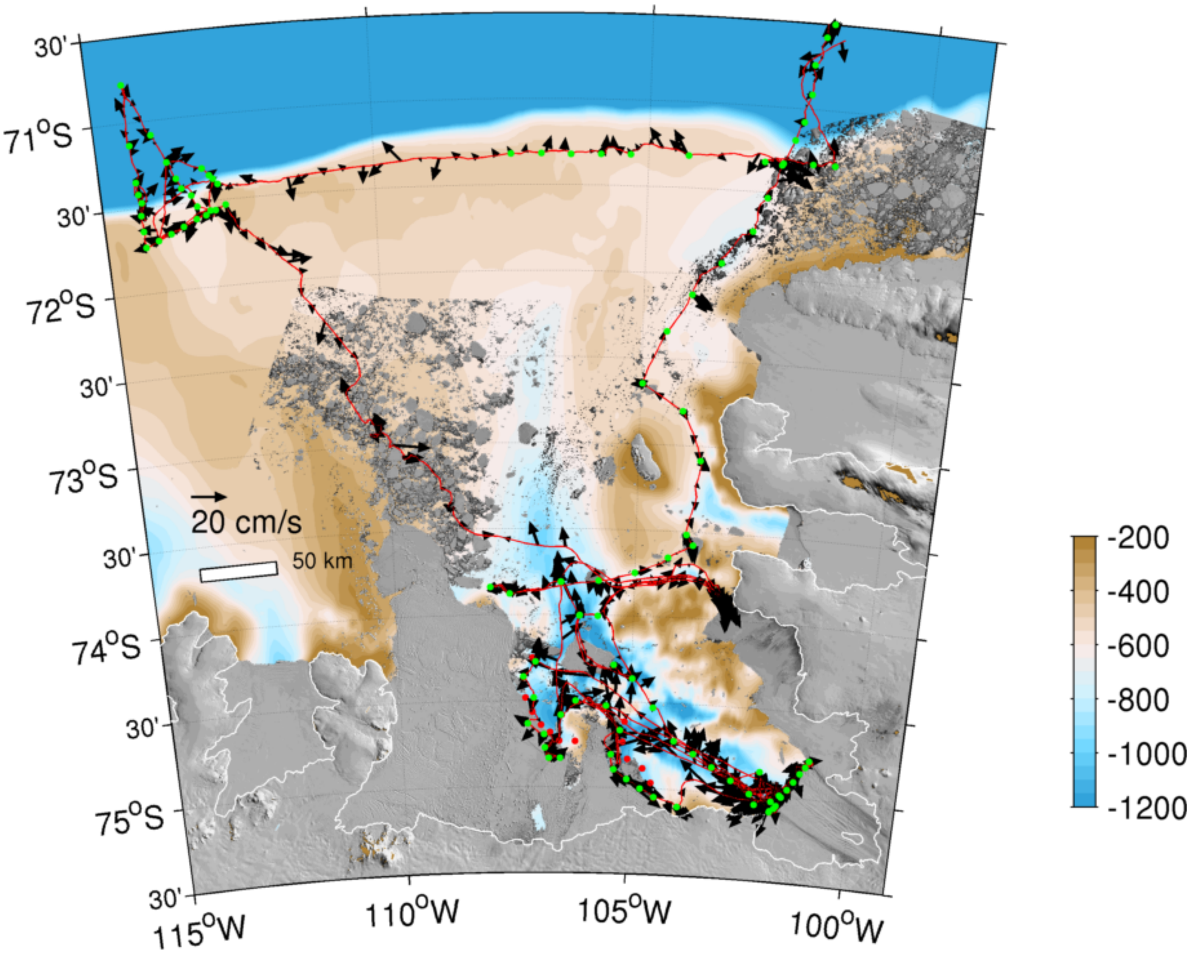


Figure 8.1: Summary map of the iSTAR cruise track (red), CTD stations (green dots) and depth-averaged SADCP observations (black vectors, one every four is shown).

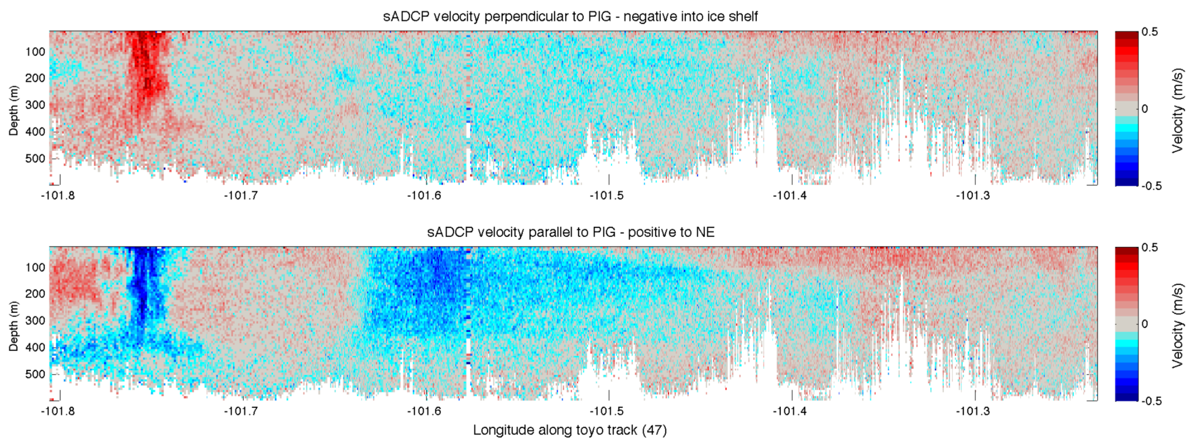


Figure 8.2: Example plot of SADCP data along toyo track 47

JR294 SADCP command file

```
; Restore factory default settings in the ADCP

cr1

; set the data collection baud rate to 38400 bps,
; no parity, one stop bit, 8 data bits
; NOTE: VmDas sends baud rate change command after all other commands in
; this file, so that it is not made permanent by a CK command.

cb611

; Set for narrowband single-ping profile mode (NP), one hundred (NN) 8 meter bins (NS), 8
meter blanking distance (NF)

; Switch on Narrowband NP1

NP1
nn100
ns800
nf0800

; Switch off Broadband WP0

WP000
WN100
WS800
WF0800
WV390

; Enable single-ping bottom track (BP),
; Set maximum bottom search depth to 1000 meters (BX)

BP00
BX10000

; output velocity, correlation, echo intensity, percent good

WD111100000

; Two seconds between bottom and water pings

TP000050

; Three seconds between ensembles
; Since VmDas uses manual pinging, TE is ignored by the ADCP.
; You must set the time between ensemble in the VmDas Communication options

TE00000100

; Set to calculate speed-of-sound, no depth sensor, external synchro heading
; sensor, no pitch or roll being used, no salinity sensor, use internal transducer
; temperature sensor

EZ1020001

; Output beam data (rotations are done in software)

EX00000

; Set transducer misalignment (hundredths of degrees)

EA6008

; Set transducer depth (decimeters) [= 6.3m on JCR]

ED00063

; Set Salinity (ppt) [salinity in transducer well = 0]

ES0

; Set Trigger In/Out [ADCP run through SSU]

CX0,0

; save this setup to non-volatile memory in the ADCP

CK
```

8.2 Output Data

Filenames from VmDas are in the format *JR294xxx_000nnn.aaa*, where xxx is the file sequence number, nnn is the file number within that sequence and aaa is the file type. The file number automatically increases each time the file size exceeds 10 MB, whilst the file sequence number increments on each restart of the system. There are 9 different file types, each with different amounts of file numbers (see table below).

The *.LOG* files are used to determine the SADCP settings for each file sequence; of particular importance are the bin size and depth. The *.N1R* file contains navigation and attitude data (time, lat, lon, pitch, roll, heading etc.) obtained from the ship's Seatex GPS system and is essential for processing. This file was used (the $PADCP line) to find the start and end times, and length of each record to begin analysis of the raw data – producing the table seen below.

Following this, the perl script *nav_gaps.pl* (written by Jeremy Robst) was used to check whether there were any missing data, duplications or backwards jumps of the ensemble number within the data. This can help identify where the SADCP missed a ping or reset the system (resulting in duplicates, or reverting to ensemble number 1). Its usage (on a mac) is:

perl nav_gaps.pl path to raw data/.N1R > nav_gaps.txt*

It is also worth bearing in mind that this script currently only looks for the largest ping number rather than the final $PADCP line – therefore when the ping number has "fallen backwards" it provides an incorrect end date. The data from this script is available in the *nav_gaps.txt* file, but it highlighted that files 018, 019, 029 and 030 have no data in them (due to the SADCP computer restarting), and that file 024 has multiple duplications and backwards jumps.

This table outlines the different SADCP files produced during JR294. It shows the sequence number of the file, the first and last $PADCP lines in the *.N1R* files (which gives the start and end time of the file sequence), the length of each sequence, a list of the relevant files for each sequence number and the configuration that was used, as well as any comments made. In the cases where more than one file of a file type was recorded (due to large file size), these filenames were abbreviated: e.g. in file sequence 008, eight *.ENR* files were created, with the names *JR294008_000000.ENR, JR294008_000001.ENR, JR294008_000002.ENR ... JR294008_000007.ENR*. This is shortened to *JR294008_000000-7.ENR*.

In addition to the filenames shown, .LOG, .LTA, .NMS, .STA and .VMO files were created. As there is always one of these file types per sequence, they are not listed in the table. It is also useful to list the bin size and number of bins for each file sequence; if the bin size varies, the user must be wary when the scripts assign the gridded depths (i.e. if switching between narrowband and broadband). During the iSTAR cruise, the SADCP was always run in narrowband (NB) mode, so this is not an issue here.

seq.	$PADCP times and length	Files	Config.	Comments
001	28/01/2014 15:47:06.01 29/01/2014 15:27:17.31 23h 40m	JR294001_000000-7.ENR JR294001_000000-7.ENS JR294001_000000-7.ENX JR294001_000000-1.N1R	NB,BT off nn100 ns800 800 m	CX0,0 Not through SSU
002	29/01/2014 15:27:28.00 30/01/2014 15:26:24.16 23h 59m	JR294002_000000-7.ENR JR294002_000000-7.ENS JR294002_000000-7.ENX JR294002_000000-1.N1R		
003	30/01/2014 15:26:34.01 31/01/2014 15:45:26.46 24h 19m	JR294003_000000-7.ENR JR294003_000000-7.ENS JR294003_000000-7.ENX JR294003_000000-1.N1R		
004	31/01/2014 15:45:37.01 01/02/2014 15:47:25.65 24h 02m	JR294004_000000-7.ENR JR294004_000000-7.ENS JR294004_000000-7.ENX JR294005_000000-1.N1R		
005	01/02/2014 15:47:36.01 02/02/2014 15:08:00.96 23h 21m	JR294005_000000-7.ENR JR294005_000000-7.ENS JR294005_000000-7.ENX JR294005_000000-1.N1R		
006	02/02/2014 15:08:24.01 03/02/2014 14:57:51.77 23h 50m	JR294006_000000-7.ENR JR294006_000000-7.ENS JR294006_000000-7.ENX JR294006_000000-1.N1R		
007	03/02/2014 14:58:06.00 04/02/2014 15:13:39.04 24h 15m	JR294007_000000-7.ENR JR294007_000000-7.ENS JR294007_000000-7.ENX JR294007_000000-1.N1R		
008	04/02/2014 15:13:53.01 05/02/2014 15:20:59.60 24h 07m	JR294008_000000-7.ENR JR294008_000000-7.ENS JR294008_000000-7.ENX JR294008_000000-1.N1R		
009	05/02/2014 15:21:11.01 06/02/2014 15:41:55.49 24h 20m	JR294009_000000-7.ENR JR294009_000000-7.ENS JR294009_000000-7.ENX JR294009_000000-1.N1R		
010	06/02/2014 15:42:06.04 09/02/2014 14:59:48.55 71h 18m	JR294010_000000-23.ENR JR294010_000000-23.ENS JR294010_000000-23.ENX JR294010_000000-5.N1R		
011	09/02/2014 15:00:02.01 10/02/2014 12:34:08.65 21h 34m	JR294011_000000-6.ENR JR294011_000000-6.ENS JR294011_000000-6.ENX JR294011_000000-1.N1R		
ADCP switched off for Autosub trials; 12h 43m				
012	11/02/2014 01:17:45.00 12/02/2014 12:55:14.07 35h 38m	JR294012_000000-11.ENR JR2940112_000000-11.ENS JR294012_000000-11.ENX JR294012_000000-2.N1R		
ADCP switched off for moorings; 2h 14m				
013	12/02/2014 15:09:38.79 13/02/2014 14:57:21.02 23h 48m	JR294013_000000-7.ENR JR294013_000000-7.ENS JR294013_000000-7.ENX JR294013_000000-1.N1R		
014	13/02/2014 14:57:33.01 14/02/2014 11:10:02.88 20h 13m	JR294014_000000-6.ENR JR294014_000000-6.ENS JR294014_000000-6.ENX JR294014_000000-1.N1R		
ADCP switched off for Autosub trials; 19h 22m				
015	15/02/2014 06:32:00.00 15/02/2014 15:58:20.93 09h 26m	JR294015_000000-3.ENR JR294015_000000-3.ENS JR294015_000000-3.ENX JR294015_000000.N1R		

seq.	$PADCP times and length	Files	Config.	Comments
016	15/02/2014 15:58:32.01 16/02/2014 15:56:42.79 23h 58m	JR294016_000000-7.ENR JR294016_000000-7.ENS JR294016_000000-7.ENX JR294016_000000-1.N1R		
ADCP switched off for Autosub mission; 8h 6m				
017	17/02/2014 00:02:31.01 17/02/2014 16:03:36.82 16h 01m	JR294017_000000-5.ENR JR294017_000000-5.ENS JR294017_000000-5.ENX JR294017_000000-1.N1R		
018	17/02/2014 16:03:38.01 17/02/2014 16:04:02.24 00h 01m	JR294018_000000.ENR JR294018_000000.ENS JR294018_000000.ENX JR294018_000000.N1R		Bad nav data
019	— — 0m	— — — JR294019_000000.N1R		No .ENX .ENR .ENS files Empty .N1R file
020	17/02/2014 16:04:18.01 18/02/2014 19:26:07.17 27h 12m	JR294020_000000-8.ENR JR294020_000000-8.ENS JR294020_000000-8.ENX JR294020_000000-1.N1R		
021	18/02/2014 19:26:42.79 18/02/2014 22:01:41.09 2h 35m	JR294021_000000.ENR JR294021_000000.ENS JR294021_000000.ENX JR294021_000000.N1R		
ADCP switched off for Autosub mission; 5h 8m				
022	19/02/2014 03:09:38.01 19/02/2014 15:29:39.12 12h 20m	JR294022_000000-3.ENR JR294022_000000-3.ENS JR294022_000000-3.ENX JR294022_000000.N1R		
023	19/02/2014 15:29:49.01 20/02/2014 17:41:14.80 26h 12m	JR294023_000000-8.ENR JR294023_000000-8.ENS JR294023_000000-8.ENX JR294023_000000-1.N1R		
024	20/02/2014 17:41:25.01 21/02/2014 23:12:14.59 29h 41m	JR294024_000000-9.ENR JR294024_000000-9.ENS JR294024_000000-9.ENX JR294024_000000-2.N1R		
025	21/02/2014 23:12:23.01 22/02/2014 17:42:45.45 18h 30m	JR294025_000000-5.ENR JR294025_000000-5.ENS JR294025_000000-5.ENX JR294025_000000-1.N1R		
026	22/02/2014 17:42:53.01 23/02/2014 19:23:17.03 25h 41m	JR294025_000000-8.ENR JR294025_000000-8.ENS JR294026_000000-8.ENX JR294026_000000-1.N1R		
027	23/02/2014 19:23:26.00 24/02/2014 22:10:44.87 26h 47m	JR294027_000000-8.ENR JR294027_000000-8.ENS JR294027_000000-8.ENX JR294027_000000-1.N1R		
028	24/02/2014 22:10:44.87 26/02/2014 12:00:18.32 37h 50m	JR2940278_000000-12.ENR JR294028_000000-12.ENS JR294028_000000-12.ENX JR294028_000000-2.N1R		
029	26/02/2014 12:00 —	JR294029_000000.ENR JR294029_000000.ENS JR294029_000000.ENX JR294029_000000.N1R		ADCP reset itself .N1R file full of junk
030	— —	JR294030_000000.ENR JR294030_000000.ENS JR294030_000000.ENX JR294030_000000.N1R		 .N1R binary file

seq.	$PADCP times and length	Files	Config.	Comments
031	26/02/2014 13:13:53.01 27/02/2014 16:55:56.49 27h 42m	JR294031_000000-8.ENR JR294031_000000-8.ENS JR294031_000000-8.ENX JR294031_000000-1.N1R		
032	27/02/2014 16:56:09.01 28/02/2014 18:52:30.48 25h 56m	JR294032_000000-8.ENR JR294032_000000-8.ENS JR294032_000000-8.ENX JR294032_000000-1.N1R		
033	28/02/2014 18:52:39.01 01/03/2014 21:05:15.48 26h 12m	JR294033_000000-8.ENR JR294033_000000-8.ENS JR294033_000000-8.ENX JR294033_000000-1.N1R		
034	01/03/2014 21:05:24.01 03/03/2014 03:10:20.51 30h 05m	JR294034_000000-9.ENR JR294034_000000-9.ENS JR294034_000000-9.ENX JR294034_000000-2.N1R		
035	03/03/2014 03:10:31.01 03/03/2014 22:23:09.67 19h 13m	JR294035_000000-6.ENR JR294035_000000-6.ENS JR294035_000000-6.ENX JR294035_000000-1.N1R		
036	03/03/2014 22:23:18.02 04/03/2014 21:26:31.73 23h 03m	JR294036_000000-7.ENR JR294036_000000-7.ENS JR294036_000000-7.ENX JR294036_000000-1.N1R		
037	04/03/2014 21:26:41.01 06/03/2014 12:52:33.43 39h 26m	JR294037_000000-12.ENR JR294037_000000-12.ENS JR294037_000000-12.ENX JR294037_000000-2.N1R		
File 038 running from 06/03/2014 to approx 08/03/2014 – return to Rothera				

8.3 Matlab Processing

The Matlab scripts for processing SADCP data were provided by Deb Shoosmith at BAS, originally obtained from IFM Kiel by Mark Inall. Over the years they have been edited by several people, and so it is important to read through the scripts to check what has been changed. For an in-depth review of each separate script, refer to the *jr165_adcp_report.pdf*.

The master script is OS75_JCR_jr294_LCB.m, and this is the only script that needs editing;

- The paths for where all the ADCP matlab scripts are stored, the raw data is stored and where the processed data is written to must be added at the top of the script.
- Cruise name variable must be updated to current cruise number (used when reading in raw data).
- The file sequences to process – can process any selection of files
- The averaging interval ('superaverage'). This was left at the default 120 seconds.
- The year must be updated.
- Which lat/lon fix to use (default is '1', indicating the fix directly after previous ADCP ping).
- Upper and lower limit of reference layer. This is important when obtaining a calibration by water tracking! For ship-board processing, 400 m and 600 m were used, but this will adjusted depending on the depth of water for each file sequence upon return to UEA.
- The misalignment angle and the scaling factor ('misalignment_nb' and 'amplitude_nb'). When running the master script for the first time, these must be set to 0 and 1 respectively. After the first run, the mean, median and standard deviation of these variable are found in adcp_calib_calc.ps – the user can choose which of these values to input for the second run to calibrate the data.

Whenever plots are produced as part of this script, they are saved as .ps files – each time the master script is re-run it's a good idea to delete the older .ps files, as the new plots are added to the end of the existing file, resulting in a huge filesize. The second run takes longer, as the quality control is more detailed on this run.

Output files

There are 8 output files from this script, but the main one used in plotting data is JR294_000_000000_zzz_abs.mat, where zzz is the highest file number included in the processing. This contains an array of absolute velocity (horizontal velocities have been corrected for ship velocity), navigation information (time is in yearday, which is julian day -1), and information on the reference layer used and bin depths. For JR294 this file is saved as above, but with 'calib' or 'nocalib' affixed to the end of the filename to signify whether it has had calibration values run through.

In addition to this file, a matlab structure file, JR294_matlabSADCP.mat will be produced; this contains the same information as the abs.mat file, but the three toyos and other interesting transects have their data separated out, and all contain the option for the velocity vectors to be rotated to parallel and perpendicular to the ice front.

Problems encountered during processing

Problem A: Whilst the OS75_JCR_jr294_LCB.m script is running, a plot is produced as the ship's attitude data file is created as part of the read_nmea_att_jcr.m subroutine, illustrating the pitch, roll, heading and PC clock offset. This figure was the first indication that some of the files were not processing correctly, as partway through the processing of JR294010_00000 and JR294012_00000 file sequences, the figure was blank.

Problem B: At the end of OS75_JCR_jr294_LCB.m, calib_points wt.m is called to calculate the amplitude and angle required to calibrate the ADCP, and for the same file sequences, this threw up an error message of *'matrix dimensions must agree'* when attempting to calculate the line below;

```
maxnb=fix(dt_max/(min(diff(time))))+2;
```

This suggests that one or both of the variables required on the particular line highlighted were empty.

The correlation between the file sequences that crashed the script and their length was used as a basis for starting to identify the problem; these were the first file sequences to have over 9 .ENX files, and the figures that were blank were those from file 010 onwards.

Solution A: The OS75_JCR_jr294_LCB.m script displays the .N1R file that it is currently trying to read during the read_nmea_att_jcr.m subroutine, and this text during the 10th file of sequence 010 read as;

```
Reading all N1R files in read_nmea_att_jcr now
N1R-file in loop: JR294010 000010.N1R
```

This indicates that instead of trying to read the JR294010_000000.N1R file first (as it should do), it was skipping straight to JR294010_000010.N1R, suggesting an error in how the filename that is to be read is constructed. The fault was found on line 45, which is where the filename is constructed. The script initially read;

```
Istr = num2str(I) %where I is the iteration it is on (starting at 0).
filename(end-length(Istr)+1:end)=Istr;
I=I+1
```

This means that only the last number of the filename (e.g. 'JR294010_000010') is removed, and replaced with '`Istr`' – obviously this creates an initial file of 'JR294010_000010.N1R'. The line;

```
filename(end-length(A)+1:end-length(Istr)+1)='0'
```

Where A is the length of the file it is reading (e.g. 'JR294010_000009' would be 1, 'JR294010_00001' would be 2). This resolved the issue with blank figures being produced – and this line was also added into the main script OS75_JCR_jr294_LCB.m on line 474.

Solution B: After setting both *max_dt* and *min(diff(time))* to display to the screen, it was found that the latter variable was empty in the 24th file of file sequence 010. This suggests that at some point, the time variable had been emptied – and none of the calculations made in calib_points_wt.m or the subroutine it contains (ave_for_calib.m) would have caused this. The previous subroutine called is quality control (qual_control.m), and within the JR165 Report is it noted that any files with less than 5 minutes of data cannot be used – upon checking, the 24th file of sequence 010 had less than 4 minutes of data, and so this file was removed from the processing routine.

Further Processing

- **Bottom blanking:** In plots produced whilst on the cruise, the EM122 centre beam bathymetry was used to blank out data lying below a depth of 86% of the bottom depth (to remove any spurious pings from bottom reflections). This bathymetry dataset has been adjusted for the speed of sound, but has not yet been despiked. Once this dataset has been despiked, it can be used for final bottom blanking.
- **Water-track calibration:** During the cruise, the water depth varied greatly (~50 m to > 1500 m). To get accurate calibration values from the water-track calibration, the reference layer used in this calculation must be adjusted for each file sequence.
- **Quality control at the surface:** To remove any spurious pings (e.g. when the ship was rolling or breaking through ice).

8.4 CODAS Processing

Data ping-processing and editing was done on board using the UHDAS and CODAS ADCP processing software created and maintained by E. Firing and J. Hummon from the University of Hawaii (see http://currents/soest.hawaii.edu for more info).
A unix bourne-shell script summarizing the processing is as follows:

```
#!/bin/csh

# Process VMDAS SADCP data using UHDAS software, transform into CODAS format
# Pierre Dutrieux
# March 2014

mkdir os75_enrproc
mkdir os75_enrproc/config
mkdir fake_uhdas_data
cd os75_enrproc/config
vmdas_info.py os ../../JR294_295_data/*LTA > vmdas_info.txt
reform_vmdas.py ../..
python vmdas2uhdas.py
proc_starter.py reform_defs.py
cd ..
adcptree.py os75nb --datatype uhdas --cruisename iSTAR
cd os75nb
cp ../../q_py.cnt .
quick_adcp.py --cntfile q_py.cnt
quick_adcp.py --steps2rerun rotate:navsteps:calib --rotate_angle -0.5455 --rotate_amplitude 1.0267 --auto
cd edit
gautoedit.py
cd ..
quick_adcp.py --steps2rerun apply_edit:navsteps:calib:matfiles --auto
adcp_nc.py adcpdb contour/os75nb iSTAR os75nb

exit
```

The processed data is available in 10 minute bin-averaged netcdf format, in the file *iSTAR_os75nb.nc* .

9 Radiosonde Launches (Richard Jones)

9.1 Introduction and equipment details

As part of the iStar Ocean2ice project a series of 40 weather balloon launches were planned. With approximately 30 science days in the study area this allowed for one launch each day with an additional 10 sondes for two or three timeseries where 4 or 5 sondes are deployed approximately 4 hours apart to examine interesting weather events. The radiosondes attached to the balloons collect an atmospheric profile of temperature and humidity, with a built in GPS unit to calculate windspeed and direction. The radiosondes will be one of the data sources used to assess the quality of meteorological reanalysis products. These reanalyses are used to force ocean models and it is important to know how well they simulate weather conditions in regions such as the Amundsen Sea which have very few direct meteorological observations.
Radiosonde launch times were flexible depending on ship activities but where possible daily balloon launches occurred close to 1100UTC so data was being recorded at 1200UTC when reanalysis charts are routinely available. The map in figure 9.1 shows the launch locations for each of the 38 successful radiosonde launches during JR294, the spatial coverage over the study region is very good.

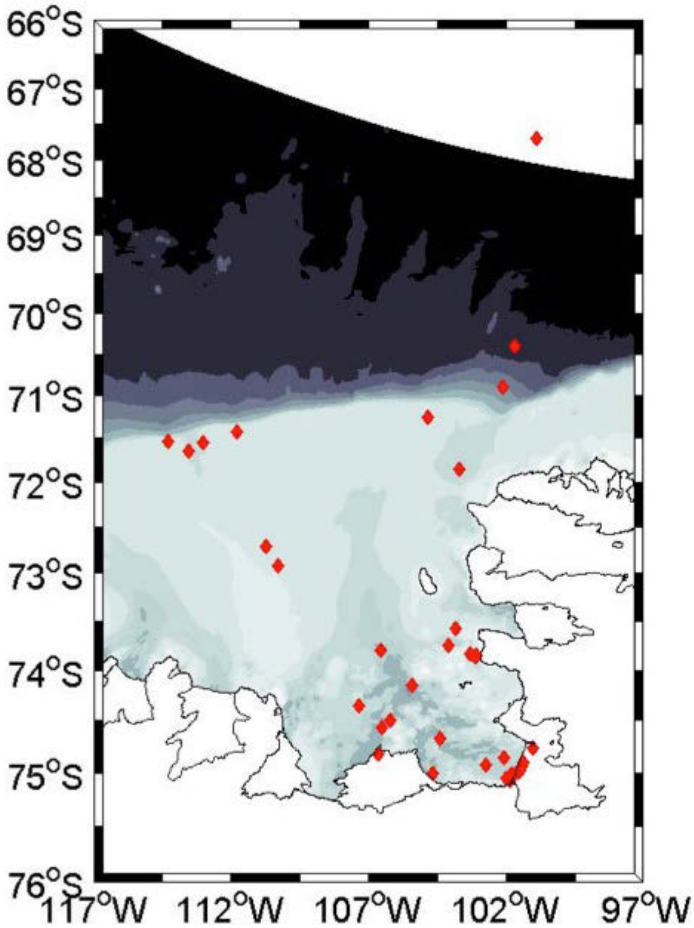


Figure 9.1: A map of the study region with radiosonde launch locations indicated by the red background, the background colour scheme shows ocean bathymetry with the shelf break shown at approximately 71°S.

The additional meteorological equipment onboard consisted of an outdoor tripod (see Fig. 9.2) with a GPS antenna for relaying the location of the radiosonde so winds can be calculated. Along with this there is a second antenna to relay data from the radiosonde to the ground station.

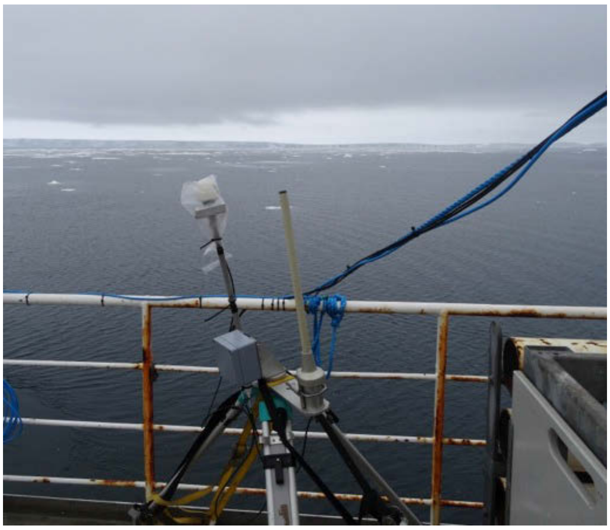


Figure 9.2: The tripod and antenna equipment on the portside of the UIC, the cable running across was cable tied to a piece of rope to make it more sturdy.

The location of the tripod with the two antennae attached was constrained by the 15m of cable to connect the antennae to an indoor ground station. The chosen location was on the port side of the UIC with the cable running through a roxtech filled hole in the bulkhead designed with that purpose in mind. This location allowed as clear a view as possible of the sky so as the antennae could find satellites. The ground station and laptop were set up on the portside of the UIC. If a longer cable were available there would have been more flexibility with the location of the meteorology work station in the UIC and the outdoor ground station.
There were also eight 50 litre (standard size) helium cylinders onboard the ship in order to fill the balloons (pictured below). Each cylinder contained enough helium to fill eight to ten 200 g balloons, only five of the cylinders were used to fill 40 balloons. Upon arrival on the RRS James Clarke Ross the helium cylinders were located on the starboard side of the boat deck. This was an unsuitable launch location as there was not enough room to fully inflate and launch the balloon. After some thought a more suitable launch location was chosen on the stern end of the naval bridge deck. The height of this location allowed the balloon to clear the a-frame on the rear of the ship. The 3 metres of hose from the regulator to the balloon nozzle allowed the balloon to be filled while sheltered from a headwind by the superstructure of the ship. Furthermore, the location was clear of overhead obstruction and there was just enough room to manoeuvre the fully inflated balloon to a safe launch location.

Figure 9.3: The launch location used during JR294 with the helium cylinders shown in the bottom right of the photo covered by a tarpaulin.

9.2 Balloon inflation and launch process

Prior to each balloon launch sonde sensors were checked and reconditioned using the Vaisala GC25 ground check set and the Digicora radiosonde software package. The system uses a small box of dessicant to recondition the humidity sensor at 0% relative humidity. With the dry air and ventilation system within the UIC the dessicant only needed changing around once every fortnight.

The final stage prior to launch is to input the current weather observations. The automatic weather station on monkey island and anemometer on the front mast provide all the data needed (pressure, temperature, humidity, windspeed and direction). The offset between the radiosondes and the AWS data was always small (~0.5hPa and ~0.2°C) indicating the AWS is well calibrated. For the anemometer data there is a problem with the true wind data stream that is shown on the screen in the UIC. It seems to increase every time the ship is steaming suggesting it is not correcting properly from the raw relative wind data. Dr. Bastien Queste has written a new Matlab script to correct for this which seems to have sorted the issue. The wind speed data is required in m/s for the Digicora software, this is approximately half the value shown in knots. For the JCR294 launch location the entered value for surface windspeed was further reduced to around a third of the value in knots due to the lower altitude compared to the anemometer and the shelter provided by the ship's superstructure.

At each radiosonde launch a team of 3-4 people was needed to safely release the balloon. Prior to inflation the balloon must be securely fastened to the regulator nozzle, using string and an easily releasable knot. The balloon must then be inflated so that it becomes buoyant, during JCR294 the volume of helium entering the balloon was not calculated instead a judgement was made by eye when the balloon had the right amount of helium in it for launch. As a general guide when the balloon becomes partly see-through it has around the correct amount of helium needed for launch.

Once fully inflated the balloon can be tied off, using a series of reef knots (or preferred knot choice), and the radiosonde attached through the plastic clip. The balloon then has to be taken off the nozzle and the neck of the balloon folded round to form a u-shape where it is once again tied to secure the sonde. At this point the balloon is ready to launch, on JCR294 a team of 3-4 people shuffled towards the railing at the stern end of the bridge deck and following a countdown the balloon was released together. In winds below 10-15knots the person in charge of the launch can simply carry the balloon towards the launch location and release without assistance.

Figure 9.4: A photo showing a launch team moving the balloon towards the correct location. In high winds the two people on the downwind side must be prepared to move quickly out of the way to avoid the balloon and sonde.

9.3 Problems and notes for future ship-borne radiosonde launches

Overall both the position of the tripod and the helium provided many opportunities for successful launches and thus far there has been a high success rate. Many successful launches have occurred while the ship has been on station for CTD casts, moorings, sea gliders and Autosub. On station the nose of the ship is always pointed into the wind allowing balloons to fly safely over the a-frame and avoiding the nearby main mast. As the ship is stationary the relative wind speed is also reduced making the process of inflating the balloon simpler and fewer people are required to stabilise it.

In total 38 of the 40 planned radiosonde launches were completed successfully. On one occasion the balloon popped against a metal railing while being manoeuvred to the stern of the ship for launching, this was human error and can easily be avoided with more care and attention- on following launches the balloon was lifted higher to avoid the railings. The other failure occurred in a high wind event while trying to complete a four radiosonde time series. In order to profile a low pressure system an attempt was made to release the balloon in 40knot winds with gusts peaking at 51knots. At this time the ship was nose to the breeze; the inflation of the balloon was difficult but successful, unfortunately upon launching the sonde crashed into the a-frame and was badly damaged. Successful launches did occur over the a-frame in 30-35knot winds and it would be possible to launch off the portside of the ship in stronger winds but this would require a cross-wind and would therefore be dependent on sea state and permission from the captain.

A final note of caution is to be careful when launching in very light winds while on station. The second balloon launch of the cruise occurred in such conditions and while the balloon went almost vertically upwards it picked up a slight tail wind which caused it to hit the main mast. Fortunately the radiosonde continued to ascend undamaged and reached a maximum altitude of 22km. In light winds it is perhaps more prudent to launch while steaming as this allows the balloon to clear the stern of the ship with ease. This technique was used for three further light wind launches during JR294 and all of these successfully cleared the ship without hitting the mast or any other part of the ship.

The tripod and antennae system was also affected by the weather. While its location allowed a clear view of overhead satellites (and therefore good communications with the sonde) it also meant that it was exposed to the weather and sea spray. After the first two balloon launches there was a problem with the antennae cable, snow had managed to get through heavy taping and into one of the connectors. At this point the GPS antennae cabling had to be disassembled; the connectors were all thoroughly cleaned and one had to be replaced to allow the system to function properly again. It is worth taking the time to fully cover and weather proof connectors, otherwise faults similar to this will occur.

Occasionally a radiosonde can fail to find a good GPS position before launch leading to a loss of wind data. This happened on three occasions during JR294 and is probably caused by the superstructure of the ship blocking the view to the sky. To prevent this it would be advisable to have somebody observing the Digicora software while the balloon is being inflated and being able to contact the launch team via radio if the GPS data drops out prior to launch.

Table 9.1 Radiosonde launches

Launch number	Date	Time (GMT)	Latitude (°S)	Longitude (°W)	Data lost height (km)	Weather Conditions and Notes
1	1st Feb	1130	67.41	100.54	19.5	8/8 low cloud cover, 15-20knots NW winds. Temperature 0°C. Launched while on station for the test CTD
2	2nd Feb	1620	70 24.101	101 40.350	22.3	8/8 low cloud cover, foggy and poor visibility. 97% surface humidity. Temp. -1.26°C. Windspeed 5 knots (Hit mast). NO WINDS. Launched while on station for CTD3, delayed due to GPS problems.
3	3rd Feb	1115	70 54.902	102 07.528	23.3	8/8 low cloud cover. Surface obs. Temp -1°C, Humidity 98%, Windspeed 6 knots. Slow ascent rate only 2-3m/s
4	4th Feb	1135	71.85	103.7	**11.2**	7/8 cloud cover. Good visibility. Thin layer of low cloud. Surface temp -2.1°C, Windspeed 5 knots NE. LOST COMMS
5	5th Feb	1220	73 34.465	103 49.627	22.6	1/8 cloud cover, almost clear blue sky, great visibility. Surface temp -4.8°C. Windspeed 10knots Southerly
6	6th Feb	1130	73 48.574	106 32.072	20.8	1/8 cloud cover, some high cirrus. Wind 20 knots from the SE. Temp -4.7°C
7	7th Feb	1200	73 45.187	104 05.122	22.9	2/8 cloud cover, some low cumulus but more high cirrus. 15 knots wind from the NE. Temp -5°C. NO WINDS
8	8th Feb	1310	73 51.622	103 04.485	21.8	Clear blue sky with bits of high cirrus cloud. 4 knots easterly breeze. Temp -5.7°C but feeling warmer in the sun. Location at Edwards Island for elephant seal tagging day.
9	9th Feb	1210	74 10.923	105 25.213	19.7	Blue sky, scatter low cloud and high cirrus 3/8 cloud cover. Close to B31 iceberg. Surface temp value needs correcting to -5.5°C
10	11th Feb	1700	74 57.413	101 26.483	21.5	Off ice flow, clear blue sky, temperature dropped to -10°C . On station for CTD 41, first launch at PIG.
11	11th Feb	2330	74 46.809	101 00.923	22.5	2nd Launch of the day, lighter off ice winds still blue sky. Launched while on station for CTD 45 near northern end of PIG.
12	12th Feb	1300	75 02.706	101 58.104	22	Layer of low cloud, SE wind- off ice flow. On station for the recovery of the U.S mooring. Balloon didn't go through low cloud.
13	13th Feb	1330	74 59.264	101 32.665	21.7	6/8 low cloud cover. Temperature -9.0 wind again from the south east, off ice flow. Launched during Toyo, while 1mile from PIG.
14	13th Feb	1620	74 58.216	101 29.302	20.6	7/8 cloud cover, very close to ice front within 1km for toyo. Wind remains off ice and ship is close to centre of low pressure.
15	13th Feb	2045	74 56.327	101 24.599	20.0	Very strong winds and pressure decreased to 974mb, still toyo'ing along the ice front- good for time series.
16	13th Feb	0100	74 54.372	101 20.901	N/A	Tried to complete time series in 40-45knot winds, sonde hit the a-frame and broke.
17	15th Feb	1115	75 04.102	101 52.250	20.3	Additional toyo section along ice front, 7/8 cover of low and high cloud with wind coming from the ice shelf at 20knots.
18	16th Feb	0930	75	102	N/A	Balloon popped on launching, sonde was reused on 2nd March
19	16th Feb	2230	75 01.514	101 45.188	20.1	On station for Autosub monitoring, clear skies and off-ice winds. Late launch time for comparison with 0000UTC reanalysis as early launch failed.
20	17th Feb	1130	75 00.472	104 40.875	22.1	Close to Thwaites ice front, almost at ice front. On station for CTD 54 Winds stronger than forecast at 20-25knots, possible orographic flow.
21	18th Feb	0800	75 01.184	101 47.100	22.1	On station for Autosub recovery after 1st proper mission. Very cold surface temp- near -15°C, off ice flow.
22	18th Feb	1145	74 51.828	102 05.078	23.0	On station for deployment of iStar 8 mooring- still -15°C and off-ice flow.
23	18th Feb	1445	74 51.849	102 05.570	21.7	Clear blue skies, feeling warmer in sun but still -12°C. Continuing time series while triangulating iStar 8 mooring.
24	18th Feb	1710	74 55.702	102 43.102	21.6	A few more clouds but still cold at -11°C. On station for CTD 60. Much more distinct boundary layer than this morning.
25	18th Feb	2130	75 02.300	101 47.300	23.2	On station for 2nd Autosub deployment under PIG. Most cloud is high cirrus, temp remains -11°C.
26	19th Feb	1715	74 49.215	106 40.229	22.1	At Thwaites glacier and coming onto station for CTD 62. Launch delayed due to late wake up and not being

						on station.
27	20th Feb	1145	74 21.671	107 19.502	20	Sunny but cold -13°C, 6/8 cloud cover but mainly clear directly above, on station for CTD 68.
28	21st Feb	1130	74 40.880	104 25.112	19.7	Steaming away from PIG after recovering Autosub following second mission. Temp. increased to -3.5 with winds from NE. NO WINDS
29	21st Feb	1645	74 29.947	106 12.309	22.1	Investigating earlier loss of wind data. Launched while on station for CTD 70, winds worked fine. Total cloud over with light ENE wind.
30	22nd Feb	1210	74 34.980	106 31.050	22.7	Launched while on station for CTD 72. Extensive low cloud cover with on/off snow, temp warmer at -2.5.
31	23rd Feb	1130	73 52.034	103 08.253	22.9	On station for second lot of seal tagging at Edwards Islands. Temp +0.06 with 20knot off ice winds from the NE. Very strong winds aloft. Start of Edwards Islands time series
32	23rd Feb	1750	73 52.025	103 03.926	21.9	Delayed 2nd launch due to 40knot gusts. 35knot winds from NE at the time of launch, evidence of downslope orographic winds.
33	23rd Feb	2110	73 50.046	103 18.696	21.8	Moved 5miles off Edwards Islands due to high winds preventing small boat deployment, 30-35knot NE'ly winds.
34	25th Feb	2245	72 55.700	110 18.372	22.1	Seal tagging north of Thwaites glacier on fast ice. 100% sea ice cover and low cloud cover with on/off light snow.
35	26th Feb	1330	72 42.971	110 43.482	-	Final morning of seal tagging, lots of sea ice and feeling very cold at -10C. 15-20 knot southerly winds.
36	27th Feb	1200	71 38.199	113 32.965	22.0	On station for CTD 78 and iStar2 mooring recovery- although mooring was not recovered. Launch only just post dawn.
37	28th Feb	1130	71 32.433	114 17.464	17.6	Launched at dawn local time, first light 45mins prior to launch. On station for iStar 4 mooring recovery. 7/8 low cloud cover.
38	2nd Mar	1330	71 33.020	113 02.293	22.0	On station for recovery of iStar 1 mooring. 5/8 cloud and similar sea ice coverage. Temp -7 with much new pancake ice forming.
39	3rd Mar	1150	71 25.362	111 48.006	16.7	Steaming towards Eastern trough section with near 100% cover of new thin sea ice. 8/8 cover of low cloud.
40	4th Mar	1130	71 15.913	104 51.187	19.8	In eastern trough steaming east towards final mooring deployment. Winds very light so launched while steaming.

9.4 Brief summary of initial results- 15th Feb launch

The average altitude reached by the radiosondes released was approximately 20km. This is well into the stratosphere (in polar regions) and significantly above the height we expected to get data to. The majority of the flights were ended due to the balloon popping rather than a loss of communications with the sonde, although there were a number of data drop outs above 16km.

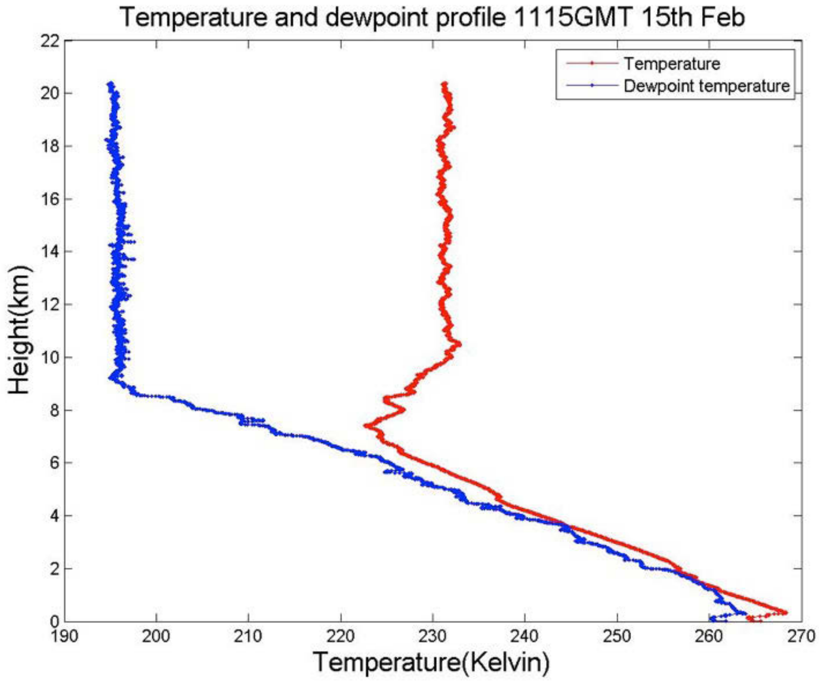


Figure 9.5: The temperature (red) and dewpoint temperature (blue) profile against altitude for the 15th Feb launch.

Starting at the bottom of the profile (shown in more detail in figure 9.6), in the lowest 200m there is a clear layer where the temperature rises 2-3°C with increasing altitude. This is the temperature inversion at the top of a shallow boundary. The temperature inversion acts as a cap beyond which air from the surface cannot rise thus preventing moist air rising to form convective cloud at the top of the boundary layer. Higher up at approximately 2km altitude there is a layer where the temperature is very close to the dewpoint temperature, this indicates a possible thin cloud layer as clouds form when relative humidity reaches ~100%. On this profile the tropopause is located at approximately 8km altitude. It is shown by the rapid reduction in relative humidity (the dewpoint temp. becomes markedly lower than the temperature) and the increase in temperature with height between 8 and 11km. In the stratosphere above 10km the temperature is near constant with height and the air is very dry.

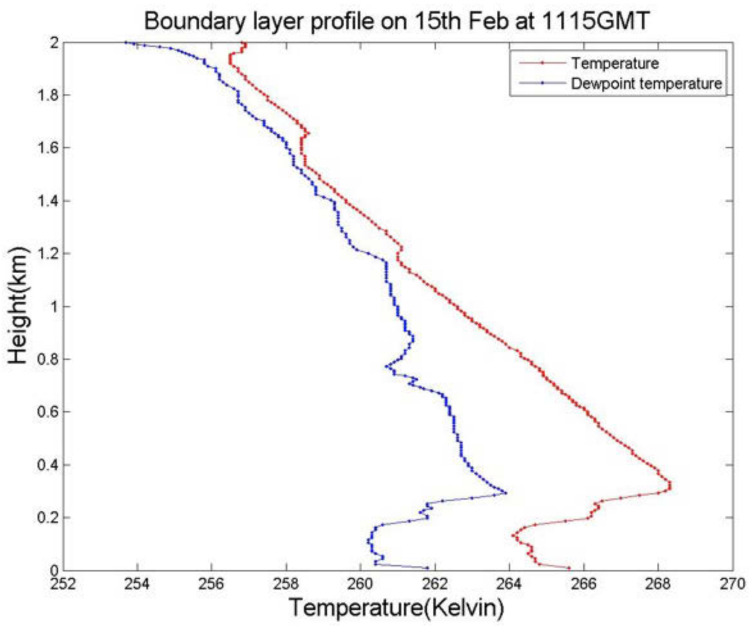


Figure 9.6: A zoomed in snapshot of the lowest 2km of the profile shown in figure 9.5.

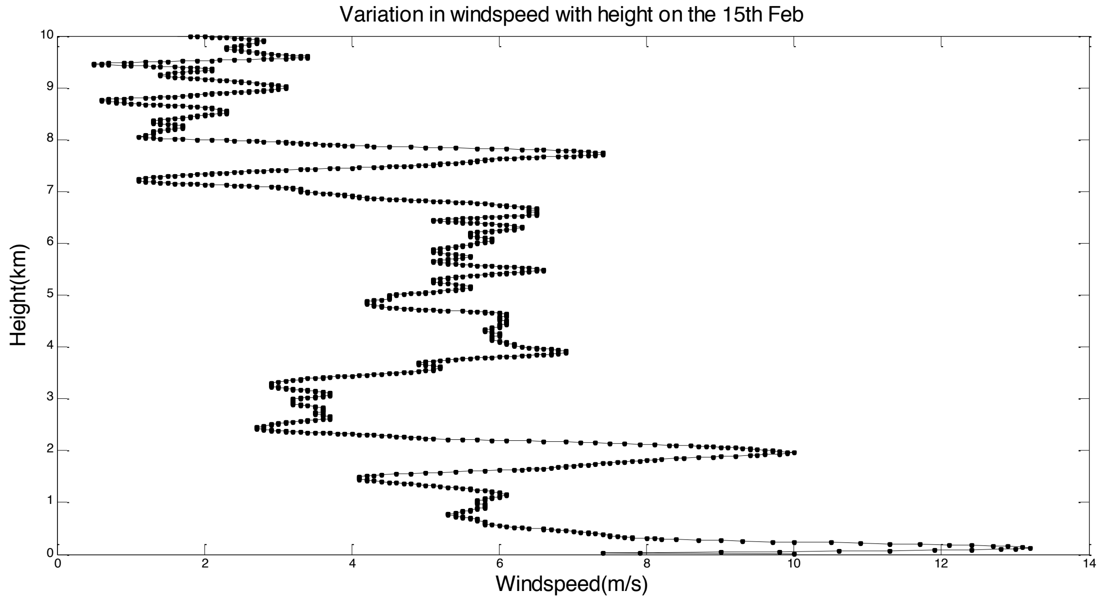


Figure 9.7: The windspeed profile taken from the same sounding on the 15th Feb 2014.

The wind profile on the same day shows that the strongest winds in the lowest 10km of the atmosphere were within 100m of the surface. At the time the sonde was launched the ship was within 1km of PIG ice front with wind flowing off the ice shelf. The wind profile suggests that the wind was accelerating as it travelled down the glacier, increasing the speed of near surface winds compared with those observed higher up in the atmosphere. This orographically enhanced near surface wind was a feature observed on numerous occasions throughout the cruise particularly during the time we were close to PIG and will be analysed more thoroughly on return to the U.K.

10 Mooring Deployments and Recoveries (Povl Abrahamsen)

Moorings are a major part of the iSTAR programme, providing time series from the shelf break, on the continental shelf, and near the Pine Island Glacier ice front. Nine moorings were deployed for the programme on RV Araon in Jan-Mar 2012, and these were recovered (or recoveries were attempted) on JR294-5. In addition, one mooring that had been deployed in 2009 from RVIB Nathaniel B. Palmer for the ASEP project (PI: Stan Jacobs) was recovered in Pine Island Bay.

Positions and deployment/recovery dates of all moorings are given in Table 10.1, and all mooring diagrams are in the Appendix to this section.

Table 10.1: Mooring deployment/recovery dates and positions. Effective speed of sound is given for use in future triangulations.

Mooring	Deployment date	Recovery date	Latitude	Longitude	Depth (m)	Vs_{eff}	CTD
iSTAR1	06/03/2012 16:00	02/03/2014 13:09	71°S 33.732'	113°W 02.759'	605	1451	97
iSTAR2	06/03/2012 05:17	-	71°S 38.351'	113°W 32.146'	615	1451	78
iSTAR3†	05/03/2012 17:42	-	71°S 42.143'	114°W 02.769'	542	1450	80
iSTAR4	05/03/2012 12:27	28/02/2014 16:49	71°S 32.702'	114°W 18.208'	513	1449	83
iSTAR5	05/03/2012 04:22	28/02/2014 14:20	71°S 25.386'	114°W 18.890'	1465	1464	85
iSTAR6	27/02/2012 05:46	06/02/2014 11:34	73°S 48.759'	106°W 32.120'	913	1456	25
iSTAR7	23/02/2012 02:53	06/02/2014 19:45	74°S 21.701'	104°W 58.121'	1346	1461	27
iSTAR8*	23/02/2012 18:26	12/02/2014 17:12	74°S 51.798'	102°W 06.250'	954	1457	59

iSTAR9*	24/02/2012 03:57	12/02/2014 13:49	75°S 03.317'	102°W 09.262'	810	1453	51
PIG_S* (iSTAR 9)	16/02/2014 13:29	-	75°S 03.534'	102°W 09.149'	747	1453	51
PIG_N* (iSTAR 8)	18/02/2014 14:00	-	74°S 52.033'	102°W 04.792'	970	1457	59
mid-shelf* (iSTAR 6)	22/02/2014 19:17	-	73°S 48.764'	106°W 32.062'	958	1456	73
trough_W (iSTAR 1)	02/03/2014 13:41	-	71°S 33.727'	113°W 02.782'	605	1451	97
trough_E	04/03/2014 19:38	-	71°S 19.763'	102°W 33.026'	634	1452	106
BSR5*	22/01/2009 09:23	15/02/2014 17:24	75°S 03.356'	101°W 59.024'	803	1453	51

* triangulated position
† triangulated and located with sonar

Instruments and methods

The iSTAR moorings were made of two types of rope: Gleistein Ropes Tasmania 12mm (polyester 12-strand double braid) and Samson Ropes Tenex 8mm (polyester 12-strand single braid). Buoyancy for the lower parts of the moorings consisted of Vitrovex 19-inch glass spheres in ribbed plastic shells on Eddygrip swivels. These were arranged in groups of 2-3 spheres on 3-m lengths of 13mm Kevlar rope, or 4-6 spheres on 5-m lengths of 13mm Kevlar. On the upper parts of the mooring, 9-inch plastic trawl floats (Pantherplast 629) were used for buoyancy. Although these are not intended for long-term deployments, they have been found to work well for several years at less than 600 m depth. Previous deployments indicate that they probably are not reliable for long-term deployments at depths below 900 m.

For combined temperature/conductivity/pressure measurements, unpumped Seabird Electronics SBE37SM "MicroCat"s were used, with a logging frequency of five minutes. After recovery, these were set to 10-s measurement intervals and deployed on CTD casts for calibration against the ship's CTD sensors; corrections for the resulting offsets have not been performed on board. Two moorings had Seabird Electronics SBE53 bottom pressure recorders, mounted on release frames borrowed from NOCS. For currents, we used Nortek Aquadopp Deep Water current meters, while two moorings had RD Instruments 75-kHz "Long-Ranger" ADCPs, and two had 300-kHz "Workhorse Sentinel" ADCPs. One of the moorings also had a 600-kHz ADCP doing high-frequency short-range measurements to measure turbulent dissipation. This was powered from two battery packs – one from its own pressure casing and one from an adjacent Long-Ranger ADCP, which had its endcap wiring modified to provide power out on two pins (and which was powered by three batteries only).

The MicroCats were attached to the rope directly, with a piece of plastic hose on the upper clamp to protect the rope. On the lower cable guide Scotch Super 33+ electrical tape was wrapped around the rope for abrasion resistance. A similar method was used on the Aquadopps, using Delrin clamps that were attached to the instruments using stainless steel hose clamps; these were based on a design from Bruce Huber at Lamont-Doherty Earth Observatory, with dimensions slightly modified to use metric hardware.

For temperature-only and temperature/pressure measurements, we used Aquatec Aqualogger 520T and 520PT loggers. The initial calibrations we received from Aquatec were not valid, with seemingly random offsets of several tenths of degrees. They were recalibrated at the factory, but in addition the sensors were calibrated to a high level of precision in a calibration bath at BAS, over a temperature range from -2.2 to 5.0 °C. As the calibration is not a polynomial, having clearly defined kinks at regular intervals between smoother temperature ranges, a lookup table was generated for each instrument, and this was used to calculate the temperature from the raw values. The Aqualoggers were attached to the mooring line with stainless steel hose clamps, with a small section of plastic hose to protect the rope.

IXSEA AR861 (Oceano 2500S Universal) releases were used on all moorings. These were deployed as single releases, except on iSTAR 7, where tandem releases were used. Novatech ST-400AX xenon flashing beacons with the “daylight off” function disabled were installed on all moorings. On the moorings with syntactic foam floats, the beacons were attached to brackets on the floats; on the other moorings the beacons were attached to plastic masts, with three trawl floats for buoyancy and a 50-cm length of chain used as a counterweight to keep the mast upright. Generally 1/2" shackles and 5/8" pear-shaped links were used, with 5/8" shackles on the anchor hardware, and 7/16" shackles with 1/2" rings used on the beacon masts. The anchors consisted of locomotive wheels, with 12.5-mm galvanised long link chain shackled through the centre hole.

Recoveries

The first mooring to be recovered was iSTAR 6 on 28/2. This was a straightforward recovery, with no notable incidents; the flashing beacon on the mooring was found to have leaked, but all other instrumentation was working. During the recovery of iSTAR 7 later the same day the 49-inch syntactic foam sphere came into contact with the stern of the ship, causing the flashing beacon to smash against the hull, breaking its bracket, and causing it to fall into the sea where it sank. The rest of the mooring was recovered with no further damage to instrumentation.

iSTAR 9 was recovered on 12/2. The recovery line, with one 9-inch trawl float separated from five floats, had parted, leaving only the five trawl floats. iSTAR 8 was recovered the same day, with no noteworthy incidents.

On 11/2 we briefly communicated with BSR5, a mooring that was deployed in 2009 from RVIB Nathaniel B. Palmer. The release, an ORE Offshore 8242xs, indicated that it was upright and not released. We returned the following day to try to recover the mooring, but after several release commands were sent, the mooring did still not rise. However, it was visible on 38-kHz sonar (EK60). On 15/2 we attempted to drag for the mooring, using two locomotive wheels as weights, attached to the ship’s coring wire, separated by 350 m. The plan was to lay out the wire drag roughly in a figure 7 around the mooring, pulling it across the release to nudge the release open. This worked well, and at 17:24 the ranges to the release started to decrease rapidly, and the mooring was observed on the surface shortly afterwards. The wire was brought back on board, and the rest of the mooring was recovered. Most of the instruments had run for more than 3 years, with two Microcats still logging data five years after deployment!

On 27/2 we attempted to recover iSTAR 2 and iSTAR 3. On arrival, the release on iSTAR 2 did not respond, and the mooring was not visible on the EK60. We continued to iSTAR 3, where the mooring was definitely present, but did not rise when released. An attempt was made to drag for the mooring using the same method as BSR5, but apparently the wire missed the mooring, as it was still upright in the water column after the dragging attempt.

On 28/2 iSTAR 5 and iSTAR 4 were recovered. Several tangles were present on iSTAR 5, but apart from that the recovery went well. Similarly the recovery of iSTAR 4 went smoothly.

On 1/3 we returned to iSTAR 3 to attempt another dragging operation. However, the area was covered in new ice with many heavy second-year floes in between, with poor visibility. Thus conditions were not considered suitable for a recovery. We returned to iSTAR 1, regularly interrogating iSTAR 2 en route. However, an iceberg was present on that site, making a recovery impossible.

On 2/3 iSTAR 1 was recovered, and another attempt was made to drag for iSTAR 3. Unfortunately the mooring did not appear to have been affected by this dragging attempt, either. As personnel were becoming tired, time was running out, and fewer crew were available in the evening, no further attempts were made to recover the mooring. Its position has been noted for future recovery attempts.

Deployments

Four of the iSTAR moorings were redeployed along with a new mooring in the eastern trough, as part of the BAS Long-Term Monitoring and Survey programme, using BAS core funds for the consumables. The mooring that were redeployed were slightly reduced versions of iSTAR 1, 6, 8 and 9, and a new mooring in the eastern trough. Tandem releases were used on all moorings except the one in the eastern trough, where only one release was available to redeploy.

Initial assessment of moorings

The data from the moorings have not yet been analyzed in detail, but initial indications are that most instruments have worked well. All of the SBE37s, SBE53s and Aqualoggers logged data throughout the deployment. The Aqualoggers were tricky to re-battery for redeployment. The batteries purchased for this purpose (generic lithium AA batteries with wire leads) were slightly different from the original batteries, and with the tight tolerances of the cases, some batteries got stuck in the ends of the housing, causing the pins on the end of the circuit boards to twist or break. The connection between the circuit board and battery was also fairly flimsy. A better design would clearly be to have a sleeve for the battery more firmly attached to the circuit board, rather than a constriction in the inside of the housing.

One Aquadopp had stopped logging upon deployment, and the batteries were almost fully depleted. The black (negative) power wire on the Y-cable connecting its two lithium batteries was found to be squashed between the metal cylinder inside the plastic pressure casing and the end cap. On one additional instrument, the red wire had also been pinched in this way, but without causing any obvious problems. It is unclear whether the pressure upon deployment could have caused the pinch to worsen, such that the instrument short circuited, or whether there was another problem with the instrument's electronics. The insulation on the wire did not appear to have been fully severed. It was generally difficult to ensure that all parts of all wires were fully inside the metal cylinder before the end cap was installed, but extra care was taken when replacing the endcaps before redeployment.

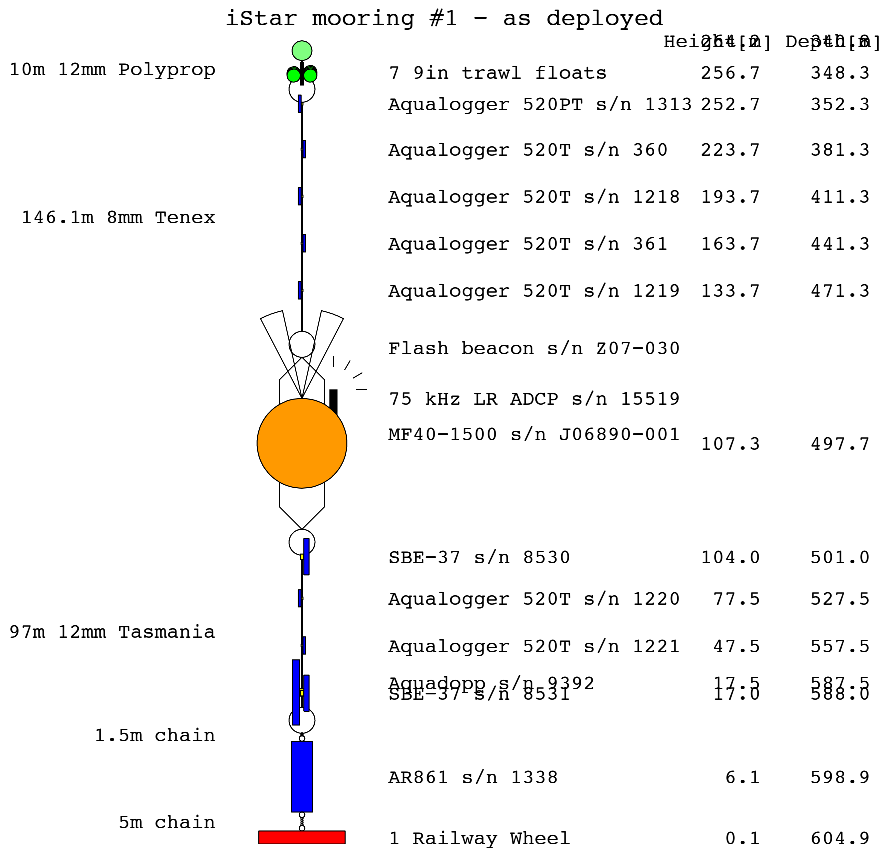
The two 300-kHz ADCPs stopped logging after around 15 months, even though the RDI software had estimated a battery use of only 86% for a two-year deployment. Before redeployment the number of pings per ensemble was decreased by 25% to hopefully obtain longer time series. The two 75-kHz ADCPs both logged data throughout. The 600-kHz ADCP logged for one year, as had been anticipated before deployment.

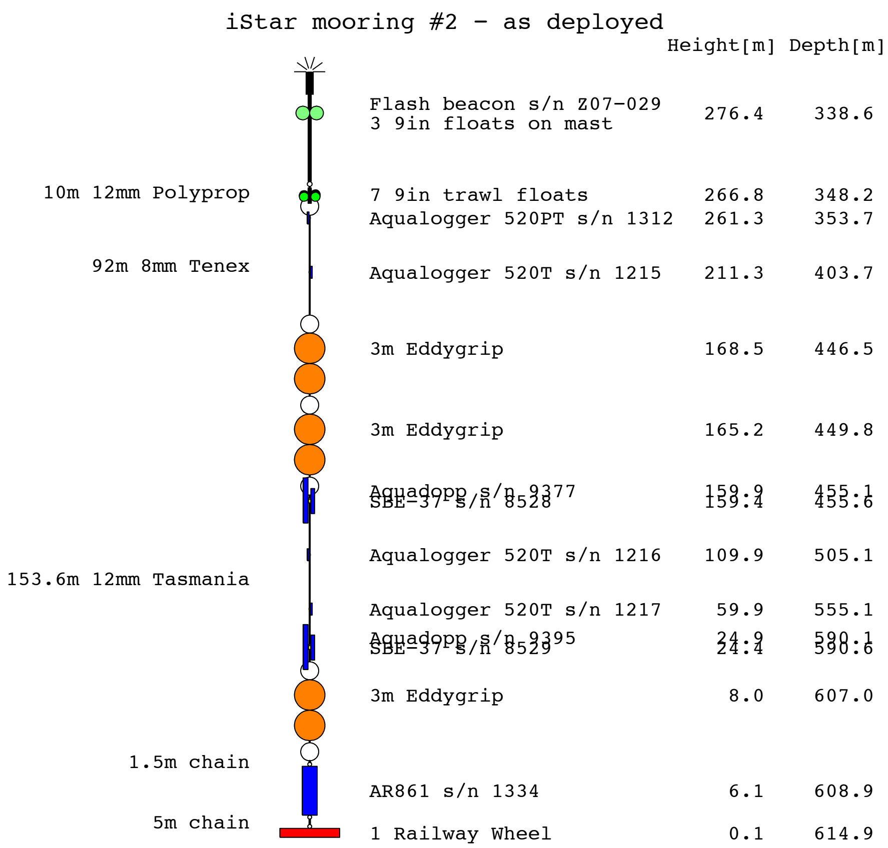
The flashing beacons did not perform well. None started flashing on recovery, but generally switched on after about an hour indoors. Perhaps the rubber on the pressure switch does not perform well in the cold.

Mooring diagrams

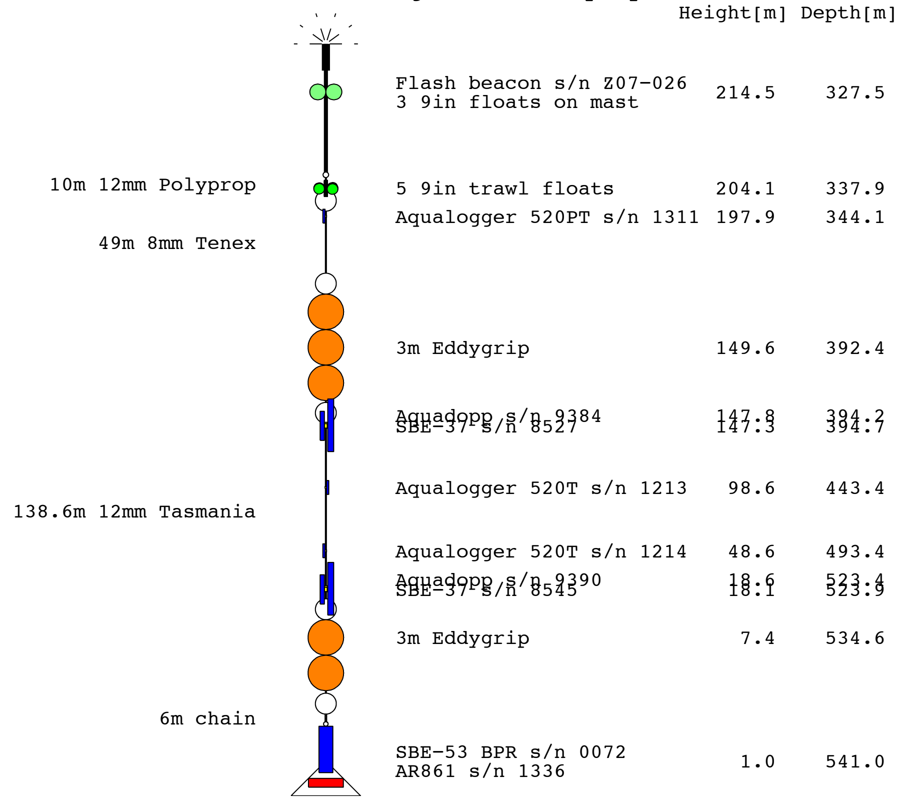
Note that all depths shown are predicted depths, not actual depths.

Recovered iSTAR moorings

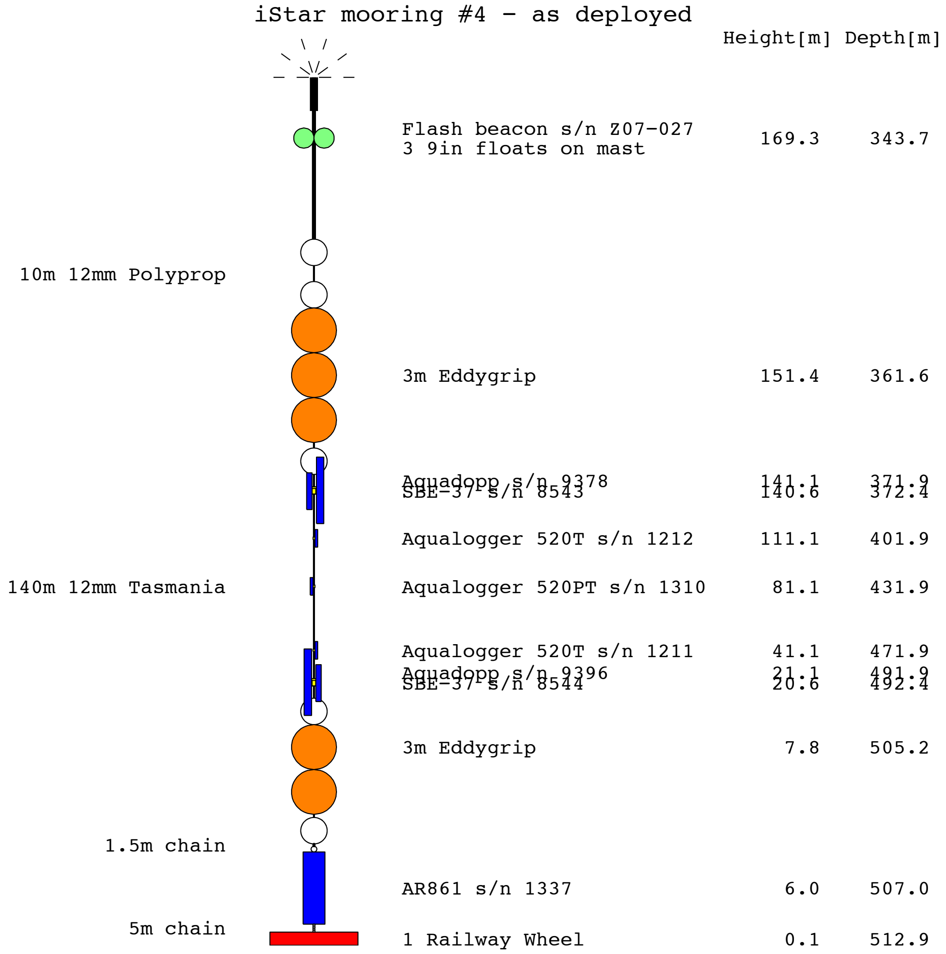




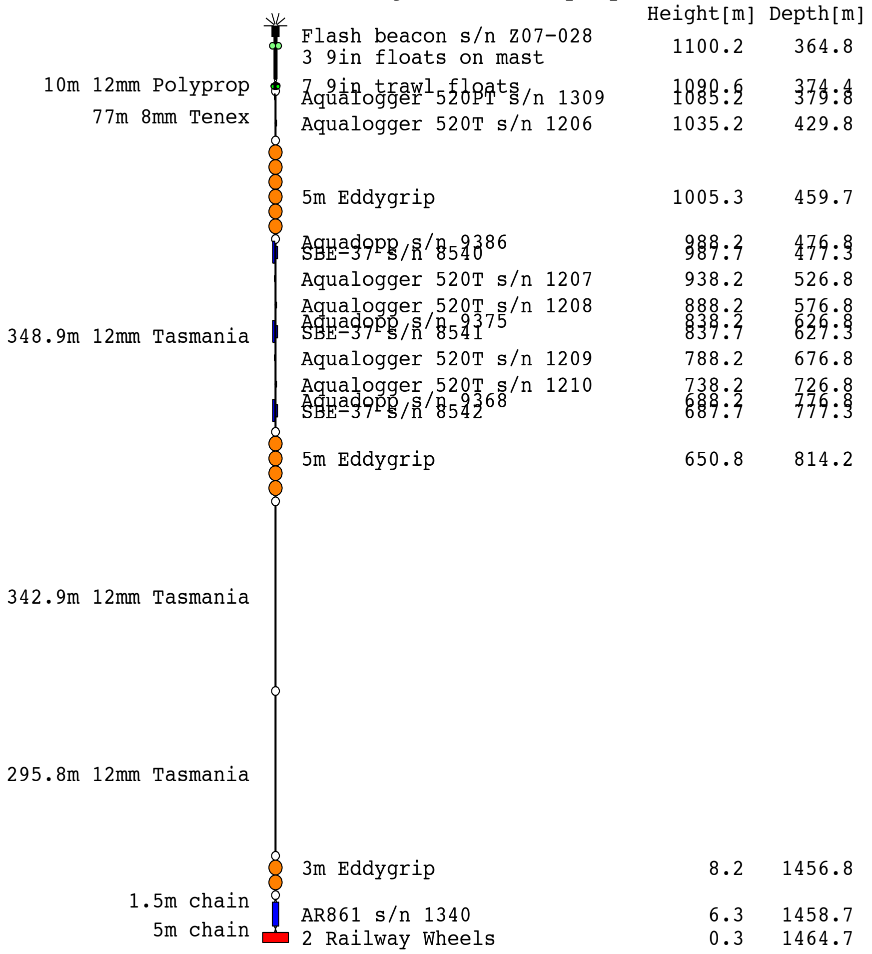
iStar mooring #3 - as deployed



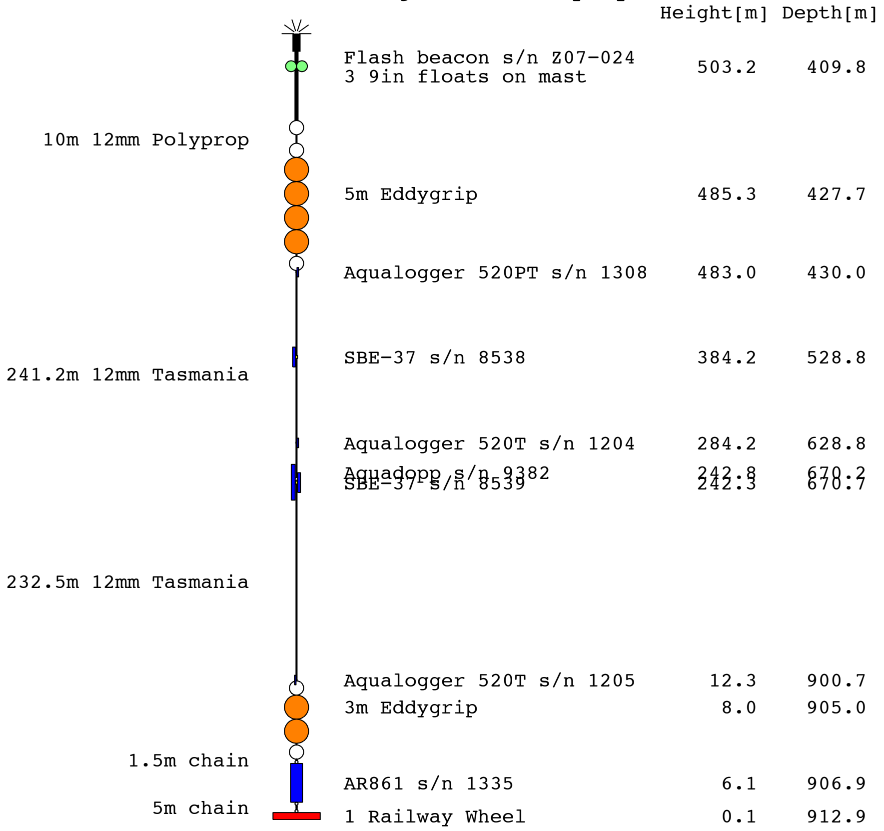
iStar mooring #4 - as deployed



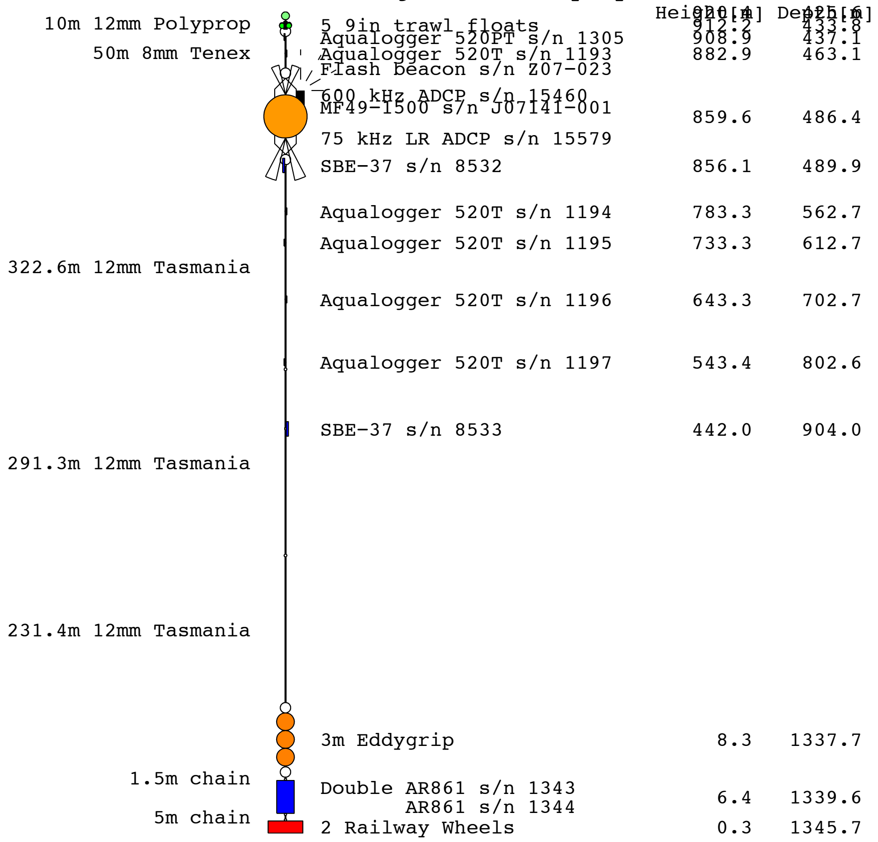
iStar mooring #5 - as deployed



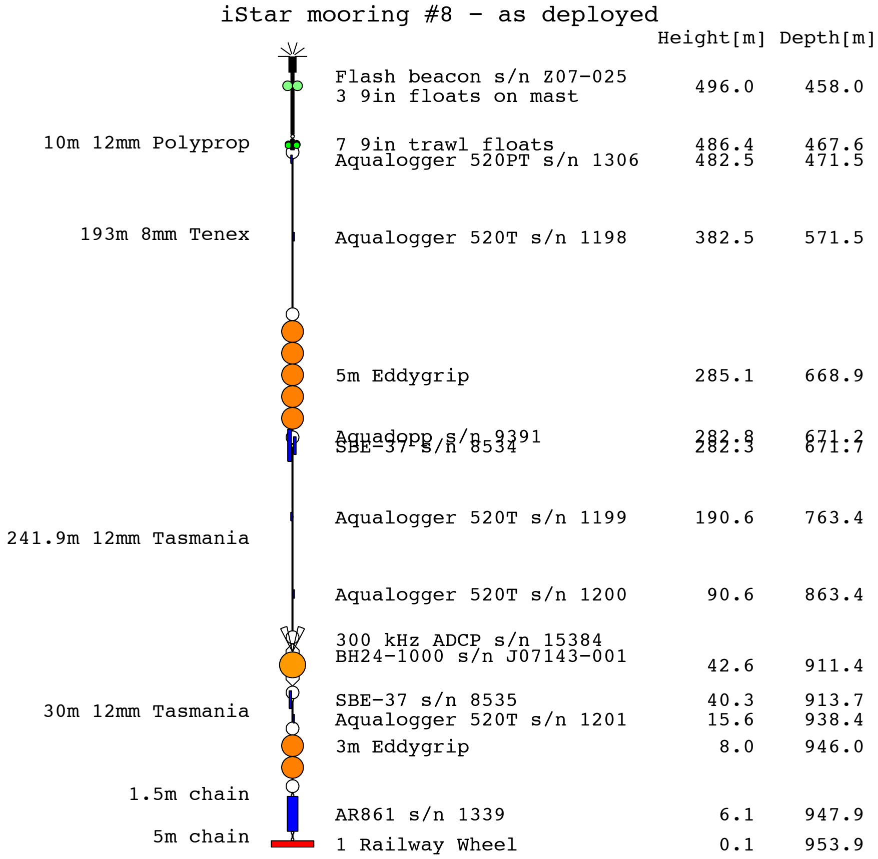
iStar mooring #6 - as deployed



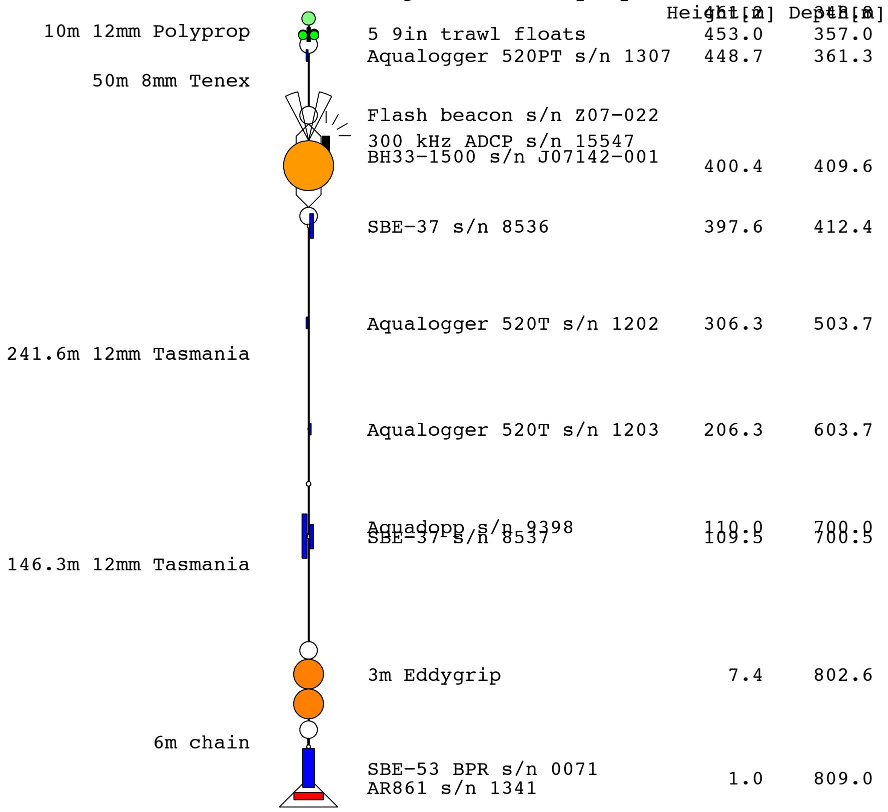
iStar mooring #7 - as deployed



iStar mooring #8 - as deployed



iStar mooring #9 - as deployed

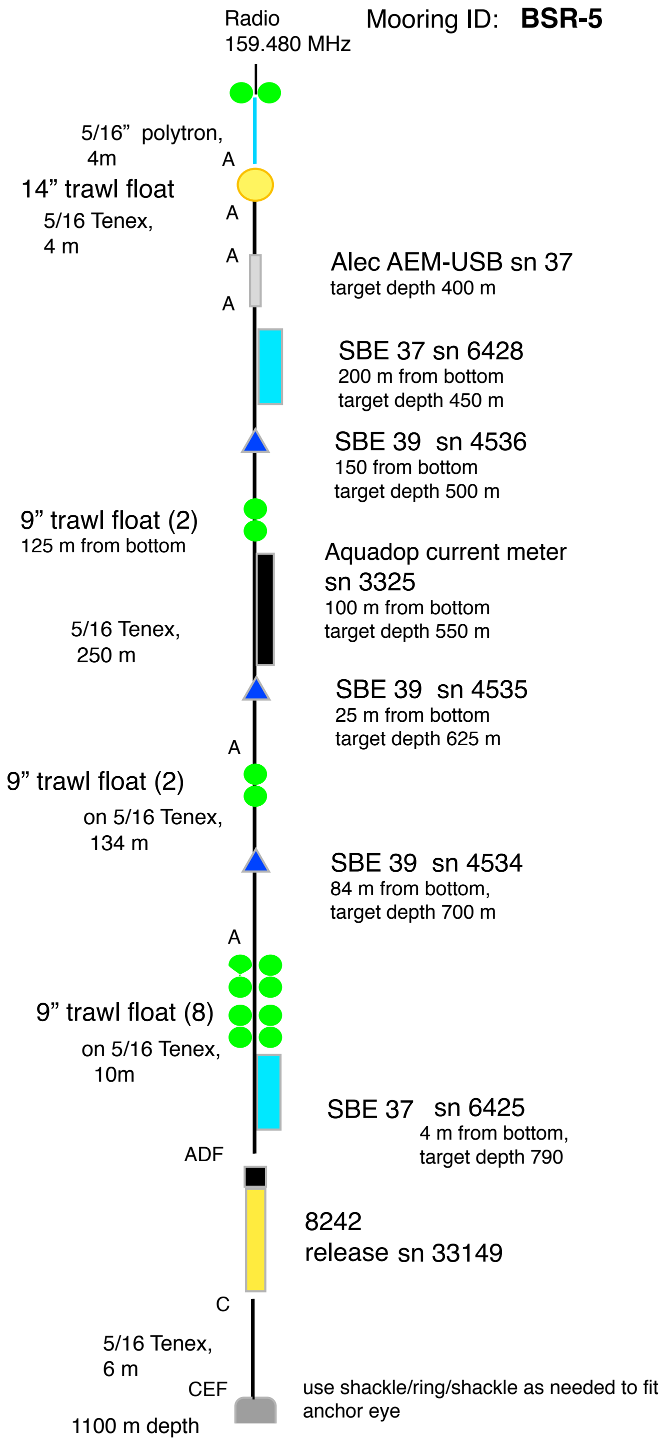


NBP0901

Enhanced
Inner Shelf (2)

Mooring ID: **BSR-5**

A - 5/16” shackle
B - 3/8” shackle
C - 1/2” shackle
D - 1/2” pear link
E - 5/8” pear link
F - 5/8” shackle



Anchor Drop

Date/Time (Z) 22 Jan 2009 09:23

Lat: 75 03.356 S

Lon: 101 59.024 W

Depth(m): 803

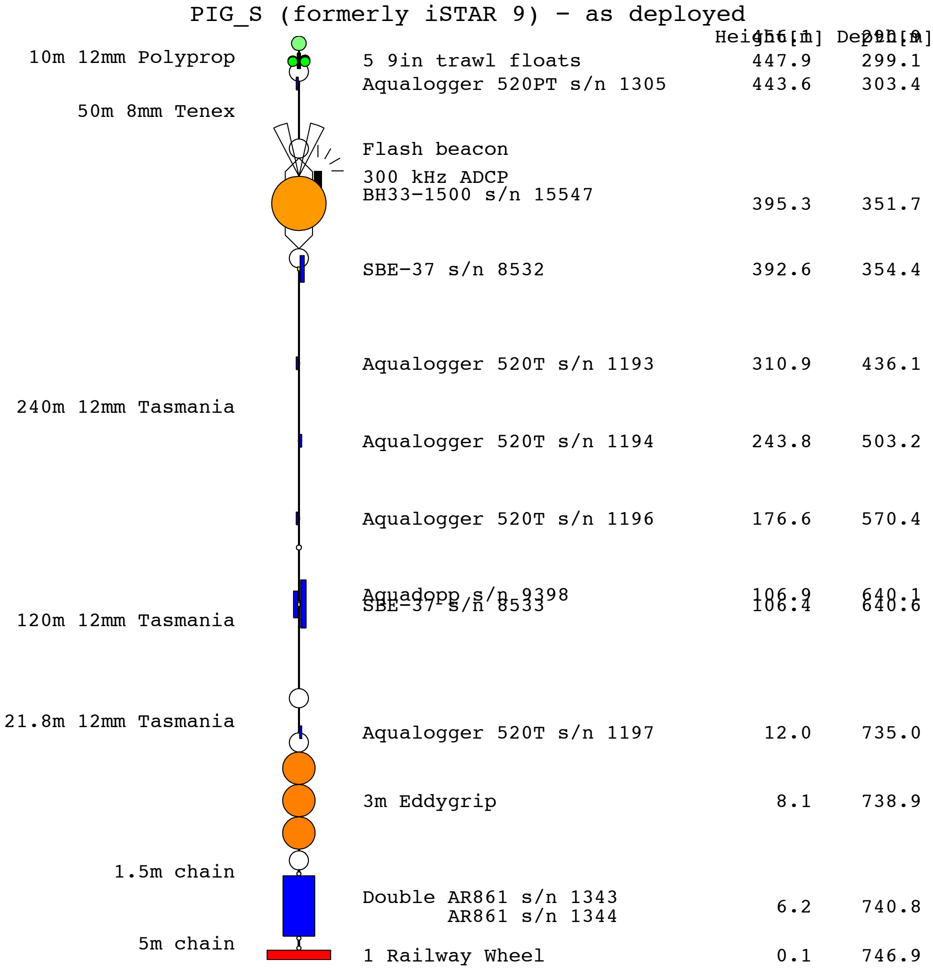
Triangulation

Lat:__________________________

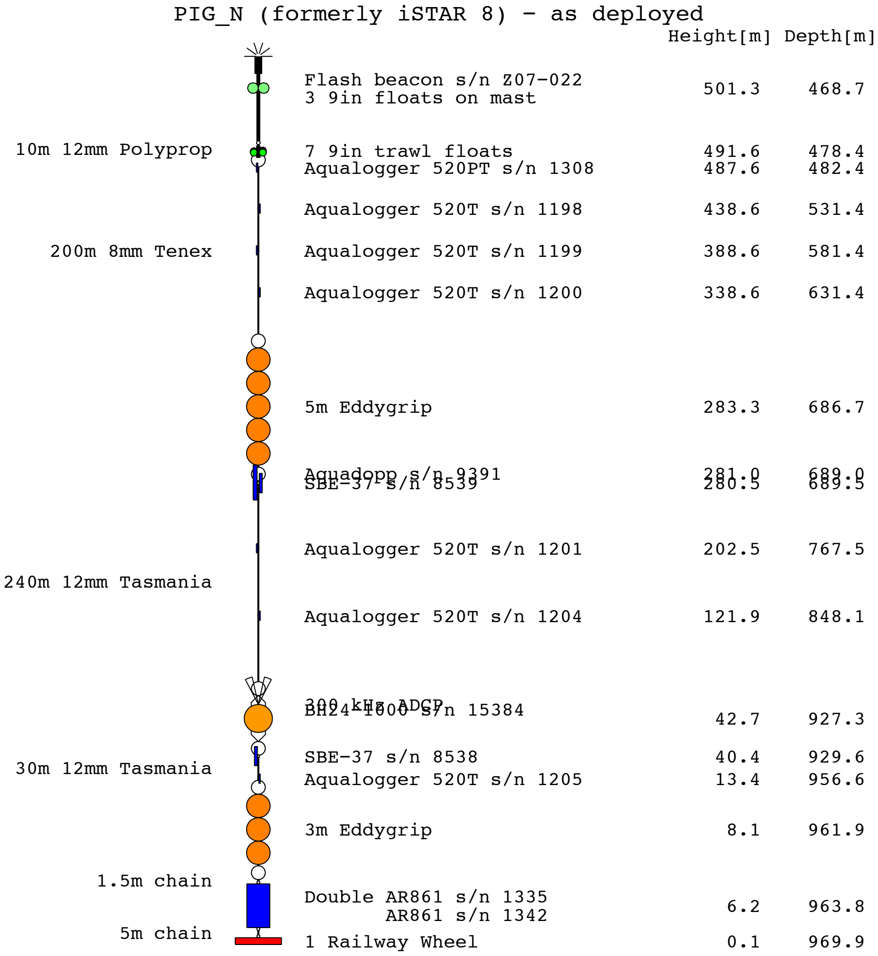
Lon:__________________________

Depth(m):______________________

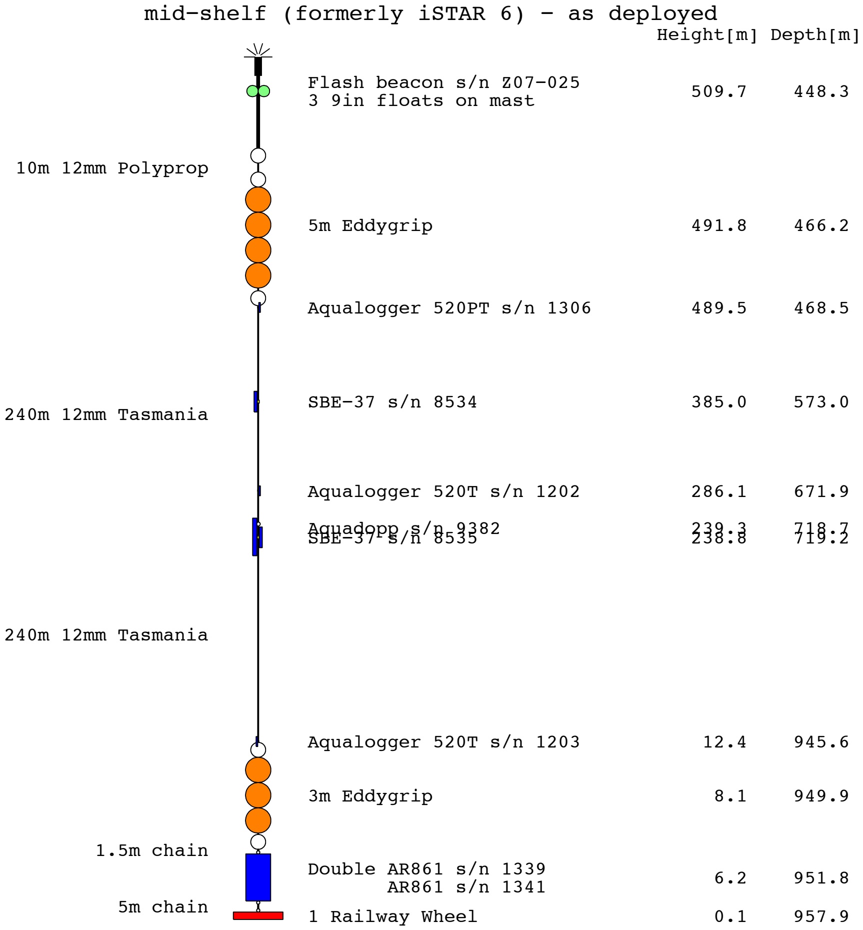
Mooring diagrams for deployed moorings



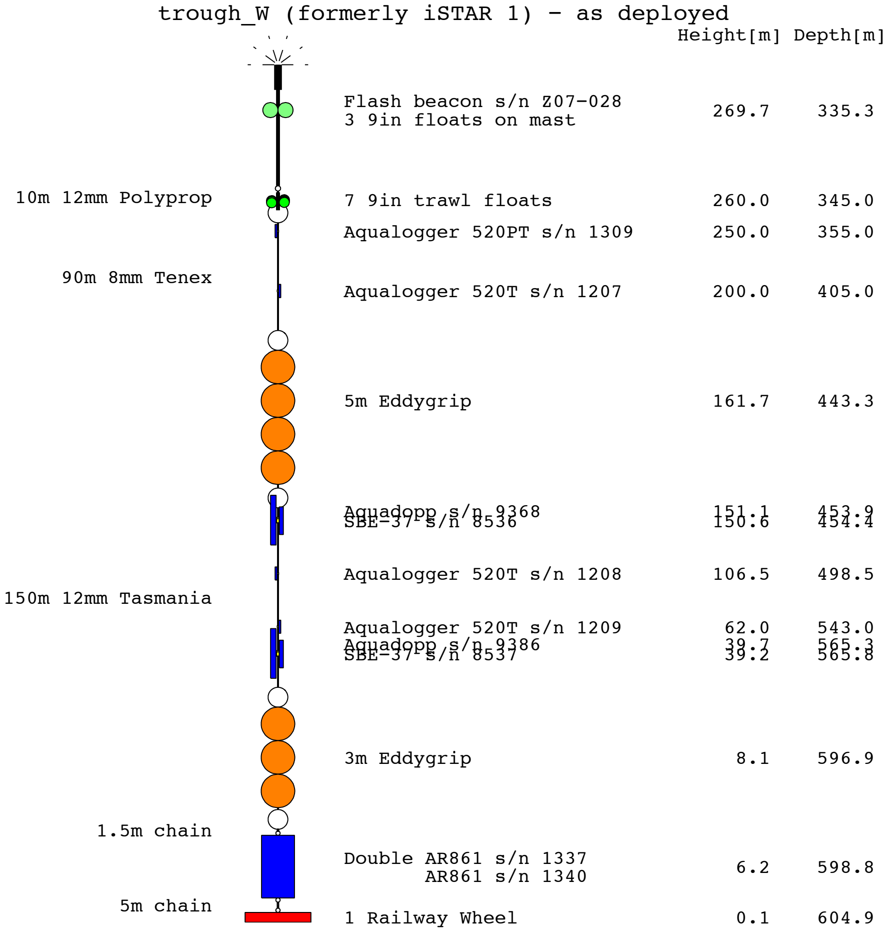
PIG_N (formerly iSTAR 8) - as deployed



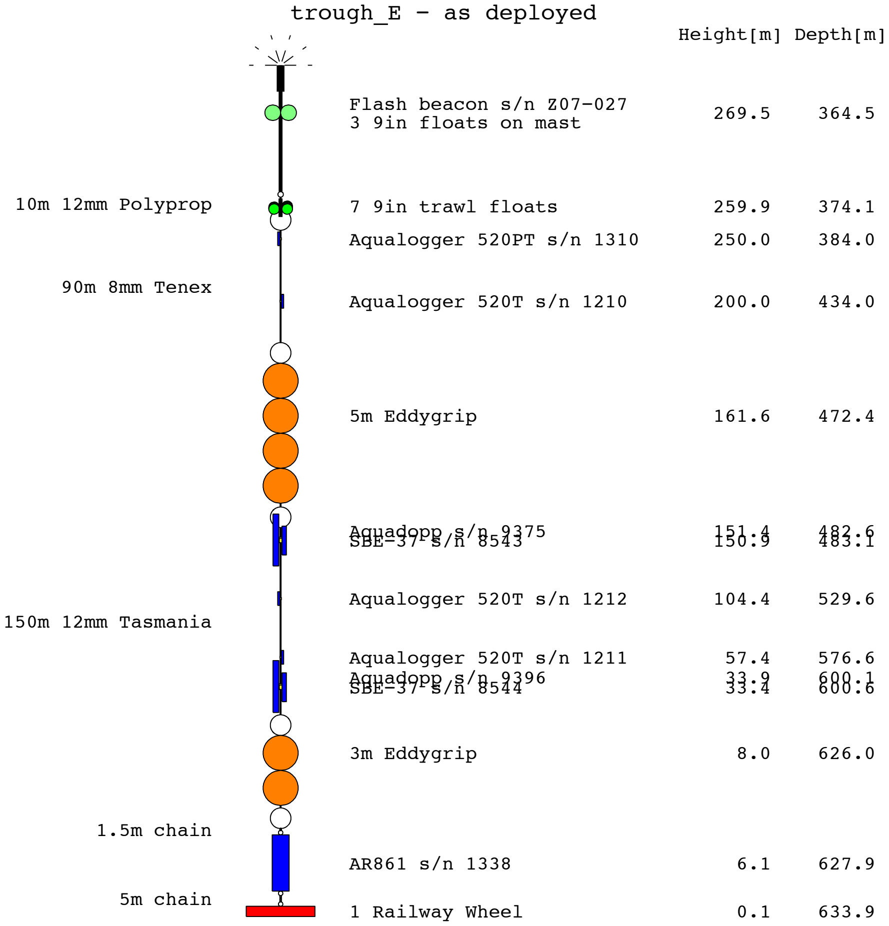
mid-shelf (formerly iSTAR 6) - as deployed



trough_W (formerly iSTAR 1) - as deployed



trough_E - as deployed



11 Moving Vessel Profiler (MVP)

11.1 MVP Summary (Pierre Dutrieux)

The Moving Vessel Profiler MVP-300 was set-up on the starboard-side of the back deck and was initially intended to be used in areas free of ice to obtain kilometre-scale resolution CTD observations from 0 to 600 m when the ship was moving at about 5 knots. The profiler was equipped with temperature, conductivity, dissolved oxygen and fluorescence sensors. Temperature and conductivity were fed and processed directly in the profiler main board, while only raw voltage were retrieved for dissolved oxygen and fluorescence. For the entire duration of the cruise, losses in raw voltage outputs were frequent and no solution was found to retrieve them. This basically limited the available observations to temperature and salinity only. After the test casts made north of the Amundsen Sea continental shelf, the MVP was used only in front of the Pine Island Glacier ice shelf, where glacial wind complicated the operations, especially due to recurrent build up of ice on the profiler boom. One section along the ice shelf edge was nevertheless obtained in ~8h between February 15th and 16th.

11.2 NMFSS MVP Operations Report (John Wynar & Paul Provost)

MVP System Configuration:
The initial sensor configuration was as follows:

- Brooke Ocean Moving Vessel Profiler MVP300-1700
- AML micro sensor CTD, s/n:7027
- Data Telemetry Module, s/n: 10217
- AML micro Dissolved Oxygen sensor, s/n: 7518
- Chelsea Minitracka fluorometer, s/n: 175222
- Tilt/roll sensor s/n: P01

Ancillary instruments & components:

- Odim MVP controller interface, s/n: 10784
- Amplicon PC, s/n: MVP300 SPARE

There was only one MVP tow made overnight starting at approximately 20.00 on the 15th February. Profiling began in relatively warm weather with an air temperature of about -2C, but as the night wore on and the temperature dropped to -10C the conditions became more problematic. Ice rapidly began to accumulate on the winch wherever the profiler cable deposited sea water. This caused particular problems on the docking switches and outboard cable sheave. Initially attempts were made to mechanically remove and/or thaw the ice but after several hours of this the survey was aborted.

Many profiles were aborted prematurely due to zero depth values being sent to the system on the NMEA data string. Disabling the seafloor collision avoidance program appeared to make no difference. Log and calibration sheets were scanned and included with the data from this cruise. All the data files were backed up on the ship's legdata K: drive.
Total number of profiles: 73
Maximum depth: 600m

Dissolved Oxygen Sensor Notes

The DO sensor (s/n: 7518) was serviced as per the notes described in the paper by D Mountifield and J Burris which is not gone into here. Essentially this meant fitting a new membrane and performing a zero and saturation point calibration. The zero point calibration was achieved using an anoxic solution and the saturation calibration carried out in air. The results were as follows:
Zero point voltage: 0.698V
Reading in anoxic solution: 0.885V
Reading in air: 1.191V at 15.9C

11.3 MVP Data (Pierre Dutrieux)

Due to time constraints, MVP observations are limited to one section along the ice front of Pine Island Glacier. The MVP temperature and conductivity sensors appear consistent with neighbouring CTD observations (figure 11.1).

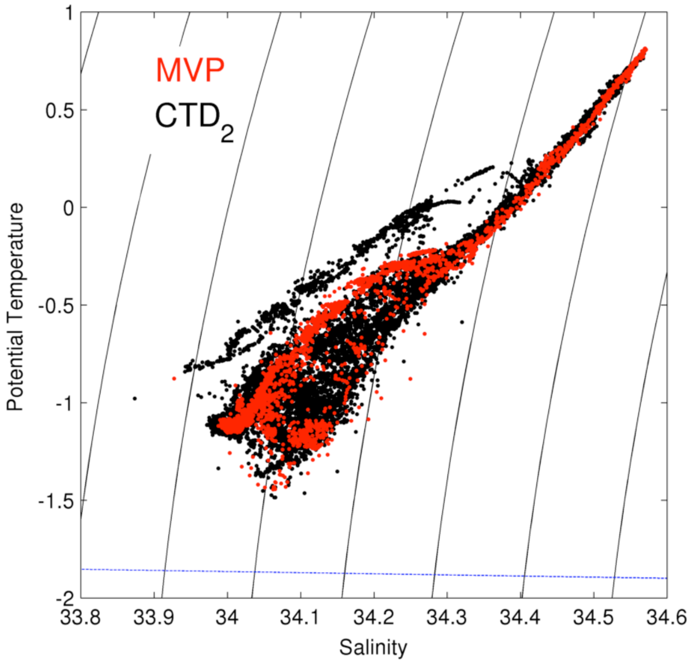


Figure 11.1 Temperature-Salinity diagram of CTD (black) and MVP (red) observations along the ice front of Pine Island Glacier.

Although limited in depth range to ~600 m, the higher horizontal resolution of the MVP section reveals the presence of fine structures along the ice front that are typically aliased in the CTD observations (figure 11.2).

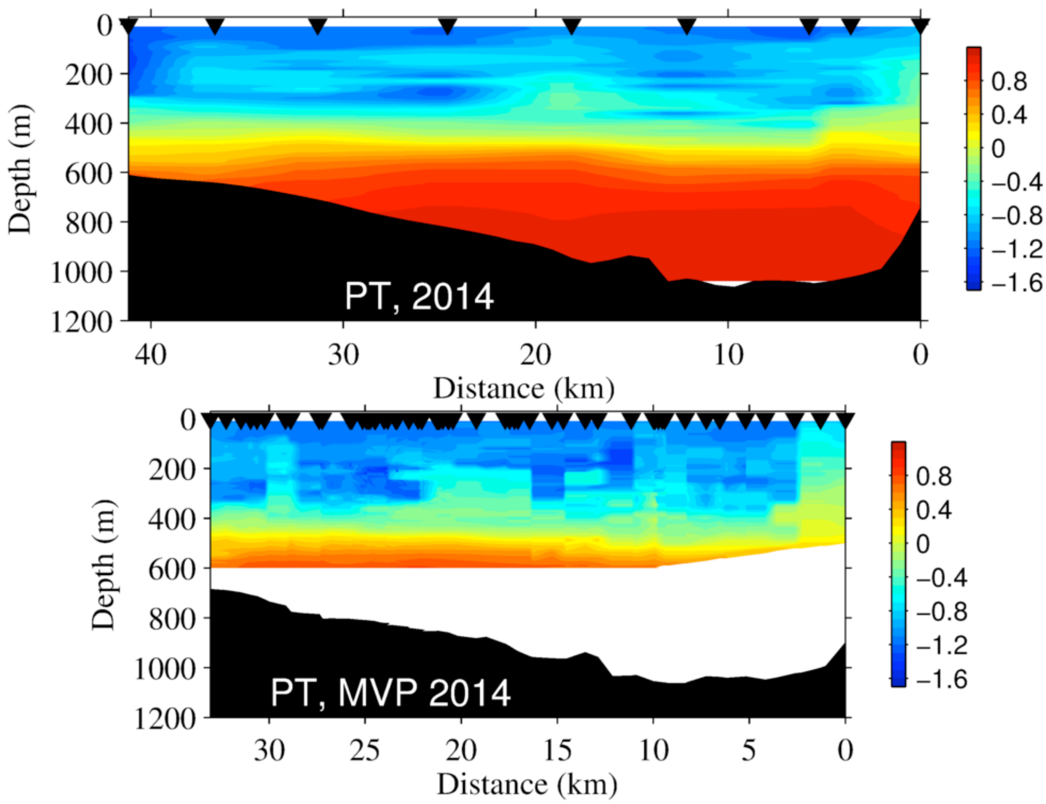


Figure 11.2 : Sections of surface referenced potential temperature using CTD (top) and MVP (bottom) observations along the ice front of Pine Island Glacier.

12 Seal Tagging — Michael Fedak

The ocean2ice project data collection strategy includes the use of instrumented seals to undertake oceanographic observations in order to augment and complement those obtained by the methodologies discussed elsewhere in the cruise report. The capture of the seals and attachment of instruments to them requires specialized procedures, knowledge and experience. It involves the ship in work that is somewhat out of the ordinary for oceanographic vessels (and that had never previously been done from the JCR). However, such work has been done from the Shackleton on 3 previous cruises in the Weddell Sea, so there is experience within BAS of the operations required. The requirements were outlined and discussed in the ocean2ice organizational meetings held at BAS in Cambridge during 2012 and 2013.

General Methodology

Sixteen specially designed “CTD-SRDLs” were built by the Sea Mammal Research Unit Instrumentation Group and shipped to Punta Arenas for use on the cruise. The tags were programmed to collect data as the seals dive and forage throughout the coming winter and to relay that data back in near real time via Argos satellites. These instruments contained new software specifically designed to collect particular elements of the CTD profiles, sub-surface temperature minimum and depth, in order to meet ocean2ice objectives. The data will aid the calculation of heat flux to the glacier ice shelf. Before deployment on seals, each of the tags was individually attached to the ships CTD during routine CTD profiling to test its performance and validate its measurements of depth, temperature and salinity in relation to the data from the CTD. The files documenting from these tests are available on the ship’s legwork drive. In addition, one tag was used to check the new software on board the device by using a CTD cast to simulate a dive by a seal, in order to check that the new software was performing correctly. This test threw up one data format issue, which was corrected. The software then was retested and proved to be working correctly.

Two species of seals and their capture sites were chosen to increase the probability of getting data near the glacier fronts and along the eastern and western deep water troughs and associated shelf break. We chose elephant seals for their deep diving habit and relatively wide geographic range, anticipating that they might forage on the shelf and shelf break. Weddell seals were chosen for their more local behavior and association with foraging sites deep within the seasonal ice cover as well as their benthic foraging habit. Ocean2ice depends largely on moorings and these CTD-SRDLs to provide subsurface in-situ data after the ship departs.

Fourteen of the 16 tags were successfully deployed, 7 on elephant seals at the Edwards Islands on 8 February and 7 on Weddell seals captured on sea ice between 24 and 26 February between 72º 23’ S, 108º 46’W and 72º 56’ S, 110º 19’W. All seal handling went smoothly with each seal taking about 30-40 minutes to process. Once sufficiently reactive, elephant seals were left on the moulting beach to fully recover. Weddell seals were left to recover on the ice flows upon which they were captured. See Table 12.1 for details of each animal captured and released.

Preliminary results

Table 12.1 gives summary details of each capture. Figure 12.1 provides a map of the tracks of seals up to the time of writing. The map is presented here to give a preliminary indication of geographic coverage. The scope of this coverage is likely to expand and some animals may change their areas of activity as sea ice forms and the seasons progress. The tags are programmed to produce a profile for deepest dive in each 4 hour period. Each seal produces about 4.5 profiles per day. We have collected 939 CTD profiles so far in 209 seal days.

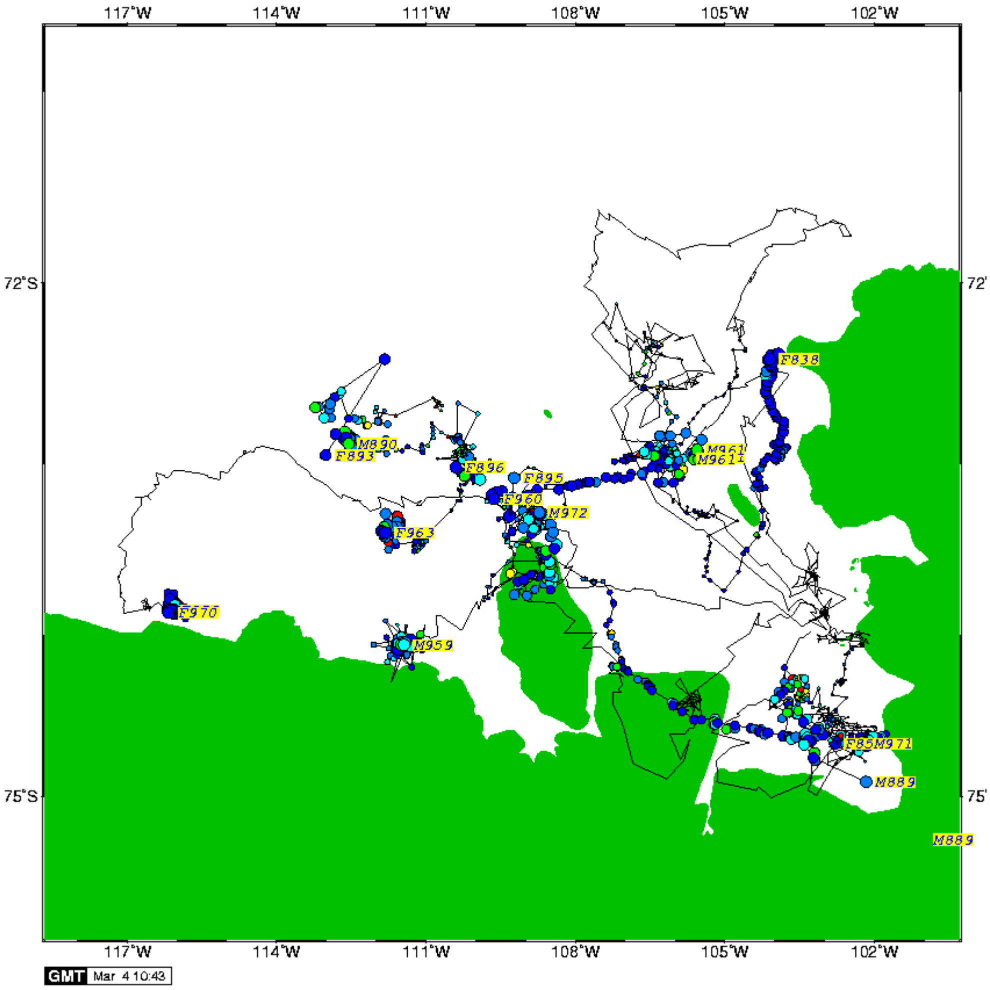


Figure 12.1. Map of the tracks of all 14 ocean2ice seals as of 2 March, 2014, plotted against a crude land outline of the P. I. G. area. Each dot indicates an Argos location. The color of the dots is keyed to location quality with red dots indicating good quality grading through yellow, green and light to dark blue dots for lower quality. The glacier front is located in the lower right corner of the plot.

Figures 12.2 and 12.3 provide sections east and west across the Pine Island Bay area from data up to 2 March derived from all seals combined. The plots are included here to give a preliminary idea of the coverage the seals may provide. The hope is that the seals will continue to broadcast data through the winter months. They have been programmed to use up their available energy approximately 230 days after deployment but other sorts of attrition (e.g.tag loss or damage, animal mortality) bay reduce lifetime.

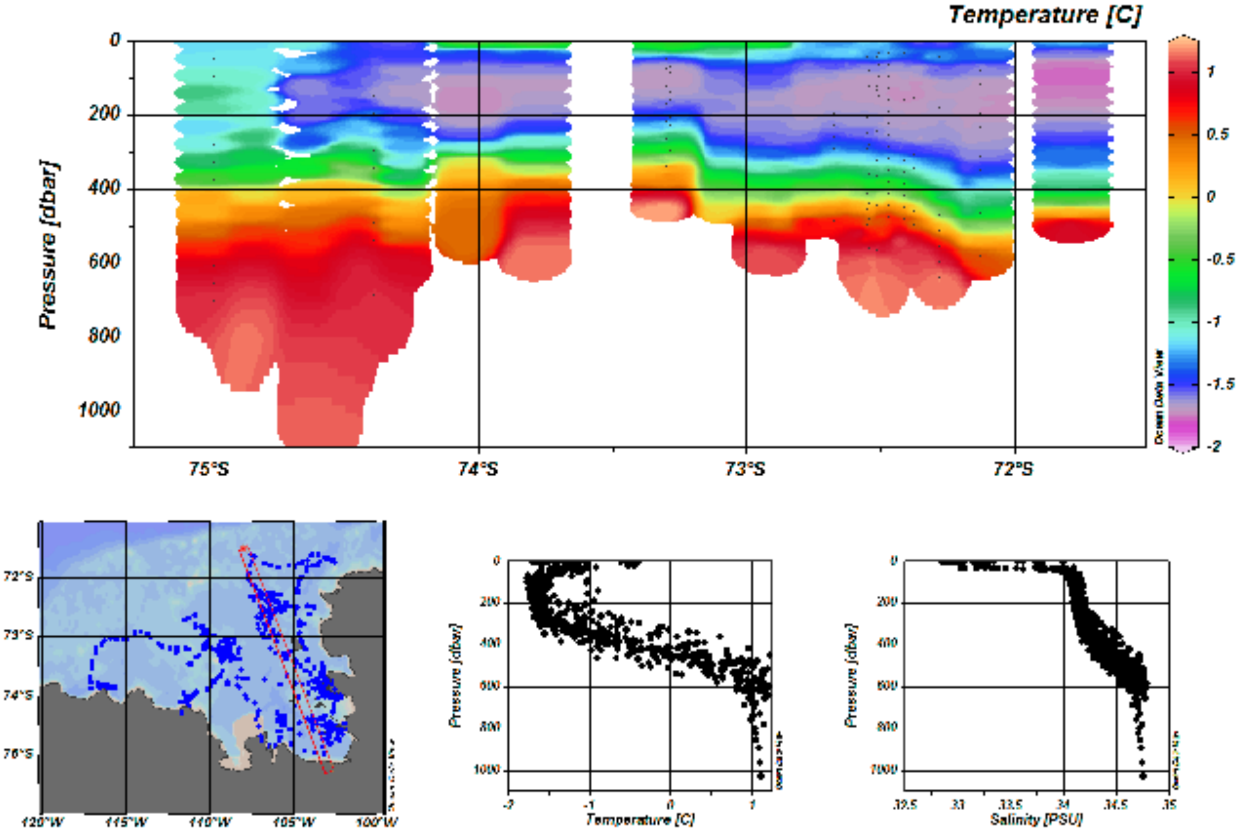


Figure 12.2 A North-South temperature section for the Pine Island Bay area created form all the casts performed by 1 March and included in the red box on the map in the lower left panel. The two panels in lower right show the temperature and salinity values plotted against pressure for the included data.

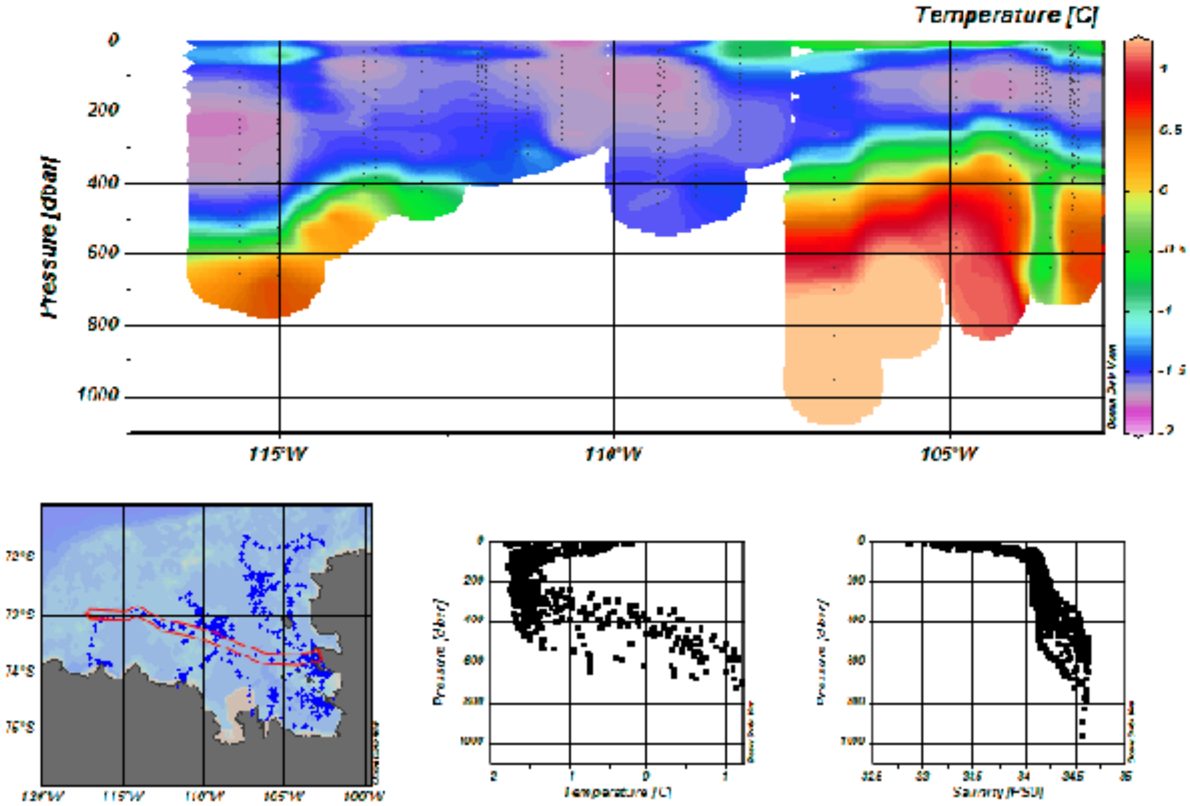


Figure 12.3. An East-West temperature section for the Pine Island Bay area created from all the casts collected by 1 March and included in the red box on the map in the lower left panel. The two panels in lower right show the temperature and salinity values plotted against pressure for the included data.

So far, the behaviour of the seals and their tags are living up to expectations.

Suitability of the JCR for seal tagging.

Two tags remain un-deployed at the time of writing. While the successful application of 14 out of 16 tags may seem to represent a reasonable success, the two undeployed tags also represent a potentially significant, lost opportunity. Because there is always risk that tags will fail or animals will move to places where the data is of limited interest, each deployed tag significantly adds to the chances of a more complete data set. The cost of getting the ship down to P.I.G. to work massively exceeds the cost of the tags, the cost of deploying those tags and the cost of data recovery via CLS Argos. See the Post-Cruise Assessment Form for comments and suggestions on how the cruise time might have been more effectively used.

Table 12.1 *Details of seals captured and released.*

date	location	species	ge clas	sex	tag no	location	tagType	body no.	length	axGirth
2/8/2014	Edward Island, 73 52.17, 102 58.38	Southern elephant seal	Adult	M			Argos	12959	395	298
2/8/2014	Edward Island, 73 52.17, 102 58.38	Southern elephant seal	Adult	M	543(4)51	L	Argos	12961	362	258
2/8/2014	Edward Island, 73 52.17, 102 58.38	Southern elephant seal	Adult	M	543(4)53	R	Argos	12971	447	286
2/8/2014	Edward Island, 73 52.17, 102 58.38	Southern elephant seal	Adult	M	543(4)54	R	Argos	12889	398	290
2/8/2014	Edward Island, 73 52.17, 102 58.38	Southern elephant seal	Adult	F					261	228
2/8/2014	Edward Island, 73 52.44, 102 59.35	Southern elephant seal	Adult	F	543(4)57	R	Argos	12838	262	199
2/8/2014	Edward Island, 73 52.44, 102 59.35	Southern elephant seal	Adult	F	543(4)58	R	Argos	12960	247	
2/8/2014	Edward Island, 73 52.44, 102 59.35	Southern elephant seal	Adult	F	543(4)59	R	Argos	12970	300	203
2/24/2014		Weddell seal	Adult	F			Argos	12895	225	165
2/24/2014	73.376518, 108.772805	Weddell seal	Adult	F			Argos	12858	229	159
2/24/2014		Weddell seal	Adult	M			Argos	12972	246	167
2/25/2014	73.074632, 109.705926	Weddell seal	Adult	F			Argos	12963	173	137
2/25/2014	72.934867, 110.31000	Weddell seal	Adult	M			Argos	12890	193	154
2/25/2014	72.933026, 110.319162	Weddell seal	Adult	F			Argos	12896	198	138
2/26/2014	72.700263, 110.735050	Weddell seal	Adult	F			Argos	12893	215	145

13 Underway Measurements

13.1 Swath bathymetry

Povl Abrahamsen, Louise Biddle

The multi-beam sonar on the JCR, a Kongsberg Simrad EM122, was running during most of the cruise, from after leaving the Chilean exclusive economic zone, until arriving at Rothera. The data have been split into six surveys, jr294_a through jr294_f, one for the transit to the Amundsen Sea (jr294_a), the first section from the shelf break to Pine Island Bay (jr294_b), the work near Pine Island and Thwaites glaciers (jr294_c), the transit from the mid-shelf mooring via Edwards Islands and the sea ice to the central trough (jr294_d), work at the central trough and along the shelf break (jr294_e), and one for the transit to Rothera (jr294_f). The division into surveys is shown in figure 13.1.

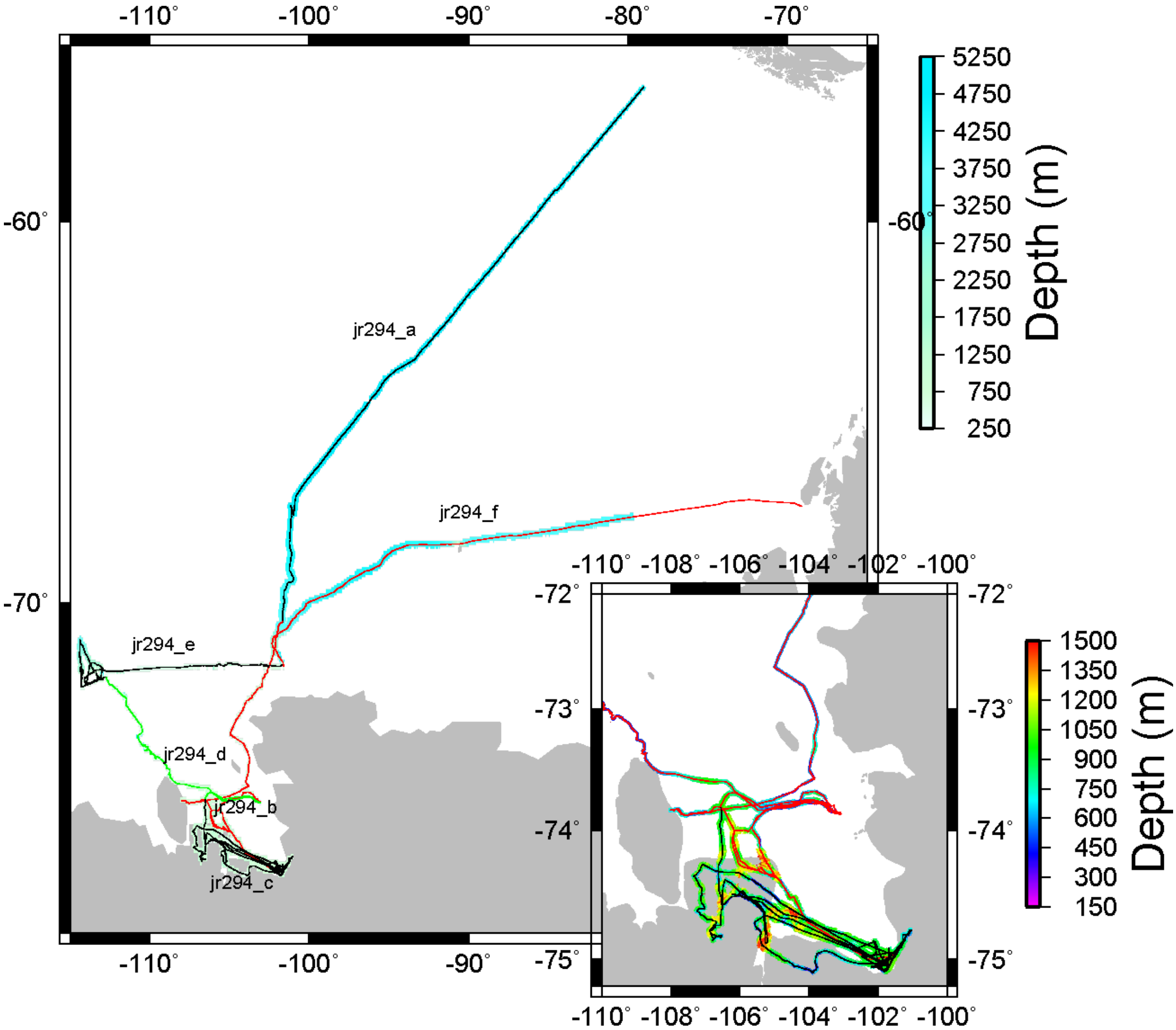


Figure 13.1. Overview of the swath bathymetry data from JR294/295, with track colours alternating between black, red and green.

Instruments and methods

Data acquisition was performed on a Windows 7 workstation, em122, running Simrad's SIS software, version 3.8.3 build 89. The default settings, as described in the notes "Using the EM122 multibeam on an opportunistic basis", by Gwen Buys and Alex Tate, version 3.0 dated 28/4/2013, were used – with varying maximum beam angles, depending on the weather and ice conditions. For most of the cruise a beam angle of 70 degrees was used on the continental shelf, with 65 degrees in deeper water, to maximise coverage of the seabed. CTD casts were imported regularly as sound velocity profiles, to represent local conditions. The details of the profiles used at different points in the cruise are in Table 13.1 below.
With the exception of a few areas surrounding moorings, the data from this cruise have not been cleaned and processed on board. Generally the data appears to be clean and of good quality, though some cleaning will be required, especially when the ship was in sea ice.
Early in the cruise, the sonar synchronisation unit (SSU) crashed several times and had to be rebooted. However, after a few days' use it appeared to work reliably. One hard disk in the EM122 computer failed and had to be replaced on 31/1. Fortunately the computer uses a redundant RAID system, so no data were lost, and the computer was offline only during the time it took to replace the hard drive itself.

Centre beam depths

The EM122 centre beam is used for the ship-track bathymetry. The output is found on the legdata folder under scs/Compress in .ACO format, and the file contains year, yearday, day, decimal day and depth. The Seatex gga GPS output is used to geolocate the EM122 centre

beam depths; this dataset is of a higher temporal resolution, and so is interpolated onto the timescale of the bathymetry dataset.
Despiking has not yet been undertaken, and will be completed upon return to the UK.

Table 13.1. Summary of swath data and speed of sound profiles used. All times UTC. Stops for science stations have not been included; a full table is available and has been saved on the legwork drive.

Survey	Note	Lines	Date	Time	XBT/CTD for SVP file name		JR294 stn.
JR294_a	 1	1 29	28/1 29/1	14:52 20:53	Unknown – last XBT from previous cruise		
	 1	30 40	29/1 30/1	21:00 06:20	Unknown – last XBT from previous cruise		
	 2 3 3 	41 46 65 73 89	30/1 30/1 31/3 31/3 1/2	06:56 15:57 11:05 18:54 11:09	JR294 CTD 1	JR294_001_thinned	 1 2
	 4 	90 112 115	1/2 2/2 2/2	13:34 12:00 15:28	JR294 CTD 2	JR294_002_thinned	2 3
JR294_b		0 3	2/2 2/2	18:11 22:06	JR294 CTD 3	JR294_003_thinned	3 4
		4 9	3/2 3/2	02:30 10:25	JR294 CTD 4	JR294_004_thinned	4 6
		10 11	3/2 3/2	13:30 14:41	JR294 CTD 6	JR294_006_thinned	6 7
		12 13	3/2 3/2	17:22 18:30	JR294 CTD 7	JR294_007_thinned	7 8
		14 15	3/2 3/2	20:39 22:24	JR294 CTD 8	JR294_008_thinned	8 9
		16 17	3/2 4/2	23:17 01:09	JR294 CTD 9	JR294_009_thinned	9 10
		18 22	4/2 4/2	02:37 08:20	JR294 CTD 10	JR294_010_thinned	10 12
		23 25	4/2 4/2	09:54 11:57	JR294 CTD 12	JR294_012_thinned	12 13
		26 37	4/2 5/2	13:59 01:45	JR294 CTD 13	JR294_013_thinned	13 17
		38 55	5/2 5/2	02:56 21:20	JR294 CTD 17	JR294_017_thinned	17 22
	 5 	56 89 117	5/2 7/2 9/2	22:37 16:57 23:45	JR294 CTD 22	JR294_022_thinned	22 34
		118 128	10/2 11/2	01:02 12:33	JR294 CTD 34	JR294_034_thinned	34 autosub 1
JR294_c		0 8	11/2 11/2	01:34 11:04	JR294 CTD 34	JR294_034_thinned	autosub 1 glider 1r
		9 103	11/2 17/2	13:16 10:18	JR294 CTD 39	JR294_039_thinned	glider 1r 54
		104 145	17/2 19/2	13:06 22:26	JR294 CTD 54	JR294_054_thinned	54 64
		146 155	20/2 20/2	00:29 14:19	JR294 CTD 63	JR294_063_thinned	64 69
		156 156 194	20/2 20/2 22/2	15:15 15:30 19:25	JR294 CTD 63 JR294 CTD 69	JR294_063_thinned JR294_069_thinned	70 mid-shelf
JR294_d	 6 7 8 9 10 	0 11 19 36 41 42 69	22/2 23/2 24/2 25/2 25/2 25/2 27/2	20:40 13:27 13:48 10:53 16:10 16:29 01:26	JR294 CTD 69	JR294_069_thinned	mid-shelf
JR294_e		0	27/2	02:59	JR294 CTD 74	JR294_074_thinned	74

		6	27/2	10:25		78
		7 16	27/2 28/2	12:24 04:50	JR294 CTD 78 JR294_078_thinned	78 85
		17 44	28/2 1/3	05:58 18:54	JR294 CTD 84 JR294_084_thinned	85 iSTAR 1
		45 112	1/3 5/3	19:11 05:57	JR294 CTD 78 JR294_078_thinned	iSTAR 1 109
jr294_f	11	0 5 36	5/3 5/3 6/3	06:45 11:40 19:36	JR294 CTD 3 JR294_003_thinned	109
		37 76	6/3 8/3	19:37 11:04	JR84 XBT no. 34 T5_00038_thinned	

Notes:
1. SSU crash; rebooted SSU.
2. Temporary dropout of SSU from 05:40 on 31/1 – seems to have started again on its own around 5:55.
3. One hard disk failed in the EM122 computer on 31/1; it was initially reset and rebuilt at 11:05-11:19, but after failing again it was replaced from 18:54-19:27.
4. Started breaking ice – many bad pings.
5. Encountered minimum depth; bad pings on starboard side.
6. Centre beam data not sent to SCS at 13:09; computer rebooted, then working fine.
7. Encountered maximum depth; some missing data in centre.
8. Finished breaking out of ice.
9. In ice; reduced depth range and forced medium mode. Changed beam angles to 50 degrees.
10. Out of ice. Beam angles back. Icebergs occasionally visible on side of swath.
11. Ice stuck under some port receivers? Sporadic interference for ~20 minutes

13.2 Oceanlogger and meteorological measurements

Principle

The JCR is equipped with an automatic recording system for data streams linked to several sensors. Oceanlogger, navigation and meteorological data were recorded throughout the JR294 cruise using an automated Matlab script.
All data collection and processing was perfomed automatically by the '*matlab*' user on the '*jrlb*' host machine. Automation is regulated by the *cron* daemon (edited with the *crontab –e* command) which triggers processing and then copies the resulting matlab dataset and figures to a shared drive.

```
jrlb:~>crontab -l

00 */7 * * * /users/matlab/jr294/oceanlogger/run_oceanlogger.sh

45 */7 * * * cp -r /users/matlab/jr294/oceanlogger/*
/users/pstar/cruise_data/work/Oceanlogger/
```

Environmental variables and matlab are setup by the run_oceanlogger.sh script before executing the *JCR_Oceanlogger.m* script:

```
jrlb:~/jr294/oceanlogger>cat run_oceanlogger.sh

#!/usr/local/bin/tcsh



# Stop setup from generating ouput & then cron trying to mail it - JPRO

setenv NCS_SHUTUP

setup dps
```

```
setup scs

setup matlab



cd ~/jr294/oceanlogger

matlab < ~/jr294/oceanlogger/JCR_Oceanlogger.m
```

The main matlab script, *JCR_Oceanlogger.m*, queries the SCS data streams provided by the JCR for the variables list in the jr294.xml file. When an existing dataset is present, it queries for records newer than the final dataset timestamp. When no dataset is present, one is created starting from the end of the first hour recorded for the current cruise's datastream (*dfinfo oceanlogger*). The *dps.pl* script triggered by matlab pulls the data to *jr294.csv* in csv format. This data is imported into matlab and concatenated with the existing dataset.

The matlab script then proceeds to calculate additional variables (true wind speed, direction, and u and v components) using Adrian Matthews' *true-wind.m* script from the ADELIE cruise before plotting each variable both as crude track maps and timeseries for rapid data visualisation. Finally, the script organises the data in a structure format.

Format

The base Oceanlogger structure contains 5 substructures:

The *raw* substructure contains 29 fields, each containing a timeseries of a variable as extracted by the *dps.pl* script.

The *flag* substructure contains a flag indicating potential issues with the raw data. A flag of 0 indicates clean data. The flag value is incremented for each test a data point fails. The value is incremented by +4 where the oceanlogger flow speed was below a set threshold (0.55 l min^{-1} for the JR294 cruise). +2 for data points identified as spurious spikes, defined as any point more than 2 standard deviations outside of the mean of a 21 (10 + 1 + 10) sample window. Finally, the flag value is incremented by +1 for data points beyond pre-set lower and upper bounds. This allows for 8 different flag values each indicating a specific combination of flags.

The *clean* substructure contains the raw data with all values flagged replaced by NaNs.

The *info* substructure contains general file metadata, a file description and two further substructures describing and providing units for each of the variables.

The *scripts* substructure contains text copies of the scripts required for redeploying this oceanlogger script on further cruises.

All scripts used and data collected during the JR294 cruise are available in the *Oceanlogger_jr294.mat* file.

List of variables

Variable Name	Description	Units
Timestamp	Timestamp	Matlab datenum format
lat	Latitude	Decimal degrees
lon	Longitude	Decimal degrees
speed	Ship's speed	Knots
heading	Ship's heading	Degrees
airtemp1	Air temperature	Celsius
humidity1	Humidity	% relative humidity
par1	Photosynthetically active radiation	umol.S-1.m-2
tir1	Total incoming radiation	W.m-2

airtemp2	Air temperature	Celsius
humidity2	Humidity	% relative humidity
par2	Photosynthetically active radiation	umol.S-1.m-2
tir2	Total incoming radiation	W.m-2
baro1	Air pressure	mbar
baro2	Air pressure	mbar
tstemp	Temperature - higher than expected, do not use	Celsius
conductivity	Conductivity	S.m-1
salinity	Salinity	PSU
sound_velocity	Speed of sound through water	m.s-1
chlorophyll	Chlorophyll a concentration (not calibrated)	ug.l-1
sampletemp	Temperature of some sort??	Celsius
flowrate	Oceanlogger flow rate	l.min-1
sstemp	Best available temperature	Celsius
anemometer_wind_dir	Wind direction measured by the ship's anemometer	Degrees
anemometer_wind_speed	Wind speed measured by the ship's anemometer	Knots
truewind_u	True wind U component	Knots
truewind_v	True wind V component	Knots
truewind_speed	True wind speed	Knots
truewind_dir	True wind direction	Degrees

Underway Data

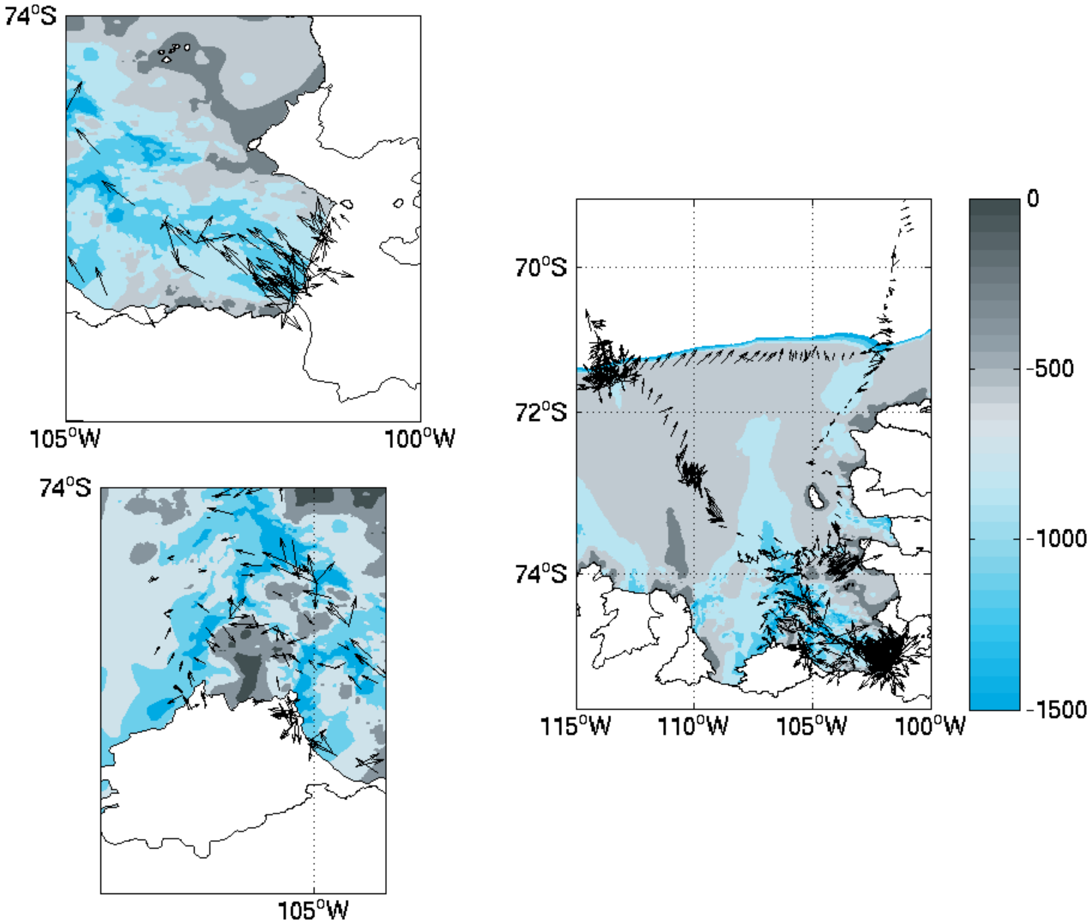


Figure 13.2 Wind velocity measured at the ship around Pine Island Glacier, Thwaites Glacier and the whole study area.

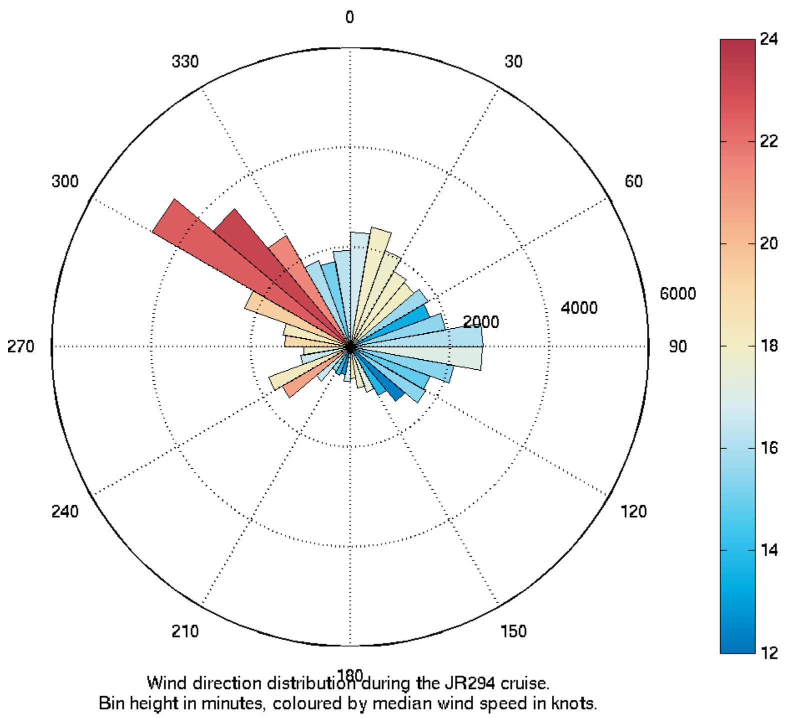
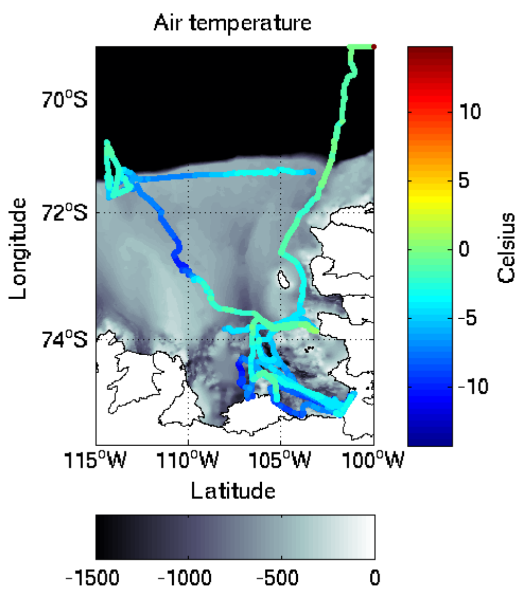


Figure 13.3 Wind rose for the cruise.



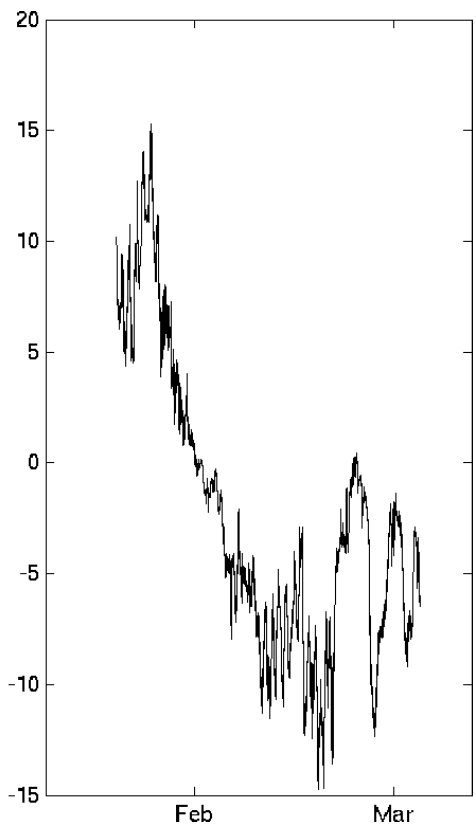


Figure 13.4 Oceanlogger air temperature data.

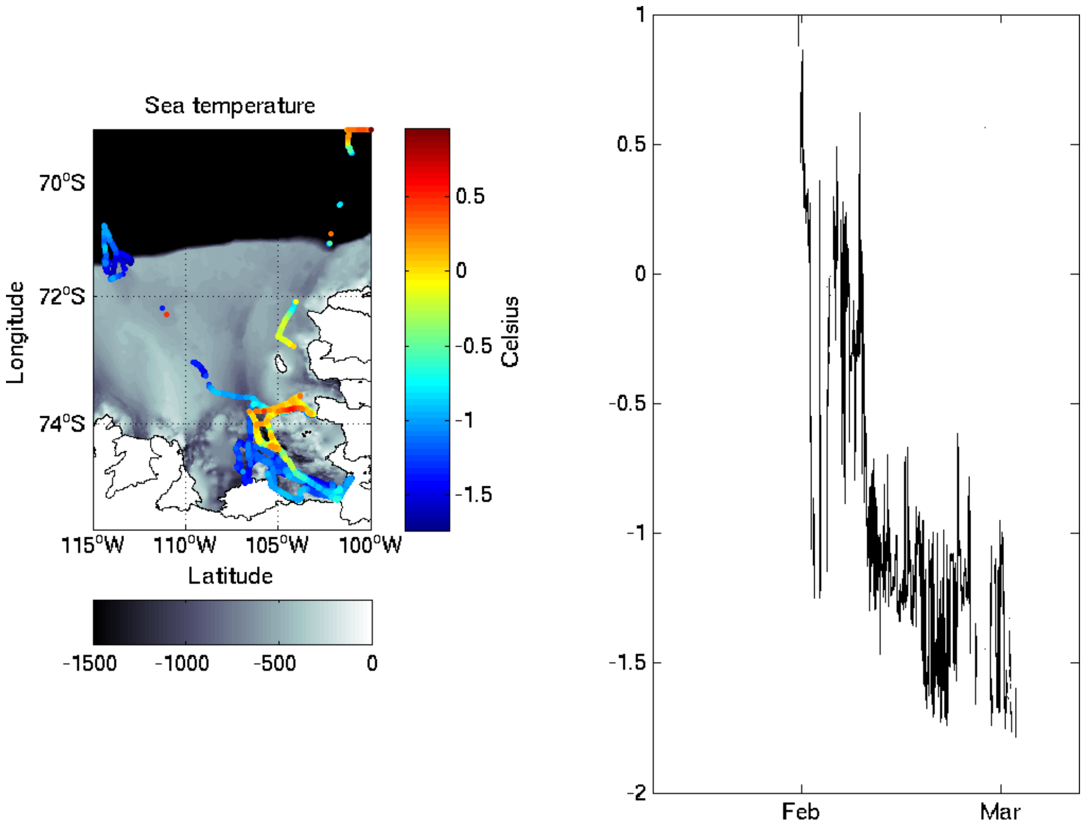


Figure 13.5 Oceanlogger sea surface temperature data (when the instrument was not clogged by ice).

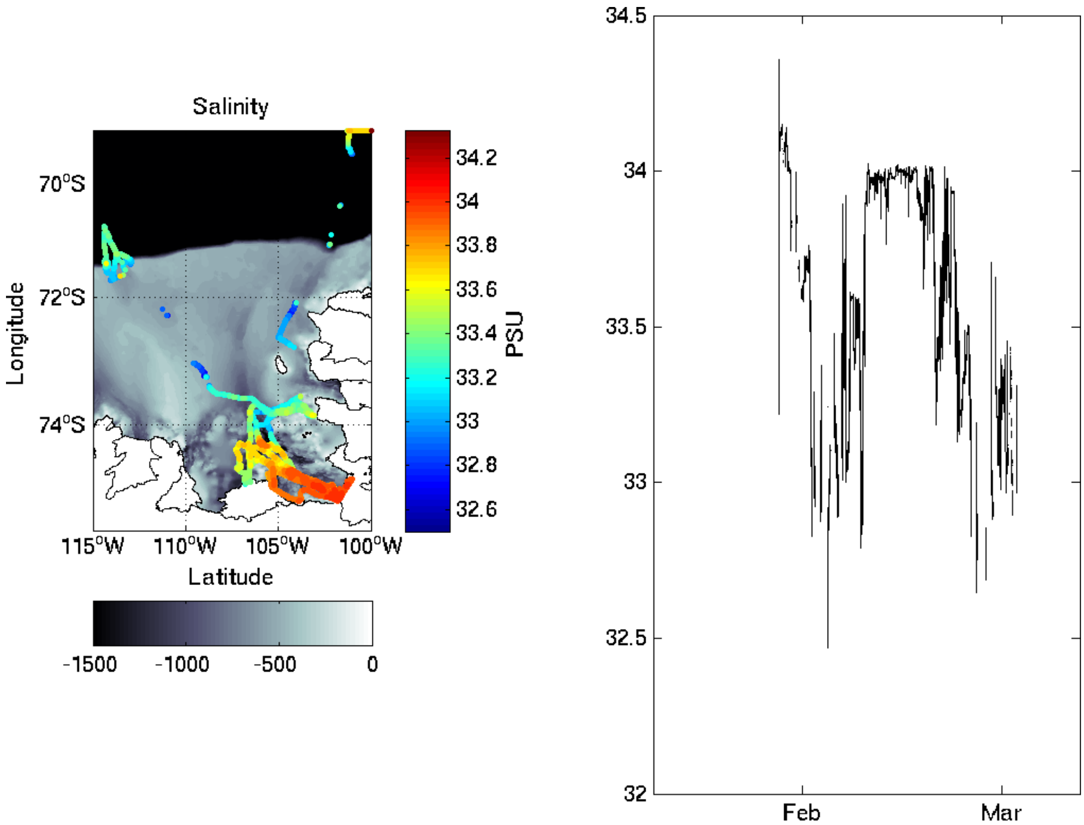


Figure 13.6 Oceanlogger sea surface salinity data (when the instrument was not clogged by ice).

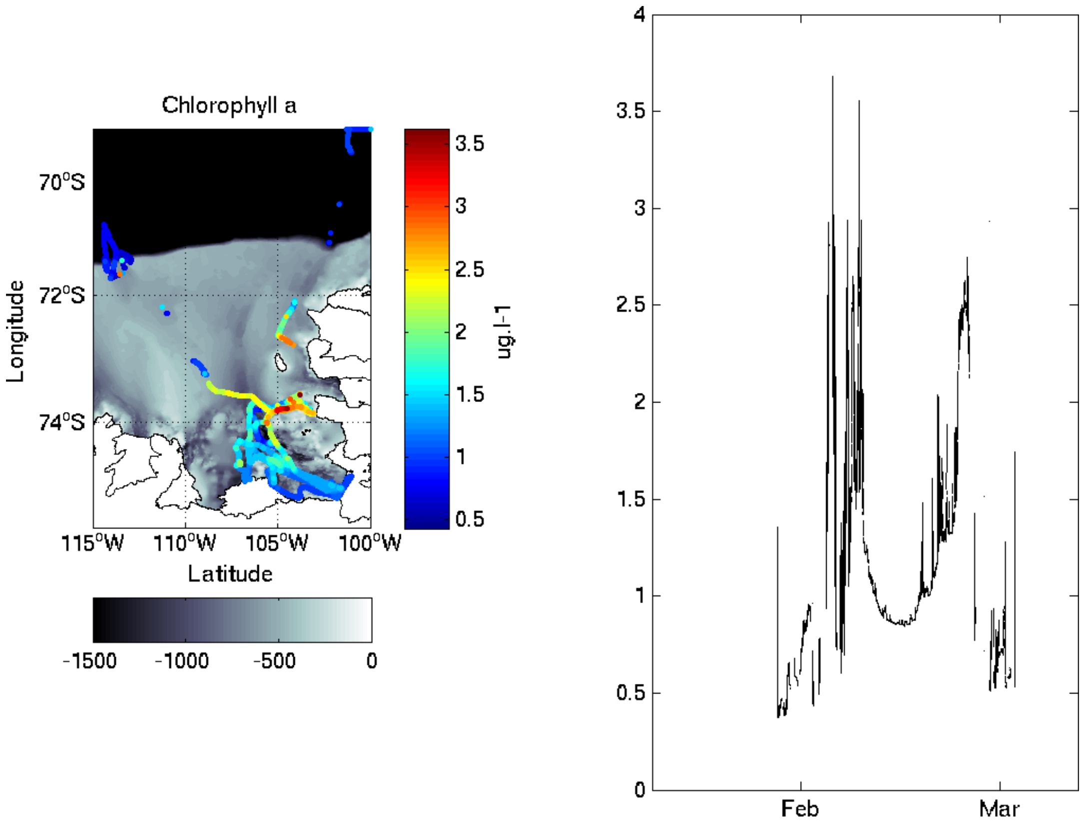


Figure 13.7 Oceanlogger measurements of chlorophyll fluorescence (uncalibrated).

14 Sea ice imagery (Povl Abrahamsen)

Before the start of JR294/5, a request was made to NERC for extra funds for synthetic aperture radar (SAR) imagery as an operational tool in support of the cruise. This was approved, and we coordinated the acquisition of images with Andrew Fleming at the Mapping and Geographical Information Centre (MAGIC) at BAS, using the existing infrastructure for the Polarview project. The previous source of SAR images for Polarview was the Envisat Advanced SAR (ASAR), but unfortunately that satellite failed in 2012. The next-generation ESA satellite, Sentinel, has not yet been launched, so the only viable option was to purchase images. The most suitable platform was Radarsat 2, operated by MDA Geospatial Services Inc. Images were acquired in SCWA mode, horizontal polarization, with each image covering approximately 500x500 km. In total, 16 images were acquired during the cruise. For use on the cruise, images were regridded into polar stereographic projection with a pixel spacing of 150 m and saved in JPEG-2000 format, with geolocation data embedded. Unfortunately because of the terms of the data license for the image, geolocated data cannot be distributed, but derived maps and products can be provided by MAGIC or from the cruise participants based at BAS. During the cruise, images were reprojected and plotted using ArcGIS and distributed to the UIC and bridge as required. In addition to the SAR images, a few MODIS visible images were downloaded using the Iridium OpenPort system, along with AMSR2 sea ice concentrations.
Coverage of the SAR images was chosen to follow the ship's track, starting in the eastern part of the shelf break, moving to Canisteo Peninsula, Pine Island Bay, Thwaites Glacier, and finally up to the western shelf break, moving east. The dates and times of image acquisition are given in Table 14.1, with an overview of the image locations shown in Figure 14.1.

Table 14.1. Date and time of Radarsat2 SAR image acquisition. The low-resolution images can be downloaded from http://www.polarview.aq/images/58_RSjpgsmall/<filename>.jpg.

Image no.	Date	Time	File name (JPEG)
1	25/1/2014	4:05:04	RS2_SS_20140125_040504_SCWA_HH_1.jpg
2	30/1/2014	9:54:33	RS2_SS_20140130_095433_SCWA_HH_1.jpg
3	4/2/2014	12:28:46	RS2_SS_20140204_122846_SCWA_HH_1.jpg
4	7/2/2014	4:25:08	RS2_SS_20140207_042508_SCWA_HH_1.jpg
5	8/2/2014	12:11:26	RS2_SS_20140208_121205_SCWA_HH_1.jpg
6	10/2/2014	9:33:42	RS2_SS_20140210_093421_SCWA_HH_1.jpg
7	12/2/2014	5:18:03	RS2_SS_20140212_051843_SCWA_HH_1.jpg
8	14/2/2014	4:20:17	RS2_SS_20140214_042057_SCWA_HH_1.jpg
9	16/2/2014	5:01:33	RS2_SS_20140216_050212_SCWA_HH_1.jpg
10	18/2/2014	12:19:47	RS2_SS_20140218_122026_SCWA_HH_1.jpg
11	20/2/2014	4:45:07	RS2_SS_20140220_044546_SCWA_HH_1.jpg
12	23/2/2014	4:57:29	RS2_SS_20140223_045808_SCWA_HH_1.jpg
13	25/2/2014	12:15:37	RS2_SS_20140225_121616_SCWA_HH_1.jpg
14	28/2/2014	4:13:18	RS2_SS_20140228_041318_SCWA_HH_1.jpg
15	2/3/2014	9:50:21	RS2_SS_20140302_095021_SCWA_HH_1.jpg
16	3/3/2014	4:25:24	RS2_SS_20140303_042524_SCWA_HH_1.jpg

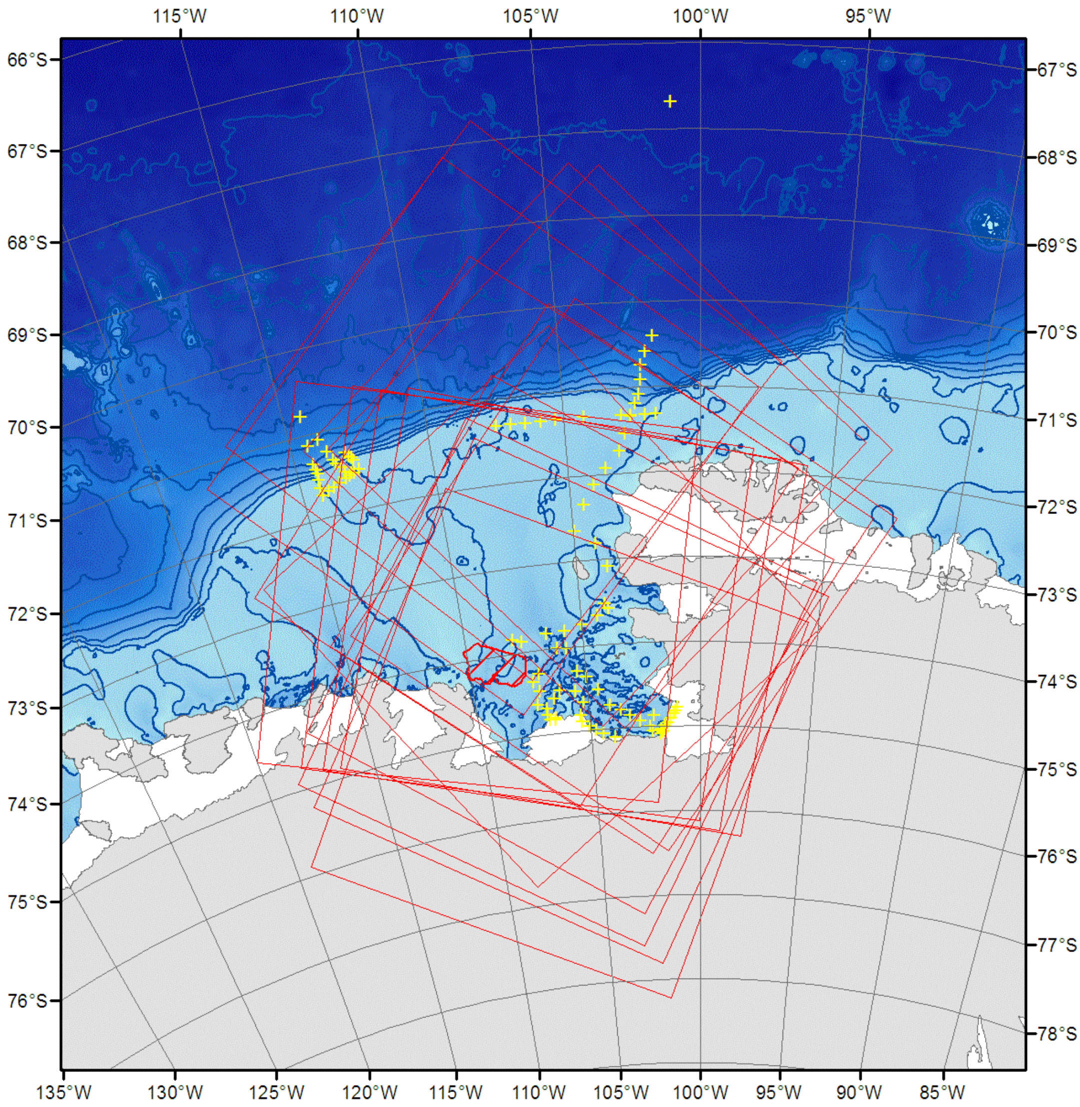


Figure 14.1. Coverage of Radarsat 2 images during JR294/5 (red squares), with CTD stations (yellow) and the approximate location of iceberg B-22A (red hatched). Polar stereographic projection.

15 Iridium communications (Povl Abrahamsen)

During the cruise planning meeting stage, the lack of VSAT coverage was pointed out, and one option that was mentioned as a method of providing communications during the cruise was Iridium OpenPort. BAS already had the hardware and an active SIM card, and iSTAR project management and the two oceanographic science projects agreed to share the cost of using the system. The system is capable of operating at a data rate of up to 128 kbps, and providing three telephone lines for voice communications. The subscriptions for the system are based on maximum data rates and amounts of data and/or voice minutes. We opted for 128 kbps throughout, choosing 10 MB in January and March, and 200 MB in February. This worked out well, with less than the allotted amount of data used in February, and slightly more used in January and March (incurring extra costs). We did not purchase any minutes, incurring slightly higher per-minute charges for any calls that were made.

The antenna for the system was located on the aft port corner of the forecastle deck, with the electronics located in the aft of the UIC, beneath the STCM system. An Ethernet cable was patched through to the spare EK60 processor, running Windows 2000; this computer was set up with a portable version of Thunderbird, and a BAS field party e-mail address, juliet-fp@bas.ac.uk was allocated to the cruise. The computer's DNS system was disabled, with only IP addresses for a few servers at BAS, UEA, and satellite imagery providers included in the hosts file. This was as a precaution to avoid inadvertent use of the data for background tasks. On a few occasions the DNS was reinstated for temporary web access. Two phone calls were made using the system, in connection with the glider deployments.

Overall the system performed excellently. There was one occasion on which the system was unable to connect to Iridium, receiving low signal, but otherwise it connected almost instantly, and while data rates are slow by modern broadband standards, they were more than adequate for sending and receiving text e-mails and downloading compressed satellite images over FTP (approx. 3 MB each – originally expected to be larger). There was also one day where an internet access disruption at BAS HQ meant that e-mail could not be sent or received.

During JR294 the main use of the system was for e-mails to UEA and Southampton in connection with the glider and Autosub deployments, and for sea ice imagery downloads. Other science groups on board and AME also used the system for business e-mails. Having an instantaneous e-mail and internet connection on board during cruises outside VSAT coverage is extremely useful, especially when using autonomous vehicles that are controlled from servers located elsewhere.