Endeavor 522

Cruise Report

SPURS
March 15 - April 15, 2013

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Endeavor 522 Science Party

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Endeavor 522 Ships Crew

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Cruise Narrative

EN522 got underway at about 10:30 on Friday March 15 from the URI pier in Narragansett. Seas were calm and winds were light at first, but picked up as the day wore on and we got further offshore. Overnight we had winds in excess of 30 knts and the ship slowed and altered course to cope with the seas. Conditions had improved by Saturday evening and we were able to make 10 knots again as we got offshore and entered the Gulf Stream.

The Thermosalinographs were running and a sampling schedule was set up for calibration bottle samples. An extra TSG was set up and fed with a special pump and debubbling system utilizing a long hose dragging across the water. The hose was held about 20’ off the starboard side of the ship well forward of the CTD deployment area. When the ship is going faster than a few knots the hose is sampling the upper 10 cm of the water. This system allowed us to sample any near-surface changes in salinity due to diurnal warming or rainfall. It was set up by Julian Schanze and tuned during the transit.

After eight and a half days of steaming we arrived at the SPURS site under much improved conditions. Winds were light and the sun was mostly bright for much of our time on site.

Sunday 3/24

The first order of business was to reset the WHOI mooring. The releases were fired and the balls and line retrieved Sunday morning, 3/24. We did not have to recover the whole mooring, just the synthetic line at depth. There was a concern for chaffing at the eyesplice termination that caused us to do this line change, and indeed we did observe some chaffing. The whole mooring operation proceeded without incident under fine weather conditions. Completing the mooring operation allowed us to clear the decks somewhat and move the small boat to the main deck for easier deployment.

Monday 3/25

We used the small boat to launch two micro-gliders. Seagliders were deployed from the ship. Two WaveGliders were recovered from their holding sites near the WHOI mooring, They were snagged from the small boat then lifted aboard with the knuckle crane. We then started steaming south to retieve a Seaglider, the Mixed Layer Float and the drifting NOAA mooring (Pico- North).

Tuesday 3/26

This was a day of securing lost assets. Seaglider 189 had run low on battery power and had been parked at the surface for some time. The Mixed Layer Float deployed in September had some ballasting issues but fortunately had not drifted too far afield. The NOAA Pico –North mooring had broken free about a month earlier and we hoped to collect it and redeploy if possible. All three of these were found and retrieved on Tuesday. The small boat was used each time, in the case of the MLF and the NOAA mooring, it was to secure a means of lifting the gear aboard the ship or bring the gear to the ship, SG189 was retrieved with the small boat. That night we did a south to north U/W CTD section back toward the mooring array.

Wednesday 3/27

We performed microstructure profiling with the VMP near to ASIP and the gliders. Several of us went over the Sarmiento for “International Salinity Summit Talks” and dinner while the Endeavor chased down the remaining WaveGlider. This WaveGlider was steaming its programmed mission but had lost communications, so could not be commanded to its holding site. However, it was easy to find by following its assigned track. Endeavor returned to Sarmiento before sunset to retrieve the three scientists via small boat. Overnight we did CTDs at the corners of the old mooring “control volume” and UnderWay CTDs between.

Thursday 3/28
At 0800 GMT we fired the release for the NOAA Pico-North mooring to recover the release, glass balls and line in order to be able to redeploy it. It took three hours for the balls to surface, and the initial (buoyant) line was reeled in easily. However the polyester (heavy) line came up all snarled in large tangles. It had clearly been sitting on the bottom, some of it was muddy. We worked hard to untangle it but found that we had to make numerous cuts in the line to get it all aboard. It looks like we would have to re-evaluate the plan to redeploy the mooring, though Jeff may be able to untangle and splice the line back to a usable length. This recovery took much of the day. That evening we deployed a Seaglider and did a CTD calibration cast near it when it dove. We then started a CTD section along 38 W to the south with 1000m stations every 5 nm. The Sarmiento had found a patch of fresh water intruding from the south in its SeaSoar surveys and we were planning ASIP, Glider and VMP work in a suitable fresh intrusion site so this section served in the search for the fresh intrusion.

Friday 3/29
After completing the CTD section we returned to the northwest to retrieve Seagliders 190 and 191 with the small boat. We then steamed toward ASIP for VMP profiling. By this time the micro-gliders were not close to ASIP. We worked on improving VMP profiling by adjusting winch settings and boat speed. VMP’s continued till midnight.

Saturday 3/30
We continued the CTD section along 38 W further to the south overnight. We then steamed to the NOAA Pico-East mooring, launched a small boat to secure a lifting tether and hoisted the buoy up at the stern A-frame using the mooring winch. The old Prawler unit was swapped out for a new unit. Our NOAA colleagues confirmed that it worked later in the day. We then steamed to the WHOI Mooring and Jeff Lord visited the buoy to check meteorological equipment, one system on the buoy seems to be down. We will likely revisit the Buoy later in the cruise once the engineers have diagnosed the problems. We then steamed to recover the two microgliders, Helo and Saul, securing them just before sunset. Plans were made to re-deploy with ASIP on Sunday at a site to the south-south west so a north to south CTD section was done overnight along 38 25’ W.

Sunday 3/31/
We stopped the section at 23 50’ N and steamed a few miles east to retrieve one of last year’s ARGO floats that had developed a small leak. We then steamed to the ASIP position and deployed Helo and Saul quite near it. We then deployed the VMP first steaming north away from the cluster of instrument then approaching again from the north along a parallel section about 1 km west of their position. This was continued till 2100 (local) then we restarted the CTD section further south along 38 25’W.

Monday 4/1

The CTD section along 38 25'W was continued, reaching 23 10'N. We then steamed north back to the ASIP/Glider site for further VMP profiling. After several hours the Sarmiento steamed into site and the chief scientists discussed plans over VHF. The Gliders were recovered at about 16:30, while Sarmiento recovered ASIP. We then began steaming to the north for a CTD section north along 38 W starting near the NOAA Pico-North mooring site. The NOAA mooring redeploy is planned for tomorrow morning.

Tuesday 4/2

One of our missions on EN-522 was to rescue and re-anchor one of the NOAA "Prawler" moorings that had come adrift. The Prawler is a unique new type of mooring that has a surface float with a jacketed wire rope suspended beneath it upon which a CTD can travel. The CTD is part of a package that uses a clever ratcheting mechanism to crawl up the wire as the wire heaves up and down with the surface waves. Once it gets near the surface the ratchet is released and the CTD package drops and collects a profile of temperature and salinity, transmitting the data by inductive coupling through the wire to the surface pod, where it is radioed via satellite to the scientists back home.

The wire extends to 700 m depth, where it is connected to synthetic line. There are two types of line used, the first after the wire is heavier than water, then that transitions to line that is lighter than water. Finally, there are glass balls for floatation, an acoustic release, and anchor. The arrangement of heavy and light synthetic causes the line to take on a sideways "S" shape in the water, since much more line is used than the depth of the water. This makes for a sizable "watch circle" that the buoy will occupy at the ocean surface, but an "S-tether" mooring means much less stress on all the line than a taut mooring would have, and the line does not get wrapped around the anchor.

When we recovered the top portion of the mooring from its drift 100km to the south, it was still working and collecting data and we had no problem locating it and pulling in the wire. We found no synthetic at all at the end of the wire, just an empty thimble in the shackle. It looked like the eye-splice had failed.

The bottom part of the mooring had been recovered on Thursday the 28th and Jeff Lord had worked diligently to splice the line back together. We were particularly interested in finding the bitter end of the line, to see how it had failed. But because of the large tangle and the necessity to make several cuts just to get it aboard, we never found the expected shorter transitional lines that the design called for. Jeff went over every inch of the line and re-spliced the larger pieces and re-spooled them on to the winch. However, since we could not find the expected termination of the line, we did not know how much of the line we had left. How a line could part in two places is a mystery, but the most likely scenario has the line parting somewhere mid-length, then a short length still attached to the wire but with no tension, was cyclically whipped around by the vertically heaving wire rope till the eye-splice parted.

We decided to go ahead with the redeployment; we had brought another anchor for the purpose. But since we did not know how much line we had, we had to be flexible in the depth of water we chose for the anchor site. As the mooring was deployed we had three different people count the revolutions of the drum and use the minimum and maximum radii to estimate the line length. The estimates came to about 2600m. It was deployed with 3400m of the heavy line so we were missing some 800m of line! These moorings were designed with quite a bit of scope but clearly we had to choose the shallowest spot available. This we could do by choosing where to release the anchor, as we trailed over 6 kilometers of line behind us. Fortunately we had a very good SeaBeam survey of the bottom in the area that we had done last September from the Knorr. Chris Duncombe-Rea searched for the minimum depth in the data set and found a nice rise in the seafloor that would still give a reasonable shape to the array of three moorings. We watched the echosounder anxiously as we steamed for the spot, and the bottom did come up smoothly. In fact we got exactly the same depth at the same spot that the Knorr had measured 6 months previously! We steamed another 300 meters to allow for anchor fall back and let it go. We surveyed the anchor by triangulating on three acoustic distances from nearby sites and hoped for the best.

Fortunately, a few hours later we got word from the folks at NOAA that the Prawler was working well. Its very gratifying when such a big mess can be straightened out by smart, hardworking people, the numbers fall into place nicely and a novel contribution to our ocean observing tools can be put right again!

Later that day we deployed the reconditioned Wave Glider and began a U/W CTD section to the east in search of a fresh water intrusion suspected from prior Sarmiento seurveys.

Wednesday 4/3

The U/W CTD survey was continued to the south then back west and then north as we converged on a slightly fresh streak we had mapped out. Sarmiento was working to the south but steamed north to join us for joint ASIP and glider studies. However, ASIP was undergoing repairs and could not be deployed today. The two ships steamed in tandem for a while then Sarmiento continued north and Endeavor stopped to deploy a microstructure glider in the "fresh" patch, expecting ASIP to be ready the next morning. That night we began a 10nm U/W CTD box survey around the glider site with 1000m CTDs casts at the corners.

Thursday 4/4

ASIP was deployed near the glider and we did VMP microstructure casts steaming slowly upwind past the glider and ASIP. That night we ran south to locate an ARGO float at first light.

Friday 4/5

The ARGO Float was retrieved before breakfast and then we steamed north to retrieve the glider. The Sarmiento has more time in the area so will leave the ASIP in for another day. We then steamed west to retrieve our other microstructure glider near the WHOI mooring. This was secured just before dark. That night we did U/W CTDs around our triangular control volume with CTD casts at the corners. A 5200 m cast was done near the WHOI mooring and then a final 1000m cast there as well. A surface drifters was deployed near the WHOI mooring before the deep cast.

Saturday 4/6
After completion of a 1000m CTD cast near the WHOI buoy, the last of our 5 SSS surface drifters was released. We are scheduled to leave the area today to begin the steam for home. We deployed the small boat twice to service moorings; Jeff Lord spent some time on the WHOI surface buoy checking instruments. Later we steamed to the NOAA north mooring to remove the sea anchor that had been used for deployment of the surface float. We ware able to depart for our return home at about noon ships time. Weather and time permitting we may attempt to rescue a Wave Glider off the east coast on our transit home.

Sunday 4/7 – Saturday 4/13
Transit under varying weather conditions, maintaining thermosaliniograph and Salinity Snake sampling.

Sunday 4/14
By 0700 we had located the errant waveglider at 38^{o} 05.3’ N, 72^{o} 24.9’ W and were able to recover it after breakfast. It was heavily fouled and had a very twisted umbilical but posed no particular problems in recovery as the seas had calmed in the mid-Atlantic bight. We then continued steaming to Narragansett Bay.

Monday 4/15
Arrived at Senesco ship yard and tied up by 0900.

Hydrographic support - Dave Wellwood

Salinity measurements were performed on this cruise using a Guildline autosal model 8400B salinometer. Salinity samples were collected from both the CTD rosette, and the ship's thermosalinograph outlet, in 250ml sample bottles and were allowed to reach a room temperature at, or slightly below, the autosal's set bath temperature of 24 degrees Celsius to achieve optimal accuracy. The manufacturer, (Guildline Instruments of Canada), claims an accuracy of +/- 0.003 psu and a resolution of 0.0002 at 35 psu. IAPSO standard seawater (current batch, P-154) was used to standardize the autosal daily before runs.

54 CTD casts were accomplished with samples drawn from 51 of those. The raw data of the analysis are saved in individual station files (\STN###.SAL), and placed on a ship's shared science directory for further processing and sensor calibration.

Wave Gliders - Dave Fratantoni and Ben Hodges

Three Liquid Robotics, Inc. Wave Gliders were deployed from R/V Knorr on September 15 and 16 during the fall 2012 SPURS cruise (KN 209-1). Each Wave Glider (WG) was equipped with two Sea-Bird GPCTDs, with intakes at roughly 30 cm and 6.5 m depth. Additionally, each WG carried an Airmar PB200 Weather Station on a one-meter mast, and an Airmar CS4500 ultrasonic water speed sensor. During their six-month deployment, the WGs cumulatively sampled nearly 20,000 km of near-surface temperature and salinity along their prescribed tracks in the SPURS area.

All of the carbon-fiber masts broke during the first weeks of deployment. The one belonging to WG WHOI-ASL2 ("Red") broke early enough that recovery and repair aboard the Knorr was possible. Red's reinforced mast survived the six-month deployment, providing air temperature and wind velocity measurements until January 20, 2013, when all communications with Red were lost. Aside from their broken masts, WHOI-ASL3 ("Yellow") and WHOI-ASL4 ("Green") performed well for the entire deployment, with the following exceptions: Yellow's sub CTD stopped reporting midway through the deployment (likely due to faulty connections in the umbilical), and none of the vehicles' sub CTDs could be made to accept commands from shore (for example, the sampling rate could not be altered).

The objectives of the present cruise with respect to the WGs were recovery, cleanup, repair/replacement of broken/worn/outdated components, recoating with e-paint, and redeployment. All three WGs were located and recovered without difficulty. Yellow and Green were parked at convenient waypoints for pickup, and Red was intercepted along her programmed track. Though she had been incommunicado for over 2 months, Red was still following the track, along which her progress could be roughly monitored thanks to a Wildlife Computers SPOT5 Argos tag. After recovery Red was rebooted, at which point she began transmitting normally.

There was considerable barnacle growth on all three vehicles (Figure WG-1). In addition, Green's float was covered in greenish brown hairy growth. The forward-most wing springs on both Yellow and Red were broken, perhaps explaining Green's higher speed. The antenna was broken off Red's radio beacon, most likely by repeatedly being bent as the broken weather mast swung across the turtle deck. Red also came aboard with approximately 20 twists in the umbilical, and though a few of these may have been introduced during recovery, it is unlikely that the majority of them were.

Figure WG-1: Gooseneck barnacle growth on Red shortly after recovery

The WGs were disassembled, scraped, sanded, and 3-4 new coats of anti-fouling e-paint were applied. Rudder modules, rudders, spring bars, umbilicals, rudder module-to-sub CTD cables, weather masts, flags, CTD anti-foulant plugs, and the front two wing springs on each vehicle were replaced with new parts. These replacements eliminated the communication problem with the sub CTDs. The Command and Control (C&C) boxes were also replaced, changing the IMEI numbers of each vehicle, so the vehicles were each given new official names. Yellow's broken radio beacon antenna was repaired, and each WG was outfitted with a SHOUT nano GPS/Iridium two-way tracking device. The maximum number of transmissions per day from the pre-existing SPOT5 Argos tags was halved from 900 to 450 to extend battery life.

One WG (Red) was outfitted with 15 HOBO TidbiT v2 water temperature data loggers. The loggers were programmed to sample at 10-minute intervals, allowing for 300 days of data storage. Ten were attached to the umbilical with zip ties and electrical tape, to provide a temperature profile spanning the upper 6 m. The remaining five loggers were bolted to the float and the sub (see Table WG-1).

Once prepared, the WGs were redeployed as conditions and other operations allowed. Yellow and Green were deployed near the moorings, Red a few dozen km to the east (see Table WG-2). After briefly holding along designated octagonal tracks near the moorings, the WGs were dispatched to resume their sampling missions (Figure WG-2).

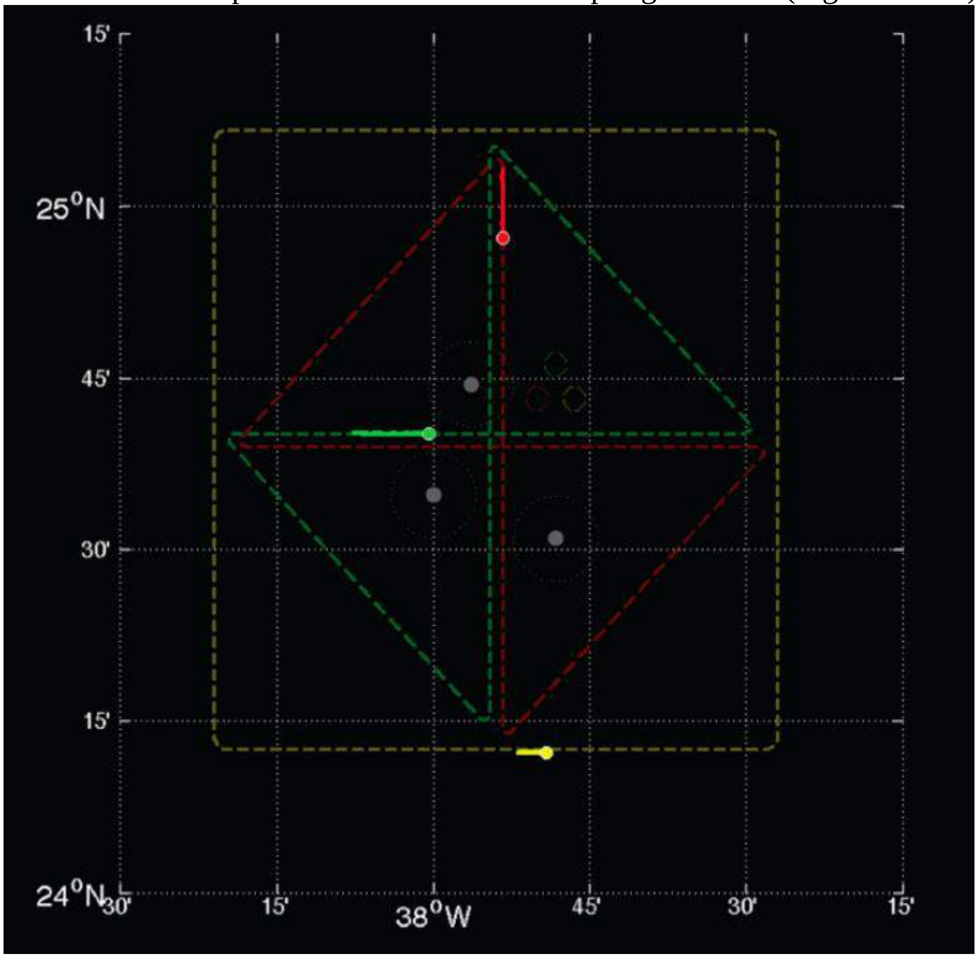


Figure WG-2: Wave glider sampling plan. Each WG's assigned track is plotted as a dotted line in the corresponding color. Initial mooring locations are shown as gray dots.

All WG data is transmitted via Iridium SBD messages, archived at LRI, and retransmitted to WHOI/ASL for initial processing and QC. Hourly-averaged scientific data and relevant supporting measurements are generated several times per hour and forwarded to JPL for assimilation and general access by SPURS participants. Raw data is available on request (dfratantoni@whoi.edu).

Table WG-1: WHOI-ASL22 TidbiT Mounting Locations

S/N	*Location*	*Estimated depth (cm)*
53	Float	5
52	Float	10
71	Float CTD	25
58	Umbilical	50
59	Umbilical	75
60	Umbilical	100
61	Umbilical	150
63	Umbilical	200
64	Umbilical	250
65	Umbilical	300
66	Umbilical	400
67	Umbilical	500
68	Umbilical	600
69	Rudder module	620
70	Sub CTD	650

Table WG-2: Wave Glider Operations

Flag color	Red	Yellow	Green
SPURS I name	WHOI-ASL2	WHOI-ASL3	WHOI-ASL4
SPURS II name	WHOI-ASL22	WHOI-ASL32	WHOI-ASL42
Recover time	27-Mar 1841Z	25-Mar 1930Z	25-Mar 2000Z
Recover location	24° 39’N, 37° 53.4’W	24° 44.2’N, 37° 46.9’W	24° 45.2’N, 37° 47.9’W
Redeploy time	4-Apr 1759Z	2-Apr 2100Z	2-Apr 1950Z
Redeploy location	24° 29.9’N, 37° 13.3’W	24° 45.6’N, 38° 2.4’W	24° 43.7’N, 38° 1.1’W

Microstructure for SPURS II, Alec Bogdanoff, Steve Lambert, James Reilly

Principal Investigators Louis St. Laurent, Carol Anne Clayson, and Raymond Schmitt of the Woods Hole Oceanographic Institution led the microstructure effort of the SPURS II cruise.

Three microstructure equipped systems were deployed during the SPURS II cruise: two Slocum Electric Gliders with Rockland Scientific MicroRider turbulence packages attached (Turbulence- or T-Gliders), and a Rockland Scientific tethered Vertical Microstructure Profiler (VMP-500). All systems are equipped with a SeaBird unpumped CTD, as well.

Each of the T-Gliders performed three missions detailed in the table below. A total of 988 profiles were completed by T-Glider 148, and 484 profiles were completed by T-Glider 64. After each mission, the gliders were taken onboard, evaluated, data downloaded, and necessary probes changes were made. T-Glider 148 was equipped with MicroRider 65, which is designed for use with two shear probes, a micro-temperature probe, and a micro-conductivity probe. T-Glider 64 was equipped with MicroRider 36, which is designed for use with two shear probes and two micro-temperature probes. The only change to the gliders other than probes during the cruise was a weight adjustment on T-Glider 64 between the first and second mission to lower the center of gravity of the glider and provide a more stable flight. Both gliders were flown near Brian Ward's Air-Sea Interaction Profiler (ASIP) during the cruise, as it was deployed from the R/V Sarmiento during a coincident cruise. Details of the glider missions are below.

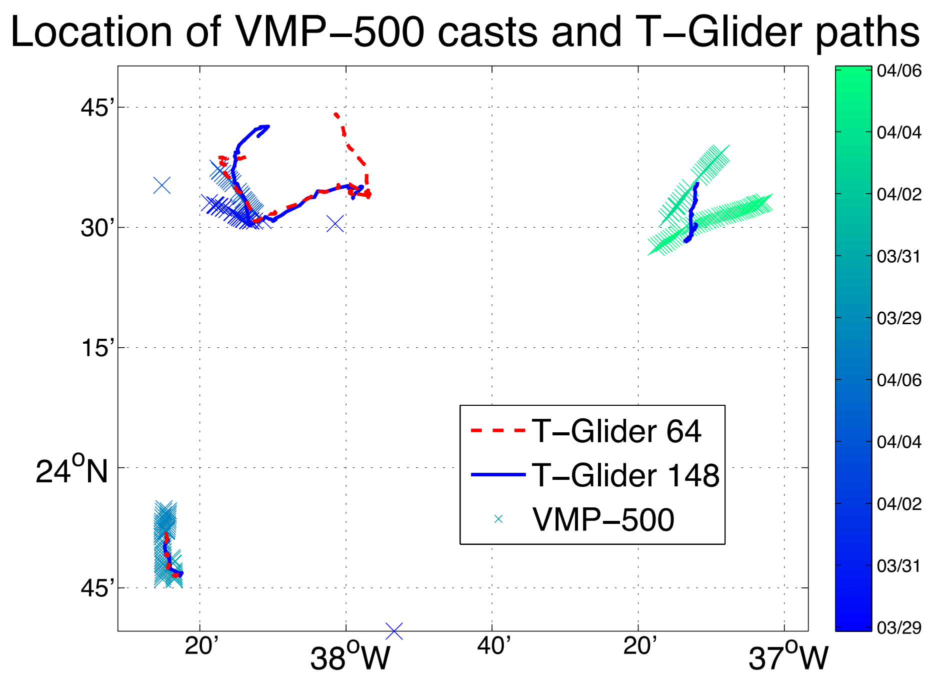
Glider/Miss.	MicroRider	# Profiles	Probes	Notes
148/1	65	636	M366, M823, T733, C23	Following ASIP
148/2	65	140	M680, M741, T733, C23	One day ASIP
148/3	65	212	M680, M741, T733, C23	Fresh patch, near ASIP
64/1	36	322	M381, M825, T734, T259	Following ASIP
64/2	36	78	M381, M384, T731, T259	One day ASIP
64/3	36	84	M381, M384, T731, T259	WHOI Mooring

The VMP was used for six time series deployments for a total of 153 profiles to a depth of at least 300m. The VMP was deployed with two shear probes and two micro-temperature probes. The VMP was initial set up with the following probes: M681, M703, T347, and T732. M383 was changed for M703 on cast 107 only, and replaced with M827 for all subsequent casts. The details of the deployments are below.

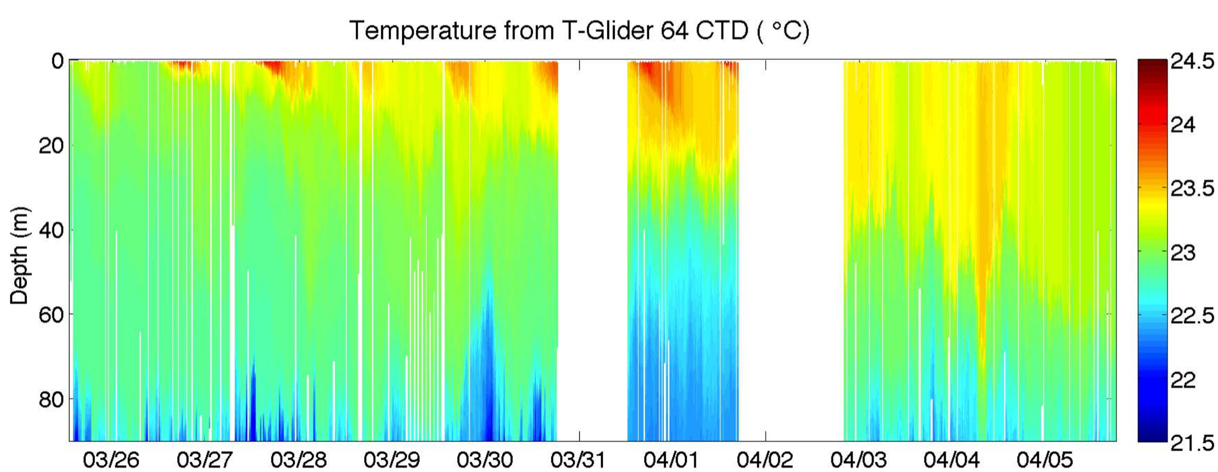
Miss. #	# Prof.	Start Time	Start Lat	Start Lon	End Time	End Lat	End Lon
1	12	3/28/2013 11:43	24.5132	-38.2084	3/28/2013 14:51	24.5468	-38.2994
2	23	3/30/2013 20:00	24.6229	-38.2921	3/31/2013 1:20	24.5287	-38.2065
3	36	4/1/2013 13:20	23.8700	-38.4095	4/1/2013 22:50	23.7676	-38.4184
4	9	4/2/2013 14:38	23.7683	-38.3918	4/2/2013 17:20	23.8129	-38.3972
5	27	4/4/2013 19:19	24.5174	-37.2683	4/5/2013 1:45	24.6547	-37.1437
6	46	4/5/2013 14:52	24.4589	-37.2922	4/6/2013 1:36	24.5528	-37.0455

Data & Preliminary Results

The MircoRider internally records the microstructure data and CTD data from the glider is record on the science bay of the glider. The glider records of microstructure and CTD must be matched up in time and depth. The tethered VMP records all microstructure and CTD data to an attached computer allowing for real-time processing. All require careful processing of the data and as such, all data shown here should be considered preliminary.



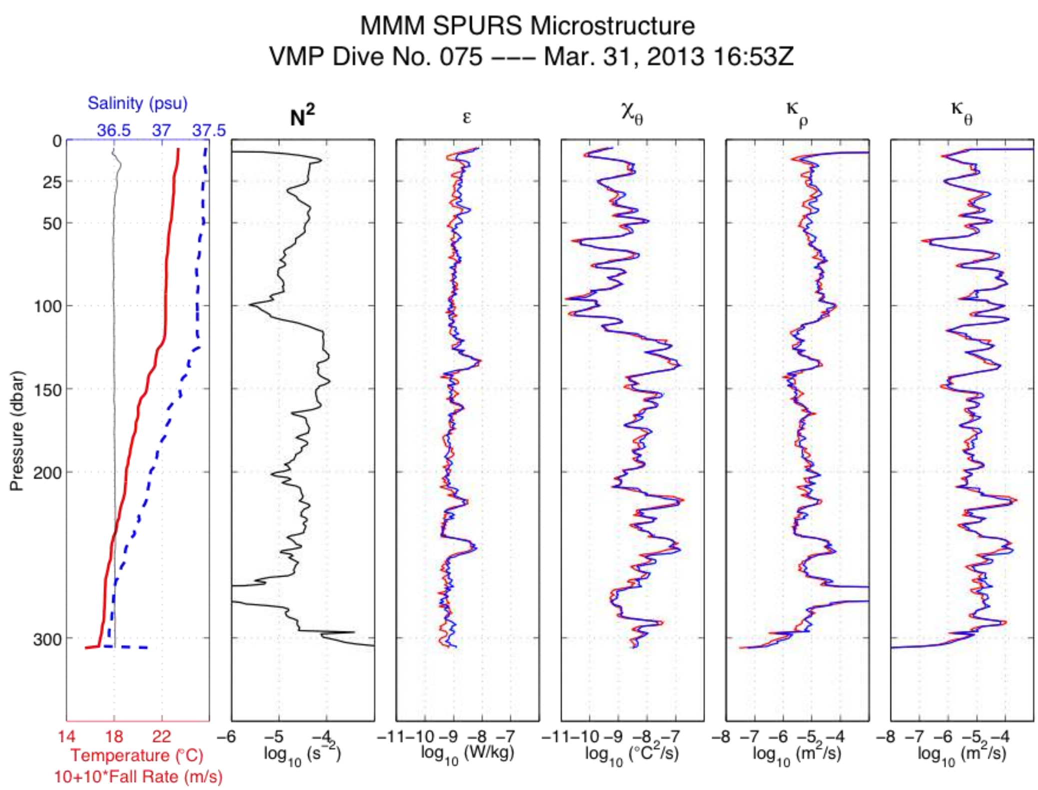
A goal of this cruise was to do profiling with the VMP near the gliders to have coincident microstructure measurements. The plot above shows the location of glider paths and VMP profiles. Several times during the cruise VMP profiling was done within kilometers of the gliders. In addition, the ASIP was profiling near the gliders. At several times



during the cruise, there were four separate instruments profiling microstructure within a relatively close distance. This will allow for comparison between the instruments.

The filled contour plot of temperature from T-Glider 64 shows several different phenomena captured by the gliders. There were six diurnal warming days captured by the gliders. During the last deployment of the gliders, T-Glider 64 was deployed near the WHOI Mooring measuring a very well-mixed deep boundary layer due to strong winds (>15 knots) for over a 36 hour period. This data provides a contrast to the diurnal warming data collected and will be examined thoroughly. T-Glider 148 was deployed in a fresher patch during the same time period. VMP casts were done in this area during most the glider deployment time.

The figure below shows the type of data collected by the VMP and T-Gliders. This is an example of one cast from the VMP. The figure includes salinity and temperature; buoyancy frequency; dissipation; χ_T; K_ρ; and $K_{\boldsymbol{\theta}}$**.** This provides insight into the processes occurring at different depths. The glider and VMP data is quite promising providing over 1500 profiles of microstructure during the cruise.



SPURS Mooring Work.

One objective of the SPURS March 2013 cruise was to service the three surface moorings at the observation site. The WHOI surface mooring required the replacement of a section of synthetic line, and an attempt to troubleshoot one of the data logging systems. One of the PMEL prawler moorings was adrift, and the other prawler mooring had a faulty prawler that needed to be replaced.

WHOI Surface Mooring

The R/V Knorr originally deployed the WHOI surface mooring on 14 September 2012. The mooring construction included an “upgrade” to the wire to nylon transition components. These changes were implemented based on experience with moorings recently deployed in the Southern Ocean. This change was meant to make the mooring more robust.

After the mooring was deployed, a WHOI mooring with similar construction failed six months after deployment. This failure had people concerned that the SPURS mooring was also at risk for failure. Since there would be a ship at the observation site in March, a decision was made to refurbish the mooring using the standard components that had been used in WHOI surface moorings for the past 25 years.

The 90-meter Nystron component in the wire to nylon transition would be replaced with 7/8” nylon line.

On 24 March 2013 the acoustic release connecting the mooring to the anchor was activated. The 80 glass balls above the release, used for backup buoyancy, came to the surface and the Endeavor maneuvered to recover the mooring from the bottom up. The 80 glass balls were recovered using the TSE winch and the a-frame.

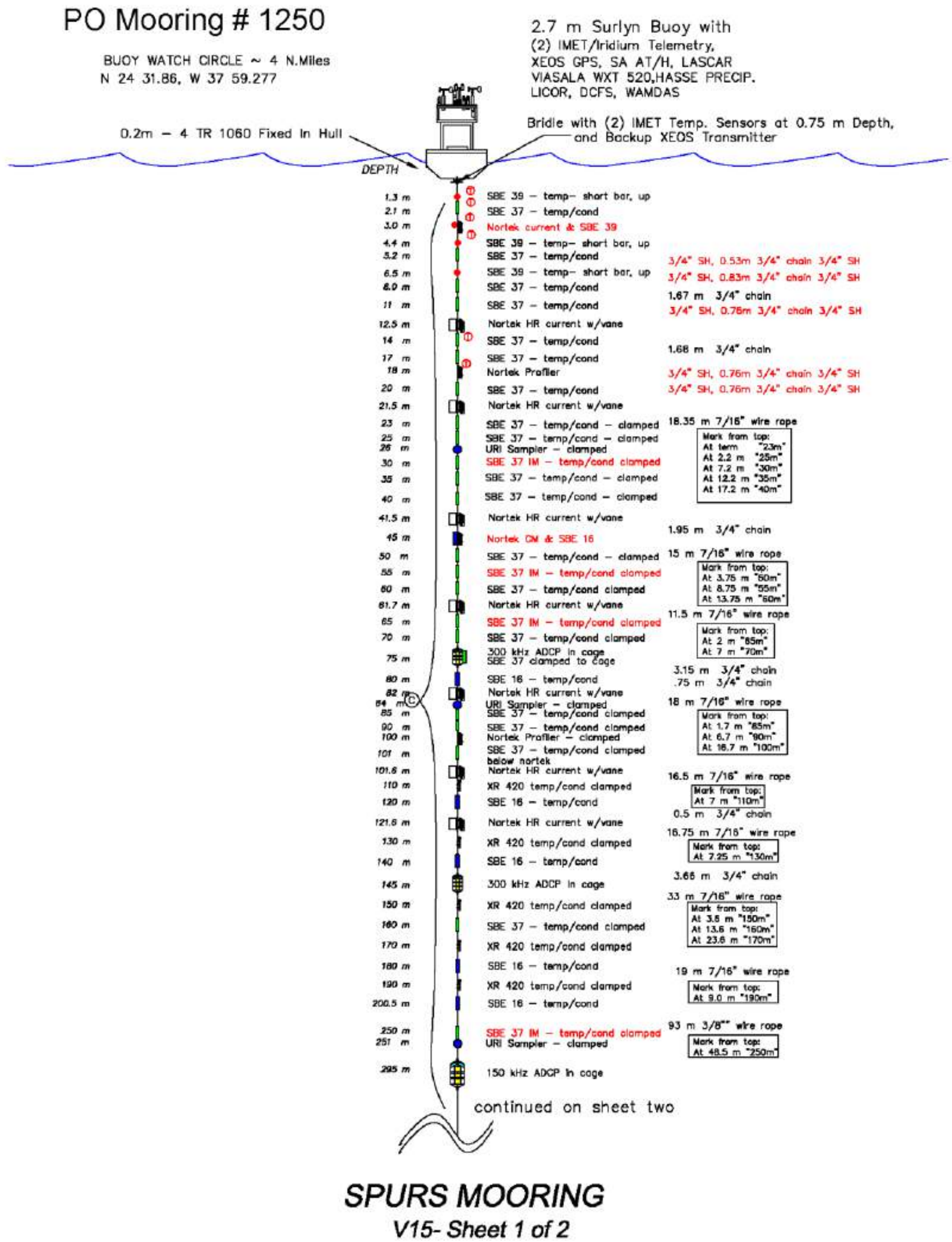


Fig. ## Page 1 of mooring diagram. This part of the mooring remained in the water during maintenance.

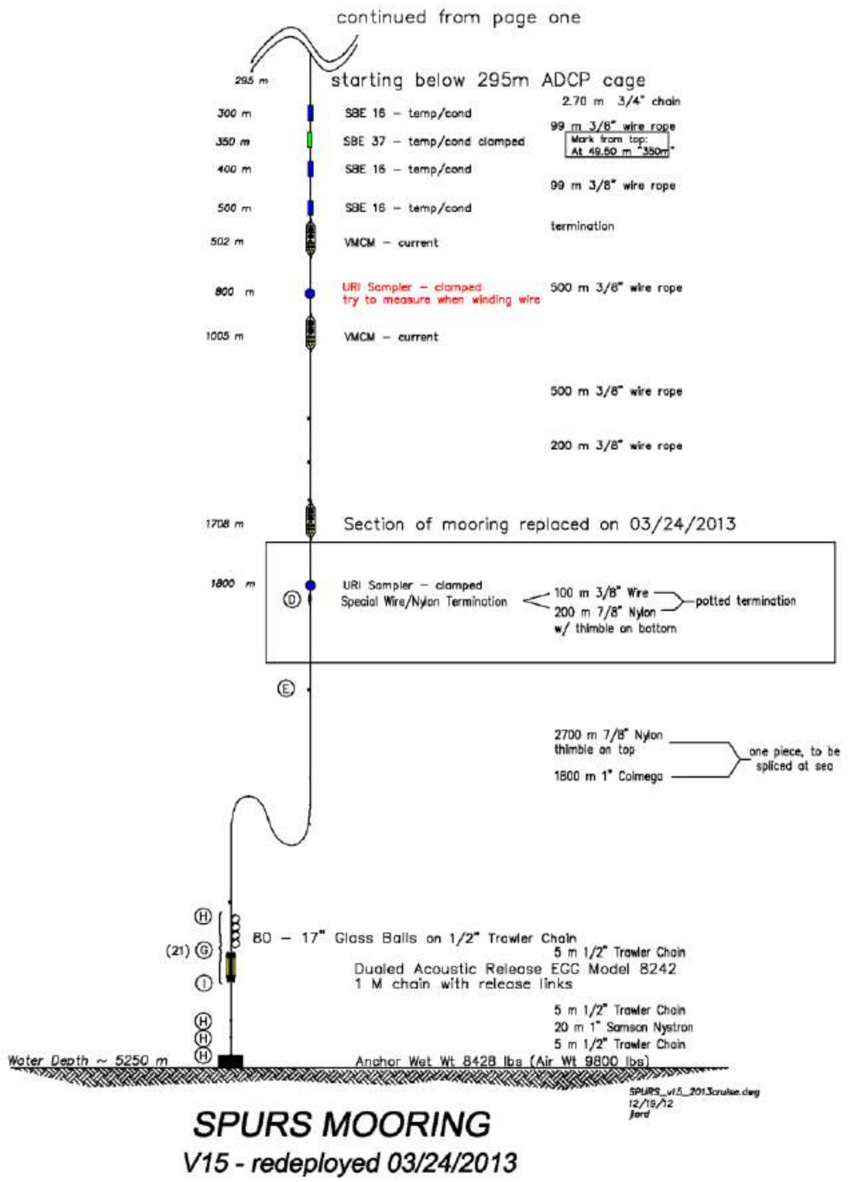


Fig. Page two of mooring diagram shows area where components were replaced

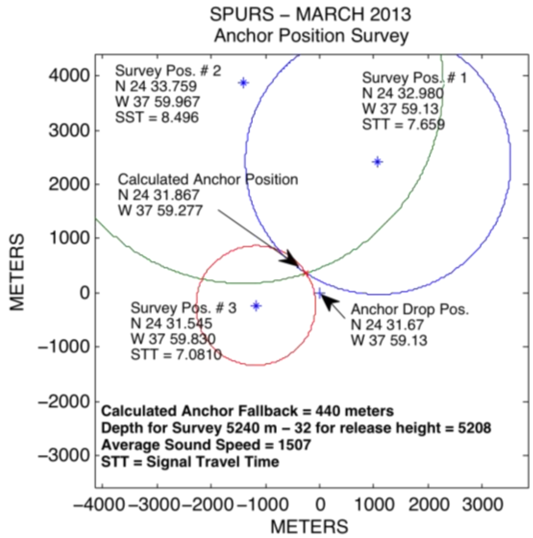
Once the glass balls were out of the way, a capstan was used to recover the 3500 meters of synthetic line into 4 large wire baskets. At the termination that connected the nylon to the Nystron, a shackle was removed and the 90-meter Nystron and 100 meter 3/8" wire rope segment were recovered using the TSE mooring winch.

Fig. R/V Endeavor Main deck configuration during recovery of 80 glass balls.

The mooring was set up to tow, and preparations were made to redeploy. The new section of wire rope and nylon was wound onto the winch. The thimble was cut off the damaged end of the 2700-meter segment of nylon line, and a new eye splice was formed using the original thimble.

Redeployment of the mooring started by connecting the wire rope on the winch with the wire rope on the section of the mooring that was being towed behind the ship. This was deployed off the winch, and then connected to the synthetic line in the wire baskets. The synthetics were deployed over an H-Bit.

Once all the synthetic line was in the water, the glass balls were inserted, followed by the acoustic release and hardware to connect the mooring to the anchor. After confirming the bottom depth was within the design tolerance of the mooring, the anchor was deployed using a tip plate to ease the anchor into the water.



An anchor survey calculated the anchor to be at N 24˚ 31.867', W 37˚ 59.277'

In addition to servicing the mooring hardware on the WHOI surface buoy, the small boat made two trips to the buoy itself. A technician boarded the buoy to confirm the operation of the #2 DCFS system, and to troubleshoot the data logger on one ASIMET system that was not transmitting. Operation of the DCFS system was confirmed. The data logger could not be addressed using the external communication port, and it was confirmed that no power was being provided to the ASIMET modules. Any further work would have required opening the buoy hatch, and it was determined that the risk was too great.

PMEL Prawler Moorings

During the September 2012 SPURS cruise on the R/V Knorr, PMEL deployed two "prawler" moorings. Each of these moorings has a small surface buoy, and a CTD profiling "prawler" that moves up and down the jacketed wire rope.

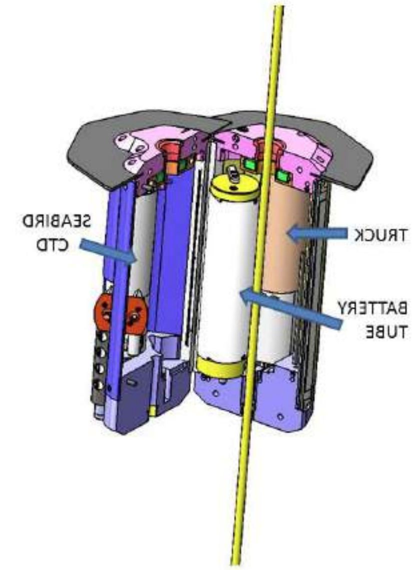


Fig ## PMEL Prawler

The mooring, designated PICO 3000 had not reported data since late December 2012. We were asked to replace the prawler during the March cruise on the Endeavor.

On 30 March 2013 the Endeavor's work boat was deployed to attach a lifting line to the PICO 3000 surface buoy. The work boat remained in the water as the ship made an approach to the buoy on the starboard side.

A grappling hook was used to snag the lifting line and pull it to the deck where it was shackled into the winch leader. The winch leader had been passed through a block in the center of the a-frame. As the buoy drifted to the back of the ship, slack was taken from the winch line. The winch continued to pull until the buoy was lifted through the a-frame, approximately 2 meters above the deck.

The buoy was held steady while the old prawler was replaced with a new one. Damage to the wire rope indicated that prawler had been "parked" just below the buoy for some time. The top stopper for the prawler was removed and reinstalled below the damaged section of wire rope.

Once the prawler was replaced, the buoy was lowered back into the water. The work boat approached the buoy and removed the recovery line that had been installed earlier.

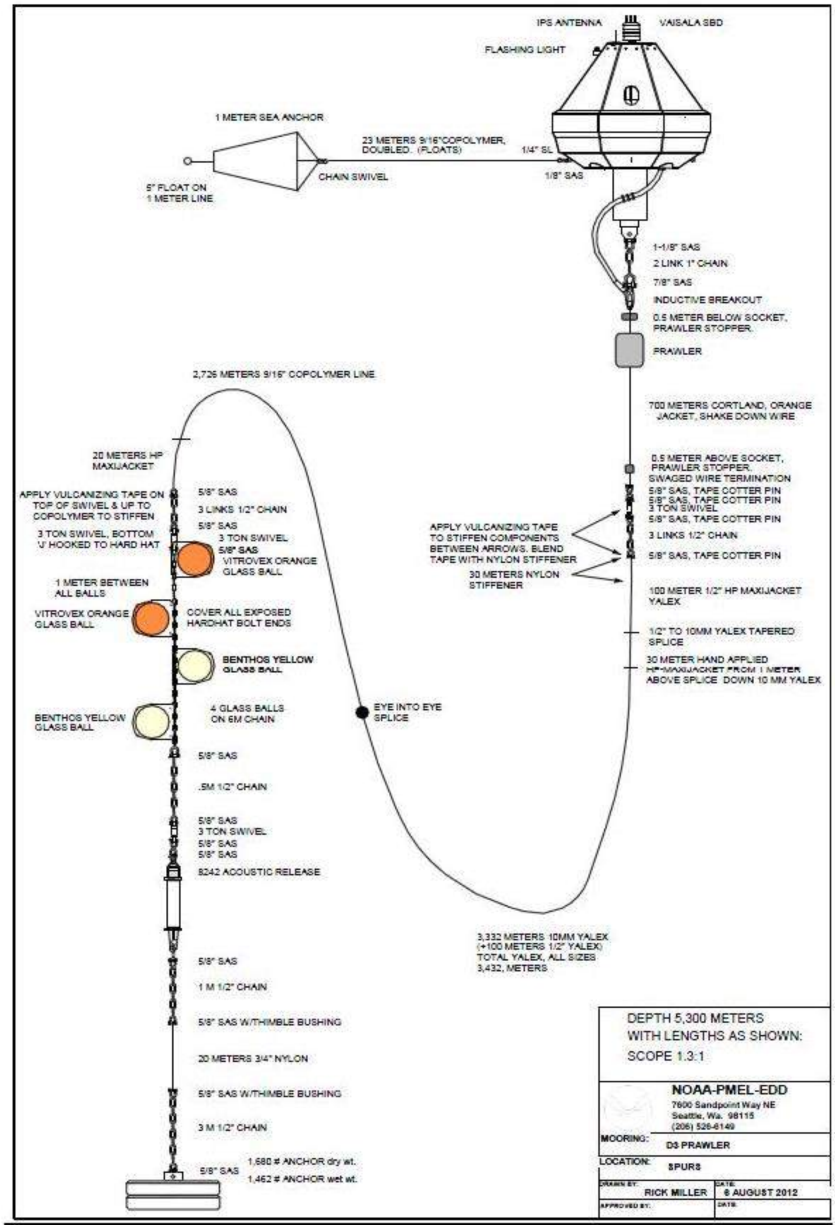


Fig. ## PMEL Prawler Mooring

On 19 February 2013, the PICO 1000 mooring failed and the buoy went adrift. The prawler continued to function and report data. The plan was to recover both ends of the mooring, and redeploy using an anchor that had been loaded on the Endeavor prior to departure from Narragansett.

On 28 March, the Endeavor recovered the top section of the PICO 1000 mooring. The work boat was used to attach a lifting line to the buoy. The work boat was recovered to the main deck before recovery of the buoy commenced.

A grappling hook was used to snag the lifting line and pull it to the deck where it was shackled into the winch leader. The winch leader had been passed through a block in the center of the a-frame. As the buoy drifted to the back of the ship, slack was taken from the winch line. The winch continued to pull until the buoy was lifted through the a-frame, approximately 1 meter above the deck.

Stopper lines were attached to the chain below the buoy and secured on cleats to the deck. The buoy was lowered to the deck, disconnected from the mooring line, and moved out of the way. The winch leader was passed through a block hanging from the knuckle boom crane and connected to the wire rope on the mooring. The winch was used to recover the wire rope. The prawler stoppers and the prawler were removed as they came out of the water. The only thing below the wire rope was the swivel, shackles, three links of chain, and the rope thimble that had been the end of the 100-meter HP Maxijacket Yalex line. It appeared that the mooring had broken at this thimble.

After the recovery of the top end of the mooring, the Endeavor steamed north, back to the SPURS observation area. The wire rope was removed from the winch and put on a wooden reel so the top and was accessible for redeployment.

On March 28 the bottom section of the mooring was recovered. The release was fired at 0600. It took three hours for the four glass balls above the release to make it to the surface.

The ship approached the glass balls, and a pickup pole with a snap hook was used to connect the mooring to the winch line. The glass balls and release were hauled in through the a-frame and the mooring was stopped off while they were disconnected.

Fig. # Recovery of Yalex on PICO 1000

The synthetic line was then recovered using the mooring winch. The 2700 meters of 9/16” copolymer line was recovered with no problems. As soon as the line transitioned to 10mm Yalex, knots started appear. The recovery had to stop three times in the first 200 meters of Yalex to stop off and untangle small knots in the line.

Soon after that larger tangles started coming up. It was obvious that all of the knots could not be untangled during the recovery process. At that point the recovery continued by reeling the clumps of knotted line directly onto the winch. Further into the recovery, some of the clumps were just too big to put on the winch and needed to be cut out of the line.

Once all of the Yalex was on board, it was placed into a wire basket. Some of the Yalex was a mess coming off the winch, and needed to be cut further. The SPURS program continued with glider ops and microstructure profiling work. Over the next two days, as time permitted, the knotted up Yalex was untangled and eventually spliced back together and wound onto the winch.

At this point the broken end of the line had not been found, and at least 100 meters of the mooring was known to be missing.

The PICO 1000 mooring was redeployed on 02 April. The buoy was positioned at the stern with sea anchor and mooring line attached. The prawler was attached to the mooring line and 30 meters of line was faked out on the deck, passed through a block, and back to the capstan. The wire rope was on a wooden reel positioned on a reel stand forward of the capstan. All synthetic line remained on the mooring winch.

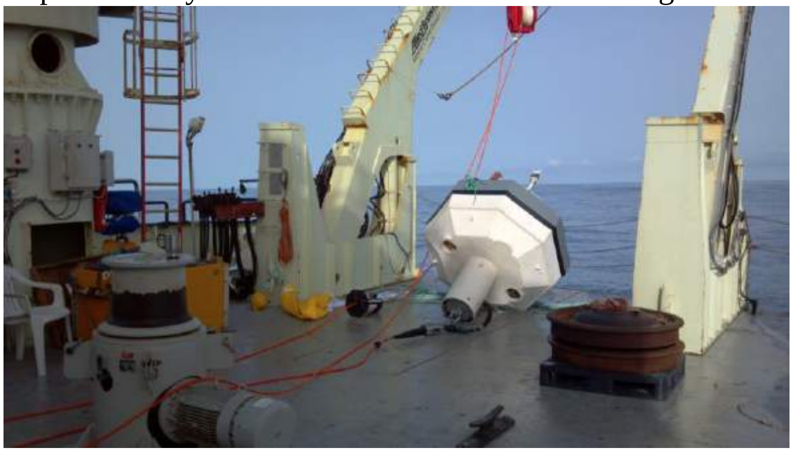
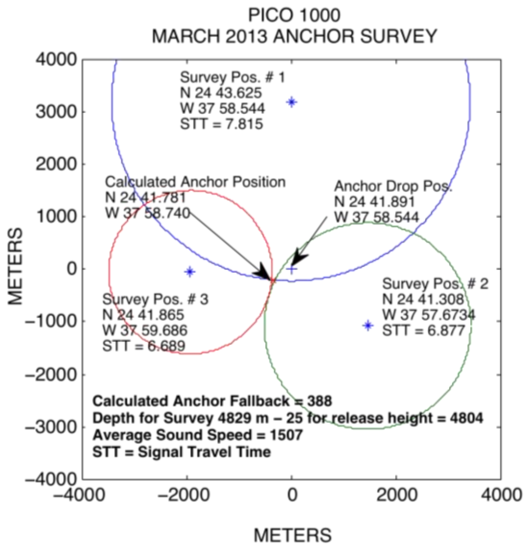


Fig. ## PICO buoy set up for deployment (Knorr September 2012)

The sea anchor was dropped into the water first, and then the buoy, suspended by a quick release hook on the winch leader, was lowered into the water. When the buoy was clear of the stern, the prawler was lifted over the stern and slipped into the water. The knuckle crane suspended the block, and wire was paid out over the capstan.

Once all the wire rope was in the water, the deployment continued, paying Yalex off the winch. Winch rotations were counted until the Yalex was in the water. It was estimated that only 2600 meters of the 3400 meters remained. At that point, we started looking for a shallow place to finish deploying the mooring. A site was selected using bathymetry taken during the September 2012 SPURS cruise.



Deployment continued, and the mooring was towed to a site with a bottom depth of 4829 meters. The anchor was released and surveyed. Final anchor position was calculated to be N 24˚ 41.7809, W 37˚ 58.7404.

Although two of the three moorings were repositioned, the desired geometry of the mooring array was maintained.

EN522 cruise report:Thermosalinograph and Sea Snake data

Julian J Schanze (jschanze@whoi.edu)

1.) Introduction

In addition to the two thermosalinographs aboard the R/V Endeavor, two additional instruments were deployed: a thermistor string in ¾" tubing, hereafter referred to as the sea surface temperature (SST) snake and a 1" vacuum-rated hose connected to a pump and de-bubbling system that was used to measure sea surface salinity (SSS). The objective of the SST and SSS snakes were to measure surface enhancements of temperature and salinity associated with the formation of a stable boundary layer during calm days. These conditions were found on multiple days for temperature and on two days for salinity intensification.

2.) Methods of data collection

a. Shipboard TSG measurements

The R/V Endeavor is equipped with two Seabird thermosalinographs: A SBE-21 unit and a SBE-45 MicroTSG unit. Both units are supplied with de-bubbled water from the hull intake at 5m depth, located along the center line of the ship in the mid-ship section. The de-bubbler used is a 3" vortex debubbler by the Instrument Laboratory at the School of Marine and Atmospheric Sciences at Stony Brook University (www.seabird.com/other_manufacturers/VortexDebubbler_Oct2012.pdf). The SBE-21 has a faster response rate than the SBE-45 MicroTSG, but the overall accuracy and stability is claimed to be higher for the SBE-45. These measurements were uninterrupted throughout the cruise with the exception of one backflushing/cleaning operation on Mar-26-2013.

b. Sea snake measurements

Figure 2: Both sea snakes mounted on boom during transit into study area

The sea snakes were deployed during the transit into the study region for calibration purposes. In the original deployment, both snakes were attached to a boom that was mounted on the stairs leading from the O1 deck to the bow deck area. This is illustrated in Figure 1. In this configuration, the two sea snakes would entangle occasionally, resulting in data problems particularly in the (non-weighted) thermal snake. The design of the salinity snake was changed throughout the cruise based on the experienced data quality and other factors. The initial design used 1 1/8" propeller shaft anodes as a weight, but the drag resulting from the exterior weight caused the tubing to ride too high in the water, resulting in a high intake of bubbles from the two ½" openings. The design was subsequently modified to include cylindrical weight of 1" outer diameter with a length of approximately 60 cm. This was inserted into the tubing and initially fastened with a hose clamp. To reduce drag further, the hose clamp was replaced with waxed string. This provided good results, but ultimately resulted in the failure of the hose at the junction between the non-weighted section of the tubing and the weighted section. Chafe marks from the weight were evident on the inside of the tubing after a failure that occurred during the transit to the study site.

The design was revised to include a shorter (~30cm) cylindrical weight consisting of a copper pipe filled with termination material (arconium). This was smoothed carefully to avoid damage to the interior tubing and wrapped with 3M Super 88 electrical tape. The reduced weight proved to be insufficient to weigh the hose down enough and rather caused the end to float up due to a change in the angle of attack. After two more experiments, the best configuration that was kept throughout the rest of the cruise was found: The number of intake holes was increased from 2 to 3 with one hole located approximately 7 cm from the end of the hose which was stoppered with a 1" PVC insert that was not fastened, but secured by warming of the hose with a warm air gun before inserting the plug, as the rigidness of the hose prevented a full insertion without warming, even with considerable force.

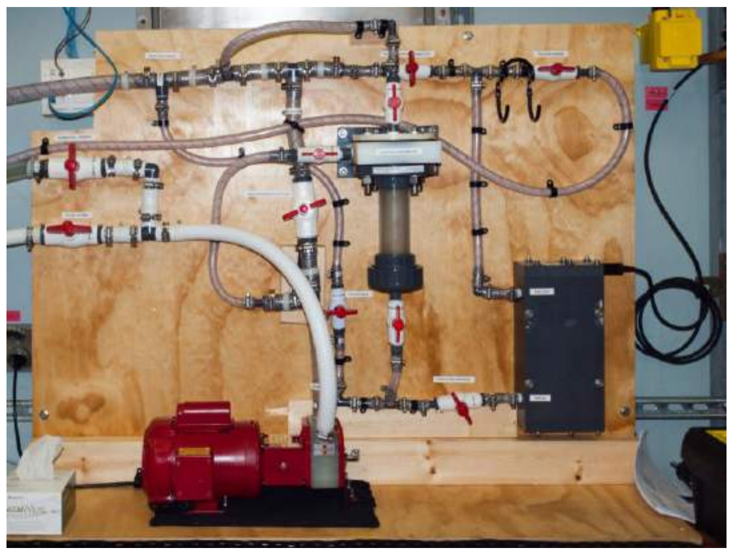


Figure 2: The vessel-side of the sea surface salinity snake, consisting of intake control (right), pump (bottom), de-bubbler (middle) and SBE-45 TSG (left) as well as discharge, priming and bypass controls.

A total of 220 ft of hose was connected to the intake, which is outlined in Figure 2. The intake is set up to accept seawater from either the salinity snake hose or the vessel's saltwater supply for priming purposes. The pump is a self-priming Vanton Flex-I-Liner pump with a nominal flow rate of 5 gallons per minute (gpm) (http://www.vanton.com/Thermoplastic_Pumps_and_Systems/FLEX-I-LINER_Sealless_Self-Priming_Peristaltic_Pumps/index.php) and was wired for 115 V. The pump was chosen after consultation with various manufacturers and suppliers as the best option for a continuous-operation, dry-priming, dry-running self-priming pump. Since flow rate of the pump is greater than the recommended flow rate for the 2" version of the vortex debubbler by the Instrument Laboratory at the School of Marine and Atmospheric Sciences at Stony Brook University (www.seabird.com/other_manufacturers/VortexDebubbler_Oct2012.pdf), a bypass valve was included in the original design. While the schematic shown above in Figure 2 was not modified significantly during the cruise, one alteration was made: The discharge from the pump was directed into a 1” PVC tee that was oriented to provide a vertical section of 1” tube to separate bubbles. The main bypass control valve was oriented to be in a vertical direction to let bubbles escape as a rudimentary first-stage debubbler, before the seawater enters the vortex de-bubbler. This is shown in Figure 3. Whenever the sea snake was not deployed, such as during mooring operations, the system was set to cross-calibration mode. This consists of shutting off the pump and switching the intake valves to close the ‘float intake’ and to fully open the ‘seawater priming’ intake, as well as disabling the main bypass. All other valves should remain in the same position. After initial experiments, it was found that the best results were obtained by limiting the flow rate of the SBE-45 at the TSG discharge valve (and separating the main and TSG discharge). In this configuration, both the inflow and the outflow valve of the de-bubbler are set in-line with the flow and the air dump valve is set to approximately 45 degrees to allow the development of a vortex without forcing too much water from the bottom of the de-bubbler. The de-bubbler bypass valve remained closed.

The pole arrangement was revised on 20-Mar with the installation of a separate boom for the SST snake. This boom was mounted to the

Figure 3: The salinity snake shipside system after modifications to include a cursory de-bubbling in the pump discharge. Note that in this picture, the system is set to use ship-supplied seawater for cross-calibration.

Figure 4: The SST snake mounted on the windsurfer mast at the starboard bow. The halyards were fastened forward, at the met mast forestay, aloft, at the met mast and aft, at the railing (visible as while line in this image). Picture used with permission by Alec Bogdanoff.

starboard bow of the vessel and consisted of a windsurfer mast of approximately 4m length with three shrouds to support the outside. This arrangement ensured no entanglement between the SST and SSS snake and proved successful until the windsurfer mast was destroyed when it was hit by a significant amount of green water over the bow on April 11.

The changes made to the SSS snake were recorded in the header files for each of the accompanying data files and are listed below. Significant changes included the addition and removal of weights until the ultimate design stage was achieved on March 28.
A number of possible surface floats were tested to keep the snake at a constant depth below the water level in variable or no speeds. From a weighted surf-board style float, which failed in initial testing at speeds above 11 knots to a more simple design, it became apparent after approximately 5 different designs that a tube with no float would provide the best possible intake. Any addition of exterior components, including hose clamps, weights and even electrical tape and heat-shrink tubing resulted in a significant increase in drag which ultimately increased the amount of bubbles taken in. The design recommendation for future sea snakes is thus to keep the intake as hydrodynamic as possible with a relatively long section of (sinking) tubing in the water, such as the reinforced marine hose used (Teleflex Marine Vac Extra Heavy Duty/FDA – Series No. 148 in 1" inner diameter). This hose was chosen for the smoothness of its outer wall and rating to complete vacuum to avoid collapse on the intake. In the final design, 4 1 ¼" inner diameter zinc anodes were used and clamped to the hose at a height to ensure that the anodes remained out of the water for approximately 90% of the time in a moderate (2-3m) sea state. The purpose of these weights is to increase the length of hose in water and to move the intake forward rather than letting the hose stretch out farther in a less vertical angle.

c. Data

All data for the thermosalinograph are recorded in the native Seabird .hex format and have been converted to Seabird ASCII files (.cnv). In addition, the original header files (.hdr) and instrument configuration files (.xmlcon) are also included. A comment was added to each logged file. These comments are provided below and detail the stages of deployment and changes to the system during the cruise. The SSS snake was directly connected to a laptop running SeaSave V7 without an external interface unit. As a result, no GPS navigational data are recorded in these files. To ensure that the time-stamp logged with the data can be used to geolocate the data in post-processing, the laptop was continuously synchronized with GPS time in UTC through a serial NMEA connection using GPStime, a freeware program for Windows (www.coaa.co.uk/gpstime.htm).
Two scripts are supplied to load the shipboard data as well as the SSS snake data and to match the timestamps to produce a geolocated output of SSS and SST ('load_all_snake_data.m' and 'read_en522_ship.m'). While the SST from the SSS snake is subject to a number of limitations due to the delay caused by the flow through approximately 70 m of hose, the changes in temperature expected with the hose used are relatively small (likely less than 0.5°C, but this may vary with insolation and the flow rate, which is varied due to the amount of bubbles). The flow rate is nominally 5gpm with no pressure or suction head, but varies considerably based on the amount of bubbles

taken in and the valve settings of the discharge. Some positive spiking in salinity may occur when the flow rate changes abruptly, causing the water in the TSG to be flushed rapidly. Additionally, bubbles may cause negative spikes in conductivity and hence salinity.

The data for the SST snake was stored on the MET computer and will be processed upon arrival at WHOI by James Edson (james.edson@uconn.edu).

Salinity samples were taken approximately every 2 hours for the shipboard thermosalinographs and less frequently for the salinity snake during transit to the study site. When the salinity snake was used, sampling was performed simultaneously for both the salinity snake and the shipboard systems. This was scheduled to occur every 2 hours. On the transit from the study site, samples were taken approximately every 4 hours. These were analyzed in a guildline 8400B salinometer by David Wellwood (dwellwood@whoi.edu).

These calibration points are saved digitally in three Excel spreadsheets:

BottleSpreadsheet_TSG.xlsx: Shipboard TSG calibration bottle samples

snakelog3_af.xlsx: Sea surface salinity snake calibration bottle samples

salinity snake tsg comparisons.xlsx: Concurrent bottle samples taken at increased sampling rate for 2 days; March 26 and April 10.

In addition to the native Seabird formats, the shipboard thermosalinograph data are logged in the ship log, a file which contains 117 variables including navigational and meteorological data. This may be loaded also with the 'read_en522_ship.m' file.

In addition to the shipboard seabird files, the following files were logged for the SSS snake:

Data files

EN522\en522_sbe45_surface_test5.hdr:
** test with adjusted sample interval
* Real-Time Sample Interval = 10.0000 seconds
* System UTC = Mar 17 2013 04:13:08

EN522\en522_sbe45_surface_CROSSCALIB_18MAR.hdr:
** cross calibration after loss of weight in snake. 19 mar 04:09Z
* System UTC = Mar 19 2013 04:09:29

EN522\en522_sbe45_surface_CROSSCALIB_21MAR_0414.hdr:
** After pulling the surface sampler out of the water on 0420 on 21 MAR UTC, back to cross-calibration with shipboard water. pump not active. Flow rate approximately 20ml/s.
* System UTC = Mar 21 2013 04:19:41

EN522\en522_sbe45_surface_CROSSCALIB_21MAR_0442.hdr:
** after reset of serial ports, resuming operation with flow through, no pump, shipboard
* System UTC = Mar 21 2013 04:43:00

EN522\en522_sbe45_surface_CROSSCALIB_21MAR_2308.hdr:
** after changing plumbing to incorporate a crude first stage de-bubbler, continuation of cross-calibration from shipboard water. Pump off. Flow rate approximately 20ml/s.
* System UTC = Mar 21 2013 23:12:03

EN522\en522_sbe45_surface_CROSSCALIB_21MAR_2340.hdr:
** fixed small leak before TSG input. new plumbing (vertical) to act as pre-separator. approx. 20 ml/s from ship with no pump. x-calibration.
* System UTC = Mar 21 2013 23:42:23

EN522\en522_sbe45_surface_SNAKE_23MAR_1814.hdr:
** re-deployment of snake upon arrival in study region. Mar 23 18:14. New double-de-bubbler active. Flow rate approx. 20 ml/s.
* System UTC = Mar 23 2013 18:15:04

EN522\en522_sbe45_surface_SNAKE_23MAR_2214.hdr:
** after boom extension by another 5ft to approx. 20ft out, the snake is back in the water. first CTD station with deep cast to 4500m. The beginning of this file will contain water intake from approx. 10m.
flow rate approx. 20 ml/s
* System UTC = Mar 23 2013 22:15:15

EN522\en522_sbe45_surface_SNAKE_25MAR_0306.hdr:
** cross-calibration after mooring ops during the day. snake pulled and remains pulled.
** flow rate 20ml/s without pump
* System UTC = Mar 25 2013 03:10:06

EN522\en522_sbe45_surface_SNAKE_26MAR_1018.hdr:
** very calm day, 23 deg S, recovering seaglider 189. Putting seasnake out. pump active, flow rate 20ml/s or so, starting with very slow ship movement
* System UTC = Mar 26 2013 10:16:16

EN522\en522_sbe45_surface_SNAKE_26MAR_1110.hdr:
** continuing surface sampling, calm day with 2-3kt winds, hopefully will see stable boundary layer. adjusted snake, moved weights up [on the hose, towards the boom] so that more tube is in the water.
* System UTC = Mar 26 2013 11:09:26

EN522\en522_sbe45_surface_CROSSCALIB_26MAR_1824.hdr:
** pulling snake for mooring ops. Now on passthrough from shipboard.
** Pump off, flow rate 20ml s
* System UTC = Mar 26 2013 18:24:57

EN522\en522_sbe45_surface_SNAKE_26MAR_2110.hdr:
** after mooring ops, redeployed snake. Removed weight from end. Taped off intake that was previously stoppered by weight. Flow rate approx 20ml/s with pump active. Backflushing first to prime snake.
* System UTC = Mar 26 2013 21:12:17

EN522\en522_sbe45_surface_SNAKE_28MAR_1753.hdr:
** snake redeployed at noaa N mooring site after recovery of bottom part of noaa pmel n mooring line (tangled). pump running,
** removed all tape from hose to prevent drag, stoppered with no securing features.

** pump active, snake only, 20 ml/s
* System UTC = Mar 28 2013 17:55:28

N522\en522_sbe45_surface_SNAKE_30MAR_0505.hdr:
** continuation of sampling with snake. pump running, flow rate through TSG is 20ml/s.
* System UTC = Mar 30 2013 05:05:49

EN522\en522_sbe45_surface_SNAKE_01APR_1501.hdr:
** continuation
* System UTC = Apr 01 2013 15:03:01

EN522\en522_sbe45_surface_SNAKE_03APR_1602.hdr:
** computer involuntarily undocked due to ship-motion, thus disabling nmea string input to sync. Re-starting computer and resuming sampling.
* System UTC = Apr 03 2013 16:03:26

EN522\en522_sbe45_surface_SNAKE_05APR_1543.hdr:
** routine continuation. Currently on station with CTD in water, intake low. pump active, flow rate 20ml/s
* System UTC = Apr 05 2013 15:44:27

EN522\en522_sbe45_surface_SNAKE_11APR_0349.hdr:
** continuation of record. SST snake boom destroyed by green water over bow. 10th of april (day 100) another calm flat day with thermal and haline stratification evident.
** pump, snake, 20ml/s
* System UTC = Apr 11 2013 03:51:11

EN522\en522_sbe45_surface_SNAKE_11APR_2100.hdr:
** Laptop disconnected from docking station, causing battery to discharge and laptop to shut down. restarting.
** snake/pump/20ml/s
* System UTC = Apr 11 2013 21:01:51

EN522\en522_sbe45_surface_CROSSCALIB_12APR_1916.hdr:
** snake and boom retracted due to weather, snake will not be redeployed during this cruise .picking up wave glider in a day and a few hours which requires no snake in the water anyway.
** continuing cross-calibration with no pump. flow rate 20-30ml/s

MATLAB files

Note that these MATLAB files are preliminary and by no means meant to produce final, quality-controlled data. Many first-order quality-control measures are implemented here, which may be too restrictive for universal use. Examples of this include filters for ship velocities below 6 knots, salinities below 35 or in excess of 38 and temperatures outside of the range expected in the study area.

Read_snake_data.m
```
cdir=pwd;
```

```
cd('EN522');tflist=dir('*.cnv');
nlist=size(tflist,1);
tyear=2013;

for ii=1:nlist
    fname=tflist(ii).name;
    [gtime,tdata,tnames]=cnv2mat_tsg(fname);
    if ii==1
        time=gtime;
        data=tdata;
    else
        time=[time; gtime];
        data=[data; tdata];
    end
end
cd(cdir);
[tdate, IX] = sort(data(:,1),1);
badlist=zeros(size(tdate));
dataout=[tdate data(IX,2) data(IX,3) data(IX,4)];
badlist(dataout(:,3)<30)=1;
dataout(repmat(logical(badlist),[1 4]))=NaN;
S6date=dataout(:,1);
S6T=dataout(:,2);
S6S=dataout(:,3);
S6C=dataout(:,4);
S6time= datenum(tyear,1,1)+S6date-1;


%%
S6timenn=S6time(isfinite(S6time));
%S6timec=interp1(EN522datec,EN522datec,S6timenn,'nearest');

 %% correlate time vectors
 corrval=NaN(size(S6timenn))'; % initialize corresponding value matrix
 for ii=1:length(S6timenn)
     tout=find(abs(S6timenn(ii)-EN522datec)<(10/86400),1,'first');
     %if isfinite(tout)
         corrval(ii)=tout;
     %end
 end
%%
S6timec=EN522datec(corrval);
S6latc=EN522latc(corrval);
S6lonc=EN522lonc(corrval);
S6Sshipc=S45c(corrval);
S6Tshipc=T45c(corrval);
S6Vshipc=SpeedLog_WaterSpeedFwd(corrval);
S6windc=TrueWindPort_Speed(corrval);
S6Sc=S6S(isfinite(S6S));
S6Tc=S6T(isfinite(S6T));
S6Cc=S6C(isfinite(S6C));

badlist2=find(S6Vshipc<6);
S6Tc(badlist2)=NaN;
S6Sc(badlist2)=NaN;
S6Cc(badlist2)=NaN;
```

Read_en522_ship.m

```
fname='C:\Users\Julian\Documents\en522_data\Data1Sec_001.elg';
fid=fopen(fname,'r','n','US-ASCII'); % open as native us ascii.

sel(    001 )=  1   ;  %    1   Date
sel(    002 )=  1   ;  %    2   Time
sel(    003 )=  0   ;  %    3   GPS-TrimbleDiff-UTCofFix
sel(    004 )=  0   ;  %    4   GPS-TrimbleDiff-Latitude
sel(    005 )=  0   ;  %    5   GPS-TrimbleDiff-Longitude
sel(    006 )=  0   ;  %    6   GPS-TrimbleDiff-Quality
sel(    007 )=  0   ;  %    7   GPS-TrimbleDiff-SatsInUse
sel(    008 )=  0   ;  %    8   GPS-TrimbleDiff-HDOP
sel(    009 )=  0   ;  %    9   GPS-TrimbleDiff-DiffAge
```

```
sel(    010 )=  0   ;  %    10  GPS-TimbleDiff-TMG
sel(    011 )=  0   ;  %    11  GPS-TimbleDiff-SMG
sel(    012 )=  0   ;  %    12  GPS-NstarWaas-UTCofFix
sel(    013 )=  1   ;  %    13  GPS-NstarWaas-Latitude
sel(    014 )=  1   ;  %    14  GPS-NstarWaas-Longitude
sel(    015 )=  0   ;  %    15  GPS-NstarWaas-Quality
sel(    016 )=  0   ;  %    16  GPS-NstarWaas-SatsInUse
sel(    017 )=  0   ;  %    17  GPS-NstarWaas-HDOP
sel(    018 )=  0   ;  %    18  GPS-NstarWaas-TMG
sel(    019 )=  0   ;  %    19  GPS-NstarWaas-SMG
sel(    020 )=  0   ;  %    20  RMY-Trans-AirTemp
sel(    021 )=  0   ;  %    21  RMY-Trans-RelHumidity
sel(    022 )=  0   ;  %    22  RMY-Trans-BaroPressure
sel(    023 )=  1   ;  %    23  RMY-Trans-SST5
sel(    024 )=  1   ;  %    24  RMY-Trans-SST1
sel(    025 )=  0   ;  %    25  RMY-Trans-LW
sel(    026 )=  0   ;  %    26  RMY-Trans-SW
sel(    027 )=  0   ;  %    27  RMY-Trans-PrecipCurrHr
sel(    028 )=  1   ;  %    28  RMY-Trans-PrecipLastHr
sel(    029 )=  0   ;  %    29  RMY-TransPrecipCurr24Hr
sel(    030 )=  0   ;  %    30  RMY-Trans-PrecipLast24Hr
sel(    031 )=  0   ;  %    31  RMY-Trans-PrecipRate
sel(    032 )=  0   ;  %    32  RMY-Trans-PortWindRelSpd
sel(    033 )=  0   ;  %    33  RMY-Trans-PortWindRelDir
sel(    034 )=  1   ;  %    34  TrueWindPort-Speed
sel(    035 )=  0   ;  %    35  TrueWindPort-Direction
sel(    036 )=  0   ;  %    36  RMY-Trans-StbdWindRelSpd
sel(    037 )=  0   ;  %    37  RMY-Trans-StbdWindRelDir
sel(    038 )=  1   ;  %    38  TrueWindStbd-Speed
sel(    039 )=  0   ;  %    39  TrueWindStbd-Direction
sel(    040 )=  0   ;  %    40  Gyro1-Heading
sel(    041 )=  1   ;  %    41  SpeedLog-WaterSpeedFwd
sel(    042 )=  0   ;  %    42  SpeedLog-WaterSpeedTrans
sel(    043 )=  0   ;  %    43  SpeedLog-GroundSpeedFwd
sel(    044 )=  0   ;  %    44  SpeedLog-GroundSpeedTrans
sel(    045 )=  0   ;  %    45  Tsal-TurnFluorometer
sel(    046 )=  0   ;  %    46  Knudsen-DepthHF
sel(    047 )=  0   ;  %    47  Knudsen-ValidHF
sel(    048 )=  0   ;  %    48  Knudsen-DucerDepHF
sel(    049 )=  0   ;  %    49  Knudsen-DepthLF
sel(    050 )=  0   ;  %    50  Knudsen-ValidLF
sel(    051 )=  0   ;  %    51  Knudsen-DucerDepLF
sel(    052 )=  0   ;  %    52  Gyro2-Heading
sel(    053 )=  0   ;  %    53  ADU2-UTCofFix
sel(    054 )=  0   ;  %    54  ADU2-Latitude
sel(    055 )=  0   ;  %    55  ADU2-Longitude
sel(    056 )=  0   ;  %    56  ADU2-Heading
sel(    057 )=  0   ;  %    57  ADU2-Pitch
sel(    058 )=  0   ;  %    58  ADU2-Roll
sel(    059 )=  0   ;  %    59  ADU2-MRMS
sel(    060 )=  0   ;  %    60  ADU2-BRMS
sel(    061 )=  0   ;  %    61  ADU2-Flag
sel(    062 )=  0   ;  %    62  Gill-Bow-WindRelSpd
sel(    063 )=  0   ;  %    63  Gill-Bow-WindRelDir
sel(    064 )=  0   ;  %    64  Gill-Bow-WindStatus
sel(    065 )=  0   ;  %    65  TrueWindBow2-Speed
sel(    066 )=  0   ;  %    66  TrueWindBow2-Direction
sel(    067 )=  0   ;  %    67  TurnerFluorometerRaw
sel(    068 )=  1   ;  %    68  Tsal-Salinity
sel(    069 )=  1   ;  %    69  Tsal-SST
sel(    070 )=  0   ;  %    70  GPS-TrimblePcode-UTCofFix
sel(    071 )=  0   ;  %    71  GPS-TrimblePcode-Latitude
sel(    072 )=  0   ;  %    72  GPS-TrimblePcode-Longitude
sel(    073 )=  0   ;  %    73  GPS-TrimblePcode-Quality
sel(    074 )=  0   ;  %    74  GPS-TrimblePcode-SatsInUse
sel(    075 )=  0   ;  %    75  GPS-TrimblePcode-HDOP
sel(    076 )=  0   ;  %    76  GPS-TrimblePcode-TMG
sel(    077 )=  0   ;  %    77  GPS-TrimblePcode-SMG
sel(    078 )=  0   ;  %    78  Time-Datum-Yearday
sel(    079 )=  0   ;  %    79  Time-Datum-Hms
sel(    080 )=  0   ;  %    80  Time-Truetime-Yearday
```

```
sel(    081 )=  0   ;  %    81  Time-Truetime-Hms
sel(    082 )=  0   ;  %    82  GPS-Furuno-UTCofFix
sel(    083 )=  0   ;  %    83  GPS-Furuno-Latitude
sel(    084 )=  0   ;  %    84  GPS-Furuno-Longitude
sel(    085 )=  0   ;  %    85  GPS-Furuno-Quality
sel(    086 )=  0   ;  %    86  GPS-Furuno-SatsInUse
sel(    087 )=  0   ;  %    87  GPS-Furuno-HDOP
sel(    088 )=  0   ;  %    88  GPS-Furuno-DiffAge
sel(    089 )=  0   ;  %    89  GPS-Furuno-TMG
sel(    090 )=  0   ;  %    90  GPS-Furuno-SMG
sel(    091 )=  1   ;  %    91  MicroTSG-Temperature
sel(    092 )=  1   ;  %    92  MicroTSG-Conductivity
sel(    093 )=  1   ;  %    93  MicroTSG-Salinity
sel(    094 )=  0   ;  %    94  MicroTSG-SoundVelocity
sel(    095 )=  0   ;  %    95  Tsal-SoundVelocity
sel(    096 )=  1   ;  %    96  Tsal-Temperature
sel(    097 )=  1   ;  %    97  Tsal-Conductivity
sel(    098 )=  0   ;  %    98  SpeedLog-GroundValidFlag
sel(    099 )=  0   ;  %    99  SpeedLog-WaterValidFlag
sel(    100 )=  0   ;  %    100 RMY-Bow-AirTemp
sel(    101 )=  0   ;  %    101 RMY-Bow-RelHumidity
sel(    102 )=  0   ;  %    102 RMY-Bow-BaroPressure
sel(    103 )=  0   ;  %    103 RMY-Bow-WindRelSpd
sel(    104 )=  0   ;  %    104 RMY-Bow-WindRelDir
sel(    105 )=  0   ;  %    105 RMY-Bow-WindStatus
sel(    106 )=  0   ;  %    106 TrueWindBow1-Speed
sel(    107 )=  0   ;  %    107 TrueWindBow1-Direction
sel(    108 )=  0   ;  %    108 RAD-LW
sel(    109 )=  0   ;  %    109 RAD-SW
sel(    110 )=  0   ;  %    110 ADU5-UTCofFix
sel(    111 )=  0   ;  %    111 ADU5-Latitude
sel(    112 )=  0   ;  %    112 ADU5-Longitude
sel(    113 )=  0   ;  %    113 ADU5-Heading
sel(    114 )=  0   ;  %    114 ADU5-Pitch
sel(    115 )=  0   ;  %    115 ADU5-Roll
sel(    116 )=  0   ;  %    116 ADU5-MRMS
sel(    117 )=  0   ;  %    117 ADU5-BRMS
sel(    118 )=  0   ;  %    118 ADU5-Flag

readchar=[1 2];
% Which values to read as character strings rather than double

headerstr='';
for strfrm=1:118
    headerstr=[headerstr '%s '];
end
en522header=textscan(fid,headerstr,1,'delimiter', ',');
% read the header

acount=1;
readstr=''; % initialize empty string
for strfrm=1:118
    if sel(strfrm)==1 % if variable is desired
        varcount(acount)=strfrm; % produce a mapping variable from original
        % layout to the new output (C).
        if sum(readchar==strfrm)
            readstr=[readstr '%s ']; % read as string
            varname{acount}=regexprep(cell2mat(en522header{strfrm}),'-','_');
            disp([num2str(acount,'%02.2d') ' = ' cell2mat(varname(acount))]);
            acount=acount+1;
        else
            readstr=[readstr '%s ']; % read as double
            varname{acount}=regexprep(cell2mat(en522header{strfrm}),'-','_');
            disp([num2str(acount,'%02.2d') ' = ' cell2mat(varname(acount))]);
            acount=acount+1;
        end

    elseif sel(strfrm)==0 % not active
        readstr=[readstr '%*s ']; % don't read as string
    else
        warning('en522:paramspec','invalid specification of variable')
```

```
    end
end

C = textscan(fid,readstr, 'delimiter', ',');
fclose(fid);

% rename variables.
%poolsize= matlabpool('size');
%if poolsize<1
%matlabpool('local');
%end
%clear poolsize
looplen=size(C,2);
for ii=1:looplen;
    if sum(readchar==varcount(ii))
        %Read these as chars as defined in readchar
        evalstr=[varname{ii} '=' 'cell2mat(C{ii});'];
    else
        % read these as double precision values
        evalstr=[varname{ii} '=' 'str2double(C{ii});'];
    end
    %disp(evalstr) % debugging: show what is being evaluated
    disp(['Now converting ' varname{ii} ' to double-precision']);
    eval(evalstr); % Evaluate the string to rename to the voriable name.
    %C{ii}=[]; % free ram at every iteration
end

T45=MicroTSG_Temperature; % Rename to more common names
S45=MicroTSG_Salinity;
C45=MicroTSG_Conductivity;

T21=Tsal_Temperature; % Same for the SBE21
S21=Tsal_Salinity;
C21=Tsal_Conductivity;
SST21=Tsal_SST;

TSGfail=[9.891e5:9.916e5 1e6:1.004e6 1.045e6:1.046e6];

T45(TSGfail)=NaN;
S21(TSGfail)=NaN;

T45(T45>35)=NaN;
T45(T45<0)=NaN;
S45(S45>40)=NaN;
S45(S45<31)=NaN;
C45(C45<2)=NaN;
C45(C45>7)=NaN;
T45(isnan(S45))=NaN;
C45(isnan(S45))=NaN;
S45(isnan(T45))=NaN;
C45(isnan(T45))=NaN;
T45(isnan(C45))=NaN;
S45(isnan(C45))=NaN;


T21(T21>35)=NaN;
T21(T21<0)=NaN;
S21(S21>40)=NaN;
S21(S21<31)=NaN;
C21(C21<2)=NaN;
C21(C21>7)=NaN;
T21(isnan(S21))=NaN;
C21(isnan(S21))=NaN;
S21(isnan(T21))=NaN;
C21(isnan(T21))=NaN;
T21(isnan(C21))=NaN;
S21(isnan(C21))=NaN;


EN522lat=GPS_NstarWaas_Latitude;
EN522lon=GPS_NstarWaas_Longitude;
```

```
EN522time=[Date Time];
EN522date=datenum(EN522time, 'mm/dd/yyyyHH:MM:SS');
%T45=str2double(EN522.textdata(2:e
nd,91);

%% 60 second intervals (b group)
T21b=binit(T21,60);
S21b=binit(S21,60);
C21b=binit(C21,60);
SST21b=binit(SST21,60);
T45b=binit(T45,60);
S45b=binit(S45,60);
C45b=binit(C45,60);
EN522dateb=binit(EN522date,60);
EN522lonb=binit(EN522lon,60);
EN522latb=binit(EN522lat,60);

%% 6-second intervals (group c)

T21c=binit(T21,6);
S21c=binit(S21,6);
C21c=binit(C21,6);
SST21c=binit(SST21,6);
T45c=binit(T45,6);
S45c=binit(S45,6);
C45c=binit(C45,6);
EN522datec=binit(EN522date,6);
EN522lonc=binit(EN522lon,6);
EN522latc=binit(EN522lat,6);
```

Figure 5: Temperature data through the cruise from the SBE-21 TSG and the SBE-45 MicroTSG. Strong diurnal warming events are evident on March 26 and April 10

3.) Results

The TSG recorded considerable temperature and salinity variance in the study area. The SBE-21 has a much shorter response time and a significantly higher flow rate than the SBE-45 MicroTSG, allowing it to sample small-scale variability. However, the overall accuracy and noise floor of the SBE-45 is superior to that of the SBE-21. Temperature from both instruments over the course of the cruise is plotted in Figure 5. The corresponding Salinity is plotted in Figure 6. Enhanced variability is evident on the March 26 and April 10, which were characterized by the highest diurnal warming and the development of a stable boundary layer. It is likely that this variability is caused by surface water being entrained under the vessel due to the turbulence under the hull of the ship, thus causing surface water to reach the hull intake at 5m depth. In addition, the vessel exhibited a significant amount of heave, roll and pitch, due to the presence of long-wavelength swells originating

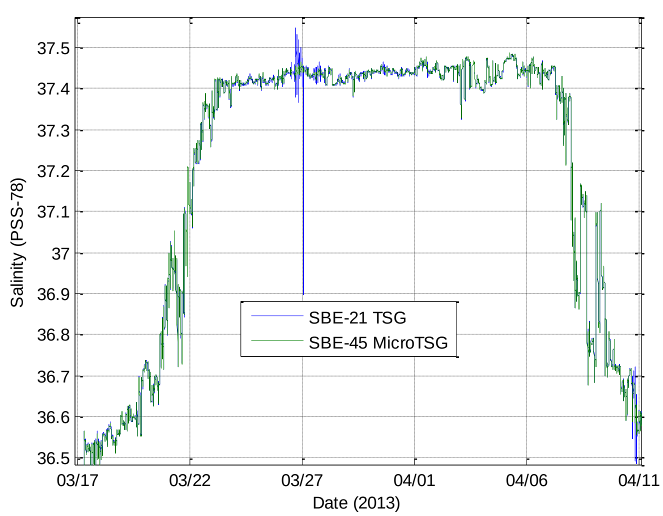


Figure 6: Salinity data from the SBE-21 TSG and SBE-45 MicroTSG. Strong variability, particularly in the SBE-21 is evident during days in which a strong stable boundary layer was observed.

from a storm system located to the North of the study site.

The calibration between bottle salts and the shipboard measurements of the SBE45 MicroTSG are shown in Figure 7. The equivalent match-up for the salinity snake is shown in Figure 8. It is evident that there is more variability in the salinity snake data. It is also clear that the calibration points during the two diurnal warming event days are higher than in the shipboard measurements, indicating enhanced surface salinities. The calibration of the SBE-21 shows readings that are approximately 0.01 high. This should be addressed in post-processing.

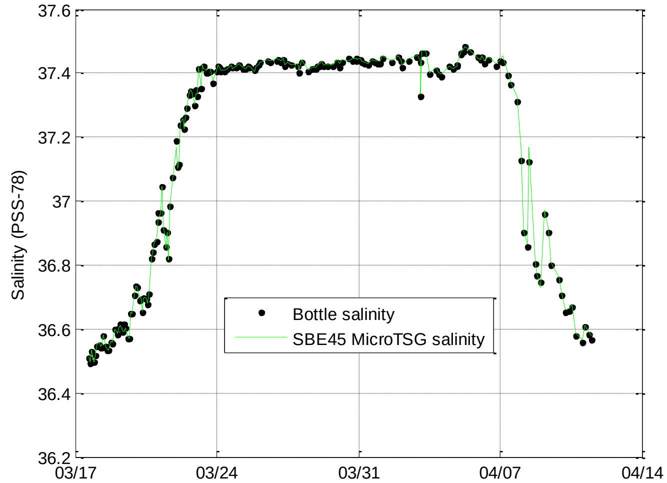


Figure 7: Salinity data from theSBE-45 MicroTSG (green line) along with bottle samples shown as black dots. A preliminary check indicates that the calibration of the instrument agrees well with the bottle samples.

To illustrate the diurnal warming event that occurred on March 26, the difference between the shipboard measurement using the SBE45 MicroTSG and the salinity snake's SBE45 MicroTSG are shown in Figure 9. It is clear that this enhancement occurs on multiple days, and a diurnal cycle is visible in the shipboard temperature record also (see Figure 5). However, a preliminary analysis indicates that the conditions required for a significant surface intensification in salinity require calmer conditions and a significant thermal stratification. The difference between shipboard salinity as measured by the vessel's SBE45 MicroTSG and the sea snake SBE45 MicroTSG reveal an enhancement of up to 0.1.

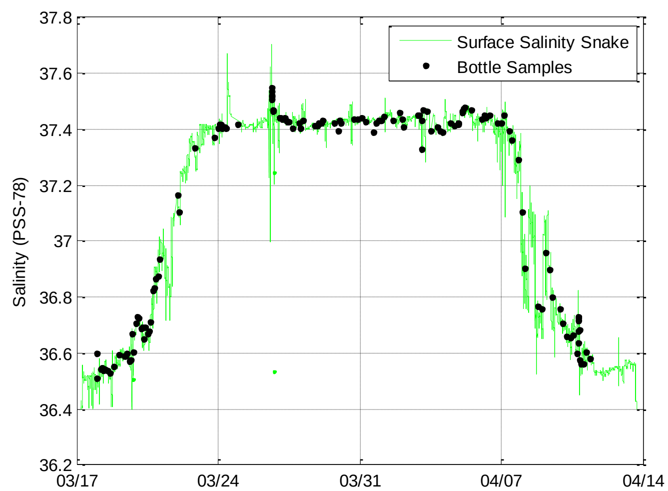


Figure 8: Salinity data from theSBE-45 MicroTSG (green line) along with bottle samples shown as black dots. A preliminary check indicates that the calibration of the instrument agrees well with the bottle samples.

4. Discussion and Conclusions

The deployment of the salinity snake and the temperature snake in addition to the ship-borne measurements allowed the observation of two events in which a significant stable boundary layer formed that lead to an intensification of both surface temperature and surface salinity, and hence a significant spice flux into the ocean (Schanze, 2012). From a preliminary analysis, it appears that very calm (less than 2 m/s) winds are necessary to produce such conditions. A preliminary analysis of the sea surface temperature data as obtained by the thermistor string in the sea surface temperature snake string by Alec Bogdanoff (abogdanoff@whoi.edu) shows enhancements similar to or exceeding those of the sea surface salinity snake.

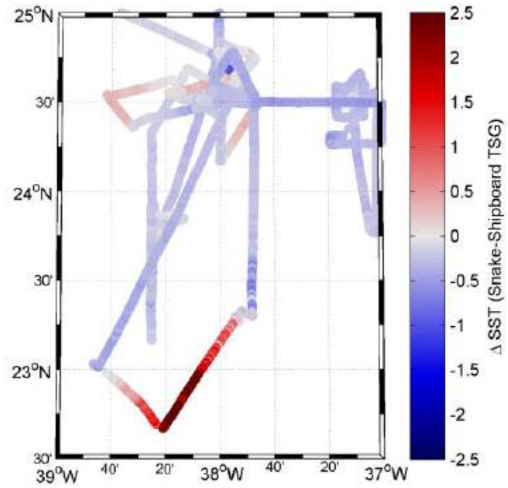


Figure 9: Temperature difference between sea surface salinity snake temperature and shipboard temperature, both using the SBE45 MicroTSG. The area of extreme enhancement exceeding 2°C is identical to that in which enhanced surface salinities were found

Reference

Schanze, J.J. (2012), The Production of Temperature and Salinity Variance and Covariance: Implications for Mixing, *Ph.D. Thesis, MIT-WHOI Joint Program in Physical Oceanography*, Woods Hole, MA.

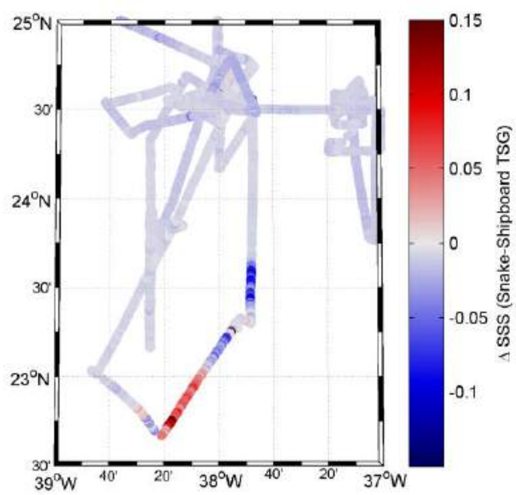


Figure 10: Difference between sea surface salinity snake and shipboard salinity measurements, both using an SBE45 MicroTSG. There is significant salinity enhancement evident in an area south of 23°N. It is clear from Figure 9 that this salinity enhancement only occurs in areas of strong surface thermal stratification.

Ship SBE 9/11+ CTD Operations – Chris Duncombe Rae

SPURS ship-based CTD operations were undertaken in a series of components as follows:

• Initial test casts were made to familiarize participants with the vessels CTD equipment and SOP for CTD operations, and to establish a sampling routine. On the first cast all 12 bottles on the rosette were tripped at 500 m, providing an initial check for salinity sampling and the salinometer analyses.

• Two full depth CTD casts were made near the site of the WHOI mooring, one at the beginning and one at the end of the cruise.

• A control volume was sampled where CTD casts to 1000 m were made to characterize the variability around the mooring sites.

• CTD stations were occupied in sections along 38W, 38 25W and 25 30N.

• A large-scale survey was conducted to characterize a surface low salinity feature to the east of the study area.

The *Endeavor*'s on-board Sea-Bird SBE 9/11 CTD and 12-bottle rosette sampler were used on the cruise. Twelve 10 L Niskin bottles were mounted on the rosette frame. On the test cast, the primary conductivity sensor failed and was replaced. The cast was repeated and the primary conductivity sensor remained unchanged thereafter. On Station 12, the secondary temperature sensor failed and was replaced. On Station 42 at about 1977 dbar pressure the data cable failed and the cast was aborted. Only downcast data to this pressure are considered reliable for this cast.

Underway CTD (UCTD) casts were made to 400 m on a section along 37 48W and between CTD casts around the control volume. UCTD casts to 200 and 250 m were made during the survey of the low salinity feature.

Data Processing

All ship CTD data were processed with the Seasoft software from Sea-Bird Electronics. The vessel's data collection system used Seasave Version 7.22.3. The CTD configuration, sensor serial numbers and calibration constants used during the cruise are tabled in the Appendix. Data processing was done using SBE Data Processing Version 7.21c. Files were created containing the complete 24 Hz data converted to ASCII and engineering units. The same processing scheme was used as on SPURS-1 (deployment cruise). Data were reduced to 1 m bins using the following sequence of modules from the SBE Data Processing suite:

1. datcnv: convert current and voltage values to engineering units. The first valid good data scan was identified and scans prior to this were excluded from further processing.

2. bottlesum: determine parameter values at bottle trip positions.

3. alignctd: compensate for the different positions of temperature, conductivity and oxygen sensors in the pumped flow through the TC duct, and differences in time constant of the sensors.

4. wildedit: remove extreme wild points.

5. celltm: compensate for conductivity cell thermal mass.

6. filter: filter spikes.

7. loopedit: remove pressure reversals.
8. derive: derive dependent variable oxygen.

9. binavg: average into 1 m depth bins.

10. derive: derive dependent variable salinity.

11. split: split into down and up casts.

File types, indicated by file extensions, produced during data collection were:

- .bl: Information about bottle trips
- .con: ASCII configuration files
- .hdr: Header file
- .hex: Raw binary data
- .nav: NMEA positions and times at mark events
- .xmlcon: Configuration information

Files types produced during data processing were:

- .btl: Final bottle data file
- .cdn: Final 1 m binned downcast
- .cnv: Final 1 m binned data, both up and down casts
- .cup: Final 1 m binned up cast

• .hdr: Header file

• .ros: Scan numbers during bottle trip events

• .xmlcon: Configuration information for the cast

CTD Sampling Protocol

The following abbreviated sampling protocol was observed on the cruise.

1. Bottles were cocked no more than 15 min prior to on-station.

2. Taps closed and caps open (top and bottom) were checked.

3. CTD powered on and logging started.

4. CTD deployed over the side.

5. CTD down to 10 m to ensure exclusion of air bubbles from the TC-duct, to wait for the pumps to turn on, and for the conductivity sensors to equilibrate to ocean temperature.

6. The CTD brought back to the surface, the winch wire-out meter zeroed and the cast proper begun.

7. Bottle depths were chosen generally at standard depths for the cruise. These were:
(a) Bottom of cast.
(b) Within surface mixed layer (50m).
(e) At about 200m intervals, generally at 1000, 800, 600, 400, 200 m.
(d) On the deep casts standard depths were nominally at 500 m intervals.

8. 45 to 60 s soak was allowed before bottle trips.

9. After the cast and the CTD out of the water, the data collection was terminated and power to the underwater unit turned off.

10. CTD was secured.

11. TC duct tubes attached and filled with deionized water.

12. Salt samples were taken.

CTD Calibration

Sensors on the CTD were freshly calibrated before the cruise, immediately prior to SPURS. Samples were taken from the rosette to check the calibration of the conductivity sensors. These samples were analyzed on a Guildline Salinometer 8400-B in the laboratory at sea (See Section ?). To monitor the sensors' response and drift during the cruise, the conductivity delta between the two sensors was observed. During the cruise the difference between the two sensors remained constant (see Figures). The difference between salinity determinations and sensor salinities was also monitored and found to remain constant during the cruise within the confidence interval. The secondary sensor was found to be closest to the salinometer salinity values (Figure 1) and thereafter the secondary channel was used to provide CTD data values. It should be noted that errors and differences in salinity determinations were within WOCE standards.

Figure 1: (Top) Difference between salinity from the primary and secondary conductivity channels of the CTD, plotted against station number. (Bottom) Difference between salinity from the primary conductivity channel and the salinometer, plotted against station number. In each case, the dashed lines indicate one standard deviation from the mean at each station. The dot-dashed line indicates the mean of all differences. The solid line is a regression line indicating the trend over all differences.

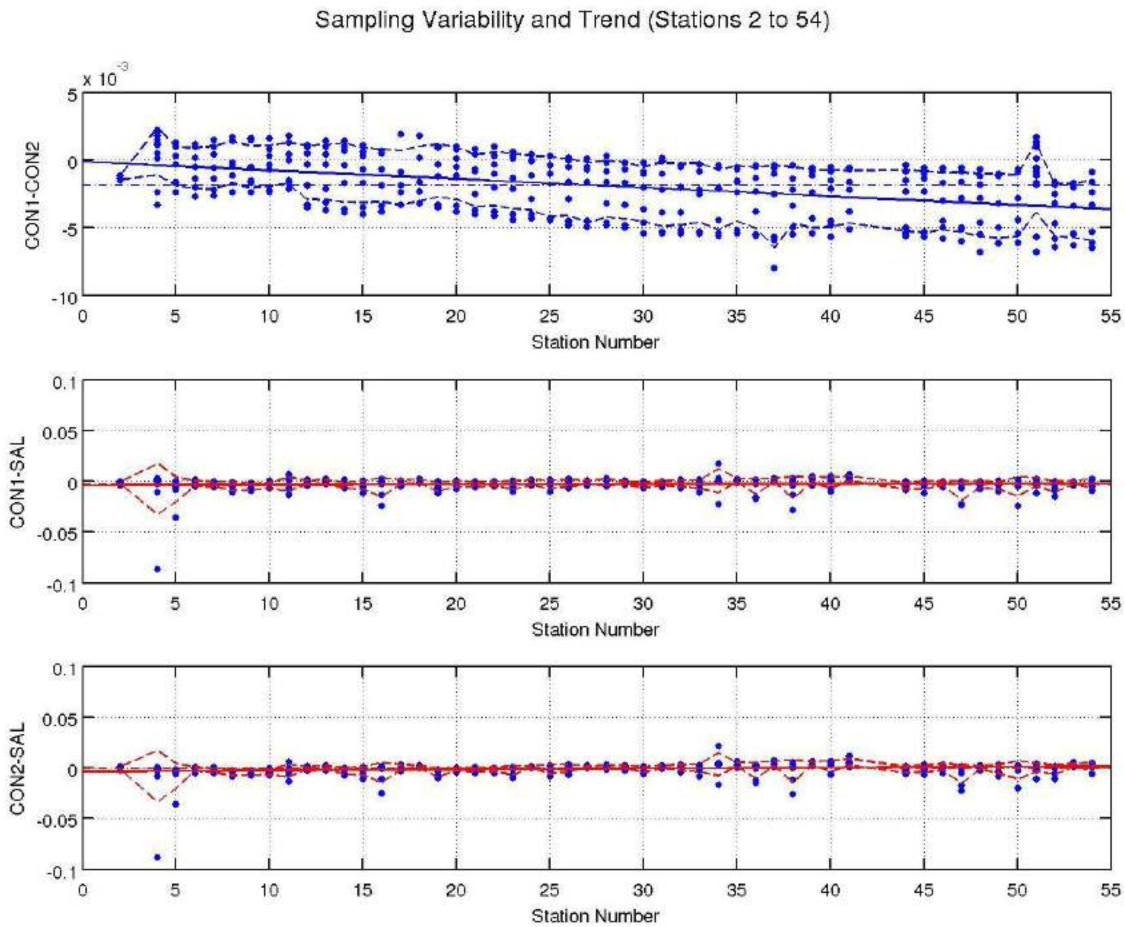


Figure 2: Variability indicated by box-and-whisker plots of the difference between salinity derived from the conductivity channels and the salinometer samples.

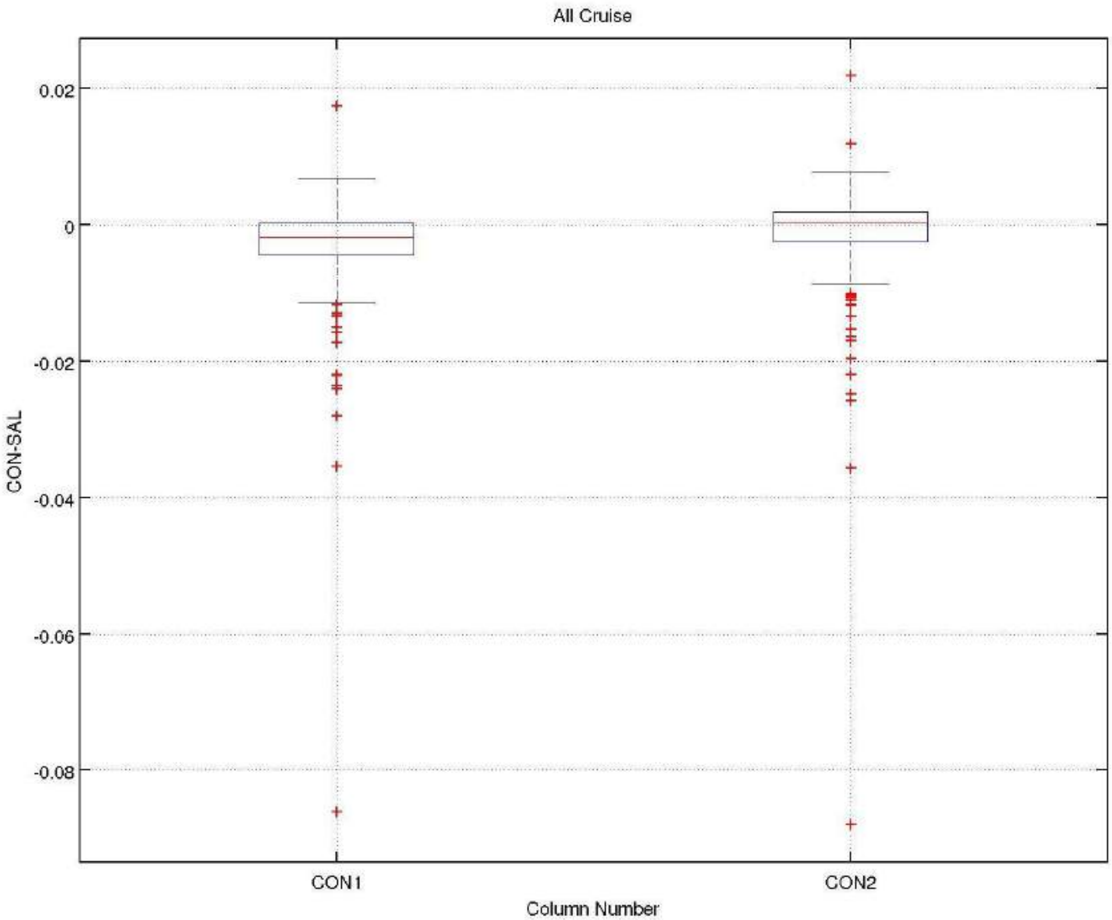


Figure 3: The regression between CTD salinity and salinometer values from Niskin samples
for primary and secondary sensors.

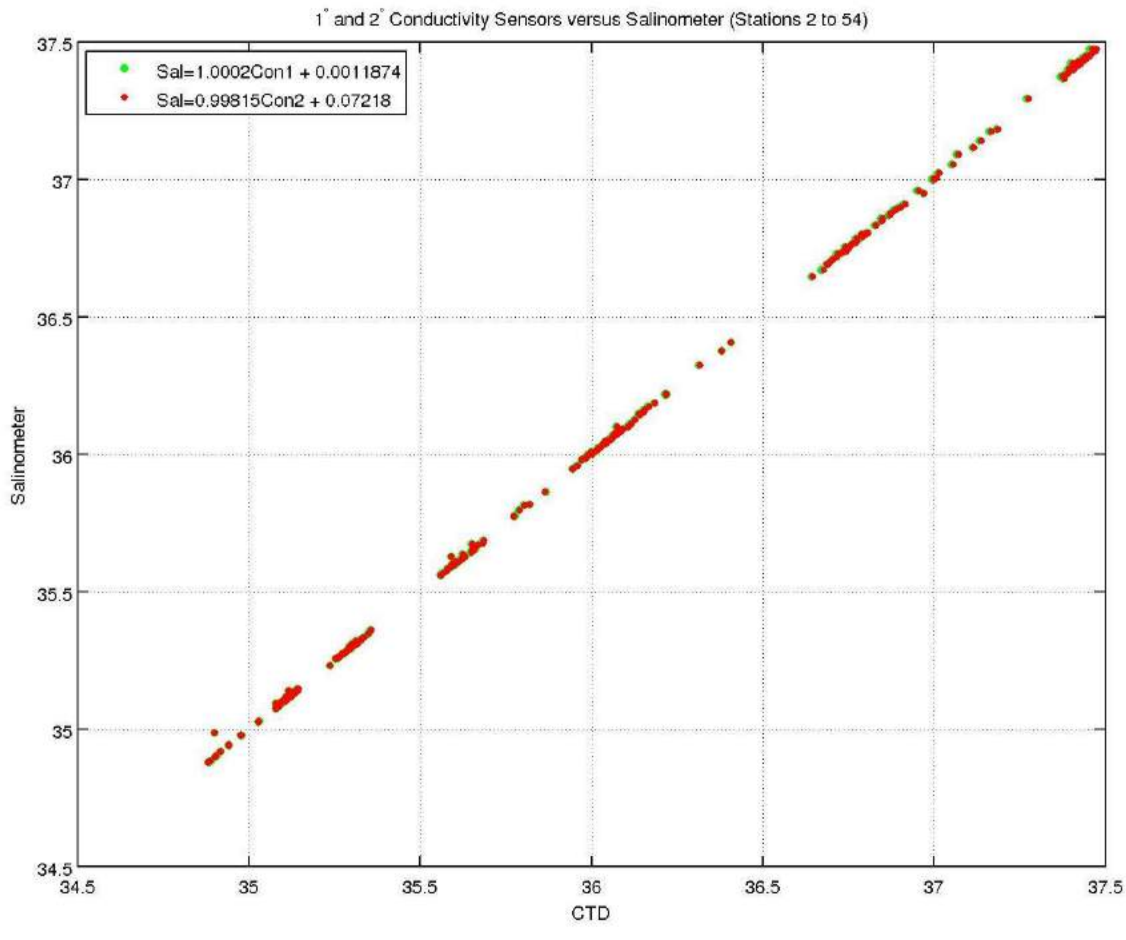


Figure 4: Difference between salinity from Niskin samples and secondary conductivity sensor
salinities plotted against Niskin bottle number.

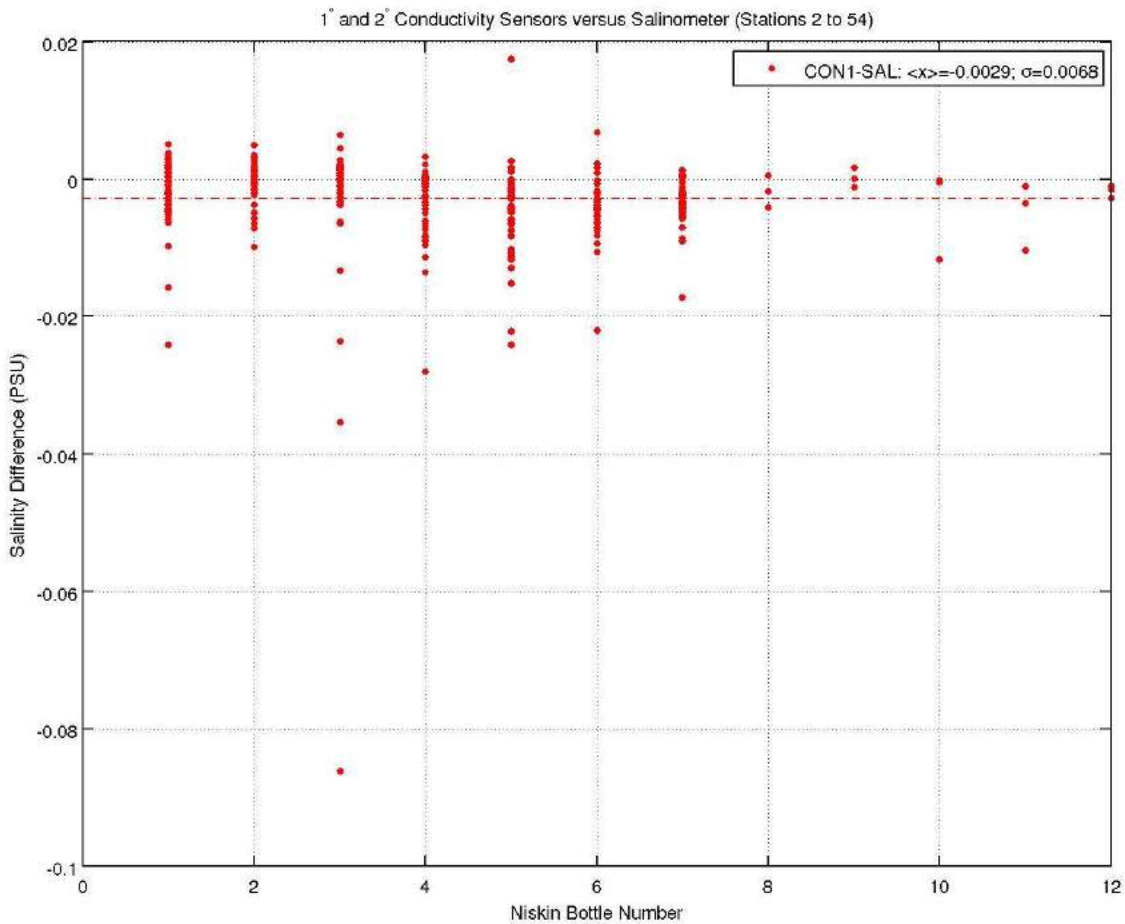
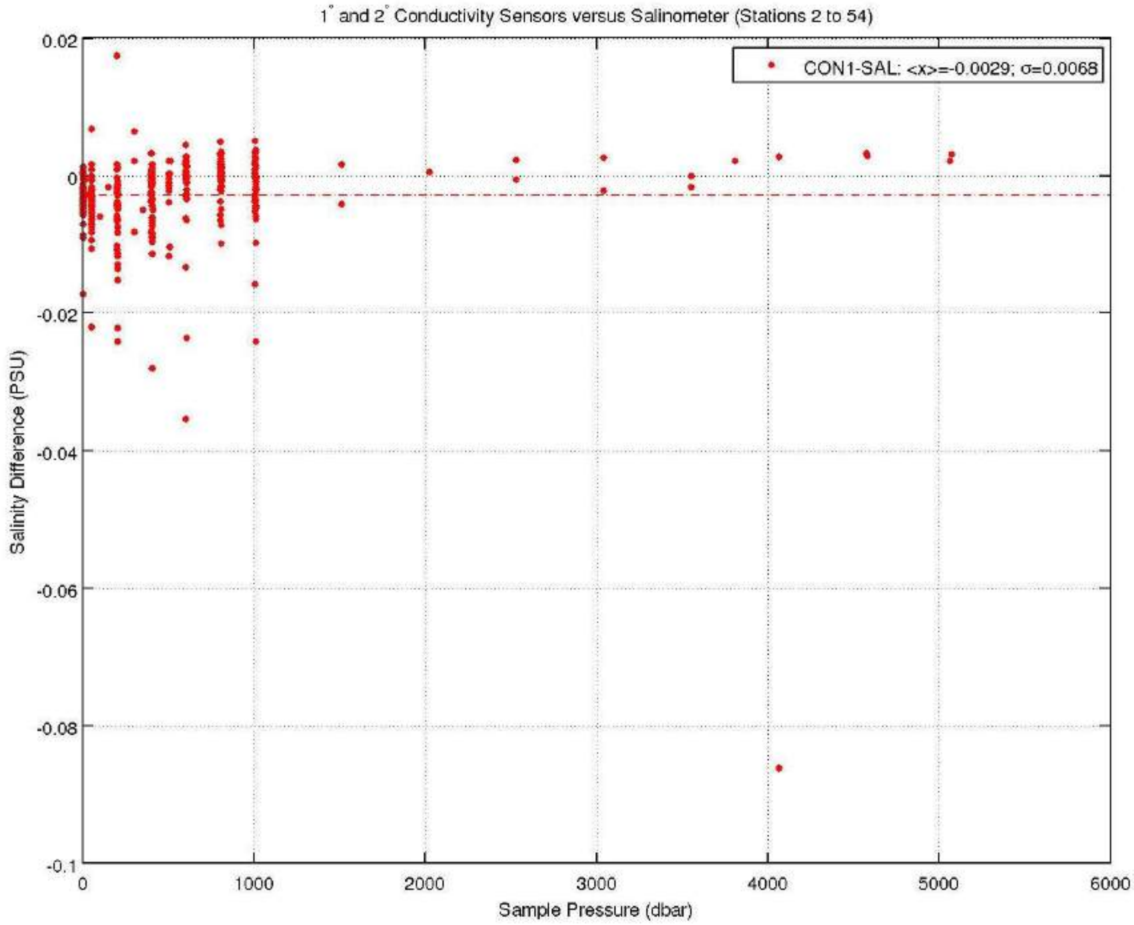


Figure 5: Difference between salinity from Niskin samples and secondary conductivity sensor salinities plotted against pressure.



CTD Stations

The CTD casts with times, positions, depths and samples are listed in a Table in the Appendix.

Stations 1 and 2 were test casts. All bottles were tripped at 500 m on Station 2 to provide a check for salinity sampling and the salinometer.

Station 3 was omitted from the numbering due to a software error. A full depth cast done on Station 4.

On Station 12, the secondary temperature sensor failed (SN 2902) and it was replaced by SN 2034. The cast was repeated without changing the station number.

Station 17 was done before Seaglider 190. Station 18 was done before Seaglider 191.

On Station 25 bottle lanyard were hooked on the wrong trigger pins and two bottle failed to close.

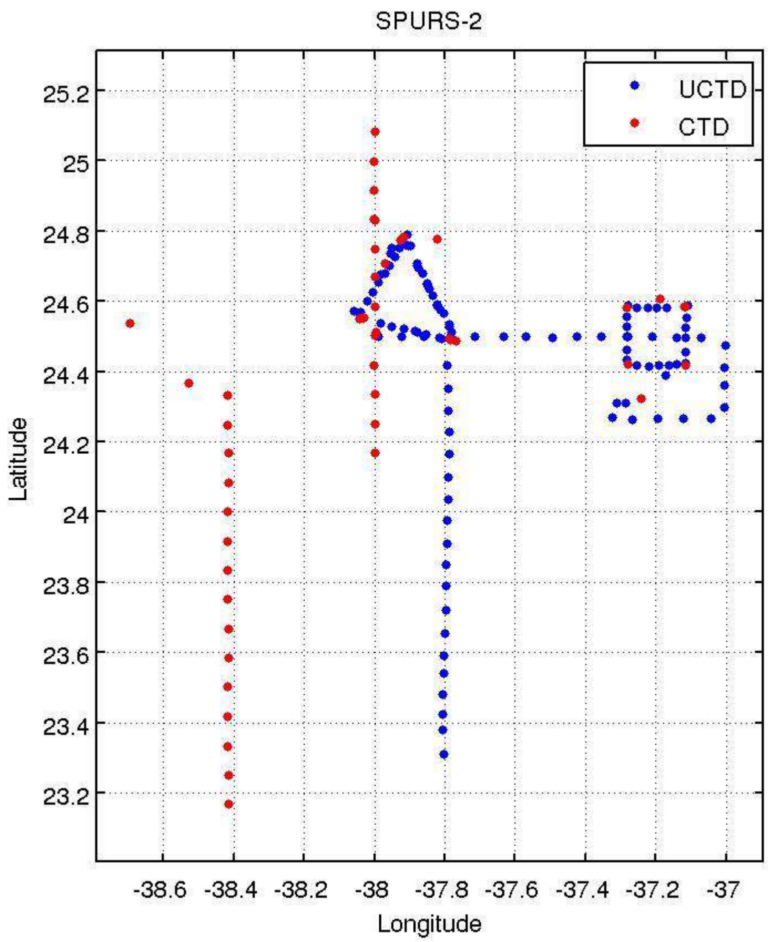
On Station 42 a faulty cable caused the pumps to turn off at 1976 m depth and the cast was aborted. The upcast data was collected as Station 43. The cable was replaced.

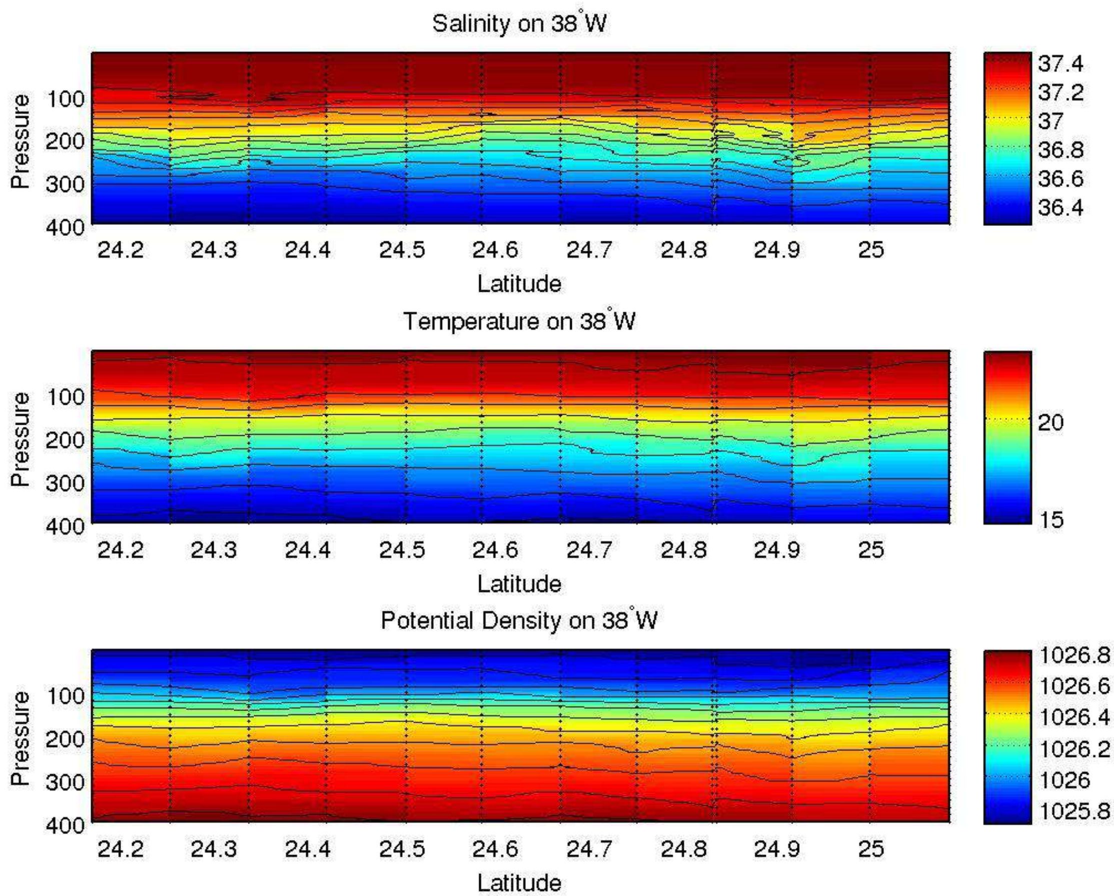
Station 51 was a full depth cast.

On the last station, Station 54, the trigger pin at position 5 (for tripping Niskin 3) was faulty and Niskin 3 was tripped from trigger position 6.

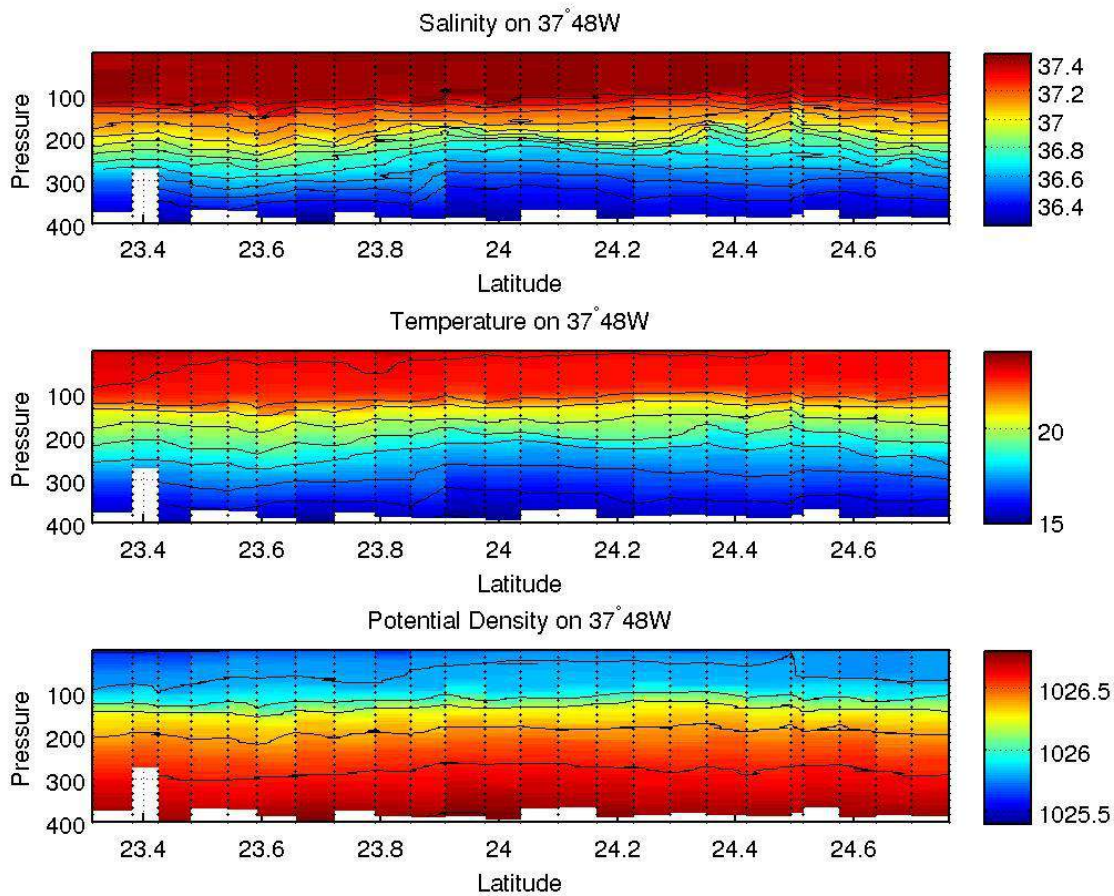
Data

Data from the UCTD and CTD casts taken on the sections are shown in the following figures.

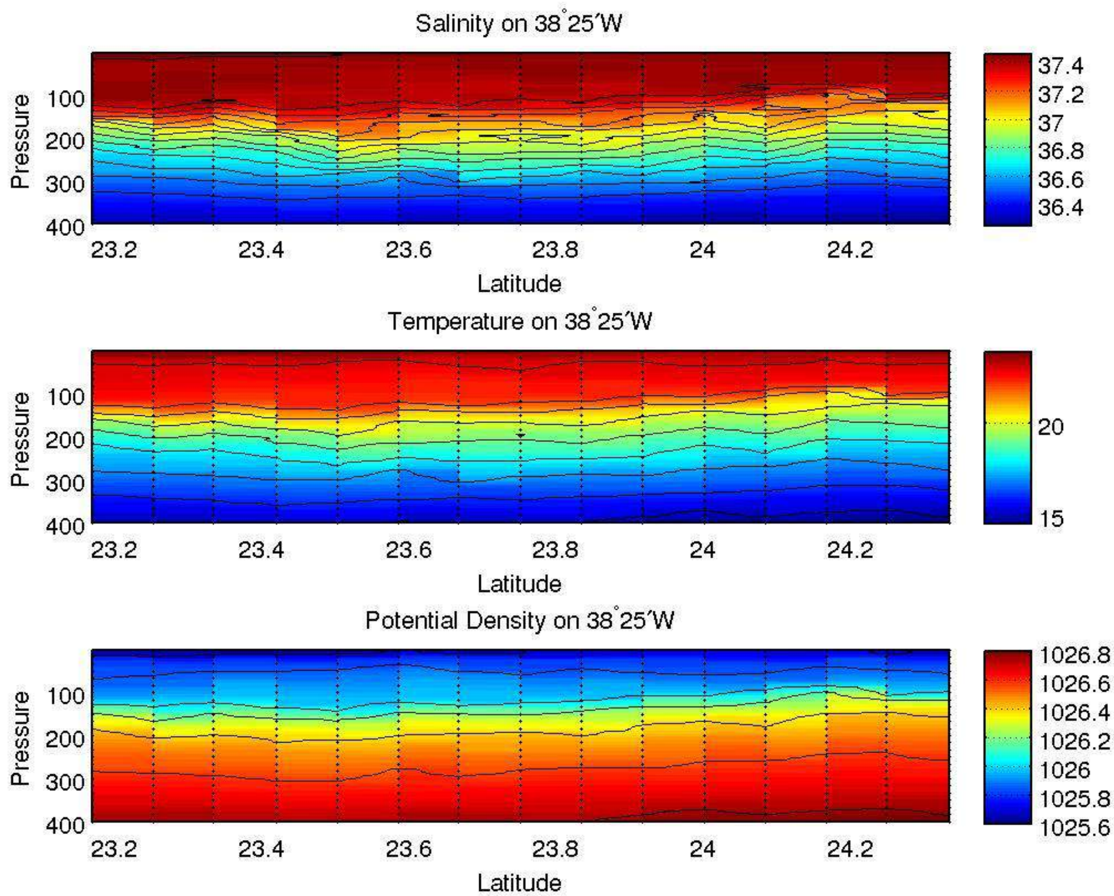




Salinity on 38°W
Pressure
100
200
300
400
24.2
24.3
24.4
24.5
24.6
24.7
24.8
24.9
25
Latitude
37.4
37.2
37
36.8
36.6
36.4
Temperature on 38°W
Pressure
100
200
300
400
24.2
24.3
24.4
24.5
24.6
24.7
24.8
24.9
25
Latitude
20
15
Potential Density on 38°W
Pressure
100
200
300
400
24.2
24.3
24.4
24.5
24.6
24.7
24.8
24.9
25
Latitude
1026.8
1026.6
1026.4
1026.2
1026
1025.8



Salinity on 37°48W
Pressure
100
200
300
400
23.4
23.6
23.8
24
24.2
24.4
24.6
Latitude
37.4
37.2
37
36.8
36.6
36.4
Temperature on 37°48W
Pressure
100
200
300
400
23.4
23.6
23.8
24
24.2
24.4
24.6
Latitude
20
15
Potential Density on 37°48W
Pressure
100
200
300
400
23.4
23.6
23.8
24
24.2
24.4
24.6
Latitude
1026.5
1026
1025.5



Salinity on 38°25′W
Pressure
Latitude
Temperature on 38°25′W
Pressure
Latitude
Potential Density on 38°25′W
Pressure
Latitude

Date: 04/14/2013

Instrument configuration file: C: Documents and Settings Chris Duncombe Rae Desktop EN522_001.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 : Yes
NMEA depth data added : No
NMEA time added : No
NMEA device connected to : deck unit
Surface PAR voltage added : Yes
Scan time added : No

1) Frequency 0, Temperature

Serial number : 4695
Calibrated on : 28-Feb-13
G : 4.39687326e-003
H : 6.43667692e-004
I : 2.15480263e-005
J : 1.76777103e-006
F0 : 1000.000
Slope : 1.00000000
Offset : 0.0000

2) Frequency 1, Conductivity

Serial number : 1446
Calibrated on : 16-Jan-13
G : -4.07373492e+000
H : 5.40141309e-001
I : 2.28357730e-004
J : 1.49667048e-005
CTcor : 3.2500e-006
CPcor : -9.57000000e-008
Slope : 1.00000000
Offset : 0.00000

3) Frequency 2, Pressure, Digiquartz with TC

Serial number : 0444
Calibrated on : 30-Mar-12
C1 : -5.378517e+004
C2 : -3.498580e-001
C3 : 1.648580e-002
D1 : 4.036100e-002
D2 : 0.000000e+000
T1 : 2.984744e+001

T2 : -3.538190e-004
T3 : 3.972770e-006
T4 : 2.922330e-009
T5 : 0.000000e+000
Slope : 0.99984127
Offset : -0.61477
AD590M : 1.125800e-002
AD590B : -8.763490e+000

4) Frequency 3, Temperature, 2

Serial number : 2902
Calibrated on : 08-Feb-13
G : 4.34457775e-003
H : 6.44485080e-004
I : 2.27013645e-005
J : 2.07625791e-006
F0 : 1000.000
Slope : 1.00000000
Offset : 0.0000

4) Frequency 3, Temperature, 2

Serial number : 2034
Calibrated on : 16-Jan-13
G : 4.38894736e-003
H : 6.44370331e-004
I : 2.23966927e-005
J : 1.95995465e-006
F0 : 1000.000
Slope : 1.00000000
Offset : 0.0000

5) Frequency 4, Conductivity, 2

Serial number : 3220
Calibrated on : 16-Jan-13
G : -1.03772289e+001
H : 1.42644641e+000
I : 2.30262514e-004
J : 5.28842599e-005
CTcor : 3.2500e-006
CPcor : -9.57000000e-008
Slope : 1.00000000
Offset : 0.00000

6) A/D voltage 0, Free

7) A/D voltage 1, Free

8) A/D voltage 2, Altimeter

Serial number : 1075
Calibrated on : 17-Aug-12deck
Scale factor : 14.780
Offset : 0.000

9) A/D voltage 3, Free

10) A/D voltage 4, Oxygen, SBE 43

Serial number : 0345
Calibrated on : 16-Feb-13
Equation : Sea-Bird
Soc : 5.34790e-001
Offset : -5.01200e-001
A : -2.82940e-003
B : 1.17460e-004
C : -2.07110e-006
E : 3.60000e-002
Tau20 : 1.46000e+000
D1 : 1.92634e-004
D2 : -4.64803e-002
H1 : -3.30000e-002
H2 : 5.00000e+003
H3 : 1.45000e+003

11) A/D voltage 5, Oxygen, SBE 43, 2

Serial number : 1648
Calibrated on : 16-Jan-13
Equation : Sea-Bird
Soc : 5.83510e-001
Offset : -5.00900e-001
A : -2.73970e-003
B : 9.84410e-005
C : -2.21180e-006
E : 3.60000e-002
Tau20 : 1.65000e+000
D1 : 1.92634e-004
D2 : -4.64803e-002
H1 : -3.30000e-002
H2 : 5.00000e+003
H3 : 1.45000e+003

12) A/D voltage 6, Free

13) A/D voltage 7, Free

14) SPAR voltage, Unavailable

15) SPAR voltage, SPAR/Surface Irradiance

Serial number : 20121
Calibrated on : 13-Apr-12
Conversion factor : 1640.98000000
Ratio multiplier : 1.00000000

Scan length : 40

Pump Control
This setting is only applicable to a custom build of the SBE 9plus.

Enable pump on / pump off commands: NO

Data Acquisition:
Archive data: YES
Delay archiving: NO
Data archive: <none selected>
Timeout (seconds) at startup: 60
Timeout (seconds) between scans: 10

Instrument port configuration:
Port = COM1
Baud rate = 9600
Parity = N
Data bits = 8
Stop bits = 1

Water Sampler Data:
Water Sampler Type: None

Header information:
Header Choice = Prompt for Header Information
prompt 0 = Ship:
prompt 1 = Station:
prompt 2 = Operator:

TCP/IP - port numbers:
Data acquisition:
Data port: 49163
Status port: 49165
Command port: 49164
Remote bottle firing:
Command port: 49167
Status port: 49168
Remote data publishing:
Converted data port: 49161
Raw data port: 49160

Miscellaneous data for calculations
Depth and Average Sound Velocity
Latitude when NMEA is not available: 0.00000000
Average Sound Velocity
Minimum pressure [db]: 20.00000000
Minimum salinity [psu]: 20.00000000
Pressure window size [db]: 20.00000000
Time window size [s]: 60.00000000
Descent and Acceleration
Window size [s]: 2.00000000
Plume Anomaly
Theta-B: 0.00000000
Salinity-B 0.00000000
Theta-Z / Salinity-Z 0.00000000
Reference pressure [db] 0.00000000
Oxygen
Window size [s]: 2.00000000
Apply hysteresis correction: 1
Apply Tau correction: 1

Potential Temperature Anomaly
A0: 0.00000000
A1: 0.00000000
A1 Multiplier: Salinity

Serial Data Output:
Output data to serial port: NO

Mark Variables:
Variables:

Digits	Variable Name [units]
0	Scan Count
4	Depth [salt water, m]
7	Conductivity [S/m]
5	Salinity, Practical [PSU]

Shared File Output:
Output data to shared file: NO

TCP/IP Output:
Raw data:
Output raw data to socket: NO
XML wrapper and settings: NO
Seconds between raw data updates: 0.00000000
Converted data:
Output converted data to socket: NO
XML format: NO

SBE 11plus Deck Unit Alarms
Enable minimum pressure alarm: NO
Enable maximum pressure alarm: NO
Enable altimeter alarm: NO

SBE 14 Remote Display
Enable SBE 14 Remote Display: NO

PC Alarms
Enable minimum pressure alarm: NO
Enable maximum pressure alarm: NO
Enable altimeter alarm: NO
Enable bottom contact alarm: NO
Alarm uses PC sound card.

Options:
Prompt to save program setup changes: YES
Automatically save program setup changes on exit: NO
Confirm instrument configuration change: YES
Confirm display setup changes: YES
Confirm output file overwrite: YES
Check scan length: NO
Compare serial numbers: NO
Maximized plot may cover Seasave: NO

Table 1: All CTD stations occupied on SPURS-2 cruise

	Start Date Time	Start Lat	Start Long	End Date Time	End Lat	End Long	Bathy Depth	Duration	Cast Depth
1	Mar 18 2013 14:54:17	33.90642	-62.1427	Mar 18 2013 15:21:29	33.91242	-62.1493	4755	28	502
2	Mar 23 2013 15:19:55	24.93483	-39.0897	Mar 23 2013 15:19:55	24.93483	-39.0897	4371	196	4984
3	Mar 23 2013 21:23:52	24.55267	-38.0327	Mar 23 2013 21:23:52	24.55267	-38.0327	160	49	1001
4	Mar 24 2013 23:18:37	24.5135	-37.994	Mar 24 2013 23:18:37	24.5135	-37.994	5567	48	1001
5	Mar 25 2013 02:02:00	24.77883	-37.919	Mar 25 2013 02:02:00	24.77883	-37.919	5848	51	1002
6	Mar 25 2013 04:50:51	24.49182	-37.788	Mar 25 2013 05:12:27	24.49157	-37.7878	5587	49	1001
7	Mar 27 2013 22:26:47	24.55	-38.0417	Mar 27 2013 22:26:47	24.55	-38.0417	5158	49	1001
8	Mar 28 2013 01:23:58	24.77333	-37.9257	Mar 28 2013 01:23:58	24.77333	-37.9257	5596	51	1000
9	Mar 28 2013 04:56:37	24.49082	-37.7862	Mar 28 2013 05:44:38	24.48977	-37.797	5650	34	501
10	Mar 28 2013 20:42:26	24.77617	-37.8227	Mar 28 2013 20:42:26	24.77617	-37.8227	4741	49	1001
11	Mar 28 2013 23:30:54	24.83017	-37.9992	Mar 28 2013 23:30:54	24.83017	-37.9992	5374	48	1001
12	Mar 18 2013 14:54:17	33.90642	-62.1427	Mar 29 2013 01:06:46	24.749	-37.999	5079	50	1001
13	Mar 29 2013 02:36:40	24.66858	-37.9989	Mar 29 2013 03:27:04	24.6664	-37.9934	5448	49	1004
14	Mar 29 2013 04:06:02	24.5842	-37.9994	Mar 29 2013 04:56:18	24.5803	-37.9953	5393	53	1002
15	Mar 29 2013 05:33:09	24.5033	-37.9984	Mar 29 2013 06:26:41	24.49628	-37.992	5665	31	504
16	Mar 29 2013 10:23:15	24.3678	-38.5284	Mar 29 2013 10:55:12	24.36387	-38.5327	5389	31	514
17	Mar 29 2013 14:31:46	24.53673	-38.6969	Mar 29 2013 15:00:30	24.5418	-38.6987	4897	52	1001
18	Mar 30 2013 03:50:33	24.41882	-38.0018	Mar 30 2013 04:42:50	24.41932	-37.9885	5838	53	1001
19	Mar 30 2013 06:01:59	24.33647	-37.9979	Mar 30 2013 06:54:09	24.33748	-37.9909	5929	52	1001
20	Mar 30 2013 07:49:25	24.25213	-37.9995	Mar 30 2013 08:41:31	24.2528	-37.993	5771	51	1001
21	Mar 30 2013 09:45:51	24.1692	-37.9998	Mar 30 2013 10:36:29	24.16878	-37.9931	5697	49	1001
22	Mar 30 2013 23:07:54	24.3341	-38.4172	Mar 30 2013 23:57:11	24.33307	-38.4209	5059	50	1000
23	Mar 31 2013 00:37:22	24.2486	-38.417	Mar 31 2013 01:27:05	24.2473	-38.4162	5370	51	1001
24	Mar 31 2013 02:03:27	24.16758	-38.4161	Mar 31 2013 02:54:31	24.1603	-38.4203	5554	49	1001
25	Mar 31 2013 03:30:48	24.08492	-38.4162	Mar 31 2013 04:20:32	24.0803	-38.4181	5643	48	1002
26	Mar 31 2013 04:57:10	24.00218	-38.4165	Mar 31 2013 05:45:16	23.9962	-38.4186	5745	50	1002
27	Mar 31 2013 06:23:45	23.91733	-38.4169	Mar 31 2013 07:13:56	23.91233	-38.4211	5781	49	1001
28	Mar 31 2013 07:57:12	23.83472	-38.4178	Mar 31 2013 08:46:07	23.82857	-38.4208	5597	48	1001
29	Mar 31 2013 23:20:12	23.7521	-38.4184	Apr 01 2013 00:08:54	23.74783	-38.4203	5768	48	1001
30	Apr 01 2013 01:10:22	23.66538	-38.417	Apr 01 2013 01:37:12	23.66243	-38.42	5893	49	1001
31	Apr 01 2013 02:12:19	23.58602	-38.4158	Apr 01 2013 03:01:06	23.59108	-38.4151	5756	50	1002
32	Apr 01 2013 03:45:12	23.5026	-38.418	Apr 01 2013 04:34:36	23.5077	-38.4249	5072	49	1001
33	Apr 01 2013 05:16:28	23.41928	-38.417	Apr 01 2013 06:05:54	23.42333	-38.4237	5180	48	1001
34	Apr 01 2013 06:55:55	23.33323	-38.4179	Apr 01 2013 07:44:46	23.33147	-38.4252	5413	49	1000
35	Apr 01 2013 08:27:36	23.25232	-38.4144	Apr 01 2013 09:16:37	23.25132	-38.4199	5360	49	1002
36	Apr 01 2013 09:58:14	23.16883	-38.4152	Apr 01 2013 10:46:42	23.16602	-38.4187	5640	47	1001
37	Apr 02 2013 01:48:29	24.83427	-38.0008	Apr 02 2013 02:35:36	24.84318	-38.0063	4927	48	1000
38	Apr 02 2013 03:10:25	24.91523	-38.0006	Apr 02 2013 03:58:29	24.92132	-38.0104	4766	47	1001
39	Apr 02 2013 04:35:31	24.99793	-38.0003	Apr 02 2013 05:23:13	25.00462	-38.0036	5182	49	1002
40	Apr 02 2013 06:07:12	25.0818	-37.9999	Apr 02 2013 06:56:09	25.07713	-38.0082	5195	38	1954

41	Apr 02 2013 15:44:03	24.709	-37.9711	Apr 02 2013 15:45:55	24.7097	-37.9713	4869	48	2170
42	Apr 02 2013 17:16:13	24.7301	-37.9761	Apr 02 2013 17:17:17	24.7304	-37.9762	NaN	48	1000
43	Apr 03 2013 12:30:34	24.32192	-37.2428	Apr 03 2013 13:18:44	24.33237	-37.2455	5237	49	1002
44	Apr 04 2013 02:51:19	24.58622	-37.1158	Apr 04 2013 03:40:26	24.5964	-37.1079	5594	50	1002
45	Apr 04 2013 05:20:27	24.4189	-37.1161	Apr 04 2013 06:10:40	24.42722	-37.1151	5527	48	1002
46	Apr 04 2013 07:42:14	24.42073	-37.2799	Apr 04 2013 08:29:14	24.42718	-37.2815	5103	48	1000
47	Apr 04 2013 09:55:16	24.5827	-37.2816	Apr 04 2013 10:42:50	24.58567	-37.2853	5350	48	1000
48	Apr 04 2013 12:11:36	24.58438	-37.1194	Apr 04 2013 12:59:50	24.59247	-37.1142	5344	50	1000
49	Apr 05 2013 15:03:23	24.6055	-37.1874	Apr 05 2013 15:53:28	24.61668	-37.176	5728	196	4973
50	Apr 05 2013 21:17:20	24.55363	-38.0304	Apr 06 2013 00:32:34	24.55973	-38.0431	5093	54	1003
51	Apr 06 2013 02:38:40	24.7821	-37.9156	Apr 06 2013 03:31:46	24.79163	-37.9093	5396	50	1005
52	Apr 06 2013 06:19:29	24.48602	-37.7678	Apr 06 2013 07:10:17	24.49502	-37.7621	5822	49	1001

Underway CTD – J Lord

An Oceanscience UCTD Underway Profiling Systems (or Underway CTD systems) was used during the cruise, with about 108 underway CTD casts being collected. Each UCTD system consists of a battery-powered, internally recording CTD with a tail spool, a tail-spool winder, and a winch (Figure X1). In "free cast" mode, a length of line is wound on the tail spool with the winder, and the probe is dropped over the stern while underway; the probe falls nearly vertically through the water as the tail spool unwinds and the winch, set to free spool, pays out line to compensate for the ship's forward motion. Winch # WI1031, rewinder # RW1005 and probes 70200027 and70200029 were used for this cruise. The probes had been freshly calibrated by SeaBird, and Oceanscience had just completed an extensive refurbish of the UCTD winch components.

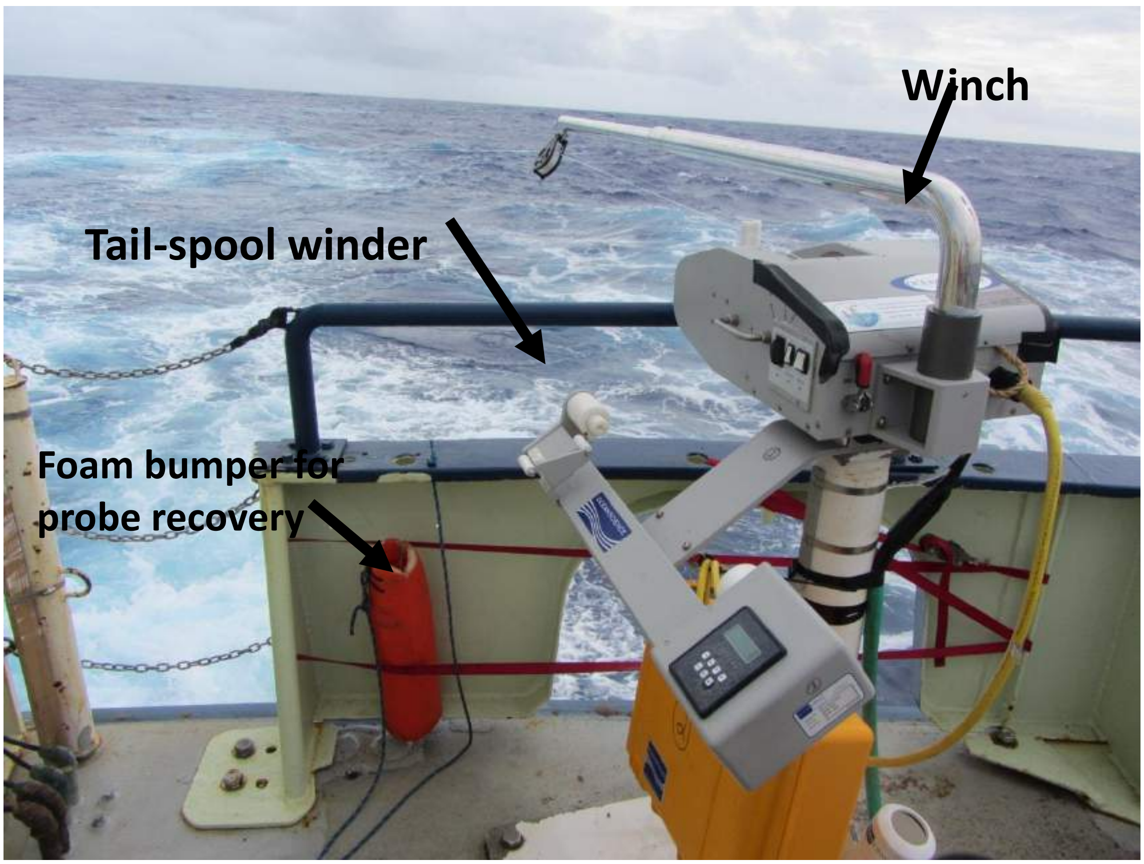


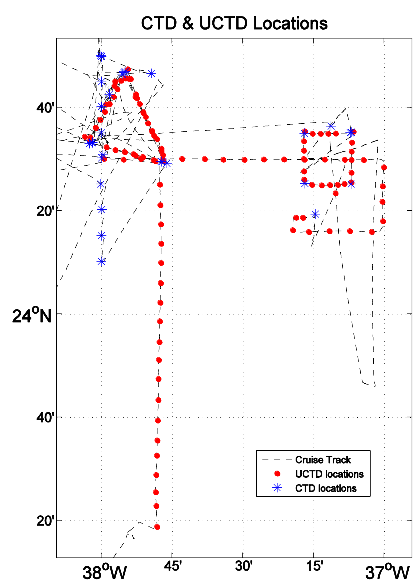
Figure 1: UCTD system as configured on stern of the RV Knorr (SPURS 1). The same configuration was used on R/V Endeavor (SPURS 2).

With 108 good casts taken, the UCTD systems saw less use compared to the SPURS 1 cruise in September 2012. The equipment operated flawlessly. However, one of the probes suffered a broken conductivity cell when it hit the ship early in the cruise.
An electronic log was kept, with an entry made each time the data were offloaded from the instrument. Each cast has a separate data file, and the header of these files is the authoritative record of the cast time. The header gives the time the instrument was turned on, and the time the cast actually starts is determined by counting the number of 16 Hz scans until the instrument pressure exceeds 1 dbar. The position of each cast can be

determined by matching this time with the 1-minute records of ship's GPS positions (from \\192.168.2.2\CurrentCruiseBackup\SCS\StdCruise*.elg files on the *Endeavor's* network). Instrument clocks were checked against the ship's GPS time periodically over the cruise, and no clock drift was detected.

Data format and processing: The data record for each cast is stored in an ascii (text) file and contains the pressure, temperature, and conductivity output by the instrument. The file names are based on the date, and approximate time; for example, file "092712_092910.asc" was collected on 27 September 2012, at approximately 09:29:10 UTC. The header of each file contains the time the instrument was turned on (i.e., when the magnet was removed), and the scan number stored in the file can be used to precisely determine the time the cast actually started. The data processing done so far has been only cursory; conductivity has been lagged by one scan (1/16 second) in an attempt to better align it with the slower temperature measurement for estimation of salinity from temperature and conductivity. From experience on the Knorr SPURS-1 cruise, this does a reasonably good job of reducing the salinity spiking that results from the mismatch of the temperature/conductivity time responses, this lag-alignment procedure may need to be revisited. The probes are designed to fall through the water at approximately 4 m/s, and the target depth for casts varied between 200 and 400 m (50-120 s fall time). There is some slight variation in the fall rate as the windings come off of the tail spool. Some casts were shallower than the target depth and some were deeper.

Data quality monitoring: Data quality was monitored continuously during UCTD operations, by comparing near-surface values of salinity from each cast to the shipboard thermosalinograph (TSG; 5-m intake) and comparing T-S profiles of nearly co-located UCTD and shipboard CTD casts. The TSG and shipboard CTD were regularly compared to water samples run on the salinometer, and they are more trustworthy than the UCTD. UCTD and CTD station positions are shown in the figure below.



STS/PAL APEX Floats
Jessica Anderson

During the SPURS R/V Endeavor cruise, 2 Argo-type profiling floats were recovered for Dr. Stephen Riser from the University of Washington. In addition to the primary SBE41 CTD, these floats were also equipped with Surface Temperature and Salinity (STS) and Passive Acoustic Listener (PAL) sensor packages. It is suspected that the thermistor in the STS sensor package on these floats, deployed during the Knorr cruise, may have a micro leak. They will be shipped back to Seattle for diagnosis. The table below indicates the date, location, and float ids of the recoveries:

Date	Float	Latitude	Longitude
03/31/2013 10:30	7600	23.850	-38.224
04/05/2013 09:30	7543	23.778	-37.070

Data Management Component
Ship: Jessica Anderson
Shore: Frederick Bingham, Peggy Li, Zhijin Li, and Quoc Vu

To help inform decisions about the daily science plan on the R/V Endeavor cruise, the shore based data management team (DMT) provided to the R/V Endeavor on a daily basis via ftp:

1) Daily image (Google earth .kml, .kmz) files of the previous day's data from all assets deployed in the SPURS study area (Seagliders, Wave Gliders, Argo floats, surface drifters, WHOI Mooring, PMEL moorings, etc.). Images of model output from ROMS (rerun daily with assimilated data) and HYCOM were also included. Additionally, satellite images for SST, SSS, SSH, and wind were provided when available.

2) Raw sea surface temperature and salinity data for all assets in the SPURS study area as well as TSG data from the Sarmiento in a .txt file.

3) ECMWF weather forecasts for the SPURS region including significant wave height, wave direction, sea level pressure, and winds.

4) Previous day raw data sets for assets in the SPURS region and satellite passes (Wave Gliders, Seagliders, SST, etc.).

5) ROMS model output for the study region for forecast times of 00Z, 24Z, and 48Z. Including, SST, SSS, salinity maximum depth, and currents.

Due to limited bandwidth on the R/V Knorr, these data sets were packaged into four different daily .tar files so that those products needed on a particular day could be downloaded individually. Transmitted data was used to track the location of assets for retrieval, construct daily maps of SSS and SST to identify locations of fresh lenses and fronts, and to plan the timing of science activities to correspond with favorable sea states.

The following data was transmitted back to shore from the R/V Endeavor on a daily basis for display on the SPURS data visualization page (http://spurs.jpl.nasa.gov) as well as integration into ROMS:

1) TSG data (hourly)
2) CTD data (downcast only)

All underway and CTD data collected during the R/V Endeavor cruise was also archived onboard for transfer to the shore DMT post cruise. Data collected from other assets was archived by the appropriate party for transfer to their PI post cruise. Table 1 below lists all data collected as part of the R/V Endeavor cruise and who to contact for access. All datasets listed are considered preliminary and should not be used for scientific publication nor shared with anyone outside of SPURS without the permission of the PI involved.

Table 1 A summary of the availability of different datasets. Note, please do not share data outside of SPURS investigators without the permission of the PI involved. Datasets are considered preliminary until finalized by the PI.

Dataset Name	**How do I get it?**
Knorr Underway including TSG and shipboard ADCP	Contact the DMT
Knorr CTD	Contact the DMT
Underway CTD	Contact the DMT or Tom Farrar
Wave Glider	Contact the DMT or Dave Fratantoni
Seaglider	Contact the DMT or Craig Lee
STS Floats	http://runt.ocean.washington.edu/argo/data/, www.coriolis.eu.org, or Steve Riser
Salinity Drifter	ftp://spurs.ucsd.edu/ (Username: spurs, Password: ftp4uspur)
VMP and T-gliders	Contact Louis St. Laurent
Sarmiento underway data	Contact the DMT
WHOI Mooring	http://uop.whoi.edu/projects/SPURS/spurs.html
Aquarius data	http://podaac.jpl.nasa.gov/
Mixed Layer Float (MLF)	Contact Andrey Scherbina
Model Results	Contact the DMT
Prawler Mooring Data	Contact Billy Kessler
Shipboard DCFS	Contact Jim Edson
Surface Salinity Snake	Contact Julian Schanze

The APL Mixed Layer Floats (MLF) and Seagliders (SG) - Ben Jokinen

On the 25th Of April the 2 Slocum gliders, SG 144 (Charlie Erickson's glider), SG122, and SG160 (Craig Lee's gliders) were deployed from the Endeavor at 24º 33.32N 37º 58.91W. Charlie noted that during deployment of SG144, an internal error occurred and the Seaglider rebooted itself. This error was not deemed critical enough for an immediate recovery and he determined dives would continue as planned. On the evening of the 25th the Endeavor began to steam to recover the delinquent APL MLF, UW Seaglider, and PMEL mooring which had drifted nearly 100nm south of the WHOI mooring site.

The ship arrived on station at first daylight the morning of the 26th and had SG189 in sight. Weather was ideal for recovery – light winds and slick calm seas. SG189 was recovered without incident via the RHIB at ~ 23º 00.787N -38º 39.15W. The MLF had gone delinquent because of steerage issues thought to be caused by improper ballasting or a fish population attaching to the float. Upon arrival at the MLF position, 22º 52.297N -38º 22.289W, an approach was made via the ship's RHIB. A school of 40-50 small fish were observed swimming around the float and after further investigation, it was determined the steerage issue may have been due to a damaged drogue - half of 1 of the 3 drogues was missing. The MLF was then towed back the Endeavor and safely recovered using the ship's crane.

During the steam back the WHOI site in the north, Charlie Erickson determined that SG144 needed to be recovered as soon as possible due to multiple reboots which had occurred at depth during a dive. SG144 was recovered without incident via the RHIB on March 27th at 24º 44.20N -37º 50.51W. The next afternoon, March 28th, SG120 (the spare Seaglider) was deployed as SG144's replacement at 24º 30.03N -38º 10.54W.

Before SG190 was recovered on March 29th at 24º 22.08N -38º 32.30W, she was sent on one last dive in order to do a CTD calibration cast in coordination with the Endeavor's CTD. The CTD cast was to 500m and SG190 dove to 300m. SG190 had not been flying properly for some time and the pilots at APL were very curious to see if she had been entangled in long-line fishing gear or Sargassum. Upon recovery via the RHIB, it was discovered SG190 was covered in a thick brown slime. After further investigation, this brown slime was determined to have been caused by a squid or octopus due to the tentacle marks that were present in the slime. There is a very high probability that the flight characteristics of SG190 had been affected by the squid or octopus attaching itself to the Seaglider.

Later in the afternoon of the 29th, SG191 was spotted and a CTD calibration dive was conducted to 100m (cast to 500m) due to time limitations. SG 191 was then recovered via the RHIB without incident at 24º 32.05N -38º 41.65W.

MLF2 was deployed without incident on April 2 at 22º 39.837N -38º 00.729W.

MLF1 with broken drogue.

SG190 Squid ink and imprints.