USCG Healy Hydrographic Systems Testing

Report of CTD, Autosal, TSG testing
Transit section Puerto Vallarta to Panama
24 June – 1 July 2003

1. Summary

The following sections describe the work and follow up tests that were performed on hydrographic equipment and data acquisition systems on USCGC Healy during transit leg between Puerto Vallarta and Panama. All work and tests were performed by SIO Shipboard Technical Support in conjunction with the shipboard MST group.

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In general, all hydrographic equipment on Healy was found to be in very good condition and well maintained. All CTD Sensors, thermosalinographs and autosals were recently calibrated at the appropriate facility. Spare parts kits for all equipment is well stocked. Lab areas were clean and well organized.

After the completion of work on July1, there are two fully operational CTD/Rosette systems. There is a third rosette that still needs a part of a frame in order to make it operational. Details and action items for all systems follow.

2. CTD EM cable and Slip Rings

Inspected CTD winch#1, slip rings and cable. During the first inspection, it was determined that approx 100 meters of cable from termination end has out of place strands. This part of the cable had to be cut off. It's probable that the cause of the out of place strands may be attributed at least in part by continuously running the cable through the five sheaves that route the cable from winch room and 'A' Frame. I marked the location where the good part of the cable begins. Prior to cutting the cable, tested CTD cable on winch #1 for continuity on each conductor end-to-end and tested for insulation breakdown on each conductor. The MST's later cut off 131 Meters of cable. Electrical testing of the cable showed good continuity of each of the three conductors throughout the length of the cable. End to end resistance of each conductor was about 320 ohms. This resistance agrees with the manufacturers specifications for resistance in this length of cable. Insulation breakdown of each conductor to the armor measured greater than 100 Mohms. Insulation breakdown of each conductor measured to each of the other two conductors measured greater than 100 Mohms. After the first CTD test cast, it was necessary to cut an additional 1000 Meters of cable. The total length of cable remaining on Winch #1 at the end of the transit cruise was approx. 9400 Meters.

Tested slip rings for continuity and insulation breakdown on each contact. Insulation breakdown measured between each contact to housing and between each contact to the other contacts.

USCGC Healy Slip Rings and test results 25 June 2003

MFG	Model	Serial	Location	Continuity	Breakdown
Meridian	MXO-6	1516	CTD Winch#1	Ok	Ok
Meridian	MXO-6	9190	Spare	Ok	Ok
Meridian	MXO-6	6583	Spare	Ok	Ok
Meridian	MXO-6	NSN	Spare	Ok	Ok
Meridian	MXO-6	6586	Trawl Winch	Not tested	Not Tested

Determined which were the best slip rings of the lot and replaced the original slip rings with the best set. Slip rings were found to be hardwired in place – no connector. After discussion with Chief MST it was decided to install connectors on the slip rings to allow easy replacement should that become necessary. Installed connectors on CTD Winch #1 and slip rings #1516. The Chief MST decided that he would install the same kind of connectors on the remaining slip rings at a later date.

Action items: 1.Install connectors on remaining slip rings.
2. Send in original CTD slip ring to manufacture for evaluation and testing.

3. CTD Systems

CTD acquisition computer was checked for proper setup of software and for the .CON file that is used by the software for each of the CTD configurations. Verified that the latest calibration information was entered for all sensors. I changed some settings in accordance with the CTD configuration.

There are three CTD/rosette systems on Healy. One of these systems was transferred from the Polarstar. The work performed and testing of each system is described below.

CTD/Rosette System#1   24 Place 12 Liter bottles   1 July 2003

Description	MFG	Model	Serial no.	Calibration Date
Carousel 24 Bottle Frame	**Seabird**	**SBE32**	**3224152-0348**	**N/a**
CTD	**Seabird**	**SBE9Plus**	**09P24152-0638**	
CTD Pressure	**Paroscientific**	**Digiquartz**	**83009**	**09-Jan-01**
Primary Temperature	**Seabird**	**SBE3Plus**	**03P2796**	**04-May-03**
Primary Conductivity	**Seabird**	**SBE4C**	**042545**	**15-May-03**
Secondary Temperature	**Seabird**	**SBE3Plus**	**03P2824**	**04-May-03**
Secondary Conductivity	**Seabird**	**SBE4C**	**042568**	**16-May-03**
Pump1	**Seabird**	**SBE5T**	**053112**	**N/a**
Pump2	**Seabird**	**SBE5T**	**053114**	**N/a**
Oxygen	**Seabird**	**SBE43**	**0430459**	**15-May-03**
Transmissometer	**Wetlabs**	**Cstar**	**CST-390DR**	**19-Dec-00**
Fluorometer	**Chelsea**	**AquaTrackaIII**	**088233**	**19-Mar-01**
Altimeter	**Benthos**	**916D**	**872**	**N/a**
Water Samplers 24 EA 12 Liters External springs	**OceanTest Equipment Inc.**	**110**	**N/a**	**N/a**

System #1 is the primary rosette system.

Disconnected and Inspected all underwater cables and bulkhead connectors. On CTD #638 discovered corrosion on several of the CTD bulkhead connectors and the mating cable assemblies. Cleaned corrosion off the connectors and determined that the connectors were not damaged to the point that they needed to be replaced. Every connector on the CTD, sensors and carousel was inspected, cleaned and properly lubricated.

Reconnected all cables. Connected test cable to deck unit. Powered up the CTD system and checked for proper operation. Tested CTD, transmissometer, fluorometer, altimeter and oxygen sensor for proper operation. Tested pumps for proper operation and verified that they turned on after at least one minute after salt water was inserted into conductivity cell.

Tested Seabird carousel for proper operation and actuated each bottle location to ensure that each latch released as it should.

Niskin bottles are all in good condition. They all are configured with external springs. Water tests performed on all 24 bottles. Bottles were filled. Testing involved opening the spigot while the vent remained closed. Tests indicated there are no leaky bottles.

CTD/Rosette System#2 24 Place 12 Liter bottles 1 July 2003

Description	MFG	Model	Serial no.	Calibration Date
Carousel 24 Bottle Frame	**Seabird**	**SBE32**	**3224152-0347**	**N/a**
CTD	**Seabird**	**SBE9Plus**	**09P24152-0639**	
CTD Pressure	**Paroscientific**	**Digiquartz**	**83012**	**09-Jan-01**
Primary Temperature	**Seabird**	**SBE3Plus**	**03P2841**	**04-May-03**
Primary Conductivity	**Seabird**	**SBE4C**	**042561**	**02-May-03**
Secondary Temperature	**Seabird**	**SBE3Plus**	**03P2945**	**01-May-03**
Secondary Conductivity	**Seabird**	**SBE4C**	**042575**	**02-May-03**
Pump1	**Seabird**	**SBE5T**	**053115**	**N/a**
Pump2	**Seabird**	**SBE5T**	**053116**	**N/a**
Oxygen	**Seabird**	**SBE43**	**0430458**	**21-May-03**
Transmissometer	**Wetlabs**	**Cstar**	**CST-436DR**	**30-Mar-01**
Fluorometer	**Chelsea**	**AquaTrackaIII**	**088234**	**19-Mar-01**
Altimeter	**Benthos**	**916D**	**843**	**N/a**
Water Sampler 24 EA 12 Liters External Springs	**OceanTest Equipment Inc.**	**110**	**N/a**	**N/a**

CTD System #2 was converted from a 12PL 30L system to a 24PL 12L system. The explanation is in the section that describes CTD system #3.

Disconnected and Inspected all underwater cables and bulkhead connectors. Every connector on the CTD, sensors and carousel was inspected, cleaned and properly lubricated.
Reconnected all cables. Connected test cable to deck unit. Powered up the CTD system and checked for proper operation. Tested CTD, transmissometer, fluorometer, altimeter and oxygen sensor for proper operation. Tested pumps for proper operation and verified that they turned on after at least one minute after salt water was inserted into conductivity cell.
Tested Seabird carousel for proper operation and actuated each bottle location to ensure that each latch released as it should.

Niskin bottles are all in good condition. They all are configured with external springs. Water tests performed on all 24 bottles. Bottles were filled. Testing involved opening the spigot while the vent remained closed. Tests indicated there are two leaky bottles.

CTD System #3

A Problem with rosette system #3 (the one from Polarstar) – a part of the rosette frame appears to be the wrong part. This means we cannot properly assemble the rosette. The frame part in question is the lower part of the frame where the carousel and bottle assembly is attached. The rosette frames are all Seabird models but it looks like the lower frame part may have been swapped with another similar looking (but wrong size) frame part from another rosette.

Due to the problem with rosette system #3 it was decided to convert rosette system #2 from a 12-bottle rosette to a 24-bottle rosette by transferring parts from rosette system #3 to rosette system#2. This gives us two complete 24-bottle rosette systems. The 3rd rosette cannot be used as is but it contains a CTD that is useable as a spare if necessary.

CTD system#3 1 July 2003

Description	MFG	Model	Serial no.	Calibration Date
Carousel	Seabird	SBE32	3210730-0116	N/a
CTD	Seabird	SBE9Plus	09P12377-0416	
CTD Pressure	Paroscientific	Digiquartz		
Primary Temperature	Seabird	SBE3Plus	03P2498	04-May-03
Primary Conductivity	Seabird	SBE4-02/0	041115	15-May-03
Secondary Temperature	Seabird	SBE3Plus	03P2015	04-May-03
Secondary Conductivity	Seabird	SBE4-02/0	041549	16-May-03
Pump1	Seabird	SBE5T	050759	N/a
Pump2	Seabird	SBE5T	051369	N/a

Disconnected and Inspected all underwater cables and bulkhead connectors. Every connector on the CTD, sensors and carousel was inspected, cleaned and properly lubricated.

Reconnected all cables. Connected test cable to deck unit. Powered up the CTD system and checked for proper operation. Tested CTD for proper operation. Tested pumps for proper operation and verified that they turned on after at least one minute after salt water was inserted into conductivity cell.

Tested Seabird carousel for proper operation and actuated each bottle location to ensure that each latch released as it should.

Gave training session to MST's to properly care for and maintain CTD connectors and cables.

Action items: 1. Obtain correct frame part in order to repair Rosette system #3

4. CTD Test Casts

CTD Test Cast #1 June 27, 2003
CTD/Rosette system#1

Prior to cast Inspected and prepared rosette for operation. CTD cast was scheduled for about 1300L but due to problems with the bow thruster it was delayed about 2 hours. Test cast started about 1500L. During the downcast the CTD system worked well. All CTD sensors ok. Fluorometer, transmissometer and Oxygen sensors ok. At approx 1000 Meters depth, stopped he winch and tripped 4 bottles. Started up upcast at 1330L. At about 1340L as the CTD was coming up at about 840 Meters the CTD wire jumped the one of the sheaves located in the upper part of the starboard staging bay. The wire jammed hard breaking all strands of the outer armor. The CTD was supported by the remaining strands of the inner armor. The Ship's crew was able to place a wire clamp to relieve tension while they unjammed the cable in the sheave. After cable free then put tension back on winch, removed clamp and slowly brought the rosette back up. After the bad spot was slowly wound around the winch, the winch was able to bring the CTD back aboard normally. After the CTD was safely aboard and secured. Approximately 1000 Meters of wire including the broken area was cut off and discarded.

The next day we Inspected the sheave where the wire jammed. After talking to the Chief MST it appeared a securing sheave pin that may have been engaged or partially engaged which would have prevented the sheave from moving freely as the wire angle shifted might have caused the problem. Chief MST has now instituted a procedure that ensures that the pin will always be accounted for and fully removed from the sheave prior to starting the winch.

CTD Test Cast #2 June 28, 2003
CTD/Rosette system#2

Prior to cast Inspected and prepared rosette for operation. In order to check to see how the CTD data responds we removed the grounding strap from the slip ring shaft on the winch. Started the cast. As the CTD descended the speed was slowly worked up to about 30MPM. There were no modula errors observed on the acquisition display. However as the winch sped up to about 40MPM modula errors started to appear and became excessive as the winch once the winch speed was faster than 40MPM. We stopped the winch, put the grounding strap back in place and recommenced the cast. This time as the winch speed approached 40MPM there were no modula errors. We picked up the winch speed to 60MPM. There were no further modula errors for the rest of the cast regardless of winch speed.

Deployed Rosette/CTD ok
CTD acquisition computer ok
CTD signal ok (after winch ground strap reattached)
All sensors ok
All instrumentation ok
All bottles tripped ok
Rosette/CTD safely recovered on deck
After cast on deck spot check revealed 2 leaky bottles. MST's noted the leaky bottles for later repair. Took salinity samples from all bottles.

CTD Test Cast #3 June 28, 2003
CTD/Rosette system#1

There was a problem with the ship's bow thruster prior to cast #2 so we proceeded with cast#2 without the use of the bow thruster. Prior to cast Inspected and prepared rosette for operation.

Deployed Rosette/CTD ok
CTD acquisition computer ok
CTD signal ok
All sensors ok
All instrumentation ok
All bottles tripped ok
Rosette/CTD safely recovered on deck
There were no leaky bottles using this rosette. Took salinity samples from all bottles.

Data from all test casts was put on disk and taken to SIO for later analysis.

5. Autosals

There are two autosals on Healy.

Description	MFG	Model	Serial no.	Cal Date
Autosal	Guildline	8400B	65-715	
Autosal (Frm Polarstar)	Guildline	8400B	65-743	28-May-03

We set up both autosals in BIO lab. I filled the tanks and let temperature stabilize.

Autosal #65-743
I noticed that this autosal would not temperature stabilize. After doing some checking I discovered that the rear panel fan was not working. I opened the rear panel and found that the rear motor was disconnected. I reconnected the motor and after a period of time the machine was able to stabilize.
After the machine stabilized , the following checks were performed.

1. Bath thermistor operation
2. Pump operation
3. Conductivity Zero and Gain
4. Sample water analysis and stability of conductivity ratio

Testing showed that the conductivity gain setting is somewhat off. It is off by about 3-4 units. The allowable tolerance is 0-1 units.

Autosal #65-715
The following checks were performed.

5. Bath thermistor operation
6. Pump operation
7. Conductivity Zero and Gain
8. Sample water analysis and stability of conductivity ratio

Autosal #65-715 seems to be the most stable of the two although both machines work ok. Running the same seawater samples on both autosal machines I can get about the same conductivity ratio values. Depending on the salinity of the sample, differences in conductivity readings can be as much as +/- 0.00003. This would equate to about +/- 0.0006 in salinity units. This small difference is probably due to the gain setting error on #65-743.

Attached ACI2000 Interfaces to each autosal. Checked out a Laptop from the Computer lab and hooked it into one of the autosal interfaces. After the ACI2000 software was loaded I tried to acquire data. I could receive the data string but the field that contains the conductivity ratio is always zero no matter what number the autosal displays. I connected the other ACI2000 interface and obtained the same result on both autosals.

I determined that the problem is in the autosals and not in the ACI2000 interface boxes. After some checking, found that a wrong integrated circuit was installed in the data output circuitry. The wrong IC was also installed in the other autosal AND … on the spare circuit card in the spares kit. I located a similar but not exact part on another circuit card in the spares kit and installed it in one of the autosals. I then tried the interface and everything worked ok. The data stream came out with all data fields.

The ACI2000 interface works ok on autosal #65-743 with the right IC. I transferred the IC to 65-715. It works for the most part but the datalog switch on 65-715 seems to be miswired as it doesn't function as it should. The result is erratic logging of the data when using the ACI2000 software on #65-715.

I installed the SIO autosal logging software on the laptop and it works ok on both autosals. The SIO software doesn't utilize the autosal datalog switch so it works well on 65-715. It also works with the ACI2000 interface. Both SIO and ACI2000 software is installed so the user can take their pick.

The part needed to fix the Autosal interface is Z311 located on the Meter PCB. It can be obtained at any electronics distributor.

Manufacturer Bourns part no. 4116R-2-102

Training on the operation and care of autosals was given to all MST's.
Topics included:

1. Preparing the autosal for use
2. Conducting operational checks prior to use
3. Operating the Autosal using the OSI ACI2000 logging software
4. Operating the Autosal using the SIO logging software
5. Autosal standardization
6. Running samples
7. End standard check
8. Procedures to be taken after using the autosal
9. Packing and storing the autosal

After the training all of the MST's participated in running the samples obtained from the CTD test casts. The autosal used to run the salinity samples was #65-715. Samples obtained from the underway system for checks on the thermosalinographs were also completed.

Action item: Procure correct parts to repair Autosal interfaces on both autosals and spare board.

6. Thermosalinograph

There are two thermosalinograph's(TSG). The forward thermosalinograph #1864 is located in the BIO lab. It is considered the primary thermosalinograph as it continuously monitors the uncontaminated seawater(UCW) line. The UCW first flows through a Vortex debubbler before going to the SBE21. The aft thermosalinograph #3107 is located in the aft steering compartment. This TSG is used only when an intake hose is deployed out the aft end of the ship. A pump then pumps the water through a Vortex debubber and TSG.

Description	MFG	Model	Serial no.	Cal Date
Thermosalinograph	**Seabird**	**SBE21**	**219266-1864**	**7-May-03**
Thermosalinograph	**Seabird**	**SBE21**	**2125795-3107**	**7-May-03**

Both TSG's are operational. The acquisition computer runs the Seabird Seasave software to acquire data. This computer then transmits the data to the central SCS acquisition system.

Comparisons of the Forward TSG to CTD casts #2 and #3 surface readings follows:

SBE21 #1864 vs. CTD Salinity Surface readings

Time	CTD Salinity	TSG Salinity	Difference	CTD Cast
2245Z 28 Jun	33.785	33.76	0.025	#2
0013Z 29 Jun	33.770	33.75	0.020	#3

SBE21 #1864 vs. CTD Temperature Surface readings

Time	CTD Temperature	TSG Temperature (Intake Sensor)	Difference	TSG Temp (Bio Lab)	CTD Cast
2245Z 28 Jun	28.277	28.273	0.004	28.582	#2
0013Z 29 Jun	28.240	28.230	0.010	28.544	#3

Several salinity check samples were taken. At the same time each sample was taken, the TSG data was noted. The salinity samples were then run on the autosal. Salinity values from the autosal results were compared to the TSG readings.

SBE21 #1864 29 June 03

Time	Autosal Salinity	TSG Salinity	Difference
1800L	32.987	32.975	0.012
1843L	32.894	32.885	0.009
1851L	32.883	32.865	0.018
1855L	32.758	32.750	0.011
0700L	32.300	32.279	0.021
0705L	32.284	32.260	0.024
0855L	32.179	32.139	0.040
0859L	32.183	32.159	0.024

SBE21 #3107 30 June 03

Time	Autosal Salinity	TSG Salinity	Difference
	30.905	30.93	-0.025
	30.898	30.921	-0.023
	32.893	30.916	-0.023
	30.889	30.914	-0.025

The manufacturers specifications for an SBE21 indicate it is accurate to about +/- 0.01 PSU. In comparison to both the CTD and Autosal check samples TSG #1864 seems to give salinity values that are about 0.020 PSU higher than they should be. The above results are an initial indication of the accuracy of the SBE21's. However, to get definitive accuracy it is necessary to take more salinity check samples in order to establish good results.

During the time that I took the check samples for the aft thermosalinograph it is noted that the pump was not working very well. Water flow rates were sporadic as the hose used to collect the water was probably popping above the surface allowing air into the system. The check samples should be retaken during times when a good pumping action can be achieved.

During high flow rates it is important to record the TSG values at the same time as the check sample is drawn. Just a few seconds delay can make a large difference in readings.

7. Oxygen Sensors

Description	MFG	Model	Serial no.	Cal Date	Operational Tests	Comments
Oxygen	Seabird	SBE43	0430459	15-May-03	Ok	System#1
Oxygen	Seabird	SBE43	0430458	21-May-03	Ok	System#2
Oxygen	Seabird	SBE43	430456	21-May-03	Not Tested	Spare
Oxygen	Seabird	SBE13	130583	22-May-03	Not Tested	Spare
Oxygen	Seabird	SBE13	130573	05-May-03	Not Tested	Spare

Testing of Oxygen sensors #458 and #459 was limited to operational tests to verify that the sensor does respond to varying degrees of oxygen. There was no Oxygen titrator available. Due to lack of time the spare Oxygen sensors were not tested. However, it is noted that they were all recently checked out and calibrated at Seabird Electronics Inc.

Oxygen sensors #458 and #459 were installed on the CTD during the test casts. They responded normally and the data plot appeared as a normal working oxygen sensor.

Oxygen sensors were cleaned in accordance with the manufacturers cleaning procedure.

8. Spare CTD Sensors

Several CTD spare sensors are onboard. Sensor types and calibration dates are as follows:

Description	MFG	Model	Serial no.	Cal Date
Temperature	Seabird	SBE03	031838	05-May-03
Temperature	Seabird	SBE03Plus	03p2855	05-May-03
Temperature	Seabird	SBE-03S	034063	05-May-03
Conductivity	Seabird	SBE-04C	042619	28-May-03

9. Bottle Data Report

The following bottle data reports provide an indication of how well the CTD sensors are working.

Bottle Data Report CTD Test Cast #2 using CTD System#2

Bottle	PrDM	T090C	T190C	T2-T190C	Sal00	Sal11	SecS-priS	Autosal	-Sal00	-Sal11
1	1006.7	4.6179	4.6180	0.0001	34.5682	34.5732	0.0050	34.5737	0.0053	-0.0005
2	1008.6	4.6100	4.6107	0.0006	34.5700	34.5748	0.0048	34.5738	0.0038	-0.0010
3	1007.1	4.6142	4.6155	0.0013	34.5686	34.5734	0.0048	34.5750	0.0064	0.0016
4	1008.0	4.6091	4.6113	0.0022	34.5696	34.5744	0.0048	34.5750	0.0054	0.0006
5	804.5	5.4779	5.4782	0.0003	34.5647	34.5696	0.0049	34.5703	0.0056	0.0007
6	804.3	5.4783	5.4785	0.0002	34.5648	34.5697	0.0050	34.5689	0.0041	-0.0008
7	804.2	5.4785	5.4787	0.0002	34.5648	34.5698	0.0050	34.5699	0.0051	0.0001
8	804.4	5.4782	5.4785	0.0003	34.5649	34.5699	0.0050	34.5707	0.0058	0.0008
9	603.1	6.8827	6.8831	0.0003	34.5797	34.5845	0.0048	34.5835	0.0038	-0.0010
10	603.4	6.8803	6.8807	0.0004	34.5796	34.5847	0.0052	34.5850	0.0054	0.0003
11	604.1	6.8750	6.8754	0.0004	34.5796	34.5846	0.0049			
12	603.1	6.8841	6.8827	-0.0015	34.5797	34.5847	0.0050	34.5823	0.0026	-0.0024
13	403.8	9.2774	9.2787	0.0013	34.6566	34.6618	0.0052	34.6567	0.0001	-0.0051
14	404.0	9.2766	9.2773	0.0006	34.6569	34.6620	0.0051	34.6573	0.0004	-0.0047
15	404.0	9.2778	9.2779	0.0001	34.6571	34.6621	0.0050	34.6582	0.0001	-0.0039
16	403.7	9.2856	9.2860	0.0004	34.6577	34.6627	0.0050	34.6573	-0.0004	-0.0054
17	202.8	12.0402	12.0406	0.0004	34.8047	34.8097	0.0051	34.8074	0.0027	-0.0023
18	202.5	12.0452	12.0454	0.0001	34.8049	34.8098	0.0048	34.8066	0.0017	-0.0032
19	202.9	12.0401	12.0404	0.0003	34.8047	34.8099	0.0053	34.8076	0.0039	-0.0023
20	202.6	12.0466	12.0468	0.0002	34.8049	34.8098	0.0049	34.8063	0.0014	-0.0035
21	52.1	14.3300	14.3232	-0.0068	34.8736	34.8795	0.0059	34.8837	0.0001	-0.0058
22	51.9	14.3049	14.3049	0.0001	34.8784	34.8837	0.0053	34.8850	0.0013	-0.0034
23	51.3	14.2971	14.2997	0.0026	34.8800	34.8843	0.0042	34.8821	0.0021	-0.0022
24	1.2	28.2776	28.2789	0.0012	33.7849	33.7882	0.0033	33.7953	0.0004	-0.0029

Bottle Data Report CTD Test Cast #3 using CTD System#1

Bottle	PrDM	T090C	T190C	T2-T190C	Sal00	Sal11	SecS-priS	Autosal	-Sal00	-Sal11
1	414.8	9.2561	9.2599	0.0038	34.6547	34.6569	0.0022	34.6578	0.0031	0.0009
2	414.6	9.2683	9.2747	0.0064	34.6543	34.6574	0.0031	34.6550	0.0007	-0.0024
3	414.4	9.2702	9.2782	0.0080	34.6548	34.6577	0.0029	34.6558	0.0001	-0.0019
4	414.0	9.2781	9.2834	0.0052	34.6552	34.6580	0.0029	34.6558	0.0006	-0.0022
5	413.6	9.2905	9.2967	0.0062	34.6559	34.6584	0.0025	34.6586	0.0027	0.0032
6	304.9	10.9167	10.9160	-0.0006	34.7348	34.7371	0.0023	34.7367	0.0019	-0.0004
7	305.0	10.9169	10.9149	-0.0019	34.7351	34.7372	0.0021	34.7345	-0.0006	-0.0027
8	305.7	10.9137	10.9082	-0.0056	34.7350	34.7371	0.0021	34.7363	0.0013	-0.0008
9	305.9	10.9099	10.9084	-0.0016	34.7349	34.7370	0.0021	34.7609	0.0260	0.0239
10	305.5	10.9119	10.9088	-0.0031	34.7351	34.7372	0.0021	34.7399	0.0048	0.0027
11	216.7	11.9798	11.9796	-0.0002	34.8019	34.8043	0.0024	34.8061	0.0042	0.0018
12	217.7	11.9666	11.9630	-0.0035	34.8014	34.8031	0.0017	34.8023	0.0009	0.0006
13	218.1	11.9583	11.9589	0.0006	34.8009	34.8033	0.0025	34.8032	0.0023	-0.0001
14	218.4	11.9563	11.9528	-0.0036	34.8009	34.8027	0.0018	34.8072	0.0063	0.0045
15	219.1	11.9419	11.9404	-0.0015	34.8000	34.8020	0.0020	34.8090	0.0090	0.0070
16	144.8	12.8137	12.8154	0.0017	34.8547	34.8565	0.0018	34.8616	0.0069	0.0051
17	145.6	12.8022	12.8000	-0.0022	34.8537	34.8555	0.0019	34.8580	0.0043	0.0025
18	146.2	12.7942	12.7966	0.0024	34.8526	34.8546	0.0020	34.8596	0.0070	0.0050
19	74.9	13.8967	13.8972	0.0005	34.8930	34.8943	0.0013	34.8899	0.0069	0.0056
20	75.5	13.8651	13.8719	0.0068	34.8899	34.8921	0.0022	34.8995	0.0096	0.0074
21	76.9	13.7912	13.8000	0.0088	34.8801	34.8828	0.0028	34.9006	0.0205	0.0178
22	46.5	14.4300	14.4314	0.0014	34.8777	34.8785	0.0008	34.8483	-0.0294	-0.0302
23	45.6	14.4385	14.4372	-0.0013	34.8753	34.8769	0.0016	34.8604	-0.0149	-0.0165
24	1.1	28.2403	28.2437	0.0034	33.7586	33.7568	-0.0018	33.7703	0.0117	0.0135

Sal00 – Salinity computed from CTD Primary Temperature and Conductivity sensors.
Sal11 – Salinity computed from CTD Secondary Temperature and Conductivity sensors.
Secs-priS – CTD Secondary Salinity minus CTD Primary Salinity.
Autosal – Salinometer Salinity obtained by measuring Bottle salinity samples.
-Sal00 – Bottle salinity minus CTD Primary Salinity
-Sal00 – Bottle salinity minus CTD Secondary Salinity
T2-T190C - CTD Primary Temperature minus CTD Secondary Temperature Deg C

Primary temperature and Secondary temperature sensors from both systems track each other very well. Primary salinity and Secondary salinity readings indicate general agreement with each other and with the results of the bottle salinity analysis. It usually takes several CTD casts on each system in order to establish the exact conductivity corrections that may need to be applied to the CTD sensors.