U.S. DEPARTMENT OF COMMERCE
NATIONAL OCEANIC AND ATMOSPHERIC ADMINISTRATION
NATIONAL OCEAN SERVICE

Data Acquisition & Processing Report

Type of Survey *Multibeam and Side Scan Sonar*

Project No. *OPR-E350-TJ-12, OPR-B340-TJ-12, OPR-B363-TJ-12, OPR-B370-TJ-12 S-B935-TJ-12*

Time Frame: 02APR2012 – 08NOV2012

LOCALITY

State *Virginia, New York, Connecticut*

General Locality *Southern Chesapeake Bay, VA; Long Island Sound, NY; Block Island Sound, RI; Eastern Long Island Sound, CT, NY Harbor and Vicinity*

2012

CHIEF OF PARTY

CDR Lawrence T. Krepp
National Oceanic and Atmospheric Administration

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Table of Contents *Page*

List of Tables *Page*

List of Figures *Page*

A. EQUIPMENT

The methods and systems described in this report are used to meet Complete and Object detection coverage requirements and are in accordance with the Hydrographic Surveys Specifications and Deliverables Manual (2012), Hydrographic Survey Directives, and the Field Procedures Manual for Hydrographic Surveying (2012).

THE SURVEY VESSELS

The platforms used for data collection were the *NOAA Ship Thomas Jefferson,* (Figure A-1), *Hydrographic Survey Launches 3101 and 3102* (Figure A-1). *Thomas Jefferson* acquired multibeam echosounder (MBES) data, Side Scan Sonar (SSS) imagery and sound velocity profile (SVP) data. The vessel is equipped with a DT Marine Products tow winch (Model 307EHLWR) for side scan deployment, a DT Marine Oceanographic winch for CTD and bottom sample deployment, and a Brooke Ocean Technology MVP 100 Moving Vessel Profiler (MVP). Launches *3101* and *3102* acquired multibeam echosounder (MBES) data, vertical beam echosounder (VBES) data, Side Scan Sonar (SSS) imagery and sound velocity profile (SVP) data. Table A-1 presents the vessel characteristics for all platforms.

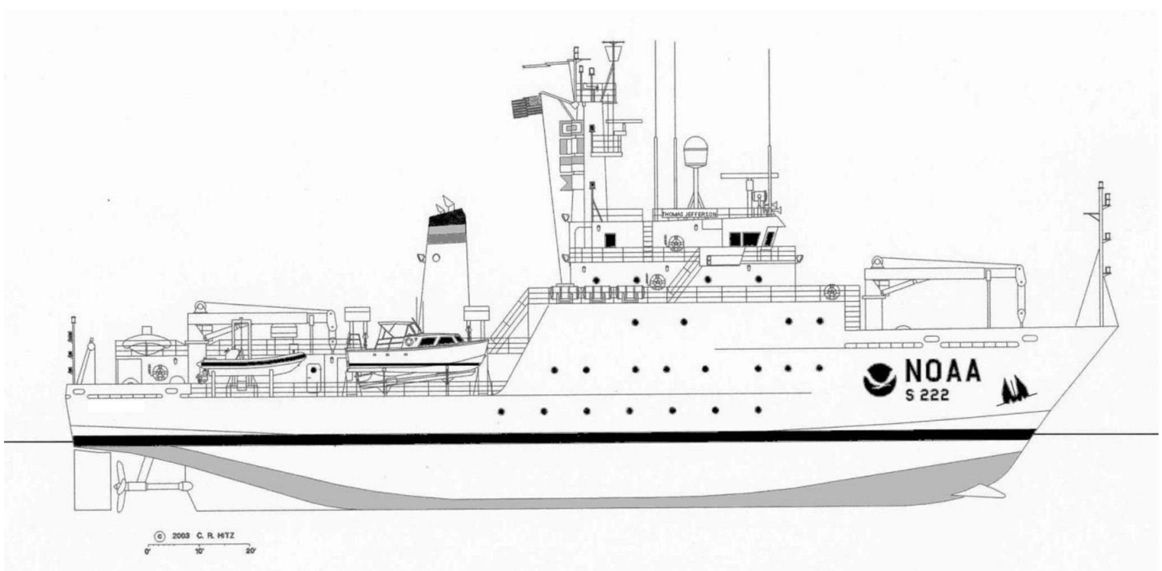

Figure A-1. NOAA Ship *Thomas Jefferson.*

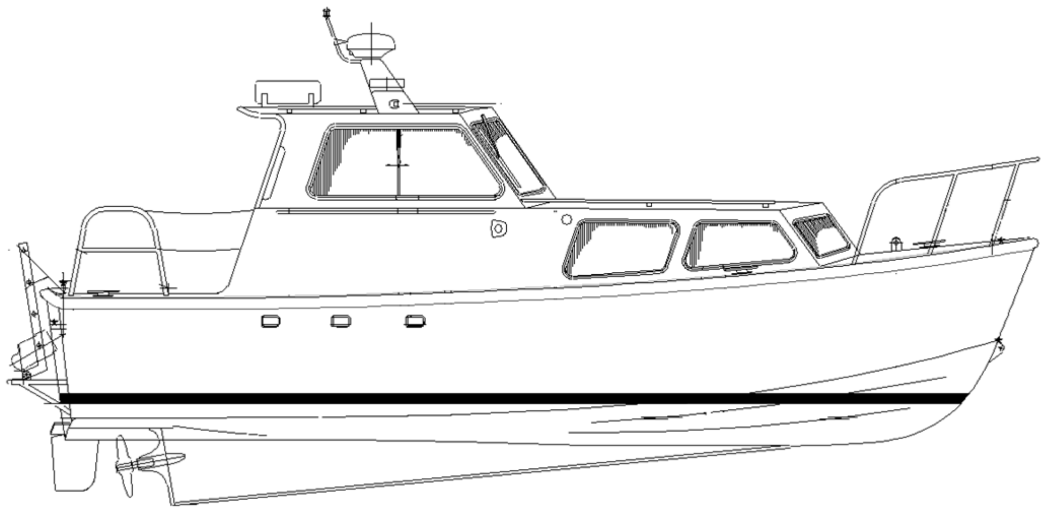

Figure A-2. Hydrographic Survey Launch 3101/3102.

Vessel Name	LOA (Ft)	Beam (Ft)	Draft (Ft)	Survey Speed	Date of last Vessel Survey	Date of last Dynamic Draft Measurement
NOAA Ship Thomas Jefferson	208’	45’	14.0’	5-10 kts	3/10/2012	4/3/2012
HSL 3101	31’	10’8”	5’2”	4-12 kts	1/20/2010	4/3/2012
HSL 3102	31’	10’8”	5’2”	4-12 kts	1/20/2010	4/4/2012

Table A-1. Survey Vessel Characteristics.

DATA ACQUISITION SYSTEMS

A complete listing of the data acquisition systems used for *OPR-E350-TJ-12*, *OPR-B340-TJ-12, OPR-B363-TJ-12, OPR-B370-TJ-12* are listed in the tables below:

Hydrographic Hardware Inventory Field Unit: Thomas Jefferson (S-222)			
SONAR AND SOUNDING EQUIPMENT			
Manufacturer	**Model**	**Serial Number**	**CD # / ACM #**
Reson	7P Processor	50357	CD0001044551
	Lower Control Unit	61206	None
	7125 Projector	1908203	None
	7125 Reciever	808042	None
Klein	5500 high speed high resolution side scan sonar towfish	280	None
	Top Side Processor Unit	135	CD0000825295
POSITIONING & ATTITUDE EQUIPMENT			
Manufacturer	**Model**	**Serial Number**	**CD Number**
Trimble	DSM212L	0220227516	CD0000658032
Trimble	DSM212L	0220159716	CD0000832703
Applanix	POS/ MV	PCS - 2321	CD0001472952
Applanix	POS M/V	IMU - 146	CD0001284522
SOUND SPEED MEASUREMENT EQUIPMENT			
Manufacturer	**Model**	**Serial Number**	**CD Number**
Seabird	SBE 19 SVP	192472-0285	CD0001776086
Applied Micro Stystems	Smart SV+T SSVS	4823	A011827
Brooke Ocean Technology LTD	Sensor 1	5340	None
	MVP PU	10332	CD0200825374
	"Fish 1"	10535	None
	"Fish 2"	10333	None
	MVP Computer	0127560	None
	Sensor 2	4988	None
	Deck Unit	10332	None

Table A-2 - *Thomas Jefferson* S222 Acquisition Systems.

Hydrographic Hardware Inventory			
Field Unit: Launch 3101			
Effective Date: October 22, 2012			
Updated Through: October 22, 2012			
SONAR AND SOUNDING EQUIPMENT			
Manufacturer	**Model**	**Serial Number**	**CD Number**
Reson	SeaBat 7125-SV TPU	1812012	None
		1812018	CD0001527832
		1812031	CD0001529723
	SeaBat 7125-SV X-Ducer	2008044	N/A
Klein	5500 LW ss towfish	319	N/A
	Top Side Processor Unit	135	CD0000825295
		136	CD0000825297
		137	CD0000825292
Odom	Echotrac CV-200	003260	N/A
POSITIONING & ATTITUDE EQUIPMENT			
Manufacturer	**Model**	**Serial Number**	**CD Number**
Trimble	DSM212L	0220243252	CD0001606186
Applanix	POS M/V	2320	CD0000825559
		IMU - 352	none
SOUND SPEED MEASUREMENT EQUIPMENT			
Manufacturer	**Model**	**Serial Number**	**CD Number**
Seabird	SBE 19 Plus SVP	19P33589-4486	CD0001776087

Table A-3- *HSL 3101* Acquisition Systems.

Hydrographic Hardware Inventory			
Field Unit: Launch 3102 Effective Date: October 22, 2012 Updated Through: October 22, 2012			
SONAR AND SOUNDING EQUIPMENT			
Manufacturer	**Model**	**Serial Number**	**CD Number**
Reson	SeaBat 7125-SV TPU	1812012	CD0001527832
		1812018	CD00016776100
		1812031	CD0001529723
	SeaBat 7125-SV X-Ducer	2008027	N/A
Klein	5500 LW ss towfish	322	N/A
	Top Side Processor Unit	135	CD0000825295
		136	CD0000825297
		137	CD0000825292
Odom	Echotrac CV-200	002917	N/A
POSITIONING & ATTITUDE EQUIPMENT			
Manufacturer	**Model**	**Serial Number**	**CD Number**
Trimble	DSM212L	0220168291	CD0000819685
Applanix	POS/MV	2562	CD0000156714
		IMU - 356	CD0001474855
SOUND SPEED MEASUREMENT EQUIPMENT			
Manufacturer	**Model**	**Serial Number**	**CD Number**
Seabird	SBE 19 Plus SVP	19P33589-4487	CD0001776088

Table A-4 ***HSL 3102*** **Acquisition Systems.**

A.1 ODOM Echotrac CV200

The Echotrac CV-200 is a dual-frequency digital recording echosounder system with a digital recorder. The systems high frequency setting is 200 kHz, low frequency is 24 kHz. It is hull-mounted on HSL *3101*and *3102*.

On Launches *3101* and *3102*, the transducer is mounted on the port side forward of the retractable arm that accommodates the RESON 7125-SV (Figure A-3). The installation of the Odom on Launch *3101*, *3102* allows simultaneous acquisition of KLEIN 5000 side scan with general survey-grade bathymetry when the ODOM is operated in either low or high frequency mode.

Figure A-3 - Odom Vertical Beam on *3101 / 3102.*

For the purposes of calculating total propagated error (TPU), the ODOM Echotrac CV-200 is assumed to be a single-frequency multibeam transducer with one beam. The maximum across-track and along-track beam angles are assumed to be identical at a value of 7.5°. The sonar is assumed to have a pulse length of 0.1 ms at 100 kHz and a ping rate of 20 Hz.

The ODOM Echotrac is used with side scan sonar to meet NOAA requirements for object detection.

Owing to its wide beamwidth, patch tests are not conducted to solve for mounting angle biases for ODOM Echotrac data. During typical acquisition conditions, the high-frequency beamwidth is wide enough to receive a primary-lobe hit at nadir regardless of vessel attitude. This breaks down, however, when the vessel pitches more than 3° or rolls more than 5°. Care is taken to avoid using the ODOM as the primary source of bathymetry in situations where the pitch or roll would cause attitude artifacts or side-lobe hits.

A.2 RESON SeaBat 7125 Multibeam Echosounder

The RESON SeaBat 7125 system is a single-frequency, digital recording multibeam echosounder with a central frequency of 400 kHz. The RESON 7125 system aboard *Thomas Jefferson* is installed in a steel housing assembly with hydrodynamic shape mounted to a pylon extending from the starboard hull of the ship (Figure A-4).

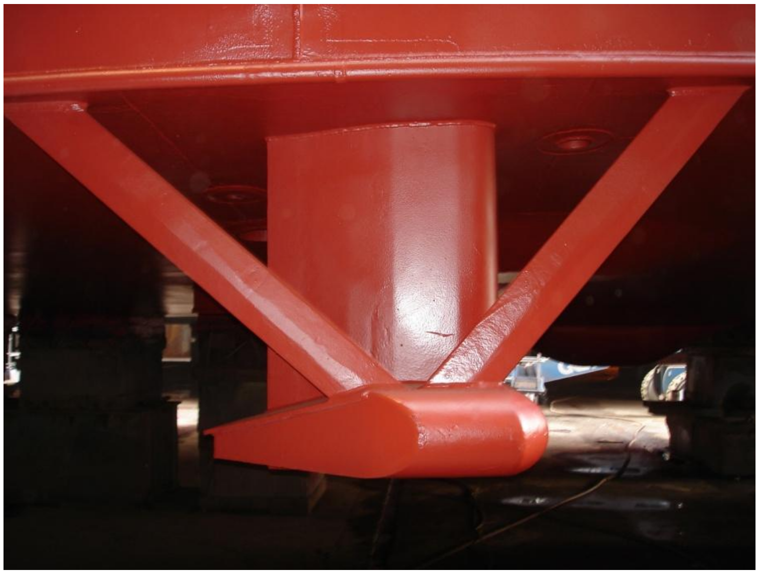

Figure A-4. 7125 Housing on *Thomas Jefferson.*

The RESON 7125 forms 256 beams and can be set to interpolate to 512 beams. The RESON 7125 can also be set to acquire equi-distant or equi-angular beam spacing. Each beam in the receive array has a 0.5° across-track resolution and 1° along-track resolution. The RESON 7125 has a maximum ping rate of 48 Hz and can achieve a full swath width to a depth of 75m. Standard operating procedure on *Thomas Jefferson* is to acquire 512 beam, equi-distant bathymetry.

The sonar contribution to the total propagated error is computed using parameters provided by the manufacturer and distributed with Caris HIPS.

The RESON 7125 performs active beam steering to correct for sound velocity at the transducer head using an Applied Microsystems LTD Sound Velocity and Temperature Smart Sensor. This sensor will be discussed in more detail in the Sound Velocity Equipment Section.

The user selectable range scale on the RESON 7125 was adjusted using the “autopilot” settings, or by hand.

A.3 RESON SeaBat 7125-SV Multibeam Echosounder

The RESON 7125-SV system aboard Launches *3101*, *3102* are installed on a RESON Seabat 7125 mounting bracket deployed on a retractable arm from the hull. (Figure A-5).

Figure A-5. 7125-SV Housing on Launch *3101/3102.*

The RESON 7125-SV forms 256 beams and can be set to interpolate to 512 beams in the receive array and can be set to acquire equi-distant or equi-angular beam spacing. Standard operating procedure on *Thomas Jefferson* is to acquire 512 equi-distant bathymetry. The 400 kHz frequency has a 0.54° across-track resolution and 1° along-track resolution. The 200 kHz frequency has a 1.1° across-track resolution and 2.2° along-track resolution. The RESON 7125-SV has a maximum ping rate of 50 pings/s and can maintain a full swath width in depths of 1-75 m for the 400 kHz, and 1-150 m for the 200 kHz systems.

The sonar contribution to the total propagated error is computed using parameters provided by the manufacturer and distributed with Caris HIPS.

The RESON 7125-SV performs active beam steering to correct for sound velocity at the transducer head using a RESON Sound Velocity Probe (SVP) 70. This sensor will be discussed in more detail in the Sound Velocity Equipment Section.

The RESON 7125-SV can be configured for roll stabilization. In roll stabilized mode, the sonar can operate in environments with up to +/- 10 degrees of roll without degrading system performance. Standard operating procedure on HSL 3101 and 3102 is to acquire data in the roll stabilized mode.

The user selectable range scale on the RESON 7125-SV was adjusted using the "autopilot" settings, or by hand.

Notable RESON7125-SV equipment changes:

Over the course of the season, three different TPUs were used between HSL 3101 and HSL 3102 as breakdowns and maintenance occurred. Additionally, a receiver cable failed and was replaced. No patch test was performed after any of these replacements, since the transducers were never removed from their mountings.

A.4 Variants of the Klein 5000 Side Scan Sonar

Klein System 5000

The KLEIN 5000 high-speed, high-resolution side-scan sonar (SSS) system is a beam-forming acoustic imagery device with an operating frequency of 455 kHz and vertical beam angle of 40°. The KLEIN 5000 system consists of a KLEIN 5500 towfish, a Transceiver/Processing Unit (TPU), and a computer for user interface. Stern-towed units also include a tow cable telemetry assembly. There are two configurations for data acquisition using the KLEIN 5000 system: stern-towed and hull-mounted. S-222 uses exclusively towed SSS, HSL 3101 is hull mount configuration, HSL 3102 can be converted from hull-mounted to towed as required. HSL 3102 operated using only the hull mounted configuration for the 2012 field season.

The KLEIN 5000 system is distinct from other commercially-available side scan sonars in that it forms 5 simultaneous, dynamically-focused receiver beams per transducer face. This improves along-track resolution to approximately 20cm at the 100m range scale, even when acquiring data at up to 10 knots. Across-track resolution is typically 7.5cm at the 100m range scale. The achievable 20cm resolution meets the NOAA Hydrographic Surveys Specifications and Deliverables Manual (HSSDM) for object detection. Digital data from the KLEIN 5000 TPU is sent directly to the acquisition computer for display and logging by KLEIN SonarPro software. Raw digital side scan data from the KLEIN 5000 is collected in (SDF) and maintained full resolution, with no conversion or down sampling techniques applied.

Towfish positioning is provided by CARIS HIPS using cable out values recorded in the Sonar Pro SDF files. This program uses Payout and Towfish Depth to compute towfish positions. The tow fish position is calculated from the position of the tow point using the cable out value received by SonarPro from the cable payout meter, the towfish pressure depth (sent via a serial interface from the KLEIN 5000 TPU to the SonarPro software), and the Course Made Good (CMG) of the vessel. This method assumes that the cable is in a straight line therefore no catenary algorithm is applied at the time of acquisition, but in processing, CARIS SIPS applies a 0.9 coefficient to account for the catenary.

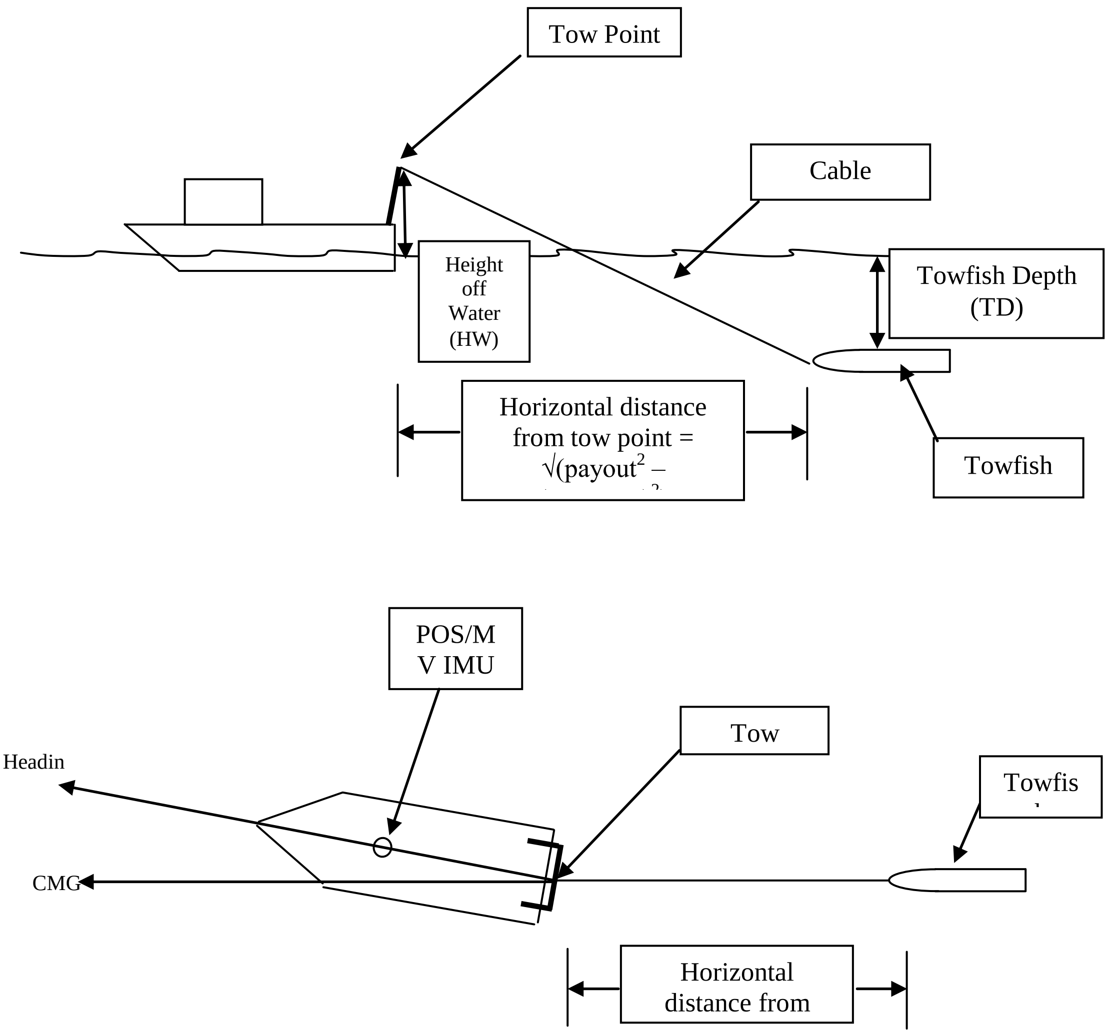

Figure A-6. Towfish orientation and position description.

When in the towed configuration, the north and east velocity vectors are filtered to calculate the ship's CMG. The CMG is used to determine the azimuth from the tow block to the side scan towfish. The position for the side scan towfish is computed based on the vessel's heading, the reference position (POS/MV IMU), the measured offsets (X, Y, and Z) to the tow point, height of the tow point above the water, Course Made Good and cable out. This calculated towfish position is sent to the sonar data collection system in the form of a GGA (NMEA-183, National Marine Electronics Association, Global Positioning System Fix Data String) message where it is merged with the sonar data file. Cable adjustments are made using a remote winch controller in acquisition in order to maintain acceptable towfish altitudes and sonar record quality. Changes to the amount of cable out are automatically saved to the SonarPro SDF.

Towfish altitude is maintained between 8% and 20% of the range scale in use (e.g. 4m-10m @ 50m range scale), when conditions permit. For equipment and personnel safety as well as safe vessel maneuverability, data may have been collected at towfish altitudes outside the 8% to 20% of the range over shoal areas and in the vicinity of charted obstructions or wrecks. When the towfish altitude was either greater than 20% or less than 8%, periodic confidence checks on linear features (e.g. trawl scars) or geological features (e.g. sand waves or sediment boundaries) were made to verify the quality of the sonar data. Confidence checks ensured the ability to detect one-meter high objects across the full sonar record range.

Another feature that affects the towfish altitude is the use of a K-wing depressor. The K-wing depressor is attached directly to the towfish and serves to keep it below the vessel wake, even in shallower near shore waters at slower survey speeds. The use of the K-wing reduces the amount of cable payout, which in turn reduces the positioning error of the towfish. Another benefit to less cable out is increased maneuverability of the ship in shallow water. Less cable out reduces the need to recover cable prior to turning for the next survey line, permitting tighter turns and increased survey efficiency.

Side scan data file names are changed automatically every 15 minutes and manually at the completion of a survey line.

Hull-Mounted Configuration

Aboard both survey launches, the lightweight or heavyweight Klein 5500 towfish can be mounted to an aluminum sled using omega brackets (Figure A-7). Positioning of the hull mounted towfish is determined by entering the X,Y, Z position of the towfish as the tow point and a layback value of zero. Otherwise, the system is processed the same as the towed configuration.

Figure A-7. Side Scan Hull Mounted on *3101 / 3102 (lightweight model shown).*

The hull-mounted configuration is normally used in depths of twenty meters or less, per the HSSDM. Aboard Launch *3101* and *3102*, sidescan may be collected concurrently with ODOM Echotrac CV-200 vertical beam bathymetry or RESON 7125 MBES.

Notable SSS equipment changes:

During the season, identical TPUs were swapped between platforms due to failures and platform acquisition requirements. The SSS fish data cable on HSL 3101 malfunctioned during the season and was replaced. Wet end hardware remained unchanged throughout these replacements.

A.5 Manual Sounding Equipment

No manual sounding equipment was used for this project.

A.6 Positioning and Orientation Equipment

Positioning for data acquired by the launches and the ship are achieved by writing differentially corrected GPS positions output from the POS/MV to the raw sonar data in real time. Upon conversion in CARIS, the positional information in the raw sonar data is used to create vessel track lines for the processed data. For projects OPR-B340-TJ-12 and OPR-B370-TJ-12, Ellipsoid Referenced Survey (ERS) methods were mandated.

When ERS are assigned, the additional positioning requirements involve logging full POSPac data from the POS/MV and utilizing POSPac MMS to derive Smoothed Best Estimate Trajectory (SBET) files. POSPac MMS requires ephemeris and clock data for the GPS constellation and data downloaded from Continually Operating Reference Stations (CORS) or other base stations to correct for atmospheric effects in the GPS data. SBET files are extremely accurate measurements of the 3-D position, speed, and motion of a vessel and can be used to apply higher quality navigation information to the processed data. Inertially Aided Post Processed Kinematic (IAPPK) navigation may be applied in CARIS during the SVP step in the processing workflow. For OPR-E350-TJ-12, OPR-B340-TJ-12, and OPR-B370-TJ-12, vertical and horizontal positioning was derived from IAPPK methods. IAPPK methods were not utilized for OPR-B363-TJ-12.

IAPPK methods are discussed in greater detail in Section C of this DAPR.

Applanix POS/MV

A basic requirement of multibeam hydrography is accurate ship's position and attitude data during data acquisition. *THOMAS JEFFERSON* uses inertial positioning and orientation sensors and U.S. Coast Guard Differential GPS (DGPS) for a highly accurate blended position and orientation solution. Surveys covered by this DAPR were acquired within approximately 50 nautical miles of USCG differential beacons. Because of this relatively short distance to the differential beacons, horizontal positioning errors of 0.5m were used in Caris HVFs for all platforms during the surveys covered by this DAPR.

THOMAS JEFFERSON, HSL 3101, and HSL 3102 are each equipped with Trimble DSM212L DGPS receivers. The DSM212L includes a 12-channel GPS receiver capable of receiving external RTCM correctors from a shore-based reference station. The DSM212L receivers are used for differential correctors to position only and not for actual positioning.

Inertial position calculations on *THOMAS JEFFERSON, HSL 3101, and HSL 3102* are provided by an Applanix POS/MV Model 320 v.4. During the winter period, all three POS/MV systems were sent to the manufacturer where they were upgraded to firmware version 5.0.3 and internal logging capability was added. At the beginning of the season, both internal and Ethernet logging of the .pos file was used to verify the quality of internal logging. Based on our analysis, the quality of internal logging met or exceeded that of Ethernet logging and Ethernet logging was discontinued.

The POS/MV 320 system includes dual GPS antennas, an inertial measurement unit (IMU), and data processor (PCS). The IMU measures linear and angular accelerations corresponding to the major motions of the vessel (heave, pitch, roll, yaw) and inputs this data to the PCS, where it is combined with a GPS position determined by carrier-phase differential measurements to give the final position solution. The POS/MV position solution is not sensitive to short period noise, but its accuracy may decay rapidly over time.

According to the manufacturer's specifications, the inertial position/orientation solution has typical values of 0.02° true roll and pitch accuracy, 0.02° heading accuracy, 2m position accuracy, and 0.03 m/s velocity accuracy. These parameters are monitored in real time during acquisition using the POS/MV user interface software. These values were entered into the HVF and were used to compute the TPU of each sounding.

All acquisition platforms are equipped with Precise Timing, a multibeam sonar acquisition configuration which synchronizes all data to the same time. The timing message is generated by the POS/MV which is received by both the acquisition computer and the RESON TPU. Precise Timing reduces the variable effects of time latency and creates a single, measurable latency (usually zero seconds +/- 0.005 seconds). This is verified during patch tests.

All platforms utilize True Heave (a long-period recording of vessel heave used to detect longer period sea swells that may not be detected during short-period heave calculations) for a post processed heave solution.

IMU's for *Thomas Jefferson, 3101,* and *3102* were all sent to the manufacturer during the winter inport 2009-2010 for tumble testing and calibration. All IMUs passed tumble testing and calibration.

A.7 Sound Velocity Profilers

A Brooke Ocean Technology Moving Vessel Profiler (MVP) with an Applied Microsystems Smart Sound Velocity and Pressure (SV&P) sensor or a Seabird Electronics SBE-19 CTD were used to collect sound speed profile (SSP) data from *Thomas Jefferson*. Seabird Electronics SBE-19 CTD+ units were used to collect sound speed profile (SSP) data from Launches 3101 and 3102. SSP data were obtained at intervals frequent enough to reduce sound speed errors. The frequency of casts is based on observed sound speed changes from previously collected profiles and time elapsed since the previous cast. Subsequent casts were made based on the observed trend of sound speed changes. As the sound speed profiles change, cast frequency and location are modified accordingly. Confidence checks of the sound speed profile casts are conducted weekly by comparing simultaneous casts taken with all sound speed determining devices on the ship and each launch.

Sound speed data are included with the survey data in Section II of the Separates for each survey's Descriptive Report. Uncertainty values for sound speed are input into Caris by survey day for each platform during the TPU process. When CTDs are used, uncertainty values of 1m/s for each hour between successive casts is recommended to determine an appropriate uncertainty value. However, to be conservative, all CTD derived sound speeds are assigned an uncertainty of 4m/s even when acquired more frequently than every 4 hrs. An uncertainty value of 1m/s is used for all MVP casts even though MVP casts rarely exceed 1 hour between successive casts. Additionally, a surface sound speed uncertainty value of 0.2m is used for launches 3101 and 3102, as recommended in the 2012 FPM.

Sea-Bird SBE19/19+ CTD Profilers

THOMAS JEFFERSON and Survey Launches 3101 and 3102 acquire water column sound velocity data using Sea-Bird Electronics SeaCat SBE19 and SBE19+ Conductivity-Temperature-Depth (CTD) profilers. Temperature is measured directly. Salinity is calculated from measured electrical conductivity. Depth is calculated from strain gauge pressure.

THOMAS JEFFERSON is equipped with a SeaCat SBE19 CTD profiler with strain gauge pressure sensor. The SBE19 is capable of CTD profiling at depths from 0-3400m. Post calibration drift is expected to be 0.02 °C yr^{-1}, 0.012S m^{-1} yr^{-1}, and 4.5 psia yr^{-1} for temperature, conductivity, and pressure, respectively. The SBE19 is deployed by hand or using the DT Marine Oceanographic winch for ship based acquisition.

HSL 3101 and HSL 3102 are each equipped with a SeaCat SBE19+ CTD profiler with strain gauge pressure sensor. The SBE19+ has a specified post-calibration temperature accuracy of 0.0005S m^{-1}, and strain-gauge pressure accuracy of 0.35 psia. Post calibration drift is expected to be 0.002 °C yr^{-1}, 0.004S m^{-1} yr^{-1}, and 0.168 psia yr^{-1} for temperature, conductivity, and pressure, respectively. The SBE19+ is capable of CTD profiling at depths from 0-350m. The SBE19+ is deployed by hand from HSL 3101 and 3102.

All CTD instruments were returned to the manufacturer for calibration during December, 2011.

Sea Surface Sound Velocimeters

Unlike CTD profilers, surface sound velocimeter sensors (SSVS) calculate sound velocity in water using two-way travel time. The typical SSVS consists of a transducer and a reflector at a known distance from the transducer. A pulse of known frequency is emitted, reflects at the reflector surface a known distance from the transducer, and returns. The two-way travel time is measured, and sound velocity is derived. SSVS are required for multibeam systems that perform active beam steering at the transducer head. The RESON 7125 and RESON 7125-SV systems both require SSVS data.

The AML Smart SV&T Probe is a real-time time-of-flight sound velocimeter and thermistor sensor. The manufacturer specified sound velocity accuracy is 0.02 m/s and temperature accuracy is 0.03 °C. Empirical observations of drift show a sound velocity drift of approximately 0.5 m/s/yr and temperature drift of approximately 0.05 °C/yr. Aboard *THOMAS JEFFERSON*, the AML Smart SV&T probe is mounted in an insulated sea chest in the sonar void. Sea surface temperature and sound velocity values are output in real time to the SIMRAD EM1002 and RESON 7125 systems at a rate of 10 Hz and are recorded in the raw Hypack .hsx files.

The surface sound speed uncertainty for the ship is based on historical analysis and the same values were used throughout the season. More details may be found in Section C of this DAPR.

RESON Sound Velocity Probe 71 (SVP)

The RESON SVP 71 is a real-time surface sound velocimeter. The manufacturer specified sound velocity accuracy is ±0.15 m/s at 0 – 50m. Surface sound velocity values are output to the RESON 7125-SV system at a rate of 20 Hz and lower. Data can be sent in real time to the RESON 7125-SV processor unit and are recorded in the raw Hypack .hsx files.

RESON SVP 71 was installed at the beginning of the 2011 field season on Launches *3101* and *3102*.

ODOM Hydrographic Systems Digibar Pro

The Digibar Pro is a real-time time-of-flight sea surface sound velocimeter. The manufacturer specified sound velocity accuracy is 0.3 m/s. Sea surface temperature and sound velocity values are output to the RESON 7125-SV system at a rate of 10 Hz. Data can be sent in real time to the RESON 7125-SV processor unit

The units were returned to the manufacturer and calibrated during the 2009-2010 inport period.

The Odom Digibar Pro is kept onboard Thomas Jefferson as a ready spare and was not utilized for any surveys covered by this DAPR.

Brooke Ocean Technology Moving Vessel Profiler 100

The Moving Vessel Profiler (MVP) (figure A-8) is a self-contained profiling system capable of sampling water column profiles to 100m depth. MVP-100 was mounted to the port quarter. The MVP consists of a computer-controlled high speed hydraulic winch, a cable metering, over-boarding and docking system, a conductor cable and a streamlined free fall fish (FFF) housing an Applied Microsystems "time of flight" SV&P Smart Sensor (see SV&P below) . The system as configured aboard the *THOMAS JEFFERSON* collects vertical profiles of sound velocity data while the ship is underway at survey speed. The unit is located on the fantail and controlled remotely from the ship's acquisition room. When using MVP casts in conjunction with the RESON 7125 MBES, sound velocity data is processed using Pydro Velocipy software, then applied in CARIS HIPS during post processing.

Figure A-8. MVP 100 on S-222

Notable equipment changes: None

AML – Sound Velocity & Pressure Smart Sensor (SV&P)

The SV&P Smart Sensor is the main instrument housed on the MVP free fall fish; it is designed to directly measure sound velocity and pressure in water. Its small size, extremely fast response time and high sampling rate make the sensor ideal for fast profiles or tow speeds. The sensor has internal calibration coefficients and outputs real-time data to allow a "plug and play" environment.

The Applied Microsystems Smart SV&P Sensor was last calibrated by the manufacturer during December 2011.

A.8 Bottom Samplers

Two types of bottom samplers are used aboard *THOMAS JEFFERSON* for analyzing bottom sediments.

The Khalisco Mud Snapper model 214WA100 may be deployed by one person by hand and is best used for shallow-water bottom samples acquired on the survey launches. (Figure A-9)

The Ponar Wildco model # 1728 sampler may be deployed by one person by hand and is sometimes used with the DT Marine Oceanographic winch for Ship based bottom sample acquisition. (Figure A-10)

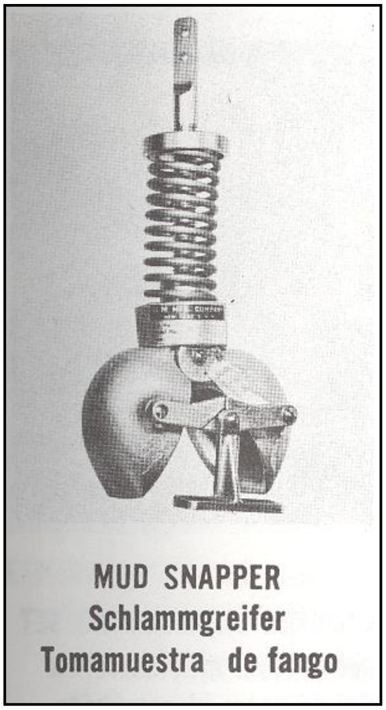

Figure A-9. Khalisco Mud Snapper

Figure A-10. Ponar Grab Sampler

A.9 Software Systems

Acquisition Software

Multibeam data were acquired using Hypack 2012 software running on acquisition computers with the Windows XP and Windows 7 operating system. Hypack is used to control real-time navigation, data time–tagging, and data logging. KLEIN 5000 side scan sonar data were acquired using KLEIN's SonarPro software running on acquisition computers with the Windows XP and Windows 7 operating system. Moving Vessel Profiler data were acquired using Brooke Ocean Technology MVP software running on a computer with the Windows XP operating system.

Data Processing: Post-acquisition multibeam processing was performed on board the *Thomas Jefferson* using processing computers with Windows XP and Windows 7 operating systems, which run CARIS HIPS&SIPS software. Side scan sonar data were reviewed for targets, side scan mosaics and contact generation in CARIS HIPS&SIPS software; Side-scan contacts were correlated with multibeam data in NOAA's Pydro software. CTD and MVP data were processed using NOAA Velocipy software. See Table A-5 below for software versions.

NOAA Ship Thomas Jefferson - Acquisition and Processing Software				
Acquisition Software	Date of Application	TJ	3101	3102
Hypack/Hysweep	Apr-12	v2012	v2012	v2012
SonarPro	Feb-10	v11.2	v11.2	v11.2
Velocipy	Oct-12	V12.9	V12.9	v12.9
Applanix MV POSView	Apr-12	v5.1.0.2	v5.1.0.2	v5.1.0.2
TSIP Talker	Aug-10	v2.00	v2.00	v2.00
MVP	Sep-09	v.2.351		
Processing Software	Date of Application	Version		
CARIS Hips and Sips	Sept-2012	7.1, SP2, HF 3		
CARIS Bathy Database	Oct-2012	4.0		
Windows 7 Pro 64-bit	Oct-2012	SP1		
Pydro	Oct-2012	12.9 r3191		

Table A-5 – Acquisition and Processing Software versions and dates of application

CARIS HIPS AND SIPS Version 7.1 SP2, HF3

CARIS HIPS (Hydrographic Information Processing System) is used for all initial processing of multibeam and vertical beam echosounder bathymetry data, including tide, sound velocity, and vessel offset correction and data cleaning. CARIS HIPS uses statistical modeling to create Bathymetry with Associated Statistical Error (BASE) surfaces in one of three ways: swath-angle weighted grids, uncertainty-weighted grids, and Combined Uncertainty and Bathymetry Estimator (CUBE) algorithm grids. Creation of grids as bathymetric products is discussed in section B of this report.

CARIS SIPS (Side-scan Information Processing System) is used for all processing of side-scan sonar imagery, including cable layback correction, slant range correction, contact selection, towpoint entry, and mosaic generation.

HSTP PYDRO Version 12.9

HSTP PYDRO is a program for the correlation and classification of side-scan sonar and multibeam bathymetry features and for the creation of preliminary smooth sheets. Multibeam features (designated soundings), side-scan sonar contacts, and detached positions are analyzed, grouped, and assigned S-57 classifications. High resolution BASE surface data is entered into the program and excessed to survey scale. The final product is a Preliminary Smooth Sheet file (PSS), which is delivered to the Atlantic Hydrographic Branch as part of the final submission package.

Pydro Versions 7.3 and later have functionality for TCARI installed. TCARI is described in detail in section C.2.1. The TCARI file for the area (when applicable) is received from NOS and loaded into Pydro along with the predicted, observed, or verified tide files for the corresponding stations. The use of TCARI is specified in the Project Instructions.

Pydro is also used for chart comparisons, generation of chartlets, generation of Danger to Navigation reports, generation of appendices to the Descriptive Report, compilation of survey statistics, and generation of standard NOAA forms such as the Descriptive Report cover sheet.

HSTP VELOCIPY

HSTP Velocipy is a program for the processing of sound velocity casts from Seabird CTDs and Moving Vessel Profiler systems. This program converts hexadecimal SeaCat data into ASCII conductivity-temperature-depth data, and then converts the ASCII data into a depth-binned sound velocity file that is compatible with CARIS HIPS/SIPS. Velocipy allows for batch processing of the numerous .calc files generated by the MVP during multibeam echosounder acquisition. The resulting .svp files are applied in CARIS HIPS during post-processing to correct for sound velocity variation within the water column. Velocipy is also used to check the accuracy of sound velocity casts and to archive sound velocity information for the National Oceanographic Data Center.

CARIS Base Editor 4.0

Base Editor is used for feature and AWOIS planning, feature de-conflicting, surface and sounding review, and chart comparison. This software is useful for visually analyzing a variety of data formats throughout each stage of the survey. Additionally, this software is used during survey content review meetings as one of the final data checks before surveys are submitted to the processing branch. During the 2012 season, most surveys primarily used Base Editor for feature management as opposed to Pydro.

B. QUALITY CONTROL

B.1 Acquisition Procedures

All platforms acquire hydrographic data according to the Project Instructions for each survey. The Project Instructions for a given survey specify the acquisition method to be used, the coverage required, and give the field unit discretion as to the best method to achieve that coverage.

The following survey types are used during field operations by *THOMAS JEFFERSON* in the 2012 Field Season:

- Complete MBES Coverage
- Object Detection SSS Coverage
- Object Detection MBES Coverage
- Concurrent Set Line Spacing MBES With Object Detection SSS
- Concurrent Set Line Spacing VBES With Object Detection SSS.

These coverage types are described in detail in the April 2012 Hydrographic Survey Specifications and Deliverables.

Line plans are designed by the field unit according to the coverage type specified in the Project Instructions. For complete coverage MBES surveys, lines are planned to acquire sufficient overlap to allow for a reasonable level of vessel deviation. Alternatively, MBES acquisition can be planned using a real time coverage matrix and polygon areas to achieve full bottom coverage. Line spacing for 100% SSS acquisition is established by multiplying the desired range scale, in meteres, by 1.6. For 200% SSS acquisition, line spacing is set to range scale multiplied by 0.8. Line planning and coverage type are discussed in detail in the Descriptive Report for each survey.

Crosslines are acquired as an additional confidence check for bathymetry. Crosslines provide a meaningful comparison between nadir beams and outer beams of mainscheme acquisition lines in the case of multibeam, and nadir to nadir for vertical beam lines. Crosslines are compared to the mainscheme lines using the standard deviation layer and hypothesis count layer of the grids in CARIS HIPS and Base Editor.

Acquisition speeds are adjusted to balance data quality, productivity, and energy efficiency. The Thomas Jefferson's bathymetric sonars typically produce densities above that which is required in Specs and Deliverables for "skunk striped" and complete coverage surveys at all survey speeds.

B.2 Quality Management

A systematic approach to Quality Management has been instituted aboard the *THOMAS JEFFERSON*, starting well before the field season begins, through to the final packaging of Survey Deliverables and delivery to AHB.

Clear and concise communication is critical at all stages of the survey, and is established between all relevant parties[1] at the earliest stage of the process. Figure 1 represents the parties involved at all stages of the Quality Management process.

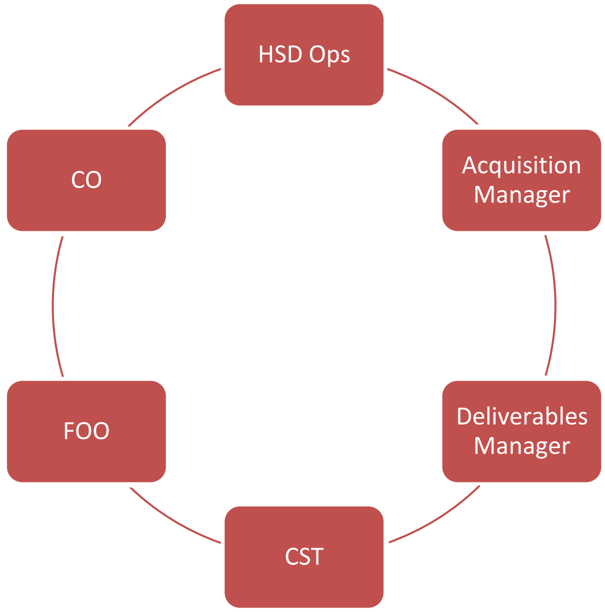

Figure B-1: Quality management loop

[1] Note on Personnel:
CO – Commanding Officer, FOO – Field Operations Officer, CST – Chief Survey Technician, HSD OPS – Hydrographic Surveys Division, Operations Branch

Below is a graphic showing the Quality review steps used aboard the *Thomas Jefferson*.

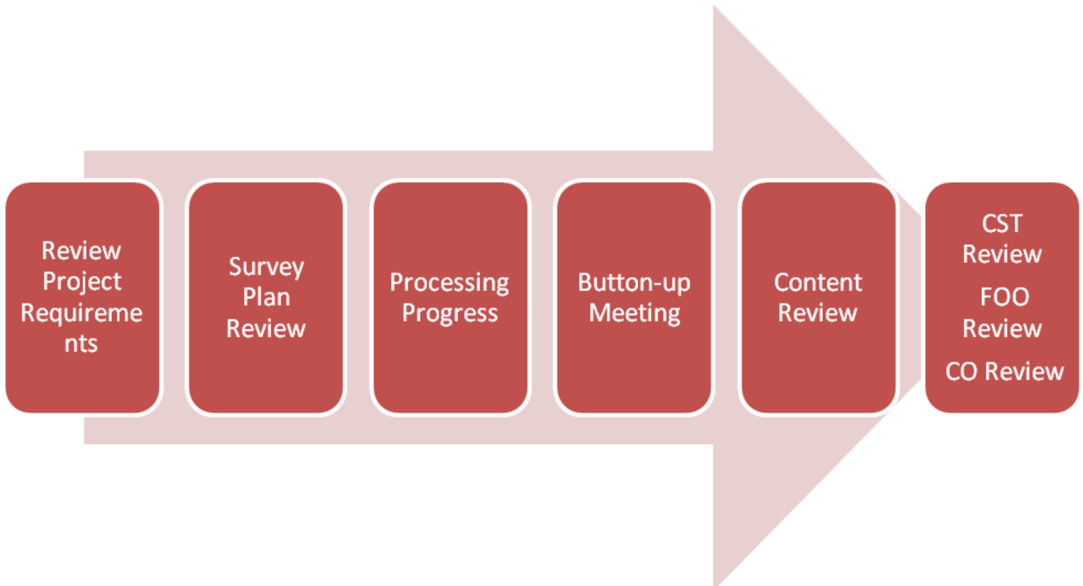

Figure B-2: Quality Review Stages

In the Review Project Requirements stage, the final project instructions are reviewed for specific criteria. Some of these are:

- Is the Survey fit for the Purpose?
- Are all charted features and AWOIS in the Composite Source File (CSF)?
- Are there any extraneous or unassigned features in CSF?
- Is the Survey a reasonable size?
- Are the resources available for the job?
- Do we have the right equipment, spares, qualified staff, OT, software and specs?
- Are there any special requirements from HSD OPS?

If any of these elements are found to be in question, dialogue is opened with HSD OPS, in order to resolve them. Once these questions have been answered, the Acquisition manager can prepare the survey plan. This would include the following requirements:

- Line plans/Polygons, Crossline plans, Bottom Sample plan
- Feature requirements as addressed in the Composite Source File (CSF) or ENC.
- Safety of Operations, i.e. where we can and cannot go.
- The plan's effectiveness and efficiency.
- Proper or maximum platform utilization.
- Survey Specific Sensor configurations, staffing plans, line plans, target files, etc.

All aspects of the survey plan are carefully reviewed by the CST, FOO and CO for any required changes initiated by the Acquisition manager before survey begins.

A weekly progress review of all planned and open surveys is conducted to evaluate and incorporate the following factors into the acquisition and deliverables schedule:

- Ship schedule (inports/transits)
- Completion rate, estimated survey end date
- Weather factors
- Equipment failures
- Processing backlog (if any)

The goal is to continuously manage multiple surveys and to establish a projected survey shipment date which accurately reflects all known factors. If processing is not keeping pace with acquisition, then additional resources can be deployed to reduce backlogs. This in turn allows for better quality assessment of collected data.

A Progress review of the survey occurs shortly before completion, with the following goals:

- Review remaining work
- Evaluate density coverage (5 Pings per grid node?)
- Confirm that all assigned features have coverage
- Prioritize remaining work for time remaining
- Adjust personnel and platform schedules as necessary
- Evaluate grids for systematic errors (Std Dev, Uncertainty)
- Review initial field sheet layout

After acquisition is complete and the Deliverables manager has applied final tides to all data, a Content Review is performed on the initial results of the survey, primarily surfaces and feature reports. Some of the particular items addressed are:

- Systematic errors evident in the child layers of the grids (Density, Std Dev, Hypothesis Count) that need to be addressed in the DR.
- Review feature report and advise changes or revisions.
- Consider any feature candidates for DtoN's.
- Determine any unusual acquisition or processing issues that need to be discussed in DR.

The final stage of the Quality Management system is a multiple review of the deliverables, by the CST, FOO and CO, each ensuring that all Specs have been met and that any revisions or changes identified in the Content Review have been made. These checks include:

- Examine finalized/thresholded grids for flyers or unresolved systematic issues. Are they discussed in the DR?
- Final check of feature report inclusions, relevance, S-57 attribution, image quality and general completeness.
- Vetting of the final DR. Does it reflect the Content Review discussion?

- Housekeeping – are all the ancillary reports, documents and data included and in the proper place?

B.3 Data Management

A daily tracking of data has been developed to maintain data quality and integrity. Several forms identify and track the flow of data as it is collected and processed. These forms are presented in the Separates section under data acquisition and processing logs, included with the data for each survey.

During data collection, watch standers continuously monitor acquisition systems, checking for errors and alarms. Thresholds set in Hypack/Hysweep, POSPAC, RESON and SonarPro alert the watch stander by displaying alarm messages when error thresholds or tolerances are exceeded. These alarms, displayed as they occur, are reviewed and acknowledged on a case-by-case basis. Alarm conditions that may compromise survey data quality are corrected and then noted in acquisition log. Warning messages such as the temporary loss of differential GPS, excessive cross track error, or vessel speed approaching the maximum allowable survey speed are addressed by the watch stander and corrected before further data acquisition occurs.

Following data acquisition, initial processing begins. See figure B.3 for an example of the typical multibeam data processing procedures. The following checks are performed to insure proper data handling throughout the process:

- A one to one comparison of raw data to acquisition logs is performed.

- Correctors, including tide files, true heave, and SVP files are checked for completeness and accuracy.

- Application of all correctors is tracked by line and by application.

Figure B.3 shows the general processing flow for Multibeam data after collection.

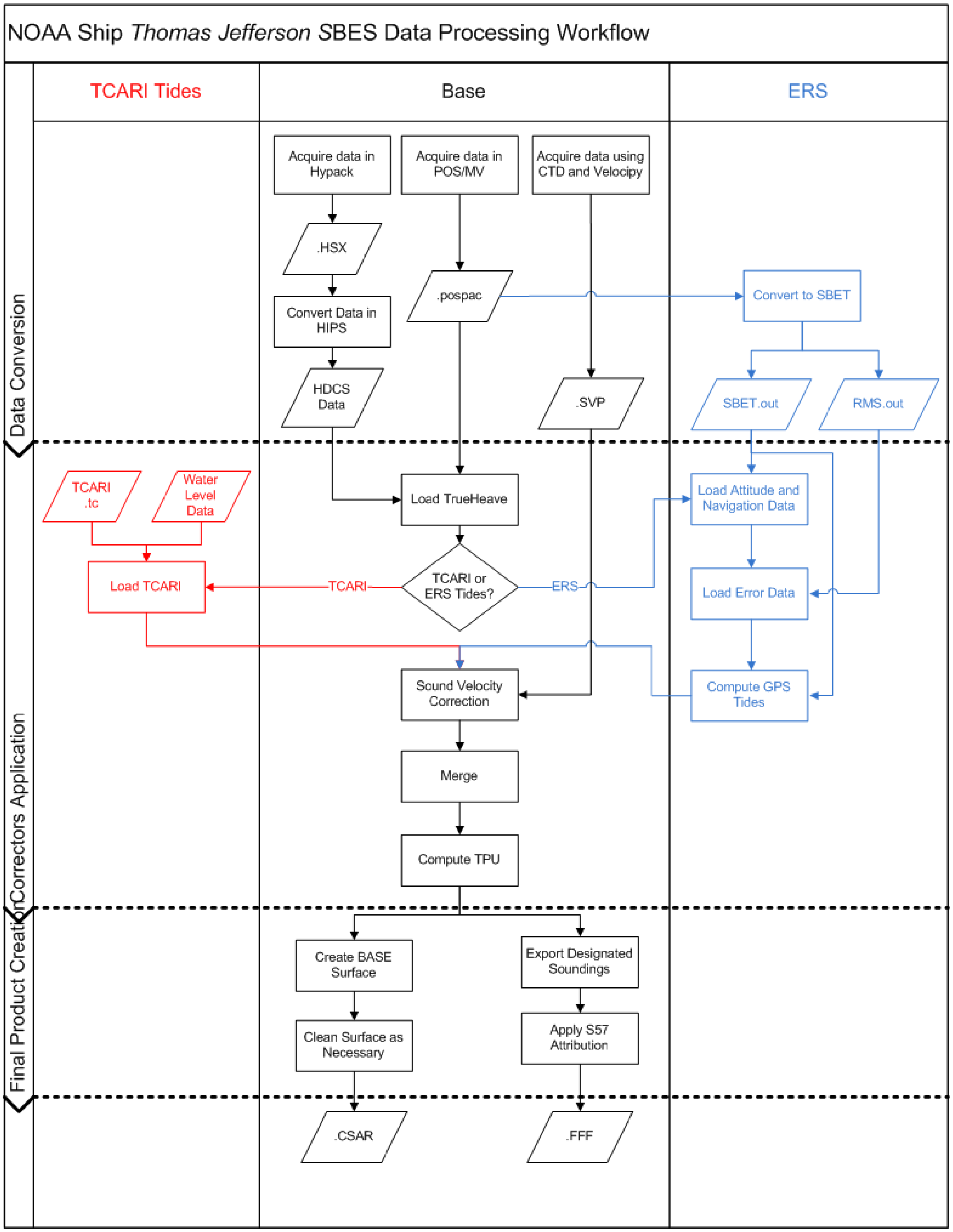

Figure B-3: Data processing flow

BASE surfaces are generated to ensure adequate data density, identify areas of high standard deviation and note any obvious problems with correctors.

Results of the processing are reviewed to determine adequacy of data and sounding correctors. Additional processing in preparation of data deliverables includes the following steps:

- Generation of side scan Contact Files and a Contact Plot
- Subset editing and review of multibeam data
- Application of verified tide correctors to multibeam data
- Application of true heave
- Cross line analysis of MBES data
- Cross line time series comparison between TCARI/Zone tides and ERS.
- Comparison with prior surveys
- Generation of shoal biased selected soundings at the scale of the survey
- Comparison with existing charts
- Quality control reviews of side scan data and contacts
- Final Coverage mosaic plots of side scan sonar data
- Correlation of side scan contacts with multibeam data
- Final quality control of all delivered data products

Processing and quality control procedures for multibeam and side scan data acquisition are described in detail below.

B.4 Bathymetry

Raw bathymetry data, (Hypack .hsx) are converted into CARIS HDCS data format upon completion of daily acquisition. Conversion parameters vary for each data format, and are stored in the LogFile of each HDCS processed line folder. After data conversion, attitude, and navigation are reviewed for outliers, and true heave, water level, and sound velocity are applied. Bathymetry lines are then merged. Following merge, Total Propagated Uncertainty (TPU) is calculated for each sounding. For a more detailed explanation of TPU calculation of multibeam and vertical beam echosounder data, refer to Section 4.2 of the 2012 NOAA Field Procedures Manuals.

Depending on acquisition type, MBES bathymetry may be processed using either an uncertainty-weighted navigation surface or a CUBE surface. Uncertainty-weighted BASE surfaces and CUBE surfaces are described in detail in the 2012 NOS Field Procedures Manual and the CARIS HIPS/SIPS Users Manual.

When the primary source of bathymetry for a survey area is a combination of VBES and MBES, a collection of finalized uncertainty-weighted mean bathymetric surfaces is generated as the product of the survey. CUBE is not permitted for this type of survey. When the primary source of bathymetry for this type of survey is set line spacing MBES data (also known as “skunk striped”), CUBE shall be used. The use of CUBE in this situation is required to guarantee proper nodal propagation distances as described in section 5.2.1, Gridded Data Specifications, of the 2012 HSSD. In most instances 95% of the nodes in a CUBE grid must contain a minimum of 5 soundings/node to adequately represent the seafloor depth in a given area.

When Complete or Object Detection (OD) MB is the primary source of bathymetry, data are processed using CUBE grids. The use of CUBE is mandatory to ensure compliance with the specification described in the paragraph above. Table 1 shows the required resolution in various survey depths.

Object Detection Coverage

Depth Range (m)	Resolution (m)
0-20	0.5
18-40	2

(Object Detection is rarely needed in depths greater than 30 meters).

Complete Multibeam Coverage

Depth Range (m)	Resolution (m)
0-20	1
18-40	2
35-80	4
75-160	8

Table B-1. Multibeam resolution requirements by depth and coverage type

Each resolution has its own CUBE parameter settings, and the hydrographer uses the appropriate resolution based CUBE parameters settings when computing each grid. CUBE parameters were distributed with the project instructions for each survey. CUBE parameters can be found in the 2012 Field Procedures Manual, Appendix 4.

B.5 Error Modeling in CARIS HIPS

CARIS computes TPU based on both the static and dynamic measurements of the vessel and survey-specific information including tidal zoning uncertainty estimates and sound speed measurement uncertainties. Offset values are entered into the CARIS *.hvf file. During processing, the tidal zoning and speed of sound measurement errors are applied. Where TCARI tides are used, uncertainty is calculated and applied during application of TCARI tidal correctors to HDCS data.

Tidal Uncertainty
-For surveys in project B363, tidal zoning was used and an uncertainty value of 0.102 meters was applied.
-For surveys in project E350, TCARI tides were used and no uncertainty value was applied manually during processing.
-For surveys in projects B340 and B370, Vdatum was used and an uncertainty value of 0.102 meters was applied.

For most surveys, tidal zoning values are provided with the Water Level Instructions, TPU parameters for tidal uncertainty are listed in each survey's Descriptive Report.

Sound Speed Uncertainty

TPU Parameters for sound speed uncertainties are documented in each survey's Descriptive Report.

Additional Uncertainties

Instrument-specific uncertainty values are obtained from either the CARIS TPU resource website or per HSD guidance. These uncertainty values are recorded in the Hips Vessel File (.hvf) for each vessel and sonar configuration. .hvf files used during the 2012 field season are included with as an attachment to this document in Appendix B.

B.6 Bathymetry Analysis and Feature Classification

Least depths of navigationally significant features are flagged as "designated soundings," which both identifies the object as a navigationally significant object for import into Pydro and forces the depth of the grid to match the least depth of the feature.

Following data cleaning in CARIS HIPS, Designated soundings and Side Scan contacts are inserted into a PYDRO Preliminary Smooth Sheet (PSS). DP and GP features are inserted using the "Generic Data Parser" tool. Images of contacts exported from CARIS are displayed in the Image Notebook Editor in PYDRO. Contacts are arranged by day and line and can be selected in the data "Tree" window. Information concerning a specific contact is reviewed in the Editor Notebook Window in PYDRO. This information includes contact positions; AWOIS item positions, contact cross references, and charting recommendations.

Contacts are classified according to type of contact (e.g. MBES, SSS, DP, etc), confidence, and proximity to other contacts. Although this will vary from survey to survey, the following general rules apply for classification of contacts:

- MBES contacts will be classified as primary contacts over SSS, DP, and GP contacts;
- If there are two or more MBES contacts for the same feature, the MBES contact of least depth is classified as the primary contact;
- If there is no bathymetry contact for a feature, then the SSS position will be classified as primary contact over DP and GP contacts;
- If there are two or more SSS contacts for the same feature, then the SSS contact that best represents the feature is classified as the primary contact;
- If there are no bathymetry or imagery contacts, then the DP contact that best represents the feature is classified as the primary contact.

Multiple representations of one distinct feature (e.g. contacts from two or more SSS lines on a known wreck) may be grouped. For a group of features, one representation is selected as the primary contact, and all others are selected as secondary contacts with respect to the primary contact.

Significant features are defined by the Hydrographic Survey Specifications and Deliverables as an object rising more than 1m above the seafloor in water depths of 0-20m, and an object rising 10% of depth above the seafloor in water depths greater than 20m. Either echosounder least depth or side-scan sonar acoustic shadow height may be used to determine height of an object off the water bottom.

Contacts appearing significant are further investigated with a MBES system capable of meeting NOAA object detection specifications. If there is no known least depth of good confidence on a significant feature, then the feature will be flagged as “Investigate.” Features with such a tag must be further developed, in order of preference, with multibeam echosounder, diver least depth gauge, or vertical beam echosounder.

Any items that are to be addressed in the Feature Report (Appendix II) of the Descriptive Report are flagged as “Report”. Examples of Report items include position of new or repositioned Aids to Navigation, permanent man-made features which do not pose a danger to surface navigation, or dynamic sedimentary bed forms which have not been previously noted on the chart. Items which have the “Report” flag set could also be further designated for inclusion in the Danger to Navigation Report by choosing the “DTON” flag. Dangers to Navigation are submitted to the Commanding Officer for review prior to submission to the Marine Charting Division (MCD).

After a feature is fully classified, primary features are flagged as “Resolved.” If a primary feature is flagged “Resolved,” then the secondary features correlated to that primary feature are automatically flagged “Resolved” and are given the same full classification as the primary feature.

CARIS BathyDataBase

For the 2012 field season, a new feature management procedure was implemented. This new procedure used BathyDataBase for all feature attribution, de-conflicting and reporting. Pydro was still used as an intermediary to extract designated soundings from bathymetry line data and place them in to a .000 file to be accessed from BathyDataBase.

B.7 Imagery

Side scan sonar data are converted from *.sdf (Sonarpro raw format) to CARIS HDCS. Processing side scan data includes examining and editing fish height, vessel heading (gyro), and vessel navigation records. When side scan sonar is towed, fish navigation is recalculated using CARIS SIPS. Tow point offsets (C-frame and cable out), fish depth, fish attitude, and water depth are used to calculate horizontal layback.

After towfish navigation is recalculated, side scan imagery data are slant-range corrected to 0.1m with beam pattern correction. The slant-range corrected side scan imagery data are closely examined for any targets. Targets-of-interest are evaluated as potential contacts based upon apparent shadow height and appearance, particularly targets which do not appear to be natural in origin. Contacts are selected and saved to a contact file for each line of SSS data. Contact selection includes measuring apparent height and width, selecting contact position, and creating a contact snapshot (*.tif) image.

Side scan sonar coverage is determined by creating mosaics using Mosaic Editor in CARIS SIPS. Mosaic Editor uses the accurately modeled backscatter correction algorithms of the Geocoder engine to process source data. This processed imagery data is stored in SIPS as Georeferenced Backscatter Rasters, or GeoBaRs. GeoBaRs are the basis for all mosaics created in SIPS. From the GeoBaRs, mosaics are created which can be examined and edited in Mosaic Editor. Once imagery has been corrected, a full mosaic can be compiled from the data. If any deficiencies in the side scan sonar data are found, a holiday line file is created from the mosaics and additional lines of SSS are acquired.

B.8 Survey Deliverables and Ancillary Product Generation

The ship's final bathymetric deliverables to the Atlantic Hydrographic Branch are a collection of BASE surfaces, the final feature file (FFF) .000, including S-57 feature classifications, the Descriptive Report, and side scan sonar mosaics (when applicable). The resolution of surfaces varies according to acquisition type specified in the Project Instructions.

C. Corrections to Echo Soundings

C.1 Sound Velocity

Sound speed data acquired by the surface sound velocity sensors on *THOMAS JEFFERSON* and *HSL 3101/3102* are recorded in the raw Hypack .hsx files and are used to calculate transmit and receive angles for the ray tracing algorithm. The surface sound velocity sensors are discussed in Section A and will not be discussed further in this section.

CTD Profiles

Sound velocity profiles for the *THOMAS JEFFERSON* and for Launches *3101* and *3102* are processed using the program HSTP Velocipy version 12.9 which generates sound velocity profiles for CARIS HIPS. Sound velocity correctors are applied to MBES and VBES soundings in CARIS HIPS during post processing only.

The speed of sound through water is determined by a minimum of one cast per week (although one per day is usually acquired) for VBES acquisition and one cast every three to four hours of MBES acquisition, in accordance with the NOS Hydrographic Surveys Specifications and Deliverables (HSSD). Casts are conducted more frequently when changing survey areas, or when environmental conditions such as changes in weather, tide, current, or significant spatial and/or temporal variation in the speed of sound is observed in the survey area that would warrant additional sound velocity profiles.

The sound velocity casts are extended automatically and applied to all bathymetric data in CARIS HIPS during post processing.

Brooke Ocean MVP

The SV data acquired by the MVP is transmitted to a raw SV file folder, where the hydrographer conducts a basic check of the data for correct day number, sound velocity data, and file format/integrity. The SV cast may also be graphically viewed and compared with other casts using the Sound Velocity vs. Depth graph in the MVP controller software.

Like CTD casts, MVP casts are processed and/or extended for use in CARIS HIPS using HSTP Velocipy.

C.2 Water Level Correctors

Zoned Tides

Soundings are initially reduced to Mean Lower-Low Water (MLLW) using preliminary (observed) water level data. Data may be obtained from the primary tide gauge through the Center for Operational Oceanographic Products and Services (CO-OPS) website. Observed water level files are converted to CARIS tide files (.tid) and/or text files and applied to all sounding data using either discrete tide zoning in CARIS HIPS or the TCARI module in Pydro. The type of water level correction used in a survey is specified in the Water Level Instructions, provided by CO-OPS.

When discrete tide zoning is specified in the Tide Note, THOMAS JEFFERSON personnel use verified water levels and final tide zoning from the Zone Definition File (ZDF) provided by CO-OPS for hydrographic product generation.

TCARI

Tidal Constituents and Residuals Interpolator (TCARI) grid files, when applicable, are submitted to THOMAS JEFFERSON as part of the Project Instruction package. A TCARI grid is computed using the shoreline, a limiting boundary, and the positions of two or more water level gauges. Harmonic constants, residual water levels, and gauge weights are interpolated for each grid point, using the data from the water level gauges as control points. Water level corrections are applied in Pydro using the TCARI tools found in Pydro. When using TCARI for datum reduction, water level corrections are not applied to echosounder data in CARIS. Following TCARI water level correction in Pydro, data is merged and processed as described in Section B.

Ellipsoid Referenced Surveys and VDATUM

ERS methods were required for all surveys in projects B340 and B370. For these surveys, processed SBETs, as described in Section A of this DAPR, are applied in CARIS Hips and Sips. First, the smoothed attitude and navigation are loaded by using the "Process-Load Attitude/Navigation data" option. Next, the error data is loaded by using the "Process-Load Error data" option. Once these steps have been completed successfully, the TPU must be recomputed and "Error Data" must be checked instead of "Vessel Settings". Following TPU computations, GPS Tide must be computed. This is accomplished by selecting the "Process-Compute GPS Tide" option and loading the .csv separation model. This separation model is either included with the project instructions, or generated by the field unit by utilizing the VDATUM tool built into Pydro. Once created, the .csv file contains a node by node offset between the ellipsoid and MLLW. If no model is applied, and the height offset is left at 0.0, then all soundings remain referenced to the ellipsoid. However, since the current guidance from the Office of Coast Survey is to reduce all soundings to MLLW, a .csv model shall be used when computing GPS Tide. The final step is to Merge the data and apply the GPS Tide computed in the previous step.

C.3 Multibeam Calibration Procedures

Heave, pitch, roll, yaw, and navigation latency biases for each vessel are corrected during a multibeam bias calibration test (patch test). MBES vessel offsets, dynamic draft correctors, and system bias values are contained in HIPS Vessel Files (HVFs). These offsets and biases are applied to the sounding data during processing in CARIS HIPS. A Patch Test or verification of certain biases is typically performed at the start of each field season and re-verified for each project before acquiring MBES data in the new survey area. Calibration reports are generated for initial calibrations at the beginning of the field season, but reports are not necessarily generated for each project when values are re-verified. Small changes in the roll bias are common, but also are not necessarily documented by official reports. Changes in .HVFs not accompanied by full calibration reports are instead documented in the comments column of the HVF entry by the date in which the change took effect. HVF files are submitted with this document under Appendix B.

C.4 Vessel Offsets, Static Draft, and Dynamic Draft Correctors

A partial re-survey of *THOMAS JEFFERSON* vessel offsets was conducted on 10 March 2005 by NGS personnel, and no physical changes in offsets have occurred since then.

Coordinate (direction)	NGS Values
X (fore and aft)	-10.282
Y (port and starboard)	1.356
Z (vertical)	-22.320

Table C-1. IMU to Primary GPS antenna offsets for *Thomas Jefferson*

Preliminary static draft measurements are made at the beginning of each leg and weekly thereafter. Static draft for *THOMAS JEFFERSON* is measured using a sight tube located in lower survey stores in the vicinity of frame 33. Additional static draft measurements are made as needed with changing conditions, such as changes in the ship's ballasting or loading. Lower survey stores is not vented to the atmosphere, and as a result, air pressure inside the ship can introduce an error in static draft measurements. As a result, a value of 0.1m was entered into the CARIS HVF as the uncertainty for static draft for the ship.

3101
Vessel offset measurements were made on *HSL 3101* on January 13, 2010 by NGS personnel. The NGS survey measured from established benchmarks on the vessel back to the reference point, in this case, the cross hairs on top of the IMU. From the surveyed benchmarks, the new RESON 7125SV, SSVS, and Odom CV200 installation offsets were measured using a steel tape. The Klein 5000 side scan was surveyed in a similar manner and offsets for the "heavy weight" and "light weight" systems were recorded.

Static draft measurements for HSL 3101 and HSL 3102 are determined using a sight tube to measure the waterline with respect to the reference point on the top of the IMU. These measurements are made during each patch test.

3102
Vessel offset measurements were also made on *HSL 3102* on January 13, 2010 by NGS personnel. The NGS survey measured from established benchmarks on the vessel back to the reference point on top of the IMU in the same manner as the survey of HSL 3101. From the surveyed benchmarks, the new RESON 7125SV, SSVS, and Odom CV200 installation offsets were measured using a steel tape. The Klein 5000 side scan was surveyed in a similar manner and offsets for the "heavy weight" and "light weight" systems were recorded.

Dynamic Draft

The *Thomas Jefferson* utilized an Elipsoid Referenced Survey (ERS) method for measuring dynamic draft for the ship, HSL 3101, and HSL 3102. This method has been termed Ellipsoid Referenced Dynamic Draft Measurement (ERDDM). Post-processed Smoothed Best Estimate Trajectory (SBET) altitude heights with respect to the ellipsoid were created in POSPac MMS 6.0 and used to measure dynamic draft.

The ERDDM was conducted by acquiring POSPac data while acquiring survey lines for the Echosounder method. The Echosounder method was modified slightly to provide additional drift values to isolate the effects of tide. This was achieved by going all stop at the end of each line and drifting dead in the water for 1 – 3 minutes. These all stop values provided visual break points for reference in the continuous POSPac data that was logged for the duration of survey operations for the day. During the ERDDM for HSL 3101, at rest periods were not acquired at the end of some of the lines. In these instances, vessel heading was used for visual break points in the POSPac data.

POSPac data was processed in POSPac MMS 5.3 and an SBET file was created. The vessel speed and the altitude plots were examined and data corresponding to the lines described in the Echosounder method above were exported into a spreadsheet and analyzed. The average vessel speed for each line and the average difference between at speed altitudes and at rest altitudes were computed and used to create a dynamic draft table.

APPROVAL SHEET

This Data Acquisition and Processing Report is respectfully submitted for the following projects:

OPR-E350-TJ-12, Southern Chesapeake Bay, VA
OPR-B340-TJ-12, Long Island Sound, NY
OPR-B370-TJ-12, Eastern Long Island Sound, NY
OPR-B363-TJ-12, Block Island Sound, RI
S-B935-TJ-12, NY Harbor and Vicinity Response

As Chief of Party, I have ensured that standard field surveying and processing procedures were adhered to during these projects in accordance with the Hydrographic Surveys Specifications and Deliverables (**4/2012**), Hydrographic Survey Technical Directives **HTD 2012-5**, and the Field Procedures Manual for Hydrographic Surveying (**4/2012**,).

I acknowledge that all of the information contained in this report is complete and accurate to the best of my knowledge.

This DAPR applies to all surveys completed in 2012 for the projects listed above.

Approved and Forwarded:

LT William G. Winner, NOAA
Field Operations Officer

CDR Lawrence T. Krepp, NOAA
Commanding Officer

Multibeam Echosounder Calibration

Field Unit: NOAA Ship THOMAS JEFFERSON

Date of Test: 3 Apr 2012

Calibrating Hydrographer(s): LT Winner

MULTIBEAM SYSTEM INFORMATION

Multibeam Echosounder System: Reson 7125 SV1 400 kHz 512 beams

System Location: 3101

Sonar Serial Number: Rx: 1409071; Tx 400: 2308097; Tx 200: 4408356

Processing Unit Serial Number: 1812018

Date of Most Recent EED / Factory Checkout:

VESSEL INFORMATION

Sonar Mounting Configuration: hull-mounted

Date of Current Vessel Offset Measurement / Verification:

Description of Positioning System: POS/MV version 4 w/ Precise Timing

Date of Most Recent Positioning System Calibration:

TEST INFORMATION

Test Date(s) / DN(s): 3 Apr 2012; 094

System Operator(s): HST Glomb

Wind / Seas / Sky:

Locality: Chesapeake Bay

Sub-Locality: Cape Charles

Bottom Type: sandy

Approximate Average Water Depth: 13 meters

DATA ACQUISITION INFORMATION

Line Number	Heading	Speed
400_1706	0	4
400_1711	180	4.4
401_1715	0	4
401_1719	180	4.3
402_1723	0	4.1
402_1728	180	4.3
403_1735	270	2.2
403_1741	270	4.2

TEST RESULTS
Navigation Timing Error: 0.00
Pitch Timing Error:0.00
Roll Timing Error: 0.00
Pitch Bias: 1.33
Roll Bias: -0.44
Heading Bias: 0.97
Resulting CARIS HIPS HVF File Name: TJ_3101_Reson7125_400kHz

NARRATIVE
Values match closesly with last year's values. Yaw lines did not overlap the object, so other lines had to be used.

Multibeam Echosounder Calibration

Field Unit: NOAA Ship THOMAS JEFFERSON

Date of Test: 4 Apr 2012

Calibrating Hydrographer(s): LT Winner

MULTIBEAM SYSTEM INFORMATION

Multibeam Echosounder System: 7125 SV1 400 kHz 512 beams

System Location: 3102

Sonar Serial Number: Rx: 0309006; Tx 400: 2208005; Tx 200: 2909185

Processing Unit Serial Number: 1812012

Date of Most Recent EED / Factory Checkout:

VESSEL INFORMATION

Sonar Mounting Configuration: hull-mounted

Date of Current Vessel Offset Measurement / Verification: Jan 2011

Description of Positioning System: POS/MV version 4 w/ Precise Timing

Date of Most Recent Positioning System Calibration:

TEST INFORMATION

Test Date(s) / DN(s): 4 APR 2012; 095

System Operator(s): HST Glomb

Wind / Seas / Sky:

Locality: Chesapeake Bay

Sub-Locality: Cape Charles

Bottom Type: sandy

Approximate Average Water Depth: 13 meters

DATA ACQUISITION INFORMATION

Line Number	Heading	Speed
400_1320	180	4.2
400_1324	0	4.2
401_1327	180	4.2
401_1330	0	4.3
402_1334	180	4.1
402_1338	0	4.5
403_1344	270	2.4
403_1349	270	4.7

TEST RESULTS

Navigation Timing Error: 0.00

Pitch Timing Error:0.00

Roll Timing Error: 0.00

Pitch Bias: 0.37

Roll Bias: -0.94

Heading Bias: -1.4

Resulting CARIS HIPS HVF File Name: TJ_3102_Reson7125_400kHz.hvf

NARRATIVE

Values match closesly with last year's values. Yaw lines did not overlap the object, so other lines had to be used.

SBE SEA-BIRD ELECTRONICS, INC.
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Temperature Calibration Report

Customer:	Atlantic Marine Center		
Job Number:	66950	**Date of Report:**	12/14/2011
Model Number:	SBE 19	**Serial Number:**	192472-0285

Temperature sensors are normally calibrated 'as received', without adjustments, allowing a determination sensor drift. If the calibration identifies a problem, then a second calibration is performed after work is completed. The 'as received' calibration is not performed if the sensor is damaged or non-functional, or by customer request.

An 'as received' calibration certificate is provided, listing coefficients to convert sensor frequency to temperature. Users must choose whether the 'as received' calibration or the previous calibration better represents the sensor condition during deployment. In SEASOFT enter the chosen coefficients. The coefficient 'offset' allows a small correction for drift between calibrations (consult the SEASOFT manual). Calibration coefficients obtained after a repair apply only to subsequent data.

'AS RECEIVED CALIBRATION' ☑ Performed ☐ Not Performed

Date: 12/14/2011 Drift since last cal: -0.00095 Degrees Celsius/year

Comments:

'CALIBRATION AFTER REPAIR' ☐ Performed ☑ Not Performed

Date: Drift since Last cal: Degrees Celsius/year

Comments:

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Conductivity Calibration Report

Customer:	Atlantic Marine Center		
Job Number:	66950	**Date of Report:**	12/14/2011
Model Number:	SBE 19	**Serial Number:**	192472-0285

Conductivity sensors are normally calibrated 'as received', without cleaning or adjustments, allowing a determination of sensor drift. If the calibration identifies a problem or indicates cell cleaning is necessary, then a second calibration is performed after work is completed. The 'as received' calibration is not performed if the sensor is damaged or non-functional, or by customer request.

An 'as received' calibration certificate is provided, listing the coefficients used to convert sensor frequency to conductivity. Users must choose whether the 'as received' calibration or the previous calibration better represents the sensor condition during deployment. In SEASOFT enter the chosen coefficients. The coefficient 'slope' allows small corrections for drift between calibrations (consult the SEASOFT manual). Calibration coefficients obtained after a repair or cleaning apply only to subsequent data.

'AS RECEIVED CALIBRATION' ☑ Performed ☐ Not Performed

Date: 12/14/2011 Drift since last cal: -0.00120 PSU/month*

Comments:

'CALIBRATION AFTER CLEANING & REPLATINIZING' ☐ Performed ☑ Not Performed

Date: Drift since Last cal: PSU/month*

Comments:

**Measured at 3.0 S/m*

Cell cleaning and electrode replatinizing tend to 'reset' the conductivity sensor to its original condition. Lack of drift in post-cleaning-calibration indicates geometric stability of the cell and electrical stability of the sensor circuit.

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SENSOR SERIAL NUMBER: 0285
CALIBRATION DATE: 14-Dec-11

SBE19 TEMPERATURE CALIBRATION DATA
ITS-90 TEMPERATURE SCALE

ITS-90 COEFFICIENTS
g = 4.12500315e-003
h = 5.75194956e-004
i = -1.00004252e-006
j = -3.14777854e-006
f0 = 1000.0

IPTS-68 COEFFICIENTS
a = 3.64764105e-003
b = 5.70460005e-004
c = 6.87852369e-006
d = -3.14771798e-006
f0 = 2297.577

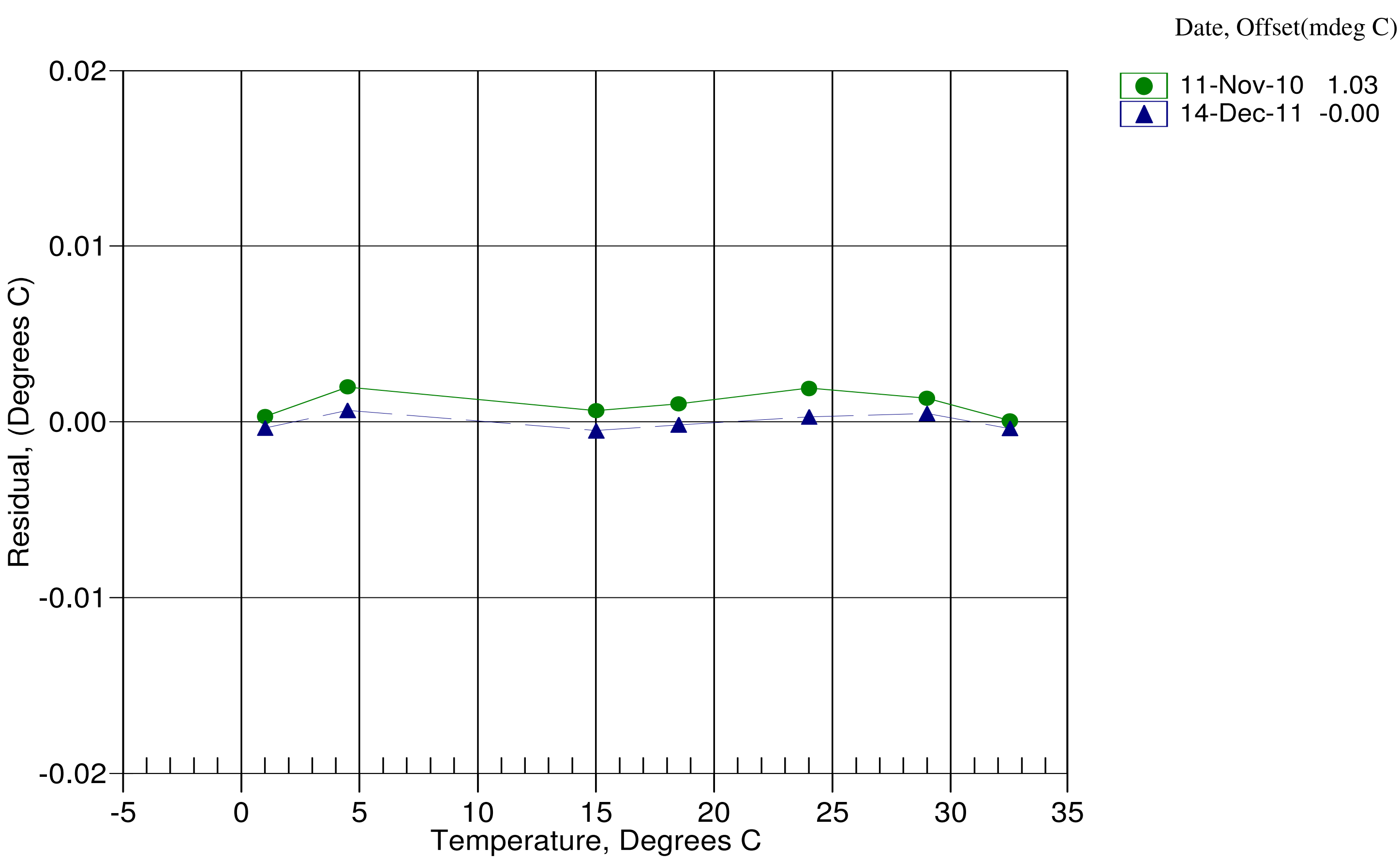
BATH TEMP (ITS-90)	INSTRUMENT FREQ (Hz)	INST TEMP (ITS-90)	RESIDUAL (ITS-90)
0.9999	2297.577	0.9995	-0.00036
4.5000	2490.753	4.5007	0.00065
15.0000	3139.098	14.9995	-0.00049
18.5000	3379.524	18.4998	-0.00017
23.9999	3783.259	24.0002	0.00027
29.0000	4178.885	29.0005	0.00047
32.5000	4472.560	32.4996	-0.00038

Temperature ITS-90 = $1/\{g + h[ln(f_0/f)] + i[ln^2(f_0/f)] + j[ln^3(f_0/f)]\} - 273.15$ (°C)

Temperature IPTS-68 = $1/\{a + b[ln(f_0/f)] + c[ln^2(f_0/f)] + d[ln^3(f_0/f)]\} - 273.15$ (°C)

Following the recommendation of JPOTS: T_{68} is assumed to be 1.00024 * T_{90} (-2 to 35 °C)

Residual = instrument temperature - bath temperature



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SENSOR SERIAL NUMBER: 0285
CALIBRATION DATE: 03-Jan-12

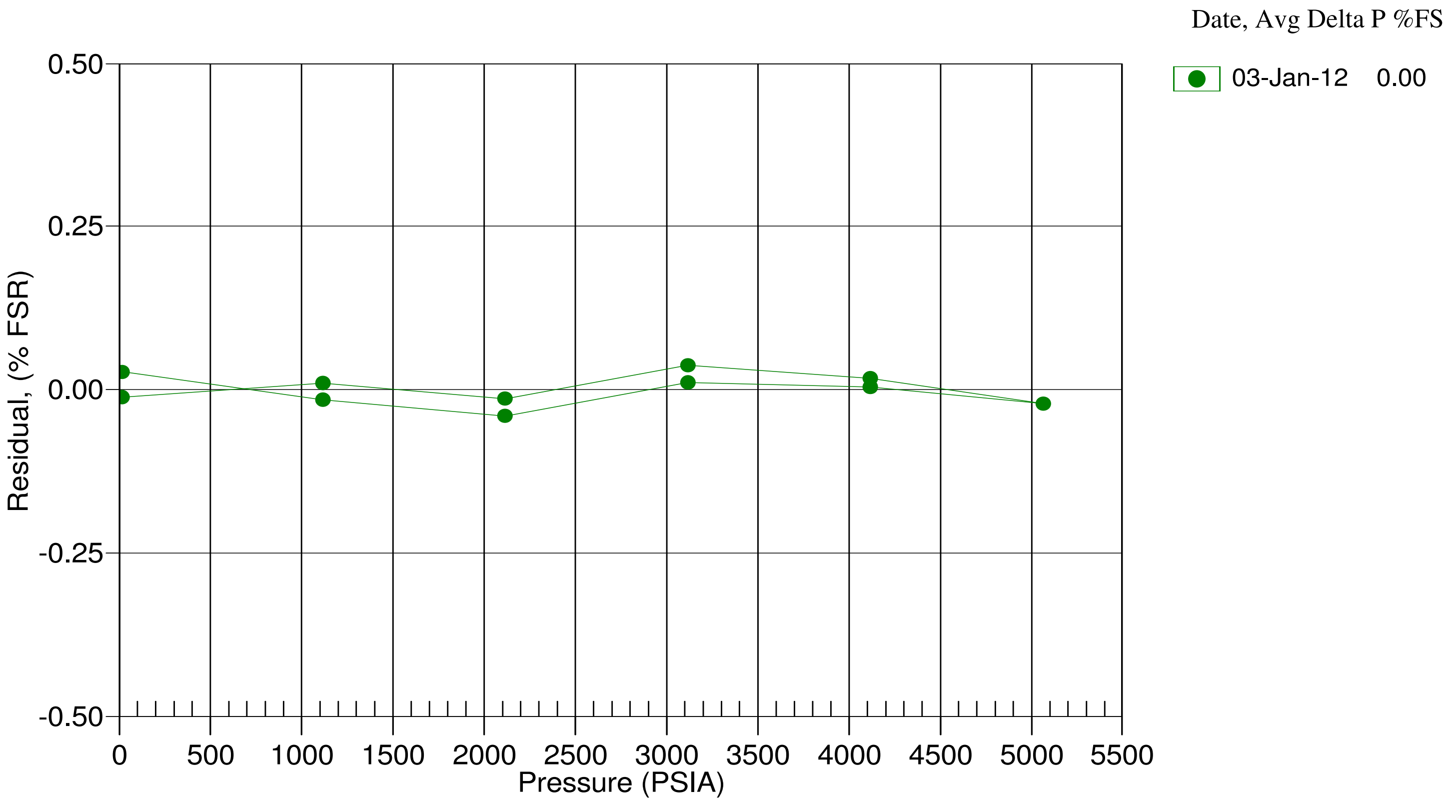
SBE19 PRESSURE CALIBRATION DATA
5000 psia S/N 133807 TCV: -121

QUADRATIC COEFFICIENTS:
PA0 = 2.491586e+003
PA1 = -6.501956e-001
PA2 = -5.844651e-008

STRAIGHT LINE FIT:
M = -6.502140e-001
B = 2.491225e+003

PRESSURE PSIA	INST OUTPUT(N)	COMPUTED PSIA	ERROR %FS	LINEAR PSIA	ERROR %FS
14.75	3806.0	16.09	0.03	16.51	0.04
1115.01	2118.0	1114.21	-0.02	1114.07	-0.02
2115.18	582.0	2113.15	-0.04	2112.80	-0.05
3115.20	-960.0	3115.72	0.01	3115.43	0.00
4115.23	-2498.0	4115.41	0.00	4115.46	0.00
5065.23	-3958.0	5064.14	-0.02	5064.77	-0.01
4115.21	-2499.0	4116.06	0.02	4116.11	0.02
3115.17	-962.0	3117.02	0.04	3116.73	0.03
2115.17	580.0	2114.45	-0.01	2114.10	-0.02
1115.03	2116.0	1115.51	0.01	1115.37	0.01
14.75	3809.0	14.14	-0.01	14.56	-0.00

Straight Line Fit:
Pressure (psia) = M * N + B (N = binary output)
Quadratic Fit:
pressure (psia) = PA0 + PA1 * N + PA2 * N^2
Residual = (instrument pressure - true pressure) * 100 / Full Scale Range



CTD - 0285, S222

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SENSOR SERIAL NUMBER: 0285
CALIBRATION DATE: 14-Dec-11

SBE19 CONDUCTIVITY CALIBRATION DATA
PSS 1978: C(35,15,0) = 4.2914 Seimens/meter

GHIJ COEFFICIENTS

```
g = -4.08457931e+000
h =  4.87502825e-001
i =  1.10067345e-003
j = -1.77211107e-005
CPcor = -9.5700e-008 (nominal)
CTcor =  3.2500e-006 (nominal)
```

ABCDM COEFFICIENTS

```
a =  7.52840059e-003
b =  4.77680955e-001
c = -4.07135887e+000
d = -9.32378835e-005
m =  2.4
CPcor = -9.5700e-008 (nominal)
```

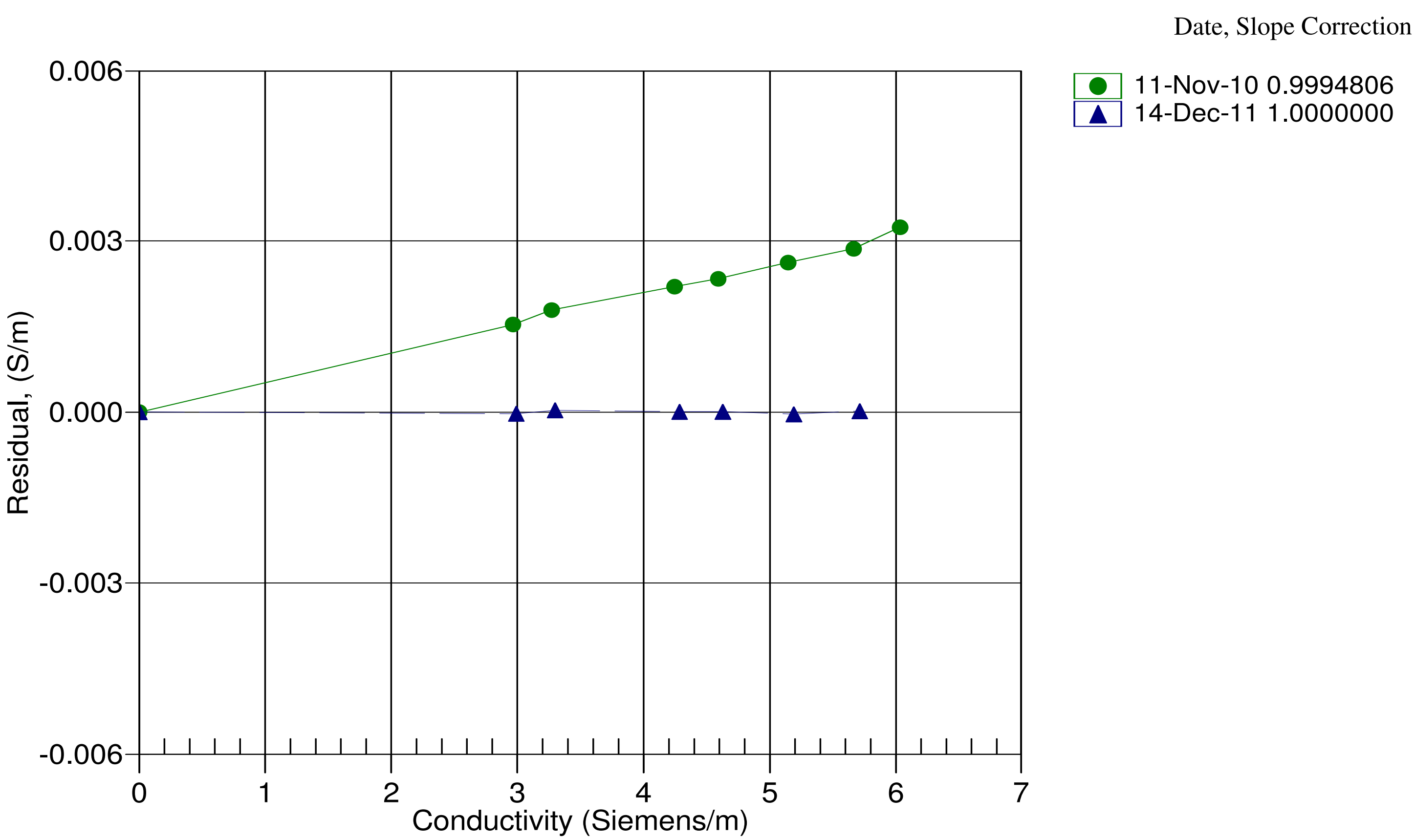
BATH TEMP (ITS-90)	BATH SAL (PSU)	BATH COND (Siemens/m)	INST FREQ (kHz)	INST COND (Siemens/m)	RESIDUAL (Siemens/m)
22.0000	0.0000	0.00000	2.88563	0.00000	0.00000
0.9999	34.9717	2.98797	8.28002	2.98794	-0.00003
4.5000	34.9512	3.29619	8.64513	3.29622	0.00003
15.0000	34.9072	4.28158	9.71912	4.28159	0.00001
18.5000	34.8971	4.62793	10.06899	4.62793	0.00001
23.9999	34.8858	5.18781	10.60972	5.18777	-0.00004
29.0000	34.8780	5.71128	11.09115	5.71130	0.00002

Conductivity = $(g + hf^2 + if^3 + jf^4) / 10(1 + \delta t + \varepsilon p)$ Siemens/meter

Conductivity = $(af^m + bf^2 + c + dt) / [10 (1 + \varepsilon p)$ Siemens/meter

t = temperature[°C)]; p = pressure[decibars]; δ = CTcor; ε = CPcor;

Residual = (instrument conductivity - bath conductivity) using g, h, i, j coefficients



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Temperature Calibration Report

Customer:	Atlantic Marine Center		
Job Number:	66950	**Date of Report:**	12/14/2011
Model Number:	SBE 19Plus	**Serial Number:**	19P33589-4486

Temperature sensors are normally calibrated 'as received', without adjustments, allowing a determination sensor drift. If the calibration identifies a problem, then a second calibration is performed after work is completed. The 'as received' calibration is not performed if the sensor is damaged or non-functional, or by customer request.

An 'as received' calibration certificate is provided, listing coefficients to convert sensor frequency to temperature. Users must choose whether the 'as received' calibration or the previous calibration better represents the sensor condition during deployment. In SEASOFT enter the chosen coefficients. The coefficient 'offset' allows a small correction for drift between calibrations (consult the SEASOFT manual). Calibration coefficients obtained after a repair apply only to subsequent data.

'AS RECEIVED CALIBRATION' ☑ Performed ☐ Not Performed

Date: 12/14/2011 Drift since last cal: -0.00030 Degrees Celsius/year

Comments:

'CALIBRATION AFTER REPAIR' ☐ Performed ☑ Not Performed

Date: Drift since Last cal: Degrees Celsius/year

Comments:

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Conductivity Calibration Report

Customer:	Atlantic Marine Center		
Job Number:	66950	**Date of Report:**	12/14/2011
Model Number:	SBE 19Plus	**Serial Number:**	19P33589-4486

Conductivity sensors are normally calibrated 'as received', without cleaning or adjustments, allowing a determination of sensor drift. If the calibration identifies a problem or indicates cell cleaning is necessary, then a second calibration is performed after work is completed. The 'as received' calibration is not performed if the sensor is damaged or non-functional, or by customer request.

An 'as received' calibration certificate is provided, listing the coefficients used to convert sensor frequency to conductivity. Users must choose whether the 'as received' calibration or the previous calibration better represents the sensor condition during deployment. In SEASOFT enter the chosen coefficients. The coefficient 'slope' allows small corrections for drift between calibrations (consult the SEASOFT manual). Calibration coefficients obtained after a repair or cleaning apply only to subsequent data.

'AS RECEIVED CALIBRATION' ☑ Performed ☐ Not Performed

Date: 12/14/2011 Drift since last cal: -0.00020 PSU/month*

Comments:

'CALIBRATION AFTER CLEANING & REPLATINIZING' ☐ Performed ☑ Not Performed

Date: Drift since Last cal: PSU/month*

Comments:

**Measured at 3.0 S/m*

Cell cleaning and electrode replatinizing tend to 'reset' the conductivity sensor to its original condition. Lack of drift in post-cleaning-calibration indicates geometric stability of the cell and electrical stability of the sensor circuit.

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SENSOR SERIAL NUMBER: 4486
CALIBRATION DATE: 14-Dec-11

SBE19plus TEMPERATURE CALIBRATION DATA
ITS-90 TEMPERATURE SCALE

ITS-90 COEFFICIENTS
a0 = 1.275141e-003
a1 = 2.593836e-004
a2 = 3.412295e-007
a3 = 1.367993e-007

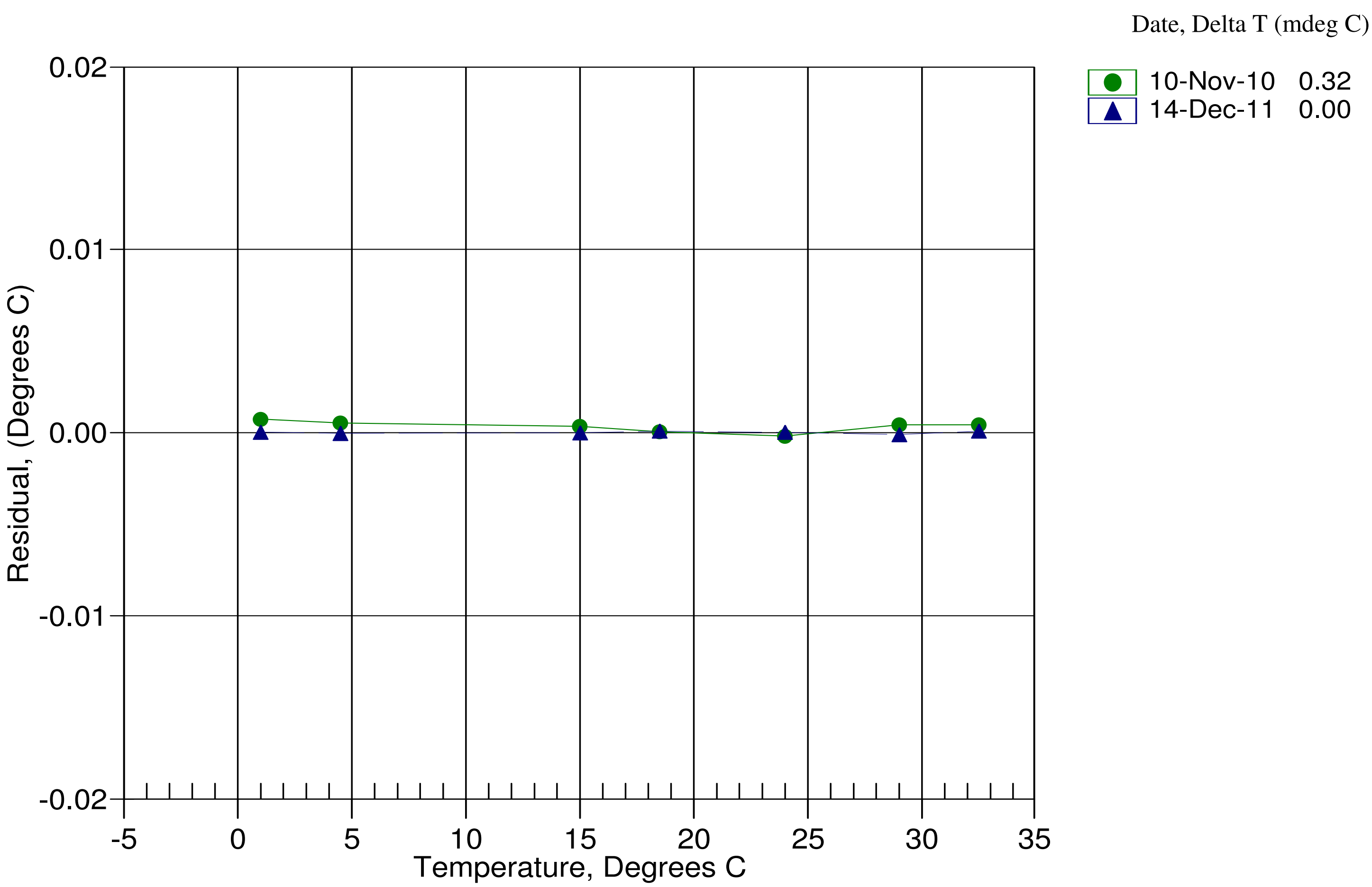
BATH TEMP (ITS-90)	INSTRUMENT OUTPUT(n)	INST TEMP (ITS-90)	RESIDUAL (ITS-90)
0.9999	604355.583	0.9999	0.0000
4.5000	535781.867	4.5000	-0.0000
15.0000	366318.467	15.0000	-0.0000
18.5000	320996.770	18.5001	0.0001
23.9999	259598.117	23.9999	0.0000
29.0000	212961.533	28.9999	-0.0001
32.5000	184834.656	32.5001	0.0001

MV = (n - 524288) / 1.6e+007

R = (MV * 2.900e+009 + 1.024e+008) / (2.048e+004 - MV * 2.0e+005)

Temperature ITS-90 = $1/\{a0 + a1[ln(R)] + a2[ln^2(R)] + a3[ln^3(R)]\} - 273.15$ (°C)

Residual = instrument temperature - bath temperature



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SENSOR SERIAL NUMBER: 4486
CALIBRATION DATE: 09-Dec-11

SBE19plus PRESSURE CALIBRATION DATA
508 psia S/N 2799

COEFFICIENTS:

```
PA0 =     2.017286e-002
PA1 =     1.549533e-003
PA2 =     7.596469e-012
PTEMPA0 = -7.556904e+001
PTEMPA1 =  4.833845e+001
PTEMPA2 = -2.487770e-001
PTCA0 =   5.246207e+005
PTCA1 =   2.799682e+000
PTCA2 =  -1.050025e-001
PTCB0 =   2.468737e+001
PTCB1 =  -7.250000e-004
PTCB2 =   0.000000e+000
```

PRESSURE SPAN CALIBRATION

PRESSURE PSIA	INST OUTPUT	THERMISTOR OUTPUT	COMPUTED PRESSURE	ERROR %FSR
14.72	534117.0	2.0	14.73	0.00
104.99	592298.0	2.0	104.97	-0.00
204.97	656708.0	2.0	204.94	-0.01
304.96	721100.0	2.0	304.94	-0.00
404.97	785446.0	2.0	404.94	-0.01
504.96	849768.0	2.0	504.96	-0.00
404.97	785478.0	2.0	404.99	0.00
304.97	721144.0	2.0	305.01	0.01
204.99	656749.0	2.0	205.01	0.00
105.03	592333.0	2.0	105.03	-0.00
14.71	534112.0	2.0	14.72	0.00

THERMAL CORRECTION

TEMP ITS90	THERMISTOR OUTPUT	INST OUTPUT
32.50	2.26	534254.28
29.00	2.19	534271.06
24.00	2.08	534281.78
18.50	1.97	534291.91
15.00	1.89	534293.49
4.50	1.67	534285.87
1.00	1.60	534278.85

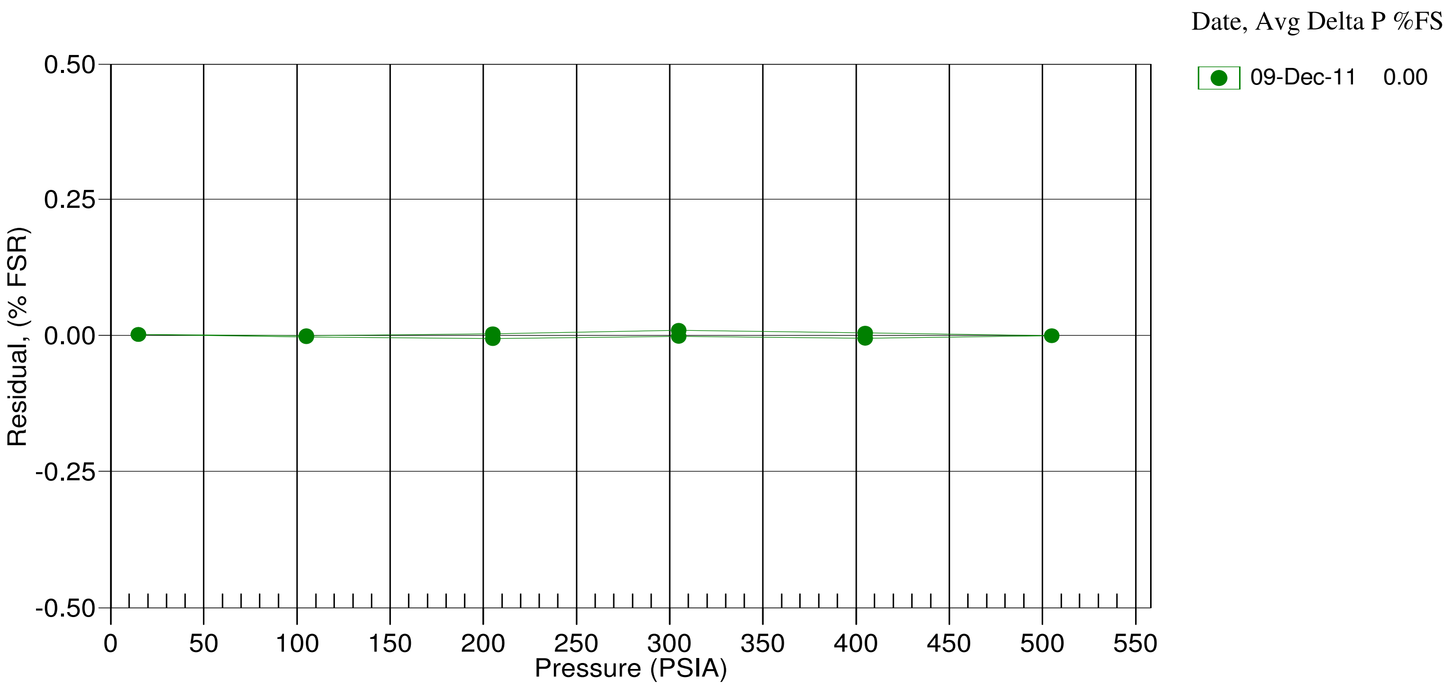
TEMP(ITS90)	SPAN(mV)
-5.00	24.69
35.00	24.66

y = thermistor output; $t = PTEMPA0 + PTEMPA1 * y + PTEMPA2 * y^2$

x = pressure output - $PTCA0 - PTCA1 * t - PTCA2 * t^2$

$n = x * PTCB0 / (PTCB0 + PTCB1 * t + PTCB2 * t^2)$

pressure (psia) = $PA0 + PA1 * n + PA2 * n^2$



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SENSOR SERIAL NUMBER: 4486
CALIBRATION DATE: 14-Dec-11

SBE19plus CONDUCTIVITY CALIBRATION DATA
PSS 1978: C(35,15,0) = 4.2914 Siemens/meter

COEFFICIENTS:

g = -1.029827e+000
h = 1.436052e-001
i = -2.467991e-004
j = 3.934339e-005

CPcor = -9.5700e-008
CTcor = 3.2500e-006

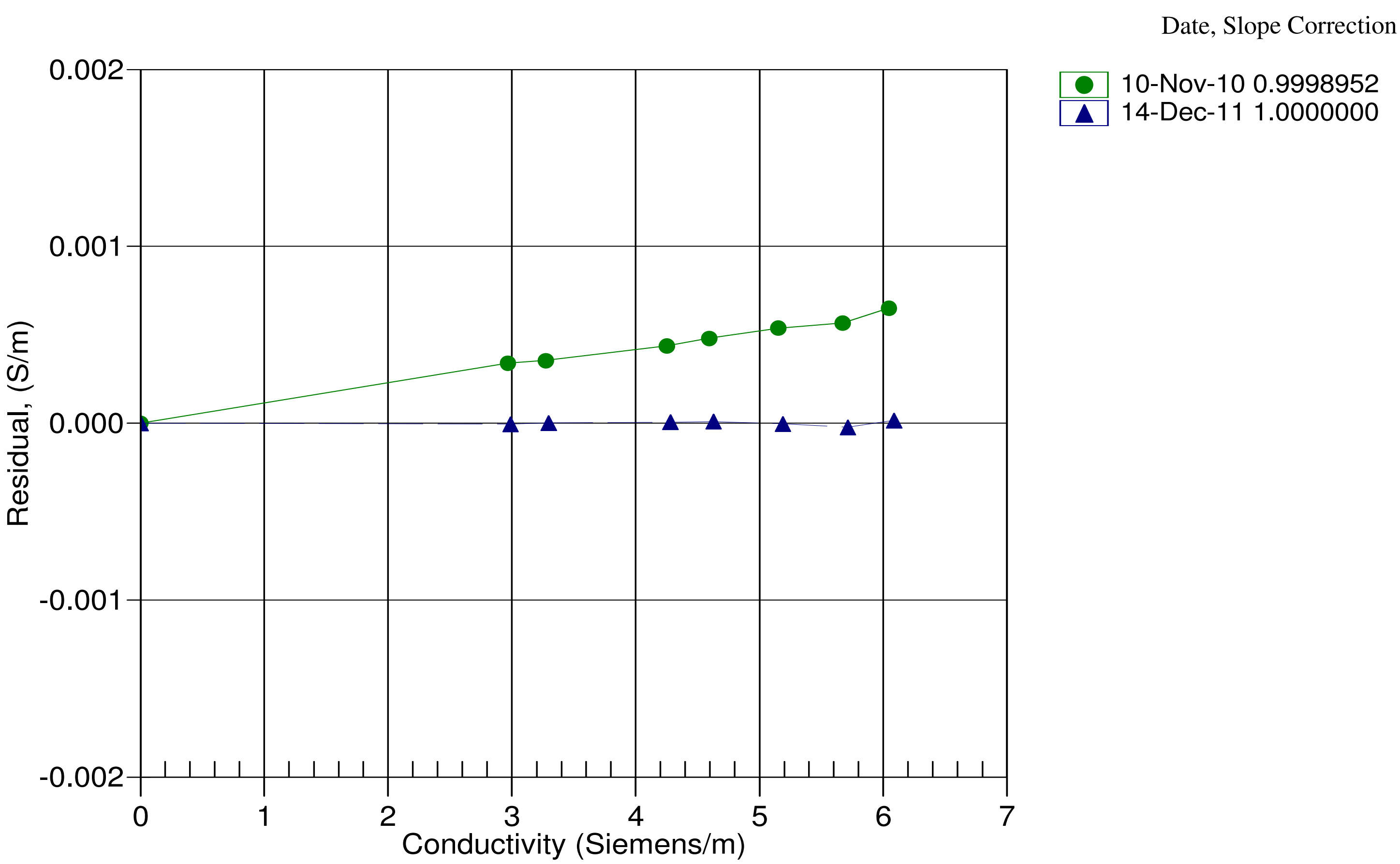
BATH TEMP (ITS-90)	BATH SAL (PSU)	BATH COND (Siemens/m)	INST FREQ (Hz)	INST COND (Siemens/m)	RESIDUAL (Siemens/m)
22.0000	0.0000	0.00000	2681.46	0.0000	0.00000
0.9999	34.9717	2.98797	5293.19	2.9880	-0.00001
4.5000	34.9512	3.29619	5491.83	3.2962	0.00000
15.0000	34.9072	4.28158	6082.71	4.2816	0.00000
18.5000	34.8971	4.62793	6276.92	4.6279	0.00001
23.9999	34.8858	5.18781	6578.43	5.1878	-0.00000
29.0000	34.8780	5.71128	6847.99	5.7113	-0.00002
32.5000	34.8714	6.08451	7033.70	6.0845	0.00002

f = INST FREQ / 1000.0

Conductivity = $(g + hf^2 + if^3 + jf^4) / (1 + \delta t + \varepsilon p)$ Siemens/meter

t = temperature[°C)]; p = pressure[decibars]; δ = CTcor; ε = CPcor;

Residual = instrument conductivity - bath conductivity



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Temperature Calibration Report

Customer:	Atlantic Marine Center		
Job Number:	66950	**Date of Report:**	12/14/2011
Model Number:	SBE 19Plus	**Serial Number:**	19P33589-4487

Temperature sensors are normally calibrated 'as received', without adjustments, allowing a determination sensor drift. If the calibration identifies a problem, then a second calibration is performed after work is completed. The 'as received' calibration is not performed if the sensor is damaged or non-functional, or by customer request.

An 'as received' calibration certificate is provided, listing coefficients to convert sensor frequency to temperature. Users must choose whether the 'as received' calibration or the previous calibration better represents the sensor condition during deployment. In SEASOFT enter the chosen coefficients. The coefficient 'offset' allows a small correction for drift between calibrations (consult the SEASOFT manual). Calibration coefficients obtained after a repair apply only to subsequent data.

'AS RECEIVED CALIBRATION' ☑ Performed ☐ Not Performed

Date: 12/14/2011 Drift since last cal: -0.00007 Degrees Celsius/year

Comments:

'CALIBRATION AFTER REPAIR' ☐ Performed ☑ Not Performed

Date: Drift since Last cal: Degrees Celsius/year

Comments:

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Conductivity Calibration Report

Customer:	Atlantic Marine Center		
Job Number:	66950	**Date of Report:**	12/14/2011
Model Number:	SBE 19Plus	**Serial Number:**	19P33589-4487

Conductivity sensors are normally calibrated 'as received', without cleaning or adjustments, allowing a determination of sensor drift. If the calibration identifies a problem or indicates cell cleaning is necessary, then a second calibration is performed after work is completed. The 'as received' calibration is not performed if the sensor is damaged or non-functional, or by customer request.

An 'as received' calibration certificate is provided, listing the coefficients used to convert sensor frequency to conductivity. Users must choose whether the 'as received' calibration or the previous calibration better represents the sensor condition during deployment. In SEASOFT enter the chosen coefficients. The coefficient 'slope' allows small corrections for drift between calibrations (consult the SEASOFT manual). Calibration coefficients obtained after a repair or cleaning apply only to subsequent data.

'AS RECEIVED CALIBRATION' ☑ Performed ☐ Not Performed

Date: 12/14/2011 Drift since last cal: +0.00020 PSU/month*

Comments:

'CALIBRATION AFTER CLEANING & REPLATINIZING' ☐ Performed ☑ Not Performed

Date: Drift since Last cal: PSU/month*

Comments:

****Measured at 3.0 S/m***

Cell cleaning and electrode replatinizing tend to 'reset' the conductivity sensor to its original condition. Lack of drift in post-cleaning-calibration indicates geometric stability of the cell and electrical stability of the sensor circuit.

Sea-Bird Electronics, Inc.

13431 NE 20th Street, Bellevue, WA 98005-2010 USA

Phone: (+1) 425-643-9866 Fax (+1) 425-643-9954 Email: seabird@seabird.com

SENSOR SERIAL NUMBER: 4487
CALIBRATION DATE: 14-Dec-11

SBE19plus TEMPERATURE CALIBRATION DATA
ITS-90 TEMPERATURE SCALE

ITS-90 COEFFICIENTS

a0 = 1.208646e-003
a1 = 2.630433e-004
a2 = -2.424026e-007
a3 = 1.540871e-007

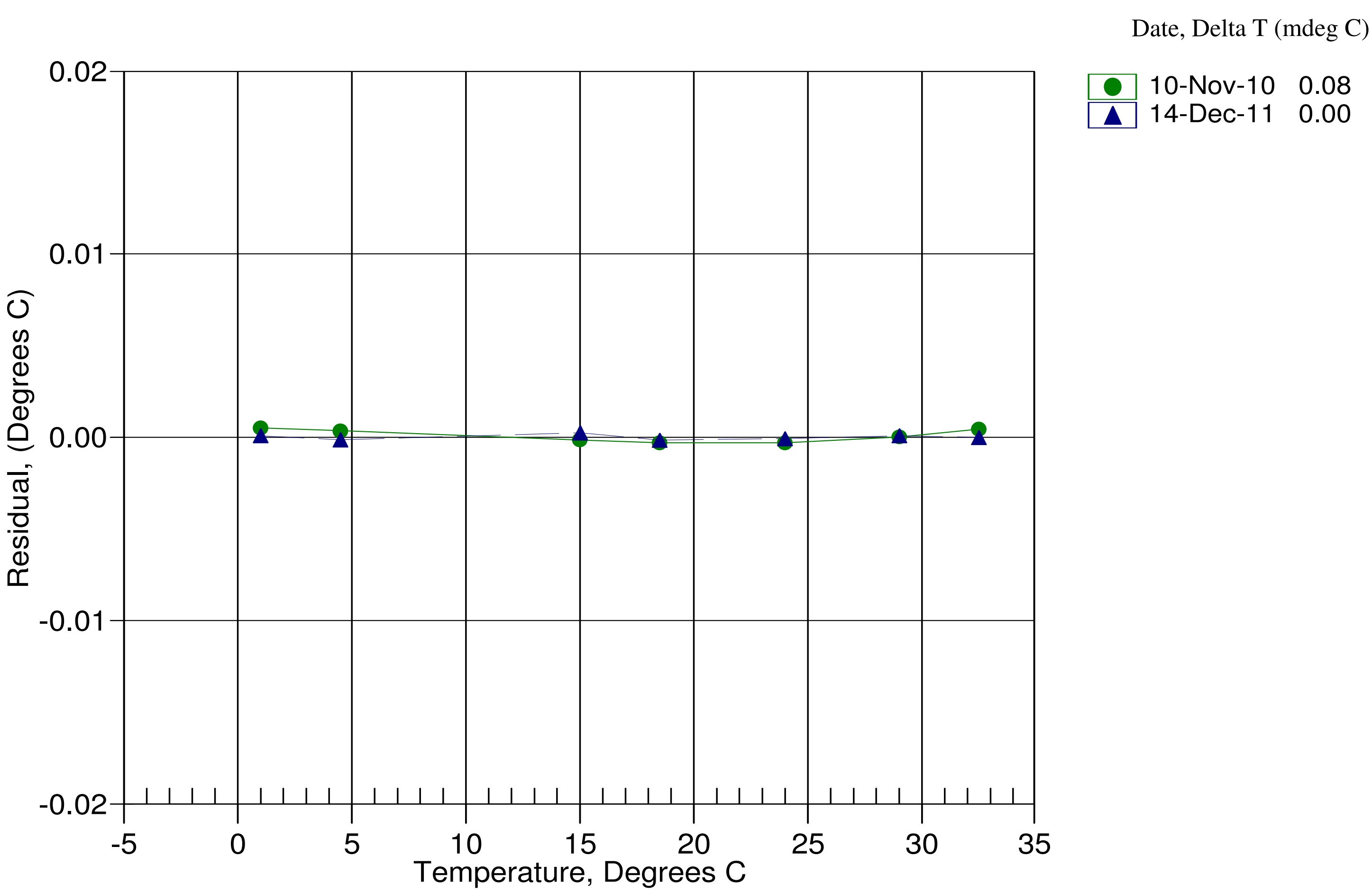
BATH TEMP (ITS-90)	INSTRUMENT OUTPUT(n)	INST TEMP (ITS-90)	RESIDUAL (ITS-90)
0.9999	713466.450	1.0000	0.0001
4.5000	638149.217	4.4999	-0.0001
15.0000	447157.683	15.0002	0.0002
18.5000	394891.918	18.4998	-0.0002
23.9999	323255.083	23.9998	-0.0001
29.0000	268206.167	29.0001	0.0001
32.5000	234744.033	32.5000	-0.0000

MV = (n - 524288) / 1.6e+007

R = (MV * 2.900e+009 + 1.024e+008) / (2.048e+004 - MV * 2.0e+005)

Temperature ITS-90 = $1/\{a0 + a1[ln(R)] + a2[ln^2(R)] + a3[ln^3(R)]\} - 273.15$ (°C)

Residual = instrument temperature - bath temperature



CTD - 4487, HSL 3102

Sea-Bird Electronics, Inc.

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SENSOR SERIAL NUMBER: 4487
CALIBRATION DATE: 09-Dec-11

SBE19plus PRESSURE CALIBRATION DATA
508 psia S/N 2837

COEFFICIENTS:

PA0 = 8.061338e-002
PA1 = 1.555712e-003
PA2 = 7.319688e-012
PTEMPA0 = -7.398211e+001
PTEMPA1 = 4.843255e+001
PTEMPA2 = -1.939711e-001

PTCA0 = 5.243986e+005
PTCA1 = 4.572438e+000
PTCA2 = -1.008803e-001
PTCB0 = 2.498675e+001
PTCB1 = -5.000000e-005
PTCB2 = 0.000000e+000

PRESSURE SPAN CALIBRATION

PRESSURE PSIA	INST OUTPUT	THERMISTOR OUTPUT	COMPUTED PRESSURE	ERROR %FSR
14.72	533864.0	2.0	14.73	0.00
104.99	591849.0	2.0	104.97	-0.00
204.97	656050.0	2.0	204.95	-0.01
304.96	720229.0	2.0	304.95	-0.00
404.97	784363.0	2.0	404.94	-0.01
504.96	848475.0	2.0	504.96	-0.00
404.97	784393.0	2.0	404.99	0.00
304.97	720262.0	2.0	305.00	0.01
204.99	656089.0	2.0	205.01	0.00
105.03	591885.0	2.0	105.03	-0.00
14.71	533861.0	2.0	14.72	0.00

THERMAL CORRECTION

TEMP ITS90	THERMISTOR OUTPUT	INST OUTPUT
32.50	2.22	534013.67
29.00	2.15	534019.36
24.00	2.04	534020.95
18.50	1.92	534022.77
15.00	1.85	534017.41
4.50	1.63	533989.33
1.00	1.56	533975.94

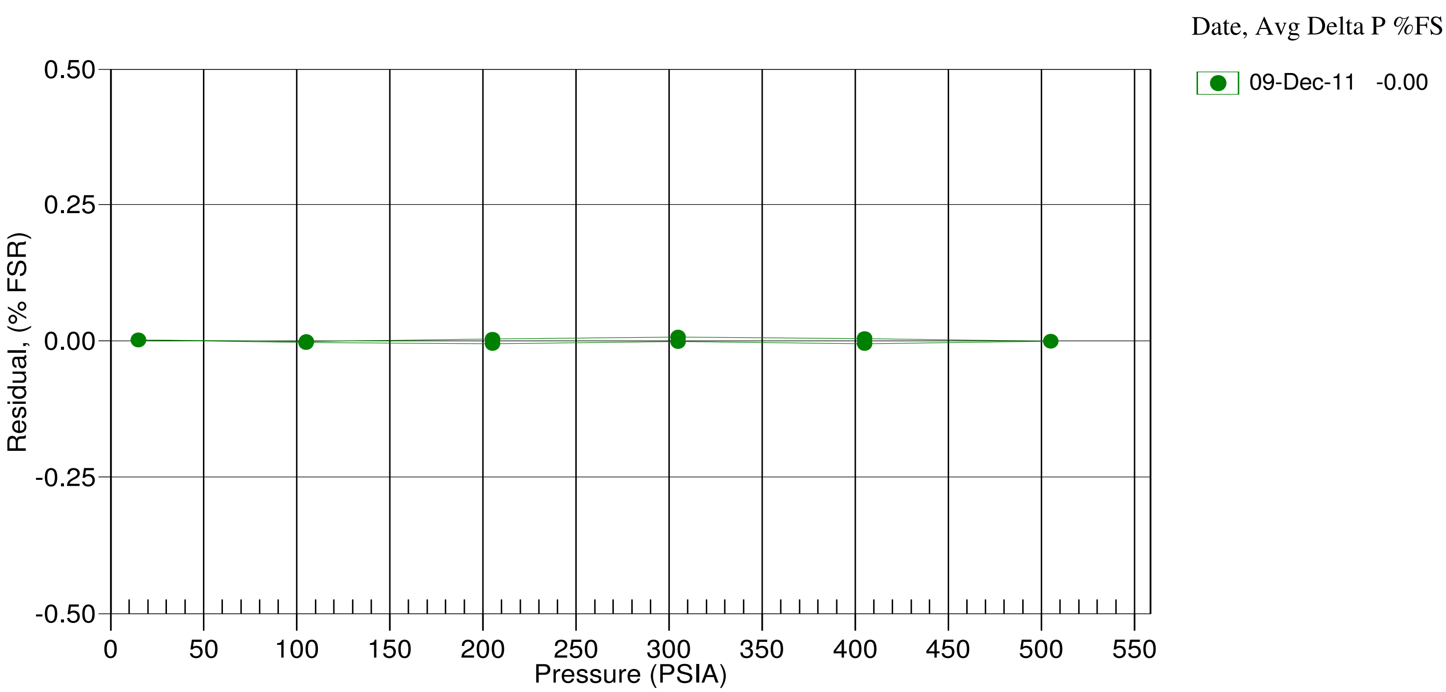
TEMP(ITS90)	SPAN(mV)
-5.00	24.99
35.00	24.98

y = thermistor output; $t = PTEMPA0 + PTEMPA1 * y + PTEMPA2 * y^2$

x = pressure output - $PTCA0 - PTCA1 * t - PTCA2 * t^2$

$n = x * PTCB0 / (PTCB0 + PTCB1 * t + PTCB2 * t^2)$

pressure (psia) = $PA0 + PA1 * n + PA2 * n^2$



Sea-Bird Electronics, Inc.

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SENSOR SERIAL NUMBER: 4487
CALIBRATION DATE: 14-Dec-11

SBE19plus CONDUCTIVITY CALIBRATION DATA
PSS 1978: C(35,15,0) = 4.2914 Siemens/meter

COEFFICIENTS:

g = -1.021817e+000
h = 1.396141e-001
i = -2.206344e-004
j = 3.674517e-005

CPcor = -9.5700e-008
CTcor = 3.2500e-006

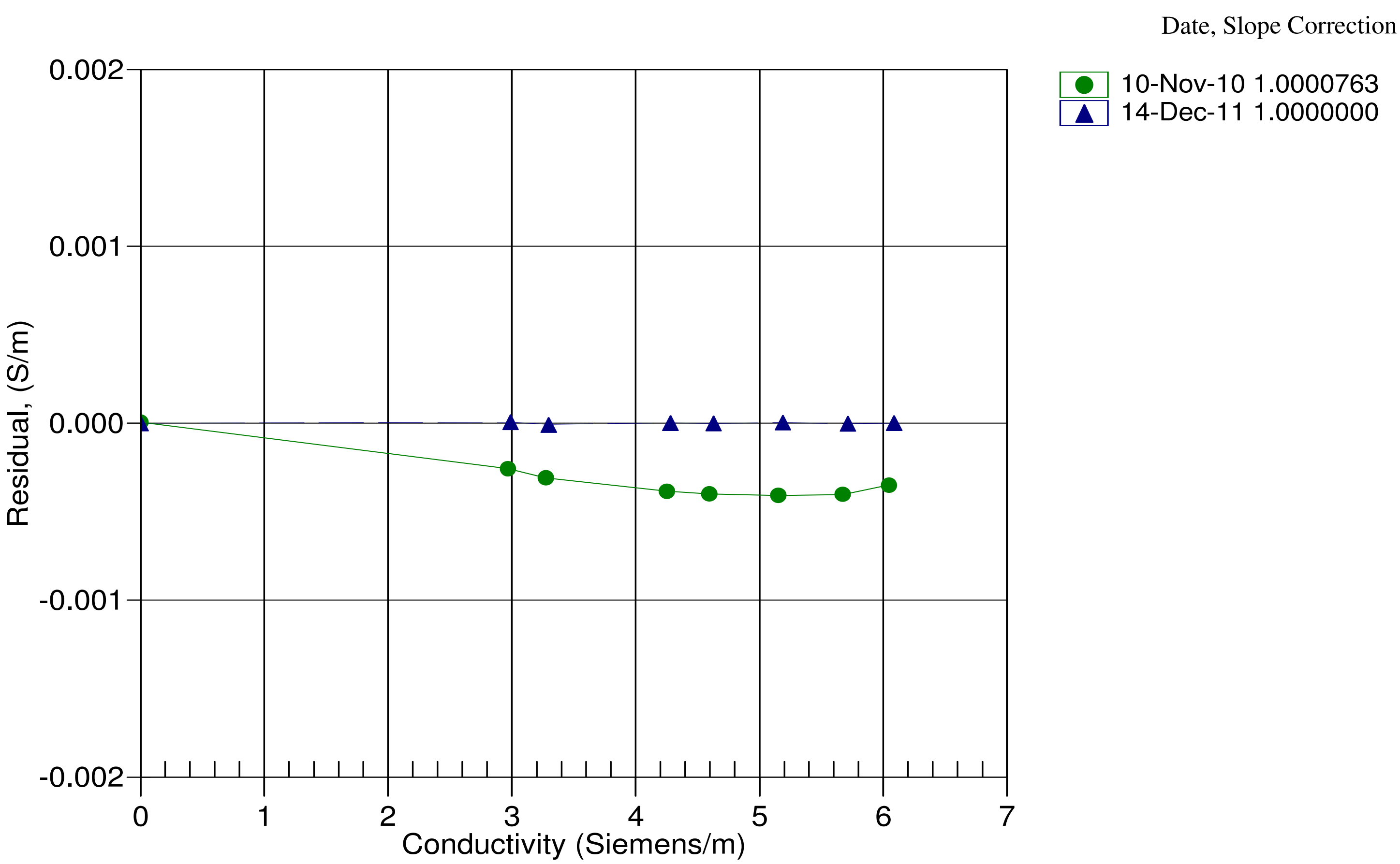
BATH TEMP (ITS-90)	BATH SAL (PSU)	BATH COND (Siemens/m)	INST FREQ (Hz)	INST COND (Siemens/m)	RESIDUAL (Siemens/m)
22.0000	0.0000	0.00000	2708.52	0.0000	0.00000
0.9999	34.9717	2.98797	5361.59	2.9880	0.00001
4.5000	34.9512	3.29619	5563.14	3.2962	-0.00001
15.0000	34.9072	4.28158	6162.62	4.2816	0.00000
18.5000	34.8971	4.62793	6359.62	4.6279	-0.00000
23.9999	34.8858	5.18781	6665.47	5.1878	0.00000
29.0000	34.8780	5.71128	6938.89	5.7113	-0.00000
32.5000	34.8714	6.08451	7127.23	6.0845	0.00000

f = INST FREQ / 1000.0

Conductivity = $(g + hf^2 + if^3 + jf^4) / (1 + \delta t + \varepsilon p)$ Siemens/meter

t = temperature[°C)]; p = pressure[decibars]; δ = CTcor; ε = CPcor;

Residual = instrument conductivity - bath conductivity



SBE

SEA-BIRD ELECTRONICS, INC.

13431 NE 20th St. Bellevue, Washington 98005 USA

Phone: (425) 643-9866 Fax: (425) 643-9954 www.seabird.com

Temperature Calibration Report

Customer:	Atlantic Marine Center		
Job Number:	66950	**Date of Report:**	12/20/2011
Model Number	SBE 19Plus	**Serial Number:**	19P60744-6667

Temperature sensors are normally calibrated 'as received', without adjustments, allowing a determination sensor drift. If the calibration identifies a problem, then a second calibration is performed after work is completed. The 'as received' calibration is not performed if the sensor is damaged or non-functional, or by customer request.

An 'as received' calibration certificate is provided, listing coefficients to convert sensor frequency to temperature. Users must choose whether the 'as received' calibration or the previous calibration better represents the sensor condition during deployment. In SEASOFT enter the chosen coefficients. The coefficient 'offset' allows a small correction for drift between calibrations (consult the SEASOFT manual). Calibration coefficients obtained after a repair apply only to subsequent data.

'AS RECEIVED CALIBRATION' ☑ Performed ☐ Not Performed

Date: 12/17/2011 Drift since last cal: +0.00019 **Degrees Celsius/year**

Comments:

'CALIBRATION AFTER REPAIR' ☐ Performed ☑ Not Performed

Date: Drift since Last cal: **Degrees Celsius/year**

Comments:

SEA-BIRD ELECTRONICS, INC.
13431 NE 20th Street Bellevue, Washington 98005 USA
Phone: (425) 643-9866 Fax: (425) 643-9954 www.seabird.com

Conductivity Calibration Report

Customer:	Atlantic Marine Center		
Job Number:	66950	**Date of Report:**	12/20/2011
Model Number	SBE 19Plus	**Serial Number:**	19P60744-6667

Conductivity sensors are normally calibrated 'as received', without cleaning or adjustments, allowing a determination of sensor drift. If the calibration identifies a problem or indicates cell cleaning is necessary, then a second calibration is performed after work is completed. The 'as received' calibration is not performed if the sensor is damaged or non-functional, or by customer request.

An 'as received' calibration certificate is provided, listing the coefficients used to convert sensor frequency to conductivity. Users must choose whether the 'as received' calibration or the previous calibration better represents the sensor condition during deployment. In SEASOFT enter the chosen coefficients. The coefficient 'slope' allows small corrections for drift between calibrations (consult the SEASOFT manual). Calibration coefficients obtained after a repair or cleaning apply only to subsequent data.

'AS RECEIVED CALIBRATION' ☑ Performed ☐ Not Performed

Date: 12/17/2011 Drift since last cal: -0.00040 PSU/month*

Comments:

'CALIBRATION AFTER CLEANING & REPLATINIZING' ☐ Performed ☑ Not Performed

Date: Drift since Last cal: PSU/month*

Comments:

**Measured at 3.0 S/m*

Cell cleaning and electrode replatinizing tend to 'reset' the conductivity sensor to its original condition. Lack of drift in post-cleaning-calibration indicates geometric stability of the cell and electrical stability of the sensor circuit.

CTD - 6667, S222 (Spare)

Sea-Bird Electronics, Inc.

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Phone: (+1) 425-643-9866 Fax (+1) 425-643-9954 Email: seabird@seabird.com

SENSOR SERIAL NUMBER: 6667
CALIBRATION DATE: 17-Dec-11

SBE19plus TEMPERATURE CALIBRATION DATA
ITS-90 TEMPERATURE SCALE

ITS-90 COEFFICIENTS

a0 = 1.246547e-003
a1 = 2.596044e-004
a2 = -1.637414e-007
a3 = 1.445447e-007

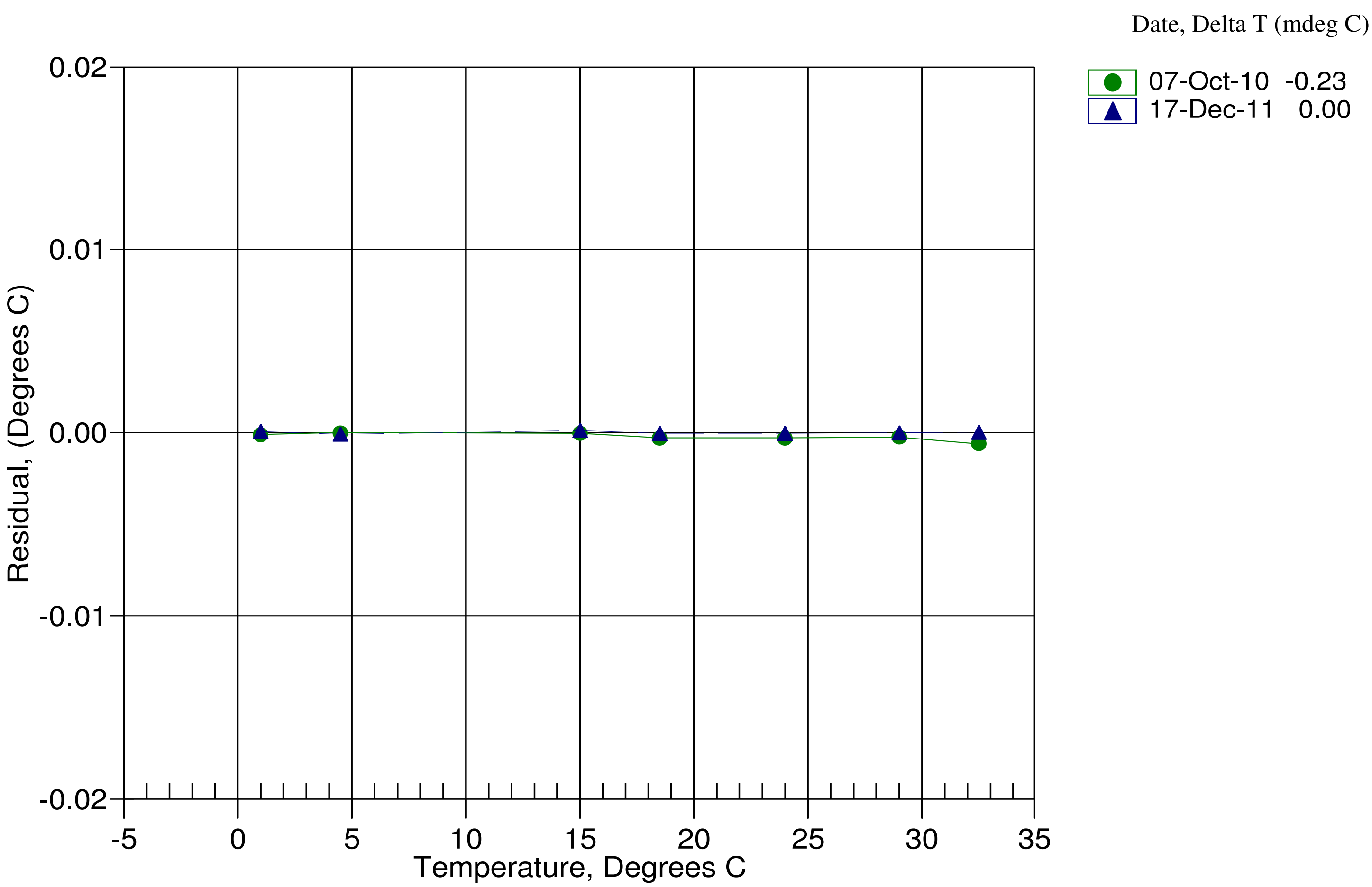
BATH TEMP (ITS-90)	INSTRUMENT OUTPUT(n)	INST TEMP (ITS-90)	RESIDUAL (ITS-90)
1.0000	702135.237	1.0000	0.0000
4.5000	626313.390	4.4999	-0.0001
15.0000	435058.390	15.0001	0.0001
18.5000	383024.458	18.5000	-0.0000
24.0000	311973.034	24.0000	-0.0000
29.0000	257611.085	29.0000	-0.0000
32.5000	224677.186	32.5000	0.0000

MV = (n - 524288) / 1.6e+007

R = (MV * 2.900e+009 + 1.024e+008) / (2.048e+004 - MV * 2.0e+005)

Temperature ITS-90 = $1/\{a0 + a1[ln(R)] + a2[ln^2(R)] + a3[ln^3(R)]\} - 273.15$ (°C)

Residual = instrument temperature - bath temperature



CTD - 6667, S222 (Spare)

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SENSOR SERIAL NUMBER: 6667
CALIBRATION DATE: 16-Dec-11

SBE19plus PRESSURE CALIBRATION DATA
870 psia S/N 3182130

COEFFICIENTS:

PA0 = 1.879247e+000
PA1 = 2.627187e-003
PA2 = 2.286017e-011
PTEMPA0 = -6.545655e+001
PTEMPA1 = 5.168516e+001
PTEMPA2 = -2.587175e-001

PTCA0 = 5.246270e+005
PTCA1 = 5.088441e+001
PTCA2 = -8.235602e-001
PTCB0 = 2.523813e+001
PTCB1 = -9.750000e-004
PTCB2 = 0.000000e+000

PRESSURE SPAN CALIBRATION

PRESSURE PSIA	INST OUTPUT	THERMISTOR OUTPUT	COMPUTED PRESSURE	ERROR %FSR
14.84	530261.0	1.7	14.83	-0.00
180.11	593057.0	1.7	180.04	-0.01
360.09	661395.0	1.7	360.04	-0.01
540.09	729655.0	1.7	540.05	-0.00
720.08	797831.0	1.7	720.06	-0.00
875.05	856461.0	1.7	875.03	-0.00
720.09	797862.0	1.7	720.14	0.01
540.12	729700.0	1.7	540.17	0.01
360.13	661450.0	1.7	360.18	0.01
180.16	593116.0	1.7	180.19	0.00
14.84	530287.0	1.7	14.88	0.00

THERMAL CORRECTION

TEMP ITS90	THERMISTOR OUTPUT	INST OUTPUT
32.50	1.91	530505.78
29.00	1.84	530493.60
24.00	1.75	530456.86
18.50	1.64	530377.95
15.00	1.57	530299.18
4.50	1.36	529927.18
1.00	1.29	529765.53

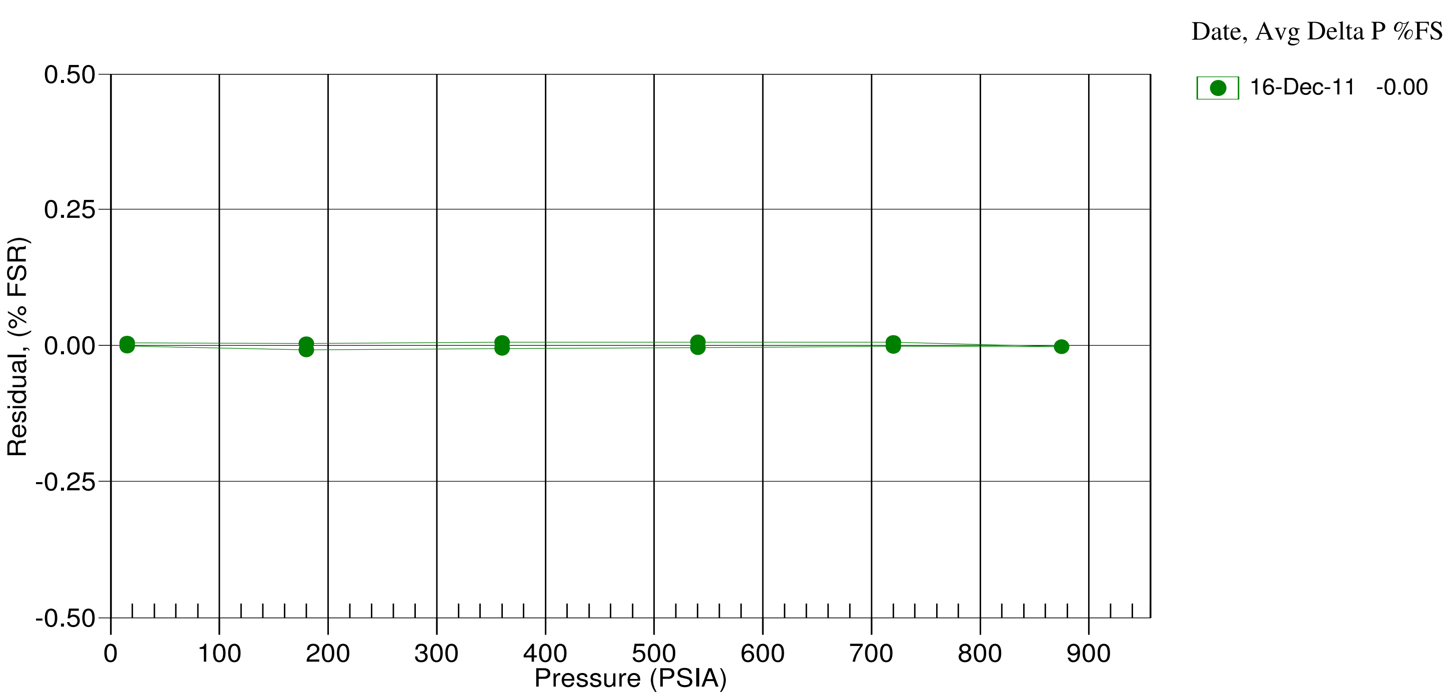
TEMP(ITS90)	SPAN(mV)
-5.00	25.24
35.00	25.20

y = thermistor output; $t = PTEMPA0 + PTEMPA1 * y + PTEMPA2 * y^2$

x = pressure output - $PTCA0 - PTCA1 * t - PTCA2 * t^2$

$n = x * PTCB0 / (PTCB0 + PTCB1 * t + PTCB2 * t^2)$

pressure (psia) = $PA0 + PA1 * n + PA2 * n^2$



CTD - 6667, S222 (Spare)

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Phone: (+1) 425-643-9866 Fax (+1) 425-643-9954 Email: seabird@seabird.com

SENSOR SERIAL NUMBER: 6667
CALIBRATION DATE: 17-Dec-11

SBE19plus CONDUCTIVITY CALIBRATION DATA
PSS 1978: C(35,15,0) = 4.2914 Siemens/meter

COEFFICIENTS:

g = -1.025366e+000
h = 1.349556e-001
i = -1.862922e-004
j = 3.127232e-005

CPcor = -9.5700e-008
CTcor = 3.2500e-006

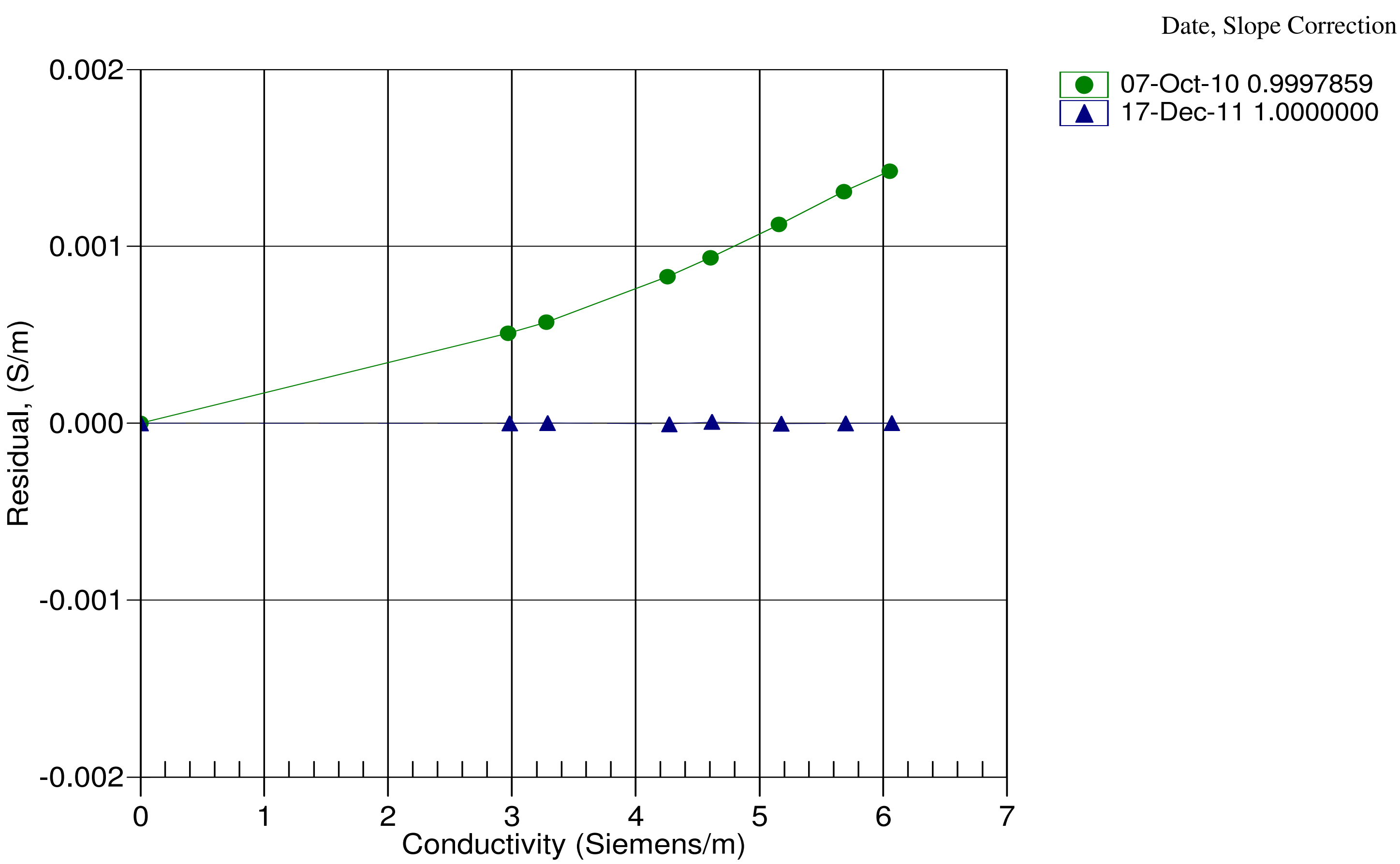
BATH TEMP (ITS-90)	BATH SAL (PSU)	BATH COND (Siemens/m)	INST FREQ (Hz)	INST COND (Siemens/m)	RESIDUAL (Siemens/m)
22.0000	0.0000	0.00000	2759.23	0.0000	0.00000
1.0000	34.8691	2.98005	5449.64	2.9800	-0.00000
4.5000	34.8488	3.28749	5654.26	3.2875	0.00000
15.0000	34.8046	4.27033	6262.94	4.2703	-0.00001
18.5000	34.7944	4.61578	6463.01	4.6158	0.00001
24.0000	34.7824	5.17414	6773.59	5.1741	-0.00000
29.0000	34.7727	5.69598	7051.19	5.6960	-0.00000
32.5000	34.7626	6.06768	7242.24	6.0677	0.00000

f = INST FREQ / 1000.0

Conductivity = $(g + hf^2 + if^3 + jf^4) / (1 + \delta t + \varepsilon p)$ Siemens/meter

t = temperature[°C)]; p = pressure[decibars]; δ = CTcor; ε = CPcor;

Residual = instrument conductivity - bath conductivity



SSVS - S222

Certificate of Calibration

Customer:	NOAA - Marine Operations Center Atlantic
Asset Serial Number:	004823
Asset Product Type:	Smart SV&T
Calibration Type:	Temperature
Calibration Range:	0 to +45 Deg C
Calibration RMS Error:	.005
Calibration ID:	004823 999999 T12501 271211 215522
Installed On:	

Coefficient A:	-4.619904E+1	Coefficient G:	0.000000E+0
Coefficient B:	2.879730E-3	Coefficient H:	0.000000E+0
Coefficient C:	-4.674987E-8	Coefficient I:	0.000000E+0
Coefficient D:	4.785235E-13	Coefficient J:	0.000000E+0
Coefficient E:	0.000000E+0	Coefficient K:	0.000000E+0
Coefficient F:	0.000000E+0	Coefficient L:	0.000000E+0
		Coefficient M:	0.000000E+0

Calibration Date (dd/mm/yyyy): 27/12/2011

Certified By:

AML Oceanographic

Robert Haydock

President, AML Oceanographic

AML Oceanographic certifies that the asset described above has been calibrated or recalibrated with equipment referenced to traceable standards. Please note that Xchange™ sensor-heads may be installed on assets other than the one listed above; this calibration certificate will still be valid when used on other such assets. If this instrument or sensor has been recalibrated, please be sure to update your records. Please also ensure that you update the instrument's coefficient values in any post-processing software that you use, if necessary. Older generation instruments may require configuration files, which are available for download at our Customer Centre at www.AMLoceanographic.com/support

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Certificate of Calibration

Customer:	NOAA - Marine Operations Center Atlantic
Asset Serial Number:	004823
Asset Product Type:	Smart SV&T
Calibration Type:	Sound Velocity
Calibration Range:	1400 to 1550 m/s
Calibration RMS Error:	.0207
Calibration ID:	004823 999999 139875 271211 215522
Installed On:	

Coefficient A:	1.524980E+3	Coefficient G:	0.000000E+0
Coefficient B:	-1.067510E+2	Coefficient H:	0.000000E+0
Coefficient C:	8.551027E+0	Coefficient I:	0.000000E+0
Coefficient D:	-8.853014E-1	Coefficient J:	0.000000E+0
Coefficient E:	0.000000E+0	Coefficient K:	0.000000E+0
Coefficient F:	0.000000E+0	Coefficient L:	0.000000E+0
		Coefficient M:	0.000000E+0

Calibration Date (dd/mm/yyyy): 27/12/2011

Certified By:

AML Oceanographic

Robert Haydock

President, AML Oceanographic

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Certificate of Calibration

Customer:	NOAA - Marine Operations Center Atlantic
Asset Serial Number:	005649
Asset Product Type:	Smart SV&T Instrument, 500m Housing
Calibration Type:	Temperature
Calibration Range:	0 to +45 Deg C
Calibration RMS Error:	.0003
Calibration ID:	005649 002099 400180 291211 162040
Installed On:	

Coefficient A:	-1.681698E+1	Coefficient G:	1.479443E-28
Coefficient B:	1.539978E-3	Coefficient H:	0.000000E+0
Coefficient C:	-2.610716E-8	Coefficient I:	0.000000E+0
Coefficient D:	4.938888E-13	Coefficient J:	0.000000E+0
Coefficient E:	-4.346158E-18	Coefficient K:	0.000000E+0
Coefficient F:	8.910081E-24	Coefficient L:	0.000000E+0
		Coefficient M:	0.000000E+0

Calibration Date (dd/mm/yyyy): 29/12/2011

Certified By:

AML Oceanographic

Robert Haydock

President, AML Oceanographic

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Certificate of Calibration

Customer:	NOAA - Marine Operations Center Atlantic
Asset Serial Number:	005649
Asset Product Type:	Smart SV&T Instrument, 500m Housing
Calibration Type:	Sound Velocity
Calibration Range:	1400 to 1600 m/s
Calibration RMS Error:	.0144
Calibration ID:	005649 002051 200506 271211 215522
Installed On:	

Coefficient A:	7.232283E-4	Coefficient G:	0.000000E+0
Coefficient B:	-7.385191E-5	Coefficient H:	0.000000E+0
Coefficient C:	6.647626E-7	Coefficient I:	0.000000E+0
Coefficient D:	-5.091818E-7	Coefficient J:	0.000000E+0
Coefficient E:	0.000000E+0	Coefficient K:	0.000000E+0
Coefficient F:	0.000000E+0	Coefficient L:	0.000000E+0
		Coefficient M:	0.000000E+0

Calibration Date (dd/mm/yyyy): 27/12/2011

Certified By:

AML Oceanographic

Robert Haydock

President, AML Oceanographic

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MVP, S222

Certificate of Calibration

Customer:	NOAA - Marine Operations Center Atlantic
Asset Serial Number:	007591
Asset Product Type:	Micro SV&P for Brooke MVP -
Calibration Type:	Sound Velocity
Calibration Range:	1400 to 1600 m/s
Calibration RMS Error:	.0112
Calibration ID:	007591 131945 135084 081211 094606
Installed On:	

Coefficient A:	7.186194E-4	Coefficient G:	0.000000E+0
Coefficient B:	-7.417913E-5	Coefficient H:	0.000000E+0
Coefficient C:	1.163344E-6	Coefficient I:	0.000000E+0
Coefficient D:	-7.809832E-7	Coefficient J:	0.000000E+0
Coefficient E:	0.000000E+0	Coefficient K:	0.000000E+0
Coefficient F:	0.000000E+0	Coefficient L:	0.000000E+0
		Coefficient M:	0.000000E+0

Calibration Date (dd/mm/yyyy): 8/12/2011

Certified By:

AML Oceanographic

Robert Haydock

President, AML Oceanographic

AML Oceanographic certifies that the asset described above has been calibrated or recalibrated with equipment referenced to traceable standards. Please note that Xchange™ sensor-heads may be installed on assets other than the one listed above; this calibration certificate will still be valid when used on other such assets. If this instrument or sensor has been recalibrated, please be sure to update your records. Please also ensure that you update the instrument's coefficient values in any post-processing software that you use, if necessary. Older generation instruments may require configuration files, which are available for download at our Customer Centre at www.AMLoceanographic.com/support

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Xchange your old ideas

Certificate of Calibration

Customer:	NOAA - Marine Operations Center Atlantic
Asset Serial Number:	007591
Asset Product Type:	Micro SV&P for Brooke MVP -
Calibration Type:	Pressure
Calibration Range:	1000 dBar
Calibration RMS Error:	.0488
Calibration ID:	007591 129146 0TE599 291211 154038
Installed On:	

Coefficient A:	-2.575685E+3	Coefficient G:	8.071607E-10
Coefficient B:	1.820538E-1	Coefficient H:	-5.916234E-15
Coefficient C:	-4.133096E-6	Coefficient I:	-1.762695E-5
Coefficient D:	2.932489E-11	Coefficient J:	1.123850E-9
Coefficient E:	5.711699E-1	Coefficient K:	-2.388330E-14
Coefficient F:	-3.660197E-5	Coefficient L:	1.691618E-19
		Coefficient M:	0.000000E+0

Calibration Date (dd/mm/yyyy): 29/12/2011

Certified By:

AML Oceanographic

Robert Haydock
President, AML Oceanographic

AML Oceanographic certifies that the asset described above has been calibrated or recalibrated with equipment referenced to traceable standards. Please note that Xchange™ sensor-heads may be installed on assets other than the one listed above; this calibration certificate will still be valid when used on other such assets. If this instrument or sensor has been recalibrated, please be sure to update your records. Please also ensure that you update the instrument's coefficient values in any post-processing software that you use, if necessary. Older generation instruments may require configuration files, which are available for download at our Customer Centre at www.AMLoceanographic.com/support

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MVP, S222

Certificate of Calibration

Customer:	NOAA - Marine Operations Center Atlantic
Asset Serial Number:	005340
Asset Product Type:	Smart SV&P for Brooke MVP -
Calibration Type:	Sound Velocity
Calibration Range:	1400 to 1550 m/s
Calibration RMS Error:	.0162
Calibration ID:	005340 999999 201222 071211 215548
Installed On:	

Coefficient A:	1.523393E+3	Coefficient G:	0.000000E+0
Coefficient B:	-1.069210E+2	Coefficient H:	0.000000E+0
Coefficient C:	8.466070E+0	Coefficient I:	0.000000E+0
Coefficient D:	-7.911434E-1	Coefficient J:	0.000000E+0
Coefficient E:	0.000000E+0	Coefficient K:	0.000000E+0
Coefficient F:	0.000000E+0	Coefficient L:	0.000000E+0
		Coefficient M:	0.000000E+0

Calibration Date (dd/mm/yyyy): 7/12/2011

Certified By:

AML Oceanographic

Robert Haydock

President, AML Oceanographic

AML Oceanographic certifies that the asset described above has been calibrated or recalibrated with equipment referenced to traceable standards. Please note that Xchange™ sensor-heads may be installed on assets other than the one listed above; this calibration certificate will still be valid when used on other such assets. If this instrument or sensor has been recalibrated, please be sure to update your records. Please also ensure that you update the instrument's coefficient values in any post-processing software that you use, if necessary. Older generation instruments may require configuration files, which are available for download at our Customer Centre at www.AMLoceanographic.com/support

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Certificate of Calibration

Customer:	NOAA - Marine Operations Center Atlantic
Asset Serial Number:	005340
Asset Product Type:	Smart SV&P for Brooke MVP -
Calibration Type:	Pressure
Calibration Range:	1000 dBar
Calibration RMS Error:	.0293
Calibration ID:	005340 999999 0ZE092 281211 133158
Installed On:	

Coefficient A:	-1.918390E+3	Coefficient G:	-9.419392E-7
Coefficient B:	-1.399663E+0	Coefficient H:	1.044152E-8
Coefficient C:	2.217375E-2	Coefficient I:	1.180306E-8
Coefficient D:	-1.520440E-4	Coefficient J:	-1.508418E-10
Coefficient E:	5.850883E-2	Coefficient K:	8.793572E-12
Coefficient F:	4.658058E-5	Coefficient L:	-1.896560E-13
		Coefficient M:	0.000000E+0

Calibration Date (dd/mm/yyyy): 28/12/2011

Certified By:

AML Oceanographic

Robert Haydock

President, AML Oceanographic

AML Oceanographic certifies that the asset described above has been calibrated or recalibrated with equipment referenced to traceable standards. Please note that Xchange™ sensor-heads may be installed on assets other than the one listed above; this calibration certificate will still be valid when used on other such assets. If this instrument or sensor has been recalibrated, please be sure to update your records. Please also ensure that you update the instrument's coefficient values in any post-processing software that you use, if necessary. Older generation instruments may require configuration files, which are available for download at our Customer Centre at www.AMLoceanographic.com/support

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RESON

SVP Test and Calibration certificate

SVP Type :	SVP70
SVP Serial No.	2011275

Date of issue :	29-09-2011

Temperature Calibration :	Hart 1504 s/n A6B554 & Thermistor s/n 3014
Point 1:	4.6 °C
Point 2:	16.6 °C
Point 3:	25.5 °C
Pressure Calibration :	Custom Built Tank (TestUnit ASF150 Ser# 41-10-0007-R03)
Point 1:	0 Bar
Point 2:	299.7 Bar
Point 3:	600.4 Bar

	RMS Speed of Sound Errors
Temperature Validation :	0.0029 m/s
Pressure Validation :	0.0710 m/s

Calibration & Final Function Test : Sign : ____

QA Signature : Inits : ____
2011.09.29

RESON

RESON A/S, Fabriksvangen 13, DK-3550 Slangerup
Fax: +45 4738 0066, Phone: +45 4738 0022

RESON

SVP Test and Calibration certificate

SVP Type :	SVP71
SVP Serial No.	4211067

Date of issue :	22-02-2012

Temperature Calibration :	Hart 1504 s/n A6B554 & Thermistor s/n 3014
Point 1:	4.6 °C
Point 2:	16.5 °C
Point 3:	25.5 °C
Pressure Calibration :	Custom Built Tank (TestUnit ASF150 Ser# 41-10-0007-R03)
Point 1:	0 Bar
Point 2:	103.3 Bar
Point 3:	204.2 Bar

	RMS Speed of Sound Errors
Temperature Validation :	0.0156 m/s
Pressure Validation :	0.0241 m/s

Calibration & Final Function Test : Sign : Find Petersen

QA Signature : Inits : OSK / for
2012.02.23

RESON

RESON A/S, Fabriksvangen 13, DK-3550 Slangerup
Fax: +45 4738 0066, Phone: +45 4738 0022

RESON

SVP Test and Calibration certificate

SVP Type :	SVP71
SVP Serial No.	4211065

Date of issue :	21-02-2012

Temperature Calibration :	Hart 1504 s/n A6B554 & Thermistor s/n 3014
Point 1:	4.6 °C
Point 2:	16.5 °C
Point 3:	25.5 °C
Pressure Calibration :	Custom Built Tank (TestUnit ASF150 Ser# 41-10-0007-R03)
Point 1:	0 Bar
Point 2:	102.5 Bar
Point 3:	203.9 Bar

	RMS Speed of Sound Errors
Temperature Validation :	0.0231 m/s
Pressure Validation :	0.0713 m/s

Calibration & Final Function Test : Sign : Find Petersen

QA Signature : Inits : Osb[illegible]
2012-02-23

RESON

RESON A/S, Fabriksvangen 13, DK-3550 Slangerup
Fax: +45 4738 0066, Phone: +45 4738 0022

RESON

SVP Test and Calibration certificate

SVP Type :	SVP71
SVP Serial No.	0710064

Date of issue :	14-09-2011

Temperature Calibration :	Hart 1504 s/n A6B554 & Thermistor s/n 3014
Point 1:	4.6 °C
Point 2:	16.6 °C
Point 3:	25.5 °C
Pressure Calibration :	Custom Built Tank (TestUnit ASF150 Ser# 41-10-0007-R03)
Point 1:	0 Bar
Point 2:	101.4 Bar
Point 3:	204.1 Bar

	RMS Speed of Sound Errors
Temperature Validation :	0.0185 m/s
Pressure Validation :	0.0766 m/s

Calibration & Final Function Test : Sign : Finn Petersen

QA Signature : Inits : 2011.09.14

RESON

RESON A/S, Fabriksvangen 13, DK-3550 Slangerup
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