NOAA FORM 76-35A

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

DATA ACQUISITION AND PROCESSING REPORT

Type of Survey Hydrographic

Project No. OPR-R306-KR-12

Time Frame May – August 2012

LOCALITY

State ALASKA

General Locality Nushagak Bay

2012

CHIEF OF PARTY

MARTA KRYNYTZKY

LIBRARY & ARCHIVES

DATE **December 20, 2012**

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NOAA FORM 77-28 (11-72) U.S. DEPARTMENT OF COMMERCE NATIONAL OCEANIC AND ATMOSPHERIC ADMINISTRATION HYDROGRAPHIC TITLE SHEET	REGISTER NO. **H12398, H12399, H12400, H12401, H12402, H12403, H12404, H12405**
INSTRUCTIONS – The Hydrographic Sheet should be accompanied by this form, filled in as completely as possible, when the sheet is forwarded to the Office	FIELD NO. **N / A**

State Alaska

General Locality Nushagak Bay

Locality Dillingham to Nushagak Point

Scale 1:40,000 Date of Survey May 24 – August 8, 2012

Instructions Dated March 22, 2012 Project No. OPR-R306-KR-12

Vessel M/V Latent Sea, It Sea, Bit Sea

Chief of party Marta Krynytzky

Surveyed by TERRASOND PERSONNEL (T. DePriest, E. Edwards, S. Glaves, S. Johnson, T. Landry, B. Lee, J McKinley, T Morino, R. Newman, A. Orthmann, P. Pack, C. Priest, S. Shaw, M. Stevie, J. Theis, K. Wade, ET. AL.)

Soundings taken by echo sounder, hand lead, pole ECHO SOUNDER – (HULL MOUNTED)

Graphic record scaled by N/A

Graphic record checked by N/A

Protracted by N/A Automated plot by N/A

Verification by

Soundings in METERS at MLLW

REMARKS:

The purpose of this work is to provide NOAA with modern and accurate hydrographic survey data for Nushagak Bay and Approaches, Alaska.

Contract No. DG133C-08-CQ-0005 ALL TIMES ARE RECORDED IN UTC

Hydrographic Survey:

TerraSond Ltd.
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Palmer, AK 99645

Tide Support:

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Anchorage, AK 99503

Data Acquisition and Processing Report

OPR-R306-KR-12

December 20th, 2012

Small Boat Harbor in Dillingham, Alaska

Vessels: ***M/V Latent Sea, M/V It Sea, M/V Bit Sea***

Locality: ***Nushagak Bay, Alaska***

Sublocalities:

- ***H12398 – Dillingham to Nushagak Point***
- ***H12399 – Coffee Point to Ekuk***
- ***H12400 – 4 NM South of Ekuk***
- ***H12401 – 7 NM West of Etolin Point***
- ***H12402 – Schooner Channel***
- ***H12403 – 3 NM SW of Etolin Point***
- ***H12404 – Mouth of Snake River***
- ***H12405 – Mouth of Igushik River***

Lead Hydrographer: ***Marta Krynytzky***

TABLE OF CONTENTS

A. *Equipment*

A.1. Echo Sounder Systems

To collect sounding data, this project utilized Odom Echotrac CV100 Single Beam Echo Sounder (SBES) systems.

A.1.1. Single Beam Echo Sounders

Three Odom Echotrac CV100 systems were used on this survey. System setups were nearly identical between vessels, though acquisition settings were changed online, as necessary, to maintain data quality.

Odom Echotrac CV100s are digital imaging echo sounders which utilize Odom eChart software to serve as the user interface. These survey systems were coupled to single-frequency (200-kHz) transducers.

Power, gain, depth filters and other user-selectable settings were adjusted, as necessary, through eChart to maximize data quality. The system was configured to output bathymetric data via Ethernet network connection to an acquisition PC running Hypack software, which logged to .RAW and .BIN files.

Echotrac CV100s are all-digital units that do not create a paper record. In lieu of paper records the .BIN files contain bottom tracking information, which is converted by and viewable in CARIS HIPS Single Beam Editor.

See table below for echo sounder specifications.

Odom CV100	
Firmware Version	4.09
Sonar Operating Frequency	100 – 750 kHz (200 kHz used)
Output Power	300 W RMS Max
Ping Rate	Up to 20 Hz
Resolution	0.01 m
Depth Range	0.3 – 600 m, depending on frequency and transducer

Table 1– Odom CV100 single beam echo sounder technical specifications.

A.2. Vessels

All data for this survey was acquired using the *M/V Latent Sea*, the *M/V It Sea* and the *M/V Bit Sea.*

A.2.1. M/V Latent Sea

The *M/V Latent Sea*, shown in the figure below, was used to collect single beam data. It was also used to collect bottom samples and to deploy submerged tide gauges. It is a 7.0 meter (m) aluminum hulled vessel with a 2.6 m beam and a 0.5 m draft, manufactured by Workskiff, Inc. The vessel is powered by twin 150Hp Honda four-stroke outboard motors. All installed survey systems including PC and monitors were powered by the vessel's 12V DC electrical supply.

Figure 1 – M/V Latent Sea near Bethel, AK.

The *M/V Latent Sea* was equipped with a Hemisphere V111 GPS Compass, an Odom Echotrac CV100 SBES system (with 200 kHz/3° hull mounted transducer), and a Trimble 5700 with Zephyr antenna. The Trimble 5700 was used for positioning, while the Hemisphere V111 provided heading. The V111 also output heave, pitch, roll and position, which were selectively used for QC functions as described in Section B of this report. Detailed vessel drawings showing the location of all primary survey equipment are included in Section C of this report.

The survey equipment on the *M/V Latent Sea* performed well with no major issues encountered, with the following exception: On JD227 the Trimble Zephyr antenna failed causing loss of positioning from the Trimble 5700. The Zephyr antenna was replaced with a Trimble Zephyr Geodetic Antenna. The replacement antenna performed well for the remainder of the project. New offsets for the replacement antenna were entered into the CARIS HIPS vessel file (HVF) for JD228 to compensate for the slight change in vertical antenna position.

***M/V Latent Sea* Survey Equipment**

Description	Manufacturer	Model / Part	Serial Number
Single Beam Sonar	Odom	Echotrac CV100	3498
Single Beam Transducer	Odom	SMBB 200-3	n/a
Positioning System	Trimble	5700	022027 5240
Heading and Heave Sensor, Secondary Positioning System	Hemisphere	V111	AA1139-1158576-0014
SV Casting Probe	Applied Microsystems	SV Plus v2	3259
SV Casting Probe	Odom	Digibar	98427, 98478 and 98014
RTK Signal Receiver	Pacific Crest	PDL Radio	0912 0720

Table 2 – Major survey equipment used aboard the M/V Latent Sea.

A.2.2. M/V It Sea

The *M/V It Sea* was used to collect single beam data. The vessel is a 150 Speedster model jet boat manufactured by SeaDoo. The vessel is 4.6 m in length with a 2.1 m beam and a 0.3 m draft. The vessel is powered by a fuel injected 1503 Rotax 4-TEC engine. The TerraSond shop in Palmer outfitted the vessel for survey operations. All installed survey systems including PC and monitors were powered by the vessel's 12V DC electrical supply.

Figure 2 – Sea Doo Speedster 150 outfitted for survey operations.

M/V It Sea was equipped with a Hemisphere V111 GPS Compass, an Odom Echotrac CV100 SBES system (with 200 kHz/3° hull mounted transducer) and a Trimble 5700 with Zephyr antenna. The Trimble 5700 was used for positioning, while the Hemisphere V111 provided heading. The V111 also output heave, pitch, roll and position, which were selectively used for QC functions as described in Section B of this report. Detailed vessel drawings showing the location of all primary survey equipment are included in Section C of this report.

The survey equipment on the *M/V It Sea* performed well with no major issues encountered.

M/V It Sea Survey Equipment

Description	Manufacturer	Model / Part	Serial Number
Single Beam Sonar	Odom	Echotrac CV100	003504
Single Beam Transducer	Odom	n/a	n/a
Positioning System	Trimble	5700	220321784
Heading and Heave Sensor, Secondary Positioning System	Hemisphere	V100	AA1139-158576-0015
SV Casting Probe	Odom	Digibar	98478 and 98427
RTK Signal Receiver	Pacific Crest	PDL Radio	0319 7603

Table 3 – Major survey equipment used aboard the M/V It Sea.

A.2.3. M/V Bit Sea

M/V Bit Sea was equipped with a Hemisphere V111 GPS Compass, an Odom Echotrac CV100 SBES system (with 200 kHz/3° hull mounted transducer) and a Trimble 5700 with Zephyr antenna. The Trimble 5700 was used for positioning, while the Hemisphere V111 provided heading. The V111 also output heave, pitch, roll and position, which were selectively used for QC functions as described in Section B of this report. Detailed vessel drawings showing the location of all primary survey equipment are included in Section C of this report.

The survey equipment on the *M/V Bit Sea* performed well with no major issues encountered.

***M/V Bit Sea* Survey Equipment**

Description	Manufacturer	Model / Part	Serial Number
Single Beam Sonar	Odom	Echotrac CV100	003505
Single Beam Transducer	Odom	n/a	n/a
Positioning System	Trimble	5700	0220320002
Heading and Heave Sensor, Secondary Positioning System	Hemisphere	V100	AA1139-158576-0016
SV Casting Probe	Odom	Digibar	98478 and 98427
RTK Signal Receiver	Pacific Crest	PDL Radio	9137601

Table 4 – Major survey equipment used aboard the M/V Bit Sea.

A.3. Speed of Sound

Speed of sound data was collected by vertical casts on the *M/V Latent Sea* using Applied Microsystems (AML) SV Plus v2 sensors and Odom Digibars. On *M/V It Sea* and *M/V Bit Sea* only the Odom Digibars were used. The sensors were calibrated prior to the start of survey operations and then compared on a weekly basis to each other, with good results.

Sound speed profiles were taken as deep as possible and were geographically distributed within the survey area. Sound speed profilers were lowered by hand and extended to the sea floor in most instances. However, on occasion swift currents prevented the profiler from reaching all the way to the sea floor.

Sound speed casts were taken at an interval of 12-hours or less during SBES operations. Exceptions were rare but are noted in the applicable Descriptive Report (DR) when they occurred.

In general, sound speed profiles were consistent with well-mixed conditions, showing little variance through the water column and between casts. An exception is in the vicinity of the mouth of the river (in particular H12401) where there was more saline influence and a less-mixed profile became apparent.

Refer to the CARIS .SVP file submitted with the digital data for specific cast positions and times. Refer to each DR, *Separate II: Sound Speed Data* for the sound speed comparison checks.

Copies of the manufacturer's calibration reports are included in the DR, *Separate II* for each survey sheet. The following instruments were used to collect data for sound speed:

A.3.1. Sound Speed Sensors

Sound Speed Gauge	Manufacturer	Serial Numbers	Calibration Date
SV Plus v2	Applied Microsystems, Ltd. Sydney, British Columbia, Canada	3259	6/1/2012 by AML Oceanographic
Digibar	Odom Hydrographic Systems, Inc. Baton Rouge, Louisiana	002992 and 98478	3/12/2012 by Odom Hydrographic
Digibar	Odom Hydrographic Systems, Inc. Baton Rouge, Louisiana	98014	3/12/2012 by Odom Hydrographic
Digibar	Odom Hydrographic Systems, Inc. Baton Rouge, Louisiana	98427	3/09/2012 by Odom Hydrographic

Table 5 – Sound speed gauges and calibration dates.

A.3.2. Sound Speed Sensor Technical Specifications

Applied Microsystems SV Plus v2	
SV Precision	0.03 m/s
SV Accuracy	0.05 m/s
SV Resolution	0.015 m/s
Pressure Precision	0.03 % of full scale
Pressure Accuracy	0.05 % of full scale
Pressure Resolution	0.005 % of full scale

Table 6 – AML SV Plus v2 specifications.

Odom Digibar Pro	
SV Accuracy	0.3 m/s
SV Resolution	0.1 m/s
Depth Sensor Accuracy	0.31 m

Table 7 – Odom Digibar Pro specifications.

A.4. Positioning & Attitude Systems

All vessels were equipped with a Trimble 5700 for positioning and a Hemisphere V111 for heading and QC. Survey system configurations described below were identical between the vessels.

The Hemisphere V111 was also used for a secondary check position and produced heave, pitch and roll data. All data was output via RS-232 serial cables to an acquisition PC where it was logged in conjunction with bathymetry in Hypack software.

Hemisphere V111 pitch and roll were not applied to the data since pitch and roll corrections are not required for SBES data. Additionally, in-house tests determined the pitch and roll corrections provided by the V111 to be of insufficient quality for application to the data.

For real-time GPS corrections, each Trimble 5700 was interfaced with a Pacific Crest radio which received Real Time Kinematic (RTK) corrections transmitted from base stations established by the survey crew on shore.

Additionally, the Trimble 5700 recorded raw data at a rate of 10 Hz to data card continuously during survey operations. This enabled post-processing of the GPS data after the fact in Applanix POSGNSS software and in conjunction with simultaneous raw base station GPS data.

Heave correction was accomplished by extracting the heave component of Post-Processed Kinematic (PPK) altitudes from the Trimble 5700. The Hemisphere V111 output heave was used only on a case-by-case basis as it was of lower quality compared to PPK heave. When these cases occur, they are outlined in the appropriate DR.

Hypack provided time sync between systems (including the PC clock) using UTC time. For the UTC time source, Hypack received a ZDA string output by the Trimble 5700 at a rate of 1 Hz. A misconfiguration prevented Hypack from syncing properly on a handful of survey days as described in Section B.3.2 of this report.

To provide a real-time positioning reality check using the Hemisphere V111, Hypack was configured with a second position node, which was simultaneously displayed in the navigation screen. The Hemisphere auto-tuned to USCG RTCM corrections, but the survey area did not have reliable USCG corrections. Therefore, Hemisphere positions could be either stand-alone or DGPS.

A.4.1. Position & Attitude System Technical Specifications

Trimble 5700		
Code Differential GPS Positioning	Horizontal Positioning Accuracy	± 0.25 m + 1 ppm RMS
	Vertical Positioning Accuracy	± 0.5 m + 1 ppm RMS
Kinematic Surveying	Horizontal Positioning Accuracy	± 10 mm + 1 ppm RMS
	Vertical Positioning Accuracy	± 20 mm + 1 ppm RMS

Table 8 – Trimble 5700 technical specifications.

Hemisphere V111	
Roll, Pitch Accuracy	< 1° rms
Heave Accuracy	30 cm
Heading Accuracy	< 0.3° rms
Position Accuracy	< 2.5 m 95% confidence (autonomous, no SA[2])

Table 9 – Hemisphere V111 technical specifications.

A.5. Dynamic Draft Corrections

Dynamic draft corrections were determined using PPK GPS methods for all vessels with a squat settlement calibration. Corrections were determined for a range that covered normal survey speeds and engine RPMs. Each vessel's Trimble 5700 and data from a nearby base station were utilized in this process. See Section C.4 for more information and results.

A.6. Base Stations

During the project, four base stations were deployed along both shores of Nushagak River and Bay to provide GPS corrections for both RTK and PPK; Dillingham (Snag Point), Clark's Point, Etolin Point and Protection Point.

Each base station consisted of a Trimble 5700 or Trimble NetRS GPS receiver with Zephyr Geodetic Antenna interfaced with a Pacific Crest PDL radio with pole-mounted antenna. In addition to logging dual frequency GPS data to compact flash card, the stations were configured to broadcast "CMR+" (Trimble format) corrections over 464.50, 464.55, 464.70 and 464.75 MHz using a 35-watt transmission for best possible range. A combination of wind and solar generation provided power where AC power was not available.

Etolin and Protection Point base stations were remote "off-grid" stations. Each was powered by six 12V batteries coupled with three 75-watt solar panels and a 400-watt wind power generator. A 12V DC timer powered-off the PDL radio at night to conserve power when survey operations were not being conducted. However, the GPS receiver bypassed this shutoff system so that base stations would continue to log 24-hours a day. The Etolin Point station was further equipped with a satellite dish which enabled remote access and download of receiver data over the Internet and an IP webcam, which enabled remote monitoring of weather conditions and physical inspection of site equipment stability.

Dillingham (Snag Point) and Clarks Point base stations were located in community buildings with available AC power. Each was connected to two 12V batteries, which were charged by a float charger. The batteries provided backup power in rare instances of AC power loss. The Clarks Point station was further equipped with a satellite dish which enabled remote access and download of receiver data over the Internet and an IP webcam, which enabled remote monitoring of weather conditions.

Station Name	GPS Receiver Type	Data Download Method	Power Source	RTK Broadcast	Additional Equipment
Dillingham (Snag Point)	Trimble 5700	Daily data card swap	AC grid power w/ battery backup	Continuously broadcasting	None
Clark's Point	Trimble NetRS	Internet	AC grid power w/ battery backup	Continuously broadcasting	Satellite Internet Dish and IP webcam to remote monitor weather conditions
Etolin Point	Trimble NetRS	Internet	625w max power from solar and wind	Timer controlled, off at night	Satellite Internet Dish and IP webcam to remote monitor weather conditions and equipment stability
Protection Point	Trimble 5700	Periodic data card swap	625w max power from solar and wind	Timer controlled, off at night	None

Table 10 – RTK base station equipment, power and download configurations.

Each vessel was configured to receive the RTK CMR+ signal via Pacific Crest PDL Radio, which output the correction message to the vessel Trimble 5700 to compute an RTK solution. Reception of the signal was highly distance and line of sight dependent with interruptions common.

Base station data logged to internal data card in a Trimble (*.T01) format at a rate of 1 Hz. The data from the remote access NetRS receivers was downloaded once to twice per day. Data from the Dillingham Trimble 5700 receiver was downloaded daily. Data from the Protection Point station was downloaded whenever personnel were able to access the station for tide observations. The accuracy of base station solutions was checked often using position confidence checks with good results. See Section B.4.4 and B.4.5 of this report for information regarding base station position confidence checks.

Figure 3 – Base station setup at Protection Point, June 13, 2012.

A.6.1. Base Station Equipment Technical Specifications

Trimble 5700	
Accuracy (Static)	Horizontal 5 mm + 0.5 ppm RMS Vertical 5 mm + 1 ppm RMS
Output Standard Used	CMR+

Table 11 – Trimble 5700 specifications.

Pacific Crest PDL (High Power Base)	
Power (TX nominal)	110 Watts (35W)
Power (RX nominal)	1.9 Watts
External Antenna	50 Ohm, BNC
Link Protocol	TRIMTALK™
Frequencies Used	464.5 to 464.75 MHz

Table 12 – Pacific Crest PDL radio specifications.

A.7. Tide Gauges

In support of this survey, three tide stations were installed in May 2012 by JOA Surveys, LLC (JOA) of Anchorage, AK. Stations were installed at historic U.S. Coast and Geodetic Survey tide station Snag Point in Dillingham, AK (946-5374), Protection Point, AK (946-5056) and a new tide station at Clark's Point, AK (946-5261).

JOA installed two WaterLOG series DAA H350XL bubbler gauges at each site. Data from the tide gauges was monitored remotely via GOES and downloaded periodically throughout the survey to be combined with staff observations and meteorological data that was collected during the project.

The WaterLOG gauges were calibrated prior to the start of survey operations. In the field, they were installed in pairs for redundancy and as a check on each other. Additionally, their installation stability was checked weekly throughout the survey with staff shot observations.

In addition, Sea-Bird SBE 26plus Wave and Tide Recorder submersible tide gauges were set in six strategic deployment locations for minimum 17-day periods during survey operations. The gauges were synced to UTC and set to log at a 6-minute interval using a 180 second averaging period and logged to internal memory. The gauges were downloaded upon retrieval prior to re-deployment at other sites. Barometric pressure was logged concurrently with a digital barometer and used to provide atmospheric pressure corrections. Data from the gauges with accompanying staff observations was used to assist with tide zoning and to provide additional ellipsoid to MLLW ties. The Sea-Bird gauges were calibrated prior to the start of the survey season.

Final processing of the tide data was completed by TerraSond and JOA. Refer to the Horizontal and Vertical Control Report (HVCR) for detailed information regarding the calibration, installation and data processing procedures used for these stations.

A.7.1. Tide Gauge Technical Specifications

WaterLOG H-350XL	
Pressure Sensor Accuracy	0.02% of full scale
Temperature Accuracy	1° C
Pressure Resolution	0.002%
Temperature Resolution	0.002%
Pressure Accuracy 0-15 PSI	0.007 ft
Pressure Accuracy 0-30 PSI	0.014 ft

Table 13 – WaterLOG H-350XL tide gauge specifications.

Sea-Bird SBE 26plus Wave & Tide Recorder	
Pressure Sensor Accuracy	0.01% of full scale
Pressure Resolution	0.2 mm for 1-minute integration
Repeatability	0.005% of full scale

Table 14 – Sea-Bird SBE26plus specifications.

A.8. Software Used

A.8.1. Acquisition Software

Each survey launch was outfitted with two dual-core PCs running Windows 7 Professional. A summary of the primary software installed and used on these systems during data collection follows.

- Hypack hydrographic data acquisition software was used on the acquisition vessels for navigation and to log all bathymetric, position and sensor data to .RAW and electronic single beam “paper” trace to .BIN format.
- Odom eChart was used during acquisition. During acquisition of SBES data, eChart served as the user interface into the Odom Echotrac echo sounders and displayed the digital bottom track trace and waveform to assist the operator with ensuring proper bottom tracking.
- Trimble Configuration Toolbox was used, as necessary, to configure common options in the Trimble 5700 base station receivers prior to data acquisition by the vessels and by base station deployment.
- Hemisphere PocketMax3 was used to configure common options in the Hemisphere V111, prior to data acquisition.
- “Putty” by Simon Tatham (Similar to Windows HyperTerminal) was used to communicate with, configure, download data from the AML SV+ v2 sound velocity sensor and download Odom Digibar data.
- Sea-Bird Seasoft was used to configure the Sea-Bird tide gauges prior to deployment and to download the data after retrieval.
- Libre Office was used to keep investigation and bottom sample logs.

Program Name	Version	Date	Primary Function
Hypack	12.0.0.1	2012	Single beam acquisition suite and navigation
Odom eChart	1.4.0	2010	Single beam echo sounder interface
Trimble Configuration Toolbox	6.9.0.2	2010	Trimble 5700 interface
Hemisphere PacketMax3	3.4.0.1010	2012	Hemisphere V111 interface
Putty	0.60	2007	Configuration and download of AML SV Plus v2 and Odom Digibar sound speed sensors
Sea-Bird Seasoft	2.0	2011	Configuration and data download for Sea-Bird SBE26 Plus tide gauges
Libre Office	3.5.5	2012	Log keeping

Table 15 – Software used aboard the survey vessels.

A.8.2. Processing and Reporting Software

Processing and reporting was done on dual-core PCs running Windows XP Professional. A summary of the primary software installed and used on these systems to complete planning, processing and reporting tasks follows:

- CARIS HIPS and SIPS 7.1 was used extensively as the primary data processing system. HIPS was used to apply all necessary corrections to soundings including corrections for motion, sound speed and tide. HIPS was used to clean and review all soundings and to generate the final BASE surfaces.
- CARIS Notebook was used to create the S-57 deliverable. Bottom samples, survey extents and shoreline detail, where required, were imported and edited in Notebook and an S-57 file exported.
- ESRI ArcGIS was used for pre-survey line planning, during survey operations to assist with tracking of work completed, progress sketches and during reporting for chartlet creation and other documentation.
- Applanix POSGNSS 5.3 (a POSPac MMS 5.4 utility) was used extensively to produce post-processed kinematic (PPK) data. Base and rover data were imported into POSGNSS and the rover data post-processed, and a navigation file in text format file with vessel positions output. These files were then imported into lines using CARIS HIPS Generic Data Parser.
- TerraLog (TerraSond in-house software) was used to process sound speed profiles. In TerraLog, sound speed profiles were inspected and de-spiked, separated into up and down components, decimated to 0.1 m resolution, where necessary, and output to CARIS-compatible format.

- HeaveXtractor (TerraSond in-house software) was used to extract heave data from post-processed kinematic GPS data. The software imported the PPK positioning files produced in POSGNSS and output heave data in text files that were then imported into lines using CARIS HIPS Generic Data Parser.
- ParsnipHysorter (TerraSond in-house software) was used to read and parse Hypack format logfiles into Excel-compatible logsheets. The utility was also utilized to scan all Hypack RAW files for time tag anomalies, and used when necessary to repair unsynced RAW files.

Program Name	Version	Date	Primary Function
CARIS HIPS and SIPS	7.1.2	2012	Hydrographic data processing
CARIS Notebook	3.1.1	2011	Feature attribution and creation of S-57 deliverables
ESRI ArcGIS	9.3.1	2009	Desktop mapping software
Applanix POSGNSS	5.3	2010	Post-processed kinematic GPS positioning and confidence checks
Microsoft Office	2010	2010	Logsheets, reports and various processing tasks
HeaveXtractor	1.0	2012	Extract heave data from 3-D PPK processed positions
ParsnipHysorter	1.0.0.4	2012	Parse, snip and sort comments and file time information for importation into processing logs. Scan all RAW files for time sync issues and repair where necessary.
TerraLog	1.0.0.12	2012	Process SVP casts

Table 16 – Software used during processing and reporting.

A.9. Bottom Samples

The *M/V Latent Sea* collected most bottom samples for this survey.

At planned locations, a Van Veen grab sampler was lowered and a bottom sample collected. Aboard the vessel, the sample was examined and its S-57 (SBDARE object) attributes noted along with time and position in a spreadsheet logsheet.

The logsheet was later imported by processing into CARIS Notebook software for producing the S-57 deliverable. A table with bottom sample locations is available in each DR, *Appendix V: Supplemental Survey Records and Correspondence.*

Note that the total number of bottom samples recorded for this project does not match the total number reported in the final progress sketch. The final progress sketch (August

2012) incorrectly included two (2) bottom samples used for training personnel on acquisition and record keeping procedures done in the small boat harbor. Total number of actual bottom samples acquired for this project is 40. The number of S-57 encoded bottom samples included in the feature files for this project is 40.

A.10. Shoreline Verification

Shoreline verification for OPR-R306-KR-12 was required only for parts of H12398 and H12399, which consisted of the Dillingham waterfront, Snake River small boat launch area and shoreline construction in Clark's Point. The work was accomplished on August 5-7, 2012 (JD218-220).

The equipment was setup in an RTK backpack design. A Trimble 5700 receiver was interfaced with a Trimble Zephyr Geodetic GPS antenna, which were mounted on a survey rod. The 5700 was set to continuously log data while the specific times of point occupation were recorded.

With this configuration, the survey crew walked the approximately 2.75 km of Dillingham and Clark's Point waterfront and took positions at any significant change in shoreline inflection, or type. Positions were only acquired on cultural shoreline features; natural shoreline was generally excluded. Field notes were kept and digital photos taken to document the data and to facilitate S-57 attribution.

Additional information and results including item descriptions are available in the DRs for H12398 and H12399. The scanned field notebook and corresponding photos are available in the DR, *Separate I: Acquisition and Processing Logs*.

After data collection, the data points were processed in POSGNSS with a correction for rod height applied. Points were extracted based on the acquisition-noted times of occupation and then exported to text file, paired with acquisition logs, and imported into CARIS Notebook 3.1. In Notebook, the points were assembled into line objects, as necessary, and assigned mandatory S-57 attributes. The photos were used to assist in making object type and attribute determination.

B. *Quality Control*

B.1. Overview

The traceability and integrity of the echo sounder data, position, and other supporting data was maintained as it was moved from the collection phase through processing. Consistency in file naming combined with the use of standardized data processing sequences and methods formed an integral part of this process.

CARIS HIPS was used for the single beam data processing tasks on this project. HIPS was designed to ensure that all edits, adjustments and computations performed with the data followed a specific order and were saved separately from the raw data to maintain the integrity of the original data.

Quality control checks were performed throughout the survey on all survey equipment and survey results. The following sections outline the quality control efforts used throughout this project; in the context of the procedures used, from acquisition through processing and reporting.

B.2. Data Collection

B.2.1. Hypack

Hypack data acquisition software was used to log all single beam data and to provide general navigation. The software features a number of quality assurance tools, which were taken advantage of during this survey.

Using the raw echo sounder depth data, Hypack generated a real-time digital terrain model (DTM) during data logging that was tide and draft corrected. To accomplish real-time tide correction Hypack applied a user-specified datum offset to the RTK altitude from the Trimble 5700. This offset was entered by the survey crew into Hypack using a single preliminary MLLW to ellipsoid separation value established for the Snag Point tide station.

The DTM was displayed as a layer in the Hypack “Navigation” view. The vessel position was plotted on top of the DTM along with other common data types including shape files containing survey lines and boundaries, S-57 charts when applicable, waypoints and GeoTIFFs exported from CARIS HIPS, as necessary.

The DTM was used to determine when the required minimum depth of two meters was achieved; it greatly assisted in preventing over-surveying (where depths significantly shoaler than required are collected) and under-surveying (where the survey vessel would need to return to an area to develop it further). The DTM was also instrumental in allowing real-time coverage analysis.

Note that the DTM was only used as a field quality assurance tool and was not used during subsequent data processing. Tide and offset corrections applied to the DTM and other real-time displays had no effect on the raw data logged by Hypack and later imported into CARIS HIPS. Final tide and offset corrections were applied in CARIS HIPS.

In addition to the DTM and standard navigation information, Hypack was configured with various tabular and graphical displays that allowed the survey crew to monitor data quality in real-time. Alarms were setup to alert the survey crew immediately to certain quality-critical situations. These included:

- Simultaneous display of independent Hemisphere V111 and Trimble 5700 positions on the navigation window as real-time position reality checks
- Alarm for loss of ZDA timing sync or positioning data from Trimble 5700
- Alarm for loss of attitude or positioning data from Hemisphere V111
- Alarm for age-of-RTK correction exceeding 10 seconds
- Alarm for loss of sonar input

It should be noted that Hypack automatically breaks and restarts RAW file logging at the Julian day rollover. This process takes a few seconds during which no data is recorded. Therefore lines run over the Julian day change may have a small (2-3 second) along-track gap. These rare gaps were deemed insignificant and re-ran only when necessary to better delineate a feature.

B.2.2. Draft and Sound Speed Measurements

Vessel static draft was measured at least once daily. With the vessel at rest, a calibrated measure-down pole or tape was used to measure the distance from the waterline to the measure-down point on the vessel gunwale. The measurement was taken on both sides of the vessel with an effort made to ensure that the vessel was loaded similarly to that experienced during survey operations. Time and measurement values were noted in the Hypack comments for later inclusion in the CARIS HIPS Vessel File (HVF) by processing.

Sound speed profiles or “casts” were collected normally at a 12-hour (or once per shift) interval during SBES data collection. More frequent profiles were deemed unnecessary as there was typically little variation between profiles. Upon transiting a large distance (generally more than 10 kilometers), or entering a new survey sheet, an additional profile was normally collected to ensure any spatial component of changes in sound speed were accounted for.

Deployed by hand, the sound speed sensor was held at the surface for approximately one minute to achieve temperature equilibrium before being lowered slowly to the bottom (typically no more than 1 meter/second (m/s)). When back aboard, the sensor was downloaded to ensure a profile was successfully acquired. If a profile was not acquired, or contained obvious problems, another profile was collected. Time and filename were noted in the Hypack comments for later use in processing. Position and filename were saved as Hypack targets and were paired with the cast file data in processing.

B.2.3. Logsheets

Hypack comments were entered continually during survey operations. Events pertinent to surveying, including surveyors’ initials, weather conditions, measure-downs and sound speed casts, were entered into the comments, which were stored by Hypack to a project text file. Comments and line file start and end times were then extracted from the text file by using in-house software and later used to form processing logsheets in Excel format. This helped ensure that all lines were recorded in a logsheet and tracked from acquisition through processing.

The following common events were recorded by the survey crew. Time tags were assigned to each event by Hypack:

- Generic line information including line name and start and stop times (auto-generated by Hypack)
- RTK base station in use and status
- Static draft measurements
- Sound speed cast events
- Sea and wind state, especially when adversely affecting operations
- Comments on any unusual observations or problems

Logsheets are available in the DR, *Separates I: Acquisition & Processing Logs*.

B.2.4. Base Station Deployment

Base stations were installed, prior to bathymetric data acquisition, in the base station area and remained until survey operations were completed. Specific equipment utilized is described previously in this report in Section A.6.

During deployment, the GPS antenna was leveled and secured to minimize movement. Antenna height over the monument was recorded and checked by at least one other surveyor. Battery voltage, logging status and other important parameters were logged to a base station deployment logsheet.

Periodically during the survey and finally at retrieval, the levelness of the GPS antenna and alignment, relative to the monument, were checked. If out of level or alignment then the necessary adjustments were made. Antenna height was measured again. Battery voltage, logging status and other important parameters were again noted in the base station deployment logsheet.

No large discrepancies occurred on this project between antenna height measurements or alignments, with subsequent measurements at 0.01 m, or better. An exception was at Etolin Point, where there was slow sinking due its deployment on soft tundra. Maximum vertical change between antenna height measurements at Etolin Point was 0.045 m. During PPK processing, the beginning antenna height was used instead of end antenna height for simplicity. The base station deployment logsheets, as well as base station confidence checks, are available with the project HVCR.

B.2.5. File Naming and Initial File Handling

A file naming convention was established prior to survey commencement for all raw files created in acquisition. Files were named in a consistent manner with attributes that identified the originating vessel, survey sheet and Julian day.

The file naming convention assisted with data management and quality control in processing. Data was more easily filed in its correct location in the directory structure and more readily located later when needed. The file naming system was also designed to reduce the chance of duplicate file names in the project.

The table below lists raw data files commonly created in acquisition and transferred to data processing.

RAW and BIN	**Hypack Files: Bathy Data**		**VesselSheet-YearBoatDayTime**
	Line Type	**Prefix**	**Example**
	Mainscheme Line	*VesselSheet-*	**1A-2012LA1472254.RAW**
	Cross Line	*VesselSheetXL-*	**1AXL-2012LA1472254.RAW**
	Test / Check / Lead Line / Bar Check	*VesselXX-* *enter a comment for line purpose*	**1XX-2012LA1472254.RAW**
SVP	Text file from Digibar or AML		**1A-2012-190-1400.DIGI** **1A-2012-190-1400.AML** *VesselSheet-Year-JD-Time.instrument*
HEX	Text file from Seabird tide gauge		**SN1221-2012-145-1522.HEX** *SerialNumber-Year-Day-Time*
T01	Trimble 5700 binary file (navigation)		*ReceiverSN/JD/FileSequenceNumber*
	Station	**Receiver SN**	**Example**
	Latent Sea	5240	**17841404.T01**
	It Sea	1784	
	Bit Sea	0002	
	Dillingham (Snag Pt) Base	0987	
	Protection Point Base	0056	
T00	Trimble NetRS binary file		*Station_ID/Date/StartTime*
	Station	**ID**	**Example**
	Clark's Point	ClarksPt	**ClarksPt201205230600a.T00**
	Etolin Point	Etolin	**Etolin201205251200a.T00**
A0x	Bubbler download files from JOA tide stations		**94628081.A05** *Station_ID/JD/Sequential*

Table 17 – Common raw data files.

Files that were logged over Julian day rollovers were named (and filed) for the day in which logging began. This was adhered to even if the majority of the file was logged in the “new” day. This was a common occurrence since Julian day midnight occurred at 16:00 local time during prime daylight hours.

During data collection, the raw data files were logged to a local hard drive in a logical directory structure on the acquisition PCs. At the end of each survey shift the data was consolidated and copied to a portable hard drive and handed over to the Lead Hydrographer in Dillingham and then transferred overnight via satellite Internet link to TerraSond's Palmer office for processing. Occasionally, when the amount of data acquired exceeded 600 MB, the .BIN files were separated from the rest of the data and mailed to the office on a thumb drive to be re-merged with RAW data files in the CARIS structure and reviewed later.

When preliminary processing of the data was completed – normally within one day – office processing staff would email a daily coverage TIF image file and communicate any feedback relating to data quality back to the Lead Hydrographer.

B.3. Data Processing

Preliminary data processing was carried out at TerraSond's Palmer, Alaska office.

Following the overnight transfer of data from the field, the office-based processing personnel would check the generated Excel logsheet against the transferred files to confirm all necessary data was included, and then store it in the appropriate location on the processing server.

Raw data was then converted, cleaned and preliminary tide and GPS corrections applied. This was normally accomplished within one day of acquisition, providing relatively rapid coverage and quality determination.

The data on the processing server was backed-up once each day onto LTO3 tapes. An additional copy of the raw data was kept in Dillingham. The system of using data storage servers with redundant disk arrays, automatic backups and off-site data copies minimized the potential for data loss due to equipment malfunction, or failure.

Checks and data corrections applied by data processors were recorded in the processing line logsheets. These are available in each DR, *Separate I: Acquisition and Processing Logs.*

B.3.1. Conversion into CARIS HIPS and Waterline Offset

CARIS HIPS software was used to create a directory structure organized by project, vessel and Julian day to store data. The RAW files written by Hypack were imported into CARIS HIPS using the conversion wizard module (Hypack RAW option). 1470 m/s was entered as the sound speed to match the value set in the Odom CV100s by acquisition, which allowed HIPS to convert depths in the RAW file to travel time for later sound speed correction. The wizard created a directory for each line and parsed the RAW components into sub-files, which contained individual sensor information.

The HIPS vessel definition file (HVF) for each vessel was updated with a new waterline value. Port and starboard measure-downs recorded in the acquisition comments were averaged and reduced to the vessel's reference point using the surveyed vessel offsets to determine the static draft, and entered into the static draft logsheet. This value was entered as a new waterline value in each vessel's HVF and checked to confirm the values fell within the normal range for the vessel. The static draft logsheet is available in each DR, *Separate I: Acquisition and Processing Logs.*

B.3.2. Re-Sync Timestamps

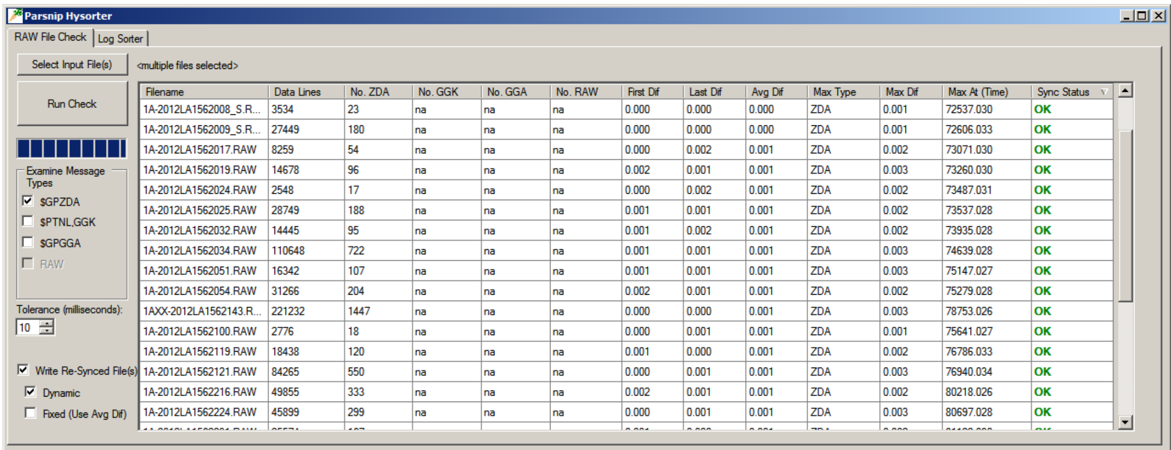
Although most lines were unaffected, it became evident late in the project that timestamps in some Hypack RAW files were not always synced to UTC properly. This was manifested as very large horizontal shifts between overlapping single beam data on affected days. After consultation with Hypack, it became apparent that the issue involved the interaction between Hypack and the Windows 7 OS on the PCs being used. Windows 7, due to user account control settings, were not always allowing Hypack to sync the PC clock, resulting in Hypack using the un-synced PC clock to timestamp data on affected days.

Hypack RAW files contain a timestamp assigned by Hypack, as well as raw ZDA messages output by the Trimble. Time tag anomalies could be identified by differencing the ZDA timestamp and the Hypack timestamp; on normal "synced" lines the difference was found to be less than 10 milliseconds between the ZDA and the Hypack timestamp. However, on "un-synced" lines, the difference could be many seconds (as great as 35 seconds in some cases), since Hypack was using the uncorrected PC clock. Furthermore, due to the tendency of the PC clock to drift over time, the offset was found to differ from the beginning of a line to the end of the line by as much as 20 milliseconds.

An in-house utility, Parsnip Hysorter, was written to scan all RAW files project-wide to search for time tag anomalies. The utility opened every RAW file, found each ZDA timestamp and the difference from the corresponding Hypack timestamp. Differences greater than 10 milliseconds were flagged and a summary report created.

The vast majority of lines were found to be correctly synced; a handful of lines were un-synced. These almost always occurred in a group, affecting an entire survey shift, but not re-occurring for the next survey shift. This corresponded to rebooting of the acquisition PC on the survey vessel.

The utility was expanded to be able to re-sync problem lines. This was possible because precise UTC time was written to every RAW file at a regular 1 second interval. The utility determined the difference between the correct time (in the ZDA message) and the Hypack timestamp, and wrote an output RAW file that was dynamically re-synced at each occurrence of a ZDA time string. These re-synced files can be identified by the "_S" in the filename where they occur. All re-synced RAW files were then put into the standard processing flow in CARIS and examined in subset mode to ensure matchup with crosslines, with good results. Un-synced lines were rejected. Affected survey shifts or lines are described in the appropriate DR.



Filename	Data Lines	No. ZDA	No. GGK	No. GGA	No. RAW	First Dif	Last Dif	Avg Dif	Max Type	Max Dif	Max At (Time)	Sync Status
1A-2012LA1562008_S.R...	3534	23	na	na	na	0.000	0.000	0.000	ZDA	0.001	72537.030	OK
1A-2012LA1562009_S.R...	27449	180	na	na	na	0.000	0.000	0.000	ZDA	0.001	72606.033	OK
1A-2012LA1562017.RAW	8259	54	na	na	na	0.000	0.002	0.001	ZDA	0.002	73071.030	OK
1A-2012LA1562019.RAW	14678	96	na	na	na	0.002	0.001	0.001	ZDA	0.003	73260.030	OK
1A-2012LA1562024.RAW	2548	17	na	na	na	0.000	0.002	0.001	ZDA	0.002	73487.031	OK
1A-2012LA1562025.RAW	28749	188	na	na	na	0.001	0.001	0.001	ZDA	0.002	73537.028	OK
1A-2012LA1562032.RAW	14445	95	na	na	na	0.001	0.002	0.001	ZDA	0.002	73935.028	OK
1A-2012LA1562034.RAW	110648	722	na	na	na	0.001	0.001	0.001	ZDA	0.003	74639.028	OK
1A-2012LA1562051.RAW	16342	107	na	na	na	0.001	0.001	0.001	ZDA	0.003	75147.027	OK
1A-2012LA1562054.RAW	31266	204	na	na	na	0.002	0.001	0.001	ZDA	0.002	75279.028	OK
1AXX-2012LA1562143.R...	221232	1447	na	na	na	0.000	0.000	0.001	ZDA	0.003	78753.026	OK
1A-2012LA1562100.RAW	2776	18	na	na	na	0.000	0.001	0.001	ZDA	0.001	75641.027	OK
1A-2012LA1562119.RAW	18438	120	na	na	na	0.001	0.000	0.001	ZDA	0.002	76786.033	OK
1A-2012LA1562121.RAW	84265	550	na	na	na	0.000	0.001	0.001	ZDA	0.003	76940.034	OK
1A-2012LA1562216.RAW	49855	333	na	na	na	0.002	0.001	0.001	ZDA	0.002	80218.026	OK
1A-2012LA1562224.RAW	45899	299	na	na	na	0.000	0.001	0.001	ZDA	0.003	80697.028	OK

Figure 4 – Example from Parsnip Hysorter used to scan all RAW files for time tag anomalies and dynamically re-synced, where necessary.

B.3.3. Sound Speed Corrections

Sound speed profiles (casts) were processed using TerraLog, an in-house program. The software assigned a timestamp based on the average time within the cast. Position was manually entered for the cast by the data processor by examining the associated Hypack target file. TerraLog separated the profile into it's up and down components and graphed the data points, allowing obvious erroneous points to be rejected. Once checked and cleaned, the software exported the combined (average of up and down components) profile to CARIS .SVP format at a regular 0.10 m interval. The output was checked for incorrect time stamps and positions and appended to the appropriate master CARIS .SVP file based on vessel and survey sheet.

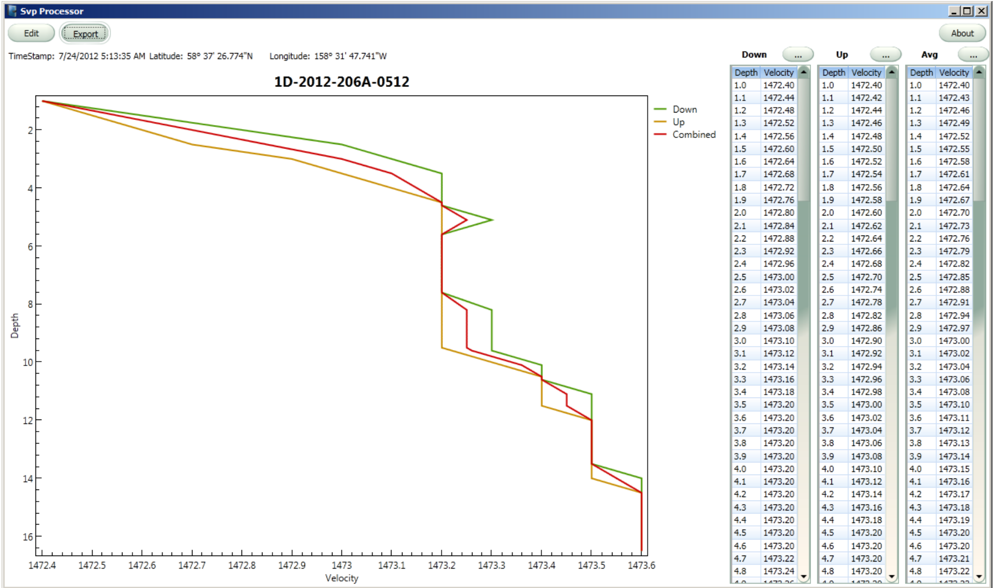


Figure 5 – Example SVP profile editing in TerraLog.

Each line was corrected for sound speed using HIPS' "Sound Velocity Correction" utility. "Nearest in distance within time" was selected for the profile selection method. For the time constraint, 12-hours was used for SBES data. These values were chosen to match the cast interval done in acquisition, which was determined by examining the average variance or difference between subsequent casts. The option to apply smoothed heave was enabled. Any deviations from this method are described in the corresponding DR.

B.3.4. Total Propagated Uncertainty

After sound speed correction, HIPS was used to compute total propagated uncertainty (TPU). The HIPS TPU calculation assigned a horizontal and vertical error estimate to each sounding based on the combined error of all component measurements.

These error components include uncertainty associated with navigation, gyro (heading), heave, tide, latency, sensor offsets and individual sonar model characteristics. Stored in the HVF, these error sources were obtained from manufacturer specifications, determined during the vessel survey (sensor offsets), or while running operational tests (patch test, settlement and squat). The individual system uncertainties used on this project are shown below and are common among all three vessels, since identical equipment and methods were used for each.

TPU Entry	Error Value	Source
Gyro	0.3°	Hemisphere V111 Gyro Specifications
Heave	5% or 0.14 m	Estimated accuracy of extracted PPK heave* (whichever is greater – 0.14 m will nearly always be larger than 5% of wave amplitude on this survey)
Roll and Pitch	0 °	Roll and pitch measurements were not applied
Navigation	0.10 m	PPK processing result reports indicate RMS positioning errors better than 0.10 m on average
Timing	0.01 sec	Hypack was time synced by ZDA time string. Hypack sync utility indicated this level of sync or better. N/A for pitch and roll
Offset (X and Y)	0.020 m	X and Y offsets were determined to within 0.020 m, or better
Offset Z	0.010 m	Z offsets were determined to 0.010 m, or better
Vessel Speed	3 knots	Average river current estimated to be 3 knots
Loading	0.020 m	Vessel loading changed an average of 0.020 meters between static draft measurements
Draft	0.010 m	Static draft was measurements were accurate to within 0.010 meters, or better
Delta Draft	0.010 m	Delta draft was measured to within 0.010 meters by PPK methods
MRU Align Gyro	1 °	Estimate of gyrocompass alignment to vessel reference frame
MRU Align Roll/Pitch	0 °	Roll and pitch measurements were not applied

Table 18 – TPU values used.

* Heave is measured at the Trimble antenna, which is offset from the vessel RP. Error is, therefore, a function of PPK altitude accuracy (0.10 m) plus potential effect of vessel roll (computed to be 0.04 m as shown below), misinterpreted as heave since no roll compensation was applied to antenna position. To estimate the effect of this error, the measured roll was extracted from a sample of survey days from H12401 (the survey area most exposed to heavy seas). The roll values fell within a range of -16 to 23.5 °. However, the roll values fell within a range of -2 to 5° at 1-sigma. A 5° roll along a lever arm of 0.44 m (the largest RP to navigation antenna X offset of the three vessels on It Sea) results in vertical error of 0.04 m. Note that one value was chosen for all three vessels for simplicity. Bit Sea and Latent Sea estimated error would be somewhat less due to shorter RP to navigation lever arms, but insignificantly so.

For “MRU to Trans” and “Nav to Trans” offsets under “TPU values,” the offset between the Trimble navigation antenna and the transducer were entered. The MRU is effectively the navigation antenna on this project since heave corrections were computed at the antenna, and no roll or pitch from the V111 was applied. No value was entered for transducer roll as no roll corrections were applied.

The tide zone ZDF (zone definition file) for the project contains error estimates for each tide zone and gauge. This ZDF was loaded in CARIS HIPS with the Compute Errors option enabled. During TPU computation these values were utilized by HIPS to estimate tidal error. Error estimates for the zones ranged from 0.054 m to 0.332 m. Error estimates for water level measurements at the gauges ranged from 0.014 m to 0.019 m. The ZDF and gauge files are included with the CARIS survey deliverables.

During TPU computation an estimated sound speed error was entered for each survey sheet with values that ranged from 0.96 m/s to 6.44 m/s. These values were derived from an analysis of the average variance between subsequent sound speed casts. The values used for each sheet are noted in the appropriate DR.

B.3.5. Load Tide and Merge

In CARIS HIPS Load Tide utility, all lines were loaded with the tide ZDF OPR-R306-KR-12_20121217.zdf provided by JOA. This file referenced a file for each gauge that contained smoothed 6-minute tide data on MLLW.

As noted in the section above, the ZDF also contained error estimates by zone and gauge that were used by HIPS for final TPU computations. After Load Tide, all lines had TPU re-computed and were merged with HIPS' "Merge" utility.

The ZDF and gauge files are included with the CARIS survey deliverables. More information regarding the tide zones and tide QC is available in the *Horizontal and Vertical Control Report.*

B.3.6. Post-Processed Kinematics

This project was located outside of the reliable USCG DGPS coverage area. Therefore, base stations were installed at strategic locations to transmit RTK corrections to the survey vessels.

However, the RTK radio link was highly susceptible to interruption and interference. Therefore, post-processed kinematic (PPK) GPS methods were utilized for final positions.

Discrete tide zones were used for vertical positioning in final processing. However, discrete tide zones could not be developed until after project completion due to lack of tide data for the area. Therefore, during the field stage of the survey, PPK altitudes were also utilized in conjunction with a preliminary ellipsoid to MLLW separation model to place soundings on datum using ERS methods.

PPK processing utilized Applanix POSGNSS software. POSGNSS makes use of dual-frequency GPS data logged at nearby shore base stations (.DAT format, converted from .T01 or .T00) and dual-frequency GPS and logged on the vessel (.T01 format). Results data are exported to text file and read into CARIS HIPS using the Generic Data Parser Utility (GDP).

This process produced a result superior to RTK for the following reasons:

- Uninterrupted overlapping rover / base data
- A backwards-in-time processing step not available in real-time
- The ability to select closer, or better, base stations when incorrect stations may have been used in real-time

RTK and PPK positions compared well (< 0.03 m vertically) when RTK was operating in its higher accuracy, "narrow-lane" mode.

To produce a GDP file with PPK altitudes, a project was setup in POSGNSS. GPS data from the vessel in ".DAT" format were imported. Base data, logged at 1 Hz, was interpolated to a 10 Hz rate to allow the final output GDP to also be at 10 Hz.

By examining the time extents and position of the vessel, the processor would select a base station to import; as a general rule, using the closest with overlapping time extents. Trimble DAT files belonging to the selected base would then be imported. These were then interpolated from their native 1 Hz rate to 10 Hz, a step necessary so that the final output GDP would be at 10 Hz (in order to capture heave swell period).

After import of the base data, 3D position (on NAD83 determined using NGS OPUS), antenna type and height were entered. Heights were entered as the phase center height of the antenna above the survey monument. For sites without survey monuments (building locations at Dillingham and Clarks Point), the height of the phase center above the antenna reference point was entered. Base station and deployment used was tracked on the PPK processing logsheet, which is available in each DR, *Separate I*.

An antenna height of 0.000 m was entered for vessel data. This resulted in final positions in the GDP to be for the phase center of the Trimble GPS antenna; corrections to vessel RP were handled by CARIS HIPS through the navigation offset entered in the HVF.

POSGNSS constantly computes error estimates and provides a number of plots and tables to QC the post-processed position quality. For each project, plots of RMS error and combined position separation were examined for issues. DOP, height profile and distance separation to base were also examined. These plots were output to PDF and can be found in *Appendix III* of the *Horizontal and Vertical Control Report*. An example is shown below.

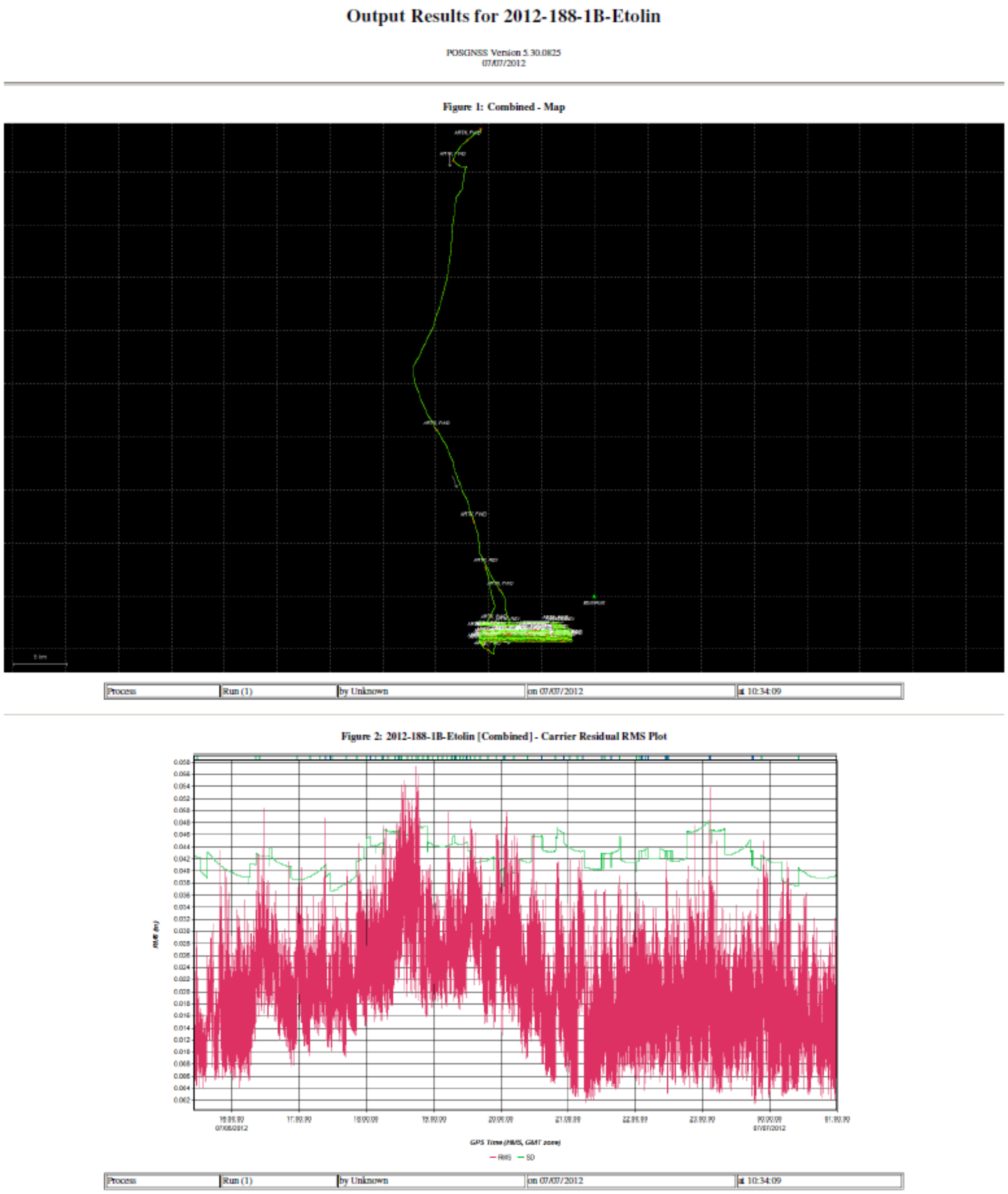


Figure 6 – Example of POSGNSS project map plot overview and RMS error plot.

When spikes or periods of unusually large error or uncertainty were encountered in the plots, they were noted in the PPK processing logsheet and further investigated. Spikes in RMS error were checked against computed altitude to determine if the error carried through to altitude. Spikes usually corresponded to periods of high-speed transit, so did not normally coincide with survey lines. If the vessel was not surveying at the time of the spike, no further QC would be done. However, if the vessel was online at the time, then the GPS data was re-processed using alternate methods until a good result was obtained. Typically choosing an alternate base station would have the desired effect.

After QC was complete on the solution status, a navigation file in text format (.TXT) was output that contained date, time, easting, northing (UTM ZONE4) and ellipsoid altitude (NAD83) at a rate of 10 Hz.

Navigation files were named based on year, Julian day, vessel and base station used. In some cases where the survey vessel worked close to one base station and then transited to work close to a different base station, the vessel navigation file would be processed twice – once for each base station, with two output files produced and named accordingly. Navigation files are included with the survey deliverables.

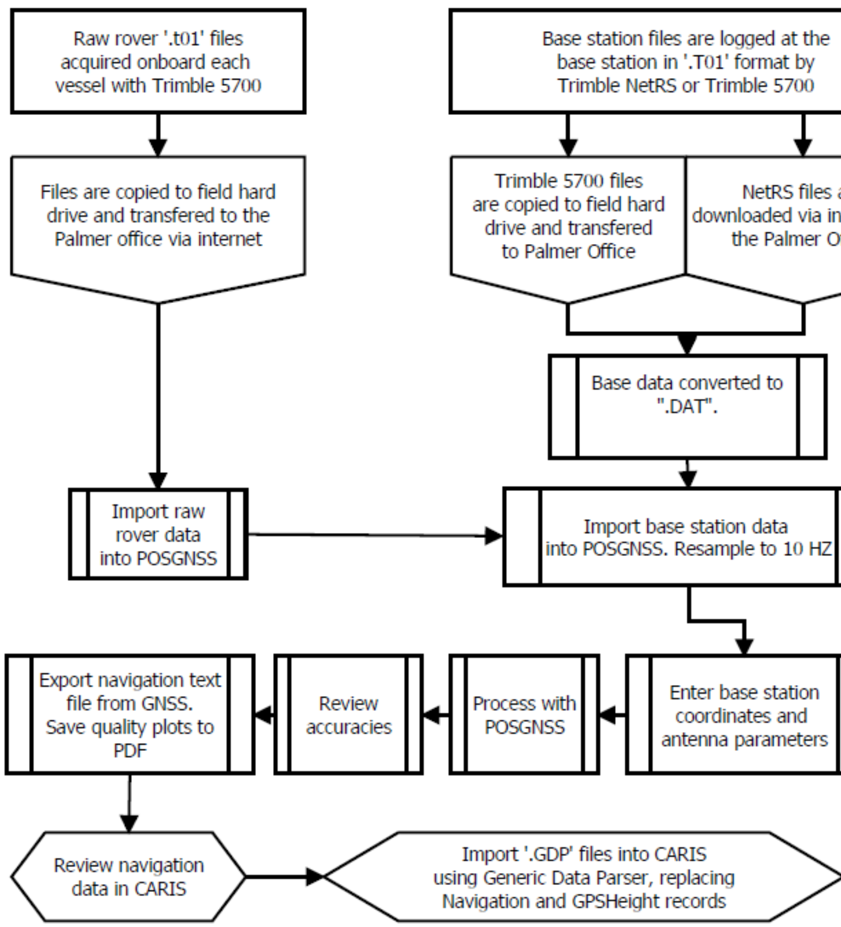


Figure 7 – Processing flow used on this project in POSGNSS.

B.3.7. Load Navigation and GPS Height through GDP

CARIS HIPS Generic Data Parser (GDP) was used to load the navigation files output by POSGNSS into each survey line. In this process, each line’s navigation and GPS height records were overwritten with the values from the navigation file. For each survey line, the name of the navigation file applied was noted by the data processor in the line logsheets.

The GDP .PAR script file that was used (2012_NOAA_PPK_GDP.par) is included with the CARIS survey deliverables.

It is important to note that this process replaced all real-time navigation originally converted from Hypack RAW file with PPK navigation, without exception.

B.3.8. PPK Heave

Final heave correctors were accomplished by extracting the heave component from post-processed kinematic (PPK) GPS altitudes.

Although the Hemisphere V111 units installed on each vessel also output heave data, the manufacture accuracy specifications for V111 heave at 0.30 m was higher than the estimated accuracy achieved with PPK methods at 0.14 m (error estimates for PPK heave are discussed in Section B.3.4 above).

GPS data was continually logged on each vessel at a rate of 10 Hz to ensure enough altitude data points existed to capture the full heave period from waves or swell. The data was processed in POSGNSS to produce navigation files in text format as described in Section B.3.6

HeaveXtractor was used to extract heave data at 10 Hz from the navigation files. HeaveXtractor is an in-house software utility that uses a high-pass filter (20-second moving average) cycled over each altitude, centered on the time of the data point for the averaging period. The filter result was subtracted from the data point, resulting in a residual value which was the heave component of the altitude. Longer term effects of dynamic draft and tide were removed through this process. The result is heave experienced at the vessel’s Trimble antenna, centered on zero.

HeaveXtractor included a number of quality control tools. These included a check for overlapping navigation files, a check to ensure the output files overlapped the CARIS line files completely, internal data integrity (spikes or noise or non-zero average heave) and data consistency (gaps >1 second).

Large spikes or gaps were usually found to occur during high-speed transits when the vessel was not surveying. Occasionally, the software detected that gaps landed within the time extents of survey lines. When these were found, the survey lines were examined. If the gap occurred when seas were rough (considered more than 0.10 – 0.20 m), heave from the V111 unit was used on the line instead. These cases were rare and are noted, when applicable, in the appropriate DR.

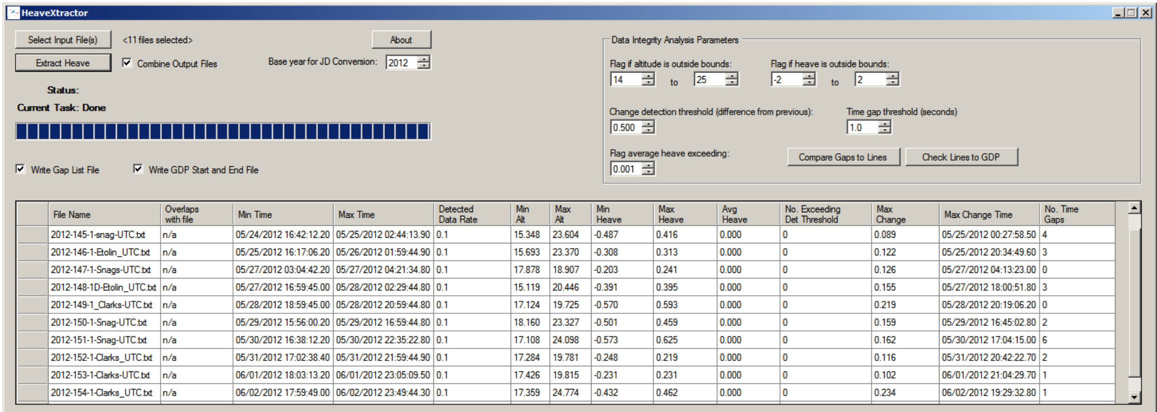


Figure 8 – Screengrab of HeaveXtractor interface.

HeaveXtractor wrote text files that contained the original PPK data, plus the moving average value and residual heave. These files were loaded into all survey lines, with few exceptions, using CARIS' HIPS Generic Data Parser (GDP). The lines were subsequently re-SVP'd and re-merged to apply the correctors. From JD183 (7/1/12) onwards, a correction to the times in the heave files of -1 seconds was applied during the loading process in GDP to compensate for navigation files corrected for the new GPS-UTC offset of 16 seconds (from 15), which began that day.

Results of this process were checked on samples of lines across the project for effect in poor weather and compared to the Hemisphere V111 heave, with good results. The following figures show examples of the results:

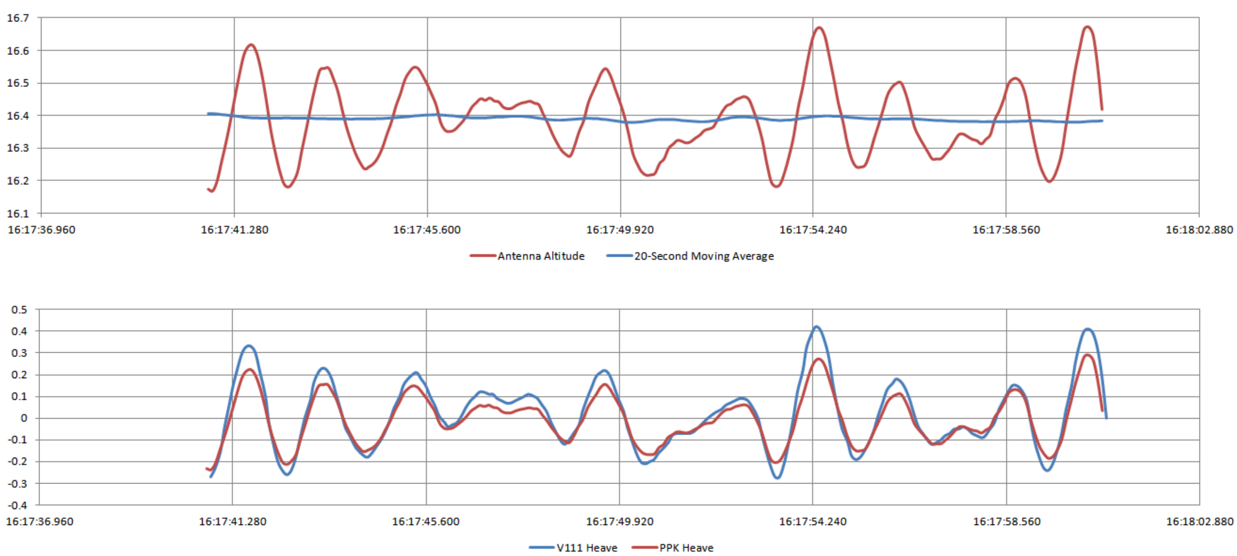


Figure 9 – Example from a rough weather line (1HXL-2012LA2271616). Top graph shows antenna altitude and the 20-second moving average computed by HeaveXtractor. The lower graph shows the output from HeaveXtractor over the same time period, plotted against heave from the Hemisphere V111 sensor.

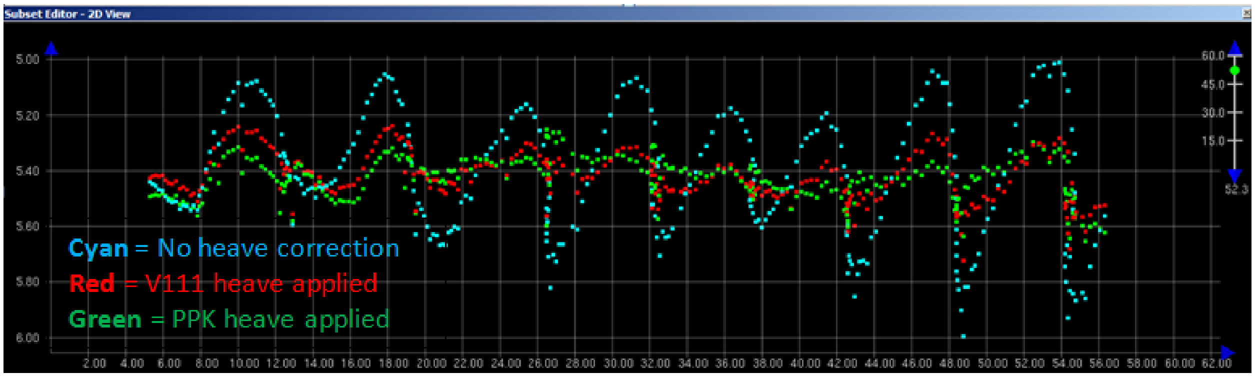


Figure 10 – Example from a rough weather line (1HXL-2012LA2271616): View from CARIS subset mode of effects of heave corrections. Residual motion after heave correction is likely a result of vessel pitch.

Text files containing the extracted heave data and the GDP scripts used to load the heave into each line are included with the CARIS deliverables.

B.3.9. Navigation and Attitude Sensor Checks

Navigation data was reviewed using the CARIS HIPS Navigation Editor. The review consisted of a visual inspection of plotted fixes noting any gaps in the data or unusual jumps in vessel position. Discrepancies were rare and were handled on a case-by-case basis.

Attitude data was reviewed in HIPS "Attitude Editor." This involved checking for gaps or spikes in the gyro, pitch, roll and heave sensor fields.

Spikes were common in Hemisphere V111 pitch, roll and heave. These were rejected for the most part, but when it became evident that V111 attitude data would not be applied, this practice was stopped. It should be noted that the pitch and roll values in the lines are not applied to the data and, therefore, QC was not fully completed on those fields. Heave was replaced with PPK heave as shown above; in the rare cases where V111 heave was used, the cleaning process was completed.

All attitude records except gyro were smoothed in CARIS HIPS Batch Editor using a 3-point moving average at 1-sigma to smooth any small spikes that may be present, esp. in heave data. The batch editor script used is included with the CARIS deliverables.

Checks done on the sensors were tracked in the line logsheets, available in each DR, *Separate 1: Acquisition and Processing Logs*.

B.3.10. Single Beam Editing

Single beam data was cleaned using HIPS Single Beam Editor. Erroneous soundings exceeding error tolerances outlined in the 2012 Hydrographic Surveys Specifications and Deliverables (HSSD) were rejected.

The digital bottom traces recorded to .BIN files in Hypack were used extensively and were critical to editing the single beam data, so that it accurately represented the bathymetry. Single beam editing in HIPS was done concurrent with the display of the bottom trace in CARIS HIPS Single Beam Editor.

Note that in the current version of CARIS HIPS Single Beam Editor, the alignment of soundings to the digital trace is not good, frequently showing a vertical shift or horizontal shift. This is due to the fact that HIPS does not correct the trace position for the effects of sound speed and other offsets from the HVF, while the soundings have been corrected. However, the trace still served as a useful guide when editing soundings.

To ensure the single beam data was thoroughly cleaned with all erroneous soundings rejected, this process was done twice – once when the data first became available (typically the day after acquisition) and again in the office prior to deliverable production.

As a final check on the SBES data for gross fliers, all SBES data was loaded into CARIS Subset mode and reviewed line by line with the 2D slice set parallel each line. Auto-exaggeration was turned on, and gross fliers were rejected.

B.3.11. Final BASE Surfaces

The final depth information for this survey is submitted as a collection of CARIS BASE surfaces (HIPS 7.1 CSAR format), which best represent the sea floor at the time of survey.

Single beam surfaces were created at 4 m resolution, as per the 2012 HSSD, as CUBE surfaces. “Density and Locale” was chosen as the disambiguity method and NOAA CUBE parameter .XML based on 4 m resolution selected as the advanced CUBE parameters. These parameters are included with the CARIS digital data deliverables.

Each surface was finalized prior to submittal. During this process, final uncertainty was determined using the “Greater of the two” (Uncertainty or Std. Dev. at 95% C.I.) option. Designated soundings were applied, though they were extremely rare on this project.

A data set containing a single S-57 file (in CARIS .HOB format) and supporting files was submitted in conjunction with each 2012 survey deliverable. The S-57 file contains information on objects not represented in the depth grid, including nature of the seabed (bottom samples), sand-wave areas and meta-data objects. For survey H12398 and H12399 shoreline detail is also included. Each feature object includes the mandatory S-

57 attributes (including 2012 NOAA extended attributes) that may be useful for chart compilation.

B.3.12. Crossline Analysis

The crossline analysis was conducted using CARIS HIPS QC Report routine. Each crossline was selected and run through the process, which calculated the difference between each accepted crossline sounding and a 4 m resolution QC BASE surface created from the mainscheme data. Note that although crosslines are included in the final BASE surfaces, they were not included in the QC BASE surfaces so as to not bias the results.

The differences in depth were grouped by beam number and statistics computed, which included the percentage of soundings with differences from the BASE surface falling within IHO Order 1. When at least 95% of the soundings exceed IHO Order 1 the crossline was considered to "pass," but when less than 95% of the soundings compare within IHO Order 1 the crossline was considered to "fail." Failures were investigated and typically determined to be a result of bottom change, tide busts, or a combination.

A discussion concerning the methodology of crossline selection, as well as a summary of results for each sheet, is available in the relevant DR. The crossline reports are included in each DR, *Separate II: Crossline Comparisons.*

B.3.13. Processing Workflow Diagram

The following figure outlines the processing flow used for this project:

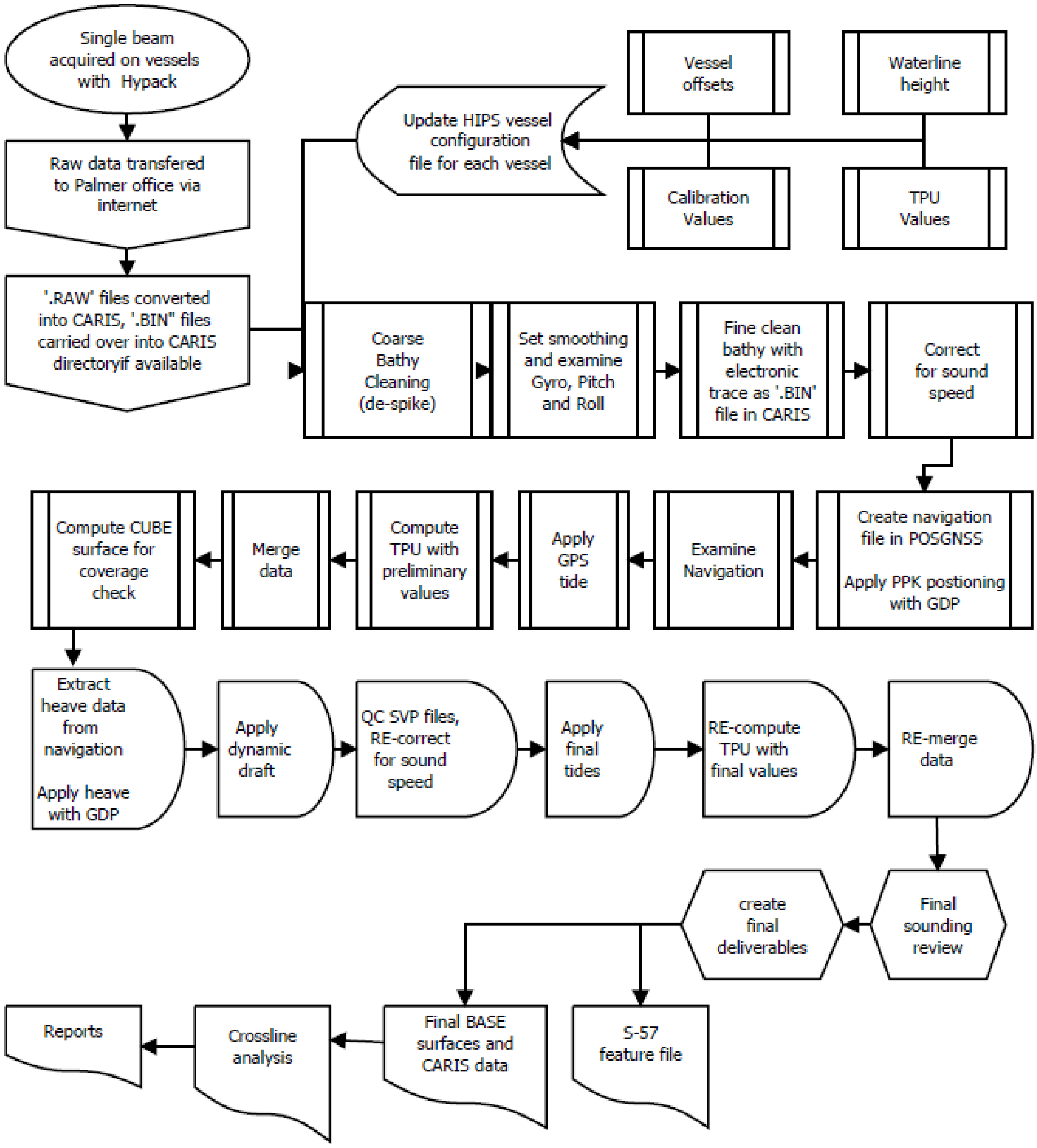


Figure 11 – Processing flow overview.

B.4. Confidence Checks

In addition to the QC steps relating to acquisition and processing procedure outlined in the above sections, formal confidence checks were undertaken throughout the survey to ensure the best possible accuracy and precision was achieved.

The following table summarizes the formal confidence checks:

Confidence Check	Purpose	Normal Frequency
Bar Checks	Ensure echo sounder accuracy Determine and refine Z offsets	Two times over survey per vessel
Lead Lines	Ensure echo sounder accuracy	Weekly
Echo Sounder Comparison	Overall check of consistency between survey systems and platforms	Weekly
SVP Comparison	Check SVP sensors for consistency	Weekly
Base Station Position Check	Ensure consistent base station position	Weekly, or at least once per deployment
Vessel Position Confidence Check	Check for consistent vessel positioning	Weekly
Staff Shots	Check of tide gauge stability	Weekly to bi-weekly

Table 19 – Summary of confidence checks.

B.4.1. Bar Checks

For this survey, bar checks were employed to determine, or refine, Z offsets and to check the accuracy of the echosounder systems. These were done twice per vessel over the course of the survey.

For SBES bar checks, an aluminum grate, roughly eight inches in width and a length equivalent to the vessel beam, was hung by chains from guide points on the vessel's gunwale. The bar chain was marked at an interval of 1 m from the bar, measured by tape. A sound velocity profile was collected and the average velocity entered into the echo sounder, and static draft was measured.

With Hypack logging and the sonar tuned to track the bar instead of the bottom, the bar was lowered by 1 m increments directly below the vessel's transducer while bar depth and time were noted in the log. Bar check max depth – which ranged from 1 to 5 m on this survey – was determined by ability to maintain a sonar lock on the bar and depth.

The bar depth was read relative to the waterline for later comparison to the HIPS results, as well as relative to the gunwale measure-down points for determining, or checking, the acoustic center offset. Bar depth versus HIPS results always compared to better than 0.10 m, but usually better than 0.03 m.

In addition to confidence checks, bar checks were critical to establish acoustic center offsets on the Odom single beam systems. Odom single beam systems have an acoustic center position that can vary from the transducer face due to electronic delays between the processor, transducer and interconnecting cable. Odom refers to this offset from the transducer face as the “index value.” Once determined for a particular layout, however, the value remains fixed.

Bar check processing logs are available in *Separate I* of each project DR.

B.4.2. Echo Sounder Comparison

Direct comparisons were normally completed weekly between the echo sounders installed on the vessels. The echo sounder comparison served as a confidence check on the total survey system.

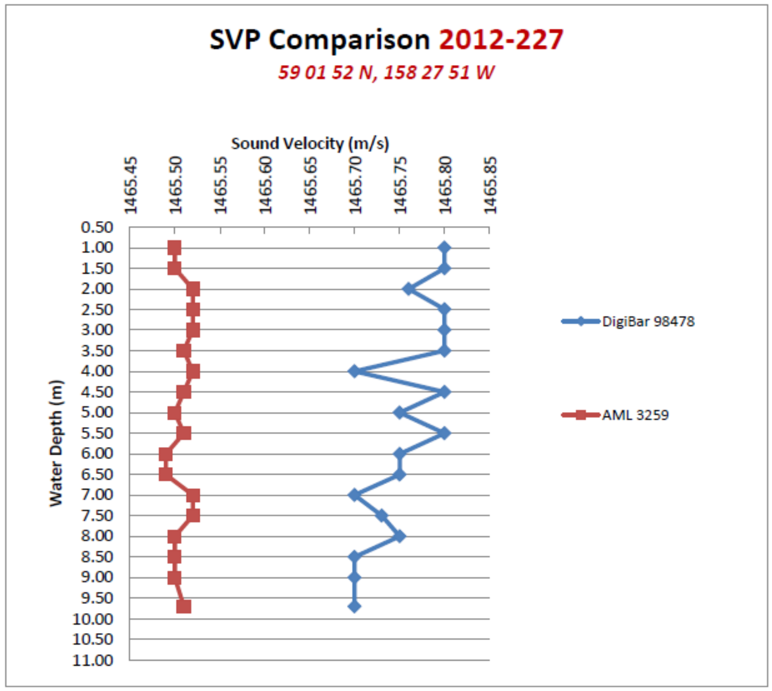
A survey line was established in an area of mixed bottom topography; each vessel would in turn run the line in both directions at an average survey speed. Typically, this was done on the same day every week, but sometimes it was not always possible.

After standard processing, the systems were examined in HIPS Subset Editor and the results noted in an echo sounder comparison logsheet. Agreement was typically 0.20 m, or better, depending on how well the single beam soundings overlapped each other on the rough terrain. Later in the project when only one survey vessel (*Latent Sea)* was present, the weekly check was compared to the prior weekly check. The echo sounder comparison logs are available in *Separate I: Acquisition and Processing Logs*.

B.4.3. SVP Comparison

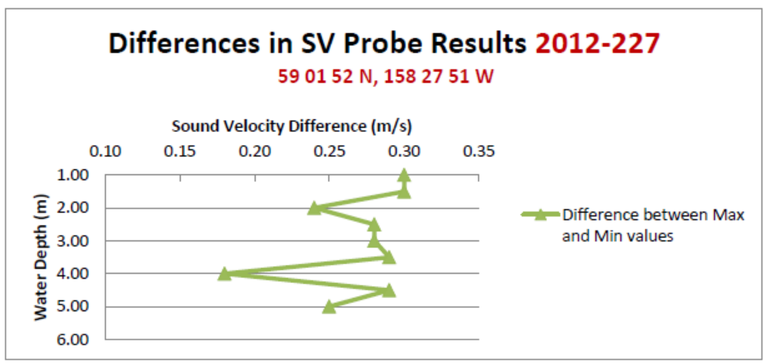
Direct comparisons were normally completed weekly between the sound speed sensors in use on the project. This was usually done, coincidentally, with the echo sounder comparisons. A cast was taken with each sensor in the area within the same time frame. The data underwent standard processing and was then compared depth-by-depth in an SVP comparison logsheet (see example below). Results were good between sensors, with all data comparing to better than 0.85 m/s, but usually to better than 0.20 m/s. Individual test results are available in *Separate II* of each DR.

SV Probe Results		
Probe:	Digibar	AML
S/N	98478	3259
Date/time:	227/23:17	227/23:14
Depth	Sound Velocity (m/s)	
1.00	1465.80	1465.50
1.50	1465.80	1465.50
2.00	1465.76	1465.52
2.50	1465.80	1465.52
3.00	1465.80	1465.52
3.50	1465.80	1465.51
4.00	1465.70	1465.52
4.50	1465.80	1465.51
5.00	1465.75	1465.50
5.50	1465.80	1465.51
6.00	1465.75	1465.49
6.50	1465.75	1465.49
7.00	1465.70	1465.52
7.50	1465.73	1465.52
8.00	1465.75	1465.50
8.50	1465.70	1465.50
9.00	1465.70	1465.50
9.70	1465.70	1465.51



(Figure 1- Sound velocity from each Sound velocity Probe)

Statistics on the SV Probe results			
	Sound Velocity (m/s)		
Depth	Max	Min	Difference
1.00	1465.80	1465.50	0.30
1.50	1465.80	1465.50	0.30
2.00	1465.76	1465.52	0.24
2.50	1465.80	1465.52	0.28
3.00	1465.80	1465.52	0.28
3.50	1465.80	1465.51	0.29
4.00	1465.70	1465.52	0.18
4.50	1465.80	1465.51	0.29
5.00	1465.75	1465.50	0.25
5.50	1465.80	1465.51	0.29



(Figure 2- Differences between the Maximum and Minimum Sound Velocity of the two casts)

Figure 12 – Example of typical SVP comparison results. JD 227 SVP comparison.

B.4.4. Base Station Position Checks

Positions of base station benchmarks were established using NOAA NGS OPUS (Online Positioning User Service) by upload of the first 24-hour GPS static session from each initial base station deployment. This position became the accepted, surveyed position.

To ensure that the benchmark did not subsequently shift over the course of the survey, and to check repeatability of the surveyed position, a static session from each reoccupation of the benchmark was uploaded to OPUS and the results compared in an Excel spreadsheet to the surveyed position. If a reoccupation of a benchmark lasted longer than a week, more than one check was done during the occupation.

Results were good, with subsequent occupations and checks always comparing to better than 0.05 m (both horizontally and vertically) but usually better than 0.01 m. See the HVCR for more information regarding specific results and the base station position check logsheet.

B.4.5. Vessel Positioning Confidence Check

To ensure that vessel positioning was consistent regardless of the base station in use – and as independent check of vessel positioning – vessel position confidence checks were done normally on a weekly basis, for each survey vessel.

To complete this check for each vessel, a random Trimble T01 file was selected from the week and processed as normal with the closest base station, producing a navigation file. The T01 file was then re-processed with an independent, but usually more distant secondary base station, producing a second navigation file.

The two navigation files were differenced and compared in Excel. This produced a difference plot, which was reported on a vessel positioning confidence check form. Results were good, usually returning differences better than 0.10 m (both horizontally and vertically). See the vessel positioning confidence check logs in *Separate I* of each DR for specific results.

B.4.6. Tide Station Staff Shots

To check the stability of tide gauge orifices and to collect data to assist with establishing MLLW to ellipsoid ties, staff shots consistent with requirements of the 2012 HSSD were done at each tide station. Typically, these were completed weekly at Snag Point, bi-weekly at Clarks Point and monthly at Protection Point.

Standard leveling procedures were used to determine the difference in elevation between a tide station benchmark and the water surface. At least one hour of observations were collected at each visit, at a six minute interval that started on the hour. If it had been more than one week since observations were collected, then at least one additional hour of observations were taken for each missed week. The staff shot readings were timed to coincide with data collected by the WaterLOG tide gauges, which were synced to UTC.

Results were logged and compared to the values recorded by the tide gauge to compute a staff shot constant. The staff shot form along with downloaded gauge data was sent by email, normally within 24-hours of collection, to TerraSond’s tide subcontractor, JOA. JOA would QC the data and send requests to the field for gauge maintenance, or other tasks, when necessary. See the HVCR for more information concerning tide operations and JOA’s tide station reports (included with HVCR), which include the staff shot forms.

C. *Corrections to Echo Soundings*

The following methods were used to determine, evaluate and apply corrections to instruments and soundings.

C.1. Vessel Offsets

Sensor locations were established with a pre-season survey of each vessel using conventional survey instruments. Acoustic center offsets were determined through bar check method for the SBES systems. For each vessel, a point near the center of the vessel was established as the center reference point (CRP) – or point from which all offsets were referenced.

All vessel-related offsets were applied in CARIS HIPS by means of the HVF.

All offsets received numerous checks including reality tests by survey tape and bar check. Checks reveal an offset uncertainty of 0.020 horizontally and 0.010 vertically. Vessel outlines and offset descriptions are provided in the following figures and tables:

C.1.1.1. M/V Latent Sea Vessel Survey

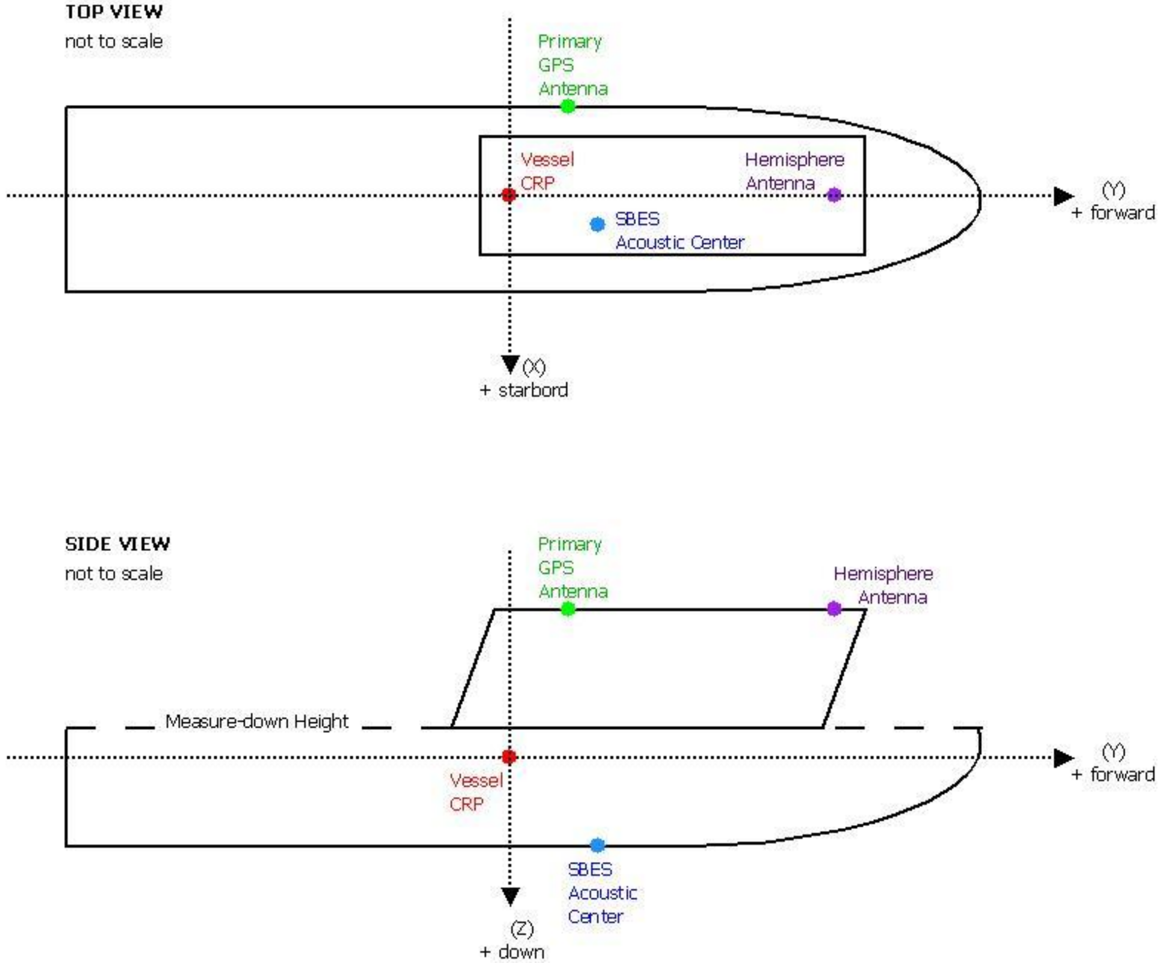
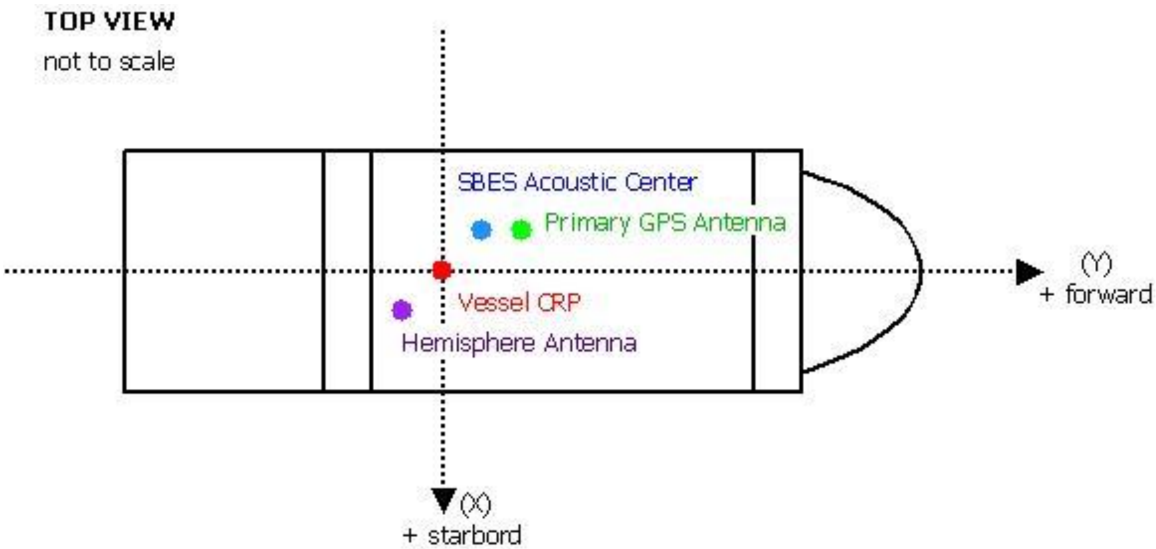


Figure 13 – M/V Latent Sea vessel survey showing the relative positions of the installed survey equipment.

Equipment	X (m) (+ stbd)	Y (m) (+ fwd)	Z (m) (+ down)	Comments
SBES Acoustic Center	0.171	0.350	0.419	Z determined by bar check
Primary GPS Antenna (Zephyr)	-0.382	0.215	-2.544	Failed, removed on 8/14/2012
Primary GPS Antenna (Zephyr Geodetic)	-0.382	0.215	-2.551	Installed on 8/15/2012
Hemisphere Antenna	0.000	1.872	-2.161	None
Draft Measure-down Points (port)	na	na	-0.832	None
Draft Measure-down Points (stbd)	na	na	-0.790	

Table 20 – M/V Latent Sea offset measurements from CRP, determined during vessel survey.

C.1.1.2. M/V It Sea Vessel Survey



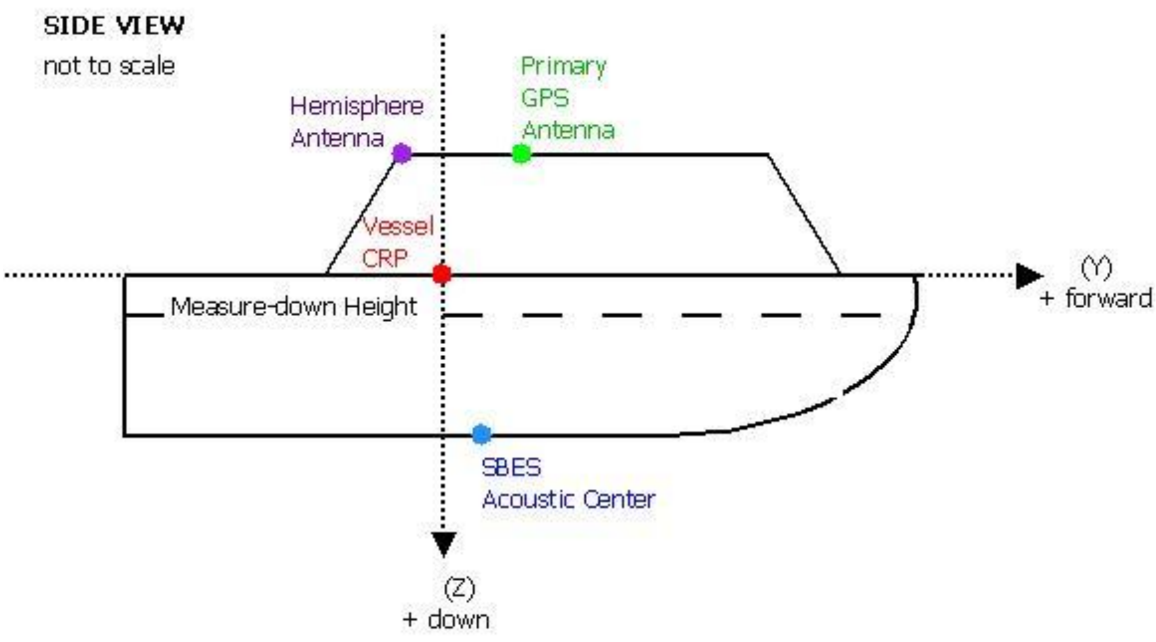


Figure 14 – M/V It Sea vessel survey showing the relative positions of the installed survey equipment.

Equipment	X (m) (+ stbd)	Y (m) (+ fwd)	Z (m) (+ down)	Comments
SBES Acoustic Center	-0.408	0.025	0.653	Z determined by bar check
Primary GPS Antenna (Zephyr)	-0.402	0.030	-1.562	None
Hemisphere Antenna	0.005	-0.005	-1.516	None
Draft Measure-down Points	na	na	0.205	None

Table 21 – M/V It Sea offset measurements from CRP, determined during the vessel survey.

C.1.1.3. M/V Bit Sea Vessel Survey

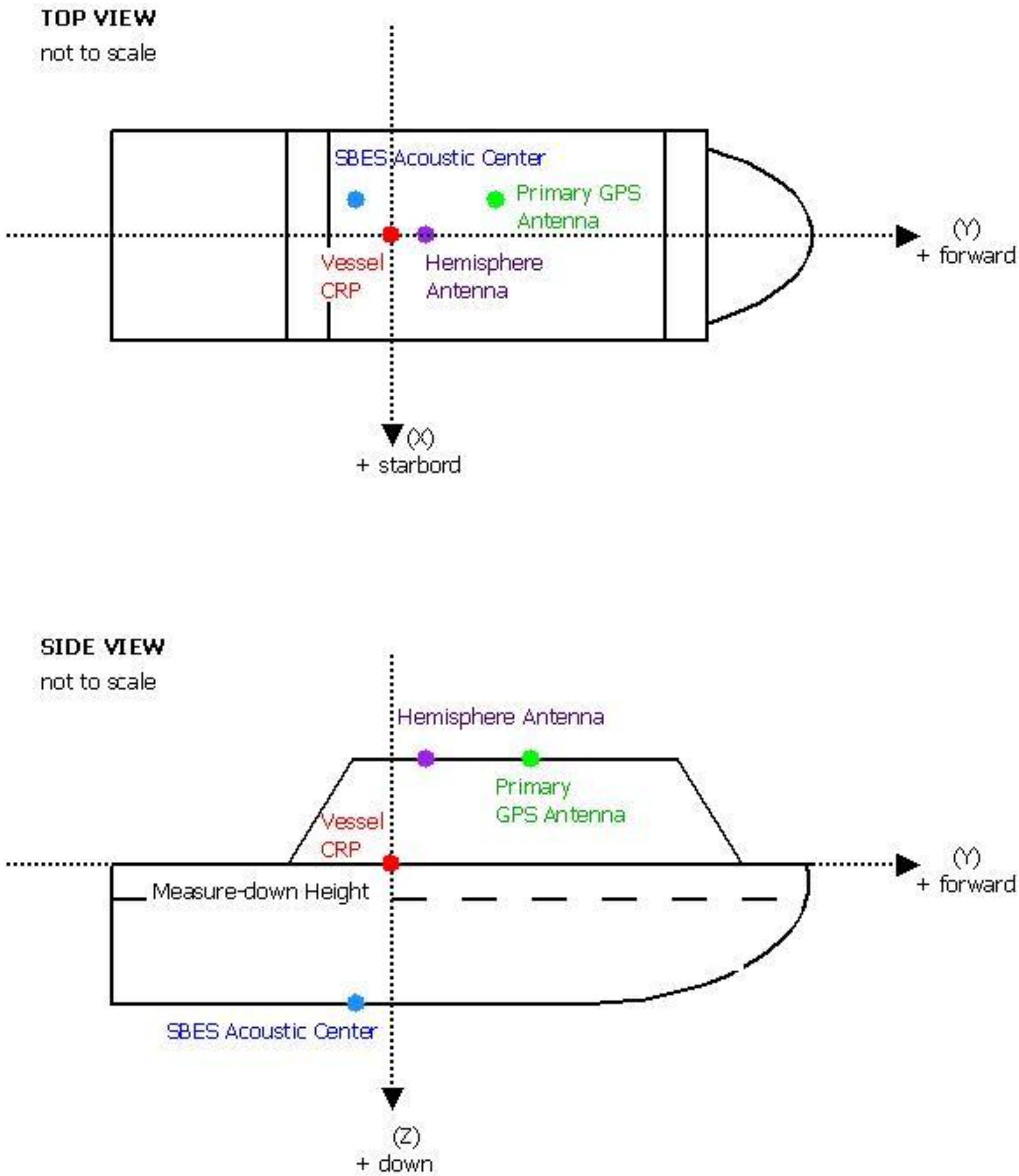


Figure 15 – M/V Bit Sea vessel survey showing the relative positions of the installed survey equipment.

Equipment	X (m) (+ stbd)	Y (m) (+ fwd)	Z (m) (+ down)	Comments
SBES Acoustic Center	-0.405	-0.010	0.658	Z determined by bar check
Primary GPS Antenna (Zephyr)	-0.440	0.060	-1.547	None
Hemisphere Antenna	-0.008	0.010	-1.518	None
Draft Measure-down Points	na	na	0.203	None

Table 22 – M/V Bit Sea offset measurements from CRP, determined during the vessel survey.

C.1.2. Attitude and Positioning

As described in previous sections of this report, primary positioning and heave data were measured on all vessels from the Trimble 5700 GPS data. The Trimble 5700 output positioning data to Hypack as standard NMEA strings via RS-232 serial cable. Raw Trimble data was recorded to a data card, processed for refined positioning and used to extract heave data, as described in Section B.3.8.

Secondary heave, roll, pitch, heading and positioning data for the three vessels were measured using Hemisphere V111 Gyrocompass. The Hemisphere V111 heave was not used except in special cases. However, V111 gyro data was used on all survey lines and the secondary position was useful as a real-time QC check on the Trimble position. The system provided output as a binary data string via RS-232 serial cable to the Hypack acquisition software. Uncertainty associated with these measurements is discussed in Section B.3.4.

C.1.3. Calibration Test Data

For single beam data, calibration tests were performed on the vessels to determine any latency. These tests were done over a sand wave covered slope near the Dillingham Small Boat Harbor. The calibration test data is available for review with the CARIS deliverables in the Calibrations project.

C.1.3.1. Navigation Latency

To determine latency, a survey line was run twice – in the same direction – at different speeds over a sand wave covered slope. The data was examined in HIPS Calibration mode. Any horizontal offset on the feature indicated latency between the positioning and sounding systems. A value (in seconds) that improved the matchup was determined and entered into the HVF for the navigation sensor. From day 183 (July 1st) onwards, an additional 1-second shift in the navigation data was necessary to bring lines into alignment. This was due to the change from a GPS-UTC offset of 15 seconds to 16 seconds, which began that day. The 16 second adjustment was also made in POSGNSS but it was apparent by examining data that the additional offset was necessary.

Results from latency tests were applied to the raw sounding data during the merge process in CARIS HIPS. Refer to Section B of this report for uncertainties associated with patch test results. The following table summarizes the results:

Vessel	Time (sec)	Patch Test Date
M/V Latent Sea	0.20 0.20	2012-151 2012-227
M/V Bit Sea	0.20	2012-171
M/V It Sea	0.20	2012-178

Table 23 – Calibration tests performed for latency during OPR-R306-KR-12.Note +1 second was added for JD183 onwards to the values shown in the table.

C.2. Speed of Sound Corrections

Sound speed profile data for OPR-R306-KR-12 was collected using an AML SV Plus sensor and two Odom Digibar sensors.

Profiles were collected by acquisition normally on a 12-hour interval. They were processed in TerraSond's TerraLog software, which produced a CARIS-compatible format at 0.1 m depth intervals. The output was appended to the master CARIS .SVP file by vessel and sheet.

Sound speed corrections were applied in processing to the raw sounding data through HIPS sound velocity correction. Nearest in distance within 12-hours was selected for the correction method. The DR, *Separate II* contains sound speed comparisons and calibration reports. Individual cast data can be found in the CARIS .SVP file submitted with the digital CARIS data for each survey.

C.3. Static Draft

Static draft was measured at least once daily on each vessel with an uncertainty of 0.01 m. Static draft was determined by measuring from a measure-down point on the gunwale of the port and starboard side of each survey vessel to the waterline. The measure-down values were recorded in the daily Hypack comments.

HIPS vessel files (HVF) were then updated by processing with a new waterline value. The port and starboard measure-downs recorded in the daily Hypack comments were averaged and reduced to the vessel's reference point using the surveyed vessel offsets to determine the static draft. This value was entered as a new waterline value in each vessel's HVF and checked to confirm that the values fell within the normal range for the vessel.

The waterline correction was applied to the soundings by HIPS during sound velocity correction. Static draft tables are available in each HVF available with the CARIS deliverables.

C.4. Dynamic Draft Corrections

Dynamic draft corrections were determined using PPK GPS methods for all vessels with a squat settlement calibration. Corrections were determined for a range that covered normal survey speeds and engine RPMs.

C.4.1. Squat Settlement Tests

During squat settlement tests, the vessel logged position data to the Trimble 5700 while a nearby shore base station logged dual frequency GPS data. A survey line was setup in the direction of the current and run up-current and then down-current at incrementing engine RPM ranges. Between each line, as well as at the start and end of the test, a "static" was collected whereby the vessel would sit with engines in idle and log for a minimum of two minutes. The survey crew would note in the Hypack comments the average speed and average engine RPM of each event.

The Trimble file was later processed with the nearby base station data in Applanix POSPac POSGNSS to produce PPK 3-D positioning data. Positioning data was exported and examined to determine altitude for each RPM range. Altitudes were imported into Excel.

In Excel, the altitude records were separated and grouped according to RPM range, or static. Each range was averaged to remove heave and motion and paired with appropriate speed averages. A 2^{nd}, 4^{th} or 5^{th} order polynomial equation was computed that best fit the static periods and used to remove the tide component from the speed. The residual result was the difference from static or dynamic draft. The up-current and down-current results were then averaged to eliminate any affect from the current.

The table of corrections for draft as a function speed was compiled from this data.

C.4.2. M/V Latent Sea

A squat settlement test was completed on the *M/V Latent Sea* on August 15-16, 2012 (JD228-229). The *M/V Latent Sea* typically surveyed at speeds below 9 knots; results are shown below.

***M/V Latent Sea* Settlement Table**

RPM	Speed (knot)	Dynamic Draft (m) (positive down)
0	0.00	0.000
800	2.62	0.016
1000	4.31	0.022
1200	5.26	0.019
1400	5.41	0.018
1600	6.35	0.009
1800	6.77	0.004
2000	6.74	0.004
2200	7.25	-0.003
2400	7.33	-0.004
2600	7.35	-0.005
2800	8.02	-0.017
3000	8.55	-0.029
3200	8.70	-0.032
3400	10.03	-0.069
3600	10.98	-0.100
3800	12.34	-0.153
4000	14.84	-0.276

Table 24 – M/V Latent Sea settlement results.

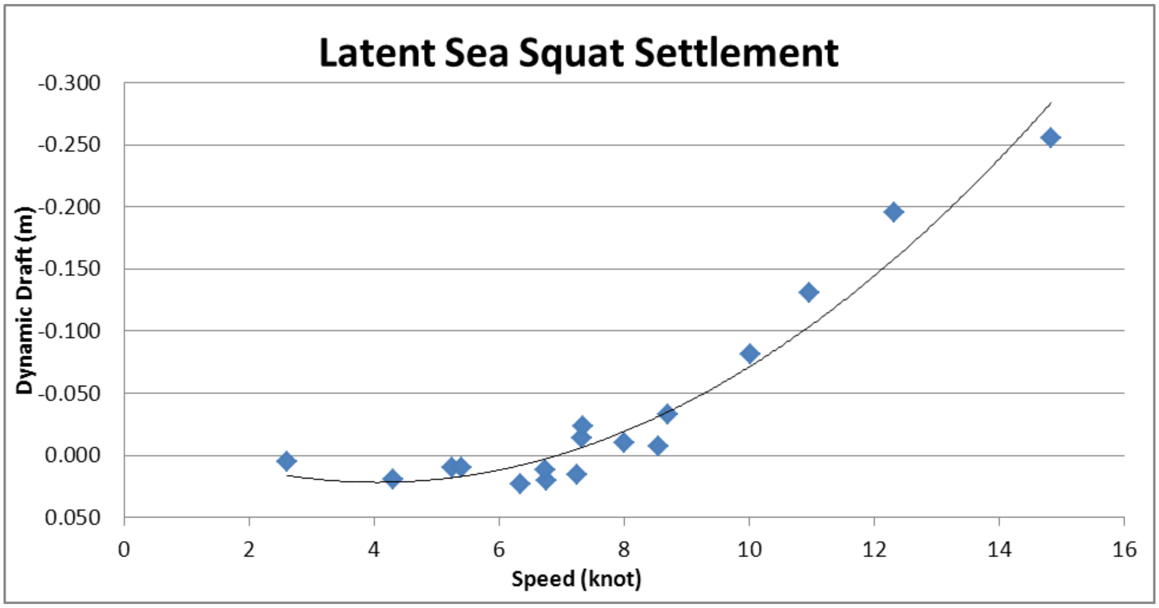


Figure 16 – M/V Latent Sea settlement results.

C.4.3. M/V It Sea

A squat settlement test was completed on the *M/V It Sea* on July 20-21, 2012 (JD202-203). The *M/V It Sea* typically surveyed at speeds below 7 knots; results are shown below.

M/V It Sea Settlement Table

RPM	Speed (knot)	Dynamic Draft (m) (positive down)
0	0	0.000
2000	3.9	0.042
2200	4.1	0.034
2500	4.55	0.024
2750	4.85	0.028
3000	5.15	0.038
3250	5.25	0.043
3500	5.6	0.062
3750	5.75	0.071
4000	5.8	0.074
4250	6	0.085
4500	6.3	0.100
4750	6.65	0.109
5000	6.85	0.109
5250	8	0.039
5500	9.4	0.102

Table 25 – M/V It Sea settlement results.

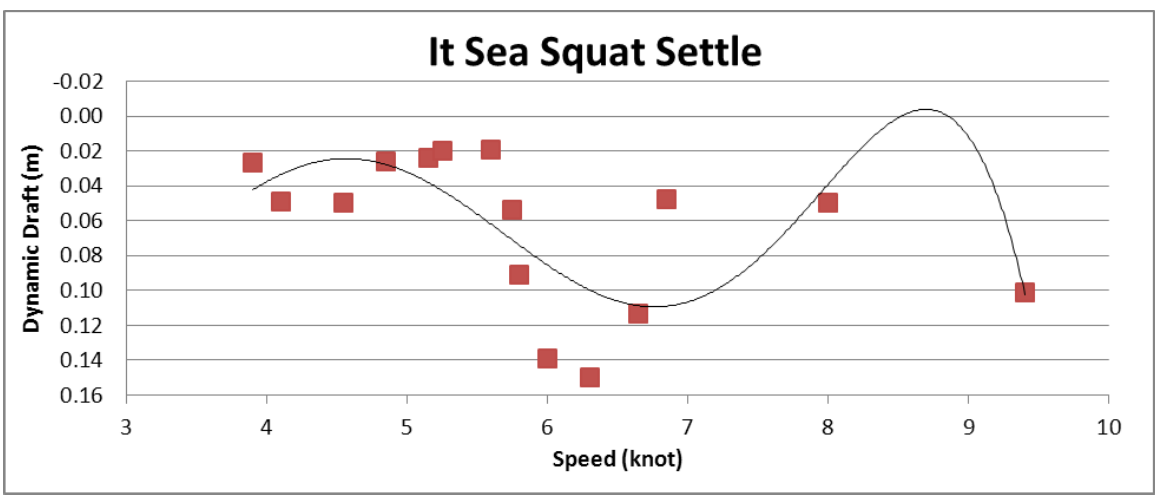


Figure 17 – M/V It Sea settlement results.

C.4.4. M/V Bit Sea

A squat-settlement test was completed on the *M/V Bit Sea* on July 21-22st, 2012 (JD203-204). The *M/V Bit Sea* typically surveyed at speeds below 7 knots; results are shown below.

***M/V Bit Sea* Settlement Table**

RPM	Speed (knot)	Dynamic Draft (m) (positive down)
0	0	0.000
2250	3.7	-0.013
2500	3.85	0.035
2750	4.5	0.068
3000	4.75	0.052
3250	5	0.038
3500	5.05	0.036
3750	5.55	0.033
4250	5.75	0.040
4000	5.85	0.045
4500	6.35	0.071
5000	6.65	0.079
5250	7.3	0.049
5500	8.35	0.006

Table 26 – M/V Bit Sea settlement results.

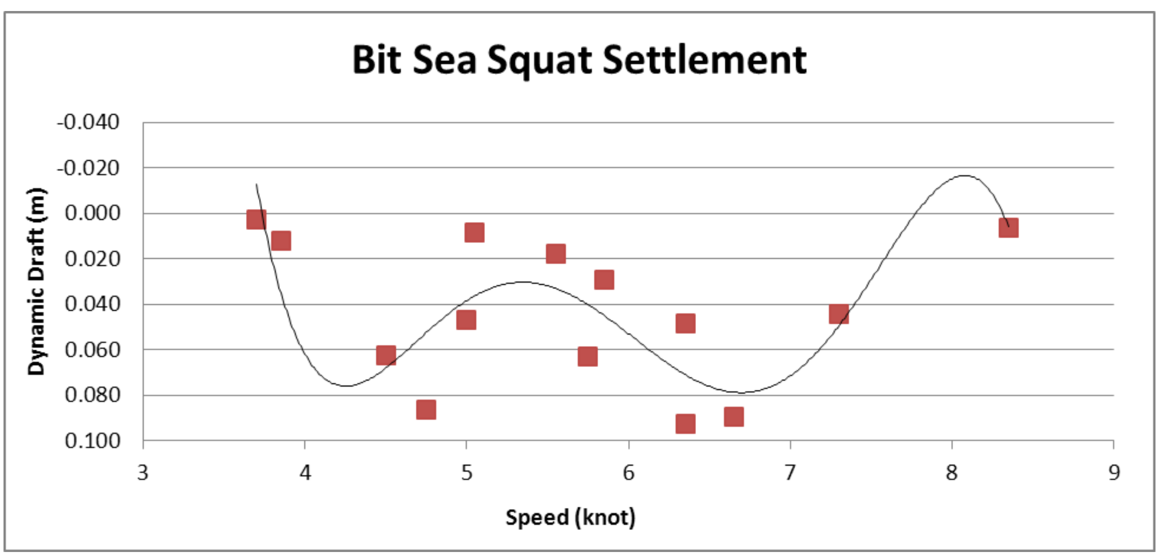


Figure 18 – M/V Bit Sea settlement results.

C.5. Tide Correctors and Project Wide Tide Correction Methodology

Traditional (discrete) tide zones were applied to the entire project to bring soundings to MLLW. Three tide stations were used in the tidal model; Snag Point (946-5374), Protection Point (946-5056) and Clark's Point (946-5261). Additionally, data from six Sea-Bird submersible tide gauge deployments and vessel PPK heights were used to facilitate the zone design. For details on tide zones and gauges, see the HVCR.

APPROVAL SHEET

For

H12398 through H12405

This report and the accompanying digital data are respectfully submitted.

Field operations contributing to the completion of this project were conducted under my direct supervision with frequent personal checks of progress and adequacy. This report, digital data, and accompanying records have been closely reviewed and are considered complete and adequate per the *Statement of Work*. Other reports submitted with this survey include the Descriptive Report (one for each survey sheet) and the Horizontal and Vertical Control Report.

This survey is complete and adequate for its intended purpose.

Marta Krynytzky

Digitally signed by Marta Krynytzky
DN: CN = Marta Krynytzky, C = US, O = TerraSond Ltd
Reason: I attest to the accuracy and integrity of this document
Location: Palmer, AK
Date: 2012.12.20 08:39:26 -09'00'

Marta Krynytzky
ACSM Certified Hydrographer (2012), Certificate No. 273
Lead Hydrographer
TerraSond Ltd.

Andrew Orthmann

Digitally signed by Andrew Orthmann
DN: CN = Andrew Orthmann, C = US, O = TerraSond Ltd
Reason: I attest to the accuracy and integrity of this document
Location: Palmer, AK
Date: 2012.12.20 08:13:23 -09'00'

Andrew Orthmann
ACSM Certified Hydrographer (2005), Certificate No. 225
Charting Program Manager
TerraSond Ltd.

APPENDIX I

Vessel Reports

See main body of DAPR for vessel reports.

APPENDIX II

Echosounder Reports

This appendix contains the following documentation:

1. Echosounder Bar Checks
2. Lead Line Logs
3. Vessel Echosounder Comparisons

1. Echosounder Bar Checks

Vessel:	**Latent Sea**
Day	2012-170 6/18/2012
Location:	Dillingham Harbor
Latitude:	59-02-23.19 N
Longitude:	158-28-37.09 W
Sensor:	Odom CV100
Measured Avg SV	1457.2 m/s
File Name	1X-2012LA1700051
Port Measure Down	0.82
Stbd Measure Down	0.81
TerraSonic Value (m)	n/a
Crew:	*not logged*

Offsets:	
CRP to MD:	-0.811
CRP to AC:	0.419
CRP to Water:	0.004

Average Measure Down: 0.815

Processed by: *AO*

	Time	**Bar Depth**	**Raw Depth (Odom)**	**AC to MD Pt**	**RP to AC**	**Difference**
RP to SBES acoustic center check: Bar held at MD POINT						
	0:51:42	4.815	3.600	1.215	0.404	-0.015
	0:52:58	3.815	2.580	1.235	0.424	0.005
	0:53:51	2.815	1.580	1.235	0.424	0.005
	0:55:23	1.815	0.590	1.225	0.414	-0.005
				Average RP to AC:	0.417	-0.003

	Time	**Bar Depth**	**Raw Depth (Odom)**	**CARIS result**	**Computed (using raw)**	**Difference (CARIS vs actual)**
Bar held at WATER SURFACE						
	0:51:42	4.0	3.600	4.01	4.015	-0.009
	0:52:58	3.0	2.580	3.00	2.995	0.000
	0:53:51	2.0	1.580	2.01	1.995	-0.009
	0:55:23	1.0	0.590	1.01	1.005	-0.009
					Average:	**-0.007**

Comments:

0.41 m draft was entered into Odom during bar check.
To compensate here, 0.41 was subtracted from raw odom depth and CARIS results

Raw depth (Odom) was not noted by acquisition. Values were pulled from the RAW file.

Vessel:	**Latent Sea**
Day	2012-229 8/16/2012
Location:	Dillingham Harbor
Latitude:	59-02-23.19 N
Longitude:	158-28-37.09 W
Sensor:	Odom CV100
Measured Avg SV	1444 m/s
File Name	1XX-2012LA2300006
Port Measure Down	0.94
Stbd Measure Down	0.92
TerraSonic Value (m)	n/a
Crew:	*PP, TD*

Offsets:	
CRP to MD:	-0.811
CRP to AC:	0.419
CRP to Water:	0.119

Average Measure Down: 0.93

Processed by: *AO*

	Time	**Bar Depth**	**Raw Depth (Odom)**	**AC to MD Pt**	**RP to AC**	**Difference**
RP to SBES acoustic center check: Bar held at MD POINT	0:17:03	4.0	3.52	0.480	-0.331	0.088
	0:20:41	3.0	2.65	0.350	-0.461	-0.042
	0:25:35	2.0	1.66	0.340	-0.471	-0.052
				Average RP to AC:	-0.421	-0.002

	Time	**Bar Depth**	**Raw Depth (Odom)**	**CARIS result**	**Computed (using raw)**	**Difference (CARIS vs actual)**
Bar held at WATER SURFACE	0:07:33	2.0	1.67		1.970	
	0:09:45	3.0	2.67		2.970	
	0:13:54	4.0	3.55		3.850	

Comments: Unable to extract CARIS results, RAW file did not contain timestamps (navigation system was not turned on)

Vessel:	**Bit-Sea**
Day	2012-170 6/18/2012
Location:	Dillingham Harbor
Latitude:	59-02-23.19 N
Longitude:	158-28-37.09 W
Sensor:	Odom CV100
Measured Avg SV	1454 m/s
File Name	2X-2012BI1701306.RAW
Port Measure Down	0.37
Stbd Measure Down	0.32
TerraSonic Value (m)	n/a
Crew:	

Offsets:	
CRP to MD:	0.203
CRP to AC:	0.658
CRP to Water:	0.548

Average Measure Down: 0.345

Processed by: *AO*

	Time	Bar Depth	Raw Depth (Odom)	AC to MD Pt	RP to AC	Difference
RP to SBES acoustic center check: Bar held at MD POINT	21:06:23	2.345	1.890	0.455	0.658	0.000
	21:19:39	1.345	0.880	0.465	0.668	0.010
	21:22:21	2.345	1.900	0.445	0.648	-0.010
				Average RP to AC:	0.658	0.000

	Time	Bar Depth	Raw Depth (Odom)	CARIS result	Computed	Difference
Bar held at WATER SURFACE	21:06:23	2.000	1.890	2.004	2.000	-0.004
	21:19:39	1.000	0.880	1.017	0.990	-0.017
	21:22:21	2.000	1.900	2.015	2.010	-0.015
					Average:	**-0.012**

Comments: A draft corrector of 0.10 m was entered into Odom during bar check. To compensate here, 0.10 was subtracted from raw odom depth and CARIS results

Raw depth (Odom) was not noted by acquisition. Values were pulled from the RAW file.

Vessel:	**Bit-Sea**		
Day	2012-204 7/22/2012		
Location:	Dillingham Harbor		
Latitude:	59-02-23.19 N	**Offsets:**	
Longitude:	158-28-37.09 W	CRP to MD:	0.203
Sensor:	Odom CV100	CRP to AC:	0.658
Measured Avg SV	1457 m/s	CRP to Water:	0.568
File Name	2X2012BI2041808.RAW		
Port Measure Down	0.35	Average Measure Down:	
Stbd Measure Down	0.38	0.365	
TerraSonic Value (m)	n/a		
Crew:		**Processed by:**	*AO*

	Time	Bar Depth	Raw Depth (Odom)	AC to MD Pt	RP to AC	Difference
RP to SBES acoustic center check: Bar held at MD POINT	18:09:57	1.365	1.050	0.315	0.518	-0.140
	18:15:12	2.365	1.830	0.535	0.738	0.080
	18:18:36	3.365	2.940	0.425	0.628	-0.030
	18:24:39	3.365	2.910	0.455	0.658	0.000
	18:29:52	2.365	1.960	0.405	0.608	-0.050
	18:33:19	1.365	1.060	0.305	0.508	-0.150
				Average RP to AC:	0.636	-0.022

	Time	Bar Depth	Raw Depth (Odom)	CARIS result	Computed	Difference
Bar held at WATER SURFACE	18:09:57	1.000	1.050	1.056	1.140	-0.056
	18:15:12	2.000	1.830	1.927	1.920	0.073
	18:18:36	3.000	2.940	3.034	3.030	-0.034
	18:24:39	3.000	2.910	3.015	3.000	-0.015
	18:29:52	2.000	1.960	2.014	2.050	-0.014
	18:33:19	1.000	1.060	1.086	1.150	-0.086
					Average:	-0.022

Comments:

Variable draft correctors were entered into Odom during bar check
To compensate here, draft correctors were subtracted from raw depth
and CARIS results

Raw depth (Odom) was not noted by acquisition. Values were pulled
from the RAW file.

Vessel:	**It-Sea**
Day	2012-176 6/24/2012
Location:	Dillingham Harbor
Latitude:	59-02-23.19 N
Longitude:	158-28-37.09 W
Sensor:	Odom CV100
Measured Avg SV	1458 m/s
File Name	3XX-2012IT1761821
Port Measure Down	0.35
Stbd Measure Down	0.38
TerraSonic Value (m)	n/a
Crew:	*AO, JT, RN*

Offsets:	
CRP to MD:	0.205
CRP to AC:	0.653
CRP to Water:	0.570

Average Measure Down:
0.365

Processed by: *AO*

	Time	**Bar Depth**	**Raw Depth (Odom)**	**AC to MD Pt**	**RP to AC**	**Difference**
RP to SBES acoustic center check: Bar held at MD POINT	18:23:05	2.0	1.56	0.440	0.645	-0.008
	18:25:59	3.0	2.56	0.440	0.645	-0.008
	18:29:53	4.0	3.56	0.440	0.645	-0.008
	18:32:26	5.0	4.53	0.470	0.675	0.022
				Average RP to AC:	0.653	-0.001

	Time	**Bar Depth**	**Raw Depth (Odom)**	**CARIS result**	**Computed**	**Difference (CARIS)**
Bar held at WATER SURFACE	18:35:34	5.0	4.80	4.855	4.883	0.145
	18:38:32	4.0	3.95	4.002	4.033	-0.002
	18:41:17	3.0	2.94	2.989	3.023	0.011
	18:43:29	2.0	1.90	1.977	1.983	0.023
	18:45:29	1.0	0.90	0.975	0.983	0.025
					Average:	**0.014**

Comments: Note: 18:35:34 for water-surface set is outlier; excluded
Note: This bar check used to determine vessel's RP-AC offset

Results: CARIS results are within 3 cm of expected

Vessel:	**It-Sea**
Day	2012-205 7/23/2012
Location:	Dillingham Harbor
Latitude:	59-02-23.19 N
Longitude:	158-28-37.09 W
Sensor:	Odom CV100
Measured Avg SV	1457 m/s
File Name	3-2012IT2051657
Port Measure Down	0.34
Stbd Measure Down	0.4
TerraSonic Value (m)	n/a
Crew:	*MK, PP, TM*

Offsets:	
CRP to MD:	0.205
CRP to AC:	0.653
CRP to Water:	0.575

Average Measure Down:
0.37

Processed by: *AO*

	Time	Bar Depth	Raw Depth (Odom)	AC to MD Pt	RP to AC	Difference
RP to SBES acoustic center check: Bar held at MD POINT	16:58:37	1.370	0.73	0.640	0.845	0.192
	17:03:39	2.370	1.94	0.430	0.635	-0.018
	17:11:09	3.370	2.92	0.450	0.655	0.002
	17:15:07	4.370	3.93	0.440	0.645	-0.008
	17:23:17	4.370	3.93	0.440	0.645	-0.008
	17:27:09	3.370	2.91	0.460	0.665	0.012
	17:32:20	2.370	1.90	0.470	0.675	0.022
	17:38:16	1.370	0.82	0.550	0.755	0.102
				Average RP to AC:	0.653	0.000

	Time	Bar Depth	Raw Depth (Odom)	CARIS result	Computed	Difference (CARIS)
Bar held at WATER SURFACE	16:58:37	1.0	0.73	0.786	0.808	0.214
	17:03:39	2.0	1.94	1.965	2.018	0.035
	17:11:09	3.0	2.92	2.984	2.998	0.016
	17:15:07	4.0	3.93	4.005	4.008	-0.005
	17:23:17	4.0	3.93	4.003	4.008	-0.003
	17:27:09	3.0	2.91	2.984	2.988	0.016
	17:32:20	2.0	1.90	1.954	1.978	0.046
	17:38:16	1.0	0.82	0.897	0.898	0.103
					Average:	**0.018**

Comments: Variable draft correctors were entered into Odom during bar check
To compensate here, draft correctors were subtracted from raw depth and CARIS results

Results: Raw depth (Odom) was not noted by acquisition. Values were pulled from the RAW file.
First and last values are outliers, excluded from averages.
Excellent results for both AC computation and CARIS results

2. Lead Line Logs

Sonar Depth Check Log -- Lead Lines

Vessel	*Latent Sea*	**Client Name**	NOAA
Units	meters	**Project Number (Client)**	OPR-R306-KR-12
Geodetics	NAD83 UTM Zone 4 MLLW	**Project Number (TerraSond)**	2012-006

JD	Time (UTC)	Filename	Position		Lead Line Depth	Delta	CARIS Depth	Delta	Comment
			Lat (N)	Long (W)					
160	21:36:15	1XX-2012LA1602133.RAW	58-41-40.45	158-41-02.76	8.6	n/a	8.3	0.3	Sand waves in area, questionable
159	14:47:27								Mud too soft in harbor

Sonar Depth Check Log -- Lead Lines

Vessel	*It Sea*	**Client Name**	NOAA
Units	meters	**Project Number (Client)**	OPR-R306-KR-12
Geodetics	NAD83 UTM Zone 4 MLLW	**Project Number (TerraSond)**	2012-006

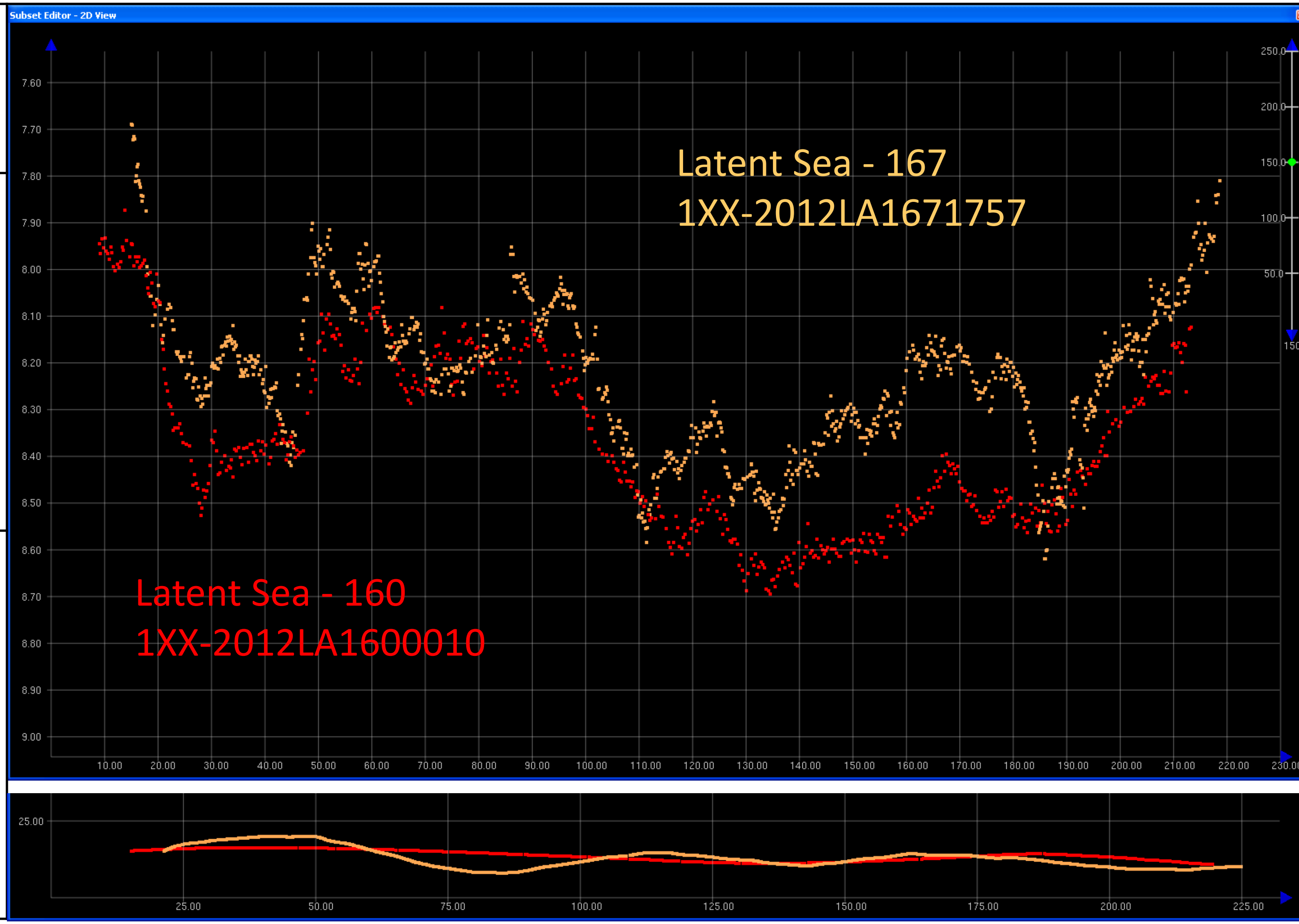
JD	Time (UTC)	Filename	Position		Lead Line Depth	Delta	CARIS Depth	Delta	Comment
			Lat (N)	Long (W)					
179	18:28:38	3XX-2012IT1791828	59-01-46.63	158-15-03.87	8.4	n/a	8.3	0.1	
191	17:07:19	3XX-2012IT1911706	59-01-22.65	158-28-37.29	7.9	n/a	7.4	0.5	Irregular ground

3. Vessel Echosounder Comparisons

Echo Sounder Comparison

Vessel(s)-Day(s):

Latent Sea –
160
167



Maximum Difference:
0.25 m

Average Difference:
0.15 m

Comments:
Lines run 7 days apart. Largest depth sounding differences are most likely due to imperfect alignment of single beam soundings over rough terrain.

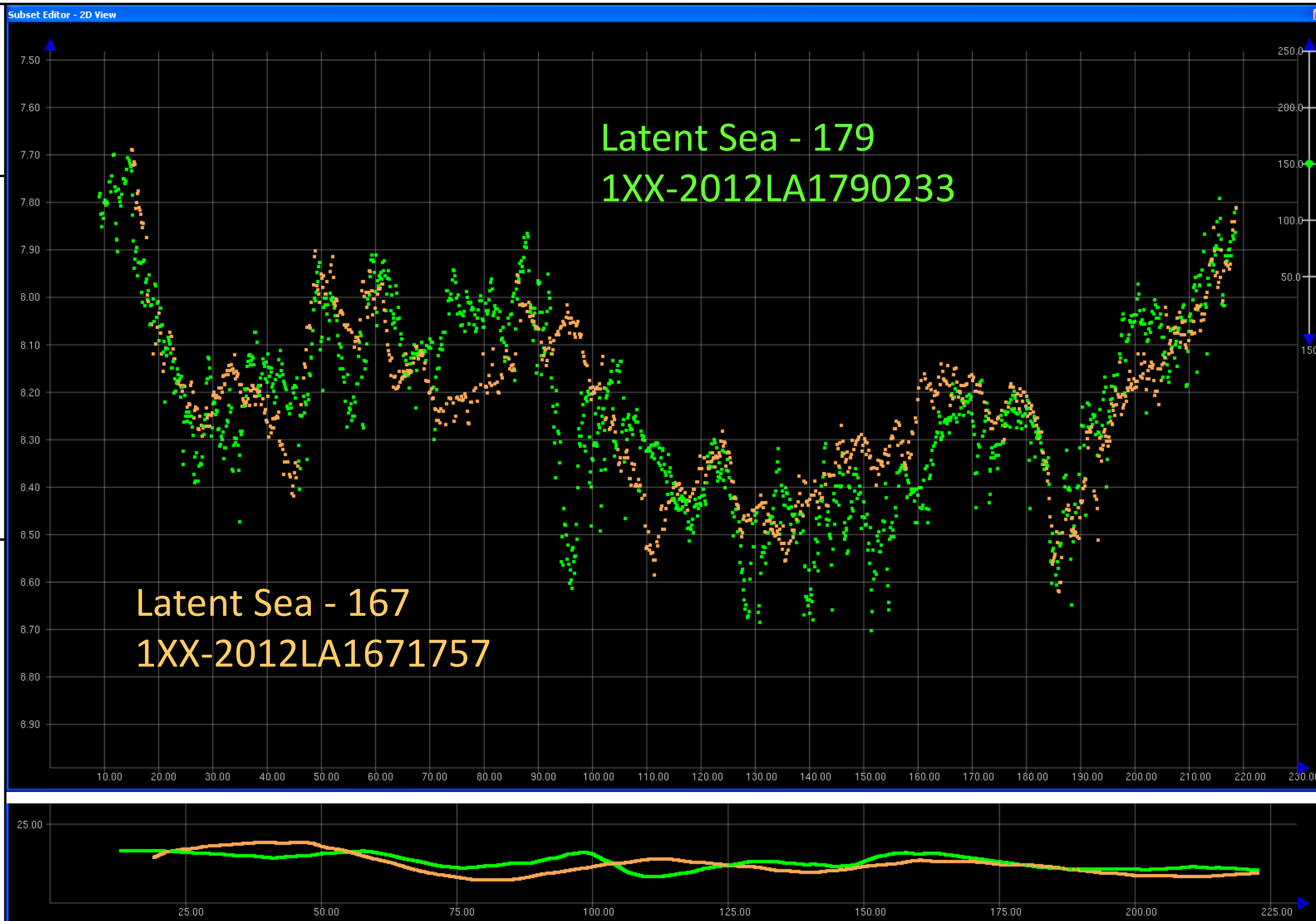
Echo Sounder Comparison

Vessel(s)-Day(s):

Latent Sea –
167
179

Maximum Difference:
0.5 m

Average Difference:
0.2 m



Comments:
Lines run 12 days apart. Largest depth sounding differences are most likely due to imperfect alignment of single beam soundings over rough terrain.

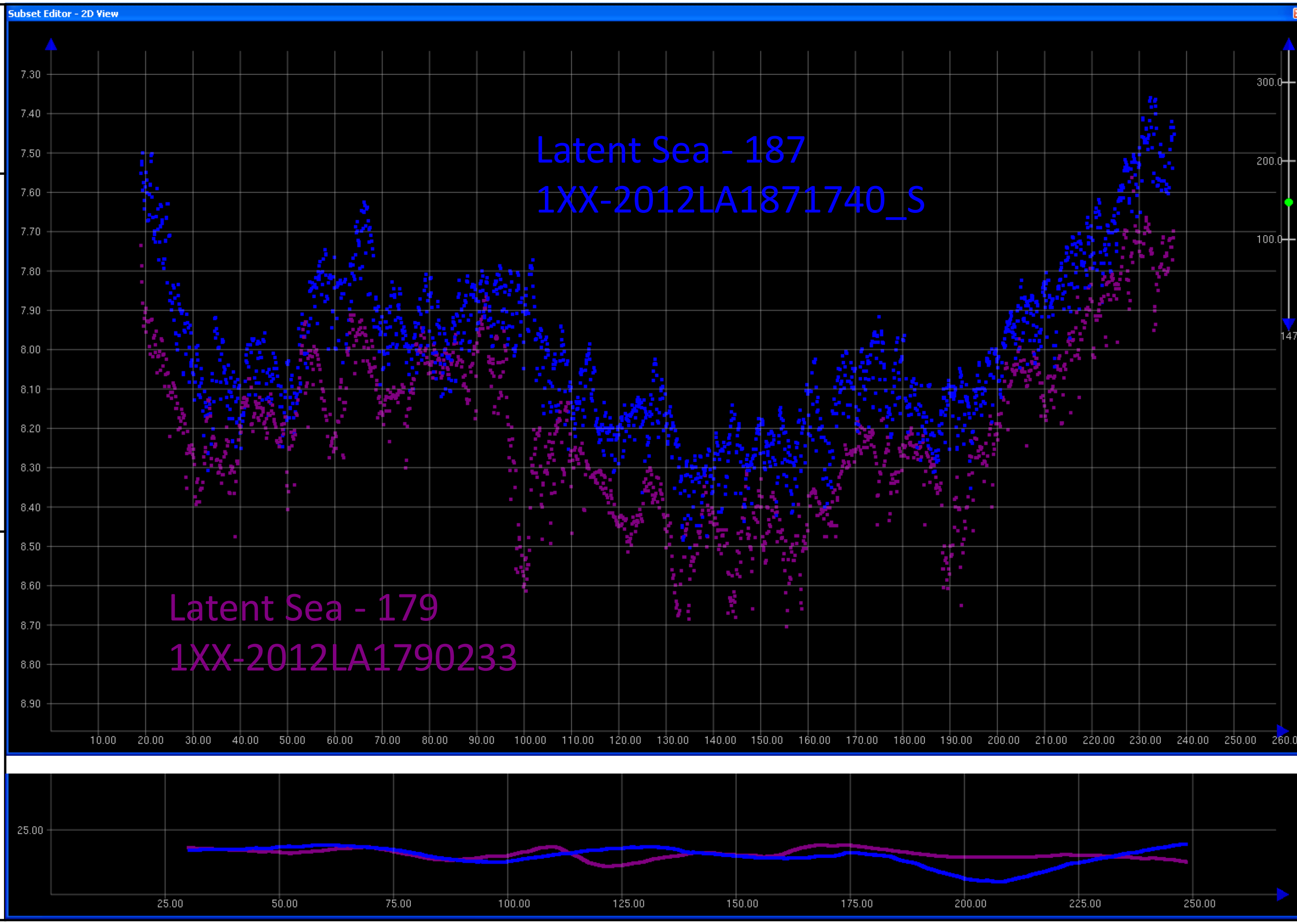
Echo Sounder Comparison

Vessel(s)-Day(s):

Latent Sea –
179
187

Maximum Difference:
0.7 m

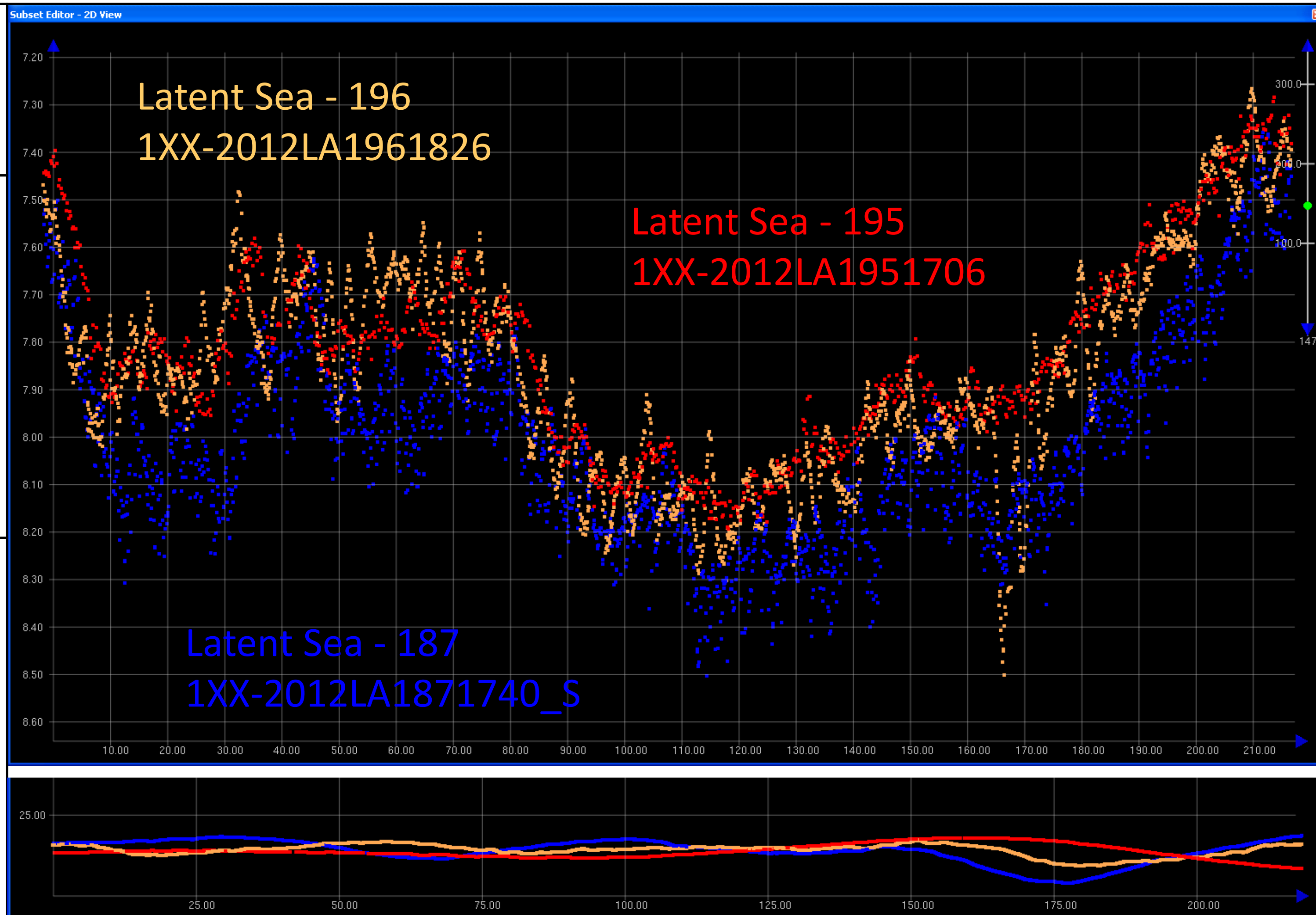
Average Difference:
0.2 m



Comments:

Lines run 8 days apart. Largest depth sounding differences are most likely due to imperfect alignment of single beam soundings over rough terrain.

Echo Sounder Comparison



Vessel(s)-Day(s):

Latent Sea –
187
195
196

Maximum Difference:
0.3 m

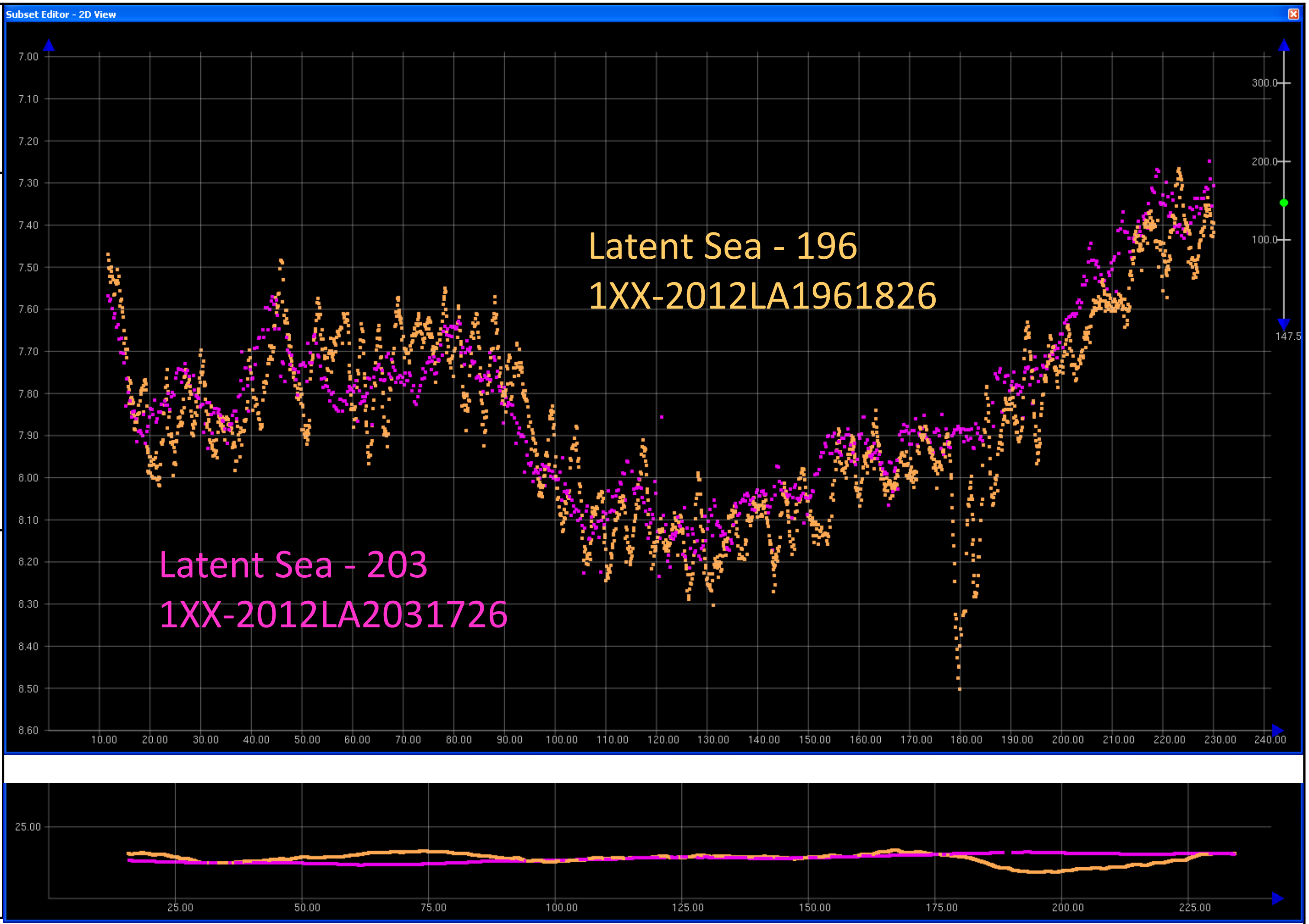
Average Difference:
0.2 m

Comments:
Lines run up to 9 day apart. Largest depth sounding differences are most likely due to imperfect alignment of single beam soundings over rough terrain.

Echo Sounder Comparison

Vessel(s)-Day(s):

Latent Sea –
196
203



Maximum Difference:
0.1 m

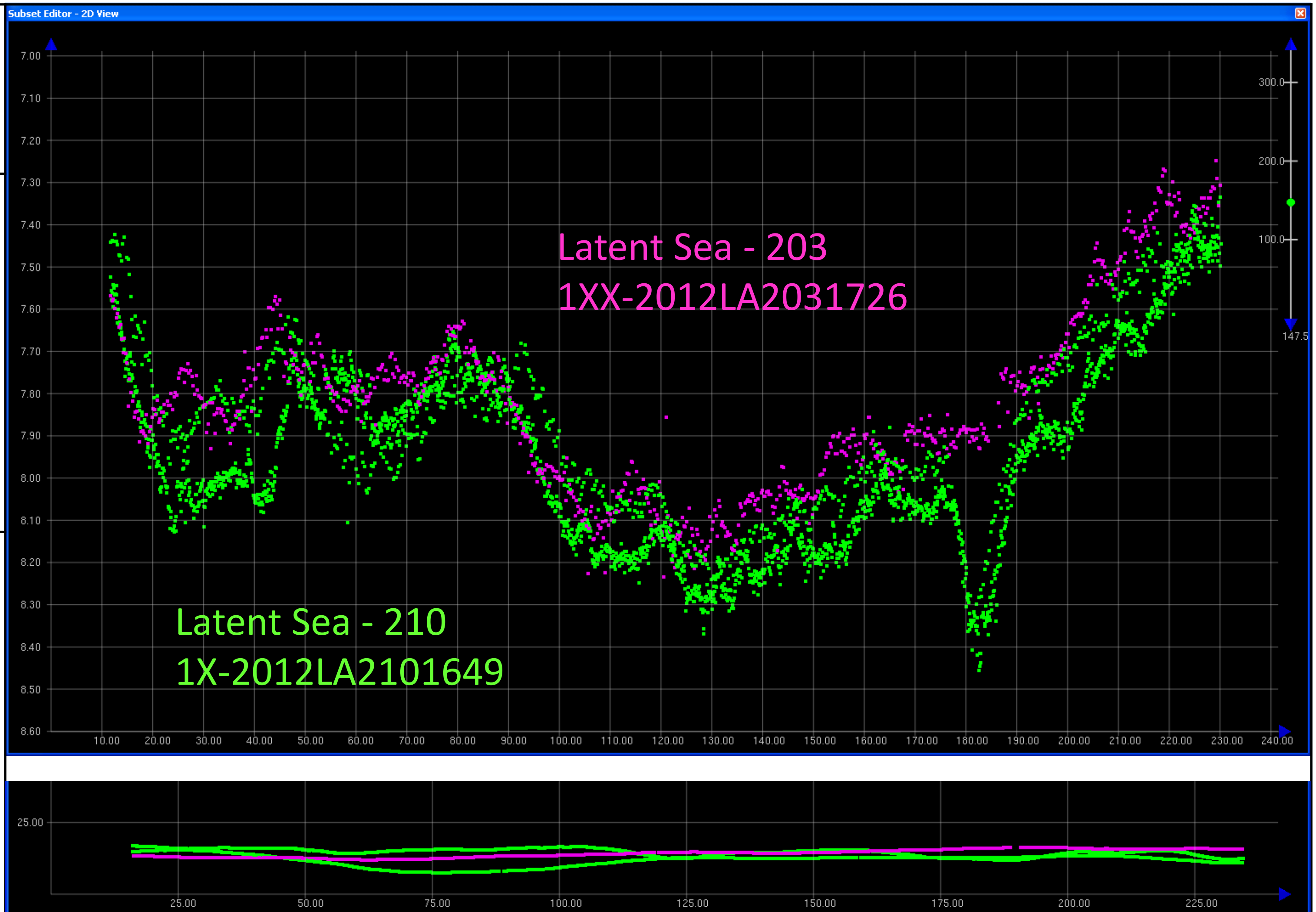
Average Difference:
< 0.05 m

Comments:
Lines run 7 days apart. Largest depth sounding differences are most likely due to imperfect alignment of single beam soundings over rough terrain.

Echo Sounder Comparison

Vessel(s)-Day(s):

Latent Sea –
203
210



Maximum Difference:
0.5 m

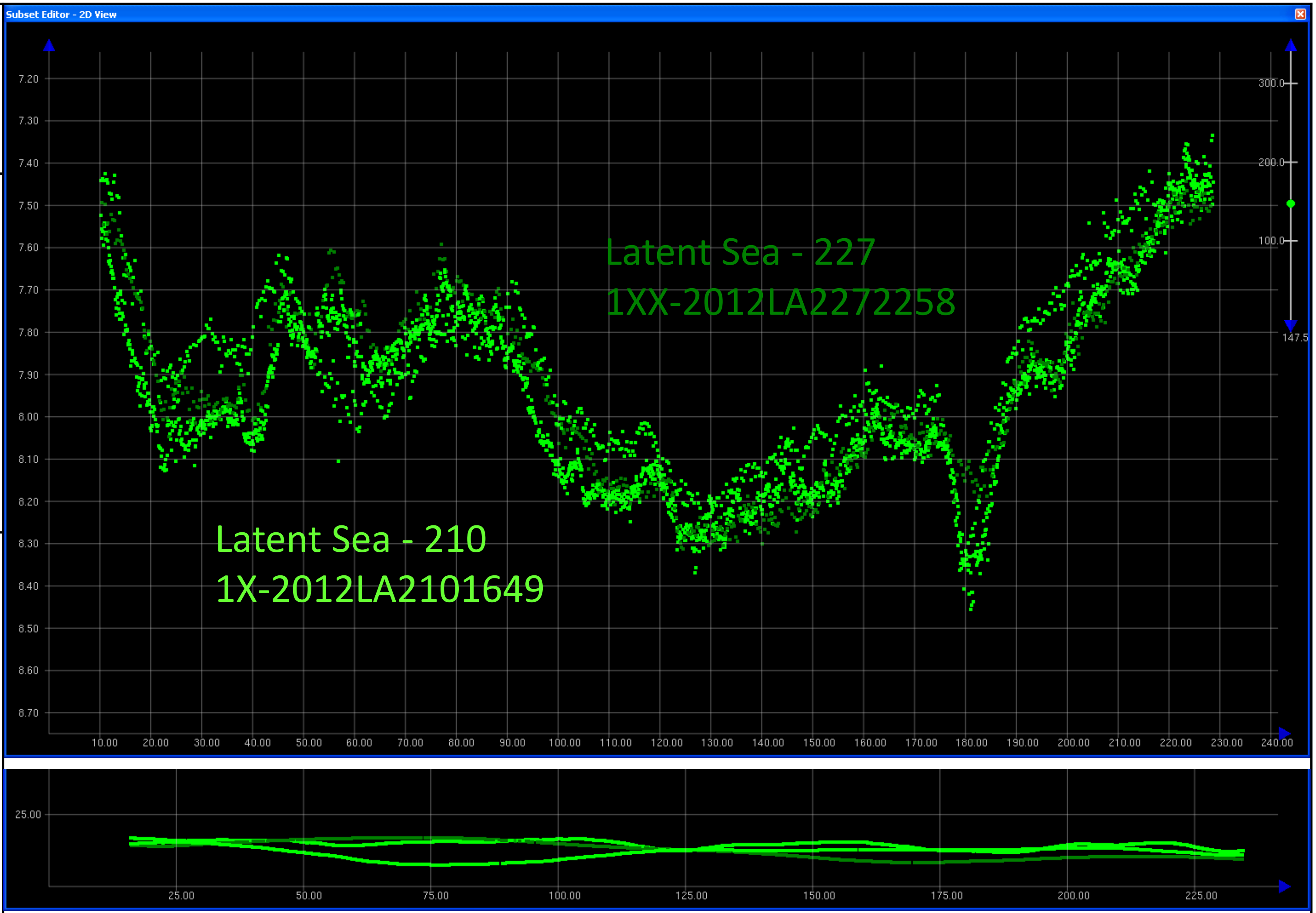
Average Difference:
0.15 m

Comments:
Lines run 7 days apart. Largest depth sounding differences are most likely due to imperfect alignment of single beam soundings over rough terrain.

Echo Sounder Comparison

Vessel(s)-Day(s):

Latent Sea –
210
227



Maximum Difference:
0.1 m

Average Difference:
< 0.05 m

Comments:
Lines run 17 days apart. Largest depth sounding differences are most likely due to imperfect alignment of single beam soundings over rough terrain.

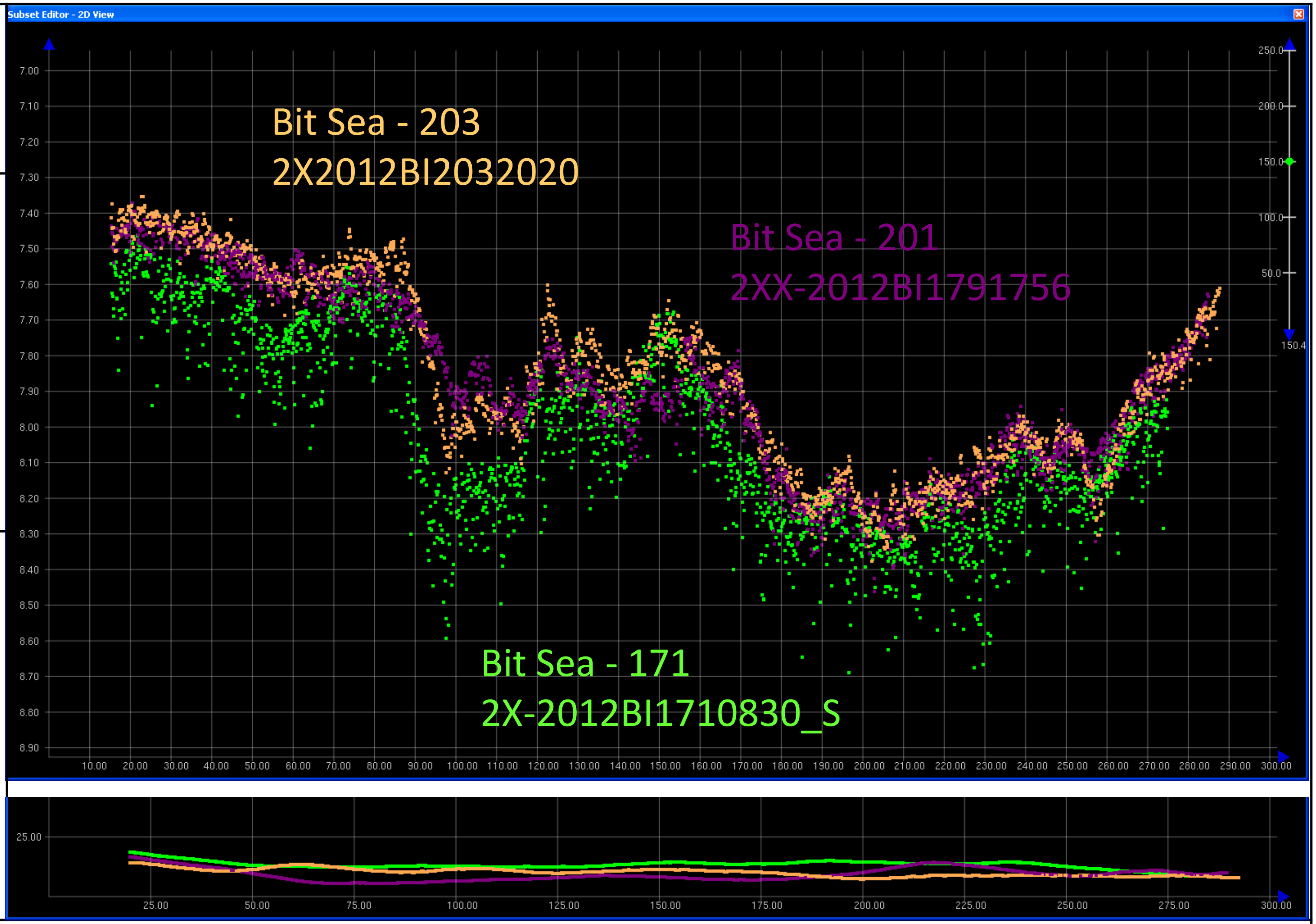
Echo Sounder Comparison

Vessel(s)-Day(s):

Bit Sea –
171
179
203

Maximum Difference:
0.2 m

Average Difference:
0.1 m



Comments:
Lines run up to 32 days apart. Largest depth sounding differences are most likely due to imperfect alignment of single beam soundings over rough terrain.

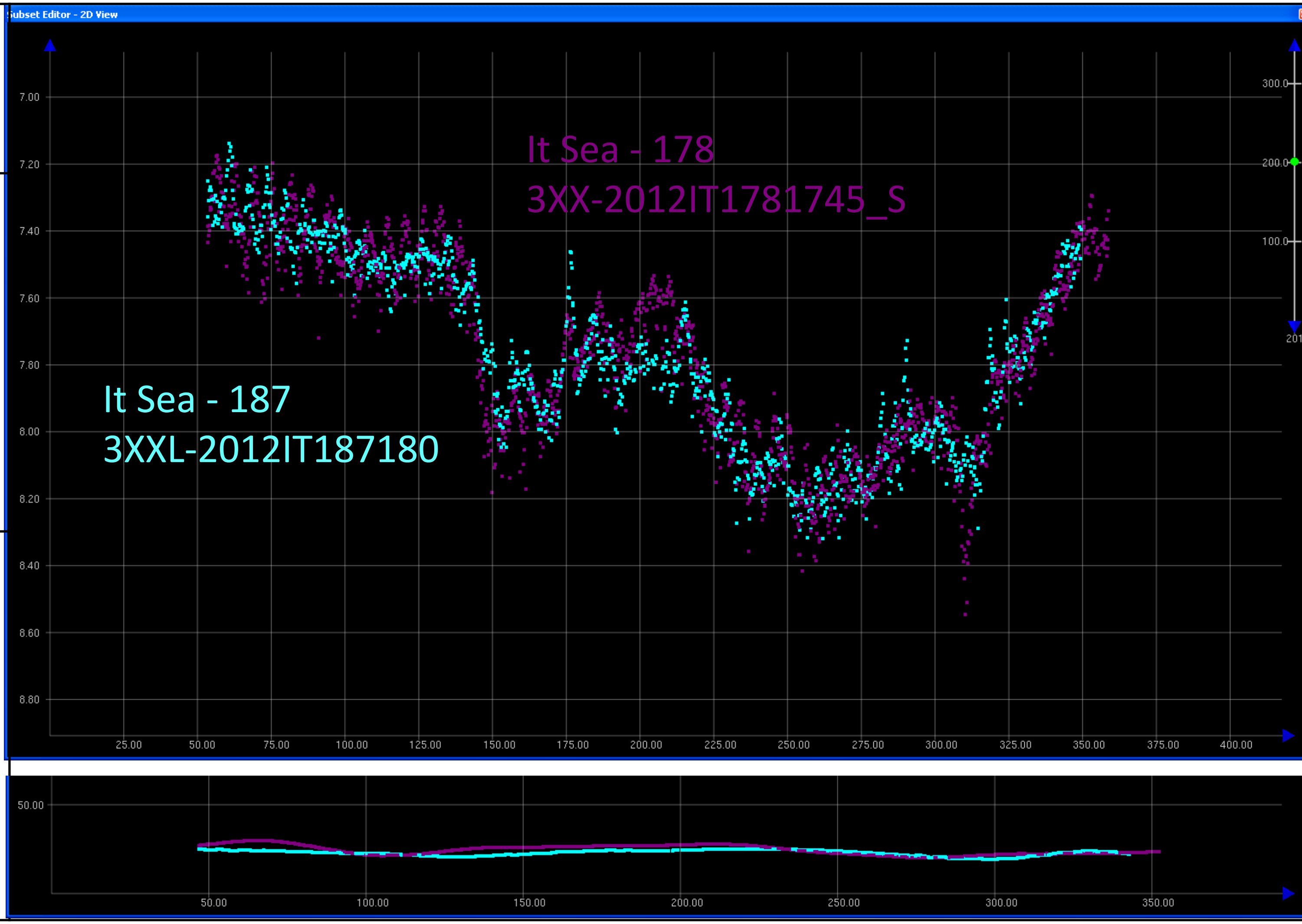
Echo Sounder Comparison

Vessel(s)-Day(s):

It Sea –
178
187

Maximum Difference:
0.1 m

Average Difference:
< 0.05 m



Comments:
Lines run 11 days apart. Largest depth sounding differences are most likely due to imperfect alignment of single beam soundings over rough terrain.

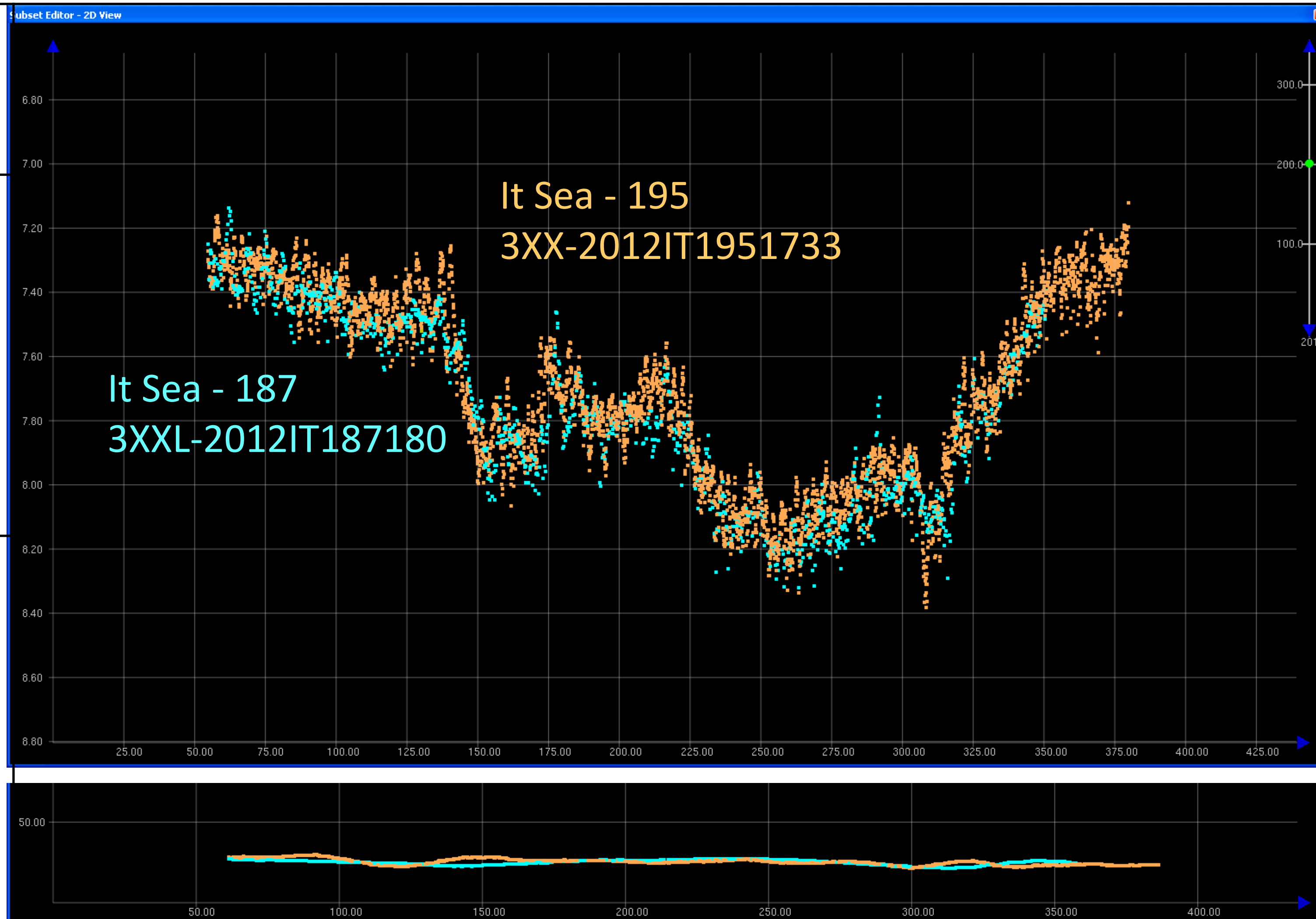
Echo Sounder Comparison

Vessel(s)-Day(s):

It Sea –
187
195

Maximum Difference:
< 0.1 m

Average Difference:
< 0.05 m

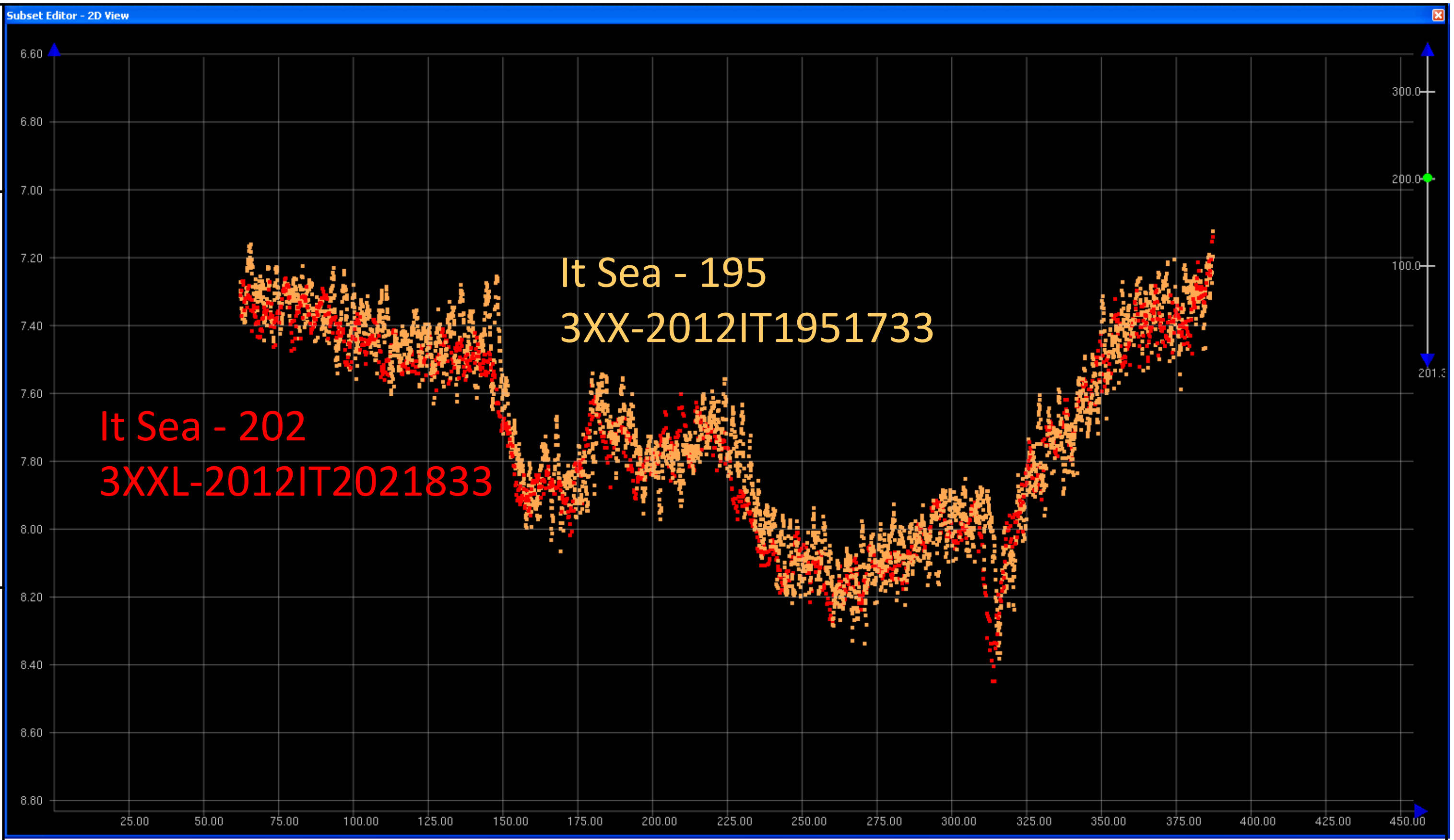


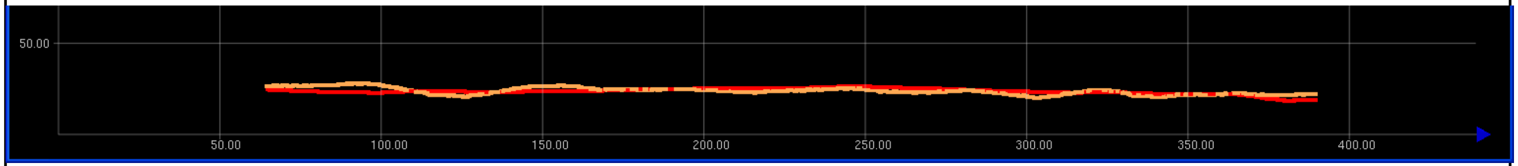
Comments:
Lines run 8 days apart. Largest depth sounding differences are most likely due to imperfect alignment of single beam soundings over rough terrain.

Echo Sounder Comparison

Vessel(s)-Day(s):

It Sea – 195
202





Maximum Difference:
< 0.1 m

Average Difference:
< 0.05 m

Comments:
Lines run 7 days apart. Largest depth sounding differences are most likely due to imperfect alignment of single beam soundings over rough terrain.

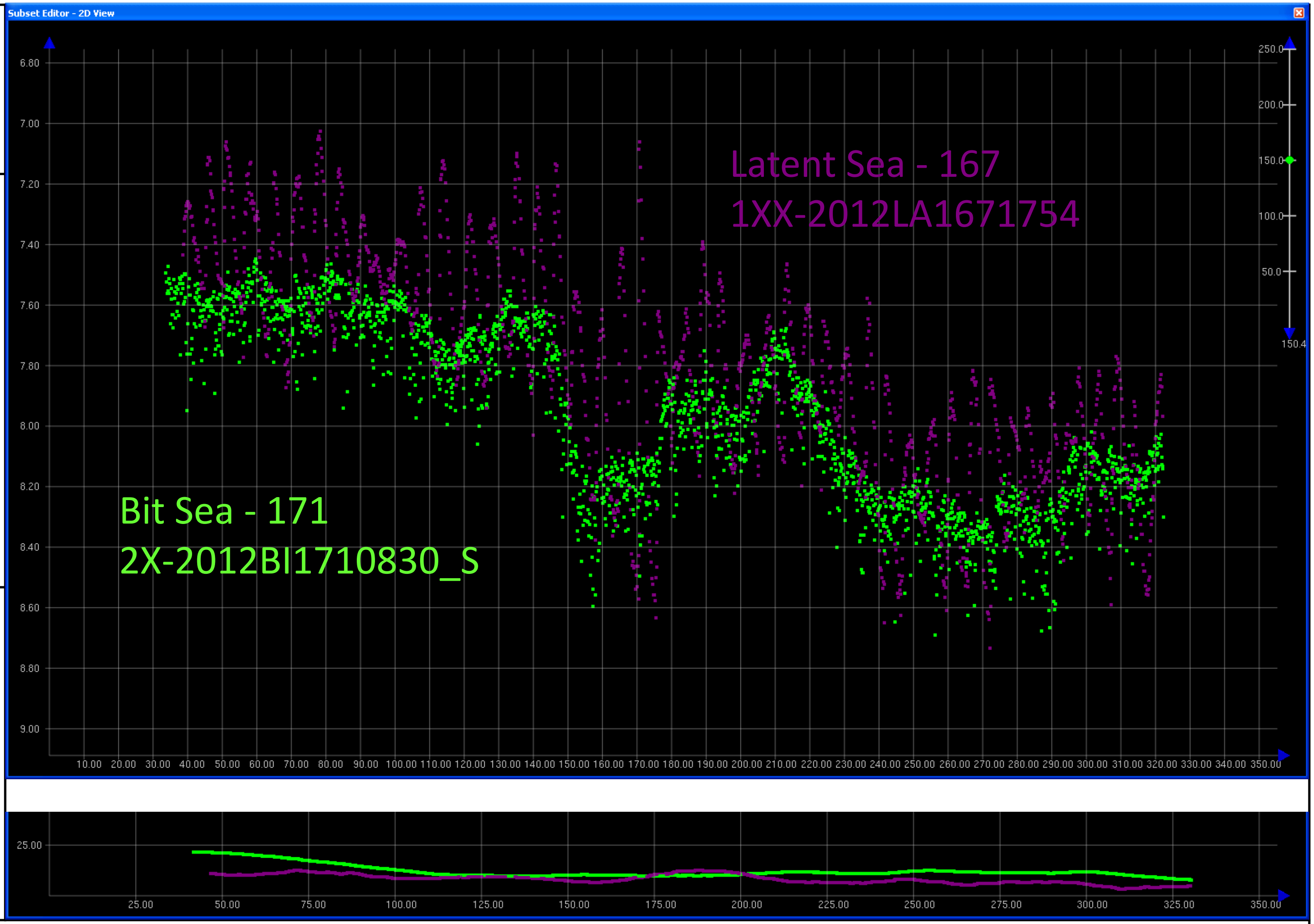
Echo Sounder Comparison

Vessel(s)-Day(s):

Latent Sea - 167
Bit Sea – 171

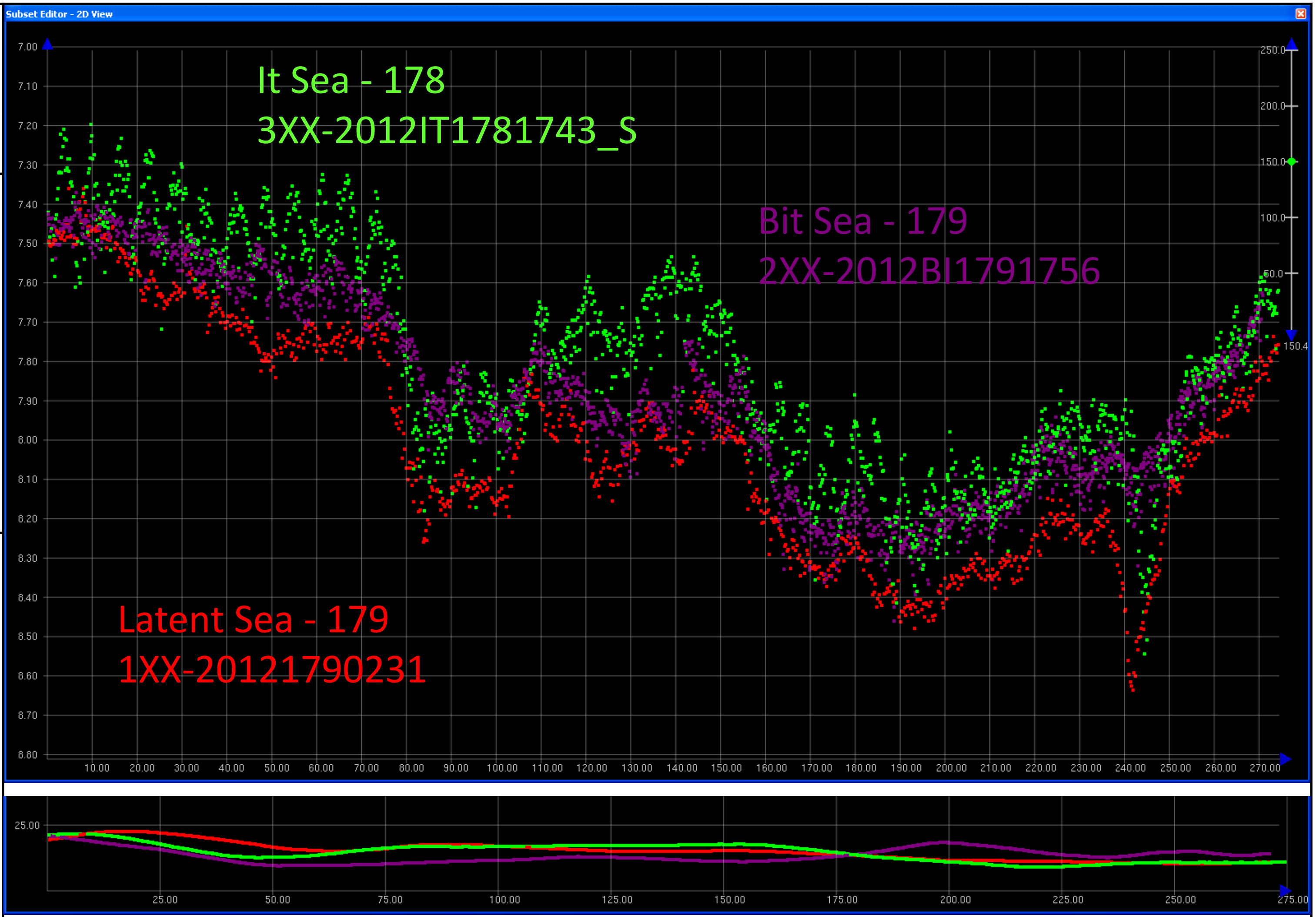
Maximum offset:
0.3 m

Average Offset:
0.2 m



Comments:
Lines run approximately 4 days apart. Largest depth sounding differences are most likely due to imperfect alignment of single beam soundings over rough terrain. Vessel motion of up to 0.8 m is evident on the purple line from the Latent Sea on day 167.

Echo Sounder Comparison



Vessel(s)-Day(s):

It Sea - 178
Latent Sea - 179
Bit Sea – 179

Maximum Difference:
0.4 m

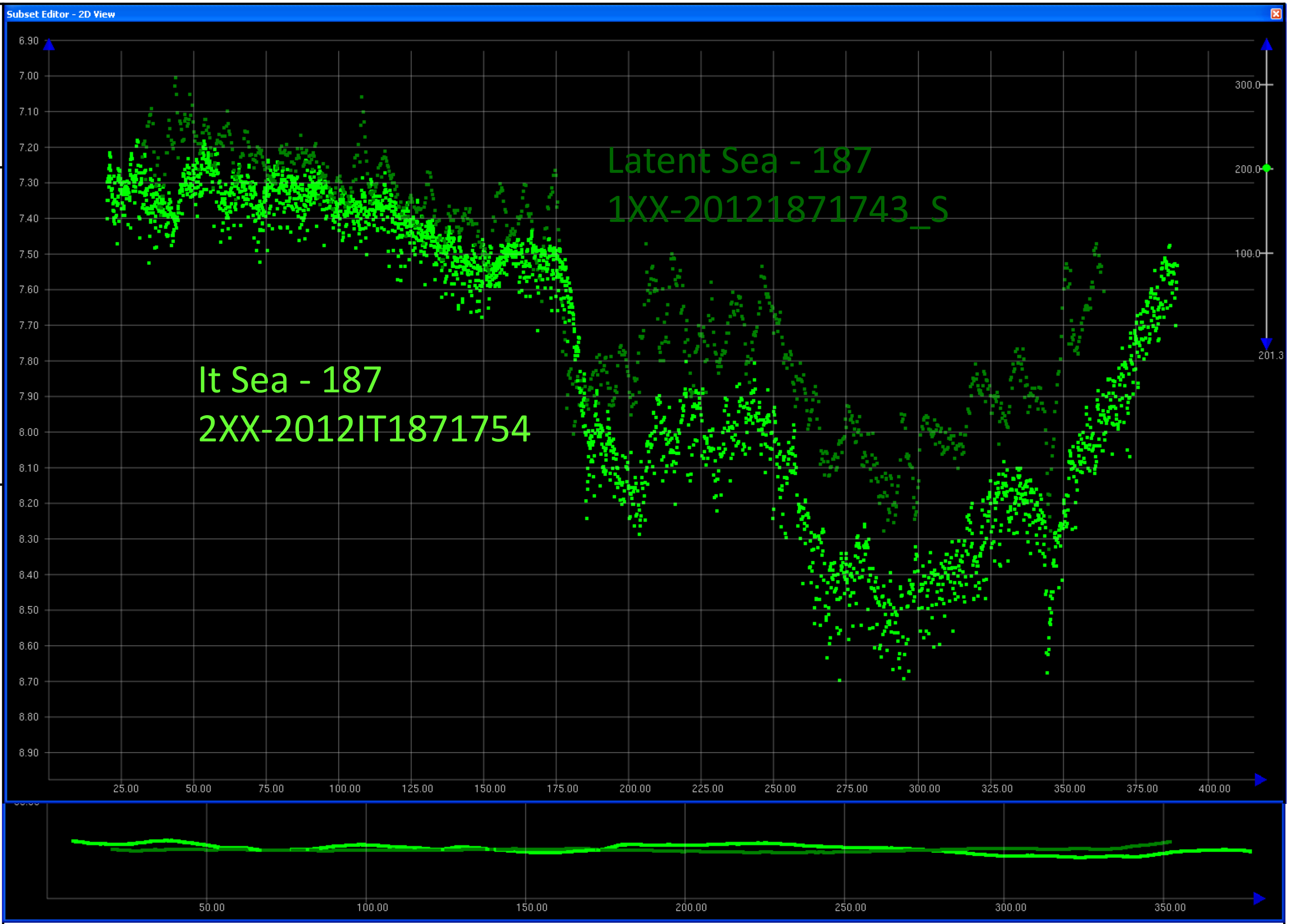
Average Difference:
0.1 m

Comments:
Lines run approximately up to 1 day apart. Largest depth sounding differences are most likely due to imperfect alignment of single beam soundings over rough terrain.

Echo Sounder Comparison

Vessel(s)-Day(s):

Bit Sea - 187
Latent Sea - 187



Maximum Difference:
0. m

Average Difference:
0.15 m

Comments:
Lines run on the same day, at nearly the same time. Largest depth sounding differences are most likely due to imperfect alignment of single beam soundings over rough terrain.

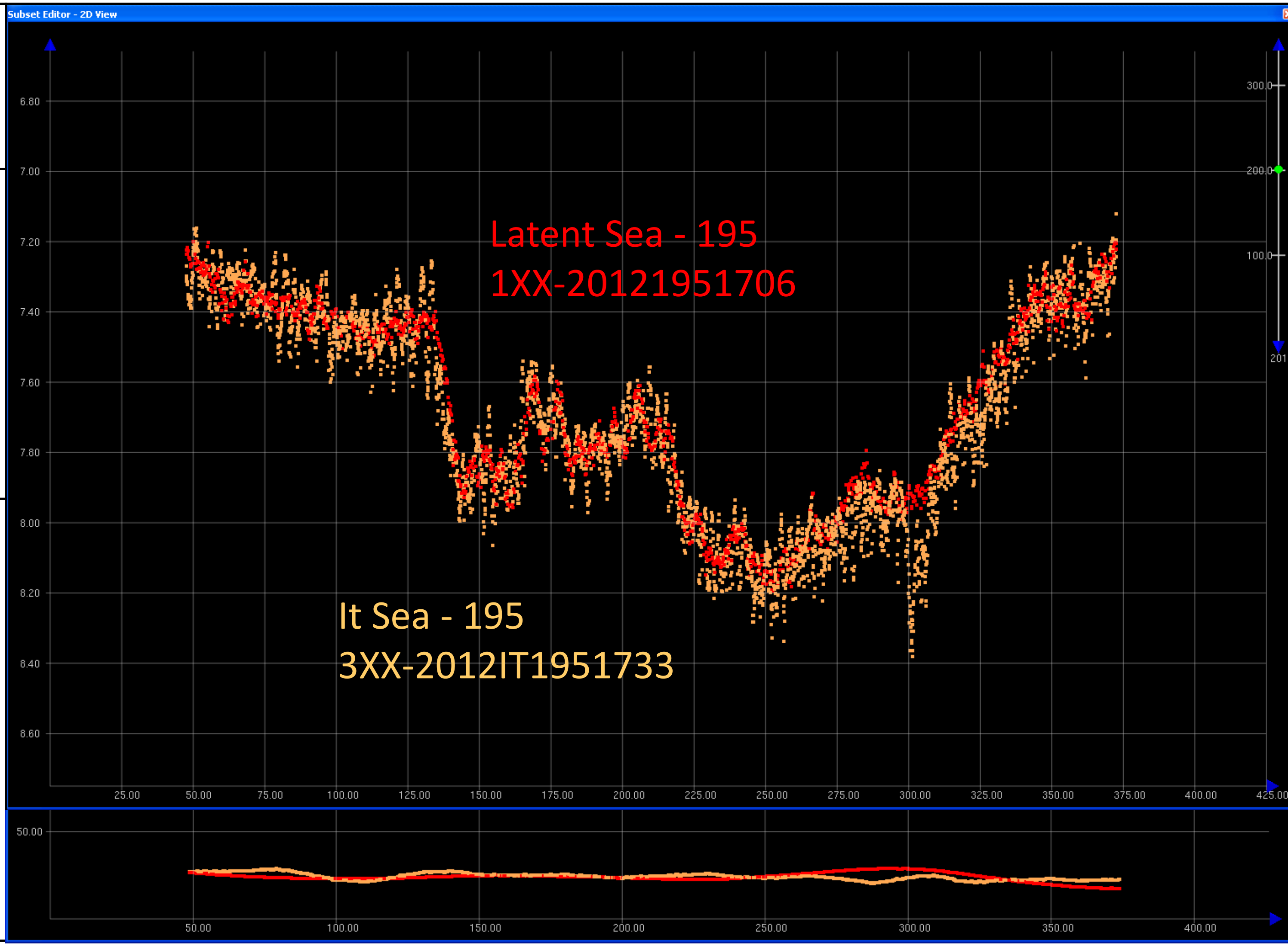
Echo Sounder Comparison

Vessel(s)-Day(s):

It Sea - 195
Latent Sea - 195

Maximum Difference:
0.1 m

Average Difference:
< 0.05 m



Comments:
Lines run on the same day at nearly the same time. Largest depth sounding differences are most likely due to imperfect alignment of single beam soundings over rough terrain.

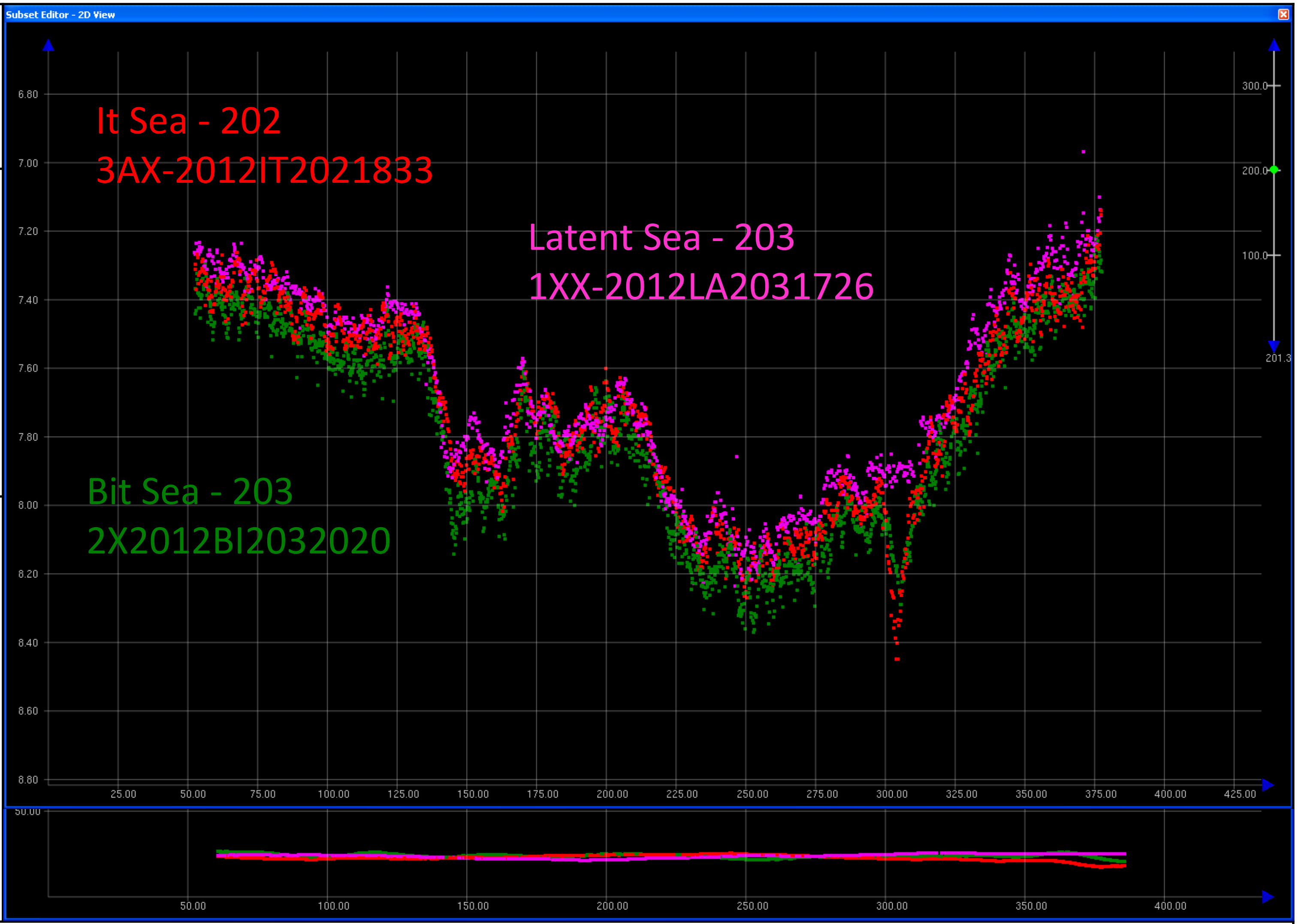
Echo Sounder Comparison

Vessel(s)-Day(s):

Bit Sea - 203
Latent Sea - 203
It Sea - 202

Maximum Difference:
0.1 m

Average Difference:
< 0.05 m



Comments:
Lines run up to 1 day apart. Largest depth sounding differences are most likely due to imperfect alignment of single beam soundings over rough terrain.

APPENDIX III

Positioning and Attitude System Reports

Requirements for this appendix do not apply to equipment used in this survey. Refer to main body of DAPR for equipment configurations, calibrations and QC procedures and results.

APPENDIX IV

Sound Speed Calibration Reports

This appendix contains the following documentation:

1. Sound Speed Instrument Calibration Reports

Date:
Mar 12, 2012

Serial #:
002992-031212

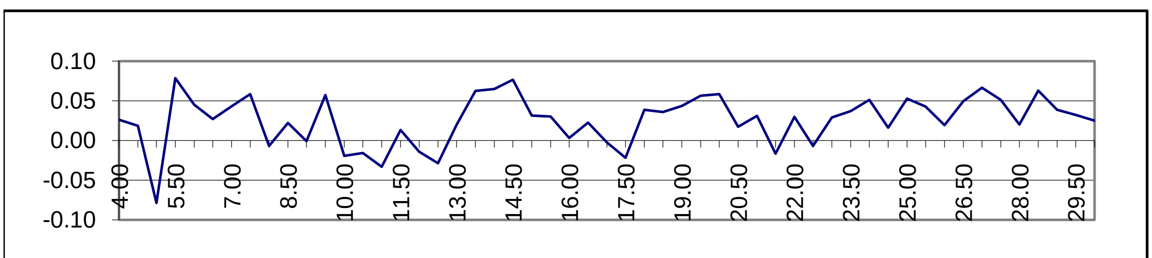
DIGIBAR CALIBRATION REPORT

version 1.0 (c) 2004

ODOM HYDROGRAPHIC SYSTEMS, Inc.

STANDARD DEL GROSSO H[2]O

TEMP	VELOCITY	MEASURED FREQUENCY	RES_VEL	OBS-CAL
4.00	1421.62	5544.01	1421.65	0.03
4.50	1423.90	5552.60	1423.92	0.02
5.00	1426.15	5560.75	1426.07	-0.08
5.50	1428.38	5569.76	1428.46	0.08
6.00	1430.58	5577.95	1430.62	0.05
6.50	1432.75	5586.10	1432.78	0.03
7.00	1434.90	5594.28	1434.94	0.04
7.50	1437.02	5602.36	1437.08	0.06
8.00	1439.12	5610.04	1439.11	-0.01
8.50	1441.19	5617.98	1441.21	0.02
9.00	1443.23	5625.63	1443.23	0.00
9.50	1445.25	5633.49	1445.31	0.06
10.00	1447.25	5640.75	1447.23	-0.02
10.50	1449.22	5648.22	1449.21	-0.02
11.00	1451.17	5655.52	1451.14	-0.03
11.50	1453.09	5662.97	1453.11	0.01
12.00	1454.99	5670.05	1454.98	-0.01
12.50	1456.87	5677.09	1456.84	-0.03
13.00	1458.72	5684.28	1458.74	0.02
13.50	1460.55	5691.36	1460.62	0.06
14.00	1462.36	5698.20	1462.43	0.06
14.50	1464.14	5704.99	1464.22	0.08
15.00	1465.91	5711.48	1465.94	0.03
15.50	1467.65	5718.05	1467.68	0.03
16.00	1469.36	5724.44	1469.37	0.00
16.50	1471.06	5730.92	1471.08	0.02
17.00	1472.73	5737.15	1472.73	0.00
17.50	1474.38	5743.32	1474.36	-0.02
18.00	1476.01	5749.71	1476.05	0.04
18.50	1477.62	5755.78	1477.65	0.04
19.00	1479.21	5761.81	1479.25	0.04
19.50	1480.77	5767.78	1480.83	0.06
20.00	1482.32	5773.63	1482.37	0.06
20.50	1483.84	5779.24	1483.86	0.02
21.00	1485.35	5784.98	1485.38	0.03
21.50	1486.83	5790.41	1486.81	-0.02
22.00	1488.29	5796.12	1488.32	0.03
22.50	1489.74	5801.44	1489.73	-0.01
23.00	1491.16	5806.96	1491.19	0.03
23.50	1492.56	5812.30	1492.60	0.04
24.00	1493.95	5817.59	1494.00	0.05
24.50	1495.32	5822.62	1495.33	0.02
25.00	1496.66	5827.85	1496.71	0.05
25.50	1497.99	5832.83	1498.03	0.04
26.00	1499.30	5837.69	1499.32	0.02
26.50	1500.59	5842.68	1500.64	0.05
27.00	1501.86	5847.55	1501.92	0.07
27.50	1503.11	5852.23	1503.16	0.05
28.00	1504.35	5856.78	1504.37	0.02
28.50	1505.56	5861.54	1505.62	0.06
29.00	1506.76	5865.98	1506.80	0.04
29.50	1507.94	5870.42	1507.97	0.03
30.00	1509.10	5874.79	1509.13	0.03



Odom Hydrographic Systems, Inc.
1450 SeaBoard Avenue, Baton Rouge, Louisiana 70810-6261, USA
Telephone: (225)-769-3051, Facsimile: (225)-766-5122
E-mail: email@odomhydrographic.com, HTTP: www.odomhydrographic.com

Date:
Mar 12, 2012

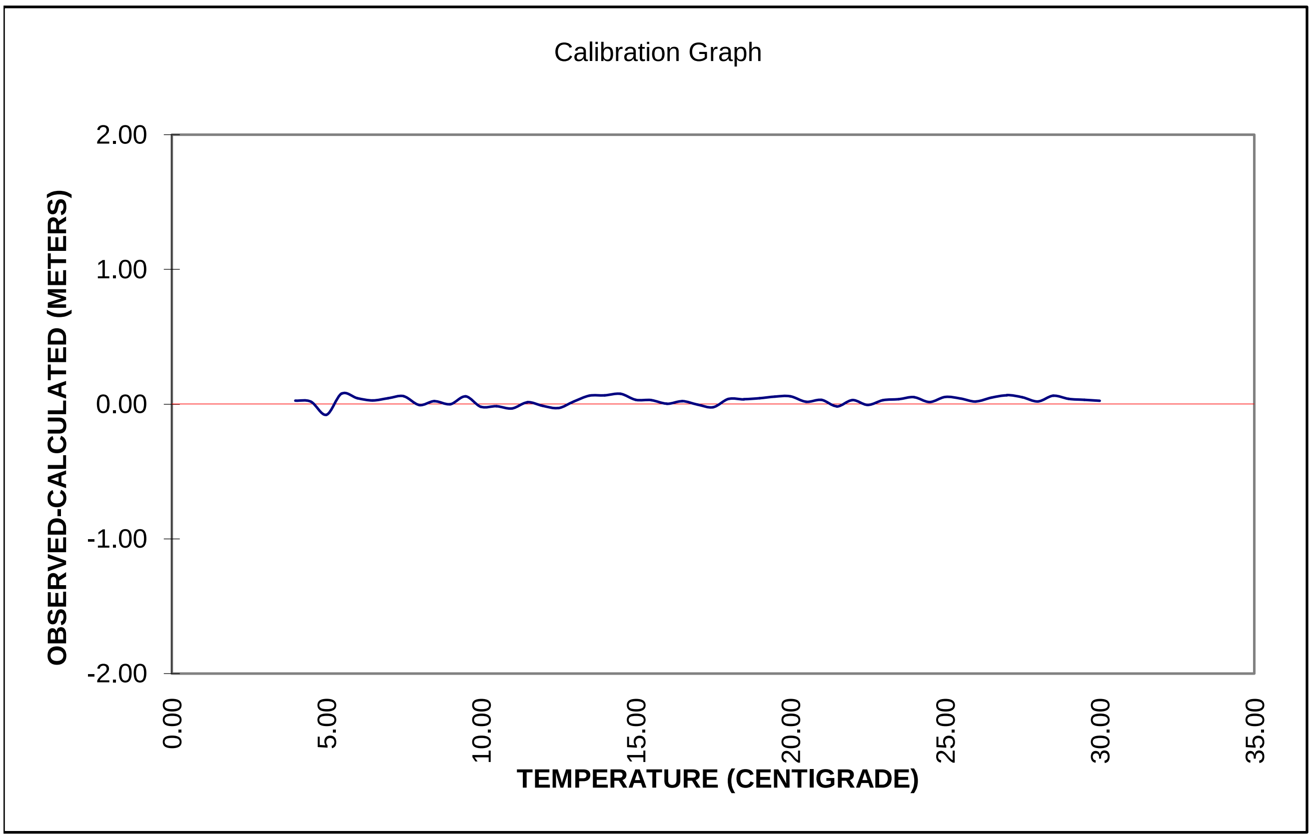
Serial #:
002992-031212

DIGIBAR CALIBRATION REPORT

version 1.0 (c) 2004

ODOM HYDROGRAPHIC SYSTEMS, Inc.

Burn these numbers to EPROM:		
	Gradient	**3386**
	Intercept	**446**



The instruments used in this calibration have been calibrated to the published manufacturer specifications using standards traceable to NIST, to consensus standards, to ratio methods, or to acceptable values of natural physical constants that meets the requirements of ANSI/NCSL Z540-1, ISO 9001, ISO 10012 and ISO 17025. Certificate/traceability numbers: 0002-2655.00-23491-001, 0002-2655.00-23491-002. ID#'s:294,295,762,172,56

Odom Hydrographic Systems, Inc.
1450 SeaBoard Avenue, Baton Rouge, Louisiana 70810-6261, USA
Telephone: (225)-769-3051, Facsimile: (225)-766-5122
E-mail: email@odomhydrographic.com, HTTP: www.odomhydrographic.com

TELEDYNE ODOM HYDROGRAPHIC
A Teledyne Technologies Company

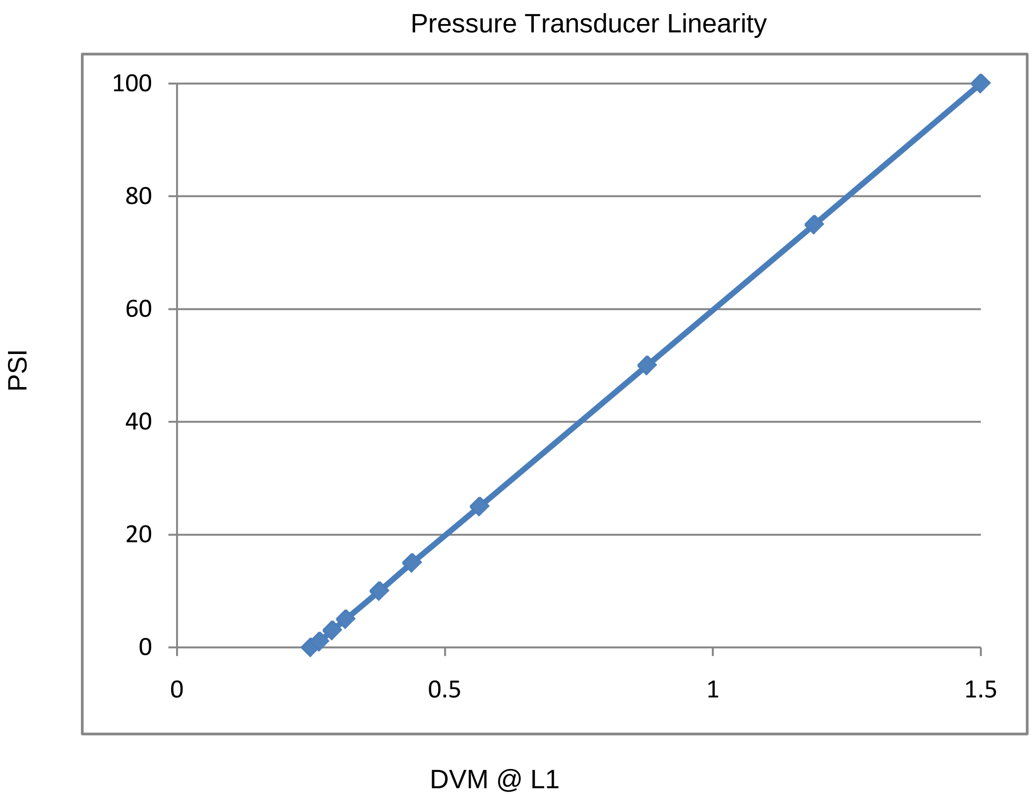
Digibar

Date	11/27/2012
Serial #	002992
SW Version	1.11
Cable Length	30 meter

Board Identification	Serial #
Power Supply	
Control PCB	
LCD	
Probe Sensor	
Probe Controller	
Airmar Transducer	1806019

Press Transducer	82808
Zero Voltage	.22
Span Volage	2.72
Mid-Scale Voltage	1.47
R5	3.9K
R9	10K
Gradient	3386
Intercept	446

Max psi:	200 psi
Velocity Check:	√
Depth Check:	√
Communications:	√
External Power:	NA



Transducer Linearity	
PSI	DVM@L1
0	0.22
1	0.232
3	0.257
5	0.282
10	0.344
15	0.407
25	0.531
50	0.843
75	1.156
100	1.47

Date:
Mar 12, 2012

Serial #:
98014-031212

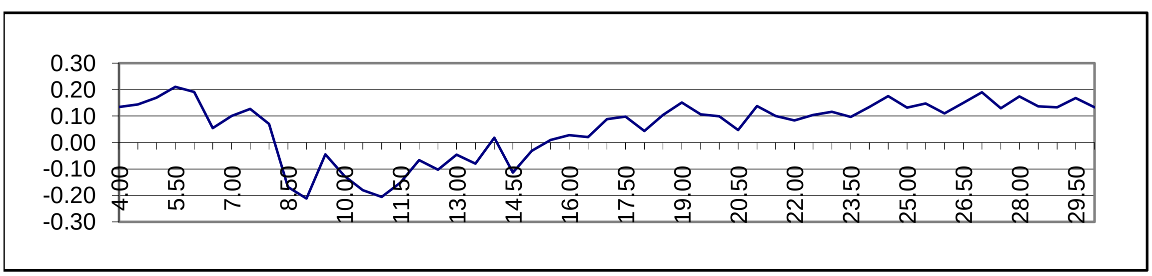
DIGIBAR CALIBRATION REPORT

version 1.0 (c) 2004

ODOM HYDROGRAPHIC SYSTEMS, Inc.

STANDARD DEL GROSSO H^2O

TEMP	VELOCITY	MEASURED FREQUENCY	RES_VEL	OBS-CAL
4.00	1421.62	5555.25	1421.76	0.14
4.50	1423.90	5563.89	1424.04	0.14
5.00	1426.15	5572.49	1426.32	0.17
5.50	1428.38	5581.05	1428.59	0.21
6.00	1430.58	5589.28	1430.77	0.19
6.50	1432.75	5596.97	1432.81	0.06
7.00	1434.90	5605.25	1435.00	0.10
7.50	1437.02	5613.36	1437.15	0.13
8.00	1439.12	5621.06	1439.19	0.07
8.50	1441.19	5627.98	1441.02	-0.17
9.00	1443.23	5635.54	1443.02	-0.21
9.50	1445.25	5643.80	1445.21	-0.04
10.00	1447.25	5651.03	1447.13	-0.13
10.50	1449.22	5658.27	1449.04	-0.18
11.00	1451.17	5665.53	1450.97	-0.21
11.50	1453.09	5673.00	1452.94	-0.15
12.00	1454.99	5680.49	1454.93	-0.07
12.50	1456.87	5687.44	1456.77	-0.10
13.00	1458.72	5694.65	1458.68	-0.05
13.50	1460.55	5701.43	1460.47	-0.08
14.00	1462.36	5708.62	1462.38	0.02
14.50	1464.14	5714.86	1464.03	-0.11
15.00	1465.91	5721.82	1465.88	-0.03
15.50	1467.65	5728.54	1467.66	0.01
16.00	1469.36	5735.09	1469.39	0.03
16.50	1471.06	5741.46	1471.08	0.02
17.00	1472.73	5748.03	1472.82	0.09
17.50	1474.38	5754.30	1474.48	0.10
18.00	1476.01	5760.25	1476.05	0.04
18.50	1477.62	5766.55	1477.72	0.11
19.00	1479.21	5772.72	1479.36	0.15
19.50	1480.77	5778.46	1480.88	0.11
20.00	1482.32	5784.27	1482.42	0.10
20.50	1483.84	5789.83	1483.89	0.05
21.00	1485.35	5795.85	1485.48	0.14
21.50	1486.83	5801.31	1486.93	0.10
22.00	1488.29	5806.77	1488.38	0.08
22.50	1489.74	5812.30	1489.84	0.10
23.00	1491.16	5817.72	1491.28	0.12
23.50	1492.56	5822.95	1492.66	0.10
24.00	1493.95	5828.32	1494.08	0.13
24.50	1495.32	5833.63	1495.49	0.18
25.00	1496.66	5838.55	1496.79	0.13
25.50	1497.99	5843.62	1498.14	0.15
26.00	1499.30	5848.42	1499.41	0.11
26.50	1500.59	5853.44	1500.74	0.15
27.00	1501.86	5858.39	1502.05	0.19
27.50	1503.11	5862.89	1503.24	0.13
28.00	1504.35	5867.72	1504.52	0.17
28.50	1505.56	5872.17	1505.70	0.14
29.00	1506.76	5876.68	1506.89	0.13
29.50	1507.94	5881.27	1508.11	0.17
30.00	1509.10	5885.53	1509.24	0.13



Odom Hydrographic Systems, Inc.
1450 SeaBoard Avenue, Baton Rouge, Louisiana 70810-6261, USA
Telephone: (225)-769-3051, Facsimile: (225)-766-5122
E-mail: email@odomhydrographic.com, HTTP: www.odomhydrographic.com

Date:
Mar 12, 2012

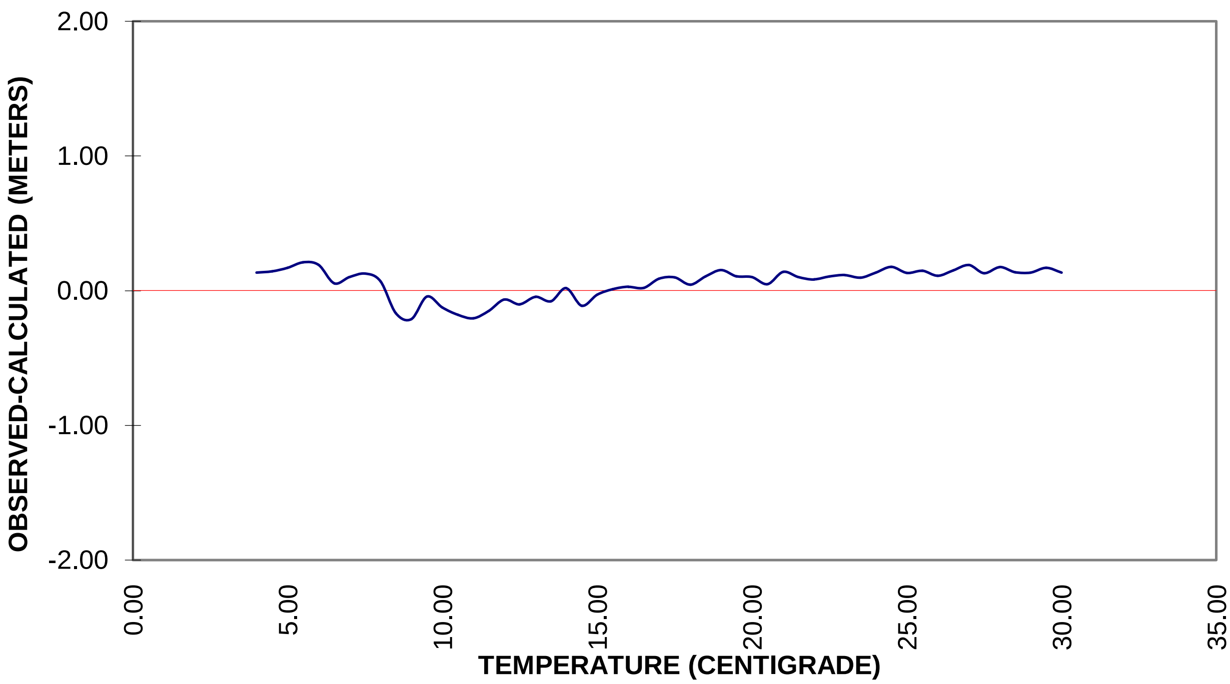
Serial #:
98014-031212

DIGIBAR CALIBRATION REPORT

version 1.0 (c) 2004

ODOM HYDROGRAPHIC SYSTEMS, Inc.

Burn these numbers to EPROM:	Gradient	**3391**
	Intercept	**497**



The instruments used in this calibration have been calibrated to the published manufacturer specifications using standards traceable to NIST, to consensus standards, to ratio methods, or to acceptable values of natural physical constants that meets the requirements of ANSI/NCSL Z540-1, ISO 9001, ISO 10012 and ISO 17025. Certificate/traceability numbers: 0002-2655.00-23491-001, 0002-2655.00-23491-002. ID#'s:294,295,762,172,56

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TELEDYNE
ODOM HYDROGRAPHIC
A Teledyne Technologies Company

Digibar

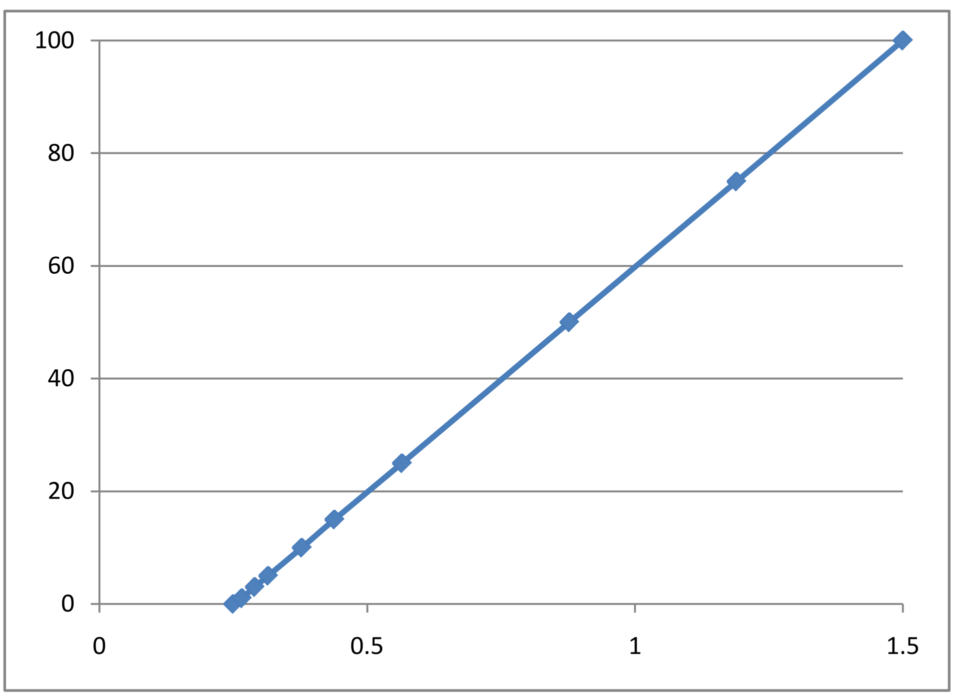
Date	11/29/2012
Serial #	98014
SW Version	1.13
Cable Length	30 meter

Board Identification	Serial #
Power Supply	
Control PCB	
LCD	
Probe Sensor	
Probe Controller	
Airmar Transducer	134307

Press Transducer	103685
Zero Voltage	.15
Span Volage	2.65
Mid-Scale Voltage	1.4
R5	3.9K
R9	10K
Gradient	3391
Intercept	497

Max psi:	70 psi
Velocity Check:	√
Depth Check:	√
Communications:	√
External Power:	NA

Pressure Transducer Linearity



PSI

DVM @ L1

Transducer Linearity	
PSI	DVM@L1
0	0.15
1	0.162
3	0.187
5	0.212
10	0.275
15	0.337
25	0.462
50	0.774
75	1.087
100	1.4

Date:
Mar 09, 2012

Serial #:
98427-030912

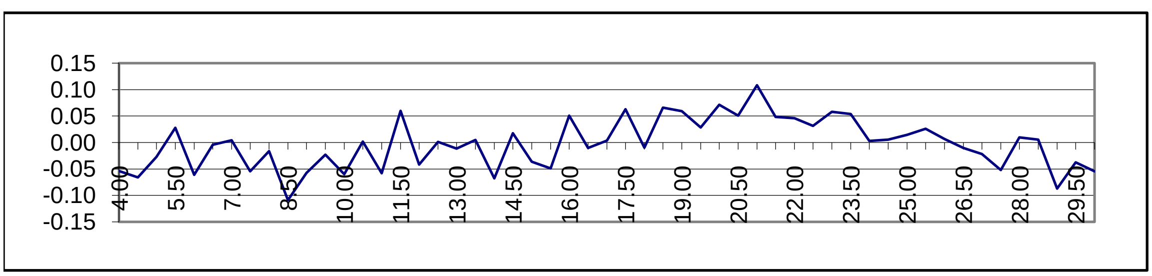
DIGIBAR CALIBRATION REPORT

version 1.0 (c) 2004

ODOM HYDROGRAPHIC SYSTEMS, Inc.

STANDARD DEL GROSSO H^2O

TEMP	VELOCITY	MEASURED FREQUENCY	RES_VEL	OBS-CAL	TEMP	VELOCITY	MEASURED FREQUENCY	RES_VEL	OBS-CAL
4.00	1421.62	5547.73	1421.57	-0.05	17.50	1474.38	5747.13	1474.44	0.06
4.50	1423.90	5556.28	1423.83	-0.07	18.00	1476.01	5753.00	1476.00	-0.01
5.00	1426.15	5564.92	1426.13	-0.03	18.50	1477.62	5759.35	1477.68	0.07
5.50	1428.38	5573.52	1428.41	0.03	19.00	1479.21	5765.31	1479.26	0.06
6.00	1430.58	5581.48	1430.52	-0.06	19.50	1480.77	5771.10	1480.80	0.03
6.50	1432.75	5589.89	1432.75	0.00	20.00	1482.32	5777.09	1482.39	0.07
7.00	1434.90	5598.02	1434.90	0.00	20.50	1483.84	5782.76	1483.89	0.05
7.50	1437.02	5605.80	1436.97	-0.05	21.00	1485.35	5788.65	1485.45	0.11
8.00	1439.12	5613.85	1439.10	-0.02	21.50	1486.83	5794.02	1486.88	0.05
8.50	1441.19	5621.31	1441.08	-0.11	22.00	1488.29	5799.53	1488.34	0.05
9.00	1443.23	5629.22	1443.18	-0.06	22.50	1489.74	5804.92	1489.77	0.03
9.50	1445.25	5636.97	1445.23	-0.02	23.00	1491.16	5810.39	1491.22	0.06
10.00	1447.25	5644.36	1447.19	-0.06	23.50	1492.56	5815.67	1492.62	0.05
10.50	1449.22	5652.03	1449.23	0.00	24.00	1493.95	5820.70	1493.95	0.00
11.00	1451.17	5659.15	1451.11	-0.06	24.50	1495.32	5825.86	1495.32	0.01
11.50	1453.09	5666.85	1453.16	0.06	25.00	1496.66	5830.97	1496.68	0.01
12.00	1454.99	5673.63	1454.95	-0.04	25.50	1497.99	5836.02	1498.02	0.03
12.50	1456.87	5680.87	1456.87	0.00	26.00	1499.30	5840.88	1499.30	0.01
13.00	1458.72	5687.81	1458.71	-0.01	26.50	1500.59	5845.68	1500.58	-0.01
13.50	1460.55	5694.77	1460.56	0.00	27.00	1501.86	5850.43	1501.84	-0.02
14.00	1462.36	5701.31	1462.29	-0.07	27.50	1503.11	5855.04	1503.06	-0.05
14.50	1464.14	5708.36	1464.16	0.02	28.00	1504.35	5859.93	1504.36	0.01
15.00	1465.91	5714.80	1465.87	-0.04	28.50	1505.56	5864.50	1505.57	0.01
15.50	1467.65	5721.31	1467.60	-0.05	29.00	1506.76	5868.67	1506.67	-0.09
16.00	1469.36	5728.16	1469.41	0.05	29.50	1507.94	5873.31	1507.90	-0.04
16.50	1471.06	5734.32	1471.05	-0.01	30.00	1509.10	5877.63	1509.05	-0.05
17.00	1472.73	5740.68	1472.73	0.00					



Odom Hydrographic Systems, Inc.
1450 SeaBoard Avenue, Baton Rouge, Louisiana 70810-6261, USA
Telephone: (225)-769-3051, Facsimile: (225)-766-5122
E-mail: email@odomhydrographic.com, HTTP: www.odomhydrographic.com

Date:
Mar 09, 2012

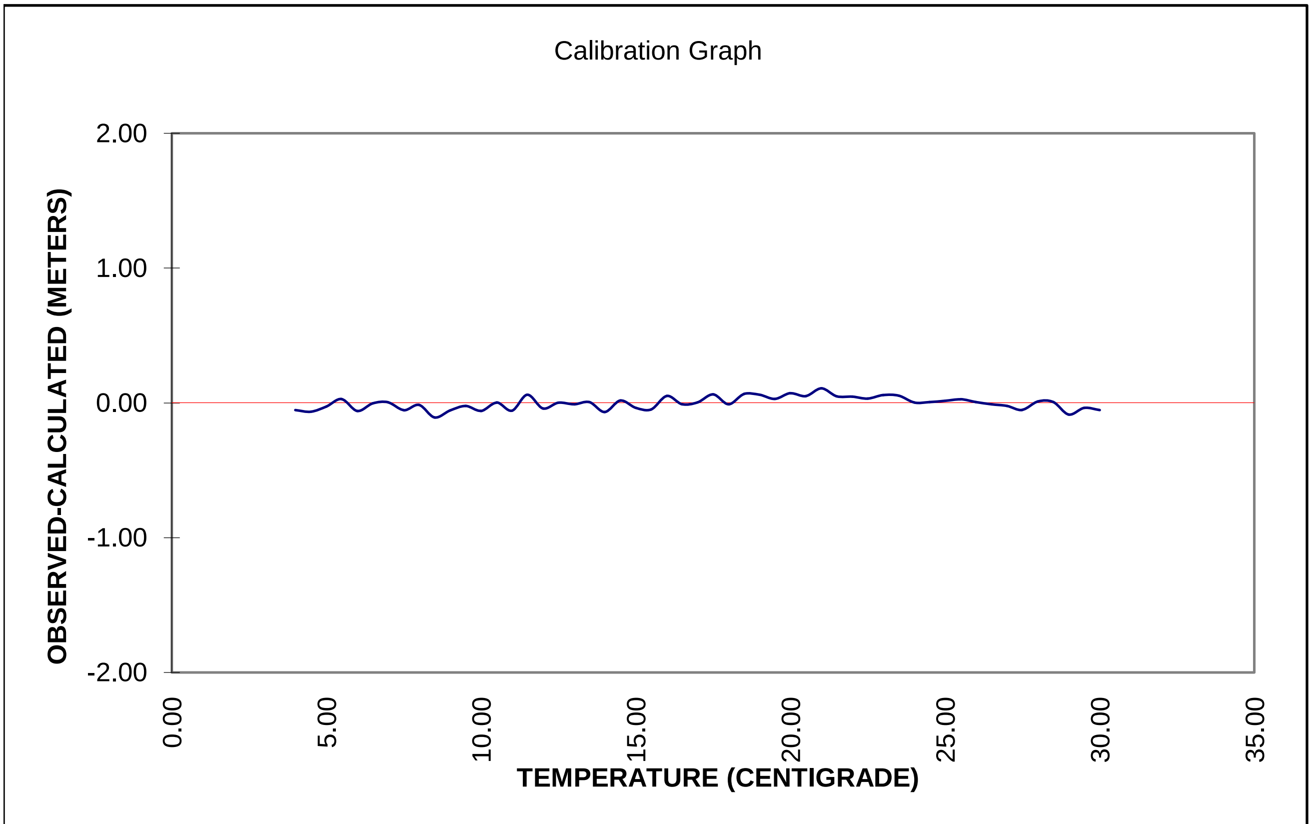
Serial #:
98427-030912

DIGIBAR CALIBRATION REPORT

version 1.0 (c) 2004

ODOM HYDROGRAPHIC SYSTEMS, Inc.

Burn these numbers to EPROM:		
	Gradient	**3395**
	Intercept	**496**



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TELEDYNE ODOM HYDROGRAPHIC
A Teledyne Technologies Company

Digibar

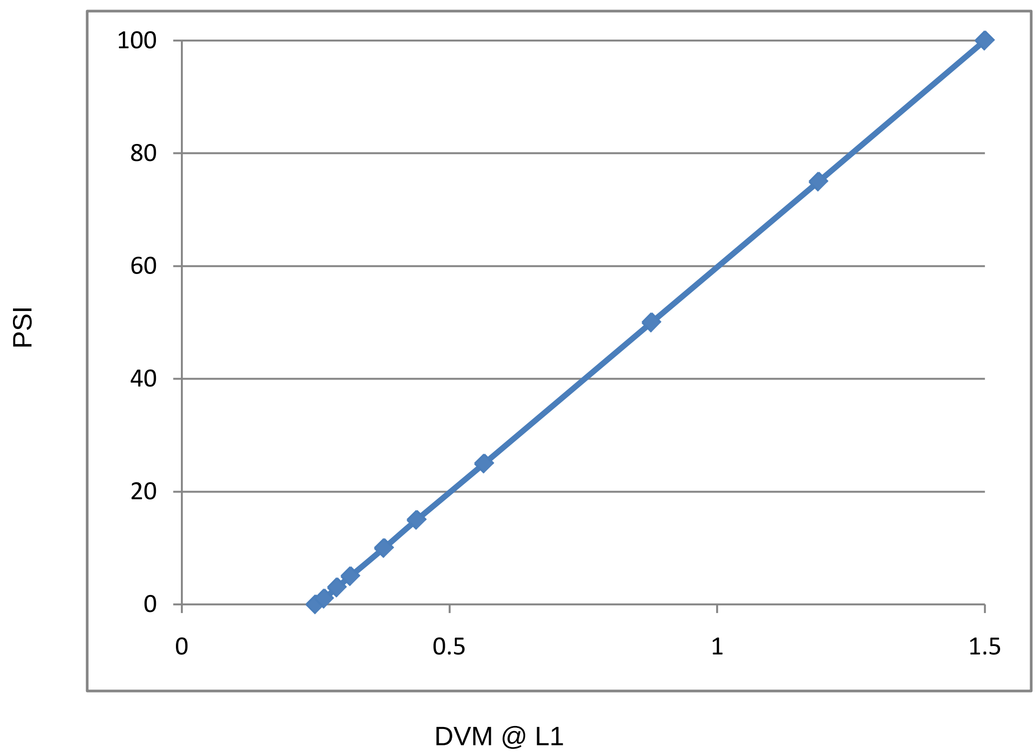
Date	11/27/2012
Serial #	98427
SW Version	1.13
Cable Length	30 meter

Press Transducer	71043
Zero Voltage	.27
Span Volage	2.77
Mid-Scale Voltage	1.52
R5	3.9K
R9	10K
Gradient	3395
Intercept	496

Max psi:	200 psi
Velocity Check:	√
Depth Check:	√
Communications:	√
External Power:	NA

Board Identification	Serial #
Power Supply	
Control PCB	
LCD	
Probe Sensor	
Probe Controller	
Airmar Transducer	828208

Pressure Transducer Linearity



Transducer Linearity	
PSI	DVM@L1
0	0.27
1	0.289
3	0.314
5	0.339
10	0.401
15	0.464
25	0.588
50	0.901
75	1.214
100	1.52

Certificate of Calibration

Customer:	TerraSond Ltd
Asset Serial Number:	003259
Asset Product Type:	SV Plus V1 Instrument
Calibration Type:	Sound Velocity
Calibration Range:	1400 to 1550 m/s
Calibration RMS Error:	.0178
Calibration ID:	003259 999999 S04303 060112 090836
Installed On:	

Coefficient A:	1.530534E+3	Coefficient G:	0.000000E+0
Coefficient B:	-1.125646E+2	Coefficient H:	0.000000E+0
Coefficient C:	9.449088E+0	Coefficient I:	0.000000E+0
Coefficient D:	-9.709921E-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): 6/1/2012

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

AML Oceanographic
2071 Malaview Avenue, Sidney B.C. V8L 5X6 CANADA
T: +1-250-656-0771 F: +1-250-655-3655 Email: service@AMLoceanographic.com

Certificate of Calibration

Customer:	TerraSond Ltd
Asset Serial Number:	003259
Asset Product Type:	SV Plus V1 Instrument
Calibration Type:	Pressure
Calibration Range:	50 dBar
Calibration RMS Error:	.006
Calibration ID:	003259 999999 0139AJ 110112 134424
Installed On:	

Coefficient A:	-6.161015E+1	Coefficient G:	0.000000E+0
Coefficient B:	2.693571E-3	Coefficient H:	0.000000E+0
Coefficient C:	-4.938229E-9	Coefficient I:	0.000000E+0
Coefficient D:	1.071829E-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): 11/1/2012

Certified By:

AML Oceanographic

Robert Haydock

President, AML Oceanographic

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AML Oceanographic
2071 Malaview Avenue, Sidney B.C. V8L 5X6 CANADA
T: +1-250-656-0771 F: +1-250-655-3655 Email: service@AMLoceanographic.com

Certificate of Calibration

Customer:	TerraSond Ltd
Asset Serial Number:	003259
Asset Product Type:	SV Plus V1 Instrument
Calibration Type:	Temperature
Calibration Range:	0 to +32 Dec C
Calibration RMS Error:	.004
Calibration ID:	003259 999999 T04901 100112 164926
Installed On:	

Coefficient A:	3.674705E+1	Coefficient G:	0.000000E+0
Coefficient B:	-1.122835E-3	Coefficient H:	0.000000E+0
Coefficient C:	1.033749E-8	Coefficient I:	0.000000E+0
Coefficient D:	-1.368665E-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): 10/1/2012

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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