Cover Sheet (NOAA Form 76-35A)

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

Field No OPR-J359-KR-18

Registry No. H13153, H13154, H13155, H13156, H13157, H13158, & F00766

LOCALITY

State Florida

General Locality Apalachicola

Sublocality Covers the regions of Cape San Blas Shoals, West of Saint Joseph Peninsula, South of Cape San Blas.

2018

CHIEF OF PARTY

Dean Moyles

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DATE..........

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Title Sheet (NOAA Form 77-28)

NOAA FORM 77-28 (11-72) U.S. DEPARTMENT OF COMMERCE NATIONAL OCEANIC AND ATMOSPHERIC ADMINISTRATION **HYDROGRAPHIC TITLE SHEET**	REGISTER NO. H13153, H13154, H13155, H13156, H13157, H13158, & F00766
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.

State Florida

General Locality Vicinity of Apalachicola

Locality Covers the regions of East, Central, West, and South Cape San Blas Shoals, and West of Saint Joseph Peninsula
Scale 1:20,000 & 1:40:000 Date of Survey 07/2018 - Present
Instructions dated July 11, 2018 Project No. OPR-J359-KR-18

Vessel M/V Pelagos (N893565), R/V Acadiana (692280), M/V MacGinitie (SAMA1083J999)

Chief of party Dean Moyles

Surveyed by Moyles, Rokyta, Boutilier, Walker, Stone, Jones, Cain, Kline, Fitzpatrick, Minton, Porter, Careen

Soundings taken by echo sounder, hand lead, pole Dual Head Reson 7125 (M/V Pelagos, Over the Side Mount), Dual Head Reson 7125 (R/V Acadiana, Over the Side Mount), Dual Head Reson 7125 (M/V MacGinitie, Bow Mount)

Graphic record scaled by Fugro Personnel

Graphic record checked by Fugro Personnel

Protracted by N/A Automated plot by N/A

Verification by

Soundings in METERS at MLLW

REMARKS: The purpose of this survey is to provide contemporary surveys to update National Ocean Service (NOS) nautical charting products.

ALL TIMES ARE RECORDED IN UTC.

FUGRO PELAGOS INC.

6100 HILLCROFT STREET

HOUSTON, TX 77081

A – Equipment

The M/V Pelagos, R/V Acadiana, and the M/V MacGinitie acquired all sounding data for this project. The equipment list and vessel descriptions are included in Appendix I.

Sounding Equipment

The M/V Pelagos, 34 feet in length with a draft of 2 feet, was equipped with an over-the-side pole that housed an underwater IMU and dual head Reson 7125 multibeam sonars (dual meaning two independent systems). The Reson 7125 is a dual frequency system operating at 200 and 400 kHz. The systems were operated in the Intermediate beam mode option, which forms 512 across-track beams (in 400 kHz), with a maximum swath coverage of 140°. Operating modes such as range scale, gain, power level, ping rates, etc. were a function of water depth and data quality and were noted on the survey line logs (see the Descriptive Report Separate 1).

The Reson systems and IMU were installed on a special mounting plate, where each Reson 7125 was rotated approximately 15°. The Reson systems were installed in their normal SV2 bracket, which included an SV70 probe (located in the nose cone) and were attached to the mounting plate by a flange. Refer to Appendix I for more information and graphics.

All 7125 multibeam data files were logged in the s7k format using WinFrog Multibeam (WFMB) v3.10.24. The bathymetric data from each Reson 7125 (records 7004/7006 & 7027) were stitched together in WFMB to create one s7k file with each ping containing 1024 beams.

The R/V Acadiana, 57 feet in length with a draft of 4.5 feet, was equipped with an over-the-side pole that housed an underwater IMU and dual head Reson 7125 multibeam sonars (dual meaning two independent systems). The Reson 7125 is a dual frequency system operating at 200 and 400 kHz. The systems were operated in the Intermediate beam mode option; which forms 512 across-track beams (in 400 kHz), with a maximum swath coverage of 140°. Operating modes such as range scale, gain, power level, ping rates, etc. were a function of water depth and data quality and were noted on the survey line logs (see the Descriptive Report Separate 1).

The Reson systems and IMU were installed on a special mounting plate, where each Reson 7125 was rotated approximately 15°. The Reson systems were installed in their normal SV2 bracket, which included an SV70 probe (located in the nose cone) and were attached to the mounting plate by a flange. Refer to Appendix I for more information and graphics.

All 7125 multibeam data files were logged in the s7k format using WFMB v3.10.24. The bathymetric data from each Reson 7125 (records 7004/7006 & 7027) were stitched together in WFMB to create one s7k file with each ping containing 1024 beams.

The M/V MacGinitie, 32 feet in length with a draft of 1.5 feet, was equipped with an over-the-bow pole that housed an underwater IMU and dual head Reson 7125 multibeam sonars (dual meaning two independent systems). The Reson 7125 is a dual frequency system operating at 200 and 400 kHz. The systems were operated in the Intermediate beam mode option, which forms 512 across-track beams (in 400 kHz), with a maximum swath coverage of 140°. Operating modes such as range scale, gain, power level, ping rates, etc. were a function of water depth and data quality and were noted on the survey line logs (see the Descriptive Report Separate 1).

The Reson systems and IMU were installed on a special mounting plate, where each Reson 7125 was rotated approximately 15°. The Reson systems were installed in their normal SV2 bracket, which included an SV70 probe (located in the nose cone) and were attached to the mounting plate by a flange. Refer to Appendix I for more information and graphics.

All 7125 multibeam data files were logged in the s7k format using WinFrog Multibeam (WFMB) v3.10.24. The bathymetric data from each Reson 7125 (records 7004/7006 & 7027) were stitched together in WFMB to create one s7k file with each ping containing 1024 beams.

All vessels, each equipped with dual head Reson 7125 sonars, were operated in the full rate dual head (FRDH) mode in the Reson topsides.

The line orientation for all vessels was generally parallel to the coastline and bathymetric contours of the area. The line spacing was dependent on water depth and data quality, with an average line spacing of three to four times water depth. Table 1 summarizes the sonar models and configurations used on each survey vessel.

Table 1 Vessel Sonar Summary

Vessel	M/V Pelagos	R/V Acadiana	M/V MacGinitie
Mount Type	Over the Side	Over the Side	Over the Bow
Sonar System	Dual Head Reson 7125 (FRDH)	Dual Head Reson 7125 (FRDH)	Dual Head Reson 7125 (FRDH)

Backscatter Imagery

Towed sidescan sonar (SSS) operations were not required by this contract, but the backscatter and beam imagery snippet data from all multibeam systems were logged and are stored in the s7k files. All beam imagery snippet data was logged in the 7028 record of the s7k file for the project.

To yield the best results when processing the backscatter from the dual head 7125 systems, we recommend using FMGT with Fledermaus version 7.8.7

Sound Velocity Profilers

The R/V Acadiana and M/V MacGinitie were equipped with a Teledyne Oceanscience Underway Profiling System or (UCTD). This is a ship based CTD system that can capture high quality Seabird Electronics CTD data while the vessel is underway and is capable of profiling to over 400m at a vessel speed of 10kt. The system consists of a probe tethered to a special winch with over 2000m of high strength Spectra line. The probe is dropped off the stern of the vessel and allowed to freefall for a set amount of time relative to the depth of the cast and the ship speed. Then the CTD sensor is reeled back in and taken inside to upload the cast data via Bluetooth using OceanScience UCast software. The instrument has the following specifications (Table 2):

Table 2 UCTD Specifications

	Conductivity (S/m)	Temperature (°C)	Depth (dbar)	Salinity (PSU)
Resolution	0.0005	0.002	0.5	0.005
Accuracy- Raw Data	0.03	0.01-0.02	4	0.3
Accuracy – Processed Data	0.002-0.005	0.004	1	0.02-0.05
Range	0-9	-5-43	0-2000	0-42

M/V Pelagos, R/V Acadiana, and M/V MacGinitie were equipped with AML 1000 dbar Sound Velocity & Pressure (AML SV&P) Smart Sensors. The AML SV&P directly measures sound velocity through a time of flight calculation, and measures pressure with a temperature compensated semiconductor strain gauge at a 10Hz sample rate. The instrument has a 0.015 m/s resolution with a ± 0.05 m/s accuracy for sound velocity measurements, and a 0.01 dbar resolution and a ±0.5 m dbar accuracy for pressure.

Each vessel was equipped with two AML SVPs. The instruments were mounted within a weighted cage and deployed using a hydraulic winch that contained 350 meters of shielded Kevlar reinforced cable via a stern mounted A-Frame.

Fugro's MB Survey Tools was used to check the SV profiles graphically for outliers or other anomalies and produce an SVP file compatible with CARIS HIPS.

The WFMB acquisition package also provided quality control (QC) for surface sound velocity. This was accomplished by creating a real-time plot from the sound velocity probe at the Reson sonar head and notifying the user (via a flashing warning message) if the head sound velocity differed by more than 5 m/s from a defined reference sound velocity. This message was used as an indication that the frequency of casts may need to be increased. The reference sound velocity was determined by averaging 50 sound velocities produced at the head. The reference sound velocity was reset after each cast and when a cast was performed due to a significant deviation from the reference sound velocity.

Positioning & Attitude Equipment

The M/V Pelagos was equipped with an Applanix Position and Orientation System for Marine Vessels (POS/MV) V4 (underwater IMU) to calculate position and vessel attitude. Position was determined in real-time using a Trimble Zephyr L1/L2 GPS antenna, which was connected to a Trimble BD950 L1/L2 GPS card residing in the POS/MV. An Inertial Measurement Unit (IMU) provided velocity values to the POS/MV allowing it to compute an inertial position along with heading and attitude. The POS/MV was configured to accept Fugro's Marinestar G2 corrections. Marinestar is a decimeter level, phase-based service using satellite 'clock and orbit' data valid worldwide, based upon GPS L1 and L2 frequencies, and provides a horizontal accuracy of 10 cm and vertical accuracy of 15 cm.

The operational accuracy specifications for this system, as documented by the manufacturer, are as follows (Table 3):

Table 3 POS/MV Specifications

POS/MV Accuracy	
Pitch and Roll	0.02°
Heading	0.02°
Heave	5% or 5-cm over 20 seconds

The R/V Acadiana and M/V MacGinitie were equipped with an Applanix Position and Orientation System for Marine Vessels (POS/MV) V5 (underwater IMU) to calculate position and vessel attitude. Position was determined in real-time using a Trimble Zephyr L1/L2 GPS antenna, which was connected to a Trimble BD950 L1/L2 GPS card residing in the POS/MV. An Inertial Measurement Unit (IMU) provided velocity values to the POS/MV allowing it to compute an inertial position, along with heading, and attitude. The POS/MV was configured to accept Fugro's Marinestar G2 corrections. Marinestar is a decimeter-level, phase-based service using satellite 'clock and orbit' data valid worldwide, based upon GPS L1 and L2 frequencies, and provides a horizontal accuracy of 10 cm and vertical accuracy of 15 cm.

The PosMvLogger and POS/MV controller software's real-time QC displays were monitored throughout the survey to ensure that the positional accuracies specified in the NOS HSSD were achieved. These include, but are not limited to, the following: GPS Status, Positional Accuracy, Receiver Status, which included Horizontal Dilution of Position (HDOP) & Precise Dilution of Position (PDOP), and Satellite Status.

The IMU contains accelerometers and gyroscopes to measure linear acceleration and angular rates on the three axes of the reference body. The IMU measurements, position, velocity, and orientation (roll, pitch, heading), are returned to the PCS where an inertial navigator produces position and orientation data. The INS navigation solution errors that build over time are controlled by the continuous input of GNSS positioning integrated into the POS/MV. A Trimble BD950 board, coupled with a L1/L2 GPS Antenna, and the corrections of the Marinestar G2 augmentation service produce the high-accuracy positioning observables that are integrated by the inertial navigator into position and orientation of the reference platform in real-time.

Fugro Marinestar G2 service is a real-time GPS and GLONASS Precise Point Positioning (PPP) providing refined satellite 'clocks and orbit' data to any GNSS receiver with a valid service subscription. Signal on the L-band with corrections is broadcasted by geo-stationary satellites. At least three of them covered the geographic region of the survey area, see Figure 1, and was received by the integrated GNSS/L-band antenna. Fugro uses the G2 service signal as the standard in the POS/MV embedded Marinestar receiver.

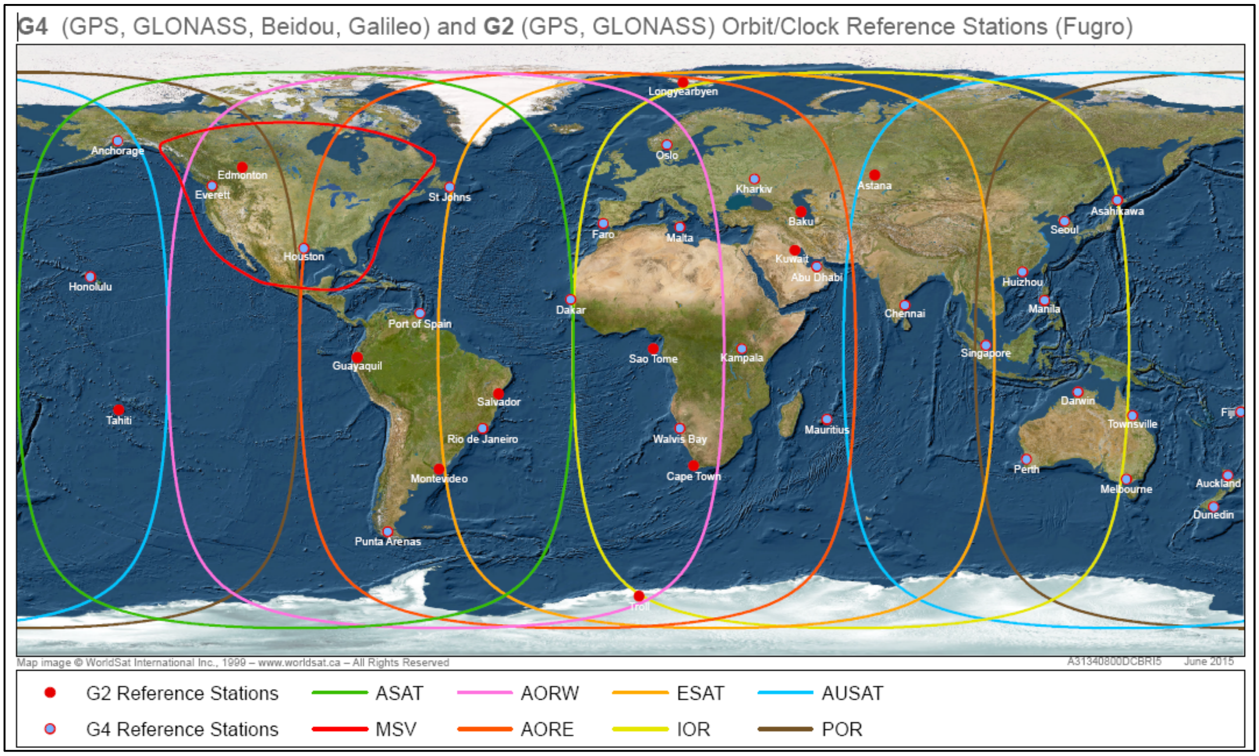


Figure 1 GNSS/IMU Positioning System

Static Draft Measurement

Depending on the vessel, static draft was measured from a tab on the side of the vessel directly above the IMU and sonar mount, or on the pole itself, and then the correction to the common reference point (IMU) was applied. Refer to the offset diagrams Appendix I for additional information.

Bottom Sampling

The M/V Pelagos, R/V Acadiana, and M/V MacGinitie were equipped with a 2.4L Van Veen Grab bottom sampler and 100 meters of line. The sampler was hand deployed and retrieved via a davit that was installed on the port side of the vessel. All samples were discarded after the sample information was recorded.

Software

MBES Acquisition

All raw multibeam data was collected with WFMB v3.10.24. WFMB runs on a Windows 7 PC with a quad-core Intel processor. Data from the Reson 7125 sonars were logged in the s7k file format. The s7k files contain all multibeam bathymetry, position, attitude, heading, and UTC time stamp data required by CARIS to process the soundings. The S7K file also contained the snippet data required by FMGT to process the backscatter data. A separate WFMB module (PosMVLogger) on the same PC logged all raw POS/MV data for the post-processing of vessel positions in Applanix POSPac MMS software. WFMB also provided a coverage display for real-time QC and data coverage estimation.

WFMB offers the following display windows for operators to monitor data quality:

1. Devices: The Devices window shows the operator which hardware is attached to the PC. It also allows the operator to configure the devices, determine whether they are functioning properly, and to view received data.

2. Graphic: The Graphics window shows navigation information in plan view. This includes vessel position, survey lines, background vector plots, and raster charts.

3. Vehicle: The Vehicle window can be configured to show any tabular navigation information required. Typically, this window displays position, time, line name, heading, HDOP, speed over ground, distance to start of line, distance to end of line, and distance off line. Many other data items are selectable.

4. Calculation: The Calculations window is used to look at specific data items in tabular or graphical format. Operators look here to view the status of the GPS satellite constellation and position solutions, real-time SV, tidal values, etc.

5. MBES Coverage Map: The Coverage Map provides a real-time graphical representation of the multibeam data. This allows the user to make judgments and corrections to the data collection procedure based on current conditions.

6. MBES QC View: The QC View contains four configurable windows for real-time display of any of the following: 2D or 3D multibeam data, snippets, pseudo sidescan, or backscatter amplitude. In addition to this, it contains a surface sound speed utility that is configurable for real-time SV monitoring at the sonar head.

Applanix POS/MV V4 or V5 controller software was used to monitor the POS/MV systems. The software has various displays that allow the operator to check real-time position, attitude and heading accuracies, and GPS status. POS/MV configuration and calibration, when necessary, was also done using this program.

Fugro's PosMvLogger v2.0 was used to provide uninterrupted logging of all Inertial Motion Unit (IMU), dual frequency GPS, and diagnostic data. Additionally, the Delayed Heave data applied in post-processing was collected concurrently in the same file. The program also provided real-time QC and alarms for excessive HDOP, PDOP, and DGPS outages.

Fugro's MB Survey Tools v3.1.16 was used to aid in file administration and reporting during data acquisition. This program created a daily file that contained survey line, SVP, and static draft records. These logs were stored digitally in a database format and later used to create the log sheets in PDF format located in the Descriptive Report Separate 1.

CARIS Onboard was used to increase efficiency with the daily processing effort. This program ran during data acquisition; converting lines and applying SVP and Total Propagated Uncertainty (TPU) values. A daily DTM was also updated as each line was processed. The CARIS Onboard daily project was copied to the server at the end of each shift along with the raw data.

Fugro's Back2Base software is a package that facilitated the transfer of large data sets from the survey location to, on this project an Amazon cloud file server. Back2Base was used to send the daily CARIS Onboard projects to the file server where processing operations took place using Amazon Workspaces (AWS).

<u>MBES Processing</u>

All lines were converted with CARIS Onboard v1.4 during data acquisition.

All Soundings were processed using CARIS HIPS v9.1.9. HIPS converted the s7k files to HIPS format, corrected soundings for sound velocity, motion, tide, dynamic draft, and vessel offset, and was used to examine and reject noisy soundings. HIPS also produced the final Bathymetry Associated with Statistical Error (BASE) surfaces.

CARIS HIPS and SIPS v9.1.9 with Caris_Support_Files_5_7 was used to generate the S-57 Feature Files.

QPS FMGT v7.8.7 was used to create the multibeam backscatter mosaics.

ESRI ArcGIS v10.3 was used for survey planning, reviewing coverage plots, creating infills & crosslines, and creating graphics.

MB Survey Tools v3.1.16 was used to extract Delayed Heave from POS files and put data into a text format acceptable to the CARIS Generic Data Parser. This was only needed when the CARIS Load Delayed Heave routine in HIPS failed to import. MB Survey Tools v3.1.16 allowed processors to track changes and add comments while processing. MB Survey Tools was also used to process all sound velocity profiles and to convert them into a CARIS format.

A complete list of software and versions used on this project is included in Appendix I.

B – Quality Control

MBES

Error estimates for all MBES survey sensors were entered in the CARIS Hips Vessel File (HVF). Additionally, measured uncertainty values were applied to the data where possible. These measured values included delayed heave RMS from the raw POS/MV files, positioning and attitude uncertainties from the Applanix POSPac MMS RMS files, and calculated surface sound velocity values. These error estimates were used in CARIS to calculate the TPU at the 95% confidence level for the horizontal and vertical components of each individual sounding.

The values that were entered in the CARIS HVF for the survey sensors are the specified manufacturer accuracy values and were downloaded from the CARIS website **http://www.caris.com/tpu/**. The following is a breakdown and explanation on the manufacturer and Fugro derived values used in the error model:

- Navigation – A value of 0.10m was entered for the positional accuracy. This value was selected since all positions were post-processed, with X, Y, and standard deviation values better than 0.10m.
- Gyro/Heading – Vessel was equipped with a (POS/MV) 320 V4 or V5 and had a baseline < 4 m, therefore, a value of 0.020 was entered in the HVF as per manufacturer specifications.
- Heave – The heave percentage of amplitude was set to 5% and the Heave was set to 0.05m, as per manufacturer specifications.
- Pitch and Roll - As per the manufacturer accuracy values, both were set to 0.02 degrees.
- Timing – All data were time-stamped when created (not when logged) using a single clock/epoch (Pelagos Precise Timing method). Position, attitude (including True Heave), and heading were all time-stamped in the POS/MV. A ZDA+1 PPS string was also sent to the Reson 7125 processor, yielding timing accuracies on the order of 1 millisecond. Therefore, a timing error of 0.001 seconds was entered for all sensors on all vessels.
- All vessel and sensor offsets were derived via conventional survey techniques (total station), while the vessel was dry docked. The results yielded standard deviations of 0.005m to 0.010m, vessel and survey dependent.
- Vessel speed – set to 0.10m/s since a POS/MV with a 50 Hz output rate was in use.
- Loading – estimated vessel loading error set to 0.05m. This was the best estimate of how the measured static draft changed through the survey day.
- Draft – it was estimated that draft could be measured to within 0.01m to 0.03m.
- Tide error was dependent upon the VDatum model and the post processing of the raw POS M/V data using Applanix' s PP-RTX. The Tide Zoning value was provided by NOAA in the project instructions to be 0.101m. The Tide Measured was derived from the PP-RTX's solutions during the project and was calculated to be 0.100m.

- Sound Speed Values were determined in MB Survey Tools, via the SVP Statistics utility. This utility calculated the Mean, Variance, Standard Deviation, and Min/Max values at a user-specified depth interval. A separate value was also taken from the manufacturer's specifications.
- MRU Align Standard Deviation for the Gyro and Roll/Pitch were set to 0.10° since this is the estimated misalignment between the IMU and the vessel reference frame.

The calculated vertical and horizontal error or TPU values were then used to create finalized CUBE (Combined Uncertainty Bathymetry Estimator) surfaces; only soundings meeting or exceeding project accuracy specifications were included in this process.

An overview of the data processing flow follows:

During Acquisition the s7k files collected by WFMB were processed by CARIS Onboard. CARIS Onboard converted the s7k files, applied a predicted tide, SVP corrected, applied TPU values, and added lines to a daily CUBE surface. This whole process was automated and ran in the background during data collection.

Once the data arrived at the field office, a review was done to confirm all lines collected had been processed by CARIS Onboard. Once this was complete, both the Preliminary Tide and Delayed Heave data were applied to all lines.

The CARIS Onboard projects were then copied to Back2Base to be compressed and sent to cloud file server.

In order for the s7k files to be collected by WFMB and used by CARIS, they must be converted to HDCS format using the CARIS ResonPDS converter routine. Prior to the files being converted, vessel offsets, patch test calibration values, TPU values, and static draft were entered into the HVF.

Once converted, the Preliminary Tide, Dynamic Draft, and Delayed Heave data were loaded into each line and the line was SVP corrected in CARIS HIPS. Prior to sound speed correction, the dynamic draft was loaded into each line via the load Delta draft routine. The TPU was then computed for each sounding and attitude. Bathymetry data for each individual line were examined for noise as well as to ensure the completeness and correctness of the data set.

The data was filtered using a time nadir depth, beam numbers, and a Reson quality flag filter (Table 4). The times nadir depth filter rejected all soundings falling from a specified cross distance from nadir, which based on the nadir water depth. The beam numbers filter soundings based on a specified beam number that is entered in the field. The Reson quality flag filter rejected soundings based on the collinearity and brightness of each ping. Note that "rejected" does not mean the sounding was deleted – it was instead flagged as bad, so not be included in subsequent processing such as surface creation. Data flagged as rejected contained valid data but were flagged to remove noise and to speed the processing flow. Valid data were manually reaccepted into the data set occasionally during line and subset editing as required.

Table 4 Reson Quality Flags

Quality Flag	Brightness	Collinearity
0	Failed	Failed
1	Pass	Failed
2	Failed	Pass
3	Pass	Pass

Multiple CARIS filter files were used during the project. The most utilized filters are shown in Table 5. The processor selected the appropriate filter file based on a brief review of the data for environmental noise and bottom topography. Filter settings were sometimes modified based on data quality, but all filter settings used were noted on each corresponding line log found in the Descriptive Report Separate 1.

Table 5 CARIS Filter File Definitions

File name	X Nadir Depth	Beam Numbers	Quality Flag
4XWD_Beams400-600_01	4.0 times nadir depth	400-600	0&1
4.5XWD_Beams400-600_01	4.5 times nadir depth	400-600	0&1
5XWD_Beams400-600_01	5.0 times nadir depth	400-600	0&1

Because of the high accuracies realized from using post-processed SBET navigation data, there was no need to post-process any of the positioning data.

CUBE surfaces were then created at each required resolution for each priority area (Table 6). Each CUBE resolution surface was then finalized using the depth thresholds for that specific resolution. The finalized CUBE surfaces were used for subset cleaning so only the surface relating to the specific resolutions' depth range would be reviewed. CUBE parameters were derived from NOS HSSD April 2018. The following depth threshold and CUBE parameter settings were used on this project.

Table 6 CUBE Surface Parameters

Surface Resolution	Depth Range	IHO S-44 Specification	Surface Creation				Disambiguation			
			Estimate Offset	Capture Distance Scale	Capture Distance Minimum	Horizontal Error Scalar	Method	Density Strength Limit	Locale Strength Maximum	Locale Search Radius
1m	0-20m	Order 1a	4	0.50%	0.71m	1.96	Density & Local	2	2.5	1 pixel
2m	18-40m	Order 1a	4	0.50%	1.41m	1.96	Density & Local	2	2.5	1 pixel
4m	36-80m	Order 1a	4	0.50%	2.83m	1.96	Density & Local	2	2.5	1 pixel
8m	72-160m	Order 1a	4	0.50%	5.66m	1.96	Density & Local	2	2.5	1 pixel
16m	144-320m	Order 1a	4	0.50%	11.31m	1.96	Density & Local	2	2.5	1 pixel

Deviations from these thresholds, if any, are detailed in the appropriate Descriptive Report.

Subset Tiles (to track areas examined) were created in CARIS HIPS. Adjacent lines of data were examined to identify tidal busts, sound velocity and roll errors, as well as to reject any remaining noise in the data set that adversely affected the CUBE surface.

While examining the data in subset mode, soundings were designated wherever the CUBE surface did not adequately depict the shoalest point of a feature. Soundings were designated when they met or exceeded the criteria for designation set forth in the NOAA HSSD (2018). Designation ensured that soundings were carried through to the finalized BASE surface.

A statistical analysis of the sounding data was conducted via the CARIS Quality Control Report (QCR) routine. Crosslines were run in each survey and compared with CUBE surfaces created from the mainscheme lines. The IHO S-44 criteria for an Order 1a survey, as specified in the Project Letter, were used in the CARIS QCR comparison on a beam by beam basis. Quality Control results are found in Separate 4 of each survey's Descriptive Report directory.

Once multibeam data cleaning was completed, the cleaned data was imported into QPS FMGT v7.8.7 for backscatter processing, paired with the raw S7K files containing snippet time series intensity values from the 7028 record (T. Initial mosaics were generated for review to ensure each mosaic was a fair representation of the seafloor and any intensity deviations were examined. Once all mosaics had been created, final Floating Point GeoTIFF files were created in ArcGIS for each priority area.

Table 7 Backscatter Processing Parameters

Parameter	AVG	Mosaic Style	Processing Parameters	
			Adjust	Reson FM Waveform
Setting used	Flat	No Nadir – if possible	Tx/Rx Power Gain correction set to calibrated	Set to ensure correct pulse bandwidth

CARIS HIPS and SIPS v9.1.9 with Caris_Support_Files_5_7 was used to produce the S-57 final feature file (FFF).

Primary and secondary flagged features are correlated using the NOAA custom attributes prkyid (Primary Key ID).

Investigation methods and results are described in CARIS HIPS under the S-57 attributes acronym "remrks". Specific recommendations are described under the S-57 attributes acronym "recomd".

Features that do not exist or were determined to be a duplicate were given a "delete" value in the "descrp" attribute. Features that were positioned incorrectly were also given the "delete" value in the "descrp" attribute, and a new feature with a "new" value in the "descrp" attribute was added in its correct location. The "primsec" field was used to distinguish deleted features from newly positioned features. The TECSOU field was populated with the "found by multi-beam attribute" for any feature verified by multibeam.

VALSOU for features investigated using the multibeam data had their values taken from the appropriate BASE surface, which was then used to determine the VALSOU attribute using the depth on the actual features and not the depth of the corresponding assigned CSF features

Any shoreline data was submitted in the edited FFF in S-57 format (.000). The SORDAT and SORIND fields were filled in for any objects added or modified in the FFF.

C – Corrections to Soundings

Sound Velocity Profiles

Sound velocity casts were normally performed every two to three hours on the vessels. Two methods of sound velocity collection were utilized for this survey. Both vessels were equipped with two AML SV&P probes. When using this equipment, prior to each cast the probes were held at the surface for one to two minutes to achieve temperature equilibrium. The probes were then lowered and raised at a rate of 1 m/s. Between casts, the sound velocity sensors were stored in fresh water to minimize salt-water corrosion and to hold them at an ambient water temperature. Aboard the R/V Acadiana and M/V MacGinitie CTD casts were also collected using a Teledyne OceanScience Underway CTD. The UCTD was allowed to freefall for an amount of time relative to reaching the bottom and then reeled in to the ship. The CTD data was then converted to a sound velocity cast.

Fugro's MB Survey Tools software was used to check the profiles graphically for outliers or other anomalies, and to produce an SVP file compatible with CARIS HIPS. The WFMB acquisition package also provided QC for surface sound velocity. This was accomplished by creating a real-time plot from the sound velocity probe at the Reson sonar head and notifying the user (via a flashing warning message) if the head sound velocity differed by more than 5m/s from a defined reference sound velocity. This alarm was used as an indication that the frequency of casts may need to be increased. This reference sound velocity was determined by averaging 50 sound velocities produced at the head. The reference sound velocity was reset after each cast and also reset when a cast was performed due to a significant deviation from the reference sound velocity.

Refer to Appendix IV for SVP Calibration Reports.

Settlement Curves

Squat-settlement tests were not performed since this is an Ellipsoid Reference Survey.

Static Draft

Static draft was measured or read from a point on the pole to the IMU. The tables below show the static draft values measured for all vessels. Due to continuing survey operations, the tables for the M/V Pelagos and the M/V MacGinitie in this report may contain only a partial record of the total survey static draft values.

Table 8 Draft Measurements for the M/V Pelagos (Dual 7125)

DRAFT #	JULIAN DAY	DATE (UTC)	TIME (UTC)	DEPTH (m)
1	321	11/17/2018	14:34	-0.59
2	322	11/18/2018	15:49:00	-0.59
3	323	11/19/2018	14:00:00	-0.59
4	323	11/19/2018	15:49:11	-0.65
5	338	12/4/2018	14:55:15	-0.58
6	339	12/5/2018	16:39:17	-0.57
7	340	12/6/2018	15:30:39	-0.6
8	341	12/7/2018	14:12:54	-0.57
9	342	12/8/2018	15:36:46	-0.6
10	344	12/10/2018	15:01:46	-0.55
11	345	12/11/2018	15:57:44	-0.58
12	346	12/12/2018	2:44:31	-0.55
13	347	12/13/2018	3:21:40	-0.56
14	347	12/13/2018	13:52:53	-0.57
15	350	12/16/2018	13:50:48	-0.58
16	351	12/17/2018	4:56:53	-0.58
17	351	12/17/2018	14:40:36	-0.6
18	352	12/18/2018	3:04:12	-0.55
19	352	12/18/2018	14:59:17	-0.6
20	353	12/19/2018	14:46:01	-0.56
21	357	12/23/2018	14:05:52	-0.58
22	358	12/24/2018	14:41:34	-0.6
23	359	12/25/2018	12:02:00	-0.58
24	360	12/26/2018	14:46:45	-0.58
25	363	12/29/2018	13:24:13	-0.59
26	364	12/30/2018	13:59:06	-0.56
27	365	12/31/2018	14:35:39	-0.59
28	1	1/1/2019	14:01:04	-0.56
29	2	1/2/2019	15:11:37	-0.58
30	6	1/6/2019	12:50:00	-0.59
31	7	1/7/2019	18:11:55	-0.59
32	8	1/8/2019	11:55:28	-0.59
33	9	1/9/2019	15:12:21	-0.61
34	10	1/10/2019	17:21:35	-0.59
35	11	1/11/2019	14:30:57	-0.58
36	12	1/12/2019	15:00:14	-0.59
37	13	1/13/2019	20:43:12	-0.59
38	14	1/14/2019	15:30:48	-0.59

DRAFT #	JULIAN DAY	DATE (UTC)	TIME (UTC)	DEPTH (m)
39	15	1/15/2019	14:19:56	-0.59
40	16	1/16/2019	15:09:08	-0.59
41	17	1/17/2019	14:33:07	-0.6
42	18	1/18/2019	15:42:32	-0.59
43	19	1/19/2019	2:23:03	-0.58
44	21	1/21/2019	13:53:34	-0.59
45	22	1/22/2019	1:56:13	-0.6
46	25	1/25/2019	18:25:00	-0.59
47	26	1/26/2019	2:02:57	-0.58
48	26	1/26/2019	15:27:40	-0.59
49	27	1/27/2019	2:04:26	-0.57
50	27	1/27/2019	15:24:30	-0.59
51	28	1/28/2019	2:49:25	-0.57
52	28	1/28/2019	15:37:15	-0.59
53	29	1/29/2019	2:46:13	-0.57
54	31	1/31/2019	2:24:39	-0.59
55	32	2/1/2019	2:38:56	-0.58
56	33	2/2/2019	2:29:40	-0.57
57	33	2/2/2019	14:49:54	-0.59
58	34	2/3/2019	2:34:51	-0.57
59	34	2/3/2019	15:16:48	-0.6
60	35	2/4/2019	2:52:49	-0.55
61	35	2/4/2019	15:00:57	-0.6
62	36	2/5/2019	2:33:39	-0.55
63	36	2/5/2019	14:54:14	-0.6
64	37	2/6/2019	2:38:47	-0.55
65	37	2/6/2019	15:09:37	-0.6
66	38	2/7/2019	2:30:12	-0.55
67	38	2/7/2019	15:06:36	-0.6
68	39	2/8/2019	2:38:34	-0.55
69	39	2/8/2019	16:02:47	-0.6
70	41	2/10/2019	2:19:28	-0.55
71	41	2/10/2019	14:29:10	-0.6
72	42	2/11/2019	3:11:26	-0.55
73	42	2/11/2019	17:57:58	-0.6
74	43	2/12/2019	2:38:55	-0.55
75	43	2/12/2019	15:04:56	-0.6
76	45	2/14/2019	2:33:18	-0.55
77	45	2/14/2019	15:11:35	-0.6
78	46	2/15/2019	16:55:55	-0.55

DRAFT #	JULIAN DAY	DATE (UTC)	TIME (UTC)	DEPTH (m)
79	47	2/16/2019	1:55:59	-0.55
80	47	2/16/2019	14:56:35	-0.6
81	48	2/17/2019	2:22:28	-0.55
82	48	2/17/2019	15:11:42	-0.6
83	49	2/18/2019	2:35:35	-0.55
84	52	2/21/2019	2:59:00	-0.55
85	52	2/21/2019	15:22:53	-0.6
86	53	2/22/2019	2:44:10	-0.55
87	54	2/23/2019	2:03:59	-0.55
88	58	2/27/2019	2:57:32	0
89	58	2/27/2019	14:15:23	-0.6
90	59	2/28/2019	15:01:23	-0.6
91	60	3/1/2019	2:44:59	-0.55
92	60	3/1/2019	19:51:51	-0.6
93	61	3/2/2019	2:51:59	-0.55

Table 9 Draft Measurements for the R/V Acadiana (Dual 7125)

DRAFT #	JULIAN DAY	DATE (UTC)	TIME (UTC)	DEPTH (m)
1	231	8/19/2018	0:00	-1.17
2	233	8/21/2018	22:50:31	-1.23
3	233	8/21/2018	23:39:14	-1.23
4	236	8/24/2018	19:43:57	-1.26
5	237	8/25/2018	0:28:20	-1.26
6	238	8/26/2018	0:06:09	-1.23
7	239	8/27/2018	13:25:13	-1.21
8	241	8/29/2018	13:05:46	-1.14
9	241	8/29/2018	14:47:56	-1.28
10	243	8/31/2018	0:03:59	-1.26
11	246	9/3/2018	14:45:45	-1.25
12	251	9/8/2018	21:45:00	-1.26
13	256	9/13/2018	0:00:00	-1.31
14	260	9/17/2018	18:48:03	-1.2
15	261	9/18/2018	0:13:33	-1.29
16	263	9/20/2018	0:27:06	-1.21
17	264	9/21/2018	14:34:12	-1.22
18	264	9/21/2018	16:00:00	-1.31
19	270	9/27/2018	13:18:37	-1.14
20	275	10/2/2018	13:32:02	-1.18

DRAFT #	JULIAN DAY	DATE (UTC)	TIME (UTC)	DEPTH (m)
21	275	10/2/2018	22:21:00	-1.26
22	278	10/5/2018	13:09:09	-0.95
23	278	10/5/2018	20:30:00	-1.29
24	280	10/7/2018	23:55:46	-1.22

Table 8 Draft Measurements for the M/V MacGinitie (Dual 7125)

DRAFT #	JULIAN DAY	DATE (UTC)	TIME (UTC)	DEPTH (m)
1	73	3/14/2019	14:36:23	0.25
2	74	3/15/2019	13:12:34	0.25
3	75	3/16/2019	12:22:36	0.25
4	76	3/17/2019	12:31:06	0.25
5	77	3/18/2019	12:04:03	0.25
6	79	3/20/2019	13:00:00	0.25
7	81	3/22/2019	11:40:34	0.25
8	82	3/23/2019	12:47:15	0.25
9	83	3/24/2019	12:35:00	0.25
10	84	3/25/2019	12:30:12	0.25
11	85	3/26/2019	12:16:19	0.25
12	86	3/27/2019	13:35:50	0.25
13	87	3/28/2019	11:55:44	0.25
14	88	3/29/2019	12:45:39	0.25
15	89	3/30/2019	12:22:47	0.25
16	90	3/31/2019	12:25:22	0.25
17	91	4/1/2019	12:50:35	0.25
18	92	4/2/2019	12:45:55	0.25
19	93	4/3/2019	12:31:22	0.25

Tides

Multibeam vertical control for OPR-J359-KR-18 was provided by way of an Ellipsoidal Reference System which was reduced to MLLW using a separation model created with NOAA's VDatum v3.6.1

During field operations, M/V Pelagos, R/V Acadiana, and M/V MacGinitie sounding data were initially reduced to MLLW using preliminary tidal data from gauge 8728690 (Apalachicola, FL) and merged in CARIS HIPS. This station is owned and operated by NOAA's National Ocean Service (NOS) through the Center for Operational Oceanographic Products and Services (CO-OPS). Preliminary and verified tidal data was assembled by CO-OPS and accessed through NOAA's Tides&Currents website (***http://tidesandcurrents.noaa.gov/***). These unverified tides were used in the field for preliminary processing only.

Vessel GPS data was post-processed using the Applanix POSPac PP-RTX routine to create an SBET file. Following creation, the SBETs were then applied to the data in CARIS HIPS, replacing the real-time GPS navigation position with a post-processed GPS position. The separation model was created with NOAA's VDatum v3.6.1 and applied in CARIS HIPS using the GPS tide function to reduce the post processed ellipsoidal heights to MLLW.

VDatum reduced tidal data were used for all final CUBE Surfaces, soundings, and S-57 Feature files.

For additional information, refer OPR-J359-KR-18 HVCR.

Vessel Attitude: Heading, Heave, Pitch, and Roll

Vessel heading and dynamic motion were measured by the Applanix (POS/MV) V4 on M/V Pelagos and Applanix (POS/MV) V5 on the R/V Acadiana and M/V MacGinitie. The system calculated heading by inversing between two Trimble GPS-generated antenna positions. An accelerometer block (the IMU), which measured vessel attitude, was mounted directly above the multibeam transducer.

Calibrations

Multibeam

For all vessel and sonar configurations, patch tests were conducted to identify alignment errors (timing, pitch, heading, and roll) between the motion sensor and the multibeam transducer(s). Patch test calibration values used to correct all soundings for the survey are shown in Table 9.

Table 9 Patch Test Results Summary

Patch Test Results						
Vessel	**Patch Test Day**	**MB Sonar**	**Timing Error**	**Pitch Offset**	**Roll Offset**	**Azimuth Offset**
M/V Pelagos	2018-322	Port 7125 400 kHz	0.000	-1.300	14.650	2.500
	2018-322	Stbd 7125 400 kHz	0.000	-0.550	-16.710	2.500
R/V Acadiana	2018-232	Port 7125 400 kHz	0.000	-0.800	14.800	2.700
	2018-232	Stbd 7125 400 kHz	0.000	-0.550	-16.450	3.700
	2018-237	Port 7125 400 kHz	0.000	2.500	14.660	-0.500
	2018-237	Stbd 7125 400 kHz	0.000	1.800	-16.580	0.700
	2018-262	Port 7125 400 kHz	0.000	0.950	14.660	-0.280
	2018-262	Stbd 7125 400 kHz	0.000	1.180	-16.580	0.000
M/V MacGinitie	2019-073	Port 7125 400 kHz	0.000	2.700	14.430	-0.750
	2019-073	Stbd 7125 400 kHz	0.000	4.200	-14.410	0.500

Notes:

- Patch Test Day represents the Julian day the actual test was conducted. May be pre- or post-dated in CARIS HVF to cover lines run before or after patch test.

- Several CARIS HIPS Vessel files (HVF) were used throughout the project; some for calibration purposes (which include PORT or STBD in file name) and others for the project's main line scheme and crosslines. For example, the CARIS HVF named "1Acadiana_PORT_7125_7027_Record_400kHz" was used to compute the patch test results for the port 400kHz 7125 system on the R/V Acadiana using the 7027 bathy record. HVF "2Pelagos_PORT_7125_7027Record_400kHz" was used to compute the patch test results for the port 400kHz 7125 system on the M/V Pelagos using the 7027 bathy record.

- The Installations Parameters 7030 record was implemented into the acquisition workflow. The 7030 record is the installation parameter of the sonar, which includes the transmit and receiver offsets. Most of the information stored in the 7030 record is not used by CARIS. To fully utilize the 7027 record in a dual head setup, the 7030 record was essential and written to the raw s7k files during data collection. During the conversion process, if the 7030 record was present in the s7k file, CARIS wrote an "InstallationParameter.XML'' file to the line directory. The HVF was set up in such a way that the sonars' receiver offsets were input under SV1 (Port receiver offsets) and SV2 (STBD receiver offsets) and the transmitter offsets were read from the 7030 record by CARIS.

D – Approval Sheet

Approval Sheet

For

H13153, H13154, H13155, H13156, H13157, H13158, & F00766

As Chief of Party, Field operations for this hydrographic survey were conducted under my direct supervision, with frequent personal checks of progress and adequacy. I have reviewed the attached survey data and reports.

All field sheets, this Data Acquisition and Processing Report, and all accompanying records and data are approved. All records are forwarded for final review and processing to the Processing Branch.

The survey data meets or exceeds requirements as set forth in the NOS Hydrographic Surveys and Specifications Deliverables Manual, Standing and Letter Instructions, and all HSD Technical Directives. These data are adequate to supersede charted data in their common areas. This survey is complete, and no additional work is required.

Approved and forwarded,

Dean Moyles, (NSPS/THSOA Cert. No. 226)
Senior Hydrographer
Fugro Pelagos Inc.
April 5, 2019

X Moyles, Dean

Digitally signed by Moyles, Dean
DN: dc=com, dc=fugro, l=america, ou=fpi, ou=people_fpi, 0.9.2342.19200300.100.1.1=moylesd, cn=Moyles, Dean, email=dmoyles@fugro.com
Date: 2019.04.05 11:16:58 -02'30'

Dean Moyles (ACSM Cert. No. 226)
Senior Hydrographer

Appendix I – Vessel Reports

M/V Pelagos

The M/V Pelagos (Table 12 and Figure 2), is owned and operated by Fugro and accommodated a survey crew for day operations. Acquisition hardware includes dual Reson SeaBat 7125 multibeam sonars installed on an over-the-side pole mount. The Reson systems and IMU were installed on a special mounting plate, where each Reson 7125 was rotated approximately 15 degrees. The Reson systems were installed in their normal SV2 bracket which included an SV70 probe (located in the nose cone) and were attached to the mounting plate by a flange. The inertial measurement unit (IMU) for the POS/MV was an underwater unit that was installed directly above the Reson 7125s (Figure 3).

All 7125 multibeam data files were logged in the s7k format using WFMB v3.10.24 The bathy data from each Reson 7125 (records 7027) were stitched together in WFMB to create one s7k file with each ping containing 1024 beams.

Table 102 Vessel Specifications (M/V Pelagos**)**

SURVEY VESSEL M/V Pelagos	
Owner	Fugro
Official Number	N893565
Length	34’
Breadth	10’6”
Max Draft	2’
Generator	7.5kw Genset with 6 dual 110VAC outlets
Propulsión	Yamaha 350hp four-stroke outboard x 2
Fuel Capacity	300 Gallons

Figure 2 M/V Pelagos

Figure 3 M/V Pelagos Dual 7125 with Underwater IMU

Figure 4 M/V Pelagos Trimble L1/L2 Antennas

Two Trimble L1/L2 antennas were Port and Starboard on top the vessel. Offset 2.354 meters port-starboard from each other, the L1/L2 antennas provided GPS data to the POS/MV for position, attitude, and heading computations. The port side antenna functioned as the POS/MV master antenna, the starboard side antenna functioned as the POS/MV secondary (Figure 4).

The AML Smart probes were deployed by hand from the windward side of the vessel.

A draft measurement point was located on the pole. The draft measurement point being located so close to the CRP (IMU) and Reson 7125 allowed a precise static draft measurement.

Offset values for the CRP to the sonar and waterline were applied to the data in CARIS HIPS as specified in the HIPS vessel file (HVF). Offsets between the GPS antennas and the CRP were applied internally by the POS/MV by entering a GPS lever arm offset. Note that the HVF does not contain navigation offsets, because the position provided by the POS/MV is already corrected to the CRP. Vessel offsets used are shown in the offset diagram (Figure 5).

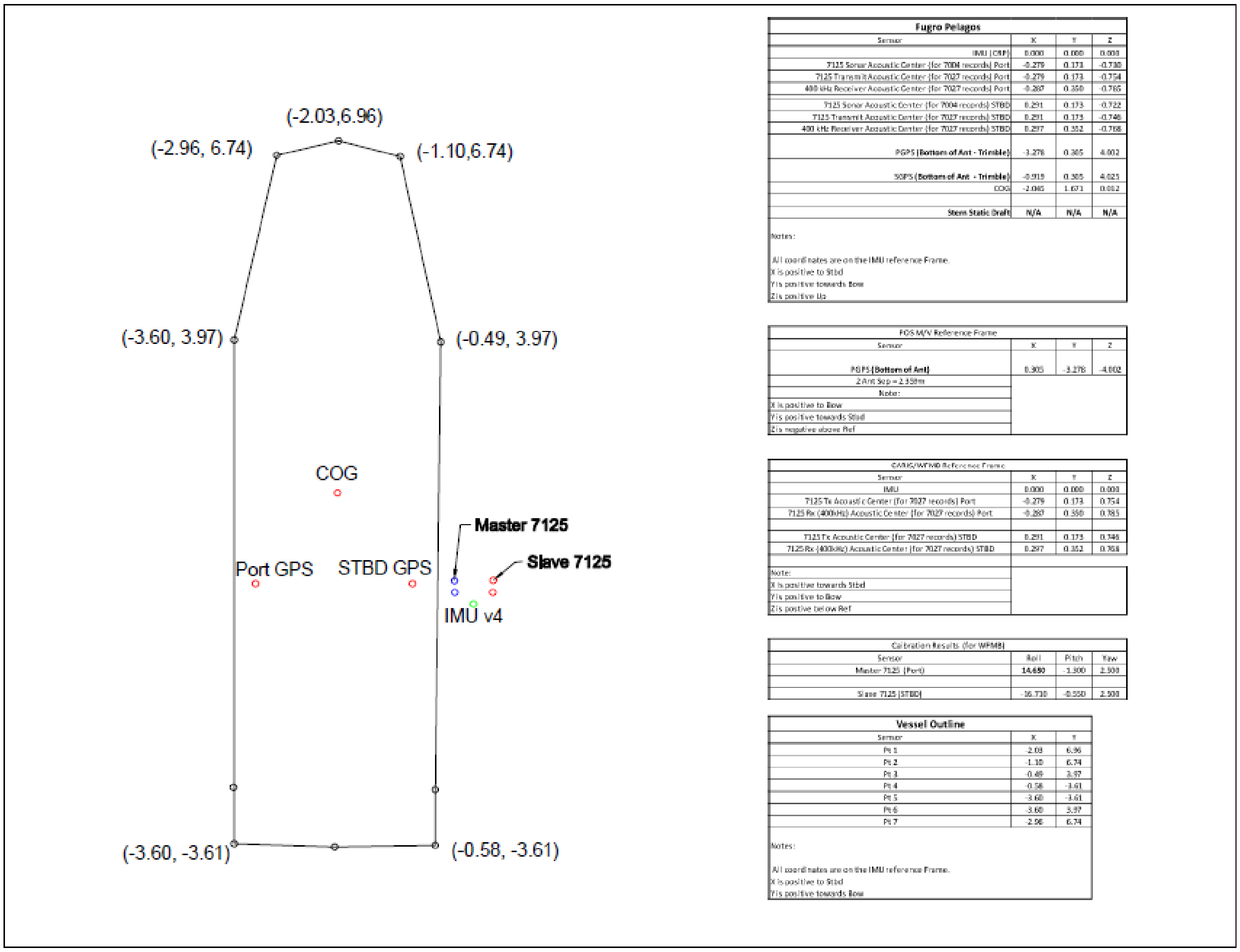


Figure 5 M/V Pelagos Offset Diagram

<u>R/V Acadiana</u>

The R/V Acadiana (Table 13 and Figure 6), owned and operated by LUMCON (Louisiana Universities Marine Consortium), accommodated a survey crew for multiple days. Acquisition hardware includes dual Reson SeaBat 7125 multibeam sonars installed on an over-the-side pole mount. The Reson systems and IMU were installed on a special mounting plate, where each Reson 7125 was rotated approximately 15 degrees. The Reson systems were installed in their normal SV2 bracket which included an SV70 probe (located in the nose cone) and were attached to the mounting plate by a flange. The inertial measurement unit (IMU) for the POS/MV was an underwater unit that was installed directly above the Reson 7125's (Figure 7).

All 7125 multibeam data files were logged in the s7k format using WFMB v3.10.24. The bathy data from each Reson 7125 (records 7004/7006, 7027) were stitched together in WFMB to create one s7k file with each ping containing 1024 beams.

Table 13 Vessel Specifications (R/V Acadiana)

SURVEY VESSEL R/V Acadiana	
Owner	LUMCON
Official Number	692280
Length	57’
Breadth	18’
Max Draft	4.5’
BHP Main Engines	3406 Caterpillar 650 hp x 2
Generator	Northern Lights 22 kw
Fresh Water Capacity	5-7 days capacity
Fuel Capacity	900 Gallons

Figure 6 R/V Acadiana

Figure 7 R/V Acadiana Dual 7125 with Underwater IMU

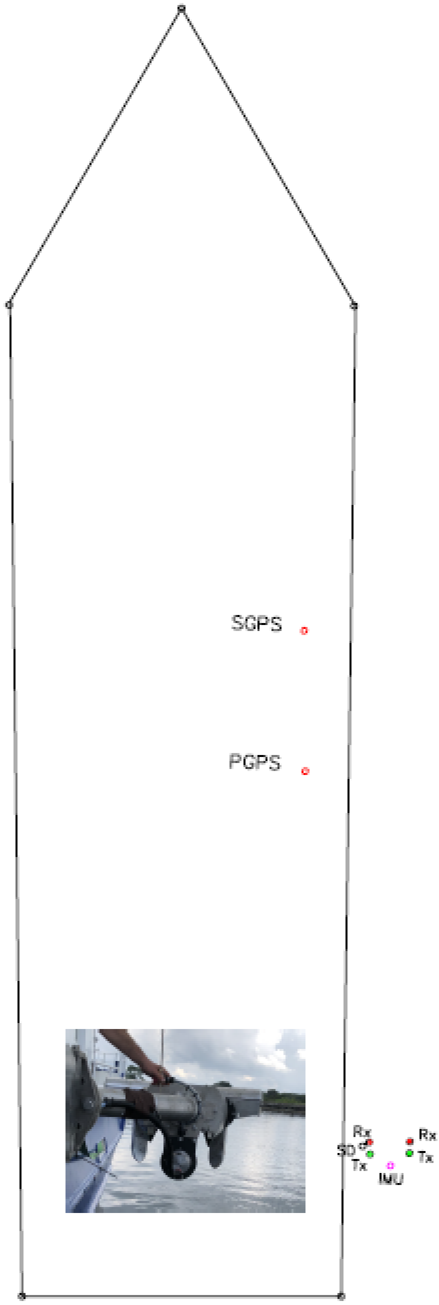
Two Trimble L1/L2 antennas were mounted above and forward from the sonar on the starboard side of the vessel. Offset 2.158 meters fore and aft from each other, the L1/L2 antennas provided

GPS data to the POS/MV for position, attitude, and heading computations. The aft antenna functioned as the POS/MV master antenna; the forward antenna functioned as the POS/MV secondary.

The AML Smart probes were deployed from the stern using a hydraulic winch.

A Draft measurement point was located on the over-the-side pole. The Draft measurement point being located so close to the CRP (IMU) and Reson 7125 allowed a precise static draft measurement.

Offset values for the CRP to the sonar and waterline were applied to the data in CARIS HIPS as specified in the HIPS vessel file (HVF). Offsets between the GPS antennas and the CRP were applied internally by the POS/MV by entering a GPS lever arm offset. The HVF does not contain navigation offsets, because the position provided by the POS/MV is already corrected to the CRP. Vessel offsets used are shown in the offset diagram (Figure 8).



Acadiana POS V5			
Sensor	X	Y	Z
IMU (CRP)	0.000	0.000	0.000
7125 Sonar Acoustic Center (for 7004 records) Port	-0.310	0.176	-0.698
7125 Transmit Acoustic Center (for 7027 records) Port	-0.310	0.178	-0.671
400 kHz Receiver Acoustic Center (for 7027 records) Port	-0.310	0.355	-0.695
200 kHz Receiver Acoustic Center (for 7027 records) Port	-0.310	0.374	-0.695
7125 Sonar Acoustic Center (for 7004 records) STBD	0.291	0.190	-0.698
7125 Transmit Acoustic Center (for 7027 records) STBD	0.291	0.190	-0.671
400 kHz Receiver Acoustic Center (for 7027 records) STBD	0.291	0.369	-0.695
200 kHz Receiver Acoustic Center (for 7027 records) STBD	0.291	0.388	-0.695
PGPS (Phase Center - Trimble)	-1.301	6.021	5.708
SGPS (Phase Center - Trimble)	-1.312	8.176	5.764
Stern Static Draft	**-0.425**	**0.296**	**3.680**

Notes:

All coordinates are on the IMU reference Frame.
X is positive to Stbd
Y is positive towards Bow
Z is positive Up

POS M/V Reference Frame			
Sensor	X	Y	Z
PGPS (Phase Center)	6.021	-1.301	-5.708
2 Ant Sep = ?????m			
Note:			
X is positive to Bow			
Y is positive towards Stbd			
Z is negative above Ref			

CARIS/WFMB Reference Frame			
Sensor	X	Y	Z
IMU	0.000	0.000	0.000
7125 Tx Acoustic Center (for 7027 records) Port	-0.310	0.176	0.671
7125 Rx (400kHz) Acoustic Center (for 7027 records) Port	-0.310	0.355	0.695
7125 Tx Acoustic Center (for 7027 records) STBD	0.291	0.190	0.671
7125 Rx (400kHz) Acoustic Center (for 7027 records) STBD	0.291	0.369	0.695
Note:			
X is positive towards Stbd			
Y is positive to Bow			
Z is postive below Ref			

Calibration Results (for WFMB)			
Sensor	**Roll**	Pitch	Yaw
Master 7125 (Port)	**Varies**	**Varies**	**Varies**
Slave 7125 (STBD)	**Varies**	**Varies**	**Varies**

Vessel Outline		
Sensor	X	Y
Pt 1	-5.63	-2.00
Pt 2	-5.83	13.15
Pt 3	-3.19	17.68
Pt 4	-0.55	13.13
Pt 5	-0.75	-2.00

Notes:

All coordinates are on the IMU reference Frame.
X is positive to Stbd
Y is positive towards Bow

Figure 8 R/V Acadiana Offset Diagram

M/V MacGinitie

The M/V MacGinitie (Figure 9 and Table 14**),** is owned and operated by Fugro and accommodated a survey crew for day operations. Acquisition hardware includes dual Reson SeaBat 7125 multibeam sonars installed on an over-the-bow pole mount. The Reson systems and IMU were installed on a special mounting plate, where each Reson 7125 was rotated approximately 15 degrees. The Reson systems were installed in their normal SV2 bracket which included an SV70 probe (located in the nose cone) and were attached to the mounting plate by a flange. The inertial measurement unit (IMU) for the POS/MV was an underwater unit that was installed directly above the Reson 7125s (Figure 10).

All 7125 multibeam data files were logged in the s7k format using WFMB v3.10.24 The bathy data from each Reson 7125 (records 7027) were stitched together in WFMB to create one s7k file with each ping containing 1024 beams.

Figure 9 M/V MacGinitie

Table 14 Vessel Specifications (M/V MacGinitie)

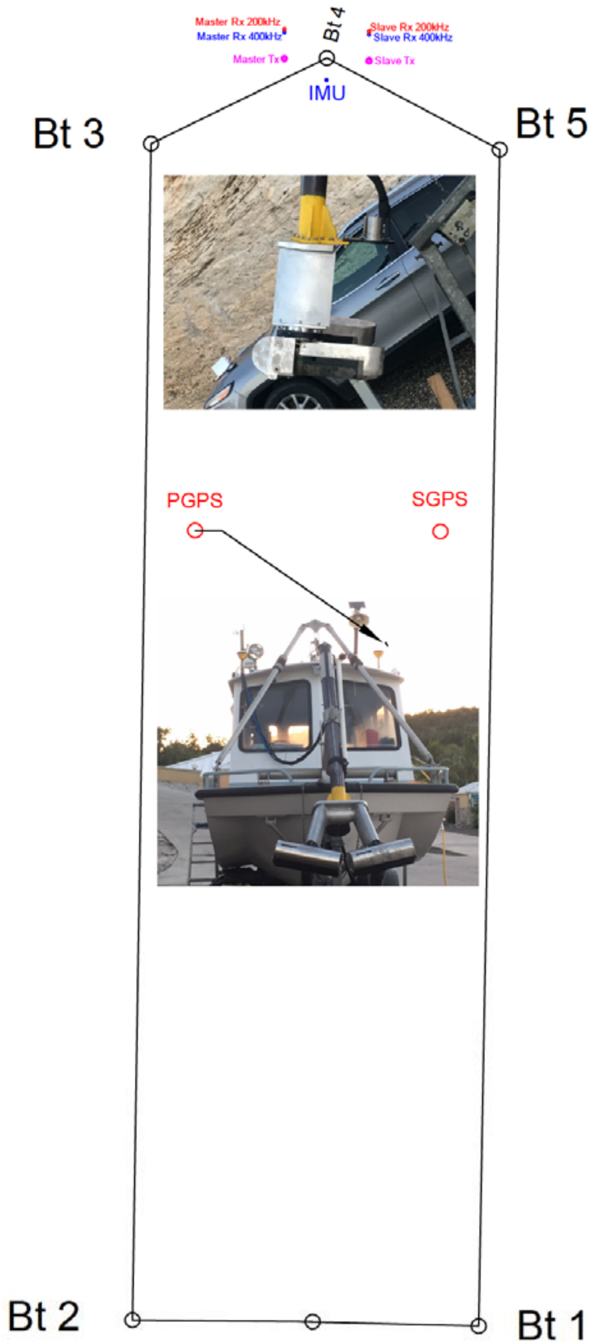
SURVEY VESSEL M/V MacGinitie	
Owner	Fugro
Hull Number	SAMA1083J999
Official Number	CF 8836 XS
Length	32’
Breadth	8’3”
Max Draft	1.5’
Electrical Power	30A 110VAC; 12V DC
Propulsión	Yamaha 130hp four-stroke outboard x 2
Fuel Capacity	100 Gallons

Two Trimble L1/L2 antennas were Port and Starboard on top the vessel. Offset 1.665 meters port-starboard from each other, the L1/L2 antennas provided GPS data to the POS/MV for position, attitude, and heading computations. The port side antenna functioned as the POS/MV master antenna, the starboard side antenna functioned as the POS/MV secondary.

The AML Smart probes were deployed from the stern using a hydraulic winch.

A Draft measurement point was located on the pole. The Draft measurement point being located so close to the CRP (IMU) and Reson 7125 allowed us to obtain a precise static draft measurement.

Offset values for the CRP to the sonar and waterline were applied to the data in CARIS HIPS as specified in the HIPS vessel file (HVF). Offsets between the GPS antennas and the CRP were applied internally by the POS/MV by entering a GPS lever arm offset. Note that the HVF does not contain navigation offsets, because the position provided by the POS/MV is already corrected to the CRP. Vessel offsets used are shown in the offset diagram (Figure 10).



MacGinitie			
Sensor	X	Y	Z
IMU (CRP)	0.000	0.000	0.000
7125 Sonar Acoustic Center (for 7004 records) Port	-0.283	0.147	-0.698
7125 Transmit Acoustic Center (for 7027 records) Port	-0.283	0.148	-0.674
400 kHz Receiver Acoustic Center (for 7027 records) Port	-0.283	0.327	-0.698
200 kHz Receiver Acoustic Center (for 7027 records) Port	-0.283	0.345	-0.698
7125 Sonar Acoustic Center (for 7004 records) STBD	0.291	0.133	-0.698
7125 Transmit Acoustic Center (for 7027 records) STBD	0.291	0.132	-0.674
400 kHz Receiver Acoustic Center (for 7027 records) STBD	0.291	0.311	-0.698
200 kHz Receiver Acoustic Center (for 7027 records) STBD	0.291	0.331	-0.698
PGPS (Phase Center - Trimble)	-0.889	-3.058	2.656
SGPS (Phase Center - Trimble)	0.775	-3.062	2.676
Stem Static Draft	**N/A**	**N/A**	**N/A**

Notes:

All coordinates are on the IMU reference Frame.
X is positive to Stbd
Y is positive towards Bow
Z is positive Up

POS M/V Reference Frame			
Sensor	X	Y	Z
PGPS (Phase Center)	-3.058	-0.889	-2.656
2 Ant Sep = 1.665m			
Note:			
X is positive to Bow			
Y is positive towards Stbd			
Z is negative above Ref			

CARIS/WFMB Reference Frame			
Sensor	X	Y	Z
IMU	0.000	0.000	0.000
7125 Tx Acoustic Center (for 7027 records) Port	-0.283	0.148	0.674
7125 Rx (400kHz) Acoustic Center (for 7027 records) Port	-0.283	0.327	0.698
7125 Tx Acoustic Center (for 7027 records) STBD	0.291	0.132	0.674
7125 Rx (400kHz) Acoustic Center (for 7027 records) STBD	0.291	0.311	0.698
Note:			
X is positive towards Stbd			
Y is positive to Bow			
Z is postive below Ref			

Calibration Results (for WFMB)			
Sensor	Roll	Pitch	Yaw
Master 7125 (Port)	14.440	1.140	-1.110
Slave 7125 (STBD)	-14.670	2.620	0.150

MacGinitie Vessel Outline		
Sensor	X	Y
Pt 1	1.03	-8.45
Pt 2	-1.31	-8.41
Pt 3	-1.19	-0.43
Pt 4	0.00	0.15
Pt 5	1.18	-0.47

Notes:

All coordinates are on the IMU reference Frame.
X is positive to Stbd
Y is positive towards Bow

Figure 10 M/V MacGinitie Offset Diagram

Equipment

Table 11 M/V Pelagos Acquisition Equipment

Description	Serial Number
Applanix IMU Type 27	64
Applanix POS/MV Processor L1/L2 (RTK)	2151
GPS Antenna L1/L2 (Primary)	1441043383
GPS Antenna L1/L2 (Secondary)	30212717
Omnistar Antenna 1	141419780
Omnistar Antenna 2	141422714
Reson NAVISOUND SVP 70 (Primary)	4506001
Reson NAVISOUND SVP 70 (Spare)	2007073
Reson 71-P Processor-7125 SV2 (FP3)	18341114131
Reson 71-P Processor-7125 SV2 (FP3)	18340313024
Reson SeaBat 7125 400kHz/200Khz Projector	1012060
Reson SeaBat 7125 400kHz/200Khz Projector	0513044
Reson SeaBat 7125 Receive Array	1912119
Reson SeaBat 7125 Receive Array	4016013
Fugro Acquisition PC	BGR 602488
UPC	BGR 602604
WinFrog Multibeam Dongle	BGR602948
AML SV Plus Velocity Probe	5283
AML SV Plus Velocity Probe	5353

Table 12 R/V Acadiana Acquisition Equipment

Description	Serial Number
Applanix IMU Type 65	2905
Applanix POS/MV Processor L1/L2 (RTK)	5125
GPS Antenna L1/L2 (Primary)	1441043383
GPS Antenna L1/L2 (Secondary)	30212717
Omnistar Antenna 1	141419780
Omnistar Antenna 2	141422714
Reson NAVISOUND SVP 70 (Primary)	1008130
Reson NAVISOUND SVP 70 (Spare)	2007073
Reson 71-P Processor-7125 SV2 (FP3)	18341114131
Reson 71-P Processor-7125 SV2 (FP3)	18340313024
Reson SeaBat 7125 400kHz/200Khz Projector	1012060
Reson SeaBat 7125 400kHz/200Khz Projector	0513044
Reson SeaBat 7125 Receive Array	1912119
Reson SeaBat 7125 Receive Array	4016013
Fugro Acquisition PC	BGR 602488
WinFrog Multibeam Dongle	BGR602948
AML SV Plus Velocity Probe	5283

Description	Serial Number
AML SV Plus Velocity Probe	5353
Teledyne Oceanscience UCTD	0132
Teledyne Oceanscience UCTD	0134

Table 13 M/V MacGinitie Acquisition Equipment

Description	Serial Number
Applanix IMU Type 65	2905
Applanix POS/MV Processor L1/L2 (RTK)	5125
GPS Antenna L1/L2 (Primary)	604066
GPS Antenna L1/L2 (Secondary)	604065
Omnistar Antenna 1	141419780
Omnistar Antenna 2	141422714
Reson NAVISOUND SVP 70	2008033
Reson NAVISOUND SVP 70 (Spare)	2008047
Reson 71-P Processor-7125 SV2 (FP3)	603355
Reson 71-P Processor-7125 SV2 (FP3)	18341315183
Reson SeaBat 7125 400kHz/200Khz Projector	4010147
Reson SeaBat 7125 400kHz/200Khz Projector	1612100
Reson SeaBat 7125 Receive Array	2709022
Reson SeaBat 7125 Receive Array	4117067
Fugro Acquisition PC	BGR 602604
WinFrog Multibeam Dongle	BGR602753
AML SV Plus Velocity Probe	121772
AML SV Plus Velocity Probe	602401

Software

Table 14 MBES Software List (Acquisition & Processing Center)

Software Package	Version	Service Pack	Hotfix
Fugro WinFrog Multibeam	3.10.24	N/A	N/A
Fugro MB Survey Tools	3.1.16	N/A	N/A
Fugro POSMVLogger	2	N/A	N/A
CARIS HIPS/SIPS	9.1.9	N/A	N/A
CARIS Notebook	3.1	1	2
CARIS Bathy DataBASE	4.1.17	N/A	N/A
CARIS Onboard	1.4	N/A	N/A
CARIS Easy View	4.1.16	N/A	N/A
ESRI ArcGIS	10.3	10.3	N/A
Applanix POS/MV V4 Controller	9.9.1	N/A	N/A
Applanix POS/MV V5 Controller	8.46 & 9.95	N/A	N/A
Nobeltec Tides and Currents	3.5.107	N/A	N/A

Software Package	Version	Service Pack	Hotfix
Microsoft Office	2013	N/A	N/A
Microsoft Windows (64-bit)	7 Enterprise	1	N/A
Helios Software Solutions TextPad	5.2.0	N/A	N/A
NOAA Extended Attribute Files	5.7	N/A	N/A
IrfanView	4.25	N/A	N/A
QPS FMGT	7.8.7	N/A	N/A

Appendix II – Echosounder Reports

Multibeam Echosounder Calibration

A patch test was completed for the MBES using seafloor topology for data to be corrected for navigation timing, pitch, azimuth, and roll offsets, which may exist between the MBES transducer and the Motion Reference Unit (MRU).

Patch tests were performed independently on each sonar and were run at various stages of survey operations to calibrate the MBES and MRU for different vessel configurations.

No adjustment was required for navigation timing error. Fugro has implemented a specific timing protocol for multibeam data acquisition. In this method, UTC time tags generated within the POS/MV are applied to all position, heading, and attitude data. The POS/MV ZDA+1 PPS (pulse per second) string is also sent to the Reson SeaBat sonar system, where the ping data are tagged. The architecture of the POS/MV ensures that there is zero latency between the position, heading, and attitude strings. The only latency possible is in the ping time. In addition, the navigation-to-ping latency will be identical to the attitude-to-ping and heading-to-ping latencies.

Navigation latency is generally difficult to measure using standard timing and patch testing techniques. However, using Fugro's timing protocol, the navigation latency will be the same as the roll latency. Fortunately, roll latencies are very easy to identify. Data with a roll timing latency will have a rippled appearance along the edge of the swath. During patch test analysis, the roll latency is adjusted until the ripple is gone. This latency value is then applied to the ping time, synchronizing it with the position, attitude, and heading data.

The pitch error adjustment was performed on sets of two coincident lines, run at the same velocity, over a conspicuous object, in opposite directions. The nadir beams from each line were compared and brought into alignment, by adjusting the pitch error value.

The azimuth error adjustment was performed on sets of two lines, run over a conspicuous topographic feature. Lines were run in opposite directions, at the same velocity with the same outer beams crossing the feature. Since the pitch error has already been identified, data from the same outer beams for each line were compared and brought into alignment, by adjusting the azimuth error value.

The roll error adjustment was performed on sets of two coincident lines, run over flat terrain, at the same velocity, in opposite directions. The pitch error and azimuth error were already identified. Data across a swath were compared for each line and brought into agreement by adjusting the roll error value.

Patch test data were then corrected using the identified values, and the process repeated to check their validity. Patch test values were obtained in CARIS HIPS calibration mode. Calculated values were then entered into the HVF (Table 19) so that data could be corrected during routine processing.

Multibeam Echosounder Calibration Results

Table 1915 Patch Test Results for Each Vessel

Patch Test Results						
Vessel	**Patch Test Day**	**MB Sonar**	**Timing Error**	**Pitch Offset**	**Roll Offset**	**Azimuth Offset**
M/V Pelagos	2018-322	Port 7125 400 kHz	0.000	-1.300	14.650	2.500
	2018-322	Stbd 7125 400 kHz	0.000	-0.550	-16.710	2.500
R/V Acadiana	2018-232	Port 7125 400 kHz	0.000	-0.800	14.800	2.700
	2018-232	Stbd 7125 400 kHz	0.000	-0.550	-16.450	3.700
	2018-237	Port 7125 400 kHz	0.000	2.500	14.660	-0.500
	2018-237	Stbd 7125 400 kHz	0.000	1.800	-16.580	0.700
	2018-262	Port 7125 400 kHz	0.000	0.950	14.660	-0.280
	2018-262	Stbd 7125 400 kHz	0.000	1.180	-16.580	0.000
M/V MacGinitie	2019-073	Port 7125 400kHz	0.000	2.700	14.530	-0.750
	2019-073	Stbd 7125 400kHz	0.000	4.200	-14.480	0.500

Notes:

- Patch Test Day represents the Julian day the actual test was conducted. May be pre- or post-dated in CARIS HVF to cover lines run before or after patch test.

- Several CARIS HIPS Vessel (HVF) files were used throughout the project; some for calibration purposes (which include PORT or STBD in file name) and others for the project's main line scheme and crosslines. For example, the CARIS HVF named "1Acadiana_PORT_7125_7027_Record_400kHz" was used to compute the patch test results for the port 400kHz 7125 system on the R/V Acadiana using the 7027 bathy record. HVF "2Pelagos_PORT_7125_7027Record_400kHz" was used to compute the patch test results for the port 400kHz 7125 system on the M/V Pelagos using the 7027 bathy record.

- The 7030 record was implemented into the acquisition workflow. The 7030 record is the installation parameters of the sonar, which include the transmit and receiver offsets. Most of the information stored in the 7030 record is not used by CARIS. To fully utilize the 7027 record in a dual head setup, the 7030 record was essential and written to the raw s7k files during data collection. During the conversion process, if the 7030 record was present in the s7k file, CARIS wrote an "InstallationParameter.XML'' file to the line directory. The HVF was set up in such a way that the sonars' receiver offsets were input under SV1 (Port receiver offsets) and SV2 (STBD receiver offsets) and the transmitter offsets were read from the 7030 record by CARIS. Any HVF with Dual in its name is using the 7027/7030 records. For example, "1Acadiana_Dual_7125_7027_Record_400kHz" is for the dual 400kHz 7125 systems on the R/V Acadiana using the 7027 bathy record and the 7030 installation parameters record.

Multibeam Bar Check

A bar check calibration of multibeam sonar systems is performed to accurately relate observed (recorded) depths to the true depth of water. Therefore, the calibration determines any error in the system's raw depth readings (as well as verifying the accuracy of the vessel offset survey).

A bar check calibration is performed by lowering a horizontal metal plate to a known depth below the waterline. Then, data at that known depth is acquired using the multibeam sonar system and processed using the CARIS HIPS and SIPS Swath Editor routine.

By processing the data in the CARIS Swath Editor routine, the vessel's equipment offsets measured during the offset survey, the sound velocity profile taken at the time of the bar check, the survey's static draft measurement procedure, and the data cleaning routine used during the survey are all applied to the data to calculate the difference between the sonar's measurement of the horizontal bar and the actual, known depth below the waterline.

Any difference in the measured depth versus the known depth can be attributed to error in the sound velocity profile, the static draft measurement procedure, the vessel offset survey, and/or the sonar system's internal capabilities.

Bar check calibrations were completed as follows: 19 August 2018 for the R/V Acadiana, 11 March 2019 for the M/V Pelagos, and 13 March 2019 for the M/V MacGinitie.

Prior to performing the bar check calibrations, accurate static draft measurements were performed. Then, a flat, metal plate was lowered to a specific depth below the waterline, using lowering lines of metal chain on both sides to have the plate horizontal.

The Reson 7125 systems were energized and data was acquired to measure the plate's depth. During data acquisition, the vessels' navigation and motion sensors, a POS/MV (v. 4) on the M/V Pelagos and POS/MV (v. 5) on the Acadiana and MacGinitie were also energized to record the vessels' attitude in the water at the time of measurement. Data were acquired for a period of 1-2 minutes to provide data samples large enough to calculate an average observed depth for each system.

An SVP cast was performed to create sound velocity profiles of the water column in the vicinity of the vessels.

The data was then processed in CARIS HIPS to reduce the observed depths to the waterline and compare them to the known depths of the horizontal plate. The processing procedure that was followed, parallels the standard data processing procedures as detailed in the report of survey. The static draft measurement, the vessel equipment offsets, the vessel attitude data, and the sound velocity corrections were all applied to the raw depth observations.

The data were then further processed in the CARIS HIPS Swath Editor routine.

The acquired observed plate's depths were exported from CARIS to Microsoft Excel to calculate an average observed depth over a 1-minute period for each system. The results of the bar check calibrations are detailed below.

Multibeam Bar Check Results

M/V Pelagos Reson 7125 (2m Bar Depth)

The image below (Figure 11) shows a CARIS HIPS Swath Editor display screen with the horizontal plate ensonified at a depth of 3.0 meters below the waterline (the value of 2.94 meters is the average depth calculated over a 1-minute period of data acquisition).

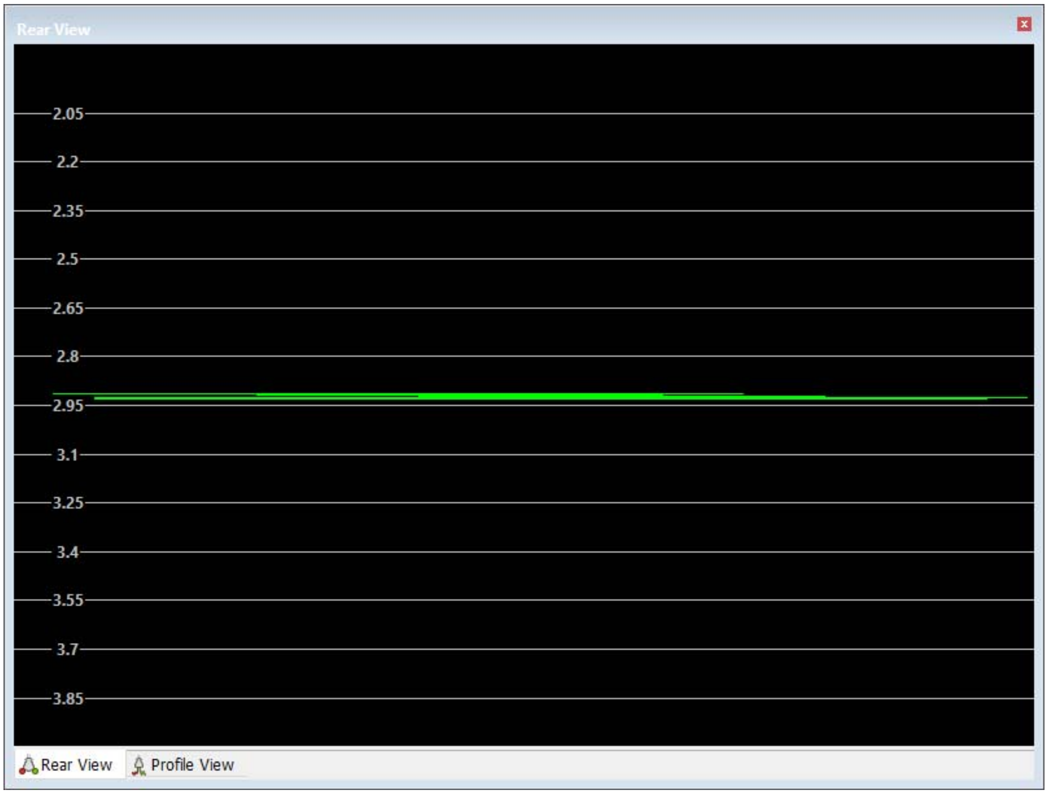


Figure 11 M/V Pelagos 3m Bar Check Showing the Bar Relative to Seafloor

R/V Acadiana Reson 7125 (3m Bar Depth)

The image below (Figure 12) shows a CARIS HIPS Swath Editor display screen with the horizontal plate ensonified at a depth of 3.0 meters below the waterline (the value of 2.98 meters is the average depth calculated over a 1-minute period of data acquisition).

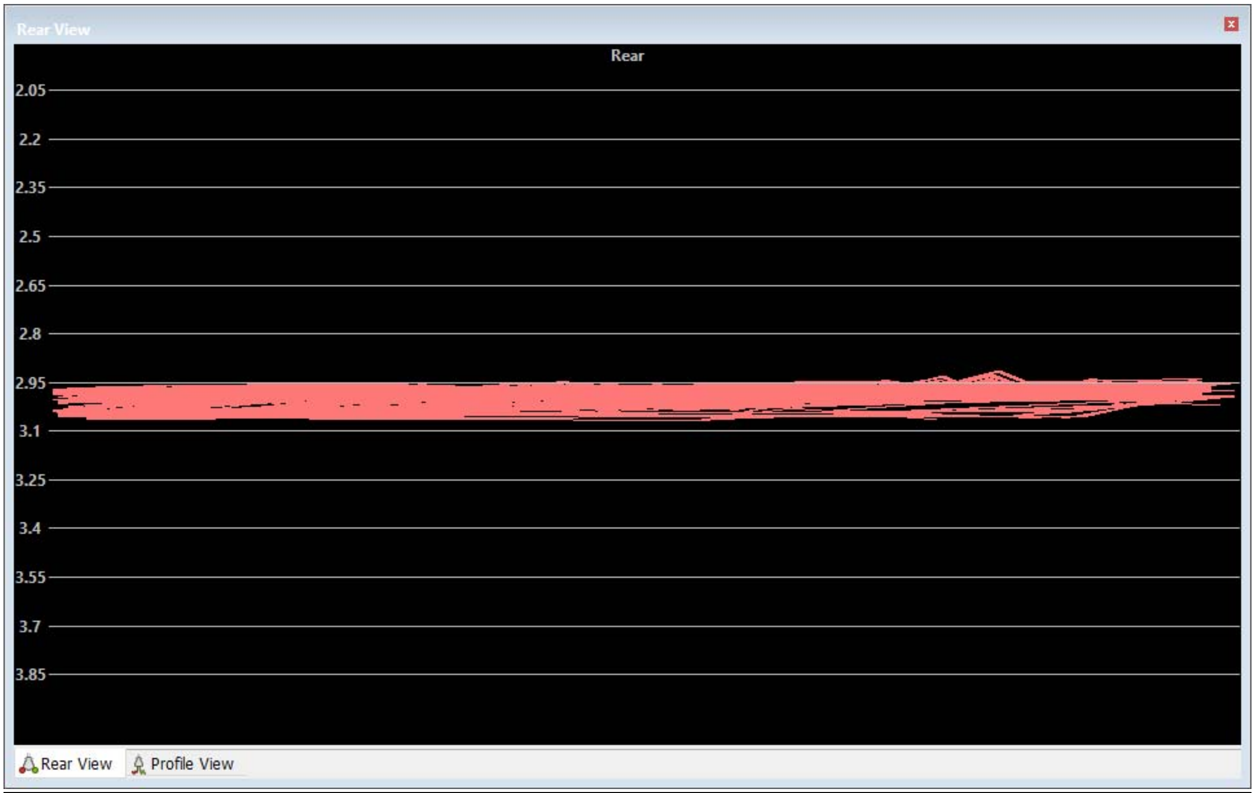


Figure 12 R/V Acadiana 3m Bar Check Showing the Bar Relative to Seafloor

M/V MacGinitie Reson 7125 (3m Bar Depth)

The image below (Figure 13) shows a CARIS HIPS Swath Editor display screen with the horizontal plate ensonified at a depth of 2.0 meters below the waterline (the value of 1.98 meters is the average depth calculated over a 1-minute period of data acquisition).

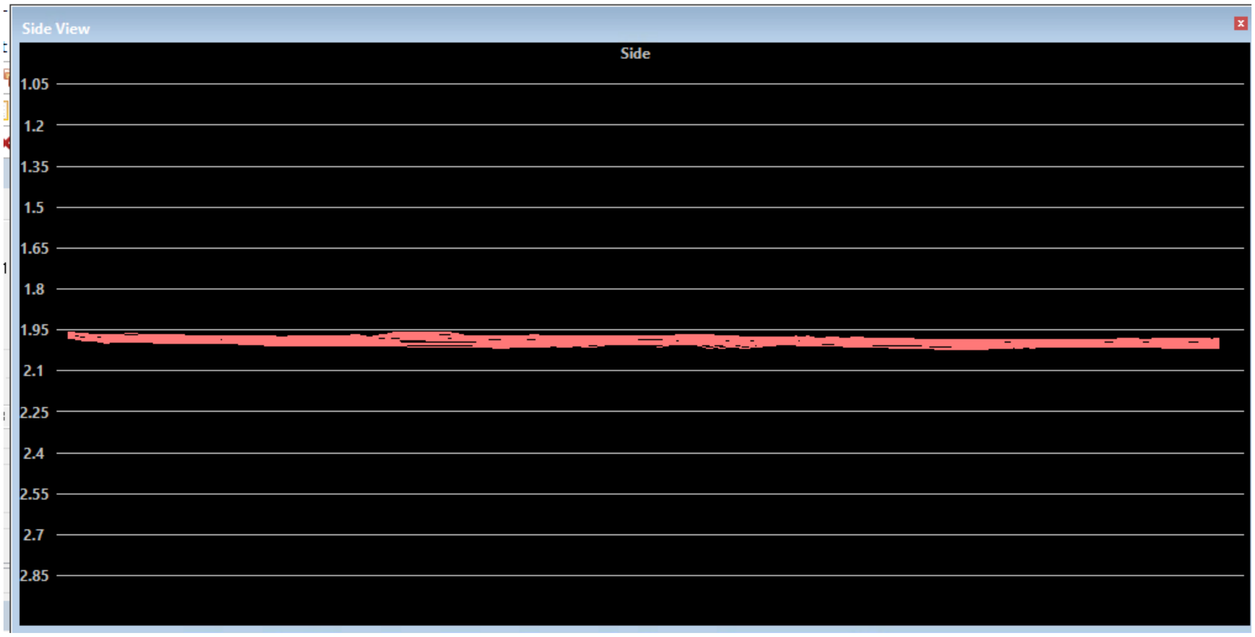


Figure 13 M/V MacGinitie 2m Bar Check Showing the Bar Relative to Seafloor

Multibeam Confidence Checks

Sonar system confidence checks, as outlined in Section 5.2.3.1 of the HSSD, were performed by comparing post processed depth information collected over a common area by each vessel. The confidence check results are outlined in Table 20 below. In addition to this, checks were performed on overlapping main scheme and crossline data collected from different vessels on different days. Due to the interruption of the survey by Hurricane Michael a direct comparison between the R/V Acadiana and the M/V Pelagos was not collected.

Multibeam Confidence Check Results

Table 16 Confidence Check Results

Surface Vessels	Mean Difference (m)	Standard Deviation (m)
Pelagos vs. Acadiana	0.04	0.05
Acadiana vs. LiDAR	+/-0.1	+/-0.3

The above results were computed from difference surfaces that were created from overlapping data collected by the M/V Pelagos and the R/V Acadiana during field operations. See Table 16 and Figure 14. The same or better results were noticed in additional checks that were performed using crossline data.

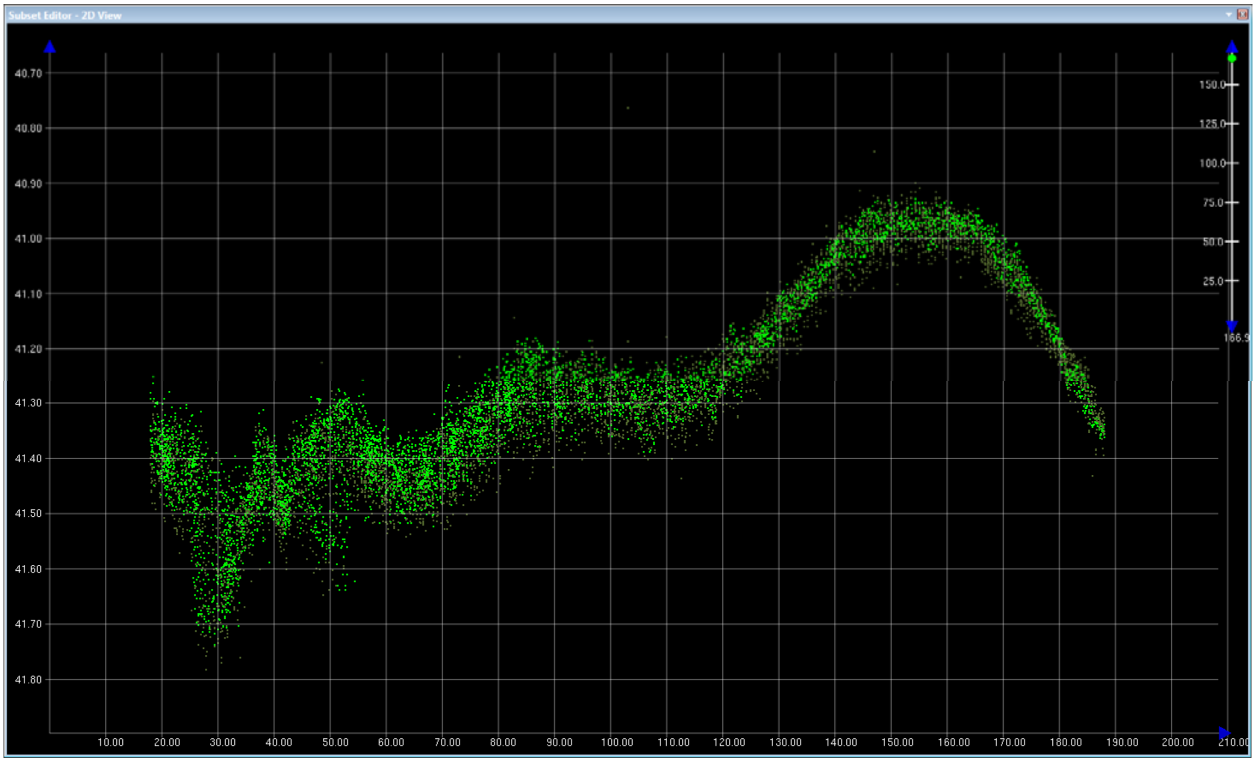


Figure 14 Pelagos vs Acadiana Comparison

Appendix III – Positioning and Attitude System Reports

GAMS Calibration

Vessel headings are measured by the Applanix POS/MV V4/V5, by way of a GPS Azimuth Measurement Subsystem (GAMS). GAMS computes a carrier-phase differential GPS position solution of a Slave antenna with respect to a Master antenna position, thereby computing the heading between the two. In order for this subsystem to provide a heading accuracy of 0.01º, the system needs to know and resolve the spatial relationship between the two antennas. During the GAMS calibration, since the offset from the IMU to the Master antenna is known (from the vessel offset survey), the location of the Slave antenna is calculated by computing the baseline between the two antennas with respect to the IMU axes.

To calibrate the heading data received from the POS/MV GAMS subsystem, the POS Viewer software is used to run the GAMS Calibration routine. First, an accurate and precise separation distance between the two GNSS antennas is entered into the POS Viewer's GAMS Parameter Setup window. Once this known offset is entered into the system, the vessel begins maneuvering with turns to port and starboard (preferably figure-eight maneuvers) to allow the system to refine its heading accuracy.

Once the heading data falls to within an allowable accuracy, the vessel ends the figure-eight maneuvers and maintains a steady course and speed. The GAMS Calibration routine is started, and the POS/MV completes the calibration. The results can be viewed in the GAMS Parameter Setup window of the POS Viewer software.

The GAMS subsystem should be calibrated only one time at the start of the survey. An additional calibration should be completed and logged any time the IMU or antennas are moved.

GAMS Calibration Results

The calculations give the following results:

Table 17 Vessel Heading Calibration (GAMS Calibration)

Vessel	M/V Pelagos	R/V Acadiana	M/V MacGinitie
Two Antenna Separation (m)	2.354	2.158	1.665
Heading Calibration Threshold (deg)	1.5	1.5	0.5
Heading Correction (deg)	0.000	0.000	0.000
Baseline Vector X axis	2.148	-0.102	0.018
Baseline Vector Y axis	-0.049	2.351	1.662
Baseline Vector Z axis	-0.200	-0.056	0.036

Appendix IV – Sound Speed Sensor Report

All SVP Calibration Reports can be found under the Appendix_IV_(SVP_Calibrations) directory.