U.S. DEPARTMENT OF COMMERCE

NATIONAL OCEANIC AND ATMOSPHERIC ADMINISTRATION

NATIONAL OCEAN SERVICE

DATA ACQUISITION AND PROCESSING REPORT

Type of Survey	**Hydrographic**
Project	**OPR-H355-KR-18**
Contract No	**EA-133C-14-CQ-0031**
Task Order No	**T0008**
Time Frame	**August 2018 - April 2019**

State	**Florida**
General Locality	**Florida Keys**

2018

CHIEF OF PARTY

David R. Neff, C.H.

LIBRARY & ARCHIVES

Date

NOAA FORM 77-28
(11-72)

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

HYDROGRAPHIC TITLE SHEET

INSTRUCTIONS - The Hydrographic Sheet should be accompanied by this form, filled in as completely as possible, when the sheet is forwarded to the office.

REGISTRY No
H13160
H13161
H13162
H13163
H13164
H13165
H13167
H13168
H13169
F00757

FIELD No

eTrac Inc.

State	Florida		
General Locality	Florida		
Sub-Locality	Florida Keys		
Scale	1:40,000 (H13169: 1:15,000 & F00757 1:10,000)	**Date of Survey**	August - December 2018
Instructions Dated	August 1, 2018	**Project No.**	OPR-H355-KR-18
Vessel	R/V Benthos, R/V Taku, R/V Marcelle		
Chief of Party	David R. Neff, C.H.		
Surveyed by	eTrac Inc.		
Soundings by echo sounder	Kongsberg 2040c, R2 Sonic 2024		
Graphic record scaled by	N/A		
Graphic record checked by	N/A	**Automated Plot**	N/A
Verification by	Atlantic Hydrographic Branch		
Soundings in	Meters at MLLW		

REMARKS:

NAD 83 (2011), UTM Zone 17

Times are in UTC

The purpose of this contract is to provide NOAA with modern, accurate hydrographic survey data with which to update the nautical charts of the assigned area.

SUBCONSULTANTS:

Geodynamics, LLC, 310A Greenfield Drive, Newport, NC 28570

Bordelon Marine, 382 Thompson Road, Houma, LA

NOAA FORM 77-28 SUPERSEDES FORM C&GS-537

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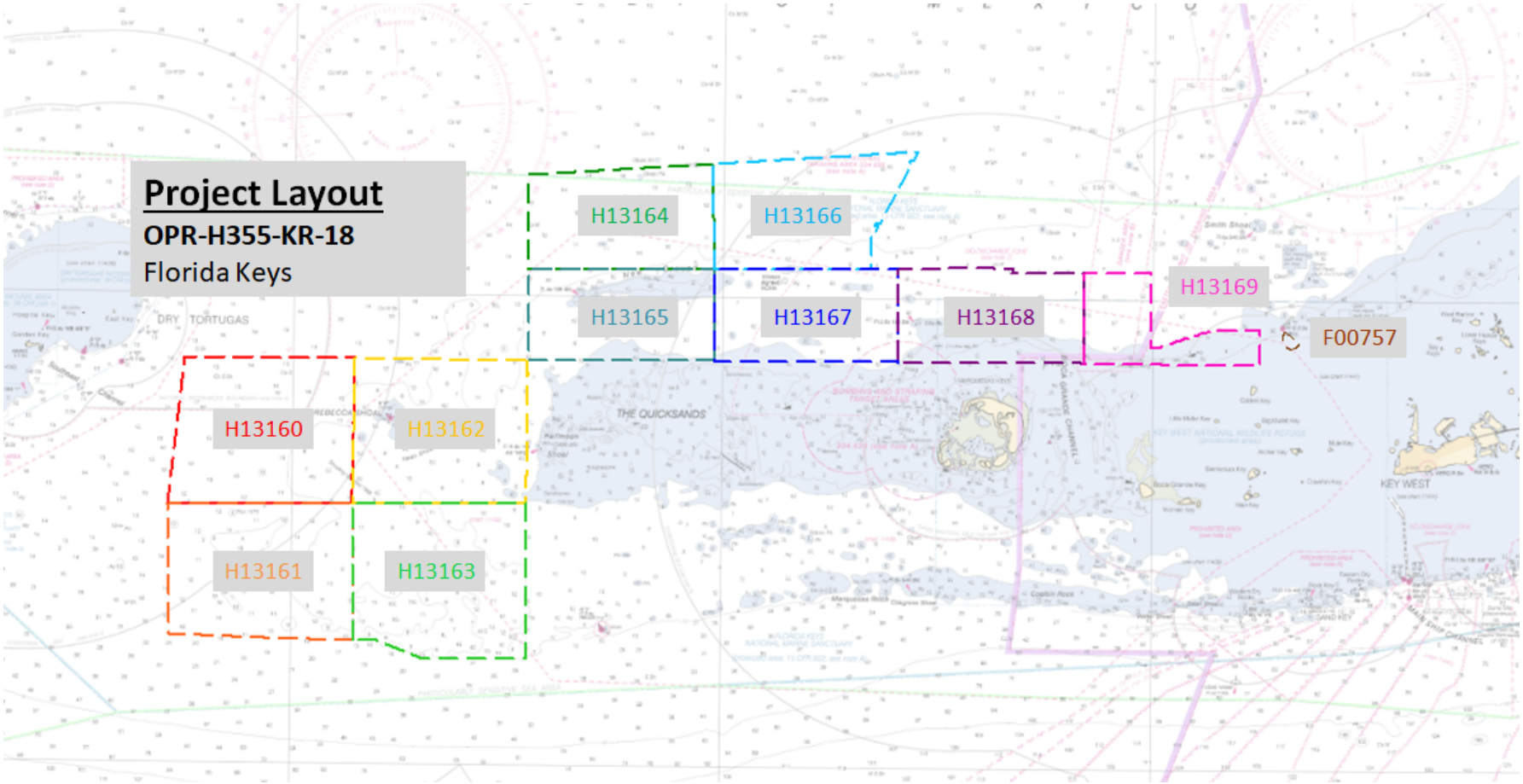

Figure 1: OPR-H355-KR-18

A. EQUIPMENT

A.1. Vessels

A.1.1. R/V Benthos

Subcontractor Geodynamics LLC provided the R/V Benthos for hydrographic survey operations on OPR-H355-KR-18. The R/V Benthos is a 34 foot Catamaran built by Armstrong Marine with the following specifications:

Overall Length:	34 ft.
Beam:	10.5 ft.
Draft:	2 ft.
Sonar Mount:	Custom hydraulic pole mount port side
Propulsion:	Twin Yamaha F300 outboard Engines
Drives:	N/A
Fuel Capacity:	248 Gal Gas, 30 Gal Diesel, 98 Gal Gas Reserve
Generator:	8KW Westerbeke Marine Generator 50AMP with PTO for hydraulics
Bridge Equipment:	Simrad NSS Radar/Chartplotter/Echosounder, AIS, VHF, Weather, Autopilot

Figure 2: R/V Benthos

Table 1: R/V Benthos Hardware

Instrument	Function	Manufacturer	Model	Serial Number	Function
Multibeam Echosounder					
Deck Unit	Bathymetry	Kongsberg	2040C	20043	MBES
Port Sonar Head	Bathymetry	Kongsberg	2040C	1300	MBES
Stbd Sonar Head	Bathymetry	Kongsberg	2040C	1284	MBES
Sound Speed					
Surface Sound Speed	Bathymetry	AML	Micro X	7762	Beam formation and steering
SV Sensor	Bathymetry	AML	SV.Xchange	201370	Removable SV sensor on Micro X
Sound Speed Profiler	Bathymetry	AML	Base.X	25101	Primary SV profiler on Base X
SV Sensor	Bathymetry	AML	SV.Xchange	200826	Removable SV sensor on Base X
Pressure Sensor	Bathymetry	AML	P.Xchange	304496	Primary pressure sensor on Base X
Navigation					
Deck Unit	Position/Attitude/Heading	Applanix	POSMV 320 V5	6619	Marinestar and inertial reference system for position, heading, heave, roll, and pitch data.
IMU	Position/Attitude/Heading	Applanix	IMU 65	3250	
Starboard Antenna	Position/Attitude/Heading	Trimble	AeroAntenna	7910	
Port Antenna	Position/Attitude/Heading	Trimble	AeroAntenna	7186	

Refer to Section A.8.1- Mobilization & Appendix I for additional vessel information.

A.1.2. R/V Taku

eTrac Inc. provided the R/V Taku for hydrographic survey operations on OPR-H355-KR-18. The R/V Taku is a 35 foot Catamaran built by Armstrong Marine with the following specifications:

Overall Length:	35 ft.
Beam:	10.5 ft.
Draft:	2 ft.
Sonar Mount:	Twin Universal Sonar Mount (Stern Mounted)
Propulsion:	Twin Honda 225 outboard Engines
Drives:	N/A
Fuel Capacity:	240 Gal Gas, 30 Gal Diesel
Generator:	8KW Westerbeke Marine Generator 50AMP with PTO for hydraulics
Bridge Equipment:	Garmin NSS Radar/Chartplotter/Echosounder, AIS, VHF, Weather, Autopilot

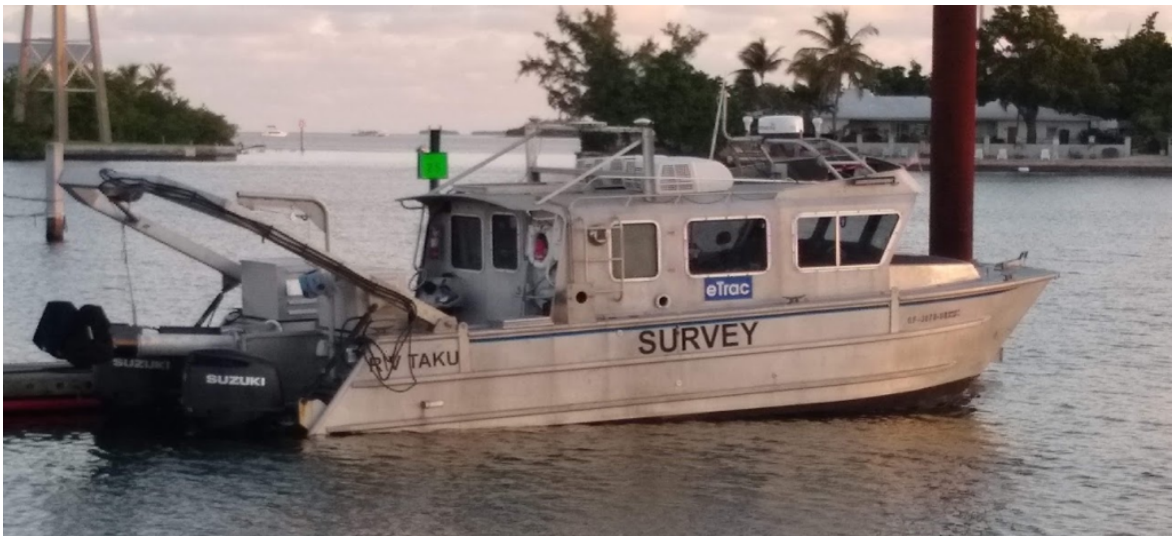

Figure 3: R/V Taku

Table 2: R/V Taku Hardware

Instrument	Function	Manufacturer	Model	Serial Number	Function
Multibeam Echosounder					
Deck Unit (Stbd)	Bathymetry	R2Sonic	2024	103575	MBES
Receiver (Stbd)	Bathymetry	R2Sonic	2024	101006	MBES
Projector (Stbd)	Bathymetry	R2Sonic	2024	806789	MBES
Deck Unit (Port)	Bathymetry	R2Sonic	2024	103757	MBES
Receiver (Port)	Bathymetry	R2Sonic	2024	100392	MBES
Projector (Port)	Bathymetry	R2Sonic	2024	806376	MBES
Sound Speed					
Surface Sound Speed	Bathymetry	AML	Micro X	10818	Beam formation and steering
SV Sensor	Bathymetry	AML	SV.Xchange	203714	Removable SV sensor on Micro.X
Sound Speed Profiler	Bathymetry	AML	Smart X	20215	Primary SV profiler on Smart X
SV Sensor	Bathymetry	AML	SV.Xchange	204702	Removable SV sensor on Smart X
Pressure Sensor	Bathymetry	AML	P.Xchange	305422	Primary pressure sensor on Smart X
Navigation					
Deck Unit	Position/Attitude/Heading	Applanix	POSMV 320 V5	7033	Marinestar and inertial reference system for position, heading, heave, roll, and pitch data.
IMU	Position/Attitude/Heading	Applanix	IMU 36	02870	
Starboard Antenna	Position/Attitude/Heading	Trimble	Zephyr Model2	5932	
Port Antenna	Position/Attitude/Heading	Trimble	Zephyr Model2	5938	

Refer to Section A.8.1- Mobilization & Appendix I for additional vessel information.

A.1.3. R/V Marcelle

eTrac Inc. contracted the R/V Marcelle Bordelon for hydrographic survey operations on OPR-H355-KR-18. The R/V Marcelle is a 149 ft Offshore Supply Vessel with the following specifications:

Overall Length:	149 ft
Beam:	36 ft
Draft:	8.5 ft
Sonar Mount:	Custom Sonar Mount (Over The Side)
Propulsion:	Diesel Propeller
Drives:	Cummins KTA 38MO
Fuel Capacity:	57,200 USG Diesel
Generator:	2-99KW/Cummins 6CTA
Bridge Equipment:	Furuno NSS Radar/Chartplotter/Echosounder, AIS, VHF, Weather, Autopilot

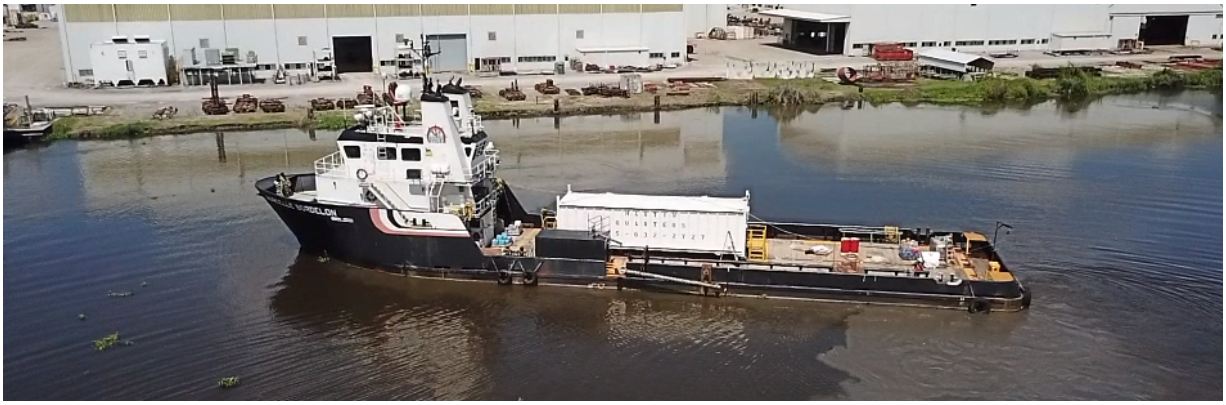

Figure 4: R/V Marcelle

Table 3: R/V Marcelle Hardware

Instrument	Function	Manufacturer	Model	Serial Number	Function
Multibeam Echosounder					
Deck Unit (Stbd)	Bathymetry	R2Sonic	2024	103575	MBES
Receiver (Stbd)	Bathymetry	R2Sonic	2024	101006	MBES
Projector (Stbd)	Bathymetry	R2Sonic	2024	806789	MBES
Deck Unit (Port)	Bathymetry	R2Sonic	2024	103757	MBES
Receiver (Port)	Bathymetry	R2Sonic	2024	100392	MBES
Projector (Port)	Bathymetry	R2Sonic	2024	806376	MBES
Sound Speed					
Surface Sound Speed	Bathymetry	AML	Micro X	10818	Beam formation and steering
SV Sensor	Bathymetry	AML	SV.Xchange	203714	Removable SV sensor on Micro.X
Sound Speed Profiler	Bathymetry	AML	Smart X	20215	Primary SV profiler on Smart X
SV Sensor	Bathymetry	AML	SV.Xchange	204702	Removable SV sensor on Smart X
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Navigation					
Deck Unit	Position/Attitude/Heading	Applanix	POSMV 320 V5	7033	Marinestar and inertial reference system for position, heading, heave, roll, and pitch data.
IMU	Position/Attitude/Heading	Applanix	IMU 36	02870	
Starboard Antenna	Position/Attitude/Heading	Trimble	Zephyr Model2	5932	
Port Antenna	Position/Attitude/Heading	Trimble	Zephyr Model2	5938	

Refer to Section A.8.1- Mobilization & Appendix I for additional vessel information.

A.2. Sounding Equipment

A.2.1. Multibeam Echosounders

A.2.1.1. Kongsberg 2040C MBES

The R/V Benthos and R/V Marcelle were both equipped with a dual-head Kongsberg 2040C Multibeam Echosounder System (MBES). The dual head 2040C utilizes 800 discretely formed beams of a selectable sector up to 200°. At 300kHz the 2040C focuses an across-track and along-track beamwidth of 1° and 1° respectively. The 2040C operates at a maximum ping rate of 50Hz and is designed to comply with IHO standards for depth measurement to a maximum range of 450 meters.

A.2.1.2. R2Sonic 2024 MBES

R/V Taku was equipped with a dual head R2Sonic 2024 Multibeam Echosounder System (MBES). The dual head 2024 utilizes 512 discretely formed beams over a selectable sector up to 160° per sonar. At 400kHz the 2024 focuses an across-track and along-track beamwidth of 0.5° and 1° respectively. The 2024 operates at a maximum ping rate of 60Hz and is designed to comply with IHO standards for depth measurement to a maximum range of 500 meters.

A.3. Positioning Equipment

A.3.1. Applanix POSMV

R/V Benthos, R/V Taku, and R/V Marcelle were mobilized with an Applanix POSMV 320 V5 Global Positioning and Inertial Reference System. The POSMV was used to acquire position, attitude, and heading throughout the entire survey. The POSMV is comprised of a rack mount processor, dual GPS antenna baseline, and an inertial motion unit. Position, attitude, and heading data were broadcast to QPS QINSy acquisition software over Ethernet/UDP at 50Hz for R/V Taku. For R/V Benthos and R/V Marcelle, position, heading and attitude were transmitted to Kongsberg SIS over RS232 serial connections, broadcasting position and heading at 10Hz and attitude at 200Hz.

The POSMV provided precise timing of sonar instrumentation and acquisition software/hardware through a number of outputs. Timing of the multibeam data was handled at the R2Sonic topside unit or Kongsberg topside processing unit (PU). A PPS (Pulse Per Second) via BNC cable connection, as well as a NMEA ZDA message via RS232 serial connection at 1Hz, were sent from the POSMV to the R2Sonic topside unit and Kongsberg PU. The NMEA ZDA 1Hz message was additionally sent to QPS QINSy acquisition software.

A.3.2. Marinestar Global Correction System

R/V Benthos, R/V Taku, and R/V Marcelle received GNSS satellite corrections over the POSMV G2+ carrier signal from the Marinestar Global Correction System maintained by Fugro.

The Marinestar system is a global realtime GNSS broadcast system that delivers corrections from a network of base stations around the world via geo-stationary satellites.

A.4. Sound Speed Equipment

All sound speed sensors used on the project were calibrated within 1 year of survey commencement per the HSSD 2018. Manufacturer certified calibration sheets can be referenced in Appendix IV of this document.

A.4.1. Surface Sound Speed Measurement

The R2sonic 2024 and Kongsberg 2040C utilize an AML Micro•X located at the sonar head for surface sound speed measurement. The AML Micro•X is a time of flight SV sensor and is powered through the R2Sonic topside or powered directly from a 12 volt power source via RS232 serial cable connection. Sound speed measurements (measured in meters per second) are output through the same serial connection at 1Hz.

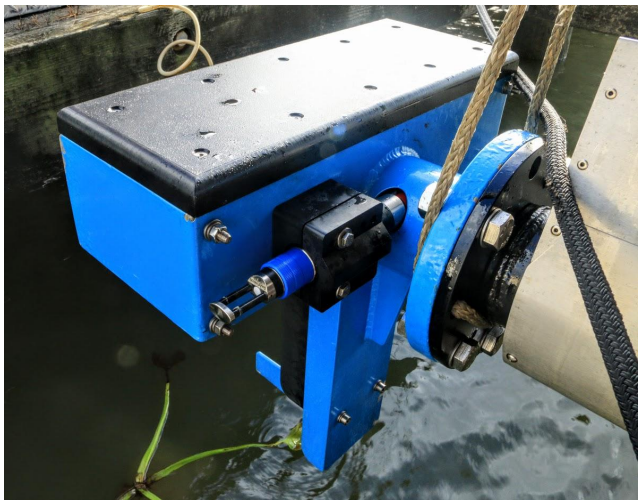

Figure 5: AML Micro•X Sensor Mobilized on an R2Sonic 2024

Figure 6: AML Micro•X Sensor Mobilized on a Kongsberg 2040C

A.4.2. Sound Speed Profilers

A.4.2.1. AML Base•X Profiler

The AML Base•X sound speed profiler is a high accuracy time of flight sound speed sensor capable of measuring sound speed in depths up to 100 meters. The Base•X is capable of transferring data via RS-232 serial cable. AML SeaCast software is run on the acquisition computer to facilitate the data transfer and profile formatting.

A.4.2.2. AML Smart•X Profiler

The AML Smart•X sound speed profiler is a high accuracy time of flight sound speed sensor capable of measuring sound speed in depths up to 500 meters. The Smart•X is capable of transferring data via RS-232 serial cable or RS-485 serial cable connection. eTrac's internal SVP Profiler software is run on the acquisition computer to facilitate the data transfer and profile formatting.

A.4.2.3. Moving Vessel Profiler

The MVP sound speed profiler is a high accuracy time of flight sound speed sensor capable of measuring sound speed in depths up to 500 meters. The MVP is towed behind the survey vessel through approximately 300m of electromechanical (0.5" cable) spooled onto a 24V oceanographic winch. The MVP is capable of transferring data via RS-485. eTrac's MVP Profiler software is run on the acquisition computer to facilitate the data monitoring, data transfer and profile formatting.

Figure 7: AML MVP•X Complete System

A.5. Bottom Drop Camera Equipment

A.5.1. Mini Remotely Operated Vehicle

A.5.1.1. Deep Trekker DTG2

The DTG2 is a commercial grade mini ROV. The DTG2 has an internal HD camera, with a 330 degree field of view and a depth rating of 100 meters. The system was mobilized on R/V Taku, and was used to satisfy "drop camera" imagery requirement on OPR-H355-KR-18.

Figure 8: Deep Trekker DTG2

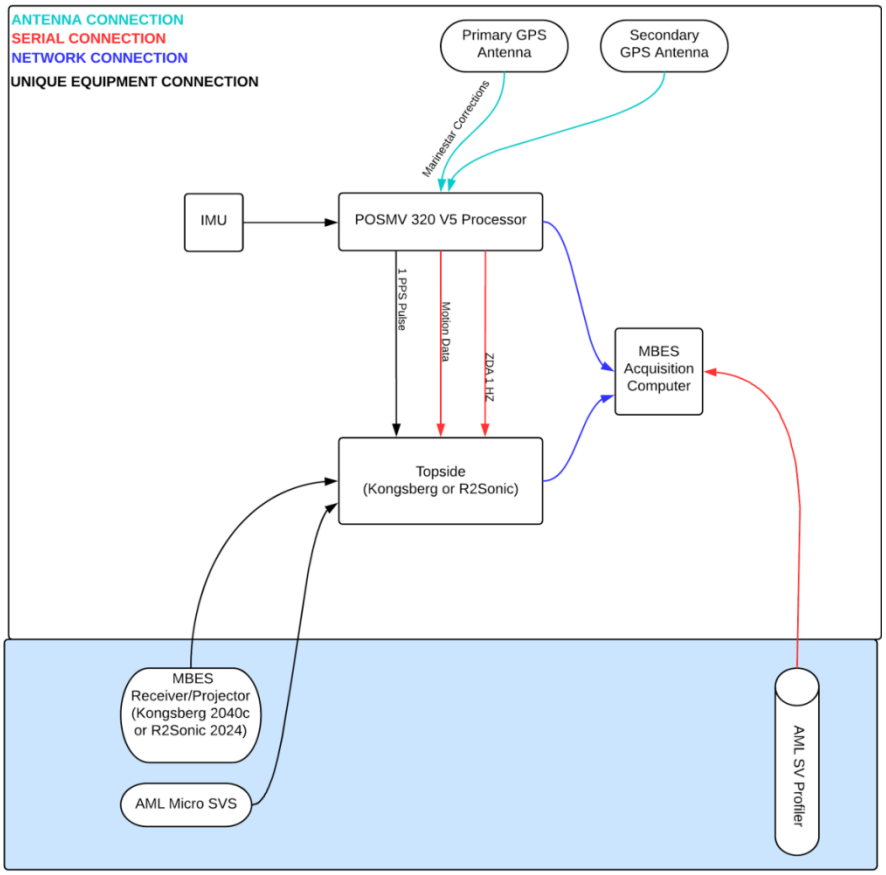

Figure 9: Acquisition Systems Diagram

A.6. Computer Hardware

A.6.1. Acquisition Computer Hardware

Seven acquisition computers were mobilized on the project. All acquisition computers were custom built rack mount chassis with identical hardware makeup. Power to all computers was supported through uninterruptible power sources (UPS) to guard against loss of data in the event of an interruption to vessels' power. A table of acquisition computer information is shown below.

Table 4: Acquisition Computer Hardware

Acquisition Computer Hardware					
Name	**Make**	**Processor**	**OS**	**Location**	**Function**
Benthos	Advantech	4 Core i7	Windows 10	R/V Benthos	MBES
Han Solo	Advantech	4 Core i7	Windows 10	R/V Marcelle	MBES
Chewy	Advantech	4 Core i7	Windows 10	R/V Marcelle	MBES
Yoda	Advantech	4 Core i7	Windows 10	R/V Taku	Spare
Leia	Advantech	4 Core i7	Windows 10	R/V Marcelle	Spare
Luke	Advantech	4 Core i7	Windows 10	Key West Office	Spare
Lando	Advantech	4 Core i7	Windows 10	R/V Taku	Spare

A.6.2. Processing Computer Hardware

Processing computers were mobilized in the project field office in Key West, on R/V Marcelle and in the main office in San Rafael. These computers were networked locally to a server hosting a redundant backup raid array. Additionally, project data were synced nightly to an external USB terabyte drive. As a final measure, data were periodically synced to a backup folder at eTrac Inc.'s main office via shipped hard drives. Final data processing was completed in San Rafael. A table of processing computer information is shown below.

Table 5: Processing Computer Hardware

Processing Computer Hardware					
Name	**Make**	**Processor**	**OS**	**Location**	**Function**
Boba	Dell	Intel Core i7	Windows 10	R/V Marcelle	MBES Processing
Dooku	Dell	Intel Core i7	Windows 10	R/V Marcelle	MBES Processing
Jaba	Dell	Intel Core i7	Windows 10	San Rafael Office	MBES Processing
Kylo	Dell	Intel Core i7	Windows 10	San Rafael Office	MBES Processing
Phasma	Dell	Intel Core i7	Windows 10	Key West Office	MBES Processing
Vader	Dell	Intel Core i7	Windows 10	Key West Office	MBES Processing
BB8	Dell	Intel Xeon	Windows 10	Key West Office	Data Server (Key West)
Synology	Synology	INTEL Atom C2538	Linux	San Rafael Office	Data Server (San Rafael)
BB9	Dell	Intel Xeon	Windows 10	R/V Marcelle	Data Server (R/V Marcelle)

A.7. Computer Software

A.7.1. Acquisition Software

Table 6: Acquisition Software

Acquisition Software			
Manufacturer	**Name**	**Version**	**Installation Date**
QPS	Qinsy	8.17	8/15/2017
R2Sonic, LLC	R2Sonic	4/13/2017	6/21/2017
R2Sonic, LLC	R2Sonic 2024 Firmware (SIM)	4/21/2017	6/21/2017
AML Oceanographic	Seacast	4.3.1	6/20/2017
Applanix	MV-POSView	8.60	7/12/2016
Applanix	PosMV 320 Firmware	8.63	7/12/2016
Kongsberg	Kongsberg SIS	4.3.2	8/15/2017
Kongsberg	Kongsberg 2040C Firmware	4.3.2	8/15/2017
Microsoft	Microsoft Excel	2003	5/1/2015
Google	Google Drive	1.31	5/1/2015

A.7.1.1. QPS QINSy

QPS QINSy was used as the main data collection and line tracking software on all vessels. Additionally, QPS QINSy was also used on each vessel for realtime quality control of the survey data.

The following realtime data inputs were combined and recorded into raw DB data files in QINSy on R/V Benthos, R/V Taku and R/V Marcelle:

- Applanix POSMV Ethernet Packets (50Hz)
- R2Sonic Ethernet Packets / Kongsberg Datagram Packets
- Marinestar G2 Message (1Hz)
- AML Micro SV Surface Sound Speed data (1Hz)
- AML SmartX / BaseX Sound Speed Profile data

Dual 27" monitors display a number of realtime data quality and coverage monitoring windows available through QINSy.

The following display windows were monitored by the hydrographer during data collection on R/V Taku:

- **Coverage Display** (Shows realtime depth colored coverage grid)
- **QC Display** (Shows realtime coverage grid colored by standard deviation)
- **Backscatter Display** (Shows realtime intensity of backscatter colored by relative hardness of bottom)
- **Alerts** (Monitors systems throughout data collection and alerts the hydrographer in the event of data loss)
- **Precise Timing** (Displays precise timing data to ensure no latency in recorded data)

- **Survey Metrics** (Displays various realtime metrics of the survey including speed, distance to go, time to go, current line name, and logging status)

The following display windows were monitored by the hydrographer during data collection on R/V Benthos and R/V Marcelle:

- **Coverage Display** (Shows realtime depth colored coverage grid)
- **QC Display** (Shows realtime coverage grid colored by standard deviation)
- **Precise Timing** (Displays precise timing data to ensure no latency in recorded data)
- **Survey Metrics** (Displays various realtime metrics of the survey including speed, distance to go, time to go, current line name, and logging status)
- **UDP SIS Trigger Displays** (for Triggering SIS logging using the QINSy controller)

A.7.1.2. R2Sonic (Sonic Controller)

The R2Sonic Sonic Controller was utilized to control the R2Sonic 2024. Realtime sonar data was viewed within the controller. Sonar settings are controlled through the Sonic Controller. Roll stabilization of the sonar data viewed in the Sonic Controller is achieved through a serial connection accepting binary motion data from the POSMV at 200Hz. Raw Water Column data collection can be enabled within the Sonic Controller during acquisition.

A.7.1.3. Kongsberg (SIS)

Kongsberg SIS was also used as the data collection software on R/V Benthos and R/V Marcelle.

The following realtime data inputs were combined and recorded into raw ALL data files in SIS:

- Applanix POSMV Position (10Hz) and Attitude data (100Hz)
- Kongsberg Datagram Packets
- AML Micro SV Surface Sound Speed data (1Hz)
- AML BaseX Sound Speed Profile data

A 27'' monitor displays a number of realtime data quality and coverage monitoring windows available through SIS. The following display windows were monitored by the hydrographer during data collection:

- **Seabed Display** (Shows realtime intensity of backscatter colored by relative hardness of bottom)
- **Numerical Display** (Numerical monitoring system for data collection. Provides a display of sonar operating settings, lat/long position, date/time, and attitude values, will display a red alert if errors arise)
- **Cross Track** (Shows the entire swath on an x-y axis, with the x axis representing swath width, and the y axis representing depth under the transducer)
- **Water Column** (Shows swath on x-y axis similar to cross track, but displays real-time water column data. It also shows when the system is logging water column data)
- **Time Series** (Graphically displays real-time pitch, roll, and heave values)

- **Beam Intensity** (Displays the quality and intensity of the beams)
- **Geographical** (Shows the real-time SIS grids being actively written)

Kongsberg SIS was utilized to control the dualhead Kongsberg 2040C. Realtime sonar data was viewed within the program. Sonar settings are controlled through the SIS program. Roll, pitch, and yaw stabilization of the sonar data is achieved in the Kongsberg 2040C PU through a serial connection accepting binary motion data from the POSMV at 100Hz.

A.7.1.4. AML SeaCast

AML SeaCast software was run on the data collection computers for configuring and transferring data from the AML Base•X and Smart•X probes. Cast data were downloaded directly after each cast and saved on the data collection computer.

A.7.1.5. Applanix POSView

Applanix POSView controller software was utilized to configure, monitor, and record the data provided by the POSMV inertial aided GNSS navigation system. System status was monitored realtime throughout data collection. Alerts were configured to display when accuracies dropped below acceptable values, which alerted the hydrographer to the degradation of various accuracies, including position, heading, attitude, and heave.

A.7.1.6. Microsoft Excel

Microsoft Excel was utilized during data collection as the host software of the digital field log. Every major aspect of field data collection was noted in the digital field log with a time-tag in order to maintain a historical record of daily operations, as well as aid the processing office.

A.7.2. Processing Software

Table 7: Processing Software

Processing Software			
Manufacturer	**Name**	**Version**	**Installation Date**
QPS	Qimera	1.6.3	8/1/2018
QPS	Qimera	1.7.1	9/1/2018
QPS	Qimera	1.7.3	10/29/2018
QPS	Qimera	1.7.4	11/14/2018
QPS	FMGeocoder Toolbox	7.7.8	8/1/2017
Applanix	POSPac MMS	8.2.1	6/29/2016

A.7.2.1. QPS Qimera

QPS Qimera is a bathymetric processing and analysis program. Qimera was utilized in the processing workflow as the exclusive MBES processing software. MBES data were acquired in DB format and processed within Qimera.

In addition to MBES processing procedures, Qimera was utilized to create, maintain, and deliver an S-57 feature file of navigationally significant objects identified from the MBES data. In addition to new features, assigned charted features were included in the S-57 Final Feature File (FFF) with updated charting recommendations.

A.7.2.2. QPS FMGeocoder Toolbox

QPS FMGeocoder Toolbox (FMGT) is a program designed to process, view, and analyze backscatter data. FMGT was utilized in the processing workflow as the exclusive snippets/backscatter processing software to confirm that snippets were collected during all MBES data collection to meet Complete Coverage requirements as specified in the HSSD. Snippets data from Qinsy Paired (DB/QPD) files and Kongsberg ALL files were brought into FMGT and processed into backscatter mosaics daily to confirm backscatter complete coverage.

A.7.2.3. Applanix POSPac MMS

Applanix POSPac MMS is a position post-processing software package designed for use with trajectory data collected by the Applanix POSMV systems. POSPac MMS was utilized in the data pipeline during daily processing efforts as well as mobilization and calibration procedures. Specifically POSPac MMS was utilized to create Smooth Best Estimate of Trajectory (SBET) from position data collected during daily operating procedures. As detailed in the HVCR, using trajectory data logged from the POSMV, along with RTX data, SBET's were created and quality checked in POSPac MMS. Upon thorough review, the SBETs were then applied in QPS Qimera.

A.7.3. Reporting Software

Table 7: Reporting Software

Processing Software			
Manufacturer	**Name**	**Version**	**Installation Date**
Google	Google Drive	1.31	5/1/2015
eTrac Inc.	Density Trac	1.0.0.17	9/15/2017
eTrac Inc.	DiffTrac	1.0.0.6	9/15/2017
eTrac Inc.	JunctionTrac	1.0.0.8	9/15/2016
eTrac Inc.	TPUTrac	1.0	10/1/2018
eTrac Inc.	XML DR	1.1.0.14	11/14/2017
NOAA HydrOffice	QC Tools	2.6.7	9/1/2018
CARIS	HIPS and SIPS	10.2.2	8/1/2018

A.7.3.1. Google Drive

Google Drive was used across the project as the cloud storage area for a variety of project related documents and spreadsheets. Processing checklists, spreadsheets, SOPs, informational documents were all hosted on the drive. Each data processor and employee

had access to the documents with permissions determined as needed. The entirety of the Google Drive project folder was backed up locally every 24 hours. There were many advantages of maintaining the project documents in a cloud based environment including version control, extended document history recording, and realtime collaboration.

A.7.3.2. DensityTrac

DensityTrac is a program developed by eTrac Inc. to determine density statistics of a dataset provided in BBH format. The file is then loaded into the DensityTrac program and statistics, along with a visual histogram, are created. This aids the operator in determining if the density specification has been met for a particular surface of defined resolution.

A.7.3.3. DiffTrac

DiffTrac is a program developed by eTrac Inc. to analyze statistics of a dataset provided in ASCII XYZ format (Easting, Northing, Difference). A difference surface between two surfaces is created and exported in an ASCII XYZ format. The ASCII XYZ is then imported into DiffTrac and statistics are displayed and reported within the software. Visual Graphs and statistics are exported for inclusion in the DR.

A.7.3.4. JunctionTrac

JunctionTrac is a program developed by eTrac Inc. to determine junction comparison statistics of two datasets provided in ASCII XYZ format (Easting, Northing, Depth). A difference surface between the two datasets is necessary to run the JunctionTrac program. Once the difference surface is created from the two datasets, it is then exported as an ASCII XYZ file with the difference value as the 3rd value in the string (Easting, Northing, Diff). These files are loaded into the JunctionTrac program, which compares the difference between the surfaces and the allowable TVU of each node determined by depth. A visual histogram is created. This aids the operator in determining if the surface to surface difference between two junctioning surveys exceeds the TVU specifications. Nodes with differences exceeding the allowable TVU value are flagged. JunctionTrac creates a CSV format file of these flagged outliers, which can be loaded into QPS Qimera. Using the locations from the created CSV format file, the operator can further evaluate the flagged nodes.

A.7.3.5. TPUTrac

TPUTrac is a program developed by eTrac Inc. to determine TPU statistics of a dataset provided in the ASCII TXT format (Easting, Northing, Depth, Uncertainty). An ASCII TXT file is created with the TPU attribute of the chosen surface as the 4th value in the string. The file is then loaded into the TPUTrac program, which compares the allowable TPU and the actual TPU which is determined by depth. Statistics along with a visual histogram are created. This aids the operator in determining if the TPU specification has been met for a particular surface of a defined resolution. TPU values exceeding the user defined threshold are flagged. TPUTrac creates a CSV format file of these flagged outliers, which can be then loaded into QPS Qimera. Using the locations from the created CSV format file, the operator can further evaluate the flagged nodes.

A.7.3.6. XML DR

XML DR is a program developed by eTrac Inc. to create each descriptive report in an XML and/or PDF format. The program organizes the descriptive report into categories with fields for descriptive inputs, which includes the metadata, area surveyed, data acquisition and processing, vertical and horizontal control, results and recommendations, and approval sheet. Each category is divided into sub-categories for corresponding information and images to compile. Once all fields for descriptive inputs are completed, the program can create a finalized XML and/or PDF formatted descriptive report.

A.7.3.7. NOAA HydrOffice – QC Tools

QC Tools is a program developed by NOAA's HydrOffice to improve data quality issues and to compute statistics of various measurements. The CUBE surface is exported as a bag file and loaded into QC Tools. Within QC Tools, there are options to identify and/or calculate depth statistics, TPU statistics, holidays and fliers. QC Tools was used throughout data collection as well as on our final CUBE surface.

A.7.3.8. Caris HIPS and SIPS

Caris HIPS and SIPS was used to assist in reporting tasks which QPS Qimera currently lacks. HIPS and SIPS was used to export a bag file into the custom ASCII file used in TPUTrac. HIPS and SIPS was also used to create shoal biased soundings in order to complete the chart comparisons.

A.8. Survey Methodology

A.8.1. Mobilization

R/V Taku and R/V Benthos were brought via roadways on trailers to Key West City Marina in Key West, Florida for mobilization. The mobilization of R/V Taku occurred on August 22nd and 25th, 2018 and the mobilization of R/V Benthos occurred on August 24th and 25th, 2018. Both vessels were located next to one another in the marina for efficient mobilization.

Figure 10: Vessel Mobilization

A full dimensional control vessel survey of R/V Benthos was performed on August 11th, 2017 by Lanier Surveying Company. A series of previously established punch marks were surveyed using a Trimble S5 precision robotic total station. Precise measurements with a hand-held metal tape to confirm the previously measured offsets were performed on August 24th, 2018 during the mobilization of OPR-H355-KR-18. The full dimensional control survey data and measured data were used to establish a fixed vessel reference frame, vessel reference point, sensor mounting locations, draft reference measurement points and reference frame orientation information. A full list of measured vessel points can be found in the vessel reports in Appendix I of this report. These vessel points were surveyed by Lanier Surveying Company and confirmed by eTrac Inc. hydrographers. Relative locations were provided in reference to a single vessel point mark for each vessel. Upon completion of the vessel survey, lever arms were derived from the vessel point locations within each vessels frame. These lever arms along with their associated uncertainties were entered into the QINSy vessel configuration template database files (vessel template DB).

A full vessel survey was performed on R/V Taku by Buchanan & Harper, Inc. on June 3rd, 2015. Traditional land survey methods using a Trimble 5000 robotic total station were utilized by Buchanan & Harper, Inc. during the field measurements. The vessel was pre-established with a number of punch marks located at various locations on the vessel (i.e. IMU Plate, GPS Antennae locations, Port and Starboard draft reference points, etc.). Precise measurements with a hand-held measuring tape to confirm and adjust the previously measured offsets were performed on August 22nd, 2018. A full list of measured vessel points can be found in the vessel reports in Appendix I of this report. These vessel points were surveyed by Buchanan & Harper, Inc and confirmed by eTrac Inc. hydrographers. Relative locations were provided in reference to a single vessel point mark for each vessel. Upon completion of the vessel survey, lever arms were derived from the vessel point locations within each vessels frame. These lever arms along with their associated uncertainties were entered into the QINSy vessel configuration template database files (vessel template DB).

R/V Marcelle was mobilized on September 13th and 14th, 2018 in the Bordelon Marine Shipyard in Houma, LA. The Kongsberg 2040C dualhead MBES system was mounted to an industry standard sonar pole customized to the dimensions of R/V Marcelle and similar ships. Precise measurements with a hand held metal tape with millimeter resolution and a laser level were performed on September 13th and 14th 2018 during the mobilization of OPR-H355-KR-18. The measured data were used to establish a fixed vessel reference frame, vessel reference point, sensor monitoring locations, and draft reference measurement points.

Figure 11: R/V Marcelle Mobilization In Houma, LA

Upon completion of the vessel survey, lever arms were derived from the vessel point locations within each vessels frame. These lever arms along with their associated uncertainties were entered into the QPS QINSy vessel configuration template database files (vessel template DB).

During the initial mobilization of R/V Marcelle, the POSMV antenna Baseline was mounted to the gunnels of R/V Marcelle. On October 7th, 2018 it was determined that the antenna baseline was being obstructed by sea spray and causing GPS outages. The antenna baseline was relocated on top of the Office Conex box and precise measurements were again taken with a hand held metal tape with millimeter resolution and a laser level. To complete the system modification, a GAMS calibration was performed and heading patchtest lines were re-run.

A.8.2. Survey Coverage

Survey coverage was based on the survey limits set forth in the Project Instructions OPR-H355-KR-18, Florida Keys. Survey limits were covered entirely or until the NALL line was reached.

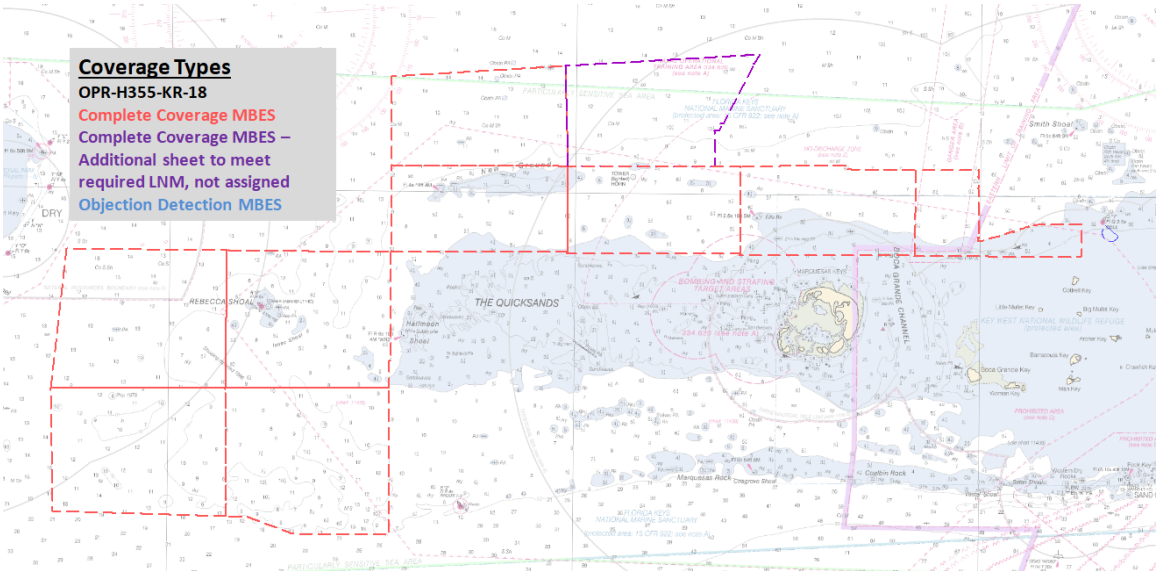

Figure 12: OPR-H355-KR-18 Survey Coverage Types

A.8.3. Multibeam Sonar Operations

Multibeam coverage was in accordance with the Project Instructions and HSSD 2018. OPR-H355-KR-18 was covered using "Complete Coverage MBES with Backscatter" standards, as well as "Object Detection with Backscatter" for F00757. R/V Benthos and R/V Marcelle were mobilized with a Kongsberg MBES system and participated in MBES collection. R/V Taku was mobilized with R2Sonic MBES systems and participated in MBES collection.

B. Quality Control

B.1. Data Acquisition

Data acquisition and processing throughout the entire project was overseen by the Chief of Party. Field acquisition was performed under the direct, onsite, supervision of a Lead Hydrographer and a Senior Hydrographer, both with well over 3 years of experience conducting hydrographic survey operations.

Line plans were established prior to survey operations. Line plan orientations were based on historical sea state, wind direction, and swell direction in order to avoid a "beam to" scenario where the vessel would be running survey lines in a direction perpendicular to the direction of the swell. Throughout the entire survey, there was never a need to revise the line plan orientation.

MBES line spacing for Complete Coverage MBES operations were based upon charted depths as well as coverage requirements set forth in the Project Instructions and the HSSD 2018.

B.1.1. Horizontal and Vertical Control

Horizontal and Vertical control methodology for OPR-H355-KR-18 is in accordance with the HSSD 2018, the Project Instructions, and the accompanying Tides Statement of Work.

B.1.1.1. Horizontal Control

During acquisition, R/V Benthos, R/V Taku, and R/V Marcelle received GNSS satellite corrections over the POS MV G2+ carrier signal from the Marinestar Global Correction System maintained by Fugro. Marinestar is a global real-time GNSS broadcast system that delivers corrections from a network of base stations around the world via geo-stationary satellites. Corrections were monitored during data acquisition to ensure no dropouts occurred throughout the survey.

During calibration procedures and throughout the project, POSMV data were logged and post-processed in POSPac MMS to output a SBET. The SBET was applied in QPS Qimera in order to reduce the THU of the data and achieve a higher accuracy.

B.1.1.2. Vertical Control

In accordance with the Project Instructions, OPR-H355-KR-18 was an Ellipsoidally Referenced (ERS) survey. Data were vertically referenced to the ITRF-08 ellipsoid using Marinestar G2+ Space Based corrections. Using VDatum, a vertical separation model was created to transform the ellipsoidally referenced data from ITRF-08 to MLLW. This separation model was applied in QPS Qinsy on the vessels in realtime to achieve MLLW in the field. Achieving MLLW in the field was extremely efficient for field operations, as the NALL was easily identified in real-time. The separation model automatically carried over into QPS Qimera through the DB files during processing. The separation model generated from VDatum is noted to have an uncertainty of 9.6 cm throughout the project area.

B.1.2. Multibeam Bathymetry (MBES)

Initial settings for the Kongsberg 2040C and R2Sonic 2024 systems can be seen below in Tables 8, 9, and 10.

Table 8: MBES Settings for Kongsberg 2040C Mobilized on R/V Benthos

R/V BENTHOS MBES SETTINGS	
2040C Parameter	**Value**
Frequency	300 kHz
Range	Variable, depth dependent
Gain	Variable, depth dependent
Power	Max (204.5 dB)
Pulse Type	Auto
Absorption	115 dB/km
Ping Rate	Variable, range dependent
Pulse Width	Variable, depth dependent
Detector Mode	Normal
Beam Spacing	Equidistant

Table 9: MBES Settings for R2Sonic 2024 Mobilized on R/V Taku

R/V TAKU	
2024 Parameter	**Value**
Range	Variable, depth dependent
Gain	Variable, depth dependent
Power	209-221 dB
Spreading	Variable , depth dependent
Absorption	126 dB/km
Ping Rate	Variable, range dependent
Pulse Width	Variable, depth dependent

Table 10: MBES Settings for Kongsberg 2040C Mobilized on R/V Marcelle

R/V MARCELLE MBES SETTINGS	
2040C Parameter	**Value**
Frequency	300 kHz
Range	Variable, depth dependent
Gain	Variable, depth dependent
Power	Max (204.5 dB)
Pulse Type	Auto
Absorption	115 dB/km
Ping Rate	Variable, range dependent

For the R2 Sonic, incremental adjustments to the range, gain, and pulse width were made during the survey and were dependent on water depth and seabed composition (bottom type). Since the Kongsberg 2040C can be operated in a more automated fashion, most sonar settings auto-adjust to varying depths and seabed composition. The main adjustment made by the hydrographer was the adjustment of swath width based on environmental conditions and sea state.

Every effort was made to tune the sonars to provide the highest quality of both bathymetric and backscatter data, with bathymetry being the primary focus. The Kongsberg 2040C and the R2Sonic 2024 were monitored realtime during all MBES acquisition efforts. Raw MBES information, including intensity, surface sound velocity, time synchronization, and ping rate, were displayed and monitored in the Kongsberg SIS Controller Interface or R2Sonic Sonic Controller Interface during acquisition.

Prior to survey operations, offsets on all vessels were determined from the static vessel surveys performed at varying times and were verified using a metal hand tape. For all vessels with a dual head system, offsets from the POSMV reference point to the acoustic center of each sonar were determined, measured, and confirmed using a metal hand tape. These offsets were entered into QPS QINSy for use during data acquisition on R/V Taku. On R/V Benthos and R/V Marcelle, these offsets were entered into Kongsberg SIS and QPS QINSy for use during data acquisition.

The R2Sonic's roll stabilization and precise timing were achieved through a combination of outputs from the POSMV. The 1PPS pulse from the POSMV is sent via BNC cable to the PPS input of the R2Sonic SIM. Additionally, a NMEA ZDA message at 1Hz is transferred from a POSMV serial port to the R2Sonic SIM via standard DB9 serial cable. For roll stabilization, the TSS1 binary motion string is transferred from the POSMV to the R2Sonic SIM via DB9 Serial connection at 200Hz.

The Kongsberg 2040C's roll, pitch and yaw stabilization is achieved in the Kongsberg 2040C PU through serial connection accepting binary motion data from the POSMV at 100Hz. The 1PPS pulse from the POSMV is sent via BNC cable to the PPS input of the Kongsberg 2040C PU. Additionally, a NMEA ZDA message at 1Hz is transferred from a POSMV serial port to the Kongsberg 2040C PU via standard DB9 serial cable. For beam stabilization, the TSS1 binary motion string is transferred from the POSMV to the Kongsberg 2040C PU via DB9 serial connection at 100Hz.

In addition to performing the confidence checks on each vessel, a vessel-to-vessel comparison was performed as an added quality assurance measure. All vessels acquired sound velocity casts independently using their assigned sound velocity probe. Data were processed though the processing pipeline and comparisons were made between the independent datasets.
On DN237 R/V Benthos and R/V Taku collected a similar line plan near a known feature. R/V Benthos on DN261 and R/V Marcelle on DN262 collected a similar line plan in the same area. Comparisons were made between the overlapping datasets. The data showed excellent agreement and added further confidence to the mobilized survey systems.

As an additional comparison, R/V Marcelle on DN263 collected data over a feature that R/V Benthos surveyed during main-scheme data collection on DN252.

Below are images of vessel-to-vessel comparisons.

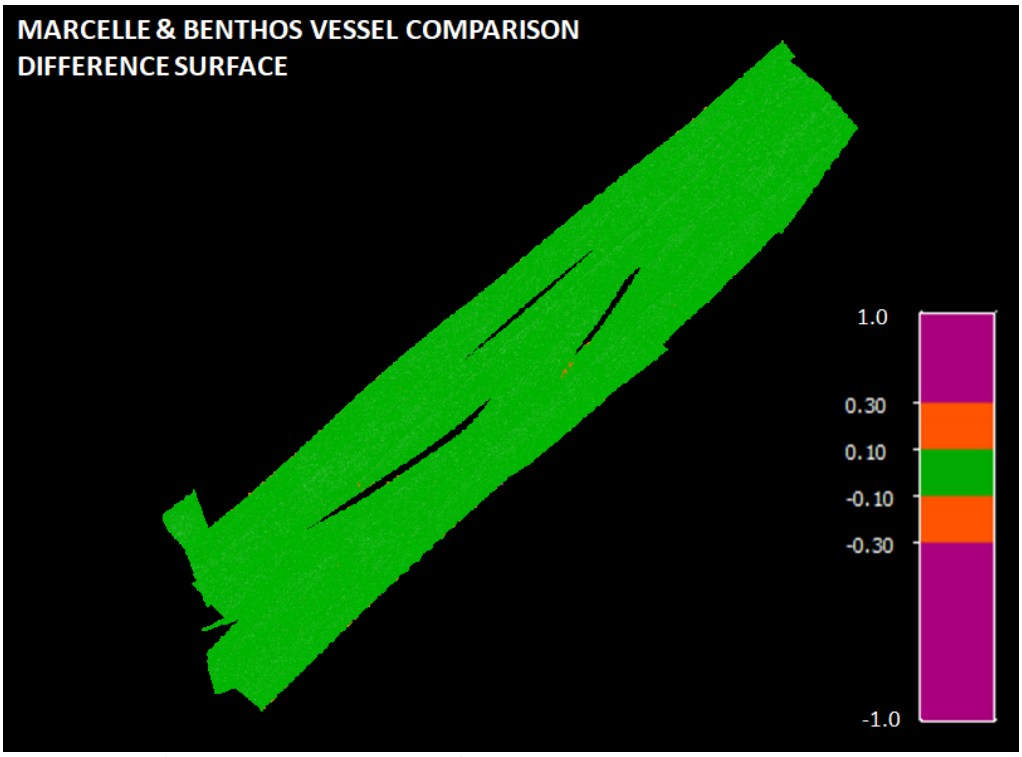

Figure 15: R/V Marcelle (DN262) and R/V Benthos (DN261) Vessel *to Vessel Comparison*

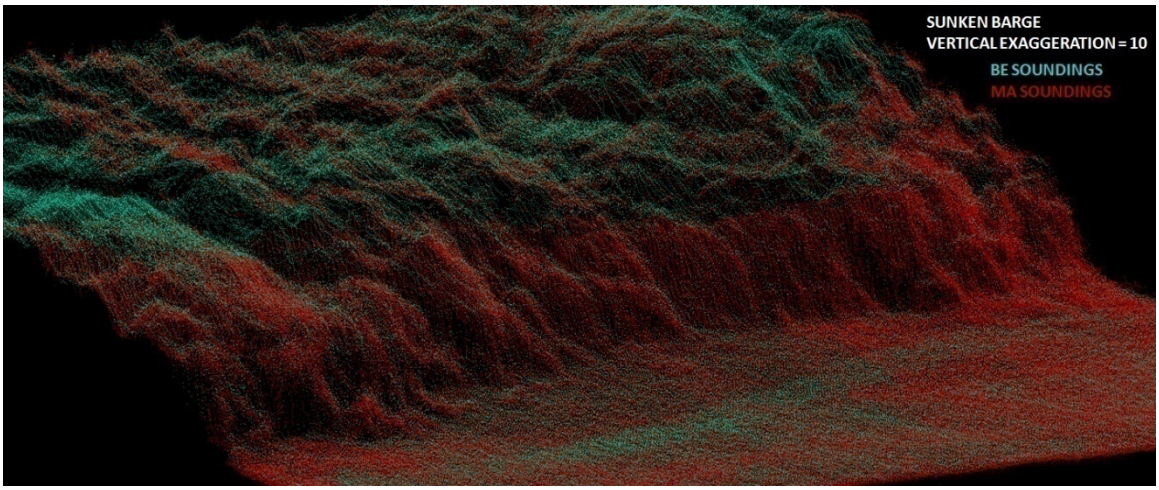

Figure 17: Vessel to Vessel Comparison R/V Benthos (DN252) and R/V Marcelle (DN263) (Subset Colored by Vessel)

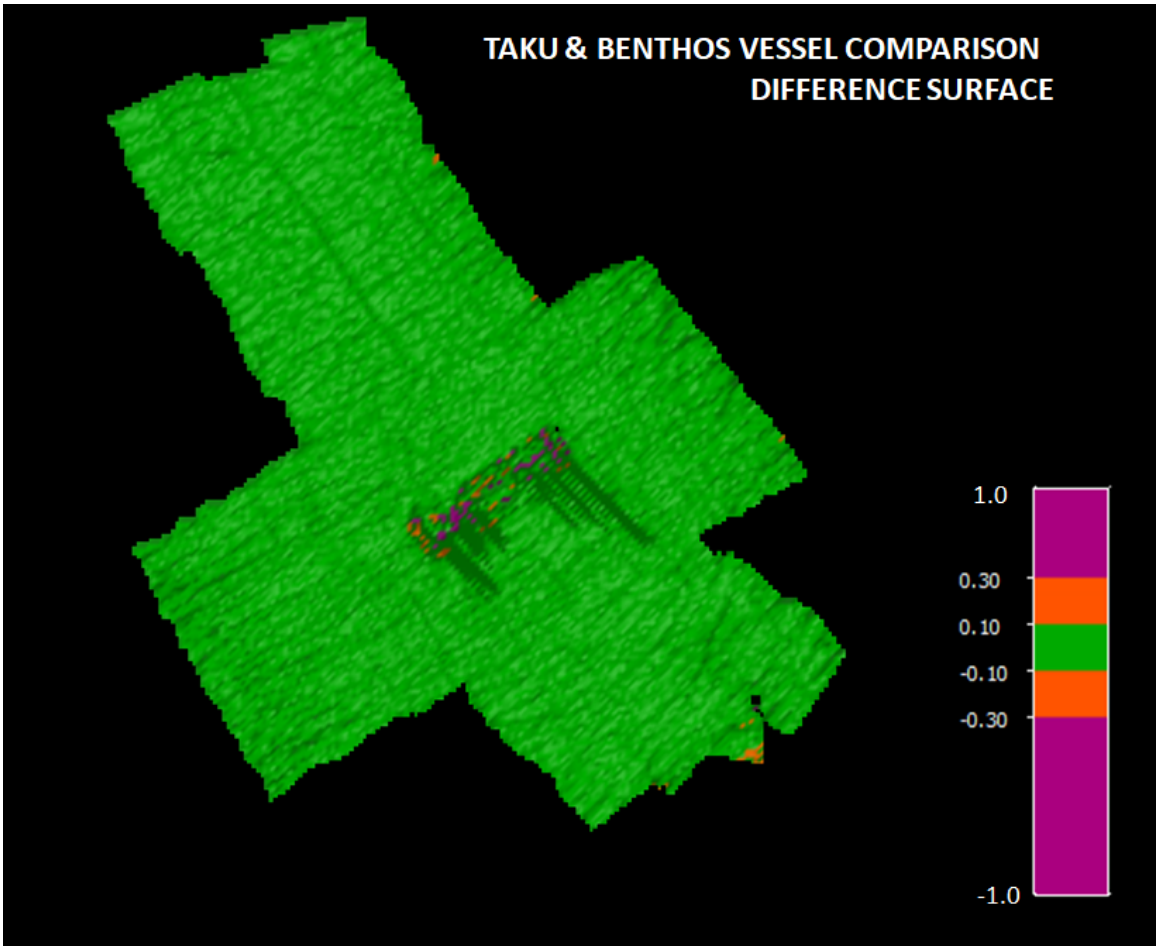

Figure 16: R/V Benthos (DN237) and R/V Taku (DN237) Vessel to Vessel Comparison

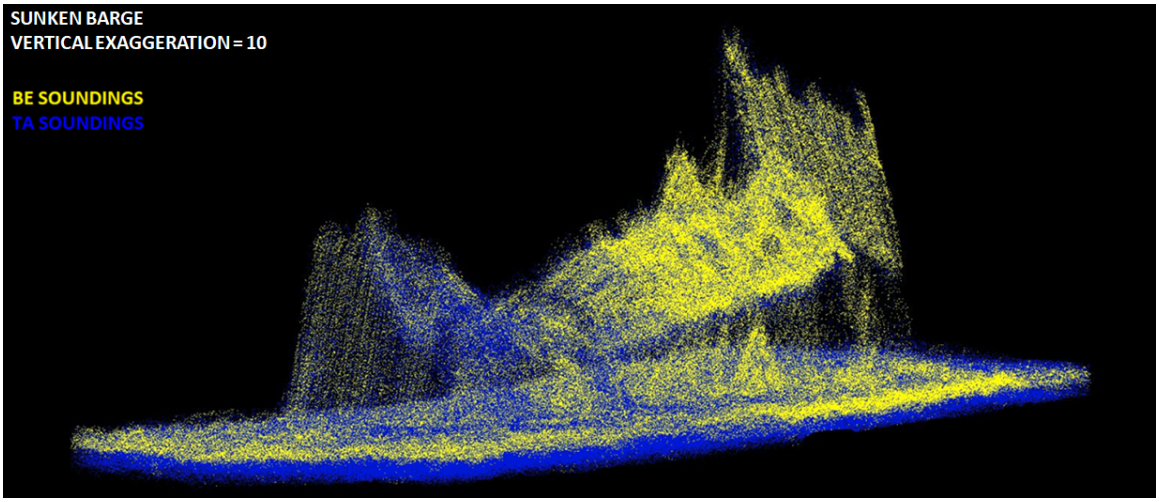

Figure 17: Vessel to Vessel Comparison R/V Benthos (DN237) and R/V Taku (DN237) (Subset Colored by Vessel)

B.1.3. Sound Speed Acquisition

All sound speed measurements were collected in accordance with specifications set forth in the HSSD 2018.

B.1.3.1. Sound Speed Profile Acquisition

Sound speed profiles were collected using AML Base•X, AML Smart•X and AML MVP•X SV profiling units. On R/V Benthos and R/V Taku, SV profilers were lowered on a data cable by hand. On R/V Marcelle, the SV profiler was lowered on a data cable mechanically. SV profiles were taken immediately prior to daily survey operations, as well as approximately every 2 hours during survey operations. In addition to planning SV casts around a 2 hour time interval, positional variance was considered when suspending survey operations to perform an SV cast.

During a cast on R/V Taku, realtime SV profiler data was collected and displayed during the downcast of the probe. The SV profiler communicated with the acquisition computer via serial data communication. The profiler data is then saved as a CSV on the MBES acquisition computer. Then, the CSV was imported to QPS QINSy acquisition software for use online and is stored in each .DB file. Once imported into the QPS QINSy software, the cast data was exported into the .SVP format for use in office processing at a later data if needed. Application of .SVP files to R/V Taku data was typically not required in post processing because the applied SVP is stored in the .DB file.

During a cast on R/V Benthos and R/V Marcelle, realtime SV profiler data was collected and displayed during the downcast of the probe. The SV profiler communicated with the acquisition computer via serial data communication. The profiler data is then saved as an ASVP and a CSV on the MBES acquisition computer. Then, the ASVP was imported in Kongsberg SIS acquisition software as well as QPS QINSy acquisition for use online and is stored in each .DB file. Once imported into the QPS QINSy software, the cast data was exported into the .SVP format for use in office processing at a later data if needed. In addition to the SV vs. depth information, the .SVP exported format included date, time, and position (lat/long) of each cast. Application of .SVP files to R/V Benthos and R/V Marcelle data was not typically required in post processing because the applied SVP is stored in the .DB file.

Surface sound speed measured by the AML Micro•X, located at the sonar head, was compared in realtime against the corresponding SV from the most current cast entered into QINSy. An alarm was set to notify the operator if the difference between the two SV readings exceeded 2m/s. If the difference was ever in consistent excess of 2m/s and persisted longer than a designated time threshold, survey operations were suspended and a new sound velocity cast was performed.

B.1.3.2. Surface Sound Speed Acquisition

Surface sound speed was measured at 1Hz during all MBES operations using the AML Micro•X. The AML Micro•X is installed using the AML or R2Sonic provided mounting bracket and installed just above the face of the MBES receiver. On R/V Benthos and R/V Marcelle, surface sound speed was transmitted at 1Hz to the Kongsberg topside

workstation, where it was utilized for realtime beam forming in the Kongsberg SIS acquisition software and recorded into the raw ALL file as well as into the raw .DB. On R/V Taku, surface sound speed was transmitted at 1Hz to the R2Sonic topside SIM box and subsequently transmitted with the MBES data to QPS QINSy, where it was permanently logged in the raw .DB files. As mentioned above, surface sound speed was additionally utilized during online operations as a QC comparison to sound speed profile data.

B.2. Data Processing

B.2.1. Uncertainty Modeling

Uncertainty values for positioning, sounding, and sound speed equipment were compiled and tabulated for each vessel. Values were determined from manufacturer's specified/suggested values and/or calibration methodology/accuracy. Uncertainty values were entered into each vessel's Template Database File (vessel DB).

Table 11: TPU Values Used in Qimera Processing

Accuracy Values for Total Propagation Error Computation			
Vessel	**R/V BENTHOS**	**R/V TAKU**	**R/V MARCELLE**
Motion Sensor	PosMV 320	PosMV 320	PosMV 320
Position System 1	PosMV 320	PosMV 320	PosMV 320
MBES System	Kongsberg 2040C	R2Sonic 2024	Kongsberg2040C
Gyro - Heading			
Gyro (°)	0.020	0.020	0.010
Heave % Amplitude	5%	5%	5%
Heave (m)	0.050	0.050	0.050
Roll and Pitch			
Roll (°)	0.010	0.010	0.010
Pitch (°)	0.010	0.010	0.010
Measurment			
Offset X (m)	0.003	0.003	0.01
Offset Y (m)	0.003	0.003	0.01
Offset Z (m)	0.001	0.001	0.01
Speed			
Vessel Speed (m/s)	0.030	0.030	0.030
Position / Nav			
Position (m)	0.100	0.100	0.100
Physical Alignment Errors*			
Alignment			
MRU align Stdev gyro	0.050	0.050	0.050
MRU align roll/pitch	0.020	0.020	0.020
*All values given as 1 sigma.			

Total Propagated Uncertainty Computation in CARIS HIPS			
Tide Values			
Tide Value Measured	0.0960	0.0960	0.0960
Sounding Speed Values			
Sound Speed Measured	0.05	0.05	0.05
Surface Sound Speed	0.05	0.05	0.05

B.2.2. QPS Vessel Template Database

A QPS Vessel Template Database file (DB) was created for each vessel. The vessel files contain sensor offsets and biases, static and dynamic draft corrections, and uncertainty values to aid in Total Propagated Uncertainty (TPU) calculations.

The Applanix POSMV on R/V Benthos was configured to output position and motion data to a tangent point between the acoustic centers of the two MBES sonar heads. The locations and angular offsets from this tangent point to each individual sonar head's acoustic center is entered into Kongsberg SIS. Therefore, this configuration yields a Qinsy Vessel DB with (-0.215,0,0) for the port and (0.215,0,0) for starboard offsets for positioning and MBES systems.

The Applanix POSMV on R/V Taku was configured to output position and motion data at the IMU. Offsets to the acoustic centers of the Port and Starboard echosounders were input in the Qinsy Vessel DB.

The Applanix POSMV on R/V Marcelle was configured to output position and motion data to a tangent point between the acoustic centers of the two MBES sonar heads. The locations and angular offsets from this tangent point to each individual sonar head's acoustic center is entered into Kongsberg SIS. Therefore, this configuration yields a Qinsy Vessel DB with (-0.215,0,0) for the port and (0.215,0,0) for starboard offsets for positioning and MBES systems.

B.2.3. Static Draft

As this project utilized an ERS workflow, static draft was not utilized in final sounding computations. Static draft values were measured and recorded during bar check procedures only.

B.2.4. Qimera

Qimera was exclusively utilized for MBES processing throughout the entire project. Processing steps and procedures are detailed below in Figure 17.

The first part (PART 1 in Figure 17) of the processing pipeline consists of a series of standard Qimera processing procedures, which are completed using the Qimera process toolbar and auto processing prompts. In order to ensure each process has been completed, processes are reviewed in the output window.

The second part (PART 2 in Figure 17) of the Qimera processing pipeline consists of detailed review and cleaning of data, as well as project specific tasks such as investigating features or preparing DTON reports for submittal.

The third part (PART 3 in Figure 17) of the Qimera processing pipeline is performed once data collection has been completed for an entire H-Cell sheet. CUBE surfaces are "finalized" by choosing the option to override the CUBE hypothesis with any flagged soundings. This finalized surface then represents the least depth of features and designated soundings.

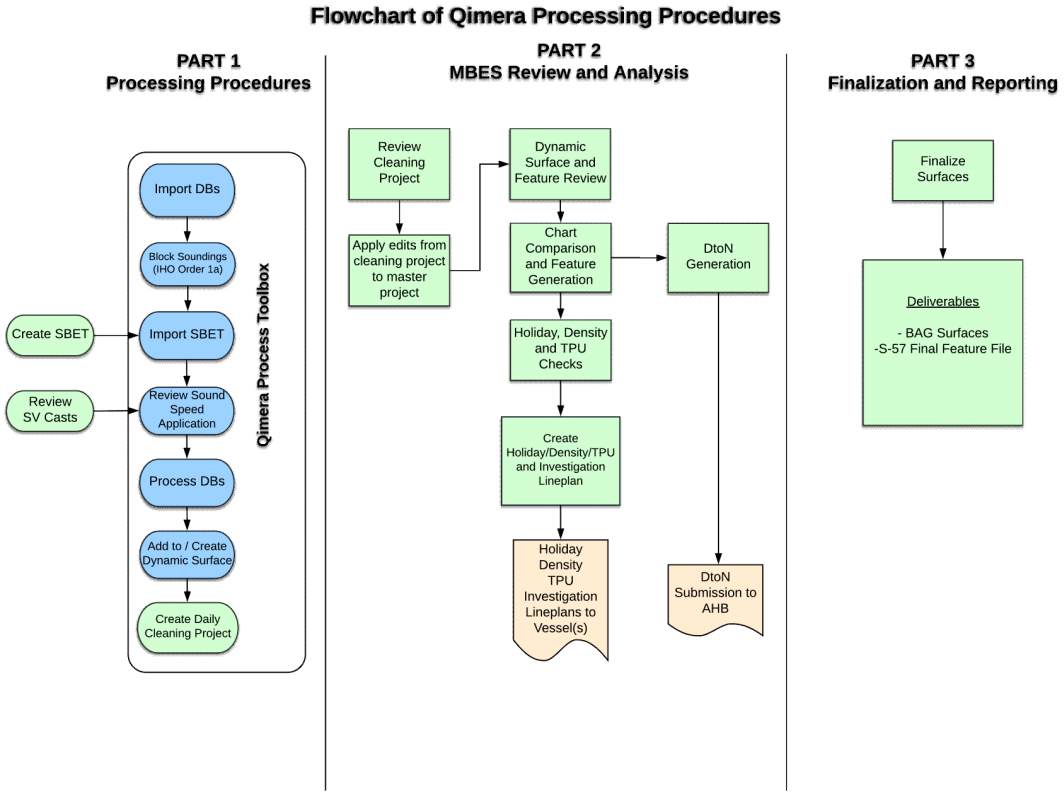

Figure 18: Qimera Processing Procedures

C. Corrections to Echo Soundings

C.1. Vessel Offsets

As mentioned previously, a static vessel survey was performed on R/V Benthos and R/V Taku prior to data collection. From the data provided in the vessel surveys, offsets were computed for sensor locations of the mobilized equipment on each vessel. Offsets were additionally confirmed on R/V Benthos and R/V Taku using a hand tape to ensure no

blunders had occurred during the static vessel survey. A systems diagram of each vessel can be found in Appendix I of this report

C.2. System Alignment

Multibeam patch tests were performed on each vessel prior to commencing data collection. A multibeam patch test is performed in order to measure the mounting/alignment biases between the MBES sensor and the inertial motion unit (IMU). In addition to mounting/alignment biases, a patch test is also performed to determine latency between MBES and position sensor data.

Latency patch tests were performed by running reciprocal survey lines at varying speeds over a local charted wreck.
Roll patch tests were performed by running reciprocal survey lines at equal speeds over a flat bottom.
Pitch patch tests were performed by running reciprocal survey lines at equal speed over a local charted wreck and prominent rock outcropping.
Yaw patch tests were performed by running parallel survey lines at equal speeds over a local charted wreck and prominent rock outcropping.

For R/V Benthos and R/V Marcelle, each pair of specific survey lines were processed onsite using SIS patch utility and further analyzed offline in Qimera Patch Test Tool. Sensor biases were determined and entered into the Installation Parameters menu in Kongsberg SIS on the vessel as well as into the QPS Vessel Template Database file.

For R/V Taku, each pair of specific survey lines were analyzed in Qimera Patch Test Tool. Sensor biases were determined and entered into the QPS Vessel Template Database file.

Patch test data were analyzed independently by 5 hydrographers for crosscheck and also to determine an accurate uncertainty value for the mounting/alignment biases.
All calibration data is included in the digital data deliverable.

Table 12: R/V Benthos Alignment Biases

R/V BENTHOS							
DN	Latency	Pitch		Roll		Yaw	
		PORT	STBD	PORT	STBD	PORT	STBD
237	0.00	0.55	0.55	35.03	-35.12	0.30	0.30

Table 13: R/V Taku Alignment Biases

R/V TAKU							
DN	Latency	Pitch		Roll		Yaw	
		PORT	STBD	PORT	STBD	PORT	STBD
237	0.00	-3.50	-3.40	13.53	-16.36	0.50	0.50
287	0.00	-2.75	-3.37	13.58	-16.25	0.60	0.07
298	0.00	-2.86	-3.48	13.59	-16.23	-0.23	-0.52

Table 14: R/V Marcelle Alignment Biases

R/V MARCELLE							
DN	Latency	Pitch		Roll		Yaw	
		PORT	STBD	PORT	STBD	PORT	STBD
263	0.00	-0.70	-0.50	35.20	-35.10	-2.70	-2.70
284	0.00	-0.70	-0.50	35.20	-35.10	1.40	1.40

C.3. Static Draft

As this project utilized an ERS workflow, static draft was not utilized in final sounding computations. Static draft values were measured and recorded during bar check procedures only.

C.4. Position and Attitude

An Applanix POSMV 320 V5 was mobilized on each vessel as the primary positioning and attitude measurement system. Prior to calibration, lever arms were calculated from the static vessel survey and hand-held measuring of R/V Benthos, R/V Taku and R/V Marcelle. All values were confirmed and entered into the POSMV configuration, including primary GPS antenna to reference point (RP), inertial motion unit to RP, sensor 1 to RP, and center of rotation to RP.

A GNSS Azimuth Measurement Sub-System (GAMS) calibration was performed with the heading accuracy threshold set to 0.5 degrees.

POSMV Calibration reports can be found in Appendix III of this report.

C.5. Delayed Heave

During acquisition, trajectory data was logged by the Applanix POSMV and post-processed with reference station data in POSPac MMS to output a SBET.

Delayed heave data (SBETs) were applied in Qimera during the processing pipeline detailed in section B.2.4.

C.7. Waterlevel Corrections

In accordance with the Project Instructions, a separation model between the ITRF Ellipsoid and the MLLW navigation surface was created using VDatum. The separation model was applied to all project data in order to reduce the ellipsoidally referenced sounding data to MLLW navigation datum. A 100x100 meter separation model was developed using VDatum. This model was carried through the entire pipeline from acquisition to final deliverables.

C.8. Sound Speed Corrections

Sound speed profiles collected in the field were applied to the MBES data. On each vessel, raw Qinsy .DB files store sound speed profile data real-time for each separate line of data. In Qimera, sound speed data is imported simultaneously with each respective raw DB file. During acquisition, hydrographers would choose which sound speed profile to apply to the bathymetry currently being collected. This decision was based on a number of factors, including age of sound speed data, deviation from current surface sound speed measurements, and changes in oceanographic characteristics. If sound speed data existed within the past 4 hours in a particular area that the ship was working in, that sound speed cast would be applied to the realtime data. Essentially, this realtime method of managing sound velocity casts produces the same result as using "Nearest in Distance within Time" as the sound speed strategy in Qimera, eliminating the need for extra sound speed processing in the office. However, in certain cases, the sound speed strategy in Qimera could be changed from "Real-Time Scheduling" to "Nearest in Distance within Time" should the processor need to engage in post collection sound speed processing.

Surface sound speed was collected at the R2Sonic or Kongsberg transducer face, and sent via serial connection directly to the R2Sonic topside unit or to the Kongsberg topside workstation in order to facilitate beam steering.

D. Approval Sheet

OPR-H355-KR-18

Registry Nos.
H13160
H13161
H13162
H13163
H13164
H13165
H13166
H13167
H13168
H13169
F00757

Data Acquisition and Processing Report

This report and the accompanying data are respectfully submitted.

Field operations contributing to the accomplishment of Surveys H13160, H13161, H13162, H13163, H13164, H13165, H13166, H13167, H13168, H13169 and F00757 were conducted under my direct supervision with frequent personal checks of progress and adequacy. This report and associated data have been closely reviewed and are considered complete and adequate as per the Statement of Work.

Digitally signed by David Neff
Date: 2018.11.20 20:56:04-08'00'

David R. Neff | eTrac Inc. | Lead Hydrographer November 20, 2018

eTrac Inc.
November 2018