U.S. Department of Commerce
National Oceanic and Atmospheric Administration
National Ocean Service

Data Acquisition & Processing Report

Type of Survey:	Navigable Area
Project Number:	OPR-Y395-KR-20
Time Frame:	May - December 2020

LOCALITY

State(s):	Illinois Indiana Michigan
General Locality:	Chicago, IL

2020

CHIEF OF PARTY
David J. Bernstein, CH, PLS, GISP

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

H13363
H13364
H13365
H13366
H13367
H13368
H13369

FIELD No

Geodynamics LLC

State	Illinios, Indiana, Michigan		
General Locality	Chicago, IL		
Sub-Locality	Vicinity of Chicago, IL		
Scale	1:5,000 1:10,000 1:20,000	**Date of Survey**	May - August 2020
Instructions Dated	March 27, 2020	**Project No.**	OPR-Y395-KR-20
Vessel	R/V Benthos, R/V Chinook, R/V Substantial, R/V Endeavor		
Chief of Party	David J. Bernstein, CH, PLS, GISP		
Surveyed by	Geodynamics LLC		
Soundings by echo sounder	Kongsberg EM2040C, 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 Low Water Datum (LWD), International Great Lakes Datum 1985 (IGLD85)		

REMARKS:

WGS84, UTM Zone 16 North
Times are in UTC
The purpose of this contract is to provide NOAA with modern, accurate hydrographic
survey data to update the nautical charts of the assigned area.

SUBCONSULTANTS:

eTrac Inc., 637 Lindaro, Suite 100, San Rafael, CA 94901
Ocean Operators LLC, 848 N. Rainbow Blvd. #4755, Las Vegas, NV, 89107

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

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Data Acquisition and Processing Report

Geodynamics LLC
Chief of Party: David J. Bernstein, CH, PLS, GISP
Year: 2020
Version: 1
Publish Date: 2020-11-21

A. System Equipment and Software

A.1 Survey Vessels

A.1.1 R/V Benthos

<table>
<tr><td><i>Vessel Name</i></td><td colspan="2">R/V Benthos</td></tr>
<tr><td><i>Hull Number</i></td><td colspan="2">ACD28CATA212</td></tr>
<tr><td><i>Description</i></td><td colspan="2">Geodynamics LLC supplied the R/V Benthos for hydrographic survey operations on OPR-Y395-KR-20. The R/V Benthos is a 9.14 meter catamaran built by Armstrong Marine. The R/V Benthos has the following specifications:</td></tr>
<tr><td rowspan="3"><i>Dimensions</i></td><td><i>LOA</i></td><td>9.14 m</td></tr>
<tr><td><i>Beam</i></td><td>3.20 m</td></tr>
<tr><td><i>Max Draft</i></td><td>0.61 m</td></tr>
<tr><td rowspan="2"><i>Most Recent Full Static Survey</i></td><td><i>Date</i></td><td>2017-08-11</td></tr>
<tr><td><i>Performed By</i></td><td>Lanier Surveying Company</td></tr>
<tr><td rowspan="2"><i>Most Recent Partial Static Survey</i></td><td><i>Date</i></td><td>2020-05-01</td></tr>
<tr><td><i>Performed By</i></td><td>Tim Malley, NC PLS</td></tr>
<tr><td rowspan="2"><i>Most Recent Full Offset Verification</i></td><td><i>Date</i></td><td>2020-05-12</td></tr>
<tr><td><i>Method</i></td><td>The R/V Benthos offset survey was verified by a team of hydrographers from Geodynamics prior to the start of field operations for OPR-Y395-KR-20. Survey instrument offsets were measured using hand measurement instruments like metal tape measures, digital levels, long carpenter levels, T-squares, and plumb bobs. All measurements were performed multiple times and in varying combinations to reduce uncertainty and blunders.</td></tr>
</table>

Figure 1: R/V Benthos

A.1.2 R/V Chinook

<table>
<tr><td><i>Vessel Name</i></td><td colspan="2">R/V Chinook</td></tr>
<tr><td><i>Hull Number</i></td><td colspan="2">IAR28CATJ607</td></tr>
<tr><td><i>Description</i></td><td colspan="2">Geodynamics LLC supplied the R/V Chinook for hydrographic survey operations on OPR-Y395-KR-20. The R/V Chinook is a 9.44 meter catamaran built by Armstrong Marine. The R/V Chinook has the following specifications:</td></tr>
<tr><td rowspan="3"><i>Dimensions</i></td><td><i>LOA</i></td><td>9.44 m</td></tr>
<tr><td><i>Beam</i></td><td>3.20 m</td></tr>
<tr><td><i>Max Draft</i></td><td>0.61 m</td></tr>
<tr><td rowspan="2"><i>Most Recent Full Static Survey</i></td><td><i>Date</i></td><td>2020-05-01</td></tr>
<tr><td><i>Performed By</i></td><td>Tim Malley, NC PLS</td></tr>
</table>

Most Recent Full Offset Verification	*Date*	2020-05-21
	Method	The R/V Chinook offset survey was verified by a team of hydrographers from Geodynamics prior to the start of field operations for OPR-Y395-KR-20. Survey instrument offsets were measured using hand measurement instruments like metal tape measures, digital levels, long carpenter levels, T-squares, and plumb bobs. All measurements were performed multiple times and in varying combinations to reduce uncertainty and blunders.

Figure 2: R/V Chinook

A.1.3 R/V Endeavor

Vessel Name	R/V Endeavor
Hull Number	338342779
Description	Subcontractor eTrac Inc. provided the R/V Endeavor for hydrographic survey operations on OPR-Y395-KR-20. The R/V Endeavor is a 13.41 meter catamaran built by Armstrong Marine. The R/V Endeavor has the following specifications:

Dimensions	*LOA*	13.41 m
	Beam	4.11 m
	Max Draft	0.76 m
Most Recent Full Static Survey	*Date*	2020-05-27
	Performed By	eTrac Inc.
Most Recent Full Offset Verification	*Date*	2020-05-28
	Method	The R/V Endeavor offset survey was verified by a team of hydrographers from eTrac and Geodynamics prior to the start of field operations for OPR-Y395-KR-20. Survey instrument offsets were measured using hand measurement instruments like metal tape measures, digital levels, long carpenter levels, T-squares, and plumb bobs. All measurements were performed multiple times and in varying combinations to reduce uncertainty and blunders.

Figure 3: R/V Endeavor

A.1.4 R/V Substantial

Vessel Name	R/V Substantial	
Hull Number	USZ00221D013	
Description	Geodynamics LLC supplied the R/V Substantial for hydrographic survey operations on OPR-Y395-KR-20. The R/V Substantial is a 16.15 meter Seaton-designed mono-hull vessel built by Marks Marine. The R/V Substantial has the following specifications:	
Dimensions	*LOA*	16.15 m
	Beam	5.48 m
	Max Draft	1.89 m
Most Recent Full Static Survey	*Date*	2020-03-25
	Performed By	Tyler McMillin, NOAR Technologies
Most Recent Full Offset Verification	*Date*	2020-07-16
	Method	The R/V Substantial offset survey was verified by a team of hydrographers from Geodynamics prior to the start of field operations for OPR-Y395-KR-20. Survey instrument offsets were measured using hand measurement instruments like metal tape measures, digital levels, long carpenter levels, T-squares, and plumb bobs. All measurements were performed multiple times and in varying combinations to reduce uncertainty and blunders.

Figure 4: R/V Substantial

A.2 Echo Sounding Equipment

A.2.1 Multibeam Echosounders

A.2.1.1 Kongsberg EM2040C Dual

The R/V Benthos and R/V Chinook were each equipped with a dual-head Kongsberg EM2040C Multibeam Echosounder System (MBES) with sonar heads mounted at 35°/-35°. On each vessel, two processing units were combined to enable dual swath mode. The R/V Substantial was equipped with a dual-head Kongsberg EM2040C MBES with sonar heads mounted at 37.5°/-37.5°. The dual-head EM2040C utilizes 512 discretely formed beams of a selectable sector up to 200° in equidistant operation mode. At 300 kHz, the EM2040C focuses an across-track and along-track beamwidth of 1° and 1° respectively. The EM2040C operates at a maximum ping rate of 50 Hz and is designed to comply with International Hydrographic Organization (IHO) standards for depth measurements to a maximum range of 450 meters.

Manufacturer	Kongsberg
Model	EM2040C Dual

Inventory	*R/V Benthos*	*Component*	Port Sonar Head	Stbd Sonar Head	Processing Unit 1	Processing Unit 2	Hydrographic Workstation
		Model Number	EM2040C	EM2040C	385406	385406	Cincoze DS-1202
		Serial Number	2549	2548	20188	20159	U726920
		Frequency	300 kHz	300 kHz	N/A	N/A	N/A
		Calibration	2020-05-30	2020-05-30	N/A	N/A	N/A
		Accuracy Check	2020-05-30	2020-05-30	N/A	N/A	N/A
	R/V Chinook	*Component*	Port Sonar Head	Stbd Sonar Head	Processing Unit 1	Processing Unit 2	Hydrographic Workstation
		Model Number	EM2040C	EM2040C	385406	385406	Cincoze DS-1202
		Serial Number	2566	2565	20190	20193	U743019
		Frequency	300 kHz	300 kHz	N/A	N/A	N/A
		Calibration	2020-05-30	2020-05-30	N/A	N/A	N/A
		Accuracy Check	2020-05-30	2020-05-30	N/A	N/A	N/A
	R/V Substantial	*Component*	Port Sonar Head	Stbd Sonar Head	Processing Unit	Hydrographic Workstation	
		Model Number	EM2040C	EM2040C	385406	Cincoze DS-1202	
		Serial Number	2532	2513	20043	U756910	
		Frequency	300 kHz	300 kHz	N/A	N/A	
		Calibration	2020-07-30	2020-07-30	N/A	N/A	
		Accuracy Check	2020-08-01	2020-08-01	N/A	N/A	

Figure 5: Kongsberg EM2040C dual-head sonar

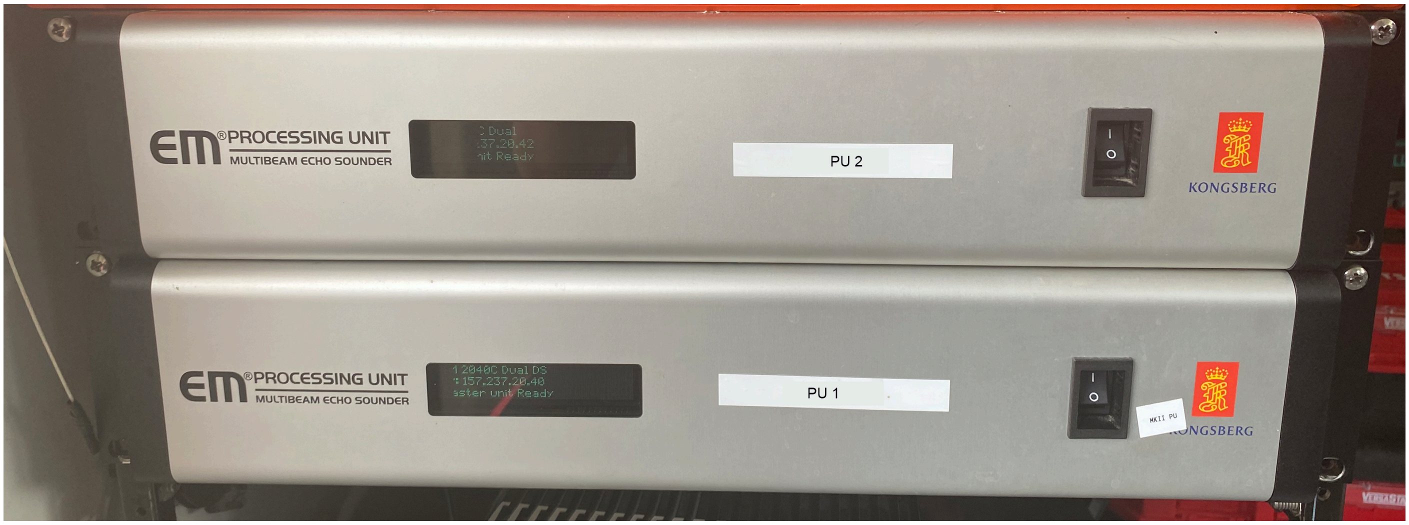

Figure 6: Kongsberg Slim Processing Unit (PU) setup in dual swath configuration

A.2.1.2 R2 Sonic 2024 Dual

The R/V Endeavor was equipped with a dual-head R2 Sonic 2024 MBES with sonar heads mounted at 20.0°/-20.0°. The dual-head 2024 utilizes 512 discretely formed beams over a selectable sector up to

160° per sonar. At 250 kHz, the 2024 focuses an across-track and along-track beamwidth of 0.9° and 1.8° respectively and at 350 kHz, the 2024 focuses an across-track and along-track beamwidth of 0.7° and 1.3° respectively. The 2024 operates at a maximum ping rate of 60 Hz and is designed to comply with IHO standards for depth measurement to a maximum range of 400 meters.

Manufacturer	R2 Sonic								
Model	2024 Dual								
Inventory	*R/V Endeavor*	*Component*	Port SIM Box	Port Receiver	Port Projector	Stbd SIM Box	Stbd Receiver	Stbd Projector	Hydrographic Workstation
		Model Number	2024	2024	2024	2024	2024	2024	Dell Precision 3431
		Serial Number	103724	101794	806829	104267	101639	807033	12657076959
		Frequency	N/A	250	250	N/A	350	350	N/A
		Calibration	N/A	2020-05-30	2020-05-30	N/A	2020-05-30	2020-05-30	N/A
		Accuracy Check	N/A	2020-05-30	2020-05-30	N/A	2020-05-30	2020-05-30	N/A

Figure 7: R2 Sonic 2024 dual-head sonar

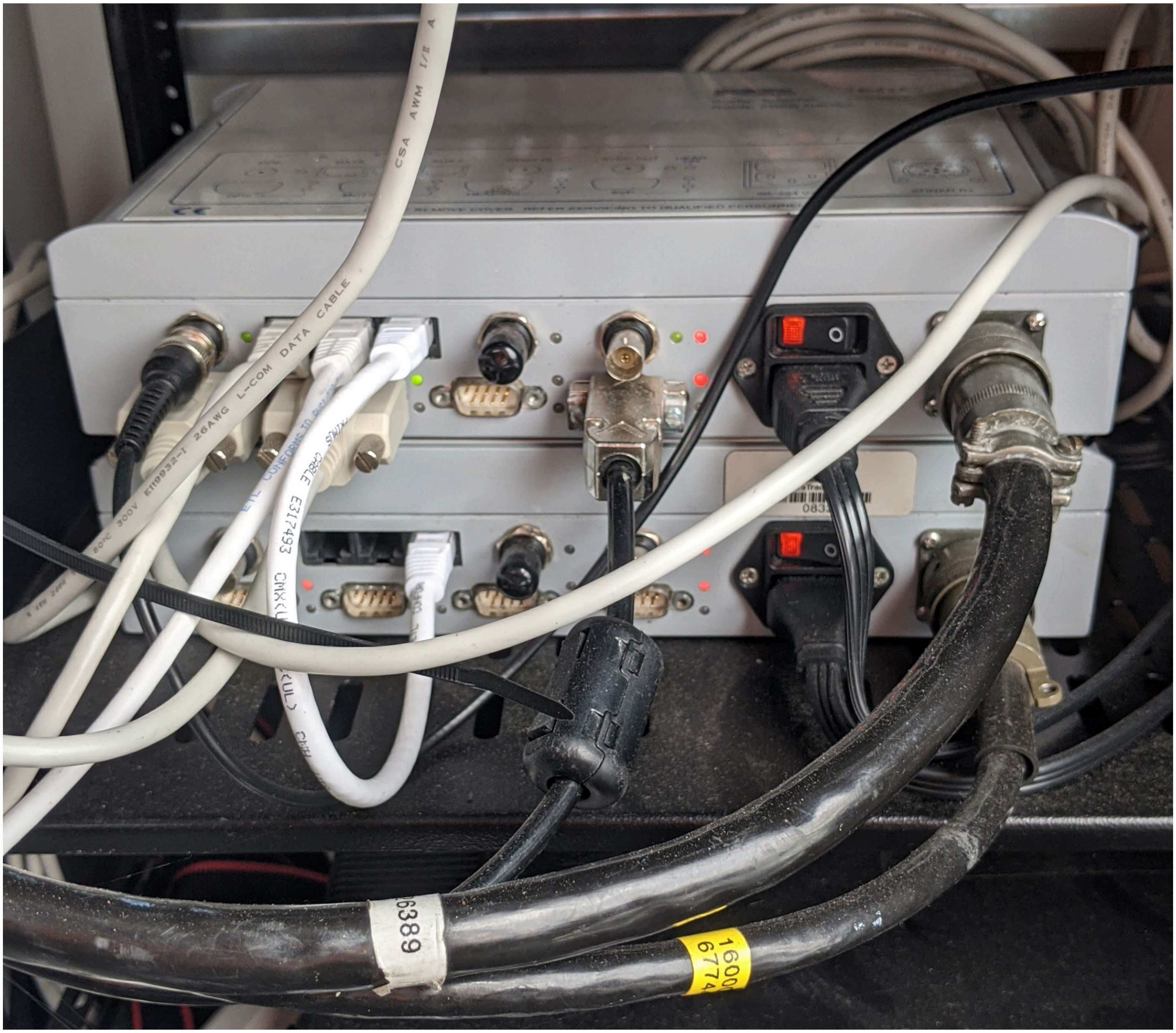

Figure 8: R2 Sonic 2024 SIM Boxes (dual-head configuration)

A.2.2 Single Beam Echosounders

No single beam echosounders were utilized for data acquisition.

A.2.3 Side Scan Sonars

No side scan sonars were utilized for data acquisition.

A.2.4 Phase Measuring Bathymetric Sonars

No phase measuring bathymetric sonars were utilized for data acquisition.

A.2.5 Other Echosounders

No additional echosounders were utilized for data acquisition.

A.3 Manual Sounding Equipment

A.3.1 Diver Depth Gauges

No diver depth gauges were utilized for data acquisition.

A.3.2 Lead Lines

No lead lines were utilized for data acquisition.

A.3.3 Sounding Poles

No sounding poles were utilized for data acquisition.

A.3.4 Other Manual Sounding Equipment

No additional manual sounding equipment was utilized for data acquisition.

A.4 Horizontal and Vertical Control Equipment

A.4.1 Base Station Equipment

No base station equipment was utilized for data acquisition.

A.4.2 Rover Equipment

No rover equipment was utilized for data acquisition.

A.4.3 Water Level Gauges

No water level gauges were utilized for data acquisition.

A.4.4 Levels

No levels were utilized for data acquisition.

A.4.5 Other Horizontal and Vertical Control Equipment

No other equipment were utilized for data acquisition.

A.5 Positioning and Attitude Equipment

A.5.1 Positioning and Attitude Systems

A.5.1.1 Applanix POS MV V5 OceanMaster

Each survey vessel deployed on OPR-Y395-KR-20 utilized an Applanix POS MV system for positioning, attitude, and precise timing of sonar data. The POS MV is a Global Navigation Satellite System (GNSS) aided inertial navigation system that provides georeferencing and motion compensation for hydrographic surveys. The POS MV is comprised of four main components: POS Computer System (PCS), Inertial Measurement Unit (IMU), Primary GNSS Antenna, and the Secondary GNSS Antenna.

On the R/V Benthos, R/V Chinook, and R/V Substantial, positioning and heading were transmitted from the POS MV at 10 Hz and attitude was transmitted at 100 Hz to the Kongsberg sonar over RS232 serial connections. These data were also broadcast to QPS Qinsy software over Ethernet/UDP at 50 Hz for vessel navigation and real-time quality control (QC). On the R/V Endeavor, position, attitude, and heading data were broadcast to QPS Qinsy over Ethernet/UDP at 50 Hz for vessel navigation, real-time QC, and sonar data logging.

The POS MV provided precise timing for sonar data to both the Kongsberg PU and the R2 Sonic SIM Box via BNC Pulse Per Second cable. Additionally, a NMEA ZDA message was transmitted at 1 Hz from the POS MV to QPS Qinsy and Kongsberg SIS.

The R/V Benthos, R/V Chinook, and R/V Substantial utilized POS MV firmware version 10.21 and POSView software version 10.20. The R/V Endeavor utilized POS MV firmware version 9.83 and POSView software version 9.82.

During pre-survey calibrations, and when required (equipment failure/change), a POS MV calibration was performed. This calibration included a GNSS Azimuth Measurement System (GAMS) calibration and details can be found in the DAPR Appendix IV.

Listed below are two IMUs (IMU 65 and IMU 38) that were each installed on the R/V Endeavor during OPR-Y395-KR-20. IMU cable failure led to the backup IMU 38 being utilized for a short duration. This is documented in DAPR Appendix IV.

<table>
<tr><td><i>Manufacturer</i></td><td colspan="2">Applanix</td></tr>
<tr><td><i>Model</i></td><td colspan="2">POS MV V5 OceanMaster</td></tr>
<tr><td rowspan="4"><i>Inventory</i></td><td><i>R/V Benthos</i></td><td>
<table>
<tr><td><i>Component</i></td><td>PCS</td><td>Primary GNSS Antenna</td><td>Secondary GNSS Antenna</td><td>IMU</td></tr>
<tr><td><i>Model Number</i></td><td>PCS-100</td><td>540AP</td><td>540AP</td><td>IMU 65</td></tr>
<tr><td><i>Serial Number</i></td><td>11164</td><td>17989</td><td>17985</td><td>3250</td></tr>
<tr><td><i>Calibration</i></td><td>2020-05-28</td><td>2020-05-28</td><td>2020-05-28</td><td>2020-05-28</td></tr>
</table>
</td></tr>
<tr><td><i>R/V Chinook</i></td><td>
<table>
<tr><td><i>Component</i></td><td>PCS</td><td>Primary GNSS Antenna</td><td>Secondary GNSS Antenna</td><td>IMU</td></tr>
<tr><td><i>Model Number</i></td><td>PCS-100</td><td>540AP</td><td>540AP</td><td>IMU 65</td></tr>
<tr><td><i>Serial Number</i></td><td>11165</td><td>17980</td><td>17992</td><td>5272</td></tr>
<tr><td><i>Calibration</i></td><td>2020-05-28</td><td>2020-05-28</td><td>2020-05-28</td><td>2020-05-28</td></tr>
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</td></tr>
<tr><td><i>R/V Substantial</i></td><td>
<table>
<tr><td><i>Component</i></td><td>PCS</td><td>Primary GNSS Antenna</td><td>Secondary GNSS Antenna</td><td>IMU</td></tr>
<tr><td><i>Model Number</i></td><td>PCS-84</td><td>540AP</td><td>540AP</td><td>IMU 65</td></tr>
<tr><td><i>Serial Number</i></td><td>6622</td><td>18417</td><td>18510</td><td>3532</td></tr>
<tr><td><i>Calibration</i></td><td>2020-07-30</td><td>2020-07-30</td><td>2020-07-30</td><td>2020-07-30</td></tr>
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</td></tr>
<tr><td><i>R/V Endeavor</i></td><td>
<table>
<tr><td><i>Component</i></td><td>PCS</td><td>Primary GNSS Antenna</td><td>Secondary GNSS Antenna</td><td>Primary GNSS Antenna</td><td>Secondary GNSS Antenna</td><td>IMU</td><td>IMU</td></tr>
<tr><td><i>Model Number</i></td><td>PCS-84</td><td>GA830</td><td>GA830</td><td>540AP</td><td>540AP</td><td>IMU 65</td><td>IMU 38</td></tr>
<tr><td><i>Serial Number</i></td><td>7163</td><td>9326</td><td>13030</td><td>18417</td><td>18510</td><td>2904</td><td>2658</td></tr>
<tr><td><i>Calibration</i></td><td>2020-05-27</td><td>2020-05-27</td><td>2020-05-27</td><td>2020-06-09</td><td>2020-06-09</td><td>2020-05-27</td><td>2020-06-09</td></tr>
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</td></tr>
</table>

Figure 9: POS MV OceanMaster system

A.5.2 DGPS

DGPS equipment was not utilized for data acquisition.

A.5.3 GPS

GPS equipment was not utilized for data acquisition.

A.5.4 Laser Rangefinders

Laser rangefinders were not utilized for data acquisition.

A.5.5 Other Positioning and Attitude Equipment

A.5.5.1 Fugro Marinestar Satellite-Based Augmentation System (SBAS)

Each survey vessel deployed on OPR-Y395-KR-20 received G2+ GNSS satellite corrections from the Marinestar worldwide correction system. SBAS settings in the POS MV were configured to receive the G2+ correction at a frequency of 1539.9325 MHz and bit rate of 1200 bits/second.

Manufacturer	Fugro		
Model	Marinestar Satellite-Based Augmentation System (SBAS)		
Inventory	*R/V Benthos*	*Component*	Marinestar SBAS
		Model Number	N/A
		Serial Number	N/A
		Calibration	N/A
	R/V Chinook	*Component*	Marinestar SBAS
		Model Number	N/A
		Serial Number	N/A
		Calibration	N/A
	R/V Substantial	*Component*	Marinestar SBAS
		Model Number	N/A
		Serial Number	N/A
		Calibration	N/A
	R/V Endeavor	*Component*	Marinestar SBAS
		Model Number	N/A
		Serial Number	N/A
		Calibration	N/A

A.6 Sound Speed Equipment

A.6.1 Moving Vessel Profilers

A.6.1.1 AML Oceanographic MVP30-350

The R/V Substantial was outfitted with an AML Oceanographic Moving Vessel Profiler (MVP) used to obtain sound speed profiles at a greater frequency without stopping the survey vessel. The AML MVP30-350 system consists of a sensor free fall fish, an integrated winch and power unit, an overboard towing sheave, and a remote system controller with dedicated operating station running the MVP Controller software. Sound speed profiles acquired with the MVP were imported into Sound Speed Manager via ethernet/UDP and then broadcast directly to Kongsberg SIS.

<table>
<tr><td>Manufacturer</td><td colspan="2">AML Oceanographic</td></tr>
<tr><td>Model</td><td colspan="2">MVP30-350</td></tr>
<tr><td>Inventory</td><td>R/V Substantial</td><td>
<table>
<tr><td>Component</td><td>Sound Speed Profiling Instrument</td><td>SV Sensor</td><td>Pressure Sensor</td></tr>
<tr><td>Model Number</td><td>MVP30-350</td><td>SV•Xchange</td><td>P•Xchange</td></tr>
<tr><td>Serial Number</td><td>M12540</td><td>209207</td><td>306273</td></tr>
<tr><td>Calibration</td><td>N/A</td><td>2020-04-22</td><td>2020-04-23</td></tr>
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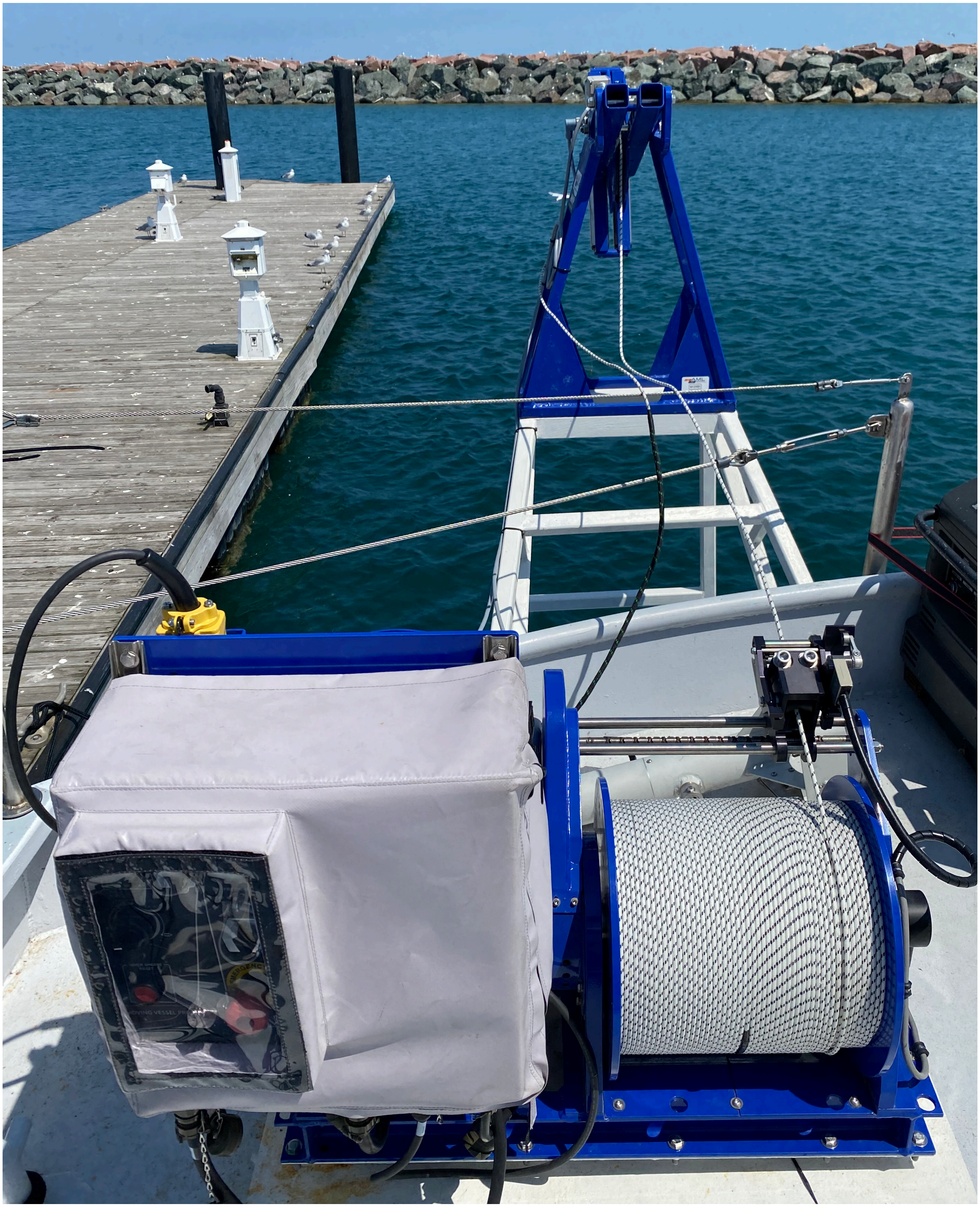


Figure 10: AML Oceanographic MVP30-350

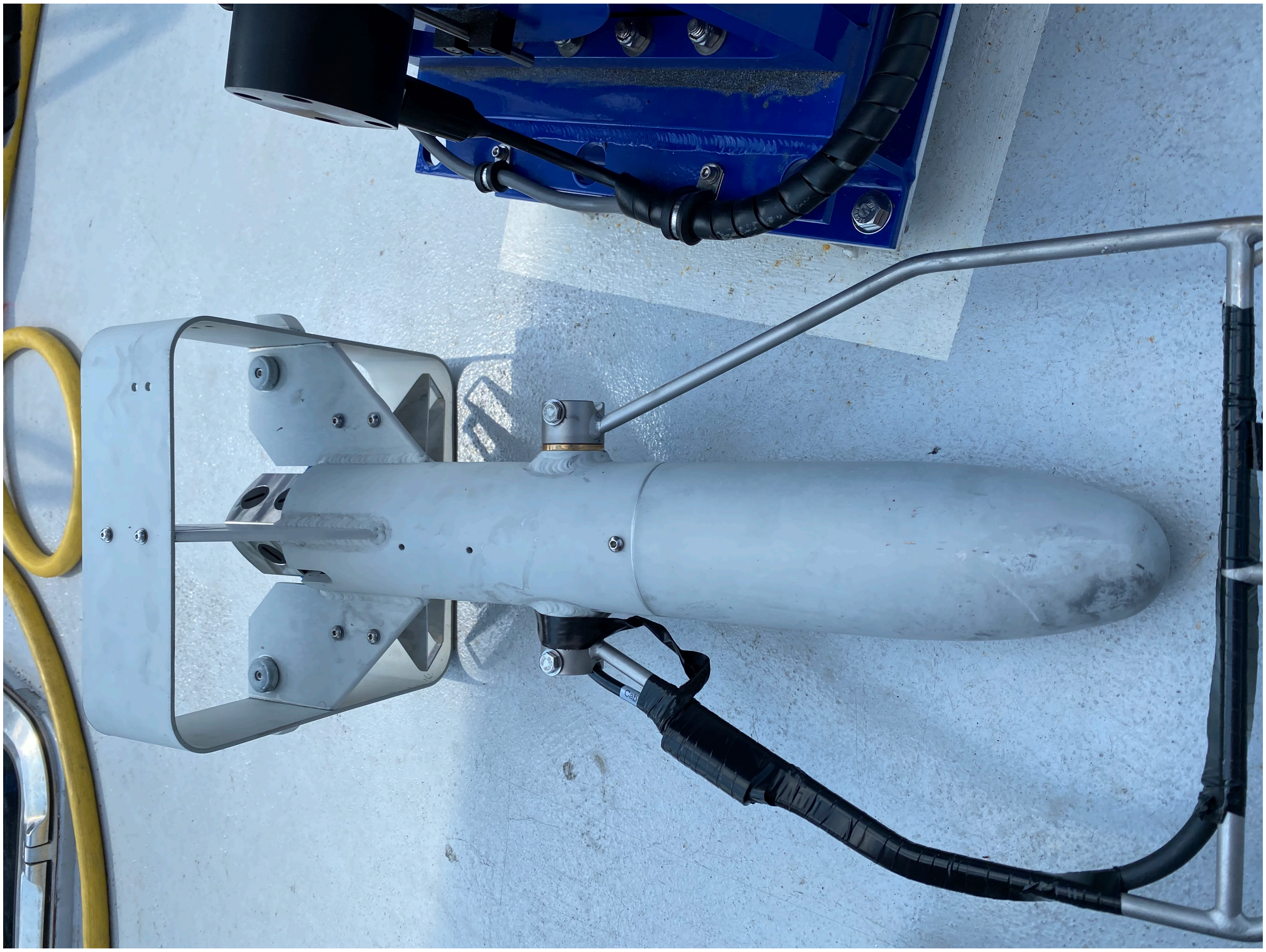


Figure 11: MVP Sensor free fall fish

A.6.2 CTD Profilers

No CTD profilers were utilized for data acquisition.

A.6.3 Sound Speed Sensors

A.6.3.1 AML Oceanographic AML Micro•X with SV•Xchange

Each survey vessel deployed on OPR-Y395-KR-20 utilized an AML Oceanographic Micro•X with SV•Xchange to provide surface sound speed to the Kongsberg PU or R2 Sonic SIM Box at 1 Hz over RS232 serial connection. The sensor, installed on the sonar head mount, was powered from a 12 volt power source for the Kongsberg systems and powered directly from the R2 Sonic SIM Box on the R/V Endeavor.

Manufacturer	AML Oceanographic			
Model	AML Micro•X with SV•Xchange			
Inventory	*R/V Benthos*	*Component*	Surface Sound Speed Instrument	SV Sensor
		Model Number	Micro•X	SV•Xchange
		Serial Number	7762	204291
		Calibration	N/A	2020-04-19
	R/V Chinook	*Component*	Surface Sound Speed Instrument	SV Sensor
		Model Number	Micro•X	SV•Xchange
		Serial Number	12031	208604
		Calibration	N/A	2019-10-24
	R/V Substantial	*Component*	Surface Sound Speed Instrument	SV Sensor
		Model Number	Micro•X	SV•Xchange
		Serial Number	11427	201370
		Calibration	N/A	2020-04-19
	R/V Endeavor	*Component*	Surface Sound Speed Instrument	SV Sensor
		Model Number	Micro•X	SV•Xchange
		Serial Number	10858	209342
		Calibration	N/A	2020-04-10

Figure 12: AML Oceanographic Micro•X with SV•Xchange

A.6.3.2 AML Oceanographic AML Base•X2 / Smart•X with SV•Xchange

The AML Base•X2 and Smart•X are sound speed profiling instruments integrated with time of flight sound speed sensors and pressure sensors to collect sound speed profiles. The Base•X2 transferred sound speed profile data to AML Seacast over Wireless Local Area Network (WLAN) connection and RS232 serial cable when needed. The Smart•X, primarily used on the R/V Endeavor, transferred data to the eTrac SVP Profiler software through an RS232 serial cable. Following a manufacturer serial cable failure, the R/V Endeavor was forced to switch to a Base•X2 and use AML Seacast. However, the same SV•Xchange and pressure sensor were still utilized.

Manufacturer	AML Oceanographic
Model	AML Base•X2 / Smart•X with SV•Xchange

Inventory

R/V Benthos

Component	Sound Speed Profiling Instrument	SV Sensor	Pressure Sensor
Model Number	Base•X2	SV•Xchange	P•Xchange
Serial Number	26045	206265	306187
Calibration	N/A	2020-04-19	2020-03-31

R/V Chinook

Component	Sound Speed Profiling Instrument	SV Sensor	Pressure Sensor
Model Number	Base•X2	SV•Xchange	P•Xchange
Serial Number	26005	208602	306129
Calibration	N/A	2019-10-24	2019-10-24

R/V Endeavor

Component	Sound Speed Profiling Instrument	Sound Speed Profiling Instrument	SV Sensor	Pressure Sensor
Model Number	Base•X2	Smart•X	SV•Xchange	P•Xchange
Serial Number	26213	20218	209355	306834
Calibration	N/A	N/A	2020-03-30	2020-04-16

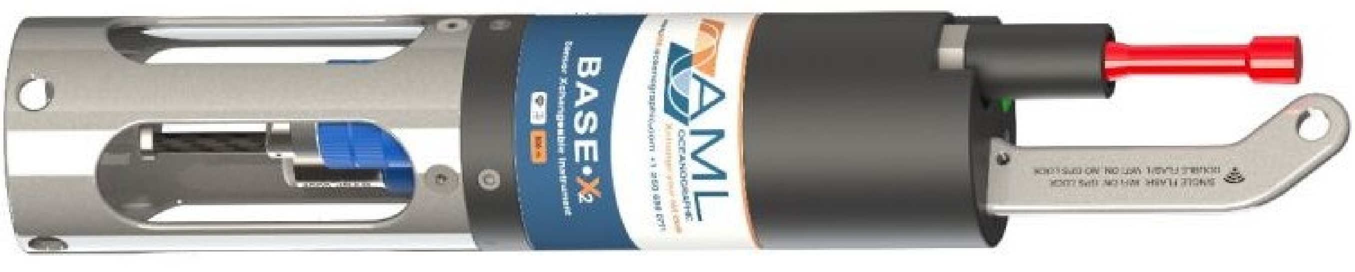


Figure 13: AML Oceanographic Base•X2

Figure 14: AML Oceanographic Smart•X

A.6.4 TSG Sensors

No surface sound speed sensors were utilized for data acquisition.

A.6.5 Other Sound Speed Equipment

No surface sound speed sensors were utilized for data acquisition.

A.7 Computer Software

Manufacturer	*Software Name*	*Version*	*Use*
QPS	Qinsy	9.1.1	Acquisition
R2 Sonic LLC	R2 Sonic Controller	2/9/2019	Acquisition
AML Oceanographic	Seacast	4.3.1	Acquisition
AML Oceanographic	Seacast	4.4.0	Acquisition
AML Oceanographic	MVP Controller	4.3.1	Acquisition
Applanix	POSView	10.20	Acquisition
Applanix	POSView	9.82	Acquisition
Applanix	POS MV Firmware	10.21	Acquisition
Applanix	POS MV Firmware	9.83	Acquisition
Kongsberg	Seafloor Information System (SIS)	4.3.2	Acquisition
Kongsberg	Kongsberg Firmware	1.6	Acquisition
NOAA Hydrographic Systems and Technology Branch (HSTB)	Sound Speed Manager	2020	Acquisition
eTrac	SVP Profiler	5/28/2020	Acquisition
Microsoft	Office 365	2020	Acquisition and Processing
Google	Google Drive	2020	Acquisition and Processing
NOAA (HSTB)	Pydro Explorer	19.4	Acquisition and Processing
ESRI	ArcGIS Online	2020	Acquisition and Processing
ESRI	ArcGIS Enterprise	10.8	Acquisition and Processing
ESRI	ArcPro	2.6.2	Processing
Teledyne CARIS	HIPS Professional	10.4.22	Processing
Teledyne CARIS	BASE Editor	4.4	Processing
QPS	Qimera	2.1.0	Processing
QPS	FMGeocoder Toolbox (FMGT)	7.9.3	Processing
Applanix	POSPac MMS with Trimble Centerpoint RTX	8.4	Processing
Adobe	Acrobat DC	2020.013.20064	Processing
TechSmith	Snagit	2020.1.3	Processing

A.8 Bottom Sampling Equipment

A.8.1 Bottom Samplers

A.8.1.1 Wildco Petite Ponar (3-1728-G42, SN 0618)

The Wildco Petite Ponar sampler was used aboard the R/V Chinook to acquire all bottom samples for OPR-Y395-KR-20. Ponar samplers are widely used for sediment sampling on a variety of bottom types such as silt, sand, gravel, consolidated marl, or clay.

Figure 15: Wildco Petite Ponar

B. System Alignment and Accuracy

B.1 Vessel Offsets and Layback

B.1.1 Vessel Offsets

Static vessel surveys were performed to determine offsets on each vessel deployed on OPR-Y395-KR-20 at differing times prior to survey operations. Tim Malley, NC PLS, performed the most recent static surveys of the R/V Benthos and R/V Chinook on May 1, 2020 using a Trimble SPS 700 Robotic Total Station at Geodynamics Headquarters in Newport, NC. These static surveys re-occupied a variety of previous vessel reference punch marks to ensure quality of the vessel offsets and reference frame measurements. Tim Dyer, of eTrac, performed the most recent static survey of the R/V Endeavor on May 27, 2020 at Crowley's Boat Yard in Chicago, Illinois. All sensor locations were surveyed, as well as a number of pre-determined punch mark locations across the vessel frame. Tyler McMillin of NOAR Technologies performed an initial survey of the R/V Substantial using a Leica RTC 360 on March 25, 2020. This survey, combined with a manual static offset survey, confirmed the vessel reference frame offsets and further developed sensor offsets. In addition to all static vessel surveys, a full offset verification was performed for all vessels onsite prior to survey operations. The offsets were verified by a team of hydrographers from Geodynamics and eTrac using hand measurement instruments like metal tape measures, digital levels, long carpenter levels, T-squares, and plumb bobs.

The R/V Benthos, R/V Chinook, and R/V Substantial are each configured such that position and attitude are output from the POS MV at the sonar reference point. The sonar reference point is defined as the tangent point between each sonar head in the dual-head configuration. The location and angular offsets from the tangent reference point to each sonar head, and also the waterline, are entered into Kongsberg SIS. Identical vessel offsets were input in the Qinsy vessel template database (.DB) file for real-time display of corrected sonar data during acquisition.

The R/V Endeavor was configured to output position and attitude data at the IMU. Offsets from the IMU to the acoustic centers of the port and starboard echosounders were input in the template .DB file. The .DB file contained sensor offsets and biases, draft corrections, and uncertainty values to aid in Total Propagated Uncertainty (TPU) calculations.

Figure 16: Static survey of R/V Benthos

B.1.1.1 Vessel Offset Correctors

Vessel offset correctors were not applied.

B.1.2 Layback

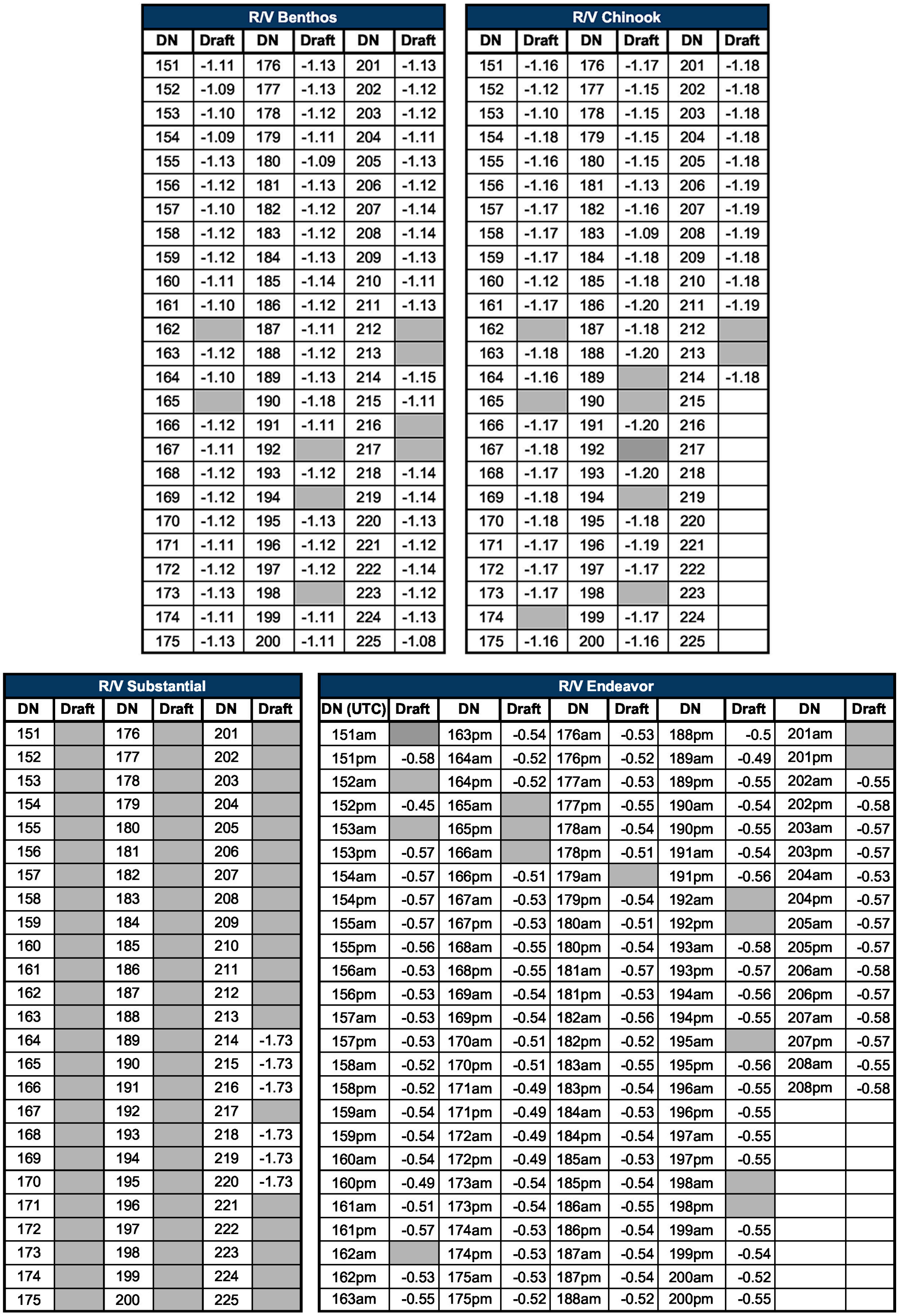
Not applicable as side scan sonar was not acquired.

Layback correctors were not applied.

B.2 Static and Dynamic Draft

B.2.1 Static Draft

While this project incorporated an Ellipsoidally Referenced Survey (ERS) workflow, static draft information was obtained to support data processing in a non-ERS workflow. This information was collected as a best practice and under guidance from the Hydrographic Survey Division (HSD) Operations (OPS) Project Manager. Each vessel utilized a set of designated draft check locations, determined during the static offset survey, to acquire water line measurements before and after each survey day. Measurements were made by attaching a metric carpenter T-square to the measurement location and recording the distance to the waterline. The R/V Substantial recorded waterline measurements during times at dock due to its extended duration of survey. Static drafts throughout the survey for each vessel can be found below in Figure 17. It should be noted that for use in CARIS HIPS, the R/V Endeavor static draft measurements should be inverted (positive) in the CARIS Hips Vessel File (HVF) to proceed with post-processing of raw XTF files.



R/V Benthos

DN	Draft	DN	Draft	DN	Draft
151	-1.11	176	-1.13	201	-1.13
152	-1.09	177	-1.13	202	-1.12
153	-1.10	178	-1.12	203	-1.12
154	-1.09	179	-1.11	204	-1.11
155	-1.13	180	-1.09	205	-1.13
156	-1.12	181	-1.13	206	-1.12
157	-1.10	182	-1.12	207	-1.14
158	-1.12	183	-1.12	208	-1.14
159	-1.12	184	-1.13	209	-1.13
160	-1.11	185	-1.14	210	-1.11
161	-1.10	186	-1.12	211	-1.13
162		187	-1.11	212	
163	-1.12	188	-1.12	213	
164	-1.10	189	-1.13	214	-1.15
165		190	-1.18	215	-1.11
166	-1.12	191	-1.11	216	
167	-1.11	192		217	
168	-1.12	193	-1.12	218	-1.14
169	-1.12	194		219	-1.14
170	-1.12	195	-1.13	220	-1.13
171	-1.11	196	-1.12	221	-1.12
172	-1.12	197	-1.12	222	-1.14
173	-1.13	198		223	-1.12
174	-1.11	199	-1.11	224	-1.13
175	-1.13	200	-1.11	225	-1.08

R/V Chinook

DN	Draft	DN	Draft	DN	Draft
151	-1.16	176	-1.17	201	-1.18
152	-1.12	177	-1.15	202	-1.18
153	-1.10	178	-1.15	203	-1.18
154	-1.18	179	-1.15	204	-1.18
155	-1.16	180	-1.15	205	-1.18
156	-1.16	181	-1.13	206	-1.19
157	-1.17	182	-1.16	207	-1.19
158	-1.17	183	-1.09	208	-1.19
159	-1.17	184	-1.18	209	-1.18
160	-1.12	185	-1.18	210	-1.18
161	-1.17	186	-1.20	211	-1.19
162		187	-1.18	212	
163	-1.18	188	-1.20	213	
164	-1.16	189		214	-1.18
165		190		215	
166	-1.17	191	-1.20	216	
167	-1.18	192		217	
168	-1.17	193	-1.20	218	
169	-1.18	194		219	
170	-1.18	195	-1.18	220	
171	-1.17	196	-1.19	221	
172	-1.17	197	-1.17	222	
173	-1.17	198		223	
174		199	-1.17	224	
175	-1.16	200	-1.16	225	

R/V Substantial

DN	Draft	DN	Draft	DN	Draft
151		176		201	
152		177		202	
153		178		203	
154		179		204	
155		180		205	
156		181		206	
157		182		207	
158		183		208	
159		184		209	
160		185		210	
161		186		211	
162		187		212	
163		188		213	
164		189		214	-1.73
165		190		215	-1.73
166		191		216	-1.73
167		192		217	
168		193		218	-1.73
169		194		219	-1.73
170		195		220	-1.73
171		196		221	
172		197		222	
173		198		223	
174		199		224	
175		200		225	

R/V Endeavor

DN (UTC)	Draft	DN	Draft	DN	Draft	DN	Draft	DN	Draft
151am		163pm	-0.54	176am	-0.53	188pm	-0.5	201am	
151pm	-0.58	164am	-0.52	176pm	-0.52	189am	-0.49	201pm	
152am		164pm	-0.52	177am	-0.53	189pm	-0.55	202am	-0.55
152pm	-0.45	165am		177pm	-0.55	190am	-0.54	202pm	-0.58
153am		165pm		178am	-0.54	190pm	-0.55	203am	-0.57
153pm	-0.57	166am		178pm	-0.51	191am	-0.54	203pm	-0.57
154am	-0.57	166pm	-0.51	179am		191pm	-0.56	204am	-0.53
154pm	-0.57	167am	-0.53	179pm	-0.54	192am		204pm	-0.57
155am	-0.57	167pm	-0.53	180am	-0.51	192pm		205am	-0.57
155pm	-0.56	168am	-0.55	180pm	-0.54	193am	-0.58	205pm	-0.57
156am	-0.53	168pm	-0.55	181am	-0.57	193pm	-0.57	206am	-0.58
156pm	-0.53	169am	-0.54	181pm	-0.53	194am	-0.56	206pm	-0.57
157am	-0.53	169pm	-0.54	182am	-0.56	194pm	-0.55	207am	-0.58
157pm	-0.53	170am	-0.51	182pm	-0.52	195am		207pm	-0.57
158am	-0.52	170pm	-0.51	183am	-0.55	195pm	-0.56	208am	-0.55
158pm	-0.52	171am	-0.49	183pm	-0.54	196am	-0.55	208pm	-0.58
159am	-0.54	171pm	-0.49	184am	-0.53	196pm	-0.55		
159pm	-0.54	172am	-0.49	184pm	-0.54	197am	-0.55		
160am	-0.54	172pm	-0.49	185am	-0.53	197pm	-0.55		
160pm	-0.49	173am	-0.54	185pm	-0.54	198am			
161am	-0.51	173pm	-0.54	186am	-0.55	198pm			
161pm	-0.57	174am	-0.53	186pm	-0.54	199am	-0.55		
162am		174pm	-0.53	187am	-0.54	199pm	-0.54		
162pm	-0.53	175am	-0.53	187pm	-0.54	200am	-0.52		
163am	-0.55	175pm	-0.52	188am	-0.52	200pm	-0.55		

Figure 17: Static drafts recorded on each vessel throughout the survey

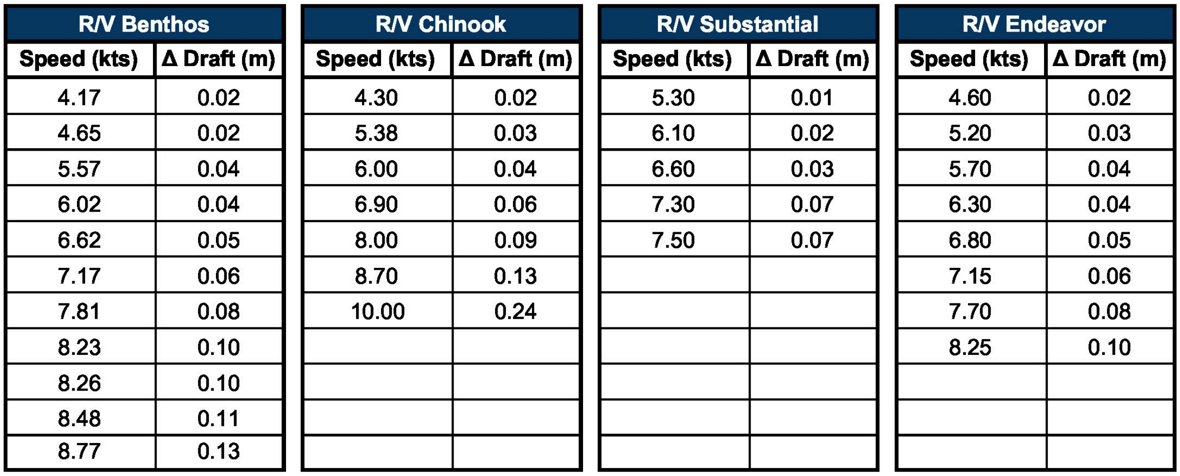
B.2.1.1 Static Draft Correctors

Static draft correctors were not applied.

B.2.2 Dynamic Draft

This project incorporated an ERS workflow and, as a result, dynamic draft was accounted for in the soundings by using post-processed ellipsoid-based corrections in addition to the real-time corrections. The combined correctors work to factor out the static draft, settlement, and squat of the survey vessel.

Dynamic draft tables for each vessel were developed through squat and settlement tests in support of any future data processing in a non-ERS workflow. Dynamic draft was calculated by collecting data on a sequence of straight survey lines with incremental Revolutions Per Minute (RPM) for approximately 60 seconds, separated by periods of stationary float for 30 to 60 seconds. The POS file was imported and processed in POSPac using the Trimble RTX correction service. The Smoothed Best Estimate of Trajectory (SBET) was reviewed for adequate altitude plots and acceptable vertical Root Mean Square (RMS) values. Post-processed GNSS heights were integrated in CARIS HIPS before calculating the average ellipsoid height at the sonar heads for both run and float lines. Dynamic draft was calculated by subtracting the run lines from the average of the before and after float lines. A third order polynomial regression was used to model the changes in vessel draft with respect to operation (RPM / speed). Results of the squat and settlement tests for each vessel can be seen in Figure 18.



R/V Benthos		R/V Chinook		R/V Substantial		R/V Endeavor	
Speed (kts)	**Δ Draft (m)**	**Speed (kts)**	**Δ Draft (m)**	**Speed (kts)**	**Δ Draft (m)**	**Speed (kts)**	**Δ Draft (m)**
4.17	0.02	4.30	0.02	5.30	0.01	4.60	0.02
4.65	0.02	5.38	0.03	6.10	0.02	5.20	0.03
5.57	0.04	6.00	0.04	6.60	0.03	5.70	0.04
6.02	0.04	6.90	0.06	7.30	0.07	6.30	0.04
6.62	0.05	8.00	0.09	7.50	0.07	6.80	0.05
7.17	0.06	8.70	0.13			7.15	0.06
7.81	0.08	10.00	0.24			7.70	0.08
8.23	0.10					8.25	0.10
8.26	0.10						
8.48	0.11						
8.77	0.13						

Figure 18: Dynamic draft correctors for each vessel.

B.2.2.1 Dynamic Draft Correctors

Dynamic draft correctors were not applied.

B.3 System Alignment

B.3.1 System Alignment Methods and Procedures

Multibeam patch tests were performed on each survey vessel to establish installation mounting biases between the attitude reference frame and the sonar reference frame. The patch tests also determined any latency bias between the sonar systems and positioning systems. Patch tests were conducted on each vessel prior to the start of data acquisition and whenever a major system hardware change was made. Patch tests were conducted in accordance with section 5.2.4.1 of the Hydrographic Survey Specifications and Deliverables 2020 (HSSD). Patch test data were assessed in QPS Qimera by multiple hydrographers to issue an uncertainty associated with each patch test bias. Patch test biases for the R/V Benthos, R/V Chinook, and R/V Substantial were entered into Kongsberg SIS as well as the Qinsy .DB file. For the R/V Endeavor, patch test values were entered into the Qinsy .DB file and the CARIS HVF. The 20 degree sonar tilt of the R2 Sonic was entered in the R2 Controller and therefore not required in the HVF. To ensure quality in system alignment and the integrity of the sonar data, daily roll lines were collected since each vessel utilized a deployable over-the-side pole mount. If/when misalignment was determined, the corresponding roll corrections were placed into the HVF.

Three separate system configurations were necessary for the R/V Endeavor due to equipment failure and replacement. Setup 1 was the initial configuration of the R/V Endeavor with a submersible IMU on a pole mount. This setup was discontinued because of submersible IMU cable failures (primary and backup). Setup 2 utilized a hull-mounted IMU 38. Setup 2 was discontinued because a new submersible IMU cable arrived onsite, therefore, the configuration reverted back to the use of the submersible IMU (Setup 3). Information regarding these configurations can be found in DAPR Appendix IV.

B.3.1.1 System Alignment Correctors

<table>
<tr><td><i>Vessel</i></td><td colspan="3">R/V Benthos</td></tr>
<tr><td><i>Echosounder</i></td><td colspan="3">Kongsberg EM2040C Dual</td></tr>
<tr><td><i>Date</i></td><td colspan="3">2020-05-30</td></tr>
<tr><td rowspan="10"><i>Patch Test Values</i></td><td></td><td><i>Corrector</i></td><td><i>Uncertainty</i></td></tr>
<tr><td><i>Transducer Time Correction</i></td><td>0.00 seconds</td><td>0.001 seconds</td></tr>
<tr><td><i>Navigation Time Correction</i></td><td>0.00 seconds</td><td>0.001 seconds</td></tr>
<tr><td><i>Pitch</i></td><td>-0.494 degrees</td><td>0.101 degrees</td></tr>
<tr><td><i>Roll</i></td><td>34.27 degrees</td><td>0.12 degrees</td></tr>
<tr><td><i>Yaw</i></td><td>359.925 degrees</td><td>0.056 degrees</td></tr>
<tr><td><i>Pitch Time Correction</i></td><td>0.00 seconds</td><td>0.001 seconds</td></tr>
<tr><td><i>Roll Time Correction</i></td><td>0.00 seconds</td><td>0.001 seconds</td></tr>
<tr><td><i>Yaw Time Correction</i></td><td>0.00 seconds</td><td>0.001 seconds</td></tr>
<tr><td><i>Heave Time Correction</i></td><td>0.00 seconds</td><td>0.001 seconds</td></tr>
</table>

Date	2020-05-30		
Patch Test Values (Transducer 2)		*Corrector*	*Uncertainty*
	Transducer Time Correction	0.00 seconds	0.001 seconds
	Navigation Time Correction	0.00 seconds	0.001 seconds
	Pitch	-0.507 degrees	0.11 degrees
	Roll	-35.95 degrees	0.061 degrees
	Yaw	359.65 degrees	0.182 degrees
	Pitch Time Correction	0.00 seconds	0.001 seconds
	Roll Time Correction	0.00 seconds	0.001 seconds
	Yaw Time Correction	0.00 seconds	0.001 seconds
	Heave Time Correction	0.00 seconds	0.001 seconds

Vessel	R/V Chinook		
Echosounder	Kongsberg EM2040C Dual		
Date	2020-05-30		
Patch Test Values		*Corrector*	*Uncertainty*
	Transducer Time Correction	0.00 seconds	0.001 seconds
	Navigation Time Correction	0.00 seconds	0.001 seconds
	Pitch	0.488 degrees	0.098 degrees
	Roll	35.922 degrees	0.039 degrees
	Yaw	0.02 degrees	0.131 degrees
	Pitch Time Correction	0.00 seconds	0.001 seconds
	Roll Time Correction	0.00 seconds	0.001 seconds
	Yaw Time Correction	0.00 seconds	0.001 seconds
	Heave Time Correction	0.00 seconds	0.001 seconds
Date	2020-05-30		
Patch Test Values (Transducer 2)		*Corrector*	*Uncertainty*
	Transducer Time Correction	0.00 seconds	0.001 seconds
	Navigation Time Correction	0.00 seconds	0.001 seconds
	Pitch	0.57 degrees	0.111 degrees
	Roll	-34.428 degrees	0.125 degrees
	Yaw	0.113 degrees	0.113 degrees
	Pitch Time Correction	0.00 seconds	0.001 seconds
	Roll Time Correction	0.00 seconds	0.001 seconds
	Yaw Time Correction	0.00 seconds	0.001 seconds
	Heave Time Correction	0.00 seconds	0.001 seconds

Vessel	R/V Substantial		
Echosounder	Kongsberg EM2040C Dual		
Date	2020-08-01		
Patch Test Values		*Corrector*	*Uncertainty*
	Transducer Time Correction	0.00 seconds	0.001 seconds
	Navigation Time Correction	0.00 seconds	0.001 seconds
	Pitch	-0.35 degrees	0.229 degrees
	Roll	37.60 degrees	0.177 degrees
	Yaw	359.80 degrees	0.165 degrees
	Pitch Time Correction	0.00 seconds	0.001 seconds
	Roll Time Correction	0.00 seconds	0.001 seconds
	Yaw Time Correction	0.00 seconds	0.001 seconds
	Heave Time Correction	0.00 seconds	0.001 seconds
Date	2020-08-01		
Patch Test Values (Transducer 2)		*Corrector*	*Uncertainty*
	Transducer Time Correction	0.00 seconds	0.001 seconds
	Navigation Time Correction	0.00 seconds	0.001 seconds
	Pitch	-0.55 degrees	0.283 degrees
	Roll	-37.30 degrees	0.177 degrees
	Yaw	0.20 degrees	0.265 degrees
	Pitch Time Correction	0.00 seconds	0.001 seconds
	Roll Time Correction	0.00 seconds	0.001 seconds
	Yaw Time Correction	0.00 seconds	0.001 seconds
	Heave Time Correction	0.00 seconds	0.001 seconds

Vessel	R/V Endeavor (Setup 1)		
Echosounder	R2 Sonic 2024 Dual		
Date	2020-05-30		
Patch Test Values		*Corrector*	*Uncertainty*
	Transducer Time Correction	0.00 seconds	0.001 seconds
	Navigation Time Correction	0.00 seconds	0.001 seconds
	Pitch	-0.73 degrees	0.307 degrees
	Roll	0.95 degrees	0.054 degrees
	Yaw	-2.00 degrees	0.20 degrees
	Pitch Time Correction	0.00 seconds	0.001 seconds
	Roll Time Correction	0.00 seconds	0.001 seconds
	Yaw Time Correction	0.00 seconds	0.001 seconds
	Heave Time Correction	0.00 seconds	0.001 seconds

Date	2020-05-30		
Patch Test Values (Transducer 2)		*Corrector*	*Uncertainty*
	Transducer Time Correction	0.00 seconds	0.001 seconds
	Navigation Time Correction	0.00 seconds	0.001 seconds
	Pitch	0.90 degrees	0.168 degrees
	Roll	0.36 degrees	0.012 degrees
	Yaw	-3.20 degrees	0.48 degrees
	Pitch Time Correction	0.00 seconds	0.001 seconds
	Roll Time Correction	0.00 seconds	0.001 seconds
	Yaw Time Correction	0.00 seconds	0.001 seconds
	Heave Time Correction	0.00 seconds	0.001 seconds
Date	2020-06-04		
Patch Test Values		*Corrector*	*Uncertainty*
	Transducer Time Correction	0.00 seconds	0.001 seconds
	Navigation Time Correction	0.00 seconds	0.001 seconds
	Pitch	-2.15 degrees	0.134 degrees
	Roll	0.08 degrees	0.035 degrees
	Yaw	-3.59 degrees	0.249 degrees
	Pitch Time Correction	0.00 seconds	0.001 seconds
	Roll Time Correction	0.00 seconds	0.001 seconds
	Yaw Time Correction	0.00 seconds	0.001 seconds
	Heave Time Correction	0.00 seconds	0.001 seconds
Date	2020-06-04		
Patch Test Values (Transducer 2)		*Corrector*	*Uncertainty*
	Transducer Time Correction	0.00 seconds	0.001 seconds
	Navigation Time Correction	0.00 seconds	0.001 seconds
	Pitch	-0.74 degrees	0.193 degrees
	Roll	-0.62 degrees	0.014 degrees
	Yaw	-3.06 degrees	0.446 degrees
	Pitch Time Correction	0.00 seconds	0.001 seconds
	Roll Time Correction	0.00 seconds	0.001 seconds
	Yaw Time Correction	0.00 seconds	0.001 seconds
	Heave Time Correction	0.00 seconds	0.001 seconds

Vessel	R/V Endeavor (Setup 2)		
Echosounder	R2 Sonic 2024 Dual		
Date	2020-06-09		
Patch Test Values		*Corrector*	*Uncertainty*
	Transducer Time Correction	0.00 seconds	0.001 seconds
	Navigation Time Correction	0.00 seconds	0.001 seconds
	Pitch	-2.418 degrees	0.315 degrees
	Roll	0.169 degrees	0.019 degrees
	Yaw	-3.151 degrees	0.606 degrees
	Pitch Time Correction	0.00 seconds	0.001 seconds
	Roll Time Correction	0.00 seconds	0.001 seconds
	Yaw Time Correction	0.00 seconds	0.001 seconds
	Heave Time Correction	0.00 seconds	0.001 seconds
Date	2020-06-09		
Patch Test Values (Transducer 2)		*Corrector*	*Uncertainty*
	Transducer Time Correction	0.00 seconds	0.001 seconds
	Navigation Time Correction	0.00 seconds	0.001 seconds
	Pitch	0.141 degrees	0.094 degrees
	Roll	-0.42 degrees	0.063 degrees
	Yaw	-2.735 degrees	0.117 degrees
	Pitch Time Correction	0.00 seconds	0.001 seconds
	Roll Time Correction	0.00 seconds	0.001 seconds
	Yaw Time Correction	0.00 seconds	0.001 seconds
	Heave Time Correction	0.00 seconds	0.001 seconds

Vessel	R/V Endeavor (Setup 3)		
Echosounder	R2 Sonic 2024 Dual		
Date	2020-06-22		
Patch Test Values		*Corrector*	*Uncertainty*
	Transducer Time Correction	0.00 seconds	0.001 seconds
	Navigation Time Correction	0.00 seconds	0.001 seconds
	Pitch	-1.534 degrees	0.118 degrees
	Roll	0.175 degrees	0.024 degrees
	Yaw	-3.633 degrees	0.104 degrees
	Pitch Time Correction	0.00 seconds	0.001 seconds
	Roll Time Correction	0.00 seconds	0.001 seconds
	Yaw Time Correction	0.00 seconds	0.001 seconds
	Heave Time Correction	0.00 seconds	0.001 seconds

Date	2020-06-22		
Patch Test Values		*Corrector*	*Uncertainty*
	Transducer Time Correction	0.00 seconds	0.001 seconds
	Navigation Time Correction	0.00 seconds	0.001 seconds
	Pitch	0.256 degrees	0.063 degrees
	Roll	-0.506 degrees	0.048 degrees
	Yaw	-3.398 degrees	0.139 degrees
	Pitch Time Correction	0.00 seconds	0.001 seconds
	Roll Time Correction	0.00 seconds	0.001 seconds
	Yaw Time Correction	0.00 seconds	0.001 seconds
	Heave Time Correction	0.00 seconds	0.001 seconds

C. Data Acquisition and Processing

C.1 Bathymetry

C.1.1 Multibeam Echosounder

Data Acquisition Methods and Procedures

All data planning, calibrations, acquisition, processing, QC, quality assurance (QA), and reporting were performed under the direct supervision of the Chief of Party. Field data collection and processing were done under the supervision of a highly qualified team including the Chief of Party, Lead Hydrographer, Senior Hydrographer, and Data Processing Manager. Chief of Party David Bernstein and Lead Hydrographer Ben Sumners are both ACSM-NSPS-THSOA Certified Hydrographers.

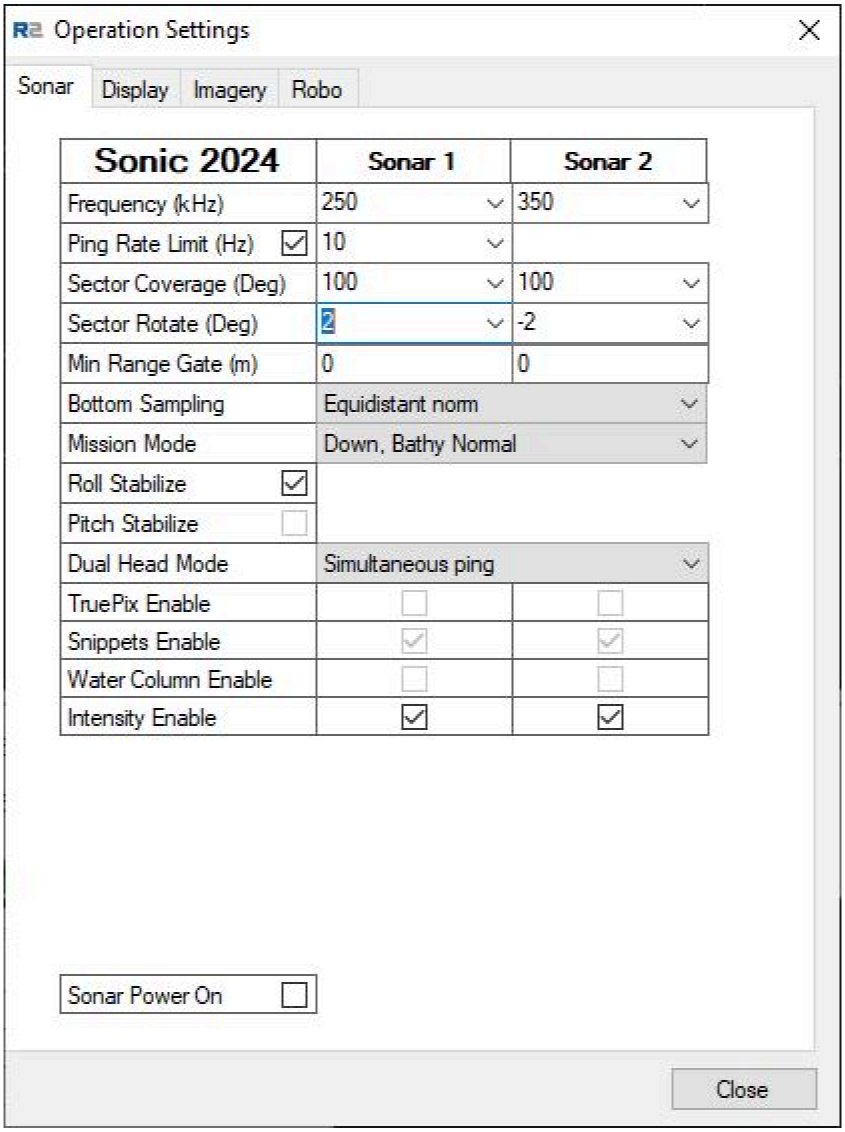
Prior to the start of data acquisition, and following static vessel surveys and verification measurements, a series of calibrations and tests took place on each vessel to prepare and validate the setup and integration of all survey systems across all vessels. These procedures included navigation/GAMS calibrations, patch tests, reference verification tests, echosounder bar checks, squat and settlement tests, and a water level float test.

Line plans were developed based on optimal multibeam coverage and quality. Data acquisition used survey lines for tracking, however, lines were mostly used as a reference for data-driven acquisition, in which case captains used ~25% overlap sectors in the helm map to guide navigation. Features identified in the field and during on-site data processing were further investigated with additional MBES data coverage when deemed necessary, to adequately develop the feature. Bathymetric data acquisition around engineered shoreline, structures, and shoals were collected with special care and safety to provide the most accurate least depths and required coverage. All vessels utilized Qinsy for navigation, monitoring of system health, data logging, real-time progress tracking, and QC assessments. Using a custom NMEA output driver and Wireless Wide

Area Network (WWAN) connection, vessel tracking information was streamed over an ESRI GeoEvent Server to a Survey Information Management System (SIMS) hosted through ArcGIS Online. This combined progress tracker and dashboard system provided real-time situational awareness of each vessel and calculated various project tracking metrics, providing critical guidance for management and hydrographers in real-time. Each vessel and survey system was optimized for data collection to meet the requirements of the Project Instructions (PI) and HSSD. The R/V Benthos and R/V Chinook were configured with dual-head dual swath EM2040C systems by synchronizing two Kongsberg PUs to provide approximately twice the along-track data density. Sonar systems were aided by the POS MV which provided real-time QC of position and attitude data, and logged ancillary POSPac data (.000 files) for post-processing. All Kongsberg systems were controlled with SIS software and operated at 300 kHz. The R/V Substantial operated on a 24 hour schedule and utilized an EM2040C dual-head sonar with a single Kongsberg PU to collect data sufficient for complete coverage requirements. All Kongsberg systems had absorption coefficients adjusted for freshwater in SIS and operated in “Normal” mode with “Auto” pulse width. Multibeam bathymetry data collected with the Kongsberg EM2040C systems were stored in the .ALL file.

The R/V Endeavor operated a dual-head R2 Sonic 2024 sonar system aided by an Applanix POS MV. The R2 Sonic absorption was set for freshwater in the R2 Controller Graphical User Interface (GUI). The hydrographer adjusted settings for range, gain, and pulse width depending on depth and bottom type. The R/V Endeavor operated on rotating 12 hour shifts every 24 hours. Multibeam bathymetry data collected with the R2 Sonic 2024 system were stored in the .XTF file recorded by Qinsy.

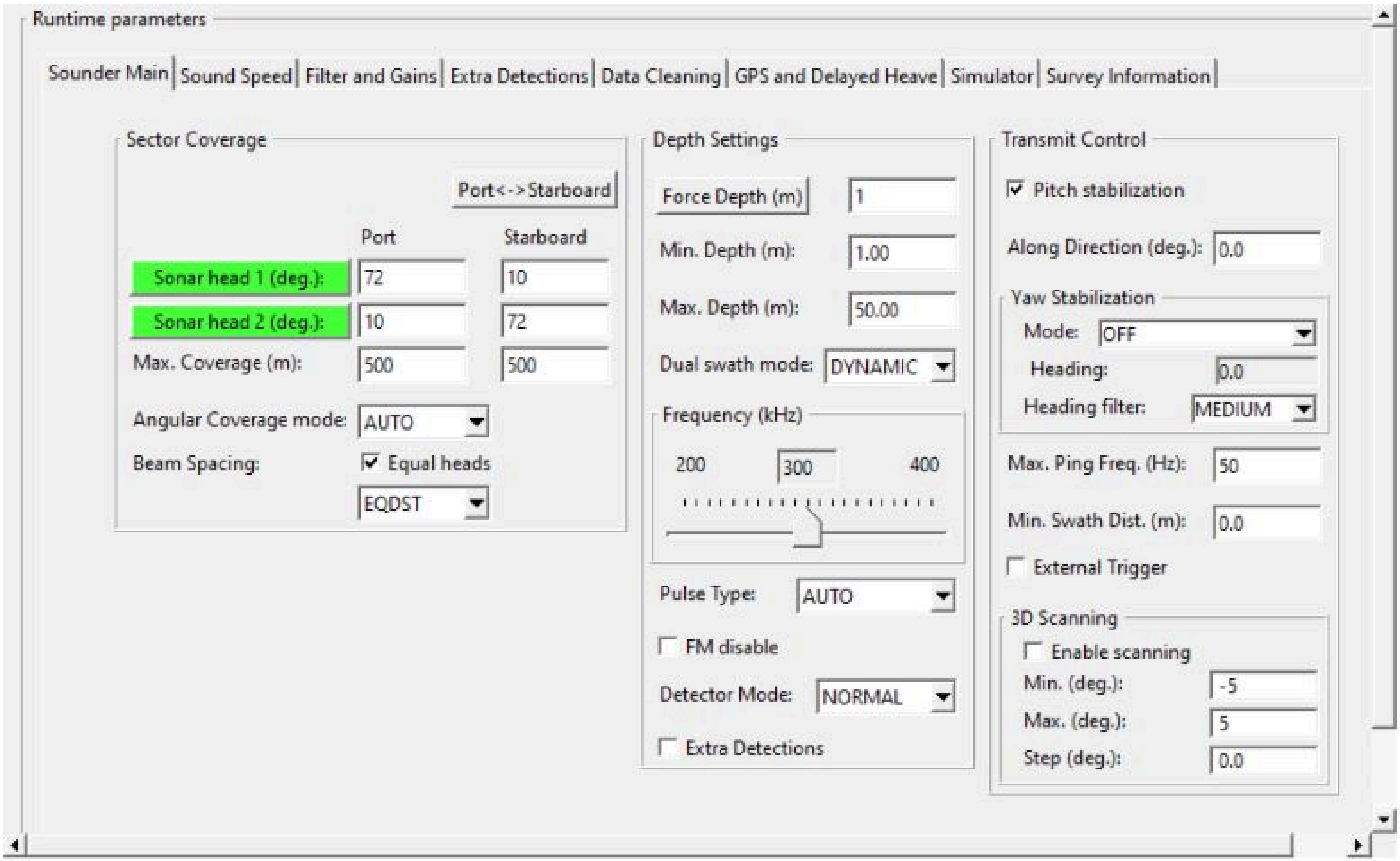
Throughout the survey, a series of QC measures were taken to ensure that the survey data met the specifications of the PI and HSSD. Hydrographers collected a daily set of “roll lines” to assess any potential biases ensued from daily deployment of the over-the-side sonar mount. Vessel speed and sonar coverage were monitored and adjusted when environmental conditions negatively impacted data quality. Vessel to vessel overlap was accomplished whenever possible for additional QC and crosslines were collected by multiple vessels.



Sonic 2024	Sonar 1	Sonar 2
Frequency (kHz)	250	350
Ping Rate Limit (Hz) ☑	10	
Sector Coverage (Deg)	100	100
Sector Rotate (Deg)	2	-2
Min Range Gate (m)	0	0
Bottom Sampling	Equidistant norm	
Mission Mode	Down, Bathy Normal	
Roll Stabilize ☑		
Pitch Stabilize ☐		
Dual Head Mode	Simultaneous ping	
TruePix Enable	☐	☐
Snippets Enable	☑	☑
Water Column Enable	☐	☐
Intensity Enable	☑	☑

Sonar Power On ☐

Figure 19: R2 Sonic Controller settings used during MBES surveys



Sector Coverage

	Port	Starboard
Sonar head 1 (deg.):	72	10
Sonar head 2 (deg.):	10	72
Max. Coverage (m):	500	500

Angular Coverage mode: AUTO

Beam Spacing: ☑ Equal heads

EQDST

Depth Settings

Force Depth (m) 1

Min. Depth (m): 1.00

Max. Depth (m): 50.00

Dual swath mode: DYNAMIC

Frequency (kHz)

200 300 400

Pulse Type: AUTO

☐ FM disable

Detector Mode: NORMAL

☐ Extra Detections

Transmit Control

☑ Pitch stabilization

Along Direction (deg.): 0.0

Yaw Stabilization

Mode: OFF

Heading: 0.0

Heading filter: MEDIUM

Max. Ping Freq. (Hz): 50

Min. Swath Dist. (m): 0.0

☐ External Trigger

3D Scanning

☐ Enable scanning

Min. (deg.): -5

Max. (deg.): 5

Step (deg.): 0.0

Figure 20: SIS Runtime parameters window

Data Processing Methods and Procedures

Multibeam data processing was accomplished with Charlene, CARIS HIPS, and POSPac MMS. Initial data processing consisted of data transfer, file conversion, merge of corrections, TPU calculation, CUBE surface generation, and SBET/SMRMSG creation (Phase I). Immediately following acquisition, data were transferred via Charlene from portable solid state drives (SSD) to the network attached server (NAS) hosting an array of SSDs. Charlene is an automated file transfer and batch data processing utility within Pydro Explorer developed by the National Oceanic and Atmospheric Administration (NOAA) Hydrographic Systems and Technology Branch (HSTB). Charlene automated the Phase 1 processing steps such that an initial surface and related QC data were generated before the next survey day. Phase 1 QC included initial QC Tools results, SBET QC, detailed surface inspection, assessment of data quality and system performance, and daily survey reporting.

Phase 2 processing began with application of SBET and SMRMSG data to the sounding data followed by sound speed corrections in HIPS. GPS tide was re-computed, soundings were re-merged, TPU computed, and then another CUBE surface was generated. During this phase, additional review of data quality was conducted along with data cleaning and feature identification/designation.

Phase 3 processing included QC and finalization of features and bathymetric surfaces. During this stage, rigorous QC was performed to ensure completeness and adequacy of the final deliverables and associated reporting.

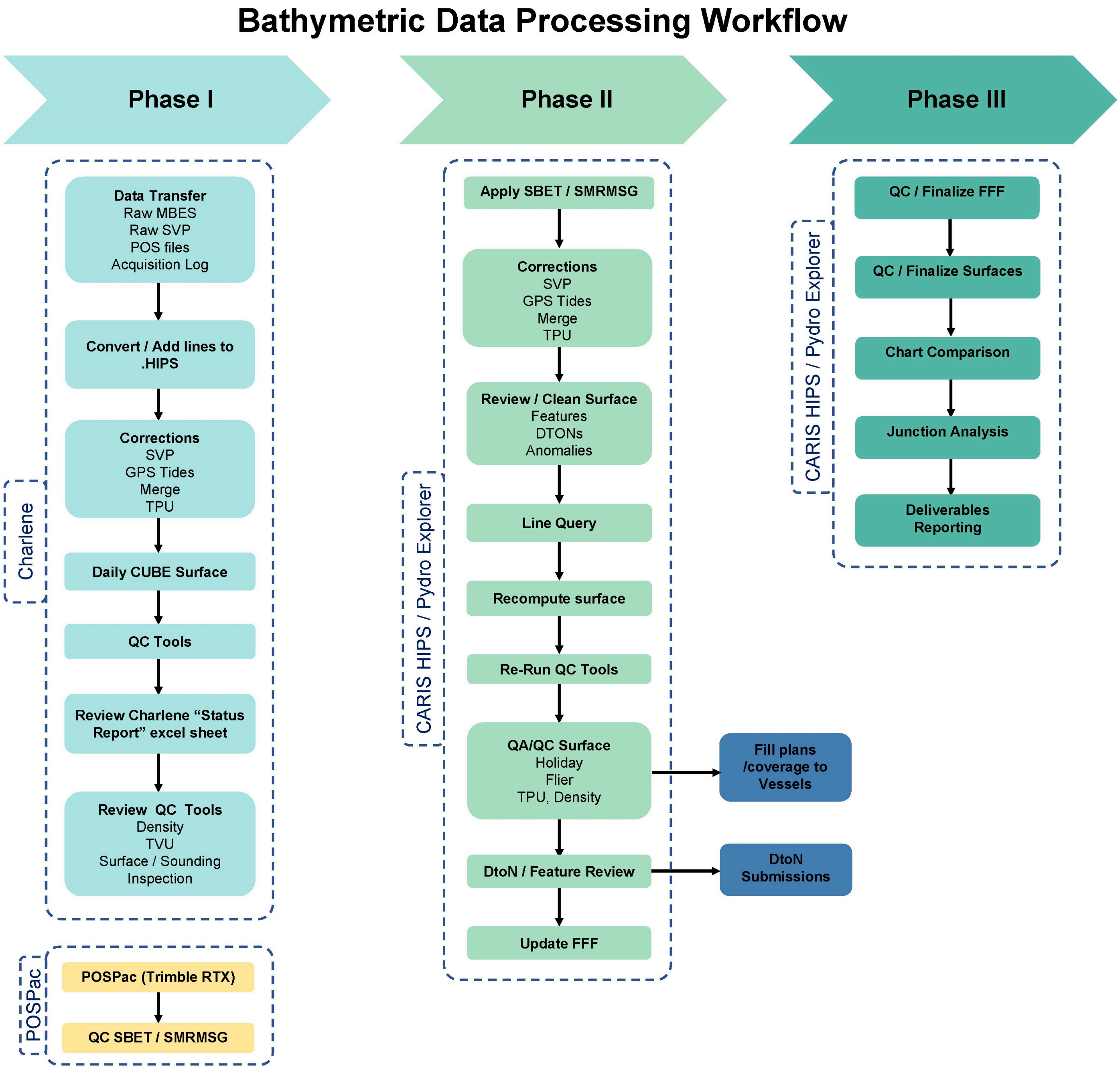


Figure 21: Bathymetric data processing workflow

C.1.2 Single Beam Echosounder

Single beam echosounder bathymetry was not acquired.

C.1.3 Phase Measuring Bathymetric Sonar

Phase measuring bathymetric sonar bathymetry was not acquired.

C.1.4 Gridding and Surface Generation

C.1.4.1 Surface Generation Overview

All bathymetric surfaces were computed from fully corrected data in CARIS HIPS using CUBE algorithms specified in the CUBEParams_NOAA_2020.xml and standards specified in section 5.2.2 of the HSSD. Parent surfaces and depth controlled finalized surfaces were provided in CSAR format for each survey.

C.1.4.2 Depth Derivation

Prior to finalizing surfaces, data were thoroughly and redundantly reviewed for completeness and adherence to specifications in the HSSD. Outer beam clipping filters and manual data cleaning were utilized to clean erroneous swath data that adversely affected the surface. Some portions of lines were clipped in the Navigation Editor if the data were unnecessary or recovered. Processed soundings and features were reviewed in Subset Editor using both 2D and 3D views to ensure accurate designation of critical soundings were performed. Line queries were performed to ensure all data had consistent and complete correctors applied. Finalized surfaces were computed utilizing the “Apply Designated Sounding” function such that the surface represented each designated sounding depth. Uncertainty of the finalized surface was assigned from either uncertainty or standard deviation, whichever is greater.

C.1.4.3 Surface Computation Algorithm

The 2020 NOAA CUBE Parameters were used for CUBE surface computation. Surface generation used the following settings:

Gridding Method: CUBE
Bounding Polygon Type: Buffered
IHO Order: 1a
Disambiguation Method: Density and Local
Cube Configuration: NOAA_0.5m, NOAA_1m, NOAA_2m (with respect to depth range and coverage requirements)

C.2 Imagery

C.2.1 Multibeam Backscatter Data

<u>Data Acquisition Methods and Procedures</u>

Multibeam backscatter data collected with the Kongsberg EM2040C systems were stored in the .ALL file. Data were acquired at 300 kHz with no changes to settings. The R2 Sonic 2024 system stored snippet data within the Qinsy .DB file. The backscatter data within the .DB file was converted to a GSF format in QPS Qimera to provide backscatter data in a singular file. Hydrographers utilized real-time displays of backscatter and saturation to help assess any potential system-wide backscatter issues. Both .ALL and .GSF files are directly importable to FMGT.

<u>Data Processing Methods and Procedures</u>

Although no processing or analysis of backscatter data were required, backscatter files were routinely processed for QA purposes in QPS FMGT. Additionally, mosaics were created to assure the coverage and quality of the backscatter (Figure 22). These mosaics were easily manipulated within the SIMS ArcGIS Online Processing Manager Application (PMA), which helped optimize the selection of bottom sample locations.

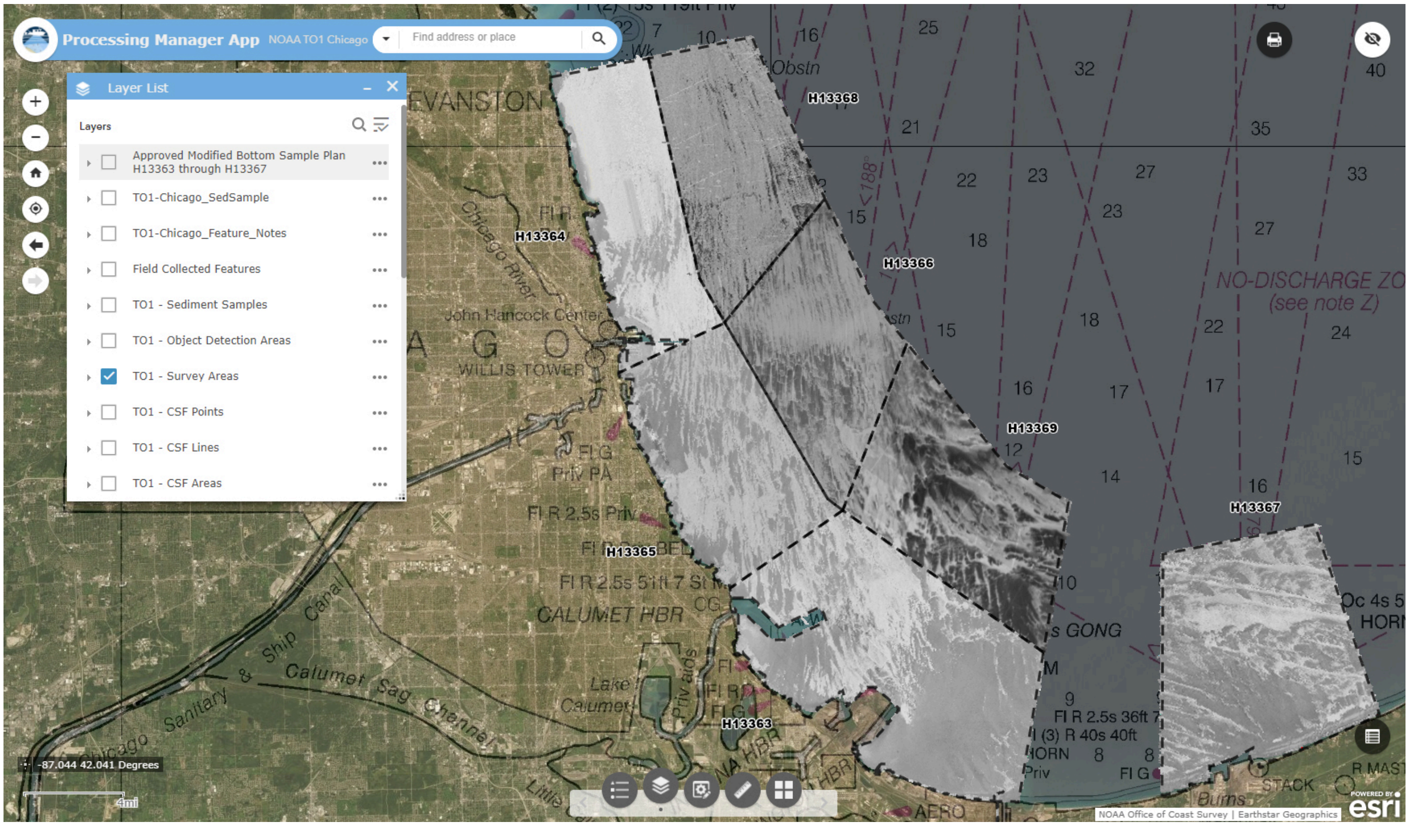


Figure 22: Processing Manager Application hosting backscatter mosaics for all surveys

C.2.2 Side Scan Sonar

Side scan sonar imagery was not acquired.

C.2.3 Phase Measuring Bathymetric Sonar

Phase measuring bathymetric sonar imagery was not acquired.

C.3 Horizontal and Vertical Control

C.3.1 Horizontal Control

C.3.1.1 GNSS Base Station Data

GNSS base station data was not acquired.

C.3.1.2 DGPS Data

DGPS data was not acquired.

C.3.1.3 Other Horizontal Control Equipment

Data Acquisition Methods and Procedures

All survey vessels received G2+ GNSS satellite corrections from the Fugro Marinestar SBAS directly through the Applanix POS MV to provide real-time corrections to positioning. The Marinestar G2+ service provides corrections for GPS and GLONASS from a network of base stations around the world via geo-stationary satellites. Solution status was continuously monitored through the POSView controller software for dropouts or degraded accuracy.

Data Processing Methods and Procedures

For all hydrographic survey activities, POSPac data were collected through the POSView controller via Ethernet Logging and/or USB Logging. All position and attitude data were post-processed in POSPac MMS software using Trimble Centerpoint RTX solutions. The SBET was applied in CARIS HIPS to overwrite all position and attitude data and improve upon the real-time Marinestar G2+ accuracies, while minimizing Total Horizontal Uncertainty (THU).

C.3.2 Vertical Control

C.3.2.1 Water Level Data

Data Acquisition Methods and Procedures

All surveys utilized an ERS workflow to reduce ellipsoid derived depths to chart datum.

All survey vessels received G2+ GNSS satellite corrections from the Fugro Marinestar SBAS directly through the Applanix POS MV to provide real-time corrections to ellipsoid heights. Solution status was continuously monitored through the POSView controller software for dropouts or degraded accuracy.

As dictated in the PI, water levels were determined from ellipsoid measurements throughout this ERS and soundings were reduced to Low Water Datum (LWD) International Great Lakes Datum 1985 (IGLD85) by way of a VDatum Separation (SEP) model. Following pre-survey calibrations, a “float test” was performed with the R/V Chinook to ensure the quality of the GNSS corrections, SEP model, and survey systems integrations. The vessel remained stationary while nearby National Ocean Service (NOS) Water Level Station 9087044 - Calumet Harbor (CALU) and recorded the LWD IGLD85 elevation of the water surface. This information was compared to the near real-time water level data collected at CALU for the same time period and showed excellent agreement. Reference the corresponding Horizontal and Vertical Control Report (OPR-Y395-KR-20_HVCR.pdf) for more information.

Data Processing Methods and Procedures

NOAA’s HSD OPS provided a VDatum SEP model package with the PI and included two models, NAD83-LWD_IGLD85 and ITRF14-LWD_IGLD85. All ellipsoid data were post-processed using the Applanix POSPac MMS software. Post-processed corrections were implemented with Trimble’s CenterPoint RTX service. The SBET was applied in CARIS HIPS to overwrite all position and attitude data to improve upon the real-time Marinestar G2+ accuracies and minimize total Vertical Uncertainty (TVU). The ITRF14-LWD_IGLD85 SEP model was utilized in CARIS HIPS to reduce the sonar data to LWD_IGLD85.

C.3.2.2 Optical Level Data

Optical level data was not acquired.

C.4 Vessel Positioning

Data Acquisition Methods and Procedures

Vessel position, attitude, and trajectory data were acquired and logged with an Applanix POS MV v5. All vessels had the offsets between the Primary GNSS antenna and Reference Point precisely measured and entered into the POSView controller software prior to data acquisition (see DAPR Appendix III). Prior to the start of surveys, GAMS calibrations were performed to align the Secondary GNSS antenna with the Primary GNSS and IMU alignment with respect to the vessel reference frame. See DAPR Appendix IV for additional information on vessel offsets, configuration, and calibration. For the duration of the project, all survey vessels maintained subscriptions with Fugro's Marinestar Global Correction System and received G2+ corrections. Position, attitude, and trajectory data were logged via Ethernet Logging and/or USB Logging whenever survey activities occurred. This included five minutes before and after acquisition for adequate post processing of kalman filtered data.

Data Processing Methods and Procedures

All position and attitude data were post-processed using Applanix POSPac MMS software and Trimble CenterPoint RTX corrections to produce an SBET file with centimeter level positioning accuracy. Post-processed solutions were reviewed for position and elevation RMS accuracies and altitude consistencies prior to exporting the SBET at the MBES systems' reference point. The SBET position and attitude data were applied to the sounding data in CARIS HIPS and further reviewed for error or inconsistencies in the post-processed data. All integrated SBETs were accompanied with a SMRMSG file for post-processed position and attitude error contributions to TPU estimates.

C.5 Sound Speed

C.5.1 Sound Speed Profiles

Data Acquisition Methods and Procedures

All sound speed instruments utilized AML Oceanographic Xchange sensors, which were calibrated within one year of survey operations. Calibration certificates can be viewed in DAPR Appendix II.

On the R/V Benthos and R/V Chinook, sound speed profiles were collected using Base•X2 instruments equipped with pressure and time-of-flight sound speed sensors. Casts were routinely conducted approximately every two hours or less, and no greater than four hours, depending on conditions. Profilers were deployed and recovered by hand using a Cannon Lake-Troll Manual downrigger spooled with 300lb braided ultra-high-molecular-weight polyethylene line, recording samples at 1 Hz. Once retrieved, profile data were automatically sent to SeaCast via Bluetooth connection. SeaCast was setup to calculate sound velocity for fresh water, use UTC time, record in meters, split the up/down cast, and delete out of range or invalid points. Casts were reviewed for location and depth criteria, and the down casts were exported as .SVP files to a folder monitored by Qinsy. The processed files were applied automatically in Qinsy and imported into the Sound Speed Manager database, and then transmitted to SIS as an extended .ASVP file. Each vessels' daily casts were exported as an .SVP file for post-processing.

The R/V Endeavor utilized a Smart•X instrument tethered to a deployment reel equipped with a slip ring to provide real-time data as the instrument was deployed and retrieved. The Smart•X was equipped with pressure and time-of-flight sound speed sensors. The eTrac SVP Profiler software was used to log casts that were then input to Qinsy for QC and application to sonar data. Following a manufacturer serial cable failure, the R/V Endeavor was forced to switch to a Base•X2 and use AML SeaCast. However, the same SV•Xchange and pressure sensor were still utilized. This situation required sound speed profiles to be logged in SeaCast, where data were reviewed for location and depth criteria and the down casts were exported as .SVP files to a folder monitored by Qinsy. The processed files were applied in Qinsy and later exported as a single .SVP file for post-processing.

The R/V Substantial was equipped with an AML MVP mounted on the stern. The MVP integrated position and real-time depth via serial data communication from Qinsy. The free fall fish was deployed approximately every 30 - 120 minutes, depending on location, bathymetry, and water properties. The free fall fish was equipped with temperature, pressure, and time-of-flight sound speed Xchange sensors. The system recorded samples on deployment at 1 Hz and was programmed to automatically retrieve when it was 2 m from the seafloor. Casts were transferred via TCP connection to the acquisition station for QC and application to sonar data. The processed files were applied automatically in Qinsy and imported into the Sound Speed Manager database where they were then transmitted to SIS as an extended .ASVP file. Daily casts were exported as a single .SVP file for post-processing.

Data Processing Methods and Procedures

Sound speed profiles collected during acquisition were thoroughly reviewed for date, time, location, depth of cast, and erroneous data. Profiles were then stored in each vessels' Raw and Processed SVP folders and also a master cast file, which stored all SVPs collected within a particular survey area (multi-vessel). While sound speed was challenging throughout the project, a variety of approaches were utilized to best minimize the effects of sound speed on the sounding data and final surfaces. Sound speed profiles, contained in the master SVP file, were typically applied using the “Nearest in Distance within Time” approach using 4 hours to guide the application of profile data. Another strategy used was to apply a single cast to a localized area when the spatial distribution of other casts did not improve the data. In some cases for the R/V Benthos, R/V Chinook, and R/V Substantial, the singular profile applied to the data in SIS during the survey was maintained throughout post-processing (i.e., not re-SV corrected in HIPS). When necessary, “Nearest in Distance within Time” using 2 hours was used to improve the data. Additional efforts in post-processing to minimize refraction artifacts included outer beam filtering and manual outer beam clipping.

C.5.2 Surface Sound Speed

Data Acquisition Methods and Procedures

For real-time beam forming and sound speed depiction of the upper water column, vessels used a Micro•X sound speed instrument mounted at the sonar heads. The Micro•X transmitted sound speed data (m/s) through a serial RS232 connection at 1 Hz. The Kongsberg systems received the surface sound speed data on the operator station through SIS and the R2 Sonic system integrated the surface sound speed data directly in the R2 Sonic SIM Box.

Data Processing Methods and Procedures

In both Qinsy and SIS, an alarm was set to warn the hydrographer when real-time surface sound speed and the most recent profile differed by more than 2 m/s. In most cases, a new sound speed profile was collected and applied. In more predictable areas, a previous cast within 4 hours was often applied to improve the data. In the case that neither technique improved the data, the vessel relocated survey efforts to a more manageable area with respect to water properties. Real-time surface sound speed was plotted geographically in Sound Speed Manager on each vessel and in the PMA for additional QC and guidance of operations.

C.6 Uncertainty

C.6.1 Total Propagated Uncertainty Computation Methods

TPU was calculated to provide an assessment of quality for the position and depth of individual soundings. Many aspects of the TPU model are based on manufacturer RMS values, while others can be more accurately modeled and minimized throughout the mobilization, acquisition, and processing phases.

The HVF contains all of the 1-sigma RMS values for the survey equipment used throughout the project for each vessel. Values for the position and attitude uncertainties are provided by Applanix, while uncertainty values with respect to sonars and frequencies are built-in to the HIPS device library. To more accurately model position and attitude uncertainties, inputs for position/navigation, gyro, pitch, roll, and GPS height were overwritten with 1-sigma RMS values stored in the SMRMSG file associated with each SBET file. Other values stored within the HVF include lever arm distances, measurement error, and patch test uncertainties. Potential uncertainties with lever arms were minimized by performing static vessel surveys using total-station methods to locate sensors with respect to each other and the vessel reference frame to within millimeters. Uncertainties for the alignment of sensors were minimized by integrating SBET solutions to more accurately determine biases from the patch tests. Patch tests were evaluated by multiple hydrographers to calculate standard deviation values for the HVF.

During acquisition, careful consideration was made to minimize artifacts and their contribution to uncertainty. Hydrographers made considerable efforts to reduce the impact of sound speed issues during acquisition. These efforts included increasing the frequency of casts, closely monitoring real-time swath “smiling” or “frowning”, utilizing alerts for surface-to-profile sound speed deviation, observing the real-time standard deviation map display, and utilizing Sound Speed Manager to track spatial changes in surface sound speed along with profile location. When sound velocity had drastic spatial variation, the survey approach would be constrained to areas of similar water properties to avoid large refraction issues.

TPU calculations are performed using the CARIS HIPS Compute TPU process. The Compute TPU process utilizes the a-priori uncertainty estimates, the “real-time” estimates from the SMRMSG data, information from the CARIS sonar device library, and static values set for water level and sound speed uncertainty to calculate the estimated horizontal and vertical TPU for each sounding.

Uncertainty of the SEP model used to reduce soundings from the International Terrestrial Reference System 2014 (ITRF14) ellipsoid to LWD IGLD85 was provided in the PI (0.045m at 2 sigma) and entered into the “Tide Measure” field of the Compute TPU process. Uncertainty input to “Sound Speed - Measured” was derived from the field tolerance of 2 m/s deviance between surface and profile sound speed and the temporal distribution of casts (~2 hours). The "Sound Speed - Surface" value of 0.05 m/s reflects manufacturer accuracy at 2-sigma.

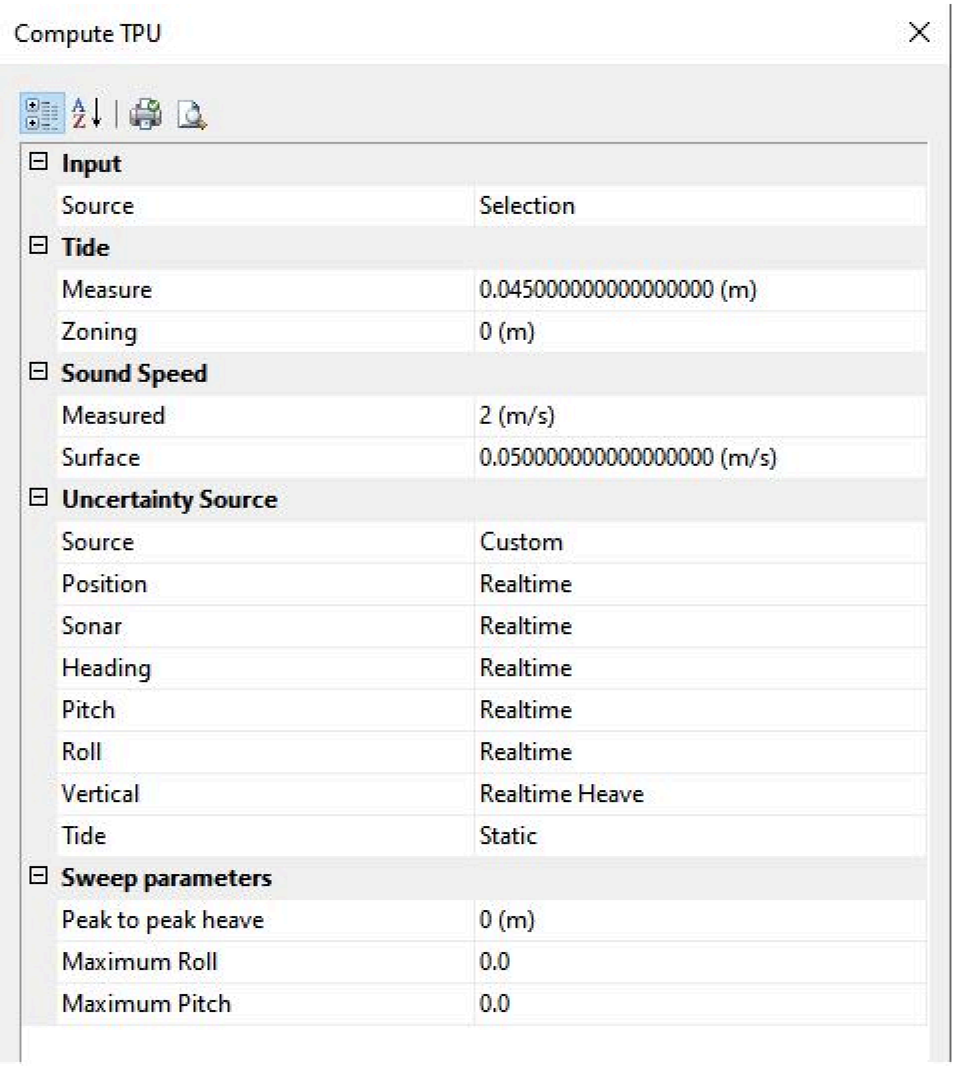
C.6.2 Uncertainty Components

C.6.2.1 A Priori Uncertainty

Vessel		R/V Benthos	R/V Chinook	R/V Substantial	R/V Endeavor
Motion Sensor	*Gyro*	0.02 degrees	0.02 degrees	0.02 degrees	0.02 degrees
	Heave	5.00% 0.05 meters	5.00% 0.05 meters	5.00% 0.05 meters	5.00% 0.05 meters
	Roll	0.01 degrees	0.01 degrees	0.01 degrees	0.01 degrees
	Pitch	0.01 degrees	0.01 degrees	0.01 degrees	0.01 degrees
Navigation Sensor		0.10 meters	0.10 meters	0.10 meters	0.10 meters

C.6.2.2 Real-Time Uncertainty

Real-time uncertainty was not applied.



Input	
Source	Selection
Tide	
Measure	0.045000000000000000 (m)
Zoning	0 (m)
Sound Speed	
Measured	2 (m/s)
Surface	0.050000000000000000 (m/s)
Uncertainty Source	
Source	Custom
Position	Realtime
Sonar	Realtime
Heading	Realtime
Pitch	Realtime
Roll	Realtime
Vertical	Realtime Heave
Tide	Static
Sweep parameters	
Peak to peak heave	0 (m)
Maximum Roll	0.0
Maximum Pitch	0.0

Figure 23: Uncertainty estimates parameters in the CARIS HIPS Compute TPU Dialog (Note: R/V Endeavor used "Vessel" for Sonar)

C.7 Shoreline and Feature Data

Data Acquisition Methods and Procedures

No shoreline investigations or shoreline data collection were required for OPR-Y395-KR-20.

Assigned features and new features identified during multibeam data acquisition were investigated and developed in accordance with the HSSD and guidance from the HSD OPS Project Manager. Additional MBES coverage was acquired when necessary to adequately determine the least depth of features.

Above water features that were not developed with multibeam bathymetry were documented though an internally developed and customized ArcGIS Survey 123 mobile data collection application. The application reduced error, streamlined the workflow, and quality controlled feature development from collection to delivery in the Final Feature File (FFF). Hydrographers recorded feature attributes through a series of guided questions using predefined selections that eliminated erroneous descriptions and guaranteed completeness and accuracy required to attribute the FFF. GPS-tagged photos for each feature were acquired and associated with the corresponding feature when stored in the PMA, where the Lead Hydrographer and Data Processing Manager reviewed each feature in near real-time.

(1 of 3)

BCNSPP_P

Processing_Status	Incomplete
BCNSHP	beacon tower
CATSPM	general warning mark
COLOUR	white,red
COLPAT	horizontal strip
GRUP	2
INFORM	Cyclindrical
LNAM	US000001101400
OBJL	9

Zoom to

(1 of 3)

TO1_Chicago_Feature_Notes: 42

Date and Time	6/6/2020, 6:40 AM
Description (Action)	Feature found as charted
Additional Notes:	LT
Status	Unprocessed
Vessel	
Hydrographer	
Hydrographer	
Hydrographer	
Hydrographer	
Enter Name	
Enter Name	
Enter Name	

Figure 24: Processing Manager Application showing assigned and documented features

Data Processing Methods and Procedures

Feature data processing consisted of addressing all assigned features in the Composite Source File (CSF) provided with the PI package and adding all new features to a single .000 S-57 file for each survey. All multibeam data were reviewed for features, and least depths over navigationally and/or potentially significant features were flagged as "designated soundings" in CARIS HIPS. Development of each feature was done in accordance with the HSSD including S-57 attribution and hydrographer recommendations.

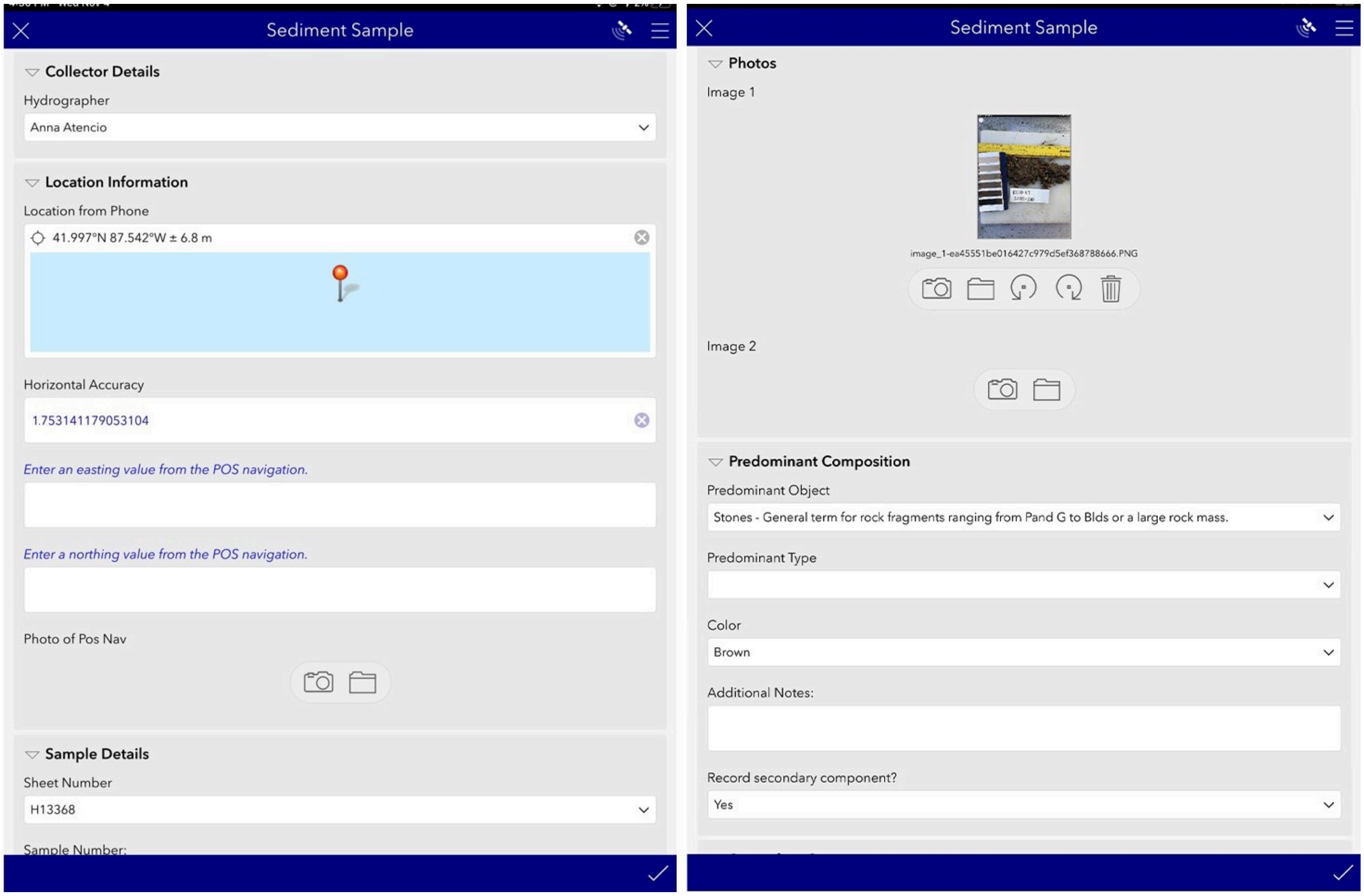
C.8 Bottom Sample Data

Data Acquisition Methods and Procedures

Predetermined bottom sample locations within each sheet were provided in the Project Reference File (PRF) prior to the start of field work. These locations were modified based on mosaicked multibeam backscatter data for all sheets, except H13369, during the survey (see Project Correspondence). Each sample was collected successfully aboard the R/V Chinook using a Pacific Pro 12 volt pot puller and Wildco petite ponar grab sampler.

To reduce error, streamline the workflow, and QC the bottom samples from collection to delivery in the FFF, Geodynamics utilized another ArcGIS Survey 123 mobile data collection application. The application's schema was designed to facilitate collection and storage of well-organized and accurate field notes. Hydrographers recorded sample location, name, and NATSUR / NATQUA attributes through a series of guided questions using predefined selections that eliminated erroneous descriptions and guaranteed completeness and accuracy as per the HSSD. GPS-tagged photos for each sample were acquired and associated with the corresponding sample when stored in the PMA, where the Lead Hydrographer and Data Processing Manager reviewed each sample in near real-time.

Figure 25: Bottom sample collected and documented in H13368



Collector Details

Hydrographer: Anna Atencio

Location Information

Location from Phone: 41.997°N 87.542°W ± 6.8 m

Horizontal Accuracy: 1.753141179053104

Enter an easting value from the POS navigation.

Enter a northing value from the POS navigation.

Photo of Pos Nav

Sample Details

Sheet Number: H13368

Sample Number:

Photos

Image 1

image_1-ea45551be016427c979d5ef368788666.PNG

Image 2

Predominant Composition

Predominant Object: Stones - General term for rock fragments ranging from Pand G to Blds or a large rock mass.

Predominant Type:

Color: Brown

Additional Notes:

Record secondary component?: Yes

Figure 26: Screen capture of Survey 123 bottom sample application during collection in H13368

Data Processing Methods and Procedures

Bottom sample data and GPS-tagged photos stored in the PMA were transferred to a CARIS .hob file for processing and QA. All bottom sample results can be found in the FFF of each sheet.

D. Data Quality Management

D.1 Bathymetric Data Integrity and Quality Management

D.1.1 Directed Editing

Direct editing of soundings was performed to clean spurious and erroneous data that adversely affected the final surface and depth determination of features. In addition to visual assessment and cleaning from the bathymetric surface, many derivative layers computed from the bathymetric surface and sounding data were used to guide data cleaning, assess quality, and illustrate adherence to the HSSD. Node standard deviation, standard deviation, uncertainty, and TVU-ness were surface layers commonly used in data cleaning and quality assessments. In addition to a visual inspection, all CUBE surfaces were analyzed using HydrOffice QC Tools Flier Finder tool to assure data does not contain fliers (anomalous data as defined by QC Tools flier finding algorithms #2-6). The tool was run with the standard presets and results were used to guide data editing.

D.1.2 Designated Sounding Selection

Designated sounding selection followed specifications in the HSSD. The CARIS HIPS Subset Editor was utilized to view soundings and the CUBE surface in 2D and 3D. Erroneous sounding data were cleaned, and a least depth was designated when necessary.

D.1.3 Holiday Identification

All CUBE surfaces were analyzed using HydrOffice QC Tools Holiday Finder to determine if the surface contained holidays, as described in section 5.2.2 of the HSSD. The tool scanned the CUBE surfaces to identify any holidays and generated an S-57 file to represent the locations of holidays. Another method of holiday evaluation was to visually pan the CUBE surfaces to identify holidays. The hydrographer would often alter the surface display (color ranges, symbology, shading) to help aid in identifying coverage gaps.

During survey operations, holidays were compiled into a shapefile line plan and loaded into Qinsy on each vessel for recovery.

D.1.4 Uncertainty Assessment

All CUBE surfaces were analyzed using the HydrOffice QC Tools Grid QA tool to assure at least 95% of the surface grid nodes meet TVU specifications. Results of the Grid QA tool are illustrated in a graphical representation of the surface uncertainty statistics.

D.1.5 Surface Difference Review

D.1.5.1 Crossline to Mainscheme

Crosslines were evaluated in CARIS HIPS with a detailed visual inspection followed by a thorough statistical analysis. To conduct the statistical analysis, a CUBE surface was generated with strictly mainscheme data and another, separate CUBE surface was generated with only crossline data. The mainscheme and crossline surfaces were analyzed using the Compare Grids tool in Pydro Explorer, which generated a difference surface and associated statistics. In addition to the direct statistics from the surface differencing, the tool assessed the difference surface statistics and computed the proportion of TVU consumed by the mainscheme-to-crossline differences per surface node.

D.1.5.2 Junctions

No junction surveys were provided for OPR-Y395-KR-20. Sheet overlap junction analyses were performed using the Pydro Compare Grids tool. The inputs for this tool were the CUBE surfaces for each individual survey at matching resolutions. The tool outputs a difference surface and the statistical results are illustrated in a graphical representation of the surface difference statistics. Additional inspection of junctions were performed using the 2D and 3D views in Subset Editor.

D.1.5.3 Platform to Platform

Vessel to vessel confidence tests were acquired at the beginning, middle, and end of survey operations to assess confidence between each survey vessel and their respective survey systems. Confidence tests were assessed in CARIS HIPS by evaluating the agreement of sounding data as well as assessing statistics derived from vessel to vessel surface differences. Results of confidence tests can be found in DAPR Appendix V.

D.2 Imagery data Integrity and Quality Management

Imagery data integrity and quality management were not conducted for this survey.

E. Approval Sheet

This report and the accompanying data deliverable are respectfully submitted.

As Chief of Party, field operations contributing to the accomplishment of Surveys H13363, H13364, H13365, H13366, H13367, H13368, and H13369 were conducted under my direct supervision, with frequent personal checks of progress and adequacy. This report and accompanying data deliverable have been closely reviewed and are considered complete and adequate as per the Statement of Work (April 2, 2020).

The survey data meets or exceeds requirements as set forth in the Hydrographic Surveys Specifications and Deliverables 2020, Project Instructions (March 27, 2020), and Statement of Work (April 2, 2020). These data are adequate to supersede charted data in their common areas.

Approver Name	Approver Title	Date	Signature
David J. Bernstein, CH, PLS, GISP	Chief of Party	11/21/2020	David J. Bernstein Digitally signed by David J. Bernstein Date: 2020.11.21 10:24:41 -05'00'

List of Appendices:

Mandatory Report	***File***
Vessel Wiring Diagram	I_Vessel_Wiring_Diagrams.pdf
Sound Speed Sensor Calibration	II_Sound_Speed_Calibration_Reports.pdf
Vessel Offset	III_Vessel_Offset_Reports.pdf
Position and Attitude Sensor Calibration	IV_Position_Attiude_Sensor_Calibration_Reports.pdf
Echosounder Confidence Check	V_Echo_Sounder_Confidence_Check_Reports.pdf
Echosounder Acceptance Trial Results	N/A