W00343

NOAA Form 76-35A

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

# DESCRIPTIVE REPORT

| | |
|---|---|
| Type of Survey: | Navigable Area |
| Registry Number: | W00343 |

## LOCALITY

| | |
|---|---|
| State: | California |
| General Locality: | Channel Islands Marine Sanctuary |
| Sub-locality: | Santa Rosa Island |

2016

CHIEF OF PARTY
Mary Yoklavich

LIBRARY & ARCHIVES

Date:

| NOAA FORM 77-28<br>(11-72) | U.S. DEPARTMENT OF COMMERCE<br>NATIONAL OCEANIC AND ATMOSPHERIC ADMINISTRATION | REGISTRY NUMBER: |
|---|---|---|
| **HYDROGRAPHIC TITLE SHEET** | | **W00343** |

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

| | |
|---|---|
| State: | **California** |
| General Locality: | **Channel Islands National Marine Sanctuary** |
| Sub-Locality: | **Santa Rosa Island** |
| Scale: | 1: **40,000** |
| Dates of Survey: | **10/16/2016 to 10/29/2016** |
| Instructions Dated: | **04/07/2016** |
| Project Number: | **OSD-PHB-17** |
| Field Unit: | **NOAA Ship *Reuben Lasker*** |
| Chief of Party: | **Mary Yoklavich** |
| Soundings by: | **Multibeam Echo Sounder** |
| Imagery by: | |
| Verification by: | **Pacific Hydrographic Branch** |
| Soundings Acquired in: | **meters at Mean Lower Low Water** |

Remarks:

***The purpose of this survey is to provide contemporary surveys to update National Ocean Service (NOS) nautical charts. All separates are filed with the hydrographic data. Any revisions to the Descriptive Report (DR) generated during office processing are shown in bold red italic text. The processing branch maintains the DR as a field unit product, therefore, all information and recommendations within the body of the DR are considered preliminary unless otherwise noted. The final disposition of surveyed features is represented in the OCS nautical chart update products. All pertinent records for this survey, including the DR, are archived at the National Centers for Envitronmental Information (NCEI) and can be retrieved via http://www.ncei.noaa.gov/.***

| Descriptive Report Summary | |
|---|---|
| Project | RL1606 |
| Survey | W00343 |
| State | California |
| Locality | Channel Islands Marine Sanctuary |
| Sub Locality | Santa Rosa Island |
| Scale of Survey | 1:40,000 |
| Sonars Used | Simrad ME70 |
| Horizontal Datum | WGS84 |
| Vertical Datum | Mean Lower Low Water (MLLW) |
| Vertical Datum Correction | Discrete Zoning |
| Projection | UTM |
| Field Unit | NOAA Ship Reuben Lasker |
| Survey Dates | 10/19/16-10/29/16 |
| Chief of Party | Mary Yoklavich, NOAA Southwest Fisheries Science Center |

## A. Area Surveyed

This hydrographic survey was acquired in accordance with the requirements defined in the RL-16-06 Cruise Plan.

Data was acquired within three priority survey areas. The three survey areas include Priority 1a, Priority 1b, and Priority 3. Priority 1a is located nearshore southwest of Santa Rosa Island, Priority 1b is located further offshore southeast of Santa Rosa Island, and Priority 3 is located southeast of Santa Cruz Island.


*Figure #1: Priority areas defined in the RL-16-06 Cruise Plans.*

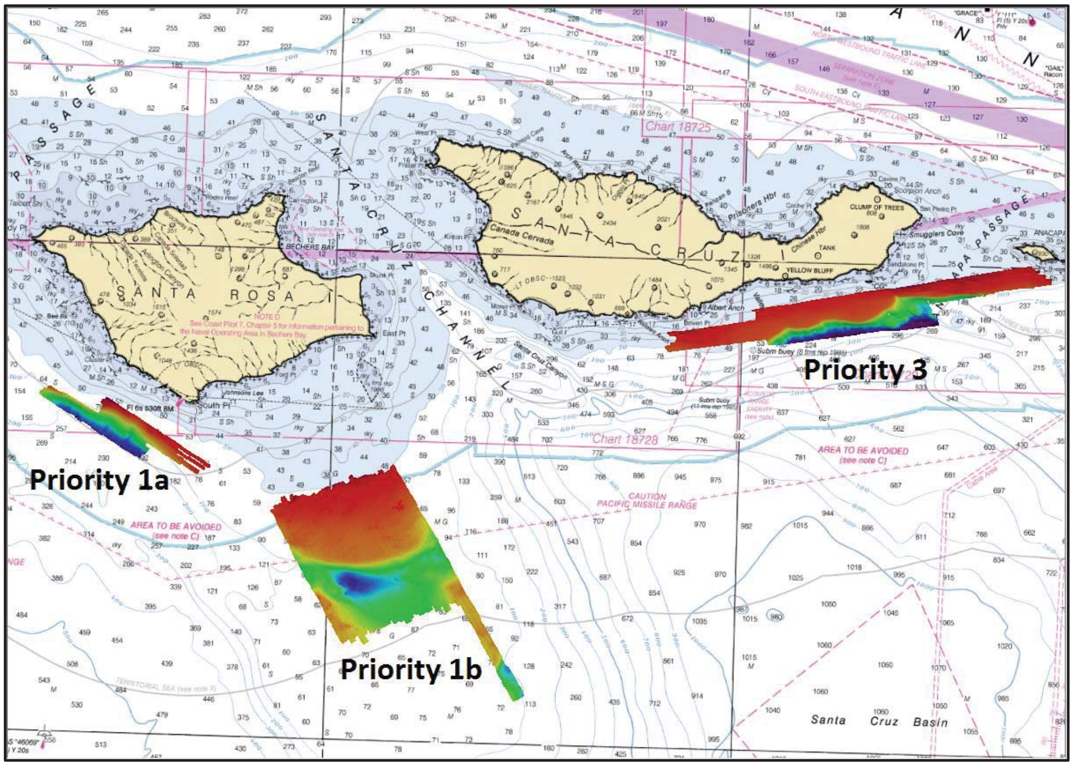


*Figure #2: RL1606 Survey Overview Including Santa Rosa Island and Santa Cruz Island*

**Priority Area #1a**

| Northwest Limit | Southeast Limit |
|---|---|
| 33-54-05.985N | 33-50-45.449N |
| 120-13-52.398W | 120-06-30.682W |

*Table #1: Survey Limits of Priority 1a South of Santa Rosa Island*

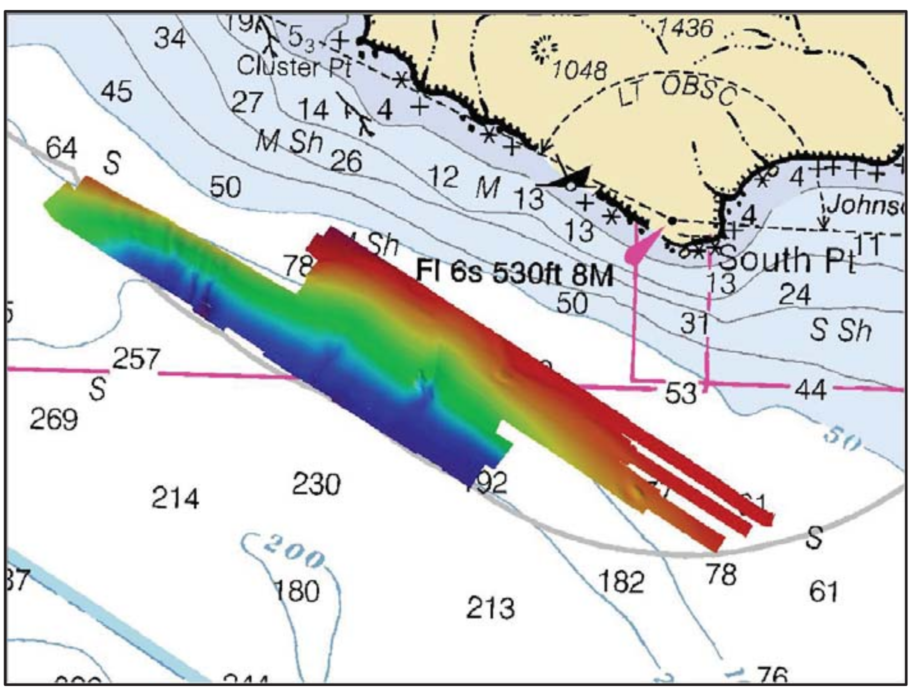


*Figure #3: RL1606 Priority 1a South of Santa Rosa Island Survey Overview*

**Priority Area #1b**

| Northwest Limit | Southeast Limit |
|---|---|
| 33-49-17.557N | 33-42-01.076N |
| 120-02-51.470W | 119-50-11.621W |

*Table #2: Survey Limits of Priority 2 South of San Miguel Island*

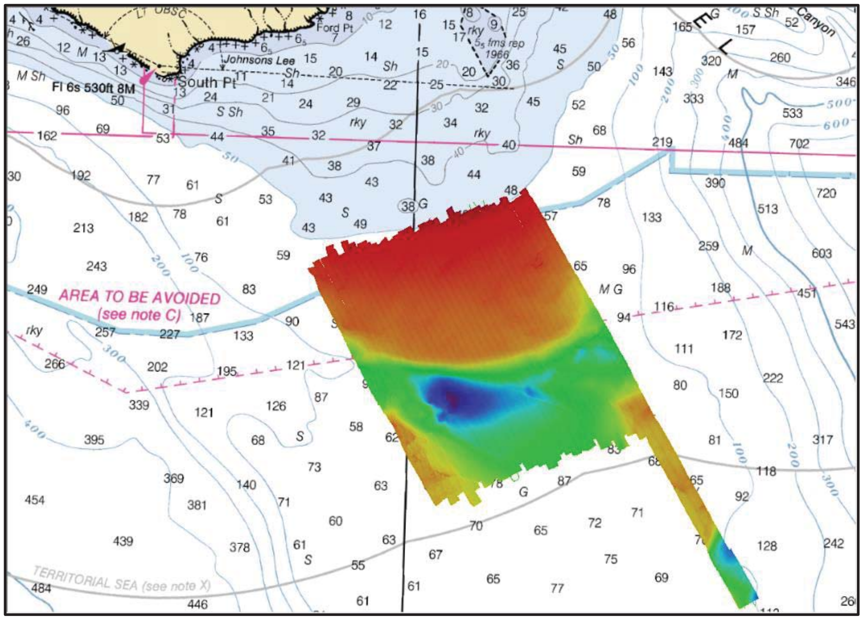



*Figure #4: RL1606 Priority 1b Southeast of Santa Rosa Island Survey Overview*

**Priority Area #3**

| Northeast Limit | Southwest Limit |
|---|---|
| 34-00-03.042N | 33-56-05.186N |
| 119-25-53.090W | 119-43-18.419W |

*Table #3: Survey Limits of Priority 3 Southeast of Santa Cruz Island*

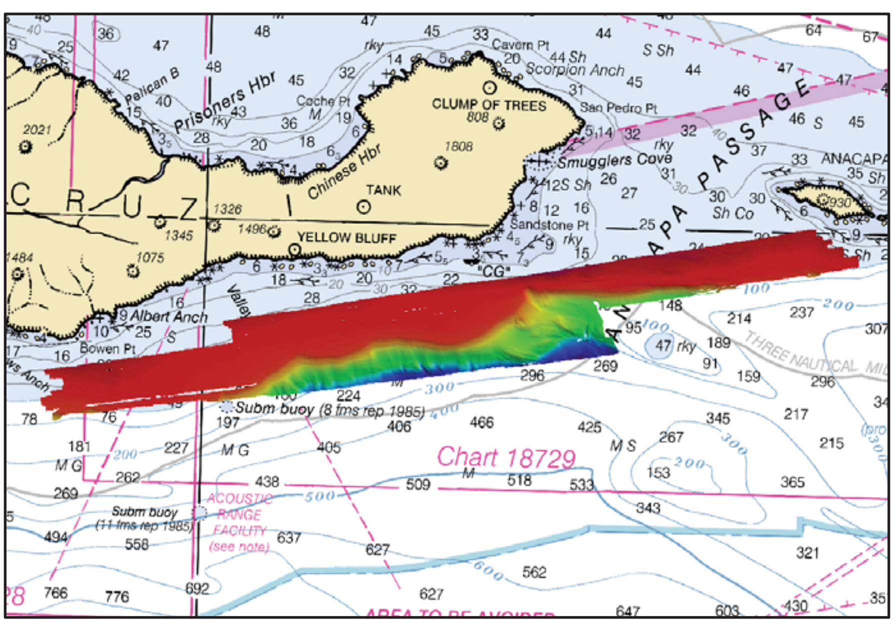



*Figure #5: RL1606 Priority 3 Southeast of Santa Cruz Island Survey Overview*

The following table lists the mainscheme and total nm miles for this survey:

| Survey | Vessel | MBES Mainscheme | Nautical Miles |
|---|---|---|---|
| Priority1a | R-228 | 49,795.05m | 26.88nm |
| Priority1b | R-228 | 401,724.9m | 216.91nm |
| Priority3 | R-228 | 334,016.3m | 180.35nm |

*Table #4: Survey Statistics*

Some of the survey coverage meets the National Ocean Service (NOS) Hydrographic Survey Specifications and Deliverables (HSSD) 2016 requirements for multibeam complete coverage. Data gaps and holidays do exist throughout the survey and are discussed in Section D.9. Two grids per survey area have been delivered within this project, 8m and 16m grids. The 8m grids do not fall within density spec but are more detailed and useful to the AUV missions. The 16m grids have been submitted to fulfill the data density requirements as per spec.

## B. Survey Purpose

As stated within the RL1606 Lasker Cruise Plan-

"There were five main objectives associated with this project:
1. Collect high-resolution bathymetry data using the ships' ME70 sonar
2. Ground truth bathymetric data using NMFS' Seabed AUV
3. Conduct visual surveys of ground fishes using NMFS' Seabed AUV
4. Work with R/V *Velero IV* (contracted by NMFS) at Footprint study site, during which time the AUV will operate as part of an underwater experiment to observe and quantify the behavior of rockfishes in reaction to mobile survey vehicles
5. Acquire water column data on the presence, relative abundance, and distribution of fishes associated with various seafloor features using the ships' EK60 and ME70.

Many species of rockfishes live in complex rocky habitats, have been over-fished, and are difficult or impossible to accurately survey using conventional bottom-trawl gear. Our ability to count these species in rocky habitats and to delineate the distribution and extent of these habitats is critical to the estimation of absolute abundance of these species for stock assessments. To that end, NMFS recognizes the need for more high-resolution mapping of the seafloor and also has initiated the Untrawlable Habitat Strategic Initiative (UHSI) field research in the Southern California Bight.

The results of this mission will lead to more accurate estimates of demersal fish populations and associated habitats in deep-water, thereby supporting NOAA's objectives to achieve sustainable fisheries and improve our understanding of marine ecosystems. Our findings will improve stock assessments of species in untrawlable habitats, and will assist in the interpretation and understanding of the use of deepwater habitats by demersal fishes."

## C. Intended Use of Survey

Selected soundings are adequate to supersede prior data and are intended for chart compilation. It is recommended that the shoaler soundings be updated on the chart.

## D. Data Acquisition and Processing (DAPR)

Currently there is not a Data Acquisition and Processing Report (DAPR) written for the ship. A Descriptive Report (DR) for another Fishery Survey Vessel (FSV), the NOAA Ship Pisces, utilizing the same hardware was submitted for reference in DR Appendix II. Also submitted within the same location is a report titled "NOAA Ship Reuben Lasker ME70 Integration Testing" written by Sam Greenaway.

### *D.1 Vessel and Equipment*

| | |
|---|---|
| |  NOAA Ship *Reuben Lasker* |
| Hull Number | R228 |
| Builder | Marinette Marine, Corp., Marinette, Wisconsin |
| Length | 63.6m (208.7 ft) |
| Beam | 15m (49.2 ft) |
| Draft Center Board Retracted | 5.9m (19.4 ft) |
| Draft Center Board Extended | 9.05 m (29.7 ft) |
| Cruising Speed | 12 knots |
| Survey Speed | 5-8 knots |
| Primary Echosounder | Simrad ME70 |
| Sound Speed Equipment | Surface sound speed: SBE21 & SBE45<br>Water column: XBT-Sippican MK21, SBE 9+ |
| Attitude and Positioning Equipment | Applanix POS MV V4, Simrad/ MX512 |

*Table #5: Vessel and equipment*

### *D.2 Bathymetry Systems*

The Simrad ME70 is a multibeam echosounder designed for fisheries research applications by collecting full water column data. The system operates in the 70 to 120 kHz frequency range with a fixed swath angle with a maximum of 45 beams. Each beam can be set to a different frequency and beam parameters can be specifically configured and applied by XML file. The XML file can specify survey parameters such as min/max range, pulse length, and frequency dependent on depth. The XML file used for this survey was written by Dr. Tom Weber from the University of New Hampshire Center for Coastal and Ocean Mapping.

*D.3 Positioning, Heading and Motion Reference Systems*

The POS MV inertial reference system supplies attitude, heading, heave, and position. The system consists of an inertial measuring unit (IMU), computer system, and two GPS antennas. The POS MV GPS Azimuth Measurement Subsystem (GAMS) provides heading aiding to the system. A GPS Azimuth Measurement System (GAMS) calibration was not performed on this cruise. It appears a GAMS calibration had been performed by the ship recently and the heading accuracy from the POS was 0.015. It was deemed unnecessary by the survey unit to perform another GAMS calibration. Issues with heading did not present throughout the course of the cruise.

*D.4 Sound Speed Equipment*

The ship has two thermosalinographs (SBE45 and SBE21) that supply seawater temperatures and sound speed in real-time. The SBE45 supplies the real-time sound speed to the ME70 for beam steering.

In order to collect full water column sound speed data, an Expendable Bathythermographic Temperature Probe (XBT) is launched off the back of the ship. This probe measures sea water temperature as the probe makes its way through the water column to the seafloor. The XBT does not provide conductivity and no official CTD casts were taken throughout the cruise by the survey team.

The XBT creates an .EDF file that is then converted to a CARIS compatible file type, .svp, using Pydro Velocipy. Here the cast is exported and the loaded straight into the ME70 for real time SV correction. Casts were taken every 2-4 hours depending on data quality and were geospatially distributed.

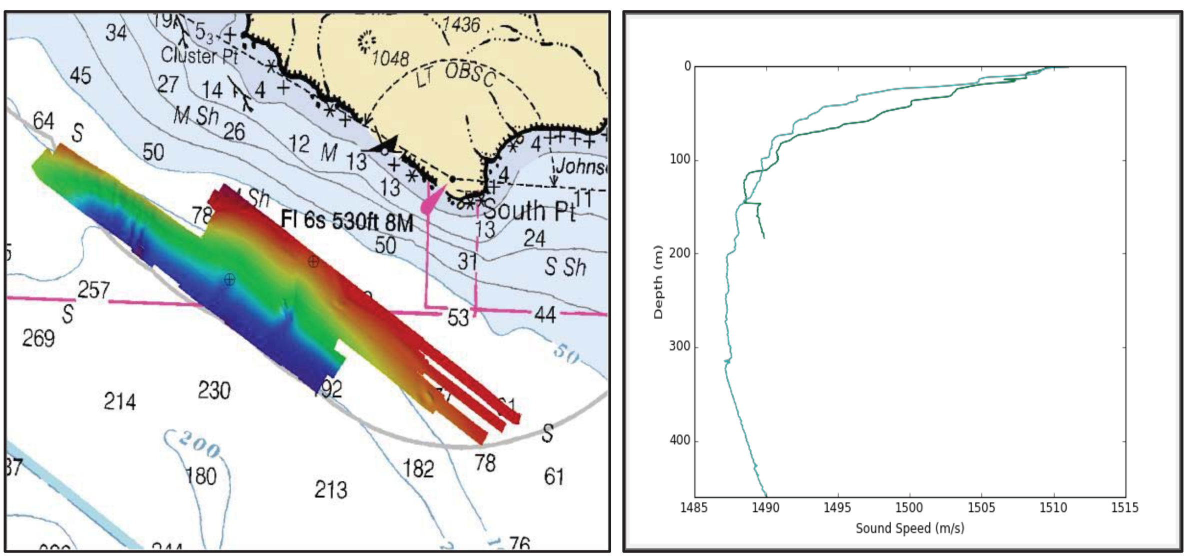



*Figure #6: Geospatial cast distribution for Priority 1a and each cast plotted for Sound Speed @ Depth*

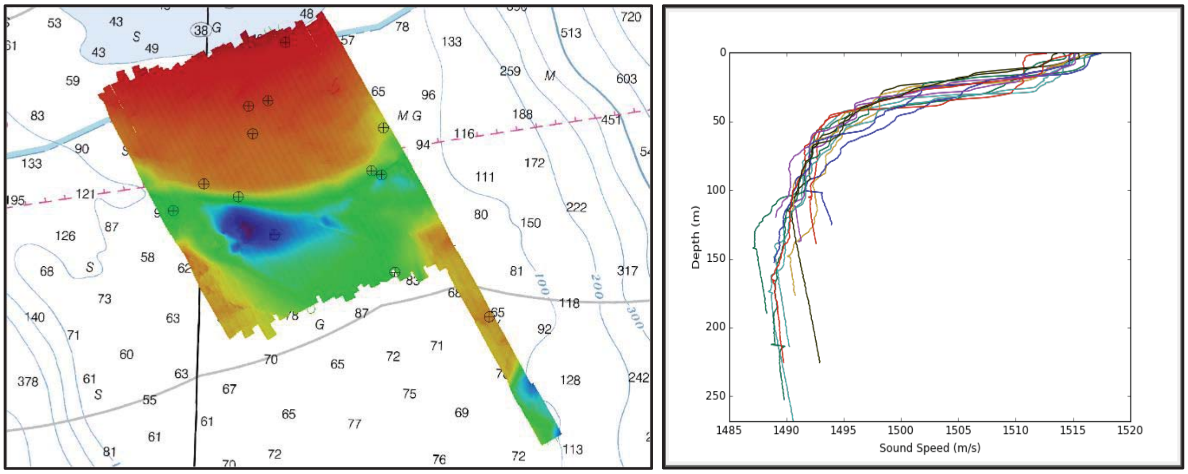



*Figure #7:Geospatial cast distribution for Priority1b and each cast plotted for Sound Speed @ Depth*

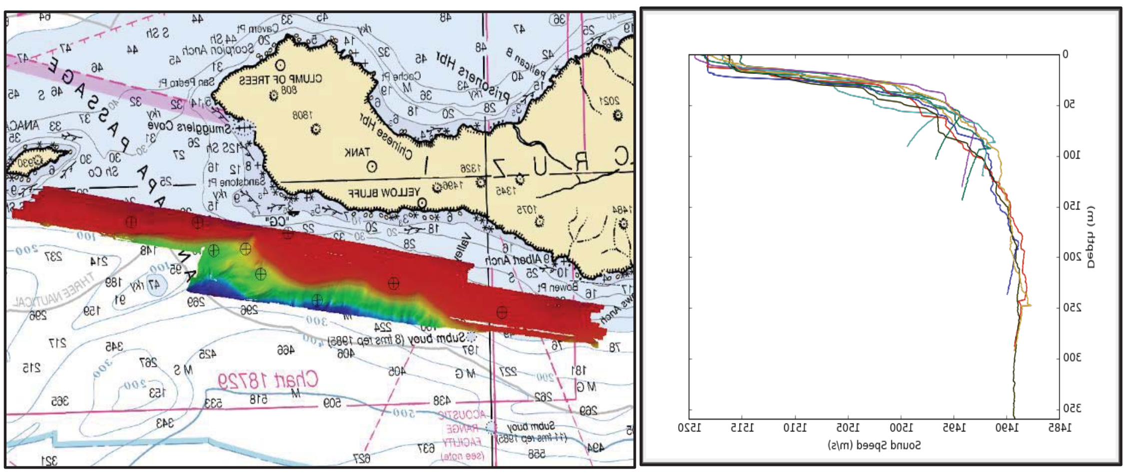


*Figure #8: Geospatial cast distribution for Priority 3 and each cast plotted for Sound Speed @ Depth*

### *D.5 Software Inventory*

| | | |
|---|---|---|
| Hypack | 2016 | Line planning, navigation |
| Simrad ME70 | N/A | Acquisition |
| MATLAB executable script | March 17th, 2015 | *.RAW to *.GSF conversion |
| POS View | V4 | Interface with POS MV |
| Caris HIPS | 9.1.7 | Process bathymetry |
| Velocipy | 14.6 | *.EDF to *.SVP conversion |

*Table #6: Software Inventory*

### *D.6 Patch Test*

A patch test was not conducted by the survey field unit. A patch test was conducted by Sam Greenaway on June 30th, 2016 off of San Francisco when the Lasker was assessed and "sea trials" to some degree were conducted. As stated in Sam Greenaways' document, "Three lines were run, two reciprocal lines for roll and pitch and one offset for yaw. The flat section above the canyon was used for roll. The steep canyon sides were used for pitch and yaw. With the surveyed offsets already entered into the POS to align the reference frames, no residual roll, pitch, or yaw were observed". Sam discusses in his document that the POS-MV was configured to output the position and attitude at the granite block located in the sonar flat. This granite block is the origin and alignment of the ships reference system adjacent to the ME70 sea chest. The reported position from the POS is the position of the granite block. The reported attitude from the POS is the attitude of the granite block with respect to a north aligned gravity level frame.

Sam measured the rotational offsets (roll, pitch, yaw) of the ME70 and IMU with respect to the ship frame. He entered these offsets into the POS interface which is documented on page 30 of his report and entered the transducer offset into the ME70 which is documented on page 28 of his report.

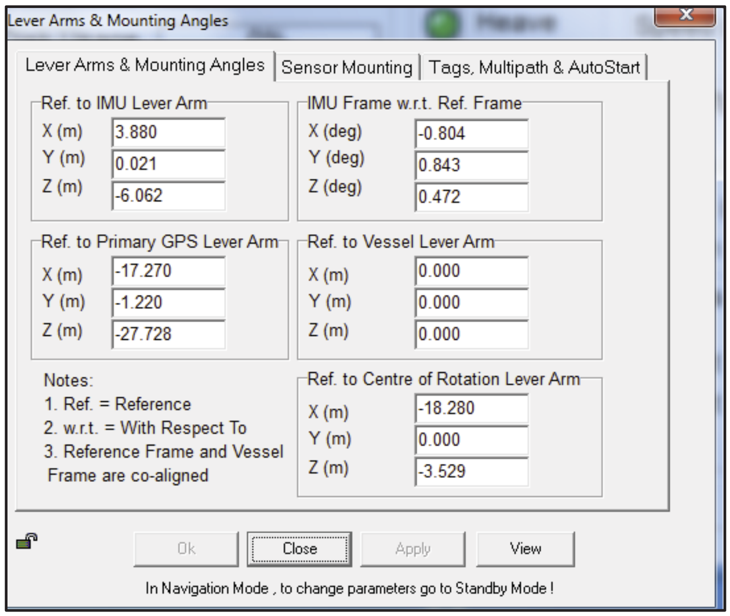



*Figure #9: Offsets for attitude located within IMU Frame w.r.t Ref. Frame located within the POSMV*

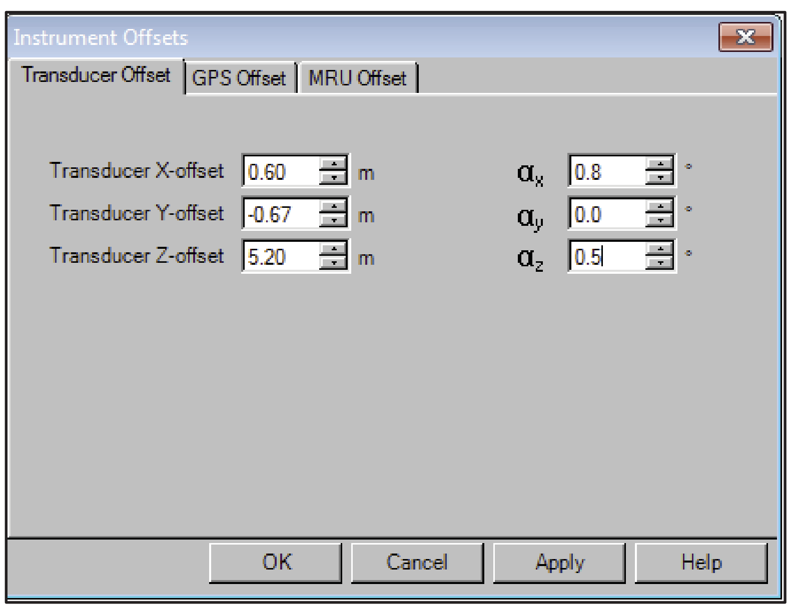



*Figure #10: Transducer offsets located within the ME70*

After a timing issue was found by Sam Greenaway, a time server was used on this cruise. Still, hourly time checks between the ME70 and the POSMV were executed. A very miniscule timing offset of 35milliseconds was found between the timesync system and the ME70. Documentation of this timing issue is provided by Sam Greenaway during his testing on the NOAA Ship Reuben Lasker and the document is located within DR Appendix II.

ESDR: A junction comparison conducted during survey H13088 (OPR-L397-RA-17) indicated that an error in static offset application occurred during acquisition for W00343. During review at the Pacific Hydrographic Branch, final grids for W00343 were shifted by 3.97m to account for the waterline offset contained in the HIPS Vessel File.

### *D.7 Tides and Water Levels*

Due to the location of the survey, there were no ideal tide stations available in the vicinity of the survey. It was decided that for this survey, predicted tides would be used from a tide station located on the mainland in Santa Barbara, Station ID: 9411340. A zoned file was provided to the Shimada Channel Islands Cruise (W00320) in May, 2016 and was used for this cruise as well. Tidal artifacts do not exist throughout the survey even though the station is 43 nautical miles from the furthest point of the survey.

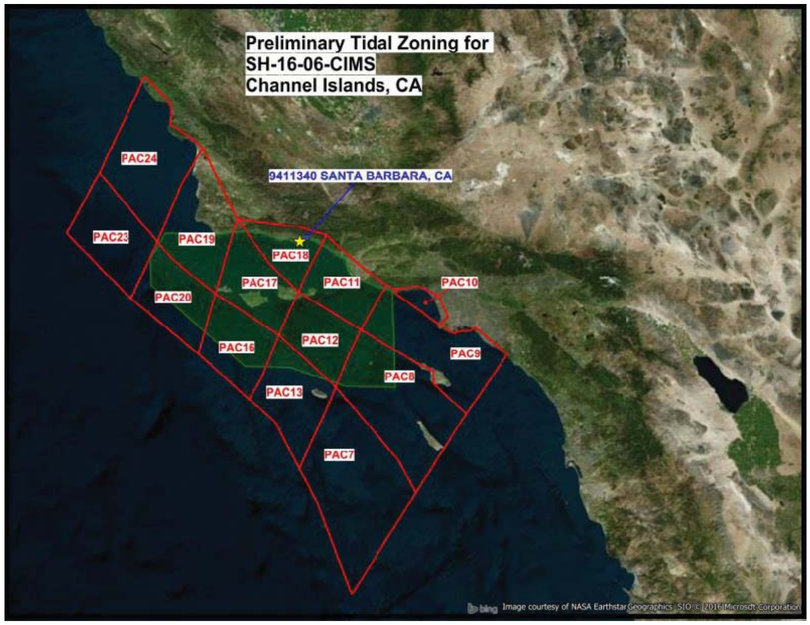



*Figure #11: Preliminary Zoned Tides for the Channel Islands*

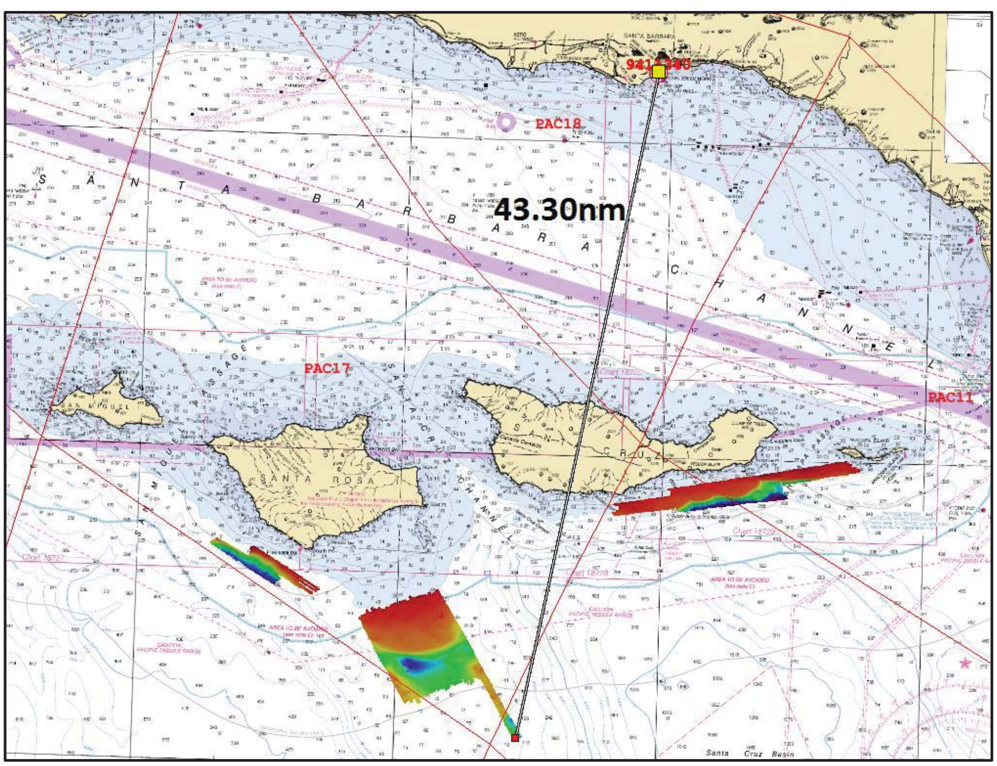



*Figure #12: Distance from the furthest corner of the data to the tide station is 43.30nm*

*D.8 Data Processing*

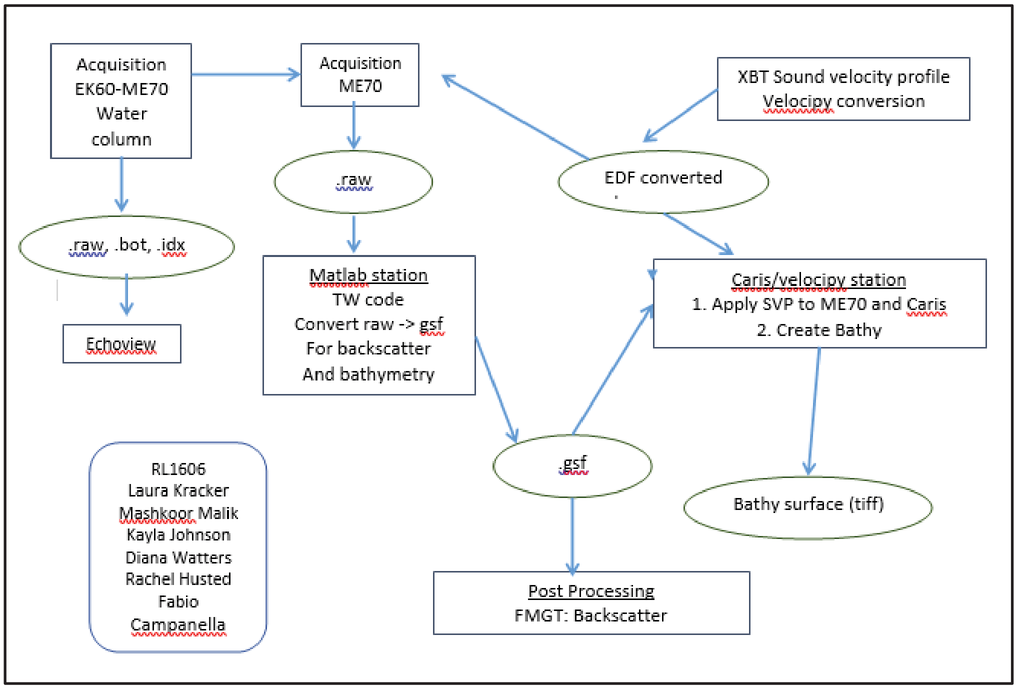



*Figure #13: General workflow for acquiring and processing data*

Outside of the general workflow, filtering of the data was necessary. Outer beam data showed a trend to have "busts" where the data collected was not useable; creating a "bowtie" appearance of the swath. CARIS Swath Editor was used to filter the data 60/60 (port/stbd) degrees from nadir. At some point throughout the survey a filter of up to 50/50 was necessary. Throughout the data there is a theme of a large overlap of beams between two lines. Because of the "bowtie" effect of the outerbeams, an artifact was created between each line. The hydrographer filtered the swath to decrease the amount of overlap as best as possible to attempt to smooth the artifacts. The filtering procedure was up to the discretion of the Hydrographer in Charge on shift.

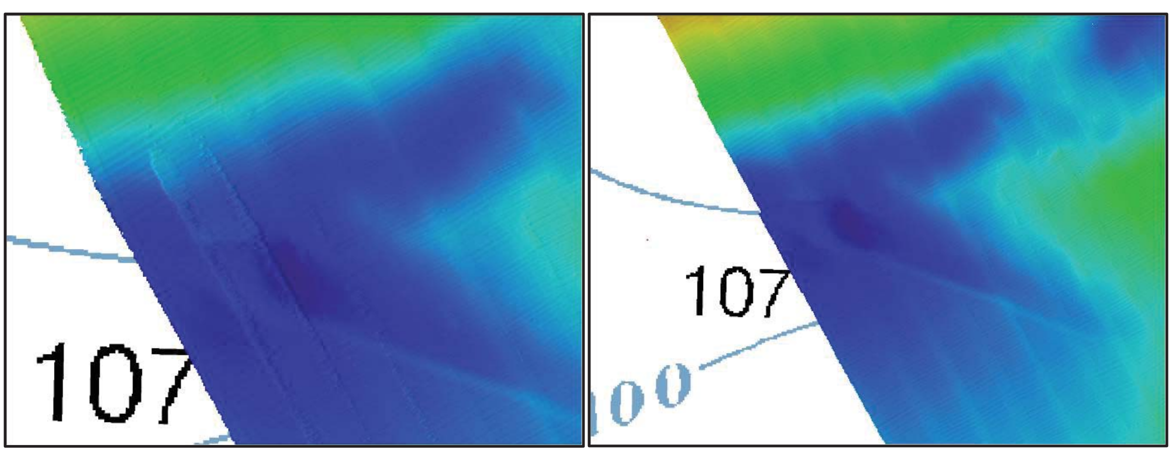



*Figure #14: Before and after image of an example of the artifact from overlapping outerbeams and then cleaned via Swath Editor*

Line plans were created in Hypack for the priority areas. Line editor was used to create lines with variable line spacing based on the shoalest soundings located on the chart. Line spacing varied given the dynamic nature of the seafloor within the project area, obstructions in the water such as rocks and areas prohibited due to safety concerns. Line files were initially converted to .csv files which was imported into Rosepoint by the ship's Navigation Officer. During the mission a python executable was developed (M. Malik) to convert from Hypack line files to Rosepoint GPX files directly. The navigation officer excluded areas shoaler than the 20 fathom contour in Rosepoint. Overall, this process was a bit cumbersome since line planning by the scientists and navigation lines used by the ship were not developed in the same software environment.
A Hypack monitor was successfully installed on the bridge to aid in line driving. However, the full utility of driving by Hypack directly – which would have shown real time multibeam coverage of the bottom - was limited by the Hypack computer which did not have enough processing capacity and fast enough refresh rates. This confirms the findings of the sea trials (S. Greenaway) which recommended replacing this computer with one equipped with a solid state drive and a high performance video card.

Heave artifacts exist throughout the entire survey. The location of the GPS units that feed into POS-MV are located on the main mast. This location has been beneficial in avoiding heading dropouts and artifacts in the data. This provides evidence that the heading dropouts experienced on the NOAA ship *Bell M. Shimada* would likely be reduced if the GPS antennas were moved from the current location on the observation deck to the top of the main mast and resurveyed. Further, this task was recently completed on the Pisces and resulted in major improvements in data acquisition and output. Attempts to post process the raw POS data were made but was not successful. Due to these heave artifacts, the grid in some places honors these artifacts as actual sea floor bathymetry. Flier Finder was used to do final cleaning of the grids but due to the heave artifacts there is a possibility fliers do still exist.

*Figure #15: Location of the POSMV on the Shimada(left) and location on the Lasker (right)*

***D.9 Gaps and Holidays***

Holidays exist within Priority 1a, Priority 1b, and Priority 3. Holidays within Priority 1a were created by poor line spacing at first and blown out outer beams that needed to be filtered drastically. These were the first few lines of the survey when operations were still shaky in the beginning. This area was surveyed to fill in a gap between two other surfaces of data collected by the NOAA Ship Bell Shimada. The decision to not fill in the holidays was made due to time constraints at this location.

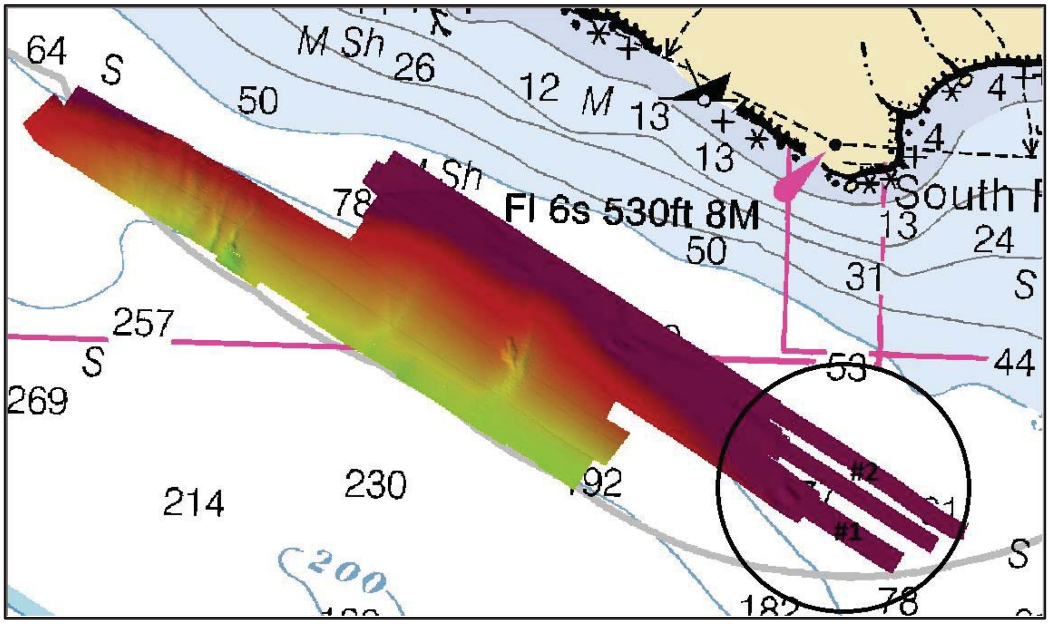



*Figure #16: Holidays #1 and #2 within Priority 1a*

Holidays within Priority 1b were created also by line spacing issues since the line plan loaded and created did not follow the contours. Holidays were also created by how much of the data was useable within the swath and had to be heavily filtered. The decision to not fill in the holidays was made due to time constraints at this location and needing to run crosslines and transit to the new location at Anacapa Island.

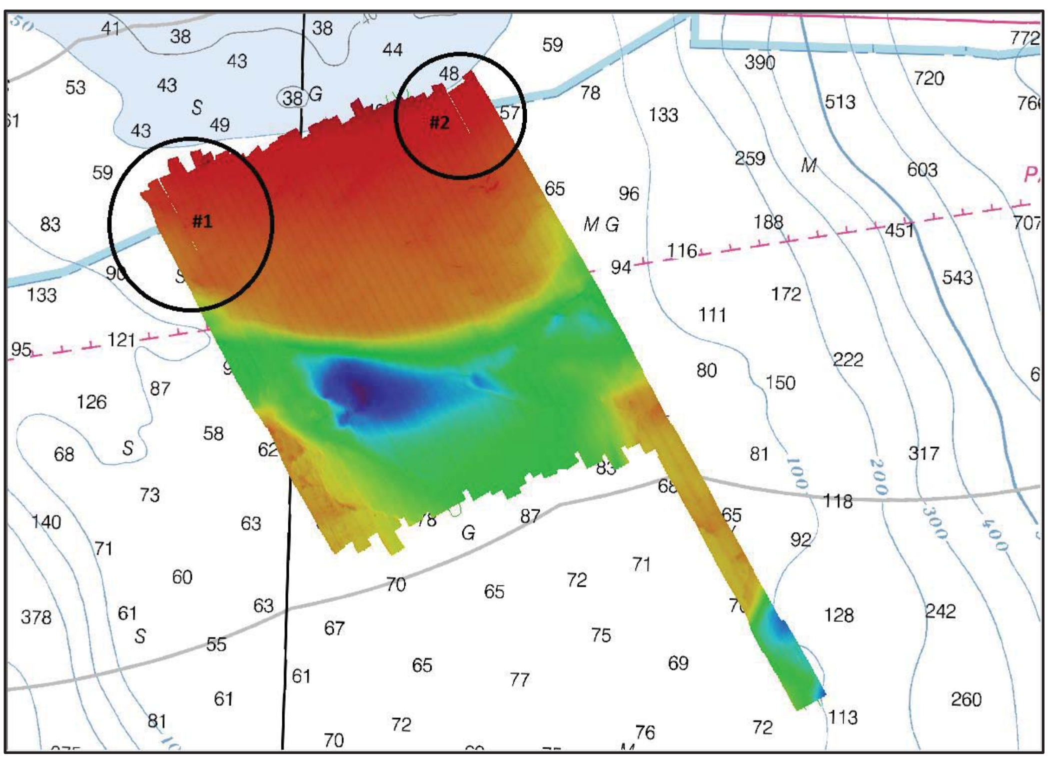



*Figure #17: Holidays #1 and #2 within Priority 1b*

Holidays within Priority 3 are attributed to time constraints working with the RV Valero. The Valero was working within our site to deploy platforms with cameras that observed how manned submersible dives affected marine life in the area. Their operations were conducted during the day and survey ops could not begin until they left the area after completing their sub dives. This cut into survey time each day and holidays were not filled in because of this. Holidays were originally completed by the large drops offs and the line plans running with the contours. The ME70 had a hard time keeping up with the depth change and is a documented limitation of the ME70 sonar itself.

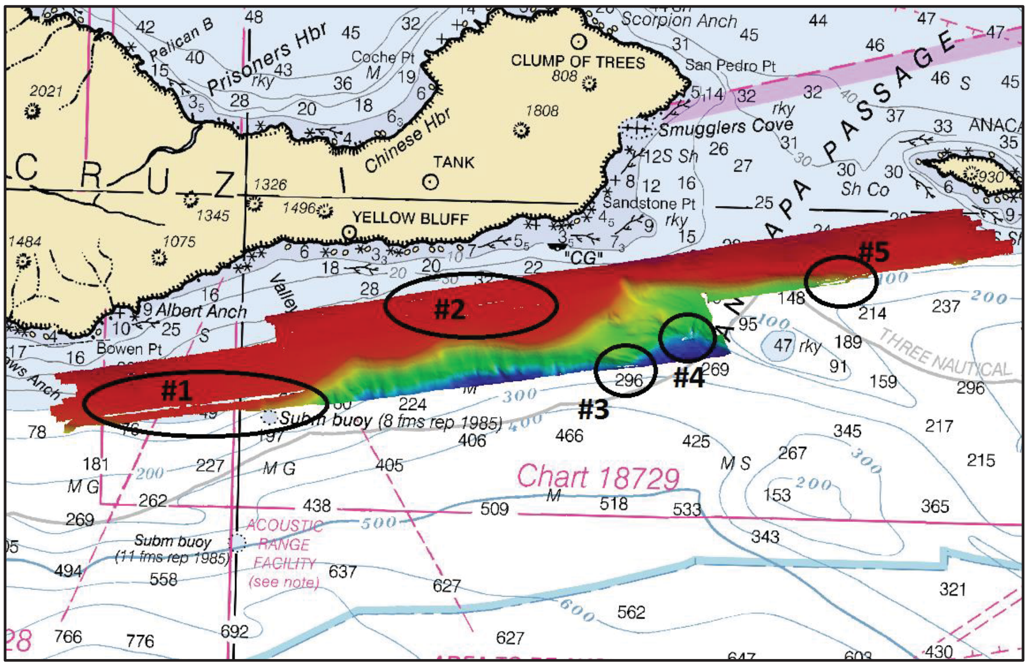


*Figure #18: Holiday areas within Priority 3*

## E. Uncertainty

### E.1 Total Propagated Uncertainty (TPU)

TPU was calculated using CARIS HIPS/SIPS 9.1.7 and the following parameters:

| | |
|---|---|
| Tide Value Measured | 0.0 m |
| Tide Value Zoning | 0.07653m |
| Sound Speed Values | 4.0 m/s |
| Surface Sound Speed Values | 2.0 m/s |

*Table #7: TPU Values.*

ESDR: TPU was recomputed during review at the Pacific Hydrographic Branch using a tidal zoning value of 0.40m due to the long distance from the survey area to the tide gauge at Santa Barbara, Station ID 9411340.

**E.2 Uncertainty**

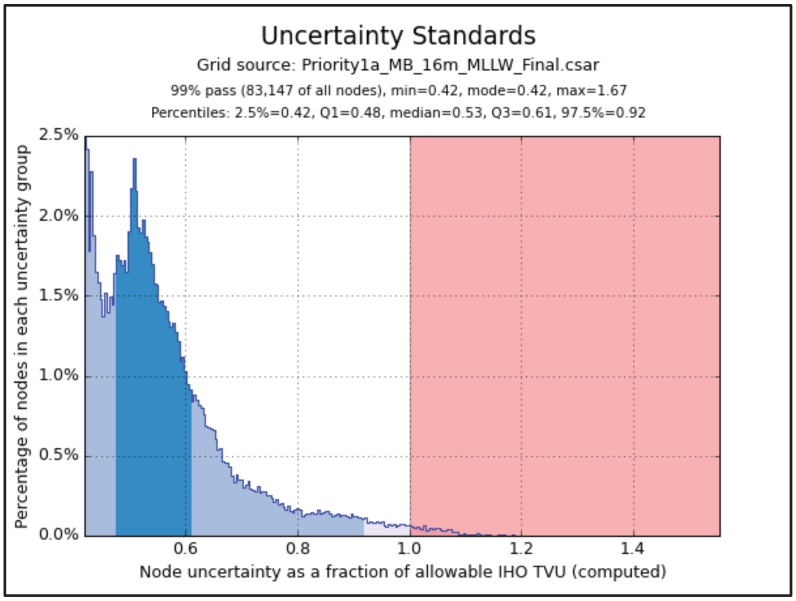



*Figure #19: Histogram representing the vertical uncertainty of each survey node in relation to IHO standards. 99% meet IHO standards in the Priority 1a_16m grid.*

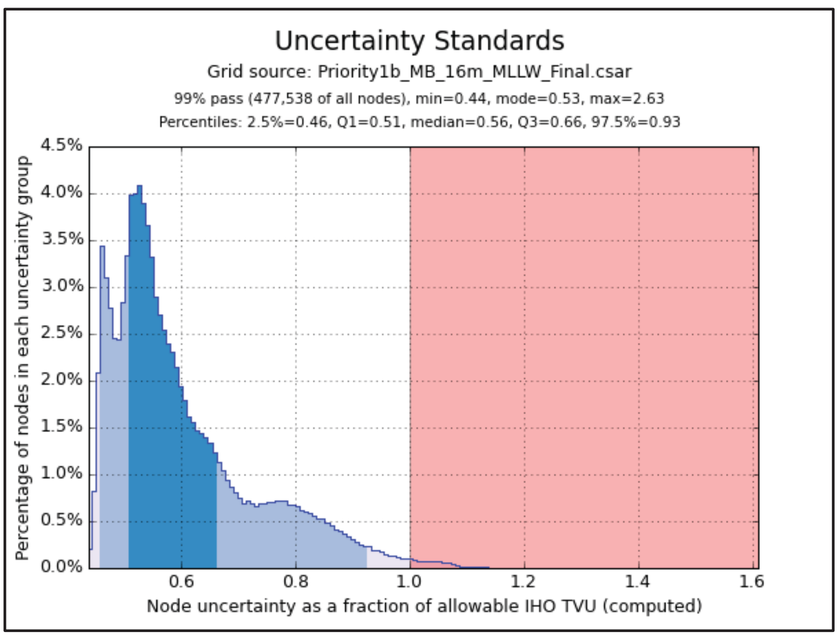



*Figure #20: Histogram representing the vertical uncertainty of each survey node in relation to IHO standards. 99% meet IHO standards in the Priority 1b_16m grid.*

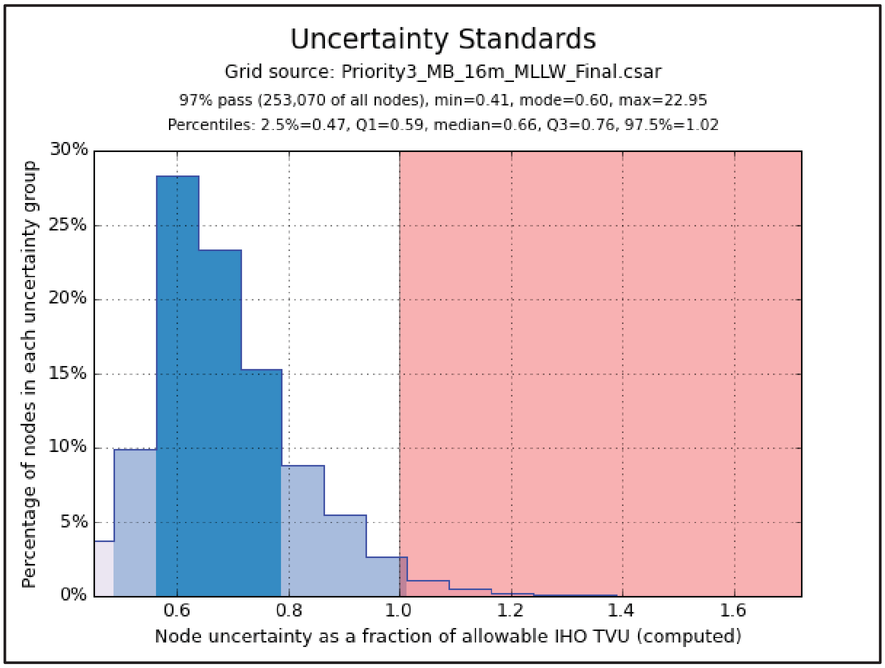



*Figure #21: Histogram representing the vertical uncertainty of each survey node in relation to IHO standards. 97% meet IHO standards in the Priority 3_16m grid.*

## F. Results and Recommendations

The following bathymetric grids were created from the processed data:

| Surface Name | Surface | Resolution | Depth Range | Surface Parameter |
|---|---|---|---|---|
| Priority1a_MB_16m_MLLW_Final | CUBE | 16m | 88.77m-394.92m | 21,525,504 (m^2) |
| Priority1b_MB_16m_MLLW_Final | CUBE | 16m | 82.55m-224.83m | 123,483,392 (m^2) |
| Priority3_MB_16m_MLLW_Final | CUBE | 16m | 27.72m-502.01m | 66,709,248 (m^2) |
| Priority1b_MB_8m_MLLW_Final | CUBE | 8m | 88.75m-394.80m | 21,104,000 (m^2) |
| Priority1b_MB_8m_MLLW_Final | CUBE | 8m | 81.72m-225.12m | 122,946,496 (m^2) |
| Priority1b_MB_16m_MLLW_Final | CUBE | 8m | 29.55m-502.22m | 65,841,088 (m^2) |

*Table #8: Submitted surfaces*

### F.1 Chart Comparison

The following is a list of the largest scale charts and ENCs common to the survey area:

| Chart | Scale | Edition | Edition Date | LNM Date | NM Date |
|---|---|---|---|---|---|
| 18720 | 1:232,188 | 34 | 7/1/2013 | 7/19/2016 | 7/23/2016 |
| 18727 | 1:40,000 | 12 | 7/01/2004 | 7/19/2016 | 7/23/2016 |
| ENC | Scale | Edition | Update Application Date | Issue Date | - |
| US5CA64M | 1:40,000 | 8 | 1/8/2016 | 1/8/2016 | - |
| US3CA69M | 1:232,188 | 16 | 7/13/2016 | 7/13/2016 | - |

*Table #9: Raster Charts and ENCs*

A rough chart comparison was completed by the hydrographer. CARIS Base Editor was not available on the ship so the normal process of creating a TIN and Contours from a Point Cloud was not possible. The hydrographer created an SS_Soundings hob file from the Combined 16m grid and did a scan of the soundings to compare to the ENC US3CA69M. For the most part the soundings were in agreement with the chart and sounding DtoNs were not found. There are areas of shoaler soundings, especially within Priority 3 where the passage between Santa Cruz Island and Anacapa Island exists. Since the charted data that was surveyed sources from the 1940s, the soundings on the chart are from lead lines and single beam therefore it is recommended that shoaler soundings be updated on the chart for safe navigation. Priority 3 was a “heavily trafficked” area for commercial squid fishing and regular recreational boating since it was closest to mainland Santa Barbara.

**F2. Density**

Each surface passed the IHO standard of having 5 or more soundings per node**.** Areas with failed nodes follow the trend of being at nadir or on outerbeams. The ME70 has its lowest density located at nadir and is seen throughout each surface. Other failed nodes are seen at holidays.

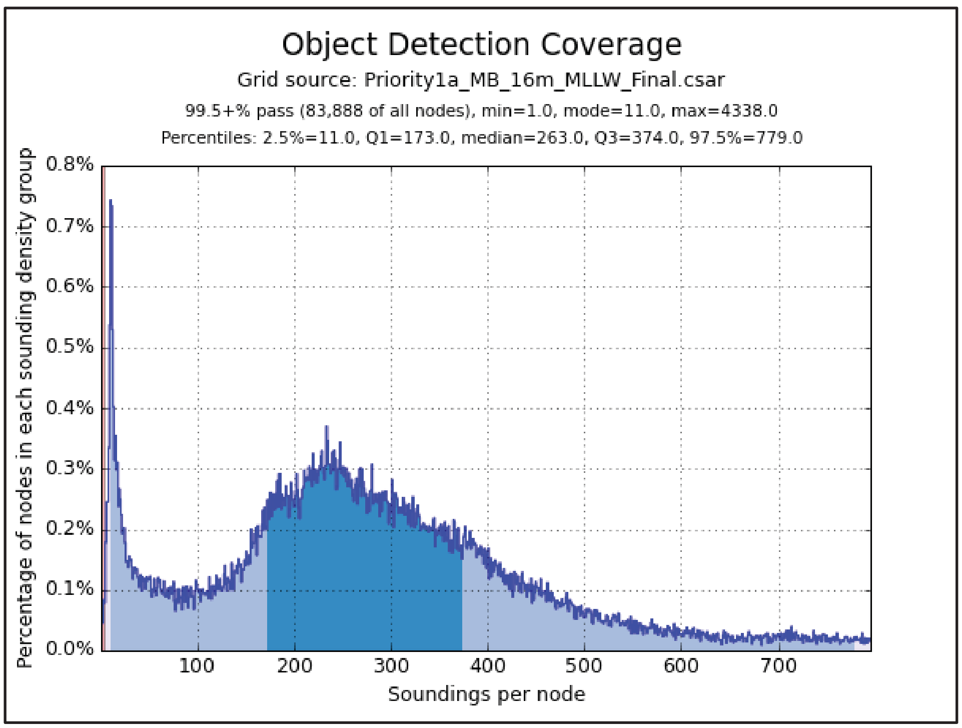



*Figure #22: Histogram representing Sounds per Node Density in relation to IHO standards. 99.5% nodes meet IHO standards having 5 or more soundings for the Priority1a _16m grid.*

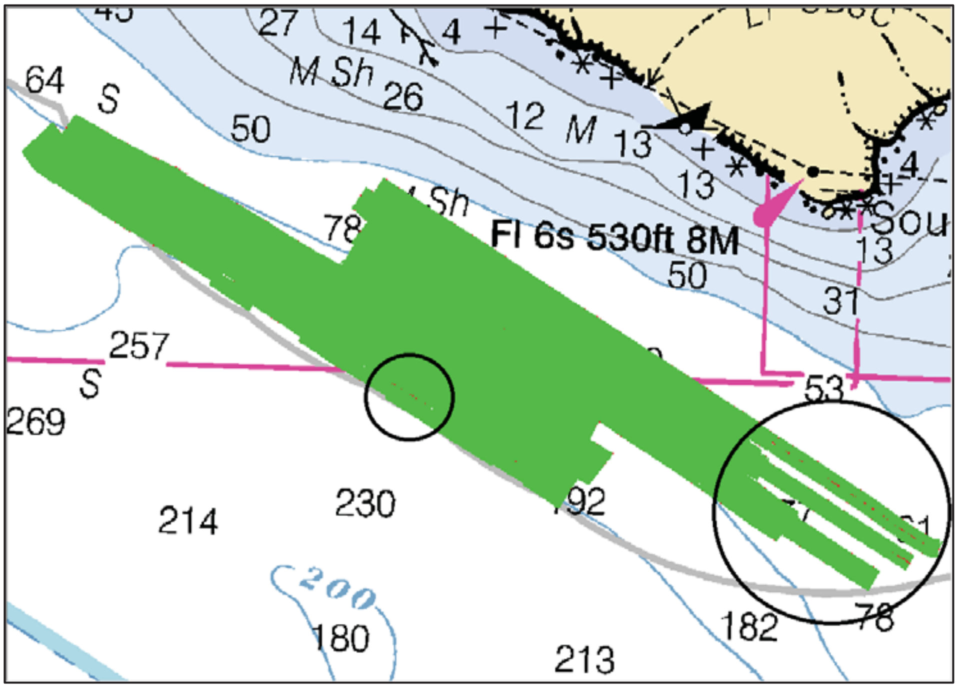



*Figure #23: Density of the Priority 1_16m surface. Green represents nodes which comply with the HSSD, red are non-compliant nodes.*

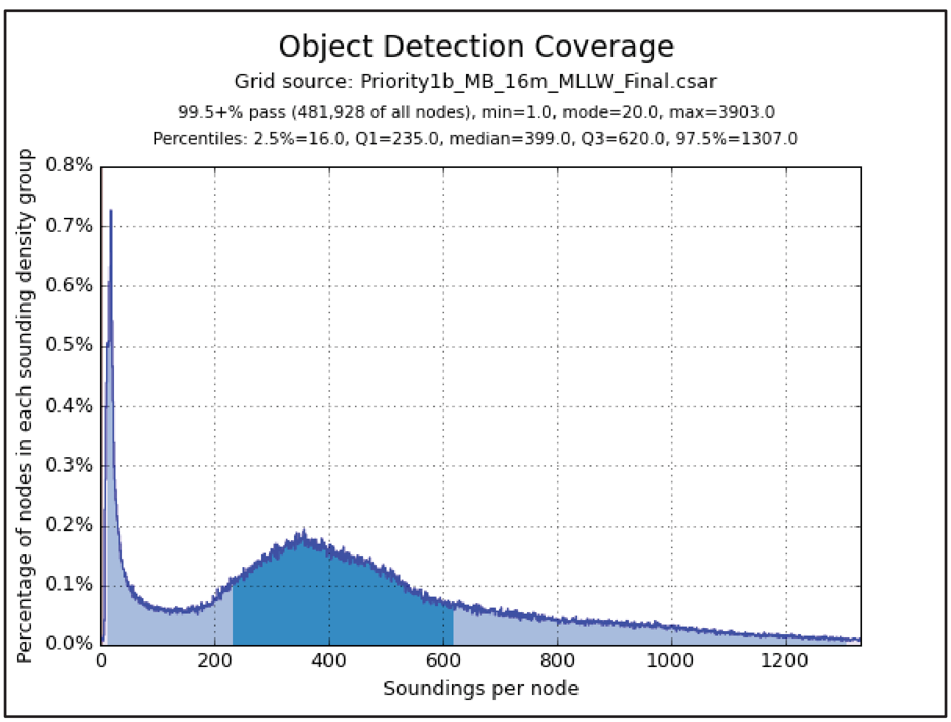



*Figure #24: Histogram representing Sounds per Node Density in relation to IHO standards. 99.5% nodes meet IHO standards having 5 or more soundings for the Priority1b _16m grid.*

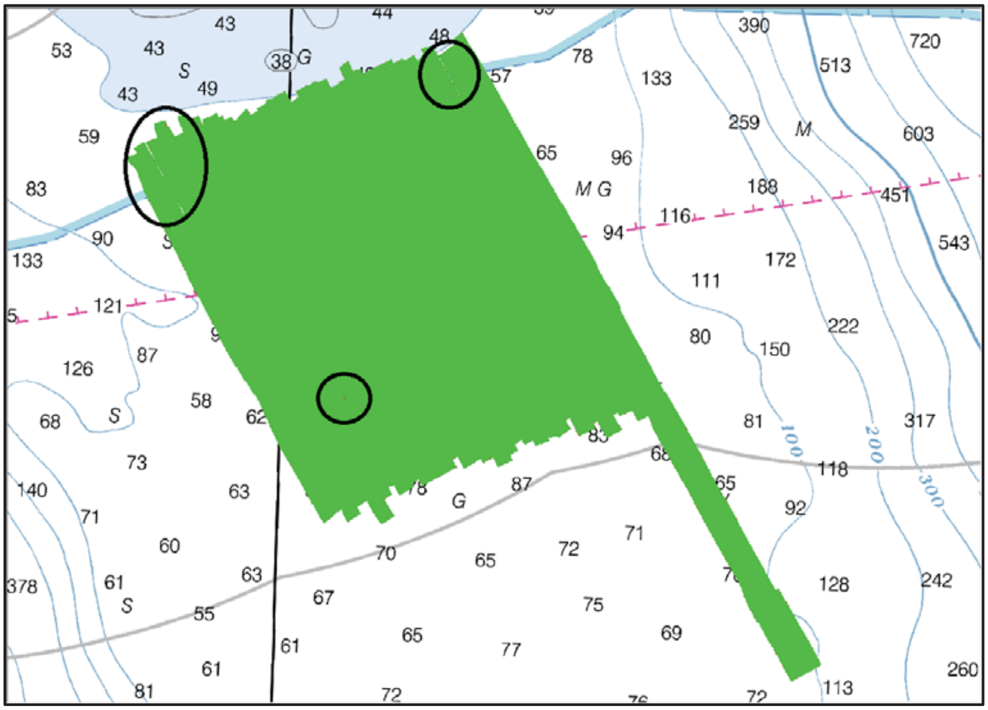



*Figure #25: Density of the Priority 1b_16m surface. Green represents nodes which comply with the HSSD, red are non-compliant nodes.*

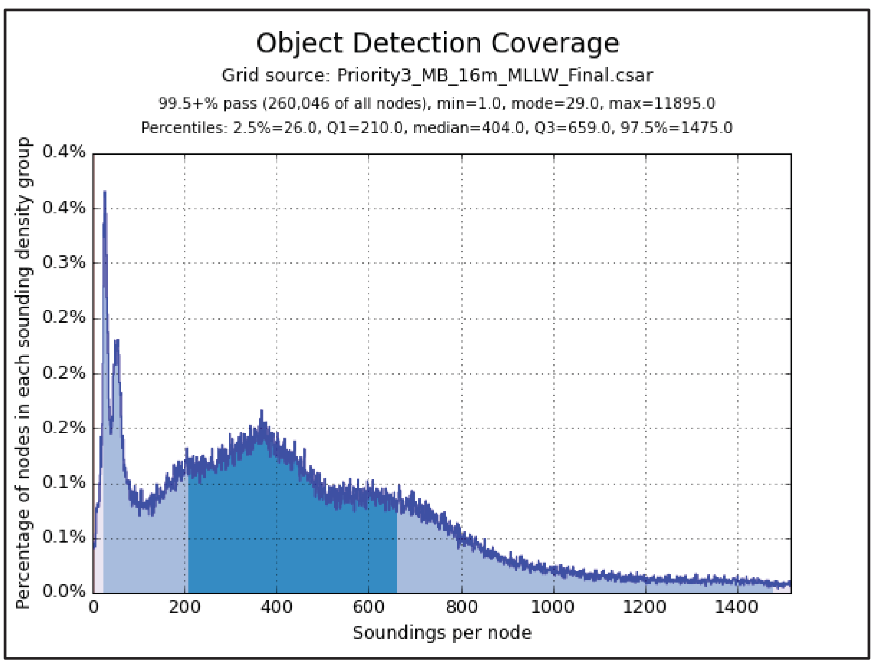



*Figure #26: Histogram representing Sounds per Node Density in relation to IHO standards. 99.5% nodes meet IHO standards having 5 or more soundings for the Priority3 _16m grid.*

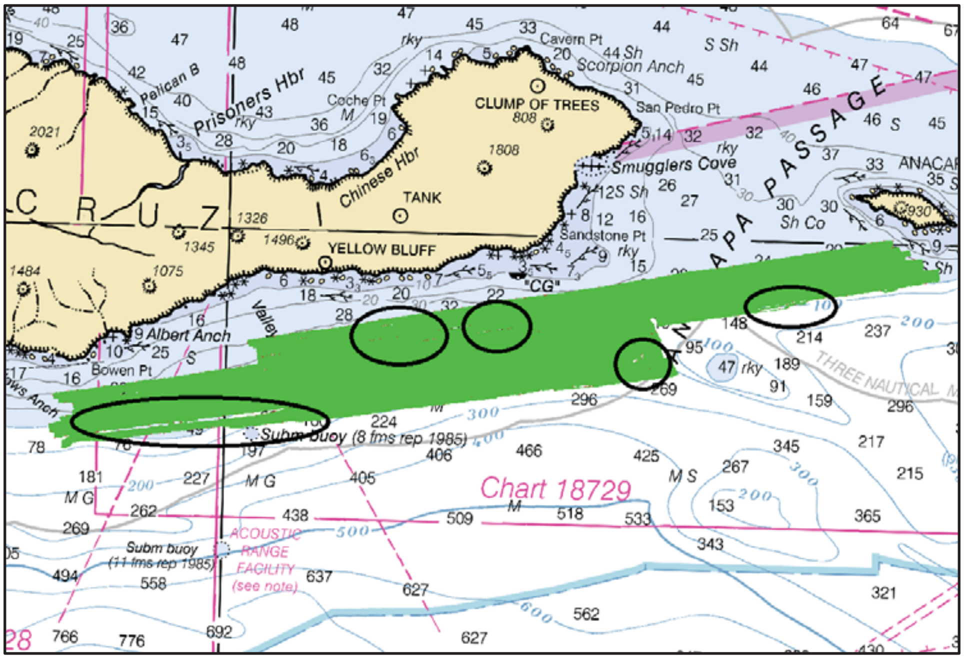



*Figure #27: Density of the Priority 3_16m surface. Green represents nodes which comply with the HSSD, red are non-compliant nodes.*

**F3. Acoustic Backscatter**

Acoustic backscatter was collected and processed within Fledermaus FMGT using the converted .gsf files. NOAA's Biogeography Branch processed the backscatter while onboard the ship in real time.

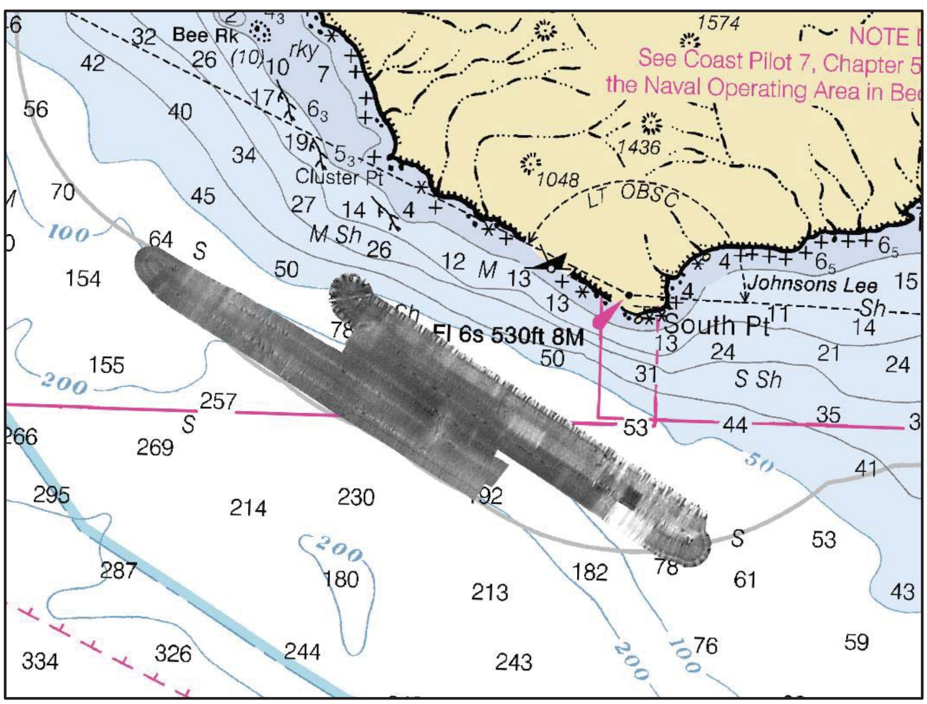



*Figure #28: Acoustic backscatter for Priority 1a*

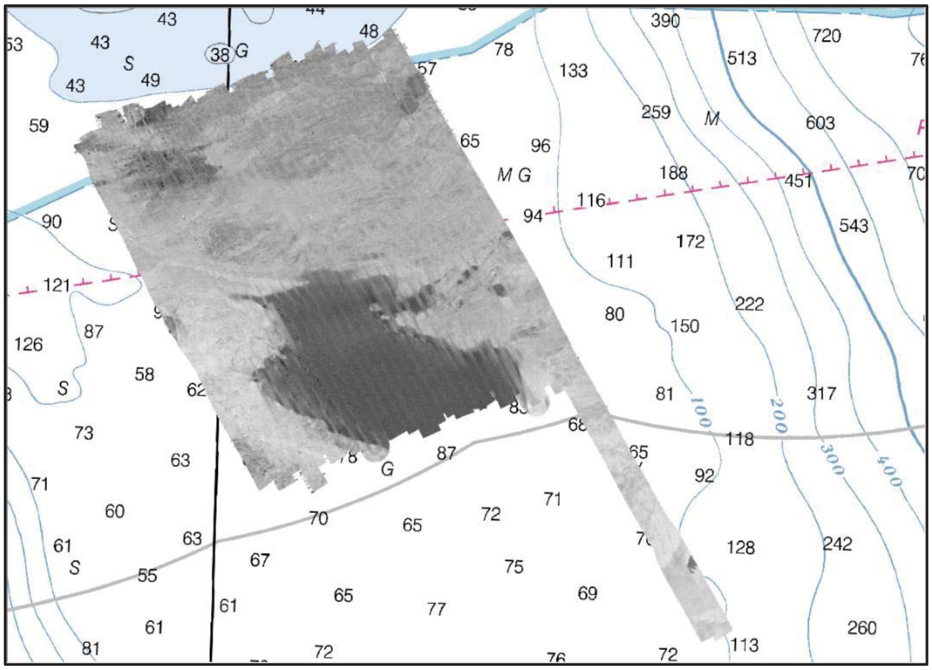


*Figure #29: Acoustic backscatter for Priority 1b*

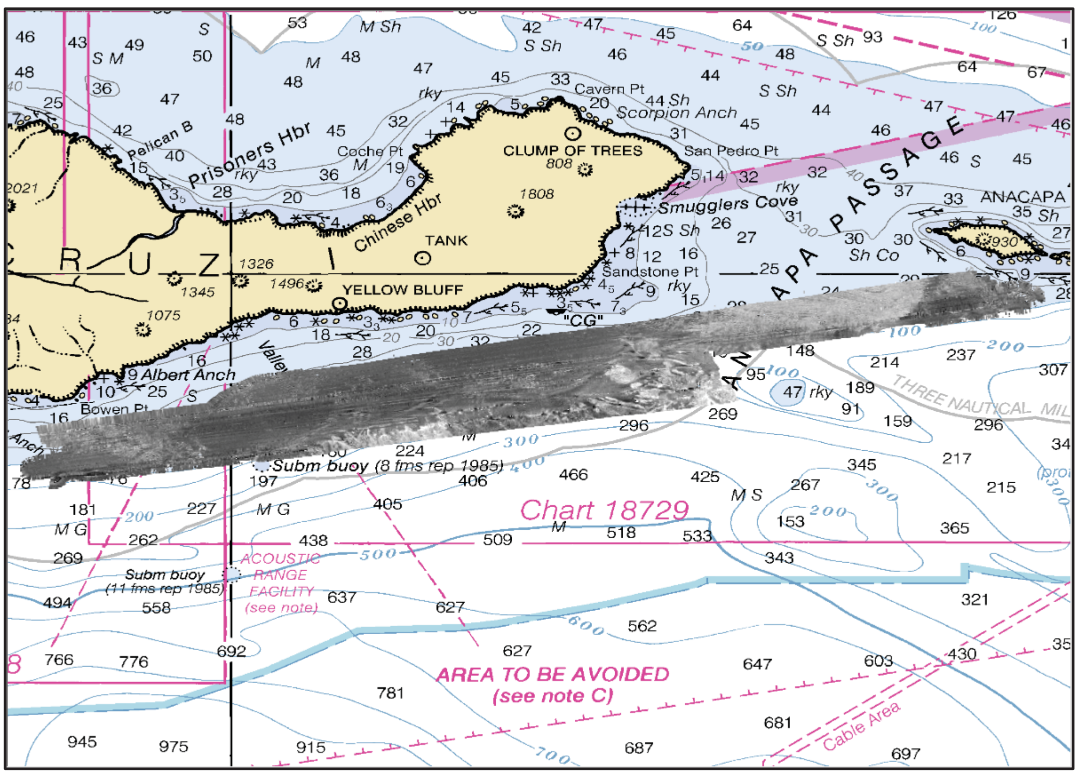



*Figure #30: Acoustic backscatter for Priority 3*

## G. Vertical and Horizontal Control

The vertical datum for this project is Mean Lower Low Water. The horizontal datum for this project is WGS84.

## H. Additional Results

Crosslines for Priority 1b and 3 were not collected due to time constraints. Priority 3 operations were dictated by the second ship conducting their day time submersible dives and cut into mapping operations.

## I. Approval

The survey data meets some requirements as set forth in the NOS Hydrographic Surveys and Specifications Deliverables Manual and Field Procedures Manual. Some data is adequate to supersede charted data in their common areas. This survey is complete and no additional work is required.

| Approver Name | Approver Title | Approval Date | Signature |
| --- | --- | --- | --- |
| Kayla Johnson | Contractor | 10/29/16 | Kayla Johnson |

# Mapping and Visual Surveys of Seafloor Habitats and Fishes

| | |
|---|---|
| Platform: | NOAA Ship *Reuben Lasker* |
| Project Number: | RL_16_06 (OMAO) |
| Project Title: | Mapping and Visual Surveys of Seafloor Habitats and Fishes |
| Project Dates: | October 19, 2016 to October 30, 2016 |
| Chief Scientist: | Mary Yoklavich (NOAA Fisheries Southwest Fisheries Science Center) |
| Mapping Team: | Laura Kracker (NOS NCCOS – Silver Spring, MD)<br>Diana Watters (NMFS SWFSC - Santa Cruz, CA)<br>Mashkoor Malik (NOS OER – Silver Spring, MD)<br>Rachel Husted (NOS NCCOS – Silver Spring, MD)<br>Fabio Campanella (NOS NCCOS – Beaufort, NC)<br>Kayla Johnson (Oceanographer – Norfolk, VA) |


NOAA NOS National Centers for Coastal Ocean Science
NOAA NMFS Southwest Fisheries Science Center
NOAA Channel Islands National Marine Sanctuary
NOAA OMAO

## 1. Introduction

Many species of rockfishes live in complex rocky habitats, have been over-fished, and are difficult or impossible to accurately survey using conventional bottom-trawl gear. Our ability to count these species in rocky habitats and to delineate the distribution and extent of these habitats is critical to the estimation of absolute abundance of these species for stock assessments. To that end, NMFS recognizes the need for more high-resolution mapping of the seafloor and also has initiated the Untrawlable Habitat Strategic Initiative (UHSI) field research in the Southern California Bight.

## 2. Objectives

During this mission, we will 1) acquire high-resolution bathymetric data around the northern Channel Islands using the vessel's ME70 sonar, 2) survey rockfishes and habitats visually using NMFS's Seabed autonomous underwater vehicle (AUV), and 3) survey rockfishes acoustically with the vessel's EK60 fishery echosounder in sync with the ME70. During part of this cruise, we will rendezvous with R/V Velero IV (contracted through NMFS) and use the AUV as part of an underwater experiment to observe and quantify the behavior of rockfishes in reaction to mobile survey vehicles (such as the AUV) as part of NMFS UHSI program.

## 3. Cruise Statistics

| | |
|---|---|
| Dates | October 19, 2016 to October 30, 2016 |
| Weather Delays | none |
| Total operational days | 12 |
| Total mapping days | 9 |
| Multibeam Survey (nmi) | Priority 1a = 26.88 nmi<br>Priority 1b = 216.91 nmi<br>Priority 3= 180.35 nmi<br>Total = 424.14 nmi |
| Area mapped ($km^2$) | Priority 1a = 21.5 $km^2$<br>Priority 1b = 123.5 $km^2$<br>Priority 3= 66.7 $km^2$<br>Total = 211.7 $km^2$ |
| Ave. ship survey speed | 5-6 knots |

## 4. Data Acquisition Priorities

Mapping priorities were based on unmapped, untrawlable habitats likely to support rockfish (Figure 1, Area 1a = yellow, 1b = white, 3 = red). Mapping priorities also incorporated results from a multi-agency workshop held at Channel Islands National Marine Sanctuary (CINMS) in August 2015. The areas mapped on this mission cover some of those priority areas (Figure 2. Areas 6, 10, 11).


Figure 1. Priority mapping areas for Mapping and Visual Surveys of Seafloor Habitats and Fishes mission RL1606 (Priority area 1a = yellow, 1b = white, 3 = red).


Figure 2. Priority mapping areas around CINMS based on multi-agency workshop (August 2015).

# 5. Seafloor Mapping – Bathymetry and Backscatter

### Mapping Sonar Setup

NOAA ship *Reuben Lasker* is equipped with Kongsberg ME70 multibeam sonar and Simrad EK60 split-beam fisheries sonar. The ME70 is a Fisheries sonar that collects data through the entire water column. A Matlab routine developed by Tom Weber (UNH-CCOM) was added to the workflow for bottom detection to convert native ME70 .raw files to a .gsf format that can be read in Caris for bathymetry and Fledermaus for backscatter. POS-MV data was collected throughout the survey and applied to correct for ship motion. Ship offsets from the granite block to GPS and sonar head, as well as other offsets were reviewed and entered into the POS-MV based on sea trials conducted by Sam Greenaway (NOAA ship *Reuben Lasker* ME70 Integration Testing 2016 – see wiring diagram copied here Figure 3). Sippican T-6 XBTs were used to produce sound speed profiles every 4 hours minimum and applied during data acquisition. The EK60 acquired additional fisheries information simultaneously, using K-synch, and was processed in Echoview software.

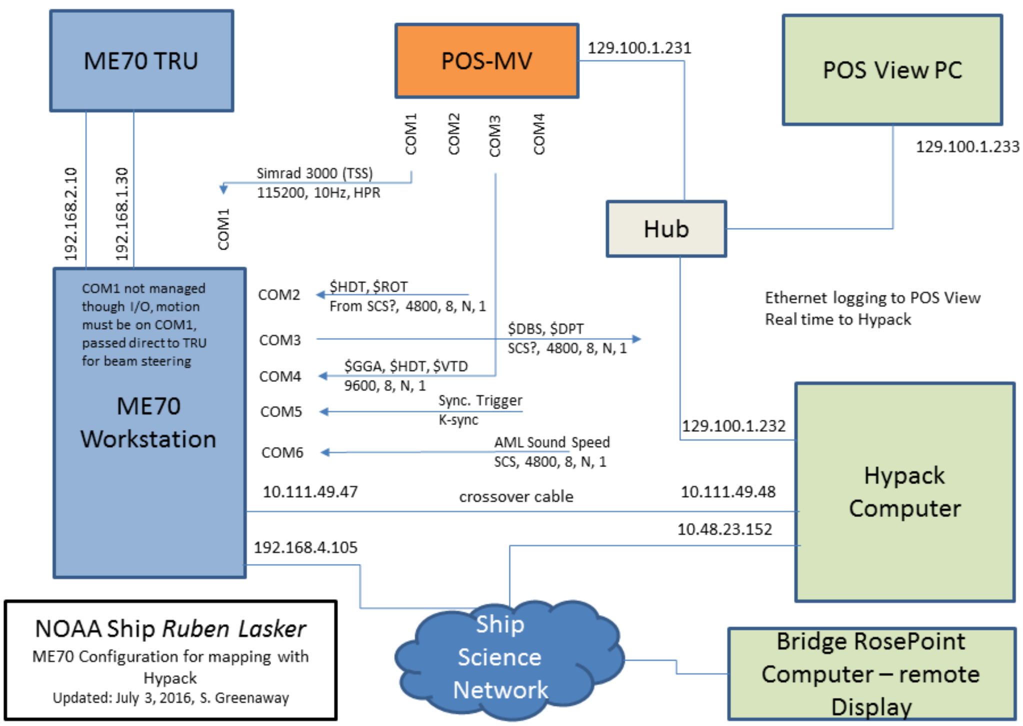



Figure 3. Wiring diagram of ME70 configuration on the NOAA ship *Reuben Lasker* from S. Greenaway report.

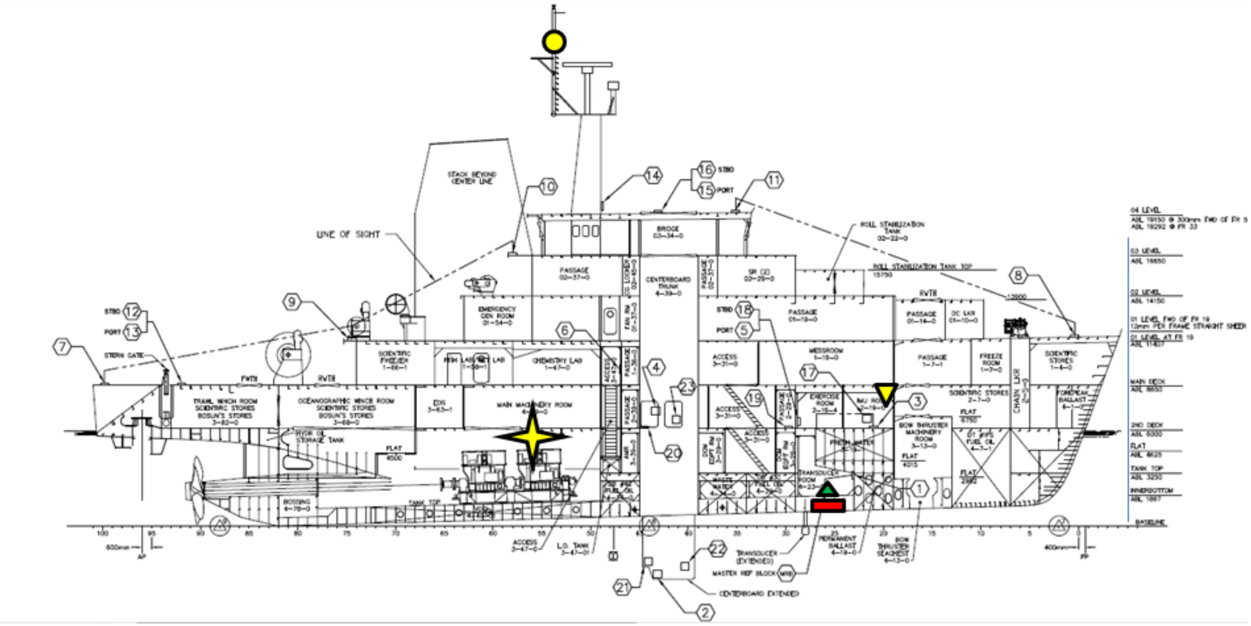


Figure 4: NOAA Ship Ruben Lasker line drawing with the positions of the primary echosounders indicated: yellow circle- GPS antennae, yellow inverted triangle- inertial motion unit, green triangle-granite block, red rectangle – ME70 transducer, yellow star- center of rotation. (from S. Greenaway Lasker Report)

**Multibeam Data Processing and Output**

Both bathymetry and backscatter surfaces were created from the ME70 multibeam data (Figure 5 through 8). An overview of the data processing workflow is provided in Appendix 10.B. An assessment of data quality for submission as outside source bathymetry data to the Office of Coast Survey will be produced.

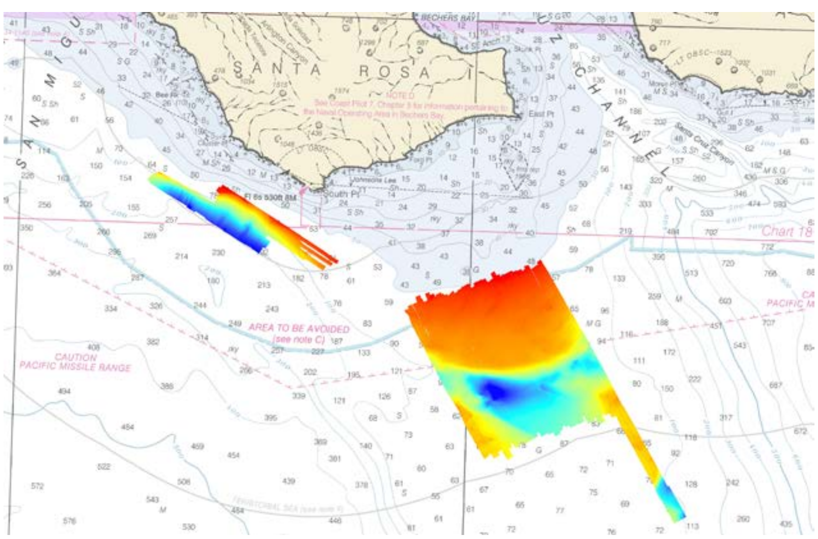


Figure 5. Bathymetry mapped during RL1606 survey in Priority 1a and 1b.

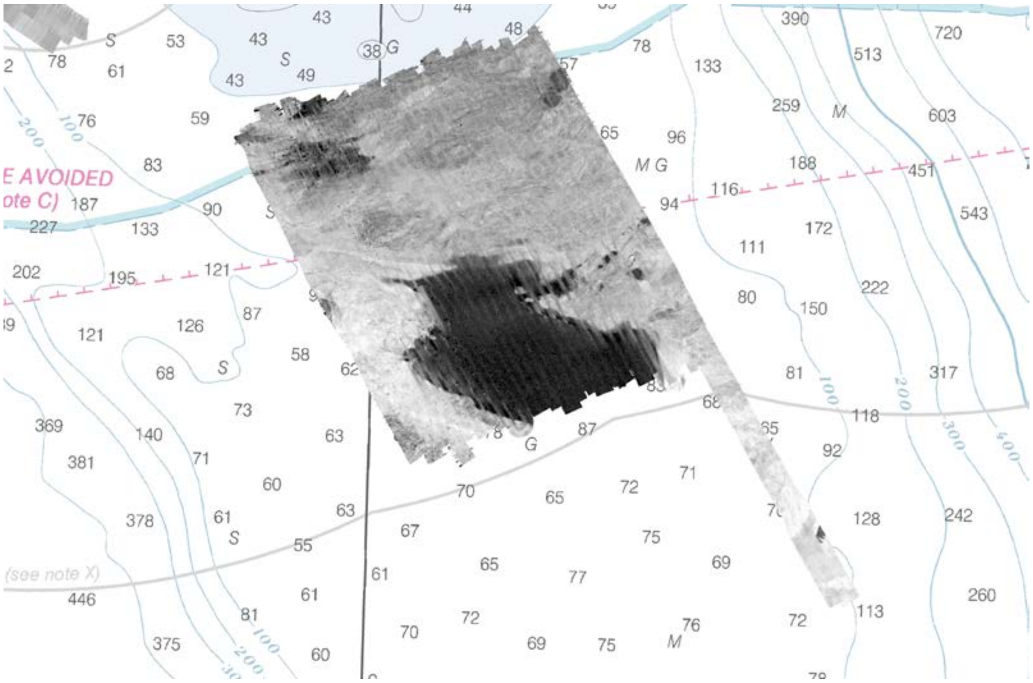



Figure 6. Backscatter mapped during RL1606 survey in Priority 1b.

**Line planning and communication with the bridge**

Line plans were created in Hypack for the priority areas. Line editor was used to create lines with variable line spacing based on the shoalest soundings located on the chart. Line spacing varied given the dynamic nature of the seafloor within the project area, obstructions in the water such as rocks and areas prohibited due to safety concerns. Line files were initially converted to .csv files which was imported into Rosepoint by the ship's Navigation Officer. During the mission a python executable was developed (M. Malik) to convert from Hypack line files to Rosepoint GPX files directly. The navigation officer excluded areas shoaler than the 20 fathom contour in Rosepoint. Overall, this process was a bit cumbersome since line planning by the scientists and navigation lines used by the ship were not developed in the same software environment.

A Hypack monitor was successfully installed on the bridge to aid in line driving. However, the full utility of driving by Hypack directly – which would have shown real time multibeam coverage of the bottom - was limited by the Hypack computer which did not have enough processing capacity and fast enough refresh rates. This confirms the findings of the sea trials (S. Greenaway) which recommended replacing this computer with one equipped with a solid state drive and a high performance video card.

Communication between the bridge and survey acquisition focused on XBT casts, start and end of lines, and general planning. Future surveys should involve survey techs in a more prominent role for acquisition of ME70 and EK60 data.

**Lessons Learned**

While the ME70 sonar system on the NOAA ship *Reuben Lasker* was not intended for seafloor mapping, procedures have been developed for FSVs across the NOAA fleet to facilitate this. While the resulting data has been adequate for the purpose of planning fisheries research, heave issues are evident and bad outer beams create artifacts at swath overlap.  In addition, survey speeds were reduced to 5-6 knots (almost half the speed of typical hydrographic surveys).

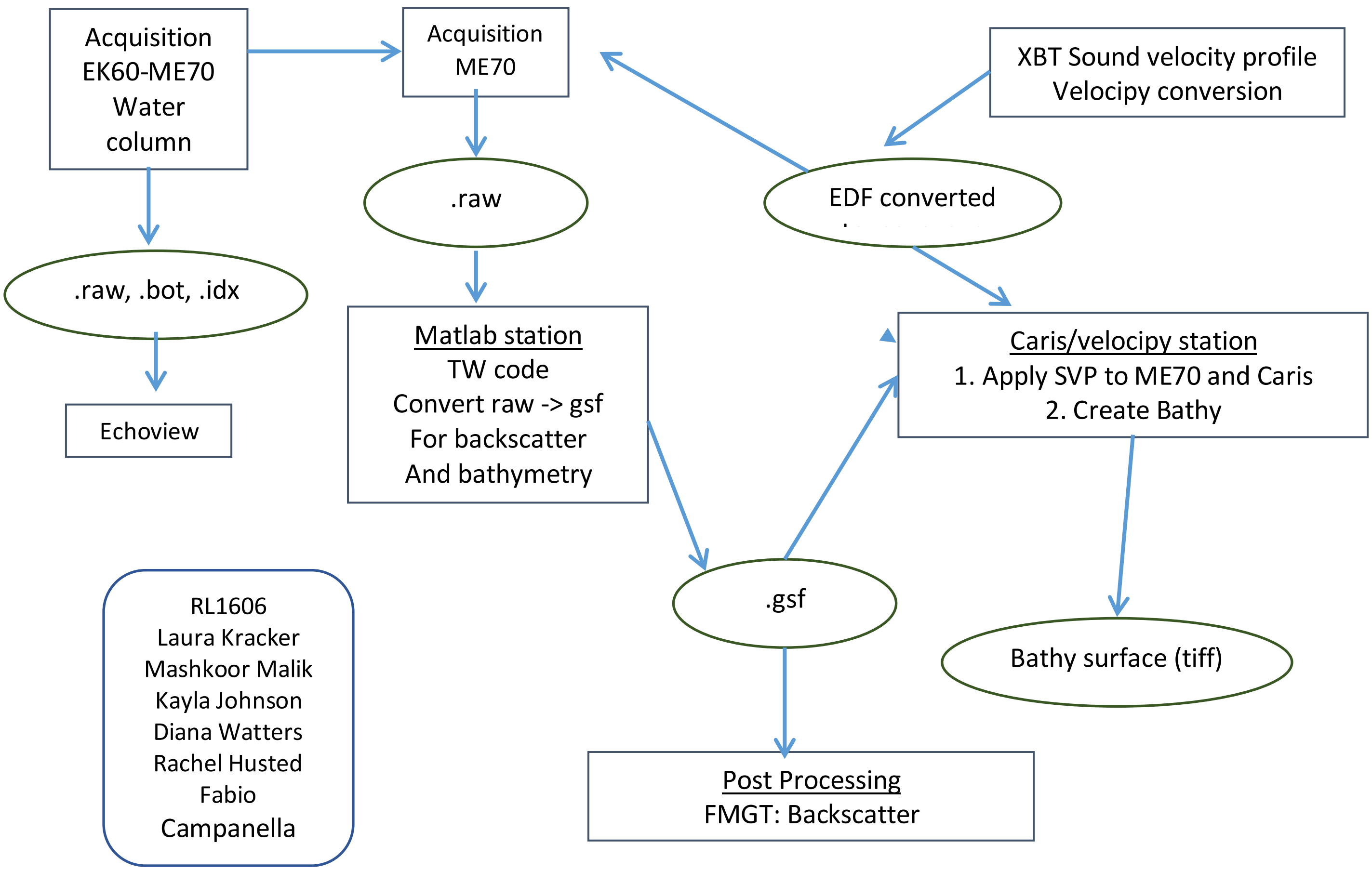
The location of the GPS units that feed into POS-MV are located on the main mast (Figure 8, left). This location has been beneficial in avoiding heading dropouts and artifacts in the data.  This provides evidence that the heading dropouts experienced on the NOAA ship *Bell M. Shimada* would likely be reduced if the GPS antennas were moved from the current location on the observation deck (Figure 8, right) to the top of the main mast and resurveyed. Further, this task was recently completed on the Pisces and resulted in major improvements in data acquisition and output.

## 6. Appendices

### A. Daily cruise log

| Date (DN) | Date GMT | OPERATIONS |
|---|---|---|
| | | |
| 293 | 19 October 2016 | depart San Diego 14:00 (local); transit to Santa Rosa flats; |
| 294 | 20 October 2016 | XBT & ME70 testing; |
| 295 | 21 October 2016 | ME70 & EK60 ops Priority Area 1a & portion of 1b; |
| 296 | 22 October 2016 | ME70 & EK60 ops Priority Area 1b |
| 297 | 23 October 2016 | ME70 & EK60 ops Priority Area 1b |
| 298 | 24 October 2016 | ME70 & EK60 ops Priority Area 1b |
| 299 | 25 October 2016 | ME70 & EK60 ops Priority Area 1b, including cross lines and holidays |
| 300 | 26 October 2016 | ME70 & EK60 ops Priority Area 3 |
| 301 | 27 October 2016 | ME70 & EK60 ops Priority Area 3 |
| 302 | 28 October 2016 | ME70 & EK60 ops Priority Area 3 |
| 303 | 29 October 2016 | ME70 & EK60 ops Priority Area 3, holidays |
| 304 | 30 October 2016 | Transit to San Francisco |
| | | *Local time is GMT - 7* |

## B. Data Processing Workflow




# NOAA SHIP RUBEN LASKER ME70 INTEGRATION TESTING

With Hydrographic Systems and Technology Branch
Multibeam Sonar Acceptance Procedures 1.0

DATES
June 26-July 4, 2016

LCDR Samuel Greenaway
NOAA Office of Coast Survey

# Executive Summary

The purpose of Coast Survey's participation in this cruise was to verify the installation and configuration of the ME70 and ancillary systems; validate the current Hypack implementation of the ME70 bottom detection code; and provide operational guidance to the future operators of this system. The transit from San Diego, CA to Neah Bay, WA offered an opportunity to test this system without interfering with other planned science objectives. While we have used the Multibeam Sonar Acceptance Procedures as a framework for this analysis, the tests and analysis contained in this report were opportunistic and do not constitute system acceptance work for routine hydrographic survey work as outlined in the Hydrographic Surveys Division Technical Directive on configuration management.

Significant progress was made during this cruise to ready the ship for anticipated mapping work in the fall of 2016. The recommendations outlined below should be addressed prior to this work.

# Significant Findings and Recommendations

1. The ME70 on *Ruben Lasker* is now appropriately configured for mapping work with the ME70, however the following items must be resolved prior to a major mapping mission:
    a. The remote display via network interface is unsatisfactory; a remote monitor display on the bridge should be configured.
    b. Hypack ran exceptionally slowly. The interface was slow enough to be difficult to use, and the slow update rate may have been the cause of the dropped pings and navigation records. The computer running Hypack should be investigated and perhaps replaced.
    c. The time server was operable, but not connected to a functional GPS antennae, so was not synchronizing to the correct time. The time server should be made fully functional and the ME70 configured to accept time control from the time server.
2. The offset and alignment survey contained some significant errors detected by Applanix during the POS-MV commissioning and was not tied to the waterline. We include a consolidated offsets and alignment report with this report that contains the consolidated, best available offsets and alignments. The oversight and quality control of alignment surveys should be strengthened.
3. Though the ME70 has inputs for offsets and sound speed profiles, the raw data output to Hypack is not-ray raced and is referenced to the transducer face. It is stabilized for roll and pitch (via the beam-former), but does need to be corrected for heave and static draft in post-processing. This is not intuitively obvious.
4. As configured, the Hypack real time gridded bathymetry (the matrix) will have a heave artifact. This artifact arises because the ME70 data is corrected for pitch and roll, but not heave, and Hypack can correct for all motion or none in the matrix calculation. This does not affect the recorded bathymetric data.
5. Some science parties may prefer to process the recorded ME70 RAW files thorough the Matlab code developed by Dr. Tom Weber or their own code. The Hypack system in no way prevents this. In any case, we recommend using the Hypack system to plan and monitor acquisition.
6. The performance of the system for bathymetric mapping is significantly worse in terms of coverage, depth performance, and resolution when compared to 100 kHz multibeam systems designed for this task (e.g. the EM710).

# Contents

# 1 General Overview

All of the *Oscar Dyson* class ships are equipped with Kongsberg ME70 multibeam echosounders. These systems were designed for pelagic fisheries applications, but have also found utility for seabed mapping. In their standard configuration, these systems do not generate bathymetric solutions. Dr. Tom Weber of the Center for Coastal and Ocean Mapping at the University of New Hampshire developed Matlab based code to extract bottom detections from the logged raw data files. The Hydrographic Systems and Technology Branch (HSTB) of the Office of Coast Survey has led an effort to incorporate this research code in Hypack, a commonly used commercial hydrographic planning and acquisition tool. The intent of this project is to provide additional capability to fisheries scientist interested in incorporating bathymetric mapping applications into their cruises on the FSVs. HSTB's objective during this cruise was to verify the installation and configuration of this system, validate the current Hypack implementation, and provide operational guidance. The transit from San Diego to Neah Bay offered an opportunity to test this system without interfering with other planned science objectives. In addition to this work, acoustic preparation for the Summer California Current ecosystem survey and a harmful algal bloom project were conducted during the transit. The ME70 system is anticipated to be used for mapping application during a fisheries cruise in October 2016.


*Figure 1: NOAA Ship* Ruben Lasker

This cruise completes the final Hypack-ME70 system the Hydrographic Systems and Technology Branch (HSTB) intends to integrate within the scope of this project. The Kongsberg ME70 is a highly configurable system originally designed for quantitative water column mapping work. The system features a fully populated array and can form multiple split-beams at user configurable frequencies and steering angles. As a development of the Kongsberg fisheries scientific sounders series, the ME70 exhibits high gain stability and large linear dynamic range. Because of these features and the ability of this system to position a point target in three dimensions using the only sonar itself, the ME70 is capable of being absolutely calibrated.   While absolute calibrations of these systems have been demonstrated [1] and we are aware of at least one calibration of a NOAA ME70, the ME70 systems in the NOAA fleet are not routinely calibrated in this fashion.

The ME70 transducer array is flush mounted in the hull in the sonar room, slightly to port of centerline and approximately one-quarter of the hull length aft of the bow.  The analog signal to and from the transducer is carried by a cable bundle to the topside processing unit located in the IMU room.  A rack mounted computer located in the acoustics lab runs the ME70 con troll software.  Figure 2 shows images of the transducer, the sonar sea-chest, and the top-side processing unit.

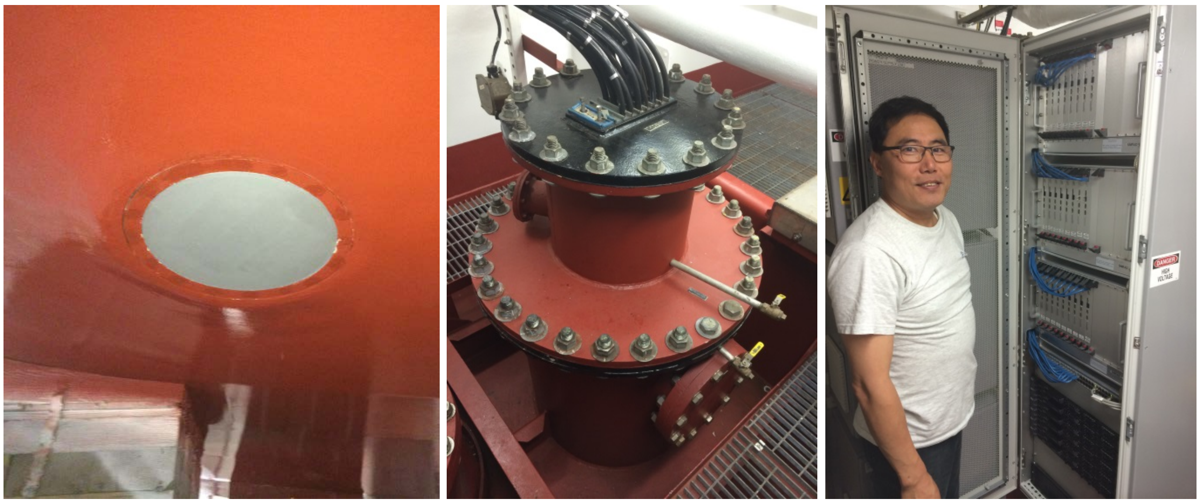


*Figure 2- The ME70, left: transducer face (identical system on* Bell Shimada*), middle: sonar sea-chest in sonar room, right: topside processing unit*

# 2 Overview of schedule and conditions

## 2.1 Preplanning

Prior to the cruise, I gathered and read the offset diagrams, survey reports, and available equipment commissioning reports.  I reviewed the status of updates to the Hypack ME70 implementation with Hypack representatives, but planned upgrades were not ready before the sailing date.

## 2.2 Executed Schedule

- Sunday, June 26 – Arrived San Diego, CA.
- Monday, June 27 – Moved piers, fueled ship, checked system configurations, offsets, and integration.
- Tuesday, June 28 – Measured draft (ERS, draft marks, and tape), departed 1000.  Worked on system integration and communications.
- Wednesday, June 29 – Initial underway testing, most in water too deep for system to reach bottom.   Figured configuration and offsets.
- Thursday, June 30 – Limited patch test off San Francisco, CA.
- Friday, July 1 – Refigured reference point, reconfigured motion data into system.
- Saturday, July 2 – Chased down acoustic interference source.
- Sunday, July 3 – Extinction tests off Grey's Harbor, OR.
- Monday, July 4 – Limited reference surface off Neah Bay, departed ship by small boat 1100.

# 3 Pre-Installation Testing

## 3.1 Test Data Processing Workflow

Representatives from Kongsberg confirmed that the software installed on the *Lasker* was the most up to date version. The Hypack software was upgraded through the June release on June 30. Because the Hypack- ME70 workflow has previously been integrated, the full workflow was not tested prior to data acquisition.

## 3.2 Determine data rates and file size

During most of the cruise, the various acoustic systems (the EK60, EK80, MS70, ME70) were cycled through a ping sequence using k-sync. This resulted in observed data rates from any one system far below what it may have been when running alone. To estimate data rates for this system used in a mapping application, we looked at data rates from the patch test conducted off of San Francisco. For this test, the other sounders were secured and the ME70 run at the minimum ping interval. This test was run in approximately 150 meters of water. The results are shown in Table 1. As expected, the data volume is dominated by the full watercolumn in the ME70 .raw file. The additional bottom detections from the Hypack process did not add significantly to the raw data collection. For mapping operations, a rough estimate of 1.2 GB/ hour or approximately 30 GB/ day should provide a useful idea of the approximate data volume for this system in this water depth.

*Table 1: Experimental Data Rates*

| File | Data Rate |
|---|---|
| ME70 .raw | 950 MB/ hour |
| Hypack .raw | 117 MB/ hour |
| Hypack .HSX | 75 MB/ hour |
| Raw POS Observables (10hz) | 85 MB/ hour |
| Total | 1,230 MB/ hour |

## 3.3 Operational hazards

No current safety regulations or hazards restrict use of this multibeam echosounder.

## 3.4 Determine user configurable system settings

The most significant configurable setting, and one unfamiliar to many multibeam operators, is the ability to configure the beam pattern. The beam geometry, center frequencies, and ping order can be configured using the beam administration function with the parameters are stored in a xml file. Two configurations were used for most of these tests: b31_sec120_xmitbyDecreasing , and GRC_noninterfering_25b_80_116kHz. The first configuration was developed by Dr. Tom Weber at the University of New Hampshire and has been used successfully for mapping work on other FSVs, the latter was developed by Dr. Randy Cutter at the Southwest Fisheries Science Center. While many beam configurations have been shown to work with the Hypack bottom detection application, not all do, and the selection of beam patterns should be carefully considered before mapping work.

The range and gain settings in the user settings window of the ME70 console window only change the display and do not change the recorded or broadcast raw data. The range setting of the system is controlled by the 'data output' section of the settings configuration. This must be manually set to an appropriate range for the working area. Additionally, the transmit power can be set at max, -6db, and -12 dB through the ‘Tx Power’ section of the operation configuration. The Tx power was kept at max throughout this cruise.

### 3.4.1 Vessel Survey and Reference Frames

A number of surveys were conducted during the build and commissioning phases and some caution is recommended when figuring the offsets. The antennae used by the POS-MV attitude and motion systems were also moved at some point and a partial survey done to re-establish the position. The POS-MV was also formally commissioned by Applanix revealing some discrepancies in the surveyed results. Consolidated offset tables with the best currently available information from all sources is included as an appendix to this report and also in the excel file ‘RL_Offsets_and_Alignments.xlsx’ distributed with this report.

During the original construction of the ship a coordinate system was established on the shop floor aligned with the centerline and waterline planes of the ship as constructed. Note that the bottom of the keel is not level with respect to the waterline. The granite block (also referred to as the Master Reference Block (MRB) and MLP (master level plane?)) was installed and verified to be aligned with this reference frame within 5 arc-seconds in roll and pitch and 7.5 arc-seconds in heading. The offsets to all benchmarks and components were reported in this system with the granite block as the origin. An image of the granite block is shown in Figure 3. The reference system is a right-handed system with x forward, y to starboard, and z down.

*Figure 3: The granite block located in the sonar flat holds the origin and alignment of the ship reference system. The block is located on the centerline of the vessel, adjacent to the ME70 sea chest. The block is shown with protective cover (left) and uncovered (right).*

The POS-MV was configured to output position and attitude valid at the granite block. That is, the alignment angles and offsets of the antennae and IMU are such that the reported position from the POS is the position of the granite block and the reported attitude (heading, pitch, roll) is the attitude of the granite block with respect to a north-aligned, gravity level frame. The ‘center of rotation’ is configured as a point near the waterline roughly above the main engines. This is presumably the center of floatation, though no specific documentation outlining this choice was found. As discussed in [2], the location of the origin of the reference system, the alignment of that frame, and the designated ‘center of rotation’ are largely arbitrary, however it is imperative that the chosen system is applied consistently.

In particular, the designation of the 'center of rotation' means that the heave filter is applied at this location; the double integrated vertical acceleration (the raw heave) measured at the IMU is mathematically translated to the 'center-of-rotation', the high-pass heave filter is applied, and the filtered heave re-translated to the reference point- in our case, the granite block. This means that the heave signal may generally have a non-zero mean given a non-zero vessel trim. It also means that should a dynamic draft correction be developed for this vessel, it must be valid for the location of the 'center-of-rotation.' A dynamic draft table has not been developed at this time, and we do consider this necessary for the type of work envisioned for this ship. The location of the major system components is shown in Figure 4

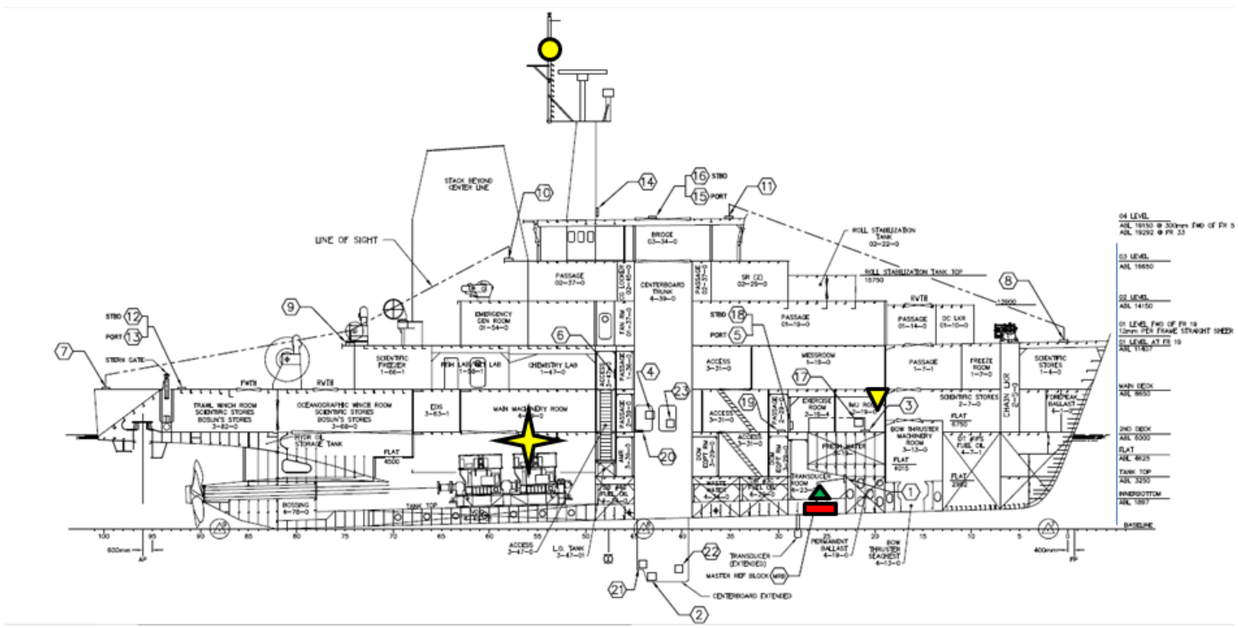



*Figure 4: NOAA Ship Ruben Lasker line drawing with the positions of the primary echosounders indicated: yellow circle- GPS antennae, yellow inverted triangle- inertial motion unit, green triangle- granite block, red rectangle – ME70 transducer, yellow star- center of rotation.*

The ME70 installation instructions state that the reference point chosen for the ME70 system is arbitrary in the x,y directions but must be on the waterline in the z direction. For the most consistency within this constraint, for the ME70 configuration we chose a reference frame parallel to the granite frame, but offset by -3.97 meters to give an origin directly above the granite block on the design waterline of the vessel. The offsets in the ME70 configuration are thus the offset from this point to the transducer, and the granite block (for both GPS position and IMU output). Because this frame is parallel to the granite block frame, and the POS-MV outputs navigation and attitude in that frame, the alignment offset for the IMU in the ME70 configuration is zero (the alignment offset is in the POS configuration). The determination of the waterline relative to the ship frame is discussed in the following section.

These offsets are presumably applied for some records that can be output from this system. However, the raw data, both in the logged .raw file and the broadcast data read by Hypack do not have translational offsets applied; the data is referenced to the transducer face. The logged NMEA navigation and attitude strings logged in the .raw file are also not translated in any way by these offsets. It is unclear if the angular offsets of the transducer are applied to the beamformer, we have assumed they are.

No offsets were configured in Hypack. This does mean the real-time bathymetric grid will be depths below transducer and there will be a slight (less than a meter) offset in the position, however, this is likely insignificant for the intended work of this platform.

The offsets between the granite block reference point and the transducer are entered in the Caris HVF file used for this report. This HVF file is included as an appendix.

#### *3.4.1.1 Draft and Water Line Offsets*

Unfortunately, the vessel offset survey did not include any of the ship's draft marks or any other method to easily reference the vessel reference frame to the water surface. This is required for both the default ME70 installation, and to conduct mapping operations with vertical control based on water levels. We used two methods to tie in the water surface to the vessel reference frame, one using post-processed kinematic (PPK) derived GPS heights of the vessel and the observed water level at a NOAA permanent gauge; the other by measuring to the water surface from benchmarks near the deck edge. Both methods agreed within measurement precision.

The PPK method was based on the approach outlined in [3]. On June 28, raw POS observables were logged while the ship was tied up alongside the pier and no major loading or ballasting operations were underway. The logged file was processed through Applanix POSPAC MMS using IN-Fusion Single Base processing on base station PLO5, approximately 8 km from the pier. This yielded a time series height of the vessel reference point with respect to the reference ellipsoid (in this case the NAD83 (2011) ellipsoid). A simultaneous water level observation relative to MLLW was obtained from NOAA San Diego water level station (94101070) approximately 2 km from the pier. No zoning corrections were applied, and the water levels were referenced to the ellipsoid by applying the VDatum NAD83 to MLLW correction (-35.237 m) at the location of the water level station. The two time series and the difference are shown in Figure 5. From these two series, the derived draft of the granite block was 4.21 m at departure. This GPS observed draft was compared to the observed draft on the three observable draft marks (two on the transom, one forward on the starboard bow). Based on a plane fit through these three marks, the observed vessel draft (base line to water surface) at departure at the location of the granite block was 6.14 m. The design draft of the ship is 5.90 meters, so correcting the GPS derived draft for the additional 0.24 m of loading at the time of the measurement; we calculate a 3.97 m draft of the granite block when the vessel is sailing at its design draft of 5.90 m. The ship was indeed significantly down by the head and low on her lines on departure due to taking on fuel and not yet discharging her forward ballast tanks. The dominant uncertainty in this result is from the observation of the draft marks, which is at best 0.05 m.

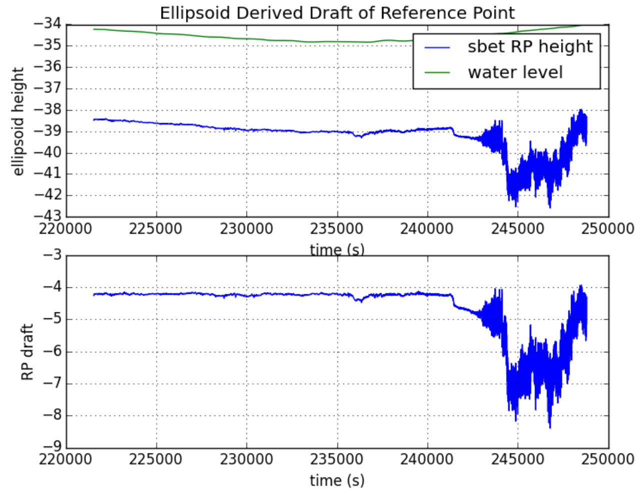



*Figure 5: Reference point (RP) draft from difference between ellipsoid referenced water level and ellipsoid referenced height of RP. The vessel is at the pier for the first half of this record.*

For an independent method to confirm the draft of the reference point, we measured from two benchmarks on the stern to the water surface and translated these measurements using the observed attitude of the ship at the time of the measurement. The offsets to the two marks in the granite block frame were transformed to a gravity level (i.e. parallel to the water surface) frame using the observed pitch and roll values from the POS and compared to the GPS derived values. Both measurements agreed within less than 0.05 m to the previously calculated results. Because of the uncertainty of the tape measurement and the methods for extending the benchmark over the deck edge, the uncertainty of this approach is most likely significantly higher than the GPS method, and so the result from the GPS measurement alone was used in all offsets. Figure 6 illustrates this method. The calculations are included in the Appendix 10.3, Vessel Offsets – Draft Calculations.

*Figure 6: Confirmation of waterline offset. The distance from the benchmark (by right foot in picture on right) to water surface checked with uncalibrated steel tape. Cardboard sign (blue and white) used to extend height of benchmark over deck edge.*

### 3.4.2 Data Flow Configuration

The wiring diagram and basic connections between equipment is illustrated in Figure 7. Only the components directly related to the ME70 are shown. The attitude data from the POS is fed into the ME70 using the Simrad 3000 format on COM1. The ME70 requires attitude on this com port and passes this directly to the beam-former circuitry for active stabilization of the beams. This port is not configured using the ME70 I/O module. Communications between the TRU and the ME70 workstation are over two dedicated Ethernet connections. Other navigation, triggering, and surface sound speed inputs are handled by the ME70 I/O module and are configured as shown.

A dedicated Ethernet crossover cable connects the ME70 to the Hypack computer, and both the ME70 and the Hypack computer are connected to the science network with independent NIC cards. The raw data from the ME70 can be recorded to a portable USB drive or to a location on the network. Portable drives will likely be the solution of choice given the rotating science missions using the platform. The raw data can also be broadcast, but only to one port at a time. For the mapping work, this was set to the card connected to the Hypack computer. Other applications (e.g. the Simrad TD50 real time water-column visualization software) may require the broadcast to be on the science network. While it is possible to receive the data packets from the ME70 on the Hypack machine via the science network, this configuration is not recommended for mapping work because of the unknown capacity and possibly variable latencies over this network.

The POS navigation and attitude data is data is passed to the Hypack computer via a hub. The Hypack software receives the raw full-watercolumn beam-angle and power datagram from the ME70 and calculates bottom detections using code based on MATLAB code developed by Dr. Tom Weber. These are saved in the RMB message in the Hypack HSX file. The timestamp of the RMB record is taken from the time in the ME70 datagram header. These timestamps are from the ME70 computer system time. The timestamps of the navigation and motion data recorded in the HSX file come from the POS timestamping at the source. Unlike most modern bathymetric systems, the fisheries mode ME70 does not have an input for time or a GPS pulse per second (PPS) input to discipline the internal clock. Left alone, the internal clock can drift significantly with the result that the bathymetry time stamps drift out of line with the motion time stamps from the POS system. *Lasker* does have a timeserver that should be configured to discipline the ME70 clock. During this cruise however, the timeserver was not connected to a working GPS antenna and was not serving the correct time. We removed the ME70 from the time server control and manually set the ME70 time to within approximately a quarter- second of the POS-MV time repeatedly through the cruise. The time server should be fixed and the ME70 brought under its control.

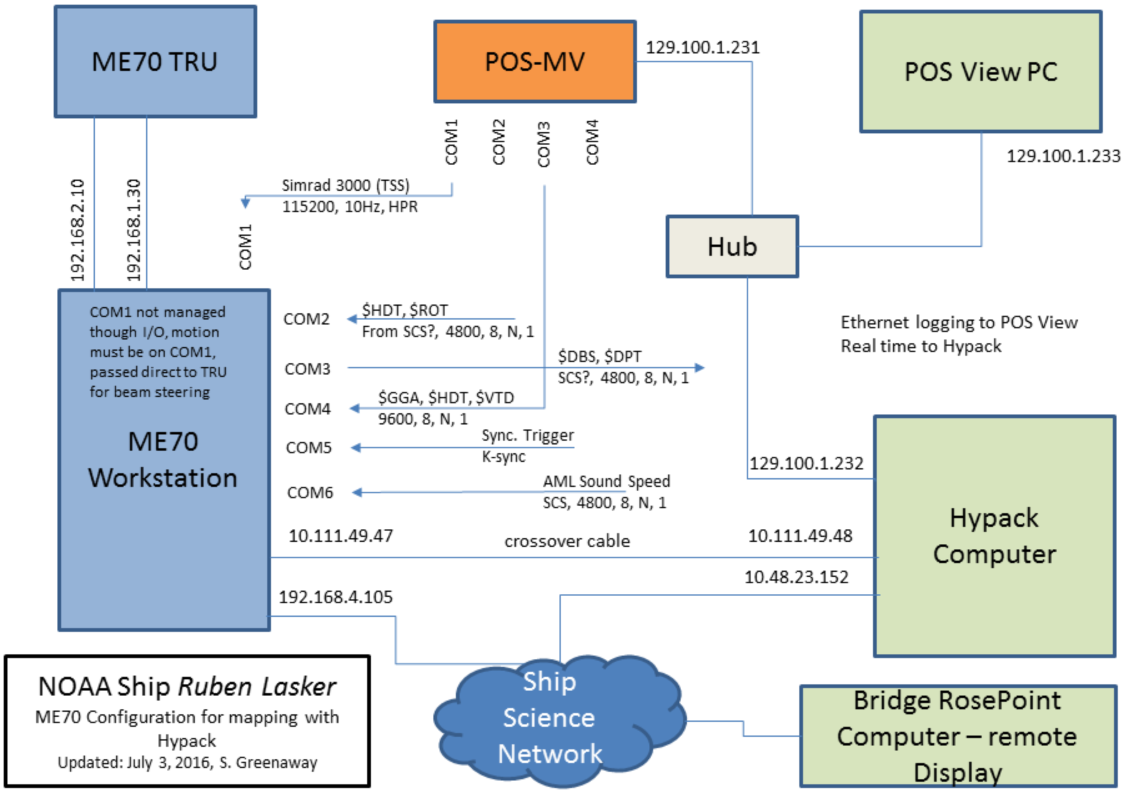



*Figure 7 – Wiring diagram as configured.*

## 3.5 Ancillary equipment setup

### 3.5.1 Position and Attitude

The POS M/V was configured to send navigation (NMEA GPGGA string) and attitude (Simrad 3000 (Tate-Bryant)) to the ME70 via serial cables. The navigation and attitude was passed to the Hypack machine via Ethernet. Configuration screen shots are documented in the appendix.

### 3.5.2 Surface Sound Speed

Surface sound speed was measured with an AML senor mounted on the centerboard. The AML sensor output is ingested in the Scientific Computer System and output to the ME70 workstation via serial cable. Configuration screen shots are documented in the appendix.

### 3.5.3 Hypack

Hypack was configured to take POS motion and attitude via a LAN distribution hub, raw bathymetry data from the ME70 workstation via crossover LAN cable, and was also connected to the ship science network for data transfer.

### 3.5.4 Horizontal and Vertical control

The POS was configured to accept the WAAS corrector signal and thus the horizontal and vertical GPS based positions are relative to WGS84. The vertical reference for acceptance work was the real time water level. Generally data were collected in water deep enough that tidal effects were not significant enough to warrant the effort to attempt tidal corrections.

# 4 Alongside Testing

## 4.1 User interface and system control

Once configured, the ME70 user interface is straight forward, with the exception of setting the beam configuration and logging range, there are few operational adjustments required.

## 4.2 System health self-tests

The ME70 built in test environment (BIST) allows visualization of the element level output either as a time series (B-scan view) or as average value matrix by element location. Examples are shown in Figure 8. This view is useful in evaluating the overall correct operation of the system. The initial view (as shown in Figure 8) with apparently dead elements was resolved by removing and reseating the appropriate card in the TRU.

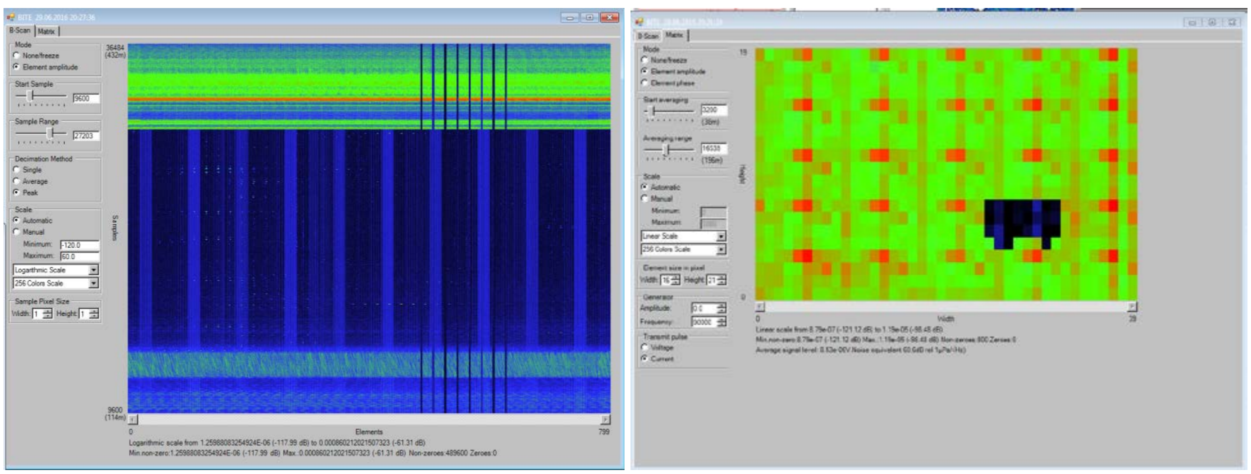


*Figure 8: BIST test views showing selection from receive cycle. B-scan (left) shows a time series (vertical axes) by element number. Matrix (right) shows time averaged intensity over selected range. In this case, one board (dark elements) was not working and was reseated.*

## 4.3 Evaluate stave data

With the exception of the BIST test view, no element level data was recorded or analyzed.

## 4.4 Backscatter quality assessment

Backscatter quality was not assessed while alongside.

# 5 Underway Testing

## 5.1 Patch Test

Three patch test lines were run over the head of pioneer Canyon off San Francisco (Figure 9). This is the same area the NOAA Ship *Fairweather* was patch tested in 2014 and good reference data was available.

Three lines were run, two reciprocal lines for roll and patch and one offset for yaw. The flat section above the canyon was used for roll. The steep canyon sides were used for pich and yaw. With the surveyed offsets already entered into the POS to align the reference frames, no residual roll, pitch, or yaw were observed.

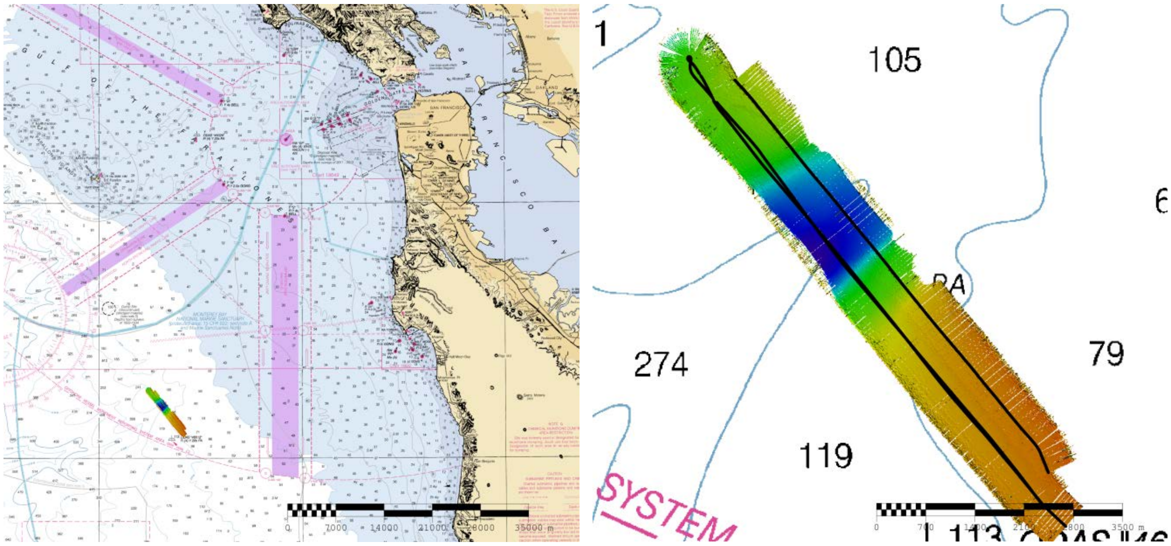



*Figure 9 - The patch test lines across the head of Pioneer Canyon. (left) shows general location southwest of San Francisco. (right) shows detail of three lines. Data is uncleaned and colored by depth. Chart background is 18680 with soundings in fathoms.*

Because of the known timing issues, no timing offsets was analyzed or corrected for in the patch test.

## 5.2 Acquire Reference Data Set

There was insufficient time to acquire a full set of reference data sets in a range of depths and operational settings. A limited reference surface was acquired near Neah Bay, WA at the conclusion of the leg in 75 to 120 meters depth. The reference surface area is shown in Figure 10.

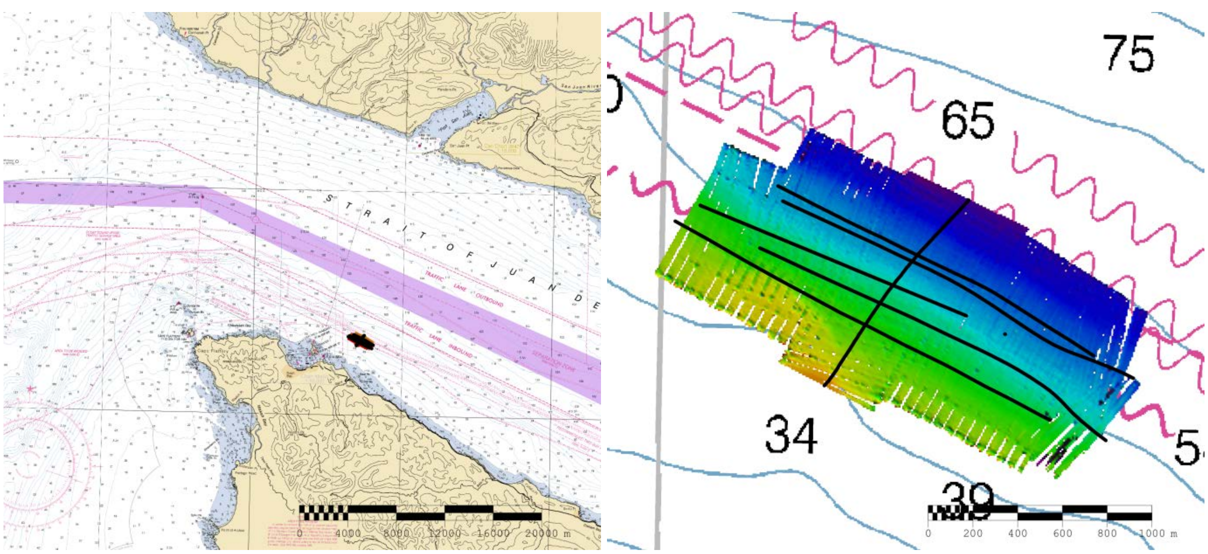



*Figure 10: Reference surface near Neah Bay, WA. Left is general location of the reverence surface in 75-120 meters depth. Right shows detail of line configuration and 8 meter reference surface.*

Five lines were run parallel to the depth contours and used to generate an eight-meter surface. One line was run perpendicular to these lines and compared to the surface using the Caris line QC tool. The mean difference, 95% confidence intervals, and compliance with IHO specifications are shown in Figure 11. The residual mean difference in the outer beams is likely due to error in the sound speed profile, but the significant increase in the confidence interval is indicative of the decrease in sonar performance at larger steering angles. The gaps shown near nadir are indicative of the relatively low sounding density at nadir. Because multiple phase-detections within the beam are only possible away from normal incidence, the data density at nadir is significantly lower than in the outer beams. Based on this test alone, the data does not meet IHO order 1 standards much past 50 degrees.

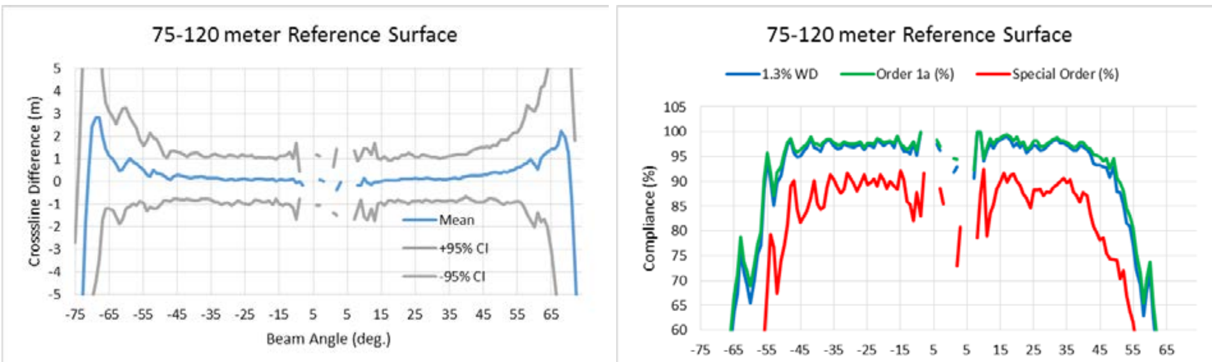



*Figure 11: Reference surface statistics. Residual mean difference (left) in outer beams is likely due to sound speed errors. Gaps at nadir are due to inability to perform multiple phase detections within beam at nadir. Compliance with specifications degrades significantly past approximately 45 degrees.*

Becasue of time constraints, no other dedicated reference surface surfaces were acquired. For a comparison in deeper water, one of the patch test lines off San Francisco was compared to a surface obtained during the Fairweather EM710 testing in 2015. This comparison data set was not orthoganal to the Lasker line and did not have a great deal of redundant data, but does serve as a useful, if limited, check on the performance in deeper water. Ony the data on the relativly flat areas in 160 to 210 meters depth were used. The residual mean difference is likely due to both uncorrected tidal effects and uncorrected refraction artifacts and does not likely reflect the fundamental system performance. The results are illustrated in Figure 12. Again, the performance of the system at nadir and past approximatly 45 degrees is signifigantly degraded.

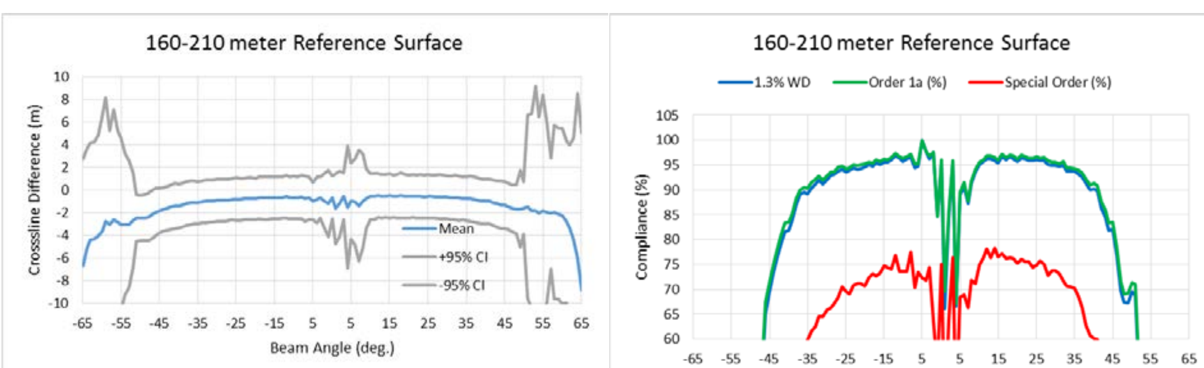



*Figure 12: Reference surface statistics from comparison to Fairweather EM710 data. Residual mean difference (left) in outer beams is likely due to sound speed errors. Compliance with specifications degrades significantly past approximately 45 degrees*

Figure 13 illustrates a 200 meter along-track segment of the upper portion of the patch test area. The divergence in the outer beams is typical for this system and is reflected in the statistics shown in Figure 11 and Figure 12

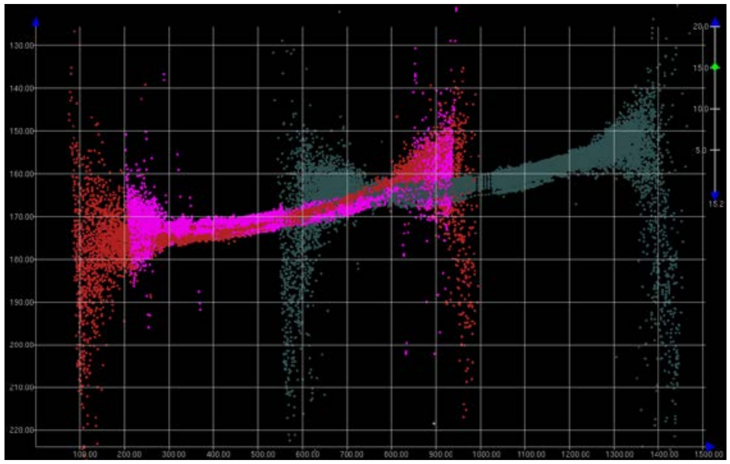



*Figure 13: Cross section of 200 meter along track segment from upper patch test. The divergence in the outer beams is typical for this system. Horizontal and vertical scales are in meters.*

## 5.3 Noise floor testing

No dedicated noise floor tests involving only the ME70 were conducted and no measurements of noise levels as a function of speed or equipment operation were conducted due to the limited nature of this cruise.

Some interference was periodically observed at particular frequencies in the ME70. The interference was observed in multiple beam configurations and appeared to be frequency rather than angle dependent. In all cases the interference was observed in beams with center frequencies from 102.3-103.2 kHz. The interference can be observed as a beam with elevated background signal levels (Figure 14). At this time, the source of this interference is unknown.

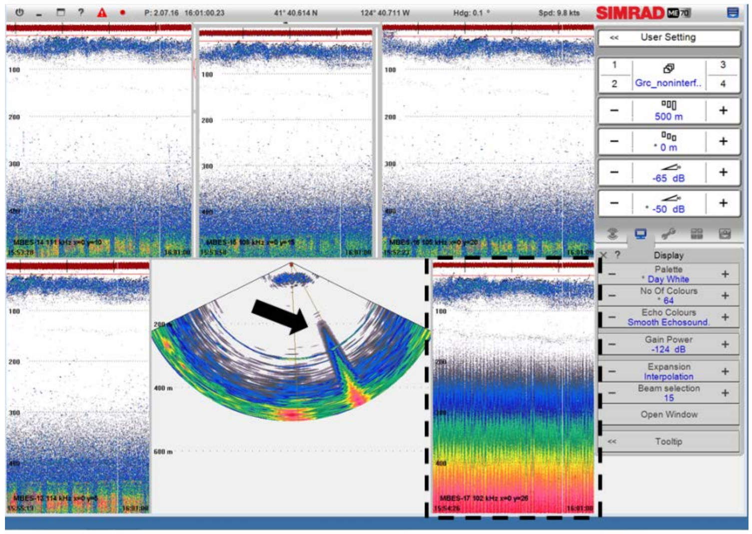



*Figure 14: Elevated background noise due to possible interference at ~102 kHz. The elevated background noise (arrow) is apparent in the water-column view as well as the beam time series view (dashed box).*

*Lasker* does have a set of three hydrophones mounted for passive monitoring of ship noise that were very effective in identifying and correcting for other interference. Figure 15 shows an example where the only active acoustic sensor known to be in use was the bridge echosounder, nominally at 50kHz. The spectrogram clearly shows an interfering signal at 38 kHz, with noticeable harmonics, and unsynchronized with any system. This was later tracked down to be part of the trawl measurement system that has active transducers on the centerboard. This system was actively transmitting even when nominally turned off. The interference was resolved by securing power to this system.

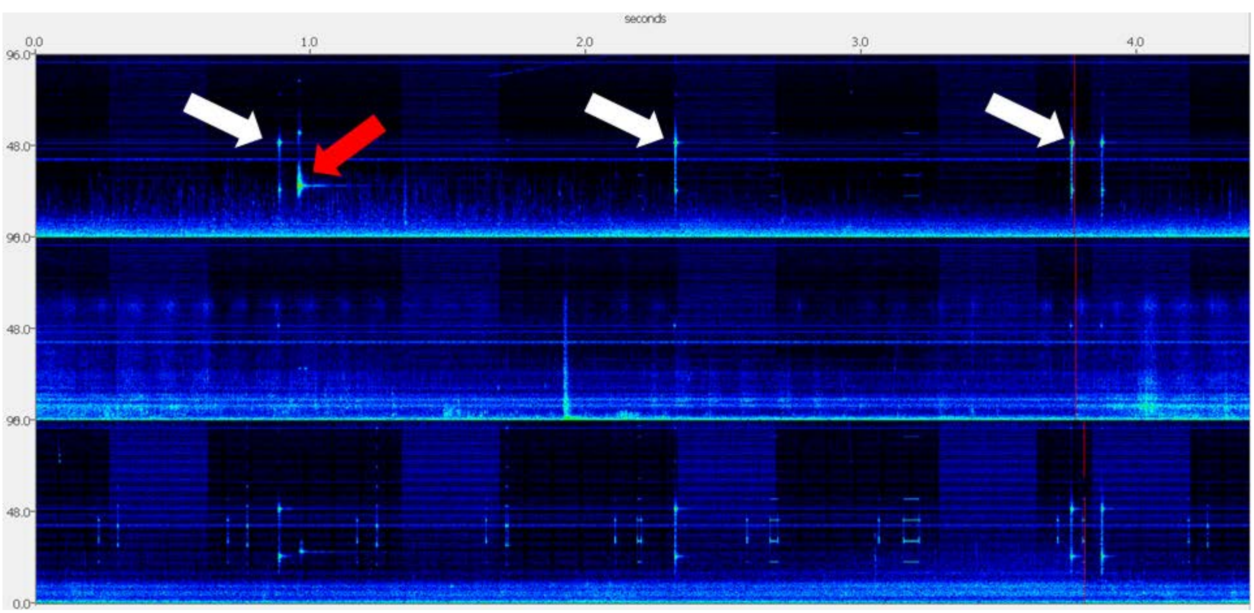



*Figure 15: Spectrograms from passive broadband hydrophones. Top panel is sonar flat, middle is centerboard, bottom is above propeller. Vertical axis is frequency, horizontal is time. Bridge echosounder (nominally 50 kHz) pulse is shown with white arrow. Interference from trawl monitoring system at 38 kHz is shown by red arrow.*

## 5.4 Target detection and recognition

No specific target detection or recognition tests were conducted during this cruise. However a wreck on the patch test lines off San Francisco was observed in the ME70 data. This wreck sits in 190 meters of water and is approximately 50 meters long. The wreck was clearly detected by the two lines passing nearly over the wreck, but was completely obscured in the outer beam of an offset line. Detection of objects of this size in this depth of water through analysis of the bathymetry alone would likely be possible only in a limited section of the swath. Figure 16 shows a section of the eight meter surface over the wreck for both the ME70 and the *Fairweather* EM710 for comparison. While both systems are nominally 100 kHz multibeam systems, the resolution from the systems are vastly different. This is the expected result- the ME70 beam widths are 3-5 degrees, the EM710 has beam widths 0.5-1 degrees.

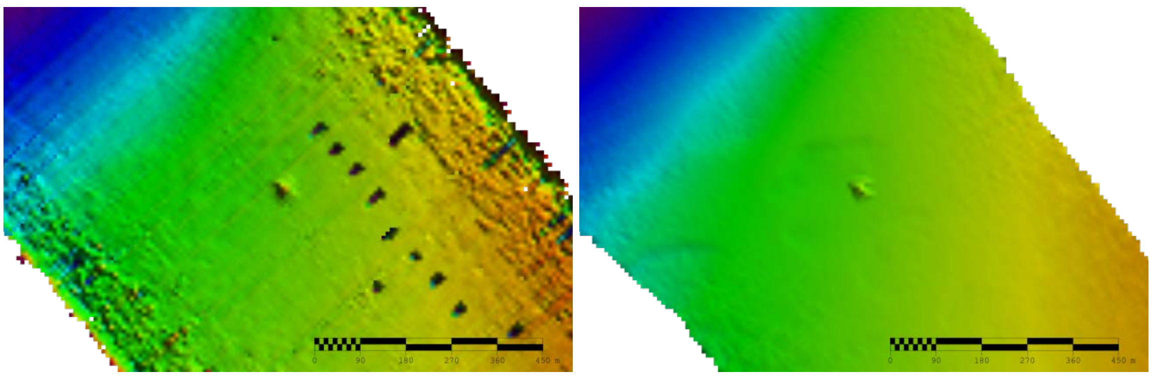


*Figure 16: Wreck at head of pioneer Canyon (190 meters depth) was detected by ME70 lines near nadir (left); Data from FA EM710 (right) shown for comparison. Both are 8-meter surfaces, 2 x vertical exaggeration.*

## 5.5 Sonar Performance Parameters

The useable swath width as a function of depth is important to survey planning, survey quality, and survey efficiency. The swath width was measured on July 4, 2016 off the Oregon Coast in the vicinity of Gray's Canyon. The beam configuration 'grc_noninterfering_25b_80to116kHz' was used for these tests. The bathymetry was hand cleaned of obvious bad detections. All valid detections as a function of depth and across track distance are shown in Figure 17. The swath width drops below the 60 degree maximum at approximately 150 meters and is effectively extinct at 500 meters. The 500 meter range limit set for the broadcast data is apparent, but it is unlikely that this restriction significantly impacted these results. While other beam configurations may improve these results, this effect is likely to be rather small.

The ME70 swath width as a function of depth is shown relative to other commonly used mapping systems currently in use in the NOAA fleet is shown in the right panel of Figure 17. This is only an approximate comparison as data from these other systems was collected over other seafloors. The overall swath coverage of the ME70 is roughly on order with a 200kHz 7125.

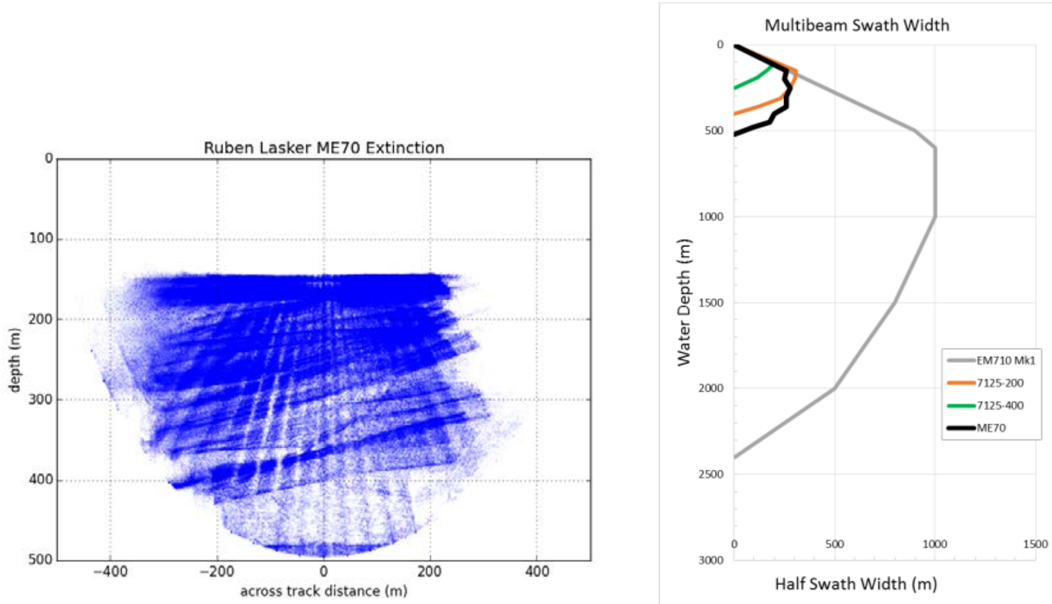



*Figure 17: Valid bottom detections as a function of depth. (left) valid detections from 150 meters to 500 meters. While the 500 meter limit on the broadcast data is apparent, the effective swath width is largely inside this limit at all depths. (right) Comparison to other commonly used mapping systems in NOAA's fleet.*

### 5.6 Backscatter quality assessment

No assessment was made with the backscatter at this time. The backscatter logged in the Hypack files has a known deficiency that is being investigated by Hypack. A revision to the Hypack code is expected in August.

## 6 Data Workflow Integration

### 6.1 Test application of post processed correctors

Post processing was conducted in Caris HIPS 9.1. The bathymetry data logged in the Hypack .HSX file is relative to the ME70 transducer face. As configured, the ME70 beam-former uses the surface sound speed and is stabilized for roll and pitch; however no other corrections are applied by the ME70 or Hypack during the bathymetric detection process. This is confusing because the ME70 accepts inputs for instrument offsets, heave, and sound velocity profiles. Adding to the confusion, many Kongsberg mapping systems do compensate for instrument offsets, heave, and do ray trace the bathymetric solutions to account for a given sound speed profile. Without the SIS bathymetry module, the ME70 does not. These inputs in the ME70 presumably do affect some available output records (e.g. the NMEA DBT telegram), but do not affect the data logged either in the ME70 .raw file or the Hypack logged .HSX file.

The Caris HVF file was configured to apply these offsets in Caris. The HVF used for the analysis in this report is included in the appendix. The reference point for the HVF matches the ship frame discussed in section 3.4.1 and is the granite block. Because the navigation and attitude are valid at this point, there are no offsets to these sensors. Because roll and pitch are compensated in the beam-former, the 'apply' flag is set to 'no' for these sensors. The 'apply' flag is set to 'yes' for heave and waterline because these are not corrected for elsewhere.

Heave is potentially problematic because of the timing issues discussed in section 3.2.2. The roll and pitch inputs to the ME70 are used to stabilize the beam former in real-time. The navigation and heave, however, are recorded in the HSX file with the POS timestamp. The bathymetry from the ME70 is recorded with the ME70 timestamp. If the POS and ME70 are synchronized to a common clock (e.g. the GPS constellation), the heave and bathymetry will be appropriately matched. If the ME70 is not synchronized to the POS time, the data records will not be appropriately matched during Caris processing. The MATLAB based code available to process ME70 bathymetry avoids this issue by using the navigation and heave logged in the .RAW file with the ME70 timestamp. Thus even if the ME70 clock is wrong, it is consistently wrong with all records.

Because of these issues, *it is imperative that the ME70 be brought under the control of a timeserver that is synchronized to GPS based time*. For the tests conducted in this report, the ME70 system clock was manually aligned to the POS time to within approximately a quarter second before conducting each test.

The real time gridded display in Hypack (the Matrix) can be corrected for heave, pitch, and roll or with corrected for motion at all; the ability to individually select only heave correction (as is needed here) is not available. With no corrections applied, this will result in an apparent heave artifact in the real time data. This should not significantly affect the extents of the coverage shown and does not cause any issue with downstream processing. Selecting to correct for roll, pitch, and heave will result in large motion artifacts in the real time display. Turning off the beam stabilization is not recommended because of the negative impact on consistent swath width.

## 6.2 Test data resolution and density

With the exception of the brief discussion in section 5.4, no specific resolution analysis was conducted.

The along track sounding density is determined by the ping rate of the system. For most of the data acquired during this cruise, the acoustic systems were alternately pinged under the k-sync control. This eliminates interference between the systems but significantly reduces the along track density.

For the patch test and reference surface tests, all other systems were secured and the ME70 was set to ping at the maximum permitted by the set data range. The observed ping rate was 60% of the theoretical maximum ping rate for the logging range that was set (ping interval was 0.90 seconds at a 400m logging range setting, theoretical minimum interval is 0.53 seconds). Ping rates as a function of range setting were not further explored.

Significant periodic gaps in the recoded bathymetry were observed throughout this cruise. An example is shown in Figure 18. Gaps in the recorded attitude were also observed nearly coincident with the bathymetric gaps. This combined with the sluggish performance of the Hypack computer indicates that the computer in use was not up to the specifications required to run this process. The recommended specifications are:

- Core i7
- 32 GB RAM
- 2 GB Video Card that supports OpenGL (nVidia)
- 500GB Solid State Drive

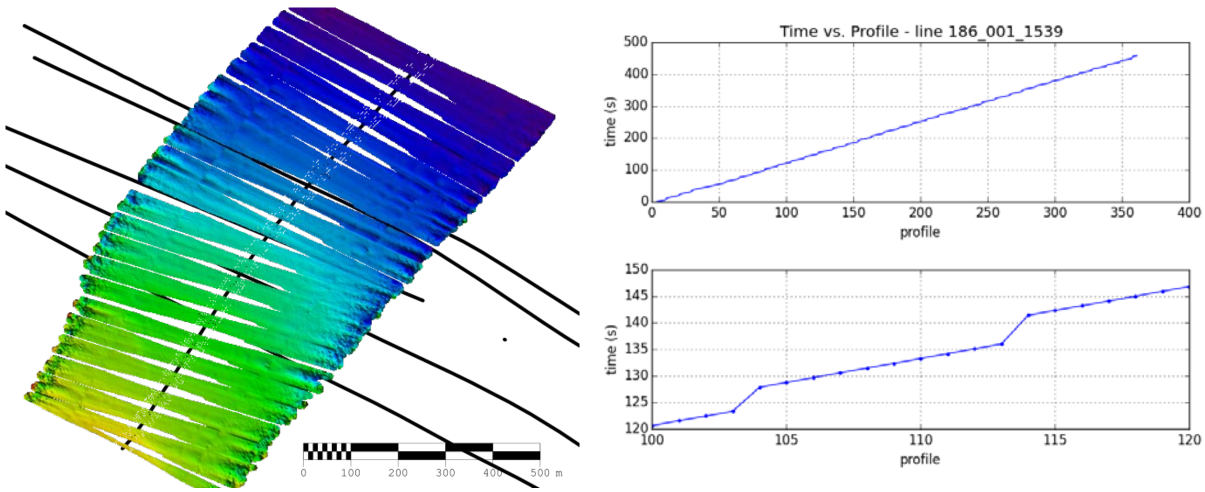



*Figure 18: Periodic data gaps were seen throughout the cruise, likely due to hardware problems with the Hypack computer. This resulted in bathymetric gaps, 2-meter surface of cross line of Neah Bay reference surface lines shown left. Ping intervals make regular jumps (right). Top right panel time vs ping (profile) number. Bottom right is detail of same data.*

## 6.3 Test bottom detection repeatability

Bottom detection repeatability was not performed.

## 6.4 Test total propagated uncertainty

The Hypack bottom detection algorithm does not determine real time uncertainty of the bottom detection, so a vessel model was used in Caris. The Caris device model does not appear to take into account the multiple phase detections within the across-track beam, which results in anomalously high uncertainty with the horizontal beam width set to the nominal 2.8 degrees.

Using the Neah Bay crossline, we re-calculated the uncertainty using different values of horizontal beam width and compared to the node standard deviation (the standard deviation of all sounding in a grid node, not just the ones contributing to the selected hypothesis). The results are shown in Figure 19. Because the total propagated uncertainty contains uncertainty components that are not stochastic over the timescale of the experiment (e.g. tides, sound speed), we expect that the uncertainty will have a base value higher than the observed standard deviation. However, as the bottom detection error increases, this should begin to dominate and be reflected in the modeled uncertainty. With enough data acquired over the full range of parameters, we expect the observed standard deviation to converge to the modeled uncertainty and the slope of the distributions shown should approach 1:1. Of all the modeled beam widths, 1.5 degrees gives the most satisfactory results, and we have updated the device model accordingly.

This approach is admittedly very crude. A more mature approach would model the uncertainty of each bottom detection. Dr. Weber's Matlab based code does have this functionality, but this was not tested here.

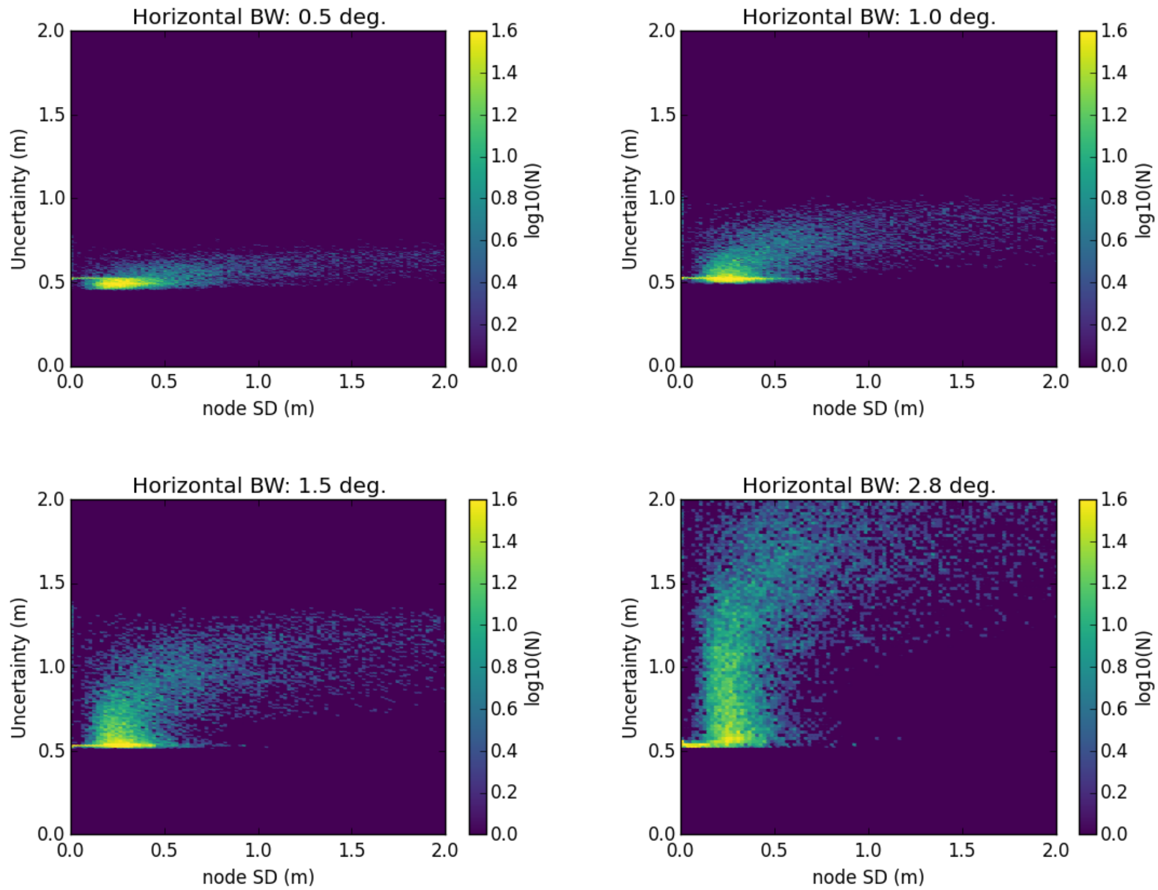



*Figure 19: Calculated uncertainty (vertical axis) relative to node standard deviation (horizontal axis) for four values of the horizontal beam width.*

The device model updated with the 1.5 degree beam width is shown in Table 2. For use in Caris, this entry needs to be appended to the file devicemodels.xml found in the C:\...\CARIS\HIPS\9.1\System folder.

*Table 2: Device Model for 31 Beam ME70*

```
</SonarModel>
  <SonarModel label="Simrad ME70 31 Beam" key="ME70">
    <Max_Num_Beams value="31"/>
    <Operating_Frequency_1 value="73"/>
    <Operating_Frequency_2 value="117"/>
    <Max_Angle value="66"/>
    <Beam_Width_Across value="1.5"/>
    <Beam_Width_Along value="2.8"/>
    <Steering_Angle value="0.0"/>
    <Range_Sampling_Distance value="0.38"/>
    <Min_Pulse_Length value="0.15"/>
    <DeviceProperties>
```

```
    <Steered value="Yes"/>
    <Splithead value="Yes"/>
  </DeviceProperties>
```

# 7 Difference Surface

With the exception of the reference surface analysis discussed in section 5.2, no difference surface with an established data set was performed.

# 8 Concluding Summary

We were able to successfully integrate the ME70 on the *Ruben Lasker* with the necessary ancillary systems and preliminarily characterize the performance of the system. Some significant items should be addressed and tested before any dedicated mapping work is undertaken with this systems; in particular:

1. The time synchronization of the ME70 should be addressed and tested.
2. The computer running Hypack should be upgraded and tested to ensure the data gap issue is resolved.
3. The remote display should be reconfigured to not run over the network interface.

The overall performance of the system is comparable, at least anecdotally, with other ME70 systems in the fleet. Should these systems become important components of mapping efforts, we recommend a dedicated effort to quantify performance and regular effort to ensure configurations and systems performance remains nominal. This is in keeping with idea and efforts of the Multibeam Advisory Committee in support of the academic research fleet (see: http://mac.unols.org/) and similar efforts by HSTB in support of the NOAA fleet supporting Coast Survey mapping efforts.

The performance of the system for bathymetric mapping is significantly worse in terms of coverage, depth performance, and resolution when compared to 100 kHz multibeam systems designed for this task (e.g. the EM710). This does not discredit the ME70; for the work it was designed to do, pelagic fisheries, it is an incomparable system. Through the efforts of Dr. Weber, Hypack, and others, we have been able to extract additional bathymetric information from these systems, and this may be of great use to users of this ship and these systems generally. However, if a primary focus of a cruise is bathymetric maps of a given area, the ME70 is likely not the ideal system for the task.

If the highlighted deficiencies are addressed and tested before the next scheduled operational use of this system for mapping purposes, the system should provide adequate performance as outlined in this report.

# 9 Works Cited

[1] E. Ona, V. Mazauric and L. N. Andersen, "Calibration methods for two scientific multibeam systems," *International Council for the Exploration of the Sea,* vol. 66, pp. 1326-1337, 2009.

[2] S. Greenaway and G. Rice, "NOAA Ship Fairweather Kongsberg EM710 Multibeam Echosounder Acceptance Trials," National Oceanic and Atmospherical Administration, Silver Spring, MD, 2015.

[3] G. Rice, "Estimating Vessel Static Waterline Using Vessel Ellipsoid Height," 2011.

Vessel: **NOAA Ruben Lasker**

Date of Survey: **2012, 2014**

Surveyor: **IMTEC**

prepared by: S. Greenaway, June 2016

## Offsets

This spreadsheet takes the original surveyed offsets and both translates and rotates them into a new reference frame. Two methods of rotation are shown. One is valid for small angles and is included to aid in understanding the result. The"General Solution" section is generally applicable for all rotations.

Origional survey in Ship Frame is Aligned with MLP (Granite Block).

Translated frame is relative to design waterline of 5.90 meters. Per calculations on 'waterline' sheet, at design draft of 5.9m, MLP (granite block) is 3.97 m below water surface.

**Rotation of Reference Frame**

| | roll | pitch | heading |
|---|---|---|---|
| degrees | 0.000 | 0.000 | 0.000 |
| radians | 0.0000 | 0.0000 | 0.0000 |

**Translation**

| X | Y | Z |
|---|---|---|
| 0.000 | 0.000 | -3.970 |

Angles are defined as angle of new frame with respect to the original frame with following order of operations: heading, then pitch, then roll. This is equivalent to a space-fixed orientation transformation in the Euler x-y-z convention.

Positive rotations are CCW looking towards the origin: heading, to starboard; pitch, bow up, roll; starboard down.

tz to mru

| Item | Mark | Description | Original Reference Frame forward X | Original starboard Y | Original down Z | Translated Frame forward X | Translated starboard Y | Translated down Z | Small Angle Approximation (order of operation invariant) Translated & Rotated Frame forward X | starboard Y | down Z | General Solution Translated & Rotated Frame forward X | starboard Y | down Z |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | PORT ANT -PHASE CENTER (3) | POSMV Antenna | -17.270 | -1.220 | -27.728 | -17.270 | -1.220 | -23.758 | -17.270 | -1.220 | -23.758 | -17.270 | -1.220 | -23.758 |
| 2 | POS - MV GAMS Vector (3) | | -0.018 | 2.693 | 0.032 | -0.018 | 2.693 | 4.002 | -0.018 | 2.693 | 4.002 | -0.018 | 2.693 | 4.002 |
| 3 | STBD ANT PHASE CENTER (3) | POSMV Antenna calculated from PORT plus GAMS | -17.288 | 1.473 | -27.696 | -17.288 | 1.473 | -23.726 | -17.288 | 1.473 | -23.726 | -17.288 | 1.473 | -23.726 |
| 4 | IMU TDC-FINAL (1) | POSMV IMU, Mark on Top | 3.88 | 0.021 | -6.062 | 3.880 | 0.021 | -2.092 | 3.880 | 0.021 | -2.092 | 3.880 | 0.021 | -2.092 |
| 5 | ADCP (2) | Center of Transducer Face | 0.752 | -1.735 | 1.076 | 0.752 | -1.735 | 5.046 | 0.752 | -1.735 | 5.046 | 0.752 | -1.735 | 5.046 |
| 6 | ME70 (2) | Center of Transducer Face | 0.604 | -0.67 | 1.233 | 0.604 | -0.670 | 5.203 | 0.604 | -0.670 | 5.203 | 0.604 | -0.670 | 5.203 |
| 7 | Hydrophone (2) | | 0.275 | -2.214 | 1.025 | 0.275 | -2.214 | 4.995 | 0.275 | -2.214 | 4.995 | 0.275 | -2.214 | 4.995 |
| 8 | Dual Axis Doppler Speed Log (2) | | -0.879 | -0.904 | 1.185 | -0.879 | -0.904 | 5.155 | -0.879 | -0.904 | 5.155 | -0.879 | -0.904 | 5.155 |
| 9 | Passive Sonar Airnmar 12 kHz (2) | | 0.006 | 1.451 | 1.143 | 0.006 | 1.451 | 5.113 | 0.006 | 1.451 | 5.113 | 0.006 | 1.451 | 5.113 |
| 10 | Scanning Sonar Transducer Trunk SX93 (2) | | -1.2 | 2.002 | 2.682 | -1.200 | 2.002 | 6.652 | -1.200 | 2.002 | 6.652 | -1.200 | 2.002 | 6.652 |
| 11 | Depth Finding (2) | | -1.437 | 0.706 | 1.206 | -1.437 | 0.706 | 5.176 | -1.437 | 0.706 | 5.176 | -1.437 | 0.706 | 5.176 |
| 12 | Acoustic speed correlation Log Valve Assy (2) | | -1.44 | 1.133 | 1.176 | -1.440 | 1.133 | 5.146 | -1.440 | 1.133 | 5.146 | -1.440 | 1.133 | 5.146 |
| 13 | GPS NAV AFT PORT (2) | Antenna Phase Center | -18.213 | -0.256 | -26.74 | -18.213 | -0.256 | -22.770 | -18.213 | -0.256 | -22.770 | -18.213 | -0.256 | -22.770 |
| 14 | GPS NAV AFT STBD (2) | Antenna Phase Center | -18.209 | 0.255 | -26.743 | -18.209 | 0.255 | -22.773 | -18.209 | 0.255 | -22.773 | -18.209 | 0.255 | -22.773 |
| 15 | GPS NAV FWD PORT (2) | Antenna Phase Center | -17.326 | -0.307 | -26.9 | -17.326 | -0.307 | -22.930 | -17.326 | -0.307 | -22.930 | -17.326 | -0.307 | -22.930 |
| 16 | Radar X-Band (2) | Center of Foundation Interface | -13.693 | -0.022 | -24.808 | -13.693 | -0.022 | -20.838 | -13.693 | -0.022 | -20.838 | -13.693 | -0.022 | -20.838 |
| 17 | Radar S-Band (2) | Center of Foundation Interface | -15.140 | -0.002 | -25.758 | -15.140 | -0.002 | -21.788 | -15.140 | -0.002 | -21.788 | -15.140 | -0.002 | -21.788 |
| 18 | FWD Gyro Center (2) | Center of scribe on top face of foundation | 3.268 | 0.017 | -3.975 | 3.268 | 0.017 | -0.005 | 3.268 | 0.017 | -0.005 | 3.268 | 0.017 | -0.005 |
| 19 | AFT Gyro Center (2) | Center of scribe on top face of foundation | 2.531 | 0.019 | -3.977 | 2.531 | 0.019 | -0.007 | 2.531 | 0.019 | -0.007 | 2.531 | 0.019 | -0.007 |
| | **CENTERBOARD COMPONENTS (Extended Position Based on 10.065 meters travel from Maintenance Storage Position)** | | | | | | | | | | | | | |
| 20 | BM2 (1) | | -10.302 | -0.256 | 5.035 | -10.302 | -0.256 | 9.005 | -10.302 | -0.256 | 9.005 | -10.302 | -0.256 | 9.005 |
| 21 | BM21 (1) | | -10.886 | -0.108 | 4.215 | -10.886 | -0.108 | 8.185 | -10.886 | -0.108 | 8.185 | -10.886 | -0.108 | 8.185 |
| 22 | BM22 (1) | | -8.601 | -0.260 | 4.183 | -8.601 | -0.260 | 8.153 | -8.601 | -0.260 | 8.153 | -8.601 | -0.260 | 8.153 |
| 23 | EK60 120kHz CTR (1) | | -9.718 | 0.195 | 5.132 | -9.718 | 0.195 | 9.102 | -9.718 | 0.195 | 9.102 | -9.718 | 0.195 | 9.102 |
| 24 | EK60 18KHZ CTR (1) | | -9.267 | 0.017 | 5.132 | -9.267 | 0.017 | 9.102 | -9.267 | 0.017 | 9.102 | -9.267 | 0.017 | 9.102 |
| 25 | EK60 200kHz CTR (1) | | -9.968 | 0.193 | 5.131 | -9.968 | 0.193 | 9.101 | -9.968 | 0.193 | 9.101 | -9.968 | 0.193 | 9.101 |
| 26 | EK60 333kHz CTR (1) | | -8.270 | 0.021 | 5.134 | -8.270 | 0.021 | 9.104 | -8.270 | 0.021 | 9.104 | -8.270 | 0.021 | 9.104 |
| 27 | EK60 38kHz CTR (1) | | -8.648 | 0.019 | 5.133 | -8.648 | 0.019 | 9.103 | -8.648 | 0.019 | 9.103 | -8.648 | 0.019 | 9.103 |
| 28 | EK60 70kHz CTR (1) | | -9.817 | -0.110 | 5.132 | -9.817 | -0.110 | 9.102 | -9.817 | -0.110 | 9.102 | -9.817 | -0.110 | 9.102 |
| 29 | MS70 CENTER (1) | | -9.325 | -0.271 | 4.288 | -9.325 | -0.271 | 8.258 | -9.325 | -0.271 | 8.258 | -9.325 | -0.271 | 8.258 |
| 30 | SPARE CENTER (1) | | -10.281 | 0.016 | 5.131 | -10.281 | 0.016 | 9.101 | -10.281 | 0.016 | 9.101 | -10.281 | 0.016 | 9.101 |
| | **CENTERBOARD COMPONENTS (Intermediate Position Based on 1.750 meters travel from Extended Position (4))** | | | | | | | | | | | | | |
| 20a | BM2 (1) | | -10.302 | -0.256 | 3.285 | -10.302 | -0.256 | 7.255 | -10.302 | -0.256 | 7.255 | -10.302 | -0.256 | 7.255 |
| 21a | BM21 (1) | | -10.886 | -0.108 | 2.465 | -10.886 | -0.108 | 6.435 | -10.886 | -0.108 | 6.435 | -10.886 | -0.108 | 6.435 |
| 22a | BM22 (1) | | -8.601 | -0.260 | 2.433 | -8.601 | -0.260 | 6.403 | -8.601 | -0.260 | 6.403 | -8.601 | -0.260 | 6.403 |
| 23a | EK60 120kHz CTR (1) | | -9.718 | 0.195 | 3.382 | -9.718 | 0.195 | 7.352 | -9.718 | 0.195 | 7.352 | -9.718 | 0.195 | 7.352 |
| 24a | EK60 18KHZ CTR (1) | | -9.267 | 0.017 | 3.382 | -9.267 | 0.017 | 7.352 | -9.267 | 0.017 | 7.352 | -9.267 | 0.017 | 7.352 |
| 25a | EK60 200kHz CTR (1) | | -9.968 | 0.193 | 3.381 | -9.968 | 0.193 | 7.351 | -9.968 | 0.193 | 7.351 | -9.968 | 0.193 | 7.351 |
| 26a | EK60 333kHz CTR (1) | | -8.270 | 0.021 | 3.384 | -8.270 | 0.021 | 7.354 | -8.270 | 0.021 | 7.354 | -8.270 | 0.021 | 7.354 |
| 27a | EK60 38kHz CTR (1) | | -8.648 | 0.019 | 3.383 | -8.648 | 0.019 | 7.353 | -8.648 | 0.019 | 7.353 | -8.648 | 0.019 | 7.353 |
| 28a | EK60 70kHz CTR (1) | | -9.817 | -0.110 | 3.382 | -9.817 | -0.110 | 7.352 | -9.817 | -0.110 | 7.352 | -9.817 | -0.110 | 7.352 |
| 29a | MS70 CENTER (1) | | -9.325 | -0.271 | 2.538 | -9.325 | -0.271 | 6.508 | -9.325 | -0.271 | 6.508 | -9.325 | -0.271 | 6.508 |
| 30a | SPARE CENTER (1) | | -10.281 | 0.016 | 3.381 | -10.281 | 0.016 | 7.351 | -10.281 | 0.016 | 7.351 | -10.281 | 0.016 | 7.351 |
| | **BENCHMARKS** | | | | | | | | | | | | | |
| 31 | MLP CENTER (1) | Granite Block | 0 | 0 | 0 | 0.000 | 0.000 | 3.970 | 0.000 | 0.000 | 3.970 | 0.000 | 0.000 | 3.970 |
| 32 | BM1 (1) | On BH, Frame 23, 1002 MM above MRB, on Centerline | 1.791 | 0.004 | -0.997 | 1.791 | 0.004 | 2.973 | 1.791 | 0.004 | 2.973 | 1.791 | 0.004 | 2.973 |
| 33 | BM3 (1) | 2nd Deck, on Frame 21, 1.487 Meters Stbd | 3.007 | 1.49 | -3.946 | 3.007 | 1.490 | 0.024 | 3.007 | 1.490 | 0.024 | 3.007 | 1.490 | 0.024 |
| 34 | BM4 (1) | Centerboard Trunk, 985 mm above 2nd Deck, 616mm Stbd | -10.39 | 0.622 | -4.958 | -10.390 | 0.622 | -0.988 | -10.390 | 0.622 | -0.988 | -10.390 | 0.622 | -0.988 |
| 35 | BM5 (RE-VALUED) (1) | 2nd deck on WT BH Frame 29, 130 mm above deck 3.011 M Port | -1.764 | -2.98 | -4.083 | -1.764 | -2.980 | -0.113 | -1.764 | -2.980 | -0.113 | -1.764 | -2.980 | -0.113 |
| 36 | BM6 (1) | On BH, Frame 47, 100 mm above Main Deck, 2.329 Stbd | -12.47 | 2.334 | -7.59 | -12.470 | 2.334 | -3.620 | -12.470 | 2.334 | -3.620 | -12.470 | 2.334 | -3.620 |
| 37 | BM7 (1) | Main Deck, 100 mm Fwd Frame 100, 2.011 M Stbd | -44.296 | 2.015 | -6.622 | -44.296 | 2.015 | -2.652 | -44.296 | 2.015 | -2.652 | -44.296 | 2.015 | -2.652 |
| 38 | BM8 (1) | 01 Level, 263 mm Aft Frame 0 on Centerline | 15.346 | 0.004 | -9.634 | 15.346 | 0.004 | -5.664 | 15.346 | 0.004 | -5.664 | 15.346 | 0.004 | -5.664 |
| 39 | BM9 (1) | 01 Level, 320mm Aft Frame 74, 2.009 M Stbd | -29.06 | 2.014 | -9.343 | -29.060 | 2.014 | -5.373 | -29.060 | 2.014 | -5.373 | -29.060 | 2.014 | -5.373 |
| 40 | BM10 (1) | 03 Level, 70 mm Aft Frame 58, 2.012 M Stbd | -19.215 | 2.02 | -14.57 | -19.215 | 2.020 | -10.600 | -19.215 | 2.020 | -10.600 | -19.215 | 2.020 | -10.600 |
| 41 | BM11 (1) | 04 Level, 130 mm Aft Frame 35, on Centerline | -5.515 | 0.004 | -17.199 | -5.515 | 0.004 | -13.229 | -5.515 | 0.004 | -13.229 | -5.515 | 0.004 | -13.229 |
| 42 | BM12 (1) | Main Deck, 50 mm Fwd Frame 92, 6.734 M Stbd | -39.539 | 6.739 | -6.619 | -39.539 | 6.739 | -2.649 | -39.539 | 6.739 | -2.649 | -39.539 | 6.739 | -2.649 |
| 43 | BM13 (1) | Main Deck, 50 mm Fwd Frame 92, 6.782 M Port | -39.536 | -6.779 | -6.612 | -39.536 | -6.779 | -2.642 | -39.536 | -6.779 | -2.642 | -39.536 | -6.779 | -2.642 |
| 44 | BM14 (1) | 04 Level, Fwd Base of Mast, on centerline, 100mm above deck | -13.733 | 0.003 | -17.204 | -13.733 | 0.003 | -13.234 | -13.733 | 0.003 | -13.234 | -13.733 | 0.003 | -13.234 |
| 45 | BM15 (1) | 04 Level, 60 mm aft Frame 43, 7.262 M Port | -9.924 | -7.257 | -17.156 | -9.924 | -7.257 | -13.186 | -9.924 | -7.257 | -13.186 | -9.924 | -7.257 | -13.186 |
| 46 | BM16 (1) | 04 Level, 60 mm aft Frame 43, 7.227 M Stbd | -9.923 | 7.234 | -17.149 | -9.923 | 7.234 | -13.179 | -9.923 | 7.234 | -13.179 | -9.923 | 7.234 | -13.179 |
| 47 | BM17 (1) | 2nd Deck, 0.4 M aft Frame 21, 130mm above deck, 2.822 M Port | 3.155 | -2.815 | -4.069 | 3.155 | -2.815 | -0.099 | 3.155 | -2.815 | -0.099 | 3.155 | -2.815 | -0.099 |
| 48 | BM18 (1) | 2nd Deck on WT BH Frame 29, 130mm above deck, 1.147 M Stbd | -1.768 | 1.15 | -4.093 | -1.768 | 1.150 | -0.123 | -1.768 | 1.150 | -0.123 | -1.768 | 1.150 | -0.123 |
| 49 | BM19 (1) | 2nd Deck, Passageway 2-29-0, 430 mm Aft BH at Frame 29, 1.153M P | -2.217 | -1.149 | -3.959 | -2.217 | -1.149 | 0.011 | -2.217 | -1.149 | 0.011 | -2.217 | -1.149 | 0.011 |
| 50 | BM20 (1) | 2nd Deck, Passageway 2-29-0, 300 mm Aft Frame 44, 1.153M P | -10.987 | -1.149 | -3.977 | -10.987 | -1.149 | -0.007 | -10.987 | -1.149 | -0.007 | -10.987 | -1.149 | -0.007 |

**Sources**

(1) 9/3/14 Survey, CFR 14-330-0030 IMTEC Final Report, NOAA FSV6RUBEN LASKER BENCH MARK & SPECIFIED ELEMENT SURVEY SEPTEMBER 2014, The IMTEC Group
(2) NOAA FSV-6 Contract AB133M-10-CN-0091, DRL A084 Navigational Reference System Report Rev A (working), Marinette Marine Corp., 2012
(3) Report for COMMISSIONING and SAT testing of the Applanix POSMV system aboard the NOAA ship Lasker, Applanix, June 2015
(4) Offsets between extended and intermediate centerboard position from drawing: 1571549-01 Rev.2 - Centerboard Weldment and Machining2000.dwg



template created by: Sam Greenaway, April, 2015

Vessel: **NOAA Ruben Lasker**

Date of Survey: **2012, 2014**

Surveyor: **IMTEC**

prepared by: S. Greenaway, June 2016

## Orientations

This spreadsheet takes the original surveyed orientations and rotates them into a new reference frame. Two methods of rotation are shown. Small angle approximation simply subtracts the reference frame orientation. This is approximatly valid for small angles and is included to aid in understanding the result. The general solution is generally applicable for all rotations.

Origional survey in Ship Frame is Aligned with MLP (Granite Block)

**Rotation of Reference Frame**

| | alpha | beta | gamma |
|---|---|---|---|
| | X (roll) | Y (pitch) | Z (yaw) |
| degrees | 0.000 | 0.000 | 0.000 |
| radians | 0.000 | 0.000 | 0.000 |

Angles are defined as angle of new frame with respect to the original frame with following order of operations: heading, then pitch, then roll. This is equivalent to a space-fixed orientation transformation in the Euler x-y-z convention.

Positive rotations are CCW looking towards the origin: heading, to starboard; pitch, bow up, roll; starboard down.

angles in DEGREES unless otherwise specified

| | | Orientation in Original Frame | | | Small Angle Approximation Orientation in Rotated Frame | | | General Solution Orientation in Rotated Frame | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | Component | X (roll) | Y (pitch) | Z (yaw) | X (roll) | Y (pitch) | Z (yaw) | X (roll) | Y (pitch) | Z (yaw) |
| 1 | Radar X-Band (2) | 0.0233 | 0.1429 | 2.6159 | 0.023 | 0.143 | 2.616 | 0.023 | 0.143 | 2.616 |
| 2 | Radar S-Band (2) | 0.0678 | -0.3973 | 2.7553 | 0.068 | -0.397 | 2.755 | 0.068 | -0.397 | 2.755 |
| 3 | FWD Gyro (2) | 0.0712 | -0.4605 | -0.0113 | 0.071 | -0.461 | -0.011 | 0.071 | -0.461 | -0.011 |
| 4 | Aft Gyro (2) | 0.0612 | -0.0389 | 0.0600 | 0.061 | -0.039 | 0.060 | 0.061 | -0.039 | 0.060 |
| 5 | ADCP (2) | 0.3192 | -0.0844 | 45.8391 | 0.319 | -0.084 | 45.839 | 0.319 | -0.084 | 45.839 |
| 6 | ME70 (2) | 0.0815 | -0.0302 | 0.5009 | 0.082 | -0.030 | 0.501 | 0.082 | -0.030 | 0.501 |
| 7 | POSMV IMU, 2012 Survey (2) | -0.0508 | 0.4099 | 0.2050 | -0.051 | 0.410 | 0.205 | -0.051 | 0.410 | 0.205 |
| 8 | POSMV IMU, 2014 Survey (1) | -0.811 | 0.837 | -0.472 | -0.811 | 0.837 | -0.472 | -0.811 | 0.837 | -0.472 |
| 9 | POSMV IMU, 2015 Commissioning (3) | -0.804 | 0.843 | 0.472 | -0.804 | 0.843 | 0.472 | -0.804 | 0.843 | 0.472 |
| 10 | MLP (Granite Block) | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |

**Sources**

(1) 9/3/14 Survey, CFR 14-330-0030 IMTEC Final Report, NOAA FSV6RUBEN LASKER BENCH MARK & SPECIFIED ELEMENT SURVEY SEPTEMBER 2014, The IMTEC Group
(2) NOAA FSV-6 Contract AB133M-10-CN-0091, DRL A084 Navigational Reference System Report Rev A (working), Marinette Marine Corp., 2012
(3) Report for COMMISSIONING and SAT testing of the Applanix POSMV system aboard the NOAA ship Lasker, Applanix, June 2015

## Waterline Offsets - Draft, etc.

No connection was made in surveyed offsets to waterline- draft marks were not surveyed in. To determine static draft of reference point (granite block), post-processed GNSS trajectory was compared to ellipsoid reference water level observations from San Diego tide gauge. Calculated offset agrees with measurements made with tape from BM7 and BM12 to water surface within accuracy of measurement.

June 2016, S. Greenaway

**Rotation of Reference Frame**

| | roll | pitch | heading |
|---|---|---|---|
| degrees | 1.000 | 0.400 | 0 |
| radians | 0.0175 | 0.0070 | 0.0000 |

**Translation**

| X | Y | Z |
|---|---|---|
| 0.000 | 0.000 | -4.210 |

Angles entered are the orientation of the gravity level frame with respect to the ship/ POS reference frame (the two frames are aligned via offsets in the POS configuration). Values entered here are thus the opposite sign of the POS reference frame with respect to gravity. This is equivalent to a space-fixed orientation transformation in the Euler x-y-z convention.
Offset is ERS derived granity block to waterline value for 6/28.
Positive rotations are CCW looking towards the origin: heading, to starboard; pitch, bow up, roll; starboard down.

**Translation of BM to Gravity Level Frame (i.e. to water-line frame):**

| | | | Original Reference Frame | | | Translated Frame | | | General Solution Offsets in Gravity Frame Translated & Rotated Frame | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Item | Mark | Description | forward X | starboard Y | down Z | forward X | starboard Y | down Z | forward X | starboard Y | down Z |
| 31 | MLP CENTER [1] | Granite Block | 0 | 0 | 0 | 0.000 | 0.000 | 4.210 | -0.029 | 0.073 | 4.209 |
| 37 | BM7 [1] | Main Deck, 100 mm Fwd Frame 100, 2.011 M Stbd | -44.296 | 2.015 | -6.622 | -44.296 | 2.015 | -2.412 | -44.278 | 1.967 | -2.756 |
| 42 | BM12 [1] | Main Deck, 50 mm Fwd Frame 92, 6.734 M Stbd | -39.539 | 6.739 | -6.619 | -39.539 | 6.739 | -2.409 | -39.521 | 6.691 | -2.802 |
| 4 | IMU TDC-FINAL [1] | POSMV IMU, Mark on Top | 3.88 | 0.021 | -6.062 | 3.880 | 0.021 | -1.852 | 3.893 | -0.011 | -1.825 |

**Measurements made in the gravity frame:**

| Distance from Benchmark to Waterline Measured by Tape on 6/28/16 | inches | meters |
|---|---|---|
| Measured waterline at BM7, deck edge to waterline | 109.5 | 2.781 |
| Measured waterline at BM12, deck edge to waterline | 108.75 | 2.762 |

note: estimated uncertainty 2", 0.05m

**Measured Waterline Relative to Reference Point in New Frame**

| | |
|---|---|
| Water line at BM7 in new, gravity level frame | 0.025 |
| Water line at BM12 in new, gravity level frame | -0.040 |

Small residuals indicte ERS derived draft of RP is consitent with tape measurements

| Draft Marks | forward X | starboard Y | down Z | |
|---|---|---|---|---|
| Aft Port Transom Draft Mark | -45.45 | 1.8 | 5.90 | draft reading 6/28 San Diego |
| Aft Starboard Transom Mark | -45.45 | -1.8 | 5.82 | draft reading 6/28 San Diego |
| Forward Starboard Mark | 12.609 | 0.7 | 6.23 | draft reading 6/28 San Diego |

note: X, value from ship drawings, Y-value from measured offset from BM7 for transom marks, from drawings for forward marl

**Calculation for Draft Mark Reading at New Location - i.e. if there were draft marks at this location, this is what you would read**

| | | | | |
|---|---|---|---|---|
| solve for new position - draft reading at location of granite block | 0 | 0.0 | 6.14 | calcuated draft (base-line to water) at granite block at departure |
| Design Draft | | | 5.90 | design draft |
| Difference | | | 0.24 | Residual Draft Correction, positiver value means ship is lower in water than design draft |

**Ellipsoid Referenced Vertical Control Analysis**

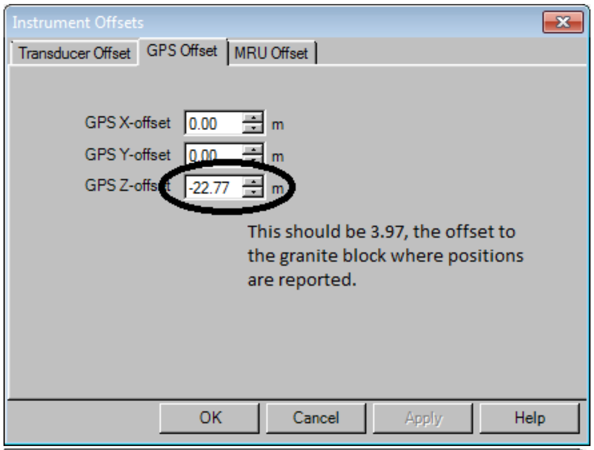
4.21 ERS determined water line to granite block at departure
3.97 ERS determined water line to granite block at design draft of 5.9m

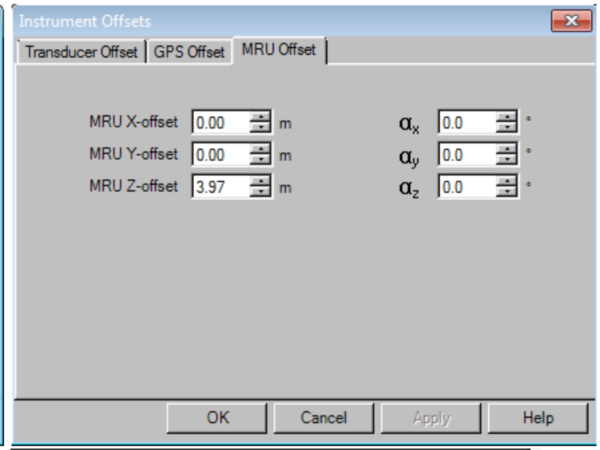
3.77 water line to granite block per drawings at design draft (not terribly accurate)
0.20 difference

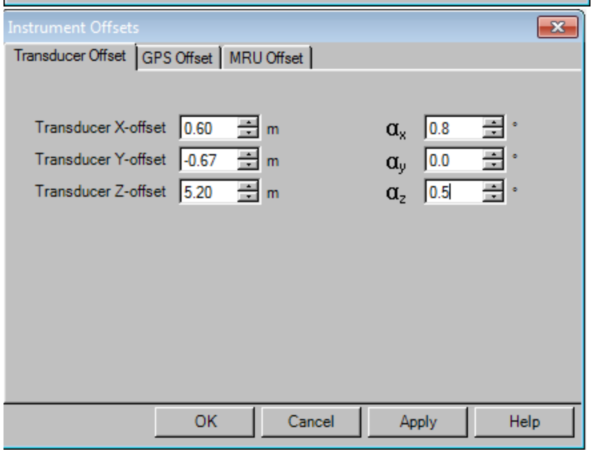
note: Design draft is 5.9 m above baseline, Granite block is approx. 2.13 m above baseline from drawings. So water line to block is 3.77 m

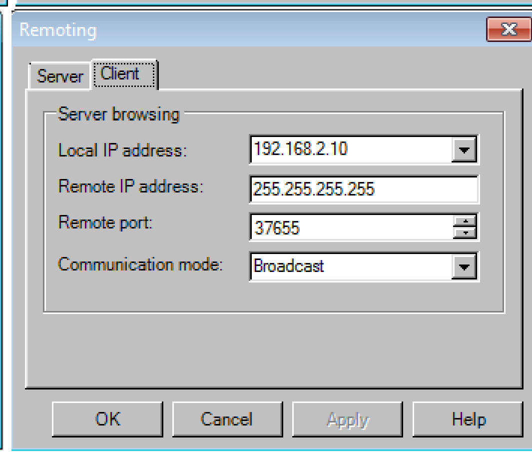
## 10.4 Configuration Screen Grabs

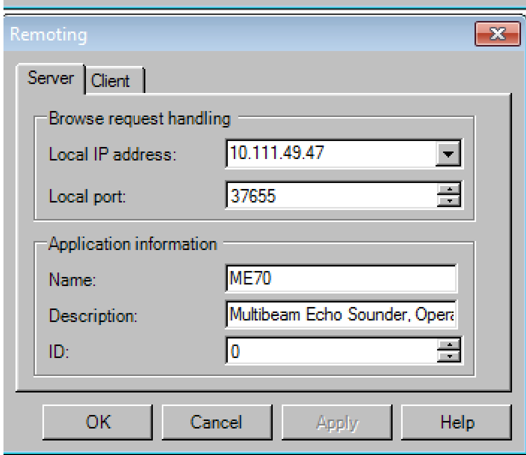
### 10.4.1 ME70



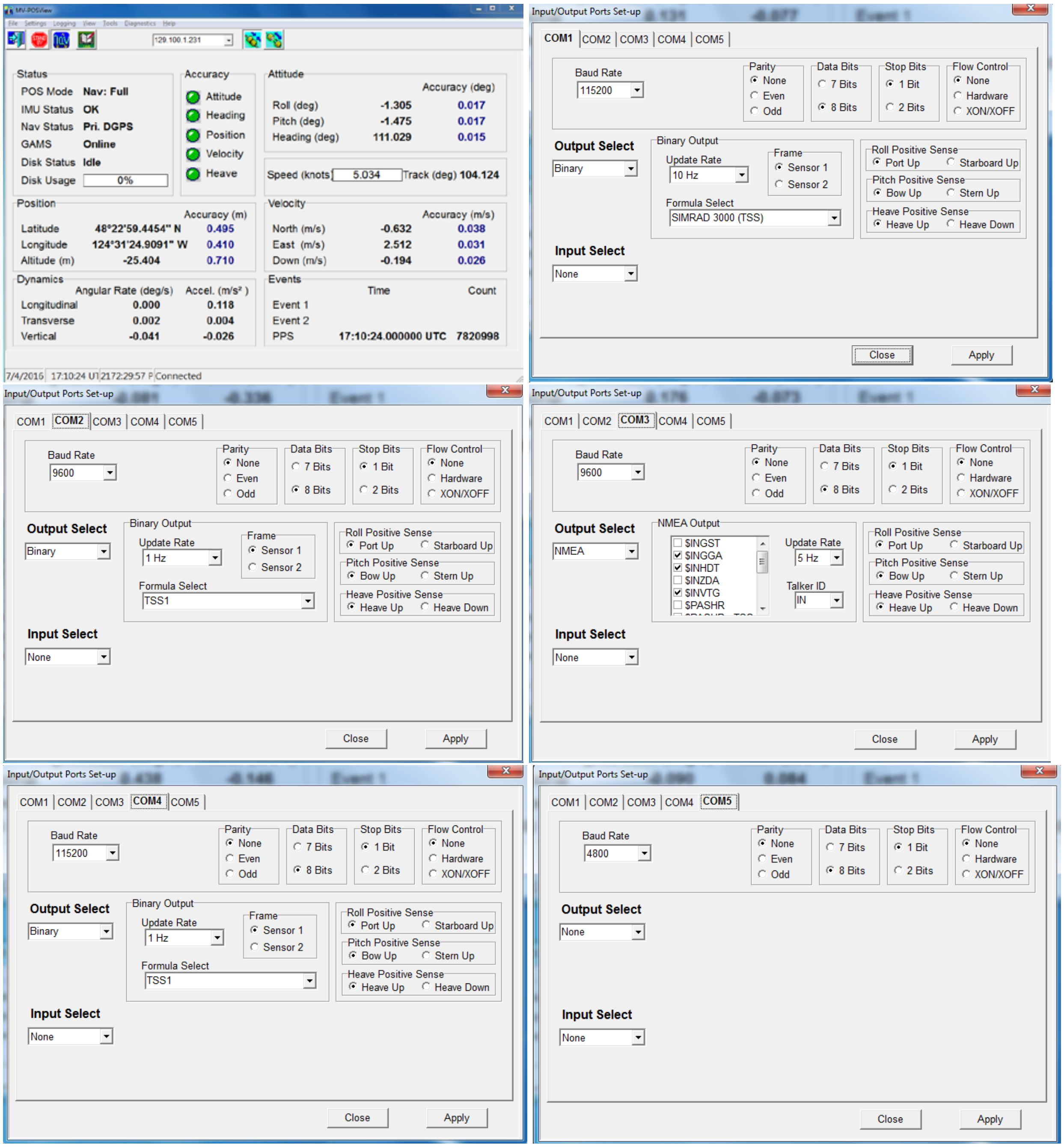



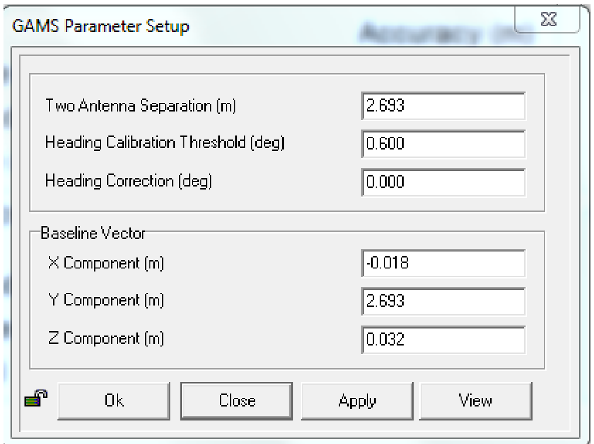



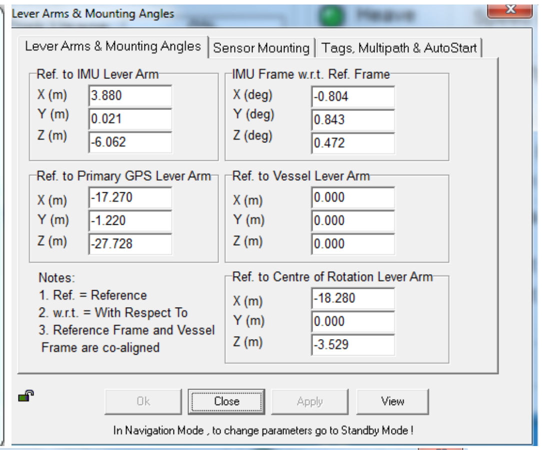



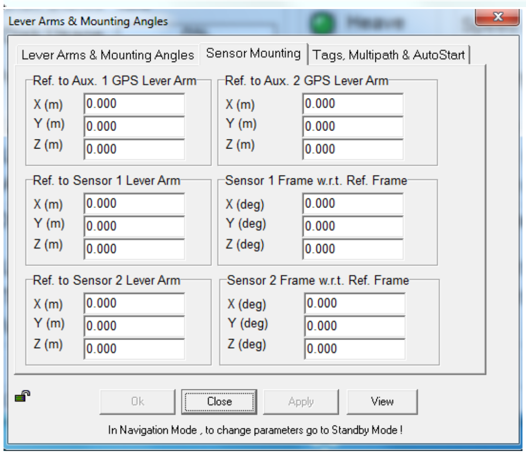
### 10.4.2 POS M/V

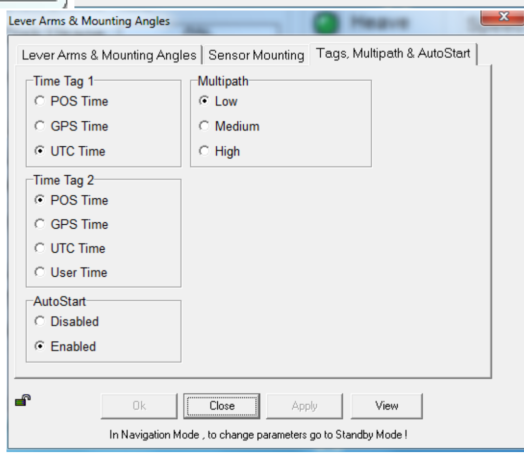
Note: only COM1 and COM3 are used by the ME70.




GAMS Parameter Setup
Two Antenna Separation (m) 2.693
Heading Calibration Threshold (deg) 0.600
Heading Correction (deg) 0.000
Baseline Vector
X Component (m) -0.018
Y Component (m) 2.693
Z Component (m) 0.032
Ok
Close
Apply
View


Lever Arms & Mounting Angles
Lever Arms & Mounting Angles
Sensor Mounting
Tags, Multipath & AutoStart
Ref. to IMU Lever Arm
X (m) 3.880
Y (m) 0.021
Z (m) -6.062
IMU Frame w.r.t. Ref. Frame
X (deg) -0.804
Y (deg) 0.843
Z (deg) 0.472
Ref. to Primary GPS Lever Arm
X (m) -17.270
Y (m) -1.220
Z (m) -27.728
Ref. to Vessel Lever Arm
X (m) 0.000
Y (m) 0.000
Z (m) 0.000
Notes:
1. Ref. = Reference
2. w.r.t. = With Respect To
3. Reference Frame and Vessel Frame are co-aligned
Ref. to Centre of Rotation Lever Arm
X (m) -18.280
Y (m) 0.000
Z (m) -3.529
Ok
Close
Apply
View
In Navigation Mode , to change parameters go to Standby Mode !


Lever Arms & Mounting Angles
Lever Arms & Mounting Angles
Sensor Mounting
Tags, Multipath & AutoStart
Ref. to Aux. 1 GPS Lever Arm
X (m) 0.000
Y (m) 0.000
Z (m) 0.000
Ref. to Aux. 2 GPS Lever Arm
X (m) 0.000
Y (m) 0.000
Z (m) 0.000
Ref. to Sensor 1 Lever Arm
X (m) 0.000
Y (m) 0.000
Z (m) 0.000
Sensor 1 Frame w.r.t. Ref. Frame
X (deg) 0.000
Y (deg) 0.000
Z (deg) 0.000
Ref. to Sensor 2 Lever Arm
X (m) 0.000
Y (m) 0.000
Z (m) 0.000
Sensor 2 Frame w.r.t. Ref. Frame
X (deg) 0.000
Y (deg) 0.000
Z (deg) 0.000
Ok
Close
Apply
View
In Navigation Mode , to change parameters go to Standby Mode !


Lever Arms & Mounting Angles
Lever Arms & Mounting Angles
Sensor Mounting
Tags, Multipath & AutoStart
Time Tag 1
POS Time
GPS Time
UTC Time
Multipath
Low
Medium
High
Time Tag 2
POS Time
GPS Time
UTC Time
User Time
AutoStart
Disabled
Enabled
Ok
Close
Apply
View
In Navigation Mode , to change parameters go to Standby Mode !

## 10.5 Caris HVF


```
<?xml version="1.0"?>
<HIPSVesselConfig Version="2.0">
 <VesselShape>
  <PlanCoordinates/>
  <ProfileCoordinates/>
  <RP Length="0.000000" Width="0.000000" Height="0.000000"/>
 </VesselShape>
 <NavSensor>
  <TimeStamp value="2016-001 00:00:00">
   <Latency value="0.000000"/>
   <Ellipse value="WG84"/>
   <Offsets X="0.000000" Y="0.000000" Z="0.000000"/>
   <Comment value="(null)"/>
   <Manufacturer value="(null)"/>
   <Model value="(null)"/>
   <SerialNumber value="(null)"/>
  </TimeStamp>
 </NavSensor>
 <GyroSensor>
  <TimeStamp value="2016-001 00:00:00">
   <Latency value="0.000000"/>
   <ApplyFlag value="No"/>
   <Comment value="(null)"/>
   <Manufacturer value="(null)"/>
   <Model value="(null)"/>
   <SerialNumber value="(null)"/>
  </TimeStamp>
 </GyroSensor>
 <HeaveSensor>
  <TimeStamp value="2016-001 00:00:00">
   <Latency value="0.000000"/>
   <ApplyFlag value="Yes"/>
   <Offsets X="0.000000" Y="0.000000" Z="0.000000" Heave="0.000000"/>
   <Comment value="(null)"/>
   <Manufacturer value="(null)"/>
   <Model value="(null)"/>
   <SerialNumber value="(null)"/>
  </TimeStamp>
 </HeaveSensor>
 <PitchSensor>
  <TimeStamp value="2016-001 00:00:00">
   <Latency value="0.000000"/>
   <ApplyFlag value="No"/>
   <Offsets Pitch="0.000000"/>
   <Comment value="(null)"/>
   <Manufacturer value="(null)"/>
   <Model value="(null)"/>
```

```
      <SerialNumber value="(null)"/>
    </TimeStamp>
  </PitchSensor>
  <RollSensor>
    <TimeStamp value="2016-001 00:00:00">
      <Latency value="0.000000"/>
      <ApplyFlag value="No"/>
      <Offsets Roll="0.000000"/>
      <Comment value="(null)"/>
      <Manufacturer value="(null)"/>
      <Model value="(null)"/>
      <SerialNumber value="(null)"/>
    </TimeStamp>
  </RollSensor>
  <WaterlineHeight>
    <TimeStamp value="2016-001 00:00:00">
      <Latency value="0.000000"/>
      <WaterLine value="-3.970000"/>
      <ApplyFlag value="Yes"/>
      <StdDev Waterline="0.000000"/>
      <Comment value="S. Greenaway; Offsets from waterline to POS RP (granite block) to waterline at design draft
of 5.9m"/>
    </TimeStamp>
  </WaterlineHeight>
  <SVPSensor>
    <TimeStamp value="2016-001 00:00:00">
      <Latency value="0.000000"/>
      <DualHead value="Yes"/>
      <Offsets X="-0.670000" Y="0.600000" Z="1.233000" X2="0.000000" Y2="0.000000" Z2="0.000000"/>
      <MountAngle Pitch="0.000000" Roll="0.080000" Azimuth="0.500000" Pitch2="0.000000" Roll2="0.000000"
Azimuth2="0.000000"/>
      <Comment value="S. Greenaway; Offsets from POS RP (granite block) to transducer"/>
    </TimeStamp>
  </SVPSensor>
  <DepthSensor>
    <TimeStamp value="2016-001 00:00:00">
      <Comment value=""/>
      <Latency value="0.000000"/>
      <SensorClass value="Swath"/>
      <TransducerEntries>
        <Transducer Number="1" StartBeam="1" Model="ME70">
          <Manufacturer value="Kongsberg"/>
          <Offsets X="-0.670000" Y="0.600000" Z="1.233000" Latency="0.000000"/>
          <MountAngle Pitch="0.000000" Roll="0.000000" Azimuth="0.000000"/>
        </Transducer>
      </TransducerEntries>
    </TimeStamp>
  </DepthSensor>
  <TPEConfiguration>
```

```
   <TimeStamp value="2016-001 00:00:00">
    <Comment value="S. Greenaway, initial config"/>
    <Latency value="0.000000"/>
    <Offsets>
     <MRUtoTransducer X="-3.200000" Y="-3.276000" Z="7.295000" X2="0.000000" Y2="0.000000"
Z2="0.000000"/>
     <NavigationToTransducer X="0.550000" Y="17.874000" Z="28.961000" X2="0.000000" Y2="0.000000"
Z2="0.000000"/>
     <Transducer Roll="0.080000" Roll2="0.000000"/>
     <Navigation Latency="0.000000"/>
    </Offsets>
    <StandardDeviation>
     <Motion Gyro="0.000000" HeavePercAmplitude="0.500000" Heave="0.050000" Roll="0.020000"
Pitch="0.020000" PitchStablized="0.000000"/>
     <Position Navigation="0.500000"/>
     <Timing Transducer="0.010000" Navigation="0.010000" Gyro="0.010000" Heave="0.010000"
Pitch="0.010000" Roll="0.010000"/>
     <SoundVelocity Measured="0.000000" Surface="0.000000"/>
     <Tide Measured="0.000000" Zoning="0.000000"/>
     <Offsets X="0.020000" Y="0.020000" Z="0.020000"/>
     <MRUAlignment Gyro="0.010000" Pitch="0.010000" Roll="0.010000"/>
     <Vessel Speed="0.050000" Loading="0.100000" Draft="0.100000" DeltaDraft="0.010000">
      <StDevComment value="S. Greenaway, initial config"/>
     </Vessel>
    </StandardDeviation>
   </TimeStamp>
  </TPEConfiguration>
</HIPSVesselConfig>
```

Kevin, Josiah.

R228

Ruben Lasker
ME 70 Integration

6/27/16 San Diego, CA.

- checked clocks & offsets
- time server is updated clocks on ME70, but is not getting time from GPS.

<u>Pos offsets</u>

| <u>was:</u> | per docs should be | |
|---|---|---|
| ref to IMU | | |
| x: +3.880 | 3.880 | |
| y: 0.021 | 0.021 | ✓ |
| z: -6.062 | -6.062 | |
| Ref to Primary GPS Lever Arm. | | |
| x: -17.270 | -17.290 | |
| y: -1.220 | -1.356 | X |
| z: -27.728 | -27.618 | |

not sure where ~~the~~ the entered values are from, do not match 2012 or 2014 survey.

6/27/16 (cont.)

<u>was</u>

1. nw w.r.t Frame

x: −0.804

y: 0.843

z: +0.472

<u>should be:</u> per docs. avg. survey.

~~−0.811~~

~~0.837~~

~~−0.472~~

Ref to vessel ⇒ ~~a~~ zero.

Ref to C.O.R

x: −18.280

y: 0.000

z: −3.529

presumably C.O.G.

Sensor 1 & 2 all zeros.

<u>note:</u> using WAAS, integrated.

<u>GAMS.</u>

sep: 2.693

heading cal: 0.600

correction: 0.000

Baseline vector — per cals

x: −0.018 — −0.017

y: 2.693 — 2.687

z: 0.032 — 0.007

6/28/16 · Log static file w/ POS alongside to check traffs.

changed · Ref to Primary GPS

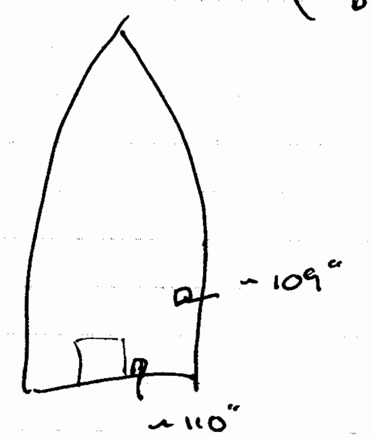
| | From | To |
|---|---|---|
| x | ·17.270 | ~~·17.290~~ |
| y | -1.220 | ~~·1.356~~ |
| z | ·27.728 | ~~·27.618~~ |

also changed IMU w.r.t Ref frame to

| | From | To | |
|---|---|---|---|
| x | ·0.804 | ~~-0.811~~ | ~~-0.804~~ |
| y | 0.843 | ~~0.837~~ | ~~+0.843~~ |
| z | +0.472 | ~~-0.472~~ | ~~-0.472~~ |

to match latest survey ~~results in POS commissioning report June 2015~~

per Applanix report reverted to values above note: StbD draft mark 71" outboard of BM




note: forgot to write down pitch, roll angles but should be able to get from POS file

note: from POS
pitch: -0.4
roll: -0.98

Starfix logging unlimited file (checked) at 1332 UTC

Drafts.
Port Aft: 5.9 m (at top of 5.8)
StbD Aft: 5.82 m (just above 5.8)

Stb fwd - ~ frame 5
i.e. ~1m fwd from 7
6.23 m

---

Aft StbD bench mark deck edge to water
1) 108.5"
2) 109.0" uncer ~ 1-2"

mid StbD aft.
1) 109"
2) 110"

→ Per Greg Youngest.

on server page.

ME70 is a client.

change server tab to output to hyrack.

under Install / Recording.
Servers: 192.168.2.10
local port: 37655
Application info
ME70
Operator station for Ifremer
Client.
192.168.2.10
255.255.255.255
port 37655
mode: broadcast

SV 1527.7 per output.

1019 LCK, underway

SV surface does not seem to be in use.
is set up for comms
4800, 8, N, ASCII. Ann

POD MW:
129.100.1.231

look at card #9
for Greg. green lights
on panel supply.
10.0 solid under
no other lights go
10.5 nominal.

1116 CT-1

amber local light say
nominal.
10.5 solid
10.4 starting.

for 8V only output
W06.xx to hundreds

important
modem in on cam
is not set up in Serial
- this is passed through to
beamformer.
hold shift, double
click on SIMRAD ~~logo~~
logo to get in to this
config.

6/28/16 2338 UTC (1638 utc)

Started new POS file,
increased data rate to
10 Hz from 1 Hz.

Hypack computer IP -

Science: 10.48.23.152
255.255.255.0
gateway 10.48.23.1
POS MV: 129.100.1.232
255.255.0.0.

ME70 BO: 10.111.49.48
255.255.255.0

6/29/16

LAN
hypack → POS - ~~129.100.1.232~~ - nedged switch.
→ Science network. ~~10.48.23.152~~
→ ME70 BO direct patch.
10.111.19.48
255.255.255.0

Kongsberg ~~to~~ ~~#~~ ME70 and
set up w/
192.168.4.105, port 37655
in Hypack software
I think this is through
network.

ME70 IP config.
Loopback interface
192.168.2.10, 255.255.255.0
TRX
192.168.1.30, 255.255.255.0
Ship LAN
~~#~~ 192.168.4.105
255.255.255.0
default gateway
192.168.4.1
.4.2
.4.3

ME70 30
10.111.49.47
255.255.255.0

changes sending server

from 192.168.4.105, 37655
to 10.111.49.47, 37655

~~after~~ could not change sending port in ME70 - perhaps because ~~of~~ the wire not connected.

~~changes ethernet output~~ ME70
~~to from 192.168.2.10~~
~~3000~~

~~to~~

w/ arc-nanointerferog. 25b
80-116 kHz
beam five,
beam #17 102.3 kHz
is higher level than other
w/ Tallis five 731-sec120 deg...

high value on beam 19
106.1 kHz steered (0,0; 12.2°)
delay 1056

w/ Test-SAT config 2
Beam #14 is higher
103.1 kHz steer 19.6°
-still there in passive

Amplitude bias for SAT config 2. Almost all of card 16, but not all
all but 5 elements on card 16.
swapped card 15 ↔ 16, seemed to fix it.

@ 1758 LCL, 0058 UTC, Restarted new .000 file.

6/30/16 0710 lcl (1710 UTC)
~~tate~~ tacking in towards Monterey. in deep water might get good data for calibration plot.
Tx power is max.
ARC-noninterfering - 25 b - 80-116 kHz.
increased range to 500 m
0747 lcl, turned to NW.
in 6 km will cross Monterey Canyon.
0800 stopped for CTD cast
0830 over 500 m deep.
file logging is only 500 m

1644 UTC, 0944 lcl

- took info off the server.
changed system time by hand to be ~1s of Pod time.
changed file out to 1,000 m

Hypack computer

windows 7, SP1

Intel Xeon CPU E5-2609
2.4 GHz / 2.4 GHz
2 processor.

16 GB RAM
64-bit OS.

even with new clock
time, swath still delayed
by ~440 m (speed 10 kts)
800 ~ (176 s)

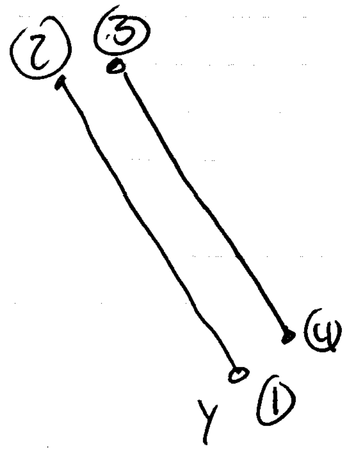
this is 28 s
these raw files should be
good for extraction.

hypack file 182-000-1702.raw
still looks like the time
~~time~~ sync is an issue.

line from deep to 120 m.

1733 UTC, changed file back
to 500 m.

System (ME70) clock seems
to match clock time.
but what is in file
to check, log.




(1): 37 21.869, -122 51.672
(2): 37 25.0870, -122 54.931

(3): 37 25.220, -122 54.700
(4): 37 22.976, ~~-122 54.407~~ -122 52.407

- to test toe: start logging a test file.

- even w/ sync to POS network analysis. Hypack machine clock & data display seem off by a few seconds.

will start logging file @ 18:19:00 per system clock

the ~~file~~ matrix latency seems resolved.

2112 UTC (1412 lcl) set up to run FA patch off SF, secured EK60, running ME70 free

changed beam file to: b81-sec120seg

- changed file output to Fan.


note: ME70 controller
min range: 30
max range: 800 for most of things, but for the 1st few.

6/30/16

Patch Roll to NW
182-001-2220

Hypack is hanging.
- SVC profile taken at 2227

Roll line to SE
182-001-2254.

Yaw line
182-002-2324

end file in ME70
1604RL-D20160630-T235441
first file of [illegible]
1604RL-D20160630-T222020

07/01 UTC 00:05 started
new RDS file.

RL.

7/11ke. looking at Radar results, there is very little motion. no ~~tank~~, roll etc.
The EM70 compensates for heave, pitch, & roll, so as long as we do not ray trace - i.e. no SVC. we can just correct & use tide & nav/age.

Per manual, the origin must be at waterline in Z.
- perhaps for SVC?

From offset document.
MRP to 7. x: -44300
y: -2136

MRP to FR. 7: 11.40 m, ~0.7m stbd.
MRP to transducer: -45.450

note design draft: 6.90 m

FR 7 to Fwd draft mks: 1.209 m

cannot find timing of
aft marks.
estimate $y_i \pm 3.7$ m from
c.l.

<u>note:</u> at ME70 tx, keel is ~
0.9m above base line.

MRB is ~ 2.13 m above base
line.

so
Draft Design 5.90m above b.l.
MRB 2.13m above b.l
3.77m. ~~2.87~~ ~~3.87m~~
below water.

---

ME70 cam 4,
GP CEA, CLL, HDT, JTG
was from Simrad GPS.

PAMGUARD for
passive acoustics.

7/2/16 0103 UTC started new
POS file

7/2/16 ~~at~~ 1008 UTC, changed
input config on multi-
cam port in back of unit 70
to accept RS232 from POS
for position.
- will not accept GGK,
GGA was unknown SEP value

Hot Beam

Grc-marine-alpha-q-251-80-116 kHz
~ ~~102 kHz~~ 102.3 kHz 25.5°
b31 - sec120deg - Xmit bypDecreased Steering
*~~#~~120, ~ ~~103 kHz~~ 103.2 kHz
Test - SadConfig 2
beam 14 ~ 103.1
Ex. wide swath
beam 18 ~ 102.4 kHz

Grc-marine-275 - 80-116 kHz,
Sim. beam 9 (on port side
~102.8 kHz -20.4°

7/13/16 1630 UTC, updated offset in ME70.

RP. in ME70 is point at design waterline 5.9m directly above granite block.

GPS & MRU are referenced to granite block.

---

186-001_0106 possible extinction line.

stopped for CTD.

186-002-0200 continuation 0226. and 0338

Data Rates

- data rates: 2:55 - 00:08,

952 MB / 2:47 min

342 MB / hr - but very slowly pinging.

from radar,

~~401 MB / 2235:41, 22~~

1.49 GB / 23:54:41 -

22:20:20

1:34:21

= 0.95 GB/hr

Seas 1.2 m.
from NW.

7/4/14
Bel Surf. off Neah Bay
- set ME70 clock. loaded
SVC profile # 17

w/ #31-sec120... scan
pattern.

186-001-1539 to E
186-002-1553 to W

186-003-1619 display froze
and lost line,
started again.

1638 changed trace bandwidth
from 12 to 18 s.

for KL increased logging
range to 400m.
was 300s.

ping interval 0.4 s theoretical for 300m range.
seeing 0.9
even at get ~ 0.95.
is this in the raw data?

---

~~note: #~~
7/19/16 processing roll-surface.

the heave matches the heave in sailing.

-changes heave flag to 'applying'. yes.

seems to have fixed heave.

# Fwd: me70 in hypack

**Pradith, Vitad - Xylem** <v@hypack.com> Wed, Jun 1, 2016 at 11:10 PM
To: Glen Rice - NOAA Federal <glen.rice@noaa.gov>, Samuel Greenaway - NOAA Federal <samuel.greenaway@noaa.gov>, Tom Weber <weber@ccom.unh.edu>, "Maddock, Dave - Xylem" <dave@hypack.com>
Cc: Michael J Annis <Michael.J.Annis@noaa.gov>

Hi Glen et al.,

We did some digging and here's the commit history of the ME70 code for reference:

2016-03-29 fix minor bug w/ uninitialized controller on first use

2015-07-31 convert backscatter dB to amplitude before logging to RMB

2014-12-06 poll for new SV at head, per request from Mike Annis

2014-10-22 change phase detect threshold from -60dB to -40dB per Tom Weber

2014-09-25 last big chunk of significant detection changes

….

In short, there hasn't been a change to the bottom detection code since 2014. The backscatter change mentioned by Brandi is literally one line of code AFTER the bottom detection happens so the backscatter (in theory anyways) is independent of the bottom detection.

Moving forward, there's a few variables here that we'll need to suss out:

- Confirmation on how the ME70 is time synching its' data. On the HYPACK end, we're using the POS MV timetags directly and passively recording the in situ timetagged ME70 datagrams. During the last cruise on the Shimada from Mike's patch test data, I immediately noticed a 0.4 second latency (with an internal fluctuating 0.05 variance with respect to the bathy messages). In general, we consider any timestamps that are not within 0.2 seconds a timing latency.

- The version of the ME70 software. As we all can appreciate, any changes to the ME70 software can wreak havoc downstream. It would be great to get an inventory of what version folks are using. (Are they consistent across the board?)

What we'll need (and Mike might already have this data):

- Any/all of the HYPACK logged ME70 HSX data AND the *.all files from Tom's Matlab code that Laura logged on the Shimada. To further clarify, the reason why Tom's Matlab code looks better is because it's only using the timestamps out of the ME70. In HYPACK, you're essentially seeing the wobbles from the mis-timed data between the POS and the ME70.  When CARIS processes the data, its' also looking at the timestamps out of the HSX file which results in the less than stellar looking data.

- The best case scenario would be to get on one of the Fish boats for some real time trouble shooting.  Any upcoming opportunities?

Cheers,

-v

-

Vitad "V" Pradith

HYPACK, A Xylem Brand

56 Bradley St.

Middletown, CT 06457

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(cell) (617) 394-8525

(email) v@hypack.com

www.hypack.com

**From:** Glen Rice - NOAA Federal [mailto:glen.rice@noaa.gov]
**Sent:** Friday, May 27, 2016 12:59 PM
**To:** Samuel Greenaway - NOAA Federal; Tom Weber; Pradith, Vitad - Xylem; Maddock, Dave - Xylem
**Cc:** Michael J Annis
**Subject:** Fwd: me70 in hypack

[Quoted text hidden]

APPROVAL PAGE

W00343

Data partially meet current specifications as certified by the OCS survey acceptance review process. Descriptive Report and survey data except where noted are adequate to supersede prior surveys and nautical charts in specific areas as delineated during office processing.

The following products will be sent to NCEI for archive:

- W00343_DR.pdf
- Collection of depth varied resolution BAGS
- Processed survey data and records
- W00343_GeoImage.pdf

The survey evaluation and verification has been conducted according current OCS Specifications. The survey has been approved for dissemination and usage of updating NOAA's suite of nautical charts.

Approved: OHauser CDR/NOAA HAUSER.OLIVIA.A.1275636009 2019.05.03 15:55:40 -07'00'

**Commander Olivia Hauser, NOAA**
Chief, Pacific Hydrographic Branch