W00219

NOAA FORM 76-35A

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

DESCRIPTIVE REPORT

Type of Survey IOCM - Fisheries Stock Assessment

Project No. N/A

Registry No. W00219

LOCALITY

State Alaska

General Locality Shumagin Islands

Sublocality General Vicinity

2010

CHIEF OF PARTY

Glen Rice – IOCM Team Lead

LIBRARY & ARCHIVES

DATE ______________________

NOAA FORM 77-20
(11-72)

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

REGISTRY No

W00219

HYDROGRAPHIC TITLE SHEET

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

State Alaska

General Locality Shumagin Islands

Sub-Locality General Vicinity

Scale

Date of Survey Feb. 23rd to 28th, 2010

Instructions Dated N/A

Project No. N/A

Vessel NOAA Ship Oscar Dyson

Chief of Party Glen Rice – IOCM Team Lead

Surveyed by NOAA/NMFS/RACE/MACE

Soundings by Echosounder

Graphic Record Scaled by Simrad ME70 MBES

Graphic Record Checked by

Evaluation by

Verification by ***Atlantic Hydrographic Branch***

Soundings in a t MLLW

REMARKS: Time in UTC. UTM Projection Zone 4

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 Geophysical Data Center (NGDC) and can be retrieved via http://www.ngdc.noaa.gov/.

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Descriptive Report to Accompany Survey W00219

NOAA Ship *Oscar Dyson*, Cruise DY10-01
Vicinity of Shumagin Islands, Alaska
February 2010

1. GENERAL DESCRIPTION AND INTRODUCTION

This survey was conducted as part of an acoustic-trawl stock assessment survey conducted by scientists from the Midwater Assessment and Conservation Engineering (MACE) Program of the Alaska Fisheries Science Center's (AFSC) Resource Assessment and Conservation Engineering (RACE) Division on the NOAA Ship *Oscar Dyson* during cruise DY10-01. This survey was designed to estimate the distribution and abundance of walleye pollock (*Theragra chalcogramma*) and primarily relied on data collected with Simrad EK60 scientific echo sounders in addition to trawl gear. In addition, data were collected using a Simrad ME70 multibeam echosounder (MBES) that was developed specifically for observing targets in the water column, rather than bathymetric mapping. The ME70 data collected during a portion of the MACE survey has been opportunistically repurposed at the University of New Hampshire Center for Coastal and Ocean Mapping / Joint Hydrographic Center and the NOAA Integrated Ocean and Coastal Mapping Center to generate soundings for charting purposes. A hydrographic survey number of W00219 was assigned by the Office of Coast Survey for the processed ME70 data from cruise DY10-01 and shall be referenced as such here forward. Despite the non-traditional nature of this survey, this opportunistic use of the data is expected to provide useful information on shoal soundings in under-charted areas and as a reconnaissance tool for planning future hydrographic surveys. Since this data was collected for non-hydrographic purposes, many aspects do not conform to normal hydrographic standards or practices.

Part of the value in the analysis performed on these data is the development of a work flow and the identification of largest uncertainties associated with using these type of data for charting purposes. This document can function as an archive for describing this work flow, but also for identifying meaningful changes for future projects with the *Dyson* that can be opportunistically used for bathymetric mapping. Effort has been made to fit this non-standard survey into a recognizable format for straight forward ingestion into the hydrographic pipeline. Some additional documents, such as the Data Acquisition and Processing Report, have been omitted. Instead, many of the details usually included in these documents is incorporated into this report.

A. AREA SURVEYED

The survey area was located in the vicinity of the Shumagin Islands, AK (Figure 1). The data described herein, which represent a subset of the data collected during AFSC Mace cruise DY 10-01, were acquired during 23-26 February 2010 and 28 February 2010 (DN 54 to DN 57 and DN 59). Fisheries MBES (Simrad ME70) data was obtained in the survey area with variable line spacing, ranging from 2-20 km. Fish trawls conducted episodically throughout the survey occasionally result in more complete coverage. A total of 629 linear nautical miles of survey lines are submitted as part of this data set. The survey area is estimated from the number of 8 m grid cells in the submitted CUBE surface, yielding 84 square nautical miles (SNM) of survey area with at least one sounding per 8 m grid cell, or 82.9 SNM with at least 5 soundings per 8 m grid cell.

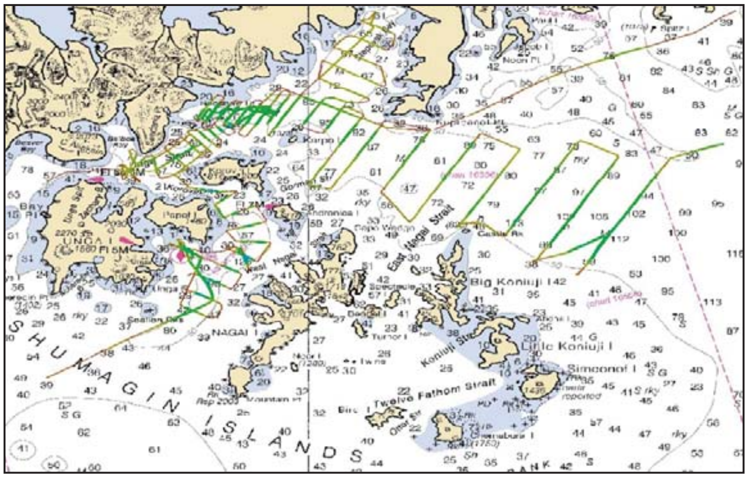


Figure 1. Survey area overlaying chart 16011

B. DATA ACQUISTION AND PROCESSING

B1. Equipment and Vessels

Specifications for NOAA Ship *Oscar Dyson* and the equipment used for data acquisition and survey operations during this survey are listed below in Table 1.

	Oscar Dyson
Hull Registration Number	R224
Builder	VT Halter Marine, Inc., Moss Point, MS
Length Overall	209 feet (63.8m)
Beam	49.2 feet (15.0m)
Draft, Centerboard extended	29.7' feet (9.05m)
Cruising Speed	12 knots
Max Survey Speed	12 knots
Primary Echosounder	Simrad ME70
Sound Velocity Equipment	SBE 911plus, SBE 45 Micro Thermosalinograph
Attitude & Positioning Equipment	POS/MV V4
Type of operations	MBES

Table 1: NOAA Ship *Oscar Dyson* Vessel Information

The Simrad ME70 is a fisheries MBES designed for collecting backscatter from midwater targets (i.e., fish) rather than bathymetric mapping. The system is configurable for number of beams, frequencies and steering angles. The ME70 has a different frequency for each beam within a range of 70 kHz to 120 kHz. Specifications for the beam configuration used for the dataset discussed in this report is outlined in Table 2. Beam numbers 0 and 30 have been excluded from this data submission.

Beam Number	Frequency (kHz)	Beam Steering Angle (Forward / Athwartship)	Beam Size (Forward / Athwartship)
0	73.2	0 / -65.9	4.5 / 11.0
1	76.1	0 / -56.7	4.3 / 7.9
2	78.9	0 / -49.7	4.2 / 6.4
3	81.8	0 / -43.8	4.0 / 5.6
4	84.7	0 / -38.5	3.9 / 5.0
5	87.5	0 / -33.8	3.8 / 4.5
6	90.4	0 / -29.5	3.6 / 4.2
7	93.2	0 / -25.5	3.5 / 3.9
8	96.1	0 / -21.7	3.4 / 3.7
9	99.0	0 / -18.2	3.3 / 3.5
10	101.8	0 / -14.8	3.2 / 3.3
11	104.7	0 / -11.5	3.2 / 3.2
12	107.5	0 / -8.4	3.1 / 3.1
13	110.4	0 / -5.4	3.0 / 3.0
14	113.2	0 / -2.4	2.9 / 2.9
15	116.8	0 / 0.4	2.8 / 2.8
16	114.7	0 / 3.2	2.9 / 2.9
17	111.8	0 / 6.1	2.9 / 3.0
18	109.0	0 / 9.1	3.0 / 3.1
19	106.1	0 / 12.2	3.1 / 3.2
20	103.2	0 / 15.4	3.2 / 3.2
21	100.4	0 / 18.8	3.3 / 3.5
22	97.5	0/ 22.3	3.4 / 3.6
23	94.7	0 / 26.1	3.5 / 3.9
24	91.8	0 / 30.0	3.6 / 4.1
25	89.0	0 / 34.3	3.7 / 4.5
26	86.1	0 / 39.0	3.8 /4.9
27	83.2	0 / 44.1	4.0 / 5.5
28	80.4	0 / 50.0	4.1 / 6.4
29	77.5	0 / 57.0	4.3 / 7.8
30	74.7	0 / 66.0	4.4 / 10.8

Table 2: ME70 beam configuration used during survey W00219

B2. Quality Control

Crosslines

Crosslines were not designed into this survey, but crossings of coverage did occur. The data within these self crossing areas is generally self consistent, with agreement for near-nadir soundings and diminished accuracy for outer beams, which increases with depth up to 9m, that is likely due to sound velocity profile issues and beam steering angle issues (see the following section Data Quality Factors).

Junctions

Due to the nature of this survey there are no assigned junction surveys, however there are prior surveys that overlap the coverage area of W00219. Comparison with these surveys, mentioned in Table 3, was performed. Nadir depths were found to be consistently deeper than prior surveys by an average of 0.5m to 1m (Figure 3.). This difference was also observed during a quality control check with NOAA Ship *Rainier* data over the Shilshole reference area in the following section. The nadir depths agree better on flat seafloor than sloped areas, most likely due to poor horizontal positioning. The outer beams were found to be shoaler than prior surveys. This difference is likely due to an incorrect refraction correction in the sounding reduction and incorrect beam steering angles, which are explained in the following section Data Quality Factors.

Survey	Date	Field Unit	Bathymetric Attributed Grid Surface
H11580	2006	NOAA Ship *Fairweather*	H11580_8m_Combined_MLLW_5of5.bag
H11581	2006	NOAA Ship *Fairweather*	H11581_MB_10m_MLLW_1of1.bag
H11582	2006	NOAA Ship *Fairweather*	H11582_20m_Combined_MLLW_4of4.bag
H12070	2009	NOAA Ship *Fairweather*	H12070_MB_8m_MLLW_combined.bag

Table 3: Surveys compared with W00219

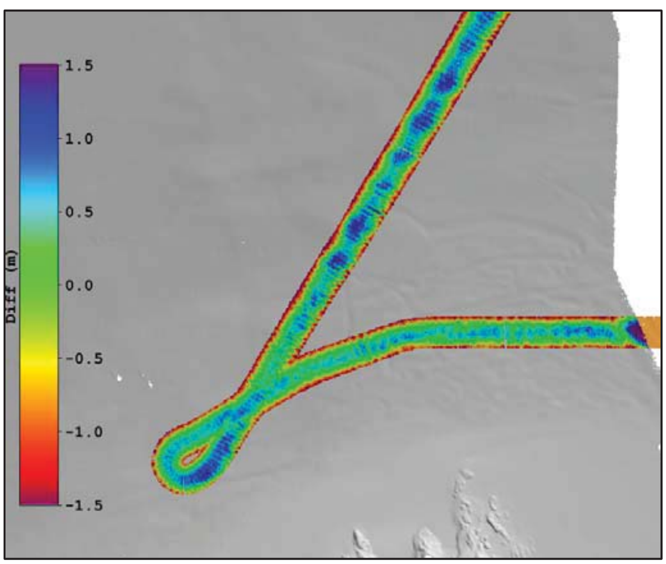


Figure 2. Surface representing difference between W00219 and prior survey H12070 (grey) in approximately 150m of water

Quality Control Checks

Simrad ME70 MBES data from the *Oscar Dyson* was collected over the Shilshole Reference Area in Puget Sound, an area often used by NOAA hydrographic vessels to conduct system quality checks. A comparison between the *Dyson* data and data collected by the NOAA Ship *Rainier* in 2008 was conducted in order to assess the accuracy of waterline and instrumentation lever arm estimates. Corrections to the instrument lever arm measurements were made and the waterline was found to be within a reasonable magnitude, however the *Dyson* and *Rainer* base surfaces continued to differ by up to 1 m at nadir, while outerbeam data tended to be slightly shoaler than the *Rainier* data, as seen in Figure 3. A similar trend was found with the comparison surveys and reasons for this offset are explained in the following section Data Quality Factors.

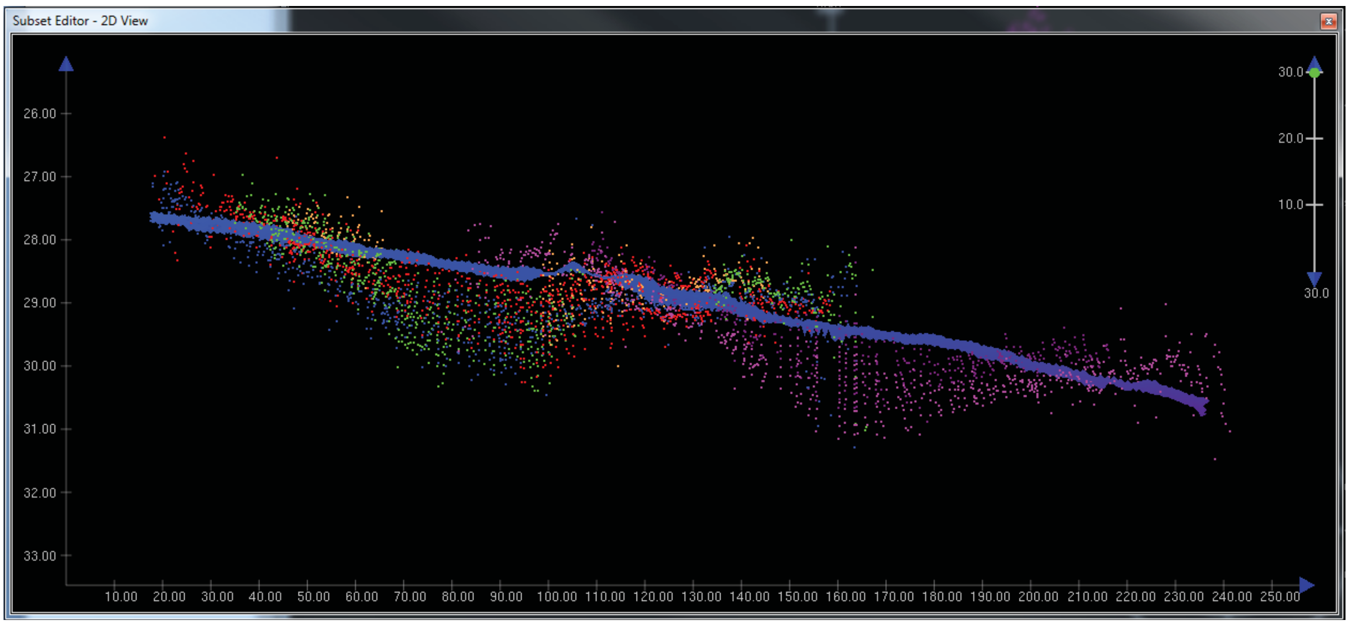


Figure 3. A cross section displaying the *Rainier* Shilshole reference surface (blue) and the *Dyson* data. *Dyson* nadir depths are deeper by up to 1m.

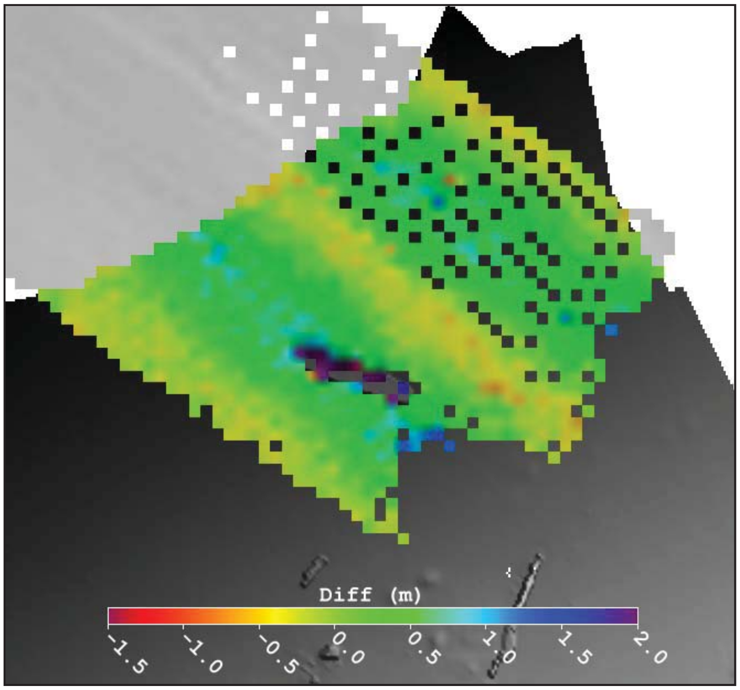


Figure 4. Colored surface representing the difference between the *Rainier* reference surface (dark grey) and the *Dyson* surface (light grey) in approximately 30m of water

Data Quality Factors

POSITIONING:

While the positioning and attitude sensor aboard *Dyson* was from a survey quality POS M/V version 4, a DGPS receiver was not aboard and raw position data was not collected for post processing. Horizontal positioning uncertainty was estimated to be 10 m (2σ) for each navigation fix in the survey.

HEAVE and ATTITUDE:

Real time heave from the POS M/V was logged in the raw sonar files during acquisition; True Heave was not recorded. Pitch and Roll are provided to the sonar at a rate of 200 Hz and are applied by the sonar through real-time beam steering.

SOUND SPEED PROFILES:

Because sound speed profiles were not collected during the survey, a set of profiles were generated through a combination of surface thermosalinograph measurements and modeled mean temperature and salinity profiles from the World Ocean Atlas (WOA) of 2001 quarter degree monthly grids (Stephens et al., 2002; Boyer et al., 2002; Boyer et al., 2005). The data from the thermosalinograph were provided as a 1 Hz time-series of temperature, salinity measurements along with a calculated sound speed. The sound speed data were extracted from the raw data files and plotted for quality assurance. Low sound speed spike outliers were visually identified and removed by setting a lower bound of 1450 m/s during data extraction from the files. The data were then downsampled to approximately the same temporal resolution as the coarse navigation data set (~8.67 minutes) followed by a merging of navigation and preliminary depth data. The time and position information associated with each surface sound speed measurement were then used to extract mean temperature and salinity profiles from WOA using a nearest neighbor algorithm with a 10 grid cell radius of influence allowing the profiles to be extended as deep as possible (note that grid nodes are 1/4 degree latitude but smaller in longitude so the search radius is not symmetric). The extracted temperature and salinity profiles were then used to compute sound speed profiles using the UNESCO sound speed equation (Fofonoff and Millard, 1983) with the measured thermosalinograph sound speed replacing the WOA derived values for profile samples shallower than or equal to 10 m. The nadir depth associated with each sample was then used as a guide to manually extend the profiles to the required ray tracing depth. Gridding artifacts near basin boundaries and sills were visually identified and removed from the sound speed profiles and all sound speed information below 600 m depth was removed as this exceeded the maximum range limitations of the ME70 sounder. Given the coarse vertical sampling of WOA profiles (ranging from 10 m near the surface to 100 m at 600 m depth), the sound speed profiles were vertically resampled to a 1 m interval. Had this not been done, the coarse vertical sampling of the WOA profiles could introduce bias if the Caris HIPS ray tracing algorithm uses a constant velocity. The 955 finalized sound speed profiles were then exported into a single text file in Caris HIPS .svp format, Version 2.

The estimated uncertainty associated with the sound speed profiles is 7.75 m/s (2σ). This estimate is based on analysis of the distribution of sound speed profiles from WOA and their associated effect on simulated ray paths, providing an overall estimate for the uncertainty in the survey area.

BEAM STEARING ANGLE

When comparing this survey with prior surveys it was found that the nadir depths tended to be deeper, while the outer beams were significantly shoaler, as mentioned previously in this section. While performing the chart comparison, surveyed depths tended to be deeper than charted depths, as presented in section D1. Incorrect beam steering angles could be part of the refraction problem.

SOUNDING COVERAGE

While the ME70 can provide several thousand soundings across track for each ping, the along track ping rate (~1.7 pings/sec) and vessel speed during normal survey operations (~6 m/s) are set by the type of survey operation. This results in a relatively low along track sounding density. For nadir beams, which have the narrowest along-track beam width, one hundred percent along track coverage is achieved only for depths greater than 210 m.

PATCH TEST

Although components of a patch test have been performed for the ME70 on the *Dyson*, a full patch test has not yet been completed. In particular, there is relatively high uncertainty in the yaw bias. Because the ME70 compensates for pitch and roll in real-time, a yaw bias in the system creates cross talk between pitch and roll. This is particularly noticeable in high sea states.

B3. Corrections to Echo Soundings

Bottom Detections

The Simrad ME70 MBES is designed to provide water column information in a manner consistent with a split beam Simrad EK60, but at multiple angles and for narrower beam widths. As a result, the amplitude and phase time series from each beam, and within each beam, is of exceptional quality. The system is not designed to provide hydrographic soundings but, because raw water column information has been collected and stored for each beam, soundings can be extracted in post processing. For a typical MBES, the number and size of beams can be used as an indicator of sounding density collected by the system. With the ME70, multiple phase detections per beam are possible if the angle of incidence to the sea floor is large enough. One sounding per beam is available where amplitude detection is used, typically in the area within 10-15° of nadir. The bottom detection algorithm that extracts soundings from the raw ME70 data was developed and implemented by Dr. Tom Weber at the Center for Coastal and Ocean Mapping at the University of New Hampshire. These bottom detections are written to a Generic Sensor Format (GSF) for import into Caris HIPS.

Uncertainty Estimation

Since the ME70 MBES is not typically used in hydrographic survey, no error model exists in Caris HIPS for proper attribution of uncertainty. Because of the flexible configuration of this multibeam, defining a static uncertainty model for Caris would be misleading. To provide sounding uncertainty into the Caris workflow the Hare Uncertainty Model is implemented during the RAW to GSF conversion process. Caris HIPS uses these predetermined estimates of uncertainty for the soundings, which includes tidal, sound velocity and vessel offset uncertainty estimates.

Instrumentation and Waterline Offsets

Typical hydrographic processes to convert raw range and angle measurements from the multibeam into georeferenced soundings were observed. As *Dyson* is not usually required to provide hydrographic quality positions of the sea floor, instrumentation offsets and the waterline location have only roughly been accounted for in the past. These offsets were verified where possible and updated where inaccuracies were found.

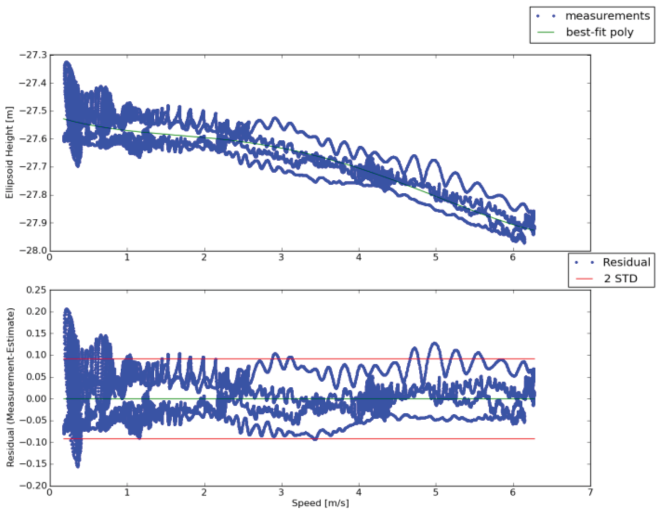
INSTRUMENTATION OFFSETS

In general, a document created by Scott Furnish at the NOAA MACE accurately describes instrumentation offsets with the exception of the vertical reference of the ME70 from the primary reference point (granite block). Another document specific to surveying the ME70 location by Westlake Consultants, Inc better describes the ME70 location but references a different datum within the sonar room. These documents have been combined and included as DysonOffsetDocuments.PDF. Observations aboard *Dyson* in June, 2011 estimate the vertical difference between the granite block and the sonar room datum to be 0.40 meters (up positive). Since the ME70 measurement reference is at the transducer face, the offset between the sonar room datum and the ME70 is -1.46 meters (West Lake Survey) plus the datum granite block difference of 0.40 meters, resulting in an updated offset of -1.06 meters vertically between the granite block and ME70 MBES.

VESSEL WATERLINE

An accurate estimate of the static waterline relative to the vessel reference point was needed to use ME70 measurements for hydrographic purposes. Given the sparse nature of the vessel drawings, the ellipsoid height of the vessel primary reference point was compared with the ellipsoid water level height at a nearby tide gauge over a period of time. Further information on this technique and specific measurement can be found in the attached document DysonStaticWaterline.PDF.

Vessel settlement with changes in speed was estimated using the changes in ellipsoid height of the vessel with changes in speed. The table for speed verses change in draft was produced using the Pydro ProcSBETDynamicDraft script macro. The output from Pydro is contained in Figure 4.



$-0.00104*X^4 +0.0138*X^3 -0.0504*X^2 +0.0951*X$

Speed [m/s]	Delta Draft [m]
0.00	0.00
0.50	0.04
1.00	0.06
1.50	0.07
2.00	0.08
2.50	0.10
3.00	0.12
3.50	0.15
4.00	0.19
4.50	0.24
5.00	0.29
5.50	0.35
6.00	0.39
6.50	0.43

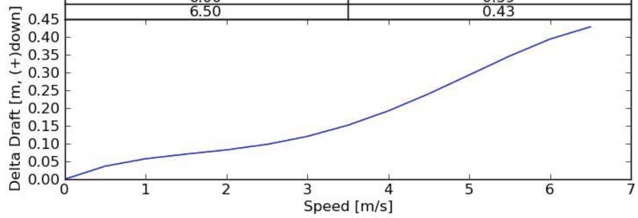


Figure 5. Pydro output for vessel ellipsoid height and regressed settlement table

B4. Data Processing

Simrad RAW files are created by the ME70 and are converted into GSF format as previously described. These files were imported into Caris HIPS 7.1 with Service Pack 2 to correct for tide, sound velocity and vessel offsets.

Data was cleaned to remove obvious flyers from the 8m surface and the outer beams were filtered to 45 degrees to remove data effected heavily by sound refraction and incorrect beam steering angle. See Figure 6.

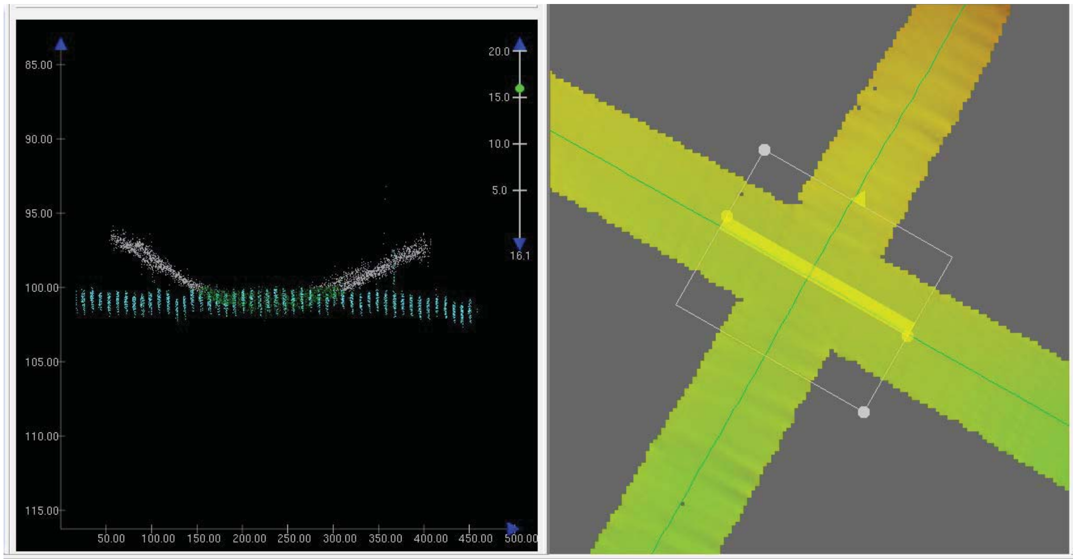


Figure 6. On the left, the blue line represents the along track nadir depths, while the green line represent the across track depths at the intersection of two perpendicular lines (right). Grey soundings represent rejected data filtered to 45 degrees.

Certain lines and segments of lines were deleted due to GPS position error, which created large horizontal jumps and positional offsets in the track line. The data in these areas exceeds the allowable horizontal position uncertainly. See Figure 7 for examples of the positional offset.

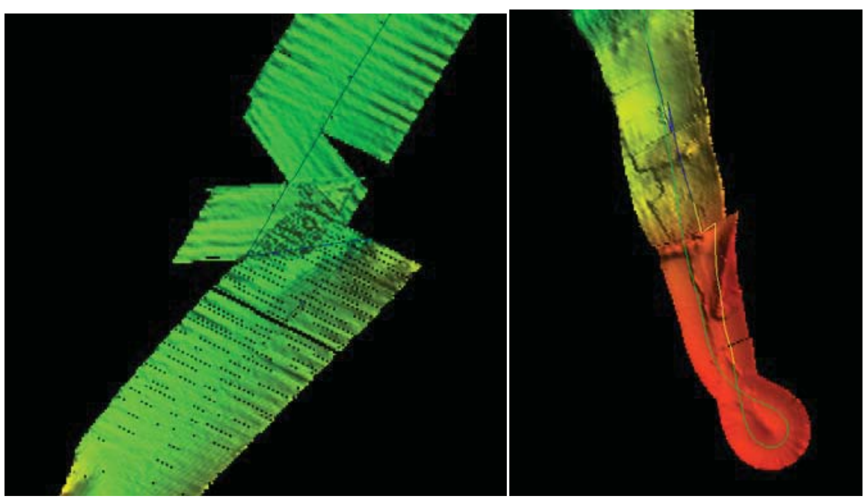


Figure 7. Lines removed due to horizontal positional offset caused by poor navigation data. Left: DY1001_31Beam_D20100224-T175549 and DY1001_31Beam_D20100224-T180427. Right: DY1001_31Beam_D20100225-T17331 and DY1001_31Beam_D20100225-T174157

Smaller horizontal positional errors exist in the data, however the data were retained to assess the accuracy of the charts and uncharted shoaling. There are approximately 30 smaller positional GPS offsets throughout the dataset.

Four lines were deleted due to poor data collected while the boat was turning frequently to ground truth fish. Figure 8 displays these lines.

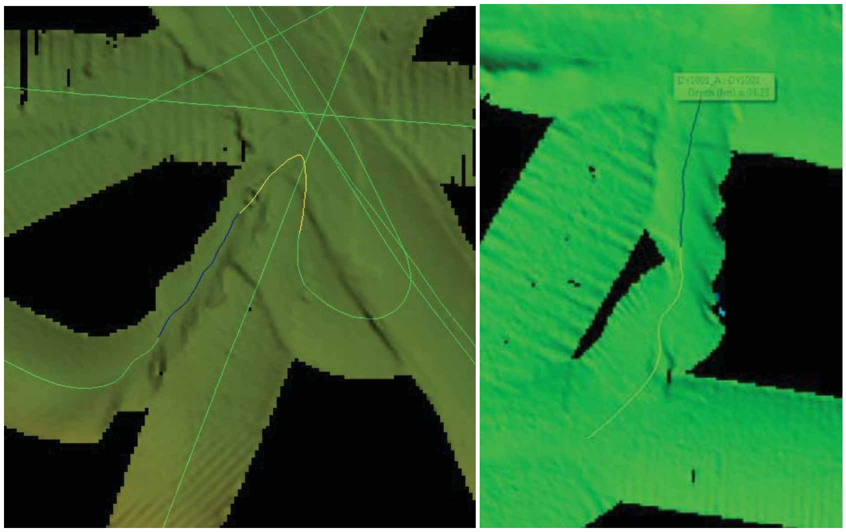


Figure 8. Lines deleted due to poor data collected while ground truthing fish.
Left: DY1001_31Beam-D20100225-T114731 and DY1001_31Beam-D20100225-T115610
Right: DY1001_31Beam_D20100225-T044410 and DY1001_31Beam_D20100225-T045249

TPU Values

The survey specific total propagated uncertainty values are calculated using the Hare uncertainty model [Hare et al 1995] and are provided on import with soundings into Caris. No TPU calculation step was required in Caris HIPS, as the values were calculated during raw to gsf conversion. The uncertainty values used to calculate the TPU can be found in Table 4.

The various contributors to the TPU at a depth of ~70 m is shown in Figure 9. The largest contributors to the depth TPU are the uncertainties due to the roll, refraction, and horizontal positioning. The roll uncertainty is dominated by the alignment uncertainty, which has been conservatively estimated at 0.2° due to difficulties associated with a patch test. The refraction error is large and is due to the high uncertainty in the sound speed profiles and the possible incorrect beam steering angle. Uncertainty for individual soundings is calculated using the Hare model for amplitude detects and is based on Lurton [2000] for the phase detections. The horizontal TPU is dominated by the horizontal position uncertainty, due to the lack of GPS corrections, and by the alongtrack beamwidth. This survey generally meets IHO order 1 within a swath angle of approximately +/-40° (Figure 10), and generally meets IHO order 2 according to the accumulated uncertainty measurements. Since the data were filtered to 45°, the processed data should be of the best quality possible given the information available.

Type	Value (1σ)
Heave accuracy	Max(0.05 cm, 5%Heave)
Lever arm offsets	0.2 m
SSP	3.88 m/s
Surface SS	0.25 m/s
Roll & Pitch alignment	0.2º
Heading Alignment	0.5º
Dynamic Draft	0.1 m
Static draft	0.04 m
Tide	0.12 m
Time Latency	1 ms
Speed over ground	0.1 m/s
Horizontal positioning	5 m

Table 4: Survey Specific TPU Parameters

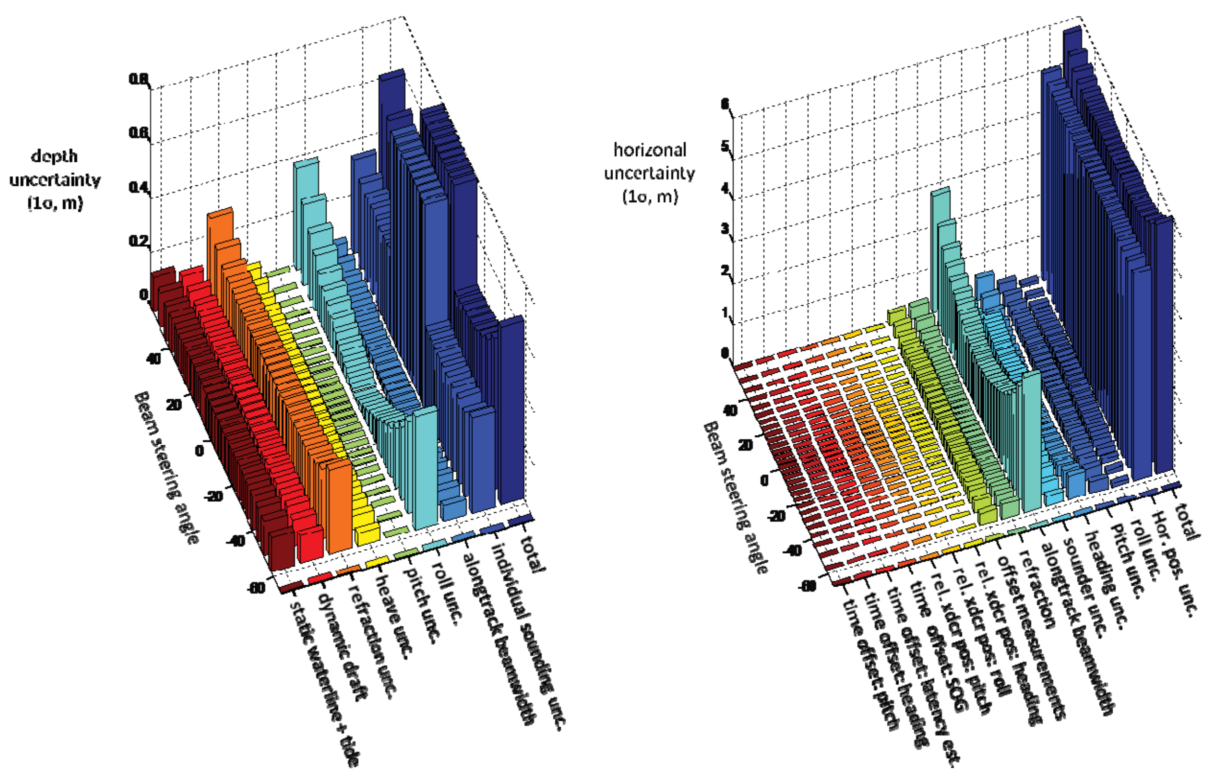


Figure 9. An example of the total propagated uncertainty and contributors for both depth and horizontal uncertainties for a depth of ~70 m.

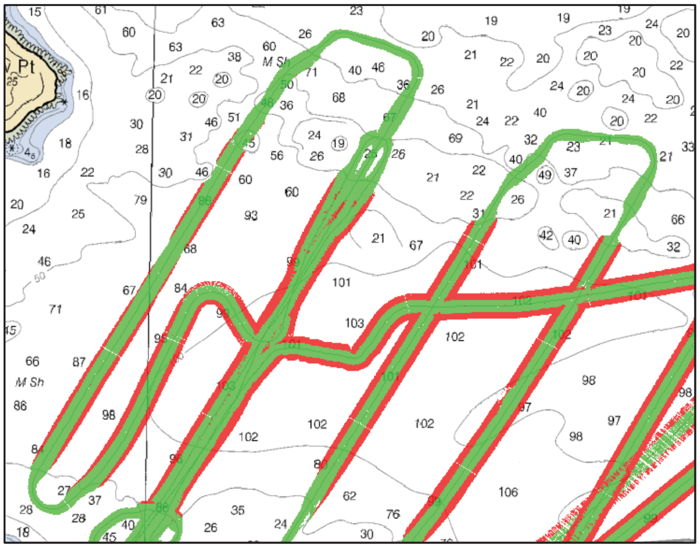


Figure 10. Data meeting IHO Order 1 (green) for a portion of the surveyed area

CUBE Surfaces

CARIS HIPS BASE (Bathymetry Associated with Statistical Error) surfaces were created using the CUBEParams_NOAA.xml for 2011. An 8m resolution was chosen for the entire survey area because it best matched the along track data coverage. No finalized surfaces were created.

Fieldsheet Name	Surface Name	Depth Ranges (m)	Resolution (m)	CUBE Parameters
DYSON_2010	W00219_8mCube_20to360m	Full survey depth range	8 m	NOAA_8m

Table 5: Depth Ranges, Resolutions, and CUBE Parameters

The 8m surface meets NOAA specifications for data density. 98.7% of the grid cells have more than 5 soundings per node, as displayed in Figure 11.

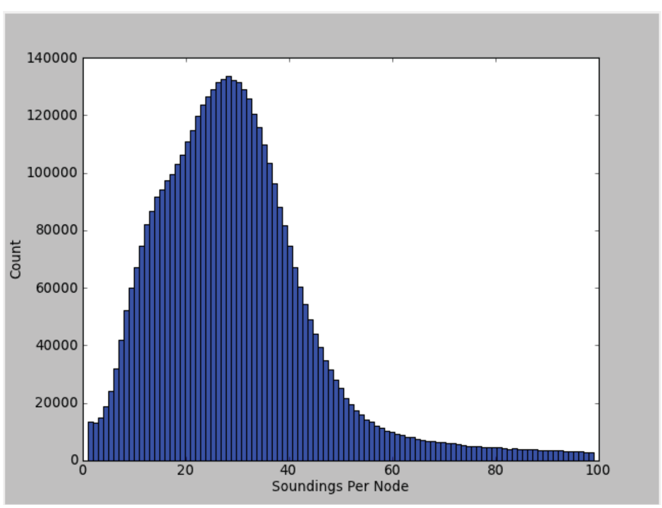


Figure 11. Sounding density per 8m grid cell

C. HORIZONTAL AND VERTICAL CONTROL

A summary of horizontal and vertical control for this survey is as follows. No additional reports for horizontal and vertical control have been formulated.

C1. Horizontal Control

The horizontal datum for this project is the World Geodetic System of 1984 (WGS84). No Differential Global Positioning System (DGPS) was used for positioning. The resulting horizontal positioning of the survey vessel is relatively poor (10 m at 2σ), so the relative maximum difference of 2 meters between WGS84 and the standard survey datum, NAD83, is not considered significant.

C2. Vertical Control

The vertical datum for this project is Mean Lower Low Water (MLLW). The operating National Water Level Observation Network (NWLON) primary tide station at Sand Point, AK (945-9450) served as control for datum determination and as the primary source for water level correctors for the surveyed area.

Tides were applied through Pydro using Final Tides and a TCARI surface originally intended for NOAA survey H12072. This TCARI grid, P183FA2009-Final, originally used a temporary water level gauge 945-9163, which was installed by the field party on Herendeen Island. As the temporary gauge data was not available during this survey, TCARI only uses the Final Tides from the Sand Point gauge to model and reduce water levels for this survey.

No further attempt was made to improve the vertical control for this survey.

D. RESULTS AND RECOMMENDATIONS

D.1 Chart Comparison

A chart comparison was conducted using Caris BASE Editor 4.0. A least depth sounding layer was extracted from the CUBE surface with 1mm spacing at a 1:80,000 scale. This sounding layer was compared to the charts listed in Table 6.

NOAA Chart Number	Chart Scale	Edition Number	Edition Date	Updated with Notice to Mariners through
16011	1:1,023,188	38th Ed.	August, 1, 2012	February 23, 2013
16013	1:969,761	30th Ed.	July 1, 2006	February 23, 2013
16540	1:300,000	13th Ed.	October 1, 2010	February 23, 2013
16551	1:80,000	10th Ed.	April 1, 2008	February 23, 2013
16553	1:80,000	7th Ed.	March 1, 2011	February 23, 2013
16556	1:80,000	6th Ed.	July 1, 2011	February 23, 2013
US4AK57M	1:80,000	13	September 19, 2012	February 23, 2013
US4AK58M	1:80,000	8	March 17, 2012	February 23, 2013
US3AK50M	1:300,000	17	June 29, 2011	February 23, 2013

Table 6: NOAA charts compared to this survey.

The chart comparisons were done in fathoms for the RNCs and meters for the ENCs. For the larger scale charts at 1:80,000 the survey was observed to agree within 1 fathom with the raster charts and to be 1 to 3m deeper than the ENC's. Contours agreed well with bathymetric trends. There are a few instances where shoal soundings were found between two deeper soundings on the RNC and ENC, however the shoals are represented by contours. These cases are displayed in the figures below.

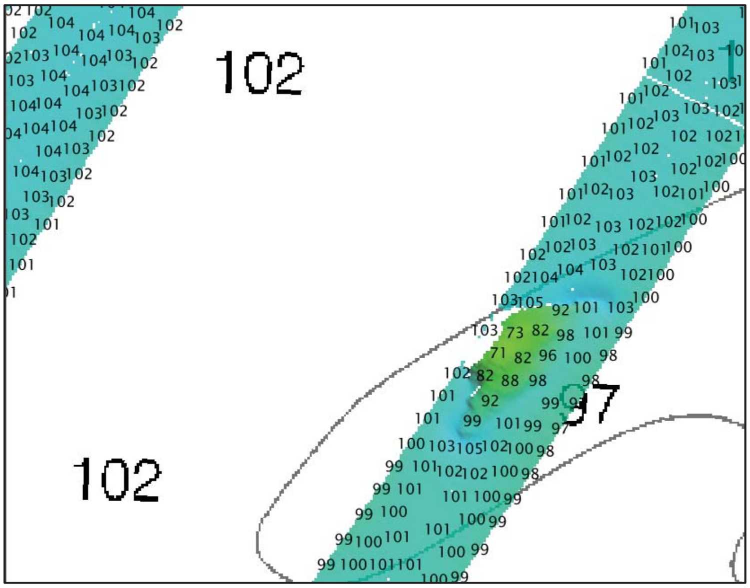


Figure 12. At position 55-34.13N and 160-14.91W a 71 fathom sounding exists between a charted 97 and 102 fathom sounding

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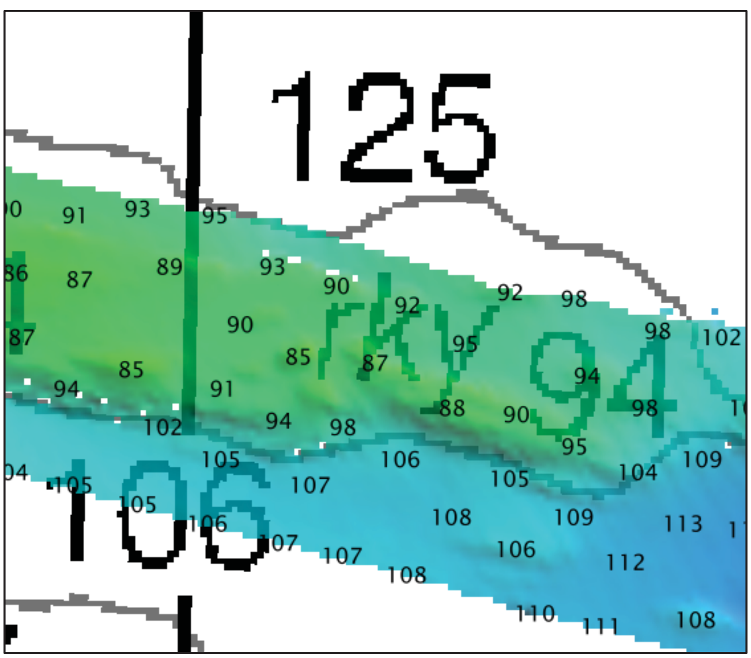

Figure 13. At position 55-22.89N, 160-19.68W a 88 and 86 fathom sounding exists between a charted 94, 106, and 125 fathom soundings

In addition, discrepancies exist between Chart 16011 (1:1,023,188) and survey depths in the area east of Popof Island. Contours and some soundings do not reflect the bathymetry. An example of this would be at position 55-14-51.38N, 160-07-20.97W a surveyed depth of 36 fathoms exists within a contour range of 50 to 100 fathoms.

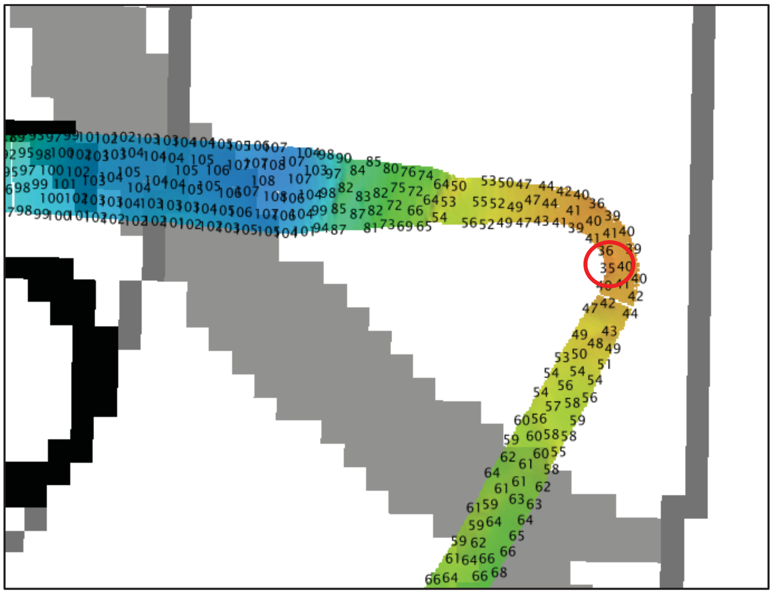

Figure 14. A surveyed 35 fathom sounding within a 50 to 100 fathom depth contour range at position 55-14-51.38N, 160-07-20.97W

ENC US3AK50M does not completely agree with RNC 16011 in this region either. Figure 15 demonstrates an example where overlapping soundings having completely different values.

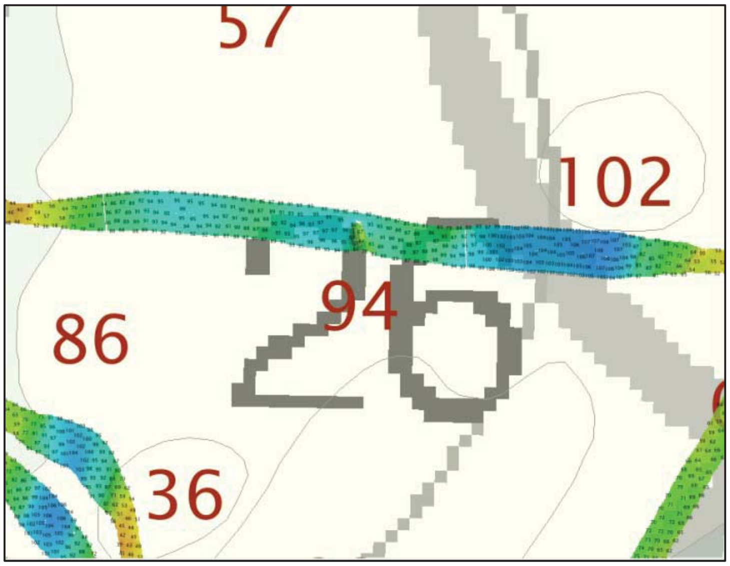

Figure 15. A charted 94 fathom sounding from US3AK50M overlapping a charted 26 fathom sounding from chart 16011 at position 55-14-43.44N, 160-10-38.86W

Chart Comparison Recommendations

While the coverage type and accuracy of this survey does not meet the requirements specified by the *Hydrographic Surveys Specifications and Deliverables Manual* (HSSDM), there are some areas where the age and type of surveys currently supporting the charts in these waters is still inferior to the data described here. While the charts largely agree with this survey within a bias, using these data to address the discrepancies and shoal soundings mentioned previously and to add soundings to areas of the chart without soundings, would still constitute an improvement to the current products.

D.2 Additional Results

Backscatter

Seafloor backscatter data is included with this data submission. Prior to the survey, the ME70 was calibrated using the standard sphere method [Foote et al, 1987]. The backscatter data contained in the raw GSF files represent calibrated, angle-dependent seafloor scattering strength. After the data were cleaned in Caris HIPS, a second set of GSF files was exported and used to generate a seafloor backscatter mosaic with the Fledermaus Geocoder Toolbox (FMGT). A mosaic representing the oblique incident backscatter for the entire survey area is shown in Figure 16.

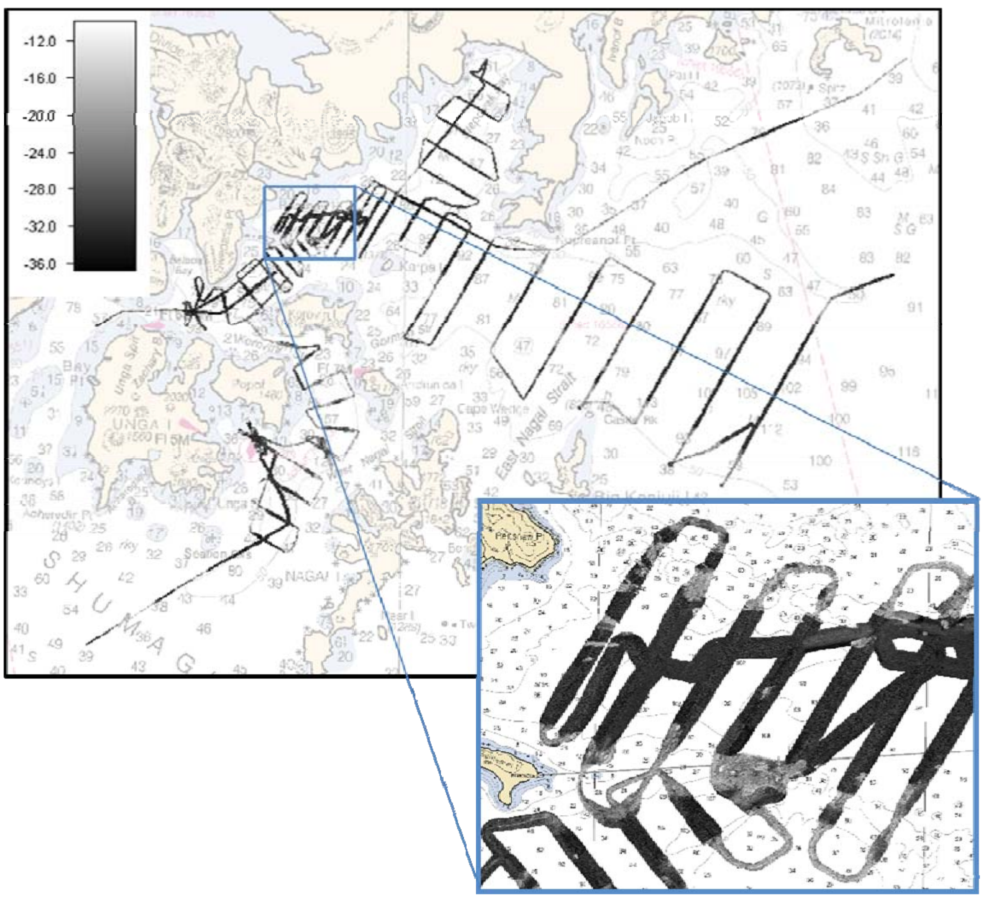

Figure 16. Seafloor backscatter mosaic for the entire survey area.
The grayscale color represents oblique incidence seafloor scattering strength in dB.

Future Survey Improvements

While these data are collected with methods designed for another purpose, there are a few changes that could be made to improve compliance with the HSSDM without modifying the current protocol aboard the *Dyson*.

1. The horizontal positioning uncertainty can be impacted positively by adding DGPS to the POS M/V. This will remove the primary contributor to the horizontal uncertainty, leaving the along track beam width as the next most significant contributor (Figure 9).
2. Sound speed profiles can be estimated using Expendable Bathy Thermographs (XBTs) without impacting survey vessel operations. This would constitute a significant improvement to data quality and the reduction of vertical uncertainty in the MBES outer beams.
3. A complete patch test for the *Dyson* should be performed.

Other changes that could improve data quality but, would also impact the survey methods would be to increase the ping rate or slow down the ship. The ship speed for these types of surveys is set to 12kts to maximize coverage area and is not likely to be changed. The along track ping rate is set by the range scale and alternating pings between the EK60 and ME70 to prevent crosstalk between the sonars. One possible solution that should be explored is to develop a new ME70 beam configuration that does not interfere with the EK60 during simultaneous transmission.

D.3 References

Boyer, T., Stephens, C., Antonov, J., Conkright, M. E., Locarnini, R., O'Brien, T. D., and Garcia, H. E. (2002) World Ocean Atlas 2001, Volume 2: Salinity. NOAA Atlas NESDIS 50. U.S.Government Printing Office. Washington, D.C., USA.

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Fofonoff, N. P., and Millard, R. C. (1983). "Algorithms for computation of fundamental properties of seawater." Rep. No. 44, Division of Marine Sciences, UNESCO, Place de Fontenoy, 75700, Paris.

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Hare, R., Godin A, Mayer L (1995), Accuracy estimation of Canadian Swath (multibeam) and Sweep (multi-transducer) sounding systems. Canadian Hydrographic Services Internal Report. 95 pp.

Lurton, X (2000). “Swath bathymetry using phase difference: theoretical analysis of acoustical measurement precision.” *IEEE J. Ocean. Eng. 25(3),* 351-363.

Stephens, C., Antonov, J., Boyer, T., Conkright, M. E., Locarnini, R., O'Brien, T. D., and Garcia, H. E. (2002). World Ocean Atlas 2001, Volume 1: Temperature. NOAA Atlas NESDIS 49. U.S.Government Printing Office . Washington, D.C., USA

E. Approval Sheet

All included information, data and reports are approved and as accurate as possible. No further processing needs to be completed on these data. The acquisition of this data was opportunistic and only minimal involvement occurred during its collection. The post processing techniques applied constitute the best available methods for providing quality bathymetric and backscatter information from this type of survey.

Glen Rice Glen Rice

8/1/2013

Glen Rice

Date

Integrated Ocean and Coastal Mapping Center, NOAA

Sarah Wolfskehl

Sarah
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8/1/2013

Sarah Wolfskehl

Date

Integrated Ocean and Coastal Mapping Center, NOAA

7/29/2013

Dr. Tom Weber

Date

Center for Coastal and Ocean Mapping, University of New Hampshire

7/29/2013

Dr. Jonathan Beaudoin

Date

Center for Coastal and Ocean Mapping, University of New Hampshire

APPENDIX I

TIDES AND WATER LEVELS

No DR Appendix I was submitted for W00219.

APPENDIX II

SUPPLEMENTAL SURVEY RECORDS AND CORRESPONDENCE

Oscar Dyson POS/MV Installation Parameters as of November 1, 2007:

The Dyson has a granite block reference point located in the transducer void, on and slightly above the centerline of the ship. The lever arm distances for the IMU, primary GPS antenna, and vessel datum, are measured from this point. The POS/MV displays geographic position, speed, heading, and dynamic motion (heave, pitch, and roll) for the vessel datum location. The POS/MV uses an x, y, z coordinate system (relative to the granite block reference point), where:

x = the longitudinal axis of the ship; +x is forward of, -x is aft of reference
y = the athwarthship axis of the ship; +y is starboard of, -y is port of reference
z = the vertical axis of the ship; +z is below, -z is above reference

Reference to IMU Lever Arm:
x = -0.277 m
y = -1.283 m
x = -4.460 m

Reference to Primary GPS Lever Arm:
x = -5.486 m
y = -0.152 m
z = -18.107 m

Reference to Vessel Lever Arm (vessel datum):
x = 0.246 m
y = 0.002 m
z = 1.530 m

Reference to Heave Lever Arm:
x = -20.177 m
y = -0.010 m
z = -5.376 m

The following parameters were entered into the ME70 motion sensor installation settings:

Ship Dimensions:
Ship Length = 63.8 m
Ship Width = 15.0 m
Ship Origo x = 45.790 m
Ship Origo y = -0.505 m

Transducer Offset (Vessel Datum to ME70 Transducer Lever Arm):
x = 0.715 m
y = -1.738 m
z = -0.505 m

The GPS and MRU offset values were left at the default of zero, since the POS/MV has already considered these offsets in providing position and motion solutions.

REPORT OF ALIGNMENT

NOAA OSCAR DYSON – ME 70-TRANSDUCER ALIGNMENT

FAIRHAVEN SHIPYARD - BELLINGHAM, WASHINGTON

DECEMBER 28, 2005

PROJECT OVERVIEW

Westlake Consultants, Inc. 3D Industrial Measurement Division provided as-built and verification services to the Fairhaven Shipyard for their alignment of the ME-70 transducer on the NOAA Oscar Dyson. Our on-site services were provided on November 30 and December 1, 2005.

When Westlake arrived, the transducer had not been installed. Additional work on the hull had not been completed. Consequently, our measurements were made to the top of the ME 70 housing and the ME 70 mounting ring in the transducer room.

Alignment Support and Verification

The ME-70 location and alignment were related to the existing datums in the transducer room.

- The plane of the ship was defined by a horizontal plane passing through the centerlines of the transducer room datums. (See attached diagram.) We refer to this as the transducer datum plane.

To check the alignment of the ME-70 housing, the following measurements were made, and repeated as necessary, during installation of the housing to confirm the housing alignment.

- Measurements were taken around the flange at the top of the ME 70 housing (see detail for Top of 2-5B flange), and the center point of this circle was calculated. This center point was used to represent the center of the ME 70 housing.

- The distance from the top of the ME 70 mounting ring (see detail) to the top of the ME 70 housing flange was measured and determined to be 941 mm.

After final alignment of the ME 70 housing, measurements were repeated to confirm alignment and location. (See diagram)

- The distance from the top of the ME 70 housing flange to the transducer room datum plane was determined to be 519 mm, (i.e., the top of the ME 70 housing flange is 519 mm below that plane).
- The distance from the horizontal plane to the top of the ME 70 mounting ring was calculated to be 1460 mm.
- The distance from the centerline of the ME 70 housing to the longitudinal datum line (defined by a line passing through the center of the fore and aft datums) was determined to be 3087 mm port.
- The centerline of the ME 70 housing to the transverse datum line (defined by a line passing through the center of the port and starboard transducer room datums) was determined to be 678 mm forward.
- The flange at the top of the ME 70 housing flange and the ME 70 mounting ring were determined to be parallel to the ship's horizontal plane.
- The tilt, roll, pitch, and the forward alignment were all set at zero.

Our measurement approach was based on the conditions at the time of our visit to the site. The transducer housing was measured, and our analysis is based on the assumption that the housing can be used to represent the ultimate location of the transducer.

Respectfully submitted,

Westlake Consultants, Inc.

Derek Colclough, Director
Industrial Measurement Services

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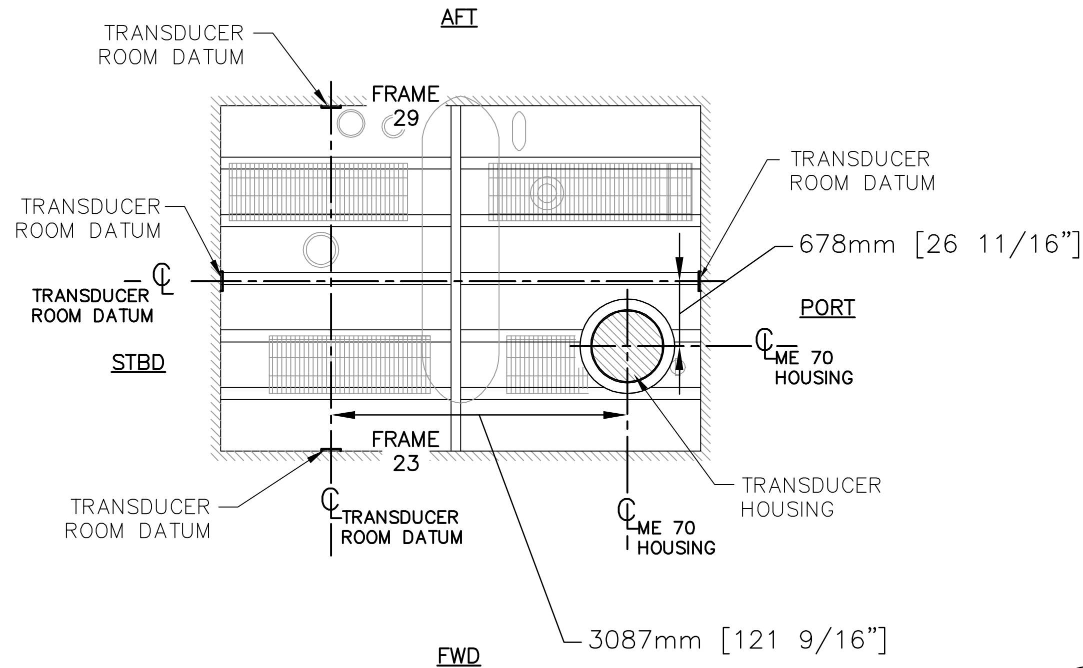
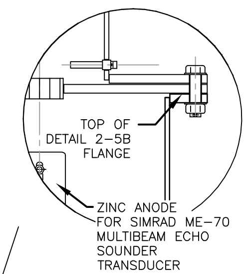
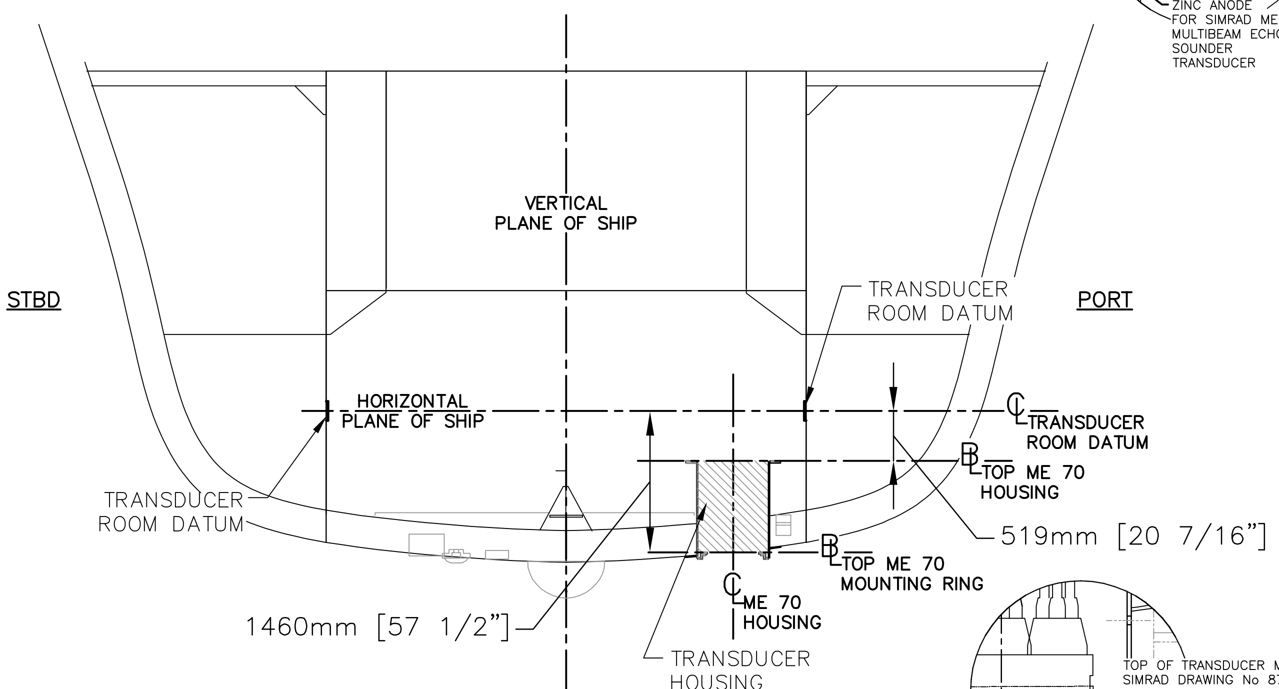
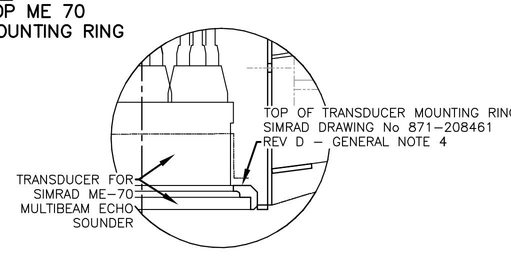


ME-70 TRANSDUCER ALIGNMENT

PLAN VIEW







ME-70 TRANSDUCER ALIGNMENT

CROSS SECTION VIEW

NOAA

OSCAR DYSON

ME-70 TRANSDUCER ALIGNMENT

DATE	12-29-05
DRAWN BY	CRB2
CHECKED BY	DAC
SCALE	N.T.S.
JOB NO.	1727-02(-)

WESTLAKE CONSULTANTS INC.

ENGINEERING ◆ SURVEYING ◆ PLANNING

PACIFIC CORPORATE CENTER
15115 S.W. SEQUOIA PARKWAY, SUITE 150
TIGARD, OREGON 97224

(503) 684-0652
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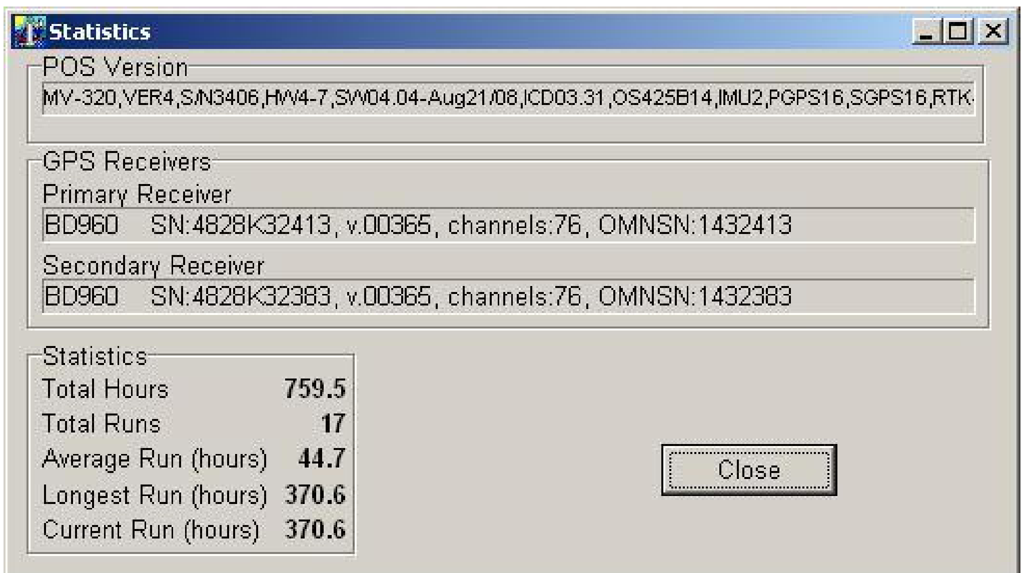
Oscar Dyson POS/MV Information
March 4, 2010

<u>Applanix POS/MV deck unit</u>
Model number: POS MV V4
Serial number: 3406
Part number: PCS-29
Date: DEC 2008
DOC property barcode: CD0001527008

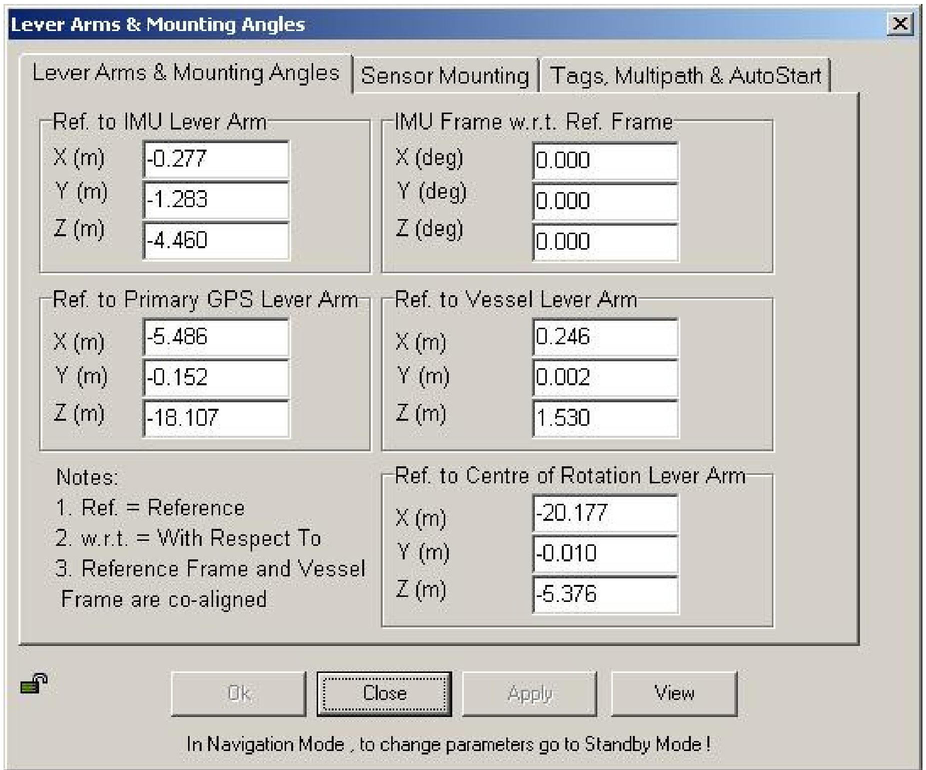
<u>Applanix IMU</u>
Model number: LN200
Serial number: 299
Part number: 1000 1506-4
Date: APR 2003
DOC property barcode: CD0001447057

<u>Statistics view</u>

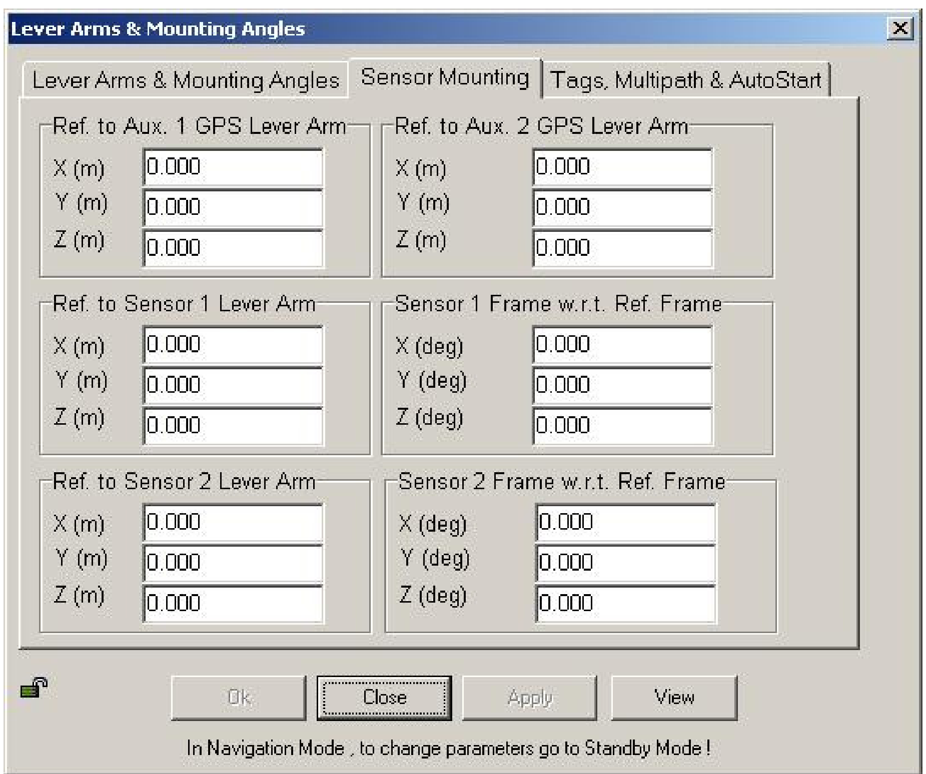


<u>POSMV IP address</u>

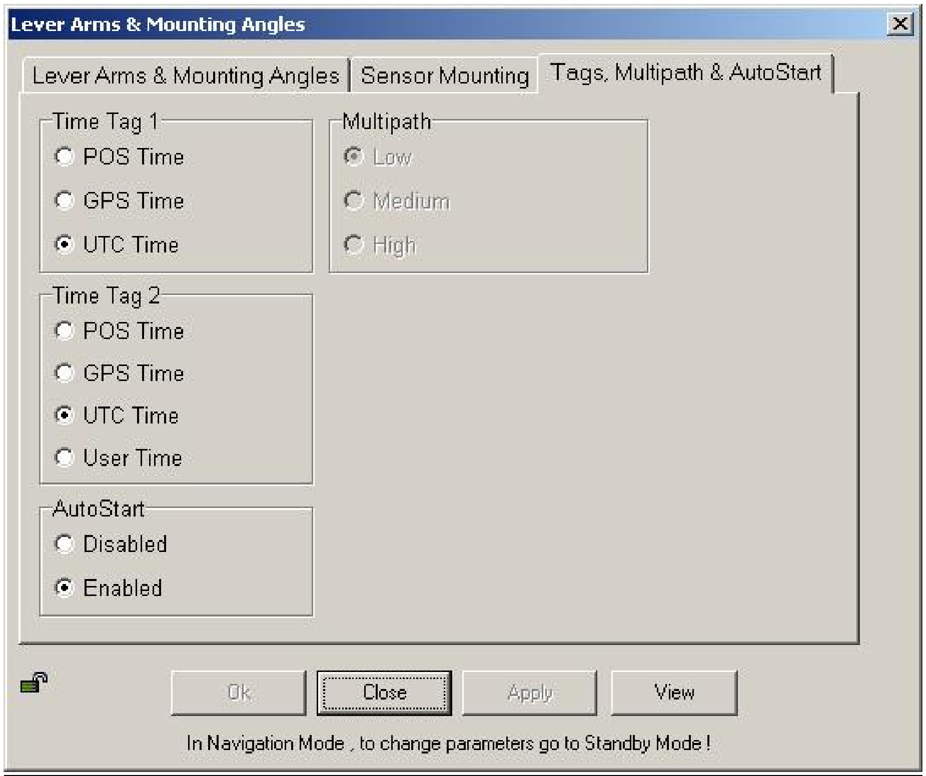
POSMV lever arms and mounting angles



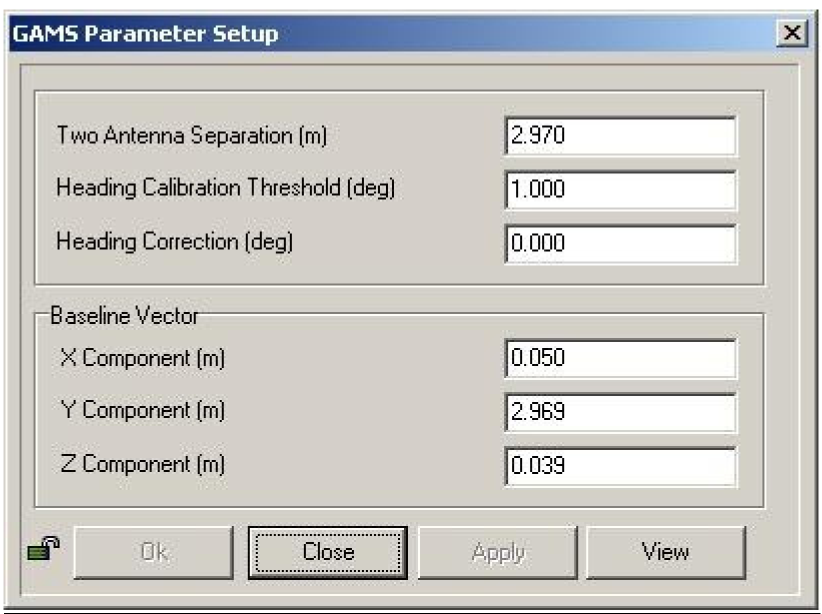
POSMV sensor mounting



POSMV tags, multipath and autostart



POSMV GAMS parameters



5/9/2011, last updated 5/27/2011

G.Rice

Estimating Vessel Static Waterline Using Vessel Ellipsoid Height

Introduction

Referencing the survey vessel waterline to the vessel reference frame is important in hydrography. This offset is used when recovering the survey time water level so that echo sounder measurements are of depth and not just distance from the transducer face. This offset is also important when ray tracing because the location of the echo sounder within the sound speed profile needs to be known. For larger vessels in particular, the primary reference point to water level offset can be difficult to estimate. Sight tubes that are open through the hull can be used for making this estimate on a regular basis, but these system need to be installed and included in a survey of the ship's reference frame. In cases where the ship does not have a site tube, the height of the vessel on the ellipsoid can be compared to the water level on the ellipsoid to make an estimate of this offset.

General Approach

To estimate the vessel waterline using the vessel ellipsoid height the vessel must be in close proximity to a water level gauge that has an ellipsoid height. The difference between the water level and the ellipsoid is known at the gauge. The difference between the water level and the ellipsoid as measured by the ship is the sum of the vessel water line to vessel reference point, and the vessel reference point to the ellipsoid (figure 1). By subtracting the water level gauge time series referenced to the ellipsoid from the vessel ellipsoid height time series, the water level to vessel reference point is obtained. A simple mean of this resulting data provides the desired estimate.

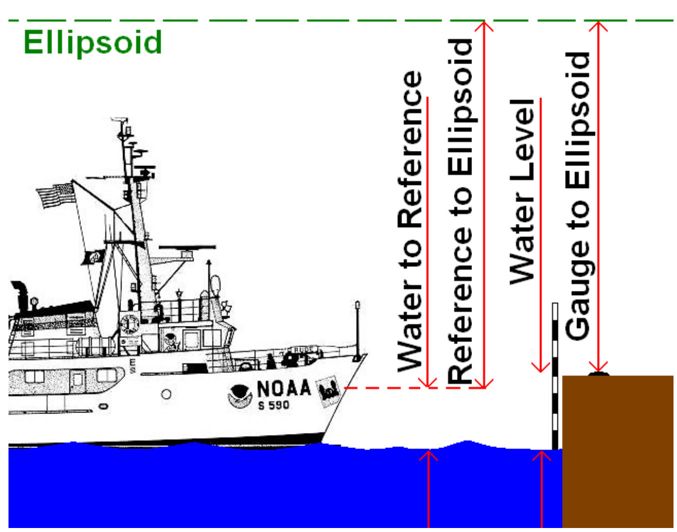


Figure 1 The water level to ellipsoid height can be found both with a Water Level gauge and with the ship. By subtracting the water level height referenced to the ellipsoid from the vessel reference point to the ellipsoid the vessel reference point to water level can be determined.

Additional constraints in using this method generally relate to how the vertical water level changes spatially relative to the ellipsoid and relative to the gauge. Large local changes in the geoid mean this method needs to be conducted very close to the tide gauge. VDatum should be consulted if available to ensure geoid and sea surface topographic effects for the vessel to gauge distance are acceptable. Water level changes associated with the movement of water and the need for tide zoning should be avoided, which also requires the vessel be close to the tide gauge. If these effects are suspected, a long time series should be obtained so phase or amplitude shifts can be revealed and possibly accounted for. In general more data is better. Data on the order of a few minutes can produce a good estimate, but it is much more likely to have a blunder than a time series collected over a 24 hour period. As usual, estimating the static water level means no effects from vessel settlement should be present, which requires that the ship be stationary relative to the water flow.

Steps

1) Download applicable gauge data to a *.tid format

2) Obtain the gauge ellipsoid height from the online resources (http://tidesandcurrents.noaa.gov/station_retrieve.shtml?type=Bench+Mark+Data+Sheets or http://www.ngs.noaa.gov/cgi-bin/datasheet.prl), installing a basestation over a tidal benchmark within the gauge network and submit to OPUS, or by contacting Corey Allen.

3) For the bench mark with an OPUS solution, retrieve the bench mark height above datum (also at http://tidesandcurrents.noaa.gov/).

4) Record a POS *.000 file and process through POSPac.

5) Record draft readings for future reference.

6) Export an SBET from POSPac at 1Hz in binary format using NAD83 as the export datum.

7) Run the attached script on a computer with Pydro by:

a) Placing the script in the same folder as the SBET and TID file.

b) Going to Start>Pydro>IPython>IPython

c) Navigate on the IPython command line to the folder with the data and script

d) On the command line type %run ERSD

e) Follow the on screen instructions

Case study

As part of an Integrated Ocean and Coastal Mapping effort, work is underway to use the multibeam from the NOAA Ship *Dyson* for hydrographic purposes. As part of this effort the POS/MV IMU to vessel waterline offset must be determined. Since no dedicated hydrographic personnel were aboard ship, the best method for determining this offset was to use the methods described here. The ship was docked in Seattle in close proximity to the Seattle tide gauge (figure 2).

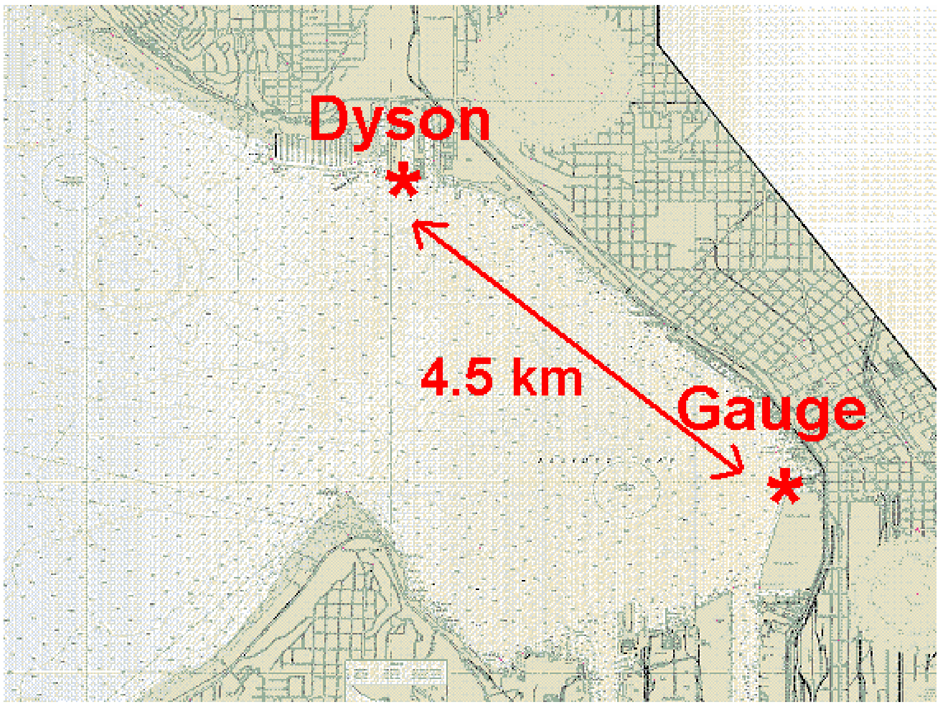


Figure 2 The location of the NOAA Ship *Dyson* and the Seattle Water Level Gauge

The OPUS solution for bench mark 944 7130 DAVE was provided by COOPS with an OPUS solution of (-18.931) meters, the COOPS website has this same mark 5.465 meters above Mean Lower Low Water (MLLW). Water level gauge data for the time period overlapping the POSM/V data was downloaded from the COOPS website. An SBET was produced in NAD83 from Applanix POSPac from the recorded POSM/V data. The resulting graphs from the described data and the attached script are shown in figures 3 and 4.

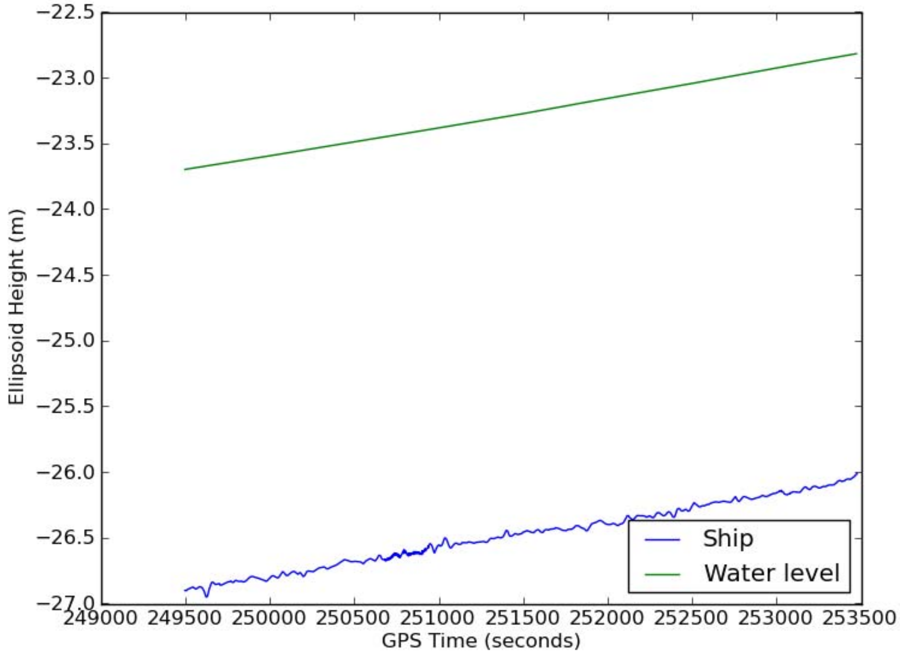


Figure 3 Time series of NOAA Ship *Dyson* and water level height relative to the ellipsoid.

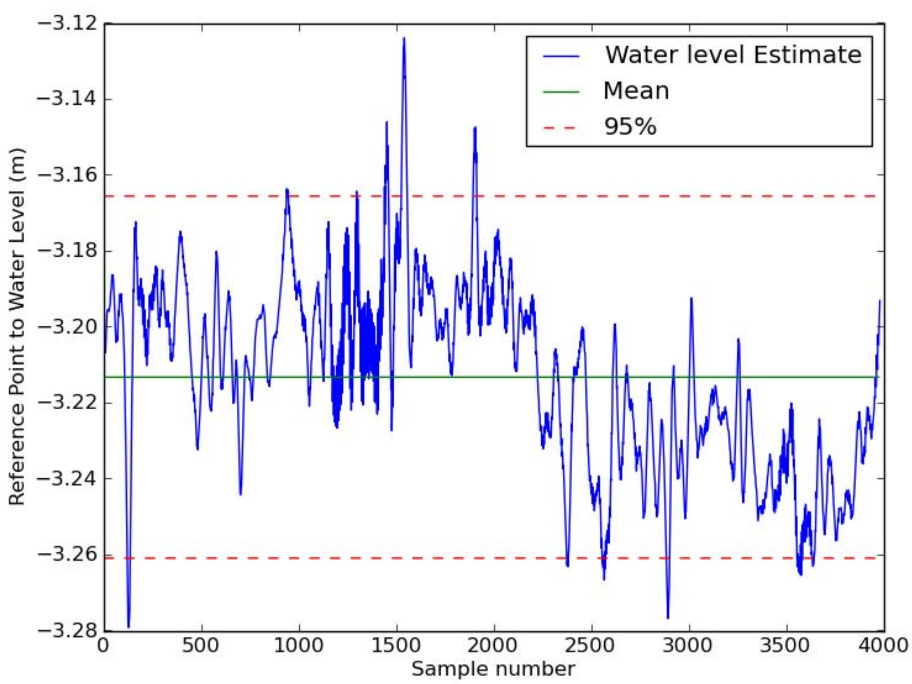


Figure 4 Estimates of the *Dyson* POS/MV IMU relative to the water line.

Using the described method the offset between the POS/MV IMU and the waterline is 3.21m. 95% of the distribution of the offset during this period was within 5cm, and is assumed to account for uncertainty in the ellipsoid height and in propagation of the water level information to the vessel. VDatum predicts a 2cm offset between the water level datum at the gauge vs at the *Dyson* moored location. While this could be added to the offset, it is added to the total uncertainty since the VDatum uncertainty in this area is around 10cm. Water level gauge uncertainty is on the order of 2cm, and the water level gauge ellipsoid height uncertainty was 4cm. The root sum square of these uncertainty components is 7 cm and is taken as the uncertainty in this estimate at 95% confidence (Table 1).

	Uncertainty at 95%
Waterline estimate	5 cm
Gauge Measurement	2 cm
Geoid offset	2 cm
Gauge Ellipsoid Height	4 cm
Total Uncertainty (Root Sum Square)	7 cm

Making thing more complicated…

Clearly there are considerable constraints on the use of this method. Propagation of gauge measurements to the vessel location through a tide model presents more layers of uncertainty, and the need to use tide models also indicates enlarged gauge to vessel distances that might include changes in the geoid or sea surface topography. For distance between the vessel and tide gauge, “how close is close enough” is answered by the usual “it depends.”

In the case described here the gauge and vessel were in close proximity in a relatively open area relative to the water flow. In the case where the gauge is separated from the vessel by a constriction in the waterway, offsets in phase and amplitude can be accounted for with a longer time series. A longer time series is required for a cross correlation between the vessel and tide gauge time series because correlation depends on shape in the time series to constrain the solution and find a phase offset. After the phase lag is calculated from the cross correlation the tide data is shifted to best match the vessel height time series. The tide gauge data is regressed through linear least squares to match the vessel height to account for changes in amplitude. The lagged tide data is subtracted from the regressed vessel height to find the offset between the ship reference point and the water level. This method is clearly more complicated and results should be scrutinized closely. The script currently restricts this type of regression to time series longer than eight hours. While this more complicated method tightened the resulting residual for the case presented here by one centimeter, the original method was favored for the KISS principle.

A few Acknowledgements

Thanks go to Dr. Tom Lippmann and Dr. Brian Calder for providing input on the cross correlation and regression, to the RACED team for recording POSPac data aboard NOAA Ship *Dyson*, and Corey Allen for retrieving the ellipsoid height from COOPS.

The Script

```
import os, struct
from datetime import date
import pylab as pl
from scipy.interpolate import interp1d
from scipy.signal import correlate
import HSTP.SetHSTPPath
PathToApp = os.path.split(HSTP.SetHSTPPath.__file__)[0]+"/Pydro/"
os.environ['PathToPydro'] = PathToApp
HSTP.SetHSTPPath.AddAll()
import parsers

class ReadSBET:
    """class for handling the SBET file."""
    def __init__(self, sbetfilename, downsample = 0):
        """opens file and initializes an mmap"""
        self.sbetfilename = sbetfilename
        #self.sbetfile = open(self.sbetfilename,'r+b')
        #self.msbet = mmap.mmap(self.sbetfile.fileno(),0)
        #self.sbetfile.close()
        self.msbet = open(sbetfilename,'rb')
        self.downsample = downsample
        self.sbet_fmt = '=17d'
        self.sbet_sz = 17*8
        self.size()

    def readblock(self):
        """reads one data point in the sbet and will downsample if
        a rate was specified on init"""
        try:
            self.tempstr = self.msbet.read(self.sbet_sz)
            assert(len(self.tempstr)==136)
            self.data = struct.unpack(self.sbet_fmt, self.tempstr)
            self.sbettime,self.lat,self.lon,self.alt,self.xvel,self.yvel = self.data[:6]
            self.vel = (self.xvel**2 + self.yvel**2)**0.5
            if self.downsample > 1:
                self.skip(self.downsample-1)
            return (self.sbettime,self.lat,self.lon,self.alt,self.vel)
        except AssertionError:
            print "end of SBET file read"
            return ('eof',0,0,0,0)

    def getverticaltimeseries(self):
```

```
        """returns a time series from the current point in the file to the
        end as time and height."""
        size = self.size()
        z = pl.zeros((size,2))
        for i in xrange(size):
            temp = self.readblock()
            if temp[0] == 'eof':
                break
            else:
                z[i, :] = temp[0], temp[3]
        if i < size:
            z = z[:i]
        return z

    def skip(self,numskip):
        """skips the specified number of data points"""
        self.numskip = numskip
        self.sbetrem = self.sbetsize * self.sbet_sz - self.msbet.tell()
        if self.sbetrem < self.numskip * self.sbet_sz:
            self.msbet.seek(self.sbetrem,1)
        else:
            self.msbet.seek(self.numskip * self.sbet_sz,1)

    def size(self):
        """returns the size of an array needed for all samples at the downsampled rate."""
        self.sbetsize = os.path.getsize(self.sbetfilename) / (self.sbet_sz)
        if self.downsample > 1:
            self.samplenum = self.sbetsize / self.downsample
        else:
            self.samplenum = self.sbetsize
        return self.samplenum

    def close(self):
        self.msbet.close()

class FindTides:
    """Read the tide file and return a timeseries for the given time stamps"""
    def __init__(self, tidefilename):
        self.t = parsers.WaterLevels(tidefilename)

    def gettimeseries(self, times):
        """convert tide times to gps seconds of the week (is that a good idea?)
        and then returns an interpolated time series at the same times as
        provided."""
        tidetimes = self.yearhourstogpstime()
        f = interp1d(tidetimes, self.t.waterlevels)
        w = f(times)
        return w
```

```
    def yearhourstogpstime(self):
        year = self.t.start_of_year.year
        firstpoint = self.t.times[0] / 24
        firstday = date.fromordinal(int(firstpoint) + date(year,1,1).toordinal())
        beginweek = firstday.toordinal() - firstday.weekday() - 1 - date(year, 1, 1).toordinal()
        tidetimes = (self.t.times - beginweek * 24) * 60 * 60
        return tidetimes

def getphase(ts1, ts2, verbose = False):
    """Through cross correlation return the phase offset in terms of index"""
    mts1 = ts1 - ts1.mean()
    mts2 = ts2 - ts2.mean()
    norm = mts1.std() * mts2.std() * len(mts1)
    p = correlate(mts1, mts2) / norm
    if verbose:
        print 'max correlation at ' + str(len(mts1) - p.argmax() -1) + ' lag.'
        lagrange = pl.linspace(-len(mts1) + 1, len(mts1), len(p))
        pl.figure()
        pl.plot(lagrange, p)
        pl.xlabel('Lag (samples)')
        pl.ylabel('Correlation')
    phase = len(mts1) - p.argmax() -1
    return phase

def removetide(ts, tide):
    x = pl.asarray([pl.ones(len(ts)), tide])
    D = pl.zeros((2,2))
    for i in xrange(len(ts)):
        for j in xrange(2):
            for k in xrange(2):
                D[j, k] = D[j, k] + x[j, i] * x[k, i]
    D = D / len(ts)
    Dinv = pl.inv(D)
    Z = pl.zeros(2)
    for i in xrange(len(ts)):
        for j in xrange(2):
            Z[j] = Z[j] + ts[i] * x[j, i]
    Z = Z / len(ts)
    A = pl.matrix(Dinv) * pl.matrix(Z).T
    modeled= pl.array(A[1] * tide + A[0])
    return modeled.T

def main(verbose = True):
    """Find the Static water level"""
    print 'Enter the name of the tide file: ',
    tidefile = raw_input('>>')
    print 'Enter the name of the SBET file: ',
```

```
sbetfile = raw_input('>>')
print 'Enter the NAD83 ellipsoid height of the bench mark: ',
markht = float(raw_input('>>'))
print 'Enter the mark height above the relevant water level datum: ',
wlht = float(raw_input('>>'))
offset = markht - wlht
minhours = 8
# Read data and get time series
sbet = ReadSBET(sbetfile)
ship = sbet.getverticaltimeseries()
ship[0, 1] = ship[1, 1]
deltat = ship[1, 0] - ship[0, 0]
recordlen = ship[-1, 0] - ship[0, 0]
tides = FindTides(tidefile)
w = tides.gettimeseries(ship[:,0]) + offset
if verbose:
   pl.figure()
   pl.plot(ship[:, 0], ship[:, 1])
   pl.plot(ship[:, 0], w)
   pl.xlabel('GPS Time (seconds)')
   pl.ylabel('Ellipsoid Height (m)')
   pl.legend(('Ship', 'Water level'), 'lower right')
#if time series is long enough, look for a lag between the time series
# and remove the regressed tide
# WARNING - This may not work yet.  It is untested with long time series.
if recordlen > (minhours*60*60):
   print '***using untested portion of code***'
   phase = deltat * getphase(ship[:,1], w, verbose)
   print 'Using phase shift of ' + str(phase) + ' seconds.'
   w = tides.gettimeseries(ship[:,0] + phase) + offset
   shipmodel = removetide(ship[:, 1], w)
   shipmean = shipmodel.mean() - w.mean()
   shipwl = ship[:, 1] - shipmodel[:, 0] + shipmean #manufacture ts for plots
   if verbose:
      pl.figure()
      pl.plot(ship[:, 0], ship[:, 1])
      pl.plot(ship[:, 0], shipmodel)
      pl.xlabel('GPS Time (seconds)')
      pl.ylabel('Ellipsoid Height (m)')
      pl.legend(('Ship', 'Ship regressed model'), 'lower right')
else: # KISS
   shipwl = ship[:, 1] - w
if verbose:
   pl.figure()
   pl.plot(shipwl)
   pl.xlabel('Sample number')
   pl.ylabel('Reference Point to Water Level (m)')
   wlmean = pl.zeros(len(shipwl)) + shipwl.mean()
```

```
        wlstd = pl.zeros(len(shipwl)) + shipwl.std()
        pl.plot(wlmean,'g')
        pl.plot(wlmean + 1.96*wlstd, 'r--')
        pl.plot(wlmean - 1.96*wlstd, 'r--')
        pl.legend(('Water level Estimate', 'Mean', '95%'))
    print 'Water line estmate is ' + str(shipwl.mean())
    print 'Uncertainty at 95% for this estimate is ' + str(1.96 * shipwl.std())
    pl.show()

if __name__ == '__main__':
        main()
```

APPENDIX III

SURVEY FEATURES REPORT

No DR Appendix III was submitted for W00219.

APPROVAL PAGE

W00219

Data meet or exceed 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 the common area.

The following products will be sent to NGDC for archive

- W00219_DR.pdf
- 8 meter resolution BAG
- Processed survey data and records

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

Approved:____

LT Matthew Jaskoski, NOAA
Chief, Atlantic Hydrographic Branch