Cover Sheet (NOAA Form 76-35A)

NOAA FORM 76-35A

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

Data Acquisition and Processing Report

Type of Survey HYDROGRAPHIC

Field No OPR-Q191-KR-11

Registry No. H12359, H12360, H12361 & H12362

LOCALITY

State ALASKA

General Locality Krenitzin Islands

Sublocality Areas in and around Akutan and Akun Islands

2011

CHIEF OF PARTY

Dean Moyles

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DATE

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Title Sheet (NOAA Form 77-28)

NOAA FORM 77-28 (11-72) U.S. DEPARTMENT OF COMMERCE NATIONAL OCEANIC AND ATMOSPHERIC ADMINISTRATION **HYDROGRAPHIC TITLE SHEET**	REGISTER NO. H12359, H12360, H12361, & H12362
INSTRUCTIONS – The Hydrographic Sheet should be accompanied by this form, filled in as completely as possible, when the sheet is forwarded to the Office	FIELD NO.

State ALASKA

General Locality Krenitzin Islands

Locality Areas in and around Akutan and Akun Islands

Scale NA Date of Survey 07/24/2011 – 08/24/2011

Instructions dated April, 2011 Project No. OPR-Q191-KR-11

Vessel F/V PACIFIC STAR (556510), R/V R2 (623241), R/V D2 (647782)

Chief of party Dean Moyles

Surveyed by MOYLES, REYNOLDS, FARLEY, ROKYTA, LYDON, TIXIER, GOODALL, CHILDS, et al.

Soundings taken by echo sounder, hand lead, pole RESON SEABAT 7125 (PACIFIC STAR, HULL MOUNT), RESON SEABAT 7101 (R2 & D2, HULL MOUNT)

Graphic record scaled by FUGRO PELAGOS, INC. PERSONNEL

Graphic record checked by FUGRO PELAGOS, INC. PERSONNEL

Protracted by N/A Automated plot by N/A

Verification by

Soundings in METERS at MLLW

REMARKS: The purpose of this work is to provide NOAA with modern and accurate hydrographic survey data for the area extending from Akun Bay to Ugamak Island.

ALL TIMES ARE RECORDED IN UTC.

FUGRO PELAGOS INC.

3574 RUFFIN ROAD

SAN DIEGO, CA 92123

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A – Equipment

The F/V Pacific Star (with launches R2 and D2) acquired all sounding data for this project. The equipment list and vessel descriptions are included in Appendices I and II.

Sounding Equipment

F/V Pacific Star, 162 feet in length with a draft of 16 feet, was equipped with a hull mounted Reson SeaBat 7125 dual-frequency multibeam echosounder system for the OPR-Q191-KR-11 project. The Reson 7125 operates at two user-selectable frequencies of 400 and 200 kHz. The 7125 forms 256 or 512 beams over 128° with a beam width of 0.5° (across-track) in the 400 kHz mode, and 256 beams over 128° with a beam width of 1° (across-track) in the 200 kHz mode. It allows the operator to select equi-angle or equi-distant beam spacing. For this project, both the 400 kHz and 200 kHz systems were configured for 256 equi-angle beams. The selection of these frequencies as well as range scale, gain, power levels, ping rates, etc. was a function of water depth and data quality and was noted on the survey line logs (see the Descriptive Report Separate 1). All 7125 multibeam data files were logged in the S7K format using WinFrog Multibeam v3.09.11.

R/V R2, a Pacific Star launch, is 29 feet in length with a draft of 3 feet. For this survey, R2 was equipped with a hull mounted Reson SeaBat 7101 multibeam echosounder. The Reson 7101 on R2 was fitted with a stick projector and operated at a frequency of 240 kHz. The system forms either 239 or 511 beams across a 150° swath width. All 7101 multibeam data files were logged in the S7K format using WinFrog Multibeam v3.09.11.

R/V D2, a Pacific Star launch, is 29 feet in length with a draft of 3 feet. For this survey, D2 was equipped with a hull mounted Reson SeaBat 7101 multibeam echosounder. The Reson 7101 on D2 was fitted with a stick projector and operated at a frequency of 240 kHz. The system forms either 239 or 511 beams across a 150° swath width. All 7101 multibeam data files were logged in the S7K format using WinFrog Multibeam v3.09.11.

The line orientation for all vessels was generally parallel to the coastline and bathymetric contours of the area. The line spacing was dependent on water depth and data quality, with an average line spacing of two to three times water depth.

The following table summarizes the sonar models and configurations used on each survey vessel.

Table 1 Vessel Sonar Summary

Vessel Sonar Summary			
Vessel	**Pacific Star**	**R2**	**D2**
Mount Type	Hull	Hull	Hull
Sonar System	Reson 7125 dual frequency	Reson 7101	Reson 7101

Backscatter Imagery

Towed Side Scan Sonar (SSS) operations were not required by this contract, but the backscatter and beam imagery snippet data from all multibeam systems were logged and are stored in the S7K files. All beam imagery snippet data was logged in the 7028 record of the S7K file for the project.

Sound Velocity Profilers

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

Each launch was equipped with two of the AML SV&Ps. The instruments were mounted within a weighted cage and deployed using a hydraulic winch that contained 350m of shielded Kevlar reinforced cable via a stern mounted A-Frame.

The F/V Pacific Star was also equipped with two of the AML SV&Ps. The instruments were mounted within a weighted cage and deployed using a hydraulic winch that contained 1000m of shielded Kevlar reinforced cable via a stern mounted A-Frame.

Positioning & Attitude Equipment

All vessels were equipped with an Applanix Position and Orientation System for Marine Vessels (POS MV) 320 V4 to calculate position and vessel attitude. Position was determined in real time using a Trimble Zephyr L1/L2 GPS antenna, which was connected to a Trimble BD950 L1/L2 GPS card residing in the POS MV. An Inertial Measurement Unit (IMU) provided velocity values to the POS MV allowing it to compute an inertial position, along with heading, and attitude. The POS MV was configured to accept differential corrections which were output from a CSI MBX-3 DGPS receiver that was tuned to the closest or strongest USCG DGPS station.
The operational accuracy specifications for this system, as documented by the manufacturer, are as follows:

Table 2 POS MV Specifications

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

The PosMvLogger and POS MV controller software's real-time QC displays were monitored throughout the survey to ensure that the positional accuracies specified in the NOS Hydrographic Surveys Specifications and Deliverables were achieved. These include, but are not limited to,

the following: GPS Status, Position Accuracy, Receiver Status (which included HDOP & PDOP), and Satellite Status.

Static Draft Measurement

The WaterLOG H3611 (Radar Water Level Sensor) was installed on the port and starboard gunwales of F/V Pacific Star to obtain a more precise static draft measurement. The WaterLOG H3611 would produce a distance from water surface sample every second with an accuracy of ±0.003m. Samples were taken over a 10 minute period and averaged to determine the vessel's draft. Traditional static draft measurement techniques were also employed as a substitute to the WaterLOG H3611 measurements when required.

Bottom Sampling

Each vessel was equipped with a 2.4L Van Veen Grab bottom sampler and 300m of line. The F/V Pacific Star deployed and retrieved samples using a hydraulic winch. The launches deployed and retrieved samples using a hydraulic crab block. All samples were discarded after the sample information was recorded.

Software

Acquisition

All raw multibeam data for all vessels were collected with WinFrog Multibeam v3.09.11 (WFMB). WFMB ran on Windows XP Pro PCs with a dual-core Intel processor. All data from the 7125 and 7101 sonars were logged in the S7K file format. These S7K files contain all multibeam bathymetry, position, attitude, heading, and time stamp data required by CARIS to process the soundings. WFMB also provided a coverage display for real time QC and coverage estimation of the acquired data.

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

1. Devices: The Devices window shows the operator which hardware is attached to the PC. It also allows the operator to configure the devices, determine whether they are functioning properly, and to view received data.
2. Graphic: The Graphics window shows navigation information in plan view. This includes vessel position, survey lines, background vector plots, and raster charts.
3. Vehicle: The Vehicle window can be configured to show any tabular navigation information required. Typically, this window displays position, time, line name, heading, HDOP, speed over ground, distance to start of line, distance to end of line, and distance off line. Many other data items are selectable.
4. Calculation: The Calculations window is used to look at specific data items in tabular or graphical format. Operators look here to view the status of the GPS satellite constellation

and position solutions.

5. MBES Coverage Map: The Coverage Map provides a real time graphical representation of the multibeam data. This allows the user to make judgments and corrections to the data collection procedure based on real conditions.
6. MBES QC View: The QC View contains four configurable windows for real time display of any of the following: 2D or 3D multibeam data, snippets, pseudo side scan or backscatter amplitude. In addition to this, it contains a surface sound speed utility that is configurable for real time SV monitoring at the sonar head.

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

Fugro Pelagos' PosMvLogger v1.2 was used to provide uninterrupted logging of all Inertial Motion Unit (IMU), dual frequency GPS, and diagnostic data required to produce a Post Processed Kinematic (PPK) GPS solution using Applanix PosPacMMS. Additionally, the True Heave data applied in post processing was collected concurrently in the same file. The program also provided real-time QC and alarms for excessive HDOP, PDOP, and DGPS outages.

Fugro Pelagos' MB Survey Tools v2.00.31.00 was used to aid in file administration and reporting during data acquisition. This program created a daily file that contained survey line, SVP, and static draft records. These logs were stored digitally in a database format and later used to create the log sheets in PDF format located in the Descriptive Report Separate 1.

Processing

All Soundings were processed using CARIS (Computer Aided Resource Information System) HIPS (Hydrographic Information Processing System) v7.1. HIPS converted the S7K files to HIPS format, corrected soundings for sound velocity, motion, tide, and vessel offset, and were used to examine and reject noisy soundings. HIPS also produced the final BASE surfaces.

CARIS Notebook v3.1 was used to generate the S57 Feature Files.

ESRI ArcMap v10.0 wase utilized for survey planning, reviewing coverage plots, creating infills & crosslines, and graphics.

Applanix POSPac MMS v5.4 was utilized for post-processing the vessel dual frequency GPS data with simultaneous base station data to calculate higher accuracy positions than those calculated in real time.

MB Survey Tools v2.00.31.00 was used to extract True Heave from POS files and put data into a text format acceptable to the CARIS Generic Data Parser. This was only utilized when the CARIS Load True Heave routine in HIPS failed to import.

MB Survey Tools v2.00.31.00 allowed processors to track changes and add comments while processing. MB Survey Tools was also used to process all sound velocity profiles and to convert them into a CARIS format.

A complete list of software and versions used on this project is included in Appendix I. Refer to the "2011-NOAA Processing Procedures" document for a detailed processing routine with procedures used.

B – Quality Control

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

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

- Navigation – A value of 0.10 m was entered for the positional accuracy in the CARIS HVF file. This value was selected since all positions were post processed, with all X, Y, and standard deviation values better than 0.10m. This value was replaced with a PPK uncertainty value that was applied at a 1Hz rate through the POSPac RMS file.
- Gyro/Heading – All vessels were equipped with a (POS MV) 320 V4 and mobilized with a manufacturer recommended baseline between the primary and secondary GPS antennas of less than 4m. A value of 0.020 was entered in the HVF as per manufacturer specifications. This value was replaced with a PPK uncertainty value that was applied at a 1Hz rate through the POSPac RMS file.
- Heave – The heave percentage of amplitude was set to 5% and the Heave was set to 0.05m, as per manufacturer specifications. This value was replaced in processing with the True Heave uncertainty value loaded from the POSMV raw 111 record.
- Pitch and Roll - As per the manufacturer accuracy values, both were set to 0.02 degrees.
- Timing – All data were independently time stamped at the source when created in logging software using a single clock/epoch developed in the Pelagos Precise Timing method. Position, attitude, including True Heave, and heading were all time stamped in the POS MV on the UTC epoch. This UTC string was also sent from the POS MV to the Reson processor via a NMEA ZDA serial string and synchronized with a 1PPS, yielding timing accuracies on the order of 1 ms. Therefore, a timing uncertainty of 0.001 seconds was entered for all vessels.
- Vessel Offsets - All vessel and sensor offsets were derived via conventional surveying techniques using total stations, while the vessels were dry docked. The results yielded standard deviations of 0.005m to 0.010m, vessel and survey dependent.
- Vessel Speed – The vessel speed value was set to 0.03 m/s as per manufacturer specifications.
- Loading – The estimated vessel loading error set to 0.05m. This was the best estimate of how the measured static draft changed through the survey day.
- Draft – It was estimated that draft could be measured to within 0.01m to 0.05m, therefore values in this range were entered, vessel dependent.
- Tide – Tide and Zoning TPU values were set to 0.10m and 0.20 respectively. The applied values are found in the NOS Hydrographic Surveys Specifications and

Deliverables (April, 2011) Section 4.1.6.

- Sound Speed Measured – The Measured Sound Speed TPU Values were determined in MBTools, using the SVP Statistics utility. This utility calculated the Mean, Variance, Standard Deviation and Min/Max values at a user specified depth interval. Sound Speed TPU values were calculated independently for each vessel on every sheet. Specific values can be found in the individual Descriptive Reports.
- Surface Sound Speed – The Surface Sound Speed value was set to 0.25m/s. This value was determined through the manufacturer stated accuracy for a 6000m Reson SV70.
- MRU Align StdDev for the Gyro and Roll/Pitch were set to 0.10° since this is the estimated misalignment between the IMU and the vessel reference frame.

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

An overview of the data processing flow follows:

In order for the S7K files collected by WFMB to be used by CARIS, they must be converted to HDCS format using the CARIS ResonPDS converter routine. Prior to the files being converted, vessel offsets, patch test calibration values, TPU values, and static draft were entered into the HVF.

Once converted, the Observed Tide and True Heave data were loaded into each line and the line was SVP corrected in CARIS HIPS. The TPU was then computed for each sounding, and the attitude, navigation, and bathymetry data for each individual line were examined for noise, as well as to ensure the completeness and correctness of the data set.

The data was filtered using a swath angle filter and a RESON quality flag filter (**Table 3**). The swath angle filter rejected all soundings falling farther from a specified angle from nadir. The RESON quality flag filter rejected soundings based on the colinearity and brightness of each ping. Note that "rejected" does not mean the sounding was deleted – it was instead flagged as bad so that it would not be included in subsequent processing, such as surface creation. Data flagged as rejected did contain valid data but were flagged to remove noise and to speed the processing flow. Valid data were manually reaccepted into the data set occasionally during line and subset editing as required.

Table 3 RESON Quality Flags

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

Several CARIS filter files were defined in project preplanning (**Table 4**). The processer selected the appropriate filter file based on a brief review of the data for environmental noise and bottom topography. Filter settings were sometimes modified based on data quality and sonar used, but all filter settings used were noted on each corresponding line log found in the Descriptive Report Separate 1.

Table 4 CARIS Filter File Definitions

File name	Angle from Nadir	Quality Flag
0_1_73deg.hff	73˚	0&1
60_Q_0.hff	60˚	0
60_Q_01.hff	60˚	0&1
65_Q_0.hff	65˚	0
65_Q_01.hff	65˚	0&1
70_Q_0.hff	70˚	0
70_Q_01.hff	70˚	0&1
Quality_0.hff	No Filter	0

Raw POS MV data were processed in Applanix POSPac MMS 5.4 with a Single Base Station Solution using the Fugro Pelagos Base Station's dual frequency GPS data. A Smoothed Best Estimated Trajectory (SBET) file containing a Post Process Kinematic Inertial Navigation Solution was created. Additionally, a POSPac MMS RMS file was created which contained uncertainty information specific to each position and attitude calculation. The SBET and RMS files were loaded into each line at a frequency of 10Hz for position records, 100 Hz for attitude records, and 1 Hz for RMS uncertainty data in CARIS HIPS. This operation replaced the real time navigation, pitch, roll, gyro, and GPS Height data with PPK navigation, attitude records, and uncertainty data. Note that all positioning data was processed to the North American Datum 1983 Ellipsoid.

Processing of the POS MV data into a SBET file using a single base solution created highly accurate ellipsoid altitudes, normally better than 10cm, for all positioning data. Real-time ellipsoid altitude data was replaced with the SBET solution and a GPS tide was then calculated for each line. The GPS tide was generated by using the ellipsoid height and subtracting the heave, dynamic draft, and static draft specific to each line. This GPS tide value allowed the sounding data to be taken to the ellipsoid without modification to the vessel configuration file. Though the GPS tide values are stored within the CARIS line file, the GPS tide values were only applied to QC potential vertical busts. All final products were created using the Verified Smoothed Zone Tide data provided by John Oswald & Associates.

CUBE surfaces were then created at each required resolution for the Sheet or Block. Each CUBE resolution surface was then finalized using the depth thresholds for that specific resolution. The finalized CUBE surfaces were used for subset cleaning so only the surface relating to the specific resolutions' depth range would be reviewed. CUBE parameters were derived from NOS Hydrographic Surveys Specifications and Deliverables (April, 2011). The following depth thresholds and CUBE parameter settings were used on this project.

Table 5 CUBE Surface Parameters

Surface Resolution	Depth Range	IHO S-44 Specification	Surface Creation				Disambiguation			
			Estimate Offset	Capture Distance Scale	Capture Distance Minimum	Horizontal Error Scalar	Method	Density Strength Limit	Locale Strength Maximum	Locale Search Radius
1m	0-20m	Order 1a	4.00	0.50%	0.707m	1.96	Density & Local	2.00	2.50	1 pixel
2m	18-40m	Order 1a	4.00	0.50%	1.414m	1.96	Density & Local	2.00	2.50	1 pixel
4m	36-80m	Order 1a	4.00	0.50%	2.828m	1.96	Density & Local	2.00	2.50	1 pixel
8m	72-160m	Order 1a	4.00	0.50%	5.657m	1.96	Density & Local	2.00	2.50	1 pixel
16m	144m-max	Order 1a	4.00	0.50%	11.314m	1.96	Density & Local	2.00	2.50	1 pixel

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

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

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

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

CARIS Notebook 3.1 was utilized to produce the S57 final feature file (FFF). Seabed Area (SBDARE) polygon objects were picked from areas with obvious rocky bottom topography from the BASE surfaces. Meta-Coverage (M_COV) and Meta-Quality (M_QUAL) objects were defined as required using the extents of the multibeam BASE surfaces. All additional features that could not be depicted in the CARIS BASE surfaces, such as rocks and bottom samples, were logged in the S-57 AFF.

C – Corrections to Soundings

Sound Velocity Profiles

Sound velocity casts were normally performed every two to three hours on the Pacific Star and launches R2 and D2. The AML Smart Probes used to determine sound velocities sampled at a rate of ten velocity and pressure observation pairs a second. For each cast, the probes were held at the surface for one to two minutes to achieve temperature equilibrium. The probes were then lowered and raised at a rate of 1 m/s. Between casts, the sound velocity sensors were stored in fresh water to minimize salt-water corrosion and to hold them at ambient water temperature.

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

All sound velocity probes were calibrated just prior to the start of survey operations and no probe's calibration exceeded 6 months at the end of survey operations.

Refer to Appendix III for SVP Calibration Reports.

Settlement Curves

Squat-settlement tests were performed on all vessels to obtain dynamic draft correctors.

The squat-settlement tests were performed by first establishing a 1000 meter line in the direction of the current. The survey vessel sat static at one end of the line for three minutes logging L1/L2 GPS data. The line was first run heading north at lowest possible engine RPM, then rerun heading south at the same RPM, stopping at the south end of the line to obtain an additional three minutes of static L1/L2 GPS data. This pattern was repeated for additional lines at incrementing vessel RPMs.

All measurements were corrected for heave, pitch, roll, and reduced to the vessel's common reference point (CRP). Static measurements observed at the end of each line set were used to compute a tide curve for tidal corrections. After post-processing with base station data in Applanix POSPac, a settlement curve of dynamic draft correctors was computed via MB Survey Tools.

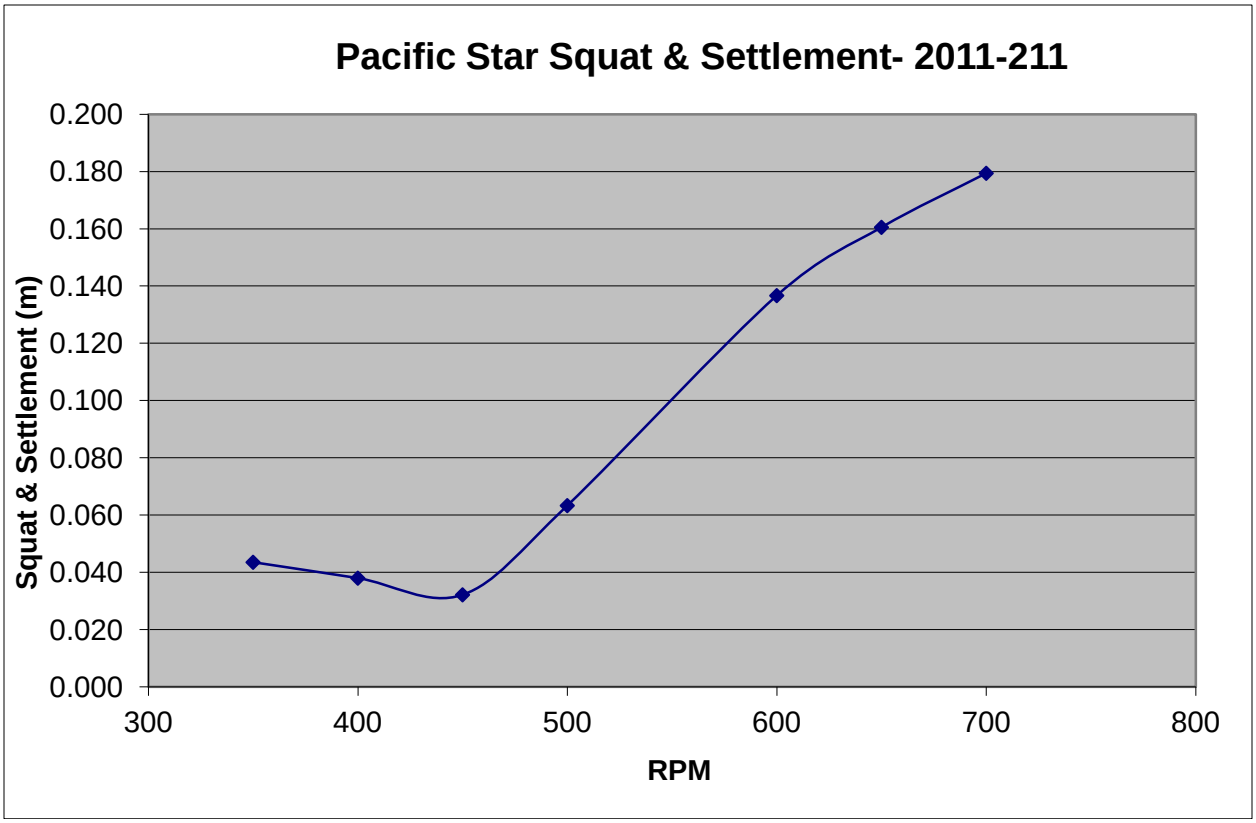


Figure 1-Pacific Star Dynamic Draft

Table 6 Pacific Star Squat Settlement Results

Pacific Star DYNAMIC DRAFT CORRECTORS		
Speed (kts)	RPM	Settlement
4.3	350	0.044
4.8	400	0.038
5.4	450	0.032
6.0	500	0.063
8.9	600	0.137
8.6	650	0.161
10.3	700	0.179

The squat settlement test for the F/V Pacific Star was conducted in the vicinity of Akun Island, AK on July 30, 2011 (Julian Day 211).

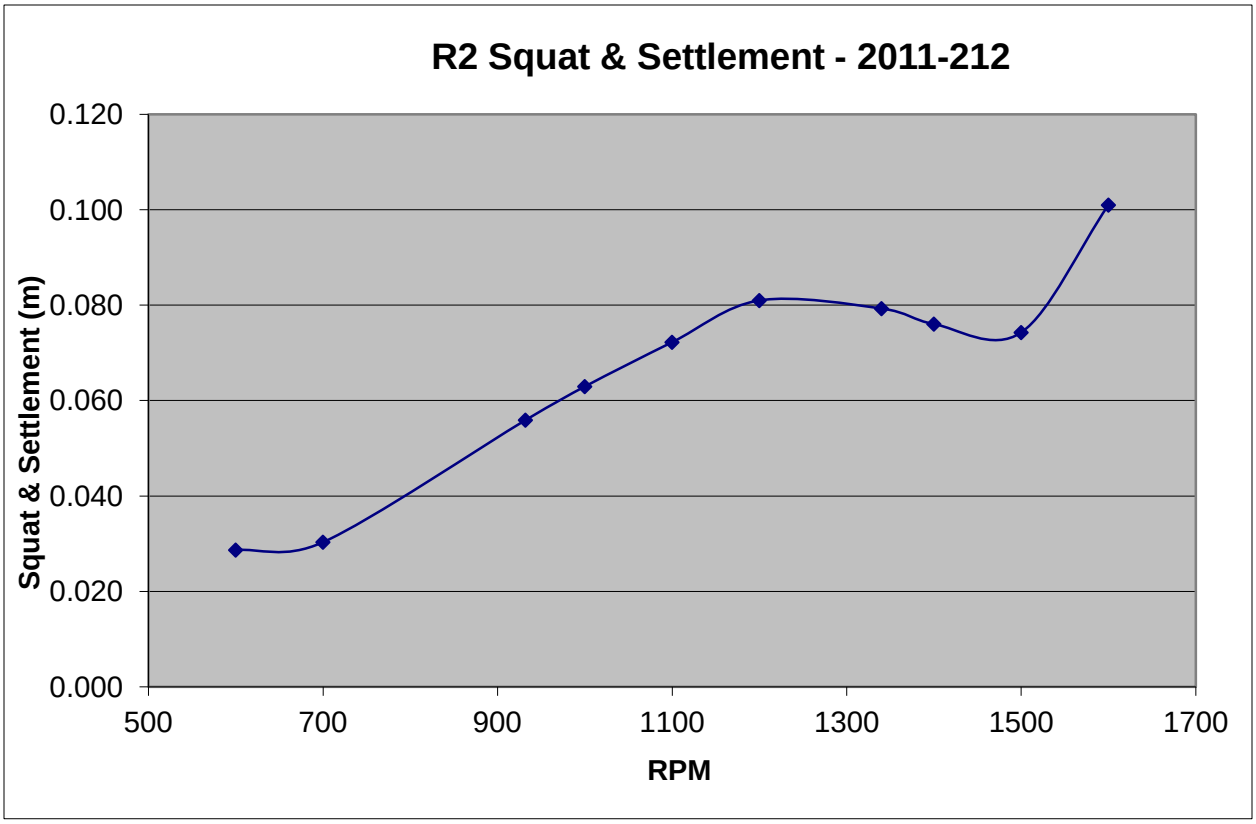


Figure 2-R2 Dynamic Draft

Table 7 R2 Squat Settlement Results

R2 DYNAMIC DRAFT CORRECTORS		
Speed (kts)	RPM	Settlement
3.6	700	-0.037
4.5	1100	-0.020
5.6	1210	-0.007
6.2	1340	0.015
6.7	1520	0.025
7.0	1630	0.053
7.4	1740	0.024

The squat settlement test for the R/V R2 was conducted in the vicinity of Akun Bay, AK on July 31, 2011 (Julian Day 212).

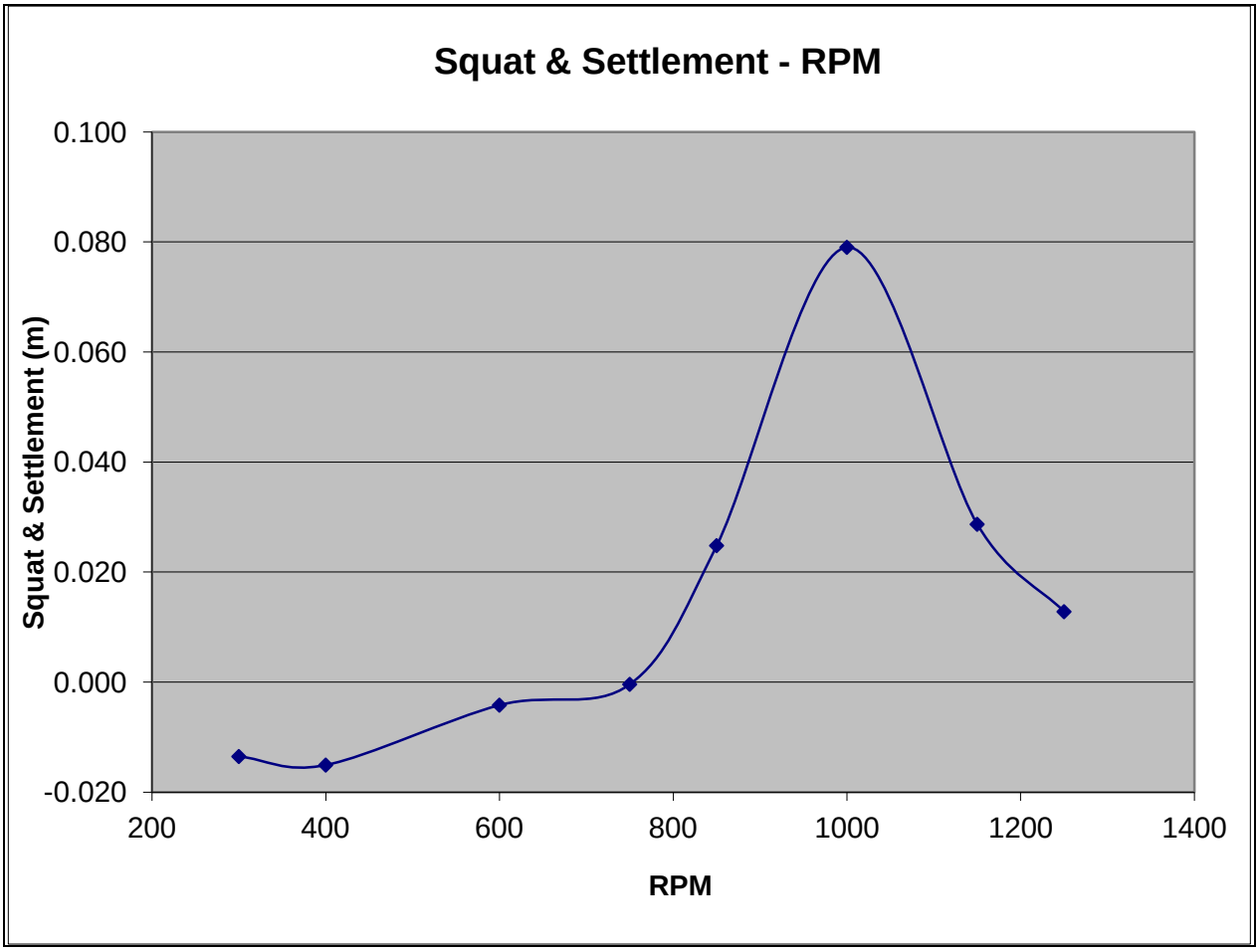


Figure 3-D2 Dynamic Draft

Table 8 D2 Squat Settlement Results

D2 DYNAMIC DRAFT CORRECTORS		
Speed (kts)	RPM	Settlement
3.1	300	-0.014
3.7	400	-0.015
3.8	600	-0.004
4.2	750	0.000
4.4	850	0.025
5.2	1000	0.079
5.2	1150	0.029
5.9	1250	0.013

The squat settlement test for the R/V D2 was conducted in the vicinity of Akun Bay, AK on July 31, 2011 (Julian Day 212).

Static Draft

Static draft was measured from tabs on both sides of the vessel, the average taken, and the correction to the common reference point applied. The tables below show the static draft values measured for all vessels.

Table 9 Draft Measurements for the F/V Pacific Star (7125)

DRAFT #	JULIAN DAY	DATE (UTC)	TIME (UTC)	DEPTH (m)
1	205	7/24/2011	14:25	-1.99
2	206	7/25/2011	15:29	-1.99
3	206	7/25/2011	4:18	-2.01
4	207	7/26/2011	15:19	-1.97
5	207	7/26/2011	2:58	-2.01
6	208	7/27/2011	15:19	-1.96
7	208	7/27/2011	3:11	-1.99
8	209	7/28/2011	16:16	-1.95
9	209	7/28/2011	2:38	-1.98
10	210	7/29/2011	3:40	-1.96
11	210	7/29/2011	16:22	-1.93
12	211	7/29/2011	3:03	-1.94
13	211	7/30/2011	15:19	-1.92
14	212	7/31/2011	15:21	-1.92
15	212	7/31/2011	3:29	-1.94
16	213	8/1/2011	5:05	-1.92
17	213	8/1/2011	21:25	-2.02
18	213	8/1/2011	15:49	-1.9
19	214	8/2/2011	15:43	-1.99
20	214	8/2/2011	3:30	-2.03
21	215	8/3/2011	17:36	-1.97
22	215	8/3/2011	3:03	-2.02
23	216	8/4/2011	15:24	-1.98
24	216	8/4/2011	3:05	-2.01
25	217	8/5/2011	16:06	-2
26	217	8/5/2011	3:27	-2
27	218	8/6/2011	15:24	-1.99

DRAFT #	JULIAN DAY	DATE (UTC)	TIME (UTC)	DEPTH (m)
28	219	8/7/2011	15:36	-2
29	219	8/7/2011	3:06	-2.01
30	220	8/8/2011	15:24	-1.99
31	220	8/8/2011	3:02	-2.01
32	221	8/9/2011	15:26	-2.01
33	221	8/9/2011	7:24	-1.98
34	222	8/10/2011	15:34	-1.97
35	222	8/10/2011	6:55	-1.99
36	223	8/11/2011	15:34	-1.96
37	223	8/11/2011	7:04	-1.98
38	224	8/12/2011	6:43	-1.97
39	226	8/14/2011	15:31	-1.84
40	226	8/14/2011	15:09	-1.87
41	226	8/14/2011	18:38	-1.82
42	226	8/14/2011	18:22	-1.82
43	226	8/14/2011	5:25	-1.86
44	227	8/15/2011	15:47	-1.81
45	227	8/15/2011	3:07	-1.85
46	228	8/16/2011	23:40	-1.95
47	228	8/16/2011	15:26	-1.81
48	228	8/16/2011	3:04	-1.84
49	229	8/17/2011	2:47	-2
50	229	8/17/2011	15:37	-1.96
51	230	8/18/2011	16:14	-1.94
52	230	8/18/2011	3:05	-1.97
53	230	8/18/2011	3:02	-1.97
54	231	8/19/2011	15:42	-1.98
55	231	8/19/2011	11:37	-2
56	231	8/19/2011	6:37	-2
57	232	8/20/2011	3:13	-2
58	232	8/20/2011	2:41	-2
59	232	8/20/2011	15:54	-1.97
60	233	8/21/2011	17:06	-1.96
61	234	8/22/2011	20:26	-1.98
62	234	8/22/2011	18:14	-1.96
63	234	8/22/2011	2:38	-1.99
64	234	8/22/2011	0:01	-1.96
65	235	8/23/2011	13:43	-1.97
66	235	8/23/2011	11:13	-1.98

DRAFT #	JULIAN DAY	DATE (UTC)	TIME (UTC)	DEPTH (m)
67	235	8/23/2011	21:07	-1.96
68	236	8/24/2011	15:59	-1.95

Table 10 Draft Measurements for the R/V R2 (7101)

DRAFT #	JULIAN DAY	DATE (UTC)	TIME (UTC)	DEPTH (m)
1	205	7/24/2011	19:05	-0.27
2	206	7/25/2011	15:43	-0.26
3	208	7/27/2011	15:24	-0.22
4	209	7/28/2011	16:23	-0.25
5	210	7/29/2011	15:36	-0.25
6	210	7/29/2011	22:51	-0.27
7	211	7/30/2011	15:20	-0.24
8	212	7/31/2011	15:22	-0.23
9	214	8/2/2011	15:53	-0.22
10	214	8/2/2011	0:45	-0.23
11	215	8/3/2011	16:01	-0.25
12	216	8/4/2011	15:21	-0.26
13	217	8/5/2011	15:49	-0.25
14	218	8/6/2011	15:32	-0.26
15	219	8/7/2011	15:34	-0.25
16	226	8/14/2011	15:43	-0.25
17	227	8/15/2011	15:46	-0.26
18	228	8/16/2011	15:33	-0.26
19	229	8/17/2011	15:40	-0.26
20	230	8/18/2011	16:12	-0.26
21	231	8/19/2011	15:50	-0.25
22	232	8/20/2011	16:13	-0.26
23	233	8/21/2011	17:15	-0.25
24	234	8/22/2011	18:31	-0.26
25	235	8/23/2011	16:40	-0.24

Table 11 Draft Measurements for the R/V D2 (7101)

DRAFT #	JULIAN DAY	DATE (UTC)	TIME (UTC)	DEPTH (m)
1	206	7/25/2011	15:39	-0.23
2	209	7/28/2011	15:16	-0.23

DRAFT #	JULIAN DAY	DATE (UTC)	TIME (UTC)	DEPTH (m)
3	210	7/29/2011	16:28	-0.22
4	212	7/31/2011	23:50	-0.18
5	213	8/1/2011	15:28	-0.22
6	214	8/2/2011	15:42	-0.22
7	215	8/3/2011	16:00	-0.21
8	216	8/4/2011	15:25	-0.21
9	217	8/5/2011	15:46	-0.21
10	218	8/6/2011	15:37	-0.21
11	220	8/8/2011	15:30	-0.21
12	220	8/8/2011	0:12	-0.21
13	221	8/9/2011	0:04	-0.16
14	221	8/9/2011	18:27	-0.21
15	222	8/10/2011	15:22	-0.2
16	223	8/11/2011	15:40	-0.18
17	226	8/14/2011	15:58	-0.21
18	227	8/15/2011	16:15	-0.2
19	228	8/16/2011	15:35	-0.2
20	229	8/17/2011	15:39	-0.21
21	231	8/19/2011	16:14	-0.2
22	232	8/20/2011	16:19	-0.22
23	233	8/21/2011	16:24	-0.21
24	235	8/23/2011	15:38	-0.1
25	236	8/24/2011	15:57	-0.19

Tides

All sounding data was reduced to MLLW initially using observed tidal data from three John Oswald and Associates (JOA) tide stations located in Akun Bay, Surf Bay and Trident Bay, AK, and one NOAA COOPS tide station located in Unalaska, AK. Tidal data for a twenty-four hour period UTC, (Alaska Daylight Time to UTC was +8 hours) was assembled by JOA and uploaded to their ftp site at the end of every Julian Day. A cumulative file for the gauges was updated each day by appending the new data. It should be noted that these unverified tides were used in the field for preliminary processing only. The NOAA supplied tidal zoning was modified by JOA, providing a more elaborate zoning scheme than those zones issued in the Statement of Work.

On November 14, 2011, JOA issued verified tidal data and final zoning for H12359, H12360, H12361, & H12362 of OPR-Q191-KR-11. All sounding data was then re-merged using CARIS HIPS and SIPS tide routine. Verified tidal data were used for all final Navigation BASE surfaces and S57 Feature files.

For additional information, refer OPR-Q191-KR-11 Horizontal and Vertical Control Report.

Vessel Attitude: Heading, Heave, Pitch, and Roll

Vessel heading and dynamic motion were measured by the Applanix (POS MV) 320 V4 on all vessels. The system calculated heading by inversing between two Trimble GPS generated antenna positions. An accelerometer block (the IMU), which measured vessel attitude, was mounted directly above the multibeam transducer.

Calibrations

Multibeam

For all vessel and sonar configurations, patch tests were conducted to identify alignment errors (timing, pitch, heading, and roll) between the motion sensor and the multibeam transducer(s). Patch test calibration values used to correct all soundings for the survey are shown in **Table 12**.

Table 12 Patch Test Results Summary

Patch Test Results						
Vessel	**Patch Test Day[1]**	**MB Sonar**	**Timing Error**	**Pitch Offset**	**Roll Offset**	**Azimuth Offset**
Pacific Star	JD207	7125 200 kHz	0.000	-0.700	-0.570	-0.500
	JD207	7125 400 kHz	0.000	0.020	-0.650	-1.300
R2	JD207	7101 240 kHz	0.000	-2.100	0.100	-2.080
D2	JD207	7101 240 kHz	0.000	-1.200	1.860	1.800

Additional Sounding Techniques

None.

[1] Julian day the actual test was done is listed. May be pre-dated in CARIS HVF to cover lines run before patch test.

D – Approval Sheet

Approval Sheet

For

H12359, H12360, H12361, & H12362

Standard field surveying and processing procedures were followed in producing this survey in accordance with the following documents:

OPR-Q191-KR-11 Statement of Work
NOS Hydrographic Surveys Specifications and Deliverables, April 2011 Edition
Fugro Pelagos, Inc. Acquisition Procedures (2011-MBES_Acquisition_Procedures_R0);
Fugro Pelagos, Inc. Processing Procedures (2011-MBES_Processing_Procedures_R0)

The data were reviewed daily during acquisition and processing, and the survey is complete and adequate for its intended purpose.

This report has been reviewed and approved. All records are forwarded for final review and processing to the Chief, Pacific Hydrographic Branch.

Approved and forwarded,

Dean Moyles, (ACSM Cert. No. 226)
Senior Hydrographer
Fugro Pelagos, Inc.
March 5, 2012

Dean Moyles

Digitally signed by Dean Moyles
DN: cn=Dean Moyles, o=FPI, ou=Marine, email=dmoyles@fugro.com, c=US
Date: 2012.03.03 14:03:51 -08'00'

Appendix I – Equipment List and Software Versions

Equipment

Table 13 Pacific Star Acquisition Equipment

Description	Serial Number
Applanix IMU LN200	49
Applanix POS MV Processor L1/L2 (RTK)	2354
GPS Antenna L1/L2 (Primary)	1441045154
GPS Antenna L1/L2 (Secondary)	1441043174
GPS CSI MBX-3 Coastguard Receiver (Primary)	9834-2211-0001
GPS CSI MBX-3 Coastguard Receiver (Secondary)	9830-2023-0001
GPS Beacon Antenna AT300 (Primary)	5702
GPS Beacon Antenna AT300 (Secondary)	5704
RESON NAVISOUND SVP 70 (Primary)	4506001
RESON NAVISOUND SVP 70 (Spare)	1008130
RESON 71-P Processor-7125 SV	1817003
Reson 7125 Receive Array	4107007
Reson 7125 400 KHz Projector	5006396
Reson 7125 200 KHz Projector	4408352
Fugro Pelagos Acquisition PC	BGR 602607
Winfrog Multibeam Dongle	3100441U
UHF Radio Modem (Boat to Boat)	075004326
AML SV Plus Velocity Probe 1000 dbar (SV1)	4820
AML SV Plus Velocity Probe 1000 dbar (SV2)	4703
Starboard WaterLOG H3611 (Draft Measurement)	1618
Port WaterLOG H3611 (Draft Measurement)	1581

Table 14 Launch R2 Acquisition Equipment

Description	Serial Number
Applanix IMU LN200	241
Applanix POS MV Processor L1/L2 (RTK)	2161
GPS Antenna L1/L2 (Primary)	1441043381
GPS Antenna L1/L2(Secondary)	1441045035
GPS CSI MBX-3 Coastguard Receiver	9834-2211-0002
GPS Beacon Antenna AT300	5701
RESON NAVISOUND SVP 70	2008042
RESON 7-1-P Processor-7101	4409002
RESON 7101 Transducer	2600002
Fugro Pelagos Acquisition PC	BGR 602605
Winfrog Multibeam Dongle	3100430U
AML SV Plus Velocity Probe 1000 dbar (SV1)	5353
AML SV Plus Velocity Probe 1000 dbar (SV2)	5282
UHF Radio Modem (Boat to Boat)	075004322

Table 15 Launch D2 Acquisition Equipment

Description	Serial Number
Applanix IMU LN200	730
Applanix POS MV Processor L1/L2 (RTK)	2355
GPS Antenna L1/L2 (Primary)	1441045035
GPS Antenna L1/L2(Secondary)	BGR603143
GPS CSI MBX-3 Coastguard Receiver	9833-2166-0001
GPS Beacon Antenna AT300	5703
RESON NAVISOUND SVP 70	2007073
RESON 7-1-P Processor-7101	3409002
RESON 7101 Transducer	210025
Fugro Pelagos Acquisition PC	BGR 602564
Winfrog Multibeam Dongle	3100433U
AML SV Plus Velocity Probe 1000 dbar (SV1)	4431
AML SV Plus Velocity Probe 1000 dbar (SV2)	4966
UHF Radio Modem (Boat to Boat)	075004327

Software

Table 16 Software List (Pacific Star, R2, D2, & Processing Center)

Software Package	Version	Service Pack	Hotfix
Fugro Pelagos WinFrog Multibeam	3.09.11	N/A	N/A
Fugro Pelagos MBSurvey Tools	2.00.31.00	N/A	N/A
Fugro Pelagos POSMVLogger	1.2	N/A	N/A
CARIS HIPS/SIPS	7.1	N/A	1-3
CARIS Notebook	3.1	1	N/A
CARIS Bathy DataBASE	3.1	N/A	N/A
ESRI ArcGIS	10.0.0	N/A	N/A
Applanix POS MV V4 Controller	3	N/A	N/A
Applanix POSPac MMS	5.4	2	N/A
IVS Fledermaus	6.7.0	N/A	N/A
Nobeltec Tides and Currents	3.5.107	N/A	N/A
Microsoft Office	2007 Professional	N/A	N/A
Microsoft Windows	7	N/A	N/A
Helios Software Solutions Textpad	5.2.0	N/A	N/A
IrfanView	4.25	N/A	N/A

Appendix II – Vessel Descriptions

F/V Pacific Star

The F/V Pacific Star **(Figure 4 & Figure 8),** a former Bering Sea crab fishing vessel, was modified to accommodate a survey crew, acquisition hardware, and survey launches. Living quarters and office space containers were installed on the back deck. Davits previously used on the R/V Davidson were installed near the aft end of the vessel to lift and deploy the R2 and D2 survey launches. Access doors and infrastructure were built to facilitate access to the launches.

A Reson Seabat 7125 multibeam sonar was hull mounted near the best estimate of the vessel's center of gravity, approximately amidships. A false keel was installed on the vessel and a 7125 sonar with sound velocity probes was mounted within the keel. The false keel provided the sonar protection from damage and limited interference. (**Figure 7**). The inertial measurement unit (IMU) for the POS MV was installed inside the hull directly above the Reson 7125.

Table 17 Vessel Specifications (F/V Pacific Star)

SURVEY VESSEL F/V PACIFIC STAR	
Owner	Pacific Star Fisheries, LLC
Official Number	556510
Length	162'
Breadth	38'
Depth	14'
Max Draft	16'
BHP Main Engines	3,000 combined BHP (1500 ea) Two Electromotive Diesels
Gross Tonnage (US)	194
Fresh Water Capacity	24,399 Gallons
Fuel Capacity	90,112 Gallons

Figure 4 F/V Pacific Star

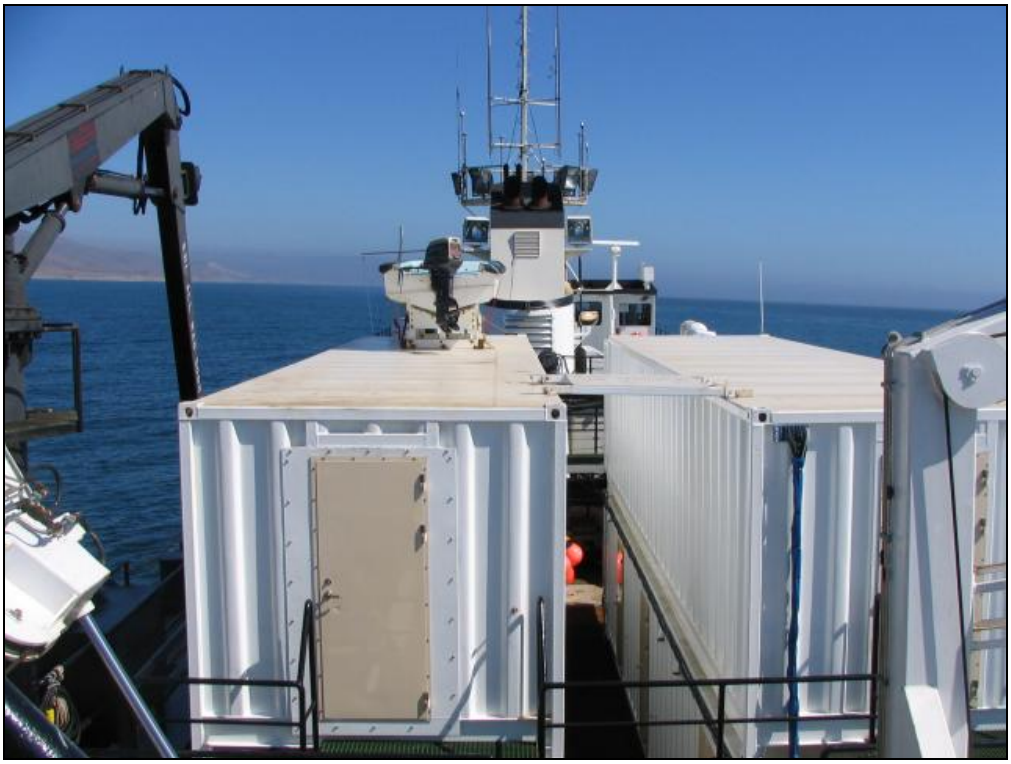


Figure 5 F/V Pacific Star Office Containers

Figure 6 F/V Pacific Star Davit Launch System

Figure 7 F/V Pacific Star Drop Keel with 7125

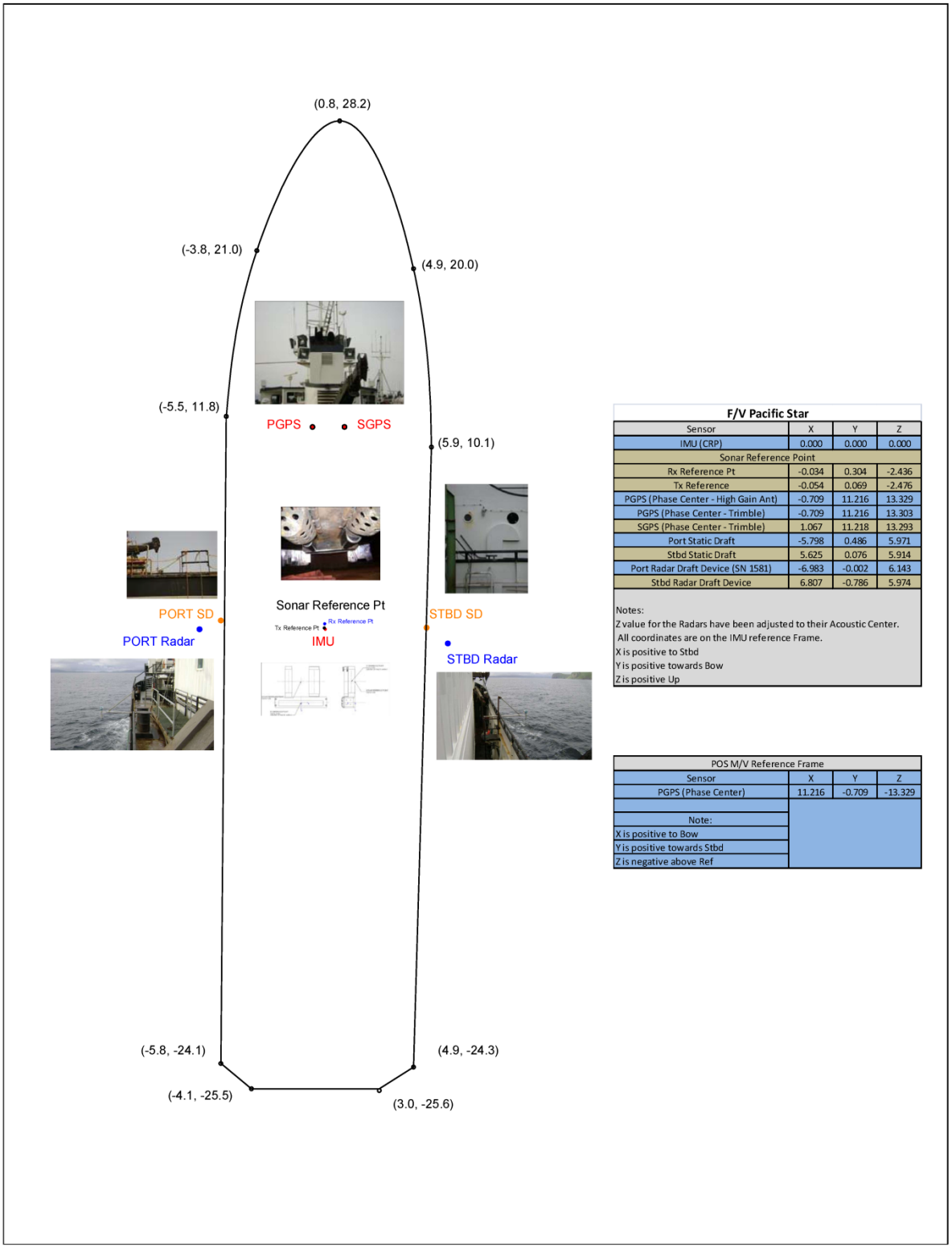
Two Trimble L1/L2 antennas were mounted above and forward from the sonar. Offset 1.8 meters port-starboard from each other, the L1/L2 antennas provided GPS data to the POS MV for position, attitude, and heading computations. The port side antenna functioned as the POS MV master antenna; the starboard side antenna functioned as the POS MV secondary.

The AML Smart Probe SV&P sensors were deployed from an A-Frame on the stern using a small hydraulic winch.

Draft measurement tabs were installed at convenient measurement stations on both the port and starboard sides of the vessel, in line with the CRP and Reson 7125. WaterLOG H3611 (Radar Water Level Sensors) were installed on the port and starboard gunwales of F/V Pacific Star to obtain a more precise static draft measurement. At times when the radar system was offline, traditional static draft measurement techniques were employed.

Offset values for the CRP to the sonar and waterline were applied to the data in CARIS HIPS as specified in the HIPS vessel file (HVF). Offsets between the GPS antennas and the CRP were applied internally by the POS MV by entering a GPS lever arm offset. Note that the HVF does not contain navigation offsets, because the position provided by the POS MV is already corrected to the CRP. Vessel offsets used are shown in the offset diagram (**Figure 9**).

Figure 8 F/V Pacific Star



F/V Pacific Star

Sensor	X	Y	Z
IMU (CRP)	0.000	0.000	0.000
Sonar Reference Point			
Rx Reference Pt	-0.034	0.304	-2.436
Tx Reference	-0.054	0.069	-2.476
PGPS (Phase Center - High Gain Ant)	-0.709	11.216	13.329
PGPS (Phase Center - Trimble)	-0.709	11.216	13.303
SGPS (Phase Center - Trimble)	1.067	11.218	13.293
Port Static Draft	-5.798	0.486	5.971
Stbd Static Draft	5.625	0.076	5.914
Port Radar Draft Device (SN 1581)	-6.983	-0.002	6.143
Stbd Radar Draft Device	6.807	-0.786	5.974

Notes:
Z value for the Radars have been adjusted to their Acoustic Center.
All coordinates are on the IMU reference Frame.
X is positive to Stbd
Y is positive towards Bow
Z is positive Up

POS M/V Reference Frame			
Sensor	X	Y	Z
PGPS (Phase Center)	11.216	-0.709	-13.329
Note:			
X is positive to Bow			
Y is positive towards Stbd			
Z is negative above Ref			

Figure 9 F/V Pacific Star Offset Diagram

R/V R2

The R/V R2 **(Figure 10),** a Pacific Star launch, was modified to accommodate a survey crew and acquisition hardware. The keel was cut just aft of mid-ship and a Reson 7101 multibeam sonar was installed. A conical cowling protected the sonar head forward and aft by way of a crescent shaped skid. The accelerometer package for a POS MV was mounted in the bilge of the vessel just over the 7101 multibeam transducer head.

Two Trimble L1/L2 antennas were mounted above the 7101 for positioning and heading. The two POS MV antennas were offset 2.0m port-starboard from each other. The port side antenna (L1/L2) functioned as the POS MV master antenna; the starboard side antenna functioned as the POS MV secondary.

The AML Smart Probe SV&P sensors were deployed from an A-Frame on the stern using a small hydraulic winch.

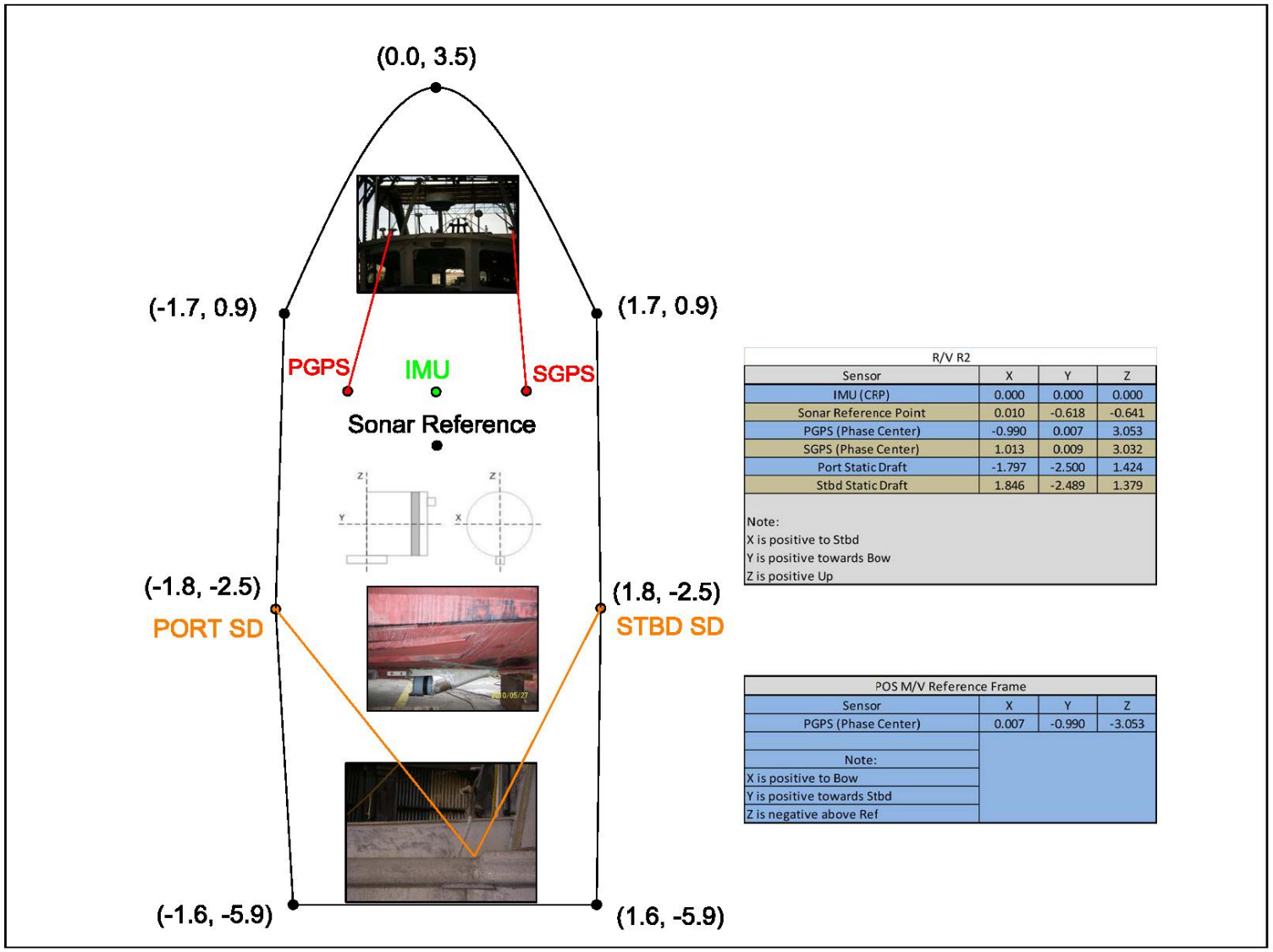
Draft measurement points were indentified at convenient measurement stations on both the port and starboard sides of the vessel, aft of the CRP and Reson 7101.

Offset values for the CRP to the sonar and waterline were applied to the data in CARIS HIPS as specified in the HIPS vessel file (HVF). Offsets between the GPS antennas and the CRP were applied internally by the POS MV by entering a GPS lever arm offset. Note that the HVF does not contain navigation offsets, because the position provided by the POS MV is already corrected to the CRP. Vessel offsets used are shown in the offset diagram **(Figure 11)**.

Figure 10 R/V R2

Table 18 Vessel Specifications (R2)

SURVEY LAUNCH R/V R2	
Owner	Stabbert Maritime Yacht & Ship
Official Number	623241
Year Built	1980/1982
Length	28.9’
Beam	12’
Draft	3’
Gross Tonnage	15
Net Tonnage	13
Mechanical Power	Caterpillar 3208
Electrical	Northern Lights



R/V R2			
Sensor	X	Y	Z
IMU (CRP)	0.000	0.000	0.000
Sonar Reference Point	0.010	-0.618	-0.641
PGPS (Phase Center)	-0.990	0.007	3.053
SGPS (Phase Center)	1.013	0.009	3.032
Port Static Draft	-1.797	-2.500	1.424
Stbd Static Draft	1.846	-2.489	1.379

Note:
X is positive to Stbd
Y is positive towards Bow
Z is positive Up

POS M/V Reference Frame			
Sensor	X	Y	Z
PGPS (Phase Center)	0.007	-0.990	-3.053

Note:
X is positive to Bow
Y is positive towards Stbd
Z is negative above Ref

Figure 11 R/V R2 Offset Diagram

R/V D2

The R/V D2 **(Figure 12)**, a Pacific Star launch, was modified to accommodate a survey crew and acquisition hardware. The keel was cut just aft of mid-ship and a Reson 7101 multibeam sonar was installed. A conical cowling protected the sonar head forward and aft by way of a crescent shaped skid. The accelerometer package for a POS MV was mounted in the hull of the vessel just over the 7101 multibeam transducer head.

Two Trimble L1/L2 antennas were mounted above the 7101 and accelerometer for positioning and heading. The two POS MV antennas were offset 2.0m port-starboard from each other. The port side antenna (L1/L2) functioned as the POS MV master antenna; the starboard side antenna functioned as the POS MV secondary.

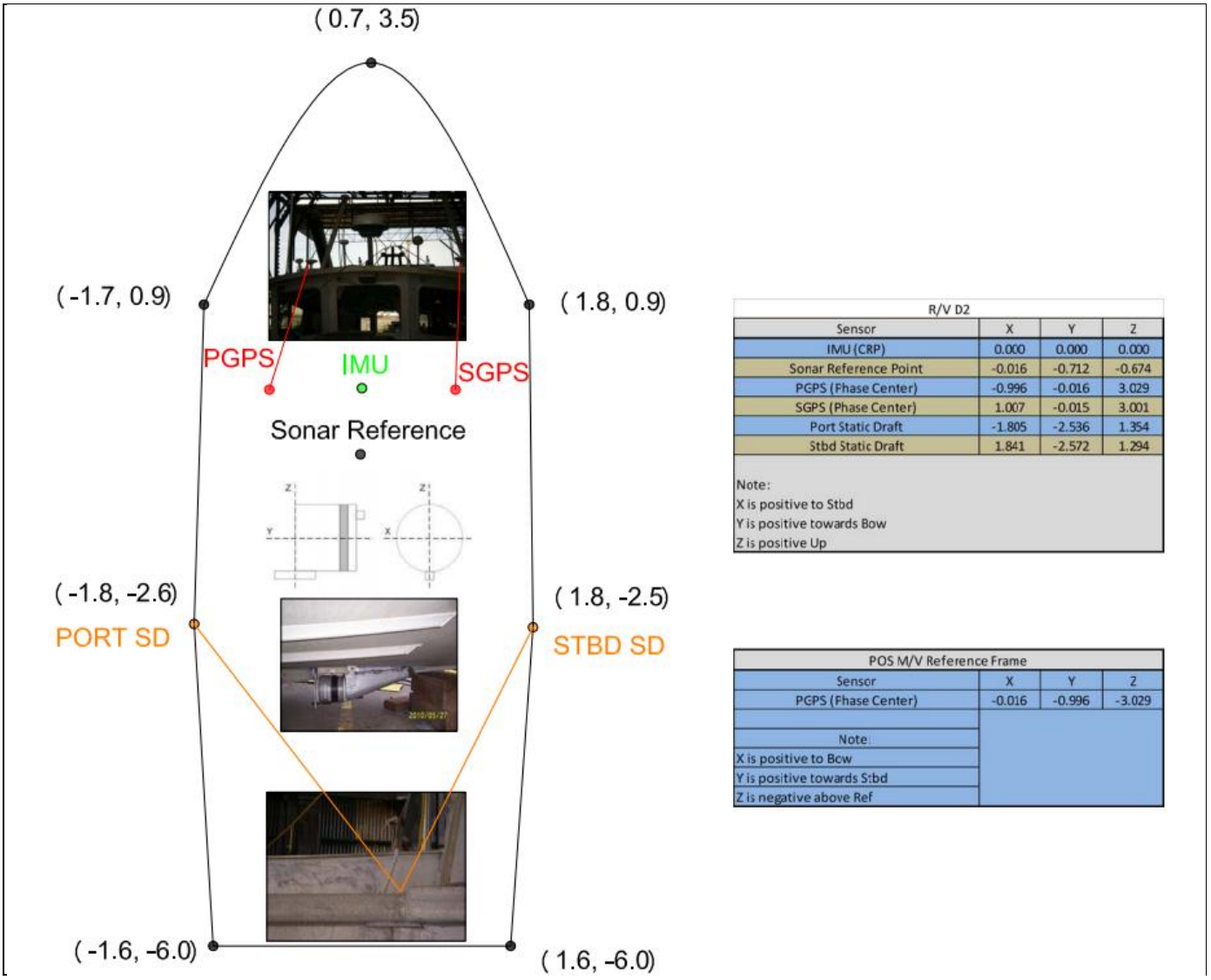
The AML Smart Probe SV&P sensors were deployed from an A-Frame on the stern using a small hydraulic winch.
Draft measurement points were indentified at convenient measurement stations on both the port and starboard sides of the vessel, aft of the CRP and Reson 7101.

Offset values for the CRP to the sonar and waterline were applied to the data in CARIS HIPS as specified in the HIPS vessel file (HVF). Offsets between the GPS antennas and the CRP were applied internally by the POS MV by entering a GPS lever arm offset. Note that the HVF does not contain navigation offsets, because the position provided by the POS MV is already corrected to the CRP. Vessel offsets used are shown in the offset diagram (**Figure 13**).

Figure 12 R/V D2

Table 19 Vessel Specifications (D2)

SURVEY LAUNCH R/V D2	
Owner	Stabbert Maritime Yacht & Ship
Official Number	647782
Year Built	1980/1982
Length	28.9’
Beam	12’
Draft	3’
Gross Tonnage	15
Net Tonnage	13
Mechanical Power	Caterpillar 3208
Electrical	Northern Lights



R/V D2			
Sensor	X	Y	Z
IMU (CRP)	0.000	0.000	0.000
Sonar Reference Point	-0.016	-0.712	-0.674
PGPS (Phase Center)	-0.996	-0.016	3.029
SGPS (Phase Center)	1.007	-0.015	3.001
Port Static Draft	-1.805	-2.536	1.354
Stbd Static Draft	1.841	-2.572	1.294

Note:
X is positive to Stbd
Y is positive towards Bow
Z is positive Up

POS M/V Reference Frame			
Sensor	X	Y	Z
PGPS (Phase Center)	-0.016	-0.996	-3.029
Note:			
X is positive to Bow			
Y is positive towards Stbd			
Z is negative above Ref			

Figure 13 R/V D2 Offset Diagram

Appendix III – Calibration Reports

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