SINGLE-BEAM BATHYMETRIC DATA NEAR STEBBINS, ALASKA, COLLECTED JULY 10-11, 2022

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Raw Data File 2023-10

Photo of M2Ocean Hydroball sensor towed behind a boat near Stebbins, Alaska, on July 10, 2022. Photo: Alaska Division of Geological & Geophysical Surveys.

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DEPARTMENT OF NATURAL RESOURCES
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SINGLE-BEAM BATHYMETRIC DATA NEAR STEBBINS, ALASKA, COLLECTED JULY 10-11, 2022

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INTRODUCTION

The Alaska Division of Geological & Geophysical Surveys (DGGS) collected bathymetric data near Stebbins, Alaska, on July 10 and 11, 2022 (fig. 1). The purpose of this survey is to provide bathymetric data for the assessment of coastal hazards and riverine erosion studies. These data were collected using an M2Ocean Hydroball integrated bathymetric sensor and processed using CIDCO DepthStar software. Coincident Global Navigation Satellite System (GNSS) base station and water level time series data were collected using Trimble survey equipment and Solinst Levelogger pressure and temperature sensors, respectively, to correct horizontal and vertical positions. This data product does not meet the International Hydrographic Organization (IHO) bathymetric coverage standard (IHO, 2022), is not intended to determine navigability, and is released as a Raw Data File with an open end-user license. All files can be downloaded from https://doi.org/10.14509/31008.

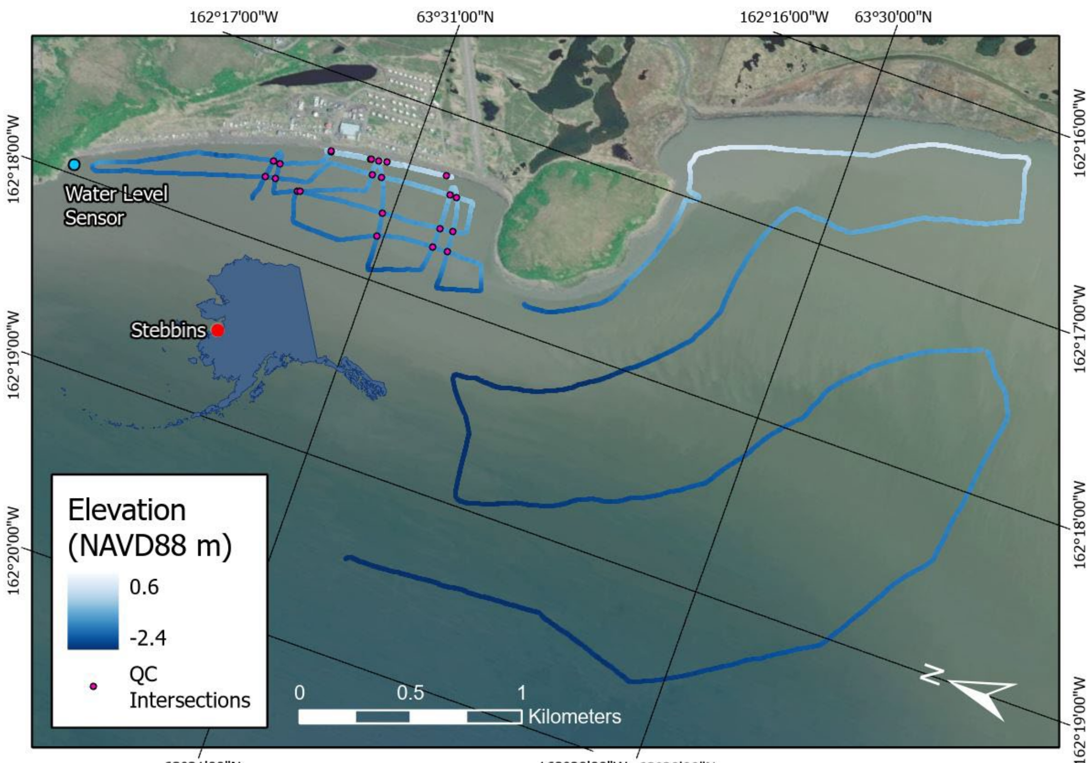

Figure 1. Map of bathymetric soundings near Stebbins, Alaska.

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LIST OF DELIVERABLES

- Bathymetric sounding data
- Data dictionary
- Metadata

METHODS

Field Collection

DGGS used an M2Ocean Hydroball bathymetric sensor, composed of an Imagenex 852 single-beam echosounder (SBES), a Tallysman TW3972 GNSS antenna, and a Honeywell HMR3000 inclinometer to collect field data. On July 10 and 11, 2022, DGGS temporarily installed a Trimble R10 receiver sampling at 5 Hz as a GNSS base station over temporary benchmarks. Base station data were used to correct the HydroBall sensor positions. To provide water level corrections, DGGS collected derived water level time series data from two temporarily installed Solinst model 3001 Levelogger IEdge LT M10/F30 pressure and temperature sensors, one fully submerged approximately 22 m offshore northwest of Stebbins (fig. 2) and the other placed in a dry, shaded location on land.

Figure 2. Solinis Levelogger instalation offshore near Stebbins, Alaska

Survey Details

The bathymetric survey was performed on July 10 and 11, 2022, from 11:55 AM to 1:30 PM and 3:00 PM to 4:45 PM AKDT, respectively. The weather during the survey on July 10 was mostly clear, with little to no wind and calm waters. The weather during the survey on July 11 was overcast, with light wind and wave heights under 0.25 m. The Hydroball was attached to a catamaran configuration and towed behind a small boat equipped with an outboard motor at speeds below 4 knots during the first portion of the survey on July 10 and throughout the survey on July 11. The Hydroball, in the catamaran configuration, was hand towed approximately 5 m from the shore during the second portion of the survey on July 10. The Imagenex 852 SBES was configured with a maximum range of 20 m, gain of 5 dB, and pulse length of 120 microseconds. Due to time and vessel constraints, the bathymetric survey was performed using a survey pattern inconsistent with the requirements outlined in the IHO standards (IHO, 2022). Approximately 22.0 km of near-shore marine bathymetry were surveyed.

Data Processing

Base positions were corrected using Online Positioning User Service (OPUS) solutions, which were used to update the Hydroball sensor positions using post-processed kinematic (PPK) adjustments from RTKLIB version 2.4.2 software with the following settings applied: L1+L2 frequencies forward and backward filtered; a 10-degree elevation mask; broadcast ionosphere and Saastamoinen troposphere corrections; a minimum fixed ambiguity ratio of 3; and L1/L2 code/carrier-phase error ratios of 100. During post-processing, DGGS applied International GNSS Service (IGS) precise orbits and final clock solutions retrieved from the Crustal Dynamics Data Information System (CDDIS) available from https://urs.earthdata.nasa.gov/. Final corrected data were exported as time-stamped position files in the WGS84 horizontal coordinate system with ellipsoidal heights.

DGGS collected temperature-compensated pressure-time series data from July 10 at 10:48 AM to July 11 at 1:48 PM AKDT at synchronized 5-minute intervals on the two Levelogger sensors. Using a barometric (millibar) to water column equivalent (meter) conversion of 1.0 mb = 0.0101972 m, DGGS converted both the submerged Levelogger and the dry air Levelogger data. Subtracting the dry air pressures in water column equivalent pressures from the submerged water column equivalent pressures provides the barometrically compensated water level. These data were then adjusted to the vertical datum NAVD88 (GEOID12B) elevation of the submerged sensor location, converted to Coordinated Universal Time (UTC), sampled to the hour to reduce excess noise due to water turbulence, and interpolated to the second using a 4-degree Lagrange interpolating polynomial,

$$z = \sum_{j}^{4} f_j(t), \qquad f_j(t) = z_j \prod_{\substack{k=1 \\ k \neq j}}^{4} \frac{t - t_k}{t_j - t_k}$$

where z_j is the observed water level elevation, t_j is the observation time, t_k represents the other three primary times used in the calculation, and z is the interpolated water level elevation at time t (fig. 3).

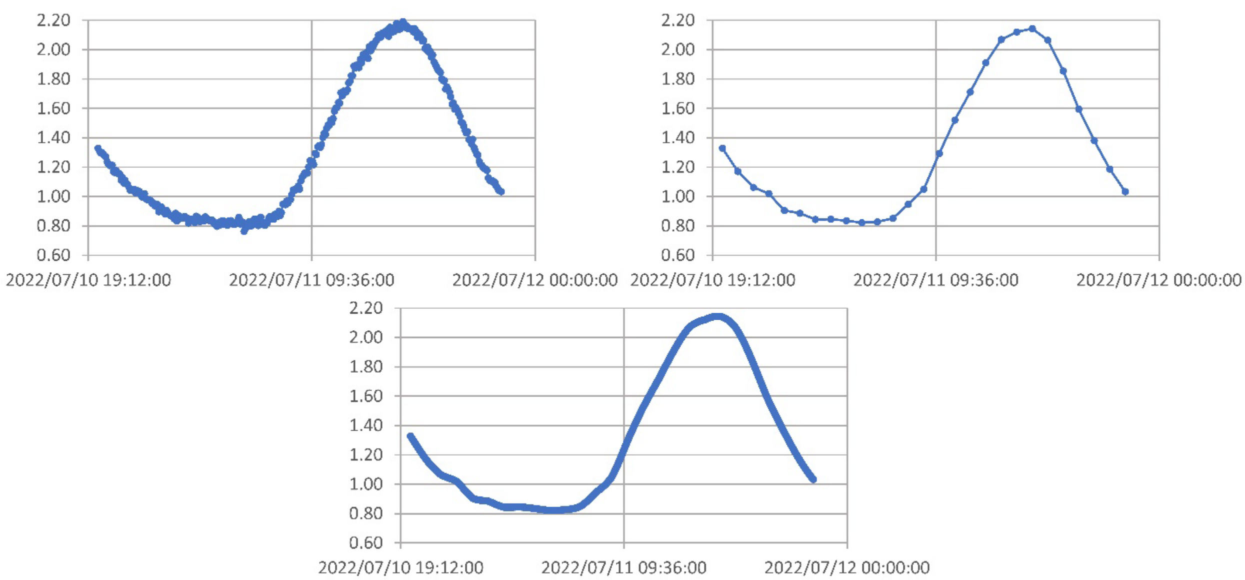

Figure 3. Comparison of 5-minute (top-left), per hour (top-right), and per second (bottom) water level elevation data throughout the survey.

Using CIDCO DepthStar software, DGGS imported the Hydroball device file containing raw GNSS position, SBES depth, and inclinometer gyrocompass data. These data were corrected to the 0.115 m catamaran draft and 0.364 m GNSS antenna reference point offset from the SBES acoustic center. These data were then georeferenced to the corrected PPK positions and interpolated water level time series using the water level reference survey (WLRS) sounding reduction method, applying a sound velocity correction of 1500 m/s (salt-water default value) to all data. The final soundings were exported with WGS84 horizontal coordinates and NAVD88 (GEOID12B) elevations. These data were projected to the horizontal coordinate system NAD83 (2011) UTM Zone 3 North using Esri ArcGIS Pro version 3.0.2 software.

Data Formatting

All data were delivered in comma-delimited (CSV) format with column headers and accompanied by a data dictionary detailing the header names, definitions, and applicable units.

Coordinate System and Datum

All data were processed in the horizontal coordinate system WGS84 and vertical datum NAVD88 (GEOID12B). All data were delivered in the horizontal coordinate system NAD83 (2011) UTM Zone 3 North and vertical datum NAVD88 (GEOID12B).

ACCURACY REPORT

Using the IHO minimum bathymetric standards (IHO, 2022) would be inappropriate for assessing these data, which do not meet the IHO-prescribed systematic survey pattern criteria. DGGS has developed an order of accuracy criteria for the qualification of bathymetric survey data separate from but based on the IHO standards to avoid misinterpretation. The reported accuracy of these data is intended to express quality only and should not be considered sufficient for safe navigation.

Horizontal Accuracy

We quantified the horizontal accuracy of the GNSS position data using the latitudinal and longitudinal peak-to-peak errors provided by OPUS (table 1). Consistent with OPUS shared solution requirements (NOAA, 2022), DGGS considers high-quality GNSS solutions to have latitudinal and longitudinal errors less than or equal to 0.04 m.

We quantified the horizontal accuracy of individual depth soundings using the maximum manufacturer-reported angular accuracy of the Honeywell HMR3000 inclinometer, 0.6 degrees. DGGS applied the following formula to determine the horizontal accuracy for each depth sounding,

$$\pm\Delta(d) = d \tan 0.6°$$

where $\pm\Delta$ is the horizontal uncertainty and d is the sounding depth at a given location.

We categorized the quality of depth sounding data by order of accuracy based on the maximum Total Horizontal Uncertainty (THU) derived from the following formula (IHO, 2022),

$$THU_{max} = \min_{i\,\in[1,n]}(a + bd_i)$$

where a represents the portion of uncertainty that does not vary with depth, b is a coefficient that represents the portion of uncertainty that varies with depth, d_i is the sounding depth at a given location, and n is the total number of soundings. These data meet DGGS 1st Order standards (table 3) with a 2-dimensional (position) 95 percent confidence level of 0.020 m.

Vertical Accuracy

We quantified the vertical accuracy of the GNSS position data using the combined ellipsoidal height peak-to-peak errors provided by OPUS and ortho height RMS error provided by NOAA's Vertical Datum Transformation software. Consistent with OPUS shared solution requirements (NOAA, 2022), DGGS considers high-quality GNSS solutions to have vertical errors less than or equal to 0.08 m.

We quantified the vertical accuracy of individual depth soundings using the manufacturer-reported range resolution, 0.02 m, as a percentage of the maximum range, 50.00m, of the Imagenex 852 single-beam echosounder. DGGS applied the following formula to determine the vertical accuracy for each depth sounding,

$$\pm\Delta(d) = \frac{0.02}{50.00} d$$

where $\pm\Delta$ is the vertical uncertainty and d is the sounding depth at a given location.

We categorized the quality of depth sounding data by order of accuracy based on the maximum Total Vertical Uncertainty (TVU) derived from the following formula (IHO, 2022),

$$TVU_{max} = \min_{i \in [1,n]} \left(\sqrt{a^2 + (bd_i)^2} \right)$$

where a represents the portion of uncertainty that does not vary with depth, b is a coefficient that represents the portion of uncertainty that varies with depth, d_i is the sounding depth at a given location, and n is the total number of soundings. These data meet DGGS 1st Order standards (table 3) with a 1-dimensional (depth) 95 percent confidence level of 0.001 m.

Overall Accuracy

We quantified the overall accuracy of the bathymetric data using the vertical separation of overlapping point-to-point 3-dimensional lines within the data. These data intersected 24 times in total, with a separation range between 0.001 m and 0.131 m, average separation of 0.040 m, and median Separation of 0.032 m (fig. 4). Overall vertical error is calculated as the root-mean-square (RMS) error of the offsets at these intersection points, with a total vertical error of 0.035 m (table 2). These data meet DGGS 1st Order standards (table 3) with a 1-dimensional (depth) 95 percent confidence level of 0.071 m.

Data Consistency and Completeness

DGGS filtered out low-quality, non-differential (single) GNSS position data using standard categorization (single, float, fixed). All 0.0 m depth soundings, excessive noise, and vertical anomalies were removed through visual inspection. DGGS used time series data for depth and attitude (pitch and yaw) to manually remove anomalous soundings and any sounding reporting an attitude deviation larger than twenty degrees. No significant erroneous areas requiring repair were identified during this quality control process.

Base station data were processed using the OPUS static processing service, which derives GNSS coordinates from the average of three independent, single-baseline solutions, each computed by double-differenced carrier-phase measurements from three nearby National Continuously Operating Reference Stations (CORS). OPUS provides the range of the three individual single baselines, known as the peak-to-peak error. These ranges include any errors from the CORS used during processing (NOAA, 2022).

OPUS ortho height ranges are estimated using the same calculations applied to horizontal error reporting, typically resulting in a much larger potential error compared to the peak-to-peak error of the ellipsoid height. For more accurate ortho height error reporting, DGGS used NOAA's Vertical Datum Transformation software for final elevation conversions from NAD83 (2011) ellipsoidal heights to NAVD88 (GEOID12B) ortho heights. This software employs accurate, multi-parameter mathematical equations and location-specific grid models to perform vertical transformations and report the total root-mean-square error (NOAA, 2016).

Table 1. Base station coordinates and GNSS errors.

NAD83 (2011) Easting	NAD83 (2011) Northing	NAVD88 Elevation	GNSS X Error (m)	GNSS Y Error (m)	GNSS Z Error (m)
635146.731	7046747.037	16.902	0.007	0.022	0.067
634856.531	7046213.615	4.722	0.011	0.005	0.069

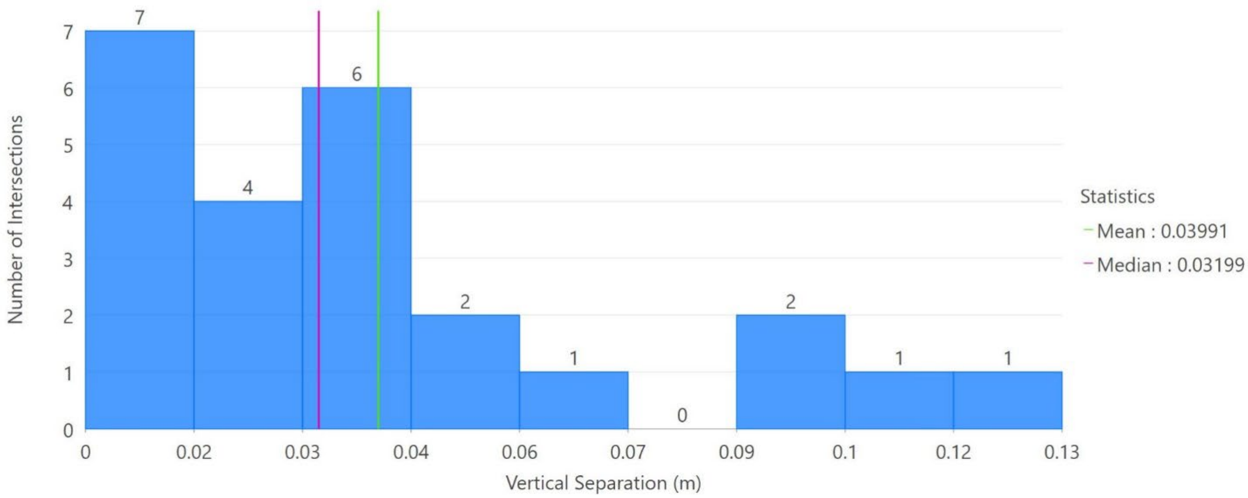

Figure 4. Histogram and summary statistics of vertical separation at data intersections.

Table 2. Survey intersection locations and vertical separations.

NAD83 (2011) Easting	NAD83 (2011) Northing	NAVD88 Vertical Separation (m)
634556.9043	7046440.6807	0.001
634552.7550	7045779.1735	0.004
634610.5361	7046048.8086	0.005
634557.1418	7045709.9015	0.006
634641.6140	7046589.0988	0.009
634644.3102	7046557.7695	0.011
634561.0345	7046428.7986	0.013
634753.0291	7046155.0421	0.019
634797.7314	7045796.1645	0.022
634820.9070	7046152.2761	0.025
634828.2774	7046114.2342	0.025
634650.8640	7045722.4952	0.031
634814.9682	7046183.6017	0.033
634575.5995	7046550.4953	0.033
634562.6035	7046598.2780	0.036

NAD83 (2011) Easting	NAD83 (2011) Northing	NAVD88 Vertical Separation (m)
634505.0594	7046029.7580	0.037
634641.3013	7045782.0704	0.044
634815.0970	7046183.1976	0.048
634758.4671	7046110.0862	0.056
634871.8062	7045842.9615	0.059
634814.5819	7046186.4343	0.097
634815.0821	7046183.2808	0.101
634800.5658	7045764.4481	0.111
634777.3317	7046365.2913	0.131
	Mean	**0.040**
	Median	**0.032**
	Standard Deviation	**0.036**
	95% Confidence Level	**0.071**
	Root-Mean-Square Error	**0.035**

Table 3. DGGS order of accuracy criteria.

Criteria	4th Order	3rd Order	2nd Order	1st Order
THU	$a = 20\ m$ $b = 0.10$	$a = 5\ m$ $b = 0.05$	$a = 2\ m$ $b = 0.00$	$a = 1\ m$ $b = 0.00$
TVU	$a = 1.00\ m$ $b = 0.0230$	$a = 0.50\ m$ $b = 0.0130$	$a = 0.25\ m$ $b = 0.0075$	$a = 0.15\ m$ $b = 0.0075$
$\boldsymbol{THU_{max}}$	**20.035 m**	**5.018 m**	**2.000 m**	**1.000 m**
$\boldsymbol{TVU_{max}}$	**1.000 m**	**0.500 m**	**0.250 m**	**0.150 m**

ACKNOWLEDGMENTS

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