W00508

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

DESCRIPTIVE REPORT

Type of Survey:	Basic Hydrographic Survey
Registry Number:	W00508

LOCALITY

State(s):	American Samoa
General Locality:	American Samoa
Sub-locality:	Pago Pago, Aunuu Island and Tau Island

2019

CHIEF OF PARTY
Val Schmidt

LIBRARY & ARCHIVES

Date:

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

REGISTRY NUMBER:

HYDROGRAPHIC TITLE SHEET

W00508

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(s):	**American Samoa**
General Locality:	**American Samoa**
Sub-Locality:	**Pago Pago, Aunuu Island and Tau Island**
Scale:	**20000**
Dates of Survey:	**07/26/2019 to 08/01/2019**
Instructions Dated:	**11/15/2021**
Project Number:	**ESD-PHB-20**
Field Unit:	**Ocean Exploration Trust**
Chief of Party:	**Val Schmidt**
Soundings by:	**Kongsberg Maritime EM 2040** (**MBES**)
Imagery by:	**Kongsberg Maritime EM 2040** (**MBES Backscatter**)
Verification by:	**Pacific Hydrographic Branch**
Soundings Acquired in:	**meters at Mean Lower Low Water**

Remarks:

Any revisions to the Descriptive Report (DR) applied during office processing are shown in red italic text. The DR is maintained as a field unit product, therefore all information and recommendations within this report are considered preliminary unless otherwise noted. The final disposition of survey data is represented in the NOAA nautical chart products. All pertinent records for this survey are archived at the National Centers for Environmental Information (NCEI) and can be retrieved via https://www.ncei.noaa.gov/. Products created during office processing were generated in WGS84 UTM 2S, MLLW. All references to other horizontal or vertical datums in this report are applicable to the processed hydrographic data provided by the field unit.

DESCRIPTIVE REPORT MEMO

November 15, 2021

MEMORANDUM FOR: Pacific Hydrographic Branch

FROM: Report prepared by PHB on behalf of field unit
Lindsay Gee
Seafloor mapper, Ocean Exploration Trust

SUBJECT: Submission of Survey W00508

The survey area is found in the South Pacific in American Samoa. Pago Pago Harbor was surveyed, as well as a section east of Aunuu Island and a third section east of Tau Island . The data was collected as part of a shakedown for a larger survey in the South Pacific done with Ocean Exploration Trust and the Nautilus Team. RTK quality positioning was used, with a modern multibeam sonar.

A large earthquake M 8.1 and tsunami occurred in 2009 (Jaffe, 2009, Dunbar et al., 2015, Kong et al., 2015) after the last surveys applied to the Chart were collected in 2004 and 2006, but before this survey was conducted in 2019.

The appended report does not include information about the survey areas east of Aunuu and Tau Islands.

This survey produced processed soundings, gridded bathymetry, and backscatter mosaics.

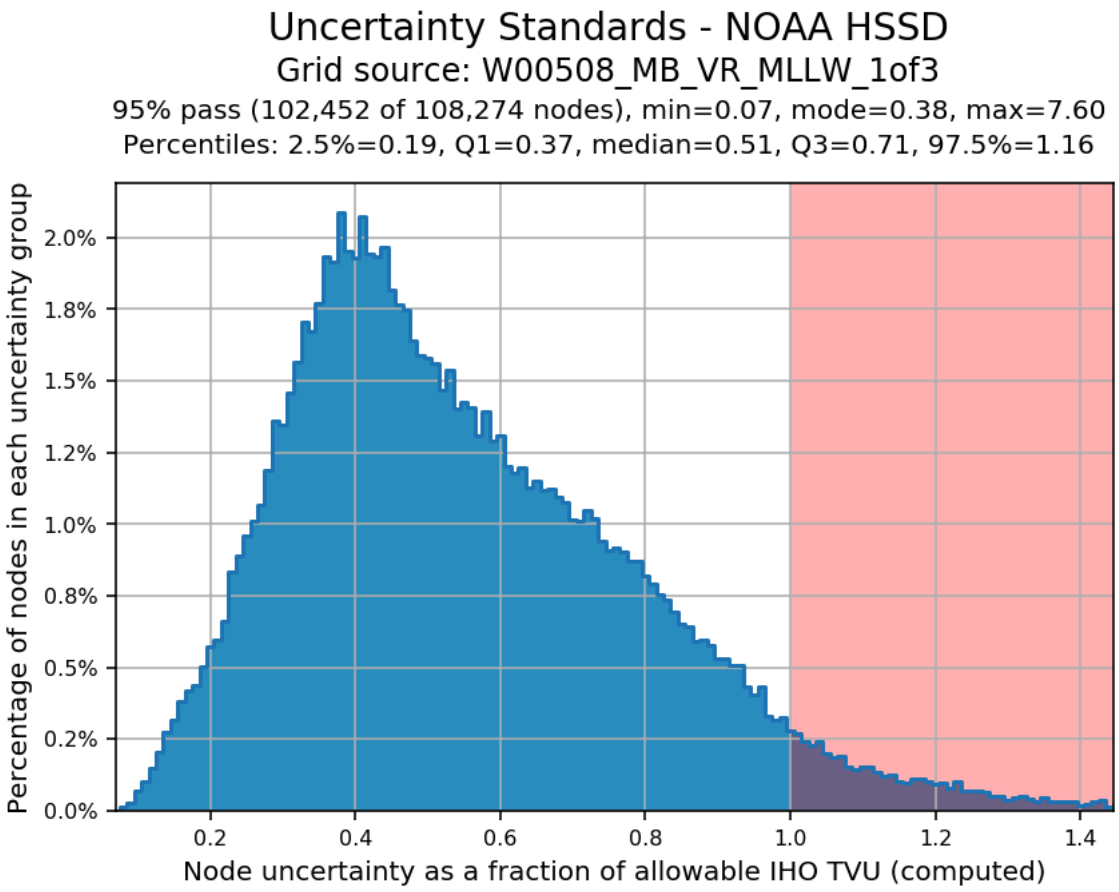
All soundings were reduced to Mean Lower Low Water using VDatum. The horizontal datum for this project is World Geodetic System (WGS) 1984. The projection used for this project is Universal Transverse Mercator (UTM) Zone 2.

There is no document that includes typical DAPR documentation, but the attached report contains similar information as a typical DR.

All data were reviewed for DTONs and none were identified in this survey.

UNH, CCOM acquired the data outlined in this report. Additional documentation from the data provider may be attached to this report.

This dataset contains hi-quality MBES and feature detection capability. The calculated gridded uncertainty within Pago Pago harbor, once finished with review at the processing branch, is different than shown later in the appended DR. See included uncertainty graph below for the updated uncertainty histogram.



Uncertainty histogram for survey in Pago Pago Harbor

This survey does meet charting specifications and is adequate to supersede prior data.

CCOM /OET ASV *BEN*
Pago Pago, American Samoa Survey
NA112: Descriptive Report

University of New Hampshire
Center for Coastal and Ocean Mapping
Joint Hydrographic Center

LOCALITY:

Territory: American Samoa

General Locality: Southern Pacific Ocean

Sub-Locality: Pago Pago Harbor, American Samoa

Year: 2019

Survey Dates: July 26, 2019

Contacts: Val Schmidt, CCOM, UNH
Survey done in conjunction with Ocean Exploration Trust(OET) and the RV Nautilus, contact: Lindsay Gee

Field Unit:	UNH ASV *BEN*
Soundings by:	Kongsberg EM 2040P
Imagery by:	Kongsberg EM 2040P
Soundings Acquired in:	Meters at WGS84
Final Product:	Meters at MLLW
Projection:	WGS84 UTM zone 2S

A. Area Surveyed

The survey area is found in the South Pacific in American Samoa. Pago Pago Harbor was surveyed. The data was collected as part of a shakedown for a larger survey in the South Pacific done with Ocean Exploration Trust and the Nautilus Team. RTK quality positioning was used, with a modern multibeam sonar.

A large earthquake M 8.1 and tsunami occurred in 2009 (Jaffe, 2009, Dunbar et al., 2015, Kong et al., 2015) after the last surveys applied to the Chart were collected in 2004 and 2006, but before this survey was conducted in 2019.

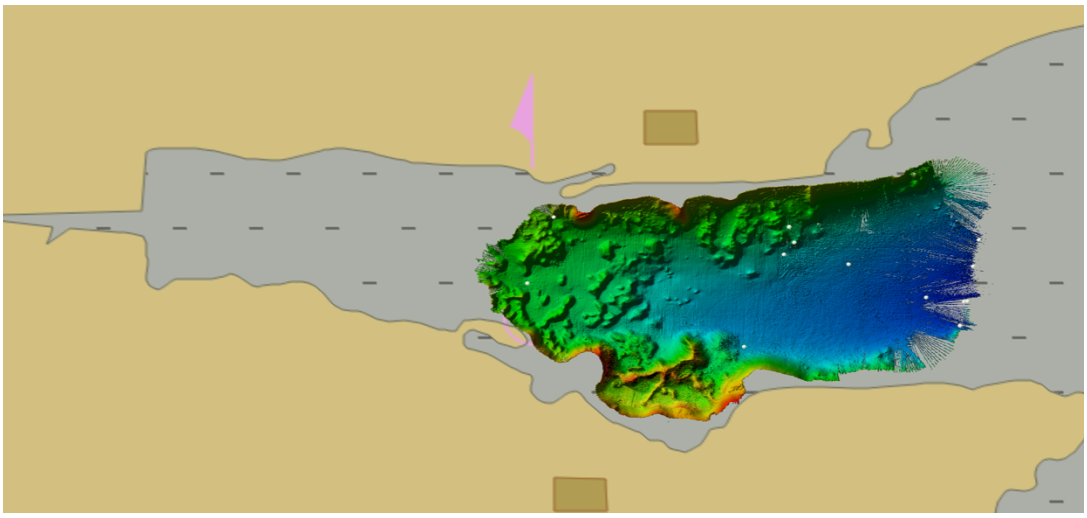


Figure 1: Pago Pago Harbor with ENC

A.1 Survey limits

This survey is within Pago Pago Harbor.

Latitude	Longitude
14°16’16.55”S	170°41’16.72”W
14°16’38.24”S	170°41’37.13”W

Table 1: Survey Limits in WG84

Depth Range: 0.88 to 83.67m below MLLW.
The survey covers an area a little over one kilometer long, and half a kilometer wide.

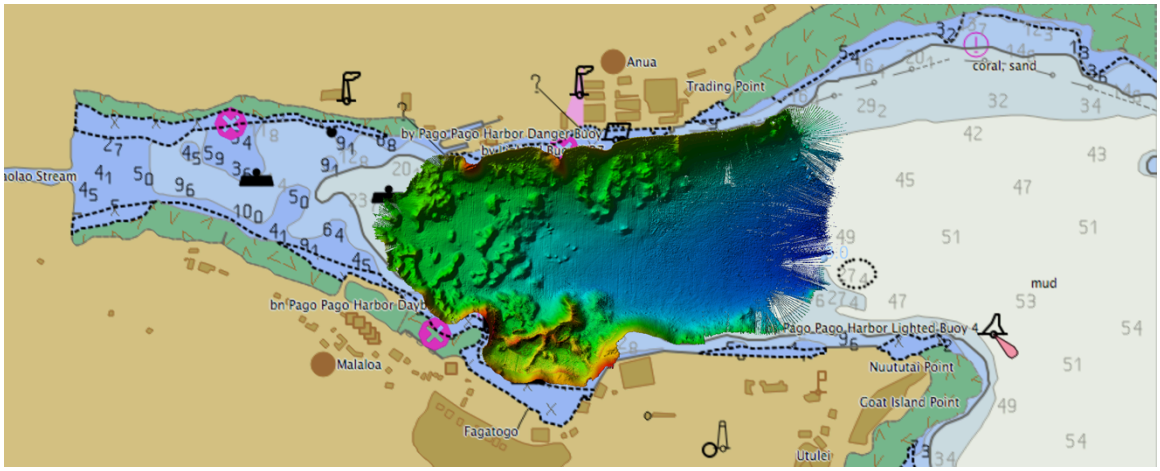


Figure 2: Coverage maps showing survey in Pago Pago Harbor, American Samoa, South Pacific Ocean with ENC

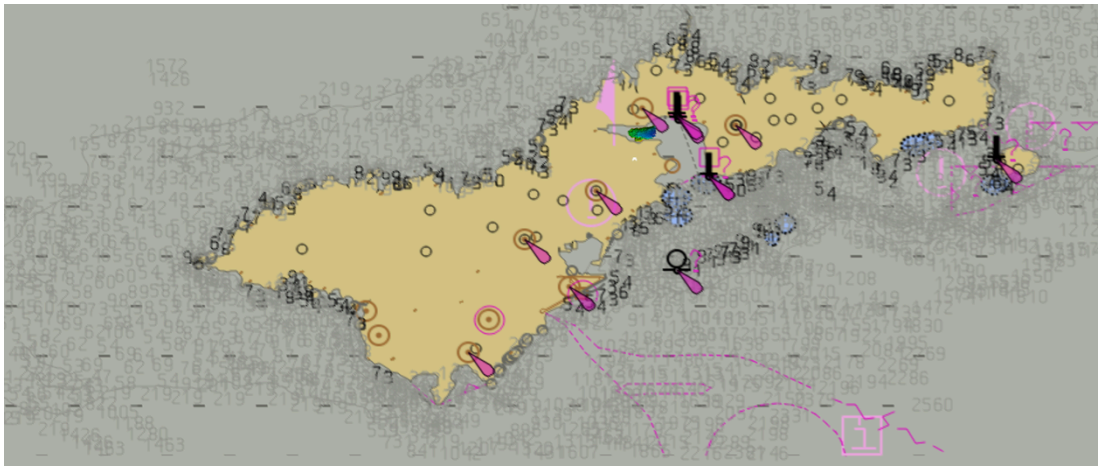


Figure 3: Survey on Pago Pago, American Samoa, South Pacific Ocean view of entire island with ENC.

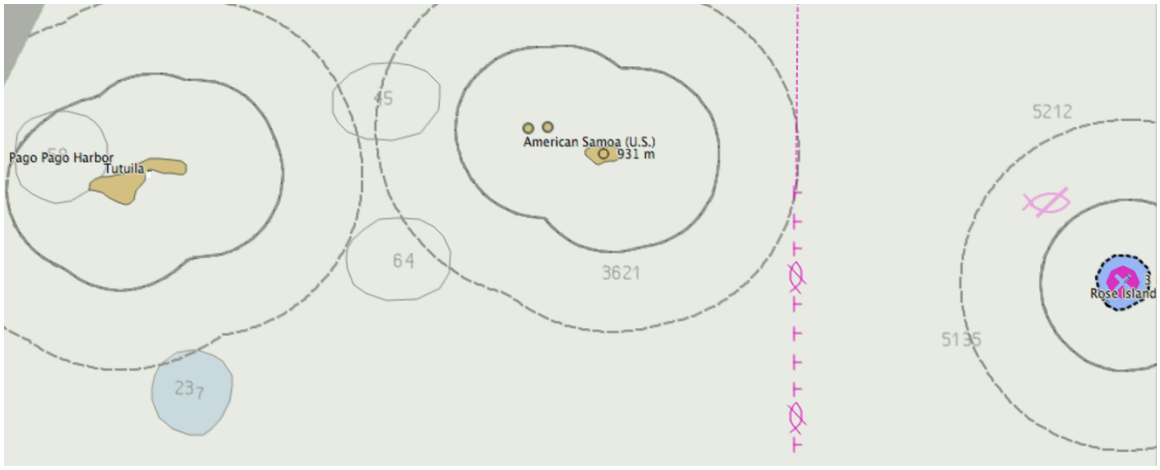


Figure 4: View of Pago Pago Harbor and Tutuila in relation to other Islands in American Samoan Territory

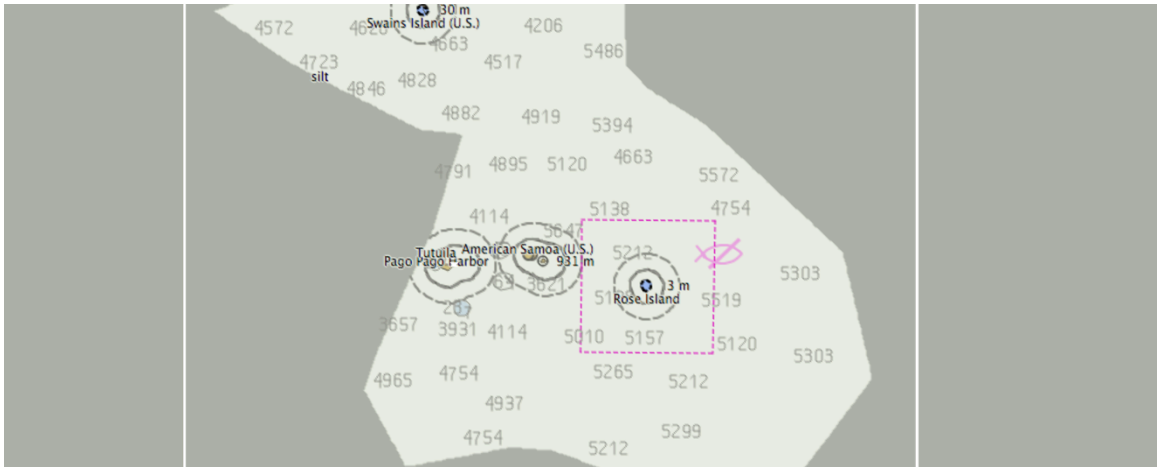


Figure 5: View of Pago Pago Harbor and Tutuila in relation to Swan's and Rose Island in the South Pacific within U.S. waters.

A.2 Survey Purpose

The survey of Pago Pago Harbor was a survey of opportunity. The survey was a part of a pre-deployment systems test for a survey being done with the Nautilus and National Geographic in the South Pacific.

Charts:

ENC: US1EEZ3M
US4SP30M
US5SP30M

RNC: 83484_1

A.3 Survey Quality

Data collected was high-resolution multibeam echo sounder coverage and is considered to be of high quality, suitable for charting.

A.4 Survey Coverage

Coverage within Pago Pago Harbor is shown below.

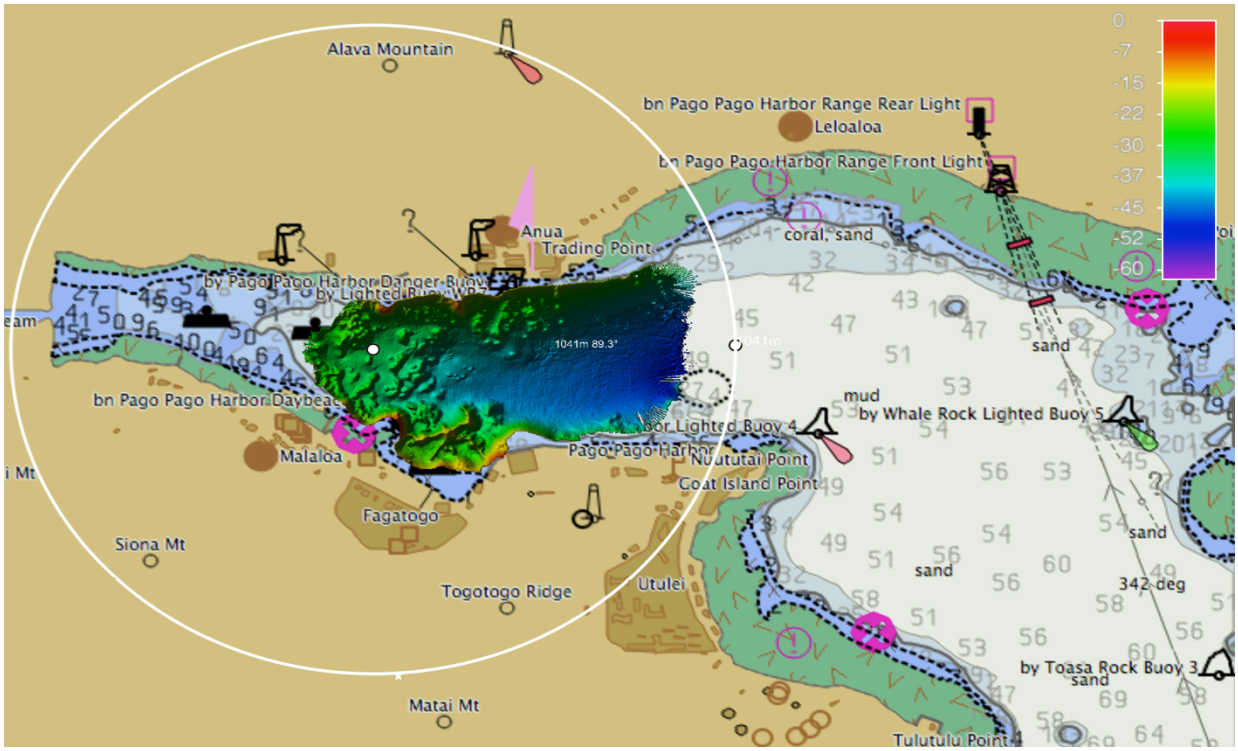


Figure 6: Survey within Pago Pago Harbor showing depth legend of 0.88 to 83.67 m, white circle has a radius of 1041m.

A.5 Survey Statistics

July 26, 2019

B. Data Acquisition & Processing
B.1 Vessels and Equipment

Equipment:
Kongsberg EM 2040P

UNH ASV *BEN* utilizes Kongsberg EM 2040P MBES and AML MicroX SVS realtime sound speed sensor in conjunction with CTD casts

Vessel:
UNH ASV *BEN*

About the Platform:

Details can be found in the US Hydrographic Conference 2019 article by Schmidt and Downs as quoted below.

"The Center for Coastal and Ocean Mapping owns and operates a "C-Worker 4"-model ASV, the "Bathymetric Explorer and Navigator ASV *BEN*. ASV *BEN* is the result of a

design collaboration with ASV Global Ltd. and was manufactured by ASV Global in 2016. The vehicle is powered by 30 HP Yanmar diesel with jet propulsion, has a top speed of 5.5 knots, a maximum endurance of 16 hours and is equipped various operator-aiding sensors including a marine radar, AIS, color and FLIR cameras and depth sounder. For hydrographic survey the Center has integrated a Kongsberg EM2040P multibeam echo-sounder, AML Oceanographic sound speed probe and Applanix POS/MV v5 inertially aided GPS (Schmidt & Downs, 2019)."

Previous descriptions of the setup one can refer to the 2018 NOAA Ship Fairweather's Data Acquisition & Processing Report (DAPR) OPR-S347-FA-18. UNH ASV *BEN* is described as the CCOM-UNH Autonomous Surface Mapping Vehicle within the document OPR-S347-FA-18_DAPR.pdf and the descriptive report for survey H13121 (H13121_DR.pdf).

The SV probe and CTD were calibrated during the winter 2018-2019 season prior to cruise deployment.

Quality Control:

QC Tools run to check for fliers

Density:

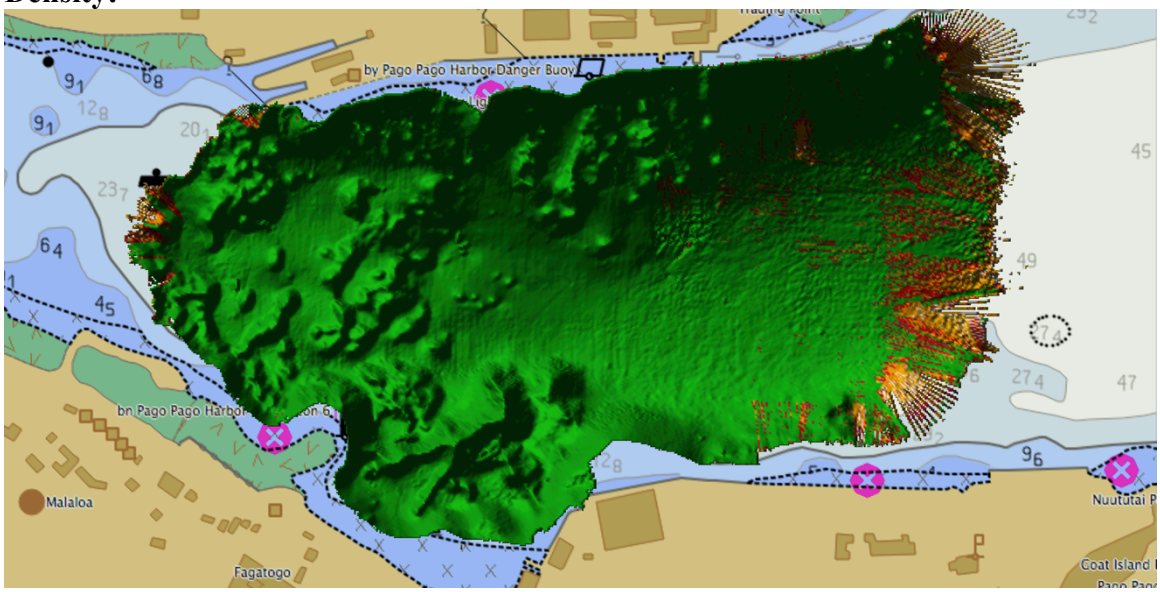


Figure 7: Density Grid: 2m CUBE MLLW Pago Pago: Green is greater than 5 nodes per cell, reds and oranges are less than 5 nodes per cell.

Uncertainty:

	Squat SD	Load SD	Tide SD
Height Standard Deviations	0.050	0.050	0.100

Table 2: Standard Deviations in Qimera

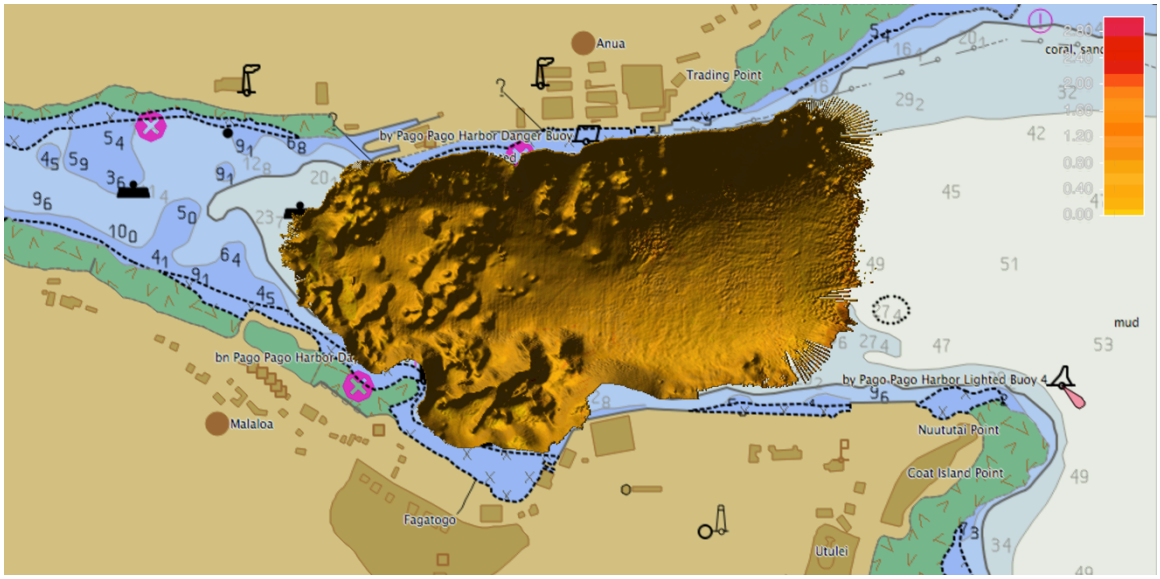


Figure 8: CUBE Uncertainty: 2m CUBE MLLW Pago Pago grid

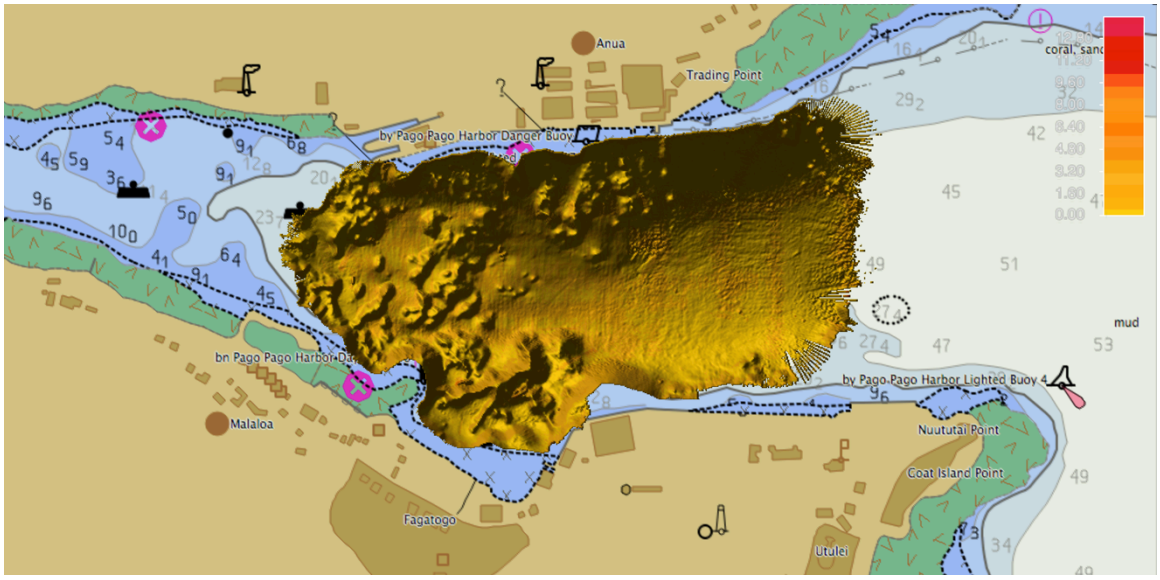


Figure 9: 95% CUBE Uncertainty 2m grid.

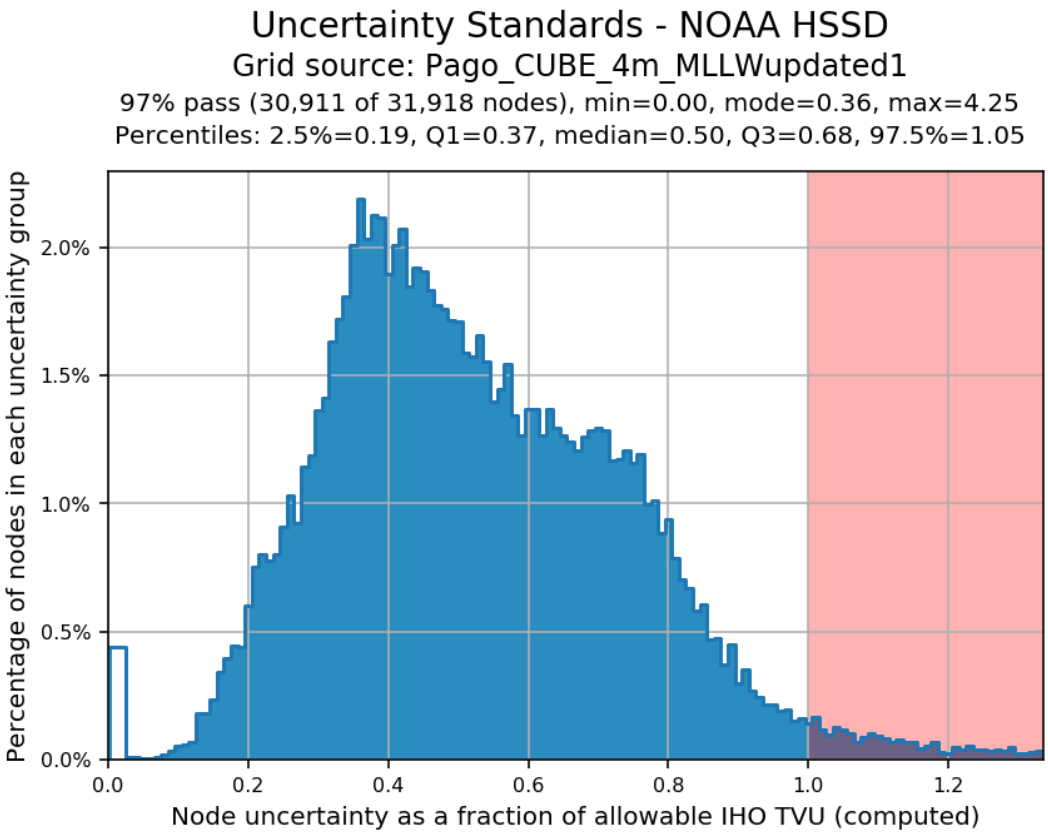


Figure 10: 4m grid Pago Pago IHO TVU from QC Tools

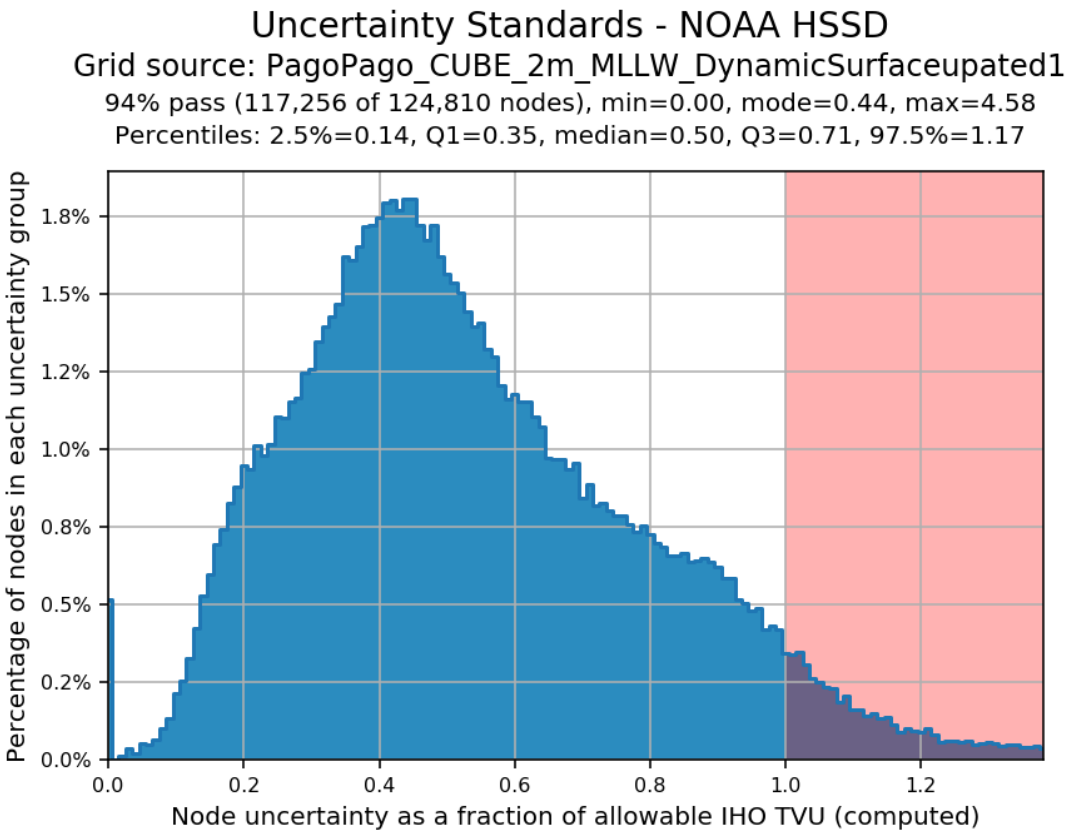


Figure 11: 2m grid Pago Pago IHO TVU from QC Tools

B.3 Echo Sounding Corrections

B.3.1 Corrections to Echo Soundings

Sound speed corrections were done. A Post Processed solution using the Trimble PP-RTX service and POSPAC software was applied to the RTK navigation data.
The tables below list offset values as used in Qimera.

	Roll	Pitch	Heading	Starboard (m)	Forward (m)	Up (m)	Positive Direction	Sonar Relative	TWTT Scale
Tx Transducer Offsets	0.445	-1.090	1.100	0.000	-0.293	-0.861	Tx Forward	Yes	1.000
Rx Transducer Offsets	0.445	-1.090	1.100	0.000	-0.293	-0.861	Rx to Port	Yes	1.000

Table 3: System Offsets as set in Qimera

speed (m/s)	squat (m)
0	0

Table 4: Squat not used because of use of RTK system

	Draft (m)	HADR (Height Above Draft Reference)
Draft	0.661	0.861

Table 5: Draft values recorded in Qimera

	Positive	Positive	Positive
Motion 1	Roll Port Up	Pitch Bow Up	Heaver Down
Motion 2	Roll Port Up	Pitch Bow Up	Heaver Down
pos-pprtx_att	Roll Port Up	Pitch Bow Up	Heaver Down
att-pprtx_20190726	Roll Port Up	Pitch Bow Up	Heaver Down

Table 6: Additional Offset Information in Qimera.

No additional offsets were applied for motion sensors within Qimera.

The POSMV configuration for Vessel Reference to IMU target is zero because the reference point for positioning, attitude, and sonar systems is the IMU target for the vessel. Please refer to the 2018 NOAA Ship Fairweather's Data Acquisition & Processing Report (DAPR) OPR-S347-FA-18 for further schematic diagrams and offsets.

B.3.2 Calibrations

This was a shakedown cruise. Previous calibrations are described in 2018 NOAA Ship Fairweather's Data Acquisition & Processing Report, OPR-S347-FA-18 DAPR.

B.4 Backscatter

Backscatter processing was done using FMGT 7.9.2. After the .kmall files were processed in Qimera, .gsf files were exported. These .gsf files were then imported to FMGT for backscatter processing.

A 2m grid and 0.5m backscatter mosaic were created. The 0.5 m mosaic gives details of features in shallower water, while the 2m mosaic shows fewer empty cells.

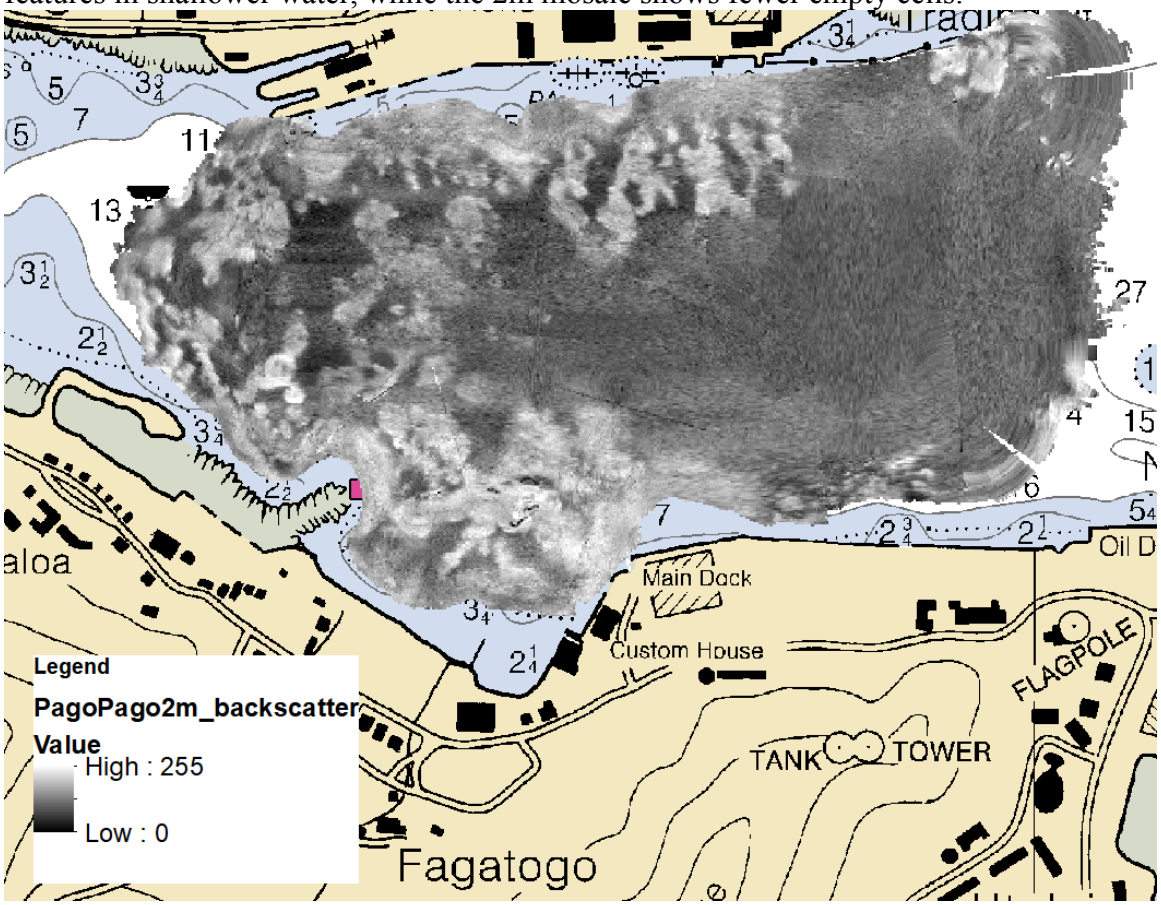


Figure 12: Pago Pago Harbor 2019 2m Backscatter: 0 to 255 greyscale

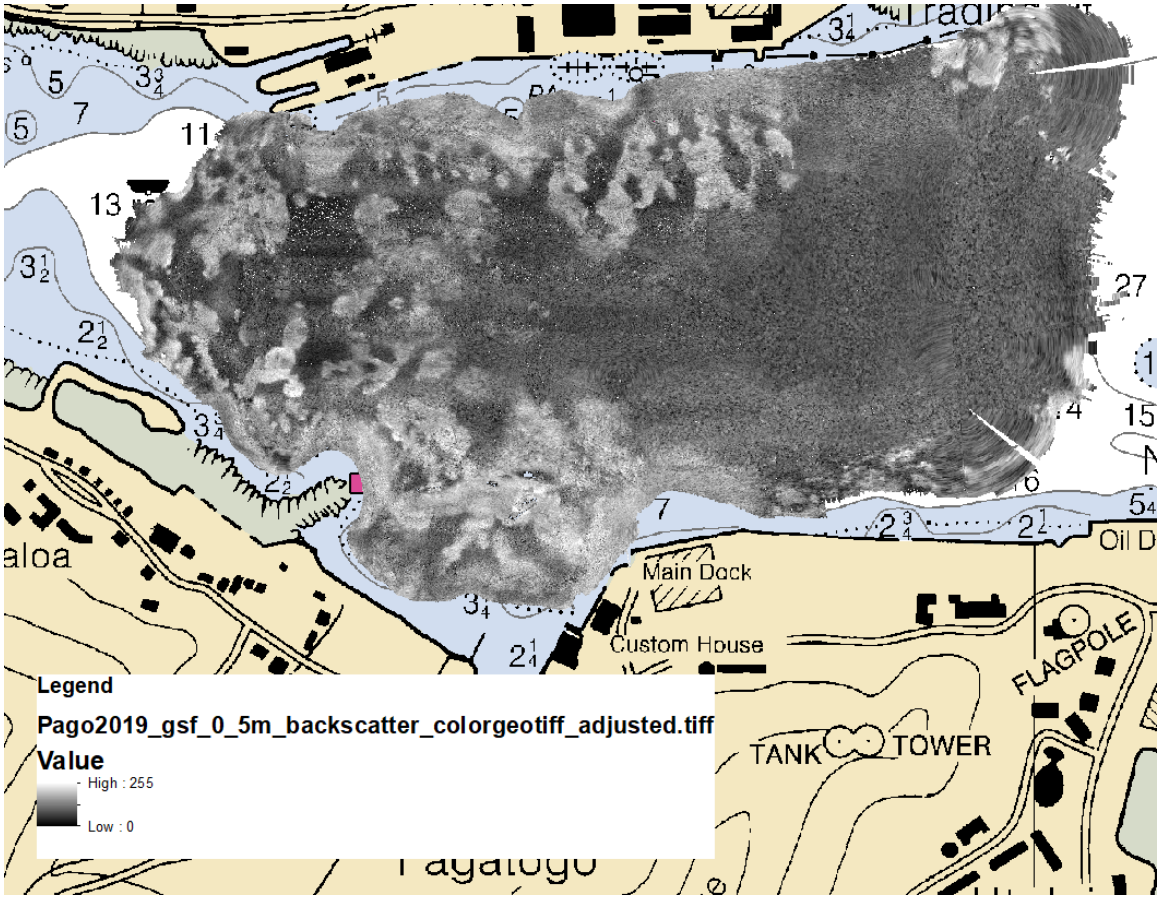


Figure 13: Pago Pago Harbor 2019 0.5m Backscatter: 0 to 255 greyscale

B.5 Data Processing

Qimera 2.1.1 used for final processing. PosPac was used to process navigation files. Backscatter was processed using FMGT 7.9.2. with the import of .gsf files.

B.5.2 Surfaces

Type	Filenames	Vertical Datum	Resolution
Bathymetry	PagoPago2019_CUBE_1m_MLLW.bag	MLLW	1m
Bathymetry	PagoPago2019_CUBE_2m_MLLW.bag	MLLW	2m
Bathymetry	PagoPago2019_CUBE_4m_MLLW.bag	MLLW	4m
Bathymetry	PagoPago_CUBE_8m_MLLW.bag	MLLW	8m
Mosaic	PagoPago2019_gsf_1m_backscatter_colorgeotiffadjusted.tiff		1m
Mosaic	PagoPago_2019_2m_gsf_colorgeotiffadjust.tiff		2m

Table 7: Surfaces

B. Vertical and Horizontal Control

A significant earthquake M 8.1 occurred in American Samoa in 2009. As a consequence none of the benchmarks surveyed by NGS for ASVD02 (American Samoan Vertical Datum 2002) elevation are valid post earthquake (Federal Register No. 2020-05047, NGS, 2020, Ed Carlson & Dan Roman, July 2020)) Benchmarks are only known relative to the local tidal elevation. Please see attached correspondence with NGS (Ed Carlson and Dan Roman, July 2020) on use of CO-OPS gauge and benchmarks to convert from WGS84 to MLLW.

Vertical Datum: MLLW

Separation from WGS84 to MLLW: 33.574 m

Separation value provided by NOAA NGS, see attached correspondence.

Standard Deviation used: 0.050 m

Data Collected in WGS84 with RTK

Vertical Datum: MLLW

Coordinate System: WGS84

WKT:

GEOGCS["FG_WGS_84", DATUM["FD_World_Geodetic_System_1984", SPHEROID["WGS_84",6378137,298.257223563, AUTHORITY["EPSG","7030"]], AUTHORITY["EPSG","6326"]], PRIMEM["Greenwich",0, AUTHORITY["EPSG","8901"]], AXIS["latitude",NORTH], AXIS["longitude",EAST], UNIT["degree",0.0174532925199433, AUTHORITY["EPSG","9102"]], AUTHORITY["EPSG","4326"]]

File Type: .kmall

C. C.2 Horizontal Control

Data collected in WGS84 and Bathymetry projected in WGS84 UTM zone 2S (WGS_84_UTM_zone_2S in Qimera).

D. Results and Recommendations

Extent of previous overlapping surveys:

The United States Naval Oceanographic Office (NAVO) conducted a lidar May 5-7, 2006 that was applied to the charts as W00185. Only the A93 selective soundings are available on NCEI for comparison. This data was gridded at 40m, and 5m to give an idea of the possible extent of coverage. The 5m gridded soundings were used to make difference surfaces with the 2019 data.

Several views of W00158 and W00185 are shown below because they are actually very large surveys compared to the area of interest in the Harbor where the 2019 ASV data was collected. Thus some views of the harbor area are shown as well as full extent of the data. Survey W00158, which was applied to the chart, was collected Feb 15 - March 12, 2004.

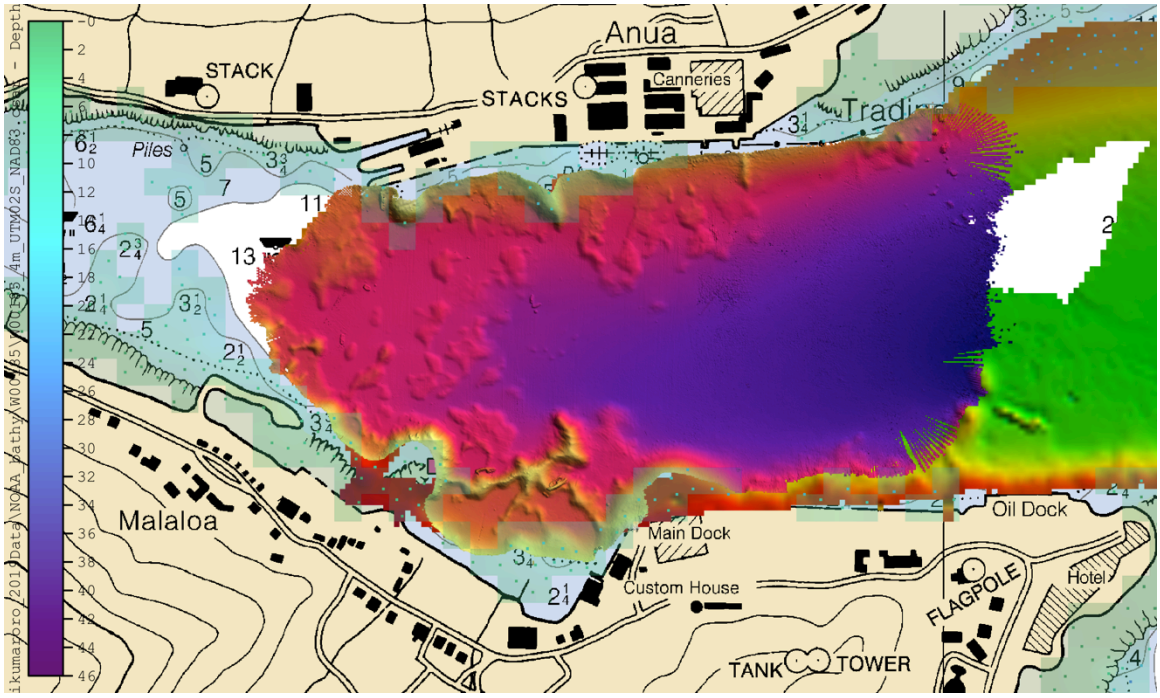


Figure 14: 2019 ASV data shown in yellow to purple colors, with green to purple semi-transparent colors showing 40m grid of W00185 lidar data, and rainbow grid colors for W00158 8m grid.

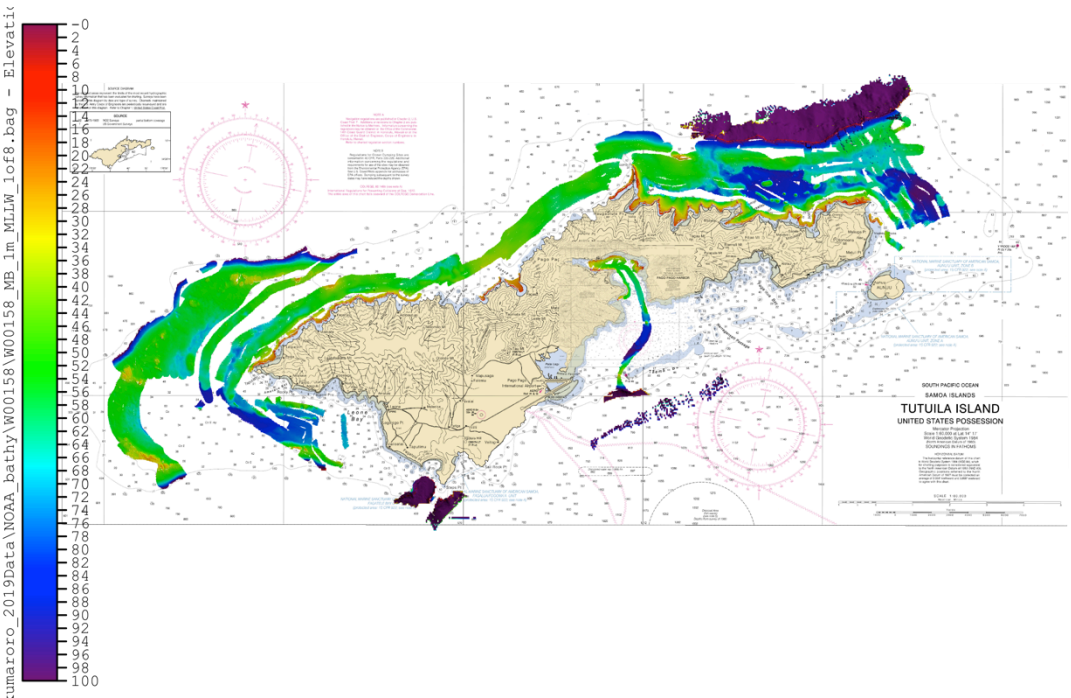


Figure 15: W00158 scaled to highlight areas in 100m or shallower, deeper areas are in dark purple.

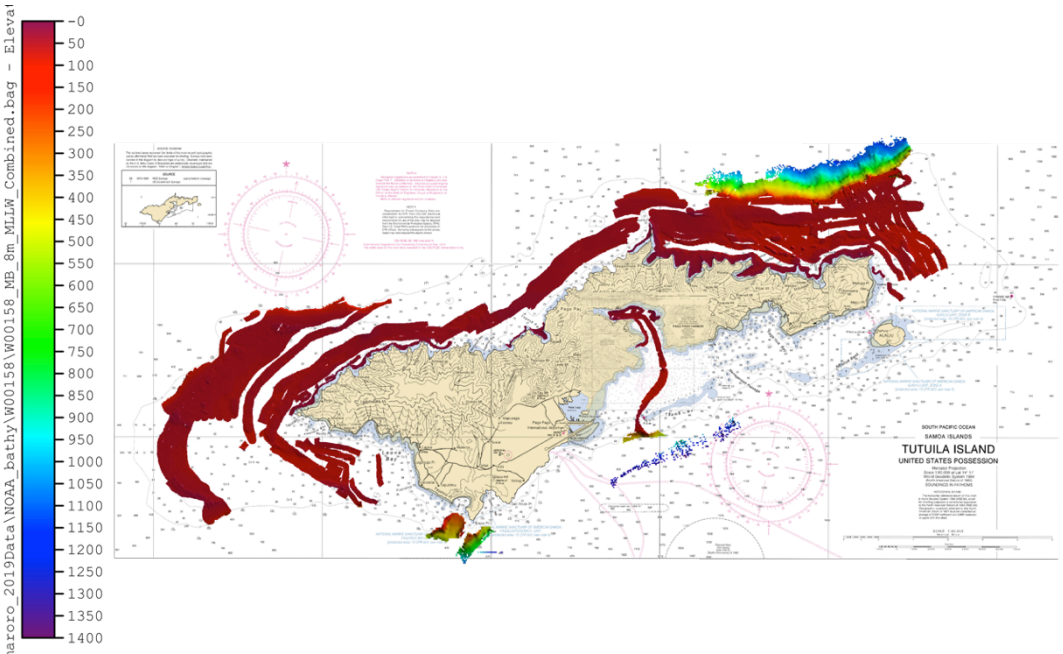


Figure 16: W00158 scaled to highlight areas deeper than 100m. All such areas are well away from the survey in Pago Pago Harbor.

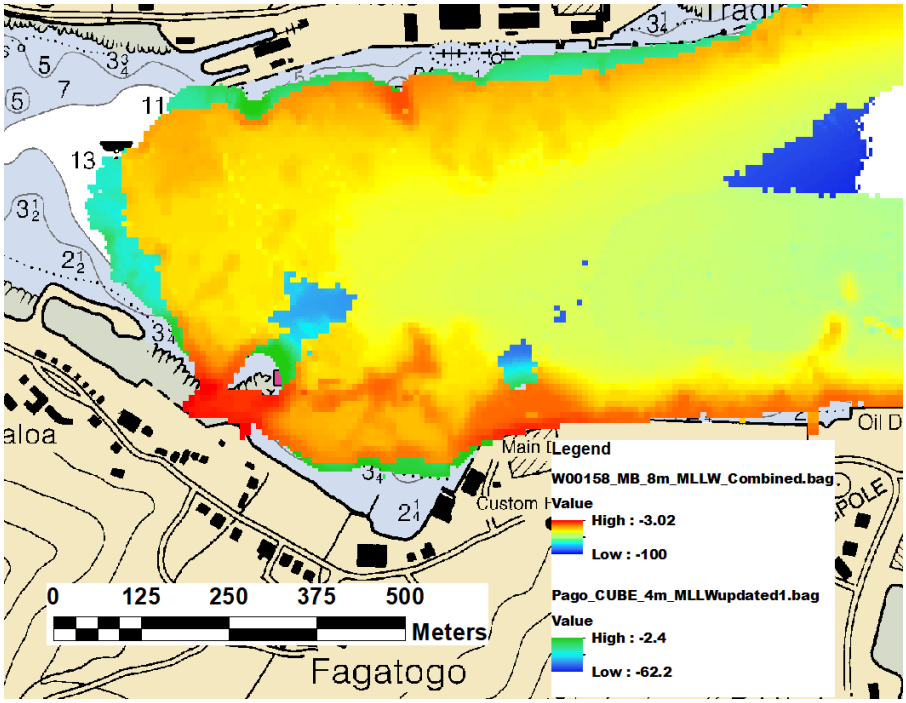


Figure 17: Overlap of extents of W00158 8m combined grid superimposed over the Pago Pago Harbor 2019 survey in blue green highlighting areas without modern coverage.

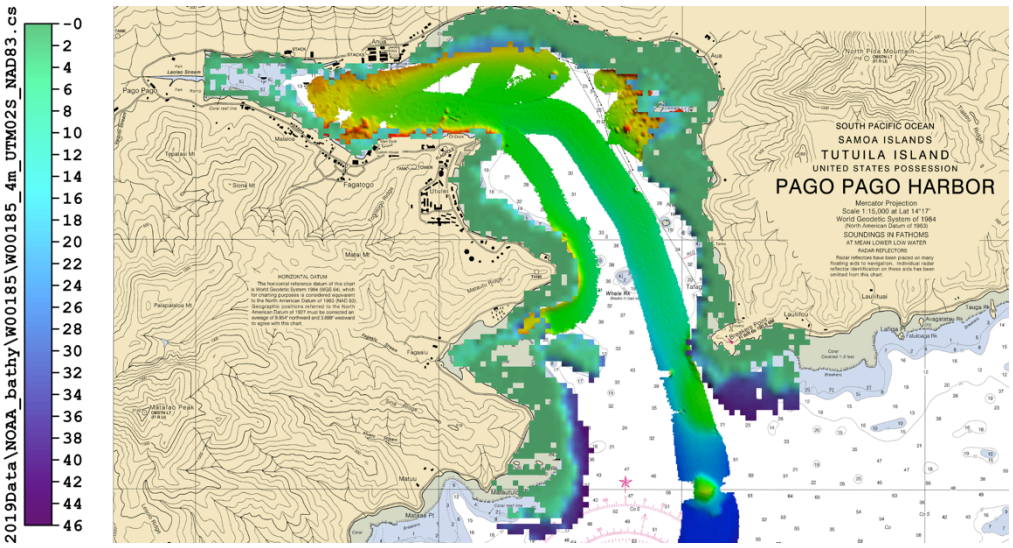


Figure 18: Lidar W00185 40m gridded soundings as semitransparent are shown with the rainbow color scale W00158 to show the coverage that already exists in the vicinity.

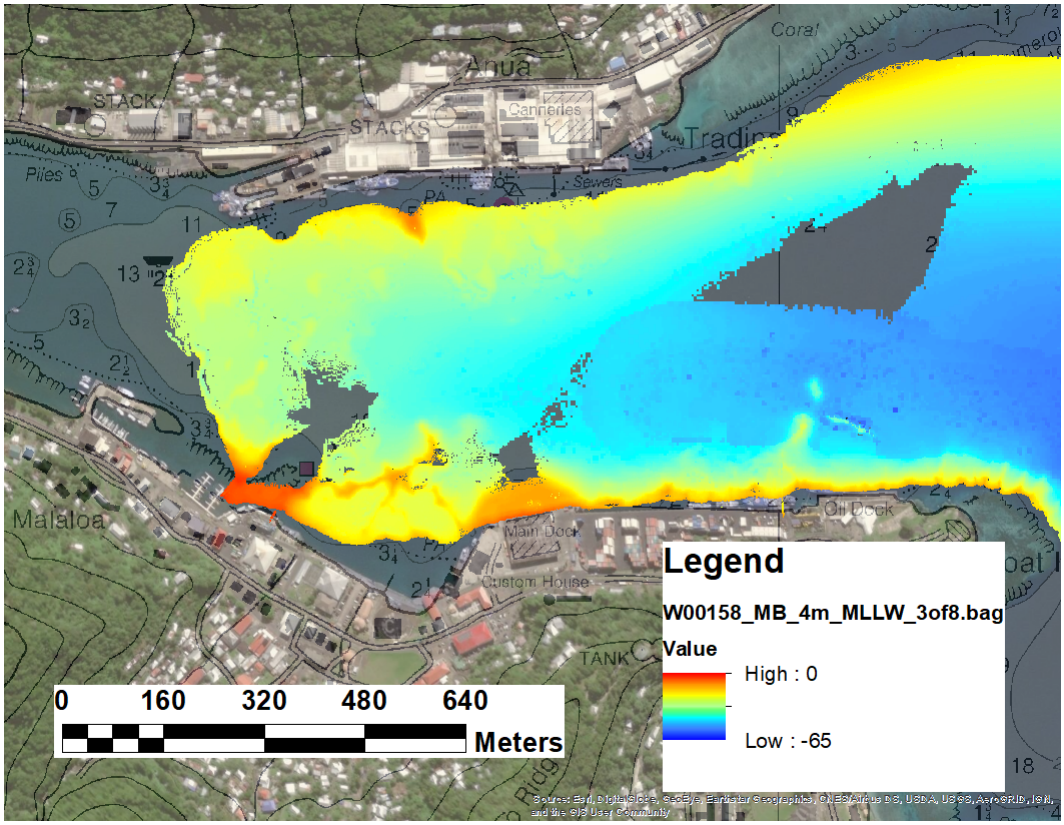


Figure 19: W00158 1m, 2m and 4m grids using the same scale of 0 to -65m, with chart and aerial imagery in background.

The 1 to 4m grids show much more in the way of noise and artifacts in the W00158 survey than are visible in the 8m combined grids. Both deep noise and shoaler edges along turns exist.

Extent of bags on NCEI for W00158:

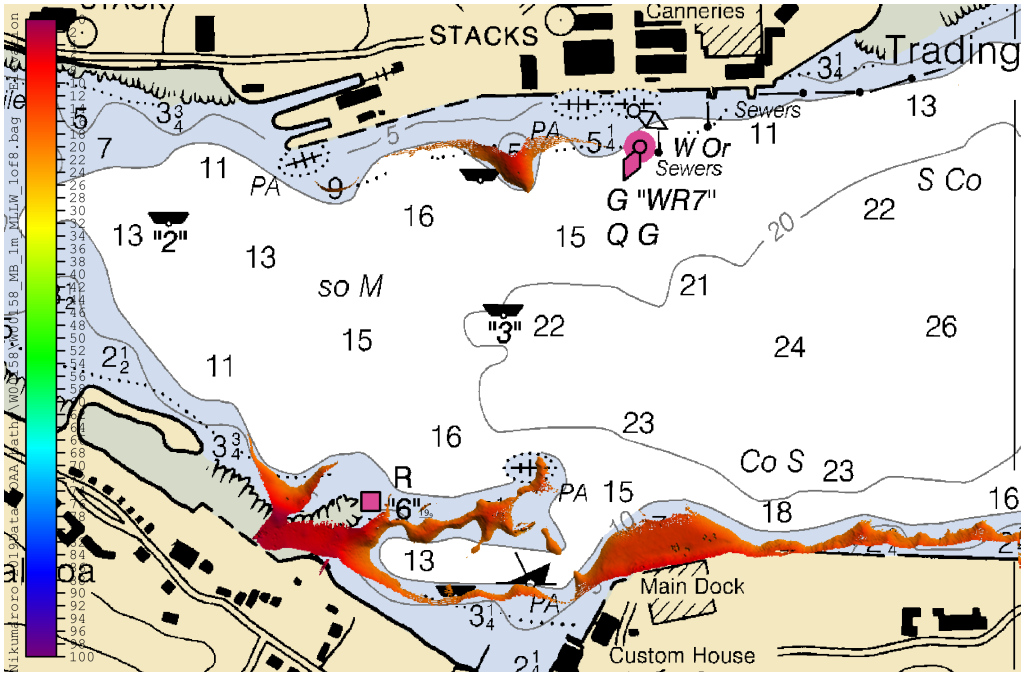


Figure 20: W00158m 1m with sun illumination plotted in caris

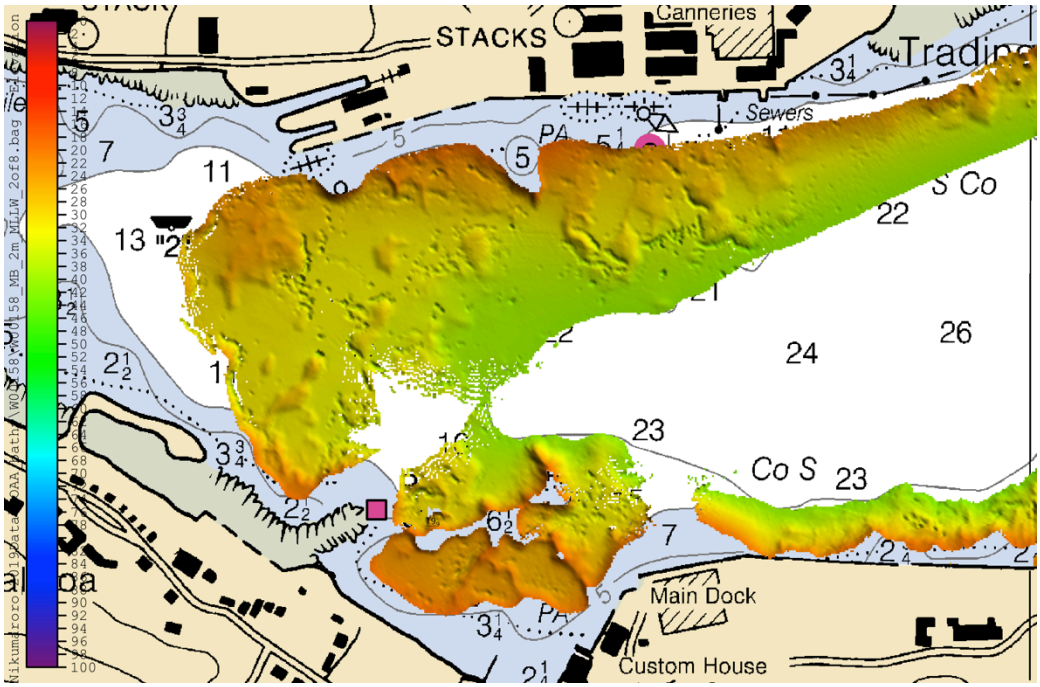


Figure 21: W00158 2m with sun illumination plotted in caris.

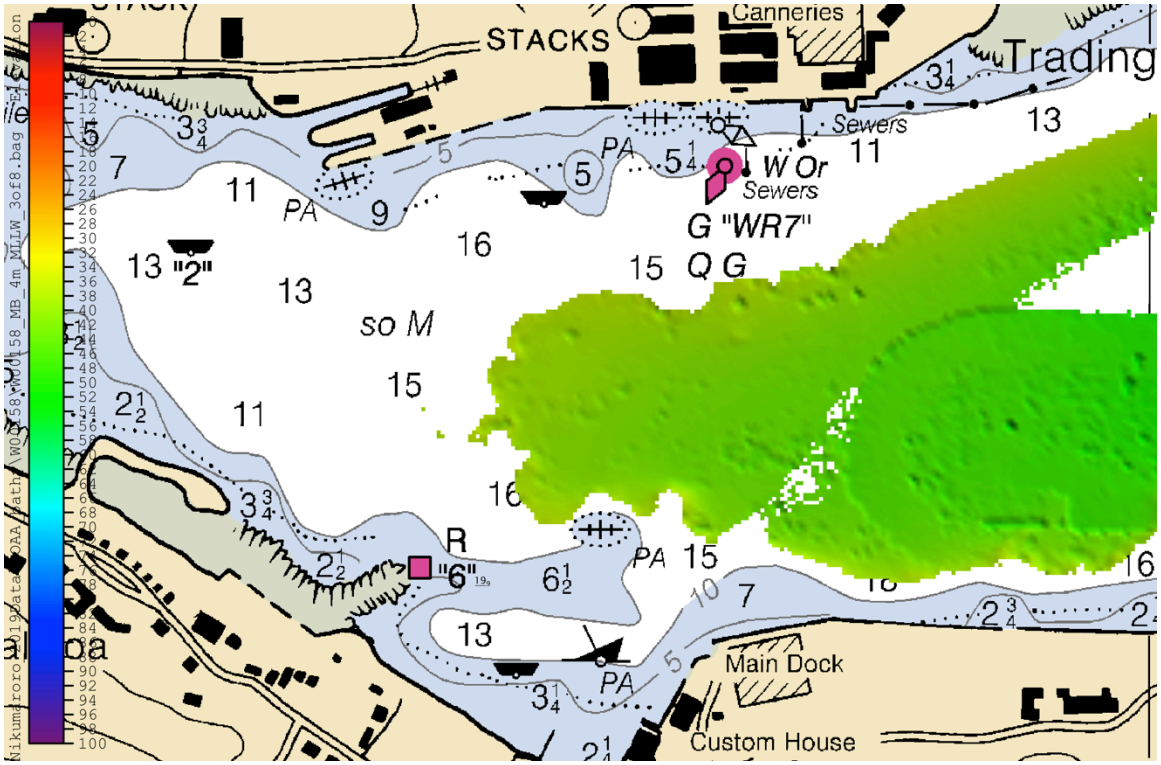


Figure 22: 4m W00158 with sun illumination plotted in caris

The 1m, 2m and 4m grids show some of the noise present in the W00158 survey that is less obvious in the 8m combined grid.

D.1 Chart Comparisons

Data on NCEI that was previously applied to the chart was compared.

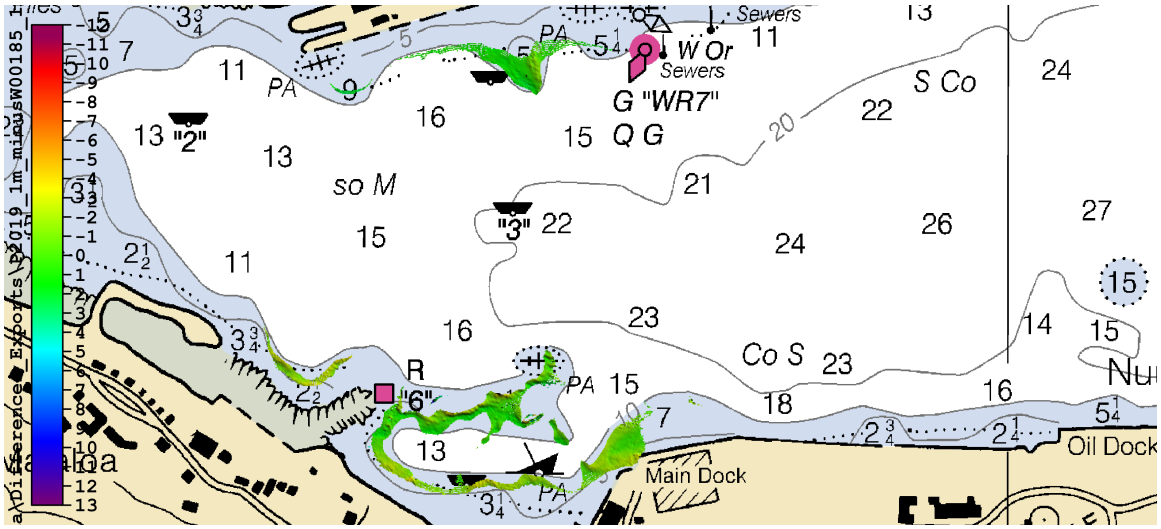


Figure 23: 2019 1m grid minus W00158 1m

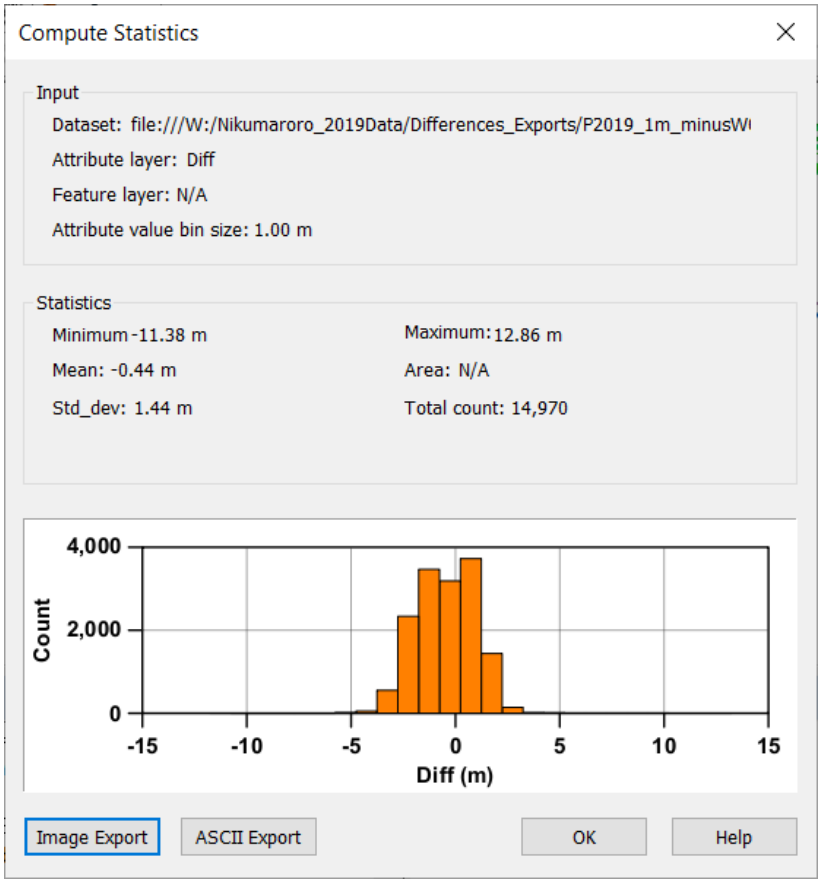


Figure 24: Statistics for 2019 1m grid minus W00158 1m

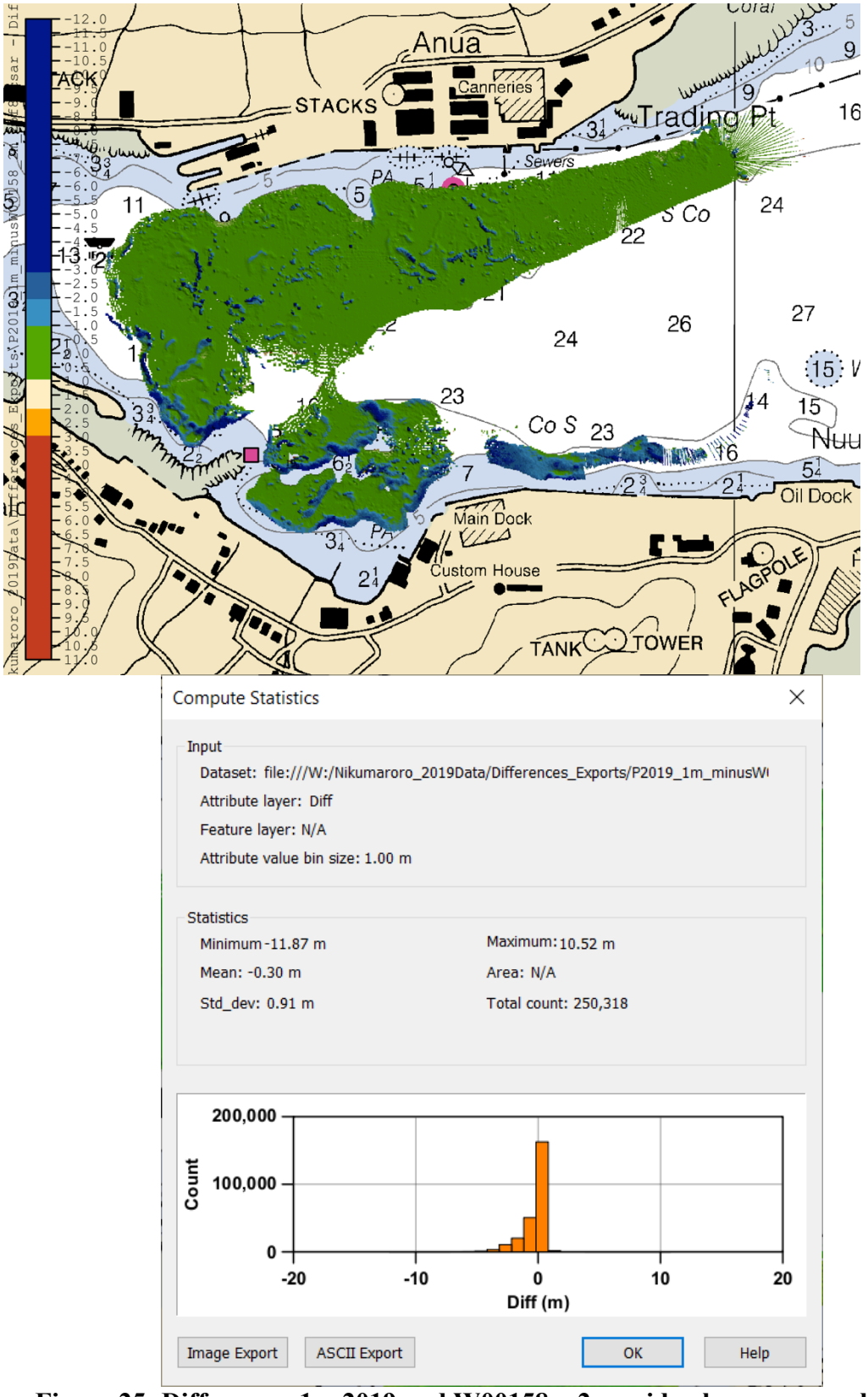
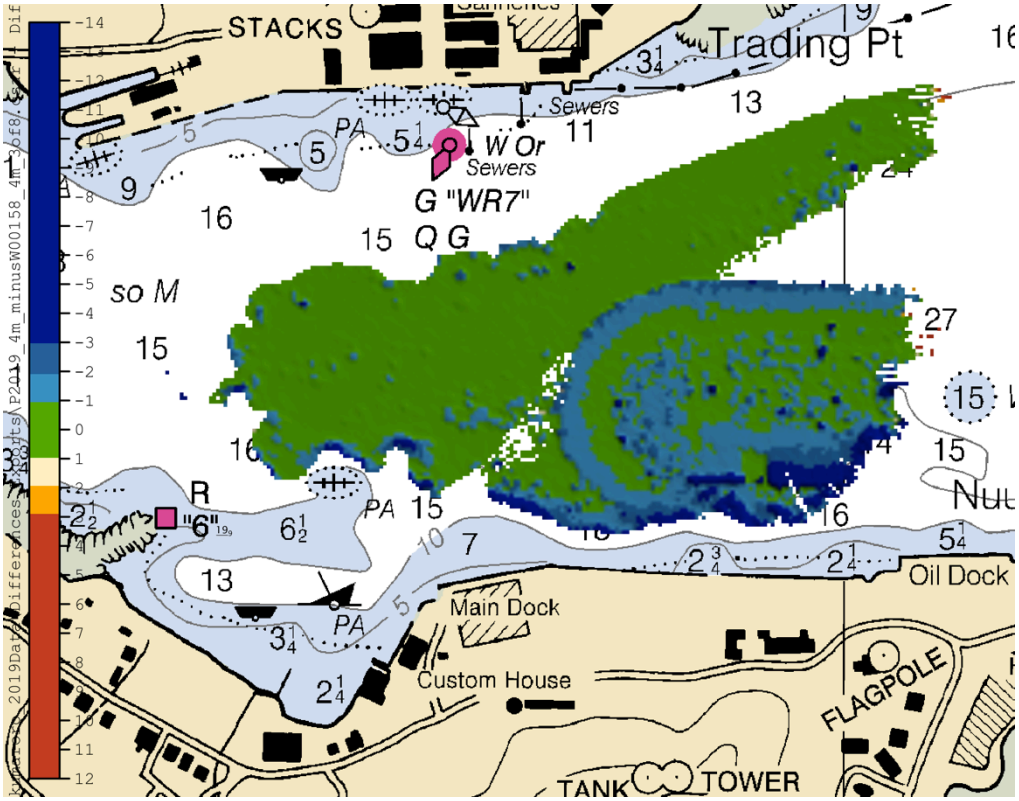


Figure 25: Differences 1m 2019 and W00158m 2m grid, where warm colors are shoaler, green is less than 1m difference, blues are deeper.



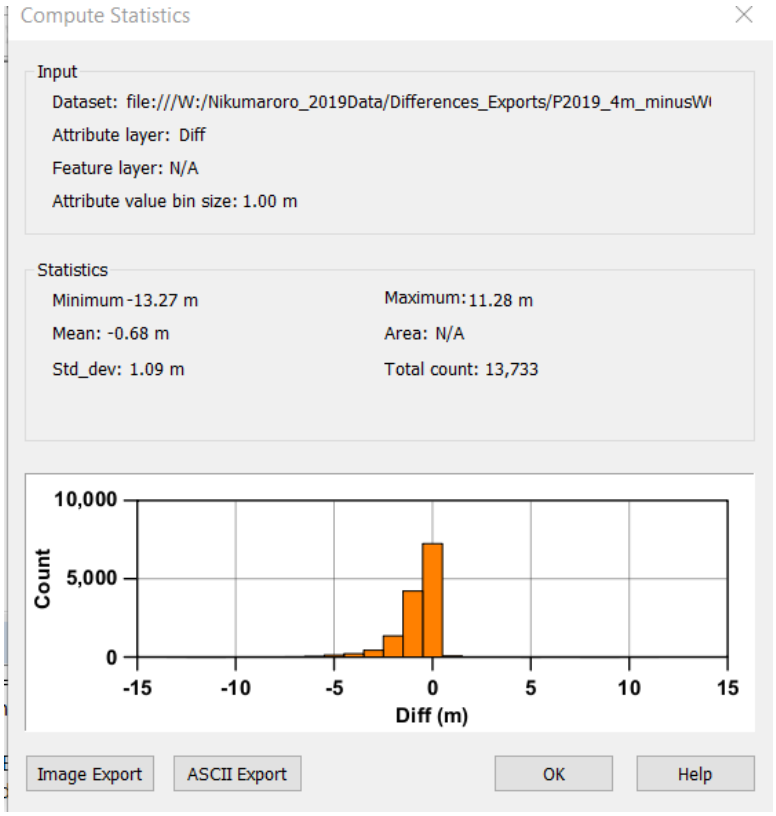


Figure 26: Difference grids: 2019 4m minus W00158 4m

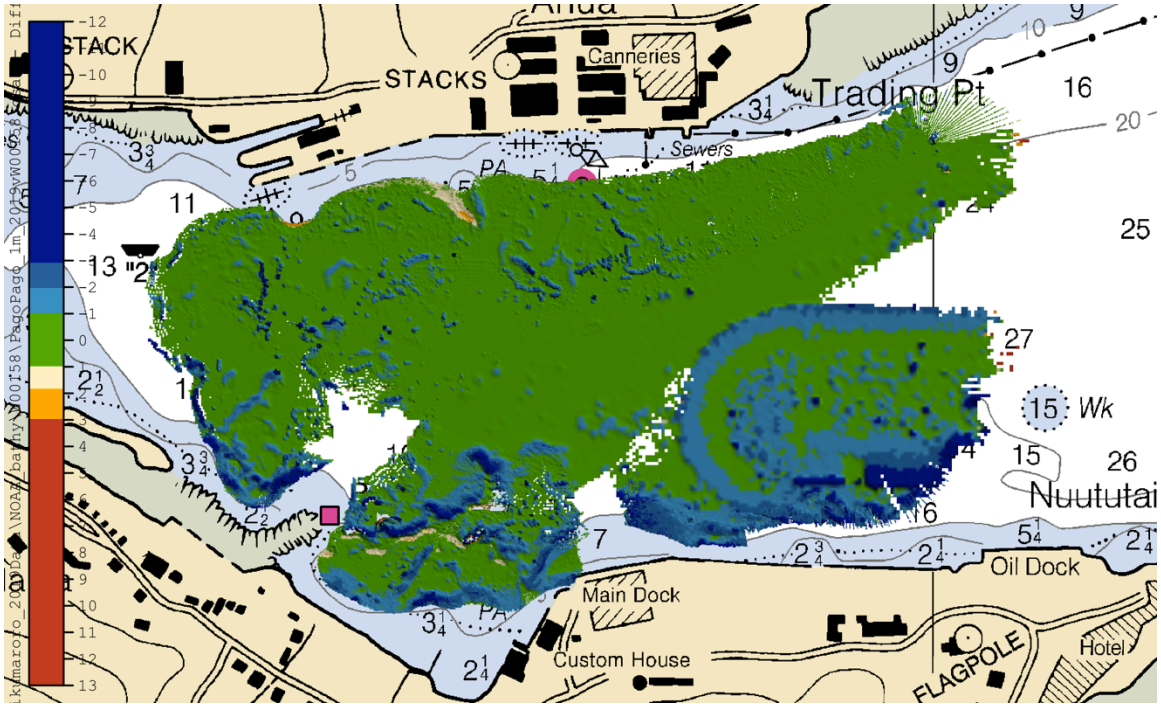


Figure 27: Difference grids all together with the same color scale for 2019 1m v 1m W00158, 1m v 2m W00158, and 4m vs 4m W00158.

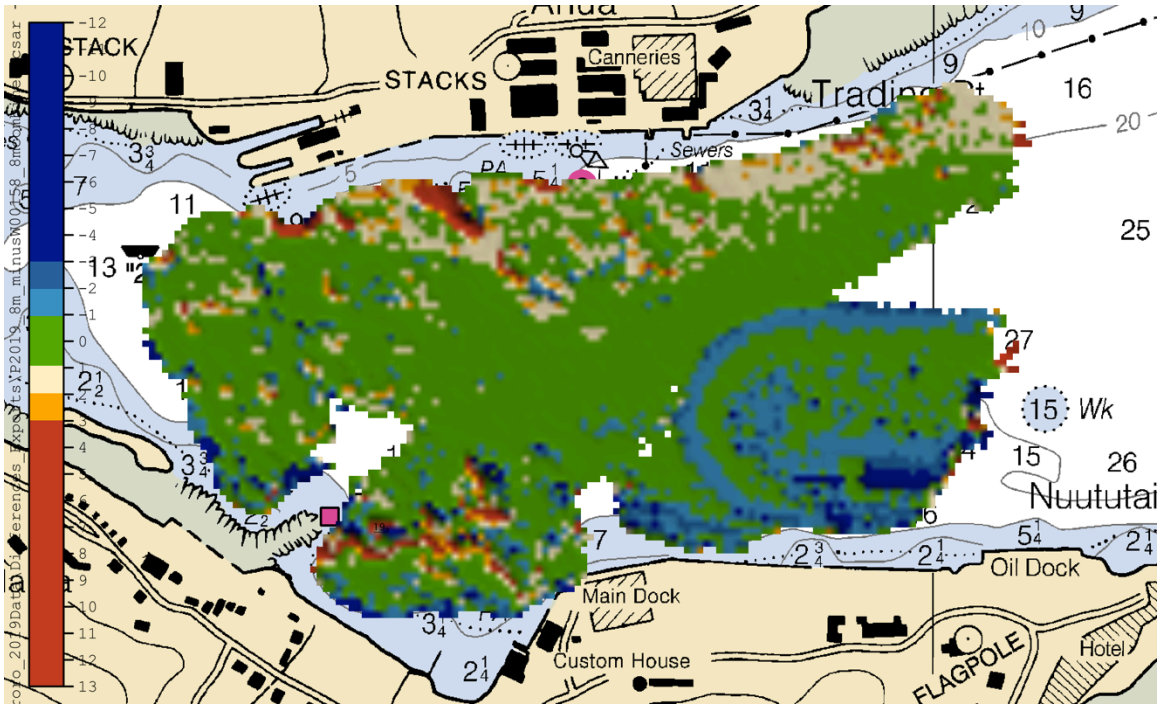


Figure 28: Difference grid between Pago Pago 2019 data gridded at 8m and W00158 8m combined .bag grid with same color scale as with higher resolution difference grids. Areas in green show less than 1m of difference. Areas in orange are shallower, dark blue is deeper in 2019 than during the W00158 survey.

Slopes show differences in the 8m comparison that are probably due to the offset of grid centers.

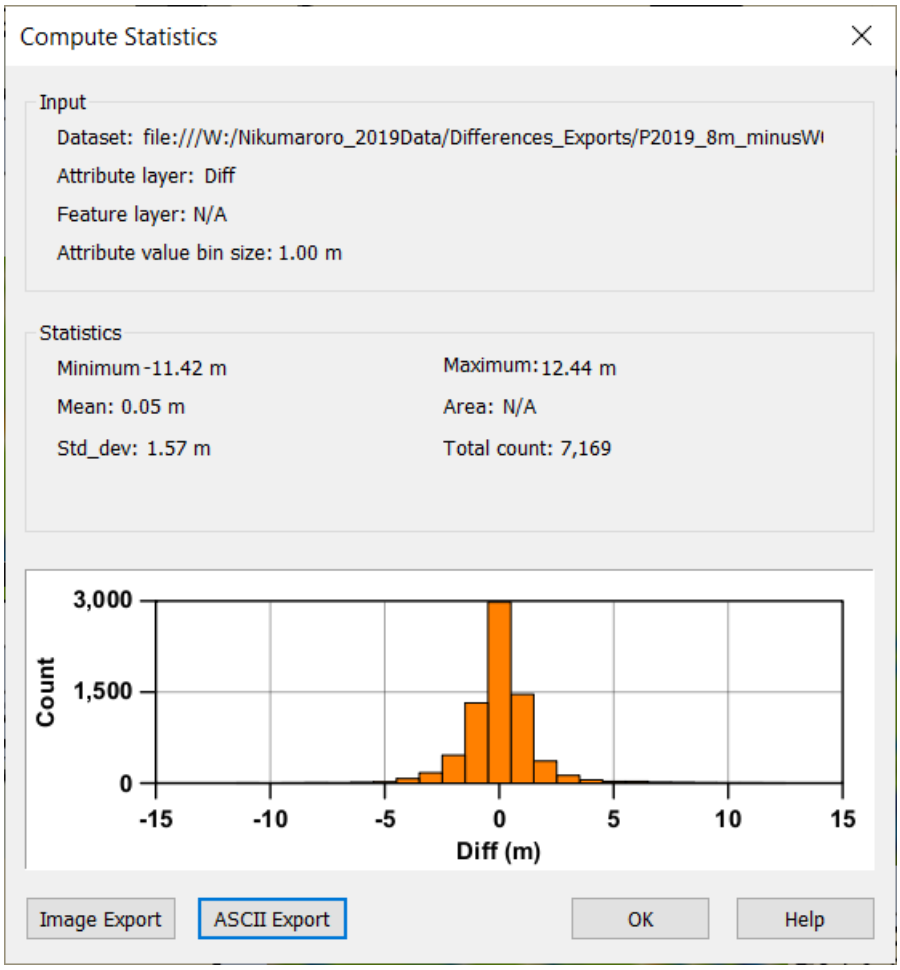
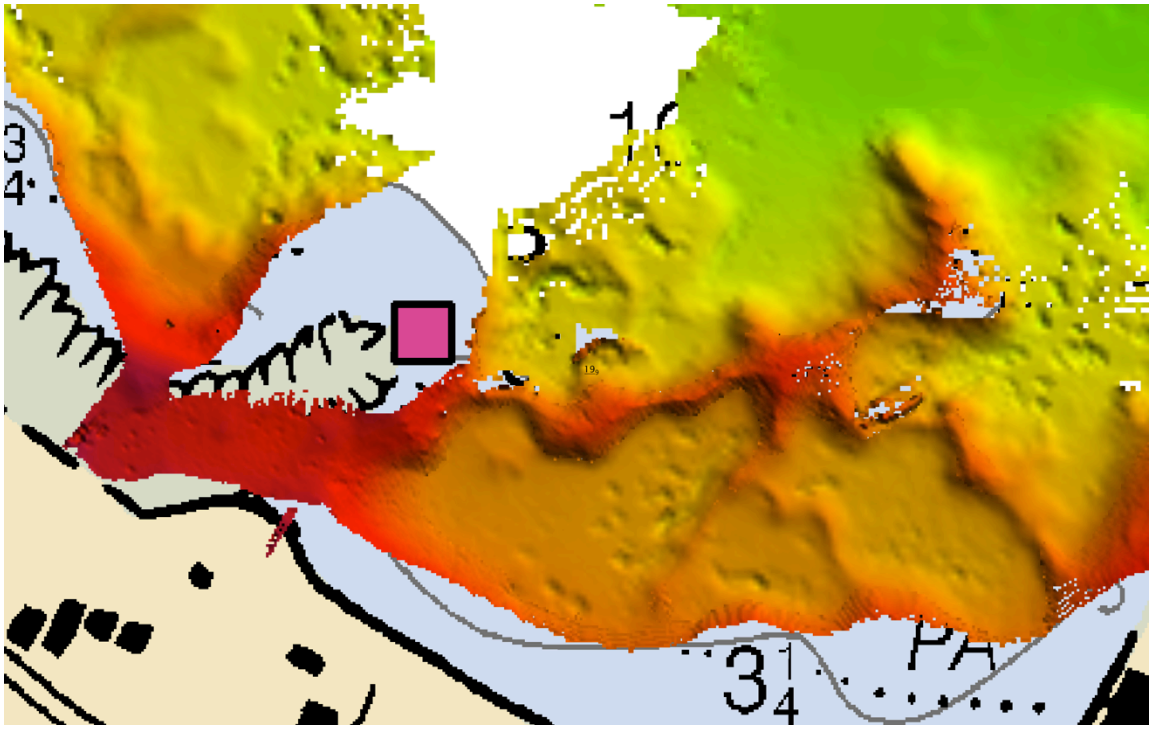


Figure 29: Statistics for the difference grid between Pago Pago 2019 data gridded at 8m and W00158 8m combined .bag grid

The W00158 data has some artifacts visible in the 1m to 4m data that seem to correspond to larger 'deeper' area difference. Deeper soundings associated with a turn in the W00158 survey are visible both on the edges of the turn, and middle of the tracks. While it was not significant in creating shoal depths applied to the chart.
there were sporadic deeper sounding artifacts present in that survey. The 2019 survey appears to have some other differences along slopes when looking at the 8m grid differences that may be due to grid cells being offset rather than changes in morphology. Thus we also have the higher resolution grids difference surfaces to compare.



s

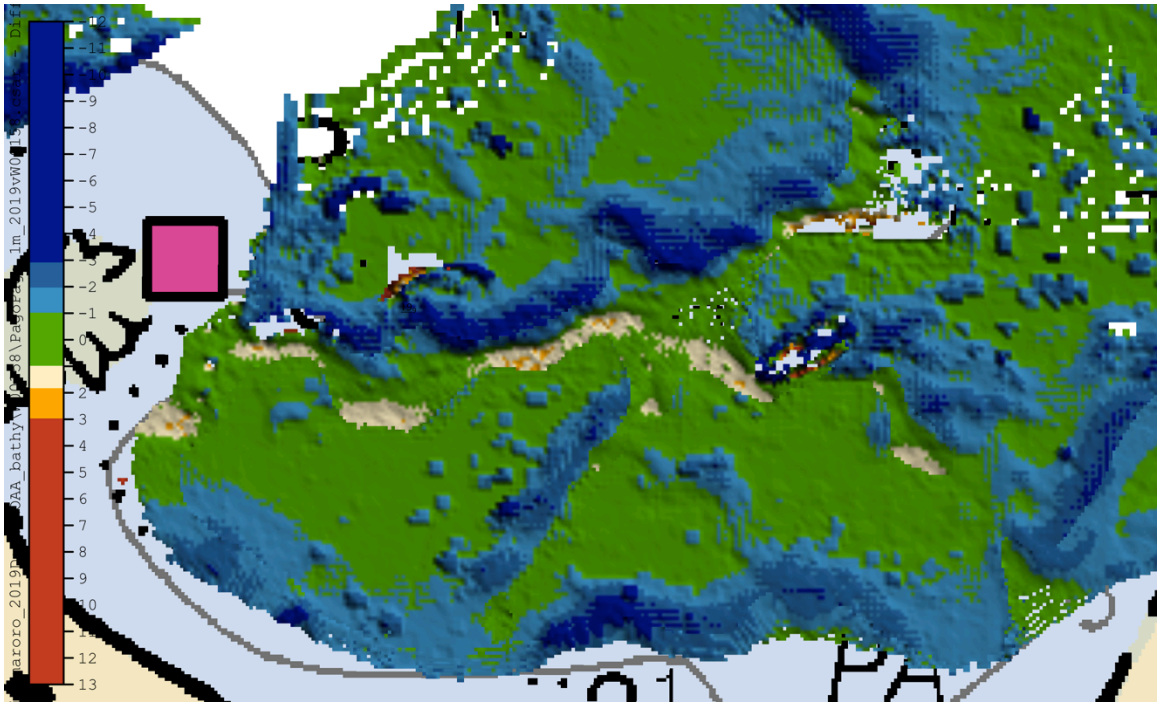


Figure 30: Top W00158 1m, 2m, 4m grids together show gaps in data near wrecks and shoals. Bottom: this is visible in the difference surfaces as well. The 8m grid comparison masks this and the location of shoaler values (reds/oranges).

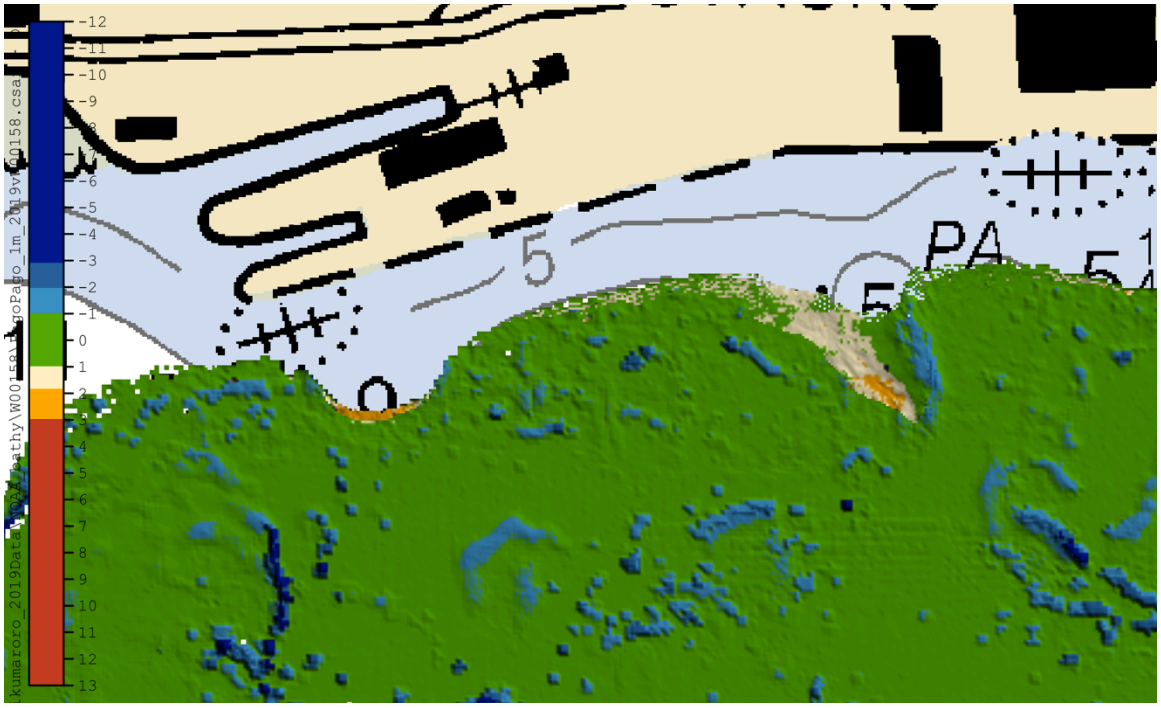


Figure 31: Difference grids together 1m, 2m, 4m show a second area of shoaling. Both areas are near newly mapped data that may affect shoal values more than these two spots would.

The dark orange brown shows areas with more than 3m difference from the previous survey. Orange is

D.1.1 Raster Chart Comparisons

No formal raster chart comparisons were made for this survey.

D.1.2 Electronic Navigational Chart Comparisons

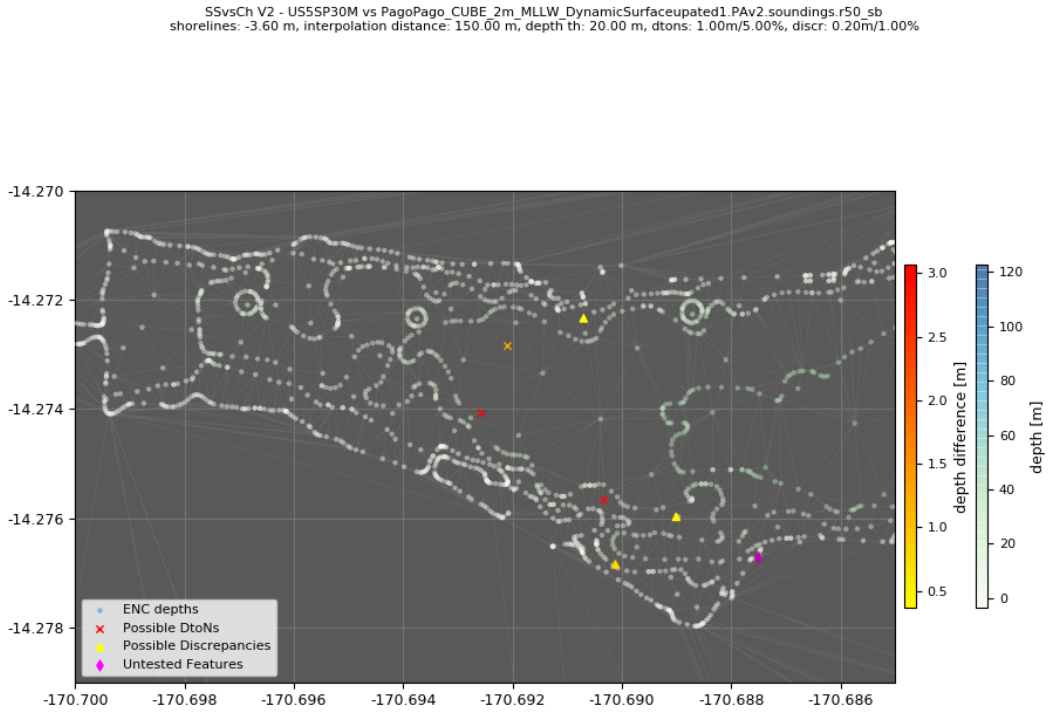


Figure 32: Chart comparison with 2 m bathymetric grid using Pydro QC Tools

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