# Singlebeam Error Analysis 2017

InPort Metadata: https://inport.nmfs.noaa.gov/inport/item/47152

## Objective:

To determine the error associated with the singlebeam sonar mounted on the NOAA Safeboat (Rubber Duck). This data is used as validation for satellite-derived bathymetry and other products. Determining the error associated with the singlebeam data will allow us to determine how well it can reasonably align with derived products. For example: if vertical error is ±1m then we cannot expect validation from singlebeam data to align better than ±1m with derived products. This known error can also be stated in the metadata, which previously has not been made available. Evaluation of the error may also allow steps to be taken to reduce errors that occur during collection of the singlebeam data.

## Equipment:

Rubber Duck (2016–2017)

- GPS: Furono GP1870F GPS has 7.5 m horizontal resolution w/Wide Area Augmentation System (WAAS)
- Transducer: AirMar TM258 1 KW transom mount transducer , Max depth 500 m, 3 – 21 degree angle of sound

Rubber Duck (prior to 2016)

- GPS: Garmin GPS 3006c has 3 m horizontal resolution w/WAAS
- Transducer: 1 kw thru hull Airmar P66 max depth 366 m, 11 - 45 degree angle of sound

## Data used:

Each cruise's singlebeam data from the Rubber Duck; HA1201, HA1305, HA1401, HA1501, HA1606 and HA1701

Highest resolution multibeam (MB) bathymetry that has overlap with singlebeam (SB) data, typically 5 or 10 m resolution.

5 m resolution bathymetry: Maug, Tau, Rose, Baker, Johnston, Palmyra, Kingman, Tinian, Wake, Jarvis 5m, Howland, Pearl & Hermes, FFS, Rota, Tutuila, Ofu, Saipan

10 m resolution bathymetry: Sarigan, FDP, Guguan, Alamagan, Agrihan, Asuncion, Pagan, Swains

20 m resolution bathymetry: Lisianski

## Process:

Multibeam and singlebeam files were overlaid in ArcGIS 10.4.1. Values from MB were extracted and exported. Depths <1 meter and ≥60 m were removed. The difference between SB and MB depth was calculated and a mean value and Standard Deviation (SD) was determined for this difference. From this, the standard error was also calculated (SD/square root*#of values). $R^2$ values were generated from scatter plots of the SB depth vs MB depth. Horizontal error was derived from the Estimated Error reported from the GPS unit when available.

As the multibeam resolution is typically 5m and multiple SB points may exist within a 5m area, data from Rose and Tau were tested to average the SB point data over a 5m grid to see if averaging the SB points would improve alignment with the MB data. Results of this test are indicated with 'avg' added to the label for example: ROS_15_avg. This trial extended the time required to process the data significantly and error values were higher than using non-averaged data.

# Results:

The analysis shows that 34 of the 45 (76%) singlebeam surveys (not including the averages tests) that have been conducted since 2012 have vertical error less than 1 m, 15 of those (33%) have error less than 0.5 m. Data from 2012 and 2015 have the best accuracy overall, but remain inconsistent over space and time similar to the other data sets.

## Temporal analysis:

Data from 2012 had extremely low error (<0.5 m) for over half of the islands (6/10). Only three islands had error > 1 m. In 2012, the GPS units were set up and calibrated for sound speed. However, there is no documentation about the settings that were used or how they were determined. Units may have had different settings after 2012 with new users and/or units.

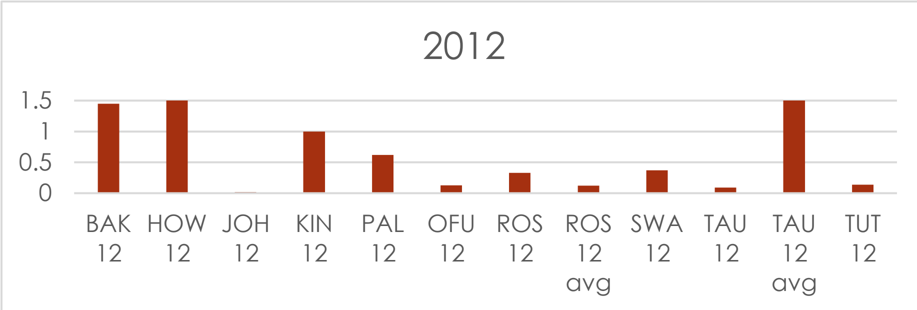
In 2013, error values for all three island surveys was <1 m with one island < 0.5 m error.

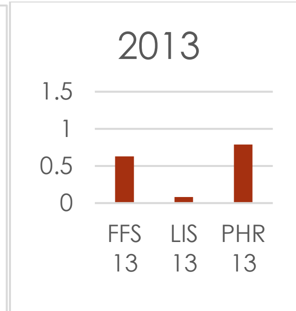
2014 had three islands with error values >1 m, and one island with < 0.5 m error.

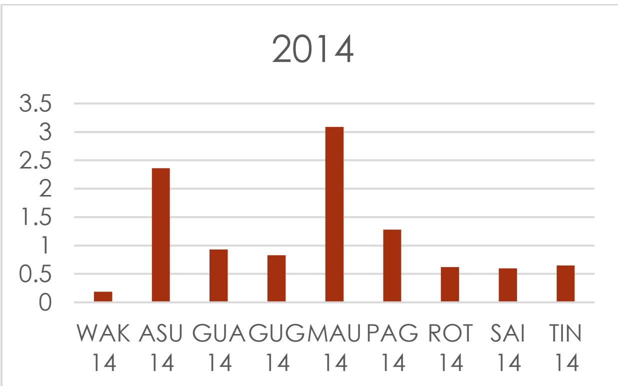
In 2015 two islands had error > 1 m, and half the islands (5/10) had an error of < 0.5 m.

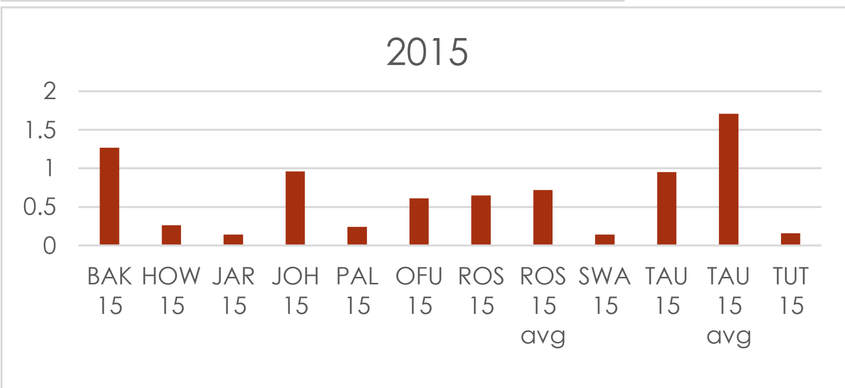
In 2016 new GPS and transducer units were installed and settings were adjusted during the use of the units in 2017 (staring with the Marianas leg). Two islands had error > 1 m, and two had error < 0.5 m.

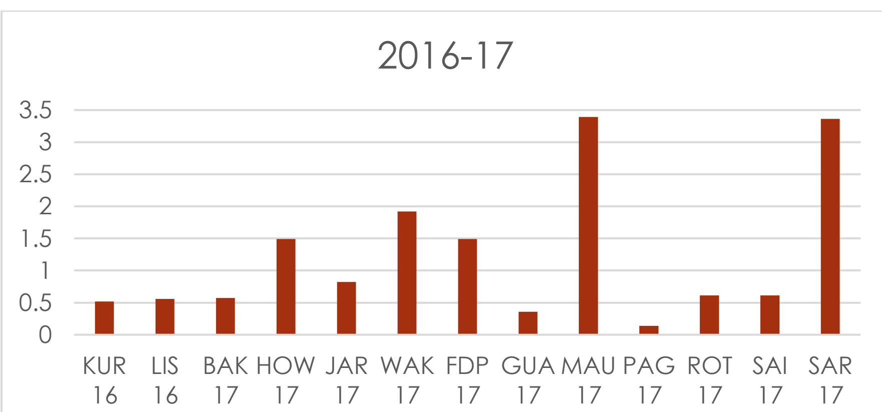
In general, error has been between 0.5 and 1 m over time, with the exception of 2012 and 2015 having lower error than other years.


2012
1.5
1
0.5
0
BAK 12
HOW 12
JOH 12
KIN 12
PAL 12
OFU 12
ROS 12
ROS 12 avg
SWA 12
TAU 12
TAU 12 avg
TUT 12


2013
1.5
1
0.5
0
FFS 13
LIS 13
PHR 13


2014
3.5
3
2.5
2
1.5
1
0.5
0
WAK 14
ASU 14
GUA 14
GUG 14
MAU 14
PAG 14
ROT 14
SAI 14
TIN 14

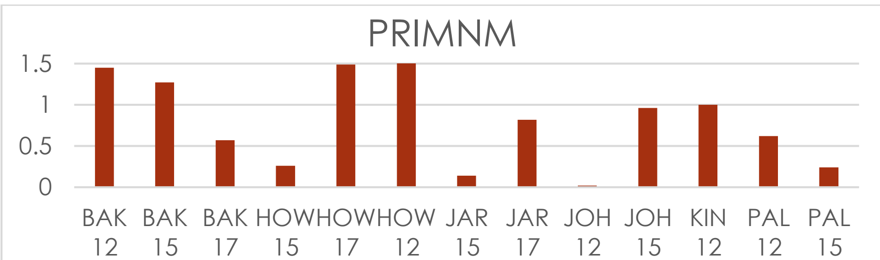

2015
2
1.5
1
0.5
0
BAK 15
HOW 15
JAR 15
JOH 15
PAL 15
OFU 15
ROS 15
ROS 15 avg
SWA 15
TAU 15
TAU 15 avg
TUT 15

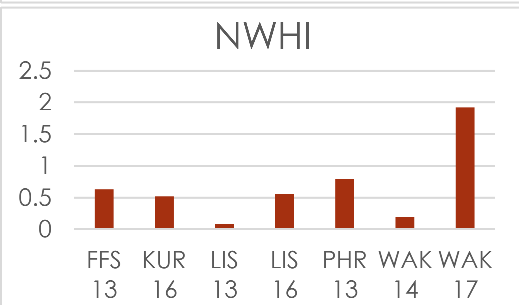

2016-17
3.5
3
2.5
2
1.5
1
0.5
0
KUR 16
LIS 16
BAK 17
HOW 17
JAR 17
WAK 17
FDP 17
GUA 17
MAU 17
PAG 17
ROT 17
SAI 17
SAR 17

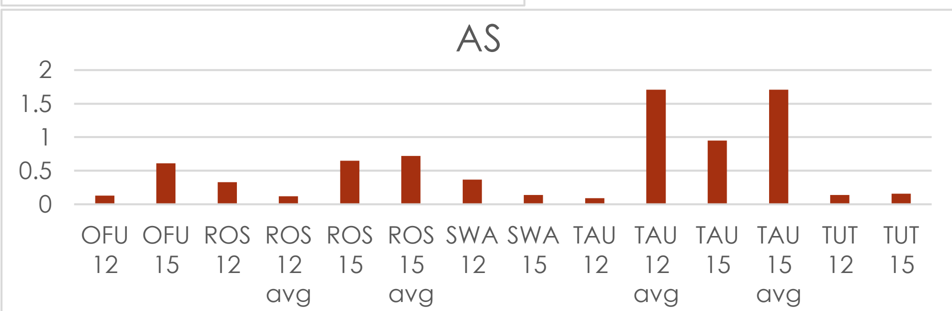
## Spatial analysis:

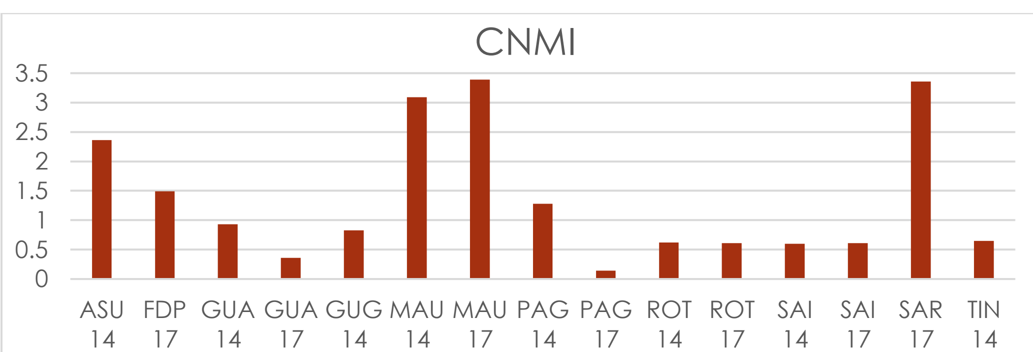
Some of the islands that we survey appear to have inherent error associated with them. These islands have been surveyed more than once and have never had error less than 0.5 m, including Baker, Saipan, Rota and Maug. Some islands that have only one survey with high error (>1 m) may be trouble spots because the multibeam bathymetry resolution is lower (10m), these include Asuncion, FDP and Sarigan. The variation and density of single beam overlap with multibeam validation depths may also be contributing to error at some islands.

In contrast, Lisianski, Palmyra, Ofu, Rose, Swains and Tutuila have had consistently low error with repeated measurements, with Rota and Saipan consistently close to but over 0.5 m error.



For all islands with > 1 m vertical error, sectors were selected that could potentially illuminate problem areas (ie. Windward vs leeward side). The results of that analysis by island:

a. Baker has repeated low accuracy on the north side of the island. However, the shallow east terrace and deep west bank may set up conditions for variable water column parameters. More error occurs in shallow waters (<30m).
b. Maug's readings from inside the caldera have extremely high error that do not persist outside of the caldera. The error associated within the caldera may be attributed to highly stratified physical water properties, as the caldera is typically very calm and protected.
c. Saipan's error appears to be associated with deeper water and outside of the northwestern lagoon, and may also be impacted by streams and subterranean fresh water input from the island disrupting the water column stratification.
d. There are no obvious patterns in the error associated with Sarigan or Asuncion. It appears that more often the SB is reading shallower than the MB.
e. Wake in 2017 has more error associated with the northern end of the island and the SB is reading shallower than the MB more often.
f. Howland has less error associated with the east side of the island and in shallow water (<30m).
g. There is more error associated with the northeast side of FDP.
h. For Pagan in 2014 most of the error is from the SB reading deeper than the MB.

## Recommendations:

**Improve data collection.** In shallow water, temperature has the highest impact on the sound speed (salinity and pressure also contribute to a lesser degree). Correcting collected depth readings with CTD readings in situ may be the most efficient way to improve measurements. Taking a CTD reading at the beginning of each day and adjusting the Furuno settings should improve performance. For example, adjusting the sound speed setting by 25 m/sec can result in a 1 meter difference in depth reading. Although the Furuno settings were adjusted during leg 2 in an attempt to improve readings, sound speed information was not available and error continued to be variable. Regardless, using a long pulse length and narrow beam for shallow water with a frequency of 200 kHz or higher will result in less scatter. See below for suggested settings.

**Understand geographic setting.** Understanding the unique oceanic and geographic conditions for areas that are known to produce poor readings may also improve accuracy. For example inside the Caldera at Maug is consistently inaccurate.

**Conduct post processing.** Settings for GPS unit and data download instructions need to be added to either the RAMP POC Project Plan OR the Cruise Prep: data management, post-cruise DM. Singlebeam data should be downloaded after surveys are completed at each island and GPS data should be cleared before starting next island to eliminate duplication of data. Single beam data need to be processed after each cruise is complete to determine and document the accuracy of the data. The CTD profiles (from the benthic towed-diver Seabird) should be averaged over each tow and used to correct the depth readings (documentation is needed for this procedure). In addition, survey areas with high error values should be further analyzed to determine (if possible) if a particular location within the area is producing the error (ie. windward vs leeward). This will allow users to select the best data available and know what accuracy can be expected when using the data for validation of derived depth products.

Since derived depth products typically do not extend beyond 30 m, it would be appropriate to limit the error analysis of the singlebeam data to only depths that will be used (ie. 0-20m) when possible. In this analysis, shallower depths generally produced more accurate results, but not in all cases.

# Furuno Settings:

## Furuno USA, Inc. suggests:

Try setting your unit this way,

Long-push ( ESC/MENU) key to show the main menu
2.) select the ( fish-finder ) icon with the Roto key, and select the ( Fish-finder setup) icon.
3.) after respective settings are completed, press the ( ESC/MENU) key three times to display the normal screen.

TRANSMISSION POWER: HIGH
50KHZ ECHO OFFSET +20
200KHZ ECHO OFFSET +20
50 KHZ BOTTOM LEVEL -60
200 KHZ BOTTOM LEVEL -60
Maybe try to run it on manual instead of auto.

## Leg 3 for MARAMP17 settings:

Set time and date to UTC:
1) long-push the ESC?MENU key to show main menu. Select menu then push the General key.
2) Select time offset as UTC, daylight saving time off, time format 24 hours, date format mm-dd-yy.
3) No daylight savings

Datum: WGS 84

Transducer: 1kW

Track recording interval:

1) open the "plotter" menu, select "track" and "track recording method"
2) select "time".
3) select the menu item "Time" then 10 seconds.
4) Press ESC/MENU key to close the menu.

Record track: On

WAAS: enabled

Units: feet – This is only for display, the unit records in meters despite what units are displayed

Depth info: Large, displays depth information in large font

Check all settings as described above and save as **user default** so that it is easy to reset if needed during cruise.

# Download Furuno Data:

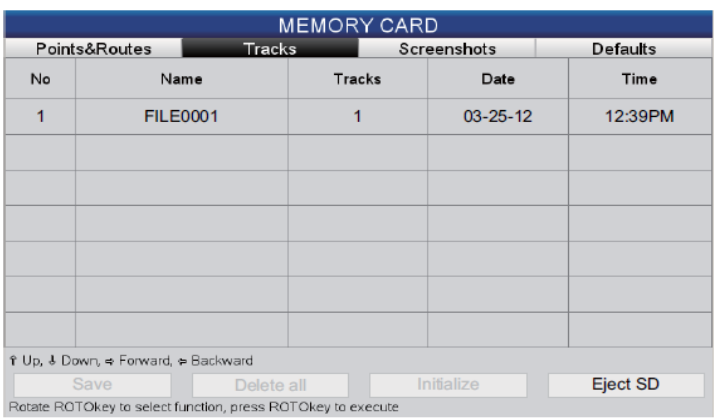
- Make sure transducer is in the water, since GPS needs to be on for awhile
- Replace GPS card with SD card, one for recording single beam data and one for uploading the tow points file (provided)
- Follow 9.4 below to save collected single beam data to the SD card (it can take awhile)
- Eject card (9.3)

## 9.3 How to Eject an SD Card

To prevent loss of data on an SD card, eject the SD card from the full RotoKey menu. (If you are in the [MEMORY CARD] menu you can use the [Eject SD] button.) After ejecting the SD card, close the cover.

## 9.4 How to Save Data to an SD Card

1. Open the [GENERAL] menu and select [MEMORY CARD].
2. Select the tab ([Points&Routes], [Track], [Screen], [Default]) corresponding to the item that you want to save.
3. Use the **RotoKey**™ to select [Save] then push the key. Wait for the message "Saving completed". to appear. Do not remove the card until the message appears. Press the **ESC/MENU** key to erase the message. In the example, below the ship's tracks were saved.
   The default file name is FILExxxx (xxxx=next sequential file number). If desired, you can change the name. A file name may have a maximum of 13 alphanumeric characters. See section 1.13 for how to enter alphanumeric data.



MEMORY CARD

Points&Routes | Tracks | Screenshots | Defaults

| No | Name | Tracks | Date | Time |
|---|---|---|---|---|
| 1 | FILE0001 | 1 | 03-25-12 | 12:39PM |
| | | | | |
| | | | | |
| | | | | |
| | | | | |
| | | | | |
| | | | | |

↑ Up, ↓ Down, ⇒ Forward, ⇐ Backward

Save | Delete all | Initialize | Eject SD

Rotate ROTOkey to select function, press ROTOkey to execute

The data should be downloaded/copied to the cruise data server with the rest of the cruise data/files when surveys are completed at each island. When the ship returns from the mission, the data needs to be reformatted using GPS Utility software.

https://drive.google.com/drive/folders/0Bw7xF059OaXZZVd4SGUyWjltcms
V=PICMakai\GIS
V:\SingleBeam\Singlebeam_Analysis