



# How to Detect Artifacts from Additional Sensors in Multibeam Data

By Ivan Isaak

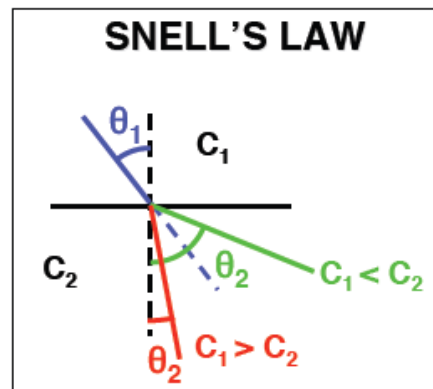
Unlike a singlebeam echosounder, a multibeam system (MBES) requires more additional sensors to improve the quality of the data. Normally, in addition to the bathymetry, MBES data consists of data from an SV Profiler, a DGPS or RTK GPS, a Heading sensor (dual antenna GPS or a Gyro) and an attitude sensor (to measure heave, pitch and roll).

The more sensors there are in a system, the more error sources there are. I'll try to illustrate how each of the parameters, measured incorrectly, can affect the data and how to determine these artifacts.

## *SOUND VELOCITY ARTIFACTS*

It is really important for the MBES to determine sound velocity profile in the water column to properly trace every individual beam. The farther the beam is from the nadir, the more effect of the sound velocity profile.

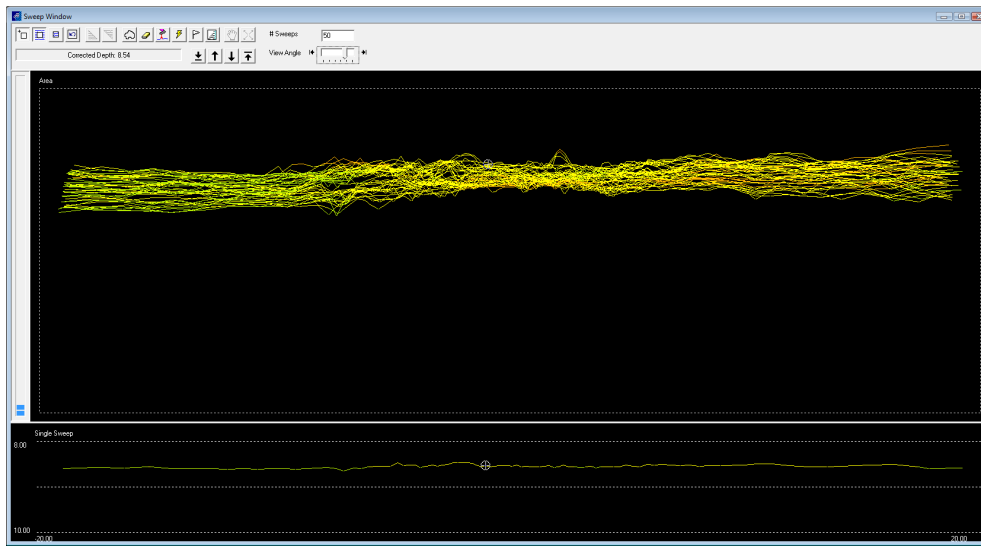
*FIGURE 1. Fig. 1 Sound Velocity refraction*



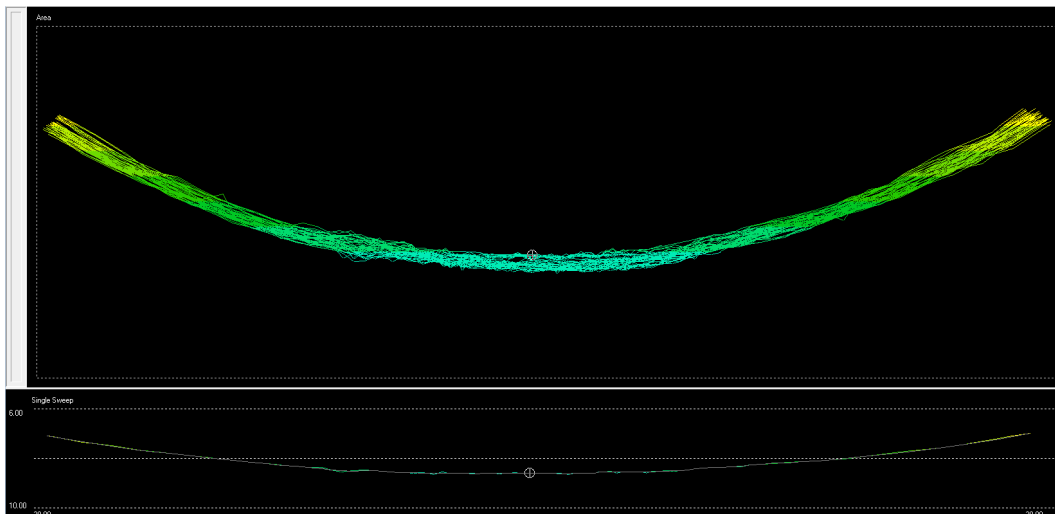
$$\frac{\sin \theta_1}{c_1} = \frac{\sin \theta_2}{c_2} = \text{ray parameter}$$

As a result, an error in the ray tracing will lead to a banded bottom profile across the track. It is easy to detect such an artifact when looking at the cross section profile on a flat bottom. If there is a "smile" in the profile, it is evidence of the sound velocity artifacts in the data.

**FIGURE 2.** Good Sound Velocity – Flat Bottom.



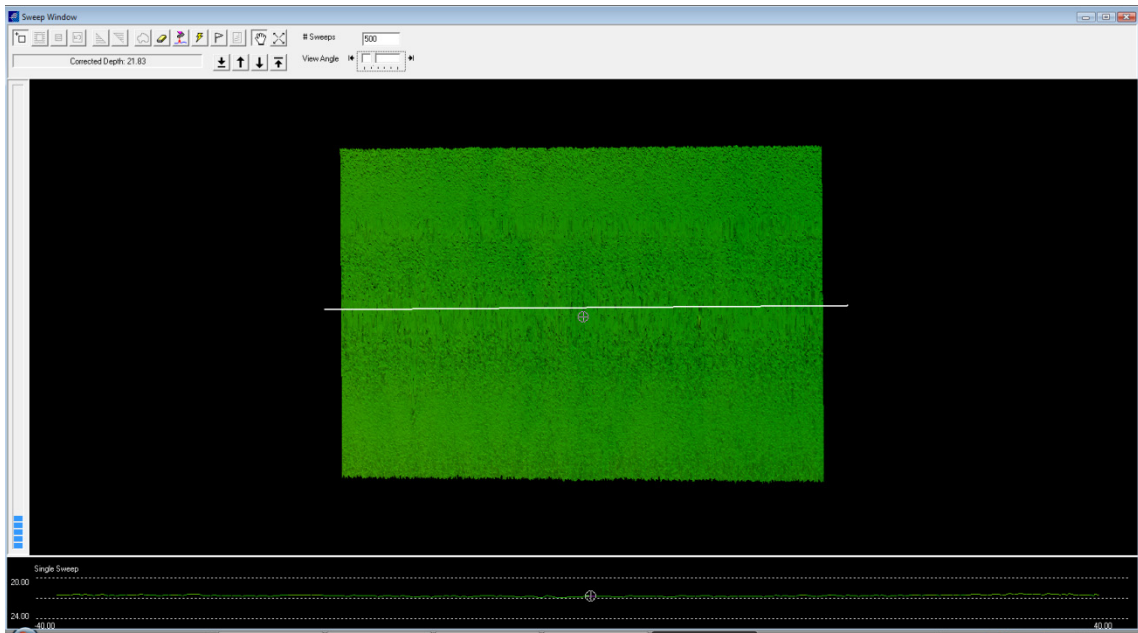
**FIGURE 3.** Abnormal Data Due to Sound Velocity Artifacts



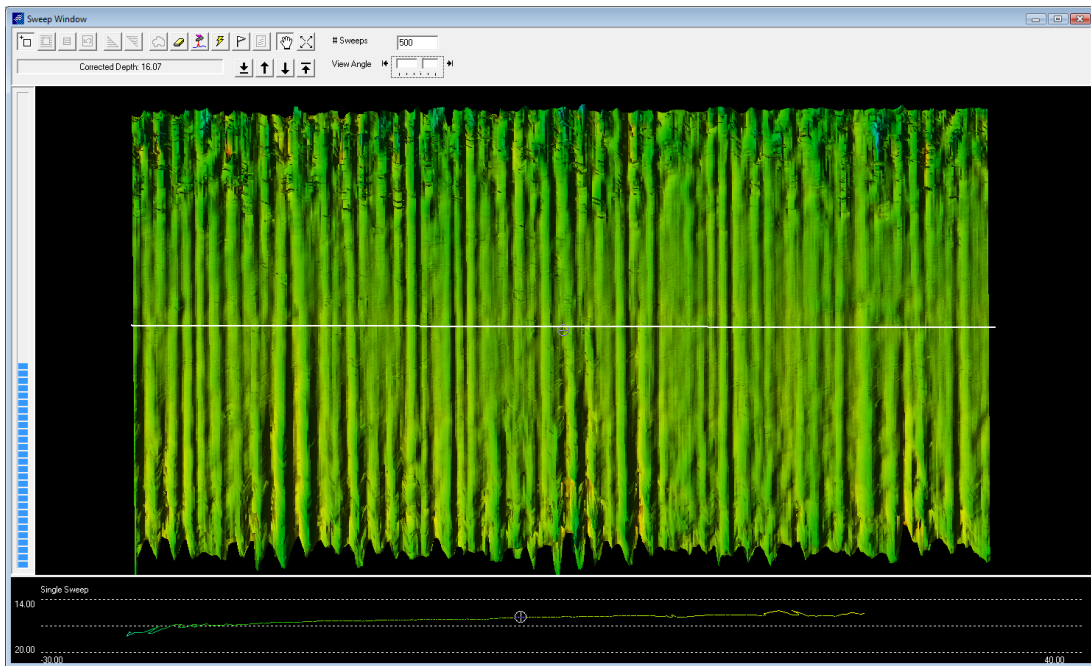
## ***HEAVE ARTIFACTS***

If there are no heave data or they are wrong, then the flat bottom will look wavy.

**FIGURE 4.** Along Track Data Corrected for Heave. The white line is a vessel track. Profile View of 500 sweeps in the HYSWEEP® EDITOR.



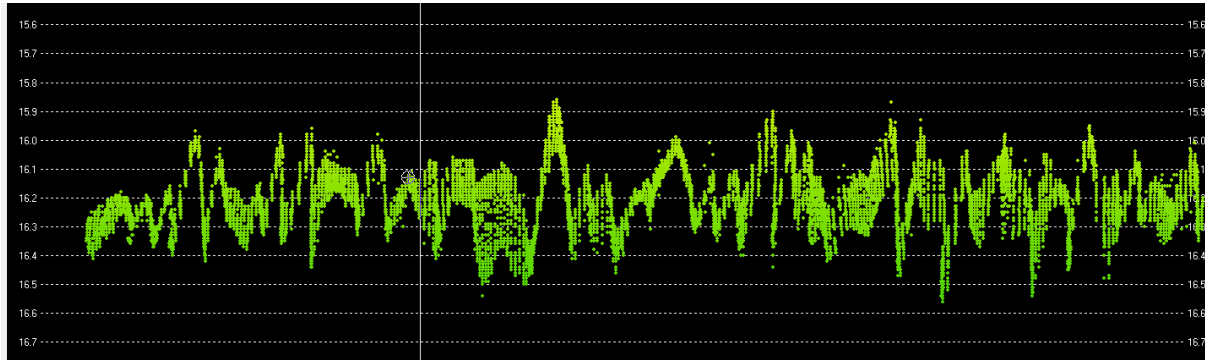
**FIGURE 5.** Along Track Data Not Corrected for Heave. Profile view of the 500 sweeps in the HYSWEEP® EDITOR, Phase 2 of Editing.



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**FIGURE 6.** Along Track Profile with the Data Not Corrected for Heave. Profile View in Phase 3 of editing in the HYSWEEP® EDITOR

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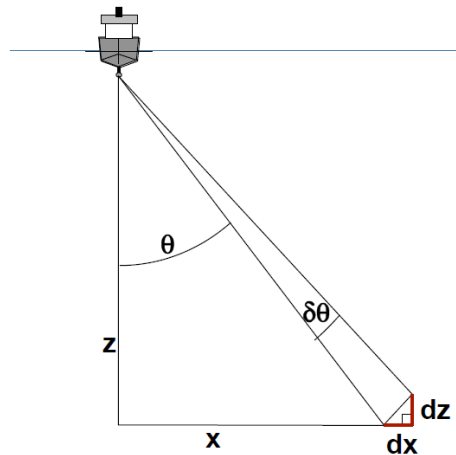
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## **ROLL ARTIFACTS**

Roll affects the MBES data in both the horizontal and vertical planes, and more so on the outer beams.

**FIGURE 7.** Roll effect

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There are 2 cases of the roll artifacts:

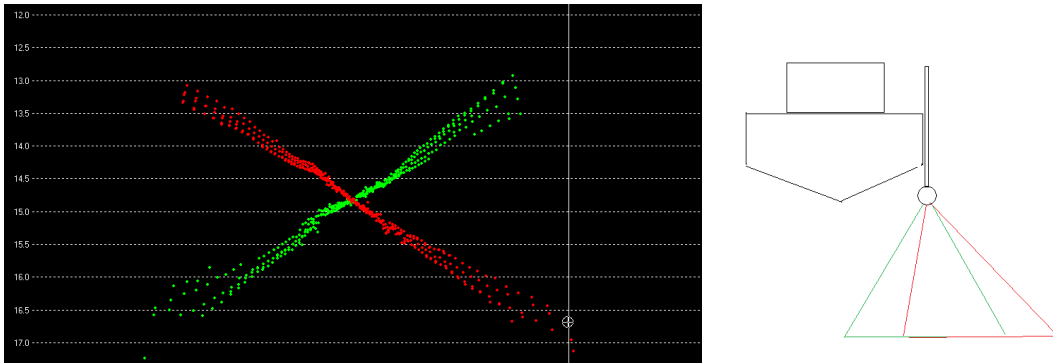
- Roll Angular Misalignment between the MBE transducer and the MRU.
- Bad roll data from MRU

## **ROLL ANGULAR MISALIGNMENT BETWEEN THE MULTIBEAM TRANSDUCER AND THE MRU**

Misalignment between the multibeam transducer and the MRU will lead to a big vertical error on outer beams.

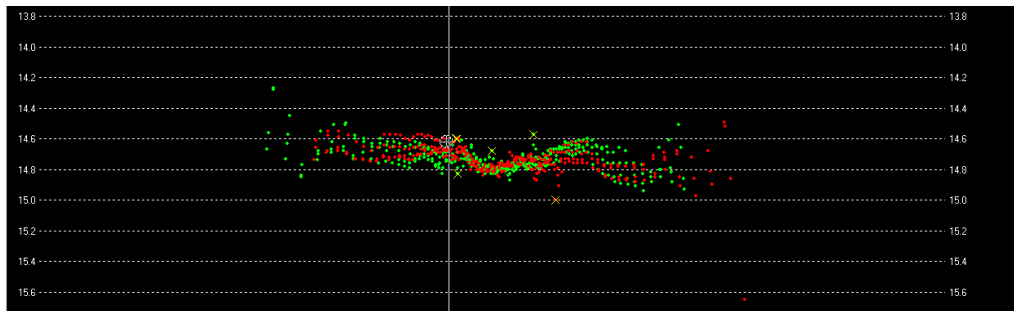
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**FIGURE 8.** Cross Section Profile of the Two Data Sets in the Profile Window, Phase 3 of the HYSWEEP® EDITOR. No Roll Angle Correction.



To determine Roll angle one needs a flat area and two reciprocal lines. In Figure 8, Roll angle was  $2.9^\circ$ . The resulting cross sections after this angle was applied is shown in Figure 9. Another way to determine the roll angle is to measure alignment between sensors with the total station while the vessel is in the dry dock.

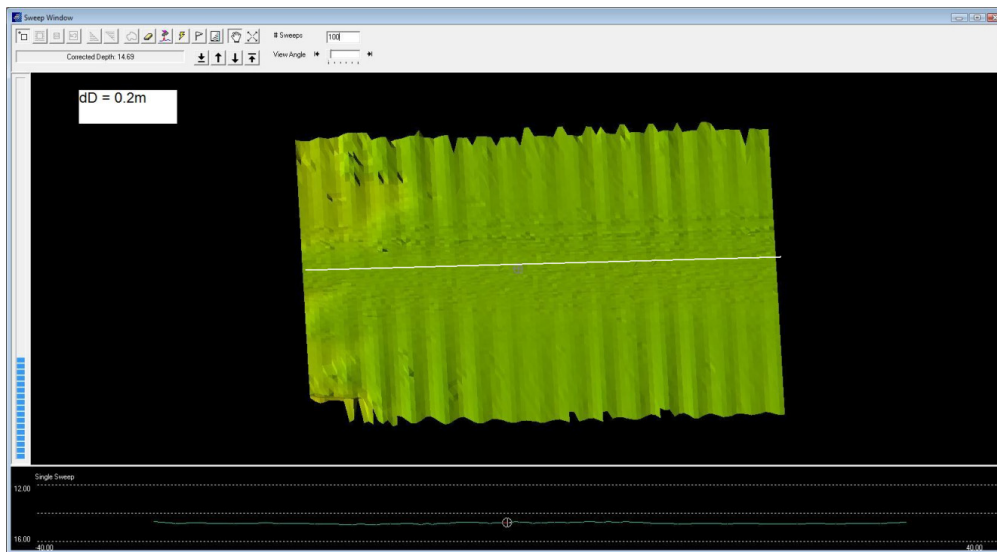
**FIGURE 9.** Fig. 9 Cross section profile of the two data sets in Profile Window, phase 3 of HYSWEEP® Editor. Roll angle correction was applied.



## BAD ROLL DATA FROM MRU

This artifact is easy to see over a flat bottom if there are alternate waves on the DTM (Digital Terrain Model) to the left and to the right of nadir. In the example below depth error on outer beams (65o) was about 20cm at 15m depth

**FIGURE 10.** Roll Artifacts in MBES data. Profile View of the 500 sweeps in HYSWEEP® EDITOR, Phase 2. White line is the vessel track.



## LATENCY ARTIFACTS

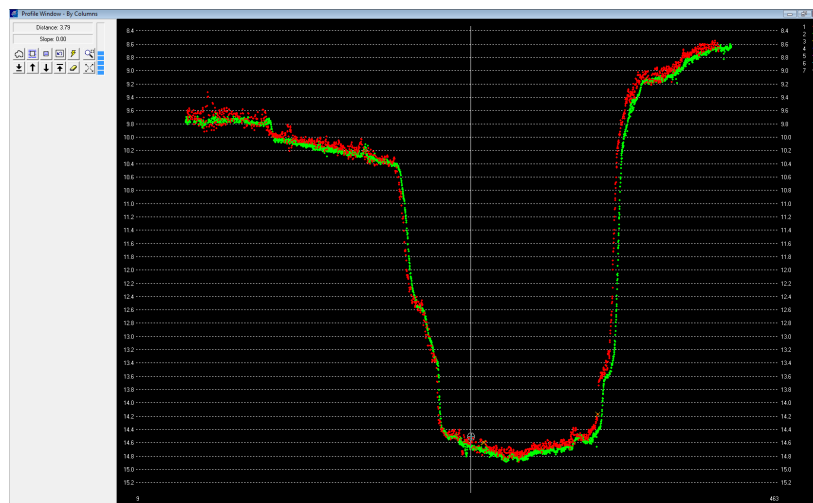
If there is any latency in the data, it can lead to a horizontal shift of the slope (or an object).

**To verify if there is any latency in the data**, one can run the same line in the same direction over a slope at different speeds.

In Figure 11, a 1 sec. latency has led to a 3.4m shift of the slope at a 8-15m depth range.

The best way to determine the latency is to perform the Patch Test.

**FIGURE 11.** Profile View of two data sets with the latency artifact. HYSWEEP® Editor, Phase 3.



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## PITCH ANGLE ARTIFACT

Pitch misalignment between the MBE transducer and the MRU ( $\delta\phi$ ) can lead to horizontal and vertical error.

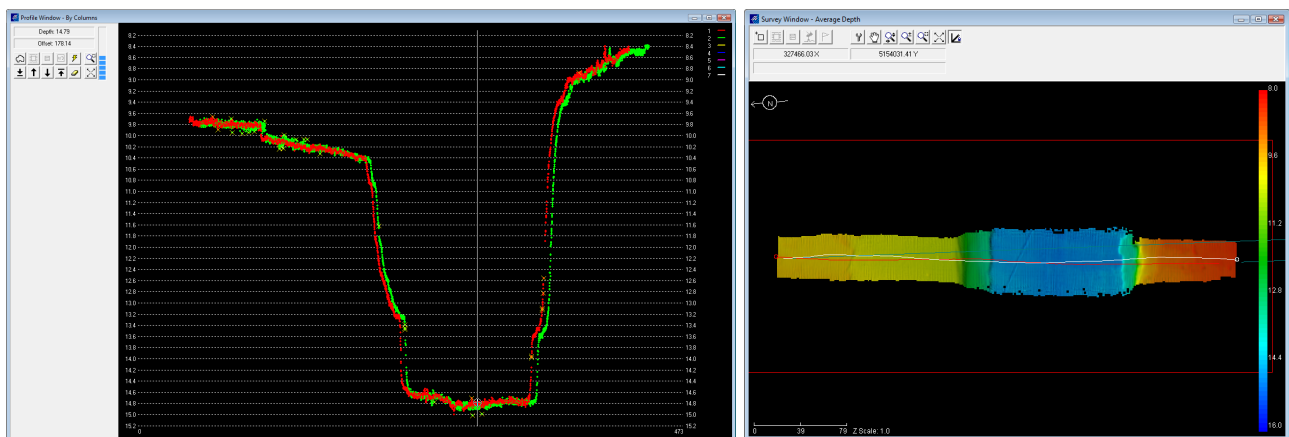
**FIGURE 12.** Pitch misalignment between MRU and MBE

For example,  $5^\circ$  pitch angle errors can result in a depth error of 0.5% of the total water depth. But, since the ensonified area is generally aimed downward, the horizontal error is always greater and the significance of the pitch error is increased with depth.

Such Pitch alignment can be verified by comparing two lines run in opposite directions over a slope or an object at the same place.

In Figure 13, a pitch error of  $10^\circ$  has led to a 7.5m shift of the slope and a 0.05m vertical error at 15m depth.

**FIGURE 13.** Pitch angle artifacts in the Profile window in Phase 3 of editing in the HYSWEEP® Editor.

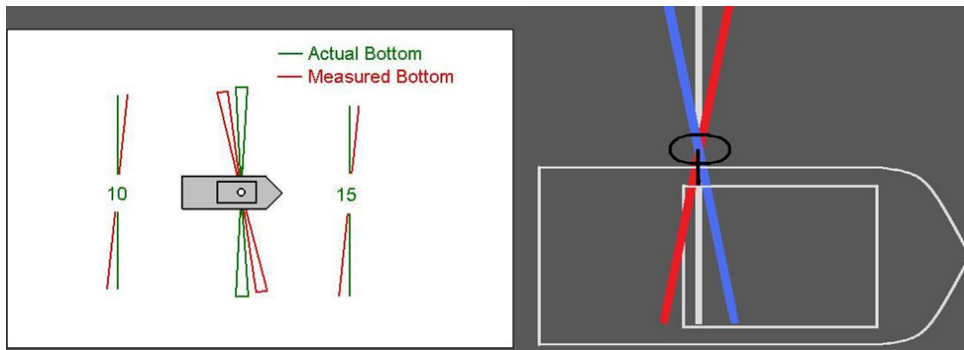


## HEADING ARTIFACTS

Since the heading is defined in the horizontal plane, any error due to heading can only result in horizontal position error. This error increases with the beam angle and greater depths.

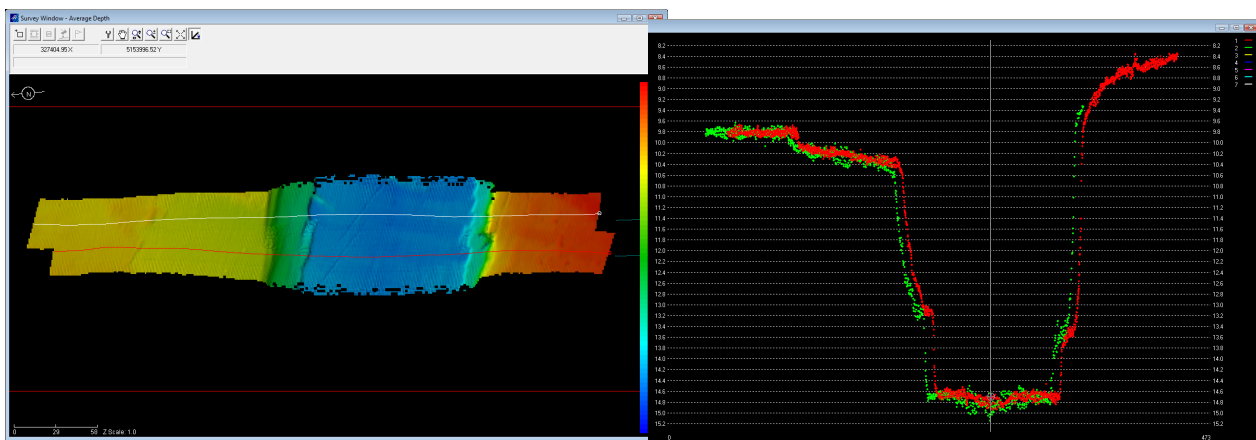
The highest portion of the heading error can appear due to angular misalignment between the MBE transducer and the vessel frame (or gyro heading).

**FIGURE 14. Heading Misalignment**



Heading misalignment can be detected visually by comparing two data sets, collected over two lines with one depth distance between them, run in the same direction over a prominent feature on the bottom. The deeper the area, the better. In the plan view, you can easily see the channel errors at two different passes and in the cross section view there is a prominent shift of the channel slopes.

**FIGURE 15. Two Profiles in a Survey Window (left) and Profile Window (right) in Phase 3 in the HYSWEEP® EDITOR. Data are not corrected for Yaw.**



**FIGURE 16.** Data corrected for Yaw angle.

