I See Multibeam Artifacts! Your Software Doesn't Work!

By Mike Kalmbach

Oh boy, here we go again. Two or three times a year I hear variations on this claim. Likewise, our Technical Support people, probably way more than me. The sales staff is not immune either!

My job: To spend whatever time it takes to find out if the software does or doesn't work. So far it's about 30 – 0 in favor of the software.

My question: Why is the connection (artifacts = software doesn't work) so automatic to some people? **If** I see artifacts in multibeam data, **then** the software doesn't work. It's extra puzzling because we've gone way out of our way in editing to show the raw data that can lead to artifacts.

Anyway, Pat has us write these articles every other month, and it seems fun to explore. See if there's an interesting conclusion.

MULTIBEAM ARTIFACTS

How should we even define an artifact? In the survey context, dictionary.com gives "*A substance or structure not naturally present in the matter being observed but formed by artificial means*". That will work!

FIGURE 1. *Sample Artifacts--15X Vertical Exaggeration*

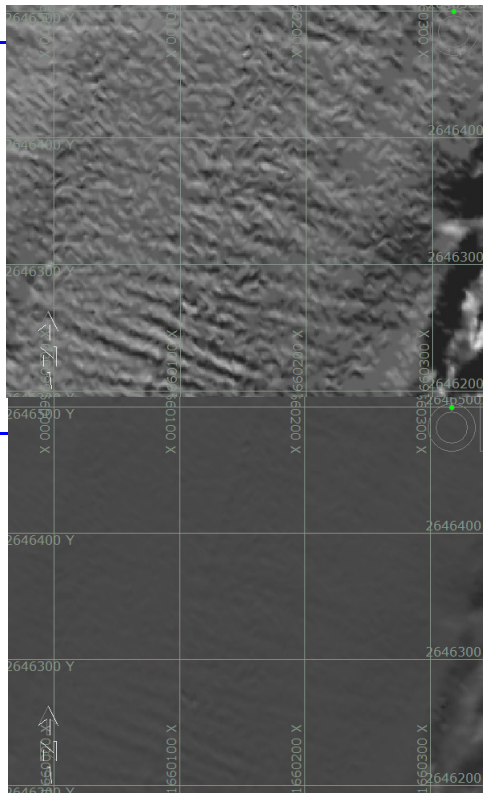


Figure 1 shows a multibeam survey with artifacts that show up clearly with 15x vertical exaggeration. It looks pretty bad. Vertical exaggeration is a good way to pull out artifacts that are not easy to see at normal scale.

OK, we have artifacts as defined by dictionary.com. The premise is that the software doesn't work. Let's check it out…

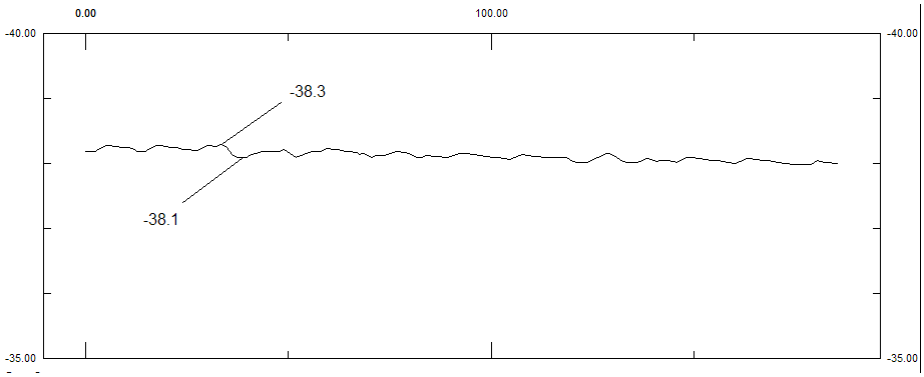
FIGURE 2. *Sample Artifacts - 0 Vertical Exaggeration*

First, a reality check. What does it look like without exaggeration? That's shown in Figure 2. The artifacts are not nearly as obvious, but you can see them with just the right angle of artificial illumination.

Next, check the time tags. Bad time tagging leads to nasty motion artifacts! Time tags are fine.

Next, find the size of the artifacts. That's easily done in HYPACK® by cutting a cross section using CROSS SECTIONS AND VOLUMES. We return to a large vertical exaggeration to make things stand out. Likewise, we assume the bottom is flat so that any depth change is an artifact.

FIGURE 3. *Cross Section of Area with Supposed Artifacts - 20X Vertica Exaggeration*



Here is the cross section, with 20x exaggeration. There are the artifacts and the magnitude is +z/ - a tenth of a foot or 3 centimeters.

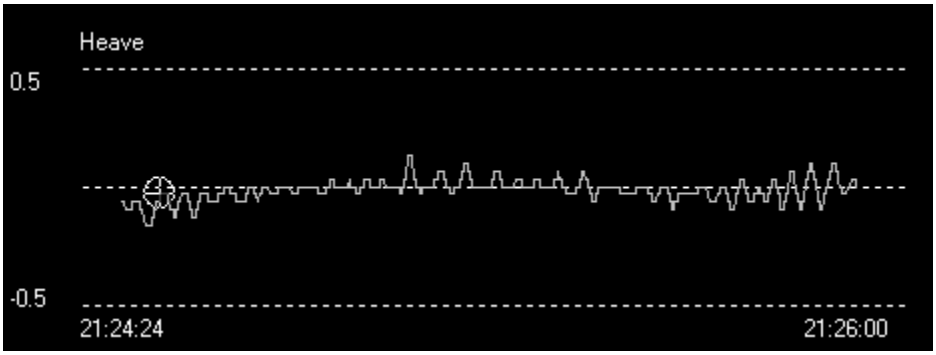
Some people would stop here, knowing that their survey is well within specs. But a select few will charge ahead! YSDW! (Your Software Doesn't Work). Sometimes an angry YSIS!

Given that my job is to show either (1) that the software *does* work or (2) to find bugs and fix them, the next step is to analyze the survey. All the sensors that contribute to accurate multibeam soundings.

It looks like a heave artifact, probably the most common complaint. So, first we look at the heave. It could also be a pitch artifact so we'll look at that also. MBMAX editing is good for looking at raw data.

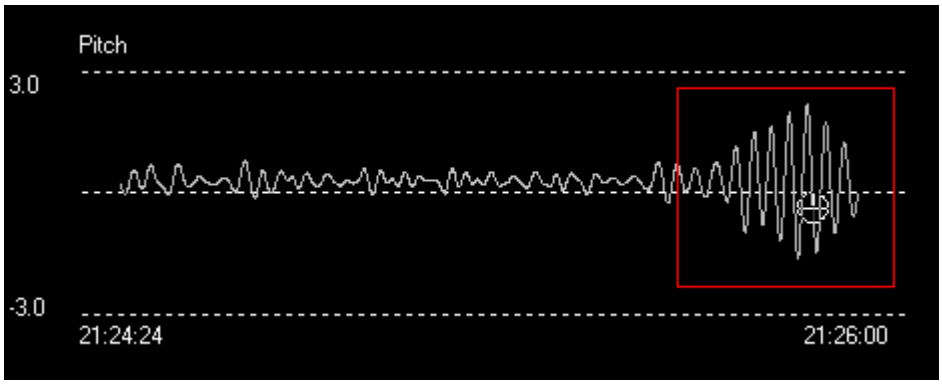
The heave graph looks at bit odd, with a long period oscillation that is probably not right. An artifact in the heave measurement. Turns out the heave was ignored in processing anyway. Instead, heave was measured by vertical GPS movement. That's a questionable strategy if you're chasing tenths, but in this case it seems valid. (i.e., the magnitude and phase of heave and vertical GPS motion match well and GPS update rate is fairly high – about 20 Hz.)

FIGURE 4. *Heave Graph*



The pitch graph shows a burst at the time of the depth artifacts. Probably crossing a wake. Given that the lever arm between boat reference and the sonar head is very small, there's no change in sonar draft (a possible source of artifacts).

FIGURE 5. *Pitch Graph*



What's the published heave accuracy of the Octopus F180? 5 cm. RTK vertical? 2 to 20 cm, depending on configuration. Enough to explain the depth artifacts.

Onward! If the software doesn't work, we need to know.

FIGURE 6. *Map View of Depths at Time of Supposed Artifacts*

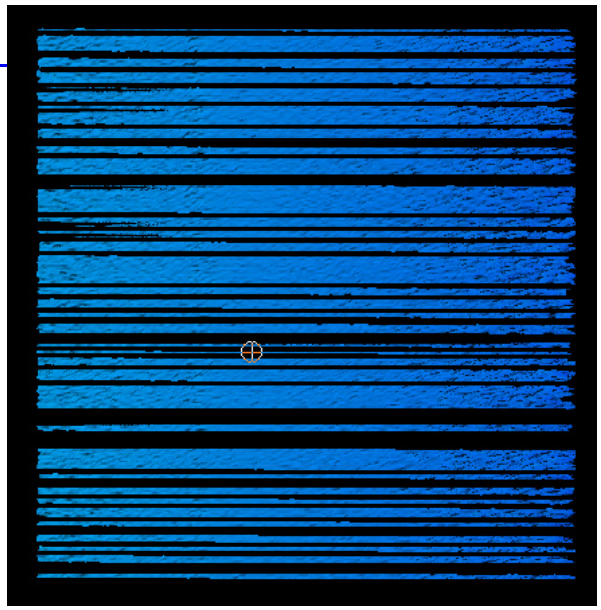


Figure 6 shows depths in map view at the time of the artifacts. Each gap is a point where the sonar lost bottom tracking. Clearly it was having trouble! Could that contribute to artifacts? Sure.

At this point, we at HYPACK® have gone as far as we can. Yes, there are artifacts in the data. They are very small. The artifacts are within the accuracy range of the motion sensor. The sonar was having trouble with bottom tracking at the time. Plenty of ways to explain the artifacts.

Hand calculations validate what the software is doing. No real choice except to conclude that the software is OK. 31-0!

CONCLUSIONS:

Nothing too interesting. People will continue to insist the software doesn't work. And we will continue to ask for the survey, analyze the hell out of it, and show as best we can that the software does indeed work.

The good part. Sometimes when we prove that the software is working, our harshest critics become our best ambassadors!