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Sound Velocity: Preplanning To Avoid Getting Bitten

By Josh Sampey

When conducting any acoustic survey, the sound velocity in water can have a major impact on the accuracy and quality of your data. During training, we are often asked how often to take a cast. As with many things in this industry, the answer usually starts with the words, “it depends”. While we have some general rules of thumb for the frequency of casting, there are many more factors that need to be examined when determining your SV cast procedures. Taking SV casts is, to some degree, an art form and requires us, as hydrographers, to combine an armful of observations to create the best cast regime for the survey. During all my training and support calls, I like to point out even the best of us will be bitten by the sound speed gremlin. By the end of reading this article, you will have a better understanding of observations you should be making when determining where and when to take a cast.

WHY DO WE CAST?

A sound velocity cast involves lowering an instrument through the water column to determine the changes in the sound speed at various depths. This allows us to then apply that information—in real time or in processing—to our data to be properly positioned. Remember that sonar does not measure depth, but time. Depth is inferred by knowing the speed of sound in water, where T= 2-way travel time. For a single beam sonar, we measure the average speed of sound in water to be 1465m/s, the sonar measures the two-way travel time to be 0.02s, the resulting depth estimation is 29.3m. Now assume that we apply an incorrect sound velocity measurement of 1480m/s the resulting depth would be 29.6m (a 30cm difference). While that does not seem like a lot, keep in mind that in shallow water <30m you may be exceeding the allowable IHO uncertainty for special order surveys. Things are way more complicated when the same happens to multibeam, as the sound no longer only takes a straight down path but goes through the water at an angle and we can no longer use just the average sound speed.

AVOIDING THE SOUND SPEED BITE!

Observing your survey environment, as well as adapting your casting and survey plan, will go a long way in reducing the chances that you will be bitten. As it may go without saying, the first step in making sure you will avoid problems with sound speed is ensuring your sensors are working correctly. This is why regularly getting your sensors calibrated, per the manufacturer's recommendations, will ensure that when you adopt your plan that you will not have to question your instrument's readings. The proceeding sections will explain methods for checking the proper operation of your equipment and some environmental conditions capable of impacting your survey. In some scenarios, you will need to plan your cast to have

more spatial distribution and in some cases a more temporal distribution is appropriate. In most cases, however, the best will be somewhere in between.

Checking your Equipment

The fastest way to check your gear is by comparing it to another piece of equipment. In the case of multibeam, you will want to regularly compare the sound speed on the multibeam head to the probe. This can be done by lowering the probe to the same depth as the sensor on the head and checking the values, they should be within ~1m/s. If they are, then all is good. However, if they are wrong and you need to determine which one is wrong, you can utilize some distilled water (sold in many major grocery stores) along with a thermometer:

Take a clean bucket/bin, fill it with the distilled water and place the instrument in question in the water. Measure the temperature of the water and check the expected sound speed for the measured temperature and compare it to the values obtained by your instrument. The engineering toolbox is a great resource for looking up the expected values.

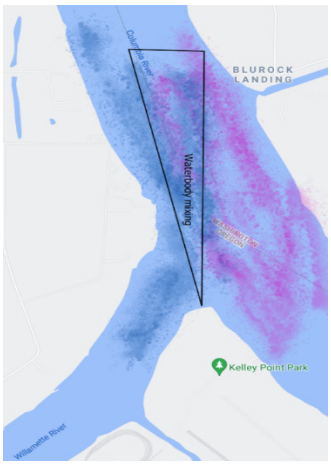
Environmental Observations

With ready access to information that the internet provides, you can start planning your approach well before you get onsite and, in most cases, only minor tweaks to your approach will be needed. While I will not be able to cover all the environmental considerations, the cases discussed in the following sections will at least point out areas that may not be commonly considered and give you some ideas on how to tackle them.

Tides and Currents

It is key to remember that both changes in tides and currents move water masses and have the potential to drastically change the sound speed profile. Tide will especially impact the sound speed should you be working in a river mouth, estuary, or anywhere else with freshwater input creating a salt wedge. In some cases, the changes will be so drastic that they may be hard to properly capture. You may have to adjust your survey times to be during one section of the tidal cycle or perhaps survey only on the slack tide. If you have access to another small vessel it is also possible to send a crew member out on another vessel to continually take SV cast throughout the survey area, this is especially helpful for multibeam surveys, where the impact of improper sound speed is more pronounced. Currents in general are easier to deal with so long as you know about them. With currents, you must get an adequate cast on both sides of the current line.

Input Sources



Input sources introduce a different body of water, with different acoustical properties to your survey area. This can be river confluences where two rivers meet, streams entering a lake, or even power plant cooling water. Also, keep in mind that input sources may also come from the seafloor for example outfalls and in some cases freshwater springs.

Issues can arise even if both sources are freshwater. Remember that in shallow water the two biggest factors impacting sound speed are temperature and salinity. It takes only a few degrees to drastically change the sound speed. When input sources are present, there will always exist a mixing zone with constantly changing sound speed characteristics. This may necessitate that you break your survey into zones surveying small sections instead of running lines through the entirety of the mixing area.

Examining your survey area and taking note of any potential sources of input will go a long way in reducing your sound speed-induced headache.

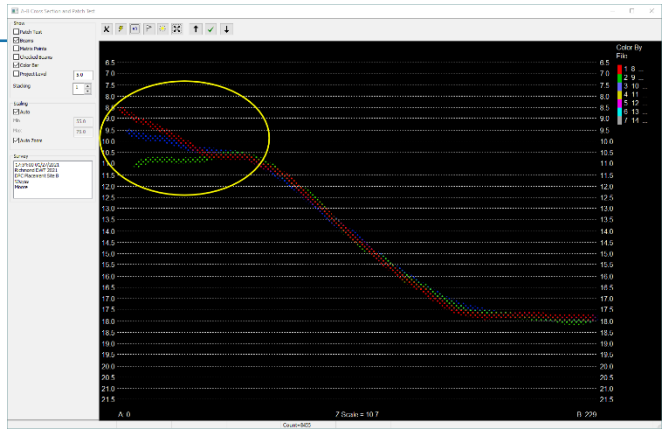
Bankline Heating

Bankline heating is where the slower moving water at the banks of a river has a chance to heat, creating a band of hot water and, therefore, a waterbody with different sound speed characteristics than the main channel.

This issue especially impacts multibeam surveys where you are attempting to survey as far up to the water's edge as possible. As you may have guessed, this issue is most predominant in the warm spring and summer months and disappears in the colder months.

This issue will become very apparent when you look at your data in the editor.

The Effects of Bankline Heating in MBMAX64



In this image, what you will see is perfectly aligned data that suddenly goes haywire once that waterbody is encountered. Mitigating this issue can be as simple as planning to run these survey lines early in the morning before the water has had time to heat up. While it can be possible to take a sound speed cast in that water body HYPACK® has limited ability to apply two different casts to different sectors of the swath.

Mounting Issues

While it may not seem obvious at first, where you mount your system on a vessel may have a huge, unforeseen impact on your data. When examining a vessel for a mounting location, make sure you are aware of any outputs from the vessel. These can be cooling water from the engines, other vessel systems, or even grey water discharge. Mounting your sonar such that hot cooling water flows directly into the sonar will cause sound speed issues in your data.

When mounting, look along the vessel side, scanning towards the bow for any outputs from the vessel, and try to mount your system as far away from the outputs as possible.

The mounting location of the surface sound speed sensor for multibeam can also impact your data quality. Multibeam sonars use the values acquired by the surface sound speed sensor for proper beam steering. This requires that the surface sound speed sensor be mounted as close to the receiver array of the sonar as possible. The farther away from the receiver array you mount your surface sound speed probe, the higher the probability that it will provide incorrect data to the sonar thereby creating the dreaded smiles and frowns. Most manufacturers of sonars recommend a mounting location in their manuals; however, I have encountered installations where the sound velocity sensor was mounted 1m or more above the sonar. In one particular case, the sound velocity sensor was reading the sound velocity in a warm surface layer while the sonar itself was pinging away below the warm thermocline.

SUMMARY

Sound speed can be a beast to deal with and is a constant source of headaches. We will all be “bitten by the sound speed monster” at some point. Taking an adequate number of casts, using narrower swath angles, and planning ahead of time can greatly reduce your potential headaches. If you begin to plan and find yourself stumped on an approach, then we are always here to help advise you on a casting approach that will help reduce the size of your sound speed monster.