Determining Optimal Mosaic Resolution

By Dave Maddock

One of the most common pitfalls with side scan processing is determining the ideal resolution to use for generating mosaics. The higher the resolution, the more detail your imagery may show however you pay the price with longer processing times and larger file sizes. And of course, if your chosen resolution is too high, you may exceed the effective resolution of your data which means you are expending all the extra time and disk space for no added benefit at all.

In this article, I will show you some simple calculations you can run to determine that ideal point.

PHYSICAL VS. DIGITAL RESOLUTION

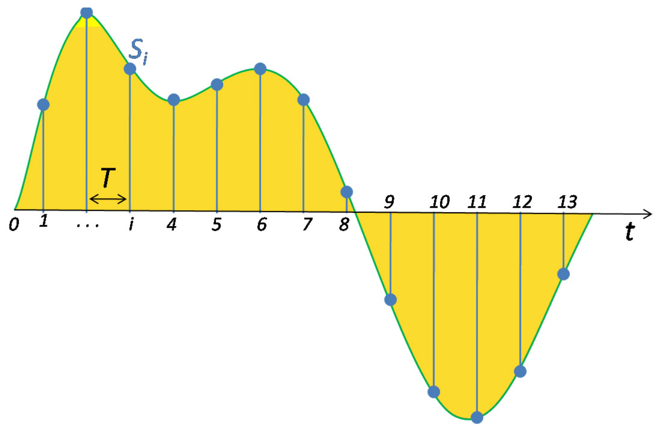
The first thing I want to clear up is what exactly I mean by resolution. In short, resolution is the ability to distinguish individual targets as distinct. At low resolution what may appear as a single blurry blob might in reality be two separate rocks close together, but you require a higher resolution to discern this.

There are both physical and digital limits to the effective resolution of your equipment. Now, the specifications of your sonar (operating frequency, pulse length) and water conditions affect the size of the sonar beam's actual footprint on the seafloor and hence, its physical resolution. But, I don't want to dwell on the physics of why this is so here because we are also limited by the digital sample rate of the sonar and it is the digital sampling which has the most direct relevance to the optimal mosaic size when we sit down to process our data.

DIGITAL SAMPLING RATE & ACROSS-TRACK RESOLUTION

As you know, a side scan sonar works by transmitting a pulse, then listening for the strength of the returned echoes from the seafloor over time. In order for the computer to understand our data, it must be turned into a digital signal. This is accomplished by "sampling" the signal at a specified interval. In Figure 1, a signal (in yellow) is being sampled (blue) at interval *T*. The higher the sample rate, the better the digital signal will approximate the continuous signal. We call a set of these digital samples a "time series." Your side scan sonar logs two such time series for each ping of data, one for each transducer.

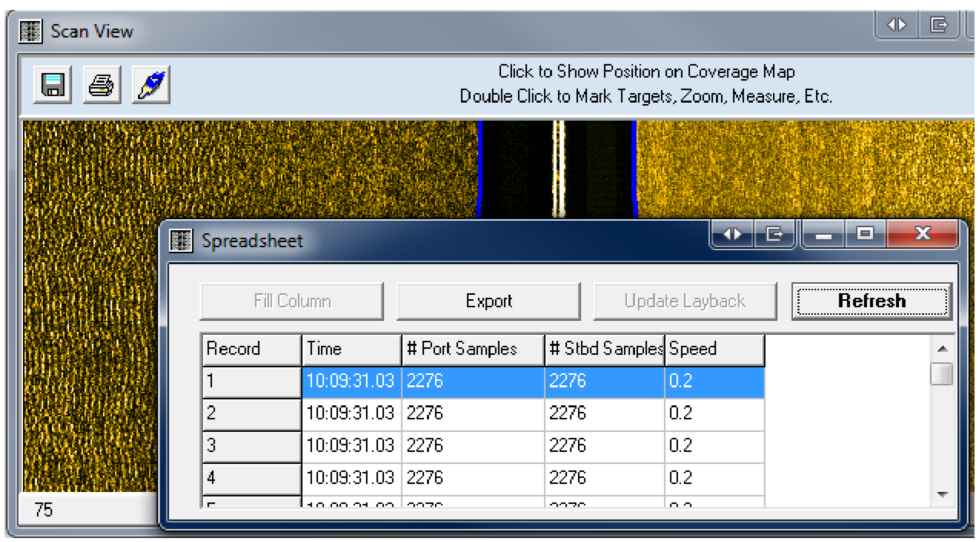
FIGURE 1. *Sampling Side Scan Data*



You can think of a time series as a row of "pixels" in a photo from your digital camera. This row is always in the across-track dimension from nadir out to the edge of your swath. As a result, this sampling rate determines how large a chunk of the seafloor one such "pixel" represents in the across-track direction. It stands to reason then that your sampling rate is one limit on your mosaic resolution.

To determine this across-track resolution divide your sonar range by the number of samples per ping. You can find this information in the spreadsheet view in HYSCAN:

FIGURE 2. *Spreadsheet View in HYSCAN*

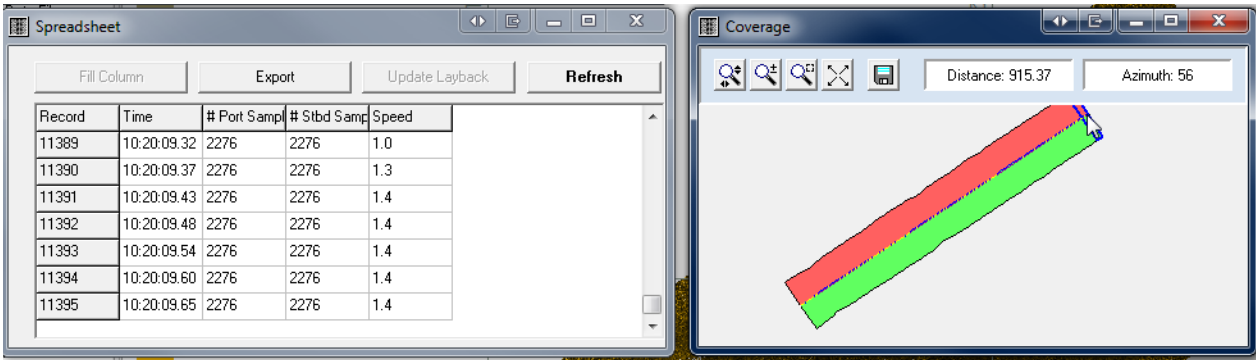


In this example, our range is 75m and the sonar is returning a time series with 2276 samples per ping. This yields an across-track resolution of 3cm. This assumes that all 2276 samples have useful imagery while in practice some will be wasted on the water column, but it's the upper bound of expectation.

ALONG-TRACK RESOLUTION

Resolution in the along-track direction is much more variable. Changes in speed and ping rate affect the distance between successive pings which causes fluctuation in the effective along-track resolution. In this case, we can make a good estimate of the average distance between pings by simply dividing the distance traveled by the number of pings. This too is easily gleaned from the spreadsheet:

FIGURE 3. *Calculating Along-track Resolution*



In this line we have 11395 pings over 915m distance for an average along-track resolution of 8cm.

WHAT DOES THIS MEAN FOR MY MOSAICS?

So in theory, the above analysis tells us that we can generate a mosaic down to a resolution of 8cm per pixel before we start seeing gaps between pings. Of course, in reality the towfish is not moving perfectly straight forward; it's all over the place--pitching & rolling, speeding up and slowing down as your boat driver nods off or takes a corner too sharply. There are going to be gaps and the HYSCAN fill gaps option handles it by filling in empty cells "inter-ping" (always a result of a chosen resolution below the across-track limit) and "intra-ping" (which may be due to fish motion or exceeding along-track resolution).

In our sample data, if we max out our mosaic resolution at 3cm in order to capture every drop of across-track resolution, we can expect HYSCAN to interpolate (ie. "invent") 2-3 pings for every real ping it processes! Clearly this is a lot of wasted time and space. Since we are limited to square cells in our TIFF mosaics, probably the best approach is to use the average of the two, in this case around 5cm.

Finally, I should mention that my sample data here is from a high resolution Klein 5000 side scan and may not be representative of your equipment. So pull out some data, crunch the numbers, and figure out exactly what level of quality you should be expecting in your mosaics.