Interpreting bottom hardness in shallow lakes and ponds: digging deeper into the data

blog.biobasemaps.com/2017/05/01/interpreting-bottom-hardness-in-shallow-lakes-and-ponds-digging-deeper-into-the-data

April 30, 2017

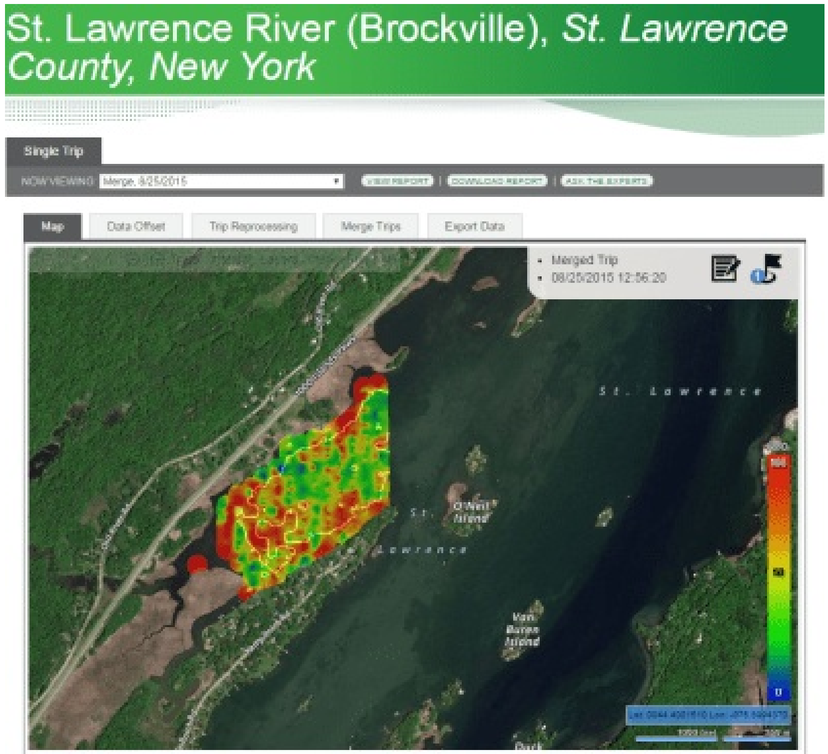
BioBase's EcoSound bottom composition (hardness) algorithm has become quite popular for researchers and lake/pond managers to determine where sedimentation from the watershed may be occurring. However, interpreting sonar returns in shallow environments (e.g., less than 7 ft or 2 m) with off-the-shelf sonar is challenging, especially if aquatic vegetation is present. Each situation is different and the objective of this blog is to inform you of how to interpret your EcoSound map in situations when you encounter counter intuitive bottom hardness results.

Here are some high level points to remember.

EcoSound maps like the one shown in Figure 1 are statistically interpolated maps based on sonar returns directly below your boat.

EcoSound maps are spatial models based on point input data, not full bottom scans. And just like regular statistical models, the type, quality, and amount of data going into the interpolation model (kriging) determine the quality and accuracy of the map output. So, if you can't get a good sonar reading in a shallow, weedy bay, EcoSound may automatically "cleanse" the sonar return data (e.g., point data) during processing and the map produced (if any) may be based on insufficient input and not accurate.

There are a variety of reasons why data may be cleansed by EcoSound. For bottom hardness, if you travel faster than 10 mph (16 km/h), or map bottoms shallower than 2.4 ft (0.74 m), or over vegetation greater than 60% biovolume (orange to red), bottom hardness points will not be produced. So interpolated results may not expand over all covered areas or be extrapolated over areas that were cleansed. We'll expand on this last point further…



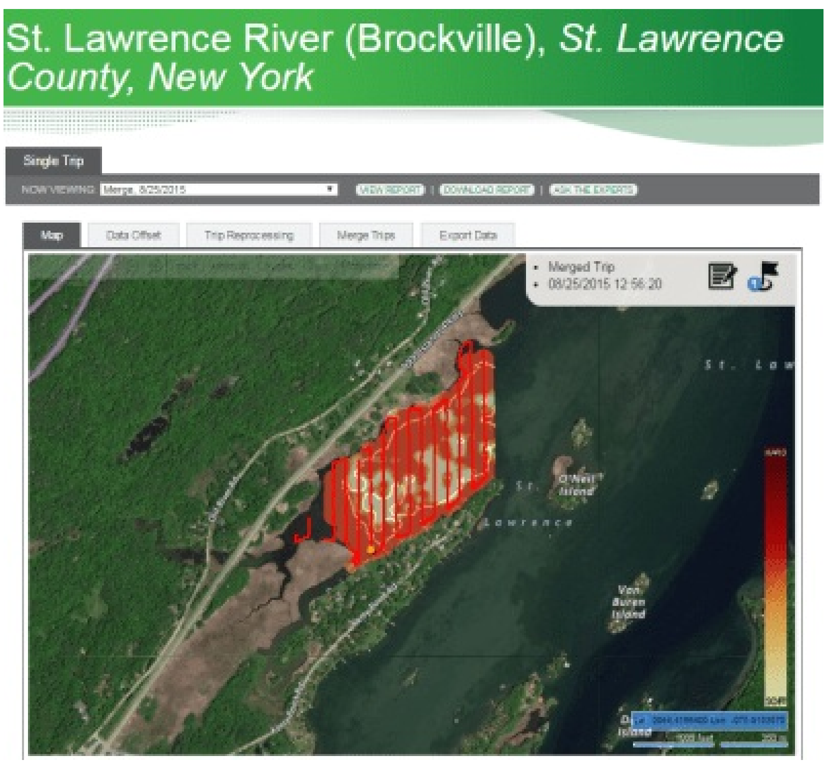


Figure 1. An EcoSound vegetation (top) and bottom hardness map (bottom) from a shallow bay on the St. Lawrence River near Lake Ontario, USA. Vegetation growing closer to the surface is indicated by red, and vegetation that grows closer to bottom is green. Red bottom hardness values indicate hard bottom scores, while tan colors indicate soft bottom scores. Transects were spaced 40-m and if not too shallow or weedy, bottom hardness data points were automatically created every 1-2 m based on the ~3 km/h speed. Data points are actually aggregations of 5-30 transducer pulses from an approximately 1 m acoustic cone (e.g., 20 degree beam width in 1 m of water).

Bottom hardness values are <u>not</u> generated in dense vegetation beds which may be on soft bottoms, but <u>are</u> generated in gaps which may be hard.

Bottom composition is often one driver of whether aquatic plants can grow in lakes and ponds. Plants typically prefer relatively soft bottoms to hard bottoms. But bottom returns from areas with dense plant growth extinguish the sonar signal and the ability to assess hardness. Thus, EcoSound checks to see if vegetation is greater than 60% biovolume before processing the signal for bottom hardness. Areas with dense vegetation get no hardness values, while a bare patch of gravel might get a value of “hard” (e.g., 0.4 to 0.5; Figure 2).

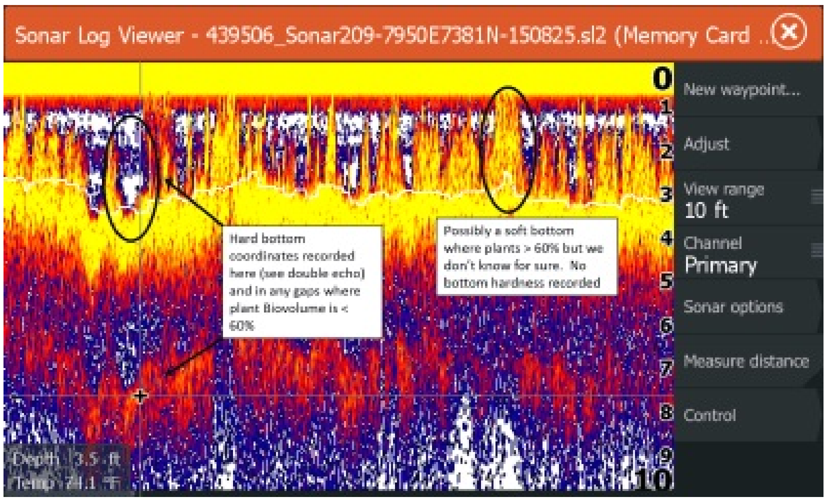


Figure 2. Cross-section of the 200 khz Sonar channel from a Lowrance .sl2 file from Thompson Bay St. Lawrence R. replayed on the Lowrance Simulator.

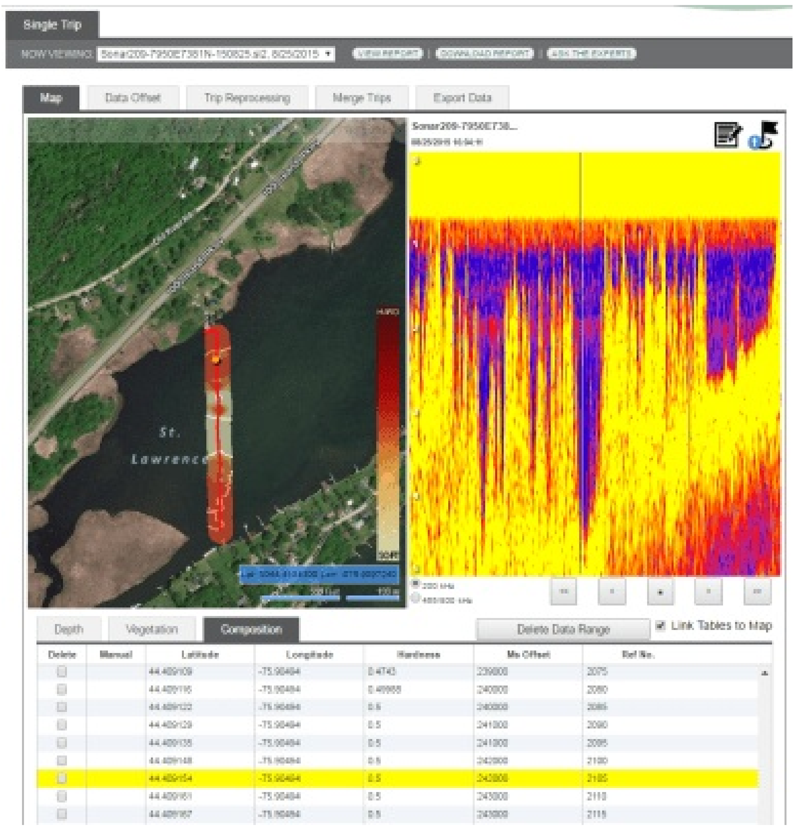


Figure 3. Top down view of bottom hardness for one transect in Thompson Bay (left), corresponding cross-section (right) and hardness point values (below). Notice the hard spot in the middle of areas of dense vegetation growth that is presumed to be soft but cannot be confirmed based on the sonar reading. Loading the data from the tabs in EcoSound pulls the coordinate data from the sonar track from the database, not the kriging grid data.

Figure 4. Bottom hardness point data exported from EcoSound and imported into ArcGIS. The different colors indicate the bottom hardness scores. Notice the large gap in the data where vegetation was the most dense (see Figures 1 and 5).

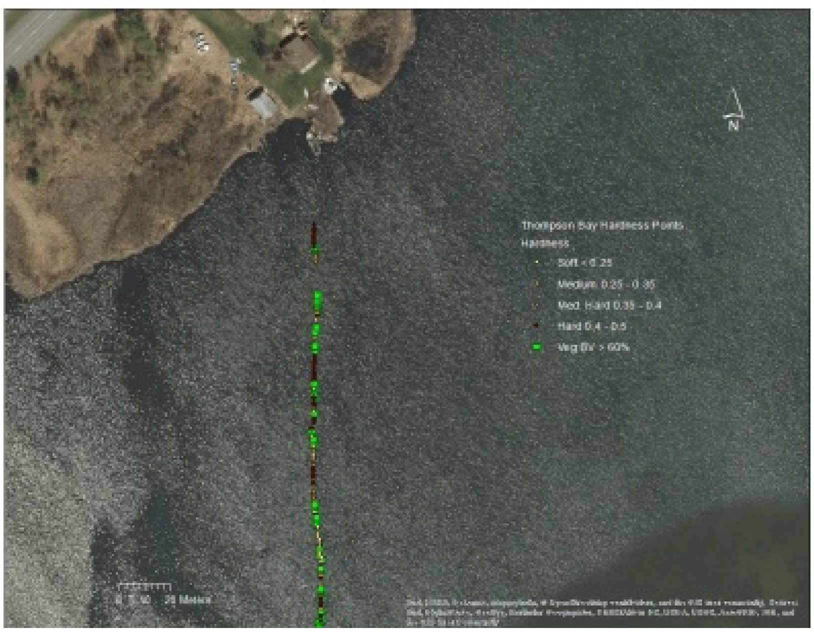


Figure 5. Bottom hardness point data overlain with vegetation point data > 60%. Notice the lack of overlap of data anywhere where dense vegetation occurred and hard scores where it didn't occur.

Interpolated (kriging) maps of bottom composition (hardness) maps may be biased toward hard scores in shallow or weedy lakes/ponds.

Above describes a situation where soft readings may not be recorded, but hard readings are. Consequently, the interpolated map might appear more hard than in real life.

Interpret maps and grid statistics from single transects with caution.

Recall, kriging predicts values in locations with no data based on locations where there is data. Wherever you see the word “grid” in EcoSound reports and exports, this refers to kriging-derived data. In contrast, like described above, “point” data are non-interpolated data collected directly below your vessel. Kriging does not care whether it is <u>inter</u>polating (ok), or <u>extra</u>polating (generally not ok because we generally have low confidence of environments outside of our data range).

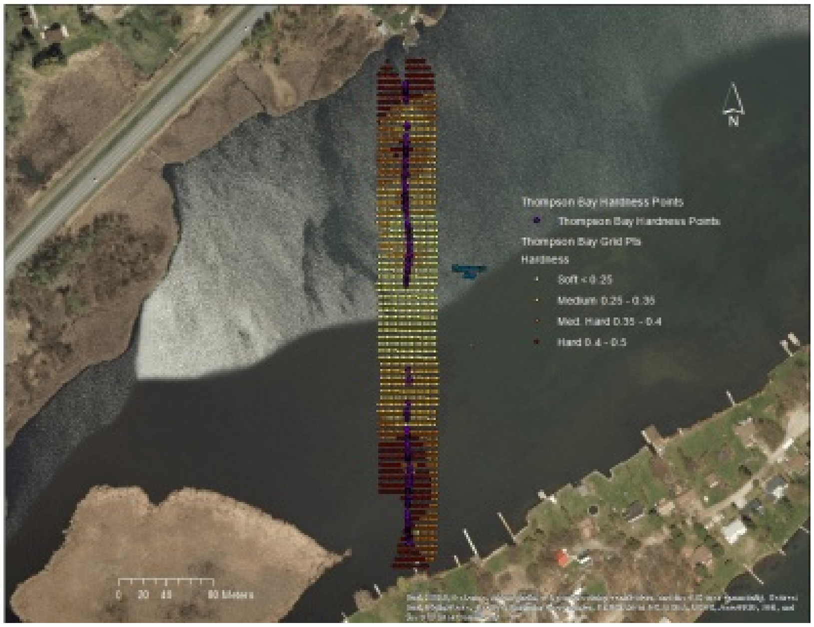


Figure 6. Example of kriging hardness grid points overlain with coordinate points exported from EcoSound and added to ArcGIS as a text event layer (WGS84 coordinate system). Kriging data values outside of the transects (extrapolated) may not be accurate. However, the map directly over the point values should be accurate. In this example, it is recommended that the user only use the point hardness data and not the grid data.

Use point data from single transects, grid data when “back and forth” or “around and around” mapping.

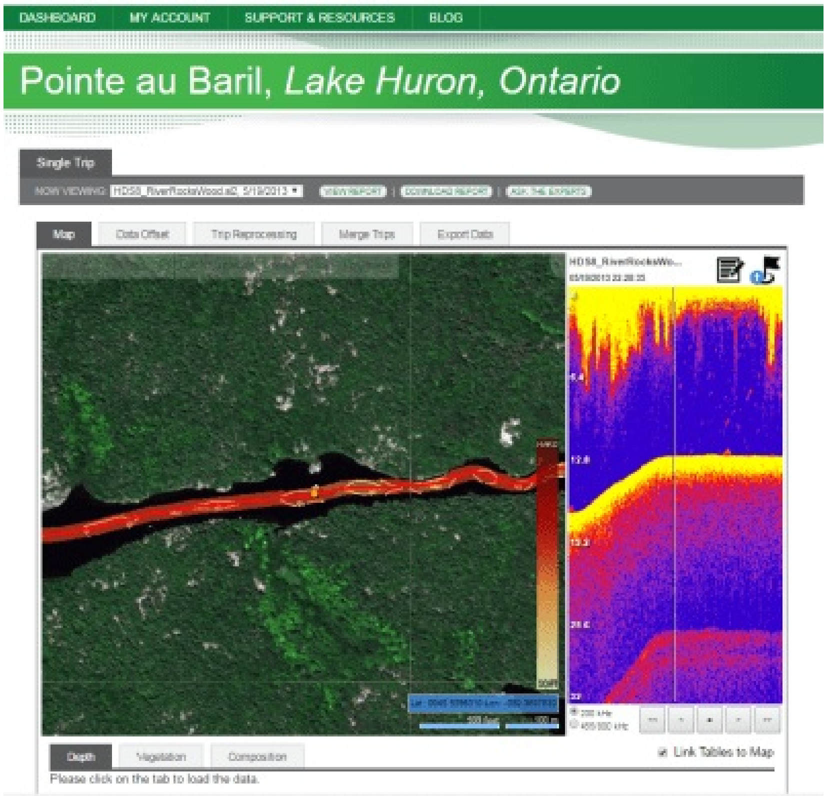


Figure 7. Bottom hardness from a river in Georgian Bay Lake Huron. Surveyors only took one mapping pass. Therefore, use the coordinate point data in any analysis. Extrapolated grid data produced by kriging outside of the track may not be accurate.

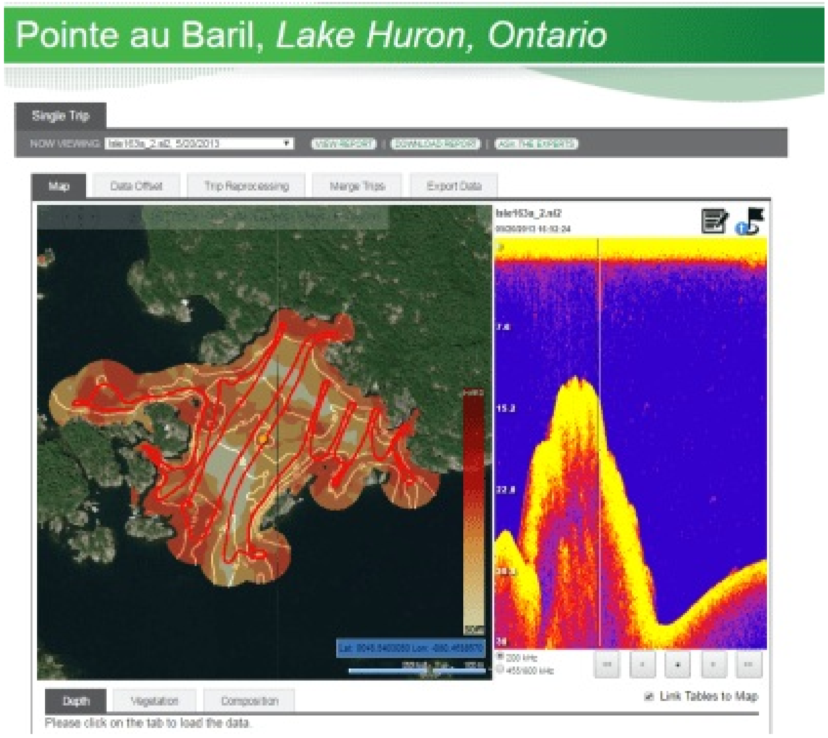


Figure 8. Bottom hardness from a similar area in Figure 7. Note the back and forth mapping passes. In this case, the map may output may be more accurate over most of the mapped area and thus, we recommend using the interpolated kriging data for any analysis. However, still exercise caution interpreting extrapolated data outside the track.

Bottom environments and true hardness is variable. Use other tools to calibrate EcoSound bottom hardness outputs

EcoSound uses characteristics of the reflectivity of the bottom to infer whether the bottom could be soft, medium, or hard. In general, sound signals reverberate strongly off of gravel and rocks and signal is absorbed into mud. Much independent test data confirm a relationship between EcoSound-derived bottom hardness and true bottom hardness.

Most experienced biologists understand that bottom environments are rarely uniform or exhibit one extreme or another. There are all sorts of substrates on the bottoms of lakes and ponds that could produce variability in hardness outputs (e.g., detritus layer, sand/silt/clay of various densities). As such, we recommend that investigators take actual composition samples where possible, upload the waypoints to BioBase, and compare with EcoSound outputs (both point and grid). In this way, the investigator can get a clearer view of what the composition map represents in real life.

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BioBase is a cloud platform for the automated mapping of aquatic habitats (lakes, rivers, ponds, coasts). Standard algorithms process sonar datafiles (EcoSound) and high resolution satellite imagery (EcoSat). Depth and vegetation maps and data reports are rapidly created and stored in a private cloud account for analysis, and sharing. This blog highlights a range of internal and external research, frequently asked questions, feature descriptions and highlights, tips and tricks, and photo galleries. View all posts by biobasemaps