Sound Speed Adjustments in MBMAX

By Mike Kalmbach

INTRODUCTION

It's important to know water sound speed (velocity) when doing multibeam surveys. Without accurate sound speed, survey results range from slightly inaccurate to completely worthless.

How it's supposed to work: A sensor at the sonar head accurately measures sound speed in real time. A cast is done periodically to find sound speed in the water column; the profile. Casting is done frequently enough so that changes that naturally occur are accurately reflected in the profiles.

What sometimes happens: The sensor at the head fails. The profiler fails. Casting is not frequently enough. All leading to multibeam survey errors.

Our adjustments can't fix everything. For example, we have no fix if the sensor at the sonar head fails. Beam angles are strongly dependent on sound speed at the sonar head and we don't adjust angles. But sound speed adjustments in MBMAX can help with other common errors.

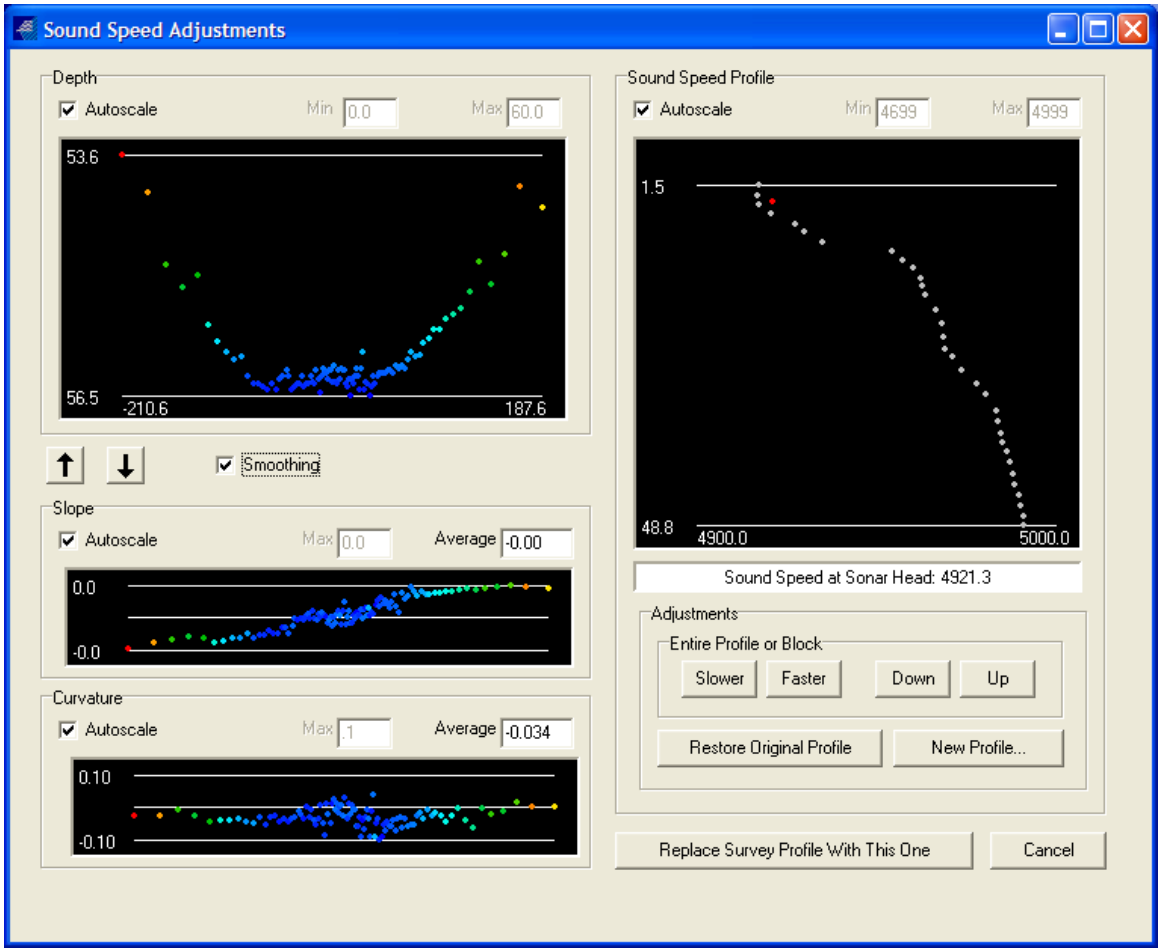
The following sections give (1) a brief overview of the adjustment module and (2) a couple of examples showing how adjustments can salvage a multibeam survey.

SOUND SPEED ADJUSTMENTS

Adjustments are done in MBMAX Phase 2 – Swath Editing. After data cleaning, select "Sound Speed Adjustments" from the Tools menu. This module has a number of sections to aid in finding a correct sound speed profile. Well, nearly correct. Correct enough!

While the value of some sections (slope and curvature graphs in particular) may not be immediately obvious, the examples should help to clarify.

FIGURE 1. *Sound Speed Adjustments Window*



Depth: This shows all valid depths in the current sweep. Without tide corrections. You may enter min and max depth scaling or allow the program to auto scale based on the range of depths. In the sample, a flat bottom area shows as a U shape or smiley face, which is indicative of sound speed errors. The adjustment goal is to flatten out the depth points.

Slope: Graph shows the slope (1st depth derivative) at all points across the sweep. Average is simply the average slope of all points.

Curvature: Graph show curvature (2nd depth derivative) at all points across the sweep. Average is the average curvature taken over all points.

Sound Speed Profile: Shows water column sound speed to end of cast.

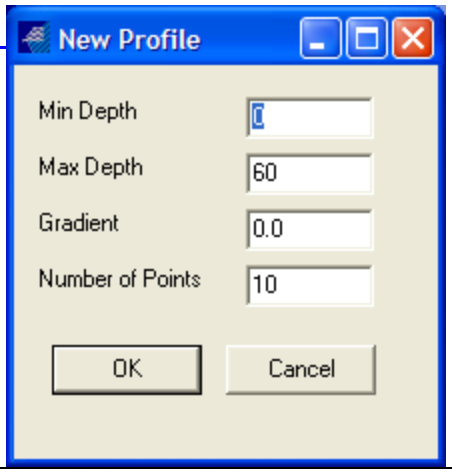
Sound Speed at Sonar Head: For reference only.

Adjustments: Profile points may be shifted left / right (slower or faster) or up / down. The mouse may be used to draw a block rectangle in the profile graph, in which case only points inside the rectangle are shifted.

Restore Original Profile: Useful for trial and error.

New Profile: Replaces the original profile with one based on user parameters:

FIGURE 2. Defining Parmeters for the New Profile



Minimum and Maximum profile depth.

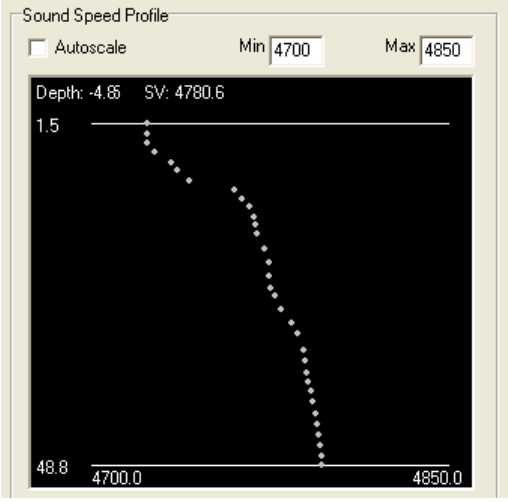
Gradient = change in sound speed with depth.

Number of Points in the new profile.

Replace Survey Profile With This One: If you are happy with the adjustments you've made, click here to update the survey with adjusted sound speed information. An option is given to adjust the current survey line or all lines.

NOTE: Sound speed adjustments work best over a flat bottom. If the survey does not include a flat bottom, find the closest you can.

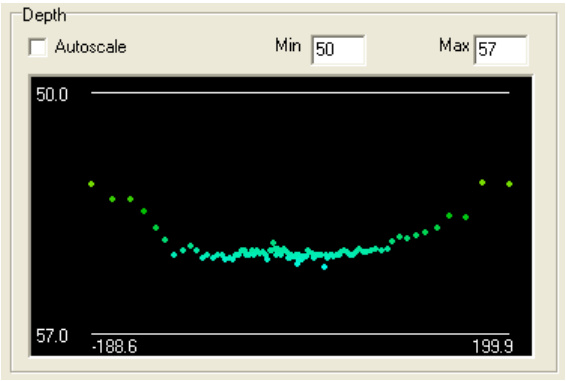
EXAMPLE 1: A SURVEY IN AN ESTUARY WITHOUT ENOUGH CASTS



Estuaries are difficult areas; there are distinct sound speed zones in the water column. Denser salt water forms a wedge under fresh water, with a mixed area between. Furthermore, the profile changes over time, depending on tide stage. A typical profile is shown.

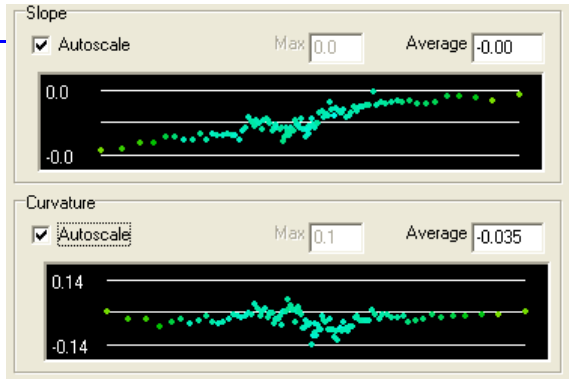
Consider a case where casts are done every 3 hours but there are significant tidal changes over that period. It's easy to collect bad data. The depth graph shows a sweep with the characteristic smiley face.

FIGURE 3. Depth Graph of Depths wiith Bad Sound Velocity Data



The slope and curvature graphs reinforce this.

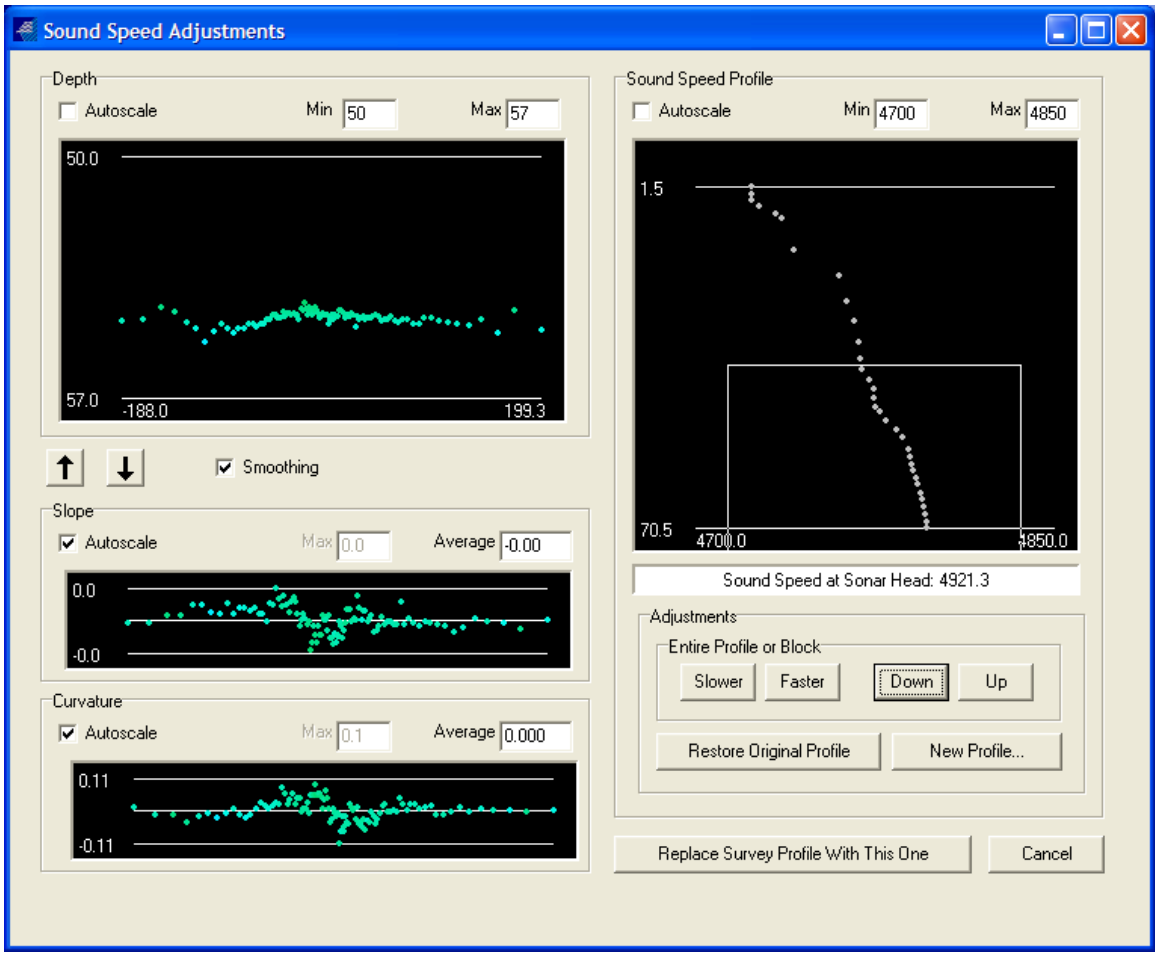
FIGURE 4. *Slope and Curvature Graphs*



The slope is at a minimum at the port end of the sweep, transitions to zero slope at nadir and is a maximum at the starboard end. There is negative curvature across the sweep and an average value of -0.35. The average value helps quantify our adjustments. We are looking to bring the average close to zero.

How to fix it? We know the tide was going out, so our suspicion is that the salt water wedge would be smaller at data collection time than at cast time. So we simply block out the wedge and adjust it downward. Voila! The sweep flattened and average curvature went to zero.

All that's left now is to replace the file profile with our adjustments. We've improved our survey significantly.



EXAMPLE 2: A SURVEY WITH NO SOUND SPEED PROFILES

You did a cast but the probe didn't come back. (Oops!) Or the batteries are dead. Or something … The end result is you know sound speed at the sonar head (from the sensor) and nothing else. But the survey continued, and this is the result. Darn smiley faces.

FIGURE 5. *Sound Velocity Only fromSonar Head*

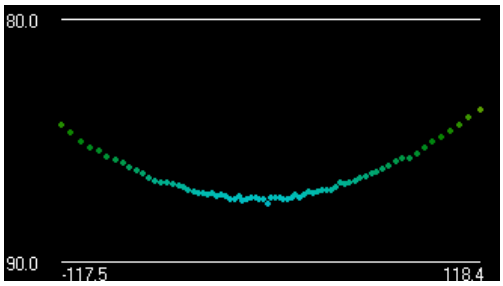
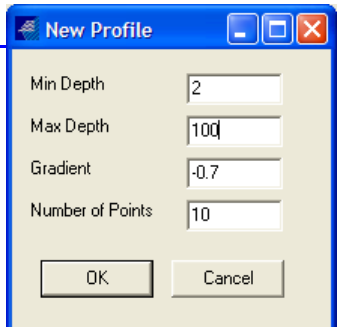


FIGURE 6. *Correcting the Effects of No Sound Velocity Corrections*



To fix this one, we click **"New Profile"** and make a best guess estimation of the correct profile. **Surface sound speed** is taken from the sensor and extended down to about 2 meters to account for surface conditions. The profile extends to 100 meters, which is the area depth. Some **gradients** are chosen (trial and error) and -0.7 seems to work the best. 10 profile points is sufficient.

The estimated sound speed profile and the resulting depths show quite an improvement.

FIGURE 7. *Estimated Sound Speed Profile*

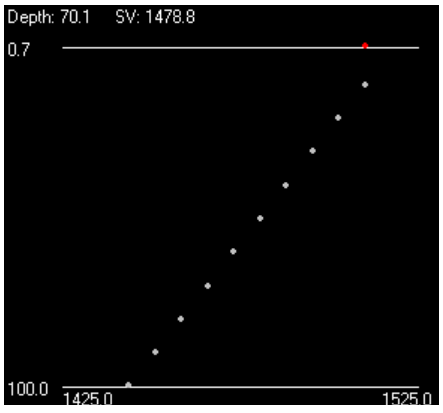
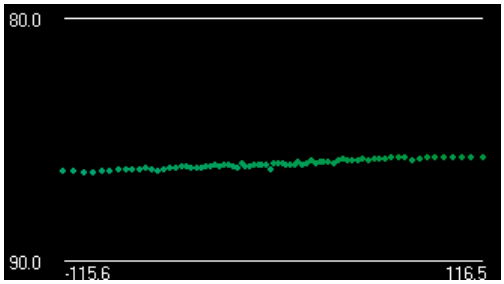


FIGURE 8. *Resulting Adjusted Depth Profile*



SUMMARY

Sound speed adjustments in MBMAX can improve multibeam data collected with incorrect or no water column sound speed information. This is done by creating a new profile or adjusting an existing profile until artifacts are removed. A target sweep is available for visual

examination at each adjustment step. Sweep curvature calculations are useful when the seafloor is quite flat – we are looking for zero curvature.

Two examples show how multibeam surveys may be improved substantially (and easily!) using the adjustment tool.