Ray Tracing Changes in Hysweep – Arc Method

By Mike Kalmbach

The Hysweep programs (Hysweep Survey and MBMAX multibeam post-processing) have recently been modified to support *arc* ray tracing. (What is arc ray tracing? What is ray tracing? Read on…) This is in addition to the existing *line* method that has existed in Hysweep since it's inception. Users may let the program decide which method is most appropriate or choose for themselves.

In addition, the programs now automatically extend SV profiles beyond the end of cast to full ocean depth, using estimated water properties. In the Delaware river, not so useful. More so in oceanographic surveys.

Ray Tracing:

The path of a sounding beam through water may not be a straight line. The direction will change wherever there is a variation in sound velocity. This is called refraction. Refraction is the main reason it's important to have an accurate sound velocity profile throughout the water column.

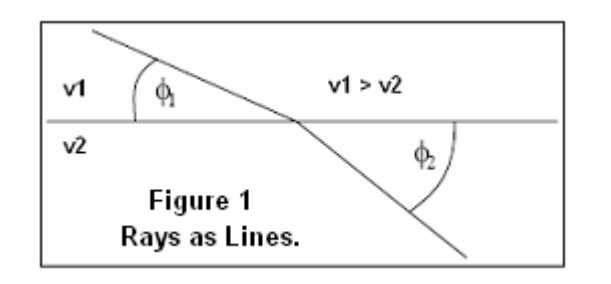


Figure 1
Rays as Lines.

The practice of tracing rays (sounding beams) through a refracting medium (water) is called ray tracing.

Arc vs. Line Method:

The refraction diagram of Figure 1 shows a ray as a series of straight lines. This is the case when sound velocity within a layer is constant. Although water doesn't behave this way, it's a very good approximation when layer thickness is small.

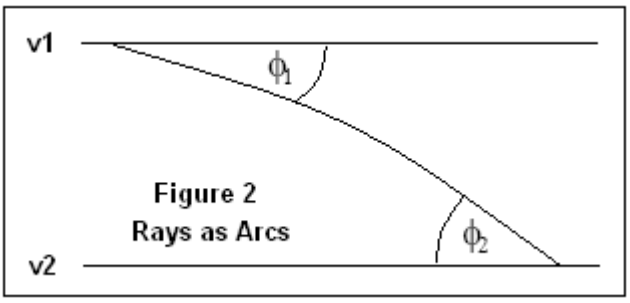


Figure 2
Rays as Arcs

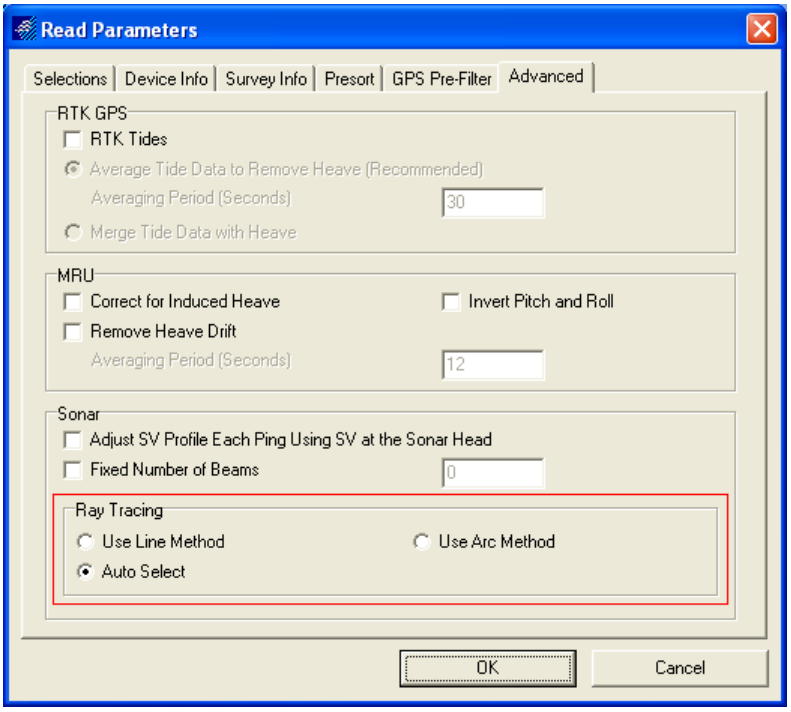
Alternatively, we can assume a constant velocity change between V1 and V2. Then the ray path is an arc (figure 2).

The line method is two times faster computationally than the arc method. In water depth of 50 meters or less with velocity measurements spaced less than 2 meters apart, the results from line tracing are virtually identical to results from arc tracing, so it is the preferred method. Beyond 50 meters depth, or with widely spaced velocity measurements, the arc method is preferred.

Program Options:

The Advanced tab of MBMAX Read Parameters provides three options.

1. Use Line Method: Forces line ray tracing.
2. Use Arc Method: Forces arc ray tracing.
3. Auto Select: Selects the most appropriate method automatically using the criteria described above.



Comparison of Methods:

The comparison graphs 3 – 6 show depth difference between the line and arc methods.

Shallow Water (figure 3) – At water depths of 60 feet (20 meters), the line and arc methods compare to 0.05 feet (1.5 cm). Virtually identical.

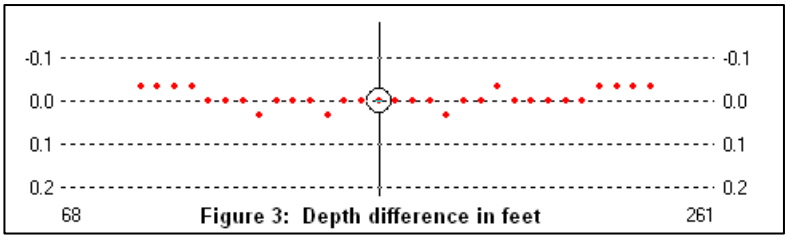


Figure 3: Depth difference in feet

Deep Water Using a Shallow Profile (figure 4) – In this test, the line and arc methods are compared in 1000 m of water, using a profile down to 200 meters. Ocean SV is estimated beyond 200 meters. The methods compare well to 45 degrees from nadir, but diverge to 2 meters difference (0.2 percent) at 75 degrees from nadir. Line method deeper.

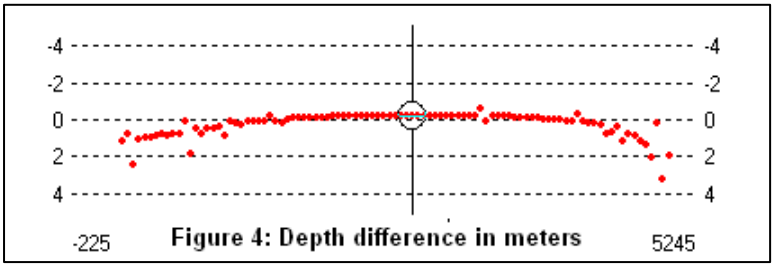


Figure 4: Depth difference in meters

Deep Water Using an Accurate Profile (figure 5) – Similar to the previous test except the SV profile extends to 1000 meters. Again, the line method calculates depths 0.2 percent deeper than the arc method.

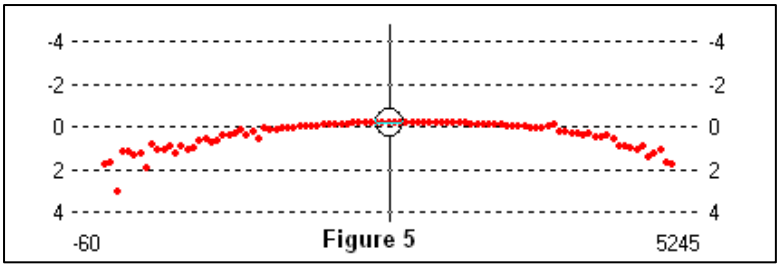


Figure 5

Deep Water Comparing Estimated to Full SV Profile (figure 6) – Using the full profile and calculating depths using the arc method, water depth is up to 5 meters (0.5 percent) deeper using the full profile.

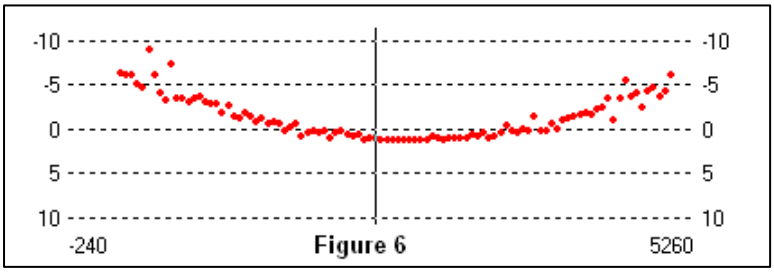


Figure 6

Conclusions:

In the shallow water test, the line and arc methods compare to less than 0.01 percent. So it makes sense to use the faster line method.

In deep water tests, the line and arc methods differ by 0.2 percent. Not a large difference, but certainly enough to justify the additional time of the more accurate arc method.

Estimating the SV profile from 200 to 1000 meters leads to an error of 0.5 percent. It's obviously best to know the full profile, but when that's not practical, the errors due to the estimated profile are relatively small.