



Single Beam Sound Velocity Correction

By Joe Burnett

The following is a brief description of how sound velocity corrections are applied in the HYPACK® SINGLE BEAM EDITOR (SBMAX). This calculation method was introduced into SBMAX back in October, 2001 to address some of the shortcomings of the previous editor.

SV PROFILE

The corrections start with a sound velocity (SV) profile, which is the measurement of sound velocity at discrete intervals through the water column. The profile shown below (left) is typical of a tidal river, with readings collected at 1.0 meter intervals. There is an approximate change of 2.5% from top to bottom.

In the second profile (below, right), the sound velocity has been roughly approximated at three points, to make the hand calculations that we are about to perform, easier to follow.

FIGURE 1. Actual Collected SV Profile (left) vs Simplified SV Profile

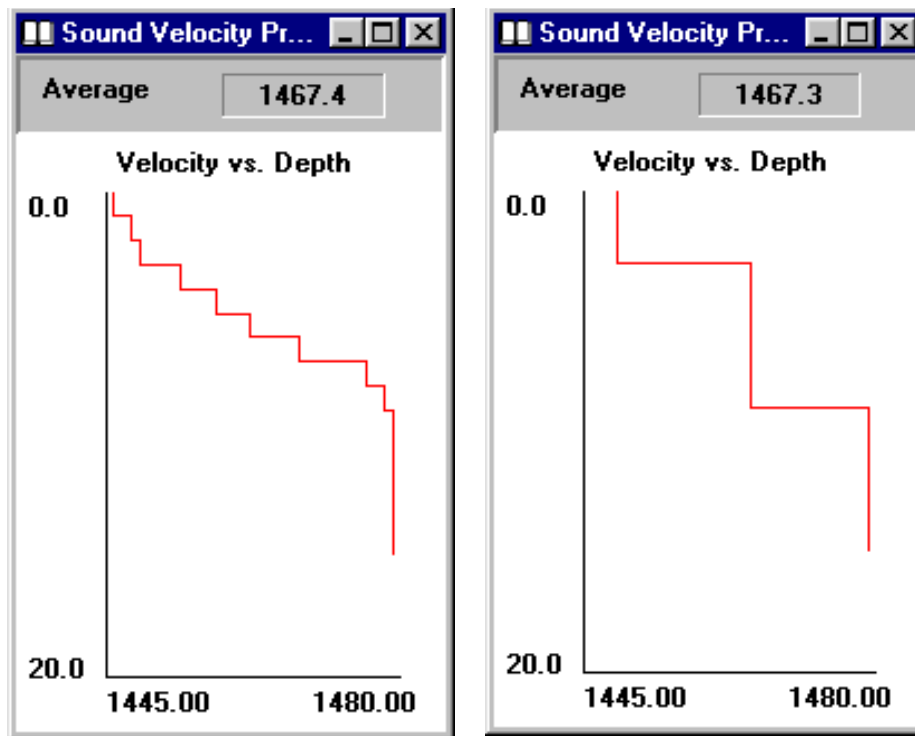


TABLE 1. Simplified SV Profile

Layer End Depth (Meters)	Layer Height – h (Meters)	Sound Velocity – V (Meters / Second)
3	3	1449
9	6	1465
15 (bottom of cast)	Unlimited	1479

The final layer is 'Unlimited' in height, because the SV profile can not extend any farther than the bottom at the location of the profiler cast. This is a good reason to pick a deep spot for casting.

SAMPLE CALCULATION

The echosounder, set with a sound velocity of 1480 m/second, measures a depth of 17.13 meters. A one meter draft has also been entered into the echosounder. The simplified SV profile above, will be used for SV correction.

The 'simple' equation for computing a depth is:

$$D = (SV * T)/2$$

where:

(D) = Depth

(SV) = Speed of Sound

(T) = Time

Now, we will rearrange the equation to find the amount of time that it took for the sound wave to travel from the transducer to the bottom, and return to the transducer:

$$T = 2*D/SV$$

$$T = (2*17.13m)/(1480 m/s) = 0.02314865 \text{ seconds (Total Round-trip Travel Time)}$$

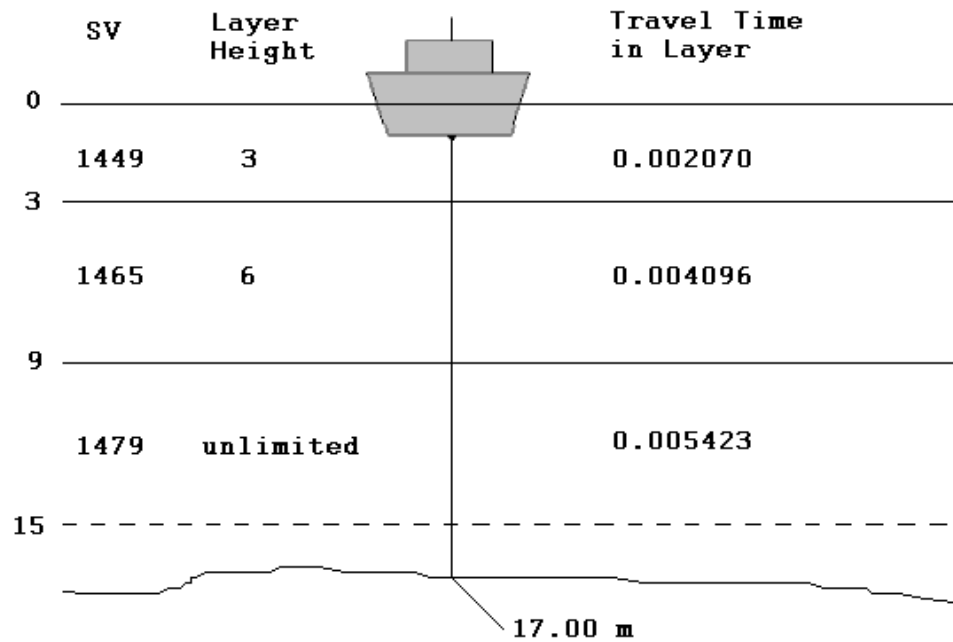
Because the sound wave had to travel from the transducer to the bottom and return, we must divide the time by 2, in order to find out how long it took the sound wave, to go from the transducer to the bottom:

$$T/2 = 0.02314865 \text{ s}/2 = 0.01157432 \text{ seconds (Total One-way Travel Time)}$$

To find the sound velocity correction using the simplified SV profile (and hence, the 'corrected Depth' value of 17.00 meters), HYPACK® programs track the portion of travel time spent within each layer.

- **Layer 1:** Sound travels through the 3 meters in 0.00207039 seconds.
(Time = Layer Height / Layer SV = 3/1449)
Subtracting that from the Total One-way Travel Time:
0.01157432 seconds - 0.00207039 seconds = 0.00950393 seconds remaining.
- **Layer 2:** Sound travels another 6 meters in 0.00409556 seconds
(Time = Layer Height / Layer SV = 6/1465)
Subtracting that from the Remaining One-way Travel Time,
0.00950393 seconds - 0.00409556 seconds = 0.00540837 seconds remaining.
- **Layer 3:** The Remaining Time will be used to calculate the distance traveled in the 3rd layer
 $T*SV = 0.00540837 * 1479 = 7.999$ or 8.00 meters.

FIGURE 2. Example 1: Portion of Travel Time Spent Within Each Layer



Summation:

3 m (Layer 1) + 6 m (Layer 2) + 8.00 m (Layer 3) = **17.00 m. depth.**

The sound velocity correction is then 17.00 (true depth) – 17.13 (echosounder depth) = **-0.13 meters.**

ACCOUNTING FOR DRAFT

Quick QUIZ!!! Were you paying attention to all that was given in the above example?

If you were, you would have already realized (as it was mentioned), that a 1.00 meter draft was entered into the echosounder, which means that the ‘actual’ depth that was measured by the echosounder, was really 16.13 meters, and then the 1.00 meter draft was added to it, before it sent the resulting sounding value to HYPACK®.

So, does that mean that the SV corrections that were calculated in the SINGLE BEAM EDITOR as shown above, are incorrect?

The answer is both, YES and NO.

- **YES**, they are correct, because HYPACK® was given no information from the echosounder that a 1.00 meter draft value had been entered into the echosounder, therefore, HYPACK® performed its calculations based upon what it was given, assuming that the values came from the transducer, which was also at the water surface.
- **NO**, they are not correct, because the ‘actual’ depth that was measured by the echosounder was 16.13 meters.

IMPORTANT: The HYPACK® SINGLE BEAM EDITOR (SBMAX) and the HYSWEEP® multibeam editors (MBMAX32 and MBMAX64), all take the draft (vertical offset in the HARDWARE setup) into consideration, when they perform SV corrections.

The HYPACK® editors, read the vertical offset (the depth of the transducer) from the echosounder setup in the HARDWARE program, which is embedded in the header of every raw file. They reference the SV profile for the correction corresponding to that depth, then break down the layers and calculate the time travel of the sound wave (from the transducer to the bottom) beginning at that depth.

Next, the editor calculates the SV corrections through each interval layer then sums the values. The program then applies the draft to this sum, and the final 'true' depth is achieved, as we will see in the following example.

Therefore, we use the 16.13 meter depth value when calculating the new 'corrected depth', based on our new information:

$$T = 2 \cdot D / SV$$

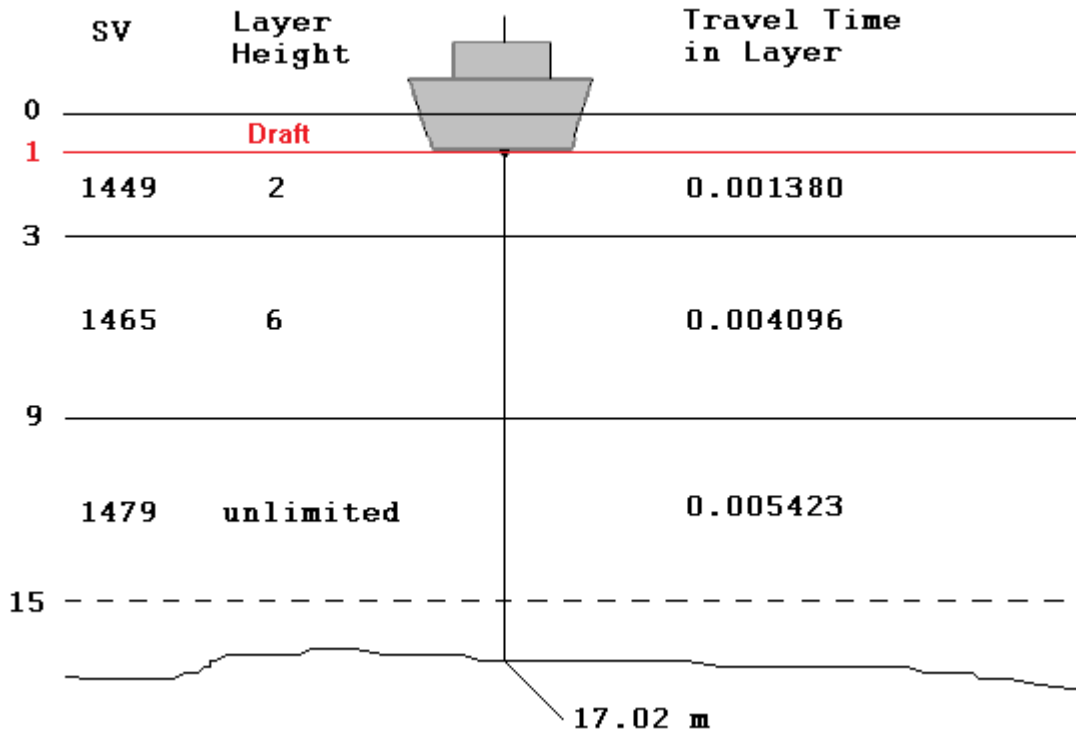
$$T = (2 \cdot 16.13 \text{m}) / (1480 \text{ m/s}) = 0.02179730 \text{ seconds (Total round-trip Travel Time)}$$

Again, we must divide the time by 2, in order to find out how long it took the sound wave, to go from the transducer to the bottom:

$$T/2 = 0.02179730 \text{ s} / 2 = 0.01089865 \text{ seconds (Total One-way Travel Time)}$$

- **Layer 1:** Sound travels through the 2 meters in the first layer in 0.00138026 seconds:
(Time = Layer Height / Layer SV = 2/1449)
Subtracting that from the Total One-way Travel Time:
0.01089865 seconds - 0.00138026 seconds = 0.00951839 seconds remaining.
- **Layer 2:** Sound travels another 6 meters in the 2nd layer in 0.00409556 seconds:
(Time = Layer Height / Layer SV = 6/1465)
Subtracting that from the Remaining One-way Travel Time:
0.00951839 seconds - 0.00409556 seconds = 0.00542283 seconds remaining.
- **Layer 3:** The remaining time will be used to calculate the distance traveled in the 3rd layer:
 $T \cdot SV = 0.00542283 \cdot 1479 = 8.020 \text{ meters.}$

FIGURE 3. Example 2: Portion of Travel Time Spent Within Each Layer Starting at the Transducer Depth



Summation: 2 m (layer 1) + 6 m (layer 2) + 8.020 m (layer 3) + 1.00 m (Draft) = **17.02 meters depth.**

The sound velocity correction is then 17.02 (true depth) – 17.13 (echosounder depth) = **-0.11 meters.**

MORAL OF THE STORY:

Where is the proper place to enter your Draft value? In the echosounder or in the software? In our opinion, here's how you should do it:

1. During the Bar Check, enter the draft in the echosounder.
2. Once the Bar Check is completed and you have derived the draft value from the Bar Check, set the draft in the echosounder to 0.0.
3. Enter the Draft value (derived from the Bar Check) in the 'Vertical' offset of your echosounder in the (HYPACK®/HYSWEEP®) HARDWARE program.
4. By performing these 3 steps, the HYPACK® editors (MBMax and SBMax) can properly calculate the SV corrections, and apply them to your data.

As we can see from the example above, performing these 3 steps did have an effect on the Final Depth. How significant is a 0.02 meter difference? That will be up to you to determine.

IMPORTANT: In deeper-draft vessels, where the transducer is at an even deeper Draft, the significance of performing proper SV Corrections, will become more evident.