Shallow Water Single Beam Surveying Concepts

For surveyors not familiar with hydrographic equipment or processes, some basic principles of operation and important equipment characteristics are described.

Surveys Use Parallel Track Lines

Hydrographic surveys are conducted in sections of parallel lines. Usually planned in advance to ensure adequate coverage of the survey area, the lines are also crossed by a smaller number of perpendicular "check" lines that allow the depth values on each pass to be compared at every intersection. During turns, depth results may be affected by roll or draft may change at lower speed so typically data are only recorded "on line" when the vessel is on a steady straight course. Data logging is suspended when lining up for the next line.

Single Beam Echo Sounder Transducers

Standard transducers for shallow water surveying operate at 200 kHz. This frequency is a good balance between depth resolution, which is better at higher frequencies, penetration through water, which increases at lower frequencies and transducer size, which increases substantially at lower frequencies. Typically 100-200 m (328 – 656 ft) is the maximum depth measurable with a 200 kHz transducer. Penetration through sediment is low, as this frequency is rapidly attenuated through solid matter and suspended sediment "fluff" may obscure the correct depth. Higher frequencies are more prone to suspended sediment effects, and have a lower maximum depth range. Larger, less precise low frequency 24-33 kHz transducers are used for deeper water surveys or when suspended material or loose sludge is present. The low frequency is able to penetrate further through the sediment and detect a harder bottom surface underneath a less compacted upper layer.

Bar Check for Calibration and Sound Velocity

A large source of error in single beam echo sounder hydrographic surveys is an incorrect speed of sound used in the depth calculations. To ensure the correct sound velocity (SV) is used, a bar check should be conducted before the survey commences. The bar check involves lowering a flat plate below the echo sounder transducer to several known depths below the surface and comparing the actual versus measured depth. As the bar is moved down, the sound velocity in the echo sounder is adjusted until the measured depth matches the actual depth. At the end of the test, the echo sounder has been fixed with the average sound velocity over the water column. As the sound velocity error magnitude increases proportionally with depth, surveys in shallow water suffer from a smaller potential absolute error. Temperature is the main influence on SV, with salinity a second order effect.

The Sound Velocity Profiler

While a bar check calibration should be a mandatory procedure before a survey to check the instrument operation and set the average sound velocity (SV), a sound velocity profiler may be used to quickly establish the SV profile at points during the survey. The profiler continuously records the SV as it is lowered and this SV profile is later loaded in the hydrographic acquisition software to correct survey data gathered in the vicinity. Lakes with seasonal thermoclines, or estuaries with substantial changes in fresh water content in the survey area are examples where SV profiles are mandatory to ensure accurate results.

Pitch and Roll Correction

In shallow water or inshore surveys, the effect of survey boat attitude (heave, pitch and roll) is usually minimized by selecting appropriate survey conditions; rarely is a motion correction device used for these single beam surveys. Echo sounder transducers emit a cone of sound that may be typically 9 degrees wide for a general purpose 200 kHz transducer. The depth recorded by the sonar will be the first return of sound energy from the bottom, and therefore even if the boat is 5 degrees out of the perpendicular some part of the 9 degree sonar beam is pointing straight down at nadir. The return from the nadir echo will still be the first received and recorded by the echo sounder. This offers some inherent cancellation of minor pitch or roll effects. If a narrower beam “engineering surveys” transducer is used (around 1.5-3 degree beam width), it is more likely that the beam may be measuring a slant range to the bottom if the boat is subject to excessive motion. In this case, judicious survey selection is needed or motion correction with a pitch/roll sensor becomes necessary.

Echo Sounder Blanking Distance

When echo sounder transducers emit a ping, the vibration in the transducer causes noise or "ringing", leading to a slight delay before the transducer can effectively "hear" any meaningful echo response above the noise of the ringing. This time can be expressed as a depth distance if multiplied by the speed of sound in water; this distance where the transducer is still too noisy to listen for any returning echo is the blanking distance. Typically set at 30 cm for 200 kHz and 100 cm for 33 kHz, blanking eliminates all data collected within this surface region. Air bubbles or debris may be present just under the transducer and may also be removed by blanking.

Automatic Bottom Tracking – "Auto Mode"

Survey echo sounders continuously modify the sonar ping characteristics as the environment and depth changes. There is no "one size fits all" approach. The settings needed to accurately detect the bottom in 1m of water would result in no return at all in 50m of water; conversely using settings for a 100m coastal survey in a 5m deep pond would result in a completely saturated and useless echo return. The "auto mode" of echo sounder operation identifies the depth and continuously adapts the sonar characteristics to track the bottom as the depth changes. This adaptive modification of the ping along with the bottom detection algorithm to follow the bottom allows survey echo sounders to operate over a wide range of depth conditions and bottom types without the operator needing to continuslly adjust the sonar settings. CEE HydroSystems echo sounder algorithms are optimized for excellent bottom tracking in shallow water.

Manual Echo Sounder Settings - Detection Threshold, Pulse Width and Gain

Some echo sounders provide the opportunity to modify sonic pulse characteristics manually in special circumstances or when the automatic bottom tracking is not giving the requisite results. The gain is the amplification applied to the signal upon receipt. Gain may be increased to view weak echoes for example when penetrating through sediment. The pulse width is the length of the ping, with longer pings penetrating further through water and sediment but with a decrease in resolution or detail. The detection threshold may be adjusted to alter the depth recorded by the echo sounder: a low detection threshold will record the bottom as the very first echo returns are received. Increasing the detection threshold will instruct the sonar to ignore the first part of the return and in some cases follow and report a lower, deeper bottom surface.

RTK Tide Elevation

To convert depth measurements to elevation above a datum, RTK GNSS elevation may be used. The fixed antenna height above the water and transducer draft below the water are subtracted from the GNSS height result. The measured depth is then removed from this figure, giving the bottom elevation. This process is managed within the hydrographic acquisition software, and provides a convenient method to express the survey results in absolute elevation above the selected datum.