3D Sidescan Sonar
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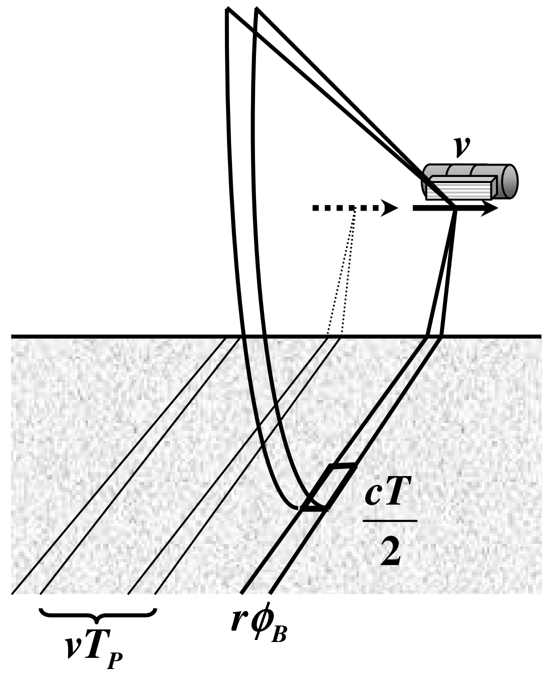
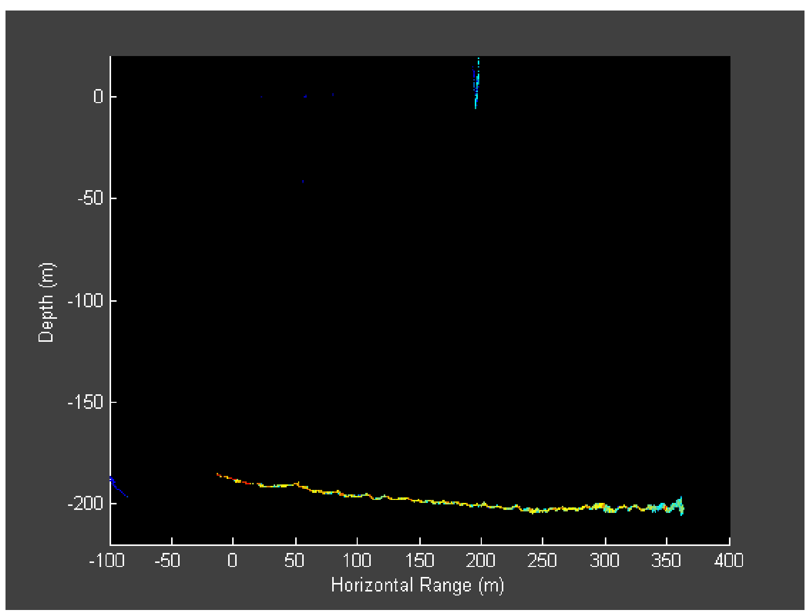
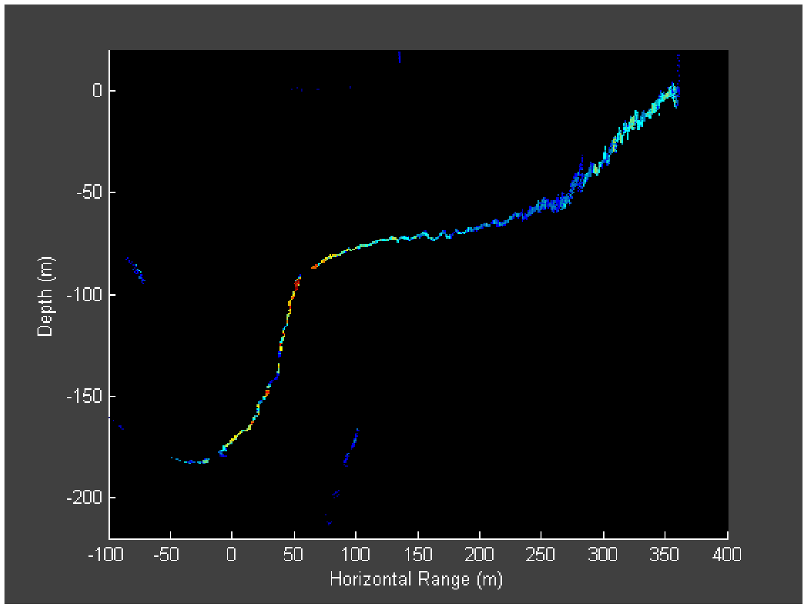
Multi-angle swath bathymetry (MASB) sidescan sonar, or 3D sidescan was developed to solve the same time (or same-range) problem that plagues interferometric bathymetry sidescan sonars. Interferometric bathymetry side-scan sonars use the phase difference between the equivalent of two transducer elements to determine backscatter angle of arrival and therefore cannot properly estimate angles when backscatter from two or more targets is received at the same time. MASB side-scan sonars employ a number of transducer elements (usually six) and can therefore estimate up to five angles of arrival simultaneously, one fewer than the number of elements. Typically, only two or three angles need to be estimated at any one time so the extra degrees of freedom are used to enhance the accuracy of the estimation.



The geometry of MASB sonar operation is illustrated in the figure. As with a side-scan sonar the transducer platform (towfish or over-the-side mount) is moved in the along track direction as an acoustic pulse sweeps the across track direction. The pulse length in the water, in terms of range, is $cT/2$ where c is the speed of sound and T is the length of the pulse in time. This pulse length maps to a similar length on the bottom at small grazing angles which is the situation depicted in the figure. The along track resolution is $r\varphi_B$ where r is the range and φ_B is the along track beamwidth in radians. The distance between scans of the bottom is related to the along track velocity of the platform, v, and the time between pings, T_p, by the formula vT_p. The pulse length on the bottom, along track resolution, and distance between scans are the same as for side-scan sonar. What makes MASB sonar different is the multi-element transducer and hence the ability to estimate multiple angles of arrival.



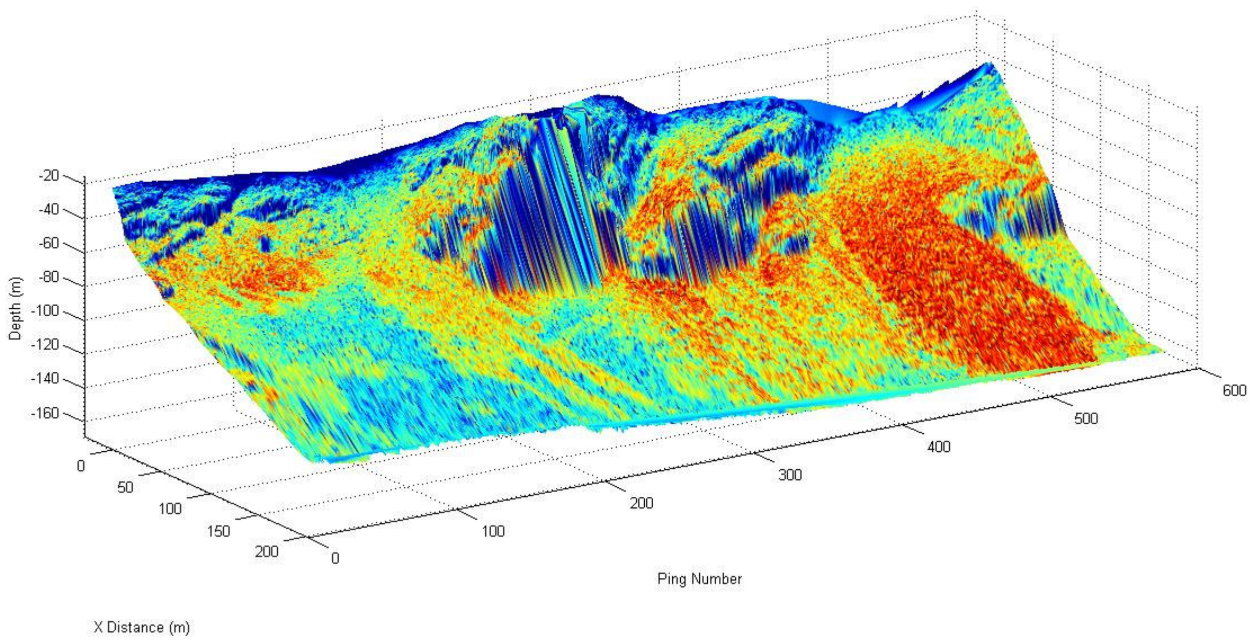
The next figure shows an MASB profile for a single ping over a relatively flat bottom. The intensity of the backscatter is shown by the color, blue being less intense than red and the frequency of the sonar was 200kHz. The vertical axis is depth in meters and the horizontal axis is horizontal distance in meters. The sonar is located at horizontal distance zero and a depth of 1 m (i.e. -1 m on plot). This particular data could have been generated by a two element interferometric sonar because there are not multi-path signals and there is only one signal coming from the bottom.



In contrast to the flat bottom profile consider the profile shown in the next figure. Again, the sonar is located at (0, -1). Note that the sonar pulse first meets the bottom at the point where the bottom turns steeply down (approximate location (70, -80)). From this point acoustic energy propagates along the flatter bottom to the right and down the steep bottom. Therefore, there is acoustic energy coming from two angles, the flat bottom and the steep bottom. The multi-angle swath bathymetry sonar (MASB) handles this situation well. However, an interferometric system would not because it can estimate only one angle. In other words, the MASB system estimates the two angles represented by the same time signals coming from the flatter and steeper bottoms and characterizes the bottom profile correctly.

The next figure (shown on the next page) shows the profiles from 600 pings strung together of form a 3D image of the bottom. Superimposed on the bottom bathymetry is the backscatter image with red indicating strong backscatter and blue weaker backscatter. This shoreline consisted of steep cliffs together with terraces and land slides. There is a rather large gravel slide on the right side of the figure.

An interesting feature of MASB processing is that the backscatter or intensity image can be calculated at a different resolution than the bathymetry. Typically, the bathymetry resolution is less than the intensity image in that some across track averaging must be employed to obtain good angle estimates, however, the intensity image can be calculated at full sidescan resolution. Therefore, the full sidescan image resolution is maintained and the side scan image is perfectly registered with the lower resolution bathymetry.



Commercialization

The 3D sidescan sonar technology is patented by SFU and is the foundation of the commercial product C3D offered by Teledyne Benthos. We would be glad to discuss further opportunities to commercialize this technology.