Long Baseline (LBL) Navigation Activity

(Suggested for grades 8 – 12)

Objective: The objective of this activity is to plot seven positions of the AUV in the mapping area below to track its motion.

Materials: Compasses, worksheets A, B, and C (The worksheets progress in difficulty. Special questions for worksheet C are at the bottom of this page.)

Explanation:
To use long baseline navigation (LBL) for AUV navigation, researchers first place at least two transponders (A and B) under water some distance apart, creating two points that define a line. The AUV will be able to locate itself by measuring its distance from both transponders, and triangulating its position. The distance between the transponders can be as little as 100 m to as much as 5 km or more. In this activity the baseline is 810 m in length.
On the AUV, an "underwater acoustic modem" generates a pulse of sound (a ping) that propagates outward at the speed of sound in water, 1500 m/s. This ping commonly has a frequency of 9 kHz. The AUV starts measuring time from the moment the ping is generated. The transponders are tuned to detect the 9 kHz ping. When transponder A receives the AUV's ping, it immediately generates an 8 kHz ping, and when transponder B receives the ping it responds with a 10 kHz ping. These response pings return to the AUV, which distinguishes the different frequencies, and measures the time for sound to travel the round trip to and from each of the transponders.

Instructions:
1. Total ping round-trip cycle time in seconds - The data in this activity gives time values for seven ping cycles. Each value is the time required for sound to go from the AUV to the transponder and back.
2. Time to AUV – Since sound travels from the AUV to a transponder and back in the time interval measured, the first calculation is to find half the time. Record half of each time interval in the middle two columns of the table.
3. Distance to AUV – Use the velocity formula, $d = vt$, to calculate distances between the AUV and the transponders. Use 1500 m/s as the speed of sound. Record distance values in the last two columns.
4. The scale at the bottom of the map shows the scale of distances in meters. Use the scale to set your compass to each distance, and scribe the distance as a circle centered on A or B.
5. The point where a pair of circles intersects is the position of the AUV.
6. Connect the AUV positions in order to show the path of the vehicle.

Questions for worksheet C:

1. Describe the difficulty with locating position #6.
   There are two positions that the vehicle could move to. Navigating near the base line is a well known problem with LBL. Other navigation solutions are needed in this region.

2. How did you decide which position to use for #6?
   Looking at the previous motion indicates that the vehicle will cross the base line. This is not certain, however, unless other data confirms it.

3. What additional data from the AUV would improve your certainty about which position to use for #6 and #7?
   The velocity vector of the vehicle would confirm its track. The Doppler sonar is used to provide this data. Its track could also be supported by knowing the time interval between each ping cycle, from which the velocity could be inferred.

4. Describe the difficulty with locating position #8.
   The position is on the base line. Small uncertainties in the distance data will cause a large uncertainty in vehicle position perpendicular to the base line.