Sonar Equation Problem Set 3

The purpose of this problem set is to provide practice using the sonar equation to calculate quantities used in echo counting and echo integration.

1. You have a 120 kHz scientific echosounder. The measured the sound pressure 1m in front of the transducer is 100 billion μPa (10^{11} μPa). A pulse is transmitted and an echo is returned from 150 m range. The size of the echo is 100 μPa.

   a. What is the SL in dB?
   b. What is the absorption at 120 kHz? (ok to use a table)
   c. What is the transmission loss in each direction?
   d. What is the TS of the target?

   a. SL = 20 log (10^{11} μPa) = 220 dB dB re 1μPa

   b. From the graph: Assuming 30% salinity and 10 degrees C, the absorption coefficient would be estimated as 33.8 dB/km. Values between 30-40 dB were considered acceptable, given that the environmental parameters were not given.

   c. TL = 20 log(150 meters) + (0.0338 dB/m * 150 meters) = 43.52 + 5.07 = 49.22 dB re 1μPa (one way)

   d. EL = SL – 2TL + TS
   TS = EL-SL+2*TL
   EL = 20 log (100/1) = 40 dB re 1μPa
   So, TS = 40-220+2*(49.22) = -81.5 dB re 1μPa @ 1 m

2. You have a 120 kHz echosounder with a source level of 230 dB and a pulse length of 20 μs. The two-way beam pattern subtends a solid angle of 0.02 steradians. You are examining a collection of –85 dB re 1 μPa scatterers at a range of 80 m. The reverberation level at that range is 89.6 dB re 1 μPa.
   Assume c = 1500 m/s, α = 0.04dB/m

   a. What is the volume of water contributing to the volume backscatter at 80 m?
   b. What is the volume backscattering strength Sv?
   c. What is the density of the –85 dB re 1 μPa scatterers?

a. $V = \frac{c\tau}{2}\Psi r^2 = \frac{(1500)(0.00002)}{2}0.02(80)^2$ = 1.92 m^3

b. RL = SL-2TL+S_v+10log(V)
TL = 20 log(80) +0.04(80) = 41.26
Sv = RL-SL+2TL-10log(V) = 89.6 -230 + 2(41.26) - 2.83 = -60.71 dB re 1μPa

c. $S_v = 10\log(s_v) = 10^{\frac{-60.71}{10}} = 8.49 \text{ x } 10^{-7}\ m^2 m^{-3}$

$$\sigma_{bs} = 10^{\frac{-85}{10}} = 3.16 \text{ x } 10^{-9}\ m^2$$

$$\rho = \frac{s_v}{\sigma_{bs}} = \frac{8.49 \times 10^{-7}}{3.2 \times 10^{-9}} = 268.57 \text{ animals } m^{-3}$$