SONOTRONICS

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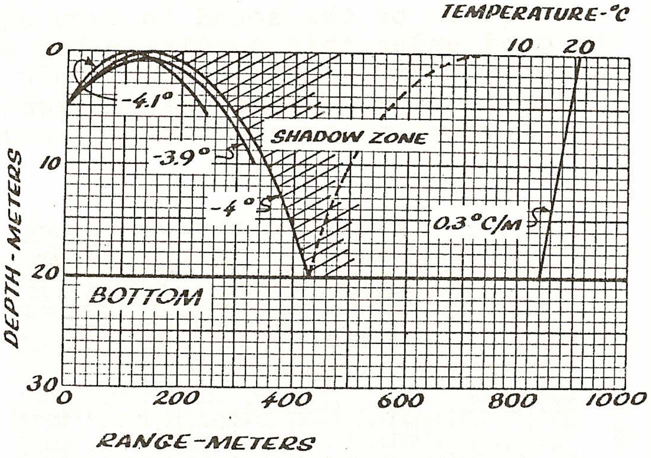
The science for determining the operating parameters of a long life, medium range fish tag has existed since the 1930's.

In performing the calculations, the primary range determinant is the spherical spreading loss of the radiated energy. The secondary is the loss due to the viscous nature of the water.

Using these factors, the range and life of a fish tag can be readily calculated. For instance, using a particular set of batteries, a life of one year can be achieved with a range of 1400 meters in fresh water. These calculations assume that the water conditions are ideal and that sound energy transmits from point A to point B in a straight line. However, in practice, the transmission medium is far from ideal. One of the greatest range determinants is the bending of sound waves in water due to refraction.



SLIDE 1

Sound travels faster in warm water than in cold, this results in refraction or bending of sound away from the warmer water. The amount of refraction is readily calculated knowing the sound velocity profile in the area under study. Sound velocity is most effected by water temperature and to a lesser degree, salinity and depth.

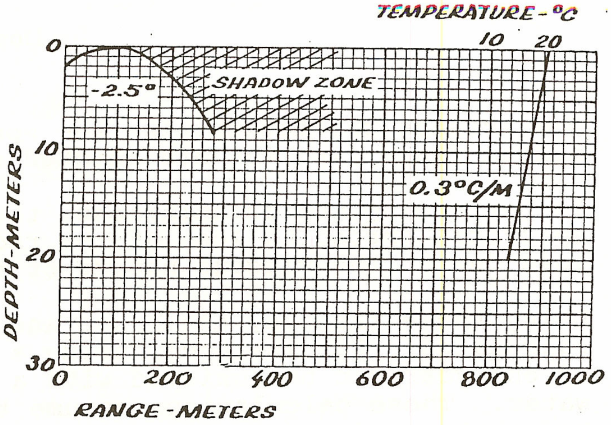
The sound path of Slide 1 marked -4 deg. is called the critical ray and is the ray of maximum range for the temperature gradient shown. Note the extreme bending effect due to temperature induced refraction. Note also the range, depth scale exaggeration. All transmission angles greater or less than the critical ray have diminished range as shown by the rays marked -3.9 deg. and -4.1 deg. The convention for marking ray angles is; angles toward the surface are negative, those toward the bottom are positive.

While the water surface acts like a near perfect reflector, the bottom does not. Rays reflected off of the bottom are greatly reduced in intensity, silt bottoms giving the greatest attenuation, hard rock bottoms less. In general, it is unlikely, at long ranges, that the bottom reflected sound will be received.

Using the same temperature gradient as in Slide 1, if the tag is located at the shallower depth, the range decreases.

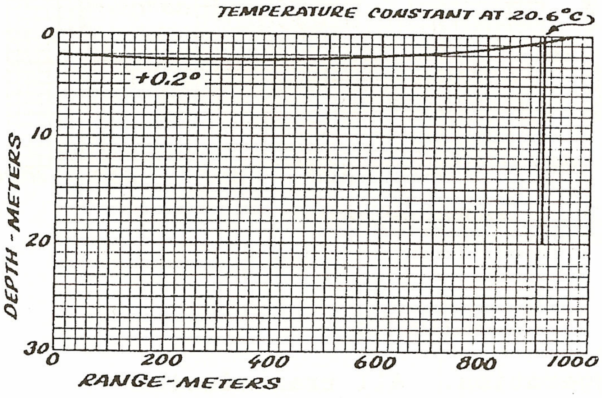
Also notice, no mention has been made of power, these boundries are irrespective of power. However, higher power will buy a slight increase in range due to the scattering effects of foreign bodies in the water.

When the water is isothermal as shown in Slide 3, sound is bent toward the surface, this is due to pressure (depth) effects on sound veolocity. Ranges under this condition approach the calculated numbers.

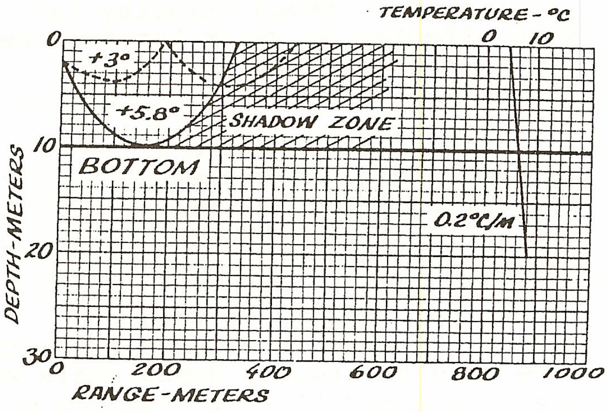


Slide 2

When the temperature gradient is positive as shown in Slide 4, the refraction of the sound is very strong toward the surface. Ranges can be good under this condition but are highly dependent on surface condition and bottom depth. Only the critical ray is considered for maximum range because the smallest surface waves will scatter the multi-refected acoustic signal causing great attenuation.



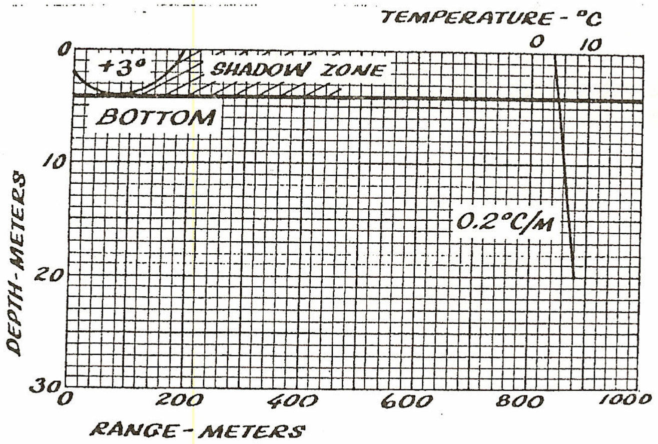
Slide 3



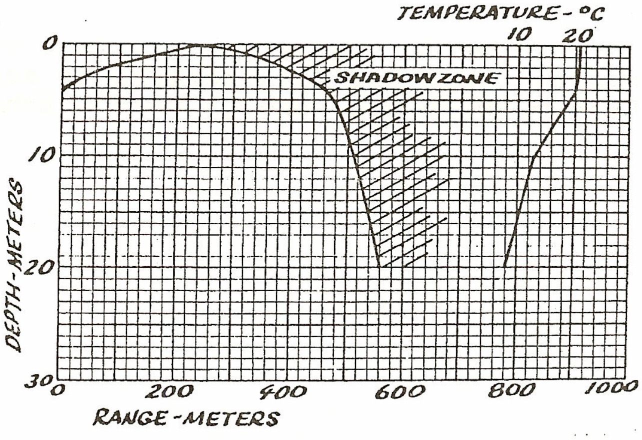
Slide 4

Slide 5 illustrates the effects on range of a lake with the same temperature profile as in Slide 4 but a maximum bottom depth of only 4 meters.

Slide 6 illustrates the complete effects of refracton on range due to a typical summer temperature profile. The 4 meter point of origin was the average depth of tagged fish as determined by temperature indicating fish tags. The measured range for this condition was 200 meters.

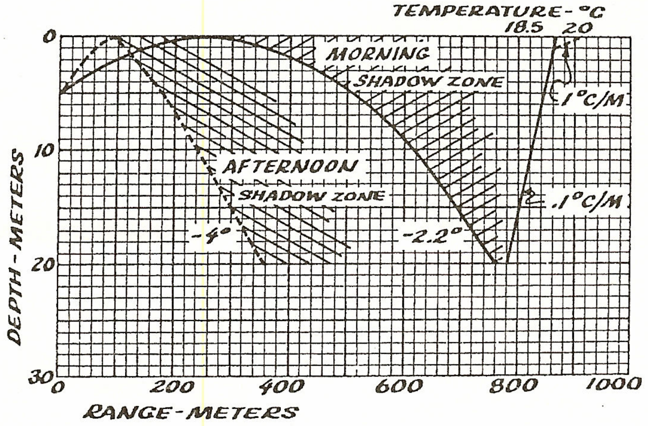


Slide 5

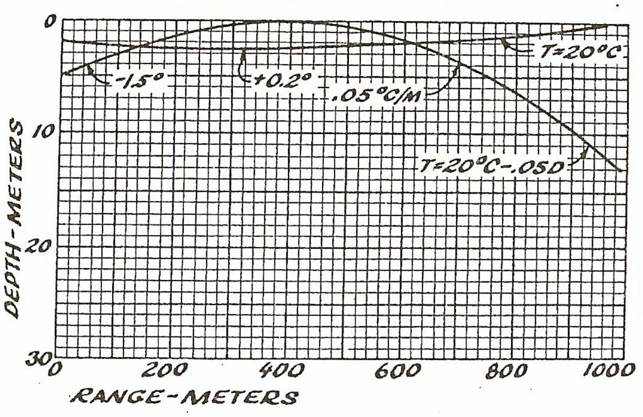


Slide 6

Fish tag ranges are generally better in the early morning than in the afternoon. This is due to the change of temperature gradient near the surface in the afternoon as shown in Slide 7.



Slide 7



Slide 8

Slide 8 illustrates the transmission difference of a destratifed body and one with a positive temperature gradient of only .05 deg. C per meter. This indicates the importance of differential temperature measuring accuracy.

There are an infinite number of temperature profiles possible; these slides show just a few cases.

In addition to refraction, particulate matter suspended in water can have a great effect on range. In one instance, a tag's range was reduced to 1/50 of normal. The only plausable explanation was a heavy phyto-plankton bloom. Later tests on the same tag with the same batteries proved its range was undiminished.

Aquatic weeds have a great effect on fish tag range. In a number of cases, range has been reduced to as little as 23 meters when transmission was through weed patches.