EFFECT OF SALINITY ON LIGHT PROPAGATION THROUGH WATER

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Abstract

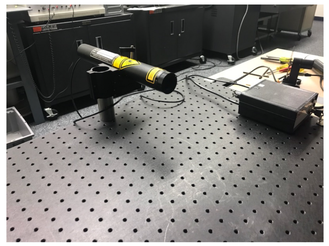
Although multiple studies have been conducted testing the effect of salinity on light scattering, further study into the effect of salinity on the amplitude of lasers will be useful for determining the efficacy of underwater optical transmission systems. The goal of this experiment is to measure the amplitude of a laser which shines through solutions with varying concentrations of salt. The research team tested the amplitude of a helium neon laser after passing through 3 different solutions of differing salinities.

Equipment

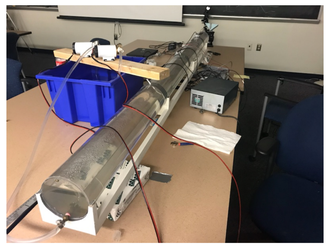
Si Free-Space Amplified Photodetector

Wavelength Range:
200-1100 nanometers

Laser
Power: 2 milliwatts
Wavelength: 633 nanometers
Beam Type: Gaussian



Water Tank
Volume : 34,900 cm^3
Length: 245 cm
Radius: 6.7 cm



Methodology

1. Fill the tank to at least the level of the laser beam with pure water.
2. Turn on the photodetector, and begin collecting data.
3. Turn on the laser, collect data for ten seconds, then turn the laser off.
4. After ensuring data has been collected successfully, add enough salt to create an environment with half the total desired salinity (25 parts per thousand). This was calculated to be 250 grams of salt.
5. Repeat data collection for the new salinity.
6. Repeat steps 4-5 after adding an additinal 250 grams of salt to the water to create a solution with similar salt content to the ocean (35 ppt).

Data Table

Salt Concentration (ppt)	Amplitude (V) Trial 1	Amplitude (V) Trial 2	Amplitude (V) Mean
0	0.0099	0.0100	0.010
12.5	0.0037	0.0057	0.0047
25	0.00055	0.0025	0.0015

References

Perlman, Howard, and USGS. “Why Is the Ocean Salty?” *U.S. Geological Survey*, water.usgs.gov/edu/whyoceansalty.html.

Sullivan, Lisa. “Introduction.” *Confidence Intervals*, sphweb.bumc.bu.edu/otlt/MPH-Modules/BS/BS704_Confidence_Intervals/BS704_Confidence_Intervals_print.html.

Data Analysis

Matlab was used to compile more than 200,000 data points for each Trial. The mean and standard deviation were calculated for each trial:

Concentration (ppt)	Mean Amplitude (V)	Standard Deviation	Sample Size
0	0.010	0.00023	477120
12.5	0.0047	0.00059	476160
25	0.0015	0.00020	478080

Statistical Test

$$(\bar{x}_1 - \bar{x}_2) \pm z\, S_p \sqrt{\frac{1}{n_1} + \frac{1}{n_2}}$$

A 99% confidence interval was calculated to determine the difference in means of the concentrations. The results follow:
1. We can say with 99% confidence that the difference between the mean amplitude of the light passing through pure water and the mean amplitude of the light passing through water with a salt concentration 12.5 ppt is **$0.0053 \pm 2.0 \times 10^{-6}$**
2. We can say with 99% confidence that the difference between the mean amplitude of the light passing through water with a salt concentration of 12.5 ppt and the mean amplitude of the light passing through water with a salt concentration of 25 ppt is **$0.0032 \pm 2.0 \times 10^{-6}$**

Conclusion

Our data do support that salinity significantly affects the amplitude of a laser propagating through water. This poses a major obstacle to underwater optical communication systems. The experiment suggests a more powerful laser is necessary for any realistic underwater optical communication system to effectively transmit data.