Array Gain and Coherences in a Fluctuating Ocean

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Array Gain (AG) is one of the most fundamental metrics in assessing and optimizing underwater acoustic passive array performance. It is defined as 10 times the logarithm of the ratio of two signal-to-noise ratios, comparing the beam SNR of a hydrophone array to that of an omnidirectional hydrophone. For a perfectly coherent signal (i.e., without amplitude or phase fluctuations along its wavefronts), AG is simply related the beampattern and the ambient noise spectral density, expressing the reduction in noise by the directional response. However, in the real ocean, the signal, and hence the directional response, would be randomized to a certain degree. In this case, AG can be shown to dependent on the signal cross-correlation coefficients as well as the noise cross-correlation coefficients between all pairs of hydrophones in the array. Consequently, for arrays that have dimensions approximately equal to or larger than the signal coherence length, the "effective aperture" is controlled by the environmental variabilities in the relevant scales. This talk begins with a brief review of the basics on beamforming and the characteristics of ocean ambient noise. The dominant environmental variabilities observed in the northeastern South China Sea that cause significant signal fluctuations and are responsible for signal decoherence are then illustrated. The discussion on the various methods to estimate the signal decoherence length is then followed.