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Type: Oral

## ambiguity in hydroacoustic triangulation through consideration of three-dimensional propagation features

*Thursday, 27 June 2019 16:45 (15 minutes)*

Ambiguity in triangulation of events recorded on the IMS hydroacoustic network depend on the accuracy in knowing when these events occurred. Considering only the direct “line-of-sight” propagation path to a station, three stations are needed to pinpoint an event time. To overcome this requirement, consideration of additional signal features relating to the propagation characteristics can improve triangulation. Two such signal features are: (1) modal dispersion characteristics of the direct path; and (2) delayed out-of-plane arrivals caused by bathymetric refraction. Detection of out-of-plane arrivals effectively add additional “virtual” stations, while characteristics of modal dispersion correspond to the propagation distance. Thus when such signal features are present in combination with the back-azimuth information, source triangulation can be accomplished from a single station. An examination of these signal features within two impulsive acoustic events, one associated with the loss of the Argentine submarine San Juan and the other a planned depth charge deployed two weeks later as part of the initial search, demonstrate the ability to triangulate with limited receiving stations (note both of these events were detected at HA10 and HA04). Furthermore, the propagation models used to capture these signal features also provide an assessment of triangulation error caused by uncertain oceanography.

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**Session Classification:** T1.3 Properties of the Ocean

**Track Classification:** Theme 1. The Earth as a Complex System