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Dynamic tracking of free-swimming whale groups using digital acoustic recording tags

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Understanding the group behavior of free-swimming whales is critical to the management and conservation of many whale species. Moreover, understanding how whales coordinate their activities could serve as a model for improving the communication and navigation systems of underwater robots and autonomous underwater vehicles (AUVs). One method for studying the group behavior of free-swimming whales involves simultaneously attaching acoustic recording tags to multiple animals within a close-swimming conspecific group. Acoustic recording tags can sample an animal's acoustic environment simultaneously with other physical parameters such as diving depth and acceleration. In this paper, methods are presented for dynamically tracking whales that vocalize regularly such as odontocetes using the DTAG, a digital acoustic recording tag developed by the Woods Hole Oceanographic Institution. A trilateration model is reviewed for tracking groups of whales that include three or more tagged whales using time of flight data and results are given from applying this model to a novel data set of three simultaneously diving and cross-audible short-finned pilot whales (Globicephala macrorhyncus). A new model is subsequently proposed for tracking whale groups that include only two tagged whales using a generalization of multilateration and data captured by stereo DTAGs.