

Horvitz-Thompson Whale Abundance Estimation Adjusting for Uncertain Recapture, Smoothed Availability Trends and Interrupted Effort

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Abstract: We examine the use of an unusual Horvitz-Thompson type estimator developed for the estimation of total population abundance of the Bering-Chukchi-Beaufort Seas population of bowhead whales in 2011 based on visual sightings and acoustic locations obtained from ice-based visual observation stations and submersed marine acoustical units. What makes this analysis unique is the derivation of three estimated correction factors required to account for complexities presented by the survey protocol and resulting features of the dataset. The first factor adjusts for detectability using uncertain recapture data to estimate detection probabilities and their dependence on offshore distance, ice condition, and whale group size. The second correction adjusts for availability using the acoustic location data to estimate a time-varying smooth function of the probability that animals pass within visual range of the observation stations. The third correction accounts for missed visual watch effort. Uncertainty in the estimates of these corrections is propagated into the final abundance estimate and an associated estimate of population trend that incorporates a time series of past estimates. Although some of the particulars of the approach are closely connected to the bowhead application, adjustments for detection, availability and effort are common and some of the methods discussed here could be adapted for abundance surveys facing similar challenges. Aside from the novel statistical aspects of our approach, the results of its application to bowhead whales has played a crucial role in the safe management of subsistence hunting of this species under the guidance of the International Whaling Commission.