From clicks to counts: using passive acoustic monitoring to estimate the density and abundance of Cuvier's beaked whales in the Gulf of Alaska

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A visual and acoustic line-transect survey of marine mammals was conducted in the central Gulf of Alaska (GoA) during the summer of 2013. The survey area was divided into four sub-strata to reflect four distinct habitats; 'inshore', 'slope', 'offshore' and 'seamount'. Passive acoustic monitoring was conducted using a towed-hydrophone array system. One of the main objectives of the acoustic survey was to obtain an acoustic-based density estimate for beaked whales. Three species of beaked whales were identified; Cuvier's (*Ziphius cavirostris*), Baird's (*Berardius bairdii*) and Steijneger's (*Mesoplodon stejnegeri*). A preliminary total of 124 acoustic encounters (including 93 localizations) of beaked whales during 6,304 km of effort were obtained compared to 13 visual encounters during 4,155 km of effort. Two distance sampling analytical methods will be used to obtain density and abundance estimates for Cuvier's beaked whales; (1) conventional distance sampling (cds) and (2) distance sampling using a depth distribution model (dsddm). Beaked whales vocalize in a three-dimensional context, so the vertical position of the animal has to be considered along with its horizontal location. Target motion analysis was used to obtain slant ranges to individual beaked whales for the cds approach. When the calling animal is deeper than the towed array, the estimated range will be an overestimate of the perpendicular range required for cds. This will result in an overestimate of the average probability of detection and an underestimate of density. Using the dsddm approach, information about the depth distribution of the study species can be directly incorporated into the maximum likelihood estimator of the detection function parameters, thereby eliminating the slant range bias in the estimate. The density and abundance estimate results from these two analyses will be compared and the advantages and disadvantages of acoustic-based density estimates will be presented. Applications of these methods to other species and areas will also be discussed.

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