

Advances in Density and Abundance Estimation for Cetaceans Using Geospatial Modeling

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Abstract: To identify and quantify spatial patterns in cetacean density in the eastern Pacific Ocean, we have built generalized additive models (GAMs) of encounter rate (number of sightings per km) and average school size based on the Southwest Fisheries Science Center's 1986-96 survey data. The survey area encompassed over 25 million sq. km, and the tracklines covered almost 200,000 km. Models were constructed using stepwise selection of predictor variables, including time-invariant geographic variables (latitude, longitude, offshore distance, ocean depth, slope of the ocean floor) and temporally dynamic oceanographic and biological variables (sea surface temperature, gradient in sea surface temperature, sea surface salinity, thermocline depth, thermocline strength, depth of the euphotic zone, and chlorophyll concentration). We built separate models to describe the northern and southern regions of our study area for each of the following eight species or species

groups: blue whale (*Balaenoptera musculus*, n= 98 sightings), fin whale (*B. physalus*, n=44), sei and Bryde's whales (*B. borealis* and *B. edeni*, respectively; n=99 sightings total), sperm whale (*Physeter macrocephalus*, n=165), dwarf and pygmy sperm whales (*Kogia sima* and *K. breviceps*, respectively; n=89 sightings total), Cuvier's beaked whale (*Ziphius cavirostris*, n=99), beaked whales of the genus *Mesoplodon* (n=94), and delphinids (n=2413). One variable that factored prominently into the analysis was sea surface temperature, which was correlated with the encounter rates of delphinids and sei/Bryde's whales, and with the school sizes of delphinids, sperm whales, blue whales, and sei/Bryde's whales. In addition, thermocline characteristics helped explain observed patterns in the encounter rates of delphinids and blue whales, and the school sizes of Cuvier's beaked whales and sei/Bryde's whales.