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An integrated approach to the foraging ecology of marine birds and mammals

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Birds and mammals are important components of pelagic marine ecosystems, but our knowledge of their foraging ecology is limited. We distinguish six distinct types of data that can be used in various combinations to understand their foraging behavior and ecology. We describe methods that combine concurrent dive recorder deployment, oceanographic sampling, and hydroacoustic surveys to generate hypotheses about interactions between the physical environment and the distribution, abundance, and behavior of pelagic predators and their prey. Our approach is to (1) map the distribution of whales in relation to the distribution of their prey and the physical features of the study area (bottom topography, temperature, and salinity); and (2) measure the foraging behavior and diet of instrumented whales in the context of the fine-scale distribution and composition of their prey and the physical environment. We use this approach to demonstrate a relationship between blue whale distribution, sea surface temperature, and concentrations of their euphausiid prey at different spatial scales offshore of the Channel Islands, California. Blue whale horizontal spatial distribution was correlated with regions of high acoustic backscatter. Blue whale dive depths closely tracked the depth distribution of krill. Net sampling and whale diet revealed that whales fed exclusively upon dense schools of *Euphausia pacifica* (between 100 and 200 m) and *Thysanoessa spinifera* (from the surface to 100 m). Whales concentrated foraging efforts upon those dense euphausiid schools that form downstream from an upwelling center in close proximity to regions of steep topographic relief. We propose that (1) the distribution of *Balaenoptera* whales in the coastal California Current region is defined by their attraction to areas of predictably high prey density; (2) the preferred prey of these whales are several species of euphausiids (*E. pacifica*, *T. spinifera*, and *N. simplex*) that are abundant in the California Current region; (3) blue whales concentrate their foraging efforts on dense aggregations of euphausiids found at discrete depths in the water column; (4) these localized areas of high euphausiid densities are predictable and sustained by enhanced levels of primary productivity in regions which are located downstream from coastal upwelling centers (indicated by sea surface temperature); (5) topographic breaks in the continental shelf located downstream from these upwelling centers work in concert with euphausiid behavior to collect and maintain large concentrations of euphausiids swarms, and (6) despite seasonal and inter-annual variability, these processes are sufficiently consistent that the distribution of *Balaenoptera* whales can be predicted.



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