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Prey consumption and energy transfer by marine birds in the Gulf of Alaska

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Abstract

We investigated prey consumption by marine birds and their contribution to cross-shelf fluxes in the northern Gulf of Alaska. We utilized data from the North Pacific Pelagic Seabird Database for modeling energy demand and prey consumption. We found that prey consumption by marine birds was much greater over the continental shelf than it was over the basin. Over the shelf, subsurface-foraging marine birds dominated food consumption, whereas over the basin, surface-foraging birds took the most prey biomass. Daily consumption by marine birds during the non-breeding season (“winter”) from September through April was greater than daily consumption during the breeding season, between May and August. Over the shelf, shearwaters, murres and, in winter, sea ducks, were the most important consumers. Over the basin, northern fulmars, gulls and kittiwakes predominated in winter and storm-petrels dominated in May to August. Our results suggest that marine birds contribute little to cross-shelf fluxes of energy or matter, but they do remove energy from the marine system through consumption, respiration and migration.
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1. Introduction

There is a long-standing interest in the relative importance of continental shelf versus deep oceanic waters for supporting higher trophic-level organisms such as groundfish, seabirds and marine mammals. In general, shelf waters are more productive and support higher densities of these top predators than basin waters (Cooney, 1986; DeGange and Sanger, 1986; Sambrotto and Lorenzen, 1986). However, the connections and energy transfer between these habitats warrant further investigation on many trophic levels. To investigate these questions in the northern Gulf of Alaska, we calculated avian energy demand and prey consumption using estimated densities of marine birds in shelf and basin waters.

More than 65 species of marine birds have been identified in the northern Gulf of Alaska, although only about 20 of these are found in either shelf or

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basin waters in densities greater than $1\,km^{-2}$ (Appendix A). Several estimates of the numbers of seabirds using the Gulf of Alaska and their prey demands are available. DeGange and Sanger (1986) estimated that prey consumption of marine birds (excluding waterfowl, loons, grebes and shorebirds) in the Gulf of Alaska was $\sim 18\,kg\,km^{-2}\,d^{-1}$ over continental shelf waters and $\sim 2.4\,kg\,km^{-2}\,d^{-1}$ over basin waters. More recently, Hunt et al. (2000) estimated that during the summer months of June, July and August, marine bird prey consumption in the Gulf of Alaska was between 0.74 and $1.72\,MT\,km^{-2}$ over the 92-day period or $8.0–18.9\,kg\,km^{-2}\,d^{-1}$. Neither of these studies included the sea ducks, loons or grebes, and neither examined the impacts of winter migrants on the shelf and basin habitats.

Many of the species of marine birds that occupy the Gulf of Alaska are seasonal migrants, and even for those species that are year-round residents, there can be considerable flux in and out of the Gulf or redistributions within the region (G. Hunt, personal observations). For example, in this study, 14 of the 19 most abundant species are seasonal migrants, and a number of these are sea ducks whose contribution to marine bird prey consumption in the Gulf has previously been neglected (Appendix A). It is therefore useful, as part of a fresh examination of the marine ecosystem of the Gulf of Alaska, to re-examine the role of marine birds and compare winter and summer use of the shelf and basin habitats.

2. Methods

We determined the density of seabirds, by species and species groups (Appendix A) by extracting counts from the North Pacific Pelagic Seabird Database (NPPSD), which is maintained by the US Geological Survey, Alaska Science Center (http://www.absc.usgs.gov/research/NPPSD/index.htm) within a 350 km by 660 km box bisected by the shelf break (300 m) in the northern Gulf of Alaska (Table 1, Fig. 1). The shelf and basin regions of this box were further divided into a pair of northeastern-sectors and a pair of southwestern sectors in recognition of spatial variability in the along-shelf dimension.

Table 1
Distribution of survey effort by regions and season

Season	Region	On-shelf	Off-shelf
(May–Aug.)	N. East	241	133
	S. West	1915	43
(Sept.–Apr.)	N. East	458	172
	S. West	3899	118

Units are individual transect segments.

For most marine bird species, shipboard surveys were used directly to calculate the mean density of birds km^{-2}. Surveys were conducted with one observer who scanned a 300 m-wide transect from the bow to 90° of the side of the ship with the best visibility. The majority of transect segments were 10–15 min long. In our analyses, all transects, regardless of length were treated as equivalent. Within each of the four sectors in each of the two seasons, we totalled the number of birds observed in a transect segment and divided by the area surveyed in that segment to obtain the mean density of birds km^{-2}. Although survey effort varied greatly by sector, the use of seabird densities provided us a de facto standardization of our measures and allowed comparisons among sectors.

Two species of albatrosses, three species of shearwaters and northern fulmars in the Gulf of Alaska are ship-attracted or clumped in their distributions (see also Hyrenbach, 2001), for which a simple summing of the estimates based on the shipboard counts resulted in totals that differed greatly from known world populations of these species based on colony counts alone (Hunt et al., 2000). Hunt et al. assumed that the ratios of the densities of each of these species across the PICES regions represented the proportion of the North Pacific population of each species in each region. Therefore, to obtain the number of individuals of a species in each region (e.g., the Gulf of Alaska), they multiplied the percentages of each species seen in a region by the estimated population for the entire PICES region (Hunt et al., 2000). This procedure was modified further for sooty/short-

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