

# Temporal and Spatial Variability in Distribution of Kittlitz’s Murrelet in Glacier Bay

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**Abstract.** We conducted surveys in Glacier Bay at monthly, weekly and daily time scales during 2003 to provide insight into the pelagic distribution of Kittlitz’s Murrelet (*Brachyramphus brevirostris*). The distribution of Kittlitz’s Murrelets in June was concentrated in the areas north of South Marble Island, the lower half of Muir Inlet, and around Russell Island in the upper West Arm of the bay. The density of Kittlitz’s Murrelets in Muir Inlet decreased throughout the season from a high in June to a low in August. The density of Kittlitz’s Murrelets in the West Arm was moderate in June, highest in July, and lowest in August. While Kittlitz’s Murrelets were observed in shallow, nearshore water (often near tidewater glaciers and glacial-river outflows), they also were observed in deep water, far from shore and any direct glacial influence.

## Introduction

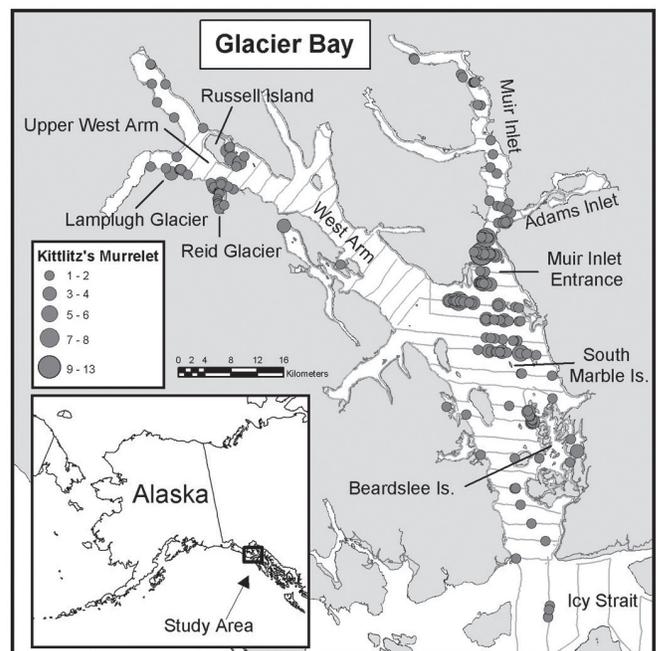
The Kittlitz’s Murrelet (*Brachyramphus brevirostris*) is one of the rarest seabirds in North America, and most aspects of its biology remain obscure. Available evidence from surveys indicates that the species is declining at an alarming rate across their core breeding range. Preliminary analysis of surveys conducted in Glacier Bay in 1991 and 1999/2000 (J. Piatt, U.S. Geological Survey, unpub. data, Robards and others, U.S. Geological Survey, written commun, 2003) suggest that populations declined by more than 80 percent during that period. Because the species is rare and declining, accurate population estimates are urgently needed. Broad-scale surveys should be conducted in areas where this species has occurred in the past and replicated surveys should be conducted in core areas to produce population trend and habitat use information.

This paper summarizes the results of systematic, at-sea surveys that were conducted in Glacier Bay, Alaska, during summer 2003. The goal of this work was to assess variability in the at-sea density and distribution of Kittlitz’s Murrelets within Glacier Bay at a variety of spatial and temporal scales. The results of this project will be incorporated into the on-going study of Kittlitz’s Murrelets in Glacier Bay being conducted by the U.S. Geological Survey.

## Methods

At-sea surveys of Kittlitz’s Murrelets were conducted within Glacier Bay and Icy Strait from June to August 2003. All surveys were conducted according to strip survey protocols established by the U.S. Fish and Wildlife Service for surveying marine birds (Gould and others, 1982). The transect lines used in this study were originally created for the annual, inter-agency Marine Predator Survey, a vessel-based survey, which has been conducted in Glacier Bay and Icy Strait during winter

(November-March) and summer (June) since 1999. The timing and geographic extent of the surveys were chosen to provide data on the bay-wide distribution of the species, as well as monthly, weekly, and daily variations in density in key areas of Glacier Bay and Icy Strait. We surveyed Kittlitz’s Murrelets during the Marine Predator Survey in June 2003 to determine bay-wide distribution of the species. The spatial scale covered by the Marine Predator survey was too large to replicate on a monthly time scale so the monthly surveys were restricted to the upper arms of Glacier Bay (Muir Inlet and West Arm; fig. 1). Weekly surveys on a much smaller spatial scale were conducted to characterize meso-scale temporal changes in murrelet distribution. These surveys were conducted in two separate areas of Glacier Bay, the Upper West Arm and Muir Inlet Entrance (fig. 1). The Upper West Arm area also was surveyed daily over five consecutive days to assess variability at a fine temporal scale.



**Figure 1.** Kittlitz’s Murrelet sightings in Glacier Bay and Icy Strait, Alaska, during surveys conducted from June 9–14, 2003. Boat survey tracks are represented by grey lines in the figure.

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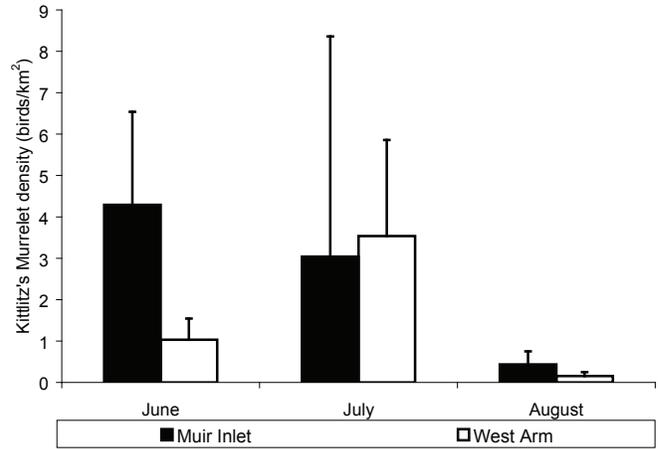
Non-parametric tests were chosen for analyses because mean transect densities were not normally distributed, some sample sizes between surveys were unbalanced, and many transect densities were derived from zero counts. A density estimate (birds/km<sup>2</sup>) for Kittlitz's Murrelets was calculated for each transect. Comparisons were made within each category of monthly, weekly and daily surveys using a Kruskal-Wallis ANOVA, based on ranked data. Multiple comparisons within each category were made using a Kruskal-Wallis multiple comparison procedure. Significance was set at  $P=0.05$  for all Kruskal-Wallis ANOVA and Kruskal-Wallis multiple comparison procedures performed.

**Results**

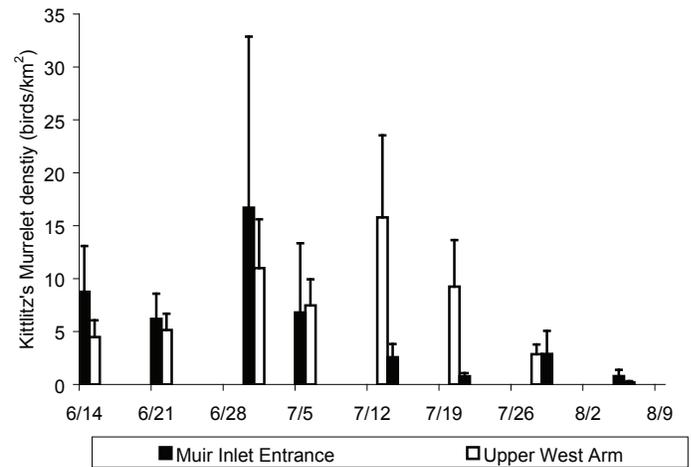
During the June bay-wide survey, Kittlitz's Murrelets were widely distributed throughout the study area with concentrations from the entrance of Glacier Bay to the upper reaches of the West Arm and Muir Inlet (fig. 1). In the West Arm of Glacier Bay the majority of Kittlitz's Murrelets were found in nearshore waters ( $\leq 200$  m from shore) of relatively shallow depth ( $\leq 100$  m), and within close proximity to a tidewater glacier (glacial-affected habitat) or glacier-fed stream outflow (glacial-stream-affected habitat). In the remainder of the bay, Kittlitz's Murrelets were found in both nearshore and offshore waters ( $>200$  m from shore), and in both shallow and deep water ( $>100$  m). While Kittlitz's Murrelets were often observed in habitat with direct glacial influence in the northern areas of Glacier Bay (West Arm and Muir Inlet), birds observed in the southern parts of the bay were in close proximity to submerged marine sills (marine-sill-affected habitat) and glacial-unaffected waters (see Day and others, 2000 for a thorough description of these habitats).

The mean density of Kittlitz's Murrelets in Muir Inlet was highest in June ( $4.3 \pm 2.3$  birds/km<sup>2</sup>) and lowest in August ( $0.4 \pm 0.3$  birds/km<sup>2</sup>; fig. 2). While there was no significant difference ( $P=0.098$ ) in the density of birds in Muir Inlet between June and July ( $3.0 \pm 5.3$  birds/km<sup>2</sup>) or between July and August ( $P=0.055$ ), the data suggest a decreasing trend, which is supported by a significant difference in densities between June and August ( $P=0.010$ ). The mean density of Kittlitz's Murrelets in the West Arm increased significantly ( $P=0.014$ ) from June ( $1.0 \pm 0.5$  birds/km<sup>2</sup>), to July ( $3.5 \pm 2.3$  birds/km<sup>2</sup>), then decreased significantly ( $P=0.002$ ) in August ( $0.2 \pm 0.1$  birds/km<sup>2</sup>; fig. 2).

The mean density of Kittlitz's Murrelets in Muir Inlet Entrance reached a high of  $16.7 \pm 16.2$  birds/km<sup>2</sup> on June 30 and a low of  $0.8 \pm 0.3$  birds/km<sup>2</sup> on July 21 (fig. 3). The mean density of Kittlitz's Murrelets in the Upper West Arm ranged from a high of  $15.8 \pm 7.8$  birds/km<sup>2</sup> on July 13, to a low of  $0.2 \pm 0.1$  birds/km<sup>2</sup> on August 6. Although statistically significant differences were determined only between the August surveys and all other survey days, the data display a noticeable trend, beginning the season with moderate densities, peaking at mid-season, and steadily declining until the end of the season. The difference between high and low



**Figure 2.** Density (birds/km<sup>2</sup>; +1 SE) of Kittlitz's Murrelets in the Muir Inlet and West Arm of Glacier Bay National Park, Alaska. Surveys were conducted monthly from June to August 2003.



**Figure 3.** Density (birds/km<sup>2</sup>; +1 SE) of Kittlitz's Murrelets in the Muir Inlet Entrance and Upper West Arm areas of Glacier Bay National Park, Alaska. Surveys were conducted weekly (mean=7.4 days) from June 14 to August 6, 2003.

densities is similar in magnitude for both areas but the peak in bird density in Muir Inlet Entrance was observed 13 days before the peak in density observed in the Upper West Arm.

Over five consecutive days of sampling the mean density of Kittlitz's Murrelets in the Upper West Arm ranged from a high on June 22 of  $5.2 \pm 1.5$  birds/km<sup>2</sup> to a low of  $2.9 \pm 0.8$  birds/km<sup>2</sup> on June 26. There was not a significant difference ( $P=0.474$ ) in density over the five day period.

**Discussion and Conclusions**

In Glacier Bay Kittlitz's Murrelet shows a clumped distribution, with very high densities in certain areas (Muir Inlet Entrance, Upper West Arm), and large gaps in their

distribution where few, if any birds occur (fig. 1). Similarly in Prince William Sound, Kittlitz's Murrelets occur in a clumped, rather than even or random distribution (Day and Nigro, 1999; Day and others, 2000). A clumped distribution could make the species more vulnerable to possible point source threats such as oil spills or vessel disturbance.

In Glacier Bay the distribution of Kittlitz's Murrelets includes both nearshore and shallow waters in the West Arm (particularly in the vicinity of Russell Island), yet in the rest of Glacier Bay Kittlitz's Murrelets were observed both nearshore and offshore, and in both shallow and deep waters. During the bay-wide survey of Glacier Bay in June birds were observed foraging greater than 2 km offshore and in water deeper than 200 m. It is not known whether birds in these areas were foraging successfully, but birds were often observed greater than 2 km from shore holding fish in their bills at the Muir Inlet Entrance. Kittlitz's Murrelets have shown a preference for nearshore and shallow waters in Prince William Sound (Day and Nigro, 2000).

The distribution of Kittlitz's Murrelet has been linked to glacial fjords in both south-eastern Alaska (Day and others, 1999) and Prince William Sound (Islieb and Kessel, 1973; Day and Nigro, 1999). Habitats affected by tidewater glaciers or glacial-streams are preferred by Kittlitz's Murrelets in Prince William Sound (Day and others, 2000). In the West Arm of Glacier Bay, Kittlitz's Murrelets were observed most often near Reid Inlet and Lamplugh Glacier which contain some of the highest concentrations of glacial-affected and glacial-stream-affected habitat (as defined by Day and others, 2000) in the park. Areas frequented by murrelets in Muir Inlet also contain tidewater glaciers (Muir, Riggs, and McBride Glaciers), and glacial-stream-affected habitat, including the river outflow of the Casement Glacier which empties into the mouth of Adams Inlet. However, in the southern parts of Glacier Bay Kittlitz's Murrelets also were observed in areas greater than 10 km from a tidewater glacier or glacial-stream. Future research effort in Glacier Bay National Park should investigate further the potential importance of these glacial-affected habitats.

## Management Implications

Due to significant population declines in its core population centers of Prince William Sound, the Malaspina Forelands, and Glacier Bay, the U.S. Fish and Wildlife Service added Kittlitz's Murrelet to the list of species regarded as a candidate for listing under the Endangered Species Act (Federal Register 2004). Information on the temporal and spatial distribution of this species within Glacier Bay National Park will be necessary for future species management and potential recovery measures, particularly to the seasonal timing of any proposed changes to regulations. These data also will be essential for identification of critical habitat and for issuing endangered species "take permits" for disturbance of murrelets by vessels in the Park.

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