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Natural Resource Stewardship and Science

Monitoring Kittlitz's and Marbled Murrelets in Glacier Bay National Park and Preserve

2013 Annual Report

Natural Resource Technical Report NPS/SEAN/NRTR—2014/841

ON THE COVER
Typical murrelet survey weather in Glacier Bay with Mt. Fairweather in the background
Photograph by: Christopher J. Sergeant, Southeast Alaska Network

Monitoring Kittlitz's and Marbled Murrelets in Glacier Bay National Park and Preserve

2013 Annual Report

Natural Resource Technical Report NPS/SEAN/NRTR—2014/841

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January 2014

U.S. Department of the Interior
National Park Service
Natural Resource Stewardship and Science
Fort Collins, Colorado

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Please cite this publication as:

Hoekman, S. T., C. J. Sergeant, and W. F. Johnson. 2014. Monitoring Kittlitz's and marbled murrelets in Glacier Bay National Park and Preserve: 2013 annual report. Natural Resource Technical Report NPS/SEAN/NRTR—2014/841. National Park Service, Fort Collins, Colorado.

NPS 132/123553, January 2014

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Executive Summary

Since 2009, the National Park Service's Southeast Alaska Inventory and Monitoring Network (SEAN) has monitored population abundance and trend of Kittlitz's (KIMU) and marbled murrelets (MAMU) in Glacier Bay National Park and Preserve, an important summer residence for both species. This annual report summarizes data in a concise format and focuses on current population abundance and spatial distribution.

Monitoring focuses on KIMU, with secondary consideration of MAMU. KIMU are an open-water, pursuit forager whose reliance on pelagic prey sources link their habitat use in some areas to dynamic physical habitat variables such as glacial extent and oceanography. The SEAN uses boat-based line transect surveys to estimate species-specific, on-water density and abundance of murrelets, accounting for detection probability and unidentified murrelets. We surveyed 214 km on 40 transects from 6-13 July 2013 across the 1,170 km^2 survey area in Glacier Bay proper. We estimated an abundance of 7,210 KIMU (SE = 2,046) and 84,428 MAMU (SE = 15,394). From 2009 to 2013, KIMU abundance estimates have ranged from 7,210 to 16,469 with annual changes of -56% to 120%, while MAMU have ranged from 28,978 to 84,428 with annual changes of -29% to 113%. Such large variation was very unlikely to reflect solely intrinsic population growth.

This season, in cooperation with the University of Montana and USFWS, the SEAN participated in field trials designed to assess the magnitude of Kittlitz's versus marbled murrelet identification error among observers of differing experience levels. The results of this work will be reported in future thesis products from A. Schaefer at the University of Montana.

Monitoring in Glacier Bay confirms that the park continues to support an important fraction of the global KIMU population. After the 2016 survey, the SEAN will synthesize existing abundance and trend information and re-examine analytic methods to assess if monitoring is likely to achieve program objectives. Our results to-date demonstrate that key operational components of our monitoring protocol are functioning as intended.

Acknowledgments

Since 2011, R. Sarwas has provided critical support for the NPTransect application. A. Schaefer assisted with field surveys and conducted murrelet identification trials that will improve future understanding of survey results. K. Nesvacil, R. Peak, and J. Saracco assisted with identification trials. The M/V Serac and crew hosted murrelet identification trials for two days. The Glacier Bay National Park and Preserve Visitor Information Station oversaw boating logistics and safety while conducting surveys. Glacier Bay staff, especially L. Sharman, L. Etherington, and A. Banks, facilitated our research in the park.

Introduction

Since 2009, the National Park Service's Southeast Alaska Inventory and Monitoring Network (SEAN) has monitored population abundance of Kittlitz's (*Brachyramphus brevirostris*, hereafter "KIMU") and marbled murrelets (*B. marmoratus*, hereafter "MAMU") in Glacier Bay National Park and Preserve. The program arose from concern over the conservation status of KIMU, potential global and local population declines (Piatt et al. 2011, USFWS 2013, Kirchhoff et al 2014), and the hypothesis that their populations respond to fluctuations in drivers of the Glacier Bay ecosystem (Moynahan et al. 2008). As part of its Vital Signs Monitoring Program, the SEAN designated KIMU as a priority natural resource with the specific objectives of monitoring abundance, trend, and spatial distributions of populations.

The KIMU is a seabird endemic to Alaska and northeastern Russia, with the highest breeding population densities in the northern Gulf of Alaska (Day et al. 1999). KIMU in summer are often associated with tidewater glacier and glacial fjord habitats, but also occur in non-glacially influenced areas (Day et al. 1999, Arimitsu et al. 2011, Kissling et al. 2011, Madison et al. 2011). KIMU often forage in proximity to glacier outflows (Day and Nigro 2000, Kuletz et al. 2003) and nest in recently de-glaciated areas with sparse vegetation (Day 1995). As a summer resident, open-water, pursuit forager, KIMU are likely to play an important role as integrators of variation in marine and terrestrial ecosystems and directly relate to the conceptual ecological models in the SEAN Vital Signs Monitoring Plan (Moynahan et al. 2008). Reliance on pelagic prey sources and glacially-influenced habitats link KIMU to dynamic physical habitat conditions such as glacial extent and oceanography that are, in part, subject to chronic changes due to climate change (Larsen et al. 2007).

SEAN monitoring focuses on estimating population abundance and trend primarily for KIMU and secondarily for MAMU. Several challenges inherent to Glacier Bay and its murrelet populations complicate estimating murrelet abundance: difficulty distinguishing between the two cryptic species, incomplete detection of murrelets along transects, large spatial and temporal variation in populations, and convoluted topography that complicates survey transect placement. The 2009 and 2010 annual KIMU reports, in conjunction with the final long-term monitoring protocol (Hoekman et al. 2013a) fully describe monitoring methods developed to address these challenges.

These annual reports are designed to efficiently report data in a simple and concise format, focusing on population abundance and spatial distributions. Periodic syntheses at six-year intervals will assess program performance and population trends. Our 2013 study objectives were to complete the fifth year of boat-based line transect surveys, estimate population abundance of KIMU and MAMU in Glacier Bay, describe their spatial distribution, and summarize results since 2009. This season, in cooperation with the University of Montana and USFWS, the SEAN also participated in field trials designed to assess the magnitude of murrelet identification error among observers of differing experience levels. The results of this work will be reported in future thesis products from A. Schaefer at the University of Montana.

Methods

This methods section includes a brief overview of survey design, survey methods, and analytic approach. Full details can be found in the SEAN long-term monitoring protocol (Hoekman et al. 2013a); relevant protocol sections are referenced below.

Study area

Glacier Bay is a narrow, glacial fjord located in Southeast Alaska. The study area encompassed 1,170 km^2 of waters north of Icy Strait and excluded some areas designated as non-motorized waters or those that did not allow safe survey vessel passage (Figure 1).

See Chapter 1 of the SEAN long-term monitoring protocol (Hoekman et al. 2013a) and Hoekman et al. (2011a) for more detail.

Survey design

We employed a generalized random tessellation stratified sampling design (GRTS; Stevens and Olsen 2004) to minimize deleterious effects of large spatial variation in murrelet abundance (Drew et al. 2008, Hoekman et al. 2011a,b) by providing a random, spatially-balanced sample. We allocated survey effort relative to expected densities of KIMU using unequal probability sampling. To avoid placing transects parallel to the observed density gradient of murrelets (Drew et al. 2008, Kirchhoff 2011) and to provide representative coverage across water depths, we oriented linear transects perpendicular to the local prevailing shoreline. In more enclosed waters we used shore-to-shore zigzag transects to avoid undesirably short transects. Transects are sampled according to an augmented, serially alternating panel design (McDonald 2003), where one panel (set of transects) is sampled annually and three others are visited on a three-year rotation, with 2013 including the first panel.

See Chapter 2 and Appendix B of the long-term monitoring protocol for more detail (Hoekman et al. 2013a).

Survey methods

We conducted boat-based line transect surveys (Buckland et al. 2001) at a speed of ≤10 km/h aboard the NPS R/V Fog Lark, an 8.5 m landing craft with a large front deck that provided a viewing height of approximately 3 m above the water line for two observers. For all groups (murrelets of one species class in a flock) initially located on the water, observers recorded group size, species class (KIMU, MAMU, or unidentified), and estimates of distance and angle from the boat. The allowable Beaufort sea state was ≤ 2. Program NPTransect (designed by R. Sarwas and W. Johnson, National Park Service) was used to record observations and associated GPS-based date/time/location stamps.

See the long-term monitoring protocol (chapter 3 of the narrative, Standard Operating Procedures, hereafter “SOPs,” 1, 2, 3, and 9, and Appendix F) for more detail (Hoekman et al. 2013a).

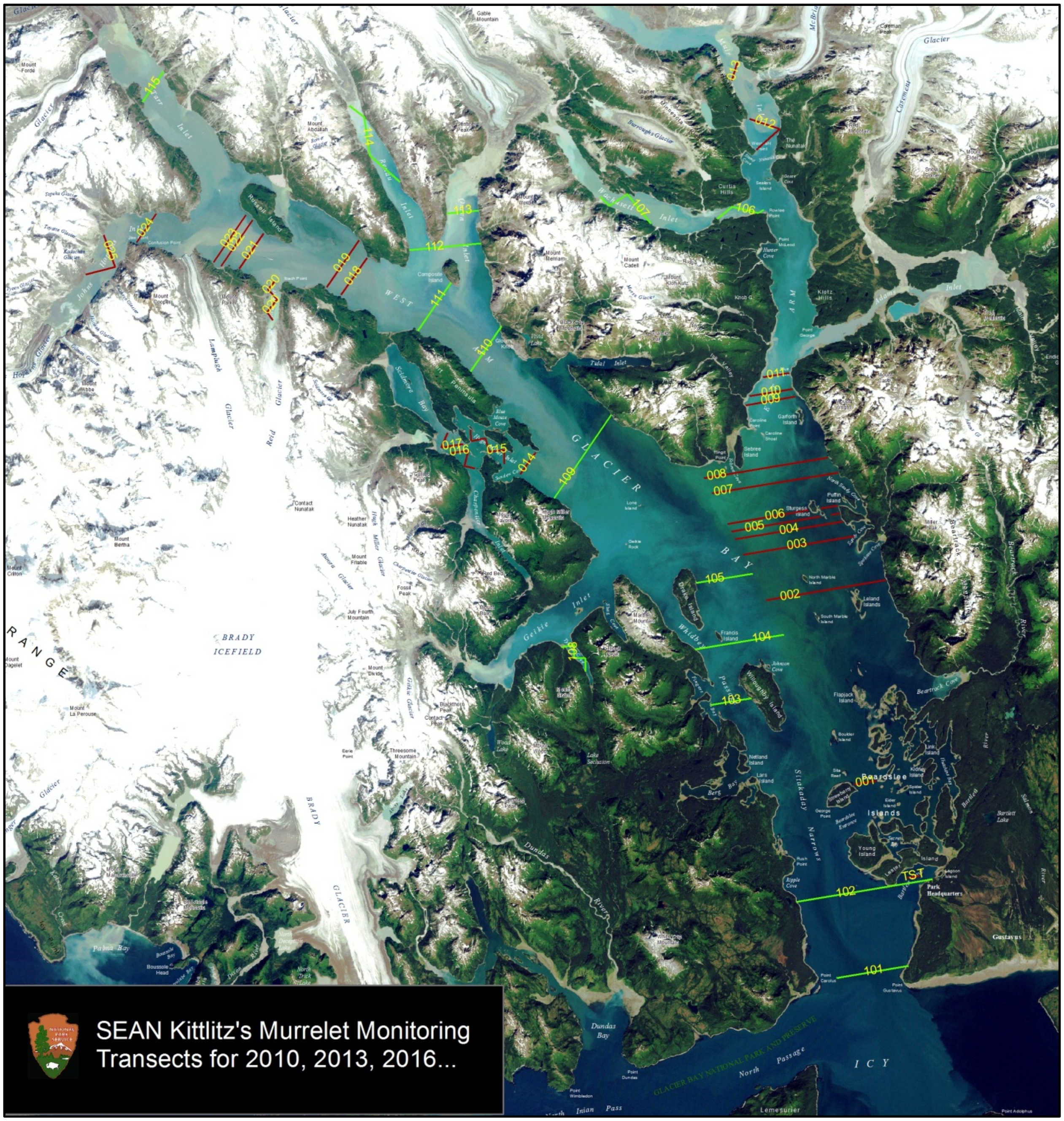

Figure 1. Line transects surveyed for murrelets in July 2013. Permanent (red lines) and Panel 1 (green) transects were surveyed as part of an augmented, serially alternating panel design with a three-year rotation. Linear transects were used in open waters (>2.5 km wide) and zigzag transects were used in more restricted waters. Transects extended from shore to shore, except a few truncated at mid-Bay to maintain optimal transect length. Linear transects were oriented perpendicular to the prevailing shoreline. The orientation of zigzag transects relative to shore was determined by width of each area.

Abundance estimation

We estimated detection probability and group size using Program DISTANCE version 6.0 (Thomas et al. 2010) and species-specific abundance using statistical software R version 2.13.0 (R Core Team 2013) following recommended distance sampling methods (Buckland et al. 2001) and protocol SOP 12 (Hoekman et al. 2013a). We modified distance sampling methods to account for incomplete detection near the transect center line and unidentified murrelets. Adjustments for unidentified murrelets assumed correct identification and identical proportions of each species in the identified and unidentified samples. Density estimates were based on several component parameters: detection probability across the transect width, detection probability near the center line, group size for each species class, and encounter rates for each species class. We estimated abundance by multiplying total study area (1,170 km^2) by estimated densities.

See Hoekman et al. 2011c and the monitoring protocol (appendices A and D, SOPs 11 and 12) for more detail.

Results

We surveyed 40 transects totaling 214 km from 6-13 July 2013 and detected 1,319 groups. Due to heavy surface ice in Johns Hopkins Inlet, we surveyed only 4.27 km of the total 5.63 km length of transect 025. We classified 179 (14%) on-water groups as KIMU, 937 (71%) as MAMU, and 203 (15%) as unidentified. Detection probability was high within 190 m of the transect center line (71%; Table 1). Twenty-eight percent of all observations were made during Beaufort sea state 0, 68% at 1, and 4% at 2. No observations were collected at higher sea states. Most observations (72%) were recorded with >50% cloud cover, with 14% recorded during rain, mist, or fog, and 15% with <50% cloud cover.

Our estimated effective strip width was 135 m. Estimated detection probability remained near 1 up to approximately 40 m from the center line, but decayed rapidly at larger distances (Figure 2). Higher average group size and encounter rates for MAMU (Table 1) resulted in estimates of on-water density and abundance ~12 times higher than KIMU (Table 2). Precision of estimated abundance, measured as the coefficient of variation (CV; in this case, standard error divided by the abundance estimate) was lower for KIMU (CV = 0.284) than MAMU (CV = 0.182). Density estimates since 2009 (Hoekman et al. 2011a,b; Hoekman et al. 2013b) for each species show considerable imprecision and variation among years (Figure 3). Estimated KIMU abundance was the lowest since NPS surveys began in 2009. Estimated MAMU abundance in 2013 was the highest on record.

The distribution of KIMU within Glacier Bay was relatively patchy in comparison to MAMU (Figure 4). The highest KIMU densities were encountered in Rendu Inlet, southwest of Russell Island, the Hugh Miller-Scidmore Complex, the mouth of the East Arm, and Beardslee Entrance. MAMU were densely distributed throughout Glacier Bay, especially lower bay, Beardslee Entrance, and the Hugh Miller-Scidmore Complex. Densities were generally lowest in the main channel of the West Arm (Figure 5).

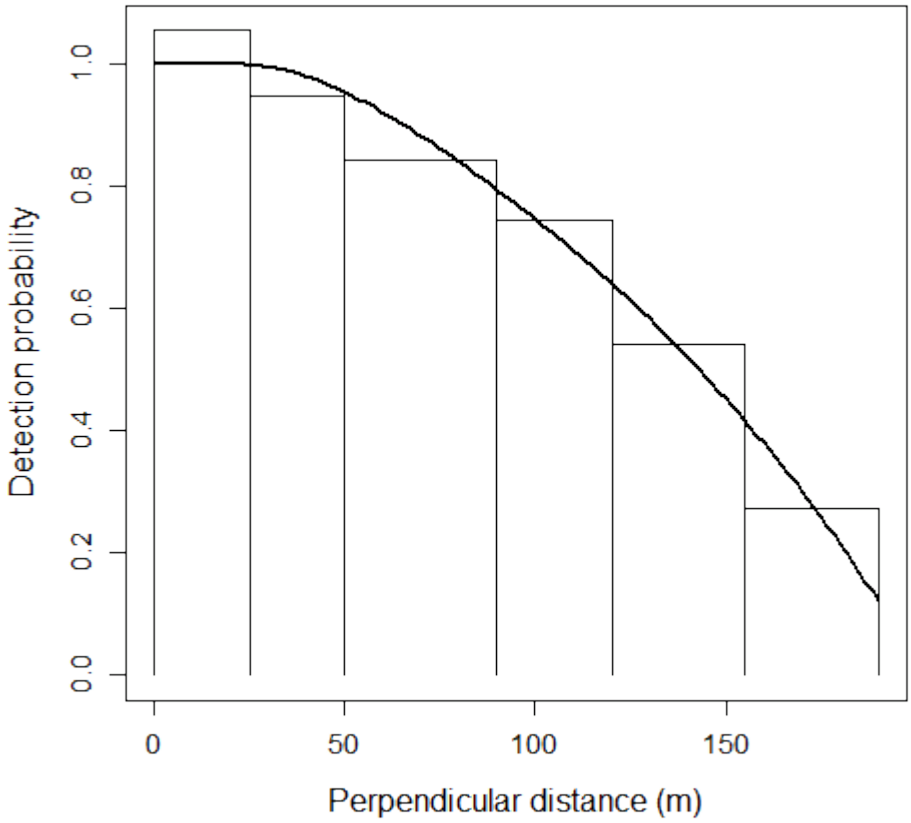

Figure 2. Estimated detection function for murrelets from line transect surveys in Glacier Bay, July 2013, illustrating detection probability of murrelet groups relative to the perpendicular distances from the transect center line.

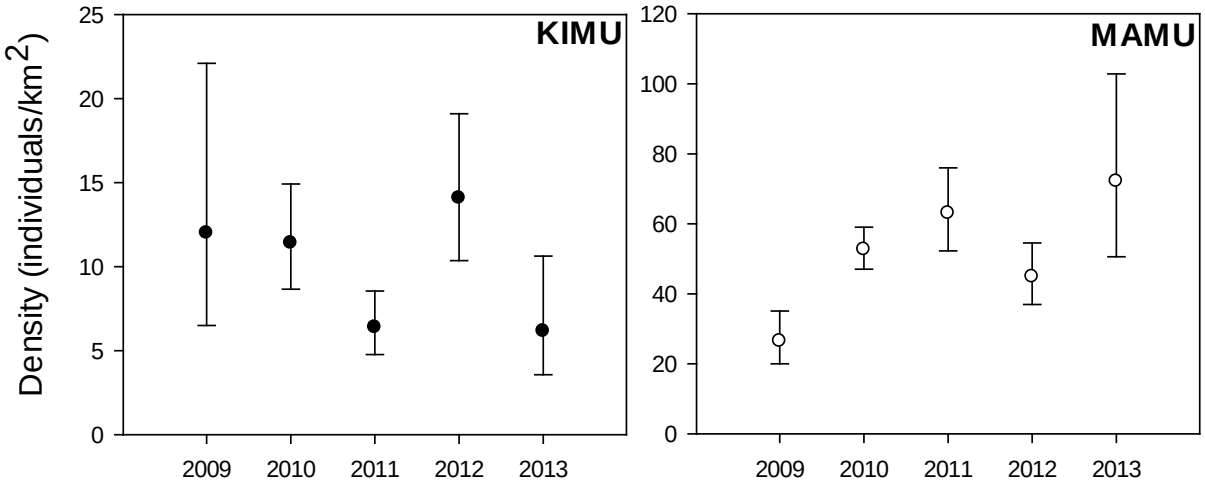

Figure 3. July densities (individuals/km^2) of Kittlitz's (KIMU, black circles) and marbled murrelets (MAMU, white circles) in Glacier Bay survey area from 2009-2013. Error bars are 95% confidence intervals. Note separate *y*-axes for density and that 2009 estimates were based on pilot survey methods (Hoekman 2011a). Densities are displayed to control for differences in survey area for 2009 (1,092 km^2) relative to 2010-2012 (1,170 km^2).

Table 1. Component parameter values used to estimate on-water density and abundance of Kittlitz's and marbled murrelets in Glacier Bay for July 2013. Group sizes were estimated as single averages for each species class (see SOP 11 of protocol for more detail). Regression estimates of group size were less appropriate to use across all species classifications.

Parameter	Estimate	SE	*P*-value	Degrees of freedom
Detection across transect width	0.71	0.03		1351
Detection near transect center line[a]	0.94	0.03		66
Group size: Average				
Kittlitz's murrelet [b]	1.80	0.08		178
Marbled murrelet [b]	2.53	0.07		936
Unidentified murrelet [b]	4.00	0.32		202
Group size: Regression estimate				
Kittlitz's murrelet	1.83	0.08	0.81	177
Marbled murrelet	2.42	0.05	0.21	935
Unidentified murrelet	3.33	0.24	0.06	201
Encounter rate (groups/km)				
Kittlitz's murrelet	0.78	0.21		38
Marbled murrelet	6.47	1.08		38
Unidentified murrelet	1.31	0.30		38

[a] Estimate from Hoekman et al. 2011c.

[b] Estimate selected for estimation of density and abundance.

Table 2. Estimates of on-water population density and abundance of Kittlitz's and marbled murrelets in Glacier Bay during July. Abundance was projected across surveyed waters only. Note that pilot surveys in 2009 differed in survey area (1,092 km^2) and methods (Hoekman et al. 2011a).

	Kittlitz's murrelet				Marbled murrelet			
Year	Density[a]	SE	Abundance	SE	Density[a]	SE	Abundance	SE
2013	6.2	1.7	7,210	2,046	72.2	13.2	84,428	15,394
2012	14.1	2.2	16,469	2,581	44.9	4.5	52,560	5,216
2011	6.4	1.0	7,477	1,119	63.1	6.0	73,766	7,055
2010	11.4	1.2	13,308	1,357	52.7	4.6	61,717	5,372
2009	12.0	3.7	13,124[b]	4,062	26.5	3.7	28,978[b]	4,077

[a]Individuals/km^2

[b]Abundance extrapolated over 1,092 km^2 of sampled waters; all others extrapolated over 1,170 km^2.

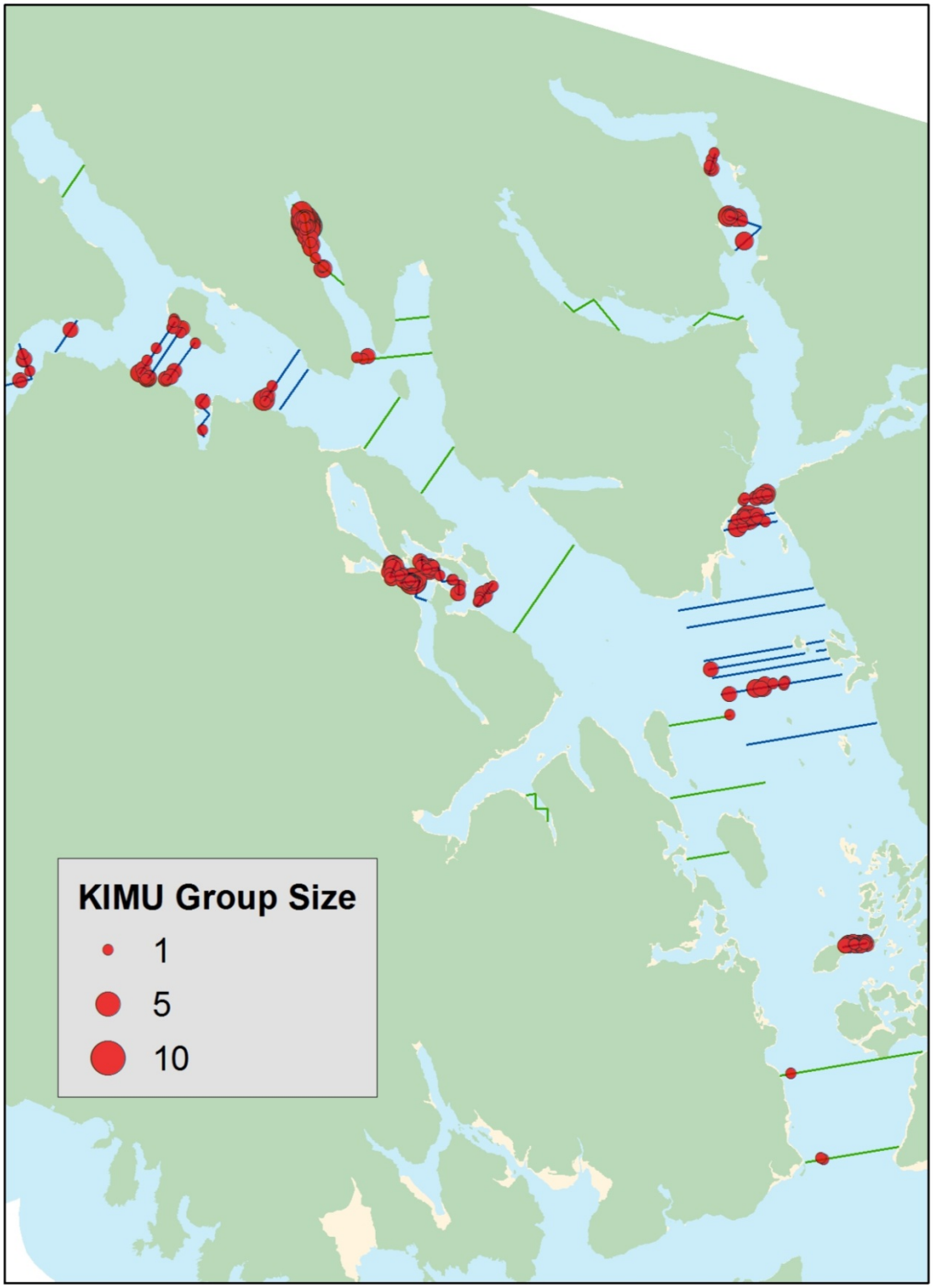

Figure 4. Spatial distribution of Kittlitz's murrelets observed during line transect surveys in Glacier Bay, July 2013. Lines indicate permanent transects (blue) and the current year's alternate panel transects (green). The area of circles is proportional to group size.

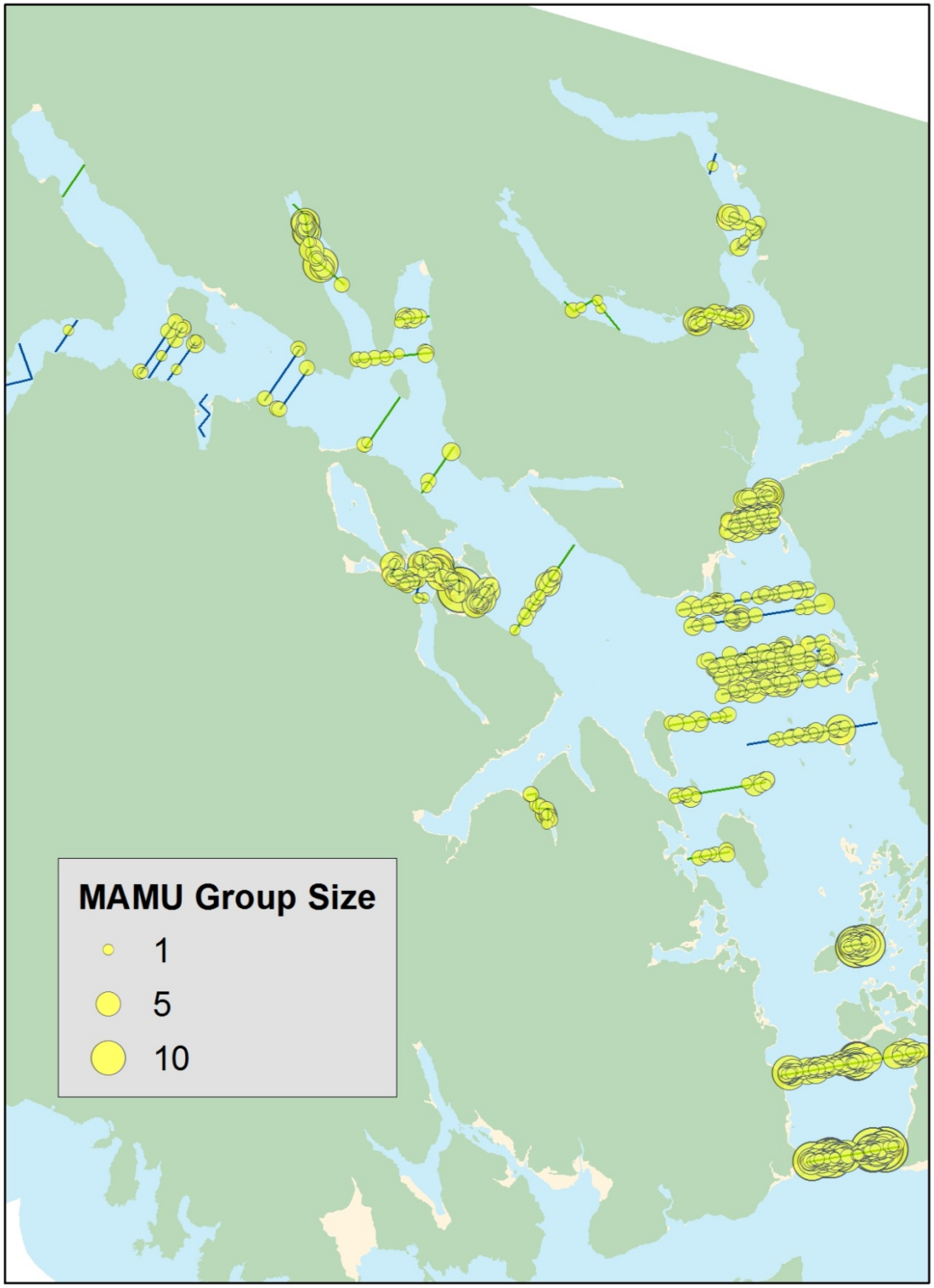

Figure 5. Spatial distribution of marbled murrelets observed during line transect surveys in Glacier Bay, July 2013. Lines indicate permanent transects (blue) and the current year's alternate panel transects (green). The area of circles is proportional to group size.

Discussion

Abundance estimates

The July 2013 on-water abundance estimate for KIMU in Glacier Bay was markedly lower than 2012 and the lowest estimate since the beginning of the SEAN KIMU monitoring program in 2009, but fewer than 300 individuals less than the 2011 count. From 2009 to 2013, abundance estimates for KIMU have ranged from 7,210 to 16,469 individuals, with annual change ranging from -56% to 120%. The breeding season population of KIMU in Glacier Bay still remains high relative to others in Alaska (Arimitsu et al. 2011; Day et al. 2011; Kissling et al. 2011; Kuletz et al. 2011a,b; Madison et al. 2011) and continues to comprise an important fraction of the global population (USFWS 2013). Since 2009, estimates of on-water MAMU abundance in Glacier Bay have ranged from 28,978 to 84,428, with annual change ranging from -29% to 113%.

For both species, abundance estimates have been highly variable across years. Change in abundance estimates between 2012 and 2013 appeared much larger than could be attributed solely to intrinsic population growth. Effects of other potential factors contributing to changes in abundance estimates, such as change in proportion of the local breeding population on surveyed waters during sampling, immigration and emigration from and to other populations, or sampling error, remain unknown. As in previous years, abundance estimates for MAMU were much higher than KIMU. Variance in encounter rates has dominated total variance of abundance estimates (Hoekman et al. 2011a, b, c), and relatively low precision of abundance estimates for KIMU reflected higher CVs for among-transect variation in encounter rates resulting from relatively aggregated distributions for KIMU. In particular, high encounters in the Beardslee Entrance (transect 001) made a disproportionately large contribution to the overall variance.

Detection and identification

Our overall estimated detection probability for 2013 surveys (0.71) was comparable to estimates from 2010-2012. Classification of murrelet groups to species was very high in 2013 (85%) in comparison to 2010-2012 percentages (67%-78%). We believe higher species identification rates can be attributed to weather conditions. Only 4% of observations occurred in Beaufort 2 conditions (30% on 2012), and only 14% made during mist, rain, or fog (19% in 2012). Our analytic methods accommodate variability in detection and identification if certain assumptions are met. A robust detection function (Figure 2) satisfied criteria for estimating detection probability. Our methods of accounting for unidentified murrelets assume similar detection and identification rates for each species and, critically, minimal misidentification.

Similarity of detection functions between species in each survey year (Appendix A, Hoekman et al. 2013a) supports our assumption of equivalence of detection and identification rates between species. Species misidentification rates are currently unknown, but as noted in the Introduction, this season, in cooperation with the University of Montana and USFWS, the SEAN participated in field trials designed to assess the magnitude of murrelet identification error among observers of differing experience levels. The results of this work will be reported in future thesis products from A. Schaefer at University of Montana.

KIMU spatial distribution

SEAN surveys have not consistently documented high occurrence of KIMU in fjord heads. Instead, KIMU generally have been most numerous in the middle portion of the west arm, the Hugh Miller-Scidmore Complex, and various locations within the main bay. In 2013, the main bay and lower West Arm were largely absent of KIMU during the survey period, with largest concentrations in the Beardslee Entrance, Hugh Miller-Scidmore Complex, and Rendu Inlet. Historically, Reid Inlet has been the only location where KIMU concentrations have consistently been associated with a tidewater glacier, but 2013 densities were much lower than prior years.

Our sampling design seeks to maximize precision of KIMU population estimates by allocating sampling intensity in proportion to expected densities of KIMU (see Hoekman et al. 2013b; Appendix B). Correspondence between expected densities and observed encounter rates has remained high for 2011 through 2013 surveys. Despite substantial variability in KIMU distributions, our allocation of effort has generally been successful in increasing sampling of areas with elevated KIMU densities. In 2013, KIMU were almost absent from low-density zones, and the majority of observations for the moderate density zone came from Beardslee Entrance. However, because of extreme variation in KIMU distributions over our (Hoekman et al. 2011a,b; Hoekman et al. 2013b) and other prior surveys (Romano et al. 2007, Drew et al. 2008, Kirchhoff et al. 2010), the potential remains for not observing large concentrations of KIMU actually present within Glacier Bay because they are outside of the survey area, using areas that were not sampled during surveys, or absent from a transect during a survey. In 2013, high densities of KIMU in Hugh Miller-Scidmore Complex suggested the potential for a large number of individuals to have been present just outside the survey area.

Recommendations

After the 2016 survey, a periodic review will assess population abundance and trend, performance of analytic methods, and ability of the monitoring program to achieve its objectives. Although monitoring success is a function of variability in murrelet populations within the survey area, our results and experience to date demonstrate that key operational components of our protocol are functioning as intended: equipment and personnel have been sufficient for timely completion of surveys; species identification rates have been adequate; procedures, equipment, and software for data collection have functioned well; detection probability has been high and detection functions have been robust; and our methods for allocating survey effort have generally been successful in increasing sampling where KIMU density is high.

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NPS 132/123553, January 2014

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