KITTLITZ'S MURRELET *BRACHYRAMPHUS BREVIROSTRIS* POPULATION TREND IN PRINCE WILLIAM SOUND, ALASKA: IMPLICATIONS OF SPECIES MISIDENTIFICATION

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SUMMARY

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Suspected population declines of the Kittlitz's Murrelet *Brachyramphus brevirostris* led to selection of the species as a candidate for listing under the Endangered Species Act (USFWS 2004). Kittlitz's Murrelet is currently classified by the International Union for the Conservation of Nature as critically endangered under criterion A4 on the basis of an estimated and projected decline of at least 80% over a period of 36 years (three generations) stretching from 24 years in the past to 12 years in the future (1986–2022) (Taylor 2011). In this paper we evaluate Kittlitz's Murrelet survey data for the initial time frame, from 1986 through present, for Prince William Sound, Alaska. We show that Prince William Sound had factors that would cause the population estimates to be sensitive to misidentification of species. We present evidence that misidentification occurred, and re-analyze the population trend censoring two years with suspected misidentification. We enhance the time series analysis by incorporating two additional years of survey from Kuletz *et al*. (2011a) – the intensive surveys of 2001 and 2009 – designed specifically for Kittlitz's Murrelets. We also present a non-linear weighted least squares regression, excluding the same two outlying years as Kuletz *et al*. (2011a) and including their intensive surveys. These analyses indicate no significant decline of Kittlitz's Murrelets in Prince William Sound.

Keywords: Kittlitz's Murrelet, Marbled Murrelet, misidentification, trend, Alaska, Prince William Sound, *Brachyramphus*, population

POPULATION ESTIMATES FOR KITTLITZ'S MURRELETS IN PRINCE WILLIAM SOUND ARE SENSITIVE TO MISIDENTIFICATION

Kittlitz's Murrelets *Brachyramphus brevirostris* co-exist in Prince William Sound with the more abundant and phenotypically similar Marbled Murrelets *B. marmoratus*. The two species cannot be readily differentiated in the field, and this leads to difficulty in monitoring (Kirchhoff 2011, Kuletz *et al*. 2011a). When misidentification occurs, and the species ratios are highly skewed, the errors will greatly inflate population estimates of the rarer species. For example, from 1996 to 2007, the average number of Marbled Murrelets in Prince William Sound was roughly 20 times greater than the number of Kittlitz's Murrelets (Kuletz *et al.* 2011a). If we assume that 100% of the birds in a hypothetical sample were identified to species, but 2% of both species were misidentified as the other species, then the Kittlitz's Murrelet population estimate would be inflated 36% by misidentification and the Marbled Murrelet population estimate would be deflated 2%.

The bias is also sensitive to the proportion of murrelets identified to species in the field. For example, in Prince William Sound, in 1993, only 11% of the sampled birds were identified to species. If observers had the same identification error rate as in the previous example (2%), but identified just 11% of the birds to species, the prorated population estimate for Kittlitz's Murrelet would be inflated by a factor of 4.3. The partial identification of the sample would have greatly amplified the effect of misidentification, resulting in a very high population estimate. In fact, the population estimate was very high in 1993 (Fig. 1).

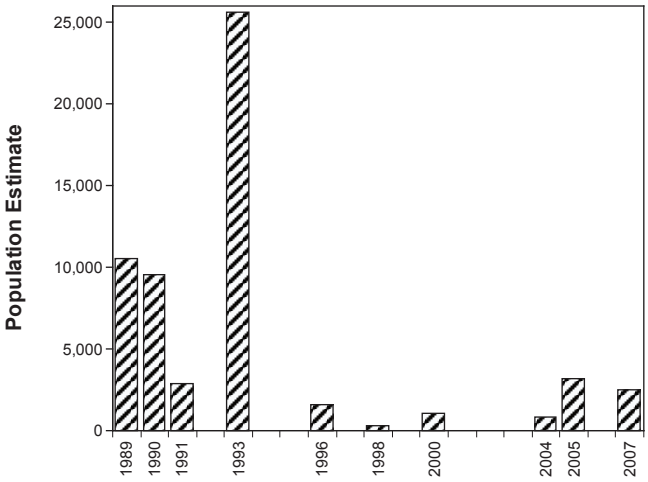

Fig. 1. Population estimates for Kittlitz's Murrelets in Prince William Sound. The unidentified birds were prorated to species by assuming the same species ratio as in the field-identified birds. This differs from the figures in Kuletz *et al*. (2011a), which display only the field-identified birds.

FURTHER EVIDENCE OF SPECIES MISIDENTIFICATION IN 1993

In Prince William Sound, the Kittlitz's Murrelet is found mainly in glacial-influenced marine habitat (Day *et al*. 2003, Kuletz *et al*. 2003). Indeed, during the period 1996–2007, just 12% of Kittlitz's Murrelets were found outside of their core areas (Kuletz *et al*. 2011a). In contrast, Marbled Murrelets were distributed abundantly throughout Prince William Sound (Agler *et al*., 1998, Day *et al*. 2003, Piatt *et al*. 2007). If Kittlitz's Murrelets were found in substantial numbers on transects outside of their core areas, this would be a reason to suspect misidentification of Marbled Murrelets as Kittlitz's Murrelets. In 1993, 65% of the identified Kittlitz's Murrelets were located outside of their core areas (Fig. 2).

Kuletz *et al*. (2011a) suggested that the abnormally high numbers of Kittlitz's Murrelets in 1993, abnormally distributed throughout Prince William Sound, could have been due to an influx of Kittlitz's Murrelets from other regions. If immigration was the cause, it represented at least 15 000 displaced birds, and it never happened again at even a reduced level (Fig. 2). We believe it is more likely these abnormalities reflect species misidentification.

There is additional reason to suspect misidentification in 1993. Lower Cook Inlet data had the same anomalous results in 1993 (Kuletz *et al.* 2011b). The Kittlitz's Murrelet population estimate was extraordinarily high, and the percent identified to species was extraordinarily low (18%). As a result, Kuletz *et al*. (2011b) corrected the Lower Cook Inlet Kittlitz's Murrelet population estimate for 1993 by substituting the average percent Kittlitz's Murrelets seen by more experienced observers in later survey years. Kuletz *et al*. (2011b:88) explained the adjustment as follows: "The survey crews during 1996–1999 had experienced murrelet observers, crew members were fairly consistent across years, protocols were identical, and observers achieved a higher rate of species identification (77% across all years)." However, the

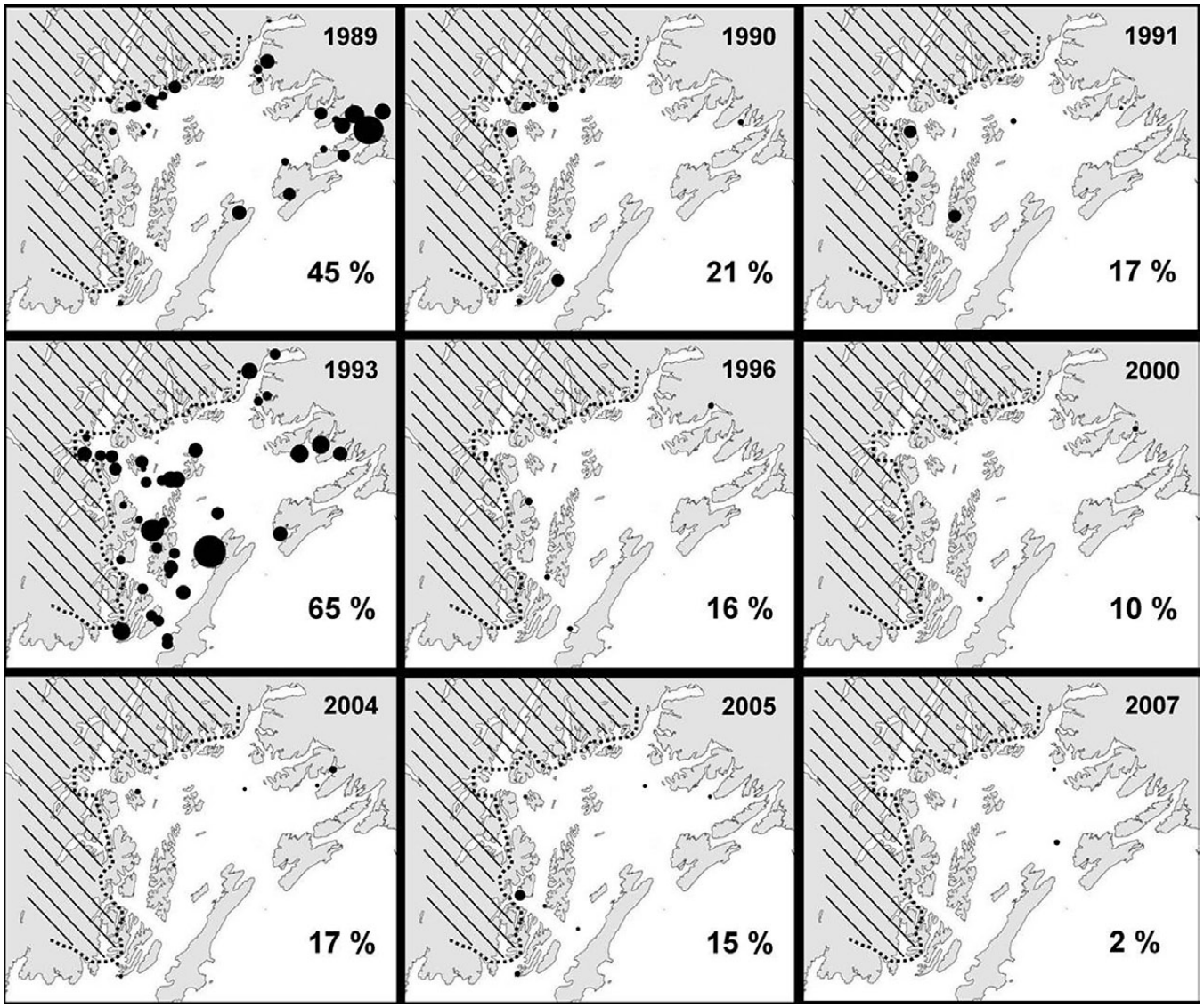

Fig. 2. Distribution of observations outside of core Kittlitz's Murrelet habitat. Hatched area is the core Kittlitz's Murrelet habitat as delineated by the intensive surveys of Kuletz *et al*. (2011). Circle size is scaled (range 1 to 150 birds) to include unidentified birds, prorated to species. Percentages represent the proportion of Kittlitz's Murrelet found outside of the core Kittlitz's Murrelet habitat.

observers in Lower Cook Inlet in 1993 were the same observers as in Prince William Sound that year. Therefore, their observations in Prince William Sound would have the same need for correction.

MISIDENTIFICATION WAS LIKELY IN 1989

Inspection of the distribution maps in Fig. 2 reveals that misidentification of species likely also occurred in 1989. An unusual percentage of Kittlitz's murrelets (45%) were seen outside of their core habitat (Fig. 2), as defined by the intensive survey area (Kuletz *et al*. 2011a). The Exxon Valdez oil spill in 1989 does not explain why so many Kittlitz's Murrelets would move out of the relatively undisturbed and non-oiled core areas (Kuletz *et al*. 2011a) into an area teeming with vessel traffic. The clustering of misidentified birds in the southeast region could be explained by misidentification within a single survey crew responsible for this area.

INTENSIVE SURVEYS PROVIDE ADDITIONAL POPULATION ESTIMATES FOR KITTLITZ'S MURRELETS

Recognizing that the surveys of Prince William Sound had allocated little effort to Kittlitz's Murrelet habitat, intensive surveys were conducted in 2001 and 2009, focusing on "core areas" or fjords in Prince William Sound where Kittlitz's Murrelets were known to occur at the highest densities (Kuletz *et al*. 2011a). The survey transects were therefore located in core Kittlitz's Murrelet habitat (delineated in Fig. 2, see also Day *et al*. 2003). These intensive surveys contained roughly 10 times as many pelagic transects (>200 m from shore) in the core Kittlitz's habitat as the previous Prince William Sound–wide surveys. Consequently, the intensive surveys were far more precise (average coefficient of variation [CV] of 0.18) than the Prince William Sound–wide surveys (average CV of 0.50). The two intensive surveys showed a statistically significant increase in population from 2001 to 2009 (Kuletz *et al.* 2011a). However, they were not included in the Kuletz *et al*. (2011a) trend analysis.

These minimum population estimates provide valuable information and two additional data points. They can be adjusted to represent Prince William Sound after applying a small correction factor for the Kittlitz's Murrelet population outside the intensive survey areas.

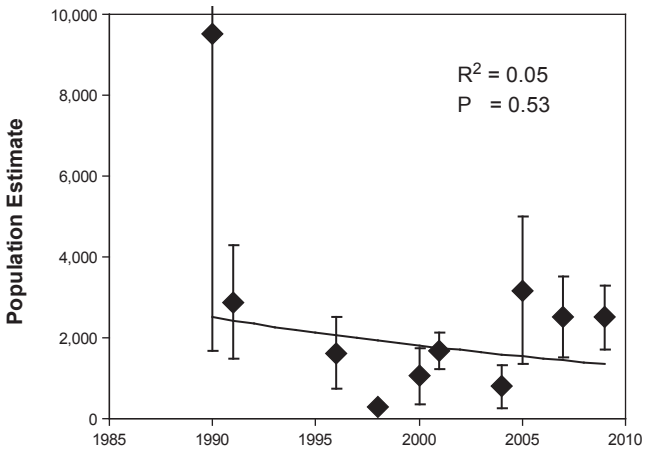

Fig. 3. Re-analysis of population estimates (with standard errors) for Kittlitz's Murrelets in Prince William Sound (trend curve based on exponential regression analysis), showing stable population over the 20-year period 1990–2009.

As mentioned earlier, the four Prince William Sound-wide surveys from 2000 to 2007 found an average of 12% Kittlitz's Murrelets outside of the intensive survey areas (Fig. 2). Thus, the intensive surveys represented an estimated 88% of the Prince William Sound-wide population. We therefore adjusted the intensive survey results by a factor of 1.14 to be comparable to the Prince William Sound-wide surveys. We also prorated the small number of unidentified birds (5% in 2001 and 6% in 2009) to species, as is the accepted practice (Kirchhoff 2011). The resultant Kittlitz's Murrelet population estimates are 1 676 in 2001 and 2 513 in 2009.

THE TWO-GENERATION (1986–2010) KITTLITZ'S MURRELET TREND ANALYSIS USING AN EXPONENTIAL REGRESSION

Kuletz *et al*. (2011a), in their summary, reported a population decline rate of -13% per annum (confidence limits -7% to -19%) from 1989 to 2007. We find a much different trend estimate over that time period by including the two intensive survey years (2001 and 2009) and excluding the two years of probable misidentification (1993 and 1989). In this analysis, the exponential trend (Fig. 3) is not statistically significant ($P = 0.53$). Hence, we cannot reject the possibility of a stable population, for which the best estimate is the mean of 2 605 Kittlitz's Murrelets.

THE TWO-GENERATION (1986–2010) KITTLITZ'S MURRELET TREND ANALYSIS USING LEAST SQUARES NON-LINEAR REGRESSION WITH WEIGHTING INVERSELY PROPORTIONAL TO VARIANCE

Our analysis used weighted least squares non-linear regression of Kittlitz's Murrelet population estimates. Kuletz *et al.* (2011a) used a similar regression analysis, which additionally incorporated Marbled Murrelets into their models. Our population estimates included the unidentified birds prorated to each species based on the ratios among the field-identified birds. We assumed the CVs were the same for the prorated estimates as the field estimates. We weighted the least squares regression using the inverse of the variance (SE squared). We removed the two outliers (1993 and 1998), which Kuletz *et al.* (2011a) also removed individually in two of their models. At this point, our trend estimate would be nearly identical to that produced by the Kuletz *et al.* (2011a) model. However, we incorporated two additional data points (the intensive surveys of 2001 and 2009), which Kuletz *et al.* analyzed separately from their regression models. Our weighted least squares regression yields a decline rate of -0.1% per annum, or -2% for the 20-year period from 1989 to 2009, not significantly different from a stable population.

CONCLUSIONS

The high population estimate in 1993 could have been caused by misidentification or by immigration. We believe the simplest and most likely explanation for 1993 was misidentification. It simultaneously explains the extraordinarily high population estimate and the atypical distribution pattern. Misidentification was possible in 1989 as well, based on large numbers of Kittlitz's Murrelets recorded outside of their core habitat.

The influence of misidentified and unidentified murrelets has been underappreciated as a factor that can inflate population estimates of rare species like the Kittlitz's Murrelet. Misidentification was most likely to occur in the earlier years, when there was less emphasis

on accurately identifying a high percentage of murrelets to species. It may be difficult to know whether misidentification problems occurred in other years in the Prince William Sound, or in other areas of their range, but it should be considered as one of the possible sources of bias.

We suggest that previous population trends of Kittlitz's Murrelet in Prince William Sound were driven by two early surveys that suffered from low identification rates and suspected higher-than-usual species misidentification. When the questionable data are censored, and the two years of intensive Kittlitz's Murrelet surveys are added, the population of Kittlitz's Murrelets in Prince William Sound shows no sign of a significant decrease since 1989. A weighted non-linear regression also showed no significant decline.

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