

SOP 8: Periodic Review

Version 1.0

Revision History Log:

Previous Version #	Revision Date	Author	Changes Made	Reason for Change	New Version #
	October 2013	S. Hoekman, W. Johnson, B. Moynahan, C. Sergeant	Initial version		1.0

Summary

Periodic review reports will be created at ~six-year intervals (or as needed) and provide more in-depth, sophisticated, and open-ended analyses of survey data than annual reports (see SOP 7). Primary objectives are to 1) estimate trend for on-water populations of KIMU and MAMU in the survey area, 2) test key assumptions of monitoring methods, 3) review current information and summarize implications for the monitoring protocol, 4) assess ability of the monitoring program to meet objectives, and 5) recommend changes to the monitoring protocol. Additional objectives can meet specific needs, such as developing or adopting improved survey or analytic methods or conducting research targeting critical information gaps. Periodic reviews require advanced statistical expertise and might be contracted to external personnel, who will develop review objectives and methods in coordination with the Project Leader, SEAN Ecologist, and other relevant parties.

Format and Content

The periodic review follows the NPS Natural Resource Technical Report format (see National Park Service 2010, available at <http://www.nature.nps.gov/publications/NRPM/>). Content is flexible, but likely will contain the following elements:

- I. **Introduction:** Overview of prior results of the murrelet monitoring program and the objectives and methods of the periodic review.
- II. **Methods:** Brief summary of monitoring methods and more detailed information on analytic methods used in the periodic review.
- III. **Results:** Summary statistics, parameter estimates, and figures relating to analyses in prior reports and the periodic review, including information on sampling effort, model selection, estimates of population status and trend, distributions of populations, tests of critical assumptions, and other information as needed.
- IV. **Discussion:** Summary and interpretation of results relevant to management issues, public interest, technical aspects of the monitoring protocol, and assessment of the monitoring program to meet objectives. Results should be placed in context of prior monitoring data and relevant scientific literature.
- V. **Recommendations:** Recommended refinements to the monitoring protocol or issues requiring further consideration (e.g., in targeted research or a subsequent periodic review).

- VI. **Literature Review** (optional): Summary of literature (emphasizing recent literature) with implications for this monitoring program or conservation of murrelets in Glacier Bay.

Statistical Analyses

Estimation of status and trend for on-water populations of murrelets in surveyed areas will be essential, but other potential analyses include modeling spatial distribution of populations or resource use, testing critical assumptions, assessing ability to meet protocol objectives, and field experiments targeting key uncertainties. Initial reviews likely will emphasize assessing monitoring methods and population status, while analyses of population trend, spatial distributions, and resource use will become more meaningful over time. We refrained from making specific recommendations for analytic methods because appropriate methods likely will change over the life of the monitoring program.

Population Status and Trend

Methods in section A.3 of Appendix A should be appropriate for annual estimates of population status if assumptions are supported, but more sophisticated analyses in periodic reviews may warranted to 1) account for violation of assumptions, 2) incorporate improved analytic methods or novel estimates of poorly known parameters (e.g., detection probability near the transect center line, probability of species misidentification, etc.), 3) employ more sophisticated and in-depth analytic methods, and 4) provide unified methods for estimation of population status and trend. Modeling the influence of covariates (e.g., Beaufort sea state, weather conditions, local encounter rates) on detection functions may increase accuracy of estimates of detection probability and also may motivate improvements to field or analytic methods. Using annual estimates of population status as data for a regression-based estimation of population trend may be adequate, but suffers from limitations imposed by doing “statistics on statistics.” Ongoing development of hierarchical or state space models, which incorporate nested sub-models, may provide flexible and robust methods for estimation of population trend directly from survey data (Gelman and Hill 2007, Royle and Dorazio 2008, Kery et al. 2009, Cressie et al. 2009). Potential benefits include providing a unified structure for model selection and estimation of population status and trend, incorporating covariates, appropriately accounting for error in population estimates, area-specific estimates of population status and trend, and reduced bias and increased precision of trend estimates.

Testing Assumptions

Our methods of accounting for incomplete species identification rely on similarity (within each survey) of detection functions between species (see Appendix A, section A.3). Preliminary analyses have supported pooling species for estimating detection functions (Appendix A, section A.2.4; Hoekman et al. 2011b), but further analyses should assess this conclusion. If differences are found, it will be essential to determine implications for population estimates and, if necessary, implement appropriate survey or analytic methods. Understanding if differences in detection functions arise from differences in detection or identification between species would aid in determining appropriate remedies.

Our methods of estimating species-specific encounter rates assume species identification is incomplete but never erroneous (i.e., no misclassification). Misclassification rates are unknown but certainly >0 . With substantial misclassification, bias in species-specific population estimates potentially is large, especially when misclassification rates or abundance are asymmetric between species (Royle and Link 2006, Kirchhoff 2011, Molinari-Jobin et al. 2011, Hoekman et al. 2011b). Field experiments (e.g., using known individuals or using multiple independent observers) could provide estimates of misclassification and factors influencing them (e.g., environmental conditions, observer experience, observation distance) that could be used to adjust population estimates. Alternatively, misclassification (i.e., occurrence of 'false positives') has been estimated directly from survey data for single-species occupancy analyses using multi-state models (Royle and Link 2006, Miller et al. 2011). However, extension of these methods to multi-species line transect surveys remains uncertain because of the large number of data states (e.g., for each species: undetected, detected/identified, detected/unidentified, and detected/misclassified), because of potential problems with parameter identifiability, and because heterogeneity in species composition may be difficult to distinguish from misclassification (Royle and Link 2006, Royle and Dorazio 2008, Miller et al. 2011). Further work is needed to determine the magnitude of misclassification, resulting bias in population estimates, and appropriate remedies.

Distance sampling methods assume correct distance measurements (Buckland et al. 2001). In practice, population estimates are sensitive to bias in distance estimates (i.e., average deviation of estimated versus true distances) but less so to unbiased variability in deviations. SOP 9 discusses these issues and describes distance estimation calibration procedures for training and assessing performance of Observers.

Analyses of distance estimation assessment data can assess whether Observer performance is meeting objectives, how performance responds to training, and how estimation error varies among Observers and relative to factors such as Observer experience, weather conditions, Beaufort sea state, and true observation distance. If performance is not within desired limits, results may suggest changes to training or survey methods. If remedial actions are unsuccessful or impractical, population estimates might be adjusted based on models of error in distance estimation, but applying this approach would require careful consideration. An intuitive approach is to adjust the standard distance sampling estimator of density D so that

$$\hat{D} = \frac{\hat{E}\hat{S}}{2w'\hat{P}_a}, \quad \text{SOP 7.1}$$

where E is the encounter rate, S is group size, P_a is detection probability, and w' is the strip width w adjusted for bias in distance estimates ($=w \cdot \{100 + \% \text{ bias in estimates}\} / 100$). However, assumptions are that proportional bias in distance estimates is constant relative to true observation distance, distance calibration assessment data are representative of survey data, and that sessions with survey buoys adequately measure performance in estimation of distances to murrelets. The first assumption is easily assessed in analyses, and the second may not hold if factors influencing bias in distance estimates (e.g., individual Observers, environmental conditions, true observation distances) also differ between assessment data and survey observations. If so, models of bias in distance estimation

including relevant covariates would need to be applied to accurately adjust survey observations. Finally, adjusting distance estimates to account for unbiased but variable error in distance estimates is much less straightforward than accounting for average bias (see references in Buckland et al. 2001).

Distribution of Populations and Resource Use

Survey data will be appropriate for analyses of spatial distributions of populations and of resource use, although these analyses are ancillary to primary monitoring objectives and their potential to inform will increase as data accrue. Potential objectives include identifying and explaining changes in population distributions over time, assessing optimality of allocation of survey effort, and identifying resource needs and vital habitat areas. Development of methods allowing inclusion of covariates in distance sampling analyses provides tools for assessing response to environmental conditions and projecting spatial distributions of populations (Hedley and Buckland 2004, Hedley et al. 2004, Fiske and Chandler 2011).

Assessing the Protocol

Analyses should assess performance of key protocol components and capacity to meet monitoring objectives. Survey methods and training should be evaluated in regard to whether detection and identification of murrelets consistently meets or exceeds desired levels and whether estimated detection functions meet shape criteria for robust estimation of detection probability (Buckland et al. 2001). Heterogeneity in population status estimates strongly decreases capacity to detection population trend (Larsen et al. 2001) and hence magnitude of this heterogeneity will be critical to assessing capacity to meet monitoring objectives. Separating process (i.e., true variation in populations) versus sampling variance may provide insight to causes and remedies for excessive variance among population estimates. The primary remedy for large process variance is lengthening the time series (Larsen et al. 2001), and the magnitude of process variance will largely determine if objectives for trend detection can be met. In contrast, excessive sampling variance in population estimates likely will be derived from variation in encounter rates among transects (Hoekman et al. 2011a, b) and should respond to design decisions (e.g., sampling effort, allocation of effort). Power analyses or simulation studies may be useful to projected capacity to detect population trend for proposed amendments to the sampling design.

Content of Results Section

Content is flexible, but results related to estimation of species-specific population status and trend are essential. We recommend the following core components:

- I. **Summary and Descriptions:** Overview of survey data and data collection (e.g., sample sizes, personnel and vessels, sampling dates, notable events for each survey year, etc.) and relevant summary statistics (e.g., numbers of groups by species class, average group sizes, survey effort, etc.).
- II. **Estimates of Density and Abundance:** For each survey year, estimates of species-specific population status (on-water density and abundance with associated sampling error) and component parameters used to estimate status (e.g., transect width, estimated detection

functions, estimated encounter rates, estimated detection probabilities, etc.) organized in tables.

- III. **Estimates of Population Trend:** For each survey year, a table of on-water abundance estimates used for trend analyses with associated sampling error. Estimates of population trend and associated sampling error should be presented along with a figure showing annual abundance estimates and estimated trend.
- IV. **Spatial Distribution of Populations:** Results presented should be appropriate to analyses conducted, but at a minimum should include visual and/or statistical summaries of species-specific spatial distribution of populations across all survey years as well as variation among years.

Content of the Discussion

Content depends on objectives and analyses conducted. Place results of population status, trend, and distribution analyses in context of prior results for this and other regions, of relevant scientific literature, and of NPS policy. Interpret population status and trend results relative to potential causal factors and/or exceptional circumstances, and generate hypotheses for further monitoring and research. Results of population analyses and assessments of protocol methods and assumptions should be used to inform assessments of protocol performance and potential enhancement of the protocol.

Content of the Recommendations

Content depends on objectives, analyses, and results. Address specific changes to protocol design, methods, or analyses necessary to improving protocol performance. Population results may motivate recommendations of policy or management actions or key research needs relevant to murrelet conservation.

Literature Cited

- Buckland, S. T., D. R. Anderson, K. P. Burnham, J. L. Laake, D. L. Borchers, and L. Thomas. 2001. Introduction to Distance Sampling: Estimating Abundance of Biological Populations. Oxford, New York, New York, USA.
- Cressie, N., C. A. Calder, J. S. Clark, J. M. ver Hoef, and C. Wikle. 2009. Accounting for uncertainty in ecological analysis: The strengths and limitations of hierarchical statistical modeling. *Ecological Applications* 19:553–570.
- Fiske, I., and R. Chandler. 2011. Unmarked: An R package for fitting hierarchical models of wildlife occurrence and abundance. *Journal of Statistical Software* 43:1–23.
- Gelman, A., and J. Hill. 2007. Data Analysis Using Regression and Multilevel/Hierarchical Models. Cambridge, New York, New York, USA.
- Hedley, S. L., and S. T. Buckland. 2004. Spatial models for line transect sampling. *Journal of Agricultural, Biological and Environmental Statistics* 9:181–199.

- Hedley, S. L., S. T. Buckland, and D. L. Borchers. 2004. Spatial models for line transect sampling. Pages 48–70 in S. T. Buckland, D. R. Anderson, K. P. Burnham, J. L. Laake, D. L. Borchers, and L. Thomas, editors. *Advanced Distance Sampling: Estimating Abundance of Biological Populations*. Oxford, New York, New York, USA.
- Hoekman, S. T., B. J. Moynahan, and M. S. Lindberg. 2011a. Monitoring Kittlitz's and marbled murrelets in Glacier Bay National Park: 2010 annual report. Natural Resource Technical Report NPS/SEAN/NRTR—2011/441. National Park Service, Fort Collins, Colorado, USA. Retrieved October 17, 2013, from http://science.nature.nps.gov/im/units/sean/AuxRep/KM/KM_F/KM_2010_Annual_report.pdf
- Hoekman, S. T., B. J. Moynahan, M. S. Lindberg, L. C. Sharman, and W. F. Johnson. 2011b. Line transect sampling for murrelets: Accounting for incomplete detection and identification. *Marine Ornithology* 39:35–44.
- Kery, M., R. M. Dorazio, L. Soldaat, A. van Strien, A. Zuiderwijk, and J. A. Royle. 2009. Trend estimation in populations with imperfect detection. *Journal of Applied Ecology* 46:1163–1172.
- Kirchhoff, M. D. 2011. A review of selected surveys of the Kittlitz's murrelet *Brachyramphus brevirostris* in Alaska: Lessons learned. *Marine Ornithology* 39:77–83.
- Larsen, D. P., T. M. Kincaid, S. E. Jacobs, and N. S. Urquhart. 2001. Designs for evaluating local and regional scale trends. *Bioscience* 51:1069–1078.
- Miller, D. A., J. D. Nichols, B. T. McClintock, E. H. Campbell Grant, L. L. Bailey, and L. A. Weir. 2011. Improving occupancy estimation when two types of observational error occur: Non-detection and species misidentification. *Ecology* 92:1422–1428.
- Molinari-Jobin, A., M. Kéry, E. Marboutin, P. Molinari, I. Koren, C. Fuxjäger, C. Breitenmoser-Würsten, S. Wölfl, M. Fasel, I. Kos, M. Wölfl, and U. Breitenmoser. 2011. Monitoring in the presence of species misidentification: The case of the Eurasian lynx in the Alps. *Animal Conservation* 15:266–273.
- National Park Service. 2010. Instructions to authors — Natural Resource Report, Natural Resource Technical Report, and Natural Resource Data Series: version 3.0. Natural Resource Report. NPS/NPRC/IMD/NRR—2010/256. National Park Service, Fort Collins, Colorado, USA.
- Royle, J. A., and W. A. Link. 2006. Generalized site occupancy models allowing for false positive and false negative errors. *Ecology* 87:835–841.
- Royle, J. A., and R. M. Dorazio. 2008. *Hierarchical Modeling and Inference in Ecology: The Analysis of Data From Populations, Metapopulations and Communities*. Academic, Boston, Massachusetts, USA.